REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

Management and conservation of renewable marine resources in the South Asian Seas region

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PREFACE

Thirteen years ago the United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972) adopted the Action Plan for the Human Environment including the General Principles for Assessment and Control of Marine Pollution. In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and co-ordination within the United Nations system" (General Assembly resolution 2997(XXVII) of 15 December 1972). The organizations of the United Nations system were invited "to adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems", and the "intergovernmental and non-governmental organizations that have an interest in the field of the environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination". Subsequently, the Governing Council of UNEP chose "Oceans" as one of the priority areas in which it would focus efforts to fulfil its catalytic and co-ordinating role.

The Regional Seas Programme was initiated by UNEP in 1974. At present, it includes eleven regions [1/] and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to controlling environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities [2/].

The Regional Seas Programme has always been recognized as a global programme implemented through regional components. Inter-regional co-operation among the various sea areas on common problems is an important element in assuming the compatibility of the different regional components.

As a contribution to the development of the Action Plan for the South Asian Seas region supported by UNEP in the framework of the Regional Seas Programme in the Indian Ocean region, the International Union for Conservation of Nature and Natural Resources (IUCN), in co-operation with UNEP has prepared this document.

This document reviews past and on-going conservation activities relevant to the South Asian Seas region at the regional and national levels; identifies priority concerns of the Governments bordering the region; and contains recommendations for interregional and regional projects to be undertaken to address these concerns. The assistance of a consultant, C.R.C. Sheppard, in the preparation of this document is gratefully acknowledged. In addition, the sections dealing with fishery aspects of conservation have been compiled and edited by the Tropical Marine Research Unit, University of York, Great Britain.

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

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

CONTENTS

INTRODUCTION

AREA COVERED

The South Asian Seas region (Region 11) is comprised of the marine and coastal environments of Bangladesh, India, the Maldives, Pakistan, and Sri Lanka. It was designated as a region to be included in the Regional Seas Programme in May 1983.

The northern Indian Ocean is divided by India into two morphologically similar halves: the Arabian Sea and Bay of Bengal. Both have areas of broad continental shelf which dips sharply to depths of 3000 m. the deep plains of both are relatively featureless apart from the cones of the Indus and Ganges. neither parts support islands beyond the continental shelf, although in the east of the Bay of Bengal the Andamans and Nicobars arise from a submerged mountain chain which follows a southwards extension of the shelf (Couper, 1983; Pathmarajah, 1982).

The major coral island feature in the Central Indian Ocean is the Laccadive - Chagos ridge which supports coral atolls along most of its length to 7^{o} south.

Other major highs in the Indian Ocean are the Carlsberg Ridge and the Central Indian Ridge which are both west of the Laccadive-Chagos Ridge, and the Ninety East Ridge in the southeast. None support islands or reach within 500 m. of the surface.

The dominant offshore sediments of the Indian Ocean are calcareous, with terrigenous sediments on the continental shelves and intruding into the Bay of Bengal. Large but isolated patches of pelagic and siliceous clays exist in the southeast.

CLIMATE

The climate varies greatly both seasonally and according to location in this large region. In general it is dominated by the monsoonal seasons and affected by cyclones.

In the beginning of the year the intertropical convergence zone (ITCZ) lies south of the equator. in the south, the southeast trades blow, while in the north the northeast monsoon is fully developed, but is dry over much of the Indian Ocean. in the second quarter, the ITCZ moves north reaching southern India in late April. The southeast trades occupy the whole of the southern ocean, while in the north rain systems become frequent in the Bay of Bengal and southeast Arabian Sea and a few develop into cyclones. in the third quarter the southwest monsoon holds sway over the Arabian Sea, India and the Bay of Bengal where mean wind speeds and rainfall reach their maximum. in the southern ocean, the southeast trades reach a mean speed of 9 m/sec - the worlds most vigorous tradewinds. in the fourth quarter, winds change to northeasterly over the north, the tradewinds in the south diminish, and the ITCZ migrates south again. the southwest monsoon diminishes but there is still heavy rainfall in parts such as the Bay of Bengal where cyclones develop (Couper, 1983; Pathmarajah, 1982).

Tropical storms and cyclones have a major importance to shallow marine ecosystems. in general, cyclones of the Indian Ocean track northwest and southwest out of the equatorial region between 5°N and 5°S where cyclones do not occur. The southwest Indian Ocean experiences the most frequent number, but land is relatively sparse in this part of the ocean. Their peak frequency is in January. The northern Indian Ocean has fewer cyclones, but many more reach populous areas. These have bimodal distribution with peaks in May and November.

OCEANOGRAPHY

Some major currents are seasonal and the northern parts are controlled by monsoons. The west flowing South Equatorial Current in the southern Indian Ocean, however, exists all year. Where this is deflected by the African mainland, the northward Somali Current flows during the northern summer, while in the winter, the Equatorial Counter Current flows east. North of the equator, seasonal reversals follow the monsoons. In winter, the Indian NE Monsoon Current flows westwards, while in the summer the Indian SW Monsoon Current flows eastwards. The Arabian Sea and the Bay of Bengal have smaller scale and rather irregular circulations of their own which result in part from monsoonal currents, these too change seasonally.

Deep currents appear more straightforward. From principal water sources in the Antarctic region, at least two northerly streams flow up both sides of the Indian Ocean. Both are deflected back towards the central Indian Ocean near or north of the equator. In the case of the western stream, this deflection occurs off Somalia and the Arabian peninsula where important, nutrient rich upwelling occurs. The upwellings account for the major productivity of the Indian Ocean (Fagoonee, 1983).

Throughout the year, surface temperatures vary between 25-30°C. In the extreme north of the Bay of Bengal and the Arabian Sea, and in the Mascarenes, temperatures fall below 30°C seasonally. Off many of the oceanic islands in particular, thermoclines may exist shallower than 50 m., below which temperatures may drop 2-4°C.

Three amphidromic points occur in the Indian Ocean, one in the southern Arabian Sea and the other two south of the region of concern. Throughout the oceanic islands, tidal ranges are usually 2 m. or less, and are similar in southern India and Sri Lanka. North of the latter, tidal ranges increase gradually to 5 m. in the northern reaches of the ocean, and in the macrotidal Gulf of Kutch tidal ranges reach 6 m. and generate tidal currents of 2.5 m/sec. The Bay of Bengal has semi-diurnal tides, while those in much of the rest of the region are mixed.

Surface salinity shows a clear gradient from greatest in the west and in the Arabian Sea, to lowest in the east and the Bay of Bengal. Although values fluctuate slightly seasonally, the highest values in the Arabian Sea are 36-37 ppt. while the lowest in the Bay of Bengal are less than 33 ppt. Locally, such as near the mouths of the Indus, Ganges and Irrawaddy, values are depressed further over wider areas.

CONSERVATION AND MANAGEMENT ACTIVITIES

Several UN bodies and their subdivisions, as well as independent bodies such as the International Union for the Conservation of Nature and Natural Resources (IUCN) have been involved in aspects of the South Asian Seas region and adjoining waters. The following section identifies most of the revelant programmes and notes the areas in which they have contributed.

From 1959-1965 the area was the subject of the International Indian Ocean Expedition, which was initiated by the Scientific Committee of Ocean Research (SCDR) but which involved several agencies, including the newly formed Intergovernmental Oceanographic Commission (IOC). Since then, however, this part of the Indian Ocean has not been the subject of any co-ordinated resource management programme (UNEP, 1982) although several of the countries within it, notably India, have extensive marine science programmes.

In 1981, a meeting of Ministers was held in Sri Lanka to initiate the South Asia Co-operative Environmental Programme (SACEP). It included all the nations later forming the South Asian Seas region. SACEP's objectives included the protection and development of the marine and coastal environment of the countries concerned.

The 1972 Stockholm Conference defined Earthwatch (the global environmental assessment programme) as one of the three basic components of the Action Plan for the Human Environment. The Global Environmental Monitoring System (GEMS) is one of the four components of Earthwatch and the "assessment of the state of ocean pollution and its impact on marine ecosystems" was adopted as GEMS' task by the Governing Council of UNEP. The implementation of GEMS is seen by UNEP as a joint undertaking of the relevant UN bodies. The monitoring of the quality of the marine environment as a component of GEMS is now implemented through the UNEP Oceans and Coastal Areas Programme. The latter was developed by UNEP in the framework of its mandate within the UN system to serve as a focal point for environmental action regarding the marine environment.

A Joint Group of Experts on Marine Pollution (GESAMP) involving the UN bodies was established in 1969. Today this body provides advice relating to scientific aspects of marine pollution and prepares reviews of the state of marine pollution and indentifies problem areas requiring attention (UNEP,1982). The first global report on the health of the oceans involving the UN bodies, was prepared by GESAMP and completed in 1981, and definitions of marine pollution as developed by GESAMP are incorporated into the Regional Seas Programmes.

Two important conventions relevant to the South Asian Seas region involve pollution from ships; these are MARPOL, which in 1973 extended an earlier oil pollution convention to include all types of pollution from ships, and a protocol which updates MARPOL, adopted in 1978 on Tanker Safety and Pollution Prevention.

The South Asian Seas region was established by UNEP Governing Council decision 11/7 in 1983 and includes the marine and coastal areas of Bangladesh, India, the Maldives, Pakistan and Sri Lanka. The precise geographical coverage of the region has not yet been defined. In March 1984 a meeting of national focal points was held at which time it was decided that as an initial step, national reports discussing the environmental condition of each of the countries involved in the region should be prepared. In this respect, the South Asian Seas Region has not yet reached

the point of development of any of the other regional programmes in the Indian Ocean area. The task currently in hand for the South Asian Seas region is preparation of the country reports for each participating nation. When these are ready, they will be consolidated into an overview of the region's environmental status and used as a basis for the drafting of a regional action plan ("Siren", 1984).

The Division of Marine Sciences of the United National Educational Cultural and Scientific Organisation (UNESCO) has also been responsible for aiding several aspects of marine and coastal science in the region. Several projects are being carried out through the Coastal Marine Project (COMAR). The Core Project is aimed at promoting research and training on the main aspects of coastal systems with emphasis on ecological structure and function, interaction of coastal systems with others, and with the relationship of coastal systems with the open ocean. The Core Project also collaborates with the International Association for Biological Oceanography (IABO) in the collection and evaluation of traditional knowledge and practices in coastal systems in order to incorporate this knowledge into research and management (UNESCO, 1984).

The Division of Marine Sciences of UNESCO has also initiated a major international programme of research and training on coastal habitats and resources (UNESCO, 1984). Its regional programmes have created a group of scientists and managers within the regions, and have laid a basis for effective management and sustained utilization of natural resources, in particular mangroves. There are also plans to involve the Congress in the results of a workshop concerned with advanced training on assessment of human induced damage to coral reefs, and to convene a further meeting to discuss coral taxonomy and future training as a follow up to the Regional Coral Taxonomy workshop held in 1984.

A UNESCO/IABO volume entitled Seagrass Research Methods is in preparation for publication in 1985. This reflects the growing realisation of the importance of this habitat, and will complement similar volumes for coral reefs and mangroves.

The COMAR Regional Programme is aimed at reinforcing the efforts and capabilities of countries to build up a base of scientific knowledge to be applied to the rational management of coastal systems. The focus of this is Regional, and at present concentrates on mangrove and coral reef ecosystems. A Regional Mangrove Project has been established as a means of disseminating information on this ecosystem.

UNESCO has also assisted in the preparation of a set of proposals for conservation, management and resource planning for the Republic of the Maldives (Kenchington, 1983). Recommendations were made to help ensure that the development of the country does not adversely affect its rich marine resources.

IUCN, too, has sponsored several projects in this region. In conjunction with UNEP, a meeting was convened in 1979 which led to the establishment of the Indian Ocean Cetacean Sanctuary. This has led in turn to a WWF/IUCN programme on Indian Ocean cetacean research, focusing on the sperm whale.

Bangladesh, India, Pakistan and Sri Lanka are all signatories of the World Heritage Convention, although no natural sites are currently inscribed.

India and Pakistan are both parties to the Convention on Wetlands of

International Importance (Ramsar Convention). India has two sites, one of which (Chilka) is a coastal lake. Pakistan has nine sites, none of which are coastal. However, under the Convention the parties have some obligation to conserve all wetland habitats. The provincial government of Sind is implementing a development scheme: "Research and Development of Wetland Wildlife Sanctuaries" for five years with a budget of Rs 2.765 million. This includes the Indus delta. In India, a working group was set up in 1983 at a national level to prepare a report on wetlands.

Bangladesh, India, Pakistan and Sri Lanka all have national committees in connection with UNESCO's Man in the Biosphere (MAB) Programme. However, while Pakistan and Sri Lanka have biospere reserves, none are coastal.

In India and Pakistan especially, WWF/IUCN are funding research into turtles, notably at Hawkes Bay and Sandspit.

In northeast India and Bangladesh, conservation activities haveIUCN has concentrated on the Sundarbans area with its vast mangrove and wildlife resources. Projects by IUCN include one on the royal Bengal tiger (Hendrichs, 1972) and on a management plan for the whole coastal region of the Sundarbans (IUCN, 1983). Various reserves in both countries in the Sundarbans total nearly 3,000 Km^2.

In India, IUCN is also providing advisory input into the development of an Indian National Conservation Strategy which includes consideration of marine resources, and has cooperated with UNEP and the government of India on a land use survey of the Nicobars and Andamans. In the latter, special note was made of the rich inshore waters and suggestions were made for their conservation.

In Sri Lanka, IUCN has carried out a study on the status of the dugong and identified replenishment areas for the very depleted remaining populations. It has also provided advisory input into the Mahaweli Environment Project which includes strengthening of management in one of the country's coastal protected areas.

Recent volumes by IUCN with relevance to the coastal and marine environment of the South Asian Seas Region include the proceedings of the World Congress on Natural Parks (McNeely and Millar, 1984). In addition, the Conservation Development Centre (CDC) section of IUCN is preparing a series of National Conservation Strategies for several countries of the Indian Ocean region.

RESOURCES, HABITATS AND SPECIES

OPEN SEA

Character

Except near land, productivity is relatively low in the Indian Ocean. In the central and nutrient poor parts of the Ocean, average planktonic productivity is <150 mg C/sq m/d which rises to 250-500 mg C/sq m/d on the limestone plateaux and to over 500 mg $C/m^2/d$ on much of the continental shelf. Zooplankton abundance in the south is <50 mg/m^3 which rises to 200 mg/m^3 in the north. Only on the west Indian continental shelf is this exceeded, where values approach 500 mg/m^3 (Couper, 1983). However, on average the tropical Indian Ocean is not less productive than the other two tropical oceans (Fagoonee, 1983).

Occurrence and Extent

Open seas are the most extensive habitat in the region in terms of total area, although its diversity and productivity are lower than the coastal habitats. Most of this habitat lies beyond the continental shelves of the mainland and island groups.

Conservational status

The major conservation achievement has been the establishment of the Indian Ocean Whale Sanctuary which was agreed to in 1979 and which extends from 20-130°E but which does not include waters south of 55°S.

Human and economic value

The major economic value of the open sea in the South Asian Seas region comes from pelagic fisheries (see sections 9 & 10).

Oil industry

The Indian Ocean contains the World's busiest oil tanker traffic. From the Arabian Sea, one route passes east across the southern tip of India and Sri Lanka to the Far East and Japan, while the other passes within a relatively short distance of many of the island groups of the western Indian Ocean. It is estimated that 33,440 tonnes/year of oil are discharged into the open sea of the western Indian Ocean, including much of the South Asian Seas Region. Sightings of oil at sea are most numerous along the major shipping lanes noted, namely along the southern part of the Bay of Bengal and in the Arabian Sea; further from the continent sightings are generally negligible.

Most of the countries do not have oilfields of their own and the island nations in particular do not have satisfactory oil spill control measures (Ferrari, 1983).

In the open sea, a massive oil spill is probably the most important

single pollution threat. Several international sets of regulations exist, but many of the nations have not ratified them despite the chronic oil pollution of the region. Ferrari (1983) recommends that top priority for this problem is necessary if a major disaster is to be avoided.

Targeted Exploitation

The major fishery in this, as in other tropical open ocean environments, is for tuna. Taiwanese, Korean and Japanese boats fish for tuna by longline, whilst French and Spanish purse seiners have recently opened a large tuna seine fishery. Detailed statistics from these fisheries are being recorded nationally, but are not easily available.

Pelagic fisheries over the continental shelf are discussed in more detail elsewhere, partly because it is difficult to separate pelagic and demersal fisheries in this region. Fish taken by coastal states in open water pelagic fisheries over the continental shelf include a variety of clupeoids, carangids and scombroids, using seiners and longliners. Closer to the shore, the species and fishing techniques diversify, and it becomes more difficult to distinguish between demersal and pelagic fisheries. Despite current trends, the vast majority of the catch is still in coastal waters.

Incidental Exploitation

It is not clear to what extent tuna school under Stenella in this region, but if this does occur, some incidental capture of small cetaceans seems inevitable. Sivasubramanian (1966) has reported harrassment of tuna longliners by killer whalers (Orcinus orca) and false killer whales (Pseudorca crassidens). Again, although not yet recorded, incidental capture on a longline, particularly of the smaller Pseudorca, would seem likely. Another animal suffering from incidental capture to any extent is the oceanic leatherback turtle (Dermochelys coriacea), but there are no definite records of this (Groombridge, 1982).

Human Impact

The major human impacts to the open seas comes from oil and offshore fishing, both of which are described above.

Management and Conservation

Activity in this direction relates principally to fisheries, including the capture of marine mammals. However, management and conservation legislation is much less than that for coastal and inshore waters.

Concerns and Recommendations

Most of the open sea habitat lies beyond territorial limits. For this reason, international agreement, which include countries with fishing fleets from outside the region, are necessary for effective conservation measures. Monitoring methods, including that for oil, which are currently employed in coastal waters, should also be extended to offshore areas.

DEEP SEA

Character

Benthic biomass on most of the seabed beyond the continental shelves averages 0.1-1 g C/m^2, with a particularly low area in the southeast of the region where values are <0.05 gC/m^2 on the plateaux and continental shelves, but deeper than the photic zone, benthic biomass rises to up to 10 gC/m^2, especially in the northern parts.

Occurrence and Extent

Deep sea areas occur throughout the region, where over 75% of the seabed lies deeper than 200m.

Conservational Status

No areas of deep seabed appear to be specifically protected.

Human and economic value.

The Indian Ocean Sea bed has extensive areas of metal rich sediments and polymetalic nodules.

Targeted Exploitation.

The greatest abundance of mesopelagic fish anywhere in the world has been located between Pakistan and Somalia. So far these species in this area have not been exploited, as the fish themselves are too small for a fishery to be economic at present. The deepest ocean area in the region is the Chagos trench (5,408 m), but there appears to be no exploitation in this region.

Gjosaeter and Kawaguchi (1980) found that mesopelagic fish off western India had a biomass of between 3 and 13 million tonnes, with trawl catch rates of 2 - 5 tons per hour. Again, the small size of the fish, and the fact that some of them are unusable due to high wax ester contents, has prevented the development of this fishery.

The Indian Government has undertaken extensive surveys for polymetabolic nodules, to assess the feasibility of deep seabed mining.

Human Impact

No extensive human impact to this habitat is known. Deep fisheries are at present limited in extent, and deep mining for minerals is not yet developed.

Management and Conservation

There appear to be no management and conservation activities specific to deep sea areas.

Concerns and Recommendations

While exploitation of deep sea resources are limited, there is little concern for this habitat. Development of fisheries and mineral exploitation, however, are likely to require increased measures for minimising harmful impact.

SOFT BOTTOM HABITATS

Character

Two categories of soft substrate are abundant: firstly generally fine particled, muddy and largely terrigenous substrates found off the shores of the countries bordering the north of the South Asian Seas region, and secondly the generally coarser, calcareous sediments found off the oceanic islands and in atoll lagoons. Both types occur in sheltered and exposed environments, often in close proximity, where environmental gradients may be marked, such as in the northern Bay of Bengal and in atoll lagoons.

Occurrence and extent

Extensive calcareous soft substrate areas are enclosed by coral reefs. These are most abundant in the lagoons of the atoll groups, notably those of the Laccadive - Chagos chain, but important areas of similar substrates occur behind fringing reefs of the high islands of the region.

Calcareous sediments associated with reefs are graded according to their overall exposure. The coarsest sediments near reefs are generally associated with exposed conditions while finer silts occur in very protected lagoons, in deep water and occasionally in shallow water on landward sides of reef flats; the biota of the sediments varies greatly according to grain size, although human exploitation of calcareous sediments involves a wide range of grain sizes.

The finer sediments are commonly the richest biologically, especially in shallow water where mats of blue-green and other algae develop. These are amongst the highest carbon producing and nitrogen fixing areas, and support substantial secondary production from many invertebrates, especially annelids and molluscs, and from birds.

Sand sediments commonly support mats of blue-green algae. Substantial interstitial fauna, especially molluscs, some crustaceans and burrowing species of fish; the green alga Halimeda may be very abundant. The coarsest sediments and rubble are generally found only immediately leeward of reef crests or piled into banks by strong wave energy. Such areas have the least secondary productivity, but may support abundant algae.

Conservational status

Soft substrate habitats occur widely in many protected areas. This is often an incidental result of the protection of various species such as dugong, birds, and commercially important invertebrates, and is not usually in recognition of the habitat's intrinsic value. However, the protection afforded to soft substrate habitat is often extensive; examples include vast muddy areas in the Sundabans, both east and west coasts of India, including the Gulf of Kutch, areas of the Indus delta, and in Sri Lanka, Dutch and Portugal Bays off Wilpattu National Park, and coastal bays of Yola.

Targeted Exploitation

Soft bottom habitats support trawl and more traditional bag net fisheries for a variety of species. The major fishery is for prawns (especially penaeids), for which there is an important export market, but in

this fishery as in the others of the region, more than one group is exploited. Near the coast, beach seines and gill nets are also used for a variety of species.

In general juvenile prawns are taken in lagoons and estuaries, whilst adult prawns move further offshore. In the Gulf of Mannar at least, where there is an extensive shallow soft bottom zone, juvenile shrimps are also taken with a variety of gears.

Although shrimps and prawns may be the main targeted groups, other species are also taken. Krishnapillai (1982) studied the trawler landings at Sassoon Dock in Bombay. 53% of the catch was a mixture of penaeid shrimps and sciaenids. Of the vessels landing at the dock, 50% were trawlers, 42% Dol (Bag) nets, with the rest gill netters and hook and line boats.

In recent years, trawling has become more important and has opened up fisheries in slightly deeper soft bottom areas. Vinci (1982) found that off western India, between 75 and 179 metres, Nemipteridae (threadfin breams) form the dominant portion of the finfish biomass, and they are also important on the east coast. Presumably catches of these species will continue to increase as trawling does.

Targeted Exploitation

Coastal lagoons and estuaries are important throughout this area for shrimp fisheries and, more recently, aquaculture development. Juvenile shrimps are most often associated with brackish water environments, which support extensive shrimp fisheries. Rao (1983) describes a typical fishery for the little Ginger shrimp, Metapenaeus kutchensis, in the Little Rann of Kutch, a lagoon on the West Indian Coast. About 2770 fishermen with 307 boats and 1620 nets were involved in this fishery in 1980. In the Little Rann of Kutch Hilsa is also caught during the wettest part of the year (July) when the salinity is low. Throughout the region the salinity of such areas of water determines the peaks of abundance of shrimp.

Incidental Exploitation

Most important are incidental captures of small cetaceans and turtles, both of which are taken in considerable numbers by trawls, gill nets and even beach seines. These are further discussed in later sections.

Direct/habitat destruction

In India dredging of calcareous sands is common. Sands are dredged for conversion into lime for the building industries, and in the Gulf of Mannar especially, "challi" which is the rubble of Acropora formosa, is extensively collected. this industry is coupled with that of quarrying the solid limestone of the reef itself, and the total effect of both is locally severe. Where entire reefs have been removed, other sediment systems which are usually of terrigenous origin take their place and these are relatively unproductive in biological terms.

Management and conservation

The management and conservation of the soft substrate habitats largely

derives from the protection measures given to notable fauna and flora within them rather than from direct concern for the habitat itself. Management of mangroves, seagrasses, dugong, birds and economic invertebrates, such as crustaceans, results in some protection to the habitat. Examples of more direct management and control of exploitation are seen in areas where calcareous substrates are excavated industrially, such as in the Gulf of Kutch and southern India.

Concerns and recommendations

The relatively inconspicuous nature of soft substrate habitats compared with, for example, mangroves and coral reefs, has resulted in a lower priority for their effective management and a lesser recognition of their economic and biological importance. Greater controls over their extraction are required to safeguard their biological wealth and that of adjacent habitats and pollution monitoring programmes should include this habitat as well as mangroves and coral reefs.

MANGROVES

Character

In the South Asian Seas Region, mangrove development is very varied. It ranges from massive in the Bay of Bengal area where the gangetic delta and sundarbans has over 500,000 ha of tidal forest, and is extensive in Pakistan and Western India where the Indus delta supports 250,000 ha (Snedaker, 1984). The Andamans and Nicobars have very good stands of mangroves. Mangrove is less developed in Sri Lanka and is patchy, thinly developed or absent in the island nations and groups of the Indian Ocean.

Occurence and extent

In the northern Bay of Bengal, the southern Gangetic delta borders both India and Bangladesh. This area, the Sundarbans, is dominated by Ceriops, Avicennia, Excoecaria, Phoenix, Sonneratia and Aegialitis (Mukherjee, 1984) and contains the important timber tree Heritiera sundri, the latter now severely reduced. Extensive coastal areas of eastern Bangladesh between Chittagong and Cox's Bazzar are also tidally flooded, and mangroves border estuaries throughout this region. However, these are more typical of Malaysian forests than of India (Snedaker, 1984). More open parts of this coastline are commonly fringed by Casurina and dune vegetation (Macintosh, 1982). Mangroves are also extensive in the Andaman and Nicobar Islands, where they have been amongst the least disturbed. Although the development of mangroves in the Bay of Bengal is the greatest in the region, diversity is less than in the peak Malayan-Indonesian region. on the east coast of India, mangrove stands continue to be important to the southern tip (Stoddart, 1973).

In the northern Arabian Sea, the Indus river delta extends from Karachi for about 200 km to the Indian border. Mangroves are also extensive here, dominated by Avicennia officinalis often in pure stands but with occasional trees of Ceriops (Salm, 1975). In Western India, mangroves are found in the estuarine systems of Kerala, Mandovi and Zuari, and in the Gulfs of Cambay and Kutch. Those of the latter are reputed to be the best examples of mangrove on the west coast of India where, amongst a total of about 20 genera (Untawale, 1984), the main species are Avicennia marina, Rhizophora mucronata, Ceriops candoleana and Avicennia alba (Chavan, 1983). The dominant floral components further south on the west coast of India are Rhizophora, Avicennia, Bruguiera, Sonneratia, Excoecaria, Aegiceras, Lumnitzera, Salicornia, Sueda, Acrostichum and Acanthus (Untawale, 1984).

Towards the south of India and Sri Lanka, mangrove diversity and abundance declines, in part because of the reduced tidal range which falls from macrotidal in the north, to a range of less than 1 m in Sri Lanka. in some parts, such as near Bombay and Mandapam, mangroves are largely replaced by salt marsh communities. most of the estuaries have a relatively thin fringe of mangroves, mainly Rhizophora, Avicennia, Bruguiera and Sonneratia. Rhizophora is the dominant genus on rocky parts, while Avicennia dominates on sandy areas. In several areas mangroves are still well developed although many areas have been greatly reduced in recent years.

Conservational status

The most important protected mangrove areas are the Sundabans in the northern Bay of Bengal. In Bangladesh, two wildlife sactuaries and a proposed one total over 400 km^2, while in India a national park of over 2,500 km^2 all afford protection to the mangroves. In India, a number of other parks and reserves include mangroves which are afforded at least nominal protection. In Pakistan important protected areas include mangroves of the Indus delta. In the Andamans, eight parks and reserves include coastal areas where mangroves are abundant.

Human and economic value

An important value of mangroves lies in their provision of a habitat for several commercial food species such as penaeid prawns which depend upon them during part of their post larval stage. Commercial shrimp production relates directly to mangrove area (Linden & Jernelov, 1980). Because of disturbance to mangroves in India and Sri Lanka, such fisheries are endangered in those countries (Salm, 1975). In Bangladesh, although one eighth of the country is covered by mangroves, one third of the population is dependant on them for their income (Linden & Jernelov, 1980).

Mangroves also make an important contribution to coastal productivity wherever they occur. Their direct organic contribution is amongst the highest of any coastal ecosystem, and they support a correspondingly high secondary production. Also they stabilize mud flats on which mats of nitrogen fixing organisms thrive, and thus increase further the organic richness of the coastal zone (Chapman, 1976). Their removal in large areas such as Bangladesh may be the principal cause of repeated catastrophic flooding (Linden & Jernelov, 1980).

Mangroves are also a valuable source of timber in northern parts of the region in particular, as firewood throughout the area and as fodder in several parts, especially Pakistan, India and Sri Lanka. However, in many of these sites exploitation has exceeded the ability of mangroves to recuperate, with resultant degredation of the resource. This is severe in many areas especially Sri Lanka, where mangrove stands are being or have already been, completely destroyed.

Targeted exploitation

Blasco (1977) outlines the ecology, botany and forestry of mangroves in the Indian Sub-continent. The total cover by mangals (mangrove formations) in India and Bangladesh has been estimated at more than 900,000 ha. Of this 600,000 ha occurs in Bangladesh, and 200,000 ha occurs in West Bengal, contiguous areas representing one of the most important regions of mangal in the world. Blasco's estimate of the area of mangal in India is 356,500 ha, roughly half the official estimate (Sidhu 1963 cited in Blasco 1977), as much of the 'official' mangal area may be devoid of any plant cover. Blasco states that even this estimate may be fairly high in view of "the present very rapid regressive evolution encountered in certain regions", citing the destruction of halophytic vegetation around Bombay. Only the very robust species remain in any secondary formations, and a number of plant species have already become rare, notably Rhizophora species, or have disappeared, such as Nypa and Heritiera fomes. On the eastern coast, mangals are managed by the forestry department, and, where they are managed, mangroves are clear-felled every 16 years in the Gangetic Delta, or over 20 years elsewhere. In the northwest region mangals were under the jurisdiction of

the Director of Marine Products until 1955. Due to the lack of wood and green fodder in this region, much of this vegetation has been destroyed or degraded into discontinuous thickets of Avicennia marina.

Indian mangals are no longer used for tannin production but have always been used in a number of other ways by coastal people, and fishermen in particular. Without any control, they have harvested the wood for firewood, plants and posts, boat-building, floats for nets, thatch material, and even for making toys. Even now a lot of bark is used to make an extract in which nets may be soaked to make them rigid and resistant to seawater. Honey is also derived from mangals, the flowers of Avicennia officianalis are chewed with betel, and one or two species produce edible leaves and fruits.

Incidental Exploitation

Throughout the sub-continent there is destruction of mangroves due to human activity, so that in some areas mangroves may be on their way to extinction. Two important aspects of this destruction should be noted. Firstly, mangal ecosystems are important nursery grounds for shrimps and prawns and for some fish species, and for the food species of other fish. The importance of India's shrimp and prawn fisheries have been noted, so that from a commercial viewpoint, destruction of mangal areas cannot be regarded with equanimity. As yet there seems to have been little study of the effects of mangal destruction on fishing interests in India or Bangladesh. Destruction of mangal areas results more than in the loss of an economically viable fishery however, as not only are valuable protective habitats for juvenile fish and crustacea lost, but also there is a loss of nutrient input into the coastal zone by way of leaf fall. Leaf fall is said to be the main constituent of detritus, which supports a large population of detritivores and their predators. This source of production is said to be much more important than that derived from phytoplankton, so that its loss must have an important effect on production in the area, including commercially important species.

The second aspect of mangal destruction lies in its effect on non-commercial animal species. The mangal 'Sunderban' forests of Bengal are home to the rare royal Bengal tigers, and throughout the region estuarine crocodiles are illegally exploited and suffer from destruction of their habitat.

Oil pollution/waste discharge/sedimentation

Mangroves are particularly susceptible to pollution by oil because of their intertidal location and because of their characteristic root respiratory systems, which are easily blocked. Sedimentation caused by dredging or terrestrial run-off also causes marked distributional changes in mangroves in the region. It is generally assumed that wastes accumulate in mangrove stands with deleterious consequences to the mangroves themselves and to their associated biota and productivity.

Direct/habitat destruction

In most areas there has been considerable disturbance and clearing of mangroves, including the massive and relatively inaccessible stands of the Bay of Bengal where total destruction has occurred over large areas (Mukherjee & Tiwari, 1984). The Sundarbans mangrove ecosystem has been

severely affected by the farakka barrage which has diverted waters of the Ganges. Floods, soil toxification, land instability and pest infestations have all increased, while fertility, water quality, fisheries and forests have all declined recently as a result. The Sundarbans management plan aims to preserve all fauna, especially the Royal Bengal Tiger, and all management activities of the area come under the auspices of the Bangladesh wildlife preservation order (1977) (IUCN, 1983).

Near Karachi the mangroves tend to be stunted as they are periodically cut for firewood and the leaves taken for fodder, and large areas have been infilled. However, towards the border with India they grow to 3-4 m and are less disturbed (Salm, 1975) and to the east of Karachi the removal of about 800 000 acres of mangrove has been prohibited under the Forest Act of 1927. In India, mangroves are extensively cut for fodder and firewood, and in the Gulf of Cambay much of the original extensive stands have been removed, which appears to be typical of much of western and southern India (Untawale, 1984; Krishnamurthy & Jeyasee, 1984). Those of the Gulf of Kutch have also been severely reduced (Chavan, 1983).

In Sri Lanka disturbance to mangroves is considerable. Nearly all stands on the southwest coast have been destroyed (Salm, 1975). Cutting for fuel is a major reason for mangrove destruction, though additional reasons include clearance of stands of Rhizophora to gain access to lagoons for boats, for the establishment of milk fish ponds or coconut groves (Linden & Jernelov, 1980) and for tannin (Salm, 1975).

Existing management policies/practices

The Sundabans Wildlife Management Plan exists to protect the wildlife of this important area of mangroves. Success in replanting mangroves has been achieved in the Gulf of Kutch on an experimental scale (Chavan, 1984). There is considerable involvement by several agencies in mangrove research and protection, which is described in more detail in the section dealing with conservation and management. UNESCO especially, is actively promoting a series of measures concerned with mangrove management and research. The activities of COMAR is one outcome of this. UNESCO activities in the region include mangrove mapping by remote sensing, a joint UNEP/UNESCO regional project on geology, sedimentology, erosion and accretion in mangrove areas, and extending to 1986, the development of a network of mangrove managers and scientists in the Indian Ocean (Steyaert, pers. comm.). A meeting is also being organised by UNESCO with the institute of rice research, to bring together scientists and managers of both disciplines which have traditionally had conflicting demands on some coastal wetlands.

Protection for mangroves which are included within reserves or parks is often inadequate, and throughout the region vast areas formerly containing rich mangrove stands have been impacted to varying but often severe degrees (Soepadmo, Rao & Macintosh, 1984).

Concerns and recommendations

Several programmes concerning mangroves are currently being developed by UNESCO, as described above. Urgent measures being pursued by the latter and recommended in Soepadmo, Rao and Macintosh (1984) include: strict enforcement of protective measures given to mangroves in parks and reserves which already exist; extension of the coverage given by parks and reserves, and research into the role of mangroves in the biological and human context.

SEAGRASSES

Character

Little information is available on the extent of seagrass beds in the northern parts of the Indian Ocean. There are no extensive beds off Hawkes Bay and Sandspit in Pakistan, despite the fact that turtles nest in these areas (Salm, 1975). Seagrasses also do not appear to be particularly important in the Gulf of Kutch or Gulf of Cambay (WWF, undated). Much of the coast of western India is very exposed and turbid, and for these reasons may lack significant expanses of seagrass. However, extensive beds are found in southern India where exposure is lower, and from many of the numerous estuaries and embayments of Sri Lanka.

Occurrence and extent

In the Gulf of Mannar in southern India, there are very large seagrass beds which used to support large dugong herds which have now, for the great part, disappeared (Salm, 1975). Possibly the most extensive areas are found in the straits between India and Sri Lanka and along the north and western coasts of the latter, where the principal species are Thalassodendron ciliatum and Halodule sp. Dugong still graze in these beds in reduced numbers.

Seagrasses are abundant in parts of many of the high island groups, notably the Andamans and Nicobars. They are generally less abundant and less diverse on the coral atoll groups (den Hartog, 1970; Aleem, 1984).

Seagrass beds are have not been reported from Lakshadweep, but two species occur in the Maldives: Thalassia hemprichii and Thalassodendron ciliatum (Bouchon, 1981).

Conservational status

Seagrasses usually have not figured highly in any Indian Ocean nation's priorities for habitat protection. Unlike coral reefs, conspicuous and commercial species and mangroves, they have never been the principal reason for creating a protected area in the countries of the South Asian regions.

Human and economic value

Together with reefs and mangroves, seagrasses provide areas of very high primary productivity with standing stocks of up to several kg/m^2 (Aleem, 1984). In common with the other important benthic habitats of the region they also support rich secondary production and have numerous secondary species associated uniquely with them. In some parts of the region such as Sri Lanka, seagrasses provide the largest part of the marine primary production and cover an area which is far in excess of that covered by mangroves and coral reefs (see maps in Salm, 1975). Although no estimates have been made for the South Asian Seas region, estimates elsewhere suggest that the economic value to be obtained from seagrass beds can be $86 000 per acre (Thorhaug, 1983).

Targeted Exploitation

Seagrasses themselves are not exploited, but seagrass habitats provide food and shelter for some commercial species, notably shrimps. Manisseri (1982) describes the shrimp fishery in the Gulf of Mannar over a sandy substrate covered in marine grass and algae. In this area the three fathom mark is not reached until up to 7km from the shore. The region is said to be favourable for juvenile prawns, especially the green tiger prawn Penaeus semisulcatus, for which there is a good export market. Increasingly these are fished by mechanized boats.

Incidental Exploitation

In the Gulf of Mannar 75% of the catch in the 'prawn' fishery is made up of fish, notably Carangids, Leiognathidae, Theraponidae and Mullidae, and a trend of increase in both catch and effort has been noted (Manisseri 1982). More important from the conservation viewpoint are catches of dugongs and turtles. Green turtles in particular are known to feed in seagrass areas, and dugongs also feed almost exclusively on sea grasses. Although no specific data are available it is clear that throughout this region incidental capture, notably in trawl nets, is an important source of mortality in dugong and turtle populations (Kar and Bhaskar 1977, FAO 1978a), so that sea grass areas must be regarded as very likely areas for a significant proportion of such incidental kills.

Direct/habitatdestruction

In part because of the relatively inconspicuous nature of this habitat, impacts on seagrass beds have been much less well documented than have those to other major marine ecosystems. Yet from their known distributions and habitats, impacts in some areas are likely to have been severe. In the Indian Ocean, the main environmental factors influencing seagrass distribution are substrate type, depth, exposure and tidal regime (Aleem, 1984). Substrate disturbance is the most important mechanism of human disturbance to seagrass beds. Estuarine disturbances such as industrial and agricultural runoff have damaged seagrass beds in Sri Lanka (Salm, 1975), and industrial wastes, sewage discharges and overfishing are known to have an effect on this habitat.

Dugong and turtles, both of which used to be numerous in Southern India and Sri Lanka, which have now declined through over hunting.

Existing management policy/practice

UNESCO/IABO are shortly to publish a volume on methods for seagrass research, in the same series as those for coral reefs and mangroves. Further, a recent meeting of the Indian Marine Biological Association emphasised the importance of seagrass beds.

Recommendations

The Indian Marine Biological Association (1985) recommended that research programmes be developed in these communities.

ROCKY SUBSTRATES AND SHORES

Occurrence and extent

The coast of Pakistan west of the Indus Delta comprises rocky cliffs interspersed with both pocket and wide, sandy beaches, river outlets, lagoons, sand dunes and tidal mud flats (Eisma, 1982). Some mangrove also occurs, but this habitat occurs mainly in and east of the Indus Delta. The region is tectonically active with continuous, large scale uplift. Large amounts of sediments are discharged by all of the rivers, such that deltaic parts of the shoreline prograde by an average of 10-25 m/year.

India has six types of coastline (Ahmad, 1982): barrierless shore of emergent aspect between the Ganges and Godavari, much of which is also strongly prograding; emergent shore with offshore bars between Krishna and Cape Comorin; rocky submergent shore in Karnataka and Maharashtra; marshy lowland shore in the Cambay region; the compound shore in the Kerala region, and parts of Kathiawar which have an offshore coast of bars and a landward shore of lagoons.

Altogether, beaches occupy about 55% of the Indian shore (Ahmad, 1982) and occur most extensively on the low eastern and Kerala coasts. Supralittoral vegetation varies greatly according to the marked rainfall gradients. Where rainfall is less than 700 mm/year in the northwest there is xerophytic bush grading into complete desert shorelines in the far northwest. Where there is about 1000 mm/year rainfall there is either tropical, dry evergreen scrub flora or, as in the southern tip of India, tropical, dry, deciduous vegetation. On the east coast where rainfall is greater than 1000 mm/year, tropical, moist deciduous vegetation exists. On the east coast this grades into mangrove as the Ganges area is approached, and mangrove shorelines dominate in Bangladesh.

The Andamans and Nicobars have rocky and sandy shorelines, though much of it is fringed by coral reef. Vegetation is tropical rain forest down to the shore (Ahmad, 1982).

The Lakshadweep and Maldive islands are all coral atolls with shores entirely fringed by reef. In their intertidal regions two main shorelines are found to leeward of reefs: coral sand and limestone beachrock. In sheltered areas sediments may be extremely fine, and mangroves can occur. Embayments with brackish water, or Barachois, provide a fourth but minor coastal environment on coral atolls.

Conservational status

Rocky shores are included in numerous protected areas but usually only as an incidental result of the protection of other elements.

Human and economic value

Use of these marine habitats varies greatly between countries. Scenic shores and a sandy shallow sublittoral are important assets in tourist industries, and are recognised as such in several countries of the region. Tourism may co-exist along shorelines in many of the countries.

In the Maldives there is perhaps the greatest separation of tourists from local inhabitants; several islands which do not have villages on them have been set aside for this industry alone.

Targeted exploitation

Rocky substrates are mostly unsuitable for sophisticated fishing methods such as trawling, so that in general more labour intensive methods such as hand-lining, trapping and even diving are employed. The species exploited in such areas are both demersal fish such as snappers, groupers and other perches as well as sharks and rays, and also rock lobsters. Mohan (1983) describes one typical hand-line fishery for groupers (Epinephelus spp.). 50-200 m of monofilament nylon line is employed with one large hook in deeper water, or several smaller ones in shallow water. Sardines, Leiognathids and scad are used as bait. The catch consisted of 72% Lutjanidae (snappers) and 21% Serranidae (mostly Epinephelus). This fishery operates on the west coast near Quilon in an area of rocky substrate, but with soft bottomed areas nearby. In this particular locality the species composition has changed in the past 15 years, as snappers have increased as a proportion of the catch, and groupers decreased. Mohan points out that trawling nearby takes large numbers of groupers but few snappers, indicating that the latter may be more confined to, and therefore protected by, the rocky substrate. Fishing for lobster on rocky bottoms is still performed in many areas by hand. It is likely that lobsters, here as almost everywhere else in the world, are over-exploited.

Management and conservation activities

No details are available on management and conservation activities relating specifically to rocky shores (other than coral rock, discussed in the next section).

Direct/habitat destruction

Construction at the shoreline including seawalls, jetties and land reclamation can affect the patterns of sediment transport sufficiently to change the nature of the coastal environment. In the Maldives the construction of walls and piers have had adverse local effects. In several island nations in particular, the removal of shoreline materials (sand, corals) for local industrial use has led to chronic erosion of shorelines and disruption to both their natural biological and scenic (tourist) resources (UNEP, 1983a). Losses resulting from this include increased erosion of coastal infrastructure such as roads.

Widescale removal of valuable shore and beach resources occurs in most countries of the South Asian Seas region. In addition to the quarrying of materials for the building industry and removal of mangroves for access and for the creation of fish farms cited earlier, there are also numerous examples of swamps being drained to plant palms.

Concurrently with excavation of shore and sublittoral habitat, land reclamation causes localised, but sometimes fairly extensive destruction. In addition to direct blanketing of the area being filled, the sedimentation which is invariably increased can affect a much wider area of sublittoral habitat. Three probably few major coastal developments in the region which have not involved reclamation to some degree (UNEP, 1983a). Important wetlands in the deltas of eastern India are also being damaged by

reclamation (WWF, undated).

Industrial and agricultural wastes and run off which affect all adjacent marine habitats have been identified from several parts of India. In the Gulf of Cambay, whose mangroves are largely destroyed, there is substantial industrial pollution which threatens other marine habitats in the large inshore and estuarine areas (WWF, undated).

CORAL REEFS

Character

Coral reefs are one of the major habitats of the South Asian Seas region in terms of productivity, diversity, and the provision of livelihood for inhabitants of coastal settlements. in several countries they are a major feature in a valuable and expanding tourist industry. In most countries, however, degradation is occurring to varying degrees which is resulting in a loss of each one of these values.

Because of the importance of coral reefs and their rate of degradation in several countries region, a coral reef directory of the Indian Ocean has been drafted, from which much of the following data is extracted (Sheppard & Wells, in prep.).

Occurrence and extent

Bangladesh and Pakistan have no coral reefs due to the high turbidity and mobile soft substrate of their coastal region which is prograding rapidly in many parts. However, corals are found on the rocky substrate west of the Indus in Pakistan. India has two widely separated areas containing reefs: the Gulf of Kutch in the northwest and at the southeast tip in Palk Bay and the Gulf of Mannar. Reefs extend only to about 2-5m in both areas, though in the latter they cover a wide expanse. Sri Lanka has shallow reefs on its south and east coasts but has less coral growth in the west.

The Indian islands of Lakshadweep are entirely composed of atolls, and therefore have extensive sublittoral reefs. The Nicobars and Andamans are mountainous with extensive fringing reefs. The reefs of all of these groups are amongst the least studied of any in the region, although those of the Andamans are being threatened by massive erosion from uncontrolled forest clearance (Whitaker, 1984).

The Maldive atolls are extensive and most parts are well populated. The reefs of only 6 atolls have been examined scientifically to any degree, and of these the southernmost, Addu Atoll, is the only one which has been studied in any detail. Several islands in the central group of atolls are used exclusively for a growing tourist industry and in these coral growth appears to be very good at present.

South of the Maldives, the Chagos Archipelago contains very rich coral reefs. Most of its reefs are totally unimpacted by man due to the uninhabited nature of the atolls, and appear to be the most diverse in the Indian Ocean as well as a possible a source area for reefs in countries of both the South Asian Seas and Eastern African regions.

The vast submerged banks which are characteristic of the Indian Ocean include some of the most extensive of all reef formations but most are largely unstudied. Few details of the benthic ecology of submerged banks exist; those of Chagos which have been studied show benthic ecosystems which are as rich and diverse as those associated with atolls.

Coral species have been accurately recorded in too few parts of this area to determine natural trends in species diversity, other than the marked reductions which occur at the peripheries of the region. Known diversities are: Gulf of Kutch about 30 species; Southeast India 117 species (65 species

in Palk Bay); Maldives <180 species; Chagos 200 species. Reefs in the Nicobars and Andaman islands could have about 220 species in common with their adjacent, Asian mainland (UNESCO, 1984). The separate group of corals characteristic of the Western Indian Ocean are not known in the South Asian Seas region. The large brain coral Ctenella chagius is endemic to the Chagos group (Sheppard et al, 1984).

Conservational status

There are very few protected areas of reef in this region. In the Gulf of Kutch, an area of 162km^2 is marked as a marine national park with 455km^2 as marine sanctuary (Chavan, 1983). In the Gulf of Mannar, Krusadi Island and its reefs have been singled out as being of exceptional biological interest, and are included in the area designated as India's 1st Marine National Park (Salm, 1981). In Sri Lanka there is little formal protection for reefs, although in the southwest tip of the island there is the rocky islets sanctuary of 1.5ha.

Human and economic value

In the case of the Maldives and Lakshadweep, whose sole substance is coral reef and islands derived from them, the importance of coral reefs is immeasurably great. Not only are they the foundation of the islands themselves, but they are the major source of food for many of the island societies. Elsewhere, reefs have an economic value as a source of limestone, though over-exploitation of this is causing extensive degradation (see later paragraphs). Coral reefs and their associated sandy shorelines are an important source of revenue from the tourist industry.

Targeted exploitation

Coral reefs provide food fish such as groupers, snappers, wrasses, rabbitfish and jacks, as well as a wide variety of fish for the ornamental fish trade (Salm 1979). There are few studies of reef fisheries in the Indo-Pacific in general (Munro 1982), and most of the fishing methods are the same as for rocky substrates.

In the past, large exports of coral from India, Sri Lanka and the Maldives has taken place (Wells, 1981). Perhaps a more immediately important form of reef exploitation is the highly destructive practice of using coral for producing lime. Large areas of reef in Sri Lanka have been destroyed as the coral is broken up and burned to make lime for whitewash and cement.

Incidental exploitation

The predominance of small scale labour intensive fisheries in reef areas once again helps to reduce the likelihood of accidental capture of non-target species. However some species of small cetacean, such as Sousa, and some turtles, notably Eretmochelys imbricata are known to be associated with reefs, and as such are at least available for incidental capture, although no specific records of this have been located. Hawksbill and Green turtles are in fact harvested throughout Sri Lanka.

Direct/habitat destruction

Threats to coral reefs are numerous. A few are noted in general terms by Kenchington and Salvat (1984) but these authors omit some of the most serious problems affecting reefs of the South Asian Seas region and adjacent nations. The wide range of destructive activities which damage reefs are given in a country specific manner below; in general, however, the main threats are reef quarrying, infilling, and sedimentation resulting from these activities and from inland deforestation.

In the Gulf of Kutch, dredging of sand for the cement industry has caused increased turbidity, and the direct removal of Acropora and other corals which are used as a source material for plastering homes has caused marked deterioration of the coral reefs (Chavan, 1983). However, recent decisions have been taken to prohibit further industrial development in the marine park belt.

In Palk Bay a major cause of reef deterioration comes from quarrying for the lime industry. Fifty boats are engaged in quarrying the reef and up to 250m^3 of reef are lost daily. Large parts of the reef have disappeared as a result. The most exploited corals are the massive genera, and because climatic conditions are also difficult for the reef (Pillai, 1973), prognosis for this reef is poor and much had been destroyed by 1973.

In the Gulf of Mannar, several reefs have been removed completely by the lime industries (Mahadevan & Nayar, 1972). This is widespread throughout the area. In Tuticorin (Venkataramanujam, 1981) Acropora formosa fragments, or "chalii" are extensively collected. In this region alone, 30 boats remove an annual 80 000m^3 of reef derived material. In addition, massive corals are collected to the extent of about 30 000m^3 per year, or 15 000 tonnes, which is used as building material. Altogether, over 400 people work in this industry in Tuticorin. Salm (1975) reports that similar destruction occurs in many other parts of the Gulf of Mannar. From Mulli, Talaivi and Vali islands the estimated removal amounts to a strip of reef 1m wide x 1m deep x 250m long each day.

Minicoy atoll in southern Lakshadweep has suffered severe disturbance over the last decade. On the reef flats, excavation of rock for building has been extensive, and has resulted in alteration of the shoreline and erosion of the land. The main entrance to Minicoy was dredged between 1968 and 1977 by the harbour department, with the dredgings being dumped into the lagoon. The effect of this was to greatly increase sedimentation, resulting in a high coral mortality. Since 1980 numerous Acanthaster planci caused massive deterioration, particularly in the lagoon. In some areas, the deposition of 0.5m of sediment in the last few years as a result of dredging and blasting has buried the corals, while in others the corals remain visible but have been killed. Pillai (1981) presents a dismal catalogue of the mortality, which is summarised by his estimate that 75% of all the coral in the lagoon of Minicoy was killed in the early 1980's or late 1970's, and that recolonisation by new corals appears at present to be negligible. The dead corals are both disintegrating and overgrown with algae. Along with the demise of the corals, the fish and invertebrate life has also disappeared. Pillai (1981) attributes the mass mortality to three factors: human interference causing siltation (caused by dredging and blasting); over exploitation; and to a lesser extent, predation by Acanthaster planci.

No data are available for the northern atolls of Lakshadweep. However, Pillai (1981) states that the natural appearance of several of the northern atolls has also been changed in a similar way.

In Sri Lanka, there has been marked degredation in recent years, for several reasons. Most of the existing information on reefs of Sri Lanka relates to their rapid deterioration in the face of mining for lime, dynamiting for fish, tourist pressure, aquarium fish collection and not least by Crown of Thorns starfish. Pigeon Island, 16km from Trincomalee in the east coast, used to have some of the richest shallow water corals, and is a bird sanctuary. Today, however tourist activity has almost destroyed the protecting fringing reef. This has been caused by boats crashing onto the reef to unload visitors, who then trample the corals. However, this area is now the subject of a reef survey with a view to conserving it (UNEP, 1984). Monsoon storms are also implicated in the damage to these reefs to an unspecified degree.

The collection of coral reef fish is also evidently substantial in Sri Lanka, since 56% of all foreign exchange earned by the export of fish products comes from the aquarium trade. The trade itself is notoriously wasteful since the majority of fish die in transit thus necessitating substantial over collection. In addition, dynamiting is used as a fishing technique in some areas (Salm, 1979). As a consequence of these activities, the reef and marine life of much of Sri Lanka has deteriorated markedly over the last decade, a fact recognised by the leading nature conservation organisations (Hoffmann, 1983).

In the Maldives a population of over 150 000 is distributed over all of the main atolls, with concentrations in the central region of North Male, and in the Tiladummati/Miladummadulu group in the north. most are dependent on agriculture and fisheries, although tourism has become well developed on the two Male atolls and others close by. Tourist facilities are located on islands which in most cases are devoted to that activity only. In North Male Atoll where the majority of visitors stay, many of the islands concerned are lagoonal islands.

In the process of making the islands more attractive, much of the natural vegetation has been cleared from the coral islands used for holidays and leaf litter is regularly removed. The result in several islands is that a canopy of coconut palms covers plain coral sand (with a mixture of additional ornamental plants). Water is also drawn extensively from wells, which after dry periods at least, becomes sulphurous and saline even from the middle of the islands when the water lens drops. There is thus considerable impact to these small islands from tourism in the form of a break in the organic and nutrient recycling process, and in alteration to the water table. Here to, reef quarrying for building materials is carried out. In the long term, therefore, such islands may deteriorate from the tourist pressure. At present, however, there is no observed degradation of the reefs, either on the seaward slopes or around lagoonal knolls and islands, which remain in excellent condition. Recently, management measures have been proposed for the reefs of the Maldives, following a visit by UNESCO (Kenchington, 1984).

Existing management policy/practice

In several of the countries whose reefs are deteriorating or being physically removed, there is inadequate or even no mechanism for reef protection. In some others, mechanisms exist but enforcement is weak. only in the remote atoll groups of the central Indian Ocean and in parts of the Nicobars and Andamans is there at present no cause for concern in general terms. In India, financial constraints are also held to be a major limitation to establishing conservation measures and marine parks.

In Sri Lanka, simple tradition ensures that many of the destructive practices continue (Salm, 1975). The main instrument for the conservation of wildlife in this island is the fauna and flora protection ordinance, which is revised and updated from time to time. It regulates and establishes a series of protected areas which include nature reserves, sanctuaries, strict nature reserves and buffer zones. The country also has a Coast Conservation Act *1981) to protect the coast from sea erosion and to ensure planning of developments within the coastal zone (2km offshore to 300m inland). Also there is a proposed action plan developed by James Dobbin Associates. On the east coast especially, erosion caused by the removal of coral reefs is, however, already extensive. Penalties for violations are often grossly inadequate (Hoffmann, 1983), while at a local level customs and immediate needs govern the use to which natural resources, including reefs, are put. The problem of changing such traditional dependence has proved to be difficult. Laws exist for the protection of several reef species, but there is evidently little or no enforcement of them. In addition, many people are engaged in reef quarrying and the lime industry, which has led to the degredation and removal of several areas of reef (as well as of adjacent forests for firewood needed in the lime reduction process).

Management and conservation activities

In the Maldives a visit by UNESCO has taken place to provide advice on conservation activities and management of the reef and island habitats (Kenchington, 1984). In Sri Lanka, only one small area of reefs is protected, totallying 1.5ha. Some reef areas, such as that around Pigeon Island, are afforded a measure of protection because the island is a reserve, though management is lacking and the reefs have deteriorated markedly. The other relatively small reef areas of India have been described above; management in the Gulf of Mannar region is not effective in several parks and enables serious degradation to occur, while in the Gulf of Kutch recent measures and proposals are intended to mitigate the degradation. As noted above, conservation activities in the island groups of Lakshadweep, Andamans and Nicobars have not been notable in the past, and little information is available on the present management procedures of the groups.

PELAGIC AND DEMERSAL FISHERIES

Character

The exploitation of inshore species is primarily artisanal or small-scale, using a wide range of gear types and crafts. The availability of the various exploited species varies seasonally and is different from each species group. As a result, artisanal fishermen often do not specialise on one particular fisheries, and use different fishing gears according to season (Kurien & Willman, 1982). Because of the small-scale nature of the fishery, demersal and pelagic catch data are usually not well separated. Only among the mechanized boats is it sometimes possible to distinguish these two categories.

The fishing fleets throughout the area are dominated by traditional and non-mechanized crafts. For example, in Sri Lanka (1979) there were 13,500 non-mechanized vessels, which represented about 68% of the total fleet and fished 30% of the inshore catch; another 3,800 17.5 ft motorized boats, accounting for 30% of the catch. The bigger 3.5 ton boats were numbered at 25,000, taking another 30% of the inshore catch, and the remaining 10% was brought by the local seine fishery (Anon., 1980a).

In India, complete figures for non-mechanized boats are not available but in 1981 they accounted on average for 90% of the fishing fleet. There were at that date 19,013 mechanized vessels in India, mainly concentrated in Maharashtra, Kerala, Gujarat, Tamil Nadu and Karnataka (Anon., 1984a).

However, all governments of this area are now giving priority in their policies to increasing mechanization of their fleets. In general, they aim at developing their offshore sector and also at replacing or adapting the traditional crafts. The input of new techniques, such as gill nets made of synthetic fibres, to the traditional sector, contribues to an increased production, at least in Sri Lanka (Anon., 1977). The effect of this increase in effort on the exploited stock is not known, but it is likely that it will be mainly directed to the inshore 20 -30km strip, where most of the fisheries are still concentrated.

Status

The total marine catch in India has stabilized in the last ten years to between 1.4 and 1.6 million metric tons (MT). For most species groups recorded (FAO, 1983), the levels of catches are more or less stationary, except for Hilsa-like shads, decreasing after a peak in 1978, Bombay-duck, congers and threadfins, also decreasing, and for the Indian oil-sardine, carangids, butterfishes, scombroids and wolf herring where a slight increasing trend is found. The orientation is now toward development of deep sea and offshore fishing in the EEZ where new potentials, especially for tuna purse-seining, are being found.

An acoustic survey off Cape Comorin and in the Gulf of Mannar gives an estimated average standing stock of 624,000t, composed mainly of pelagic species (Anon., 1980b). The Stolephorus (anchovies) stock amounted to 82% of this total. On the east coast, the annual potential yield for pelagic resources is estimated around 670,000t. Estimates of potential yield from the demersal fisheries for areas up to 40 fathoms vary between 143,000 t and 420,000t, depending on the regions surveyed. For the Wadge Bank area and the part of Pedro Bank now under the Indian EEZ, the potential demersal

yield is evaluated at 8400t and 400t respectively.

Sri Lanka has been progressively increasing its total marine catch from 123,314 MT in 1976 to 177,230 MT in 1981. There has been, during that period, a two-fold increase in clupeoid catch (FAO, 1983). Although no real change has occurred in catches of skipjack and yellowfin tuna, catches in tuna-like fishes have increased substantially. An acoustic survey done in 1978 gave a provisional estimate of a potential annual yield of 170,000 tons for the pelagic fisheries and 80,000 tons for the demersal fisheries (Anon., 1980b). Although some opportunities exist for the expansion of artisanal and small boat trawling in coastal waters, the principal resources of Sri Lankan waters are pelagic species (Campleman, 1978).

In Pakistan the landings have been averaging 270,000 tons per year for the past few years. Both coastal provinces (Sind and Baluchistan) record a catch of about 50,000 tons per year of edible fish for local consumption (Fish. News Int., Oct. 1984). The catch of Indian oil-sardine has jumped from 5739 tons in 1976 to 56,346 in 1981, it now accounts for about 20% of the total catch, while skates and rays make up 17%. Hilsa landings have decreased considerably from 9594 tons in 1976 to 3923 in 1981 (FAO, 1983). A potentially important resource for Pakistan is the offshore squid, Symplectotenthis ovalensis, which has been found in high densities by the research vessel R/V Shoyo Maru (Yamanaka et al, 1978).

Most of the fish catch in Bangladesh comes from freshwater areas (about 80%) (Anon., 1979a). However recorded marine landings have been steadily increasing from 100,000 tons in 1976 to 130,000 tons in 1981. One problem in the evaluation of the catch is that a good fraction of it does not enter the commercial market and are consumed locally, thus real statistics on yield trends of number of stocks in Bangladesh are not available. Various surveys have been conducted in the Bay of Bengal by a number of international agencies. Three main fishery grounds have been charted covering a total area of 14,000km^2, with estimates of standing stock of 8.4 to 16.0 tons per square mile (Anon., 1980c).

In the Maldive Islands most of the industrial effort is geared towards the tuna fishery. The catches for most species groups have been stationary since 1976 around a total of 330,000 tons per year. Skipjack tuna, the main catch, has been decreasing since 1977 and accounts now for about 60% of the total catch (FAO, 1983; Anon., 1984b).

Human and economic value

In Sri Lanka, marine fisheries account for about 85% of the country's present food fish production. The total coastal production in 1981 was valued at US$122.5 Millions (Econ. Review, June 1983). The fisheries sector provides employment to about 74,000 persons in fishing and to about 20,000 persons in related ancillary occupations such as marketing, boat building, ice-making, etc. At present this industry supplies about 70% of the animal protein consumed by the population. Fish product exports are estimated at about 2% of the total production (over 3,000 t in 1982), and are mostly frozen prawns, shrimps and lobsters.

In India, the total active population employed in the fisheries sector, both marine and inland, was assessed in 1979 at 1,786,000. Fishery per se employed about 50% of that group, followed by fish marketing (around 20%), net mending (12%), fish processing, (5%) and miscellaneous work (13%).

According to a 1967/68 survey (Anon., 1978), there were about 29,000

marine fishermen's households and 42,000 active marine fishermen in the five marine districts of Bangladesh. Of the total, 72% were located in the Chittagong district. Fish production was valued in 1978 at $16.11 million although no figure was provided for the marine fraction of it (Anon 1979a). In the Maldives, fishing brings almost 40% of foreign exchange earnings, and it is estimated that more than 45% of the working population is employed in the industry (Fish. New Int., Oct. 1982).

Targeted Exploitation

Pelagic Fisheries

Among the coastal pelagic resources, the clupeoids, scombroids and carangids are the dominant groups in all the countries. In the clupeoid group, Sardinella and Stolephorus are important in all countries except Bangladesh. Among the scombroids, Rastrelliger is important in all countries. The tunas and tuna-like fishes as well as the Spanish mackerel, are exploited in Sri Lanka and in Tamil Nadu (India). Carangids are represented by many genera, with different distributions along the coasts. Information is more readily available on the tunas and the tuna-like species, because they sustain a targeted fishery that has a specialized and diverse technology. A section below gives details on this fishery.

In India and Sri Lanka, the clupeoid group is the most important in terms of catch. The landings for this group in India were of 412,000 MT in 1981 (29% of total marine catch) of which 78% due to the Indian oil-sardines alone (FAO, 1983). The 1981 total catch of clupeoids in Sri Lanka amounted to about 64,500 MT, and is on steadily increasing. The Sardinella catch in Pakistan is also dominant with a figure of 56,350 MT in 1981. No separate estimate is available for Bangladesh.

The abundance of various stocks of the shoaling pelagic groups varies greatly from year to year; it is not known if it is due to variations in recruitment or to migrations. There are presently no identified instances in which overfishing clearly exists (Tussing, 1984). However, the multi-species character of this fishery makes it impossible with the available data to assess the current status.

In the Bay of Bengal, there are gill netting operations targeted mainly at Hilsa which can account for up to 90% of the catches. The Hilsa yield in Bangladesh appears, with some fluctuations, to be stable or possible increasing over the last few years, with total annual landings estimated at some 90,000 - 100,000 t (Dunn, 1982), corresponding to about 40% of the marine catch (Shahidullah, 1978).

Tuna catches have highly seasonal fluctuations probably caused by their migration patterns. For example, peak catches are recorded in May-July in Kerala, and in July-September in Tamil Nadu. Species composition also varies along the coasts of India and between countries. In Kerala (west coast) 70-80% of the landings is for little eastern tuna while in Tamil Nadu (east coast) the little eastern tuna and the frigate tuna are equally represented (Skillman, 1982). The 1982 total production of tuna in India has been about 20,600 tons of which 2,400 tons of skipjack, 1160 tons were kawakawa, 1890 tons of frigate and bullet tuna and 4680 tons were other species. Previously, surface trolling was the main method of fishing; the introduction of mechanization and of nylon gill nets has steadily increased the tuna catches (Anon., 1984).

In the Maldives, and in Sri Lanka skipjack tuna is the main species caught, although its proportion in the catch has declined in favour of yellowfin tuna; in Sri Lanka this change is largely attributed to the expansion in use of the gill nets (Sakurai, 1984). Other tunas caught in those areas are frigate tuna, bullet tuna and kawakawa. Pole and line and trolls are the main fishing gears used in the Maldives, due to a ban on the use of all net gears in the recent past. Net techniques are now allowed (IPTP, 1984c).

In Pakistan, skipjack and kawakawa are the main species found. The catches of kawakawa have decreased in the past ten years to 5677 MT in 1982, almost equalled by the skipjack (Anon., 1984b). No breakdown of catch by gear is available. Annual production in the Maldives has declined from 58,900 tons (1971) to 25,800 tons (1978). In Sri Lanka, the production had been increasing until 1976, but has now stabilized around 15 - 18,000 tons (FAO, 1983).

Incidental Exploitation

Pelagic fisheries

The present annual production of the Sri Lankan tuna fisheries (30-35,000 MT) constitutes 15-20% of the total fish catch (Joseph, 1984). Smaller tuna species and young stages of larger ones are found mainly inshore. The large tunas such as Yellowfin and Bigeye move into deeper waters as they grow older. In the targeted tuna fishery, Bill fishes can make up a good proportion of the catch, although there is little information about this apportionment. In certain areas of the west coast of India, bill fishes seem to be the target of the pelagic fishery rather than the by-catch (Skillman, 1982).

In the fishery of small pelagic groups the dominance of any species is often very low. However, species groups usually sub-dominant in the catches in India are the flying fishes, barracudas, pompanos and mullets. The threadfins, which were abundant in 1976, fell to a low catch level in 1981 (FAO, 1983).

Demersal fisheries

The demersal fisheries, especially in the trawling sector, is most often targeted at shrimp. However, fish caught as a by-catch represents about 80% of the catch in weight (Subasinghe, 1982). This subject is dealt with in the shrimp section below.

In general, Elasmobranchs (sharks and rays), catfishes, eels and sciaenids, croakers, drums, etc) are the important demersal groups caught. Their proportions in the catch varies greatly between regions, but there is often no dominance from one group or another. From trawler catch statistics of the Bangladesh Fisheries Development Corporation (1981), catfish dominated the catches (37%), followed by sharks (5.3%), eels (1.4%), pomfrets (1.3%), indian salmon and sciaenids (1% each); "mixed small fish" accounted for 39.6% and "mixed bag fish", for 11.1% (Anon., 1980c). No information is available on the levels of exploitation of various stocks, due to the difficulty of gathering data in the small-scale sector, and to the practice of discarding most of the by-catch at sea in the operations by the larger trawlers (Silas et al., 1984).

Waste discharge

In India, the Kalu River, discharging on the Arabian Sea, is the most highly polluted river of the west coast, due to a high number of industries and high densities of population in and around Bombay. In 1974, the water had a pH as low as 1.2 (Jhingram, 1974). The migratory Hilsa, which used to support a good fishery, no longer ascends the river. The Bay itself is used for disposal of sewage. Other coastal rivers also receive a high pollution load from industrial discharges. In the Hooghly River, West Bengal, the

density of zooplankton, fish eggs and larvae, and benthos, is very low, although industrial pollution is dissipated by the tidal action.

Existing management policy

In Sri Lanka, the 1984-89 plan of the Ministry of Fisheries is to increase the total annual catch to 300,000 t. For doing so, it has three priorities (Fish. News Int., June 1984).

1) Help the deep-sea fishery with more private participation, by improving the training facilities, providing subsidies for the purchase of deep-sea vessels, and encouraging joint ventures with tax incentives;

2) Overhaul the marketing sector and its strategies; and

3) Support coastal fisheries by the introduction of new technology for improving vessel designs and catching methods.

Among policies already existing, is a ban on the use of explosives for fishing purposes, and the interdiction for mechanized boats to operate in certain coastal waters where artisanal fishermen have been traditionally fishing. No licences are at the moment being issued for foreign fishing vessels in national waters (Anon., 1980b).

In India, general order stipulate that the area inshore of 5km from the coast is reserved for the non-mechanized sector; between 5 to 10km, the small mechanized boats can operate; operation of the larger commercial vessels is permitted beyond 10km from the coast. The Fisheries Survey of India is presently being re-organised and strengthened; the data assembled by the FSI will be passed onto commercial enterprises to help them undertake more efficient fishing operations (Fish. News Int., March 1984). In Andhra Pradesh, the government's strategy for 1980-84 was to establish new fishing harbours, expand the mechanized fleet for coastal fishing and provide subsidies to traditional fishermen for new equipment (Anon., 1980b).

In Bangladesh there is at present no regulation protecting the small scale fisheries (Anon., 1980b). The area within 12 miles of the coast is exclusive to national boats; two vessels have recently been launched to work in the Bay of Bengal on offshore protection duties (Fish. News Int. Feb. 1984).

In Pakistan the government's priorities since 1981 have centered on mechanizing the fishing fleet. It is also in the process of expanding Karachi harbour and building a new harbour in Karangi with financial help from the EEC and the Asian Development Bank. There have been surveys of the 200m belt of inshore waters for resource assessment since 1982 (Fish. News Int., December 1984).

Priority concerns

Stock conditions, levels of fishing effort and catch rates of shoaling pelagic species require special attention because these species tend to be sensitive both to environmental conditions and to fishing mortality. Excessive effort has in several pelagic fisheries around the world (e.g. Peruvian anchovetta, California sardine) has been followed by a rapid collapse of the recruitment and a virtual extermination of the stock. Information gathering would require collaboration between various countries,

as it is not known if pelagic fishes in different waters constitute a single stock or several.

Because of indirect indications of stock reduction of some of the commercially important species (for example, certain tunas) conservation regulations might be necessary. There is in general very little or complete absence of stock monitoring. Information on the effects of increasing effort is needed, especially in the coastal areas where most boats operate.

Careful management is required to make use of the trawling industry demersal by-catch. Although there is at present no evidence of overfishing of Hilsa at least in Bangladesh, an increase in the use of purse-seines to take fish schools at sea could lead to a level of exploitation that cannot be sustained (Dunn, 1982).

Priority recommendations

A specific programme for the establishment of a catch and effort data base for the use of all countries in the region needs to be set up for the pelagic fisheries. This programmme should be carried out in conjunction with stock definition studies to determine the distributional structure of the main pelagic species. Since effort must be limited at the local level, especially for the small scale fisheries, this information must be made available directly to local authorities along with appropriate support for its application.

An effort should be made to collate existing data on catch rates and species composition throughout the region extending as far back in time as possible. Analysis of this information along with continued monitoring will enable identification of components of the fisheries which require management action.

SHRIMP FISHERIES

Character

The major development of mechanization in India and the region as a whole, took place in the 1950's when shrimp trawling was introduced. Trawling is increasingly practiced in most areas, and mechanization is slowly replacing or being adapted to the traditional fishing crafts (Silas et al., 1984). In general, most of the shrimp exploitation occurs on in inshore and brackish water areas. More effort has recently been put into exploration and possible exploitation of other species of shrimp in deep water (over 200m) and development of shrimp farming. Since the shrimp production represents a high proportion of marine export products, increased attention is also being given to improvements in the processing industry, including better quality control.

The shrimp resource is exploited using a wide range of gear. Trawlers fish in coastal waters as well as offshore. Smaller motorized or non-motorized crafts operate seine nets, scoop nets, and drift nets. Shore seines are used in flat sandy coastal areas, and in certain brackish water areas as in the Indian province of Kerala where juvenile prawns are trapped at low tide and harvested with dip nets or by filtration. The inshore harvesting season concentrates around monsoon months, while trawlers operate from October to May or year round in the case of the bigger ones (Joseph, 1971).

In India, the west coast produces more than 85% of the landings, with Maharashtra and Kerala provinces accounting for 48% and 31% respectively of the total catch. Shrimp trawling in Sri Lanka is carried out in the coastal waters of Jaffna and Mannar, and in the shallow waters of Palk Bay, and Palk Bridge. These soft muddy bottom fishing grounds have yielded more than 60% of the total 1979 shrimp production (Subasinghe, 1982).

In Bangladesh penaeid shrimp farming accounts for 80% of the country's annual harvest, while trawling operations in the Bay of Bengal provide the remaining 20% (Fish. News Int., Jan. 1984). Most of the shrimp trawlers in Pakistan operate out of Karachi in the province of Sind, where the canneries and freezer plants are also based.

Status

In India, the landings of shrimp increased rapidly to a peak of 220,000t in 1975; thereafter a downward trend was observed to actual values below 176,000t (Silas et al., 1984; FAO, 1983). Landings have declined in most states, although production has increased in the east coast provinces of Tamil Nadu and Andhra Pradesh (Silas et al., 1984). In the latter, the strategy of the government is a phased conversion of suitable brackish water areas into shrimp and fish farming (Anon, 1983). However the extensive transformation of such habitats is deleterious to the natural shrimp stocks, as these are used as nursery grounds for juveniles of many species.

The likelihood of shrimp stock depletion is a problem shared by the whole area. In Sri Lanka, a survey conducted by R.V. Dr Fridtjof Nansen in 1978 indicated that the commercial size of prawns has declined. There is also concern over the excessive capture of juvenile prawns (Anon., 1980).

Surveys are now being done to assess the potential of deep sea prawn stocks. One work reported by Joseph (1971) found 3,000 km of trawlable

grounds off Kerala with an estimated standing stock of 3,500 t of prawns, which made up 50% of the catch. Deep sea shrimp have also been found along the lower east coast, the coast of Orissa, and on the west coast off Goa, Kerwar and Ratnagiri. In general potentially good fishing grounds for demersal fishes and shrimps exist along the continental shelf edge and the upper continental slope. Joint ventures with foreign companies for deep sea shrimp fishing is now encouraged by India, Pakistan and Sri Lanka.

Human and economic value

In the whole South Asian Seas region, shrimp production is aimed mostly at export, these having a high value on international markets. In India, the 1979/1980 export of shrimps (in frozen, canned and dried state) was valued at US$160 million and amounted to 51,318 tons. It accounted for 85% of the total export of marine products, and about 3.5% of total exports. The shrimp fisheries also support a processing industry mainly in the provinces of Kerala, Kanataka and Tamil Nadu. In 1980, there were 322 freezing plants and 69 in rural industries. The employment figures are not known (Anon., 1983b).

Seafood export in Sri Lanka for 1983 amounted to US$25.6 million, 25% up from 1982 (Fish. News Int., 1984). Shrimps account for 75% of this figure (Economic Review 1983).

In Pakistan, 9,000t of shrimps are exported annually, and account for 85% of the total marine product exports. Japan is the major market, followed by U.S.A. and Britain. Seventeen freezer plants and 11 canneries already exist in the country although working at 25% and 1% respectively of their total capacity of about 4,500t/year (Fish. News Int., Jan. 1984).

Shrimp export from Bangladesh is valued at US$51.25 million in 1982/83, an increase from $38.75 million in 1980/81. Japan is the main importer. Forty shrimp processing plants exist in the country.

Targeted exploitation

India's shrimp fishing fleet, according to a 1974 - 79 census, is comprised of 106,480 non-mechanized boats (catamarans, canoes, plank-built boats), averaging a yearly catch of 31,758t of shrimp, and 12,000 mechanized boats (motorized indigenous crafts, Dan boats, Pablo boats, trawlers) including about 100 large steel trawlers, averaging 153,057 tons per year (Anon., 1983b). This division between mechanised and non-mechanised sectors exemplifies the fisheries in the whole area.

A trawler shrimp catch will usually yield a low proportion of shrimp compared to its by-catch; the mean proportion of bycatch is around 80%. Penaeid shrimp comprise most of the canned and frozen prawn exports. There are about 12 species of penaeid shrimps on the west coast of India. According to Joseph (1971) Penaeus indicus and P. monodon (large prawns) accounted for 11% of the penaeid catch. Metapenaeus affinis, M. monoceros and M. brevicornis (medium prawns), about 26%, and M. dobsoni, Parapenaeopsis stylifera, and Solenocera indica (small prawns), about 54%. However, these proportions might have changed since then in favour of the larger groups due to the growing importance of the offshore sector. There are also wide variations according to the habitat exploited. For example in south-east India, Penaeus semisulcatus (green king prawn) dominates the commercial catches (Manisseri, 1982).

Total shrimp landings in India and Sri Lanka have stabilized since 1976 and were respectively 175,746 MT (metric tons) and 7180 MT in 1981. Pakistan has increased its catch from 21,746 MT in 1976 to 30,000 MT in 1981. (FAO, 1983). In Bangladesh the 1983 harvest from pond areas of coastal districts amounted to 10,000t, which put the total landings for the year at 125,000t. The per acre production in shrimp farms is about 50kg/yr; it is planned to double this production over the next 5 years by keeping the predatory fish out and using fertilizers (Fish. News Int., January 1984).

Incidental exploitation

Around 80% of the shrimp trawler catch consists of a large variety of fish, with the dominant species rarely exceeding 20% of the total. In Sri Lanka, it is mainly composed of small fish of low economic value, mainly silver bellies; only 10 to 25% of the by-catch is used commercially (Subasinghe, 1982). In Mannar, two fishmeal plants use 3-4 tons/day. The rest of the catch is salted and sun-dried thus dependent on weather conditions.

In India, only a negligible quantity is discarded, except when the shrimp catches of small trawlers are heavy, and for the small number of large Gulf of Mexico type trawlers, where most of the by-catch is discarded at sea. The following are average species compositions as found by trawling surveys: 31% perches, 21% sciaenids, 14% silverbellies, 4.5% each of elasmobranchs, eels, ribbonfishes, crustaceans and cephalopods, 3% each flatfishes, catfishes and lizard fishes, occasional white fish, pomfret, barracudas, dorabs, thread fins and carangids, 25% other species (Silas et al., 1984). However, this composition varies tremendously; for example, cephalopods can account for up to 70% of the by-catch on the west coast of India, (James, 1982) and pomfrets are very common around Bombay.

Waste discharge

Estuaries are used as nursery grounds for many species of shrimps, and are also areas of high human density and industrial development. Large-scale domestic and industrial discharges can cause considerable damage to the habitat in general and especially to the natural stocks of shrimps. The effects on their populations is little known.

Direct destruction

Large-scale conversion of brackish-water habitats for agricultural purposes affects the distribution the juvenile shrimps by reducing the total area of nursery grounds. This is presently happening in Vembanad Lake in Kerala State where a barrier has been built across the lake as part of a salt water extrusion project (Silas et al., 1984). Changes in the salinity are also likely to be detrimental to the juvenile stages and some inshore species of prawns.

Existing management policy

The Indian Government has recently announced new concessions to assist the trawling industry, especially in relation to improving conditions for fishing equipment (Fish. News Int. 1985) In Andhra Pradesh on the Bay of Bengal, the strategy of the government is to gradually transform brackish water areas into shrimp and fish farms. In the province of Kerala, the

paddy-field prawn fishery is allowed to operate from middle of November to middle of April, perhaps more in the interest of rice cultivation (Joseph, 1971).

Policies in the shrimp fisheries follow the general lines mentioned in the previous section (pelagic and demersal fisheries).

Priority concerns

A clash of interest between traditional fishermen and the mechanised sector has been showing up, as exemplified by a recent 50 day demonstration in Kerala for the total ban of mechanized trawlers along the state's coast during the shrimp spawning season (Fish. News Int., Aug. 1984).

An important concern is the lack of proper data to document the apparent depletion of shrimp stocks, such as changes in catch and in size of the animals, sex ratio, etc. (Fish. News Int., Aug. 1984).

Priority recommendations

Overfishing problems must be dealt with by local authorities and international programmes should assist them in this work, primarily through funding.

Survey work on the extent of reclamation of estuarine and brackishwater habitats is needed. A study on the relationship between these habitats and shrimp stock abundance and species composition is recommended. In addition, a study on the effects of trawling on the productivity of some known shrimp spawning grounds should be conducted to address one aspect of the conflict between traditional and commercial fisheries.

Information on the use of separator panels selecting shrimps from by-catch in trawl nets should be made available. Trial of such devices would enable an evaluation of its efficiency in this region.

OTHER CRUSTACEANS

Character

Fisheries for crustaceans other than shrimp are, at present, rather small and of little economic importance except in the case of lobsters. Many species of crabs and stomatopods (Scylla) are found in brackish-water habitats, such as mangrove forests, seagrass beds and lagoons, although marine species also exist. Lobsters live on rocky bottoms in coastal areas, and some deep-sea populations have been indicated by surveys.

Status

A spiny lobster (Panulirus spp.) fishery exists in Sri Lanka and along the south-east coast of India, especially at Tuticorin, Madras and Mandapam. There are indications that these populations are presently being heavily exploited or over-exploited, and that a good percentage of the catch consists of juvenile lobsters (Joseph, 1971; Anon., 1982). The crab fishery is gaining importance along the east coast of India. The crab and lobster catches account for 4.6% of the total marine catches on the east coast of India, and about 3% in Sri Lanka (FAO, 1983).

Human and economic value

Lobster fishery is mainly directed at the export market. In Sri Lanka, 480MT of frozen lobster was sold on the international market in 1982 at a value of RS 33.4 million, which is about 4% of the total value of marine products exports (Econ. Review, June 1983).

Targeted exploitation

The main lobster species are Panulirus homarus, P. ornatus and P. versicolor. In the Mandapam area of India, estimates of population size have been calculated at 2.6 tons, and the rate of exploitation is evaluated at 22.7% (Anon. 1980c).

Lobsters are caught by traps, pots, hooks and gill nets; they are also taken in seine and trawl nets. The main fishing season is from November to April (Joseph, 1971). The main crab species caught are Portunus pelagica, P. sanguinolentus and Scylla serrata (Anon., 1980c).

In 1971 there was one processing unit in India (Calicut) which processes crab meat for export (Joseph, 1971).

Existing management policy

In Sri Lanka, there are regulations relating to lobster fishing; there has been a size limit regulation for spiny lobster since 1973; lobster fishing is probited in an area off the coast of Colombo which has been overfished (Anon., 1977). No information is available for the other countries.

Priority concerns

The shallow water lobster fishery is easily vulnerable to over-exploitation. Exploitation of deep sea populations is an alternative in terms of exports, but the shallow water species will remain an attractive source of income for local fishermen.

Priority recommendations

Regulation enforcement in this fishery is difficult to realize, but a further effort should be made by local authorities. A survey should be conducted to assess the potential of offshore crustacean resources.

MARINE MAMMALS

Character

At least 25 species are known to exist in or around this area, and the number may in fact exceed 30 species.

Status

Of the baleen whales, fin, blue, minke, sei, Bryde's and humpback are all thought to inhabit waters of this region. The populations of all these species are depleted throughout the world, especially fin blue and humpbacks. Of the other species found here, sperm whales may be depleted too, after decades of hunting in the Southern Indian Ocean and Antarctic waters. The Indian Ocean having been declared a reserve, all of these species could now be increasing in number.

Of the smaller toothed whales, at least 5 species of beaked whales may be found in these waters, but these deep water animals are only rarely seen in coastal waters, and as a consequence only a very few records are available. Mesoplodon gingkodens has been recorded in Sri Lanka, but other species are only inferred to exist here including M. densirostris, M. pacificus, and Ziphius cavirostris.

Pygmy and dwarf sperm whales, rough toothed dolphins, humpbacked dolphins, melon headed whales, pygmy and false killer whales, killer whales, short-finned pilot whales, Fraser' dolphin, bottlenose dolphin, Risso's, spinner, striped, spotted and common dolphin, finless porpoise, Indus susu and dugongs are the other species either known or thought to exist here.

There is very little quantitative information on any of these species, but the Dugong is certainly depleted throughout the area. Incidental catches in gill-net and other fisheries of coastal species of small cetaceans such as bottlenose dolphins, finless porpoise, common dolphins and humpbacked dolphins can also be expected to have had some effect on the abundance of these species, though the extent is unknown. The Indus susu, a river species, is endangered.

Human andeconomic value

As there are no directed fisheries, the simple commercial value of these species should be none. However, incidental and illegal captures undoubtedly contribute to the diets of an unknown but small number of people.

Targeted exploitation

There is no legal directed fishery for any of these species, but some of the coastal species are caught in very large numbers and it is evident that some are taken for human consumption.

Incidental exploitation

Jones (1976) has estimated that tens of thousands of small cetaceans are taken annually in Indian coastal waters. One recent study indicates

that around 10,000 small cetaceans may be killed every year in Sri Lankan waters through net entanglement. Dugongs too are known to be taken for human consumption. Mostly these are taken in gill nets and beach seines. Although it is illegal, some of these incidentally caught marine mammals are sold in markets for food. The exact quantitative impact of this take on the populations is unknown. The scale of these incidental catches of marine mammals is similar to, or greater than, that in the Eastern Tropical Pacific, or the North Pacific salmon gill net fishery. Whilst this kill of small cetaceans particularly, is occurring in the Indian Ocean whale sanctuary, it clearly deserves considerably more attention.

Oil industry, waste discharge, sedimentation, direct destruction

There is no evidence that either waste discharge or the oil industry has any effect on marine mammals in this area, although for coastal species such as those mentioned above, this could clearly be a problem. Dugongs are known to be adversely effected by these phenomenon. Indirect impacts on Dugong populations could be as important to their decline as direct impact from fishing nets.

Recreation and tourism

Tourism has some potential with regard to marine mammals in this region, where, for example, off Trincomallee in East Sri Lanka, blue whales and humpback whales are known to congregate. Tourist ventures to view these species have been proposed (Whitehead, 1983) and are commercially viable elsewhere (e.g. the USA and Mexico).

Existing management and management practice

The Indian Ocean is a whale sanctuary and all deliberate killings of cetaceans is forbidden. For the larger whales this policy would seem to be effective under the rules of the IWC. For smaller coastal species incidental takes may be more or less deliberate in different areas. It is a matter for dispute whether IWC policy applies to such species.

Priority concerns

Priority concerns would be the conservation of the dugong and the potential effect on small cetaceans of incidental kills in fishing nets.

Priority recommendations

There are enormous gaps in knowledge concerning the status of marine mammals of the area. Little more is known than that very large numbers of small cetaceans are taken. There are no population estimates of any marine mammals in this area. Numbers of dugongs and other coastal species need to be recorded. Incidental kills need to be documented, and species, distribution of kills, and gears involved all need to be investigated.

Larger whales could also be censused and their movements studied, as they are a potential source of tourist revenue for some areas. More attention could also be paid to strandings and stomach contents of stranded or incidentally caught marine mammals, since as little is known of their feeding habits and many of the fish stocks are locally over-exploited.

TURTLES

Occurrence and extent

In Pakistan, very important nesting beaches are found at Hawkes Bay and on the outskirts of Karachi at Sandspit, where the green turtle Chelonia mydas and the Olive Ridley turtle Lepidochelys olivacea come to nest (Groombridge, 1985); the nesting population of the former species is one of the world's dozen largest. Turtles also nest on beaches at Buleji and Paradise points in Sind and Somniani in Baluchistan.

In India, the green turtle is not abundant along the mainland coast, but is more common in Lakshadweep and in the Andaman and Nicobars. The latter areas are possibly feeding grounds for populations which nest in Burma, while the Gulf of Kutch is possibly a feeding area for green turtles which nest in Pakistan (Groombridge, 1985). Southeast India has substantial feeding grounds, especially on the offshore islands. The annual turtle catch in this region is about 4-5000 (Jones & Fernando, 1973), about 70% being the green turtle Chelonia mydas. Hawksbills, Eretmochelys imbricata and the leatherback turtle Dermochelys coriacea are found mainly in the islands of Lakshadweep, Andamans and Nicobars, and are much less common in mainland India (Groombridge, 1985). Both species are caught, mainly for their scuta and oil respectively. The Olive Ridley occurs widely in India, and nests in massive numbers in Orissa on the east coast.

In Sri Lanka, 5 species of turtles are found; the above four and the loggerhead, Caretta caretta which occurs mostly on the west side. The leatherback turtle nests on the coast of the Yala National Park from October to December. Most species are not especially abundant, but the Olive Ridley has substantial nesting populations in this country.

In Bangladesh, only the Olive Ridley is thought to have substantial breeding sites (Groombridge, 1985).

On the atolls of the region the green and hawksbill turtles are the commonest species. Both nest on many oceanic atolls of the region (Sheppard, 1980).

Human and economic value

Groombridge (1985) suggests that the populations of Olive Ridley turtles nesting in India could be sustainably exploited, given proper management. However, most of the turtle populations in the South Asian Seas region are in decline due largely to human predation.

Targeted exploitation

Sea turtles are protected throughout most of this region by wildlife protection acts in most countries. Also, CITES controls trade in turtle products. Nevertheless, depredation of eggs by coastal dwellers and netting or spearing of adults for food and tortoiseshell, the price of which has increased dramatically, still continues.

Kar and Bhaskar (1981) review the status of sea turtles in this area. In Gujerat the eggs of Olive Ridley turtles are known to be consumed by humans in Kutch, but turtle meat is rarely consumed in Gujerat. Instead, turtle fat is said to be used for caulking boats and as protection from

marine borers. The salted flipper hide may also be used as tough shoe leather. In Maharashtra green turtles and Olive Ridleys are known to nest, apparently in low concentrations. Nesting turtles and their eggs are taken by humans in this state. In Goa, Olive Ridleys are the most common and they and occasionally Leatherbacks are netted by fishermen for consumption. In Karnataka much of the coast is rocky and no surveys have been made. A rocky shore does not preclude the existence of (non-nesting) hawksbills. In Kerala, again green turtles and Olive Ridleys occur, but dense human habitation, including sea wall construction has prevented nesting along much of the shore. Where nesting occurs, eggs and adults are taken for local consumption. The occurrence of leatherbacks appears to have declined considerably since last century. In Tamil Nadu all five species are found, with populations of Ridley, green, hawksbill and loggerhead found in the sea grass and coral reef areas of the Gulf of Mannar and Palk Bay. These are caught and eaten, with between 4000 and 5000 turtles being taken annually in Southern Tamil Nadu. Olive Ridleys and loggerheads together make up about one fifth of the catch.

North of Point Calimere, Olive Ridleys are the only turtles to nest in significant numbers along the east Coast. Along a 50km stretch of beach an estimated 90% of 5000 nests are removed by villagers, iterinerant turtlers, jackals and dogs. Fishermen, however, regard the turtle as sacred in this region. In Andhra Pradesh a leatherback was reported deliberately killed when it came ashore in 1979, and at Visakhapatnam, a former tortoiseshell centre, less than a dozen turtles are taken a day. Some people in this region eat turtles, and an unknown but possibly large number are transported to Calcutta. Off the coast of Orissa there is a considerable illegal Ridley fishery. Two landing ports in Bengal saw 21,361 turtles pass through between October 1978 and January 1979 (Biswas 1979 cited by Kar and Bhaskar 1981), and exploitation continues up the coast to the Sunderbans in West Bengal.

In the Lakshadweep and Amindivi Islands, sea turtles are harpooned for their fat, used for caulking boats, and for their meat which is not commonly eaten but may be used for shark bait. More commonly, eggs (Olive Ridley, hawksbill and green turtle) are eaten. In the Adamans and Nicobars, turtle eggs and meat are said to be eaten everywhere; these include leatherbacks, hawksbills, green and Ridleys.

Incidental exploitation

Turtles are caught incidentally by fishermen throughout this area. In Sri Lanka at least, these are sometimes liberated. In the Gulf of Mannar, turtles are common in the sea grass beds in which shrimp trawlers operate and off the coast of Orissa and Bengal, and in Andhra Pradesh the increasing numbers of mechanised trawlers is said to be having the effect of increasing incidental catch rates (Kar & Bhaskar 1981). Presumably this is also true in other areas.

Direct/habitat destruction

The principal cause of the decline in turtle numbers is human capture, including that of their eggs. This is widespread. In addition, encroachment of beach houses in Pakistan and unearthing of eggs by animals has been cited by Salm (1975) as noteworthy factors which may have an impact on turtle numbers in the important nest sites in that country.

Existing management policy/practice

In several areas, notably in Pakistan, and in marine parks elsewhere, turtles are protected by local law, although law enforcement is commonly difficult. In the northern Arabian Sea, all turtles and their eggs are protected under the Sind Wildlife protection ordinance of 1972 (Salm, 1975). Throughout India, all species are nominally given total protection, but their numbers are being greatly depleted (Kar & Bhaskar, 1981). Turtles are afforded legal protection in Sri Lanka also, although laws regarding turtle capture have in the past been suspended, and the nests of several species are dug up by both people and by dogs and boar (Salm, 1975). It is likely that both species occur and nest commonly on many of the lesser known islands of the western Indian Ocean.

BIRDS

Targeted exploitation and incidental exploitation.

There are no records of targeted or incidental capture of marine birds in this area, although occasional net entanglements might be expected.

OTHER RESOURCE SPECIES

Targeted exploitation

In India 80-90% of the total cephalopod catch (12-14,000t) comes from the west coast. As on the east coast, more than half the catch is taken by the trawl fishery. The remaining is landed by shore-seines and boat-seines (Chikuni, 1983). On the east coast and in Sri Lanka, the cephalopods are considered a by-catch of the trawl fishery. Wadge Bank is a good Sri Lankan fishing ground for cuttlefish. The cephalopod products of this region are mainly exported to South-East Asia, France and Japan (Jhingram, 1982). It is believed that the cephalopod catches could be increased considerably, as they are now only fished in relatively shallow waters (to about 40m depth). There are also some Taiwanese long-range trawlers operating in waters around Sri Lanka and along the west coast of India up to eastern Pakistan (Chikuni, 1983). Small quantities of other molluscs, including oysters, may be taken throughout the area, but the fishery is not intensive. There is also a joint venture Chinese-Sri Lankan fishery for sea cucumbers underway (Anon., 1985). In India the pearl fishery is more productive on the east coast, especially at Tuticorin. In the Gulf of Mannar and in Palk Bay, the pearl oysters are gathered by divers (Jhingram, 1982).

Three species of crocodile are found in this area, although two, the mugger, Crocodylus palustris and the Indian Gharial are confined to fresh waters. The estuarine crocodile (Crocodylus porosus) although protected is still hunted for its excellent hide. There are, however, little more than a thousand thought to be left in this area (IUCN 1979).

Incidental exploitation

There is no indication that any of the crocodile species mentioned above is exploited incidentally. However, the destruction of mangrove swamps, one of the estuarine crocodiles prime habitats, has the incidental effect of further reducing the population.

CONCLUSIONS AND RECOMMENDATIONS

PRIORITY CONCERNS

Priority concerns for each habitat, species group and nation in the South Asian Seas region have been introduced in the section on resources, habitats and species: where the background descriptions of the habitats and species emphasised the problems which presently affect them. The most important or most urgent are summarised here.

In the open ocean, oil spills are probably the most important pollution threat. Although several international sets of regulations exist, some nations of the Indian Ocean have not ratified them despite the presence of chronic oil pollution along their shores, and some do not have satisfactory oil spill control measures (Ferrari, 1983).

Of major importance also in the open ocean is continuing support for the Indian Ocean Whale Sanctuary and its extension to encompass smaller cetaceans and other vertebrates. Small cetaceans are killed in large numbers by the coastal gill net fisheries.

Sediments are commonly very rich areas of nitrogen fixation and secondary productivity, but are not usually considered as a high priority for protection. Their invertebrate faunas commonly support very diverse and large bird populations (eg. in the Gulf of Kutch). However, it is often the case that while the bird populations may be protected in a direct sense, their soft substrate habitats are not usually protected but may be subjected to various forms of disturbance, notably dredging and infill.

Dredging of calcareous sands is common in India and Sri Lanka, for conversion into lime for the building industry. This is usually coupled with extraction of the reef, such that associated sediment bodies are rendered unstable and mobile. Terrigenous erosion associated with both reef removal and poor land management also results in accumulations of sediments in shallow coastal areas.

A major concern in all of the countries is the considerable destruction of mangroves, including those of the Bay of Bengal (Mukherjee & Tiwari, 1984). The Sundarbans mangrove ecosystem has been severely affected by the Farakka Barrage which has resulted in increased floods, soil toxification, land instability and pest infestations, and in decreased soil fertility, water quality and fisheries. In India, mangroves are extensively cut for fodder and firewood, and much of western and southern India has lost its original, extensive stands (Untawale, 1984; Krishnamurthy & Jeyasee, 1984). Those of the Gulf of Kutch have also been severely reduced (Chavan, 1983).

In Sri Lanka there is a smaller development of mangroves, and disturbance to them is considerable. Nearly all stands on the southwest coast have been destroyed (Salm, 1975). Reasons for their destruction include their use for fuel and fodder, and to a change in the use of the land for farming milk fish, coconuts, or for clearing access to lagoons for boats (Linden & Jernelov, 1980; Salm, 1975).

A major concern arising from the destruction of mangroves lies in their loss as provision of a habitat for several food species such as penaeid prawns which depend upon them. Commercial shrimp production relates directly to mangrove area (Linden & Jernelov, 1980). Because of disturbance to mangroves, these fisheries are endangered in India and Sri Lanka (Salm, 1975). In

Bangladesh, one third of the population is dependant on mangroves for an income, for food or for fuel (Linden & Jernelov, 1980).

Mangroves also make an important contribution to coastal productivity and stability throughout the mainland parts of the region. Their removal may be the main cause of flooding in the Bay of Bengal (Linden & Jernelov, 1980).

Seagrasses have usually been overlooked in priorities for protection in the countries of this region, and have been the subject of much less research than has been the case for mangroves and coral reefs. They are a highly productive and economically valuable resource, but estuarine disturbances, infilling and dredging are all known to have affected areas of seagrass. One consequence of this is to place additional stress on the endangered dugong populations.

Some of the most serious problems affecting the coastal parts of the South Asian Seas region involves their coral reefs. In general, the main concerns are reef quarrying, infilling, and sedimentation which results from these activities. Sedimentation from inland deforestation is also very destructive to reefs in areas of the Indian Ocean, and is reported to be causing much damage in the Andaman Islands (Whitaker, 1984).

In the Gulf of Kutch, Palk Bay, the Gulf of Mannar and Sri Lanka, a major concern comes from reef quarrying for the lime industry. In the Gulf of Mannar and Sri Lanka, several reefs have been removed completely by the lime industries (Mahadevan & Nayar, 1972). This is widespread throughout the area, where several hundred people are engaged in the quarrying industry and where the amount of reef removed annually is many tens of thousands of tons (Salm, 1975).

In Lakshadweep, Minicoy Atoll has suffered severe disturbance over the last decade. dredging activities have greatly increased sedimentation, resulting in a high coral mortality. Since 1980 Acanthaster planci has also caused widespread damage. In some areas, the deposition of 0.5 m of sediment in the last few years as a result of dredging and blasting has buried the corals, and about 75% of all the coral in the lagoon of Minicoy was killed in the early 1980's or late 1970's (Pillai, 1981). Recolonisation by new corals appears at present to be negligible, and Pillai (1981) also expresses concern also over other atolls in Lakshadweep.

In a few parts of the region, notably Sri Lanka, dynamiting is used as a fishing technique, with attendant severe reef destruction. In the same country, the aquarium fish trade causes reef destruction by trampling and from the nets used during collection.

In the Maldives, much of the natural vegetation has been cleared from the coral islands used for holidays, and leaf litter is regularly removed. There is considerable impact to these small islands from tourism in the form of a break in the organic and nutrient recycling process, and in alteration to the water table. Reef quarrying to obtain building materials occurs here too, and the construction of jetties and breakwaters also results in some reef destruction. There is concern that such islands may deteriorate from the tourist pressure. At present, however, there is no observed deterioration to the reefs of either the seaward slopes or around lagoonal knolls and islands, which remain in excellent condition. Recently, management measures have been proposed for the reefs of the Maldives, following a visit by UNESCO (Kenchington, 1983).

Other major concerns which affect all habitats involve the effects of industrial and domestic pollution. These concerns are often the least clearly

defined and least well quantified. They are usually concentrated in inshore and estuarine areas, often those extensively used for fishing and as nursery areas for commercially or biologically important species.

RECOMMENDATIONS FOR ACTION

Many UN and independant agencies have issued sets of recommendations, either as part of serial publications (e.g. the UNEP Regional Seas Reports and Studies Series) or following discussion group meetings or symposia.

The viability of any long term regional programme requires the political and financial commitment of the governments of the region. Within the UNEP Regional Seas Programme this commitment is usually formalized through binding regional legal agreements and through an agreed set of activities. It is understood that these activities will eventually receive full financial support from the governments of the region (UNEP, 1982).

Recommendations for action by the countries of the South Asian Seas programme are similar, in general terms, to those for the adjacent Eastern African region which is further advanced in its formulation. Of the countries of the present region, only India has a comprehensive marine science programme. In common with much of the Indian Ocean, there is a need for a comprehensive classification of coastal and marine habitats at both the national and regional levels across the whole region. Research has traditionally tended to concentrate on the characteristics of a particular study site. However, an assessment of the site characteristics of each part of the coasts in the regional context is required if there is to be an assessment of the representation of each type of habitat or species group in protected areas in the region (see UNEP, 1984).

In the context of the Indian Ocean Alliance, where there are several separate Regional Seas Programmes, the above assumes even more significance. The broad geographical spread of habitats increases the need for uniform assessments of habitat and species presence in protected areas.

At the national level, the logistic steps necessary to implement the above are outlined in detail in UNEP 1984 (pp. 9-29). These steps, designed for the Eastern African region, are in general applicable to the South Asian Seas region (and to the Indian Ocean Alliance) with appropriate modifications to take into account the existing institutions of the countries concerned, such as India, where stronger institutional activities in marine science already exist.

At the regional level, directories of all major marine and coastal habitats are required for the effective implementation of the above. This is being achieved at present for coral reefs of all the countries of the Indian Ocean, where the status and condition of the reefs such as they are currently known are being summarised in the Indian Ocean Volume of the IUCN series of coral reef directories (Sheppard & Wells, in prep.). Deficiencies of this volume arise largely from the fact that although based on available literature and on documents supplied by numerous specialists, no fieldwork was carried out to provide uniformity between countries and to complete sections of coast which remain undocumented. Nevertheless, it represents a first regional assessment of coral reef biota and condition in the Indian ocean, covering nations of at least four Regional Seas Programmes. Companion volumes for the other major marine ecosystems are strongly recommended, especially mangroves, and soft, sub-tidal substrates including seagrasses. For these to have maximum value, greater provision should be made to ensure a high degree of comparability of survey and assessment between each country.

UNESCO recommends that future programme activities should emphasise basic mangrove research and investigations on the mitigation of the harmful effects of coastal development on mangrove ecosystems (UNESCO, 1984).

A new research perspective on high diversity marine ecosystems has been proposed by a joint meeting of IABO/SCOR/UNESCO. One of its terms of reference complements the above recommendation by proposing the development of improved concepts and models of high diversity marine ecosystems, and experiments to contribute to a better understanding of these ecosystems and their improved management. Training and information were recommended as being major areas in need of special attention, especially with regard to management of coral reefs (UNESCO, 1984). COMAR programmes are also involved in research and training in support of coral reef management.

UNESCO (1984) recommends that coral reef and mangrove programmes be extended and expanded, to lead to the establishment of a regional and co-ordinated approach to research and management of these ecosystems.

Recently, the Marine Biological Association of India hosted a symposium on endangered marine animals and marine parks (MBAI, 1985) which included all nations from the South Asian Regional Seas Programme. Recommendations from the symposium included:

(1) that the states of the Indian Ocean look after the interests of the Indian Ocean Whale Sanctuary at least for the next 10 years;

(2) that dugong research be pursued and massive efforts be launched in cooperation with local village organisations to cease further exploitation of this species;

(3) that strategies for the conservation and management of sea turtles be developed through habitat and species protection and through law enforcement, and that the recommendations of the sea turtle workshop of 1984 be implemented;

(4) that the long proposed national marine park at the Gulf of Mannar be established with adequate finance and manpower, and that this should be modelled to demonstrate multiple use and utilisation of the area;

(5) that surveys and studies be made of seagrass beds along the Indian coasts including those of the Andaman, Nicobar and Lakshadweep islands, and to protect and propagate mangroves in areas where they have been severely disturbed; and

(6) that each nation provide protection to coral reefs.

One top priority stressed at the symposium was the need for a comprehensive research and management programme for the Andaman and Nicobar Islands. The symposium also recognised the essential role of public awareness programmes in achieving success in halting further deterioration of the coastal ecosystems and species and recommended that this aspect be developed. Finally, the symposium acknowledged that the resource of several of the endangered marine animals are distributed beyond national and even regional boundaries and that international cooperation beyond national and regional boundaries would therefore be to mutual benefit and advantage (MBAI, 1985).

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