THANKS

A multidisciplinary team composed by has prepared this report:

- Denis Ody, Ph.D., Oceanographer and Environmental Consultant, GIS Posidonie, France, Project Manager
- Matthew Naud, Environmental Consultant, ICF Incorporated, USA
- Marc Vine, Ph.D., Oil Industry Specialist, Senior Consultant, Det Norske Veritas, United Kingdom
- Reinhard Kaiser, Physician, Epidemiologist, Institute for Social and Prevention Medicine, Basel University, Switzerland

Bertrand Charrier, Ph.D. of Physics, Executive Director of Green Cross International, Switzerland led this “Environmental Assessment of Kuwait, Seven Years after the Gulf War”.

Special thanks to Paul Walker, Ph.D., Legacy Program director, Global Green, USA, for his useful contribution.

Green Cross International thanks the general management of the Public Authority for Assessment of Compensation for Damages Resulting from Iraqi Aggression (PAAC) for its trust and the Environmental Claims and Studies Division’s staff for its constant support.

Special thanks to the representatives of the following Institutions: Kuwait Foundation for the Advancement of Sciences (KFAS), Kuwait Institute for Scientific Research (KISR), Regional Organization for the Protection of the Marine Environment (ROPME), and the Environmental Protection Authority (EPA) that contribute to the report.

PRESENTATION

This report has been prepared by Green Cross International with the financial support of the Kuwait Foundation for the Advancement of Sciences and the technical assistance of the Public Authority for the Assessment of Compensation for Damages Resulting from Iraqi Aggression.
The findings, interpretations, and conclusions expressed in this document are entirely those of the authors and organizations to which they belong. Green Cross International has relied on reports and studies, reviewed the literature, analyzed the data, and conducted visits to Kuwait, and applied its best professional judgement. Wherever possible, Green Cross International has confirmed and corrected any inadvertent misstatements. However, any errors in presentation are unintentional and sole those of the authors.

GREEN CROSS INTERNATIONAL

Green Cross International, a non-governmental organization, was founded in 1993, building on the Rio de Janeiro Earth Summit. Mikhail Gorbachev has been chairing the Green Cross International since 1993. The objective of the Green Cross is to promote new values and to facilitate change in the relationship between humankind and the environment. A sustainable society must build on a balance with nature.

Green Cross acts with the spirit of dialogue and mediation. The organization plays the role of catalyst and mobilizes the strength of its whole network for environmental conflict mediation and resolution. Green Cross is a constructive force across multiple sectors, working with governments, corporations, religious groups, international organizations, NGOs and individuals.

The 21 worldwide Green Cross National Organizations implement dozens of projects under the umbrella of 5 main programs: the Earth Charter Initiative, Environmental Legacy of Wars, Water and Desertification, Energy and Resource Efficiency, Environmental Education and Communication.

The Environmental Assessment of Kuwait, Seven Years after the Gulf War is part of the Environmental Legacy of Wars program, in which Green Cross strives to overcome environmental, economic and social threats posed by the aftermath of wars.

ENVIRONMENTAL PUBLIC AUTHORITY

The Environmental Public Authority (EPA) acts to safeguard the different natural resources and administer the same with a more rational way to achieve sustainable development.

The EPA is competent to carry out all activities and functions to ensure the protection of the environment in the state of Kuwait.

The Environmental Public Authority is established by laws nr. 21 in 1995 and nr. 16 in 1996. The Higher Council of EPA is chaired by the Prime Minister.

KUWAIT FOUNDATION FOR ADVANCEMENT OF SCIENCES

Kuwait Foundation for the Advancement of Sciences, a private organization oriented towards public service, was established according to an Amiri Decree issued on Thel Hijja, 1396 A.H., December 12, 1976.

The general aims of KFAS are to support efforts for modernization and scientific development within the state of Kuwait.

Some of the Kuwait Foundation for the Advancement of Sciences' aims are:

- Sponsoring basic and applied research through grants awarded in the fields of Natural Science, Engineering, Health, Food, Sociology, Economics and others.
- Awarding grants to support and encourage research related to investment projects, development works, and experiments related to Kuwait's economy.
- Awarding grants, prizes and recognition to enhance the intellectual development in Kuwait and other Arab countries.
- Training Kuwaiti nationals by granting scholarships and fellowships for academic/training purposes and holding symposiums and scientific conferences.
- Encouraging, supporting and developing research projects and scientific programs jointly executed by Kuwaiti scientific establishments on one hank, and Arab and International scientific establishments on the other.

GENERAL INFORMATION

We welcome any additional information or statistics relevant to this document.

For further information, please contact:

Green Cross International (GCI)

160a, route de Florissant
CH-1231 Geneva-Conches
Tel: +41 22 789 16 62
Fax: +41 22 789 16 95

E-mail: secretariat@gci.ch

Kuwait Foundation for the Advancement of Sciences (KFAS)

P.O. Box 25263
13113 Safat – Kuwait
Tel: +965 242 58 98
Fax: +965 241 53 65

Environmental Public Authority (EPA)

P.O. Box 24395
13104 Safat - Kuwait
Tel: +965 482 05 80
Fax: +965 482 05 70

1.3 Natural Resources

1.3.1 Fisheries

The fisheries are very important food resource for Kuwait and contribute to food security. The shrimp fishery is also the second highest export earner of the country.

1.3.1.1 Fishing

The fleet is composed of artisanal dhow boats, speed boats, and industrial trawlers. The former target both shrimp and fish. The latter work only on the shrimp stock, indirectly contribute to the fish landings through by-catch. It appears from the literature that the composition of the fleet has varied considerably with time.

A Kuwait Institute for Scientific Research report (1989, *in* PAAC, 1997) gives the following numbers:

- Dhows targeting fin-fish fishery: 46
- Dhows targeting shrimp: 124
- Speed boats: 773
- Industrial trawlers: 70.

Abdul-Ghaffar and Al-Ghunaim (1994) indicate that the number of dhows used for shrimp fishing was 145 at the beginning of the 1980's and that this number decreased to 23 with the implementation of a ministerial decree. However, authors note that a number of dhows licensed for fin-fish had actually trawled for shrimp as well. As a result more than 70 dhows boat were trawling for shrimp during the 1993/1994 and 1994/1995 seasons. The same paper indicates that the number of industrial trawlers belonging to the three companies (United Fisheries of Kuwait, Bubiyan Fisheries Company, National Fishing Company) is 35 (at the date of paper publication in 1994), a number given also by Siddiqui *et al.,* 1998.

The main gear used for fin-fish fishery are:

- Gargoor (fish trap), used by dhows and speed boat
- Gill net's used by dhows and speed boat
- Trawls used by dhows and industrial vessels (by-catch of shrimp fishery)
- Hadra (fish trap installed perpendicular to the coast in shallow waters) harvested from the land.

1.3.1.2 Species and Landings

The fish landings are dominated by a few number of species: Zobaidy (*Pampus argenteus)*, Newaiby (*Otolithes argenteus)*, Subbor (*Tennalosa ilisha)*, Maid (*LIza carinata*) and Hammor (*Epinephelus coioides*). These five species account for about 56 % of the total landings (1992-1996). The average annual landings before the war, 1980-1989, was 5,445 tons (PAAC, 1997).

An important part of the fish landings comes from by-catch of the shrimp fishing. This by-catch is difficult to evaluate because numbers varied in the different sources. Mathews and Samuel (1989) estimate the volume of by-catch at 8,000 to 12,000 tons per year. They indicate that most of the by-catch taken in Kuwait is discarded at sea. In a report made by PAAC (PAAC, 1997), the bycatch from industrial shrimp trawlers is given as 400 tons from a paper of Baddar *et al.* (1990, *in* PAAC, 1997). The main concern is the amount of this by-catch that is discarded at sea. A Food and Agriculture Organization (FAO) report states that "By-catch and consequent discards are a serious problem in the waters of Kuwait, Iran, Saudi Arabia and Bahrain, where the by-catch of shrimp trawlers can be as much as ninety-five percent (95%) of the catch…". Even though it is difficult to quantify, it could be said that only the most appreciated species are retained and that a great amount of by-catch fish are discarded that could be used for human consumption or for processing into other products, as it is done in other countries like India.

The shrimp fishery relies on two main species *Penaeus semisulcatus* and *Metapenaeus affinis* and to a lesser extent on *Parapeneopsis stylifera*. The two main stocks are independent, and even though *Penaeus semisulcatus* is the main targeted species, these stocks tend to compensate for each other, depending on the year. When the catches of *Penaeus semisulcatus* are low, the proportion of *M. affinis* in the landings should increase up to 40% (Bishop, pers.com.). The average annual shrimp landings during the pre-war decade was 2,441 tons (PAAC, 1997).

1.3.1.3 Management

In terms of management, it is important to know if the stocks are local or shared with other countries. Al-Hossaini (unpublished data) categorized some major species (Table 1-2).

Table 1-2: Type of stocks for some major species in Kuwait.

LOCAL STOCKS	SHARED STOCKS
Hamoor (*Epinephelus coioides*)	Zobaidy (*Pampus argenteus*)
Maid (*Liza carinata*)	Suboor (*Tennalosa ilisha*)
Shaem (*Acanthopagrus latus*)	Nagroor (*Pomadasys kaakan*)
Shrimp (*Penaeus semisulcatus*)	Newaiby (*Otolithes argenteus*)
Shrimp (*Metapenaeus affinis*)	Khobat (*Scomberomorus guttatus*)
	Chanaed (*Scomberomorus commerson*)

For local stocks, spawning and recruitment happen within the local waters, migration to or from neighboring waters is thought to be negligible. For shared stocks, spawning and/or recruitment occur out of Kuwait's waters and shared stocks migrate to Kuwait's waters on a seasonal basis for feeding.

Before 1968, there were few if any management policies implemented in Kuwait. The first management effort was undertaken in 1968 when industrial vessels were forbidden from trawling in Kuwait Bay and waters within two miles of the coast (Van Zalinge *et al.,* 1981 in Abdul-Ghaffar and Al-Ghunaim, 1994). This decree was expended in 1980 to prohibiting any trawling in Kuwait Bay and in the three mile band from the Kuwaiti coast.

In 1980, a closed fishing season was established. After a test period, it appeared that July 1 was the best date for opening and since 1987 the opening of the season happens on this date (Abdul-Ghaffar and Al-Ghunaim, 1994). The closing of the season is decided during the fishing operations depending on the landing trends: when the daily catch of the industrial trawlers decrease below 80-100 kg/day, the season is closed in order to protect the stock (Bishop, pers.com.). From 1980/1981 to 1989/1990, the season lasted for four months on average, and for six months from 1991/1992 to 1996/1997.

The fishing effort was also limited as a result of the alarming long-term downward trend of the recruitment index. From 1986/1987 to 1989/1990, the total effort had dropped from 10,400 to just over 4,000 boat-day, principally as a result of the limitation on the number of dhow boats licensed for shrimp fishery (from about 145 to 23, *see* above).

The fisheries management policies, that limited the number of licenses associated to good environmental conditions appeared to be fruitful because the 1988-1989 and 1989-1990 seasons show record landings, 5,125 and 4,057 tons respectively.

1.3.1.4 Recreational fishing

Recreational fishing is very important in Kuwait. The catches from recreational fishing have been estimated to be 10% of the total landings before the war, and have noticeably increased since the liberation. A number of recreational fishermen seem to have increased the number of gear they use. As an example, some of them use as much as 50 gargoor, a traditional Arab fishing basket, while professional fishermen use 100 on average (Al-Hossaini, pers.com.).

2.2 The Gulf War Impacts on the Marine Environment

2.2.1 Introduction

It is established that the oil spills impacted primarily the southern coasts of Kuwait and the Saudi Arabia coasts north of Abu Ali, which corresponds to a maximum distance of about 400 km from the source (Readman *et al.,* 1996; Gundlach E.R.*et al.,* 1993; Jones *et al.,* 1996; Fowler *et al.,* 1993). For the Saudi Arabia shoreline alone, it is estimated that 707 km have been oiled, of which 366 km were heavily soiled (oil coverage > 50%). The width of the oil cover ranged from 1 to 1,000 m, the oil penetration into the sediment was 1 to 12 centimeters. The total amount of oily sediment is estimated at 1,254,490 m^3 (Gundlach *et al.,* 1993).

There were relatively few early surveys made on the Kuwaiti coast because mines and unexploded ordnance prohibited access for months after the War. However, later investigations and satellite or airborne radar images indicate that the most oiled shoreline were located in the southern part of the coast (from Ra's al Zour to the Saudi Arabia border) (Randolph *et al.,* 1998). Fortunately, the Kuwaiti islands escaped the oil spill (Downing, 1992), as did most of the extensive intertidal areas of Kuwait Bay.

The question arose during the oil spill whether the oil will remain on the surface or sink with time as it did during the Nowruz oil spill. One author (Thorhaug A., 1991) estimated that about one sixth of the spill may have incorporated bottom sediment and become tar balls. In a more recent work, Michel *et al.,* 1993, it was suggested that there is no evidence of large scale sinking of oil in the nearshore subtidal habitats along the coastline of Saudi Arabia. The oil was either recovered or grounded before the shamal winds seasons, and these conditions limited the ability of the slick to be loaded with sand and desert dust and to sink.

According to the crew of the industrial shrimp trawler *Al-Amattar*'s observations, a number of tar balls were caught in the trawls during the first two years after the War. The number of these tar catches has reduced with time and is now close to zero. On this fishing boat, the trawls never catch pockets of oil. These observations suggest that a certain amount of weathered oil has sunk and formed tar balls, but also suggests that the presence of oil pockets or oil pools on the sea bottom is very unlikely.

Another question is the impact on the sea from the fallout from the oil well fires. The specific compounds produced during high temperature combustion of oil (Polycyclic Aromatic Hydrocarbons, PAHs) are different from those resulting from its natural degradation. Thus it has been possible to evaluate the respective impacts of both pollution events. The oil well fire fallout have impacted the marine environment less than the oil spill, and have not resulted in any large-scale contamination of coastal area in the Gulf in the short-term (Fowler *et al.,* 1993).

2.2.2 Impact on Coral Reefs

Regarding the magnitude of the Gulf War oil spill, the smallness of coral reef islands in Kuwait, and the delicacy of the coral polyps, observers feared irremediable damages on coral reefs. Actually, the literature is relatively unanimous in concluding that Kuwait's coral reefs escaped from this situation.

Downing (1992) made a terrestrial and marine survey of Kuwait's coral island ecosystem (Qaru, Umm al Maradem, Kubbar) a few months after the War. The conclusion was that the corals reefs were almost intact. In comparison with data before the War (1984-87) there is an improvement in the percent of living cover of *Porites* and *Acropora* in 1991. Coral appears perfectly healthy, showing no sign of oil impact nor ecological problems.

The noticeable impact on coral was a damaged zone in the inner reef of Qaru island.

A survey on offshore reefs in Saudi Arabia made by Vogt (1995) 3.5 years after the Gulf War led to the same conclusion. Comparison of videos of six permanent transect lines indicated a significant increase in live coral cover between 1992 and 1994 (6.9% increase). There were no visible signs of immediate or late effects up to 3.5 years after the Gulf War (Vogt, 1995).

On the other hand, a survey in early 1992 made by scientists participating in the NOAA Mt. Mitchell Gulf cruise reported that the northern inshore and offshore reefs were significantly impacted and have undergone a sudden, rapid deterioration (Fadlallah *et al.,* 1992 *in* Downing and Roberts, 1993).

In 1993, the areas surveyed in 1991 were surveyed again for possible long-term effects. The reduction of water temperature had been detected (Downing, 1991, McCain *et al.,* 1993 for Saudi Arabia) as a result of the smoke plume(s) from the oil well fires, and the potential toxicity of the polyaromatic hydrocarbons from the soot fall-out.

Increase of dead coral, in particular *Acropora sp.* at Kubbar and Umm al Maradem island was observed. Inshore reefs in Kuwait that are close to point sources of oil released during the War were monitored. Getty Reef showed no sign of stress or recent coral kills. However, Qit'at Urayfijan reef had quite clearly been impacted in particular at the shallowest depths. This extensive survey showed that large colonies remained healthy and almost all the dead colonies had small disks of new coral growth.

Each coral reef has reacted on its own pattern: *Acropora* died at Kubbar and Umm al Maradem, but not at Qaru; *Porites* was affected at Umm al Maradem and Qaru, but not at Kubbar; the inshore reef Qit'at Urayfijan was impacted, but Getty Reef showed no sign of stress even though it lies directly downstream from the points of oil release.

Of the three Kuwaiti islands, only Kubbar showed evidence of a significant overall decrease in fishes abundance. Throughout most of the survey, the presence of small individuals or juvenile fish populations indicated that recruitment had not been adversely affected by War pollution. However, these fish populations are known to present considerable natural fluctuations that make interpretation of changes difficult (Downing and Roberts, 1993)

To explain their observations, the authors propose the following hypothesis: reduced sunlight and lower water temperature during the summer of 1991 may have prevented the accumulation of lipid reserves, impairing the ability of corals to tolerate the low winter temperatures. Widespread bleaching events of *Acropora* have occurred in the past with no obvious cause being isolated. It is highly unlikely that the War was the only cause of the observed corals mortality and decrease in fish abundance, and it is quite possible that it has only a minor influence compared to background environmental factors.

Some researchers (Readman J.W. *et al.,* 1996) have demonstrated that even if not seriously affected, the corals record the contamination events in their calcareous skeleton by trapping the contaminants during the seasonal aragonite deposition. Thus the corals could be used as historical recorders of pollution events. The analyses of corals (*Porites lutea*) from Qaru islands suggest that the War spillage did impact Qaru because the highest concentrations of oil contaminants were found in the band corresponding to the end of 1990 and early 1991.

The carcinogenic PAHs produced during the high temperature combustion of oil were not present in the coral's skeleton (or were there but below the detection limits) suggesting that Qaru was not impacted by atmospheric fallout from the burning wells. This finding is interesting because Downing (1992) reported that Qaru was covered with a layer of soot over the high tide mark a few months after the War.

The more recent literature discussing coral reefs in Kuwait do not report any visible long-term impact from the War. Carpenter *et al.,* 1997 made intensive surveys of the corals reefs in 1995 and concluded that the massive oil spill had less impact on the coral reefs than expected. This conclusion is also true for the heavily oiled coral reefs in Saudi Arabia that do not show evidence of significant changes as a result of the oil spill (Vogt, 1995).

Recent work has shown that at least some of Kuwait’s coral species are capable of successful sexual reproduction (Harrison *et al.,* 1997 *in* Carpenter *et al.,* 1997) despite the extreme environmental conditions. Spawning has been recorded from May to June, possibly continuing until August. The eggs, sperm bundles and planula larvae remain suspended in the water column about seven days in the seawater before settling. Because the oil spill occurred during winter, it could be inferred that oil spill potential effect to the corals’ spawning is low.

It appears that in the short-term, Kuwait's coral reefs have been less impacted than was expected given the magnitude of the oil spill. The main reason is that most of these coral reefs escaped direct contact with the spill (Downing, 1992). The decrease in temperature and sunlight resulting from the smoke plumes should have had a negative impact on corals but it is difficult to distinguish this impact from that coming from natural extreme environmental conditions that occur regularly in Kuwait waters. The apparent resistance of corals to oil spills may also result from an adaptation to such pollution. Kuwait's corals have been submitted to decades of anthropogenic chronic oil pollution, and to centuries of natural oil seepage. Such natural oil seepage occurs for example close to Qaro island.

For the long-term, it is difficult to rank the potential causes of damage to the reefs: there may be long-term effects from the Gulf War oil spill, from continuing chronic oil seepage, from oil releases linked to tanker traffic; or natural environmental conditions. When taking into account the recovery of the corals impacted by oil (Qit'at Urayfijan) and the health of the Qaro island corals despite the proximity to natural seepage, there is an optimistic prognosis for the future of Kuwait’s coral reefs with respect to long-term effects from the War.

2.2.3 Impacts on Intertidal Areas

The intertidal areas were in direct contact with the slick, and have been the most severely impacted by the War. In Kuwait, the most impacted areas were located in the northern islands and in the southern part of the coast (*see above*). The exposed beaches with strong wave action have been generally less impacted and recovered faster than sheltered areas where the oil is more slowly weathered (Sauer *et al.,* 1993). Consequently, the Al-Khiran creeks with low hydrodynamics are one of the most impacted areas in Kuwait. (Behbehani, pers.com.)

The oil trapped in shallow embayments remain for a long time before being removed or naturally degraded. There is a striking correlation between the nearshore morphology and the persistence of intertidal oil. (Hayes *et al.,* 1993)

Jones *et al.,* 1996, monitored the impact of the War oil spill on the Saudi Arabian coastline from November 1991 to April 1993. They observed that the oil quickly drifted to the drier upper-shore, where it was rapidly weathered, forming tar layers. By April 1993 a minimum of 60% reduction was seen in the tar cover, as a result of natural degradation. Mid- and low-shore biomass appears to have survived the oil impact, but despite a 34% increase through the monitoring period, the species' diversity remained 30% below that of unpolluted areas. However, many key supratidal species were absent or virtually extinct. The littoral fringe species diversity was reduced by over 80% in November 1991 and, despite a doubling of this value by April 1993, remained at half that of unpolluted areas. The species without planktonic larvae that rely on the resident adult population for recolonization have been the most severely impacted, and show no signs of recolonization where the whole population was destroyed by the oil spill.

Hayes *et al.,* 1993, studied the same area one year after the oil spill. They reached the same conclusion but, also stress the amount of oil that has penetrated into the sediment. They estimate that the amount of oil remaining in the subsurface of the intertidal zone is several million gallons. This oil is trapped in the sediment at depths sometimes over 40 cm and is protected from the weathering process. This oil will remain for many years in the most sheltered areas.

In Kuwait, Randolph *et al.,* 1998) studied the sediment contamination and toxicity. They conclude that 30 months after the oil spill, the sediment's petroleum concentration remains high, and that these contaminated sediments are potentially toxic to the local benthic infauna. They also point out the risk of long-term contamination from the oil trapped deep in the sediment.

These findings are corroborated by the changes in the benthic communities observed in the intertidal areas along the Al-Khiran creeks. These benthic communities have not recovered to their pre-war equilibrium seven years after the oil slick (Behbehani pers.com.).

The intertidal areas were in direct contact with the oil slick and were severely impacted, in particular the sheltered areas and the upper part of the intertidal areas. The intertidal communities suffered from high mortality rates, and natural recovery was still not complete several years after the War. The oil trapped in the sediment remains a major concern. This oil is protected from weathering and bacterial degradation and should remain for a number of years. These sediments may regularly release oil compounds in the natural environment, with long-term detrimental effects on the intertidal communities, and on the ecological functions assumed by the intertidal areas.

It has been demonstrated that the intertidal sediment comes primarily from the surface sediment of land (KISR, 1985). This highlights the possibility of long-term contamination of the intertidal areas by airborne particulates originating from contaminated soil (e.g., weathered oil lake sludge or soot) and should be considered carefully.

The intertidal areas are intensively used as recreational areas by Kuwaitis, in particular the southern coast. Mines and unexploded ordnance prohibited any use of the beaches in the years following liberation. But even after their cleaning, the remains of the War oil slick have impeded a normal recreational use of the intertidal areas.

2.2.4 Impacts on Subtidal Areas

2.2.4.1 Sediment contamination

Contrary to the intertidal area findings, the subtidal areas were not in direct contact with huge amounts of oil, and the oil did not stay for a long time on the sea bottom. Sauer *et al.,* 1993, analyzed about 200 intertidal and subtidal sediment samples along the Saudi Arabian coast. The results show remarkable differences between both types of sediment: the total hydrocarbon concentrations are two to three orders of magnitude lower in the subtidal samples than in the intertidal samples.

Michel *et al.,* 1993, studied the contamination of subtidal sediments in the same area, in March-April 1992, to determine: whether the oil had sunk and contaminated subtidal sediment and whether the oil initially stranded in the intertidal zone was accumulating in the nearshore subtidal area. At first, the authors found that one year after the oil spill the contamination of the subtidal sediment was limited to the very surface (e.g., 2-5 cm). The level of contamination is correlated with the sediment type; muddy sediment showed the highest oil contamination. Therefore it is not a surprise that the sheltered zones with fine-grain sediment are the more contaminated. There was no evidence of large-scale sinking or accumulation of oil in the nearshore subtidal habitats. The presence of tar balls that have been seen by divers at three locations may be explained by the erosion of intertidal oiled sediment. The primary mechanism of subtidal sediment contamination seems to be absorption of oil on fine-grain particles from suspended sediment. Analysis of the suspended sediment exhibited low levels of contamination - close to the background level - thus demonstrating that the contamination of subtidal sediment was not an on-going process one year after the War.

Readman *et al.,* 1996, analyzed the petroleum contents of subtidal surface sediments from Kuwait and Saudi Arabia. These analyses showed that the oil pollution of Kuwait's beaches (Bidaà, south of Kuwait Bay and Az-Zor, north of the Saudi Arabia border) in 1992 is similar to that of Saudi Arabia's beaches. There is a general trend toward recovery from 1991 to 1992 for most of the stations, with a decrease of approximately 50% in oil concentrations. Surprisingly, two stations in Saudi Arabia and the two stations in Kuwait exhibited an increase of oil contamination from 1992 to 1993 which led, in some cases, to higher concentrations than in 1991 just after the War oil spill. This may be due to increased tanker traffic and associated deballasting following the cessation of hostilities, or migration of oil from the beaches into subtidal areas.

The metal contamination of sediments has been investigated by Abdulrahman and Alam (1993) in Saudi Arabia. They confirmed that the most oiled sites show the higher trace metal concentrations. On a broader scale, Basaham and Al-Lihaibi (1993) compared sediment samples from Kuwait to Qatar. They find a north to south decreasing gradient in trace element concentrations. This gradient does not seem to be related with the level of pollution. It mainly reflects the granulometry of the sediment. The muddy sediment in the north shows the higher trace element concentration: the ratio for north to south extreme values is 20 to 40 for almost all the elements. The authors state that the values obtained stay within the range of those published in the literature for unpolluted areas. The values for Kuwait's sediments are similar to those of Baltic Sea. The War did not significantly increase the trace element concentration in the Gulf sediments.

Nevertheless, it should be noted that the mud content of Kuwait's sediment makes it more sensitive to trace element contamination as well as oil contamination.

These findings are confirmed by the analyses of sediment, bivalves and fish made by Fowler *et al.,* 1993. They found that despite the size of the oil spill and of the oil well fires, the post-war levels of PAHs in sediments were no higher than concentrations that have been reported for coastal areas in northern Europe and the United States. Outside the most heavily impacted area, hydrocarbon levels were as low or lower than concentrations reported from these sites before the War. The authors indicate that these good results may be partially explained by reduced oil production and transport activities in the sector before and just after the War.

2.2.4.2 Impact on Benthic Vegetation

To our knowledge there is no available literature about the War impact on benthic vegetation in Kuwait. Kenworthy *et al.,* 1993, studied seagrass in several contaminated bays along the northern coastline of Saudi Arabia. But seagrass beds are rare in Kuwait waters and these findings, even extrapolated to Kuwait, only partially reflect the Kuwait situation. According to Kenworthy *et al.,* the distribution, the species composition, the abundance, and the productivity of seagrass in oil contaminated areas reveal that seagrass has not experienced acute or long-term degradation as a direct result of the War oil spill. In an attempt to evaluate what impacts might have occurred when the oil initially beached, a physiological assessment of the possible acute toxicity of unweathered Kuwait crude oil was undertaken by the same team. They found that the photosynthetic and respiratory responses of leaf tissues are normal for *Halophila ovalis*, *H. stipulacea* and *Halodule uninervis* exposed between twelve and eighteen hours to unweathered Kuwait crude oil.

Regarding the fact the macroalgae are seasonal, the above findings suggest that War impacts on macroalgae should not be worse than those impacts on seagrass. Any direct impact should not last more than one year.

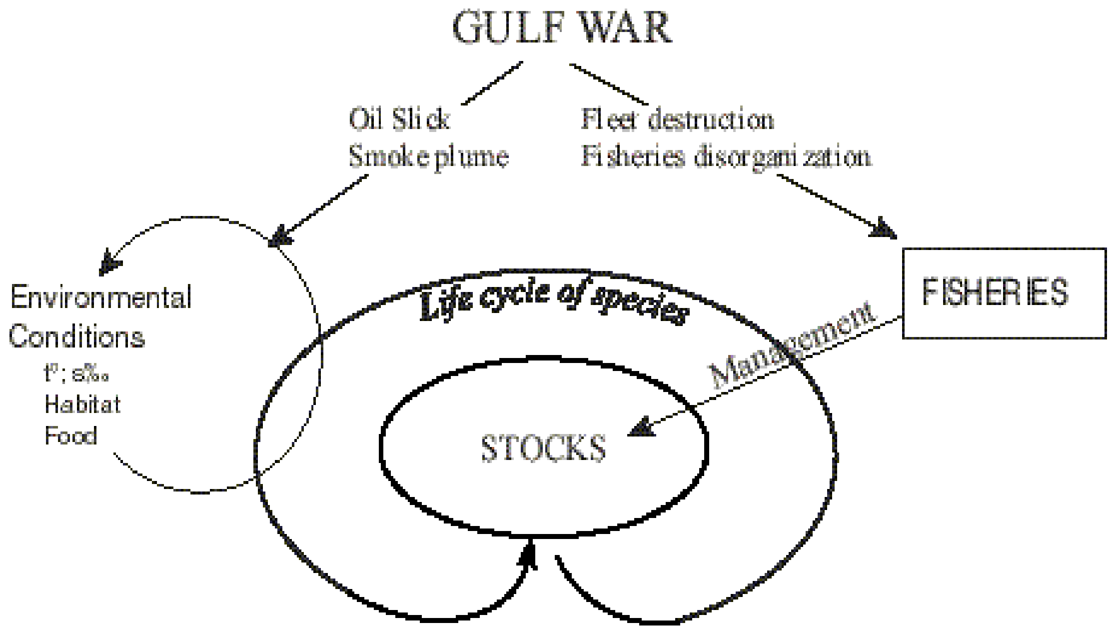
The subtidal areas were less affected than the intertidal areas. The level of contamination is correlated with the sediment granulometry, the fine-grain sediment found in the sheltered areas being the most contaminated.

It seems that most of the subtidal contamination results from the export of contaminated intertidal sediment or suspended sediment. The analysis of sediment deposits collected in traps shows low oil contamination level, within the range of the background level. This suggests that the subtidal contamination process ended one year after the War oil spill.

Taking into account the low level of subtidal contamination, the results of studies on seagrass showing no acute impact, and the seasonality of macroalgae prevalent in Kuwait, the ecological functions assumed by the nearshore subtidal zones have been preserved.

2.2.5 Impacts on Fisheries

The War should have impacted Kuwait's fisheries in two different ways: by affecting the biological resource or by affecting the fisheries infrastructure and organization (Figure 3).



t°: temperature; s‰: salinity.

Figure 3: Schematic representation of the interactions between stocks, environmental conditions and fisheries, with potential impacts from War

2.2.5.1 Impacts on Biological Resources

The main potential impacts of the War on the biological resources should be the following:

- Direct mortality resulting from the toxicity of the oil or the oil well fire fallout,
- Detrimental changes in the physical environmental conditions, in this case, decrease in the sea water temperature and in the sunlight resulting from the huge smoke plume from the oil well fires,
- Destruction or changes of the habitats used by the species through their life cycle, and
- Limitation of the amount of food available for species through their life cycle.

High mortality of adult fish from toxicity of the oil slick or oil well fires fallout is unlikely because most of the fishery species do not live in the upper layer of the sea as adults and should swim away to escape the slick.

It is more likely that the planktonic larval stages or the eggs of many species would have suffered such mortality. Mathews *et al.,* 1993, comparing pre-war and post-war data in the Saudi Arabian waters, have found that there were significant differences in the density of Penaid shrimp larvae (6,77 individuals/m^3 in 1976 versus 0,275 individuals/m^3 in 1992), while eggs were completely absent. Direct poisoning is one of the explanations they propose together with these others:

- Decrease in sea temperature with consequences on the reproductive biology (e.g., temperatures too low to reach a trigger temperature for spawning).
- Decrease in solar energy inducing decrease of primary production and food available directly for the larval stages and indirectly for adult shrimp.
- Problem with the day/night cycle due to heavy smoke that could disturb the spawning cycle.
- Toxicity of oil burned products and soot falling on to the sea for larval stages of shrimp.

- The effect of the oil spill directly (physically), or indirectly (starvation).
- Physical alteration of the habitat of the shrimps as a shelter or a source of food, in particular the inshore habitat of the juveniles.
- Poisoning via direct mortality or indirectly through the impossibility of escaping predators or of finding enough food.

This recruitment collapse explains the dramatic drop of the shrimp landings in 1992, which was only 25 tons, compared to 4,000 tons in 1989, at the end of the first half of the season and caused the suspension of shrimp fishing for the season.(Mathews et al., 1993)

There are few reports available that assess the eventual damages of species habitats. Bishop (1995) has inspected the shallow shrimp nursery habitat in Kuwait Bay and the southern coastal waters. The inspection conducted in July and August 1993 on 40 stations studied previously in 1985-1986, found no overt evidence resulting from the invasion of the War. These results are consistent with the general findings on the subtidal areas (*see above*) that do not demonstrate huge impacts on these zones.

The reduction in light and sea temperature resulting from the oil well fires smoke plume must have had impacts on the primary production and therefore, through the food chain, and on the food resource of the fishery species. The decrease in temperature also influenced the growth rate of the species. Mohammed *et al.,* 1994, have found that lengths and weights of *Penaeus semisulcatus* were significantly lower in 1991-1992 than the other seasons, and this could be attributed to the significant decrease of the sea water temperature observed during this season.

2.2.5.2 Impacts on Fisheries Infrastructures and Organization

The Iraqis destroyed most of the fisheries infrastructures during the invasion. The industrial and artisanal fleet was destroyed or stolen, the harbor and the fish market were also severely damaged, and the mines and ordnance remained a hazard after the liberation. The management of the fisheries also suffered from the War: buildings, equipment, research vessels were occupied, looted or stolen, data were lost, and some of the experienced researchers and managers never came back after the War (PAAC, 1997).

These acute impacts had consequences for several years. The mines impeded fishing operations for months after liberation. The fishermen and fishery companies had to buy new boats and rebuild all their infrastructure. To repay their loans and compensate for their losses, they were driven to increase their pressure on the fish stocks - to the detriment of biological stocks, fishery management, and fishery efficiency (Al-Hossaini, com.per.). Poaching, by the difficulties to enforce the fishering management, became a serious problem after the liberation. This situation was enhanced by the lack of enforcement. As an example, the number of dhow licensed for shrimp fisheries was 28 after the War (25-26 before the War) but may have been as many as 80 dhow boats trawled for shrimp during seasons 1993 to 1995-1996 (Bishop, com.pers.).

The budget assigned to fisheries management was also decreased after the War as a result of Kuwait's effort of reconstruction. (PAAC, 1995)

2.2.5.3 Impacts on Fisheries Landings

Shrimp

The year following liberation (1991-1992) was not a full season for shrimp fishing. Most of the industrial vessels were not in operation and the season was closed early on 28 February (Mohammed, 1994). Total landings for shrimp in 1991-1992 was 582 tons and the average catch per unit effort (CPUE) was also very low, 7.5 kg per fishing hour. During the seasons 1988-1989 and 1992-1993 the CPUE were respectively 17.4 kg/h and 13.2 kg/h (Mohammed *et al.,* 1994). These low CPUE may have resulted from the same phenomenon discussed by Mathews *et al.,* 1993, for Saudi Arabian Fisheries (*see above*).

The landings of the first full season (1992-93) was 2,530 tons. This quantity must be compared to the pre-war seasons (1988-1989; 1989-1990) landings of about 4,000-

5,000 tons. The 1992-1993 record appears grossly under-reported due to non-officially declared fishing by indigenous and foreign fleets from Kuwait's waters (Bishop, 1995). Adding all these catches, the total landings for Kuwait's 1992-1993 season are estimated to 5,800 tons, 670 tons greater than the official all-time record of 5,125 tons set in 1988-1989 (Bishop, 1995 and Mathews, 1993).

Fish

Fishing operations for fin-fish resumed in October 1991. The total landings for 1991 was 1,349 tons and in 1992 there were 4,245 tons caught (Al-Hossaini *et al.,* 1995). Average annual landings before the War (1980-1989) was 5,445 tons (PAAC, 1995) which is similar to those after the War (1992-1996, Al-Hassaini, unpublished data): 5,708 tons.

The statistics show some change in the catch composition - increase in Zobaidy and Suboor and decrease in Hamoor and Hamrah - that can be explained by a major shift in effort from gargoor, traditional fish traps, to gill net fishery, and to shrimp fishery (Al-Hossaini *et al.,* 1995). No significant changes have been detected in the growth and mortality rates of the fin-fish species investigated in the study of Al-Hossaini *et al.,*.

For the longer term, the situation is more complex to evaluate for fish stocks than for shrimp stocks because impacts on the earlier life stages should appear a few years later. Because of this delay, it is difficult to distinguish the War impacts from other factors such as changes in the fishing practices or impacts from other environmental changes.

In Kuwait waters, the biological resource must have been impacted by the War, but the magnitude of this impact and its consequences for fisheries are difficult to quantify. The fact that fisheries resumed operation only about one year after the liberation should have masked short-term impacts. For the medium-term, the shrimp and fish landings do not demonstrate acute impacts because pre-war and post-war averages are similar.

The fisheries infrastructure was severely impacted by the War and the consequences will be felt for several years because of the fishery stock exploitation. The increase in the fishing pressure resulting from the fishermen's efforts to compensate for their losses coupled with the lack of management, enforcement and research in the year following the War, have had and should continue to have more detrimental effects on the biological resource than the War oil pollution itself.

.

3.2 Current State of Marine Ecosystems and Resources

3.2.1 Coral Reefs

An extensive survey of Kuwait's coral reefs was carried out in 1995 by the Kuwait Institute for Scientific Research in cooperation with the United Nation Development Program (Carpenter *et al.,* 1997). The authors of this survey noted that one of the most remarkable aspects of Kuwait's coral reefs is the fact that they survived the largest oil spill in history, most probably because they escaped inundation by oil.

It was also noted that a number of human activities are clearly damaging these reefs. The most obvious form of physical disturbance is anchor damage caused by fishing vessels and recreational boating. The reduced cover of branching and plate corals at Umm Al-Maradeem, Kubbar and Qit'at Uraifjan, may be related to the high visitation rates at these reefs. Because corals provide habitat for reef fish and other reef organisms, any reduction in the coral's diversity would lead to similar reduction in the fish community diversity. Over fishing appears to be having serious impacts on the populations of many of the larger fish species around Kuwait's coral reefs. Very few fish larger than 20cm can be seen on the most popular reefs. Littering is also a problem on some reefs.

Green Cross International made some observations by diving on the coral reef of Qaro island. As a general pattern the marine life is not as flourishing as those found on others corals reefs in the world, but the coral reef's communities appear quite healthy. The corals do not exhibit evident traces of bleaching. Necrosis or partially dead corals covered by algae are present but not abundant. There is no visible trace of oil on the corals. The main observable impact on the corals is the breaking of the most fragile species, *Acropora*. A number of small branches have been broken, as well as some bigger parts that fell on the bottom upside down. The magnitude of this mechanical destruction is of concern, regardless of the small size of the reef.

The fish community is not very abundant in comparison with other coral reefs in the world, and most of the fish are small. The fish have in general a shy attitude toward the diver, that may be the result of spearfishing pressure.

The sea urchins were mainly represented by the long-spine sea urchin (*Diadema*) and were quite abundant. The density of *Echinometra mathaei* appears low in regard with the densities reported in some publications.

A Kuwaiti organization, the Kuwait Diving Team, is currently implementing a program supported by the Environmental Public Authority to install mooring buoys around the most popular reefs. This kind of operation has proven to be efficient worldwide (Bahamas, Fidji islands, etc.) in preventing anchor damage while allowing people to enjoy their visit to the coral reefs.

Conclusion

The coral reefs and the coral islands are the jewels of Kuwait’s marine ecosystem. Though direct negative impacts from the War may not be observable, seven years later, the reefs do suffer from an increasing visitation rate. The physical damage to the corals by anchoring is an important concern, regardless of the small size of the corals reefs in Kuwait.

It is suggested that ongoing private and governmental efforts to protect the reefs should be intensified and efforts to install mooring buoys should be increased. The designation of these islands and coral reefs as *protected areas* would allow more comprehensive management in order to reduce fishing pressure, and littering of the sea and reefs, as well as educating visitors on the vulnerability of such reef systems in Gulf waters.

Though the coral islands themselves represent a very small part of Kuwait’s territory, they considerably extend the boundaries of Kuwait's national waters. Reef structures are the result of a dynamic equilibrium between erosion forces and coral growth. The destruction of coral reefs - which is foreseeable within the coming decades if the negative practices continue uncontrolled - could lead to the disappearance of the whole island. This would have obvious implications for the definition of what constitutes Kuwait’s national waters.

3.2.2 Intertidal Areas

Most of the literature about intertidal areas focuses on the years 1991 to 1993. Unfortunately, there is little information available for the following years, 1994 to 1998. This is sometimes because the results have not yet been published, but also because there are few long-term monitoring programs currently implemented in Kuwait, that address specifically the long-term impacts of the War.

The intertidal areas are on the way to natural recovery. However, traces of the War oil spill remain on the southern beaches in particular. In Al-Khiran, weathered and underground oil is still present seven years later, and the benthic communities have not yet recovered to their pre-war equilibrium (Behbehani, pers.com.). The potential occurrence and impact of continuous leaching from oil trapped in the sediment is a main concern and should be investigated in the long-term.

The intertidal meiofauna has not yet recovered its pre-war equilibrium in a number of stations along Kuwait’s coast (Muna Faraj, per.com.). The actual causes of these disturbances could come from the War, as well as from other anthropogenic chronic pollution.

From the point of view of long-term protection of these vital marine zones, it seems apparent that the most severe threat is that of pollution emanating from industrial areas. In sediment samples collected in 1995, Metwally *et al.,* 1995, found that the highest concentrations are near the Shuaiba Industrial area and the Shuwaikh Port area where both industrial and boating activities and land-based wastewater discharges, are most common.

The development of the coastline is also a major concern. It results in irreversible losses of natural intertidal zones and induces long-term disequilibrium in the erosion process along the coast. Such development has obvious consequences on the ecosystem and on the use of these areas for recreational purposes in the long-term.

From Kuwait to the Saudi border most of the coast is heavily developed and only few if any stretches of shoreline remain in the natural state. A number of coastal constructions such as jetties, boat ramps, and even small harbors have been built without authorization, and thus without any environmental impact assessment (Osama Al-Duaij, pers.com.). Numerous landfilling operations have been carried out along the coast, and it is obvious that in some cases the material used (e.g., waste, scraps) is not suitable for such purposes, and could have detrimental effects on the environment. The dredging of the nearshore areas, which generally comes with the landfilling operations is also a source of major disturbance of the intertidal communities.

The concern of coastal construction is far from new in Kuwait because it was outlined by a Kuwait Institute for Scientific Research report in 1985 (KISR, 1985) that concluded that the most significant activities affecting the intertidal environment are the filling and dredging processes of land reclamation along the coast.

3.2.2.1 Conclusion

The intertidal areas have been the most impacted of the marine ecosystem. Seven years after the War, natural recovery is taking place at a rate consistent with knowledge based on prior major spills around the world. Recovery, has been slowed in the most sheltered areas like Al-Khiran and is not yet completed. However, a comprehensive survey of intertidal areas is required to assess the ecological risk that resurlted from the massive contamination with oil.

Discharges from industrial areas are now the main sources of pollution for the intertidal areas. This threat on an area made fragile by the dramatic pollution of the War should worsen the War impacts or at least slow down the natural recovery of these zones.

The coastal development results from a legitimate wish of Kuwaitis to enjoy the proximity of the sea, but an excessive and uncontrolled development could lead to a significant decrease in the ecological value of the coastal areas. Thus, instead of increasing the enjoyment of the coastal area, excessive development could result in a general decline of their value for human use.

More concerted implementation of ecologically sound land-use planning along Kuwait's coast is urgent for a nation so dependent on the economic, aesthetic, and cultural value of healthy coastlines.

3.2.3 Subtidal Areas

A number of studies about war impacts gave indirect estimates of the pressure endured by the coastal ecosystems from the chronic oil pollution. Readman *et al.,* 1996, explained the increase in the petroleum content of subtidal sediment between 1992 and 1993 by the increase of the oil transport activities that followed the War. Alternatively, Fowler *et al.,* 1993, make the hypothesis that the low level of PAHs in sediment and bioindicators they found despite the War oil spill should result from the reduction of oil transportation activities.

These results suggest two plausible scenarios: the background chronic oil pollution is high because it may hide the War oil spill impacts, or the impact of the War oil spill was low. Both are probably true.

Another study provides a synthetic picture of the oil pollution by studying petroleum components in sediment and biota samples. Literathy *et al.,* 1995. The offshore sediment sample was divided in three layers (from top to 30-35 cm depth) representing recent pollution, previous pollution, and natural background. The comparison among the different layers indicates that the level of the anthropogenic petroleum input is quite high. The total petroleum hydrocarbons content in the upper layers is on average two to seven times greater than in the natural background layer. One exception is the sample in the vicinity of Qaro island where natural oil seepage occurs. However, their conclusion is that the overall concentration on the different petroleum compounds does not indicate a serious environmental problem, and that Kuwait's marine environment has acclimated to cope with the present level of pollution.

Some papers indicate that fish or shrimp have been contaminated by oil compounds. Al-Yakoob *et al.,* 1995, found that the health risks associated with the intake of polycyclic aromatic hydrocarbons (PAHs) through the consumption of fish is apparent. Bishop, 1995, found petroleum as well as associated nickel and vanadium in the shrimp species *Metapenaeus affinis.* Even though the levels recorded should not endanger human health, they demonstrate that marine species consumed by human may be contaminated by oil compounds.

Another major concern is intense coastal development that demands dredging and landfilling. This can cause major disturbances of the most shallow subtidal areas, with direct and definitive losses of these productive areas that assume major ecological functions. Several authors (Sheppard *et al.,* 1992; Bishop, 1995; Mathews *et al.,* 1993) highlight landfilling and dredging as the main threat on the intertidal and subtidal areas as nursery ground for shrimp species.

Conclusion

Inspite of the fact that no systematic survey of oil contamination in subtidal areas of Kuwait have been made, the observations seem to suggest that the impacts of the war oil spill on subtidal areas are difficult to distinguish from chronic pollution. Even though the anthropogenic petroleum input is high, the sediment pollution level seems to remain reasonable. Analysis of shrimp, fish and other bioindicators indicate a certain level of contamination, suggesting that sediment pollution could reach human beings through consumption of marine resources.

In the long-term, it is not unrealistic to think that continuous pollution of subtidal sediment should increase the contamination of fishes or shrimp at a level that renders them unsuitable for human consumption. Therefore, it is important to prevent any contamination of human food through the food chain. Relevant bioindicators are necessary. The limitation of the industrial discharges must be understood as a public health issue.

3.2.4 Fisheries

3.2.4.1 Shrimp

The comparison of the shrimp landings before and after the War (Table 3-1) shows no significant difference. The fishing effort shows marked fluctuations from year to year before and after the War. The effort increases to 9,000-12,000 standardized United Fisheries of Kuwait boat-day (UFK boat-day) in the years 1982-1983 to 1987-1988 and then goes down to 4,000 UFK boat-day, following the implementation of a ministerial decree (Figure 5). Just after the War, the effort was low because of the fleet destruction but it rises very steeply to an all time record of about 18,000 UFK boat-day in 1993-1994 and then decreases again.

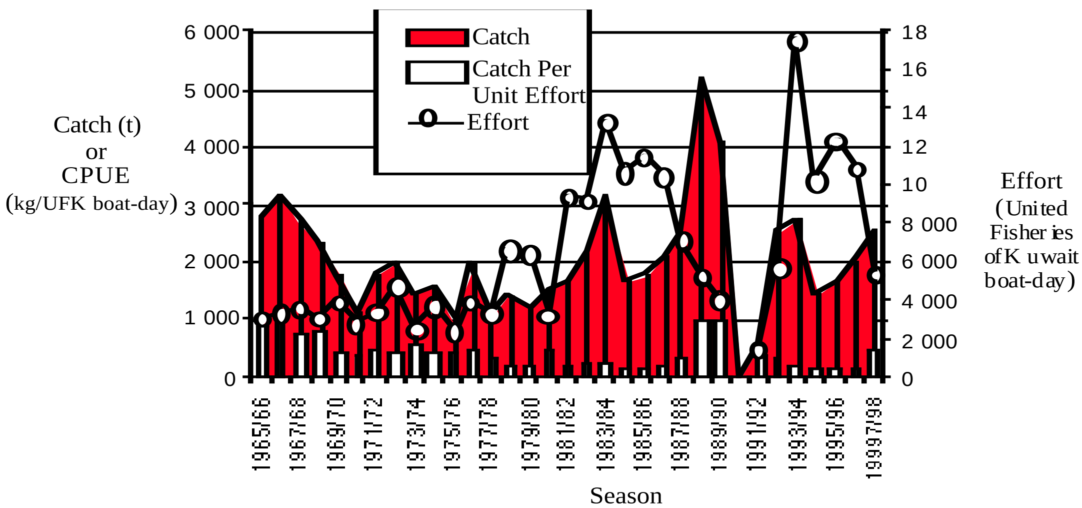
Table 3-1: Comparison of annual shrimp landings before and after the War

Before the War*		After the War**	
Years	Landings (tons)	Years	Landings (tons)
1979-80	1,215	1992-93	2,530
1980-81	1,515	1993-94	2,727
1981-82	1,699	1994-95	1,461
1982-83	2,156	1995-96	1,657
1983-84	3,140	1996-97	2,100
1984-85	1,648	1997-98	2,551
1985-86	1,778		
1986-87	2,065		
1987-88	2,455		
1988-89	5,126		
1989-90	4,057		
Mean	**2,441**		**2,171**

Source: PAAC (1995), Bishop (com.pers.)

Looking to the curve of catch and effort (Figure 5) it can be said:

- There is no evidence of any trend in the landings since the War (slope = -0,000582)
- The relation between catches and effort is obvious: low catches in 1994-1995 for example, resulted from excess effort expended in the 1993-1994 season, which negatively impacted spawning stock biomass (Mohammed and Bishop, 1996). The situation improved in 1997-1998 with an effort below 6,000 UFK boat-day (Bishop, unpublished data). The good results of the years 1989-1991 followed the decrease of the effort.



CPUE: Catch Per Unit Effort - UFK: United Fisheries of Kuwait

Figure 5: Catch, Effort and Catch Per Unit Effort for Kuwait's shrimp fishery from 1955 to 1998[3]

[3] From Hussain M. Al-Foudary (unpublished data).

It has been assessed that the shrimp stock is a local one. Even though this stock may not be totally disconnected from neighboring waters and foreign fisheries, this assumption is operational in terms of stock management, as demonstrated by the good results of the pre-war seasons.

The shrimp fishery relies on a one-year cycle: the shrimp are born, grow, spawn and are caught within about one year. Thus, the annual production of the shrimp fishery depends almost entirely on annual recruitment. The success of this recruitment results from favorable, both environmental conditions and appropriate management, to protect the spawning stock biomass. When both conditions meet, like in 1989 and 1990, the season is exceptional.

Because there were good landings in 1992-93, there is no trend in the landings during the post-war period. The mean annual landings are similar before and after the War, it can be concluded that there is no evidence of continuous unfavorable environmental conditions since the War.

The fishing effort during the post-war period is far over the optimal effort that had been estimated at 4,000-6,000 UFK boat-day (Morgan and Garcia, 1982 *in* Mohammed and Bishop, 1996). However, the catches are on average close to the long-term sustainable landings: about 2,100 tons per year (all shrimp species) (Bishop, com.pers.).

Therefore, the fluctuations of the landings in the post-war period appear to be mainly the result of fishing efforts, instead of as a consequence of biological/ecological impact from the War on the shrimp stock. As mentioned previously, the increase in the fishing effort should be considered war related: in order to compensate for their losses from the War, a number of fishermen increased their fishing effort, and/or have shifted from the fin-fish fishing to the more profitable shrimp fishing (Al-Hossaini *et al.,* 1995).

The high concentrations of petroleum hydrocarbons in the oiled sediments at Al-Khiran, Kuwait and along an extensive coastal area of Saudi Arabia revealed a high potential for continued contamination of the near-shore area, including the sea-surface microlayer (R. Cean Randolph and John T. Hardy *et al.,* 1998). The fact that shrimps larval stages are found near sea surface (being planktonic), could also have a major effect on the stocks.

Conclusion

The satisfactory results of the last season (2,551 tons in 1997-1998) indicate that the potentiality of the shrimp resource is still intact. The fact that the shrimp fishery relies on a one year cycle makes it easier to protect the shrimp resource. Even though there is over-fishing, controlling of the season closing date through catch rate monitoring allows at least some protection of the genitor stock.

The longer term impact from the War could come from a continued contamination of the near-shore area and from a modification of the habitat or the food resource of the shrimp species. According to current knowledge, there is no evidence that War impacts should alter these parameters seven years later.

Nevertheless, Human activities have impacts on habitat and food resources of the shrimp species. Dredging and landfilling damage the intertidal and subtidal nursery areas. The developments in the Tigris and Euphrates basins should lead to major changes in the northern Gulf ecology. The projected development on Bubiyan Island and the building of a bridge across Kuwait Bay should also have detrimental impacts on the marine resources.

3.2.4.2 Fish

There is apparently less literature on fin-fish fishery than on shrimp fishery, and the assessment of the current state of the fish stocks is a very complex task.

It can be said from the annual landings from Kuwait waters that there is no obvious evidence for a decrease in the fin-fishes catches as a whole since the War. The comparison of the fin-fish landings before and after the War (Table 3-2) shows no significant difference, and no trend can be detected since the War.

Table 3-2: Comparison of annual fin-fish landings before and after the War.

BEFORE THE WAR*		AFTER THE WAR**	
YEARS	LANDINGS (KG)	YEARS	LANDINGS(KG)
1980	3,588,670	1992	4,189,616
1981	4,701,707	1993	5,297,520
1982	4,794,218	1994	6,145,779
1983	5,579,161	1995	7,021,649
1984	7,341,644	1996	5,889,048
1985	7,699,352		
1986	5,549,259		
1987	4,985,727		
1988	5,749,339		
1989	4,469,456		
Mean	**5,445,853**		**5,708,722**

Source: PAAC, 1995, Al-Hossaini (unpublished data)

However, Al-Hossaini gives some indications about the state of some important stocks. For a number of commercial species, the current catches are close to or over the maximum sustainable yield (*Hamoor, Hamrah, Newaiby, Nagroor, Fersh, Shaem, Suboor, and probably Zobaidy*) (Al-Hossaini, unpublished data).

The author notes that no surveys or stock assessment studies of shrimp by-catch have been conducted. Thus the status of these by-catch is unknown, and the effect of heavier fishing by the shrimp fishery could not be evaluated.

Conclusion

Despite the War, the marine resources still have a great potential and are a main contribution to the food supply in Kuwait.

However, it seems that a number of important commercial species of shrimp and fish are currently fished close to or over the maximal sustainable yield.

The conjunction of on-going negative environmental factors with high fishing pressures resulting from the decrease of the fishery efficiency since the War should lead to over fishing.

Kuwait can rely upon the good scientific competency and management policies that have proven to be efficient in the past. The implementation of these management policies should help the marine resources to overcome ongoing environmental detrimental factors.

Some detrimental environmental factors, such as the changes in the Shatt Al-Arab discharges, are not under the control of Kuwait. Technical and political solutions to counteract them must be taken under the umbrella of an international body through international cooperation.