REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

Environmental problems of the marine and coastal area of Pakistan: National Report

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PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten 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/].

In May 1982 the UNEP Governing Council adopted decision 10/20 requesting the Executive Director of UNEP "to enter into consultations with the concerned States of the South Asia Co-operative Environment Programme (SACEP) to ascertain their views regarding the conduct of a regional seas programme in the South Asian Seas".

In response to that request the Executive Director appointed a high level consultant to undertake a mission to the coastal States of SACEP in October/November 1982 and February 1983. The report of the consultant on his mission was transmitted to the Governments of the South Asian Seas region in May 1983, and the recommendations of the Executive Director were submitted to the Governing Council at its eleventh session.

By decision 11/7 of 24 May 1983, the UNEP Governing Council noted "the consultations carried out in accordance with Council decision 10/20 of 31 May 1982" and requested "the Executive Director to designate the South Asian Seas as a region to be included in the regional seas programme, in close collaboration with the South Asia Co-operative Environment Programme and Governments in the region, and to assist in the formulation of a plan of action for the environmental protection of the South Asian Seas".

As a first follow-up activity to decision 11/7 of the Governing Council, the Executive Director convened, in co-operation with the South Asia Co-operative Environment Programme (SACEP), a meeting of national focal points of the States of the region in order to seek their views on how to proceed in developing a comprehensive action plan for the protection and management of the marine and coastal environment of the South Asian Seas region (Bangkok, Thailand, 19-21 March 1984).

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

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.

The meeting discussed the steps leading to the adoption of an action plan and reached a consensus on the items to be considered for further development of the action plan[3/].

The meeting recommended that the Governments, with the assistance of UNEP and other organizations as appropriate, should initiate the preparation of country reports reviewing their:

- national environmental problems defined as priority areas of regional concern;

- activities which may usefully be carried out under the action plan to resolve or mitigate these problems; and

- national institutional and manpower resources which are, or may be, involved in dealing with these problems, including the identification of the need to strengthen their capabilities.

It was also recommended that UNEP prepare in cooperation with SACEP, and other organizations as appropriate:

- a draft overview report, based on the country reports, reviewing the environmental problems of the region defined as priority areas;

- a document addressing the essential legislative aspects relevant to the action plan; and

- a draft action plan reflecting the conclusions of the country and regional reports.

The present document is the country report on environmental problems in Pakistan prepared by experts designated by the Government of Pakistan. The assistance of a consultant, Dr. Muzammil Ahmed, in the preparation of this report is gratefully acknowledged.

3/ Report of the meeting of national focal points on the development of an action plan for the protection and management of the South Asian Seas region, Bangkok, 19-21 March 1984 (UNEP/WG.105/5).

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INTRODUCTION

The magnitude of pollution in the marine environment of a country depends, directly or indirectly, on several such factors as the population of the country, state of industrial development, economic affluence and degree of pollution consciousness.

Pakistan is a developing country. Its population approximates 85 million, having more than doubled during the last 38 years of its independence. The birth rate is in excess of 3 percent. About 70 percent of the total population lives in rural areas and the rest is concentrated in such large urban centres as Karachi, Lahore, Faisalabad, Multan, Hyderabad, Peshawar and Rawalpindi. Karachi is by far the largest city of Pakistan. It is also the largest industrial centre of the country and the only such centre to be located on the coast. The population of Karachi has grown in leaps and bounds over the last four decades owing to influx of people from different parts of the country. At present the population of the Greater Karachi area approximates seven million. The projected figure for this area, in the year 2000, is 11-13 million. On the other hand, the coastal belt of Pakistan, excluding Karachi, is very sparsely populated. The coastal towns of Keti Bunder, Ormara, Pasni, Gwadar and Jiwani all have small populations. Several other fishing towns and villages dot the coastline but their populations are yet smaller. From the standpoint of pollution Pakistan is, therefore, fortunate to have a thinly populated coastal belt.

Pakistan is basically an agricultural country. Indus, its principal river, traverses the country from North to South through a territory of about 1,500 km before discharging directly into the Arabian Sea. This river has shifted its course several times in history. Its present delta is located near the fishing town of Keti Bunder, about 150 km South-east of Karachi. Pakistan has one of the largest artificial irrigation canal systems in the world based on the waters of the Indus and its tributaries.

Pakistan is not a heavily industrialized or technologically advanced country though it has a steel mill and a nuclear power plant. It is also not an oil producing country but an oil importing one. Its present indigenous oil production amounts to about 40,000 barrels per day (bpd). No oil is obtained from the continental shelf, though exploration for oil has just begun on the coast of Sind. Pakistan has two ports, the Karachi Port and Port Muhammad Bin Qasim. Both are located at a distance of about 25 km from each other in the Karachi area. The Port of Karachi has been, until recently, the only port of Pakistan through which the commerce of the country moved for about 36 years. There is virtually no industry in any other coastal town of Pakistan so that Karachi remains the largest industrial and largest urban centre of the country.

There is virtually no pollution consciousness in the country, particularly in the coastal belt where living conditions are very unhygienic and socio-economic conditions very poor. The literacy rate in the Greater Karachi area and large urban centres such as Lahore, Faisalabad and Multan may be as high as 27 percent but it is extremely low in the rural areas. Civic sense in the populace of Pakistan is also quite low so that very little attention is paid to the cleanliness of living quarters, streets, roads and parks.

The following account discusses the current state of marine pollution in Pakistan in the light of the country attributes mentioned above together with a discussion of the oceanographic features, sensitive marine resources and the facilities and amenities which need to be protected. It is a national obligation of Pakistan to prevent, reduce and control pollution in its marine environment.

OCEANOGRAPHIC CONDITIONS

Coast

Pakistan has a coastline of about 825 km bordering the Arabian Sea in the North. It has a territorial coastal zone of 23,820 km^2 and an Exclusive Economic Zone (EEZ) of 196,600 km^2 (Appleyard et. al., 1981). This entire coastline lies within the subtropics although the southern boundary of the country, which is marked by the 23° 50 N latitude, misses the Tropic of Cancer only by a few tens of kilometers. The coast of Pakistan (Fig. 1) is divisible into the coasts of Sind and Baluchistan (the latter is sometimes called the Mekran coast). The depths along the coast of Sind change gradually and the 200 meters contour lies between 40 to 70 miles (about 70 to 120 km) whereas the Baluchistan coast is steep and the 200 meters contour lies between 10 to 25 miles (16 to 42 km). The coast is mostly devoid of vegetation, except for date palms here and there. Small hills and mud volcanoes occur along the Baluchistan coast. The coast protrudes into the sea in the form of capes and peninsulas at a few sites and is cut off into several small and large bays. Islands are mostly absent along the coast, except for Astolla Island, located between Ormara and Pansi and a few small ones near Karachi. On the coast of Sind the shelf is flat and soft-bottomed but on the coast of Baluchistan rocky outcrops are more frequent.

Winds and currents

The climate of Pakistan is tropical and is dominated by the monsoon regime. The average rainfall on the coast of Sind amounts to about 20 mm and that on the coast of Baluchistan about 10 mm per year. The Southwest (SW) Monsoon season lasts from May to September and the Northeast (NE) from November to March, with April and October being transition months. Wind speeds during the SW Monsoons are about 25 knots and those during the NE 5-10 knots (according to Gololobov and Grobov, 1970, wind velocity is 12 m/sec during June-July and 3.5 m/sec from January to March). Atmospheric and oceanic circulation during the SW monsoon is therefore more vigorous than during the NE Monsoon. The SW Monsoon circulation appears to penetrate deeper affecting the movements of water masses below the thermocline whereas the drift during the NE Monsoon is rather shallow (Wyrtki, 1973).

During the SW Monsoon season winds blow from the sea towards the coast whereas during the NE Monsoon season their direction is from land towards the sea. Pollutants, more particularly oil spills and tar balls, would be pushed towards shore during the SW Monsoon season and taken away from shore during the NE Monsoons.

It is now a well-established fact that, with the onset of the SW Monsoon season, water starts flowing towards the East everywhere in the Arabian Sea. For about 8-10 months of the year the dominant pattern is from West to East clockwise, particularly during the May to September period. During the remaining 2-4 months the pattern reverses, from East to West becoming counterclockwise. In general it is held that the currents are clockwise for about 10 months and counterclockwise in the remaining two months (see Nichols and Moller, 1981). During the counterclockwise circulation the winds come from the North-east and during the clockwise circulation from the South-west (see Banse, 1968).

Current speeds in the Arabian Sea range from 1.0-1.5 knots per hour (see Banse, 1968; Wyrtki, 1973; Haq, 1976; Ali Khan, 1976). This knowledge is essential to compute the flow of pollutants in the Arabian Sea. It is also important to remember the presence of the Somali Current which flows northwestwardly as an intense boundary current to about 8° N leaving the Somali coast and turning eastward. Panikkar (1966) refers to this powerful current moving northeastwardly in a clockwise direction touching Arabia, Pakistan and the North-west coast of India (see Wyrtki, 1973 also). From a pollution standpoint it is important to have a clear understanding of current patterns in the Arabian Sea (see Figs. 2a and 2b).

In passing it may be pointed out that there would always be more pollution on the coast of Sind (because the network of saltwater creeks and backwaters is not so well flushed) than on the coast of Baluchistan (where much of the coastline is mercilessly pounded by waves and where conditions are mostly oceanic and neritic).

Tides

Tides are of the mixed semidiurnal type with two highs and two lows every day. The tidal range is about 3.5 m with a slightly higher range on the coast of Sind. At low spring tides the mud-flats and rocky beaches become exposed to about 1.5 km on an occasional spot, particularly on the coast of Sind. Pakistani beaches would thus become vulnerable to oil spills which manage to reach the coast.

Temperatures

Temperatures from the surface to the 10 m depth are as follows (in °C): February 21.8°-24.1°, March-May 26.0°-28.0°, May-June 26.0°-29.0°, June-July 28.0°-30.0°, August-September 26.4°-23.4°, October 27.7°, November-December 23.0°-26.0° (Gololobov and Grobov, 1970; Haq, 1976; Anonymous, 1977 in Ahmed, 1985; Banse, 1984). Maximum mixing of the coastal waters seems to occur during the May to July period when maximum sunshine, high air temperatures and high wind speeds occur. Maximum evaporation of oil spills would be expected to occur during the period May to August and in October when water temperatures are high.

Salinity

The entire Arabian Sea is filled with high salinity water (Wyrtki, 1973). The average salinity values for the Arabian Sea are 34-37‰ (Panikkar and Jayaraman, 1966). Salinity in the inshore waters of the Karachi area ranges from 35.5 to 36.9‰ and may rise as high as 41-42‰ in the backwaters and tidal creeks (Ahmed and Rizvi, 1981). The high salinity of the Arabian Sea is caused by intensive evaporation at the surface in the northern part, as well as due to the intrusion of high salinity waters from the Persian Gulf and the Red Sea (Wyrtki, 1973). The coastal waters of Pakistan seem to be relatively dense so that pollutants would have fewer chances to sink into the water column and mix.

Dissolved oxygen

Oxygen content in the mixed layer is fairly high throughout the year with values of 4.4 to 5.0 ml/l (Gololobov and Grobov, 1969; Doe, 1965 in Haq, 1976). In the deeper layers, however, a significant reduction in oxygen concentration occurs. During the SW Monsoon months water of low oxygen (1.5 ml/l and less) may rise up in shallow areas (Banse, 1968). A poor oxygen layer also ascends to shallow waters off the coast of India (Banse, 1968; Dietrich, 1973). It seems that, everywhere the Arabian Sea, North of 20° N, dissolved oxygen depletes rapidly with increasing depth (Banse, 1984). Thus an excess of pollutants in an oxygen-poor environment would create highly lethal conditions for marine life in general.

Upwellings

The usual type of upwellings, per se, do not occur along the coast of Pakistan, but small-scale wind-induced upslopings of nutrient-rich cool water do occur all along the coast (see Banse, 1968 and 1984; Williams, 1984). The productivity in the inshore waters is, however, not high. It seems that the biological effects of upslopings have been annulled by the excessive turbidity which occurs in the local waters. The salt water creeks and backwaters in the Karachi area, in particular, have excessive turbidity (Ahmed and Rizvi, 1981).

Estuaries

As stated earlier, the Indus is the only major river on the coast of Pakistan. Its discharges to the ocean have been drastically reduced owing to the diversion of its water for irrigation purposes. At present, it discharges in the Arabian Sea at two points, Turshian and Khobar, but the delta functions as a positive estuary only for about two months per year (Ahmed, 1985) because of the total diversion of its waters through barrages constructed on its course. The unused water of the Indus, which emerges after irrigational use, reaches the ocean throughout the year through an outfall channel near Garo (Mirpur Sakro) where shellfish culture is now being undertaken. The old delta of the Indus lies near Karachi and is represented by the anastomosing network of tidal creeks where salinities are high.

The coast of Baluchistan, which is also known as the Mekran coast, is devoid of a major river, but small rivers such as the Hingol, Hab, Basul and Dasht do occur. These make only nominal contributions to the local marine environment. Their catchments depend entirely on monsoon rains. On the coast of Karachi, the Lyari River adds small quantities of fresh but polluted water to the Karachi Harbour (Manora Channel) throughout the year. This runoff increases substantially during the monsoon season so that the salinity of the channel decreases slightly. Thus Manora Channel and its backwaters function as a positive estuary.

SENSITIVE RESOURCES

The coast of Pakistan is fairly rich in seaweed resources. Anand (1940 and 1943) recorded 45 species of green and 79 of red algae from the coast of Karachi in the respective years. Several other species have been recorded since then. Their biomass is, however, not so large as to give sustained yields. The maximum abundance of seaweeds occurs in the post SW Monsoon period. Mangroves are also fairly abundant in salt water creeks of the Indus delta and in the backwaters.

The intertidal fauna of the coast of Pakistan is quite diverse and has been regarded as a kind of thinned out tropical fauna (Ahmed, 1977). Although the number of species is large, each species is represented by small numbers and the size of the animals is also small. On exposed rocky shores gastropod molluscs dominate followed by decapod crustaceans (Ahmed, 1977; Ahmed et.al., 1982). The maximum number of bivalve molluscs (some of which are commercially important) recorded from a beach in Pakistan is 16 (that from the semi-exposed beach of the West Bay of Gwadar; Ahmed et.al., 1982).

Filter feeding and detritus feeding molluscs, such as oysters and clams are found in very small numbers on the coast of Pakistan (Ahmed, 1979). Although about eight species of oysters of the genera Crassostrea and Saccostrea have been recorded from Pakistan (Ahmed, 1971 in Ahmed et.al., 1982) they no longer occur in commercially exploitable stocks. At present the largest assemblage of edible oysters, namely, C. madrasensis, C. rivularis and C. gryphoides, occurs in the Hab River delta on the coast of Baluchistan, some 50 km from Karachi (Ahmed, 1979). Four species of oysters occur in the West Bay of Gwadar (Ahmed et.al., 1982). The two pearlbearing bivalves, Placuna placenta and Atrina sp. occur in very small numbers in protected muddy and gravelly habitat, respectively, on the coast of Sind (Ahmed, 1979). Pearl oysters of the genus Pinctada are normally not found on the coast of Pakistan owing probably to the high turbidity which prevails in the Pakistan waters. The green mussel Perna viridis occurs on the coast of Sind but more abundantly on the coast of Baluchistan (Ahmed et.al., 1982). Mussel beds at Pasni are large and can probably yield sustained yields (Moazzam, personal communication) but they are not being exploited at present. No oyster, mussel or clam farms exist in the country at present because molluscan shellfish are not accepted for consumption by the local population. Here they are mostly consumed by tourists.

The shrimp, crab and lobster fauna of the country is fairly rich and consists of about 25 species of penaeid shrimps (of which Penaeus merguiensis, P. penicillatus, P. indicus, Metapenaeus

monoceros, M. affinis and Parapenaeopsis stylifera are the most important), three species of the spiny lobsters (Panulirus polyphagous, P. homarus and P. versicolor) and three species of edible crabs (Scylla serrata, Portunus pelagicus, and P. sanguinolentus) see Tirmizi, 1980; Ahmed, 1980 b. None of these is artificially cultured yet. The farming of shrimps has, however, been started on an experimental basis near Garo (Mirpur Sakro) in the creeks of the Indus delta proper. Shrimps constitute the backbone of the marine fisheries industry of Pakistan earning about 80 percent of the foreign exchange in this sector through exports. The earnings from the export of lobsters and crabs are insignificant (Hand Book of Fisheries Statistics of Pakistan, 1983).

The backwaters and creeks of the coast of Pakistan are fairly rich in juveniles of penaeid shrimps (Ahmed, 1980 and 1982; Hassan, 1983). The Indus delta at Keti Bunder is particularly rich in shrimp and fish juveniles which could be used for the stocking of shrimp and fish ponds (Ahmed, 1980).

The fish fauna of the coast of Pakistan is also quite rich. A checklist of about 400 species of marine fishes was published by Jaleel and Khaliluddin (1972). Several more species have been identified by other workers since then. The coastal waters of Pakistan are particularly rich in sardines and anchovies (see Ahmed, 1985). Salt water creeks of the Indus delta proper are rich in juveniles of mullets and some other fishes (Ahmed, 1980 a). The intertidal habitats of all protected muddy and sandy beaches of salt water creeks and backwaters swarm with mud-skippers which burrow in holes and guard their territories (Ahmed, 1977 and 1982).

The open coast sandy beaches in the vicinity of Karachi, such as those at Sandspit, Hawksbay and Paradise Point, serve as nesting sites of the Green Turtle Chelonia mydas. The Pacific Olive Ridley Turtle, Lepidochelys olivacea, also visits these beaches in small numbers. The sea turtles have been declared as endangered species on the coast of Pakistan. This resource is now being conserved through protection and artificial propagation. A turtle hatchery is in operation at Sandspit and Hawksbay. As a part of the activities of the project about 200,000 hatchlings of turtles have been released to sea and numerous others have been tagged (Kabraji and Firdous, 1984).

The coast of Pakistan is devoid of large concentrations of marine birds (excluding migrants). They do occur in small numbers here and there and belong to several different species (see Khanum et.al., 1980). The scantiness of their numbers points to the low productivity of Pakistan's coastal water (Ahmed, 1985). Thus in the event of an oil spill along the coast the threat to bird populations would be minimal. Marine birds are said to be abundant on Astolla Island located between Ormara and Pasni (Moazzam, personal communication). The island lies about 4.5 km from the coast. Bird populations on this island would be threatened if an oil spill occurs in the vicinity.

Pakistan is not a whaling nation; dolphins and porpoises do occur in Pakistan waters in small numbers. Sometimes these venture close to the beaches. Since marine mammals have to visit the sea surface for breathing they would stand threatened in the event of an oil spill. Several dugongs died during the Nowruz oil spill disaster, as also sea turtles and sea snakes (DAWN 1984).

The following species, having academic and/or commercial importance on the coast of Pakistan, would require protection from oil spills.

- Green turtles, particularly during their spawning runs to the sandy beaches during the post SW Monsoon season (October onwards).

- A copper coloured oyster which occurs only in the West Bay of Gwadar and nowhere else on the coast of Pakistan. The oyster was earlier thought to be a species of the genus Crassostrea by Ahmed et.al., (1982) It has now been identified as Saccostrea margaritacea. This species occurs on the East coast of Africa (Stenzel, 1971; in Ahmed, 1985). At Gwadar this species occurs in very small numbers. It could be useful as food if cultured artificially.

- The crinoid Commanthus samoanus occurs only on one beach of Pakistan, that is, the rocky shore of Jiwani (Ahmed et.al., 1982), at the doorsteps of the Gulf of Oman. This is a delicate species and would not tolerate oil pollution.

- The lugworm Arenicola brasiliensis occurs on several sandy-cum-muddy beaches of Pakistan. It is said to occur abundantly near Pasni on Baluchistan coast (Moazzam, personal communication). It also occurs at Buleji (see Ahmed, 1980) but has disappeared from the sandy beach between Manora Channel and Clifton. This is also a very sensitive species and may serve as an indicator of pollution.

- The brachiopod Lingula anatina is a rare species of marine invertebrates occurring on the muddy-cum-sandy beaches of the coast of Sind. It used to occur in large numbers on the mud-flats of Manora Channel (Javed and Khan, 1974; in Ahmed, 1977) and at Korangi Creek, but is now facing extinction from this coast, probably due to advancing oil pollution (Ahmed, 1977).

- The small gastropod snail Potamides cingulatus has been called an indicator of pollution by Ahmed, 1977. It occurs wherever stagnant conditions prevail on the bottom and in great abundance near the Lyari outfall in Manora Channel and on many other sites where the circulation of water is poor.

OIL POLLUTION

Types of oil

As stated earlier Pakistan is not an oil producing country. Its indigenous output of oil amounts to only about 40,000 bpd. It does maintain an active programme of oil exploration on land which has also been extended to the continental shelf recently. Exploration had first begun on the inner continental shelf near the Indus delta.

The current oil imports of Pakistan amount to 4-6 million tons of crude oil, 1.1 m. tons of diesel and kerosine oils whereas the export amounts to 1.0 m. ton of bunder oil and naphtha per year (Nichols and Moller, 1981). Tanker traffic along its coast is not heavy: about 100 oil tankers move in and out of its ports every year. All incoming oil is unloaded at four piers of an oil terminal located in the low part of the Karachi Harbour (Manora Channel). This oil is stored in the Burmah Shell tank farm situated close to the oil terminal to which it is linked by a short pipe-line. The imported oil is refined at two refineries located between Korangi and Gizri salt water creeks and the refined oil is supplied for domestic consumption through numerous petrol stations. Oil trucks are the usual means of transportation. These trucks are a major source of oil leakage on the roads of Pakistan.

The crude oil imported by Pakistan is relatively light and low in viscosity as well as in persistence. Such oils are likely to evaporate and disperse rapidly in the event of an oil spill in the marine environment of Pakistan. Diesel oil, naphtha and kerosine are all non-persistent oils. They can, nevertheless, pose fire hazards if spilled on piers and jetties. Bunker oil, which is exported by Pakistan, is also non-persistent oil.

It is believed that oil imports of Pakistan would double in the next five years so that oil pollution in the marine environment of the country is bound to grow.

Sources of oil pollution

The following constitute the main sources of oil pollution on the coast of Pakistan:

- About 2,500 ships visit Karachi Port (Manora Channel) every year and some 15 million tons of cargo is handled (Ahmed, 1979). Ship traffic has also started in Port Qasim where the number of visiting vessels is increasing gradually. The vessels visiting the two Pakistani ports are of the 50,000 to 75,000 DWT capacity.

- Oil pollution in Pakistan ports, inshore waters, creeks and bays occurs through oil tankers, cargo vessels passenger ships, mechanized fisheries vessels, trawlers, harbour craft, pleasure craft and KPT flotilla.

- The sources of oil pollution in Manora channel are the bilges, washings from engine rooms of vessels, discharges and leaks from bunkering points, leaks and small spills occurring during loading and unloading of oil at oil piers, pipeline leakages and ruptures (Ahmed, 1977 and 1979; Haq, 1976; Moazzam and Rizvi, 1979; Mian, 1979; Khaishgi, 1979; Sardar Ahmed, 1979). Some oil is brought to the channel through the Lyari discharge.

- In the open inshore and offshore waters of Karachi oil pollution occurs through a large number of ships waiting to enter the Karachi Port (ships have to wait outside the channel sometimes for months due to overcrowding in the harbour).

- The Gadani ship-breaking yard located about 40 km North-west of Karachi (believed to be second largest in the world) is an important source of oil pollution in the inshore environment.

- Some oil may enter the local marine environment from an occasional ship which may drift shorewards and become grounded in the sand off Clifton's sandy beach during the SW Monsoon season. Fortunately no oil tankers have grounded so far in this manner along the coast.

- There is a lot of oil pollution on the thorough fares of Karachi. This is an outcome of oil leaks from petrol stations, workshops, taxis, trucks, a large number of buses of the public and private sectors, private cars and other automobiles. The Karachi area has the maximum number of automobiles in Pakistan. During the rainy season all the oil which has leaked on the streets and roads of Karachi finds its way to the nearby sea.

- Pakistan seems to receive some of its oil pollution from the neighbouring waters. Although Pakistan is not located directly on international shipping lanes (see OCIMF, 1979), a fair amount of oil and its degradation products reaching this coast may be attributable to oil tanker traffic moving in and out of the Persian Gulf. Although the 1983 Persian Gulf oil spill did not create any immediate problems for the coast of Pakistan, a large number of tar balls were found on the coast of Pasni and Gwadar several months after the spill (Mozzam, personal communication).

  Nichols and Moller (1981) mention that offshore lightering operations are frequently conducted in the Arabian Sea from large to small tankers, particularly off the Gulf of Kutch and off Bombay and Cochin. The Bombay High crude is either piped ashore or loaded in tankers. There have been reports of the occurence of large oil spills along the open North-west coast of India near Gujrat. The oil tanker M/T Cosmos Pioneer spilled 18,000 tons of black oil (L.D.O.) on the West coast of India near Gujrat (Rao, 1976). Spills have also occurred off the coast of Somalia and Saudi Arabia (UNESCO, 1976). An estimated 30,000 tons of oil reaches the sea off the East coast of Africa through ships (Phombeah, 1984). This pollution may reach the open sea waters of Pakistan through the Somali current. Oil spills occurring on the East coast of Africa, the Persian Gulf, Gulf of Oman are likely to affect the coastal waters of Pakistan, mainly as tar-balls, for about 8-10 months of the year when currents move clockwise. Oil pollution off the Indian coastline may affect the marine resources of Pakistan during the winter and spring months when the currents are counterclockwise.

- It would seem that the EEZ of Pakistan would receive considerable amounts of oil pollution from oil tankers (VLCC's and ULCC's) leaving the Persian Gulf and from discharges of ballast water from tankers heading for the Persian Gulf. Large fisheries vessels of the joint fishing ventures operating in the EEZ of Pakistan must also be contributing different types of pollutants to the area.

- The Indus river must also bring some degradation products of oil to the marine environment of Pakistan from inland.

Present state of oil pollution

The following seems to be the present state of oil pollution in the marine environment of Pakistan:

- The waters of Manora Channel (Karachi Port) are currently the most affected by oil pollution on the coast of Pakistan (Ahmed, 1977 and 1979; Moazzam and Rizvi, 1979; Sardar Ahmed, 1979; Mian, 1979 Khaishgi, 1979). In this lagoon-like channel the worst affected spots are located in the vicinity of the main oil terminal, the Manora Channel seawall, the Chinna Creek area, the Karachi Fish Harbour and the area around the merchant ship berthing quay. At places, such as in Chinna Creek, oil accumulates in such large concentrations that the water turns almost black. Small oil slicks with their typical greenish sheens can almost always be spotted in the area. The jetties, stairs and other permanent structures of the harbour are also oiled. In the channel, oil is present in the sediments of the benthic environment. Nowhere else on the coast is there so much oil pollution as in Manora Channel.

- The open coast beaches of the coast of Pakistan are relatively free from oil pollution. Although a lot of oil pollution is present in Manora Channel (and this is flushed out daily to the Arabian Sea with the ebbs of tides) virtually no trace of it can be found on the open coast beaches in the vicinity of the channel. This may be due to the large scale dilution of the effluents which must occur when they reach the Arabian Sea. Oil and other effluents moving out of the channel would have a tendency to be carried towards the South-east of the channel mouth since currents are clockwise for the greater part of the year.

- Evidence of oil pollution along the coast of Pakistan is also found in the form of tar-balls beached on many shores all along the coast. A large number of these have been found at such open coast sandy beaches as Sandspit and Hawksbay (Moazzam and Rizvi, 1979). Tar-balls have been found in the plankton samples which were collected from the inshore and offshore waters all along the coast and from the screens of the Karachi Nuclear Power Plant (Ahmed, 1977; Moazzam and Rizvi, 1979). Tar-balls and oil slicks have been sighted off Pasni and Gwadar on the Mekran coast (Moazzam and Rizvi, personal communication). A large number of tar-balls appeared at Pasni in December, 1984 (Moazzam, personal communication).

- The sandy and rocky intertidal zones at Gadani are smeared with oil which flows from the oil tanks of numerous local and foreign vessels being scrapped at the ship-breaking yard. Here oil is beached on the shore, has penetrated into the sediments and forms slicks in nearshore waters.

- The intertidal habitat in the vicinity of oil refineries at Korangi and Gizri creeks is blackened with oil discharges (Ahmed, 1977 and 1979).

- No observations of oil pollution are available from the South-east coast of Pakistan. The Indus delta is located at a safe distance from the different sources of oil pollution which exist in the Karachi area. No tar-balls or tar beached on shore was found during the survey of the Keti Bunder area undertaken by Ahmed and co-workers (Ahmed, 1980). The small number of mechanized fisheries boats, present in this area, are the only source of oil pollution in the deltaic creeks. Tar-balls from the West coast of India may, nevertheless, reach here earlier than on any other part of Pakistan's coast.

Pollution effects

Sea life

In Pakistan effects of oil pollution on marine organisms are mostly noticeable in the Karachi Harbour area. Ahmed (1977 and 1979) has mentioned the smothering of marine organisms with oil on the seawall near the oil terminal in Manora Channel. Mortality of the oyster O. folium was noted on the section of the seawall closest to the oil terminal. On Baba and Bhit Islands located nearby in the same channel mortality of the oyster C. glomerata and the brachiopod Lingula sp. was also noted. On the seawall, however, some animals such as the gastropod This rudolphi and Drupa tuberculata, the crab Grapsus grapsus and the barnacles seem to be living well despite being smeared with oil. Mortality of barnacles was, however, noted in Chinna Creek in the same channel (Haq, 1976; Moazzam and Rizvi, 1979). The lugworm Arenicola brasiliensis (=cristata) is believed to have disappeared from the mud-sand flats on the Clifton-side of the Manora Channel seawall and Moazzam and Rizvi (1979) attributed their disappearance to oil pollution found in the channel. Populations of the green mussel Perna viridis from Chinna Creek show tainting with oil so that they would not be suitable for human consumption. These are occasionally brought to the fish market for sale by local fishermen. Some organisms were found to be coated with oil at the Gadani ship-breaking yard and in the Hingol River on the Baluchistan coast (Moazzam and Rizvi, 1989). These included species of the seaweeds Sargassum and Hypenea. At Port Qasim the seaweeds Enteromorpha and Ulva were found smeared with oil at the oil jetty (Ahmed and Rizvi, 1981).

It seems that oil only causes mortality to those sensitive marine organisms once they have become heavily coated with it. Marine organisms in the lower section of the Manora Channel are certainly stressed by oil pollution but, with the exception of one or two places, the stress is not high enough to cause large scale mortalities. The effects of oil pollution in the channel environment may be more of a chronic nature. Oil may be affecting the marine communities of the channel synergistically with other types of pollutants which enter the harbour from different sources.

Fisheries industry

Table 1 lists the important characteristics of the marine fisheries industry of Pakistan. It seems that small or large oil spills do not immediately affect stocks of fish and shellfish. It is believed that freshly spilled oil and oil floating in the open sea is not hazardous to fish and shellfish stocks (Korringa, 1968; Simpson, 1968). Even recruitment to fish stocks may not be immediately affected (GESAMP, 1977). The affects of oil may be gradual and chronic resulting in long range reduction of fish production. Light refined oils are known to be more toxic to adult fish than crude and heavy fuel oils (GESAMP, 1977).

Large oil spills can, however, disrupt fishing activities almost to the extent of paralyzing the industry causing great economic losses to the fishermen and everyone associated with the industry. On all fish-landing centres of Pakistan, except Karachi, catches of marine fish land directly on the sandy or muddy beaches. The fishing boats are also pulled on to the beaches for mooring. This means that fish catches, fishing crafts, fish drying on the beaches and fishing gear would get smeared with oil in the event of a large spill. Pelagic fisheries would be more affected than demersal. All fishing gear such as cast nets, beach seines, floating gill-nets, purse seines (a modified version is used in Pakistan) and the fishes caught with them (inshore fishes, sardines and anchovies etc.) would become tainted. Other nets such as the shrimp trawl and bottom-set gill-nets are liable to be contaminated at the time of their lowering and hauling. Some of these nets are very expensive and would cost fortunes to the fishermen. All fishing activities might have to be suspended in the areas most affected with large spills. The exaggerated coverage which the Nowruz oil spill received in Pakistani press created quite a commotion among the fishermen on the coast of Baluchistan.

Oil spills can prove disastrous to mariculture activities also. Freshly spilled oil is greatly toxic to shrimp and fish juveniles. Fortunately, in Pakistan, shrimp culture is being developed in the estuarine area near Garo (Mirpur Sakro) where the ponds are located in a highly

protected environment far from the open Arabian Sea where oil spills can be expected to occur. The delta of the Indus at Turshian and Khobar and the small estuaries of the rivers Hab and Hingol on the coast of Baluchistan, could all be polluted with oil relatively rapidly in view of their nearness to the open coast. In such cases oil would cause mortalities of fish and shellfish juveniles found in these nurseries.

Table I. - Some statistics of the marine fisheries industry of Pakistan

Fish Catch	Karachi-Sind: Baluchistan: Total:	202,572 m.t. 77,362 m.t. 283,043 m.t.
Foreign Exchange Earnings:	1983 1981	908 million rupees 654 million rupees
No. of Fishermen	Sind Baluchistan Total	63,525 21,531 85,056
Fishing Boats:	Trawlers Gill-netters Mechanized-cum-sail-driven Non-mechanized sail boats Total:	820 353 3,790 3,242 8,205
Boat Size		6-25 met.
Fishing Gears:	Cast nets, lines, encircling nets, gill-nets, bach-seines, trawl-net, stake-nets.	

(Source: Hand Book of Fisheries Statistics of Pakistan, 1983).

Solar salt production

In developing countries such as Pakistan large quantities of solar salt are produced for domestic consumption in households and industry. In the Karachi area, salt pans are located in the upper reaches of Manora Channel, at Ibrahim Haidri in Korangi Creek and at Bhambhor in the Gharo-Phitti Creek system. Solar salt is also prepared on the coast of Baluchistan. Oil spills can affect the quality of the salt either by direct contamination or through spraying of oil by incoming waves.

Amenities and facilities

There are some excellent beaches on the coast of Pakistan which, if smeared with oil, would pose aesthetic problems. The country, however, does not have a beach-oriented tourist industry.

Pakistanis themselves are not a beach-minded people. It is true that an occasional open coast wave-swept sandy beach in the vicinity of Karachi is visited by local public and by those visiting Karachi from inland, particularly in the sun-baked season. The sandy beaches of Clifton and Manora Island are thronged by people only because they are the most easily accessible beaches in the area. The sandy beaches at Sandspit, Hawksbay and Paradise Point, which serve as the nesting sites for green turtles, are also used as seaside resorts by higher income groups of the country.

Major ports and harbours of the world are characterized by chronic oil pollution resulting through small spills. Sometimes the levels of this chronic pollution can be fairly high. Contamination of port structures, jetties, piers and stairs is not desirable as it hinders routine activities. Freshly spilled oil is also a fire hazard. It poses difficulties during new constructions and creates problems for the maintenance of the old structures. Large spills occurring in harbours can be problematical for boat and ship-building activities and for welding and construction works. In Pakistan, as has been pointed out earlier, Manora Channel is the area most affected with pollution. There is always the likelihood that in future a large oil spill might occur within the channel itself due to a tanker disaster or it might occur outside the channel in the Arabian Sea and may rapidly move into the channel along with tides and currents. The following are some of the facilities from where oil would have to be removed in the event of a large oil spill:

- Karachi Shipyard and Engineering Works,
- boat-building workshops at the Karachi Fish Harbour,
- salt pans in the upper harbour,
- residential quarters of the fishermen at Baba and Bhit Islands in Manora Channel,
- Keamari Boat Club,
- several beaches of Manora Channel which serve as thoroughfares for the local fishermen.

Similarly, if a large oil spill were to move into Gharo-Phitti creek system, the site of Port Quasim, several backwater beaches and facilities would be smeared with oil. A large oil spill occurring in Port Qasim or moving into it from the Arabian Sea (through the navigational channel) would pose problems to the following facilities:

- intake of Pakistan Steel Mill,
- intake of Pakistan Steel Mill Thermal Power,
- intake of Korangi Thermal Power Plant,
- intake of Sind alkalies plant,
- numerous local beaches,
- on the open coast a large oil spill would pose a major problem to the intake of the Karachi Nuclear Power Plant (KANUPP) located at Paradise Point. Tar-balls of large size have earlier been found to choke the screens of these facilities (Moazzam and Rizvi, 1979; Ahmed, 1977).

On the coast of Baluchistan the following facilities and amenities would require protection from oil spills:

- intake of Gwadar desalination plant,
- sail and mechanized boat fleet,
- wells for domestic water supplies,
- residential huts of fishermen close to water front.

Vulnerability of beaches

There are several exposed rocky and sandy beaches on the coast of Pakistan (Figs. 1 to 4, Tables 2 to 4). Some of these are located on Manora Island, Sandspit, Hawksbay, Paradise Point, Buleji and Clifton. Usually the rocky beaches alternate with sandy beaches. The area from Gizri Creek to Sonmiani Bay and onwards to Jiwani has numerous sandy beaches some of which can genuinely

be called 'long beaches'. The sandy stretch at Clifton is one of the longest sandy beaches on the coast of Sind. The sandy and rocky beaches of the coast of Pakistan facing the Arabian Sea are all high energy beaches from where oil would be washed out to sea relatively rapidly compared to the protected low energy beaches.

The coastline of Baluchistan is formed by several crescentic bays of which the most notable are the East and West bays of Gwadar and part of the Gwadar Bay. Semi-crescentic bays occur at Ormara and Pasni. All these bays have rocky and sandy beaches of a semi-protected nature. Beaches at Jiwani, the Pakistani town close to the Gulf of Oman, are also rocky and partly sandy and semi-exposed. Other rocky beaches, which alternate with sandy stretches on the coast of Baluchistan, are those at Gadani and towards the North and northwestward of it. On this coast a tarmac road exists up to Sonmiani Bay (Damb) and an unpaved one from here to Ormara. Beaches westward of Ormara are not approachable by road. Pollution combating activities would thus be hampered due to this limitation.

On the coast of Baluchistan, Sonmiani Bay, which is 65 km long and 25 km wide, is an almost completely enclosed bay or lagoon lying parallel to the Arabian Sea. It gets drained to a great extent at low spring tides exposing the muddy-cum-sandy flats which stretch for miles in view. This bay has a deeper area which is used for the anchoring of fishing fleet at Damb. The bay is rich in fisheries resources. During the turbulent SW Monsoon season when practically no fishing is possible in the open sea the local shrimp fishery becomes confined to this bay. Shrimps are also caught in Kalmat Bay during the SW Monsoon season.

Vulnerability indices

One way to assess the vulnerability of beaches, and, of the resources contained therein, is to make an evaluation of their physical and biological characteristics (see Gundlach et.al., 1979). Tables 2 to 4 list the important beaches of the coast of Pakistan along with this information. The vulnerability of different beaches to the impact of oil has been determined by taking into consideration the following factors: energy, diversity of habitat, richness of the fauna and flora, important species, recreational value of the beach and presence of installations and facilities to be protected. The following procedure has been adopted to obtain the indices:

- The more exposed the beach and higher the energy the lesser the need for a clean-up. A score of 3 here signifies a sheltered habitat where smothering would occur and clean-up operations should be undertaken without inflicting a damage other than that caused by oil.

- The greater the diversity of habitat on a beach the greater the likelihood of damage from oil. Beaches with highest diversity of habitat would have priority for clean-up; highest score is 3.

- The greater the diversity of fauna and flora the greater the desirability for a clean-up; maximum score is 3.

- The occurrence of an endangered species (such as green turtles) on a beach is assigned a maximum of 4 points. The presence of more than one important species is also assigned a score of 4 (for instance oysters and mussels together in the same area).

- Recreational beaches, public facilities and installations have to be protected, sometimes ahead of biological considerations; maximum score is 3 in each case.

Table 2. Physical characteristics of important exposed and semi-exposed beaches on the coast of Pakistan.

Beach	Slope	Energy	Habitat Diversity	Habitat Types
Jiwani	Gradual	Medium	Medium	Flat rocks, few boulders, few cobbles, puddles, low cliffs at high tide zone.
Gwadar				
East Bay	Steep	Medium	Medium	Lowcliff-like boulders, small boulders, pools, mud-covered stones.
West Bay	Medium	Medium	Medium	Small and large boulders, mud-pools, cobbles, plastic mud, gravel, sand.
Pasni				
Ras Juddi	Medium	Medium	Medium	Rocky ledge, boulders, rock pools.
Juddi Khor	Low	Low	Low beach.	Creek, sand-flat, Arenicola
Ormara				
Demi Zur	Medium	Medium	Low	Sandy and muddy creeks.
Jetty	Medium	Medium	Medium	Muddy, rocky, boulders, rock-pools.
Sonmiani Bay	Gradual	low	Low	Tidal-flats, muddy, swampy
Gadani	Gradual	High	Low	Vertical rocky cliffs on sandy substrate.
Cape Monze	Gradual	High	Medium	Flat rocks, small boulders, puddles, stones.
Paradise Point	Steep	High	Medium	One-piece rocky platform, few small boulders, sand.
Buleji	Gradual	High	High	Flat granite, few boulders, pools with rock and sand, algal covers, stones.
Hawksbay	Steep	High	Low	Coarse sand with gravel, fine sand at high tide zone.
Sandspit	Steep	High	Low	Fine sand, coarse sand, some gravel.

Table 2 contd.

Beach	Slope	Energy	Habitat Diversity	Habitat Types
Manora Isl. (exposed)	Gradual	High	Very	Flat rocks, small and large boulders predominate, cobbles sandstones, sand under boulders, pools, algal cover.
Clifton	Very gradual	Medium	Low	Fine sand with metallic sheen, compact habitat.

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Table 3. Physical characteristics of some backwater and estuarine areas of the coast of Pakistan

Area	Slope	Energy	Habitat Diversity	Habitat Types
Jiwani (Bindri)	None	Low	Low	Sandy, muddy, fine sand.
Hab River	Gradual	Low	Medium	Creek environment, muddy, sandy, oyster reefs.
Manora Channel	Steep	Low	Medium	Mud, sand cobbles, gravel, rocks, occasional boulders, swampy mangroves.
Port Qasim (Gharo-Phitti creek syst.)	Gradual Steep	Low	Medium	Sandy beaches, mud-swamps, some rocky areas, cobbles, gravel, mangroves, algal covers on mud-flats, turbid waters.
Salt Water creeks	Gradual	Low	Low	Mangrove swamps, mud, sand, turbidity.
Indus delta	Gradual	Low	Low	Mud-flats covered with grass, sandy patches, mangrove habitat, high turbidity.

Table 4. Values of relative usefulness of important beaches and areas on the coast of Pakistan taking into consideration energy and habitat diversity (from tables 2 & 3), fauna and flora, important species, installations and recreational values of the beaches; F.rich=fairly rich, V. rich=very rich.

Beach	Fauna Flora	Important Species	Installations value	Recreational score	Vulnerability
Jiwani	Rich	Commanthus	-	-	10
Gwadar					
East Bay	Rich	Mussels	Desalination plant	-	13
West Bay	Rich	Oysters	-	-	10
Pasni					
Juddi Khor	Rich	Arenicola	-	-	9
Shadi Khor	Rich	Mussels	-	-	10
Ormara					
Demi Zur	Poor	-	-	-	4
Jetty	F.rich	-	-	-	6
Sonmiani Bay	F.rich	Shrimp Fish	-	-	9
Gadani	F.rich	-	-	Some	5
Hab River	F.rich	Oyster reefs	-	-	9
Cape Monze	F.rich	Sea urchins	-	Some	8
Paradise Point	F.rich	Turtles	-	High	9
Kanupp beach	F.rich	-	Power Plant	-	8
Buleji	V.rich	-	-	Some	9
Hawksbay	Poor	Turtles	-	High	10
Sandspit	Poor	Turtles	-	High	10
Manora Island (Exposed)	V.rich	-	-	High	10
Manora Channel	Rich	Mangroves Mussels	Industry	Resident areas	18
Clifton	Poor	Clams	-	V.High	9
Port Qasim	F.rich	Razor clams	Industry	-	13
Salt water Creeks	F.rich	Placuna Atrina Oysters Mangroves	Salt pans	-	10
Indus Delta	F.rich	Fish and shrimp seed	-	-	9

The vulnerability scores, shown in Table 4, provide the overall standing of a beach. These establish priorities for clean-up. However, decisions for clean-up are sometimes made on the weight of ecological, amenity and facility considerations, individually or jointly. The foremost aim of combating oil spills ought to be the reduction of ecological impact and not just the removing of visible oil to reduce the aesthetic effects.

Table 4 shows that Manora Channel, with a maximum total score of 18, is the most oil-vulnerable site on the coast of Pakistan should a large oil spill occur in its vicinity. It already is the most polluted habitat on the coast being the site of the Karachi oil terminal where all oil imports of the country disembark. Any large oil spill moving into the channel from the Arabian Sea would prove catastrophic to the biota, to numerous salt pans which exist in this area and to the residential quarters and facilities on the banks of the channel. The second position is occupied by Port Qasim and the East Bay of Gwadar, each having 13 points. Seven beaches have 10 points each and six have 9. The remaining have 4 to 8 points. The turtle beaches are all high energy beaches. Oil will have a tendency to be washed out to sea from here relatively rapidly. If, however, oil is beached here during a large spill every effort should be made to remove it, particularly during the spawning runs of turtles to these beaches.

Strategies

The occurrence of large oil spills (100,000 gallons or more; see Brown, 1979) in the marine environment is not an every day affair. When such spills do occur, they create emergency situations for governments, industry and scientists, all of whom may sometimes get caught unprepared to handle them adequately. At the time of a major spill there is generally chaos and confusion. The following guidelines are provided to ward off such situations.

- It is generally difficult to protect all the beaches and marine resources of the entire coastline of a large country. This is particularly true for a developing country like Pakistan.

- Oil spills occuring in the open sea should not be of concern if there is no danger of their reaching the shoreline.

- Once oil reaches shore, several important decisions are to be made. On the coast of Pakistan, protection and clean-up measures can be undertaken without much difficulty in the areas between Karachi and Sonmiani Bay and Karachi and Gharo-Phitti creeks. All other areas are not easily approachable by road from Karachi. A majority of the beaches lying between Sonmiani Bay and Jiwani on the coast of Baluchistan and Gharo-Pitti creeks and the Indus delta on the coast of Sind are open coast wave-swept beaches. Oil produces very short-lived toxic effects on open coast beaches and, after the initial damage, the weathered oil produces little damage to intertidal life. Therefore, the open coast beaches of Pakistan where no amenities and facilities are to be protected, should be left alone to self-clean.

- The coastal belt within a radius of about 40 km from Karachi is the most heavily fished in Pakistan. Here much of the fishing is done for shrimps and the area is overcrowded with trawlers. If a large oil spill occurs here it would be disastrous for the shrimp fishery. If Pakistan could develop its facilities the spilled oil could be skimmed and reclaimed; but this may not be possible during the turbulent SW Monsoon season (May to September). Therefore, the use of dispersants might have to be considered for dispersing oil.

- Attempts should be made never to allow oil to reach the mangrove areas, such as those existing in Manora Channel and in the salt water creeks of Sind. The entrance of these creeks can be guarded with containment booms and any oil that may enter the shallow protected creeks should be skimmed. A mangrove ecosystem destroyed by oil may take about 20 years to re-populate (see Gundlach et.al., 1979).

- The intake of power plants and of the Pakistan Steel Mill and the desalination plant at Gwadar would require protection from oil spills. This can be achieved by guarding the intakes with containment booms.

- Clean-up measures in protected areas should be undertaken in such a way as to inflict minimum damage to the habitat.

- In all cases the principle, that the more exposed the beach the lesser the need for a clean-up, should be followed.

Probability of oil spills

As mentioned earlier, Pakistan is not directly located on an oil tanker route and its coast is not a high risk area (although some 330 million tonnes of crude is transported in about 2,500 tankers including VLCC and ULCC's which pass close to Pakistan's EEZ from the Persian Gulf to South and South-east Asia). It is also an agreed upon fact that oil spills generally do not occur in the open seas but at or near the point of destination of oil tankers (OCIMF, 1980). Thus the probability that a major oil spill would occur anywhere between Jiwani-Gwadar and Karachi is very low. The spill may occur near the town of Jiwani or Gwadar in view of their proximity to the Gulf of Oman, or near Karachi, which is the point of destination for all oil shipments to Pakistan. The chances of oil spills occurring off the mouth of the Indus delta at Turshian and Khobar are remote although oil spills have occurred on the West coast of India (Rao, 1976; OCIMF, 1980). The most likely site where an oil spill may occur on the coast of Pakistan is the section of the Arabian Sea off Manora Channel or within the channel itself due to a mishap involving oil tankers, or due to operational procedures (as happened at the end of November, 1985 when some oil was spilt outside the channel due to the grounding of an oil tanker which was being towed away to Gadani shipyard for scrapping).

The spills on the coast of Pakistan are most likely to occur, if ever, during the SW Monsoon season (May to September) when the Arabian Sea becomes very rough, wind speeds are high and even dust storms occur. A lot of merchant ships and oil tankers have to wait outside the Karachi Port for considerable periods of time before they are able to secure berthing spots in the harbour. Almost every year during the SW Monsoon season cargo ships have drifted shorewards and grounded in the sandy stretch off Clifton's public beach. If somehow an oil tanker were to be grounded in this area and large quantities of oil were spilt the greatest impact of such a spill would occur on the low energy beaches of the salt water creeks of Sind (located South-east) and on the rocky and sandy beaches of Manora Island, Clifton, Sandspit, Hawksbay, Paradise Point and Buleji.

Pakistan is fortunate that no large oil spill has occurred along its coast so far and whatever oil pollution is found in its waters today is the result of small oil spills from its own sources or from oil pollution (tar-balls, which are believed to have formed from tank washings of oil tankers; Nichols and Moller, 1981) arriving at its coasts from neighbouring waters. The OCIMF (1980) considers the Persian Gulf area as a low risk area where, although traffic density is high and diverse, tanker movement occurs in defined lanes. It also considers the East coast of Africa as a low risk area and the southern coast of India and Sri Lanka as moderate risk areas. The coast of Pakistan is not mentioned by the OCIMF.

Oil spills in neighbouring regions

The question as to how great an impact a large oil spill such as the Nowruz Oil Spill (through which about 180,000 tons of oil reached the sea) which occurred in the Persian Gulf in the spring of 1983, can have on Pakistani beaches and marine resources, merits discussion here. The Straits of Hormuz are located at a distance of about 700 km from Jiwani, the Pakistani town touching the Gulf of Oman. Currents within the Persian Gulf may range from half to one knot and one to 1.5 knots/hr outside it. Considering the speed of currents it would appear that oil spills occuring within the Persian Gulf would take months to reach Pakistani waters. Spills occurring in the Gulf

of Oman would reach Pakistan shores relatively earlier; at least their effects would be felt earlier. Effects of the Nowruz oil spill were not felt on the Pakistani coast even several months after the event and the concern which it had caused among the public proved baseless.

The impact of a large oil spill or oil disaster could be immense within the Persian Gulf itself. According to cautious estimates 45,000 to 60,000 tons of oil can be spilled in the Persian Gulf annually from different sources (such as tanker transport, offshore production and discharge by coastal refineries); one estimate puts the figure at 150,000 tons (see Lehr, 1984). The Persian Gulf is a shallow marine environment based on the continental shelf, where high salinities (40-70‰) and high temperatures prevail (Lehr, 1984). It is a marine environment where chronic oil pollution has heavily stressed several of the Persian Gulf's marine resources which now require protection. The Persian Gulf has public beaches, desalination plants and public works, fish and shrimp farms, the Shatt-al-Arab estuary, mangrove habitats, highly productive lagoons, marine parks, reserves for endangered species (such as the marine mammal dugong and for green turtles), bird sanctuaries, coral reefs, pearl oysters and rich marine life on rocky, muddy and sandy shores (see UNESCO, 1976). States participating in UNEP's Kuwait Action Plan for the Protection and Development of the Marine Environment and the Coastal Area (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates) have agreed to respond promptly to any oil pollution emergency. These states have the resources to obtain maximum and adequate technology to combat oil spills in their waters no matter what their magnitude.

The Arabian Sea is a very large body of water. States bordering it are not congesting the region as they are located at considerable distance from one another. In the South the nearest source of oil pollution for Pakistan is the Gulf of Kutch (at the port of Kandla oil is transferred through pipelines and by lightening through small tankers) and the Bombay High oil fields in India (located at a distance of about 1,200 km from Keti Bunder) and the general West coast of India. India imports about 21 million tons of oil yearly. Sri Lanka is located even farther from Pakistan towards the South (about 3,000 km from Keti Bunder). Its oil imports amount to about 1.5 million tons per year. The Maldives are a small island nation located at a distance of 2,500 to 3,500 km from southeastern tip of Pakistan. Countries of the East coast of Africa and Gulf of Aden are situated similarly, at great distances from Pakistan. An estimated 30,000 tons of oil are believed to reach the marine environment off the East coast of Africa through ships (Phombeah, 1984).

It seems that oil pollution is likely to be generated anywhere along the coasts of the above mentioned countries at any time of the year and would be carried to other parts of the Arabian Sea according to the direction of currents, winds, wind speeds and other oceanographic conditions, prevailing at that particular time. The Arabian Sea is a tropical environment where evaporation rates are high as are precipitation rates. It is most likely that evaporation, biodegradation and sinking of oil would have occurred before the spills are transported long distances. Thus countries located close together stand to be affected from each other's oil pollution to a greater extent than those located at greater distances from one another. Pakistan has greater chances of being affected from the oil pollution occurring in the KAP-region than anywhere else in the Arabian Sea. The large number of tar-balls found on its beaches are evidently an outcome of this pollution as well as the result of tank washings of VLCC's operating close to its EEZ. The Arabian Sea is, however, a large body of water, and considerable dilution and dispersion of different types of pollutants can be expected before they are transported long distances.

Monitoring and combating

Facilities

In Pakistan the state of affairs is such that if a large oil spill were to occur today along its coast no clean-up measures would probably be taken because the country is not prepared for a response. This is evident from the fact that no attempts have ever been made to remove even the small-scale spills which occur in Karachi Port, Port Qasim, off Gadani ship-breaking yard and at other spots from different sources. Different types of facilities are required to contain or

remove oil spills in the offshore and inshore environment. Required facilities include: containment booms, skimmers, dispersants and facilities to store and transport the same (such as trucks, trailers, tug-boats, marine vessels, helicopters and small planes), spill surveillance and monitoring facilities, scientists, technicians and unskilled workers. It seems that Pakistan has some of these facilities, not under one umbrella, but scattered under different governmental and semi-governmental departments so that it would require great effort to mobilise them for a common spill-fighting operation. The various facilities available are listed below:

- boats and vessels of the Pakistan Navy, the Coast Guard, the Karachi Port Trust (KPT) and Port Qasim;

- turbo-prop twin engine planes of the Pakistan Air Force;

- helicopters of the Plant Protection Department, Karachi, for the spraying of dispersants;

- large labour force which could conduct the clean-up operations manually using shovels, rakes, absorbents, straw, sawdust, rice-husk, tree barks and sugar-cane sticks.

At present Pakistan lacks such facilities as containment booms (for calm and rough seas), skimmers, belts and other specialized equipment. Arrangements are, however, being made by the concerned governmental agencies for their procurement. Stocks of dispersants and other chemicals are also to be procured.

No oil spill monitoring work is in progress in Pakistan at present but facilities are being developed. For reporting of oil slicks the use of different manned lighthouses of Pasni, Gwadar, Jiwani and Ormara has been suggested (Mian, 1979). The task can also be entrusted to the vessels of the PNSC, PIA and PN aircrafts. Low flying planes of these agencies would be the most suitable.

As stated earlier, it is generally not possible, nor is it advisable, to protect all the beaches and marine resources of the entire coastline of a large coastal country. Therefore, Pakistan should develop its oil combating facilities on a limited scale only. This is advisable because Pakistan is located in a somewhat safer corner of the Arabian Sea, away from the direct routes of tanker traffic and in a rather uncongested zone. While developing its spill-fighting facilities Pakistan would have to consider two options. The facilities could be developed at important coastal towns like Karachi, Ormara, Pasni, Gwadar and Jiwani or stockpiled at Karachi from where they could be flown to wherever emergency situations develop along the coast. The second alternative would probably be more suitable. If the second option is taken then the spill-fighting equipment should be stocked at suitable points in Karachi Harbour and at Port Qasim. Special arrangements should be made at oil terminals and piers. Large spills occur once in a long while. It is to the small spills in harbours and inshore waters that Pakistan should accord its immediate attention.

Contingency planning

Contingency plans should be prepared in order to assist authorities in making sound clean-up decisions and in carrying them out without chaos and confusion in oil spill emergencies. Contingency plans are written with the aim that once a large oil spill has occurred, oil should be prevented from reaching sensitive areas and resources and, if it does reach there, it should be removed with minimum damage to the environment and resources. Contingency plans outline guidelines for minimum impact clean-up operations.

A contingency plan for tackling oil spill emergencies is under preparation in Pakistan. In 1983 a Hard Core Committee had been established in the country for handling the Nowruz oil spill emergency, under the joint supervision of the Director General Port and Shipping and the National Institute of Oceanography, Pakistan. The establishment of a Pollution Control Centre (PCC) is also being given consideration.

Combating authority

The Director General Port and Shipping, under the Ministry of Communications, is the national authority for the monitoring and combating of oil pollution in Pakistani waters. A Pollution Control Centre or a new section charged with the functions of such a centre is likely to be established at this Directorate. The Directorate has requested funds to procure spill fighting equipment from the Federal Government. A National Contingency Plan is being prepared at this Directorate which is also engaged in establishing legislation for the combating of oil pollution in Karachi Harbour. Before this legislation comes into effect the Directorate is taking steps to install reception facilities in Karachi Harbour. The Directorate would supervise the pollution control activities of the country through an advisory body named COPME (Committee for the Protection of the Marine Environment) which is composed of scientists working in different marine and non-marine science organizations of the country.

Existing legislation

While new legislation for the control of different types of pollution is being established in the country it may be of interest to mention that simple imprisonment of up to 6 months and a fine of Rs. 50,000 has to be paid by anyone responsible for polluting the Karachi Port under the Ports Act of 1908 (Gazette of Pakistan Extraordinary, March 5, 1975). This fine is considered to be insignificant for oil pollution resulting through large oil spills in the harbour. Mian (1979) suggested an enhancement of this fine to Rs. 100,000 until such time as reception facilities are provided in our ports and Pakistan ratifies the 1973 MARPOL and other relevant Protocols and Conventions.

Oil dispersant toxicity

The use of dispersants is one way to combat oil spills. Dispersants come in both powder and liquid form and are generally believed to cause a negative impact on the environment when used. They are quick in action since they immediately break-up oil spills by converting them into oil-in-water emulsions. Dispersants thus extend the reach of the oil to several feet below the surface affecting marine organisms which would normally not have been affected had oil remained confined to the surface. Fine droplets of oil are believed to have far greater toxicity to marine life than oil floating on the surface. The combined action of dispersants and oil may be doubly harmful to marine organisms.

Dispersants are to be used cautiously for the combating of oil spills. They are used to disrupt off-shore oil spills or in cases when it is not possible to recover oil mechanically (due to rough seas or long distances involved). They can also be used when an important resource or facility is to be protected on the shoreline. Oil floating on the surface is acted upon by winds but dispersed oil is quickly removed from the spill site by currents. Some damage to marine life does occur on the very spot where dispersants are used to break-up oil spills but this damage is much less compared to that which would occur if the oil spill is allowed to reach a shoreline (OCIMF, 1979 and 1980).

When and where dispersants are to be used along the coast of Pakistan during oil spill emergencies has to be specified in advance in the National Contingency Plan. The question should not be deferred until a real oil spill occurs along the coast. Every effort should be made to avoid the use of dispersants in the creeks, backwaters and estuaries of Pakistan.

NON-OIL POLLUTION

Industrial Pollution

Industrial pollution on the coast of Pakistan is found mostly on the coast of Karachi. In order to study the nature of this pollution the Greater Karachi area can be divided into three zones:

The SITE AREA (Sind Industrial Trading Estate)

Beg et.al. (1984) mention that the Site area covers about 4,000 acres of land and has 300 major and 900 minor industries of which the textile industry is the largest (60% of the total). Other industries are: battery, cement, chemicals, electroplating, electricity generating plants, food and beverages, heavy engineering works, tanneries, meat, oil refining, paints and dyes, paper, pesticides, pharmaceuticals, plastic and rubber, tobacco, and vegetables.

The LITE AREA (Landhi Industrial Trading Estate; includes Korangi)

This area has fewer industries. Of these textiles, meat, fish-meal and soda ash factories are important. A recent trend in the Greater Karachi area is the upsurge in the development of the poultry industry particularly in the area between Karachi and Hyderabad. Small and large units of this industry are scattered in both SITE and LITE areas.

The Rest of Karachi area is based on residential houses, offices and educational institutions. A cement factory, emitting about 3,000 tons of dust per year, is also located in this area. Ahmed (1983) has recently listed several industries and discussed the industrial pollution on the coast of Karachi.

Effluents of the SITE sector are brought to the Manora Channel through the Lyari River. During the rainy season of the SW and the NE Monsoons this river runs in spate; at all other times it flows as a narrow stream discharging black water into the channel. Industrial and domestic wastes of the LITE area are collected by the Malir River and discharged on the tidal flats of the Gizri salt water creek from where they pass on to the adjoining creeks before finally moving out to the Arabian Sea.

In the Karachi area industrial and domestic wastes reach the backwaters and saltwater creeks in mixed form. The BOD load was found to exceed 1,000 tons per day (Zainul-Abedin, 1978). Industrial wastes compose 84 percent of the total industrial pollution. Of this 89 percent are contributed by the textile industry and 8 percent by the chemical industry. In all, 615 tons of BOD are contributed by the SITE area per day. The LITE area contributes 550 tons of BOD per day.

The Lyari River was shown to bring sulphates, calcium, alum, magnesium and arsenic in significant amounts to the channel waters (Beg et.al., 1975) and the suspended matter is said to reach the coast at an average rate of 30 tons/day, creating dredging problems for the channel. Beg et.al. (1984 a) have recently worked out the values of total solids, total halides, sulphates, bicarbonates, calcium, magnesium, sodium and potassium reaching different parts of the Manora Channel and nearby offshore beaches (such as Sandspit) through the Lyari River. These values are higher than the values expected for the open coast unpolluted waters. In a recent article Ahmed (1983) pointed out that the industrial wastes contain organic solvents like Benzene and Toluene as well as chlorides, acids and alkalies. He also mentions that the Karachi Shipyard discharges considerable amounts of Sulphuric Acid with its waste waters into Manora Channel.

Heavy metals

Some heavy metals are toxic to both marine organisms and man, if present in high concentrations in sea water and in marine food chains. Mercury is the most important heavy metal

both for marine organisms and man and organic mercury (Methyl Mercury) is believed to be about ten times more toxic than inorganic mercury ($HgCl_2$) (Bernhard and Zattera, 1975). Mercury causes permanent celebral and nerve damage, irreversible mental illness and finally death to man. The most well-known episode of mercury poisoning is the Minimata Disease which occurred in Minimata Bay, Japan, where hundreds of people died in 1953 and then in 1964, after consuming shellfish contaminated with methyl mercury. Zinc and copper follow mercury in toxicity but they are mainly important to marine organisms. Just as important to both marine organisms and man are lead (which deposits in bones) and cyanides. Arsenic (As), Cadmium (Cd), Chromium (Cr) and Tin (Sn) are less hazardous even to marine organisms (see Bernhard and Zattera, 1975).

It has been pointed out by some Pakistani workers that several heavy metals are reaching the coastal waters of Karachi through industrial discharges (Beg et.al., 1975; Haq, 1976; Ahmed, 1977 and 1979; Ahmad, 1983; Beg et.al., 1985; Dr. Altaf Khan, Microbiology Department, Univ. Karachi, Pers. Comm.). Swan Wooster (1979) indicated the possibility of heavy metal leaching from the Pakistan Steel Mill plant. The following is the information available on heavy metals in the marine environment of Pakistan.

Swan Wooster (1979) expected dissolved Zn to reach the Gharo-Phitti creek environments from the galvanizing works of the Pakistan Steel Mill. Subsequently Ahmed (1982) found a value of 0.36 ppm of Zn in those waters. Higher values of Zn were found near the Karachi Shipyard and Engineering Works in Manora Channel. For instance Ahmad (1983) found a value of 100 ppm of Zn at this site and Altaf Khan noted very high values of Zn (1,300 mg/l) in the effluents of the shipyard going to the channel. The pH at the site was found to be between 2 and 3 and Khan pointed out that at such low pH values the high quantity of Zinc discharged would pass into solution (pers. comm.). He believes it would be worthwhile to recover Zinc from the Karachi shipyard effluents. Beg et.al. (1985) have also found high Zinc values near the Lyari River outfall in the Manora Channel.

Determinations of some heavy metals have been carried out from the Gharo-Phitti salt water creeks (Ahmed, 1982). Copper was found to be insignificant but in the detectable range (6.6 to 11.0 ppb) near the Pakistan Steel Mill outfall. Iron occurred in the range 0.042-0.178 ppm in the same system. Effluents of the Pakistan Steel Mill outfall in the Gharo-Phitti system have recently been examined by Rizvi et.al. (1985). According to these workers the red colour of the effluents is due to the presence of Ironoxide. At some places the intertidal zone in Bakran Creek shows red muds also. The following values of different heavy metals were found: Fe-4.7 to 459 ppm, Mn-0.22 to 1.49 ppm, Cu-0.02 to 4.5 ppm, Zn-0.03 to 4.97 ppm and Co-0.26 to 0.405 ppm. The maximum concentration of Iron amounted to 5,000 ppm in Bakran Creek.

Ahmad (1983) analysed the heavy metal contents of the effluents of a local oil refinery and found the following values (in mg/l):

	Cr	Co	Fe	Pb	Zn	Ni
Before treatment	2.2	0.5	2.2	0.4	0.8	0.5
After treatment	0.2	0.05	0.9	0.2	0.15	0.03

He also (1983) found the following values of different heavy metals in sea water samples collected from Mauripur salt works (values in mg/l): Mn-0.29; Ni-1-12; Cu-0.09; Cd-0.21; Zn-1.08; Pb-1.48.

Ahmed mentioned that a fair amount of chromium passes into the sea from tanneries at Shershah (SITE Area) since he found a value of 5 g/l in tannery effluents.

Beg et.al. (1985) have found lead to be in the 0.1-0.3 ppm range near the Lyari outfall in Manora Channel, particularly in the sludge. In the overlying water the metal was in the 1-3 ppm range (at the locality known as Kala Pani or Black Water). Lead shows up irregularly at this site according to these workers. They mention that brine, especially black salt produced at the salt

pans near the Lyari outfall contains heavy metals, particularly lead. These workers could not find any heavy metals in the white crystalline salt produced in the salt pans. Lead amounted to 1.48 mg/l in seawater samples collected from Mauripur salt works (Ahmad, 1983).

Beg et.al. (1985) found low values of arsenic and copper at the Lyari outfall in Manora Channel. Cadmium was not detectable by these workers or was very low. Although no studies have been made so far, the Gadani ship-breaking yard must be a constant source of several heavy metals in the coastal environment of Karachi.

Altaf Khan (for Environment and Urban Affairs Division, 1980) and Ahmad (1983) have determined heavy metals from the waste waters and effluents of several industries in the Karachi area. Khan found Cu, Zn, Mn, Cd, Ni, and Pb in variable concentrations in the effluents of 14 different industries of the SITE area. The following were the respective values of the above metals in the Karachi Shipyard effluents: 0.28, 1-342.5, 5.30, 0.100, 0.740 and 11.75 (mg/l). In a personal communication Khan mentioned that the heavy metals from the 14 industries examined by him were going into the coastal waters through the Lyari outfall.

Mercury has not been found in the coastal waters of Pakistan so far probably because the local heavy metal investigators either do not possess the appropriate facilities to detect the metal or the metal is still below the range of detection. This opinion is supported by the work of Beg et.al. (1985) who mention that mercury is below the range of detection in Manora Channel waters. Ahmad (1983) found mercury in the waste water discharges of several industries of SITE and LITE areas, so that mercury can be expected to reach the marine environment where, because of excessive dilution the metal remains below detection.

It thus seems that several heavy metals are reaching the coastal waters through industrial discharges. Occasionally one of these heavy metals is found in high concentrations at localized spots, such as zinc at the Karachi Shipyard outfall in Manora Channel. Collection of seafood from Manora Channel waters should, therefore be prohibited. There are additional reasons for such a prohibition (oil pollution and fecal coliforms).

Organic pollution

Organic pollution in the marine environment results from human sewage, garbage, pesticides and herbicides, polychlorinated biphenyls (PCB's) detergents, wastes from wood processing plants, cyanides, polynuclear aromatic hydrocarbons (PAH) such as 3-4 Benz-a-pyrene, Vinyl Chloride, Vinyl polymers and plasticizers, creosols, floating plastic particles and their pellet-shaped weathered remnants (Duuarsma and Merchant, 1974; Landner, 1978). In Pakistan some data are available about the following types of organic pollutants.

Domestic wastes

The quantity of domestic wastes produced per household in Pakistan varies from 80 to 280 litres per day (Zain-ul-Abedin, 1978). Latest figures are not available. There are several sources of sewage and garbage on the coast. Domestic sewage from the North and northwestern part of Karachi is brought to the Manora Channel by the Lyari River. Strong raw sewage and untreated effluents may also enter the Manora Channel from several drainage outfalls. Sewage and garbage from the human habitations on the islands of Manora, Baba, Bhit and Shamspir and from Mauripur area are also discharged in this channel, as are the organic wastes from the fish processing plants from Karachi Fish Harbour. Discharge of garbage and human wastes continues unchecked in the open waters off Karachi from a large number of vessels awaiting entry in Karachi harbour. Such dumpings continue to be made within the harbour itself by ships moored along the jetty. A substantial portion of organic wastes in the form of cereals, wheat, rice etc. must also reach the channel waters from the shipments arriving from abroad as well as from those exported from the country. Port Qasim area would also suffer from these organic inputs into the Gharo-Phitti creek system since bulk shipments of rice, wheat and other grains would be handled at the port.

The Manora Channel and its backwaters have the most sewage and garbage pollution on the coast of Pakistan. At some places in the channel conditions are extremely unhygienic. For instance the smell of H_2S is present everywhere at the Karachi Fish Harbour and in the Premises of the seafood plants. This smell is a perpetual health hazard. Channel water in the immediate vicinity of the Lyari outfall is almost always black and smelling of H_2S. In several places the banks of the channel and the surrounding area is littered with plastics, cups, bottles and discarded paper causing aesthetic pollution. Trucks of a local civic organization were observed by the author dumping garbage in the channel backwaters. The use of polythene bags has grown considerably in the Greater Karachi area, and these are littered almost everywhere on the roads of Karachi. These would eventually end up in the sea.

Beg et.al. (1975) mentioned that the Lyari was discharging the following amounts of wastes into the Manora Channel: 131,000 tons of T.D.S., 16,000 tons of organic matter, 800 tons of nitrogen, 90 tons of phosphates, all originating from the SITE area. According to the above named authors, the inshore marine environment is badly polluted as a consequence of these discharges. Beg et.al. (1984 a and b) have drawn attention to the contamination of the beaches of Manora Channel and of the adjacent open coast beaches, such as Sandspit, with fecal coliforms brought by the Lyari River. A high count of 918/dl was found. The count of fecal coliforms was found to increase during the rainy months of June, July, October and December. Total bacterial counts (MPN) were also found to increase. The workers mention that although the contamination of the beaches is not good for human health, organic pollution of Manora Channel seems to have been beneficial to mangroves which are thriving with luxuriance in this habitat.

The salt water creeks for the coast of Sind also receive sewage and garbage from several fishing villages of which Ibrahim Haidri, Wagudar, Rehri, Bhambhor and Keti Bunder are important. Raw sewage enters the marine habitat from these sources. The intertidal mud-sand-flats in these creeks serve as defecaeting sites for local inhabitants on the coast of Baluchistan also. There are about 38 small and large fishing villages on the coast of Baluchistan from which all organic wastes and pollutants reach the sea untreated. In view of the vastness of the coastline and open sea conditions of the receiving waters these wastes do not seem to pose much problem because of the large scale dilution which occurs in these waters.

Effects of domestic wastes

Human wastes and domestic wastes in general are sources of nutrients in coastal waters. Upslopings, such as those which occur on the coast of Pakistan, also transport nutrients to the surface. Nutrients increase the productivity of a body of water and constitute a beneficial addition to the marine environment. They increase fish production. However, the addition of an excessive amount of nutrients and a building-up of their concentrations in the coastal environments is synonymous to over-fertilization and to marine pollution. It leads to eutrophication or an over production of phytoplankton which remains unconsumed and eventually sinks to the bottom where it decays, fouls and causes deoxygenation of water (BOD problems). An excess of nutrients in coastal waters causes the production of blooms of toxic phytoplankton. Shellfish feeding on these blooms may also become toxic and pose severe health hazards to man if consumed. Diseases such as paralytic shellfish toxicity, nervous disorders and respiratory disturbances result through these. Fish-kills have been reported due to such toxic blooms. Crabs and shellfish can be affected.

In the local waters eutrophication has been observed in polluted spots. Ahmed (1977) refers to blooms of phytoplankton in the Manora Channel. Excessive amounts of seaweed belonging to the genera Enteromorpha and Ulva may accumulate in certain seasons on the tidal flats of Krangi, Lyari outfall, backwaters of Manora Channel, Gharo-Phitti creeks and in Sonmiani Bay. In most of these places nutrients accumulate due to low flushing rates and result in the production of algal covers on the tidal flats.

When the load of nutrients and other pollutants is unmanageable by the environment, mortalities of marine organisms occur. Ahmed (1977) documented mortalities of some marine animals on the Lyari beach as a consequence of the Lyari discharge. At the Lyari outfall no life

is visible in the dark black zone of the beach up to where the river can be seen flowing into the channel. The surface sediments are black, changing into shades of greenish black and finally brown on the distant margin of the flats. The odour is that of sewer sludge and H_2S. This is the only beach in Pakistan where a reduction in the number of species has occurred as a consequence of pollution (about six species in all). Ahmed (1979) mentioned that the water quality improves as one moves away from the Lyari outfall towards the mouth of the channel. A similar trend is noted in the diversity of animal life in Manora Channel.

Contamination of marine waters with sewage and domestic wastes may produce several infectious diseases such as typhoid, viral hepatitis, influenza and fungal diseases. These occur due to viruses, bacteria and protozoa and fungi. Such organisms are taken up by fish and shellfish from contaminated waters and transmitted to man. Engle (1976) cites the following examples: crabs and shrimps act as vectors of gastroenteritis caused by bacteria; oral epidermal papillomas occur in fish feeding near sewer outfalls (carcinogenic); crabs accumulate viruses either by feeding on contaminated shellfish or by feeding in contaminated waters. In Pakistani waters the following examples need to be considered from a human health point of view.

- Several species of fish and shellfish are caught by local fishermen from the Manora Channel for subsistence purposes. The green mussel Perna viridis is collected from Manora Channel and sold for food in Karachi fish markets occasionally. These might pose health problems as the channel is highly polluted with sewage and industrial wastes. No cases of infectious hepatitis have so far been recorded from this area since mussels and other shellfish are not eaten raw in the country. (Ahmed, 1977).

- Several salt pans located in Manora Channel were found to be contaminated with fecal coliforms and with organic matter which remains the main source of pollution for these salt pans (Beg et.al., 1984 a and b).

- The Bathing beaches in the vicinity of the Lyari outfall were also found to be contaminated with fecal coliforms (Beg et.al., 1984 a and b). Therefore, the risk of bathing can not be taken in the channel itself in view of the acute pollution found there.

Sewage, garbage and human excreta present on several intertidal mud and sand-flats all along the coast pose aesthetic problems.

Treatment facilities

Karachi has two treatment plants, one in the SITE area (T.P. 1) and another in the LITE area (T.P. 2). Each has a treatment capacity of 20 m.g.d. but the two are collectively treating only 36.38 m.g.d. of domestic wastes. Ahmed (1983) mentions that a total of about 90 m.g.d. of domestic wastes are discharged by the Karachi area so that about 50 m.g.d. of domestic wastes go to the sea untreated. He also mentions that an additional 12-16 m.g.d. of waste water is discharged and this also goes untreated to the sea. Only primary treatment seems to be given at both plants which often work below capacity due to functional disorders.

Pesticides and fertilizers

Pesticides are organophosphorous and organochlorine compounds of very persistent nature. They accumulate in fatty tissues and their concentrations increase ten fold at every link of the food chain through the process of bio-accumulation. Pakistan is basically an agricultural country, and pesticides and herbicides as well as fertilizers are abundantly used on its crop-lands. The pesticide fertilizer load generated in the agricultural sector must reach the coastal waters of Pakistan through the Indus. The Indus, however, does not discharge into the Arabian Sea directly for about eight months of the year as its water is diverted almost entirely for irrigation purposes. Therefore, the delta of Turshian and Khobar (near Keti Bunder) will not receive the pesticide load for the greater part of the year. This load would, however, reach the ocean through the irrigation outfall channels in the Mirpur Sakro area (Garo) which drain in the estuary

round the year. The dilution in this area is not of the same magnitude as it would be at the delta at Turshian where the Indus directly discharges into the Arabian Sea when flowing uninterrupted. A programme of shrimp culture has just been initiated at the Garo estuary, and it is likely that pesticide concentrations would build up in the natural fish and shellfish found here as well as in the cultivated species.

There are virtually no data available on the occurrence of pesticides in the coastal waters of Pakistan. A preliminary study has recently been undertaken by Khan (1983) on the concentrations of DDT, BHC, Aldrin and Heptachlor found in the tissues of the commercially important shellfish C. glomerata, C.rivularis and Perna viridis from several localities on the coast. Values were found in nannogrammes, far below the toxic levels. Even at Keti Bunder DDT levels in oysters were insignificant. The low levels of pesticides found might have been due to the fact that samples of oysters were collected at a time when practically no Indus discharge reaches the sampling area.

Sediments

Sediments create turbidity in the sea which in turn is not conducive to primary production. An excess amount of sediments in the sea is thus injurious to fish production and is considered marine pollution.

Prior to the construction of different barrages on it, the river Indus discharged large quantities of water and suspended sediments into the coastal waters of Pakistan. Different estimates of sediment discharge are available in literature. For instance Qureshi (1975) refers to Holeman who estimates the suspended sediment load of the Indus as 480 million tons per year. Qureshi also refers to Goldberg and Griffin who believed that much of the suspended load of the Indus gets trapped on the continental shelf of Pakistan and that the Swatch Canyon, which indents the coast of Pakistan, may be funneling the Indus sediments to the deep sea. Milliman et.al. (1984) show the Indus load to be 250 mt in 1940 and only 50 mt today and indicate that, owing to the imposition of barrages, the bulk of the sediment load of the Indus gets deposited before reaching the ocean. According to these authors the high coastal erosion found along the coastline of Pakistan may be due to this fact. Qureshi (1975) mentioned that the sediment load discharged into the sea by Indus had great influence on the marine environment of Pakistan.

Turbidity in the coastal waters of Pakistan, particularly in the salt water creeks, is very high (Ahmed and Rizvi, 1980 and 1981). It seems that sediments are brought into the creeks from the erosion-prone open coast beaches as well as through small rivers and inlets. At Karachi the small stream, known as Lyari River, discharges fair amounts of suspended matter into the Manora Channel throughout the year. These were estimated to amount to about 30 tons per day (Beg et.al., 1975). Part of this settles on the bottom of the channel and may be responsible for the chronic siltation problems from which the channel suffers perpetually and owing to which it has to be dredged year round. Evidently a significant amount of sediment load of the channel probably comes from the open Arabian Sea along with tides and currents. Malir River is another source of sediments on the coast of Karachi. The river remains dry for the greater part of the year but overflows its banks during the heavy SW Monsoon rains. The sediment load brought by this river enters the Arabian Sea through the Gizri creek.

On the coast of Baluchistan the Hab River enters the Arabian Sea near Cape Monze. Almost as large or larger is the Hingol River near Ormara. Other small rivers on the Baluchistan coast also introduce small sediment loads into the ocean.

The entire coast of Baluchistan in Pakistan seems to be affected with erosion problems. There are wave-cut sea caves and beaches, eroded headlands and crescentic bays on the coast which are relentlessly pounded by strong waves. To some extent this is also true of the coast of Sind. The coast of Pakistan contains the Arabian Sea in the North. As mentioned earlier, the coastal erosion generates a lot of sediments which become distributed along the coast with littoral drift. One interesting aspect of this phenomenon is the introduction of plastic mud which enters the West Bay of Gwadar from rocky headlands present in the bay (Ahmed et.al., 1982).

Other sources of sediments in the local marine environment consist of the large scale earth moving activities conducted in dry river beds for the construction of residential houses, roads, bridges and dams which continue year round in the Karachi area and its suburbs. According to one estimate, the city of Karachi, which is spread over an area of 400 sq.miles, (app. 1036 km^2) receives about 250,000 tons of dust through small or large dust storms during a year. Sand dunes exist all along the coast at one place or another and the desert of Thar lies, at some distance to the East of Karachi, in India. In the summer and, sometimes in winter, when rains turn the entire city of Karachi into a pool of water and when the Lyari and Malir rivers also run in spate, the dust and other construction material must find their way to the nearby coastal waters.

Marine pollution through the atmosphere

The city of Karachi and its suburbs suffer perpetually from problems of acute air pollution. This results from the following sources:

- The foremost source is the large number of automobiles (about 250,000) which include private cars, trucks, taxis, oil trucks, long vehicles, buses of the public transport system etc. These create dense traffic jams on the streets of Karachi. Since exhaust emission standards have not been established in the country there exist no checks on the automobiles which freely discharge black sooty exhausts particularly in the peak hours. As a result tree leaves on main thoroughfares have become black with soot. Deposition of soot can also be seen on the buildings along the roads. The particulate matter and different kinds of gases present in the atmosphere of Karachi are eventually washed down by the rain and carried to the coastal waters of Karachi. The following points are also to be noted in this regard:

  (i) Emissions of automobile exhausts containing lead, from lead-enriched fuels, end up in increased levels of lead in the inshore environment.

  (ii) The generation of CO_2 beyond the absorption capacity of the inshore environment would result in a reduction of pH of the local waters and in an increase of the bicarbonate content of the beaches. Beg et.al. (1984 b) found that the pH (7.5) and bicarbonate content (200) of Manora Channel water did not conform to that of standard seawater (pH 8.2 and bicarbonate content 140). The high bicarbonate content of seawater is harmful for shellfish growth (Beg et.al., 1975 and 1984 a).

- Air pollution in the Karachi area also results from the burning of oil, kerosene, coal and firewood in residential and industrial areas. Stack gases are produced by local power plants which may possibly contain Benz-a Pyrene in low levels. Some air pollution is expected to be caused by air traffic in the Karachi area where three airports are located.

- Yet another aspect of air pollution in the Karachi area is dust pollution. Although Karachi is the most modern city of Pakistan, it still has vast stretches of undeveloped land with untarred roads. There also exists a very active gravel digging industry which transports to Karachi enormous quantities of sand and gravel from dry river beds in the province of Sind, to be used in the construction of a large number of residential apartments and high-rise buildings. During the last decade the maximum investment in the private sector has been made in the house building industry so that a lot of construction, demolition and digging work has gone on and still remains in progress in this area. A lot of sand is thus introduced into the air through these activities. The consumption of cement has also gone up substantially in the Karachi area so that more cement factories are in the process of being set-up in Karachi-Hyderabad region.

- In the Karachi area emissions of fine sand and cement particles occur in the atmosphere from cement factories, power plants, steel mills, and from the industrial area in general. A lot of sand was introduced into the salt water creeks from sand dunes during the construction of Port Qasim facilities. The South-west monsoon season, beginning in May every year, also

brings dust storms. All these factors combined make the Greater Karachi area a highly smoggy one. This smog can be seen by ships approaching Karachi (Nicholas and Moller, 1981). A process of continuous dust-fall may, therefore, occur in the inshore waters of Karachi region resulting in an increase in the turbidity of the marine environment. An increase in turbidity results in decreased light penetration. Dust-fall may, nevertheless, have a positive contribution to make, that is, of sinking and dispersing oil spills.

Thermal pollution

The main source of thermal pollution on the open coast of Pakistan is the Karachi Nuclear Power Plant (KANUPP) located 18 km North-west of Karachi. The plant utilizes 650,000 litres of sea water per minute for cooling purposes. It can produce a maximum of 450 MW of thermal energy as a result of power generation. Of this about two-thirds heat is released to the sea through a long effluent outfall channel so that the water discharged is never more than 4.5 percent above the normal sea water temperature at the discharge site (Siddiqi and Mirza, 1979). This discharge may also contain chlorine which is used for the control of fouling organisms in the plant.

The following sources of thermal pollution are important in the creeks and backwaters on the coast of Sind:

- 400 MW Pipri-Pakistan Steel Mill power plant operated on high diesel and furnace oil.
- 382 MW power plant of the KESC (Karachi Electric Supply Corporation) located at Ibrahim Haidri in Korangi Creek.
- 80 MW gas-operated power plant at West Wharf, Karachi.

Hot water discharges from power plants can be damaging to the environment only where the receiving waters are small (such as small bays). It would, therefore, seem that the warm water discharged on the coast of Karachi from different power plants can only be locally damaging to the fauna and flora, since the input is relatively small compared to the receiving environment. The KANUPP discharge occurs directly in the Arabian Sea where the dilution factor is very high. The slight elevation in temperature occuring at the discharge site may affect, to some extent, the distribution of intertidal organisms found near the outfall (Ahmed, 1977). Some beneficial effects may also follow in the form of fish aggregations at the discharge site, particularly during the cold weather. However, the discharge of residual chlorine with elevated temperatures may prove toxic to local biota because of their synergistic action. The hot water discharged by the KESC power plant at Korangi Creek also does not seem to have any apparent adverse effects on the local fauna and flora (Ahmed, 1979; Swan Wooster, 1979). The window-pane oyster (Placuna placenta) which once used to be very abundant at Ibrahim Haidri has, however, disappeared from the site and it is possible that elevated temperatures may in part be responsible for its disappearance. A 3° to 6°C elevation of seawater temperature has been recently noted in Bakran Creek near the Pakistan Steel Mill outfall (Rizvi et.al., 1985). Very few live organisms are found on the stones surrounding the mouth of the outfall. The local fauna and flora, however, seems to be well adapted to high temperatures so that slight increases would not matter much. On the other hand, if the number of such power plants were to increase on the coast greater damage may be caused to fish and shellfish since in the tropics and subtropics marine organisms are living near the upper limits of temperature tolerance (see Hedgpeth, 1978).

Radioactive wastes

These can reach the marine environment through nuclear power plants, industry, agriculture and scientific research. The major source of artificial radioactivity on the coast of Pakistan is the KANUPP which is located on the shore of Buleji (Open Arabian Sea). It is a 137 MW heavy water moderated and cooled natural Uranium horizontal tube reactor. A departmental report of the plant indicates that the plant manages to release only 1.2 percent of the permissible allowance of

radioactivity to the environment and this amounts to 4 m REM annually (Siddiqi and Mirza, 1979). The plant discharges low and intermediate level solid, liquid and gaseous wastes. The liquid wastes pass into the sea after dilution into the cooling sea water. The solid wastes have the following nucleides: ^{60}Co, ^{58}Co, ^{65}Zn, ^{59}Fe, ^{54}Mn, ^{51}Cr, $^{95}Zn/^{95}Nb$, ^{137}Cs, ^{134}Cr, $^{140}Ba/^{140}La$. Before release the wastes are carefully treated. The combustible solid wastes are burnt and non-combustible wastes are stored in specially made trenches ensuring that no radioactivity leaks to the environment. The gaseous wastes are discharged through a 60 m high stack. These may include very low quantities of tritium, iodines, radioactive particulates, $^{14}Argon$, noble fission gases such as ^{88}Kr, ^{138}Xe and other daughter products.

Although the discharges from nuclear power plants throughout the world are kept at a minimum it is always desirable to check the seafood for any concentration of nucleides in the vicinity of nuclear power plants. These discharges contaminate seaweed, fish and shellfish. Seaweeds such as Porphyra are known to concentrate radioiodine. Contamination of shore sediments may also occur. Radionucleides can build up in marine organisms over a period of time through the process of bioaccumulation.

The KANUPP undertakes periodic monitoring of the radioactivity in the environment through surveys of surrounding grass and soil material (Siddiqi and Mirza, 1979). These surveys have shown that the burden of radioactivity in the local waters has not increased. No radioactive accumulation was found in seaweeds such as Dasyllus marginatus and Sargassum sp. and in the marine gastropod Turbo marmoratus and in an occasional fish that was examined (see Ahmed, 1977). Only the naturally occuring isotope ^{40}K was found.

A second, much larger nuclear power plant is being built up country near Chashma in Mianwali district. Some radioactivity may reach the coastal waters of Pakistan through this source, via the Indus, but the levels are expected to be insignificant.

MANGROVES AND POLLUTION

Present state

Mangroves occur in sheltered intertidal marshy swamps of tropical and subtropical countries. They thrive well in estuaries and bays where salinities are low. In Pakistan mangroves occur on about 800,000 acres of swamps of which 40 percent have mangrove cover (see Saifullah, 1982). On the coast of Sind they are more abundant near the Indus delta (but absent at Keti Bunder) where fresh water input is relatively large. They are dwarfed and shrub-like on the coast of Karachi where salinities are high. In the Manora Channel, where a fair amount of fresh water is introduced by the Lyari River and which functions as a mini-estuary, mangroves thrive luxuriantly (Ahmed, 1977; 1979). Mangroves are virtually absent from the coast of Baluchistan where they once occurred in abundance. This may be attributable to the absence of a permanent river and presence of high salinity (Saifullah, 1983). The drastic artificial cutbacks which have occurred in the Indus discharge to the ocean have greatly affected the abundance of mangroves on the coast of Pakistan (Ahmed, 1979; Saifullah, 1983).

Eight species of mangroves are known to occur on the coast of Pakistan, 95 percent of which seem to belong to the species Avicennia marina, 4 percent to Ceriops tagal and 1 percent to Bruiguiera conjugata (Saifullah, 1983). Mangroves are used all over the world for timber, charcoal, firewood, pulp, tannin, lignin, cellulose, wax production and for other uses, according to the suitability of the species. Vast mangrove areas may also be set aside as national parks. In Pakistan mangroves are used for fuel, as fodder for camels and cattle, for tanning products and as well as medicinal purposes.

Mangroves play an important role in the marshy-swampy ecosystem. They bind silt, accrete shorelines, halt erosion of beaches and coastlines, and prevent flooding. Avicennia sp. is believed to do this better than other species of mangroves. Mangroves also provide shelter and serve as nursery grounds for marine organisms. Marine bacteria convert the leaf-litter of mangroves into detritus which serves as a source of energy to juveniles of shrimps, fish and other marine organisms. In some tropical countries, such as Malaysia, and in East Africa, shrimp production is linked to the abundance of mangroves (MacNae, 1968). Although mangroves are important to the marine fisheries of Pakistan, the slogan of 'no mangroves no shrimps' does not hold true for Pakistan. Shrimps are abundant on the coast of Baluchistan where mangroves have virtually disappeared.

The mangrove swamps of the coast of Sind are not rich in the associated macrofauna and flora, although elsewhere in the tropical and subtropical habitat the mangrove associated macrofauna is very rich (MacNae, 1968). The local fauna is comprised of a few species of small economically unimportant crabs, small numbers of the edible crab Scylla serrata, occasional specimens of the snail Telescopium telescopium, the bivalve Solen truncatus, the snail Potamides cingulatus, mud-skipper fishes, burrowing shrimps and fiddler crabs. Only one species, the barnacle Euraphia withersii settles on the leaves and stems of the mangroves. A few bird species can also be seen but their numbers are exceedingly small. However, commercially important finfish do occur in the creeks surrounded by mangroves. Shrimp juveniles are also fairly abundant (Ahmed, 1982).

Habitat degradation

The mangrove ecosystem of the coast of Pakistan is already a heavily stressed system in view of the high salinities and turbidity which prevail along the coast. The retreat of the Indus delta to the North-east and subsequent reduction in the Indus discharge to the sea has further stressed the ecosystem considerably. There are several man-made activities on the coast of Pakistan which would be further detrimental to the growth and abundance of local mangroves. In the first instance, oil pollution is increasing on the coast of Pakistan, particularly in the backwaters and creeks. The main cause of this increase in oil pollution is an increase in ship traffic owing to the construction of a second port, Port Qasim, in the vicinity of Karachi Harbour. Secondly, offshore oil and gas exploration has now commenced on the continental shelf of Sind. Although no large oil spills have occurred so far along the coast of Pakistan small spills leading to chronic oil pollution continue to occur in the local environment, particularly in the harbours and the inshore marine environment. Oil affects the mangroves by making the environment anaerobic and by elevating temperatures in their root system following the absorption of solar radiation in black tar which may smother the penumatophores, leaves and seedlings of mangroves.

Turbidity and siltation can also negatively affect mangroves by reducing gaseous exchange and oxygen supplies to their root system. A lot of turbidity is being generated in the mangrove ecosystem of the coast of Sind through dreging and dumping of dredge-spoils of ship harbours and through airborne pollution and dustfall. Mangroves are known to tolerate slow but not rapid siltation. Some mangrove areas have been lost in the Gharo-Phitti creek system due to reclamation of land following filling operations required for the construction of jetties and several other port facilities. Sewage pollution carrying high concentrations of pesticides and herbicides is also known to affect mangroves. Thermal loading may also have an adverse effect but there is not so much of this in the local environment.

CORAL REEFS AND POLLUTION

So far as is known no coral reefs seem to occur on the coast of Pakistan. Qureshi (1961) mentioned the presence of fossilized forms of corals in sandstone of hills dotting the Baluchistan coast. According to him the seabed on Makran coast is mostly muddy but at places patches of coral and rocks are present. Coral reefs occur in the Persian Gulf and the Gulf of Oman (UNESCO, 1976). They also occur on the coast of India. The fringing type of coral reef occurs around

southern India and Sri Lanka and extensive atypical atolls in the Laccadives and Maldives. Extensive intertidal-subtidal coral reefs are present in Pirotan Island in the Gulf of Kutch, an account of which has been given by Kohn (1969).

In Pakistan there are greater chances for the development of coral reefs on the coast of Baluchistan than on the coast of Sind. Corals require hard bottoms, crystal clear water, high salinities and high temperatures (not lower than an annual average of 20°C). Substrates are comparatively harder on the coast of Baluchistan than on the coast of Sind. Temperatures seem favourable for the formation of coral reefs on both coasts but there is much more turbidity on the coast of Sind. Coral assemblages of limited extent are probably present on the coast of Baluchistan, and a thorough search might reveal their presence. Offshore areas, such as those around Astolla Island, near Pasni and Ormara, are the likely spots where coral reefs may be found. Coral-like rocks were cited in these areas by Qureshi (1961).

Corals comprise a group of very sensitive organisms which are affected by pollution to a great extent. Oil pollution proves inimical to coral existence. Large oil spills can affect corals at low tide when subtidal coral reefs become partly exposed.

POLLUTION FROM SEABED EXPLORATION

Oil exploration

Exploration for oil and gas on the continental shelf constitutes a fairly important source of pollution in the marine environment. These activities include drilling of wells, laying of pipe-lines, construction of platforms, loading facilities, offshore and onshore storage facilities and supporting onshore activities. Some of these activities result in the disruption of the seabed. They interfere with fishing activities also, as for instance trawl fishing which becomes affected where and when such activities are in progress. They also disturb navigation, particularly when these activities are conducted near active shipping lanes.

Discharges from offshore oil rigs can be of two types: production water and displacement water and platform drainage discharge or discontinous discharge (due to daily operation of clean-up of platform, machinery and equipment). The standard permissible discharge limits vary from 30-90 mg/l. It is believed that much less oil pollution is introduced into the marine environment through offshore oil production than through oil production activities on land. The offshore oil production technology is believed to be safer.

Pakistan has recently embarked upon a programme of offshore oil and gas exploration on its continental shelf. These activities have begun in the near-shore waters on the continental shelf of Sind. This is the area where the bulk of Pakistan's shrimp catches are made. The drilling sites are located close to the Indus estuary so that oil spills originating from these sites would adversely affect the breeding and nursery ground of fish and shellfish. The fauna and flora of this coast is quite diverse and mangroves are found in the creeks. The sandy beaches in this area serve as nesting sites for green turtles which have been officially declared endangered species. An occasional beach in this area, is also used for public recreation. Then again, the Karachi Nuclear Power Plant is also located in this area and tar-balls may constitute a grave threat to the screens of the plant. Thus the risk of damage to sensitive areas and resources would develop in the event of an oil spill or a rig blow-out. The OGDC, which is the local governmental agency for oil exploration in Pakistan, and its foreign counterpart consultant firm should, therefore, be required to develop all the necessary oil combating facilities as well as offshore and onshore oil storage and reception facilities.

Mining

Several mineral resources, such as heavy mineral concentrations (placers), sand, gravel, shell, lime-mud, phosphates, manganese oxide nodules and others can be obtained from the continental shelf, slope and deep waters. Substances such as sand, shell and lime-mud are obtained from near-shore waters. These are extracted on an industrial level in several countries for meeting the needs of the construction business. Since these can be obtained from the inshore waters their costs are not prohibitive. Phosphorite can be obtained from the inner continental shelf and slope. It abounds where upwellings occur but its concentration varies, from great abundance to sparse distribution. Manganese nodules can also occur in great abundance along a coast but in deep waters varying from 3,500-4,500 meters. These are mined for their rich nickel, copper and cobalt contents. Special technology is required for the extraction of minerals from the seabed, especially for manganese nodules.

The seabed mineral resources of Pakistan have not been surveyed, so no information is available with regard to the type of mineral resources available on the continental shelf and in the deep sea. Need for sand and gravel has grown considerably in the Greater Karachi area as is evident from the digging of sandy beaches (such as the one at Clifton) in which local sand-suppliers have been found to be illegally involved. Such tampering with the sandy beaches is injurious to the local marine environment and should be prohibited. Phosphorite and manganese nodules are of greater importance but whether these are in Pakistan's EEZ in abundance is also not known. What environmental hazards are associated with the extraction of different kinds of minerals from the seabed also needs to be researched. There is considerable paucity of data on these aspects of ocean resources. Certainly, turbidity would increase in the inshore waters due to sand, gravel and lime mining and manganese nodule extraction would introduce heavy metals into the environment (such as manganese, nickel, copper and cobalt). The extraction of phosphorite would introduce phosphorous with resultant nutrient enrichment.

Dredging

There are two sites on the coast of Pakistan where year-round maintenance dredging has to be conducted in order to create suitable depths for large ships. The first is Manora Channel, the site of Karachi Harbour. The channel occupies an area of 7.17 km^2 and is fed directly by the Arabian Sea. It is an artificial harbour and suffers from chronic siltation problems. An estimated 456,000 m^3 of silt is removed annually from the channel (Haq, 1976) and the dredge spoils are dumped at a distance of about 5-6 km South-west of the channel mouth in the Arabian Sea (Ahmed, 1977). The second site is Port Qasim, located in the Gharo-Phitti creek system. It also suffers from chronic siltation problems due to regular inputs of sand and silt from the Arabian Sea to which it is directly connected. Some 20 million m^3 of silt were removed from the navigational channel of this port during the first phase of its construction and dumped offshore at about 20 m depth off the mouth of the approach channel and some on the margins of mud-flats or in deeper waters of other creeks in the area (Ahmed, 1977). The problem of siltation is so acute that despite this active dredging programme groundings of vessels occur occasionally at the mouth of the navigation channel. Ahmed (1979) pointed out that silt may be transported to Port Qasim navigational channel by currents from the site where dredge spoils of Manora Channel are dumped (at about 20 km distance from here, North-west) or even from the site where dredge spoils of Port Qasim channel itself are dumped.

Dredging disturbs the stable benthic habitat. It causes mortalities of the biota through direct kills and in other ways. Dredging also causes turbidity which inhibits light penetration in the water column affecting phytoplankton production. Decrease in phytoplanktons results in a decrease in the stocks of herbivorous fishes such as those of the coastal sardines and anchovies. The Gharo-Phitti creek environment suffers from excessive turbidity and high salinities (Ahmed and Rizvi, 1980 and 1981). It is probably this turbidity, more than any other factor, which has caused the depletion of oyster stocks from the coast of Sind (Hornell, 1910; Ahmed, 1977 and 1979). That oysters were abundant in the Gharo-Phitti creek system in the recent past and were then wiped out due to different causes (high turbidity, high salinity and pollution) has been

mentioned by Ahmed and Rizvi (1980; 1981) and Ahmed (1982). It is because of high turbidity that the productivity of the coastal waters of Sind has decreased considerably although one would expect high productivity in view of the nutrient-rich upslopings which are known to occur along this coast.

ENVIRONMENTAL LEGISLATION

Some progress has been made by Pakistan in this field over the last five years. The following are major achievements:

- The Pakistan Environmental Protection Ordinance was promulgated by the President of Pakistan in 1983. It would be under this ordinance that the National Environmental Policy of the country would be enforced.

- A Pakistan Environmental Protection Council has been set up and is headed by the President of Pakistan. This Council would approve the National Environmental Policy, which is to be prepared by the Pakistan Environmental Protection Agency (PEPA). The latter agency is headed by a Director General. The PEPA would establish standards of quality and discharge standards and would make it mandatory for all new and upcoming industries to file an Environmental Impact Statement before permission is granted to them to go into operation.

- The Environmental Protection Ordinance would apply to marine pollution also. According to the provisions of this ordinance penalties for polluting the harbours and marine waters would consist of a fine of Rs. 100,000, or a two year term of imprisonment, or both, with an additional fine of Rs. 10,000 per day for default (Askari, 1983). These penalties would supercede the provisions of section 21 (1) of the 1908 Ports Act (of Rs. 50,000 fine and imprisonment of up to 6 months).

- The Environment and Urban Affairs Division of the Ministry of Housing and Works is engaged in developing legal instruments for the protection of marine pollution in Pakistan. Work on the formulation of industrial standards in marine waters is also in progress at the said Division.

- The Port and Shipping Department is engaged in developing a Merchant Shipping Act and draft legislation for the prevention of water pollution from ships as well as reception facilities in Pakistani ports.

MARINE POLLUTION RESEARCH

The following type of research is desired for the monitoring and combating of pollution in the marine environment of Pakistan:

- toxicity tests of effluents (bioassays);

- determination of heavy metals such as mercury, cadmium, lead, zinc, copper and others in the natural waters of bays, estuaries, backwaters and saltwater creeks and in selected species of fish and shellfish;

- determination of pesticides in the waters of the Indus estuary at Keti Bunder and Garo (the site of shrimp culture) and pesticide levels in marine organisms;

- determination of fecal coliforms from highly polluted areas such as Manora Channel as well as other lagoon-like bodies of water along the coast;

- determination of organic pollution wherever large quantities of sewage and domestic wastes enter the coastal environment;

- determination of beach tar, tar-balls and oil slicks on different beaches, in inshore waters and in plankton;

- monitoring of radioactivity around KANUPP particularly levels of radionucleides in selected species of food fish and shellfish;

- research on current patterns in inshore and offshore waters with a view to learning the probable pattern of movement of oil slicks in Pakistani waters.

Some research has already been done in Pakistan along the above lines (Beg et.al., 1975; 1984 a and b; Ahmed, 1977 and 1979; Ahmed and Rizvi, 1980 and 1981; Moazzam and Rizvi, 1979; Ahmed, 1983, Khan, 1983). The data are, however, scanty and much more work is needed to form a basis for sound control decisions.

The following institutions have facilities and manpower for marine pollution work in the Karachi area:

- Centre of Excellence in Marine Biology, University of Karachi;
- Laboratories of the PCSIR, Karachi;
- National Institute of Oceanography, Pakistan (Karachi);
- Department of Applied Chemistry, University of Karachi;
- Department of Microbiology, University of Karachi;
- Zoological Survey Department, Pakistan (Karachi);
- Environmental Study Centre, University of Karachi;
- Pakistan Navy (research ship BEHR PAIMA).

The laboratories of some of the above-named institutions are fairly well equipped for marine pollution research. The scientists of these departments are also well-qualified to undertake research on different aspects of marine pollution. It is from these departments that the bulk of research on marine pollution has been published in Pakistan. There is however, a general shortage of manpower in this sector and Pakistan needs to build up its manpower and facilities for the monitoring and combating marine pollution. The ESCAP (Economic and Social Commission for Asia and the Pacific) has recently determined the requirements for training fellowships of different member countries for the next ten years after having scrutinized questionnaires and country reports. Ranking the requirements as O-no requirements, A-low, B-medium, C-high, the following requirements were outlined for Pakistan:

General Oceanography (B); Meteorology and Ocean Phenomena (B); Marine Biology and Ecology (B); Marine Ecosystem Planning and Management (B); Mangrove Ecosystem Management (B); Coral Ecosystem Management (O); Living Resources Planning and Management (B); Non-Living Resources Planning and Management (O); Marine Pollution Monitoring and Control (B); Industrial Pollution (C); Domestic Pollution (B); Sedimention Survey and Control (A); Integrated Coastal Zone Management (O); Intergrated water Quality Management (C); Environmental Impact Assessment (C); Ocean Engineering (A); Environmental Legislation (B); Environmental Education and Training Support (C).

RECOMMENDATIONS

The report shows that the coastal waters of Pakistan are polluted with different types of pollutants to one extent or another, but it is only the Karachi area, more particularly the Manora Channel (Karachi Harbour), where the greatest concentration of pollutants are found. As far as oil spills from international sources (oil tankers, regional countries) are concerned, it becomes

apparent that Pakistan is located in a somewhat safe corner of the Arabian Sea where no large oil spills have occurred so far and the probability of their occurrence in the future is low. Since Pakistan is not an economically affluent country it has not the resources to embark upon an ambitious marine pollution control programme in its coastal waters. In view of these limitations it is recommended that Pakistan develops a modest pollution control programme and that, too, in phases according to the priorities listed below. The national policy for the control of marine pollution should aim first to protect and clean the inshore areas and second to manage the open coast beaches only if an important marine resources facility or amenity is to be protected. The national priorities appear to be the following:

1. the setting up of a marine pollution control centre;

2. development of facilities for combating acute oil pollution (such as large accidental oil spills from oil tankers and rig blow-outs) and chronic oil pollution (small leaks and spills in harbours and inshore waters);

3. preparation of a national contingency plan for large oil spill emergencies;

4. development of facilities in order to check and prevent pollution from Pakistani and foreign vessels passing through Pakistan's territorial waters and the EEZ;

5. establishment of standards for discharges resulting from installations and devices involved in oil and gas exploration and development of facilities to prevent, reduce and control pollution from all seabed and subsoil explorations on the shelf;

6. development of cooperative programmes with the countries of the region for the prevention, reduction and control of marine pollution in the northern Arabian Sea;

7. continuous programme for the prevention and control of chronic oil pollution focussing on:

   - Karachi Harbour (Manora Channel);
   - Port Muhammad Bin Qasim;
   - Gadani Ship-breaking yard area;
   - salt water creeks of Sind;
   - East and West Bay of Gwadar;
   - Pasni-Ormara area;
   - Gwattar Bay at Jiwani;
   - Indus Delta area.

8. in the case of pollutants other than oil, maximum attention should be accorded to Karachi Harbour (Manora Channel) which is the site of large concentrations of organic and inorganic (industrial) wastes. The following steps need to be taken:

   - all industries discharging pollutants into the Lyari River should be required to appropriately, treat all of their effluent before discharging them into river;

   - all industries, plants and engineering works discharging pollutants directly into Karachi Harbour should also be required to treat them properly before discharging them into the channel waters;

   - discharge standards should be established for all plants and industries located in the Karachi area;

   - the efficiency of the two treatment plants located in Karachi should be improved;

   - standards for automobile exhaust emissions should be established in the Karachi area.

SUMMARY

A marine pollution combating programme is generally geared towards the protection of marine life and fisheries resources of a country together with protection of different facilities and installations along the coast and protection of the beaches, particularly those which are used for public recreation. In Pakistan the following resources would require protection from acute and chronic pollution:

Marine life

The marine fauna and flora and the marine fisheries resources of Pakistan are fairly extensive. The marine fisheries industry of the country earns about 900 million rupees per year from foreign exchange (export-oriented) and shrimps constitute its most important component. In the event of an oil spill all fishing activities would come to a standstill in the affected region.

Mangrove areas

The mangrove-covered backwaters and creeks on the coast of Sind constitute some of the most important areas which serve as nurseries for fish and shellfish.

Turtle beaches

The open coast beaches near Karachi serve as nesting sites for green turtles. These are being artificially propagated in hatcheries at Sandspit and Hawksbay and have been officially declared an endangered species.

Facilities and installations

In the backwaters, creeks and bays of the coast of Pakistan there are several facilities and installations (such as salt pans, power plant and steel mill intakes) which would require protection. On the open coast, however, there are no such facilities except for the intake of the Karachi Nuclear Power Plant.

Recreational beaches

Although Pakistani beaches are among the best in the world a beach-oriented foreign tourist industry does not exist in the country. An occasional beach in the Karachi region is used, however, for public recreation.

Pakistan has a coastline of about 825 km. From the standpoint of pollution, the country is fortunate to have a thinly populated coastal belt which is also devoid of industry except in the Greater Karachi area which constitutes the largest urban and industrial centre on the coast (as well as in the country). At present, pollution on the coast of Pakistan is mostly limited to the Greater Karachi area, particularly to the Karachi Harbour (Manora Channel) where virtually every kind of pollution is found, the most important being oil (from ships and from the oil terminal) industrial and domestic (from the Lyari River and other sources). The backwaters, creeks and bays which are located at some distance from Karachi, seem to be relatively free from pollution, although tar-balls have been found on some open coast beaches. The different types of pollution found on the coast of Pakistan are summarized in Table 5.

The greatest threat to the marine environment and resources of Pakistan is posed by oil pollution. Pakistan is an oil importing country and its current oil imports, which come from the Persian Gulf, amount to about 4 to 6 million tons per year. About 20,000 tons of oil are believed to leak to the local waters from different sources. A major oil spill has luckily not occurred along the coast of Pakistan and the probability of its occurrence is low. The coast of Pakistan

is threatened, however, from oil pollution originating elsewhere, such as in the Persian Gulf region, from oil-tanker traffic operating close to Pakistan's EEZ and from the West coast of India. The pattern of water movements in the Arabian Sea is such that for the greater part of the year oil, or its degradation products, would reach the coastal waters of Pakistan from the Persian Gulf region and to a lesser extent from the West coast of India.

Table 5. Summary of different types of pollutants on the coast of Pakistan; + low, ++ medium, +++ high, ++++ highest.

Area	Oil slicks	Tar on beaches	Tar balls	Industrial pollution	Sewage domestic	Sedimentation	Thermal pollution wastes
Jiwani	++	-	++	-	-	-	-
Gwadar							
East Bay	++	+	++	-	+	-	-
West Bay	++	-	+++	-	-	-	-
Pasni	+	-	+++	-	+	-	-
Ormara	+	-	+	-	-	-	-
Sonmiani Bay	+	-	-	-	+	-	-
Gadani	++	++	++	+	-	-	-
Cape Monze	-	-	+	-	-	-	-
Paradise Point	-	-	++	-	-	-	++
Buleji	-	-	+	-	-	-	-
Hawksbay	-	-	++	-	-	-	-
Sandspit	-	-	++	-	-	-	-
Manora Island (exposed)	-	-	+	-	-	-	-
Manora Channel	++++	+++	++	++++	++++	++++	+
Clifton	++	-	+	+	+	+	-
Korangi Cr.	+	-	+	+	+	+	-
Port Qasim	++	+	+	++	+	++++	+++
Indus Delta	-	-	-	-	+	++++	-

Since much of the coast of Pakistan is today free from pollution and Pakistan is located in a somewhat uncongested area of the Arabian Sea at fairly large distances from the hot spots of pollution, the country may be better off if it develops a modest programme of monitoring and combating of pollution in its waters. To begin with, it needs to accord immediate attention to pollution found in Karachi Harbour (Manora Channel) and to coastal waters in the vicinity of Karachi. Oil spills occuring in or near the fishing grounds would have to be tackled on a priority basis, and attempts should be made to prevent oil from reaching important beaches. It would not be possible for Pakistan to protect its entire coastline but oil combating equipment should be acquired and stockpiled at Karachi from where it could be air-lifted and transported to emergency situations which arise on important sites along the coast. The national policy for the control of marine pollution should be first to protect and clean the inshore areas and then the open coast beaches if an important marine resource, facility or amenity is to be protected.

Pakistan needs to develop discharge standards for different pollutants reaching its waters, to establish reception facilities in its ports as well as to acquire facilities and infrastructure for marine pollution research and for the enforcement of its pollution laws and provisions.

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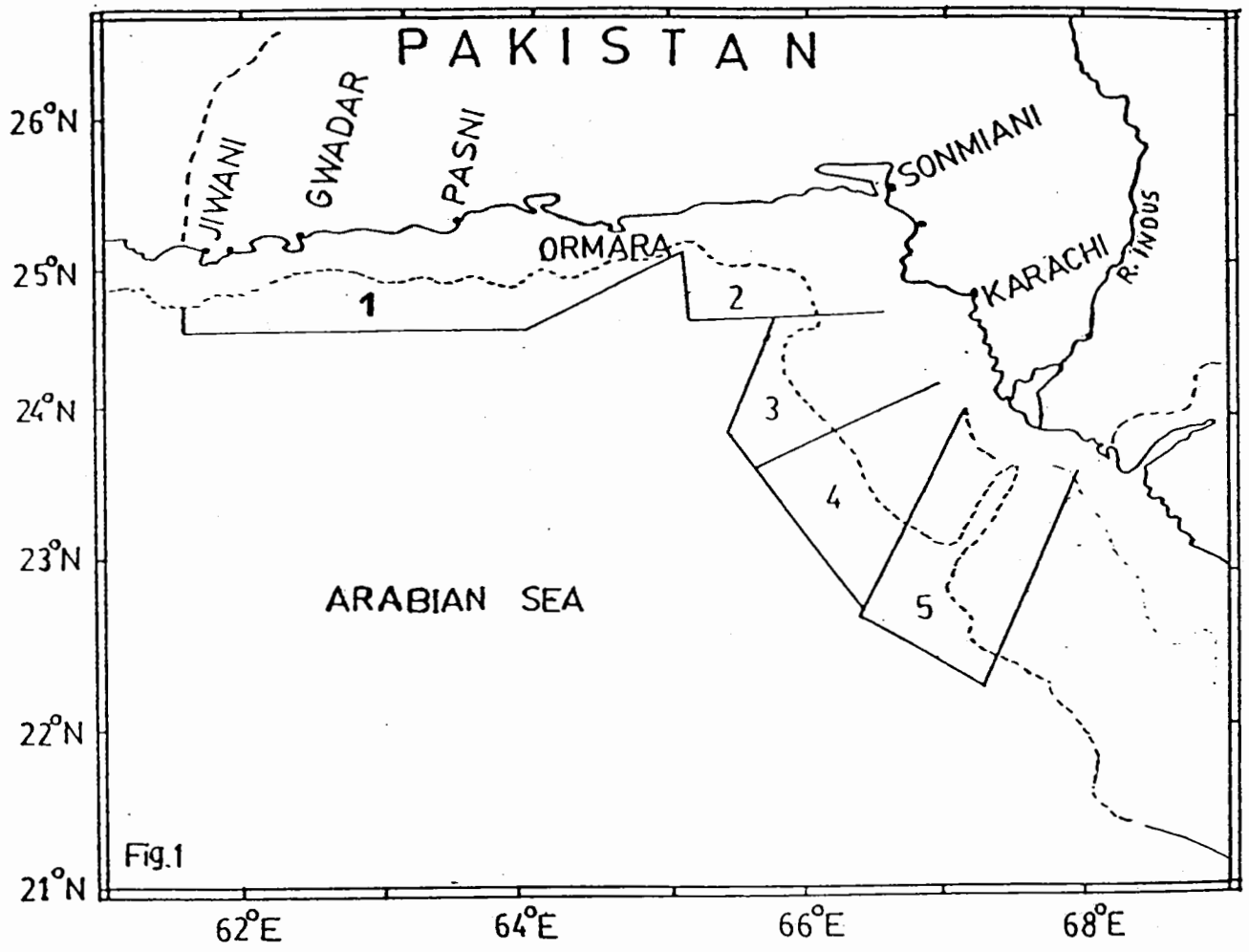

Figure 1: Map of the coast of Pakistan showing the location of principal coastal towns, the Indus River, and the major fishing grounds (1 to 5). Both Manora Channel and Port Muhammad Bin Qasim are located in the Karachi area. Off-shore oil exploration is being conducted on the continental shelf corresponding to fishing grounds 4 and 5. The shelf on the coast of Sind is wider than on the coast of Baluchistan and pollutants would have a greater residence time on the continental shelf corresponding to fishing grounds 4 and 5.

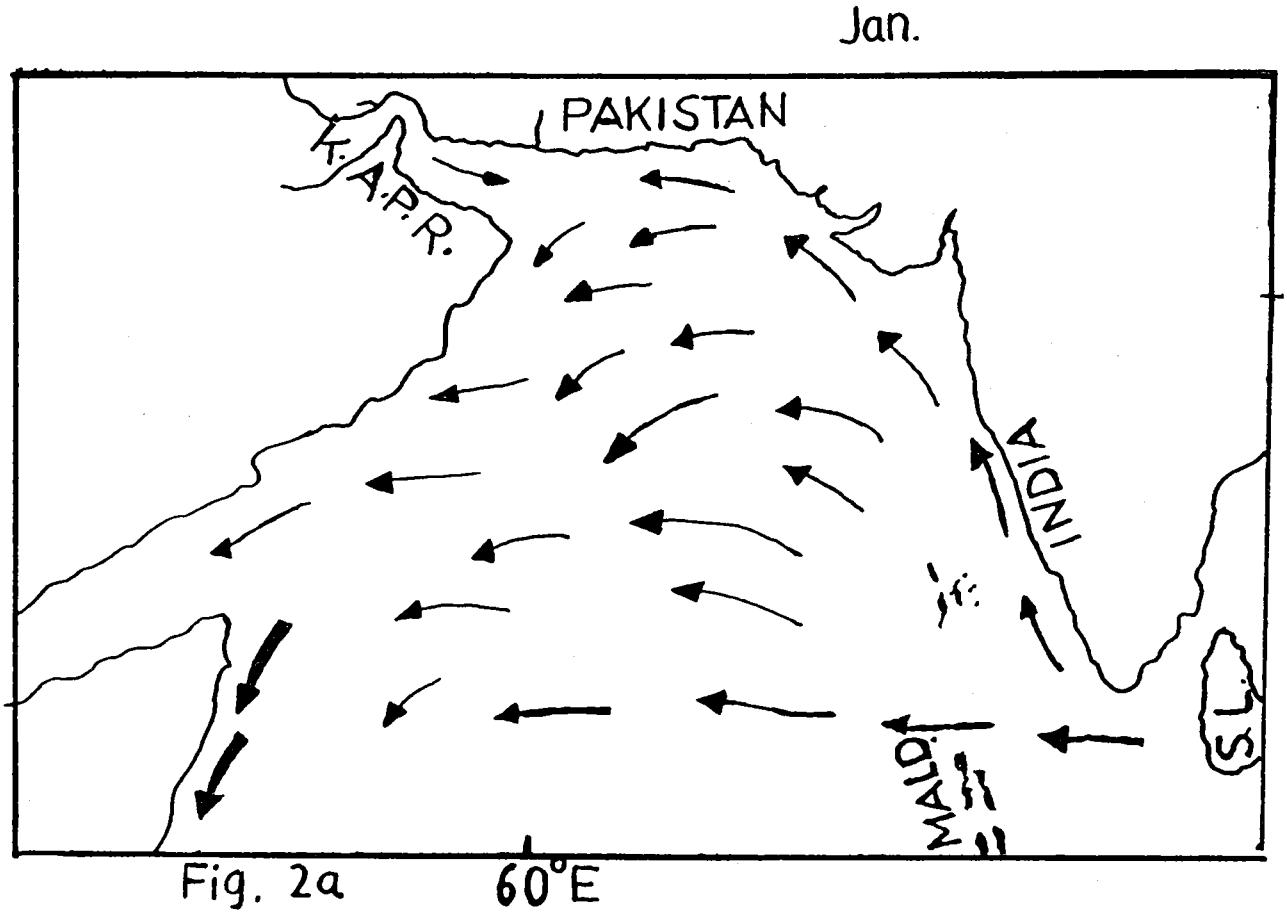

Figure 2a: Current patterns in the Arabian Sea in the month of January (counterclockwise; representative of the NE Monsoon pattern of currents).

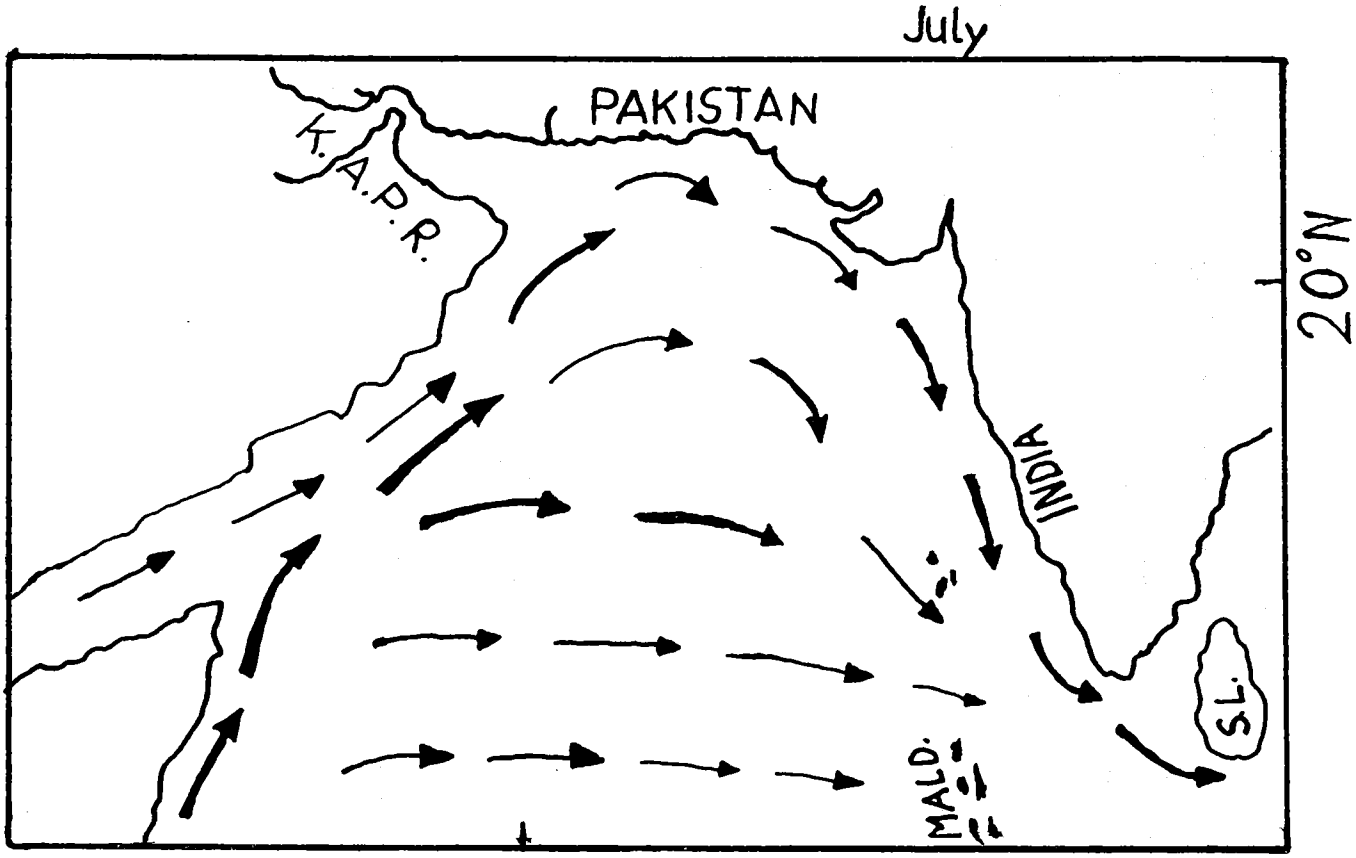

Fig. 2b

Figure 2b: Current patterns in the Arabian Sea in the month of July (clockwise; representative of the SW Monsoon pattern of currents). K.A.P.R. denotes the Kuwait Action Plan Region; the Somali Current is represented by dark strong arrows on the East coast of Africa and near the Gulf of Aden.

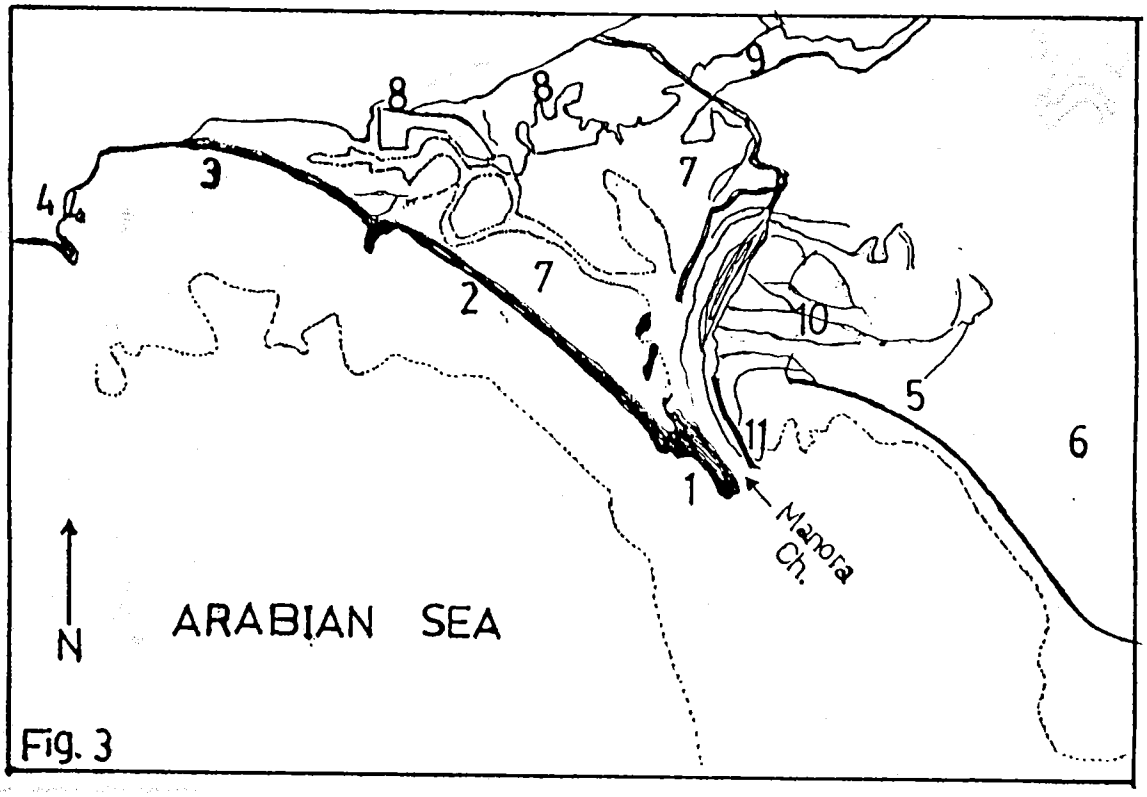

Figure 3: The Manora Channel (Karachi Harbour) area

1. Manora Island
2. Sandspit
3. Hawksbay
4. Buleji;Paradise Point Area
5. Clifton
6. Gizri area (site of oil refineries and pollution treatment plant 2)
7. Mangrove area in the Manora Channel
8. Salt pans
9. Lyari River
10. Chinna Creek area (polluted with oil)
11. Seawall (polluted with oil; oyster mortalities).

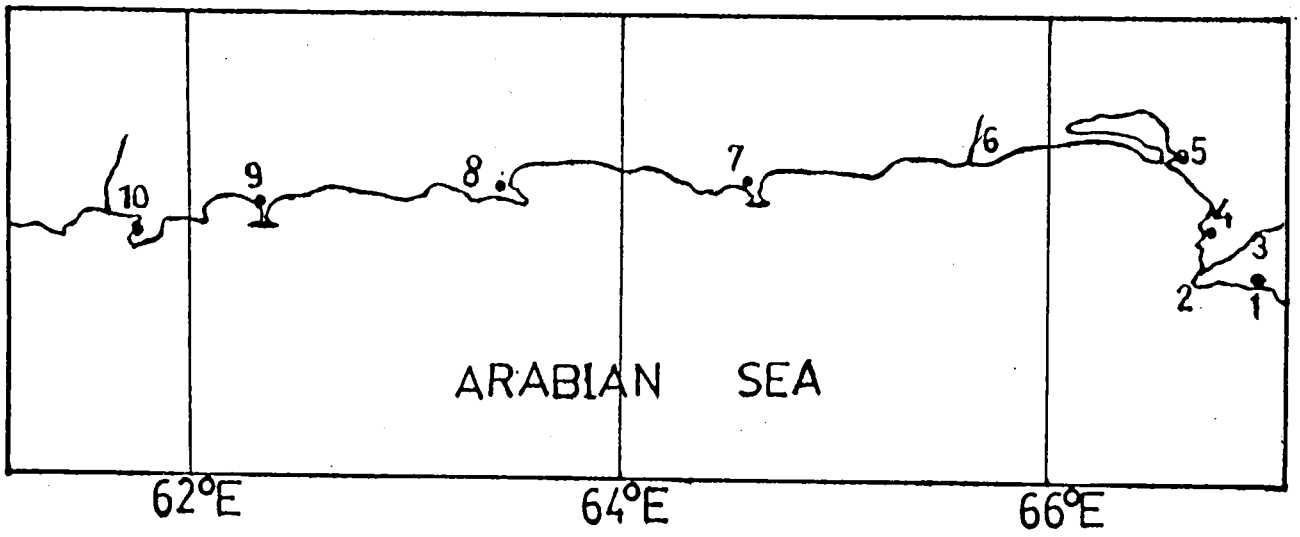

Fig. 4

Figure 4: Map of the coast of Baluchistan and a part of the coast of Sind, showing the locations of:

1. Karachi area
2. Cape Monze
3. Hub River
4. Gadani
5. Sonmiani Bay (Damb)
6. Hingol River
7. Ormara
8. Pasni
9. Gwadar
10. Jiwani

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