State of the Marine Environment Report

2013

ROPME

Regional Organization for the Protection of the Marine Environment - Kuwait

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In the name of God the Compassionate, the Merciful

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FOREWORD

The ROPME Region has witnessed considerable economic and social developments at a remarkable pace, particularly during the first decade of this millennium. It is timely, therefore, to revisit the "State of the Marine Environment" of the ROPME Sea Area, as requested by the ROPME Council.

The purpose of regular reporting process is to track possible environmental changes, resulting from development activities since the previous "State of the Marine Environment Report" (SOMER), the last of which was prepared and published by ROPME Secretariat in 2003, and to report on the likely impacts of such changes on the marine and coastal environments and their resources.

Clearly, the ultimate objective of such periodic reporting is to bring any observed environmental changes and their associated impacts on the RSA to the attention of the Governments of the Region. In doing so, we will be able to assess the existing environmental challenges and their root causes, and hence, to adequately define the priority actions that need to be taken by the concerned authorities in each of the ROPME Member States. These priority actions should be distinctly defined for different levels of the decision-making process individually by the State, and collectively by ROPME, to address the common concerns and the Regional emerging issues that threaten our RSA as a common heritage for the humankind, in general, and for all of us, in particular.

It is truly felt that SOMER 2013 and the environmental outlook of the RSA, contained therein, represent a real challenge to all of us in the Region. It clearly demonstrates that serious problems still exist in our marine environment, in spite of all the dedicated efforts of ROPME and the Member States throughout the 35 years of ROPME's existence. These environmental problems must be effectively addressed and remedied through our collective action.

SOMER 2013, like the preceding Reports in the SOMER series, has been prepared by ROPME in close consultation with, and based on inputs from individual National Focal Points of ROPME Member States, within the limits of the data and information available to each of them. Their time, effort, and dedication as well as those of the rest of the so many contributing individuals and cooperating organizations, particularly UNEP/ROWA and the AGU in Bahrain are gratefully acknowledged and highly appreciated. ROPME is also grateful to ROPME Consultant, Dr. Makram Gerges, former UNEP's Regional Director for West Asia for his valuable contribution in reviewing and editing of this Report.

Dr. Abdul Rahman Al-Awadi

Executive Secretary of ROPME

PREFACE

In response to the standing request and recommendation of ROPME Member States, and pursuant to the relevant Decisions of the ROPME Council, the state of the marine environment in the ROPME Sea Area (RSA) has remained under regular scrutiny in order to keep the environmental health of the RSA under control and continuous review.

Accordingly, a series of Regional "State of the Marine Environment Reports" (SOMER) has been prepared by ROPME Secretariat in close consultation with the Member States, and were published in 1999, 2000 and 2003.

As mandated by ROPME Council, the overall objectives of these reports are as follows:

- To assess and document the current state of the marine environment of the RSA, taking into consideration the recent changes in the environmental conditions and the impacts of human activities on the marine environment and coastal areas;
- To highlight and discuss, based on available data and information, current regional concerns and emerging issues which present major challenges; and
- To suggest regional strategies, policy alternatives and policy actions relevant to these concerns and issues, to guide decision makers in Member States in addressing these challenges at the national level and within the regional and global contexts.

The present Report (SOMER 2013) provides a synthesis of information on the current status of the marine environment of the Region, covering the period from 2003 to 2012. It is based on data and information available from various sources. These sources include the national "State of the Marine Environment Reports" of the respective Member States, the findings of ROPME's oceanographic cruises, in addition to selected remote sensing observations, results of contaminant screening studies and some regional and international scientific reviews.

SOMER targets a wide range of audience, including the policy and decision-makers in the Member States, researchers and scientists, staff and associates working in the field of marine environment in Member States, environmental authorities, as well as other governmental agencies, relevant non-governmental organizations (NGOs) and volunteer groups.

The Report is developed mainly in accordance with the process recommended in the Fifth Global Environment Outlook (GEO-5) of the United Nations Environment Programme (UNEP) (www.unep.org/geo/), in which the analysis of environmental trends and policies is one of the core elements of the integrated environmental assessment (IEA).

The causal framework (Driving Forces, Pressures, State of the Environment, Impacts and Response), known as DPSIR is adopted here in order to analyze the linkages and interactions between society and the environment in the RSA during the last decade.

It is to be noted further that the ever-expanding commercial activities and the growing population since the discovery of oil, are causing substantial changes in the marine and coastal environment of the RSA as documented by numerous reports. Some of these environmental changes have been positive, but others have had negative consequences on the environment.

In order to highlight the cost of environmental changes on the available ecosystem services, and the resulting impacts on human well-being and economic development of the society, three cross cutting key issues were identified as the main storyline of SOMER 2013.

Given the arid conditions of the Region, most of the developments are concentrated along the shoreline. Coastal degradation, biodiversity loss, and deterioration of fisheries are intricately interlinked.

The intense urbanization of the western coast of the Inner ROPME Sea Area (I-RSA), in the form of minor and mega constructions, is imposing acute changes due to extensive coastline alterations, increased rate of habitat loss, and creation of beds of shifting or suspended sediments due to reclamation.

The fragmentation and loss of suitable living and breeding habitats obviously lead to biodiversity loss and depletion of living resources. The alarming decrease of fish landings throughout the RSA is one clear indicator of the deterioration of the ecosystems and the need for Ecosystem-Based Management (EBM) of such resources.

With all the above in view, and in order to follow the GEO Process and the recommended DPSIR framework, Chapter 1 of SOMER 2013 sets the scene by briefly describing the main physiographic features of the ROPME Sea Area (RSA), avoiding duplication with previous SOMERs.

The spatial distribution of the social and economic activities in the Region, the demand for a variety of goods and ecosystem services, and related land uses, collectively forming the Drivers, in the RSA are examined in Chapter 2 in correlation with the environmental Pressures build up due to these socio-economic deriving forces.

Whereas, Chapter 3 gives a fuller description of the environmental state and trends of the RSA and summarizes the likely impacts of the observed pressures on the marine environment of the RSA, outlining the possible changes in the physical and biological parameters, and characterizing the level of degradation.

Inter-linkages, within and between environmental changes and human dimensions are further elaborated in Chapter 4 to illustrate the Impact of these changes on human and social welfare.

Emerging issues such as the climatic changes and the various plans to build nuclear power plants are highlighted in Chapter 5.

Chapter 6 focuses on the challenges by summarizing the Impact of changing environment, as well as addressing some promising opportunities that may help resolve some of these problems.

The report in Chapter 7 foresees the Future Outlook of the Region considering both the ‘Business as Usual’ and ‘Sustainable RSA’ scenarios, to guide choices and strategies that can lead to a pathway that connect the current situation to a more sustainable future in the decades ahead.

Finally, after analyzing the current policies, conventions and legislation and the various governance tools in effect in the Region, Chapter 8 concludes with key messages relevant to Policy Options, the application of which by policy and decision-makers would elicit the required Response to optimize corrective management actions and mitigate the identified impacts. Needless to mention that SOMER will remain an open book to reflect the current State of the Marine Environment with full transparency to expose all dimensions and concerns in the Region. We all join hands to make SOMER a truthful reflection of our marine environment.

ROPME Secretariat

EXECUTIVE SUMMARY

In accordance with decisions of ROPME Council, the present Report on the State of the Marine Environment (SOMER-2013), is prepared mainly to review the major environmental issues in the marine environment of the Region. It also highlights the efforts of ROPME and its Member States in monitoring and assessing the changes in the state of the environment over the reporting period (2000 - 2013).

The inputs from Member States, the analysis and interpretation of data collected during ROPME's oceanographic cruises carried out in recent years, and of the results obtained from ROPME's continued research programmes as thoroughly examined in the Report provide the state and trends of marine pollution in the RSA, as well as the current environmental challenges of the Region.

This has proved to be useful in identifying sound scientific basis for addressing the challenges with a view to achieve an effective protection, wise management and sustainable development of the ROPME Sea Area (RSA) and its resources.

The Report further addresses the pressures caused by marine pollution from different sea-based and land-based sources on the marine environment, the coastal and marine ecosystems, the critical habitats and the fisheries resources of the Region.

The emerging environmental issues, such as the potential risk of nuclear radiation, the increased frequency and intensity of dust storms and cyclones, the global warming, climate change and sea level rise, and the frequent occurrence of harmful algal blooms (HABs) and the mass mortality of marine life, have also been identified and discussed.

The findings of the various chapters of the Report lead to some major conclusions, on the basis of which concrete recommendations are made. These findings were published separately in a comprehensive “Executive Summary for Decision-Makers”, that was made available to the Member States of ROPME at the Sixteenth Council Meeting, held in Jeddah, Saudi Arabia on 28 November 2013.

The main purpose of the Executive Summary was to provide the Governments of the Region an insight into the state of their common marine environment, to support decision-makers in their efforts to tackle the main challenges facing the Region with sound policy decisions for the development and management of the RSA and its resources in a sustainable manner, for the benefit of present and future generations.

The present summary, however, is to provide and highlight some general conclusions, and relevant recommendations, for necessary action, and for ROPME's focus on work programme directions in the coming years.

A. CONCLUSIONS

- The Region is witnessing large-scale development activities, as associated with considerable expansion of urban settlements and popoulation growth, particularly in the coastal zone. This will naturally increase the demands on ecosystem services and resources
- The develoment activities may, in the short-term, reduce the effectiveness of on-going and/or planned efforts for the protection of the marine and coastal ecosystems of the Region. And in the longer term, they will adversely affect both the environment and human well-being, due to

increased pollution from domestic and industrial discharges and due to the deterioration of air quality from harmful emissions into the atmosphere

- The overuse of water and electricity by urban communities will result in increasing demand for energy and freshwater from the power and desalination plants, respectively. This would further impact the marine and coastal ecosystems, through emissions and thermal pollution of the coastal waters
- The coastal area development for residential, industrial, recreational and commercial purposes, besides impacting the marine and coastal ecosystems through increased pollution and emissions, is exerting further severe impact on the highly productive intertidal zones, reducing the nursery and feeding grounds for most of the commercial shrimp and fish species
- The fisheries resources of the Region are also over-exploited or have already reached their optimum exploitation levels for some major fish species
- The reduction in freshwater influx from Shatt Al-Arab, the degradation of the river basin, the soil erosion, the change in water quality and currents, and the drying up of the Mesopotamian marshlands, clearly affect the biophysical and social systems. The biophysical aspects include a number of problematic challenges such as biodiversity loss, deterioration of water quality, and increased vulnarability to climate change
- The reduction of proper habitats would adversely affect fish landings and fish stocks. The consequence of reduction in catches, coupled with increasing the demand would certainly lead to increasing market prices and would ultimately affect food security and the livelihood of coastal communities
- The marine/coastal ecosystems get degraded due to human pressure, their services will diminish and the resilience of the environment to endure the impacts of climate change will drop.These issues may reach a point of no return, where societies lack the capacity to reverse the ecological degradation that undermines livelihoods and human well-being
- The focus on ecosystem services can enable authorities to identify and implement innovative financing to maintain those services, whereas economic valuation of coastal ecosystems and ecosystem services is a good tool to quantify the benefits of conservation, and demonstrate the costs of degradation and damage to both livelihoods and economies
- The fact that several potential sources of radiation hazard exist in the RSA, which requires special attention, ROPME has established a “Regional Nuclear Emergency Response Plan (RNERP)”, the main objective of which is to provide a response structure and guidance, to support a regionally-coordinated response to any radiological emergency, that might happen within the RSA
- The “Global Warming” and the anticipated “Climate Change” may impact the RSA ecosystem by affecting the coral reefs and reef associated invertebrates; causing more Harmful Algal Blooms (HABs), degrading water quality and leading to mass marine mortality; and ultimately reducing fish landing
- The most important policy lesson is that investment in human resources development, Research and Development (R&D), governance improvement, and regional cooperation amongst ROPME Member States are key issues in the protection and sustainability of the RSA ecosystem. The riparian countries of the RSA should act as the custodians of this common resource pool, to cater for their current socio-economic development needs and for the needs of future generations

- The environment is not compartmentalized and nor should environmental policies be; RSA protection policies should be integrated and mainstreamed into the national socio-economic development plans; sound sustainable policies should have the human-being and the environment central to planning

- The current trends, practices, and level of governance and sustainable management of the RSA are inadequate and will lead to its irreversible degradation and the loss of its ecosystem functions and services. This is expected to have dire consequences and negative impacts on the socio-economic development of the Member States

- The prolongation of national and regional political tensions and conflicts will lead to the victimization of human well-being and the environment, and to an exacerbation of the current RSA environmental pressures. Cooperation and dialogue at the national, regional, and inter-regional levels should replace tensions and armed conflicts between countries.

B. RECOMMENDATIONS

The following set of recommendations is drawn from the various substantive chapters of this Report and the discussions thereof. These recommendations are brought to the attention of the Member States of ROPME, their governmental bodies in charge of environmental affairs, and the national authorities/agencies, responsible for setting and following-up the environmental policies, for their possible action. Where relevant, some of these recommendations are also addressed to the marine and environmental research institutions in the respective countries for their consideration, as deemed appropriate.

The recommendations are categorized below by the relevant substantive areas and issues addressed in this Report, as far as possible.

1. On the the Region's coastal development activities

- ROPME Member States, to impose more stringent government restrictions on the rapid expansion of urban settlements in the coastal zone, and rigorously enforce regulations on coastal development projects, dredging operations and reclamation activities, particularly where such activities are intensively and extensively practiced and/or planned

2. On the conservation of biodiversity, coastal habitats and fisheries resources in the ROPME Sea Area

- ROPME Member States, to issue and/or closely follow-up on existing national regulations governing the conservation and protection of the marine environment, and, as deemed neccessary, designate additional Marine Protected Areas (MPAs) throughout the Region. An assessment of the effectiveness of these regulations, and the establishment of an integrated coastal management plan of these MPAs and of the coastal zone in general are needed at both the national and regional levels

- ROPME Member States, to seriously address the questions related to the conservation of marine biodiversity, and to adapt integrated fishery management approaches locally and regionally

- ROPME Member States, should consider the adoption of the,"Ecosystem-Based Management" approach, now being widely used in many parts of the world, in order to fulfill the sustainable development target for each country and for the Region as a whole

3. On the Emerging Environmental Issues

- ROPME Member States, to consider the formulation and adoption of a regional policy regulating nuclear activities and reducing the carbon emissions of the Region

- ROPME Member States, to support ROPME's Regional Nuclear Emergency Response Plan (RNERP), and to facilitate its mission in providing adequate response structure and guidance in the framework of a regionally-coordinated response system in case of any radiological emergency in the ROPME Sea Area

- ROPME Member States, to agree on plans and actions that commensurate with the efforts of the international community to mitigate possible impacts of global climate change on the Region's marine ecosystems and coastal areas, according to the IPCC best agreed scenarios for the Region

4. On Environmental Policies and Governance

- ROPME Member States, to adapt the principles of sustainable development in the formulation of national environmental policies and legislation, and in their long-term strategies, in order to realize a common management perspective, that would also foster regional cooperation in implementing regional programmes for pollution abatement and control, for addressing cross-boundary environmental challenges, and for resource conservation and management

- ROPME Member States, to adopt economic growth policies that would achieve sustainable socio-economic development, stimulate investment initiatives that are associated with adequate considerations to environmental protection and would, on the long-run, decrease any environmental degradation resulting from the negative impacts of unwise development practises, and hence lead to the required improvement in human well-being

- ROPME Member States, to integrate and mainstream their environmental management and protection policies into the national socio-economic development plans, with human and environmental considerations being central to planning

5. On Regional Protocols and International Agreements

- ROPME Member States should effectively pursue the implementation of the ROPME's Regional Protocols, and in particular, the Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources of 1990, as it addresses, control measures for the most important sources of pollution in the Region

- ROPME Member States, to implement the provisions of the international conventions relevant to the protection of the marine environment, including MARPOL 73/78, and to develop pertinent national legislation, allowing sanctions for non-compliance

- ROPME Member States to be further involved, at high expert and governmental levels, in the development of global environmental conventions and Multilateral Environmental Agreements (MEAs), to ensure that any future legally-binding instrument, negotiated globally, takes into consideration the specific nature and needs of the Region. In the meantime, ROPME Member States should encourage and facilitate the participation in the global programmes aiming at the protection and sustainable development of the marine environment and resources

6. On Regional Cooperation

- ROPME Member States, as the custodians of the common pool of resources in the RSA, have the collective duty to cooperate to improve its ecosystem health and sustain its functions and services for their current and future generations. To this effect, ROPME Member States should cooperate in areas related to the sustainable management of the RSA ecosystem. The main areas of cooperation are in the fields of trans-boundary bio-reserves and protected areas, regional Integrated Coastal Zone Management (ICZM) and planning, enforcement of laws and regulations, environmental monitoring and assessment, data analysis and interpretation, information exchange and knowledge sharing

- ROPME should sparehead the regional efforts to establish a “Regional Network of Research Institutions and Collaborating Centers” for the RSA, as an important step towards initiating and implementing RSA-oriented scientific research and capacity building programmes and projects

- ROPME Member States, to cooperate in developung a shared vision for the RSA, with long-term environmental goals and targets, to be agreed by all countries of the Region, with the objective of achieving superior quality of life and healthy environment. This should be accomplished in the long-term by strong emphasis and heavy investment on human development through relevant educational, training and capacity building programmes

- Joint activities between ROPME and other regional environmental bodies, such as PERSGA, as well as with relevant international organizations in all fields of mutual interest are required and should be encouraged and formalized

7. On Capacity Building

- ROPME and its Member States, should invest heavily in human resources development through education, training, and capacity development programmes in all aspects related to protection and integrated management of the coastal and marine ecosystems, and the sustainable development of the RSA. In this respect, regional planning for building the Region’s environmental expertise and capabilities is crucial, and ROPME is encouraged to draw upon the important and critical mass of scientists and local environmental institutions and expertise of the Region

8. General

- ROPME Member States, should, by all means, endeavor to avoid regional conflicts, and to invest in key issues for environmental protection and sustainability, such as human resources development; research, development and innovation; governance improvement; and regional cooperation. This would enable all governments of the Region to focus their attention on achieving sustainable development targets, and the Mellinnium Development Goals (MDGs) in their respective countries

ABBREVIATIONS AND ACRONYMS

A

AEOI	Atomic Energy Organization of Iran
AIS	Automatic Identification System
AME Info.	Information about the Middle East Region
AoA	Assessment of Assessment

B

BAPCO	Bahrain Petroleum Company
BAU	Business As Usual
BNBSAP	Bahrain National Biodiversity Strategic Action Plan
BTs	Butyltins

C

CAMRE	Council of Arab Ministers Responsible for the Environment
CC	Climate Change
CEU	Chrysene Equivalent Unit
COAMPS	Coupled Ocean-Atmospheric Mesoscale Prediction System
COP	Conference of the Parties
CVI	Coastal Vulnerability Index

D

DDD	Dichlorodiphenyl dichloroethane
DDE	Dichlorodiphenyl dichloroethylene
DDMU	Dichlorodiphenyl monochloroethylene
DDT	Dichlorodiphenyl trichloroethane
DPSIR	Drivers, Pressures, State, Impacts and Response

E

EA	Ecosystem Approach
EAC	Ecotoxicological Assessment Criteria
EAD	Environment Agency – Abu Dhabi
EAF	Ecosystem Approach to Fisheries
EBFM	Ecosystem-Based Fishery Management
EBM	Ecosystem-Based Management
EIA	Environmental Impact Assessment
ENSO	El-Nino Southern-Oscillation

EPA-Kuwait	Environment Public Authority of Kuwait
ERL	Effects Range Low
ERM	Effects Range Medium
ESCWA	Economic and Social Commission for Western Asia
EWS-WWF	Emirates Wildlife Society in association with World Wide Fund for Nature

F

FAO	Food and Agriculture Organization of United Nations
FSC	Flag State Control

G

GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Global Environment Outlook
GHGs	Green House Gases
GIS	Geographic Information System
GNP	Gross National Product
GPA	Global Programme of Action
GPA-LBA	Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
Gwh	Gigawatt hour

H

HABs	Harmful Algal Blooms
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HMW	High Molecular Weight

I

IAEA	International Atomic Energy Agency
ICAM	Integrated Coastal Area Management
ICZM	Integrated Coastal Zone Management
IEA	Integrated Environmental Assessment
IFs	International Futures
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission

IOSW	Indian Ocean Surface Water
IPCC	Intergovernmental Panel on Climate Change
I-RSA	Inner ROPME Sea Area
ISO	International Organization for Standardization
ITAs	Important Turtle Areas
IUCN	International Union for Conservation of Nature

J

JICA	Japan International Cooperation Agency

K

KTCP	Kuwait Turtle Conservation Project

L

LBA	Land-Based Activities
LBS	Land- Based Sources
LMW	Low Molecular Weight

M

MA	Millennium Assessment
MAR	Managed Aquifer Recharge
MARDOS	Dose Assessment from Marine Radioactivity
MARPOL	International Convention for the Prevention of Pollution from Ships
MAU	Business as Usual
MBT	Monobutyltin
MEA	Millennium Ecosystem Assessment
MECA/ESO	Ministry of environment and Climate Affairs/Environment Society of Oman
MEHRAs	Marine Environment High Risk Areas
MEL-IAEA	Marine Environmental Laboratory of the International Atomic Energy Agency
MEMAC	Marine Emergency Mutual Aid Centre
MEPC/ IMO	Marine Environment Protection Committee of the International Maritime Organization
MESL	Marine Environmental Studies Laboratory
MMPA	Marawah Marine Protected Area
MODIS	Moderate Resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
MPAs	Marine Protected Areas

MRF	Marine Research Foundation
M-RSA	Middle ROPME Sea Area
MSC	Marine Science Center, Iraq
MTCS	Maritime Traffic Control Systems

N

NASA-GSFC	National Aeronautics and Space Administration's Goddard Space Flight Center
NASA-OBPG	National Aeronautics and Space Administration's Ocean Biology Processing Group
NCRI	National Coral Reef Institute
NGOs	Non-Governmental Organizations
NOAA-NGDC	National Oceanic and Atmospheric Administration's National Geophysical Data Center

O

OPEC	Organization of Petroleum Exporting Countries
O-RSA	Outer ROPME Sea Area

P

PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyl
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PHs	Petroleum Hydrocarbons
POPs	Persistent Organic Pollutants
PPP	Polluter-Pays Principle
PSC	Port State Control

R

R&D	Research and Development
RA	Risk Analysis
RAMSAR	Convention on Wetlands of International Importance
RAP	RSA Action Plan
RECOFI	Regional Commission for Fisheries
RECSO	Regional Clean Sea Organization
RIEOS	Regional Integrated Environmental Observation System
RIIS	ROPME Integrated Information System
RML	Radiometrics Laboratory

RMW	ROPME Mussel Watch
RNCT	Regional Nuclear/Radiological Coordination Team
RN-EPR	Regional Nuclear Emergency, Preparedness and Response Plan
RNERP	Regional Nuclear Emergency Response Plan
ROEq	ROPME Oil Equivalents
ROPME	Regional Organization for the Protection of the Marine Environment
RPA	Regional Programme of Action
RSA	ROPME Sea Area

S

SAP	Strategic Action Plan
SBS	Sea- Based Sources
SCENR	Supreme Council for the Environment and National Reserves
SCUBA	Self-Contained Underwater Breathing Apparatus
SDI	Spatial Data Infrastructure
SEA	Strategic Environmental Assessment
SLR	Sea Level Rise
SOMER	State of the Marine Environment Report
SRSA	Sustainable ROPME Sea Area
SST	Sea Surface Temperature
STEEP	Social, Technological, Economical, Environmental and Political

T

TBT	Tributyltin
TDA	Trans-boundary Diagnostic Analysis
TFR	Total Fertility Rates
TOC	Total Organic Carbon
toe	tone of oil equivalent
TSE	Treated Sewage Effluent

U

UAE	United Arab Emirates
UCM	Unresolved Complex Mixture
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity

UNCLOS	United Nations Convention on the Law of the Sea
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP/GPA	United Nations Environment Programme/Global Programme of Action
UNEP/ROWA	United Nations Environment Programme – Regional Office for West Asia
UNESCO	United Nations Educational, Scientific and Cultural Organization
UTC	Universal Time Coordinated (or) Coordinated Universal Time

W

WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund
WWTP	Waste Water Treatment Plant

CHAPTER 1

INTRODUCTION

The Regional Conference of Plenipotentiaries on the 'Protection and Development of the Marine Environment and the Coastal Areas' of Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE)' convened in Kuwait on 24 April 1978. The Conference adopted:

1) The Action Plan for the Protection and Development of the Marine Environment and the Coastal Areas (ROPME, 1978a),

2) The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (ROPME, 1978b), and

3) The Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (ROPME, 1978b).

At that time, the term 'ROPME Sea Area' (RSA) was coined to denote coastal zones and sea areas surrounded by the eight Member States of ROPME, and covered by the Kuwait Regional Convention of 1978.

Several other legal instruments were developed and adopted by the Member States of ROPME as Regional Protocols in support of the Kuwait Regional Convention (Box 1.1).

BOX 1.1 – ROPME Protocols

- Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (ROPME, 1978b).
- Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf (ROPME,1989)
- Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources (ROPME, 1990)
- Protocol on the Control of Marine Trans-boundary Movements and Disposal of Hazardous Wastes and Other Wastes (ROPME, 1998)

1.1 DEFINITION AND GEOGRAPHIC LIMITS OF THE ROPME SEA AREA

Article II of the Convention defines the boundaries of the ROPME Sea Area (RSA), as shown in Figure 1.1.

Furthermore, the continuous effort of ROPME/MEMAC succeeded in declaring the sea area located northwest of the rhumb line between Ras Al-Hadd (22^o 30′ N, 60^o 00′ E) and Ras Al-Fasteh (25^o 04′ N, 61^o 25′ E) as a "Special Area" by the International Maritime Organization (IMO) on 1^{st} August 2008 (See Box 1.2) for the Special Area declared by IMO).

1.1.1 Geographical Divisions of the RSA

The RSA is further divided into three geographically and environmentally distinct parts (Figure 1.1). The division referred to as the Inner RSA (I-RSA) consists of the marine area west of 56^oE longitude that extends along the NW/SE axis from the north boundary of the RSA to the north of Strait of Hormuz. The Middle RSA (M-RSA) covers the Sea of Oman, and the Outer RSA (O-RSA) stretches over the entire southern boundary of the RSA across the Arabian Sea that starts from Ra's Al-Hadd to the southern border of Oman (for detailed description see SOMER 2003).

Figure 1.1 Geographical coverage and divisions of the RSA

The RSA is bounded in the south by the rhumb lines16° 39'N, 53° 3'30'E; 16° 00'N, 53° 25'E; 17° 00'N, 56° 30'E; 20° 30'N, 60°00'E; 25° 04'N, 61° 25'E, adding up approximately to a surface area of 465,000 km² comprising three geographically and environmentally distinct parts: the Inner RSA (I-RSA), the Middle RSA (M-RSA) and the Outer RSA (O-RSA) as described above.

1.1.2 Geology and Geomorphology of RSA

The RSA has evolved as a result of the interaction of the Arabian-Eurasian plate. According to Wood *et al*. (2011), the Arabian-Eurasian plate boundary is marked by an along-strike tectonic transition from continent-continent collision in Zagros Mountains to ocean-continent convergence and subduction at the Makran Trench (Figure 1.2). Much of the deformation and seismicity responsible for the high-relief topography of Zagros Mountains and the north-eastern margin of RSA can be explained within the context of active tectonics associated with plate convergence (Wood *et al*., 2011). In contrast, the aseismic low-relief coastal regions along the southern margin of the RSA are widely considered to be tectonically quiescent region (US Geological Survey, 2011). Wood *et al*, 2011 indicated that the coastline along the southern Inner RSA between Al-Jubail, Kingdom of Saudi Arabia (KSA), and Dubai (UAE) appears to have risen at least 125 m in the last 18,000 years. The present shorelines were reached shortly before 6000 years ago and exceeded as relative sea level rose 1-2 m above its present level, inundating the low-laying areas of lower Mesopotamia (Lambeck, 1996).

BOX 1.2 – Special Area Status

In its 56th Meeting, 9th – 13th July 2007, the Marine Environment Protection Committee (MEPC/ IMO), adopted the Resolution on declaring the RSA as a Special Area, with effect from 1th August 2008. This status imposes special discharge requirements in accordance with the regulation 1.11.5 of MARPOL Annex I and regulation 5(1)(e) of MARPOL Annex V in respect of the Gulf's Area Special Areas. MEMAC has informed Member State and Shipping industry of these requirements (Summarized in the tables below).

DISPOSAL OF GARBAGE FROM SHIPS ACCORDING TO MARPOL - THIS APPLIES TO ALL SHIPS REGARDLESS OF SIZE. It is prohibited to discharge any garbage into the sea except food waste when the ship is more than 12 NM from the nearest land. This applies to all ships and offshore platforms regardless of size.

Source: MEMAC 2008.

GARBAGE TYPE	OUTSIDE SPECIAL AREAS	INSIDE SPECIAL AREAS
All plastics, including but not limited to fishing nets, synthetics, plastic garbage bag and incinerator ashes from plastic products.	Prohibited	Prohibited
Floating dunnage, lining and packing materials	Prohibited less than 25 Nautical Mile (NM) from land	Prohibited
Food waste, paper, rags, glass, metal, bottles, crockery and similar refuse	Prohibited less than 12 Nautical Mile (NM) from land	Prohibited
Food waste comminuted of ground	Prohibited less than 3 Nautical Mile (NM) from nearest land	Prohibited less than 12 Nautical Mile (NM) from nearest land

Box – 1.2 (Contd…)

DISPOSAL OF OIL FROM SHIPS ACCORDING TO MARPOL

CONTROL OF DISCHARGE OF OIL (Machinery Space of all Ships)	OUTSIDE SPECIAL AREA	INSIDE SPECIAL AREA
Ships of 400 GT and above	Prohibited to discharge oil or oily mixture into the Sea except when all of the following conditions are satisfied: - The ship is proceeding en route - The oily mixture is processed through an Oil Filtering Equipment (Any ships of 400 GT and above but less than 10,000 GT Oil Filtering Equipment) (Any ships of 10,000 GT and above Oil Filtering Equipment with the alarm arrangements and automatic stopping device) - The oil content of the effluent without dilution does not exceed 15 ppm - The oily mixture does not originate from cargo Pump- room bilges on Oil Tankers - The oily mixture, in case of Oil Tankers, is not mixed with Oil Cargo residues Prohibited to discharge oil or oily mixture into the Sea except when the following conditions are satisfied: - The ship is proceeding en route; - The oily mixture is processed through an Oil Filtering Equipment with alarm arrangements and automatic stopping device - The oil content of the effluent without dilution does not exceed 15 ppm - The oily mixture does not originate from cargo pump-room bilges on oil tankers - The oily mixtures, in case of Oil Tankers, is not mixed with Oil Cargo residues	Prohibited to discharge oil or oily mixture into the Sea except when the following conditions are satisfied: - The ship is proceeding en route; - The oily mixture is processed through an Oil Filtering Equipment with alarm arrangements and automatic stopping device - The oil content of the effluent without dilution does not exceed 15 ppm - The oily mixture does not originate from cargo pump-room bilges on oil tankers - The oily mixtures, in case of Oil Tankers, is not mixed with Oil Cargo residues

CONTROL OF DISCHARGE OF OIL (Machinery Space of all Ships)	OUTSIDE SPECIAL AREA	INSIDE SPECIAL AREA
Ships of less than 400 GT	Oil and all oily mixtures shall either be retained on board for subsequent discharge to reception facilities or discharge into sea in accordance with the following provisions: Oil and all oily mixtures shall either retain on board for subsequent discharge to reception facilities or discharge into sea in accordance with the following provisions: - The ship is proceeding en route - The ship has in operation equipment of a design approved by the Administration that ensures that the oil content of the effluent without dilution does not exceed 15 ppm - The oily mixture does not originate from cargo Pump-room bilges on Oil Tankers - The oily mixture, in case of Oil Tankers, is not mixed with Oil Cargo residues	Oil and all oily mixtures shall either be retained on board for subsequent discharge to reception facilities or discharge into sea in accordance with the following provisions: - The ship is proceeding en route - The ship has in operation equipment of a design approved by the Administration that ensures that the oil content of the effluent without dilution does not exceed 15 ppm - The Oily mixture does not originate from cargo Pump-room bilges on Oil Tankers - The oily mixture, in case of Oil Tankers, is not mixed with Oil Cargo residues
Oil Tankers of 150 GT and above	Prohibited to discharge oil or oily mixture into the Sea except when all of the following conditions are satisfied: - The Tanker is not within a Special Area - The Tanker is more than 50 nm (Nautical miles) from the nearest land - The Tanker is proceeding en route - The instantaneous rate of discharge of oil content does not exceed 30 liter per nm - The total quantity of oil discharged into the sea does not exceed 115,000/ of the total quantity of the particular cargo of which the residue formed a part (for the Tankers delivered on or before 31 December 1979 and 130,000/ for the Tankers delivered after 31 December 1979 - The Tanker has in operation an oil discharge monitoring and control system and a slop tank arrangement	Prohibited to discharge any oil or oily mixture from the Cargo area
Oil Tankers of less than 150 GT	- Retention of oil on board with subsequent discharge of all contaminated washing to reception facilities	- Same as outside Special Area

1.1.3 Bathymetry

The bathymetry of the RSA varies considerably over its three different parts (Figure 1.2). The I–RSA is a sedimentary basin, shaped to a great extent by a Tertiary fold system, which causes its deepest depression to run along its northern side (Sheppard *et al.*, 1992). It is asymmetric, with its northwest southeast axis separates a stable and very gradually sloping Arabian shoreline on one side from a geologically unstable and steeper Asian or Iranian shoreline (Purser and Seibold, 1973). No part of the I–RSA has a continental shelf edge and there are no large or abrupt changes in bathymetry, except at the entrance to the M–RSA in the east. Today the I–RSA is a basin which is relatively shallow sea with a depth ranging between 10–100 m which means almost all parts of it lie within the photic zone (Al-Ghadban and Abdali, 1998).

The deepest region being closest to the Iranian coast, with its bottom slopes gradually from the very shallow deltaic northern part to deeper waters in the south, where it reaches more than 100 m at the entrance of the Straits of Hormuz. There is no silt in the Strait of Hormuz; the trough simply deepens to more than 100 m through the Strait and drops quickly to more than 2000 m within 200 km outside the Strait (Reynolds, 1993), in the M-RSA. The basin of the M-RSA (Sea of Oman) widens and gets deeper towards the Arabian Sea, reaching depths exceeding 5000 m in the O-RSA.

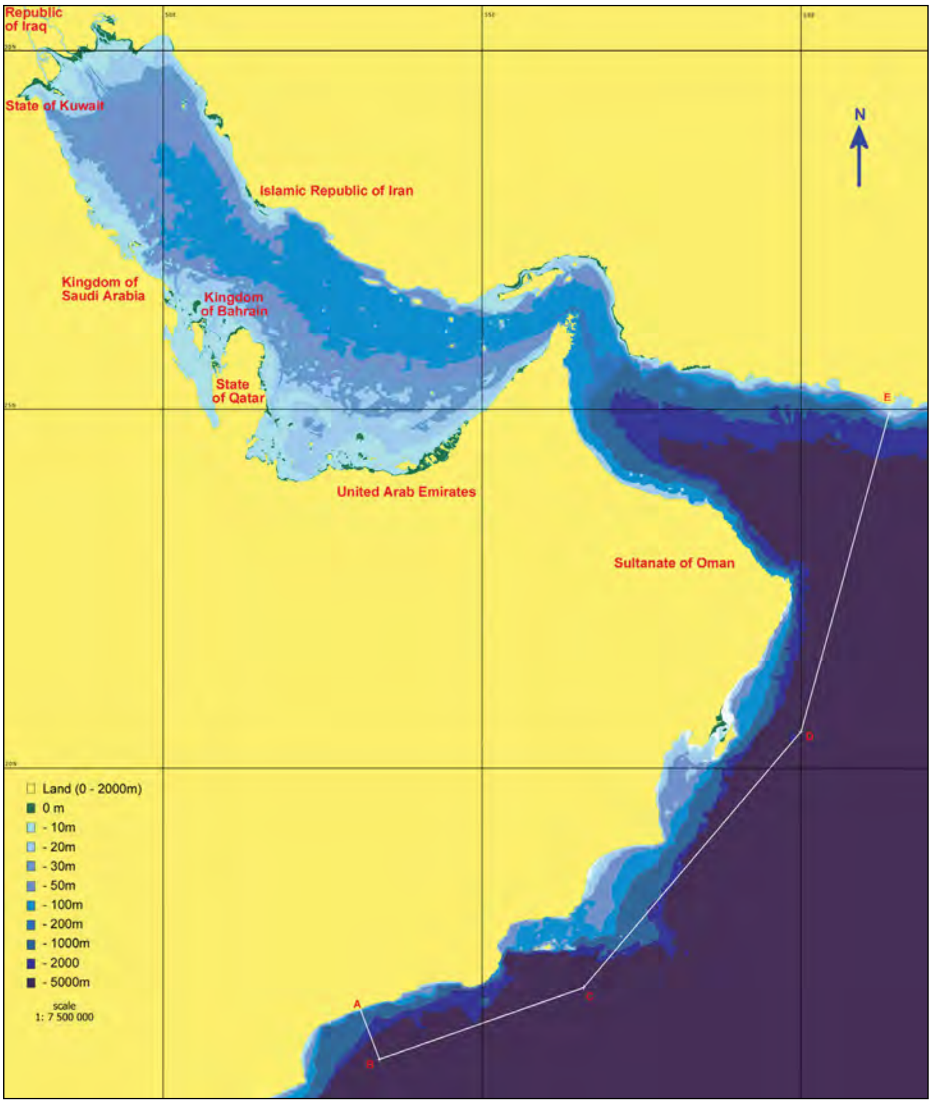


Figure 1.2 Bathymetry of the RSA

1.2 BRIEF DESCRIPTION ON THE APPROACH OF SOMER-2013

The present report provides what could be considered as the best presentation possible of the current state of the marine environment of the ROPME Sea Area, based on data and information available in the "National State of the Marine Environment Reports" of the Member States, and ROPME Secretariat, in addition to other sources, including regional and International scientific reports.

As mentioned in the "Preface", SOMER-2013 has been developed in accordance with the "Global Environment Outlook" (GEO) process, which is being followed by UNEP in its global environmental reporting. It also adopts the causal framework describing the interaction between the **D**rivers, the **P**ressures, the **S**tate of environment, the **I**mpacts, and the **R**esponse (DPSIR), schematically described in (Figure 1.3).

DPSIR Framework for State of Environment Reporting, developed by the "Global Environment Outlook" (GEO) process of UNEP, defines DPSIR as the framework, used to assess and manage environmental problems. Drivers are the socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment. Pressures are the stresses that human activities place on the environment. State, or state of environment, is the condition of the environment. Impacts are the effects of environmental degradation. Response refers to the responses by society to the environmental situation.

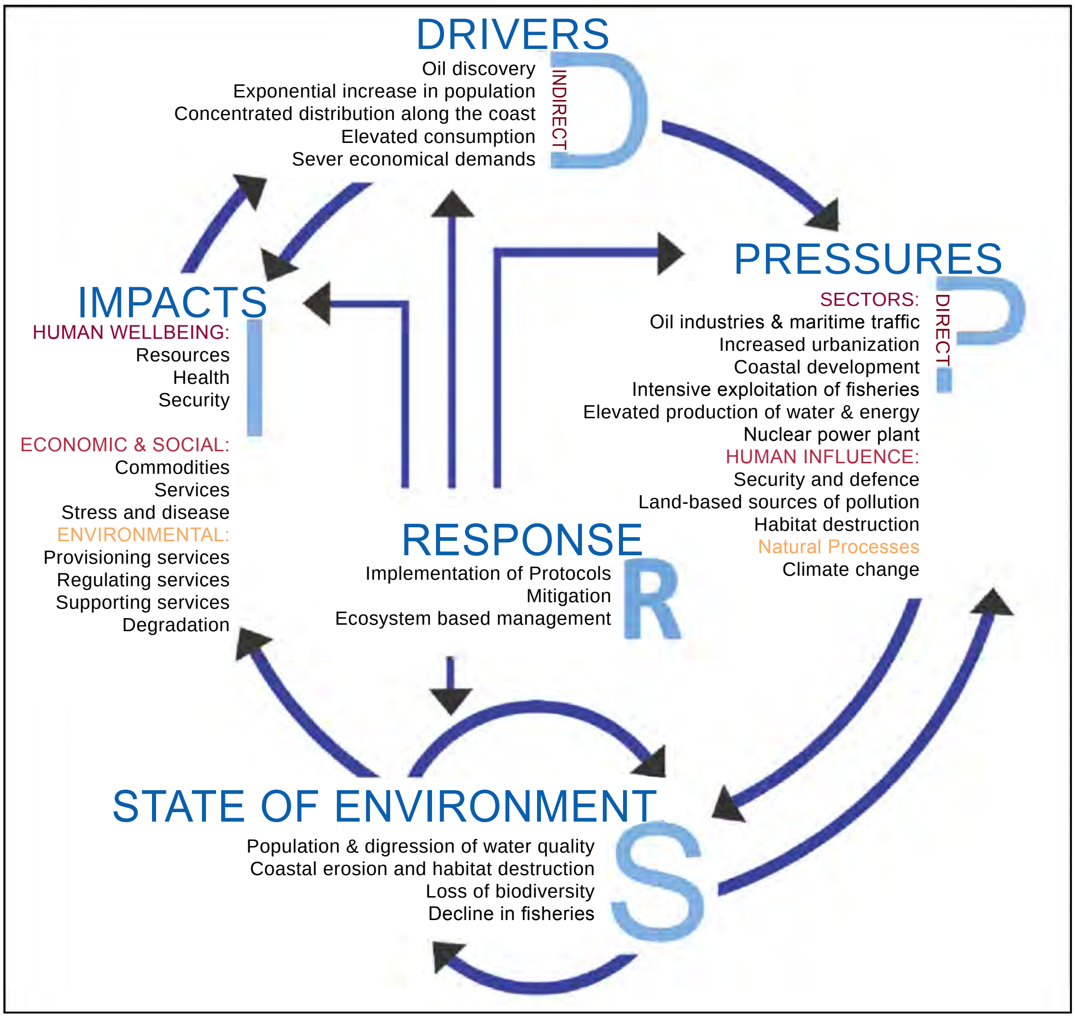


Figure 1.3 DPSIR Framework for State of Environment Reporting by UNEP's GEO

CHAPTER 2

SOCIO-ECONOMIC ACTIVITIES AND DRIVERS

KEY MESSAGES

- The population growth and increased urban settlement along the coastal areas in RSA, has increased the demands on ecosystem services and resources, stretching the coastal and marine ecosystems beyond the carrying capacity
- The associated environmental impacts of urban life affects both human well-being and the environment, due to increased pollution from both domestic and industrial sources
- The coastal area development for residential, industrial and commercial purposes, has severely impacted the highly productive intertidal zones, reducing the nursery and feeding grounds for most of the commercial shrimp and fish species
- The fisheries resources are over-exploited or have already reached optimum exploitation for some major species
- The overuse of electricity and water is further impacting the marine and coastal ecosystems, through increased pollution and emissions
- The problems of urban sprawl in the RSA is crucial for sustainable development of the region and should be addressed attentively

The discovery of oil in the first half of the twentieth century and the realization of its financial returns, bringing widespread prosperity by enhancing the livelihoods in the Region, have fuelled rapid socio-economic and political transformation of the Member States. Consequently, the Region has been witnessing unprecedented rates of population growth due to increase

Figure 2.1 Night lights demonstrating the intensive distribution of the population on the coasts of the RSA. (Source: Imhoff of NASA GSFC and Christopher Elvidge of NOAA NGDC, 2010. Image by Craig Mayhew and Robert Simmon, NASA GSFC) (http://visibleearth.nasa.gov/view.php?id=55167)

of local population due to the influx from within, as well as migration from outside. This has resulted in intensive coastal urbanization, transforming the shallow and productive marine and coastal ecosystems into lands for large-scale infrastructure to support oil industries, housing, and recreation, coupled with other supportive facilities such as mega desalination plants and waste handling and disposal systems. The extent of settlement within the coastline has exceeded 50 per cent in some of the ROPME Member States (Figure 2.1). This rapid urban change, and three regional wars disturbing the marine and terrestrial ecosystem, has imposed a number of anthropogenic pressures surpassing the carrying capacity of the marine and coastal ecosystems, especially due to high demands and consumption of energy, freshwater, and fisheries resources.

Therefore, this Chapter focuses on socio-economic driving forces and, activities imposing pressure and leading to adverse impacts on the marine and coastal ecosystems, particularly those resulting from coastal population growth, urbanization, maritime transport, as well as urban sprawl and physical alteration of the coastal areas.

2.1 DEMOGRAPHIC INDICATORS

Demographic developments in the Member States of ROPME are one of the most dominant factors creating pressures on the RSA natural resources of the Area. In the last four decades, the total population of the RSA countries, including the expatriates, has tripled, increasing from 46.5 millions in 1970 to almost 150 millions in year 2010 (Figure 2.2). Recently, there have been some efforts to control population growth in many ROPME Member States. Nonetheless, it is projected that the rates of growth in the countries of the Region will decline to 2.1% or less than the global replacement rate during the next two decades, reaching a projected total population of about 200 million in 2030 (UNDP, 2009; UNDESA, 2010).

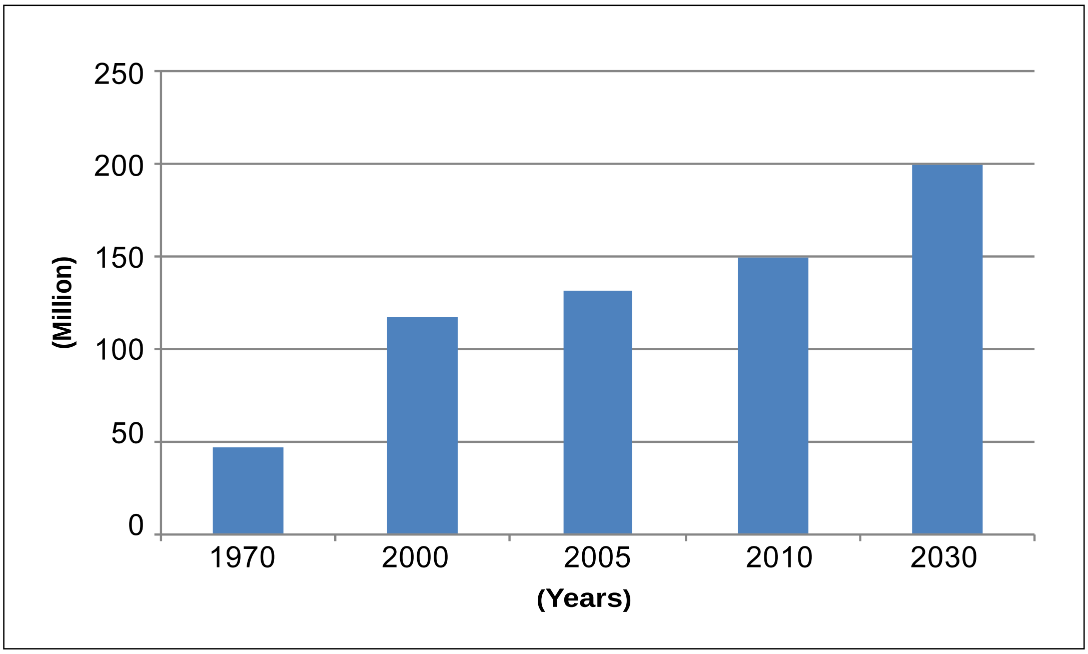


Figure 2.2 Total populations of the ROPME Member States. The total population, including the expatriates, of RSA countries has increased from 46.5 millions in 1970 to 150 millions in 2010. Nonetheless, it is projected that the rates of growth in RSA countries will decline to reach 2.1% or less than the global replacement rate during the next two decades. (Source: UNDP, 2009; UNDESA, 2010)

Population size varies remarkably between the countries of the RSA (Figure 2.3). The population growth rates also vary through the RSA countries indicating divergent social, economic and cultural factors. During the period 2000 - 2005 the average percentage growth rates ranged from 1.3% in Iran to 5.86% in UAE, whereas the period 2006 - 2010 witnessed tremendous growth rates in some of the RSA countries, for example slightly exceeding 11% in Bahrain and 12% in UAE (Figure 2.4). The high growth rate of population in the west coast countries, in particular, is due to rapid natural increase rates: high fertility rates (Figure 2.5), low mortality rates and increased average life expectancy at birth (Figure 2.6), as well as high influx of foreign and expatriate workers (UNDESA, 2010; UNDP, 2010).

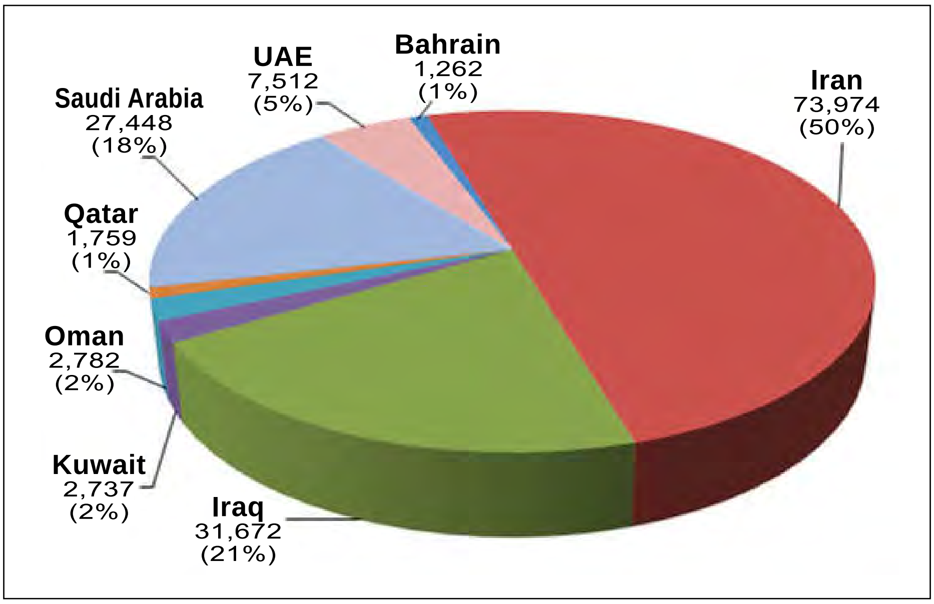


Figure 2.3 RSA population by country in 2010 (Source: UNDESA, 2010)

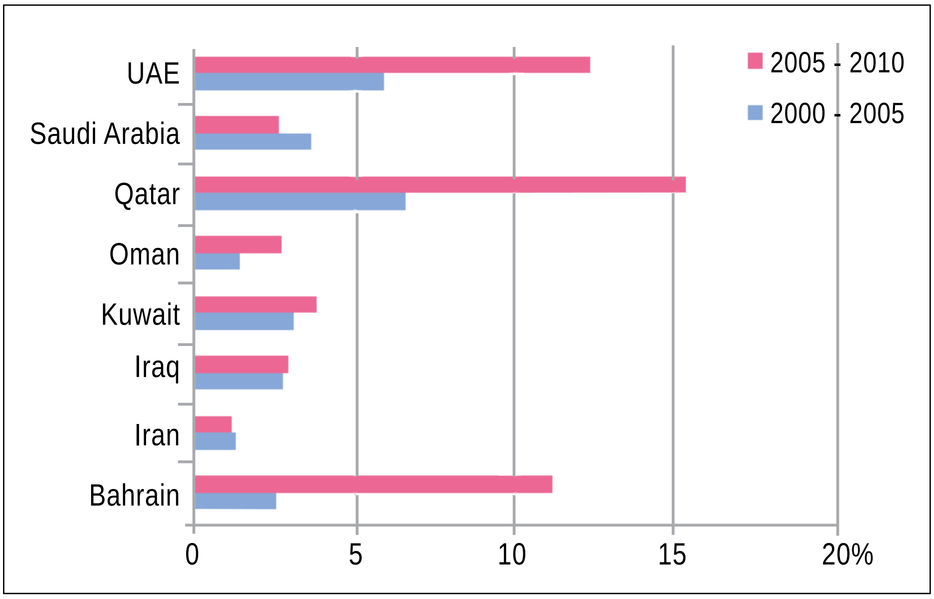


Figure 2.4 Periodic population growth rates in the ROPME Member States between 2000 and 2010 (Sources Kuwait Central Statistical Bureau, 2012; Oman Census, 2012; Qatar Census, 2010; UNDESA, 2010)

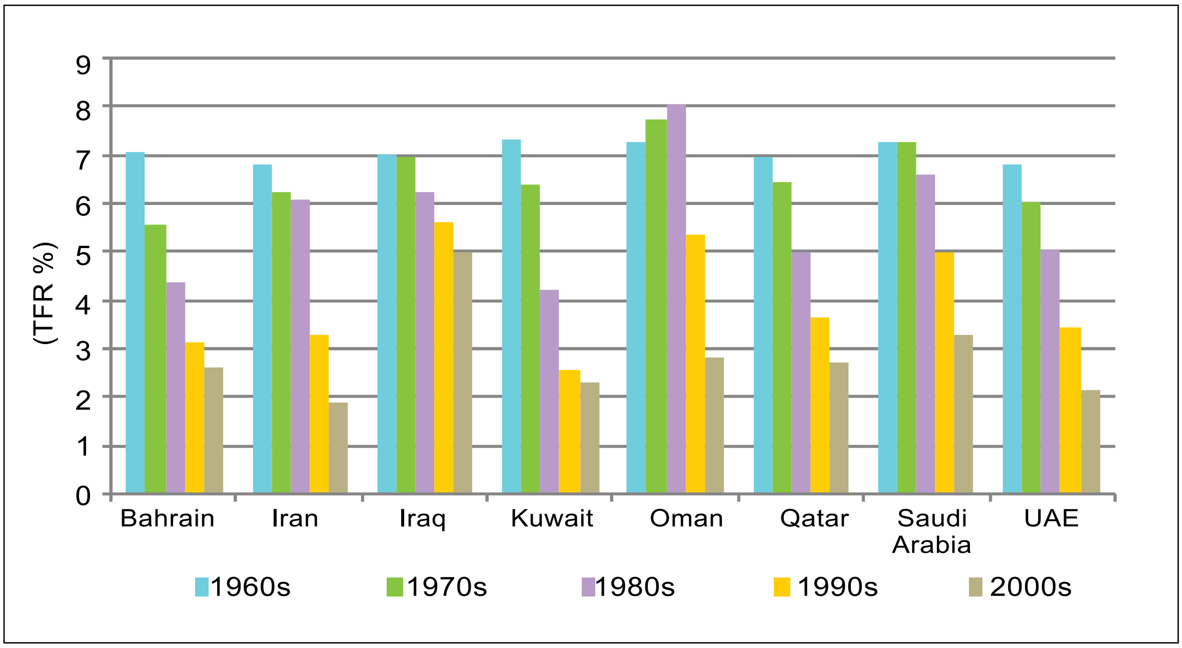


Figure 2.5 Total Fertility Rates-TFR (children/women) in RSA Countries (1960 - 2010). In most of the countries of the RSA the average TFR rates dropped by half between 1960 and 2010, from about 6.0 children to 2.5 children per woman, partly because of the rapid economic development but also because of a complex mix of social and cultural forces and greater access by women to education, income earning opportunities and sexual and reproductive health services. Nonetheless, the TFR for various Countries of the RSA is still above the global average of 2.1 children per woman, which is expected to remain higher in the next two decades with a rate of 3.1 children per woman for the period 2010- 2020. (Sources: Kuwait Central Statistical Bureau, 2012; Oman Census, 2012; Qatar Census, 2010; UNDESA, 2010)

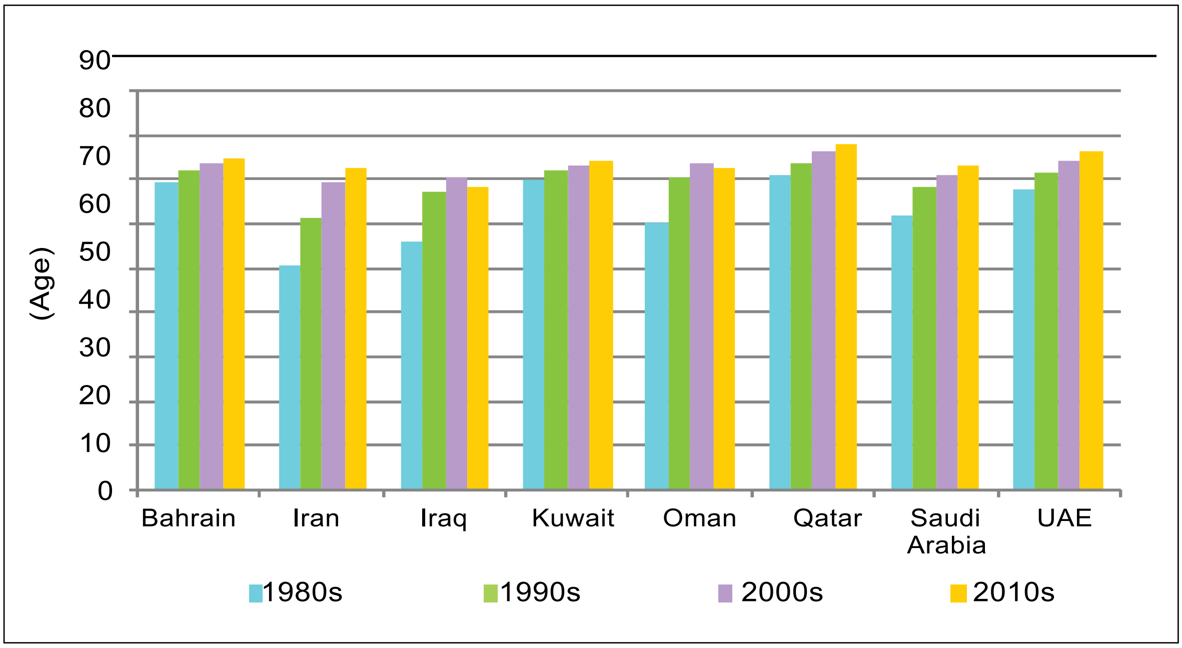


Figure 2.6 Average life expectancy in RSA Member States (1980 - 2010). The average life expectancy at birth in the Countries of RSA has been increasing over the last decades, ranging in 2011 from 67.8 in Iraq to 77 in UAE (Sources: Kuwait Central Statistical Bureau, 2012; Oman Census, 2012; Qatar Census, 2010; UNDESA, 2010; UNDP, 2009, 2011)

2.1.1 Urban Sprawl in the Coastal Areas

Out of the total population of the Member States, the total urban population in 1970 was 21.8 millions. This has increased to 84 millions in 2000, 95.23 millions in 2005, 106.7 millions in 2010, and is projected to increase to 153.3 millions in the year 2030 (UNDESA, 2010). In states located on the western side of I-RSA, almost 80% of the total population is living in urban settlements (Figure 2.7). Given the shortage of suitable land for development, in many Member States, such as Kuwait, Qatar and UAE, most of the major cities are situated on the coast (Figure 2.8), and almost up to 100% of the total population is living in urban areas located mainly along the coastal areas (Figure 2.9). For example in the case of UAE (Figure 2.10), 70 % of the total population is living in coastal urban centers (www.citypopulation.de/UAE.html).

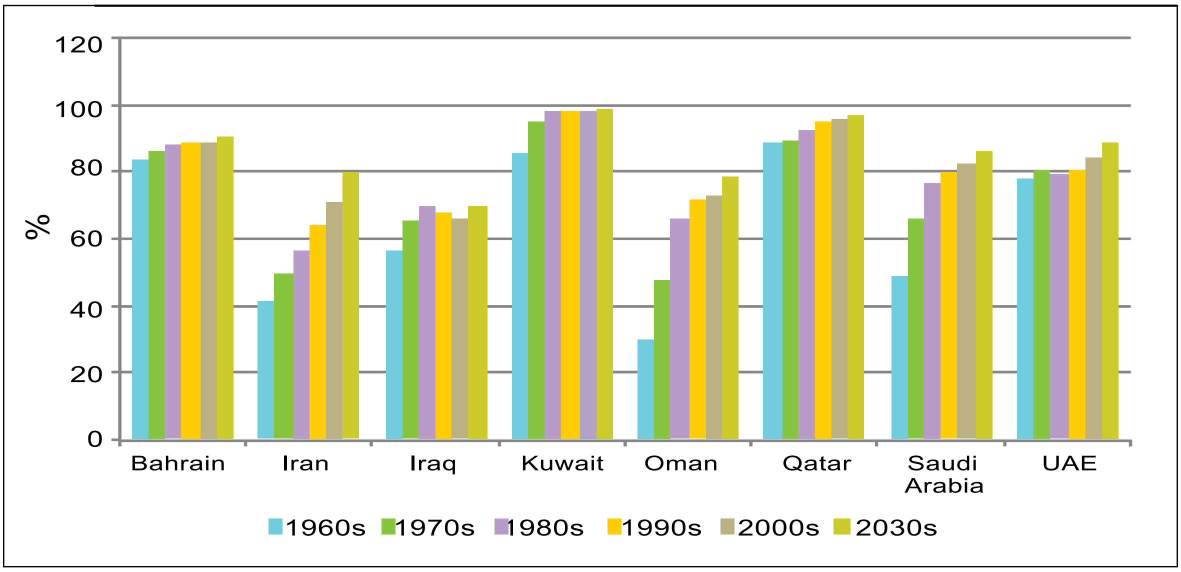


Figure 2.7 Percentage urban population in the ROPME Member States (From 1970s and the projection for 2030). (Sources: Kuwait Central Statistical Bureau, 2012; Oman Census, 2012; Qatar Census, 2010; UNDESA, 2010)

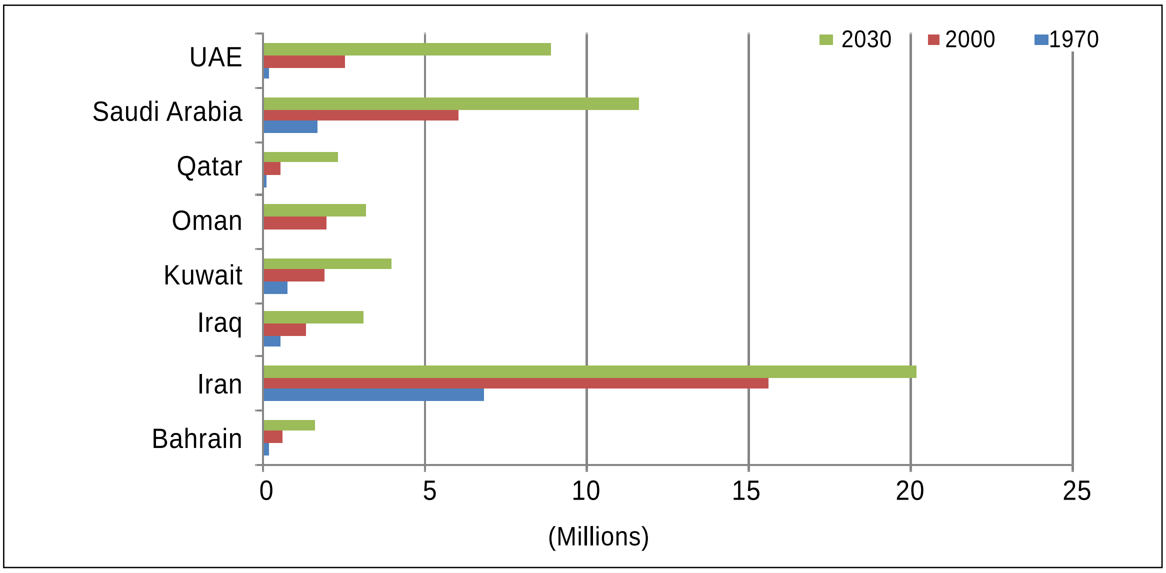


Figure 2.8 Population within coastal area in the ROPME Member States. Total population (Millions). (Sources: Kuwait Central Statistical Bureau, 2012; Oman Census, 2012; Qatar Census, 2010; UNDESA, 2009)

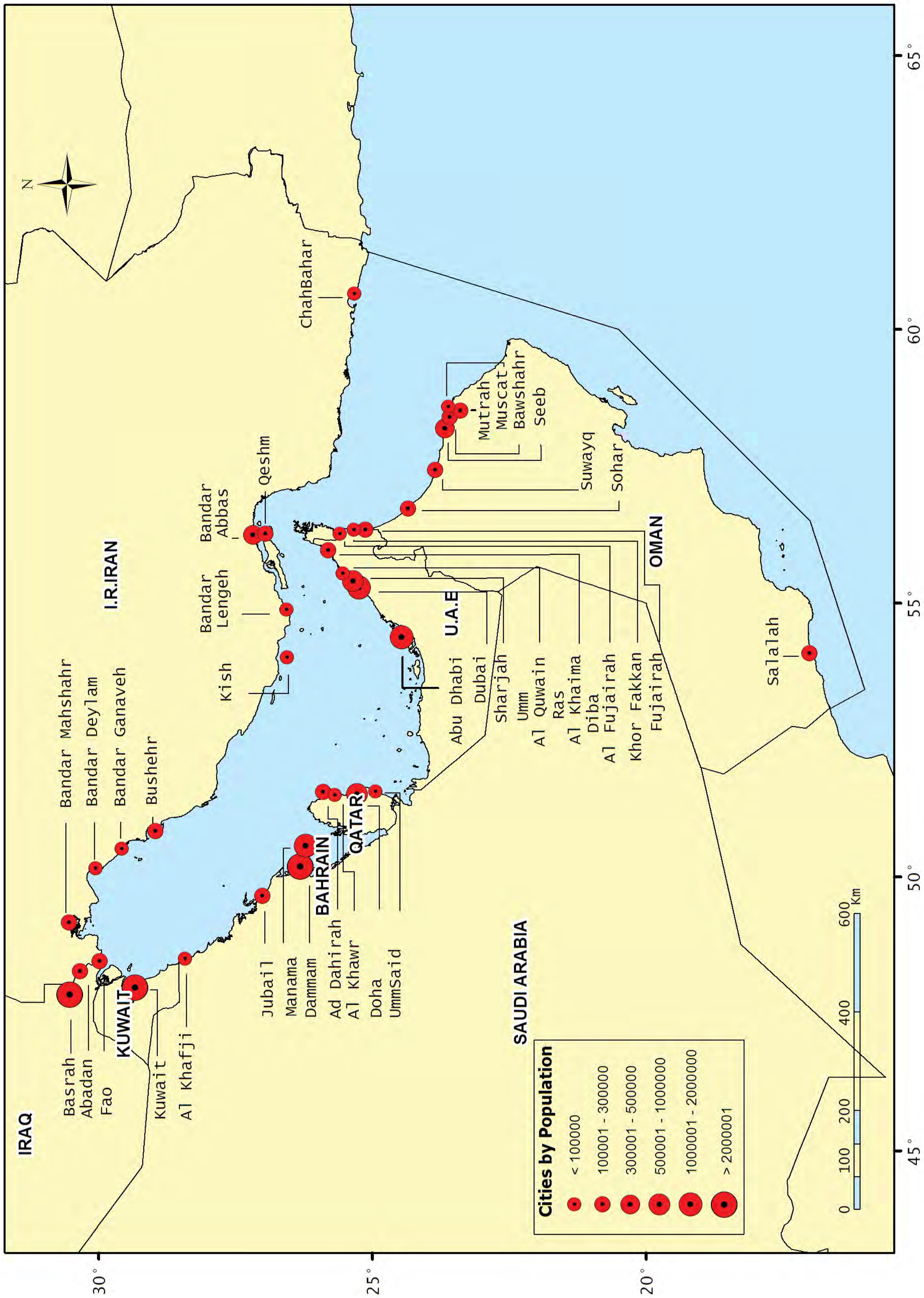


Figure 2.9 Major cities surrounding the ROPME Sea Area

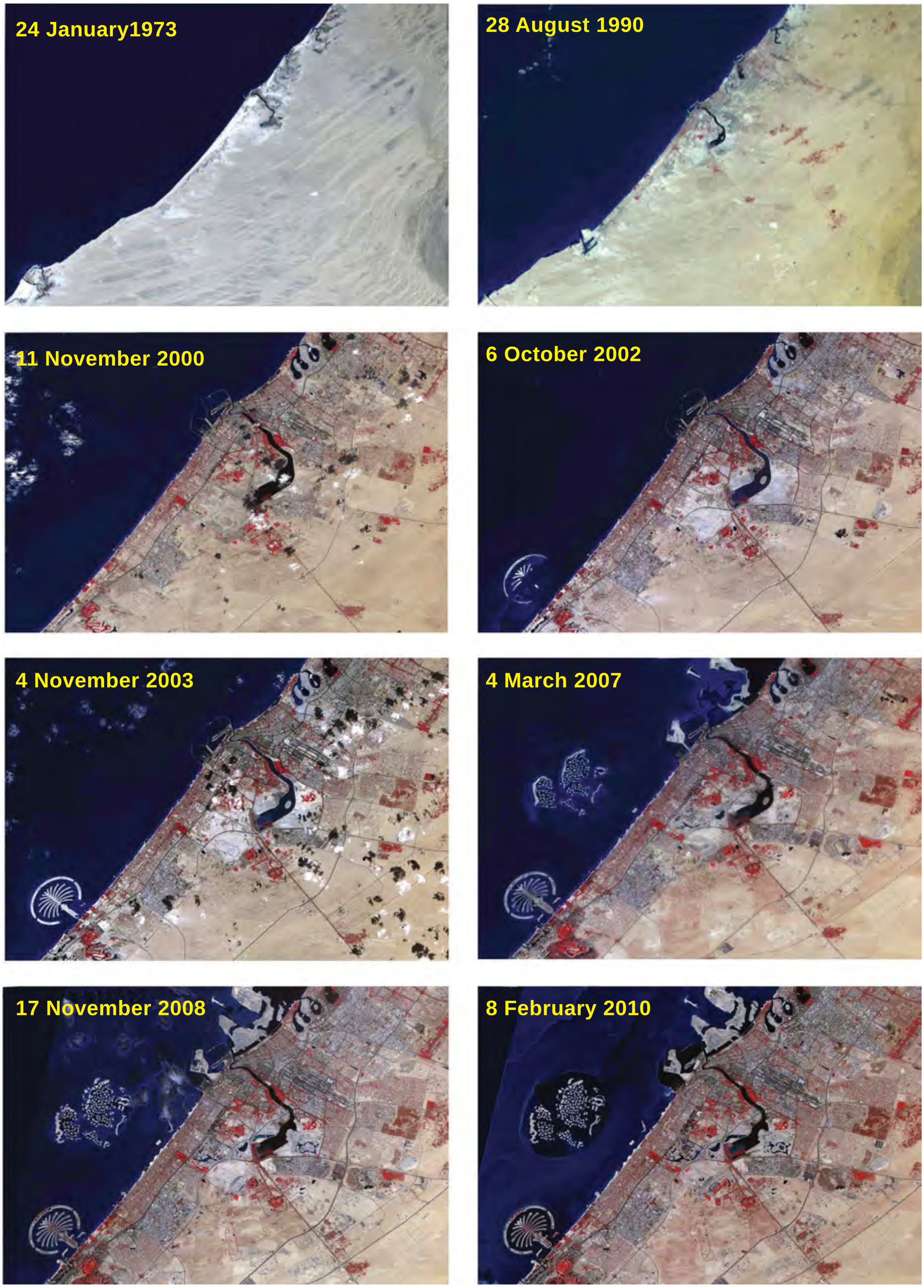


Figure 2.10 Urban developments in Dubai – UAE, between 1973 and 2010

As urban areas expand, demand for land increases and prime coastal habitats are transformed into land for infrastructure, housing, tourism, recreation and industrial developments. In most of the countries of the RSA the coastal ecosystems are continuously threatened by urban land conversion, which range from filling of coastal lowlands and marshes to large-scale dredging and landfilling projects. Such population growth and urbanization rates created and continue to exert tremendous pressures on the marginal terrestrial resources and the RSA marine ecosystems. These development activities can lead to loss of agricultural lands, accelerates the depletion of ground water tables, salinization, pollution, and alteration of the hydrological balance and alteration of coastal ecosystems.

Addressing the problems of urban sprawl in the RSA is crucial for sustainable development. Any analysis should take into consideration sectorial, rural and urban socio-economic policies, which are key inputs for controlling current and future environmental degradation of the coastal ecosystems at the local, national and regional levels. The trade-offs between preserving existing marshes, wetlands and marine ecosystems, on the one hand, and the conversion of such areas into land suitable for urban developments, on the other, are often decided by policies based on the positive impacts of urbanization on development and the need to satisfy the ever-growing demands for urban growth.

2.2 ECONOMIC INDICATORS

The economic situation in most of the RSA is unique, where many countries of the area have a small population and large hydrocarbon reserves, and the work force relies heavily on non-national labor (expatriates). Statistics show that the western coast countries collectively account for 40% of world proven oil reserves, which makes them leading oil producers by supplying about 23% of world crude oil production. Additionally, the RSA countries have at their disposal up to 23% of the world natural gas reserve and account for 8% of the world natural gas production. Therefore, the economies of most of the RSA countries have been dominated by the oil and gas sectors (Figure 2.11), although, the relative contribution of other sectors to Gross Domestic Product (GDP) have increased over the years. As the main source of wealth in the Region, any change in oil price can affect the GDP widely.

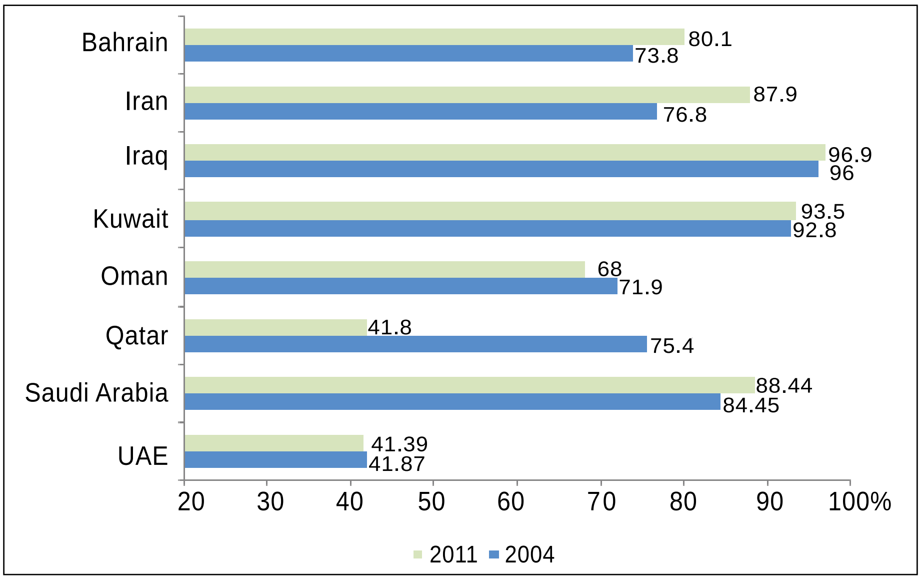


Figure 2.11 Percentage contribution of the oil sector in the economies of the ROPME Member States (2004 and 2011). (Source: OPEC, 2012)

The tremendous increase in the price of petroleum products during the last few years created an economic boom in RSA, so that the real GDP per capita grew faster than the trend rate of past economic growth. However, the global economy slowed down from mid 2008, impacting the world economy. This was reflected in some parts of the Region. Several countries of the RSA showed strong economic recovery in 2010 (Figure 2.12), as the intensity of the global recession began to level and ease, coupled with a gradual increase in oil and gas revenues, the reserves from the oil sector was used to support the non-oil sectors.

2.2.1 Economies of the RSA Countries

During 2009 - 2010 the higher oil prices combined with increased crude output and ever increasing demand of energy by Asian economies, helped to push the collective nominal GDP of the GCC States up by almost US$ 133 billion (Figure 2.12). On the other-hand I.R. Iran, due to sanctions, has suffered almost halving of its revenues due to the decline in oil and gas exports, as its main source of foreign exchange. Nonetheless, in Iran and Iraq as oil production and export volumes is pickup gradually and domestic demand is gaining momentum, further growth of their GDP are expected, leading to rising revenues, consumption and resumption of public spending and socio-economic development. In Iraq, social and economic growth are further contingent upon establishment of political stability and security.

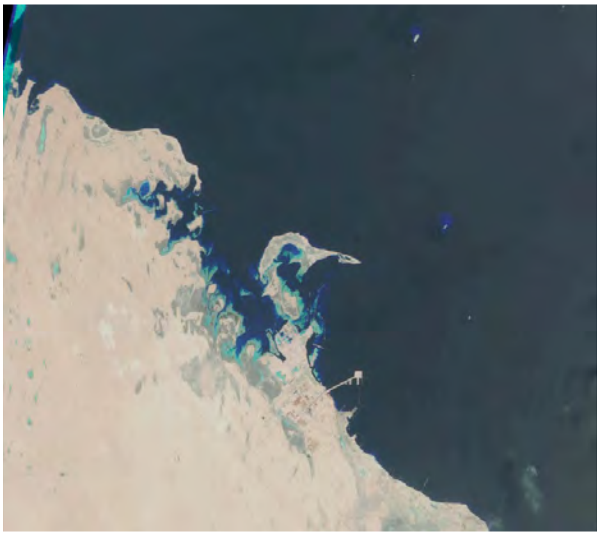
Figure 2.12 Real GDP Growth Rates (%) for the RSA countries for the years 2005, 2010 and 2011. (Sources: World Bank, 2011)

2.2.2 Major Industries and Industrial Production

The industrial sector has witnessed unprecedented growth during the past 30 years (Figure 2.13). Key industries include petroleum refineries, petrochemical complexes, desalination plants, power plants, as well as light industries such as agricultural and livestock production, and food and beverage processing. These industries are one of the major sources of pollution in general, and main contributors to the organic carbon load in the marine environment and the main sources of oxygen demand, in particular.

In 2009 industrial and manufacturing sectors in Bahrain contributed 10% (oil and gas), and 12.4% to GDP respectively. In Iran the industrial sector alone contributed about 45.9% of its GDP in 2010. On the other hand, the industrial sector in Kuwait contributed 48.3% of its GDP in 2010. Bahrain has a daily production of 1,700 tons of granulated urea and an annual production of 500,000 tons of high-grade aluminum. The wastes from these industries include high amounts of gases, liquids and solid wastes (UNEP, 1999).

Based in I.R. Iran, the refinery in Bandar Abbas is the largest refinery in the Middle East. It re-started working in early 1998. Many oil refineries in I.R. Iran were damaged during the Iraq-Iran War, some have since been renovated and others under construction. The total production of the Abadan refinery was 2,500 barrels/day in 1912 (LBA–I.R. Iran, 1999), it increased to 610,000 barrels/day in 1977 (pre Iraq-Iran War) and has been maintained at 450,000 barrels/day since the system was rebuilt in 1993.



1984

2004

Figure 2.13 Industrial development in Jubail. In Saudi Arabia, approximately 40% of the coastal area on the RSA has been developed into industrial and supportive residential and commercial areas along the coast. Particularly Jubail, Tarut Bay, Damman and Khobar, demonstrate the extent of coastal infilling and landfilling in the Region. In Jubail city, more than 200 million cubic meters of sediments adjacent to the development have been removed and 46.5 square km of coastal habitat have been dredged in Jubail and Dammam. These areas of shallow subtidal coast are highly productive and form nursery and feeding grounds for most commercial shrimp and fish species

Some of the largest heavy industrial plants of I.R. Iran are located in five major cities of the Karun River basin (LBA–I.R. Iran, 1999). The amount of industrial effluent discharge varies from 0.03 m^3/hr from the Fakhr Khorramshahr chemical company to 14,640 m^3/hr from the Abadan refinery, which discharges the waste into the Arvand River (LBA–I.R. Iran, 1999). The most polluting industries, in terms of the quantity of industrial sewage discharged into the Karun basin, are the cellulose-processing industries, followed by the chemical and petrochemical plants, followed by the food processing and steel industries.

In Kuwait, oil production in 2012 reached 3.1- 3.2 million barrels per day; the production of refined oil from three refineries in 2012 amounted to 910,000 barrels per day. Liquid oil gas production in 1998 amounted to 121,000 barrels per day. The production of liquid ammonia stands at 594,000 metric tons per annum, and the annual production of urea is 792,000 metric tons. Annual petrochemical production of products such as ethylene, hard density polyethylene and ethylene glycol reached 650,000, 350,000 and 350,000 metric tons respectively in 1997 (EPA-Kuwait, 2002). Currently the tertiary industrial wastewater treatment facility at Umm Al-Haiman is of capacity that reaches 6,000 m^3/day (Data for the year 2012 was provided by EPA-Kuwait).

The National Oil Distribution Company (NODCO) of Qatar processes about 62,000 barrels/day of crude oil and is presently going through an expansion process to increase the crude-oil refining capacity to 82,000 barrels/day. In addition, 27,000 barrels of stabilized condensate from the North field are also processed daily (LBA–Qatar, 1999). Two identical plants were established in 1973 and 1979 in Qatar, which produce 800,000 tons/yr of ammonia and 900,000 tons/yr of urea. A third plant was established in 1997 to produce 547,500 tons/yr of ammonia and 730,000 tons/yr of urea and a fourth plant is under construction (LBA–Qatar, 1999). Other petrochemical products from Qatar include 525,000 tons/yr of ethylene, 360,000 tons/yr of low-density polyethylene and 70,000 tons/yr of sulphur.

The estimated production of the three refineries along the eastern coast of Saudi Arabia in the RSA, namely, Jubail, Ras Tanura and Ras Al-Khafji is 551,351 barrels/day. Nine petrochemical plants situated in the area produce 7.32 million tons annually of petrochemical products ranging from methanol, ethanol, ethylene chloride, ethylbenzene, styrene, chloride, caustic soda, formaldehyde, MTBE, polyethylene, methane, ethylene, nitrogen, oxygen gases, monoethylene glycol, etc. (LBA–Saudi Arabia, 1999).

The total production of oil refineries in the UAE has increased from 180,000 barrels/day in 1986 to 240,000 barrels/day in 1997, representing 12% of UAE oil production. About 50% of this is for local consumption (LBA–UAE, 1999).

i. Liquid and Solid Wastes

Oil and gas industries are the main source of solid and liquid industrial waste in the RSA. It consists of drilling waste, operational sludge and oily fluids from unused fracturing fluids or acids, plants cooling towers cleaning waste, painting waste, waste solvents, and used equipment lubricating oils. The common contaminants are hydrocarbons, metals, sulphides, as well as altering the pH level of coastal and marine waters. Cement, steel and aluminum industries also generate a considerable amount of solid waste containing high levels of trace metals such as chromium, nickel and lead, iron dust and several other solids. Whereas spent catalysts that originate in ammonia and urea production are the main sources of hazardous wastes from nitrogenous fertilizer plants. Other sources of liquid waste are dairy industry, poultry farms, and slaughter houses.

In the particular case of liquid wastes, industries located along the coast usually discharge their effluents directly into the sea. In the RSA, desalination and power plants discharge around 48% of the total industrial effluent volume load directly in the marine environment. The petroleum refineries have been reported to contribute 28% of the total waste volume. Petrochemical and other industries contribute 19% and all other industries 5%, of the total discharge into the RSA, respectively (ROPME, 2000).

While recognizing the vital role that these plants play in the urban and industrial development of the respective countries, the quantity of cooling and brine water discharged from the desalination/power plants is of high thermal and pollution load. The impacts include the air emissions resulting from fossil fuel burning, discharges of heated brines containing disinfection byproducts, corrosion products and additives of the desalination process, all of which have direct impact on human health, the sustainability of fisheries and the overall health of the marine ecosystems (Al-Musawi, 2009). The generation of solid wastes in the Region has become an important environmental issue, due to the escalating growth in populations and the changing life style, leading to new trends of unsustainable consumption patterns concomitant with inflation in waste production. The Figure 2.14 shows the available data on the quantity of solid wastes generated in ROPME Member States (UN, 2011).

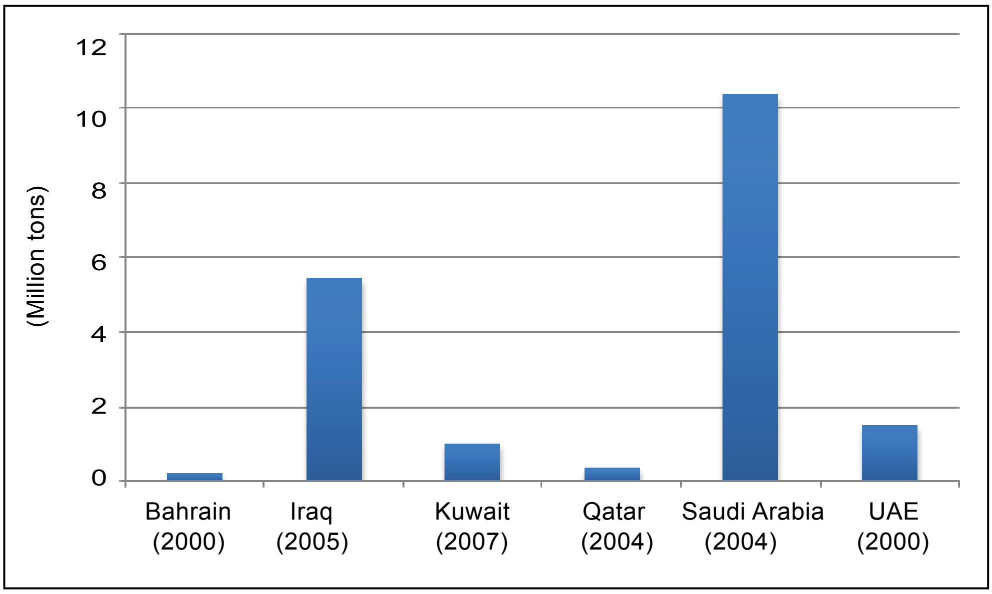


Figure 2.14 Municipal solid waste produced in the ROPME Member States (Source: (UN, 2011).)

Domestic sewage discharges from urban and rural areas of Member States have major impacts on the coastal and marine environment (Table 2.1). Part of the sewage is either partially treated or untreated, depending on the source and the types of treatment available. The volume of domestic sewage is on the increase and the capacity of the sewage treatment plants in the RSA is also increased simultaneously.

Table 2.1 Available data for produced and treated wastewater in the ROPME Member States (Source: www.fao.org/nr/aquastat; *UN, 2011; **provided by EPA-Kuwait, 2013)

Country	Total Wastewater (10^6 m^3/yr)	
	Produced	**Treated**
Bahrain	44.9 (1991)	61.9 (2001)
I.R. Iran	3075 (2001)	130 (2001)
Iraq	790 (2007)*	364 (2007)*
Kuwait	310 (2013)**	310 (2013)**
Oman	90 (2000)	37 (2006)
Qatar	55 (2005)	58 (2006)
Saudi Arabia	730 (2000)	547.5 (2002)
United Arab Emirates	500 (1995)	289 (2006)

ii. Atmospheric Emissions

The major sources of atmospheric emissions that pollute the environment of the RSA are the industrial areas encompassing oil refineries, oil gathering centers, oil platforms, petrochemical and fertilizer plants, and desalination/power plants, as well as motor vehicles. Additionally, the existence of polycyclic aromatic hydrocarbons (PAHs) from the combustion of fuel from vehicles' exhausts poses a great risk to both the environment and human health. Atmospheric deposition also contributes to regional marine environmental pollution to a certain extent.

2.2.3 Fisheries

The contribution of marine fisheries sector to RSA economies may appear to be of low importance compared to the oil industry (RECOFI, 2010). However, it is one of the most important natural renewable resources in the Region contributing to local food supply and exports of fish products. In addition, the fisheries sector (including aquaculture) provides employment to some 250,000 people in RSA countries directly, and assuring livelihood for more than one million people (RECOFI, 2010). According to FAO estimates, the total catch from the RSA was 792,000 tons in 2007 and 766,000 tons in 2008, and the trade in fisheries products accounted for US$ 996 million in 2007 (Al-Husaini *et al.*, 2005; RECOFI, 2010; Van Lavieren *et al.*, 2011).

The fisheries of RSA are commercially supported by over 1000 finfish and 15 shellfish species. The exploitation of fish, crustaceans and mollusks species is becoming a serious concern, as they seemed to be targeted species for their high price, subject to over-exploitation (Figure 2.15). The population expansion will continue to place increasing pressures on the marine resources and especially on high value resources. The exploitation level of the resources is pertained to the sub-regions or countries. According to Al-Husaini *et al.* (2012), the demersal resources, including shrimps, and species such as silvery pomfret, hilsa shad, rock lobster and abalone are generally over-exploited or reaching optimum exploitation levels for some species such as, king mackerel (De Young, 2006).

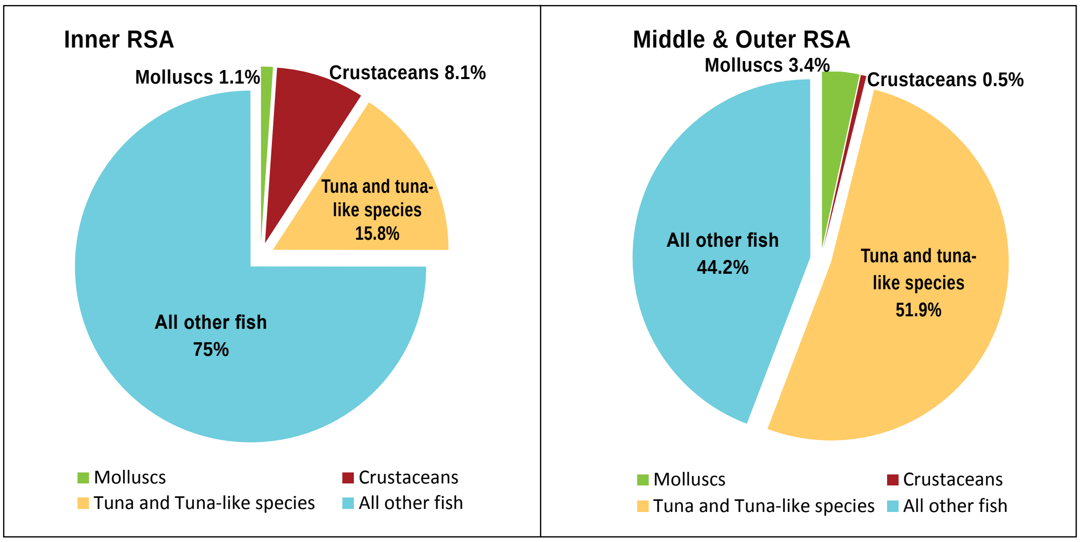


Figure 2.15 Catch composition of major groups in RSA. The composition reflects variations between I-RSA and M/O-RSA due to topographic and oceanographic conditions. I-RSA being a shallow and semi-closed sea; coastal fish and crustaceans form the bulk of total catches and are most valuable target species. Whereas in the deeper and more open sea of middle and O-RSA, tuna and tuna-like species contributed over 50 percent of the catches especially during the recent three years, 2005 - 2007

The fishing methods of trawling, gill netting and setting bottom traps pose tremendous environmental problems as well as they become the driving force behind the destruction of the marine ecosystem, especially on the bottom habitat and they further cause serious by-catch problems, mortality of immature and undersized young fish, ghost fishing by discarded or missing nets and traps. Bottom trawling is a non-selective method of fishing, which can cause catastrophic damage to the bottom environment. The epibenthic species of corals, sponges and sea grasses are vulnerable to trawling activities. The annual by-catch from trawling is enormous, ranging from 18 to 40 million tons worldwide (Pascoe,1997). Studies on by-catch from trawling have also been carried out in Bahrain, Kuwait and Saudi Arabia (Abdulqader and Mansoor, 1996; Ye *et al.*, 1999).

The total landings of priority species remained relatively stable in the RSA division, around 50% of the total landings from 2000 to 2007, whereas it decreased from more than 50% in 2001 to 30% in 2006 in the Oman Sea division (Figure 2.16). A simple Productivity Susceptibility Analysis (PSA) conducted in 2008 by the RECOFI Working Group on Fisheries Management revealed that shrimp trawls and driftnet were the two main gears that could give greater impact on priority species and that sharks were the most sensitive to gears used in the Region, followed by groupers and emperors (Mannini, 2010).

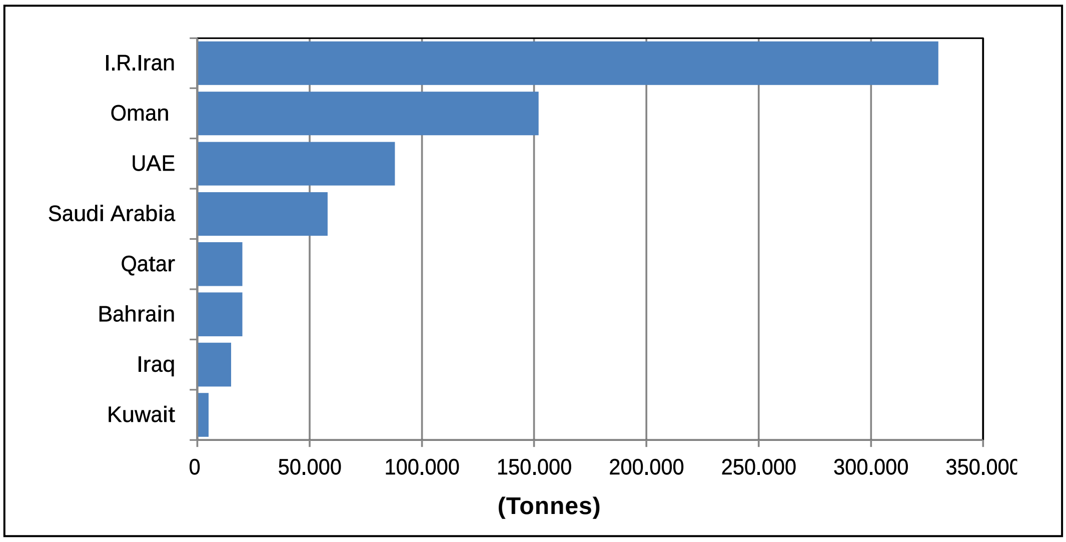


Figure 2.16 Capture productions by RSA countries in 2007. (Source: Mannini, 2010)

2.2.4 Coastal Development and Physical Alterations of the Coastline

Given that the development of recreational and tourism facilities in the coastal area is an important industry for the diversification of national economies, ROPME Member States are developing, at a rapid rate, recreation and tourism facilities on the coast, along with the necessary coastal roads and other infrastructures to cater for the diverse needs of individual travellers and tourist groups. In the last decade, these development activities have considerably increased in Bahrain (Figure 2.17), Oman and UAE. Similar activities are also taking place in Saudi Arabia on the Jurayd and Jana Islands, Jubail, Muntazah, Dawhat As Sayh and Zalum and Al-Khobar; in I.R. Iran at Kish and Qeshm Islands; and in Kuwait at the waterfront and Al-Khiran recreational areas (Figure 2.18). The construction of water sports facilities, marinas and campsites is a recent development along the Omani coasts, where beaches are used for a variety of recreational purposes, which include water sports, football, fishing, picnicking and camping.

Considerable stretches of the intertidal areas along the Kuwait City coast and some sections along the southern coast of Kuwait have been landfilled. Landfilling not only causes permanent destruction of coastal habitats but could also lead to indirect environmental impacts due to the disturbance of the natural hydrodynamic conditions of the coastal water and local beach processes. As a result, significant erosion problems have developed along most of the fill edge of the landfilled areas. Al-Bakri *et al*. (1985) indicated that the effect of these landfilling activities is not only the partial or total loss of the upper intertidal areas but also the modification of the physical nature of the adjacent tidal flat.

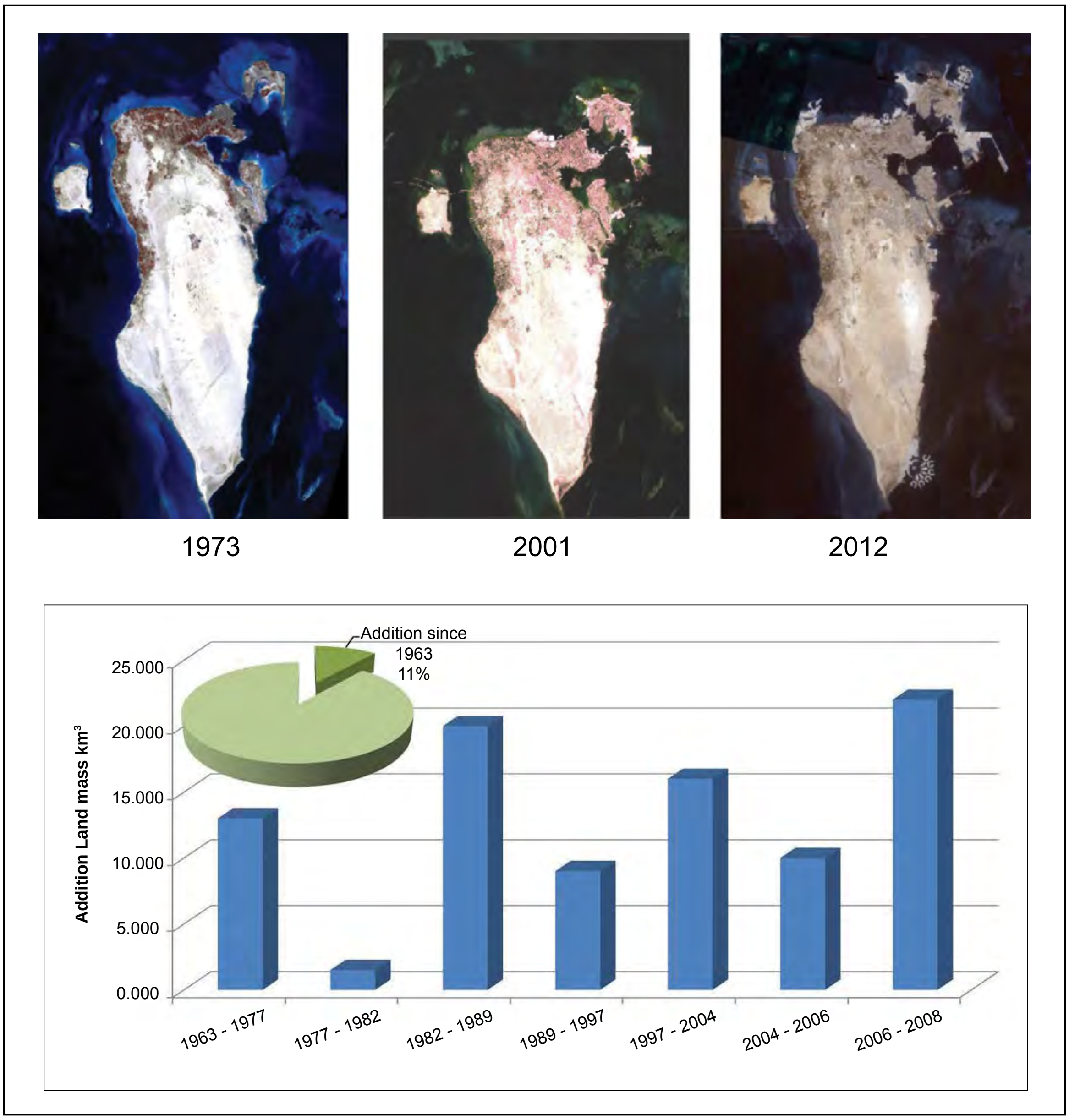


Figure 2.17 Landfilling in Bahrain. Many RSA countries have already developed 40 per cent of the coastline. For instance, 10 km of the Omani coastline has been reclaimed with quarry and sand beach material. Landfilling activities in Bahrain increased considerably since the 1970s, due to industrial and residential pressures. In Bahrain, the land area has increased 11% since 1963. (Source: http://www.seos-project.eu/modules/world-of-images/images/ bahrein_kompsat.jpg)

The alarming magnitude of the physical alteration of the RSA coastline has several adverse environmental effects on the coastal ecosystem, including damage to the spawning ground of various marine species, sea grass beds, and the alteration of the benthos that form the main source of food for many commercial fish species. This has been accompanied by an increase in siltation due to the release of fine material during dredging and resulting in an increase in water turbidity, which irritate fish gills, interfere with visual feeding and inhibit photosynthesis.

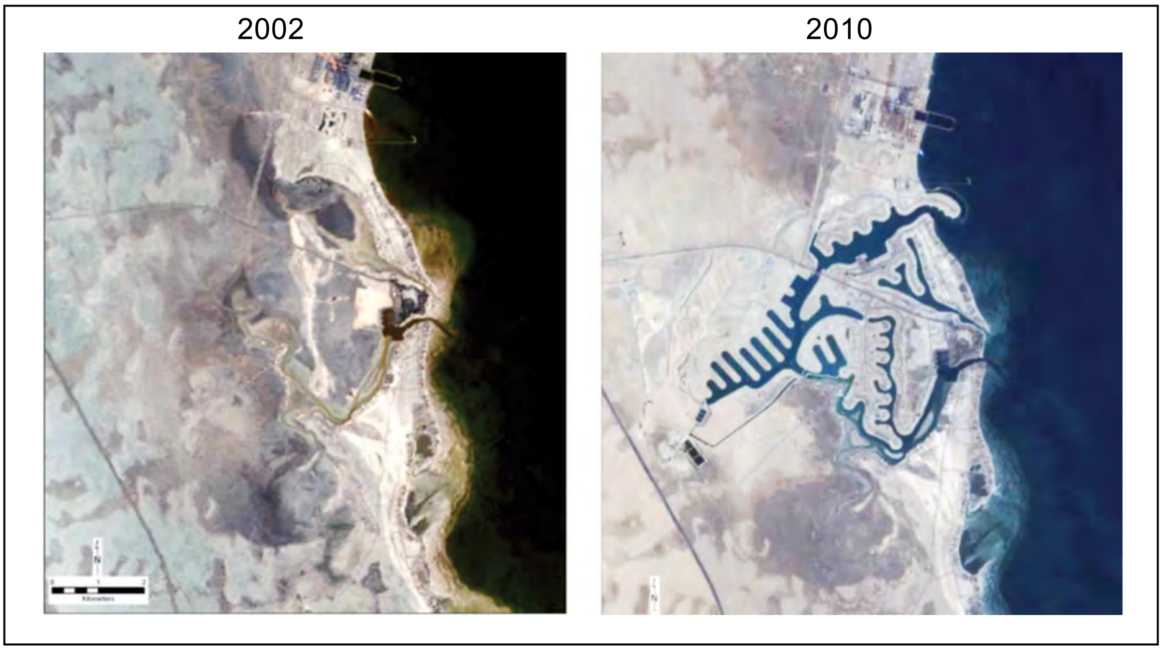


Figure 2.18 Development of Khairan. In Kuwait, considerable parts of the inter-tidal area in front of Kuwait City and in areas on southern coast have been developed, leading to significant erosion problems along most of these areas

i. Dredging

Large-scale dredging activities have been carried out in most of the coastal areas of the RSA. Regular dredging operations are carried out to keep harbors, rivers and other waterways from silting up, as well as for new construction and engineering projects offshore. The dredged material consists of sandy and muddy substances which are used for infilling.

When the dredged material is uncontaminated and properly handled it causes only a few long-term problems, and indeed can serve a variety of useful purposes, including landfilling, building of artificial reefs and rehabilitation of previously damaged coastal sites. If dumped at sea, its physical impact must be taken into account and careful selection and management of the dumpsites is important. However, around 10% of dredged materials are found to be contaminated by a variety of sources, including shipping, industrial and municipal discharges, and land run-off. Typical contaminants include oil, trace metals, nutrients and organic chlorine compounds. Dumped dredged material has liquid and suspended particulate phases, but the greatest impact generally comes from the settleable or solid-phase material, which may affect benthic organisms by smothering and physical disruption of habitats; and from bioaccumulation and toxicity from both soluble and suspended phases.

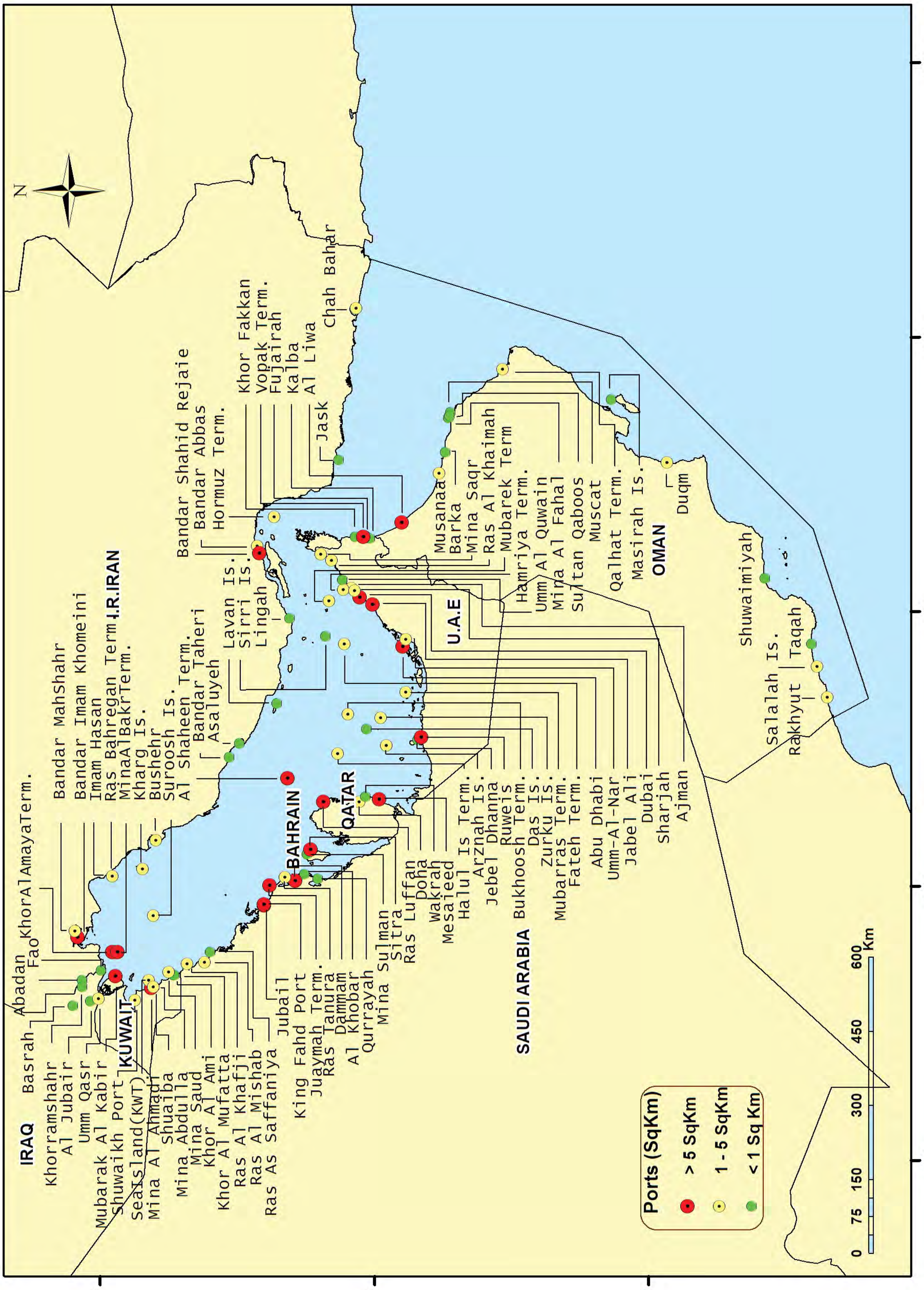


Figure 2.19 Major Ports in RSA. (Source: MEMAC, 2012)

ii. Maritime Traffic

The RSA is a relatively small body of water located in a subtropical arid region, bordered by major oil-producing states. Since the discovery of oil in the first half of the twentieth century, the Region has been undergoing rapid economic growth. In 2010, the Region was producing around 25 million barrels of oil per day, comprising 23% of the global production (www.cia.gov), with 49% of this production being shipped through the RSA. In addition, 1.79% of the World's total shipping activity is through the RSA Region (MEMAC, 2008).

The RSA coastline is punctuated with successful and transported maritime ports (Figure 2.19). The income from these ports and logistics zones and the import and export through them composes a significant proportion of the GDP. Several Member States are further investing in building new ports and upgrading existing infrastructure. For example, Dubai Ports Authority in 2006 undertook major expansion and modernization of the Al-Hamriyah Port in Dubai. The expansion project involves development and expansion of three quays at the port, including augmentation of the commercial quay by 2.5 km in two phases. In 2010: Bahrain invested additional US$ 70 million to upgrade the equipment in the new Khalifa Bin Salman Port; Iraq embarked on the Al-Faw Port project, which will cost about US$ 6.1 billion at an estimated capacity of 99m tons per year and will be one of the largest ports in the Region; Kuwait has already completed 45% of the first phase of Mubarak Al-Kabir Port on the south east of Bubiyan Island, a US$ 1.1 billion project expected to be completed in 2016; and Oman has plans to build nine new fishery harbours at Rakhyut, Taqah, Sadah, Al-Shuwaimiyah, Mahout, Duqm, Barka, Al-Musanaa and Liwa in accordance to its Five Year Development Plan (2011 - 2015).

The RSA experiences a high volume of maritime traffic, Figure 2.20 illustrates ship callings at various ports in given time, where vessels of 250 million tonnages are visible in satellite imagery. The annual number of vessels passing the Strait of Hormuz has increased from 28,500 in 2005 to 43,750 in 2009 (Figure 2.20a). The ship callings and total ship gross tonnage varies per Member State (Figure 2.20 b&c), and particular port (Figure 2.20d). Jebel Ali Port is the world's largest man-made harbor and is the biggest port in the Middle East, covering over 134 Km^2, with around 7000 calls each year.

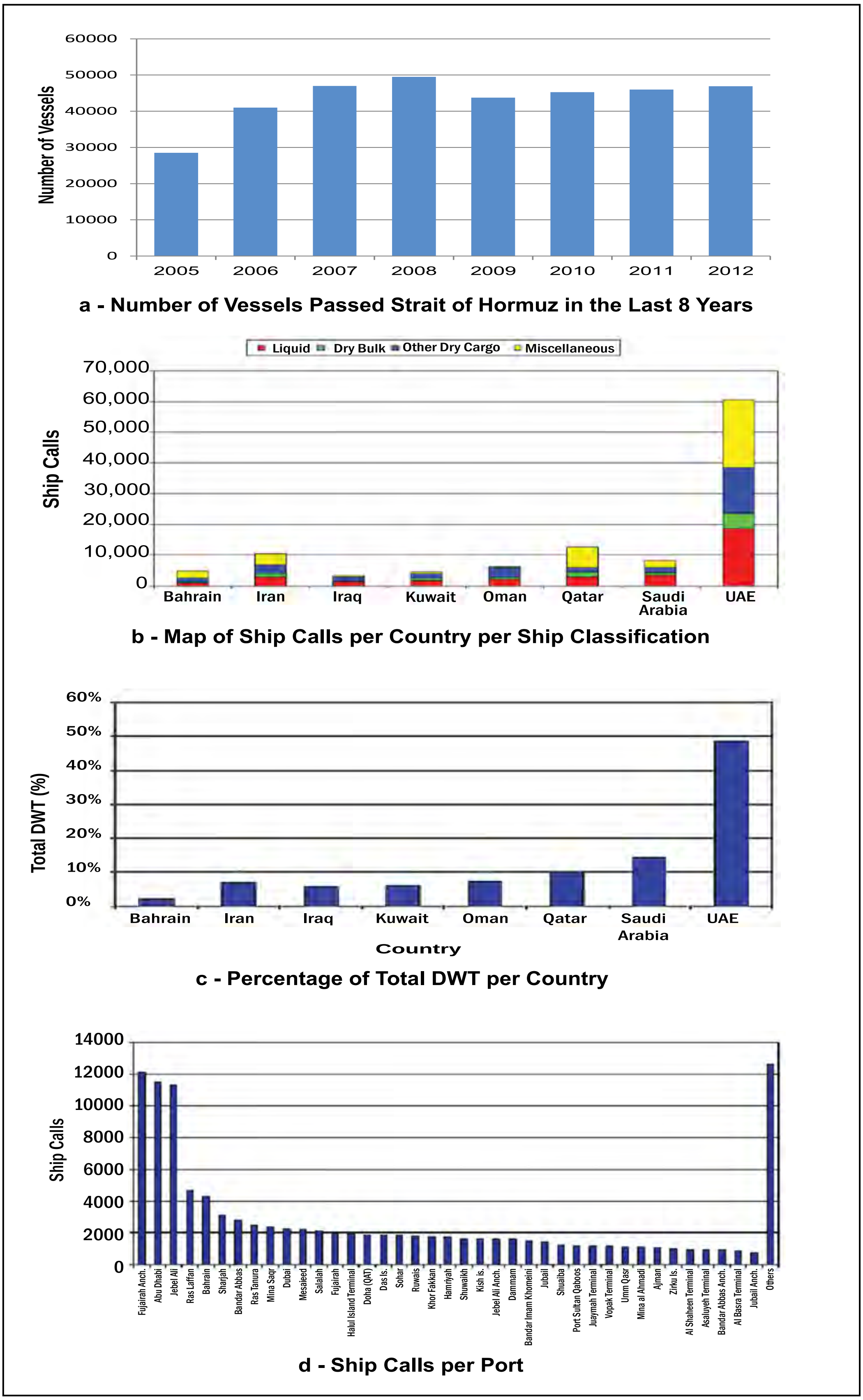


Figure 2.20 Status of shipping traffic in the RSA during 2012. (Source: MEMAC, 2012)

2.2.5 Environmental Risk Assessment in RSA

In 2010 MEMAC carried out a study to identify the Marine Environmental High Risk Areas (MEHRAs), which are at risk from shipping in the RSA (MEMAC, 2010a). The project combined shipping risk assessment with a review of the environmental sensitivity of the coastline to identify candidate MEHRAs for each Member State. In the study the shipping data was combined to create a shipping database of all significant merchant shipping routes passing through the RSA Region, each route containing information on annual ship movements. Ship characteristics, such as type and size information, were also identified. Also, an Automatic Identification System (AIS) was set up to track the ships using satellite data. The AIS provided very accurate information on ship routing (Figure 2.21), as well as mean shipping routes (Figure 2.22) and shipping densities (Figure 2.23).

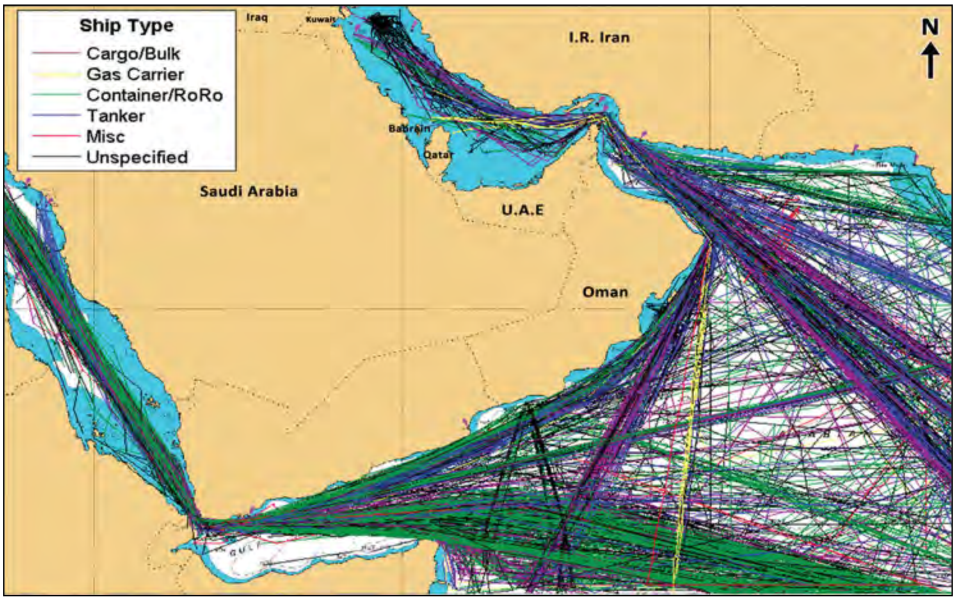


Figure 2.21 Satellite tracking of ships by type. (Source: MEHRAs, MEMAC, 2010a)

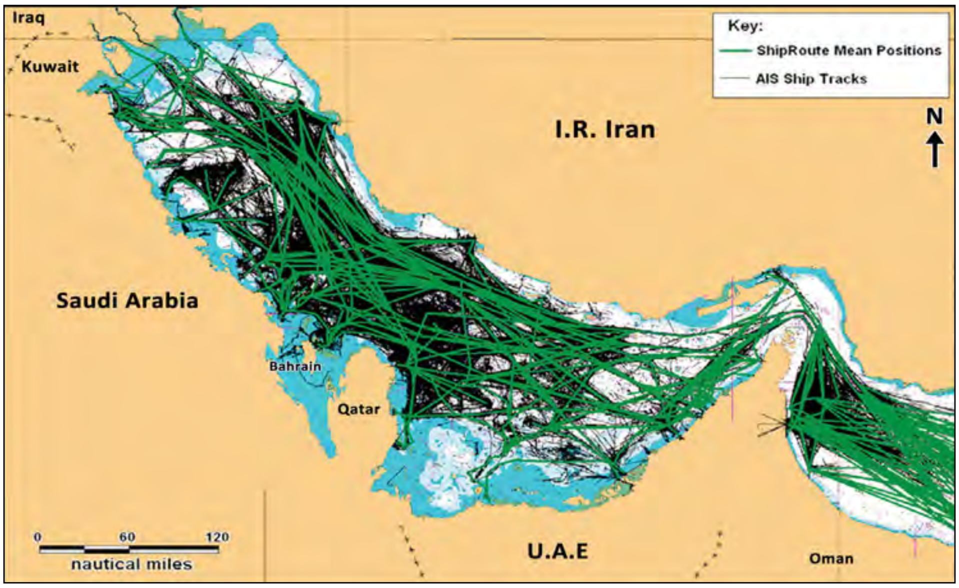


Figure 2.22 Overview of Automatic Identification System (AIS) Data relative to Mean Route Positions. (Source: MEHRAs, MEMAC, 2010b)

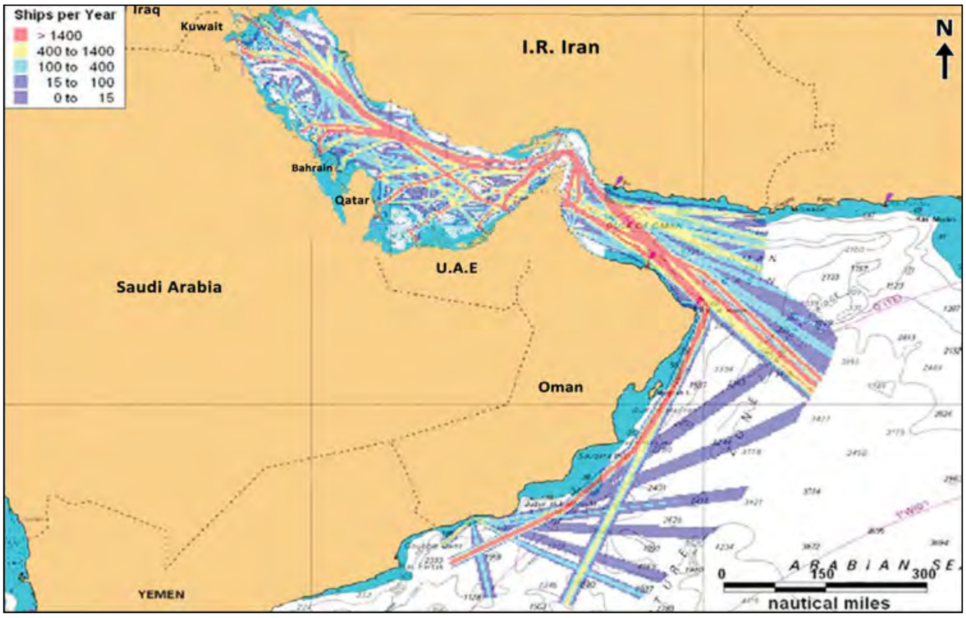


Figure 2.23 Overview of ship density grid for ROPME Area. (Source: MEHRAs, MEMAC, 2010b)

Based on the review of shipping data, it is concluded that the shipping database established using mainly Port Callings and AIS Data for the shipping risk assessment, gives a comprehensive coverage of shipping activity and mean shipping routes within the ROPME Sea Area. Other data sources were consulted including, Satellite tracking data, MEMAC expert advice and detailed admiralty charts which served to validate the overall shipping picture for the RSA. A shipping density layer was created for use in the accident frequency models, which are used to predict the type and location of different incidents, i.e., Foundering, Ship Collision, Fire / Explosion and Groundings.

i. Accident Frequency

Oman had the highest accident frequency. It has by far the largest sea area of the countries assessed and includes shipping “hot-spots” such as the Strait of Hormuz. Conversely, Iraq, which is the smallest by area, had the lowest shipping accident

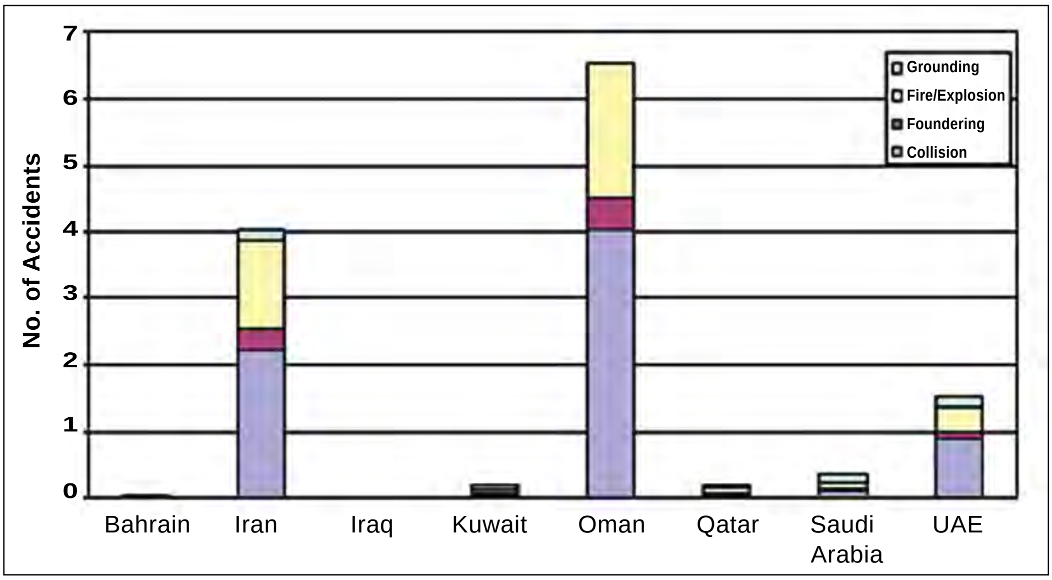


Figure 2.24 Number of accidents per year by country and cause. (Source: MEHRAs, MEMAC, 2010b)

frequency. The accident frequency per cause within each Member State is presented in Figure 2.24 (MEHRAs, MEMAC, 2010b).

ii. Spill Frequencies and Quantities

Such high volume of maritime transport and related activities presents major sources of adverse effects resulting from contamination from waterfront industry as well as ship discharges and emissions, spills and leakages. In terms of spill quantities (tons of oil), it was estimated that 8,598 tons are spilled in the Region per year. It should be noted that this should be considered a long-term average and will vary year-on-year. Historical data indicates that infrequent, major spills tend to dominate the risk picture.

iii. Historical Review of Maritime Incidents

MEHRAs also analyzed the maritime incidents recorded within the RSA and were compared with the modeled results to ensure the shipping risk models were valid for the study area. A total of 159 incidents were reported during the period 1965 -2008. The yearly variation in incidents is presented in Figure 2.25, for the major shipping accidents (e.g., collision, grounding, etc.).

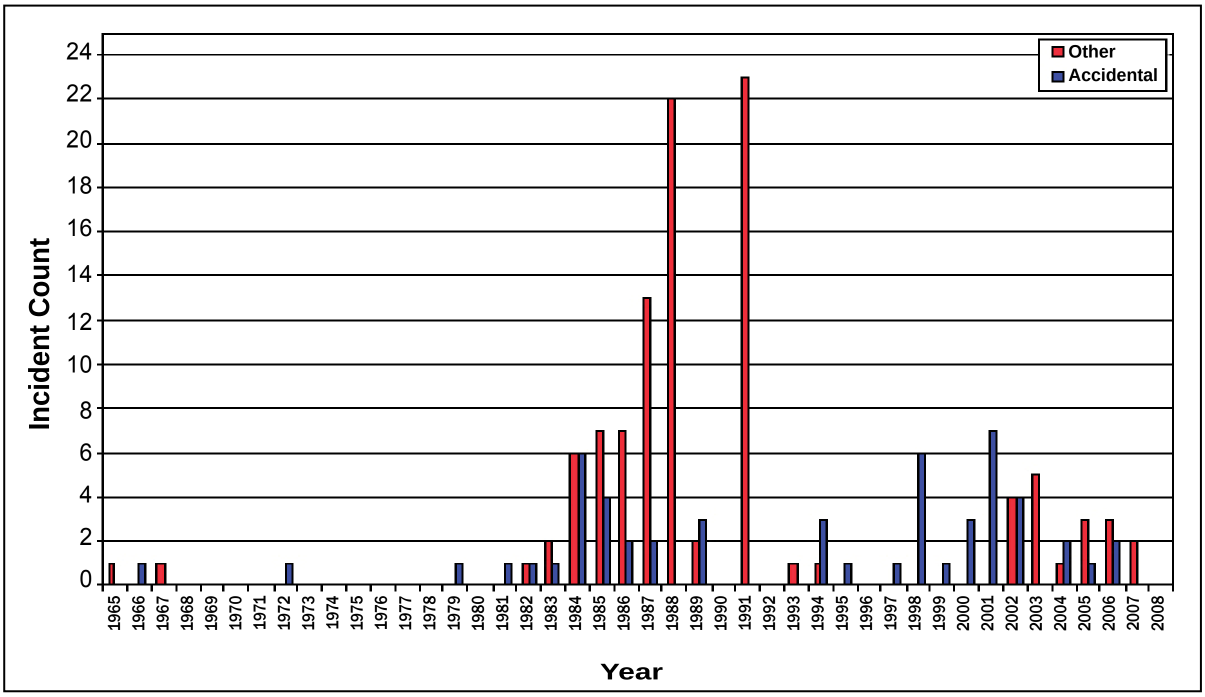
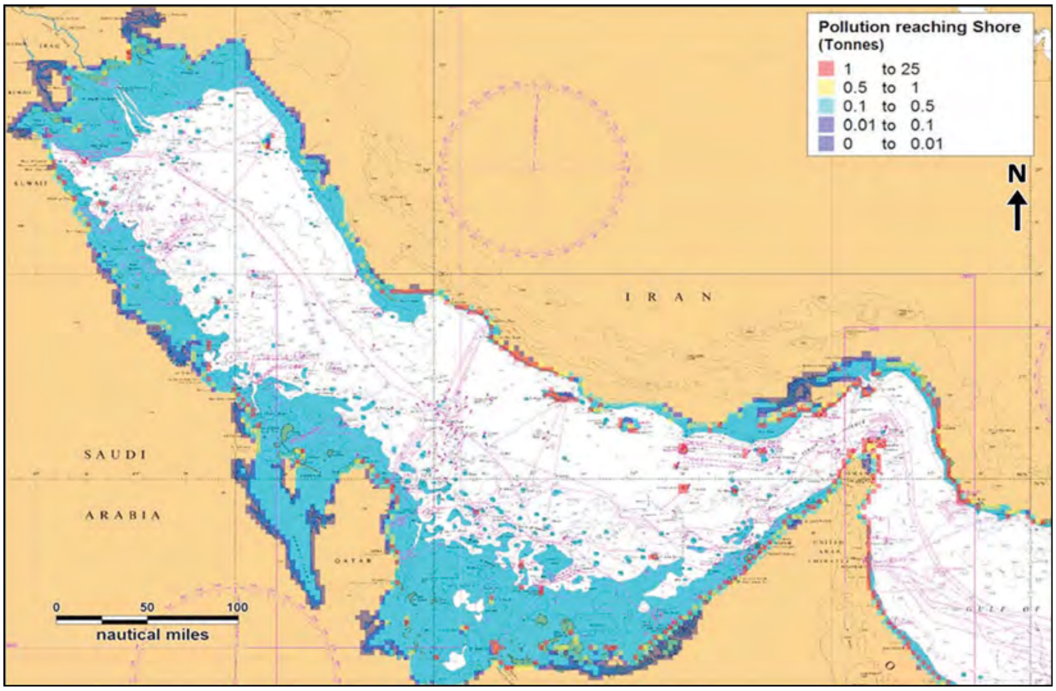


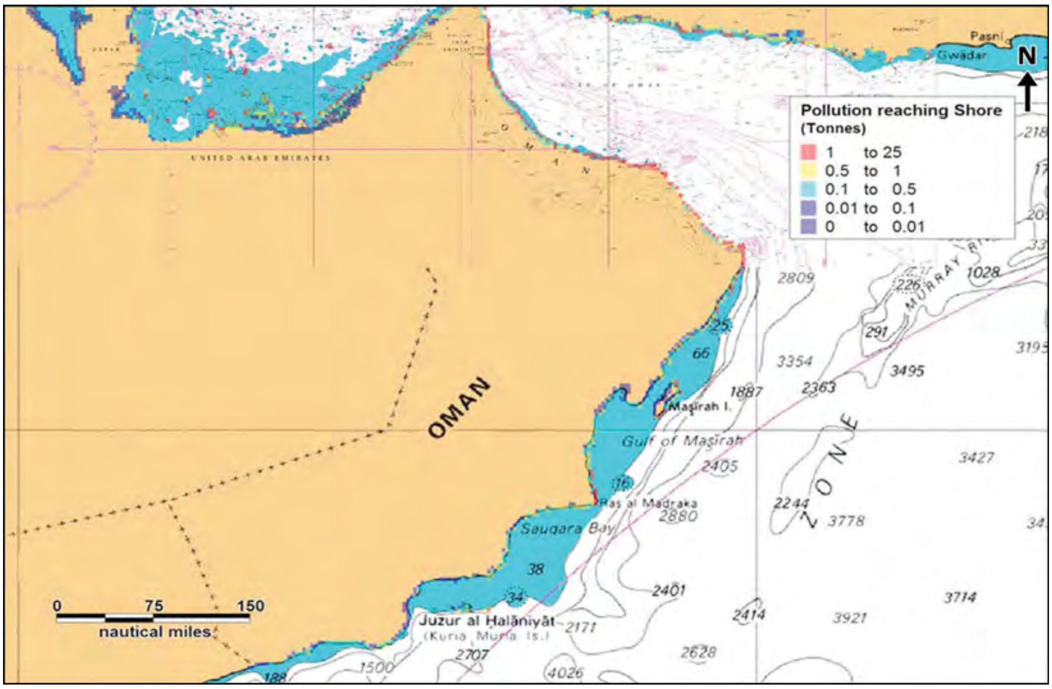
Figure 2.25 Historical review of number of Incidents per year. (Source: MEHRAs, MEMAC, 2010b)

iv. Pollution Risk Modeling

The main objective of MEHRAs project was to estimate coastal pollution. This is from direct oil spills on the shore through grounding accidents, as well as from pollution at sea, e.g., due to oil released from a ship collision drifting to the shore under the influence of the prevailing conditions. Combining the direct pollution spill data for the coast, i.e., from groundings, with the results of the oil spill drift model, the overall pollution risk of the RSA coastline was predicted (Figure 2.26 a, b). Approximately 84% of the total pollution reaching shore came from accidents at sea, with the remainder from ship groundings (MEMAC, 2010b).



(a)



(b)

Figure 2.26 Estimated Pollution. (a) reaching shore (N and W), (b) reaching shore (S and E)

2.2.6 Energy and Water

RSA countries depend mainly on fossil fuels for energy. Total energy production in 2009 was about 1,500 million toe (Figure 2.27). Saudi Arabia came first with 34% of the total, while Bahrain came last with no more than 1.2% (Figure 2.28). Energy production rate remained almost unchanged between 2004 and 2009 except for Saudi Arabia, which had a slight reduction in 2009 (IEA, 2006; IEA, 2007; IEA, 2008; IEA, 2009; IEA, 2010; IEA; 2011).

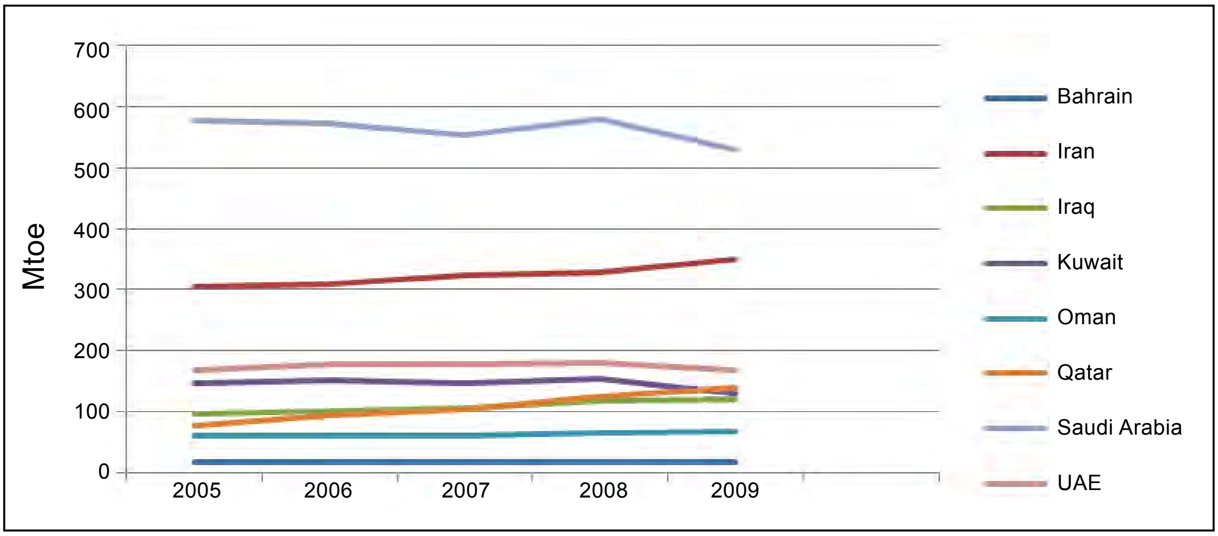


Figure 2.27 Energy production in RSA countries between 2004 and 2009 in million ton oil equivalent (toe). (Source: International Energy Agency (IEA) 2006, 2007, 2008, 2009, 2010, 2011)

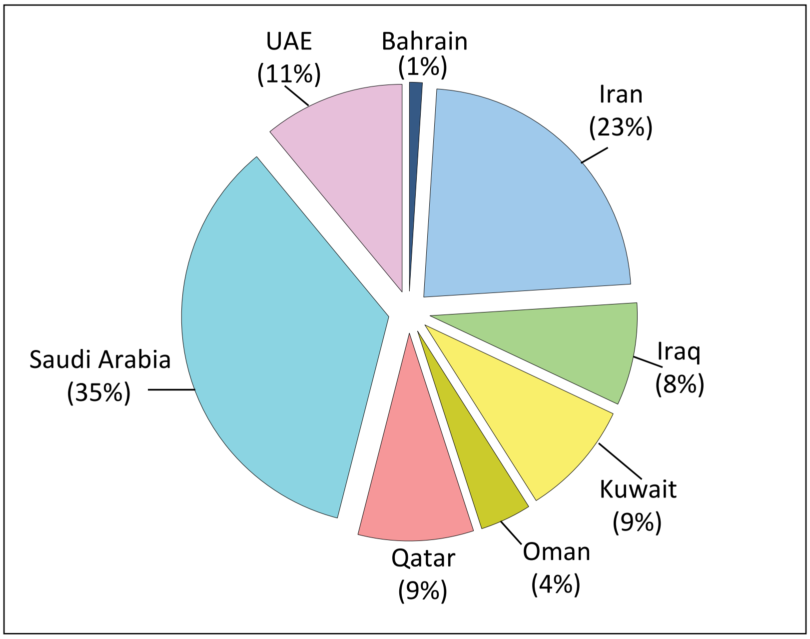


Figure 2.28 Energy production in RSA countries in 2009. (Source: IEA, 2011)

The availability of fossil fuels at low production costs in the RSA has resulted in the investment in energy-intensive industries such as desalination, petrochemicals, and aluminum smelting (Abdel Gelil *et al*., 2011). Thus, energy intensity is relatively high in the area. The average energy required to produce one unit of GDP is 0.54 toe/thousand 2000 US$, which is nearly 3 times the world average (0.19 toe/thousand 2000 US$) and more than some developed countries such as UK, USA, Australia and Japan, or emerging economies like China and India (IEA, 2011).

Electricity consumption is relatively high in RSA countries as well. The average electricity consumption is around 10,000 kwh/capita (Figure 2.29), while the world average is 2,729 kwh/capita, that is more than 3 folds the world average (IEA, 2011). Electricity consumption is slightly increasing in RSA countries between 2004 and 2009 except for Iran (IEA, 2006; IEA, 2007; IEA, 2008; IEA, 2009; IEA, 2010; IEA, 2011).

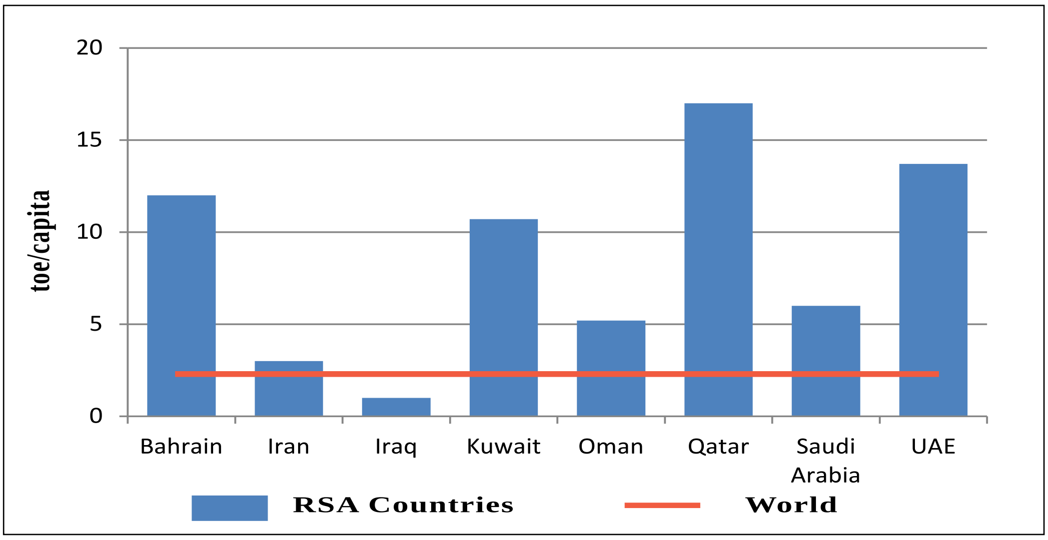


Figure 2.29 Energy consumption per capita in RSA countries in 2009. (Source: IEA, 2011)

Renewable energy is still at experimental stages in many RSA countries (Figure 2.30). Renewable energy makes less than 0.1% of the total energy production in RSA countries (IEA, 2011). Renewable alternatives are implemented in I.R. Iran where it makes around 0.7% of the total energy and Iraq where it is around 0.2% of the total (UNDP, 2011). The main renewable energy resources are the hydro energy and the wind energy.

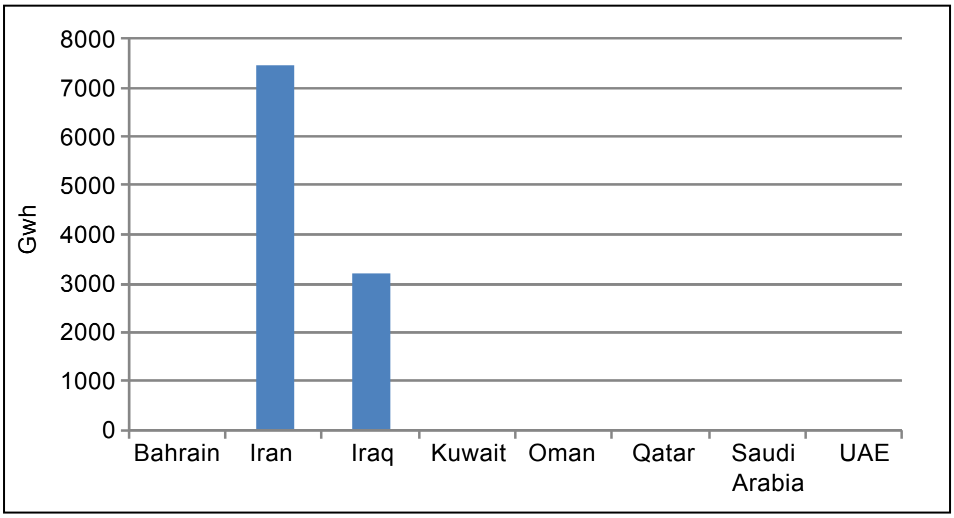


Figure 2.30 Renewable energy production in RSA. (Source: IEA, 2011)

Water is a scarce resource in most RSA countries. Most RSA countries depend mainly on freshwater resources, desalination and treated seawater (Figure 2.31). The contribution of groundwater abstractions to the total supply ranges between 68% in Kuwait to 90% in Bahrain (Dawoud, 2006; Bushnak, 2010).

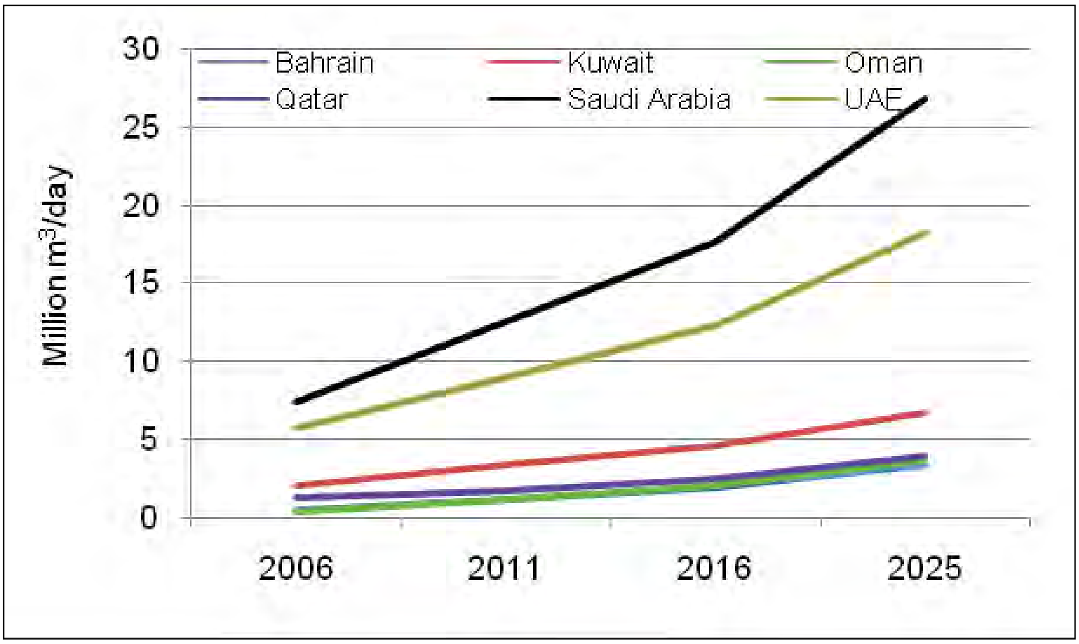


Figure 2.31 Desalination capacity in RSA countries (million m^3/day). Source: World Bank (Desalination capacity in 2000 in Iran was 200 million m^3/day; Van Lavieren *et al*., 2011, and in 1996 in Iraq was 324 m^3/day, UN, 2009)

Desalination history in RSA goes back to 1938, particularly in Saudi Arabia and Kuwait. Saudi Arabia is ranked first worldwide in desalination capacity and 45% of the world desalination capacity is found in the area (Dawoud, 2006). The desalination market is expected to increase rapidly in most of RSA countries due to drought conditions, population growth, and increasing demand of water for industry and tourism (Dawoud, 2006). Desalination capacity in most of RSA countries is expected to increase more than double between 2006 and 2025 (World Bank, 2011).

CHAPTER 3

STATE AND TRENDS IN THE MARINE ENVIRONMENT OF RSA

KEY MESSAGES

- The Region is witnessing large-scale coastal and marine development activities, which may in the short-term reduce the effectiveness of any on-going and/or planned efforts for the protection of marine and coastal ecosystems
- Basin-wide trend analysis is essential to reflect the current and most recent situation of the quality of marine environment, including effects of oil spills, land-based sources of pollution, as well as challenges related to global climate change and its possible impacts
- All Member States have issued regulations governing the conservation and protection of the marine environment, and have designated several Marine Protected Areas (MPAs) throughout the Region. However, an assessment of the effectiveness of these regulations, and the establishment of an integrated management plan of these MPAs are needed on the national and regional levels
- Addressing marine biodiversity and integrated fishery management approach needs regional commitment
- The phenomena of increasing dust storms, in frequency and intensity, require regional cooperation and integrated actions towards reducing the possibly-related land degradation

The main environmental parameters and the prevailing oceanographic characteristics that fairly describe the general state of the marine environment of the ROPME Sea Area have been fully addressed and extensively analyzed in previous issues of SOMER (for example, SOMER - 2003, Chapter 2).

Therefore, and as stated earlier, the ultimate objective of this chapter is basically to track and highlight the major environmental changes observed during the main reporting period, i.e. during the past decade (2002 - 2012). This would essentially be done here through presenting only the results of new and genuine research that was carried out in the Region during that period, in addition to some updated information obtained from various credible sources on the current environmental conditions in the RSA.

To this effect, this chapter attempts to present a full account and scientific details of the results of the recent oceanographic cruises and research programmes conducted or sponsored by ROPME, particularly those carried out during the last decade. It includes:

A. An account of the state and trend of marine pollution by oil and other contaminants, and the changes thereof;

B. An assessment of the pressures caused by marine pollution on the fisheries and shrimps and on the various biodiversity elements in RSA;

C. An account on the state and possible effects on marine and coastal ecosystems and critical habitats such as the coral reefs and mangroves in the RSA;

D. Observations on the recent occurrences of the Harmful Algal Blooms (HABs) phenomenon and the mass mortality of fish in the RSA; and

E. The results of MEMAC's study on "Environmental Sensitivity" of the coastal and marine area of the respective Member States of ROPME.

The emphasis is given here to the interlinkages between causes (drivers and pressures), described in the preceding chapter, and the environmental outcomes (state of the environment), and then in pursuing chapters to establish the link to activities (policies and decisions) that can shape a better environmental future in the coming decades in the RSA.

By taking this approach, the requirements of the recommended GEO-DPSIR framework are fulfilled and, hence, the set overall objective for this SOMER could be adequately achieved.

3.1 PHYSICAL ENVIRONMENTAL CHARACTERISTICS

3.1.1 Climatology and Meteorological Characteristics

In general, the RSA is known to be one of the hottest areas in the world (Hamza and Munawar, 2009), Figure 3.1. The climate of the Inner ROPME Sea Area (I-RSA) is markedly different than the climate in the Middle ROPME Sea Area (M-RSA) and the Outer ROPME Sea Area (O–RSA).

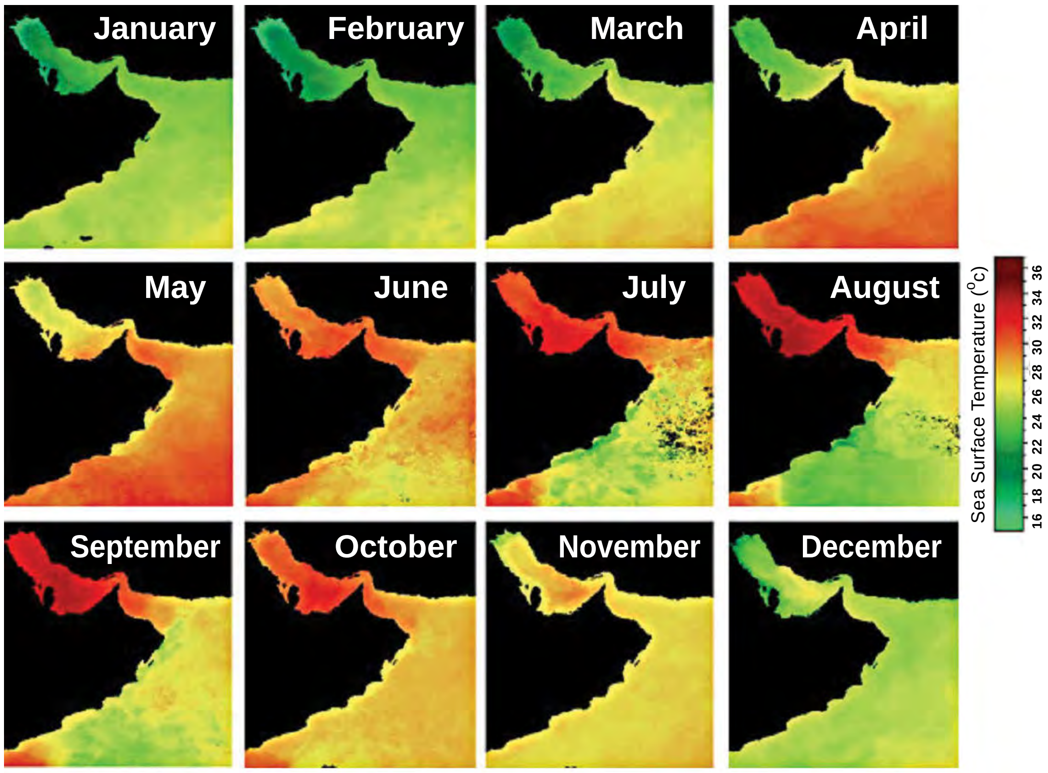


Figure 3.1 Monthly averaged day sea surface temperature (SST) composites (Ocean Level-3). Produced from MODIS Aqua data over the RSA in 4 km/pixel resolution during 2010. (Source: http://oceancolor.gsfc.nasa.gov/cgi/l3).

The I–RSA is located between latitudes 24 - 30°N where most of the Earth's deserts are located. The local climate is influenced by the Zagros mountains of Iran; and the Hejaz mountains of the Arabian Peninsula together with the Tigris–Euphrates Valley, form a northwest southeast axis that strongly influences the tracks of extra– tropical storms to a southeast direction (Reynolds, 1993). The climate is sub–tropical, even though it is located within the large, arid, East Asian landmass, with fierce tropical summers, and temperate winters, in comparison to most seas of equivalent latitude. In summer, air temperatures reach 45 - 50°C, while in winter, water and air temperatures can drop to 3 - 13°C (Walters *et al.*, 1990; Sheppard, 1993); with relative humidity ranging from 40 to 100%.

The climate of the M-RSA is also extremely hot and dry most of the year. It is affected mainly by the extra–tropical weather systems from the northwest, I-RSA, M-RSA, and the tropical weather systems of the O-RSA (Reynolds, 1993). The warmest average air temperature is between 33°C and 38°C. The Gharbi (an Arabic word that literally means western), a strong wind that blows from the Empty Quarter, can raise temperatures in areas on the Sea of Oman by 6°C to 10°C, but seldom exceed 47°C in lower plains. The coolest average air temperature is in the range of 19 - 22°C. Given the low elevation, the humidity may be as high as 90 percent.

The yearly cycle in the O–RSA, is affected by the fact that it is a part of the tropical basin of the Arabian Sea. The climate pattern is affected by the semi-annually reversing monsoon wind system, normally divided into a northeast monsoon, characterized by moderate winds from the northeast during the late fall and winter, a southwest monsoon, characterized by strong winds from the southwest during the late spring and summer and fall and spring inter–monsoons (Tudhope *et al*., 1996). In summer, the strong southwest winds drives humid air into the Arabian Sea, and in winter the weak northeast trade winds brings cool, dry continental air into O-RSA. The transition periods can vary from year to year and can occur at different times from region to region (Al-Awadi, 2011).

a. *Wind patterns*

The RSA has four types of prevailing winds (Figure 3.2). The Shamal (“Shamal” is an Arabic word that means “North”) during the winter and summer; the Kaus (a local term taken from the word “south-east”) coastal winds brought by sea breezes (Ali, 1994); and the monsoon winds that prevail during the south-west and north-east monsoon periods in summer and winter respectively.

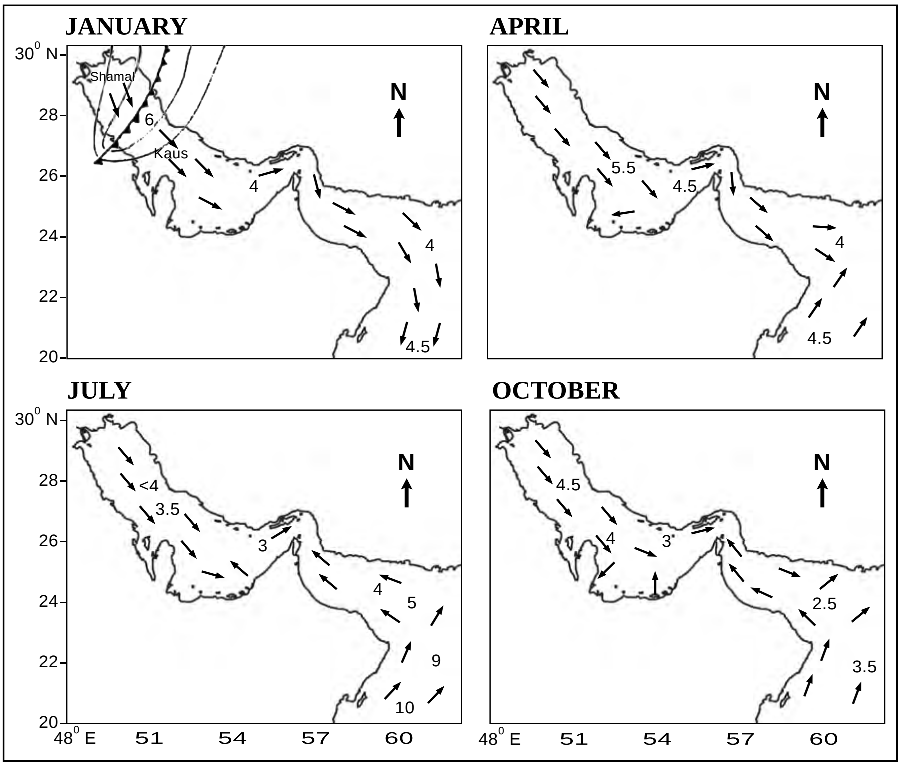


Figure 3.2 Typical wind patterns. A schematic of typical wind patterns in the RSA during the year. The arrows indicate typical (mean) directions and the numbers show the mean wind speeds during the season. A synoptic pressure pattern and accompanying synoptic winds for a Shamal / Kaus wind event are overlaid over the mean pattern for the month of January. (Reynolds, 2002)

Winds in the area ahead of an approaching cold front blow from the southeast. These winds, called “Kaus” in Arabic, slowly increases in intensity as the front approaches. They may reach gale force before the passage of the front and the onset of the Shamal. Due to the channeling of the low–level air flow by the Zagros mountains, the strongest of the southerly winds occur on the eastern seaboard (Reynolds, 1993).

According to Fett *et al.*, (1983) there are basically four seasons associated with the monsoonal flow patterns over the Middle East/O-RSA: a. The southwest monsoon regime (June through September); b. The fall transition period (October and November); c. The northeast monsoon regime (December through March); and d. The spring transition period (April and May).

b. *Dust*

The major sources of contemporary mineral dust (suspension of minerals constituting the soil) are found to be the desert regions of the Northern Hemisphere, in the broad “dust belt” that extends from the eastern subtropical Atlantic eastwards through the Sahara Desert to Arabia and southwest Asia (Figure 3.3), with remarkably little

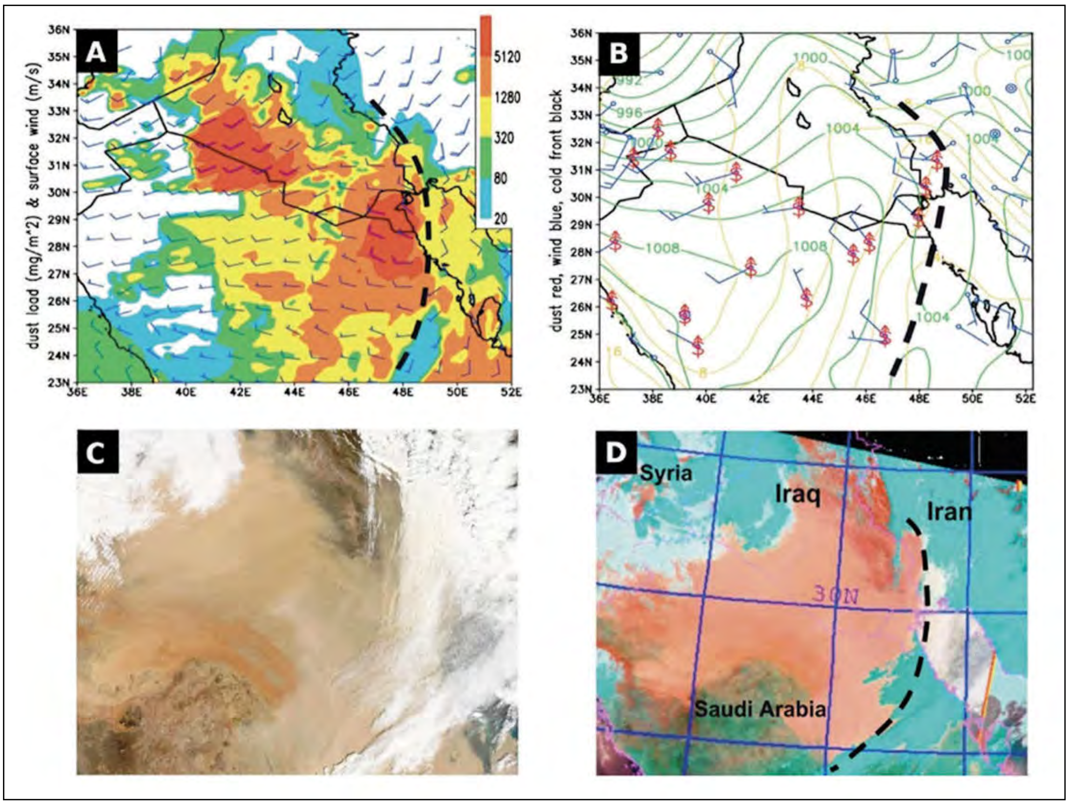


Figure 3.3 Dust forecast:

(a) A 56-h forecast of dust mass load (the vertical integral of concentration) and surface wind vectors from the 9-km grid for 08:00 UTC 26th March, 2003. B shows the observed surface winds and dust storm observations at 06:00 UTC 26th March, 2003 with an overlay of a 6-h forecast of sea level pressure and surface temperature produced by the U.S. Navy’s Coupled Ocean–Atmospheric Mesoscale Prediction System (COAMPS)

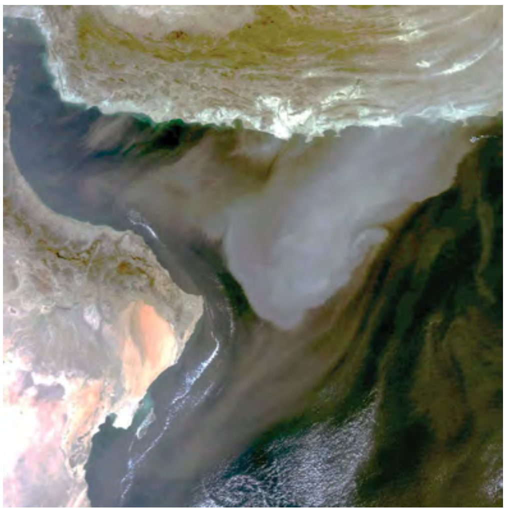
(b) Shows the true color image of MODIS Terra at 07:45 UTC 26th March, 2003 shows the dust covering most of Iraq and the northern Arabian Peninsula approaching the I-RSA

(c) Shows the same MODIS Terra images using a false color composite proposed by Miller (2003) to demonstrate the capability of MODIS at distinguishing airborne dust from the surface and other atmospheric features, by replacing the red channel of the true color composite with a multi–spectral term derived from seven channels from the visible, short–wave and thermal infra–red spectrum large–scale dust suspension outside this Region (Prospero *et al*., 2002). Estimates by ROPME (2003) suggest that the average monthly dust deposition at various sites in the northwestern part of the Region can range from 10 to 100 g/m^2. However, a maximum deposition of 600 g/m^2 has been recorded in some areas, which are among the highest in the world (Linden *et al*., 1990). Dust storms passing over the northern part of the I-RSA are major sources of marine sediments, as in the month of July alone, depositing up to 1000 g/m^2 of sediment in the I-RSA (ROPME, 2003).

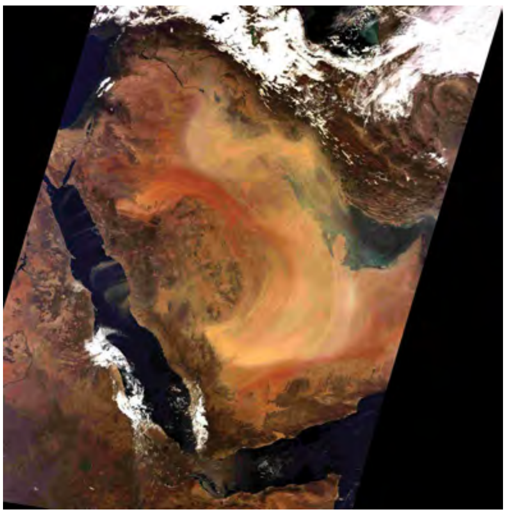
Other aerosol types also dominate the atmospheric aerosol load in this Region (Basart *et al*., 2009) and they include maritime aerosols which are those found over the oceans; fine polluted aerosols mainly originating from urban and industrial activities; contributions from burning biomass, as well as fine mode pollution particle sources from petroleum extraction and processing facilities which are located on islands, offshore platforms and coastal regions. The long–range transport of these dust particles usually takes place at higher altitudes (above 1500 m), whereas, urban–industrial and maritime aerosols concentrate at lower altitudes (Basart *et al*., 2009).

The start of dust storms over the land areas surrounding the I-RSA are largely influenced by diurnal changes of wind speed. During the summer Shamal, wind speeds are generally light at night and free from convectional eddies due to a strong low–level inversion. As the inversion disappears one to two hours after sunrise, turbulence increases rapidly, and surface winds exceed the critical dust–raising speed of about 16 knots (Hubert *et al*., 1983). It is widely believed that the land war activities that emerged during the 1991 War and the Second War of 2003 caused the land's gravel and compacted sand surface to break up, which is behind the increase in the frequency of dust storms and the deposition of sand in populated coastal zone areas of the I-RSA (WCMC,1991).

Recently, satellite imagery from the ROPME Remote Sensing Station has been reporting occasional massive dust storms on the Iranian coast and Afghanistan (Figure 3.4) on the O-RSA. This could be caused by progressive desertification.



(A)



(B)

Figure 3.4 Dust storm over ROPME Sea Area

(A) Spreading from North over the O-RSA and Sea of Oman, 5 December 2010;
(B) Covering Northern part of the I-RSA, 18 March 2012
(Source: ROPME Remote Sensing Ground Station)

c. *Cloud and Precipitation*

The I–RSA is characterized as extremely arid with approximately 80% cloud–free conditions (Al-Awadi *et al*., 2008). The Region lies at the edge of two global weather systems, the Asian and the North Africa weather systems, whose fluctuations cause varied and severe environmental conditions: the summers are hotter and the winters colder than most sub–tropical zones (Sheppard *et al*., 1992). The majority of rainfall events occur during winter months (October–April) from cloud bands that migrate from the eastern coast of Africa, or from the frontal systems that originate in the Mediterranean when the Siberian high pressure shrinks north–eastwards by late winter, or may be due to the southward advance of active westerly troughs over the southwestern part of the Arabian Peninsula (Bento, 2010).

Rainfall can also occur during the summer months due to: clouds drifting in from the Indian monsoon over the O–RSA; afternoon convective clouds due to orographic effects; and, in rare cases due to the Inter Tropical Convergence Zone shifting northward over the UAE and causing overcast weather and thunderstorm activity.

In the M-RSA and O–RSA area rainfall results from a combination of the general weather situation (e.g. monsoons, tropical cyclones and extra–tropical depressions) and the topography of the land. At present, when the air is sufficiently moist, rain falls when the air rises as it meets the mountain ranges in Iran, Oman or the UAE (Hassan and Gerges, 1994). The average precipitation in the RSA over a period of 17 years has been calculated at about 78 mm/yr (ROPME, 2003). O-RSA receives on average 99 mm of precipitation annually. Rainfall in the mountains, particularly over Jebel Akhdar, is much higher and may reach 900 millimeters.

Occasionally, a cyclone from the North Indian Ocean makes landfall, bringing with it heavy rain. Oman was hit by Super Cyclone Gonu in June 2007 and by Very Severe Cyclone Phet in June 2010. Large areas in the capital region in the Governorate of Muscat, and in Amerat and Quriyat were severely affected.

3.1.2 OCEANOGRAPHIC CHARACTERISTICS

Comprehensive information on the hydrographic structure of the RSA can be found in the results of basin-wide investigations carried out by different open sea cruises in this area. All previous investigations in the RSA have pointed out that physical oceanographic conditions in the Region are strongly controlled by the intensive evaporation (ROPME, 2010).

a. *Sea Surface Temperature (SST)*

The Sea Surface Temperature (SST) is 10ºC warmer in the south of the I- RSA than in the north. The minimum SST is observed in the middle of the northern part of the RSA. Temperature increases generally towards the coastline. This is perhaps due to the heating effect of the local human activities, which take place near the shoreline. The heating is about 2ºC within 20 to 30 km from the shoreline (Al-Rashidi *et al*., 2007).

With regards to the I-RSA, the averaged SST and salinity attains a robust, steady seasonal cycle within 4–5 years of simulation time and onward (Facey, 2008). The shallowness of the area accentuates the seasonal differences of SST with temperatures as cold as 13°C and colder occurring at the head of the area in February and nearing 35°C at the height of the long summer. The temperature difference between summer and winter is greatest (greater than 20°C) in the north– western part and least (less than 11°C) at Hormuz (Hassan and Gerges, 1994). Because there is no sill separating I-RSA from the M-RSA, the waters of the I-RSA is characterized by seasonal temperatures, and high salinity forms. Due to the long summer in the I-RSA, the warm, high salinity pulse prevails over the cold, high salinity pulse in the intermediate water that reaches the M-RSA (Hassan and Gerges, 1994).

The water temperatures in the M-RSA are moderate compared to the I-RSA and are not affected by the monsoons to the same extent. Typical winter surface water temperatures fall to 22–23°C (minimum recorded of 12°C in February), while summer temperature is characterized by a highly fluctuating regime caused by the rise and fall of a shallow, but strong thermocline (Bento, 2010). Summer water temperatures range between 23–31°C (maximum recorded of 35°C in August–with water along the Arabian coast being generally warmer than along the Iranian coast) (Hassan and Gerges, 1994; Rezai *et al*., 2004). The cool water influences in the M-RSA are less constant, although occasional upwellings occur and can replace surface waters very rapidly so that falls of up to 10°C over one or two days may occur. Such upwellings that have significant impact on the marine ecology, and hereby areas of reef development are few (Randall and Hoover, 1995).

In the outer RSA, the seasonally reversing winds induced by the monsoon create a strong upwelling which causes the remarkable, low sea temperatures off southeast Arabian Peninsula in the hottest summer months (Sheppard *et al*., 1992). With the onset of the summer monsoon the temperature rises to around 28°C in May but as upwelling takes hold the temperature in the upwelled areas drops to below 22°C near the coast in August. The low temperature near the coast continues until the upwelling weakens, and in November it is again around 26°C in the whole area starting a new cycle. The lowest temperature (20.07°C) was recorded close to Ras Sharbithat in September, while the highest (27.59°C) at Raysut on the Dhofar coast in December (Thangaraja, 1995).

b. *Salinity*

Salinity gradually increases from south to north due to higher evaporation, with lower salinity being found along the Iranian side. In summer, the surface salinity varies from 34.0 psu (June) on the southern Omani coast of the Arabian Sea to 38.9 psu in the northern part of the Sea of Oman, and increases up to 42 psu just off Bahrain. Very high water salinity, 70 psu, has been reported in the Gulf of Salwah at its southern extremity (Figure 3.5). Surface water with low salinity, about 37 psu, enters the I-RSA through the Strait of Hormuz during the summer season. This same flow, with a salinity of 39 psu, has also been observed in the winter (Reynolds, 1993).

The salinity in the northern I-RSA ranges from 40 to 41 psu, but can sometimes exceed 50 psu due to the high rates of evaporation (Al-Yamani *et al*., 2004) and the reduction in freshwater discharge from the Euphrates and Tigris rivers. This reduction is caused primarily by the southeastern Anatolia Development Project (ADP) in Turkey (Al-Yamani *et al*., 2007), where a total of 22 dams and 19 power plants have impounded 1.22 Å~ 1011 m^3 of water mainly for agricultural purposes (El-Fadel *et al*., 2002).

Salinity less than 37 psu spreads westward into the I-RSA from January–February into March–April. In May–June most contours spread 20–40 km further northwestward into the I-RSA (Swift and Bower, 2003). Low–salt water remains within the Iranian half of the I-RSA despite a wide–spread, well–developed thermocline at this time. By July–August, however, water with salinity less than 38.0 psu retracts almost 100 km southeastward along the coast and covers an area smaller than it does in January–February (Swift and Bower, 2003). Surface salinity values greater than 40 psu have

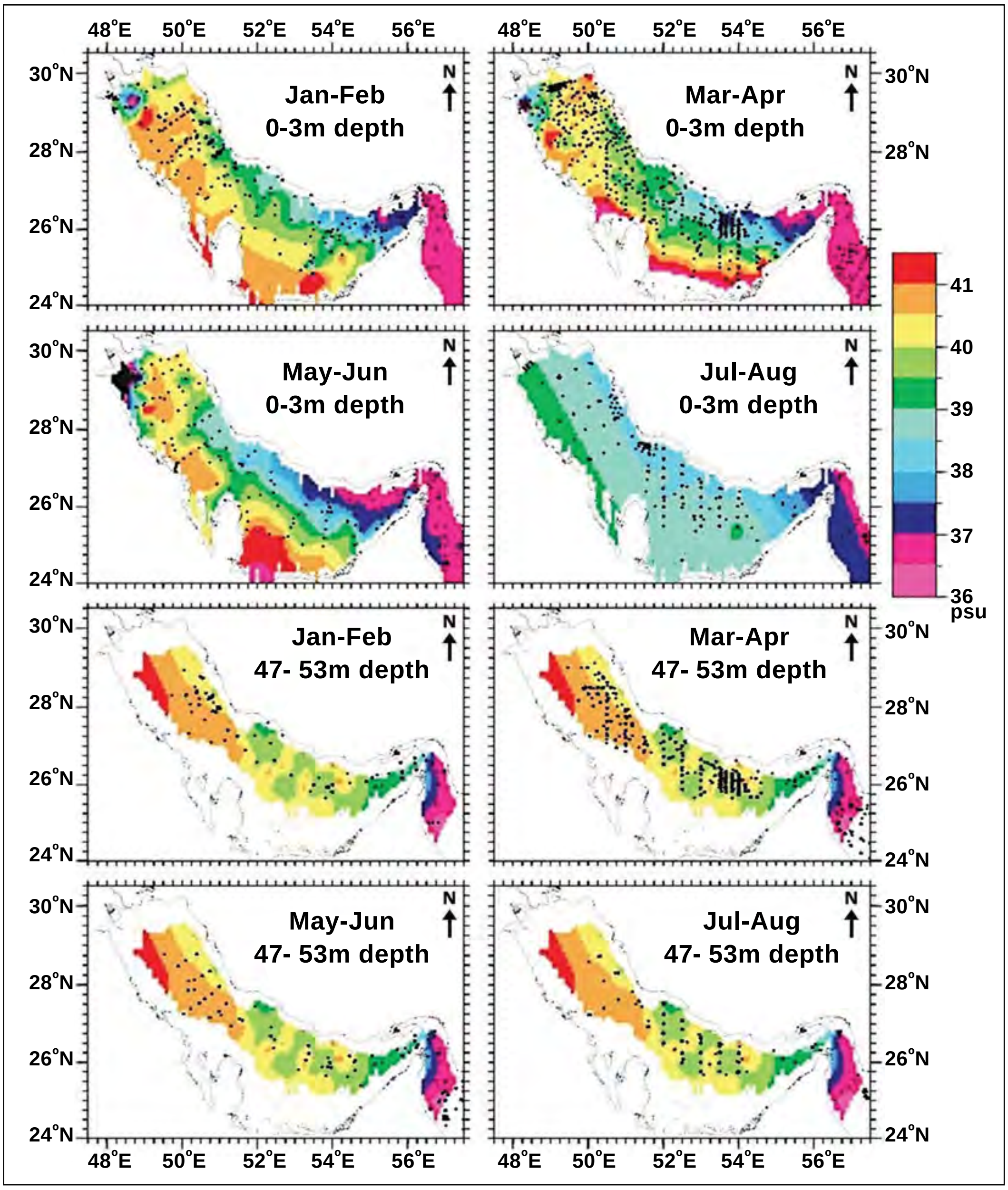


Figure 3.5 Temporal surface salinity variation in the RSA. Modified Indian Ocean Surface Water (IOSW) progressively moves farther up I–RSA from January to June. This data suggest that surface water with salinity less than 38 psu then retreats ~100 km eastward toward the Strait of Hormuz in July. Since the seasonal thermocline develops in May–June, this retreat is unrelated to summer warming. Salinity distribution of I–RSA Deep Water at 50 m depth (bottom four panels) shows comparatively little seasonal change. (Source: Swift and Bower, 2003)

disappeared, and the distribution of values is more uniform than for other months. The apparent uniformity in surface salinity in July–August could result from mixing water from high and low salinity sources (Swift and Bower, 2003). The uniformity could also result from the lower offshore flow of high–salinity water along the southern coast as peak winds decrease and the number of severe northwest Shamal wind events decreases in July and from the slower spreading of Indian Ocean Surface Water (IOSW) through the Strait of Hormuz. The maps of salinity at 50 m depth, indicate that the salinity of most of the water at this depth does not change significantly between

May–June and July–August. Introduction of a new summer water mass from off the coasts flanking the Strait of Hormuz is unlikely because the higher temperatures are typically accompanied by normal or lower salinity, whereas high salinities, as well as high temperatures, are common in bays and on the shallow banks of the I–RSA in the summer (Sugden, 1963).

A basin-wide measurement of the surface and surface to bottom water salinity profile was carried out in the I-RSA during the Oceanographic Cruise investigation of August 2001 and Winter 2006. The surface salinity of the water of the I-RSA during 2001 ranged from 36.98 to 41.07 psu, of which the minimum and maximum salinity levels were recorded at stations in the Strait of Hormuz and Kuwaiti waters respectively. During both cruises, salinity on the bottom was higher than in the surface waters almost everywhere in the domain. This stratification is caused by the baroclinic density-driven flow (ROPME, 2010a).

High salinity water flows out of the I–RSA and spreads at 200–350 m depth eventually exiting the Strait of Hormuz into the M–RSA (Hunter, 1986). Replacement water flows in through the Strait of Hormuz at the surface levels, passing inwards along the Iranian coast before reaching the Arabian coasts in a broadly anti–clockwise flow (Rochford, 1964) .The distribution of salinity in the surface waters of the M-RSA, Sea of Oman, from the Strait of Hormuz in the Musandam peninsula to Ra's Al-Hadd at the entrance to the Sea of Oman show that water salinity varies from 36.5 to 38.9 psu.

In the O-RSA, the Arabian Sea from Ra's Al-Hadd to the southernmost part of the Sultanate of Oman, surface salinity variation is found to range from 35.50 to 37.70 psu. The variation in salinity in the surface to bottom water column of the Sea of Oman and the Arabian Sea is small, which indicates a thorough mixing of waters. In most of the sites of the middle and outer RSA, the surface and the bottom readings are either the same or differ by only one or two (ROPME, 2003).

c. *Water Balance*

The shallow depth and very high net evaporation rate (estimated by different authors as 1.44–1.68 m yr^{-1} (Privett, 1959; Johns *et al*., 2003; Nikolay *et al*., 2010), typical of this arid region, result in the production of hypersaline water mass, especially intensive in the southern shallow coastal waters east of Qatar, where salinity can be nearly 42 psu. Formation of hypersaline water leads to inverse estuarine circulation with the highly saline waters concentrating in the bottom layer, leaving the I-RSA through the deep part of the Strait of Hormuz and the M-RSA (Sea of Oman) and spreading at the depth 200–300 m throughout the Arabian Sea (Banse, 1997; Prasad *et al*., 2001), Figure 3.6. Evaporated water is replaced by a surface inflow of lower salinity (about 36.5 psu) from the Sea of Oman. This inflow penetrates into the I-RSA and is carried northwards along the Iranian coast, gradually increasing in salinity to more than 40 psu (Reynolds, 1993). The inflow is seasonal, with maximum in late spring (Swift and Bower, 2003), when it spreads as far as the northwestern part of the I-RSA. The main freshwater supply of the I-RSA comes from the Tigris, Euphrates and Karun rivers, which all discharge into the Shatt Al-Arab waterway in Kuwaiti and Iraqi coast. There is no systematic record of freshwater flow from Shatt Al-Arab River into the I-RSA. The freshwater entering the northern I-RSA via Shatt Al-Arab, with an estimated annual discharge rate from 5 to 100 km^3/yr (Grasshoff, 1976). In 1993, it was estimated that the river discharge volume varied between 36 and 110 km^3 yr^{-1}, i.e., 0.15–0.46 m yr^{-1} averaged over the entire I-RSA area (Reynolds, 1993) The flow conditions might have changes significantly after this publication, due to the actions of previous forceful diversion works. The Shatt Al-Arab's watershed and associated marshes are the main sources of nutrients that sustain high productivity in the northern I-RSA. The original marsh area before its destruction was ranging from 15,000 to 20,000 km^2. During 2000, Iraq completed its diversion of the Euphrates River to a man-made canal named the Third River, which flows to the northwestern part of the I-RSA through Shatt Al-Basra Canal. More than 85% of the marshes in southern Iraq have been drained as of 2000 (UNEP 2001). Such developments as well as the major construction of dams across the tributaries and distributaries of Tigris and Euphrates Rivers in Turkey, Syria, Iran and Iraq has exerted a great environmental impact, not only in the Iraqi marsh area but also in the I-RSA (Al-Ghadban *et al*., 2000 and 2006; Al-Yamani, 2003). In a study carried in 2012 by Marine Science Centre, University of Basra, Abu Floos station was chosen to capture the amount of freshwater discharge from Tigris and Euphrates Rivers into Shatt Al-Arab during the ebb period, while Al-Faw station was chosen to capture the amount of water discharged from the I-RSA into Shatt Al-Arab during the tide period (Figure 3.7). Maximum freshwater discharge occurs in late spring–early summer. Precipitation over the RSA is also very low (0.07–0.1 m yr^{-1}) (Marcella and Eltahir, 2008); the total freshwater input is less than the evaporation rate by a factor of 5–10. The Shatt Al-Arab discharge is expected to amplify the Saudi Arabia-UAE coastal current (Reynolds, 1993); its influence is especially evident along the south-western I-RSA coast from Iraq to Qatar. Deep part of the I-RSA is characterized by pronounced haline stratification (Brewer and Dyrssen, 1985; Reynolds, 1993; Swift and Bower, 2003). Currently, the Marine Science Centre, University of Basra is reporting that the salt water intrusion through Shatt Al-Arab River is reaching Al-Seeba about 70 km north to the Shatt Al-Arab mouth. In contrast, water column in the shallow (less than10–15 m) northern, western and southern I-RSA is well mixed as a result of wind stress and tidal turbulence (John, 1992). Off Kuwait, spring tidal ranges are 2 m in the south and up to 4 m in the north, while off Bahrain the range is 2 m at extreme springs (Sheppard, 1993). At the same time, deep regions are characterized by much shorter flushing time than coastal regions: 1–3 yr in open waters vs. 3.5 yr in northwestern coastal and less than 5 yr in southern coastal zone (Sadrinasab and Kampf, 2004). On the other hand, Al-Osairi *et al*., (2011) mentioned that the water residence time in I-RSA is more than 3 years along the Arabian coast and shorter along the Iranian coast

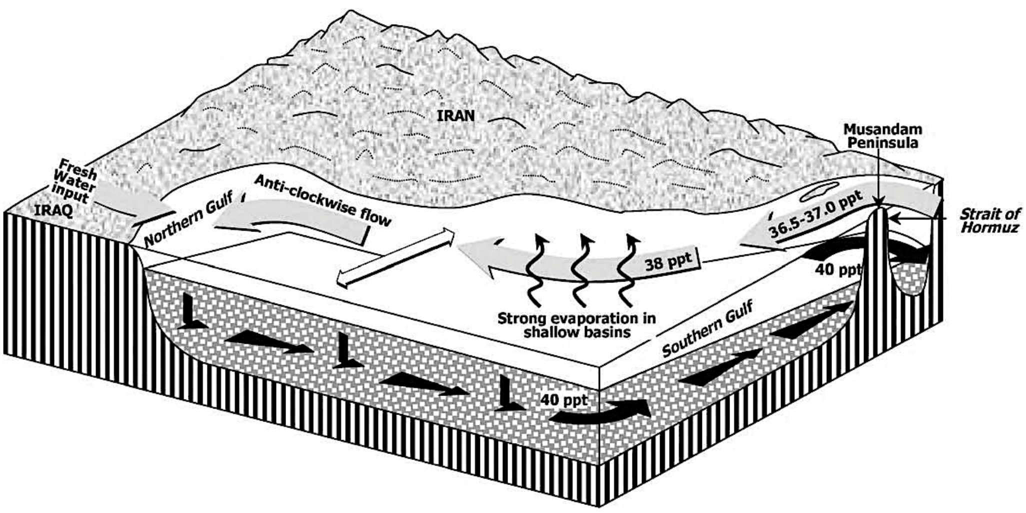


Figure 3.6 RSA circulation patterns. Counter–clockwise circulation patterns of the M–RSA that are driven by density currents. Salinity in the I–RSA is slightly higher than the O–RSA. Light arrows indicate incoming surface water from the M–RSA, and dark arrows indicate a denser deeper water flow. (Sheppard *et al*., 1992)

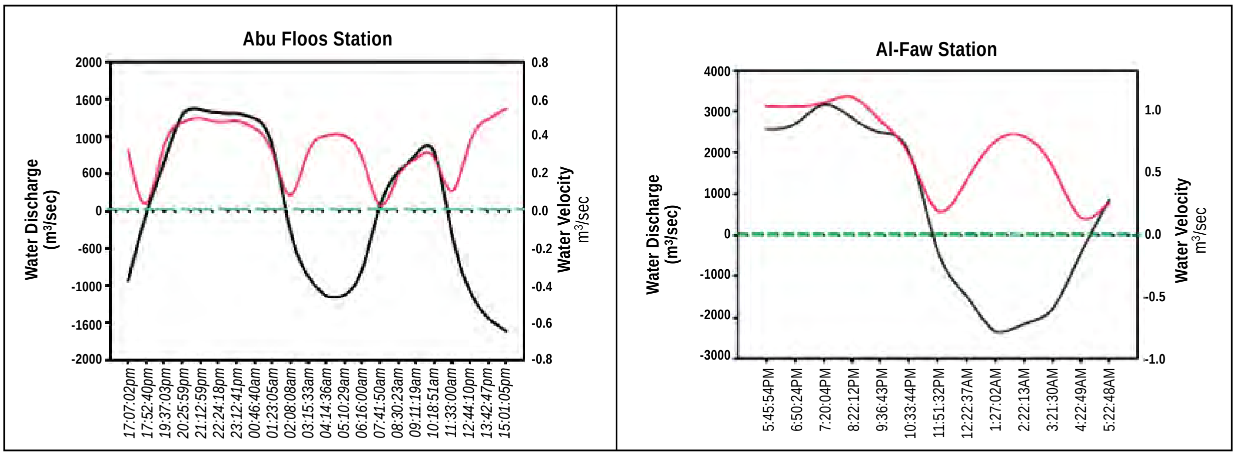


Figure 3.7 Freshwater discharge from Shatt Al-Arab. (Water discharge and Water velocity of Shatt Al-Arab at Abu Floos port station. The results show that the highest water discharge of Shatt Al-Arab at Abu Floos station during the tide was 1627 m^3/sec, while the highest water discharge during the ebb was 1352 m^3/sec. The differences between the water discharge during the highest tide and the highest ebb was approximately 275 m^3/sec. This indicates that the discharge at Abu Floos station during high tide is higher than that during ebb. Therefore, there is a distinct RSA water intrusion into the Shatt Al-Arab River. On the other hand, the highest water discharge of Shatt Al-Arab at Al-Faw station during the tide was 2349 m^3/sec, while the highest water discharge during the ebb was 3169 m^3/sec. The differences between the water discharge during the highest tide and the highest ebb was approximately 820 m^3/sec. Although, the results of water discharge at Al-Faw station indicate that the water discharge during high ebb is higher than that during tide, there is no concrete evidence to conclude that there is a freshwater intrusion into the RSA). (Source: Marine Science Centre, University of Basra, Iraq).

d. *Tidal movement*

Tides in the RSA are complex and vary from semi-diurnal to diurnal (Reynolds, 1993). The tidal range in the I-RSA varies from about 1 m (during neap tides) to 4 m (during spring tides) in the north of the I-RSA (Rakha *et al.*, 2007). The average velocity of the surface and bottom residual current in the RSA is about 6 cm (Al-Rashidi *et al.*, 2009). When onshore winds are strong, the level of coastal

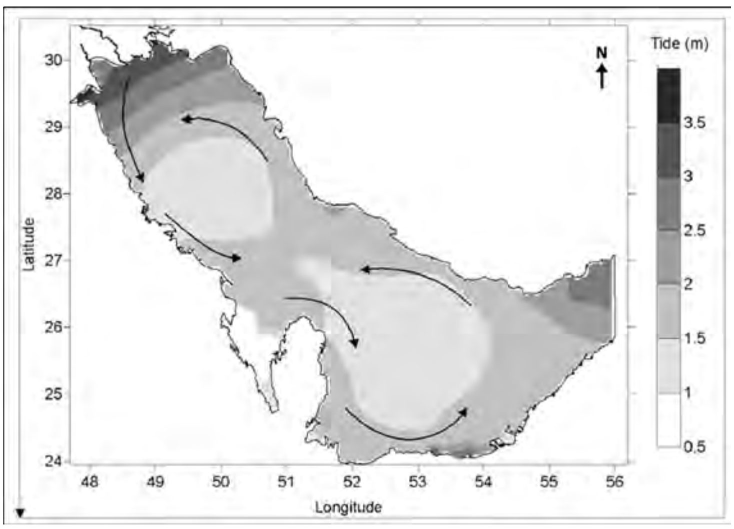


Figure 3.8 The maximum tidal range in the RSA. The greatest variation is in the northern part of the I-RSA (4m in Kuwait Bay). The arrows show general circulation patterns in the I-RSA (Rakha *et al.*, 2007; Robinson and Brink, 2006)

waters, especially the southern part may rise by 2.4 m above tidal levels and cause extensive flooding on the low sabkhas. Tidal currents are strong (1m/s) near the western end of the Strait of Hormuz, but in other areas, except between islands or in estuaries and lagoon entrances, rarely exceed 0.2–0.4 m/s (Reynolds, 2002). The tidal range is lowest in the central basin of the area, ranging from about 1 to 2 meters in Bahrain. Tidal hydrodynamic simulations (Najafi, 1997) predict tidal flows of ~0.9 m/s near the Strait of Hormuz and at the head of the I-RSA, and 0.3–0.6 m/s elsewhere in the I-RSA (Figure 3.8).

The tides are basically semi-diurnal, but the heights reached by the two tides of each day often differ considerably. The tidal range is least in the centre of the area, being about 1 to 2 metres in Bahrain. In the north, at the Shatt Al-Arab, tides are normally about 2.5 metres, and in the south (in the Sea of Oman), the range is about 2 metres. In Dubai and Lengeh (Iran) ranges of 3 to 4 metres are observed (UNEP, 1990).

e. *Water circulation*

Persistent north-westerly winds produce southeastward coastal currents and resulting upwelling along the north-eastern (Iranian) and down-welling along the south-western (Saudi Arabia) coasts (Reynolds, 1993). Winds are most intensive in spring–summer, when the intense “Shamal” events propagate from the northwest to the central and southern I-RSA. During autumn the winds are weaker and less variable. Intense temperature differences between land and water result in strong breeze winds, which in turn stimulate intensive mixing processes in coastal regions (El-Shorbagy *et al*., 2006).

The general circulation of the water in the RSA is anticlockwise due to the Coriolis Effect. Due to the shallow nature of the I-RSA, wind has a significant effect on the water circulation and mixing (Swift and Bower, 2003). The northern part of the I-RSA is dominated by north-westerly winds which force the currents southwards (Rakha *et al*., 2007). This flow drives the river plume southwards along the Kuwaiti and Saudi Arabia coasts.

According to Hossinibalam *et al*., 2011, the thermohaline fluxes produce a northwestward surface flow from Hormuz Strait to the head of the I-RSA along the Iranian shoreline (Figure 3.9). In winter and spring main stream of surface inflow driven by thermohaline fluxes follows a westerly course from the Hormuz to the Qatar peninsula and then continues close to the Saudi Arabia and Kuwait coasts. In spring-autumn southeastward thermohaline flow along the Kuwait and Saudi Arabia coast, which is stronger in summer, augments the riverine plume. In spring and summer, the wind stress generates south-eastern surface currents of magnitude about 5 cm/s along the Saudi Arabian and Iranian coasts. In addition, both the wind stress and heat fluxes cause the southward currents with speeds of 5–10 cm/s from the Hormuz Strait and main basin of I-RSA toward the UAE coast and Bahrain–Qatar shelf. In winter and autumn, the cooling effect of the thermohaline fluxes leads to removal of the thermal stratification and density contrast between the surface and bottom waters (Hossinibalam *et al*., 2011). The static stability of water column weakens significantly and the baroclinic eddies with diameters of about 40–70 km and speeds of about 8–15 cm/s form in some parts of the I-RSA. In addition, the wind stress, due to weak conditions of static stability, leads to shear instability and produce eddies with diameters of 30–120 km and speeds 4–15 cm/s in most parts of the I-RSA.

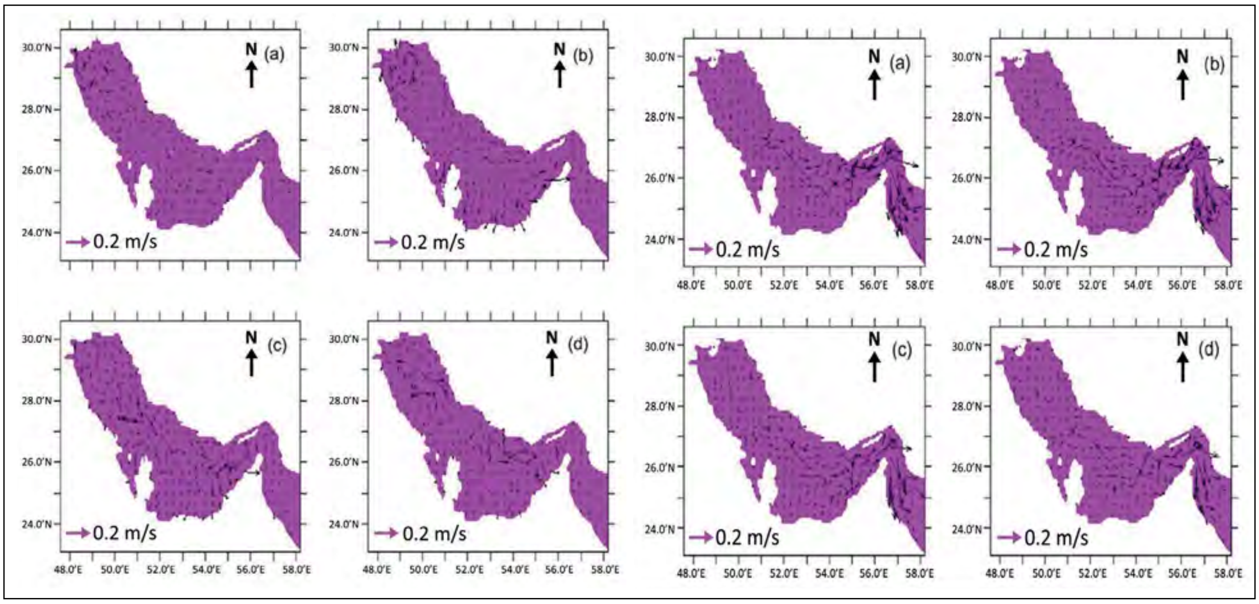


Figure 3.9 Thermohaline circulation at the surface averaged over seasons of (a) winter, (b) spring, (c) summer, and (d) autumn. (Source: Hossinibalam *et al*., 2011)

The densest waters form in the southern shallows and Bahrain–Qatar shelf under the influence of the heat fluxes during the year (Hossinibalam *et al*., 2011). The densest waters are formed in southern shallows and around Bahrain, and the bottom water is driven from these regions toward the Hormuz Strait during the year. The seasonal cycle of intensification of this bottom outflow is associated with the density contrast and the change of sea surface between these regions and water at the Oman–Iran continental shelf outside the Strait. There is a coupling between the strength of the bottom outflow and that of the IOSW inflow into the I-RSA, so that the intensified bottom outflow magnifies the influx of IOSW into the I-RSA. Both bottom outflow and surface inflow generated by thermohaline fluxes peak in March–April (Hossinibalam *et al*., 2011). Wind stress shifts the maximum of inflow/outflow generated by thermohaline to May–June. The heat fluxes are dominant factor in generating residual flow over almost the entire I-RSA. Furthermore, under the action of the lateral and vertical mixing eddies produced by the wind, the surface water in winter becomes saltier than summer. The wind stress shifts the salinity minimum from early spring to late spring (Hossinibalam *et al*., 2011).

f. *Sea currents*

The I-RSA exhibits a reverse estuarine circulation in which, due to geostrophy (Figure 3.10), the dense bottom outflow follows the coastline of UAE. As for the M-RSA, it is renowned for its complicated flow pattern consisting of several eddies (Bohm *et al*., 1999). The circulation in the coastal region off Oman is driven mainly by local winds and there is no remotely–driven western boundary current in this area. During the northeast monsoon period (November–February), the winds blow from the northeast and have maximum wind stress magnitudes of about 2 dyn/cm2 (Shetye *et al*.,1994). The inflow from the IOSW follows the Iranian coastline (Sugden, 1963) in a counter clockwise movement driven by density currents (Emery, 1956; Sheppard *et al*.,1992).

The circulation pattern in O-RSA consists of several eddies and meanders, with a pronounced anticyclonic (clockwise) eddy around 24°N, 64°E (Figure 3.11). In general, eddies appear to have appreciable deep vertical extension (Qasim, 1982) attributed

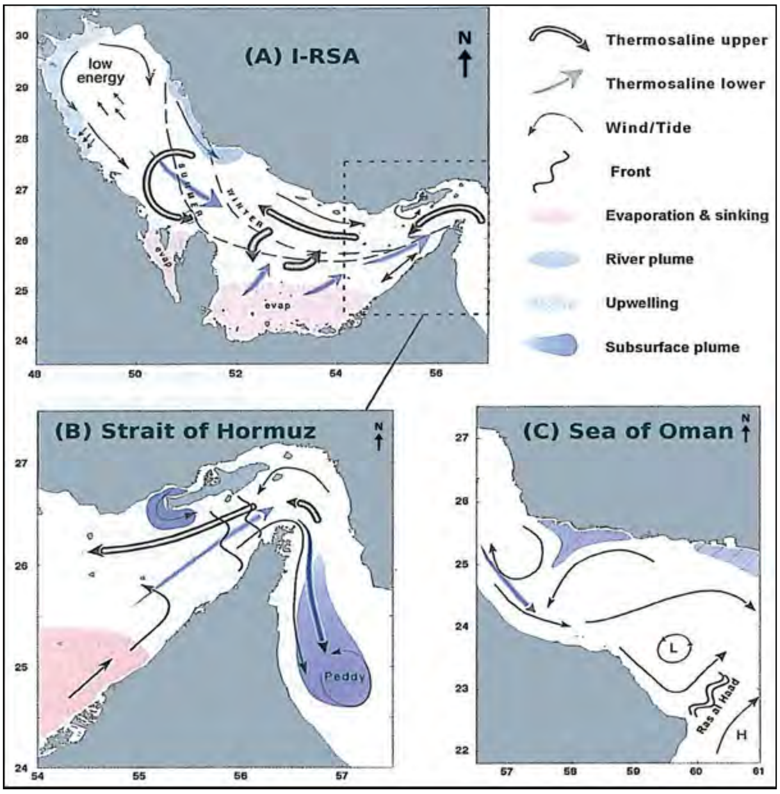


Figure 3.10

Major oceanographic vector. The major oceanographic vector processes in the (A) I–RSA, (B) Strait of Hormuz and (C) Sea of Oman. (Source: Reynolds, 2002)

to the influence of bottom topography, which is marked by depressions and rises (Das *et al*., 1980). Dynamics and thermodynamics of the surface layer of the O–RSA are dominated by the monsoon–related annual cycle of air–sea momentum and heat fluxes. The surface currents in the open–sea region of this layer can be largely accounted for by Ekman drift, and the thermal field is formed by local heat fluxes (Shetye *et al*., 1994).

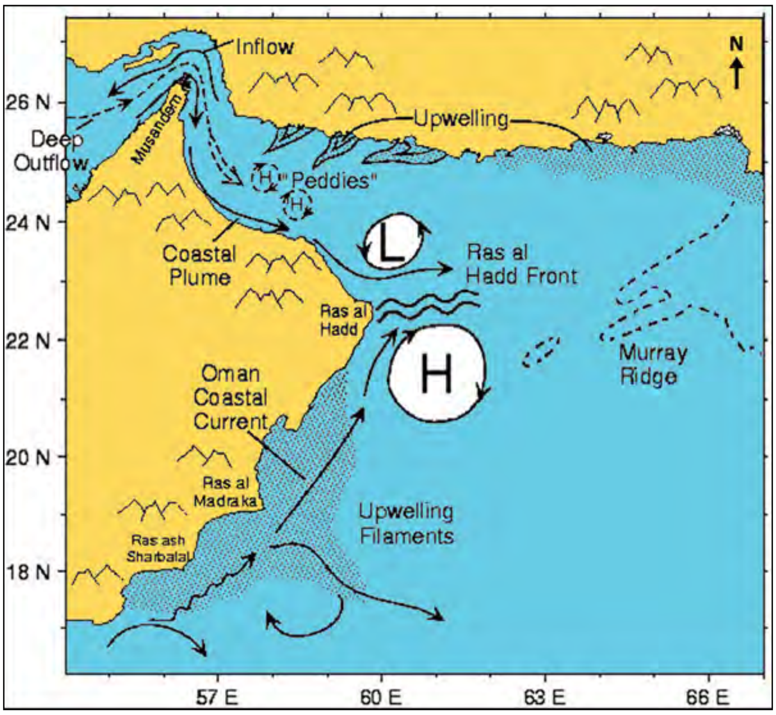


Figure 3.11

Schematic diagram of oceanic circulation in the M–RSA and O–RSA during the southwest monsoon. (Source: Rosenstiel School of Marine and Atmospheric Science, University of Miami)

3.1.3 BIOLOGICAL DIVERSITY

i. Plankton in the RSA

ROPME Oceanographic Cruises, Summer 2000, 2001, and Winter 2006, documented the phytoplankton taxa in the sampling locations covered by the relevant cruise. During Summer 2000 Cruise, a total of 17 species, whereas in Summer 2001 Cruise, 147 species of phytoplankton were recorded and presented in SOMER 2003 (ROPME, 2003). This report outlines the findings of only the 2006 Cruise (Figure 3.12). The ecological differences and the current regime throughout the RSA are important in characterizing the distribution of different plankton groups and their abundance configuration.

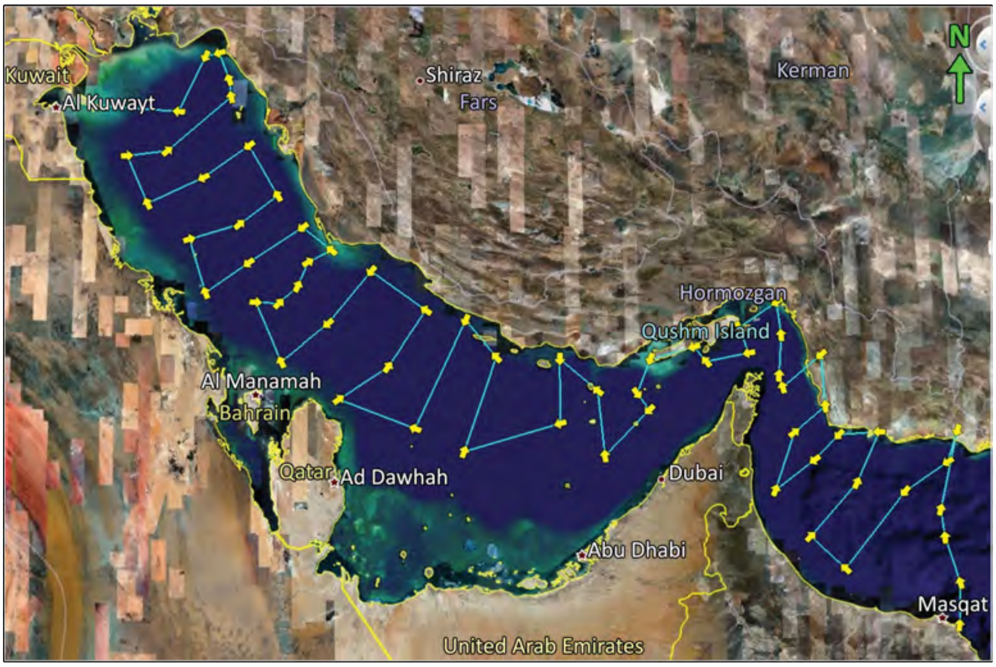


Figure 3.12 Sampling track for the ROPME Oceanographic Cruise Winter 2006

a. Phytoplankton

Phytoplankton community during winter 2006 cruise was very diverse with 337 identified species taxa, representing eight classes (Figure 3.13), and about 15 phytoplankton species were reported to be dominant in the RSA. Whereas a total of 58 identified taxa belonging to five different classes, are considered potentially harmful species (Figure 3.14), out of which, 20 species are potentially toxic to humans, 15 species are potentially causing marine fish mortality and 23 are potentially bloom-forming species. Further, for the distribution of harmful algal blooms in Kuwait's marine environment and intertidal sediments see Saburova *et al*., 2009; Al-Yamani *et al*., 2010 and 2012.

The composition of phytoplankton significantly varied with depth especially for the most prevalent species (Figure 3.15). Analysis of phytoplankton spatial distribution of the RSA revealed macro-scale heterogeneity within the phytoplankton community. Significant differences were detected between the Inner RSA and the Sea of Oman, most probably related to the general scheme of the RSA hydrodynamics: the Inner RSA – freshwater outflow from the Shatt Al-Arab estuary in the north and the monsoon-induced inflow from the Arabian Sea and the Sea of Oman in the southern part of the Inner RSA. The interaction between the different currents forms two large frontal zones in the central part of the Inner RSA and in the southern part near the Strait of Hormuz (Figure 3.10). This front, probably contributes to the significant distinction in the phytoplankton structure between Sea of Oman and I-RSA (Figure 3.11). The second frontal zone is located in the central part of the Inner RSA and divides the area into northern and southern zones. It generally consists of a large stagnant zone in the northwest part of the Inner RSA, bordering a down-welling zone on the Saudi Arabian coast, which might be influenced by the river plume.

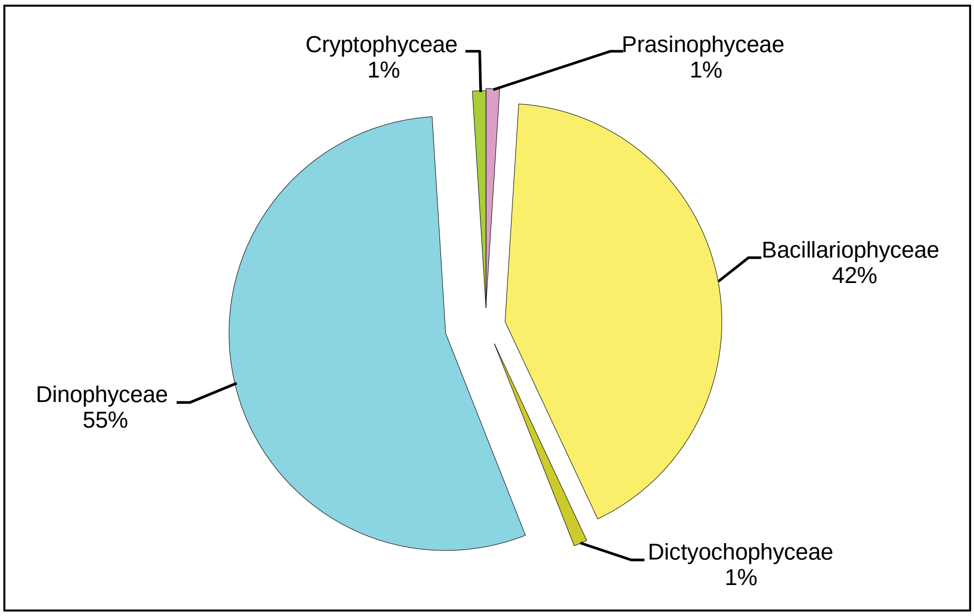


Figure 3.13 Phytoplankton group composition in RSA during winter 2006. Diatoms (Bacillariophyceae) and dinoflagellates (Dinophyceae) were the most diverse groups. (Source: ROPME, 2010c)

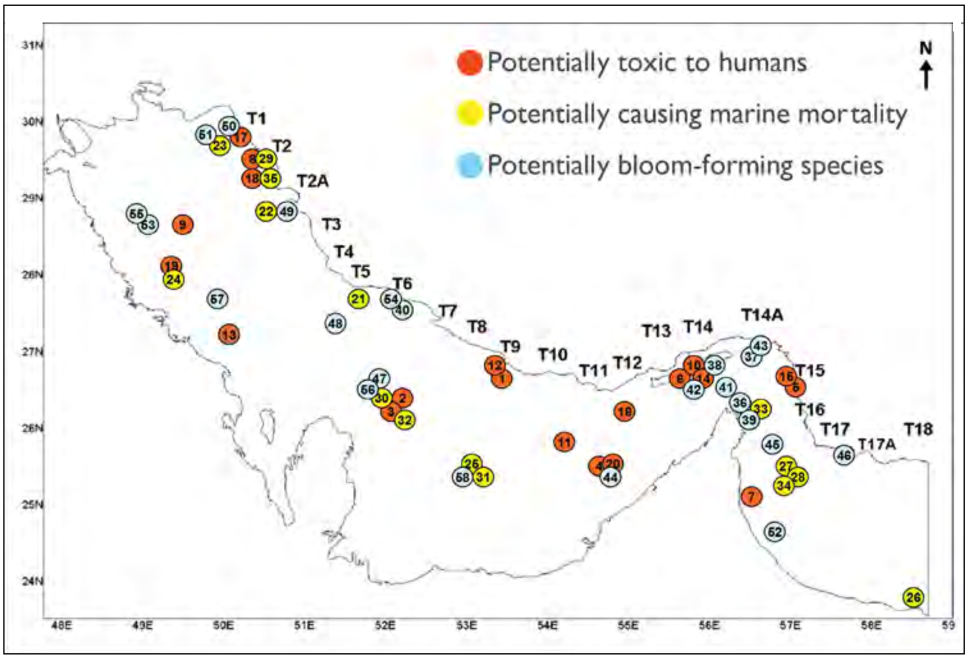


Figure 3.14 Distribution of the maximum abundance for the potentially harmful algae species in the RSA. (Source: ROPME, 2010c)

1. *Trichodesmium* sp.
2. *Pseudo-nitzschia delicatissima* complex
3. *Pseudo-nitzschia pungens*
4. *Pseudo-nitzschia seriata/australis* complex
5. *Alexandrium tamiyavanichi*i
6. *Dinophysis acuminata*
7. *Dinophysis caudata*
8. *Dinophysis miles*
9. *Dinophysis mitra*
10. *Dinophysis rapa*
11. *Dinophysis* cf. *rotundata*
12. *Gymnodinium catenatum*
13. *Karenia papilionacea*
14. *Lingulodinium polyedrum*
15. *Prorocentrum balticum*
16. *Prorocentrum minimum*
17. *Prorocentrum rhathymum*
18. *Protoperidinium curtipes*
19. *Protoperidinium divergens*
20. *Pyrodinium bahamense* v. *compressum*
21. *Proboscia alata* f. *gracillima*
22. *Akashiwo sanguinea*
23. *Ceratium furca*
24. *Ceratium fusus*
25. *Cochlodinium polykrikoides*
26. *Dissodinium pseudolunula*
27. *Gonyaulax poligramma*
28. *Noctiluca scintillans*
29. *Peridinium quinquecorne*
30. *Prorocentrum micans*
31. *Protoceratium reticulatum*
32. *Scrippsiella trochoidea*
33. *Phaeocystis* sp.
34. *Dictyocha fibula*
35. *Dictyocha speculum*
36. *Bacteriastrum delicatulum*
37. *Bacteriastrum furcatum*
38. *Chaetoceros compressus*
39. *Chaetoceros curvisetus*
40. *Chaetoceros lorenzianus*
41. *Chaetoceros pseudocurvisetus*
42. *Chaetoceros socialis*
43. *Chaetoceros tortissimus*
44. *Guinardia delicatula*
45. *Gymnodinium*-like group
46. *Lauderia borealis*
47. *Skeletonema costatum*
48. *Teleaulax* sp.
49. *Leptocylindrus danicus*
50. *Coscinodiscus wailesii*
51. *Guinardia flaccida*
52. *Cerataulina pelagica*
53. *Chaetoceros peruvianus*
54. *Ceratium trichoceros*
55. *Prorocentrum compressum*
56. *Prorocentrum gracile*
57. *Prorocentrum sigmoides*
58. *Prorocentrum* cf. *gracile.*

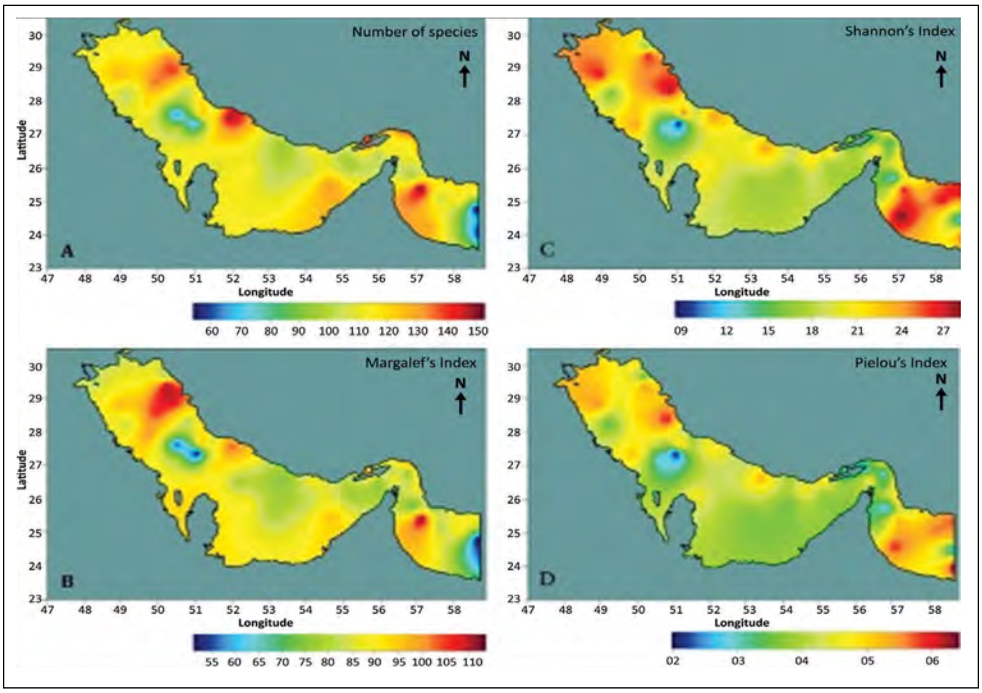


Figure 3.15 Spatial variability of the Phytoplankton diversity within the studied RSA during Winter 2006. Phytoplankton was more abundant in the surface layer, and mean abundance gradually decreased from the surface layer to the bottom layer, i.e. two times less than surface. A high diversity level characterized the winter phytoplankton community in the RSA In order to assess the diversity of the phytoplankton community within the RSA, (A) species richness (number of species per sample and (B) Margalef's Index, (C) species diversity (Shannon's Index) and (D) community evenness (Pielou's Index) were calculated for each station from data for the surface, middle and bottom layers. (Source: ROPME, 2010c)

b. ***Zooplankton***

The observations made on zooplankton samples collected during Summer 2000 and Summer 2001 Cruises were preliminary, and the recorded zooplankton were 65 and 71 taxonomic entities, respectively (ROPME, 2003). However, during winter 2006, zooplankton community in the RSA appeared to be highly diversified, comprising 233 species, distributed among numerous taxonomic phyla of the animal kingdom (Figure 3.16). Of the total recorded species during the present study, 116 species appeared to be new to the RSA, particularly in the I-RSA. Since all of them are Indo-Pacific, it is difficult to define whether these species are endemic in I-RSA but were not recorded before or they were transferred to the area recently with low salinity surface current water from the Sea of Oman.

The community structure and standing crop of zooplankton during the 2006 study exhibited pronounced spatial differences across the RSA. The large number of zooplankton species (230 species), and the wide variations in species number among the sampled stations (17-69 species) reflect the wide array of ecological niches in the study area. The zooplankton community in the I-RSA was more diversified (210 species) than in the Strait of Hormuz and Sea of Oman (144 species) (For Macrozoobenthos of northwestern I-RSA see Al-Rifaie *et al*., 2012; Al-Yamani and Saburova, 2010 and 2011; Al-Yamani *et al*., 2012) . The distribution of zooplankton in the surface layers of RSA indicated that high standing crop was found in the outer RSA as well as in the NE corner of RSA (Figure 3.17). An area of low standing crop was found to be on the western coast of the I-RSA and the Iranian side of the Strait of Hormuz.

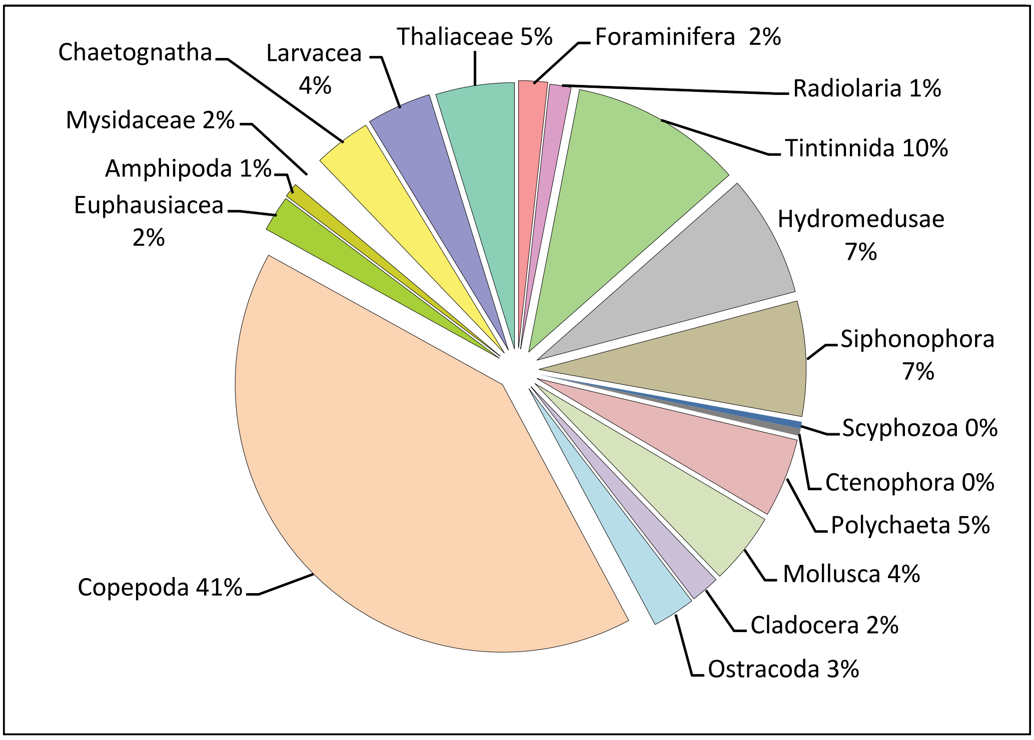


Figure 3.16 Percentage composition of Zooplankton communities. (Source: ROPME, 2010d)

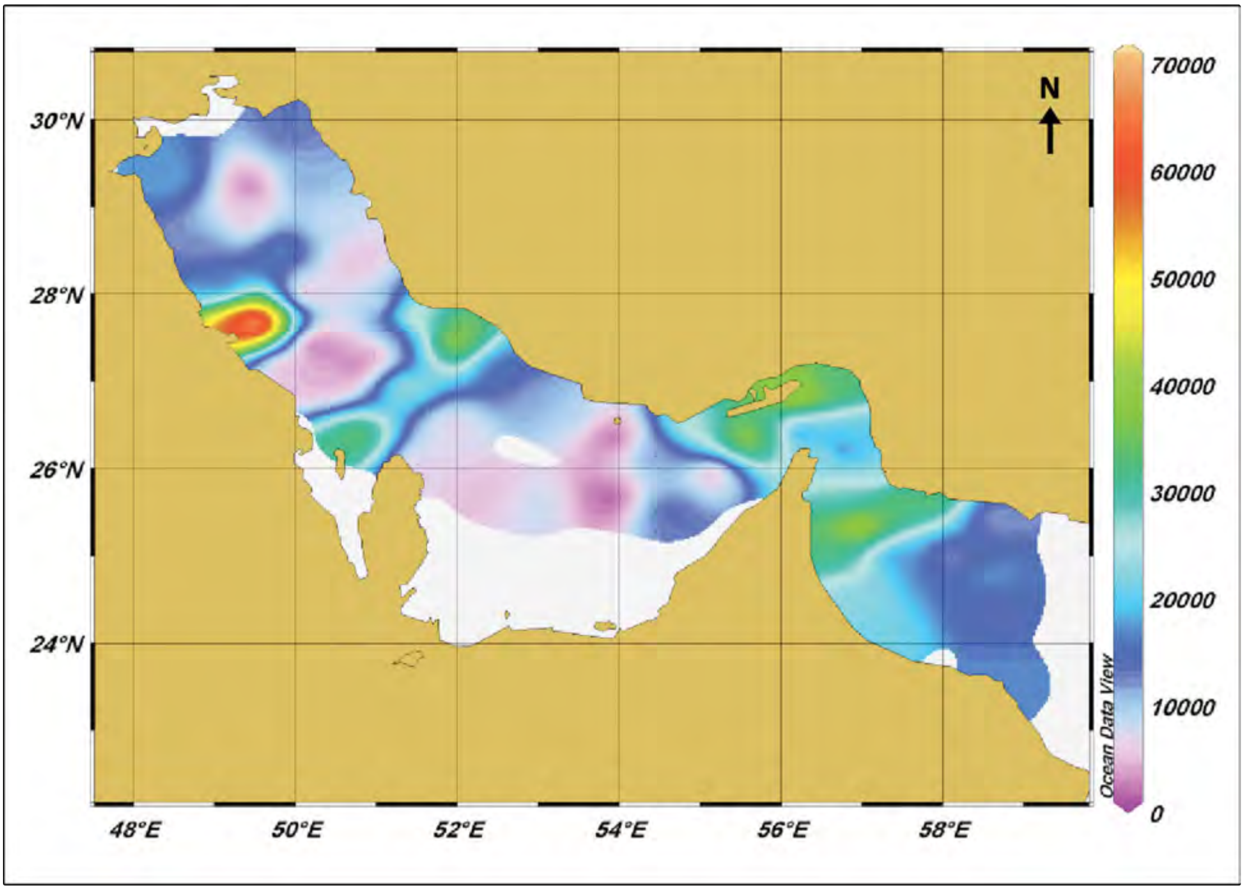


Figure 3.17 Spatial distribution of Zooplankton (species/m^3). (Source: ROPME, 2010d)

The planktonic larvae of benthic animals displayed relatively low contribution (6.8%) to total zooplankton (Figure 3.18), but it reached up to 35.3% in the I-RSA and slightly dropped (up to 22%) in the Sea of Oman. The mollusks larvae were the predominant component, which dominated (up to 95% of meroplankton) at the greatest majority of the sampled stations (Figure 3.19). Polychaetes larvae demonstrated variable contribution to the meroplankton (5.5%), with more effective role (average: 9.4%) in the I-RSA than (Average: 1.6%) in the Sea of Oman (Figure 3.20). However, the percentage increased to 71.2% in the northern I-RSA and 26.3% in the Sea of Oman. Decapods larvae were represented mainly by crabs and prawns larvae, forming together 26% of total meroplankton, but prawns larvae showed markedly active contribution (22.2%) than crab larvae (3.7%). Prawns larvae were abundant in the southern I-RSA and in the Sea of Oman (Figure 3.21), constituting up to 100% of total meroplankton at some stations. In the meantime, the larvae of crabs attained the highest contribution (up to 80%) at stations scattered mainly in the I-RSA (Figure 3.22). The other meroplankton representatives such as cirripedes larvae, crustacean eggs, fish larvae and eggs were found in low numbers, except at a few stations.

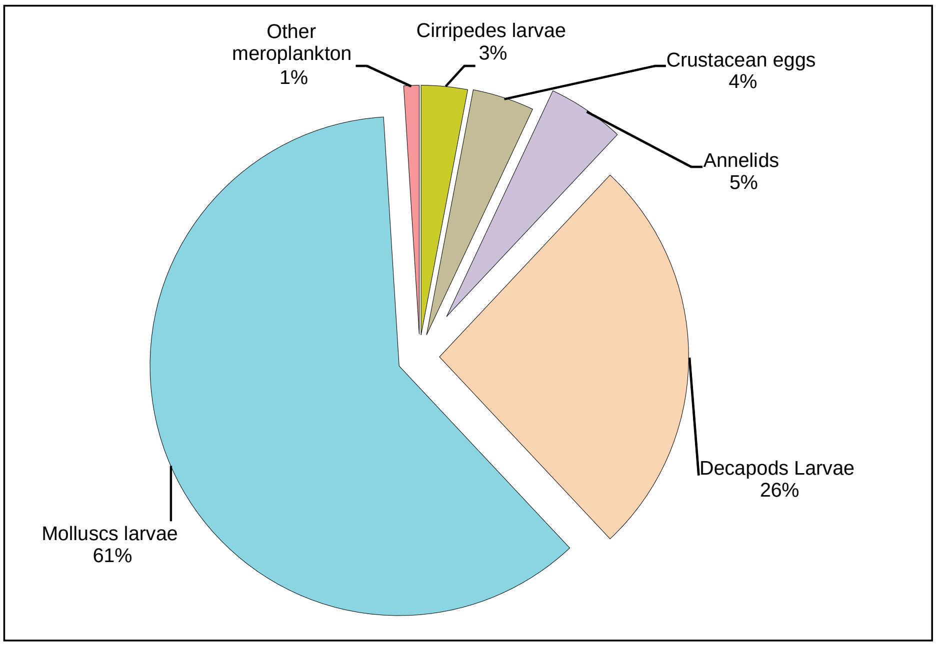


Figure 3.18 Relative abundance (%) of Meroplankton to total Zooplankton in RSA Winter 2006. (Decapods larvae were represented mainly by crabs and prawns larvae, forming together 26% of total meroplankton, but prawns larvae showed markedly active contribution (22.2%) than crab larvae (3.7%). (Source: ROPME, 2010d)

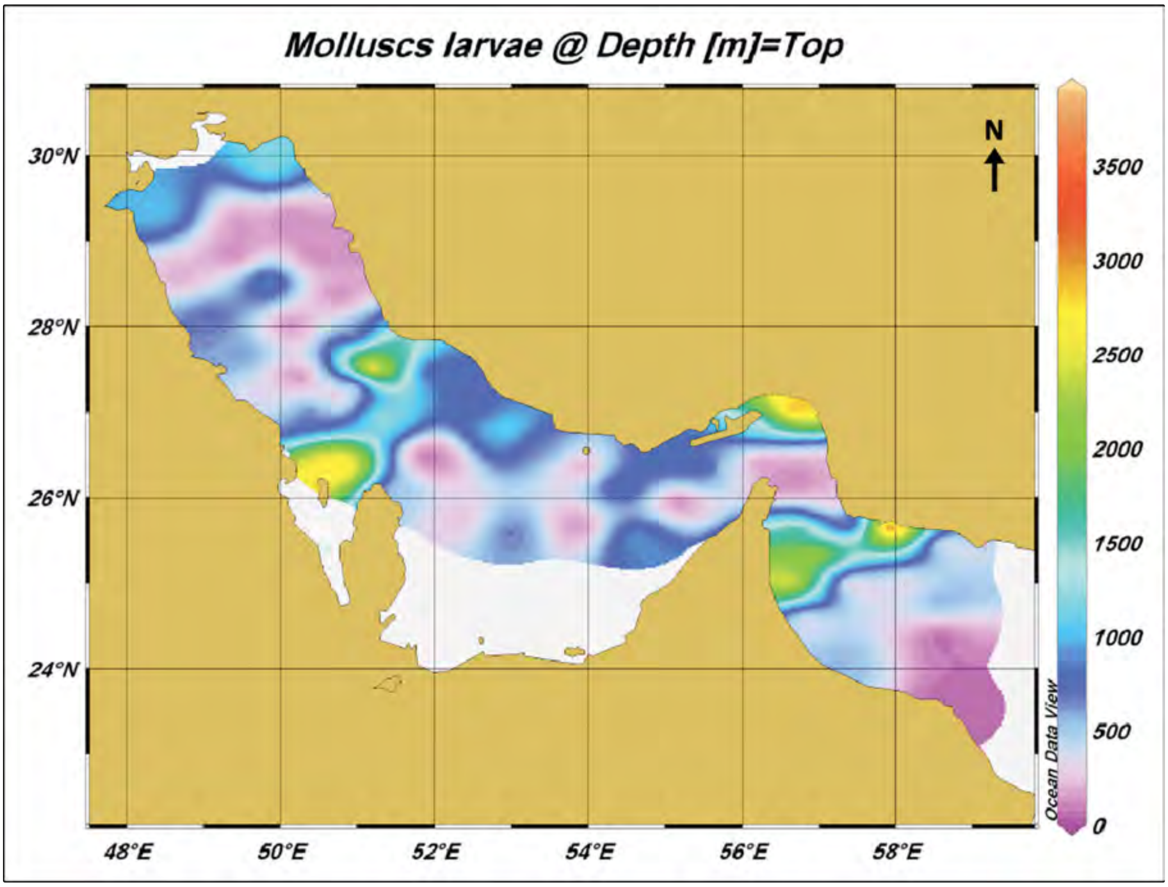


Figure 3.19 Abundance of Molluscs larvae (individual/m^3). (Source: ROPME, 2010d)

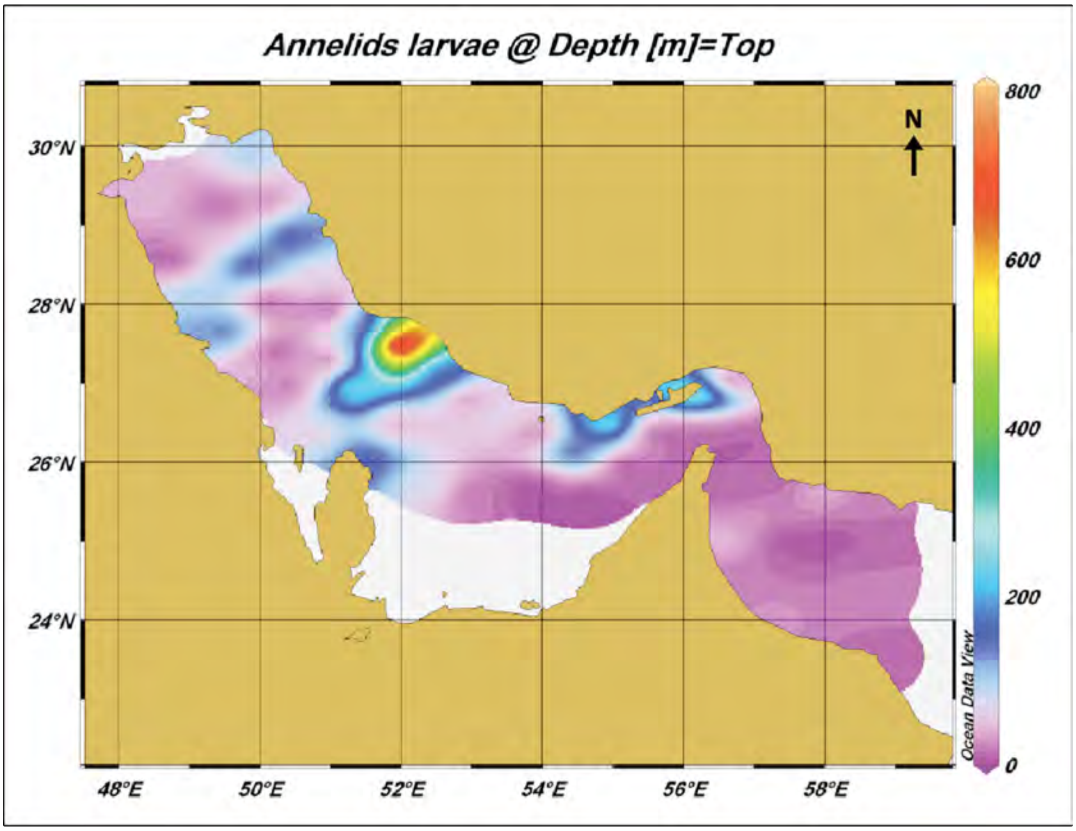


Figure 3.20 Abundance of Polychaetes larvae (individual/m^3). (Source: ROPME, 2010d)

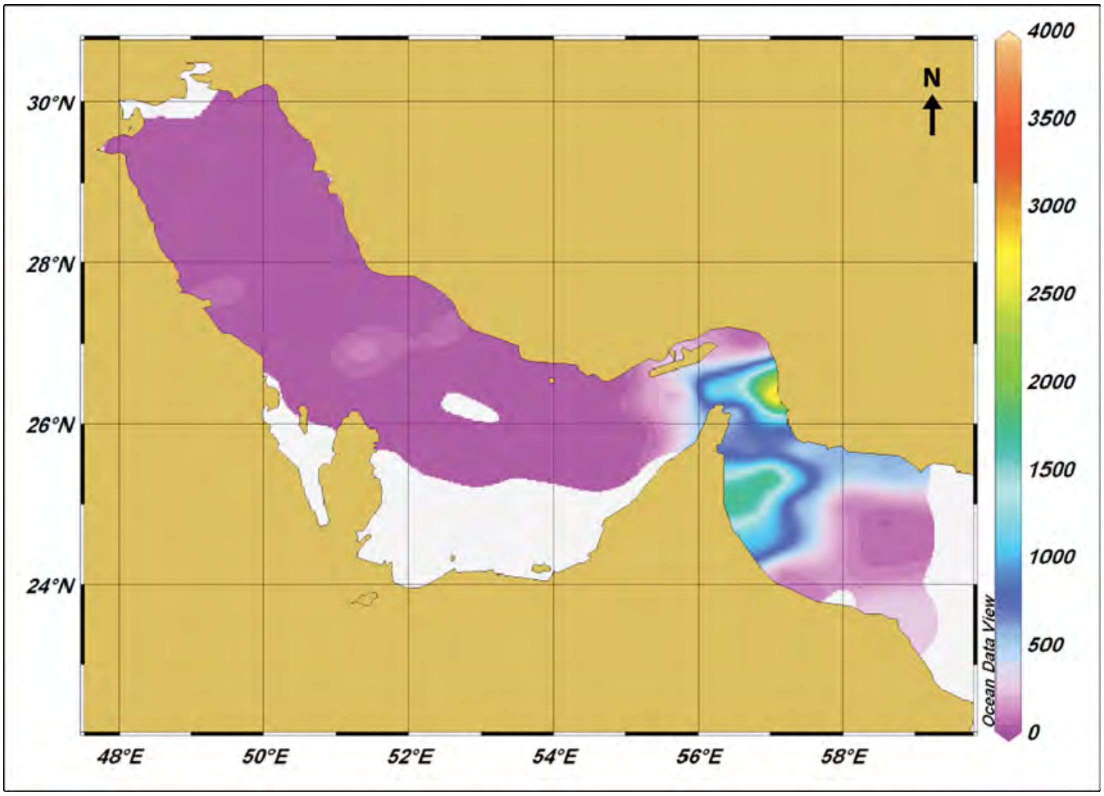


Figure 3.21 Abundance of Prawn larvae (individual/m^3). (Source: ROPME, 2010d)

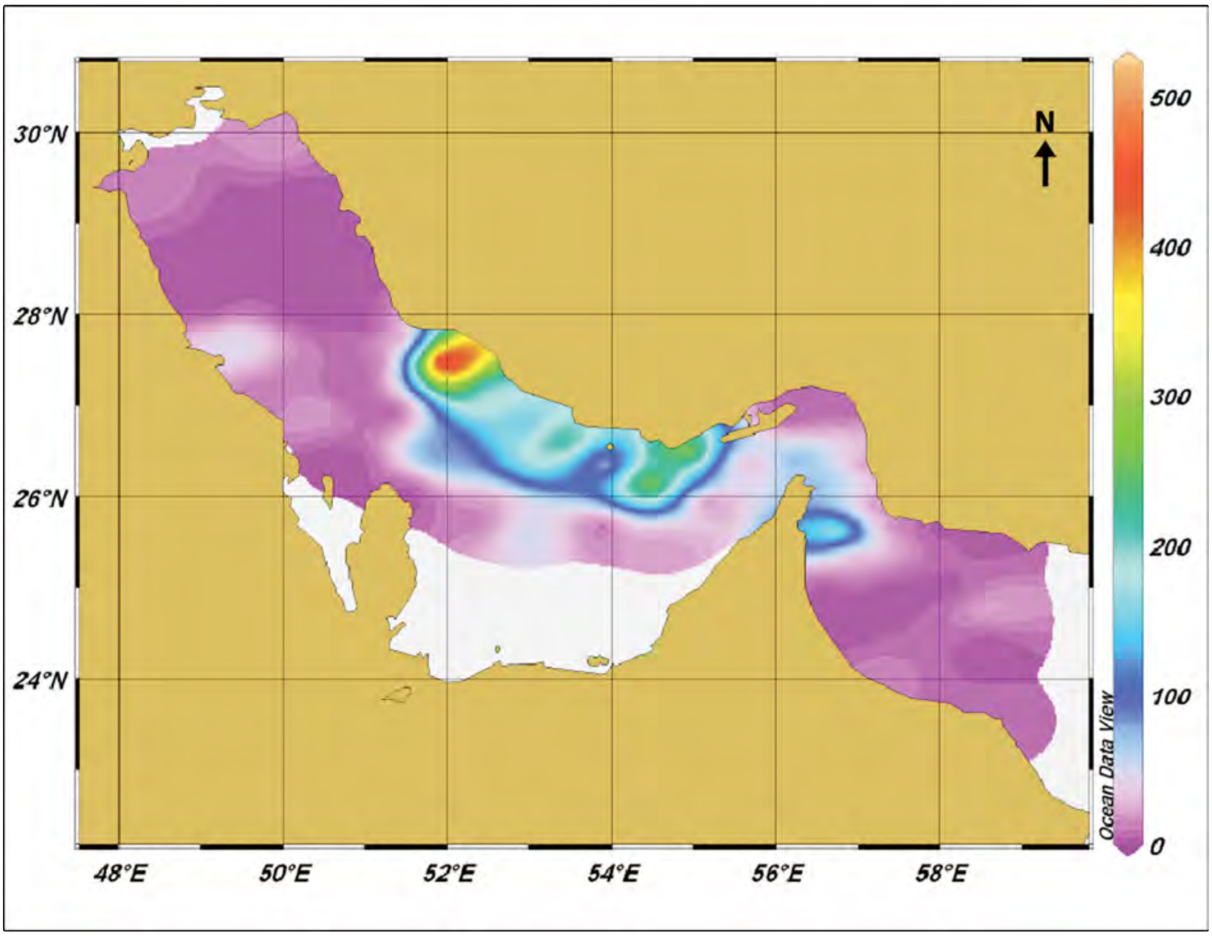


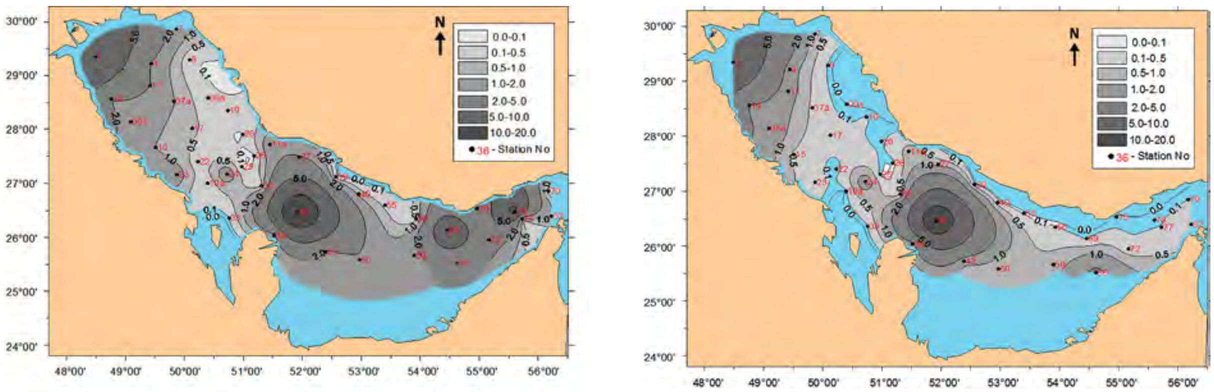
Figure 3.22 Abundance of Crab larvae (individual/m^3). (Source: ROPME, 2010d)

c. *Ichthyoplankton*

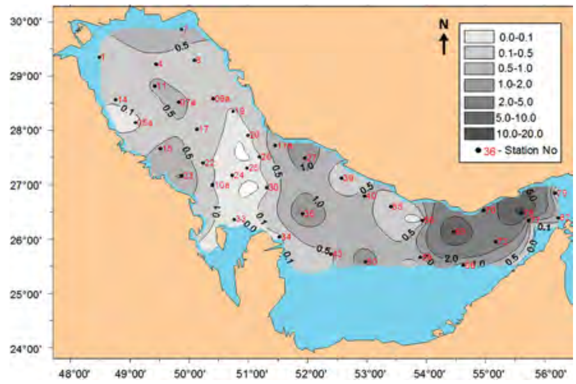
Ichthyoplankton are the eggs and larvae of fish found in the near-surface water. Monitoring of the ichthyoplankton can provide an indication on ecosystem health. Regional surveys based on time series of ichthyoplankton are vital since it is possible to map the marine areas to determine patterns of breeding, Earlier studies indicated that a total of 53 families include 41 genera, 24 species and 84 specific types of larvae (Houde *et al*., 1986). During 1989 and 1990, fish larvae and eggs were identified in M-RSA (Sea of Oman) and O-RSA (Arabian Sea). The total fish eggs and larvae recorded were 54 and 93 species respectively. The overall fish eggs and larval abundances estimated disclosed that the Arabian Sea had a 20 times greater egg abundance than the Sea of Oman, whereas the Sea of Oman had 2.6 times higher larval abundance than the O-RSA (Thangaraja and Al-Aisry, 2001).

Recently and during the 2006 survey, the maximum ichthyoplankton concentration was found in the Sea of Oman with a low abundance in the I-RSA (Figures 3.23 and 3.24). The maximum amount of fish larvae was found in the Strait of Hormuz. Vosoghi *et al*., 2009 studied the fluctuation of Coralline Fish Larvae of the Iranian coast, near Kharko and Khark Islands. They found that the peak of fish larvae diversity and abundance to be during spring season, and the distribution of fish larvae seemed to be correlated to sea current (Vosoughi *et al*., 2010).

In general, the most diverse community of ichthyoplankton are those in M-RSA (Sea of Oman) and I-RSA waters at north-west of Bahrain (Shannon Index, Figure 3.25). Probably, this pattern reflects results of interactions between hydrodynamic properties, spawning, and behavior of the fish, including migrations.

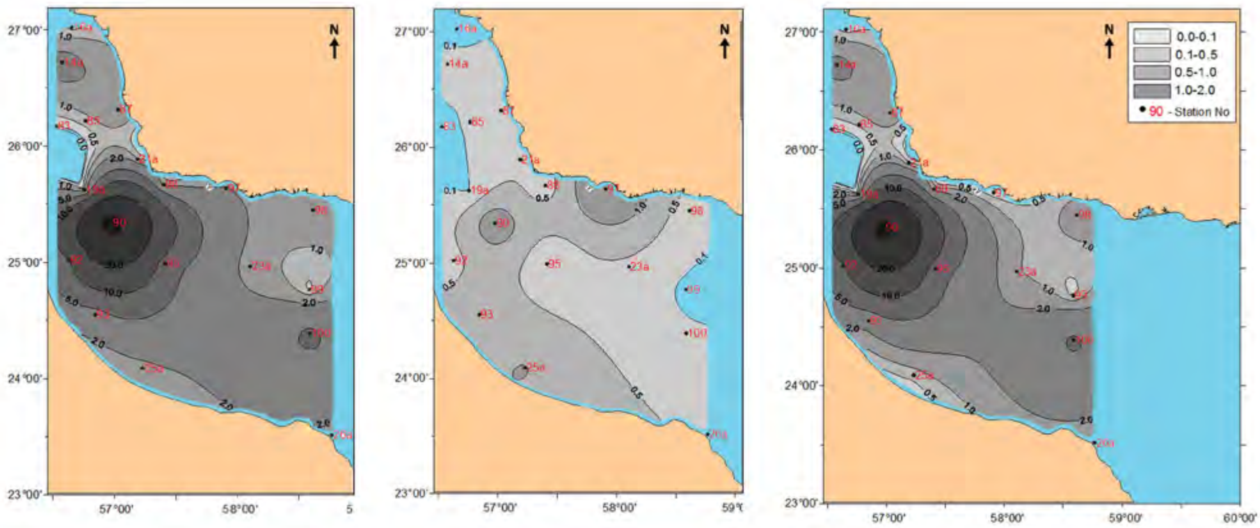


(A) (B)



(C)

Figure 3.23 Distribution of Ichthyoplankton: (A) ichthyoplankton, (B) fish eggs, (C) fish larvae abundance (individuals/m^3) in I-RSA. (Source: ROPME, 2012a)



(a) (b) (c)

Figure 3.24 Distribution of (a) ichthyoplankton, (b) fish eggs, (c) fish larvae abundance (individuals/m^3) in the Sea of Oman (M-RSA) (Source: ROPME, 2012a).

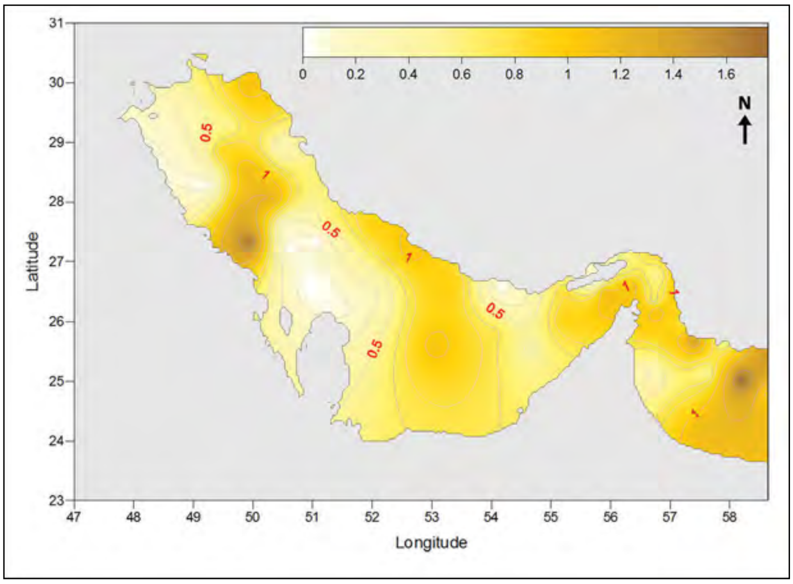


Figure 3.25 Diverse of community of Ichthyoplankton (Shannon Index values). (Source: ROPME, 2012a)

ii. Benthic Communities

a. *Meiofauna*

Successive three ROPME oceanographic cruises indicated that a total of 70 species of meiofauna were identified during Summer 2000 Cruise, 205 species in Summer 2001 Cruise and 281 species in Winter 2006 Cruise.The highest number of meiofauna species recorded as 39 at station 18 for Summer 2000 Cruise; 40 species at station 50 in the middle of southern part of the I-RSA for Summer 2001 Cruise and 65 species at station 98 in the Iranian coast of Sea of Oman for Winter 2006 Cruise. The substrates of these three stations were dominated by high proportion of silt and clay fractions, ranging from 84.4% to 94.80% and relatively high proportions of Total Organic Matter ranging from 8.14% to 11.83%. Seven dominant groups of meiofauna were represented, out of them, foraminifera, ostracoda and micro molluscs were the important taxa. Foraminifera contributed between 90 and 97.05% of the total numbers of meiofaunal groups during the three cruises conducted in the RSA. The result of grain size analysis of sediment during three cruises revealed that the mixture of silt-clay and sandy sediments is hospitable substrates for meiofauna to reside, with larger pores than highly silt-clay sediment. Therefore, meiofauna species diversity and abundance are higher in substrates with mixture of silt-clay and sandy sediments than highly silt-clay sediment (ROPME, 2013e).

The spatial distribution of meiofauna in RSA during the three ROPME Cruises showed some relationship with the environmental parameters. Significant correlations ($P<0.05$) were found between meiofauna and depth ($r = -0.315$ for Summer 2000 and $r = -0.332$ for Summer 2001). There was also a significant correlation between total meiofauna and salinity ($r = -0.24$) during Winter 2006 Cruise. The temperature values showed negative significant correlation with depth ($r = -0.279$ for Summer 2000 and $r = -0.765$ for Summer 2001 at $p< 0.01$), however, positive significant correlation ($r = 0.425$) in Winter 2006 Cruise. Although the water temperature shows variation from surface to the depth of 104 m, in the three cruises, temperature did not show significant correlation with the meiofauna communities. The r-values between temperature and meiofauna communities were -0.116, 0.054 and 0.163 ($p<0.05$) for the years Summer 2000, Summer 2001 and Winter 2006 respectively. This result could be related to the shallow depth of the stations. The dissolved oxygen concentration values during three cruises showed a negative significant correlation with depth (r = -0.739 for Summer 2000, r = -0.322 for Summer 2001 and r= -0.625 for Winter 2006). The correlation coefficient between total meiofauna and environmental parameters of all the three ROPME cruises are depicted in Tables 3.1 to 3.3.

Table 3.1 Correlation coefficient between total meiofauna and environmental parameters (Summer 2000 Cruise)

	Depth (m)	Salinity (‰)	Temp (°C)	DO (ml/l)	pH	Silt & Clay (%)	TOM (%)
Salinity (‰)	0.262						
Temp. (°C)	-0.279	-0.426*					
DO (ml/l)	-0.739*	-0.081	0.215				
pH	-0.51	-0.104	0.298	0.426*			
Silt and Clay (%)	-0.024	-0.1	-0.144	-0.171	-0.172		
TOM (%)	-0.294	0.042	0.055	0.419*	0.219	-0.228	
Total meiofauna	-0.315*	0.015	-0.116	0.196	-0.026	0.041	0.037

*Correlation is significant at the 0.05 level (2-tailed)

Table 3.2 Correlation coefficient between total meiofauna and environmental parameters (Summer 2001 Cruise)

	Depth (m)	Salinity (‰)	Temp (°C)	DO (ml/l)	pH	Silt & Clay (%)	TOM (%)
Salinity (‰)	.231						
Temp. (°C)	-.765**	-.309					
DO (ml/l)	-.322	-.315	.487**				
pH	.260	.049	-.192	.212			
Silt and Clay (%)	.014	.090	-.053	-.056	.026		
TOM (%)	.000	-.210	.056	-.149	.254	-.065	
Total meiofauna	-.332*	-.045	.054	.106	.213	-.144	.129

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 3.3 Correlation coefficient between total meiofauna and environmental parameters (Winter 2006 Cruise)

	Depth (m)	Salinity (‰)	Temp (°C)	DO (ml/l)	pH	Silt & Clay (%)	TOM (%)
Salinity (‰)	-0.103						
Temp. (°C)	0.425	-0.619					
DO (ml/l)	-0.605*	0.534	-0.814*				
pH	-0.250	0.543*	-0.49*	0.531*			
Silt and Clay (%)	-0.239	0.036	-0.265	0.364*	0.321*		
TOM (%)	-0.052	-0.196	-0.092	-0.029	-0.153	0.303*	
Total meiofauna	0.103	-0.24	0.163	-0.265	-0.183	-0.169	-0.166

*Correlation is significant at the 0.05 level (2-tailed)

b. ***Macrofauna***

A total of 202 species of macrofauna belonging to 141 genera and 100 families were recorded during the winter 2006 cruise. In North and South of I-RSA and the M-RSA (Sea of Oman) representations of polychaetes and crustaceans were higher with lesser molluscs abundance in the Sea of Oman (Figure 3.26). The percentage composition of the macrofauna in all three zones of RSA is depicted in Figure 3.27.

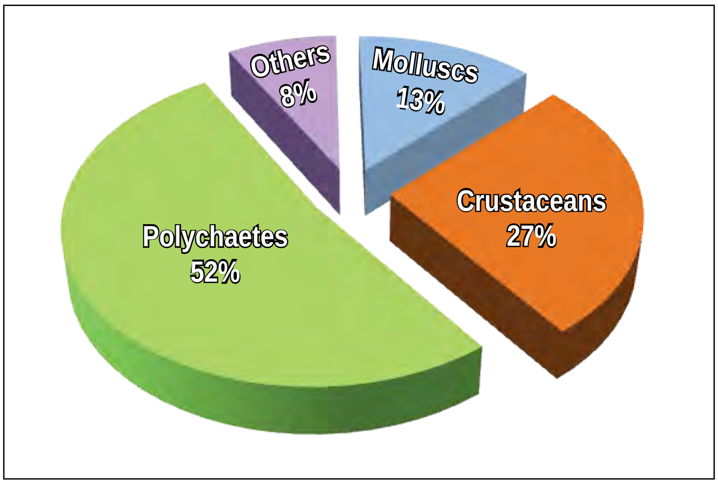


Figure 3.26 Percentage composition of major Macrofauna taxa of RSA. (Source: ROPME, 2012b)

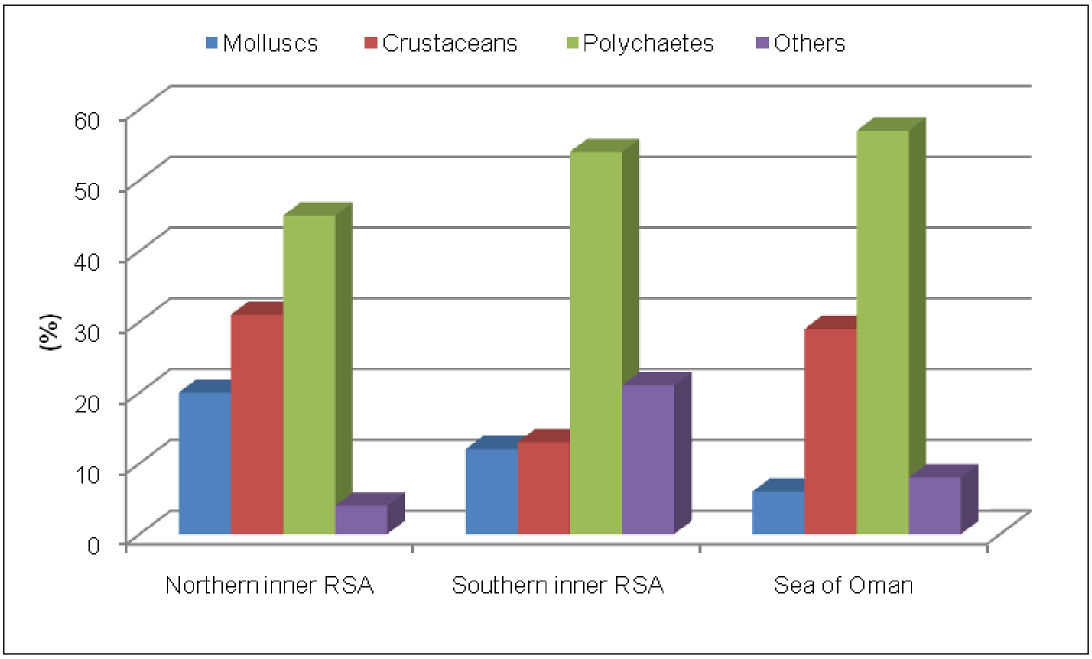


Figure 3.27 Percentage composition of major Macrofauna taxa of the three RSA zones: Northern I-RSA, Southern I-RSA and M-RSA (Sea of Oman). (Source: ROPME, 2012b)

Population density of total macrofauna, polychaetes, crustaceans and molluscs show the spatial variation in fauna. The higher number of macrofauna density in the Sea of Oman is mainly due to the higher abundance of polychaetes and crustaceans (Figure 3.28).

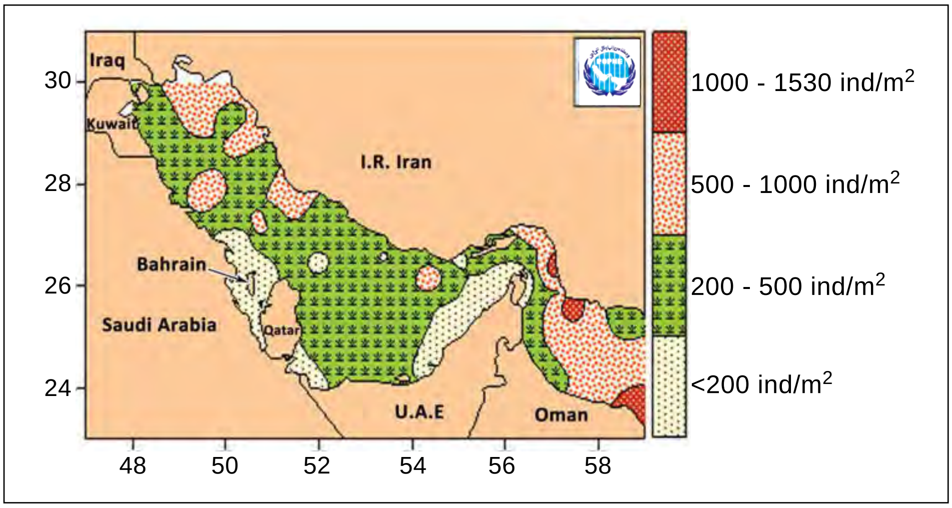


Figure 3.28 Total Macrofauna abundance (ind. m^{-2}) of RSA

Relatively higher abundance of crustaceans and molluscs made the increase in total benthic faunal abundance in the northern inner RSA compared to southern inner RSA. This is evident in Figure 3.29 which shows the region-wise comparison of macrofauna of the three regions of the RSA. Average density was higher in Sea of Oman (686 ind. m^{-2}) and lowest was in Southern inner RSA (298 ind. m^{-2}). Northern inner RSA showed an average density of 422 ind. m^{-2}.

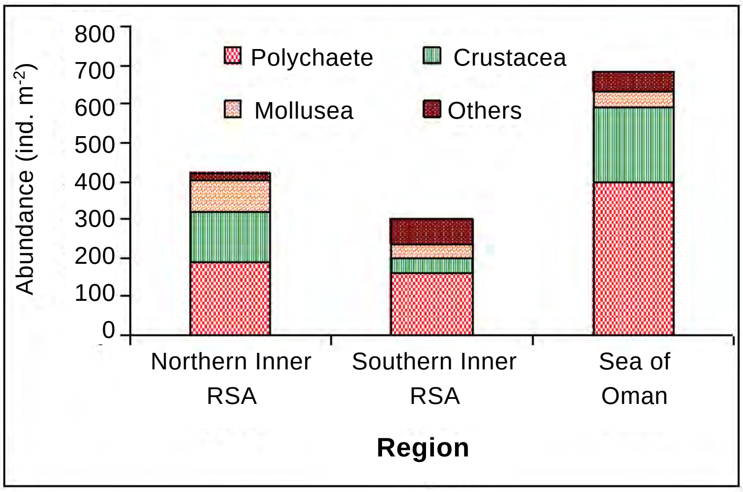


Figure 3.29 Region-wise comparison of Macrofauna of the three regions of RSA

iii. Marine Reptiles

a. *Marine Turtles*

The marine turtles have a small resident and a large migratory population in RSA (Figure 3.30). Of the seven species of marine turtles, five species are found in RSA. The recorded species are: the green turtle *Chelonia mydas*; the hawksbill *Eretmochelys imbricate*; the loggerhead *Caretta caretta*; the olive ridley *Lepidochelys olivacea*; and the leatherback *Dermochelys coriacea*. These turtles breed in the coastal waters and the female turtles come to the beach for nesting. Although the nesting locations are found scattered throughout the region, three locations in Oman are of international significance, namely Masirah Island for the loggerhead turtles, Ra’s Al-Hadd for the green turtles and Damaniyat Islands for the hawksbill turtles. Of the five species, the leatherback and hawksbill turtles are listed by the Member States as ‘Critically Endangered Species’, whereas the other three species as ‘Endangered Species’. Several projects are being undertaken to document and conserve the habitat of turtles in the RSA (Box 3.1).

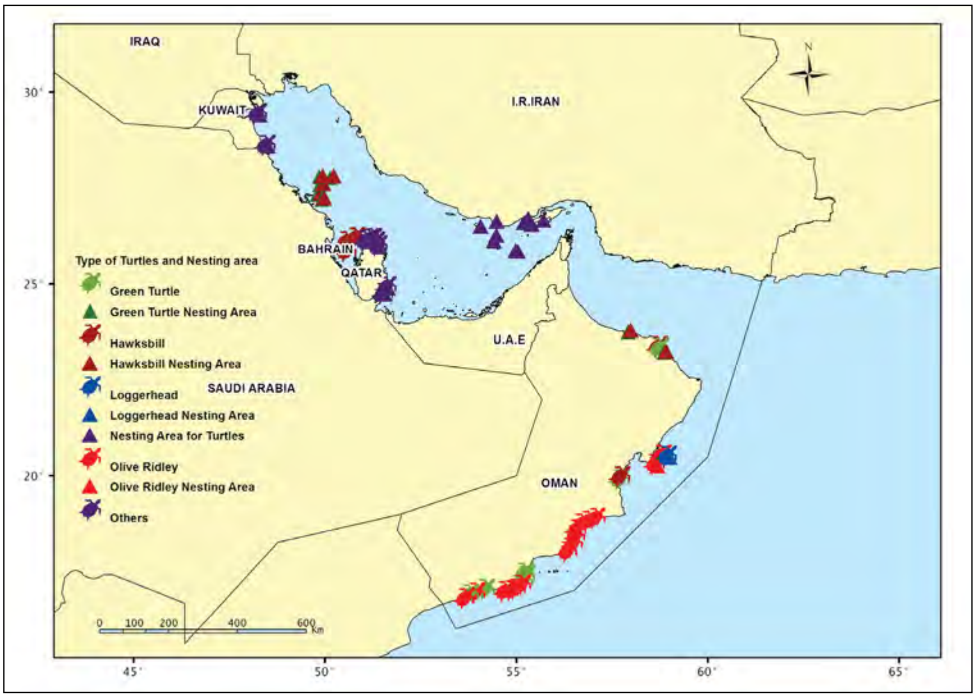


Figure 3.30 Distribution of turtles in RSA

BOX 3.1 – Turtle Conservation

Kuwait

In an effort to accomplish a systematic research of Kuwait’s main sea turtle dwelling areas, and after a successful similar endeavor, which took place in the four previous years (2005 -2008) in Masirah Island, Oman, the Kuwait Turtle Conservation Project (KTCP) began in June 2008 and continued for three years.

During the three years of the project, an international team of researchers and a team of Kuwaiti volunteers were present on Qaru and Umm Al-Maradim Islands for 8 - 15 days from May to September 2008 (as these are the main turtle nesting and hatching months). They monitored in night and early morning surveys nesting emergence frequency of female Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtles. It was concluded that, as opposed to two decades ago, this frequency is significantly lower today. Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) turtle occurrences reported in Kuwaiti waters were documented and taken into account. Nest inventories were carried out in June and July to establish hatching success of the turtles’ nests, which were marked with GPS coordinates and received temperature and humidity loggers.

Based on the obtained results, various awareness actions (articles, books, television appearances, school presentations, participations at international fora, discussing conservation measures with decision-makers and law-enforcers etc.) were taken in order to benefit national, regional and international communities.

BOX 3.1 (Contd...)

Oman

In Oman, Masirah Island hosts the largest population of loggerhead turtles in the world (an original population of over 30,000 females was estimated in the late 1970's). Despite population declines, Masirah remains one of only two similarly-sized nesting populations in the world, the other being in Florida, USA. Each of these sites hosts 40 - 45% of the global population and so together they host up to 80 - 90% of all female loggerheads. This gives Oman an unusually large global responsibility for the protection of this species.

Threats to loggerheads that nest on Masirah Island are increasing rapidly and have caused an apparent decline in the population, possibly by more than 50% over the last 30 years (MECA/ESO, 2011). Among the threats are activities related to tourism, an industry which nevertheless has potential to utilize turtles as a sustainable resource with high economic potential and marketing value. Turtles are already part of a growing tourism industry elsewhere in the country (for example, at Ras Al Hadd Turtle Reserve).

Genetic studies have shown that adult populations are highly structured with no overlap in distribution among adult loggerheads in the North Indian Ocean, Southwest Indian Ocean, and Southeast Indo-Pacific. There is no evidence or reason to believe that female loggerheads from the Southwest Indian Ocean or Southeast Indo-Pacific would repopulate the North Indian Ocean nesting beaches should those populations be lost (Conant *et al.,* 2009).

Nesting beaches of Masirah Island host three other species of turtles, including the second largest nesting population of hawksbill turtles in the country.

United Arab Emirates

In 2010, Emirates Wildlife Society in association with the World Wide Fund for Nature (EWS-WWF) launched the Marine Turtle Conservation Project (www.gulfturtles.com) in collaboration with the Marine Research Foundation (MRF).

During the first three years of the project, EWS-WWF, alongside project partners, carried out fieldwork to deploy satellite transmitters onto 75 post-nesting female hawksbills on beaches of the 4 partner countries; Iran, Oman, Qatar and the UAE, in order to track their movements throughout the inner ROPME Sea Area and Sea of Oman.

Having received over 20,000 validated tracking data points over the 3 years, the project has recently analysed this data and has identified Important Turtle Areas (ITAs) that these turtles visited, exploring the reasons they were visiting whether for foraging or during migration.

It has revealed that much of the waters in the South-eastern inner ROPME Sea Area as well as those of Abu Dhabi emirate have been found to be important for the movement and foraging of the species, as are the waters around the south-west of Masirah Island in Southern Oman.

The summer migration describes a finding that was unexpected at the beginning of the project. It presents the evidence that hawksbill turtles within the inner ROPME Sea Area make a concerted movement toward deeper and cooler waters during the summer months in response to either a thermoregulatory effect or a change in foraging availability. A key finding was that hawksbill turtles are a truly regional species that do not remain within the waters of their nesting country, travelling across boundaries to reach their foraging grounds.

b. *Sea Snakes*

The nine species of sea snakes occurring in the Region are: *Enhydrina schistose*, *Hydrophis cyanocinctus*, *H. lapemoides*, *H. ornatus*, *H. spiralis*; *Lapemis curtus*, *L. viperina* (*Praescutata viperina*); *Microcephalophis gracilis* (*Hydrophis gracilis*) and *Pelamis platurus*. Of these, the hook-nosed or beak-nosed sea snake, *E. schistose*, is the most dangerous species and the annulated sea snake, *H. cyanocinctus*, is the second most dangerous species in RSA (Gallagher, 1990). In Kuwait, the species, such as *Hydrophis lapemoides*, *H. ornatus* and *Pelamis platurus* are listed as 'Threatened Marine Species'.

iv. Sea Birds

The species diversity of seabirds varies among the Member States. All along the coasts of RSA, the intertidal zone supports about 4 million waders in winter which makes RSA one of the five most important regions of the world especially for wintering waders (Zwart *et al*., 1991). Throughout I-RSA, the number of waders during winters may be as high as 1 - 2 millions. Mudflats support higher densities than rock flats or sand flats of wader feeding of birds (Figure 3.31). As described earlier, the mudflats are more extensive along the coasts of the inner part of RSA than the middle and the outer parts.

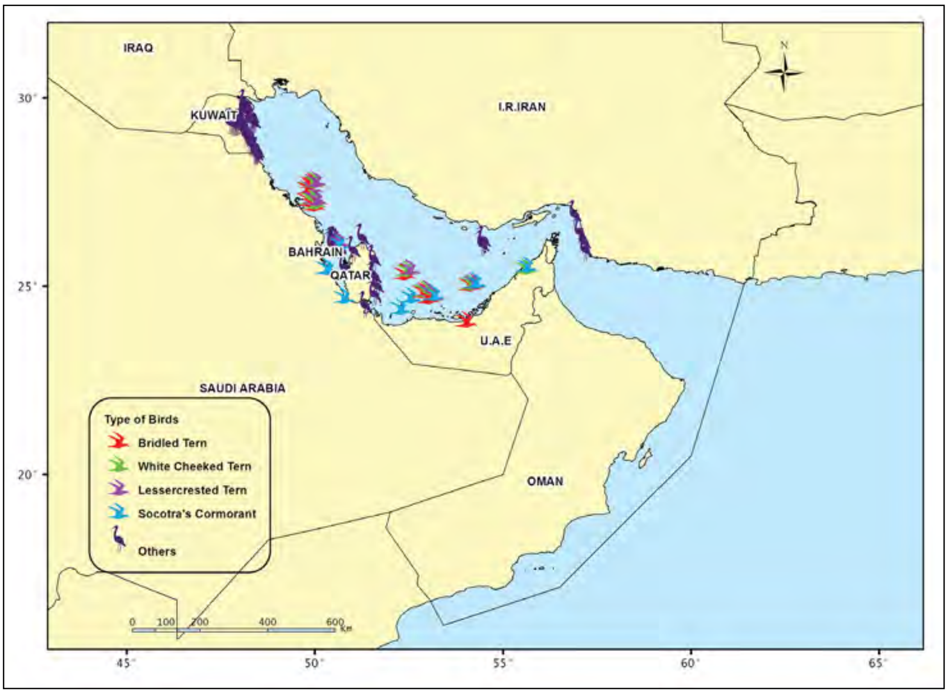


Figure 3.31 Distribution of seabirds in RSA

A large population of world's Socotra cormorants (*Phalacrocorax nigrogularis*) is existing in the islands of Bahrain and UAE which are also a home to flamingos and a colony of breeding sooty falcon *Falco concloor*. In the northern part of I-RSA, along the Iranian coasts, 88 species of birds are recorded of which 19 species are resident and 69 species are either wintering or migrants (46 species) or breeding sea birds (23 species).

One hundred and thirty seven species of seabirds have been recorded in the coastal intertidal area of Kuwait. The coastal population of birds includes 45 species of waders and 65 species of waterfowl, which are regular users of the coastal areas. In Oman, the birds inhabits in offshore waters, islands and islets, coastal cliffs, the rocky shores in Musandam, the sandy beaches of the Batinah Coast, the tidal flats in Bar

Al-Hikman, the Khawr environment and mangroves. Oman's coastal zone supports huge numbers of wintering and migrating birds, and of breeding and non-breeding bird species (Eriksen, 1998 and 2000). The seabirds population recorded during mid-winter is from 300,000 to 500,000, belonging to 90 - 110 species, most of which are shorebirds identified at a single site in Barr Al-Hikman, opposite Masirah Island. The IUCN (International Union for the Conservation of Nature) has developed a global list of threatened species called the IUCN Red List. Bird breeding and feeding areas which are threatened in Oman have been plotted. The following chart presents the areas where bird species are listed as 'Endangered', 'Vulnerable' and 'Near Threatened' in the IUCN Red List (Figure 3.32).

Breeding colonies of seabirds are found in several localities around the coast and islands of Qatar. A quarter million waders visit during winters in Saudi Arabia. Its offshore islands provide major nesting sites for at least three different species of terns. The most common is the lesser-crested tern, with an estimated 25,000 pairs nesting on five Saudi Arabian islands. The mudflats of UAE support huge numbers (13 million) of visiting waterfowl annually. Sixty-three species of seabirds are listed as 'Threatened Marine Species', and 4 species are listed as 'Concerned Marine Species'.

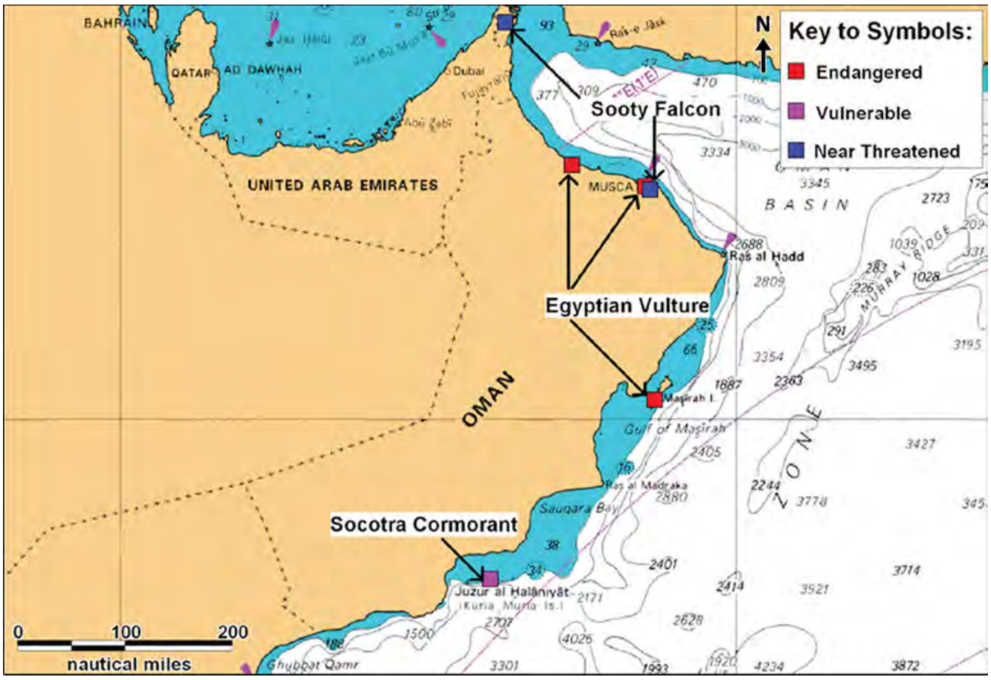


Figure 3.32 Location of threatened bird species in Oman. (Source: MEMAC, 2010a)

v. Marine Mammals

The dugong habitats in the inner RSA (Figure 3.33) occur on either side of Bahrain, in the pocket of Saudi Arabian territory (Figure 3.34) between Qatar and the UAE, and to the west of Abu Dhabi. Dugongs are not seen in I.R. Iran, Iraq, Kuwait and Oman waters. The estimated population of dugongs in the RSA is 7310. This makes the inner RSA the most important area for the dugongs in the western half of its distribution range, and one of the most important known areas outside of Australia (Preen, 1989).

Other marine mammals of interest include whales and dolphins, i.e., Brydes whale and the Humpback whale (Figure 3.35), the Bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific humpbacked dolphin. Other dolphins and whales known to inhabit adjacent parts of the Indian Ocean are also likely to be observed in the inner part of the RSA. The dolphin species of the RSA were reported by Basson *et al*. (1977). The finless porpoise, *Neophocaena phocaenoides*, is also found in the RSA. In the waters of the Middle and Outer RSA, about 20 dolphin and whale species representing 25% of all known species in the world were found to exist (Baldwin, 1995). Among the mammals recorded in the RSA, 11 species of dolphins, 1 species of dugong and 15 species of whales are listed as 'Threatened Marine Species'.

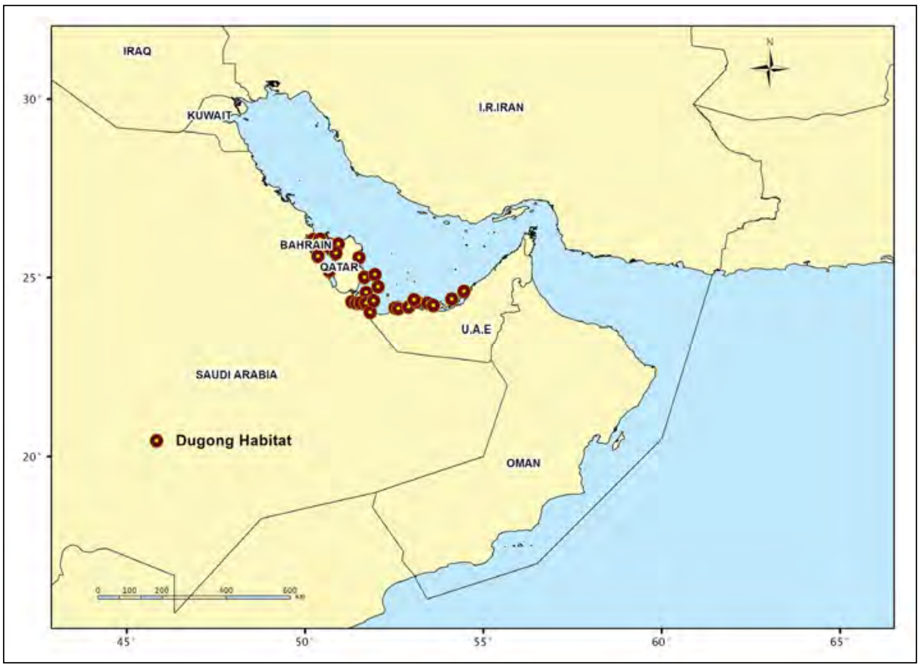


Figure 3.33 Distribution sites of dugong in RSA

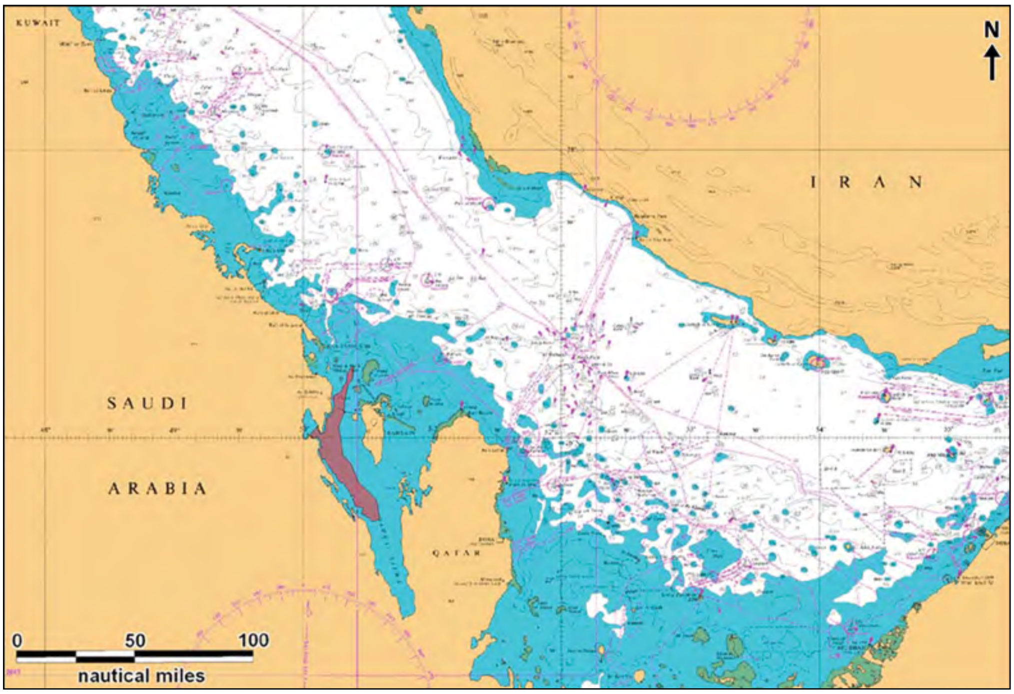


Figure 3.34 Dugong habitat at the Saudi coast of I-RSA. (Source: MEMAC, 2010a)

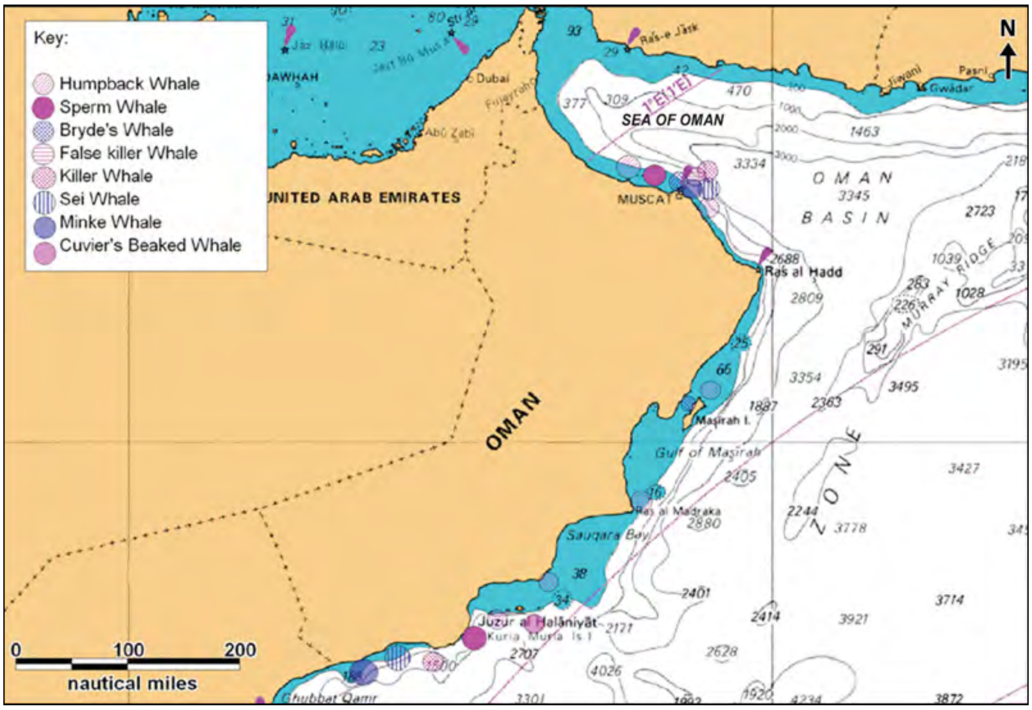


Figure 3.35 Cetacean sightings in Oman. (Source: MEMAC, 2010a)

vi. Marine Habitats

a. Coral Reefs Status and Trend

The coral reefs of the RSA are critical habitats of cultural, socio-economic and scientific value (Figures 3.36 and 3.37). However, their development is constrained by a variety of oceanographic factors including: temperature extremes above and/or below usual coral tolerance limits; high salinities; macroalgal competition, high level of suspended sediments, limited surface area of substratum suitable for the settlement of recruits and the scoring action of mobile sediments (Eghtessadi-Araghi, 2011). In addition, diseases and outbreaks of Crown-of-Thrones starfish represent naturally occurring threats to coral reefs though the former may be aggravated by stressor derived from human activities (Table 3.4).

Many of the ‘Coral reefs’ described for the RSA (Figure 3.38) are of hard substratum which are not actively accreting but modern veneers of living coral on much older limestone domes or recently formed diagenetic hard grounds many of which are visually indistinguishable from true reefs (Sheppard *et al*., 2010). These, together with the relatively few true reefs, provide the most diverse habitats, though not necessarily the most productive.

The differences in species occurrence within the RSA probably correspond to different environmental factors affecting corals in various areas and they may also relate to greater habitat diversity available for coral settlement and growth. In 2012, Iraq reported for the first time the discovery of a coral reef community in the Iraqi territorial water (Box 3.2).

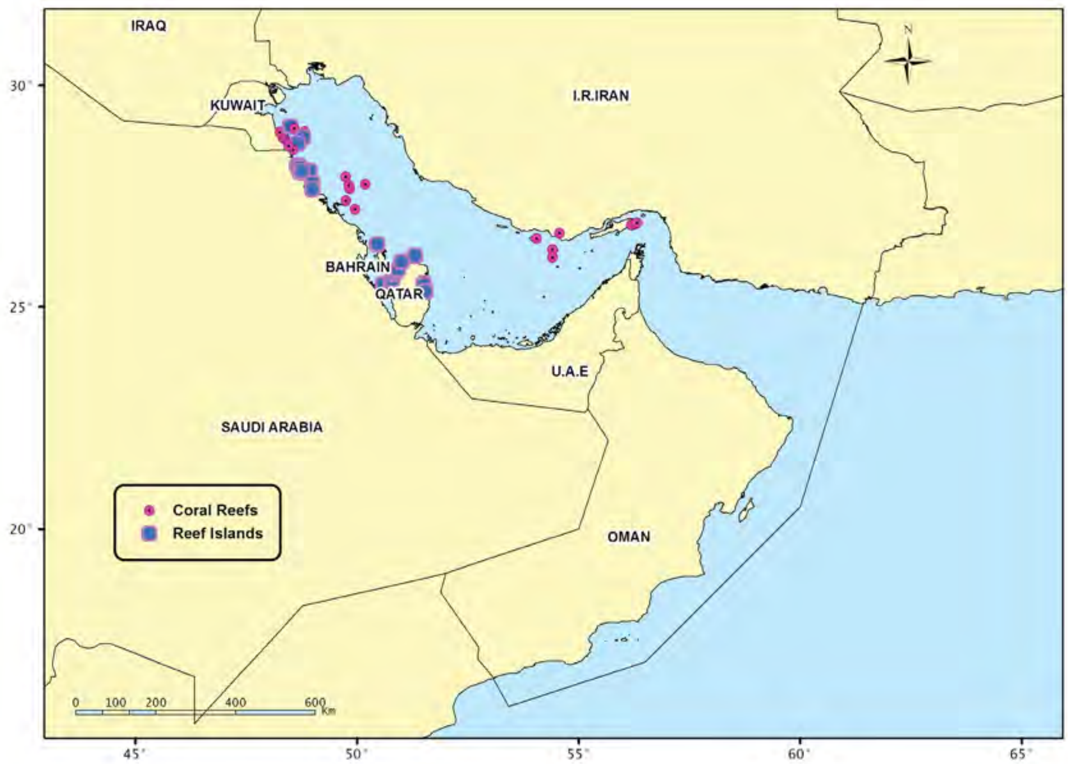


Figure 3.36 Distribution of corals in the RSA

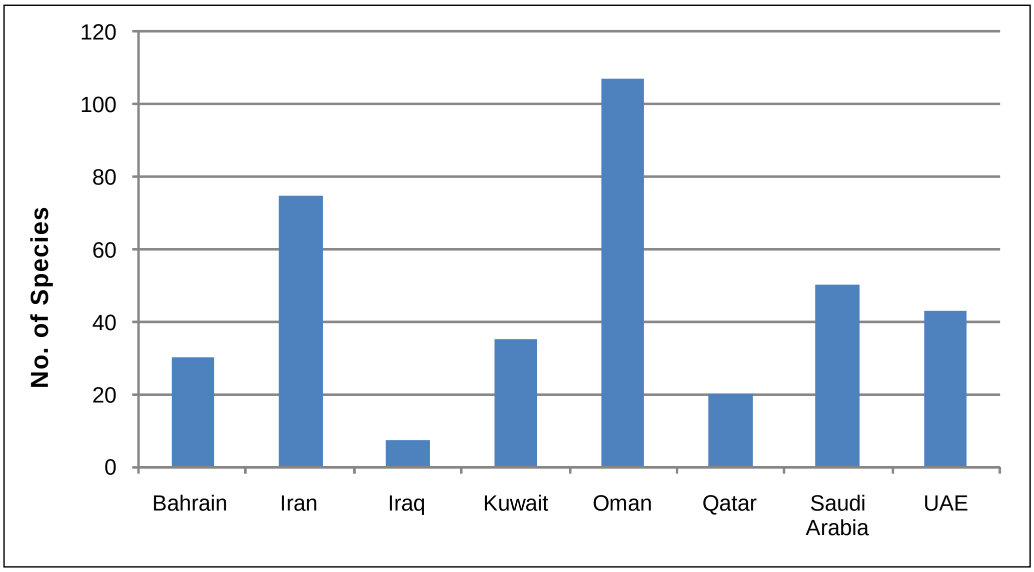


Figure 3.37 Number of soft and hard coral species in each ROPME Member State. (Sources: Eghtessadi-Araghi, 2011; Species number: Bahrain: Khalaf and Barder, 2005; IR Iran: Eghtessadi-Araghi, 2005; Rezai and Mohammadi, 2007; Iraq: Al-Cibahy, 2012; Kuwait: Faraj and Al-Tamimi, 2007; Oman: Sheppard and Salm, 1988; Qatar: Al-Muftah and Al-Mansouri, 2007; Eghtessadi-Araghi, 2005; KSA: Al-Sofyani, 2007; UAE: De Roy, 2008)

Table 3.4 Threats on Coral Reefs in ROPME Member States (Source: Eghtessadi-Araghi, 2011)

COUNTRY	THREATS
Bahrain	Anchoring damage, over fishing, spear fishing, Crown-of-Thorns, increasing coral disease by human stressors.
I.R. Iran	Oil production and oil pollution, temperature fluctuations, breakwater construction, sedimentation during land reclamation, dredging, depletion of corals by local peoples, ornamental fishing for aquarium, extensive anchoring damage, discharge of nutrients and sewage.
Kuwait	Fishing and recreational boating, littering smothers reef organisms, oil pollution, discharge of ballast water, coastal development, global warming.
Oman	Coastal destruction, destructive fishing, hazardous/solid wastes, over-fishing, depletion of rare species, oil pollution, trampling, eutrophication and siltation due to coastal development.
Qatar	Bleaching, anchors of local fishing boats, oil pollution.
Saudi Arabia	Discharge of sewage from vessels, ship discharge of solid wastes, oil spills from exploration-production and transport, illegal disposal of toxic wastes, global warming effect, diseases.
UAE	Oil spill, sewage runoff, anchoring, over fishing, Crown-of Thorns, increasing coral disease by human stressors.

BOX 3.2 – Discovery of Coral Reefs in Iraqi Territorial Waters

As part of the on-going efforts of the Marine Science Centre, University of Basra, a marine expedition survey "Basra Pearl" was undertaken to study the Shatt Al-Arab estuary and the Iraqi waters in the north western parts of I-RSA. The researches have recorded for the first time a coral reef community in the Iraqi territorial water. The location of the discovery is approximately 26 km southeast of the Iraqi coast in an area of shallow water (less than 6 m) as shown in Figure below. The exact GPS coordinates are: 29°37'.631 N 48°47'.832 E. A total of seven coral species were identified and confirmed by an MSC marine expert. None of the species were previously unknown in the I-RSA (Al Cibahy, 2012). The species identified were: *Favia* sp.; *Favites* sp.; *Siderastrea savignyana*; *Carijoa* sp.; *Zoanthus* sp.; *Junceella* sp; and *Trimuricea* sp. Evidence of dead corals was also observed. Further investigations are underway in collaboration with the University of Freiberg-Germany.

Location of Coral Reef Discovery. [Source: MSC, Iraq (2013)]

The distribution of RSA coral species among families is quite anomalous compared to the Indo-Pacific as a whole (Coles, 2003) (Figure 3.38). Only about 10% of Indo-Pacific coral species is occurring in the RSA. In addition to the arid conditions, the past and present isolation of the RSA from the Indo-Pacific limited the recruitment, settlement, survival and growth of corals, favoring a few that are adapted to the uniquely harsh conditions of the region (Coles. 2003).

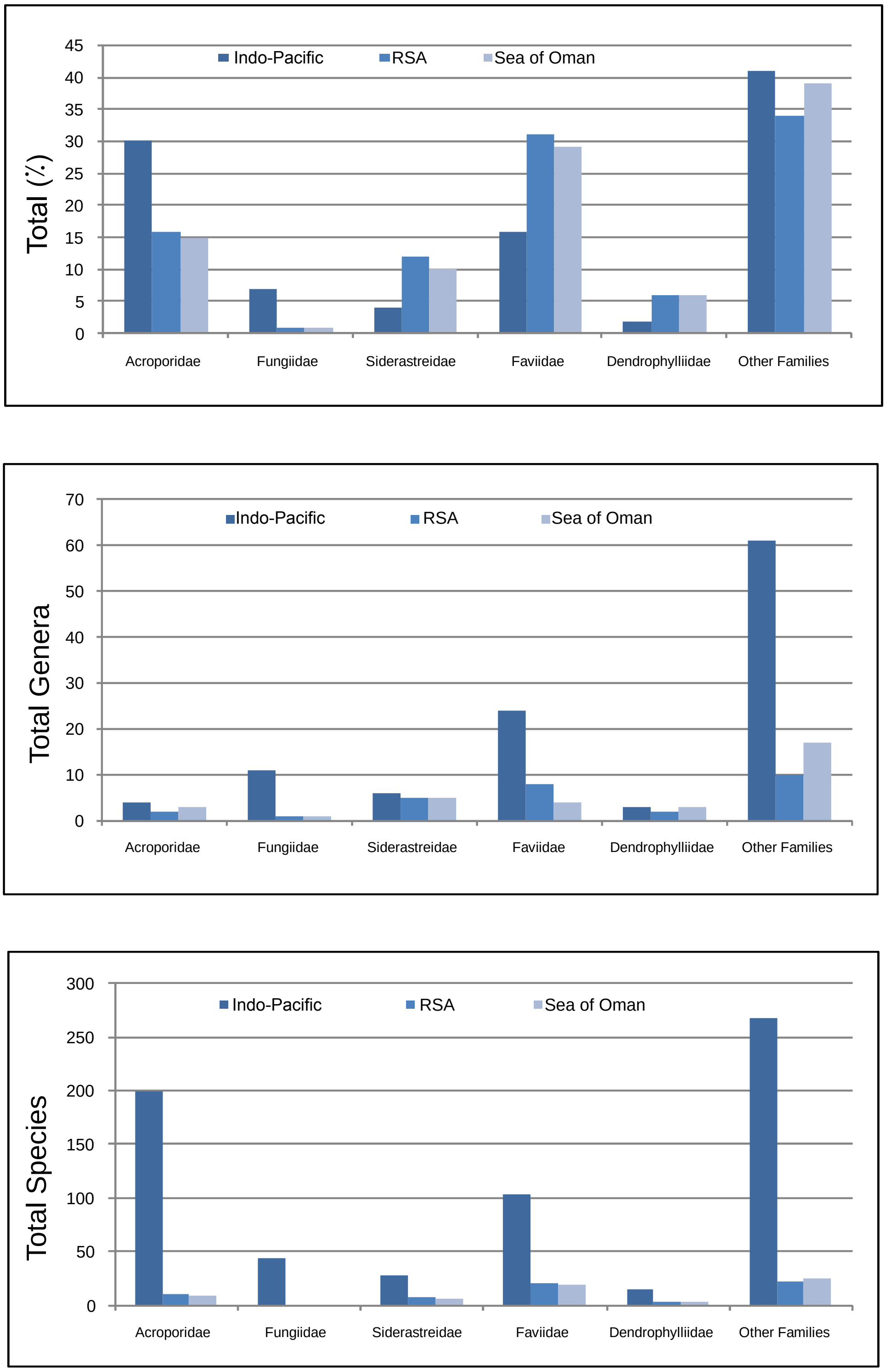


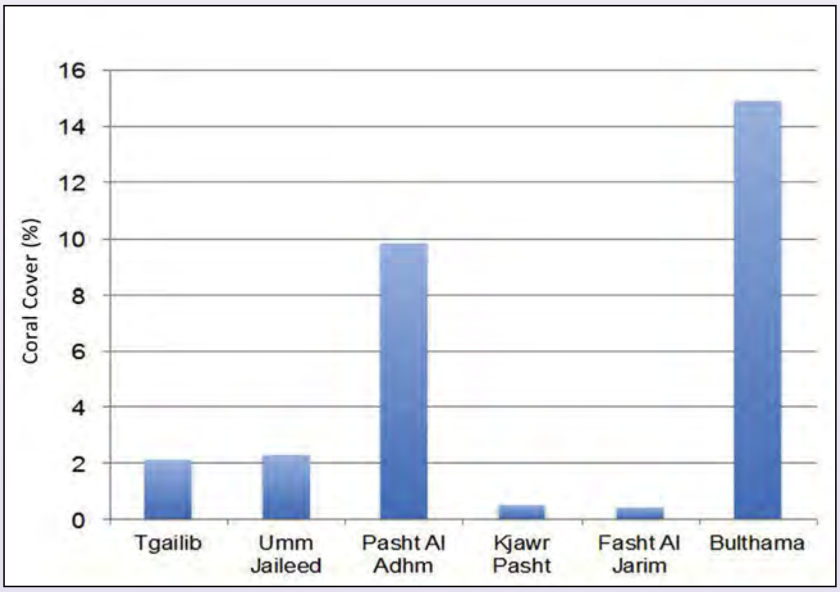
Figure 3.38 Comparison between Inner RSA, Sea of Oman (SO) and Indo-Pacific (IP) coral reefs diversity. (Source: Coles, 2003)

The family Acroporidae, which is the most diverse in the Indo-Pacific with nearly 200 species or 30% of all species reported, is presented by only 10 - 11 species in the RSA region or about 15% of the total species reported. A similar reduction in species is shown for Fungiidae in the RSA with only one species reported (1% of total) compared to 44 species (7% of total) for the Indo-Pacific. By contrast, the families Siderastreidae, Faviidae and Dendrophylliidae have percentages of total species two to three times greater in the RSA region than in the Indo-Pacific (Coles, 2003).

Stress events occurred in 1996, 1998 and 2002, were perhaps, the strongest disturbance spanning a century but the corals survived. That apart, their active reproduction indicates they remain in good health (AME Info, 2005). Several thermal anomalies have been recorded historically from the area and it is now believed that RSA coral communities represent a very dynamic system that shrinks and expands in response to mortality events triggered by temperature variations. This is a biologically significant characteristic of RSA coral reefs (AME Info, 2005). (Boxes 3.3 - 3.7).

BOX 3.3 – Assessment and Rehabilitation Project in Bahrain

The main coral reefs in Bahrain are limited to a few areas (see figure) and grow in extreme environmental conditions. Live coral cover is generally low, with evidence of recent, widespread coral mortality. These coral communities are at the very limits of tolerance to salinity, temperature, and sediment load. There are 28 species of coral in Bahrain. The reefs recently experienced two major coral bleaching events: summer of 1996; and more severely in the summer of 1998. These events resulted in the high mortality of corals on Fasht Al-Adhm, west Fasht Al-Dibal, Khwar Fasht, north Jabari, Samahij, and Fasht Al-Jarim (Pilcher *et al.*, 2000). The only live coral reef surviving in Bahrain is on Abul Thatna, a small raised area surrounded by 50 m deep water about 72 km north of the main island. While previous studies focused on Fasht Al-Adhm, this project aims to cover most of the reefs in Bahrain.



Coral Cover in Kingdom of Bahrain

BOX 3.4 – Distribution and Health Status of Coral Reefs in I.R. Iran

Status of coral reefs of six islands (Farur, Farurgan, Kish, Hendurabi, Khark and Kharkoo) and Nayband Bay in the Inner RSA were studied from February to September 2007, by Department of Environment, Division of Marine Environment. Totally, 44 hard coral species (25 genera/11 families), the highest number of species were recorded for Iranian waters.

Farur, Kharkoo and Khark Islands by having respectively 29 and 21 hard coral species and respectively 68.75, 68 and 64 live coral cover were found as the best developed and healthy reef areas. Nayband Bay with 42.56.88%- coral cover showed lowest species richness (14 species) and Farur Island with 11.2568.75%- live coral cover showed highest species richness (29 species).

Faviidae (17 species), Siderastreidae and Poritidae (each with 5 species), Agariicidae, Dendrophyllidae (each with 4 species), Acoroporidae and pocilloporidae (each with 3 species) were the most diverse coral families in the 7 reef areas of the region. Coral cover of the areas was dominated by Poritidae, Acroporidae and Faviidae families.

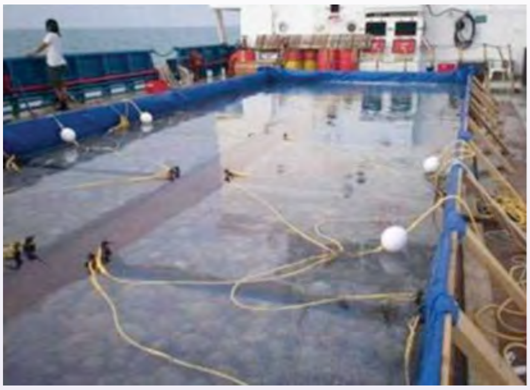
In addition to uncontrolled coastal development, sedimentation and land-based pollution, natural stressors, particularly elevated sea water temperature has affected coral reefs of Iranian waters dramatically. In September 2007, a severe increase in water temperature as high as 35.5° to 37°C was recorded in the survey area that can be considered as one of the main reasons for the coral bleaching (Valavi *et al*., 2009).

BOX 3.5 – Coral Reef Relocation at Chabahar in I.R. Iran

In order to develop Shahid Beheshti port in Chabahar, The Department of Environment of the I.R. Iran, in cooperation with Ports and Maritime Organization decided to relocate a number of coral reefs in danger of destruction to a different location in Chabahar Bay and create a new coral region to protect these crucial ecosystems as the most important marine ecosystems in this region. So, a large-scale coral relocation project was conducted by the Iranian Fisheries Research Organization under the supervision of the Department of Environment in 2011.

The project saved and relocated more than 28,000 hard corals to a new area to protect them from port development and construction activities. The investigations indicated high survival rates, and hence proved a successful relocation of the coral reefs under this project (Azhdari, 2012).

BOX 3.6 – Relocation of Coral Reef in North of Qatar



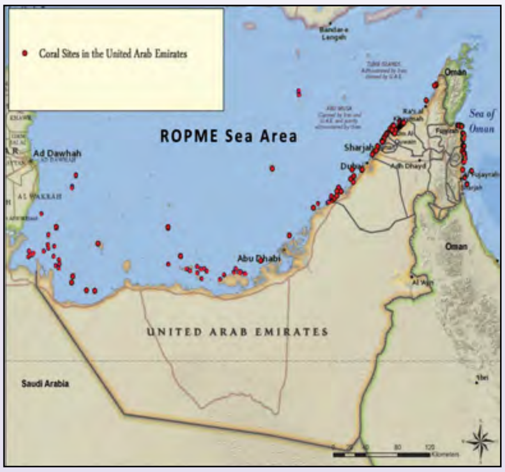
Source: Kilbana *et al*., 2008

A large-scale, long-distance coral relocation project was conducted as mitigation for impacts to hard coral habitat associated with marine construction activities offshore Ras Laffan Industrial City, Qatar. Working under the guidance of the Supreme Council for the Environment and Natural Reserves (Now named: Ministry of Environment), Qatar Gas Operating Company Limited and its Venture partners engaged in a hard coral relocation project. The project salvaged and relocated over 4,500 hard corals from pipeline corridors to mitigate the impacts of pipeline installation and other maritime operations.

Proven techniques for coral reattachment and newly developed methods to enhance coral survival were used for the mass recovery, transport and reattachment of the corals. Corals were transported 46 km, a single day transit, from the north coast of Qatar to a coral habitat along the east coast and reattached with concrete (See Figure). Initial monitoring of approximately 5% of the reattached corals and randomly selected reference corals indicates high survival rates. This project represents an option for off-site mitigation and is an example of proactive environmental regulation, corporate responsibility, and advanced field technology applied in concert to reduce impacts to a viable hard coral habitat.

BOX 3.7 – Monitoring of Coral Reefs along the East Coast of UAE

Installation of coral reef monitoring stations, accompanied by a survey of reefs, was undertaken in early August 2007, along the coast of Fujairah, UAE. The operation was initiated by the Department of Environment (Fujairah Municipality), National Coral Reef Institute (Florida, USA) and the EWS–WWF. All four monitoring stations are positioned on the seabed between Fujairah city and Dibba. The purpose of the monitoring stations is to study the re-growth and re-colonization of corals damaged during Cyclone Gonu, which struck the coast of Oman, UAE (Emirate of Fujairah), I.R. Iran and Pakistan in June 2007. The coral reefs sites of UAE are marked (See Figure).



b. *Seagrass and Sea-weeds*

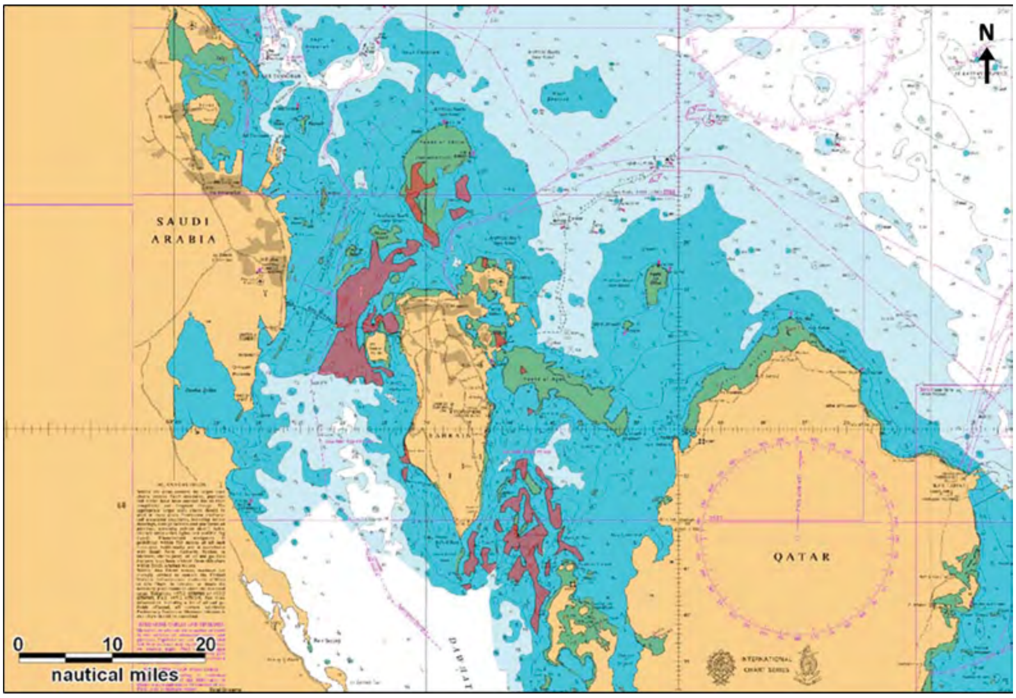
Seagrass provide some of the best habitats for many marine species. The occurrence of more than 600 marine species was recorded to live in the seagrass habitats in I-RSA (Al-Hasan and Jones, 1989; Coles and McCain, 1990). This composes about 9% of fauna species of I-RSA, of which half are molluscs (Sheppard *et al*., 2010). Dugongs consume seagrass directly; however, green turtles, sea urchins and most fish species utilize seagrass indirectly as detritus, after it has been broken down by mechanical and microbial action. Seagrass beds also provide important habitats for fishes and crustaceans such as the commercially significant shrimp, *Penaeus semisulcatus* in the Ghubbat Hashish Bay in Oman (Jupp and Goddard, 2001). Four species of seagrass occur (*Halodule uninervis*, *Halophila ovalis*, *Syringodium isoetifolium* and *Thalassodendron ciliatum*), of which *H. uninervis* and *H. ovalis* are common in the seagrass beds of RSA. Seagrass beds occur along the coasts from I.R. Iran and through Iraq, Kuwait, and Saudi Arabia. The beds also stretch beyond Bahrain and UAE reaching Oman.

Large seagrass area can be found on the western side of Bahrain around Umm Al Na'san Island. There are also fragmented beds to the southeast between Bahrain Island and the Hawar Islands (Figure 3.39a). Extensive seagrass beds are found near the mouth of rivers and in the area of Chabahar in I.R. Iran. Currently, the seagrass bed distribution is rather limited in Kuwait. The shallow parts of coast of Oman have sporadic beds of seagrass, where the most common species are *Halodule uninervis* and *Halophila ovalis*. However occasional beds of the larger species *Syringodium isoetifolium* and *Thalassodendron ciliatum* are found in the Masirah Channel where the highest biomass of *Halodule* has been found in intertidal zones, with increased biomass of *Halophila* in deeper areas. In Saudi Arabia, while the distribution is patchy and less prevalent in offshore areas, high concentration could be found between Safaniya and Manifa, in Musallamiyah and the south of Abu Ali (Figure 3.39b).

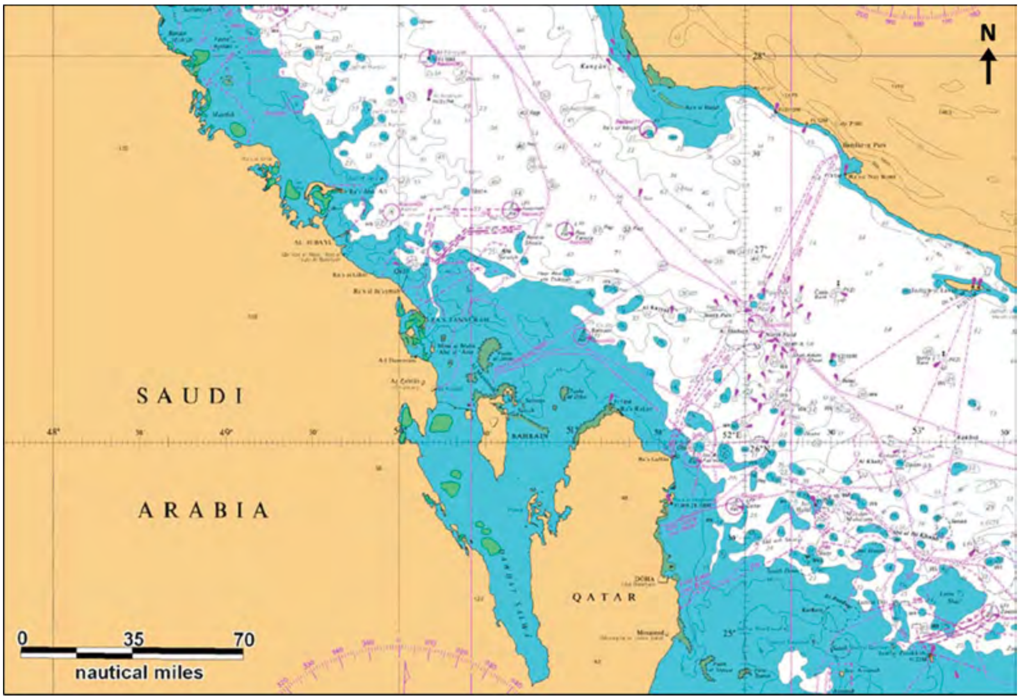
Seaweeds or macro-algal species occurring in the algal bed habitats of RSA belong to red, brown and green algal communities. The brown algae found at most depths are of small species, while large forms occur on reef crests and on the rocky platforms of streams where upwelling is important.

Algae instead of corals dominate several areas of hard substrate in RSA. This is especially true on the Omani coast. This may occur in shallow coral reef areas, where algae tend to be filamentous greens and small browns, which grow as 'algal lawn' (Sheppard *et al*., 1992). Algal communities in most of RSA are seasonal. Their seasonality is correlated to water temperatures where the inner part of RSA is coldest in winter and the Arabian Sea is coldest during the summer upwelling. Significant growth of seaweeds in the intertidal zone is mainly the result of seasonal development along the Arabian Sea coasts during and for some time after the summer south-west monsoon when the wind-driven waves and spray give rise to a dense intertidal flora. High air temperatures and desiccation reduce growth outside these periods. Dense subtidal beds of seaweeds develop along the Arabian Sea coast during the south-west monsoon and persist in the post-monsoon period until January. These dense seaweed beds, especially in Dhofar, form the basis of food chains in shallow coastal waters.

Seaweed beds are also found along the Chabahar coastline (200km from Tang to Guatr Bay) and the shores of Lengeh, Bostaneh and Bushehr in I.R. Iran (MNR-I.R. Iran, 2003). The Iranian southern shoreline supports different agrophytes, *Gelidium*, *Hpnea*, *Laurencia* and *Gracilaria* (Ghoroghi *et al*., 2001). A recent study revealed the occurrence of 232 taxa in Omani waters (Jupp and Goddard, 2001). Several herbivores will directly depend on the algal beds in Omani waters such as the commercially important abalone *Haliotis mariae*, rabbitfish *Siganus* spp., parrotfish *Scarus* spp., and the green turtle *Chelonia mydas* whereas eight species of Cyanophyta have been recorded along the coast of Saudi Arabia, as well as one species of Chlorophyte *Gomontia polyrhiza*.



(a)



(b)

Figure 3.39 Seagrass beds around (a) Bahrain and (b) Saudi Arabia. (Source: MEMAC, 2010a)

c. *Mangroves*

Worldwide mangrove habitat contains more than 60 species of trees and provides living space for more than 2,000 species of fish, invertebrates and epiphytic plants (Clough, 1993). Severe climatic conditions in conjunction with limited habitats and niches (Sheppard *et al*., 1992) mean that only one eurythermal and euryhaline species, *Avicennia marina* occurs naturally in RSA.

The mangrove vegetation, Avicennia marina, varies from 2-6 m in height in the Sea of Oman and up to 10 m in the Arabian Sea (Fouda and Al-Muharrami, 1996), whereas in the inner part of RSA proper trees are poorly developed and often stunted (1-2 m), at least along the western shores (Price *et al*., 1993).

In RSA, scattered populations of the mangrove *Avicennia marina* occur where there are mudflats. Since the air temperatures drop to freezing in winter over the extreme NW part of I-RSA, mangrove trees are not found in Kuwait and most of NE coasts of Saudi Arabia. However, experimental cultivation of mangroves in few sites along the coastal areas of Kuwait is being initiated with limited success. The distribution of mangroves in the I-RSA is less extensive where about 125 - 130 km^2 of mangrove vegetation remains, 80% of which are on the Iranian side. Mangroves in I.R. Iran covers over 15000 ha distributed from the Sea of Oman to the Mond protected area in the western part of I-RSA (Mehrabian *et al*., 2010). The other species *Rhizophora mucronata* is also found at Sirik in I.R. Iran, in the Strait of Hormuz where it covers about 20 ha (Danehkar and Jalali, 2005). The largest grove of 6,800 hectares is located in the Khouran Straits (UNEP, 1999). Mangroves also occupy the north-east coast of Qatar where they intermingle with the Sabkha frontier vegetation. In UAE, the tallest and shortest stands of mangroves are seen in different size.

Oman being the lead Member States of ROPME for mangrove studies, with the help of JICA (Japan International Cooperation Agency), initiated a project for mangrove afforestation in khawrs in 2000 (Figures 3.40 and 3.41). Mangroves are found

Figure 3.40 Plantation of mangrove seedlings in Oman. (Photo taken by Mr. Badar Al-Builushi, Ministry of Environment and Climate Affairs, Sultanate of Oman)

scattered over more than 20 sites, Northern Batinah, Muscat extending to Sur, in the Gulf of Masirah and Bar Al-Hikman, and the Dhofar region. The main sites of mangroves forests are Shinas (53ha), Khawr Harmul (56ha), Qurm (74ha), Bandar Khayran (83ha), Quriyat (80ha), Sur (>58ha), Khawr Jaramah (137ha), Mahout Island (162ha) and Salalah (7.5ha [Khawr Taqa 1.6ha; Khawr Qurm Saghir 1.7ha; Khawr Qurm Kabir 4.2ha]) (Shoji, 2008).

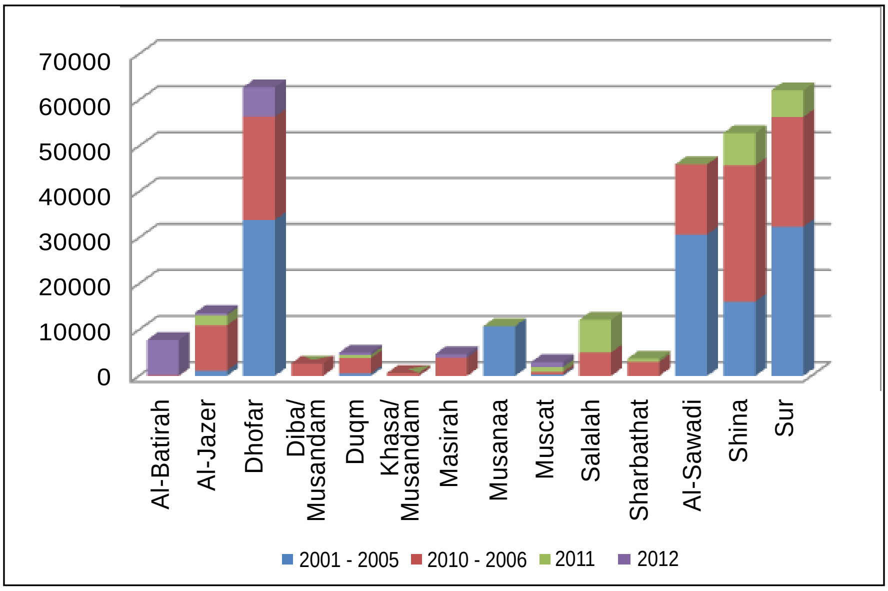


Figure 3.41 Cultivation area of mangroves in Oman. (Estimated coverage area by transplanting in m^2)

The gross primary productivity in Avicennia stands has been estimated to be <1kg $C/m^2/yr$ (IUCN, 1987), however the biological value of mangrove is much more important. Mangrove communities in Oman include faunal assemblages of fish (more than 100 species), crabs, shrimps, *Penaeus indicus* and *P. semisulcatus*, and various shells and clams. The large wildlife supported by Omani mangroves also includes three turtle species including Olive Ridley turtle, *Lepidochelys olivace*, and four mammal species. It supports over 200 bird species, such as cormorants, herons, egrets, spoonbills, flamingos, and many waders, gulls and terns. Mahout and Bar Al-Hikman are home to internationally important concentrations of shorebirds, notably crabplovers, sandplovers, demlins and redshank.

Several efforts have been made to restore mangroves all over RSA. In 1991 the Kuwait Institute for Scientific Research initiated studies to naturalize mangroves under Kuwait's coastal environmental conditions (Sheppard *et al*., 2010). Three experimental plantations established in 1993 and five more established during 1999–2000 suggested that various ecotypes had good potential (Bhat *et al*., 2004). The *Avicennia marina* used were procured from the UAE, and marine fauna flourished in these plantations. Large amounts of leaf debris accumulated in the inter-tidal zones and crab burrows increased (Al-Nafisi *et al*., 2009). In Dubai Creek also, extensive mangroves were planted in the early 1990s, using seedlings with different genetic origin, into mudflats where mangroves did not naturally occur, so that intertidal birds in those mudflats had disappeared. They do now have important resident and migratory bird populations, though not of 'natural' origins. In Qatar, on the other hand, some replanted mangroves (as well as existing mangrove areas) have subsequently been eradicated on a large scale after planting, for various construction reasons, including the desires of nearby residents who dislike them (Gillespie, 2009; Sheppard *et al*., 2010).

Remote Sensing data for Khor Al-Bazam area in the vicinity of Abu Dhabi, UAE, covering the years 1994, 2000 and 2003, were used to determine the changes in mangroves and seagrass cover (Howari *et al*., 2009). Since 1994, there has been an increase in mangrove cover, likely because of plantation activity, the closure of nearby shipyards, and an increase in public awareness regarding mangrove preservation.

d. *Intertidal Sand and Mudflats*

The most widespread benthic habitats in RSA are muddy substrates, which extend from intertidal zone, salt-marches and mudflat, to the maximum depths of the I-RSA (Sheppard *et al*., 2010). Extensive mudflat habitats are located in the northwest of RSA in the proximity of the Shatt Al-Arab delta. In I.R. Iran, intertidal mudflats are located in Kolahi, Jask, Sirk and to the north of Qeshm Island (MNR–I.R. Iran, 2003). Mudflats are also found in Bahrain on the north-eastern side in bays, which are relatively sheltered from the prevailing wind and wave action and thus their sediments are stable. This habitat also constitutes a major part of the coastal areas in Kuwait. Several of these prime habitats have been and continue to be lost or degraded by coastal developmental activities (Nightingale and Hill, 1993).

Given that the photic zone in RSA is commonly <10 m depth, much of the benthos lacks significant plant life, but the large extent of this habitat, together with its high secondary productivity, make it extremely important (Sheppard *et al*., 2010), as the tidal mudflats make the greatest contributions to primary production in RSA (Price *et al*., 1993). Muddy tidal flats in Kuwait Bay (Figure 3.42), for example, support dense algal mats where plenty of diatoms, and filamentous blue-green algae play important roles in food chains (Al-Zaidan *et al*., 2006). These areas are prime stopover locations for migratory birds, providing feeding area for wintering waders and passage migrant birds (Medio, 2006), which fertilize these flats as they feed during their brief stay (Zwart *et al*., 1991). In UAE, the Emirates of Ras Al-Khaimah and Umm Al-Quwain have extensive submerged tidal muddy habitats where plenty of invertebrate species, stingrays, high density of juvenile fish and 37 species of birds are observed.

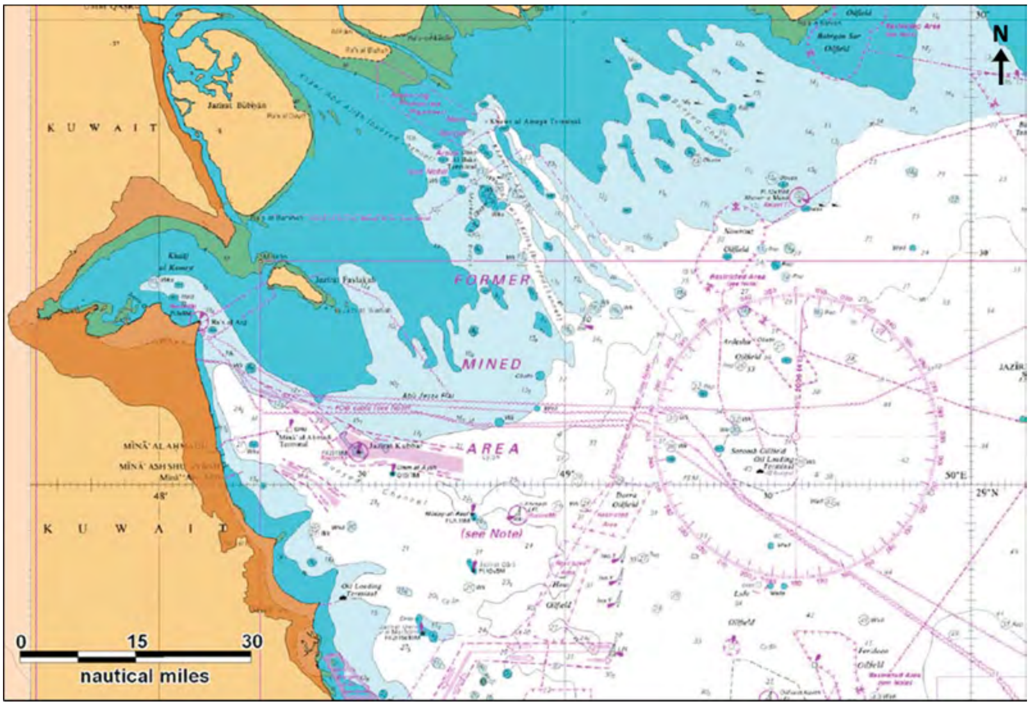
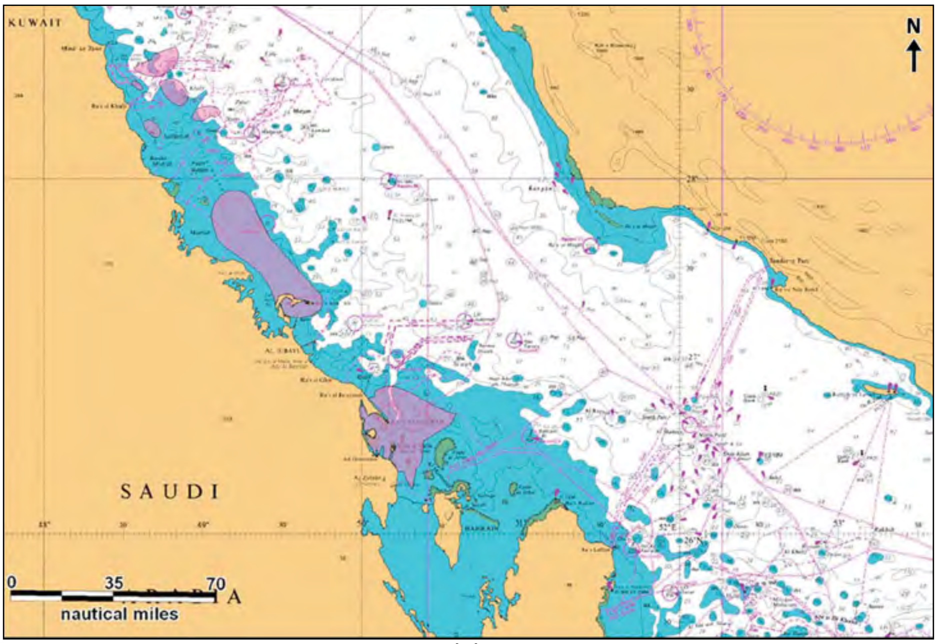


Figure 3.42 Coastal mudflats in Kuwait. (Source: MEMAC, 2010a)

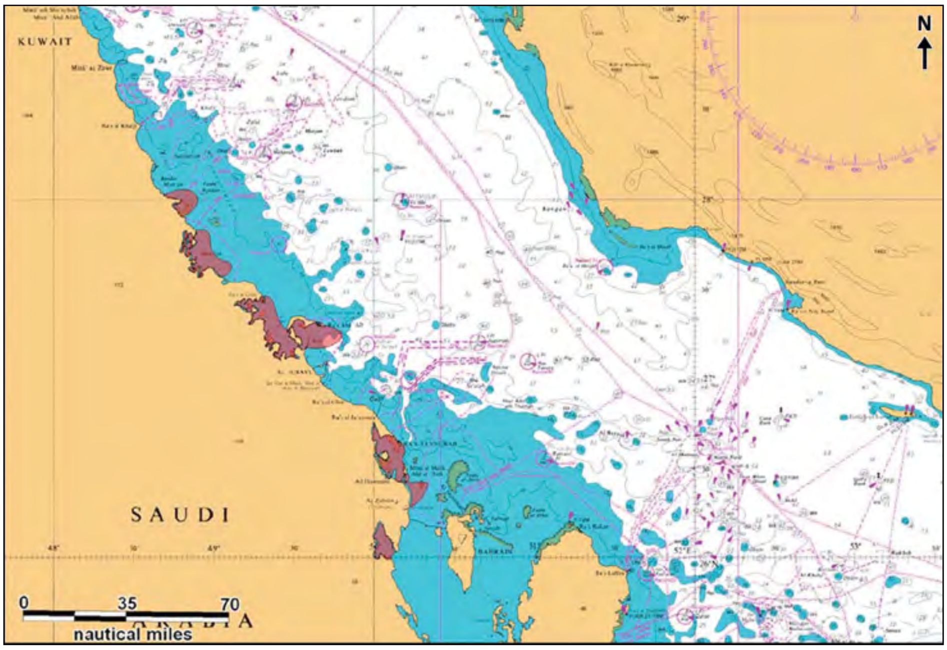
vii. Fisheries

Given the complex semi-enclosed nature of the I-RSA ecosystem, the marine resources are shared between coastal countries, as many marine species use different habitats at different stages of their life cycle, which may involve trans-boundary migration (Khan, 2007). About 500 fish and invertebrate species are considered of major ecological importance in the area (FAO, 1997), some of which are regarded as priority for their relevant commercial value (FAO, 2008; Mannini, 2010).

Shrimps historically provided high-value resources in the RSA (Figure 3.43), and are now considered overexploited throughout the Region (De Young, 2006). Shrimps are mostly recorded as *Penaeus semisulcatus* (Green tiger prawn), *Penaeus* spp.



(a)



(b)

Figure 3.43 (a) shrimp habitats and (b) breeding grounds at the Saudi coast of I-RSA . (Source: MEMAC, 2010a) or *Natantia*, including the species *P. semisulcatus* and *Metapeaneus monoceros* (Speckled shrimp). Landings of shrimps reached 20,000 tons in 2007 and the major producer countries in the Region were Saudi Arabia (Figure 3.44), Iran, Kuwait (Box 3.8) and Bahrain. In Saudi Arabia the trend in landings increased from 5,000 tons in 2001 to over 9,000 in 2007 and the species *P. semisulcatus* represent more than

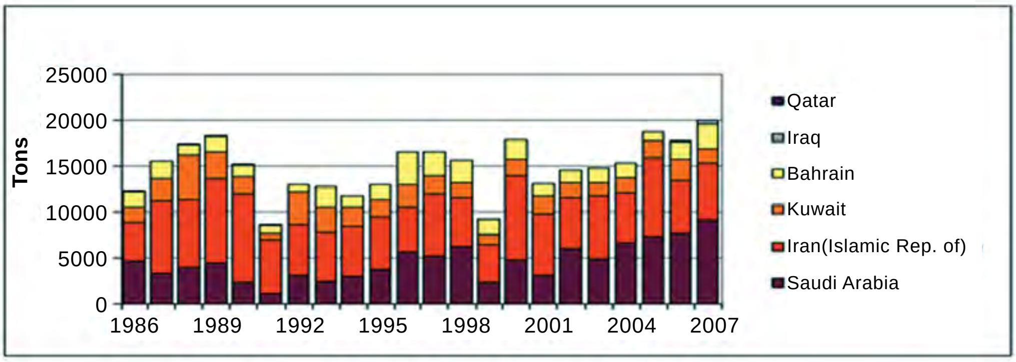
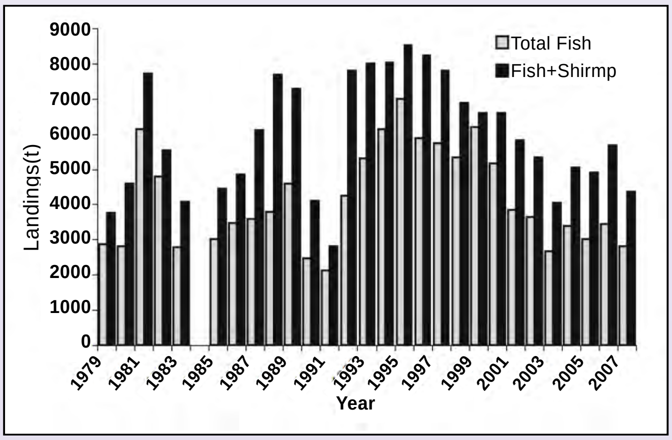


Figure 3.44 Capture production of Natantia in the I-RSA. [Source: RECOFI Capture Production (1986- 2007)]

BOX 3.8 – Fisheries and Aquaculture Case Studies from Member States

Kuwait's total fisheries landings initially fluctuated notably until the mid 1990s during its expansion phase. However, the general production of the fisheries sector in Kuwait started to decline thereafter. The registered landings in 2007 were less than half of 1995 peak level. The large fluctuations were in 1990 and 1991. Particularly hard hit were the species directly affected by the serious reduction of Shatt Al-Arab discharge, such as the anadromous *Tenualosa ilisha ilisha* and estuarine-dependent *Pampus argenteus*. From 1995 to 2007, landings of the former decreased by 93% (from 1197 tons to just 78 tons), while the latter decreased by 91%, (from 1128 tons to 101 tons). These two species accounted for 32% of Kuwait's total finfish landings in 1995, but in 2007, they accounted for 6%. Other important species in decline were *Epinephelus coioides* and *Lutjanus malabaricus*, whose landings decreased by 68% and 92%, respectively (Sheppard *et al*., 2010). Circumstantial evidence shows a relationship between the decreased landings of these species and the decreased river discharge, although overfishing is undoubtedly important (Sheppard *et al*., 2010). The changed salinity conditions have been favorable for other species: sport fishermen report catching *Lethrinus nebulosus* in Kuwait Bay, a species formerly confined to Kuwait's southern waters. Commercial landings of this species from 1994 to 2007 increased from 17 to 92 tons, an increase of 441%. Another species whose landings have increased since the mid 1990s include *Nemipterus japonicas* (Sheppard, 2010). However, the total amounts are low and do not offset losses of the others, including some of Kuwait's most esteemed fish (Sheppard *et al*., 2010).



Kuwait Landings of fish and shrimp (tons) from 1979 through 2007. (Source: Sheppard *et al*., 2010)

90% of the annual shrimps landings. From 2000 to 2007 in Iran, the landings of Natantia fluctuated around 5,000 and 8,000 tons, while in both Bahrain and Kuwait varied between 1,000 and 2,000 tons (Mannini, 2010). Shrimps are mainly caught by shrimp trawls wih the high rate of by-catch (about 50%), broadly represented by juveniles of commercially important coastal species, is a common concern for the RSA countries (FAO, 2009).

Another shared resource is the Narrow-barred Spanish mackerel *Scomberomorus commerson*, locally called chanaad (Arabic) and commonly known as kingfish. This fish is one of the most important pelagic commercial species supporting substantial small scale fisheries. Greater part of landings come from selective gears like kingfish fixnet, gillnets and long-lines (FAO, 2009). *S. commerson* is a highly migratory species and research on stock structure using genetic markers indicated that a single intermingling genetic stock is present in the I-RSA and the M-RSA/Sea of Oman (Hoolihan *et al*., 2006). In addition, numerous studies on the life history parameters and distribution of this species supported the existence of several local spawning grounds in the RSA Region (Mannini, 2010). The total landings of *S. commerson* shows a period of high landings reaching 36,000 tons in 1988, before stabilization at lower values around 20,000 tons from 1995 to 2007. In 2007, 44% of the total capture production was reported by Iran, followed by United Arab Emirates (21%), Oman (14%) and Saudi Arabia (12%) (Mannini, 2010).

Several management measures are in place for the regulation of the shrimp and fisheries in the Member States. These measures including minimum mesh size, closed nursery areas and closed season (FAO 2009). Aquaculture and releasing farmed fish is another approach utilized by some Member States to enhance fish stocks (Box 3.9).

BOX 3.9 – Fish Larvae released into UAE Mangroves

Sixty-four thousand farmed fish fingerlings have been released into UAE mangroves along the RSA so far to boost fish stocks and increase the country's food security. The Ministry of Environment and Water's Marine Resources Research Centre farms several varieties of fish, including the orange-spotted grouper, or hamour, and release them as fingerlings annually.

The total of 6,245 fish fingerlings were released in Abu Dhabi, 1,600 in Dubai, 6,174 in Sharjah, 29,460 in Umm Al-Quwain, 10,382 in Ajman, 3,750 in Fujairah and 6,389 in Ras Al-Khaimah. This represented about 50 per cent of the total 2010 target.

The UAE's fishing catch has declined in the past decade and is now estimated at about 90,000 metric tons per year, down from 118,000 metric tons in 1999. Against a decreasing annual catch, there has been an increased domestic consumption and a growth in fish processing for export.

a. Pressure on RSA Fisheries

Fishing makes an important contribution to food security in the RSA countries and has historical and traditional significance as well as being a source of recreation (Sheppard *et al*., 2010). Commercial vessels tend to target shrimps and pelagic, while artisanal fishers tend to focus upon predatory demersal species (groupers, emperors) using gill-nets, traps (gargoor), staked nets (hadra) and hand lines (De Young, 2006). Saenger (1993) and Bishop (2002) have shown a link between the permanent loss of inter-tidal and shallow sub-tidal nursery grounds with declining fish and shellfish catches. Data from two areas clearly show very substantial declines in commercial fish over the past 10–20 years, following growth of this industry in the period 1970s to 1990s (Sheppard *et al*., 2010). Probable reasons include overfishing, nursery ground destruction, and reduced discharge of the Shatt Al-Arab (Sheppard, 2010).

b. Environmental Hygiene

Microbiological measurements are one indicator of sewage pollution in the marine environment. Among the Member States, microbiological data are only available from Kuwait and UAE, and are not sufficient to draw any meaningful conclusions on the hygienic conditions of the marine environment in the RSA. The observations taken in Kuwait at 12 permanent locations indicate that the median concentration varies from 214-500 colonies/100 ml for total coliform, from 12 - 47 colonies/100 ml for fecal coliform and from 63 - 180 colonies/100 ml for fecal streptococci in the coastal waters (MNR–Kuwait, 1999).

Regular monitoring of the recreational bathing areas at eight locations around Abu Dhabi during the period January to November 2002 revealed that the levels of total coliforms ranged from 4–1,100 cfu/100 ml (permitted level 2,000 cfu/100 ml) and *Streptococcus* from ND–400 cfu/100 ml (permitted level 400 cfu/100 ml). The measurements undertaken on *E. coli* and total coliforms at ten locations along the Dubai Creek during 1999 and 2000 indicated that they were within the permitted levels (MNR–UAE, 2003).

3.1.4 Existing Protected Areas in RSA and their Characteristics

Following the ratification and accession of the United Nations Convention on Biological Diversity (UNCBD) by all Member States of ROPME, the Member States have actively allocated Marine Protected Areas (MPAs) in selected key ecosystems in the Region, and are planning further allocations in the future.

Accordingly, ROPME Member States are committed to the “Strategic Goals of Aichi Biodiversity Targets” set forth in 2011. In particular, Member States are working towards implementing Strategic Goal C to improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity, by which Member States are to allocate 10% of the coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area based conservation measures, and integrated into the wider landscapes and seascapes” by 2020.

Table 3.5 provides a summary of the status of the designated Marine Protected Areas (MPAs), and Figure 3.45 shows their locations within the RSA

However, there is an obvious need to develop sound regional management plans, and build the capacity of concerned government staff through intensive training on coastal zone management and planning (Van Lavieren and Klaus, 2012).

Bahrain has designated 5 MPAs, as reported in Bahrain National Biodiversity Strategic Action Plan (BNBSAP, 2012). Tubli Bay and the mangrove area at Ras Sanad were declared as a natural reserve in 1988, and subsequently Tubli bay was later declared as a protected area in 1995 and designated as a RAMSAR site in 1997. Tubli Bay is a sheltered intertidal bay, which hosts the only remaining mangrove site in Bahrain. This mangrove site is an important nursery ground for two commercially

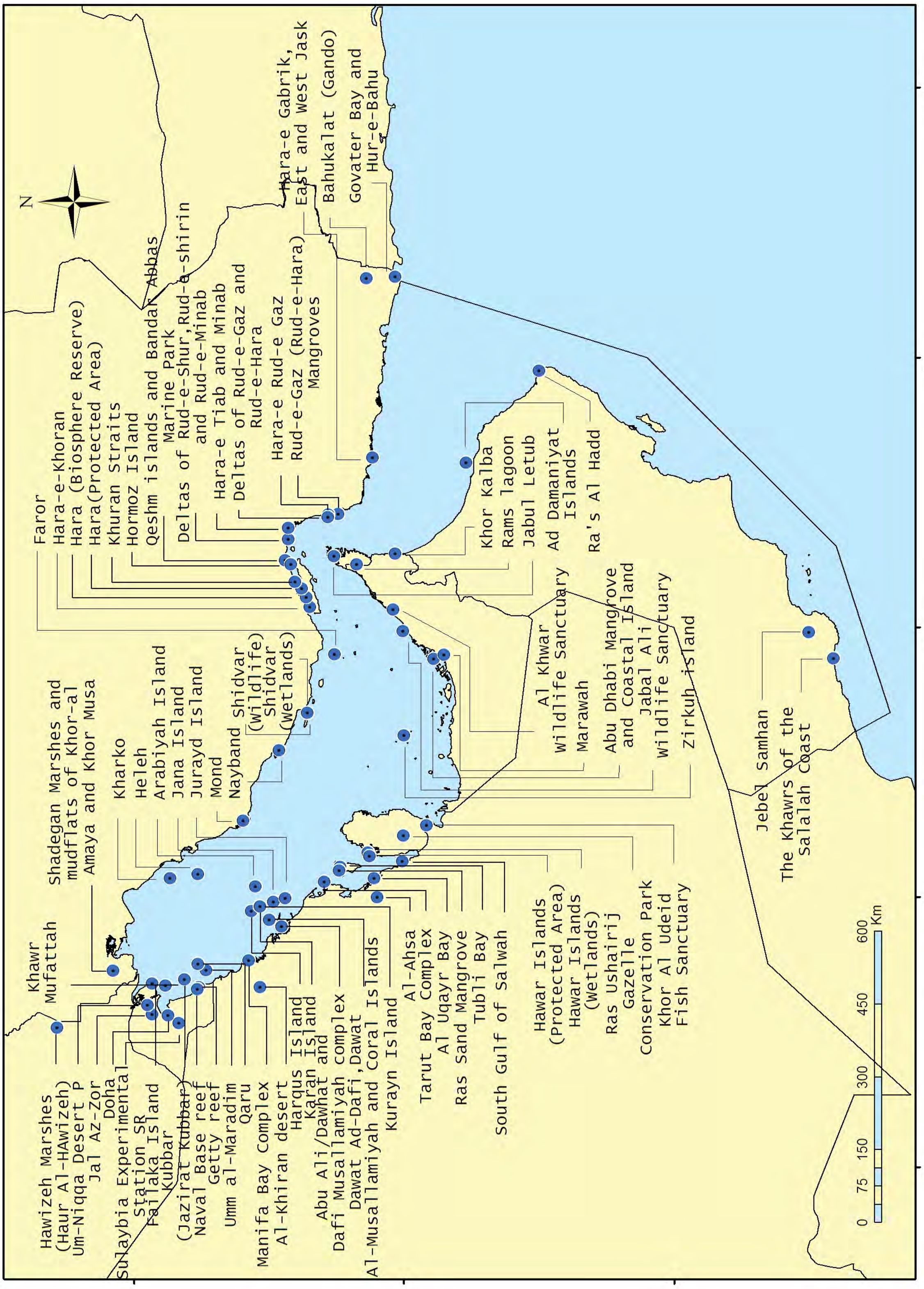
Table 3.5 Total number of MPAs by Member State and number of MPAs 'Designated' and 'Proposed' under national legislation, or 'Adopted' or 'Proposed' (included in square brackets) under international conventions (Wetland of International Importance (RAMSAR), UNESCO Man and Biosphere Reserve or World Heritage Site). There are 176 MPAs covering 7.8% of the RSA (36,182.03 km^2). (Source: Van Lavieren and Klaus, 2012)

Country	Total number of MPAs	Designated	Proposed	RAMSAR	UNESCO-MAB	World Heritage Site (proposed)
Bahrain	7	5	2	2	[1]	[1]
Iran	31	17	14	5	[1]	[2]
Iraq	0	0	0	0	0	0
Kuwait	30	6	24	0	0	0
Oman	57	16	41	1	0	0
Qatar	7	7	0	0	1	[1]
Saudi Arabia	16	1	15	0	0	0
UAE	28	15	13	0	1[1]	[1]
Total	**176**	**67**	**109**	**8**	**2**	**0**

important species of prawn and many fish. The intertidal mud and sands also provide a good wintering site for migrating waterfowl. The marine area around the Hawar Islands was declared as a Wildlife Sanctuary since 1995, and in 1997, the site was declared as RAMSAR site. The Hawar Islands are an important breeding ground for the Socotra Cormorants (*Phalacrocorax nigrogularis*), which has the largest concentration of breeding pairs in the world. Seagrass beds around the islands provide refuge for sea turtles and support a large population of Dugongs. Since then, Mashtan Island and surrounding reef area was declared as a Protected Area in 2002; and in 2007 the sheltered bay at Dowhat Araad was declared as a Marine Natural Protected Area. In 2012, the Ministry of Culture and the Public Commission for the Protection of Marine Resources, Environment and Wildlife announced the new initiative of applying of Ecosystem-Based Management (EBM) approach to Conserve Pearling Zones in Bahrain. The protected marine area and its buffer zone is almost twice as large as the entire land constitute of Bahrain, and include Najwat Abolthama (declared a protected area in 2007), Hayr Abolthama, Hayr Shtayyah, and Hayr BuAmamah (Figure 3.46).

All coastal areas in Kuwait up to three nautical miles are protected by the law. The Sabah Al-Ahmad National Park was enlarged by annexing the coastal strip in north Kuwait Bay. Sheikh Zayid MPA was established in Doha Bay as bird refuge. More Recently, Kuwait has designated two thirds of Bubiyan Island as a MPA, and is progressively working towards declaring it as a RAMSAR site. In addition, Kuwait has designated Um Niqqa as protected area with coastal and terrestrial elements.

Currently there are seven MPAs declared in Qatar, including Khor Al-Odaid, Al-Dakhirah and Umm Tais. The Khor Al-Odaid MPA has been declared as a protected water body since 1993. It is located at the southeastern coast. The MPA harbors natural habitats for large number of mammals, birds, fish, oysters and corals. Despite of the high salinity of the khor especially the inner parts, it is considered as an important spawning ground for marine fish (SCENR/EAD/NCRI/WS-WWF, 2008). Al-Dakhirah



* Datasource - WDPA data for 2011

Figure 3.45 Major Marine Protected Areas in RSA. (Source: http://www.protectedplanet.net/)

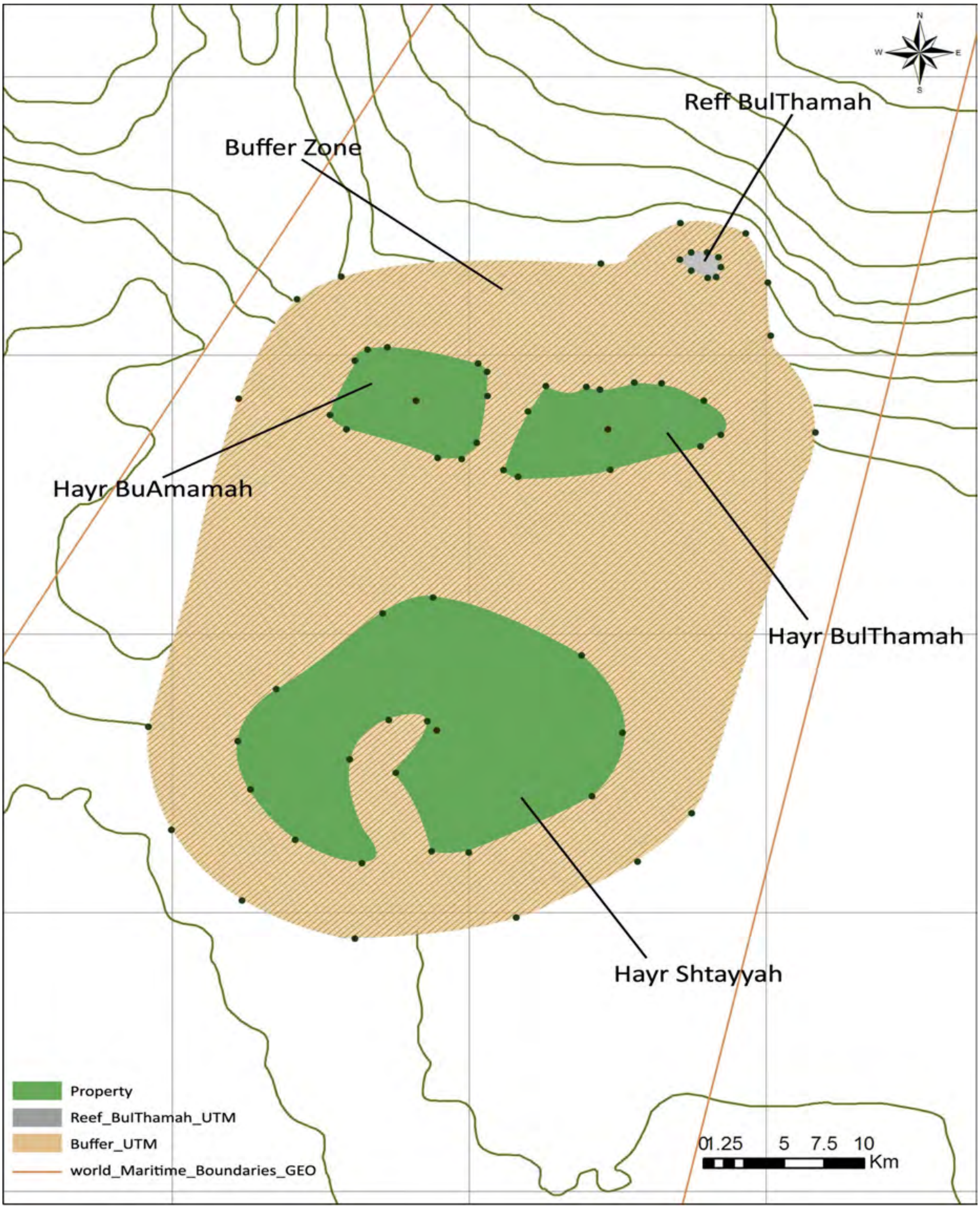


Figure 3.46 Pearling zones in Bahrain. [Source: Ministry of Culture and the Public Commission for the Protection of Marine Resources, Environment and Wildlife, 2012 (http://www.protectedplanet.net/)]

MPA was announced in August 2006. The land-sea interconnection area harbors one of the largest and best mangrove habitats in the Middle East. It is located 64 km north to the Capital Doha extending inshore to 75 - 100 km^2 and offshore to 300 km^2. The area encompasses extended sabkhas and marsh lands and is a main nesting and resting area for marine birds. The marine area harbors extensive communities of artificial reef deployed along shallow and deep waters, which shows very promising growth side by side to the natural reefs. Seagrass dominated by *Holidule uninervis* and Halophila ovalis extends along vast areas acting as main feeding, nursery and spawning grounds for fish. Considerable numbers of marine turtles especially the Hawksbill visit the beaches of the protected area during the period of March to July every year. A plan was prepared with Gas Industry to manage and protect Al-Dakhirah protected area in 2007. UNESCO study of 2002 presented to Supreme Council for the Environment and Natural Reserves of the State of Qatar (SCENR) suggested the inclusion of Al-Dakhirah MPA in the Man and Biosphere (MAB) Reserves Programme (SCENR/EAD/NCRI/WS-WWF, 2008). Umm Tais island is located opposite to the northern tip of the Qatar peninsula. The MPA is located between the island and the land and was declared as protected area in December 2006. The area harbors mangrove trees, sabkha, coral communities, seagrass beds, halophytes as well as rich intertidal habitats. Both Green and Hawksbill Turtle nest along Umm Tais beaches, while the island is an important resting area for many migrating birds (SCENR/EAD/NCRI/WS-WWF, 2008). The northwestern region of Qatar was also declared as a protected area in 2005. In proportion with the surface of the country, Al-Reem is considered as one of the largest protected areas in the world, constituting about 10.4% of the land area (1,190 km^2). The area was proposed by SCENR to UNESCO to be considered as a Man and Biosphere Reserve. Al-Reem is characterized by natural attractive areas harboring the deer Al-Reem and Arabic Oryx in addition to the presence of most of the farms within its premises Ras Ushairaj Protected Area located within the core zone (SCENR/EAD/NCRI/WS-WWF, 2008).

In addition to these protected areas, Fashts around Qatar for example, Fasht Al-Bisheria, Fasht Al-Hadeid, Fasht Al-Aref, Fasht Al-Dibel, Fasht Al-Ghabi, Fasht Al-Hurabi and Fasht Al-Noof are not protected but continuously patrolled for illegal fishing. Cleaning campaigns managed by SCENR Marine Surveillance Department take place regularly to keep the Fashts environment and surroundings suitable for coral growth. Studies are currently underway to announce all Fashts as protected areas. Specifically, Fasht Al-Hurabi needs a management plan for conservation and protection since most of the corals especially from Ras Laffan marine area are relocated in this fasht. Meanwhile, all marine islands are protected and continuously patrolled and fishing (except with lines), is band around them. The protected areas (land and marine) currently occupy 17% of the country's surface area, and the target is to reach 23% by 2010 (SCENR/EAD/NCRI/WS-WWF, 2008).

In Saudi Arabia, the Gulf Wildlife Sanctuary was planned, by the Royal Commission for Jubail and Yanbu, to be one of the greater wildlife sanctuaries in the RSA. Only Jubail is designated as a protected area, whereas the rest is considered as environmentally sensitive areas. It includes Dawhat ad-Dafi and Dawhat Al-Musallamiya, on the I-RSA coast north of Jubail, Eastern Province, encompassing embayments in the northern part of I-RSA, between Jubail and the two long, flat islands, Batima and Abu Ali in the south-southeast, and Ras az Zawr in the northwest. The Sanctuary also covers the Coral Islands, approximately 190 ha, excluding surrounding reefs (Harqus 2 ha, Karan 128 ha, Kurain 8 ha, Jana 33 ha and Juraid 20 ha). Likewise Sabkhat Al-Fasl Lagoons is now within the boundaries of the proposed part of the Sanctuary, stretching over approximately 500 ha. 27 °00′N, 49 °40′E on the southwest edge of Jubail Industrial City, Eastern Province. Collectively, this Sanctuary will conserve various habitats such as sandy beaches, mangroves, mudflats and corals. It will provide nesting grounds for terns and turtles. A comprehensive management plan has been prepared, and rangers recruited, in readiness for its final declaration as a reserve/protected area.

In UAE, there are 3 Marine Protected Areas in Abu Dhabi Emirate: Marawah, Al-Yasat and Bul Syayeef (SCENR/EAD/NCRI/WS-WWF, 2008). The Marawah Marine Protected Area (MMPA) was declared in 2001. It covers an area of 4,255 km^2 and is considered to be the largest marine protected area in the UAE as well as in the RSA (Al-Cibahy and Al-Abdessalaam, 2005). This area is considered to be a representative sample of the diverse marine habitats and species that exist in the Region. It includes numerous islands, the most important of which are Marawah, Jenanah, Salahah, Al-Bazm Al-Gharbi and Bu Tinah, and a coastline stretching over 120 km, comprises several important habitats with national and regional significance. It was established to conserve and protect fisheries and marine resources, endangered and threatened species (mainly dugong and sea turtles) and the habitats supporting these species and resources, including coral communities, seagrass beds and seaweed and mangrove areas. The area also provides crucial nursery and spawning grounds for a wide variety of fish species and is regionally important as a foraging habitat for green and hawksbill turtles. Furthermore, the islands inside the protected area provide important nesting sites for hawksbill turtles and a number of migratory birds (SCENR/EAD/NCRI/WS-WWF, 2008). The Management of the MMPA follows IUCN guidelines of category VI as a “managed resources protected area: protected area managed mainly for the sustainable use of its natural resources”. Oman has also set up two marine protected areas. The Daymaniyat Island Reserves is the largest, and was established in 1997. It covers an area of 203 km^2 of sea and seabed of 9 islands, rocks and reefs and offshore shoals situated 16 - 18 km off the Seev-Barka coast. The islands provide nesting grounds for seabirds and Hawksbill turtles. The human interference, sensitivity of natural resources, carrying capacity of resource use and other stakeholders interests are the major aspects influencing the development of the current zoning plan (SCENR/EAD/NCRI/WS-WWF, 2008).

Al-Yasat MPA (YMPA) was declared in 2005. The area of 482 km^2 comprises a chain of 4 islands, the largest of them is Al-Yasat Al-Sofly. The marine waters around these islands include extensive seagrass beds in the eastern side and deep fringing reef in the western side. *Porites* sp. and *Acropora* sp. are found in healthy condition and support a wide variety of fish species. The marine areas of YMPA are considered no-take zones. EAD surveillance and monitoring staff are enforcing these regulations in coordination with the management of the two islands: Al-Yasat Al-Ali and Al-Sofly (SCENR/EAD/NCRI/WS-WWF, 2008). Bul Syayeef MPA was established in April 2007 and is considered to be the third MPA in Abu Dhabi. The total area of 282 km^2 is composed of shallow marine ecosystems of seagrass meadows and wetlands. The area has many channels, of which the natural ones have poor population of coral reef species. Because of its vicinity to Abu Dhabi city, the plan is to consider it as the first destination for diving and camping (SCENR/EAD/NCRI/WS-WWF, 2008).

Management regulations governing marine protected areas generally forbid commercial fishing other than by artisanal fishermen using traditional gear, and ban the catching of any dugong, turtle, or marine mammal. They may also restrict construction, dredging, filling, or other shore-based development activity. Similar restrictions apply to oil leases (Sale *et al*., 2011). However, while there is little direct information concerning effectiveness with which these regulations are enforced, casual observation suggests that while policing can be effective, management otherwise is quite weak (Sale *et al*., 2011). Effectively managed Marine Protected Areas (MPAs) could significantly lower rates of exploitation of fishery species while also protecting other valued species (Sale *et al*., 2011). Thus, by strengthening enforcement of the existing regulations, RSA could substantially improve the management and conservation of their marine resources.

3.2 MARINE ENVIRONMENTAL POLLUTION

One of prime mandate of ROPME is to maintain good marine environmental quality in the RSA, which is crucial for several socio-economic reasons. The Region relies heavily upon the seawater itself as a source of freshwater through desalination (Price *et al*., 1993). The seafood, notably fish and shrimp, is of value for both local consumption and export revenue. However, the relatively fragile ecosystem experiences high temperatures, salinity and UV exposure. As a result, many species function close to their physiological limits (Sheppard, 1993) and the added stress imposed by pollutants is likely to have severe consequences. Such a problem can be aggravated, given that contaminant inputs undergo more limited dilution and slower dispersion than would occur in open marine systems because the Inner RSA is a relatively shallow, semi-enclosed sea with poor flushing characteristics and very high evaporation rates (Sheppard, 1993).

To secure a reliable database on the temporal and spatial changes in the environmental quality, ROPME has implemented regular Regional monitoring programmes in collaboration with MEL/IAEA since the early 1980's. The programmes include the screening and assessment of contaminants along the coastal marine environment, periodical organization of oceanographic cruises for the assessment in open sea environment and more recently, a Regional Mussel Watch Programme has been initiated.

3.2.1 Contaminants Screening in Nearshore Environment of the RSA

This monitoring and surveillance programme comprises the periodical collection of marine samples from the coastal areas to ascertain the status of pollution and its evolution with time. This activity has generated reliable, long-term data on the levels of principal groups of contaminants in sediments and biota in the whole coastal marine environment of the Region. Since the start of the programme, screening has been carried out five times, during 1994, 1997, 1998, 2000 / 2001 and 2005. The results of these surveys have been published by ROPME (1996, 1998, 1999, 2001 and 2006) and distributed among Member States. The aim of the latest survey undertaken in February - March 2005 was to screen for trace inorganic and organic contaminants in key coastal areas (Figure 3.47) of the ROPME Member States, and to compare the results with those from earlier surveys in the same areas.

i. Oil Pollution

a. Petroleum Hydrocarbons in Nearshore Sediments

According to guidelines for pollution levels in bottom sediments of the RSA (Massoud *et al*., 1996), concentrations <15 µg g^{-1} as Chrysene Equivalent Units (CEU) are considered to represent natural background levels in this Region.

This threshold value was exceeded in the sediments, near the BAPCO refinery in Bahrain (214 µg g^{-1}) and, according to these guidelines, this site could be classified as a heavily polluted area. The threshold was also surpassed in sediments from Bushehr in I.R. Iran, Sulaibikhat in Kuwait, and Abu Ali in Saudi Arabia, consequently these areas can be categorised as slightly polluted with values lower than 50 µg g^{-1} as CEU.

From the analytical results, levels and trends in both Total Petroleum Hydrocarbons (TPHs) and Unresolved Complex Mixture (UCM) are used to identify "hot spots" in the Region. As shown in Figures 3.48 and 3.49, concentration levels of TPHs as ROPME Oil Equivalents (ROEq) in sediments during 2005 survey were generally higher in BAPCO (Bahrain), Bushehr (Iran), Ras Al Zor (Kuwait) and Ras Al Zawr (Saudi Arabia) than in Oman, Qatar and UAE (Box 3.10).

The levels of Total Polyaromatic Hydrocarbons (PAHs) were <100 ng g^{-1} in most collected sediments from Oman, Qatar, Saudi Arabia and the UAE during 2005 survey, which is typical of locations distant from contamination sources (Baumard *et al*., 1998). Moderately contaminated sites, with PAHs values > 100 ng g^{-1} and lower than 500 ng g^{-1}, include the sediments from Askar, Bandar Abbas, N. Kuwait Bay, Dukhan, Abu Ali, and Umm Annar. Exceptionally high concentrations of Σ PAHs (Figure 3.50) were measured in the sediments near the BAPCO refinery (3.5 µg g^{-1}) Ras Al-Zour (1.7 µg g^{-1}), Sulaibikhat (0.7 µg g^{-1}), Bushehr (0.5 µg g^{-1}), and Raysut Port (0.5 µg g^{-1}). The high PAH concentration at BAPCO approached the NOAA sediment quality guideline value for the Effects Range Low (ERL) of 4000 ng g^{-1} dry weight (Long *et al*., 1995).

Typical profile of petrogenic PAHs, was observed at the most contaminated sites in Iran, Oman and Saudi Arabia (Figure 3.51). Some degree of physical weathering of the petrogenic profile in sediment was extremely high off BAPCO refinery and Askar (Bahrain). They were also relatively enhanced at Doha Bay and Dukhan (Qatar); Al-Marfa and Umm Annar (UAE). Other sites, such as Ras Al-Zour and Sulaibikhat in Kuwait exhibited a slight contribution of combustion-derived PAHs, amongst a higher proportion of petrogenic PAHs.

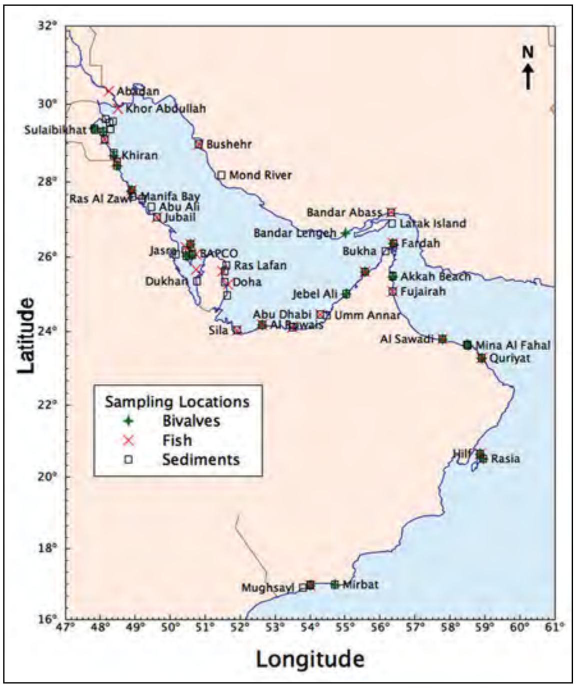


Figure 3.47 Sampling locations for sediments and biota in the RSA during 2005. (Source: ROPME, 2006)

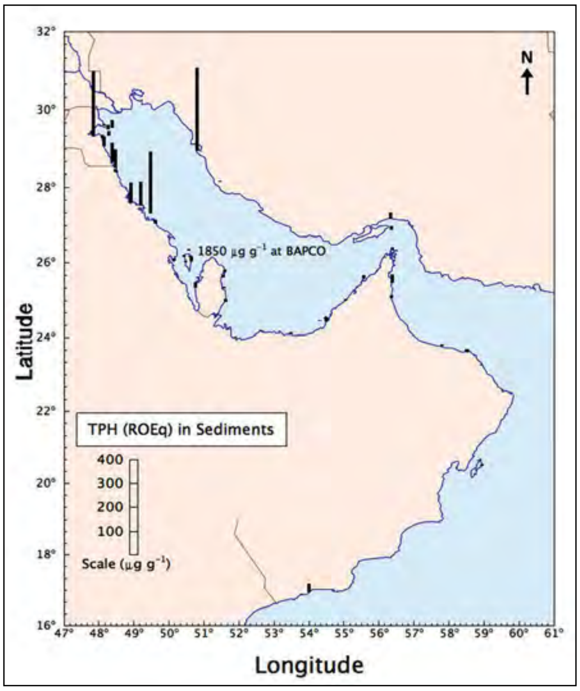


Figure 3.48 Distribution of TPH as ROEq (µg g^{-1}) in coastal sediments from the RSA, omitting the maximum value of 1850 µg g^{-1} measured at the BAPCO refinery in Bahrain, during 2005. (Source: ROPME, 2006)

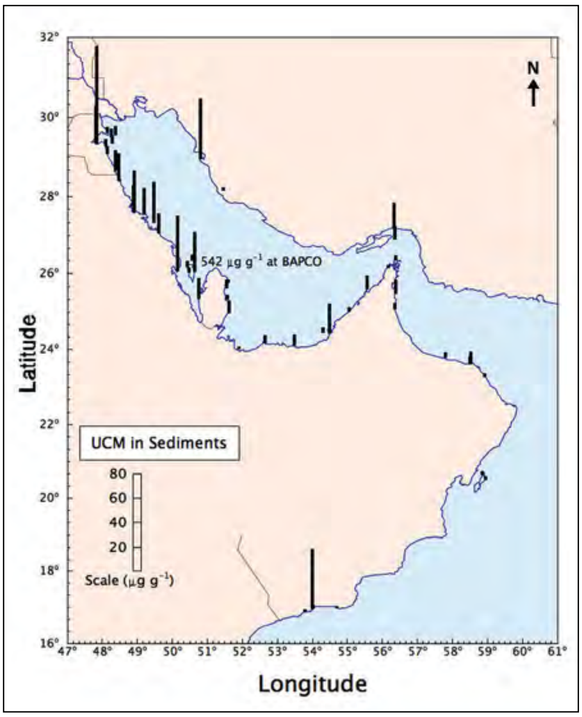


Figure 3.49 Distribution of UCM (µg g^{-1}) in coastal sediments from the RSA, omitting the maximum value of 542 µg g^{-1} measured at the BAPCO refinery in Bahrain, during 2005. (Source: ROPME, 2006)

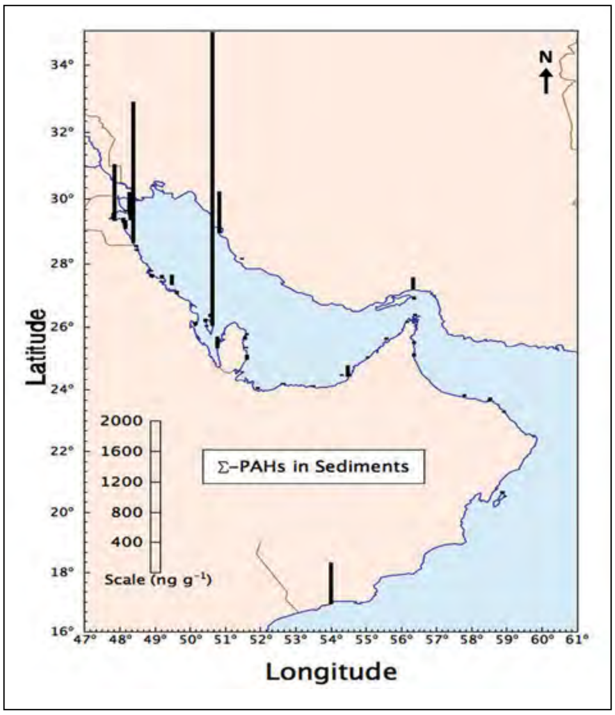


Figure 3.50 Distribution of Σ PAHs (ng g^{-1}) in coastal sediments from the RSA during 2005. (Source: ROPME, 2006)

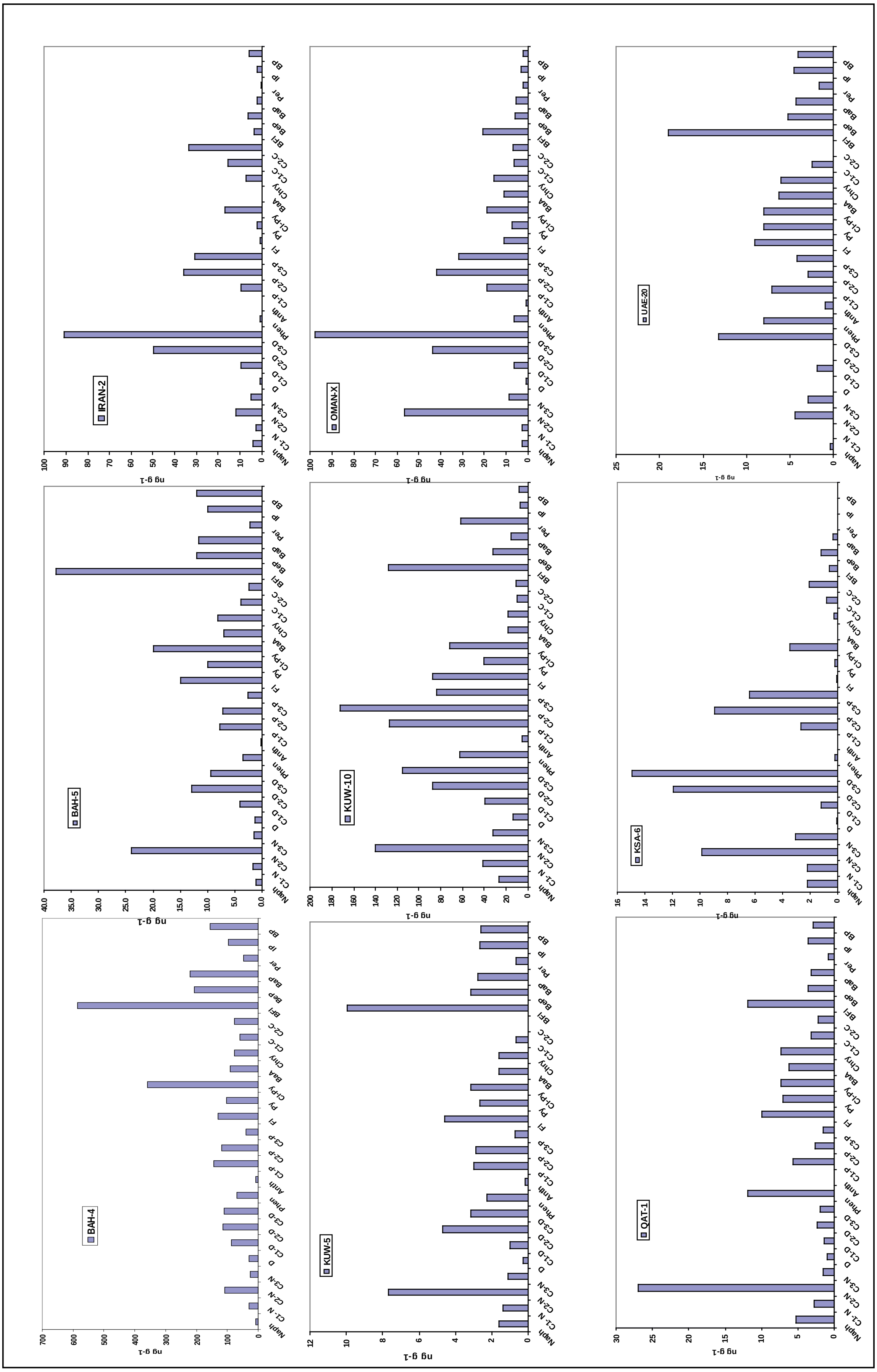


Figure 3.51 Distribution of selected PAHs in representative sediment samples from RSA during 2005. (Source: ROPME, 2006)

BOX 3.10 – Oil Pollution Hot Spots in RSA

Bahrain

Coastal sediments collected from the vicinity of BAPCO refinery showed signs of substantial oil contamination with concentrations of 1850 µg g^{-1} ROEq. Earlier measured levels in the sediments from the same area (ROPME, 2001) indicate that this site is chronically contaminated by oil. However, petroleum levels at both Askar and Jasra sites showed some decrease in oil contamination between the years 2000 and 2005.

I.R. Iran

The highest concentrations of TPHs in sediments were measured in Bushehr with values of 318 µg g^{-1} ROEq. Much lower values were measured at Bandar Abbas and no evidence of contamination was observed in sediments from the Mond River site.

Kuwait

In sediments, the levels of TPHs ranged from 2 to 251 µg g^{-1} ROEq with the highest value measured at Sulaibikhat, followed by Ras Al-Zour and Fahaheel.

Oman

The maximum concentration of TPHs (35 µg g^{-1} ROEq), was measured at Raysut Port. The other Oman sediment samples exhibited much lower concentrations (0.4 to 9 µg g^{-1} ROEq). These latter values were similar to those measured in the 2000 survey. The TPH concentrations measured in the sediments at Mina Al-Fahal in 2000 and 2005 were one order of magnitude lower than those reported in 1990 (Badawy *et al*., 1993), indicating that the sediments analyzed in 2005 and 2000 surveys were not impacted by the oil terminal and refinery plant at this site.

Qatar

TPHs concentrations were highest at Dukhan (18.5 µg g^{-1} ROEq) and Ras Al-Nouf (12 µg g^{-1} ROEq). In the 2000 survey, slightly lower concentrations were measured at Dukhan (7.1 µg g^{-1} ROEq), whereas higher level was noted earlier in Ras Al-Nouf (64 µg g^{-1} ROEq, Tolosa *et al*., 2005).

Saudi Arabia

The levels of TPHs ranging from 6 to 238 µg g^{-1} ROEq, were observed with the highest value recorded at Abu Ali, followed by Ras Al-Zawr, Manifa Bay and Ras Al-Khafji. The relatively high values measured in sediment from Abu Ali (238 µg g^{-1} ROEq dry weight), a location heavily contaminated by the oil spill of the 1991 War, imply chronic contamination of this area. However, the present concentrations at Ras Al-Khafji (72 µg g^{-1} ROEq) indicate low to moderate oil pollution, but it is at least one order of magnitude lower than those measured just after the oil spill of the 1991 War (1140 to 1340 µg g^{-1} ROEq at the sites of Ras Al-Khafji and Ras Al-Mishab, respectively, [Fowler *et al*., (1993); Readman *et al*., 1996)]. A more important decrease since 1991 has been observed at Ras Al-Mishab, which now exhibits relatively low levels of TPHs (10 µg g^{-1} ROEq). In contrast, TPHs in Manifa Bay sediments show a less pronounced decline and still exhibit moderate levels of TPHs (78 µg g^{-1} ROEq).

BOX 3.10 (Contd...)

UAE

The area around Akkah Head and Akkah Beach on the east coast of the Sea of Oman and Umm Annar showed indications of some oil contamination, with TPHs from 17 to 33 µg g^{-1} ROEq. These TPH concentrations are slightly lower than those measured in 2000 (from 73 to 100 µg g^{-1} ROEq, (Tolosa *et al*., 2005) and are similar to the levels measured eight months after the 1994 oil spill near Akkah Head from 11 to 17 µg g^{-1}, as Iranian crude oil (Shriadah, 1998). They are also in the lower range reported for nearshore marine sediments of the UAE in 1994, namely from 0.4 to 212 µg g^{-1} (Abu-Hilal and Khordagui, 1994) and similar to those measured at the identical sites of Umm Al-Quwain in 1991 and Jebel Ali in 1991 and 2000 (Fowler *et al*., 1993; Tolosa *et al*., 2005).

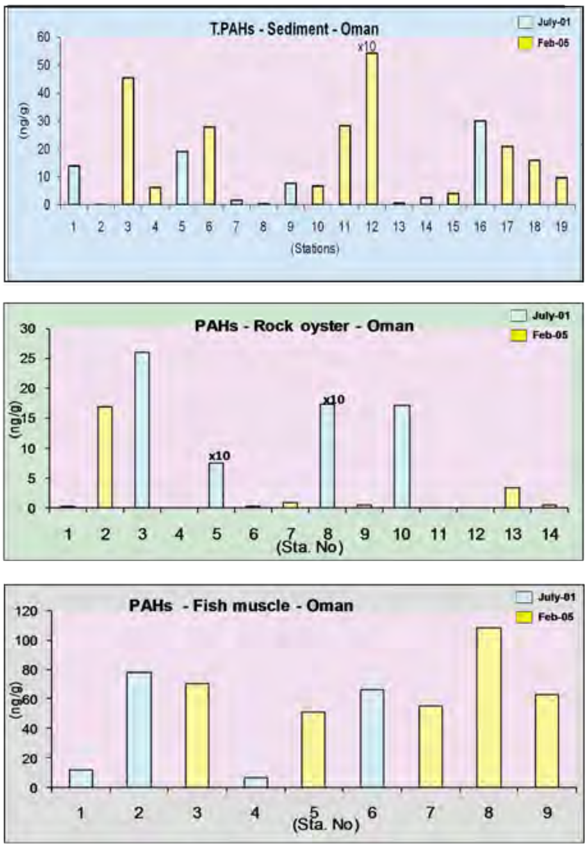
b. *Petroleum Hydrocarbons in Biota*

Except for rock oysters from Mina Al-Fahal (Oman), the measured levels of Petroleum Hydrocarbons (PHs) in various collected fish and bivalves were comparable to the concentrations observed in relatively unpolluted areas elsewhere in the world. Approximately fourteen years after the greatest oil spill in the history, pH concentrations in biota have decreased to values reported before the 1991 War. Relatively low pH concentrations were also noted in the oysters around Akkah Head, eleven years after the oil spill that occurred in the Sea of Oman off the east coast of the UAE.

During the survey of 2005, the recorded TPHs concentrations ranged from 0.9 to 572 µg g^{-1} ROEq dry weight with the highest one measured in rock oysters from Mina Al-Fahal and Mirbat (Oman). Although the sediments from these two sites did not seem to be highly contaminated, probably due to the coarse nature of the sediment, the high concentrations of TPHs in oysters from Mina Al-Fahal site (572 µg g^{-1} ROEq, 418 µg g^{-1} of UCM and 13.7 µg g^{-1} PAHs) presumably reflect chronic contamination by the oil terminal and refinery plant at this site. Slightly lower TPHs concentrations (81 -118 µg g^{-1} dry weight) were reported for oysters from near Mina Al-Fahal in 1990 (Badawy *et al*., 1993).

Other bivalves showing some oil contamination were pearl oysters from Askar (Bahrain), clams from Kuwait and Saudi Arabia, rock oysters from Raysut Head and Hilf in Oman. ROEq, UCM and total PAHs were all somewhat elevated in these bivalves, indicating some moderate chronic oil contamination. On the other hand, the bivalves from the UAE exhibited the lowest levels of TPHs from all countries (0.9 - 11 µg g^{-1} ROEq, 8 - 20 µg g^{-1} of UCM and 19 - 160 ng g^{-1} PAHs). It is noteworthy that pearl oysters from Akkah Head and Jebel Ali (UAE) and rock oysters from Al-Sawadi, Ras Al-Hamra and Mirbat in Oman exhibited similar concentrations as those measured in the 2000 survey (Tolosa *et al*., 2005). Moreover, the present concentrations in bivalves from Ras Al-Mishab and Ras Al-Tanajib (Saudi Arabia) were, respectively, one and two orders of magnitude lower than those measured in these same sites following the 1991 War (Fowler *et al*., 1993). They have now decreased to the typical background values of TPHs that were reported before the war for Saudi Arabian bivalves, viz. 1 - 21 µg g^{-1} dry weight (Lindén *et al*., 1990).

The concentration of total PAHs ranged from 19 to 13,740 ng g^{-1} dry weight (Figure 3.52). If the maximum level which has been recorded in the sediment from Mina Al-Fahal in Oman, the levels of total PAHs from the RSA were only slightly higher than unoiled sites elsewhere.



Sultanate of Oman	
Sta. No.	Station Name
1	Quriyat
2 3	Mina Al Fahal
4	Ras Al Hamra
5 6	Al Sawadi
7 8	Mughsayl Beach
9 10	Raysut Port Area
11	Raysut Head
12	Raysut Port
13	Mirbat
14 15	Ras AlYei
16 17	Hilf
18	Fardah (Rarkian)
19	Bukha

Figure 3.52 Levels and trend of Polyaromatic Hydrocarbons (PAHs) in the coastal Marine Environment of Sultanate of Oman during 2001 - 2005. (Source: ROPME, 2006)

Similar to that observed in sediments from some sites in the RSA (Figure 3.51), the distribution of PAHs patterns in some bivalves showed a typical profile of petrogenic PAHs. However, the concentrations of PAHs in bivalves from Fardah in the Sea of Oman and Strait of Hormuz suggest their source from crude oil or degraded crude in Saudi Arabia and UAE, while from inputs of fresh crude oil from combustion-generated PAHs in clams from Kuwait (Doha Bay) and in pearl oyster from Askar in Bahrain. These differences suggest that bivalves in RSA were not directly exposed to the contamination adsorbed onto sediment grains, but were mainly contaminated by the oil present in the water column.

Total PHs as ROEq in fish muscle from the orange spotted grouper were unexceptional and ranged from 0.29 to 6.8 µg g^{-1} dry weight. Somewhat higher concentrations of 8.8 and 20 µg g^{-1} ROEq were measured in the tuna from Abadan (Iran) and Quriyat (Oman), which also exhibited the highest lipid contents. Surprisingly, low concentrations of PHs were measured in a Hamour from Bushehr (Iran) even though the sediment from this site exhibited moderate pollution.

Overall, the relatively low PH concentrations (0.29 to 6.8 µg g^{-1} dry weight) in Hamour compared with those measured in the 2000 - 2001 survey (ROPME, 2001) as well as those from sites in Bahrain (0.8 to 3.8 µg g^{-1} dry weight) and Oman (from 2.4 to 7.3 µg g^{-1} dry weight) that were not impacted by the 1991 spill (Fowler *et al*., 1993). The detected levels during 2005 are generally comparable to uncontaminated fish tissue (0.333.7- µg g^{-1} wet weight) from the Inner RSA collected in 1991 (Sen Gupta *et al*., 1993), and are similar to concentrations reported for fish collected in 1990 from coastal waters near Mina Al-Fahal in Oman (Badawy *et al*., 1993).

Total parent PAH concentrations in the Hamour muscle ranged from 0.4 to 5.5 ng g^{-1} with the highest level measured in the tuna with high lipid content from Abadan. Much higher levels of total parent PAHs, 73 to 135 ng g^{-1} dry weight, were measured in the muscle of Spangled Emperor from oil-impacted areas in Qatar surveyed one year after the 1991 oil spill (Al-Yakoob *et al*., 1993) and in orange spotted grouper samples from Kuwaiti fish markets in 1993 (181 to 267 ng g^{-1} dry weight) (Saeed *et al*., 1995). The PAHs composition in fish muscle reflects a predominant origin from oil pollution rather than from pyrolitic sources. Only the Hamour from Abadan in Iran, exhibited an important contribution of some combustion-derived compounds while all samples of fish muscle were more enriched in the most of volatile compounds, compared to the bivalve samples. In general, although the number of the analysed fish samples during 2005 survey was too small to provide definitive conclusions, the recorded low PAH concentrations suggest that human consumption of fish from the Region should be of very little concern for public health.

ii. Organochlorine Contaminants

The survey of this category of contaminants in the marine environment, including Persistent Organic Pollutants (POPs), has been conducted periodically since the start of ROPME contaminant screening programme in 1994 and represents an important contribution to the Regional database for the RSA. The survey based on the assessment of marine contaminants arising from organochlorinated compounds derived from industrial and agricultural activities and their spatial distribution in the RSA. Several organochlorines of agricultural origin (e.g., DDT and its breakdown products, lindane, endrin, dieldrin, endosulfan) and from industrial sources (PCBs) are measured in coastal sediments and biota (fish and various bivalves).

a. *Organochlorines in Nearshore Sediments*

The measured residues of Σ DDTs (the sum of DDT and the breakdown products DDD, DDE and DDMU) in sediments from the RSA during 2005 were quite low, being ~20 pg g^{-1} at half of the sites examined (Figure 3.53). The maximum level was 3,808 pg g^{-1} at Sulaibikhat in Kuwait. Moreover, all sites in Kuwait had concentrations of Σ DDTs in excess of those found throughout Oman, Qatar, UAE and Saudi Arabia (except in Jubail). Excluding Sulaibikhat, the highest levels of Σ DDTs found were in Iran, with 236, 184 and 312 pg g^{-1} at Bushehr, Mond River estuary and Bandar Abbas, respectively.

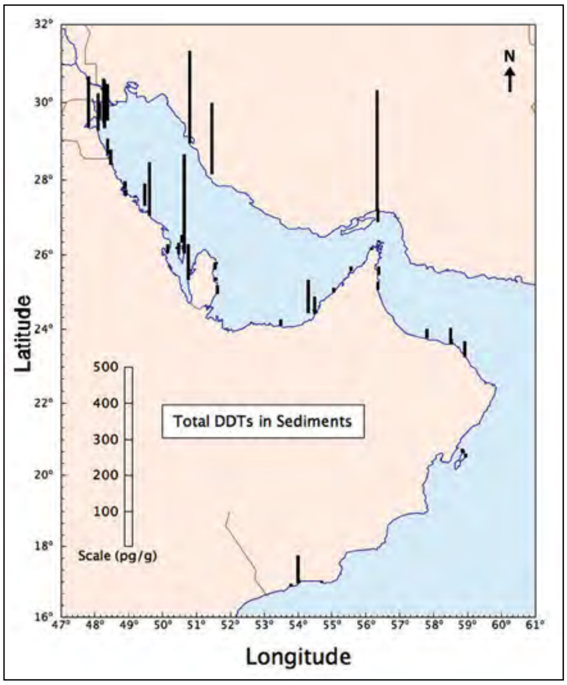


Figure 3.53 Distribution of Σ DDTs (pg g^{-1}) in sediments from the RSA during 2005, excluding the maximum concentration of 3808 pg g^{-1} in Kuwait (Sulaibikhat) (Source: ROPME, 2006)

Overall, the concentrations of Σ DDTs in the RSA are quite low by global standards (de Mora *et al*., 2004b; Fowler, 1990), and fall well below the sediment quality guideline value of 1,600 pg g^{-1} (Long *et al*., 1995), except that found at Sulaibikhat sediments.

Fresh DDT in coastal sediments was observed only at sites with quite low or negligible concentrations of Σ DDTs, as in Oman for example. Such observations suggest that the DDT in the Region is generally historic, rather than recent.

Several other organochlorinated pesticides were measured in sediments such as Hexachorohexane (HCH), Lindane, Endrin, Dieldrin and Enosulfan, but of very low values and could be considered of little environmental concern. For example, the concentrations of Hexachlorobenzene (HCB) shown in Figure 3.54 were too low and ranged from 1.0 to 92 pg g^{-1}. However, relative maxima of concentration of Dieldrin were found near the BAPCO complex in Bahrain (78 pg g^{-1} dry weight) and in Sulaibikhat, in Kuwait (47 pg g^{-1} dry weight) and of Endrin (50 pg g^{-1}) occurred in the BAPCO complex and at Larak Island in Iran (33 pg g^{-1}). Although such concentrations are well within the range previously reported for these pesticides in the RSA (Fowler, 2002, de Mora *et al*., 2005), they are considerably lower than the levels reported for the Shatt Al-Arab River in Iraq (Douabul *et al*., 1987).

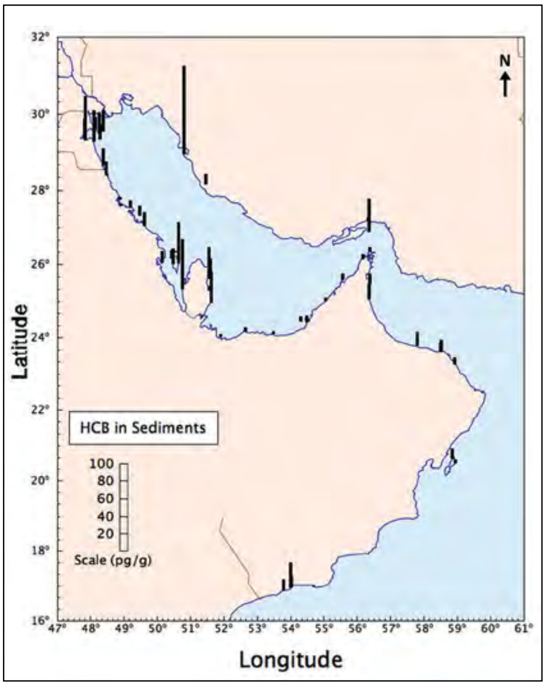


Figure 3.54 Distribution of HCB (pg g^{-1}) in sediments from the RSA during 2005. (Source: ROPME, 2006)

With respect to chlorinated hydrocarbons derived from industrial sources, relatively high levels of Polychlorinated biphenyls (PCBs), based on the sum of Aroclors, were observed in coastal sediment during 2005 at only a few sites: near the BAPCO refinery in Bahrain (12.4 ng g^{-1}), Doha Bay (2.26 ng g^{-1}), Sulaibikhat (7.84 ng g^{-1}) in Kuwait and Dukhan in Qatar (10.6 ng g^{-1}). As shown in Figure 3.55, the sediment profiles of the relative distribution of PCB congeners according to chlorine substitution was largely dominated by penta-, hexa-, and hepta-chloro congeners indicating the contribution of a highly chlorinated commercial formulation, such as Aroclor 1260 (Schulz *et al*., 1989). The amounts of PCBs in the sediments from all other locations in the RSA were not exceptional, and were comparable to levels that have been previously reported for these or nearby sites (Fowler, 2002; de Mora *et al*., 2005).

In summary, the PCBs content was fairly low by global standards for nearshore sediments (Fowler, 1990) and even the maximum concentration found near the BAPCO complex (9.8 ng g^{-1}) did not exceed the sediment quality guideline value of 23 ng g^{-1} dry weight (Long *et al*., 1995).

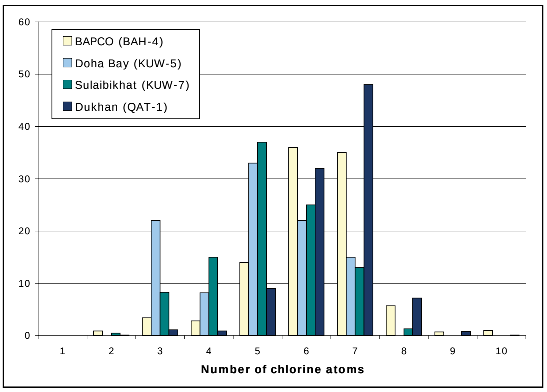


Figure 3.55 Relative distributions of PCB congeners according to chlorine substitution in two sediment samples from the Middle RSA during 2005. (Source: ROPME, 2006)

b. *Organochlorine Contaminants in Biota*

Distribution of Σ DDTs (ng g^{-1} dry) in various collected bivalves is illustrated in Figure 3.56. In contrast to the case for Σ DDTs in sediments, the highest levels were observed in the rock oysters collected in Iran and in the Sea of Oman. This observation, presumably reflecting more the differences affinity of various species with respect to intake, degradation mechanisms and retention of the DDT compounds than merely the magnitude of their concentration in the surrounding environment.

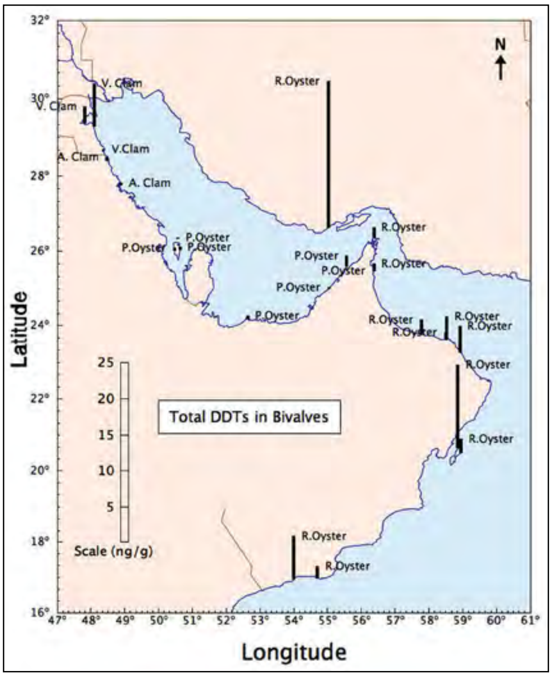


Figure 3.56 Distribution of Σ DDTs (pg g^{-1}) levels in various bivalves (clams and oysters) from the RSA during 2005. (Source: ROPME, 2006)

All of the sampled bivalves during 2005 showed generally low contents of pesticide residues in their tissues (Figure 3.56). Meanwhile, rock oysters from Bandar Lengeh in Iran gave an indication of agrochemicals contamination with the highest level of Σ DDTs (19.1 ng g^{-1} dry).However, the detailed analyses showed that most of the DDT had degraded to p,p' DDE, thereby indicative of an earlier contamination episode. Many of the other considered pesticides, such as HCB, cis-chlordane, dieldrin and endosulfan sulfate, were also elevated in the oysters from Bandar Lengeh in Iran, but the levels were not exceptional when compared with concentrations measured previously in these species from the region (Badawy *et al*., 1988; Fowler, 2002).

DDT residues in rock oysters have been periodically monitored outside the Strait of Hormuz since 1980 (de Mora *et al*, 2004a). Upon the examination of the temporal data for Σ DDTs, it is clear that the levels, while relatively low, have varied little over the last two decades. These low, fairly constant concentrations of Σ DDTs present in oysters from urbanized and remote areas confirm both their environmental persistence, and their chronic input to the RSA, most likely via long range atmospheric transport.

In general, total PCBs as Aroclor 1254 in the regional bivalves usually varied between low ranges; 0.4 in Jebel Ali (UAE) and 1.5 ng g^{-1} in Askar (Bahrain) in pearl oysters. In rock oysters, the relative maximum values were measured in those from Mina Al-Fahal (6.2 ng g^{-1}) and from Raysut Head (6.6 ng g^{-1}), both in Oman. The chlorination profile of the sample from Mina Al-Fahal (Figure 3.57) was very close to the distribution obtained for sediment (Figure 3.53). The historical data of PCBs in this species indicates an irregular but generally decreasing trend of concentrations over the last two decades (ROPME, 2006).

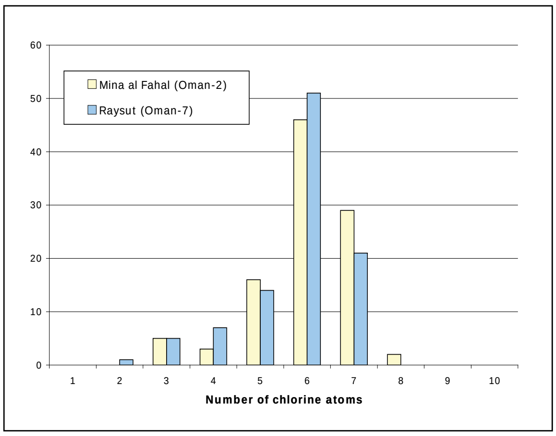


Figure 3.57 Relative distributions of PCB congeners according to chlorine substitution in rock oyster from Oman during 2005. (Source: ROPME, 2006).

Considering PCBs in bivalves other than oysters, the concentrations were quite high in the Venus clam from Kuwait. The Aroclor 1254 content was up to 13.0 ng g^{-1} dry weight for the sample collected in Doha Bay, comparable to previous measurements of 10 ng g^{-1} dry weight for clams from Kuwait (ROPME, 2001) and elsewhere in the world.

Generally, the measured Levels of Σ DDTs were low in the muscles of most fish in the Region and varied in the range 0.10-25 ng g^{-1} dry weight during the survey of 2005. The two highest concentrations were measured in the two tuna fish samples from Abadan in Iran (25 ng g^{-1}) and Quriyat in Oman (21 ng g^{-1}). Overall, the levels of Σ DDT in Hamour were much lower, with the relative highest concentrations found in fish collected in the northwest of the RSA (Figure 3.58). Regarding concentrations averaged on a national basis, Σ DDTs contamination in Hamour from Iran (4.79 ng g^{-1}) and Kuwait (4.09 ng g^{-1}) were about an order of magnitude higher than the average obtained for fish from Bahrain (0.41 ng g^{-1}), Oman (0.78 ng g^{-1}), Qatar (0.57 ng g^{-1}), Saudi Arabia (0.71 ng g^{-1}) and UAE (0.56 ng g^{-1}). These values never exceeded the maximum acceptable concentrations in sea food of 14.0 ng g^{-1} wet weight, i.e., about 70 ng g^{-1} dry weight, for Σ DDTs (Environment Canada, 2001).

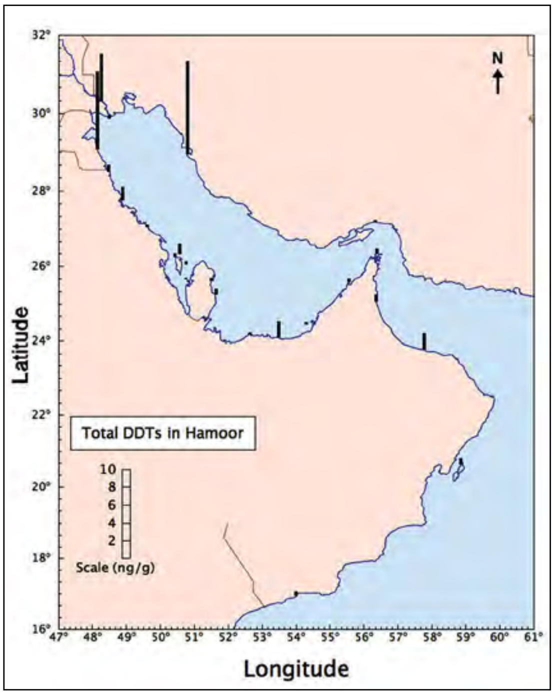


Figure 3.58 Distribution of Σ DDTs (pg g^{-1}) in Hamour muscle from the RSA during 2005. (Source: ROPME, 2006)

Other chlorinated pesticides, such as lindane, dieldrin, endrin and HCB, were all present in rather low concentrations in fish muscle. Dieldrin was detected in all of the 26 samples collected and analyzed while endrin was detected only in 4 samples. Similarly, the levels of endosulfan sulfate were also very low, with a maximum of 92 pg g^{-1} in the tuna collected in Abadan, I.R. Iran.

Concentrations of PCBs as Aroclor 1254 varied in the range from 0.24 ng g^{-1} to 24 ng g^{-1} in fish muscle, with the highest concentration being in the tuna collected in Abadan, Iran. For Aroclor 1260, the levels varied between 0.15 ng g^{-1} and 2 ng g^{-1} in muscle. In all cases, the lowest concentrations were found in the fish collected at Abu Dhabi and Al-Marfa in the UAE. The organochlorine contents reported for the latest survey of 2005 fell in the lower range, which probably reflect the chronic contamination of the area from outside rather than the influence of coastal discharges.

iii. Trace Metals

a. *Trace Metals in Nearshore sediments*

In general, the observed levels of the 20 surveyed metals in sediment during the 2005 survey were not exceptionally important and fell within the range reported during previous surveys. Some sites stand out in terms of their relative elevated levels while others maintained their previous levels or decreased. Table 3.6 groups the range of measured levels of metals and country means in nearshore sediments in the RSA.

The greatest extent of heavy metal contamination in the Region, observed in Bahrain, was at the BAPCO refinery site with levels for Pb (120 µg g^{-1}) and Hg (310 ng g^{-1}), which were nearly three and two times higher than the level described in the sediment quality guidelines (47 µg g^{-1} and 150 ng g^{-1} respectively).

Of the three sediment sampling sites in Iran, data obtained from Bushehr showed higher levels of all trace metals (except nickel, which was slightly lower compared to the other sites). Manganese levels at the three sites ranged from 190 to 630 µg g^{-1}; these were amongst the highest point source values observed for Mn in the survey of 2005.The observed Ni and Cr data for the two other sites (Mond River and Bandar Abbas) exceeded the sediment quality guidelines for Ni by factors of five and three respectively (105 and 69 µg g^{-1} cf 21 µg g^{-1} respectively); Cr by factors of two and four respectively (150 and 300 µg g^{-1} cf 81 µg g^{-1} respectively). It seems probable that these values represent natural variability rather than an anthropogenic source of pollution.

Sediment data was also obtained from 10 sites off the coast of Kuwait. On the basis of the observed concentrations, sampling sites in south Bubiyan Island, north Kuwait Bay, south Failaka Island and Sulaibikhat exhibited the highest levels of contamination (notably for Co, Cr, Cu, Mn, Ni, V and Zn). Results for Cr and Ni exceed the sediment quality guidelines (observed ranges for Cr from 135 to 205 µg g^{-1} cf 81 µg g^{-1} and for Ni from 77 to 90 µg g^{-1} cf 21 µg g^{-1}).

Sediments from 8 of the 13 surveyed sites in Oman exhibited evidence of raised concentrations for Cr, Mn and Ni on the basis of the observed concentration data; indeed the Cr and Ni values exceed the sediment quality values significantly (from 1.02 at Raysut Head) to an order of magnitude (Al-Sawadi) for Cr; from 1.03 at Raysut Head to a factor of 39 at Quriyat. The sediment from Quriyat and Ras Al-Hamra exhibited As values of approximately 15 µg g^{-1} which is almost twice the limit of 8.2 µg g^{-1} set in the sediment quality guide.

Of the five marine sediment sampling sites for Qatar, only Ras Al-Nouf exhibited raised concentrations for Cr, Ni and Mn. The Cr and Ni values were respectively 4.7 and almost 17 times above the sediment quality guideline values. The Mn value observed at this site was twice the maximum value observed elsewhere in Qatar (Dukhan) and approximately seven times the values seen at the other sites (11 to 22 µg g^{-1}).

In Saudi Arabia, elevated values for Cr, Mn, Ni and V were recorded in sediments from Ras Al-Mishab with the Cr and Ni values being twice the sediment quality guideline values respectively. Observed Cr levels in sediment from Manifa Bay and Ras Al-Zawr were both above the guideline values by about 50%.

Sediment from Fujairah in UAE showed raised levels of As, Cr, Mn, Ni and V; the levels of As, Cr and Ni exceeding the sediment quality guidelines by factors of approximately 2, 8 and 40 respectively. The Ni levels in sediment from Fujairah and Akkah Beach were 215 and 1000 µg g^{-1} respectively. Mn levels ranged from 27 µg g^{-1} (Umm Al-Quwain) to 524 µg g^{-1} (Fujairah) across the 10 sites sampled off the UAE coast.

Table 3.6 Country-wise mean concentrations of metals in nearshore surface sediment of RSA during February 2005 (Source: ROPME, 2006).

Country	Metal	Al	Ca	Fe	Mg	Ag	As	Ba	Cd	Co	Cr	Cu	Mn	Ni	Pb	Sb	Sn	U	V	Zn	Hg	Lipids	Obs. No.
	Conc	mg/g				µg g-1															ng/g		
	ERL					1,000	8,200		1,200		81,000	34,000		20,900	46,700					150,000	150	mg/g	
	ERM					3,700	70,000		9,600		370,000	270,000		51,600	218,000					410,000	710		
Bahrain	Average . Abs. Conc	4.310	267.400	1.867	10.118	0.066	3.558	55.520	0.080	0.657	19.682	9.816	38.320	5.154	39.628	0.049	0.774	3.112	9.906	8.242	66.034	0.03	5
	Range	4.31-6.81	267.4-340	1.867-4.98	10.118-17.7	0.066-0.133	3.558-4.65	55.52-102	0.08-0.154	0.657-1.88	19.682-37.7	9.816-36.2	38.32-72.5	5.154-15.3	39.628-121.1	0.05-0.102	0.774-1.92	3.112-4.7	9.906-24	8.242-19-9	66.034-311	0.26-0.9	
Iran	Average	27.980	206.667	18.983	23.800	0.050	7.533	113.433	0.145	8.427	173.533	12.477	425.667	62.567	8.157	0.195	1.129	2.067	56.067	23.353	6.407	0.12	3
	Range	5.74-39.4	141-322	4.85-27.1	12.7-34.4	0.05-0.05	6.39-9.58	43.3-150	0.107-0.177	1.88-12.5	60.6-306	3.23-19.8	193-631	14-105	5.05-10.4	0.103-.243	0.556- 1.49	1.64-2.49	13.3-79.4	9.96-36.1	4.67-8.11	0.001-0.4	
Kuwait	Average	21.025	164.140	11.365	13.891	0.055	4.668	149.300	0.089	5.617	93.984	8.923	244.290	37.417	6.437	0.164	0.945	2.053	37.315	16.007	10.943	0.05	10
	Range	4.14-40.8	27.3-331	0.99-25.8	1.31-32.5	0.05-0.078	0.848-8.7	46.1-324	0.05-0.152	0.322-13.3	2.94-205	1.16-22.1	21.8-533	0.797-89.4	1.6-12	0.041-0.262	0.271-1.68	0.502-4.38	3.6-80.2	2.48-41.7	0.636-35.2	0.01-0.2	
Oman	Average	13.425	269.862	10.642	34.805	0.050	4.634	84.492	0.167	7.307	210.222	4.773	181.923	137.297	3.181	0.134	0.659	2.478	27.671	7.308	3.224	0.02	13
	Range	0.444-35.3	98.2-369	0.355-30.7	4.49-116	0.05-0.05	0.338-15.4	13-354	0.05-0.625	0.116-32	4.1-803	0.298-16.3	11.4-390	1.11-821	0.557-.09	0.025-0.333	0.293-1.39	1.05-4.29	2.12-61.3	0.636-17.1	0.5-16.7	0.001-0.9	
Qatar	Average	2.853	370.200	3.247	16.348	0.132	2.379	36.340	0.053	3.839	98.020	1.796	54.760	74.138	1.479	0.078	0.540	3.040	9.694	2.994	3.329	0.04	5
	Range	0.364-9.42	198-609	0.27-9.88	8.47-33.4	0.05-0.46	0.945-4.27	13.1-103	0.05-0.063	0.136-17	17-384	0.547-3.74	11.3-142	0.941-353	0.37-4.01	0.025-0.144	0.333-0.857	1.95-3.94	2.29-22.7	0.632-6.41	0.593-7.73	0.001-0.1	
Saudi Arabia	Average	10.708	184.138	3.063	5.321	0.052	1.999	134.675	0.070	1.281	66.288	2.023	81.700	8.504	2.766	0.094	0.538	2.078	13.431	3.918	1.696	0.10	8
	Range	1.73-18.5	27.1-286	0.693-6.56	2.3-9.99	0.05-0.067	0.905-3.91	35.5-195	0.05-0.196	0.332-3.27	13.1-150	1.12-4.76	20.1-169	2.72-22.9	1.25-3.62	0.025-0.152	0.296-.935	0.465-2.9	4.02-29.9	1.98-8.6	0.5-4.45	0.02-0.2	
UAE	Average	8.177	253.900	8.806	35.915	0.050	4.899	73.960	0.072	10.620	171.983	3.577	166.640	215.926	2.236	0.094	0.491	2.248	17.281	6.940	8.099	0.94	10
	Range	0.608-22.4	10-351	0.676-35	6.92-123	0.05-10	1.57-19.3	10-173	0.05-10	0.27-45.1	6.23-936	0.87-13.4	10-524	0.953-1000	0.568-10	0.025-10	0.081-10	1.0-10	3.22-58	0.912-28.9	0.5-66.2	0.001-10	
Overall Regional	Average	12.2	223.8	8.2	19.0	0.2	4.2	86.2	0.2	5.3	115.2	5.0	166.0	74.2	3.7	0.2	0.8	2.4	23.8	8.9	5.2	0.2	54
	Range	1.29-27.98	140-370.2	0.844-18.98	5.32-18-81	0.05-0.96	2.0-7.53	17-149.3	0.05-0.98	0.258-10.56	7.14-210.22	1.09-12.48	21.2-425.67	2.09-197.21	0.798-8.16	0.025-0.99	0.307-1.36	2.053-3.04	6.04-56.07	1.61-23.36	1.7-10.94	0.02-0.94	

b. ***Trace Metals in Biota***

To provide the following ranges and estimates of variability of levels of metals in biota within the RSA, recorded data of 2005 survey was pooled and estimated means for bivalves are represented in Table 3.7 for Pearl oysters (Bahrain), Rock oysters (Iran, Oman and UAE) and Clams (Kuwait and Saudi Arabia)

In the case of silver, often used as an index of contamination of the marine environment from sewage, the level in bivalves ranged from not detected (< 0.03 µg g^{-1}) up to 6 µg g^{-1}. For fish, the maximum value was 0.24 µg g^{-1} and the metal was not detected in 20 of the 26 fish samples analyzed.

Cadmium ranged from 0.24 µg g^{-1} in bivalve up to a maximum value of 26 µg g^{-1}. The most contaminated specimens were found in Oman. Interestingly, no cadmium could be measured in any of the fish samples analyzed.

Tin compounds used in anti-fouling treatments for maritime vessels have been the cause of particular concern due to possible genetic effects on certain marine animals. For the fish during the 2005 survey, no correlation between observed concentrations of tin and the geographical origin was obvious. The observed concentrations ranged from not detected (< 0.01 µg g^{-1}; n = 5) up to 0.75 µg g^{-1}. In bivalves, the concentrations ranged from undetected up to 0.47 µg g^{-1}.

Antimony was not detected in the fish and was present in 13 of the 23 bivalve samples and its concentrations ranged from 0.007 to 0.07 µg g^{-1}.

Lead concentrations observed in fish ranged from not detected up to 0.14 µg g^{-1}. In the bivalves, the concentration range was from 0.07 up to 23 µg g^{-1}. The Codex Alimentarius maximum permissible value for Pb in fish is 0.3 µg g^{-1}, so it is highly likely that the oyster sample would not have been accepted for human consumption in many jurisdictions.

Vanadium levels in fish ranged from undetected to up to 0.25 µg g^{-1}. In bivalves, the range was from 0.26 to 9.5 µg g^{-1}.

The concentration of Chromium in fish ran from undetected to up to 0.14 µg g^{-1}, whereas in bivalves the range was from 0.3 to 4.8 µg g^{-1}.

A surprisingly wide range of Arsenic concentrations was observed in the fish samples, ranging from 0.45 to 35.3 µg g^{-1}. In the oyster and clam samples, the range was from 9 to 119 µg g^{-1}.

Mercury in fish muscles ranged from 0.06 up to 2.1 ng g^{-1} and in bivalves from 0.009 to 0.49 ng g^{-1}. Mercury was the only element monitored that was found at a higher average level in fish tissues than in the bivalve samples. Generally, total Mercury concentrations in fish commonly consumed in the RSA (Hamour) were found to be below the 0.5 µg g^{-1} wet threshold value set by many countries and were similar to levels measured in the same species during earlier years. The status of pollution by different classes of contaminants in the nearshore environment in the RSA is summarized in Box 3.11.

Table 3.7 Country-wise mean concentrations of metals in bivalves of RSA during February 2005. (Source: ROPME, 2006).

Country	Metal	Ag	Al	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sb	Sn	V	Zn	T.Hg	Lipids	Obs. No.
	Conc in	µg g-1															ng/g	mg/g	
Bahrain	Average	0.23	96.40	43.20	5.54	0.19	0.52	4.01	210.33	8.80	0.85	1.29	0.01	0.18	4.80	1930.00	0.07	49.67	3
	Range	0.03-0.54	40.4-177	14.4-68	1.56-7.95	0.159-0.22	0.33-0.89	3.19-5.33	176-276	8.02-10.2	0.58-1.08	0.275-3.1	0.01	0.035-0.47	2.25-6.38	1490-2280	0.049-0.09	42-61	
Iran	Average	0.76	128.00	17.00	4.10	0.33	0.73	688.00	248.00	7.14	1.50	0.55	0.01	0.02	0.55	2980.00	0.25	174.00	1
	Range																		
Kuwait	Average	1.49	165.33	29.90	0.67	3.15	1.10	8.82	364.67	52.47	17.07	2.80	0.01	0.08	1.11	71.23	0.12	65.00	3
	Range	0.252-3.46	144-207	19.1--36.3	0.464-0.91	2.05-4.49	0.883-1.52	6.98-11	305-446	18.4-120	12.8-20.1	0.808-6.14	0.01	0.052-0.13	0.861-1.24	61.4-76.9	0.106-0.15	43-93	
Oman	Average	2.389	20.630	14.944	9.913	0.347	0.702	209.167	124.478	8.859	1.321	0.228	0.009	0.031	0.843	792.333	0.069	99.222	5
	Range	0.822-4.26	6.18-47.1	8.98-27.2	3.32-26.4	0.099-0.67	0.297-1.61	47.5-374	54.6-244	3.22-15.8	0.39-3.56	0.068-0.45	0.007-0.014	0.01-0.07	0.26-2.32	308-1220	0.045-0.125	69-134	
Qatar	Average	No samples																	
	Range																		
Saudi Arabia	Average	5.42	151	102.25	1.0495	6.825	1.54	10.04	1012	309.65	27.75	4.68	0.058	0.092	1.87	47.15	0.4375	48.00	2
	Range	4.79-6.05	150-152	85.5-119	0.38-1.72	5.59-8.06	1.32-1.76	7.08-13	654-1370	58.3-561	17-38.5	3.11-625	0.05-0.07	0.04-0.14	1.37-2.37	33.6-60.7	0.39-0.49	47-49	
UAE	Average	0.23	92.76	23.82	5.93	2.84	1.65	5.70	226.20	13.00	4.95	5.21	0.02	0.11	2.65	1345.00	0.02	57.50	6
	Range	0.03-.04	16.7-179	15.4-38.2	3.42--10.8	0.144-13.1	0.426-4.83	0.48-11	107-377	10.0-17.0	0.87-14.7	0.075-23	0.007-0.063	.034-0.309	.26-9.49	654-1720	.009-0.039	50-64	
Overall Regional	Average	**1.75**	**109.02**	**38.52**	**4.53**	**2.28**	**1.04**	**154.29**	**364.28**	**66.65**	**8.91**	**2.46**	**0.02**	**0.09**	**1.97**	**1194.29**	**0.16**	**82.23**	**20**
	Range	0.226-5.42	20.63-165.33	14.94-102.25	0.67-9.91	0.1936.825	0.521-1.65	4.013-688	124.48-1012	7.14-309.65	0.847-27.75	0.228-5.214	0.007-0.058	0.021- 0.182	0.548-4.797	47.15-2980	0.024-0.4375	48-174	

BOX 3.11 – Status of Contaminants in the Nearshore Marine Environment of the RSA (1994 - 2005)

Oil Pollution:

- With few exception in the RSA, general temporal decrease in levels of Petroleum Hydrocarbons is evident
- PHs in nearshore sediments observed during the period 1994 - 2005 lie within the permissible level (15 µg/g, as CEU)
- Chronic pH pollution prevails in the vicinity of the BAPCO industrial complex (Bahrain), at Mina Al-Fahal (Oman) and to lesser extent in the surrounding of Sulaibikhat and Doha Bay (Kuwait)
- pH concentrations in biota have decreased to values reported before the 1991 War
- Prevailed concentration of pH in fish and bivalves are actually comparable to the concentrations observed in relatively unpolluted areas elsewhere in the world
- The historical high levels of pH in Oysters from Mina Al-Fahal (Oman) and around Akkah Head (UAE) are still maintained

Organochlorinated Compounds:

- Generally, concentrations of agrochemicals, as DDTs, and industrial, as PCBs, in sediments and biota maintain their extremely lower levels than global standards during 1994 - 2005

Trace Metals:

- Majority of trace metals levels in sediments and biota correspond to natural background levels
- Mercury concentrations continue to be very low for the sediment, and total Hg levels in fish (Hamour) maintained to be below the 0.5 µg g^{-1} wet threshold
- Unexplained high concentrations of Arsenic maintained in some bivalves during the all screening periods. This observation needs to be related to possible source; contamination or natural biogeochemical processes in the Region
- Nickel and Chromium concentrations were high in almost all nearshore sediments in the RSA

3.2.2 Basin-wide Pollution in the RSA

Parallel to the periodical survey of contaminants along the coastal marine environment of the RSA, regular assessment of the state of marine pollution in the offshore basin (open sea) has been and still is a major task in the Regional Action Plan, under the umbrella of the Kuwait Convention.

For the assessment of contaminants in the open sea area of RSA, six Oceanographic Cruises have been conducted during the last two decades, beginning with the Mt. Mitchell Cruise in 1992 to the Winter 2006 Cruise. During the 2006 Cruise, over 150 chemical contaminants were analyzed in surface sediments collected from 76 sites (Figure 3.59), of which, 41 polycyclic aromatic hydrocarbons (PAHs), 28 petroleum hydrocarbons, 23 organochlorine pesticides, 33 polychlorinated biphenyls (PCBs), and 23 major trace elements were the main groups of the contaminants measured.

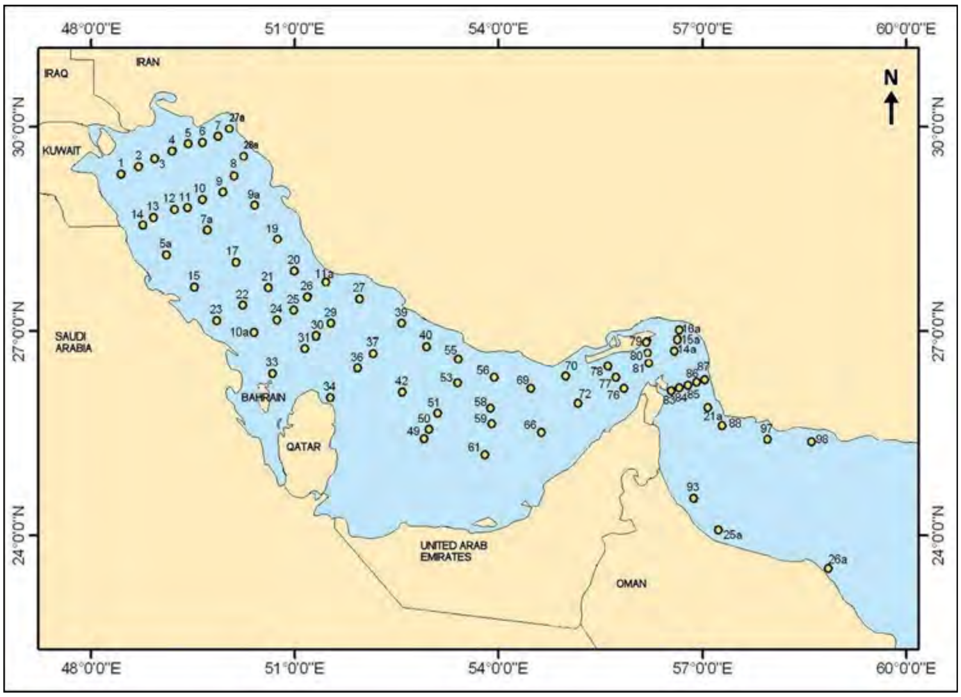


Figure 3.59 Sediment sampling locations for contaminants survey in the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2010a)

i. Sediment Texture and Composition

The ratio of silt to clay in a sediment sample, known as percent fines (silt/clay) composition helps to define sediment as sands (<20% silt/clay), intermediate muddy sand (20 - 80%), and mud (>80% silt/clay; Nelson *et al.*, 2005). Percent fines ranged widely from mud to sands in the RSA (Figure 3.60). Not surprisingly, Stations in the southern RSA showed high sand composition and the Iranian coast showed high mud composition. The lowest % fines value occurred at Station 69 (0.7%) while the highest value occurred at Station 87 (86.2%), which is located near the estuary of Rudkhaneh-ye Gaz River. Twenty Stations were classified as sands (<20% silt/clay) and one Station as mud (>80% silt/clay).

The concentration of organic carbon plays an important role in controlling the bioavailability of non-ionic organic compounds in sediments (DiToro *et al.*, 1991, Swartz, 1999). The average total organic carbon (TOC) in the sediments collected during the Winter 2006 Cruise (Figure 3.61) was 0.91%, and ranged from a low of 0.37% to a high of 1.81%. These values are on the same range as those measured in the same area in 1992 (0.4 to 2.8 % with an average of 1.3 %. (Al-Ghadban *et al.*, 1994).

The lipid content varies in the range from 0.023 to 0.260 mg g^{-1} and the sediments are characterized by a relatively high percentage of carbonate, with a mean of 6.65%.

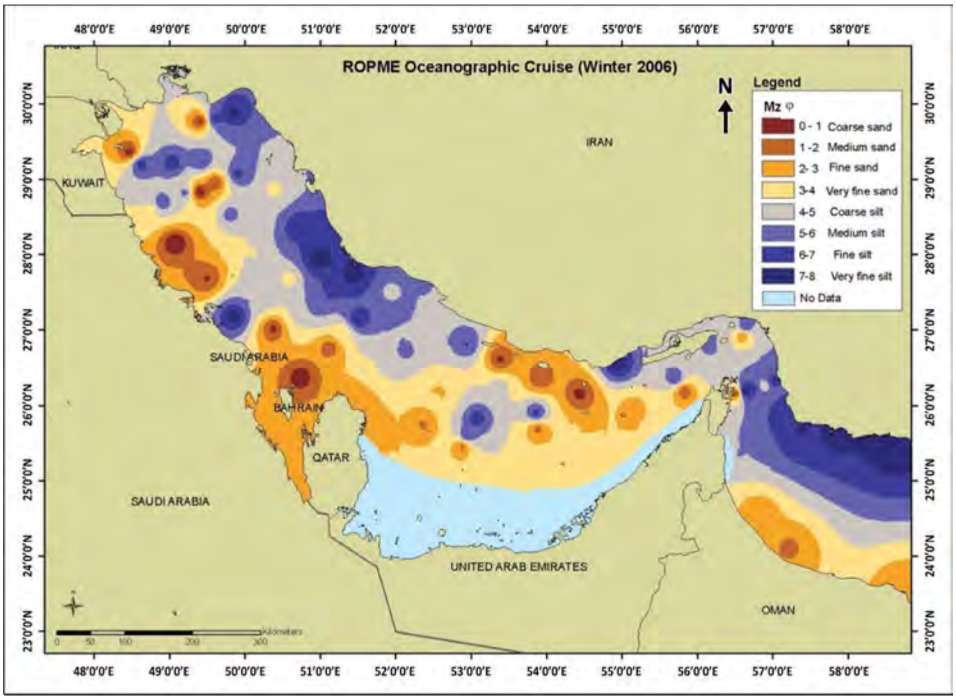


Figure 3.60 Sediment grain size distribution in the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, Under preparation)

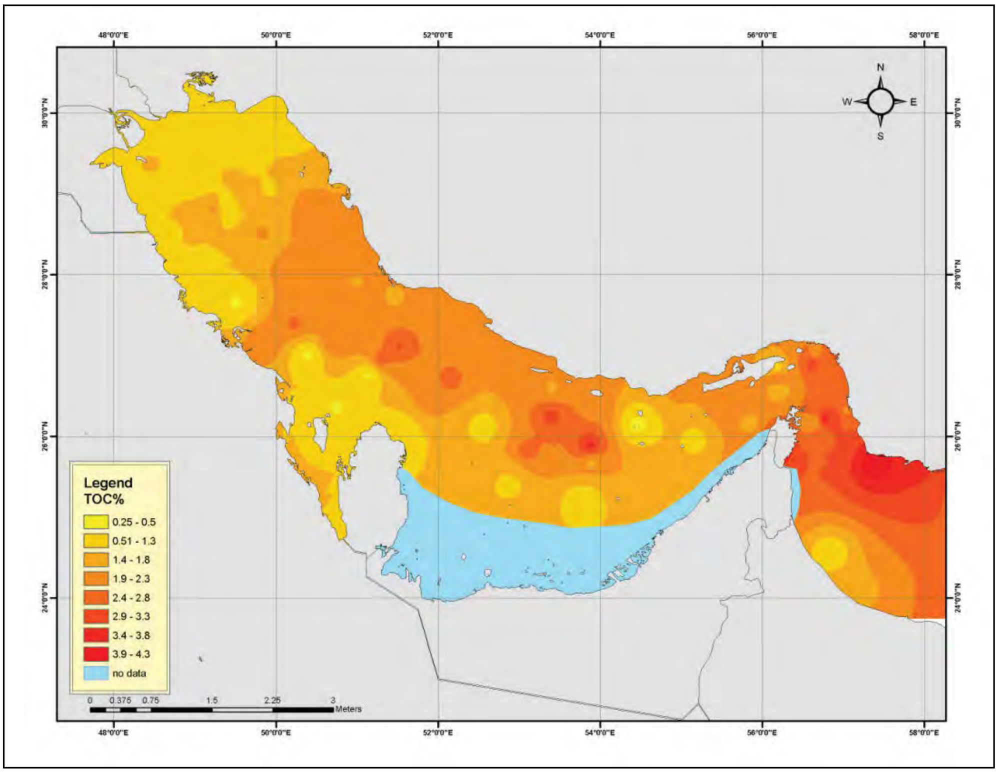


Figure 3.61 Spatial distribution of Total Organic Carbon (TOC %) in surface sediment of the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME - Under preparation)

ii. Oil Pollution in Offshore Sediments

The results of the analysis of oil pollution in the surface sediment samples, collected during ROPME Winter 2006 Oceanographic Cruise (Figure 3.62) showed that the total petroleum hydrocarbon (TPH) concentration ranges from 7 to 80 µg g^{-1} with an average of 20 µg g^{-1}; from 1.3 to 140 µg g^{-1} (average of 20 µg g^{-1}) as ROPME Oil Equivalent and from 0.2 to 18 µg g^{-1} (average of 2.7 µg g^{-1}) as Chrysene equivalents, respectively (ROPME, 2010). These concentrations are comparable to those reported for the same open sea sites of the RSA in the survey undertaken in December 1994 (5.492- µg g^{-1}, average 33 µg g^{-1}, as ROEq (Al-Lihaibi and Ghazi, 1997) and generally lower than those measured in 1992 at the same sites (Massoud *et al*.,1996). They were also significantly lower than those reported from coastal sediments of the ROPME Sea Area that were affected by the 1991 War Spill (Fowler *et al*., 1993; Readman *et al*., 1996; ROPME/IAEA, 1996, 1998, 2001, 2006). The recorded levels of petroleum hydrocarbons concentrations are lower than the natural background level in this area (15 µg g^{-1}, as CEU).

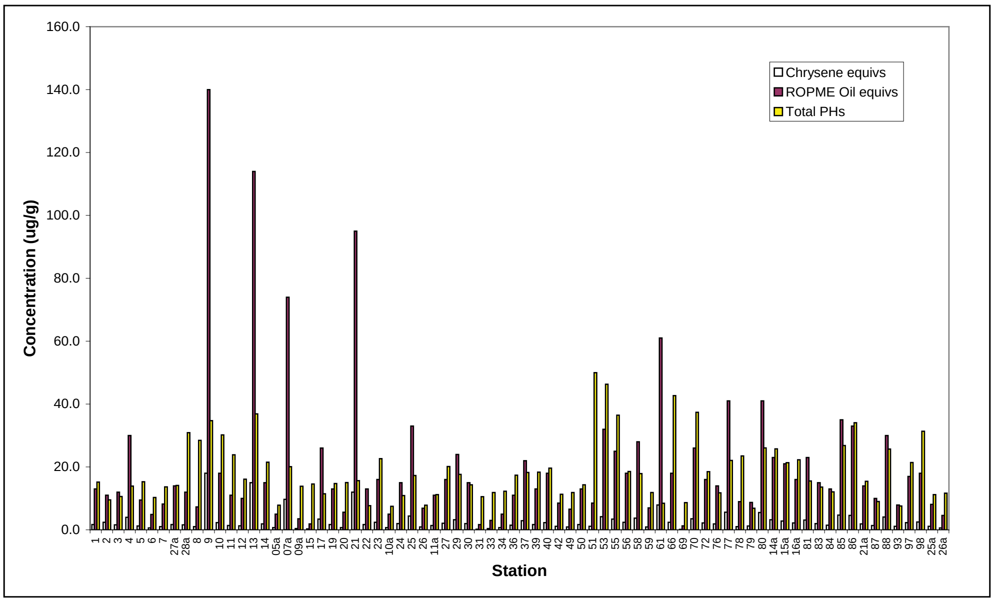


Figure 3.62 Spatial distribution of petroleum hydrocarbons in the sediment of RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2010b)

The fractional analyses of measured petroleum hydrocarbons in most of collected sediment samples during the last two cruises of 2001 and 2006 showed the dominance of low molecular weight fraction over the heavier one (Figure 3.63). This observation is possibly indicating a chronic petrogenic source (e.g., petroleum product from fuel spills or other oily waste discharges). From the other side, it was observed for the collected sediments adjacent to the Strait of Hormuz and also in the central coast of I.R. Iran and Saudi Arabia that they contain PAHs with dominance of low molecular class over the heavier class (Figure 3.63), which could be indicative of more recent oil discharges, perhaps from ships and oil fields. Accordingly, it was possible to conclude from the analyses of results from the fine analyses of petroleum hydrocarbons classes and individuals, that most of the sites in the marine environment of RSA are subjected to chronic discharge of fuel (Figure 3.64). Considering the temporal trend of oil pollution levels in RSA (Figure 3.65), it could be noted that the trend increased with time but still not exceeding the adopted background level for the Region (15 µg g^{-1} as CEU).

During June 2012, a monitoring programme of oil pollution in the coastal environment was conducted in front of Shatt Al-Arab. As shown in Figure 3.66, the measured levels of petroleum hydrocarbons (as ROPME Oil Equivalent) in water and surface sediment samples, collected at five stations, varied within very low levels. In water with an average of 5.5 µg/l, while for the offshore sediments, the average attained five times more than that in water (25.5 µg/g) which nearly corresponds to the same average concentration recorded for the nearest transect during ROPME's Cruise of Winter 2006 (ROPME, 2010b).

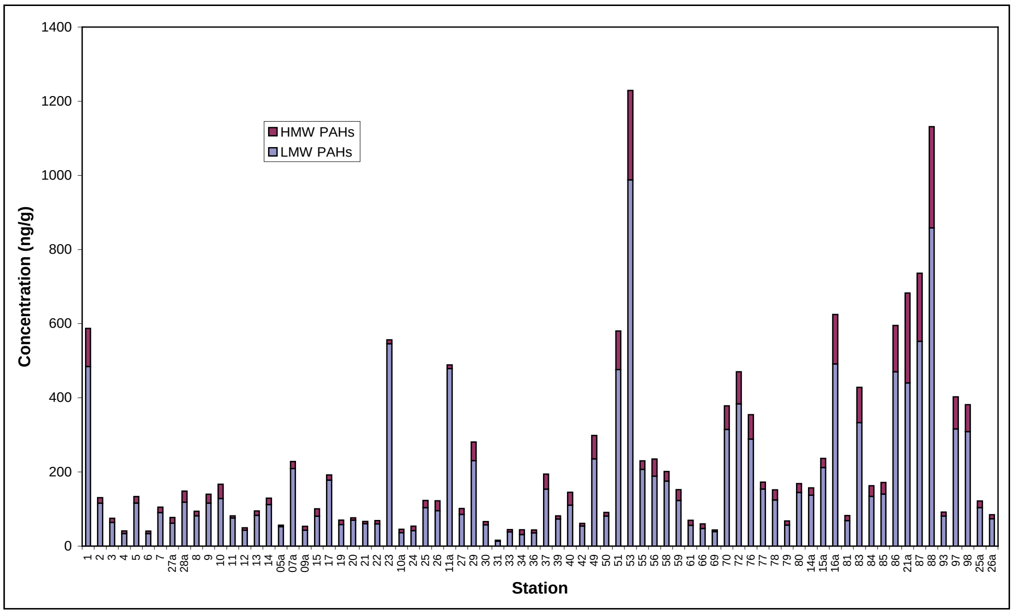


Figure 3.63 Low Molecular Weight (LMW) vs High Molecular Weight (HMW) PAHs in sediments from the RSA during ROPME Oceanographic Cruise – Winter 2006. (LMW PAHs = sum of 24 low molecular PAHs; HMW PAHs = sum of 17 high molecular PAHs). (Source: ROPME, 2010b)

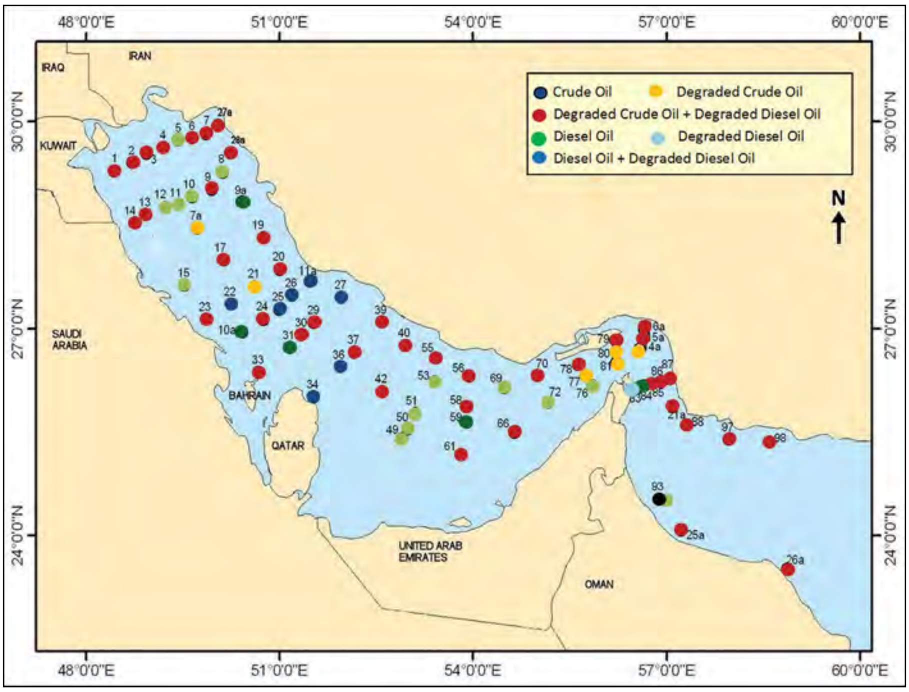


Figure 3.64 Spatial distribution of different types of oils in surface sediments of RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2010b)

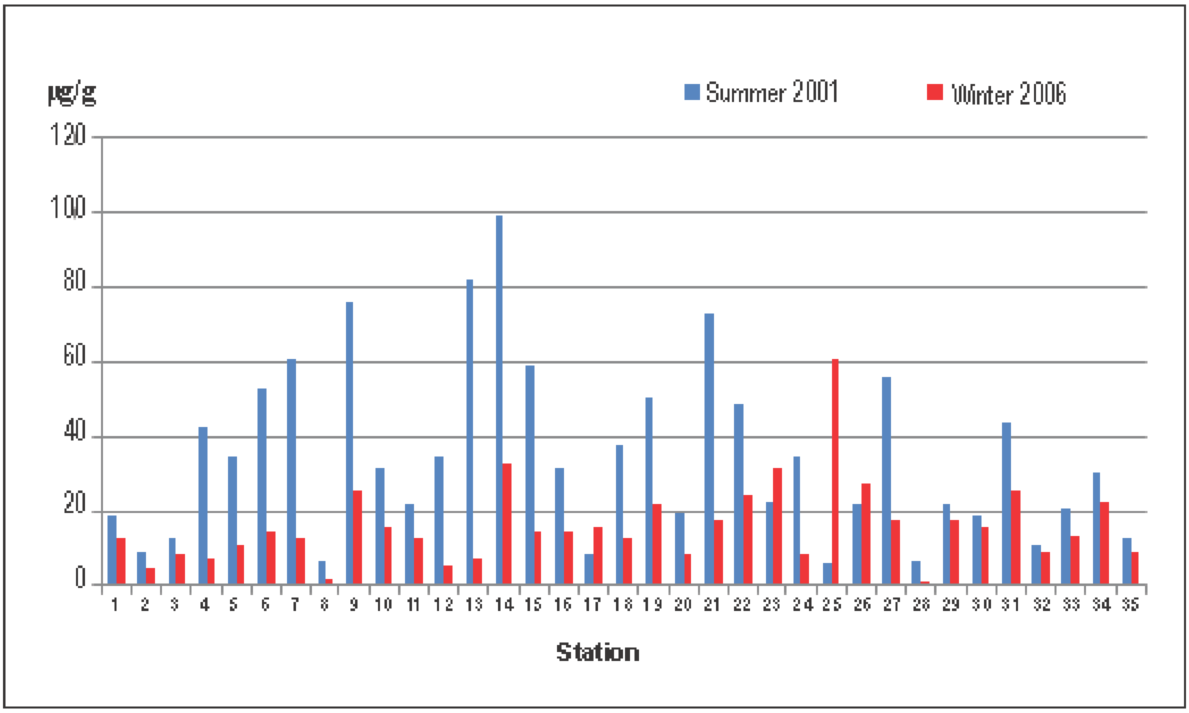


Figure 3.65 Trends of oil pollution levels in surface sediments of the Inner RSA during ROPME Oceanographic Cruises – Summer 2001 and Winter 2006. (Source: ROPME, 2010b)

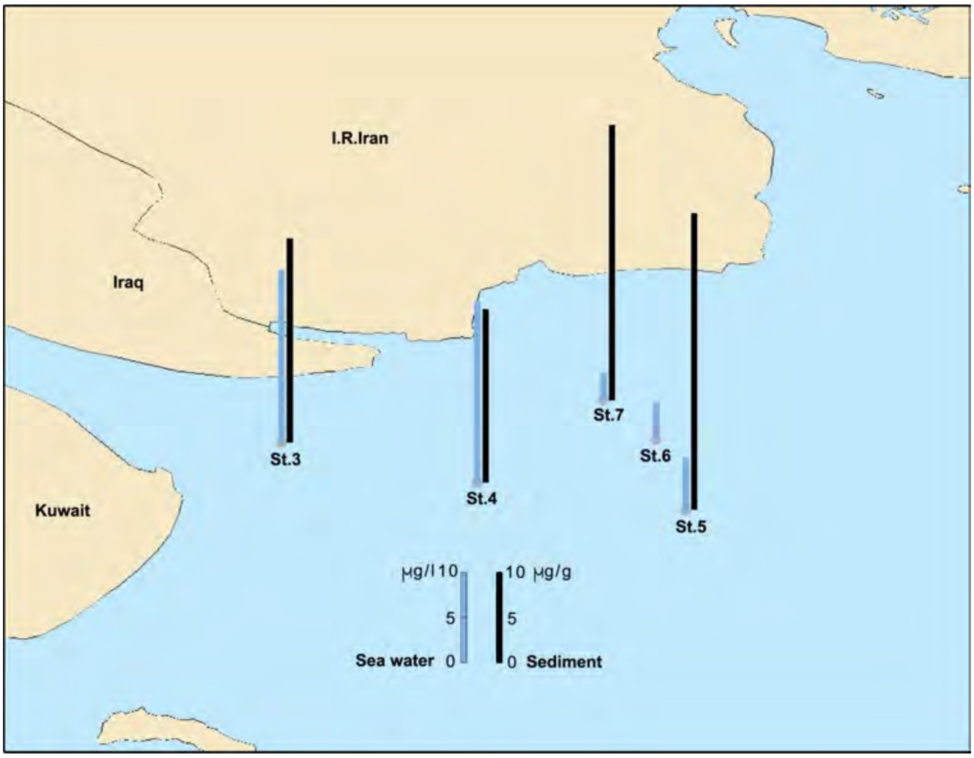


Figure 3.66 Spatial distribution of petroleum hydrocarbons in the offshore area in front of Shatt Al-Arab. (Source: Data provided by Marine Science Centre, University of Basra)

iii. Organochlorinated Compounds

The recorded levels of PCBs in the offshore sediments of RSA during 2006 were generally far below the Effects Range Low (ERL) in the developed numerical guidelines by NOAA (1998) to estimate the toxicological relevance of contaminants in sediment. The distribution of total PCBs (sum of 33 PCB congeners) throughout the RSA sediments (Figure 3.67) was quite uniform while several stations around the central coast of I.R. Iran (Stations 51, 53, 56 and 70) showed elevated levels of total PCBs.

As shown in Figure 3.68, all detected concentrations of total DDTs in sediment were below the ERL value of 1,580 pg g^{-1}. The only location where comparatively high concentration was exhibited was at Station 05a, which is located near the coast of Saudi Arabia. Very high level of op DDD was detected at this Station (3207 pg g^{-1}). Eastern coast of I.R. Iran showed a little higher concentrations of total DDTs compared to other locations of the RSA.

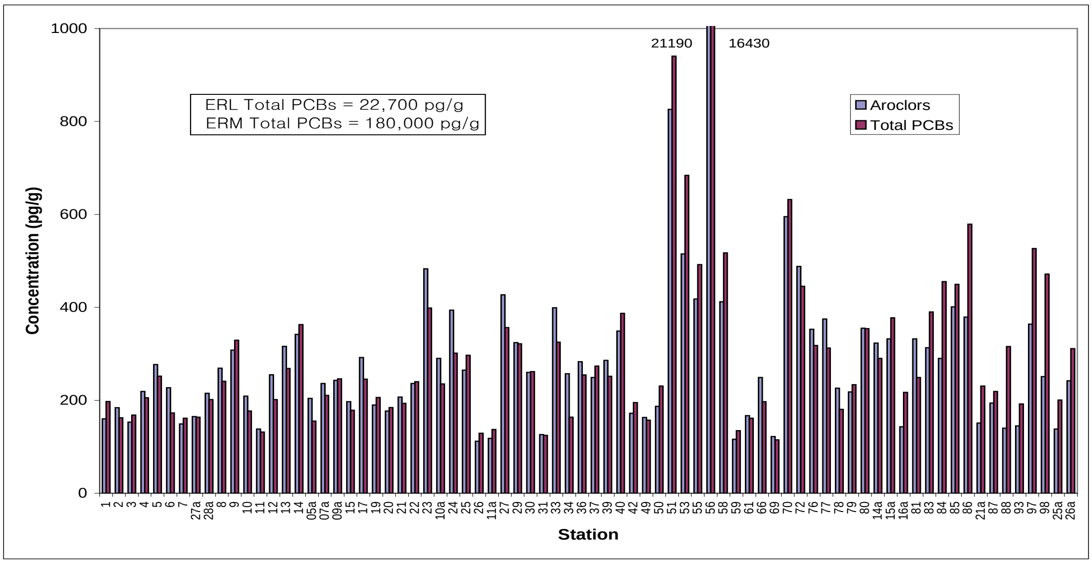


Figure 3.67 Detected total PCBs by station in sediments of the RSA during ROPME Oceanographic Cruise - Winter 2006 (Source: ROPME, 2010b)

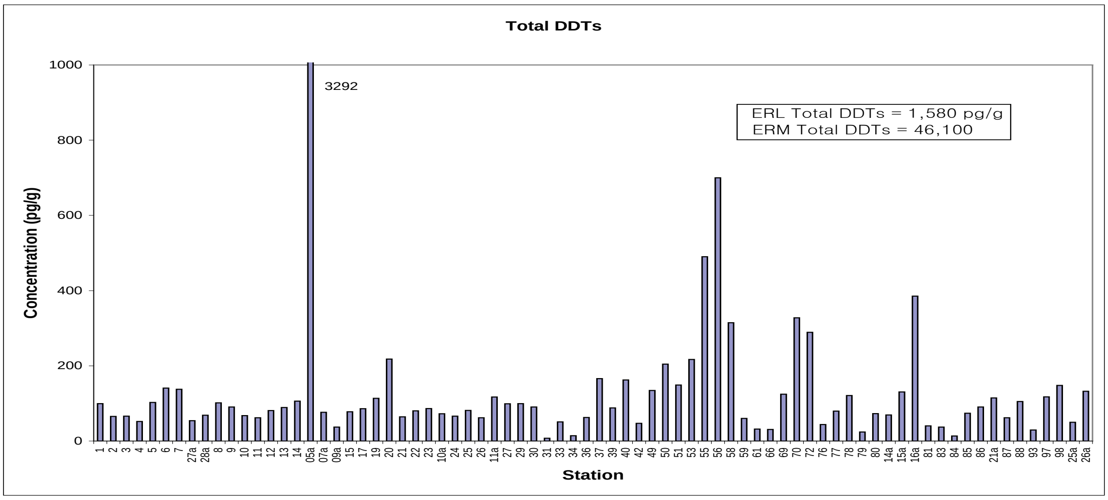


Figure 3.68 Detected total DDTs by station in sediments of the RSA during ROPME Oceanographic Cruise - Winter 2006 (Source: ROPME, 2010b)

A number of other organochlorine pesticides included in the last survey of 2006 were also detected in the sediments in the RSA, including HCB, total HCHs (sum of α HCH, β HCH, lindane and δ HCH), total dieldrins (sum of dieldrin and aldrin), total chlordanes (sum of cis-chlordane, trans-chlordane, trans-nonachlor, heptachlor and heptachlor epoxide), and total endosulfans (sum of α endosulfan, β endosulfan and endosulfan sulfate). None of these compounds or compound classes currently has attained the level of either the Effects Range Low (ERL) or the Effects Range Medium (ERM).

iv. Trace Metals

Twenty three major trace elements were analyzed in the collected sediment samples during Winter 2006 cruise. Most of the measured metals showed a strong correlation with Al, producing spatial distribution patterns very similar to that of Al, and showing the same trend of decreasing concentration from northeast to southwest which was already reported for many previous surveys (IAEA 1998, Basaham and Al-Lihaibi, 1993, Alam *et al*., 1998). In general, normalized concentrations of considered metals to Al did not show specific trend or revealed any contamination source except for the high chromium (Cr) and Nickel (Ni) background levels along the coast of Oman. The overall mean and median of concentrations of both elements in the RSA sediments exceeded the ERL value, but not the ERM value of Long *et al*., (1995), except at Station 25a at the coast of Oman, where concentrations exceeded ERM values (513 $\mu g\ g^{-1}$ for Cr and 504 $\mu g\ g^{-1}$ for Ni). It is assumed that the elevated concentrations of Cr and Ni stem from their high natural backgrounds in the region. De Mora *et al*., (2004a) reported elevated Cr and Ni from the Omani and eastern UAE coasts probably related to the presence of ophiolite rich in chromite and Nickel sulphide. The spatial distributions of Cr and Ni are represented in Figures 3.69 and 3.70, respectively.

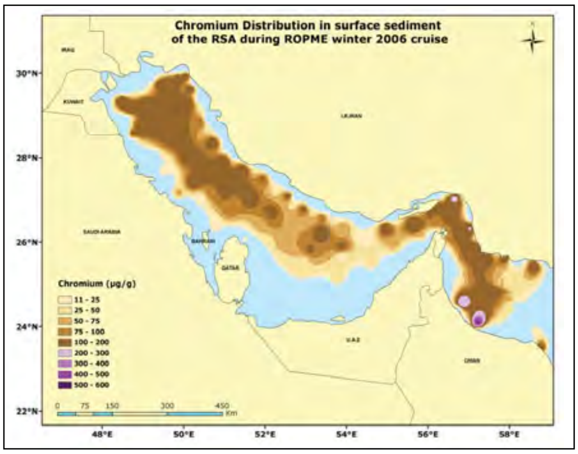


Figure 3.69 Spatial distribution of Chromium (Cr) in the sediment of the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2010b).

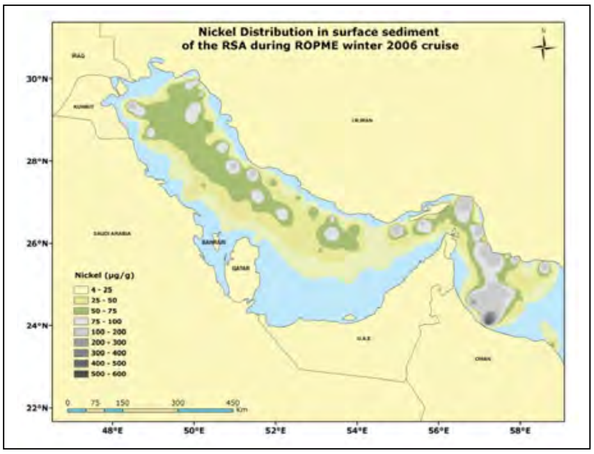


Figure 3.70 Spatial distribution of Nickel (Ni) in the sediment of the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2010b).

For the other measured metals in the last survey of 2006, almost all of them were distributed relatively uniformly throughout the RSA with range of concentrations considerably lower than the ERL value. However, some exceptions were noted as in the case of Arsenic (As) where relatively high concentrations were recorded above the ERL value of 8.2 $\mu g\ g^{-1}$ in the sediments from four sites in the western part and eight sites in the eastern part of the RSA (Figure 3.71). The same observation was reported for the collected sediments from the east side of the RSA during ROPME summer 2001 cruise (IAEA, 2002).

The highest concentration of some metals was found localized in the sediments from some sites in the RSA. For example, Copper (Cu) in the middle of Inner RSA at Stations 37 (73 µg g^{-1}) and in Inner RSA at Station 25a (134 µg g^{-1}), Lead (Pb) in the west coast of Iran at Station 28a (42.2 µg g^{-1}), Silver (Ag) around the east coast of I.R. Iran at Stations 15a, 86 and 98 and Zinc (Zn) around the Strait of Hormuz at Station 80 (357 µg g^{-1}) and Station 97 (206 µg g^{-1}) exceeded ERL value, but not the ERM value.

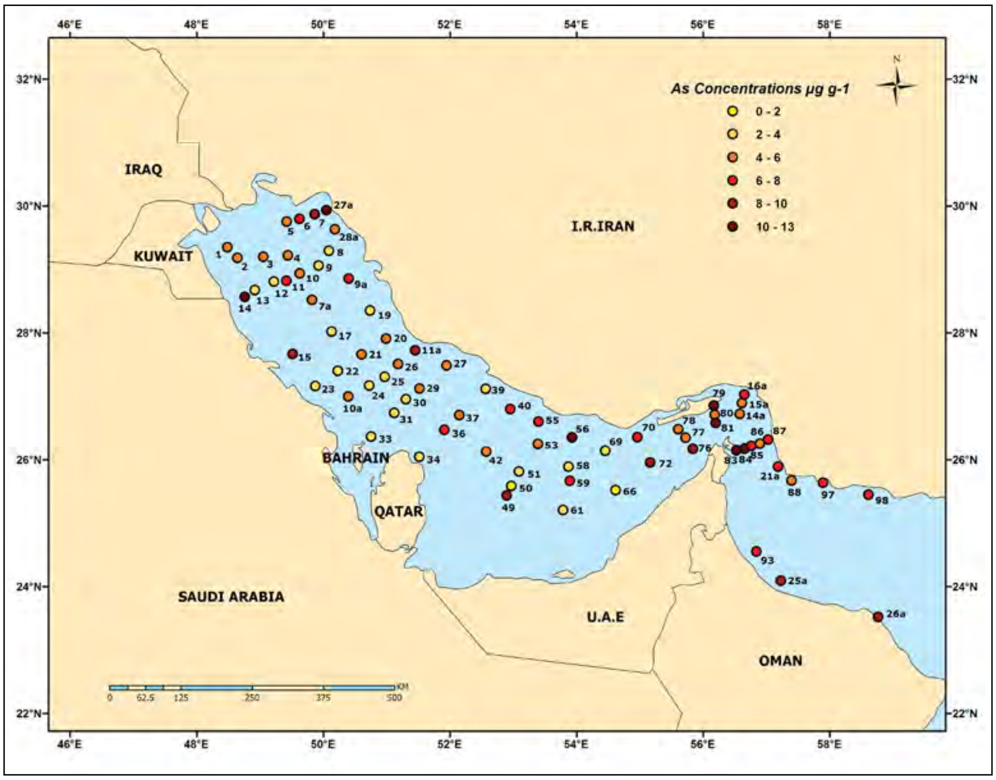


Figure 3.71 Levels of detected Arsenic (As) in the sediments of the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source : ROPME, 2010b).

v. Organotin compounds in Offshore sediments

Among the 18 offshore sediment samples from the RSA investigated for their contents of organotin compounds (Figure 3.72), only the sediments from station 51 in the middle of the southern part of the Inner RSA could be considered contaminated with respect to the total butyltins (i.e. TBT>1.3 ng g^{-1} as Sn) according to the classification scheme of Dowson *et al*., (1993). The sediments from the other monitored stations contained low levels of TBT (less than 0.2 ng g^{-1} as Sn). Taking into consideration the distribution of butyltin species in the sediments from this site (Figure 3.73), and the fact that TBT degrades only slowly in marine sediments (Stewart and de Mora, 1990) the presence of monobytiltin (MBT) in the highest relative percentage of total TBT indicates that there has been little recent input of TBT into the marine environment of these locations.

vi. Radionuclides in Offshore Sediments

To assess the baseline levels of radionuclides in the offshore sediments in the ROPME Sea Area, 18 grab sediment samples collected during ROPME Winter 2006 cruise were selected (Figure 3.74) and analyzed by the Radiometrics Laboratory (RML) of the International Atomic Energy Agency (IAEA).

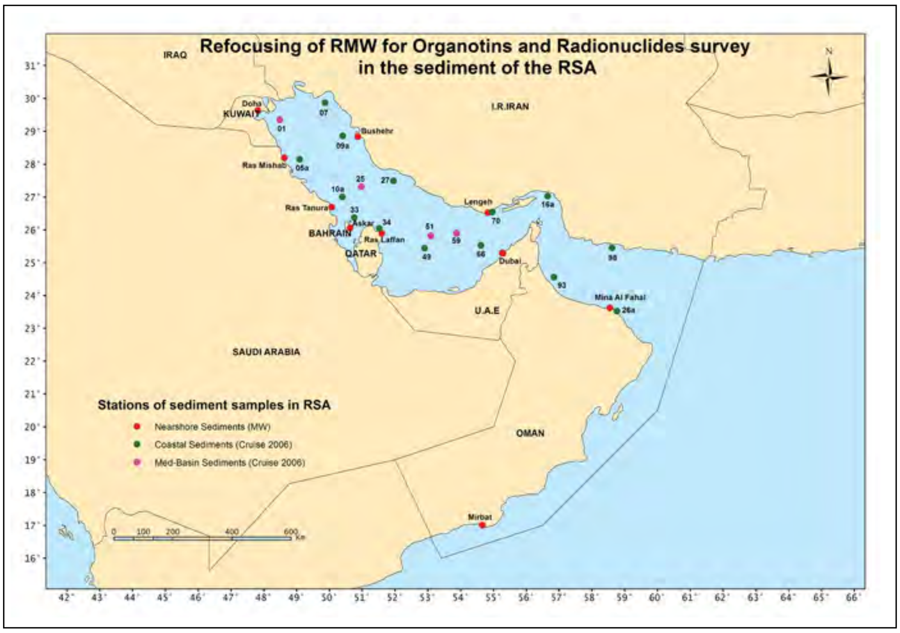


Figure 3.72
Sediment sampling sites selected for Organotin contaminants and Radionuclides assessment of the offshore sediments in RSA. (Source: ROPME, 2013c)

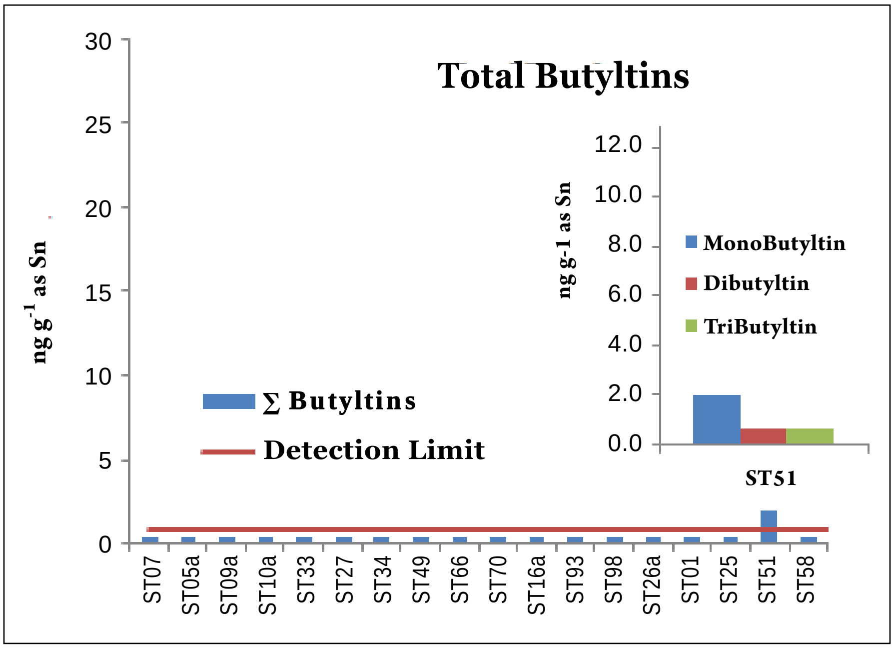


Figure 3.73
Levels of Butyltins in the offshore sediments of the RSA during 2006. (Source: ROPME, 2013c)

As shown in Figure 3.74, the results indicate that the levels of ^{137}Cs as for the other assessed radionuclides were very low and no trend pattern can be observed. This observation is expected because of the texture of the analyzed sediments, which are sand or sandy with presence of shell debris. This observation is confirmed from the measured levels of ^{40}K which is characteristic for such type of sediments.

However, no particular observation could be made concerning the specific activities of the reported five radionuclides as compared to similar sediments elsewhere in the World Ocean (MARDOS, 1995) or in the ROPME Sea Area [Abdi *et al*., (2006), Al-Kheliewi and Shabana (2007), and Al-Sulaiti *et al*., (2010) Al- Zamel *et al*., (2005) and Zara *et al*., (2012)], other than they are generally on the lower end of the reported levels.

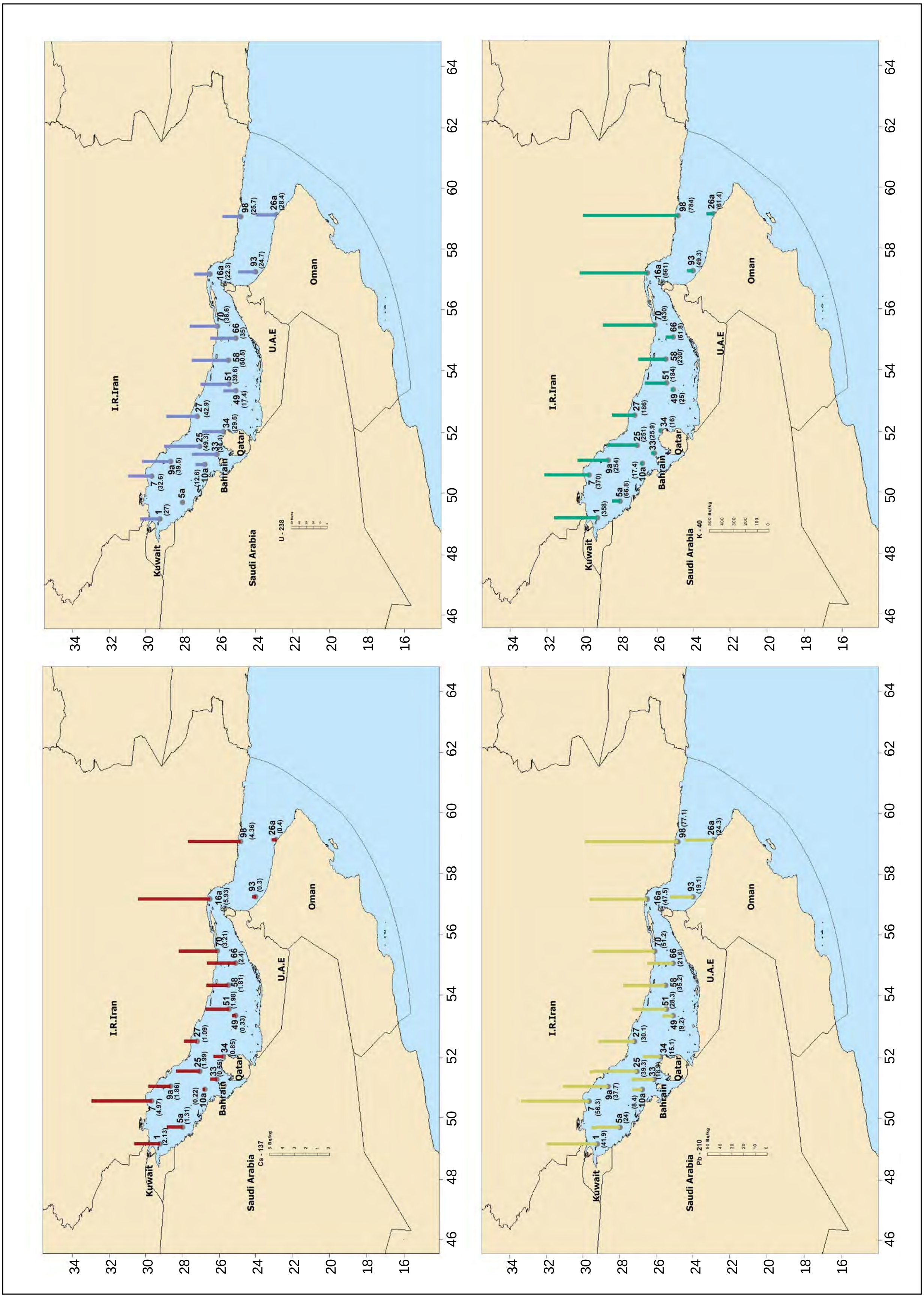


Figure 3.74 Radionuclides Levels in offshore sediments of the RSA during ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2014)

vii Status and Trend of Pollution in the Offshore Sediments

Cumulative percentage distribution plots were used to investigate pollution trend from 2001 to 2006 in the RSA. Among 35 sites which were surveyed in ROPME summer 2001 cruise, 33 sites were revisited during winter 2006 cruise and these data were used for the comparison. The results are shown in Table 3.8. From this table it is evident that the total petroleum hydrocarbons, HCHs and Hg exhibited a decreasing trend. But PAHs, HCB, total DDTs, As, Cr, Pb, Ag, and Zn exhibited an increasing trend while it was difficult to find significant trends in other pollutants.

The status of pollution by different classes of contaminants in the offshore sediments in the RSA is summarized in Box 3.12.

Table 3.8 Temporal trend of different classes of contaminants in the RSA. (Source: ROPME, 2006)

Target Pollutants	>ERL (n=75)	>ERM (n=75)	Trend (2001 - 2006) (n=35)
Oil Pollution			
Total PAHs			Increased
HMW PAHs			Increased
LMW PAHs			Increased
Total pH			Increased
Organochlorines			
Total PCBs (33 Congeners)			Decreased
Total PCBs (Arochlors)			Decreased
HCB			Increased
Total HCHs			Decreased
Total DDTs			Increased
Trace Elements			
As	13	0	Increased
Cd	1	0	-
Cr	57	1	Increased
Cu	3	0	-
Pb	1	0	Increased
Hg	0	0	Decreased
Ni	12	S2	-
Ag	0	0	Increased
Zn	2	0	Increased

BOX 3.12 – Status of Contamination of Offshore Sediments in the RSA

Oil Pollution:

The RSA is characterized by background levels of natural hydrocarbons derived from mixed autochthonous and terrestrial origin, with low levels of anthropogenic input of degraded petroleum hydrocarbons. The pattern of n-alkanes showed an unusual distribution dominated by the long-chain homologues (C27, C29, C31, C33, and C35) derived from terrestrial higher plant waxes. There was much higher contribution of low molecular weight (LMW) than high molecular weight (HMW) PAHs in the sediment samples, possibly indicating a petrogenic sources such as petroleum product from fuel spills or other discharges.

Organochlorinated contaminants:

The levels of total DDTs, total HCHs, and total PCBs in sediments are relatively uniform except for a few sites. The only site in RSA where comparatively high concentrations are obtained are at one site along the Saudi coast for total DDTs and for total HCHs, and at another site along the Iranian coast for total PCBs. Overall, the concentration of organochlorinated compounds in the surface sediments in the RSA was relatively low by international standards.

Trace Metals:

The recorded metal concentrations are strongly correlated to the aluminum concentration in sediment, a good proxy for terrigenous material and the amount of fine-grained material present. Several metals (As, Cr, Ni) exhibited concentrations sufficiently high to exceed sediment quality guidelines. Such metals, at least in the case of Cr and Ni, undoubtedly have a high natural background in this mineral-rich region. However, anthropogenic activities, notably mining, may have further enhanced the metal burdens in the sediments of the RSA. On the other hand, several metals (Cd, Pb, Hg, Ag) have relatively low levels that pose no environmental concerns.

3.2.3 ROPME Mussel Watch Programme (RMW)

Mussel Watch is usually initiated in response to increasing public and scientific concern for the quality of the marine environment and is being used successfully worldwide as a tool for orienting environmental monitoring activities in a country or in a region towards priorities and integrated coastal zone management.

To ensure the continuation of contaminants screening in the ROPME Sea Area, it was found important and useful to initiate and implement a “Mussel Watch Programme” for the Region.

The first complete round of the programme was conducted successfully during early 2011 when sediment and bivalves samples were collected from designated 22 sites along the coast of the RSA (Table 3.9 and Figure 3.75). Preliminary, the target analytes for the programme was focused on the monitoring of organic contaminants and trace metals and then refocused to include the survey of organotins and radionuclides while planned to consider biotoxins in future. The target bivalves for the programme were:

- Rock oyster (*Saccostrea cucullata*) from I.R. Iran, Oman, UAE
- Pearl oyster (*Pinctada radiata*) from Bahrain, Qatar and UAE
- Venus clam (*Circentia callipyga*) from Kuwait
- Asiatic clam (*Meretrix meretrix*) from Saudi Arabia

Table 3.9 Mussel watch sampling sites (February – March 2011). (Source: ROPME, 2013a)

ROPME Member State	Site		Coordinates	
	Name	**Code**	**Lat**	**Long**
Kingdom of Bahrain	***Askar ****	BAH-5	26° 03.105’N	50° 37.805’E
	Jazirat Ya'suf	BAH-8	26° 06.276’N	50° 26.621’E
	Marwada	BAH-9	26° 18.796’N	50° 26.566’E
Islamic Republic of Iran	***Lenge Port ****	IRAN-4	26 31’360N	54 49’742E
	Qeshm	IRAN-2-0	26 50’196N	56 08’002E
	Parsian	IRAN-2-2	27 07’ 201N	53 01’438E
	Daier	IRAN-2-1	27 49’901N	51 54’981E
	Bushehr* (Rostami port)	IRAN-2	28 50’ 063N	50 52’ 507E
State of Kuwait	***Newaiseeb***	KUW-0	Not Available	
	Doha *	KUW-5	29°22’N	47°49’E
	Fahaheel*	KUW-9	29°05’N	48°08’E
Sultanate of Oman	***Mirbat****	Oman -8	17°00’N	54°40’E
	Masirah	Oman -8-1	20°40’N	58°50’E
	Qalhat	Oman -8-2	22°45’N	59°20’E
	Mina Al-Fahal *	Oman - 2	23°37’N	58°33’E
	Khasab	Oman- 2-2	26°11’N	56°14’E
State of Qatar	***Palm Island-Doha****	Doha-4-1	25°28’N	51°31’E
	Ras Laffan*	Doha-4-2	25°53’N	51°36’E
Kingdom of Saudi Arabia	***Ras Tanura***	KSA-3	26° 41’ 092 N	50° 04’ 083E
	Ras Mishab *	KSA-2	28° 11'269N	48°37' 846E
United Arab Emirates	***Umm Al-Qaiwain ****	UAE - 7	25°35’N	55°33’E
	Dubai	UAE-7-1-2	25° 16' 915N	55° 17' 520E
	Dubai	UAE-7-1-1	25° 17' 374N	55°16' 373E

* Locations sampled during the ROPME Contaminants Screening Project (1994-2005)

Figure 3.75 Mussel Watch sampling sites during 2011 (RMW-2011). (Source: ROPME, 2013a)

The obtained analytical results of the monitoring of different target analytes can be summarized as follow:

i. Trace Metals

In general, the observed levels for the monitored 22 trace elements in sediments (Figure 3.76) and bivalves (Figure 3.77) were not exceptionally important and were within the range reported previously (Basaham and Al-Lihaibi, 1993; de Mora *et al*., 2004a), with the exception of the oysters from Dubai (UAE-7 - 2) where the concentration of Cu in oyster is about two times higher than that observed in the same species from other sampling sites. Some differences in the concentrations of Hg, Ni and Pb were also found between different bivalve species. Whilst comparing results from the 2005 and 2011 contaminant screening, few differences could be underlined, particularly for Askar (BAH-5, site close to BAPCO). Sites close to the BAPCO refinery (BAH-4 and BAH-5) show very high level of Pb in sediment collected in 2005, while level for 2011 is below the Effects Range Low (ERL) level. The usual high levels of Cr observed on certain sites (de Mora *et al*., 2004a) were not present in 2011.

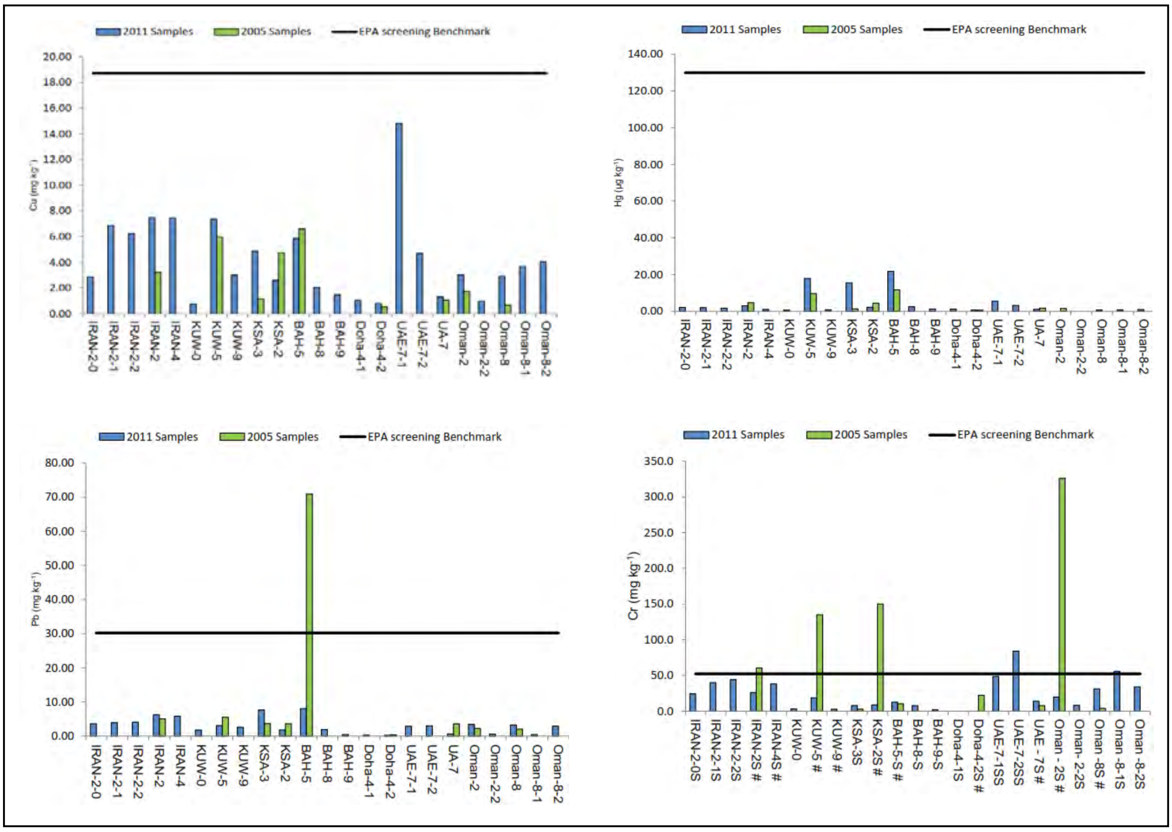


Figure 3.76 Some observed levels of trace metals in sediments during 2011. (Source: ROPME, 2013a)

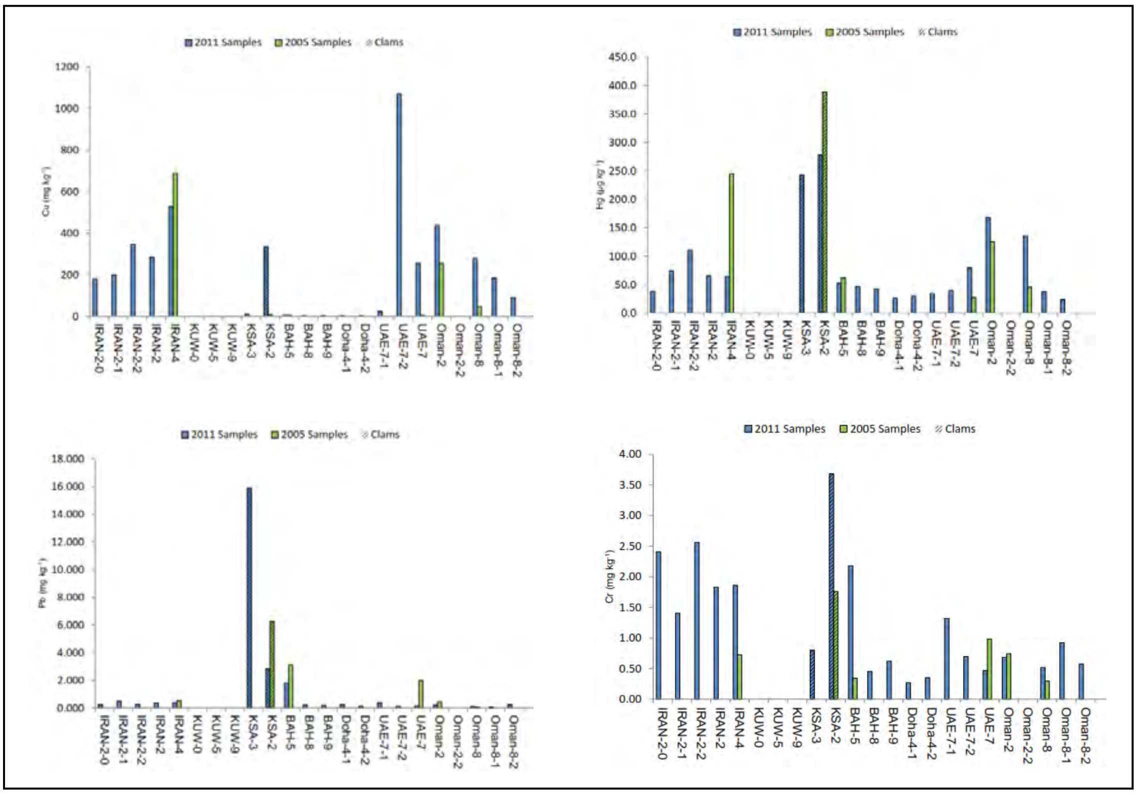


Figure 3.77 Some observed levels of trace metals in bivalves during 2011. (Source: ROPME, 2013a)

ii. Organic Contaminants

a. *Oil Pollution*

The present screening results on oil pollution from the seven countries surveyed in 2011 indicates that oil pollution is only a problem in some limited areas of the RSA. The trends in total petroleum hydrocarbons (TPHs) in sediments and bivalves as ROPME Oil Equivalents (ROEq) were generally higher in I.R. Iran, Saudi Arabia, Bahrain and Kuwait than in Oman, Qatar and UAE (Figure 3.78).

Extremely high concentrations of combustion-derived PAHs were found in sediments from Doha (KUW-5) and to lesser extents in Fahaheel (KUW-9), Askar (BAH-5) and certain other sites in I.R. Iran and Saudi Arabia (Figure 3.79). High concentrations of petroleum hydrocarbons were also measured in bivalves from Qeshm (IRAN-2- 0), Mina Al-Fahal and Mirbat (OMAN-2 and OMAN-8).

Except for rock oysters from Qeshm (IRAN-2 - 0), Mina Al-Fahal and Mirbat (OMAN-2 and OMAN-8), the levels of PHs in various bivalve species were comparable to the concentrations observed in relatively unpolluted areas elsewhere in the world. Approximately twenty years after the greatest oil spill in the history, PH concentrations in biota have decreased to values reported before the 1991 War.

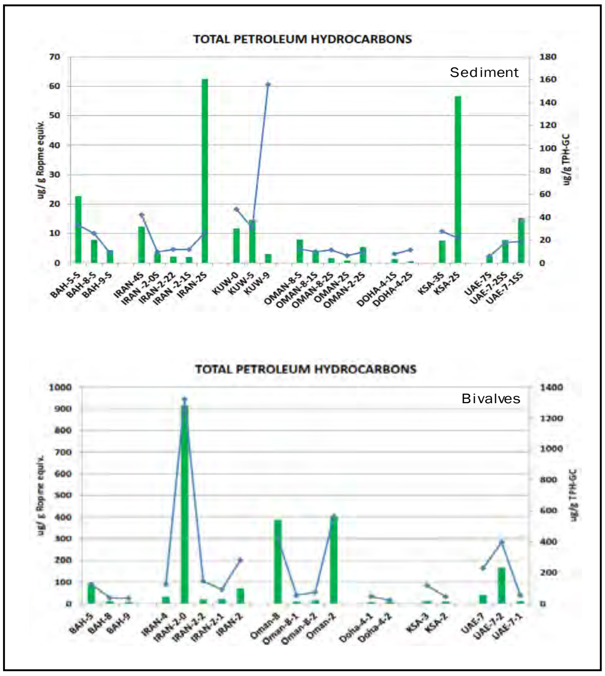


Figure 3.78 Concentration of Total PHs in nearshore Sediments and Bivalves from the RSA as ROPME Oil Equivalents (bars) and as the sum of Total Aliphatic and Total PAHs measured by GC (in lines) during 2011. (Source: ROPME, 2013b).

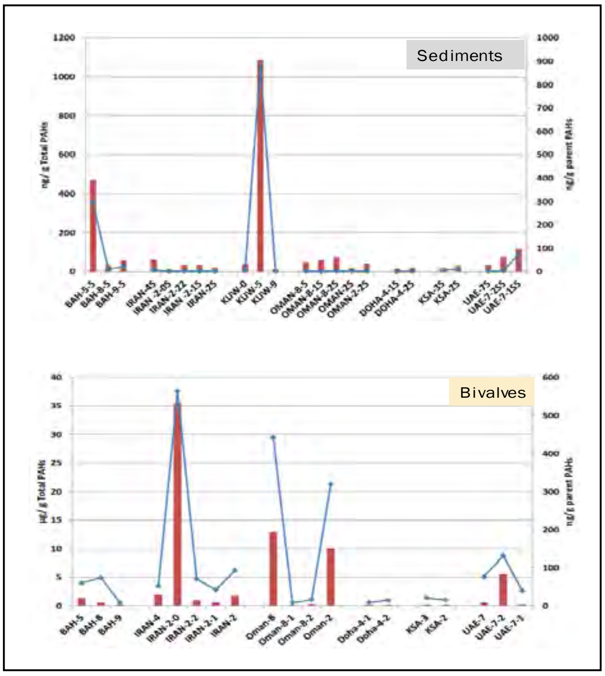


Figure 3.79 Concentrations of Total PAHs (in bars) and Total Parent PAHs (line) for the sediments and bivalves from the RSA during 2011. (Source: ROPME, 2013b)

b. Organochlorinated Contaminants

The measured organochlorinated compounds from agricultural (e.g. DDT and its breakdown products (Lindane, Endrin, Dieldrin, Endosulfan) and from industrial sources (PCBs) in bivalves and sediments in the RSA are generally presented in extremely low levels with some relative increase compared to the previous 2005 survey. Except for the high concentrations of DDTs in rock oysters from I.R. Iran (Figure 3.80), the organochlorine contents fell in the lower range of those reported as globally and probably reflects the atmospheric contamination of the area rather than the influence of coastal discharges. The historical relatively low, of Σ DDTs in the rock oysters from the Sea of Oman have remained uniform, there has been an irregular but generally decreasing trend in concentrations of Σ PCBs during the last two decades, followed by some relative increase in the samples collected more recently in 2011 (Figure 3.81).

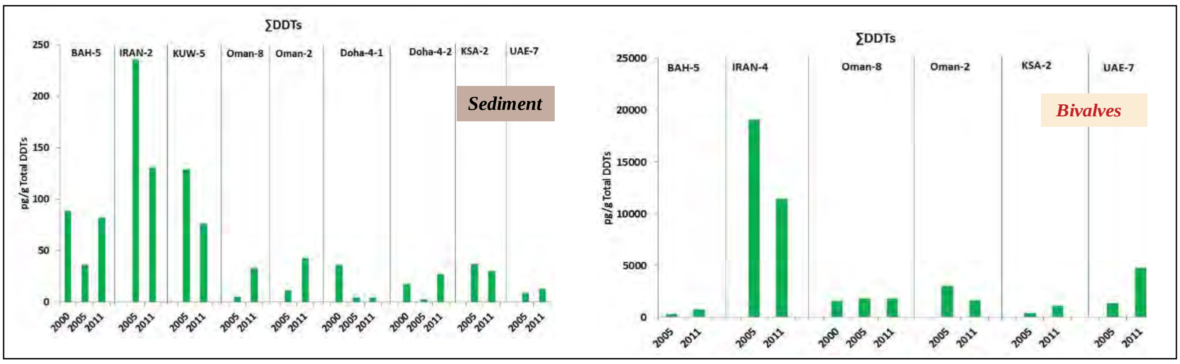


Figure 3.80 Temporal trend of ΣDDTs in sediments and bivalves from the RSA during 2011. (Source: ROPME, 2013b).

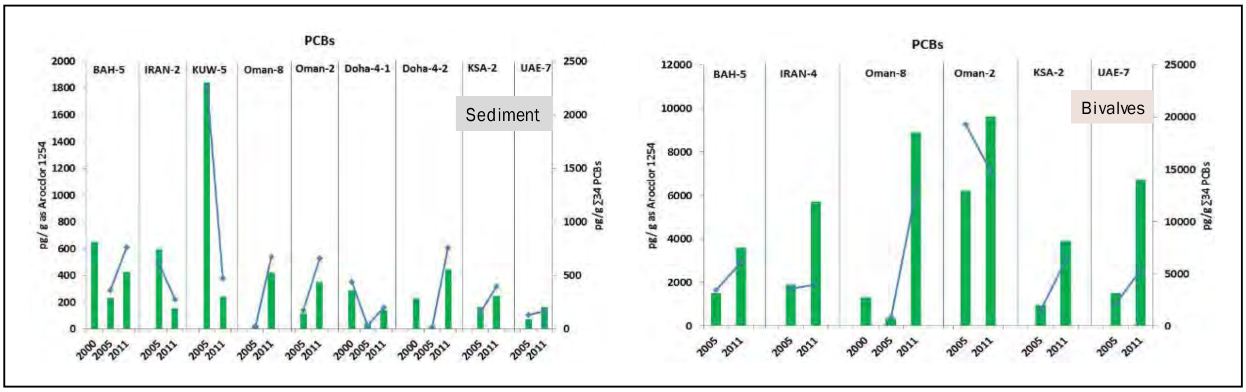


Figure 3.81 Temporal trend of T.PCBs in sediment and bivalve as Aroclor 1254 (bars, left y-axis) and as sum of 34 congeners (in lines, right-axis) during 2011. (Source: ROPME, 2013b)

c. *Organotin Compounds*

The concentration of butyltins (BTs) were very low in most sediments collected during the first Mussel Watch round and not exceeding the guideline level of <0.5 ng^{-1} as Sn. Only, the sediments from Rostami port in I.R. Iran (IRAN-2) and from Dubai (UAE-7- 1 and UAE-7- 2) presented measurable concentrations of butyltins (Σ BTs of 24, 17, and 4.5 ng g^{-1} as Sn, respectively), (Figure 3.82).

The measured levels of BTs in bivalves generally fall in the lower end of the range of typical concentrations and similar to those reported by de Mora *et al*. (2003) in the bivalves collected from Oman, Bahrain and UAE during 2000 and 2001. Only half of collected samples presented measurable concentrations of butylated tin. As shown in Figure 3.83, the measured ratios between TBT and DBT+MBT indicate a relatively fresh input of TBT in some sites as in Dubai (UAE-7.1 and UAE-7.2) and in Askar (BAH-5).

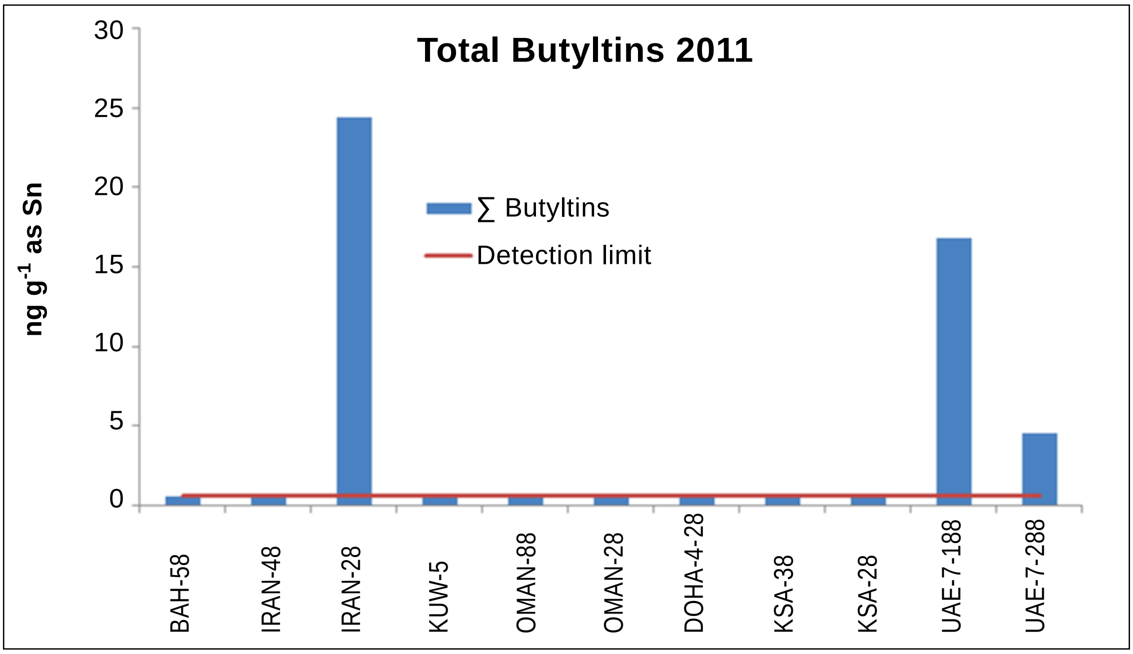


Figure 3.82 Total Butyltins in nearshore sediments of the RSA during 2011. (Source: ROPME, 2013c)

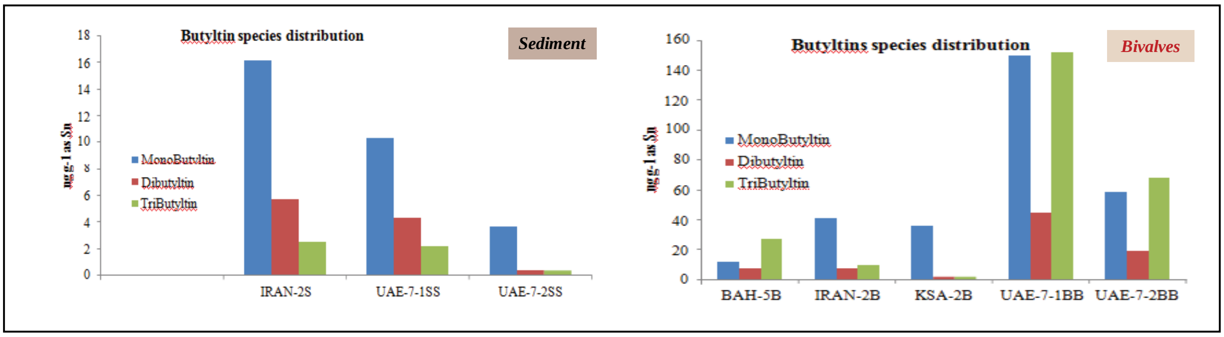


Figure 3.83 Butyltin species distribution in sediment and bivalves from selected sites in the RSA during 2011. (Source: ROPME, 2013c)

According to the adopted Ecotoxicological Assessment Criteria (EAC) values for TBT in water, sediments and biota (OSPAR, 2004), half of the analyzed bivalves contained TBTs amount below the EAC lower value (4.91 ng g^{-1} as Sn), while bivalves from Bahrain and I.R. Iran relate to an intermediate EAC value, meaning that some biological effects are likely to take place. Levels of TBT in rock oyster from Dubai (UAE-7- 2) was close to the upper EAC (71.7 ng^{-1} as Sn), while in pearl oyster (UAE-7 -1) exceeded the EAC upper level.

In general, and based on concentration limit in the Environmental Health Criteria (WHO, 1990), the present reported range of organotin concentrations in edible bivalves from the ROPME Sea Area pose no immediate risk to public health.

iii. Radionuclides in Nearshore Environment

In some nearshore sediment and biota samples collected during the Mussel Watch sampling of February 2011 (Figure 3.84), a preliminary assessment of some radionuclides has been conducted by the Radiometrics Laboratory (RML) of the International Atomic Energy Agency (IAEA). The obtained results represented in Figure 3.85 shows that the levels of ^{137}Cs are very low, as expected for the type of analyzed sediment and no particular patterns for the assessed radionuclides can be observed. This is confirmed by the measured levels of ^{40}K, which is characteristic for sand and sandy sediments in the presence of shells debris.

Figure 3.84 Selected sediment and biota sampling sites for Radionuclides assessment in nearshore environment in the RSA (RMW-2011). (Source: ROPME, 2014)

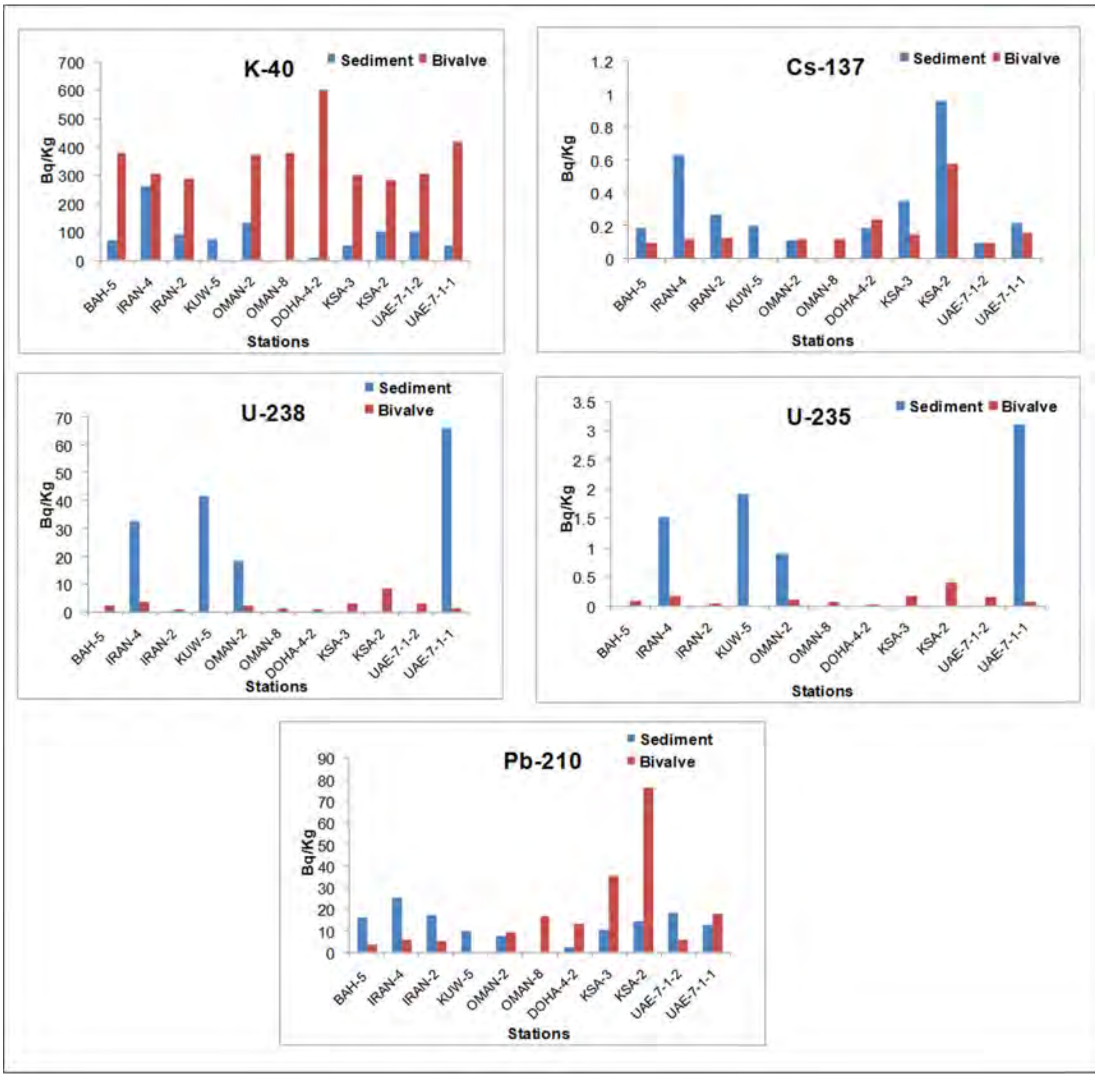


Figure 3.85 Radionuclides levels in nearshore sediments and biota of the RSA during 2011. (Source: ROPME, 2014)

In general, no particular observation can be made concerning the specific activities of the reported five radionuclides as compared to similar sediments elsewhere in the World Ocean (MARDOS, 1995) or in the ROPME Sea Area [Abdi *et al*., (2006), Al-Kheliewi and Shabana (2007), and Al-Sulaiti *et al*., (2010) Al-Zamel *et al*., (2005) and Zara *et al*., (2012)], other than that they are generally on the lower end of the reported levels.

vi. Reconstruction of Oil Pollution History in the ROPME Sea Area

In order to evaluate the effectiveness of the counter-measures taken against oil pollution in the Region during the last two decades, a study for the reconstruction of oil pollution history was conducted by ROPME in 2006. As it was difficult to collect fresh sediment cores when the study was recommended, four sediment cores were constructed from the stored sediment cores of Cruise 2001 and the fresh surface grab sediments collected during 2006 Cruise in the ROPME Sediment Bank. The positions of the four cores were selected along the med-basin of the I-RSA as shown in Figure 3.86.

Among the investigated cores, the superficial sediment of station 25 and in particular its eighth 1-cm section were heavily polluted, indicating a high contamination of degraded crude oil. By using diagnostic biomarkers ratios, the maximum concentration found at about 12–13 cm deep of station 25 was similar to the Kuwait reference crude oil which was spilled during the 1991 War. Moderately contaminated sections along the sediment core were also found in station 58, and in particular sections 4 and 9 showed substantial chronic contamination typical of degraded light bunker oil, with chemical diagnostic parameters similar to the Light Arabian crude oil. High concentrations of derived oil-PAHs were also found in the mid sections of station 58 (Figure 3.87).

Interestingly, all of the other superficial sediments of the four sites did not exhibit important signs of oil pollution. These substantial decreases in sedimentary levels of TPH and PAHs between 2001 and 2006, particularly at stations 1 and 58, could be partially attributed to improvements in emission controls and to the continuous substitution of oil fuels by liquefied gases. The PAHs distribution and concentration ratios were consistent with a petrogenic source of PAHs, and with a high proportion of alkylated PAHs. No apparent pyrogenic PAHs sources were observed, probably because the residual oil swamped out he low-level pyrogenic PAHs.

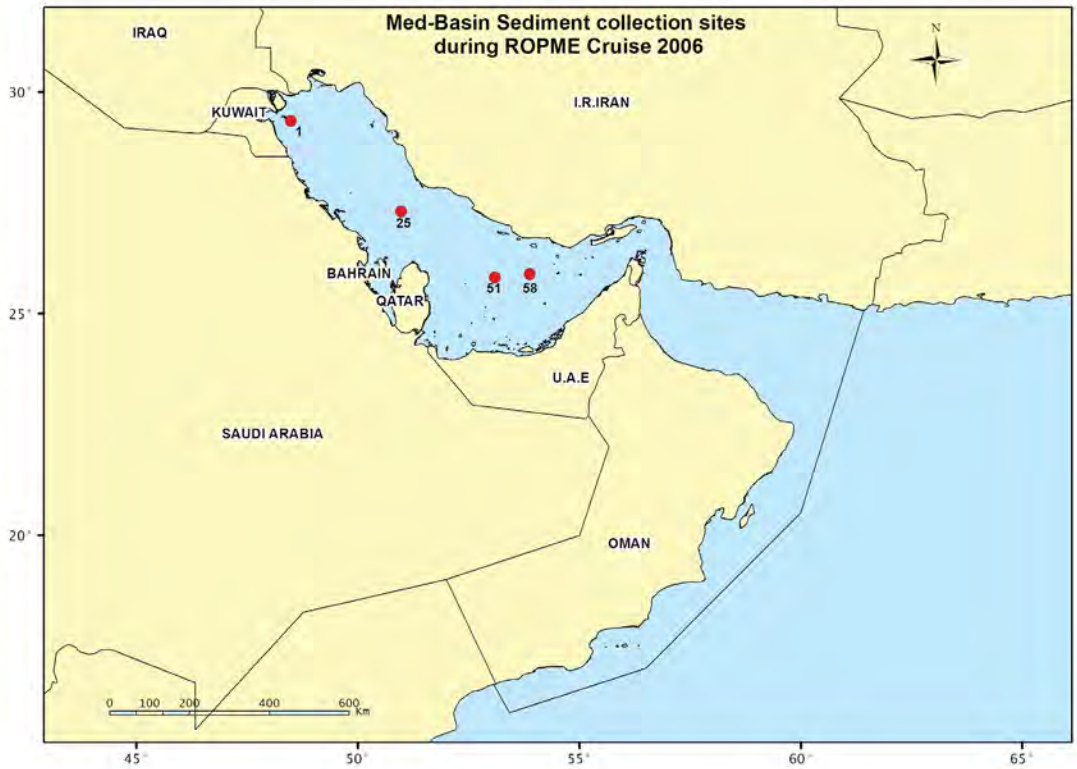


Figure 3.86 Positions of investigated sediment cores in the Inner ROPME Sea Area for the "Reconstruction of Oil Pollution History" during the ROPME Oceanographic Cruise - Winter 2006. (Source: ROPME, 2013d)

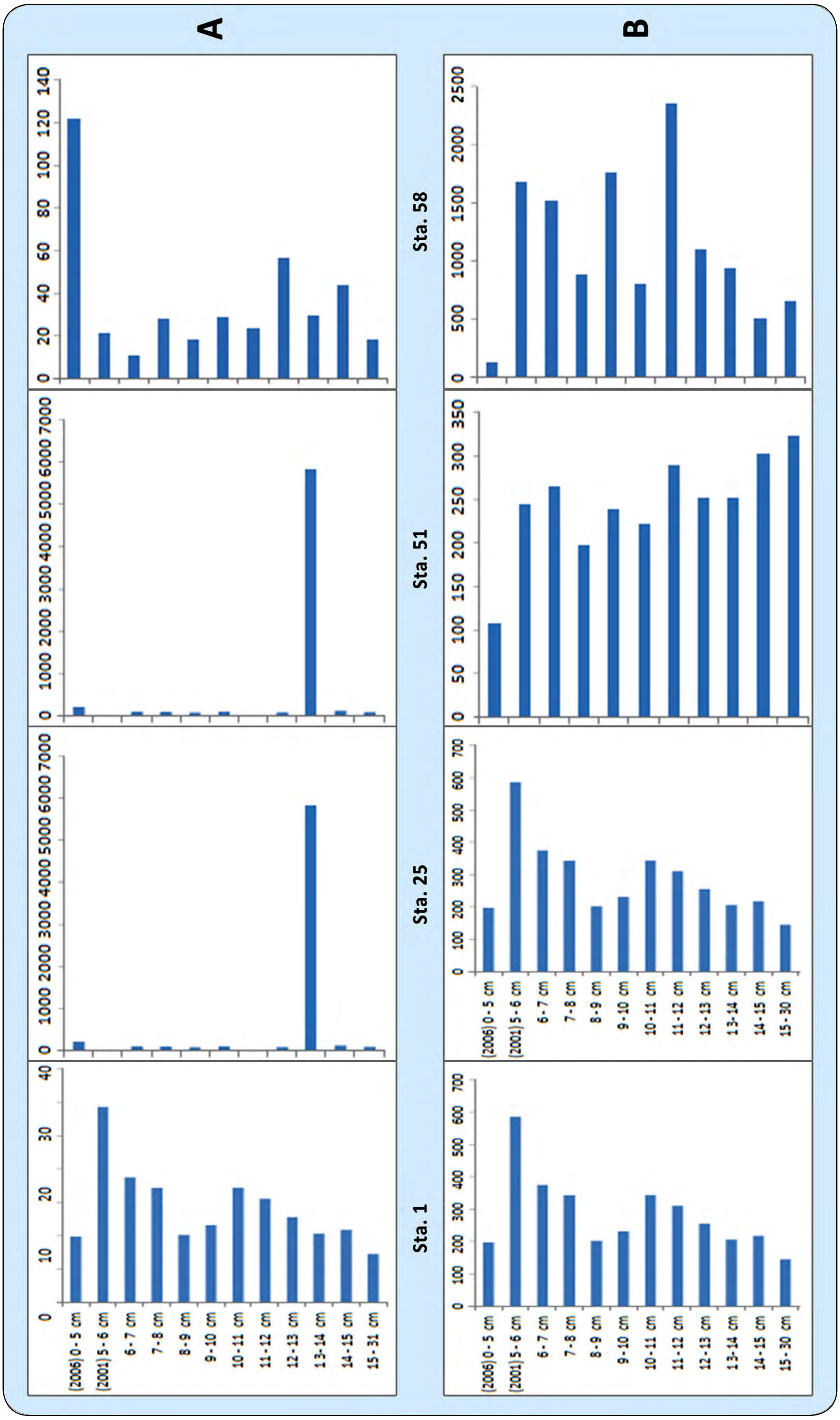


Figure 3.87 Vertical profiles of Total Petroleum Hydrocarbons in sediments along the med-basin of the RSA as ROPME Oil Eq in µg g^{-1} (A) and Total Polyaromatic Hydrocarbons (B) in ng g^{-1}. (Source: ROPME, 2013d)

3.3 HARMFUL ALGAL BLOOMS

In the last decade, the RSA has been witnessing increasing occurrences of Harmful Algal Blooms (HABs), with some of the incidents assuming disastrous proportion, resulting in fish kills and affecting coastal and marine environment services (Figure 3.88). In Kuwait, toxic species were reported in low densities in waters (A review for the HAB species and incidences in Kuwaiti waters is found in Al-Yamani *et al*., 2012). Whereas, during September-December 2008, several HABs incidents occurred on the coasts of UAE, Oman and I.R. Iran, causing huge losses to fishery and desalination facilities. Public inconvenience was wide and health effects were of particular concern. More recently, in 2010 and 2011 continuous plankton blooms have been observed during November throughout December in the RSA, including the inner part of RSA (Box 3.13).

ROMPE remote sensing observations indicate that the blooms are becoming an annual and widely spread feature in the O-RSA. In response to this increasing threat, since August 2008, ROPME has been providing the concerned Member States with early alerts and satellite images depicting intensive biological activity, algal patches with high chlorophyll concentration and Sea Surface Temperatures (SST) of the affected areas with warnings on the probability of possible HABs and marine mortality.

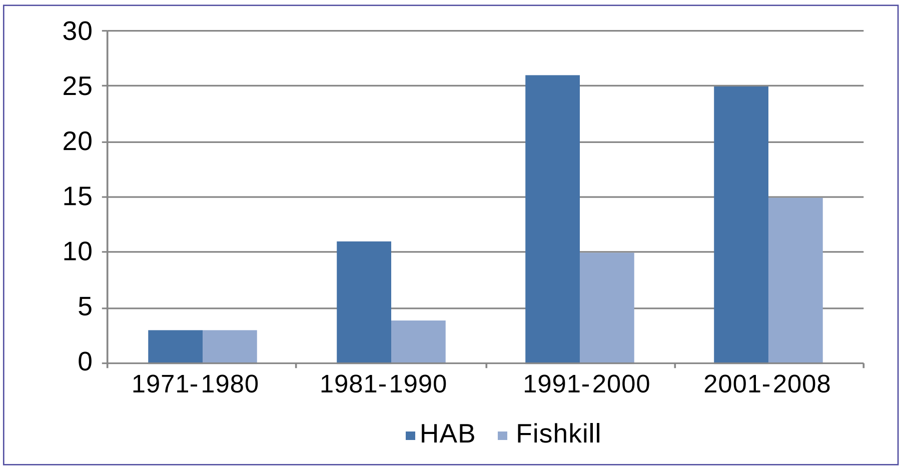


Figure 3.88 Inter-annual change and trend in the HABs and Fish Kill events in Oman. (Source: http://omansea.org/ Modified after Piontkovski)

3.3.1 Seasonal and Inter-annual Trends of Phytoplankton and Algal Blooms

Chlorophyll (CHL) is considered as an indicator of phytoplankton bloom in marine environment. A recent study reported that the seasonal CHL cycle in the I-RSA open water is characterized by winter maximum and summer minimum (Nezlin *et al*., 2010). From spring to autumn, the productivity of the IOSW increases due to seasonal upwelling in the Arabian Sea, due to South-Westerly monsoon (Levy *et al*., 2007). The southern part of I- RSA is likely to be affected by this increase more than the northern part.

One of the best documented examples is an episode that occurred, in autumn 2009, with a very intensive and prolonged bloom which had started in the southern reaches of the RSA in the fall of 2008 (Sale *et al*., 2011). Starting in the fall of 2008, a HAB initiated in the Sea of Oman expanded north along the Musandam coast and into the

BOX 3.13 – ROPME Harmful Algal Blooms (HABs) Related Activities

Manual for Investigating Marine Mortality Incidents in the ROPME Sea Area (RSA)

With marine mortality becoming a regular phenomenon in the Region, ROPME prepared a manual which is structured into four Chapters covering all the tasks necessary for the marine mortality studies, including sub-chapters for the elements of HABs studies on field procedures, sampling and preservation, methods for identification of species, sampling techniques for dinoflagellates' cysts from sediments, sample processing and analyses of cysts as well as general information on phytoplankton.

Regional monitoring by ROPME Remote Sensing

ROPME started providing its concerned Member States with early alerts and satellite images depicting intensive biological activity, algal patches with high chlorophyll concentration and Sea Surface Temperature (SST) of the affected areas with warnings on the probability of possible HAB events and marine mortality incidents, with a view to facilitate investigations and management actions.

Regional Meetings

ROPME has conducted regional meetings on Harmful Algal Blooms (HABs) during the periods of HABs incidents in the RSA. The outcome of these meetings has been the establishment of Regional Task Force, Regional Action plan, National Task Forces and National Action Plans on HABs.

Training Courses

ROPME has conducted a capacity building training programme for regional scientists on the identification and taxonomy of HABs species with the technical assistance and expertise from FAO and IOC-UNESCO.

Monograph on the taxonomy of phytoplankton species of the RSA

ROPME oceanographic cruises in the Region have given immense chances to trace out the phytoplankton species diversity, and their spatial occurrence and abundance in the RSA. The recorded 337 species as categorized into different groups on the basis of their natural characteristics, could help to identify the potentially causative as well as the alien invasive HAB species in the Region. The species collected during the oceanographic cruises were an important source for the preparation of a "Regional Monograph" on the taxonomy of phytoplankton species of the RSA which was published and distributed to Member States.

ROPME Integrated Information System (RIIS)

ROPME has an Integrated Information System (RIIS) with various components. A regional portal/module dedicated to HABs in RIIS is given special attention.

ROPME's Regional Action Plan on HABs

ROPME's vision is to protect the coastal and marine environment, marine living resources, human health and related interests of its Member States from the effects of HABs through scientific, technical and regulatory means of consensus and foresight. The Regional Action Plan (RAP) contains activities for HABs monitoring, early warning,

BOX 3.13 – (Contd...)

control and mitigation of all HABs vectors, with particular focus on the alien invasive species introduced by ships' ballast water and sediments. RAP also assigns priority to early warning, risk assessment of HABs/Alien Invasive Species and the conduct of scientific baseline studies and modeling.

HABs and related Marine Mortality Reporting Formats

ROPME has prepared two sets of reporting formats for recording HABs and related marine mortality, one for initial and immediate reporting and the other for final reporting of the Member States. The initial reporting format is a single page form requesting general information on location and date of incident, the species involved, as well as information on environmental conditions prevailing at the time of the incident. The final reporting format includes six forms, namely, HABs toxicity information; on-site specific information; water analysis of off-site measurements; sediment analysis of off-site measurement; biota of off-site measurement; and socio-economic aspects of marine mortality.

Other Activities and Achievements

ROPME has published useful information on HABs/Alien invasive species as brochures, calendars and posters for public awareness purposes.

ROPME is to assign Regional Reference Laboratories for the investigation, standardization and quality assurance related to HABs taxonomy, toxicology and integrated research.

Inner RSA as far as the shores of Dubai by the end of 2008, eventually dissipating by August 2009. The dominant species in the prolonged bloom was *Cochlodinium polykrikoides*, a fish-killing species common in other areas throughout the world. This was the first confirmed report of this species in the I-RSA (Richlen *et al*., 2010). While the fish-killing attributes of *C. polykrikoides* are well known, this bloom also damaged other marine fauna, particularly the hard coral communities and the associated fish fauna (Bauman *et al*., 2010). Richlen *et al*., (2010) confirmed that the outbreak was due to a strain of *C. polykrikoides* that was commonly found in American and Malaysian waters - indicating the global expansion of this invasive species, probably through ballast water discharge (Richlen *et al*., 2010).

MODIS observations, monitored by ROPME's Ground Station (Box 3.14), are showing eddies and currents with an important role in the production and dispersing of this phenomena in the RSA. Seasonal and interannual variability of remotely-sensed chlorophyll in the RSA can be explained by local meteorological and oceanographic factors, including vertical stratification, precipitation, and aeolian dust transport. The periods of low precipitation in 2000 and 2008 coincided with aerosol properties indicating elevated level of dust deposition over the surface resulting in phytoplankton blooms in the open waters. Dust fertilization was suggested to be an essential factor regulating phytoplankton growth in the RSA (Rao and Al-Yamani, 1999). The intensity of aeolian dust deposition (supposedly associated with iron micronutrient) may play an important role as a factor regulating phytoplankton variability in the area. The frequency of dust storms in the region increased during the last decade due to several natural and man-made causes, such as the drainage of Iraqi Marshes, military activities, and global climatic changes.

In addition, data collected by the Ministry of Agriculture and Fisheries (Oman) on fish kill and HABs were averaged over decades. Apparently, the tendency to increase was well pronounced for both characteristics (Figure 3.89). A significant feature implied by this analysis is the ratio between HABs and fish kills incidents. Throughout four decades, the frequency of HABs has exceeded the frequency of fish kills. This means that not all HABs had caused fish kills. Nevertheless, the causative pattern of this relationship makes its way throughout the decades of observations; in the latest decade, more algal blooms had reached the HAB category and the number of fish kills had increased and become more associated with HABs, in comparison to the three earlier decades (http://omansea.org, Access on 16 July, 2011).

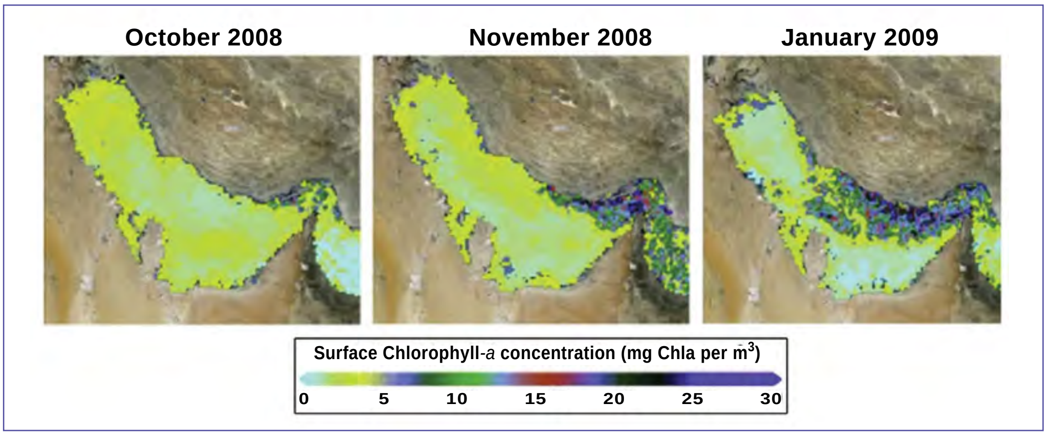


Figure 3.89 Progression of the 2008–2009 Harmful Algal Blooms (HABs) in the RSA. (Distribution of chlorophyll-*a* concentration is shown for October and November 2008, and January 2009. Initially present along the eastern coast of Oman, it developed west of the Strait of Hormuz, particularly along the Iranian coast, and also down the coast of the UAE.)

The I-RSA, being an enclosed, shallow body of water experiencing increasing human influence, is susceptible to HABs. The busy maritime traffic can provide a channel for the invasion and establishment of new algal populations, through possible discharges of ballast water into the warm stable waters with elevated nutrients of the Region (Hamza, 2006; Sale *et al*., 2011). Construction of further protected lagoons, power/desalination plants, ports and marinas, and increases in anthropogenic discharge, combined with projected, episodic warming events (Sheppard *et al*., 2010), may create suitable conditions leading to the expansion of HAB events throughout the I-RSA (Sale *et al*., 2011).

The catastrophic impacts of HABs clearly illustrate the need for coordinated regional monitoring programmes for HAB species, as well as development and test of protocols and/or technology to prevent the closure of desalination plants during severe HAB events.

BOX 3.14 – Remote Sensing Applications in RSA

Remote Sensing Applications in RSA

In the year 2003, ROPME established its first Regional Satellite Ground Station. The station receives NASA's EOS Terra and Aqua MODIS Direct Broadcast to enhance its capabilities of maritime monitoring. In addition to archiving the near real time data received from MODIS, the remote sensing unit of ROPME also houses an extensive satellites archives belonging to NOAA, AVHRR, Landsat, Radarsat, Aster and Airborne data.

This data is undergoing regular validation processes through the regional network of the individual Member States, in the form of joint projects conducting in-situ measurements using various instruments like, for example, ROPME's hand held spectrometer.

The ROPME Region is characterized by a number of noticeable physical and biological events that are attributed to a number of factors like, anthropogenic and climatic. Amongst these events are the algal blooms / red tide, marine mortalities, oil spills / maritime accidents, dust storms and land-based activities. In addition, the coastal marine habitats, such as coral reefs, seagrass beds, mangroves are all important elements of the region's ecosystem.

With regard to oil spill and algal blooms monitoring, the station in cooperation with Focal Points of Member States, act as a regional early warning system in spill detection and algal bloom identification.

To further develop the skills and knowledge base capabilities of ROPME Member States in the field of remote sensing, ROPME has established a well equipped training center to provide professionals and academics with hands-on training sessions to all interested parties. The ROPME marine community has lent strong support to satellite remote sensing techniques that have emerged over the last 10 years in the ROPME Secretariat.

Over the last decade, the RSA experienced repeated seasonal occurrence of massive algal blooms. The Station has coupled custom-developed thematic algorithms and processing, together with standard NASA MODIS products, to detect and map chlorophyll levels and algal blooms, especially floating algae, throughout the RSA in general, and particularly in the Sea of Oman, the Strait of Hormuz and the Southern part of Inner RSA (See Figure). The Station has been actively monitoring the phenomena, and issuing Early Warning Alerts of any unusual biological activity, especially massive algal blooms and red tide, and relevant marine mortality. Most of the reported cases in the Region are related to *Noctiluca* species. The current capabilities of the Station allow for differentiating of the main types of surface algae: green, red and brown tides, with better resolution than standard MODIS Ocean colour biogeochemistry products.

ROPME is planning to develop new channels to make near real-time regional remotely sensed data/products more accessible to Member States and relevant interested scientific and industrial entities. It also aims at expanding the overall operational use of data processing and state-of-the-art remote sensing technology in the ecological monitoring of the RSA, and within the global context.

Detailed information on the yearly events observed by ROPME's Remote Sensing facility are available upon request of interested Member States.

Observed major algal bloom incidents by ROPME for the period 2005- 2012.
(Source: ROPME Remote Sensing Ground Station)

3.4 ENVIRONMENTAL SENSITIVITY

In 2010 MEMAC carried out a study on environmental sensitivity to identify the Marine Environmental High Risk Areas (MEHRAs), which are at risk from shipping in the RSA (MEMAC, 2010a). The project combined shipping risk assessment with a review of the environmental sensitivity of the coastline to identify candidate MEHRAs for each Member State.

The objective of the ranking process was to classify each country's coastal and sea areas, according to environmental sensitivity using a detailed GIS grid, categorizing sites according to several parameters including wildlife designations and sites of cetacean sightings in Oman, vulnerability of seabirds to oil pollution at identified sites;

fishing data, including fish farms, shell-fishing areas etc. such as 6 shrimp breeding grounds within Saudi Arabia; amenity site and beach locations in Kuwait, and both landscape and geological sites such as Bahrain inter-tidal sensitive areas, including Heritage Coastal, National Parks and Areas of Outstanding Natural Beauty, such as the RAMSAR Sites of Iran, UNESCO Tentative List Sites in Qatar and Al-Yasat protected area in UAE.

Due to the varying quantity and quality of environmentally sensitive data sets available per country, it was not appropriate to apply a universal ranking for the whole region, the ranking was carried out for each country separately as the environmental sensitivity data available per country varied in quantity and quality, hence, the environmental scores also varied, which means the MEHRAs scores are not directly comparable.

Higher scores are attributed to the presence of vulnerable areas, features or important resources within each cell. For example, a cell may contain seagrass, which will support a wide variety of marine wildlife such as shrimp, turtles and dugong populations.

In the Figure 3.90, the eastern coast of Bahrain Island has been given a high score due to the presence of sea grass, corals, sea turtles, dugongs and a number of water intake pipes for desalination facilities. Sea cells to the north of Bahrain have a relatively low score due to the lack of major habitats and / or marine biodiversity, with the exception of cells containing the UNESCO World Heritage Sites (oyster beds). The candidate MEHRAs are on the east coast of Bahrain between Al-Muharraq and Sitrah, and near Ad Dur.

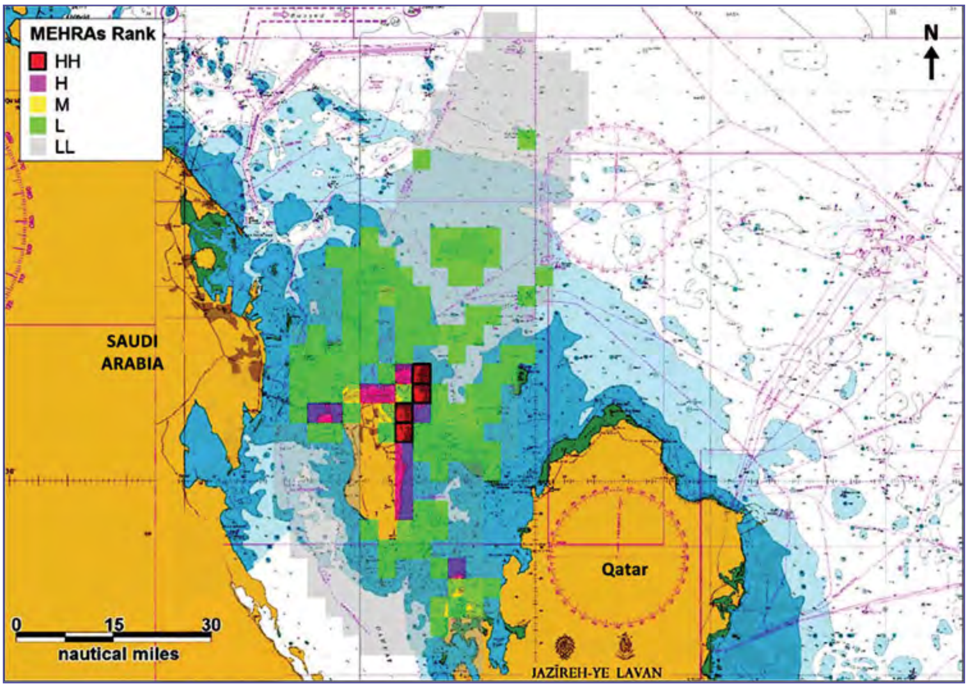


Figure 3.90 MEHRAs Ranking of Bahrain coastline. (Source: MEMAC, 2010a)

As for Iran, High sensitive areas include RAMSAR sites of the Shadegan Marshes, Sheedvar Island, Kuran Straits, Rud-e-Shur and Rud-e-Minab Deltas. Qeshm Island and Harra Mangrove Forest also increased the sensitivity score of the Khuran Straits region, due to the high biodiversity and being listed on the UNESCO World Heritage Site Tentative List. The candidate MEHRAs are widespread along the coast as shown in Figure 3.91.

The environmental sensitivity ranking for Iraq cells were based on scoring coastal cells as 5 and sea cells as 1 in the absence of any country-specific sensitivity data. The candidate MEHRAs is in the Khawr Abd Allah channel between Iraq and Kuwait. The Iraq assessment was dominated by pollution as the environmental scores were basic (Figure 3.92).

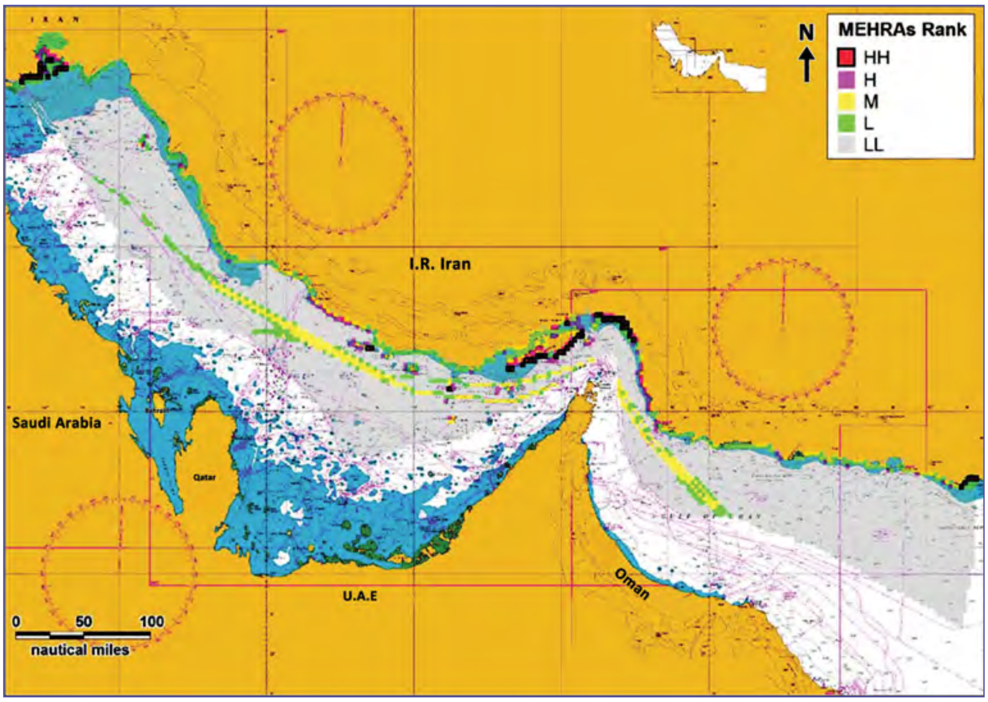


Figure 3.91 MEHRAs Ranking of I.R. Iran coastline. (Source: MEMAC, 2010)

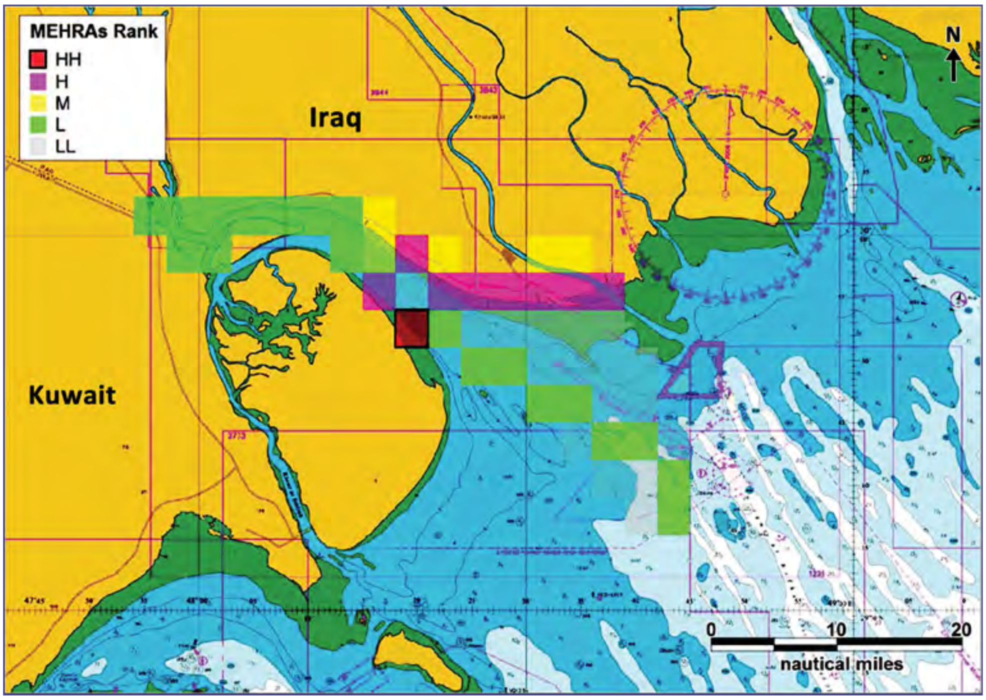


Figure 3.92 MEHRAs Ranking of Iraq coastline. (Source: MEMAC, 2010a)

Kuwait Higher sensitivity scoring cells have been attributed to the presence of: amenity beaches, coral reefs, desalination facilities, and some geological features. Candidate MEHRAs run along the east coast from Kuwait City southwards to the border with Saudi Arabia (Figure 3.93).

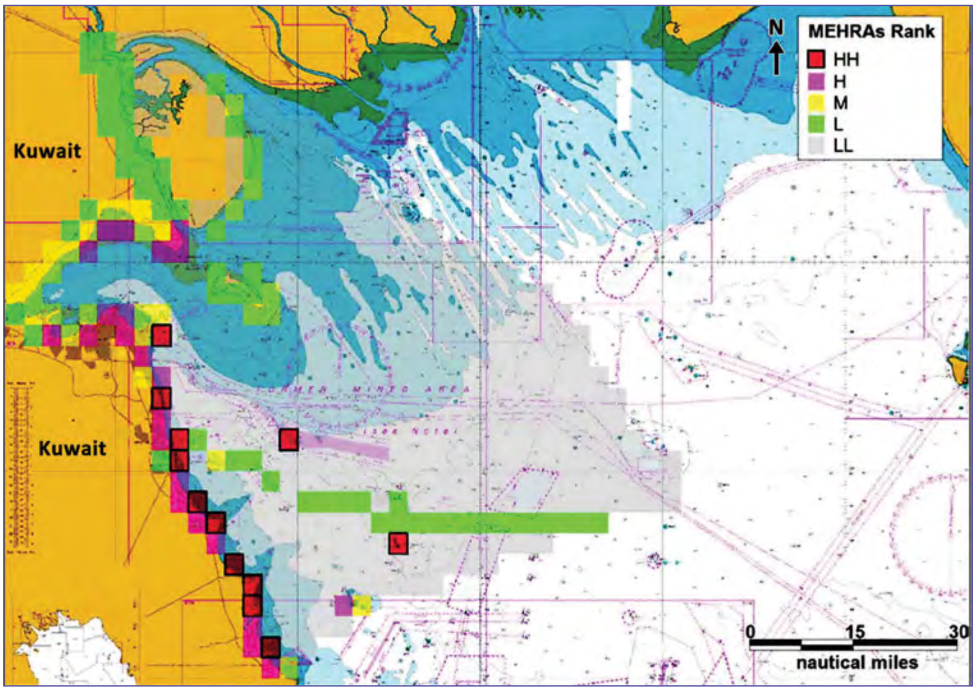


Figure 3.93 MEHRAs Ranking of Kuwait coastline. (Source: MEMAC, 2010a)

As for Oman, highly sensitive areas include the Kuria Muria Islands due to many species of cetacean, sea turtle breeding and feeding grounds, and regenerating corals within the island group. The coastline south of Ras Al-Hadd to Masirah Island is highly sensitive due to the topography, sand desert and Hufq. The Musandam Peninsula to the north is also highly sensitive due to the extensive coral mountainous geology. Candidate MEHRAs are distributed in various parts of the Omani coast as shown in Figures 3.94 a and b, particularly along the northern coast in the vicinity of the Strait of Hormuz.

One of the most sensitive areas of the Qatar Peninsula is near Khawr Al-Udayd to the south, due to being a sensitive tidal area. The Eastern coast of the peninsula is relatively sensitive due to the diverse marine habitats. Desalination facilities near Mesaieed, Al-Wakrah, Al-Khawr, Ra's Rakan and Umm Bab have increased sensitivity scores around the coastline. The candidate MEHRAs are on north and east coast of Qatar as shown in Figure 3.95.

Some of the highest sensitive areas in Saudi Arabia (Figure 3.96) are around Al-Jubail, Dammam and Saffaniyah. This is due to the presence of desalination facility water intakes, sea grass beds and shrimp breeding grounds, which may be associated with the presence of the seagrass beds. The candidate MEHRAs run intermittently along the coast between Ra's Al-Khafji in the north to Ra's Munaysuf in the south.

In the UAE, the most sensitive area to an oil spill is near the Al-Yasat Marine Protected Area to the south west of the UAE (Figure 3.97). Desalination and power plant facilities located near Abu Dhabi, Mina Jebel Ali and Dubai are also highly sensitive. Lagoons, mudflats and mangrove sites near Umm Al-Qaywayn have increased sensitivity along the north-western coast of the UAE.

MEHRAs project represents a big step forward in having a regional approach to assist in the management of oil spills and for the protection of the coastline. There has been a significant move towards forming a regional AIS network. This provides essential input to analysis work within this Region and MEMAC is working further on developing it.

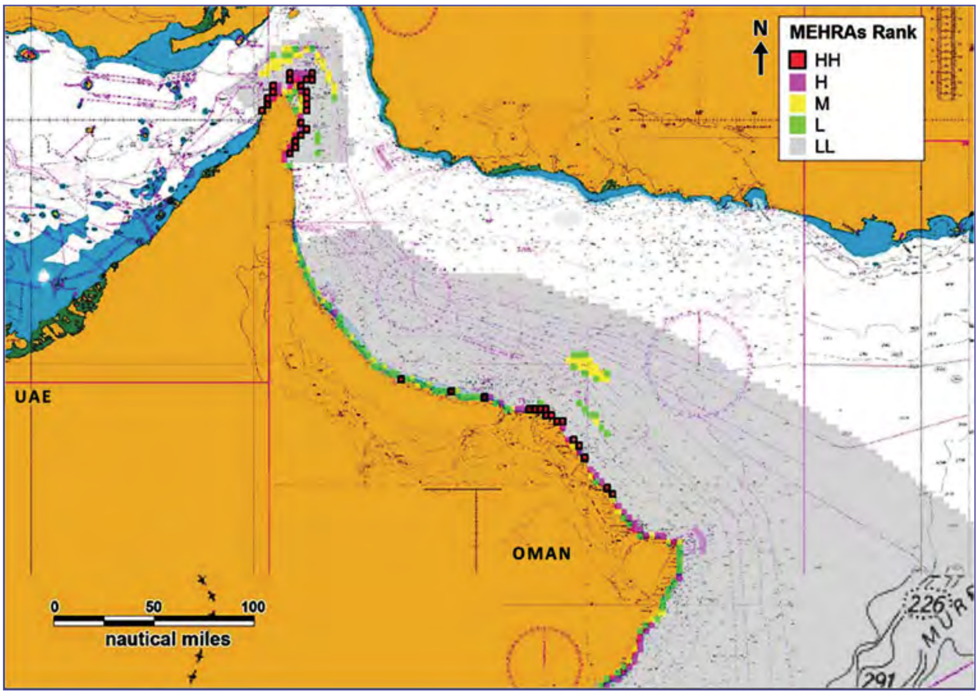


Figure 3.94a MEHRAs Ranking of Northern Oman coastline. (Source: MEMAC, 2010a)

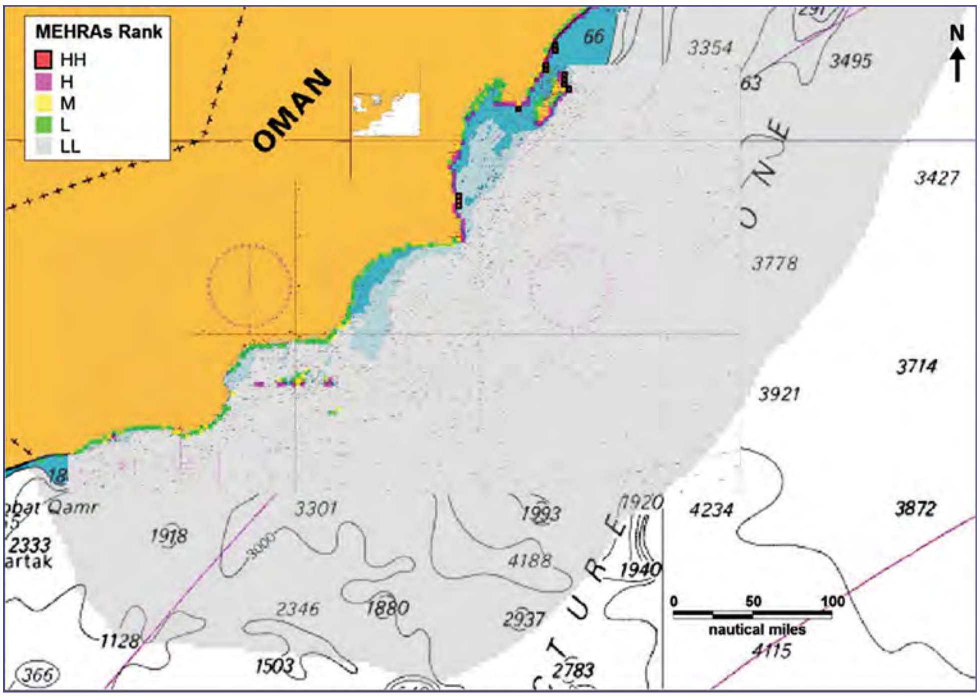


Figure 3.94b MEHRAs Ranking of Southern Oman coastline. (Source: MEMAC, 2010a)

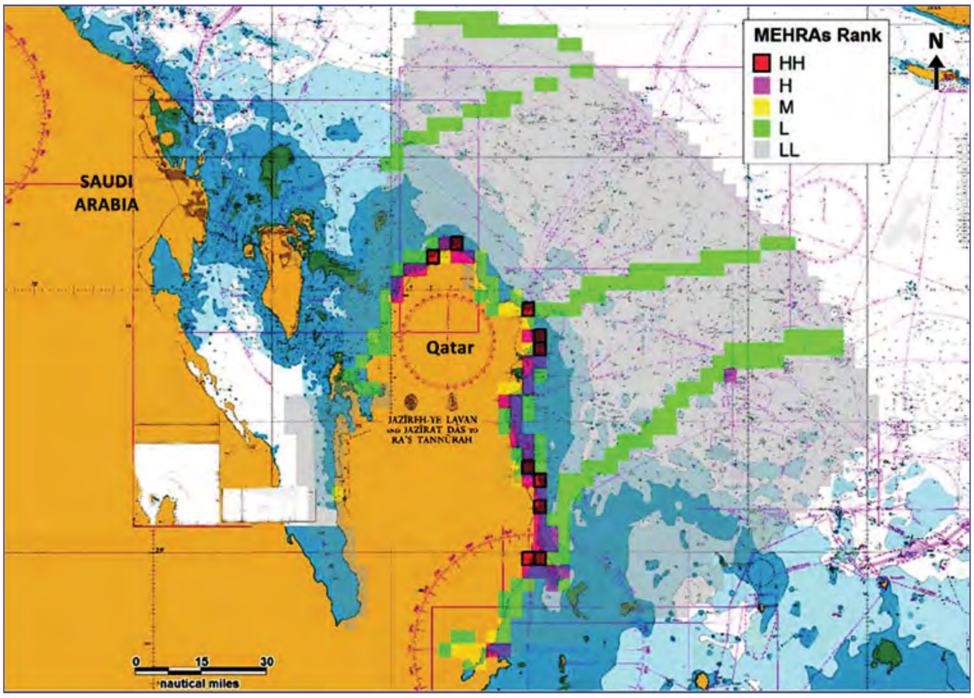


Figure 3.95 MEHRAs Ranking of Qatar coastline. (Source: MEMAC, 2010a)

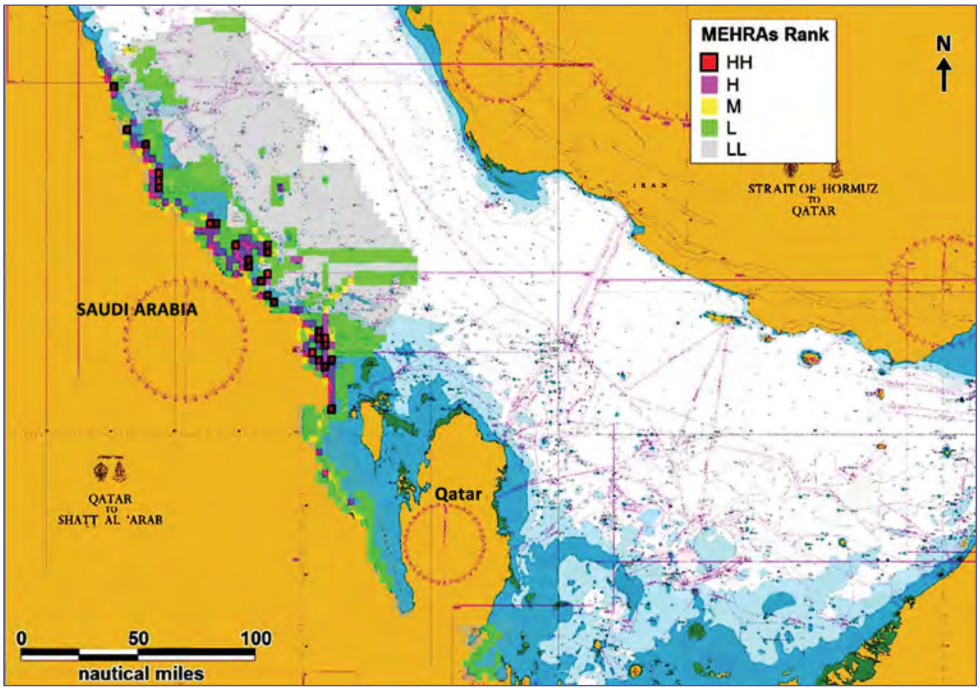


Figure 3.96 MEHRAs Ranking of Saudi Arabia coastline. (Source: MEMAC, 2010a)

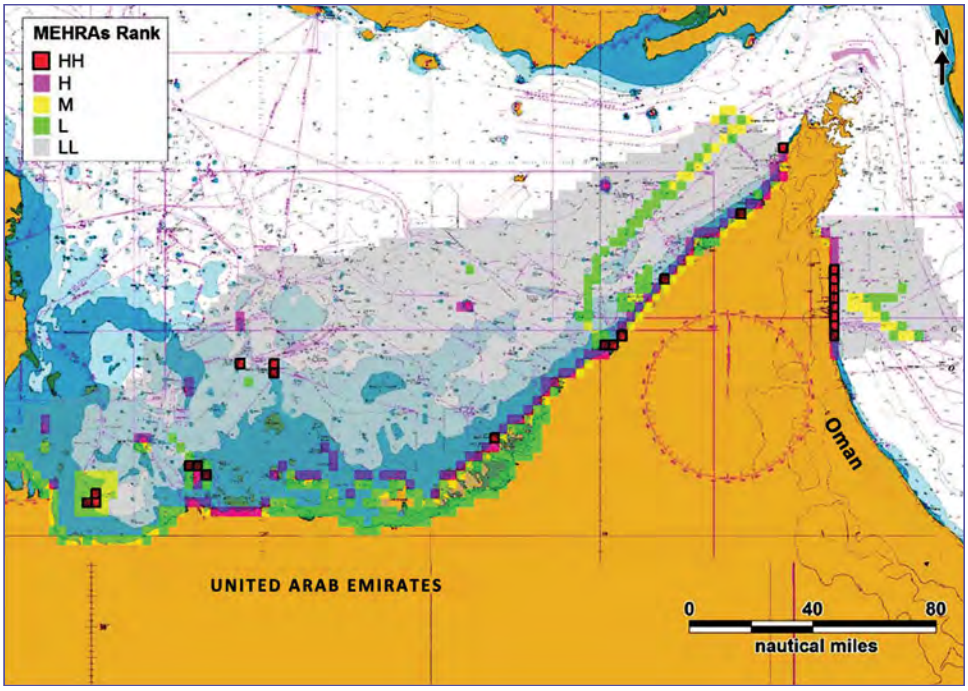


Figure 3.97 MEHRAs Ranking of United Arab Emirates coastline. (Source: MEMAC, 2010a)

CHAPTER 4

INTERLINKAGES

KEY MESSAGES

- Mega coastal developments and upstream dam building in the Region are by far much larger in proportions than those seen globally
- The reduction in freshwater influx from Shatt Al-Arab, the degradation of the basin, the erosion of the soil, the change in water quality and currents, and the drying up of the Mesopotamian marshlands, affect the biophysical and social systems
- The biophysical aspects include a number of challenges such as biodiversity loss, deterioration of water quality, and increased threats due to climate change
- The reduction/loss of habitats adversely affect fish landings and fish stocks, reducing catches, increasing the prices, affecting food security and the livelihood of coastal communities
- The environmental degradation may reach a point of no return, where societies lack the capacity to reverse the ecological degradation that undermines human well-being
- The coastal and marine environment as gets degraded due to human pressure, its ecosystem services will diminish and the resilience of the environment to endure impacts of climate change notably drops
- The economic valuation of coastal ecosystems and ecosystem services and the cost of degradation are good tools to quantify the benefits of conservation, and demonstrate the costs of degradation and damage to both livelihoods and economies
- The focusing on ecosystem services can enable authorities to identify and implement innovative financing to maintain those services

With the increasing interest and efforts towards achieving sustainable development, it is important to identify the complex interactions between environmental factors and some of the major pressures imposed by human development, and the impact of these interlinkages on human well-being in the RSA. The complex cause-and-effect interlinking analysis of the drivers, human activities and environmental changes can prove beneficial at the national and regional level, as decision-makers can select effective responses based on the outcomes of similar analysis, especially with regards to applying measures required to insure sustainability.

4.1 SOCIOECONOMIC DRIVERS

The exponential population increase in the RSA in the last few decades in general, and the further accelerated overall rate of increase in the Region's population by 49 percent in the last decade as detailed in Chapter 2 of this report, has imposed intensive pressure on the coastal and marine resources in the region. The related human activities are causing environmental changes that in turn influence the quality of ecosystem services and human well-being. For example, the increased population is coupled with increased demand on prime location with access to sea view. In many Member States on the west coast of RSA, more than 50% of the coastal areas are developed mainly for the obvious reasons of better climatological conditions and the easy access to recreational facilities in the case of urbanization, and to water resources and the proximity to ports and shipping services in case of industrial development.

Mega coastal developments in the Region are by far much larger in proportions than any similar development that is seen globally. Coastal landfilling and marine dredging activities are physically changing large sections of the coastline along the entire RSA, fragmenting the proper habitat of many organisms, decreasing the biodiversity in the Region and disrupting the entire food chain with cascading effects leading to greater reductions in fish stock.

Social and biophysical systems are dynamic, and characterized by thresholds, time-lags and feedback loops. Examples of possible tipping points in the RSA include the destruction of the natural habitats such as coral reefs, mangroves, marshlands, tidal flats, seagrass beds and estuarine ecosystems, affecting the ecosystem resilience and leading to episodes such as the partial collapse of the RSA fisheries and fish stocks and increasing frequency of red tide (UNEP, 2010).

4.2 LANDFILLING AND DREDGING

Developments along coastal areas in RSA are not recent, and date back to several decades. In the early years of coastal development, only financial considerations were studied; and environmental and social factors were not taken into account. Although the recent marine landfilling projects take into account environmental aspects through integrated environmental assessment studies, the huge size of landfilling projects for residential, tourism, and industrial purposes along RSA are threatening the sustainability of ecosystem services and human well-being.

Developing coastal areas leads to both structural and functional changes in the coastal and marine ecosystems. In most of the cases, mudflats and wetlands in particular are thought of being of lower economic value and filled and developed for industrial and domestic use. However, these ecosystems are of great value in maintaining hydrological balances, recharging freshwater aquifers, preventing erosion, and acting as buffer land from storms (Bishop, 2002; Khan *et al*., 2002; Khan, 2007; Jones *et al*., 2007; Munawar *et al*., 2002; Zainal, 2009).

Unfortunately, most development activities have been carried out on coasts which are known to be the most productive ecosystems especially from the biodiversity and fisheries point of view. For example, the areas of primary production (i.e. mud flats and seagrass areas) such as northern Bahrain, eastern Qatar and Kuwait Bay, are causing adverse effects on biodiversity and food chain. The major adverse environmental effects of dredging and landfilling are damaging spawning grounds of the various marine species, and causing serious damage to the seagrass beds, mangroves, and coral reefs due to increase in the turbidity and inhibition of photosynthesis.

By the early 1990s, over 40% of the coast of most RSA had been subjected to modification resulting in significant loss of biodiversity and productivity (Al-Ghadban and Price, 2002). This loss of habitat is now expanding even more rapidly with increasingly ambitious projects including causeways and artificial islands (Erdelen, 2007). Many projects involve massive deposition of material into shallow waters, resulting in replacement of several square kilometers of productive tidal flat by inert fill material. Creation of offshore islands and structures has involved destructive dredging of seagrass and algal beds whose ‘reclaimed’ material, taken from ‘borrow pits’ then further destroys other areas onto which it is dumped. Areas with constricted water flow, such as Dubai Creek, have become polluted, with grossly changed fauna (Saunders *et al*., 2007).

Moreover, some dredging activities have been carried out in areas where ground water was low laying causing intrusion of seawater into the aquifer such as Al-Batina in Oman and Eastern Bahrain. Landfilling also affects the general current pattern, water movement and water quality in the area. It increases the salinity of ground water due to mixing of seawater with ground water in the dredging areas and disconnection of natural drainage of irrigation water leading to rising water tables and increasing the salinity of agricultural soils.

The potential for these issues and to avoid reaching a point of no return where societies lack the capacity to reverse the ecological degradation that undermines human well-being and social stability, is the urge that interlinkages need to be kept under close review.

4.3 WATER DEMANDS, DESALINATION AND POTENTIAL IMPACT ON FISHERIES

The same drivers are leading to increased demands on natural resources, such as water and fisheries, placing tremendous pressure on the marine environment. The Region is being stretched beyond its carrying capacity with the influx of expats working in the various oil and related industries, as well as all of the other domestic and commercial sectors flourishing with the oil boom. This is reflected in the increased demands on water and energy (Figure 4.1).

It is estimated that around 70% of freshwater needs in the RSA are met through desalination, reaching almost 100% in Kuwait and Qatar. This socioeconomic importance of desalination/power plants masks their adverse environmental impact on the adjacent marine ecosystem. Desalination has a high environmental cost (Purnama *et al*., 2005). The combined seawater desalination capacity in the RSA countries exceeds 11 million m^3 per day, which is 45% of the total world capacity (Lattemann and Hopner, 2008), equivalent to 15% of the former flow of the Euphrates. This water may be brine (from desalination plants) and is commonly hot, and often also contains pollutants including biocides introduced to prevent pipe corrosion and conduit biofouling. Moreover, the concentrated brine; and chlorine, bromate, and heavy metals discharges to the marine environment, and a subsequent increase in water temperature and salinity, are the most obvious environmental threats associated with the process of desalination in the RSA (Hoepner and Lattemann, 2002; WHO, 2006). In April 2009, Saudi Arabia opened the world's largest desalination plant in the Jubail II Industrial Zone in the country's Eastern Province. The US$ 3.8 billion plant is designed for daily outputs of 800,000 cubic meters of water and 2,750 mega watts of electricity. In addition, it may actually increase Green House Gasses emissions. It also affects the air quality through the emission of CO_2 as well as Non-CO_2 emissions such as SOx and NOx.

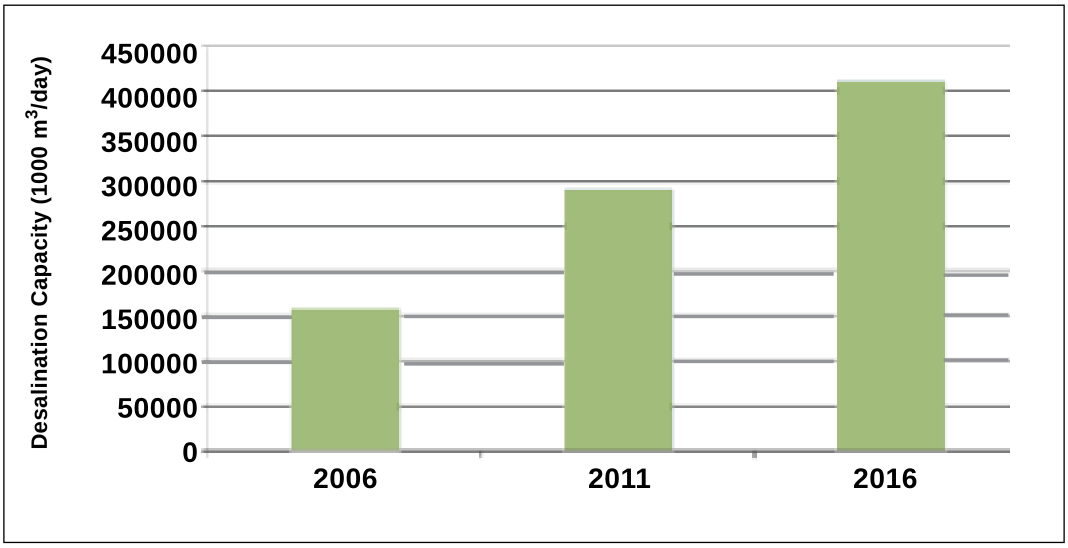


Figure 4.1 Desalination capacity (1000 m^3/day) in RSA (except I.R. Iran and Iraq). Although large-scale desalination plants have been operated since the 1950s, there is very little information available on the extent of the impact of desalination plants on the marine organisms. For example, internationally few monitoring studies have been conducted on the impacts of discharges of desalination plants on marine resource. In shallow waters and enclosed areas of arid environments, such as the I-RSA, the severity of these effects may very well exceed the boundaries of the outfall channel. Only recently special attention is being paid to plants operating in the Middle East, Spain, the Virgin Islands, and Cuba. (Sources: Hoepner and Lattemann, 2002; Hashim and Hajjaj. 2005; Elabbar and Elmabrouk, 2005; Fernandez-Torquemada *et al*., 2005).

Marine ecosystems in the vicinity of desalination plants are subjected to physical, thermal and chemical stress. Usually, these plants are built on coastal land, thus physically disturbing the breeding grounds and destroying the base of the food chain. Also, the process of desalination is not environment friendly per se, as the discharges from the seawater desalination plants affect coastal water quality. The resulting discharged brine from thermal desalination plants is usually of a temperature ranging from 8 to 15°C above ambient seawater temperature. As low as 1°C above ambient is reached as soon as the concentrate is diluted 10-fold by the receiving seawater. At the point of discharge, the temperature of the receiving bays and shores would be on average 5°C above the ambient water temperature. The high temperature effluent released reduces the amount of dissolved oxygen and leads to serious suffocation problems during hot summer days, particularly in shallow waters. The effluent's temperature strongly influences the physical properties of seawater and, can directly or indirectly deteriorate its quality. Furthermore, the oxygen demand of biota rises at high temperatures; further depressing dissolved oxygen levels in the water, which could create life-threatening conditions. The synergistic effect of organic loading and the elevated water temperature with an accelerated rate of bacteria respiration may promote anoxia or hypoxia in marine ecosystem, particularly in summer. This is a real threat in the RSA's arid environment where water temperature is already very high during the summer. In addition, the effluent from desalination plants is essentially a multi-component waste discharge, containing residual chemicals from the pretreatment process (especially disinfection by-products), as well as heavy metals from corrosion or intermittently used cleaning agents. These compounds exert multiple effects on the quality of water and sediments as well as impacting marine organisms.

The impact of thermal changes is not limited to the sublittoral zone, it also affects benthic invertebrates with relatively limited mobility. Thermal changes reduces the diversity and abundance of benthic forms (Fernandez-Torquemada *et al*., 2005), reduces the growth of the clam (Chesher, 1975; Ostroumov, 2005) and, leads to a significant death rate of the adult benthic species such as corals and mangrove (Miri and Chouikhi, 2005).The hypersaline conditions affects the growth and survival of seagrass. These beds provide shelter and breeding grounds for a vast array of organisms, such as algae, vertebrates and invertebrates.

Furthermore, a study on the long term changes in salinity near outfall of Al Zour Power and Desalination Plant in south Kuwait, reported salinity values peak of around 50 psu up to 5 kilometers in the open sea from the outfall. Such high salinity could impair the marine biodiversity in the vicinity of the outfall (Uddin *et al.*, 2011).

Changes in salinity and/or temperature from the brine discharges may also affect migration patterns of fish along the coast. If some fish species sense a change in salinity or temperature, they may avoid the area of the plume and move further offshore. As a result, the fish would be forced to swim a longer distance, leave the areas of highest food concentrations, and suffer increased exposure to predators. The potential impacts of such nature are uncertain because of limited knowledge about fish migration along the coast and the deficiency in our knowledge regarding how large the plume would have to be to cause such effect. As the coastal and marine environment gets degraded due to human pressure, its ecosystem services will diminish. This includes reduced quality of sea water and reduced fish landing. Coupled with increased fish consumption in some regions, such as Oman, UAE and Kuwait, and the fact that most of the catch is exported or shipped directly to Japan and other Eastern Asian countries, such pressures adversely affect fish landing and fish stocks, reducing catches, increasing the prices, affecting food security and the well-being of coastal communities (Sheppard, 2010). Consequently, a major issue is the loss of opportunity in jobs and hard currency revenues of the fisheries sector.

4.4 CLIMATE CHANGE INTERLINKAGES

As the coastal and marine environment gets degraded due to human pressures, the ecosystem services will diminish and the resilience of the environment to endure the disasters related to climate change impacts drops. Communities along the ROPME Sea Area are losing one of the most important ecosystem services, namely, regulating and supporting functions of wetlands, mudflats and salt marshes in erosion control and climate regulation.

Climatic changes may impact the RSA by affecting the coral reefs and reef associated invertebrates, degrading water quality and leading to more frequent and massive marine mortality, and ultimately reducing the landings of the regional fisheries (Sheppard *et al.*, 2010).

Furthermore, recent evidence indicates that moderate warming of sea water in the range of 0.51^{o}C may have the potential to trigger abrupt increase in abundance of some planktonic organisms, including the toxic dinoflagellates mainly responsible for the outbreaks of the Harmful Algal Blooms (HABs).

Actually, the interlinkage between the impacts of climate change and fisheries can be examined from two angles. Firstly, increasing water temperature and salinity will induce migration of some fish species and cause major changes in species composition and distribution. As a result, species that are commercially important in some areas may no longer be available in the near future. Secondly, with the proliferation of non-indigenous invasive species, some native species may be outcompeted or replaced. This could mean that markets would have to explore other target species rather than those currently sold.

In addition, as habitat changes are expected due to alterations of the marine biota, some habitat functions could be compromised with important consequences for the reproduction of juvenile development of commercial species.

4.5 DEGRADATION OF THE TIGRIS-EUPHRATES AND DRAINING OF THE MARSHLANDS

Another example on the interlinked social and biophysical system is the effect of the reduction in freshwater influx from Shatt Al-Arab, the degradation of the basin, the erosion of the soil (Figure 4.2) and the drying up of the Mesopotamian marshlands (Figure 4.3). Shatt Al-Arab is the main source of freshwater in the Inner RSA. Over the last decades the Tigris and Euphrates have been heavily dammed and as a result, the freshwater influx has been considerably reduced. The average annual discharge from Shatt Al-Arab at Al-Faw in the last century and early of this century has been measured as (1000 m^3/sec). Between 2010 - 2012 the estimated discharge from Shatt Al-Arab was about (50 m^3/sec) in Al-Quran city north of Basrah (Iraq's Ministry of Water Resources). However since 2008 until now, and due to the charging of the systems of the dams in Turkey, Syria, Iraq and Iran, the discharge to Shatt Al-Arab at Basrah city is estimated as (10 - 20 m^3/sec) 2009 - 2011 (Al-Bomola, 2011). The situation is further stressed by the general lack of precipitation, and the decreasing trend in rainfall in most of the Region.

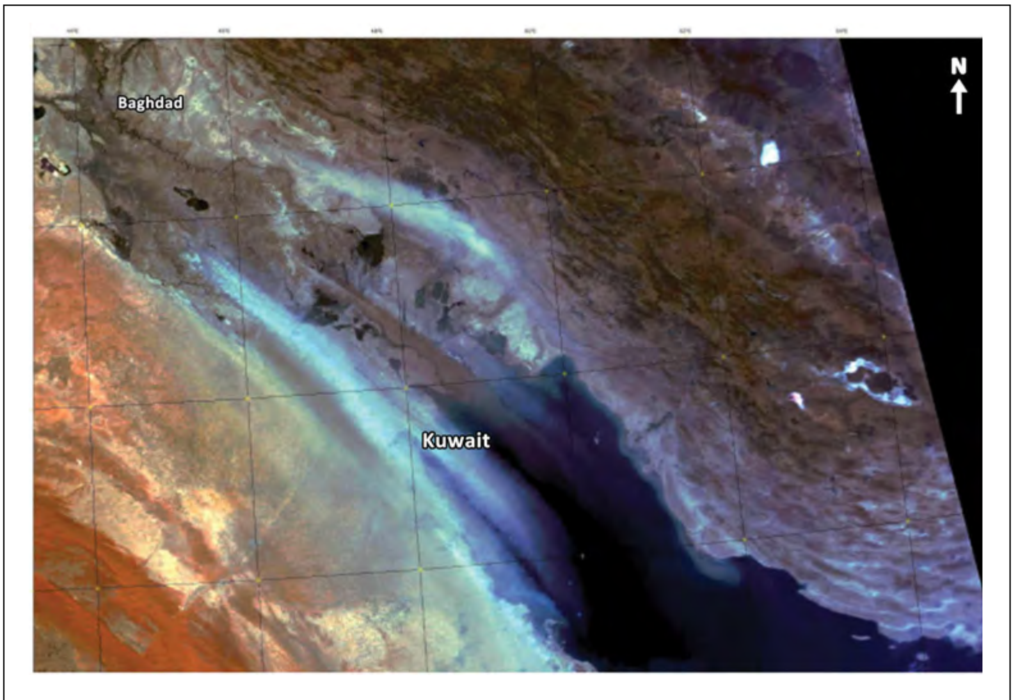


Figure 4.2 Soil erosion leading to dust storms and run-off due to the degradation of the Tigris-Euphrates and draining of the marshlands. (Source: ROPME Ground Station, MODIS, 2 May 2011)

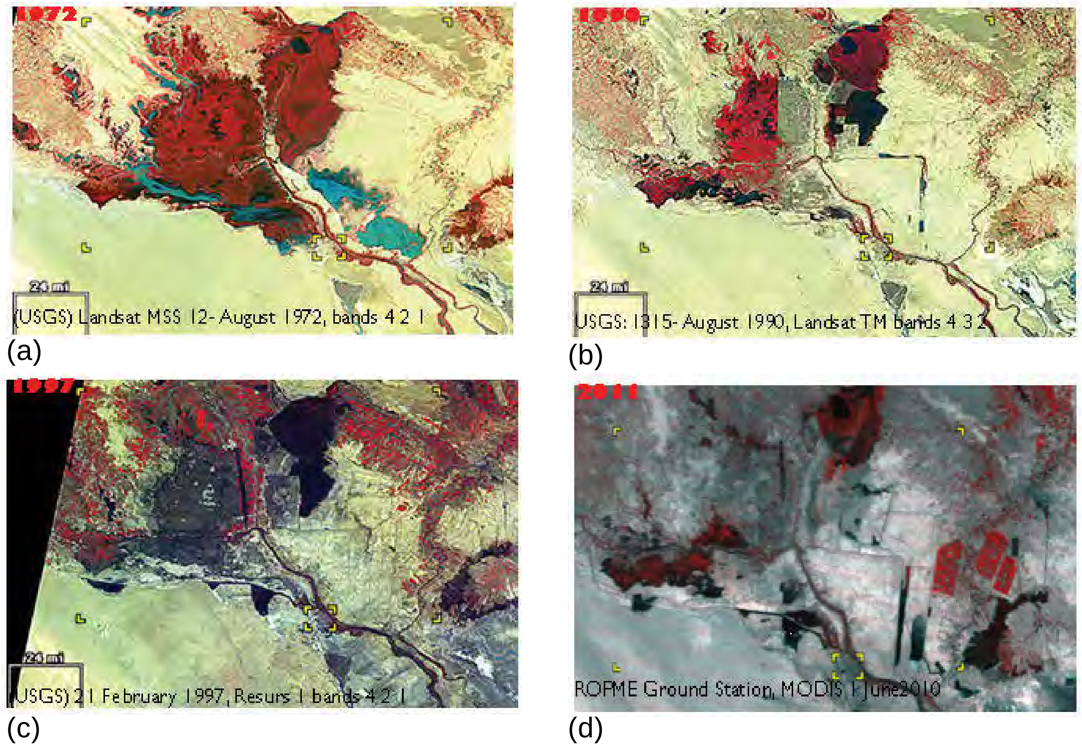


Figure 4.3 Drying of the Mesopotamian marshes. (Sources: (a) USGS: Landsat MSS 12 August 1972, bands 4 2 1; (b) USGS: 13-15 August 1990, Landsat TM bands 4 3 2; (c) USGS: 21 February 1997, Resurs 1 bands 4 2 1; (d) ROPME Ground Station, MODIS 1 June 2010)

The freshwater dilutes the high salinity of the water in the I-RSA. With the continuous reduction in freshwater influx, the salinity has reached up to 40 psu in many parts in the I-RSA. The water quality is further degraded due to the contamination from urban, industrial and intensive agriculture along the basin. An increasing trend in major ions (Ca, Mg, Na, K, Cl and SO_4) and related variables (Cond, TDS, Alk, Hard) was observed along the river (Al-Bomola, 2011) and in the northern waters of Kuwait (Al-Ghadban and El-Sammak, 2005). This increase originated from effects of pollutants discharge into the river. The dissolved contaminants reduce the oxygen carrying capacity of water, thereby, harming aquatic organisms, and changing the composition of plankton (Al-Yamani *et al*., 2007).

This is further complicated by the reduction in water purification services of the Marshes, such as denutrification. Furthermore the marshes are connected to the RSA not only hydrologically, but also through the movement of aquatic species, some of which are of commercial importance. With the drying up of the marshes, large areas of Phragmites reeds are lost. The ecosystem not only filters excess nutrients, but also provides breeding grounds for a number of species.

The availability of satellite images enables better understanding of the extent of changes. The Shatt Al-Arab runoff in the northwest of I-RSA is affected by the counterclockwise circulation. The river discharge leads to the formation of a classical river plume of a width of 30 - 40 km depending on tides and amount of inflow. Usually, as the plume moves away from its source it widens because of entrainment of the surrounding fluid at its edges. Tidal mixing dissolves the river plume with ambient marine waters along the coast of Iran, Kuwait and Saudi Arabia. Recent images document the increase of the area affected by the sediment plume and turbidity from about 11,000 km^2 to almost 12,680 km^2 in 2011 (Figure 4.4).

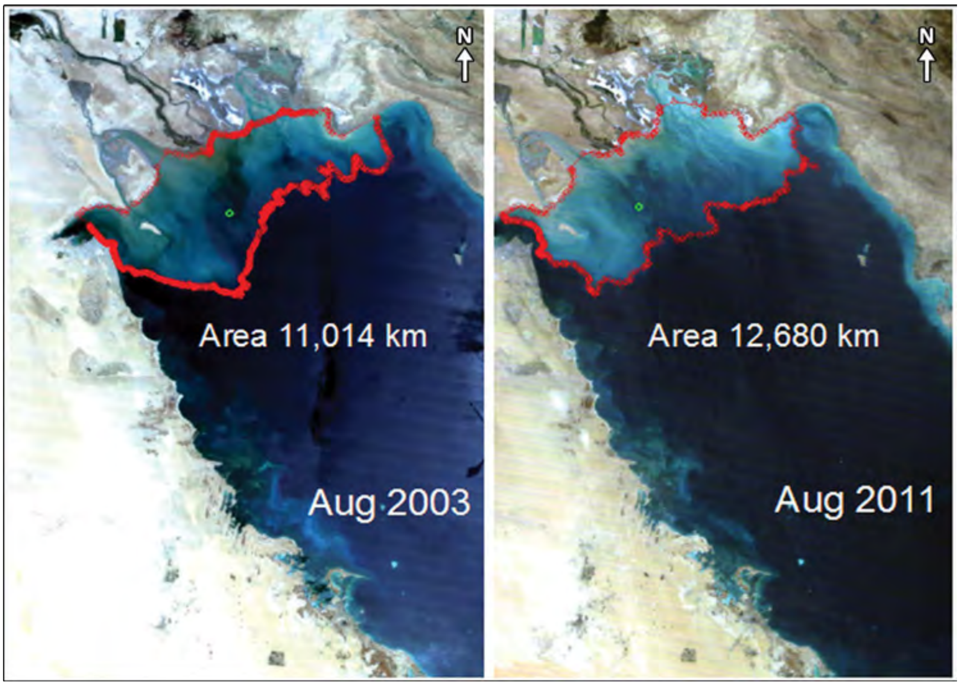


Figure 4.4 Changes in sediment plume and turbidity. Both images are from morning time, with good illumination for studying the sediment plume and turbidity phenomena in the water. In 2003, the contents exhibit more chlorophyll as well (see Uddin 2012 for the application of an algorithm developed to use satellite-based optical sensors in mapping suspended particulate). (Source: ROPME Ground Station)

Several studies have documented the impact of the reduction of freshwater flow from the Shatt Al-Arab and the loss of the important filtering function by drying up of the marshlands. These studies have the change in the nature of suspension and the sedimentation pattern in the northern part of I-RSA. A comparison of bottom sediment distribution by Al-Ghadban (2000) with a study undertaken by Anderlini *et al.,* in 1980, indicated that some finer sediments were being deposited in the northern area of inner RSA. The study suggested that such deposition can be attributed to the nature of suspension. Excess erosion in the river banks produces sediment and suspended particles that reduce light penetration. The drying of the marshes also leads to increase in the rate of erosion of the top soil that could be washed into the RSA waters or carried by winds, and hence causing more frequent dust storms.

In addition to the overfishing, the nursery ground destruction, the reduced discharge of the Shatt Al-Arab and the degradation of its water quality are among of the main probable causes of decline in total fish landing in the I-RSA (Sheppard *et al*., 2010). When overlaying the fish and shrimp landings in Kuwait [data from CSO, (1979–2007)], with the annual average flow of the Euphrates (Al-Bomola, 2011), the pattern and relationship is quite apparent (Figure 4.5).

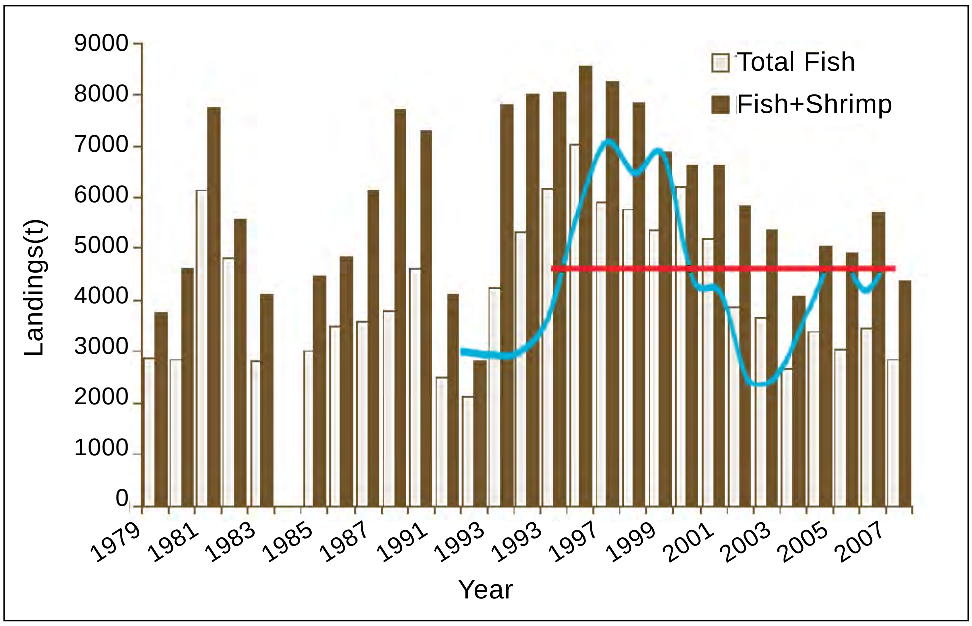


Figure 4.5 Effect of reduction in freshwater influx from Shatt Al-Arab on fish and shrimp landing. (Fish and shrimp landing from Kuwait exhibit a close pattern to the annual average flow of the Euphrates). (Sources: Sheppard *et al*., 2010 and Al-Bomola, 2011)

4.6 GOVERNANCE AND MANAGEMENT OF THE RSA

The previous sections of this Chapter accentuate that environmental changes are linked across time and between geographical regions through both biophysical and social processes. The earlier Chapters have demonstrated that there are interlinkages within and between environmental changes such as coastal and marine ecosystem deterioration, biodiversity loss, decreases of freshwater in-flow and climate change, which emphasize the increasing need for an Ecosystem Based Management (EBM) of the RSA (Box 4.1).

BOX 4.1 – Ecosystem-Based Management (EBM)

EBM is an integrated approach to management that considers the entire ecosystem, linkages across systems and disciplines, and the cumulative impacts of different human sectors. Its aim is to sustain ecosystems in a healthy, productive and resilient condition so that they can provide the functions, goods and services that enrich and sustain human well-being. As such, ecosystem-based management necessarily incorporates biological, physical and human components, including social and economic systems.

EBM emphasizes ecological interactions within an ecosystem, rather than human activities, and implies that it is possible to understand, control and manage entire ecosystems, in the face of the dynamic and complex nature of the marine and coastal ecosystems and the suite of human activities that occur within them.

Within EBM framework, and taking spatial planning perspective in consideration, national efforts will be transformed into a regional vision, guiding strategic planning of human use, and enable Member States to take joint steps towards implementation of sustainable development. Such shift is only achieved by linked and coherent governance and policy responses developed in collaboration between the Member States, to manage interlinked environment-development challenges. (Box 4.2).

BOX 4.2 – Economic Valuation of Coastal Ecosystem

Economic valuation of coastal ecosystems and ecosystem services highlights the benefits of conservation as well as the costs of degradation and damage to both livelihoods and economies. It can improve decision-making on how resources are managed, used and allocated. Economic valuation of coastal ecosystem services can, therefore, be a valuable tool to generate both positive conservation and well- being benefits as well as understanding the existing trade-offs between conservation and well-being.

Focusing on ecosystem services can enable authorities to identify and implement innovative financing to maintain those services such as “Payments for Ecosystem Services,” wherein a business or jurisdiction that benefits from a particular service pays a fee to have that service delivery assured. Investment in maintaining habitats and biodiversity like this, namely to keep ecosystem services flowing, can make good business sense.

CHAPTER 5

EMERGING ISSUES

KEY MESSAGES

- There are several potential sources of radioactive pollution in the RSA which need special attention
- The main objective of the ROPME Regional Nuclear Emergency Response Plan (RNERP) is to provide a response structure and guidance to support a regional, coordinated response to any radiological emergency in international waters within the RSA
- The climate change may impact the RSA by affecting the coral reefs and reef associated invertebrates, causing more harmful algal blooms, degrading water quality and leading to mass marine mortality, and ultimately reducing the landing of fisheries
- The nuclear risk, the increased frequency of dust storms and cyclones, and the sea level rise due to climate change, are both drawing serious attention in the Region. Policies regulating nuclear activities and reducing the carbon offprint of the Region, as well as plans and actions to mitigate possible impacts of climate change are not yet fully in place in the RSA

5.1 NUCLEAR AND RADIOACTIVE RISKS

It is important to stress that the nuclear risk and the climate change as two main emerging issues, are of particular concern for which we have to raise public awareness and flag the consequences of inactions or lack of clear policies, legislation and enforcement towards alleviating possible risks.

There are several potential sources of radioactive pollution in the RSA, as after the shell explosion, uranium has evaporated and then dispersed into atmosphere in oxidized particulate form, and it is well-known that the particulates can be transmitted to distances of up to several kilometers before deposition (Saad and Al-Azmi, 2002). Although depleted uranium itself does not pose appreciable extra normal radiation hazard, some of the U-238 daughters namely Ra-226; Pb-214, Bo-214 and Pb-210 are classified as the highest toxic radioisotopes (IAEA, 1963; Saad and Al-Azmi, 2002). The study on the level of radioisotopes in the coastal sediments of Kuwait have found that the levels of the isotopes were still below the international levels (Saad and Al-Azmi, 2002).

The nuclear energy on the other hand, is among those industries that have a significant impact on the surrounding environments and livelihoods (Beheshti, 2011). This impact is initiated and lasts up to the disposal of nuclear waste and decommission of the power plant (WNA, 2009).

The intense and enormous growth of population in the Region, and the major industrial projects such as oil production, aluminum smelting and steel production, demand large supply of electricity. Renewable sources of energy such as solar and wind are just being introduced to the Region, and the production by such alternatives may not be enough to provide for the high-energy demand of this arid Region.

To meet such rising electricity demand while reducing reliance on polluting fossil fuels, many of the ROPME Member States have already turned to nuclear power as a major new source of energy. I.R. Iran has been steadfastly building its Nuclear Power Plant. In 2010, I.R. Iran in collaboration with Russia loaded fuel on its first nuclear power plant at the coast of the inner RSA, which is now operational. Additionally, the Atomic Energy Organization of Iran (AEOI) has called for vast exploration of uranium mines across the country to secure its growing need for nuclear fuel.

It is important to mention that I.R. Iran is not the only country attempting to build nuclear power plants in the RSA. Iraq in 2009 started negotiating to re-enter the nuclear field after the suspension of its programmes by the UN resolution. Whereas, Kuwait only recently abandoned similar plans after the Fukushima disaster. Qatar is still considering the option and taking part in serious studies and action in this field in collaboration with Russia, South Korea and France (Beheshti, 2011). Saudi Arabia plans to build 16 nuclear reactors by 2030. UAE has already launched its plan for construction of 5600 MW of nuclear energy capacity by 2020, and in 2009 UAE awarded a South Korean consortium a contract to build four nuclear power plants to generate about 23 percent of UAE's power by 2020.

Given the inherent risks of nuclear power, and with the increasing concerns over radiological and nuclear (RN) safety within the RSA Region, MEMAC in collaboration with the International Atomic Energy Agency (IAEA) are developing the ROPME Regional Nuclear Emergency Preparedness and Response Plan (RN-EPR). The main objective of the Plan is to provide a response structure and guidance to support a regional, coordinated response to any radiological emergency that might occur in international waters within the RSA, or, if and when requested by a Member State, for an emergency within their jurisdiction. A key component of the RN-EPR is the Regional Nuclear/Radiological Coordination Team (RNCT). This regional response mechanism is comprised of a committee of senior representatives from Member States that collectively manage a coordinated and effective response to a radiological or nuclear incident that may occur in the RSA.

In concert with this initiative, many Member States have or are currently developing their national radiological safety programs to effectively prepare and respond to radiological issues.

MEMAC is also in the process of developing a "Legal Framework on the Exchange of Radiation Monitoring Data". These efforts are aiming mainly to further develop preparedness for nuclear and radiological emergencies; to keep better relationship between the ROPME Member States, and to contribute to a multilateral co-operation on exchange of radiation monitoring data to the benefit of all parties.

In the meantime, three studies have been undertaken by Kuwait Institute for Scientific Research (KISR) that have looked at the concentration of ^{210}Po in Kuwait's commercial fish species (Uddin, 2012a), and baseline radionuclide specific activity in commercial fishes of Kuwait (Al-Ghadban *et al.*, 1999; Al-Ghadban *et al.*, 2012), and concentration of selected radionuclides in seawater from Kuwait (Uddin, 2012b). With changing trend in the Region to embrace nuclear energy, these studies provide a baseline, and create a reference to record the influence-functioning of upcoming power plants for the relevant part of the I-RSA. The bioaccumulation factors showed that ^{210}Po is absorbed from water by phytoplankton and concentrated by micro-zooplankton, and then transferred to the next trophic level of the marine food chain.

However, the lowest concentration of ^{210}Po was measured in larger carnivorous fishes like Hamour (0.089 Bq kg^{-1}), while the highest was found in the fishes that feed on algae, zooplanktons and detritus, like battan (3.30 Bq kg^{-1}).The results of the second study documented low concentration of tritium, polonium, strontium and cesium; their concentration is comparable to most oceanic waters of Kuwait.

ROPME had further carried out analyses of radionuclides in marine sediment and mussel in the whole I-RSA, and has organized Proficiency Test on radionuclides measurement among national laboratories of Member States, in collaboration with the Marine Environment Laboratory of IAEA (See Chapter 3).

5.2 INITIAL INDICATORS OF GLOBAL WARMING

The global assessments of the authoritative Intergovernmental Panel on Climate Change (IPCC), established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), suggest that the presently observed global warming of the World's atmosphere is best explained by the increased amount of Green House Gases (GHGs) emitted from land into the atmosphere. The IPCC Assessment Reports further indicate that if the current GHG emission trends are not fundamentally altered, global temperatures will rise between 1.4 and 5.8^{o}C by the year 2100. Over the next century, global warming could speed up the melting of the polar ice caps, causing major flooding of lowlands, and more frequent and extreme weather events that would disturb normal hydrological cycles and global water distribution leading to significant changes in the ecological conditions in oceans (with impact on fisheries products) and on land (with impact on crop production) that will greatly affect people's livelihood in many countries around the world, particularly in small island states and low-lying coastal areas.

In this respect, the ROPME Sea Area is not an exception. The Fourth Assessment Report of the IPCC of 2007, noted that among the areas, most vulnerable to climate change are the coastal plains whose economies are closely linked with climate-sensitive sources and those in areas prone to extreme weather events. It is, therefore, expected that future climatic changes due to the projected temperature elevations and sea level rise, in combination with the expected decrease in precipitation will lead to adverse impacts on a number of vulnerable sectors, systems and livelihoods in the countries of ROPME Sea Area, placing additional stress on the regional political and economic systems (IPCC, 2007).

The climatic changes may impact the RSA by affecting the coral reefs and reef associated invertebrates, causing more harmful algal blooms (HABs), degrading water quality and leading to mass marine mortality, and ultimately reducing the landing of fisheries (Sheppard *et al*., 2010). The impacts in I-RSA are already noticeable. For example, Riegl (2003) based on his research on coral reefs in Abu Dhabi, Dubai and Sharjah, demonstrated that local marine ecosystems in RSA are substantially affected by climate change and must be placed amongst the "most stressed reef environments on earth".

In 1998, average temperatures exceeded 37.3°C in central regions of the I-RSA being more than 2°C above average. This was the largest temperature rise in the southern I-RSA since 1870 and also emphasizes the increase in sea surface temperature in the I-RSA of at least 0.2°C per decade for the last 50 years (Richer, 2008). The anticipated further rising in temperature is 1.8°C by 2040 and 3.6°C by 2100 will render wider areas of the I-RSA unfit for agriculture and inhabitable for a non-nomad population (Kumetat, 2009).

According to recent results of a World Bank study, (Das Gupta *et al.*, 2007), Qatar, UAE and Kuwait are among the most vulnerable in terms of their land mass, where 1% to 3% of land in these countries will be affected by a 1m Sea Level (SL) increase. Sea-level rise may threaten up to 15 km of coastline in Bahrain (Raouf, 2008) and endangers the reclaimed areas of I/M-RSA, especially in UAE (Kumetat, 2009). This will put further stress on the already existing socio-economic and demographic fault line (Kumetat, 2009) as domestic water use in the I-RSA is about six times above the natural renewable rate. Sea level rise is already leading to salt water intusions up the Shatt Al-Arab and freshwater aquifers recharged from the RSA (Box 5.1).

BOX 5.1 – Impacts of Sea Level Rise (SLR) Vulnerability and Adaptation to Climate Change In Bahrain

With climate change, it is expected that future increases in climatic variability will lead to adverse impacts on a number of vulnerable sectors, systems, and livelihoods in the countries of the RSA. The following clearly demonstrates two specific examples in the case of Bahrain.

Coastal Zone

The Kingdom of Bahrain is a small island state, where almost all of the population and development activities are located in close proximity to the coastline, with very limited capacity to adapt to sea-level rise (SLR). Most of the coastal areas of the Bahraini islands do not exceed 5 meters above current mean sea level and it will be physically and economically difficult, if not impossible, to establish zoning setbacks for new development or for marine habitats to migrate toward higher land elevations.

In order to account for both near-term and long-term impacts associated with sea level rise, two methodologies were applied. A scenario-based inundation analysis was carried out to examine long-term impacts relative to the latest Intergovernmental Panel on Climate Change (IPCC) sea level rise projections in the Fourth Assessment Report. To support near-term coastal zone planning, a vulnerability indexing approach was used, adapted from methods applied successfully elsewhere.

Table 1 summarizes the results of the long-term inundation analysis under each scenario for the years 2050 and 2100. Even under the “no accelerated deglaciation” scenario, 83 km^2, or 11% of the total land area of Bahrain, would be lost by 2050 from a 0.3-meter increase in mean sea level. Approximately 18 km^2 of built-up and industrial areas would be under water. This accounts for about 7% of these areas, about 2% of the country’s entire land area, and a substantial portion of its socioeconomic activity.

Under the “extreme deglaciation rate” scenario, 418 km^2, or 56% of the total land area, would be lost by 2100 due to a 5-meter increase in mean sea level. Of this amount of inundated land, 164 km^2 would correspond to built-up and industrial areas, roughly 64% of these areas and about 22% of the country’s entire land area.

Regarding near-term vulnerability, the entire coastline of Bahrain’s main island was classified into one of four levels of vulnerability; low, moderate, high, and very high, based on the development of a Coastal Vulnerability Index (CVI) Figure 1.

Box - 5.1 (Contd...)

Table 1 Results of the long-term inundation scenario analysis

		No accelerated deglaciation				Low deglaciation rate				Extreme deglaciation rate			
		2050(SLR=0.3m)		2100(SLR=1.5m)		2050(SLR=0.5m)		2100(SLR=2.0m)		2050(SLR=1.0m)		2100(SLR=5.0m)	
Land use type	Total area (km^2)	Inundation (km^2)	(%)	Inundation (km^2)	(%)	Inundation (km^2)	(%)	Inundation (km^2)	(%)	Inundation (km^2)	(%)	Inundation (km^2)	(%)
Built Up	209	10	5%	46	22%	10	5%	64	31%	46	22%	126	60%
Industrial	46	8	17%	29	63%	8	17%	32	69%	29	63%	38	82%
Vacant	79	5	7%	24	30%	5	7%	27	34%	24	30%	38	48%
Agriculture	71	5	7%	15	21%	5	7%	23	32%	15	21%	57	80%
Wetland	2	1	69%	1	77%	1	70%	1	80%	1	74%	2	100%
Barren	304	29	10%	52	17%	29	10%	68	22%	51	17%	122	40%
Heritage	2	0	0%	0	0%	0	0%	0	0%	0	0%	0	1%
Sabkhs	35	26	75%	33	97%	26	76%	34	98%	33	97%	35	100%
Total	748	83	11%	200	27%	84	11%	248	33%	199	27%	418	56%

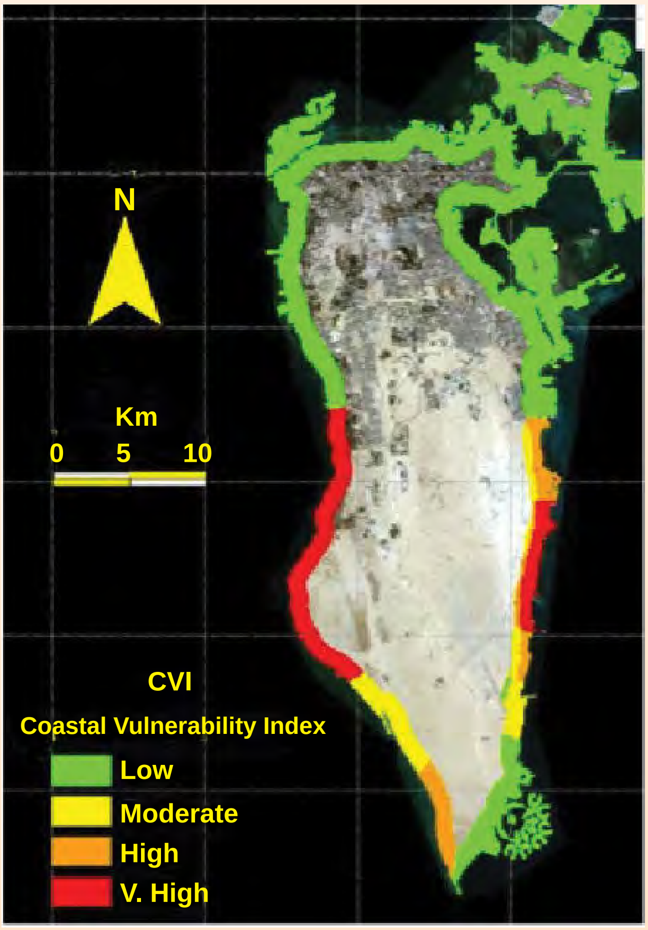


Figure 1 Coastal vulnerability hot spots

Box - 5.1 (Contd…)

Bahrain's near-term vulnerable hotspots are located along the central portions of the western and eastern coastlines. The vulnerability of these areas is mostly driven by their characteristically shallow coastal slopes, low elevations, and erosion-prone nature of the sandy soils present. These areas comprise a total of 54 km, or about 8% of the shoreline and should be the priority focus of near-term adaptation planning.

Another 33 km of coastline are classified as highly vulnerable (5%). These areas are located along the eastern coast adjacent to the vulnerable hotspots. In addition, the western coast of the southern tip of the main island is also a highly vulnerable area. For the purposes of adaptation planning, these areas are also considered priority vulnerable hotspots.

The remaining coastal areas of Bahrain are classified as low to moderate vulnerability. Comprising a total length of 630 km (88% of the total length of the coastline), these areas benefit from a combination of hard coastal protection structures and high rates of shoreline change (i.e., reclamation activities). Figure 1 summarizes the partition of coastal area in Bahrain according to the estimated CVI.

The major implication is that mainstreaming adaptation to account for the impact of sea level rise needs to be integrated as soon as possible into the national policy-making process. Protection is the only adaptation option for Bahrain in the long-run. Capacity strengthening, integrated planning, local/regional stakeholder engagement, and hard coastal protection are core principles underlying a future climate change adaptation plan for Bahrain's built-up coastal areas.

Water resources

Bahrain is a water-scarce country characterized by an extremely arid environment, high average annual temperatures, erratic and scanty rainfall, high evapo-transpiration rates, and no perennial rivers. Over the last four decades, rapid population growth and urbanization, coupled with the expansion of irrigated agriculture and industrialization have led to very high water demand and increasing vulnerability of water supply on the island.

Groundwater is the only natural relatively freshwater source available to Bahrain. It is obtained from the Dammam aquifer, a large transboundary groundwater system that extends from central Saudi Arabia, where the aquifer crops out and where its main recharge area is located, to the RSA groundwater systems, including Bahrain, Kuwait, southern Qatar, UAE and Oman.

Bahrain relies on the Dammam aquifer for more than 30% of its water supply. However, the aquifer is now in a state of severe decline and quality deterioration due to decades of unsustainable use. Hence, the main water resource management challenge is how to balance decreasing water supply and increasing water use (i.e., the supply-demand gap) on a long-term sustainable basis while promoting national development with the least social, economic, environmental and other costs.

With climate change in the background, this challenge becomes even more urgent and pressing, particularly in view of the expected seawater intrusion into groundwater

Box - 5.1 (Contd...)

supply due to sea level rise. To assess this impact, quantitative predictions of aquifer behavior were made for three plausible socioeconomic development scenarios, with and without sea level rise, using the best available regional groundwater models.

Figure 2 shows the magnitude of seawater intrusion into the aquifer up through 2025 for the scenarios. Without considering the impact of sea level rise, the amount of seawater intrusion increases under each of the three scenarios (solid lines) due to unsustainable groundwater consumption.

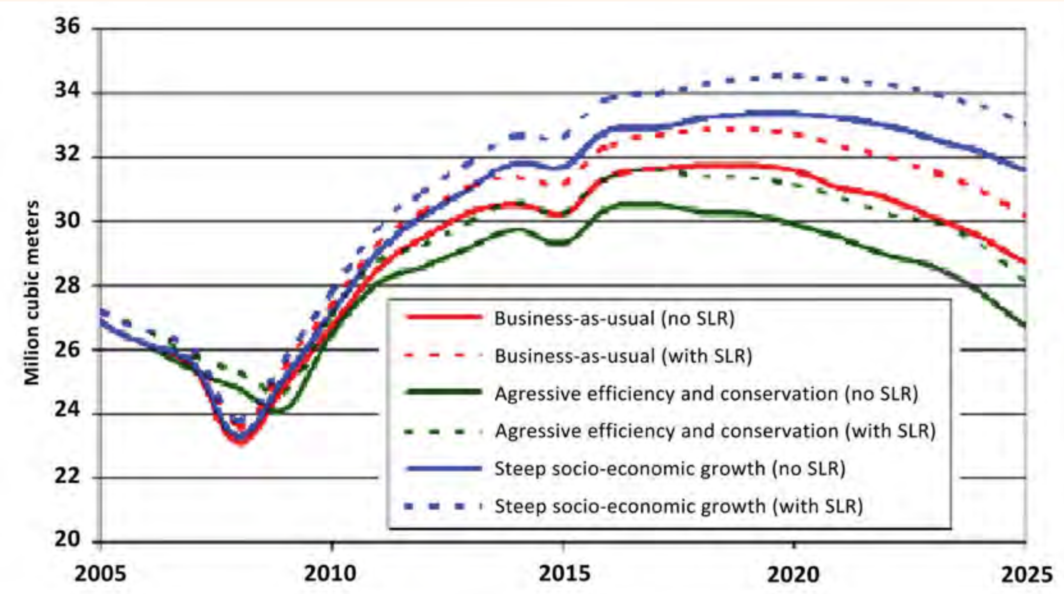


Figure 2 Seawater intrusion in the Bahrain aquifer, with and without sea level rise. (Source : Aljenaid *et al*., 2010 and Zubari *et al*., 2010)

With sea level rise, there will be additional pressure placed on the already stressed groundwater resources. The amount of seawater intrusion is greater (dashed lines) than the levels in the three scenarios without sea level rise. Even under the Aggressive efficiency and conservation scenario, the impact of sea level leads to an additional 1 million cubic meters of seawater annually entering the aquifer by 2025, relative to Base Year levels

In short, sea level rise makes an already dire groundwater supply situation in Bahrain even worse. Moreover, if sea level rise proceeds in a manner more consistent with the assumption of the Low deglaciation rate scenario applied in the coastal zone vulnerability assessment, seawater intrusion levels would probably double or more by 2025, and the downward seawater intrusion trend in the post-2020 period would likely disappear.

Groundwater vulnerability to climate change would be larger still if it accounted for indirect impacts in up-gradient areas (i.e., in eastern Saudi Arabia). Reducing groundwater use to sustainable levels in Bahrain alone would not necessarily promote recovery of the Dammam aquifer – much depends on groundwater development along the central and eastern regions of Saudi Arabia and the emergence of a mechanism for collaborative transboundary management scheme of this vital resource.

Box - 5.1 (Contd…)

At a broad adaptation planning level, it will be important for Bahrain to establish an effective aquifer management framework that can promote recharge, enhance storage, reduce demand, protect quality, and limit discharge. Important steps in this direction are already underway. At a more detailed adaptation planning level, the promotion of managed aquifer recharge (MAR) has been identified as a high priority near-term strategy. MAR involves building infrastructure and/or modifying the landscape to intentionally enhance groundwater recharge. The implementation of MAR requires suitable conditions, all of which are met in Bahrain. These include falling groundwater levels, hydrogeological suitability, and the availability of surplus unused treated sewage effluent (TSE) for aquifer recharge (Aljenaid *et al*., 2010 and Zubari *et al*., 2010).

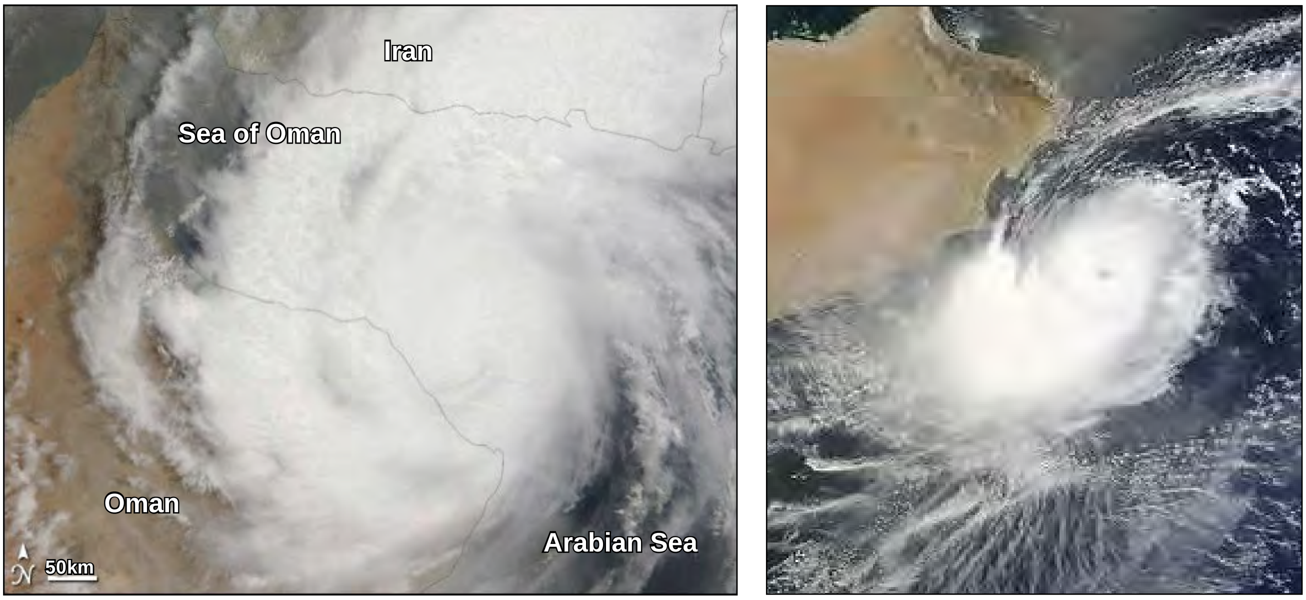
5.3 CYCLONIC STORMS, TSUNAMI AND EARTHQUAKE INFLUENCES

The recent active period of intense hurricanes in the Region has triggered a hot debate in the scientific community whether the increase in the frequency and intensity of hurricanes is due to natural climate variability similar to the El-Nino southern-oscillation (ENSO) (Krishna and Rao, 2009). On average the Arabian Sea records 1-2 cyclonic storms each year. Most of these cyclonic storms are quite weak and tend to fizzle out quickly.

The annual distribution of monthly total cyclonic storm days over the Arabian Sea region is bimodal, with two tropical cyclone seasons, the pre-monsoon (May and early June) with cyclonic storms rarely occurring in both months within the same year; and post-monsoon (October and November), although some of these cyclonic storms form during September. The tropical cyclone activity decreases during the peak of the Indian monsoon.

Most Arabian Sea Cyclones form close to the western coast of the Indian subcontinent and follow a northerly or northeasterly track. Several storms have formed more toward the center of the basin or closer to the equator and have taken a more easterly path. Three ROPME Member States are particularly affected by Arabian Sea storms: UAE- if it passes through the Sea of Oman, I.R. Iran, and Oman, listed in order of increasing frequency.

Forty-one cyclonic storms formed in the Arabian Sea during the period 1979 – 2008, of which 23 made landfall with tropical depression or stronger intensities (Evan and Camargo, 2011). The average lifetime of these storms was 3.4 days, and the range of lifetime was 1 - 9 days. In this record, 8 storms were classified as severe cyclonic storms, 7 were classified as a very severe cyclonic storms and 1 super cyclonic storm (Super-cyclone Gonu, 1-6 June 2007) was recorded (Evan and Camargo, 2011) (Figure 5.1a). The last very severe cyclonic storm (Cyclone Phet) has happened during the period 30 May – 6 June 2010. (Figure 5.1b). Over the period of 1979 – 2008, there has been an average of 4.7 cyclonic storm days over the Arabian Sea, with 1981, 1990, 1991, 2000, 2005, 2008 having 0 storms; and 1998 and 2004 having more than 15 cyclonic storm days.



(A)

(B)

Figure 5.1 (A) Super cyclone 'Gonu' (June 6, 2007); (B) Very Severe Cyclone 'Phet' (June 1, 2010). (Source: ROPME Ground Station)

CHAPTER 6

CHALLENGES AND OPPORTUNITIES

KEY MESSAGES

- It is crucial for all ROPME Member States to implement the obligations of the international conventions, including MARPOL 73/78, and to develop pertinent national legislation, allowing for sanctions for non-compliance
- It is important to impose and enforce strict government restrictions on dredging and reclamation activities, especially in the coastal areas, where such activities are practiced or planned
- ROPME Member States should effectively pursue the implementation of the ROPME's Protocols particularly the Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources
- Joint activities between ROPME and other regional and international environmental organizations in all fields of mutual interest are required and should be encouraged and formalized
- ROPME Member States continue to be involved, at high expert and governmental levels, in the development of global environmental conventions and the Multilateral Environmental Agreements (MEAs), to ensure that any future legally-binding instrument, negotiated globally, takes into consideration the specific nature and needs of the Region
- Environmental, legal, institutional, as well as governance and other important challenges and opportunities commonly emerge in connection with the national and regional efforts to achieve environmental sustainable development. They also clearly manifest themselves while building the national capacities of the countries concerned to engage in the sustainable development activities

The following are the major challenges and opportunities for achieving sustainable development in the ROPME Sea Area:

6.1 ENVIRONMENTAL CHALLENGES:

6.1.1 Sustainable Development Strategies and Priority Actions

One of the foremost difficulties at the national level is the lack of national environmental policies based on the principle of sustainable development or where these policies exist, there is lack of implementation. The adoption of sustainability principles in the formulation of national environmental policies and strategies in the RSA Region will help realize a common management perspective among the ROPME Member States and will help in fostering the necessary co-operation in many cross-boundaries environmental challenges as well as in pollution abatement and resource conservation of regional programmes.

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. Government support is required to ensure that the regional and global priorities are adequately addressed and are supported through local legislation, policy measures that would facilitate effective implementation of the relevant regulations, enforcement of laws and legally binding regional agreements and protocols, and, at the same time, through capacity building of regional and national institutions and experts. 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 the essence of the Rio Declaration (1992). This section identifies some of the priority issues to be included in strategies for environmental protection in the Region.

6.1.2 Global Climate Changes

Admittedly, climate change is one of the most important and complex challenges facing humanity in the 21st Century. There are already ample evidences of the physical and environmental impacts of climate change in the ROPME Sea Area.

One of the most visible impacts of climate change is the sea level rise that can cause severe property damage along the coastline due to the expected increase in the rates of coastal erosion and in the frequency and strength of coastal storms such as the Gonu Hurricane of 2007 that resulted in considerable property damage.

The impacts in the Inner RSA (I-RSA) are already noticeable. For example, Riegl (2003), based on his research on coral reefs in Abu Dhabi, Dubai and Al-Sharjah, demonstrated that local marine ecosystems in RSA are substantially affected by climate change and must be placed amongst the “most stressed reef environments on earth”.

In 1998, average temperatures recorded in the central regions of the I-RSA exceeded 37.3^{o}C, being more than 2^{o}C above normal. This was the largest temperature rise in the southern I-RSA since 1870, and thus emphasizes the increase in sea surface temperature (SST) in the I-RSA of at least 2^{o}C per decade for the last 50 years (Richer, 2008). The anticipated further rising in temperature is 1.8^{o}C by 2040 and 3.6^{o}C by 2100 (Kumetat, 2009), that will render wider areas of the I-RSA unfit for agriculture and inhabitable for a non-nomad population (Kumetat, 2009).

Russell (2011) indicated that while Iraq, Iran and Saudi Arabia will not have significant coastal population that might be affected by dramatic rise in sea levels, this is not the case for other States in the ROPME Sea Area.

The results of a World Bank study (Das Gupta *et al*., 2007) clearly indicated that Qatar, UAE and Kuwait are among the most vulnerable in terms of their land masses, where 1% to 3% of land in those countries will be affected by a 1 m increase in sea level (SL). Such sea level rise may threaten up to 15 km of coastline in Bahrain (Raouf, 2008) and endangers the reclaimed areas of Inner and Middle RSA, especially in the UAE (Kumetat, 2009). This will put further stress on the already existing socio-economic and demographic fault line (Kumetat, 2009), where domestic water use in the I-RSA that is estimated to be about six times above the natural renewable rate. Sea level rise is already leading to salt water intrusion up to the Shatt Al-Arab, and the freshwater aquifers recharged from the RSA (Box 5.1)

With all the above in view, and taking the observations given in sections 4.4 and 5.2 of this Report into consideration, it is evident that the issue of the expected climatic changes due to continuing emissions of GHGs into the atmosphere at the current high rates, constitutes a serious challenge. This issue, therefore, deserves a greater deal of attention by the Member States of ROPME due to the significant impacts outlined in the preceding sections.

While the World leaders are working to reduce the GHGs emissions globally, we must act regionally. We must also work aggressively to restore and protect the health of the ROPME Sea Area marine environment to enable it to better respond and adjust to the expected changes in climate, and to increase its resilience to their anticipated impacts.

6.1.3 Freshwater Scarcity

All statistical indicators suggest that the RSA exists in one of the hottest, most water-starved environments on the planet. With the exception of Iraq and Iran, most States in the RSA suffer from an acute freshwater scarcity, defined by the World Bank as access to per capita share of less than 1,000 m^3/year. This scarcity promises are to become even more acute as the world's temperature rises due to global warming and the demand for freshwater increases due to population growth. Domestic water demand is projected to double in the Region by 2025; the demand for water required for industrial uses will increase threefold over that period. As indicated earlier, the baseline of renewable freshwater availability in today's I-RSA is already an environmental crisis (Russell, 2011).

All of the RSA Member States have taken dramatic steps to address chronic freshwater shortages by building desalination plants. The Region today boasts the most developed infrastructure for freshwater production in the world. Desalinated water is extremely expensive to produce; costing on average $.50 -.60 per cubic meter (Dickei, 2007). The RSA today operates over half of the world's estimated 10,400 desalination plants, which produce over 35 million cubic meters of water per day around the world (Russell, 2011). These desalination plants put environmental stress on the RSA ecosystem. The hot brine outfalls cause significant impact on the coastal habitats (Nour-El-Din, 2004; El-Sammak *et al.*, 2011), as well as having regional impact on increasing salinity of the Inner RSA (Sheppard, 2010).

6.2 GOVERNANCE CHALLENGES

6.2.1 Legal and Institutional Frameworks

All ROPME Member States now have environmental ministries or institutions in place. Some countries have restructured these institutions in recent years to give them higher political standing. At present, four Member States have ministers of environment in the cabinets, namely Iraq, Oman, Qatar and UAE. I.R. Iran has established the post of Vice-President for the environment. Bahrain has a Public Commission for the Protection of Marine Resources, Environment and Wildlife, Kuwait has the Environment Public Authority, and Saudi Arabia has the Presidency of Meteorology and Environment.

While there have been national initiatives to introduce regulatory instruments and programs for environmental protection, environmental assessments, and integrated coastal zone management, they general by lack a regional perspective and the progress in their implementations has been generally slow (Khan 2008). The environmental protection laws and administrative mechanisms in RSA were initiated as early as 1964 when Kuwait enacted a Marine Pollution Control Law. The eight ROPME Member States sharing the RSA ecosystem have varying degrees of administrative and legal mechanisms for the protection and management of their territorial waters. However, the institutions suffer from a lack of adequate manpower and expertise, and often the power to implement the nationwide policies (Khan, 2008). Regionally, the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution (Kuwait Convention) and its Action Plan for the Development and Protection of the Marine Environment and the Coastal Area (Kuwait Action Plan or KAP), to which all ROPME Member States are signatories provide the basis for recognizing the RSA as integrated and dynamic system and to develop a cooperative strategy for its sustainable management (Khan, 2008; Nadim *et al.*, 2008).

There are several other regional organizations and agreements, such as CAMRE and GCC which could be highly instrumental in achieving the overall objectives of the Convention and in the development of an integrated regional strategy for sustainable management based on the Ecosystem-Based Management (EBM) approach as well as to establish an integrated research programme to support the EBM approach strategy.

The most recently, ROPME Council has adopted two Regional Action Plans, namely the “Regional Action Plan for Preventing and Combating Marine Pollution” and the “Regional Strategic Plan for Ships’ Ballast Water Management”, in order to provide a set of measures to mitigate the adverse impact of Marine Pollution in RSA.

6.2.2 Implementation of ROPME Protocols

The Kuwait Regional Convention has four protocols relating to various aspects of marine environmental protection and management. These Protocols have been adopted to further clarify the mandate of the Convention with the objective of ensuring that development and other human activities are controlled and do not cause damage to the marine environment, jeopardize its living resources or cause hazards for human health. Another objective has been the development of an integrated management approach for the use of the marine environment and the coastal areas in a sustainable way, to enable the harmonious achievement of environmental and developmental goals.

It becomes necessary therefore, for the implementation of ROPME’s Protocols to be further enhanced and followed up vigorously by the concerned authorities in each Member State, in order to achieve the objectives set by these important legal instruments. Such strengthening of Protocols 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.

It is worthwhile to mention that there is the compelling need for the review and the amendment of the ROPME Protocols in order to meet the new environmental challenges in RSA.

6.2.3 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 and has gained momentum ever since. Cooperation with the ROPME Member States on issues such as conducting the study on reception facilities, development of port state control and the preparation of a Regional Protocol on Biodiversity and the Establishment of Protected Areas are further examples of possible areas for Regional cooperation.

The Memorandum of Understanding (MoU) between CAMRE, PERSGA, ROPME and UNEP, which was signed in 1999, provides for regional cooperation with full transparency, avoidance of duplication and sharing of experience and information. ROPME has also established close working relations and collaboration with many international organizations and their related conventions/ programmes particularly with FAO, IAEA, IHO, IMO, IAEA, IOC, ISO, IUCN, OPEC, RESCO, UNEP, UNDP, UNESCO and WHO. Similar activities between ROPME and other regional environmental bodies and between regional and international environmental organizations are required and should be encouraged and formalized. In this regard, UNEP's Regional Seas Programme which brokers 'twining' arrangements between sister regional seas programmes offers an important platform for increased collaboration. Further, the establishment of the Regional MoU on Port State Control (PSC) with the participation of all ROPME Member States will be a useful tool in order to enhance the Regional cooperation within the Region.

6.2.4 Harmonization of Legislation

ROPME Member States as members of the international community collectively have a significant role to play in the global arena. However, the process can only be a two-way stream, i.e., contributing to global policies, conventions and programmes, and adapting the national policies and legislation to meet the global objectives. Global conventions can only be unfair to our Region, if we fail to be present at their development stages. UN Conventions are developed by hard negotiations but on the basis of consensus, however, once they enter into force, change becomes even harder. Member States should therefore continue to be involved in the development of global conventions to ensure that they take into consideration the needs and opportunities afforded by the Region.

6.2.5 Conservation Strategies

Because of the increased threats to the marine and coastal environments and their integrity, there is an urgent need for more effective mechanisms for conservation in a manner that could counteract fragmented decision-making. The protection and, where necessary, restoration of coastal and marine habitats is of highest priority for biodiversity conservation. Spawning grounds and critical nursery areas of key species are of particular importance. 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.

6.3 CONTROL AND MITIGATION MEASURES

6.3.1 Control of Land-Based Sources of Pollution

ROPME Member States should seriously pursue the implementation of the ROPME Protocols particularly the Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources and the associated Regional Programme of Action (RPA). RPA components include surveys of land-based activities, pilot studies on pollutants, implementation of technical guidelines for the management of Land-Based Activities (LBA), training programmes, establishment of database systems and development of a river basin management plan for the Shatt Al-Arab and other rivers in the RSA. Such efforts will require potential cooperation and relationships with countries outside the RSA, and the ability to draw on the support and cooperation of the international and regional organizations concerned. To this effect, one of the key areas emphasized in the WSSD Plan of Implementation was an advance response to pollution caused by municipal wastewater in the period 2002-2006. ROPME expressed willingness and begun cooperating with UNEP/GPA in its Strategic Action Plan on Municipal Wastewater.

6.3.2 Control of Dredging, Landfilling and Reclamation Activities, and the Modification of Coastal Morphology

Dredging and reclamation activities are an almost permanent feature in many coastal areas in the RSA. As a remedial measure, strict government restrictions on dredging and reclamation activities should be imposed, and where legislation prohibiting these activities exists, it should be enforced and strictly adhered to. It is preferable that such destructive activities be totally avoided, if possible. If not, Environmental Impact Assessments (EIA) 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. Impacts of such projects on the adjacent marine and coastal ecosystems should be carefully assessed and monitored. Projects involving landfilling and alteration of coastal morphology of a given State need to be evaluated from a regional perspective in consultation with ROPME in order to avoid major ecological changes in the Sea Area.

6.3.3 Control and Management of Oil Spills

As elaborated earlier in the Report, oil pollution is the most significant form of pollution in the RSA, and oil spills with their visible and invisible impacts have long constituted a serious threat to the Region. In spite of extremely heavy shipping traffic through the RSA, and the requirements of the RSA Special Area Status, the existing number of the Reception and Treatment Facilities in the RSA, are not at the satisfactory level. However, taking into account that all ROPME Member States have ratified the MARPOL 73/78, there have been a number of initiatives throughout the Region to tackle this issue. The lack of monitoring and surveillance capabilities in the Region often leads to illegal dumping of huge quantities of oily wastes into the marine environment, thus contributing to the already observed high level of oil pollution in the Region.

Implementing the obligations of the international conventions, including MARPOL 73/78, by all ROPME Member States and the development of necessary legislation in order to provide sanction to the violating vessels are of prime importance.

National and Regional requirements would be among the regional comprehensive measures that can lead to significant decrease of illegal discharge of oily wastes in the navigable waters of the RSA.

Acceding to MARPOL 73/78, the establishment of the reception and treatment facilities (Box 6.1) would also require the adoption of Regional Port State Control (PSC) and Flag State Control (FSC) procedures, according to which vessels entering all the RSA Ports shall be subject to the comprehensive PSC and FSC regimes and inspections by duly authorized officers in order to ensure their compliance with international obligations that are in force in the Region. The Port State Control provides the standardized procedures in accordance with the Regional and International Maritime Safety and Marine Environment Protection requirements in order to make sure that ships meet their obligations towards International Conventions and to apply the relevant sanctions with adequate severity in case they are not fulfilling their obligations.

Recognition of the ROPME Sea Area as an asset requires putting in place some stringent measures in order to prevent marine pollution in the Area. The ratification of MARPOL Convention and its full implementation by all ROPME Member States will achieve the complete objectives for the control of intentional pollution of the marine environment by oil and other harmful substances as well as the minimization of accidental discharge of such substances.

In addition to the Kuwait Convention, there are a number of International conventions relevant to the prevention of pollution in RSA. It is important that ROPME Member States take the necessary actions to ensure that relevant conventions are ratified and implemented in full. The Riyadh MOU on the PSC can serve as a starting point to improve regional cooperation to enhance maritime safety and to protect the marine environment of the Region.

Even though all of ROPME Member States have ratified the MARPOL Convention, not all countries have yet established a national legal framework to effectively implement the Convention and, in particular, a comprehensive framework to enforce the provisions and prosecute offenders. In some countries, there may even be the need to raise the level of awareness among government officials as to the importance of this issue if illegal discharges from ships are to be tackled seriously.

Box 6.1 – Provision of Reception and Treatment Facilities

An important provision of the MARPOL Convention is reflected in the "Prevention and Emergency Protocol", which indicates that all States parties to the Convention should provide adequate facilities in their ports for the type of vessels visiting these ports and the different types of waste and cargo residues. The lack of adequate reception facilities in the RSA ports has long been a matter of concern for the international community as well as the RSA States themselves. There are a number of problems associated with the lack of adequate port reception facilities in the RSA Region. The first is the lack of sufficient guidance on the technical requirements for providing adequate reception facilities for different types of ship-generated waste and cargo residues. Secondly, there is the problem of ultimate disposal of waste in environmentally satisfactory conditions. This is essentially a waste management problem and requires the establishment of appropriate procedures between the port authority (which generally is not a waste disposal authority) and the local waste management authorities for different types of waste.

6.3.4 Control of Maritime Traffic

Maritime Traffic Control Systems are already established in some areas of the RSA. However, there have already been incidents, where coastal States of the RSA have lost track of vessels, which may pose a threat of pollution. There is certainly a case for establishing additional Maritime Traffic Control Systems (MTCS) in the Region in order to effectively implement the Prevention and Emergency Protocol.

It is to be noted that, however, there is a general lack of monitoring and surveillance of RSA waters, necessary for effective implementation of the MARPOL Convention. This lack of surveillance allows, even encourages, discharge of dirty ballast water or oily wastes, or even garbage, without fear of detection. This situation is compounded by the fact that a limited number of RSA States have established beyond their territorial waters an area under their jurisdiction, allowing them to enforce the provisions of the MARPOL Convention.

In view of the need to improve the monitoring of ships in the RSA, particularly those posing a risk to the marine environment, the potential of the RSA System, which also includes the on-going Safe Sea Net project, should be fully exploited by the RSA coastal States. In this regard, every effort should be made to identify the possibilities that might exist under the RSA Partnership mechanism for the development and establishment of an *ad hoc* infrastructure.

6.3.5 Restoration of Mangroves and Coral Reefs

Mangroves, coastal lagoons, seagrass beds and coral reefs represent important components of the ecological systems of the RSA, which have been subject to rapid deterioration and destruction. The restoration of damaged ecosystems and the re-introduction of lost species or populations through cooperation between research institutions, fisheries and environmental protection authorities are essential steps towards reversing the tide of destruction and moving towards recovery of the Region's habitats. In the meantime, since the restoration projects are extremely costly, it is expected that governments, development and funding agencies and regional banks, as well as the private sector are to support such an important regional effort.

6.4 MANAGEMENT AND MONITORING ISSUES

6.4.1 Integrated Monitoring and Assessments

Although much progress has been made since 1999 in the development of regular environment assessments and monitoring systems, as addressed in the 1999 State of the Marine Environment Report, an integrated 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 (GEO) process of UNEP, and will be developed in co-operation with regional and international scientific institutions and the concerned United Nations agencies.

ROPME has already made considerable efforts to adapt advanced space age-based technologies for monitoring and assessment efforts and to obtain accurate and predictive information and data on the location, type and quantities of oil spills almost in real time. Other data such as water quality, coastal morphology changes, and information that would otherwise require monitoring and surveillance programmes will also be obtained. Member States are to support this major regional effort.

Satellite-based technologies are widely used in environmental monitoring and research activities. To this effect, ROPME has established a Remote Sensing Ground Station to acquire the existing aerospace remote sensing materials and to prepare the satellite thematic mapping and habitat characterization and distribution in the Region. ROPME also upgraded the satellite capabilities and acquired a Satellite Receiving and Processing System for monitoring of marine and coastal areas in early 2003. Member States and the concerned regional and international organizations supported ROPME in acquiring the satellite receiving station.

The amount of data that are now available from monitoring programmes as well as the results from ROPME Cruises and other literature can be increased and utilized to develop an environmental information system with Geographic Information System (GIS) capabilities. Such an information system can be extensively used by and benefit all interested scientists and concerned authorities in the Region. It is equally important that scientific data be communicated in a meaningful and timely manner to policy and decision-makers as well as the general public to assist their action planning. 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.

6.4.2 Trans-boundary Nature of Issues and the Need for Ecosystem-Based Management

In recent years, coastal and marine environment in the RSA are experiencing notable degrees of degradation due to the rapid developments and the fact that RSA is one of the most heavy navigation traffic waterways in the world. RSA, therefore is in need of a regional management based on the Ecosystem-Based Management (EBM) approach. In this connection, Trans-boundary Diagnostic Analysis (TDA) and Strategic Action Plan (SAP) are very important tools for defining the priority areas for intervention as well as for the identification of gaps in information in order to make sound and fact-based management decisions.

The main purpose of TDA/SAP is, therefore, to provide a tool for the identification and prioritization of key issues concerning management of coastal and marine environment in RSA. The TDA/SAP should further serve to define the potential areas in need of intervention to address such issues as a basis for the development of a comprehensive and regionally-agreed and implementable plan. Figure 6.1 represents simple diagram for the steps needed to implement the suggested TDA and Figure 6.2 contains the schematic presentation of TDA process.

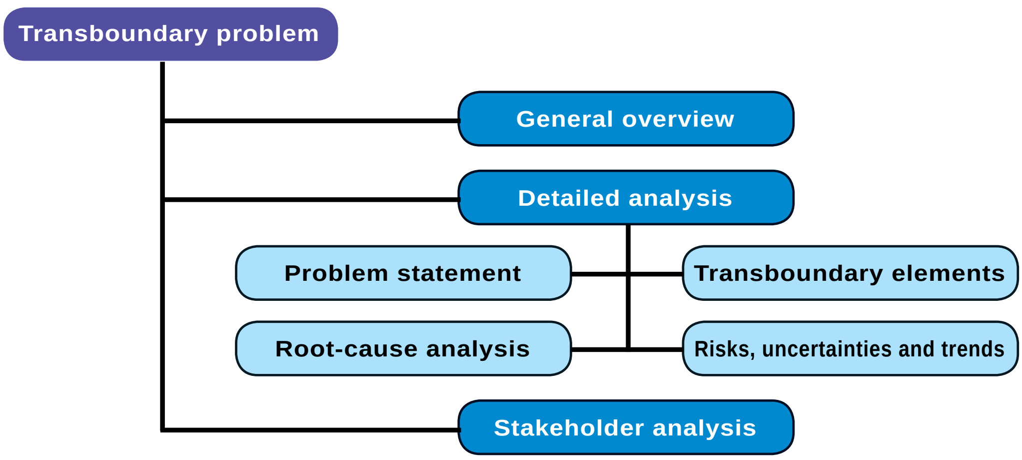


Figure 6.1 Schematic presentation of the problem analysis framework as envisaged by UNEP-GEF

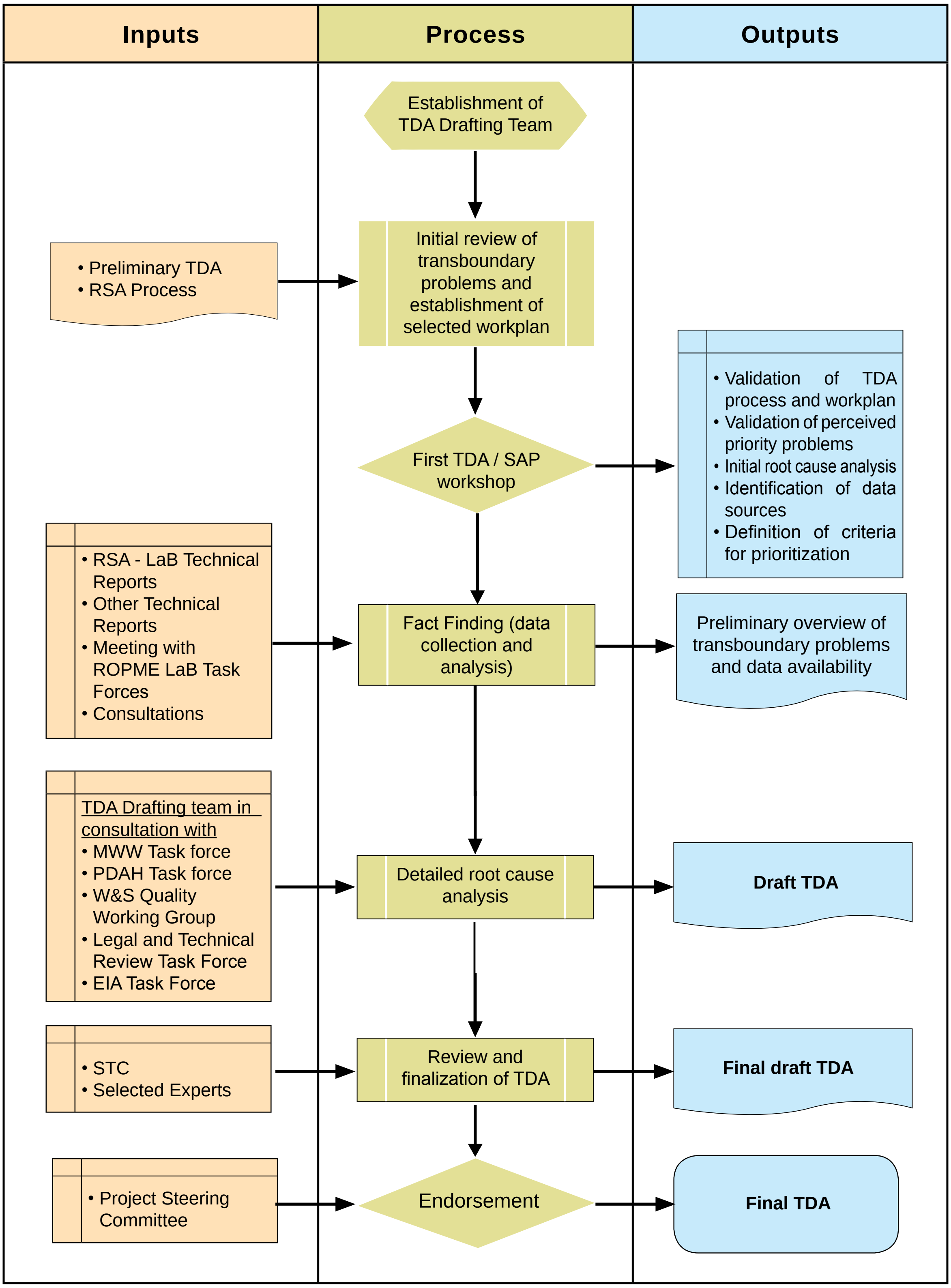


Figure 6.2 Schematic presentation of TDA process Master Plan for the ROPME Sea Area (Risk Analysis and Cost-Benefit-Assessment). (Modified after UNEP-GEF, 2008)

It is to be noted, however, that the implementation of EBM approach is a challenge since the RSA is shared by eight Member States and the ecological boundaries transcend political divides. It is important to mention that EBM approach should be to foster a shared vision of the strategic importance of RSA resources. Since Ecosystem-Based Management approach must deal with the complex variety of interdependencies and trade-offs between economic, social, and environmental variables, its implementation is, therefore, considered a challenge. The biggest constraint in applying the EBM approach to management in the RSA lies in the sectorally oriented culture that prevailing in the area. Khan (2008) mentioned that government business is conducted through agencies or ministries representing sectors such as agriculture, fisheries, health and commerce, whose interests are often conflicting. EBM advocates development of enabling mechanisms to foster a common understanding of issues at various spatial scales such as local, national, regional and global.

6.4.3 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 urban and industrial areas, areas around industrial ports and free zones, and special plans for management of tourist areas and ecologically sensitive areas including coastal and marine reserves and protected areas.

Another planning tool that is complementary to ICAM, but also applies to major development projects and human activities, is the Environmental Impact Assessment (EIA) procedures that would help to significantly reduce the degradation of the environment, particularly from land-based activities. EIA procedures are required in all Member States to facilitate sound environmental management and more effective economic development.

Khan (2008) mentioned that one of the foremost issues in coastal zone management is that administrative and legal institutions are fragmented and are based on social economic interests. At national level, it is common in the RSA to find several agencies representing various sectors such as oil and gas exploration and development; industrial and urban development; fisheries, maritime transportation, recreation, etc. Many of these sectors have conflicting interests in coastal resources; hence the sectoral agencies are often not motivated and reluctant to cooperate in integrated and coordinated management planning (Khan, 2008). On the regional level, the situation become further complicated, since the RSA is shared between eight Member States with different political and socio-economic plans. Thus a rationalization and coordination of conflicting interests and responsibilities need to be established at both national and regional level by examining factors that facilitate collaboration with the aim to encourage a shared vision of the strategic value of RSA (Khan, 2008).

6.5 OTHER IMPORTANT CHALLENGES AND OPPORTUNITIES

6.5.1 Capacity Building

An important factor in achieving the environmental objectives, and in effectively addressing the prescribed concerns, is building the national and regional capacities that enable Member States of ROPME to meet the challenges and honour their obligations.

Intensive capacity building programmes should therefore be rigorously pursued both at the national and regional levels and in all areas outlined in this Report. ROPME's continuous National and Regional training courses, Regional research programmes expert meetings, and technical support to National institutions has considerably added to the capacity building efforts in the Region. However, ROPME programmes for in-house training, short courses, or visits to qualified laboratories/institutions are to be further encouraged and augmented by establishing 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.

MEMAC's efforts in enhancing the Regional Capacity Building measures by conducting various training courses and the Regional Drills and exercises can be a good example to be pursued alternatively.

6.5.2 Public Awareness

Environmental public awareness is an essential component of any national policy for the protection and conservation of the environment. At the regional level, strategies for the enhancement of environmental awareness among the public should be continuously revised and followed-up, making use of the national experiences already available in several Member States of ROPME. In this connection, it has to be noted that the large number of stakeholders involved in the coastal area require multi-level awareness programmes targeting different groups.

6.5.3 Strengthening Monitoring and Data Quality Assurance

One of the main ROPME missions is the development and upgrading Regional capacity in the analyses of contaminants in the marine environment for producing assured results of high quality; through the periodical organization of specialized National and Regional training courses, Inter-calibration exercises and Proficiency Tests among National Laboratories.

Towards the implementation of planned scientific programmes and to conduct the relevant analyses in competent National Laboratories in the Region, ROPME Secretariat conducted during 2011 four Regional "Proficiency Tests" in collaboration with MEL/IAEA among National Laboratories that were willing to participate in the analyses of trace metals, organic contaminants, organotin compounds and radionuclides.

The conclusion from conducting these Proficiency Tests showed the necessity to continue similar exercise with emphasis on data uncertainty and validation among National Laboratories in the Region.

6.5.4 Cooperation with Non-Governmental Organizations (NGOs)

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. A good example to note is the Environmental Protection Society of Kuwait which has recently formulated a diver team that helped with some diving activities for the cleanup of contaminated sites (ROPME, 2000). EPA-Kuwait adopted a method to enhance and promote the concept of environmental protection among all sections of society, by selecting an environmental lady-mayor for each residential area, to look after environmental issues (http://env304.wordpress.com/marine-pollution-control/).

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. In addition, there is a need for capacity building to increase the involvement of NGOs as well as other institutions and the private sector in the environmental policy-making and in taking action in the respective priority areas of ROPME's programme. The NGOs themselves also need to ascertain their objectives and roles in the development of national policies and to provide advice, constructive criticism and assistance to national environmental authorities.

CHAPTER 7

FUTURE OUTLOOK

KEY MESSAGES

- ROPME Member States are the custodians of the common pool of resources in the RSA. It is their duty collectively to cooperate to improve its ecosystem health and sustain its functions and services for their current and future generations.RSA shared vision with long-term environmental goals and targets need to be developed by the countries of the Region
- The current trends, practices, and level of governance and sustainable management of the RSA are inadequate and could lead to its irreversible degradation and the loss of its ecosystem functions and services. This is expected to have dire consequences and negative impacts on the socio-economic development of the people of the member countries
- The prolongation of national and regional political tensions and conflicts will lead to the victimization of human wellbeing and the environment and to the exacerbation of current RSA environmental pressures. Avoiding conflicts and investing in human resources development, Research and Development (R&D), governance improvement, and regional cooperation of the RSA countries are key issues in the protection and sustainability of the RSA ecosystem
- RSA management and protection policies need to be integrated and mainstreamed into the national socio-economic development plans, with human and environment central to planning
- Heavy Investment in human resources development through education, training, and capacity development programmes in the fields of environmental management of the coastal and marine ecosystem is a critical element in the sustainable management of the RSA
- Regional cooperation between the RSA Member States is vital for the sustainable management of the RSA ecosystem. The main areas of cooperation are in the fields of trans-boundary bio-reserves and protected areas, regional Integrated Coastal Zone Management (ICZM) planning, enforcement of laws and regulations, monitoring and assessment, and data and information exchange and knowledge sharing
- Establishment of RSA network of research Institutes and collaborating centers under the auspices of ROPME is an important step towards building an RSA-oriented scientific research and capacity building programme. The role of the NGOs in monitoring and raising awareness need to be enhanced

An increasingly common approach in environmental assessments for exploring the future has been the use of scenarios, serving as useful tools for evaluating future environmental problems and assessing policies to resolve them, and for synthesizing and communicating complex and extensive information to decision makers and the public at large. The value added for scenarios to the traditional State of the Environment is in their capabilities in handling and assimilating enormous amounts of information and insights, and providing an effective format for bringing these information together. Moreover, as scenarios are written in the form of stories, the results of an assessment can be communicated to a large and diverse audience, both technical and non-technical. Finally, probably the most important function of both scenarios and environmental assessments is that they act as a crucial bridge between environmental science and policy. They influence policymaking by summarizing and synthesizing scientific knowledge in a form that can be used by policymakers to develop policies. They help policymakers to visualize the different aspects and connections of an environmental problem, as well as its large time scale (Alcamo, 2001; UNEP, 2002; MA, 2003).

This chapter builds on previous chapters of this Report by exploring how current social, economic and environmental trends in the countries of ROPME Sea Area (RSA) may unfold along the divergent development paths in the future and what might this mean for the environment, development and human well-being in these countries. It presents two scenarios – the **Business as Usual (BAU)** and the **Sustainable ROPME Sea Area (SRSA)** - to the year 2040, using narrative storyline to explore different policy approaches and societal choices made by the countries of the Region.

It further explores the Region's future through the lens of "environment and development", and concentrates on the end results of these various choices that might be taken through the use of scenarios thinking.

7.1 SCENARIOS ANATOMY

Based on the findings of the previous chapters in term of the nature and scale of environmental degradation, it is very likely that the environment of RSA would degrade further without additional intervention policies by the riparian countries. Therefore, it is necessary to identify actions and policies to halt or "bend the curve" of environmental degradation and possibly reverse the trends. This chapter looks at the RSA riparian countries choices that can influence current trends on the long term, marked by the year 2040; i.e., within a 30 year horizon.

BOX 7.1 – UNEP's GEO Scenarios Archetypes

Markets First: the private sector, with active government sector support, pursues maximum economic growth, trusting this to be the best path toward the improvement of the environment and human well-being for all;

Policy First: the government sector, with active private and civic sector support, implements strong policies intended to improve the environment and human well-being for all, while still emphasizing economic development;

Security First: the government sector and certain private sector actors compete for control in efforts to improve, or at least maintain, human well-being for selected elite groups;

Sustainability First: the civic, government and private sectors work collaboratively to improve the environment and human well-being for all, with a strong emphasis on equity.

Source: UNEP, 2007

Most of previous UNEP's GEO reports have explored alternative scenarios in order to explore the uncertainties of very different futures (UNEP, 2002, 2007). This is made through the use of four scenarios archetype or framework (Markets First, Policy First, Security First, and Sustainability First - Box 7.1) that represent different policy approaches and societal choices. However, it has been concluded in many previous regional scenarios that the underlying assumptions of the first three scenarios (i.e., Markets First, Policy First, and Security First scenarios) are interplaying in the RSA Region and the region has been experiencing them at different locations and at different times. In other words, while many countries of the region have been placing extreme emphasis on markets and economic growth as a way to improve social conditions, and sometimes over-relying on the self-correcting logic of competitive markets to solve social and environmental problems (i.e., Market First Scenario), policy constraints on market forces - although not strong enough - have been made by some countries in order to minimize their undesirable effects on human and environment (i.e., Policy First Scenario); probably, the lessons learned from the 2008 global financial crisis have helped in strengthening this direction and have shown the dangers of the neoliberal economic ideology and that markets do not have self-correcting mechanisms.

Furthermore, the Region has been undergoing prolonged national and regional political tensions and conflicts (i.e., the two RSA wars, Iraq occupation, and the current national instability in some countries), not to mention the international interests and foreign interventions and pressures in the Region, all of which portray the Security First Scenario, which impact negatively on the development process and the environment.

In view of the above, two distinct scenarios have been designed based on the current trends and aspired future to map out the choices and strategies that can lead to a pathway connecting the current situation (which is a combination of the first three scenarios) to a more sustainable future in the next three decades. These are the “Business as Usual” Scenario and the “Sustainable RSA” Scenario. The first scenario represents a conventional projection of the current prevailing system and trends (in governing the RSA ecosystem), while the second scenario represents the current understanding of sustainability of the RSA Region and its marine environment. Furthermore, in order to explore the potential impacts of surprises and discontinuities, which have the power to completely change the outcomes of these two scenarios, the premises and components of the “Security First” Scenario are embedded in the “Business as Usual” Scenario as a wild card in the form of military instability and man-made disasters caused by political conflict and tension, such as radioactive pollution, oil spills, and others disasters.

These two distinct scenarios, which explore different policy approaches and societal choices, are presented using a narrative storyline. It should be noted that these two developed scenarios for the RSA are not predictions, nor should they be taken as the most likely of possible futures. At most, they portray pictures of limited number of possible futures based upon a certain set of assumptions about driving forces, critical uncertainties, and system relationships. These drivers include governance, demography, human development, economic development, science and technology, culture, and regional cooperation among the riparian countries of the RSA. Their rationale is not to indicate what will, but rather what might happen if certain choices are made. Their purpose is to assist in thinking more carefully about how things might evolve under the current system and practiced policies, and what is needed in terms of transformative policies to have a positive image of the future of the RSA and meet the environmental targets.

7.2 ROPME SEA AREA ENVIRONMENTAL SCENARIOS

What is the future of the natural environment of the RSA and human well-being of its riparian countries? What are the main driving forces that will shape this future? Which of the current social, economic, and environmental trends will continue and which will see a dramatic shift? What are the impacts of these changes on the RSA environment and human well-being? Finally, as the custodians of the RSA, what role can these countries play in shaping this future to ensure its environmental health and sustain its services for their future generations?

All these questions need to be addressed if the countries of the region want to have a role in determining the RSA future destiny, by taking policies and actions that will take it from its current deteriorating state to the future that they hope for, and that for their future generations, or at least, to enable the RSA to adapt and adjust itself to future external developments and avoid/alleviate their negative impacts. Better still, to be able to identify future opportunities and benefit from them in building a healthy and environmentally flourishing future for the RSA.

In order to achieve that, it is necessary first to identify the main driving forces that impact the RSA, which could be social, technological, economical, environmental, and political (termed STEEP driving forces), whether they are internal (that the countries take) or external (that are imposed on them), and know their past trends and their various impacts on humans and environment. Then, try to forecast/predict what might happen if these driving forces continue or discontinue on the long-term, and imagine the future that might be reached if these driving forces/policies/choices continue, and examine whether these policies are adequate to take us to the hoped future socially, economically, and environmentally.

7.2.1 Scenarios Key Questions

The scenarios presented here are designed to try to answer the following main question: Over the next 30 years, could the countries of the RSA protect their common pool resource, reverse its current state of degradation, and maintain its ecosystems functions and services to serve their sustainable development goals; If yes, how? And if not, why?

Other key more specific questions the scenarios are trying to address and explore are: Under the current socio-economic development policies and trends of the RSA countries, what are the impacts on human well-being and their consequences on the environment in general and RSA ecosystem functions and services in particular?; Under the current environmental policies, is it possible to avoid environmental negative impacts or mitigate them?; What are the compromises/trade-offs involved?; Can environmental and natural resources of the RSA continue to be exploited to increase economic development and human welfare without victimizing these resources?; and, finally, what are the environmental, economic, and social costs that would result from this exploitation on the long-term?

7.2.2 Key Environmental Challenges and Focal Issues

Generally speaking, the key environmental challenges and focal issues in the ROPME Region are known to be: water scarcity and quality, land degradation and desertification, degradation of coastal and marine environment, management of the urban environment, and the impact of violence and conflict on the environment. Although the countries of the RSA have different socio-economic and geopolitical characteristics, exploitation of natural resources and sustained growth of population and urbanization constitute major driving forces for all the countries' economies. The issues of governance and cooperation, on the regional level, represent two of the over-arching driving forces that will have major impact in shaping the future of the RSA. Furthermore, a protracted history of wars and political tensions in the Region, as well as within the countries, has placed peace and security at the center of human well-being and environmental concerns. Thus, security and military spending versus investment in human resources development and environmental protection represents a key general driving force in the Region.

The ROPME Sea Area key environmental challenges and focal issues that are leading to the deterioration of the marine and coastal environment have been highlighted in Chapter 6 of this Report and their major impacts could be summarized in the following:

- **Impacts of sea-based activities** (Oil Spill, oil exploitation, tar balls and slicks on beaches and in water, discharge of ballast and bilge water, leakage from pipe- lines)
- **Impacts of land-based activities** (discharge of Industrial wastes, discharge of untreated or partially treated sewage, desalination effluents, agricultural drainage)
- **Impacts of urban and Tourism Development** (large-scale urban and tourism development and extensive dredging and land-filing)
- **Habitats destruction** (destruction of mangroves, sea grass, coral reefs by anchoring, trawling and landfilling)
- **Over-exploitation of living marine resources** (overfishing, decline in landings, increased fishing efforts, landing beyond maximum sustainable yield, destructive fishing techniques)
- **Expected impacts of climate change** (e.g., coral bleaching)

7.3 THE SCENARIOS NARRATIVE

The following two scenarios narrative storyline attempts to explore the level of impacts of the different policy approaches and choices that could be made by the countries of the Region on the current and future environmental challenges and issues the RSA is facing. While they show the impacts of the various STEEP drivers on the future paths of the countries, they also show how acting reactively (Business as Usual Scenario) or proactively (Sustainable RSA Scenario) would affect and determine these paths. The two scenarios narrative storyline is supported by quantitative modeling of some socio-economic and environmental indicators using International Futures® (*IFs*) Modeling Programme (Hughes, 2008). The purpose of these quantitative indicators is for illustration and comparisons between the two scenarios, and they should not be taken in their absolute values.

7.3.1 Business as Usual Scenario

Most of the countries in the Region have undergone economic policy reforms and restructuring, sometimes with fast transformation of the state role from a service provider to service enabler and regulator. Privatization is perceived as the main solution to lower government economic burden, attract foreign investment, increase services efficiency, and enhance cost recovery. At certain times, the environment received low priority and is overridden by investment policies; to attract investments, environmental legislation and regulations are relaxed to investors with minimal interventions. However, some of the countries decided to integrate social and environmental issues into economic and fiscal policies to mitigate rising environmental, social, and cultural costs of free market economics. Examples of implemented environmental policies by these countries to reduce the negative environmental cost on the marine environment are Strategic Environmental Assessments (SEA), Integrated Coastal Zone Management (ICZM), and Integrated Environmental Assessment (IEA), which have contributed to decreasing the rate of environmental degradation and consequently improvement of human well-being. However, pressures from investment policies continued to be high. While a positive impact on resources use efficiency and overall performance of services is achieved, social disparity and environmental problems continue to increase.

Population grows at a slower rate compared to that at the turn of the century in most of the countries of the Region. However, population continued to increase due to both investment policies and failure of government population policies (Figure 7.1). Growth rates, and in some countries population size, continued to constitute a core development problem, leading to increased levels of unemployment and poverty, with an overall negative impact on the environment, natural resources, and the economy. Constitutional democratization, public representation and free voting, women empowerment, auditing and transparency continued to spread in the riparian countries of the RSA, good governance advances (Figure 7.2). Civil society empowerment advanced, and public participation impacted major decision-making. Health and environmental issues are gradually becoming the main concerns of the civil society, hence enhancing and strengthening the role of environmental authorities in the decision-making process at the national level. This has its reflection at the regional level; a greater regional harmony and cooperation at the level of ministerial forums and organizations, such as ROPME has occurred. However, peace and security continue to be absent and instability and tension continued in the Region. Regional and national political conflicts, though contained from escalating, erupt every now and then (Box 7.2), and have their negative impacts and are often causing interruption of development programmes and exacerbating environmental problems.

Water stress continued to increase due to the higher population growth rates and the limitation of renewable water resources (Figure 7.3). Water demands continued to exceed available water resources, leading to their over-exploitation and quality degradation, increasing land degradation, reducing food production, and increasing water-related health problems.

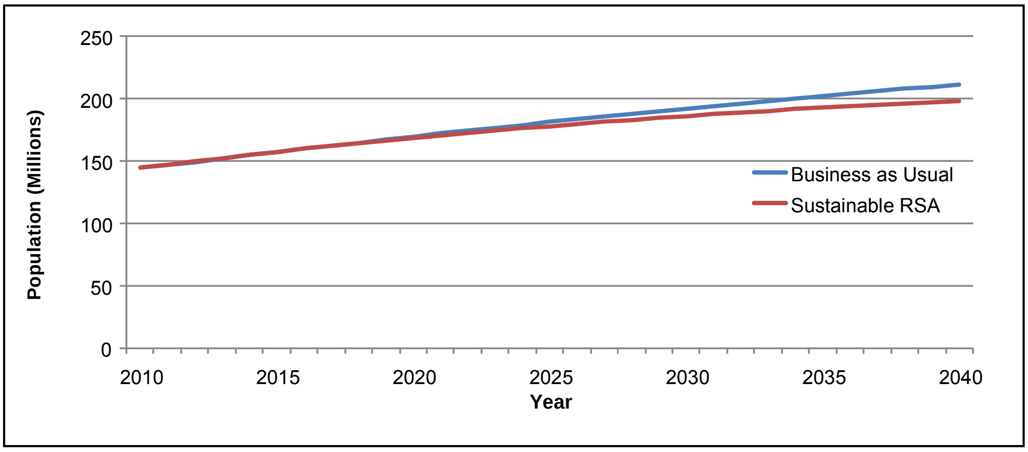


Figure 7.1 RSA total population projection for the period 2010 - 2040

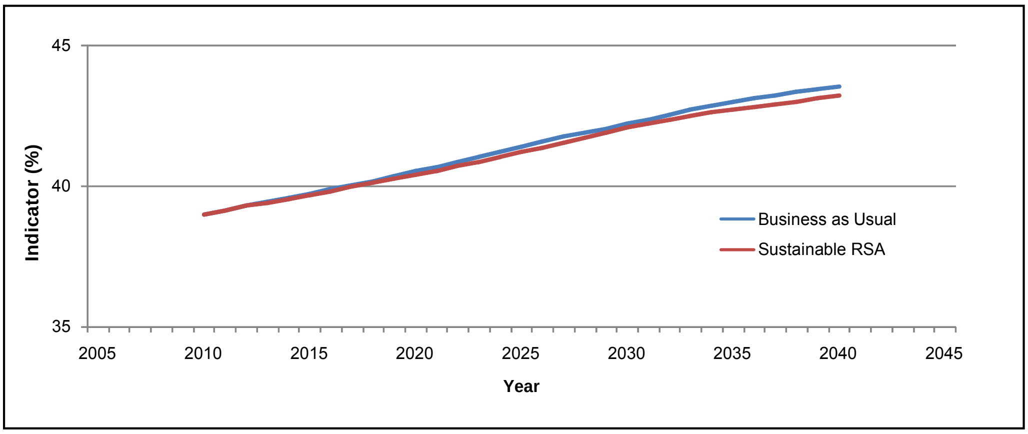


Figure 7.2 RSA Freedom House Indicator (%)

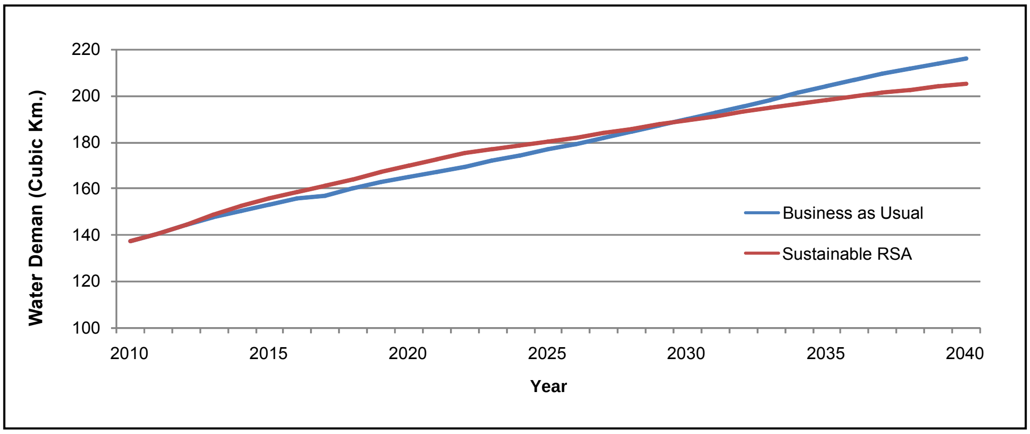


Figure 7.3 RSA countries total water demands (km^3.)

BOX 7.2 – The Uncertainty of Armed Conflicts and Political Tension

Political conflicts and tensions, superpowers interventions, sanctions, lack of economic and political reforms, social inequity, increasing regional disparity, have contributed to stalling human and economic developments, and crippled the progress towards regional economic cooperation. Regional and national political tensions, with increased frequencies of armed conflicts prevail in the Region. The share of military expenditure has increased tremendously, and accompanied by high population growth rates, have contributed to economic stagnation and lowering living standards, and adversely impacting human resources development, the environment, and natural resources capacity. In general, the environment and natural resources are victimized to meet security demands.

Under these conditions, the elements constituting human well-being, particularly water, food, and personal security, will be highly endangered. Increasing food demand, lack of cooperation between riparian conflicting countries, and lack of environmental regulations and/or enforcement lead to the over-exploitation of marine living resources and fish stocks and to increasing pollution load to the RSA. These conditions have resulted in rapid degradation of the marine ecosystem, irreversible loss of habitats and biodiversity, and accelerated trends of species extinction, with eventual negative impacts on food security of the countries of the Region. Furthermore, in countries depending on desalination for providing their domestic water supply, the water security of the population is put at risk and is threatened by water shortages and quality deterioration. At the individual level, the political instability in the RSA has led to a deterioration of personal security in terms of access to resources (particularly marine), personal safety, and protection from disasters.

As scarcity increased, water became an increasingly expensive commodity in the region, and the use of non-conventional water resources, desalination and treated wastewater, is intensified to meet escalating demands. Desalination continued to depend on fossil fuels and is associated with environmental problems, such as air, coastal and marine pollution. While the use of clean renewable energies, such as solar and wind which are abundant in the Region, increased, their share in the Region's energy sector continued to be marginal. As desalination becomes increasingly the main source for domestic water supply in the majority of the countries of the Region (i.e., GCC), its associated negative impacts on the RSA ecosystem and its services continue to increase with time.

Furthermore, generated wastewater escalates with the rising rate of population, surpassing the capacities of the wastewater treatment plants. This consequently leads to major discharge of partially treated/untreated wastewater from urban areas, which in addition to its environmental impact on the coastal and marine environment, contributes to frequent fish kill incidents and to human health problems in the Region.

Planned and unplanned urbanization continued to increase in size (Figure 7.4). Despite its social benefits in terms of employment and easier access to educational and health services, urbanization pressures constituted a major threat to RSA ecosystem. The Intensified development of coastal and marine areas along with poor management and unenforced regulations resulted in marine ecosystem and habitat degradation and consequently to loss of biodiversity and reduction of carbon sinks in the marine environment, such as mangroves, sea grass, algae (i.e., Blue Carbon).

As food demand (agricultural and fisheries) increases with population, agriculture activities are intensified with excessive use of water, chemical fertilizers, pesticides, and hormones, leading to an increase in the volumes of agricultural drainage water, eventually reaching the sea. With this intensification of agriculture and the use of these chemical compounds, agricultural drainage water continued to negatively impact the coastal areas of the RSA.

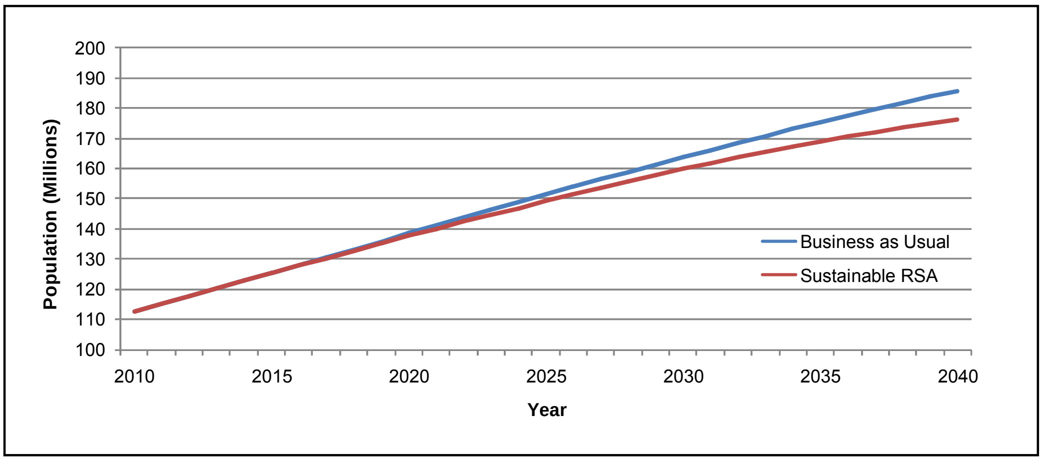


Figure 7.4 RSA countries urban population (millions) under the two scenarios

Moreover, increasing food demand in the Region and weakening of cooperation have lead to the over-exploitation of marine resources and fish stocks. Furthermore, aquaculture and mariculture, driven by the private sector, thrived in an attempt to meet escalating food demands. In most cases, these industries expanded with no concerns for potential environmental and health consequences. These conditions resulted in rapid degradation of the marine ecosystem, irreversible loss of habitats and biodiversity, and accelerated trends of species extinction. Many rare marine species are threatened or extinct.

These trends are slowed down by national coastal and marine resources protection strategies and legislation, which included the implementation of coastal zone management plans, well-planned and increased national marine bio-reserves and protected areas, and rational management of marine resources. Degradation rates of marine ecosystems and habitats and biodiversity loss is slowed down; however, fish stocks continue to be depleted.

Furthermore, as oil continued to dominate energy sector in the the world and the Region, oil exports from the Region increased with time (Figure 7.5), bringing higher risks of oil spills and spread of invasive species. Some countries have imposed stringent regulations to protect the marine environment from oil spills, spread of invasive species and land-based contamination, the overall impact of which is to slow down the degradation of marine resources and in some cases the achievement of effective local rehabilitation. ROPME and MEMAC continued to play a major role in the early warning against such threats to the RSA, but their role continued to be of mitigation rather than prevention.

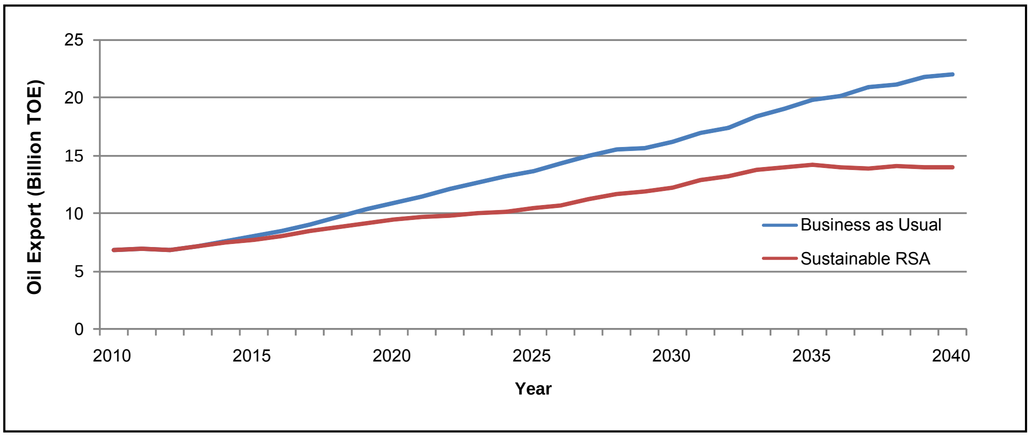


Figure 7.5 RSA countries energy export in billion ton oil equivalent (toe)

By energy subsidies and relaxed environmental regulations by a number of countries in the RSA to fulfill their policies of economic diversification and attraction of foreign investments, industrialization in the coastal zones expanded, leading to an increase in contamination to the marine environment from land-based activities. There is a general deterioration of the marine ecosystem, habitats and losses of biodiversity, and more incidents of fish mortality, leading to an overall decrease in marine food production and economic losses in the fishery industry.

Governance and management of RSA marine ecosystem continues to be fragmented. This is true for both at the regional level and the national level. At the regional level, there is a lack of cooperation and absence of coordination of the conflicting socio-economic interests and responsibilities. At the national level, national decisions continue to be mostly reactive instead of proactive, sectoral or issue-based with weak cooperation in integrated and coordinated management planning among the national agencies. Implementation of ROPME Protocols is not an integrated part of the national strategies of the member countries. Moreover, the role of NGOs in the management and planning process and societal awareness continued to be limited.

Integrated Coastal Area Management planning (ICAM) with a regional RSA perspective continue to be absent in most of the RSA. Control and management of sea-based and land-based activities continue to be ineffective due mainly to lack of enforcement of national laws and regulations, urban and tourism development and their associated dredging and landfilling activities as a major threat to the sustainability of RSA ecosystems goods and services. The destruction of habitats by bad fishing practices, landfilling, urban encroachment, pollution, and over-exploitation of living marine resources continue. The situation is exacerbated by the impacts of climate change on marine ecosystems, and is further compounded by the lack of employment of policies based on integrated scientific approaches in the management of the RSA ecosystem. Under this scenario, it is expected that by the year 2040, the RSA ecosystem' carrying capacity would have been considerably surpassed and reached an irreversible degree of deterioration, which heavily impacts development and the elements of human well-being of the riparian countries of the RSA.

7.3.2 The Sustainable RSA Scenario

The ROPME Member States witness significant improvements in governance accompanied by sustainable policies, where human development and environmental protection are central to planning. A more visionary state of affairs prevails where proactive solutions to the challenges of sustainability are provided, and sustained link between social, economic and environmental policies is made. This is achieved by the adaptation of long-term integrated strategic planning, with the objective of achieving superior quality of life and healthy environment, and accomplished in the long-term by strong emphasis and heavy investment on human development through educational, training and capacity building programmes. The aim is to create a productive knowledge-based society to fulfill the needs of these countries' economic development. Environmental sustainability is pursued through changing education system and human behavior and attitude towards the surrounding environment for long-term viability and success. Furthermore, Scientific Research and Development (R&D) to solve the society′s social, economic and environmental problems is encouraged greatly with significant funds allocations in the countries' national budget drawn from both the private sector and the governments. The RSA countries universities and research institutes are capable of carrying out competitive research projects in all fields of sciences, including environmental management, new energy sources, water desalination and waste water treatment.

The Region's societies will have moved more closer to complete democracy, with civil society empowerment reaching high levels, including active public participation in the decision-making process. High level of environmental awareness is achieved at all levels of society and health and environmental issues have become the main concern of the civil society. As a result, government environmental authorities will have a strong impact on the decision-making process, leading to favoring environmental policies on economic policies in cases of their conflict. Moreover, national decisions have become more integrated and coordinated among the various pertinent agencies. Gradually, awareness and understanding of the value of the functions and services of the RSA ecosystem at the level of the policy makers and the society at large have become more widespread; RSA ecosystem protection moves from the periphery of the socio-economic development policies and decision making process to its core.

On the regional level, an end to the conflicts in the Region is achieved, with dialogue replacing tension. Military spending has been considerably reduced and government expenditures are directed towards human resources development and environmental protection. The Region now has high levels of economic cooperation. Regional environmental organizations, such as ROPME, are enhanced and strengthened by this development. Regional environmental policies are formulated at the regional level with full cooperation of the Member States and are implemented at the national level. Moreover, the Region has become an active partner in setting the global environmental policies.

Whether this scenario becomes a reality in the Region or not, the Region is expected to be very short in some resources, the most vital of which is water. Being aware of this reality, the water scarcity problem absorbs the full attention and consideration of governments in the Region and they embark on taking sufficient measures to ease the problem. The adoption of sustainable water resources management strategies with strong emphasis on demand management and conservation aided by the relatively slowing population growth rates (Figure 7.1), significantly reduced water stress. This in turn has slowed down the expansion in desalination and subsequently its negative impacts on the coastal and marine environment. These developments significantly reduce generated wastewater from urban coastal areas, and thus reduce wastewater discharge to the coastal and marine environment. Furthermore, major regional investments in R&D in the development and use of non-conventional water technologies, paralleled with the same in cleaner renewable energies leads to major breakthrough in desalination and treatment technology without major environmental problems, and an overall reduction in Green House Gas (GHG) emissions represented by the eventual reduction in the Region's carbon emissions from fossil fuels shown in Figure 7.6.

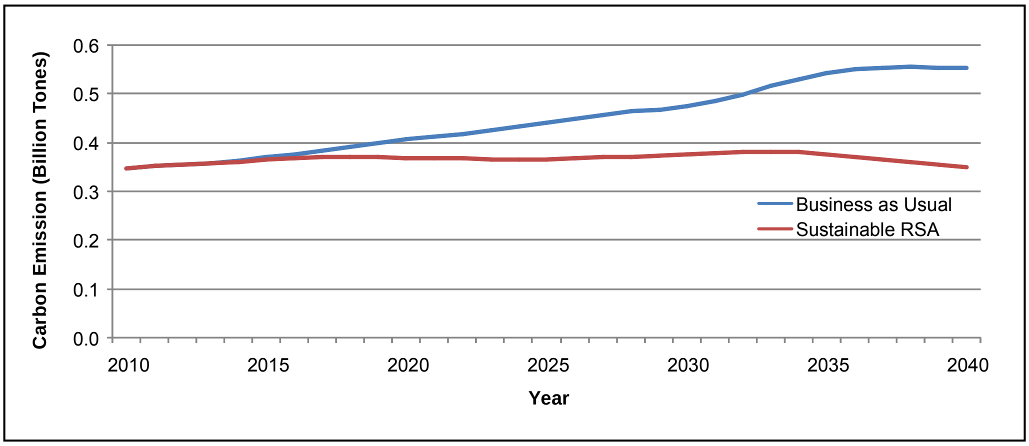


Figure 7.6 RSA countries annual carbon emissions from fossil fuel (Billion tons)

Investment policies in the development of renewable energies, such as solar and wind, made by the majority of the countries in the Region, as well as in the world, has lowered overall fossil energy use in the Region and its export from the Region to the world. This development has not only lowered the risk of oil pollution which was the most significant form of pollution in the RSA, but also has increased the life of the oil reserves in the Region, and has given the RSA a competitive edge and a large share in the renewable energy market. Still the RSA countries have been active by complementing this by imposing stringent regulations and have made the implementation of ROPME protocols as part of their national strategies to protect the marine environment from oil pollution and spread of invasive species. The overall impact is the rapid reduction in the pollution by sea-based activities and the degradation of marine resources.

To face increasing food demand by the growing population, policies of sustainable agricultural production were pursued by the countries of the RSA; the adoption of modern irrigation and agricultural techniques, replacing chemical fertilizers and pesticides with organic types, economizing on water use and using better-quality water all help reduce the volume and hazards of the agricultural drainage water reaching the RSA. Aquaculture and mariculture industries continued to expand and become inevitable in the face of increasing food demand. However, their potential environmental and health consequences are well-researched and mitigated through precautionary planning.

Unplanned and random development of coastal and marine areas was stopped by coastal and marine resources protection strategies and the wide implementation of ICZM. Laws regulating coastal areas are issued, and are strictly enforced. New developments in sensitive areas are totally banned, and tight control is imposed on developments in other coastal areas. Extensive efforts were made to restore degraded coastal and marine ecosystems and habitats. Industrialization in the coastal zones continued, however, with strict environmental regulations and compliance. This has resulted in lower pollution loads from land-based activities to the coastal and marine environment. All these interventions allows the gradual rehabilitation of these habitats and ecosystem, slowing down and in some cases stopping of biodiversity loss, as well as increasing carbon sinks in the marine environment. The coastal and marine ecosystem shows symptoms of recovery, after long deterioration.

Moreover, a regional strategy for fisheries management based on an ecosystem approach with the ultimate goal to ensure long-term sustainability for the whole marine system, including fisheries resources, human communities, and their supporting natural environment, has been adopted by the RSA countries. This strategy includes rational management and preservation plans of marine resources with strict regulations on fishing and development, and regionally planned marine bio-reserves and protected areas, which not only reaches the world standards, but surpasses it.

At this stage, all Member States have ratified and jointly implemented relevant Multilateral Environmental Agreements (MEAs), fulfilled their obligations of the declaration of ROPME Sea Area as a Special Area, established oil wastes reception facilities, enforced the prevention of pollution by oil and wastes, all of which resulting in significant reduction of marine pollution. The Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA-LBA) is also strictly implemented, significantly reducing sewage releases into the marine environment.

Governance and management of RSA marine ecosystem have become more integrated and coordinated, with ROPME continued to play a major role in the early warning against threats to the RSA, and as supported by the member countries, the role of the organization is transformed from mitigation to prevention. National and regional enforcement of laws and regulations and implementation of ROPME protocols have made the control and management of sea-based and land-based activities more effective, dredging and landfilling activities reduced tremendously, habitats destruction by unsustainable and unwise fishing practices stopped, and pollution has been significantly reduced. Climate change adaptation measures are integrated and mainstreamed in national coastal and marine environmental policies. Policies based on integrated scientific approaches have replaced *ad hoc* sectoral policies in the management of RSA ecosystem. By the year 2040, the RSA ecosystem becomes sustainable and healthy. The countries in the Region enjoy the benefit of its functions and services, which contribute to their sustainable development and economies.

7.4 CONCLUSION AND POLICY LESSONS

The Business as Usual is a depressing scenario for the RSA; the current trends and practices and level of governance and management of the RSA will lead to its irreversible degradation and the loss of its ecosystem functions and services. This is expected to heavily impact the development of the RSA countries and the elements of human well-being. Although adopted economic growth policies by many countries in the Region is important to achieve socio-economic development, investment initiatives that are not associated with adequate considerations to environmental protection could increase environmental degradation and lead on the long-run to weakened and negatively impacted development process. While governments interventions in "bending the curve" of these RSA deteriorating trends lead to a relative decrease in environmental degradation and improvement in human well-being, pressures from investment policies will continue to be exerted on the environment. Furthermore, the governance approach in this scenario, in addition to its top-down approach, suffers from being a reactive rather than proactive and tends to be slow in responding to change.

Moreover, the prolongation of national and regional political tensions and conflicts, might lead to increased frequencies of armed conflicts. Under these conditions human well-being and the environment will be sacrificed or at least compromised. The current RSA environmental pressures, namely pollution from land and sea-based activities, habitat destruction, and over-exploitation of living marine resources, will be exacerbated by unplanned and rapid development activities and by overfishing in the Region.

In Sustainable RSA, the prevalence of a more visionary state of affairs, where proactive solutions to the challenges of sustainability are provided, and a sustained link between social, economic, and environmental policies is made, offers solution to the sustainability challenge in the Region. Cooperation and dialogue at the national, regional, and inter-regional levels are replacing tensions and armed conflicts. The countries of the Region adapt long-term integrated strategic planning, with the objective of achieving superior quality of life and healthy environment, and accomplished in the long-term by strong emphasis and heavy investment on human development through educational, training and capacity building programmes. All these national and regional developments reflect positively on the RSA. An RSA shared vision is achieved, and its governance and management become more integrated and coordinated among its riparian countries. The implementation of protection strategies and action plans by the Member States of ROPME lead to a sustainable and healthy ecosystem of the RSA and to an increase in the contribution of its functions and services to these countries' goal to achieve sustainable development.

Probably, the most important policy lesson that this scenarios exercise offer, in addition to the above, is that investment in human resources development, Research and Development, governance improvement, and regional cooperation amongst ROPME Member States is a key issue in the protection and sustainability of the RSA ecosystem. The riparian countries of the RSA should act as the custodians of this common resource pool, to cater for their current socio-economic development needs and for their future generations.

7.5 KEY SCENARIOS MESSAGES AND STRATEGIC RECOMMENDATIONS

The above two scenarios have investigated the implications of different choices, premises, approaches, and priorities on the natural environment and human well-being in the RSA Region with emphasis on the ROPME Sea Area. This section attempts to summarize the key messages concluded from both scenarios. Although they have many uncertainties involved in their derivation and are based mainly on qualitative analysis, these scenarios can provide valuable insights for the broader process of policy-making, and could help decision-makers to give special thought to how they might direct their actions to creating the best possible future hoped for the countries in the Region and the RSA. Box 7.3 contains the main messages and strategic recommendations to policy-makers and decision-makers of the Region.

BOX 7.3 – Main Messages to Policy-Makers

- The most important choices affecting the RSA ecosystem in the future are not necessarily environmental choices; achieving RSA environmental sustainability will rely on a multitude of potential interventions and developments that are outside the environmental sector and need to be made at the national level, such as the governance approach, the education system, the implementation of technological innovations, and changing the behavior of people
- The environment is not compartmentalized and nor should environmental policies be; RSA protection policies should be integrated and mainstreamed into the national socio-economic development plans; sound sustainable policies should have human and environment central to planning
- Achieving long-term goals for the RSA requires long-term strategic planning; long-term planning is vital for guiding near-term actions towards a sustainable future
- Political conflicts and tensions are contradictory to sustainability; under conflict conditions it is likely that the environment, natural resources, as well as human well-being are victimized to meet security demands

7.6 STRATEGIC RECOMMENDATIONS TO ENVIRONMENTAL DECISION-MAKERS

For the ROPME Region, the major strategies that need to be adopted can be summarized in the following:

- Heavy Investment in human resources development through education, training, and capacity development programmes in the fields of environmental management of the coastal and marine ecosystem is a key issue in the sustainable management of the RSA
- Regional cooperation between the RSA countries is vital for the sustainable management of the RSA ecosystem. The main areas of cooperation are in the fields of trans-boundary bio-reserves and protected areas, regional integrated coastal area management planning, enforcement of laws and regulations, monitoring and assessment, and data and information exchange, and knowledge-sharing
- Establishment of an RSA network of research Institutes network/collaborating centers under the auspices of ROPME is an important step towards building an RSA-oriented scientific research and capacity building programme, as well as cooperation and exchange of expertise and information between the countries. Moreover, the role of the NGOs in monitoring and awareness building need to be encouraged and enhanced
- The lack of national environmental policies based on the principles of sustainable development in many countries hinders the effective management of the RSA. The adoption of the sustainability principles in the formulation of national environmental policies and strategies in RSA Region will help realize a common management perspective among the ROPME Member States. It will also help in fostering the necessary cooperation in many cross-boundaries environmental challenges as well as in regional programmes for pollution abatement and control and for resources management and conservation

CHAPTER 8

POLICY OPTIONS FOR THE RSA

KEY MESSAGES

- Ecosystem-Based Management Programme is now widely used, and the Region should adapt such programme in order to fulfill the sustainable development target for each country and for the Region as a whole
- Member States are encouraged to draw upon the important and critical mass of scientists and local marine environmental expertise in the Region
- Participation of ROPME Member States in the global programmes aiming at the protection and sustainable development of the marine environment and resources is crucial
- Regional planning for building the Region's environmental expertise and capabilities is essential to ensure the sustainability of the RSA

8.1 DEFINITION OF POLICIES AND GOVERNANCE

The previous chapters of this Report reviewed the current state of the marine environment of the RSA in order to understand the physical and ecological features of the Region, the major socio-economic activities as well as the health of the ecosystem. The present chapter summarizes and updates the information on measures, policies and strategies for sound environmental management and sustainable development of the RSA.

The policy can be defined as any form of intervention or societal response. This includes not only statements of intent, such as a water policy or forest policy, but also other forms of intervention, such as the use of economic instruments, market creation, subsidies, institutional reform, legal reform, decentralization and institutional development. Policy can be seen as a tool for the exercise of governance. When such an intervention is enforced by the state, it is called public policy (UNEP, 2012). While Governance is the manner in which society exercises control over resources, it denotes on the mechanisms through which control over resources is defined and access is regulated. For example, there is governance through the state, the market, or through civil society groups and local organizations. Governance is exercised through institutions: laws, property rights systems and other forms of social organizations.

Most policy frameworks have two aspects; (i) the legal elements that are in place at all levels of government, and (ii) the various planning and management tools, including assessment processes that are delivered at the national or local levels of government (WWF, 2001). However, the existing framework in RSA has often been developed reactively in response to a variety of needs. The policy process includes three components of choice, implementation and assessment (Box 8.1).

Sustainable development is generally considered to be at the intersection of environment, economy, and society. This term is now often expanded into phrases reflecting ecosystem services and limits, fair and durable prosperity, and health and social justice. A fourth dimension of “Political Sustainability” is now being used, which refer to governance mechanisms that continuously deliver sustainable development through the use of responsible science and economics (Sherman and Hempel, 2008).

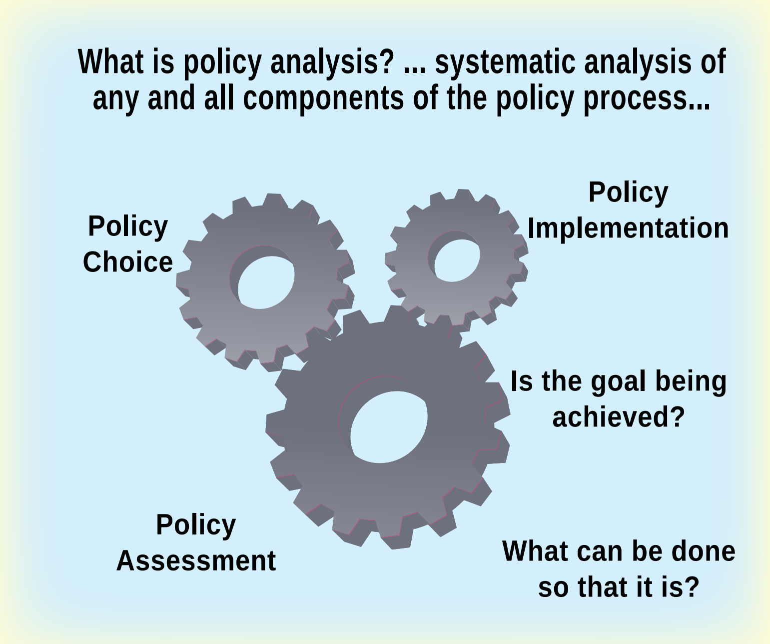
The Assessment of Assessment Report (AoA) published by UNEP and IOC-UNESCO (2009), identified a number of current and emerging environmental issues to be addressed by policy-makers and managers for RSA. These are:

1. Degradation of major habitats and habitat loss due to sea reclamation for infrastructure projects;
2. Pollution from river basins, coastal areas (Land-based and sea-based activities, including introduction of invasive species);
3. Lack of continuity in regional programmes to fill data gaps and improve the consistency, quality and reliability of data and information; and
4. Lack of harmonization and strict implementation of environmental regulations.

BOX 8.1 – Gears of the Policy Process

The policy process includes the formal activities of policy formulation and implementation of policy life cycle. Najam (2005) describes the policy process as consisting of three primary components: policy choice, policy implementation and policy assessment. With policy choice, government and society are formulating the goal that should be achieved and the types of policy instruments that could achieve the goal.

Following implementation of these instruments, assessment links policy choice to implementation and asks if the original goal is being achieved, and if not, why not. All three gears of policy process need to move in order for policy to work (Najam, 2005).



8.2 LEGISLATION, CONVENTIONS AND AGREEMENTS

Environmental legislation, conventions and agreements pertinent to RSA include principal instruments such as, national legislation/regulations, the Kuwait Regional Convention and its Protocols, and the international conventions and programmes relevant to the protection of the marine environment.

8.2.1 National Legislation/Regulations

More recent attempts have been made at harmonization of environmental legislation and institutions in the Region. Some Member States have imposed new types of liability or increased penalties for environmental offences in order to secure better environmental quality. In Bahrain, for example, any person found guilty of causing oil pollution in the marine environment or of dumping wastes in territorial waters from ships or land-based sources is liable to large fines. In Kuwait, the resolution to establish the so-called Environmental Court has been adopted by the government. Violators are also responsible for the cleanup of the contaminated area within a specific time (UNEP, 1995). Nevertheless, most national environmental legislation and regulations in some countries of the Region obviously need updating and revising, particularly with reference to acceptable and adequate norms and standards.

All the Member States of RSA, have established their own national laws regulating the protection of the environment, noting that several amendments are carried out to these legislation, but still some remain old and not compatible with the new developments in the field of protection of the marine environment.

There is no national legislation enacted so far to deal solely with the question of civil liability and compensation. This subject has been regulated by secondary legislation in some countries, by general principles of civil law in the others, or by international conventions to which the state in question is a party to.

Except for Bahrain, Kuwait, Oman and Saudi Arabia, the other states have no oil spill contingency plans. However, in the UAE, there are oil contingency plans for most of the Emirates, while national oil contingency plans are drafted and already submitted to the cabinet for approval.

Most of the ports and oil loading terminals in the ROPME Member States have their own rules or instructions, which regulate the “conduct” of the vessels within the port area.

8.2.2 Regional Convention and Protocols

Although ROPME Members States adhere to ROPME’s legal instruments (Kuwait Convention and its various Protocols dealing with different aspects of environmental protection), they also actively participate in international conventions and agreements dealing with the marine environment. The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (1978) has four related Protocols that have been developed in accordance with the respective recommendations of ROPME Council as the Legal Constituent of the Kuwait Action Plan. These protocols are:

(i) Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency, 1978:

This protocol was essentially intended to ensure regional cooperation in dealing with spills or other emergency situation. As such, in accordance with Article III of this protocol, a Marine Emergency Mutual Aid Centre (MEMAC) was established in 1982 in Bahrain, whose primary function is to facilitate cooperation among contacting parties in the event of a spill or emergency relating to oil or other harmful substances (Khan, 2008).

(ii) Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf, 1989:

Article 208 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) has formed the basis for this Protocol. The emphasis is on the use of best available and economically feasible technology for the prevention, abatement and control of marine pollution from offshore oil exploration and production. As such, permits could only be issued if the proponent satisfies this criterion. It also requires a full environmental assessment of pollution risks associated with the proposed project. The Protocol also prohibits ocean dumping of sewage, litter, etc. from the offshore installation (Khan, 2008).

(iii) Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources, 1990:

In accordance with Article IV of the Kuwait Convention, and based on Articles 207, 212 and 213 of the 1982 Law of the Sea Convention (UNCLOS), this Protocol regulates airborne, waterborne, or direct discharges from the coast into the Protocol Area through pipelines, watercourses, or offshore installations serving purposes other than exploration and exploitation of the seabed.

Contracting states are required to conduct Environmental Impact Assessment and monitoring relating to selected development projects. In areas of shared jurisdictions (e.g. Shatt Al-Arab waterway) countries are called upon to cooperate in the application of the protocol (Khan, 2008).

(iv) Protocol on the Control of Marine Trans-boundary Movements and Disposal of Hazardous Wastes and Other Wastes, 1998:

This Protocol covers the trans-boundary movements of wastes, the dumping of wastes at sea, the ballast water of oil tankers, and the wastes of commercial ships. The protocol also promotes regional cooperation for the establishment and management of reception facilities for the treatment of ballast water and other wastes from ships, as well as the development of an effective monitoring and surveillance system to detect and control dumping of wastes at sea (Khan, 2008).

The status of signature and ratification of the Kuwait Regional Convention, the Emergency Protocol and the three subsequent Protocols by the ROPME Member States is presented in Table 8.1.

It is important to note here that these are the most important legal instruments on the marine environment specifically negotiated for the Region. There are several other regional organizations and environmental agreements such as the Council of Arab Ministers Responsible for the Environment - CAMRE, The Gulf Cooperation Council - GCC, and The Regional Clean Sea Organization - RECSO, which could be highly instrumental in achieving the overall objectives of the Convention and in the development of an integrated strategy for the sustainable management of the RSA ecosystem and the funding of an Integrated Research Programme to support the implementation of ROPME's activities and Action Plan.

8.2.3 International Agreements

Internationally, the countries of the RSA have obligations and opportunities to ensure protection of the marine environment under a variety of international treaties and conventions, which have been variously signed by the countries of the Region (Khan, 2008).

Table 8.1 Status of signature and ratification of Kuwait Regional Convention and its Protocols by ROPME Member States

	Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution and its Protocol on Emergencies (1978)	Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf (1989)	Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources (1990)	Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and other Wastes (1998)
Bahrain	■	■	■	■
I.R. Iran	■	■	■	■
Iraq	■	■		
Kuwait	■	■	■	■
Oman	■	■	■	
Qatar	■	■	■	■
Saudi Arabia	■	■	■	■
United Arab Emirates	■	■		■
Entered into Force	30 June 1979	17 February 1990	2 January 1993	4 September 2005

The international agreements relevant to the protection of the marine environment are divided into international conventions and global programmes. The United Nations Convention on the Law of the Sea (UNCLOS, 1982) is the overarching international convention that deals with almost all matters related to the ocean and seas in the world. Other conventions deal with specific subjects relevant to the prevention and control of marine pollution.

8.3 POLICIES AND POLICY CLUSTERING

While a policy can be described as an “Interrelated set of decisions and goals”, a policy instrument is a tool or mechanism used as a means to accomplish policy goals (UNEP, 2007). There are a variety of different policy instruments available to governments. These different policy instruments can be categorized in four general categories:

- Economic instruments (e.g. taxes, subsidies, tradable permits, etc.)
- Regulatory (e.g. Laws and regulations);

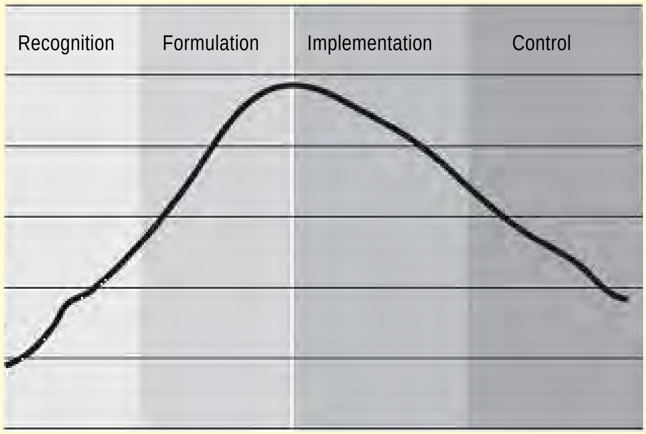
- Direct expenditure (Research and Development, education, training and awareness, infrastructure projects, etc.); and
- Institutional instruments (sector and cross strategies, green procurement).

It is important to mention that each policy has a life cycle which starts with recognition stage and ends with control stage (Box 8.2).

BOX 8.2 – Policy Life Cycle

Environmental policy is developed in a socio-economic and political context, usually in response to a problem. Addressing specific problems often takes a predicable course, called «the policy life cycle». The typical policy life cycle has four stages: recognition, formulation, implementation and control. Each of these stages carries a certain amount of political weight, which varies over time. These four stages is simplified view of a highly complex and often contentious process (UNEP, 2007).

Public concern and political weight



Stages in the policy cycle

This section includes a screening of the current policies/cluster of policies related to the Region. The most promising policies are then discussed in details.

The main criteria for cluster of policies / policies that have to be fulfilled are:

- Effective in speeding up regional goal of sustainable development
- Potential for replication
- The most efficient in implementation
- Equitable and non-discriminatory
- The best in terms of indicative benefits and drawbacks
- Allow monitoring and tracking of results
- Potential for up-scaling

A cluster of policies may be analyzed as a whole on the assumption that implementing the cluster of policies is more beneficial than the sum of the separate policies therein. The policies were divided into national policies and regional policies.

8.3.1 National Policies

The following section summaries the main important policies which are related to the Region. This preliminary screening is important since it shows the enabling factors and obstacles which affect the implementation and up-scaling of these policies. Based on this screening, the most promising policies will be further analyzed and recommended. The regional policies are divided into three areas: 1. marine biodiversity, special habitats and protected areas; 2. Fisheries; and 3. Pollution and Contamination.

i. Policies related to Marine Biodiversity, Special Habitats and Protected Areas

Table 8.2 represents policy screening for the current policies in the Region related to biodiversity, special habitats and protected areas.

Based on the above mentioned criteria, some policies are selected which can be considered as promising policies. These policies are: National Biodiversity Strategies; Integrated Coastal Zone Management (ICZM), Ecosystem-Based Management (EBM); Artificial marine ecosystem; and Management of Marine Protected Areas.

Table 8.2 Summaries of the main important policies related to ROPME Region

Policy	Enabling conditions	Possible obstacles
National Policies concerning Biodiversity, Special Habitats and Protected Areas		
Integrated Coastal Zone Management (ICZM)	• **Existence of an overall framework for coastal area management**	• **Lack of Expertise** • **Fragmental Management policies in some cases** • **Lack of enforcement**
Ecosystem-Based Management (EBM)	• **Based on Ecosystem Approach** • **Balance between coastal development and conservation of biodiversity**	• **Lack of Expertise** • **Lack of interest and awareness**
Environmental Impact Assessment (EIA)	• **Reduce the degradation of marine environment, particularly from Land-Based Sources** • **Ensure the sustainable uses of coastal area**	• **May overview some major environmental issues** • **Not well implemented**

a. National Biodiversity Strategies

The ROPME Member States are much concerned about the biodiversity of the Region in general. ROPME has developed “Regional Action Plan for the Conservation of Coral Reefs in the Arabian Seas Region” with the participation of relevant International Organizations such as IUCN, UNEP/ROWA, etc. which represents important steps in the right direction (Krupp *et al.,* 2006). Key habitats and resources, such as the important coastal wetlands, should be included in Marine Protected Areas (MPAs). The status of MPAs in the RSA has been reviewed by Krupp (2002).

According to the Biodiversity Synthesis of the Millennium Ecosystem Assessment (MEA), considerable additional efforts were needed to achieve, by 2010, a significant reduction in the rate of biodiversity loss at all levels. This target was subsequently endorsed by the World Summit on Sustainable Development and the United Nations General Assembly and was incorporated as a new target under the Millennium

Development Goals. The Conference of the Parties to the Convention on Biological Diversity considered the 2010 Target during deliberations on the Convention's Strategic Plan during its 6th, 7th, 8th and 9th meetings. At the Conference of the Parties (COP), the Parties from ROPME Member States had prepared their respective "National Biodiversity Strategy" in line of achieving the 2010 Biodiversity Target. All Member States published respectively "The National Report on Biodiversity" during 2010. These national reports were done through extensive national efforts in the field of enhancing environmental education and public awareness, building capacity of personnel working in the conservation field, expanding establishment of new protected areas in accordance with the National System Plan.

b. *Ecosystem-Based Management (EBM)*

Ecosystem-Based Management is a new way of looking at management of living resources. The traditional management strategy for fisheries and other living resources has been focusing on one species of fish and shellfish in isolation. For example, if there were a decline in the number of a certain kind of fish, authorities might decide to lower the number of that species that could be removed by fishing in a given year. But fishing of a single species is only one variable that affects the health of its population. Additional elements come into play, such as interactions with other species and the effects of pollution and other stresses on habitat and water quality. To more effectively assess the health of any given fishery and to determine the best way to maintain it, the entire ecosystem must be taken into account. Ecosystem approaches to management use integrated approaches to study and manage the resources of an entire ecosystem. This approach considers the cumulative impacts from various sources and the balance of conflicting uses, and includes multiple factors such as pollution, coastal development, harvest pressure, predator/prey and other ecological interactions, and watershed management (http://chesapeakebay.noaa.gov/ecosystem-based-management).

It is important to mention that, Ecosystem-Based Management Programmes are now being introduced into the Region. For example, Bahrain is applying the concept of EBM in a pilot project in cooperation with UNEP. The Region should adapt such programmes in order to fulfill the sustainable development target for each country. Box 8.3 represents the concept of shifting to EBM approach in the Region.

BOX 8.3 – Ecosystem-Based Management as Paradigm Shift

From Traditional Management	To Ecosystem- Based Management
• Individual Species	• Ecosystem
• Small Spatial Scale	• Multiple Scale
• Short-term Perspective	• Long-term Perspective
• Human Independent Ecosystem	• Humans as integrated part of ecosystem
• Management divorced from research	• Adaptive Management
• Managing commodities	• Sustainable Production potential for ecosystem goods and services

Source: Duda and Sherman, 2002.

c. *Management of Marine Protected Areas (MPAs)*

Properly managing existing protected areas while recalling the current practices of land-use and encouraging sustainable use of natural resources, is an important issue in the ROPME Sea Area. Management regulations governing protected areas in RSA routinely forbid commercial fishing other than by artisanal fishermen using traditional gear, and catching of dugong, turtle, or marine mammals (Sale *et al.,* 2011). They may also restrict construction, dredging, filling, or other shore-based development activities with negative impacts on the marine environment. However, while there is little direct information concerning effectiveness, with which these regulations are enforced, casual observation suggests that while policies can be effective, management otherwise is quite weak.

Effectively managed marine protected areas could significantly lower the rate of exploitation of fishery species while also protecting other valued species. By strengthening enforcement of the existing regulation, ROPME Member States could sustainably improve the management and conservation of RSA marine resources (Sale *et al.,* 2011).

d. *Development and Management of Artificial Coral Reef Habitats*

Chronic risk of oil pollution (ROPME, 2010b) in the RSA, industrial and domestic wastes, extensive loss and degradation of ecologically productive coastal habitats, and overfishing of fishery stocks have let to a rapid decline in the health and sustainability of marine ecosystem in the Region (Sheppard *et al.,* 2010, Sale *et al.,* 2011, Feary *et al.,* 2011),. Added to these anthropogenic stressors, there have been increasing accounts of climate-induced warm episodes and some harmful algal bloom outbreaks (Burt *et al.,* 2008). High priority should therefore be given to the protection and where necessary restoration of coastal and marine habitats (Krupp *et al.,* 2006). Within the RSA, artificial habitats are increasingly being suggested as a policy to mitigate such environmental impacts that affect the RSA biodiversity. The decision to create artificial habitats such as artificial reefs is often based on suggestion of benefits to ecology, economics and management of marine environment (Feary et al, 2011). There has been a rapid increase in the numbers, types and size of the artificial reefs (both planned and unplanned) within RSA, however there is still a lack of understanding on the role and importance of these artificial structures in affecting the composition and abundance of RSA marine communities (Azhdari and Azhdari, 2008). Most planned artificial reefs in RSA are developed to act as aggregation devices for commercial fisheries (EAD, 2008), as a dive sites for recreational SCUBA Organizations (Al-Saffar and Tamimi, 2006), and as means to minimize coastal erosion or mitigate impacts to natural habitats (Azhdari, 2003; Abdel-Moati, 2006; Al-Saffar and Tamimi, 2006). However, in most cases the objectives for constructing these structures are not stated explicitly (Feary *et al.,* 2011). Construction of marine structures such as waterways, canal and islands should be monitored to ensure that these would enhance rather than decrease coastal productivity (Krupp *et al.,* 2006).

The benefits of artificial communities to the RSA include: Aggregation and enhancement of commercially important species, Enhancement of eco-tourism; Prevention of habitats damages by trawling and Mitigation of impacts to natural biological communities.

The ecology of artificial structures within RSA remains relatively understudied given the number of planned and unplanned structures (Feary *et al.,* 2011). However, a number of well-designed studies in the RSA indicated that the construction of artificial structures often results in unintended and sometime quite negative consequences.

Within Dubai, the abundance of adult fish associated with coastal breakwaters have shown significant seasonal changes over the course of a year with a threefold increase in abundance observed in the summer (Burt *et al.,* 2010). Such seasonal patterns in attraction of fishes to artificial reefs may indicate the ease with which artificial reefs could be used to aggregate fish for commercial capture, leading to further stock reductions of already over-exploited species.

Artificial reefs are not surrogates for natural reefs although artificial structures have been used to mitigate negative impacts (Abdel Moati, 2006), however there is a growing evidence that artificial reefs support fish assemblages that differ significantly in composition and structure from assemblages on nearby natural habitats in the RSA (Feary *et al.,* 2011). A range of research focused on the UAE ecosystem has shown that benthic communities associated with artificial reefs often substantially lower species richness and diversity compared with adjacent natural communities (Burt *et al.,* 2009, 2010, 2011). Artificial structures represent barriers to water flow, and this can have substantial effects on the communities that develop on these structures and in the surrounding soft sediments (Feary *et al.,* 2011). There is increasing evidence that artificial structure may contribute to the relative decline of regionally isolating barriers, enabling dispersal of non-indigenous species beyond the limits set by the availability of natural substrate (Airoldi *et al.,* 2005, Page *et al.,* 2006). Artificial structures are increasingly prevalent throughout the RSA Region; such structures may potentially act as “stepping stones” enhancing the spread of invasive species that need a hard-boom habitats. It is important to mention here that the introduction and spread of invasive species into RSA is likely enhanced by high volume of commercial traffic in the RSA with much of this traffic discharging planktonic prologues in ballast wastes from around the world (Colautti *et al.,* 2006).

ii. Policies related to Fisheries

a. Ecosystem-Based Fishery Management (EBFM)

Ecosystem-Based Management can be an important complement to existing fisheries management approaches. When fishery managers understand the complex ecological and socio-economic environments, in which fish and fisheries exist, they may be able to anticipate the effects that fishery management will have on the ecosystem and the effects that ecosystem change will have on fisheries. However ecosystem-based management cannot resolve all of the underlying problems of the existing fisheries management regimes. In absence of the political will to stop over-fishing, protect habitat, and support expanded research and monitoring programmes, an ecosystem-based approach cannot be effective (Box 8.3).

Ecosystem-Based Fishery Management (EBFM) is a new direction for fishery management, essentially reversing the order of management priorities so that management starts with the ecosystem rather than a target species. EBFM aims to sustain healthy marine ecosystems and the fisheries they support. Pikitch et al. (2004) describe the potential benefits of implementation of EBFM that, in their view, far outweigh the difficulties of making the transition from a management system based on maximizing individual species.

An Equivalent approach to EBFM is the Ecosystem Approach to Fisheries (EAF). The overarching principles of EAF are an extension of the conventional principles for sustainable fisheries development to cover the ecosystem as a whole. They aim to ensure that, despite variability, uncertainty and likely natural changes in the ecosystem, the capacity of the aquatic ecosystems to produce fish, food, revenues, employment and, more generally, other essential services and livelihood, is maintained indefinitely for the benefit of the present and future generations. The FAO Technical Guidelines on the ecosystem approach to fisheries (FAO, 2003) define EAF as follows:

"An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries," http://www.fao.org/fishery/topic/13261/en.

b. *Fish Stock Enhancement*

Data clearly show very substantial decline in commercial fish catch over the past 10 - 20 years (Sheppard *et al.,* 2010), while Bishop (2002) and Sheppard et al. (2010) have demonstrated a link between the permanent losses of inter-tidal and shallow sub-tidal nursery groups with declining fish and shellfish catches.

Marine stock enhancement, an approach that addresses these issues, involves a set of management measures for releasing farmed organisms to enhance or restore fisheries. Engineered artificial reefs, which help to restore lost or degraded marine and coastal environments, can also enhance re-stocking of depleted commercial fish and shellfish.

The benefits of this policy are mostly in rehabilitating depleted fisheries, and also include the potential to reduce the time needed to rebuild some severely over-exploited ones or improve the productivity of other healthy fisheries. However, it has to be emphasized here that enhancement policy is not a substitute for fisheries management policies (GEO5, 2012).

iii. Policies related to Pollution and Contamination

a. *Environmental Assessment and Monitoring*

ROPME Member States have different Monitoring programmes. A few examples are given in the following:

In Bahrain, during 2010, a buoy was deployed to the north of Bahrain Petroleum Company (BAPCO) area to measure nutrients and other contaminants, in addition to the meteorological parameters. However, the buoy is not operational anymore (ROPME, 2010a).

In the I.R. Iran, the Department of Environment established a marine Spatial Data Infrastructure (SDI). The data of the HAB events of 2008 are part of the SDI system.

In Oman, the Ministry of Agriculture and Fisheries and the Sultan Qaboos University are responsible for the marine monitoring programme of the Sultanate. The coast of Oman has been subjected to a number of natural hazards, such as HABs, jelly fish outbreaks, marine mortality and storms. The Ministry of Environment and Climate Affairs of Oman has therefore recently expanded its monitoring programme to include climatic parameters and events. In addition, one marine monitoring buoy was deployed during 2009 in a coral reef area for continuous monitoring. Oman is also interested in the deployment of an early warning system for algal blooms, oil spills, jelly fish and tsunami events.

In Kuwait, the Environment Public Authority (EPA) has established its monitoring programme for coastal and offshore areas. The programme has been operating for more than 30 years, and is regularly collecting environmental data on a monthly basis.

Qatar has a monitoring programme for regular water quality monitoring and analysis of contaminants in sediment and water in the Qatari coastal areas.

8.3.2 Regional Policies

i. Policies related to Maritime Traffic in RSA

Dominated by the oil and gas sector, the RSA is one of the busiest maritime areas in the world. 90 per cent of oil export from the RSA and 45 per cent of globally traded oil are passing through the Strait of Hormuz. The protection of marine environment is causally interconnected to safety in navigation, and *vice versa*. Among Land-Based pollution, the direct correlation between pollution prevention by maritime safety governance and state of the environment is evident. During the last four decades much has been done by the ROPME Member States on the national and regional levels to cope with growing challenges of marine environmental protection and maritime safety.

In 2006, the ROPME Council launched the "Co-ordinated Action: Master Plan for the Protection of the Marine Environment in the ROPME Sea Area" as an umbrella project. The steps for implementing the Action Plan include Risk Analysis (RA) and Cost-Benefit Assessment (Table 8.3).

Table 8.3 Master Plan for the Protection of the Marine Environment in the RSA

Master Plan Section	Sub-section	Targets
Risk Analysis (RA)	Gap Analysis	Assess implementation of mandatory International Maritime Organization (IMO) instruments
	Quantitative RA	Analyze traffic patterns, causalities, regional Risk exposure
Cost-Benefit Analysis	Risk Reduction	Improve safety and environment infrastructure and services
	Cost-Benefit Assessment	Valuate environmental and socio-economic indicators
	Financing Structure	Apply Polluter-Pays Principle (PPP) and cost-sharing by beneficiaries

On the regional level, Gap Analysis reveals that the progressive ratification record of International and Regional conventions and treaties by ROPME Member States now has to be caught-up by means of implementing and enforcing appreciated mechanisms, structure and instruments to eventually reach full compliance with those legally-binding conventions under international law.

The RA covers traffic patterns and data on reported maritime casualties scenarios, ship size, types and facilities, and locations (hot spots).

Since the marine environment and its resources are capital and need to be treated and protected as an asset, the cost-benefit calculation valuates selected environmental and socio-economic indicators to estimate the benefits gained from the implementation of the Master Plan's Risk Reduction Packages. These indicators are: Seawater feed for desalination; fish exports, mangrove as marine habitat and nursery ground, costs involved to avert 1 ton of spilled oil threshold (reciprocal) value and human lives. Due to its topicality and transferability to the conditions at RSA ports and terminals the "casualty impact on trade cargo" has been added.

Since RSA was identified as a "Special Sea Area", the area needs a regional cooperation particularly for reducing risk from traffic and the pollution released from ships passing through RSA (Chapter 1, Box 1.2: Special Area Status).

There are several regional policies and actions adopted in RSA. These policies aim to conserve the marine environment and enhance the sustainable development approach. The regional policies include the following:

a. *Regional Action Plan for Prevention of and Response to Marine Pollution from Ships*

This Action Plan has been developed to provide guidance to the ROPME Member States on the direction of environment protection and response strategies to marine pollution incidents in the Region.

The general objectives of the RSA Action Plan (RAP) are threefold. Each of the three tasks includes some policies or actions that should be implemented in order to prevent and respond to oil pollution from ship. The threefold task, and the policies included, is as follows:

- Prevention of pollution from ships
- Prevention of maritime accidents
- Preparation for response to major pollution incidents

b. *Marine Environmental High Risk Areas (MEHRA's)*

MEHRA's are comparatively limited areas of high environmental sensitivity which are also at risk from shipping (MEMAC, 2010a). Three steps were recommended for MEHRAs identification. The first step considers ranking of environmental sensitive areas, the second is the marine pollution risk estimated by modeling the geographic variations to spill risk. The third stage is to combine environmental sensitivity and pollution risk results to generate MEHRAs score for each area.

MEHRA's project was developed by ROPME aiming at identifying the areas within ROPME Member States, which can be designated as Marine Environmental High Risk Areas. The project has also intended to establish a GIS model as a toolkit which can be updated as new information on environmental sensitive and / or shipping risks become available.

ii. Policies related to Environmental Monitoring and Observations

a. *Long-term Environmental Monitoring of RSA by Remote Sensing*

The coastal regions are the heaviest populated areas in the RSA and the coastal waters are highly affected by human activities. The marine ecosystems are subjected to biogeochemical forcing due to the influx of large amounts of agricultural and industrial pollutants and sewage. Continuous long-term observations of coastal waters are very important for regional-climate impact studies and for environmental monitoring. Satellite

Remote Sensing measurements, especially MODIS Data-Base are for continuous monitoring of large areas such as RSA. The major water constituents, which can be considered as key indicators for environmental health and can be determined by optical remote sensing include, suspended matter, phytoplankton.

b. Development of Regional Integrated Environmental Observation System (RIEOS) for ROPME Member States

The RIEOS is a concept of sharing facilities and optimizing the following combined resources:

- ROPME remote sensing, oceanographic and contaminants screening programme
- Member States monitoring facilities including moored buoys, fixed /mobile stations and remote sensing
- Inter-Governmental Oceanographic Commission (IOC) of UNESCO facilities, which consists of buoys, floats, tide gauges, ships of opportunity and remote sensing

c. Regional Action Plan on Harmful Algal Blooms/Alien Invasive Species and related Marine Mortality in the ROPME Sea Area

This Action Plan has been developed with clear principles, plans and practices of all appropriate actions to be taken at both National and Regional levels. It consists of four major foci, each one includes a set of key actions to be taken towards realizing the vision of protecting the coastal and marine resources and services of the Region from the effect of HABs, as given below:

- Making reliable situation assessments
  - ➤ Organization of a Network of National marine observing and HAB monitoring Programme
  - ➤ Early assessment of Invasive Species/HAB incidents, causes and impacts and identification of risk areas and hotspots
  - ➤ Establishment of HABs web portal and clearing house mechanism for information exchange
  - ➤ Development of Invasive HAB Species/HABs information pathway in the ROPME Integrated Information System (RIIS)
- Establishing operational mitigation mechanisms
  - ➤ Development of scientifically sound, technically feasible and legally acceptable methods of HABs and Invasive Species mitigation and control
- Strengthening technical capacity
  - ➤ Designation of a Lead Member State on HABs/Invasive HAB Species
  - ➤ Assignment of a Regional Reference Laboratory and National Laboratories
  - ➤ Development of policy framework on HABs/Invasive HAB Species
  - ➤ Development of trained capacity, sustenance of key research activities and promotion of awareness

- Sustaining an effective mechanism of implementation
  - ➤ Preparation of detailed Regional Action Plan and establishment of Regional Task Force
  - ➤ Preparation of National Action Plan in harmonization of the Regional Action Plan and establishment of National Task Force by each Member State

d. Regional Plan of Action on Mortality of Marine Mammals and Turtles

The Regional Plan of Action on Mortality of Marine Mammals is aimed to ensure rapid response to marine mammal mass mortalities as well as to set a mechanism to collect information on the distribution, abundance, by-catch in fish gears and mortality of marine mammals in RSA. The PoA is also aiming to recommend measures for protecting of marine mammals and their habitats in RSA.

The PoA has two mechanisms for implementation: (1) Establishment of a permanent Regional Group of Experts and (2) Establishment of National Committees on Mortality of Marine Mammals.

8.4 GAPS IN ENVIRONMENTAL POLICIES

There are a number of gaps, which can be identified based on the previous chapters. These gaps can be classified into the following categories:

- Gaps in institutional arrangements
- Gaps in information, knowledge and data-base
- Gaps in environmental awareness
- Gaps in regional coordination and harmony

ROPME as the principal Regional Organization has the potential to foster collaborative efforts to address these gaps. This role can be pursued through the followings:

- Drawing upon the critical mass of local marine scientists and environmental expertise
- Encouraging participation from the global marine research communities
- Targeting the critical scientific and governance needs of the Member States
- Building the necessary capabilities in all ROPME Member States to ensure the sustainability of the RSA

8.5 POLICY PROSPECTUS

8.5.1 Special Consideration of RSA

Taking into consideration the nature of environmental characteristics of the RSA with heavy traffic, a comprehensive regional policy must be drawn based on the realignment and harmonization of national policies of countries bordering the Sea Area. Furthermore, compliance in terms of enforcing national and regional legislation is of priority importance to lessen the pollution impact on the sea.

8.5.2 Monitoring of Compliance

A mechanism has to be developed to monitor compliance at all governance bodies to ensure adherence with national and regional regulations. This requires strengthening capacity of national and regional institutions and enabling them to fulfill their respective mandates.

8.5.3 Critical Policy Areas to be addressed

A number of policy areas must be addressed to ensure RSA sustainability in the next 10 years. These include; health risks associated with seafood, marine and coastal biodiversity, fisheries management, control of invasive alien species, safe disposal of hazardous substances, eutrophication/nutrient management, control of oil pollution and derived substances, litter management, wastewater management, coastal development and sprawling of coastal cities. It is a matter of urgency to develop regional plans and programmes to address these areas.

8.5.4 Ecosystem-Based Management (EBM)

Ecosystem-Based Management (EBM) approach as a policy instrument offers an opportunity of incorporating all the elements into a formal joint plan that can be executed at countries level where integrated policy instruments can be aligned and harmonized. In this context ICZM is the proper vehicle to incorporate (EBM) and streamlining other national policies and translating them into action plans. Furthermore, a new decision making process must evolve to accommodate for EBM, and an evidence-based policy-making process must substitute the current policy practices to evaluate achievements of set objectives (Box 8.4).

8.5.5 Green Economy

The green economy is the future and the course to be taken to alleviate driving forces and pressures affecting the state and trend of the RSA. This requires reformulating national policies in the various sectors of economy, and move environment in general, and the RSA environment, in particular, to the center of the decision-making process.

8.5.6 The Policy Process

The policy process includes the formal activities of policy formulation and implementation of policy life cycle. Najam (2005) describes the policy process as consisting of three primary components: Policy choice, policy implementation and policy assessment. With policy choice, government and society are formulating the goal that should be achieved and the types of policy instruments that could achieve the goal. Following implementation of these instruments, assessment links policy choice to implementation and asks if the original goal is being achieved, and if not, why not. All three gears of policy process need to move in order for policy to work (Najam, 2005).

BOX 8.4 – Ecosystem-Based Management as Paradigm Shift

Policies concerning Fisheries		
Fisheries Landing Statistics	Provide general trend and performance of particular fisheries that need management plan	Delay the catch from arriving the Fish Market
Fisheries law and Regulations	Ensure effective fishery management	Need periodically review
Controlling Trawl Fishery	Common method in some RSA countries	• By catch of unwanted fish and other invertebrates • Very destructive to sea bottom epibenthic assemblage such as coral reefs and sea-grass beds
Fishery and Shrimp Closing Season	• Avoid and reduce overfishing • Protect recruitment to natural stock	• Fishermen complain
Regulating Aquaculture	Resources necessary to initiate trails in fish release in order to enhance the declining stocks in some fish species	• Limited resources • Extreme climatic condition and shortage of suitable sites
Fish Stock Enhancement	Enhancement of fish stock which is repeatedly exploited and depleted over the years as a result of too many fishermen catching limited fish stock	Large quantities of small size commercial fish species entering the market just after fish release
Fishery Co-management	Collaborative and participatory process of regulatory decision making of different stakeholders	Stakeholder conflict
Community-based Fishery Management	• Manage and restrain the take of fish from the resources • Control the activities of fishermen on land and at sea	Stakeholder conflict
Incentive Fishery Management	Creating an incentive for fishermen to compete	Competitive race for fish lead to rising cost of fish effort and dissipation of rent
Ecosystem-based fishery management (EBFM)		

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