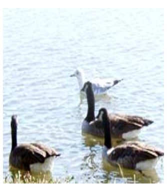
SUMMARY

State of the Marine Environment Report
2003

ROPME

Regional Organization for the Protection of the Marine Environment - Kuwait



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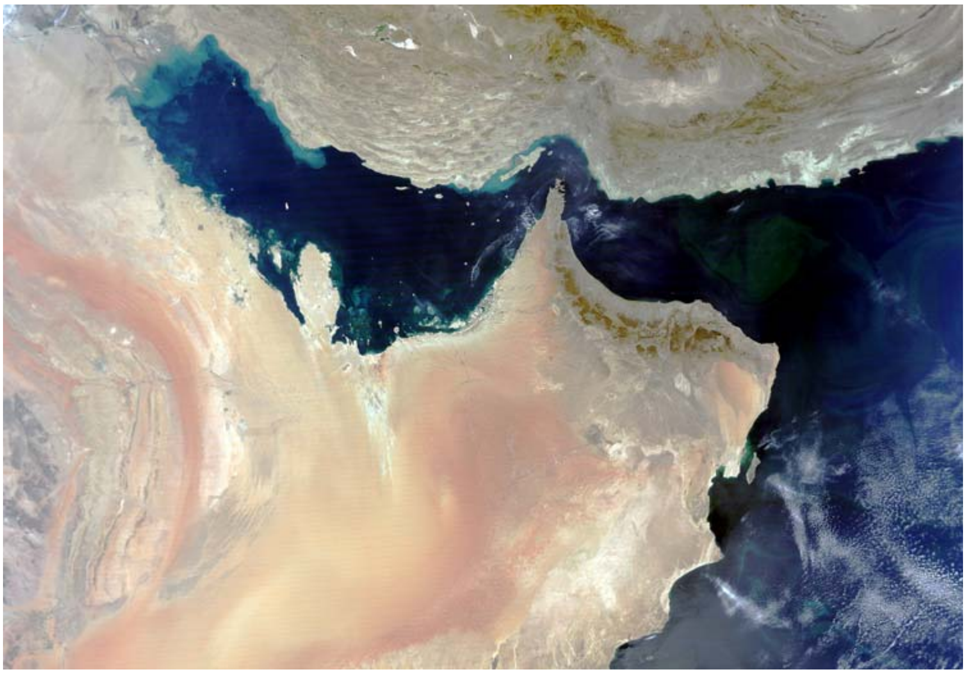

Regional Organization for the Protection of the Marine Environment

KUWAIT

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FOREWORD

H.E. Dr. Abdul Rahman Al-Awadi
Executive Secretary, ROPME

The Third Edition of the State of the Marine Environment Report (SOMER) is prepared in accordance with the provisions of ARTICLE XVII (d-ii) of the Convention, and Decision CM12/1 of the Twelfth Meeting of the ROPME Council. The First and the Second Editions of SOMER were published in 1999 and 2000 respectively, and were distributed to various regional and international institutions and personalities.

In view of updating SOMER 2000, national state of the marine environment reports were received from NFPs I.R. Iran, Oman and UAE, and a few sets of national data and information from NFPs Bahrain, Kuwait, Qatar and Saudi Arabia. The draft Report of SOMER 2003 then was concluded in December 2003, and was reviewed jointly by a consultant from UNEP and experts from ROPME in February 2004 and subsequently by the NFPs Contact Persons in a meeting convened at ROPME Secretariat in May 2004.

This Report is prepared based on the available data and information from Member States, results of oceanographic cruises, results of ROPME-IAEA Contaminant Screening studies, and the published articles from regional and international scientific literature. The information presented in the Report is the latest on the state of the marine environment of the Region. It covers comprehensive information from various sources together with recommendations of experts, and as such is maintained truly of consensus standards. However, we welcome further contributions and shall be grateful for any comments, amendments and proposals for the improvement of the text.

ROPME has received the support of Member States and the cooperation from regional experts in preparing SOMER 2003. We are grateful to all the contributors and the Member States' designated Contact Persons, Dr. Shaker A.A. Khamdan – Bahrain, Dr. Seyed Mohammad Reza Fatemi and Mr. Mohammad Reza Sheikholeslami – I.R. Iran, Mr. Mohammed G. Abel, Dr. Nahida Bader Al-Majed Bu Tayban and Dr. Bahgat B. Habashi – Kuwait, Mr. Musallam bin Mubarak Al-Jabri – Oman, Mr. Ibrahim Salem Al-Darwish and Mr. Saif Shandhour – Qatar, Mr. Hamdan S. Al-Ghamdi – Saudi Arabia and Dr. Saad Al-Numairy – UAE. We look forward to closer collaboration with Member States for better results in our future endeavour. Special gratitude is extended to Dr. Fatemi, Dr. Al-Numairy and Mr. Al-Jabri in recognition of their efforts in preparing of their national reports, to Mr. Sheikholeslami for his technical review of the manuscript, and to Ms. Katharine Mann-Jackson for the English edit of the text.

The contribution of UNEP/Regional Seas and UNEP/ROWA for arranging the visits of experts, Mr. Dave MacDevette from EASD, Dr. Adel Abdel-Kader (UNEP/ROWA) and Mr. Hassan Partow (UNEP/Regional Seas) during the course of reviewing the draft text of the Report is highly appreciated. Thanks are also extended to UNEP/GPA for the financial support as provided for editing and printing of the Report.

The efforts of Dr. M. Thangaraja, Environmental Specialist of ROPME for incorporating the updated information into the Report is greatly appreciated. He processed certain data, worked with regional and international experts, prepared the final design and gathered published materials for the preparation of the Report.

The constructive contribution of Dr. Hassan Mohammadi, Coordinator of ROPME is particularly noted and valued. He led the regional scientists in their preparation of national reports, procured new data through international organizations, arranged experts' review of the manuscript and played the role of chief editor of SOMER 2003.

Captain Abdul Munem Al-Janahi, Director of MEMAC provided updated information on spilled oil, Dr. Peter Petrov, Remote Sensing Expert provided satellite images, Dr. R. Sudarshana, Programme Facilitation and Remote Sensing Applications Expert helped in final design of this Executive Summary and Mr. Ibrahim Hadi, Finance and Administrative Officer provided all necessary facilities for the production of the Report. The neat typing, arranging the figures, tables and text of SOMER 2003 were carried out by Mr. Francis Picardo and the setting and printing by Mr. Basheer Ahmed. To all of them I extend my gratitude.

Finally, my sincere thanks and appreciation are extended to all individuals who provided new data and information and sent their valuable comments and suggestions. SOMER will remain an open book to reflect the current State of the Marine Environment with full transparency to expose all dimensions and concerns of every interested person. We all join hands to make SOMER a truthful reflection of our marine environment. I hope that SOMER 2003 will reach a large audience and inspire them to contribute towards a better and safer marine environment.

1. BACKGROUND

This Report is an updated version of the State of the Marine Environment Report (SOMER) of the ROPME Sea Area (RSA) that was published twice in 1999 and 2000. The main objectives of the Report as stated by the ROPME Council Decision are:

- *To assess and document the current state of the marine environment of the RSA, giving due attention to recent changes in the environmental conditions and the impacts of human activities on the marine environment and coastal areas;*
- *To identify current regional concerns and emerging issues which present major challenges; and*
- *To suggest regional strategies and priority actions commensurate with these concerns and issues to enable governments and decision-makers to meet these challenges at the national level, as well as in regional and global contexts.*

The main objectives of the SOMER are to assess and document the state of the marine environment, identify current concerns & emerging issues, and suggest appropriate strategies & actions to meet the challenges

The ROPME Sea Area is the sea area located at the most north-western part of the Indian Ocean, surrounded by the eight Member States of ROPME: Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. The term 'ROPME Sea Area' was coined by the Plenipotentiaries of the Member States to describe the area covered by the Kuwait Regional Convention of 1978 (Figure 1).

The RSA is made up of three parts, each with its own distinct physical and biological characteristics. These include, the inner RSA which extends over 1,000km along the NW/SW axis from the Strait of Hormuz to the northern coast of Iran. This part is in effect a shallow embayment with a mean depth of about 35m and a depth of about 100m near its narrow entrance at the Strait of Hormuz which connects it to the Gulf of Oman and the Arabian Sea.

The middle RSA consists of the Gulf of Oman, which is a deep basin with depths exceeding 2,500 metres along its central channel. On the Iranian side, it extends from the Strait of Hormuz to Chah Bahar at the Pakistani border.

The outer RSA extends from Ra's Al-Hadd to the southern border of Oman. It is an integral part of the Indian Ocean, bounded to the north by the relatively mountainous landmasses of Oman and I.R. Iran, and deepening rapidly to the south with no barriers separating it from the Arabian Sea and the rest of the Indian Ocean.

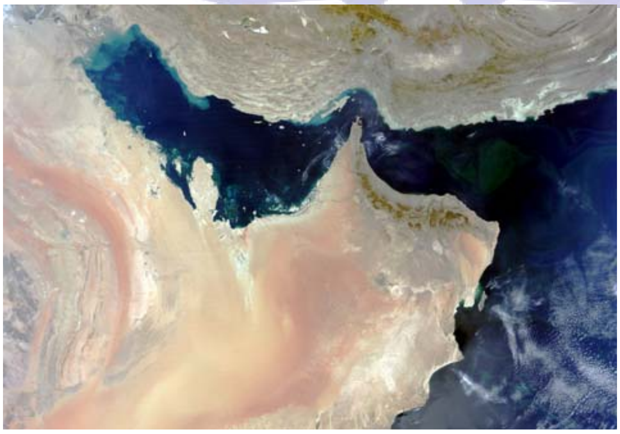


Figure 1

ROPME Sea Area and the surroundings as seen from MODIS sensor of Aqua

2. MAJOR ENVIRONMENTAL ISSUES IN THE ROPME SEA AREA

The impact of the events of the past 30 years or so on the RSA marine environment has been considerable. The most pressing environmental concerns include the decline of seawater quality, degradation of marine and coastal environments, and coastal reclamation. Other major environmental issues include deteriorating conditions in coastal settlements, the loss of biodiversity, industrial pollution, and inappropriate management of toxic chemicals and hazardous wastes. Power and desalination plants also account for or result in an increase in the water temperature in the receiving basins. This will eventually add more stress to the health of ecosystems in the Region.

Rapid and profound changes in this area have produced serious environmental management problems. State environmental authorities are generally young, and experts are needed not only to address current issues but also to study trends in the depletion of natural resources and the pollution of the environment. Environmental issues are gradually coming to the forefront of national concerns. There are also encouraging signs of an emerging awareness among the public of the need to protect the environment. The past two decades have seen the emergence of environmental NGOs that are beginning to promote popular support for national efforts to protect the environment. The business community has also begun to take its environmental responsibilities more seriously.

The most pressing current and emerging environmental issues in the RSA include haphazard coastal developments, introduction of various pollutants, degradation of habitats, over-exploitation of marine biological resources and the introduction of invasive species

Broadly speaking, the most pressing current and emerging environmental issues in the RSA include, the introduction of various pollutants, physical alteration, including destruction of habitats, the use of destructive fishing techniques and overexploitation of marine biological resources, and the introduction of invasive species. These can be summarized as follows:

- *Discharges from land-based activities into the sea are mainly from industries such as petroleum, petrochemicals, desalination, cement and construction materials, textiles, ship repairing and food processing. In the northern part, pollutant-related sources include sewage, organic pollutants, pesticides, trace metals and oil. Population growth and the concentration of the population along the coasts have not matched the pace of infrastructure development. Liquid wastes from coastal cities, villages and resort areas are often discharged directly or indirectly into the sea without treatment, causing eutrophication in coastal waters. Recreational sites along the coasts may contribute to eutrophication problems along the north-western part of the RSA.*

- *The major impacts on the marine ecosystem are caused by physical alteration of the coastline and coastal habitats, by infilling for coastal reclamation, dredging, increased sewage output, the release of industrial effluents, dumping of oily wastes from tankers and oil-loading terminals, and dumping of litter from both land and sea-based sources.*

- *Annually around 1.2 million barrels of oil are spilled into the RSA from marine transportation activities. The level of petroleum hydrocarbons in the area exceeds that in the North Sea by almost three times and is twice that of the Caribbean Sea. ROPME Member States generate from 2–8 times more hazardous wastes per capita than does the United States.*

- *Petroleum hydrocarbons from refineries, petrochemical industries, oil terminals, oil spills from ships (Figure 2) and the disposal at sea through pipelines of oil-contaminated ballast water and dirty bilge, sludge and slop oil are a major concern. Oil pollution continues to be a problem in various areas of the RSA.*

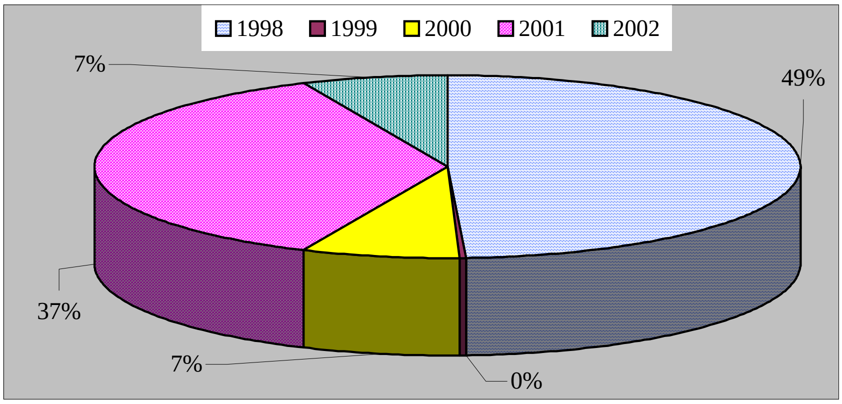


Figure 2 Percentage of oil spilled in the ROPME Sea Area during the period 1998-2002

- *About 20–30% of the sewage discharged into the sea is estimated to be untreated or only partially treated. This poses a potential threat of eutrophication in enclosed areas like bays.*

- *Sand and dust depositions from the atmosphere as high as 29g/m^2/year have been reported.*

- *Levels of persistent organic pollutants (POPs) are still relatively low but the screening of contaminants in marine sediments and biota has revealed low levels of halogenated pesticides, PCBs and organic phosphorous compounds. PCB concentrations in oyster populations have appeared to decrease over the past two decades, but the concentrations of DDT compounds have varied little during the years.*

- *Trace metal concentrations are generally low but there are hotspots near the old outfalls of chemical plants where there are relatively high levels of mercury. Copper and nickel levels are also relatively high near the outfalls of desalination and power plants. Contamination of sediment with high levels of some trace metals, such as nickel, but also with pesticides, suggest that dumping activities have been taking place in certain areas.*

- *Discharges of concentrated and hot brines from desalination plants constitute some of the major environmental pressures in the RSA.*

- *The Region contains only about 8% of the world's mapped coral reefs but almost two-thirds of those in the RSA are classified as at risk, mainly as a result of over-fishing and because more than 30% of the world's oil tankers move through this area every year.*

- *Fisheries are an important resource in ROPME Member States. The fish harvest is decreasing because of coastal pollution, over-fishing, the use of destructive fishing techniques, and inadequate fisheries management.*

- *Marine organisms in the RSA are dying as a result of various environmental factors. The causes of marine mortality in the RSA have been identified as pollutants, sudden changes in the physico-chemical processes of the sea, outbreaks of bacteria, viruses, fungi and parasites, harmful algal blooms and red tides.*

- *Invasive marine species are a potential form of threat to the marine environment of the RSA. An in-depth scientific study is necessary to*

The fish harvest from the RSA is decreasing because of coastal pollution, over-fishing, use of destructive fishing techniques, and inadequate fisheries management

identify the invasive species of the RSA and possible means for their abatement.

- *The Region has witnessed three wars with devastating effects on the environment from the late 1980s to early 2003. Subsequent reconstruction resulted in substantial developments along the shores of the affected countries. The uncontrolled expansion of coastal cities, in which much of the Region's population lives, during the 1990s put even more stress on the marine and coastal environment.*

- *The three wars in the Region have caused extensive damage to the environment of the Sea Area. The Iraq-Iran War, which lasted eight years, targeted refineries, oil terminals, offshore oil fields and tankers; however, the 1991 War exceeded all other environmental disasters of the past four decades. Over 9 million barrels of oil were released into the marine environment. Environmental recovery after an oil spill is a slow process. Fallout from burning oil products produced a sea surface micro-layer that was toxic to plankton and the larval stages of marine organisms. The long-term impacts of these wars on fisheries and the marine environment in general have yet to be assessed. Several projects to assess the long-term impact of the 1991 environmental catastrophe on Kuwait and nearby Member States' ecosystems including, terrestrial, marine and fisheries have been carried out in the different countries since 1991. Respiratory problem and other illnesses related to the crises have also been included in these studies. The recent war in Iraq (March/April 2003) also had a considerable environmental impact in the Region (Figure 3). Moreover the accumulation of hundreds of ship wrecks in the waterways of Iraq and Kuwait poses a continuous threat to the marine life and environment, navigation and public health.*

The three wars in the Region have caused extensive damage to the marine and coastal areas, and the long-term impacts to the environment of the Region are yet to be assessed

Figure 3 An oil well set ablaze at the Rumeila oilfield, Southern Iraq in March 2003

3. ENVIRONMENTAL CHARACTERISTICS OF THE ROPME SEA AREA

The ROPME Sea Area is located in the north temperate tropical region. It is hot and dry in summer and relatively cool in winter with small amounts of rainfall in winter and spring. The winter (December to January) season in the

Region is short and often, spring, which occurs in March or April only lasts for a month.

The Arabian Peninsula and the ROPME Region are considered to be one of the hottest areas in the world. Temperatures in excess of 49°C have frequently been recorded at some measuring stations in the Region in summer especially in the northern part of the RSA. Winter is characterized by mean daily temperatures below 20°C with temperatures sometimes dropping to lows of around 0°C in the north-western part of the RSA.

In the ROPME Region four types of wind prevail in a year. These include the Shamal (Shamal is an Arabic word that means “North”); the Kaus (a local term used to describe a wind, taken from the word for south-east); the sea breezes of coastal areas; and the Monsoon.

Four types of wind prevail in the Region, of which, ‘Shamal’ is the most common type occurring during summer and winter. Shamal causes dust storms & haze and widespread adverse effects on the environment

The Shamal wind is the most common and blows down the axis of the RSA from the north-west in both summer and winter. The summer Shamal can reach speeds of 153 kilometres/hour, causing dust storms and haze. The Kaus blows from south-south-east ahead of an approaching cold front. A strong sea breeze occurs along the entire coastline, especially along the Arabian Peninsula. Wind patterns in the middle and outer RSA are strongly influenced by tropical circulation of the Arabian Sea with south-west monsoon winds during the summer and north-westerlies in the winter months.

Dust and sand storms are among the most important weather phenomena in Kuwait, southern Iraq and I.R. Iran. Dust storms can deposit up to 1,002.7t/km^2 of sediment in the inner RSA in the month of July alone. The dust storms passing over the northern part of the RSA are a major source of marine sediments (Figure 4).

Figure 4 A high-density yellowish dust storm blew over Kuwait City on 26 March 2003

The amount of precipitation in the Region varies greatly, but the general trend is for decreasing precipitation as one goes from north to south, it varies from 48mm in Doha, Qatar to 275mm in Bushehr, I.R. Iran. The average precipitation in the RSA over a period of 17 years has been calculated at about 78mm/yr, which corresponds to 1.9 x $10^{10}m^3$/yr.

Evaporation from the open water of the RSA has been estimated at 144cm/yr. Maximum and minimum mean monthly evaporation from the coastal and the central regions of the RSA have been estimated at 29.3cm in June and 8.1cm in February, respectively.

River flow into the RSA occurs mainly in the north (Tigris, Euphrates and Karun) and primarily on the Iranian side. The Tigris (Dijlah) and Euphrates (Al-Furat) rivers together provide an annual average of 708m^3/sec; and the Karun adds 748m^3/sec. Thus, the total average outflow from the Shatt Al-Arab is 1456m^3/ sec.

The sedimentary nature of the RSA is the result of heavy rainfall that occurred during the Pleistocene era and which brought sediments from the Tigris and Euphrates rivers flowing through the marshes of Iraq and I.R. Iran (the Ahwar or Khors), the Karun and Karkha rivers from the Iranian Zagros mountains and the now dry Al-Batin river from the highlands of the west central part of the Arabian Peninsula. Riverine input is reflected in the composition of sediments on the bottom. It should also be noted that relatively large amounts of sand are deposited by the prevailing NW winds blowing across the axis of the RSA. It is estimated that as much as 100t/km^2 of sand are deposited annually in the inner RSA. Fine (mud) sediments predominate in the north-western part of the RSA and reflect the influence of the river inputs into the area. Much of the RSA floor is made up of biogenic sediment, produced mainly from micro-organisms, predominantly Foraminifera. There is a wide range of other limestone-producing fauna and flora such as corals and some calcareous algae, though in terms of sediment production these are quantitatively unimportant. Carbonate sands are predominant in Saudi Arabia and the UAE coast, whereas, on the Iranian side these are mixed with a greater proportion of terrigenous sediments from the wind, and numerous small riverine inputs (Figure 5).

The sedimentary nature of the inner RSA is the result of heavy rainfall that occurred during Pleistocene, bringing sediments from rivers and hinterland marshes

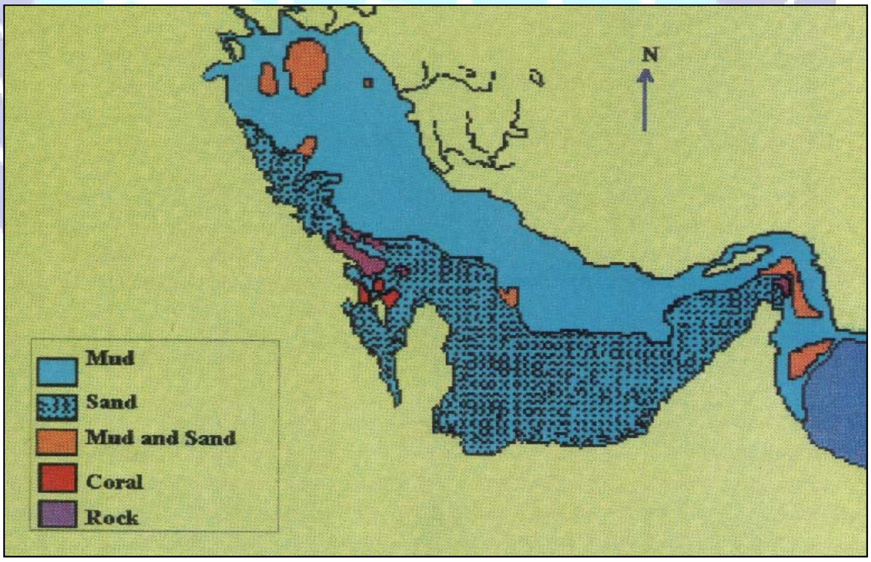


Figure 5 Sediment types in the RSA

The surface water temperature of RSA varies between 12°C in winter and >35°C in summer.

Tides in the RSA are complex and vary from semi-diurnal to diurnal. The tidal range is large with values greater than 1m everywhere. The tidal range varies in the inner RSA from about 1.4m near Qatar to 3m in the extreme north-west and to 2.8m in the extreme south-east. The tidal regime in the Omani coastal waters (middle and outer RSA) is predominantly of the mixed, prevailing semi-diurnal type. Average ranges around the Omani coast are between 1.5m and 2m, with a high of about 3m.

The schematic circulation model of the RSA devised by Hunter (1983) indicated that the flow is predominantly density-driven with surface flow inward from the Strait of Hormuz and adjacent to the Iranian coast. A southward coastal flow is present along the entire southern coast of the RSA. The flow stagnates east of Qatar, where high evaporation and sinking forms a dense, bottom flow to the north-east and out of the Strait of Hormuz. The inflow from the Strait of Hormuz is stronger (about 20cm/sec) in summer and weaker (about 10cm/sec) in spring and autumn. The circulation pattern of the inner RSA has also been classified as one of both high- and low-salinity water exchange in the Strait of Hormuz; density-dominated circulation in the central and southern inner RSA; a frictional balanced, wind-dominated regime in the NW inner RSA; and evaporation-induced bottom flow.

Water circulation in the RSA is predominantly density-driven with surface flow inward from the Gulf of Oman through the Strait of Hormuz, continuing adjacent to the Iranian coast. A southward flow along the southern coast of the inner RSA stagnates east of Qatar, where high evaporation and sinking forms a dense bottom flow to the north-east that eventually flows out of the Strait of Hormuz

The concentration of nutrients in seawater varies over space and time. Measurements of nutrients indicated that the surface nutrient content in the middle and outer RSA is much higher than in the inner RSA. High phosphate surface water (>1µmol/l) from the outer RSA rapidly loses phosphate through mixing and biological stripping as it moves north to the inner RSA (<0.1µmol/l) and the nitrate concentrations (2 to >10µmol/l) frequently drop below detectable limits. This may be taken as circumstantial evidence that nitrates are a limiting nutrient in the inner RSA during winter-time.

Salinity gradually increases from southern to northern parts as a result of higher evaporation, with lower salinity along the Iranian side. In summer, the surface salinity varies from 34‰ (June) on the southern Omani coast on the Arabian Sea to 38.9‰ in the northern part of the Gulf of Oman and increases up to 42‰ just off Bahrain. Very high water salinity, 70‰, has been reported in the Gulf of Salwah at its southern extremity. In winter, salinity is somewhat higher than in early summer in the upper NW of the RSA, apparently due to the variation of fresh water influx from Shatt Al-Arab and meteorological effects, particularly evaporation.

Surface layer dissolved oxygen is normally saturated with a concentration of 6mg/l or higher depending on the temperature and salinity of the water. Depletion of dissolved oxygen occurs in certain shallow waters as a result of nutrient enrichment.

Surface pH in the middle and outer RSA (8.130–8.214) is in general lower than in the inner RSA (8.210–8.320). The pH drops with depth and might reach 7.454 at about 800–900m depth in the Gulf of Oman. Seawater is naturally a buffered solution so there is little variation in pH between the surface and bottom waters. This is evident in the waters of the RSA.

Bathing in sewage-contaminated seawater with microgerms poses significant risks of gastrointestinal disease; and consumption of contaminated seafood causes hepatitis diseases worldwide.

Chlorophyll analyses and phytoplankton cells counts have shown that phytoplankton production is limited to certain areas and does not occur throughout the whole RSA. Chlorophyll-*a* levels ranging from 0.2 to 0.86mg/m^2 have been reported in the inner RSA, while measures of 0.5 mg/m^3 have been reported in the Arabian Sea. A recent estimate made during the Ghods Cruise in summer 2001, showed ranges of phytoplankton of 0.11 to 1.46µg/l at the surface waters of the inner RSA (Figure 6). A total of

147 taxonomic entities of phytoplankton were recorded from the samples gathered by the cruise in the inner RSA and the number of species found at each measuring station ranged from 17 to 62. Relatively limited information is available about the microbiological characteristics and primary productivity of the RSA, thus further research is needed to fill the lacunae.

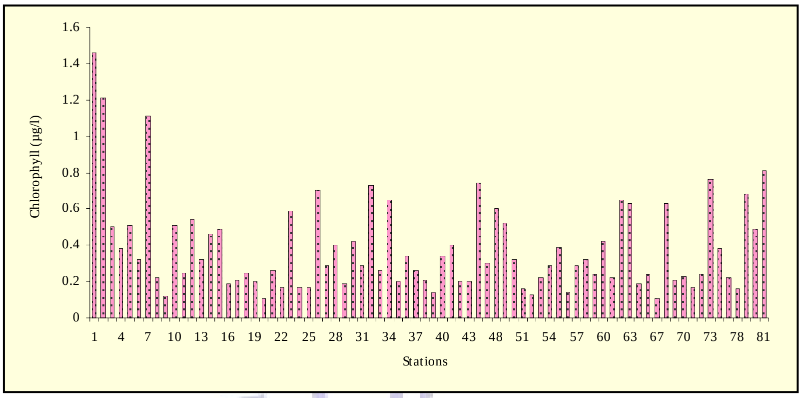


Figure 6 Concentration of Chlorophyll-*a* pigments in the surface waters of the inner RSA measured during the Oceanographic Cruise – Summer 2001

Zooplankton biomass in the RSA varies over time and space, attaining higher in winter than in summer

Zooplankton production in RSA varies over time and space, and estimates have been made through different types of analyses, therefore, comparison of the production levels is difficult. Maximum levels of zooplankton biomass were found in the north-east of the RSA where seawater with high temperatures, low salinity and high concentrations of nutrient and chlorophyll-*a* was recorded. Abundance of zooplankton estimated during the Umitaka-Maru cruises indicated a mean value of 2064.5 ±3282/m^3. Among the species studied, copepods dominated with a mean of 10680 ± 1383/m^3. Copepods are consistently the most abundant constituents with an average of 48.93% of the total zooplankton in Muscat waters as well. In Kuwaiti waters, zooplankton biomass varied from 4.8mg/m^3 (dry/wt.) to 288mg/m^3 with a mean of 186.7mg/m^3. In Qatari waters, it ranged from 100–500mg/m^3. In the Gulf of Oman, the mean overall biomass was found to be 84681mg/100m^3 (wet wt.), whereas on the Arabian Sea coast of Oman it was 62,645mg/100m^3. The Arabian Sea biomass was less than the biomass of the Gulf of Oman by a factor of 1.35. Seasonal variations in zooplankton abundance have indicated that its biomass was higher in winter than in summer. In the inner and middle RSA during winter, zooplankton biomass was 3–3.5 and 2.27 times respectively, higher than in summer.

Most of the marine fishes spawn in the open sea and produce pelagic eggs and larvae, known as ichthyoplankton. Those areas with the highest density of fish eggs and larvae are looked upon as spawning grounds for a number of fish species, and if need be, are closed to fishing, as a conservation and stock replenishment measure. In the inner RSA, the predominant families of eggs belong to the Engraulidae and Clupeidae families, which account for 45.4% of all eggs, whereas the larvae are Engraulidae, Clupeidae and Gobiidae and account for 42.5% of all larvae. A total of 53 families of fish larvae have been identified in the inner RSA. However, in the middle and outer RSA, 54 species of fish eggs and 93 species of fish larvae have been recorded. The highest larval abundance was recorded in the Gulf of Oman where sardines (*Sardinella longiceps* and *S. gibbosa*) and mesopelagic larvae (*Benthosema pterotum*) dominated. For the first time the larvae of kingfish, *Scomberomorus commerson* (Figure 7) were collected from Masirah Bay (outer RSA) in September 1990. Comparative studies of the middle and outer RSA have indicated that the Arabian Sea has 20 times greater egg abundance than the Gulf of Oman, whereas the Gulf of Oman has 2.6 times higher larval abundance than the Arabian Sea. Sardines and mesopelagic larvae dominate in the Gulf of Oman. The eggs and larvae were found in higher concentrations in summer, which is the peak spawning period in the RSA.

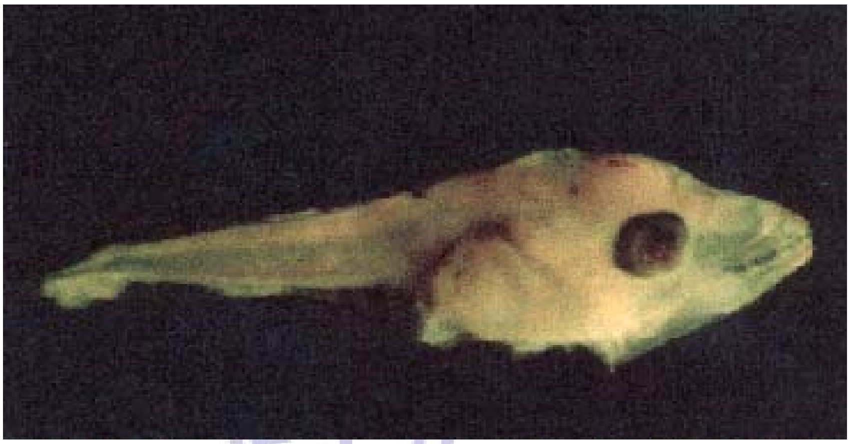


Figure 7 Microscopic view of post-larva (4.9mm size) of kingfish, *Scomberomorus commerson*

The higher concentration of fish eggs and larvae in the RSA during summer indicates that the peak spawning activities of fish take place in this season

Benthic faunal analyses of samples gathered from a recent cruise indicated the presence of 304 taxonomic entities in the inner RSA. The greatest abundance of benthic invertebrates was recorded near the coast of Qatar, while the smallest number was recorded in waters adjacent to the Kuwait and Iraq coastline (Figure 8). The mollusc population was higher in the offshore waters of Qatar (Figure 9), whereas Echnoid concentration was higher in the waters of UAE. Crustacean and Annelid abundances were higher in Qatar and I.R. Iran waters respectively. This study is to be extended to other areas in future.

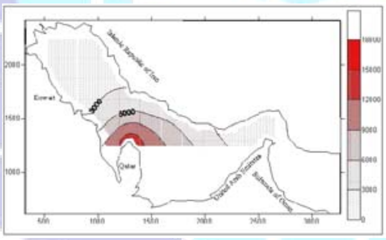


Figure 8 Total number of benthic Invertebrates/m^2 in the inner RSA – Summer 2001

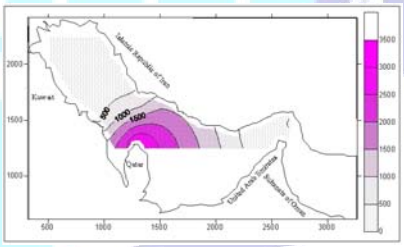


Figure 9 Total number of Molluscs/m^2 in the inner RSA – Summer 2001

4. MARINE RESOURCES OF THE ROPME SEA AREA

The marine environment provides the largest inhabitable space for marine fauna and flora. The marine habitat ranges from exposed beaches to the open sea environment which includes the benthic deep and shallow subtidal habitats, intertidal habitats; rocky, sandy and muddy shores; pelagic, mesopelagic and demersal habitats and so on. Of these, certain habitats are in a critical situation, among them the mudflats, which provide shelter to varieties of organisms. The marine habitats of the RSA are listed and over 85 sites are marine protected areas (Figure 10).

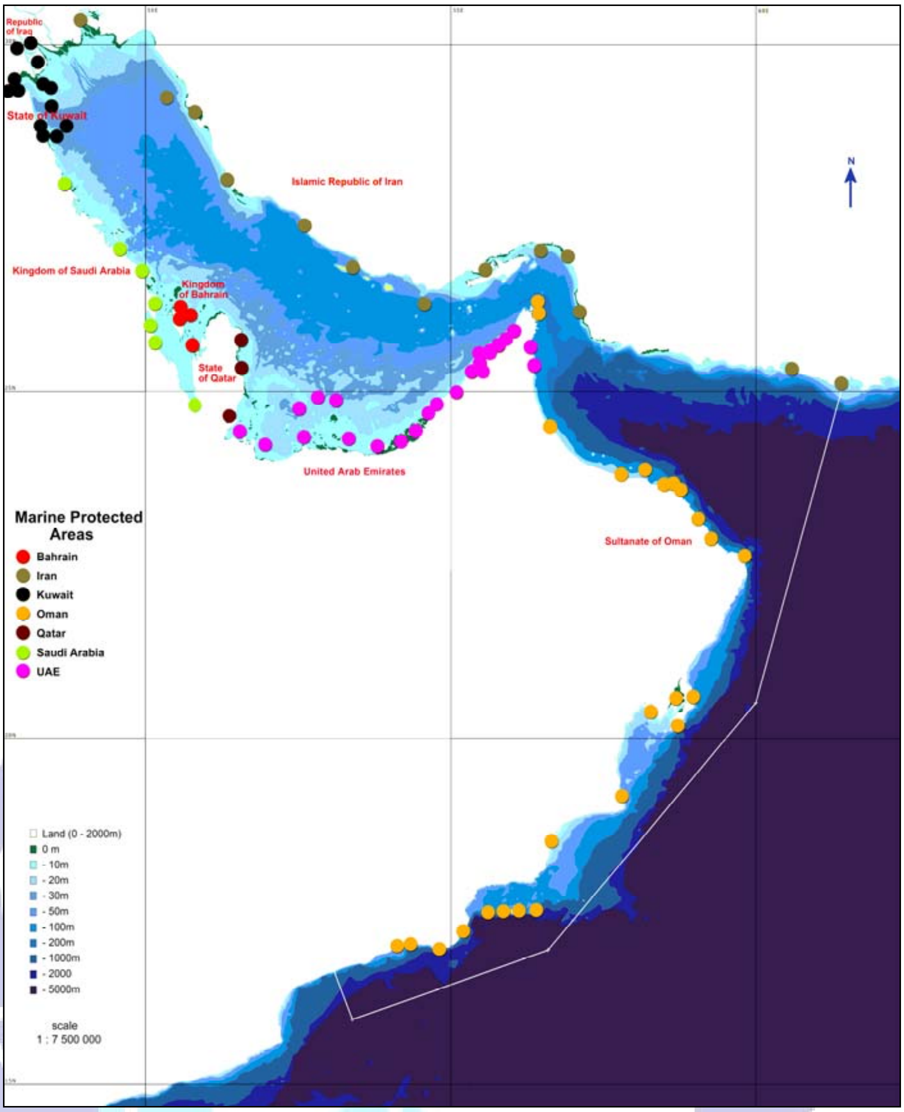


Figure 10 Sites of proposed and established coastal and marine protected areas

Eight parks and reserves have been established along the coast, and over 85 sites are recommended for protection and continuous monitoring

Seagrasses and seaweeds are an important food source as well as good substrates and provide shelter to a number of marine organisms. Seaweeds are commercially important, exploited for alginates, agar and carrageenan. They are often used directly as food for human consumption and organic manure. Marine algae are rich in protein, vitamins A, B, C and E, minerals, folic acids, phenolic compounds, sterols, terpenoids and hologenated substances, used for the preparation of drugs. The seaweeds, Phaeophyta (brown algae), Rhodophyta (red algae) and Chlorophyta (green algae) are harvested worldwide. Four species of seagrass are commonly found in the RSA. Of these, *Halodule uninervis* and *Halophila ovalis* are the most common. The seagrasses of Masirah form an important part of the diet of the Green turtle, *Chelonia mydas*. A recent study revealed that there are 232 taxa of seaweeds in Omani waters. Significant quantities of beached brown algae such as *Nizamuddin* and *Sargassum*, and green algae *Ulva* sp. (Figure 11) were found on the beaches in the Dhofar coast between September and January. The drift material is dominated by brown algae. Dense subtidal beds of seaweeds on the Dhofar coast of Oman form the basic food for several herbivores such as the abalone, *Haliotis mariae*; rabbitfish, *Siganus* spp.; parrotfish, *Scarus* spp.; and the Green turtle, *Chelonia mydas*.

Sargassum sp. *Ulva fasciata* *Nizamuddinia zanardinii*

Figure 11 Drifting seaweed species

Mangroves are found on the mudflats, and provide living space for more than 2,000 species of marine organisms. In the RSA, because of severe climatic conditions and limited habitats, there is only one species of scattered population of mangrove, the *Avicennia marina* (Figure 12). Because the air temperature drops to freezing in winter over the extreme NW part of the inner RSA, mangrove trees are not found in Kuwait and most of the NE coasts of Saudi Arabia. On the Iranian coast, about 10,000 hectares of *Avicennia marina* plants are found. Along the Oman coasts and islands mangroves are scattered over more than 20 sites with faunal assemblages of many species of fish, crabs, shrimps and clams, over 200 bird species, three species of turtles and four mammal species. In Qatar, mangroves are found on the north-eastern coast. The standing biomass of the UAE coast has been estimated between 70 and 110t/ha.

Owing to the severe climatic conditions and limited habitats, scattered population of one species of mangrove, Avicennia marina is found in the areas of mudflats of the RSA, except in Kuwait and most of the NE coasts of Saudi Arabia

Figure 12 Mangroves (*Avicennia marina)*

Coral reefs (Figure 13) are the jewels of the sea. Their presence in the RSA is a unique example of the adaptation of marine organisms in such extreme environmental conditions. There are many patch reefs in the RSA, with coral islands representing the peak of their development. About 55–60 zooxanthellate species have been identified in the RSA. Coral reefs in the inner RSA live in an environment characterized by great extremes of temperature and salinity, and high turbidity. However, no coral species occur in places with >46‰ salinity. Coral survival is limited where physical conditions are more extreme.

Figure 13 *Acropora* colony

Survival of coral reefs in the RSA is a unique feature, and is limited by extreme physical conditions and the infestation of Crown of Thorns Starfish

The numbers of coral species distributed among ROPME Member States' coastal waters are: 31 species in Bahrain; 19 species in I.R. Iran; 26 species in Kuwait; 91 species in Oman; 8 species in Qatar and 34 species in UAE. Coral bleaching has been reported in Bahrain, Oman, Saudi Arabia and UAE because of high temperatures. Coral reefs are extensively destroyed by Crown of Thorns Starfish (COTS) in Oman and UAE (Figure 14). Manual removal of COTS from infected coral reefs prevents mass destruction of coral reefs in the RSA.

Figure 14 Infestation of Crown of Thorns, *Acanthaster planci,* on coral reefs

Shrimp is one of the most important seafood commodities in the RSA. The richest shrimp resources are found in I.R. Iran and Kuwaiti waters, with smaller catches in Bahrain, Oman, Qatar and Saudi Arabia waters. The main species used for commercial exploitation in Kuwait are *Penaeus semisulcatus* and *Metapenaeus affinis*.

In Omani waters, although 12 known species occur, four species are used in commercial fisheries, namely *Penaeus indicus*, *P. semisulcatus*, *Metapenaeus monoceros* and *M. stebbingi*, and the total catch during 1986–2000 is given in Figure 15. In Bahraini waters, of the seven penaeid species that exist, commercial landings are from a single species, *P. semisulcatus*.

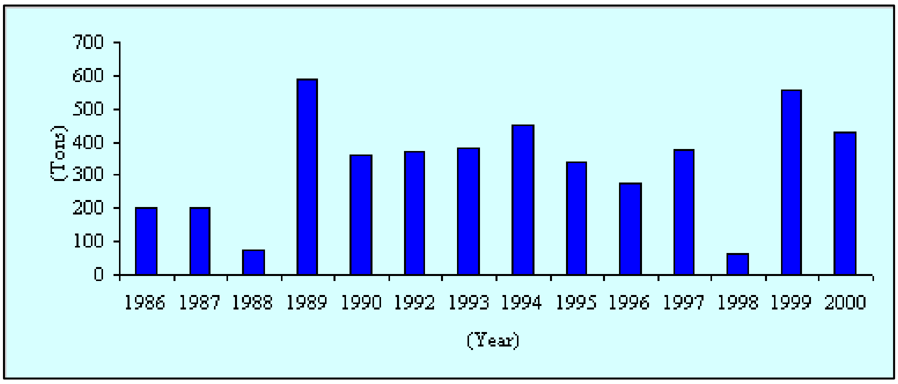


Figure 15 Total catch of shrimps in Oman during 1986 – 2000

Among lobsters, two species of spiny lobster, *Panulirus homarus* (Figure 16) and *P. versicolor* are commercially exploited in the middle and outer RSA. The shovel nose lobster, *Thenus orientalis* is exploited as shrimp by-catch in Bahrain, whereas *Scyllarides squammasus* is commonly caught in traps in Oman. Crabs are found in different habitats in RSA. The families Grapsidae and Ocypodidae are the dominant faunal species of the intertidal flats and mangroves of the Region, where six species of grapsid and 21 taxa of ocypodid crabs are known to occur. The crabs, *Portunus pelagicus* and *Scylla serrata* are commercially important species in the RSA.

The shellfish is one of the most important seafood commodities in the Region that contributes significantly to the marine bio-diversity

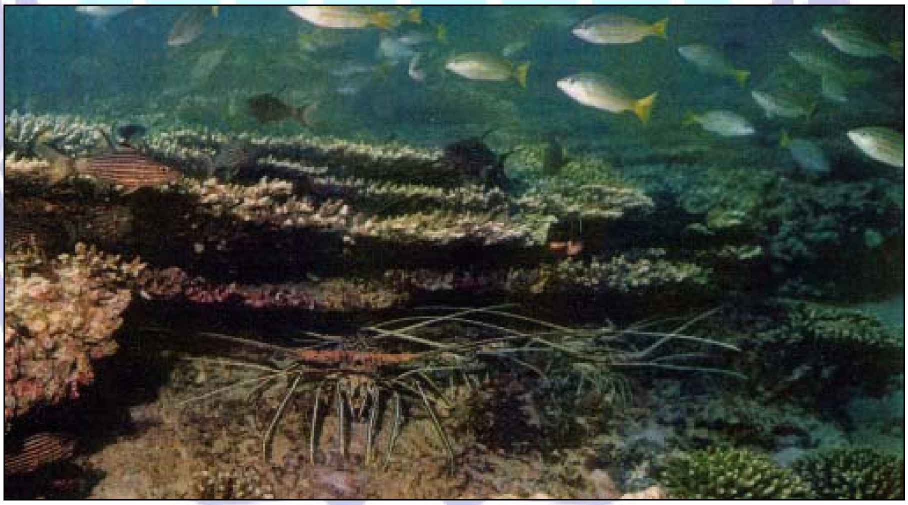


Figure 16 Spiny lobster, *Panulirus homarus,* inhabit the crevices of coral reefs

Among molluscs, the abalone, *Haliotis mariae* (Figure 17) is found only in outer RSA, restricted to the Dhofar coast of Oman. It is commercially exploited. Pearl oysters belonging to the *Pinctada* species are found in the RSA. The species, *Pinctada radiata* is abundant in Bahraini waters, and also common in Kuwaiti and Saudi Arabian waters. However, *P. margaritifera* is abundant along the Iranian coast. Interestingly, both of these species are found along the Oman coast in the Gulf of Oman. Among cephalopod molluscs, squids, cuttlefish and octopus are the commercially important groups occurring in the RSA. The Pharaoh cuttlefish, *Sepia pharaonis* (Figure 18) is also an important commercial species in the RSA.

Figure 17 Abalone, *Haliotis mariae*

Figure 18 Pharaoh cuttlefish, *Sepia pharaonis*

The inner RSA has >500 species of fish which live in pelagic, demersal and coral reef habitats. Of these species, about 130 species occur in Kuwait, 71 species in Bahrain and 106 species in Saudi Arabia. In the middle and outer RSA off Oman, about 1,138 species of fish are known to occur. Environmental extremes in the inner RSA have restricted the distribution of many species of fish. On the other hand, the high species diversity of Oman's fish fauna is a result of the diversity of coastal habitats, a wide climatic spectrum and the geographic location in the north-western upwelling region of the Indian Ocean.

Marine turtles have a prominent place amongst the fauna of the RSA, and their nesting locations at Masirah Island, Ra's Al-Hadd and Damaniyat Islands are of international significance

Marine turtles have a prominent place among the fauna of the RSA. All five species of sub-tropical sea turtle are known to occur in the Region, where the females come to the beach for nesting. Although turtles nest on the beaches and certain islands of Bahrain, I.R. Iran, Kuwait, Qatar and Saudi Arabia, three of the turtle nesting locations in Oman are of international significance. Masirah Island has the largest nesting population of Loggerhead turtles, while Ra's Al-Hadd supports the largest nesting aggregation of Green turtle (Figure 19) known in the northern Indian Ocean, and Damaniyat Islands support extensive Hawksbill turtle nesting. Sea bird *Sterna* spp. and Ghost crab, *Ocypode rotundata* are the major predators of turtle hatchlings.

Figure 19 Green turtle, *Chelonia mydas*

Sea snakes are the most venomous snakes in the world. Nine species of sea snake are known to occur in the RSA. Of these, the hook-nosed or beak-nosed sea snake, *Enhydrina schistosa* and the annulated sea snake, *Hydrophis cyanocinctus* are the most dangerous species in the Region. The

Hydrophis is the most common species in the Region (Figure 20), found in muddy, warm waters and its preferred habitat is the soft substrate of the inner RSA.

Figure 20 Sea snake, *Hydrophis lapemoides*

The RSA has a diverse marine bird community of great international importance. A large number of seabirds breed on the offshore islands, especially the Socotra cormorant and the terns Sterninae. The intertidal zone of the RSA is estimated to support up to four million waders during winter, making RSA one of the five most important regions of the world for wintering waders. The subtidal zone is also internationally important during migratory seasons for populations of about 20 other species of water birds including grebes, cormorants, herons, flamingos, gulls, noddy and terns (Figure 21).

The RSA has a diverse marine bird community of great international importance, and its intertidal zone alone supports up to four million waders during winter

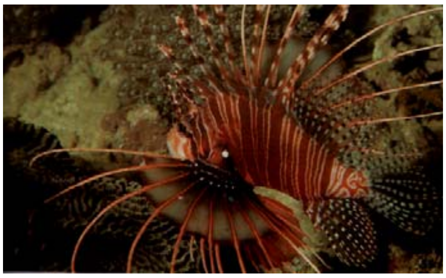
Common noddy, *Anous stolidus*

Bridled tern, *Sterna anaethetus*

Figure 21 Birds photographed in Oman

Marine mammals, dugongs, dolphins and whales inhabit the RSA. The estimated population of dugongs in the RSA is 7,310, making the RSA the most important area for this species in the western part of its range and second in global importance only to Australia. Altogether, about twenty dolphins and whale species are known to occur in the RSA.

Of the living marine resources of the RSA, certain species are dangerous to human beings, and cause injury or intoxication during direct encounters. Species of dangerous organisms of the Region belong to both invertebrate and vertebrate groups, from Phylum coelenterata (Jellyfish) to vertebrata (fishes) are listed (Figure 22). Many serious incidents can be avoided through raising public education and awareness, since it is important for the general public to know about the dangerous organisms which pose threats to human beings in the Region.


Spotfin lionfish, *Pterois antennata*

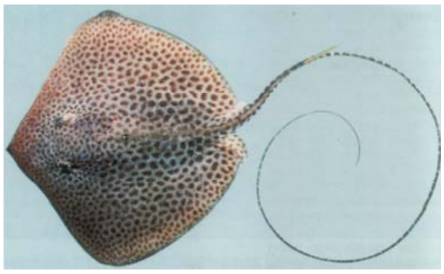

Darkspotted stingray, *Himantura uarnak*

Figure 22 Venomous fishes of the RSA

5. SOCIO-ECONOMIC ACTIVITIES AND STRUCTURES AFFECTING THE ROPME SEA AREA

Prolific socio-economic activities of ROPME Member States along the coastal stretch and the sea have considerably affected the environment of the Region. The substances from land and sea-based activities such as domestic sewage, industrial effluents, toxic substances, petroleum hydrocarbons, nutrients, and litter pose a major threat to the environment and should be controlled region-wide.

The heavy industries of the Region are the main sources of organic carbon load, thermal load, and residual chlorine that have detrimental impacts on the marine environment

The heavy industries of the Region, which include petroleum refineries, petrochemical industries, desalination and power plants, food, agriculture and livestock industries are the main sources of organic carbon load. The pollution load from each industry varies according to the production capacity and the type of product of the industry. For example, petrochemical plants produce a wide range of products namely, methanol, ethanol, ethylene chloride, ethylbenzene, styrene, chloride, caustic soda, formaldehyde, polyethylene, ethylene, nitrogen, oxygen gases, urea, ammonia, etc. All these products have their own detrimental impacts on marine life.

The cooling water and brine discharges from power and desalination plants contain the pollutants of residual chlorine and thermal loads. Desalination plants discharge heated brine into the sea which leads to changes in the physico-chemical and biological characteristics of the local marine ecosystem.

Effluents from oil refineries contain liquid hydrocarbon, phenol, sulphides and dissolved solids. In addition, heavy loads are added from fertilizers and petrochemical industries, and gas and fuel production industries of the RSA. Oil sludge is the main solid industrial waste found in the RSA. The solid wastes generated from various industries affect the environment considerably if they are not managed properly (Figure 23).

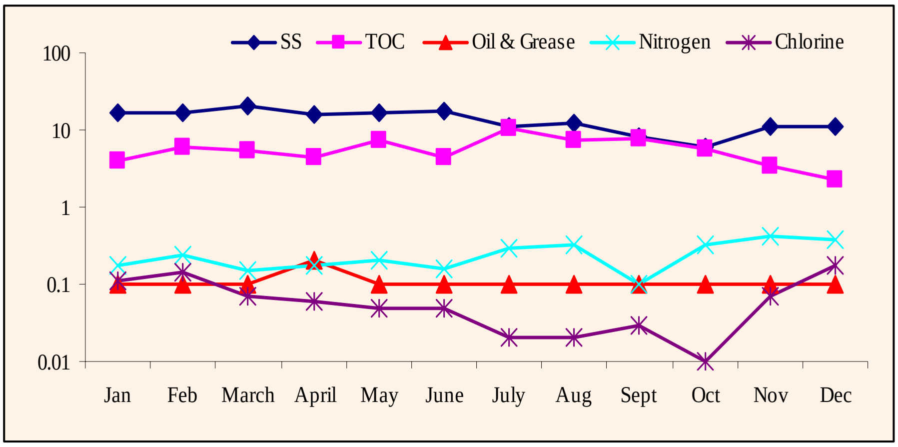


Figure 23 Levels of SS, TOC, Oil & Grease, Nitrogen and Chlorine (mg/l) in industrial liquid wastes discharged from Saudi Arabia in 2001

Atmospheric emission loads from land-based industrial activities and sewage discharges from urban and rural areas cause stress on the marine environment of the Region

The atmospheric emission loads to the RSA from land-based industries eventually reach the marine environment. The major sources of emissions are oil refineries, petrochemical and fertilizer plants, power plants, motors vehicles, etc. Rapid increases in the number of motor vehicles have contributed significantly to air pollution. Emissions from industries contaminate the atmosphere with sulphur oxides, CO, nitrogen oxides and hydrocarbons (Figure 24). Particulate matters from industrial emissions cause more stress for the marine environment.

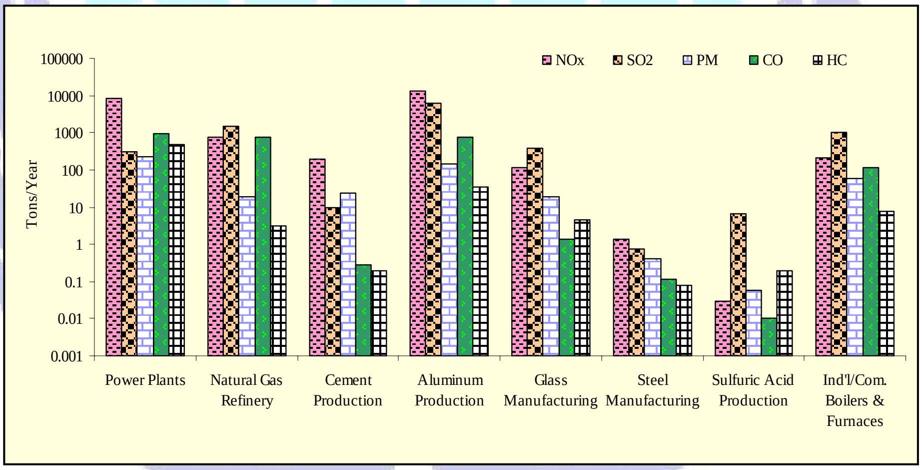


Figure 24 Emissions and contaminant loads from industries of Dubai, UAE in 1999

Sewage discharges from urban and rural areas into the coastal and marine environment of the RSA are another source of pollution. These are either partially treated or untreated. The combined sewage treatment plant capacity in the region is more than 2 millions m^3/day. However, greater volumes of untreated sewage are continuously entering the RSA causing degradation of the marine environment. The sewage treatment capacity of Member States varies, and certain effective steps are being taken by Member States to mitigate contamination (Figure 25). Treated sewage water is mainly used for irrigating landscape areas, parks, recreation facilities, highways and golf courses.

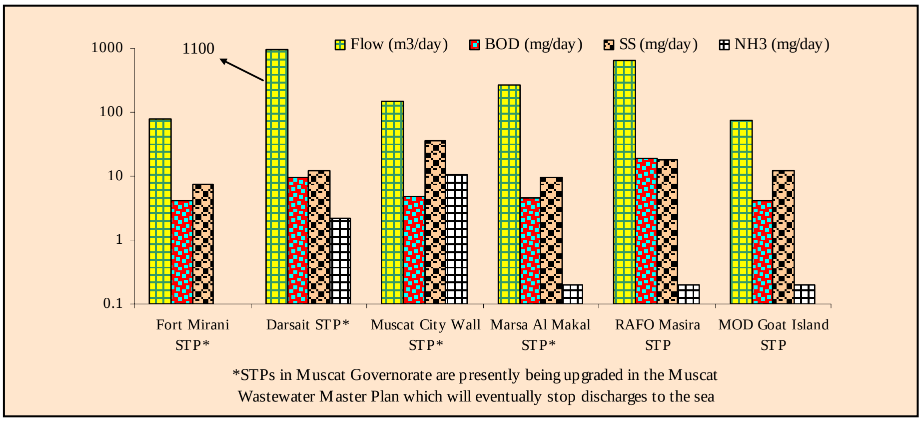


Figure 25 Industrial and domestic waste discharges from Sewage Treatment Plants (STPs) in the Sultanate of Oman in 2001

Development activities of certain Member States in river basins, such as dam construction, water diversion, etc. have significantly affected the marine ecosystem of the RSA. They have caused considerable changes in normal river hydrological regime and flow patterns, and changes in the quality and quantity of water entering the RSA. The impacts are enormous in the Shatt Al-Arab ecosystem and also for the fisheries resources of the NW part of the RSA. The reduction in river water flow into the RSA causes various ecological problems in the Region, which require cooperation among the countries for continuous monitoring and arrangements for regional river basin management.

Physical alteration along the coastal areas of the RSA for developmental purposes is a major threat to the marine ecosystem that requires continuous monitoring and management

Physical alteration for coastal development is a major threat to the marine environment of the RSA (Figure 26). Coastal development requires extensive dredging and land reclamation, or increasing the land area by land filling for future development. These activities include various construction activities for the development of industries, residential areas, sports complexes, causeways, fishing ports, commercial ports, harbours, etc. Physical alteration along the coastline damages the spawning grounds of a number of marine species, and destroys the seagrass beds and mudflats. It also increases siltation and water turbidity which irritates or clogs fish gills, inhibits photosynthesis of marine flora and creates coastal erosion. Rapid and continuous coastal zone development activities in the RSA require strategic impact assessment, well-defined management plans and monitoring.

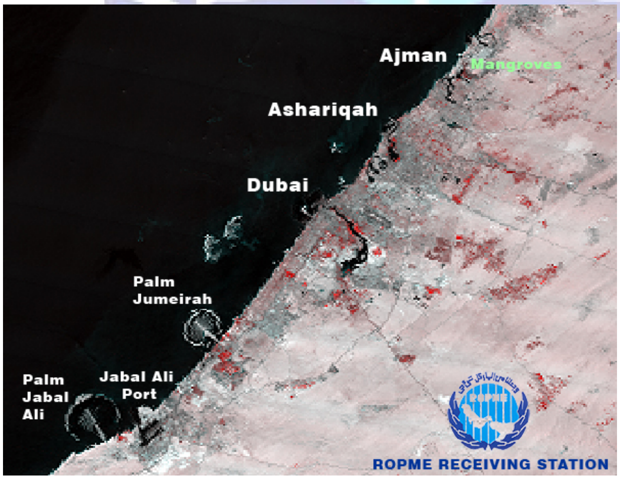


Figure 26 The MODIS image shows Dubai Conglomerate (from Ajman to Jebel Ali). Urban areas are seen in mixed dark grey. Highways are as grey lines. Vegetation is red and reddish. Significant urban development is seen in all coastal areas, including patches of intensive agriculture. Land filling processes are visible along Jumeirah beach – Dubai Palm Island. Shallow waters are in light bluish. Channels are dark, as seawaters. Coastal sabkhas are greyish.

The fast rate of development of recreational and tourism facilities along the coast poses a great threat to the environment of the Region. Marinas, water sports, sport fishing, marine parks and beach camping facilities are all being developed. The adverse impact of these facilities should be carefully monitored and mitigated to protect the coastal area against further degradation.

Environmental degradation of the RSA by various man-made activities has affected the marine living resources. The destruction of nursery and spawning grounds of many marine species by coastal reclamation and the reduction of the outflow of freshwater resources from Shatt Al-Arab have had a significant impact on the living resources of the RSA. In addition to this, destructive fishing methods cause severe impacts to the fisheries and the marine ecosystems of the Region. Over-exploitation of targeted species, has considerably affected the stocks of many commercially important species. These problems could be tackled effectively by the introduction of regulations and enforcement such as restriction of fishing efforts, fishing net mesh size, determining the capture size and the introduction of closed fishing seasons and areas.

Wide-scale dredging along the coastal areas, over-exploitation of living and non-living resources, and development of recreational facilities along the coast are causing chronic environmental impacts in the Region

Non-living marine resources, oil and natural gas, are exploited from offshore deposits by Member States and seawater is used for desalination, cooling and steam production to generate electricity. The sand and gravel from coastal waters are also exploited for various uses. Offshore exploitation and production of oil and gas cause chronic environmental problems in the Region. Discharges of chemicals and enormous volumes of water produced from offshore fields, increase the magnitude of environmental impacts, and are of major concern.

Dredging activities are undertaken on a wide scale in the coastal stretch of the RSA, particularly for land reclamation, de-silting of harbours, etc. The dredged materials contain varieties of substances which may contaminate the environment. Suitable techniques should be adopted to dispose off the dredged materials without causing adverse environmental impacts. The oil spill, ballast water, sewage, tar ball deposits along the coast (Figure 27) and garbage from tankers should be restricted as they are continuously contaminating the entire RSA waters. The large network of pipelines lying on the sea floor of the RSA is another source of oil pollution which frequently causes environmental hazards on account of pipe ruptures and oil leakage.

Figure 27 Tar balls deposited along the coast of Oman in 1996

6. CONTAMINATION OF THE ROPME SEA AREA

Although the coverage of surveys carried out in some areas of the coastal waters has not been comprehensive during the contaminant screening survey, several pertinent findings and general conclusions can nonetheless be highlighted based on the screening results from the four Member States surveyed in 2000 and 2001, as well as on previous data for the Region generated through surveys using similar sampling sites, sample preparation techniques, analytical methodologies, quality assurance measures and analyses.

Oil pollution continues to be a problem in various parts of the RSA. Approximately six years after a severe oil spill occurred in the Gulf of Oman off the east coast of UAE, relatively high petroleum hydrocarbon concentrations were still noted in the sediments and oysters around Akkah Head. The existing concentrations in sediments are much lower than those measured just after the spill, but nevertheless, attest to the slowness of the process of environmental recovery from acute oil spills in the Region. Interestingly, sediments from this area also contained extremely high levels of trace metals (e.g., nickel) and high concentrations of certain organochlorine pesticides. In contrast, trace metal levels in oysters from Akkah Head and Akkah Beach were not particularly high suggesting that contaminant trace metals in sediments may act more as a sink than a source of contamination to the bivalves living near them. The source of the varied mixture of contaminants found at Akkah Head and Akkah Beach is not known, but it is likely that it is not a directly result of the 1994 oil spill. Regular monitoring of the area and more specific analyses are required to determine if any dumping activities have taken place in this area.

Pollution is a major problem in the RSA. Thus, it is imperative to carry out time-series measurement of contaminants to identify "hot-spots". Synoptic coverage of spatial and temporal variation of contaminants is also essential

Moreover, it has been over three years since the last time-series measurements of petroleum residues and related contaminants were made in specific areas of north-western Saudi Arabia and Kuwait which were heavily affected by the 1991 War oil spill. In order to achieve a high resolution time-series data set which will allow better assessment of the ecosystem recovery potential in this affected region, further screening measurements should be undertaken at the same locations in the near future. Such screening surveys in all the above-mentioned areas will continue to pinpoint local 'hotspots' as well as ensure the capture of data with more synoptic coverage of spatially and temporary determined contaminant levels in the RSA.

Another location where chronic pollution involving a mixture of contaminants has occurred is off the BAPCO industrial complex in Bahrain. The highest concentrations of a variety of toxic substances were found there, and the extremely high levels of benzo(a)pyrene recorded off BAPCO and at Askar should be viewed with concern and warrant continued monitoring.

In particular, the new results on organochlorine compounds have proven useful in expanding the existing time-series data sets for the Region. Whereas PCB concentrations in oyster populations have appeared to decrease over the last two decades (Figure 28), concentrations of DDT compounds have varied little during this time (Figure 29). Such data sets are unique and should be extended to coastal water sediments in well-defined locations so that the countries can better evaluate temporal changes and recovery potential in areas that have been heavily contaminated, such as Akkah Beach in UAE and off BAPCO in Bahrain.

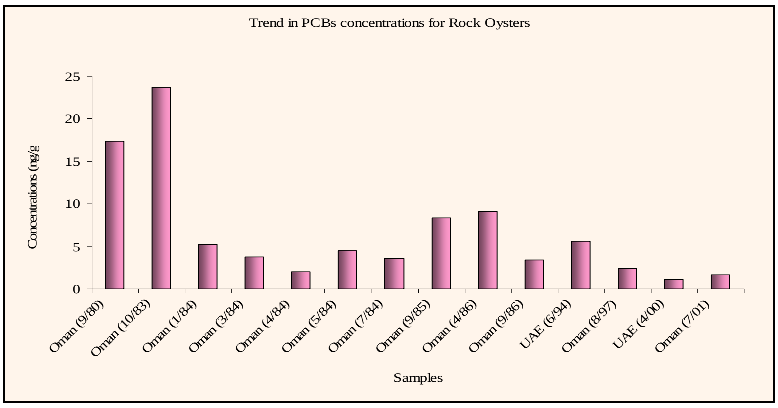


Figure 28 Trend of PCBs in rock oysters within two decades in selected areas of the RSA (1980 – 2001)

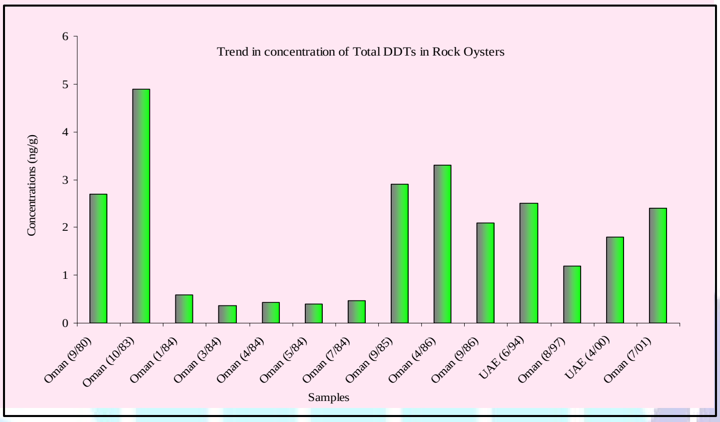


Figure 29 Trend of Total DDTs in rock oysters within two decades in selected areas of the RSA (1980 – 2001)

Most interesting and yet surprising fact is the high concentration of arsenic in certain bivalve species and accumulation of cadmium in the livers of some fish species in the RSA

The origins of high trace metal and organotin compound levels in rock oysters from certain locations on Masirah Island are not obvious, but the high trace metal concentrations may be a result of natural geochemical and oceanographic processes. Likewise, the interesting observation of very high Cd concentrations in the livers of some fish from southern Oman may result from the bioaccumulation of high Cd levels in the food chain, brought into the productive surface waters by the natural upwelling processes that occur in this region. Only more detailed spatial and temporal sampling will help resolve these unexplained observations.

Detailed sampling of fish (liver) in the south of Oman should be continued to try to explain the high concentrations of Cd observed in the samples (food chain bioaccumulation through natural upwelling, or other source).

Mercury concentrations generally continue to be very low in sediments, and total Hg levels in top predator fish commonly consumed in the RSA were found to be below the 0.5µg g^{-1} wet threshold value set by many Member States and were similar to levels measured in the same species during earlier years.

Most interesting, and as yet unexplainable, is the observation of very high arsenic concentrations in certain bivalve species from the RSA when compared to those from other regions in the world. Again, it is not clear whether this is related to point sources of contamination (unlikely) or to natural biogeochemical processes in the Region (more likely). It is evident that to properly interpret sources of possible metal contamination, it is imperative to understand the natural bioaccumulation potential and naturally occurring levels of elements like As in the species under study since content and ratios of trace metals vary greatly among the bioindicator species (particularly bivalves) used in the RSA.

Aside from the specific aspects mentioned above which should be given attention in future monitoring work, we still have gaps in our knowledge of the spatial (and local) distributions of some of these key contaminants in the coastal waters of the RSA. Most of the reliable existing data that have been obtained relate to the north-western region of the RSA. Areas around the north-eastern Shatt Al-Arab have been little surveyed as have many locations along the eastern and south-eastern shores of the RSA. Because the Shatt Al-Arab drainage system is the most likely source of the large-scale input of agrochemicals and many other industrial and urban contaminants in the RSA, this is a critical area to screen for POPs as well as other potential contaminants originating from land-based sources.

The Shatt Al-Arab drainage system is a critical area to screen for POPs as well as other potential contaminants from land-based sources

It should be also noted that the last screenings carried out in Kuwaiti and Saudi Arabian coastal waters were made in 1998, over 5 years ago. These countries were heavily affected by the 1991 War oil spill. In order to achieve a high-resolution time-series data set that will allow a better assessment of ecosystem recovery potential in this affected region, further screening measurements should be undertaken at the same locations in the near future.

Neither faecal sterols from sewage inputs nor organotin compounds arising from biocide use appear to be major problems in the areas screened in these surveys. The environmental levels of organotins found in coastal sediments from the RSA were relatively low by global standards. Similarly, the organotin content of the marine biota is comparatively low and does not pose any immediate public health problems.

The basin wide contaminants study of the sediment samples gathered by the Oceanographic Cruise – Summer 2001 revealed that the open RSA has naturally occurring hydrocarbons derived from a mixture of autochthonous and terrestrial origins, and low levels of anthropogenic input of degraded petroleum hydrocarbons (Figure 30). Since the high concentration and widespread distribution of the C_{12}-C_{22} n-alkanes with a strong even carbon number masked almost all evidence of spilled oil, a continued watch should be maintained on the area in order to track any changes in the aliphatic distribution.

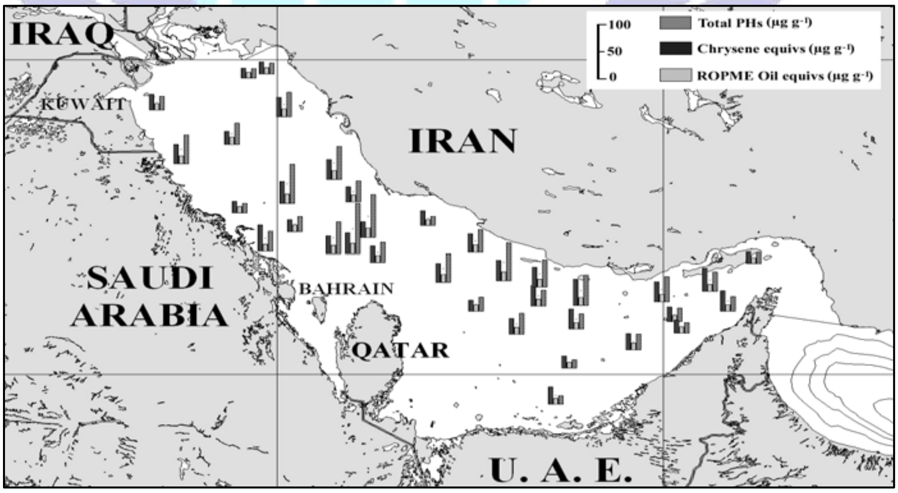


Figure 30 Total petroleum hydrocarbon concentrations in sediments from the inner RSA in 2001

With the exception of a few stations used during the Oceanographic Cruise – Summer 2001, the concentrations of total DDTs, total HCHs, and total PCBs were relatively uniform. The only stations where comparatively high concentrations were recorded were Station 20 for total DDT, Station 56 for total HCHs, and Stations 27 and 78 for Total PCBs. Overall, the concentration of organochlorinated compounds in sediments in the inner RSA is relatively low by global standards.

Local sources affect the strengths and propensity of fine-grained material to accumulate and influence the distribution of metallic contaminants in sediments of the inner RSA. Trace metal concentrations are strongly correlated to the aluminium concentration, a good proxy for terrigenous material and the amount of fine-grained material present. Several trace metals, such as Arsenic (Figure 31), Chromium and Nickel exhibit sufficiently high concentrations to exceed sediment quality guidelines. Such trace metals, at least in the case of Cr and Ni, undoubtedly have a high natural occurrence in this mineral-rich Region. However, anthropogenic activities, notably mining, may have further increased the trace metal burdens in the sediments of the RSA, which could explain the presence of an apparent hotspot for zinc in one region. Several trace metals (Ag, Cd, Pb) have relatively low levels that pose no environmental concerns.

Trace metals such as arsenic, chromium and nickel exhibit high natural occurrence in the mineral rich sediments of the Region

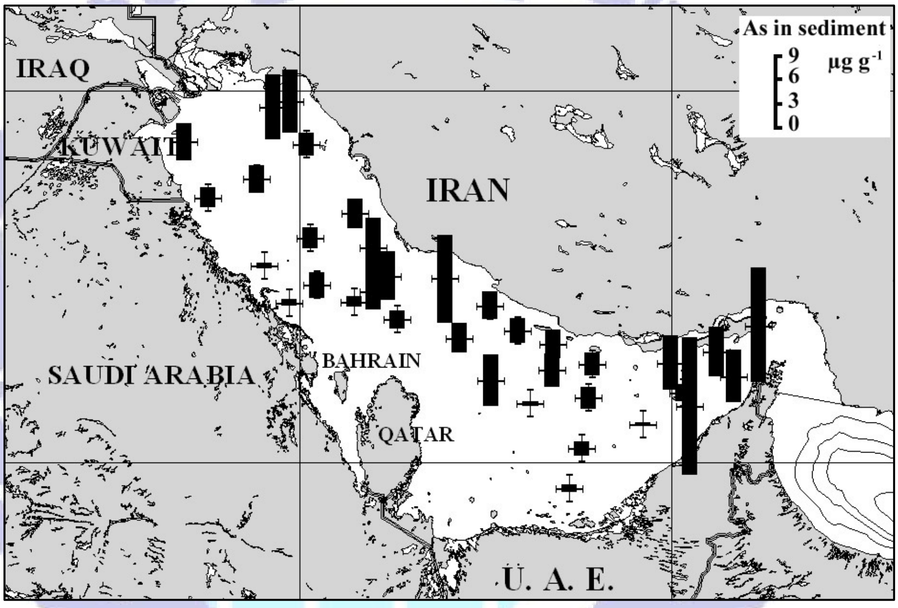


Figure 31 The distribution of arsenic in sediments from the inner RSA in 2001, whereby the mid-point of the bar designates the sample location

7. MAJOR ACCIDENTS AND EPISODIC EVENTS

This Region is the most crowded shipping route in the world, with some 25,000 tankers carrying about 60% of the world's total crude oil exports by sea. Annual oil spills in the RSA are the equivalent of about 1.2 million barrels. Transportation and tanker accidents are the main source of oil released into the sea in comparison with inputs from natural seepage, atmospheric fall-out and urban run-off.

The most dramatic environmental impact in RSA has been caused by wars. The Iraq-Iran War and the blowout of the Nowruz offshore oil wells off the Iranian coast, which spilled over 2 million barrels of crude oil into the marine environment was the first environmental catastrophe of its kind. During the 1991 War, the quantity of oil discharged and spilled from various sources into the RSA exceeded 9 million barrels which caused tremendous environmental stress to the entire ecosystem. This oil spill has had a significant impact on the onshore and offshore areas of Kuwait and Saudi Arabia. The setting of fire to more than 730 Kuwait oil wells was another episodic event of the 1991 War. Oil well fires caused serious air and water pollution as well as health problems in human beings and other organisms.

The 1991 oil spill has damaged the marine environment and affected the habitats of many organisms in the RSA. The water currents dispersed the oil into all coastal areas and islands in Kuwait and the eastern parts of Saudi Arabia and Qatar. The oil deposited on the bottom of the sea affected the growth of the coral reefs and other benthic organisms. Enormous numbers of land mines were laid in the coastal zone during the war (Figure 32) and have had negative impacts on the marine and coastal environment as well as posing a serious threat to the lives of beach users and fishermen.

Marine mortality occurs in the RSA due to pollutants, sudden changes in the physico-chemical processes of the sea, harmful algal blooms and outbreak of harmful germs

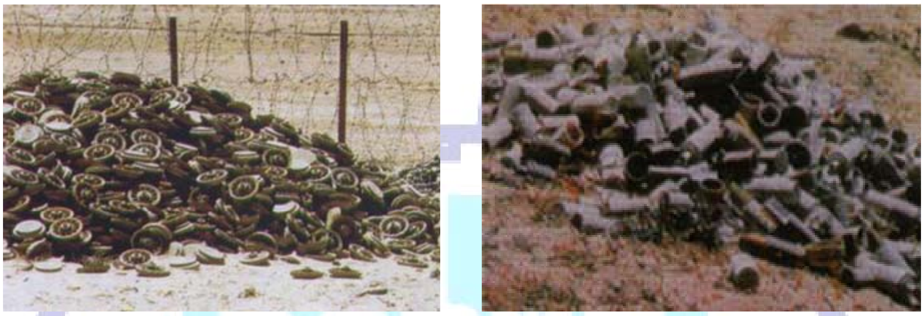


Figure 32 Recovered Iraqi mines left over from the 1991 War

Mortality of marine organisms (Figure 33) in the RSA is the result of various environmental factors. The causes of marine mortality in the RSA have been identified as pollutants, sudden changes in the physico-chemical processes of the sea, outbreaks of bacteria, viruses, fungi and parasites, harmful algal blooms and red tides (Figure 34). The marine mortality incidents in the RSA between 1986–2001 are documented and the causes of mortality are also explained.

Figure 33 Dead fishes stranded along the coast of the RSA

Figure 34 Red tide bloom

Invasive marine species constitute a new form of threat to the marine environment, where they could destroy rare native species by preying them, competing with them for shelter, food or both, introducing harmful germs and parasites, and finally changing the normal function of the affected marine ecosystem. An in-depth scientific study is necessary to identify invasive species in the RSA especially the Little mauve stinger jellyfish, the Gilthead seabream (Figures 35 and 36), Crown of Thorns, etc. and the possible ways to bring about their abatement. This is a difficult task which requires thorough long-term planning along with regional and international cooperation.

Figure 35 Little mauve stinger jellyfish

Figure 36 Gilthead seabream

8. MARINE POLLUTION CONTROL, EMERGING ISSUES AND STRATEGIES FOR SUSTAINABLE DEVELOPMENT

This Chapter provides a summary of the information on the measures, policies and strategies for sound environmental management and sustainable development of the RSA and includes information on environmental challenges, Mechanisms for Prevention and Control of Marine Pollution and Strategies, and priority action for Sustainable Development.

Based on current and emerging environmental issues, the specific environmental challenges that face the Region can be described as follows:

- ***Conservation and restoration of marshlands of Mesopotamia*.** In this connection a river basin management programme should be developed for the Shatt Al-Arab and its entire basin. ROPME could provide an important forum for transboundary cooperation to rehabilitate the Mesopotamian Marshlands, but there is also need for international support and UNEP to assist in facilitating a process of regional dialogue between Member States to pursue a successful programme to address this environmental disaster.

- ***Pollution from land-based activities.*** Over the last three decades the ROPME Region has witnessed one of the highest rates of economic growth in the world. The rise in industrialization together with high population growth and rapid urbanization, have resulted in ever-increasing environmental problems in the Region. In order to deal with these problems ROPME has developed guidelines on Integrated Coastal Area Management to harmonize development activities in the coastal zone. Member States are also taking appropriate measures to develop ICAM plans, and to prevent, abate and combat pollution from land-based activities.

- ***Pollution from ships.*** The RSA is an area with one of the highest oil pollution risks in the world from various sources such as, offshore installations, tanker-loading terminals and the huge volume and density of marine transportation of oil. Smaller scale oil pollution incidents such as submarine pipeline rupture and well blowout are more frequent in the RSA. ROPME is supporting every effort to encourage the ratification of

Invasive species constitute a new form of threat by way of competing with the native species. They also introduce harmful germs & parasites and change the normal function of the affected marine ecosystem the MARPOL Convention and meet the requirements for the construction of adequate reception facilities in the Region in order that the RSA be declared a Special Area with the assistance of Member States, regional and international organizations and oil companies.

- ***Pollution from offshore operations.*** The impact of offshore operations on the marine environment especially in shallow waters or near to ecologically sensitive areas is more noticeable. The high salinity, temperature and oil content of produced water by offshore oil wells are among the main causes of stress to marine life. To this end, ROPME is making every effort to address all aspects of produced water in a comprehensive way so as to minimize its detrimental impact on the marine environment.

- ***Conservation of biodiversity.*** Marine mortality episodes are familiar phenomena in the Region and their toll on fish, dolphins, dugongs, whales, waterfowl, algae and corals has reached record levels in the past two decades. The mortality phenomena have been attributed to high levels of anthropogenic contaminants, unseasonably warm temperatures, disease agents, biotoxins and changes in food supply. ROPME has initiated a Plan of Action on Marine Mortality (PAMM) and has established a permanent Regional Group of Experts to address these mortality events. Preparation of a Protocol concerning the Conservation of Biological Diversity is underway by ROPME and several Legal/Technical Expert Meetings have been conducted to review the draft text of the Protocol. Ratification of this protocol by Member States will hasten regional efforts for conservation of RSA Biodiversity.

ROPME could provide an important forum for environmental conservation, pollution prevention & control, policy making, environmental legislations and institutional arrangements

The mechanism for prevention and combating marine pollution starts from the adoption of policies and preventive measures, the establishment of environmental legislation and the development of necessary institutional arrangements for implementation and enforcement.

- ***Policies for pollution prevention and control.*** Policies for pollution prevention and control address national policies and initiatives, regional initiatives and policy instruments, protected areas and marine parks, contingency plans and emergency response, precautionary environmental protection policy, public awareness and implementation procedures. The latter include an overview of Environmental Impact Assessment (EIA) procedures and the necessity to adopt the ambient coastal and marine water quality criteria.

- ***Environmental legislation.*** Environmental legislation includes principal issues such as, national legislation/regulation, the Kuwait Regional Convention and its Protocols, and the international conventions and programmes relevant to the protection of the marine environment. The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (1978) has four related protocols that were developed in accordance with the recommendations of the Legal Component of the Kuwait Action Plan. ROPME countries also are members of international conventions and agreements. However, most national environmental legislation and regulations in some countries of the Region obviously need updating and revising, particularly those sections that relate to acceptable and adequate norms and standards.

- ***Institutional arrangements.*** Institutional arrangements are made at the regional level, as well as the national level, in the form of government and non-governmental bodies dealing with environmental issues or through follow-up with the overall coordination bodies. Some of the countries in the RSA have restructured these institutions in the recent years, giving them higher political standing. The role of non-governmental organizations (NGOs) is becoming increasingly important particularly in areas that require active public participation, and in raising public awareness of environmental issues. In almost all ROPME Member States, environmental NGOs are operational and have a wide range of activities, many of which are related to the marine environment.

As far as strategies and priority action for Sustainable Development are concerned, a long-term high-level commitment by the Governments of the Region is crucial for the effective protection, management and sustainable development of the RSA and its resources. Integration of regional and global conventions and policies into national legislation provides the Region with the opportunity to interact, benefit from and influence the development of global programmes and policies. ROPME can act as an interface between global and national concerns. Integrating environmental concerns of the Region into the political and socio-economic agenda of Member States is at the essence of the Rio Declaration (1992). The following priority issues should be included in strategies for environmental protection in the Region.

Long-term commitment by the Governments of the Region is crucial for the effective protection, management and sustainable development of the RSA and its resources

- ***Integrated Coastal Area Management (ICAM).*** National ICAM plans may be developed with a regional perspective to provide an overall framework for coastal area management, complemented by more specific plans for different coastal development.

- ***Environmental impact assessment.*** Another planning tool that is complementary to ICAM is the environmental impact assessment (EIA) procedures that would help to significantly reduce the degradation of the environment, particularly from land-based activities in all Member States.

- ***Conservation strategies.*** The integrity of the Region must be taken into consideration and areas that are of regional significance should receive special attention. Both national and regional regulatory systems need to be improved to enhance habitat conservation. National and regional conservation strategies are complementary and should be developed for key habitats such as coastal wetlands, mangroves, seagrass beds, coral reefs and oyster banks in the RSA.

- ***Strengthening the implementation of ROPME Protocols.*** As mentioned above, the Kuwait Regional Convention has four related Protocols dealing with various aspects of marine environmental protection and management. These protocols have been adopted to further specify the mandate of the Convention. In order to achieve the objectives set for these important legal instruments, strengthening of Protocol implementation should be part and parcel of the national strategies of Member States for the protection and sustainable development of the marine and coastal areas under their jurisdiction.

- ***Capacity building.*** The efforts aimed at ROPME capacity building such as in-house training, short courses, or visits to qualified laboratories/institutions are to be further encouraged and increased through the establishment of a programme of exchange of scientists both within the Region and in cooperation with other regions. This requires greater interest in environmental issues by teaching institutes and universities. These issues should be a major part of all the curricula taught in different specialties in order to train specialists in various fields of the environment to face the future challenges of the Region.

- ***Enhancing public awareness, information sharing and networking.*** At the regional level, strategies for the enhancement of environmental awareness among the public should be developed and followed-up, making use of the national experiences already available in several ROPME Member States. In this connection, it has to be noted that the large number of stakeholders involved in the coastal area requires multi-level awareness programmes targeting different groups.

- ***Cooperation with non-governmental organizations (NGOs).*** A growing number of non-governmental organizations (NGOs) have been established in most countries of the ROPME Region. However, their role in planning and implementation needs to be strengthened.

- ***Coordination between regional and international organizations.*** An equally important strategic element is the increased coordination between regional environmental organizations and bodies dealing with the marine environment. An excellent example of such coordination is that existing between ROPME and PERSGA which culminated in the organization of the Sea to Sea Conference in 1995. In this connection, the ROPME's efforts to collaborate with regional, international and related stakeholders such as FAO, IAEA, IHB, IMO, IOC, ISO, IUCN, OPEC, GCC, UNEP, UNDP, UNESCO and WHO should be mentioned.

- ***Harmonization of legislation.*** ROPME Member States as members of the international community collectively have a significant role to play in the global arena. But the Member States should realize that the role of ROPME is to be involved in the development of global conventions to ensure that they take into consideration the needs and opportunities afforded by the Region.

- ***Environmental assessment and monitoring.*** Although much progress has been made since 1999 in the development of regular state of the environment assessments and monitoring systems, a strengthened monitoring and assessment programme is required to address new challenges in the Region. This programme will be integrated with larger global assessments such as the United Nations Global Marine Assessment and the Global Environment Outlook process and will be developed with regional and international scientific institutions and with relevant United Nations agencies. ROPME capacity for remote sensing application combined with harmonized efforts by Member States would help to achieve better environmental assessments and monitoring of the region in future (Figure 37).

ROPME capacity for remote sensing applications, harmonizing the efforts of Member States, would help to achieve better environmental assessments and monitoring of the Region

Figure 37

Remote sensing ground station at ROPME Secretariat

- ***Control and management of oil spills.*** As mentioned, oil pollution is the most significant form of pollution in the RSA. Only limited numbers of inadequate reception facilities exist in the Region. This general lack of adequate facilities in the Region often leads to illegal dumping of huge quantities of ballast waters and other oily wastes into the marine environment. Acceding to and implementation of MARPOL 73/78, and adoption of Port State Control procedures by all Member States are the main instruments for controlling oil pollution in RSA.

- ***Control of land-based sources of pollution.*** ROPME Member States should seriously pursue the implementation of ROPME's Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources and the associated Regional Programme of Action (RPA), particularly the integrated management of the Shatt Al-Arab river basin and the management of Municipal Wastewater. ROPME has expressed willingness and begun cooperating with UNEP/GPA in their Strategic Action Plan on Municipal Wastewater.

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- ***Control of dredging, reclamation activities and modification of coastal morphology.*** Dredging and reclamation activities are an almost permanent feature in many coastal areas in the RSA. It is preferable that such destructive activities be totally avoided, if possible. If not, environmental impact assessments for such operations should be carried out and formal permits obtained prior to the initiation of any small- or large-scale project requiring dredging or filling, particularly those adjacent to environmentally sensitive areas. Furthermore, authorized dredging operations should follow clear operational standards.

- ***Restoration of mangroves and coral reefs, protection of wetlands.*** Mangroves, coastal lagoons, seagrass beds and coral reefs represent important components of the ecological systems of the RSA and have been subject to rapid deterioration. The restoration of damaged ecosystems and re-introduction of lost species or populations through the cooperative efforts of research institutions, fisheries and environmental protection authorities are essential steps to push back the tide of destruction and move towards the recovery of these habitats. In the meantime, since the restoration projects are extremely costly, governments, development and finance funds/banks and the private sector should support such important regional efforts.

- ***Development of an Environmental Information System and reporting programme.*** There is an urgent need for the development of an environmental information system with GIS capabilities. Such an information system can be extensively used and benefited from by all concerned scientists and authorities. To this end, ROPME's environmental reporting capacity needs to be strengthened and its reporting outputs disseminated in printed and electronic formats, including through the upgrading of its Website.

There is an urgent need for developing an integrated environmental information system, adequate reception facilities, implementation of ROPME's Protocols, control of physical alteration of coastal zone and restoration of marine habitats of the Region