1994

Cleaning up the Arabian Gulf: Aftermath of an oil spill

Peter Saenger
Southern Cross University

Publication details

Pre-print of Saenger, P 1994, 'Cleaning up the Arabian Gulf: Aftermath of an oil spill', *Search*, vol. 25, pp. 19-22.

The Gulf Oil Spill: Two Years On

P. Saenger

Centre for Coastal Management
Southern Cross University, P.O. Box 157
Lismore, NSW 2480

With the destruction of over 730 oil wells by the retreating Iraqi forces in February 1991, huge volumes of hydrocarbons were released directly into the marine environment while additional volumes entered the marine environment indirectly as fall-out from the numerous oil fires. Together with shipping losses and the destruction of oil processing facilities, it is estimated that around 10.8 million barrels of oil (MEPA, 1993) were released into Arabian Gulf waters over the period from January to June 1991, oiling the shorelines of Kuwait and, at least, as far south as Abu Ali in Saudi Arabia.

Seen in a global perspective (Table 1), this oil spill into the northern Arabian Gulf far exceeded any previous single spill. In addition, being a semi-enclosed waterway linked with the Indian Ocean only by a narrow passage, the Strait of Hormuz, the turnover time for waters of the Arabian Gulf is long and has been estimated to be 3.5 years. As a consequence of the slow turnover time and its dimensions (approximately 1000 km long, with an average width of 300 km and an average depth of around 35 metres), extremely adverse and long-lasting effects were expected from this spill, raising considerable international concern.

Table 1: Comparative size of earlier notable oil spills and the Gulf War oil spill.

Date	**Source**	**Oil Volume (10^5 tonnes)**	**Location**
1991	Gulf War	15.12	Arabian Gulf
1980	Ixtoc blowout	5.28	Gulf of Mexico
1983	Al-Nowruz oil-rig	2.86	Arabian Gulf
1978	Amoco Cadiz	2.33	France
1961	Torrey Canyon	1.19	Britain
1989	Exxon Valdez	0.36	Alaska

The initial response to the oil spill, during February 1991, was co-ordinated through UNEP (UN Environment Program) who organized a United Nations Inter-agency Plan of Action (UNIPA) consisting of ROPME (Regional Organisation for the Protection of the Marine Environment) and a number of UN and international organizations (such as the International Oceanographic Commission, World Health Organisation and World Wildlife Fund). This plan of action provided a preliminary estimate of the likely extent of ecological damage resulting from the spill and the information needed to prioritize efforts to protect ecologically sensitive habitats. Additionally, some data was collected which identified areas where clean-up responses would be feasible and the types of clean-up procedures to be used. Some data on direct or lethal impacts on an acute basis was also collected (e.g. IUCN, 1991; Greenpeace, 1992) together with data on the volume of hydrocarbons released and their immediate distribution. The International Maritime Organization (IMO) co-ordinated the clean-up financed through a special fund. The relatively quick and successful international and national response to the spill has been recognized (MEPA, 1993) by the Australian Banksia Environmental Foundation award for 1991 presented to the Saudi Arabian Meteorology and Environmental Protection Administration (MEPA).

This initial clean-up phase was followed by studies primarily designed to measure any delayed lethal or sublethal effects for several months to one year after the initial spill impact. Such efforts, conducted during late 1991 and early 1992, included continued quantitative sampling for biological baseline data, productivity measurements and data on the re-distribution of hydrocarbons together with the major processes responsible for their degradation. Specific projects consisted of coral reef inspections to assess the extent of damage (Downing, 1991; Downing and Roberts, 1992) as well as the 100-day cruise through, and investigation of, the oil affected Arabian Gulf by the NOAA research vessel "Mt. Mitchell", co-sponsored by regional and national agencies (Anon, 1993).

As a result of these investigations, it became apparent that the effects of the massive oil-spill had been very patchy - with some environments (e.g. coastal saltmarshes and algal mat communities) showing considerable oiling effects while the majority of habitats showed relatively few. For example, it was concluded by the "Mt. Mitchell" investigations (Anon, 1993) that:

* no significant increase in trace metals in sediment and water occurred as a consequence of the oil spill;

* from Kuwait to Qatar, subtidal sediment contained relatively low and uniform concentrations of polycyclic aromatic hydrocarbons (PAHs), the low molecular weight but toxic fractions of oil;

* the most severely impacted areas were marsh/algal mat complexes and mudflats at the heads of sheltered bays where nearly all halophytes were dead and there was no sign of living epibiota;

* pyrogenic hydrocarbons ie. those produced from incompletely burned oil, were not visible above the petroleum derived hydrocarbons in most sediment samples;

* in sheltered muddy bays, concentrations of total hydrocarbons ranged from 500-900 ppm - about three times the background concentrations;

* in water, oil decomposition was rapid and low concentrations ($<4\mu g/L$) of oil was present although barely above background levels; breakdown products occurred in concentrations 10 times those of parent hydrocarbons, but they declined rapidly from most heavily oiled zones and did not constitute hazardous levels;

* the three species of seagrasses examined *(Halodule uninervis, Halophila ovalis* and *H. stipulacea)* exhibited no significant effects on respiration or photosynthesis to 12-18 h exposure to a 1% solution of Kuwait crude oil in seawater and these results, coupled with field observations, suggest that the oil spill had little effect on the subtidal seagrasses;

* while the intertidal areas were very heavily impacted (see above), there was no visual impact on subtidal biota and no area of subtidal sediment containing more than a few hundred µg/g dry weight of oil could be located;

* one year after the oil impacted the coastline, levels of oil in most subtidal sediments were too low to cause depression in the rate of benthic community respiration or production; such effects were limited to areas in very enclosed bays, adjacent to heavily oiled shores;

* coral reefs examined appeared to be in good condition although the three reefs examined in Kuwait showed signs of stress (presumed to be due to unusually low water temperatures during winter) but overall no demonstrable direct effects of oil could be discerned;

* observations indicated that spawning of staghorn corals *Acropora* spp. found on reefs in the path of the spill was not impaired during 1991 or 1992;

* in terms of fish, there were few unequivocal oil pollution effects attributed solely to the 1991 oil spill although tantalizing suggestions of localized pollution did exist;

* otoliths (which show regular growth rings) of common fish species showed no obvious abnormal growth patterns;

* some sediments showed elevated aromatic compounds and in bile samples from more than 100 fish from several species, only *Lethrinus nebulosus* indicated that some of these fish had been exposed to aromatic hydrocarbons;

  and

* enzymatic induction of cytochrome P-450, an enzyme involved in the breakdown of toxins, increased with increased proximity to the areas most affected by the 1991 oil spill but limited samples precluded definitive interpretation.

Clearly, these conclusions (together with the more descriptive ones such as Greenpeace, 1992; Price, 1993) set the scene for studies which, generally, could be expected to address more chronic life-history impacts, such as disruption of normal cellular histopathology, genetic impairment or disruption, and alteration or modification of normal physiological pathways. Such studies, currently being implemented by the Kuwaiti and Saudi Arabian Research Institutes, the Environmental Protection Agencies and by the Regional Organization for the Protection of the Marine Environment (ROPME), are designed to measure impact for one to three years or longer after the initial spill event, and to document the recovery phase of the impacted systems.

With hindsight, it can be concluded that, although the input of hydrocarbon into the marine environment of Kuwait and Saudi Arabia was massive, relatively few effects and rapid ecosystem recovery have been recorded (Downing, 1991; Khordagui, 1991; Downing and Roberts, 1992; Readman et al., 1992; Khordagui and Al-Ajmi, 1993; Anon, 1993; Price, 1993). This finding is consistent with the observations during the Al-Nowruz oil-well spill during the Iran-Iraq war (Khordagui, 1991). In fact, Khordagui (1991) has suggested that the oil pollution self-purification processes are considerably enhanced in the Arabian Gulf compared with elsewhere for three major reasons:

1. The environment has been subjected to hydrocarbon pollution for thousands of years, through natural oil seeps originating in the seabed. Oil leaking through natural seeps over long periods has given rise to an assemblage of micro-organisms that are adapted and acclimatized to oil pollution. The presence of such specially adapted strains of micro-organisms significantly promotes hydrocarbon degradation process in comparison with other places around the world;

2. The exceptionally high ambient temperature (reaching up to 35°C during summer) accelerates the evaporation of light toxic fractions and some intermediate products of biodegradation and photo-oxidation (light induced breakdown). In addition, high temperatures also lead to extremely high rates of biodegradation; and

3. The rate of photo-oxidation is extremely high when compared with data reported from other parts of the world. This enhancement of photo-oxidation was attributed to the rareness of cloud formation, the long duration of daylight, and the shallowness of the northern coastal water of the Arabian Gulf where the average water depth near the shoreline of Kuwait nowhere exceeds 20 m. At such shallow depth, sunlight is able to penetrate and reach the bottom, causing photo-oxidation of dispersed oil in the water column and precipitated oil on the sea bed.

So what are the implications for similar regions of Australia, particularly for such areas as the Great Barrier Reef which has long been considered as extremely susceptible to hydrocarbon pollution?

One obvious lesson is that effects observed with oil spills in temperate areas (e.g. North Sea or Alaska) cannot readily be extrapolated to tropical regions. Similarly, however, caution needs to be used when extrapolating from the Arabian Gulf to the Coral Sea. The coral communities of the Great Barrier Reef are clearly different from those of the Arabian Gulf - there are many more species over a much larger area on the GBR. Other environmental differences are also present; summer temperatures on the GBR are not as extreme while summer light levels are often lower due to extensive cloud cover.

In Kuwait, the living and dead coral cover of six reefs was examined in detail from 1982 to 1985 and these data showed that, while generally healthy coral communities prevailed, various perturbations had occurred over this period. Thus, *Acropora* and *Porites* die-back had occurred (in 1983 and 1985 respectively) followed by periods of active recruitment (Downing, 1985b). These episodes were ascribed to extreme temperatures (Downing, 1985a; b), a finding supported by experimental evidence from selected coral species in Saudi Arabia (Coles and Fadlallah, 1990; Coles and Jokiel, 1991). In 1992, *Porites* die-back of a similar magnitude occurred again and, although low winter temperatures were suspected (Downing and Roberts, 1992), some hydrocarbon effects could not be ruled out (Fadlallah et al., 1993).

These observations indicate that the coral communities are existing at their ecological limits with respect to low temperature (Coles and Fadllalah, 1990) and high salinities (Coles and Jokiel, 1991). As a result of these latitudinal extremes, the coral communities of the Arabian Gulf are restricted in the number of species (approximately 25 species in total) that comprise these communities (Table 2) and that even this limited species assemblage experiences occasional periods of reversal when die-off of some individual species occurs.

Table 2: Scleractinian coral species richness of reefs in the Arabian Gulf from north to south. (* Communities within oil slick during the war; data from Fadlallah et al., 1993).

Locality	**Co-ordinates**	**Reef-type**	**Species**	**Families**
*Taylor Rock, Kuwait	29°04 48°33	Offshore, platform	11	5
*Qita't Urayfijan, Kuwait	29°00 48°16	Inshore, platform	16	6
*Khaji Reef, Saudi Arabia	28°18 48°34	Nearshore, platform	10	4
*Manifa Reef, Saudi Arabia	27°40 49°04	Nearshore, platform	6	4
*Karan Island, Saudi Arabia	27°42 49°50	Offshore, island	19	7
*Jana Island, Saudi Arabia	27°21 49°54	Nearshore, island	23	8
Arabiyah Is., Saudi Arabia	27°47 50°10	Offshore, island	17	9
Fasht al Jarim, Bahrain	26°33 50°32	Inshore, platform	10	5
5-Mile Reef, Qatar	25°50 51°58	Inshore, platform	10	3

There are no apparent trends associated with oiled and non-oiled reefs. One-way analysis of variance (ANOVA) shows that there is no significant difference in species number between inshore, nearshore and offshore coral communities. In terms of numbers of families, ANOVA (Fisher least significant difference) suggests a marginal increase between the number of families in offshore communities compared with those from inshore and nearshore locations. Two-way analysis of variance between impact (oiled vs non-oiled) and reef type showed no significant differences for either species or families.

In view of the ecological setting of these coral reefs, it can be expected that any additional stressors on these communities is likely to lead either to direct mortality of some or all of the corals, or via sublethal effects (on growth, survival or reproduction) to marked changes in their species composition with time. Species richness data from those reefs surveyed by the 'Mt. Mitchell' suggest that there has been no statistically significant change in species absence or presence since the Gulf War oil spill. Similarly, the species cover data (Downing, 1991; Downing and Roberts, 1992) suggest that there has not been an overall change in species abundances resulting from the Gulf War.

Both of these findings are unexpected (see reviews by Loya and Rinkevich, 1980; Knap et al., 1983; Brown and Howard, 1985; Bak, 1987) given the massive quantity of oil spilled and they suggest that the coral communities of the Arabian Gulf are responding in an unexpected and alternate way.

Most importantly, however, the absence of a 'catastrophic' response in the Arabian Gulf generally, and of the coral communities in particular, is very encouraging, particularly in relation to the Great Barrier Reef. Nevertheless, the likely response of coral ecosystems on the Great Barrier Reef to oil spills is still virtually unstudied and firmly underlines the need for further studies on a range of GBR organisms.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge and thank the following organisations who facilitated this report: UN Environment Program, UN Industrial Development Organisation, UN Development Program, Regional Organisation for the Protection of the Marine Environment (ROPME), the Kuwait Institute for Scientific Research, Environmental Protection Council (Kuwait), the Saudi Arabian Ministry of Agriculture and Water, the Meteorological and Environmental Protection Agency, and the National Commission for Wildlife Conservation and Development.

REFERENCES

Anon, 1993. Final report of the scientific workshop on the results of the R/V Mt. Mitchell cruise in the ROPME sea area. Vol. 1, Kuwait, 24-28 January 1993. ROPME, IOC (UNESCO), UNEP, NOAA, EPC(Kuwait).

Bak, R.P.M., 1987. Effects of chronic oil pollution on a Caribbean coral reef. Mar. Pollut. Bull. 18:534-539.

Brown, B.E. and L.S. Howard, 1985. Assessing the effects of 'stress' on reef corals. Adv. Mar. Ecol. 22:1-63.

Coles, S.L. and P.L. Jokiel, 1991. Effects of salinity on coral reefs. In: Connell, D.W. and D.W. Hawker (Eds.), Pollution in Tropical Systems. CRC Press, Florida, pp. 147-166.

Coles, S.L. and Y.H. Fadlallah, 1990. Coral survival and mortality at low temperatures in the Arabian Gulf: new species-specific lower temperature limits. Coral Reefs 9:231-237.

Downing, N., 1985a. Coral reef communities in an extreme environment: the northwestern Arabian Gulf. Proc. 5th Int. Coral Reef Congr., Tahiti, 6:343-348.

Downing, N., 1985b. Coral reef communities in the northwestern Arabian Gulf. KISR Ann. Res. Rep., pp. 12-15.

Downing, N. 1991. A survey of the coral islands of Kubbar, Qaru and Umm Al Maradem, Kuwait, 13-19 July, 1991. Report to the International Union for the conservation of Nature and the World Wildlife Fund, pp. 1-12.

Downing, N. and C. Roberts, 1992. Report presented to Dr. Habashi (EPC Special Representative) on a survey of Kuwait's coral reefs undertaken 28 November - 2 December 1992.

Fadlallah, Y.H., C.M. Eakin, K.W. Allen, R.A. Estudillo, S.A. Rahim, M. Reaka-Kudla and S.A. Earle, 1993. Reef coral distribution and reproduction, community structure and reef health (Qatar, Bahrain, Saudi Arabia and Kuwait). In: Anon, 1993. Final report of the scientific workshop on the results of the R/V Mt. Mitchell cruise in the ROPME sea area. Vol. 1, Kuwait, 24-28 January 1993. ROPME-IOC(UNESCO)-UNEP-NOAA-EPC(Kuwait), pp. 1-27.

Greenpeace, 1992. The environmental legacy of the Gulf War. A Greenpeace Report, Greenpeace International Amsterdam, February 1992.

Guzman, H.M. and I. Holst, 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea.* Mar. Pollut. Bull. 26:276-282.

IUCN, 1991. Preliminary assessment of war-related and other impacts along the Saudi Arabian coast of the ROPME sea area. Unpubl. report.

Khordagui, H. 1991. Comments on current environmental events in Kuwait. Environ. Manag. 15:455-459.

Khordagui, H. and D. Al-Ajmi, 1993. Environmental impact of the gulf war: an integrated preliminary assessment. Environ. Manag. 17:557-562.

Knap, A.H., T.D. Sleeter, R.E. Dodge, S.C. Wyers, H.R. Frith and S.R. Smith, 1983. The effects of oil spills and dispersant use on corals: a review and multidisciplinary experimental approach. Oil & Petrochemical Pollut. 1:157-169.

Loya, Y. and B. Rinkevich, 1980. Effects of oil pollution on coral reef communities. Mar. Ecol. Progr. Ser. 3:177-180.

MEPA, 1993. Saudi Arabia's response to the 1991 ROPME sea area oil spill. In: Anon, 1993. Final report of the scientific workshop on the results of the R/V Mt. Mitchell cruise in the ROPME sea area. Vol. 2, Kuwait, 24-28 January 1993. ROPME-IOC(UNESCO)-UNEP-NOAA-EPC(Kuwait), pp. 14-39.

Price, A. 1993. The Gulf War 1990-1991: Effects on fisheries and other marine systems. IUCN Marine and Coastal Areas Newsletter No. 1.

Readman, J.W., S.W. Fowler, J.-P. Villeneuve, C. Cattini, B. Oregioni and L.D. Mee, 1992. Oil and combustion-product contamination of the Gulf marine environment following the war. Nature 358:662-665.

Biographical Note: Professor Peter Saenger is the head of the Centre for Coastal Management at the Southern Cross University. He has extensive experience in marine science and management, not only in Australia but throughout the world. During 1993, he was initially commissioned by the Saudi Arabian Ministry of Agriculture and Water to advise on coastal studies and rehabilitation of damaged ecosystems; he was subsequently contracted by the United Nations Industrial Development Organisation and the Environment Program to assist the Kuwait Institute for Scientific Research to design and implement marine recovery studies following the Gulf Oil Spill.