The Creation of a Marine Sanctuary after the 1991 Gulf War Oil Spill

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A task force of the Commission of the European Communities, which participated in international remediation efforts following the Gulf war oil spill, proposed the establishment of a Marine Habitat and Wildlife Sanctuary for the Gulf Region. Since October 1991 an international, interdisciplinary team of scientists has been working in an area north of Jubail, Saudi Arabia, monitoring the effects of the oil spill on habitats and biota, developing methods for habitat restoration, and assessing conservation needs. A conservation management plan for the area has been drafted. Two years after the oil spill, the upper intertidal is still covered with an almost continuous band of oil and tar. It has lost most of its typical plant and animal communities. On some rocky and sandy shores there are signs of recovery and recolonization. The lower intertidal was only locally affected and most of it has recovered by now. Subtidal habitats and biota largely escaped oil contamination. They are in reasonably healthy condition. On the offshore islands marine turtles nested within the expected numbers. The breeding success of terns was normal in 1991, but declined dramatically in 1992.

During the 1991 Gulf War an estimated 1 million t of crude oil were released into the Gulf, an enclosed, shallow, epicontinental sea. Most of the oil that was washed ashore, was deposited along the Saudi Arabian coastline, causing the largest oil spill in human history. The Gulf has always been subjected to oil pollution (Sheppard et al., 1992). Michel et al. (1986) estimated that within 10 years 1.5 million t of crude oil are released into the Gulf. Price et al. (1987) reported on the occurrence of tar on the Saudi Arabian Gulf shore. During a survey in 1986 they encountered beach tar balls at 77% of 53 sites visited. The magnitude of the Gulf War oil spill by far exceeded all earlier spills and required an international response. Within this framework the Commission of the European Communities (CEC) seconded a task force to the concerned authorities in Saudi Arabia. In conjunction with the National Commission for Wildlife Conservation and Development (NCWCD), the Meteorology and Environmental Protection Administration (MEPA) and King Fahd University of Petroleum and Minerals (KFUPM), the European scientists drafted an Environmental Response Plan for habitat assessment and remediation, habitat protection and wildlife rehabilitation. On the basis of this plan, which has resulted in the development of a comprehensive CEC environmental initiative, and in consultation with the concerned regional authorities, the establishment of a ‘Marine Habitat and Wildlife Sanctuary for the Gulf Region’ was suggested.

Since it was not possible to extend this project to the entire coastline affected by the oil spill, an area north of Jubail was selected for the proposed Marine Sanctuary. To the south it is bordered by the islands of Batina and Abu Ali, while Ras az-Zawr forms its northern boundary (Fig. 1). The northwest-southeast extension of the area is about 45 km aerial distance. However, the coastline with its large shallow bays fragmented by inlets, headlands and inshore islands is about 400 km long. Additionally, the five coral islands of Harqus, Karan, Kurayn, Jana and Jurayd, which lie 20 to 70 km offshore, form part of the proposed sanctuary.

The project area lies in the central coastal lowlands of Saudi Arabia's Eastern Province. From its western boundary, the Summan Plateau, this region slopes with an almost invisible declination. The coastline is thus characterized by a wide intertidal zone extending into the shallow waters of the Gulf. The mean annual rainfall is 80 to 100 mm, while open surface evaporation may amount to 3000 mm yr⁻¹. Air temperatures range from less than 10°C in the winter to over 40°C in the summer, thus creating extreme environmental conditions (Barth & Niestlè, 1992). Except for some cliffs and coastal terraces the relief is rather monotonous. Still, the area is of great scenic beauty, almost unpopulated and rich in plant and animal life. This small stretch of coastline contains a great variety of coastal and marine habitats: dunes, sandsheets, rocky outcrops on land, soft bottom tidal flats, and rocky shores, saltmarshes and mangroves in the intertidal, sandy bottom, macroalgal beds, seagrass beds, coral patches and coral reefs subtidally. Baseline data on habitats and biota of the Western Gulf are found in Basson et al. (1977), MEPA/IUCN (1987), Krupp (1991) and Sheppard et al. (1992).

The Senckenberg Research Institute of Frankfurt a.M. in conjunction with an international, interdisciplinary team of about 40 scientists from six European countries, was commissioned by CEC with the implementation of the project. NCWCD became the
key Saudi Arabian counterpart. The project was subdivided into two phases: a project initiation phase from October 1991 to April 1992, followed by an implementation phase from May 1992 to October 1993. Two buildings, which had been set up as a Wildlife Rescue Centre during the war by NCWCD and the Royal Commission for Jubail and Yanbu (RCJY), were made available to the project. In October 1991, they were transformed into a Field Research Station with dry and wet laboratories, a computer room offices, stores and a visitors' room with displays for the general public. By November 1991, these temporary facilities were operational and project scientists arrived.

A Geographical Information System (GIS) was installed on project computers, allowing rapid data analyses. From existing maps, satellite images, aerial photographs and supplemented by ground-truth and sea-truth data an up-to-date base-map of the area was produced and digitized into the GIS, providing an important tool to the geographical, chemical and the various biological teams of scientists.

Objectives of the project are:

1. To assess the damage caused by the oil spill on coastal and marine habitats and biota.
2. To develop methodologies for the restoration and enhancement of coastal and marine habitats and biota which could serve as a case study for the region.
3. To assess and document biological diversity and address on a manageable spatial scale the major conservation needs, with an emphasis on those requiring urgent attention after the oil spill.
4. To contribute to an integrated management approach which will have a lasting effect on environmental quality in the region.

Results and Discussion

The effects of the Gulf War oil spill on the coastal and marine habitats of the proposed marine sanctuary

The oil reached the project area in mid-February 1991. It was washed ashore by wind and high tides and transported into the most distant reaches of the intertidal zone. While subtidal habitats largely escaped oil contamination, the upper intertidal was severely affected. Two years after the spill this area is still covered by an almost continuous band of oiled sediment and tar (Fig. 2).

The habitats and biota of the supratidal, intertidal and subtidal zones of the area proposed for protection are briefly characterized, and the effects of the oil spill described below.

The supratidal. Terrestrial habitats reaching up to 20 km inland are proposed for inclusion in the Sanctuary. This area is characterized by a moderate relief with limestone exposures, dunes and miniature escarpments. Widely rolling dune systems, stabilized by a relatively dense vegetation are a typical feature. Sabkhas, highly saline flats devoid of higher vegetation, cover several
hundred square kilometres of coastal and inland areas. Parts of the coastal sabkhas are periodically flooded during high tides and were thus reached by the oil spill (Barth & Niestlé, 1992).

A diffuse perennial vegetation covers less than 15% of the area. The inter-shrub spaces are bare for much of the year, but after the rainy season they are covered for a few weeks by ephemerals. Over 100 plant species have been identified from this area, with *Calligonum comosum*, *Panicum turgidum* and *Pennisetum devisum* being the most prominent ones. These delicately balanced arid-environment communities are highly sensitive to man-induced changes (Barth & Niestlé, 1992, Böer & Warnken, 1992). Since adjoining terrestrial areas may have a direct impact on marine habitats, they are included in the sanctuary as a buffer zone. Furthermore, the terrestrial fauna is highly diverse (CEC/NCWCD, 1992), and is therefore included in the protection scheme.

Although the oil was carried far inland through tidal channels and coastal sabkhas, the terrestrial habitats were not affected by the oil spill, except for the upper tidal fringe. This transition area between supra- and intertidal, is described below.

**The intertidal.** The intertidal zone covers a vast area. Shores are shallow and mainly sandy, the water has many shoals and sandbanks. Changes in tide and wind direction may cause the water front to shift back and forth over several kilometres (Barth & Niestlé, 1992). The tidal regime prevalent in the study area has a semi-diurnal pattern with a tidal range of 0.8 to 1.35 m. In winter the highest spring tide occurs during the middle of the day, while during summer the lowest spring tide is at night. Thus the tidal regime does not place additional environmental stress on intertidal biota (Jones, 1986; Jones & Richmond, 1992).

During the oil spill, the dynamics of tidal fluctuations were responsible for the transport and accumulation of petroleum hydrocarbons in this zone. Most of the oil was finally deposited between the high water springs and high water neaps and the upper intertidal has lost most of its typical plant and animal communities. The entire study area was covered by a continuous band of oil and tar 0.5 to 400 m wide. Due to prevailing wind directions during the arrival of the oil, beaches exposed to the north and north-east are more severely affected than other areas. The penetration depth of the oil was determined by the intertidal morphology and the sediment structure, ranging from 2 to 50 cm. Underlying beach rock often prevented deeper penetration. Most rocky shores are covered by a layer of tar (Jones & Richmond, 1992; Barth & Niestlé, 1992).

Tar mats also cover oiled soft sediment. Beneath these mats the oil is often fluid and a potential source of secondary oil contamination. Without artificial removal these sediments will retain the oil for very long periods. On low energy beaches with fine, silty sediments, where the penetration depth is less than on sandy, high energy shores, animal burrows often conduct the oil to greater depths. The total hydrocarbon burden of rocky and soft bottom beaches ranged from 1.4 to 20 kg m$^{-2}$ (Höpner et al., 1992). A few months after the Gulf War, large areas were covered by fresh sediment, making it difficult to map the extent of the oiled shores.

While on some beaches natural recovery is taking place, other areas will have to be cleaned artificially. Cleaning methods must be compatible with the ecological requirements of a Marine Sanctuary. To this end, various clean-up techniques have been evaluated. A detailed description is given in Watt et al. (1993).

The intertidal zone is covered by extensive mats of blue-green algae (cyanobacteria). Pre-war satellite images reveal the existence of these algal mats before the oil spill. Most of them were severely affected by the oil, but had re-colonized the area by mid-1992. On oiled surfaces they were only observed where the tar layer is covered by sediment. The most widespread morphologies are folded, pinnacle shaped, flat, dome-discoid and polygonal mats, each being characteristic of a certain species composition. The various mat types show a marked zonation. During extended dry periods, the polygonal mats curl up at their edges, lifting the tar layer (Fig. 3). The oiled sediment underneath is then exposed to further weathering (Hoffmann, 1993). Blue-green algal mats might play an important role in natural biodegradation, but the mechanisms are not yet fully understood.

In this study area, more than 20 km$^2$ are covered by intertidal salt marshes. These are highly productive and important feeding grounds for birds and other animals.
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They have been severely affected by the oil spill with almost 50% of the intertidal vegetation being extinguished. Of the three dominant plant species Arthrocnemum macrostachyum lost 35%, Halocnemum strobilaceum 30% and Salicornia europaea more than 95% of its population. In this area, the tar layer changes soil characteristics and inhibits the penetration of water and gases. Reduced evaporation, combined with increased energy absorption on the black surface result in raised temperatures, causing additional stress to plants and animals (Böer & Warnken, 1992; Böer, 1993).

Only a single species of mangrove, Avicennia marina, occurs in the study area. Most of the pneumatophores were smothered with oil. After the war many experts predicted that these, the northernmost mangrove stands of the Gulf, would not survive the oil spill (Heneman, 1991; MEPA, 1991; Barth, 1991). On Qurma Island, where the most extensive mangrove stand north of Abu Ali occurs (Fig. 4), contractors of the International Maritime Organization (IMO) flushed the free-floating oil from the heavily impacted areas to the open water, using high volume, low pressure techniques. This may have saved mangroves on that island. Altogether, 50% of the mangroves survived and a few new seedlings successfully colonized some of the impacted areas after the clean-up (Böer & Warnken, 1992). Re-plantation experiments are providing promising results (Böer, 1993).

In order to set up a monitoring programme for the intertidal fauna, a rapid assessment survey was conducted at regular intervals along the coastline in November 1991, using a Standard Site Information Sheet (Price, 1990) and a Key Species Presence–Absence Data Sheet (Jones & Richmond, 1992). Altogether 37 rapid assessment stations were covered, including four reference sites outside the oil-polluted shoreline. The study area contains good examples of the full range of intertidal habitats for the entire western Gulf. Similarity between stations was assessed by Principal Component Analysis based on species lists obtained for each station. Independent analyses of physical and biological habitat data confirmed the groupings, allowing the selection of representative examples of all intertidal habitats for long-term monitoring. A Permanent Transect Line (PTL) was set up for each habitat type (a total of 10 PTLs, Fig. 1). At these PTLs quantitative data on the distribution of intertidal taxa of epi- and infauna at five tidal levels were collected (Jones & Richmond, 1992).

Key intertidal species were absent at most sites within the study area, while they were present at normal population densities at the control sites. In winter 1991/92 the lower eulittoral and the subtidal fringe of most shores showed normal species diversity, though population densities were reduced (Jones & Richmond, 1992).

By November 1992, the fauna of the lower shore in the study area was no longer different from that of the control sites. On the upper shore, however, the tar mats largely continued to prevent natural degradation of the oil and faunal resettlement. In very sheltered mudflats there is almost no sign of recovery or resettlement on the higher beaches. In rocky shore areas the thin layers of tar dried and weathered, and peeled off the substrate. New recruitment into these areas was observed in the second half of 1992. In general, there is a trend towards recovery with species diversity and population densities increasing, although recent population fluctuations in species such as Nodolittorina suggest that biota stability has not been established (Jones et al., 1993).

Recruitment of crabs (Cleistostoma dotilliforme and

![Fig. 4 Dead mangroves on Qurma Island. The pneumatophores are smothered with oil. About 30% of the mangroves north of Abu Ali fell victim to the oil.](image-url)
*Hyoplax frater* was an important refueling stop on wader migration routes (Heneman, 1991). Zwarts et al. (1991) estimated that a quarter of a million waders are wintering along the Saudi Arabian Gulf coast, based on counts made in January/February 1986. However, these counts must be treated with care. Actual numbers are obviously much lower (Symens & Suhaibani, 1993b). Sabkhat al-Fasl, which lies in the southern part of the study area, is the most important site for wintering waders south of Al Jubail. It supports high numbers of waders, ducks and flamingoes. The north-eastern part of Abu Ali is of extremely high ornithological value as a post-breeding, moult, feeding and roosting area (CEC/NCWCD, 1992). More than 30,000 wintering seabirds, mainly grebes and cormorants, have been killed by the oil spill. Although the estimated mortality of individual species exceeded 50% of regional populations, the oil spill probably did not diminish any species to a level from which it is unlikely to recover (Symens & Suhaibani, 1993a).

The nearshore subtidal. Most of the inshore subtidal areas are very shallow, resulting in extremes of temperature (high and low) and salinity (high), which place considerable environmental stress on biota. In Qurma channel, water temperatures range from 10 to 16°C in winter (in January 1992, 12 to 15°C were measured) and 30 to 35°C in summer. At the Gulf end of the bays salinities ranged from 40 to 43 ppt while they may well exceed 55 ppt in the shallowest regions at the landward end of small bays (Richmond, 1993). Coles & McCain (1990) showed that there is a dramatic reduction in species diversity with increased salinity.

Jones & Richmond (1992) and Richmond (1993) conducted a rapid subtidal assessment, gathering basic information such as geographical position, water depth, substrate type, ecotype and water temperature at 88 sites. These sea-truth data were used for a subtidal habitat map. Based on this information, Subtidal Monitoring Stations were selected, where abundance and percentage cover of epibenthic organisms were assessed on a regular basis. Additionally, cores were taken at soft sediment sites. These habitats were reasonably healthy. The expected species composition, as compared to that reported in the literature, was found. Biota showed a clear seasonality with the lowest species richness during the winter months.

Krupp & Anegay (1993) studied 27 subtidal stations in the area and three control sites south of Abu Ali in March and April 1992. They identified five major habitats: plain sand bottom, macroalgal beds; seagrass beds, coral patches and coral reefs. Species diversity was similar to pre-war conditions. There were no visible signs of damage from oil pollution.

Bare sand ground occurs mainly in areas with strong currents. Most animal species are unable to settle on mobile sand, resulting in a poor epifauna. Richmond (1993) found sponges, polychaetes and crustaceans on bare sand near Ras az-Zawr. Fifty-one infaunal species, mainly polychaetes, were identified. Extensive dredging around Qurma, down to depths of 5 m, has demonstrated a substrate of fine sand and silt where epibenthic organisms are rare. In these channels a few weathered tar balls were found.

Basson (1979) provides descriptions of 84 taxa of marine macroalgae collected along the Gulf coast of Saudi Arabia. De Clerck & Coppejans (1993) have identified about the same number of species from the study area. Since climatic conditions inhibit their development in the intertidal, they are confined to the subtidal, where in some shallow areas north of Abu Ali they grow on tar-covered sediments. The Gulf War oil appears to have floated over the algal beds, leaving them unaffected. Most species are annual, showing a pronounced seasonal variation. For example, *Sargassum* was present as small leaves in January, dominated most surfaces in May and June with plants over 1 m in length, and was absent in October (Richmond, 1993). The genus *Ulva* was missing and *Enteromorpha* was very rare, indicating low nutrient levels in the bays (Coppejans, 1992), confirmed by Höpner et al. (1992).

The extensive seagrass beds in the area are composed of three species: *Halodule uninervis* is dominant with the widest depth range, *Halophila ovalis* forms patches in shallow water, while *Halophila stipulacea* occurs in deeper areas. Krupp & Anegay (1993) found a few, small, scattered tar balls on a seagrass bed south of Ras az-Zawr. These tar balls were weathered and obviously originated from the intertidal. There are no visible signs of oil damage in any seagrass bed.

Fourteen isolated coral reefs are present in the area. A few patch reefs exceed 1 km² while the fringing reef north of Abu Ali is over 8 km long. *Porites compressa* is the dominant species, but at least seven other genera are present in nearshore areas. Despite the close proximity to massive surface oiling, these reefs are in good condition without signs of bleaching or any other form of oil damage (Richmond, 1993; Krupp & Anegay, 1993).

During the oil spill, only very localized fish mortalities were observed, the largest occurring around Qurma, where about one to two dead fish were found per square metre of beach. Bottom, midwater and surface feeders were among the dead fish and their sizes ranged from 1 cm to 1 m (MEPA, 1991). Saudi Arabian fisheries were heavily affected by the war (Carpenter, 1992; Sheppard et al., 1992). The war zone was closed
to fishery for almost 1 year. Test fishing in inshore areas that were covered with oil for up to 3 months revealed apparently healthy, edible fish with no petroleum taste (Carpenter, 1992).

During a 20 day survey in spring 1992 Krupp & Anegay (1993) recorded 92 species of bony fish in the nearshore areas. This number compares favourably with data from adjacent areas in the literature (McCain et al., 1985; Coles & Tarr, 1990). Population densities were within the expected range with no signs of oil damage. Fish populations on nearshore reefs were observed and counted over an 18 month period. They showed a pronounced seasonal variation in visible species diversity and population densities. Both decreased dramatically during the cold season, with the decline starting around October. McCain et al. (1985) observed a similar phenomenon in reefs of the Manifa-Ras Tanajib area further north and concluded that there is a large emigration or mortality from those reefs, presumably due to lower water temperatures in winter. Emigration is very unlikely, since these reefs are surrounded by unprotected sandy areas where reef fish would immediately fall victim to predators. During cold winters like 1991/92, most reef fish die off (pers. obs.). The reefs are recolonized in spring and summer by recruitment from the plankton. For this reason many species of reef fish occurred only as juveniles or subadults throughout 1992. Water temperatures were much higher during the winter of 1992/93. There was also a decrease in visible reef fish populations, but many fish probably hid in the reef and started re-emerging with rising water temperatures. Fish mortality on these reefs is obviously a natural phenomenon and cannot be attributed to the oil spill (Krupp & Müller, 1993).

Robineau & Fiquet (1992) observed four species of cetaceans in the study area, among them the finless porpoise, *Neophocaena phocoenoides*, a species which is extremely rare in the Gulf. They concluded that the oil spill caused no more than a slight mortality among marine mammals.

**The offshore islands.** The five coral cays Harqus, Karan, Kurayn, Jana, and Jurayd off the coast of Saudi Arabia are between ca. 260 and 2000 m long and 80 to 630 m wide. They have a maximum elevation of 3 m above the high tide level. All except Harqus are vegetated (Basson et al., 1977). The northern islands were severely affected by the oil spill. On Karan, IMO-contractors removed 14 000 m$^3$ of tar and oiled sediment from sandy beaches. Clean marine sand was used to re-establish the original contour of the beach. Rocky areas on Karan and Jana are still covered by a layer of tar which originates from several oil spills. During the cold season this tarmac is solid, but in the summer it melts and becomes viscous. The vegetated areas of the islands have not been reached by oil.

These offshore islands are of international importance as breeding sites for three species of terns: the bridled tern (*Sternula albifrons*), the white-cheeked tern (*S. repressa*) and the lesser crested tern (*S. bengalensis*, Fig. 5). Additionally, swift (= greater crested) terns (*S. bergii*) breed there. In 1992, almost 80 000 birds were estimated to have bred on these islands, including the largest known colonies of lesser crested terns in the world. In 1991, Symens & Evans (1993) observed a breeding success of 72–91% and concluded that neither the terns nor their breeding activities had been seriously affected by the oil spill. The terns had not yet returned to their breeding grounds when the oil spill occurred. By the time they arrived, there was no more oil floating on the water surface. Hence the terns escaped contamination during this oil spill.

The high breeding success also indicated that the oil spill did not affect the food sources of the birds in 1991 (Symens & Evans, 1993). This was in contrast to the situation in 1992. The breeding success of the white-cheeked terns on Karan Island in this year was nil since all chicks were predated on by swift terns. The breeding success of the other species ranged between 33 and 46%, which means a 50% decline from the 1991 values. Both phenomena may be attributed to a shortage of

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**Fig. 5** The offshore islands support the largest breeding colonies of lesser crested terns worldwide. In 1992, their breeding success declined dramatically.

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pelagic fish on which these birds feed. At present, it cannot be determined whether this is a late effect of the oil spill on pelagic fish populations, or whether this is due to low water temperatures in winter 1991/92 or a combination of both (CEC/NCWCD, 1992). It might also indicate natural fluctuations in fish populations.

The Socotra cormorant is endemic to the Gulf and southern Arabia. In the area of the oil spill, its local populations were severely affected (Fig. 6). The only breeding site in the study area is on Kurayn Island where ca. 60 pairs were seen in winter 1991/92. This is the only surviving colony in the northern Gulf. In winter 1992/93 the breeding biology of this species was studied on Judhaim Island in the Gulf of Salwa, where almost 10,000 breeding pairs were observed (Symens et al., in press).

The offshore islands are also the primary nesting sites of green and hawksbill turtles in the Gulf. Miller (1986) provides baseline data on marine turtles of the area. The breeding biology of these two species was monitored on Karan and Jana. In 1991, 164 hawksbills and ca. 1100 greens nested on these two islands. In 1992 there was some decrease, with 700 greens and 150 hawksbills nesting. These differences may perhaps be attributed to natural fluctuations. In general, marine turtles continue to nest in (apparently) normal numbers on the offshore islands, the last major nesting sites in the Saudi Arabian portion of the Gulf (Pipeher & Al-Merghani, 1992).

The coral reefs around these islands are the most diverse in the Gulf, with about 50 coral species occurring there (Sheppard & Sheppard, 1991). Except for anchor damage, which is most severe on Jurayd, but was also observed on Karan and Jana, offshore coral reefs are healthy without any visible sign of oil damage (Fig. 7). On Karan a few bleached Acropora were observed, but their number did not exceed normal levels. At certain periods, some of the shallow water reefs are smothered with macroalgae, above all Hydroclathrus clathratus, but this is also a normal phenomenon which does not affect the corals.

About 150 species of fish were recorded in the study area, most of which occur near the offshore islands. Fish populations showed the expected species diversity and normal population densities. As of May 1992, massive recruitment from the plankton has been observed. Despite extensive artisanal fisheries, large specimens of commercial species were encountered commonly. Impact from oil pollution on fish cannot be detected (Krupp & Müller, 1993).

An approach towards the establishment of a Marine Habitat and Wildlife Sanctuary

The area between Abu Ali and Ras az-Zor contains good examples of all shoretypes for the entire western Gulf. It supports a long-standing artisanal fishery and is of the highest educational and recreational value. Owing to the high diversity of its habitats and flora and fauna, it had been earmarked for protection by NCWCD several years before the war. MEPA/IUCN (1987) identified 11 environmentally sensitive areas along the Saudi Arabian Gulf coast. The System Plan for Protected Areas in Saudi Arabia (Child & Grainger, 1990) proposes 14 marine reserves, largely covering these sensitive areas. The Dawhat ad-Dafi/Dawhat al-Musallamiya embayment system and the Gulf coral islands are included in both categories. The 1991 Gulf War oil spill added a new dimension to the task of establishing a marine sanctuary in this area, requiring international action. Due to extreme environmental conditions, many marine and coastal plant and animal species live at the limits of their distributional range. Like arid terrestrial environments, they are particularly sensitive to man-induced changes. In many areas, the Gulf War caused a severe destabilization of this environmental equilibrium.

The establishment of a Marine Habitat and Wildlife Sanctuary, as proposed by the Commission of the European Communities and NCWCD, is seen as an appropriate response. After remediation and recovery from the effects of the oil pollution and other man-induced disturbances, this Sanctuary will help conserve the unique biota of the Gulf and at the same time form a nucleus for the recolonization of other areas affected by the oil spill. Within the framework of MEPA's National Contingency Plan, special emphasis is placed on the development of a regional contingency plan, protecting the area from future oil spills.

The area suggested for protection covers about 1100 km² of land and 1000 km² of sea. It will be subdivided and managed according to NCWCD's System Plan for

Fig. 6 Oiled dead cormorant lying on the shores of Jinna Island 1 year after the oil spill.

Fig. 7 Coral reef near Kurayn Island. The coral reefs around the offshore islands are the most diverse in the Gulf. They do not show any visible damage from the oil spill.
Protected Areas in Saudi Arabia (Child & Grainger, 1990). Most of the area has been proposed as a Resource Use Reserve (RUR), where no hunting, removal of bird or turtle eggs, corals, shells or any other form of marine life will be allowed. Artisanal and recreational fishing will be strictly regulated on good scientific evidence that such harvest is ecologically sustainable. Recreational use will be in terms of a tourism plan. Destructive activities, such as cross-country tourism or dune racing will be entirely banned from the area. The marine and grazing resources will be allocated for the exclusive use of traditional local resource use right holders.

The RUR will serve as a buffer zone for the Special Natural Reserves (SNR) which will be established in Dawhat ad-Dafi, Dawhat al-Musallamiya, Sabkhat al-Reserve (RUR), where no hunting, pollution has been developed (Fleming, 1993). A sustainable, recreational use will be in terms of scientific evidence that such harvest is ecologically scientific research, a Marine Research Station will be built in Marduma Bay, opposite Qumra Island. The long-term success of such a project largely depends on the support it receives from the local and regional population. To secure their support an educational programme for environmental awareness with specific reference to the Gulf and potential threats from marine pollution has been developed (Fleming, 1993). A Visitors' Centre with displays, aquaria, lecture room and laboratory will be established next to the Research Station.

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