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:	202,572 m.t.
	Baluchistan:	77,362 m.t.
	Total:	283,043 m.t.
Foreign Exchange Earnings:	1983	908 million rupees
	1981	654 million rupees
No. of Fishermen	Sind	63,525
	Baluchistan	21,531
	Total	85,056
Fishing Boats:	Trawlers	820
	Gill-netters	353
	Mechanized-cum-sail-driven	3,790
	Non-mechanized sail boats	3,242
	Total:	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