

STATE OF THE MARINE ENVIRONMENT

REPORT FOR THE RED SEA AND
GULF OF ADEN: 2006

Regional Organization for the Conservation of the
Environment of the Red Sea and Gulf of Aden

PERSGA – “*The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden*” is an intergovernmental organization dedicated to the conservation of the coastal and marine environments in the region.

The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) 1982 provides the legal foundation for PERSGA. The Secretariat of the Organization was formally established in Jeddah following the Cairo Declaration of September 1995. The PERSGA member states are Djibouti, Egypt, Jordan, Palestine, Saudi Arabia, Somalia, Sudan, and Yemen.

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FOREWORD

Twenty five years ago, the Jeddah Convention (1982), its Marine Emergency Protocol and the Action Plan were signed by the Arab countries bordering the Red Sea and Gulf of Aden. In accordance with this Convention the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) was established in 1995 as a secretariat for the Convention.

PERSGA has played a key role in addressing various threats facing this unique region. Increase in human population in coastal areas and the rapid rise in economic growth has resulted in considerable pressure on the environment including destruction of coastal ecosystems through land-filling and dredging, and the disposal of industrial and domestic wastes into the marine environment.

The Council of Arab Ministers Responsible for Environmental Affairs (CAMRE) was established in 1987 to enhance cooperation when dealing with defined environmental problems and to facilitate the priority actions required to address them in the Arab region. CAMRE is also involved in following-up on the implementation of international conventions dealing with the environment.

CAMRE is concentrating on three main programmes that require priority actions in the Arab world: desertification, industrial pollution, and education, awareness and environmental information. These programmes are being implemented in close collaboration and in coordination with relevant international organizations such as UNEP, and regional organizations such as PERSGA.

In this context PERSGA has been given the responsibility for coordination and follow-up on marine pollution incidents and marine catastrophes in the Arab region within the framework of the implementation of the *Sustainable Development Initiative* in the Arab region.

This publication—*State of the Marine Environment Report for the Red Sea and Gulf of Aden*—will contribute to the implementation of the *Sustainable Development Initiative* of CAMRE, supporting continued efforts for sustainable use of marine and coastal resources.



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PREFACE

It is well known that the Red Sea and Gulf of Aden contain unique coastal and marine environments. While the Red Sea is famous for its globally important repository of marine biodiversity, represented by the extraordinary system of coral reefs and their associated fauna and flora, the Gulf of Aden, being influenced by nutrient rich upwelling waters, is known for prodigious fishery production.

Concerns for the protection of these unique environments began in the early seventies with the initiation of the *Programme for the Environment of the Red Sea and Gulf of Aden* (PERSGA). The key achievement of this initiative was the signing of the Jeddah Convention (1982), its Marine Emergency Protocol, and the Action Plan.

In accordance with the articles of this convention the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) was established (1995). PERSGA's mandate is to perform the functions necessary for the management of the Jeddah Convention (1982) and its Action Plan.

Thus, PERSGA, in close collaboration with relevant regional and international organizations, began implementing activities and programmes to deal with the various threats facing the coastal and marine environments in the region.

The most significant threats included: environmental degradation, non-sustainable use of living marine resources, maritime traffic, oil production and transport, urban and industrial development, and the rapid expansion of coastal tourism.

The *Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden*, executed by PERSGA with GEF support, was one of the most ambitious programmes undertaken. The SAP was largely executed through a diverse set of training, workshops, surveys and action plan development which resulted in a substantive number of reports, documents and outputs across all the SAP components. The availability of this information formed an excellent basis for the production of the *State of the Marine Environment Report (SOMER) for the Red Sea and Gulf of Aden*.

The SOMER aims to support continuing efforts towards the sustainable use and conservation of the Red Sea and Gulf of Aden. It is hoped that this report will provide a foundation for improved decision making at all levels, and increase awareness and understanding of environmental trends and conditions—their causes and consequences—among all stakeholders. The report can also provide source material for academic studies and a baseline of integrated information against which future assessments can be compared.



Prof. Ziad Abu Ghararah
Secretary General
PERSGA

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ABBREVIATIONS AND ACRONYMS

ACT	Aden Container Terminal
AIS	Automatic Identification Systems
BFS	Burum Fishers' Society (Yemen)
BPD	Barrels per day
DAP	Diammonium phosphate
EEZ	Exclusive Economic Zone
ENC	Electronic Navigation Chart
EU	European Union
FAO	Food and Agriculture Organization
FMP	Fisheries management plan
FMS	Fisheries Marketing and Services Corporation (Yemen)
FSO	Floating storage and offloading vessel
GBP	GloBallast Partnerships
GCN	Global Core Network
GEF	Global Environment Facility
GIS	Geographic information system
GLOSS	Global Sea Level Observing System
GPS	Global positioning system
GRT	Gross Registered Tonnage
IAS	Invasive aquatic species
IBC Code	International Code for the Construction and Equipment of Ships Carrying Dangerous Goods in Bulk
ICA	International Cooperative Association
ICZM	Integrated coastal zone management
IHO	International Hydrographic Organization
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
INFOSAMAK	Centre for Marketing Information & Advisory Services for Fishery Products in the Arab Region
IOC	Intergovernmental Oceanographic Commission
IOMoU	Indian Ocean Memorandum of Understanding

ITOPF	International Tanker Owners Pollution Federation
Jeddah Convention	Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment
LMR	Living marine resources
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
l.o.a	Length overall (i.e. maximum length of boat, ship or other vessel)
MAIB	United Kingdom's Marine Accident Investigation Branch
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978
MCS	Monitoring control and surveillance
MEMAC	Marine Emergency Mutual Aid Centre
MFW	Ministry of Fish Wealth, Yemen
MoU	Memorandum of understanding
NAO	North Atlantic Oscillation
NIOHC	North Indian Ocean Hydrographic Commission
NRT	Net registered tonnage
OBM	Outboard motors
ODA	Overseas Development Aid
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PIP	Programme Implementation Phase
ppb	Parts per billion
ppm	Parts per million
PSC	Port State Control
PSMSL	Permanent Service for Mean Sea Level
RCRC	Reference Collection Regional Centre
RECOFI	Regional Commission on Fisheries
RHC	Regional Hydrographic Commission
RLR	Revised Local Reference
RNC	Raster Nautical Chart
ROPME	Regional Organization for the Protection of the Marine Environment

RoRo	Roll on-Roll off
RSGA	Red Sea and Gulf of Aden
SAP	Strategic Action Programme for the Red Sea and Gulf of Aden
SBT	Segregated ballast tanks
SCA	Suez Canal Authority
SOLAS	Safety of Life at Sea (Convention)
SPM	Single point mooring
SRR	Search and rescue regions
SUMED pipeline	Suez to the Mediterranean Pipeline
TDW	Tons dead weight
TSS	Traffic separation schemes
UKHO	United Kingdom Hydrographic Office
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
WGS	World Geodetic Systems
WOCE	World Ocean Circulation Experiment
YR	Yemeni rials (riyals)
YRS	Yemen Red Sea
YFCU	Yemeni Fish Cooperatives Union
‰	Parts per thousand

EXECUTIVE SUMMARY

The Red Sea and Gulf of Aden are globally renowned for their great diversity of marine and coastal environments, the number of unique species, and the importance of the marine resources to the continued social and economic development of the region. However, the Red Sea and Gulf of Aden have experienced a pace of development in the coastal zone in the past four decades that is, perhaps, unmatched anywhere in the world. This has been followed by degradation of the marine and coastal environments in some places and a loss of its potential to sustain the livelihood of coastal populations.

Great advances have been made in recent years in management and in the knowledge that has been gained about the marine environment of the Red Sea and Gulf of Aden. This review of the available information on the state of the marine environment of the Red Sea and Gulf of Aden provides an assessment of its status, the current issues, the needs for additional actions, and the constraints to continued progress in environmental management and understanding.

Significant progress is occurring in:

- the establishment of marine protected areas,
- capacity building and management experience,
- scientific understanding of some species and ecosystems, and
- improving safety measures for maritime transport.

The continuing and emerging issues for the environment of the Red Sea and Gulf of Aden are:

- habitat degradation and destruction by pollution, coastal development and tourism,
- over-fishing and its associated socioeconomic consequences for coastal populations,
- lack of management action, especially the implementation of management and enforcement,
- limited technical capacity and management experience,
- limited scientific knowledge and monitoring of key habitats, species, and activities (especially fisheries-related data),
- the risks of further coral bleaching events and sea level rise attributed to global climate change, and
- the spread of invasive aquatic species.

PHYSICAL ENVIRONMENT OF THE RED SEA AND GULF OF ADEN

Status

The Red Sea and Gulf of Aden is a unique body of water consisting of the semi-enclosed Red Sea and the Gulf of Aden linked to the Indian Ocean.

It forms part of a vital route for world trade. Since the opening of the Suez Canal to shipping in 1869 new trading links have been created between Europe and America to the west of Suez and The Gulf, East Africa, India and the Far East to the east.

The Red Sea is the warmest of the world's seas due to the climate of the region, while the Gulf of Aden is strongly affected by the north-east and south-west monsoons.

Water is exchanged at the northern end of the Red Sea between the Gulf of Suez and the Mediterranean via the Suez Canal, and at the southern end with the Gulf of Aden via the Strait of Bab el Mandeb.

The Red Sea is the most saline water body in direct contact with world oceans. The ambient salinity levels may be very close to the physiological limits of many species, which highlights the potential sensitivity of the Red Sea biota to localised anthropogenic increases.

The semi-enclosed nature of the Red Sea limits the opportunity for renewal of the water mass. The renewal time for the entire water body of the Red Sea is around 200 years.

Primary productivity throughout most of the Red Sea is low, relative to other oceans, due to the thermocline preventing the recycling of nutrients from deeper water to the euphotic zone. The Gulf of Aqaba is de-stratified during winter (December–April) from declining sea surface temperatures and wind mixing, resulting in elevated nutrient levels and higher primary productivity in the shallow waters.

There are no known upwellings in the Red Sea. However, there is an important upwelling of cold water in the Gulf of Aden, particularly towards the eastern end, driven by the south west monsoon in August and September. Nutrient concentrations in the southern Red Sea are higher due to the inflow of nutrient-rich waters from the Gulf of Aden in late summer.

Most of the Red Sea and Gulf of Aden is surrounded by dry, largely arid hills and semi-desert regions.

The Red Sea is shallow at its northern and southern ends and has depths of up to 2,000 m in its central section. The Gulf of Aden is relatively deep, reaching a depth of over 5,000 m at one point.

Navigational charts that are based on hydrographic surveys rely in many cases on data that is inadequate for modern navigational purposes.

Climate change and the likelihood of sea level rises are matters of serious concern to the countries bordering the Red Sea and Gulf of Aden.

Progress

New charts of the southern Red Sea have been published for use by international shipping, based on a major new hydrographic survey of the area between the Hanish Islands and Bab el Mandeb that was initiated by PERSGA. These charts are designed to improve the safety of navigation in this important area of the Red Sea and Gulf of Aden.

A new chart of Port Sudan showing recent developments in the port has been produced by the United Kingdom Hydrographic Office, based on data supplied through PERSGA.

A new planning chart of Yemeni waters covering the area between the maritime border with Saudi Arabia to a line east of the Socotra Archipelago was published by the United Kingdom Hydrographic Office in December 2006. This chart forms the basis of a Yemen Fisheries Chart covering the same area, which is marked with a grid dividing the area into squares covering 100 square nautical miles for the purpose of recording fish catches.

Capacity building in navigation safety/hydrographic surveying and chart re-scheming, has been achieved through training workshops held throughout the region and new survey boats are being built to enable at least some surveying to modern standards to be undertaken in the Red Sea and Gulf of Aden.

One or more new tide gauges in the Gulf of Aden will form part of a tsunami early warning system for the Indian Ocean.

The proposed new tide gauge at Aden could provide vital information on long term sea level changes in the region.

Constraints to Continued Progress

Cooperation between states bordering the Red Sea and Gulf of Aden, and an appreciation of the importance of agreeing on boundaries, is needed to enable maritime boundaries and exclusive economic zones to be fully defined.

An extensive programme to improve hydrographic surveys in the region, many areas of which have not yet been adequately surveyed, is needed but resources for this work are very limited.

COASTAL AND MARINE RESOURCES

Status

Coral reefs are generally healthy throughout the Red Sea and Gulf of Aden, with 30 to 50% live coral cover at most locations and more than 50% total cover on average. Coral reefs are locally impacted in the vicinity of urban and industrial centres from land-filling and dredging; port activities (damage caused by anchors, oil and waste water discharges); sewage and other pollution (causing localised areas of coral disease, poor recruitment, and excessive algae); and tourism (damage from anchors and recreational scuba divers).

One-third of coral reefs in the region were destroyed or impacted by coral bleaching in 1998. Impacts were most intense in the central-northern Red Sea of Saudi Arabia (especially near Rabigh) and in Yemen (Belhaf, Hadhramaut, Socotra Archipelago). Most reefs are recovering. Outbreaks of crown-of-thorns starfish were recently reported only from the Iles des Sept Frères and Ras Siyyan Marine Protected Area (Djibouti).

Three-quarters of mangrove stands are impacted from camel grazing, felling, cutting, solid wastes, sewage, burial by mobilised sand dunes, or obstruction to tidal flows.

Populations of invertebrates are generally healthy except for localised declines of giant clams (Egypt, Eritrea) and other molluscs (Sudan), lobsters (all of the Red Sea and Gulf of Aden) and sea cucumbers (Sudan).

Among fishes commonly targeted by fishers, the grouper (family Serranidae) are relatively common compared to other reefs in the world, apart from some localised heavy exploitation (Sudan). The highest density of grunts (family Haemulidae) recorded globally in 1997–2001 was at a reef in Ras Mohammad National Park (Egypt). The globally vulnerable humphead wrasse *Cheilinus undulatus* (family Labridae) was not recorded in Egypt, Eritrea or the Socotra Archipelago but was recorded in Sudan and Djibouti. There are concerns about fishing pressure at spawning and nursery sites, and sharks are heavily exploited. Collection of ornamental fishes occurs in Egypt, Saudi Arabia and Yemen but the impacts have not been quantified. Fish community structure is significantly altered on reefs adjacent to industry in Aqaba (including pathological changes) and Yanbu.

There is a regionally/internationally significant turtle nesting site on Mukawwar Island (Sudan). Turtle populations are affected by illegal capture or by-catch (Djibouti, Socotra Archipelago, Somalia, Sudan); oil spills and habitat degradation (Saudi Arabia); and feral dogs (Gulf of Aden).

There are thirty-one Important Bird Areas of which the Hurghada and Socotra Archipelagos are globally significant. General threats to breeding seabirds include human disturbance, human exploitation, introduced predators, habitat destruction (especially urban expansion), pollution, over-fishing and lack of information on population status.

The number of dugong to be found off Jizan and the Farasan Islands (Saudi Arabia) and in the Mukawwar Island and Dungonab Bay Marine Protected Area (Sudan) has declined, probably due to losses from accidental drowning in nets. The Sudan population of dugong may be the most important remaining on the coast of Africa.

Of the 15 species of cetaceans known to occur in the Red Sea and Gulf of Aden two are listed as Threatened, five are dependent upon conservation actions to prevent their listing as Threatened, five are insufficiently known to assign a conservation status, and only three are Secure.

Progress

There has been recent, substantial progress in the management of the marine resources of the Red Sea and Gulf of Aden.

A regionally applicable manual of standard survey methods for key habitats and key species in the Red Sea and Gulf of Aden was produced.

Collection of essential baseline data on key habitats and species (coral reefs, mangroves, seabirds, turtles) and preparation of up-to-date status reports has taken place. There have been substantial gains in scientific knowledge of Red Sea and Gulf of Aden corals, coral communities, and reefs.

Regional action plans (following regional surveys) were developed for corals, mangroves, turtles and breeding seabirds and are being implemented nationally via national action plans.

The signing of the Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas by PERSGA member states in December 2005 will provide a regionally coordinated approach to conservation.

A Regional Master Plan for the Regional Network of Marine Protected Areas has been produced.

Progress is occurring towards the complete establishment of the RSGA Regional Network of Marine Protected Areas: two proposed marine protected areas were officially declared in 2005 (Iles des Sept Frères and Ras Siyyan in Djibouti and Mukawwar Island and Dungonab Bay in Sudan) and management plans are being implemented in each one. A zoning plan was developed for the Socotra Archipelago Marine Protected Area.

Survey design guidelines for marine protected areas (MPAs) have been prepared and ecological and socio-economic surveys have been completed at four proposed MPAs. All MPA survey data has been entered into a regional GIS. Site-specific master plans, with management guidelines, have been written for four proposed MPAs with the involvement and participation of local stakeholders.

A large number of managers and scientists have been trained (via workshops and on-the-job training) in marine protected area management, field surveys, and monitoring techniques. There has been an international, regional and national exchange of experience.

Substantial progress has been made in the field of integrated coastal zone management (ICZM). This includes:

- Approval of ICZM plans for the Aden Governorate and their implementation.
- Completion of coastal profiles in Sudan and Djibouti and preparation of ICZM plan for Sudan (awaiting official approval).
- Establishment of a regional ICZM working group and raised awareness of the need for and use of this tool in coastal management.
- Improvements in regional capacity in remote sensing and GIS applications.
- Design, creation and establishment of a GIS unit at PERSGA with global internet access.
- Incorporation of all biodiversity, protected area, ICZM and other data from the Strategic Action Programme into the GIS for full programme integration.

PERSGA's environmental awareness programme concentrated on conservation including the production of the Environmental Education Learning Supplement, and the implementation of 17 community participation projects.

Five public environmental information centres and 150 school nature clubs have been established within the region, with associated teacher training.

These activities have resulted in raised awareness of PERSGA and its activities at the national, regional and international level.

Constraints to Continued Progress

The potential performance of marine protected areas is compromised by a general lack of surveillance and enforcement, a lack of management expertise and experience, and often by weak implementation of management plans.

The existing marine protected areas do not fully represent the range of regionally significant and representative habitats and species (mangroves, turtle nesting and feeding, breeding seabirds). Additional marine protected areas are needed to fill these gaps.

Information gaps prevent an assessment of the current status of some species (breeding seabirds, marine mammals, marine turtles) and the distribution and status of many habitats (sabkha, saltmarsh, sandy shores, rocky shores, seagrass in some countries, and subtidal soft substrata). These gaps also constrain monitoring and assessments of the representativeness of existing marine protected areas.

Though the situation varies between the countries, the general underlying impediments include poorly developed national environmental legislation; lack of funding (for research, management, monitoring, surveillance and enforcement); the need to strengthen the political will to implement management; and lack of scientific expertise and experience in marine environmental management.

There has been limited use of community-based monitoring.

SEA-BASED ACTIVITIES AND SOURCES OF POLLUTION

Status

The number of ships in transit through the Suez Canal largely determines the types and numbers of ships operating in the Red Sea and Gulf of Aden. These numbers continue to rise, while the structure of the traffic is changing as maritime transport evolves.

So far the Red Sea and Gulf of Aden have been remarkably fortunate to escape a major oil pollution or chemical pollution event due to shipping incident(s).

However, recent worrying episodes give warning that a major pollution incident could easily occur.

The semi-enclosed nature of the Red Sea and Gulf of Aden almost guarantees that any spill of oil or chemicals will have a major impact on the coastline somewhere in the region.

The extension of routeing measures to passages near islands further north in the Red Sea and into the lower northern part of the Red Sea has been identified as a necessary move to further improve navigation safety in the region.

Port development in the region, particularly over the past 30 years, has been dynamic with ports expanding to handle the growth in trade and hence cargo volumes.

The threat of pollution from new chemical, oil and liquefied natural gas terminals and refineries in the region, and maritime transport to and from these terminals, needs to be carefully monitored.

The arrival of ballast water on ships trading to ports in the Red Sea and Gulf of Aden, particularly ballast in tankers and bulk carriers, but also container ships and other types of vessel, and on ships in transit through the Red Sea and Gulf of Aden, has the potential to do more harm to the marine environment than a major oil pollution incident.

Invasive aquatic species in ships' ballast water is now considered to be one of the four greatest threats to the world's oceans, the other three being land-sourced marine pollution, over-exploitation of living marine resources, and physical alteration/destruction of habitat.

Dumping of hazardous materials at sea in waters close to the Gulf of Aden has the potential to carry serious pollution hazards into the region.

Progress

In general, oil spills around the world are reducing due to initiatives by the International Maritime Organization and other factors.

PERSGA has achieved significant success in getting new routeing measures adopted for use by international shipping in the southern Red Sea.

PERSGA has established a new lighthouse fitted with Automatic Identification Systems (AIS) on the Hanish Islands.

Capacity building in combating oil pollution, port state control, marine incident investigation, navigation safety/hydrographic surveying, contingency planning and ballast water management has been achieved through training workshops held throughout the region.

PERSGA has established the Marine Emergency Mutual Aid Centre at Hurghada and this is receiving support from the International Maritime Organization.

National contingency planning in the Red Sea and Gulf of Aden has improved and national plans are now in place in Jordan, Egypt, Saudi Arabia and Sudan.

The capacity to carry out port state control of ships has also improved in recent years.

Constraints to Continued Progress

The capacity for monitoring oil and chemical spills in the Red Sea and Gulf of Aden remains very limited.

The level of understanding of the potential impact of ballast water movements in the Red Sea and Gulf of Aden remains insufficient and needs to be improved.

Support for the Red Sea and Gulf of Aden will therefore have to be mobilised in order to prepare the region to deal effectively with invasive aquatic species.

National contingency plans have not yet been developed for Eritrea, Somalia or Yemen.

Only a few regional states have become parties to the 1972 London Dumping Convention or its 1996 Protocol and this situation needs to be addressed.

LAND-BASED ACTIVITIES AND SOURCES OF POLLUTION

Status

Despite the semi-enclosed nature of the Red Sea and Gulf of Aden and intensive coastal developments in some nations there is no evidence of region-wide alteration of the marine environment from land-based sources or activities.

The most pressing issue is the poor management of wastewater (sewage, industrial wastewater) causing localised increases in nutrients.

The disposal of solid waste causes localised problems for coastal habitats in all countries.

Contaminated runoff arising from pesticide use is a potential problem in some countries that requires investigating.

There is no evidence for generalised elevations of trace metals in water, sediments or organisms but elevated levels may be an issue in some localised areas.

Preliminary monitoring results indicate elevated levels of some water column nutrients. However, a longer time series is required to discern trends and to establish acceptable limits in each country.

Understanding and responding to ecosystem degradation must be based upon monitoring that integrates both chemical (e.g. dissolved nutrients) and biological variables (e.g. sea urchins, herbivorous fishes).

Progress

Recent changes in management practices have led to some environmental improvements, especially on the coral reef adjacent to the Phosphate Port, Aqaba.

The signing of PERSGA's Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden, and the implementation of the Regional Environmental Monitoring Programme are substantial outcomes.

Capacity building has been achieved (via training workshops) in integrated coastal zone management, environmental impacts of development projects, management of solid

wastes in industrial areas, environmental inspection, and improvement of wastewater management.

A national programme of action for the protection of the marine environment from land-based activities was prepared for Yemen and is being prepared for Egypt.

A preparatory and fund raising phase of the Regional Programme of Action for the Protection of the Marine Environment from Land-Based Activities is being prepared for the Red Sea and Gulf of Aden comprising the following:

- collection of relevant information for the development of four projects in the following fields:
 - collection, treatment and disposal of municipal wastewater,
 - identification of pollution hot spots and sensitive areas,
 - management of marine litter, and an
 - assessment of the quality of bathing waters and beaches;
- production of the joint PERSGA/UNEP publication 'Financing for the Environmental Conservation of the Red Sea and Gulf Aden' and
- organization of a regional training course on municipal wastewater treatment management.

There has been a rapid uptake of GIS (including a regional GIS database in PERSGA) as technology to support navigation planning and risk assessments for pollution.

Constraints to Continued Progress

Waste water treatment facilities are lacking, operating above capacity, or relying on outdated technology.

The problems of infrastructure are compounded by lack of enforcement of laws.

There is limited understanding of the environmental effects of solid waste disposal and litter.

Implementation of the Regional Environmental Monitoring Programme in Djibouti, Sudan and Yemen will require continued support and capacity building owing to limitations in scientific infrastructure and trained personnel.

LIVING MARINE RESOURCES

Status

The unique value of the biological resources of the Red Sea and Gulf of Aden to the prosperity of the region has long been recognised. The local fisheries have provided food and employment for thousands of years.

Regional Red Sea stocks of sharks are over-fished. Over-fishing by industrial trawlers in the near-shore waters of the Gulf of Aden has depleted cuttlefish and deep-sea lobsters. Industrial trawl fisheries in the Red Sea are placing considerable pressure on shrimp stocks and other living marine resources (via the large by-catch of non-target species).

In the Egyptian Red Sea there are approximately 4,300 artisanal fishers and fishers working in semi-industrial fisheries. The semi-industrial sector includes about 230 trawlers and 83 purse seiners.

In Saudi Arabia there are over 15,800 artisanal fishers and about 160 semi-industrial trawlers working in the Red Sea.

The number of Yemeni artisanal fishers in 2004 was 75,000–80,000. The figure has almost quadrupled since 1990. Many artisanal fishers have very low income that is often supplemented by loans. The foreign industrial fleet stood at slightly over 130 boats in 2004 but by 2006 had fallen sharply to less than 30 boats due to management measures taken by the government.

Artisanal fisheries are under-exploited in Djibouti, Sudan and Somalia.

Catches by industrial fisheries of Indian mackerel, kingfish, sharks, cuttlefish, shrimp, rock-lobster and trochus have declined.

Collecting of fishes for the aquarium trade is significant in Saudi Arabia and Yemen.

Marine aquaculture in the region includes shrimp farming in Egypt and Saudi Arabia and pearl-oyster farming in Sudan.

Progress

The regional status of the living marine resources in the Red Sea and Gulf of Aden has been assessed and baseline information has been collected.

There has been a substantial rise in capacity in fish stock assessment, data collection and analysis; environmentally sound aquaculture; fisheries management; and ornamental fish assessment and management. Two training facilities and a reference collection centre have been established and equipped. There is an increased awareness among decision makers of the complementary linkages between conservation of the environment and sustainable development.

A system is in place for the standardised collection and transfer of fisheries data.

Information has been obtained for Egypt, Jordan, Djibouti, Saudi Arabia and Yemen on the trade in ornamental fishes and its impact on the environment. A management plan for ornamental fishes has been prepared.

The management of elasmobranch fisheries has improved through: training; an identification guide; a management plan; and improved data collection.

New fisheries regulations have been issued in Egypt, Saudi Arabia and Yemen. Additionally in Yemen fisheries management plans were prepared for Socotra fisheries and rock lobsters.

Constraints to Continued Progress

There is insufficient data collection and analysis, and minimal monitoring. In Egypt, Sudan and Jordan data collection is *ad hoc* and poorly organised, and in Somalia very little reliable information is available. There is minimal enforcement of regulations and penalties for infringements are too low to act as an effective deterrent or to encourage compliance by fishers.

Lack of funding has constrained the following: human resource development; the development of national and regional monitoring, control and surveillance systems; and research and monitoring.

The institutional and technical capacities for conducting research and stock assessment studies are weak.

The Regional Commission on Fisheries is not established.

The implementation of regional programmes is constrained by the socioeconomic variations among the member countries of the region.

A focus on ecological studies without any consideration to socioeconomic aspects has limited the potential for sustainable management.

Coordination between ministries responsible for fisheries and for the environment is weak or inadequate and the agencies carry out their activities independently.

The direct effects of fishing on fish stocks and its indirect effects on the marine environment are not well understood.

Fisheries resources management in the member countries of PERSGA is still dominated by top-to-bottom decisions.

The last regional stock assessments were made in the late 1980s.

The legal framework providing for fisheries management and development is weak in many countries. Internationally accepted models for management are not incorporated, such as the principles laid down in the FAO Code of Conduct for Responsible Fisheries or the establishment of fisheries management plans.

Participatory approaches involving all stakeholders in fisheries management are totally lacking.

A lack of awareness of the need for and benefits of effective fisheries management by stakeholders in the fisheries sector is a critical problem.

A lack of infrastructure in many rural areas in Sudan, Somalia and Yemen's Red Sea coast limits the expansion of artisanal catches and often results in poor quality and, consequently, reduced earning potential for rural fishers.

RECOMMENDED PRIORITY ACTIONS

Significant progress in conservation of the marine environment of the Red Sea and Gulf of Aden has been made in a relatively short time. The following priority actions are needed to ensure continued progress.

Information Needs

The international maritime boundaries and exclusive economic zones of each country bordering the Red Sea and Gulf of Aden need to be agreed upon and defined.

Continued efforts to develop innovative and appropriate conservation and management approaches will be enhanced by a strong culture of pure and applied research and monitoring. In particular, local scientists need encouragement and financial and logistical support to undertake research on the information gaps raised in this report and in the various action plans. This requires long-term investment in university education and the training of young researchers (e.g. by providing international scholarships).

Information is urgently needed on:

- the extent and status of most ecosystems;
- the status of marine turtles and their habitats;
- the status of all breeding seabirds;
- the identification of significant sites for marine mammals;
- the impacts in the marine environment of contaminated runoff arising from pesticide use in the coastal zone and catchments; and
- the taxonomy of many groups of marine organisms.

The continued implementation of the Regional Environmental Monitoring Programme must be supported as a priority.

Monitoring of soft bottom fauna is needed throughout the Red Sea and Gulf of Aden because of extensive and rapid coastal development and the operations of commercial benthic trawl fisheries throughout large parts of the region.

PERSGA should arrange for up-to-date, continuous, and consistent records of oil spills in the region to be maintained.

Regionally agreed procedures for investigating marine accidents need to be established and further training in investigation methods is required.

Support needs to be secured for the conduct of hydrographic surveys in the region to modern standards.

Maritime Transport

The need for reception facilities throughout the region should be reviewed and the major ports that do not yet offer these facilities should be encouraged to establish them.

PERSGA should provide support for the establishment of the necessary legal structures and competent maritime authorities in member states. It should encourage its member states to become parties to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972. PERSGA should establish a mechanism for regional cooperation on the prevention of illegal dumping in the waters of the Red Sea and Gulf of Aden.

PERSGA should seek a mechanism through which states in the Red Sea and Gulf of Aden become members of a memorandum of understanding on port state control.

After completing appropriate investigations, PERSGA should submit proposals for new routing measures for adoption by IMO that will have the effect of separating north bound and south bound traffic throughout the Red Sea and thus improve navigation safety along this important international route.

Conservation

All remaining undeclared marine protected areas in the Red Sea and Gulf of Aden Regional Network of Marine Protected Areas should be officially declared as soon as possible. Site-specific management plans are required for all marine protected areas in the Red Sea and Gulf of Aden Regional Network of Marine Protected Areas.

Regional action plans are required for: sabkha, saltmarsh, intertidal sandy and muddy shores, intertidal rocky shores, seagrass, algal communities, and subtidal soft bottoms.

Specific conservation action is required for the breeding seabird White-eyed Gull (*Larus leucophthalmus*). Its status is Near Threatened.

Specific conservation action is required for dugong in the Mukawwar Island and Dungonab Bay Marine Protected Area (Sudan). This should include a ban on fixed fishing nets in those parts of the marine protected area important for dugong.

Living Marine Resources

The process of collecting region-wide baseline information that was begun during the Strategic Action Programme needs to continue so that the appropriate fisheries management plans can be refined and modified in light of changing future circumstances.

Funding is required for further training that was not covered during the Strategic Action Programme.

Funding is required to establish national and regional monitoring, control and surveillance systems. Improved monitoring of artisanal activities is urgently required.

The Regional Commission on Fisheries must be formed. It will serve as a useful tool for the management of shared stocks by the PERSGA member countries.

Research is needed into the effects of fishing on fish stocks and the marine environment, and the inter-connectedness between poverty and over-exploitation of the environmental resources.

Poverty alleviation is required in Djibouti, Eritrea, Somalia, Sudan and Yemen. Improvements in infrastructure to allow the processing and storage of fish are needed to reduce the fishing pressure on other species such as sharks.

PERSGA member countries require assistance (technical, financial) in preparing fisheries management plans. In particular, the management of shark fisheries needs to be developed through the combined efforts of PERSGA member countries. Production of guidelines for proper fish handling, transporting, storing, and processing of fish and fish products must be undertaken in close collaboration with FAO.

PERSGA member countries must be encouraged to prohibit bottom trawling and the use of explosives in fishing.

PERSGA could assist member countries in institutional and legal capacity building of the environmental and fisheries management agencies to bridge and strengthen coordination towards sustainable use of the resources.

Capacity Building and Institutional Strengthening

Needs for management capacity building include:

- planning and implementation of relevant control mechanisms (legislative or procedural);
- development of maritime laws;
- integrated coastal zone management plans;

- environmental assessment methods;
- port facilities;
- marine protected area planning and management; and
- pollution management strategies.

Knowledge on how to control the movement of invasive aquatic species carried in ballast water remains very limited within the region and much work needs to be done to improve the current situation. PERSGA should continue to liaise closely with the International Maritime Organization and the GloBallast team to secure funding for additional training and baseline surveys of harbour and coastal waters. This will help provide the region with the means of monitoring and controlling ballast water discharge at ports and terminals.

Planning and Management

Integrated coastal zone management plans are required in several countries or need to be implemented in other countries where they already exist.

Treatment facilities for waste water throughout the Red Sea and Gulf of Aden urgently need to be installed or updated. The relevant national laws need to be enforced.

The situation regarding contingency planning in the region as a whole remains unsatisfactory. PERSGA should seek donors who would be prepared to sponsor the implementation of an important Action Plan that has been developed for the region with IMO support, stressing the need to have proper national and regional contingency plans in place before a major spill occurs.

An emerging issue is habitat conversion for shrimp farms. This is currently a substantial issue for mangroves regionally and the impacts need to be considered in environmental assessments of development applications for shrimp farms.

Climate Change

Rising sea levels in the Red Sea and Gulf of Aden could have serious consequences for many areas near the coast and for man-made structures, including harbours and the Suez Canal. PERSGA should carry out a study of areas close to the coasts of the Red Sea and Gulf of Aden to determine the likely impact of a rise in sea level on coastal areas and resources. PERSGA should also take every opportunity to support the establishment of new tide gauges, express its concern over rising sea levels at regional and international fora, and point out the potential impact on the region of rising sea levels. It should bring to the attention of the maritime community the probability that there will be an increase in tropical species migrating through the Suez Canal into the Mediterranean as sea temperatures increase world wide.

The Red Sea and Gulf of Aden have already experienced extensive coral bleaching and the incidence of coral bleaching may increase in the future as sea temperatures rise, associated with global climate change. PERSGA should facilitate the cooperation of regional scientists with international networks of scientists engaged in monitoring global sea temperatures for early warning signs of coral bleaching. In particular, coral reef research into the sensitivity and resilience of Red Sea and Gulf of Aden coral reefs (especially those reefs that form part of the Regional Network of Marine Protected Areas) to bleaching events should be actively supported and encouraged.

Sustainable Livelihoods for Coastal Communities

There is a great need to reduce camel grazing in mangroves and the felling and cutting of mangrove trees. Efforts to manage camel grazing and wood collecting require alternative sources of food, fuel and construction materials to be provided.

Community Education

There is a need to develop community education programmes that highlight the impacts of coastal communities on reef ecology, including degradation, anchor damage, littering, waste disposal and souvenir collection. These could be integrated with programmes of community-based monitoring that involve recreational scuba divers or fishers.

Political

The structure and operation of government departments needs to match the ways in which marine environmental management are done, especially the need for integrated approaches to decision-making (e.g. major coastal developments). Political support is needed to ensure that existing laws, regulations and standards are enforced.

Infrastructure

Infrastructure needs to be installed or upgraded for waste water (including sewage) collection and treatment, solid waste collection and disposal, communications, and navigational aids.

Networking

There is a need to integrate current and future research and monitoring into global initiatives such as the International Coral Reef Initiative, the Global Coral Reef Monitoring Network, and the ongoing research and monitoring of PERSGA nations.

STATE OF THE ENVIRONMENT REPORTING IN THE RED SEA AND GULF OF ADEN

Dr William Gladstone

1.1 INTRODUCTION

The Red Sea and Gulf of Aden (RSGA) is a globally significant marine ecosystem. It is renowned for its unique and beautiful marine and coastal environments and species richness, which includes many species found nowhere else on Earth. The global conservation values of the RSGA include: the diversity of coral reef habitats in the central Red Sea of Saudi Arabia and Sudan; its distinct zoogeography and number of endemic species; the unique coral reefs around the Sinai; the atoll-like formation of Sanganeb Atoll in Sudan; the extensive stands of mangroves and populations of dugong and turtle in the southern Red Sea; the unique biodiversity of the Socotra Archipelago; and, the extensive stocks of commercial fishes in the Gulf of Aden.

The living marine resources of the RSGA have played a major role in the history, development and cultural heritage of all countries of the region. The use of the RSGA as a transit route for a significant percentage of the world's petroleum, dry bulk and other cargoes gives the marine environment a global strategic focus, while at the same time being one of the major challenges to its sustainable use. Other uses for the coastal and marine environments by the inhabitants of the RSGA with a much longer heritage have proven to be both ecologically and socially sustainable.

However, increasing coastal populations, rapid development and human exploitation threaten the sustainability of current uses and the special conservation values. In several countries there has been the development of petroleum-based economies that require sea transport and port facilities for petroleum exports. The growth of international dive tourism has

caused destruction of coral reefs at heavily visited reefs. General population growth in the coastal zone has led to localised habitat destruction and modification, and the release of pollutants. Stocks of invertebrates, fishes and sharks (and their associated ecosystems) are affected by over-fishing. The ability of many countries in the region to address issues will be constrained by limitations in both technical expertise and the required experience in management.

Despite the enormous economic growth that has occurred in some countries, many coastal communities continue to rely for their livelihood on small-scale usage of marine resources, especially fisheries. The social and economic structure of these communities is threatened by the accumulated impacts occurring within the marine and coastal environments.

Managing human use of the marine and coastal environments of the RSGA will be most effective when based on a solid foundation of knowledge. This knowledge that has been built up by a long history of endeavour in the bio-physical and social sciences, allows managers, scientists, decision-makers and the wider community to devise appropriate management strategies that respond to the impacts of human uses confronting them. It also provides them with the hard evidence needed to assess the effectiveness of their decisions. A major problem has been that the available information was available in fragmented sources. No baselines had been established against which the success, or otherwise, of management could be gauged. The absence of long-term monitoring limits our understanding of the magnitude of natural variations in marine ecosystems and consequently our ability to interpret the meaning of changes due to human activities.

1.2 A DECADE OF GREAT PROGRESS

It is a fitting time to assess the state of the marine environment of the RSGA. Beginning in 1995, there has been a decade of intense activity in marine and coastal management and science. The Sea to Sea Conference in Jeddah in 1995 drew together managers, scientists and decision-makers from the Gulf and from the RSGA regions and the international donor community. It provided a comprehensive overview of current knowledge and innovative management, and highlighted many emerging issues.

Also in 1995 the Regional Organization for the Conservation of the Red Sea and Gulf of Aden Environment (PERSGA) was formally established by the seven member states: Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen. PERSGA has implemented, and continues to implement, a large number of projects throughout the RSGA with funding from ALECSO, the Islamic Development Bank, other international donors, and member states. The PERSGA Secretariat is based in Jeddah and is hosted by the Kingdom of Saudi Arabia. The establishment of PERSGA has been a pivotal step in a regional approach to sustainable use and conservation of the marine resources and environments. A regional approach to the marine environment is essential given the semi-enclosed nature of the Red Sea and the transboundary nature of many issues.

One of the most ambitious programmes executed by PERSGA was the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden, planned from 1995 to 1998 and carried out between 1999 and 2003. The SAP was funded through the Global Environment Facility (GEF) implementing agencies (UNDP, UNEP, and the World Bank), the Islamic Development Bank, and the PERSGA member states. The SAP's global objective was to safeguard the coastal and marine environments of the RSGA and ensure sustainable use of its resources. The SAP's activities were organised around the following objective-based components:

1. Institutional Strengthening to Facilitate Regional Cooperation
2. Reduction of Navigation Risks and Maritime Pollution
3. Sustainable Use and Management of Living Marine Resources
4. Habitat and Biodiversity Conservation
5. Development of a Regional Network of Marine Protected Areas
6. Support for Integrated Coastal Zone Management
7. Enhancement of Public Awareness and Participation, and
8. Monitoring and Evaluation of Programme Impacts

The SAP was highly significant for the RSGA environment, for PERSGA member states' capacity for conserving the RSGA and managing its uses, and for the future socioeconomic development of the region. A large amount of the information assembled for this review was synthesized from many of the technical reports produced under the SAP components.

Large projects funded by the international donor community and RSGA countries were implemented throughout the RSGA in the last decade e.g. the Red Sea Regional Framework Project, and projects in the Socotra Archipelago, Djibouti, Egypt, Eritrea, Jordan, Saudi Arabia, and Yemen. These have provided a large amount of new scientific information and understanding about the RSGA, management actions, and capacity building. The outcomes of these projects have contributed deeply to this state of the marine environment report.

1.3 STATE OF THE ENVIRONMENT REPORTING IN THE RED SEA AND GULF OF ADEN

The development of the coastal zone of the RSGA in the past forty years is unlikely to have occurred at the same pace elsewhere in the world. Earlier assessments of the overall state of the marine environment of the RSGA include those of ORMOND (1987), SHEPPARD et al. (1992), HALIM et al. (1994) and ABU-GIDEIRI (1997). ORMOND (1987 page 406) commented

that “In the late 1960s, probably 98% of the total Red Sea coast was in practically virgin condition...Since that time, the situation has changed very rapidly as intense commercial and industrial development has taken place along many coastal sections...”. ORMOND (1987) concluded that the main threats were likely to come from pollution, sedimentation, coastal construction, fishing and other exploitation, and visitor impacts. SHEPPARD et al. (1992) similarly viewed the main impacts to the RSGA to be caused by pollution (from oil, domestic, urban and industrial sources); loss and degradation of productive coastal habitats (from dredging, landfill, and sedimentation), collecting, tourist activities, and inland agriculture. At the time of SHEPPARD et al’s (1992) assessment there was information about the concentrations of pollutants in the marine environment for certain parts of the Red Sea, but a limited understanding of the ecological consequences. The present report on the state of the marine environment will show that, since then, there have been great advances in knowledge of the ecological consequences of pollution in parts of the RSGA.

ABU-GIDEIRI (1997) concluded that there was a need for the development of integrated institutional arrangements to support coastal zone management, generalised appropriate legal instruments, and capacity building. Specific environmental issues for the RSGA have been reviewed and assessed in other reports (in addition to those covered as part of the SAP and covered in detail in other parts of this report). The impacts of land-based sources and activities were reviewed by UNEP/PERSGA (1997). That report concluded that the main source of environmental degradation was “...the physical alteration and destruction of habitats as a result of dredging and filling operations associated with urban expansion, tourism and industrial developments...” (page 49). This conclusion was echoed by ABU-GIDEIRI (1997) in his overall judgement of the main issues facing the RSGA.

The SAP country-by-country review identified five major threats to the environment and coastal and marine resources of the RSGA: habitat destruction;

non-sustainable use of living marine resources; navigation risks, petroleum transport and petroleum production; urban and industrial development; and the rapid expansion of coastal tourism. Other concerns included the illegal disposal of toxic substances by foreign vessels in the Gulf of Aden; sedimentation from agriculture and grazing; and the introduction of pesticides and fertilisers in some locations (GLADSTONE et al. 1999).

The recent Global International Waters Assessment (UNEP 2006) reviewed the impacts of fisheries, pollution and habitat modification on the Red Sea large marine ecosystem. The review concluded that there were severe environmental impacts from habitat modification and moderate environmental impacts from pollution. The impacts from over-exploitation of fisheries were assessed as moderate and the impacts from excessive by-catch and destructive fishing practices were assessed as slight. The supporting technical document (MISTAFA & ALI 2005, page 56) concluded that “The major threats to the marine environment of the Red Sea and Gulf of Aden are related to land-based activities. These include urbanization and coastal development (for example, dredge and fill operations), industries including power and desalination plants and refineries, recreation and tourism, waste water treatment facilities, power plants, coastal mining and quarrying activities, oil bunkering.”

There has been great progress in environmental management in the RSGA since ORMOND (1987 page 406) called for “...urgent and effective conservational and environmental management measures to conserve and protect the unique resource of the Red Sea marine environment.” This report reviews the recent progress and achievements and the indicators of this. This report also points to the need for continued action in many priority areas. Most of the earlier state of the environment reports and assessments agreed on the major threats to the marine environment and resources of the RSGA, and subsequent management action has gone some way to addressing these.

This state of the marine environment report was prepared with the aim of supporting continued efforts for the sustainable use and conservation of the RSGA. The report's scope is the biological and physical environments, human uses, and recommendations for management action.

Chapter 2 is a review of the physical environment of the RSGA. This is a necessary foundation for understanding the processes that shape the marine and coastal habitats, the productivity that supports the region's fisheries, the challenges to navigation (and the risks this poses for pollution incidents), the potential for pollutant dispersal, and the modifications that have occurred to the natural coastlines from human development in the coastal zone.

Chapter 3 is an up-to-date review of current knowledge of the biodiversity of the RSGA. It addresses all major habitats (e.g. coral reefs, mangroves), important groups of organisms (algae, some invertebrates, fishes, marine mammals, turtles, seabirds), endemism and biogeography. Chapter 3 also assesses the current status of each group, based on the available information. The information provided in this section is specifically designed to be the baseline against which changes will be assessed in future state of the marine environment reports.

Chapter 4 reviews sea-based activities and sources of pollution. The chapter reviews oil and gas activities, shipping and navigation, port activities, and the critically important issue of invasive alien species.

Chapter 5 is concerned with land-based activities (including tourism) and sources of pollution. This chapter builds on the foundation provided in chapter 2 by providing information on the current status of a number of key physical and chemical

indicators of the sustainability of human uses (e.g. nutrients, trace metals).

Chapter 6 covers the living marine resources of the RSGA and specifically focuses on fisheries-related resources. The socioeconomic significance of fishing warrants its separate treatment from general marine biodiversity (chapter 3). However, much of the biological and ecological understanding presented in chapter 3 supports assessments of the wider ecological impacts of fishing. Chapter 6 provides available information on the status of fisheries in the region and the important species. This chapter also assesses the current economic status of fishing communities. This is significant because of the link between socioeconomic conditions and the need (or not) to over-fish.

Each chapter in this state of the marine environment report highlights the progress that has occurred in recent years in management and also in scientific understanding. This is accompanied by an assessment of the gaps remaining in both knowledge and action. All of this information serves as the foundation for chapter 7, which is a synthesis of the priority actions (identified in all previous chapters) that are required in the RSGA. Importantly, chapter 7 should support future decision-making about the priorities for additional action and information.

The material reviewed for this state of the marine environment report included a large number of papers from the published scientific literature, all published reports arising from the Strategic Action Programme for the Red Sea and Gulf of Aden, data collected recently as part of the Regional Environmental Monitoring Programme, reports prepared as part of other international donor projects, and the authors' experiences from working in the RSGA over many years.

THE PHYSICAL ENVIRONMENT OF THE RED SEA AND GULF OF ADEN

Captain Roy Facey and Dr William Gladstone

2.1 SUMMARY

2.1.1 Status

The RSGA is a unique body of water consisting of the semi-enclosed Red Sea and the Gulf of Aden, linked to the Indian Ocean.

It forms part of a vital route for world trade that, since 1869, has allowed shipping to pass through the Suez Canal in order to form trading links between Europe and America to the west and The Gulf, East Africa, India and the Far East to the east.

The Red Sea is the warmest of the world's seas due to the climate of the region, while the Gulf of Aden is strongly affected by the north-east and south-west monsoons.

Water is exchanged at the northern end of the Red Sea between the Gulf of Suez and the Mediterranean, and at the southern end with the Gulf of Aden via the Strait of Bab el Mandeb.

The Red Sea is the most saline water body in direct contact with world oceans. The ambient salinity levels may be very close to the physiological limits of many species, which highlights the potential sensitivity of the Red Sea biota to localised anthropogenic increases.

The semi-enclosed nature of the Red Sea limits the opportunity for renewal of the water mass. The renewal time for the entire water body of the Red Sea is around 200 years.

Primary productivity throughout most of the Red Sea is low, relative to other oceans, due to the thermocline preventing the recycling of nutrients from deeper water to the euphotic zone. The Gulf of Aqaba is de-stratified during winter (December-April) from declining sea surface temperatures and wind mixing, resulting in elevated nutrient levels and higher primary productivity in the shallow waters.

There are no known upwellings in the Red Sea. However, there is an important upwelling of cold water in the Gulf of Aden, particularly towards the eastern end, driven by the south-west monsoon between May and September. Nutrient concentrations in the southern Red Sea are higher due to the inflow of nutrient-rich waters from the Gulf of Aden in late summer.

Most of the RSGA is surrounded by dry, largely arid hills and semi-desert regions.

The Red Sea is shallow at its northern and southern ends and has depths of up to 2,000 m in its central section.

The Gulf of Aden is relatively deep, reaching a depth of over 5,000 m at one point.

Navigational charts that are based on hydrographic surveys rely in many cases on data that is inadequate for modern navigational purposes.

Climate change and the likelihood of sea level rises are matters of serious concern to the countries bordering the RSGA.

2.1.2 Progress

New charts of the southern Red Sea have been published for use by international shipping, based on a major new hydrographic survey of the area between the Hanish Islands and Bab el Mandeb that was initiated by PERSGA.

These charts are designed improve the safety of navigation in this important area of the RSGA.

A new chart of Port Sudan showing recent developments in the port has been produced by the United Kingdom Hydrographic Office (UKHO), based on data supplied through PERSGA.

A new planning chart of Yemeni waters covering the area between the maritime border with Saudi Arabia to a line east of the Socotra Archipelago was published by the UKHO on 21 December 2006.

This chart forms the basis of a Yemen Fisheries Chart covering the same area, which is marked with a grid dividing the area into squares covering 100 square nautical miles for the purpose of recording fish catches.

Capacity building in navigation safety/hydrographic surveying and chart re-scheming, has been achieved through training workshops held throughout the region and new boats are being purchased to enable new survey work to be undertaken in the RSGA.

One or more new tide gauges in the Gulf of Aden will form part of a tsunami early warning system for the Indian Ocean.

The proposed new tide gauge at Aden could provide vital information on long term sea level changes in the region.

2.1.3 Constraints to Continued Progress

Cooperation between states bordering the RSGA, and an appreciation of the importance of agreeing on boundaries, is needed to enable maritime boundaries and exclusive economic zones (EEZs) to be fully defined.

An extensive programme to improve hydrographic surveys in the region, many areas of which have not yet been adequately surveyed, is needed, but resources for this work are very limited.

2.2 THE RED SEA AND GULF OF ADEN – GENERAL DESCRIPTION AND BOUNDARIES

The Red Sea is a narrow elongated body of water running north-north-west and south-south-east separating the land masses of Africa and Arabia. At its northern end it forks to form the Gulfs of Suez and Aqaba while, in the south, it meets the Gulf of Aden and the Indian Ocean through a narrow strip of water 26 km wide and 200 m deep, known as the Strait of Bab el Mandeb, separating the coastlines of Djibouti in Africa from Yemen in Arabia. The Gulf of Aden is closely associated with the Indian Ocean and lies on the north-western edge of this water body. The Red Sea is approximately 360 km across at its widest point and its main body is about 1,950 km in length. At Ras Banas in latitude 23° 54' N, longitude 35° 47' E, about two thirds of the distance from the southern end of the Red Sea to the Gulfs of Suez and Aqaba, the Red Sea is only about 170 km wide. It has a total surface area of 438,000 sq km and a maximum depth of 2,640 m. It extends from the Suez Canal to Bab el Mandeb. The northern limit in the Gulf of Suez at Suez Bay is in latitude 29° 57' 18" N. The northern limit of the Red Sea in the Gulf of Aqaba lies in latitude 29° 32' 48" N. The coastlines of Egypt, Sudan, Eritrea and part of the coastline of Djibouti define the western boundary of

the Red Sea, while the coastlines of Egypt, Israel, Jordan, Saudi Arabia and part of the Yemeni coastline define the eastern boundary of the Red Sea. The southern limit of the Red Sea at Bab el Mandeb is in latitude 12° 37' 00" N¹.

The geographical coverage of the Red Sea and Gulf of Aden is defined in Article II of the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, known as the Jeddah Convention, as follows:

Article II - The present Convention shall apply to the entire sea area, taking into account integrated ecosystems, of the Red Sea, the Gulf of Aqaba, the Gulf of Suez, the Suez Canal to its end on the Mediterranean, and the Gulf of Aden as bounded by the following rhumb lines:

From Ras Dharbat Ali in Latitude 16° 39' 00" N, Longitude 53° 03' 05" E, to a point in Latitude 16° 00' 00" N, Longitude 53° 25' 00" E, thence to a point in Latitude 12° 40' 00" N, Longitude 55° 00' 00" E lying ENE of Socotra Island, thence to Ras Hafun in Latitude 10° 26' 00" N, Longitude 51° 25' 00" E.

Thus the boundary between the Red Sea and Gulf of Aden is not identified in the Jeddah Convention.

The Gulf of Aden is approximately 350 km across from north to south at its widest point and is about 1,260 km from east to west. It has a total surface area of 410,000 sq km and a maximum depth of 5,390 m in a position 165 km south-south-west of Ras Fartak. The Gulf of Aden, as described in the Jeddah Convention and in this present document, extends from the Bab el Mandeb to a line to the east of the Yemeni island of Socotra. The coastline of Yemen defines the northern boundary of the Gulf of Aden, while the coastlines of Djibouti and Somalia define the southern boundary².

Thus nine countries border the Red Sea and Gulf of Aden, namely: Djibouti, Egypt, Eritrea, Israel, Jordan, Saudi Arabia, Somalia, Sudan and Yemen. Israel and Eritrea are not members of the Jeddah Convention.

The Red Sea is typically bounded on the landward side by a more or less narrow coastal strip generally from 40 to 60 km wide, backed by high hills or mountains which can rise to 3,000 m in some regions. The sea bed consists of three main levels. A central trough in the Gulf of Aqaba reaches to depths of 1,800 m. In the northern and central Red Sea this central trough reaches to depths of more than 2,000 m, with the greatest depth, 2,640 m, recorded in latitude 19° 30' N. From this trough, the sea bed rises sharply to a terrace at depths of between 1,000 m and 600 m. This terrace rises again to a continental shelf which is rarely deeper than 300–400 m, and is often much

¹ The International Convention for the Prevention of Pollution from Ships, 1973, known as MARPOL 73/78, defines the Red Sea area as follows (MARPOL 73/78 Regulation 10 (1) d): "The Red Sea Area means the Red Sea proper including the Gulfs of Suez and Aqaba bounded at the south by the rhumb line between Ras Si Ane [Ras Siyyan] (12° 28.5' N, 43° 19.6' E) and Husn Murad (12° 40.4' N, 43° 30.2' E)". Thus Mayyun (or Perim) island is considered by MARPOL 73/78 to lie within the Red Sea. The Gulf of Aden as defined by MARPOL 73/78 covers a significantly smaller area than that encompassed within the definition used in the Jeddah Convention.

² For the purposes of MARPOL 73/78 the islands of the Socotra Archipelago are not included, and the Gulf of Aden area is defined as follows: "The Gulf of Aden Area means that part of the Gulf of Aden between the Red Sea and the Arabian Sea bounded to the west by the rhumb line between Ras Si Ane [Ras Siyyan] (12° 28.5' N, 43° 19.6' E) and Husn Murad (12° 40.4' N, 43° 30.2' E) and to the east by the rhumb line between Ras Asir (11° 50' N, 51° 16.9' E) and the Ras Fartak (15° 35' N, 52° 13.8' E)".

shallower at around 50 m deep. The width of this continental shelf varies considerably down the Red Sea, being generally broader to the south, and is of major significance in determining the nature and distribution of shallow water marine habitats. It is on this shelf that almost all the offshore coral reefs and islands are located, generally occurring where faulting within the shelf floor has lifted parts of the sea bed close to, or above, the water's edge.

Two areas of the Red Sea do not have this central trough. These are the Gulf of Suez, which is relatively shallow with depths typically around 60 m, and the main body of the Red Sea between latitude 16° 00' N southwards to Bab el Mandeb, which also has no trough and is relatively shallow, typically 150–180 m.

In the Gulf of Aden the central trough descends to below 1,000 m eastwards from a line between Aden and Berbera, with a narrow trough deeper than 1,000 m and about 15 km wide extending close to the coast of Djibouti at Ras Bir. Almost all of the Gulf of Aden more than 50 km from the shore is deeper than 1,000 m and the depth south of Ras Fartak in latitude 14° 05' N longitude 51° 50' E reaches an impressive 5,390 m. The narrow coastal ledge is generally up to 25 km wide, with broader ledges at the western end of the Gulf of Aden close to Aden and Djibouti. Two broader ledges exist between longitudes 50°E and 53°E that extend up to 45 km from the coast of Yemen, and a ledge off the Socotra Archipelago extends to a distance of 80 km southwards from these islands.

2.3 THE RED SEA AND GULF OF ADEN AS A MAJOR EAST-WEST TRADING ROUTE

It is difficult to over-emphasise the significance of the Red Sea and Gulf of Aden, forming part of the main east-west maritime trading route, to international trade. Even before the Suez Canal was built across the Isthmus of Suez to provide a navigable link between the Mediterranean and the Red Sea, Suez was an ancient trading site at the head of the Gulf of Suez and a major naval station under the Ottoman Empire. Suez was the landing and loading point for goods traded between the Red Sea and Gulf of Aden, India and The Gulf³, with the Mediterranean countries and Europe, and a point of departure for pilgrims from North Africa and other places to Mecca. The Suez Canal was constructed between 1854 and 1869. The opening of the 164 km long Canal in 1869 immediately added to the importance of the ports in the Red Sea and Gulf of Aden. For example, the distance from London in the United Kingdom to Aden by sea was reduced from 10,065 nautical miles via the Cape of Good Hope, to 4,567 miles⁴. This eventually resulted in Aden becoming, by the 1950s, the second most important ship bunkering port in the world after New York⁵. By this time it was acting as a middle distance bunkering port for ships on the Europe to India and Far East trade routes via the Canal.

It is estimated that this route now carries between 7% and 8% of total world trade. The numbers of ships using the Canal has varied over time. It reached over 22,545 ships in 1982, totalling 363 million net registered

³ 'The Gulf' in this document refers to the body of water off the eastern coast of Saudi Arabia variously known as the Arabian Gulf or the Persian Gulf.

⁴ Standard maritime route distance tables such as those found in Lloyd's Maritime Atlas, Lloyds of London Press, or the Admiralty Distance Tables NP350(1), Atlantic Ocean, European Waters, Mediterranean etc., and NP350(2), Indian Ocean, including Red Sea and Gulf of Aden, and adjacent waters.

⁵ Port of Aden Annuals, 1949 to 1967.

tons (NRT) of average size 16,000 tonnes, and fell to 13,472 ships by 1998, totalling 386 million NRT, average size 28,600 tonnes. The total tonnage of ships transiting the Canal is now rising as the average size and numbers of ships using the Canal rises. This is driven primarily by the increasing size of container ships employed in world trade and by the rising capacity of the Canal to handle larger vessels⁶. Until 1993 all container ships used in world trade were 'Panamax' size, able to transit the Panama Canal. Since then 'post-Panamax' container ships have entered service, which are no longer able to use the Panama Canal because of the length, breadth and draught limitations imposed on ships by the dimensions of the canal.

Both the Panamax and post-Panamax ships can transit the Suez Canal; hence containerized cargoes from the Far East carried on post-Panamax ships can reach the east coast ports of the USA and South America via the Suez all-water route. This is often seen as a good alternative to crossing the Pacific by sea and then transferring to smaller ships, train or truck transport for the remainder of their journey to the east coast of the USA or, for example, to Chicago. Thus a small but growing proportion of trade from the Far East to east coast USA now uses the Suez route⁷.

A further factor adding to the importance of the route is oil movement across the Isthmus of Suez via the SUMED (Suez to the Mediterranean) Pipeline. This pipeline allows ships that are too large to transit the Canal to discharge their cargo at Ain Sukhna, south of Suez, at the oil terminal built for this purpose. The SUMED pipeline runs from Ain Sukhna to Sidi Kerir on the Mediterranean coast of Egypt, west of Alexandria. It now has a capacity of 120 million tonnes of oil/year, a 50% increase from the original 80 million tonnes/year

following the installation of a booster pumping station in the pipeline⁸. Loaded tankers can call at the Ain Sukhna Oil Terminal to discharge their cargo to shore and return southwards in ballast to reload, generally in Red Sea or Gulf ports. Tankers can also partially discharge at Ain Sukhna in order to reduce their draughts and then transit the Canal part-loaded.

For ships trading between the Mediterranean and the Indian Ocean, the limiting depth at present is the depth of the Suez Canal, which governs the maximum size of ship that can use this major route. The original depth of the Canal was less than 7 m and, as the size of ships in international trade has increased, the Canal has been deepened and widened to allow a growing proportion of world shipping to transit the Canal.

By 1980 the total length of the Canal had reached its current recorded length of 190.25 km (SCA 2004). Branches have been added at several points along the Canal to 'double' the waterway, allowing northbound and southbound convoys to pass each other at these points. By 1980, the total length of the branch canals had reached their current recorded length of 78 km. The annual capacity of the Canal is stated by the Suez Canal Authority (SCA) to be 76 ships/day. Usage of the Canal was 46 ships/day in 2004, an increase from 37 ships/day in 1998. This implies that the Canal has sufficient reserve capacity for some years ahead. The current depth in the main sections of the Canal allows it to handle ships of 20.12 m draught, equivalent to a ship size of around 225,000 TDW fully loaded.

A ship leaving the Canal enters the relatively shallow and narrow Gulf of Suez, which is navigable throughout its length by all modern ships and, unlike the Straits of Malacca on the continuation of this route to

⁶ For brief historical records, and the latest capacity, depth and other details of the Suez Canal, see Suez Canal Yearly Reports published by the Suez Canal Authority, Information Centre, Postal Code 41515, Ismailia, Egypt.

⁷ Containerization International Yearbooks 1993 to 2004, and monthly magazine, various articles.

⁸ See for example http://www.solarnavigator.net/suez_canal.htm, where the SUMED capacity is quoted at 2.5 million barrels per day, equivalent to around 120 million tonnes per year.



Plate 2.1 Southern entrance to the Suez Canal, November 2005

(Photo: R. A. Facey).

the Far East, does not require any dredging to maintain its depth. From the southern end of the Canal to the exit from the Gulf of Suez at the Strait of Gubal, 310 km to the south, water depths are generally 40 m or better throughout, with some small patches of 20 or 25 m reported in places that need to be avoided by ships with drafts approaching these depths.

Because of the particular constraints within the Gulf of Suez due to the relatively shallow water, routes whose width is constrained by shoals, oil platforms, oil terminals and other obstructions, and where in places ships cross the main north-south route from east to west to reach ports and terminals, special regulations covering the conduct of navigation have been adopted by the IMO. Chart BA5501 titled 'Mariners Routeing Guide', illustrating these regulations, has been produced for the guidance of ships' masters, and the regulations are also explained in the 'Red Sea and Gulf of Aden Pilot' book.

Entering the Red Sea at Shaker Island at the entrance to the Strait of Gubal, water depths immediately increase to several hundreds of metres and, apart from small isolated reefs at El Akhawein and Abu El Kizan off the

coast of Egypt, ships have a clear passage from Shaker Island southwards to Jazirat At Tair in Yemeni waters, around 1,550 km south-south-east.

Between Jazirat At Tair and Bab el Mandeb in the southern Red Sea the waters again become shallow, with a minimum depth of 28 m over some shallow patches along this section of the route⁹.

After leaving the Red Sea at Bab el Mandeb and entering the Gulf of Aden, water depths increase rapidly to over 1,000 m along the central passage, with no obstructions in this section. The route then leaves the Gulf of Aden east of the Socotra Archipelago, where ships pass either north or south of these islands before setting course to pass south of Sri Lanka if headed for Singapore and the Far East. Ships trading between The Gulf, Pakistan and India, the Indian Ocean islands, East and South African ports, Australia and New Zealand, on routes to and from Europe and the Americas, also pass through the Red Sea and Gulf of Aden.

The future importance of this major east-west shipping route will continue to be very high. However, given that the water depth over patches along the route in the Gulf of Suez can be as low as 20–25 m, it is important to note that the depth of the Canal by the end of 2006, around 25 m, will be similar to depths in parts of the Gulf of Suez. Large vessels whose draughts approach this figure need to be navigated through the Gulf of Suez with considerable accuracy. The draughts of ships on passage at full speed is normally greater than the zero speed draught due to ship squat and changes in trim. There is a continuing need for periodical and accurate hydrographic surveys to be carried out in the Gulf of Suez to verify existing water depths, and to verify that depths are not changing. Similarly, in the southern Red Sea, there is

⁹ The hydrographic survey of the main southern Red Sea route from the Hanish Islands to Bab el Mandeb conducted under the auspices of PERSGA in 2001 disproved two 12 m patches that had been reported in the late 1990s to lie at critical points on this route. By disproving these patches, it was possible for the ship routeing measures designed by PERSGA to be implemented for use by international shipping. These were adopted by IMO and came into force in July 2003.

a need for shallow patches marked on the present charts, whose existence is in some cases doubtful, to be proved or disproved, and for the depths over proven patches to be verified.

A further potential medium-term impact on the Canal is the possibility that as ice over the North Pole melts, shipping could access an ice-free route from the Far East to Europe, passing north of Canada, Siberia and Russia. For some trades, for example from China to Northern Europe, this would give shipping a shorter route than the route across the South China Sea, Indian Ocean, Mediterranean and eastern Atlantic. If this becomes possible during the 21st century, as has been predicted in various reports, the volume of traffic for some important ship types currently using the Suez Canal, such as container ships and car carriers, could diminish¹⁰. If this proves to be the case, then it must be anticipated that the steady growth in traffic through the Suez Canal that ships of this type help to generate will level off, and could diminish, with a corresponding potential reduction in the risk of pollution from ship-based sources due to collisions, groundings or ship operations (see chapter 4).

Additionally, over the course of the 21st century, it is predicted in various publications and commentaries that the steady growth in the number of loaded oil tankers using the Suez Canal will reduce as oil reserves in the Middle East diminish¹¹. The impact of rising demand for oil from India and China as their economies continue to grow would tend to take oil from the Gulf states in an easterly direction, avoiding the Red Sea and Gulf of Aden. However, oil from Sudan, for example, can be expected to be in demand by oil consumers in South Asia and the Far East, and there is no apparent diminution of

demand from Europe and the USA. Another factor affecting transport of oil by ship is the growing use of long-distance pipelines for oil transport, but whether these will have any major impact on the use of tankers for the transport of Middle Eastern oil in the coming decades remains to be seen.

2.3.1 Maritime Boundaries and Exclusive Economic Zones for the Countries in the RSGA¹²

Maritime boundaries for countries in the Red Sea and Gulf of Aden are only partially defined at this stage, though progress has been made since the start of the PERSGA Strategic Action Programme (SAP) in 1999. Volume 5 of the UK Admiralty List of Radio Signals deals with boundaries between countries that have been agreed for search and rescue purposes. With reference to the Red Sea and Gulf of Aden, Volume 5 states that:

The basic principle of an equidistant line for provisional SRR (Search and Rescue Regions) for North and Central Areas (of the Red Sea) has been agreed.

Provisional SRR boundaries for the Southern Red Sea between Eritrea, Sudan, Saudi Arabia, Yemen and Djibouti have yet to be established.

In most cases maritime boundary definition is or will be based on an equidistant line between the coastlines of the two countries. Adjustments for offshore islands, extensions of national continental shelves, water depths and other relevant features or elements are normally agreed following negotiations between the states concerned. In the northern part of the Red Sea further work is needed to define the boundaries

¹⁰ See for example: <http://www.arctic.noaa.gov/detect/human-access-arctic.shtml>, confirming changes that have taken place in the 20th century as recorded by the Arctic Climate Impact Assessment (ACIA) team. The report discusses use of the Northwest Passage (NWP) in the Canadian Arctic and the Northern Sea Route (NSR) along the northern Eurasian coast.

¹¹ See, for example, <http://www.globalagendamagazine.com/2005/matthewsimmons.asp>

¹² The place names used in this section are those currently recorded on UK Admiralty Charts.

between Egypt, Israel, Jordan, Saudi Arabia and Sudan¹³.

In the Gulf of Aqaba a maritime boundary between Israel and Jordan entered into force in 1996. The boundary is in two segments, the first a straight line that runs offshore for a short distance between the states, the second a median line. Further work by experts from both sides is required to finalise the geographical co-ordinates of the boundary. To complete it, an agreement with Egypt will have to be reached.

On the eastern side of the Red Sea the maritime boundary between Saudi Arabia and Yemen, agreed in 2000, extends from a point on the coastline at Orete Point in approximate latitude 16° 24' N. It is in three segments. The first segment extends west along a line of latitude, the next segment heads in a south-westerly direction. The third segment is again on a line of latitude, passing through the Pearly Gates channel along a line that lies north of Dawharab Island and its lighthouse, which come under Yemeni jurisdiction, thence heading due west. The line is a pragmatic solution between the two countries that allocates sovereignty over various small islands in the Farasan group to either Saudi Arabia or Yemen. Definition of the seaward end of the boundary will require an agreement with Eritrea to be reached.

The maritime boundary between Eritrea and Yemen has been partially defined following international arbitration in 1998 and 1999. It lies roughly north-north-west and south-south-east, starting in approximate latitude 14° 38' N at a point mid-way between the mainland coasts of the states. The area from this point northwards to the Saudi Arabia-Yemen border in latitude 16° 24' N remains undefined at present, and agreement with Saudi Arabia and Eritrea will be needed to complete this part of the maritime boundary. This area contains the Zubair Islands and Jazirat At-Tair, which are under Yemeni jurisdiction. The boundary passes west of

the Avocet Rock and the Hanish Islands, thence between the Haycock Islands and the Hanish Islands along a line roughly equidistant between the mainland coasts at the ports of Mukha and Aseb. The line terminates in approximate latitude 12° 27' N at a point mid-way between the mainland coastlines of the states, and has yet to be extended to complete the definition of the border between Eritrea and Yemen, Yemen and Djibouti, and Eritrea and Djibouti. Thus the Hanish Islands are under Yemeni jurisdiction and the Haycock and Muhabbakah islands south and west of the Hanish Islands are under the jurisdiction of Eritrea.

In the Gulf of Aden boundaries between Djibouti and Yemen, and between Somalia and Yemen, have not been formally defined. It is considered that the Djibouti/Yemen boundaries can be resolved without difficulty, but the boundaries between Somalia and Yemen may take some time to be resolved pending the establishment of a stable government enjoying international recognition in Somalia. The line between Somalia and the islands of the Socotra Archipelago will require detailed negotiation. At the eastern end of the Gulf of Aden, the maritime boundary between Oman and Yemen has been partially agreed, with the coordinates of the agreed section defined in 2004/2005.

Countries in the region are aware of the need to establish exclusive economic zones (EEZ) and to have these registered by the United Nations by 2009. For most of these countries the maritime boundaries in the Red Sea and Gulf of Aden, when agreed, will define the limits of their EEZs. Somalia and Yemen are the only two countries which can expect to enjoy EEZs extending 200 miles from their coastlines. Yemen has recently established an organization to study the extent of its national EEZ and is examining whether a submission to extend the EEZ beyond the 200 mile boundary should be submitted for consideration by the United Nations. It has

¹³ International Maritime Boundaries, David A. Colson & Robert W. Smith, Volume V (Region VII, Red Sea and Persian Gulf), Brill Academic Publishers. ISBN: 9041103457.

also established a coastguard service, which will be responsible for monitoring fishing and other activities, and for providing maritime security, within its EEZ.

2.4 ATMOSPHERIC PRESSURE, WIND PATTERNS, VISIBILITY AND WAVE HEIGHTS

During the winter months there is high pressure in the north-western part of the region and a ridge of high pressure extends south-east across Arabia¹⁴. A trough of low pressure extends north-north-west along the Red Sea and west-north-west into The Gulf. During the summer, wind patterns are shaped by low pressure over Iran and high pressure to the west over Ethiopia and Eritrea, and over Egypt.

The whole of the Gulf of Aden and parts of the southern part of the Red Sea are affected by the monsoon winds that blow between the Horn of Africa region and the Indian subcontinent. The dominant winds are north-east from late September to early May each year, then after a period of calm as the monsoon changes, blow strongly from the south-west during the summer months, dying away from early September to a second period of calm weather.

2.4.1 The Red Sea

In January, winds in the northern half of the Red Sea generally blow from the north-north-west at between Beaufort Force 2 and Force 6 (Table 2.1), occasionally Force 7¹⁵. This pattern extends from the northern end of the Gulf of Suez southwards to latitude 20°N. Winds in the Gulf of Aqaba during this period tend to be between north-west and north. Occasional southerly winds in this part of the Red Sea blow during the winter months, particularly towards the middle of the Red Sea. Occasionally very active cold fronts affect the north-west part of this area, giving rise to squalls and thunderstorms. Very high winds associated with frontal systems have been known to

affect the coast of Saudi Arabia from time to time, and have, for example, caused damage to container handling cranes and other equipment in the port of Jeddah¹⁶.

This north-north-west wind pattern, generally blowing between Force 2 and Force 6, occasionally Force 7, is consistent in the Gulfs of Suez and Aqaba and in the main Red Sea south to latitude 20°N, from April and throughout the rest of the year.

In the southern part of the Red Sea, south of latitude 20°N, between the coasts of Eritrea and Yemen, winds blow from the north-north-west during the colder winter months. By April a low pressure area has formed between latitudes 15° and 20°N and the wind south of 15°N blows from the south-south-east towards this area at between Force 2 and Force 6, rarely Force 7. By July the influence of the south-west monsoon affects the southern Red Sea and winds come from the north-north-west again, blowing towards the Strait of Bab el Mandeb. By October a low pressure area has formed between latitudes 14° and 21°N and the wind becomes south-south-east again, Force 2 to 6 and occasionally Force 7.

2.4.2 The Gulf of Aden

In the western part of the Gulf of Aden, during the colder winter months, winds blow from between north-east and east, between Force 2 and 6, and rarely Force 7, under the influence of the north-east monsoon. Close to Bab el Mandeb the winds in this part of the Gulf of Aden veer to south of east at this time of the year to blow into the Strait. Further east the winds tend to be from the north-east at about the same strength. By April the influence of the north-east monsoon has diminished in the eastern part of the Gulf of Aden and winds are light and variable, with a higher percentage of calms. Wind strength also decreases in the western part of the Gulf of Aden at this time.

¹⁴ The 14th edition of the Red Sea and Gulf of Aden Pilot, NP64, published in 2004, contains charts showing mean barometric pressure and wind distribution, swell distribution, and mean sea surface temperatures.

¹⁵ Red Sea and Gulf of Aden Pilot, NP64, chapter I, Natural Conditions.

¹⁶ Lloyds List reports for May 1995. See also http://www.iop.org/EJ/article/1742-2140/2/3/009/jge5_3_009.pdf on storms affecting western Saudi Arabia.

Table 2.1 Conversion of Beaufort Wind Force to knots and metres per second for an effective height of 10 m above sea level (based on the Mariner's Handbook, Table 5.2)¹⁷.

Beaufort Number	Descriptive Term		Probable mean wave height in metres
	Mean wind speed equivalent		
	Knots	m/sec	
0	<1	0-0.2	-
1	1-3	0.3-1.1	0.1 (0.1)
2	4-6	1.6-3.3	0.2 (0.3)
3	7-10	3.4-5.4	0.6 (1)
4	11-16	5.5-7.9	1 (1.5)
5	17-21	8.0-10.7	2 (2.5)
6	22-27	10.8-13.8	3 (4)
7	28-31	13.9-17.1	4 (5.5)
8	34-40	17.2-20.7	5.5 (7.8)
9	41-47	20.8-24.4	7 (10)
10	48-55	24.5-28.4	9 (12.5)
11	56-63	28.5-32.6	11.5 (16)
12	64 and over	32.7 and over	14 (-)

By mid-June the south-west monsoon is well established, and winds in the eastern part of the Gulf of Aden blow from the south-west at between Force 2 and Force 6, occasionally 7. Winds off the Horn of Africa and around the Socotra Archipelago are generally much stronger, reaching Force 8 to 11 during June, July, August, and sometimes reaching this strength into early September¹⁸.

Another influence on local winds in the coastal zone is a diurnal change of wind direction from offshore during the day to onshore at night driven by differential heating and cooling of the land and sea, giving rise to 'sea breezes' and 'land breezes' that can overcome the direction of the prevailing monsoon winds in some areas.

Tropical cyclones can affect the Gulf of Aden on rare occasions, but none of these

cyclones have ever been recorded in the Red Sea. In general, the cyclones forming in the Arabian Sea do not move east of 60°E, i.e. they do not affect the Socotra Archipelago or the area north of this. The majority of the cyclones in the Arabian Sea occur outside the monsoon period, forming in May and June, October and November. The 1980 edition of the UK Admiralty 'Red Sea and Gulf of Aden Pilot', NP64, updated to 1987, recorded that five tropical storms with winds of Force 8 or more had reached the coast in the Gulf of Aden over a 50 year period. This number included those that reached the Omani coast outside the Gulf of Aden as defined in the Jeddah Convention, which was in fact the majority of the storms.

More recently, in May 2002, a tropical storm struck the port of Salalah in longitude 54°E on the coast of Oman. It brought strong winds, heavy rainfall, serious local flooding with damage to property and equipment,

¹⁷ See NP 100, The Mariner's Handbook, UKHO Publications.

¹⁸ On the north coast of Socotra Island winds are affected by the 1,500 m high mountains. In June 2003, winds reaching and far exceeding the lower limit for hurricane force were recorded on the coast east of the main town of Hodiboh. The wind blew from various directions at speeds sometimes in excess of 170 km/hour, exceeding hurricane force fifty times within an 18 hour period and dropping to relative calm in between. In early September 2003, a fishing trawler operating in Qormih Bay, on the north coast of the island, experienced winds of Force 11 from the south-south-west and had to run before the wind for several hours towards the Omani coast.

and had a short-term impact on the town and port operations. It passed close to Socotra and also brought bad weather to the island during what is normally a calm inter-monsoon month.

Visibility in the region can be good to very good, particularly during the winter months. In winter, hills may be seen at distances of up to 100 km in the southern part of Yemen and the mountains of Eritrea can be seen from mountains close to the Yemeni coast on the other side of the Red Sea. Fog is rare throughout the year. Visibility in much of the Gulf of Aden is reduced during the south-west monsoon period and generally falls to perhaps 5–10 km, particularly where there is upwelling of cold water off the southern coast of Yemen. Blowing sand and dust can reduce visibility to less than 1,000 m in the western part of the Gulf of Aden during the south-west monsoon. Visibility in the southern Red Sea is often reduced during the summer months, and bad visibility can occur as far north as Port Sudan. Occasional sand storms created by frontal systems, of short duration, can affect the western part of the Gulf of Aden and reduce visibility to a matter of 1–200 m. Cold fronts may also generate sand and dust storms in the north-west part of the region, severely reducing visibility.

As would be anticipated, wave heights and directions in the region are determined by the prevailing winds. The heights of sea waves depend on the distance from the land upwind, or the fetch, generally increasing in height the further the wind blows from the land.

During the winter months, wind generated waves and swell in the northern Red Sea, as far south as 20°N, are normally less than 2 m in height from the north-north-west, but occasionally reach heights of over 2 m. South of 20°N waves are from the south-south-east in winter and can be higher, with a percentage of waves of between 2.1 and 4 m in height, and can rarely exceed 4 m. In the Gulf of Aden, waves during the winter months are also generally below 2 m in height, from the west or north-west, but on rare occasions can exceed 2 m.

During the south-west monsoon period in the summer months, the situation in the northern Red sea remains much the same, with wind and swell waves from the north-north-west, generally less than 2 m in height. Due to the summer-time reversal of wind direction in the southern Red Sea, waves south of 20°N are also from the north-north-west and generally less than 2 m in height.

In the Gulf of Aden, wave heights change significantly from west to east. Close to Berbera, Djibouti and Aden, sea and swell wave heights are generally less than 2 m and are from the south-west, but exceed 2 m about 30% of the time. Wave heights increase towards the eastern part of the Gulf of Aden as the fetch increases, reaching around 4–5 m at Mukalla and the Ash Shihr oil terminal on occasions. At the Horn of Africa, north, south and east of Socotra, wave heights from the south-west can exceed 8 m in open water. They are frequently between 2.1 and 4 m, and from 4.1 to 6 m in height about 20% of the time. Ships off Salalah, and passing the Socotra Archipelago, can experience very heavy weather during this period. Small vessels, dhows and yachts are generally advised not to attempt passages through the eastern part of the Gulf of Aden after the south-west monsoon has become fully established, until it dies away in September.

2.4.3 Surface Currents

Water currents in the Red Sea are generally wind-driven and reflect the influence of the Indian Ocean monsoons as well as the daily and seasonal differential heating of the land and sea. Surface water currents tend to be anti-clockwise with low salinity water travelling north up the east coast of the Red Sea, becoming more saline as it crosses to the west, and then travelling south down the west coast of the Red Sea. This general pattern does not necessarily hold locally, due to deflection and eddying caused by the shape of the coastline and the presence of offshore reef complexes. The currents tend to be slow moving and ill-defined (UNEP 1985)¹⁹.

¹⁹ See also British Admiralty 'Red Sea and Gulf of Aden Pilot', NP64, 2004.

During the winter months from November to April the surface current generally sets from Bab el Mandeb to the southern end of the Gulf of Suez at rates of 0.5 knots in the southern part of the Red Sea, decreasing to around 0.25 knots from 16°N. A current sets southwards through the Gulf of Suez, and continues to set south close to the coast of Egypt to as far as about 25°N. Along the east and west coasts of the Red Sea in shallower waters currents are variable, tending to set from north to south in eddies. Mariners are warned that these currents can set towards the coasts, but they are generally weak.

During the summer, from June to September, the situation reverses, with currents setting south-south-east throughout the main body of the Red Sea at an average rate of around 0.25 knots in the northern section, and 0.5 knots south of 15°N. Eddies and minor currents on the west coast are generally from south to north, and on the east coast from north to south. In the transitional months of May and October there is no predominant set in the Red Sea except south of 14°N, where the set is predominantly north-west through the Strait of Bab el Mandeb.

Due to evaporation in the Red Sea and an absence of inflow from any rivers, more surface water flows into the Red Sea from the Gulf of Aden than flows out. Currents through the Strait generally set north-west at an average rate of around 0.75 knots between October and May, but can reach 3.0 knots at times. Below the surface flow there is a persistent outflow of highly saline water from the Red Sea into the Gulf of Aden. Between June and August the set is generally south-east at an average rate of 0.5 knots. In September currents are weak and variable.

Currents are stronger in the Gulf of Aden than in the Red Sea and are associated with the direction and force of the north-east and south-west monsoons. During the winter, driven by the north-east monsoon, they set west-south-west along the coast of Yemen at an average rate of around 0.25 knots. Off the coast of Somalia and into the middle of the Gulf of Aden, the current sets from the Horn of Africa to the west at average rates of 0.5 knots. However, stronger rates have

been reported in some parts of the Gulf of Aden. For example, at the oil terminal 60 km east of Mukalla, maintenance diving on the oil loading buoys has been delayed from time to time due to strong currents of perhaps 1.5 knots setting to the west.

During the south-west monsoon in the summer months, the current along the Yemeni coast consistently sets east-north-east at an average rate of 1.0 knot, although rates of up to 3.0 knots have been recorded at this time. In the middle of the Gulf of Aden the currents are more variable, with counter currents tending to set from east to west. Easterly sets of up to 2 knots off the coast of Somalia have been reported. Off the Horn of Africa and passing the Socotra Archipelago the currents are again rather consistent, setting strongly north-east to east-north-east at average rates of between 1.5 to 2.0 knots, and sometimes exceeding 3 knots.

2.4.4 Tides

The tide of the Indian Ocean and Gulf of Aden does not enter the Red Sea, where a different tidal regime is found. In the Gulf of Aden tides are generally diurnal, or a mix of diurnal and semi-diurnal tide. The maximum spring range at Aden is 2.7 m and at Djibouti 3.0 m. At the eastern end of the Gulf of Aden the tide becomes more semi-diurnal, with an extreme range of around 2.7 m. Tidal streams in the Gulf of Aden are generally weak and masked by the current. The tidal regime in the Red Sea is a local oscillatory type with a semi-diurnal characteristic. The oscillation is not large, and when it is high water in the northern part of the Red Sea it is low water in the southern part, and vice versa. At Shaker Island at the southern entrance to the Gulf of Suez, the spring range is around 0.6 m. At Massawa and Kamaran Island in the southern part of the Red Sea, spring range is around 0.9 m. In the central part of the Red Sea at places such as Suakin (Sawakin), Port Sudan and Jeddah, there is no appreciable semi-diurnal tide. There is also a small diurnal tide which oscillates in a different manner to the semi-diurnal tide, resulting in a very small diurnal variation in water levels in the central Red Sea.

The Red Sea tidal oscillation enters the Gulf of Suez, giving a spring range in the Gulf of about 1.5 m. High tide occurs almost simultaneously over the whole of the Gulf of Suez. A rising tide at Suez results in a north-going tidal stream in the Gulf, and a falling tide in a south-going tidal stream, at a maximum rate of 1.5 knots during spring tides and 0.5 knots during neap tides. In the Strait of Gubal tidal streams can reach 1.5 to 2.0 knots and tend to set north for longer than they set south.

The Red Sea tidal oscillation also enters the Gulf of Aqaba, giving a spring range in the Gulf of between 0.6 and 1.2 m. High tide occurs almost simultaneously over the whole of the Gulf of Aqaba. In the Strait of Tiran tidal streams are uncertain, but can reach considerable rates. A rate of 3.25 knots setting north was reported some years ago during a Force 4 to 6 southerly wind, and a rate of 1.0 knot setting south during a north-north-east wind of Force 5.

2.4.5 Red Sea and Mediterranean Water Exchange via the Suez Canal

Unlike the Panama Canal, where locks are used to lift ships above sea level as they pass from the Atlantic to the Pacific, the Suez Canal has no locks. At the northern end of the Gulf of Suez there is an exchange of water between the Red Sea and the Mediterranean via the Canal. Currents and tidal streams interact in the Canal between the Mediterranean Sea, the lakes in the Canal, and the Gulf of Suez.

Lying about two-thirds of the distance from Port Said on the Mediterranean coast to Suez are the Great Bitter Lake and the Little Bitter Lake. The level of water in the Great Bitter Lake is slightly higher than the sea level in the Mediterranean between November and April, resulting in a generally north-flowing current between this Lake and Port Said. But current direction and rate depend upon variations in the level of the Mediterranean, and the current can flow south at times during this period. From June

to October the current reverses and becomes generally south-going. The average rate of the current is rarely more than 1.0 knot, but rates of between 0.5 and 2.0 knots can be experienced, lessening towards the Great Bitter Lake.

Between the Little Bitter Lake and Port Tewfiq at Suez there are tidal streams, flowing north and south, driven by the rise and fall of tide at Suez. One to two hours before high water Suez the south-going stream slackens and the north-going stream commences. Five hours after high water Suez, the north-going stream slackens and the south-going stream commences. The stream at the southern entrance to the Little Bitter Lake starts to flow north 50 minutes after the north-going stream at Suez commences, because the level of the water in the Lake remains constant and the level in the Canal has to rise to become higher than the level of the Lake before the north-going stream can start. Tidal streams near the bed of the Canal turn five to ten minutes later than those at the surface.

The highest flow rate in the Canal is normally around 1.75 knots some 13 km north of Suez, but rates can reach 2.5 knots following strong southerly winds in the Gulf of Suez if these winds cause a rise in sea level at the same time as a spring tide occurs.

Migration of species from the Red Sea to the Mediterranean is known as “Lessepien Migration”²⁰. The Suez Canal has been colonised by species from both water bodies since the Canal opened in 1869, and it is reported that some hundreds of species have migrated from the Red Sea to the Mediterranean during this time through a Canal described as ‘an open gate with slightly unbalanced water levels at either end’. However, the Mediterranean is a warm sea populated by cold species, whereas the Red Sea is a tropical water body in which temperatures do not fall below 18°C in winter. To enable Red Sea species to establish themselves north of their usual habitat, tropical species require

²⁰ Named after the French engineer responsible for building the Canal, Ferdinand de Lesseps. See www.sbg.ac.at/ipk/avstudio/pirofun/1m/lesseps.htm

summer temperatures high enough for the reproductive process and development of eggs, and minimum winter temperatures above their lethal limits. The change of global climate and temperature patterns could provide another boost to the ongoing process of northward migration by tropical species. Migration of species southwards from the Mediterranean to the Red Sea does not appear to have occurred to any degree.

A further factor hindering the movement of species from the Red Sea to the Mediterranean has been the high salinity in the Bitter Lakes. De Lessops estimated that the original thickness of the salt in the Great Bitter and Little Bitter lakes, essentially dry salt valleys 13 km long and 5 km wide, was 13.2 m. The salty bottoms of these lakes gradually dissolved over a period of some 60 years, making the area in and around the lakes hypersaline (up to 68‰). It is now considered that the salt bed of the lakes has been completely dissolved. With the deepening of the lakes as the Canal has been deepened over the years, and reduced salt concentrations to equalise density differences, an exchange of water along the Canal, together with migrant species, is further facilitated.

2.4.6 Red Sea and Gulf of Aden Water Exchange via Bab el Mandeb

The Red Sea and Gulf of Aden are linked through the Bab el Mandeb. Bab el Mandeb is a relatively narrow and shallow sill with a width between the 100 m isobath lines on either side of the channel of around 12 km, and a depth between these lines that varies from 140 m on the Yemeni side to 290 m on the Djiboutian side. The water depth south and west of Hanish AlKubra is around 140 m. This depth restriction physically limits the influence of the Indian Ocean on the Red Sea. As stated above, tidal range in the Red Sea is low, with the average spring range about 0.5 m in the southern and northern parts, but decreasing from both ends of the Red Sea towards the centre where, near Port Sudan and Jeddah, there is no appreciable semi-diurnal tide. Another nodal zone with negligible tide occurs just to the north of Bab el Mandeb. Tidal range in the Gulf of

Aden is significantly greater than in the Red Sea, reflecting the unrestricted influence on its tides of the Indian Ocean. Tidal range is reflected in the figures for Mean Sea Level given in the Admiralty Tide Tables for the Indian Ocean and South China Sea, Volume III, NP203. Mean Sea Levels, measured above Chart Datum, as recorded for ports in the western part of the Gulf of Aden and southern Red Sea and given in Part III of this volume, are:

- In the Gulf of Aden: Aden 1.39 and Djibouti 1.87.
- In the southern Red Sea: Aseb 0.5 and Mukha 0.52.

Evaporation in the Red Sea is high, estimated at around 2 m y^{-1} , while annual precipitation does not exceed 10 mm. Thus a net inflow of water from the Gulf of Aden to the Red Sea is required to maintain water levels in the Red Sea. It is estimated (EDWARDS 1987) that the water renewal time in the upper 200 m of water, i.e. water above the thermocline, is of the order of 6 years, while the time for turnover of water for the whole Red Sea is about 200 years. This allows a net inflow from the Gulf of Aden to the Red Sea to be estimated, with estimates varying between 0.03 and 0.16 million $\text{m}^3 \text{ y}^{-1}$.

The flow through Bab el Mandeb is complex and is controlled in the surface layer by the monsoon winds. It is thought to consist of a wind-driven surface flow of water from south to north during the winter months when warmer, fresher water flows into the Red Sea from the Gulf of Aden. At the same time cooler saltier water flows into the Gulf of Aden at the lowest level (Figure 2.1, top diagram). Gulf of Aden intermediate water lies to the south of Bab el Mandeb during this time and does not flow into the Red Sea.

During the summer months the regime in Bab el Mandeb is very different. The high salinity outflow from the Red Sea is almost arrested, the flow in the surface layer is reversed, and intermediate water from the Gulf of Aden flows in to the Red Sea between the two out-flowing layers (Figure 2.1, lower diagram).

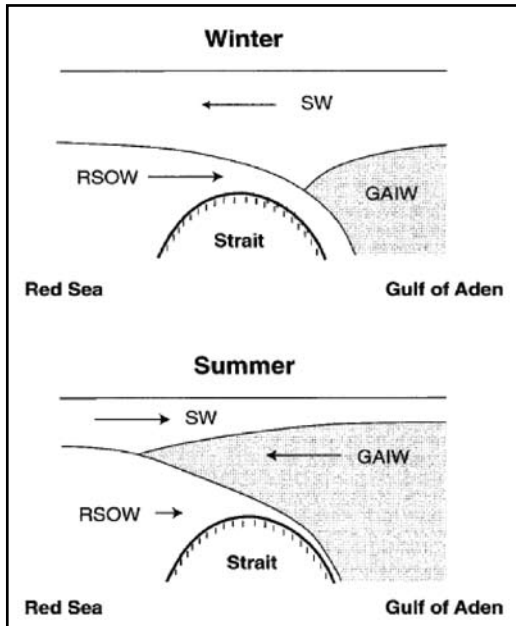


Figure 2.1 Sketch of the two circulation patterns in the Bab el Mandeb: winter and summer. Here, SW surface water, GAIW Gulf of Aden intermediate water, and RSOW Red Sea outflow water (source: SMEED 2000).

SMEED (2000) developed a three-layer model of hydraulically controlled exchange flows that demonstrated how the seasonal variability could be explained by the monsoon driven upwelling of cold water in the Gulf of Aden. The model was refined by SIDDALL et al. (2002; 2003) who showed that the model agreed quantitatively with observations of the exchange fluxes made by MURRAY & JOHNS (1997).

2.4.7 Sea Temperature Variation in the Red Sea and Gulf of Aden

In winter time (February) sea surface temperatures reach their lowest point in the region. In the northern part of the Gulf of Suez these are as low as 18°C, rising gradually towards the south. At the southern entrance of the Gulf of Suez they reach 21°C and continue to increase to a maximum of 26.5°C in about latitude 17° 30' N. The temperature is then almost constant through the Strait of Bab el Mandeb and the Gulf of Aden, falling only slightly to 25°C well east of the Socotra Archipelago.

In summer time (August) sea surface temperatures are at their maximum. The mean temperature in the Gulf of Suez is 27°C, rising to 31.5°C in the southern half of the Red Sea between Yemen and Eritrea, and falling to below 30°C in the western end of the Gulf of Aden. Temperatures then continue to fall towards the east, dropping to below 25°C east of the Horn of Africa. Upwelling in the Gulf of Aden, driven by the south-west monsoon, brings cooler water to the surface, driving down the sea surface temperatures.

2.5 CHEMICAL OCEANOGRAPHY

2.5.1 Salinity

The Red Sea is warm and saline. Evaporation in the Red Sea averages 1–2 m yr⁻¹ in both summer and winter. Very high evaporation rates occur in the Gulf of Aqaba (2 m yr⁻¹) and in the southern Red Sea (2.35 m yr⁻¹). The result of this extreme loss of water is a gradual increase in salinity towards the north. Salinity at Bab el Mandeb averages 37‰ and in the northern Red Sea at the entrance to the Gulfs of Aqaba and Suez salinity averages 41‰. Salinity throughout the Red Sea is higher in summer than winter. In the northern Red Sea the seasonal variation is 1‰ and in the southern Red Sea the seasonal variation is 0.5‰. Combined with very low freshwater input, the Red Sea could be considered as the most saline water body in direct contact with world oceans (SHEPPARD et al. 1992). The ambient salinity levels may be very close to the physiological limits of many species, which highlights the potential sensitivity of the Red Sea biota to localised anthropogenic increases.

There is an increase in salinity with depth in the Red Sea. The depth gradient is greater in the southern Red Sea due to the influence (to a depth of 200 m) of low salinity water from the Gulf of Aden. At depths greater than 200 m in the deep basins of the Red Sea the salinity is remarkably homogeneous at 40.6‰ (with the exception of the hot brines) (MORCOS 1970).

The Red Sea was the first region where hot brines were discovered on the sea floor (DEGENS & ROSS 1969). Hot brines emerge from the sea floor in areas with an active seafloor rift and are characterised by very high salinity and high temperatures. The hot brines region of the Red Sea occurs at depths of more than 2,000 m where water temperatures can reach up to 60°C and salinity exceeds 300‰. Between 1965 and 1979 the water temperature in the lower brine increased from 55.9 to 61.7°C and in the upper brine increased from 41.2 to 49.9°C (MISTAFA AND ALI 2005). The water and muds in the vicinity of the Red Sea hot brines are rich in cadmium, copper, iron, manganese, and zinc. There are also elevated concentrations of carbon dioxide and hydrogen sulphide. Twenty hot brines are known to occur in the Red Sea, 10 of which face the Egyptian coastline (PERSGA 2001).

2.5.2 Hydrodynamic Regimes

The semi-enclosed nature of the Red Sea limits the opportunity for renewal of the water mass. The renewal times are around 200 years for the entire water body of the Red Sea (SHEPPARD et al. 1992), six years for the top 200 m (SHEPPARD et al. 1992), 30–45 years for deep waters of the Red Sea (PLÄHN et al. 2002), and one to two years for the Gulf of Aqaba (HULINGS 1989). The Red Sea is permanently stratified by a strong thermocline so that the high nutrient concentrations in the deep waters are effectively isolated from the nutrient depleted shallow waters (LONGHURST 1998). High evaporation drives a thermohaline circulation that advects nutrient-poor water from the northern Red Sea through the Straits of Tiran into the Gulf of Aqaba that is balanced by outflow of deeper dense water. The water body of the Gulf of Aqaba is more dynamic than the adjacent northern Red Sea. The Gulf of Aqaba is de-stratified during winter (December-April) to depths of at least 600 m following declining sea surface temperatures and wind mixing, resulting in elevated nutrient levels in the shallow waters (MANASARAH et al. 2004).

2.5.3 Primary Productivity

The high transparency of the waters means that the euphotic zone is deep, extending to 77–105 m in the Gulf of Aqaba and to 74–94 m in the northern Red Sea (STAMBLER 2005). However, primary productivity throughout most of the Red Sea is low, relative to other oceans, due to the thermocline preventing the recycling of nutrients from deeper water to the euphotic zone. Terrestrial runoff is also very low and unpredictable and therefore nutrient supplies from rivers are very limited to non-existent. The input of terrigenous nutrients is limited to sporadic dust events (SHEPPARD et al. 1992).

Pelagic primary productivity varies seasonally and spatially throughout the RSGA (Table 2.2). Pelagic primary productivity is high along the Gulf of Aden coastline of Somalia to the Socotra Archipelago during summer months of May to September. During this time surface water chlorophyll can attain peaks of 3.5 to 5.5 mg chlorophyll *a* m⁻³. The high pelagic primary productivity follows the enrichment of the shallow waters with cool, nutrient-rich water upwelling from the depths of the Gulf of Aden during the south-west monsoon. Movement of Gulf of Aden surface water

Table 2.2 Annual average primary productivity (g carbon m⁻² d⁻¹) in the Red Sea and Gulf of Aden (source: SHEPPARD et al. 1992).

Location	Primary productivity
Gulf of Aqaba	0.2 – 0.9
Gulf of Suez	0.22
Northern Red Sea	0.21 – 0.50
Central Red Sea	0.39
Southern Red Sea	1.60
Gulf of Aden	1.60

into the southern Red Sea extends high pelagic primary productivity to 19°N. By this point the water body is nutrient-depleted because the dissolved nutrients in the northward flowing water body have been reduced by phytoplankton uptake. This transition between the northern and southern Red Sea according to productivity and nutrient status is also matched by transitions in many floral and faunal groups (see chapter 3).

Seasonal peaks of chlorophyll in the northern Red Sea occur in spring (February–May) when surface water concentrations reach 0.4 mg chlorophyll *a* m⁻³. Significant primary production occurs at 200 m in the Gulf of Aqaba due to high water transparency (SHEPPARD et al. 1992). The strong seasonal fluctuations in the waters of the Gulf of Aqaba associated with de-stratification cause a seasonal succession in the phytoplankton community that is more like temperate waters than tropical waters (LINDELL & POST 1995; POST et al. 2002).

In the Red Sea blooms of the blue-green algae (cyanobacterium) *Oscillatoria erythraeum* are common. These blooms are important to primary productivity due to their ability to fix nitrogen in the Red Sea's nutrient poor waters (SHEPPARD et al. 1992). Cell densities of *O. erythraeum* in blooms are 9×10^5 cells L⁻¹. Their fixation of nitrogen into ammonia and amino acids leads to a succession of other phytoplankton groups, commonly dinoflagellates in summer and diatoms in winter.

2.5.4 Nutrient Status

Nutrients (nitrogen, phosphorous, silica) are utilised by phytoplankton for growth and reproduction. The Red Sea is regarded as oligotrophic except for small areas off the Sinai Peninsula, the transition zone between the Red Sea and Indian Ocean, and local areas of anthropogenic enrichment. There are no known upwellings in the Red Sea due to stratification and limited mixing (WEIKERT 1987). In late winter-early summer the surface waters near Jeddah experience nutrient enrichment resulting

from the regeneration of nutrients from winter plankton blooms (SHAIKH et al. 1986). The Gulfs of Aqaba and Suez are nutrient-poor compared with the Indian Ocean (SHEPPARD et al. 1992). Nutrient concentrations in the southern Red Sea are higher than the central and northern Red Sea. This is attributed to the inflow of nutrient-rich waters from the Gulf of Aden in late summer that leads to a 25% increase in nutrient concentrations relative to the central Red Sea (THIEL 1990).

Maximum concentrations of phosphate in the southern Red Sea in October follow upwellings in the Arabian Sea in August and September. Phosphate (PO₄) levels are below 1.5 mg m⁻³ in the northern Red Sea with a sudden drop in surface water nutrients north of 19°N (SHEPPARD et al. 1992). Surface water phosphate levels vary seasonally in the Gulf of Aqaba, ranging between 0–0.25 μM in summer (May–November) and 0.75–1.0 μM in winter (December–April) (BADRAN 2001).

Surface water nitrate attains values of 19 μM in upwellings off the coasts of Somalia and southern Yemen (MISTAFA AND ALI 2005). In the Red Sea the maximum values (20.0 μg kg⁻¹) occur in the southern Red Sea in the vicinity of Bab el Mandeb at depths of 80–500 m. Nitrate concentrations decrease northwards so that levels are very low in the waters of the northern Red Sea and Gulf of Suez. Surface water nitrate levels vary seasonally in the Gulf of Aqaba, ranging between 0–0.05 μM in summer (May–November) and 0.05–0.1 μM in winter (December–April) (BADRAN 2001).

Average silicate concentrations throughout the Red Sea are low, averaging between 0.1 and 0.8 μg kg⁻¹. Maximum silicate concentrations (25 μg kg⁻¹) occur in the southern Red Sea at depths between 80 and 200 m. Seasonal variations in silicate concentrations follow the variations in phosphate concentrations (RUSHDI 1996). Surface water silicate levels in the Gulf of Aqaba range from 0–1.1 μM in summer (May–November) to 1.1–1.4 μM in winter (December–April) (BADRAN 2001).

2.5.5 Dissolved Oxygen

Concentrations of dissolved oxygen in the Red Sea are determined by horizontal and vertical water circulation, water temperature, and salinity. Dissolved oxygen is lowest in warm waters of high salinity. Dissolved oxygen levels are near saturation (i.e. 4.8–6.5 mL O₂ L⁻¹) in surface waters in most of the Red Sea and Gulf of Aden (SHEPPARD et al. 1992; QUADFASEL AND BAUDNER 1993). Dissolved oxygen is typically high in the northern and southern Red Sea, and lower in the central Red Sea. This spatial variation is associated with lower water temperatures in the north and high primary productivity in the south. Dissolved oxygen concentrations in surface waters are lower in summer than winter due to higher temperatures and salinity (POISSON et al. 1984).

The saturated layer in the Red Sea extends to a depth of about 100 m, after which values drop to 10–25% saturation in the oxygen minimum layer and then rise to double this in the deep water layer. The Gulf of Suez has near-saturated waters at all depths, whilst in the Gulf of Aqaba there is a gradual decline with depth but never below 50% saturation. In other parts of the Red Sea dissolved oxygen reaches minimum concentration at 400–600 m depth. In this layer dissolved oxygen concentrations vary between 0.5 and 1.75 mL L⁻¹. Dissolved oxygen in deep waters is higher than the intermediate depths.

The current status and issues associated with the physical and chemical oceanography are covered in chapter 3 (Biological Environment), chapter 4 (Sea-Based Activities and Sources of Pollution) and chapter 5 (Marine Pollution from Land-Based Sources and Activities).

2.6 TERRESTRIAL TOPOGRAPHY ACROSS THE REGION, DEFINITION OF COASTLINES

The description of the terrestrial topography across the region arbitrarily uses the 500 m contour line and the distance of this line from the coastlines of the Red Sea and Gulf of Aden as an indicator of the terrain

and width of the coastal plain. It contains additional notes on the heights of the main hills or mountains further back from the coast, the nature of the coast itself and comments on wadis extending to the coast. It considers the coastlines from north to south, dealing with the Gulfs of Suez and Aqaba, then down the west coast of the Red Sea, down the east coast of the Red Sea, the north coast of the Gulf of Aden from west to east and similarly the south coast of the Gulf of Aden from west to east, ending at the Socotra Archipelago.

The topography generally consists of a more or less broad coastal plain, usually arid with little or no vegetation, with many wadis carrying occasional rainfall, but no permanent rivers flowing into the Red Sea or Gulf of Aden.

2.6.1 Gulfs of Suez and Aqaba and the Red Sea

The Gulf of Suez is bounded on both sides by arid hills and mountains rising to over 1,700 m. The 500 m contour line is an average distance of 30 km from the coastline on the western side of the Gulf, and within 25 km along the eastern coast. At some points where isolated hills rise more steeply the 500 m contour is within 4–5 km of the coast. Mount Sinai (2,285 m) and Gebel Katherina (2,642 m) lie roughly in the middle of the Sinai peninsula, 55 km from the Gulf of Suez and the same distance from the Gulf of Aqaba. The hills on either side of the Gulf of Aqaba also rise steeply from the coastline. The 500 m contour on the west side of the Gulf is generally within 5 km of the coast, and the east side within 7 km. On the coast in the two gulfs are some areas of relatively narrow beach, but in many parts the coastlines are rocky.

Following the coast of Egypt from the Strait of Gubal to the border with Sudan the 500 m contour is set back around 40 km from the coast, giving a wider coastal plain. From Egypt to the Sudanese border the coastline has large areas of sandy beaches, with far fewer areas of rocky coastline. Wadis at various points along this coast carry runoff to the sea when occasional local rains fall, but there are no rivers continually taking

materials into the Red Sea. Most wadis are small. Further inland at a distance of 60 km from the coast occasional hills rise to 1,500 m or more.

Along the Sudanese coast the 500 m contour gradually moves closer to the sea, being around 20 km from the coast at Port Sudan, and the hills 60 km from the coast now reach 2,000 m in height, with wadis at various points carrying runoff to the sea. The coastal plain widens out towards the border with Eritrea, then closes towards the coast again, with the 500 m contour around 40 km from the coast, and at Massawa 30 km from the coast. At 60 km inland from Massawa are mountains over 3,000 m in height, in the central part of Eritrea. South from Massawa to the border with Djibouti the 500 m contour is again around 40 km from the coast, with occasional sections of much wider coastal plain and many small wadis extending to the coast. At Bab el Mandeb the coastal plain widens, with the 500 m contour 60 km from the coastline.

From the Strait of Tiran down the eastern coast of the Red Sea, the 500 m contour is set back around 35 km from the coast, with occasional hills of around 2,000 m within this coastal strip. However, the distance to the 500 m contour extends inland for 90 km in some parts in latitude 27°N, then averages 60 km from the coast down to the latitude of Jeddah. From Jeddah to the border with Yemen the 500 m contour is around 55 km from the coast, with the 2,000 m contour on average 70 km from the coast, and mountains up to 3,000 m in height. From the border with Yemen to the Strait of Bab el Mandeb the 500 m contour is again 60 km from the coast, reducing to 45 km close to Bab el Mandeb. The 2,000 m contour is on average 75 km from this part of the coast, with land over 2,500 m a short distance behind this line. In general most of the eastern coast of the Red Sea consists of beaches, with very few rocky outcrops close to the coastline. Many small wadis extend to the coast.

2.6.2 Gulf of Aden

Along the north coast of the Gulf of Aden from Bab el Mandeb to the border with Oman

at the eastern end of the Gulf, the coastline largely consists of sandy beaches, with some exceptions where rocky headlands are interspersed with sandy beaches, such as those around the Aden promontory, 550 m high. The coast is again rocky from Belhaf in longitude 48° 10' E, 100 km eastwards to Mukalla in 49° 10' E, with outcrops sometimes over 500 m in height and beaches and sand dunes in between. The coast from Ras Fartak in longitude 52° 10' E, to Nishtun 20 km to the north again consists of rocky outcrops interspersed with beaches.

Away from the rocky headlands, the 500 m contour line between Bab el Mandeb and Aden is set back around 50–60 km from the coast, with mountains rising steeply behind this to heights of up to 2,800 m. A large number of wadis run down from the hills at the western end of this section, carried by culverts or depressed sections of road built of concrete over which the water can flow to the coast. From Aden to Belhaf the 500 m contour is as close as 10 km from the coast, and as far as 60 km. This section of the coastline consists of long beaches, with sand dunes in some areas, cut by some large wadis in places. At Mukalla the 500 m contour is 5 km from the coast.

From Mukalla to Ras Fartak the coastline is again sandy, with the 500 m contour between 7 and 15 km from the coast. Wadi al Masilah, in longitude 51° 05' E marks a major indentation in the hills north of the coast and several other wadis in this section also carry occasional run-off to the sea.

Ras Fartak is a striking headland 680 m high and falling very steeply to the sea. At this point the coast turns north into the bay of Ghubbat al Qamar, then east-north-east to the border with Oman. The coastline from Fartak to the small fishing port of Nishtun, 20 km north of Fartak, consists of steep cliffs. North of Nishtun the terrain levels out again, returning to sandy beaches with wadis reaching the coast as far as the Yemeni-Omani border. Al Ghaydah lies in the centre of a broad coastal plain between Nishtun and the Omani border, about 120 km across, where the 500 m contour is up to 70 km from the coast. The plain carries several large wadis. At its eastern

end on the Yemen/Oman border the 500 m contour comes within 4 km of the coast.

The west and south coasts of the Gulf of Aden start from Bab el Mandeb and track southwards to Djibouti, then east to the Horn of Africa at Ras Casey. From Bab el Mandeb to the Gulf of Tadjoura the 500 m contour is around 35 km from the coast, then it closes to within 6 km of the coast at Tadjoura itself, with the Massif de Gouda rising to 1,750 m some 20 km west of the coast at this point. On the north and south sides of Ghoubbet Kharab the land rises steeply from the coast, with the 500 m contour within 3 km of the sea along the Gulf of Tadjoura to a point west of Djibouti, where the coastal plain broadens

along this section within 6 km of the coast. South of the small port of Caluula, in longitude $50^{\circ} 45' E$, the coastal plain widens with the 500 m contour 35 km from the sea, but then it comes to within 8 km of the coast immediately west of Ras Casey. The coastline along this section is rockier with beaches between the many headlands, and a large number of wadis leading from the hills to the south carry the occasional rainfall to the sea.

The islands forming the Socotra Archipelago are generally rocky with extensive sandy beaches between headlands. From the west, Abd al Kuri, 37 km in length, rises to a height of 573 m. The rocky islet of Kal Farun, 22 km north of Abd al Kuri, is 86 m



Plate 2.2 Beer Alajuz, Abd Al Kuri (Photo courtesy of Yemen Ports Authority, 2004).

and the 500 m contour is found 45 km from the coast at the border with Somalia. The topography at the western end of Somalia consists of a coastal plain where the 500 m contour is 60 km from the coast. It then reduces in width towards Berbera as the contour comes within 25 km of the coast. The coast consists largely of sandy beaches that extend from Djibouti as far as Bosaso (Boosaaso) in longitude $49^{\circ} 10' E$. From Berbera the 500 m contour is generally between 20 and 30 km from the coastline, giving a relatively narrow coastal plain and numerous wadis carrying occasional runoff from the hills behind, which rise to over 2,000 m.

From Bosaso to Ras Casey in longitude $51^{\circ} 15' E$ the topography is more rugged, with the 500 m contour coming right down to the coastline in places and generally not more than 10 km from the sea. Mountains over 1,000 m in height are found in places

high. Jazirat Samhah and Jazirat Darsa are 779 m and 392 m high respectively. The rocky islet of Sabuniyah, 20 km west of Socotra, is 69 m high. The main island of Socotra is 135 km in length and 39 km wide. Rugged mountains in the centre rise to a height of 1,519 m. In contrast to the vast majority of the topography of this region, Socotra is well watered by rains that fall from clouds formed as air is lifted and cools over the mountains. The highland areas of Socotra, generally over 500 m above sea level, are covered with lush vegetation and contain very many endemic species, such as the famous 'Dragon's Blood Tree'. Even in June and July, at the height of summer and the south-west monsoon, the climate in the highlands of this island is normally cool, cloudy, damp and pleasant, with generally moderate wind speeds away from the coast. The topography reflects the impact of these special climatic conditions on the island.

2.6.3 Definition of Coastlines

The definition of coastlines in the region is affected by the lack of modern hydrographic surveys carried out in the Red Sea and Gulf of Aden. In many parts of the region the coastline and coastal features may be inaccurately shown on the latest charts. Coastlines have been adjusted to reflect their positions as defined by the World Geodetic System 1984 (WGS84), but the positions of many of the coastlines is based on old and sometimes inaccurate data. Many of the charts of the region carry a note on satellite-derived positions and chart accuracy, stating: "Positions obtained from satellite navigation systems, such as the Global Positioning System (GPS), are normally referred to the World Geodetic System 1984 Datum. Such positions can be plotted directly on this chart. However, due to the age and quality of some of the source information, such positions may be more accurate than the charted detail."

An example of inaccuracy was recorded in 2003 when a vessel carrying out a hydrographic survey around 200 m off the northern coast of Socotra recorded its position as being around 350 m south of the satellite-derived position shown on its track plotter. The ship's track was therefore observed to be moving across the land on its electronic chart.

Positions of the coastline on the northern side of the Gulf of Aden are believed to be as much as half a nautical mile from the charted position in some locations. The Government of Yemen wishes to undertake a series of new surveys of the shallower waters close to the Yemeni coastline in the Gulf of Aden, including the islands of the Socotra Archipelago, to provide data on which the construction of fishing ports along this coast can be based.

In 2005, the UK Hydrographic Office (UKHO) discovered discrepancies between the satellite-derived positions, satellite imagery and the charted positions when attempting to produce a new chart of Port Sudan and of new berths and an oil terminal completed at or close to the port. These

discrepancies delayed the work of producing the new chart for some time. Readings taken in the Port Sudan area in November 2005 allowed the production of a revised chart to be completed early in 2006.

The Government of Eritrea has stated that it wishes to undertake a full hydrographic survey of its territorial waters and EEZ, which would allow the many islands, reefs and shallow areas in the Dhalak Bank to be accurately defined and located.

It is evident that a considerable amount of re-surveying of the coastline itself in most of the region, and several of the ports, is required in order to produce accurate paper and electronic charts that show the coastlines, and other features, in their correct positions.

2.7 STATUS OF HYDROGRAPHIC SURVEYING IN THE REGION

2.7.1 Current Navigation Charts

Chapter V of the IMO Safety of Life at Sea (SOLAS) Convention requires all ships to carry navigation charts. These charts have in the past normally been paper charts, but with the advent of electronic chart systems, Electronic Navigation Charts (ENCs) have become available and are now used on many ships as a means of improving navigation safety and efficiency. SOLAS Chapter V recognises that an Electronic Chart Display and Information System (ECDIS), supported by appropriate back-up arrangements, can meet its requirements for the carriage of charts. Charts, whether paper or electronic, must be provided by or through a recognised hydrographic office and must be kept up to date in order to meet SOLAS requirements.

ENCs are vector charts that conform to the International Hydrographic Organization (IHO) specifications contained in the IHO Special Report S-57. They are compiled from a standardised database of individual items containing all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart,

such as sailing directions and environmental requirements to be followed by ships. They can be programmed to give warning of impending danger, such as a need to alter course at a certain point along the ship's route.

Raster Nautical Charts (RNCs) are raster charts that conform to IHO specifications and are produced by digitally scanning a paper chart image. The resulting digital file may then be displayed in an electronic navigation system where the vessel's position, generally derived from electronic position fixing systems, can be shown. RNCs are merely a digital photocopy of the original paper chart and the image has no intelligence and cannot be interrogated.

In general, because of the lack of modern survey data in much of the region, the status of hydrographic surveying in the Red Sea and Gulf of Aden is unsatisfactory with respect to the provision of the accurate paper and electronic charts needed by modern shipping. Ships are increasingly making use of electronic charts rather than the traditional paper charts, but the region is not well served by ENC's. As IHO points out, although the number of electronic charts now available has increased, a matching improvement in the quality of the source data from which these charts are derived is not yet evident.

However, the region is, in fact, well covered by the current folio of nautical charts, which are based on the available data. The UKHO carries responsibility for charting this region, which falls within the area designated by UKHO as Area 6. Area 6 covers the Red Sea, Gulf of Aden and a major part of the Indian Ocean. The UKHO world-wide chart series consists of a mixture of charts compiled using a variety of sources and methods. In waters where the UKHO has the responsibility for producing charts, or where there are as yet no other chart producers, charts are compiled from 'raw' data such as hydrographic surveys. In areas where national or other hydrographic offices produce charts, UKHO may recompile charts from the data shown on these charts, or reprint them in the traditional UKHO format. Such reprints may form part of the

International (INT) Chart Series, in which members of the IHO publish charts with internationally agreed limits and scales. Each of these charts carries a unique INT number as well as the UKHO national number allocated to it²¹.

2.7.2 The IHO Regional Assessment of Hydrographic Surveying

As indicated in the statistics provided by the Suez Canal Authority, the sizes and draughts of ships operating in the region are generally increasing, making the measurement of depths and channel widths in shallow waters vitally important to navigation safety. In order to produce the accurate charts of the region needed by modern shipping, high quality hydrographic survey data is essential. The latest International Hydrographic Organization Special Report 55 (or S-55) on the Status of Hydrographic Surveying and Nautical Charting worldwide is dated July 2004. It covers the bathymetry for the waters of the region and the data shown in the tables that follow are taken from this report²². Area J, as defined in this IHO report, is under one of the Regional Hydrographic Commissions (RHC), the North Indian Ocean Hydrographic Commission (NIOHC). The Gulf of Aden and the Red Sea are included within the NIOHC.

The table for Djibouti (Table 2.3) indicates that 66% of the water area with depths less than 200 m has been adequately surveyed so far, but none has been adequately surveyed with depths greater than 200 m. Much of the water area less than 200 m in depth lies inside reefs close to the Port of Djibouti, with only a relatively narrow strip along the remainder of the coastline less than 200 m in depth. This means that 34% of the shallower area requires to be resurveyed to modern standards, and 100% of the deeper waters. In the Gulf of Tadjoura, water depths within 1–2 km from the coast drop to several hundreds of metres, then to over 1000 m immediately to the east of the Gulf. Part of the 2000–2001 PERSGA hydrographic survey was in the waters of Djibouti north of the Iles des Sept Frères (Jaza'ir Seba).

²¹ See The Mariner's Handbook, Chapter 1.

²² See www.iho.shom.fr for further details (Note: Check Main Report then Composite Report on this site).

Egypt (Table 2.3) has waters under two RHCs, Area F (the Mediterranean and Black Seas Hydrographic Commission), and Area J, the NIOHC. Countries with sea areas lying in two RHCs, such as Egypt, have been asked to prepare data for both of the RHCs with which they are concerned. The July 2004 report for Egypt does not give any data. However, Egypt does have a national capability to conduct hydrographic surveys. Source diagrams for charts of the Gulf of

Suez indicate that data has been obtained from surveys conducted between 1830 and 1872 (after the Suez Canal was opened), and between 1978 and 1984. In view of the high level of importance of the Gulf of Suez to world shipping and trade, the situation with respect to modern surveys in the Gulf of Suez deserves to be carefully monitored.

The waters of Eritrea (Table 2.3) cover approximately 25% of the total area of

Table 2.3 The status of survey coverage in each country of the Red Sea and Gulf of Aden for water depths below and above 200 m. A = percentage which is adequately surveyed. B = percentage which requires re-survey at larger scale or to modern standards. C = percentage which has never been systematically surveyed. Bracketed dates indicate most recent update.

Country	Water Depth	Survey Coverage Status		
		A	B	C
Djibouti (Nov 2003)	< 200m	66%	34%	0%
	> 200m	0%	100%	0%
Egypt	< 200m	N/A	N/A	N/A
	> 200m	N/A	N/A	N/A
Eritrea (May 2004)	< 200m	2%	0%	98%
	> 200m	2%	0%	98%
Jordan (Jan 2004)	< 200m	0%	90%	10%
	> 200m	0%	0%	100%
Kingdom of Saudi Arabia (Dec 2003)	< 200m	25%	5%	70%
	> 200m	25%	0%	75%
Somalia (May 2004)	< 200m	5%	1%	94%
	> 200m	3%	2%	95%
Sudan (May 2004)	< 200m	1%	0%	99%
	> 200m	2%	0%	98%
Yemen	< 200m	1%	6%	93%
	> 200m	5%	2%	93%

the Red Sea. Much of the area lies in the shallow Dhalak Bank or between this Bank and the border with Djibouti north of Bab el Mandeb. Only to the north of the Dhalak Bank do the waters of Eritrea exceed 200 m in depth. The table for Eritrea indicates that 2% of the water area with depths less than 200 m has been adequately surveyed so far, and 2% where depths are greater than 200 m, therefore 98% of Eritrean waters below and above 200 m in depth have not yet been systematically surveyed. The area reported as having been adequately surveyed lies in the approaches to the harbours at Massawa and Aseb, and in Ghubbet Mus Nefit, or is part of the area surveyed in 2000–2001 through the PERSGA SAP prior to introducing new ship routing measures in the southern Red Sea. Part of the 2000–2001 PERSGA survey was in the waters of Eritrea around the Haycock Islands. The Government of Eritrea has stated its interest in having its waters properly surveyed, but the means for achieving this is not evident at this stage.

The table for Jordan (Table 2.3) indicates that none of the water area with depths less than or greater than 200 m has been adequately surveyed. Ninety per cent of the shallower area requires to be resurveyed to modern standards, but no such survey of deeper waters is required. This reflects the configuration of the 26 km long Jordanian coastline, as the coast is steep, reaching depths of over 200 m within 1–3 km of the coast, with no significant dangers to navigation lying offshore.

The table for Saudi Arabia (Table 2.3) indicates that 25% of the water area with depths less than 200 m has been adequately surveyed so far, and 25% in depths of greater than 200 m. Five per cent of the shallower area requires to be resurveyed to modern standards, and 0% of deeper waters. Seventy per cent of the shallower waters of Saudi Arabia are reported to have been systematically surveyed, and 75% of the waters greater than 200 m in depth. There is a need for offlying islands and reefs surveyed in the 1970's and 1980's to be re-surveyed, especially where these are close to international shipping routes. A programme to survey all major ports and

several smaller ports along the Red Sea coast of Saudi Arabia, and their approaches, is reported to be underway at present.

Figures for the waters of Somalia (Table 2.3) have been estimated by UKHO. A modern survey in the area around Ras Caseyr was carried out and limited surveys have been reported in the approaches to the ports of Bosaso and Berbera. Most source data for charts of Somali waters is now very old and based on lead-line surveys. Offlying dangers may therefore exist that have not yet been discovered. UK Admiralty Chart 2950, "Plans on the Coast of Somaliland", shows 15 ports and anchorages around the coast. It was published in 1950, shows depths in feet and fathoms and is in urgent need of updating. With the exception of Chart 2950, all other navigation charts of the region are now metricated.

The table for Sudan (Table 2.3) indicates that only 1% of the water area with depths less than 200 m has been adequately surveyed so far, and 2% in depths of greater than 200 m. Ninety-nine per cent of the shallower area requires to be resurveyed to modern standards and 98% of the deeper waters. Most of the surveys conducted in the waters of Sudan were by lead-line, and offlying dangers may exist that have not yet been discovered. New charts of Port Sudan, El Khair Oil Terminal, the Bashayer Oil Terminals 1 and 2, and the port of Suakin are urgently required to reflect changes that have taken place in recent years.

The table for Yemen (Table 2.3) indicates that only 1% of the water area with depths less than 200 m has been adequately surveyed so far, and 5% in depths of greater than 200 m. Six per cent of the shallower area requires to be resurveyed to modern standards, and 2% of deeper waters. Ninety-three per cent of Yemeni waters have not, so far, been systematically surveyed. For waters shallower than 200 m, a good part of the area reported as having been adequately surveyed lies inside harbours, or in the area surveyed in 2000–2001 through the PERSGA SAP prior to introducing new ship routing measures in the southern Red Sea.

The tsunami that resulted from an earthquake on the eastern side of the Indian Ocean, off the west coast of Sumatra on 26 December 2004 caused damage and some loss of life on Socotra, on the coast of Somalia, and in the Gulf of Aden. This major event has again emphasised the need for more accurate hydrographic surveys around the world, and specifically in this region, to be completed. It is recognised that, if accurate surveys of waters off a coastline are available, it becomes possible to issue warnings of likely wave heights and times, based on a better appreciation of the underwater topography, before a tsunami wave reaches the coast²³.

IHO S-55 contains details of the status of nautical charting around the world and Table 2.4, covering regional states, has been taken from this report²⁴.

The table clearly states the generally unsatisfactory situation with regard to electronic navigation charts in the region meeting the standards defined in IHO Special Publication S-57. Although ENC's for the region are available from commercial suppliers, they cannot meet the required IHO S-57 standards because of the quality of the source data on which they are based. S-55 identifies as a major deficiency that needs to be addressed with regard to hydrographic surveys "The deeper waters of the Red Sea between the S approaches to the Gulf of Suez and the N approaches to the Strait of Bab el Mandeb." During the survey of the Red Sea in late 2004 for the communications cable from Europe to the Far East (SeMeWe4) along a narrow strip of the Red Sea, it was reported that some depths in the deeper parts of the Red Sea are 200 m less than recorded on the present charts²⁵.

2.7.3 The PERSGA Contribution to Regional Hydrographic Surveying

In 2000, under the PERSGA SAP, an important new survey of the main shipping routes was carried out in the southern Red Sea in the waters of Djibouti, Eritrea and Yemen, where the existing charts were largely based on surveys conducted between the 1840s and mid-1900s, and on records of soundings from ships on passage. The survey was proposed and executed to allow new ship routing measures for the area to be designed and presented to IMO for consideration. The survey extended from south of Bab el Mandeb in about latitude 12° 30' N, northwards to latitude 14° 22' N.

The survey ship worked continuously in the area for six months to cover the shipping routes through Bab el Mandeb and northwards past the Hanish Islands²⁶. The area surveyed passed through Bab el Mandeb as a single route as far north as latitude 13° 15' N, where the route divides into two, one passing east of the Hanish Islands, one passing to the west. The survey continued, on the eastern side, northwards through the Abu Ali Channel and also east of the Abu Ali islands, to latitude 14° 10' N, covering waters previously unsurveyed or last surveyed between 1881 and 1901. A full hydrographic survey of the Avocet Rock, which lies about 8 km east of the main sea routes in latitude 14° 22' N, was also undertaken, the first time that this navigation hazard had been properly surveyed.

The surveyed route to the west from the bifurcation point in latitude 13° 15' N passed south and west of Hanish Al Kubra island, covering a large area around the Haycock Islands, South West Rocks, where shallow patches had been reported by ships on passage, and extended as far north as latitude 13° 41' N.

²³ Following the tsunami, the IMO, IHO and IALA (International Association of Lighthouse Authorities) met on a number of occasions to discuss the short, medium and long-term actions required following this event. A need for additional hydrographic surveys of sea areas near to coastlines to improve the quality of tsunami warnings has been widely recognised.

²⁴ See www.iho.shom.fr Publications, S-55, September 2006, Nautical Charting.

²⁵ Personal communication with survey staff, November 2004.

²⁶ From the end of December 2000 to early June 2001.

Table 2.4 The percentages covered in the countries of the region in three sub-categories: (i) Offshore passage/small scale charts, (ii) Landfall, coastal passage, medium scale charts, and (iii) Approaches, ports, larger scale charts. A = % covered by INT series or national equivalent meeting the standards in M-4. B = % covered by Raster Navigational Charts meeting the standards in S-61. C = % covered by ENC's meeting the standards contained in S-57²⁷.

INT Chart Region J	Offshore passage /small scale			Landfall, coastal/ medium scale			Approaches, ports/ large scale			Comments
	A	B	C	A	B	C	A	B	C	
Djibouti	100	100	0	100	100	0	14	14	0	
Egypt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No data provided
Eritrea	100	100	0	100	100	0	100	100	0	1. Figures supplied by UK 2. No charts are referred to WGS Datum 3. Most source data is very old
Jordan	100	100	100	100	100	0	100	100	0	Figures supplied by UK
Saudi Arabia ²⁸	60	0	0	40	0	25	40	0	0	1. All paper charts produced by the Ports Authority require updating 2. ENC's are not commercially available
Somalia	100	100	0	100	100	0	100	100	0	1. Figures supplied by UK 2. Most source data is very old 3. Plans for smaller ports and anchorages require modernization
Sudan	100	100	0	100	100	0	66	66	0	1. Figures supplied by UK 2. Most source data is very old 3. Bashayer Oil Terminal (SBM) is only charted at 1:150,000 scale
Yemen	100	100	0	100	100	0	0	0	0	A large scale ENC of Aden Harbour will soon be available

The total area surveyed covered 850 km², representing a major contribution to the improvement of navigation safety through the provision of chart data to modern standards. It allowed new routeing measures to be presented to IMO for adoption, consisting of three separation schemes joined by two recommended routes. The system came into force on 1 July 2003 and is now marked on charts of the area, providing guidance for ships operating in waters where a large number of dangerous rocks and small islands exist²⁹.

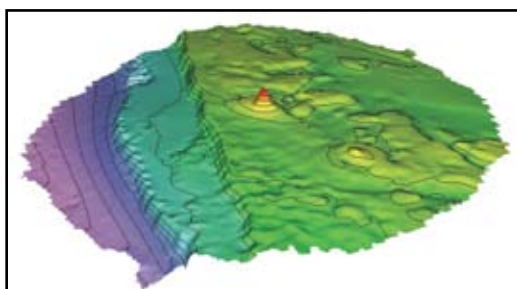


Plate 2.3 Survey results for the Avocet Rock, southern Red Sea (Courtesy of Gardline Surveys³⁰).

As the IHO has pointed out in its web site in 2004, “Members of . . . PERSGA have provided another example of concerted action to address a major regional deficiency, and a new Traffic Separation Scheme and other recommended routeing measures are now in place in the northern approaches to the Strait of Bab el Mandeb.” PERSGA also worked with the UKHO during the survey to re-scheme charts in the southern Red Sea to improve coverage and thus

navigation safety. Seven re-schemed charts were published by UKHO as a result of this work.

During 2005/6 the PERSGA navigation safety adviser assisted UKHO in producing a chart covering the waters of Yemen in the southern Red Sea and Gulf of Aden, and a more accurate chart of Port Sudan and the nearby El Khair Terminal, compatible with WGS84. UKHO is also in the process of replacing the last of the non-metricated charts in the region covering ports and anchorages on the coast of Somalia with a metric version.

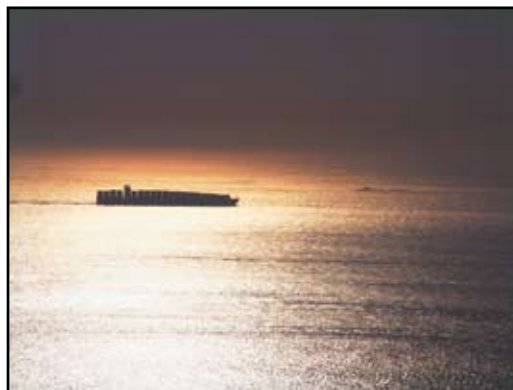


Plate 2.4 Container ship using the routeing measures passing the South West Rocks, south of Hanish Al Kubra, 2004 (Photo: R. A. Facey³¹).

Since 2000 there have been signs that the region is taking a more active role in hydrographic surveying. The major survey that PERSGA initiated was an important start. During 2006 support has been received

²⁷ From the end of December 2000 to early June 2001

²⁸ Figures and comments contained in Area I, The Gulf. No figures for Saudi Arabia are given for Area J.

²⁹ The survey ship also carried out tide and current measurements at key points in the area and took seabed samples covering the corners of every square kilometre over the area surveyed. Ninety per cent of these samples were sent to Sana’a University to be stored; 10% were returned to the UKHO for examination. From the current measurements taken, tidal diamonds are now shown on the new charts of the area at Bab el Mandeb, immediately north of the bifurcation point on the route, and immediately to the south of the Abu Ali channel.

³⁰ The hydrographic survey in the southern Red Sea conducted under the auspices of PERSGA in 2001 covered the sea mount known as the Avocet Rock. Survey results show this mount rising abruptly from a shelf with a depth of around 50 m to a 400 m x 400 m rocky platform at a depth of around 6 m below sea level that has been responsible for a number of shipping casualties in the past. This rock had been reported over the past 125 years to lie in positions that varied by up to 8 nautical miles, giving rise to the belief at one stage that more than one rock existed in this area.

³¹ Members of PERSGA staff have visited the Hanish Islands and Abu Ali Island to observe ships using the routeing measures and have requested feedback from ships’ captains and navigators on the routes. Comments received have been positive as the new routes have brought a large degree of order to an area where previously ships could not predict which track an approaching vessel would follow.

by the IHO to enable a young surveyor from Yemen to attend the North Indian Ocean Hydrographic Commission meeting held in Colombo, Sri Lanka, between 14 and 16 March 2006. A hydrographic surveyor from the Maritime Affairs Authority (Yemen) attended a training programme offered by the UKHO in mid-2006. UKHO is also making arrangements for a surveyor from Yemen to be given long-term training. The Port of Aden is purchasing a new hydrographic survey boat fitted with the latest technology, including multi-beam echo sounding equipment, for use in ports and coastal waters, and a new inshore survey boat for the Red Sea was ordered by Saudi Arabia in 2006.

The UKHO is pro-actively seeking opportunities to sign 'Bi-Lateral Agreements' with regional states on the exchange of hydrographic data to allow navigation charts to be improved. It has signed such an agreement with Yemen and has been in contact with authorities in Saudi Arabia and Sudan for the same purpose. Senior members of the IHO and UKHO are due to visit the region in 2007 to offer advice on the optimum means of meeting coastal state responsibilities for hydrographic services, as defined in the SOLAS Convention Chapter V, Regulations 4 and 9. This visit has been endorsed by the IHO Capacity Building Committee (IHOCBC) and included in the IHO Work Program for 2007.

2.7.4 Climate Change and Sea-level Rise, Potential Impacts on Regional Coastlines

The gradual and almost imperceptible rise in sea levels around the world has been widely reported. It is generally considered that rising sea levels pose a huge threat to ports, coastal regions and islands. Global warming is blamed for the rising air and sea temperatures around the globe. Air temperatures are forecast by the United Nations Intergovernmental Panel on Climate Change (IPCC) to rise by between 1.4 and

5.8°C between 1990 and 2100²⁷. Rising CO₂ levels in the atmosphere, driven by the emissions from cars, power/desalination plants, factories and other industrial plants, are thought to be responsible for temperature rises. At present, due to thermal expansion of the world's water bodies as temperatures rise and to melting ice over Greenland and Antarctica, the rise in sea level is believed to be of the order of 0.08 inches/year, or 2 mm/year. It is reported by the IPCC that sea levels rose by 3.9 to 7.8 inches (9.75 cm to 19.5 cm) over the 20th century, and the Panel forecasts that by 2100 sea levels could be between 2.7–26.8 inches (9 cm to 88 cm) higher than in 1990³³. Some experts believe that an increasing rate of ice melt indicates that the rise by 2100 will be towards the higher end of this range, others dispute this.

For the Red Sea and Gulf of Aden, rising sea levels may pose a threat in a number of low-lying areas. These include the Ghoubbet Kharab at the landward end of the Gulf of Tadjoura in Djibouti; new mangrove plantations in Massawa Harbour; islands in the Dhalak and Farasan Banks and large areas of sabkha along the shores of Saudi Arabia; infrastructure developments close to the coast, such as sections of new roads close to the coast in Yemen, Eritrea, Sudan and Egypt; and sewage plants built at or close to sea level with outfalls to the sea at Aden and in other parts of the region. Harbours which have been built with the heights of the quay walls and working areas elevated less than a metre above the spring high tide levels, or new Free Zone areas built on reclaimed land at the edge of the sea, such as those at Aden and Jeddah, will also be at risk³⁴.

2.7.5 Sea Level Monitoring

It is evident that changes in sea level have occurred historically in the Red Sea and Gulf of Aden region for hundreds of thousands of years. Work reported in the journal Nature

²⁷ See, for example, www.ipcc.ch/ report - Climate Change 2001: Impacts, Adaptation and Vulnerability, Section 3.8.2.

³³ Ibid.

³⁴ In some European countries concerns over rising sea levels have resulted in structures close to the coast, such as docks protecting marinas in parts of the UK being built with walls around 1 m higher than are currently necessary as a long-term precautionary measure.

in 2003 indicates that sea levels in Bab el Mandeb were at one stage around 120 m lower than at present (SIDDALL et al. 2002)³⁵.

The region is fortunate in having tide-gauge records from Aden that date back to 1879³⁶. These are held at the Bidstone Observatory in Liverpool (established 1866) and the Observatory encourages holders of all such records to lodge copies with them. The Permanent Service for Mean Sea Level (PSMSL, established in 1933), based in Liverpool and Paris, holds records for tide gauge stations around the world on which time series analysis of sea level changes can be performed. To construct the series at each station the monthly and annual means have to be reduced to a common datum. Data adjusted in this way forms the 'Revised Local Reference' (RLR) dataset, which is the preferred dataset for scientific purposes. The RLR datum at each station is defined to be approximately 7000 mm below mean sea level; an arbitrary choice made many years ago to avoid negative numbers in the resulting RLR monthly and annual mean values. Each station is given a station number and the country a country code.

Tide gauge records in the region are also available from PSMSL stations at Port Tewfiq in Suez Bay from 1925, from Port Sudan from 1986, from Djibouti from 1970, and more recently at the eastern end of the Gulf of Aden, from Salalah from 1989. As shown in the table below, in recent years the stations in the Red Sea and Gulf of Aden have not been reporting tide gauge data to PSMSL. There are also a number of gaps in the records submitted by the stations in this region, some gaps lasting for many years. PSMSL Country Codes have been allocated for Djibouti (475), Egypt (330), Sudan (477)

and Yemen (485), but not for Eritrea, Jordan, Saudi Arabia and Somalia.

In order to monitor sea level changes in the region, tide gauges at key locations through the RSGA, particularly at sites for which long-term records are already available, are highly important³⁷. Keeping such gauges in a fully operational condition in the long term and ensuring that the records are lodged with PSMSL will derive maximum benefit from them and is clearly essential to the objective of understanding changes in sea level on both global and regional scales.

The region should also be aware of, and involved in as appropriate, the Global Sea Level Observing System (GLOSS). This is a programme coordinated by the IOC for the establishment of global and regional sea level networks for oceanographic, climate change and coastal research purposes. The main component of GLOSS is the 'Global Core Network' of 287 stations around the world for long term climate change and oceanographic sea level monitoring. Recent years have seen major efforts to collect higher frequency (typically hourly) sea level data in order to provide an 'in-situ' World Ocean Circulation Experiment (WOCE) dataset, primarily for comparison to and validation of sea level data obtained from satellite radar altimetry. The designated 'WOCE tide gauges' are mostly GLOSS island sites and pairs of gauges across straits and total about 100 stations. There are two WOCE Sea Level Centres: one at the British Oceanographic Data Centre at Bidston Observatory alongside the PSMSL (the so-called 'Delayed mode centre'), and the other at the University of Hawaii Sea Level Center (the so-called 'Fast centre') (WOODWORTH 1998). The situation recorded by the PSMSL in the RSGA is shown in Table 2.5.

³⁵ See also: www.noc.soton.ac.uk/JRD/PROC/people/das/redsea.php.

³⁶ The tide gauge at Aden was the most westerly station in the Indian Ocean to record perturbations in sea level due to the Krakatoa explosion on 27 August 1883.

³⁷ Aden is the only station in the region, and indeed within 4,000 km, that has RLR records for more than 40 years. The closest stations to Aden with such records are on the west coast of India.

Table 2.5 The situation recorded by the PSMSL for tide gauges in, or close to the Red Sea and Gulf of Aden. Information recorded includes: the details of the site (name, dates for which data is recorded, latitude, longitude); whether or not a Sea Level (SL) Plot is available; if a map or plan showing the location of the tide gauge in the port is available; whether hourly values of tidal height are provided (WOCE Fast); whether delayed mode records are available (WOCE Del).

Site	Between years:	Latitude N	Longitude E	SL Plot	Map	WOCE Fast	WOCE Del
Suez	1925-86	29° 56'	32° 34'	No	No	No	No
Port Sudan	1986-92	19° 38'	37° 07'	No	No	No	No
Djibouti	1970-72	11° 35'	43° 09'	No	No	No	No
Aden	1879-68	12° 47'	44° 59'	Yes	No	No	No
Salalah	1989-04	16° 56'	54° 00'	No	Yes	Yes	Yes

Following the tsunami of 26 December 2004, funds have become available for establishing a network of tide gauges in the Indian Ocean through the Intergovernmental Oceanographic Commission (IOC) of UNESCO. A visit to Aden was made by a consultant working with IOC in July 2006. IOC intends to establish a new tide gauge at Aden that would be part of the network of sea level stations forming the Indian Ocean Tsunami Warning System. The equipment would consist of (i) a radar gauge (primary sensor); (ii) a pressure gauge (secondary sensor); (iii) data logger; (iv) a display unit for the port office and (v) a satellite transmitter unit to link the tide gauge by satellite to a central recording unit. It is possible that a second tide gauge could be established on Socotra Island. The purpose of this network of tide gauges, linked to a central point by satellite, is to allow warnings of tsunamis to be broadcast around the Indian Ocean as soon as tide gauges in the system detect a tsunami event³⁸. As part of the tide gauge network, the IOC is providing training in sea level observation and interpretation for participants from the Indian Ocean region.

If the datum for a new tide gauge at Aden can be established in relation to the benchmarks in Aden that were set up during the Survey of India Great Trigonometrical Survey benchmarks, it will be possible to link tidal measurements for 2007 with the records from 1879 to 1968.

Mean Sea Level is also affected by other factors. The two main deficiencies of the PSMSL data set are known to be its geographical coverage and the problem of decoupling land movements from sea level change within tide gauge records. The former is being approached by using the advances in altimetry and the development of GLOSS (IOC 1998). The latter will be addressed by the use of GPS and other advanced geodetic devices at gauge sites (NEILAN et al. 1998). Satellite altimetry is now available to measure the levels of both land and sea to very high accuracies³⁹.

The problem of determining sea level change is further complicated by long-term oscillations of large water bodies, such as the North Atlantic Oscillation, which is believed

³⁸ In 1945 a tsunami was started by an earthquake off the coast of Pakistan, killing many people in this Western Indian Ocean region. Establishment of the tide gauge network would be linked, as it is in Japan, with civil exercises in coastal areas where the population is trained in when and how to leave coastal areas for higher land.

³⁹ www.noc.soton.ac.uk/JRD/SAT/SeaLevel/SeaLevel.htm

to have affected water levels not only in the Atlantic, but also the Mediterranean and the Black Sea (TSIMPLIS & JOSEY 2001; WAKELIN et al. 2003). Whether sea levels in the Red Sea and Gulf of Aden are affected by oscillations in the Indian Ocean is an area for further study.

As an example of what might be possible in the Red Sea and Gulf of Aden in future in determining vulnerability to sea level rises and other factors, a study on the vulnerability of coastal structures and communities around the UK is a useful template. The study titled “Towards a Vulnerability Assessment for the UK Coastline” (2001–2003), is based on the premise that coastal communities are more vulnerable to climate change than inland communities because they are affected (especially) by increases in sea level and in wave height⁴⁰.

Sea level measurements from coastal tide gauges and from satellites are being used to estimate the contribution of global climatic change, as well as the effect of changes in regional climatic parameters as expressed by changes in the North Atlantic Oscillation, on coastal sea levels. Satellite measurements of wave height and wave direction are being used to assess the effects of climatic change on the wave climate. By using suitable models that include estimates of land movements, sea level, wave heights and directions, the potential effects on coastal communities will be assessed.

2.8 POPULATION INCREASE

All countries in the region are experiencing a rapid rise in population, typically of three per cent or more annually in countries such as Egypt, Saudi Arabia and Yemen. Coastal port cities are perceived as centres where employment is likely to be available often based on port operations and the related activities which act as multipliers to the

number of personnel employed in the port itself. This factor, and the access to the sea that can add to the quality of life, tends to draw people towards active coastal cities. Fishing and tourism are two other activities that increase employment opportunities on or near the coast.

Population growth inevitably results in pressure on the coastal environment and although some measures are being taken in almost all countries in the region to mitigate the pressure, the success of these measures in stemming the loss of several aspects of environmental quality is questionable. All too often, financially-driven developments take priority over the concepts of sustainable use and long-term benefit. In Jeddah, construction work on new roads, housing, hotels and other infrastructure is being extended ever further from the original core of the port city. Observers in Jeddah state that the quality of diving in the waters off the Red Sea coast of Saudi Arabia, in terms of the variety of coral species, fish diversity and abundance has deteriorated over the past ten years to a distance of some 100 km north and south of the city.

With regard to population growth, a continuous watch therefore needs to be kept on coastal development. The PERSGA programme for marine protected areas and coastal zone management provides a valuable resource for the region. Infrastructure projects able to provide treatment for sewage and other waste materials such as the plastic bags and bottles seen along so much of the coast, together with new technologies to improve the management of waste, are urgently required. In cases where the future flooding of coastal roads is a danger, raising them on levees can provide a solution though setting them well back from the shore, with branches to the coast only when required, may be preferable.

⁴⁰ See www.tyndall.ac.uk/research/theme4/final_reports/it1_15.shtml

COASTAL AND MARINE RESOURCES

Dr William Gladstone

3.1 SUMMARY

3.1.1 Status

Coral reefs are generally healthy throughout the Red Sea and Gulf of Aden, with 30 to 50% live coral cover at most locations and more than 50% total cover on average. Coral reefs are locally impacted in the vicinity of urban and industrial centres from land-filling and dredging; port activities (damage caused by anchors, oil and waste water discharges); sewage and other pollution (causing localised areas of coral disease, poor recruitment, and excessive algae); and tourism (damage from anchors and recreational scuba divers).

One-third of coral reefs in the region were destroyed or impacted by coral bleaching in 1998. Impacts were most intense in the central-northern Red Sea of Saudi Arabia (especially near Rabigh) and in Yemen (Belhaf, Hadhramaut, Socotra Archipelago). Most reefs are recovering. Outbreaks of crown-of-thorns starfish were recently reported only from the Iles des Sept Frères and Ras Siyyan Marine Protected Area (Djibouti).

Three-quarters of mangrove stands are impacted from camel grazing, felling, cutting, solid wastes, sewage, burial by mobilised sand dunes, or obstruction to tidal flows.

Populations of invertebrates are generally healthy except for localised declines of giant clams (Egypt, Eritrea) and other molluscs (Sudan), lobsters (all of the Red Sea and Gulf of Aden) and sea cucumbers (Sudan).

Among fishes commonly targeted by fishers, the grouper (family Serranidae) are relatively common compared to other reefs in the world, apart from some localised heavy exploitation (Sudan). The highest density of grunts (family Haemulidae) recorded globally in 1997–2001 was at a reef

in Ras Mohammad National Park (Egypt). The globally vulnerable humphead wrasse *Cheilinus undulatus* (family Labridae) was not recorded in Egypt, Eritrea or the Socotra Archipelago but was recorded in Sudan and Djibouti. There are concerns about fishing pressure at spawning and nursery sites, and sharks are heavily exploited. Collection of ornamental fishes occurs in Egypt, Saudi Arabia and Yemen but the impacts have not been quantified. Fish community structure is significantly altered on reefs adjacent to industry in Aqaba (including pathological changes) and Yanbu.

There is a regionally/internationally significant turtle nesting site on Mukawwar Island (Sudan). Turtle populations are affected by illegal capture or by-catch (Djibouti, Socotra Archipelago, Somalia, Sudan); oil spills and habitat degradation (Saudi Arabia); and feral dogs (Gulf of Aden).

There are thirty-one Important Bird Areas of which the Hurghada and Socotra Archipelagos are globally significant. General threats to breeding seabirds include human disturbance, human exploitation, introduced predators, habitat destruction (especially urban expansion), pollution, over-fishing and lack of information on population status.

The number of dugong to be found off Jizan and the Farasan Islands (Saudi Arabia) and in the Mukawwar Island and Dugonab Bay Marine Protected Area (Sudan) has declined, probably due to losses from accidental drowning in nets. The Sudan population of dugong may be the most important remaining on the coast of Africa.

Of the 15 species of cetaceans known to occur in the Red Sea and Gulf of Aden two are listed as Threatened, five are dependent upon conservation actions to prevent their listing as Threatened, five are insufficiently known to assign a conservation status, and only three are Secure.

3.1.2 Progress

There has been recent, substantial progress in the management of the marine resources of the Red Sea and Gulf of Aden.

A regionally applicable manual of standard survey methods for key habitats and key species in the Red Sea and Gulf of Aden has been produced.

Collection of essential baseline data on key habitats and species (coral reefs, mangroves, seabirds, turtles) and preparation of up-to-date status reports has taken place. There have been substantial gains in scientific knowledge of Red Sea and Gulf of Aden corals, coral communities, and reefs.

Regional action plans (following regional surveys) were developed for corals, mangroves, turtles and breeding seabirds and are being implemented nationally via national action plans.

The signing of the Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas by PERSGA member states in December 2005 will provide a regionally coordinated approach to conservation.

A Regional Master Plan for the Regional Network of Marine Protected Areas has been produced.

Progress is occurring towards the complete establishment of the RSGA Regional Network of Marine Protected Areas: two proposed marine protected areas were officially declared in 2005 (Iles des Sept Frères and Ras Siyyan in Djibouti and Mukawwar Island and Dungonab Bay in Sudan) and management plans are being implemented in each one. A zoning plan was developed for the Socotra Archipelago Marine Protected Area.

Survey design guidelines for marine protected areas (MPAs) have been prepared and ecological and socio-economic surveys have been completed at four proposed MPAs. All MPA survey data has been entered into a regional GIS. Site-specific

master plans, with management guidelines, have been written for four proposed MPAs with the involvement and participation of local stakeholders.

A large number of managers and scientists have been trained (via workshops and on-the-job training) in marine protected area management, field surveys, and monitoring techniques. There has been an international, regional and national exchange of experience.

Substantial progress has been made in the field of integrated coastal zone management (ICZM). This includes:

- Approval of ICZM plans for the Aden Governorate and their implementation.
- Completion of coastal profiles in Sudan and Djibouti and preparation of ICZM plan for Sudan (awaiting official approval).
- Establishment of a regional ICZM working group and raised awareness of the need for and use of this tool in coastal management.
- Improvements in regional capacity in remote sensing and GIS applications.
- Design, creation and establishment of a GIS unit at PERSGA with global internet access.
- Incorporation of all biodiversity, protected area, ICZM and other data from the Strategic Action Programme into the GIS for full programme integration.

PERSGA's environmental awareness programme concentrated on conservation including the production of the Environmental Education Learning Supplement, and the implementation of 17 community participation projects.

Five public environmental information centres and 150 school nature clubs have been established within the region, with associated teacher training. These activities have resulted in raised awareness of PERSGA and its activities at the national, regional and international level.

3.1.3 Constraints to Continued Progress

The potential performance of marine protected areas is compromised by a general lack of surveillance and enforcement, a lack of management expertise and experience, and often by weak implementation of management plans.

The existing marine protected areas do not fully represent the range of regionally significant and representative habitats and species (mangroves, turtle nesting and feeding, breeding seabirds). Additional marine protected areas are needed to fill these gaps.

Information gaps prevent an assessment of the current status of some species (breeding seabirds, marine mammals, marine turtles) and the distribution and status of many habitats (sabkha, saltmarsh, sandy shores, rocky shores, seagrass in some countries, and subtidal soft substrata). These gaps also constrain monitoring and assessments of the representativeness of existing marine protected areas.

Though the situation varies between the countries, the general underlying impediments include poorly developed national environmental legislation; lack of funding (for research, management, monitoring, surveillance and enforcement); the need to strengthen the political will to implement management; and lack of scientific expertise and experience in marine environmental management.

There has been limited use of community-based monitoring.

3.2 INTRODUCTION

The Red Sea and Gulf of Aden (RSGA) are renowned for their diversity of ecosystems, habitats and species, the numbers of endemic species, and their biogeographic significance. A consequence of the diversity of habitats in the RSGA is the great species richness of marine flora and fauna. The Red Sea is one of the most important repositories of marine biodiversity on a global scale. This has been recognised in

the declaration of the Socotra Archipelago as a UNESCO Biosphere Reserve, and the nomination as World Heritage Sites of Ras Mohammad (Egypt) and the Belhaf/Burum coast (Yemen).

Much of the available information is based on research in the Red Sea, especially the northern Red Sea. Far less is known of the flora and fauna of the southern Red Sea and the Gulf of Aden is one of the least well known areas of the Indian Ocean in terms of its biodiversity.

3.3 SABKHA

Sabkha-based habitats exist at the highest level of the intertidal and are usually only seasonally inundated. They are composed of sparse halophytes embedded in a sodium chloride and gypsum crust, below which is a microbial/algal mat consisting of cyanophytes, bacteria and diatoms (CHIFFINGS 1995). They are a highly productive habitat with nitrogen fixation occurring in the microbial/algal mat. A characteristic feature of sabkhas is the presence of pools which, because of the high salinity and temperatures, contain a specialised fauna of benthic invertebrates and a complex microbial community (SHEPPARD et al. 1992). Although little is known of the ecology and biodiversity of sabkhas, they are a significant feature and in some areas occupy an area greater than that of mangroves and saltmarsh combined (SHEPPARD et al. 1992).

Large areas of sabkha exist along the Gulf of Suez (Egypt). They are an ancient source of principal salts, containing halite, sylvite, polyhalites, gypsum, anhydrite, dolomite and other carbonates (PERSGA/GEF 2001).

Large areas of sabkha exist along the coastline of Saudi Arabia and Yemen. Over 50% of the Red Sea coastline of Yemen is sabkha and saltmarshes (PERSGA/GEF 2001). On low profile shores, sabkha may extend far inland. Midi-Al-Luhayyah has a flat sabkha coastline with extensive offshore sandbars and intertidal mudflats (PERSGA/GEF 2003b). The Al-Mukha-Al-Khawkhah

area runs for 70 km along the Red Sea coast and includes sandy patches in the north and areas of sabkha in the south (PERSGA/GEF 2003b). Large areas of sabkha occur in the Net and Nojid plains on Socotra Island, where the only organisms inhabiting them are the microalgae *Dunaliella salina* and occasionally the ghost crab *Ocypode cordimanus* (SIMÕES et al. 2001).

3.3.1 Status, Trends, Issues

There is no information on the extent of sabkha in Sudan, Djibouti or Somalia or the status of sabkha in all RSGA countries. There are also no standard methods for the assessment and monitoring of sabkha (PERSGA/GEF 2004a). Given the high primary productivity of sabkha this represents a major gap in the ability of agencies to conserve sabkha and manage human uses of this ecosystem.

3.4 SALTMARSHES

Saltmarsh communities in the Red Sea generally occur supratidally in the splash zone or in the high intertidal, and are important as localised sources of high primary productivity. Saltmarshes are subject to periodic inundation by the sea and are more or less covered in halophytic vegetation (JONES 2004). This habitat also occupies the zone landward of mangroves. Halophytes stabilise sediment, with tidal flows forming a network of channels and creeks between patches. Saltmarshes are highly productive, shelter abundant bird populations and are therefore significant for conservation. Halophytic communities are categorised according to their dominant species, height above sea level and immersion periodicity (CHIFFINGS 1995). The most common species belong to the genera *Phragmites*, *Typha*, *Halocnemum*, *Limonium*, and *Nitraria* (SHEPPARD et al. 1992).

Saltmarsh occurs throughout the Red Sea, declining towards the southern Red Sea. Significant areas of saltmarsh exist in the northwestern area of the Red Sea along the Egyptian coastline (Ras Mohammed, Abu Monqar, Wadi El Gemal, Jebel Elba) where

3% of the coast is saltmarsh (CHIFFINGS 1995). The saltmarsh community is dominated by 3–4 plant species especially *Halocnemum strobilaceum*, and *Zygophyllum album*. Other significant areas of saltmarsh are found on the Sudanese coastline (SHEPPARD et al. 1992), the Farasan Islands (GLADSTONE 2000), and the southern Red Sea coastline of Yemen.

3.4.1 Status, Trends, Issues

Apart from localised reports of saltmarsh being degraded by vehicle traffic and sand excavation on Farasan Island (GLADSTONE 2000), the status of saltmarsh in the RSGA is unknown. Standard survey methods for saltmarsh and for relevant indicator species in the Red Sea and Gulf of Aden were developed by JONES (2004). There is a need to use these standard techniques to obtain information on the status of saltmarshes throughout the RSGA.

3.5 SANDY AND MUDDY SHORES

Despite the small daily tidal range of much of the Red Sea, extensive intertidal areas exist as a result of the low lying nature of most of the coastline. The predominant intertidal habitats are sandy and muddy shores, and rocky shores. Sandy shores in the north-central Red Sea exist as narrow beaches between rocky shores (of a range of types) and behind coral reef flats, and as wider beaches behind lagoons in the southern Red Sea. There is a vertical zonation of beach fauna, with dominant groups on sandy beaches including ghost crabs, hermit crabs, and amphipods, and with large populations of gastropods dominating muddy shores (SHEPPARD et al. 1992).

Mud flats are usually found in sheltered bays, wadis or harbours protected from wave action. They usually occur seaward of saltmarsh or mangrove habitats. They are composed of soft sediments with the predominant particle sizes being silt (3.9 – 62 µm) and clay (less than 3.9 µm). Much of the primary production is carried out by microalgae occurring as a mix of pennate diatoms and Cyanophyta known as microbial mats (JONES 2004).

The north coast of Djibouti from the Eritrean border to Ras Bir consists mainly of shallow, sandy areas with a few rocky outcrops. The south-east coast is sandy and shallow. There are two large estuaries on the north coast of Djibouti (Khor Angar and Godoriya) and several smaller estuaries on the south-east coast (PERSGA/GEF 2001). The most common wetland type on the Red Sea coast of Egypt is intertidal mudflats. This habitat occurs on the Gulf of Suez side of Sinai and a large area at Wadi Kid, Gulf of Aqaba. The southern Red Sea coast of Egypt has a few scattered mudflats, especially at openings of large wadis, such as Wadi el Jimal (PERSGA/GEF 2001).

The western coastline of Somalia between Saylac (Zeila) and Berbera is shallow with exposed, high energy sandy beaches. The central portion of coastline between Berbera and Bosaso is mainly shallow, sandy shorelines with rare protruding rocky outcrops and cliffs. Short segments of narrow, sandy beaches are interspersed with rocky shores with steep cliffs in the east between Bosaso and Ras Casey. The western-central Gulf of Aden coastline of Somalia is largely high energy sandy beaches. Aibat (Ceebaad) Island is low lying and exposed, with sandy beaches and sand flats (PERSGA/GEF 2001; PERSGA/GEF 2003b).

Large sections of the coastline of Saudi Arabia consist of flat sandy beaches. These beaches occur on the landward edge of reef flats in the northern and central Red Sea coast. On the southern coast of Saudi Arabia beaches alternate with mangroves and volcanic rock shores (ORMOND et al. 1984).

The majority (75%) of the southern Red Sea coastline of Yemen is soft sediments (overlaid in parts by sabkha and saltmarsh). Midi-Al-Luhayyah has flat sabkha coastline with extensive offshore sandbars and intertidal mudflats. The Al-Mukha-Al-Khawkhah area runs for 70 km along the Red Sea coast of Yemen and has sandy patches in the northern section. The southern Gulf of Aden coastline of Yemen is characterised by rocky cliffs alternating

with sand beaches. Intertidal sandy beach is the major coastal habitat on the Socotra Archipelago (PERSGA/GEF 2001; SIMÕES et al. 2001; PERSGA/GEF 2003b). Intertidal muddy shores on Socotra Island occur on the landward fringes of wadis and khawrs (coastal lagoons) (SIMÕES et al. 2001).

3.5.1 Status, Trends, Issues

Sand excavation for urban construction on the beaches of Farasan Island (GLADSTONE 2000) has altered the shape of shorelines. Tar balls are common on many beaches of the Farasan Islands (GLADSTONE 2000) and are indicative of low-level oil pollution from ship traffic. Apart from these localised observations, there is no information on the specific status of intertidal sandy and muddy shores (or their associated species). The available information consists of broadscale maps of the distribution of each habitat.

Standard survey methods for sandy and muddy shores and for relevant indicator species in the Red Sea and Gulf of Aden were developed by JONES (2004). The ghost crab *Ocypode cordimana* is listed as an indicator species for assessment of sandy shores. Studies elsewhere (Australia) have shown that counts of the number of burrows of *O. cordimana* are a useful indicator of anthropogenic disturbance to sandy beaches (BARROS 2001).

3.6 ROCKY SHORES

Rocky shores provide an intertidal habitat that occurs in the RSGA on ancient coral reefs occurring now above the tidal limit (i.e. 'fossil reefs'), where coral sand has formed beach rock, and where coastal geological formations (e.g. lava flows) protrude into the sea. This habitat may be restricted to a very narrow zone on vertical raised coral reefs or cliffs or a wide and extensive zone on gently sloping volcanic formations. Fossil reefs are derived from uplifting or they were formed during the early part of the Holocene when sea levels were up to 1 m higher than present (SHEPPARD et al. 1992).

In comparison to other tropical regions there is a limited area of intertidal habitats in the

Red Sea. Tidal movements consist of small diurnal tides, seasonal tides, and temporary sea level changes due to strong and persistent onshore winds (EDWARDS 1987). In the central Red Sea the semidiurnal tidal range is minimal or non-existent but the northern and southern Red Sea may have a range of up to 1 m (SHEPPARD et al. 1992).

Major groups of invertebrates occupying this zone include gastropod molluscs, grapsid crabs, rock oysters, barnacles, chitons, and mussels. Rocky shores in the central Red Sea are dominated by barnacles during winter when sea levels are higher. However, these die off during the summer sea level fall and only blue-green algae films remain.

Twenty per cent of the Egyptian Red Sea coast is rocky shore (CHIFFINGS 1995). The northern coastline of Djibouti from the Eritrean border to Ras Bir is mainly shallow and sandy, except for a few rocky outcrops such as Ras Siyyan and Kadda (PERSGA/GEF 2001).

In Saudi Arabia, rocky shores occur on the undercut surfaces of raised coral reefs and as beach rock in the northern and central Red Sea and the Farasan Islands. Areas of volcanic rock run down to the coast in the southern Red Sea producing a sloping and topographically complex rocky shore (ORMOND et al. 1984).

High mountains located near the eastern Gulf of Aden coastline in Somalia produce a shoreline largely comprised of rocky shore and cliffs plunging directly into the sea (PERSGA/GEF 2001). The central coastline between Berbera and Bosaso consists mainly of shallow, sandy shorelines with, occasionally, protruding rocky outcrops and cliffs (PERSGA/GEF 2001). Short segments of narrow, sandy beaches intersperse with steep rocky cliffs in the east between Bosaso and Ras Caseyr (PERSGA/GEF 2001). Sandy beaches have an underlying rocky substratum.

Rocky shores extend along considerable lengths of the coastline of the Socotra Archipelago. There may be flat terraces

extending out to fringing reefs (often strewn with boulders), rock platforms, cobble beaches, or 1,000 m high vertical cliffs (PERSGA/GEF 2001; SIMÕES et al. 2001; JONES 2004). Rocky shores, volcanic in origin, extend along part of the Gulf of Aden coastline of Yemen (SHEPPARD et al. 1992; PERSGA/GEF 2001).

3.6.1 Status, Trends, Issues

There is comparatively little information on the status or ecology of intertidal rocky shores in the RSGA (JONES 2004). SIMÕES et al. (2001) concluded that the intertidal rocky shores of Socotra Island were in almost pristine condition and likely to be of regional significance for their zoogeographic value. The limited regional distribution of rocky shores and their unique biota emphasises the importance of conserving representative samples in MPAs. There is a need for a status report and a regional action plan for rocky shores modelled on the information produced for coral reefs and mangroves.

3.7 MANGROVES

Four species of mangrove have been recorded from the RSGA, with the two most common being *Avicennia marina* and *Rhizophora mucronata*. Other species recorded from the region are *Bruguiera gymnorhiza* and *Ceriops tagal* (SHEPPARD et al. 1992). In the region, *A. marina* is the most abundant mangrove species and is reported to occur in all mangrove areas. Most mangrove stands are mono-specific stands of *A. marina* (PERSGA/GEF 2004b). Typically mangroves grow as thin or, rarely, thick forests along the coastal shoreline; on the coasts of nearshore and offshore islands; and fringing tidal creeks and channels (known as khors, sharms, mersas or marsas). Stands are generally thin (50–100 m wide) but their length can vary from 100 m to more than 20 km (Figure 3.1). However, the mangrove stands of the RSGA are generally too small for sustainable harvesting for timber and animal fodder (PERSGA/GEF 2004b). The productivity of Red Sea mangroves is generally low, with gross primary productivity of stands in the northern Red

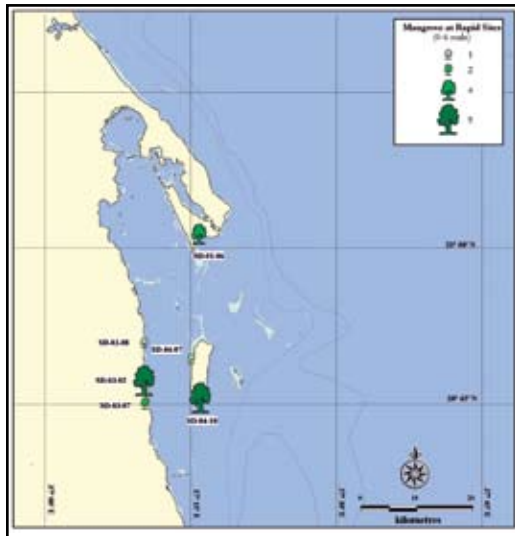


Figure 3.1 The distribution and relative abundance of mangroves around Dungonab Bay and Mukawwar Island, Sudan (source: PERSGA/GEF 2004f).

Sea probably less than 1 kg carbon m⁻² yr⁻¹ (PERSGA/GEF 2001).

Mangrove stands provide numerous habitats and are therefore inhabited by diverse and abundant communities of algal, mobile and sessile macrofaunal species. The trunk and pneumatophores are utilised by intertidal species, such as *Littorina* spp. and barnacles. Mangrove lagoons and channels are occupied by numerous fish species including many commercially important species. The leaves and shade zones provide additional habitat. The ichthyofauna of mangroves includes: true residents that spend their entire life cycle in mangroves (e.g. *Aphanius dispar*, *Gerres oyena* and some gobiids); closely associated species that are found there as juveniles only or as juveniles and subadults (e.g. *Acanthopagrus berda*, *Chanos chanos*, *Crenidens crenidens*, *Hypoatherina temminckii*, *Leiognathus equulus*, *Terapon jarbua*, *Pomadasys commersonni* and some mugilid species); and loosely associated species that are occasional visitors seeking food or shelter (e.g. *Sillago sihama*, *Thryssa baelama*) (PERSGA/GEF 2004b).

Overall, a diverse fauna of more than 250 species of marine invertebrates and vertebrates occurs in association with mangrove systems in the Red Sea. However,

this appears to be less than comparable mangrove systems in the nearby Indian Ocean, presumably as a result of the harsher temperature and salinity regimes within the Red Sea (SHEPPARD et al. 1992).

In addition to marine organisms, mangroves are used as a food source by terrestrial vertebrates (including the sand gazelle on Farasan Island) and as a roosting and nesting site by many species of birds. Assuming that these systems are functioning in a similar way to mangroves elsewhere in the world, they exist as a critical habitat, stabilizing nearshore sediments, trapping nutrients, exporting energy to nearshore subtidal habitats, and functioning as a nursery habitat for a range of fish and invertebrate species (SHEPPARD et al. 1992).

Mangroves occur throughout the region on the coastlines of all countries except Jordan. Their occurrence on the Saudi Arabian coast of the Gulf of Aqaba is their northernmost distribution in the Greater Indian Ocean. In most countries mangroves exist as distinct but isolated stands. Extensive stands occur in the southern Red Sea of Saudi Arabia and Yemen where the continental shelf is widest and there is a greater depositional environment allowing for stable sediment layers to develop. Mangroves are absent from the Gulf of Aden coastline of Yemen, apart from a unique, isolated population in the crater lake at Kharif Sha'ran. There are extensive areas of mangrove (*A. marina*) around the Socotra Archipelago (PERSGA/GEF 2004b). Mangrove stands on Socotra Island are almost completely terrestrial being separated from the sea by sand dunes (SIMÕES et al. 2001). Dense, healthy stands of both *A. marina* and *R. mucronata* occur in Somalia (PERSGA/GEF 2004b).

Human uses for mangroves include the harvesting of wood for fuel and for the construction of houses, boats, fence posts and railroad ties; the manufacture of rayon; the commercial use of bark as a source of tannin in tanning leather and preserving fishing nets; as a source of various dyes and stains; and the collection of leaves for livestock fodder (PERSGA/GEF 2004b).

3.7.1 Status, Trends, Issues

Apart from biodiversity surveys, there is limited information on the structure and functions of mangroves in the Red Sea and Gulf of Aden. Much of the understanding about these mangroves is based on studies of mangrove ecosystems from other parts

of the world and it is assumed that the mangrove ecosystems of the RSGA function in similar ways. A summary of the current status of mangroves in each nation and the major issues is provided in Table 3.1. Of 79 stands surveyed 57 (74%) were impacted, while 22 (26%) were in good condition.

Table 3.1 Summary of the status of mangroves in the Red Sea and Gulf of Aden region (from PERSGA/GEF 2004c).

Country	Location	Status/issue
DJIBOUTI	Ras Siyyan	Seriously affected by camel grazing, cutting and burial by creeping sand dunes
	Khor Angar	Heavily grazed, stunted, and cut
	Godoria	Generally undisturbed
	Obock	Severely destroyed by cutting and camel grazing
	Moucha Island	Mass mortality due to sand infilling, some cutting by tourists
	Maskali Island	Critically disturbed by tourist activities, solid waste and cutting
	Gaan-Maan	Being destroyed by camel grazing, cutting, sewage pollution
EGYPT	Shura Al-Manquata	Included within protected area, good condition
	Shura Al-Rowaisseya	Included within protected area, good condition
	Mersa Abu Zabad	Included within protected area, good condition
	Shura Al-Gharqana	Included within protected area, good condition
	Ras Mohammed	Included within protected area, good condition
	Geisum Island	Disturbed by solid waste accumulation and small tar mats
	Al-Gonah	Impacted by tourism developments and modified hydrological regimes from construction of artificial lagoons and channels
	Abu Minkar Island	Affected by oil pollution and solid waste accumulation
	Safaga Island	Suffers from accumulation of solid wastes
	South Safaga	Suffers from accumulation of solid wastes
	Wadi Abu Hamra	Good condition
	Sharm El-Bahari	Affected by coastal road and tourist developments and accumulated solid waste
	Sharm El-Qebli	Heavy grazing by camels

	Mersa Shagara	The stand is separated from the sea by a newly formed sandy beach which has cut off tidal flow, and shows no regeneration
	Wadi El-Gimal, W. El-Gimal Island, Ras Baghdadi	Good condition, included within Wadi El Gimal Protected Area
	Hamata mangroves	Impacted by camel grazing
	Shawareet Island	Suffers from the accumulation of solid waste
	Wadi Lahmy	The landward fringe of the stand is being impacted by camel grazing
	Quoraat Hartawy	The stand is severely impacted by camel browsing
	Mersa El-Hamira mangrove	Reduced water exchange (due to causeway), heavy camel grazing
	Shalateen Island	Disturbed by abundant solid waste accumulation
	Sharm- El-Madfaa	Dense growth of <i>Avicennia marina</i>
	Mersa Shaab	Good condition
	Mersa Abu Fassi	Good condition
	Wadi Al-Hoor	Landward fringe affected by camel grazing otherwise good condition
	Adaldeep	Landward fringe affected by camel grazing and wood cutting otherwise good condition
SUDAN	Mohammed Qol	Affected by camel grazing, felling and limb cutting
	Arakiyai	Heavily affected by camel grazing, felling and limb cutting
	Halut	Heavily browsed by camels with potential to be impacted from construction of shrimp farm
	Kilo Tammania	Severe camel grazing, physical disturbance by visitors, solid waste pollution
	Klanieb	Affected by camel grazing and hydrological changes (channels and salt production ponds)
	Mersa Atta	Severely affected from heavy grazing by camels, felling and cutting
	Lagagengeeb-Fagum	Severely affected from heavy grazing by camels, felling and cutting
	Haydob	Severely affected by felling and cutting
	Sheikh Ibrahim	Severely affected from heavy grazing by camels, felling and cutting
	Sheikh Saad	Severely affected from heavy grazing by camels, felling and cutting
	Shabarango-Gafud	Severely affected from heavy grazing by camels, felling and cutting

	Ashat	Dominated by dead, standing trees attributed to localised changes in tidal flow regimes	
SAUDI ARABIA	North of Jeddah to Yanbu	Dense stands of <i>A. marina</i> at Wadi Farrah	
	Jeddah South Corniche	Impacted by sewage pollution	
	North of Al-Lith	Dense stands of <i>A. marina</i> near Qishran Bay	
	Between Al-Lith and Khor 'Amiq	Well-developed <i>A. marina</i> mangroves	
	Khor 'Amiq to Al-Qahmah	Large stands of <i>A. marina</i>	
	Shuqaiq Mangrove	Some impact from small-scale cutting, camel grazing and recreational visitors and threatened by recent shrimp farm developments	
	Khor Wahlan	Grazed heavily by camels and goats	
	Farasan Islands	Construction of a soil dam has led to dry-up and significant mortality of one of the mangrove stands on Farasan Kebir. Some effort has been undertaken to rehabilitate the area affected by mortality	
	YEMEN	Midi to Al-Luhayyah	Thirteen stands: 6 heavily affected by grazing and cutting
		South of Al-Luhayyah	Two stands both heavily affected by grazing, cutting, domestic solid wastes
Al-Khawbah to Ras Isa		Six stands, all heavily affected by grazing and cutting	
Between Al-Harounia and Al-Salif		Generally in good condition	
Kamaran Island		Good condition	
Al-Urj		Severe cutting in parts of the stand	
North of Al-Hudaydah		Severely damaged by camel grazing, cutting, solid waste and sewage pollution	
Al-Hudaydah islets		Mangroves on 4 islets, 1 severely affected by camel grazing and cutting	
South of Al-Hudaydah to Al-Ghurairah (Bab el-Mandeb)		Four stands in good condition	
Between Al-Ruays and Yakhtul		Impacts from grazing by camels and goats, felling, excessive burial by moving sand dunes, diversion of tidal water into saltpans, solid waste	
South of Al-Mukha	Severely damaged by camel grazing		
Between Al-Kadaha and Al-Ubaidah	Severely impacted from sand burial and grazing		
Al-Ghurairah	Impacts from sand movement obstructing tidal flow, grazing, solid waste		

The area of undisturbed mangroves is rapidly shrinking, whilst degraded and threatened areas are expanding. Degradation and destruction of mangroves will seriously affect marine fisheries, increase coastal erosion and degrade adjacent habitats such as coral reefs and seagrass beds (PERSGA/GEF 2004b) based on similar impacts that have occurred in other mangrove ecosystems.

Red Sea mangroves may be less resilient to the effects of exploitation than mangrove stands in other parts of their range because they are growing in a very hostile environment at the extremes of their range and at the limits of their physiological tolerance (PERSGA/GEF 2004b). Predicted climate changes over the next several decades, especially projected increases in sea levels, are expected to cause major changes in mangrove distribution, productivity and resilience to stress and disturbance. Reduced rainfall in the region over recent decades has possibly contributed to mangrove degradation (PERSGA/GEF 2004c).

Degradation of inland pasture has also forced local inhabitants to shift to mangroves as an alternative source of wood for fuel and for camel fodder. The rate at which mangroves are utilised for fodder and firewood is unsustainable in most areas (PERSGA/GEF 2004b; PERSGA/GEF 2004c).

Camel grazing of mangroves is widespread. Where heavy grazing occurs, impacts include: a considerable reduction in green parts; dryness of upper- and outer-most parts of grazed branches; vertical growth limitation due to multi-stemmed bushes; and seedling and pneumatophore destruction by trampling. Depauperate animal communities are observed in mangroves degraded by heavy camel grazing and woodcutting (PERSGA/GEF 2004b). For example, the abundance of the grapsid crab, *Metopograpsus* sp. appears to be largely influenced by the density and condition of the mangroves. Well-developed and relatively undisturbed mangroves support dense crab populations, whilst degraded and disturbed mangroves had much lower populations.

Mangrove crabs play a significant role in degrading leaf litter and reductions in crab abundance in a mangrove ecosystem will have effects on decomposition processes and nutrient recycling.

Cutting the limbs of living trees (for timber and fodder) is more destructive than camel grazing and the impacts are severe due to the limited size of most stands (Figure 3.2). Stands affected by severe cutting have significantly fewer trees, denuded patches, and barren depressions with altered hydrological regimes and soil compaction. Cutting also provides additional access for camels. Mangroves occurring within MPAs are also subjected to camel grazing and cutting, which indicates deficiencies in existing management and enforcement (PERSGA/GEF 2004b) and the need for management plans to consider this impact (PERSGA 2002; PERSGA/GEF 2004f).

Mass mortality is a severe problem in several areas. The major cause appears to be localised modifications of the coastal topography leading to diversion or blocking of tidal water flow and drying up of mangroves. The ultimate causes include: construction involving dredging and filling for new harbours, jetties, dams, bridges and shrimp farm ponds; the diversion of water to feed salt pans; excessive sedimentation or sand infilling of tidal inlets and channels that prevents flooding of mangroves by seawater (PERSGA/GEF 2004b).

The most important factor leading to the destruction of mangroves in recent years has been the expansion of shrimp ponds into mangrove forests (PERSGA/GEF 2004b). The RSGA countries are striving to become a shrimp producing region. Mangrove stands are favoured for shrimp farms as they are flooded with brackish water that is ideal for aquaculture.

The lack of perennial rivers and aridity of the Red Sea region means that the main source of freshwater, other than desalination, is rainwater harvested from the lower reaches of major valleys. Rapidly increasing coastal populations, industrial development and urbanisation of rural areas have increased



Figure 3.2 Distribution and relative abundance of mangroves in 2002 in Iles des Sept Frères and Ras Siyyan MPA, Djibouti (source: PERSGA 2002). Mangroves are being impacted by camel grazing and cutting.

demand for freshwater. Soil dams are being constructed that considerably reduce freshwater reaching the sea from runoff. Mangrove distribution is greatly affected by the amounts of surface water runoff and alluvium deposited at valley mouths by seasonal floods. Damming damages mangroves by: increased saltwater intrusion causing unsuitable hypersaline habitats; shrinkage of deltas due to decreased alluvium and sediment deposition at river mouths; increased sand in-filling and deposition from the sea obstructing tidal inlets and channels through which tidal flow normally floods mangroves.

Domestic solid waste (e.g. polythene bags and bottles, rubber, plastic and metal cans) is often dumped directly into mangrove stands or dumped nearby and transported in by wind and water, becoming trapped among trees and aerial roots. Several mangrove stands suffer from large accumulations. Untreated or poorly treated sewage leads to stunted, multi-stemmed trees and/or branched, twisting and dead pneumatophores.

Current impediments to management include: major gaps in knowledge of the physical environment of mangroves, floral

and faunal communities and short/long term effects of natural and anthropogenic impacts; lack of sufficient funds; and the fact that mangroves may fall under the jurisdiction of various different authorities.

Specific information about the status of mangroves in the region was summarised in PERSGA/GEF (2001) and PERSGA (2004b), which provide excellent sources of information on the current issues for mangroves in each country. These documents provide a source for a summary of current issues for mangroves in the RSGA (Table 3.1 and Figure 3.3). In addition to the regional synthesis presented in Table 3.1, SIMÕES et al. (2001) reported extensive damage to most mangrove stands on Socotra Island.

3.8 ALGAE AND ALGAL REEFS

More than 500 taxa of benthic algae have been recorded from the Red Sea (PAPENFUSS 1968). Shallow coral reef areas of the northern and central Red Sea are often seasonally dominated by filamentous greens, small browns and tuft-forming red algae (LELIAERT & COPPEJANS 2004). Algal lawns on some reefs in Egypt have standing stocks of about

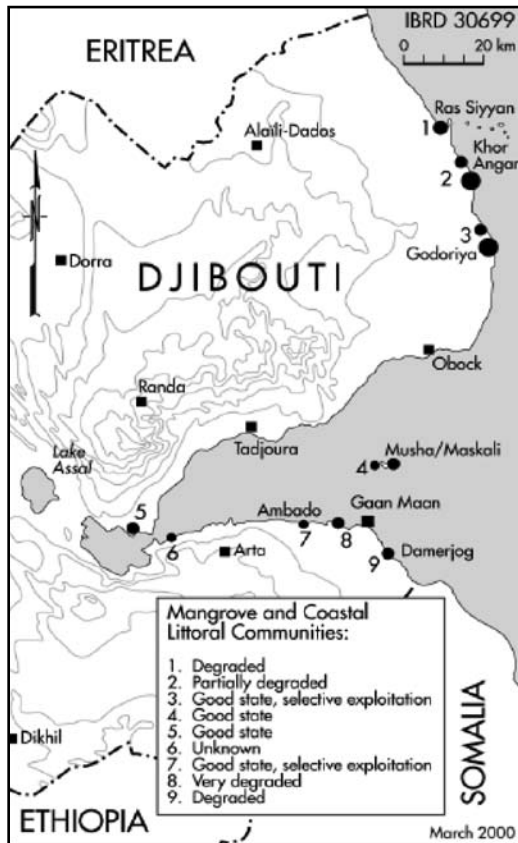


Figure 3.3 General condition of mangroves along the shorelines and on islands of Djibouti (source: PERSGA/GEF 2001).

25 g dry weight m⁻² (PERSGA/GEF 2001). Perennial brown algae, like *Sargassum*, *Cystoseira* and *Hormophysa* are dominant over shallow, hard substrates in the southern Red Sea. Macroalgae often form the major cover of hard substrates in areas too turbid for coral growth (GLADSTONE 2000; PERSGA/GEF 2001).

Red algal reefs occur in shallow coastal waters from the Saudi Arabian border south to the Ras Isa Peninsula (Yemen), and on many nearshore islands. The depth is less than 6 m and typically 2–4 m. There are a few small coral colonies, but reefs are essentially built by red coralline algae of the genera *Porolithon* and *Lithothamnium*. Also present are fleshy macroalgae mainly *Caulerpa* spp., *Sargassum* spp. and *Padina* spp. (PERSGA/GEF 2003b). Fifty taxa of seaweeds belonging to Chlorophyta, Phaeophyta and Rhodophyta have been

reported from the Red Sea coast of Sudan (MISTAFA & ALI 2005). Extensive colonies of macroalgae exist on hard subtidal substrates along parts of the Somali coastline (PERSGA/GEF 2001).

ORMOND & BANAIMOON (1994) reported 163 taxa of macroalgae from the Hadhramaut region of the Gulf of Aden coastline of Yemen. Early phycological studies on the Socotra Archipelago (DICKIE 1888; HOLMES 1903) reported 27 species of marine algae for Socotra Island and Abd al-Kuri. More recent studies have focused on specific taxonomic issues of Socotra's macroalgal flora (KEMP 1998; SCHILS & HUISMAN 2003). In a recent study SCHILS & COPPEJANS (2003a) reported 124 species of marine algae from the Socotra Archipelago that occurred in five distinct communities: algae of coral-dominated reefs; the northern coast of Socotra Island; a transition zone at the eastern extremity of Socotra Island; the southern coast of Socotra Island; and the outer islands. The occurrence of different algal communities is related to the degree of exposure to upwellings and sedimentation (SCHILS & COPPEJANS 2003b). The more exposed southern coasts of the Socotra Archipelago are dominated by macroalgal communities (KEMP 1998; DE VANTIER et al. 2004).

3.8.1 Status, Trends, Issues

Techniques for identifying, collecting, preserving, and qualitatively and quantitatively assessing algae were comprehensively reviewed by LELIAERT & COPPEJANS (2004). Although there have been substantial improvements in knowledge of the algae of the RSGA in recent years, the Gulf of Aden and the northern coastline of Somalia remain as distinct gaps in knowledge (LELIAERT & COPPEJANS 2004). The recognition of distinct algal communities around the Socotra Archipelago (SCHILS & COPPEJANS 2003a) may serve as a useful basis for mapping the associated faunal communities; however this relationship needs to be verified. At present, there is no information on the status of algal communities in any RSGA nation.

3.9 SEAGRASSES AND SEAGRASS BEDS

Eleven species of seagrass occur in the RSGA, ranging from mid-water to depths of 70 m (MISTAFA & ALI 2005). The most commonly recorded species are *Halodule stipulacea*, *H. uninervis*, *Thalassodendron ciliatum*, *Syringidium isetifolium* and *Halophila ovalis* (MISTAFA & ALI 2005). Seagrass beds generally occur in protected areas in lagoons and bays (GLADSTONE 2000). There appear to be three major groupings of seagrass assemblages along the eastern Red Sea that are separated by latitude, which suggests three distinct biogeographic groupings (PRICE et al. 1988). Similarly, three types of seagrass assemblage have been differentiated in the Gulf of Aqaba (SHEPPARD et al. 1992).

In Djibouti seagrasses form large beds in Ras Siyyan lagoon, but are absent from the islands of Sept Frères (Figure 3.4). *Halodule* spp. and *Thalassia* spp. are abundant in the

middle and the northern sector of the lagoon. Local fishers report that seagrass is an important food source for dugong. Seagrass beds are also present in the lagoon to the south of Ras Siyyan in front of Khor Angar. The total area of seagrass beds within the Iles des Sept Frères and Ras Siyyan MPA is 3.2 km² (PERSGA 2002).

In Egypt, the size of seagrass beds increases southward along the Red Sea coast (PERSGA/GEF 2001). This is attributed principally to the wider and shallower shelf and the greater prevalence of unconsolidated sediment. Seagrass beds are protected within the Ras Mohammed National Park and Abu Galum Protected Area (PERSGA/GEF 2003b).

In Jordan, seagrass meadows are composed of *Halophila ovalis*, *Halophila stipulacea* and *Halodule univervae*. The largest seagrass meadow is located at Al-Mamlah Bay and is dominated by *H. univervae* (KHALAF & KOCHZIUS 2002a).

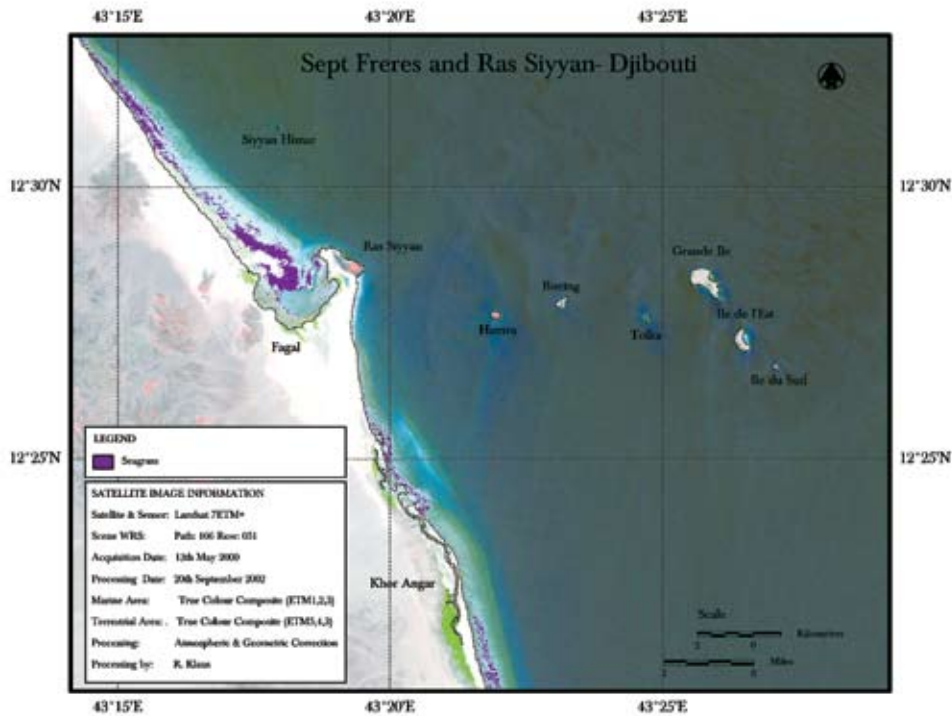


Figure 3.4 The distribution of seagrass biotopes (areas highlighted in purple) around Sept Frères and Ras Siyyan (source: PERSGA 2002).

Seagrasses are widespread along the Red Sea coast of Saudi Arabia. There is a progressive increase in abundance of seagrass beds towards the southern Red Sea owing to the development of the shallow and wide continental shelf area (PRICE et al. 1988; PERSGA/GEF 2001). Seagrass beds tend to be concentrated in shallow water areas such as lagoons, sharms and mersas due to the presence of soft-bottom sediments. Ten species of seagrass have been recorded along the Saudi coast (PERSGA/GEF 2001). Important areas of seagrass include: Al-Wajh Bank, Sharm Habban and Sharm Munaybirah, Ghubbat Bal'aksh, Khor 'Amiq to Al-Qahmah; Shuqaiq; Jizan and the Farasan Islands (GLADSTONE 2000; PERSGA/GEF 2003b; PERSGA/GEF 2003c; PERSGA/GEF 2004b).

The Gulf of Aden coastline of Somalia has very few seagrass beds due to the high energy environments. Seagrass beds are found mainly in the extreme north-west of Somalia near Sa'adadin Island. Further east, sand movement prevents seagrass settlement (PERSGA/GEF 2001). However, detailed surveys are required to confirm these patterns of distribution.

Seagrass beds in Sudan are frequently found in shallow mersas and lagoons between the coast and fringing reefs (PERSGA/GEF 2001). The most abundant species are *Halodule uninervis*, *Thalassia hemprichii*, *Cymodocea rotundata* and *Halophila ovalis* (MISTAFA & ALI 2005). The total area of seagrass in the Dungonab Bay–Mukawwar Island MPA is 11.68 km² (made up of at least seven species), making it a nationally and regionally significant site for seagrass (Figure 3.5). This is especially significant because it is likely to be supporting a substantial population of dugong (PERSGA/GEF 2004f).

Approximately 42% of the coastline of Yemen supports seagrass beds, mostly in shallow, sheltered areas of the Red Sea coastline (ROUPHAEL et al. 1999). The most extensive beds occur north of Salif and at Khawba, Mukha, Luhayyah, Midi and As Salif (ROUPHAEL et al. 1999; MISTAFA & ALI 2005). Nine species have been recorded from the Red Sea coast and three species have been recorded from the Gulf of Aden. Large seagrass beds occur at Khor Umaira and Ras Imran on the Gulf of Aden coast (PERSGA/GEF 2001). The Gulf of Aden coast and the Socotra Archipelago have relatively fewer seagrass beds due to their high energy environments. Five species have been recorded from the Socotra Archipelago (SCHILS & COPPEJANS 2003b) and substantial areas of *Halodule* sp. and *Cymodocea serrulata* occur in areas protected from wave exposure (PERSGA/GEF 2001).

Seagrass beds in the Red Sea are inhabited by a diverse fauna that increases from 49 species in the Gulf of Aqaba to 91 species further south. The major groups inhabiting seagrass beds include molluscs, polychaetes, crustaceans, echinoderms, and fishes, with perhaps close to 10% of species occurring in seagrass beds occurring nowhere else. The standing crop and productivity of Red Sea seagrass beds is



Figure 3.5 The distribution and relative abundance of seagrass around Dungonab Bay and Mukawwar Island, Sudan (source: PERSGA/GEF 2004f).

comparable to that reported from other tropical regions. Like seagrass systems in other parts of the world, in the Red Sea region seagrass beds stabilise nearshore sediments, provide a juvenile habitat for a range of commercially important crustaceans and fishes, are a source of food for significant species (e.g. dugong, turtle), and probably export nutrients and energy to adjacent subtidal systems (SHEPPARD et al. 1992).

3.9.1 Status, Trends, Issues

Although species of seagrass are known to occur in all parts of the RSGA (including the Gulfs of Aqaba and Suez), the distribution of seagrass beds overall is poorly known (PRICE et al. 1988). The species composition, abundance and distribution of seagrass in the northern Red Sea are well known (FISHELSON 1971; LIPKIN 1979; JACOB & DICKS 1985). Seagrass abundance and distribution has been documented along the Red Sea coast of Saudi Arabia (PRICE et al. 1988; PRICE et al. 1998) and parts of Yemen (BARRATT et al. 1987; ROUPHAEL et al. 1999). Much less is known of the distribution and status of seagrass in other countries, although as part of the Strategic Action Programme (SAP) some preliminary data on seagrass beds in each country were assembled (PERSGA/GEF 2001). There are standard techniques for collecting seagrasses and for *in situ* surveys (ENGLISH et al. 1997). These were adapted for the RSGA by LELIAERT & COPPERJANS (2004).

There is a need for a regional assessment of the status of seagrass beds using the standard methods and for the development of a regional action plan. Information about seagrass in the Gulf of Aden area is particularly inadequate. Indicators of the status of seagrass ecosystems need to be selected from the standard survey methods and updated regularly for the production of future state of the environment reports.

3.10 SUBTIDAL SOFT BOTTOMS

Extensive areas of subtidal sand and mud occur throughout the RSGA and each has

distinct assemblages of flora and fauna. Sand-based systems occur in high energy environments in shallow water close to reefs or on high energy, exposed coastlines. Mud-based systems occur in protected, low energy environments, such as khors and bays. Within the Red Sea soft bottoms of coarse sands and gravel mixed with mud are inhabited by a distinct community of crabs, bivalves and macroalgae. Gravel-shell substrates overlaying silty mud are inhabited by mollusc-dominated communities (SHEPPARD et al. 1992).

3.10.1 Status, Trends, Issues

Extensive and rapid coastal development and the occurrence of commercial benthic trawl fisheries throughout large parts of the region mean there is an increasing need for monitoring soft bottom fauna throughout RSGA (KEMP 2004). In common with many other countries with coral reefs, the subtidal soft bottom habitats have received less attention for conservation than the coral reef, mangrove and seagrass ecosystems (but see FERNANDES et al. 2005). This has occurred despite the acknowledged importance of inter-reefal soft bottom habitats as repositories of distinct assemblages of biodiversity, as nursery areas for commercially important fishes and other species, as nocturnal feeding grounds for many reef fishes, and as sites for decomposition and nutrient transfer (ALONGI 1990).

A critical first step is the compilation of maps of the distribution of subtidal soft bottom habitats. The review by KEMP (2004) covers the techniques, equipment, and sampling protocols required to assess the biodiversity of soft bottom habitats.

Uncertain knowledge of the extent of soft bottom habitats in most countries of the RSGA means that it is difficult to assess the potential impacts of human activities and the representativeness of existing MPAs. In particular, it is unclear how well locations selected for the RSGA Regional MPA Network include subtidal soft bottom habitats.

3.11 CORALS, CORAL REEFS AND CORAL COMMUNITIES

The Red Sea is most famous for its extensive and beautiful fringing coral reefs that drop steeply into the depths and are swept by very clear water. The coral reefs of the Red Sea are the best developed reefs in the western Indian Ocean (PERSGA/GEF 2004d). There are, in addition, many other reef types that contribute to the great diversity of this system within the region, and hence support an enormous reef-associated biota. The two terms 'coral reefs' and 'coral communities' are used here to emphasise the distinction between biogenic, accreting reefs produced by scleractinian corals, and coral communities growing on rock or soft substrates. Corals occur primarily on fringing reefs around the mainland and islands, barrier reefs, pinnacles, and atolls. Other habitats that also contain corals include submerged patch reefs, coralline red algal beds, relic reef formations, and volcanic rock flows (PERSGA/GEF 2003b).

The richness of hermatypic corals in the Red Sea was believed to be 180–200 species (SHEPPARD & SHEPPARD 1991; SHEPPARD et al. 1992). However, a recent extensive study of the central-northern Red Sea coastline of Saudi Arabia extended this to probably 260 species, based on recently described species and range extensions (DE VANTIER et al. 2000a).

Thirteen types of coral communities have been identified for the Gulfs of Aqaba and Suez and the eastern Red Sea to the Yemen border, defined by species presence and their relative abundances. There is a clear north–south trend in the occurrence of the different community types and it appears that latitude, bathymetry and coastal morphology are the underlying factors responsible for this pattern (SHEPPARD et al. 1992).

Reef development varies from north to south in the Red Sea. North of 20°N reefs are well-developed, occurring as narrow fringing reefs with steep slopes that drop into very deep water. The eastern shore of the Gulf of Suez has limited areas of reef

development but extensive small coral patch reefs. By comparison, the western shore has a well-developed system of fringing reefs. The Gulf of Aqaba has narrow fringing reefs that plunge vertically into deep water. An almost continuous band of fringing coral reefs occurs on both sides of the Red Sea southward to about 18–20°N. Reef types diversify toward the southern limit of this distribution as the width of the fringing reef increases and other reef types occur offshore. A longitudinal series of coral reefs exist within the Red Sea, effectively forming a series of barrier reefs. These barrier reefs are 10–40 km offshore of the Saudi Arabian coastline and extend southward for 400 km. Similar systems of reefs occur on the African side of the Red Sea. There are also isolated patch reefs and atoll-like structures, the most famous of which is Sanganeb Atoll in Sudan.

South of 20°N the continental shelf widens and therefore reefs are less well developed vertically, and often occur in more turbid water (SHEPPARD et al. 1992). In many places the coastal fringing reefs disappear and are replaced by stands of mangroves, sand beaches, and scattered patch reefs near the coast. For example, fringing coral reefs occur along only 25% of the Red Sea coast of Yemen (PERSGA/GEF 2001). Seasonal coverings of macroalgae are a feature of shallow coral reefs in the southern Red Sea, and they often form the major coverage of hard substrates in areas too turbid for coral growth (GLADSTONE 2000; PERSGA/GEF 2001). Reef diversity in the southern Red Sea is greatest offshore and includes platform and patch reefs, barrier reefs, coral cays, and extensive fringing reefs around island systems, especially the Farasan and Dahlak (Eritrea) groups of islands.

Descriptions of the composition and status of corals, coral reefs and coral communities of the Red Sea and Gulf of Aden occur in SHEPPARD & SHEPPARD (1991); SHEPPARD et al. (1992); DE VANTIER et al. (2000a, 2004); KEMP (1998); and KEMP & BENZONI (2000). The following overview of the status of corals and coral reefs is based primarily on PERSGA/GEF (2003a) and PERSGA/GEF (2003b).

The Egyptian coastline is about 1,800 km along the Gulfs of Suez and Aqaba and the Red Sea proper. Most of the coastline is bordered by fringing coral reefs. Coral reefs also exist as submerged reefs and fringing reefs on about 35 small islands. The distribution and development of reef building corals in Egypt is mainly restricted by water temperature, sediment load, salinity and light intensity. These factors combined make the Gulf of Aqaba a more suitable reef habitat than the Gulf of Suez. The greatest development of corals occurs at the tip of Sinai Peninsula at Ras Mohammed and between Hurghada and Safaga.

Coral reefs in the northern and central sections of the Egyptian Red Sea are more diverse than reefs in the southern sections of the Egyptian Red Sea. Diversity of reef building corals in Egypt is distributed in the following pattern: Gulf of Aqaba (47 genera, 120 species); Gulf of Suez (25 genera, 47 species); northern Red Sea (45 genera, 128 species); central portion of the Egyptian Red Sea (49 genera, 143 species); and southern Egyptian Red Sea (31 genera, 74 species) (PERSGA/GEF, 2003b). Fifty-three species of reef-building corals were found at reefs off Hurghada (AMMAR & AMIN 2000).

Fringing reefs border up to 50% of the Jordanian coastline and support a high diversity of coral and associated fauna. The coastline is short (27 km) compared to other RSGA countries and its coral reefs are therefore significant for the overall conservation value of Jordan. There are at least 158 coral species from 51 genera. Only one MPA, Aqaba Marine Park, is located in the southern portion of the Jordanian Gulf of Aqaba.

There have been many detailed studies of the coral reefs of Saudi Arabia and much is known about their species composition, assemblage diversity, and threats compared to other RSGA countries. There are at least 260 species of scleractinian corals from 68 genera and 16 families. The most speciose families are Acroporidae, Faviidae and Poritidae. There are at least 30 taxa of soft

corals, fire corals, zoanthids and gorgonians, but lack of taxonomic expertise means actual species diversity is likely to be substantially higher. Species richness of scleractinian corals in northern–central Red Sea ranges from 20–100 species, with an average of 61 species per survey site. Deeper sites are slightly richer in coral species than shallow sites. No clear latitudinal or longitudinal differences are apparent in the diversity of corals in Saudi Arabia.

The coral reefs of Saudi Arabia support a unique composite fauna of corals that includes widespread Indo-Pacific species (e.g. *Pocilloporadamicornis*, *Gardineroseris planulata*); widespread Indo-west Pacific species (e.g. *Stylophora pistillata*, *Acropora muricate*); species previously known only from the Pacific Ocean (e.g. *Cantharellus noumeae*); species widespread in the Indian Ocean (e.g. *Coscinaraea monile*, *Siderastrea savignyana*); species widespread in the western Indian Ocean (e.g. *Acropora hemprichii*); Red Sea (e.g. *Symphyllia erythraea*, *Merulina scheeri*, *Cantharellus doederleini*); and a number of species not yet described (PERSGA/GEF 2003a).

Coral reefs fringe much of the Saudi Arabian Red Sea coastline and offshore islands (Figures 3.6 and 3.7). Extensive mainland fringing reefs occur around Rabigh, Ras Baridim Umluj, Al-Wajh to Duba and the Gulf of Aqaba. Island fringing reefs are common in the Tiran area and from Duba to Al-Wajh Bank to Umluj. The best developed barrier reef system in the region occurs along the seaward margin of Al-Wajh Bank. South of Jeddah reefs become less well developed along the coast. However, offshore complex reef structures develop on the Farasan Bank and islands, including tower reefs which are rare or absent in other areas of the Saudi Arabian Red Sea.

The near continuous reef tract along the Saudi Arabian coastline has high local, regional and global conservation significance. Most of the world's reef types are represented including mainland fringing, island fringing, platform patch, pinnacles and barrier reefs. Reefs are highly developed in sharms, a characteristic reef

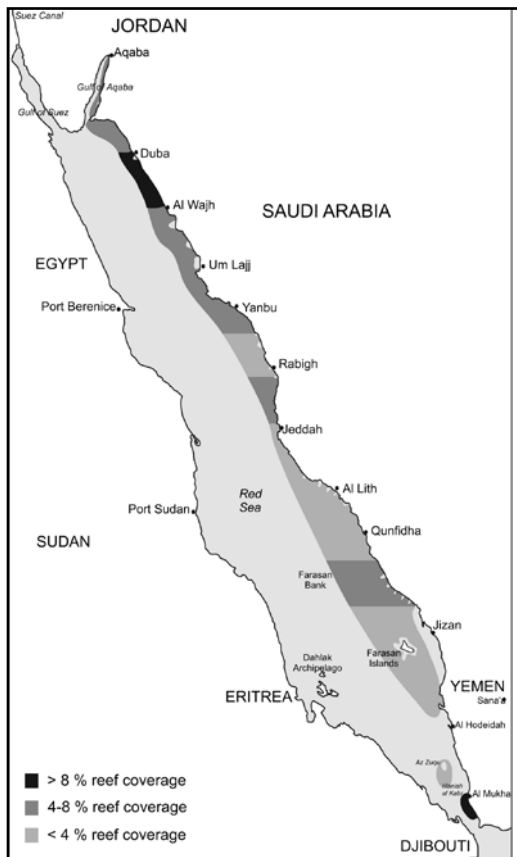


Figure 3.6 Map of the eastern coast of the Red Sea indicating coral reef densities: shading represents areas of a 500 m by 500 m quadrat which was reef (source: PERSGA/GEF 2003b).

form largely restricted to the Red Sea. Most reefs are actively accreting. They support coral communities with highly variable live coral levels and diversity, including endemics and others not yet described. On a global scale, the area spanning the Farasan Islands to Haql (Gulf of Aqaba) is one of the most important coral reef areas for coral reef management.

There are four regions of special conservation importance for coral reefs in Saudi Arabia:

1. Gulf of Aqaba: reefs of the Gulf of Aqaba have a high level of coral cover and species diversity, including species that are rare or apparently absent elsewhere (e.g. *Cantharellus doerderleini*, *Caulastrea tumida*). Of particular note are the characteristic narrow contour reefs (less than 50 m wide) which are present on steep coastal slopes and are among the most species-rich reefs of the entire region. The Gulf of Aqaba is the north-west most extent of reef development in the Indo-Pacific region.
2. Tiran area: this extends from north of Duba to the entrance to the Gulf of Aqaba. Reef complexes support a high species diversity that includes Red Sea endemics, presently undescribed species and species with restricted distributions that are rare

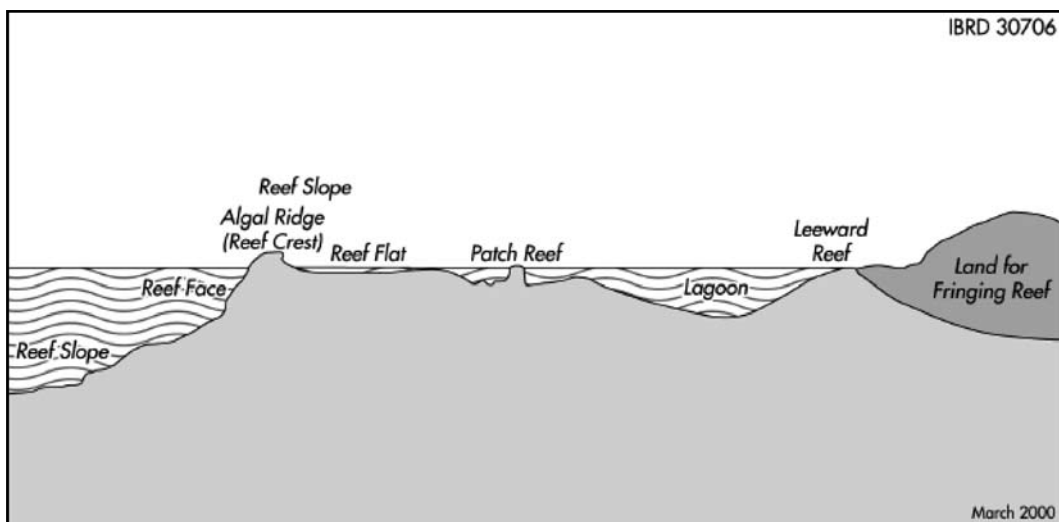


Figure 3.7 Cross sectional schematic diagram of Saudi Arabian coral reef structure (source: PERSGA/GEF 2001).

- or otherwise absent in the Red Sea.
3. Al-Wajh Bank: this area supports the greatest range of reef types in region. The Al-Wajh Bank also includes Red Sea endemics, undescribed species and species with restricted distributions.
 4. The Farasan Islands and Farasan Bank support a wide variety of reef types, including tower reefs.

The coast of Sudan contains the most diverse reefs of the Red Sea (Figure 3.8). The primary coral reef habitats are barrier reefs, fringing reefs, isolated patch reefs, and one oceanic atoll (Sanganeb). Most of 750 km coast is bordered by 1–3 km wide fringing reefs separated by deep channels

from a barrier reef 1–14 km offshore. The outer slopes of the barrier reefs drop steeply to several hundred metres depth. The 12 km² Sanganeb atoll is one of the most unique reef structures in the Red Sea, with steep slopes rising from the seafloor at over 800 m depth. Sanganeb atoll has highly diverse and complex coral reefs, diverse reef-associated fauna, sharks, marine mammals and mantas. The Dungonab Bay–Mukawwar Island MPA has a great diversity of corals and coral habitats. Eight coral habitats have been identified and mapped (PERSGA/GEF 2004f) (Figure 3.9).

BENAYAHU et al. (2002) reported 28 species of soft corals from the Dahlak Archipelago in Eritrea. The coral reefs of

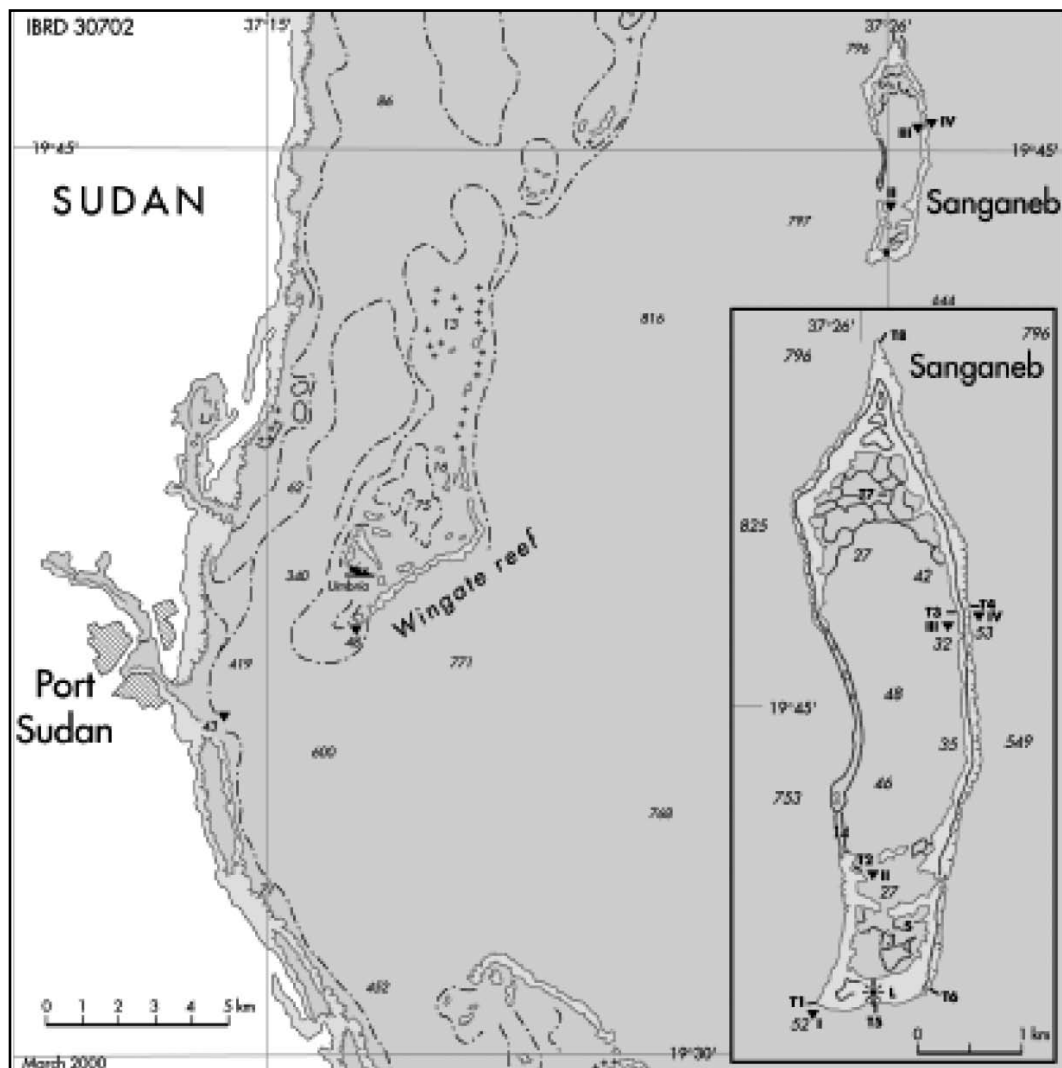


Figure 3.8 Reefs in the vicinity of Port Sudan (source: PERSGA/GEF 2001).

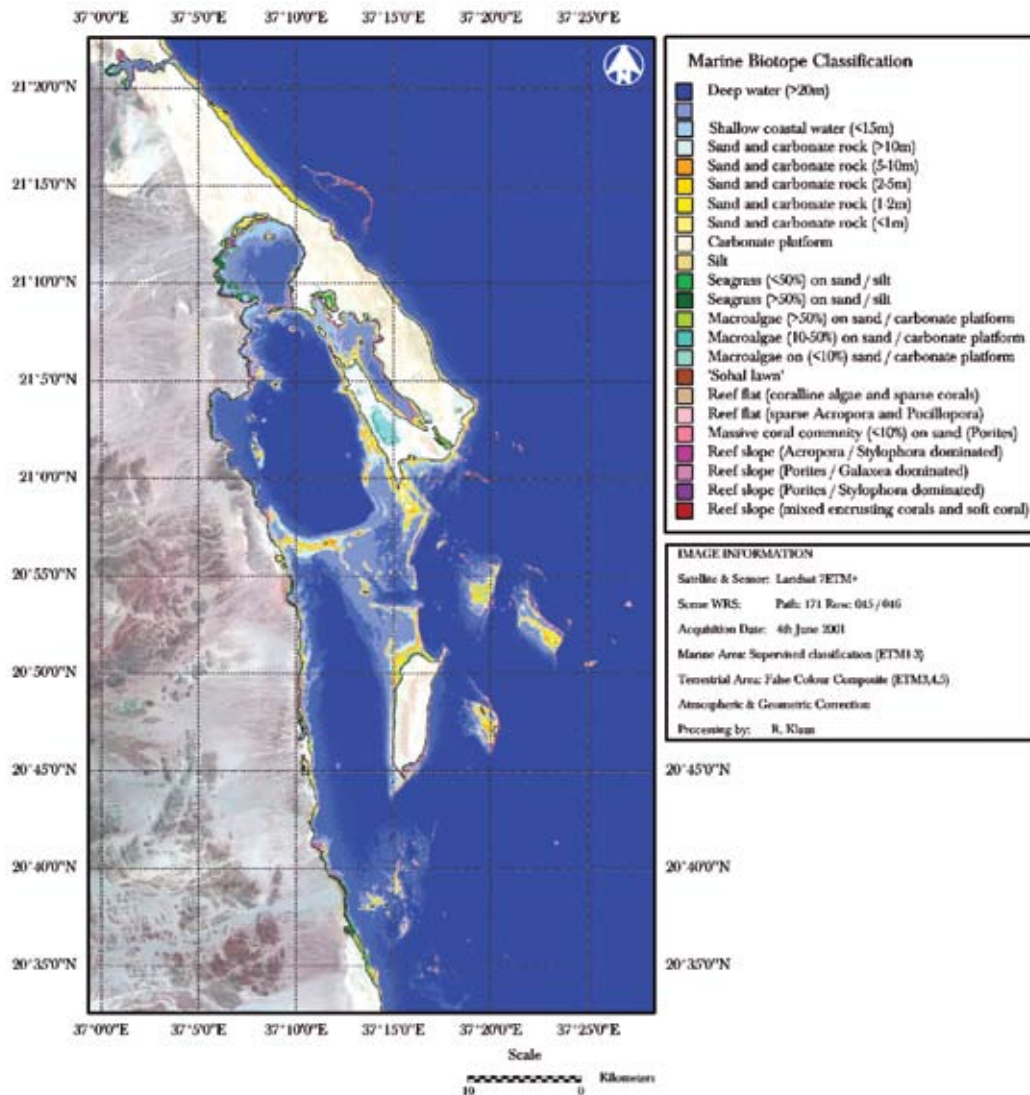


Figure 3.9 Coral-based biotopes within the Dugonab Bay–Mukawwar Island MPA (source: PERSGA/GEF 2004f).

Somalia are reported to have representatives of at least 74 species of scleractinian corals, 11 species of alcyonacean coral and 2 species of fire corals (PERSGA/GEF 2003b).

The coral reefs and coral communities of Yemen have developed in some of the most extreme environments known for coral. The Red Sea environment of Yemen includes high sea temperatures, minimal tidal movement and relatively calm seas. The Gulf of Aden coastline of Yemen experiences seasonal cool water upwellings and large oceanic waves. Fringing coral reefs occur along only 25% of the Red Sea coast of Yemen. In spite of these physical difficulties, more

than 300 species (60 genera, 16 families) of reef building corals have been identified from Yemen's reefs and coral communities. About 176 species (56 genera, 14 families) are known from the Yemeni Red Sea, with the species richness of individual sites ranging from 1–76 species (TURAK & BRODIE 1999). These values are likely to increase with more samples awaiting identification.

TURAK & BRODIE (1999) recognised a number of coral growth forms in the Red Sea of Yemen: coral reefs (including fringing reefs off the south mainland coast and islands; and submerged patch reefs

scattered from offshore Al Hudaydah to the southern Farasan Islands); and coral communities (including coral communities on red algae reefs; coral growth on relic Pleistocene/Holocene reef formations; coral communities on volcanic rock, around volcanic islands, and on terraces formed by old lava flows). TURAK & BRODIE (1999) further recognised six distinct community types of corals: semi-protected island reefs; clear water corals; corals of deep water pinnacles; low diversity communities; exposed, monospecific communities; and the fringing reefs south of Khawkhah. The combination of data on reef types and coral communities is an excellent basis for the selection of representative MPAs.

The Gulf of Aden coast of Yemen appears to have lower diversity of corals, with about 100 species (38 genera, 14 families). However, the coral biodiversity remains poorly studied. The richest area of coral communities on the Gulf of Aden coast of Yemen occurs in the Belhaf–Bir Ali area, where about 100 species of scleractinian corals have been recorded and coral cover ranges from less than 10% to more than 75%. Coral-based fringing reefs occur on only 5% of the Gulf of Aden coastline of Yemen, with extensive fringing coral reefs occurring only around the islands of Sikha and Halareya in the Belhaf–Bir Ali area (PERSGA/GEF 2001). More recent studies along the northern Gulf of Aden coastline of Yemen have revealed extensive coral communities on all rocky coasts surveyed and in several areas with unconsolidated, sandy substrates. Three distinct community types were recognised that appear to be geographically-based: southern Oman, al-Mukalla, and Shabwa province (KEMP & BENZONI 2000). The absence of fringing reefs along this coastline is a result of higher wave energies, nutrient enrichment from upwellings, and the existence of large areas of unstable sandy substratum.

One hundred and sixty-seven species of corals have been recorded from Djibouti, including three species of black coral. Spatial patterns in the distribution of coral biodiversity can be assessed from the results of recent surveys. Ten per cent of coral

species were found at all sites surveyed, 40% were found at several sites, and 50% were restricted to a few sites. Coral cover is dominated by *Acropora hemprichii*, *Echinopora fruticulosa* and *Porites nodifera*. Only *Porites lutea* was recorded at every survey site. The highest diversity of corals was recorded from Arta Plage, Gulf of Tadjoura (93 species) followed by Iles des Sept Frères (84 species) and Trois Plages, Gulf of Tadjoura (75 species) (PERSGA/GEF 2003b). The corals of Djibouti are a unique assemblage of species due to the confluence of several biogeographic zones including the tropical warm water biota of the Indian Ocean and Red Sea and species common to cold water upwelling habitats of the Somali and Arabian regions.

The coastline of Djibouti is fringed in places by extensive coral reefs (Figures 3.10 and 3.11). In particular, coral outcrops occur at Ras Siyyan and Kadda. Iles des Sept Frères are fringed by reefs and extensive coral reefs surround Iles Moucha and Maskali. The southern coast has poorly developed reefs due to cold water upwelling from the Indian Ocean.

There are extensive areas of coral reef along the Gulf of Aden coastline of Somalia around Sa'adadin Island, which is on the extreme north-west of the coast near the border with Djibouti. These may be the largest coral reefs in the Gulf of Aden. Smaller coral reefs occur west of Xabo and between Buruc and Bosaso. Reefs of limited extent occur near Ras Khansir, Ras Cuuda and Siyara. There are considerable reef areas off El Girdi and west of Berbera. The diversity and abundance of scleractinian corals is extremely high on reefs of Sa'adadin Island and comparable to the healthiest reefs in the western Indian Ocean and Red Sea. The high diversity is due to the mixing of species from different areas: the Indian Ocean, Red Sea, and Arabian Sea.

The Socotra Archipelago supports 253 species of scleractinian corals (58 genera, 16 families), placing it among the richest sites in the western Indian Ocean. This is significant given the small area of coral communities and the similarity in richness

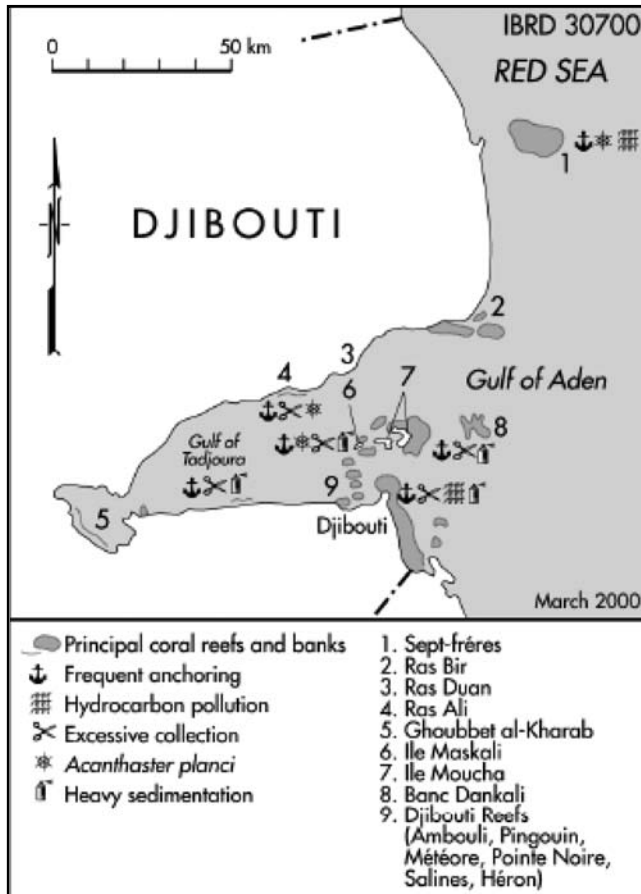


Figure 3.10 The coral reefs of Djibouti and their status (source: PERSGA/GEF 2001).

to the entire Red Sea (DE VANTIER et al. 2004). The high diversity is related to the co-occurrence of a composite coral fauna from the Indo-Pacific region, the Indian Ocean, East Africa, Arabia and the Red Sea (PERSGA/GEF 2003a). There is only minor development of coral reefs around the Socotra Archipelago, existing mostly as small reef flats at a few locations on the northern sides of islands. Coral communities are generally non-accreting, growing on rocky substratum or on fossil reef structures. The dominant biotic habitat on the more exposed southern coasts consists of macroalgal communities growing on non-reefal rock. Despite the limited extent of coral reefs and coral communities the existing communities have a high regional conservation value. Coverage of living stony corals approaches 100% in some areas, and such high coverage is rare elsewhere in the Gulf of Aden and Arabian Sea (KEMP 1998; DE VANTIER et al. 2004).

3.11.1 Status, Trends, Issues

Reef health is generally good throughout the RSGA, with 30 to 50% live coral cover at most locations and more than 50% total cover on average. These values are within the range of other reefs surveyed globally as part of the Reef Check programme (Table 3.2). Coral diversity and reef-associated fauna were considered amongst the highest in the Indian Ocean region.

General threats to coral reefs and coral communities of the RSGA include the following: land filling and dredging for coastal expansion; destructive fishing methods; shipping and maritime activities; sewage and other pollution discharges; damage from the recreational scuba industry; global climate change; and insufficient implementation of legal instruments that affect reef conservation such as MPAs (PERSGA/GEF 2003b).

Live coral cover in Egypt varies from 55% in exposed areas to 85% in sheltered areas. There is a significant variation in coral cover between reef habitats. Live coral cover varies from 11–35% in reef flat areas, 12–85% along walls, 5–62% on reef slopes and 11–65% on reef edges (Table 3.3). Rapid coastal development over recent decades has generated a range of anthropogenic threats to Egypt's coral reefs: high sedimentation, nutrient enrichment, dredging, destructive fishing, tourism and curio trading. Resort development is proceeding very rapidly. Significant declines in live coral cover associated with the recreational scuba diving industry have been reported for a number of years. RIEGEL & VELIMIROV (1991) found a significant increase in coral breakage on reefs highly frequented by tourists. HAWKINS & ROBERTS (1992) recorded a significant increase in reef damage (measured as frequency of damaged or dead corals and number of loose coral fragments) on heavily dived

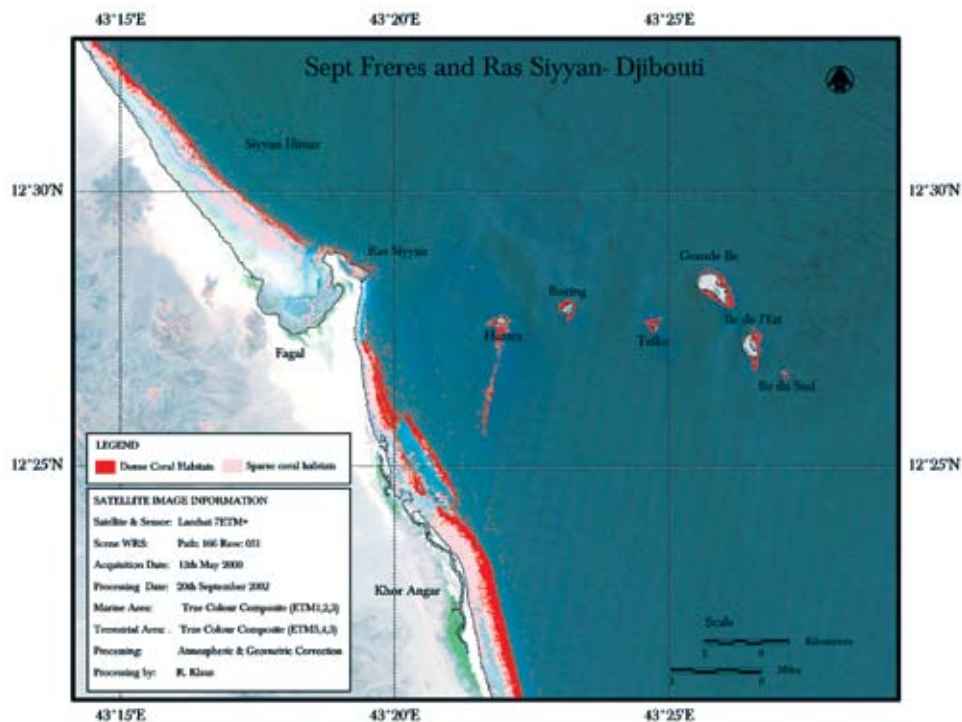


Figure 3.11 The distribution of coral habitats around Sept Frères and Ras Siyyan, Djibouti (source: PERSGA 2002). Dense coral habitats (in red) indicate where the area is dominated by corals. Sparse coral habitats (in pink) indicate areas where corals were found in association with other more dominant groups such as macroalgae or turf algae.

reefs. MEDIO et al. (1997) found that diver-related damage was the major cause of coral mortality in the Ras Mohammad National Park. Surveys of reefs between Hurghada and Safaga between 1996 and 1998 found a decrease in living coral cover and an increase in dead coral and coral rubble, with diver damage being the most probable cause (ABOU ZAID & KOTB 2000). JAMESON et al. (1999) developed an index of coral damage for use in rapid assessment of reef condition and found that 40% of their survey transects between Hurghada and Safaga were 'hotspots' of coral damage requiring management action. The depth distribution of coral damage suggested that most of the damage in shallow sections of reefs was caused by anchors.

Expansion of the dive tourism industry in Egypt has meant that some dive sites are experiencing very high usage levels. Dive sites in the Ras Mohammad National

Park received up to 20,000 dives per year (MEDIO et al. 1997). Of the reefs between Hurghada and Safaga, Ras Abu Sama reef experienced 45,600 dives per year and Small Giftun reef experienced 121,200 dives per year (JAMESON et al. 1999). This level of usage far exceeds the estimated sustainable carrying capacity for Egyptian coral reefs of 5,000 to 6,000 dives per year (HAWKINS & ROBERTS 1997).

Four MPAs in the RSGA Regional Network of MPAs in Egypt include coral reefs (PERSGA/GEF 2003b): Ras Mohammed National Park, Nabq Multiple Use Management Area, Abu Galum Multiple Use Management Area and Elba Protectorate. An additional MPA is proposed that would also encompass a considerable area of coral reefs: the Red Sea Marine Protected Area from Hurghada to Gebel Elba (PERSGA/GEF 2003a).

Table 3.2 Summary of Reef Check results for 1997–2001 for reefs surveyed in Egypt, Eritrea and the Socotra Archipelago (adapted from HODGSON & LIEBELER 2002). Also shown is a comparison with global or regional averages. Values are number of individuals per 100 m² (except for percentage cover of live coral).

Indicator	Country	Status	Comparison
Live coral	Egypt	none-high	3% reefs (global) with cover >70%
	Eritrea	low	
	Socotra	low	
Lobster	Egypt	0	90% Indo-Pacific reefs with zero
	Eritrea	0	
	Socotra	0	
Crown-of-thorns starfish	Egypt	0	78% reefs (global) with zero
	Eritrea	0	
	Socotra	0	
<i>Tridacna</i> spp. giant clams	Egypt	0	29% reefs (global) with zero
	Eritrea	0	
	Socotra	4–11	
Sea cucumbers	Egypt	0 to >5	50% reefs (global) with zero
	Eritrea	2–5	
	Socotra	>5	
Butterflyfishes	Egypt	17–44	Indo-Pacific average = 10
	Eritrea	17–44	
	Socotra	>44	
Groupers	Egypt	2 to >4	48% Indo-Pacific reefs with zero
	Eritrea	>4	
	Socotra	>4	
Snapper	Egypt	0 to >20	57% Indo-Pacific reefs with zero
	Eritrea	>20	
	Socotra	1–2	
Parrotfish	Egypt	0 to >4	55% Indo-Pacific reefs with zero
	Eritrea	0	
	Socotra	0	
Humphead wrasse	Egypt	0	88% reefs (global) with zero
	Eritrea	0	
	Socotra	0	

Table 3.3 Average percentage of live coral cover in different reef zones along the Egyptian coastline (from PERSGA/GEF 2003b).

Sector	Zone			
	Reef Flat	Reef Edge	Reef Wall	Reef Slope
North of Hurghada	30	65	68	35
Hurghada - Safaga	18	25	50	20
Safaga - El Quseir	16	45	33	20
El Quseir - Marsa Alam	14	25	50	5
Marsa Alam - Hamatah	11	20	45	12
Hamatah - Baranis (Berenice)	12	20	22	10
Baranis - Shalatein	20	11	12	45
Shalatein - Halaib	35	48	85	62

Coral reefs in Jordan are localised. As a result of intense coastal development, the small area of reef has been put under considerable pressure. Threats to the health of Jordan's coral reefs include coral predators, pollution, and port activities. Overall, the reefs are in good condition, supporting up to 90% cover of scleractinian coral. There was no evidence of bleaching observed after the 1997–98 bleaching event. A high density (212 m⁻²) of the muricid gastropod, *Drupella cornus*, was recorded in 1994 (PERSGA/GEF 2003a). In 1997 black band disease was significantly more prevalent in coral colonies at reefs near the Industrial Area compared with corals immediately offshore from the Marine Science Station (AL-MOHRABI 2001). In 2000, skeleton eroding band disease, another coral disease, was most prevalent at the tourist area and industrial zones in Aqaba, compared with the prevalence at the Marine Science Station (WINKLER et al. 2004).

Coral cover in Saudi Arabia shows considerable variability due to reef-specific characteristics, disturbance histories and species-specific tolerance to stress, particularly exposure, sediment levels, turbidity and light. Between 1998 and 1999 in the central-northern Red Sea living coral cover ranged from less than 10% to more than 75% and averaged 35%. Approximately

17% of sites had living cover of greater than 50%, particularly on shallow reef slopes dominated by mono- or multi-specific stands of *Acropora*, *Porites* and *Millepora* spp. Dead coral cover was relatively minor (average less than 7%). Reef Check surveys in the Al-Wajh Bank recorded an average cover of hard corals of 42% and an average cover of dead corals of 10% (DE VANTIER et al. 2000a).

Most reefs in the central-northern Red Sea in 1998–1999 were in good condition (DE VANTIER et al. 2000a). There was little evidence of human impact apart from on reefs near urban areas. The incidence of coral injuries and death was low (less than 10% cover of dead corals). Coral communities were affected by bleaching, crown-of-thorns starfish, or sedimentation on approximately 10% of reefs.

Coral reefs of the Saudi Arabian Red Sea are generally in good condition, with the exception of those near Jeddah and Yanbu. Specific anthropogenic threats to reefs derive from pollution, industrial and urban development (specifically dredging and land-filling), recreation and tourism. Coral reefs in the vicinity of the waste water discharge at Yanbu have been significantly impacted, compared to reference locations (PAIMPILLIL et al. 2002). Excessive sediment and phosphate loads reduced

coral recruitment and live coral coverage and promoted an excessive growth of filamentous algae. Continuing stress from the waste water discharge was limiting the recovery of the coral reef from the initial impacts associated with construction of the facility.

The condition of Sudan's coral reefs was assessed in 1997 (PERSGA/ALECSO in press) and 1999 (NASR & AL-SHEIKH 2000; PERSGA/GEF 2003b) (Figure 3.12). Average live coral cover on reefs in less than 10 m depth ranged from 5–75%. Healthy colonies of framework corals were observed below 10 m. In 1997, four fifths of coastal fringing reefs had a high percentage of thin algal film cover and on these reefs coverage of algal film averaged 28.8%. Algal film was the dominant substrate cover in water less than 10 m deep and was attributed to a thermal event (possibly runoff of high temperature waters from a lagoon). Live coral cover ranged from 5–60%, with dead coral cover higher than 1% noted at only five sites. In the 1999 surveys live coral cover varied between 23.5% and 50% at a relatively pristine location (Abu Hashish Jetty) to less than 10% at one location (Abu Auros) believed to be affected by tourism activities.

Coral reefs in the Dugonab Bay–Mukawwar Island MPA were assessed in 2002. Major differences in the health of coral communities were present between parts of the MPA. The coverage of living coral was generally greatest within Dugonab Bay (Figures 3.13 and 3.14). The greater coverage of dead coral outside Dugonab Bay was attributed to the effects of the 1998 coral bleaching event. Corals within Dugonab Bay may be pre-adapted to greater ranges in sea surface temperature because of the semi-enclosed nature of the bay. Additionally, it is possible that Dugonab Bay may not have experienced the elevated sea surface temperatures because it is somewhat isolated from the main body of the Red Sea, unlike coastal areas of the MPA (PERSGA/GEF 2004f).

Sanganeb Marine National Park and Dugonab Bay–Mukawwar Island are the only MPAs in Sudan. Both MPAs have large areas of coral reefs. Three other MPAs proposed for Sudan also contain coral reefs: Shuab Rami; Suakin archipelago; and Abu Hashish. Current threats to the coral reefs of Sanganeb include anchor and fin damage from recreational diving.

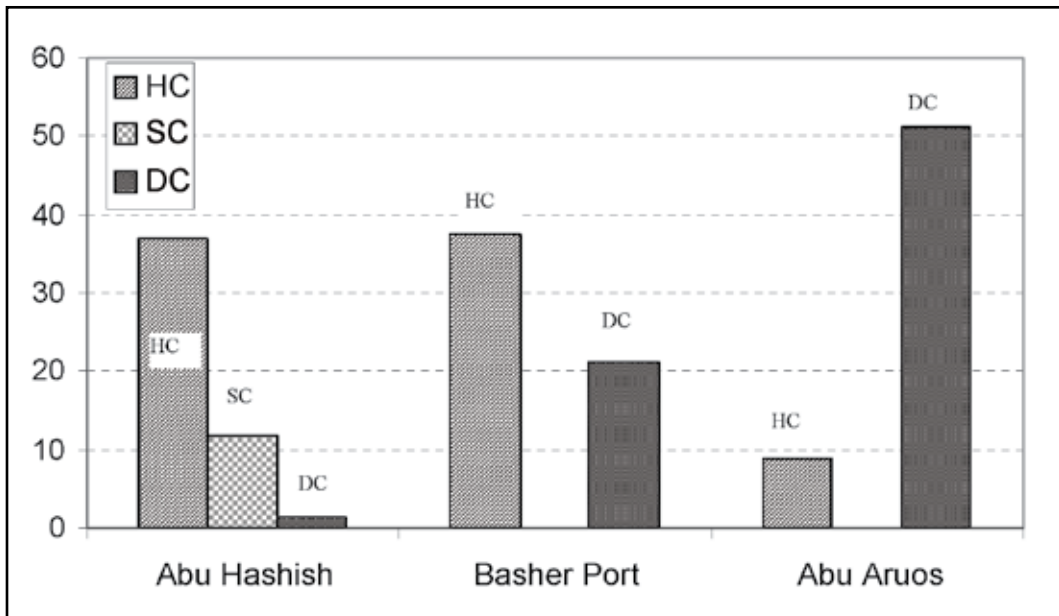


Figure 3.12 Average percentage of coral cover from three selected sites, Sudanese Red Sea coast (NASR & AL-SHEIKH 2000) (source: PERSGA/GEF 2003b). HC = live hard coral, SC = soft coral, DC = dead coral.



Figure 3.13 Coral health indices (cover of live coral/total cover of live and dead coral) in the Dungonab Bay–Mukawwar Island MPA in 2002 (source: PERSGA/GEF 2004f).

Overall, the coral reefs of Sudan are in moderate to good health. Anthropogenic threats include: maritime transport (especially in the vicinity of Port Sudan where anchor damage is extensive on Wingate and Towartit reefs); limited navigational devices; maritime pollution; dredging and land filling for the extension of Port Sudan and the port at Suakin; destructive fisheries; land-based pollution from the petroleum industry and other industrial activities. Sudan has the technical expertise and infrastructure for regular monitoring and effective management. However, there is a widespread lack of awareness and enforcement by the concerned authorities, a weak legal framework and an absence of surveillance. Lack of funding for research and management is a major problem.

Understanding of the coral reefs and coral communities of Yemen has advanced considerably in recent years (TURAK & BRODIE 1999; KEMP & BENZONI 2000; DEVANTIER et al. 2004; PERSGA 2003a; PERSGA 2003b). The following synthesis of indicators of Yemen’s coral reefs and coral communities is based on these publications (Table 3.4).

On the Red Sea coastal and fringing reefs, living coral cover was generally higher in the south than on most of the central and northern coasts. Semi-protected islands in Yemen’s northern Red Sea had low live coral cover (average 17%), high dead coral (average 34%), high macroalgal cover (average 20%), but a high species richness (average 44 species). Coastal and island fringing reefs from north of Al Khawkhah to Midi had 3% live coral, 34% dead coral, 34% macroalgal cover and a low species richness (average of only 9 species). Reefs occurring in clear water, open ocean facing areas (Zubayr group, At Tair Island, Mayun Island) had 29% live coral cover, 14% dead coral, low macroalgal cover and a high species richness (average of 46 species). Deep water pinnacles and submerged patch reefs had 24% live coral, 28% dead coral, and an average species richness of 56 species. Fringing reefs in the southern Red Sea (south of Yakhtul to Dhubab) had 15% live coral, 23% dead coral, and 14% macroalgal cover.

Key sites for corals along the north-west Gulf of Aden coast of Yemen include: Khor Umairah; Crater, Aden (30–50% live coral cover); and Shuara (30–40% live coral cover). Key sites along the north-east coast include: Belhaf (which was badly affected

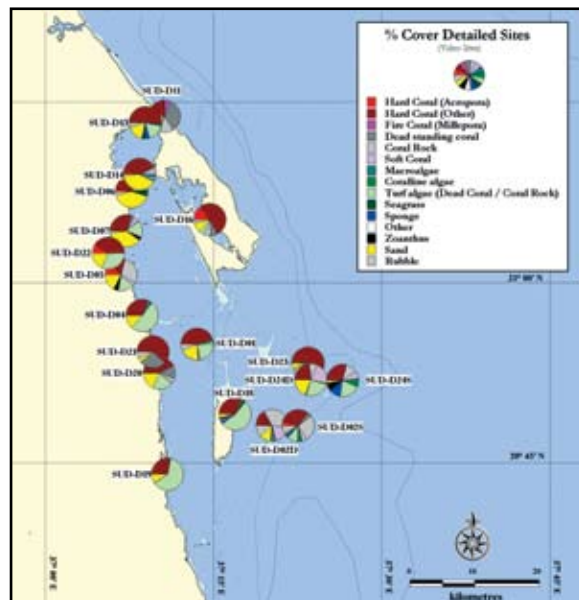


Figure 3.14 Summary of substrate transect data in Dungonab Bay–Mukawwar Island MPA in 2002 (source: PERSGA/GEF 2004f).

Table 3.4 Average cover of coral and other life forms in Yemen (summarised from PERSGA 2003b and DE VANTIER et al. 2004).

Location	Life form percentage cover			No. coral species
	Live coral	Dead coral	Macro algae	
Northern Yemeni Red Sea (semi-protected islands)	17	34	20	44
Al Khawkhah to Midi (north & central coast/islands)	3	34	34	9
Zubayr islands, At Tair Island & Mayun Island	29	14	Low	46
Deep water pinnacles & submerged patch reefs	24	28		56
Yakhtul to Dhubab (fringing reefs, southern Red Sea)	15	23	14	
Socotra Archipelago (overall)	22			
North coast (& outer islands*)	25			
South coast	5	10	25–27	48
Socotra Island	17			
The Brothers	35			
North-west coast				
Crater, Aden	30–50			
Shuara	30–40			
North-east coast				
Bir Ali & offshore islands				
Al Mukalla – shallow reefs	50			50
Al Mukalla – deep reefs	10			

by bleaching in 1998), Bir Ali and offshore islands (representing the most concentrated distribution of coral communities in the northern Gulf of Aden with up to 50 species of corals and greater than 50% coral cover in some sites); Burum; Al Mukalla (with shallow water (1–10 m) assemblages composed of massive poritids, faviids and mussids and tabular *Acropora* spp., with live coral cover approaching 50%); Ras Fartak and Ras Fantas.

Overall live coral cover in Socotra Archipelago was an average of 20%. Sites where a high cover of live corals (i.e. exceeding 50%) were recorded include Medina, Ras Anjara Bay, north and north-east Samha. Living coral cover of 50% was recorded at Dham-Qubbah, Hawlaff Port, small outer island rock stacks of Kal Farun and Sabuniyah Rocks. Overall, cover of live corals on the northern coastlines (25%) was higher than the southern coastlines (5%).

Anthropogenic threats to the coral reefs and coral communities of Yemen include: coastal development (especially Aden Port, Aden Free Zone, and the proposed harbour and airport developments in Socotra); shipping (associated with oil spillages and leakage); fishing practices that damage coral reefs; and pollution (including the discharge of raw sewage at Aden, Mukalla and smaller towns and the discharge of high temperature brine from power stations at Mukha, Ras Katheeb and Hiswa).

Structural issues for the Yemen marine environment include a lack of funding to establish and implement regulations in MPAs, and a lack of funding for research and monitoring. There is one MPA established in Yemen – the Socotra Archipelago. Six other MPAs are proposed, four of which have coral reefs: Belhaf and Bir Ali area; Ras Isa and Kamaran Island; Khor Umaira; and Bab el Mandeb and Perim Island. The

Socotra Islands MPA and the proposed Belhaf-Bir Ali MPA are part of the Red Sea and Gulf of Aden Regional MPA Network.

Most coral reefs in Djibouti are in average to good condition (PERSGA/ALECSO 2003). Living hard coral cover across reefs averaged 39% with a maximum of 80% (Figure 3.15). Coral cover in the Iles des Sept Frères and Ras Siyyan MPA was assessed in 2002 (Figure 3.16). In the lagoon north of Ras Siyyan corals were generally sparse and percentage cover was typically less than 5% and dominated by *Pocillopora* sp. On the continuous fringing reef south of Ras Siyyan coral cover ranged between 10–55%. Coral cover in the Iles des Sept Frères ranged from 30–65%, with 90% cover recorded at Tolka Island. Dead coral cover was greatest at Grande Ile (7%) and half of this mortality was attributed to anchor damage (PERSGA 2002).

Human interference or damage to coral reefs is generally low in Djibouti, but is severe in specific areas and is likely to increase in the future. Specific issues include degradation of coral reefs by silt from coastal developments; coral damage from recreational usage and anchors; urchin damage to corals; lack of funding for management and research; and lack of technical expertise.

Living coral cover on parts of Somali reefs unaffected by bleaching (narrow fringing bands on the outer perimeters of reefs) varied between 60 and 80%. There are no declared MPAs in Somalia. Of the three MPAs proposed for Somalia (Daloh Forest Reserve, Mait Island, Aibat and Sa'adadin Islands) only one has significant coral growth—Aibat and Sa'adadin Islands.

There are limited anthropogenic threats to the coral reefs of Somalia. Urban population growth around the two main ports on the Gulf of Aden (Berbera and Bosaso) is rapid and largely uncontrolled. Domestic sewage is a locally significant pollutant. Corals are collected in the north-west for the tourist market, but the extent of this activity is unknown. More pressing threats to the sustainability of Somalia's coral reefs relate to structural issues with

the current political situation. There are no long-term monitoring programmes. Laws and regulations are not enforced. Although Somalia is a signatory to a host of international agreements and protocols, the ability to effectively implement them is limited. National environmental legislation is poorly developed. There is a lack of experienced coral reef experts and of funds for environmental management.

3.12 OTHER INVERTEBRATES

There have been a large number of collections of other invertebrates from the RSGA and it is beyond the scope of this chapter to review all studies and their findings. However, it is important to acknowledge some of the more recent findings as a way to highlight further opportunities. Many of the recent studies have been associated with the SAP or other integrated environmental management projects.

Sixty species of calanoid copepods have been reported from the southern Red Sea and 46 species in the northern Red Sea (SHEPPARD et al. 1992). One hundred and seventy species of echinoderms have been reported from the Red Sea (SHEPPARD et al. 1992). Nine species of thalassinidean decapods (representing four families and six genera) have been recorded in the Socotra Archipelago from three islands (Socotra, Darsah, Abd al-Kuri) (SAKAI & APEL 2002). In a much larger study SIMÕES et al. (2001) recorded 130 species of decapod crustaceans from Socotra Island. Species were recorded from rocky coasts (55 species), cobble beaches (30 species), sand shores (30 species), and mud/mangrove habitats (13 species). Sixty-six species of decapod crustaceans were recorded during a recent survey of the Red Sea coastal zone of Yemen (KRUPP et al. 2006). The RSGA are highly significant in the polychaete fauna of the Arabian region. WEHE & FIEGE (2002) recorded the following numbers of polychaetes: Red Sea (567 species); Arabian Gulf (231 species); Gulf of Aden (177 species); Arabian Sea (141 species); Suez Canal (91 species); and Gulf of Oman (60 species).

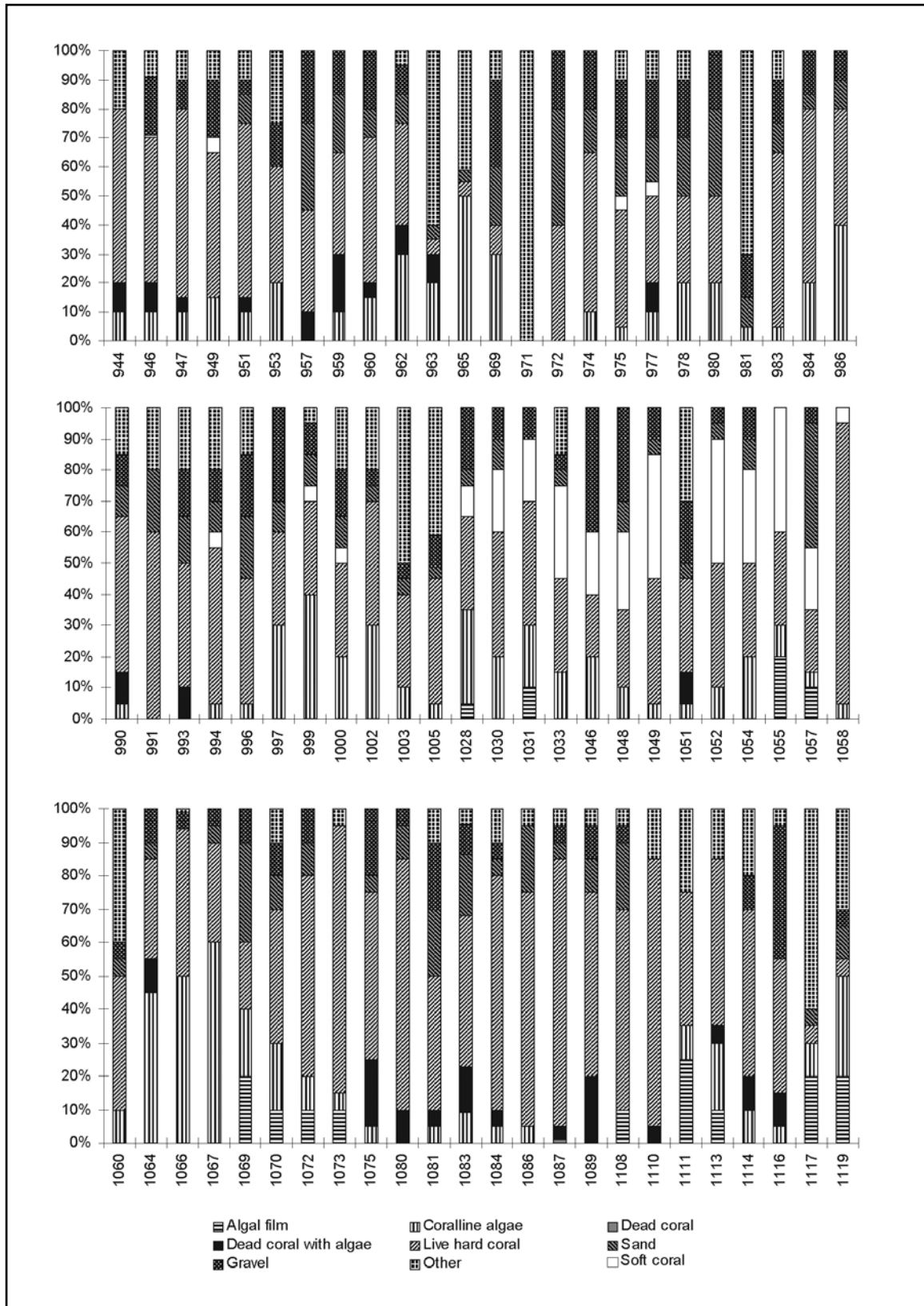


Figure 3.15a Percentage cover of various life forms and abiota for seventy two reef assessment quadrats in Djibouti (from PERSGA/ALECSO 2003).

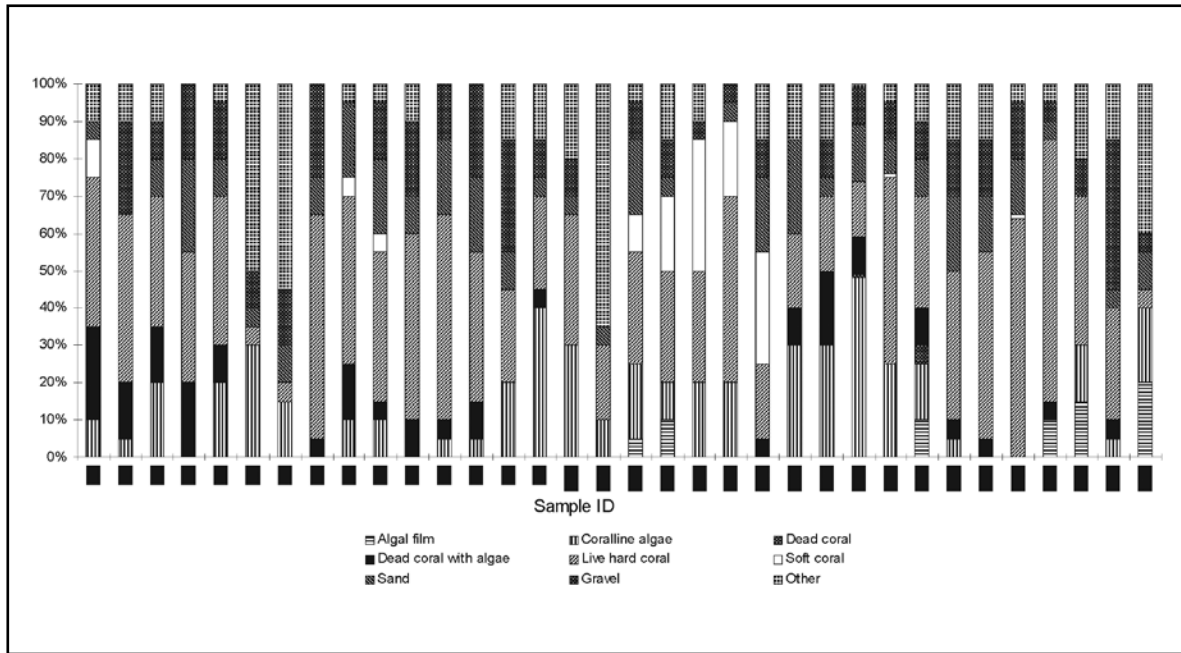


Figure 3.15b Percentage cover of various life forms and biota in reef edge swims in Djibouti (from PERSGA/ALECSO 2003).

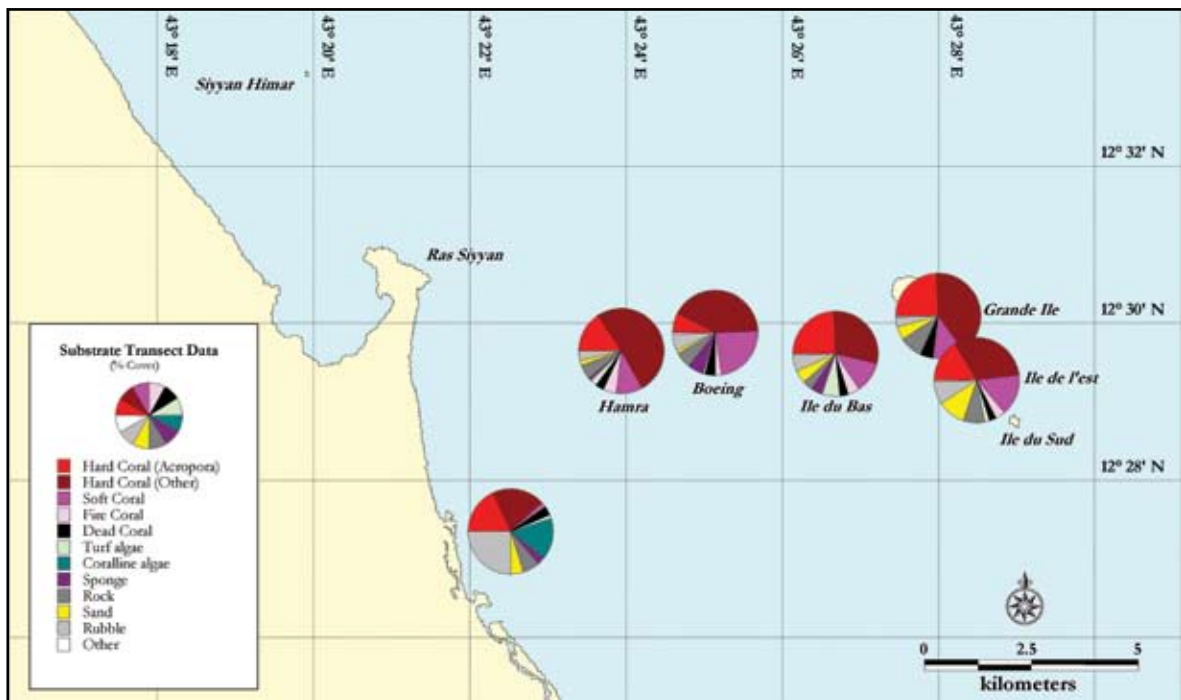


Figure 3.16 Relative coverage of different substrata in Djibouti 2002 (source: PERSGA 2002).

3.12.1 Status, Trends, Issues

Many benthic fauna are subjected to fishing and collection pressure including top-shells, sea cucumbers, giant clams and lobsters (PERSGA/ALESCO 2003). In Djibouti recent field surveys revealed a low abundance of anemones, with the maximum number at any survey site being seven at Rhounda Dabali (Sept Frères Islands). Giant clams (*Tridacna* spp.) are collected for subsistence and for sale in the southern Red Sea (GLADSTONE 2000). No giant clams were recorded on survey reefs in Egypt and Eritrea but they were reported in the Socotra Archipelago (Table 3.2). Giant clams were abundant in 2002 in the area of the proposed Mukawwar Island and Dungonab Bay MPA (prior to the MPA declaration in 2005) (Figure 3.17). Giant clams were found at a majority of surveyed sites in Djibouti and occurred at densities of between one and 52 individuals (PERSGA 2002; PERSGA/ALESCO 2003) (Figure 3.17).

No lobsters were recorded at any of the Reef Check survey sites in the RSGA (Table 3.2), which accords with the situation on 90% of Indo-Pacific reefs.

The density of sea cucumbers in the RSGA is greater than the global average of reefs surveyed for Reef Check (Table 3.2). The density of sea cucumbers on most reefs was more than five individuals per 100 square metres (Table 3.2) including high densities in Djibouti (Figure 3.18). However, there is severe over-fishing for sea cucumbers in Sudan (Figure 3.18). In the vicinity of Dungonab Bay sea cucumbers have been fished out from many shallow areas forcing divers to travel further and exploit deeper waters (PERSGA/GEF 2004f).

In Sudan there has been severe over-fishing of the molluscs *Trochus* spp., *Strombus* spp., *Lambis* spp., and *Murex* spp. Most individuals of these species observed in the wild are small and occur at low densities (PERSGA/GEF 2004f).

The ecological impacts arising from the bio-accumulation of pollutants has not

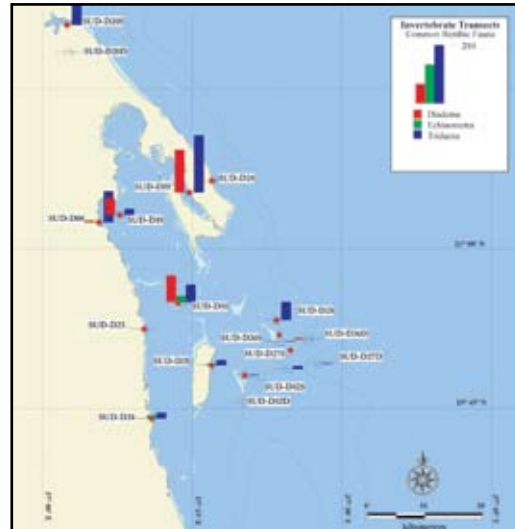


Figure 3.17 Relative abundance of benthic invertebrates in 2002 in the area of the proposed Mukawwar Island and Dungonab Bay MPA prior to the MPA declaration in 2005 (source: PERSGA/GEF 2004f).

been investigated in detail in the RSGA. However, such impacts on individuals have the potential to explain community-wide changes. For example, BRESLER et al. (2003) examined impacts of pollution from a fish aquaculture facility in the Gulf of Aqaba on an intertidal gastropod mollusc and a subtidal bivalve mollusc. Significant cellular and molecular changes were observed in animals from the polluted site compared with unpolluted control sites.

3.13 FISHES AND ELASMOBRANCHS

About 1,350 species of fishes are known from the Red Sea (GOREN & DOR 1994). A total of 49 species (5 orders, 15 families) of sharks and 45 species of batoids (4 orders, 9 families) have been reliably recorded in the RSGA. Of these, 44 species of sharks and 33 species of batoids are utilised to some extent in the region's fisheries (BONFIL & ABDALLAH 2004).

A total of 261 species of fishes (89 genera, 46 families) have been recorded from the Red Sea coast of Egypt. Southern reefs have a greater diversity of fishes than northern reefs. Exposed reefs have a higher diversity than sheltered reefs. This trend is considered

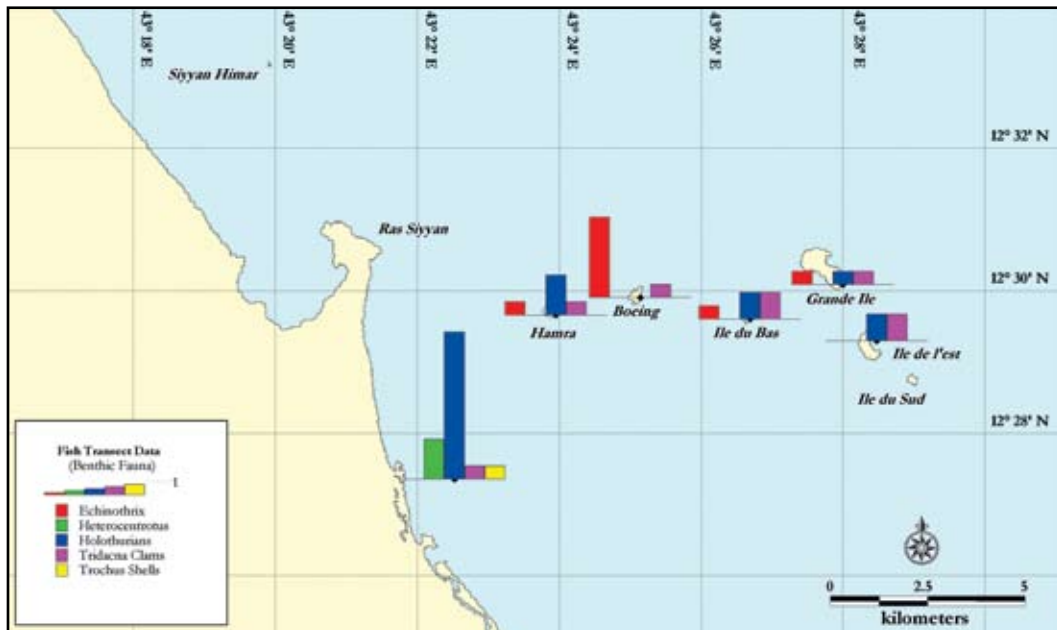


Figure 3.18 Relative distribution and abundance of benthic fauna in Djibouti in 2002 (source: PERSGA 2002).

to be due to less diving and fishing occurring on exposed reefs. The most abundant family of reef fishes in Egypt is Pomacentridae with 16–26 species occurring across all sites. The second most abundant family is Labridae with 20 species. The least abundant family is Scaridae (9 species). The diversity of Chaetodontidae increases in the north, where the most common species are *Chaetodon larvatus*, *C. auriga* and *C. fasciatus* (PERSGA/GEF 2003b).

Surveys of the occurrence and abundance of chaetodontids in northern, central and southern areas of the Eritrean Red Sea coast found distinct differences in species assemblages from the three areas (ZEKERIA et al. 2005). Two species are restricted to the northern coast of Eritrea, three species occur only in the south, and six species occurring in the central area also occur in the north and south.

A recent study of the shore fishes of the Jordanian coast of the Gulf of Aqaba recorded 198 species, and a combined total of 362 species from other studies (KHALAF & KOCHZIUS 2002a). The total number of species from the Gulf of Aqaba could be as high as 1,000 (PERSGA/GEF 2003b). Blacktip, hammerhead and whale sharks,

and pelagic fish such as skipjack tuna and bonito are found in the open waters of the Gulf of Aqaba (PERSGA/GEF 2001).

Recent estimates of the diversity of reef fishes of Saudi Arabia vary widely, from 508 to 1,248 species. Differences may be due in part to differences in the definition of reef fishes (PERSGA/GEF 2003b).

The fish communities of Somalia are believed to be diverse. An abundance of large fishes observed in recent surveys indicates a relatively unexploited resource and pristine environment. The largest number of fish species (140 species) is known to occur on coral reefs. Notably, the fish communities include large schools of Lutjanidae and Carangidae and an abundance of large individuals from the families Serranidae and Plectorhynchidae. Diverse fish communities currently occur in Berbera Harbour (32 species), western Ras Cuuda (35 species), Siyara (70 species), and El Girdi (65 species). Fishes are currently abundant in Berbera Harbour, Ras Cuuda to Ras Xaatib, Siyara, and El Girdi (PERSGA/GEF 2003b).

The Dunganab Bay–Mukawwar Island MPA is significant for the conservation of

fish diversity in Sudan. Major differences exist between the inside and outside of Dugonab Bay in the communities of butterflyfish (family Chaetodontidae) and angelfish (family Pomacanthidae). Communities inside Dugonab Bay closely resemble communities from the southern Red Sea (Yemen and central Eritrea). In particular, communities inside Dugonab Bay are more similar to communities in the Gulf of Aden (more than 1,000 kilometres away) than they are to communities outside Dugonab Bay (less than 10 km away). Communities outside the Bay are similar to communities from the north-central Red Sea. The basis of this pronounced difference in community structure is likely to be differences in water quality, temperature, and turbidity. The Dugonab Bay–Mukawwar Island MPA encompasses fish communities more usually separated by several hundred kilometres (PERSGA/GEF 2004f). Additionally, the Dugonab Bay–Mukawwar Island MPA is also well known for its aggregations of whale sharks (*Rhincodon typus*) and manta rays (*Manta birostris*) during summer (VINE & SCHMID 1987; PERSGA/GEF 2004f).

Over 600 species of reef-associated fishes have been identified from Yemen's reefs and coral communities (PERSGA/GEF 2003b). Six species (2 genera) of chaetodontids occur in Yemen, with the most abundant species being *Chaetodon larvatus* (KHALAF & ABDALLAH 2005). BRODIE et al. (1999) recorded 229 species of fishes from Yemen's Red Sea coast and, surprisingly, found no evidence of cross-shelf variation in fish assemblages of coral reefs (despite substantial cross-shelf variation occurring in the coral community composition and coral reef structure). AL-SAKAFF & ESSEN (1999) listed 195 species of fishes caught in commercial trawlers from the Gulf of Aden and Arabian Sea coastline of Yemen. KEMP (2000) surveyed the ichthyofauna of the Shabwa and Hadhramaut provinces and recorded 267 species, including eight new records. Seventy species of coral reef-associated fishes were recorded during a 2004 survey of Hanish al-Kabir Island (KRUPP et al. 2006).

Owing to the close association of butterflyfish (family Chaetodontidae) with coral communities and the impacts of coral degradation on chaetodontid assemblages, it has been proposed that obligate corallivorous butterflyfishes are an excellent indicator of coral reef health (KHALAF & ABDALLAH 2005). A total of 5062 individuals representing 14 species and 2 genera were sampled in Egypt, Yemen, Saudi Arabia, Djibouti and Jordan. The average density of species was highest on the Egyptian coast, followed by Saudi Arabia, Djibouti, Jordan and Yemen. Total species richness was highest on the coast of Saudi Arabia, followed by Egypt, Djibouti, Jordan and Yemen. Assemblages of chaetodontids from the southern Red Sea and Gulf of Aden differ from assemblages in the northern Red Sea (KHALAF & ABDALLAH 2005). These differences in assemblages may be attributable to habitat variation. There are significant differences in reef structure and coral assemblages between the northern and southern Red Sea. The reef structures of the southern Red Sea (Yemen and Djibouti) are dominated by shallow macroalgal-dominated frameworks. Seven species of chaetodontid are endemic to the Red Sea or spread no further than the Gulf of Aden.

3.13.1 Status, Trends, Issues

Issues relating to the artisanal and commercial capture of fishes are covered in chapter 6 (Living Marine Resources). The following issues are currently relevant to the conservation of fish biodiversity. Issues for elasmobranchs are included here because of the potential for wider ecosystem impacts arising from their exploitation.

Butterflyfishes (family Chaetodontidae) are an indicator group in the Reef Check global monitoring programme. Densities of butterflyfishes recorded on survey reefs in Egypt, Eritrea and the Socotra Archipelago are substantially higher than the average density recorded at reefs throughout the Indo-Pacific region (Table 3.2). Recent syntheses of the usefulness of butterflyfishes as indicators of coral health in the Red Sea and Gulf of Aden (KHALAF

& ABDALLAH 2005) provide quantitative estimates of density and will serve as a useful baseline for future monitoring.

Grouper (family Serranidae) have been fished out from most coral reefs in the world. The 1997–2001 Reef Check status report (HODGSON & LIEBELER 2002) reported that 48% of reefs had no grouper larger than 30 cm. By comparison, the grouper fauna at reefs surveyed in the RSGA appears to be relatively healthy. Most reefs surveyed recorded grouper larger than 30 cm at densities of at least four per 100 m² (Table 3.2). Groupers were more abundant in Sudan in comparison to other sites in the Red Sea, with more than 20 grouper recorded in over half of 20-minute timed swims (PERSGA/GEF 2003b). In Djibouti, two commercially important species (*Plectropomus truncatus*, *Variola louti*) were not recorded at any sites (PERSGA/GEF 2003b).

Grunts (family Haemulidae) have been recorded at variable densities in the Red Sea and Socotra Archipelago (Table 3.2). Particularly high densities have been recorded on reefs in Egypt and Eritrea. The highest density of grunts recorded globally in 1997–2001 was at a reef in Ras Mohammad National Park (Egypt) where densities of 25 per 100 m² were reported (Table 3.2 and HODGSON & LIEBELER 2002). In the Indo-Pacific region 57% of reefs recorded no grunts.

Parrotfish (family Scaridae) are important consumers of algae on coral reefs and contribute to coral dynamics and habitat formation (BELLWOOD et al. 2003). Their conservation is therefore important for the maintenance of coral reef ecosystems. Parrotfish are caught for subsistence and for sale in the RSGA (GLADSTONE 1996, 2002). Low numbers of parrotfish were recorded on reefs in Egypt, Eritrea and the Socotra Archipelago (Table 3.2) reflecting a similar situation at reefs in the Indo-Pacific region. However, parrotfish density is likely to vary in response to reef type and coral cover and the low densities at survey reefs may not necessarily indicate an anthropogenic impact. Other surveys (PERSGA/GEF 2003b) recorded high densities of parrotfish in Egypt.

Humphead wrasse *Cheilinus undulatus* (family Labridae) are a favoured food item in the live fish trade and their numbers have declined globally (HODGSON & LIEBELER 2002). *C. undulatus* consume a range of invertebrate prey items and grow to 230 cm in length (HODGSON & LIEBELER 2002). They are therefore likely to be important in the ecology of coral reef ecosystems and their loss is of concern. The World Conservation Union (IUCN) has listed *C. undulatus* as 'Vulnerable' throughout its range. Between 1997 and 2001 no *C. undulatus* were recorded at 88% of global reefs and none were recorded from Egypt, Eritrea and the Socotra Archipelago (Table 3.2). However, recent surveys elsewhere in the RSGA recorded *C. undulatus* at three of 25 survey sites in Sudan and at all reefs surveyed in Djibouti (PERSGA/GEF 2003b). The maximum number of *C. undulatus* recorded from Maskali Island in Djibouti was five (PERSGA/GEF 2003b).

Sharks are top carnivores in coral reef ecosystems and their global decline from fishing may have significant impacts on biodiversity and ecosystem functions (BAUM & MYERS 2004). Shark resources in the RSGA are heavily exploited, especially in Sudan, Djibouti, Yemen and Socotra Archipelago. Reported catches to FAO for 1998 indicate the region's major shark fishing nations are Yemen (5,000 tonnes), Saudi Arabia (1,500 tonnes), and Egypt (135 tonnes). There is believed to be a significant shark fishery in Sudan, but no catch reporting is in place (BONFIL & ABDALLAH 2004).

Shark fishing nations in the RSGA have limited management measures to ensure sustainable exploitation. This difficulty is compounded by a number of other factors: there is a general lack of knowledge of the number of species in the region and of the species that are significant in catches; there are limited statistics on both catch and effort; juveniles are heavily exploited in pupping and nursery areas; shark finning is unregulated; and there are increases in illegal fishing by foreign vessels, including RSGA fishers operating outside their territorial waters, servicing the south-east Asian shark fin market (BONFIL & ABDALLAH 2004).

There is a substantial market for good quality Red Sea and West Indian Ocean tropical marine fishes for the aquarium trade in the USA, Hong Kong, Germany and Europe (PERSGA/GEF 2001). Collection of ornamental fishes occurs in Egypt, Saudi Arabia and Yemen (GLADSTONE 2004). In 2000, activities in each country were directed at the export market and industry size was regarded as small. Up to 50,000 fishes are exported annually. Considerable differences exist between countries in the number of species collected. Fifty species are exported from Egypt and 117 species are exported from Saudi Arabia. Overall the impacts from collecting ornamental fishes are largely unquantified throughout the RSGA.

There is potential for greater monitoring and management of the trade in ornamental fishes in the RSGA. PERSGA recently implemented a number of initiatives in response to the acknowledged issues surrounding this trade. A training workshop was conducted in Jeddah to train participants in (i) the collection of data from companies exporting ornamental fishes; (ii) the identification of species of ornamental fishes; (iii) methodologies for the collection and analysis of export data on ornamental fishes; and (iv) sampling methodologies that allow field data to be collected to monitor the impacts of the trade in ornamental fishes (EDWARDS 2002). Standard survey methods for reef fishes were developed that were also designed for monitoring species targeted for the trade in ornamental fishes (GLADSTONE 2004).

For future management of the trade in ornamental fishes the workshop recommended that (i) an obligation be introduced requiring the provision of annual data on collector/fisher effort for each collection area; (ii) the Dead on Arrival/Dead After Arrival 1 per cent level requirement, be reviewed; and (iii) that 'optimal health' be redefined to be consistent with best practice. The workshop further recommended that the Marine Aquarium Council's Full Standards and Best Practice Guidance and the certification of companies involved in the trade in ornamental fishes

are the optimal approaches to management of the trade (EDWARDS 2002).

Within Egypt there may be a threat resulting from the demand for dried and inflated pufferfish (*Arothron hispidus*) as souvenirs (PERSGA/GEF 2001). Many specimens of *A. hispidus* are made into lamp shades. This species is a major predator of the crown-of-thorns starfish (*Acanthaster planci*) and the needle-spined sea urchin (*Diadema setosum*), which can cause damage to coral reefs. There is evidence of damage to reefs near Hurghada by *D. setosum* sea urchins. This may be due to the removal of the puffer *A. hispidus*, for the souvenir market.

In Djibouti the most abundant fishes recorded in the Iles des Sept Frères and Ras Siyyan MPA in 2002 (prior to the MPA declaration in 2005) were snappers (family Lutjanidae). Fish populations around the islands were greater than populations at mainland sites. The total abundance of fishes at Hamra and Boeing was more than twice the total abundance of other sites (Figure 3.19). Large mono-specific aggregations of *Plectorhinchus gaterinus* (family Haemulidae) or *Lutjanus ehrenbergi* (family Lutjanidae) were observed at more than 60% of surveyed reefs. Their daytime sedentary nature and tendency to aggregate makes these species especially vulnerable to over-fishing. Shark populations in the Iles des Sept Frères and Ras Siyyan area had been severely depleted by illegal fishing prior to the MPA declaration (PERSGA 2002).

In Sudan, fishes in the proposed area of the Mukawwar Island and Dunganab Bay MPA were surveyed in 2002 prior to the MPA declaration in 2005 (PERSGA/GEF 2004f) (Figure 3.20). Large groupers (family Serranidae) were rare and nagil (*Plectropomus* spp.) over 30 cm in length were rarely observed, suggesting a high fishing pressure on these species. Fishing pressure was intense at spawning and nursery sites for nagil and other species especially at the southern end of Mukawwar Island. Continuation of this form of fishing will undoubtedly lead to the loss of some of the most important fisheries species.

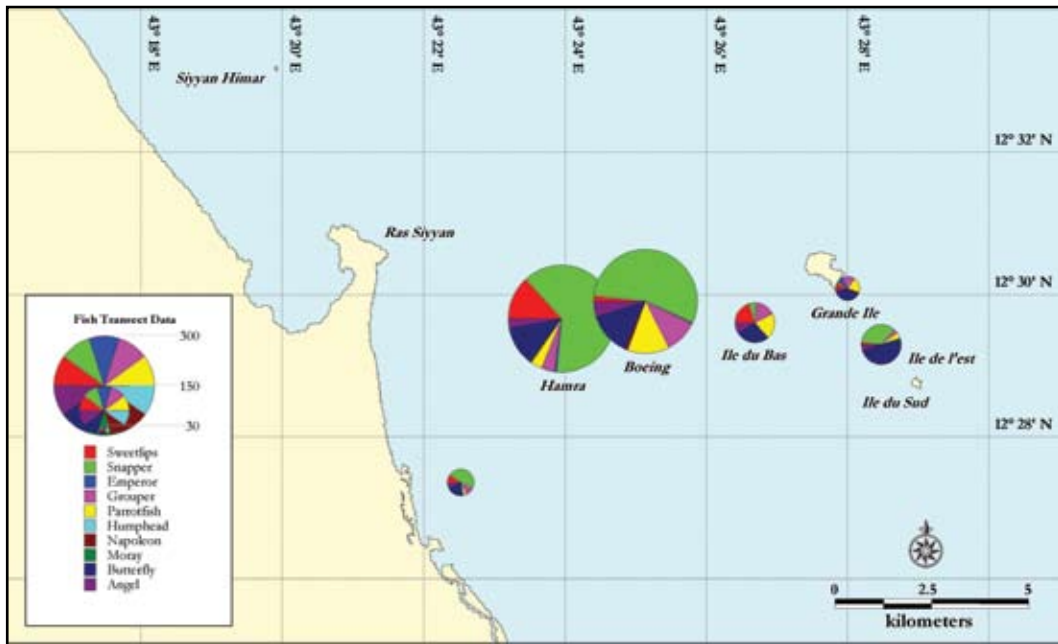


Figure 3.19 Relative abundance of different fish groups in the Iles des Sept Frères and Ras Siyyan MPA in 2002 prior to the MPA declaration in 2005 (source: PERSGA 2002).

Shark fishing (by fishers from Port Sudan and from outside Sudan) was common prior to the MPA declaration with the result that very few sharks were observed anywhere in the area of the MPA.

Industrial development has led to significant changes in coastal reef fish communities. Reefs adjacent to the Jordan Fertiliser Industries experience shipping traffic, solid waste disposal, chemical and oil spillages, increased coral diseases, and pollution from phosphate and heavy metals. Changes to the fish community at the industry site, relative to undisturbed sites, have included: a 50% reduction in total fish abundance; a greater abundance of herbivorous fishes (due to overgrowth of algae on shallow reef slopes); a decreased abundance of invertebrate- and fish-

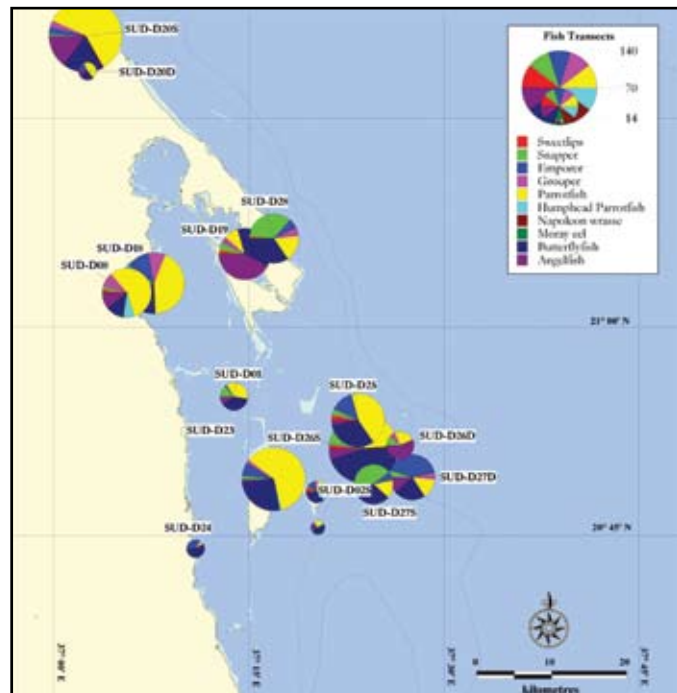


Figure 3.20 The relative abundance and distribution of fish from transects, as surveyed by the Reef Check Belt Transect method in the Mukawwar Island and Dunganab Bay MPA (Sudan) in 2002, prior to the MPA declaration in 2005 (source: PERSGA/GEF 2004f).

feeders (due to habitat degradation); and increased abundance of planktivorous fishes (KHALAF & KOCHZIUS 2002b).

Pollution from a fish aquaculture facility at the northern part of the Gulf of Aqaba (Israel) has been associated with pathological changes to fish on adjacent reefs. Pollution, in the form of significant elevations in fish faeces and dissolved nutrients, has created partly anaerobic conditions in sediment and an accumulation of organic substances. Fish in the vicinity of the aquaculture facility displayed pathological and cytological changes in the thymus, spleen, head-kidney, and liver compared to fishes from an unpolluted section of the coast (FISHELSON 2006).

Ghost fishing is the phenomenon of lost or discarded fishing equipment continuing to catch fishes and other marine life. It represents a potentially significant impact because of the difficulties of re-locating lost equipment and the equipment's durability means that it may continue 'fishing' for lengthy time periods. UNEP's Asian Tsunami Task Force estimated that on the Gulf of Aden coast of Yemen 500 fishing nets, 1,500 octopus traps, and 8,000 lobster traps were lost to sea as a result of the December 2004 tsunami. Fishers on the Island of Socotra also lost approximately 174 fishing nets and 37 hook lines (UNEP 2005).

3.14 TURTLES

The RSGA contains globally important feeding and nesting grounds for green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*) turtles. Leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) are infrequently seen but no nestings have been recorded. All species of marine turtle (except the loggerhead which is classified as Vulnerable) have been classified as Endangered or Critically Endangered and listed in CITES Appendix 1.

Turtles have been used by coastal people for hundreds if not thousands of years, particularly in the southern states of the Red Sea. The turtle catch was for

subsistence and was limited by equipment and storage considerations. Turtles were an important nutritional supplement in remote locations, such as Djibouti and the Socotra Archipelago. The carapaces were used as cooking vats, dwelling hut apexes and as storage vessels. In modern times mechanised boats, refrigeration systems and a network of distribution opportunities have caused the demand for turtles in coastal communities to exceed the sustainable harvest levels of the past (PERSGA/GEF 2004d).

Marine turtles need a number of different habitats to complete their life cycle. Shallow foraging sites such as seagrass beds and coral reefs are utilised. Nesting sites are chosen on the basis of a complex of beach characteristics and the likelihood of anthropogenic disturbance. Nesting is unlikely on cluttered, developed beaches or close to bright lights. Important requirements include relatively clean sand and a suitable depth at the dune area that is not flooded by the high tide. Erosion can expose egg clutches, whilst sea level rise can inundate them. Accumulated debris such as logs, discarded nets, solid waste and plastics can deter nesting females (PERSGA/GEF 2004d).

Marine turtles make very deliberate journeys to specific nesting sites and show high site fidelity. Turtles tagged whilst nesting on Socotra Island have been recaptured in the vicinity of Sept Frères Islands (Djibouti) and the southern coasts of Yemen and Oman. Migrations also occur from Djibouti to Sri Lanka and Oman (PERSGA/GEF 2004d).

Important nesting and feeding grounds for marine turtles occur in most countries of the RSGA (Table 3.5). In addition to the sites listed in Table 3.5 the Dahlak Archipelago (Eritrea) is recognised as an important nesting ground (MILLER 1989; PERSGA 1998). The Ras Sharma nesting site for green turtles is internationally significant with up to 6,000 females nesting there each year, making it the second largest in the Arabian region. The region between Jabal Aziz Island and Perim is the most important nesting ground for hawksbill turtles in the Arabian region (PERSGA/GEF 2001).

Table 3.5 Key nesting and foraging sites and population statistics for marine turtles in the Red Sea and Gulf of Aden (from PERSGA/GEF 2004d).

	Species	Key Nesting Sites	Nesting Season	Size of Nesting Population	CCL (cm)	CCW (cm)	Key Foraging Sites
Djibouti	Green	Iles Moucha & Maskali, Ras Siyyan, Iles des Sept Frères	Jan.-Apr.	~100	66.67	63.3	Gabel
	Hawksbill	Ras Siyyan, Sept Frères	Mar.-Jun.	ND	59.5	65.5	All fringing reefs
	Loggerhead	ND	ND	ND	ND	ND	Haramous Loyada
Egypt	Green	Wadi Al-Gimal, Ras Banas, Sarenka, Siyal, Zabargad & Rowabil Islands	Jun.-Aug.	~200	--	----	ND
	Hawksbill	Shedwan, Giftun Kabir & Giftun Sagheir Islds.	May-Jul.	~200	--	--	All fringing reefs
Jordan	Green	None	n/a	n/a	--	--	All fringing reefs
	Hawksbill	None	n/a	n/a	--	--	All fringing reefs
Saudi Arabia	Green	Ras Baridi	Aug.-Nov.	~100	105.69	96.5	Al Wajh Bank, Farasan Islands
	Hawksbill	Farasan Islands	Feb.-May	~50	ND	ND	All fringing reefs
Somalia	Green	Raas Xatiib to Raas Cuuda, Berbera	Jan.-Apr.	<50	ND	ND	ND
	Hawksbill	Sa'adadin, Aibat Islands, Raas Xatiib to Raas Cuuda	Mar.-Jun.	<50	ND	ND	All fringing reefs
Sudan	Green	Seil Ada Kebir Island, Suakin Mukawwar Is.	All year	<50	ND	ND	Unknown
	Hawksbill	Mukawwar Is. Seil Ada Kebir Suakin	Mar.-Jul. ND	ND ND	71.93 66.0	64.63ND	All fringing and barrier reefs
Yemen	Green	Ras Sharma	July	~6000	106.0	96.0	Khor Umeira
	Hawksbill	Jabal Aziz	ND	~500	ND	ND	All fringing reefs
	Loggerhead	Socotra	Jul.-Aug.	~50-100	94.3	85.8	Unknown

Sources: Djibouti: PERSGA 2003b; Egypt: Frazier & Salas 1984, PERSGA 2003a; Saudi Arabia: PERSGA 2003c, Miller 1989, Pilcher & Al-Merghani 2000; Somalia: Schleyer & Baldwin 1999, IUCN 1997; Sudan: Diamond 1976; PERSGA 2003e; Yemen: PERSGA 2003d, Pilcher & Saad 2000, UNEP/IUCN 1996. ND = No Data.

3.14.1 Status, Trends, Issues

GEF (2001, 2004b).

Major issues for marine turtles are summarised in Table 3.6. However, it is worth noting here the specific nature of many of these issues and their localities as a baseline against which the progress of future management activities can be assessed. Unless stated otherwise the following overview is based on PERSGA/

Despite a comprehensive survey effort by PERSGA in 2000, there is still a shortage of data on the distribution of habitats, particularly foraging sites, within the region. Important additional site-specific information has been provided recently from Djibouti (PERSGA 2002) and Sudan (PERSGA/GEF 2004f).

Table 3.6 Threats and conservation initiatives matrix for marine turtles in the Red Sea and Gulf of Aden (from PERSGA/GEF 2004d).

Country	Major Threats				
	Dredging / Land-filling	Commercial Fisheries	Artisanal Fisheries	Habitat Destruction	Oil Industry
Djibouti	3	2	4	2	2
Egypt	1	2	4	3	2
Jordan	2	1	3	2	2
Saudi Arabia	3	4	2	4	2
Somalia	1	4	4	1	2
Sudan	2	2	2	2	2
Yemen	2	2	3	2	2
Value	14	17	24	16	15
Average	2.0	2.4	3.4	2.3	2.1
(Ranking)	(5)	(2)	(1)	(3)	(4)

Country	Conservation Initiatives				
	Legislation & Coordination	Research & Monitoring	Enforcement & Implementation	Education & Awareness	Community Participation
Djibouti	2	2	2	2	3
Egypt	1	2	2	2	3
Jordan	2	3	1	2	2
Saudi Arabia	2	1	3	2	3
Somalia	3	3	3	3	3
Sudan	3	3	3	3	3
Yemen	1	2	3	2	2
Value	16	17	19	17	21
Average	2.3	2.4	2.7	2.4	3.0
(Ranking)	(5)	(3)	(2)	(3)	(1)

Notes:

Major Threats Scale: (1)-None; (2)-Small; (3)-Moderate; (4)-High; (5)-Critical

Conservation Initiatives Scale: (3)-Negligible; (2)-Moderate; (1)-Established & Operational

Artisanal (Traditional) Fishing includes egg collection.



Figure 3.21 Distribution and abundance of turtle nesting pits in Iles des Sept Frères and Ras Siyyan in 2002 prior to the MPA declaration in 2005 (source: PERSGA 2002).

Not all key marine turtle habitats overlap with established MPAs (Table 3.7). Gaps in protection of important nesting and feeding grounds occur at Shedwan, Wadi Al-Gimal, Ras Banas, Sarenka, Siyal Islands, Zabargad, and Rowabil Islands (Egypt); Ras Baridi (Saudi Arabia); Raas Xatiib to Raas Cuuda (Somalia); and Jabal Aziz (Yemen). There is a shortage of skilled personnel, equipment and resources to carry out research and monitoring.

In Djibouti, the illegal capture of turtles and collection of eggs is widespread (including within the boundaries of the Iles des Sept Frères and Ras Siyyan MPA). Turtle meat, oil and eggs are an important subsidiary food source for artisanal fishers and shells are sold to tourists. Significant nesting sites occur within the boundaries of the Iles des Sept Frères and Ras Siyyan MPA at Ile de l'Est and on the northern tip of Ras Siyyan (Figure 3.21). The lack of mainland nesting sites is attributed to predation and disturbance from scavengers, dogs, and humans (PERSGA 2002).

In Saudi Arabia the main threats come from oil spills, loss of habitat and development activities that endanger nesting beaches. For

example at Ras Baridi where uncontrolled particulate emissions from a large cement factory coat the beach and create hazards for emerging hatchlings.

Marine turtles in Somalia are hunted directly or caught as by-catch. However, the level of fishing pressure and the impacts on populations are unknown. Artisanal fishers in Sudan still collect turtle eggs on offshore islands as a subsidiary food source.

The eastern shore of Mukawwar Island (Sudan), within the boundaries of the Mukawwar Island–Dungonab Bay MPA, is a turtle nesting site of regional and possibly international significance (Figure 3.22). Several thousand nesting pits were likely to have been present over 8–10 km of the shore of Mukawwar Island in 2002. There is no deliberate capture of turtles within the MPA (PERSGA/GEF 2004f).

In Yemen, the use of turtle meat and eggs by northern and southern Socotri people is pronounced. Turtles are brought daily to market in Hadibo and are captured as far away as Gubba. Feral dogs, which are common along the coast near human settlements, are believed to prey on turtle

Table 3.7 Overlap (shaded regions) between the Red Sea and Gulf of Aden Regional MPA Network and key marine turtle habitats (from PERSGA/GEF 2004d).

Country	Key Marine Turtle Habitats	PERSGA Network of Established and Proposed MPAs
Djibouti	Iles des Sept Frères / Ras Siyyan	Iles des Sept Frères / Ras Siyyan
	Moucha & Maskali Islands	Moucha & Maskali Islands
	Giftun Islands	Giftun Islands and Straits of Gubal
	Shedwan	Straits of Tiran
	Wadi Al-Gimal	Ras Mohammed National Park
Egypt	Ras Banas	
	Sarenka	
	Siyal Islands	
	Zabargad	
	Rowabil Islands	
Jordan		Aqaba Marine Park
Saudi Arabia	Farasan Islands	Farasan Islands Protected Area
	Wajh Bank	Wajh Bank
	Ras Baridi	Straits of Tiran
Somalia	Aibat and Sa'adadin, Islands	Aibat and Sa'adadin Islands
	Raas Xatiib to Raas Cuuda	
Sudan	Mukawwar Island and Dungonab Bay	Mukawwar Island and Dungonab Bay
		Sanganeb Marine National Park
Yemen	Jabal Aziz	Belhaf Bir Ali Area
	Socotra	Socotra Islands Group

hatchlings and eggs in Dhobba and Ras Sharma in the Gulf of Aden.

The Regional Action Plan for the Conservation of Marine Turtles and their Habitats (PERSGA/GEF 2004d) contains an extensive list of management actions in response to the issues impacting marine turtles. This needs to be viewed as a check list against which progress towards better turtle conservation and management is assessed.

3.15 SEABIRDS

True seabirds are dependent on the sea for the majority of their food and usually breed on islands or along coasts (PERSGA/GEF 2004c). There are 17 true seabird species and 14 other water bird species recorded from the RSGA (Tables 3.8 and 3.9). Seabirds endemic to the RSGA include the white-eyed gull (*Larus leucophthalmus*), red-billed tropic bird (*Phaeton aethereus indicus*), spoonbill (*Platalea leucorodia archeri*) and brown noddy (*Anous stolidus plumeigularus*) (PERSGA/GEF 2003b). Important non-

endemic breeding populations include Jouanin's petrel (*Bulweria fallax*), sooty gull (*Larus hemprichii*), swift tern (*Sterna bergii velox*), white-cheeked tern (*Sterna repressa*) and Socotra cormorant (*Phalacrocorax nigrogularis*).

Important Bird Areas (IBA) are sites of high importance for their avifauna (PERSGA 2004e). Thirty-one IBAs are listed in the RSGA (Table 3.8). Of particular importance is the Hurghada Archipelago IBA which contains the largest breeding population of the white-eyed gull in the world (3,000 pairs). The Jasiira Ceebaad and Jasiira Sacaada Diin (Sa'adadin) IBAs in Somalia contain more than 100,000 breeding pairs of the bridled tern. The Jasiira Maydh IPA in Somalia contains 20,000 breeding pairs of the brown noddy. During 1999 approximately 10,000 Persian shearwater, *Puffinus persicus*, were estimated to be breeding inland on Socotra Archipelago, representing probably the most important breeding area in the world for this species (PERSGA/GEF 2003c).

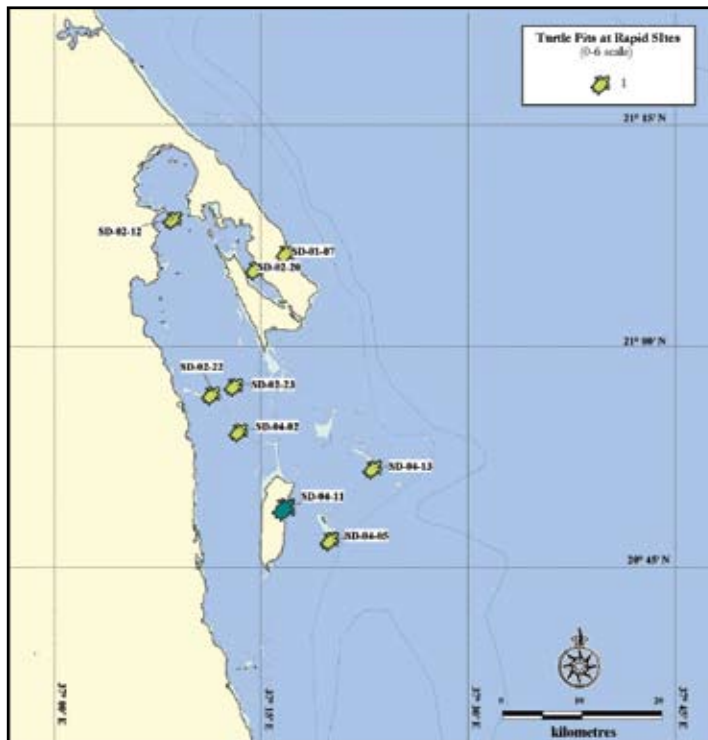


Figure 3.22 Distribution and abundance of turtle nesting pits in 2002 in the Mukawwar Island and Dungonab Bay MPA prior to declaration in 2005 (source: PERSGA/GEF 2004f).

3.15.1 Status, Trends, Issues

Available information on seabirds in the RSGA is limited, most studies conducted 10–20 years ago (PERSGA/GEF 2003c). The Socotra cormorant (*Phalacrocorax nigrogularis*) is the only true seabird species in the RSGA recognised as Globally Threatened by Bird Life International, and is classified as Vulnerable. Three other species are classified as Near Threatened: Jouanin’s petrel (*Bulweria fallax*), Persian shearwater (*Puffinus persicus*), and the white-eyed gull (*Larus leucophthalmus*). A number of species are listed under the Convention on Migratory Species (see Table 3.9). The current status of breeding seabirds (Tables 3.8 and 3.9) will be used as an indicator to assess (via monitoring) progress towards conservation of breeding seabirds in the RSGA.

Only 11 (35%) of the 31 IBAs listed in the RSGA are currently fully protected within existing MPAs or similar. All of the sites

listed in Table 3.11 require protection. In particular, the sites shown in Figure 3.23 have the greatest priority for protection (Iles des Sept Frères and Ras Siyyan MPA (Djibouti) and Mukawwar Island and Dungonab Bay MPA (Sudan) were declared in 2005). The lack of enforcement and monitoring in many MPAs is a serious issue for sustainable conservation of breeding seabirds (PERSGA/GEF 2004e). In addition to on-the-ground management, available resources for MPAs need to include institutional strengthening and capacity building in conservation and assessment of breeding seabirds.

The population status of most species is poorly known (PERSGA/GEF 2004e). This limits the ability of scientists and managers to detect changes in population status through time (whether natural or anthropogenic), to develop appropriate management strategies, and to assess the success of management. Information gaps are particularly significant for the following:

Table 3.8 Summary of Important Bird Areas (IBAs) in the Red Sea and Gulf of Aden of special importance to breeding seabirds (from PERSGA/GEF 2004e).

IBA	IBA number	Coords	Area (ha)	Protected status	Breeding seabird species	Reason for inclusion*	Comments
Djibouti							
Isles des Sept Frères	DJ004	12°28'N 43°23'E	c.4,000	Unprotected (proposed)	<i>Sterna bengalensis</i> , <i>Sterna bergii</i> , <i>Sula leucogaster</i>	<i>Sterna bengalensis</i> , <i>Sterna bergii</i>	
Egypt							
Hurghada Archipelago	EG015	27°28'N 33°49'E	150,000	Partially protected (National Park)	<i>Sula leucogaster</i> , <i>Phaethon aethereus</i> , <i>Larus hemprichii</i> , <i>Sterna caspia</i> , <i>Sterna bergii</i> , <i>Sterna bengalensis</i> , <i>Sterna anaethetus</i> , <i>Sterna repressa</i>	<i>Larus leucophthalmus</i> <i>Sterna repressa</i> <i>Sterna caspia</i> <i>Sterna bengalensis</i>	Largest breeding population of the white-eyed gull in the world, with 3,000 breeding pairs
Tiran Island	EG016	27°56'N 34°33'E	3,100	National Park	<i>Larus leucophthalmus</i> , <i>Sterna represa</i> , <i>Sterna bengalensis</i> and <i>Sterna caspia</i>	<i>Larus leucophthalmus</i>	Part of Ras Mohammed National Park
Wadi Gimal (Jimal) Island	EG017	24°40'N 35°10'E	200	National Park	<i>Phaethon aethereus</i> , <i>Larus hemprichii</i> , <i>Larus leucophthalmus</i> and <i>Sterna caspia</i>	<i>Larus leucophthalmus</i>	
Qulân Islands	EG018	24°22'N 35°23'E	300	National Park	<i>Phaethon aethereus</i> , <i>Larus hemprichii</i> , <i>Larus leucophthalmus</i> and <i>Sterna caspia</i>	<i>Larus leucophthalmus</i>	
Zabargad Island	EG019	23°37'N 36°12'E	450	National Park	<i>Sula leucogaster</i> , <i>Larus leucophthalmus</i> , <i>Sterna caspia</i> , <i>Sterna bengalensis</i> , <i>Sterna anaethetus</i> , <i>Sterna repressa</i>	<i>Larus leucophthalmus</i>	
Siyal Islands	EG020	22°47'N 36°11'E	200	National Park	<i>Larus leucophthalmus</i> , <i>Larus hemprichii</i> , <i>Sterna caspia</i> , <i>Sterna represa</i>	<i>Larus leucophthalmus</i>	
Rawabel Islands	EG021	22°25'N 36°32'E	<100	National Park	<i>Larus leucophthalmus</i> , <i>Larus hemprichii</i> and <i>Sterna caspia</i>	<i>Larus leucophthalmus</i>	
Saudi Arabia							
Al Wajh Bank	SA011	25°35'N 36°45'E	c.288,000	Unprotected	<i>Larus leucophthalmus</i>	<i>Larus leucophthalmus</i> <i>Larus hemprichii</i> <i>Sterna repressa</i>	
Madinat Yanbu al- Sinaiyah	SA016	23°56'N 38°14'E	c.700	Biological Reserve	<i>Sterna repressa</i> , <i>Sterna saundersi</i>	<i>Sterna repressa</i> <i>Sterna saundersi</i>	

Table 3.8 continued. Summary of Important Bird Areas (IBAs) in the Red Sea and Gulf of Aden of special importance to breeding seabirds (from PERSGA/GEF 2004e).

IBA	IBA number	Coords	Area (ha)	Protected status	Breeding seabird species	Reason for inclusion*	Comments
Qishran Bay	SA025	20°15'N 40°10'E	c.400,000	Unprotected	<i>Sterna anaethetus</i>		Not selected on basis of seabird populations breeding at site
Umm al-Qamari	SA026	18°59'N 41°06'E	c.14.7	Special Nature Reserve	<i>Larus leucophthalmus</i> , <i>Larus hemprichii</i>	<i>Larus leucophthalmus</i> <i>Larus hemprichii</i>	
Farasan Islands	SA038	16°45'N 42°00'E	c.620,000	Special Nature Reserve, Natural Reserve, Resources use Reserve and Controlled Hunting Reserve	<i>Larus leucophthalmus</i> , <i>Sula leucogaster</i> , <i>Larus hemprichii</i> , <i>Sterna repressa</i> , <i>Sterna anaethetus</i> , <i>Sterna bergii</i> , <i>Sterna saundersi</i> , <i>Anous stolidus</i>	<i>Larus leucophthalmus</i> <i>Sula leucogaster</i> <i>Larus hemprichii</i> <i>Sterna repressa</i> <i>Sterna anaethetus</i> <i>Sterna saundersi</i> <i>Anous stolidus</i>	
Somalia							
Jasiira Ceebaad (Albat island) and Jasiira Sacaada Diin (Saad a-din Island)	SO001	11°28'N 43°28'E	c.690	Unprotected (proposed)	<i>Sula leucogaster</i> , <i>Larus hemprichii</i> , <i>Larus leucophthalmus</i> , <i>Sterna repressa</i> , <i>Sterna bergii</i> and <i>Sterna bengalensis</i> , <i>Sterna anaethetus</i>	<i>Larus leucophthalmus</i> <i>Larus leucophthalmus</i> <i>Sterna anaethetus</i>	Over 100,000 breeding pairs of <i>Sterna anaethetus</i> recorded
Jasiira Maydh (Mait Island)	SO002	11°14'N 47°15'E	45	Unprotected (proposed)	<i>Phaethon aethereus</i> , <i>Sula dactylatra</i> , <i>Sterna fuscata</i> , <i>Sterna anaethetus</i> and <i>Anous stolidus</i>	<i>Anous stolidus</i>	20,000 breeding pairs
Sudan							
Mukawwar Island and Dunganab Bay	SD002	20°50'N 37°17'E	c.12,000	Unprotected	<i>Sterna bengalensis</i> , <i>Sterna repressa</i> , <i>Sterna anaethetus</i> , <i>Larus hemprichii</i> , <i>Larus leucophthalmus</i> , <i>Sterna bergii</i> , <i>Sterna bengalensis</i> , <i>Sterna repressa</i> , <i>Sterna anaethetus</i> , <i>Anous stolidus</i> , <i>Sula leucogaster</i> ; <i>Larus hemprichii</i>	<i>Larus leucophthalmus</i> <i>Larus leucophthalmus</i> <i>Sterna bengalensis</i>	
Suakin Archipelago	SD004	18°50'N 38°00'E	150,000	Unprotected		<i>Sterna bergii</i> <i>Sterna bengalensis</i>	
Yemen							
Midi - Luhayyah	YE001	16° 00'N 42° 50' E	30,000	Unprotected	<i>Larus leucophthalmus</i>	<i>Larus leucophthalmus</i> , <i>Sterna repressa</i>	
Islands north of Al-Hudaydah (Hodeidah)	YE004	15°40'N 42°30'E	c.5,000	Unprotected	<i>Larus leucophthalmus</i> , <i>Phaethon aethereus</i> , <i>Sula leucogaster</i> , <i>Sterna bengalensis</i> , <i>Sterna repressa</i> , <i>Larus hemprichii</i>	<i>Larus leucophthalmus</i> <i>Phaethon aethereus</i> <i>Sula leucogaster</i> , <i>Sterna bengalensis</i> <i>Sterna repressa</i> <i>Larus hemprichii</i>	

Table 3.8 continued. Summary of Important Bird Areas (IBAs) in the Red Sea and Gulf of Aden of special importance to breeding seabirds (from PERSGA/GEF 2004e).

IBA	IBA number	Coords	Area (ha)	Protected status	Breeding seabird species	Reason for inclusion*	Comments
Bahr Ibn Abbas-Ra's Isa	YE007	15°20' N 42°50' E	c.35,000	Unprotected	<i>Larus leucophthalmus</i> , <i>Sterna repressa</i> , <i>Larus hemprichii</i>	<i>Larus leucophthalmus</i> <i>Sterna caspia</i> <i>Sterna repressa</i> <i>Larus hemprichii</i>	Many non-breeding seabirds occur as summer visitors
Al-'Urj	YE010	15° 05' N 42° 55' E	1,500	Unprotected	<i>Numenius phaeopus</i> , <i>Sterna saundersi</i>	<i>Sterna saundersi</i>	
Jaza'ir Al-Zubayr	YE012	15° 00' N 42° 04' E	c.3,300	Unprotected	<i>Larus leucophthalmus</i> , <i>Phaethon aethereus</i> , <i>Sula leucogaster</i> , <i>Sula dactylatra</i> , <i>Sterna bengalensis</i> , <i>Sterna repressa</i> , <i>Puffinus persicus</i> , <i>Larus hemprichii</i>	<i>Larus leucophthalmus</i> <i>Puffinus persicus</i> <i>Larus hemprichii</i>	
Nukhaylah-Ghulayfiqah	YE015	14° 30' N 43° 00' E	9,000	Unprotected	<i>Larus leucophthalmus</i>	<i>Sterna repressa</i>	
Al-Fazzah	YE016	14° 08' N 43° 07' E	3,500	Unprotected	<i>Larus leucophthalmus</i>	<i>Sterna repressa</i>	
Jaza'ir al-Hanish	YE019	13° 52' N 42° 45' E	28,000	Unprotected	<i>Larus leucophthalmus</i> , <i>Larus hemprichii</i> , <i>Sula leucogaster</i>	<i>Larus leucophthalmus</i> <i>Puffinus persicus</i> <i>Larus hemprichii</i> , <i>Sterna repressa</i>	
Qishen Beach	YE027	15° 26' N 51° 45' E	c.100	Unprotected	<i>Phalacrocorax nigrogularis</i> , <i>Larus hemprichii</i>	<i>Phalacrocorax nigrogularis</i>	
Islands off Bir Ali	YE030	13° 50' N 48° 20' E	c.300	Unprotected	<i>Phalacrocorax nigrogularis</i> , <i>Larus hemprichii</i>	<i>Phalacrocorax nigrogularis</i>	
Aden	YE033	12° 45' N 45° 04' E	c.10,000	Unprotected	<i>Larus leucophthalmus</i>	<i>Larus hemprichii</i>	
Qalansiya Lagoon, Socotra	YE035	12° 42' N 53° 30' E	c.100	Protected	<i>Larus hemprichii</i>	<i>Larus hemprichii</i>	
Sabuniya and Ka'l Fir'awn, Socotra	YE054	12° 33' N 52° 42' E	c.10	Protected	<i>Phalacrocorax nigrogularis</i> , <i>Sula leucogaster</i> , <i>Sula dactylatra</i>	<i>Sula dactylatra</i> <i>Bulweria fallax</i>	
Al-Mukha – Al-Khawkhah	YE057	13° 35' N 43° 17' E	c.7,000	Unprotected	<i>Larus leucophthalmus</i>	<i>Larus leucophthalmus</i> <i>Puffinus persicus</i> <i>Larus hemprichii</i> <i>Sterna repressa</i> <i>Sterna saundersi</i>	

* Note: IBAs are identified on the basis of four strict criteria. These are that the site contains species of global conservation concern as follows: (A1) The site regularly holds significant numbers of globally threatened species, or other species of global conservation concern; (A2) The site is known or thought to hold a significant component of the restricted-range species whose breeding distributions define an Endemic Bird Area (EBA) or Secondary Area (SA); (A3) The site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome; (A4i) The site is known or thought to hold, on a regular basis, >1% of a biogeographic population of a congregatory seabird species; (A4ii) The site is known or thought to hold, on a regular basis >1% of the global population of a congregatory seabird or terrestrial species; (A4iii) The site is known or thought to hold, on a regular basis, >20,000 waterbirds or >10,000 pairs of seabirds of one or more species, and (A4iv) The site is known or thought to exceed thresholds set for migratory species at bottleneck sites. See EVANS (1994) and FISHPOOL AND EVANS (2001) for more details.

Table 3.9 National and international conservation status of breeding seabird species in the Red Sea and Gulf of Aden region (from PERSGA/GEF 2004e).

Species	IUCN	CMS App. I/II	AEWA Annex II	Conservation status						
				Djibouti	Egypt	Jordan	Saudi Arabia	Somalia	Sudan	Yemen
Jouanin's Petrel <i>Buweria fallax</i>	LR/nt			-	-	-	No breeding confirmed	No breeding confirmed	Uncertain	Near-threatened
Persian Shearwater <i>Puffinus persicus</i>	LR/nt			Near-threatened	-	-	Near-threatened	Near-threatened	ID	Near-threatened
Red-billed Tropicbird <i>Phaethon aethereus indicus</i>	-			Scarce breeder, not threatened	ID	-	Rare breeder, not threatened	Uncertain	Uncertain	Scarce breeder, not threatened
Brown Booby <i>Sula leucogaster plotus</i>	-			Uncertain	Rare, threatened	-	Threatened	Declining, threatened	ID	Threatened
Masked Booby <i>Sula dactylatra melanops</i>	-			-	-	-	Non-breeder	Threatened	-	Threatened
Socotra Cormorant <i>Phalacrocorax nigrogularis</i>	VU	II	X	-	-	-	Vulnerable	Vulnerable	-	Vulnerable
Sooty Gull <i>Larus hemprichii</i>	-	II	X	Widespread, stable population	Scarce, not threatened	-	Widespread, evenly distributed, not threatened	Widespread	ID	Widespread, not threatened
White-eyed Gull <i>Larus leucophthalmus</i>	LR/nt	I/II	X	Near-threatened	Near-threatened	-	Near-threatened	Threatened	Near-threatened	Threatened
Caspian Tern <i>Sterna caspia</i>	-	II*	X	-	Stable breeding population	-	Small breeding population, widespread, not threatened	Non-breeder	-	Scarce breeder, threatened

Table 3.9 continued. National and international conservation status of breeding seabird species in the Red Sea and Gulf of Aden region (from PERSGA/GEF 2004e).

Species	Conservation status									
	IUCN	CMS App. I/II	AEWA Annex II	Djibouti	Egypt	Jordan	Saudi Arabia	Somalia	Sudan	Yemen
Swift Tern <i>Sterna bergii velox</i>	-	II**	X	Uncertain	Small breeding population	-	Not threatened	Resident breeder, uncertain status	Breeder in small numbers, not threatened	-
Lesser Crested Tern <i>Sterna bengalensis</i>	-	II**	X	Small breeding population, status uncertain	Common, not threatened	-	Widespread, not threatened	Uncertain	Abundant	Threatened
White-cheeked Tern <i>Sterna repressa</i>	-	II	X	Uncertain, small numbers	Breeder and migrant, common	-	Widespread, not threatened	Uncertain	Abundant	Widespread, not threatened
Sooty Tern <i>Sterna fuscata</i>	-	-	-	-	-	-	-	Uncertain	-	-
Bridled Tern <i>Sterna anaethetus</i>	-	-	-	Uncertain, breeds in one island	Common, not threatened	-	Increasing number, not threatened	Abundant, not threatened	Abundant	-
Little Tern <i>Sterna albifrons</i>	-	II	X	-	Scarce breeder and on migration	-	-	-	-	-
Saunders' Little Tern <i>Sterna saundersi</i>	VU	I/II	X	-	No confirmed breeding	-	Rare breeder, threatened	ID	Rare, little known	Rare breeder, threatened
Brown Noddy <i>Anous stolidus</i>	-	-	-	Uncertain	-	-	Abundant, stable	Abundant, not threatened	Uncertain	Not threatened

National threat status is based on a species listing in Red List of each PERSGA country and the national seabird status reports; NA = no national assessment of threat status has been undertaken; ID = insufficient data.

IUCN categories. VU = Vulnerable; LR/nt = (Lower Risk) Near-threatened; LR/lc = (Lower Risk) Less concern (BIRDLIFE INTERNATIONAL 2000). CMS App. I/II – Listed on Convention on Migratory Species Appendix I or II. * - listed for West Eurasian and African populations. ** - listed for African and South West Asian populations. AEWA Annex II – Listed on Annex II of the African-Eurasian Migratory Waterbird Agreement.

Table 3.10 Distribution and population of breeding seabirds in the Red Sea and Gulf of Aden (from PERSGA/GEF 2004e).

Species	Distribution of species or subspecies	RSGA population estimate (pairs)	Reference PERSGA/GEF 2003a and others as given
Jouanin's Petrel <i>Bulweria fallax</i>	Endemic to northwest Indian Ocean	3,000 **	AL-SAGHIER et al. (unpublished)
Persian Shearwater <i>Puffinus persicus</i>	Endemic to the Indian Ocean and Gulf of Aden	10,000 **	
Red-billed Tropicbird <i>Phaethon aethereus indicus</i>	Subspecies endemic to RSGA and Arabian Sea to Arabian Gulf	700	
Brown Booby <i>Sula leucogaster plotus</i>	Subspecies occurs throughout Indo-Pacific	15,000*	
Masked Booby <i>Sula dactylatra melanops</i>	Subspecies endemic to western Indian Ocean	1,000	
Socotra Cormorant <i>Phalacrocorax nigrogularis</i>	Endemic to Arabian Sea and Gulf of Aden	15,000***	JENNINGS 2003 and AL-SAGHIER 2002a
Sooty Gull <i>Larus hemprichii</i>	North-west Indian Ocean	4,000	
White-eyed Gull <i>Larus leucophthalmus</i>	Endemic to RSGA Region	11,000*	
Caspian Tern <i>Sterna caspia</i>	Widespread beyond Region	500*	
Swift Tern <i>Sterna bergii velox</i>	Subspecies endemic to RSGA Region	3,500*	
Lesser Crested Tern <i>Sterna bengalensis</i>	North African coast, Arabian Sea, Indo-Pacific	14,000	
White-cheeked Tern <i>Sterna repressa</i>	RSGA Region, Arabian Sea, northwest Indian ocean	27,000*	
Sooty Tern <i>Sterna fuscata</i>	Tropical and subtropical zones of Pacific, Indian and Atlantic oceans	7,000	DELANY & SCOTT 2002
Bridled Tern <i>Sterna anaethetus fuligula</i>	RSGA, Arabian Gulf, Arabian Sea, Indo-Pacific and locally West Africa	240,000*	
Little Tern <i>Sterna albifrons albifrons</i>	Widespread, west Palearctic, India, Pacific, West Africa, North America and Caribbean	-	-
Saunders's Little Tern <i>Sterna saundersi</i>	RSGA, northwest Indian Ocean and east African and north-west Indian coasts	200*	DELANY & SCOTT 2002
Brown Noddy <i>Anous stolidus</i>	Widespread in tropical and subtropical zones in Atlantic, Indian and Pacific Oceans	26,000*	

* = Count of breeding birds from surveyed coasts and islands; ** = Estimated breeding population on Socotra Island Group, *** = Estimated breeding population on islands off Bir Ali and Socotra

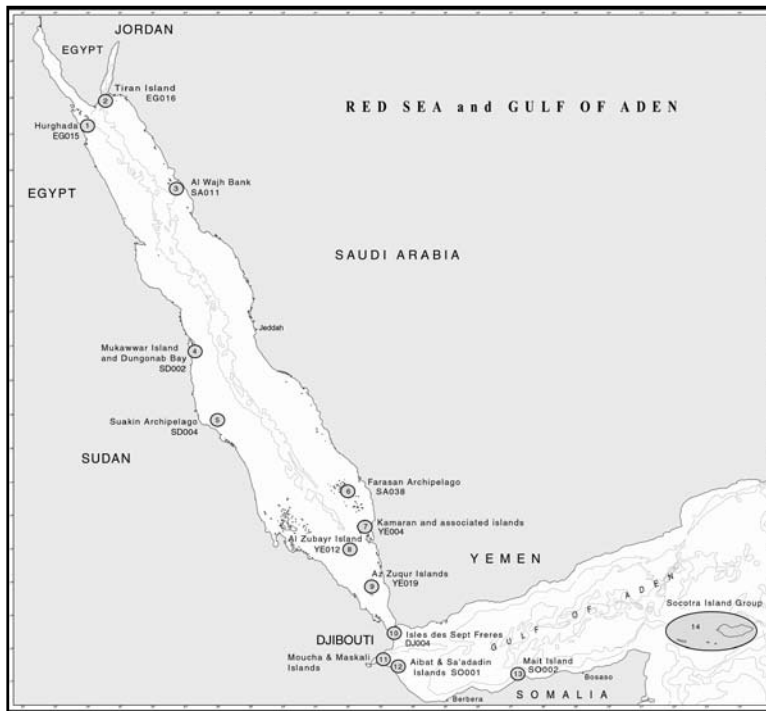


Figure 3.23 Priority sites for the conservation of nesting seabirds in the Red Sea and Gulf of Aden (from PERSGA/GEF 2003c, 2004e).

- (i) Jouanin's petrel, *Bulweria fallax*, is considered to be Near Threatened globally. There are no estimates of number of breeding pairs available for the region.
 - (ii) Persian shearwater, *Puffinus persicus* is considered to be Near Threatened globally. In 1999 approximately 10,000 birds were estimated to be breeding inland on Socotra Archipelago, representing probably the most important breeding area in the world. Although not scientifically documented, the breeding season is believed by locals to be March/April to December/January. The number of breeding pairs and the extent of the breeding season require further attention.
 - (iii) Masked booby, *Sula dactylatra*, is listed as Near Threatened. This species is declining rapidly and the few remaining colonies are threatened with extinction (DEL HOYO et al. 1992; AL SAGHIER et al. 1999). A major constraint to conservation and assessment is that habitat and colony type are not well described.
 - (iv) Swift tern, *Sterna bergii velox*. This is a subspecies endemic to the Red Sea and north-west Somalia. The status of this species requires more investigation and it is currently classified as Insufficiently Known.
- The white-eyed gull, *Larus leucophthalmus*, is a priority for conservation action. This species is endemic to RSGA. Birds breed in all countries of the RSGA but not on the Socotra Archipelago. The global population is estimated to be 20,000 birds of which 12,000 – 13,000 pairs breed in PERSGA countries. Populations in the region are likely to decline due to potential threats and poor protection. This species is considered to be Near Threatened (PERSGA/GEF 2003c, 2004e).
- General threats to breeding seabirds include human disturbance, human exploitation, introduced predators, habitat destruction (especially urban expansion), pollution, over-fishing and lack of information on population status (PERSGA/GEF 2003c,

Table 3.11 Number of pairs of breeding seabirds recorded from PERSGA countries (from PERSGA/GEF 2003c).

Species	Estimated Number from PERSGA Countries						
	Djibouti	Egypt	Jordan	Saudi Arabia	Somalia	Sudan	Yemen
Jouanin's Petrel	0	0	0	0	0	0	+50
Persian Shearwater	0	0	0	0	?	0	10,000*
Red-billed Tropicbird	3-7	?	0	11-100	?	?	520-700
Masked Booby	0	0	0	0	100-240	0	800-1,150
Brown Booby	100-150	57-70	0	2000	?	?	13,230
Socotra Cormorant	0	0	0	0	?	?	?
Pink-backed Pelican	?	0	0	?	?	?	?
Little Green Heron	?	40-60	0	?	?	?	?
Cattle Egret	0	0	0	1,900*	?	?	30
Western Reef Heron	20-40	130-200	0	?	?	?	?
Gray Heron	?	0	0	?	?	?	?
Purple Heron	?	0	0	?	?	?	?
Goliath Heron	?	<10	0	?	?	?	?
Spoonbill	?	30-50	0	?	?	?	?
Osprey	10-20	150-200	0	?	1-3	?	+66
Sooty Falcon	5-10	+300	0	260-380	?	?	+45
Crab Plover	?	?	0	1100-1500	1,000	333-500	1060
Kentish Plover	?	+100	0	?	?	?	+70
Sooty Gull	?	+100	0	1,000-1,500	50-100	?	+2525
White-eyed Gull	600-700	2,500	0	>1,500	1,200-2,200	300-1,000	+3900
Caspian Tern	0	250-350	0	100-200	?	?	?
Swift Tern	500-600	?	0	2,000	<1,000	?	?
Lesser Crested Tern	1,000 (1985)	+1,500	0	2,000-4,000	?	3,000-5,000	5,000
White-cheeked Tern	60-80	+2,500	0	7,500	?	?	+8,910
Bridled Tern	530	+1,200	0	60,000	+100,000	8,000	70,230
Saunders's Little Tern	0	0	0	?	?	?	?
Brown Noddy	5-10	0	0	7,500	10,000-20,000	?	3,940

? = breeding but no estimate of the breeding population; * counted as individuals

2004e). Information is available on specific issues for seabirds in PERSGA countries (PERSGA/GEF 2003c, 2004e). In Djibouti existing publications provide limited information on seabird breeding, with some records of breeding seabirds not confirmed (PERSGA/GEF 2003c). The mainland coast of the Iles des Sept Frères and Ras Siyyan MPA is important, especially the western coast of Ras Siyyan (Figure 3.24). Tourist pressure has been reported as causing a negative impact on breeding seabirds on Moucha and Maskali Islands. Egg consumption is common.

In Egypt there are records of 16 species of global conservation concern. Pollution from coastal industries is likely to be more severe where there are concentrations of particular industries, such as in the Suez area. Vehicles on islands in Egypt pose a major threat to ground nesting birds. Rates of egg consumption by humans are unclear. Some fishery practices are damaging to breeding seabirds in Egypt.

There are no islands in the Jordanian Red Sea and no breeding seabird sites. Several seabird species recorded along the Gulf of Aqaba utilise the marine environment for feeding and roosting. These species

are likely to be affected by pollution from industries in the Gulf of Aqaba.

In Saudi Arabia, pollution from coastal industries is likely to be more severe where there are concentrations of particular industries, such as around Jeddah and Yanbu. Egg consumption appears to have generally declined among fishers and local people except in parts of the Farasan Islands (GLADSTONE 2000). White-tailed mongoose, *Ichneumia albicauda*, and other small carnivores are known to have had severe adverse effects on osprey breeding success in the Farasan Islands (FISHER 2001). In the Farasan Islands unsustainable and environmentally damaging fishery practices, and increased fishing pressure could affect breeding seabirds. Access to seabird breeding islands is forbidden to decrease human pressure. However disturbance by tourists, recreational users and fishers still occurs.

Urban expansion on the mainland of Somalia has been reported as causing the breeding failure of seabirds at Sa'adadin Islands. Extensive agricultural use of pesticides, insecticides and herbicides occurs along the coast of Somalia. Egg consumption is severe. The current economic situation



Figure 3.24 Seabird distribution and relative abundance at sites in the Iles des Sept Frères and Ras Siyyan MPA in 2002 prior to its declaration in 2005 (source: PERSGA 2002).

probably led to recent increases in seabird egg consumption.

Extensive agricultural use of pesticides, insecticides and herbicides is known to occur along the coast of Sudan. Potential hazards include the Tokar Delta Agricultural Scheme and the country's Locust Control Programme. Egg consumption occurs but not at the high levels reported for other countries. The black rat, *Rattus rattus*, is recorded on Suakin Archipelago. The black rat preys on both birds' eggs and chicks, and affects gulls. It appears to be the main mammalian predator in coastal and island areas. There are large numbers of nesting osprey (*Pandion haliaetus*) in the Mukawwar Island and Dungonab Bay MPA. Of particular note is the occurrence of occupied and undisturbed nests close to human settlements within the MPA (PERSGA/GEF 2004f).

There is extensive agricultural use of pesticides, insecticides and herbicides along the coast of Yemen. Fishers have been observed eating Socotra cormorant, petrel and Persian shearwater chicks. A severe infestation of rats on Darsa Island (Socotra Archipelago) has resulted in heavy mortality among sooty gulls and abandonment of the breeding colony. The introduction of the lesser Indian civet cat, *Viverricula indica*, along with feral cats to Socotra Island resulted in the disappearance of ground nesting seabirds, apart from small numbers of Saunders little tern. The Indian house crow, *Corvus splendens*, has recently spread to Socotra Archipelago and is a cause of deep concern as an introduced predator. Egg consumption is still practiced and could be significant on the mainland. The 2002 oil spill from the MV Limburg between Al Mukalla and Bir Ali in the Gulf of Aden was not fully assessed. The environmental impacts could have been significant, especially for the breeding colony of Socotra cormorant in the area. Beaches near Bir Ali were reported to be badly fouled by oil and covered with thousands of feathers. Over-fishing is a particular problem mainly due to badly monitored foreign vessels trawling close to shore. Of particular concern for the status of breeding seabirds is the reduction

in food availability resulting from intensive fishing effort.

3.16 MARINE MAMMALS

Dugong (*Dugong dugon*) have been reported from both the Red Sea and the Gulf of Aden (PREEN 2004a). Within the Red Sea dugong have been reported from Djibouti (PERSGA/GEF 2001), the African coast of Egypt (south of Quesir) (MARSH et al. 2002), the Gulf of Aqaba (Nabq and Abu Galum Marine Park) (MARSH et al. 2002), Saudi Arabia (Tiran Islands, Wajh Bank, Farasan Islands, Jizan, Sharm Munaibara, Qirshan Island, Khawr Nahoud) (PREEN 1989; SHEPPARD et al. 1992; MARSH et al. 2002; PERSGA/GEF 2003b), and Eritrea (Dahlak National Park) (MARSH et al. 2002). Surveys by PREEN (1989) estimated there were 4,000 dugong within the Red Sea and 2,000 of these occur in Saudi Arabian waters.

Important dugong areas in the Red Sea are the Tiran Islands, Wajh Bank, Farasan Islands, Jizan, Sharm Munaibara, Qirshan Island, and Khawr Nahoud (PREEN 1989; MARSH et al. 2002; SHEPPARD et al. 1992; PERSGA/GEF 2003b). The Red Sea coast of Saudi Arabia is one of the most important areas for dugong in the world (PERSGA/GEF 2001). Although there are no confirmed records of dugong in Yemen, suitable habitat exists and dugong are likely to occur at low population densities (PERSGA/GEF 2001). A recent review (MARSH et al. 2002) confirms the existence of common populations between Saudi Arabia and Egypt around the Tiran Islands.

The cetacean fauna of the RSGA is not well known (PREEN 2004a). The limited number of systematic surveys has made the identification of significant cetacean sites difficult. It has also meant that there are uncertainties about the species of cetaceans occurring in the RSGA (GLADSTONE & FISHER 2000; PREEN 2004a). Forty-four species of cetaceans are known from the Indian Ocean, but only 15 have been reported from the Gulf of Aden and only 11 from the Red Sea (PREEN 2004a).

The following cetaceans have been reported from the RSGA: false killer whale (*Pseudorca crassidens*), killer whale (*Orcinus orca*), Indo-Pacific humpbacked dolphin (*Sousa chinensis*), common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*S. coeruleoalba*), spinner dolphin (*S. longirostris*) and Bryde's whale (*Balaenoptera edeni*). The rough-toothed dolphin (*Steno bredanensis*) has been reported only from the Red Sea. The following species have been reported only from the Gulf of Aden: blue whale (*Balaenoptera musculus*), sperm whale (*Physeter macrocephalus*), melon-headed whale (*Peponocephala electra*) and short-finned pilot whale (*Globicephala macrorhynchus*).

3.16.1 Status, Trends, Issues

Dugong are listed as Vulnerable by the World Conservation Union (IUCN) (Table 3.12) and are protected in all countries of the RSGA. There is little information about specific issues for dugong in the RSGA. There are reports of dugong accidentally captured on occasions in fishing nets in Djibouti and the Farasan Islands (Saudi Arabia) (GLADSTONE 2000; PERSGA/GEF 2001). PREEN (2004a) observed a decline in numbers of dugong between 1987 and 1993 in the vicinity of Jizan and the Farasan Islands (Saudi Arabia) and suggested this indicated the level of accidental net drownings of dugong was unsustainable.

A major issue for future conservation of dugong is the lack of information on dugong populations, particularly on the western coast of the Red Sea. There is an urgent need for population surveys (PREEN 2004a). The recent development of standard survey methods will facilitate the acquisition of population data and monitoring (PREEN 2004a).

Of the 15 species of cetaceans known to occur in the RSGA two are Threatened species (Endangered or Vulnerable), five

are dependent upon conservation actions to prevent their listing as Threatened, five are insufficiently known to assign a conservation status, and three are Secure (Table 3.12). The number of species listed as insufficiently known highlights the need for further information. The presence of two Threatened species highlights the great need for properly designed surveys and monitoring (see PREEN 2004a) to assess the trends in their population numbers.

General issues for marine mammals in the RSGA include: accidental drowning in mesh-nets; marine pollution; disturbance from shipping, military activities, seismic exploration, boating activity; and loss of seagrass (PREEN 2004a). A pressing concern is the absence of systematic information and monitoring of cetaceans in all countries in the RSGA. There are currently few country-specific issues for cetaceans. Three species of cetaceans were reported from the Iles des Sept Frères and Ras Siyyan MPA in Djibouti (PERSGA 2002) and there are reports of occasional accidental captures of dolphins in fishing nets (PERSGA/GEF 2001). Dugong are rare in the Iles des Sept Frères and Ras Siyyan MPA (PERSGA 2002).

Dugong occur in the Mukawwar Island and Dugonab Bay MPA (Sudan). The population there may be the most important remaining on the coast of Africa. However, numbers have declined sharply in recent years. The cause is most likely accidental capture in fixed fishing nets. Two species of dolphin occur in the MPA (PERSGA/GEF 2004f).

A dramatic decline in the abundance of cetaceans in the Arabian Gulf in recent years (PREEN 2004b) and of coastal cetaceans and dugongs in other areas of the Indian Ocean (PREEN 1998; MARSH et al. 2002) is cause for great concern. These declines emphasise the need for systematic monitoring to detect the beginnings of such declines. The declines also emphasise the global conservation value of the remaining dugong populations within the Red Sea, especially on the African coast.

Table 3.12 Species of marine mammal reported from the Red Sea (RS) and Gulf of Aden (GA), and their conservation status (source: PREEN 2004a). IUCN (1996) categories: EN: endangered; VU: vulnerable; CD: conservation dependent; DD: data deficient.

Species	IUCN status	Distribution & Reference		Rarity 1=more common 2=less common
		GA	RS	
Dugong	VU	1	5	1
Blue whale	EN	2,4		2
Bryde's whale	DD	2		1
Sperm whale	VU	2,4		1
Melon-headed whale		2		2
False killer whale		2	3,4	2
Killer whale	CD	2	4	2
Short-finned pilot whale	CD	2,4		1
Indo-Pacific humpbacked dolphin	DD	2	3,4	1
Common dolphin		2	4	1
Bottlenose dolphin	DD	2	3,4	1
Risso's dolphin	DD	2	3,4	1
Pantropical spotted dolphin	CD	2	3,4	1
Striped dolphin	CD	2	4	2
Spinner dolphin	CD	2	4	1
Rough-toothed dolphin	DD		4	2

1. Robineau and Rose 1982; 2. Small and Small 1991; 3. Beardon 1991; 4. Frazier et al. 1987; 5. Preen 1989.

3.17 ENDEMISM

A taxon is endemic to an area if it occurs there and nowhere else. Areas with a high number of endemic taxa may represent unusual environmental conditions, have been isolated for periods of time, or have escaped otherwise widespread environmental changes (GASTON & SPICER 2004). The Red Sea has long been considered an important area for endemic species. This high level of endemism in the Red Sea may have arisen because of its

potential isolation during periods of lower sea level, its extreme environment, and the limited exchange that occurs through the Bab el Mandeb.

There is great variation in the level of endemism in the flora and fauna of the Red Sea. Nine per cent of Red Sea benthic algae are endemic, and 64% are pan-tropical (PAPENFUSS 1968). About 6% of Red Sea corals are endemic (SHEPPARD et al. 1992). Amongst the polychaetes, 13% of Red Sea taxa and 10% of Gulf of Aden taxa

are endemics (WEHE & FIEGE 2002). Five per cent of all echinoderms are endemics (SHEPPARD et al. 1992). However, within the echinoderms endemism is between 33 and 70% (crinoids), 23% (holothuroids), and 13% (asteroids) (CAMPBELL 1987). Four of 11 species of nudibranchs belonging to the family Phyllidiidae are endemic to the Red Sea, representing a level of endemism of 36% (FAHRNER & SCHRÖDL 2000). Estimates of the level of endemism of Red Sea fishes vary between 10% (RANDALL 1983) and 17% (ORMOND 1987). However, there is great variation between different families and functional groups. For example, the level of endemism amongst small benthic, territorial groups such as dottybacks (*Pseudochromidae*) and triple fins (*Tripterygiidae*) is about 90%, while endemics are almost absent amongst pelagic species (SHEPPARD et al. 1992). Endemism amongst Red Sea butterflyfishes (*Chaetodontidae*) may be 50% (RIGHTON et al. 1996).

Estimates of endemism are important for assigning conservation value. The spatial scales of such assessments range from local to global. A major constraint to assigning conservation values to areas throughout the RSGA, and in comparing the RSGA to the rest of the world's oceans, is the limited taxonomic record. For example, BENAYAHU et al. (2002), in describing the soft coral fauna of the Dahlak Archipelago (Eritrea), concluded that it was not possible to comment on the level of endemism amongst the Red Sea soft corals because of patchy and incomplete sampling and a lack of records from other areas within the Red Sea. There is an urgent need for further taxonomic studies (including the compilation of inventories and distribution maps) within the RSGA for many groups.

3.18 BIOGEOGRAPHY

SHEPPARD et al. (1992) concluded that most biota within the RSGA (along with the Arabian Sea, Gulf of Oman and Gulf) belonged to a single biogeographical subregion within the Indo-west Pacific region. Similarly, KLAUSEWITZ (1978,

1989) considered the ichthyofauna of the Red Sea, Gulf of Aden and Arabian Gulf to be a distinct subregion. SCHILS & COPPEJANS (2003a, b), after field work on the subtidal algae of the Socotra Archipelago, considered that the Arabian Sea warranted delineation as a distinct phytogeographical subprovince within the Indo-Pacific and the larger Arabian region.

At a smaller spatial scale the RSGA can be subdivided into distinctive species assemblages arising from the influence of environmental variation. The available information on temperature, salinity, surface nutrient status, and primary productivity suggests that the RSGA can be divided into six regions, including five within the Red Sea itself (SHEPPARD et al. 1992). The Red Sea regions are: northern, central, southern, Gulf of Suez, and Gulf of Aqaba (Figure 3.25). The latter two regions are also well separated according to differences in physical properties: the Gulf of Suez is shallow (average depth of 50 m), is vertically well mixed throughout the year, with well-developed latitudinal gradients in salinity and temperature. The Gulf of Aqaba is deep (800–1,800 m), with vertical mixing that is seasonal, and less well-defined salinity and temperature gradients (SHEPPARD et al. 1992).

This division, based on physical characteristics, is supported by studies of a number of different groups of biota. A consistent pattern in these studies is the division between the northern and southern Red Sea. ORMOND et al. (1984) recognised two faunal provinces: the Gulf of Aden and the Red Sea. Based on extensive survey work along the coastline of Saudi Arabia and water mass similarities between the western and eastern coastlines, ORMOND et al. (1984) suggested that the Red Sea province can be further sub-divided into four distinct sub-provinces or regions: Gulf of Aqaba, northern Red Sea, Central Red Sea and outer Farasan Bank, inshore southern Red Sea.

Using presence-absence data for corals throughout the Arabian region, SHEPPARD



Figure 3.25 Biogeographical regions in the Saudi Arabian Red Sea (source: PERSGA/GEF 2001).

& SHEPPARD (1991) described a regional zoogeography that consisted of two broad groups: Red Sea; and the Gulf, Gulf of Oman, and Arabian Sea. Three regions were recognised within the Red Sea: northern Red Sea, Gulf of Suez and Gulf of Aqaba; central Red Sea; southern Red Sea from Al Lith to the Bab el Mandeb. Results of a recent detailed survey of corals in the central-northern Red Sea of Saudi Arabia and the Socotra Archipelago (DE VANTIER et al. 2000a, 2004) indicate that the coral fauna of each area are a complex composite of species from a number of biogeographic provinces. The coral fauna of the central-northern Red Sea of Saudi Arabia includes representatives of species

with the following distributions: Indo-west Pacific; Pacific Ocean; Indian Ocean; western Indian Ocean; Red Sea endemics; and presently undescribed species. The coral fauna of the Socotra Archipelago includes species with the following distributions: Indo-west Pacific; Indian Ocean; western Indian Ocean; Oman–Arabian Gulf; Oman; species previously regarded as Red Sea endemics; and several presently undescribed species (DE VANTIER et al. 2004).

BENAYAHU et al. (2002) described a north to south decrease in species richness of soft corals within the Red Sea, related to environmental differences such as temperature, salinity, nutrient concentrations, and turbidity. All of the species recorded by BENAYAHU et al. (2002) belonged to the wider Indo-Pacific fauna.

Using regional data on chaetodontid fishes, KEMP (1998) divided the Arabian representatives into three groups: Red Sea and western Gulf of Aden; Socotra, Oman and the Gulf; East Africa, the Seychelles, and the Maldives. On this basis, the Socotra Archipelago has a regionally high conservation value because its fish fauna

appears to be distinctly different from the rest of the Red Sea and Gulf of Aden. KHALAF & ABDALLAH (2005) described the biogeography of chaetodontid fishes in more detail. Four distinct biogeographic distribution patterns are apparent. Red Sea endemics occur only in the northern and central Red Sea e.g. *Chaetodon austriacus* and *C. paucifasciatus*. A number of species are endemic to the Red Sea but also occur in the Gulf of Aden e.g. *C. larvatus*, *C. fasciatus*, *C. semilarvatus*, *C. mesoleucus* and *Heniochus intermedius*. A group of species occurs in the Gulf of Aden but not in the Red Sea e.g. *C. melapterus*, *C. vagabundus* and *Heniochus acumiatus*.

A widespread group of species occurs throughout the Indian Ocean and the entire Red Sea e.g. *C. auriga*, *C. lineolatus*, *C. melannotus* and *C. trifascialis*.

The biogeography of shallow-water holothuroids (sea cucumbers) consists of species occurring in the northern Red Sea and species in the southern Red Sea. The southern Red Sea fauna shows greater affinity with the holothuroid fauna of south-east Arabia and the Gulf, suggesting that the Bab el Mandeb is no longer a major barrier for this group (SAMYN & TALLON 2005).

Information on biogeographic affinities is important for the selection of representative MPAs. However, the reality of the regionalizations are dependent upon the quality of the data collected. Under-sampling and non-systematic site selection are likely to be issues in the RSGA (except possibly for corals). Further sampling should consider the standard survey methods for the region (PERSGA/GEF 2004a), sampling effort, and the method of site selection.

3.19 CORAL BLEACHING

The 1997–1998 mass coral bleaching event was probably the most geographically widespread and most severe ever observed (WILKINSON 1998). Bleaching is the loss of symbiotic algae (zooxanthellae) from hard and soft corals in response to stressors such as elevated sea-surface temperature (SST), extremely low tides and freshwater runoff after coastal flooding. Bleaching can be a common and seasonal occurrence in some regions, from which the corals naturally recover after a short period of time. However, death occurs when sea-surface temperatures remain well above the summer average for an extended period of time, often in association with calm seas. The 1997–1998 mass bleaching event appears to have been correlated, in some regions of the world, with a very strong El Niño event. This was an exceptional event because bleaching was recorded from both shallow and deep water (as deep as 50 m) and it also caused the mortality of massive *Porites* spp. corals, which are normally more

resistant to bleaching. This is a concern for the community structure of coral reefs as these corals can be up to 700 years old (WILKINSON 1998).

Bleaching occurred throughout the RSGA in mid-1998. Coral bleaching occurred in the central-northern Red Sea of Saudi Arabia in August–September 1998 when sea-surface temperatures exceeded 31°C, which was more than 2°C above the mean monthly average (DE VANTIER et al. 2000b). About 10% of reefs between Jeddah and the Gulf of Aqaba showed evidence of bleaching. Bleaching was most intense near Rabigh, with recently dead and bleached coral accounting for up to 90% of total cover on shallow reef slopes. On affected reefs, bleaching was most intense in depths less than 6 m but it was also observed below 20 m. Coral cover in the worst affected communities should recover in 1–2 decades. However, predictions of increases in climate extremes suggest that other bleaching events may occur in the future.

Water temperatures reached 40°C in Eritrea during August and September 1998 and bleaching occurred on shallow and deep reefs. However, most corals recovered (WILKINSON 1998). The coral reefs of the northern coastline of Somalia were surveyed in 1999. Live coral cover on reefs affected by bleaching varied between 0 and 80% and averaged 2–5%. Although most reefs showed the effects of bleaching, the overall effects of bleaching were not significant (PERSGA/GEF 2003b). In Sudan, the poor cover of living coral in 2002 in the Mukawwar Island and Dunganab Bay MPA outside of Dunganab Bay was attributed to the 1998 bleaching event (PERSGA/GEF 2004f).

Significant bleaching occurred in Yemen in June 1998 after SST increased by about 2°C. However, the onset of the south-west monsoonal upwelling rapidly cooled this in July (DE VANTIER & AL-HARIRI 2000). Bleaching-associated mortality was particularly significant at Belhaf and Hadhramaut reefs. In April 1998 live and dead coral coverage was, respectively, 51–75% and 1–10% at Belhaf, and 31–50%

and 1–10% at Hadhramaut. In December 1998 live and dead coral coverage was, respectively, 11–30% and 31–50% at Belhaf, and 11–30% and 11–30% at Hadhramaut (DE VANTIER & AL-HARIRI 2000).

Bleaching mortality also occurred at Socotra Archipelago in May–June 1998 (DE VANTIER & AL-HARIRI 2000). Intense bleaching occurred on some reefs on the north coast of Socotra and Abd El Kuri, with more than 50% of total cover bleached or recently dead. Bleaching occurred to depths of 20 m but was most intense in depths less than 5 m. Growth of coral recruits appears to have been greater around the Socotra Islands since the 1998 bleaching (PERSGA/GEF 2003b). Corals on the south coasts of Socotra and Abd El Kuri and on Samha and Darsa Islands were little affected or untouched.

The frequency of mass coral bleaching events appears to have increased since the mid-1970s (GLYNN 1996). This increase coincides with an increased rate of global warming. There is concern about the potential impacts of global warming on the long-term survival of coral reefs due to the apparent increase in frequency and intensity of mass bleaching events (e.g. HOEGH-GULDBERG 1999; LOUGH 2000). It is therefore likely that further mass bleaching events will occur in the RSGA.

3.20 CROWN-OF-THORNS STARFISH

The crown-of-thorns starfish (*Acanthaster planci*) is one of the few animals to feed on living coral tissue. Low densities of crown-of-thorns starfish on a coral reef present no problem to the population growth of corals. However, densities of crown-of-thorns starfish greater than 30 mature individuals per hectare consume living coral tissue at a rate greater than the rate of replenishment and the coverage of dead coral increases. This represents an ‘outbreak’ of crown-of-thorns starfish. Outbreaks have been reported since the 1970s from Australia, the Red Sea, Japan, Palau and Fiji. Large fluctuations in populations of crown-of-thorns starfish may be a natural phenomenon. They have also

been attributed to anthropogenic changes in marine ecosystems such as changes in predator-prey dynamics associated with over-fishing or collecting of natural predators and nutrient enrichment (MORAN 1986).

Outbreaks of crown-of-thorns starfish have been reported for many years in the Red Sea and believed to be associated with the removal of predators (by fishing) such as pufferfish and triggerfish (ORMOND & CAMPBELL 1971, 1974; MOORE 1990). Between 1997 and 2001 no crown-of-thorns starfish were recorded at any of the Reef Check survey sites in the Red Sea or Socotra Archipelago (HODGSON & LIEBELER 2002).

Crown-of-thorns starfish were rarely observed in Egypt prior to 1990s. In 1994 there was a localised outbreak of 200 individuals at Ras Mohammed that was estimated to have caused 20–30% loss of total live coral cover. Between 1995 and 1998 the population of crown-of-thorns starfish increased and attained a maximum density of five per 10 m². In 1998 there were outbreaks of 250–300 small individuals at Ras Mohammed and 10,000 starfish around Gordon Reef near Tiran Island. Between 1998 and 1999 over 60,000 starfish were removed from reefs (PERGA/GEF 2003b). Coral damage from the 1998 outbreak at Ras Mohammad was estimated to be 60% at 35–40 m depth and about 100% at 60–70 m (ABOU ZAID & KOTB 2000).

There was little evidence of non-bleaching related coral mortality in the central-northern Red Sea of Saudi Arabia in 1998, with the exception of the Al-Wajh Bank. Crown-of-thorns starfish were present on patch reefs at a density of about 100 per hectare. Some sites had suffered substantial reductions in coral cover with associated shifts in relative abundance and community structure (DE VANTIER et al. 2000b).

Coral reefs in Sudan were extensively damaged by crown-of-thorns starfish in the 1970s and 1980s. However, in 2002–2003 there was no evidence of outbreaks and numbers of starfish were generally low

(KOTB et al. 2004; PERSGA/GEF 2004f). Outbreaks are believed to have occurred in Yemen in 1994–1996 (TURAK & BRODIE 1999). Surveys of nearshore and offshore reefs revealed extensive areas of dead coral and crown-of-thorns starfish were observed feeding away from cover during daylight (a sign of outbreak conditions). On some reefs nearly all branching and tabular *Acropora* spp. corals were dead (TURAK & BRODIE 1999). Many crown-of-thorns starfish were observed at Addar Ali Island in 2004 (KRUPP et al. 2006).

Only 96 crown-of-thorns starfish were seen in 34 reef surveys in Djibouti and no aggregations were observed (PERSGA/ALECSO 2003). In May 2000 a large number of crown-of-thorns starfish were observed at Khor Ambado and at Moucha Island. However, the impact on corals was minimal and not considered to be indicative of an outbreak (PERSGA/GEF 2003b). Outbreaks of crown-of-thorns starfish were still present in 2002, with large numbers of starfish (including juveniles) reported from all the Sept Frères islands (Figure 3.26). Populations of crown-of-thorns were regarded as ‘not significant’ in Somalia (PERSGA/GEF 2003b).

In Eritrea, SCHLEYER (1998) reported observations of crown-of-thorns starfish around the Dahlak Archipelago in 1997. A small number were observed at “Nakuru Gate” and extensive coral damage was observed at Entere Island.

3.21 MARINE PROTECTED AREAS

Marine Protected Areas (MPAs) are established to restore degraded habitats, to allow stock recovery following over-fishing, to protect representative samples of biodiversity (species, habitats, ecosystems), to support fisheries in surrounding areas, and to support social and economic development. There are reports from many countries around the world quantifying these benefits from MPAs (BABCOCK et al. 1999; EDGAR & BARRETT 1999; SHEARS & BABCOCK 2003). As a result, MPAs are now recognised as a management tool for integrated coastal area management, biodiversity conservation, and to a lesser extent in fisheries management.

During the formulation of the SAP it was decided that an ecosystem approach to conservation and management was most appropriate to assure long-term

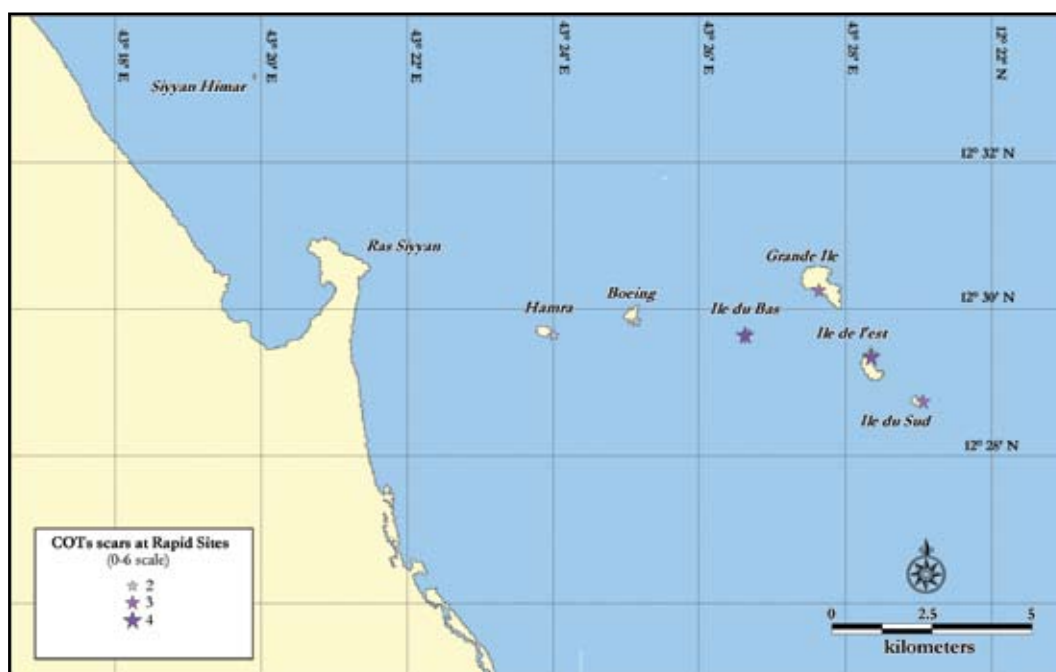


Figure 3.26 Distribution and abundance of crown-of-thorns starfish scars in the Iles des Sept Frères and Ras Siyyan MPA in 2002 prior to the MPA declaration in 2005 (source: PERSGA 2002).

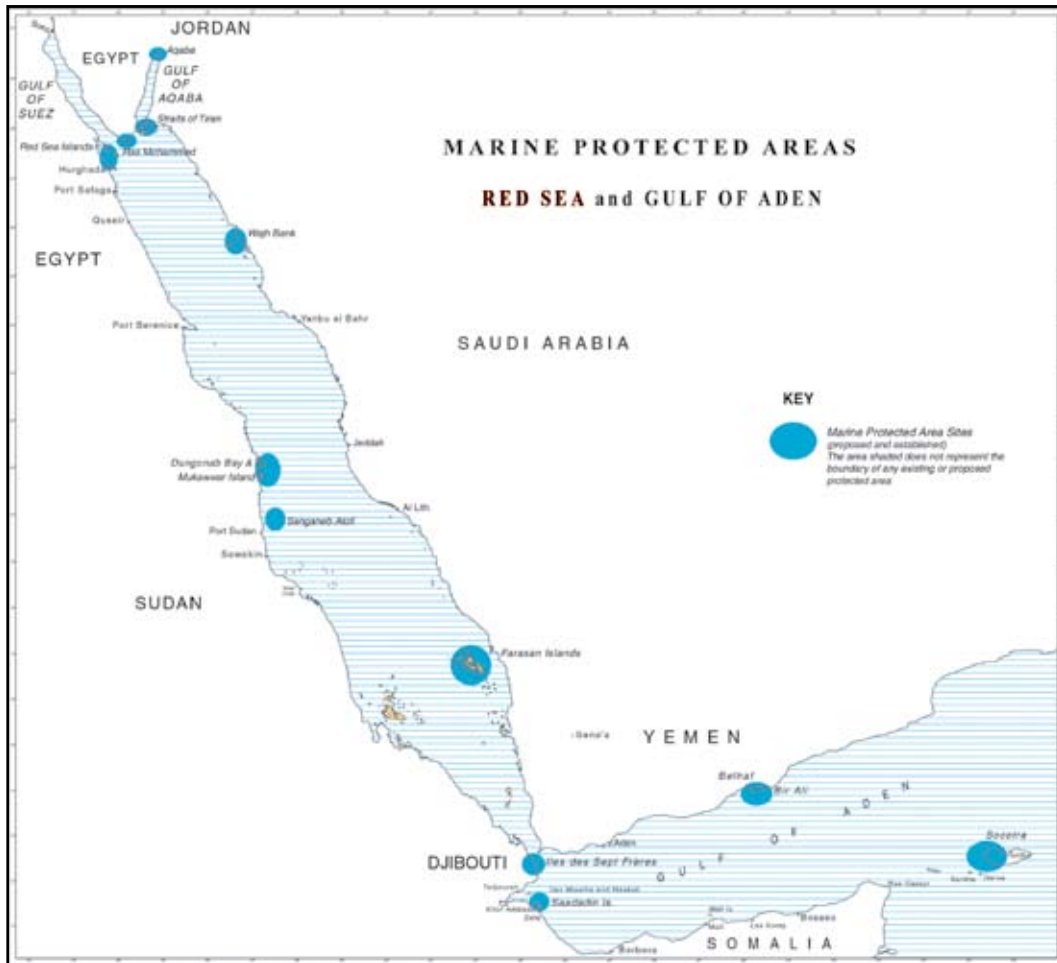


Figure 3.27 Red Sea and Gulf of Aden Regional Network of Marine Protected Areas (source: PERSGA/GEF 2002).

sustainability of the region's critical habitats and populations of globally important species. This would be achieved by establishing an integrated regional network of MPAs supported by effective integrated management and planning. Sites were selected to be representative of the region's biogeography (and include representative habitat types and species as well as bird and turtle nesting sites, and seagrass beds used by dugong) and cultural heritage, and include feeding, breeding and roosting sites, larval sources and sinks, and migratory routes of key biota (GLADSTONE et al. 2003).

Twelve MPAs were selected for the regional network of MPAs (Table 3.13 and Figure 3.27): Iles des Sept Frères and Ras Siyyan (Djibouti); Ras Mohammed National Park; Straits of Gubal (Egypt); Aqaba coral reefs (Jordan); Straits of Tiran; Wajh Bank, Sharm

Habban and Sharm Munaybirah; Farasan Islands (Saudi Arabia); Aibat and Sa'adadin Islands, Saba Wanak (Somalia); Sanganeb Marine National Park; Mukawwar Island and Dunganab Bay (Sudan); Socotra Islands; Belhaf and Bir Ali area (Yemen).

When other MPAs are counted, 75 MPAs have been established or recommended for the RSGA. The status of the Network MPAs at the time the Network was established (2002) was:

- (i) Declared MPAs
 - Ras Mohammed National Park
 - Aqaba Marine Park
 - Farasan Islands Marine Protected Area
 - Sanganeb Marine National Park
 - Socotra Islands group National Protected Area

Table 3.13 Current status of Red Sea and Gulf of Aden Representative Network of Marine Protected Areas.

Country	Protected area	Size	Year declared	Major habitats and regional significance	Impacts and conflicts	Management/Projects
Djibouti	Iles des Sept Frères and Ras Siyyan	Undefined	2005	Group of high aspect, rocky islands and adjacent coastal stretch with mangrove-fringed bay, diverse coral reef and rich reef associated fish and invertebrate fauna at the junction between the Red Sea and the Gulf of Aden, nesting seabirds	Recreation pressure, fishing, siltation caused by passing vessels	Field surveys undertaken for management plan development
Egypt	Ras Mohammed National Park	480 km ²	1992	Coral reef, mangrove, sandy areas, fish, turtles, important for environmental education	High recreation pressure	High, supported by EU project
Egypt	Gifftun Islands and Straits of Gubal	Undefined	Proposed	Group of islands off the western coast with well-developed and diverse coral reefs and rich reef-associated fauna, turtle and bird nesting	Recreation pressure, anchor damage, fishing	GEF-Egypt and EU projects
Jordan	Aqaba Marine Park	7 km length	Declared	Complex and diverse fringing reefs with a rich and diverse reef-associated fauna at the northern tip of the Gulf of Aqaba	Reef fisheries, recreation pressure, development pressure	GEF-Jordan project
Saudi Arabia/ Egypt	Strait of Tiran	Undefined Ras Mohammed National park marine section	Proposed Exist for Egypt	Islands and extensive coral reefs with diverse reef associated fauna in transition area between Gulf of Aqaba and Red Sea, turtle nesting, dugong	Part of the area used by divers/tourists from Egypt	None
Saudi Arabia	Wajj Bank, Sharm Habban and Sharm Munaybirah	2840 km ²	Proposed	Extensive shallow water area with mainland coast and offshore islands, most extensive coral reef system of entire Red Sea, diverse reef associated fauna, seagrass beds, mangroves (<i>Avicennia</i> and <i>Rhizophora</i>), turtles, bird nesting sites, key area for dugongs	Collection of turtle and bird eggs, fishing	None

Table 3.13 continued. Current status of Red Sea and Gulf of Aden Representative Network of Marine Protected Areas.

Country	Protected area	Size	Year declared	Major habitats and regional significance	Impacts and conflicts	Management/Projects
Saudi Arabia	Farasan Islands	3310 km ²	1996	Terrestrial and coastal reserve, archipelago of coral islands, mangroves, coral reefs, seagrass beds, marine mammals, nesting seabirds, two species of mangroves, endemic gazelle	Fishing, development, recreational pressure expected to increase	Terrestrial: high Marine: low
Somalia	Albat & Sa'adadin Islands, Saba Wanak	ca 300 km ²	Suggested	Low-lying mangrove islands with probably largest coral reef area in Gulf of Aden, coastal area with 27 water courses, largest saltmarsh, swamp and mangrove area in Gulf of Aden, <i>Rhizophora</i> and <i>Avicennia</i> , very important nesting site for seabirds and probably turtles	Fishing, egg collection, collection of corals	None
Sudan	Sanganeb Marine National Park	12 km ²	1990	Atoll-like reef with highly diverse and complex coral reefs, diverse reef associated fauna, sharks, marine mammals, manta rays	Recreation pressure, anchor damage from tourist boats	Low
Sudan	Mukawwar Island and Dungenab Bay	300 km ²	2005	Coral reefs, whale sharks, largest schools of manta rays in entire Red Sea, bird nesting sites, oyster beds	Shark fisheries, oyster culture	Draft management plan developed
Yemen	Socotra Islands	3625 km ²	1996	Island group with outstanding terrestrial plant and animal endemism; diverse and largely pristine marine environments and biota	Fishing	GEF-Socotra biodiversity project
Yemen	Belhaf and Bir Ali area	Undefined	Proposed	Coastal stretch and group of high aspect islands, scenic coastline, extensive coral reefs and rich fishing area, bird and turtle nesting, crater lake with mangroves	Tourism development, fishing activities	None

(ii) Proposed MPAs

- Iles des Sept Frères and Ras Siyyan
- Giftun Islands and Straits of Gubal
- Strait of Tiran
- Wajj Bank, Sharm Habban and Sharm Munaybirah
- Aibat & Sa'adadin Islands, Saba Wanak
- Mukawwar Island and Dungonab Bay
- Belhaf and Bir Ali area

Two of the proposed MPAs were declared in 2005: Iles des Sept Frères and Ras Siyyan in Djibouti and Mukawwar Island and Dungonab Bay in Sudan. In 2006 a proposal to officially declare the Giftun Islands and Straits of Gubal MPA was undergoing stakeholder consultations. Mukawwar Island and Dungonab Bay were surveyed in detail in 2002 prior to the development of a zoning and management plan (PERSGA/GEF 2004d). The African Parks Organization has been contracted by the Red Sea State of Sudan to manage the MPA and to train ten national rangers in MPA management.

There are a number of issues for existing and proposed MPAs. Few of the declared MPAs are managed appropriately. There is limited technical capacity and experience throughout the region in MPA management. Some countries lack the necessary pool of experts to provide the knowledge, training and skills necessary for MPA management. Much of the existing capability in MPA management is at the Ras Mohammad National Park (Egypt), the best example of a fully functional MPA in the region. Lack of surveillance and enforcement in MPAs is widespread in the RSGA. There are gaps within existing MPAs in representation of regionally significant and representative habitats.

Specific training has been delivered to MPA managers, scientists and rangers from the region to address the lack of expertise in MPA management. Courses have covered management issues, marine and coastal surveys and monitoring, scuba diving, ranger duties, policing and public relations. The first course was held at the Ras Mohammad National Park.

PERSGA's Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas, Article 4 (General Obligations), requires contracting parties to (i) protect, preserve and manage in an environmentally sound and sustainable manner areas that are unique, highly sensitive or regionally representative, notably by the establishment of protected areas; and (ii) adopt appropriate planning, management and supervision including legislation and monitoring measures for the protected areas. Under Article 9 nations shall draw up a 'List of Protected Areas of Importance to the PERSGA region'. Contracting parties are also required to develop management plans and a list of sites of special importance for possible future declaration as MPAs.

The short time between the signing of the Protocol and this review has not allowed for any of the activities to be implemented. However, PERSGA's Framework of Action for 2006–2010 lists activities to implement the Protocol. These include actions to verify critically threatened areas and to establish monitoring programmes for habitats and biodiversity.

3.21 PROTOCOL CONCERNING THE CONSERVATION OF BIOLOGICAL DIVERSITY AND THE ESTABLISHMENT OF PROTECTED AREAS

An important step was taken towards a regional approach to conservation of biodiversity with the signing by PERSGA member states in December 2005 of the Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas. The Protocol is an addition to the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (the Jeddah Convention). The Objectives (Article 1) and General Obligations (Article 4) of the Protocol are set out in Box 3.1.

The Protocol provides for: the protection and conservation of species; the protection of selected marine and coastal areas; the application of a common management framework throughout the region (including

integrated coastal area management; environmental impact assessment; restoration of ecosystems and populations of species; criteria for selection of additional protected areas); specific measures (such as access to genetic resources and technology exchange); and an institutional framework for national implementation and oversight of the Protocol.

Contracting Parties are required to submit a report on implementation of the Protocol,

in particular on: (a) threatened species; (b) harvested species whose exploitation is regulated, including species of economic/cultural importance; (c) alien species and genotypes; (d) the status and state of areas included in the PERSGA Protected Area list; (e) any changes in the delimitation or legal status of the PERSGA Specially Protected Areas list and protected species; (f) and areas of special importance which are not (currently) included in the PERSGA Protected Areas List.

Box 3.1 Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas (Articles 1 and 4)

Article 1: OBJECTIVES

1. To provide for the conservation, protection and restoration of the health and integrity of the ecosystems and biological diversity in the PERSGA region;
2. To safeguard the threatened species, the critical habitats, sites of particular importance, as well as representative types of coastal and marine ecosystems, their biodiversity and their sustainable use and management, to ensure long-term viability and diversity.

Article 4: GENERAL OBLIGATIONS

Contracting Parties shall take all appropriate measures to:

1. Protect, conserve and manage their natural biological diversity with particular emphasis on threatened species;
2. Protect, preserve and manage in an environmentally sound and sustainable manner areas that are unique, highly sensitive or regionally representative, notably by the establishment of protected areas;
3. Adopt strategies, plans and programmes for the conservation of biodiversity and the sustainable use and management of marine and coastal biological resources;
4. Adopt appropriate planning, management and supervision including legislation and monitoring measures for the protected areas, including contingency plans for environmental emergencies;
5. Adopt comprehensive Environmental Impact Assessment (EIA) to evaluate the suitability of proposed mariculture operations, assess their consequences for coastal and marine biological diversity and promote techniques which minimise adverse impacts;
6. Control land-based and sea-based sources of pollution that pose a significant impact on habitats and species;
7. Ensure that systems of coastal and/or land-use and tenure provide for inter-generational equity and are consistent with the principles for conservation and sustainable resource use and management; and
8. Designate Competent Authorities responsible for the fulfillment of the obligations and duties specified in the Protocol.

3.22 RESPONSES

A manual of standard survey methods was published, covering methods of rapid assessment, and methods for the detailed assessment of intertidal habitats and mangroves, corals and coral communities, seagrass and seaweeds, subtidal habitats, reef fishes, marine turtles, seabirds, and marine mammals (PERSGA/GEF 2004a). The development of standard survey methods will facilitate the acquisition of population data and monitoring.

Training and capacity building in the standard survey methods has produced regional specialist teams competent to carry out the standard survey methods. Regional training workshops were held for mangroves and intertidal habitats; turtles; ornamental fishes, data collection and analysis of the trade in ornamental fishes; corals; seagrass and algae; breeding seabirds; elasmobranch identification, sampling and stock assessment methods.

There have been a number of responses to the coral damage caused by dive tourism in Egypt. Installation of mooring buoys helped reduce anchor damage on dive sites between Hurghada and Safaga (ABOU ZAID & KOTB 2000). Pre-dive briefings on environmentally friendly dive techniques in Ras Mohammad National Park reduced divers' contacts with live coral by approximately 35% (MEDIO et al. 1997). Further management responses, such as additional rangers and diver management plans, are expected to further reduce the impacts of divers (JAMESON et al. 1999).

Pilot surveys of the status of coral reefs in PERSGA countries were undertaken (PERSGA/GEF 2001). Detailed assessments of the coral reefs of PERSGA countries were undertaken and a regional status report (PERSGA/GEF 2003b) and regional action plan (RAP) were produced (PERSGA/GEF 2003a).

The need to avoid anchoring on coral reefs is emphasised in Admiralty Sailing Directions, which list the positions on anchoring points, and on charts of the RSGA. For example,

Admiralty Chart 159, Red Sea, Suez to Berenice, contains the following note:

Protected Reefs: Vessels should only use the fixed moorings on or adjacent to coral reefs in Egyptian coastal waters between:

- a) latitudes 26° 37' N and 27° 02' N
- b) latitudes 27° 08' N and 27° 26.3' N
- c) (locations around the Strait of Tiran and in the Gulf of Aqaba stated in the note)

The reefs surrounding El Akawain (26° 19' N, 34° 33' E) are also protected and damage to the coral may lead to prosecution. Except in an emergency anchoring on these reefs is prohibited. For further information see Admiralty Sailing Directions.

Damage to coral reefs due to ships grounding the reefs has also occurred in various parts of the RSGA, including the waters of Egypt, Saudi Arabia, Sudan and Yemen. In most cases the ships causing the damage are prosecuted by the relevant national authorities (R. FACEY, personal communication).

Mangrove areas in the region were assessed by pilot surveys, with a short inventory provided in the SAP Country Reports (PERSGA/GEF 2001). A Mangrove Survey Programme (using the standard survey methods) was conducted in PERSGA countries in 2001. A regional and five national mangrove status reports and a RAP for mangrove conservation were developed (PERSGA/GEF 2004a, b).

Prior to the SAP there was very little research or monitoring of turtles in the RSGA (ROSS & BARWANI 1982; MILLER 1989; GASPARETTI et al. 1993; GLADSTONE 2000). As part of the SAP standard survey methods for marine turtles were developed (PILCHER 2004) and a training course was conducted in Yemen. In 2003 baseline surveys were undertaken in five countries (Djibouti, Egypt, Saudi

Arabia, Sudan and Yemen). The Regional Action Plan for the Conservation of Marine Turtles and their Habitats (PERSGA/GEF 2004d) was a major initiative towards improving the understanding of marine turtles and establishing a framework for their management and conservation.

There have been several recent responses to the need for greater understanding of the status of seabirds and for their conservation. Standard survey methods for seabirds that are regionally applicable have been developed (NEWTON 2004) and regional seabird specialists have been trained in these methods. Surveys were conducted to assess the status of breeding seabirds in all PERSGA countries (PERSGA/GEF 2003c). A RAP was developed from these surveys for the conservation of breeding seabirds (PERSGA/GEF 2004e). The RAP provides specific management actions that should serve as indicators for future assessments of progress towards the conservation of breeding seabirds in the RSGA.

Given the differences in priorities, capacities and other aspects among the RSGA countries, the RAPs needed to be adapted to suit each particular country. Therefore national action plans (NAPs) were developed for the countries, to facilitate implementation of the actions at the national level. This is achieved through identifying national stakeholders, mechanisms, institutions, etc., and integrating the RAP activities into the existing national ICZM plans. In individual countries, implementation will occur through integrated networks of national and local working groups, government departments, agencies and personnel, non-governmental organisations and other stakeholders. It is expected that NAPs will be implemented from 2006 onwards, except in Somalia.

The Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas was signed by PERSGA member states in December 2005.

The Red Sea and Gulf of Aden Regional Network of MPAs was established in 2002. Subsequently two of the Network

MPAs (Iles des Sept Frères–Ras Siyyan in Djibouti and Mukawwar Island–Dungonab Bay in Sudan) were officially declared in 2005. All MPAs in the Network contain significant areas of coral reef and ten of the MPAs contain local or regionally significant mangrove stands. Detailed site assessments were undertaken of Iles des Sept Frères–Ras Siyyan and Mukawwar Island–Dungonab Bay. A Regional Master Plan for the Network was produced (PERSGA/GEF 2002) that included guidelines for the development of individual site-specific management plans. The latter will facilitate the endeavours of individual countries to select and manage their MPAs.

Training has provided knowledge and skills to MPA managers, scientists and rangers from throughout the region to address the lack of expertise. Training has addressed MPA management, survey techniques, GIS, remote sensing, scuba diving, ranger duties, policing and public relations.

The Integrated Coastal Zone Management (ICZM) component of the SAP supported the preparation and implementation of model ICZM plans in PERSGA nations. ICZM plans have been prepared by Egypt and Saudi Arabia, completed for Aden (Yemen) and are being prepared for Djibouti and Sudan.

Several of PERSGA's public awareness activities have concentrated on habitat conservation and regular features on different habitats and important species are published in PERSGA's newsletter *Al Sanbouk*.

Oil spill contingency plans have been developed for Egypt, Jordan and Saudi Arabia and Sudan's plan is awaiting approval. Contingency plans are likely to prevent or minimise the damage from oil spills to critical coastal habitats such as mangroves, seagrass and coral reefs.

A regional database for key habitats and species was established in PERSGA. A Biodiversity Information System provides information for decision makers and researchers about the status of marine species in the RSGA.

A Regional Reference Collection Centre was established in early 2003 within the premises of the Faculty of Marine Science, King Abdulaziz University in Jeddah, Saudi Arabia. A training course for the managers of the Centre was held in the Senckenberg Museum (Frankfurt, Germany). On-the-job-training was provided for the technicians working in the Centre.

Benefits from each of these activities should continue to be seen throughout the RSGA for many years. Continued progress will also be underpinned by the implementation of PERSGA's Framework of Action for 2006–2010, which outlines specific programmes to be achieved by PERSGA. Of relevance to the material of this chapter are the following anticipated outcomes:

- Improvement of the protection status of globally significant biodiversity in the RSGA region caused by a

sustainable use of marine and coastal resources in the region;

- A wide adaptation and effective implementation of spatial planning, ICZM and conservation plans in the region;
- A well implemented initiative towards poverty reduction in the coastal areas;
- Built-in regional capacity for monitoring and evaluation with clear indicators and targets which results in a complete data base for a comprehensive State of the Environment Report;
- On-the-ground activities that translate the plans into actions and present a model for effective implementation of sustainable development with its three pillars: social, economic and environment.

SEA-BASED ACTIVITIES AND SOURCES OF POLLUTION

Captain Roy Facey

4.1 SUMMARY

4.1.1 Status

The number of ships in transit through the Suez Canal largely determines the types and numbers of ships operating in the RSGA. These numbers continue to rise, while the structure of the traffic is changing as maritime transport evolves.

So far the RSGA has been remarkably fortunate to escape a major oil pollution or chemical pollution incident due to shipping.

However, recent worrying events give warning that a major pollution incident could easily occur.

The semi-enclosed nature of the RSGA almost guarantees that any spill of oil or chemicals will have a major impact on the coastline somewhere in the region.

The extension of routing measures to passages near islands further north in the Red Sea, and along the shipping route west of Zubair Islands and Jazirat At Tair, are identified as a necessary move to further improve navigation safety in the region.

Port development in the region, particularly over the past 30 years, has been dynamic, with ports expanding to handle the growth in trade and hence cargo volumes.

The threat of pollution from new chemical, oil and liquefied natural gas terminals and refineries in the region, and from maritime transport to and from these terminals, needs to be carefully monitored.

The arrival of ballast water on ships trading to ports in the RSGA, particularly ballast in tankers and bulk carriers, but also ballast carried in container ships and other types of vessel, and on ships in transit through the RSGA, has the potential to do more harm

to the marine environment than a major oil pollution incident.

Invasive aquatic species in ships' ballast water is now considered to be one of the four greatest threats to the world's oceans, the other three being land-sourced marine pollution, over-exploitation of living marine resources, and physical alteration or destruction of habitat.

Dumping of hazardous materials at sea in waters close to the Gulf of Aden has the potential to carry serious pollution hazards into the region.

4.1.2 Progress

In general oil spills around the world are reducing due to initiatives by IMO and other factors.

PERSGA has achieved significant success in getting new routing measures adopted for use by international shipping in the southern Red Sea.

PERSGA has established a new lighthouse fitted with an AIS (Automatic Identification System) on the Hanish Islands.

Capacity building in combating oil pollution, in port state control, marine incident investigation, navigation safety/hydrographic surveying, contingency planning and ballast water management has been achieved through training workshops held throughout the region.

PERSGA has established the Marine Emergency Mutual Aid Centre at Hurghada and this is receiving support from the International Maritime Organization.

National contingency planning in the Red Sea and Gulf of Aden has improved and national plans are now in place in Jordan, Egypt, Saudi Arabia and Sudan.

The capacity to carry out port state control of ships has improved in recent years.

4.1.3 Constraints to Continued Progress

The capacity for monitoring oil and chemical spills in the RSGA remains very limited. The level of understanding of the potential impact of ballast water movements in the RSGA remains insufficient and needs to be improved.

Support for the RSGA will therefore have to be mobilised from internal and external sources in order to prepare the region to deal effectively with invasive aquatic species (IAS).

National Contingency Plans have not yet been developed for Eritrea, Somalia or Yemen.

Only a few regional states have become parties to the 1972 London Dumping Convention or its 1996 Protocol and this situation needs to be addressed.

4.2 INTRODUCTION

Marine pollution is generally considered in the context of oil entering the world's oceans from shipping activities and, to a lesser extent, from offshore oil exploration. Major oil spills anywhere in the world attract a great deal of media coverage, with reporters often giving the impression that such spills occur with greater frequency than is supported by the facts. But the fact is that oil spills are of major concern to all those connected with the sea and with the protection of the marine environment.

Other very significant sources of pollution must be considered. One important source that has only recently been recognised is the impact of ballast water transfers into the waters of RSGA from tankers, and other vessels, that carry sea water as ballast from other parts of the world and discharge this into the RSGA before loading their cargoes.

The dumping of hazardous and toxic materials in waters close to the RSGA is an issue that has been highlighted since

the 2004 tsunami disturbed the seabed and coastal waters of Somalia. The potential impact of earlier dumping practices in Somali waters is a matter of concern to regional states, and to Somalia and Yemen in particular.

The carriage by sea of liquefied gas and chemicals from the RSGA to overseas destinations and the potential impact of these on the marine environment may also cause damage to this environment. Figure 4.1 illustrates the inputs of energy to shipping and some of the potential outputs from ships that can cause damage to the marine environment.

The threat of oil pollution in the region must be faced and the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982, or the 'Jeddah Convention', includes a Protocol concerning Regional Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency. This Protocol to the Jeddah Convention also envisaged the establishment of the Marine Emergency Mutual Aid Centre (MEMAC), which was formally opened in May 2006, and is currently being staffed and funded through PERSGA. This is expected to play an important role in enhancing regional co-ordination and co-operation in the matter of oil spill preparedness and response. The MEMAC is not a provider of oil spill combating equipment which, the Parties have decided, would not be an appropriate function of the Centre. IMO is providing valuable support for the MEMAC (PERSGA communication 2006).

The Jeddah Convention provides the legal basis for taking coordinated action to combat oil and other kinds of pollution. In particular Article IX(3) of the Jeddah Convention states that:

“The Contracting Parties shall co-ordinate their national plans for combating pollution in the marine environment by oil and other harmful substances in a manner that facilitates full co-operation in dealing with pollution emergencies.”

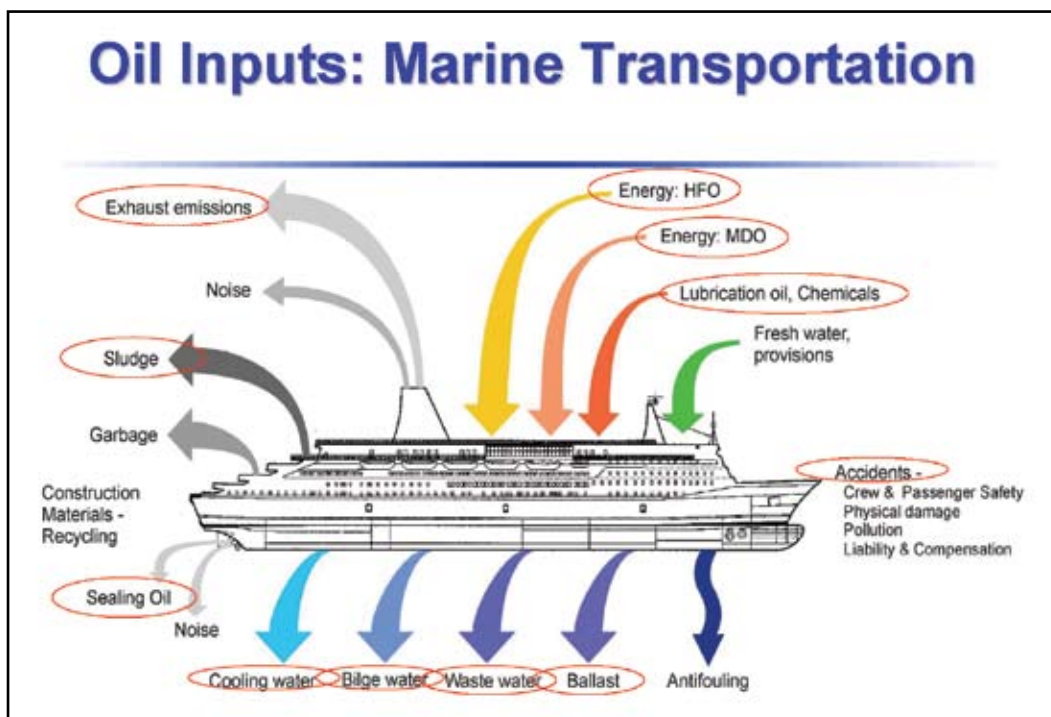


Figure 4.1 Inputs to the marine environment due to maritime transport; HFO: heavy fuel oil; MDO marine diesel oil (source: ITOPI technical presentation).

This general principle is further elaborated in the Protocol to the Convention Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency. However, the framework for response to marine oil spills varies considerably throughout the region. Disparity in the legal and institutional framework, including the adoption of national contingency plans by regional states, is matched by a similar disparity in the availability of equipment stockpiles for combating pollution incidents.

The revised PERSGA/IMO 'Action Plan for the Development of National Systems and Regional Mechanisms for Preparedness and Response to Major Marine Oil Spills in the Red Sea and Gulf of Aden', June 2005, gives details of the current status of contingency planning in the RSGA. It provides a structured programme of interventions to

develop the national systems of countries that do not yet have these, and to establish a regional mechanism for achieving a coordinated response to any major spills.

4.3 WORLD OIL AND GAS PRODUCTION – A BRIEF OVERVIEW

Over the past 80 years oil production in various countries around the world has grown massively. Some RSGA countries, Saudi Arabia in particular, are responsible for generating these high levels of production. As of 2005, states bordering the RSGA, namely Egypt, Saudi Arabia, Sudan and Yemen, together accounted for 12.54 million barrels of oil production per day (BPD) out of a total world production of 81.09 million BPD¹. The states bordering the RSGA therefore currently produce around 15.5% of total world production. This 12.54 million BPD equates to around 1.79 million

¹ Figures from BP (British Petroleum); figures quoted include crude oil, shale oil, oil sands and natural gas liquids. See <http://www.bp.com/productlanding.do?categoryId=91&contentId=7017990>

tonnes of oil per day, or a total of 650 million tonnes/year². After deducting a percentage for use within the RSGA for national energy and industrial requirements, most of the 12.54 million BPD will be exported as either crude or refined oil from terminals in The Gulf and in the RSGA. In the case of oil produced by Saudi Arabia, exports will leave from terminals in The Gulf or on its Red Sea coast.

Similarly, two of the states bordering the RSGA, Saudi Arabia and Egypt, are players in world gas production. Together they produced 104.2 billion m³ of gas in 2005, 3.8% of total world production. The planned opening of a liquefied natural gas (LNG) export terminal on the coast of Yemen in 2007 will add to the transport by ship of gas products in the Gulf of Aden.

4.3.1 World Trends in Oil Spills

In total it is estimated that around 2.35 million tonnes of oil enter the world's marine environment per year at present³. While oil spills due to marine activities certainly contribute to marine pollution, oil enters the marine environment from several other sources. On a world-wide basis it is estimated that around 50% (1.175 million tonnes/year) of the oil entering the marine environment is from land-based sources, 13% from air pollution, 11% from natural sources, 2% from offshore production, and

that inputs due to transport are around 24%, or 560,000 tonnes/year. The majority of the 560,000 tonnes/year input is from maritime transport (Figure 4.2)⁴.

From 1975 to 1983, the number of spills of >7 tonnes per 1,000 billion tonne miles remained roughly constant. Since 1983, as shown in Figure 4.3, due to improving technology, new ship designs, more stringent regulations, better crew training etc., the number of spills per 1,000 billion tonne miles has declined from around 11 to less than 2, up to 2004.

Thanks to the several factors that have brought about improvements, it can be estimated that 99.999% of the oil carried by sea now arrives at its destination without incident⁵. It is the 0.001% entering the

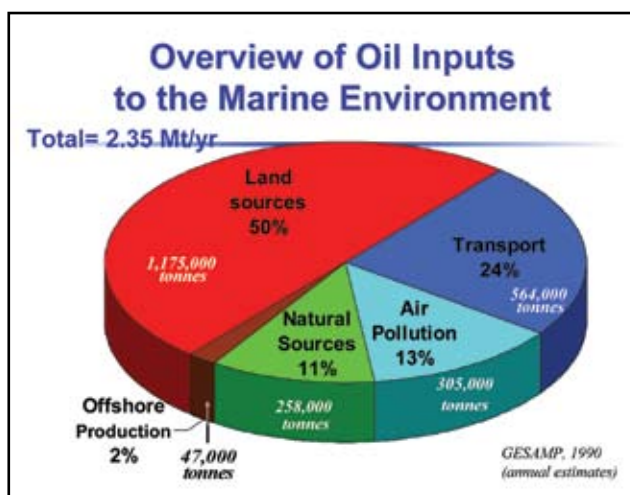


Figure 4.2 Overview of oil inputs to the marine environment (source: ITOPF, based on GESAMP estimates 1990).

² One barrel of oil contains 42 US gallons. One US gallon equals 3.79 litres. There are 159.18 litres to a barrel, or 6.28 barrels to a cubic metre. Conversion to tonnes depends on the specific gravity of the oil and a SG of 0.9 tonnes/m³ has been used in this paper to give a figure of around 7 barrels to one tonne.

³ This equates to approximately 60% of the output from The Gulf states in one day.

⁴ Various estimates of the quantities of oil entering the marine environment have been made. The IPIECA publication *Action Against Oil Pollution* contains a similar diagram, citing the UK's National Research Council report of 2003, *Oil in the Sea III Inputs, Fates and Effects*, National Academies Press, Washington D.C. IPIECA points out that waste disposal on land together with the illegal dumping or discharge of waste oil represents a substantial source of pollution to the sea from land run-off. See http://www.ipieca.org/downloads/oil_spill/AAOP/AAOP.pdf. The IPIECA diagram allocates 47% to natural seeps, 33% to consumption activities, (land-based run-off, non-tanker operational releases and spills, 8% to tanker spills, 4% to transportation (cargo washings, coastal facility and pipeline spills), 3% to extraction (platforms and produced waters) and 5% to 'other' (atmospheric deposition and jettisoned aircraft fuel).

⁵ This statement was made in a BBC World Service broadcast on 20 November 2002 following the 'Prestige' incident that took place on 13 November 2002, by a tanker operator during an interview on the question of the impact of oil spills on the environment. The figure can be confirmed by checking the estimated tonnage of oil spilled annually against the total quantity carried by sea.

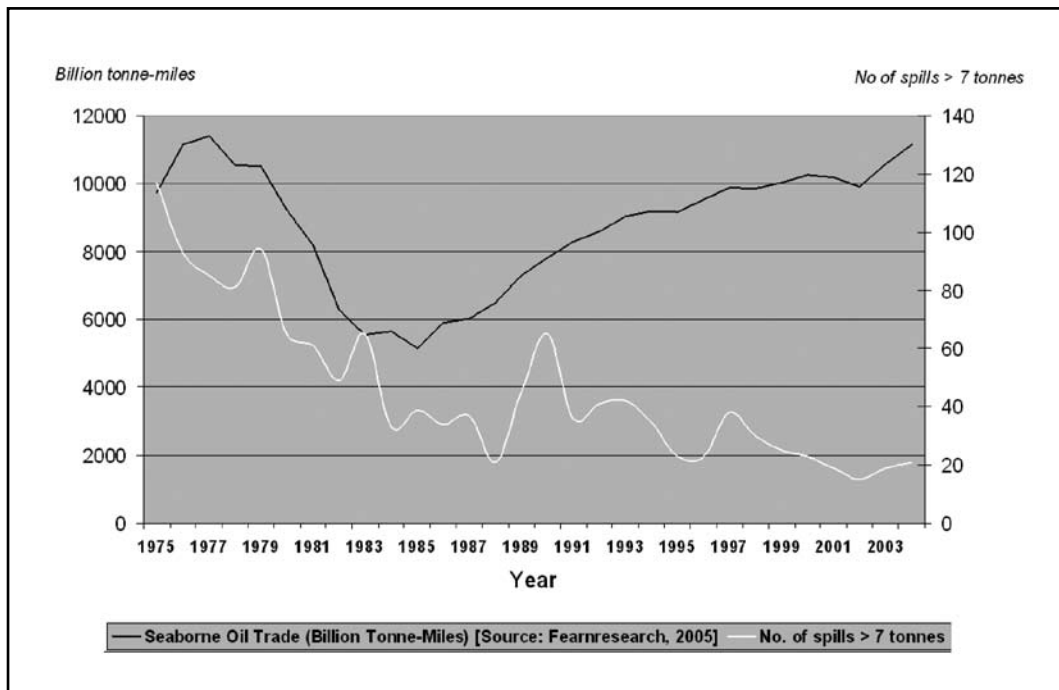


Figure 4.3 Seaborne oil trade (billion tonne miles) (source: Fearnresearch 2005, giving number of spills > 7 tonnes).

marine environment from significant oil spills, in particular, that causes headlines in the world's press.

There are three main contributions to the total oil entering the marine environment that are due primarily to maritime transport.

These are: (1) pollution from bilges and fuel oil generated by all types of ship; (2) day-to-day tanker operations; and (3) tanker accidents. Other less significant causes include operations at marine terminals, ship scrapping, non-tanker accidents and dry docking, but these are relatively minor contributors (Figure 4.4).

The International Tanker Owners Pollution Federation (ITOPF) is a primary source of data on oil spills. The ITOPF database contains world wide information on around 10,000 oil spills from various ship types, including tankers,

combination carriers and barges. Spills are divided by ITOPF into three categories, large spills (>700 tonnes), intermediate spills (between 7 and 700 tonnes) and small spills (<7 tonnes)⁶. The number of large spills recorded world wide during the 1990s was less than a third of the number

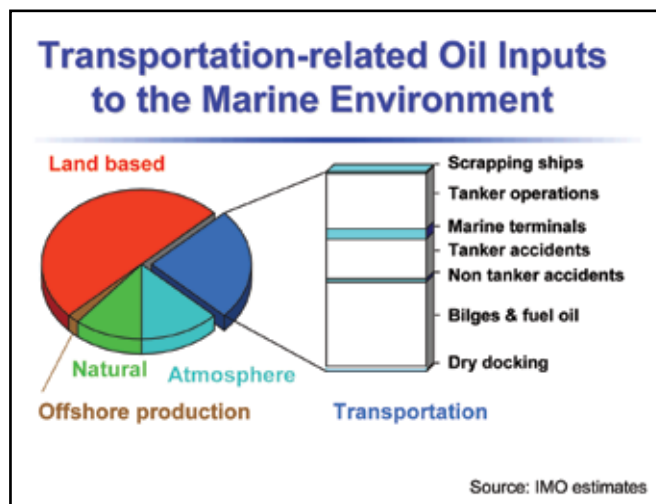


Figure 4.4 Transportation-related inputs to the marine environment (source: ITOPF, based on IMO estimates).

⁶ The International Tanker Owners Pollution Federation (ITOPF) Handbook 2006/2007.

recorded in the 1970s. Figure 4.5 shows that the average fell from 25.2 spills per year in the 1970s to 9.3 spills/year in the 1980s, 7.8 spills/year in the 1990s and has fallen again to 3.7 spills/year since 2000⁷.

This has been due to the combined efforts of the tanker industry and of governments, acting largely through the International Maritime Organization (IMO), to improve safety and pollution prevention. Such a dramatic improvement in recent years has also been helped by better training and education, greater adherence to IMO regulations, improved and more extensive port state control inspections and the sharing of information on sub-standard ships within a region through regional memoranda of understanding, with the targeting of ship types, flags and classification societies that are recorded as having unsatisfactory results during port state control inspections.

Other factors include the influence of P&I clubs (Protection and Indemnity) on their

members through insurance premiums and other means, improvements in ship design, safety equipment, operational procedures and back-up systems such as duplicated steering equipment resulting from ‘lessons learned’ from earlier incidents, together with improved technology, for example more accurate navigation aids such as the global positioning system (GPS). Shore monitoring to alert ships to potentially dangerous situations has also had an impact in some areas of the world. Commercial constraints on operators due to the current high cost of oil and its products may also have had a positive impact⁸.

While most spills resulting from shipping operations are relatively small, very large spills not only make headlines but also dramatically increase the total spilled in the year that they occur, as shown in Figure 4.6. An incidental consequence of large spills is that the names of the ships responsible become well known around the world due to media coverage of the incident.

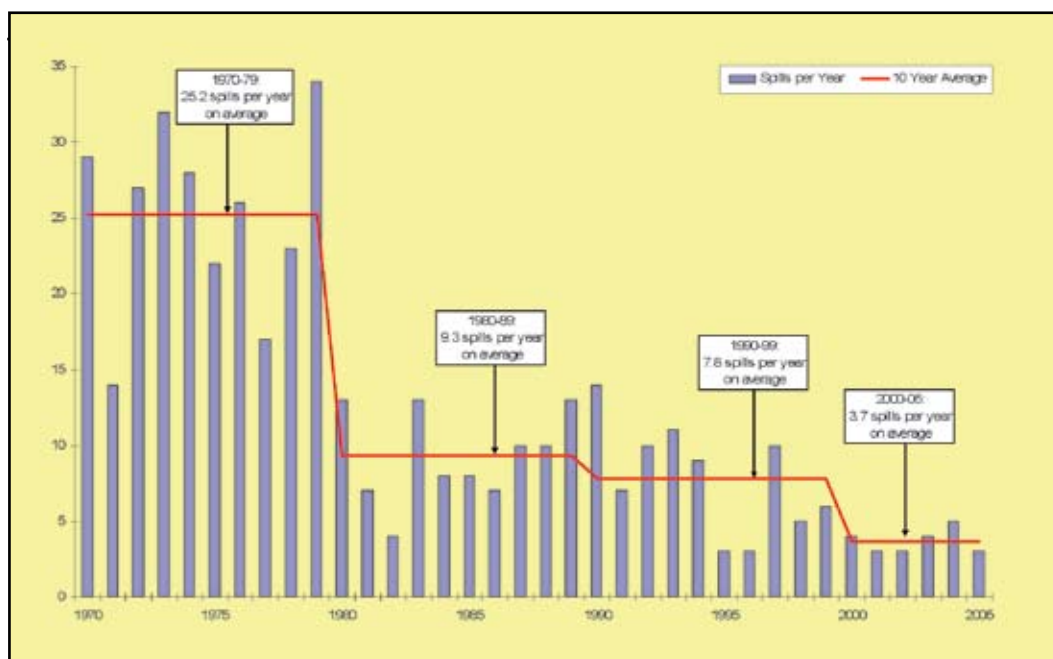


Figure 4.5 Numbers of spills of >700 tonnes 1970-2005 (source: ITOPF).

⁷ Ibid.

⁸ Dumping cargo over the side as a means of lightening and thus attempting to save a ship has been known since the earliest days of shipping. One ship’s officer recalled that, in the 1960s, ships off the coast of Africa encountering heavy weather would sometimes pump oil cargo over the side to lighten a tanker (based on a personal discussion). Article 8 of the London Dumping Convention permits dumping to be carried out “in cases of *force majeure* caused by stress of weather, or in any case which constitutes a danger to human life or a real threat to vessels...”

Figure 4.6 shows that since 1970, when the price of oil rose from \$1.70 a barrel to \$5.19 a barrel in 1973, then to \$11.65 a barrel in early 1974 following the Middle East war in October 1973, the average annual volume of oil spilled has generally fallen around the world. The price increase raised international awareness of the critical nature of this commodity to the world's economy and, in fact, depressed demand for oil for ten years.

In the RSGA the number of spills has not yet been systematically recorded. In 2006 PERSGA prepared a Record of Maritime Accidents and Incidents in the RSGA that provides a partial record. This has not been structured into an annual record of spills, does not provide an accurate record of quantities spilled, and sometimes quotes quantities spilled in tonnes, sometimes in barrels of oil, and sometimes has no information on the quantity spilled. It shows an average of about one incident per year between 1980 and 2006, not all of which resulted in an oil spill. It is evident from a number of reports that oil losses due to operations on tankers and other ships contribute to the total volume of oil entering the RSGA, but as yet the volume of oil spilled has not been quantified by PERSGA.

The other important factor relating to oil spills from shipping operations is the cause of the spill. Causes are analysed by ITOPF for spills world wide. Figures 4.7a and 4.7b illustrate the causes of large spills and intermediate spills between 1974 and 2005. They illustrate the importance of preventing collisions between ships and groundings of ships. Collisions and groundings account for 28.3% and 34.4% of large spills respectively, and 25% and 19% of intermediate spills; i.e. for about 53% of significant oil spills around the world. The other 47% of spills in the two classes are caused by hull failures, fire and explosion, other/unknown causes, loading and discharging operations, and other operations. Hull failure accounts for 12.5% of large spills, and loading/discharging operations account for 28% of intermediate spills.

For the RSGA, the causes of spills have not yet been analysed and recorded in a systematic way and this task remains to be done.

The work of IMO through its main instrument for the control of marine pollution by oil, the 'International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978', frequently referred to as MARPOL 73/78,

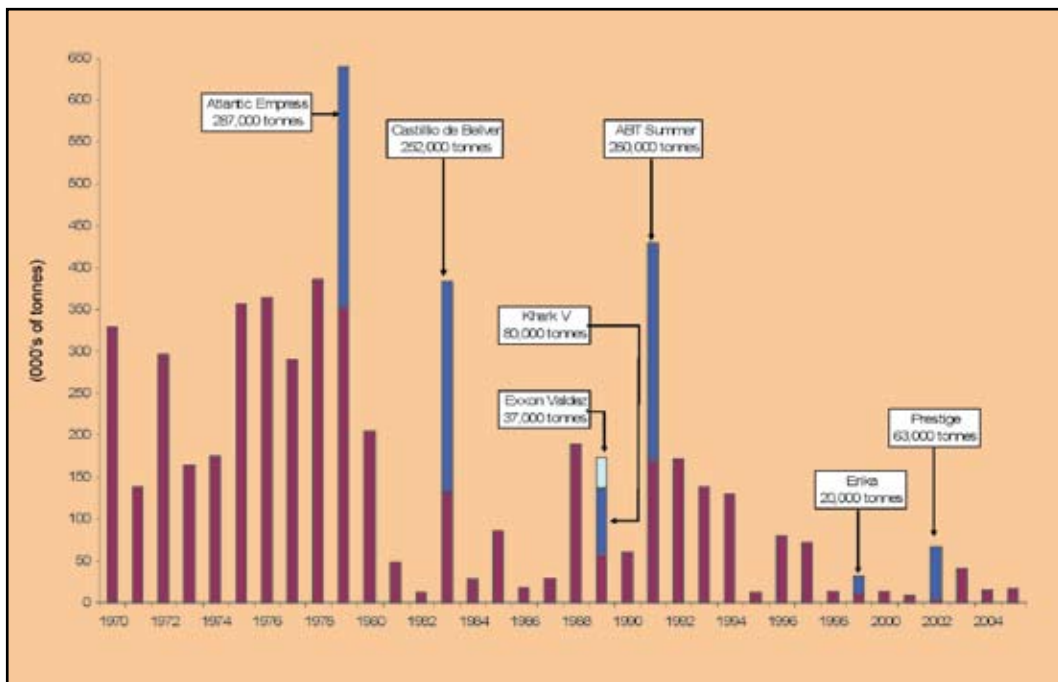


Figure 4.6 Quantities of oil spilled 1970-2005 (source: ITOPF).

has been critically important in reducing oil losses due to the operations of tankers and other ships. Annex I of this Convention lays down criteria for the discharge of cargo oil by tankers (Table 4.1).

It has been noted in chapter 2 that the RSGA has been designated as a Special Area under MARPOL Regulation 10 (1) (d). However, this Special Area status does not come into effect until IMO determines the date, after notification by the coastal states that

they have in place adequate reception and treatment facilities for dirty ballast and tank washing water from tankers⁹. Also, as noted in chapter 2, the Gulf of Aden as defined by MARPOL covers a significantly smaller area than the area defined under the Jeddah Convention.

Under Annex I of MARPOL 73/78 severe restrictions are placed on the discharge of any ‘machinery space oil’ or oily mixtures from any ship, including tankers¹⁰. As a

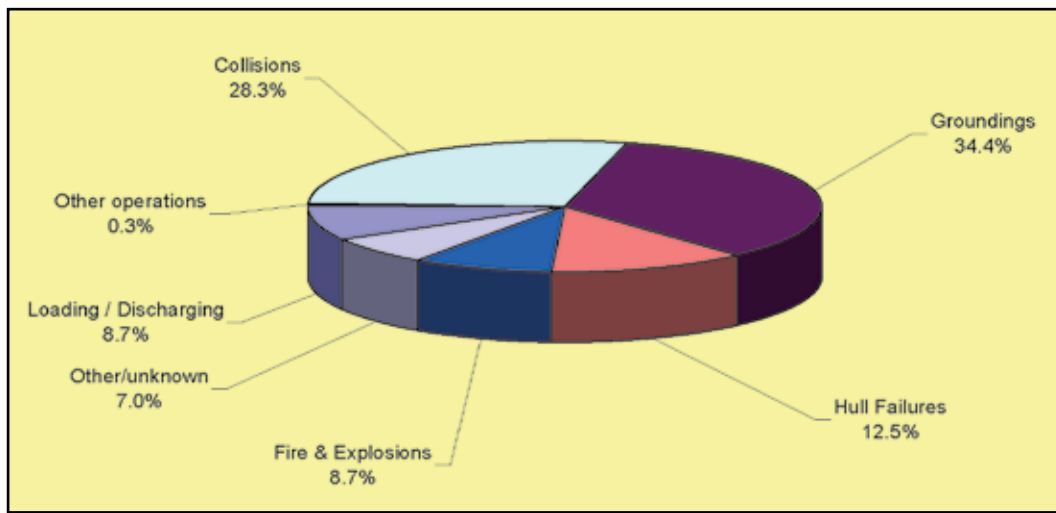


Figure 4.7a Causes of tanker spills >700 tonnes (large spills) 1974–2005 (source: ITOFF).

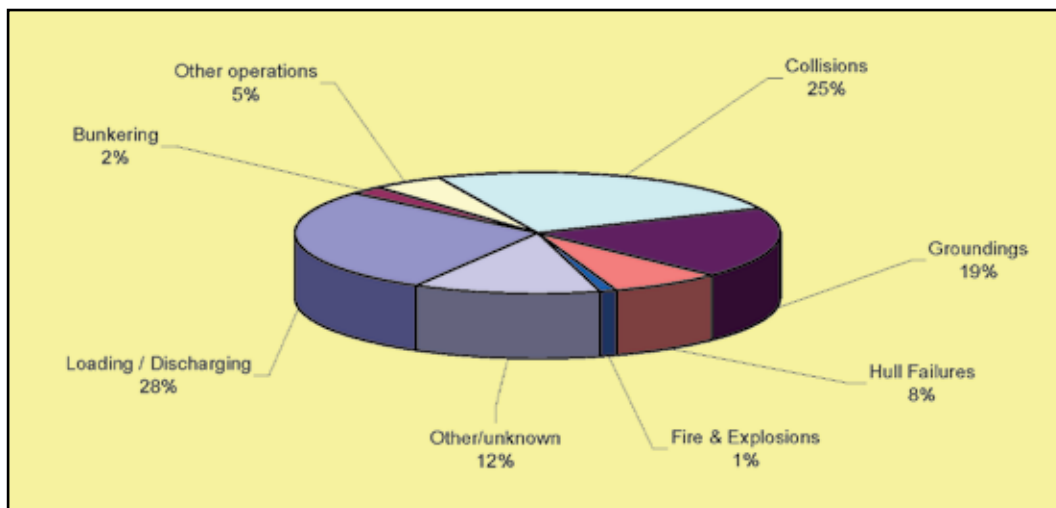


Figure 4.7b Causes of tanker spills of between 7 and 700 tonnes (intermediate spills) 1974–2005 (source: ITOFF).

⁹ See MARPOL 73/78 Regulation 10 (7) (b) (i) and (iii), and also Regulation 12. The states bordering the RSGA have yet to advise IMO on this matter, as several ports do not yet have adequate facilities.

¹⁰ See MARPOL 73/78 Consolidated Edition 2002, Regulation 9. MARPOL may formally be referred to as ‘The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto’.

Table 4.1 Criteria for the discharge of cargo oil by tankers, from Annex I of MARPOL 73/78.

Sea Area	Discharge Criteria
Within 50 nautical miles from land	No discharge except the discharge of clean or segregated ballast
Outside Special Areas more than 50 nautical miles from land	No discharge except either: <ul style="list-style-type: none"> • Clean or segregated ballast or when: • Tanker is <i>en route</i>; and • Rate does not exceed 30 litres per nautical mile and • Quantity does not exceed 1/30,000 of total quantity of cargo carried on the previous voyage; and The tanker has in operation an oil discharge monitoring and control system and slop tank arrangement (Annex 1 Reg. 9(1)(a) and Reg. 15)
Within a Special Area	No discharge - Except clean or segregated ballast (Regs.1(16) 10 (2), 10(3) (a))

tanker loads and discharges its cargo it must maintain a certain minimum draught and control the trim of the vessel. This is achieved by discharging ballast water as the cargo is taken on board, and by loading ballast as the cargo is discharged. Various methods of doing this without polluting the sea have been devised, including tank washing with cold and hot water, tank washing with the cargo (crude oil washing), using clean ballast tanks which have been cleaned before ballast is loaded into them, and, for the past 20 years, segregated ballast tanks (SBT), where cargo is never loaded in tanks designated as ballast tanks. This last method has proved to be most effective in reducing oil pollution and has, for example, largely eliminated the incidence of tar balls observed along the coast of Yemen since 1997¹¹.

4.3.2 Oil Terminals, Tanker Traffic and Oil Movement in the RSGA

Navigation charts covering the RSGA show that the Red Sea consists of a largely unrestricted central body of deep water in which ships can operate without encountering significant hindrance,

while the Gulf of Suez and the islands in the southern end of the Red Sea present various challenges to safe navigation. The Gulf of Suez is particularly important and potentially difficult as it leads to and from the southern entrance of the Suez Canal, resulting in highly concentrated maritime traffic. Further hazards are presented by the numerous offshore oil and gas production platforms, pipelines that lead from these platforms to shore storage facilities and land pipelines, and by dangerous reefs and shoals. A number of incidents have been recorded by the Egyptian authorities where ships have collided with offshore platforms, causing damage to both ship and platform, sometimes damaging pipelines and causing pollution.

As noted below, a number of oil terminals and other oil handling facilities are located in the RSGA. The main ones are the oil import terminal at Ain Sukhna, the import/export terminal at Aqaba, the King Fahd Industrial Port at Yanbu, through which much of the Saudi Arabian oil production is exported, the petrochemical complex at Rabigh¹², the oil bunkering facilities in Jeddah, the import/export terminal at El Khair and the

¹¹ Personal communication with the NEXEN petroleum terminal at Ash Shihr near Mukalla, Yemen, November 2005.

¹² As noted below, by 2008 new investment and development of Rabigh will greatly expand its role as the largest integrated refining and petrochemical complex in Saudi Arabia.

export terminals at Bashayer in Sudan, the oil bunkering facilities at Djibouti and the oil export terminals at Ras Issa, Rudum and Ash Shihr in Yemen. The oil import/export terminal at the oil harbour in the Port of Aden and the bunkering facilities in the port are also important facilities.

The majority of the oil produced in the RSGA is exported from the producing countries by sea on tankers to consumers worldwide. Figure 4.8 shows the routes normally taken by vessels operating in the Red Sea and Gulf of Aden, carrying oil (and other commodities) from RSGA terminals to destinations in the Americas, Europe, Africa, the Indian subcontinent and the Far East.

Oil transport within the RSGA is of world importance. It includes movements of crude

oil and products from The Gulf into the Red Sea via the Gulf of Aden¹³. Some tankers from, for example, Kuwait, operate shuttle services between The Gulf and Ain Sukhna, where their cargoes are discharged to the SUMED Pipeline Terminal to be pumped across the Isthmus at Suez for reloading at Sidi Kirir on the Mediterranean coast for onward carriage, allowing the tanker to return to The Gulf via the RSGA for its next cargo. Some tankers will unload part of their cargo at Ain Sukhna and pass through the Canal before reloading the cargo at Sidi Kirir for onward carriage to northern Europe or other destinations¹⁴. Similarly, tankers operating on the west coast of Saudi Arabia may carry oil northwards to Ain Sukhna, or to the Suez Canal, and to other destinations. Currently around 40 million tonnes of crude oil pass through the Suez Canal from the Red Sea to

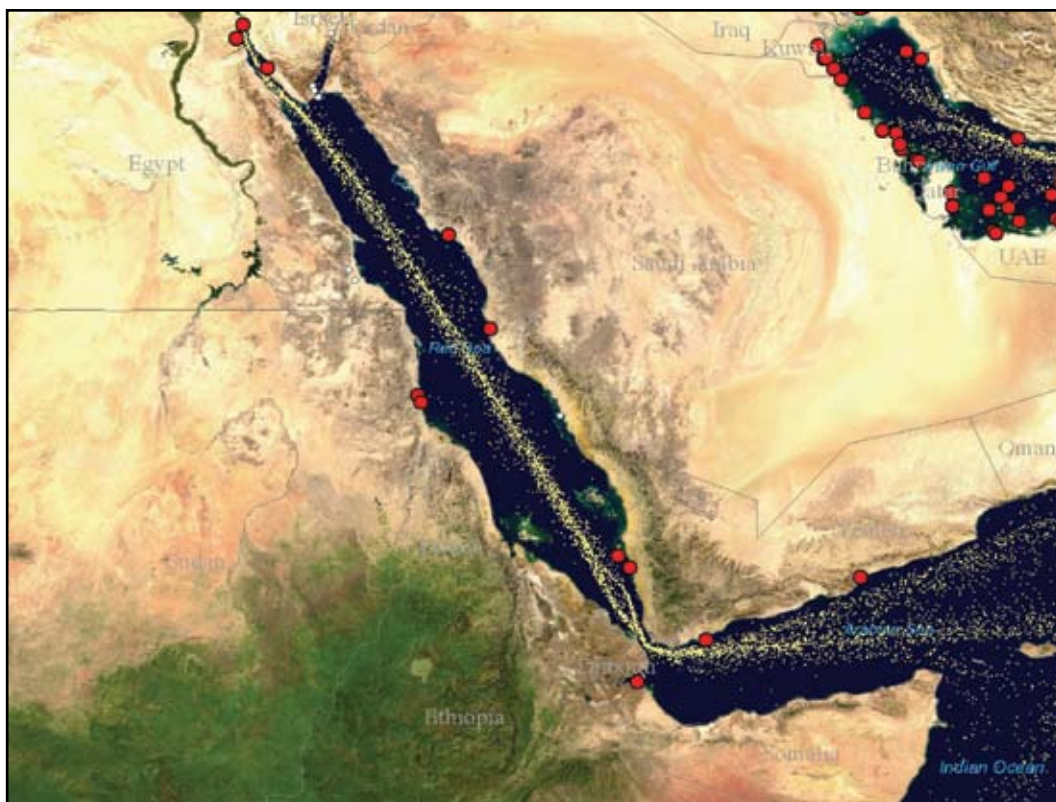


Figure 4.8 Main shipping routes in the RSGA (source: IMO).

¹³ To encourage use of the Suez Canal rather than the Cape route, the Suez Canal Authority offers discounts to tankers of up to 30% for varying quantities of oil transported through the Canal each year. It also offers discounts for double hull tankers (2%) and segregated ballast tankers (4%). South bound VLCCs (very large crude carriers) of over 200,000 tons in ballast are also offered a discount of up to 40%, depending on their port of origin.

¹⁴ “In cooperation with SUMED Co., SCA allowed partially-loaded supertankers to transit the Suez Canal after lightering part of their cargo in SUMED pipeline. As a result, 564 supertankers, totaling 85.1 million tons, transited the Suez Canal since 1997 to the end of 2004”. SCA Yearly Report 2004, page 45.

Box 4.1 Terrorism as a cause of pollution

The impact of terrorist attacks has now added to the problems faced by ships and has highlighted the potential of such incidents to cause pollution. The maritime world reacted very strongly to an attack on the modern double-hulled French tanker Limburg at the Yemeni oil terminal at Ash Shihr in the Gulf of Aden on 06 October 2002. War Risk insurance rates for Yemeni ports went up by 16 times, effectively destroying the container transshipment business at the Port of Aden that had grown at an average rate of 40% per year since 1995. Higher insurance costs on ships raised the cost of living for Yemeni citizens and were in place for a year before measures taken by the Yemeni government were effective in bringing them down to pre-Limburg rates.

The attack resulted in some 20,000 tonnes of crude oil being spilled from the damaged tank on the starboard side of the ship into the Gulf of Aden, close to the shore. Fortunately, around 18,000 tonnes of this burned off in the fire that resulted from the explosion. Oil reaching the coastline of Yemen was cleaned up using various methods, and oil mixed with sand was used for road building works.

the Mediterranean, and 120 million tonnes through the SUMED pipeline. In addition, Suez Canal Authority (SCA) statistics for 2004 show that 21 million tonnes of oil and products was carried through the Suez Canal south bound.

Oil exported from Sudan is generally destined for the Far East. Oil from Yemen is either refined in Yemen (at the refinery in Aden) or is exported to the USA, the Far East and other consuming centres. There is also movement of refined products, bunker fuel etc., between oil terminals and ports in the RSGA, such as bunker fuel from Yanbu to Jeddah¹⁵, imports of gas oil and other products at the El Khair Terminal in Sudan from Aden and other sources, imports of power station and motor fuel at Hudaydah (Hodeidah), Mukha and Mukalla from Aden, imports of power station and bunker fuel at Djibouti and fuel oil, gasoline etc. at Berbera and Bosaso. These movements often require smaller tankers to cross the main shipping route through the RSGA in order to deliver their cargoes.

So far the focus has been on large oil tankers operated by companies with a reputation to protect and with serious consequences, both financial and in terms of public relations, if their ships are involved in an oil spill. However, not all tankers operating in the

RSGA are well maintained and operated and, as discussed below, port state control measures are an important means of regulating the operations of such vessels. Sub-standard vessels have the potential to cause environmental damage, and the authorities in the RSGA are endeavouring to reduce the numbers of such vessels operating in the region, or if possible eliminate them completely.

4.3.3 Liquefied Natural Gas Movement

Egypt and Saudi Arabia are both important producers of liquefied natural gas (LNG). Egypt produced 34.7 billion m³ and Saudi Arabia produced 69.5 billion m³ of gas in 2005¹⁶. The new gas terminal under construction on the Yemeni coast of the Gulf of Aden at Belhaf will add to the volume of gas being transported in the RSGA from 2008 onwards, and other similar developments can be anticipated in the region. However, pollution from gas tankers has not yet been a significant cause for concern in the RSGA, nor indeed world wide, and has not featured to any degree in reports on pollution. However, the potential for pollution due to a collision between a large gas carrier and another ship, the grounding of a gas carrier or other serious incident involving a gas carrier cannot be ignored, and measures to monitor and improve the operational safety

¹⁵ The Industrial Port at Yanbu recorded that 504 fuel oil tankers lifted 6.77 million tonnes of fuel oil in 2005. See www.ports.gov.sa, Port Statistics, Yanbu Industrial Port.

¹⁶ The Industrial Port at Yanbu recorded that 2.32 million tonnes of LNG was loaded on 64 gas tankers in 2005. See www.ports.gov.sa, Port Statistics, Yanbu Industrial Port.

of gas carriers is an ongoing requirement for RSGA terminals¹⁷.

In addition to the movement of LNG from terminals in the RSGA, LNG carriage between export terminals in The Gulf to Europe or North America is a further factor. The Suez Canal Authority (SCA) encourages the use of the Canal by gas carriers, as it offers a discount to these vessels, as follows (SCA 2004):

“A discount of 35% of Suez Canal dues is to be granted to loaded north bound LNG’s to encourage the opening of new markets in European countries, such as Spain, France and Turkey. Further rebates to Liquefied Natural Gas quantities (cargo incentive) transported through the Suez Canal, shall be given as shown hereunder . . . (it then lists the discounts available on SCA dues, of up to 15%, for varying quantities of LNG transported through the Canal each year).

4.3.4 Movement of Chemicals

The availability of large quantities of oil and gas in Saudi Arabia and Egypt has led to the establishment of petrochemical complexes and the production of a range of chemical products as these countries seek to reduce their heavy dependence on crude oil exports. Petrochemicals are produced in Suez and at the King Fahd Industrial Port at Yanbu on the coast of Saudi Arabia.

Some chemical products are also imported. In 2005, for example, 72 chemical tankers

called at the King Fahd Industrial Port at Yanbu to discharge 327,000 tonnes of chemicals, mainly liquid feedstock (300,000 tonnes). Most ports in the RSGA import chemicals, some of which have led to pollution and safety problems in these ports¹⁸.

Exports of chemicals from Yanbu are more significant, although much lower than the quantities exported from the Saudi east coast industrial port of Jubail in The Gulf. In 2005, 20 chemical tankers loaded 175,000 tonnes of cargo at Yanbu after discharging, while 113 chemical tankers called to load 1.28 million tonnes of bulk liquid chemicals, giving an average parcel size of 11,000 tonnes¹⁹. The main commodities exported from Yanbu Industrial Port include sulphur, naphtha, mono-ethylene glycol, di-ethylene glycol and methyl tert butyl ether.

In addition to bulk chemicals exported from production centres such as Yanbu, significant quantities of chemicals are now carried in containers, either in tank containers or in drums and other smaller units inside 20 and 40 foot standard ISO containers. Some parts of the world report cases of chemicals in containers or drums being lost over the side in heavy weather, or as a result of fire and explosions on board the ship²⁰. The number of incidents involving chemical carriers in various parts of the world, including the grounding or sinking of chemical carriers, has so far been small, but the carriage of many millions of tonnes of chemicals in bulk on specialised carriers, or on container and cargo ships in this region indicates strongly that an incident that could or would cause damage to the marine environment of RSGA is a distinct probability²¹.

¹⁷ A report published in the USA by Sandia National Laboratories in 2005 on the threat of terrorist attacks on gas carriers noted that risk from accidental spills from collisions and groundings involving such ships was ‘small and manageable’, but threats from major terrorist attacks were potentially far more serious. Proper measures to prevent such attacks are therefore needed.

¹⁸ Faulty drums caused chemicals to leak in the cargo working area at Djibouti in 2003, causing health hazards to port workers and pollution of the quay area. (Source: Lloyds List reports 2003 and other articles in the maritime press.)

¹⁹ See www.ports.gov.sa, Port Statistics, Yanbu Industrial Port.

²⁰ For example the fire on board the ‘Hyundai Fortune’ in the Gulf of Aden in early 2006, when containers carrying a wide range of commodities, including chemicals, were destroyed by fire or lost over the side.

²¹ Various incidents at sea involving chemicals carried by ships have been reported in recent years. For example, three containers of toxic chemicals were lost overboard in early 2004 in the North Sea area and recovered through a costly salvage operation, while in late 2005 a 3,800 GRT chemical tanker grounded in the River Scheldt and was re-floated by Dutch and Belgian salvage companies, fortunately without causing any pollution.

With increasing volumes of LNG being discovered and extracted from the RSGA and the countries bordering it, other petrochemical complexes are likely to be established in the region, leading to a further rise in the tonnages of chemicals that will be in transit through these waters.

4.4 OTHER SHIP TYPES AND THROUGH TRAFFIC

The RSGA provides a vital route for maritime commerce and is currently estimated to carry around 7–8% of world trade. The Suez Canal Yearly Reports published by the SCA are an important source of statistical data on the numbers, sizes and types of ships transiting the Canal. As many of these ships are ‘through traffic’ and do not call at ports in the RSGA, the SCA reports provide a good indication of the mix of traffic operating in the region.

However, it should be remembered that ships also operate between The Gulf and ports and terminals in the RSGA without using the Canal. Similarly, some of the dry cargo or container traffic from the Far East and Australia is operated on a ‘pendulum service’, where the ships leave a port in the Far East such as Singapore, call at a port or ports in the RSGA, then return to Singapore. Container, general, bulk ships (often carrying grain) and livestock carriers also operate services to RSGA ports that do not use the Suez Canal. In addition a number of container feeder services, livestock carrying services etc., operating within the RSGA, do not transit the Canal. Thus, non-Canal traffic adds considerably to the total volume using the RSGA.

The depth of the Suez Canal, and thus the draught of ships able to transit, has continued to increase over the past decade or more. In 1994 the limiting draught for ships in transit was 56 feet (17.07 m), in 1996 it was 58 feet (17.68 m), in 2001 it was 62 feet (18.90 m) and in 2006 it was 66 feet (20.12 m).

The SCA Yearbook 2004 recorded a total of 16,850 full transits of the canal north and south bound, compared with 15,667 transits in 2003. This was a rise of 7.6% and gave a daily average of 46 ships using the Canal for north and south bound transits. The average size of ships using the Canal is also increasing. In 2004 the tonnage of ships using the Canal, based on Suez Net Registered Tonnage (NRT) figures, was 621.2 million NRT, up from 549.4 million NRT in 2003. This represents an increase of 13.1% in the NRT. The average tonnage of ships in 2003 was 35,067 NRT, rising to 36,866 NRT in 2004, an increase in the average size of ship by 5.1%. It may be anticipated that the average tonnage of ships using the Canal will continue to rise as a result of increases in ship sizes for certain types in world trade, such as container ships, and the deepening of the Canal (Table 4.2).

In 1996 container shipping accounted for 27.7% of the total number of ships using the Canal and 32% of the tonnage. In 2004 container shipping formed the largest percentage of traffic through the Suez Canal by a significant margin, accounting for 35.1% of ships by number and 45.8% by tonnage. The average size of container ships continues to increase rapidly, rising from 46,700 net tons in 2003 to 48,000 net tons in 2004. In 1996 the number of general cargo ships was 3,057 falling to 1,787 in 2004. This reflects the increasing use of containers to transport a wider range and greater tonnage of the world’s commodities by sea as container shipping becomes increasingly competitive in comparison with other methods of moving cargo.

4.4.1 MARPOL 73/78 – Annexes II-VI ²²

MARPOL 73/78 is the main IMO instrument for the control of marine pollution by oil and has been critically important in reducing oil losses due to tanker operations, and due to the operations of other ships. Annex I of MARPOL 73/78, dealing with discharges

²² For full details of these Annexes see MARPOL 73/78 Consolidated Edition 2006. Annex I regulates the discharge of oil by all ship types, including cargo oil carried in bulk on tankers and fuel oil etc. carried on all types of ships.

Table 4.2 Suez Canal traffic by ship type in 2003 and 2004 (source: SCA 2004).²³

Ship Type	Number of Vessels			Net Tons (x1000)		
	2003	2004	% Change	2003	2004	% Change
Tankers	2,709	3,258	16.4	118,877	141,999	19.5
Bulk Carriers	3,212	3,359	4.6	96,143	102,485	6.6
Combined Carriers	66	35	-47.0	3,155	1,692	-46.4
General Cargo	1,742	1,787	2.6	16,525	17,862	8.1
Container Carriers	5,209	5,928	13.8	243,368	284,307	16.8
Lash Ships	11	8	-27.3	365	250	-31.5
RoRo Ships	683	518	-24.2	16,286	13,346	-18.1
Car Carriers	867	1,058	22.0	43,556	52,564	20.7
Passenger Ships	55	64	16.4	821	1,231	49.9
Warships	395	222	43.8	7,573	3,281	56.7
Others	628	613	-2.4	2,712	2,213	-18.4
Totals / % Change	15,667	16,850	7.6	549,381	621,230	13.1

of oil by tankers, has been referred to above. Annexes II and III contain the regulations applying to the carriage of chemicals in bulk and in packaged form. Annexes IV, V and VI apply to ship sewage, garbage and air pollution respectively. Parties to the Convention must accede to Annexes I and II, and can choose to accede to Annexes III to VI, or not. The provisions of these annexes are briefly addressed in this section.

Annex II, 'Control of Pollution by Noxious Liquid Substances' applies to the carriage in bulk of all noxious liquid substances in bulk, except oil. It therefore covers the carriage of chemicals in bulk, which have been divided into Categories X, Y and Z in the Convention.

It is important to note that the responsibility for the safe carriage of bulk chemicals lies

with various parties namely, the producers of the substance, the shippers, the ship owners and operators, the ports and the national maritime administrations. The regulations governing their carriage are both complex and stringent, and are governed not only by MARPOL 73/78 but also by the International Code for the Construction and Equipment of Ships carrying Dangerous Goods in Bulk (the IBC Code) and other instruments. The carriage of such substances is only permitted in ships certified as chemical carriers, except that offshore supply vessels, many of which operate in northern part of the Red Sea, are also permitted to carry certain chemicals in order to support offshore drilling operations.

Annex III of MARPOL 73/78, 'Prevention of Pollution by Harmful Substances in Packaged Form', is the first of the

²³ Suez Canal net tonnage figures reported in December 2006 jumped to 671 million in 2005 and are expected to reach 680 million in 2006. Suez transit revenue for 2006 is expected to reach \$3.82 billion, up sharply from \$1.95 billion recorded in 2002.

'voluntary' annexes. These substances are identified in the IMO's International Maritime Dangerous Goods (IMDG) Code, and Annex III prohibits carriage of these substances except in accordance with the requirements of the Annex. Requirements cover packaging, marking, labelling, documentation, stowage, quantity limitations and exceptions that relate to the safety of the ship or saving of life. Regulation 1.1.3 of the IMDG Code links Annex III to the code through the definition of 'packaged form'. The Code consists of schedules under each class of substance, and dangerous goods as marine pollutants are clearly identified in the schedules. Shippers must therefore declare the shipment as a pollutant, comply with the IMDG Code as far as the type of packaging is concerned, and arrange for the packaging to be marked in a specific manner. All dangerous goods must be declared on a separate list carried by the ship, which must state where these goods are stowed on board.

Annex IV of MARPOL 73/78, 'Prevention of Pollution by Sewage from Ships', entered into force on 27 September 2003. Discharge of sewage from ships is restricted under this Annex, depending on the distance of the ship from the land, whether or not it has an approved sewage treatment plant on board, whether it has facilities for comminuting (reducing to minute particles) and disinfecting the sewage, and when more than 12 nautical miles from land, the speed at which the ship is proceeding. Ports are required to provide adequate reception facilities for ships that are not equipped with sewage treatment plants.

Annex V of MARPOL 73/78, 'Prevention of Pollution by Garbage from Ships', applies to all ships of any size. Any and all types of plastic cannot be disposed of at sea and must be sent ashore for disposal. Dunnage²⁴ and other packaging materials that float can only be put over the side when the ship is more than 25 nautical miles from land. Ground up food waste and other waste, less than 25 mm in diameter, can be disposed

of when more than three nautical miles from land. Non-comminuted food waste and other waste above this size must be disposed of only when 12 nautical miles from land. In Special Areas only food waste can be disposed of at sea, and only when the ship is more than 12 nautical miles from land. Under this Annex, all ships must have a garbage management plan, crews must be trained in application of requirements, and ports must provide adequate reception facilities for garbage.

Annex VI of MARPOL 73/78, 'Prevention of Air Pollution from Ships', was adopted by IMO in September 1997 and entered into force on 19 May 2005. It addresses the problems of the release of ozone depleting substances by ships and air pollution by ships. It is designed to control the emission of nitrous oxides (NO_x) and sulphur oxides (SO_x) from ship exhausts, and volatile organic compounds in ports and oil terminals. It contains provisions for the establishment of SO_x emission control areas, where emissions must not exceed 1.5 per cent by mass (% m/m), and requires these to be limited to 4.5% m/m elsewhere. It provides for the use of shipboard incinerators, and for shore-based reception facilities for ozone depleting substances such as halons and chlorinated hydrocarbons carried on board ship.

MARPOL 73/78 has only been ratified by Djibouti, Egypt, Jordan and Saudi Arabia within the RSGA, with the highly important Saudi Arabian ratification taking place in 2005. The situation in 2006 is that Djibouti has ratified MARPOL 73/78 Annexes I-II, Egypt and Jordan have ratified MARPOL 73/78 Annexes I-V and Saudi Arabia has ratified MARPOL 73/78 Annexes I-VI. Eritrea, Somalia, Sudan and Yemen have not yet ratified the Convention. In view of the steady growth in the numbers and the total tonnage of ships entering the RSGA, conformity with MARPOL 73/78 and its annexes will become increasingly important to this region.

²⁴ 'Dunnage' is the name given to packing materials used to prevent damage to cargo in the holds and includes items such as wood, plastic, jute and tarpaulins.

4.4.2 Port State Control

Port state control (PSC) is the means established by IMO by which ports are authorised to inspect foreign (and national) ships to ensure that they meet required safety, construction, equipment and manning standards, and if necessary to detain the ships that fail to meet required standards; i.e. when the ships are considered to be sub-standard. To improve the ability of states in regions around the world to monitor and control sub-standard vessels, groups of states around the world have co-ordinated their PSC activities so that they can inform other states in their region when a sub-standard ship has been detected and may be expected to call at ports in another regional state. This is achieved through regional Memoranda of Understanding (MoU) on PSC agreed by the states who are parties to the MoU.

In 1999 two of the states in the RSGA, Egypt and Jordan, were members of the Mediterranean MoU on PSC, while Sudan, Yemen and Eritrea were members of the Indian Ocean MoU on PSC (IOMoU). In March 2002 a workshop was convened by PERSGA in Jeddah, attended by PERSGA member states, Eritrea, representatives of ROPME member states and the IMO. At the workshop the advantages of membership of one MoU on PSC for the region were stated. The Gulf States subsequently established a Gulf MoU on PSC with the purpose of providing regional coverage for the ROPME area²⁵.

PERSGA has promoted the improvement and expansion of PSC inspections of ships in the RSGA in order to discourage the use of regional ports by sub-standard ships. The

number of inspections and the competence of inspectors and the administrations within the region are gradually growing, but there is still much work to be done in order to control the environmental risks arising from sub-standard vessels operating in the RSGA. The fact that the states within the RSGA are members of three different MoUs on PSC and that two of these states are not members of any MoU on PSC does nothing to harmonise their systems of ship inspections or to assist with the control of sub-standard shipping at a regional level.

PERSGA can continue to support the improvement of PSC inspections and national skills, and may be able to encourage regional states to become members of one MoU on PSC²⁶.

4.4.3 Invasive Aquatic Species in Ships' Ballast Water and the IMO Ballast Water Convention ²⁷

The focus of discussions on marine pollution, until almost the end of the 20th century, was on the carriage by sea of oil and, to a lesser extent, liquefied gasses and chemicals. The falling incidence of oil spills and the lower volumes being spilled due to the actions taken to improve tanker safety have been very encouraging. But it is now increasingly being realised that the carriage of ballast water by ships can potentially cause greater harm to the marine environment than a major oil spill.

While MARPOL 73/78 Annex I prohibits the discharge of any oil within a Special Area, Regulations 1 (16), 10 (2) and 10 (3) (a), for example, conspicuously allow clean or segregated ballast water to be discharged in a Special Area, which the RSGA has been

²⁵ ROPME member states are Bahrain, Iraq, Iran, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

²⁶ The IOMoU covers the whole of the Indian Ocean from Iran to South Africa and east to Australia and Indonesia, and includes the RSGA. Because of this, Eritrea, Sudan and Yemen joined the IOMoU. Jordan has a single port on the Red Sea and no port on the Mediterranean coast. Membership of two MoUs on PSC is not uncommon where countries have coastlines bordering the areas covered by two MoUs on PSC. Egypt has both Mediterranean and Red Sea coastlines and could be a member of the Mediterranean and Indian Ocean MoUs on PSC. Similarly Saudi Arabia could be a member of MoUs on PSC in The Gulf and the Red Sea.

²⁷ Invasive aquatic species in ships' ballast water is now considered to be one of the four greatest threats to the world's oceans, the other three being land-sourced marine pollution, over-exploitation of living marine resources, and physical alteration/destruction of habitat.

designated to become under MARPOL 73/78.

The movement of aquatic species from one part of the world to another on the hulls of ships has existed ever since sailors started to explore the world. However, when ships began, in the late 19th century, to use water as ballast on ships in order to control their draught, trim and heel, rather than solid materials such as iron, ballast water was inevitably moved from one part of the world to another. But it is only in recent years that the movement of aquatic species around the world has become an issue that is recognised as potentially more harmful than the oil spills that have damaged the marine environment in many parts of the world since large oil tankers came into service in world trade in the 1960s²⁸. These tankers carry not only oil cargoes, but up to 120,000 tonnes of sea water ballast from one part of the world to another when on a ballast voyage. And while the impact of a massive oil spill on the environment can eventually diminish to zero over time, the impact of invasive aquatic species (IAS) on a local environment can, and normally does, increase over time as the species spreads in a region. As IMO has pointed out, ‘Global shipping... transfers around 12 billion tonnes of ballast water across regions each year’²⁹.

Examples of the damage caused by such invasions are many—zebra mussels blocking the power station cooling water intakes in the Great Lakes of America and Canada, starfish affecting ports and harbours in Australia, and ‘ghost crabs’ impacting fisheries developments in Scotland. These and other damaging movements of IAS have been widely recorded and reported³⁰. In some cases the costs of dealing with IAS damage can exceed the costs of cleaning up a large oil spill. Costs of removing the

invasive species are likely to recur over time unless drastic action is taken, while stopping the invasion through such action is normally only possible when a small area that can be contained is affected. While there have been isolated examples of an invasion being stopped when the invasion has been by small numbers confined to a small area, experience shows that invasions in general cannot be prevented once the invading species becomes established in a new area; i.e. these invasions are most often irreversible.

Typically the impact of IAS will adversely affect fisheries, the coastal infrastructure and port operations³¹. Although ballast water has been moved around the world for 100 years or more, the problem continues to be of concern because ships are getting faster and are carrying larger volumes of ballast water, thus increasing the survivability of various types of organisms, and are visiting new parts of the world that are becoming sources of raw materials (Figure 4.9).

While the main focus is on the transfer of species from one part of the world to another, the transfer of pathogens is also an important issue. Cholera can, for example, be moved from one country to another by ship and has, in South America, been demonstrated to be the cause of deaths within a coastal population. To quote from *Exotic Organisms, 1999*:

“In addition to red tide organisms, we also now know that cholera can be moved about the world in ballast water. It appears that in the 1990s the epidemic strain of South American cholera was transported in ballast water into the Gulf of Mexico, where it was found in oysters and fish along the U.S. coast” (COHEN 1999).

²⁸ ‘It is believed that a marine species invades a new environment somewhere in the world every nine weeks’ (Source: http://www.imo.org/includes/blastDataOnly.asp/data_id%3D3997/BallastWater-Pughuic.pdf).

²⁹ Ibid.

³⁰ ‘Ballast Water News’, published and circulated by the GloBallast Programme Phase I until 2004, contained many articles on areas affected and general information on IAS.

³¹ For example, the annual recurring cost of zebra mussels from the Caspian Sea on power station intakes in the Great Lakes is a major element in the estimated \$20 billion cost of cleaning up the Lakes over a five year period. See www.ens-newswire.com/ens/jul2005/2005-07-11-03.asp.

Figure 4.9 GloBallast poster illustrating the impact of invasive aquatic species in various parts of the world (source: IMO/GloBallast/GEF publication).

Ten of the Most Unwanted

Marine plants, animals and microbes are being carried around the world attached to the hulls of ships and in ships' ballast water. When discharged into new environments, they may become invaders, and seriously disrupt the native ecology and economy. Introduced pathogens may cause diseases and death in humans.

Chironomid
A common freshwater insect larva introduced to North America, Gulf of Mexico and other areas. Some chironomid species appear to be directly associated with the decline of the American oyster industry. The larvae are also found in ballast water from ships in the Gulf of Mexico, suggesting that they may have been introduced to the Gulf by ballast water.

Cladoceran Bryozoa
A common freshwater invertebrate introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

Atlantic Cladocera
A common freshwater invertebrate introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

North Pacific Seastar
A common marine invertebrate introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

Asian Carp
A common freshwater fish introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

European Green Crab
A common marine invertebrate introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

Asian Mussel
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A common marine invertebrate introduced to the East and Central Oceans. It is a highly competitive species that dominates large populations that dominate the benthic environment. It is also found in ballast water from ships in the Gulf of Mexico, suggesting that it may have been introduced to the Gulf by ballast water.

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The species presented here are for illustrative purposes only. Their introduced ranges may be greater than depicted. There are numerous other examples of serious marine bio-invasions around the world.

While all ship types require to carry and to manage ballast water at various times, the main ship types of concern in the waters of the RSGA are oil tankers which, since the early 1980s, have been required to carry their ballast in segregated tanks. Segregated ballast tanks (or SBT) have been regarded as the environmentally responsible way to carry ballast on tankers, as the ballast water should not, under normal circumstances, become contaminated by oil and therefore this water can be discharged overboard without being treated to deal with any oil content. The heightened awareness over the past ten years regarding the transfer of IAS in ballast water has now caused the whole question of ballast water in tankers to be revisited. Similarly, ballast water carried in bulk carriers, which has not previously been regarded as a problem for the ports where ballast has to be discharged, has become a matter of considerable concern to port and environmental authorities. Dry bulk carriers calling at ports in the RSGA often discharge their cargoes of bulk wheat, etc. and take on ballast water, but on occasions arrive at ports such as Aqaba and Safaga to load dry bulk cargoes and, before or during loading, discharge their ballast water into the sea or into harbour waters. Other ships types, such as container ships, dry cargo ships, car carriers etc., also use ballast to maintain

draught and trim, and may need to discharge ballast taken on board at distant places into the waters of ports in the RSGA.

In the early 1990s, because the movement of IAS had adversely affected its waters, Australia brought the problem to the attention of the International Maritime Organization. Persistent lobbying led to the establishment of the Global Ballast Water Management Programme (GloBallast), funded by the Global Environment Facility (GEF). The GloBallast programme was implemented by IMO and supported by UNDP. For the Pilot Phase, which lasted from 01 March 2000 to 31 December 2004, six areas were selected around the world, including Iran as a focal point within the waters of The Gulf. Iran is the closest of the Pilot Phase countries to the RSGA (Figure 4.10). Various activities were conducted in these test areas through technical cooperation, including capacity building and institutional strengthening. It was possible to establish port biological baseline conditions in some of the ports, to monitor the movement of ballast water from one area to another and to promote technological solutions to the problem through research and development. Global and national task forces on ballast water management were established.

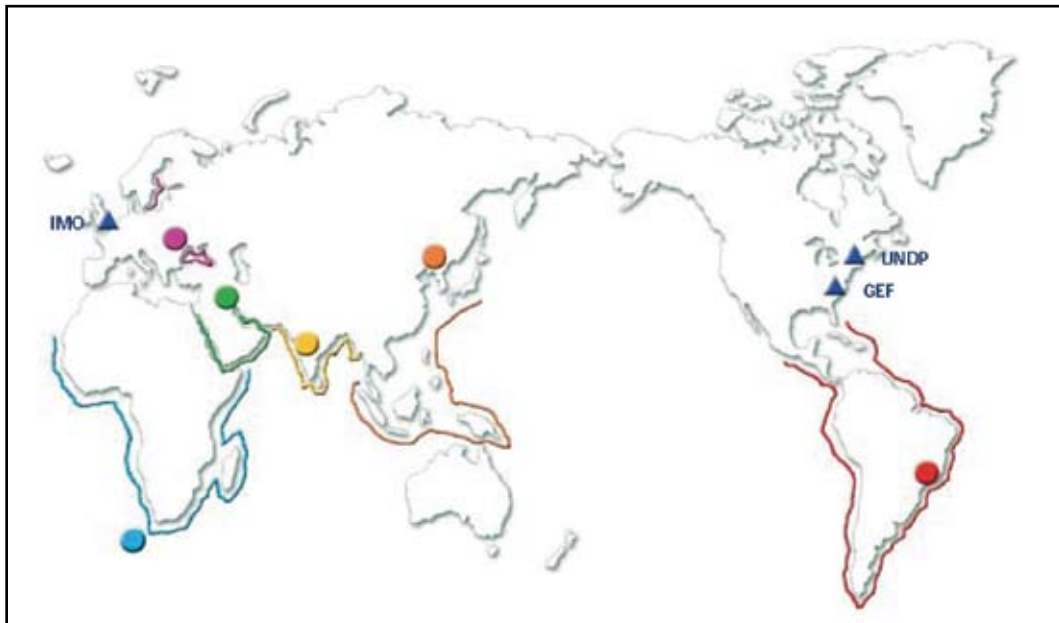


Figure 4.10 The GloBallast project, pilot phase centres 2000 to 2004 (source: IMO/ GloBallast/GEF publication).

IMO prepared and circulated posters to inform the international shipping community, and general populations, on the dangers of 'unwanted stowaways'. One such poster illustrates over 30 places in various parts of the world that have suffered from the impact of IAS (Figure 4.9). Guidelines giving ships' officers advice on handling ballast water, as described in IMO Resolution 868 (20) of 1997, were prepared. This identifies the exchange of ballast water at sea as one possible method of trying to address the problem of IAS transfers.

In February 2004, following a diplomatic conference in London, IMO adopted a new Convention, the 'International Convention for the Control and Management of Ships' Ballast Water and Sediments', which is the international convention dealing specifically with the control and management of ships' ballast water and of the sediments that result from the carriage of this water.

By 30 November 2006 six countries had become parties to the Convention³². Several other countries, including Egypt, are believed to be in the process of acceding to the Convention. Other countries in the region, such as Sudan and Yemen, have expressed their wish to learn more about the Convention and have indicated a positive interest in ratifying it. The Convention will enter into force 12 months after 30 States with 35% of the world's gross tonnage have ratified or acceded to it. The objective of the Convention is to prevent, minimise and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments. It allows parties to the Convention to impose more stringent measures than those described in the Convention, requires reception facilities to be provided for sediments from ballast tanks, and provides for the survey, certification and inspection of ships carrying ballast water.

The Pilot Phase of the GloBallast Programme was evaluated and considered to be highly successful in the areas that it addressed. The next phase of the GloBallast Project is being prepared, termed GloBallast Partnerships (GBP). Finance has been provided to develop a Project Document for GBP, to identify strategic partners and co-financing opportunities, and the draft document is ready. The planned duration of this new project is from late 2007 to 2011.

A British Broadcasting Corporation (BBC) documentary on the IAS problems experienced by different countries has been prepared, with filming taking place in many parts of the world. This film is now being circulated by the BBC and IMO as a very useful tool to bring the problems of IAS into sharper focus in this region and elsewhere³³.

At a workshop held at IMO Headquarters in July 2005, attended by PERSGA, delegates fully recognised the environmental significance of the RSGA region and the potential damage that could be inflicted on it by IAS³⁴. The RSGA was therefore selected as one of two key areas in the world that should receive support during the GBP project. Following the July workshop, IMO worked with PERSGA to arrange an awareness raising and fact-finding mission to the region on ballast water management, and on MARPOL matters, in November 2005. The mission was funded through the IMO International Technical Co-operation Programme, enabling visits to be made by IMO consultants, including a ballast water expert, to Egypt, Yemen, Sudan and Saudi Arabia (a planned visit to Jordan had to be deferred). The objective of the mission was to determine the level of awareness in these countries regarding the carriage, exchange and management of ballast water on ships calling at regional ports and terminals, and the level of knowledge of the Ballast Water Convention. It also investigated the

³² Maldives, Nigeria, St Kitts and Nevis, Spain, the Syrian Arab Republic, Tuvalu.

³³ VELA, an oil tanker company based in Saudi Arabia, has been an important private sector contributor to the costs of making this documentary, and has also supported research into a system for continuous ballast water exchange at sea. Details of the documentary are available from the GloBallast team at IMO Headquarters, London.

³⁴ Due to the huge volume of ballast water carried in tankers, and to a lesser extent by other ships, the confined waters of the RSGA are particularly at risk from IAS. This is particularly true when the ballast has been loaded in an area where sea water characteristics are similar to those prevailing in the RSGA, and where the local species are already stressed due to other pressures on the region.

measures in place, if any, to control and handle ballast water at these ports and terminals, assess the need for regulations to be developed, the level of interest in the new Convention and the willingness of the countries to participate in the GloBallast Partnerships Project.

At the end of the mission a regional workshop was held in Jeddah between 27 November and 01 December 2005, attended by delegates from all the PERSGA states plus Eritrea. The workshop covered both the Ballast Water and the MARPOL 73/78 Convention. Compact discs containing the workshop materials were distributed to all participants. This event was most successful in raising awareness within the region on the issue of ballast water. The essential conclusions of the mission and the Jeddah workshop were that:

- A few key officials in some countries, such as Egypt and Saudi Arabia, are well aware of the problems that can be generated by IAS, and are acting to counter these.
- Other officials in the same countries were unaware of the problems imported with 'clean' ballast water, but as a result of the workshop have rapidly gained a good understanding and are keen that action should be taken.
- Oil terminals in the region are generally aware of the ballast water/IAS issue, but apart from asking ships to exchange ballast at sea before arriving at the loading port (for example in the case of the Bashayer Terminal in Sudan), little is being done at present to address the issue.
- There is, however, considerable willingness and a desire at these terminals and within the region

generally, to cooperate fully with the next phase of the GloBallast Programme in order to protect the marine environment from IAS.

- The problems associated with the ballast carried on bulk carriers arriving at ports in the region to load various cargoes, such as potash and rock, have not been appreciated to date. But those involved in ports where there is a potential problem, such as Aqaba, are eager to see mitigating action taken.

It is evident that PERSGA, working closely with IMO and the GloBallast Programme, is in a strong position to provide solutions to the problem of ballast water control and management in the region. An excellent start has been made through the regional mission and workshop and funding for part of the outreach needed in future can be expected to come from the GEF in 2007. However, PERSGA needs to maintain a momentum, assisting its members and Eritrea to take steps to conduct risk assessments, start monitoring the movement of ballast water on ships into the region, and to move towards ratification of the new convention.

Various methods have and are being explored to deal with the problem of the movement of IAS by ships, all of them in relation to the IAS carried in ballast tanks. Ships may exchange ballast at sea, i.e. pump out the ballast loaded at the start of the voyage and exchange this for water from the deep ocean while they are on passage. This is based on the concept that coastal species are less likely to survive in deep ocean waters, and vice versa³⁵. But there are several practical problems associated with this method relating to the safety of the ship and its crew while at sea³⁶. Another method is to continuously exchange the ballast while

³⁵ Regulation B-4 of the Ballast Water Convention states, in summary, that Ballast Water Exchange should be undertaken in waters 200 nm from land, and at least 200 m in depth, or in waters 50 nm from land and at least 200 m in depth, or in an areas designated by the port state. It should not delay the ship, and should only be carried out when the safety of the ship is guaranteed.

³⁶ In July 2006 a car carrier approaching Vancouver carrying 5,000 cars listed to an angle of 60 degrees. Press reports stated that 'rules designed to protect the marine environment could have caused the car carrier to roll on its side. Ships are required to exchange ballast water before entering some ports to ensure alien species are not released into local waters.' See http://www.cargolaw.com/2006nightmare_cougar-ace.html#the-feature.

on passage by drawing in fresh ballast to the tanks while at the same time discharging the ballast already in them.

In addition, several treatment technologies are being investigated, including heating the water, treating it with chemicals and disinfectants, treating it with ultraviolet light or ultrasound, filtering it, and others. None of these has yet proved to be completely satisfactory. A further option is to discharge ballast into shore tanks on arrival where it can be held before being treated and released into the waters of the loading port. In view of the huge volumes that can be involved, this could require a massive provision of storage capacity. A further suggestion is to ballast tankers with fresh water for their return voyages to countries with little rainfall that could be used for irrigation or other purposes.

An acceptable treatment technology for ballast water may be available by 2009, which is the earliest date by which the Ballast Water Convention, Regulation D-4, states that the use of a technological solution will be required to achieve standards specified in Regulation D-2. At present there is no one technology that solves the problems of the carriage of IAS in ballast water. And no one technology is likely to fit all types of ship, as they vary widely in the amount of ballast carried, its distribution on board and the method of using it while on passage and in port to keep the ship upright and on an even keel, deepen it, or lighten it.

A number of precautions may be taken when loading ballast, such as avoiding loading in 'high risk' areas, loading by day rather than night, and avoiding loading in shallow water and thus lifting bottom sediments. One immediate requirement, as recommended

by the GloBallast Programme and the IMO convention, is for ships carrying ballast water to maintain a 'ballast water record book' similar to the Oil Record Book, so that origins and destinations of ballast water can be tracked, and for ports and terminals to maintain records of ships arriving with ballast water and discharging it nearby³⁷.

4.4.4 Dumping of Hazardous Materials at Sea

Following the tsunami of 26 December 2004, reports of hazardous materials being found on the Indian Ocean coast of Somalia appeared in various places³⁸. Somalia, as a Least Developed Country, has been largely unprotected against illegal dumping of nuclear and toxic materials on its coastline, and probably in the waters of the Indian Ocean close to the coast, over the past 25 years. Reports indicate that radioactive uranium waste, lead, cadmium, industrial, hospital, chemical, leather treatment and other toxic waste materials have been found on the coast. Health problems reported have included mouth bleeding, abdominal haemorrhages, unusual skin chemical reactions and death after inhaling toxic materials. It is likely that the tsunami, the effects of which extended down to the sea bed, caused the movement of some materials on the sea bed that had been in place for many years and brought them to the surface or to the shore.

During the south-west monsoon that blows from late May to early September each year, one of the strongest ocean currents in the world flows northwards along the Indian Ocean coast of Somalia towards the islands of the Socotra Archipelago and the eastern end of the Gulf of Aden, as it is defined by the Jeddah Convention³⁹. Materials dumped

³⁷ Terminals may monitor the discharge of ballast water as a matter of good practice, but in general they are checking that there is no oil being discharged with the ballast that may form a film on the sea surface. They are not, at the present time, normally concerned with the contents of the sea water ballast, such as IAS, which cannot be seen during the process of discharging the water from the ships' tanks to the sea.

³⁸ See, for example, the section on Somalia in the UNDP report on the tsunami at: http://www.unep.org/tsunami/reports/tsunami_report_complete.pdf

³⁹ The north-flowing current and very heavy sea conditions south of the Socotra Archipelago during the south-west monsoon season can prevent small ships sailing south from the Gulf of Aden from reaching ports on the east coast of Africa. One such vessel, the 'Mariam IV', was unable to make headway on her passage from Aden to Kenya and she tried to turn back to shelter in Bosaso. Engine failure in the heavy seas resulted in the ship being carried towards the island of Abd al Kuri, where she foundered on 01 July 2006 with the loss of six of her 19 crew members.

at sea off the Indian Ocean coast of Somalia can therefore be carried northwards into the Gulf of Aden. During the north-east monsoon, from October to April, the currents in the eastern part of the Gulf of Aden flow westwards, which would be likely to carry hazardous materials into the Gulf of Aden. In view of the increasing importance of EEZs to countries such as Somalia and Yemen, prevention of pollution by toxic materials in these zones is particularly important.

Illegal dumping of waste materials at sea is prohibited by the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972, often referred to as the London Dumping Convention⁴⁰. Under the Convention and its protocols, “dumping” has been defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves. Contracting Parties undertake to designate an authority to deal with permits, keep records, and monitor the condition of the sea, while other articles are designed to promote regional co-operation, particularly in the fields of monitoring and scientific research.

The 1996 Protocol to the 1972 Convention represents a major change of approach to the question of how to regulate the use of the sea as a depository for waste materials⁴¹. It is ‘free standing’ and is intended to replace the 1972 Convention. Therefore states do not have to be party to the 1972 Convention in order to be party to the 1996 Protocol. The 1996 Protocol also introduces the ‘precautionary principle’ in relation to dumping at sea. It also emphasises that

Contracting Parties should ensure that the Protocol should not simply result in pollution being transferred from one part of the environment to another. The Protocol, which entered into force on 24 March 2006, is also far more restrictive than the 1972 Convention.

In recent years concern has been expressed at the practice of exporting wastes which cannot be dumped at sea under the 1972 Convention, to non-Contracting Parties, as appears to be the case with Somalia. Article 6 of the 1996 Protocol states that “Contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea.” The Protocol contains provisions to ‘assess and promote compliance...’ by parties. Importantly, Article 26 allows a transitional period for new Contracting Parties to phase in compliance with the convention over a period of five years. Article 26 is supported by extended provisions for technical assistance to be provided for new Contracting Parties.

Within the RSGA, Egypt is a party to the London Dumping Convention 1972 and its 1996 Protocol. Jordan is a party to the 1972 Convention but not the 1996 Protocol, and Saudi Arabia is a party to the 1996 Protocol but not the 1972 Convention. No other states in the region have become parties to the 1972 Convention or its Protocol. In view of the significance of the 1996 Protocol as an instrument to prevent illegal dumping, and the articles promoting regional cooperation that could be effective in helping to prevent pollution of the RSGA by toxic materials, it is important that other states in the region should become parties to this key Convention through the 1996 Protocol⁴².

⁴⁰ For details of the London Dumping Convention see www.imo.org, Conventions.

⁴¹ IMO is responsible for Secretariat duties relating to the 1972 Convention and is the depository for the 1996 Protocol.

⁴² The 1996 Protocol is also being used to combat global warming by allowing the storage of CO₂ in the seabed. Contracting Parties to the London Protocol, at their first meeting held in London from 30 October to 3 November 2006, adopted amendments (to the 1996 Protocol). The amendments regulate the sequestration of CO₂ streams from CO₂ capture processes in sub-seabed geological formations. See IMO Briefing No. 43/2006 dated 08 November 2006.

4.4.5 Ship Routeing Measures

Ship movements in the RSGA result in a mix of through traffic heading roughly north/south in the Red Sea and east/west in the Gulf of Aden, combined with movements between ports in the RSGA that frequently result in traffic needing to cross the main shipping route. The picture is further complicated by traffic that joins and leaves the main shipping route in order to call at ports in the RSGA.

To assist ship masters and navigating officers in the RSGA and to protect sensitive areas, a number of ship routeing measures, including traffic separation schemes (TSS), have been introduced in the RSGA. An early routeing measure was introduced in the Gulf of Suez and, after modifications at various times, this now extends from the entrance to Suez Bay south to the southern end of Shaker Island at the entrance to the Strait of Gubal. The TSS separates north and south bound traffic in the Gulf of Suez by varying distances, generally between 0.5 and 1.5 nautical miles, through the use of a separation zone between the north and south bound lanes. Special provisions are made along the TSS for ships wishing to enter or leave the Ain Sukhna (SUMED) Oil Terminal, or the Ras Shukheir Oil Terminal, where they are required to cross the main flow of traffic. A 'precautionary area' exists on the TSS at Ras Shukheir.

To further assist navigators, a special chart of the Gulf of Suez, Admiralty Chart No. 5501, 'Mariner's Routeing Guide – Gulf of Suez', has been published, showing the routes and providing guidance notes on precautions to be taken when navigating in the Gulf of Suez. This chart shows the locations of oil fields and the exclusion areas around the fields, and areas where no anchoring and/or fishing is permitted. Chart 5501 points out that "The traffic lanes in the Gulf of Suez are narrow and in places the separation zone between them is only 5 cables wide⁴³. Exceptional care is needed, when overtaking, not to enter the separation zone or force the overtaken ship to do so." It also points out that some fixed oil/gas

production platforms are located in the separation zone between the traffic lanes.

At the southern end of the Sinai Peninsula, and on its eastern side, a relatively short traffic separation scheme for the Strait of Tiran was adopted by IMO for use by international shipping.

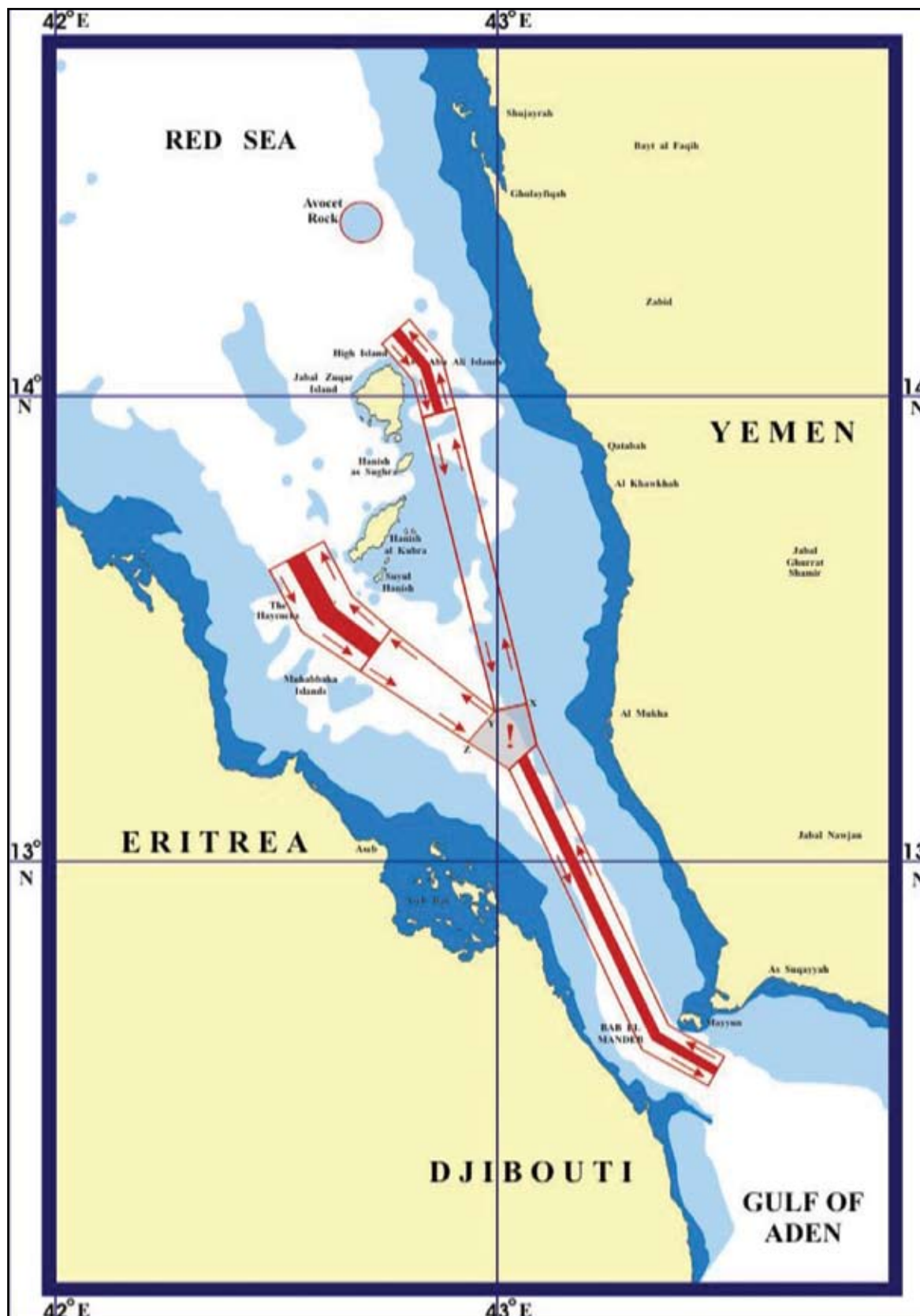
Further south in the Red Sea routeing measures for ships entering and leaving the ports of Yanbu Al Bahr and Al Malik Fahd on the coast of Saudi Arabia have been established. These measures separate ships entering and leaving the deepwater channel between the offshore reef and the coastline.

At the southern end of the Red Sea a TSS was established in 1968 in the Strait of Bab el Mandeb through the channel to the west of Mayyun Island. Following a study of navigation safety in the Red Sea in 1998 carried out on behalf of the World Bank, the Navigation Working Group of PERSGA concluded in 2000 that the Bab el Mandeb routeing measure should be extended northwards to guide traffic passing east and west of the Hanish Islands. After a hydrographic survey covering the area in which the new routeing measures would be placed had been conducted, proposals were submitted to IMO. The proposed new measures consisted of an extended TSS through Bab el Mandeb leading to a precautionary area west of the Yemeni port of Mukha. From there recommended routes led to two further TSS, one between Abu Ali Island and Zuqar Island on the east side of the Hanish Islands, the other on the south-western side of Hanish Al Kubra for traffic passing south and west of the islands. The new routeing measures were adopted by IMO in December 2002 for use by international shipping and entered into force on 1 July 2003.

The southern end of this routeing measure lies partially in the Gulf of Aden and is currently the only ship routeing measure defined for this body of water. It may be argued that, with current traffic levels and patterns, there may be no need for additional routeing measures in the Gulf of Aden.

⁴³ A cable is a tenth of a nautical mile.

Figure 4.11 Routing measures in the southern Red Sea - general layout of measures.



However, this should be kept under review as new ports and terminals are developed and as traffic patterns change.

Except for tankers and other ships calling at terminals in the Gulf of Suez, routing measures in the Red Sea do not cater for crossing traffic. A number of ferries carry passengers between the east and west coasts of the Red Sea, for example between Sudan and Saudi Arabia, Egypt and Saudi Arabia, Egypt and Jordan. Many of these ferries have to cross busy lanes used by ships in transit through the RSGA, often needing to avoid a series of north and south bound ships operating on routes between the Strait of Gubal and Bab el Mandeb. Similar routes crossing the Red Sea are followed by product tankers and container ships operating between Saudi Arabia and Sudan, Yemen and Sudan.

Although the northern and southern ends of the Red Sea are served by traffic separation schemes and schemes exist to guide ships calling at Yanbu and Al Malik Fahd ports, the main deepwater body of the Red Sea does not include any routing measures. Vessels operating between the southern and northern ends of the Red Sea currently follow a relatively wide variety of routes in order to reach their destinations, resulting in an east to west spread of north bound and south bound ships that will meet the ferries, product tankers and container ships crossing from one side to the other. With an estimated total of 25,000 transits by ships in the RSGA each year, a number of commentators have remarked on the particular problems of navigating in the Red Sea.

Captain R. A. Cahill in his authoritative book, 'Collisions and their Causes', makes the following statement (CAHILL 2002, p. 44):

“In heavily trafficked areas such as the Red Sea where most of the traffic encountered seems to fall either under Rule 13 or 14 (overtaking or head on)

stubborn adherence to the red to red meetings, where the green to green option is permissible, can readily create problems where none existed before. Where one is frequently meeting several vessels as well as being overtaken or overtaking several more, one must take advantage of the option, where available, of an alteration to either port or starboard simply from the standpoint of practical seamanship.”

Captain Cahill then discusses the lateral separation between ships passing each other, recommending a separation of one nautical mile and, as a minimum, half a mile. Under the circumstances existing in the main body of the Red Sea, outside the routing measures established in the Gulf of Suez and the southern Red Sea, ships in transit will meet other vessels coming from the opposite direction that may be on their port bow or starboard bow. At present ships are not guided on the 'best' path to follow along this route, so the passage plans of any one ship will differ from the plans of another. The establishment of carefully designed and located routing measures for the main through traffic of the Red Sea could have the effect of separating the north bound and south bound streams by around five nautical miles. This could bring a level of control to the ships in transit by ensuring that, for the vast majority of cases, they do not need to alter course for a vessel 'head on' to them, allow them to focus their attention on vessels overtaking them, being overtaken, or crossing. It would also make the task of the navigators crossing the Red Sea, who have to decide on collision avoidance measures to be taken by themselves and/or by the through traffic that they encounter, considerably easier⁴⁴.

The pressure to introduce such measures is emphasised by a number of factors, some of which have become more significant in recent years. These include the poor

⁴⁴ The situation in the RSGA is similar in some ways to that in the English Channel. Traffic separation schemes for ships operating in the central and western parts of the English Channel were adopted by IMO some years ago to improve navigation safety for through traffic, and for the crossing traffic operating between the United Kingdom and France or Spain.

visibility that is often experienced in the Red Sea, the increasing size of ships operating on the route, the higher speeds of the growing numbers of container ships operating on this route and the increasing volumes of traffic calling at RSGA ports. The volume of traffic calling at Jeddah, for example, has increased rapidly in recent years, rising from 4,654 ships in 2004 to reach 4,874 ships in 2005, a rise of 4.7%. The port recently announced that a third container terminal will be built to cater for increasing traffic volumes, adding to the two already in operation, which indicates that future throughput at the port is likely to grow significantly⁴⁵. As indicated by the Suez Canal Authority's statistics, a growing proportion of the ships operating in the Red Sea are container ships. Large modern container ships operate at speeds of 20–26 knots in open waters, and the majority of these ships will pass through the Suez Canal and Strait of Bab el Mandeb, where they will encounter tankers and other ships entering and leaving the RSGA.

If and when implemented, new routing measures will be designed to separate the north bound and south bound streams of traffic operating between the southern end of the Gulf of Suez and the Hanish Islands by around five nautical miles. PERSGA could also consider recommending that south bound traffic should pass west of the Hanish Islands and north bound traffic east of these islands, creating a large 'roundabout' in the southern Red Sea. This would virtually eliminate the current crossing situations that sometimes occur in the precautionary area west of Mukha when a north bound ship decides to turn to port to pass west of the islands, and by doing so may need to cross the course of a south bound ship passing east of the islands.

The danger of high speed container ships under instruction from their owners to maintain tight schedules and operating at speeds which may be considered too high in areas of restricted manoeuvrability or visibility (as are found in various parts of the

waters of the RSGA) has been highlighted in the 2005 annual report of the United Kingdom's Marine Accident Investigation Branch (MAIB). The MAIB report records significant increases in both collisions and groundings from the incidents that it investigated during 2005 compared with 2004⁴⁶.

Other ship routing measures can also assist in reducing pollution of the marine environment. These include 'Areas to be Avoided', which are designated areas that are not to be entered by certain ships. For example, UK Admiralty Chart No. 2375, 'Ashrafi to Safaga and Strait of Tiran', carries a note stating:

"Areas to be Avoided: In order to protect the environment, Areas to be Avoided have been established in the areas indicated. All vessels carrying dangerous or toxic chemical cargoes, or any other vessels exceeding 500 GRT, should avoid entering these restricted areas. The Areas to be Avoided centred on 27° 43' N, 34° 12' E and 27° 33' N, 34° 21' E have been adopted by the IMO."

'Areas to be Avoided' may be adopted by IMO for use by international shipping and form part of the routing measures shown on navigation charts. For example, the area south of Ras Mohamed referred to in the note above and shown on Admiralty Chart No. 2375 and other charts of the area, thus excludes certain categories of ships from entering this environmentally sensitive area.

4.5 PORT AND TERMINAL DEVELOPMENT

Port development in the Red Sea and Gulf of Aden will inevitably be associated with impacts on the environment, which can be considerable. While there has sometimes been some concern over the environmental impact of port development in earlier times, it

⁴⁵ See www.ports.gov.sa, Port Statistics, Jeddah Islamic Port.

⁴⁶ See MAIB Annual Report 2005, www.maib.gov.uk/cms_resources/Annual%20Report%202005.pdf

is only in recent years that an environmental impact assessment has been required where a port is being established or extended, or where significant changes are being made to the port such as dredging in its approach channel. The construction work involved in building or extending the port will often result in dredging, reclamation, deposition of materials, damage to coral reefs etc.. The environment will also be affected by the industry that grows up in association with the port, such as ship repair and bunkering facilities, oil refineries, grain and cement silos, flour mills, steel plants, bagging plants and factories with their problems of dust, noise and often vermin, and by the effluent generated by the population of the port city. A further impact comes from the construction of roads to provide access for the cargo handled at the port, with their associated truck and other traffic, or from the construction of pipelines carrying crude oil or products to the loading or discharging point.

The section that follows briefly describes the more important ports and terminals in the region, clearly dominated at present by port activities in Saudi Arabia. Other minor ports, such as fisheries harbours, are not covered in this report. Port development in the region, particularly over the past 30 years, has been dynamic. Many new ports and terminals have been developed in the region to handle new business, while other established ports have been expanded, in some cases massively, to handle the growth in trade and hence cargo volumes. Ports are covered by country, working from north to south through the Red Sea and west to east in the Gulf of Aden.

4.5.1 Egypt

The port of Suez, located in Suez Bay, handles 1.5 million tonnes of cargo and 1.5 million passengers a year. It has 2,300 m of relatively shallow water quays (5–8.8 m), ship repair facilities, including a large floating dock of length 177 m, capacity 30,000 tonnes, a dry dock of length 148 m, two slipways and a ship lift.

Adabiya, also in Suez Bay, handles 6 million tonnes of cargo a year, general cargo, containers for manufactured goods etc., bulk wheat imports, and vegetable oil exports. There are seven berths with depths alongside up to 13.0 m.

Ain Sukhna, in the Gulf of Suez 36 km south of the entrance to the Suez Canal, is a new port that was constructed by excavating a basin in the coast so that the quay walls could be built 'in the dry', with the sea being allowed to flood the basin after construction was completed. It has been designed to be expanded when traffic levels warrant this. Ain Sukhna currently handles 3.5 million tonnes of cargo a year, bulk, agro bulk and 250,000 TEU of containers⁴⁷ using two quayside container gantry cranes, plus livestock. Four berths are in operation so far on two quays, each 750 m in length and with a depth of 17 m alongside.

Ain Sukhna Oil Terminal lies south of the dry cargo port. This handles tankers calling to discharge oil for transport by pipeline from Ain Sukha to Sidi Kerir on the Mediterranean coast of Egypt. It has four single point mooring (SPM) buoys connected by pipelines to the shore. The deepest of these SPMs (No. 4) is 5 km offshore and has a depth of 41 m. It can handle tankers of up to 500,000 TDW (tons dead weight) and can move 120 million tonnes of oil/year from the Red Sea coast to the Mediterranean coast and is Egypt's most important Red Sea oil terminal.

There are a further seven important oil and liquefied petroleum gas (LPG) loading terminals on the Red Sea coast of Egypt handling oil and LPG produced by platforms in the Gulf of Suez, or ashore.

Hurghada, in the Red Sea proper, is a tourist port and also handles ferries operating to Sharm El-Sheikh and to Dibba in Saudi Arabia. A 150 m long jetty is used by these ferries. Hurghada also handles large numbers of dive boats carrying tourists visiting the offshore reefs and reefs and wrecks around Shaker Island.

⁴⁷ Container capacity or throughput is almost always stated in *twenty-foot equivalent units* (TEU). FEU, forty-foot equivalent units, is the abbreviation for the other main size of containers, 40 feet in length.



Plate 4.1 Hurghada 2006 (Photo: R. A. Facey).

Hurghada is also the location of the PERSGA operated Marine Emergency Mutual Aid Centre (MEMAC) for the RSGA.

Safaga is the main Egyptian port at the northern end of the Red Sea proper. Archaeological evidence indicates that it has been in operation as a port for over 4,000 years, providing services to ships trading within the RSGA. It handles exports of phosphate ore, imports wheat, alumina and cement. It provides a base for tourist traffic and commercial ferries operating to Saudi Arabia (Dibba, Jeddah). Berths consist of the Commercial Wharf, 750 m in length, No. 1 berth, with a depth alongside of 14.0 m, able to handle ships up to 290 m in length, draught 12.8 m, No 2 berth, with an alongside depth of 10.0 m, and No. 3 berth with an alongside depth of 10.5 m. The Phosphate berth consists of a pier where ships can moor stern-to. There is an oil berth and a ship lift at Safaga, both operated by the Egyptian Navy, and a lighter wharf.

El Quseir is a phosphate loading port in the Red Sea with a single berth, maximum depth at the berth 8.8 m. Marsa Mubarak (also known as Port Ghabil, in the Red Sea) is a minor port used by yachts northbound to the Gulf of Suez and Suez Canal, providing new marina facilities. Yachts call to obtain visas and cruising certificates for Egyptian waters.

Sharm El-Sheikh is a tourist port on the Sinai Peninsula used by large passenger cruise liners and ferries operating from the western Red Sea coast of Egypt. It has a quay over 440 m in length with an alongside depth of 8.0 m. Ships of up to 30,000 GRT (Gross Registered Tonnage), draught 9.0 m and length 250 m can call at Sharm El-Sheikh and may anchor off if their draught is too great for the berth.

Nuweiba El Muzina, in the Gulf of Aqaba has a quay with three berths, maximum depth alongside 8.0 m. The main business comes from RoRo traffic carrying loaded trailers of general cargo and other goods between Egypt and Aqaba, Jordan.

4.5.2 Jordan

The Port of Aqaba in the Gulf of Aqaba is Jordan's only port. It is a multi-purpose port operated by the Aqaba Ports Corporation and provides bulk loading berths, a RoRo berth, berths for handling general cargo, containers, passengers, oil tankers and industry. It is situated within the Aqaba Special Economic Zone. Two of the main exports from Jordan are phosphate and potash, both of which are stored at the port and can adversely affect the marine environment during loading operations. Aqaba operates silos for grain, cement and rice. The Hamza Pollution Combating

Centre, located within the port, has been provided with craft and significant stocks of equipment to assist it in combating pollution incidents up to Tier 1 level. At the Al Mushraraq Tanker Terminal in Aqaba there is an additional limited stock of equipment.

4.5.3 Saudi Arabia

Dibba, the northernmost port on the Red Sea coast of Saudi Arabia, is a relatively new port located 28 km north-west of the town of Dibba. It handles ferries carrying passengers between Egypt, Jordan and Saudi Arabia, as well as cargo. Cement is exported from Dibba, and livestock, foodstuffs and general cargo are the main imports. The main berths in the port lie on a quay 600 m long, providing three berths at a depth of 10.5 m. A passenger terminal is situated on the quay. There is a RoRo berth at the south end of the main quay, a service quay for service vessels, a fishing vessel quay and a quay for use by the coastguard. About 4.5 km east-south-east of the town of Dibba is a tanker terminal handling bulk oil, where storage tanks are connected to a jetty that extends across the reef to a berth consisting of mooring buoys and two concrete piles for ships to secure to.

Yanbu Al Bahr is the second largest general cargo port on the Red Sea coast of Saudi Arabia. It is the closest port on the west coast of Saudi Arabia to the holy city of Medina, and serves this city. Its main imports are grain and cement. It is around 22 km north-west of King Fahd Industrial Port. The deepest berths, 5 to 9, have a depth of 12.0 m alongside, while berths 1 to 9 have a total length of 1,900 m. Berths 5-9 include facilities for RoRo vessels.

King Fahd Port is a major crude and refined oil, LPG, bulk and general cargo port. It is linked by a 1,200 km long pipeline to oil production fields carrying crude oil from the eastern province of Saudi Arabia to the west coast. The port serves an oil refinery, a natural gas fractioning plant, a petrochemical complex, an industrial facility and many manufacturing plants and light industries. It can handle oil tankers of up to 500,000 DWT, with a limiting draft of

29.6 m. The port has facilities for receiving oily waste. Its facilities are located on the eastern side of a deep channel inside the offshore reef, which provides protection for the port. They include a general cargo and container terminal consisting of seven berths with an alongside depth of 14.0 m, a service harbour for small boats with a depth alongside of 8.0 m and a bulk terminal with two alongside berths, able to handle bulk carriers of up to 60,000 TDW and to a maximum draught of 13.9 m. The Export Refinery Terminal has nine alongside berths able to accommodate ships of between 5,000 to 150,000 TDW, with a maximum draught of 16.65 m. Two of these berths are for chemical tankers. One is a short-haul berth for ships of between 5,000 and 35,000 TDW, maximum draft 12.2 m. The crude oil terminal consists of four jetty berths that can handle ships of up to 500,000 TDW at a maximum draught of 28.95 m. The NGL Terminal is for the export of refrigerated LPG. It consists of two berths which can accommodate ships of up to 16.2 m draught. The Yanbu Refinery Terminal consists of four berths. Two of these can handle ships of up to 20,000 TDW and two ships of up to 80,000 TDW. South-east of the Refinery Terminal there is a Construction Support Terminal, which is reported to be no longer in use, but could be re-activated. About 13 km south-east of the Construction Support Terminal is the Ras Al Maajiz Terminal, providing three tanker berths for ships of up to 500,000 TDW of maximum length 471 m, draft 29.6 m. This Terminal has no facilities for the disposal of oily wastes.

Rabigh is located in an inlet 140 km north of Jeddah and 160 km from Medina. The inlet was dredged to allow construction of the Rabigh Industrial Port which handles crude oil and oil products from a large refinery immediately south of the harbour. The port is operated by the Petromin Petrola Rabigh Refinery Company. Depths in the turning basin on the north-west side of the port are 26 m. Liquid cargo berths 2 and 3 have alongside depths of 26 m and can handle ships with a maximum length of 400 m and of up to 325,000 TDW at a maximum draught of 23.5 m. Two new berths have been built



Plate 4.2 Jeddah 2005 (Photo: R. A. Facey).

for ships of up to 80,000 TDW. Rabigh has reception facilities for oily waste. A berth serving the power station can take ships of up to 100,000 TDW. Dry cargo berths for general and RoRo traffic are available at Rabigh, with depths alongside from 6 to 14 m. Other dry cargo berths with depths alongside of 10 to 13 m have been built in a separate basin.

The future role of Rabigh could be far more significant to the country, as in December 2005 the Government of Saudi Arabia announced plans to construct a Mega Economic City at Rabigh, with a projected investment of \$27 billion. The development, that was started immediately, will eventually cover 5,500 ha of land, spread along 35 km of coastline. It is planned that this will become the centre of the largest integrated refining and petrochemical complex in Saudi Arabia, with an investment of \$9.8 billion⁴⁸. It will provide a new port covering 260 ha, an industrial area, education zone, finance zone, tourist resort and residential areas. The port is expected to handle 500,000 pilgrims per year, arriving and departing by sea. Road, rail and air links are to be provided within the Kingdom and beyond.

Jeddah is the main Red Sea port of Saudi Arabia. Its importance is related to its proximity to Mecca, 70 km to the east. It is a major commercial centre and handles a wide variety of shipping from bulk carriers, container ships, livestock carriers, ferries carrying pilgrims and other passengers, RoRo vessels, car carriers, tankers and naval ships. Jeddah is now handling around 5,000 ships per year. It is also an important port for pollution combating, with a number of pollution control vessels stationed at the port, one of which is a dedicated ship and others have pollution combating equipment fitted on board. Reception facilities are available at the ship repair yard. The limiting depth in the port approach channel is 16 m, allowing ships of up to 14.5 m draught to enter the port. Depths alongside are generally up to 15.5 m at the larger berths. The North Basin contains bulk cargo handling berths on a quay 700 m long, the North Container Terminal, 1000 m in length, RoRo berths and a pilgrim/passenger terminal. There are also berths for smaller ships. The South East Basin is dredged to 12 m, with alongside depths between 11 and 12 m. It handles general cargo and has two container berths. The South West Basin contains the South Container Terminal, with depths from 14 to

⁴⁸ See, for example, an article describing some of the development of Rabigh at www.ain-al-yaqeen.com/issues/20060324/feat2en.htm

15.5 m alongside, and a livestock terminal. Plans for a third container terminal for Jeddah were announced in July 2006. South of the main port are the Chyoda Island Oil Terminal, which is a stern-to buoy berth, for loading crude oil and bunkers, and the JRD Tanker Terminals, where tankers moor to dolphins. This is able to handle crude oil tankers of up to 100,000 TDW and draught 12.8 m. JRD Inner Harbour contains eight berths for vessels between 6,000 and 49,000 TDW, depths from 10 to 14 m, that berth stern-to with anchors out forward. The Royal Saudi Arabian Navy has facilities south of the main port and an ammunition pier is operated close to these facilities. A ship repair yard at Jeddah is situated on the seaward side of the North Terminal. It operates two floating docks with lifting capacities 19,000 and 11,000 tonnes respectively.

Gizan, the southernmost Red Sea port of Saudi Arabia, is used for the import of general cargo, bulk grain and livestock, and for the export of oil. There are 13 main berths with depths alongside from 10.7 to 8 m. A service quay has an alongside depth of 8 m. There is also a coastguard harbour. The Oil Terminal has two SPM buoys south of the main harbour area, suitable for use by ships of between 10,000 and 49,000 TDW, maximum length 220 m and maximum

draught 16.3 m. A small jetty for tankers of up to 5,000 TDW, maximum draught 5.5 m, lies between the main port and the oil terminal.

4.5.4 Sudan

Port Sudan is the main port for Sudan and has 14 berths for general and other cargoes, plus two berths for containers on 420 m of quay. New berths are due to be built on the south side of the entrance channel to handle larger container ships in the near future. Since 2004, four large berths (970 m of quay) have been built into the coral reef on the seaward side of the main port to handle bulk carriers and general cargo. This area, known as the Green Port, uses the remaining strip of reef to protect the new berths from waves.

El Khair Oil Terminal, close to the south of Port Sudan, has one berth for oil tankers, and handles a range of import and export products. It handled 50 tankers and 400,000 tonnes of oil in 2004. El Khair has also been built into the coral reef and uses the remaining strip of reef on the seaward side to provide berth protection.

The Bashayer Crude Oil Export Terminal handled 12 million tonnes of oil exports in 2004 at a SPM buoy. Bashayer Terminal



Plate 4.3 Port Sudan 2005 (Photo: R. A. Facey).



Plate 4.4 Massawa 2002 (Photo: R. A. Facey).

No. 2 is currently under construction and is expected to provide a similar capacity for oil exports from the south of the country.

Suakin, or Osman Digna Port, has a quay for passenger ferries and car carriers at which ships normally moor stern-to. Jetties for liquefied natural gas, livestock and other products have recently been constructed and further port expansion is expected. The port is due to be dredged to widen the channel and turning area.

4.5.5 Eritrea

Massawa has six berths for containers, general cargo, bulk and RoRo cargo. Berths 5 and 6 have a depth of 12.0 m alongside and are mainly used for handling containers. There is a dedicated cement discharging berth and cement handling plant. Massawa has old and limited ship repair facilities. There are no facilities for tank washing.

Assab has seven alongside berths with depths of up to 11.0 m and a RoRo berth, protected by a 700 m long detached breakwater. It also has a four buoy oil berth connected to shore tanks by pipeline, a berth for coastal tankers, an oil products jetty and a (now disused) salt loading berth with overhead ropeway. There are no facilities for ship

repair or tank washing. Cargo throughput at Assab has been almost zero since the border with Ethiopia was closed in the late 1990s.

4.5.6 Yemen

Salif is a relatively new port located 60 km to the north of Yemen's main Red Sea port of Hudaydah (Hodeidah) and is administered by the Port and Marine Affairs Corporation in Hudaydah. It is becoming an increasingly important centre in the north of the country for bulk imports and exports of 'value added' goods. Salif handles mainly bulk imports of wheat, some general cargo imports, and exports of bagged flour and rock salt. Bulk wheat can be unloaded at rates of up to 22,000 tonnes/day (TPD), with an average rate of around 18,000 TPD. The main quay is 450 m long with an alongside depth of 13.0 m, and can berth ships of up to 50,000 TDW. A cement berth is located at the eastern end of the main quay, able to handle ships of up to 30,000 TDW. There is also an offshore berth, south of the main town, with an alongside depth of 13.0 m, and a RoRo quay for smaller ships inshore of this berth.

The Ras Issa Marine Terminal handles crude oil exports. It consists of a floating storage and offloading vessel (FSO) called the



Plate 4.5 Massawa–Assab coast road 2002 (Photo: R. A. Facey).

SAFER, with a capacity of 400,000 TDW. This is used to collect oil from the Marib fields east of the Yemeni capital, Sana'a. SAFER is moored in a water depth of over 30 m to a fixed turret mooring buoy at the southwest end of a submarine oil pipeline extending around 8 km from the shore. A single point mooring buoy carrying a light is situated 2.7 km north-north-east of the SAFER. Ships of up to 307,000 TDW can be moored alongside SAFER and ships of up to 285,000 TDW can moor astern of SAFER. Minimum vessel size is 80,000 TDW. There are no facilities for the reception of dirty ballast at Ras Issa.

Hudaydah is Yemen's main Red Sea port and is the closest port in terms of distance from the capital Sana'a. It handles bulk wheat, flour, rice, sugar, cement, steel, timber imports, containers, oil imports (power station fuel, motor fuels etc.), bran exports, general cargo imports and exports, and exports of hides, skins, fish, shrimp and lobster. It has an entrance channel 20 km long from the pilot station to the berths, dredged to a depth of 10.0 m. The main berths in the port lie on two quays at right angles to each other. Berths 1-5 lie on a quay 670 m long at depths from 7.0 to 9.75 m. Berths 6 and 7 are mainly for containers but also handle bulk carriers. They offer a

depth alongside of 10.5 m for ships of up to 10.0 m draught. Berth 8, at right angles to Berth 7 currently has a depth alongside of 6.4 m and is due to be developed. Maximum size of ship that can enter the channel and berth at Hudaydah is around 25,000 TDW. There is also a tanker berth in the harbour connected to shore storage tanks by pipeline handling oil imports. Ships of up to 15,000 TDW moor here using buoys in a water depth of 9.75 m. There are no facilities for the reception of dirty ballast at Hudaydah, but limited quantities of oily bilge water and dry oily waste can be disposed of here. There is a slipway with a capacity of 500 tonnes and the port operates a floating crane with a lifting capacity of 75 tonnes. On the west side of the entrance channel is Khawr Khatib where pontoon berths with a depth of 6.7 m are used by navy ships.

The ancient port of Mukha, 170 km south of Hudaydah and 75 km north of Bab el Mandeb, became famous for handling Yemen's coffee exports. These were shipped to Suez and onwards to Europe, and also, in the 17th to 19th centuries, southwards around the Cape of Good Hope to the Americas and Europe. Mukha is administered by the Port and Marine Affairs Corporation, Hudaydah. Mukha now handles general cargo, oil imports (mainly for a large power

station 6 km north of the port), livestock imports and some exports of foodstuffs. It has good road connections to Hudaydah, Taiz (some 100 km inland), and to Aden via the new road south to Bab el Mandeb and then east along the coast. The berths at Mukha were largely rebuilt in the late 1980s and now consist of a jetty 150 m in length, depth alongside 8.5 m able to berth ships of up to 15,000 TDW. Tankers of up to 12,000 TDW carrying oil products (imports) can berth on the eastern side of the breakwater and discharge to pipelines connected along the breakwater to shore tanks. Smaller ships can berth at the southern end of the jetty and RoRo ships at the head of the jetty.

The Port of Aden, lying 180 km east of Bab el Mandeb, lies in a very large sheltered bay protected on three sides by high hills and/or land. The area of the harbour between the two main headlands is around 60 km². It has a large and expanding hinterland, benefiting from the improving road network in Yemen. This extends well north of Taiz to the capital Sana'a, and eastwards along the coast to the Hadhramaut region. Aden's strategic location, requiring a deviation of only four miles from the main east-west sea route to reach the pilot station, was historically highly significant and remains so in modern times. The port handled 1,730 ships in 2005.

Aden's oil harbour is a separate port inside the bay operated by the Aden Refinery Company, while Yemen Ports Authority provides pilots and some marine services. It handles imports of crude oil, around 4.5 million tonnes/year, and exports (by sea) of refined products, at around 4 million tonnes/year. The oil harbour has four oil berths, maximum depth alongside 15.8 m, two alongside berths, depth 11.0 m alongside, and a RoRo berth, depth 11.0 m. Dirty ballast and slops can be received at the oil harbour reception facilities which have a capacity of 4,000 tonnes.

The main harbour or inner harbour handles a similar range of items to the port at Hudaydah, bulk wheat, flour, rice, sugar, cement, steel, timber imports, containers, oil imports (power station fuel, motor fuels etc.), livestock imports, bran exports, general cargo imports and exports, and exports of hides, skins, fish, and lobster. The port also handles passenger cruise ships and yachts. It has an entrance channel 7 km long from the pilot station to the inner harbour breakwater, currently dredged to a depth of 15.0 m and due to be deepened. This leads to a turning area inside the harbour 700 m in diameter. The inner harbour encloses two main cargo terminals, plus a ship repair yard with a floating dock and a commercial fishing harbour. This harbour also provides



Plate 4.6 Passenger ship in the Port of Aden, December 2005 (Photo: R. A. Facey).

dolphin and buoy berths for oil bunkering, passenger ships, dry cargo loading and discharge and longer-term stays in port. The inner harbour can accept oily waste, dry and liquid, and, subject to certain conditions, can dispose of liquid oily waste via the reception facilities at the refinery. The fishing harbour handles commercial trawlers and other fishing boats.

The Aden Container Terminal (ACT) handles containers on a quay of depth 16.0 m alongside, length 700 m. The ACT can handle ships of up to 120,000 GRT, 330 m in length with a draught of 14.8 m. The Ma'alla Container and Multipurpose Terminal is 750 m in length providing four main berths with an alongside depth of 11.0 m. Two berths are equipped with container gantry cranes and handle container and other ships, the other two berths handle bulk, general, livestock and other cargoes. There is a RoRo berth at right angles to the main berths, 150 m long and 7.62 m deep. At the eastern end of the main berths are two smaller Home Trade berths, total length 250 m and alongside depth 6.7 m.

Rudum is minor oil terminal with a mooring buoy, 350 km east of Aden that handles occasional export consignments of oil brought to the coast by pipeline. At Belhaf, 30 km east of Rudum, construction of a new LPG export terminal for Yemeni Gas commenced in 2005. On completion in early 2008 this will become an important LPG export terminal for the country.

Mukalla, 500 km east of Aden, is administered by Yemen Ports Authority, Aden. A port has existed at Mukalla for very many years to serve the Hadhramaut area of eastern Yemen. It was moved 2 km east of the town to Khalf Harbour in the mid-1980s, where two main berths inside a breakwater have been built. It handles bulk wheat and bulk cement, general and containerized cargo imports, oilfield equipment, drums of oil and fish exports. Mukalla is now the chief port for Yemen's oil industry and handles most of its oilfield supplies. Depth

alongside each berth is 9.2 m. A fisheries quay 162 m long, depth alongside 5.0 m, is also situated in the harbour. Berth 1 can also handle product tankers and is connected to oil storage tanks by pipeline. There are no facilities for the reception of dirty ballast at Mukalla.

Ash Shihr Terminal, operated by the NEXEN Petroleum Company, is 46 km east of Mukalla and is Yemen's principal oil exporting facility, handling around 20 million tonnes of oil exports from the Masila and other onshore fields annually. It consists of a small service harbour for tugs, supply boats, pilot boats, security craft etc., and two SPM buoys 3 km south of this harbour. Water depth at the buoys is 36 m and each buoy is connected by pipeline to the shore. Three light buoys mark the 27 m depth contour on the landward side of the SPMs. Ash Shihr can handle tankers of up to 400,000 TDW, with a loading restriction of 265,000 tonnes of oil. There are no facilities for the reception of dirty ballast. Ash Shihr Terminal has membership of the ORSL/EARL organization and can call on its resources if and when an oil spill needs to be cleaned up. It also operates light aircraft that can be used to detect the extent of any spill that might occur at the terminal.

4.5.7 Somalia

Berbera Port is administered by the Somaliland Port Authority and has a main quay of length 650 m with a depth alongside of 12.0 m. The Oil Terminal berth is 180 m in length, with a depth of 14.0 m. The port operates a workshop for minor repairs. There are no facilities for tank washing or for the reception of oily waste.

At Bosaso the main berth, 153 m long and 6.5 m deep, is on the south side of the mole⁴⁹ that protects the harbour. The port also provides a RoRo berth with the same depth, and three small berths for coastal vessels and dhows with an alongside depth of 3.5 m.

⁴⁹ A mole is a large solid pier extending from the shore.

MARINE POLLUTION FROM LAND-BASED SOURCES AND ACTIVITIES

Dr William Gladstone

5.1 SUMMARY

5.1.1 Status

Despite the semi-enclosed nature of the Red Sea and Gulf of Aden and intensive coastal developments in some nations there is no evidence of region-wide alteration of the marine environment from land-based sources or activities.

The most pressing issue is the poor management of wastewater (sewage, industrial wastewater) causing localised increases in nutrients.

The disposal of solid waste causes localised problems for coastal habitats in all countries.

Contaminated runoff arising from pesticide use is a potential problem in some of the countries that requires investigating.

There is no evidence for generalised elevations of trace metals in sea water, sediments, or biota but elevated levels may be an issue in some localised areas.

Preliminary monitoring results indicate elevated levels of some water column nutrients. However, a longer time series is required to fully discern trends and to establish acceptable limits in each country.

Understanding and responding to ecosystem degradation must be based upon monitoring that integrates both chemical (e.g. dissolved nutrients) and biological variables (e.g. sea urchins, herbivorous fishes).

5.1.2 Progress

Recent changes in management practices have led to some environmental improvements, especially on the coral reef adjacent to the Phosphate Port, Aqaba.

The signing of PERSGA's 'Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden' and the implementation of the Regional Environmental Monitoring Programme are substantial outcomes.

Capacity building has been achieved (via training workshops) in integrated coastal zone management, environmental impacts of development projects, management of solid wastes in industrial areas, environmental inspection, and improvement of wastewater management.

A national programme of action for the protection of the marine environment from land-based activities was prepared for Yemen and is being prepared for Egypt.

A preparatory and fund raising phase of the Regional Programme of Action for the Protection of the Marine Environment from Land-Based Activities is being prepared for the Red Sea and Gulf of Aden comprising the following:

- Collection of relevant information for the development of four projects in the following fields:
 - collection, treatment and disposal of municipal wastewater,
 - identification of pollution hot spots and sensitive areas,
 - management of marine litter, and an
 - assessment of the quality of bathing waters and beaches;
- Production of the joint PERSGA/ UNEP publication 'Financing for the Environmental Conservation of the Red Sea and Gulf Aden' and
- Organization of a regional training course on municipal wastewater treatment management.

There has been a rapid uptake of GIS (including a regional GIS database in PERSGA) as technology to support risk assessments for pollution.

5.1.3 Constraints to Continued Progress

Waste water treatment facilities are lacking, operating above capacity, or relying on outdated technology.

The problems of infrastructure are compounded by lack of enforcement of laws.

There is limited understanding of the environmental effects of solid waste disposal and litter.

Implementation of the Regional Environmental Monitoring Programme in Djibouti, Sudan and Yemen will require continued support and capacity building owing to limitations in scientific infrastructure and trained personnel.

5.2 INTRODUCTION

The semi-enclosed nature of the Red Sea considerably reduces the potential for pollutant dispersion. Much of the input of contaminants occurs to geographically localised areas around urban and industrial developments (PERSGA/GEF 2001). The impacts to the marine environment from land-based sources of pollution and activities have been recognised for many years (LOYA 1975; FREEMANTLE et al. 1978; WALKER & ORMOND 1982). Threats from land-based sources and activities have risen rapidly in recent decades in conjunction with increasing urbanization and coastal developments (see Box 5.1).

PERSGA's 'Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden' uses the following definitions:

- Land-based activities means any human land activity which results, directly or indirectly, in pollution of the marine environment and exposes live or non-live natural resources to

destruction or threat

- Land-based sources means mobile or stationary land-based municipal, industrial or agricultural sources whose solid, fluid or gaseous discharges or emissions reach the marine environment.

Necessary background information about the chemical oceanography of the RSGA is provided in chapter 2. This discussion on the impacts of land-based activities and sources should be read in conjunction with the information provided in that chapter.

Nutrients (nitrate, phosphate, ammonium, silicate) are required for the growth and productivity of phytoplankton, and are therefore important contributors to total productivity. Phosphate is regarded as a limiting nutrient in many marine ecosystems and increases in phosphate, in these ecosystems, will lead to increased growth and replication of phytoplankton (RASHEED et al. 2005). Nitrate and phosphate are also known to increase the rate of growth of macroalgae under some circumstances. Excessive nutrients, alone or in combination with other factors, can be deleterious to shallow coastal ecosystems leading to accumulation of epiphytic algae on seagrass (LAPOINTE et al. 2004), and negative impacts on survival, growth and reproduction of corals (LAPOINTE 1997; KOOP et al. 2001; EREZ et al. 2003).

Current issues of great concern throughout the RSGA are nutrient inputs from agriculture and sewage; pollution from coastal industry and ports; and the physical impacts arising from coastal construction and land reclamation. Issues of localised concern in particular countries include pesticide inputs from pest control programmes and agriculture; and inputs of chemicals from industry and shipping (PERSGA 2005).

UNEP (2006), in its global review of the status and prospects for regional waters, judged the overall environmental impacts from pollution in the Red Sea to be "moderate". Of the 34 large marine ecosystems evaluated, 4 were experiencing

Box 5.1 Desalination in the Red Sea

The construction of seawater desalination facilities has occurred alongside the development of major coastal urban centres in the RSGA. The availability of potable water from desalination plants has supported the establishment and continued growth of these coastal urban centres. However, desalination plants are associated with a range of environmental impacts on the marine environment arising from the discharge of heated, concentrated brine and associated chemicals. The chemical load arises from chemicals added to intake water to improve the performance of desalination plants and to prevent corrosion.

Twenty-one desalination plants are located in the central-northern Red Sea. Total desalination capacity is 1,579,664 m³ per day and 96% of this capacity occurs along the coast of Saudi Arabia. The capacity of the Gulf of Aqaba is 30,171 m³ per day and the capacity of the Gulf of Suez is 4,225 m³ per day.

Salinity levels in the Red Sea are naturally very high due to the arid climate, high evaporation rate, low rainfall, and lack of fluvial discharges to the sea (see chapter 2). Brine discharges from desalination plants are therefore likely to have a negligible impact on the overall distribution of salinity in the Red Sea. However, local effects may occur when brine is discharged into areas with restricted circulation.

Chlorine concentrations in discharges from desalination plants are, on average, 0.25 ppm. There is likely to be a total daily discharge into the central-northern Red Sea of 2,708 kg of chlorine. The bulk of this discharge will be to the marine environment of Saudi Arabia. Chlorine is a biocide and also reacts with organic compounds in seawater to produce chlorinated and halogenated by-products. Many of these compounds are carcinogenic and harmful in other ways to marine life.

Total copper discharged daily into the central-northern Red Sea amounts to 36 kg. Copper is a micro-nutrient for most organisms but is toxic at high concentrations. Copper will be dispersed by water circulation following discharge. Some copper will also be transported into sediment where it can be later remobilised following a change in environmental conditions. The discharge concentration of copper from the desalination plant in Al Jubail, Saudi Arabia (15 ppb) exceeds the short-term and long-term water quality criteria of 4.8 ppb and 3.1 ppb respectively of the United States Environmental Protection Agency.

Antiscalants are added to feed water (at 2 ppm) to prevent corrosion. They are relatively stable and are therefore likely to enter the marine environment in outlet discharges at the same concentration. The total daily load of antiscalants to the central-northern Red Sea is likely to be 9,478 kg. Antiscalants in the marine environment have a relatively low toxicity and are diluted rapidly, and they are therefore unlikely to pose a significant threat. However, the limited information on their behaviour in water bodies such as the Red Sea warrants further investigation.

The effects of chlorine and copper are most likely to be apparent close to the outlets because of reductions caused by dilution, decomposition of chlorine, and copper transport into sediment. Therefore the total daily discharges of chlorine and copper will not produce measurable effects in the Red Sea, but may cause local impacts.

At present, it appears that there are no conflicts between the desalination industry and the environmental values of the Red Sea.

Sources: UNEP/PERSGA (1997); HOEPNER & LATTEMANN (2002)

severe impacts, 20 were experiencing moderate impacts, 9 were experiencing slight impacts and only 1 was experiencing no impact.

Hydrocarbon pollution originates from eight refineries around the shores of the RSGA, and from poorly regulated discharge of oil-contaminated water at ports and harbours. Localised increases in nutrients (principally nitrogen and phosphorus) are a primary area of concern for all RSGA nations. Their sources include fertiliser factories, agricultural run-off, and sewage discharges. The threat from nutrients arises because of the oligotrophic nature of the Red Sea, which has rendered marine organisms susceptible to only slight changes in nutrient loads. Pollution from pesticides or heavy metals is not currently considered as a significant problem in any country.

5.2.1 Status, Trends, Issues

Djibouti

The main population centres on the coast of Djibouti are Djibouti City (population 428,000), Tadjoura (population 38,000) and Obock (population 12,300). Industrial activities concentrated around Djibouti City result in chronic release of industrial pollutants, mostly untreated (PERSGA/GEF 2001). There are few sewage treatment plants and those operating are generally poorly maintained (MISTAFA & ALI 2005). As a result there is chronic pollution from untreated, or insufficiently treated, sewage from households, slaughterhouses and hospitals. Septic tanks are pumped out directly to the sea (PERSGA/GEF 2001). About 95% (equivalent to 28,920 m³/day) of waste water from Djibouti City is discharged directly into the sea (UNEP/PERSGA 1997). The main reasons for these issues include outdated, inadequate technology and equipment and a lack of enforcement of existing regulations. The associated impacts are localised, particularly around Djibouti City (Table 5.1).

There is considerable tourist activity on Moucha and Maskali Islands. However, there are currently no sewage reception

facilities on these islands. At current levels, sewage discharge is unlikely to pose a significant threat, but may become so in the future with increased tourism (PERSGA/ALESCO 2003). Litter and refuse (mostly plastics, glass bottles, discarded fishing nets) occur throughout the Iles des Sept Frères and Ras Siyyan MPA, especially in areas frequented by people (Figure 5.1).

There is a potential for spillage of organic chemicals during loading, unloading and transshipment via ports (PERSGA 2005). Similarly, the risk of oil spillage from containers is greatest around the capital.

There is a household waste dump site at Douda but no infrastructure exists to treat the runoff. A particular concern surrounds the risk of wash-out of pesticides and organic chemical wastes dumped inland in wadis (PERSGA 2005). Elsewhere, solid waste from households and industry is dumped on the shoreline. The main cause is lack of efficient collection and disposal systems. The extent of this activity is compounded by lack of public awareness about the environmental impacts. These activities are likely to impact upon groundwater, alter water quality in the coastal environment and pose risks to human health. The dumping of solid waste damages coastal and marine habitats and life, and reduces aesthetics (PERSGA/GEF 2001).

Egypt

The main population centres on the Gulf of Suez coast of Egypt are Suez (population 488,000), Hurghada (Ghardaqah) (population 95,000), and Safaga (population 33,000). Sharm el Sheikh, at the tip of the Sinai Peninsula has a population of 23,000. The main population centres on the Gulf of Aqaba coast are Dahab and Nuweiba. Untreated or poorly treated effluent is one of the main sources of pollution of the coastal area (UNEP/PERSGA 1997). Treated and untreated sewage is usually discharged at, or just below, the intertidal zone via pipelines (PERSGA/GEF 2001). Industrial and municipal waste water is discharged into the Gulf of Suez. These discharges total 3,713 m³ of waste water, 3,189 m³ of cooling

Table 5.1 Summary of land-based pollution in Djibouti (summarised from PERSGA/GEF 2001).

Issue	Symptoms / Impacts	Immediate Causes	Root Causes	Extent	Severity
Medium oil spills (20–100 tonnes)	Beach contamination, damage to coastal and marine biota	Discharges from terminals	Inadequate control and monitoring of procedures, equipment and personnel, inadequate training	Localised, throughout the area	Moderate to severe
Discharge of untreated or insufficiently treated sewage	Groundwater impacts, eutrophication and alteration of marine environment, threats to public health	Lack of sewage treatment plants, lack of maintenance of existing plants	Inadequate pollution control regulations, monitoring and enforcement	Localised, capital area	Severe
Disposal of solid waste	Damage to coastal and marine life, deterioration of aesthetics	Improper garbage disposal	Lack of adequate waste disposal regulations and enforcement, lack of a waste management system, inadequate public awareness	Localised, capital area	Low to moderate
Disposal of waste oil	Soil and groundwater pollution	Improper disposal of used motor oil	Lack of proper oil disposal and recovery options, lack of effective regulations and enforcement	Localised	Low

water and 11,154 m³ of untreated sewage per day (UNEP/PERSGA 1997). Damage to marine life from sewage discharges from tourist facilities is evident in Taba, Nuweiba and Sharm el Sheikh (MISTAFA & ALI 2005). The discharge of untreated or poorly treated sewage is mostly a problem for coastal habitats. The composition of

sewage varies considerably along the coast. Major effects arise from increased nutrient and suspended solid loading (PERSGA/GEF 2001).

Initial results of nutrient monitoring in surface waters from Egypt for the Regional Environmental Monitoring Programme



Figure 5.1 Distribution and relative abundance of litter in the Iles des Sept Frères and Ras Siyyan MPA in 2002 prior to its declaration in 2005 (source: PERSGA 2002).

are shown in Table 5.2. Comparison with average background levels (WEIKERT 1987; BADRAN 2001) revealed the following:

- the range of nitrate levels exceeded average background levels in all months, and the greatest increase occurred in the Gulf of Suez;
- nitrite levels exceeded background averages in the Gulf of Suez in all months;
- phosphate levels exceeded average background levels in all months with the exception of the Gulf of Aqaba and Red Sea waters in September 2004;
- ammonium levels exceeded average background levels in all months in the Gulf of Suez.

Inputs of phosphate, manganese and bauxite from ship loading are a major pollution source along the Egyptian Red Sea coast (PERSGA/GEF 2001). Fertiliser factories are a source of nutrient pollution, primarily nitrogen and phosphorous and their compounds (PERSGA 2005). Industries in the Suez area have been reported to produce

107,485 t of calcium nitrate and 54,127 t of ammonium sulphate per year (UNEP/PERSGA 1997).

Industrial wastewater inputs to the marine environment arise from desalination plants, fertiliser plants (such as urea in Suez), refineries, and other industrial processes. Egypt's oil industry is concentrated in Gulf of Suez. Ineffective and inefficient operation of equipment, illegal discharge of dirty ballast water, lack of monitoring for leaks and spills leads to small 'spills' occurring on a monthly basis (PERSGA/GEF 2001).

Large quantities of insecticides are sprayed annually along coastal areas. Runoff into the coastal zone is likely to have impacts on nearshore habitats and could give rise to human health problems from accumulation through the food web (MISTAFA & ALI 2005).

There is no evidence of generalised elevations of trace metals within the Egyptian Red Sea or Gulf of Aqaba. Levels of water column trace metals (iron, zinc, manganese, nickel, copper, cadmium, cobalt, lead) are much lower than values

Table 5.2 Summary of nutrient levels in surface waters of the Red Sea of Egypt recorded as part of the Regional Environmental Monitoring Programme (summarised from raw data provided to PERSGA and made available to the author). Values shown are the minimum and maximum of recorded values. All values in $\mu\text{mol L}^{-1}$; NO_3 nitrate; NO_2 nitrite; NH_4 ammonium; PO_4 phosphate.

Date	Location	NO_3	NO_2	NH_4	PO_4
January 2004	Gulf of Suez	0.405–17.86	0.025–1.325	0.18–44.62	0.03–2.1
	Gulf of Aqaba	0.41–1.18	0.025–0.27	0.08–0.44	0.03–0.09
	Red Sea	0.26–1.195	0.01–0.195	0.15–0.95	0.03–0.145
March 2004	Gulf of Suez	0.11–11.86	0.08–0.66	0.39–10.83	0.03–0.325
	Gulf of Aqaba	0.18–0.455	0.05–0.105	0.20–0.77	0.015–0.065
	Red Sea	0.17–0.55	0.19–0.125	0.33–0.72	0.03–0.305
May 2004	Gulf of Suez	0.215–18.565	0.065–1.93	0.4–31.46	0–0.335
	Gulf of Aqaba	0.175–0.765	0.16–0.43	0.48–16.57	0.01–0.6
	Red Sea	0.3–0.67	0.015–0.075	0.21–1.165	0–0.10
July 2004	Gulf of Suez	0.415–18.005	0.14–4.1	0.49–31.19	0.05–0.17
	Gulf of Aqaba	0.255–1.035	0.14–0.205	0.44–1.59	0–0.06
	Red Sea	0.225–0.64	0.085–0.17	0.68–1.445	0.03–0.415
Sept 2004	Gulf of Suez	0.27–23.22	0.1–1.55	0.03–15.78	0.03–1.17
	Gulf of Aqaba	0.25–5.83	0.11–0.18	0.08–0.35	0–0.03
	Red Sea	0.28–0.88	0.06–0.13	0.22–1.58	0.03–0.05

reported for the Mediterranean Sea and are typical of open ocean water (SHARIADAH et al. 2004). However, elevated levels of some trace metals may be an issue in some localised areas. Bivalves and fish in the vicinity of some industrial areas show elevated concentrations of lead, mercury and copper (PERSGA/GEF 2001).

Large amounts of garbage (especially plastic containers) enter the sea from urban and recreational areas. These solid wastes create problems by smothering shoreline habitats, inhibiting oil spill clean-up operations, and degrading the aesthetic values of the shoreline (PERSGA/GEF 2001).

Jordan

The main urban and industrial area on the Gulf of Aqaba coastline of Jordan is at Aqaba (population 70,000). The Gulf of Aqaba is

especially susceptible to the effects of land-based discharges. Dispersion of pollutants will be slow given the Gulf is a semi-enclosed ecosystem (due to the shallow, constricted entrance at the Straits of Tiran) within a semi-enclosed ecosystem (the entire Red Sea). Jordan's major industries are located along its Gulf of Aqaba coastline in the South Coast Industrial Zone, immediately south of Jordan's planned South Coast Tourism Zone and adjacent to the Saudi Arabian border. These include a thermal power station, a fertiliser manufacturing plant, port facilities, a storage and loading area for potash, and a "Solvochem" tank farm for chemicals, oils and solvents. There are several environmental impacts associated with these activities (Table 5.3).

The main manufacturing facility is a fertiliser factory south of Aqaba that annually produces 740,000 tonnes of diammonium

phosphate (DAP) and 432,000 tonnes of phosphoric acid. Between 1990 and 1995 fertiliser accounted for approximately 10% of Jordan's total export revenues. There are frequent spills of small quantities of sulphur and DAP during unloading and loading from ships. A major concern associated with these facilities is runoff (e.g. arising from a flash flood) from a 'gypsum mountain' where 2 million tonnes of fluorine-containing waste is deposited annually in an unlined, unconfined setting (GLADSTONE et al. 1999).

Phosphate dust emissions during ship loadings at the Phosphate Port were highlighted as a significant problem for Jordan's marine environment in the 1970s and 1980s (FREEMANTLE et al. 1978; WALKER & ORMOND 1982; ABU-HILAL 1985) and also in more recent reviews (UNEP/PERSGA 1997; GLADSTONE et al. 1999). Problems reported included increased sedimentation, coral death, and a proliferation of algae and sea urchins. The environmental problems associated with the port were compounded by the discharge

Table 5.3 Summary of land-based pollution in Jordan (summarised from PERSGA/GEF 2001).

Issue	Symptoms/Impacts	Immediate Causes	Root Causes	Extent	Severity
Industrial chemical spills	Health risk and potential damage to marine life	Accidental spill during transport, storage or use of chemicals	Inadequate control and monitoring of hazardous substances	Local	Moderate
Cooling water discharges	Alteration of marine environment	Release of cooling waters from electrical facility and fertiliser plant	Inadequate thermal pollution control standards, monitoring and enforcement	Local	Low
Phosphate dust emissions	Decreased coral growth around phosphate port	Release of phosphate dust during port operations	Inadequate pollution control standards, monitoring and enforcement	Local	Low
Gypsum disposal	Potential leaching of gypsum into the Gulf of Aqaba	Unconfined storage of gypsum at the fertiliser factory	Lack of proper sites, regulations and enforcement for hazardous waste disposal	Local	Low
Solid Waste Pollution	Aesthetic deterioration, physical damage to reefs and marine life	Beach litter	Inadequate solid waste collection, disposal, public awareness and enforcement	Regional	Moderate

of municipal sewage in the port's vicinity. However, recent changes to management practices have reversed these impacts. Cessation of sewage discharge and changes to phosphate handling have resulted in the sedimentation rate, phosphate levels, algal cover, and sea urchin density being only slightly elevated compared to reference locations, and coral mortality rates are not different to reference locations (Table 5.4) (BADRAN & AL ZIBDAH 2005).

Nutrient levels recorded off the Jordan coast of the Gulf of Aqaba in 2005 as part of the Regional Environmental Monitoring Programme are shown in Table 5.5a and b. Maximal values of nitrate and ammonium exceeded background levels in each month. Levels of nitrite and phosphate were within the range of background levels in each month with the exception of May 2005 when the maximal phosphate level exceeded background levels.

The concentration of industry along the coast results in considerable discharges into the Gulf of Aqaba. The fertiliser factory discharges chlorinated cooling water (from its own electricity generating plant) into the Gulf of Aqaba at a rate of 20,000 m³ per hour. Discharges occur through pipes at 145 m offshore and 30 m deep. As a result the surrounding water is 3°C higher than ambient water temperature. The Jordan Electricity Authority thermal power plant discharges 38,000 m³/h of cooling water into the Gulf through pipes located 200 m offshore and 20 m deep. Water at the outlet is 3°C higher than the ambient water temperature, falling to 1°C above ambient temperatures at a distance of 10–15 m from the discharge outlets (UNEP/PERSGA 1997; PERSGA/GEF 2001).

The Port of Aqaba is the third largest in the Red Sea after Suez (Egypt) and Jeddah (Saudi Arabia). Over 2,300 ships pass through the port annually, but there are no reception facilities for oil-contaminated bilge or ballast water. Small to minor oil spills occur frequently causing localised environmental damage. Between 1993 and 1996 there were 49 small (0–2 tonnes) to minor (2–20 tonnes) spills (PERSGA/GEF

Table 5.4 Comparison between a set of environmental parameters at the phosphate loading berth (Jordan) relative to other coastal areas during the 1970s and recent records from 2000–2001 (summarised from BADRAN & AL ZIBDAH 2005). Values for each variable are the ratio of the value recorded at the Phosphate Port to the value recorded at reference locations.

Variable	Average recent records 2000–2001	Old records
Sedimentation rate	1.7	4.3
Soluble phosphate	1.1	3.5, 2.6
Coral death	1.1	4.7
Algal cover	1.4	2.2
Sea urchin density	1.2	3.1

2001). There were seven incidents in 2004 (personal communication from Jordan Maritime Authority to R. Facey).

Sewage discharges have been reported to cause the proliferation of algae, which has depressed coral growth in the Gulf of Aqaba's heavily settled northern reaches (PERSGA/GEF 2001).

Solid waste is a particular, high-visibility problem on the Gulf of Aqaba coast of Jordan. Solid wastes in the coastal zone originate from ships' crews, ferry passengers, beach vacationers and local residents. Beaches, nearshore reefs and seagrass beds are heavily polluted by discarded plastic and other refuse (MISTAFA & ALI 2005).

Saudi Arabia

Saudi Arabia has undergone a rapid transformation from a state of relative underdevelopment, with severe constraints to development and public welfare, to a modern industrial country in only the past four decades. Much of Saudi Arabia's development has taken place in or has had an effect on coastal lands and waters. Between 1974 and 1992 Saudi Arabia's population

Table 5.5a Summary of nutrient levels in surface waters of the Gulf of Aqaba (Jordan) recorded as part of the Regional Environmental Monitoring Programme (summarised from raw data provided to PERSGA and made available to the author). Values shown are the minimum and maximum of recorded values. All values in $\mu\text{mol L}^{-1}$; NO_3 nitrate; NO_2 nitrite; NH_4 ammonium; PO_4 phosphate.

Date	NO_3	NO_2	NH_4	PO_4
April 2005	0.37–0.73	0.07–0.17	0.29–0.47	0.04–0.09
May 2005	0.20–0.74	0.03–0.07	0.20–0.55	0.05–0.16
June 2005	0.20–0.44	0.02–0.03	0.17–6.90	0.04–0.07

Table 5.5b Summary of background levels of nutrients (in $\mu\text{mol L}^{-1}$) in surface waters of Gulf of Aqaba (Jordan) as a comparison against the values shown in Table 5.5a (source: BADRAN 2001).

Date	NO_3	NO_2	NH_4	PO_4
April	0.25–0.50	0.10–0.15	0.05–0.10	0.05–0.08
May	0.25–0.50	0.05–0.10	0.05–0.10	0.05–0.08
June	0.00–0.25	0.00–0.05	0.00–0.05	0.03–0.05

grew from 7 million to nearly 17 million at an average annual rate of 3.2%. Urban population growth, however, was nearly 7%. Approximately 15% of the population lives in the Red Sea coastal zone (PERSGA/GEF 2001). The largest urban centres on the Red Sea coast are Jeddah (population 2.8 million), Yanbu (189,000), Jizan (100,000), and Rabigh (43,000).

Saudi Arabia's need for potable water to supply expanding coastal and urban developments has resulted in the construction of 18 desalination plants along its Red Sea coast with more proposed (Box 5.2). The combined capacity of Saudi Arabia's Red Sea desalination plants is 726,343 m^3 per day (MISTAFA & ALI 2005). Desalination plants in Jeddah discharge chlorine, anti-scaling chemicals and 1.73 million cubic metres of brine at a salinity of 51,000 ppm (more than 1.3 times ambient salinity) and temperature of 41°C (over 9°C above ambient temperature). It is likely that in coastal areas with poor flushing and dilution these loadings stress marine biota that are already living at the upper end of their temperature tolerance range (PERSGA/GEF 2001).

Most sewage and industrial effluent is managed by waste water treatment

facilities. Approximately 146,000 m^3/day of treated (chlorinated) waste sewage water from Jeddah is discharged into the Red Sea. The Al Khumra Sewage Treatment Station (south of Jeddah city) discharges daily 100,000 m^3 of treated and untreated sewage into the coastal waters, representing 12 tonnes of organic matter. The concentrations of nitrogen and phosphorous in the coastal waters immediately adjacent to the discharge are from 10 to 100 times greater than normal values for the Red Sea (EL SAYED 2002). This is likely to be having considerable impacts on local marine habitats. Many sewage treatment plants are operating beyond their intended capacity, resulting in the discharge of untreated effluent to the marine environment, eutrophication of coastal lagoons, and malodorous inputs into the human environment (Tables 5.6 and 5.7) (UNEP/PERSGA 1997; PERSGA/GEF 2001).

Yanbu is an important petroleum shipping terminal and has three oil refineries, a plastics facility, and several other petrochemical plants. It is the country's second port (after Jeddah). Approximately 70% of the treated industrial waste water from the industrial area in Yanbu is discharged into the Red Sea. The waste

Table 5.6 Estimated Red Sea pollution generated by Saudi Arabia's municipal sewage treatment in metric tonnes per annum (source: PERSGA/GEF 2001). *This amount was estimated by per capita production rates from towns where no information was available during the study period. The 'unaccounted for' values do not necessarily represent discharges to the Red Sea and do not include the inland cities of Taif, Makkah, Madina, Qassim, Khamis Mushayt.

Town	COD	BOD	P	N	NH ₃
Jeddah	92,000	37,000	2,200	8,000	
Yanbu	99	39	2	8	
Western region, unaccounted for *	100,000	40,000	2,000	8,700	10,000
Northern region, unaccounted for *	66,000	26,000	1,300	5,700	
Southern region, unaccounted for *	48,000	19,000	950	4,200	
Total	306,099	122,039	6,452	26,608	10,000

water discharged has elevated levels of nutrients that have hindered coral recovery (following the initial impacts resulting from the construction of the industrial facility) by promoting algal growth, and have also reduced fish species richness (PAIMPILLIL et al. 2002).

Nutrient levels recorded off the Red Sea coast of Saudi Arabia in 2004–2005 (as part of the Regional Environmental Monitoring Programme) are shown in Table 5.8. Comparison with average Red Sea values for each nutrient (WEIKERT 1987) shows that values of nitrate and nitrite were within the range of average values. High levels of phosphate were recorded off Jeddah and Yanbu on each sampling occasion and in July 2005 off Al-Qunfudah. Maximal silicate levels were higher than average maximal levels (2 µM) off Jeddah and Yanbu in April 2005 and December 2005 respectively.

Somalia

The current population of Somalia is estimated to be about 8.8 million inhabitants (population counting is complicated by the large number of nomads and by refugee movements in response to famine and clan warfare). The largest town along the Gulf of Aden coast is Berbera. Its population varies seasonally between an estimated

50,000 and 150,000 inhabitants. The second largest (perhaps now the largest) town is Bosaso which has grown from 5,000 to over 100,000 inhabitants. Other significant settlements along the coast are Saylac (Zeila), Laas Qoray, Qandala, Xabo and Caluula with 1,000 to 3,000 inhabitants each. The population of coastal towns and villages is significantly higher during the winter than during the summer. The Gulf of Aden coast of Somalia is still in a largely pristine state. There is little development and anthropogenic pressure is low and restricted to the immediate vicinity of the larger settlements (PERSGA/GEF 2001). Threats to the marine environment from land-based pollution are summarised in Table 5.9.

Solid waste pollution is a major problem in Somalia. Near human settlements, especially Bosaso, Berbera and Saylac, solid waste is dumped on the shore and into the sea. These inputs are likely to be locally detrimental to nearshore habitats and their associated species, as well as degrading the visual amenity of the coastal zone. There are few sewage plants and these are generally poorly maintained with the result that discharge of untreated sewage may be a problem for local areas of the marine environment (UNEP/PERSGA 1997; PERSGA/GEF 2001; MISTAFA & ALI 2005).

Table 5.7 Marine pollution emissions (in metric tonnes per annum) from Red Sea coastal provinces in Saudi Arabia (from PERSGA/GEF 2001).

Pollutant	Sewage	Industrial Cities	Desalination	Refineries	Petro-chemicals	Total
COD	293,200	2,570			270	296,040
BOD	144,580	1,114		1,543		147,237
P	51,580	9				51,589
TSS				1,623		1,623
SS		1,071			63	1,134
N	29,480					29,480
NH ₃	10,000					
N _{tot}		88				88
Barium	285					285
Copper	345					345
Cadmium	10					10
Chromium	54					54
Chlorine			630	146	100	876
Iron	825					825
Lead	195					195
Manganese	195					195
Nickel	2,909					2,909
Oil				1,164	369	1,533
Phenol				49		49
Phosphorus	3,298	95			2	3,395
Phosphate			3.2			3.2
Sulphides				452		452
Zinc	13,043					13,043
Heat load gram cal/yr			18,250,000			18,250,000
Brine			1.73E+09			1.73E+09

The Gulf of Aden coast of Somalia has no heavy industry. The urban population is growing rapidly and urban development in Bosaso and Berbera is largely uncontrolled. Wastewater is mostly collected in septic trenches and some reaches the sea directly,

though it is probably not a major source of marine pollution. In the absence of any monitoring, it is not possible to estimate the amount of toxic leachates entering coastal waters.

Table 5.8 Summary of nutrient levels in surface waters of the Red Sea of Saudi Arabia recorded as part of the Regional Environmental Monitoring Programme (summarised from raw data provided to PERSGA and made available to the author). Values shown are the minimum and maximum of recorded values. All values in $\mu\text{mol L}^{-1}$; NO_3 nitrate; NO_2 nitrite; NH_4 ammonium; PO_4 phosphate.

Location	Date	NO_3	NO_2	NH_4	PO_4	Silicate
Jeddah	Oct. 2004	0.021–0.252	0.008–0.048	0.130–0.933	0.020–0.18	0.895–1.392
	Apr. 2005	0.103–1.131	0.008–0.029	0.186–0.639	0.123–0.31	1.356–3.071
Yanbu	Jun. 2005	0.164–0.479	0.026–0.099	0.263–0.797	0.047–0.158	0.727–1.698
	Dec. 2005	0.158–0.353	0.018–0.086	0.470–1.507	0.005–0.105	0.485–6.440
Al	Jul. 2005	0.168–0.309	0.026–0.051	0.199–1.387	0.170–0.590	1.778–2.425
Qunfudah	Sep. 2005	0.124–0.210	0.024–0.051	0.287–0.845	0.021–0.037	1.455–2.344
	Dec. 2005	0.132–0.168	0.013–0.088	0.040–1.060	0.005–0.011	0.727–2.102

Table 5.9 Summary of land-based pollution in Somalia (summarised from PERSGA/GEF 2001).

Issue	Symptoms/Impacts	Immediate Causes	Root Causes	Extent	Severity
Discharge of untreated or insufficiently treated sewage	Groundwater impacts, threat to public health and coastal ecosystems	Lack of sewage treatment plants	Lack of pollution control regulations, monitoring and enforcement	Localised, urban areas	Low to moderate
Disposal of solid waste in coastal areas, disposal of human faeces	Damage to coastal and marine life, deterioration of aesthetics, threats to human health	Improper disposal	Lack of adequate waste disposal regulations and enforcement, lack of a waste management system, inadequate public awareness, lack of sanitary facilities	Localised	Low to moderate

Sudan

The Sudanese Red Sea coast is about 750 kilometres long, including bays and inlets. Most of the Sudanese Red Sea is still largely pristine. Port Sudan is the largest coastal city with a population of about 400,000. The state is well endowed with natural resources, but its inhabitants are comparatively poor, especially those living in rural and marginal

urban areas (PERSGA/GEF 2001). Oil is increasingly important to the Sudanese economy, with oil production at Bashayer being 750,000 barrels per day in 2006 (R. Facey personal communication).

Anthropogenic pressure is particularly high in the vicinity of the two coastal cities, Port Sudan and Suakin; however, growing urban, industrial and recreational developments

may lead to additional impacts in other localised areas (Table 5.10 and Figure 5.2). Discharge of untreated sewage has caused damage to the marine environment, especially in Port Sudan harbour and at Abu Hashish. Port Sudan power plant discharges waste oil directly into the sea. This situation is mainly due to outdated, inadequate technology and lack of enforcement of existing laws (UNEP/PERSGA 1997; PERSGA/GEF 2001).

Near human habitation, solid waste and litter are dumped on the shore and into the sea. This is likely to have significant local impacts on nearshore habitats and their biota. This problem is due to a lack of efficient waste collection and disposal systems, aggravated by a general lack of awareness. The problem is especially severe around Port Sudan (PERSGA/GEF 2001) and human settlements in the Mukawwar

Island and Dugonab Bay MPA (PERSGA/GEF 2004f) (Figure 5.3). Daily effluent from shrimp farms between Marsa Halot and Marsa Ashat is estimated at 4.5–6 million cubic metres per day. Effluents from mining, mainly gold at Gebeit el Maadin and gypsum at Eit, pose a serious threat to the Red Sea environment (UNEP/PERSGA 1997). Most mining activities occur far from the coast. However, the concentration of mining products in the coastal area (e.g. gypsum, salts, cement) and the storage and transport of chemicals used for gold mining (e.g. cyanide, mercury) may have serious impacts on the coastal and marine environment. In particular, the open storage of large amounts of cyanide poses a serious threat (PERSGA/GEF 2001).

There is concern about the risk of wash-out of pesticides and organic chemical wastes that have been dumped inland in wadis. In

Table 5.10 Summary of land-based pollution in Sudan (summarised from PERSGA/GEF 2001).

Issue	Symptoms/Impacts	Immediate Causes	Root Causes	Extent	Severity
Industrial pollution	Decline in water quality	Chronic release of pollutants	Lack of enforcement, inadequate technology	Localised, emerging issue in Free Zone	Currently moderate
Discharge of untreated or insufficiently treated sewage	Groundwater impacts, eutrophication and alteration of marine environment, threats to public health	Lack of sewage treatment plants, lack of maintenance of existing plants	Inadequate pollution control regulations, monitoring and enforcement	Localised, urban areas	Moderate to severe
Disposal of solid waste	Damage to coastal and marine life, deterioration of aesthetics	Improper garbage disposal	Lack of adequate waste disposal regulations and enforcement, lack of a waste management system, inadequate public awareness	Localised	Low to moderate
Use of pesticides in the coastal zone	Contamination of soils and water	Large-scale use of pesticides for locust control	Inadequate planning and surveillance, lack of awareness	Throughout much of the area	Moderate to severe

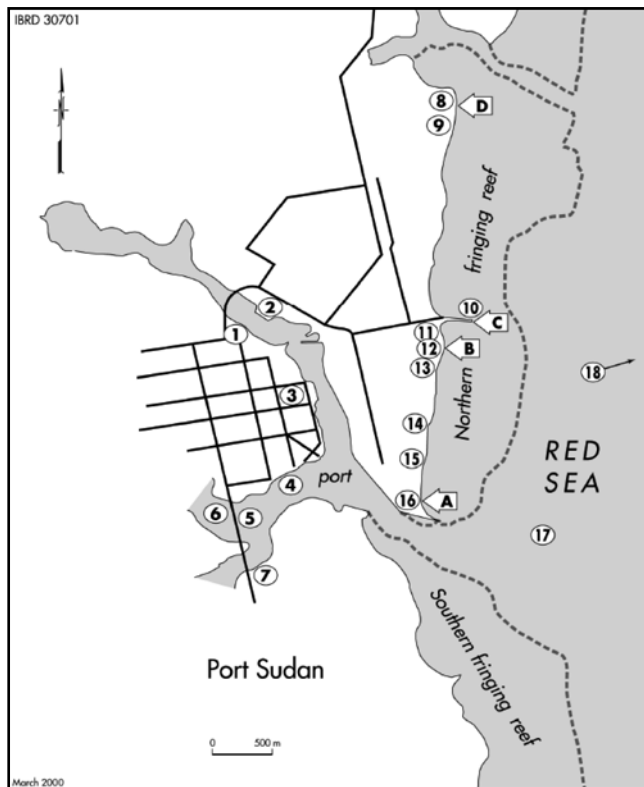


Figure 5.2 Pollution and land reclamation in the vicinity of Port Sudan (source: PERSGA/GEF 2001).

Sources of pollution:

1. Power plant; 2. Boatyards; 3. Tourist boats, yachts; 4. Khor Kilab rums; 5 and 6. Khor Kilab truck loading area; 7. Power plant; 8. Tyre factory; 9. Tannery; 10. Abu Hashish dam; 11 and 12. Oil mills; 13 and 14. Beaches, partly used as storage area; 15. Molasses trucks; 16 and 17. Garbage dumps; 18. Anchorage area.

Reclamation sites:

A. Seaports Corporation garbage dump; B. Oil mill extensions; C. Abu Hashish dam; D. Tyre factory, dam and beach. The new Green Port between A and B involved construction of 14.6 m deep berths through the coral reef. Part of the southern fringing reef has been removed to create the Al Khein Oil Terminal. (R. Facey personal communication).

the past the Locust Control Programme was considered to be a major source of pesticide pollution to the marine environment. However, donor funding has now ceased and amounts used have reduced (PERSGA 2005).

Yemen

The total population of Yemen is around 15 million, of which about 7.6 million live in the eight coastal governorates. About 1,080,000 people live in major coastal settlements. Aden is the largest coastal city (population 480,000), followed by al-Hudaydah (population 160,000) and Mukalla (population 50,000). Only 30–40% of the coastal population is served by public sewage networks. Aden has little treatment, with raw sewage discharged into the sea near the port. Raw sewage is discharged into the harbour at Ma'alla, despite new sewage works and pipes being constructed

(R. Facey personal communication). This is likely to cause local nutrient enrichment and impact nearshore habitats. In al-Hudaydah, wastewater is carried to a series of stabilizing ponds before being discharged into the sea. In Mukalla and the smaller towns, sewage is discharged directly to the sea without treatment (PERSGA/GEF 2001) (Table 5.11).

Power stations at Mukha, Ras Katheeb and Aden discharge saline, high temperature water directly into the sea. This leads to a local increase in seawater temperature; however the ecological effects are yet to be quantified. Non-biodegradable hospital and industrial wastes are often disposed of near the shoreline. Additionally, solid domestic waste is dumped in or near the sea (PERSGA/GEF 2001). Fertiliser and pesticide use are widespread and run-off into the marine environment is a potential issue (MISTAFA & ALI 2005).

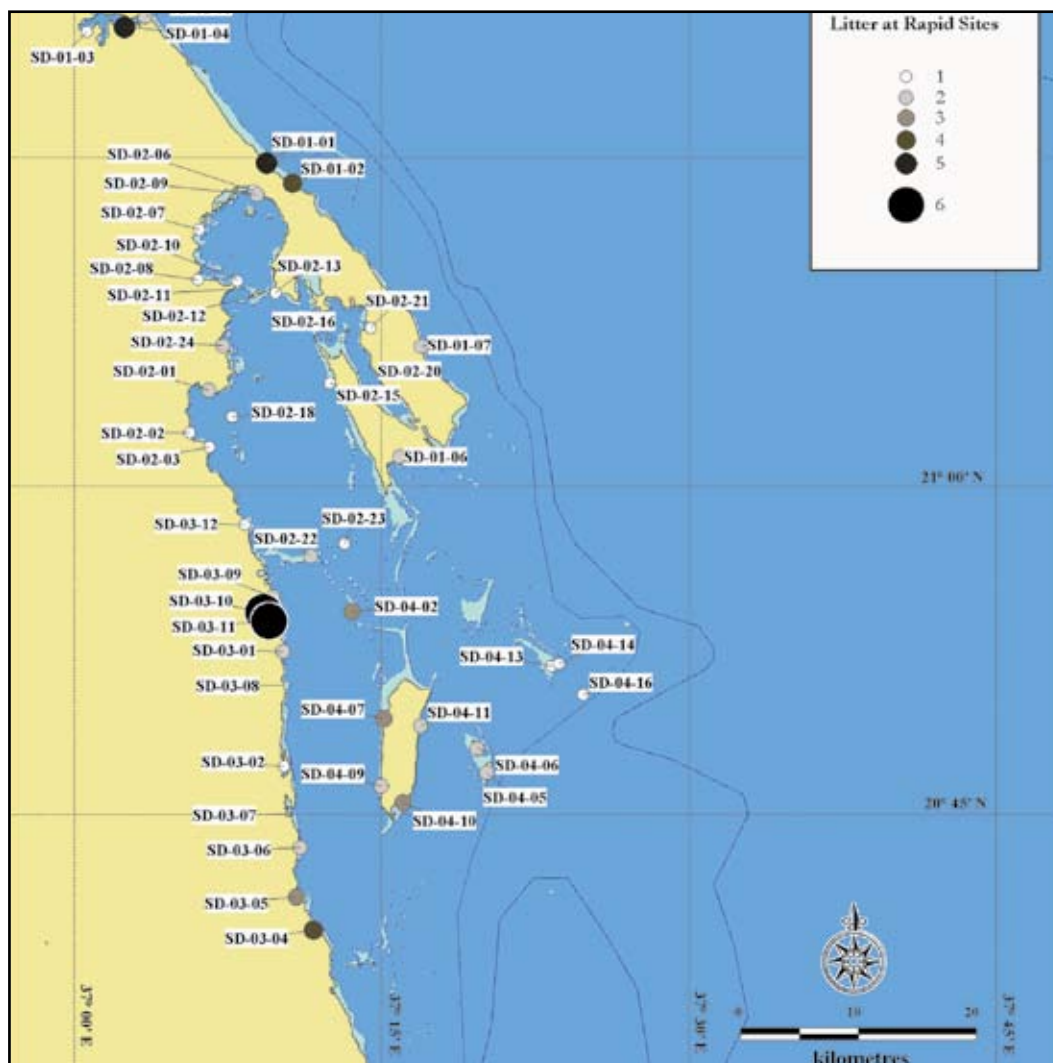


Figure 5.3 The distribution of litter in 2002 in the Mukawwar Island and Dungonab Bay MPA prior to the MPA declaration in 2005 (source: PERSGA/GEF 2004f).

Coastal waters of the Red Sea coast of Yemen show no evidence of widespread pollution from trace metals. However, levels of cadmium, cobalt and lead in surface waters and sediments were elevated and at levels that could cause harm to marine life after prolonged exposure. There is uncertainty about the origin of these elevated metals (e.g. there are very large inputs of terrestrial material via erosion and wind) with the exception that the maximum levels of metals in sediments occurred in the vicinity of a power station at Al-Khawka (AL-SHIWAFI et al. 2005). A recent study of trace metals in Aden harbour found elevated levels of lead, chromium and zinc. The potential sources of this contamination

include waste water discharged from the desalination plant, power station or refinery; oil spills from ships and pipelines; and domestic waste water (NASR et al. 2005). There is a need for further research to determine the origin and fate of trace metals in the coastal waters of Yemen.

5.3 RESPONSES

5.3.1 Regional Environmental Monitoring Programme (REMP)

An outcome of the SAP was the recognition of the need for a Regional Environmental Monitoring Programme (REMP) that would integrate with the regional monitoring of

Table 5.11 Summary of land-based pollution in Yemen (summarised from PERSGA/GEF 2001).

Issue	Symptoms /Impacts	Immediate Causes	Root Causes	Extent	Severity
Industrial pollution	Decline in water quality	Chronic release of pollutants	Lack of regulations and enforcement, inadequate technology	Localised, emerging issue in free zone	Currently low to moderate
Discharge of untreated or insufficiently treated sewage	Groundwater impacts, eutrophication and alteration of marine environment, threats to public health	Insufficient capacity of sewage treatment plants, lack of maintenance of existing plants and discharge pipes	Inadequate pollution control regulations, monitoring and enforcement	Localised, urban areas	Moderate to locally severe
Disposal of solid waste	Damage to coastal and marine life, deterioration of aesthetics	Improper garbage disposal	Lack of adequate waste disposal regulations and enforcement, lack of a waste management system, inadequate public awareness	Localised	Moderate to locally severe
Use of pesticides and fertilisers in the coastal zone	Contamination of soils and water, presence of pesticides in marine organisms	Large-scale use of pesticides and fertilisers for agricultural purposes	Inadequate planning and surveillance in use of pesticides, lack of control and awareness	Localised	Low

species and habitats (see chapter 3). A core component of the REMP is a contaminant-monitoring programme that consists of a common set of parameters to be monitored by all member states as an integral part of their national monitoring programmes. The REMP addresses common and transboundary pollution issues, rather than national issues.

The primary objectives of the REMP are:

- to ensure that adverse trends are detected in sufficient time to implement remedial action, and
- to provide an objective test of the effectiveness of existing

environmental management practices (on a local, national and regional scale).

The issues of great regional concern in the RSGA are: nutrient inputs from agriculture and sewage; hydrocarbon inputs from coastal industry, ports, and shipping; and the physical impacts of construction and land reclamation. Additional localised issues include: pesticide inputs from pest control programmes and agriculture; and heavy metals from industry and shipping. These have guided the selection of parameters to be monitored.

Owing to the differing capacities of RSGA nations and funding constraints, the REMP is being implemented in a phased manner and supported by parallel capacity building initiatives. Phase 1 of the REMP focuses on ensuring that all countries have the necessary technical and human resources to monitor the following: nitrogen and phosphorus compounds in seawater and sediments; and hydrographic parameters (temperature, salinity, dissolved oxygen, pH, turbidity). In addition, central lab or labs from the region will be involved in monitoring hydrocarbons in water and sediments, persistent organic substances in sediments, and heavy metals in sediments.

The need for all nations in the REMP to possess a common capacity prompted the establishment by PERSGA of a Capacity Building Initiative (CBI). The CBI will enhance the technical capabilities and human resources of the PERSGA member states and facilitate their full participation to ensure the success of the REMP. As part of the CBI, PERSGA provided countries involved in implementing the REMP (except Somalia) with the equipment necessary for monitoring the parameters identified for Phase 1.

The first sampling for water quality monitoring in Egypt, Jordan and Saudi Arabia occurred between 2004 and 2005 (see summaries of these results in Tables 5.2–5.8). Monitoring in Djibouti, Sudan and Yemen began in 2006. PERSGA's Framework of Action 2006–2010 includes activities relevant to regional monitoring. Programme Element 2 (Marine and Coastal Science Research), has outcomes that include the establishment of a monitoring programme for the effects of land- and sea-based sources of pollution, and an environmental programme for industrial effects. Implementation of both programmes is expected to cost US\$2 million.

The approach taken in this review has been to compare nutrient results with published data on average background levels for each nutrient. However, this approach needs to be modified in future by setting meaningful limits. This can only be done after several

years of monitoring when there will be a greater understanding of the range of natural variation of each nutrient in each country, and the ecological significance of that variation. The establishment of these limits, and guidelines about the acceptable frequency of exceeding them, must become a priority target within the monitoring programme.

A number of recent initiatives in monitoring in Jordan will provide resources for continuing assessments of the responses of Jordan's marine environment to management. The Marine Science Station (MSS), jointly operated by the University of Jordan and Yarmouk University, has been monitoring the coastal ecosystem in front of the Industrial Complex of the Jordanian Mines Company since 1996. The monitoring focuses on: seawater (for nutrients, dissolved oxygen, pH, alkalinity, chlorophyll *a*, salinity, temperature, transparency); bottom sediments (for grain size, chemical composition, organic carbon, phosphorus, nitrogen, heavy metals, hydrocarbons); benthic assemblages; and fishes. A database of marine environmental parameters (incorporating current and old records) has been established at the Aqaba Special Economic Zone Authority for the use of scientists, investors, and coastal managers (BADRAN & ZABIDAH 2005).

Monitoring within marine environments will be most successful and useful when the results of physical and ecological monitoring are considered and interpreted together (see Box 5.2).

5.3.2 Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden

An important step was taken towards a coordinated regional approach to addressing the issues arising from pollution from land-based activities with the signing by PERSGA member states in September 2005 of the 'Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden'. The Protocol is an addition to the 'Regional

Box 5.2 The need for integrated monitoring

Concentrations of dissolved inorganic nutrients are routinely measured in marine environmental monitoring programmes as one indicator of the status of ecosystems. As reviewed earlier in this section on Land-Based Sources and Activities, there are many examples from tropical regions around the world of the association between elevated nutrient levels and coral reef degradation (usually via the proliferation of macroalgae). However, the link with nutrients is usually not a direct link. Many cases of reef degradation also involve related impacts on herbivores, especially fishes and sea urchins. It appears that reduced biomass of herbivorous fishes (through overfishing) may be more significant in the degradation of coral reefs via overgrowth of macroalgae, than simultaneous increases in nutrients (LAPOINTE 1997; HUGHES et al. 1999; LAPOINTE 1999; McCOOK 1999).

The need for a clear separation of cause and effect in explaining reef degradation when nutrients are implicated (e.g. McCOOK 1999) indicates that it is insufficient to rely solely on monitoring of dissolved nutrients as an indicator of reef health. The results of the scientific research reinforce the need for monitoring of coral reefs to be comprehensive and include chemical variables (such as dissolved nutrients) as well as biological variables (such as herbivore density or biomass). Judgements about the status of reefs need to be based upon both sources of information.

Convention for the Conservation of the Red Sea and Gulf of Aden Environment' (the Jeddah Convention). The General Provision, General Obligations, and Articles of the Protocol are set out in Box 5.3.

The Protocol obliges contracting states to: prevent pollution from land-based sources, with particular emphasis on the gradual elimination of inputs of toxic, persistent and biologically accumulating substances by implementation of work plans based on source control.

Contracting Parties are required to submit a report every two years covering the measures taken and results achieved, and if need be, the problems encountered in the implementation of the Protocol. These reports will be a valuable resource for future state of the environment reports to assess changes and improvements to the issues raised in this report.

5.3.3 Institutional Strengthening and Capacity Building

Training workshops have been held in the following fields related to land-based sources and activities:

- combating oil pollution
- integrated coastal zone management
- environmental impacts of development projects
- management of solid wastes in industrial areas.

5.3.4 Support for Planning and Decision Making

A regional GIS system was established within PERSGA. Support for managing pollution and navigation planning will come from charts covering harbours, anchorages, navigational hazards, coastal navigation, offshore navigation and passage planning.

5.4 TOURISM

An attractive marine life and favourable climate have encouraged the rapid development of a major tourist industry along the coasts of the Red Sea (PERSGA/GEF 2004e). Tourism has been actively promoted in some countries (e.g. Egypt, Jordan), while other countries with similar opportunities (e.g. Sudan and Yemen) lack the necessary physical and technological infrastructure (GLADSTONE 2002).

Box 5.3 Summary of PERSGA's 'Protocol Concerning the Protection of the Marine Environment from Land-Based Activities in the Red Sea and Gulf of Aden'

GENERAL PROVISIONS

The Contracting Parties to this Protocol shall take all appropriate measures to protect the environment of the Red Sea and Gulf of Aden against pollution resulting from any land-based sources or activities and to reduce and/or eliminate such pollution to the maximum extent possible with priority given to the gradual elimination of toxic, persistent, and biologically accumulating inputs.

ARTICLE 5: GENERAL OBLIGATIONS

- 1 The Contracting Parties shall prevent pollution from land-based sources, with particular emphasis on the gradual elimination of inputs of toxic, persistent and biologically accumulating substances by implementation of work plans based on source control as specified in Annex II of the Protocol, taking into consideration the priorities of the Region.
- 2 The Contracting Parties shall, for this purpose, formulate and implement, individually or jointly, as necessary, national and regional work programmes and plans that incorporate measures and timetables for the implementation of the same.
- 3 The Contracting Parties shall approve the priorities and timetables for the implementation of the work plans and requisite measures. The Council shall review the same once every two years in accordance with the provisions of Article 18 of this Protocol taking into account the items set forth in Annex I.
- 4 The Contracting Parties shall, when approving programmes, procedures and work plans, take into consideration, individually or jointly, the best available technologies and environmental practices, including, as appropriate, clean production technology.
- 5 The Contracting Parties shall, individually or jointly, endeavour to take the appropriate preventive measures to reduce to the minimum possible extent pollution hazards resulting from land accidents in the Area of the Protocol.

Other articles address the following specific matters:

- Treatment and Management of Used Water (Article 6)
- Management of Solid Wastes (Article 7)
- Sedimentation and Dredging Practices Threatening the Marine Environment (Article 8)
- Protection of Habitats (Article 9)
- National Legislation and Regional Guidelines for Waste Disposal (Article 10)
- Licensing and Waste Disposal Regulations (Article 11)
- Environmental Monitoring and Data Management (Article 12)
- Environmental Impact Assessment (Article 13)
- Scientific and Technological Cooperation (Article 14)
- Scientific and Technical Assistance (Article 15)
- Trans-boundary Pollution and Settlement of Disputes and Compensation (Article 17)
- Regional Work Programme (Article 19)

Tourism is the third most important source of revenue for Egypt after oil and foreign remittances and has been the fastest growing economic sector with annual growth peaking in 1992. Between 1985 and 1996 the number of international arrivals grew (on average) by 13.2% per year from 1.3 million to 3.4 million. In contrast, average annual growth in tourism throughout the rest of the world over the same time period was 5.9%. In previous years the main tourism focus was Egyptian antiquities. Twenty years ago the Red Sea coast began to attract international scuba divers due to the high quality of its coral reefs. This has led to an average annual growth of tourism in the South Sinai (the focus of diving in the Egyptian Red Sea) of 42% (PERSGA/GEF 2001).

Tourist resorts have spread along the Red Sea coastline of Egypt. The main tourist attractions are national parks (e.g. Ras Mohammed), sand beaches and coral reefs in the Gulfs of Suez and Aqaba, and the warm coastal climate from Hurghada southwards (PERSGA/GEF 2001). Nature-based tourism represents the main economic activity along the Red Sea and the second largest sector of the nation's tourism industry (PERSGA/GEF 2003c). Large stretches of the coast have been developed into beach resorts (PERSGA/GEF 2004e).

Jordan has a growing tourism industry centred on Aqaba (PERSGA/GEF 2001; PERSGA/GEF 2003c). Located south of Aqaba is a 6 km coastal stretch named the South Coast Tourism Zone. This will be the site for major tourist and residential developments planned for the next 20 years. This area is also included in the proposed Red Sea Marine Park (PERSGA/GEF 2001).

In Djibouti, coastal and marine tourism are still in their infancy (PERSGA/GEF 2001). In the past European tourists visited between October and March, mainly for scuba diving at the Sept Frères Islands.

Tourism in the central-southern Red Sea and in the Gulf of Aden is significantly

less developed than in the northern Red Sea. In Saudi Arabia in the mid-1990s a considerable number of large projects (including recreational facilities, hotels and restaurants) were developed around the Jeddah area, mostly for domestic tourists and locals (PERSGA/GEF 2001; PERSGA/GEF 2004e). A small number of domestic tourists visit the Farasan Islands but, unlike northern Red Sea nations, there is limited dive-related tourism (GLADSTONE 2000).

In Yemen, coastal and marine tourism presently play a minor role in the national economy. However, there are plans for extensive tourism developments in the Belhaf-Bir Ali area on the Gulf of Aden coast. At present, there is a scuba operation based at Mukalla. Limited tourist facilities exist on the Red Sea coast at al-Khaukha (PERSGA/GEF 2001).

5.4.1 Issues, Trends, Responses

Coastal development for tourism in Egypt has particularly occurred around Hurghada and Sharm el Sheikh. Other centres of more recent development include Dahab, Nuweiba and Taba on the Gulf of Aqaba coast, Safaga and Quseir on the Red Sea coast, and the northern sector of the Gulf of Suez. Rapid, loosely controlled development has occurred around Hurghada and Sharm el Sheikh, with continuous belts of coast allocated to tourist development. In 2000, 22.2% (or 10,549 rooms) of Egypt's total hotel capacity was located along the Red Sea coast, with the majority concentrated along a coastal stretch of 300 km (SHAALAN 2005). The tourist areas of the South Sinai were anticipated to have approximately 40,000 beds and 5 million tourists per year by 2005 (PERSGA/GEF 2001). Hurghada and Sharm el Sheikh may have been developed beyond their ecological and social carrying capacities. There are already signs of environmental degradation including in protected areas such as Ras Mohammad National Park (see Corals, Coral Reefs and Coral Communities in chapter 3).

In 2001, 66% of tourists entering Jordan visited Aqaba (PERSGA/GEF 2001). Aqaba

had 35 hotels with about 3,300 beds and an estimated 300,000 hotel bed nights annually. Significant expansion of this tourist sector, with emphasis on luxury accommodation, is projected. This is planned to include 11 five- and four-star resort hotels, a 54 hectare 'Disney type' amusement park, two golf courses and 930 vacation units.

There is currently negligible tourism in Sudan (although considerable potential exists) and no tourism in Somalia (PERSGA/GEF 2001).

The reefs near Djibouti city are more frequently visited by local tourists, mainly members of the expatriate community. Moucha and Maskali Islands in the Gulf of Tadjoura are commonly used by tourists

and the military on weekends. These are important seabird breeding areas (PERSGA/GEF 2003c). There are currently no sewage reception facilities on the islands. At current levels of usage, sewage discharge is unlikely to pose a significant threat but may become so in the future with increased tourism. Small sandy beaches on Kadda Dabali Island, in the Iles de Sept Frères, are used by tourists and fishers for landing and picnics (PERSGA/GEF 2003c). Many tourists and military personnel visit the resort at Khor Ambado each weekend (PERSGA/ALESCO 2003).

Issues for specific ecosystems arising from tourism (e.g. the impacts of dive-related tourism on coral reefs) are addressed in chapter 3.

LIVING MARINE RESOURCES

Dr Khaled Hariri

6.1 SNAPSHOT

6.1.1 Status

The unique value of the biological resources of the Red Sea and Gulf of Aden to the prosperity of the region has long been recognised. The local fisheries have provided food and employment for thousands of years.

Regional Red Sea stocks of sharks are over-fished. Over-fishing by industrial trawlers in the near-shore waters of the Gulf of Aden has depleted cuttlefish and deep-sea lobsters. Industrial trawl fisheries in the Red Sea are placing considerable pressure on shrimp stocks and other living marine resources (via the large by-catch of non-target species).

In the Egyptian Red Sea there are approximately 4,300 artisanal fishers and fishers working in semi-industrial fisheries. The semi-industrial sector includes about 230 trawlers and 83 purse seiners.

In Saudi Arabia there are over 15,800 artisanal fishers and about 160 semi-industrial trawlers working in the Red Sea.

The number of Yemeni artisanal fishers in 2004 was 75,000–80,000. The figure has almost quadrupled since 1990. Many artisanal fishers have very low income that is often supplemented by loans. The foreign industrial fleet stood at slightly over 130 boats in 2004 but by 2006 had fallen sharply to less than 30 boats due to management measures taken by the government.

Artisanal fisheries are under-exploited in Djibouti, Sudan and Somalia.

Catches by industrial fisheries of Indian mackerel, kingfish, sharks, cuttlefish, shrimp, rock-lobster and trochus have declined.

Collecting of fishes for the aquarium trade is significant in Saudi Arabia and Yemen.

Marine aquaculture in the region includes shrimp farming in Egypt and Saudi Arabia and pearl-oyster farming in Sudan.

6.1.2 Progress

The regional status of the living marine resources in the Red Sea and Gulf of Aden has been assessed and baseline information has been collected.

There has been a substantial rise in capacity in fish stock assessment, data collection and analysis; environmentally sound aquaculture; fisheries management; and ornamental fish assessment and management. Two training facilities and a reference collection centre have been established and equipped. There is an increased awareness among decision makers of the complementary linkages between conservation of the environment and sustainable development.

A system is in place for the standardised collection and transfer of fisheries data.

Information has been obtained for Egypt, Jordan, Djibouti, Saudi Arabia and Yemen on the trade in ornamental fishes and its impact on the environment. A management plan for ornamental fishes has been prepared.

The management of elasmobranch fisheries has improved through: training; an identification guide; a management plan; and improved data collection.

New fisheries regulations have been issued in Egypt, Saudi Arabia and Yemen. Additionally, fisheries management plans were prepared for Socotra (Yemen) fisheries and rock lobsters.

6.1.3 Constraints to Continued Progress

There is insufficient data collection and analysis, and minimal monitoring. In Egypt, Sudan and Jordan data collection is *ad hoc* and poorly organised, and in Somalia very little reliable information is available. There is minimal enforcement of regulations and penalties for infringements are too low to act as an effective deterrent or to encourage compliance by fishers.

Lack of funding has constrained the following: human resource development; the development of national and regional monitoring, control and surveillance systems; and research and monitoring.

The institutional and technical capacities for conducting research and stock assessment studies are weak.

The Regional Commission on Fisheries is not established.

The implementation of regional programmes is constrained by the socioeconomic variations among the member countries of the region.

A focus on ecological studies without any consideration to socioeconomic aspects has limited the potential for sustainable management.

Coordination between the ministries that are responsible for fisheries and for the environment is weak or inadequate and the agencies carry out their activities independently.

The direct effects of fishing on fish stocks and its indirect effects on the marine environment are not well understood.

Fisheries resources management in the member countries of PERSGA is still dominated by top-to-bottom decisions.

The last regional stock assessments were made in the late 1980s.

The legal framework providing for fisheries management and development is

weak in many countries. Internationally accepted models for management are not incorporated, such as the principles laid down in the FAO Code of Conduct for Responsible Fisheries or the establishment of fisheries management plans.

Participatory approaches involving all stakeholders in fisheries management are totally lacking.

A lack of awareness of the need for and benefits of effective fisheries management by stakeholders in the fisheries sector is a critical problem.

A lack of infrastructure in many rural areas in Sudan, Somalia and Yemen's Red Sea coast limits the expansion of artisanal catches and often results in poor quality and, consequently, reduced earning potential for rural fishers.

6.2 INTRODUCTION

The Red Sea and Gulf of Aden (RSGA) region is located in an arid and semi-arid geographical zone. However, the diverse habitats and ecosystems of the RSGA have endowed it with rich fisheries resources. The Red Sea has a number of unique marine habitats, including seagrass beds, salt-pans, mangroves, coral reefs and saltmarshes (see also chapter 3). The Gulf of Aden is an area of oceanic upwelling, resulting in high productivity of fish resources, particularly towards the eastern end. The Socotra Archipelago constitutes a separate ecosystem; the importance of its unique environment and endemic biodiversity is on a par with the Galapagos Islands. The RSGA has always been a vital maritime trade-route linking Europe with the other continents of the Old World. Over the course of the past few decades, the oil industry and marine transportation of oil have increased the significance of the RSGA. This has placed it in the centre of the geopolitical strategies of the industrialized nations. At the same time an increasing interest in the living marine resources (LMR) of the region and their habitats has developed both at the local and international levels.

The unique value of the biological resources of the RSGA to the prosperity of the region has long been recognized, particularly among the coastal populations. The local fisheries have provided food and employment for thousands of years especially in the Gulf of Aden where nutrient-rich cold water rises during the monsoon periods provide ideal conditions for the growth of plankton and subsequently their predators, the fish. The Gulf of Aden is considered a fish-rich area and is generally under-exploited, the fisheries consisting of mostly small pelagics (sardines and anchovy) and several high-value demersal species. The unexploited resource of mesopelagic fish in the Gulf of Aden as well as in the Gulf of Oman, estimated to be not less than 1.5–2 million tonnes, is another resource which offers potential.

One of the components (i.e. Component 3) of the Strategic Action Programme for the Red Sea and Gulf of Aden (SAP), executed by PERSGA during the period 1999–2003, dealt with the sustainable use and management of LMR in the RSGA. PERSGA/SAP identified, in 1999, the following as the major issues to be addressed:

- Lack of information on trans-boundary stocks
- Inadequate data on benthic and demersal stocks
- Unregulated exploitation of high profile species especially sharks and lobsters
- Lack of co-operation in management of shared stocks
- Lack of training in collection of fisheries data
- Lack of public awareness in sustainable use of LMR
- Lack of surveillance and enforcement of existing fisheries regulations
- Shrimp and fish farming resulting in environmental degradation
- Lack of monitoring.

This chapter is intended to update information on the status of LMR in the RSGA with a focus on the development of management of these resources, particularly fisheries resources, at the regional and national levels. It highlights

the impact of SAP/LMR activities in terms of the achievements, the constraints and the prospects for increased regional cooperation to achieve sustainability and optimal fisheries resources management in the region. Linkages with other SAP components are briefly discussed. Most importantly, the chapter explains the socioeconomic aspects related to the use of LMR, particularly the fisheries resources. The chapter briefly examines the extent of success of the countries of the RSGA region in addressing the issues mentioned above at the national and regional level. The analysis is mostly based on recent data and information on the LMR status, particularly fisheries resources, in Egypt, Saudi Arabia and Yemen.

6.3 BACKGROUND

The coral fringing reefs of the Red Sea, with their complex and diverse associated fauna, are world-renowned. Most fringing reefs extend only a few tens of metres from the steep shores in the north, but where there are old alluvial fans, and further south, they commonly extend a kilometre seaward from alluvial plains up to seven kilometres wide. Offshore, extensive series of submerged limestone platforms form the foundations for a barrier reef. Further south, fringing reefs diminish and in many places are completely replaced by broad and thick stands of mangrove and extensive seagrass beds, by muddy flats and sand deposits. Calcareous red 'algal' reefs exist in the absence of coral reefs, and a very conspicuous increase in brown algae, mainly *Sargassum*, occurs on shallow hard substrates.

Mangrove systems have developed in the conditions prevailing in the relatively nutrient poor (or oligotrophic) waters of the Red Sea, characterized by high salinity, high temperatures and low oxygen concentration, which limit faunal diversity. A major consequence of the Red Sea mangroves is the accumulation and retention of sediments and prevention of coastal erosion. Mangroves are well developed especially in the southern part of the Red Sea, contributing their high primary productivity to the ecosystems of the area and providing important nursery grounds

for a wide range of marine and terrestrial fauna. Sandy beaches provide important nesting grounds for marine turtles.

Seagrasses constitute the only group of higher plants to have adapted to a sub-aquatic habitat and inhabit shallow water areas with soft benthos, in depths usually between the mid-tidal level to about 70 m depth. The RSGA's seagrass areas are highly productive ecosystems where many species of living marine resources abound. For example, in the Khor-Umeira lagoon in the west of the Gulf of Aden, *Halodule* spp. provide important feeding grounds for green turtles (*Chelonia mydas*) and many species of sea cucumbers, that form the basis of important artisanal fisheries (HARIRI et al. 2002).

The oceanographic characteristics of the region offer considerable potential for scientific research and investigation. To oceanographers the Red Sea is a nascent ocean and essentially a product of the divergence of the African and Arabian plates, and further research is needed to fully understand its development. The Gulf of Aden's abundance of fish species is due to upwelling in its eastern part, in the Arabian Sea, a phenomenon that has not been adequately studied in any detail to date.

The problems of physical alteration and destruction of habitats are a result of dredging and filling operations associated with urban expansion, tourism, and industrial development. In general, the main sources of marine pollution come from land-based activities, including urbanization and coastal development, industries including power and desalination plants, refineries, recreation and tourism, wastewater treatment facilities, coastal mining and quarrying activities, oil bunkering and oil tankers.

6.4 LINKAGES WITH OTHER SAP COMPONENTS

The SAP emphasized that the scope of the LMR component, which focused on ecosystem health and biodiversity conservation, was different from previous

fisheries studies in the area and the background data required were more diverse, including environmental and socioeconomic information. In the original Project Proposal of 1997, SAP Components 3 and 4, Sustainable Use and Management of LMR and Habitats and Biodiversity Conservation respectively, were treated as one component. An emphasis on socioeconomic aspects was made as follows:

- Shark fisheries: local socioeconomic parameters of fishing communities;
- Sustainable Management Strategy for Transboundary Fish Stocks and Invertebrates that includes community-based management, building on the revival and strengthening of traditional fisheries conservation practices, awareness programmes for fishing communities and other users of marine resources;
- Regional conservation plans for turtles, sea birds and marine mammals, building on traditional beliefs and conservation practices and participation of coastal communities;
- Development of small-scale pilot projects for the poorest fishing communities in Sudan and northern Somalia to reduce pressure on turtles and other near shore resources;
- Development of a regional framework for the region's mangroves for site-specific action, including sustainable use of mangrove resources, alternative animal fodder, fuel and building materials, and management of freshwater resources;
- Survey of mangrove-associated fauna with special emphasis on sensitive stages of harvestable resources;
- The significance of local mangrove nurseries and re-plantation schemes.

The Programme Implementation Phase (PIP) of 1999 emphasized the following socioeconomic aspects in the LMR component:

- Management strategies to include community-based management which builds on the revival and strengthening of traditional fisheries

- conservation practices;
- Public awareness programmes for target groups, especially fishing communities and other users of marine resources.

The PIP also emphasized the following socioeconomic aspects in the separated Conservation of Habitats and Biodiversity Component:

- Conservation plans for turtles, sea birds and marine mammals initiated through programmes for public awareness and with participation of the coastal communities;
- Small-scale pilot relief projects for the poorest fishing communities in Somalia and Sudan to reduce pressure on turtles and nearshore resources. These programmes will include the provision of boats and basic fishing gear.

Other socioeconomic aspects mentioned site-specific action for mangrove areas including sustainable use of mangrove resources; alternative animal fodder, fuel and building materials; and the management of freshwater resources. The Marine Protected Areas Component, the Integrated Coastal Zone Management and the Public Awareness Programme were also to deal with beneficiaries utilizing the LMR, and coastal communities.

6.5 ACHIEVEMENTS OF PERSGA/ SAP LMR COMPONENT

SAP Component 3 dealt with the Sustainable Use and Management of Living Marine Resources (LMR) and it was implemented by the United Nations Development Programme (UNDP). The following paragraphs briefly describe the achievements accomplished through the implementation of the SAP activities under this component.

6.5.1 The Status of the LMR in the RSGA and Their Management

A report, with the above title, was prepared based on information submitted by local

specialists from PERSGA member countries. It is a comprehensive, important document containing updated information on the fisheries resources and fishing activities in the region. The report is considered as a key reference for researchers, fisheries economists and workers in fisheries development in the RSGA region.

The report includes a range of highly generalized descriptions of fisheries and fisheries-related activities and as such is a useful initial reference source. The level of analysis is generally macro, however, and little or no information on the social dynamics of coastal communities or patterns and traditions of resource management are presented. Little or no fieldwork was undertaken during the preparation of the LMR report and there was no involvement of the communities in the identification of key challenges and priorities.

6.5.2 Elasmobranchs

Shark fishing had increased during the past two decades concomitantly with the increase in the shark-fin trade, and there is clear evidence that the regional Red Sea stocks are exposed to over-fishing as witnessed by the decline of shark catches in Yemeni fisheries. A number of species have not been caught for several years, e.g. sawsharks (family Pristiophoridae), and there is a disproportionate abundance of smaller sized individuals in the catches for several species such as the scalloped hammerhead *Sphyrna lewini* and the great hammerhead *S. mokarran*. Twenty specialists were trained during 2001 on shark identification and data collection for stock assessment. PERSGA has completed a detailed field guide for elasmobranch identification which has been published by FAO.

6.5.3 Ornamental Fishes

One training workshop was held in Jeddah (9–15 April 2000) on methods of evaluating the present status of ornamental fishes. Studies were then made in Egypt, Jordan, Djibouti, Saudi Arabia and Yemen to record the present trade in ornamental fishes and

its impact on the environment. A report was prepared, based on the studies, and it is expected that it will be used by member countries to assist sound management decision-making concerning the trade in ornamental fishes in the RSGA region.

6.5.4 Environmentally Sound Aquaculture

PERSGA held a workshop on environmentally sound aquaculture and fisheries management in Hurgada on 17 September 2000. The workshop recommended that national governments prepare and implement action plans to advance fisheries and aquaculture policies that are environmentally sound.

6.5.5 Sub-Regional Fisheries Research and Training Centres

Training under SAP Component 3 was largely conducted through workshops and on-the-job field activities. The main beneficiaries were technical staff members from the environmental and/or fisheries agencies in member countries. A report on training needs assessment in LMR management in RSGA was prepared in 2000. The identified training was to be for policy makers, scientists, technicians and fishers to develop capacities particularly on stock assessment and fisheries resources management. Although a proposal for financial support from the European Union (EU) was made, the anticipated funding was not forthcoming and many aspects of the envisaged training programmes did not occur. It was envisaged that two subregional training centres would be supported by PERSGA to conduct the training activities not only in the management of LMR but also for the other components.

In early 2001, PERSGA supplied ten computers to the Fisheries Manpower Training Centre in Aden, Republic of Yemen. The second training centre selected was the College of Marine Sciences in Jeddah (Saudi Arabia) where PERSGA also established in 2003 the Reference Collection Regional Centre (RCRC) for the LMR of the RSGA.

6.5.6 Monitoring Control and Surveillance (MCS) Systems

A report was prepared in 2000 to establish national and regional MCS systems in order to alleviate the problem of illegal fishing and poaching of fisheries resources, particularly in the southern part of the RSGA. The report was made in the form of a proposal for EU funding. Unfortunately, there was no financial support and the issue of illegal fishing and poaching still remains unaddressed.

6.5.7 Regional Commission on Fisheries

PERSGA initiated contacts with various United Nations (UN) agencies, including the Food and Agriculture Organization (FAO), to create a Regional Commission on Fisheries (RECOFI), but it has not yet been established. It is anticipated that forming a RECOFI for the RSGA would be an extremely useful tool in assisting the PERSGA member countries in the management of their shared fish stocks.

6.5.8 Improving Capacity to Manage Living Marine Resources

Several activities were conducted under SAP Component 3 in order to strengthen the capacity of PERSGA member countries to effectively manage their LMR. These included regional training workshops on fisheries statistics, and on the identification of elasmobranchs. It was envisaged that members of the working group established by PERSGA and operating under the LMR component would engage in an exchange of fisheries data and information.

The implementation of regional programmes is often challenged by the socioeconomic variation found among the member countries of the region, the conceptualization of their roles and the degree of assistance that can be given to fulfil the programme. Environmental sustainability programmes at the regional level are met, furthermore, with the problem of proper coordination with the multiple sectors involved in the environment and natural resources management in each country. Box 6.1 summarizes the limitations

Box 6.1 The limitations of implementing the SAP/LMR component

Several factors impeded the full attainment of the SAP's immediate objectives for the sustainable use and management of LMR, designed during preparation and stipulated in the PIP:

1. The non-availability or inadequacy of funding for a number of important activities. Furthermore, important objectives such as the development of MCS regional and national systems, and the publication of a comprehensive identification guide on the LMR of the region were left for non-GEF funding.
2. The proposals for EU funding and the draft letter of intent and agreement with FAO which were accomplished in the first two years of implementation were not realized. This was another constraint impeding the development of potential regional fora and agreements on the management of LMR in the RSGA region. It reflected the problem of not fully recognizing the linkages between sound natural resources management (in this case fisheries resources) and the health of the ecological environment.
3. A focus on ecological studies without any consideration to socioeconomic aspects. The limited distribution of the ecological reports meant that dissemination of the information contained in them was very restricted. There was no attempt to involve local fishers in such studies or to gain from their accumulated knowledge and their good management practices.
4. The region was not seen as a vast eco-socio system. As a result, the large numbers of fishers involved in fishing activities in countries like Yemen, Somalia, Djibouti and Sudan were virtually excluded.

At the level of member countries, a different problem existed. The main contacts of PERSGA are the official agencies responsible for the environment (including the coastal/marine environment). This is well understood on the basis of the nature of the responsibilities of PERSGA and its mandate. However, these official environmental agencies are recently formed (mostly late 1980s). They are, in general, mandated to propose environmental policies, plans and legislation. They are legally required to coordinate with other ministries and agencies, but they are not able to implement/execute management actions in other sectors under the responsibility of line ministries. Many of them are not directly represented at ministerial levels in their countries. Politically they are weak, and often looked at as hindering economic development. Their technical and technological capacities are still low and inadequate. On the other hand, the responsibility of managing fisheries resources is vested in the long established relevant line ministry (such as the Ministry of Fisheries or the Ministry of Agriculture and Fisheries). Management of LMR (mostly fisheries resources) lies directly under the ministries responsible for fisheries and not the environment. Often the mandates of the environmental agencies contain jurisdictional powers which overlap or contradict those stipulated in the mandates of the fisheries (or other marine affairs agencies if they exist) particularly in conservation of the marine environment and its resources. In effect, coordination between them is weak or inadequate and the agencies carry out their activities independently.

and constraints met by PERSGA, and the member countries, in implementing the SAP/LMR component.

6.6 THE SOCIOECONOMIC ASPECTS OF FISHERIES IN THE RSGA REGION

“Environmental management is an integral component of efforts to reduce poverty and achieve sustainable and equitable growth” (Declaration of the 2000 Millennium Summit).

The socioeconomic importance of the artisanal and industrial fisheries in the RSGA to the national economies and rural communities is significant in all the PERSGA member countries, with the exception of Jordan which has minimal fisheries in the Red Sea. However, despite the importance of fishing as a source of income and in terms of national food supply, the direct effects of fishing on fish stocks (especially vulnerable species such as sharks, cuttlefish, shrimps and rock lobster) and indirectly on the marine environment, are not yet studied well. The main reason for this is a lack of reliable information on fisheries and environmental interactions throughout the RSGA.

The relatively small area over which fisheries take place means those most important fisheries resources can be considered as being shared stocks. Many are truly highly migratory, for example tuna and small shoaling pelagic species. However, over-fishing by industrial trawlers in the Gulf of Aden near-shore waters during the past three decades has resulted in the depletion in some valuable resources, such as cuttlefish and deep-sea lobsters. These stocks have not fully recovered, due primarily to a lack of effective fisheries management. In the Red Sea, there are signs that industrial trawl fisheries for penaeid shrimps are placing considerable pressure on shrimp stocks. The large but unrecorded by-catch of non-target species taken by shrimp trawlers, which is dominated by juveniles, is having an unknown impact on the recruitment of other living marine resources. Non-fish resources

including marine turtles, mammals and sea-birds are important species in the biodiversity of the region and also require proper management measures.

Fisheries resources management in the member countries of PERSGA is still dominated by top-to-bottom decisions concerning fishing seasons, fishing grounds, control of mesh sizes, limitation of fishing effort and similar traditional measures. Mostly, single commercial species are targeted by such measures and no consideration is made regarding the interrelationships of species in a given ecosystem. The last regional stock assessments were made in the late 1980s. The legal framework providing for fisheries management and development is weak in many states. Penalties for infringements are too low either to act as an effective deterrence or to encourage compliance by fishers. Enforcement is virtually non-existent in most of the region. Internationally accepted models for management, such as the principles laid down in the FAO Code of Conduct for Responsible Fisheries, are not incorporated and executed through fisheries management plans (FMP). Participatory approaches involving all stakeholders in fisheries management is totally lacking. National institutional structures still lack the administrative and technical capacity to formulate and implement realistic and effective fisheries management policies and strategies.

A generic problem throughout the RSGA region is the lack of financial and material resources devoted by national governments to those authorities responsible for fisheries research, management and development. A lack of integrated planning and management is the basis for the rapid growth of unplanned settlements and increased pressure on coastal and marine resources. A lack of awareness of the need for and benefits of effective fisheries management by stakeholders in the fisheries sector is a critical problem. Insufficient resources are allocated to human resource development in both the public and private sectors in all PERSGA member countries.

6.6.1 Small-scale Fisheries

Small-scale fisheries (called also ‘traditional’ or ‘artisanal’ fisheries) can be defined as fisheries which constitute a labour-intensive production system based on the harvest of fish products by small units of artisanal craftsmen (generally belonging to the same household, a cluster of households or the same kin group) with or without the use of external hired workers. In the RSGA region the term artisanal fisheries should not be considered as subsistence fisheries.

The main characteristics of the small-scale fisheries are:

- low level of income and investment
- small amounts of capital and energy
- the large importance of the production reserved to the market
- strong dependency on the services provided by a number of external agents (e.g. auctioneers, traders, transporters, retailers)
- ownership (or rental) of relatively small, open-decked fishing vessels (less than 20 metres long) with outboard (less often inboard) engines
- organization of short fishing trips close to shore (a distance of about eight nautical miles) not exceeding seven days, but usually half-day or overnight
- strong dependency on seasonality (which includes a certain degree of migration)
- relatively modest levels of production
- use of relatively simple or unsophisticated technology and equipment (e.g. no processing equipment, except for salting, drying and, less often, icing fish)
- the various activities of the fisheries (i.e. fish catching, processing, distribution, marketing) may be made by full-time resident, migrant, seasonal, part-time, and full-time fishers and/or by specialized associate stakeholders (wholesalers, retailers, auctioneers, transporters).

This general definition obviously gives only a static picture of the production system. The reality is more dynamic and complex, as individual production units are heavily dependent on a variety of social, economic and ecological variables, each of which can have more or less of an impact (BONFIGLIOLI & HARIRI 2004).

In the RSGA region many artisanal fishers form fishers’ cooperatives (see Box 6.2) which provide several services to their members particularly in the form of providing fishing gear or engine spare parts at less than the market price, in addition to saving the fisher from the burden of going to the usually distant town to buy goods. They also provide soft loans for the purchase of boats/engines or act as guarantors to their members, thereby assisting them to obtain credits from commercial banks.

Box 6.2 Definition of a cooperative

According to the official International Cooperative Association (ICA) a cooperative is ‘an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through jointly-owned and democratically-controlled enterprise’. A cooperative comprises a legal entity owned by its members, with no passive shareholders. Unlike a union, a cooperative may assign different numbers of votes to different members; typically a cooperative is governed proportionally according to each member’s level of economic interest in the cooperative. However, many cooperatives maintain a strict ‘one member—one vote’ policy to avoid the concentration of control by an elite. Cooperatives may be generally classified as either consumer or producer cooperatives depending on their function.

Egypt

In Egypt fish catches from the Red Sea Egyptian waters (Gulf of Suez, Gulf of Aqaba and Red Sea) for the past four years are shown in Table 6.1.

Table 6.1 Fish catches from Red Sea waters of Egypt (source: BARRANIA, A. 2005, pers. comm.).

Year	Production (tons)
2001	73,549
2002	72,889
2003	70,408
2004	63,914

Official statistics show that artisanal fishers in the Egyptian Red Sea waters use 917 small boats with lengths between 6 and 15 metres. These are operated with outboard engines of 20–200 h.p. There are also 982 non-powered sail boats of 6–7 metres lengths. There are 5,084 artisanal fishers and their fishing gear is made up of beach seine nets, gillnets, trammel nets, longlines, veranda nets and cast nets. There are 4,308 artisanal fishers and fishers working in semi-industrial fisheries enrolled in 13 cooperatives. The cooperatives provide fishing gear and equipment to their members at prices lower than the prevailing market prices. Some

cooperatives provide social services to their members and neighbouring communities such as medical services or on certain social occasions (marriage, death and births). The cooperatives give soft loans to their members and sometimes act as guarantors for them if credits are obtained from the commercial banks. In addition, there is the 'Fund for Supporting Cooperatives' which is jointly administered by the 'Water Resources Cooperatives' Union' and the 'Public Authority for Water Resources'. The Fund provides short, medium and long term soft loans to the cooperatives to enable them, in turn, to provide loans to their members under suitable conditions. However, the Fund's resources are often inadequate and the cooperatives turn to commercial banks to satisfy their needs.

There are several fish landing sites, but only two of them could be considered as small fishing ports with wharfs and shore facilities. These are the Ataqa landing site in Suez and the Hurghada fish landing site in Hurghada. Table 6.2 shows the average monthly revenue per type of fishing vessel operating in the Red Sea waters. Table 6.3 shows the average monthly expenditure per type of boat and Table 6.4 shows the average monthly revenue per fisher per type of boat. There is no available data for average monthly income per household.

Table 6.2 Average monthly revenue /fishing boat in Egyptian pounds (£) (source: BARRANIA, A. 2005, pers. comm.) (US\$1.00 = £5.763).

Type of Boat	Good Season	Bad Season
Trawler	150,000	80,000
Purse Seiner	70,000	50,000
Longliner	60,000	40,000

Table 6.3 Average monthly expenditure (£) by different fisheries in Egypt (source: BARRANIA, A. 2005, pers. comm.).

Type of Boat	Good Season	Bad Season
Trawler	30,000	25,000
Purse Seiner	30,000	25,000
Longliner	15,000	12,000

Table 6.4 Average monthly revenue (E£) per fisher in Egypt (source: BARRANIA, A. 2005, pers. comm.).

Type of Boat	Good Season	Bad Season
Trawler	1,100	900
Purse Seiner	600	500
Longliner	2,000	1,500

Saudi Arabia

In Saudi Arabia, 15,866 artisanal fishers were recorded as operating in the Red Sea in 2004. They were made up of 5,114 fishers, 481 walking fishers, 9,477 labourers, and 753 temporary fishers. There were also 41 fishers who were investors in fishing boats but no longer practised fishing. The number of boats involved in fishing activities was 8,952 of which 157 were semi-industrial boats and the rest (8,795) were small, traditional, open-deck boats.

The catch is principally composed of the following: family Serranidae, *Scomberomorous commersoni* (family Scombridae), family Lethrinidae, family Carangidae, family Lutjanidae, other fishes in the family Scombridae, elasmobranchs and *Siganus rivulatus* (family Siganidae) (Table 6.5).

Table 6.5 Fish catch from the Red Sea of Saudi Arabia in 2004 (source: QAZZAZ, M. 2005, pers. comm.).

Type of Fish	Quantity (tons)
Family Serranidae	2,813
<i>Scomberomorous commersoni</i>	2,778
Family Lethrinidae	2,521
Family Carangidae	2,284
Family Lutjanidae	887
Barracudas	795
Family Scombridae (excluding <i>S. commersoni</i>)	589
Elasmobranchs	413
<i>Siganus rivulatus</i> (Family Siganidae)	372

There are two fishers' cooperatives, in Thawl and in Amluj. These cooperatives provide services to their members such as boats and engine repairs, supply of ice and supply of fishing gear and equipment (Mr. QAZZAZ LMR-WG member for Saudi Arabia, September 2005, pers. comm.). Services to the community are in the form of a contribution to the building of a kindergarten. The Agriculture Bank provides credits to the artisanal fishers. In 2004 allocations were made to build wharfs in Amluj, Qunfutha and Farasan. In addition, the private sector constructed a number of small fish landing facilities.

Yemen

In Yemen, the fisheries sector is of high economic significance due to the geographical location of the long coastline, the hydrometeorological conditions leading to the production of relatively rich LMR resources, the large number of fishers and other persons involved in fisheries-related activities, the supply of fish protein to the domestic market and the foreign earnings from export.

Yemeni waters constitute a complex and unique tropical marine ecosystem. The length of the Yemen coast is 2,350 km. In addition, the Republic of Yemen possesses many islands in the Red Sea, in the Gulf of Aden and in the Arabian Sea. Yemen claims sovereignty over a territorial sea of 12 nautical miles, a three nautical mile coastal limit and a 200 nautical mile exclusive economic zone (EEZ) off the southern coast. The number of Yemeni artisanal fishers in 2004 was estimated to be between 75,000 and 80,000. The figure had almost quadrupled since 1990 when the number of fishers was reported as only 20,000 (MINISTRY OF FISH WEALTH

STATISTICS DEPARTMENT Report 1991). By the end of the last decade the number of artisanal fishers had exceeded 55,000. The increase in the number of artisanal fishers could be attributed to the influx of emigrant returnees who had no other work opportunities except to join the fisheries. In addition, the Yemen government initiated several programmes, granting small fishing boats and/or subsidizing prices of the boats to new entrants to the fishing profession, as part of its effort to alleviate poverty. A small but unknown number of fishers and/or labourers in fishing boats have arrived as refugees from Somalia and Eritrea.

Most of the Yemeni fishers are members of the 107 fishers' cooperatives spread along the coastline and the larger islands of Kamaran and Perim in the Red Sea and the Island of Socotra in the Gulf of Aden (Figure 6.1, Table 6.6). There are 37 cooperatives located along the Red Sea, 64

along the Gulf of Aden and 6 in Socotra. Many of the cooperatives, especially those along the Yemen Red Sea (YRS) coast, are recent and were established after 1998. Details on governance, management and development of small scale fisheries in Yemen can be found in BONFIGLIOLI & HARIRI (2004).

The fishers' cooperatives form the Yemeni Fish Cooperatives Union. The Union has branches at the governorates level. It acts as an umbrella to cooperatives and functions as a representative of Yemeni fishers at the national level. It receives and disseminates fisheries information, trains cooperative staff and seeks funding for development projects for the cooperatives. The fishers' cooperatives in Yemen can be classified into three categories: strong, mediocre and weak. The criteria for this classification are based on the number of members, assets, financial status, fishing and marketing



Figure 6.1 Map of Yemen coastline overlooking the Red Sea and Gulf of Aden (source: www.fao.org/fi/fcp/en/YEM).

Table 6.6 The contribution of fishers' cooperatives in Yemen to total fisheries production and value during 2000–2003 (source: Fish Cooperatives Union Yemen, Status of Artisanal Fisheries May 2004); (US\$ 1.00 = YR 192.5, September 2005).

	2000	2001	2002	2003
Total Yemen fish catch landed (in tons)	114,750	142,198	179,584	228,000
Total Yemen fish catch landed by members of fishers' cooperatives (in tons)	98,965	122,493	155,477	209,000
Value of Yemen's fish catch (in YR)	19,424,454	23,919,332	33,091,660	35,000,000
Value of fish catch landed by members of fishers' cooperatives (in YR)	16,173,117	20,604,725	28,649,501	32,033,000

activities carried out, services provided to the members and the coastal communities, compliance with the prevailing laws in book keeping, accounts at the bank, and regular meetings of the operational bodies in the cooperative such as the board of directors, the audit committee and the general assembly.

The artisanal fishers deliver their catch to 50 landing sites spread along the coastline (Figure 6.1). The artisanal fishers operate from 14,000 boats mostly constructed of fibreglass and powered by outboard motors (OBM) or inboard engines depending on the size of the boat. They are all open-deck boats. Two types of boats are used by the local fishers:

1. The *huri* is the most common type of boat used. It is a canoe-like boat (from 6 to 20 metres length) of 15, 20 or 25 tons hold-capacity, with an outboard engine. The crew is generally made up of 2 to 6 persons. Originally, the *huri* was for inshore use, but today, larger *huris* (with two OBM of 75 horsepower each) are built and used for offshore fishing. *Huris* larger than 15 m are made of wood. Smaller *huris* (between 7 and 11 m) are made of fibreglass. The *huris* are single-day fishing boats, and their fishing areas are close to shore, within a range of about 20 nautical miles. Small *huris* can be seen anchored or lying on the beach, at all fishing centres. They cannot be operated when the seas are too

rough and in the Red Sea this is between October and December.

2. The *sambuq* is a large wooden boat, with an inboard engine. There are different types of *sambuq*, ranging from 25 to up to 70 tons hold-capacity, with 12–15 m long keels and 150–250 horsepower diesel engines. The *sambuqs* operate like the larger *huris*. They differ in the total duration of their fishing trips (up to 10 days at sea), capacity (up to 5 tons of iced fish), and size of the crew (10 to 20 persons or more).

On the Red Sea coast of Yemen there are only four to five viable cooperatives performing satisfactorily, 10 to 11 mediocre semi-operational cooperatives, and 14 to 16 cooperatives that are weak and performing unsatisfactorily. The strong, fully operational cooperatives prevail in the Gulf of Aden, particularly to the east. Many of them were established in the 1970s. The two most well-established fishers' cooperatives are the Mukalla and Shihr Cooperatives in Hadhramaut. Both were established in 1966.

BONFIGLIOLI & HARIRI (2004) described the different types of Yemeni fishers' cooperatives as:

- **The fully-operational cooperatives:** These cooperatives were created in the 1970s and the 1980s and their members have therefore developed the culture of self-help organizations.

They have an average of about 400 members, own key assets (e.g. petrol stations, processing areas and sheds, landing sites, cold stores, insulated trucks), and are able to provide a large variety of services to their members including auctioning and social security. The forms of social security provided by these cooperatives may include the following: a form of health insurance (i.e. payments during sickness or operations); support in cash (grants or soft credit) or in-kind during occasions of marriage or death, including those of direct relatives (mothers, wives, fathers, sons and daughters); payments for severe injuries during fishing if the accident prevents the fisher from continuing fishing even if it continues until death (e.g. blindness due to stings from rays); and support to widows if lonely and not supported by her own family members. These cooperatives may also produce a surplus. The surplus allows them to embark on some income-generating projects (e.g. agricultural plantation, investment in small boat-building yards) and some social activities. In the Red Sea area, only four cooperatives belong to this first category.

- **The semi-operational cooperatives:** These cooperatives, with an average of 100–200 members, undertake a number of activities. However, having been created more recently, they have only a few assets and are able to provide only a limited number of services (e.g. credits to purchase fishing gear) to their members. Their sources of revenue are limited, mainly linked to auctioning (a total of 5 per cent of the value of the catch) and sale of shares to the members.
- **The run-down cooperatives:** These cooperatives are relatively new, small, with little or no assets. The members pay their annual fees and some leaders regularly participate in major meetings. However, the cooperatives are not able to

undertake any significant economic or social activities. One reason is that their members joined them under the mistaken assumption that cooperatives were a simple means to obtain funds from the government or external donors.

In Yemen, fishers' cooperatives have been conceived and more or less successfully developed as the only organizations capable of supporting the sound development of artisanal fisheries and of also tackling the great variety of social and economic problems of their members. It would be extremely difficult for the cooperatives to cease their social services and shift totally to business activities in the absence of appropriate entities capable of providing the same services.

Sudan

Sudan's Red Sea artisanal fleet comprises all locally-made wooden boats. Boat-building continues to be an important activity along the coast, especially near Suakin. Non-mechanized dug-out canoes, mechanized 'houris' and 'sambuqs' using OBMs and inboard diesels are used. Fishing methods include handlines, bottom-set and pelagic gillnets, surrounding nets, trolling, cast nets and traps. Handlining accounts for over 80% of catches. The most productive areas are the inner edges of the offshore reefs. The main species taken by the handline fishery include groupers, emperors, coral trout, and snapper (especially *Lutjanus bohar*). Pelagic species caught include Spanish mackerel, barracuda and jacks. Gill nets are employed to take rabbitfish (e.g. *Siganus rivulatus*), unicornfish (e.g. *Naso unicornis*), grey mullets, trevallies and wrasses (e.g. *Cheilinus undulatus*).

Hand-diving for trochus shell or 'kokian' (*Tectus dentatus*), *Trochus virgatus* and black mother-of-pearl shell (*Pinctada margaritifera*) is also important for income generation in the coastal areas where lack of ice and other shore and road infrastructure constrains the marketing potential of fresh fish to the domestic market. Traditionally, the Suakin area was the centre of kokian

fisheries, but the main production area recently shifted to Mohammed Qol and Dungonab Bay (ANONYMOUS 1988; ELTAYEB 1999). The shells are collected by free-diving from *houris* (4 m long with sails), *felukas* (6–8 m long with engines) and launches (8–12 m long with engines). The main fishing season is May–December and reflects the monsoon season rather than any legislative control.

A former Overseas Development Aid (ODA) funded project introduced the exploitation of sea cucumber (beche-de-mer) along the Sudanese coast. Production was based on two species (*Holothuria* sp. and *Actinopyga* sp.). In 1981, 15 t of dried sea cucumber were exported. Thereafter, production stopped because of low prices on export markets and difficulties in collecting. However, in the present situation of declining fish and kokian landings, sea cucumber exploitation has resumed in the Marsa Ashat area south of Suakin.

Djibouti

In Djibouti, the artisanal fleet comprises some 90 fishing boats. Most are small, open boats of 6–8 m length and powered by OBMs. Each boat operates with an average of three fishers. Fifteen per cent of the boats are equipped with inboard engines. They are 10–14 m in length and carry an average of five fishers per boat. The small boats undertake one day trips while the larger boats usually stay out for four days. The main fishing areas are to the north and south of the Gulf of Tadjoura. The northern area is most productive and least exploited because of a lack of cold storage and other shore facilities and its distance from the city of Djibouti, the main population centre.

The main fishing gear includes ring nets, handlines (the most common method), trolling, gillnets and cast nets. The main species caught include snappers, jacks, Spanish mackerel, barracuda, groupers and tunas especially skipjack (*Katsuwonus pelamis*) and little eastern tuna (*Euthynnus affinis*). Fishing operations vary seasonally, with most activity in May and minimum activity in February. Many Djiboutian

fishers operate at the subsistence level and fishing effort is generally low. The number of artisanal vessels has more than doubled since 1992. Most boats have a crew of about three persons, but those employing surrounding nets have larger crews. A *sambuq* has a crew of around 10. Small fibreglass boats are normally owned by one of the three fishers operating it but joint ownership by two or more fishers is common. Non-fishing boat owners are rare.

6.6.2 Semi-Industrial/Industrial Fisheries

Semi-industrial boats could be defined as simple trawlers/seiners or multi-purpose fishing boats with hulls constructed from wood, steel or fibreglass. They are not open deck and have cabins for the captain, second mate, engineers and crew. Most of them use ice in insulated holds for preserving fish. Some of the fish caught may also be preserved in salt or brine solution or preserved by sun-drying or smoking. They have simple radio, radar and navigation equipment and normally stay at sea for a fortnight.

Industrial fishing boats/vessels are high seas, long distance, navigating, fishing boats usually equipped with freezers, cold stores and sometimes other processing plants such as fishmeal plants and/or canneries. There are no national, industrial fishing vessels belonging to the PERSGA member countries and operating in RSGA region. The industrial fishing boats belonging to Saudi Arabian boat owners are mostly shrimpers of small and medium sizes. The boats working outside Saudi Arabian waters are equipped with freezers and cold stores. The industrial vessels of foreign countries may be fishing in the southern waters of the RSGA either by poaching or legally under licences issued by the fishing authorities concerned.

In Egypt the semi-industrial sector includes 228 trawlers powered by inboard 400–1000 h.p. engines that vary in length between 24 and 30 metres. These fishing vessels use bottom trawl nets. There are 83 purse seiners powered by inboard engines of

300–400 h.p. that engage in seining during daylight. All the semi-industrial boats use ice to preserve the catch in insulated holds. The fishers working on these boats are all nationals. They are paid a percentage of the value of the catch after deducting the costs of the fishing trip.

In Saudi Arabia the semi-industrial boats number 157 and most of them fish by bottom trawl nets. There are no processing plants or equipment on board. Most of the crew are foreign labourers and are either paid wages or a percentage of the catch.

In Yemen, foreign companies were licensed on the basis of annual agreements with the Ministry of Fish Wealth (MFW). For the industrial fisheries, there are 23 fishing companies in the industrial sector working in Yemen waters, 11 in the Red Sea and 12 in the Aden Gulf and the Arabian Sea. These companies caught 17,858 tons of fish in 1998, principally demersal fish and cuttlefish. Production by sector over the period 1999–2002 is shown in Table 6.7. In 2004 the licensed foreign industrial fishing fleet included 131 boats, 63 in the Red Sea and 68 in the Gulf of Aden and the Arabian Sea. However, the number of industrial trawlers decreased sharply in 2005 due to management measures taken by the government, and by the end of 2006 only 26 trawlers were operational, 10 at work in the Yemeni Red Sea and 16 in the Gulf of Aden.

The main groups of fishes caught are: small pelagics (sardines, anchovies, Indian mackerel, horse mackerel); large pelagics (bluefin tuna, longtail tuna, barracuda, black runner, king fish); highly migratory species (yellowfin tuna, sharks); and demersal species (snappers, groupers, jacks).

The average monthly revenues of Yemeni fishers vary between Red Sea fishers and Gulf of Aden fishers due to the difference of the systems of sharing revenues in the two areas and the capacity of fishers' cooperatives. Details of revenues and expenditures per type of fishing boat and per household in two selected districts in the two fishing areas are shown in Box 6.3.

In the Red Sea most of the cooperatives do not have their own auction sheds where the catch is auctioned. Instead the fishers depend on private auctioneers who are paid 5% of the value of the catch. The auctioneer, due to the weakness of the cooperatives, is also the money lender, the buyer of the fish, and the exporter. In general, the fishers are poor along the YRS coastline. Along the Gulf of Aden coastline, the situation is quite different. The cooperatives are mediocre or strong, but they all have their own auction sheds. The strong cooperatives pay the auctioneers monthly wages according to their work during fish landing in the daytime and the evenings.

The living marine resources targeted by the artisanal fisheries sector are under-exploited

Table 6.7 Production (in tonnes) of fish and other marine organisms by sectors for the period 1999–2002 in Yemen (source: Fisheries Statistics Book, MFW July 2005).

	1999	2000	2001	2002
Public sector	271	86	188	216
Co-operative sector	109,835	98,965	122,493	155,477
Mixed sector	269	0	2,715	4,878
Private sector (vessels of local and foreign companies)	14,009	15,699	16,802	19,013
Total	124,384	114,750	142,198	179,584

Box 6.3 Comparison of artisanal fisheries expenditures and revenues in selected Yemen Red Sea and Gulf of Aden areas (source: BONFIGLIOLI AND HARIRI 2004).

All figures are in Yemeni Rials (YR); at the time of the study US\$ 1.00=183 YR.

Red Sea

1. Small *hour* (7 m l.o.a*; 5.5 m keel; 15–40 h.p. outboard engine)

Gross Revenue

Average sales in low season 2,500YR/d for 25d/month for 6 months.....	375,000 YR
Average sales in high season 4,000 YR/d for 25d/month for 6 months.....	600,000 YR
Total	975,000 YR

Deduction from sales 5% (auctioneer), 3% (FMSC), 2% (cooperative).....	97,500 YR
Revenue/boat	877,500 YR

Expenditure

Petrol 20 L/d at 50YR/L for 300 d	300,000 YR
Lubrication oil and engine maintenance	50,000 YR
Sub-total	350,000 YR

Net revenue/year	527,500 YR
Income for crew (3 persons) (50% of net revenue)	263,750 YR
Income per fisher/year	88,000 YR
Income/fisher/month	7,340 YR

Boat owner revenue (50% of net revenue)	263,750 YR
Depreciation for engine (5 years) per year	50,000 YR
Depreciation for boat (10 years) per year	35,750 YR
Fishing gear purchase per year	5,000 YR
Net income/year for boat owner	173,000 YR
Income per month for boat owner	14,400 YR

Household expenditure

Household monthly expenses are 12,000–20,000 YR. To cover the deficit the fisher normally turns to the auctioneer to borrow to pay for monthly household needs.

2. Large *hour* (9–11 m l.o.a*, 7–8.5 m keel; 55–75 h.p. outboard engine)

Gross Revenue

Average sales in low season 3500 YR/d for 25d/month for 6 months.....	525,000 YR
Average sales in high season 6000 YR/d for 25d/month for 6 months	900,000 YR
Total	1,425,000 YR

Deduction from sales 5% (auctioneer), 3% (FMSC), 2% (cooperative)	142,500 YR
Revenue/boat	1,282,500 YR

Expenditure

Petrol 30 L/d at 50 YR/L for 300 d	450,000 YR
Lubrication oil and engine maintenance	70,000 YR
Sub-total	520,000 YR

Net revenue/year	762,500 YR
Income for crew (3 persons) (50% of net revenue).....	381,250 YR

Box 6.3 continued. Comparison of artisanal fisheries expenditures and revenues in selected Yemen Red Sea and Gulf of Aden areas

Income per fisher/year	127,080 YR
Income /fisher/month	10,590 YR
Boat owner revenue (50% of net revenue)	381,250 YR
Depreciation for engine (5years) per year	120,000 YR
Depreciation for boat (10years) per year	50,000 YR
Fishing gear purchase per year	6,000 YR
Net income/year for boat owner	205,250 YR
Income per month for boat owner	17,100 YR
Fishers in Burum–Maifa’ District	
Average earnings of one fisher in Burum District through Burum Fishers’ Society (BFS)	
Gross earnings per <i>hour</i> per annum	948,733 YR
5% deduction for BFS per annum	47,437 YR
3% of the gross earnings reserved for fishers (28,462 YR). This deduction is kept as reserve for the individual fishers to use themselves whenever they need. It affects in the calculations only the cash amount received.	
Earnings after 5% deduction	901,296 YR
Fuel and lubricants cost per annum	150,000 YR
Net annual earnings	751,296 YR
Share for three fishers per annum (60% of net revenue)	450,777 YR
Income of one fisher per annum	150,259 YR
Income per month for an average fisher	12,521 YR
Boat owner obtains 2 shares for the boat and engine plus his share if he is among the crew which is usually the case.	
Consumption of Qat is low among fishers in Burum–Maifa’ as it was only introduced after Yemen unification and is not part of the tradition of the households. Average monthly household expenditure in the district ranges between 10,000 and 11,000 YR.	
* I.o.a – length overall; FMSC Fisheries Marketing and Services Corporation; BFS Burum Fishers’ Society.	

in Djibouti, Sudan and Somalia. However, declines in catches for the industrial sector are reported for several fisheries, e.g. Indian mackerel, kingfish, sharks, cuttlefish, shrimp, rock-lobster and trochus.

Collecting of fishes for the aquarium trade is significant in Saudi Arabia and Yemen. Saudi Arabia has at least seven exporters of aquarium fishes in operation (HARIRI et al. 2002).

Marine aquaculture in the region includes shrimp farming in Egypt and Saudi Arabia, and pearl-oyster farming in Sudan. In Yemen a private local company is starting construction of a shrimp farm in the

Luhayyah–Midi coastal area north of Hudaydah. It is important to note that no environmental impact assessment had been carried out prior to the construction. Hence, there is no environment management plan and no mitigation measures have been suggested (HARIRI 2005).

6.7 FISHERIES DATA COLLECTION

The efficiency of fisheries data collection, analysis and dissemination systems varies throughout the Region. Saudi Arabia and Djibouti have reasonable systems in place to monitor catch by species at major landing sites. In Egypt, Sudan and Jordan data collection is *ad hoc* and poorly

organized, and in Somalia very little reliable information is available. Data for the industrial fleets is generally of better quality than artisanal fleets, but the greater socioeconomic importance of artisanal fisheries underlines the fact that improved monitoring of artisanal activities is urgently required. Current data collection systems are designed to record catch at landing sites for the production of annual catch summaries. Biological information is not generally recorded.

6.8 FISH PROCESSING

Fish processing information is also unrecorded. National authorities do not have access to data of sufficient quality to allow stock assessment or economic evaluation of fisheries activities. Shore-based facilities are relatively well developed in Egypt, Saudi Arabia and along Yemen's Gulf of Aden coast. Most artisanal catches are marketed freshly chilled on ice. However a lack of ice machines, cold storage, fish processing and marketing infrastructure in many rural areas in Sudan, Somalia and Yemen's Red Sea coast limits the expansion of artisanal catches and often results in poor quality and, consequently, reduced earning potential for rural fishers. Large stretches of Sudan's coastline are without even basic facilities. The lack of infrastructure in Sudan, especially ice and road communications, has led to increased pressure on resources such as trochus, pearl shell and beche-de-mer. Most of Somalia's shore facilities were destroyed during the civil war in the 1990's. Consequently fishing pressure on sharks has increased for the production of sun-dried meat and fins. This is not only because sun-drying requires minimal infrastructure, but also because dried sharks' fins (particularly large white dorsal, pectoral and tail fins) attract high prices in the south-east Asian markets.

The photo beside (Plate 6.1) shows sharks in Qusaiyer, east of Mukalla, in the Hadhramaut

governorate. It is worth mentioning that shark meat is consumed sun-dried, salted or smoked in the Hadhramaut, or cooked as ground shark meat or in sauce in other parts of Yemen.

6.9 EXPORT OF LIVING MARINE RESOURCES

Yemen is the main LMR exporter in the RSGA region. Table 6.8 shows the fishery product exports of Yemen during the period 1999–2002.

It should be noted that the exports do not reflect the catch in a particular year, as part of the catch is exported in the following year. The export of shark fins in 2002 was increased compared to the previous years. The rise could be attributed to the following: increased exports early in 2002 for fins dried in 2001; increased landings of dried fins caught in neighbouring countries for exports from Yemeni ports; increased exports of grade 11 and 111 (small fins and black fins).

Exports of sea cucumber increased in 2001 and then in 2002 because of more entrants to the fishery in those years. Fishers moved to new fishing grounds adjacent to a number of the Yemeni islands in the Red Sea (e.g. Habl Island). Fishers move from one island to another once they clear sea cucumber



Plate 6.1 Drying sharks in Qusaiyer (Hadhramaut, Yemen) illustrating traditional processing for dried shark meat (Photo: K. Hariri, June 2005).

Table 6.8 Exports of fish for the period 1999–2002 from Yemen (in tons) (source: Fisheries Statistics Book, Ministry of Fish Wealth, July 2005).

Product	2002	2001	2000	1999
Fresh fish	24,601	15,574	6,873	6,065
Frozen fish	17,827	13,648	6,350	6,887
Fish fillets	1,087	340	136	40
Shark fins	183	9	8	22
Ground fish (fishmeal)	281	203	16	20
Anchovy	0	0	15	771
Dried fish	415	1,758	590	30
Shrimp	694	472	497	622
Lobster tails	23	22	33	46
Deep-sea lobster	0	0	0	4
Live lobster	63	41	45	36
Lobster whole frozen	147	35	24	12
Cuttlefish	6,946	15,192	7,170	5,338
Sea cucumber	259	20	0	9
Squid (<i>harika, yarika</i> *)	149	207	185	371
Other invertebrates	84	1	0	0
Blue crab and octopus	0	0	21	1
Total	52,759	47,522	21,963	20,274

*Japanese names for two types of squid.

from the previous island. Unfortunately they do not follow safe diving practices, do not use modern diving equipment and dive individually rather than in pairs (HARIRI 2005). The increase in fishmeal production from 2001 is due to the operations of a new privately owned fishmeal plant with a capacity of 150 metric tons/day in Al Ghaidha in the Mahra governorate. Cuttlefish catches declined in 2003 because of overfishing which had occurred in the previous year.

6.10 FISHERIES MANAGEMENT TRENDS IN THE RED SEA AND GULF OF ADEN 2000–2005

“Conservation and management measures, whether at local, national, subregional or regional

levels, should be designed to ensure the long-term sustainability of fishery resources at levels which promote the objective of their optimum utilization and maintain their availability for present and future generations; short term considerations should not compromise these objectives” (from the Code of Conduct for Responsible Fisheries, FAO).

Management of LMR still needs to be fully addressed by the countries of the region at the local and regional levels. Undoubtedly, PERSGA/SAP efforts during the period 1999–2003 have paved the way for further actions and initiatives to realize fully the sustainable use and management of LMR, particularly the commercial fisheries

resources. Box 6.4 highlights some of the impacts of SAP activities on LMR management.

Fisheries management in member countries of PERSGA and at the regional level is still characterized by the following:

- Weak statistical data collection systems, though a number of countries, benefiting from SAP and FAO training, are improving their data collection from landing sites. Semi-industrial and industrial fishing fleets have more reliable statistics.
- The institutional and technical capacities for conducting research and stock assessment studies are weak. Research institutes lack adequate funding for operational costs.
- The legal framework providing for fisheries management and development is weak in many states. Penalties for infringements are too low to act as an effective deterrence and encourage compliance by fishers. Enforcement is virtually non-existent in most of the region.
- Internationally accepted models for management are not incorporated,

Box 6.4 SAP impacts on the management of living marine resources (LMR) in the Red Sea and Gulf of Aden (RSGA).

PERSGA/SAP activities led to several positive impacts, though limited, at the national and regional levels that are expected to lead directly and/or indirectly to improved management of the LMR. Examples of such impacts are:

- *Increasing the natural capital* in terms of a better understanding of the habitats and ecosystems in the RSGA as reflected in the several studies conducted through various SAP components.
- *Increasing, to some extent, the human capital* in terms of training through workshops and field activities of all SAP components.
- *Increasing awareness, at least among decision makers*, of the complementary linkages between conservation of the environment and sustainable development. It emphasized the significance at the national level of participatory approaches and involvement of all stakeholders in the decision-making processes pertinent to natural resources management. This notion of participation was conspicuous in the SAP Integrated Coastal Zone Management (ICZM) component. Integrating LMR in ICZM plans is envisaged to become part of the agenda of the national authorities concerned with the implementation of ICZM plans.
- *Initiating contact with FAO and other relevant UN agencies* for the purpose of establishing a regional commission on fisheries (RECOFI) to handle problems of management of shared stocks and trans-boundary stocks and bring together efforts of PERSGA member countries to improve current management practices.

However, it is apparent that some of the issues identified during the preparation of the SAP and the PIP were not addressed at all, while others were only partially addressed, and the objectives were not fully realized. There were several good outputs on ecological studies, including well-structured and scientifically sound reports on several topics. But, the outputs including the so-called ‘action plans’ were not linked to implementation modalities and rarely contained options aimed at changing on-going approaches to resource management, and replacing them with recommended and clearly spelled out, ‘better approaches’. No attempt was made to build on existing management practices found amongst local communities in the coastal areas in the region.

such as the principles laid down in the FAO Code of Conduct for Responsible Fisheries.

- Lack of monitoring, control and surveillance systems weakens the ability to penalize infringements of the laws and regulations regarding fisheries management. It has encouraged poaching especially in the southern Red Sea, Somalia, and Yemeni waters in the Gulf of Aden and Socotra.
- Lack of awareness of the need for and benefits of effective fisheries management by stakeholders in the fisheries sector.
- Countries which regulate fishing effort in the RSGA region use traditional management practices based on stock assessment studies to limit fishing effort.
- There is limited development of Fisheries Management Plans (FMPs). Currently, there are no FMPs in place in Djibouti, Jordan, Saudi Arabia, Somalia or Sudan.

It should be noted that stock assessment is much more than predicting sustainable yield levels. Sustainable yield is only one of many considerations for fisheries management and development and in many cases is both unknowable and reasonably unimportant. In a new fishery, expected changes in catch rate will be much more important than potential yield and in a developed fishery managers usually want to know if yields can be improved by reduced fishing effort. In both these cases the actual estimated potential yield is not the most pressing question.

The fishing of sharks is largely carried out by the Yemeni fishers in the RSGA region (Plate 6.2). Management of shark fisheries need to be developed through a combined effort of PERSGA member countries.

A conceptual diagram that indicates the relationship between stock assessment and the various fishery management functions in a hypothetical 'model' fishery is indicated in Figure 6.2.

Nonetheless, some countries progressed towards improved LMR management practices during 2000–2005.

Egypt

In Egypt, for instance, some of the regulations issued were:

1. *Resolution 410 for 2001* issued by the Chairman of the Board of Directors of the Public Corporation for Fisheries Resources Development. The resolution specifies mesh sizes of the nets used in Hurghada and its islands. It prohibits using some types of nets in coral reef areas.
2. *Resolution 424 for 2001* issued by the Chairman of the Board of Directors of the Public Corporation for Water Resources specifying mesh size of the nets used in fishing red mullets.
3. *Resolution 410 for 2002* issued by the Minister of Agriculture prohibiting fishing sea cucumber in marine protected areas, around the islands and in coral reef areas.



Plate 6.2 Dried shark fins for export to south-east Asia (Photo by K. Hariri, June 2005).

4. *Resolution 22 for 2003* issued by the Governor of the Red Sea banning sea cucumber fishing for a period of one year starting from March 2003.

Some resolutions are renewed annually e.g. the resolution that stops shrimp fishing in Suez and Hurghada during June–September (BARRANIA, A. 2005. pers. comm.). However, there is no integrated Fisheries Management Plan (FMP) for the Egyptian Red Sea fisheries. The exception is the effort of the Program Support Unit to prepare such a plan within the Egyptian Environmental Policy Program.

Saudi Arabia

Similar resolutions (in terms of controlling mesh size, season openings and closures) are also undertaken by the Ministry of Agriculture in Saudi Arabia to regulate the catches of the main commercial species.

Yemen

In Yemen, due to the depletion of a number of important stocks targeted for export

(such as cuttlefish, lobsters, shrimps, sea cucumber, demersal fishes, sharks) several major activities were undertaken during the period 2000–mid 2005. The objectives were to allow for stock recovery and more importantly establish effective fisheries resources management in order to maintain the sustainability of use of these valuable resources. These activities included preparation of policies and strategy documents, resolutions controlling fishing efforts and FMPs. The main documents, published in Arabic, were:

1. ‘Main Trends for Organizing Fishing Operations in the Marine Waters of Yemen’ issued by MFW (2003/4 undated). This document describes the classification of fishing boats, fishing methods and fishing gear, the water areas according to distances from the low water mark for each type of fishing boats, fishing areas (zones), fishing effort, fishing seasons, criteria for licensing fishing, management of rock lobsters, management of cuttlefish, fishing agreements, financial

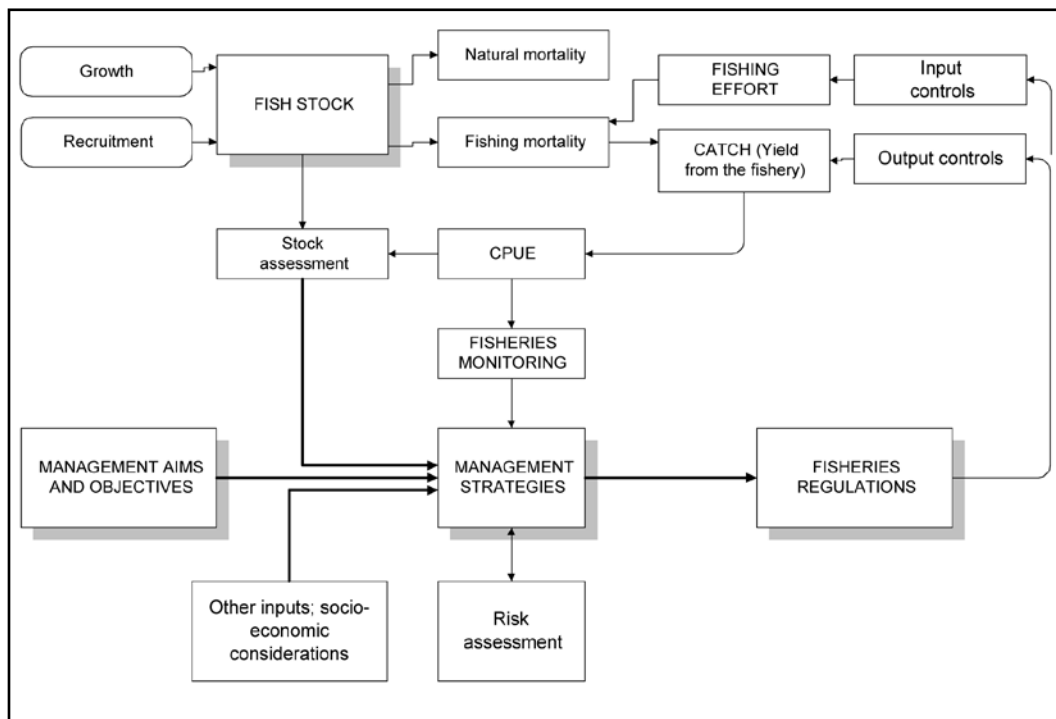


Figure 6.2 Functional relationships between stock assessment, management objectives, strategies and regulations (source: HARIRI et al. 2002).

resources, marine monitoring and surveillance and quality control, reception and transportation boats for fish products, and developing the fisheries infrastructure. The document then elaborates on the objectives and benefits which would ensue from the trends, provides standard forms of agreements concerning fishing for coastal fisheries, industrial fishing outside eight nautical miles from the low water mark, and fishing pelagic and demersal fishes in the EEZ.

2. 'Ministerial Resolution (63) for 2004 on the Mechanism for Obtaining Licenses for Coastal and Industrial Fishing Boats' Issued by Minister of MFW (18/10/2004). It has 14 articles. Articles 2–13 deal with the required procedures for conducting coastal fishing activities.
3. 'Evaluation Report on the Activities of the Yemeni Fish Cooperatives Union for the Period June 2002–October 2003' issued by the YFCU Executive Bureau –October 2003.
4. 'Status of the Artisanal Fisheries and its Development Role' (May 2004).

The increased number of licensed foreign trawlers resulted in heavy pressure on demersal species and commercial invertebrates. Frequent violations of the fishing licences, fish discards and destruction of fishing gear belonging to artisanal fishers augmented the problem. In May 2003, the minister of MFW banned all foreign trawlers which had finished their licence period, no licences were renewed and no new ones were issued. The resolution was appreciated by the fishers and resulted in increased production of fishers' cooperatives as well as exports.

An integrated participatory FMP for Socotra fisheries was completed in 2001 under the GEF-funded project 'Conservation and Sustainable Use of the Biodiversity of Socotra Archipelago.' Slight modifications

were made in 2003 but the FMP, for a number of reasons, was not implemented. Another plan was prepared with assistance from FAO for the management of rock lobsters *Palinurus homarus* in Hadhramaut coastal areas. Yemen has an ongoing project funded by the EU to develop capacity in monitoring, control and surveillance systems of fisheries operations.

In 2004/2005 a new fisheries programme was prepared for funding by the World Bank and the EU specifically concerning fisheries resources conservation and management. The first phase is expected to commence in early 2006. The programme comprises stock assessment of some species, improving quality control, establishing and implementing FMPs for important species at governorate levels, developing the capacity of fishers' cooperatives and developing fisheries infrastructure.

6.11 FUTURE REGIONAL COOPERATION IN LMR MANAGEMENT

Management of the LMR must be built on sound data collection systems, sustainable institutional processes, national structures, participation of the fishers' communities, and use of their management practices and knowledge. PERSGA has a significant role to play in developing the capacities of its member countries to prepare FMPs, at the national and regional levels, along the following lines:

- *RECOFI*: contacting FAO and urging member countries to contact FAO to establish the regional forum for fisheries management (RECOFI). The experience of the RECOFI in the Gulf area, in terms of its relationship with the Regional Organization for the Protection of the Marine Environment (ROPME), could be beneficial to the region.
- *FMP*: assisting member countries in preparing FMPs based on full participation of fishers and other stakeholders.

- *Linkages with fishers*: ecological studies must involve fishers and make use of their accumulated knowledge and experience.
- *Significance of socioeconomic assessments*: linking environmental management with the socioeconomic conditions of coastal communities is a *sine qua non* requirement for sound management.
- *Environmental management and poverty alleviation*: poverty alleviation ranks high on the agenda in Djibouti, Eritrea, Somalia, Sudan and Yemen. The LMR are relatively rich, particularly in the Red Sea area south of latitude 20°N and in the Gulf of Aden where thousands of fishers and their families in the coastal communities depend for their livelihoods on these resources. The interconnectedness between poverty and over-exploitation of the environmental resources must be studied to design appropriate management measures.
- *Subregional approach*: effective LMR sustainable use and sound management would require unemotional approaches in confronting the problems associated with the use of natural resources. The similarities and level of technical and technological capacities among neighbouring countries are of paramount importance in the management of the LMR. The potential for subregional cooperation amongst the southern countries in the RSGA region appears to have great and as yet untapped potential.

OPTIONS FOR ACTIONS

Dr William Gladstone, Captain Roy Facey, Dr Khaled Hariri

7.1 INTRODUCTION

Significant progress in conservation of the marine environment of the RSGA has been made in a relatively short time. A number of fundamental issues remain that need to be addressed to ensure continued progress. The actions needed are laid out in excellent detail in the various regional action plans produced as part of the SAP. Also, many of the actions cross over all regional action plans. A number of issues and needs have been revealed in relation to continued state of the environment reporting.

Definition of Red Sea and Gulf of Aden Boundaries and International Maritime Boundaries

The IMO MARPOL Convention 73/78 currently defines the RSGA differently from the definition used in the Jeddah Convention. The Jeddah Convention includes the Suez Canal, and takes the boundary of the Gulf of Aden out to the east of the Socotra Archipelago. In order to further protect the RSGA from marine pollution, particularly from pollution by invasive aquatic species, it would be very useful for PERSGA to open negotiations with the IMO with a view to amending the definition of the RSGA currently found in MARPOL 73/78 to be the same as that contained in the Jeddah Convention.

Agreements on maritime boundaries between states can bring about important benefits. These include the development of marine resources within national EEZ's, avoidance of disputes, clarity in search and rescue operations for ships or persons in distress, and the co-ordination of efforts to combat marine pollution when an incident occurs. PERSGA should take every opportunity to encourage states to establish bilateral or tri-lateral committees to establish agreed maritime boundaries for all states in this region.

7.2 RESEARCH AND MONITORING

Continued efforts to develop innovative and appropriate conservation and management approaches will be enhanced by a strong culture of pure and applied research and monitoring. In particular local scientists need encouragement and financial and logistical support to undertake research on the information gaps raised in this report and in the various action plans. This requires long-term investment in university education and the training of young researchers (e.g. by providing international scholarships).

Specific research gaps revealed by this state of the environment report include:

- Reports of illegal dumping of toxic wastes off the coast of Somalia indicate that a potential issue exists for the ecosystems and human uses of the Gulf of Aden from the spread of these toxic wastes via ocean currents. A risk assessment needs to be undertaken covering the impact of illegal dumping of toxic wastes on the Gulf of Aden (and for other areas where this may take place). This would take into account the most up-to-date information on current patterns in the region, and seek to obtain additional information (e.g. more detailed information on currents) where existing information is inadequate.
- The extent of sabkha in Sudan, Djibouti and Somalia, and the status of sabkha in all RSGA countries is not known. There are no standard methods for the assessment and monitoring of sabkha. Given the high primary productivity of sabkha this represents a major gap in the ability of agencies to conserve sabkha and manage human uses of this ecosystem.

- The status of saltmarsh throughout the RSGA is not known.
 - The status of intertidal sandy and muddy shores (and their associated species) throughout the RSGA is not known.
 - The status and ecology of intertidal rocky shores throughout the RSGA is poorly known. The limited regional distribution of rocky shores and their unique biota emphasizes the importance of conserving representative samples within the boundaries of MPAs.
 - The status of algal communities throughout the RSGA is unknown.
 - The distribution of seagrass beds is poorly known in parts of the Gulf of Aden (Yemen and Somalia), Djibouti, and Sudan.
 - The status of populations of marine turtles and the distribution of habitats, particularly at foraging sites, is poorly known.
 - The population status of all breeding seabirds has not been determined. Information is especially needed for the following species: Jouanin's petrel (*Bulweria fallax*); Persian shearwater (*Puffinus persicus*); Masked booby (*Sula dactylatra*); Swift tern (*Sterna bergii velox*).
 - The status of the marine mammal fauna of the RSGA, including species of cetaceans and identification of significant sites for dugong and cetaceans (especially the western coast of the Red Sea) is not well known. Of the 15 species of cetaceans known to occur in the RSGA two are Threatened species (Endangered or Vulnerable), five are dependent upon conservation actions to prevent their listing as Threatened, five are insufficiently known to assign a conservation status, and three are Secure. The number of species listed as 'insufficiently known' highlights the need for further information. The presence of two Threatened species highlights the great need for properly designed surveys and monitoring to assess the trends in their population numbers.
 - The population of dugong in the Mukawwar Island and Dugonab Bay MPA (Sudan) may be the most important remaining on the coast of Africa. Its status is unknown.
 - The impacts on the marine environment of contaminated runoff arising from pesticide use in the coastal zone and catchments in some countries have been insufficiently studied.
 - There is an urgent need for further taxonomic studies (including the compilation of inventories and distribution maps) for many groups. Such studies are the basis of conservation planning, ecological research, and environmental assessments.
- The results of research and monitoring programmes, in addition to informing conservation planning and on-ground management, will be utilized in future state of the environment reports to assess trends. Five issues are important for this data to be most useful:
1. It is essential that monitoring programmes are designed to incorporate all potential sources of variation at all relevant spatial and temporal scales. Only then can the extent of natural variation be described and the significance of any trends assessed. Monitoring programmes should be designed with the assistance of qualified statisticians and ecologists familiar with this approach.
 2. Monitoring programmes must be resourced for long periods of time to allow the magnitude of natural dynamics to be understood, and must be seen as a core activity of the responsible agency. Only in this way can baseline conditions be determined.
 3. Trigger points for action need to be set for each of the variables monitored. This must be based upon understanding of the natural

dynamics of the variable being measured and its ecology and biology.

4. Monitoring data needs to be collated in a PERSGA database and be readily accessible.
5. It is certain that research and monitoring will occur other than that coordinated by PERSGA, e.g. by universities, overseas scientists, consultants. This research is usually published in the international scientific literature. PERSGA should maintain an up-to-date database of scientific publications on all aspects of the marine environment of the RSGA. An excellent format for this is PERSGA's Bibliography of Oceanographic and Marine Environmental Research.
6. Additional data and information relevant to future state of the environment reports are published in the annual reports and other related documents produced by state agencies and authorities (e.g. the annual reports of the Suez Canal Authority). PERSGA should identify these relevant agencies and authorities and request copies of annual reports (and other relevant documents) to be forwarded routinely to PERSGA headquarters for inclusion and cataloguing in the PERSGA library.

The continued implementation of the Regional Environmental Monitoring Programme must be supported as a priority. Substantial progress has been made in beginning the monitoring of dissolved nutrients and physico-chemical parameters in Egypt, Jordan and Saudi Arabia. It is essential that this implementation continue, and be supported, in the remaining nations. Implementation of the monitoring programme in Djibouti, Sudan and Yemen will require continued support and capacity building owing to limitations in scientific infrastructure and trained personnel.

Understanding and responding to ecosystem degradation must be based upon monitoring that integrates both chemical (e.g. dissolved nutrients) and biological variables (e.g. sea urchins, herbivorous fishes).

Extensive and rapid coastal development and the occurrence of commercial benthic trawl fisheries throughout large parts of the region mean that there is an increasing need for monitoring soft bottom fauna throughout the RSGA.

Records of oil spills within the region are limited at present and there is no table giving the number of spills each year, the volume spilled, and types of oil spilled. Such information would be very useful in establishing whether any pattern of spills exists, which parts of the RSGA are particularly liable to suffer from spills, and the causes of the spills. PERSGA should arrange for further work to be done in order to prepare this information, together with an electronic version of a map showing the locations of spills that can be maintained and kept up-to-date. The work should seek out information available from ports and maritime authorities in the region, and should include a section on 'lessons learned' from previous incidents. In line with this objective, PERSGA should continue to encourage the establishment of regionally agreed procedures for investigating marine accidents, and provide further training in investigation methods.

Community participation in monitoring is currently occurring through the Reef Check programme. There are potentially other opportunities for community-based monitoring that should be explored e.g. the involvement of fishers in monitoring turtles, whale sharks, or manta rays.

7.3 MARITIME TRANSPORT

The status of hydrographic surveying in this region leaves much to be desired and the base of skills available within the region to undertake such surveys is very limited. PERSGA should take every opportunity of securing support for hydrographic survey work in the region, in cooperation with the

International Hydrographic Organization, the UK Hydrographic Office, the World Bank and other organizations that may be able to offer assistance. The need to re-survey regional waters to modern international standards in order to define accurately coastlines and provide data for up-to-date charts is a task that will take many years to accomplish. There is an immediate need to prove or disprove some shallow patches in the southern Red Sea that could affect future ship routing measures, to conduct surveys in the area off Port Sudan, Bashayer and Suakin and to re-survey the central section of the Red Sea. Surveys of the eastern end and central sections of the Gulf of Aden would provide data on which forecasts of the likely impact of any future tsunami in the Indian Ocean on the coastal areas of the Gulf of Aden can be made.

The RSGA will become a Special Area under MARPOL 73/78 when states in the region have established adequate reception and treatment facilities for dirty ballast and tank washing water from tankers. Regional states would then be in a position to ratify MARPOL 73/78, which is not the case at present. PERSGA should review the need for reception facilities throughout the region, including facilities for the reception of sewage, and encourage at least the major ports that do not yet offer these facilities to establish them. In addition, PERSGA should arrange for a questionnaire to be circulated to shipping companies calling at regional ports, based on standard IMO forms, to determine what reception facilities for ship waste are required at ports in the region. To provide the shipping industry with the information ships require in voyage planning in relation to where ships can discharge MARPOL waste materials, a map of the region should be produced showing what reception facilities are available at each of the region's ports. The map and full details of the facilities available should be published and posted on PERSGA and port web sites. This measure will assist in the process of allowing IMO to decide when the Special Area status of the RSGA will enter into force.

PERSGA should also make all member states, and Eritrea, aware of the important provisions contained in the 1996 Protocol to the IMO Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972. It should provide support for the establishment of the necessary legal structures and competent authorities in member states and encourage them to become parties to this Protocol, then establish a mechanism for regional cooperation on the prevention of illegal dumping in the waters of the RSGA. It should request IMO to provide technical assistance as appropriate and necessary.

Sub-standard shipping is being controlled to some extent by Port State Control (PSC) inspections carried out in the region. At present PERSGA member states and Eritrea are variously members of the Gulf Memorandum on PSC, the Indian Ocean Memorandum on PSC, the Mediterranean Memorandum on PSC, or no memorandum of understanding (MoU) on PSC. For the purposes of co-ordinating control of sub-standard shipping that could seriously harm the marine environment in the region, this situation is undesirable. PERSGA should seek a mechanism through which states in the RSGA become members of an MoU on PSC, which could be the Indian Ocean MoU on PSC, to link the region with the control of sub-standard shipping activities in the wider Indian Ocean. It is possible that Egypt may wish to become a member of the Indian Ocean MoU in addition to its membership of the Mediterranean MoU. Similarly, Saudi Arabia may wish to take out membership of the Indian Ocean MoU in addition to its membership of the Gulf MoU. As Aqaba lies in the Gulf of Aqaba/Red Sea, Jordan may wish to re-consider whether it should be a member of the Indian Ocean MoU rather than the Mediterranean MoU. An alternative would be for a separate MoU on PSC to be established for the PERSGA States and Eritrea, but this has disadvantages in terms of costs and administration.

PERSGA achieved an important breakthrough when the new routing measures in the southern Red Sea were

adopted for use by international shipping, providing guidance for ship masters and navigators on routes to be followed in this important sea area. This work was achieved as a result of carrying out a costly hydrographic survey of the area in which the new routing measures lie, but has also led to the publication of improved and re-schemed charts of the region that are of great benefit to international shipping. To further extend the benefits of routing measures for shipping in the Red Sea in particular, PERSGA should carry out a study of additional measures designed to guide ships in those parts of the Red Sea that lie between the routing measures that already exist in the Gulf of Suez and in the southern part of the Red Sea. The purpose of the new measures would be to separate north bound and south bound streams of traffic throughout the Red Sea by a suitable distance. Such new measures could virtually eliminate 'end-on' encounters by ships and would greatly simplify the task for crossing traffic and through traffic in deciding on actions to be taken to avoid collisions. The new measures would be based on research carried out on the existing tracks used by vessels in the Red Sea, as required by IMO guidelines on establishing new routing measures.

7.4 CONSERVATION

The RSGA Regional Network of MPAs will not be fully effective until site-specific management plans have been developed for each MPA and are being implemented and enforced. Each of the MPAs is in a different stage of establishment and implementation. Their progress towards establishment and implementation of day-to-day management should be monitored for future state of the environment reports as indicators of the effectiveness of management.

MPAs proposed for the Regional Network that still require declaration are:

- Giftun Islands and Straits of Gubal (Egypt)
- Strait of Tiran (Egypt/Saudi Arabia)
- Wajj Bank, Sharm Habban and

Sharm Munaybirah (Saudi Arabia)

- Aibat & Sa'adadin Islands, Saba Wanak (Somalia)
- Belhaf and Bir Ali area (Yemen)

Gaps exist in the protection provided by currently designated and proposed MPAs:

- Marine turtles: the following important nesting and feeding grounds of marine turtles are currently unprotected by MPAs: Shedwan, Wadi Al-Gimal, Ras Banas, Sarenka, Siyal Islands, Zabargad, and Rowabil Islands (Egypt); Ras Baridi (Saudi Arabia); Raas Xatiib to Raas Cuuda (Somalia); and Jabal Aziz (Yemen).
- Breeding seabirds: the following Important Bird Areas are a priority for inclusion in MPAs or other similar strategy, to protect breeding seabirds: Moucha and Maskali Islands (Djibouti); Tiran Islands (Egypt/Saudi Arabia); Hurghada Archipelago (Egypt); Aibat and Sa'adadin Islands, Mait Island (Somalia); Suakin Archipelago (Sudan); Kamaran and associated islands, Al Zubayr Island, Al Zuqar Island (Yemen).
- Safeguarding a greater proportion of the region's mangroves requires the declaration of the remaining MPAs and their enforcement. All mangroves within existing MPAs are in good condition.

The Regional Network includes sites in each country that are regionally significant and representative. National networks of MPAs are also required in each country to ensure representation of all levels of marine environmental diversity throughout the RSGA.

Coastal cetaceans and dugongs in other areas of the Indian Ocean and parts of the Arabian Gulf are under great pressure. The long-term survival of the dugong will almost certainly rely on the establishment of an adequate network of MPAs where the impacts of human activities can be minimised. Specific conservation action is required for dugong in Mukawwar Island

and Dugong Bay MPA (Sudan). This should include a ban on fixed fishing nets in areas of the MPA important for dugong.

Regional action plans modelled on the existing plans for mangroves and coral reefs are required for: sabkha, saltmarsh, intertidal sandy and muddy shores, intertidal rocky shores, seagrass, algal communities, and subtidal soft bottoms.

Specific conservation action is required for the breeding seabird White-eyed gull (*Larus leucophthalmus*); its status is Near Threatened.

7.5 LIVING MARINE RESOURCES

The process of collecting region-wide baseline information that was begun in the SAP needs to continue so that the appropriate fisheries management plans can be refined and modified in light of changing future circumstances.

Funding is required for further training that was not covered during the SAP. The priorities for further training are:

- Fisheries statistical data collection from landing sites. This will require training of fishers.
- LMR biological data collection, at landing sites, for management purposes. This involves the training of technical staff.
- Concepts and objectives of fisheries management plans. This training should include high level policy and decision-makers in agencies responsible for fisheries management.
- Stock assessment with an emphasis on models for multiple species, multiple gear and multiple direct exploiters of the fishery stocks (for fisheries scientists).
- Fish handling, processing and marketing (domestic and international markets). Training should include fishers and staff of fishers' cooperatives.
- Integrating fisheries in coastal areas management. This will involve

the training of fishers, fish traders, cooperatives, and local officials in different sectors that benefit from the coastal areas.

- Environmental impact assessments and environmental management plans of fisheries projects including aquaculture and mariculture projects.
- Training on safety requirements in all aspects in the fisheries sector including boats, shore facilities and transportation facilities. This training must include fishers.
- Traceability requirements for fishery exports. This involves training for fishers and fish traders. Training could be undertaken in close collaboration with INFOSAMAK (Centre for Marketing Information & Advisory Services For Fishery Products in the Arab Region).
- Monitoring, control and surveillance (MCS) systems, technologies and techniques.

The subregional training centres in Aden and Jeddah should be used as much as possible for training in LMR and other relevant needs.

Funding is required to establish national and regional monitoring, control and surveillance systems. Improved monitoring of artisanal activities is urgently required.

Forming the Regional Commission on Fisheries (RECOFI) in the RSGA will provide a useful tool that can assist the PERSGA member countries to manage their shared stocks. This will require a regional approach to FAO from PERSGA and national approaches to FAO from individual nations.

Research is needed to support management of living marine resources. As far as possible research must involve fishers and make use of their accumulated knowledge and experience. In particular, research is needed into:

- the effects of fishing on fish stocks and the marine environment

- the inter-connectedness between poverty and over-exploitation of environmental resources.

Management of living marine resources needs to be integrated with broader environmental management. There is a need, for example, for environmental impact assessments to be part of all aquaculture developments.

Linking environmental management with the socioeconomic conditions of coastal communities is an essential requirement for sound management. Poverty alleviation is required in Djibouti, Eritrea, Somalia, Sudan and Yemen. Improvements in infrastructure to allow the processing and storage of fish are needed to reduce the fishing pressure on other species such as sharks.

PERSGA member countries require assistance (technical, financial) in preparing fisheries management plans. In particular, the management of shark fisheries needs to be developed through the combined efforts of PERSGA member countries.

The similarities and level of technical and technological capacities among neighbouring countries are of paramount importance in the management of the living marine resources. The potential for subregional cooperation amongst the southern countries in the RSGA region appears to have great and as yet untapped potential.

Production of guidelines for proper fish handling, transporting, storing, and processing of fish and fishery products must be undertaken in close collaboration with FAO.

Fishing societies and cooperatives need to be encouraged to replace destructive fishing with more sustainable practices e.g. replace gill netting of sharks by longlines. This is essential for proper management.

PERSGA member countries need to be encouraged to prohibit demersal trawling and the use of explosives in fishing.

PERSGA could assist member countries in institutional and legal capacity building of the environmental and fisheries management agencies to bridge and strengthen coordination towards sustainable use of the resources.

7.6 CAPACITY BUILDING AND INSTITUTIONAL STRENGTHENING

Clear differences in capacity remain between the nations of the RSGA. This review has revealed differences between countries in the availability of scientific information and in the implementation of management. The issue of scientific capacity was addressed under the needs for research and monitoring. This will be supported by additional capacity building in relevant technologies such as scuba diving, remotely operated vehicles, side-scan sonar and multibeam echo sounding, satellite mapping and geographical information systems (GIS).

Government agencies responsible for the marine environment may have limited technical expertise or actual experience in marine environmental management and species conservation. Although training workshops were held as part of the SAP these must be ongoing to cater for staff turnover. Further needs for management capacity building include training in: planning and implementation of relevant control mechanisms (legislative or procedural), development of maritime laws, integrated coastal zone management (ICZM) plans, environmental assessment methods, port facilities, MPA planning and management, and pollution management strategies.

In addition to on-ground management, available resources for MPAs need to include institutional strengthening and capacity building in conservation and assessment of breeding seabirds.

In November 2005 a workshop on ships' ballast water was held in Jeddah. Knowledge on how to control the movement of invasive aquatic species carried in ballast water remains very limited within the region and much work needs to be done to improve

the current situation. As first steps towards improving the situation PERSGA should undertake the following:

- Continue to liaise closely with IMO and the GloBallast team in order to secure funding for additional training for the conduct of port biological baseline surveys of harbour and coastal waters which would provide the region with one of the tools to monitor and control ballast water discharge in future;
- Post data relating to port biological baseline surveys on the PERSGA website;
- Conduct risk assessments for all major ports in the region;
- Obtain sufficient copies of the BBC film on ballast water from IMO to circulate these to all key authorities in the region;
- Encourage ministries to require ships carrying ballast water and calling at ports and terminals in the region to maintain a 'ballast water record book', similar to the Oil Record Book, to allow the origins and destinations of ballast water to be tracked, and to require ports and terminals to maintain records of ships arriving with ballast water on board and discharging it at the port or nearby.

In the medium term, PERSGA should provide appropriate assistance, as required, to regional states wishing to become parties to IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments.

7.7 PLANNING AND MANAGEMENT

Issues are most comprehensively dealt with as part of integrated coastal zone management. ICZM plans are required in several nations or need to be implemented in other countries where they already exist. To be truly integrated these ICZM plans need to consider shipping, environmental assessment procedures, coastal development, pollution control (including oil spill contingency planning), aquaculture,

effective and enforced implementation, monitoring and evaluation.

A pressing issue throughout the region is the poor management of wastewater (sewage, industrial wastewater) and solid waste. Treatment facilities are lacking, operating above capacity, or relying on outdated technology. The problems are compounded by lack of enforcement of laws. These issues are causing localized problems for coastal habitat in all countries.

The situation regarding contingency planning in the region as a whole remains unsatisfactory. The revised PERSGA/IMO 'Action Plan for the Development of National Systems and Regional Mechanisms for Preparedness and Response to Major Marine Oil Spills in the Red Sea and Gulf of Aden', June 2005, offers a structured programme of interventions to develop the national systems of countries that do not yet have these, and to establish a regional mechanism for achieving a co-ordinated response to any major spills. PERSGA should seek donors who would be prepared to sponsor the implementation of this important Action Plan, stressing the need to have proper national and regional contingency plans in place before a major spill occurs.

An emerging issue is habitat conversion for shrimp farms. This is currently a substantial issue for mangroves regionally and the impacts need to be considered in environmental assessments of development applications for shrimp farms.

National Action Plans for corals, turtles, seabirds, mangroves (that build on the Regional Action Plans) need to be developed as a priority and provided with sufficient funding support to allow them to be implemented.

7.8 CLIMATE CHANGE

Rising sea levels in the RSGA could have serious consequences for many areas near the coast and for man-made structures, including harbours and the Suez Canal.

PERSGA should carry out a study of the RSGA coastline to determine the likely impact of a rise of say, 80 cm, on coastal areas and resources. It should also take every opportunity to support the establishment of new tide gauges, express its concern over rising sea levels at regional and international fora, and point out the potential impact on the region of rising sea levels. It should draw the attention of the international community to the probable increase in tropical species migrating through the Suez Canal into the Mediterranean as sea temperatures world wide rise.

Addressing the impacts of global climate change requires global action, and this can directly involve attempts by all global states to reduce their emissions of greenhouse gases. PERSGA should promote and support attempts by states in the RSGA to reduce their emissions of greenhouse gases, as part of its attempts to conserve the marine environment of the RSGA for future generations.

The RSGA region has already experienced extensive coral bleaching and the incidence of coral bleaching may increase in the future as sea temperatures rise in association with global climate change. PERSGA should facilitate the cooperation of regional scientists with international networks of scientists engaged in monitoring global sea temperatures for early warning signs of coral bleaching. In particular, coral reef research into the sensitivity and resilience of RSGA coral reefs (especially those reefs that form part of the regional network of marine protected areas) to bleaching events should be actively supported and encouraged.

7.9 SUSTAINABLE LIVELIHOODS FOR COASTAL COMMUNITIES

There is a great need to reduce camel grazing in mangroves, and the felling and cutting of mangrove trees. Efforts to manage camel grazing and wood collecting require alternative sources of food, fuel and construction materials to be provided.

Camels graze in mangrove because inland pastures have been degraded by over-grazing. Mangrove conservation must be integrated with efforts to achieve sustainable land management.

7.10 COMMUNITY EDUCATION

There is a need to develop community education programmes that highlight the impacts of coastal communities on reef ecology, including degradation, anchor damage, littering, solid and liquid waste disposal and souvenir collection. These could be integrated with programmes of community-based monitoring that involve recreational scuba divers or fishers.

7.11 POLITICAL

The structure and operation of government departments needs to match the ways in which marine environmental management is done, especially the need for integrated approaches to decision-making (e.g. major coastal developments). The necessary legislation and regulations exists in most nations of the RSGA. However, lack of implementation and enforcement remain as regional issues. Political support is needed to ensure that existing laws, regulations, and standards are enforced.

7.12 INFRASTRUCTURE

Infrastructure needs to be installed or upgraded for waste-water (including sewage) collection and treatment, solid waste collection and disposal, communications, and navigational aids.

7.13 NETWORKING

There is a need to integrate current research and monitoring into global initiatives such as the International Coral Reef Initiative (ICRI), the Global Coral Reef Monitoring Network (GCRMN), and the ongoing research and monitoring of PERSGA nations.

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برامج تعليمية للمجتمعات الساحلية

هناك حاجة إلى وضع برامج تعليمية تبرز تأثير المجتمعات الساحلية على بيئة الشعاب بما في ذلك التدهور والأضرار الناتجة عن مراسى القوارب، والفضلات البحرية المبعثرة، والتخلص من النفايات وجمع الهدايا التذكارية من بيئة الشعاب المرجانية. ويمكن أن يكون ذلك متكاملًا مع برامج الرصد والمراقبة المبنية على المجتمعات والتي تشمل مراقبة استخدام أجهزة الغطس الترفيهية المختلفة أو أنشطة الصيادين.

نواحي سياسية

يجب أن تتناسب هياكل وأداء الإدارات الحكومية مع الطرق المتبعة في إدارة البيئة البحرية، خصوصاً الحاجة إلى النهج المتكامل في اتخاذ القرارات (أي التطورات الرئيسية الساحلية). والحاجة ماسة للدعم السياسي اللازم للتأكيد على أن القوانين والأنظمة والمعايير السائدة يتم تطبيقها.

البنية التحتية

تحتاج البنية التحتية إلى إنشاء أو تحديث بالنسبة لجمع ومعالجة المياه المهدورة (بما في ذلك مياه الصرف الصحي) ، جمع النفايات الصلبه والتخلص منها، الاتصالات ومعينات الملاحة.

التعامل مع الشبكات

هناك حاجة إلى إدماج أنشطه البحث والرصد الحالية مع المبادرات العالمية مثل المبادرة الدولية للشعاب المرجانية ، الشبكة العالمية لرصد الشعاب المرجانية، واستمرار عملية الأبحاث والرصد للدول الأعضاء في الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن.

من المسائل الناشئة تحويل الموائل لإنشاء مزارع الربيان؛ ويعتبر ذلك حالياً مسألة جوهرية بالنسبة لغابات الشورى على مستوى الإقليم؛ ويجب أخذ التأثيرات فى الاعتبار عند إجراء تقييم التأثيرات البيئية بالنسبة لتطوير إنشاء مزارع الربيان.

تغير المناخ

يمكن أن تترتب على ارتفاع منسوب مياه البحر فى البحر الأحمر وخليج عدن عواقب خطيرة بالنسبة لكثير من المناطق القريبه من الساحل والمنشآت المقامة عليها ، بما فى ذلك الموانئ وقناة السويس. ويجب أن تسعى الهيئة إلى إجراء دراسة للمناطق الواقعة بالقرب من سواحل البحر الأحمر وخليج عدن لتحديد الآثار المحتملة لارتفاع مستوى سطح البحر على المناطق الساحليه ومواردها. كما يجب أن نغتنم الهيئة كل فرصة ممكنة لدعم إنشاء أجهزة جديدة لقياس المد والجزر ، وأن تعرب عن قلقها إزاء ارتفاع مستويات البحار فى المحافل الاقليمية والدولية ، وأن تشير إلى إمكانيه التأثير على الإقليم من جراء ارتفاع منسوب مياه البحر ، وأن تجذب انتباه المجتمع البحرى لاحتمال إمكانية زيادة هجرة الأنواع الاستوائية عبر قناة السويس إلى البحر المتوسط نظراً لارتفاع درجات الحرارة فى جميع أنحاء العالم.

لقد شهد إقليم البحر الأحمر وخليج عدن ظاهرة ابيضاض الشعاب المرجانية الواسعه، وهذه الظاهرة يمكن أن تزيد فى المستقبل بازيداد ارتفاع درجات الحرارة المرتبطه بتغير المناخ العالمى. ويمكن للهيئة القيام بتسهيل التعاون الإقليمي للعلماء مع الشبكات الدولية للعلماء فى رصد درجات الحرارة على سطح البحار فى العالم كعلامات للإنذار المبكر لظاهرة ابيضاض الشعاب المرجانية. وعلى وجه الخصوص يجب دعم وتشجيع إجراء الأبحاث على الشعاب المرجانية فيما يتعلق بحساسية ومرونة الشعاب المرجانية فى البحر الأحمر وخليج عدن (خاصة الشعاب المرجانية التي تشكل جزءا من الشبكة الاقليمية للمناطق البحرية المحمية).

سبل العيش المستدام للمجتمعات الساحليه

هناك حاجة ماسة إلى خفض رعى الإبل على غابات الشورى وقطع أشجارها. وتتطلب الجهود المبذولة لإدارة رعى الجمال وجمع الأخشاب توفير مصادر بديلة من المواد الغذائية والوقود ومواد البناء.

يجب تشجيع الدول الأعضاء فى الهيئة على منع استخدام شباك الجر القاعى واستخدام المتفجرات فى صيد الأسماك.

يمكن للهيئة الإقليمية أن تساعد الدول الأعضاء فى بناء القدرات المؤسسيه والقانونية للهيئات البيئية والخاصة بإدارة مصايد الأسماك لوضع الجسور وتعزيز التنسيق من أجل الاستخدام المستدام للموارد.

بناء القدرات وتعزيز المؤسسات

إن متطلبات بناء القدرات الإدارية تشمل : تخطيط وتنفيذ آليات الرقابة ذات الصلة (التشريعية والإجرائية)؛ تطوير القوانين البحرية؛ خطط الإدارة المتكاملة للمناطق الساحلية؛ أساليب التقييم البيئي ؛ تسهيلات الموانئ؛ تخطيط وإدارة المناطق البحرية المحمية ؛ واستراتيجيات لإدارة التلوث.

إن معرفة كيفية السيطرة على تحركات الأنواع البحرية الدخيلة والتي تتم عن طريق مياه الصابورة محدودة جدا داخل الإقليم، والحاجة ماسة لكثير من العمل يتعين القيام به لتحسين الوضع الحالي. ويجب على الهيئة الإقليمية مواصلة الاتصال الوثيق مع المنظمه البحرية الدولية وفريق عمل مشروع مياه الصابورة (GloBallast) لتأمين تمويل إضافي للتدريب، وإجراء مسوحات أساسية للموانئ والمياه الساحلية لتزويد الإقليم بوسائل المراقبة والسيطرة على تصريف مياه الصابورة فى الموانئ والمحطات فى الإقليم.

التخطيط والإدارة

إن خطط الإدارة المتكامله للمناطق الساحلية مطلوبة فى العديد من الدول أو تحتاج إلى التنفيذ فى الدول الأخرى التى توجد بها هذه الخطط.

إن مرافق معالجة مياه الصرف الصحى فى كافة أنحاء البحر الأحمر وخليج عدن فى حاجة ماسة إلى إنشاء أو تحديث؛ كما أن القوانين الوطنية ذات الصلة بحاجة إلى التطبيق.

لا يزال الوضع الراهن للتخطيط للطوارئ البحرية فى الإقليم ككل غير مرض؛ ولا بد للهيئة الإقليمية أن تسعى إلى الاتصال بالمانحين الذين ينبغي أن يكونوا على استعداد لتمويل تنفيذ خطة العمل للتخطيط للطوارئ البحرية، مؤكدين الحاجة إلى وضع خطط الطوارئ الوطنية والإقليمية موضع التنفيذ قبل حدوث أى انسكاب كبير فى الإقليم.

الحاجة إلى إجراءات محددة بغرض المحافظة على الطير البحري المعشش النورس ببيضاء العين (Larus leucophthalmus)؛ ووضعه الراهن باعتباره بالقرب من التعرض للخطر. الحاجة إلى إجراءات محددة بغرض المحافظة على الأطوم فى المنطقة البحرية المحمية فى جزيرة مكور وخليج دنقنا (السودان). وينبغي أن يشمل ذلك الحظر الثابت على استخدام شباك الصيد فى المنطقة المحمية البحرية المهمة بالنسبة للأطوم.

الموارد البحرية الحية

يجب متابعة عملية جمع المعلومات الأساسية الشاملة التي بدأت مع برنامج العمل الاستراتيجي حتى يمكن تنقيح وتعديل الإدارة المناسبة لمصايد الأسماك فى ضوء الظروف المتغيرة فى المستقبل.

الحاجة إلى التمويل اللازم لتدريب آخر لم يكن مشمولاً فى برنامج العمل الاستراتيجي. الحاجة إلى التمويل اللازم لإنشاء أنظمة وطنية وإقليميه للرصد والمراقبة والإشراف. كما أن الحاجة ماسة إلى تحسين الرصد والمراقبة للأنشطة التقليدية بصورة عاجلة. يجب إنشاء اللجنة الإقليمية لمصائد الأسماك باعتبارها أداة مفيدة فى مساعدة الدول الأعضاء فى الهيئة فى إدارة المخزون المشترك.

الحاجة إلى الأبحاث بشأن آثار الصيد على الثروة السمكية والبيئة البحرية ، والربط بين الفقر والإفراط فى استغلال الموارد البيئية.

إزالة الفقر مطلوب فى جيبوتي واريتريا والصومال والسودان واليمن؛ وكذلك الحاجة إلى إجراء تحسينات فى البنية الأساسية لإتاحة معالجة وتخزين الأسماك لتخفيف ضغوط الصيد على الأنواع الأخرى مثل أسماك القرش.

حاجة الدول الأعضاء فى الهيئة الإقليمية إلى المساعدة (التقنية والمالية) فى إعداد خطط إدارة مصائد الأسماك ، ولا سيما حاجة إدارة مصائد أسماك القرش إلى تطوير من خلال جهد مشترك للدول الأعضاء فى الهيئة. كما أن وضع مبادئ توجيهية ملائمة لصيد الأسماك ونقلها وتخزينها وتجهيز الأسماك والمنتجات السمكية يجب ان تكون فى تعاون وثيق مع منظمة الأغذية والزراعة (الفاو).

الحاجة للحصول على دعم لاستكمال أعمال المسح الهيدروغرافي وإعداد خرائط ملاحية جديدة لوسط وشمال البحر الأحمر بمعايير حديثة.

النقل البحري

الحاجة الملحة إلى مرافق استقبال في كافة أنحاء الإقليم وتشجيع، على الأقل، الموانئ الرئيسية، التي لا تقدم حتى الآن هذه المرافق، على القيام بذلك.

أن تقوم الهيئة الإقليمية بتقديم الدعم لوضع الإطار القانوني والهيكل المختصة بالشؤون البحرية في الدول الأعضاء وتشجيعها على الانضمام الى بروتوكول عام 1996 لاتفاقيه منع التلوث البحري الناجم عن إغراق النفايات والمواد الإخرى (1972). وأن تقوم الهيئة كذلك بإنشاء آلية للتعاون الإقليمي في منع الإلقاء غير المشروع في مياه البحر الأحمر وخليج عدن.

أن تسعى الهيئة الإقليمية إلى البحث عن آليه يمكن عبرها أن تتضمن الدول الأعضاء إلى مذكرة التفاهم بشأن تحكم الدولة في الموانئ.

أن تقوم الهيئة الإقليمية، بعد استكمال الدراسات المناسبة، بتقديم مقترحات لإجراءات جديدة خاصة بمسارات السفن ليتم تبنيها من قبل المنظمة البحرية الدولية، والتي سيكون من شأنها فصل مسارات السفن المتجهة شمالاً والمتجهة جنوباً على طول البحر الأحمر، وبالتالي تحسين سلامة الملاحة وتقليل مخاطر التلوث على طول هذا المسار الملاحي الدولي.

المحافظة على البيئة البحرية والساحلية

يجب ان يتم الإعلان رسمياً في أقرب وقت ممكن كل ما تبقى من المناطق المحمية البحرية غير المعلنة في البحر الأحمر وخليج عدن ضمن الشبكة الاقليمية للمناطق المحمية البحرية. كما أن الحاجة ماسة إلى خطط الإدارة للمناطق المحددة (Site-specific) لجميع المناطق المحمية البحرية في البحر الأحمر وخليج عدن ضمن الشبكة الاقليمية للمناطق المحمية البحرية.

الحاجة إلى خطط عمل اقليميه بالنسبة إلى: السبخات ، المستنقعات الملحية (saltmarsh) ، الشواطئ الرملية والطينية والصخرية في المناطق المد جزرية ، الأعشاب البحرية ، الطحالب ، والقيعان السهلة تحت المدية.

توصيات بالإجراءات ذات الأولوية

تم إحراز تقدم كبير في المحافظة على البيئة البحرية في البحر الأحمر وخليج عدن في وقت قصير نسبياً. والحاجة ماسة للإجراءات ذات الأولوية التالية لضمان استمرار التقدم في مجال المحافظة على الشعب المرجانية.

الحاجة إلى المعلومات

هناك حاجة ماسة لتحديد والاتفاق على ترسيم الحدود البحرية الدولية والمنطقة الاقتصادية الخاصة بكل دولة مطلة على البحر الأحمر وخليج عدن.

سيتم تعزيز مواصلة الجهود لتطوير نهج مبتكر ومناسب للإدارة والصون بالثقافة القوية الكامنة في البحث التطبيقي والرصد الكامل. وعلى وجه الخصوص يحتاج العلماء المحليون إلى التشجيع والدعم المالي واللوجستي لإجراء بحوث عن الفجوات في المعلومات التي أثرت في هذا التقرير وفي مختلف خطط العمل. ويتطلب ذلك استثماراً طويلاً في التعليم الجامعي والتدريب للباحثين الشباب (أى بتوفير المنح الدراسية الدولية).

تتركز المعلومات المطلوبة بصفة عاجلة على : (1) مدى ووضع معظم الأنظمة الإيكولوجية؛ (2) حالة السلاحف البحرية وموائلها؛ (3) الوضع الراهن لكل الطيور المعششة؛ (4) تحديد المواقع الهامة للتدييات البحرية؛ (5) التأثيرات السلبية في البيئة البحرية من جراء التلوث الناجم عن مياه الأمطار واستخدام المبيدات في المناطق الساحلية ومستجمعات المياه ؛ (6) تصنيف فئات كثيرة من الكائنات البحرية.

يجب أن يتم دعم استمرار تنفيذ البرنامج الاقليمي للرصد البيئي على سبيل الأولوية.

هناك حاجة متزايدة لرصد ومراقبة حيوانات القيعان السهلة على طول البحر الأحمر وخليج عدن نظراً للتمية الساحلية الواسعة والسريعة، ووجود شباك الجر القاعى لصيد الأسماك القاعية التجارية في كافة أنحاء أجزاء كبيرة من الإقليم.

هناك حاجة ملحة لسجلات حديثة مستمرة ومتسقة للانسكابات النفطية في الإقليم.

ضرورة إنشاء إجراءات متفق عليها إقليمياً للتحقيق في الحوادث البحرية وتوفير المزيد من التدريب في أساليب التحقيق.

ضعف القدرات المؤسسية والتقنية في إجراء الأبحاث والدراسات المتعلقة بتقييم المخزون. لم يتم إنشاء الهيئة الإقليمية لمصايد الاسماك.

إن تنفيذ البرامج الإقليمية تعوقها التغيرات الاجتماعية والاقتصادية بين دول الإقليم. أدى التركيز على الدراسات البيئية دون أي اعتبار للجوانب الاجتماعية والاقتصادية إلى الحد من إمكانيه الإدارة المستدامة.

التنسيق بين الوزارات المسؤولة عن البيئة ومصائد الأسماك إما ضعيف أو غير كاف وتقوم الجهات المختلفة بتنفيذ انشطتها بشكل مستقل.

الآثار المباشرة لصيد الأسماك على المخزون والآثار غير المباشرة على البيئة البحرية ليست مفهومة جيداً.

لا تزال إدارة موارد مصايد الأسماك في الدول الأعضاء في الهيئة تهيمن عليها القرارات من الأعلى إلى الأسفل.

آخر تقييم للمخزون على المستوى الإقليمي تم في أواخر الثمانينات.

ضعف توفير الإطار القانوني لإدارة مصايد الأسماك والتنمية في كثير من البلدان. والنماذج المقبولة دولياً للإدارة ليست مدرجة ، مثل المبادئ المنصوص عليها في مدونة قواعد السلوك لصيد الأسماك أو وضع خطط إدارة مصائد الاسماك.

عدم توفر النهج التشاركي الذي يشمل جميع أصحاب المصلحة في إدارة مصائد الاسماك. يعتبر انعدام الوعي بضرورة وفوائد الإدارة الفعالة لمصائد الاسماك من قبل أصحاب المصلحة في قطاع مصايد الاسماك مشكلة حرجة.

انعدام البنية التحتية في كثير من المناطق الريفية في السودان والصومال واليمن على ساحل البحر الأحمر تحد من توسيع حدود الصيد التقليدي، وكثيراً ما يؤدي الى سوء النوعية وبالتالي انخفاض الدخل الريفي المحتمل للصيادين الريفيين.

يتم جمع أسماك الزينة للتجارة بشكل ملحوظ في كل من المملكة العربية السعودية واليمن. تشمل الفلاحة البحرية في الإقليم تربية الروبيان في السعودية ومصر وتربية محار اللؤلؤ في السودان.

الإنجازات التي تحققت

تم تقييم الوضع الإقليمي الراهن وجمع المعلومات الأساسية للموارد البحرية الحية في البحر الأحمر وخليج عدن.

وكانت هناك زيادة كبيرة في القدرة على تقييم مخزون الأسماك وجمع البيانات وتحليلها؛ وتربية الأحياء السليمة بيئياً؛ وإدارة مصائد الأسماك وتقييم وإدارة أسماك الزينة. كما تم إنشاء مركزين للتدريب في مجال مصائد الأسماك ومركز إقليمي للمجموعة المرجعية. وهناك وعي متزايد لدى متخذي القرارات فيما يتعلق بالعلاقة بين المحافظة على البيئة والتنمية المستدامة.

تم وضع نظام موحد لجمع ونقل بيانات مصائد الأسماك.

تم الحصول على معلومات حول تجارة أسماك الزينة وأثرها على البيئة في مصر والأردن وجيبوتي والسعودية واليمن. وقد تم إعداد خطة تنظيمية لأسماك الزينة.

لقد تم تحسين إدارة الأسماك الغضروفية من خلال : التدريب ؛ إعداد دليل للتعريف؛ وضع خطة للإدارة؛ وتحسين جمع البيانات.

تم إصدار أنظمة جديدة لمصائد الأسماك في مصر والمملكة العربية السعودية واليمن. بالإضافة إلى ذلك تم في اليمن إعداد خطط لإدارة مصائد الأسماك بالنسبة لسوقطرة ومصائد الشروخ الصخري.

المعوقات التي تحول دون مواصلة الإنجازات

لا يزال هناك نقص في جمع البيانات وتحليلها وقلة من عمليات الرصد. ويتم جمع البيانات في مصر والسودان والأردن بصورة متقطعة وتنظيم ضعيف، وفي الصومال يوجد قليل جداً من المعلومات الموثوق بها. وهناك حد أدنى من تطبيق اللوائح ومعاينة الانتهاكات ومدنيه لدرجة أنها لا تشكل رادعاً فعالاً للمخالفين أو تشجع بذلك إذعان الصيادين.

نقص التمويل يقيد تنمية الموارد البشرية؛ ووضع نظم وطنية وإقليمية للرصد والتحكم والإشراف؛ والبحث والرصد.

الموارد البحرية الحية

الوضع الراهن

من المعلوم أن القيمة الفريدة للموارد البيولوجية فى البحر الأحمر وخليج عدن تسهم فى ازدهار المنطقة منذ زمن بعيد. فمصائد الأسماك المحلية توفر الغذاء وفرص العمل منذ آلاف السنين.

هناك صيد مفرط لمخزونات أسماك القرش على المستوى الإقليمى. كما أدى الإفراط فى صيد الأسماك من سفن الصيد الصناعية فى خليج عدن فى المياه القريبه من الشاطئ إلى استنفاد الحبار وشروخ البحار العميقة. إن صيد الأسماك الصناعى بشباك الجر فى البحر الاحمر قد وضع ضغطاً كبيراً على مخزون الروبيان وغيرها من الموارد البحرية الحيه (عبر الصيد العرضي الكبير للأنواع غير المستهدفة).

فى سواحل البحر الاحمر المصرية هناك 4.300 من الصيادين التقليديين والصيادين العاملين فى مصائد الأسماك شبه الصناعية. ويتضمن القطاع شبه الصناعي 228 من سفن الصيد الكبيرة (جرافة) و 83 من سفن الصيد بشباك الجر القاعى.

فى المملكة العربية السعودية هناك 15.800 من الصيادين الحرفيين و160 من سفن الصيد شبه الصناعية (جرافات) العاملة فى البحر الاحمر.

لقد قدر عدد الصيادين التقليديين اليمنيين فى عام 2004 بحوالى 75.000-80.000؛ وهذا الرقم يشير إلى أن العدد قد تضاعف أربعة اضعاف تقريباً منذ عام 1990. والعديد من الصيادين التقليديين هم من ذوي الدخل المحدود جداً والذي كثيراً ما يستكمل بالقروض؛ أما أسطول قوارب الصيد الصناعية المرخصة فقد وصل عددها إلى 131 قارب فى عام 2006. ومن جانب آخر فقد انخفض عدد الجرافات الصناعية فى عام 2005؛ وبنهاية عام 2006، ونظراً لإجراءات إدارية اتخذتها السلطات الحكومية، أصبح عدد الجرافات الصناعية العاملة حالياً 26 جرافة فقط، عشر منها فى المياه اليمنية للبحر الأحمر وستة عشر فى خليج عدن.

لا يجري استغلال مصائد الأسماك التقليدية بصورة كاملة فى جيبوتي والسودان والصومال مع ملاحظة انخفاض صيد سمك الباغة ، وأسماك القرش والحبار والجمبرى وشروخ الصخور والكوكيان.

تواصلت عملية بناء القدرات (عن طريق ورش العمل التدريبية) في المجالات الآتية : مكافحة التلوث النفطي ، الإدارة المتكاملة للمناطق الساحلية، تقييم التأثير البيئي للمشاريع التنموية، إدارة النفايات الصلبة في المناطق الصناعية ، وسلامة الملاحة والمسح الهيدروغرافي ، تحكم الدولة في الموانئ ، والتحقيق في الحوادث البحرية، وأنظمة التفتيش البيئي، وتحسين إدارة مياه الصرف الصحي في المدن الساحلية.

تم إعداد الخطة الوطنية لحماية البيئة البحرية من الأنشطة البرية في اليمن ويجري إعدادها في مصر.

قامت الهيئة بإعداد المرحلة التحضيرية والتعبئة للبرنامج الإقليمي لحماية البيئة البحرية من الأنشطة البرية تتضمن الآتي:

- استكمال المعلومات والبيانات في دول الإقليم لإعداد أربعة مشروعات في المجالات الآتية:
- أنظمة معالجة والتصرف في مياه الصرف الصحي للمدن التي يزيد تعدادها عن 50. 000 نسمة؛
- النقاط الساخنة والمناطق الحساسة لسواحل البحر الأحمر وخليج عدن؛
- إدارة النفايات الصلبة في المناطق الساحلية في البحر الأحمر وخليج عدن؛
- نوعية مياه الاستحمام والشواطئ في البحر الأحمر وخليج عدن؛
- إصدار منشور مشترك بعنوان "التمويل اللازم للمحافظة على البيئة في البحر الأحمر وخليج عدن".

- عقد دورة تدريبية إقليمية مشتركة حول إدارة ومعالجة مياه الصرف الصحي. حدث استيعاب سريع لنظم المعلومات الجغرافية (بما في ذلك قاعدة بيانات لنظام المعلومات الجغرافية الإقليمية في الهيئة) كتقنية لدعم التخطيط للملاحة وتقييم مخاطر التلوث.

المعوقات التي تحول دون مواصلة الإنجازات

الافتقار إلى مرافق لمعالجة المياه المستعملة ، وعمل هذه المرافق فوق قدرتها ، أو الاعتماد على تكنولوجيا قديمة.

مشاكل البنية التحتية مصحوبة بعدم تنفيذ القوانين.

محدودية تفهم الآثار البيئية للتخلص من النفايات الصلبة والفضلات المبعثرة.

تنفيذ البرنامج الإقليمي للرصد البيئي في جيبوتي والسودان واليمن يتطلب دعماً متواصلًا وبناءً للقدرات نظراً لمحدودية البنية التحتية العلمية والموظفين المدربين.

الأنشطة البرية ومصادرها

الوضع الراهن

بالرغم من الطبيعة شبه المغلقة للبحر الأحمر وخليج عدن والتنمية المكثفة للمناطق الساحليه في بعض الدول فليس هناك أي دليل على وجود تغيير للبيئة البحرية، على نطاق الإقليم، نتيجة للأنشطة أو المصادر البرية.

غير أن القضية الأكثر إلحاحاً هي سوء إدارة المياه المهدورة (مياه الصرف الصحي ومياه الصرف الصناعي) والتي تسبب زيادة محلية في كمية المغذيات.

كما أن التخلص من النفايات الصلبة يسبب مشاكل محلية للموائل الساحليه في جميع الدول. إن الجريان السطحي للمياه الملوثة الناجمة عن استخدام المبيدات هي مشكلة محتملة في عدد من دول الإقليم وتتطلب إجراء بعض التحقيق.

لا يوجد دليل على ارتفاعات عامة للمعادن النزرة في المياه أو الرسوبيات أو الأحياء البحرية؛ غير أن ارتفاع مستويات مثل هذه المعادن قد يكون موضوعاً في بعض المناطق المحلية.

وتشير النتائج الأولية للرصد إلى ارتفاع مستويات بعض المغذيات في العمود المائي. لكن هناك حاجة إلى سلسلة من الأوقات الطويلة لتبيين الاتجاهات وتحديد الحدود المقبولة في كل بلد.

إن الفهم والاستجابة لتدهور النظام البيئي يجب أن يكون مبنياً على عملية مراقبة متكامل فيها المتغيرات الكيميائية (المغذيات الذائبة) والبيولوجية (قنفاذ البحر والأسماك العاشبة).

الإنجازات التي تحققت

لقد أدت التغييرات الأخيرة في الممارسات الإدارية إلى بعض التحسينات البيئية (خاصة على الشعاب المرجانية القريبه من ميناء الفوسفات في العقبة) منها وجود خطط الإدارة المتكاملة للمناطق الساحلية في المملكة العربية السعودية ومصر، واستكمالها في محافظة عدن (اليمن) والسودان والإعداد لها في جيبوتي.

كما كان للتوقيع على بروتوكول حمايه البيئة البحرية من الأنشطة البرية في البحر الأحمر وخليج عدن، وتنفيذ البرنامج الإقليمي للرصد البيئي نتائج كبيرة.

ولقد حققت الهيئة الإقليمية نجاحاً كبيراً في تنفيذ الإجراءات الجديدة الخاصة بمسارات السفن والتي تم تبنيها لاستعمالها في الملاحة الدولية في جنوب البحر الأحمر. كما قامت الهيئة بإنشاء فئار جديد مجهز بنظام التعرف الآلى على جزر حنيش. وتم تحقيق بناء القدرات في مجال مكافحة التلوث النفطي وفي مجال تحكم الدولة في الموانئ ، والتحقيق في الحوادث البحرية، والتخطيط للطوارئ البحرية، وإدارة مياه الصابورة من خلال حلقات العمل التدريبية في جميع أنحاء الإقليم. وحققت الهيئة كذلك نجاحاً كبيراً في إنشاء مركز المساعدات المتبادلة للطوارئ البحرية وقد باشر مهامه في بناء قاعدة المعلومات وإصدار دليل ونشرات وعقد عدد من ورش العمل التدريبية لرفع الكفاءة في دول الإقليم. وقد تحسنت في السنوات الأخيرة عملية التخطيط للطوارئ الوطنية في البحر الأحمر وخليج عدن (خطط الطوارئ الوطنية في الأردن والسعودية والسودان ومصر). كما تحسنت القدرة على القيام بعمليات تحكم الدولة في الموانئ.

المعوقات التي تحول دون مواصلة الإنجازات

لا تزال القدرة على القيام بعملية الرصد لحوادث انسكاب النفط والمواد الكيميائية في البحر الأحمر وخليج عدن محدودة. كما أن مستوى فهم الأثر المحتمل لمياه الصابورة في البحر الأحمر وخليج عدن ضعيفاً ويحتاج إلى التحسين. وتبعاً لذلك فإن التعبئة ضرورية لدعم البحر الأحمر وخليج عدن، من موارد محلية وخارجية، من أجل إعداد المنطقة للتعامل بفعاليته مع الأنواع البحرية الدخيلة. لم يتم وضع خطط الطوارئ الوطنية بالنسبة لإريتريا والصومال أو اليمن. كما أن هناك قلة من دول الإقليم التي أصبحت أطرافاً في اتفاقه لندن لعام 1972 أو بروتوكولها لعام 1996 ، وهذا الوضع يحتاج إلى معالجة.

يعتبر البحر الأحمر وخليج عدن محظوظاً حتى الآن لعدم وجود حوادث رئيسية للتلوث النفطي أو التلوث الكيميائي بسبب حوادث السفن.

غير أن الحوادث المقلقة الأخيرة تنذر بإمكانية حدوث تلوث رئيسي بسهولة. فطبيعة البحر الأحمر وخليج عدن بكونه شبه مغلق يؤكد تقريباً أن أي انسكاب للنفط أو لأي مواد كيميائية سوف يكون له تأثير كبير على الساحل في مكان ما في الإقليم.

لقد تم تحديد تمديد إجراءات مسارات السفن لتمر بالقرب من الجزر في شمال البحر الأحمر وعلى طول خط مسار السفن غرب جزر زبير وجزيرة الطير، كخطوات ضرورية لتحسين سلامة الملاحة في المنطقة.

وكانت حركة تطوير الموانئ في الإقليم ، خاصة خلال السنوات الـ 30 الماضية ، نشطة ، مع توسيع الموانئ لمعالجة النمو في التجارة وبالتالي حجم الشحن.

تجدر الإشارة إلى أن هناك محطات جديدة تم إنشاؤها لشحن واستقبال المواد الكيميائية والنفط والغاز الطبيعي السائل ومحطات التكرير في الإقليم مما ينذر بخطر التلوث من هذه المحطات أو من النقل البحري من وإلى هذه المحطات ، والحاجة ماسة إلى الرصد والمراقبة لهذه المصادر.

إن احتمال التأثير السلبي على البيئة البحرية من جراء وصول مياه الصابورة في السفن التجارية إلى موانئ البحر الأحمر وخليج عدن، خصوصاً في ناقلات النفط وأيضاً من مياه الصابورة المحمولة في ناقلات البضائع السائبة وسفن الحاويات وغيرها ، يفوق بكثير تأثير أي حادث تلوث نفطي رئيسي.

وتعتبر الأنواع الدخيلة ضمن مياه الصابورة واحدة من أكبر الأخطار الأربعة التي تواجه محيطات العالم؛ وتشمل الثلاثة الأخرى التلوث البحري من المصادر البرية ، والاستغلال المفرط للموارد البحرية الحية ، وتدمير الموانئ.

كما أن هناك احتمال وجود مخاطر جسيمة من التلوث في الإقليم من جراء التخلص من المواد الخطرة في المياه القريبه من خليج عدن.

الإنجازات التي تحققت

إن حوادث انسكاب النفط في مختلف أنحاء العالم ، على وجه العموم ، قد انخفض بشكل ملحوظ نظراً لمبادرات من المنظمة البحرية الدولية وغيرها من العوامل.

وتم إنشاء خمسة مراكز عامة للمعلومات البيئية ومائة وخمسين من الأندية البيئية المدرسية على مستوى الإقليم مع توفير تدريب للمعلمين. ولعبت هذه الأنشطة دوراً في تعزيز التعريف بالهيئة وأنشطتها على المستوى المحلي والإقليمي والدولي.

المعوقات التي تحول دون مواصلة الإنجازات

إن إمكانيات الأداء الحالية للمناطق المحمية البحرية يمكن أن يعزى إلى قلة الخبرة والخبراء الإداريين، وفي الغالب ضعف التنفيذ لخطط الإدارة.

ومن جانب آخر فإن المناطق البحرية المحمية القائمة لا تمثل تمثيلاً كاملاً المدى الواسع للموائل والأنواع الهامة إقليمياً (أشجار الشورى، ومناطق تعشيش وتغذية السلاحف والطيور البحرية)؛ والحاجة ملحة لمناطق بحرية محمية إضافية لملء مثل هذه الفجوات.

إن وجود فجوات في المعلومات يحول دون إجراء تقييم للوضع الحالي لبعض الأنواع (الطيور البحرية المعششة، والثدييات البحرية والسلاحف البحرية) وحالة وانتشار كثير من الموائل (السبخات والمناطق الرطبة، والشواطئ الرملية، والشواطئ الصخرية، والأعشاب البحرية - في بعض البلدان - والقيعان الطينية تحت المدية). كما أن هذه الفجوات تعوق أيضاً عملية الرصد والتقييم للمناطق البحرية المحمية الموجودة حالياً.

وعلى الرغم من اختلاف الوضع من دولة لأخرى فإن المعوقات العامة تشمل الحاجة الملحة إلى وضع التشريعات البيئية في بعض البلدان؛ وتوفير التمويل (لأغراض البحث والإدارة والرصد والمراقبة والتطبيق)؛ والحاجة إلى تعزيز الإرادة السياسية لتنفيذ الإدارة البيئية؛ والحاجة إلى الخبرة العلمية والخبرة في إدارة البيئة البحرية.

ومن جانب آخر كان استخدام الرصد على مستوى المجتمع المحلي محدوداً.

الأنشطة البحرية ومصادرها

الوضع الراهن

تحدد أعداد السفن العابرة لقناة السويس أنواع السفن العاملة في البحر الأحمر وخليج عدن؛ وبينما تظل هذه الأعداد في تزايد مستمر، تتغير حركة المرور بتطور النقل البحري.

في جيبوتي وجزيرة مكور وخليج دنقناب في السودان)؛ ويجرى حالياً تنفيذ خطط الإدارة في المناطق البحرية المحمية، بالإضافة إلى تطوير خطة لتقسيم المنطقة البحرية المحمية لمجموعة جزر سوقطرة إلى مناطق. وتأتي هذه الأنشطة في إطار استكمال إنشاء الشبكة الإقليمية للمناطق البحرية المحمية في الإقليم.

كذلك تم إعداد إرشادات لتصميم أعمال المسح للمناطق المحمية البحرية، كما تم الانتهاء من أعمال المسوحات البيئية والاجتماعية/الاقتصادية لأربع مناطق محمية بحرية مقترحة. وقد تم إدخال البيانات المتعلقة بهذه المسوحات في نظام المعلومات الجغرافية. ومن جانب آخر تم إعداد خطة رئيسية للمناطق المحددة مع إرشادات للإدارة لأربع مناطق محمية بحرية مقترحة بمشاركة المستفيدين المحليين.

لقد تم تدريب عدد كبير من المديرين والعلميين (من خلال حلقات العمل والتدريب في موقع العمل) في مجال إدارة المحميات البحرية، والمسوحات الميدانية وتقنيات الرصد، وقد تم تبادل الخبرات على المستوى الوطني والإقليمي والدولي في هذا المجال.

فيما يختص بالإدارة المتكاملة للمناطق الساحلية كان هناك تقدم ملحوظ في الجوانب التالية:

- الموافقة على خطة الإدارة المتكاملة للمناطق الساحلية لمحافظة عدن.
- استكمال دراسة الوضع الراهن للسواحل في السودان وجيبوتي وإعداد الخطة الوطنية للإدارة المتكاملة للمناطق الساحلية في السودان (في انتظار الموافقة الرسمية).
- إنشاء مجموعة إقليمية للإدارة المتكاملة للمناطق الساحلية وتعزيز التوعية العامة بالحاجة إلى هذه الأداة واستخدامها في الإدارة الساحلية.
- التحسن الملحوظ في القدرات الإقليمية في تطبيقات الاستشعار عن بعد ونظام المعلومات الجغرافية.
- تصميم وإنشاء وحدة لنظام المعلومات الجغرافية في الهيئة مع حرية الوصول إلى الإنترنت.
- تضمين كل البيانات الناتجة عن تنفيذ برنامج العمل الاستراتيجي والمتعلقة بالتنوع الحيوي والمناطق المحمية، و الإدارة المتكاملة للمناطق الساحلية، في نظام المعلومات الجغرافية.
- لقد تركز برامج التوعية العامة للهيئة على ضرورة المحافظة على الموائل بما في ذلك إصدار حقيبة التعليم البيئي وتنفيذ 17 مشروع في إطار برامج مشاركة المجتمع.

البشرى، إدخال المفترسات، التدهور البيئى (خصوصا التوسع العمراني)، التلوث، الإفراط في الصيد والافتقار إلى المعلومات المتعلقة بالوضع الراهن للسكان.

إن أعداد الأطوم قد انخفض فى جيزان وجزر فرسان (السعودية) وفي المنطقة البحرية المحمية فى جزيرة مكور وخليج دنقنا (السودان) ربما بسبب الغرق غير المقصود فى شباك الصيادين. وقد تكون أعداد الأطوم الموجودة فى السودان من أهم الأعداد الباقية على الساحل الإفريقي.

من بين الخمسة عشر نوعاً من الحيتان المعروفة بوجودها فى البحر الأحمر وخليج عدن هناك نوعان مهددة، وخمسة أنواع تعتمد على إجراءات حماية لمنع تسجيلها من ضمن الحيوانات المهددة، وخمسة أخرى غير معروفة بقدر كاف لتحديد أي وضع للحماية، وثلاثة أنواع لا خوف عليها.

الإنجازات التي تحققت

تم إحراز تقدم ملحوظ في مجال إدارة الموارد البحرية للبحر الأحمر وخليج عدن. فقد تم إصدار كتيب بعنوان "الطرق الموحدة لمسح الموائل والأنواع الرئيسية فى البحر الأحمر وخليج عدن" قابل للاستخدام على مستوى الإقليم.

وتم جمع المعلومات الأساسية عن الموائل والأنواع الرئيسية (الشعاب المرجانية، وأشجار الشورى، والطيور البحرية والسلاحف) وإعداد تقارير عن الوضع الراهن لهذه المجموعات. وحدثت زيادات كبيرة في المعرفة العلمية للمرجان، والشعاب المرجانية والمجموعات المرتبطة بها في إقليم البحر الأحمر وخليج عدن.

وتم تطوير خطط عمل إقليمية (على إثر المسوحات الإقليمية) للشعاب المرجانية وأشجار الشورى والسلاحف والطيور البحرية المعششة ويجرى حالياً تنفيذها على المستوى الوطنى من خلال خطط عمل وطنية.

ومما يعزز التناول المنسق إقليمياً لموضوع المحافظة التوقيع على بروتوكول المحافظة على التنوع البيولوجي وإنشاء مناطق محمية من قبل الدول الأعضاء فى الهيئة فى ديسمبر 2005.

لقد تم إصدار الخطة الإقليمية الرئيسية لمنظومة المناطق المحمية البحرية فى الإقليم، كما تم الإعلان رسمياً عن اثنتين من المناطق البحرية المحمية فى عام 2005 (جزر السوايح ورأس سيان

دلت المسوحات إلى أن ثلث الشعاب المرجانية في الإقليم تم تدميرها أو تأثرت بظاهرة ابيضاض المرجان في عام 1998. وكانت التأثيرات الأكثر كثافة في الوسط الشمالي للبحر الأحمر في السعودية (خصوصاً قرب رابغ) وفي اليمن (بلحاف ، حضرموت ، ومجموعة جزر سوقطرة). وقد استعاد أكثر المرجان عافيته . كما تم مؤخراً تفشي انتشار النجمة البحرية ذات الإكليل الشوكي في المناطق البحرية المحمية في جزر السوابع ورأس سيان (جيبوتي).

وكذلك تأثر ثلاثة أرباع أشجار الشورى من جراء رعي الجمال وقطع الأشجار ، والنفائات الصلبة ومياه الصرف الصحي والدفان وزحف الكتبان الرملية ، أو إعاقة حركة المد والجزر. أما مجموعة اللاقريات فهي عموماً في وضع صحي جيد باستثناء انخفاض شديد في أعداد المحار العملاق (مصر وإريتريا) والرخويات الأخرى (السودان) والكرند (كل إقليم البحر الأحمر وخليج عدن) وخيار البحر (السودان).

من بين الأسماك التي استهدفها الصيادون عائلة الكشر والناجل ، والتي تعتبر ظاهرة شائعة نسبياً مقارنة بالشعاب المرجانية الأخرى في العالم ، بغض النظر عن الاستغلال المحلي الكثيف (السودان). وقد تم تسجيل أعلى كثافة عالمياً لعائلة الأسماك التي ينتمى إليها سمك القطرين (Haemulidae) خلال الفترة 1997-2001 في الشعاب المرجانية في متنزه رأس محمد الوطني (مصر). أما سمكة نابليون من عائلة لابريدي (Labridae) والمعرضة للهجوم عالمياً فلم يتم تسجيلها في مصر، إريتريا أو في مجموعة جزر سوقطرة ولكن تم تسجيلها في السودان وجيبوتي. ويسود حالياً قلق حول ضغوط الصيد في مناطق الحضانة ومواقع تكاثر الأسماك وصيد أسماك القرش بكثافته. ويحدث جمع لأسماك الزينة في مصر والمملكة العربية السعودية واليمن ولكن الآثار الكمية لم يتم تحديدها بعد. وكذلك حدث تغيير كبير في تركيبة مجموعة الأسماك على الشعاب المرجانية القريبة من المناطق الصناعية في العقبة (بما في ذلك التغيرات الباثولوجية) وينبع.

ثمة مناطق هامة لتعشيش السلاحف معروفة إقليمياً ودولياً في جزيرة مكور (السودان). وتتأثر أعداد السلاحف بالصيد غير المشروع أو الصيد العرضي (جيبوتي ومجموعة جزر سوقطرة والصومال والسودان)؛ وانسكابات النفط وتدهور البيئة (السعودية)، وهجوم الكلاب الضالة (خليج عدن).

توجد إحدى وثلاثين منطقة هامة للطيور من أهمها عالمياً منطقة الغردقة ومجموعة جزر سوقطرة. وتشمل التهديدات العامة التي تواجه الطيور البحرية المعيشة الاضطراب والاستغلال

لقد تم تحقيق بناء القدرات في مجال سلامة الملاحة / المسح الهيدروغرافي وإعادة رسم الخرائط من خلال عقد حلقات العمل التدريبية في جميع أنحاء الإقليم ويجري العمل حالياً على بناء مراكب مسح جديدة لتسهيل، على الأقل، القيام بأعمال مسحية بمعايير حديثة في البحر الأحمر وخليج عدن.

وستشكل أجهزة قياس المد والجزر في خليج عدن جزءاً من منظومة الإنذار المبكر لتسونامي في المحيط الهندي.

كما يمكن أن توفر أجهزة قياس المد والجزر الموجودة في موانئ البحر الأحمر، بالإضافة إلى الجهاز الجديد المقترح في عدن، معلومات حيوية على المدى القصير للتغيرات في مستوى سطح البحر في الإقليم.

المعوقات التي تحول دون مواصلة الإنجازات

هناك حاجة إلى التعاون المستمر بين الدول المتاخمة للبحر الأحمر وخليج عدن وتقدير أهمية الاتفاق على الحدود لتمكين التعرف على الحدود البحرية والمنطقة الاقتصادية الخالصة.

والحاجة ماسة كذلك لوضع برنامج شامل لتحسين عمليات المسح الهيدروغرافي في الإقليم والتي لم يتم مسح الكثير منها بشكل كاف، غير أن استكمال أعمال المسح الهيدروغرافي يتطلب توفير موارد مالية كبيرة.

الموارد الساحلية والبحرية

الوضع الراهن

الشعاب المرجانية في حالة صحية جيدة بشكل عام في كافة أنحاء البحر الأحمر وخليج عدن بنسبة 30 إلى 50٪ تغطية للمرجان الحي في معظم المواقع، وأكثر من 50٪ من مجموع التغطية في المتوسط. وقد تأثرت الشعاب المرجانية محلياً في المناطق الحضرية والصناعية من جراء عمليات الردم والتجريف؛ وأنشطة الموانئ (مسببة الأضرار الناتجة عن الرسو وتصريف النفط والمياه المستعملة)؛ ومياه الصرف الصحي والملوثات الأخرى (والتي تسبب أمراض الشعاب المرجانية في مناطق محلية؛ وضعف إنتاج أعداد جديدة من الأنواع، وازدياد الطحالب)؛ والسياحة (الأضرار الناتجة عن المراسي والغوص الترفيهي باستخدام أجهزة التنفس تحت الماء).

تتميز مياه البحر الأحمر بعدم وجود ظاهرة التيارات الصاعدة؛ غير أن هذه التيارات الصاعدة للمياه الباردة موجودة في خليج عدن خصوصاً تجاه الجانب الشرقي، نتيجة لحركة الرياح الموسمية الجنوبية الغربية بين شهري مايو وسبتمبر. كما أن تركيزات المغذيات في جنوب البحر الأحمر أعلى بسبب تدفق المياه الغنية بالمغذيات من خليج عدن في أواخر الصيف.

إن معظم أجزاء البحر الأحمر وخليج عدن محاط بمناطق جافة وشبه صحراوية وتلال قاحلة. والبحر الأحمر ضحل في أطرافه الشمالية والجنوبية، ويصل عمقه إلى حوالي 2.000 م في أجزائه الوسطى، بينما يعتبر خليج عدن عميقاً نسبياً حيث يصل العمق فيه إلى أكثر من 5.000 متر في نقطة معينة.

تعتمد الخرائط الملاحية، والتي تقوم على المسح الهيدروغرافي، في كثير من الحالات على بيانات غير كافية لأغراض الملاحة الحديثة.

يعتبر التغير المناخي واحتمال ارتفاع مستويات البحار مصدر قلق بالغ للبلدان المطلة على البحر الأحمر وخليج عدن.

الإنجازات التي تحققت

تم نشر خرائط ملاحية جديدة لجنوب البحر الأحمر لاستخدام النقل البحري الدولي استناداً على مسح هيدروغرافي رئيسي جديد بدأت الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن في المنطقة الواقعة بين جزر حنيش وباب المندب. وكان الغرض الأساسي لهذه الخرائط الملاحية هو تحسين سلامة الملاحة في هذا الجزء الهام من البحر الأحمر وخليج عدن، وبالتالي التقليل من مخاطر التلوث التي تنجم عن وقوع مثل هذه الحوادث.

كما تم إصدار خريطة جديدة لمنطقة بورتسودان بواسطة مكتب المسح الهيدروغرافي البريطاني استناداً على بيانات تم استلامها عبر الهيئة الإقليمية؛ وتوضح هذه الخرائط التطورات الأخيرة التي حدثت في ميناء بورتسودان.

وقد نشر مكتب المسح الهيدروغرافي البريطاني أيضاً في عام 2006 خريطة تخطيطية للمياه اليمنية تغطي المنطقة الواقعة بين الحدود البحرية مع المملكة العربية السعودية وخط يمر شرقي مجموعة جزر سوقطرة. وتشكل هذه الخريطة الأساس للتخطيط لمصائد الأسماك في اليمن يشمل نفس المنطقة وقد تم تحديدها بوضع علامة شبكية تقسم المنطقة إلى مربعات يغطي 100 ميل بحري لغرض تسجيل المصيد من الأسماك.

- محدودية المعارف العلميه ورصد الموائل الرئيسية والأنواع ، والانشطة (خاصة البيانات المتعلقة بمصائد الأسماك)
- مخاطر المزيد من ظاهرة ابيضاض الشعاب المرجانية وارتفاع منسوب مياه البحر والذي يعزى إلى تغير المناخ العالمي
- انتشار الأنواع البحرية الدخيلة.

البيئة الطبيعية (الفيزيائية) للبحر الاحمر وخليج عدن

الوضع الراهن

إن إقليم البحر الاحمر وخليج عدن عبارة عن جسم مائى فريد يتكون من البحر الأحمر شبه المغلق وخليج عدن الذى يتصل بالمحيط الهندي.

وهذا الإقليم يشكل جزءا من الطريق التجاري الحيوي للتجارة العالمية. فمنذ افتتاح قناة السويس فى عام 1869 تم إنشاء روابط تجارية بين اوروبا وامريكا غرب السويس، والخليج وشرق افريقيا والهند والشرق الاقصى من جهة الشرق.

ومن جانب آخر يعتبر البحر الأحمر من أدفأ بحار العالم نظراً للمناخ السائد فى المنطقة، بينما يتأثر خليج عدن تأثراً شديداً بالرياح الموسمية الشمالية الشرقية والجنوبية الغربية.

ويتم تبادل المياه فى الطرف الشمالي للبحر الاحمر بين خليج السويس والبحر الأبيض المتوسط ، وفى الطرف الجنوبي مع خليج عدن عن طريق مضيق باب المندب.

وكذلك يعتبر البحر الأحمر من أكثر الأجسام المائية ملوحة، ولذلك نجد أن مستويات الملوحة المحيطة قد تكون قريبة جدا من الحدود الفسيولوجيه لكثير من الأنواع مما يبرز إمكانيه حساسية النباتات والحيوانات فى البحر الاحمر تجاه التزايد البشري فى المناطق الساحلية.

كما أن طبيعة البحر الأحمر بصفته بحر شبه مغلق يقلل من فرص تجديد المياه علماً بأن الفترة الكافية للتجديد الكامل لمياه البحر الاحمر تقدر بحوالي 200 سنة.

إن الإنتاجية الأولية فى معظم أنحاء البحر الأحمر منخفضة نسبيا مقارنة بالمحيطات الأخرى بسبب الفوارق الحرارية بين طبقات المياه والتي تمنع إعادة تدوير المغذيات من المياه العميقه إلى المنطقة المضيئة. غير أننا لا نجد هذه الفوارق بين طبقات المياه فى خليج العقبة أثناء الشتاء (ديسمبر - ابريل) نظراً لهبوط درجات الحرارة فى المياه السطحية وحركة الرياح ، مما يؤدي إلى ارتفاع مستويات المغذيات وزيادة الانتاجية الأولية فى المياه الضحلة.

تقرير الوضع الراهن للبيئة البحرية فى البحر الأحمر وخليج عدن ملخص تنفيذى

من المعروف عالمياً أن إقليم البحر الأحمر وخليج عدن يتميز بتنوع كبير فى بيئاته البحرية والساحليه ، وعدد الأنواع الفريدة الموجودة فيهما ، وأهمية الموارد البحرية فى استمرار التنمية الاقتصادية والاجتماعية فى الإقليم. غير أن هذا الإقليم قد شهد تنمية متسارعة فى المنطقة الساحليه خلال العقود الأربعة الماضية لا نظير له فى أي مكان آخر فى العالم. وتلى ذلك تدهور فى البيئتين البحرية والساحليه فى بعض الاماكن وفقدان قدرتها على استدامة سبل العيش لبعض سكان المناطق الساحليه.

لقد تم إحراز تقدم كبير فى السنوات الاخيرة فى الإدارة والمعرفة التي اكتسبت عن البيئة البحرية للبحر الأحمر وخليج عدن. وتستعرض هذه الوثيقة المعلومات المتاحة عن حالة البيئة البحرية للبحر الأحمر وخليج عدن لتقديم تقييم لوضعها الراهن ، والقضايا الجارية ، والحاجة الى اتخاذ إجراءات إضافية ، والقيود التي تحول دون مواصلة التقدم فى مجال الإدارة البيئية وفهمها.

وبناءً على ما ورد فى هذه الوثيقة فقد تحقق تقدم ملحوظ فى جهود المحافظة على بيئة البحر الأحمر وخليج عدن فى المجالات التالية:

- إنشاء المحميات البحرية
 - بناء القدرات الفنية والخبرة الإدارية فى دول الإقليم فى مجال المحافظة على البيئة البحرية.
 - الفهم العلمي لبعض الأنواع والنظم الايكولوجيه
 - وتحسين النقل البحري.
- أما القضايا المستمرة والناشئة لبيئة البحر الأحمر وخليج عدن فتتلخص فى الآتى:
- تدهور وتدمير الموائل البحرية نتيجة تصريف الملوثات، والتنمية الساحلية إضافة إلى الأنشطة السياحية.
 - الإفراط فى الصيد وعواقبه الاجتماعية - الاقتصادية بالنسبة لسكان المناطق الساحلية.
 - الافتقار إلى أى عمل للإدارة ، وخاصة وضع الإدارة موضع التنفيذ
 - محدودية القدرات التقنيه والخبرة الإدارية

الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن، هي هيئة حكومية تهتم بالمحافظة على البيئات البحرية والساحلية في الإقليم .

تستمد الهيئة قاعدتها القانونية من الاتفاقية الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن (1982). وقد تم إعلان إنشائها في القاهرة في سبتمبر 1995 حيث تتخذ من مدينة جدة مقراً لها. تضم الهيئة في عضويتها كل من الاردن ، جيبوتي ، السعودية ، السودان ، الصومال ، مصر واليمن .

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تم إعداد الوثيقة "تقريرالوضع الراهن للبيئة البحرية فى البحر الأحمر وخليج عدن" بالتعاون مع الخبراء الموضحة أسماؤهم أدناه وبمعاون مع الهيئة الإقليمية وتحت إشرافها:

الدكتور ويليام قلايستون

القبطان روي فايسى

الدكتور خالد حريرى

التحرير والتنقيح المبدئى: الدكتور ويليام قلايستون

التسيق والمتابعة : الدكتور ضرار حسن نصر

ترجمة الملخص التنفيذى: الدكتور ضرار حسن نصر

وقد تم إعداد التقرير بناءً على البيانات التى تم جمعها، ونتائج المسوحات والأنشطة المختلفة التى قامت بها الهيئة الإقليمية ودول الإقليم أثناء إعداد وتنفيذ برنامج العمل الاستراتيجى للبحر الأحمر وخليج عدن (1996 - 2005).

إن الملاحظات التى تم إبدائها في هذه الوثيقة تمثل وجهة نظر المؤلفين ولا تمثل بالضرورة وجهات نظر الهيئة، وكذلك لا يعبر عن أي فكرة معينة تُنسب للهيئة، فيما يتعلق بالحدود القانونية لأي دولة.

يمكن إعادة إنتاج هذا المنشور كلياً أو جزئياً بأي شكل من الأشكال ، وذلك لأغراض تعليمية وغير ربحية بشرط أن يتم التنويه عن مصدر المنشور . وسوف تكون الهيئة الإقليمية شاكراً ومقدرة لاستلام أي منشور يستفيد من هذا التقرير كمصدر من مصادر المعلومات .

لا يسمح بنسخ هذا المنشور أو توزيعه إلكترونياً أو بيعه مرة أخرى أو لأي أغراض تجارية أخرى بدون ترخيص مسبق ومكتوب من الهيئة الإقليمية .

الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن

الخلاصة

تقرير

الوضع الراهن للبيئة البحرية
في البحر الأحمر وخليج عدن

2006