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

Coral Reefs in the Red Sea and Gulf of Aden

Surveys 1990 to 2000
Summary and Recommendations

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List of Acronyms

ARA	Aqaba Regional Authority
ALECSO	Arab League Educational, Cultural and Scientific Organization
CAMP	Coastal Area Management Programme
CBD	Convention on Biological Diversity
CERD	Centre for Scientific Research (Djibouti)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COTS	Crown of thorns starfish
CZM	Coastal Zone Management
DANIDA	Danish International Development Agency
DAP	Di-ammonium Phosphate
DC	Dead Coral
EARO	Eastern Africa Regional Office (IUCN)
EEAA	Egyptian Environmental Affairs Agency
EFZ	Economic Free Zone (Sudan)
EGPC	Egyptian General Petroleum Corporation
EIA	Environmental Impact Assessment
EPC	Environment Protection Council (Yemen)
EPCCOM	Environmental Protection Coordinating Committee
ENSO	El Nino Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FIMPA	Farasan Islands Marine Protected Area
FRT	Fisheries Research Team
GAFRD	General Authority for Fish Resources Development (Egypt)
GCC	Gulf Cooperation Council
GCEP	General Corporation for Environmental Protection (Jordan)
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GIS	Geographical Information System
GNPOC	Greater Nile Petroleum Operating Company
GTA	General Tourism Authority (Yemen)
HC	Hard Coral
HCENR	Higher Council for Environment and Natural Resources (Sudan)
HCEP	Higher Council for Environmental Protection (Jordan)
ICED	International Center for Environment and Development (Egypt)
ICRI	International Coral Reef Initiative
ICLARM	International Centre for Living Aquatic Resources Management
ICZM	Integrated Coastal Zone Management
IMO	International Maritime Organization of the United Nations
ITMD	International Tyre Manufacturing and Distribution (Sudan)
IUCN	World Conservation Union (formerly International Union for the Conservation of Nature)
JICA	Japanese International Co-operation Agency
JPMC	Jordan Phosphate Mines Company
JREDS	Jordan Royal Ecological Diving Society
JSS	Jordan Standards Specifications
KFUPM-RI	King Fahd University of Petroleum and Minerals Research Institute

KISR	Kuwait Institute for Scientific Research
LMR	Living Marine Resources
MARPOL	International Convention for the Prevention of Pollution from Ships
MAW	Ministry of Agriculture and Water
MEMAC	Marine Emergency Mutual Aid Centre
MEPA	Meteorology and Environmental Protection Administration (Saudi Arabia)
MFW	Ministry of Fish Wealth (Yemen)
MoD	Ministry of Defence
MOU	Memorandum of Understanding
MP	Marine Park (Jordan)
MPA	Marine Protected Area
MPD	Ministry of Planning and Development (Yemen)
MSRRC	Marine Science Research and Resources Centre (Yemen)
MSS	Marine Science Station (Jordan)
MSY	Maximum Sustainable Yield
NCWCD	National Commission for Wildlife Conservation & Development (Saudi Arabia)
NCICZM	National Committee for Integrated Coastal Zone Management (Egypt)
NEAP	National Environmental Action Plan
NGO	Non-governmental Organization
NIOF	National Institute of Oceanography and Fisheries (Egypt)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOSCP	National Oil Spill Contingency Plan
NPK	Nitrogen Phosphorus Potassium
ODA	Overseas Development Authority
PCMA	Public Corporation for Maritime Affairs (Yemen)
PDRY	Peoples Democratic Republic of Yemen
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
REA	Rapid Environmental Assessment
RMP	Regional Master Plan (for Marine Protected Areas)
ROPME	Regional Organization for the Protection of the Marine Environment
ROV	Remotely Operated Vehicle
RSG	Red Sea Governorate (Egypt)
SAP	Strategic Action Programme for the Red Sea and Gulf of Aden
SCUBA	Self Contained Underwater Breathing Apparatus
SD	Standard Deviation
SES	Saudi Environment Society
SMCC	Sudan Marine Conservation Committee
SRRP	Somali Relief and Rehabilitation Programme
SWCC	Saline Water Conversion Corporation (Saudi Arabia)
TAPLINE	Trans-Arabian Pipeline
TDA	Tourism Development Agency (Egypt)
TS	Technical Secretariat (Yemen)
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDOS	United Nations Development Office for Somalia
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOPS	United Nations Office for Project Services
USAID	United States Aid for International Development
WAJ	Water Authority of Jordan
YAR	Yemen Arab Republic

Executive Summary

The status of coral reefs in Egypt, Sudan, Djibouti, Somalia, Yemen, Saudi Arabia and Jordan[1] are presented, collated from surveys undertaken in the late 1990s.

Corals in this region are found primarily on the following:

- fringing reefs along the mainland and around islands,
- barrier reefs,
- pinnacles,
- atolls.

Several other habitats contain corals, including:

- submerged patch reefs,
- coralline red algal beds,
- relic reef formations,
- volcanic rock flows.

In general, reef health was considered good, with 30 to 50 % live coral cover at most locations and more than 50 % total cover on average. Coral diversity and reef-associated fauna were considered amongst the highest in the Indian Ocean region. Coral bleaching caused extensive die-offs in the northern-central Red Sea in 1998, and on the Sudanese coast a red algal film was present over most shallow reefs. The bleaching followed a period when sea surface temperatures exceeded mean monthly averages by more than one degree Celsius (Centigrade).

A review of the major threats to coral reefs was compiled during the preliminary phase of the Strategic Action Programme for the Red Sea and Gulf of Aden (World Bank 1998). They include:

- land-filling and dredging for coastal expansion,
- destructive fishing methods,
- shipping and maritime activities,
- sewage and other pollution discharges; lack of public awareness,
- damage from the recreational SCUBA diving industry,
- insufficient implementation of legal instruments that effect reef conservation.

Increasing atmospheric carbon dioxide is expected to alter the alkalinity of the world's oceans over the next century, making it increasingly difficult for corals and other carbonate secreting organisms to grow. Present predictions are that calcification rates may slow by as much as two-thirds over the next 50 years, with the potential for catastrophic effects on reef growth and marine biodiversity in general (KLEYPAS et al. 1999).

[1] Country order anticlockwise from Egypt around the Red Sea.

The countries of the region have become signatories to a number of international, regional, bilateral or multilateral agreements and other legal instruments. Each country also possesses a relatively complete set of national laws and regulations. However, the implementation of these remains generally poor and in some cases there is no implementation or enforcement.

For coral reef conservation to improve and to be effective in the Region, there is a need for increased public awareness, increased implementation and enforcement of national and international legal instruments, and the execution of coastal management plans that integrate coastal development, pollution control, and tourism with the maintenance of environmental quality in marine habitats.

Egypt

The Arab Republic of Egypt is home to over 1800 km of diverse coral reef habitats along the western Red Sea coast and in the Gulfs of Suez and Aqaba. Data is drawn from surveys carried out by staff from the Suez Canal and the Al-Azhar Universities from 1997-99, a recent overview of reef status and a Rapid Environmental Assessment at several frequently visited dive sites.

Corals accounted for 55 % of reef cover in non-sheltered areas and 85 % of cover in sheltered areas. The percentage of live coral cover was highly variable along the coast, with the highest cover occurring on reef walls and the leading edges of the reefs. Southern reefs housed a greater diversity of fish species than northern reefs. Exposed reefs contained a higher diversity of fishes than sheltered reefs. Until recently the reefs were considered healthy and free of major anthropogenic stresses but lately sedimentation from land reclamation works, oil spills and physical damage from the recreational SCUBA diving industry have taken their toll, and coral cover at many places has dropped by as much as 30 %. Natural threats include flooding, disease and predator outbreaks[2].

Egypt currently has four marine protected areas, which include coral reefs, established around the Sinai Peninsula. Seven additional areas have been proposed to the Government for protected status. Three national institutions are in charge of the management of coral reef resources, the Tourism Development Agency, the Egyptian Environmental Affairs Agency and local governments through three Red Sea Governorates. In addition, several secondary agencies play a role in environmental management, including the Egyptian General Petroleum Corporation and the National Committee for Integrated Coastal Zone Management. A number of tertiary agencies are also responsible for the protection of the marine environment.

Egypt is a signatory to a number of international conventions under which the conservation of coral reef resources is stipulated or indirectly addressed. The country has also passed a number of laws and presidential decrees that give coral reefs direct or indirect protection. To improve the current response to, and mitigation of, natural and anthropogenic threats, the development of an integrated coastal area management plan, the review and upgrading of existing regulations and more efficient monitoring and control of pollution sources and coastal development are required.

[2] Outbreaks of crown-of-thorns starfish (COTS) *Acanthaster planci* may be caused by overfishing of reef-associated fish predators in the families Lethrinidae, Balistidae and Tetraodontidae (ORMOND et al. 1990).

Sudan

The Sudanese Red Sea coast is approximately 750 km long inclusive of bays and inlets, and encompasses three primary coral habitats:

- barrier reefs,
- fringing reefs and
- Sanganeb, an oceanic atoll.

Surveys in 1997 and 1999 indicated that the coral reefs were in moderate to good health, despite reports of an extensive coverage of algae over a high proportion of the fringing reefs. The reefs are patchy at depths down to 10 m, with average live coral cover ranging from 5 to 75 %. Below 10 m, the reefs contain healthy colonies of framework corals. Fish health was considered good and over-fishing was not a severe problem on the coral reefs. Key indicator species were abundant and diversity appeared high relative to other Red Sea sites. The crown-of-thorns starfish was not recorded in plague numbers at any of the Sudanese reefs. In 1999, bleached corals were estimated to cover 14 % of the substrate. There is one established protected area: Sanganeb Marine National Park. Four other areas have been proposed as protectorates and await government decisions and implementation.

Fisheries play a minor role in the economy but are important at a subsistence level. Neither commercial nor artisanal landings reach the estimated maximum sustainable yields. Fisheries are believed to have great potential for growth, but face logistical problems such as refrigeration, transport and market access.

The most severe threats to reefs come from shipping, and dredging for ports and infrastructure development. Though currently small-scale, tourism has a negative impact on the reefs. Both anchoring and fin damage by divers contribute to reef impairment.

Sudan has much of the infrastructure needed for regular monitoring and effective management of coral reef resources, but many of the present problems with coral reef conservation are attributed to a lack of law enforcement, a lack of awareness, a weak legal framework and the absence of surveillance. An integrated coastal management plan that takes into consideration shipping, coastal development, pollution and natural resources, along with effective and enforced implementation, would address most of the issues mentioned.

Djibouti

Djibouti has a coastline of 372 km. The north coast is generally shallow and sandy with occasional coral outcrops, while the Sawabi archipelago east of Ras Siyyan is fringed by coral reefs. The southern coast is shallow with poorly developed coral reefs, linked to the cold-water upwelling from the Indian Ocean. Most of the coasts and territorial waters are still in a largely pristine state, but there are signs of degradation and threats to the environment are increasing rapidly.

Two short, but extensive, reef assessments in 1998 and one comprehensive subtidal survey in 1999 have provided a wealth of information on Djibouti's reefs. At the south-western tip of Ile Maskali, turbidity was high and the reefs were very poor. Iles Moucha and Maskali had moderate to good live coral cover (> 30 %). Live coral on the reefs to the north of Moucha and Maskali was moderate to good (25 to 40 % cover). The reefs of Khor Ambado had an average hard coral cover of 52 %. Species diversity of benthic and sessile organisms was low. *Porites* and *Pocillopora* were the dominant reef forming-corals on the reef edge and reef

slope. Coral and other fauna were relatively rare on the back reef and reef flat. Eastwards from Khor Ambado the reef was in moderate to good condition with coral cover up to 80 %. The status of reefs at Iles des Sept Frères was good (cover averaged 34 %) and most of the archipelago had balanced and healthy reefs. No significant signs of recent bleaching were recorded on the reef face or reef flat. In 1998, 166 species of coral were recorded.

The reefs of Djibouti are under pressure from many anthropogenic sources, primarily tourism and sewage discharges. The major economic sectors in the coastal zone are maritime transport and port-related activities. Pressure is particularly high in the vicinity of the capital. Fisheries play a limited role, although subsistence fisheries are locally important.

Djibouti has two declared marine protected areas, while two additional areas are proposed for protected status, one of which is of regional importance. Several key actions at the national level in the form of legislation and implementation could reduce the risks of ship-based pollution and oil spills. A dedicated research and monitoring programme that fed back into coastal area management plans would contribute greatly to efficient conservation actions.

Somalia, north coast

The north coast is generally shallow with exposed, high-energy sandy beaches. The central portion consists of shallow, sandy shorelines with occasional outcrops and cliffs that may extend into the shallow water.

Three short surveys along this coast between 1966 and 1999 provide the bulk of the current information on the status of coral reefs. Each of these used simple, rapid assessment methods.

Coral reefs of limited development occur near Ras Khansiir, Ras Cuuda, Siyara, off El Girdi and west of Berbera. Reefs are shallow (1 to 10 m) and have developed on fossilised rock. The coral communities on the reefs varied considerably in condition. All have been affected by bleaching to some degree. The shallow reefs to the east of Berbera had suffered nearly total mortality. Deeper reefs (2 to 5 m) were in better condition. At the Saardin Islands (Saad ad-Din), coral diversity, fish populations and individual fish sizes were large. A total of 69 species of scleractinian coral, 11 species of alcyonacean coral and two species of fire coral were found in one study. In general the area is both productive and relatively pristine, apart from the deleterious effects of coral bleaching and, to a lesser extent, predation by crown-of-thorns starfish on the coral reefs.

Somali fishermen target a limited number of demersal stocks, bound by fishing gear limitations, and a range of coral reef fish. Fishing by Somali people is limited and nearly entirely artisanal in nature. Though still underdeveloped, these fisheries are essential for the livelihood of a large proportion of the coastal population. Along the north coast, most commercial operations are carried out by foreign vessels.

Three areas along the north coast have been proposed for protection, of which only the Aibat, Saad ad-Din and Saba Wanak area (two islands and an adjacent stretch of coastline near Zeila [Saylac]) includes coral reefs. The effects of human activity on the environment appear to be minimal, the only exceptions being the relatively heavy, opportunistic exploitation of turtles and sharks. Fisheries and transport are only a small component of the national economy and are not significant threats to coral reefs.

Although signatory to several conventions and protocols Somalia's ability to effectively

implement international or national legislation is limited.

The two key requirements for improved conservation of coral reefs are funding and personnel. Conservation of coral reefs is currently given a lower priority than nation building and the eradication of poverty. There is a need to develop a system of marine protected areas, and for the adoption of oil spill response measures, broad-scale environmental education and continued research and monitoring for early detection of reef deterioration.

Yemen

The Republic of Yemen lies in the south-western corner of the Arabian Peninsula and includes the Socotra Island Group. The coastline is about 2,200 km long, roughly one third of which is in the Red Sea and the remaining two-thirds facing the Gulf of Aden. Only about 25 % of Yemen's Red Sea coastline supports coral reefs. The most highly developed reefs occur offshore, in the vicinity of the many islands that characterise the southern Red Sea. Only 5 % of the Gulf of Aden coast supports either fringing coral communities or reefs, while there is extensive coral growth around the Socotra Island Group.

Several major projects have recently assessed the distribution, composition and status of living marine resources around the Yemen coastline. More than 300 species of reef building corals and 600 species of reef-associated fishes have been identified on Yemeni reefs and coral communities. In particular, coral and fish communities of the Socotra Island Group are extremely diverse. A total of about 176 species of stony corals have been recorded from the Red Sea coast of Yemen, with richness at individual sites ranging from 1 to 76 species. At least 19 new records have been identified for the southern Red Sea. Diversity is lower along the mainland Gulf of Aden coast, which is thought to support some 100 coral species. The area remains relatively poorly studied. The Belhaf - Bir Ali area supports the most concentrated collection of coral communities known from the northern Gulf of Aden, with large coral patches developed offshore from the Bir Ali village and coral communities fringing the offshore islands. These communities display moderate to high diversity (about 100 spp. of *Scleractinia*) and wide-ranging coral cover (< 10 to > 75 %).

The Socotra Island Group supports a diverse fauna of about 250 stony coral species, placing it among the richest sites in the western Indian Ocean. Most extensive coral development has been found on north facing coasts where coral cover and diversity are higher than in macroalgal-dominated south coast locations which are more exposed to the south-west monsoon.

Coverage of stony corals, dead corals, soft corals and algae were all highly variable among different sites within the Red Sea, Gulf of Aden and Socotra Island Group. Ratios of live/dead coral cover at individual sites were related largely to the differential effects of recent disturbance, notably coral bleaching in 1998. Reefs in the northern Yemeni Red Sea showed low live coral cover (average 17 %), high dead coral cover (average 34 %) and a high percentage cover of macroalgae (20 %). The northern and central Yemeni coast and nearshore islands had very low live coral cover (3 %) and high dead coral cover (average 34 %). Around the Socotra Island Group, the cover of stony corals ranged from less than 1 % to more than 75 %, and in large patches (about 1,000 m^2) attained almost 100 %. Overall, living stony coral cover averaged about 20 %, with highest cover (about 35 %) on the outer islands.

Bleaching effects in 1998 were patchily distributed around the Socotra Island Group and the north-east Gulf of Aden. At the worst affected sites, more than half the species were injured and about half of the live coral cover was killed. Pocilloporids, table and branching *Acropora* spp., and fire corals *Millepora* spp. were the worst affected.

Fishing is a traditional profession for thousands of Yemenis. Total annual catches vary between 90,000 and 95,000 metric tonnes. Reef-based fisheries, for the most part, are underdeveloped and at a subsistence level.

Only in recent years has the protection of coral reefs been addressed. There is one official protected area - the Socotra Island Group - and a further six have been proposed. Coastal development, the petroleum industry and maritime shipping pose a significant risk to reefs in the form of untreated sewage, land filling and hydrocarbon pollution.

Kingdom of Saudi Arabia

Saudi Arabia's Red Sea coastline measures approximately 1,840 km. Coral reefs are found fringing the entire length and the offshore islands. Several major surveys have been carried out along the coast in the 1980s and 1990s, the most recent being a joint study between the National Commission for Wildlife Conservation and Development and the Japanese International Co-operation Agency. Reefs are generally in a good condition, with the exception of those near Jeddah and Yanbu. In the early 1980s, 194 species of corals were recorded with the greatest diversity from the central portion.

Bleaching caused mass coral mortality in the central-northern Saudi Arabian Red Sea in late 1998. Bleaching was patchily distributed and highly variable in intensity. The most intense bleaching occurred near Rabigh, where more than 65 % of total coral cover was bleached or had died recently. Significant levels of coral mortality were observed along the southern Red Sea, where at some sites (i.e. Abalat Islands) live coral cover declined from 80 % in 1993 to about 10 % in 1999. Mean monthly sea surface temperatures were found to be unusually high (> 32 °C) three months prior to the first reports of coral mortality.

Threats to Saudi Arabia's coral reefs originate primarily through industrial development and maritime transport, including oil spills, land-filling, pollutant discharges and effluents from desalination activities. Most acute damage to reefs is localised around major urban areas.

Many marine areas have been proposed for protected status, dating back to the mid and late 1980s. However, with the exception of the Farasan Islands, protected in 1996, no other marine protected areas have been established on the Saudi Arabian Red Sea coast.

Saudi Arabia has carried out a number of programmes and adopted a number of legal measures to conserve coral reefs. These include laws on pollution discharges and the establishment of protected areas. However, a number of issues remain unresolved or are poorly addressed, most importantly - the enforcement of existing emission standards, industrial development (particularly land-filling), and the integration of the public and private sectors in reef conservation.

Jordan

The Jordanian coastline extends approximately 27 km along the north-eastern reaches of the Gulf of Aqaba. Approximately 30 % of the coast is used for port activities.

Fringing reefs border up to 50 % of the coast, supporting a high diversity of coral and associated fauna (158 coral species in 51 genera and over 280 fish species).

Jordan's coral reefs are in good condition, supporting up to 90 % cover of scleractinian corals. No bleaching events were recorded in 1998, possibly as a result of Jordan's more northerly latitude.

There are no official marine protected areas, although the area within the Marine Station grounds known as the Aqaba Coral Reef Protected Area is, de facto, a protected area and is the only proposed protected area in the country.

Jordan has revised its legal and regulatory framework for environmental protection at a national and international level. The country is party to eight international conventions or treaties that directly or indirectly have an impact on the conservation of coral reefs.

The Gulf of Aqaba is highly susceptible to pollution. At present pollution is limited and localised. The main threats are oil spills and discharges, industrial discharges, municipal and ship-based sewage and solid waste. The development of the tourism sector might also further threaten the coral reefs.

Summary

To improve the conservation status of coral reefs, there is a need to strengthen the overall institutional capabilities of government agencies. This can be achieved through the hiring and training of staff, the implementation of environmental protection laws and regulations, and improving regional cooperation to co-ordinate and enhance the efforts of individual Gulf-bordering nations. Several additional measures are also needed. These include the development of an integrated coastal zone management strategy, capacity building at the legislative, management and operational levels, the establishment of marine protected areas and the harmonisation of existing regulations at the national and international level.

Résumé Analytique

Les résultats d'études menées à la fin des années 1990 portant sur l'état des récifs coralliens en Égypte, au Soudan, à Djibouti, en Somalie, au Yémen, en Arabie Saoudite et en Jordanie1 sont detailles dans ce rapport.

Les coraux de cette région sont principalement

- des récifs frangeants les continents et les îles,
- des récifs-barrières,
- des pinacles et
- des atolls.

On y trouve également plusieurs autres habitats, notamment

- des platiers de corail submergés,
- des tapis d'algues rouges coralliennes,
- des récifs reliques et
- des coulées de roches volcaniques.

En général, les récifs de la région sont considérés comme etant en bonne santé, avec une couverture de corail vivant de 30 à 50 % sur la plupart des sites et une couverture totale moyenne de plus de 50 %. La diversité des coraux et de la faune corallienne est considérée comme l'une des plus élevées dans la région de l'océan Indien. Un épisode de blanchissement a produit la mort de vastes étendues de coraux dans la mer Rouge septentrionale et centrale en 1998 , et sur la côte soudanaise. Une pellicule d'algues rouges recouvre la plupart des récifs des fonds.

Parmi les grandes menaces qui pèsent sur les récifs coralliens figurent

- le remblayage de la mer et le dragage pour l'aménagement du littoral,
- les méthodes de pêche destructives,
- les dégâts causés par les plongeurs sous-marins,
- le transport maritime et la navigation,
- les rejets des eaux usées et d'autres polluants,
- le manque de sensibilisation du public et
- l'absence d' application des dispositions juridiques relatives à la conservation des récifs coralliens.

Les pays de la région sont signataires de multiples conventions internationales, régionales, bilatérales et multilatérales ainsi que de divers autres instruments juridiques. Chaque pays possède également un ensemble relativement complet de lois et de règlements nationaux. En revanche, c'est généralement au

[1] Pays classés par ordre anti-horaire à partir de l'Égypte selon leur situation géographique autour de la Mer Rouge.

niveau de la mise en œuvre que se situent les faiblesses. Dans certains cas même, celle-ci fait entièrement défaut et les lois restent lettre morte.

Il faut, pour améliorer véritablement la conservation des récifs coralliens dans la région: accroître la sensibilisation du public, renforcer la mise en œuvre et l'application des dispositions juridiques nationales et internationales et exécuter des plans de gestion intégrée des zones côtières qui tiennent compte du développement de ces zones, de la lutte contre la pollution et de la réglementation des activités touristiques d'une manière équilibrée et respectueuse de la qualité de l'environnement et des habitats marins.

Égypte

La République arabe d'Égypte possede plus de 1,800 km de cote comprenant la côte occidentale de la mer Rouge et les golfe de Suez et d'Aqaba. On y trouve des récifs coralliens. Les données concernant ces habitats proviennent d'études effectuées par le personnel des Universités du Canal de Suez et d' Al-Azhar de 1997 à 1999, d'un récent examen général de l'état des récifs coralliens et d'évaluations environnementales rapides menées sur des sites de plongée fortement fréquentés.

Les coraux représentent 55 % de la couverture récifale dans les zones non abritées et 85 % dans les zones abritées. Les taux de couverture corallienne vivante présentent de fortes variations le long des côtes; les plus élevés étant observés a la peripherie des récifs. La diversité de la faune ichtyologique est plus grande sur les récifs du sud que sur ceux du nord et sur les récifs exposés que sur les récifs abrités. Jusqu'à une date récente, les récifs étaient considérés comme etant en bonne santé et exempts de stress d'origine anthropique mais depuis peu, la sédimentation résultant des projets d'aménagement des terres, les déversements d'hydrocarbures et les dégâts causés par les activités de plongée sous marine qui ont eu un grave impact : en de nombreux points, la couverture corallienne a diminué parfois de 30 %. Parmi les menaces naturelles figurent les inondations, les maladies et les infestations de prédateurs.

L'Égypte possède actuellement quatre aires marines protégées qui englobent les récifs coralliens de la péninsule du Sinaï. Le classement de sept autres zones en tant qu'aires marines protégées a été proposé aux pouvoirs publics. Trois institutions nationales sont chargées de la gestion des ressources des récifs coralliens:

- l'Agence de développement du tourisme,
- l'Agence des affaires environnementales egyptienne et
- les administrations locales par l'intermédiaire des trois gouvernorats de la Mer Rouge.

Par ailleurs, plusieurs organismes secondaires interviennent dans la gestion de l'environnement, notamment la Société Générale du Pétrole Égyptien et la Commission Nationale de Gestion Intégrée des Zones Côtières. Plusieurs organismes tertiaires sont également chargés de la protection de l'environnement marin.

L'Égypte est signataire de diverses conventions internationales en vertu desquelles elle a pris des engagements, directs ou indirects, en matière de conservation des ressources des récifs coralliens. Le pays a également promulgué un certain nombre de lois et de décrets présidentiels protégeant directement ou indirectement les récifs coralliens. Pour renforcer les mesures actuelles visant à faire

face aux menaces naturelles et anthropiques et à les atténuer, il s'avère nécessaire d'élaborer un plan de gestion intégrée des zones côtières, d'examiner et de renforcer les règlements en vigueur et d'exercer un suivi et un contrôle plus efficace des sources de pollution et de l'aménagement du littoral.

Soudan

La façade soudanaise de la Mer Rouge s'étend sur une longueur d'environ 750 km, y compris les baies et les bras de mer. On y trouve trois types de coraux:

- des récifs-barrières,
- des récifs frangeants et
- un atoll océanique a Sanganeb.

L'état de santé des récifs coralliens est considéré comme modéré à bon, bien qu'il ait été signalé récemment la présence d'une vaste couverture algale sur une forte proportion des récifs frangeants. À moins de 10 m de profondeur, les récifs sont discontinus et la moyenne de la couverture de coraux vivants varie de 5 à 75 %. À plus de 10 m, les récifs contiennent des colonies coralligènes en bonne santé. La santé de la faune ichtyologique récifale est considérée comme bonne et la surpêche ne constitue pas un problème grave. Les principales espèces utilisees comme indicateurs sont abondantes et leur diversité est élevée par rapport aux autres sites de la Mer Rouge. Il n'a pas été observé une epidemie d'*Acanthaster planci*, étoiles de mer dites couronnes d'épines (CdE) sur les récifs soudanais. En 1999, on estimait que les coraux blanchis couvraient 14 % du substrat. Il existe une aire protégée classée, le Parc national marin de Sanganeb. Quatre autres aires ont été proposées et l'on attend les décisions des pouvoirs publics pour procéder à leur mise en place.

Les principales activités industrielles sont les transports maritimes et les activités portuaires connexes, mais les secteurs du tourisme et des pêcheries possèdent un fort potentiel de croissance. La pêche, qui ne joue qu'un rôle mineur dans l'économie nationale, est importante en tant qu'activité de subsistance. Ni les prises commerciales ni les prises artisanales n'atteignent les taux estimés de rendement maximal soutenable et la croissance actuelle des pêcheries est négligeable. Le secteur possède, estime-t-on, un grand potentiel, mais qui ne pourra se réaliser qu'à condition de résoudre les problèmes logistiques de la réfrigération, du transport et des marchés.

Les menaces les plus graves qui pèsent sur les récifs proviennent des transports maritimes et du dragage. Le secteur du tourisme contribue par ailleurs à la degradation des coraux par les ancres de bateaux et les plongeurs . Le Soudan possède l'essentiel de l'infrastructure requise pour exercer un suivi régulier et assurer une gestion efficace des ressources des récifs coralliens, mais nombre de problèmes actuels de la conservation des récifs sont attribuables à des carences dus a la non application des règlements et de l'absence de la sensibilisation, à la faiblesse du cadre juridique et à l'absence de surveillance des sites. Un plan de gestion intégré des zones côtières qui porterait sur les transports, l'aménagement du littoral, la pollution et les ressources naturelles, assorti de mesures efficaces de mise en œuvre et d'application, permettrait de résoudre la plupart des problèmes évoqués ici.

Djibouti

Djibouti possède un littoral de 372 km de long. La côte nord est généralement sablonneuse, avec des eaux de faible profondeur et des affleurements coralliens ponctuels, tandis que l'archipel des îles des Sept Freres, à l'est de Ras Siyyan, est entouré de récifs frangeants. Le troncon de la cote au sud est de la ville de

Djibouti a des eaux peu profondes et les récifs coralliens y sont peu développés, du fait de des upwelling d'eau froide de l'océan Indien. La plupart des eaux côtières et territoriales sont encore essentiellement intactes, mais on relève certains signes de dégradation et les menaces environnementales s'intensifient rapidement.

Deux évaluations des récifs, brèves mais de vaste portée, menées en 1998 et une étude complète des zones subtidales effectuée en 1999 ont fourni une somme considérable d'informations sur les récifs djiboutiens. À l'extrémité sud-ouest de l'île Maskali, la turbidité est élevée et la sante des récifs s'en ressent. Les îles Moucha et Maskali possèdent une bonne couverture corallienne vivante (plus de 30 %); la couverture est modérée à bonne sur les récifs situés au nord de Moucha et Maskali (25 à 40 %). La couverture de coraux durs des récifs de Khor Ambado est en moyenne de 52 %. La diversité des espèces d'organismes benthiques et sessiles est faible. *Porites* et *Pocillopora* sont les coraux bâtisseurs dominants en bordure des récifs et sur les pentes récifales. Les coraux et autres espèces fauniques sont relativement rares sur l'arrière-récif et le platier. À l'est de Khor Ambado, l'état du récif est modéré à bon, avec une couverture corallienne atteignant 80 %. L'état des récifs aux îles des Sept Frères est bon (couverture moyenne de 34 %) et la plupart de l'archipel possède des récifs en équilibre et en bonne santé. Il n'a pas été relevé de signes notables de blanchissement récent sur les faces récifales ni sur les platiers. En 1998, il a été dénombré 166 espèces de coraux.

Les récifs djiboutiens subissent les pressions d'origine anthropique, principalement du tourisme et des rejets d'eaux usées. Les principales activités économiques de la zone côtière sont les transports maritimes et les activités portuaires connexes. Les pressions sont particulièrement fortes au voisinage de la capitale. Les pêcheries jouent un rôle limité dans l'économie, mais la pêche de subsistance est importante au niveau local.

Djibouti possède deux aires marines protégées classées et deux autres aires ont été proposées, l'une d'elle étant d'importance régionale. Plusieurs mesures clés à prendre au niveau national dispositions législatives assorties de mesures de mise en œuvre pourraient réduire les risques provenant de la pollution des navires et des déversements d'hydrocarbures. Un programme spécialisé de recherche et de suivi qui appuierait des plans de gestion des zones côtières apporterait un appui important aux activités de conservation et contribuerait à leur efficacité.

Somalie (côte nord)

La côte nord de la Somalie a généralement des eaux peu profondes et des plages de sable fortement exposées à l'action de la mer. Dans sa partie centrale, la côte sablonneuse présente en certains points des affleurements rocheux et des falaises qui s'étendent parfois dans les eaux de faible profondeur.

Trois brèves études menées sur cette côte de 1966 à 1999, selon des méthodes simples d'évaluation rapide, fournissent la majorité des données actuellement disponibles sur l'état des récifs coralliens.

On trouve des récifs coralliens peu developpe près de Raas Khansiir, de Raas Cuuda et de Siyara, au large d'El Girdi et à l'ouest de Berbera. Ils sont de faible profondeur (1 à 10 m) et se sont formés sur une roche fossile. L'état des communautés coralliennes présente des variations considérables. Toutes ont été touchées par le blanchissement dans une certaine mesure. La mortalité est presque totale pour les récifs de faible profondeur à l'est de Berbera. Les récifs plus profonds (2 à 5 m) sont

en meilleur état. Aux îles Sa'adadin (Saad ad-Din), on note une forte diversité des coraux et une faune ichtyologique nombreuse avec des specimens de grande taille. L'une des études a relevé la présence de 69 espèces de corail madréporaire, 11 espèces d'alcyonaires et deux espèces de *Millepora* (corail de feu). En général, la région est productive et relativement intacte, mis à part les effets destructeurs du blanchissement et, dans une mesure moindre, de la prédation des couronnes d'épines.

Les pêcheurs somaliens exploitent un nombre limité d'espèces démersales, avec des limites imposées quant au matériel de pêche, et toute une gamme de poissons récifaux. Leurs activités sont limitées et presque entièrement artisanales. Bien qu'encore sous-développées, ces pêcheries constituent les moyens d'existence essentiels pour une forte proportion de la population du littoral. Il existe une pêcherie de langoustes établie qui exploite les récifs situés à proximité de la côte sud-est. Sur la côte nord, la plupart des activités de pêche commerciale sont le fait de navires étrangers.

Il a été proposé d'établir trois aires protégées sur la côte nord, seule celle de Aibat, Sa' adadin et Saba Wanak (deux îles et la côte adjacente à proximité de Zeila [Saylac]) possédant des récifs coralliens. Les effets des activités anthropiques sur l'environnement semblent minimes, à la seule exception de l'exploitation opportuniste, relativement intense, des tortues et des requins. Les pêcheries et les transports ne représentent qu'une petite composante de l'économie nationale et ne sont pas source de menaces significatives pour les récifs coralliens.

Bien que signataire de plusieurs conventions et protocoles, la Somalie ne possède que des capacités limitées à mettre en œuvre les accords internationaux et les dispositions législatives nationales.

L'amélioration de la conservation des récifs coralliens dépend de l'apport de deux types de ressources, à savoir les ressources financières et les ressources humaines. Par ailleurs, cette conservation se place actuellement au troisième rang des priorités nationales, derrière la construction de la nation et l'éradication de la pauvreté. Il sera nécessaire d'établir un système d'aires marines protégées, d'adopter des mesures de lutte contre les déversements d'hydrocarbures, d'instaurer un système d'éducation environnementale de grande envergure et de poursuivre les activités de recherches et de suivi en vue d'une détection précoce de la détérioration des récifs.

Yémen

La République du Yémen est située dans la région sud-ouest de la péninsule Arabique, son territoire comprenant également l'archipel de Socotra. Ses côtes s'étendent sur quelque 2,200 km, dont environ un tiers se trouve sur la Mer Rouge et deux tiers sur le golfe d'Aden. Seul environ un quart des côtes yéménites de la Mer Rouge possède des récifs coralliens. Les plus développés de ces récifs se trouvent au large, à proximité des nombreuses îles de la Mer Rouge méridionale. Seuls 5 % de la côte du golfe d'Aden possèdent des récifs frangeants ou autres. On constate en revanche une forte croissance des coraux dans la zone de l'archipel de Socotra.

Plusieurs projets d'une importance majeure ont permis d'évaluer récemment la répartition, la composition et l'état des ressources biologiques marines de la côte du Yémen. Plus de 300 espèces de coraux bâtisseurs de récifs et 600 espèces de poissons récifaux ont été recensés sur les côtes yéménites. Les communautés coralliennes et la faune ichtyologique récifale de l'archipel de Socotra en particulier sont extrêmement diverses. Au total, quelque 176 espèces de corail madréporaire ont été recensées au Yémen sur la

côte de la Mer Rouge, la diversité des sites s'échelonnant de une à 76 espèces. Pas moins de 19 nouvelles espèces ont été identifiées pour la Mer Rouge méridionale. La diversité est moindre le long de la côte continentale du golfe d'Aden où se trouve, estime-t-on, une centaine d'espèces de coraux. Cette région n'a fait l'objet que de quelques études. La zone de Belhaf-Bir Ali contient la plus forte concentration de communautés coralliennes connues depuis le nord du golfe d'Aden, avec de vastes bancs coralliens au large du village de Bir Ali et des récifs frangeants entourant les îles. La diversité de ces communautés est de modérée à forte (une centaine d'especes) et la couverture corallienne présente de larges variations (moins de 10 à plus de 75 %).

L'archipel de Socotra contient une faune diverse comptant quelque 250 espèces de madrépores, ce qui le classe parmi les sites les plus riches de l'océan Indien occidental. Le développement des coraux est le plus élevé sur les côtes orientées vers le nord; la couverture et la diversité coralliennes y sont plus grandes que sur les côtes orientées vers le sud, dominées par les macroalgues et plus exposées à la mousson du sud-ouest.

Les taux de couverture des coraux madréporaires, des coraux morts, des coraux mous et des algues présentent tous une forte variabilité entre les différents sites de la Mer Rouge, du golfe d'Aden et de l'archipel de Socotra. Les variations des proportions de la couverture de coraux vivants par rapport aux coraux morts sont dues dans une grande mesure aux différents effets des perturbations récentes, notamment du blanchissement corallien de 1998. Au Yémen, sur les côtes nord de la Mer Rouge, les récifs ont une faible couverture de coraux vivants (17 % en moyenne), une forte couverture de coraux morts (34 % en moyenne) et une forte couverture de macroalgues (20 %). La côte continentale septentrionale et centrale et celle des îles côtières présentent une couverture de coraux vivants très basse (3 %) et une forte couverture de coraux morts (34 % en moyenne). Dans l'archipel de Socotra, la couverture de madrépores varie de moins de 1 % à plus de 75 % et, sur certaines formations de grande superficie (environ 1,000 m^2) avoisine 100 %. Dans l'ensemble, la couverture de coraux madréporaires vivants atteint une moyenne d'environ 20 %, les taux les plus élevés (environ 35 %) ayant été relevés sur les îles extérieures.

Le blanchissement de 1998 a eu des effets inégalement répartis dans l'archipel de Socotra et le nord-est du golfe d'Aden. Sur les sites les plus durement frappés, plus de moitié des espèces ont subi des lésions et environ 50 % de la couverture de coraux vivants ont été tués. Les espèces les plus touchées sont celles de la famille des pocilloporidés, les coraux tabulaires et arborescents *Acropora* spp., et les coraux de feu *Millepora* sp.

La pêche est une profession traditionnelle pour des milliers de Yéménites. Les prises annuelles varient de 90,000 à 95,000 tonnes métriques et plus de 90 % de la production halieutique totale du pays provient des pêcheurs artisanaux. Les pêcheries récifales sont, pour la plupart, sous-développées et se situent au niveau de la subsistance.

Ce n'est que ces dernières années que la protection des récifs coralliens a été prise en considération. Il existe une aire marine protégée, celles de l'archipel de Socotra, et des propositions ont été émises en vue d'en établir six autres. L'aménagement du littoral, l'industrie pétrolière et les transports maritimes présentent des risques significatifs pour les récifs, sous forme de rejets d'eaux usées non traitées, de remblayage de la mer et de la pollution par les hydrocarbures.

Arabie Saoudite

Le littoral de l'Arabie Saoudite sur la Mer Rouge s'étend sur environ 1,840 km. Des récifs coralliens frangeants se trouvent sur toute la longueur de ce littoral et autour des îles situées au large de la côte. Ils sont généralement en bon état, à l'exception de ceux qui se trouvent à proximité de Djeddah et de Yanbu. Au début des années 1980, 194 espèces de coraux ont été recensés dans la partie centrale de la côte, où ils présentent la plus grande diversité.

Le blanchissement a causé une mortalité massive des coraux en Arabie Saoudite dans la partie centrale et septentrionale de la Mer Rouge à la fin de l'annee 1998. Ses effets ont été inégalement répartis et d'intensité très variable. L'épisode de blanchissement le plus intense est survenu près de Rabigh, où plus de 65 % de la couverture corallienne en a subi les effets. On a constaté une mortalité corallienne significative dans le sud de la Mer Rouge où sur certains sites (tels que les îles Abalat), la couverture de coraux vivants qui était de 80 % en 1993 n'était plus que d'environ 10 % en 1999. On a également noté que la moyenne mensuelle des températures de surface de la mer étaient anormalement élevées (plus de 32 °C) trois mois avant les premiers rapports signalant la mortalité corallienne.

Les menaces auxquelles sont exposés les récifs coralliens en Arabie Saoudite proviennent principalement du développement industriel et des transports maritimes et comprennent les déversements d'hydrocarbures, le remblayage de la mer et les rejets de polluants et d'effluents dus aux activités de dessalement de l'eau de mer. Les dégâts graves causés aux récifs sont localisés pour la plupart aux environs des grands centres urbains.

De nombreuses propositions de création d'aires marines protégées ont été soumises aux autorités depuis le milieu et la fin des années 1980. Toutefois, à l'exception des îles Farasan, protégées depuis 1996, aucune autre aire n'a été établie en Arabie Saoudite sur les côtes de la Mer Rouge.

L'Arabie Saoudite a exécuté plusieurs programmes et adopté un certain nombre de mesures juridiques visant à la conservation des récifs coralliens. Ces mesures comprennent en particulier des lois sur les rejets de polluants et sur l'établissement des aires protégées. Mais il reste plusieurs problèmes à résoudre ou partiellement pris en considération, et notamment l'application des normes d'émissions en vigueur, le développement industriel, qui comprend le remblayage de la mer, et l'intégration des interventions du secteur public et du secteur privé pour la conservation des récifs.

Jordanie

La Jordanie possède environ 27 km de côte à l'extrémité nord-est du golfe d'Aqaba, dont quelque 30 % sont le site d'activités portuaires. Cinquante pour cent de cette côte est bordée de récifs frangeants qui présentent des coraux et une faune associée d'une grande diversité (158 espèces de coraux appartenant à 51 genres et plus de 280 espèces de poissons).

Les récifs coralliens de la Jordanie sont en bon état, leur couverture de madrépores atteignant 90 %. Ils ont été épargnés par les épisodes de blanchissement survenus en 1998, peut-être en raison de la situation de la Jordanie plus au nord que les autres pays.

Il n'existe pas d'aire marine protégée proprement dite, mais la zone de la station maritime dite Aire protégée des récifs coralliens

d'Aqaba est, de fait, une aire protégée; c'est également la seule du pays dont il soit proposé de faire une aire protégée classée.

La Jordanie a révisé son cadre législatif et réglementaire relatif à la protection de l'environnement aux niveaux national et international. Elle est partie de huit conventions ou traités internationaux qui ont un impact direct ou indirect sur la conservation des récifs coralliens.

Le golfe d'Aqaba est sujet à une forte pollution. Celle-ci est actuellement limitée et localisée. Les principales menaces sont les déversements et les rejets d'hydrocarbures, les rejets industriels et les eaux usées et les déchets solides des navires et des municipalités. Le développement du secteur du tourisme pourrait également faire peser de nouvelles menaces sur les récifs coralliens.

Sommaire

Il est nécessaire, pour améliorer la conservation des récifs coralliens, de renforcer les capacités institutionnelles générales des instances gouvernementales. Cela peut se faire par le recrutement et la formation de personnel, par la mise en œuvre de lois et de règlements de protection de l'environnement et par l'amélioration de la coopération régionale pour coordonner et étayer les efforts des différents États riverains du golfe. Plusieurs mesures supplémentaires sont également requises, et notamment la formulation d'une stratégie de gestion intégrée des zones côtières, un renforcement des capacités en matière de législation et de gestion ainsi qu'au niveau opérationnel, l'établissement d'aires marines protégées et l'harmonisation des règlements existants aux niveaux national et international.

Coral Reefs of Egypt

Introduction

The Egyptian Red Sea coast extends approximately 1800 km along the Gulfs of Suez, Aqaba and the Red Sea, and is bordered by fringing reefs for most of this length. There are also several submerged reefs and fringing reefs surrounding some 35 small islands (Fig. 1).

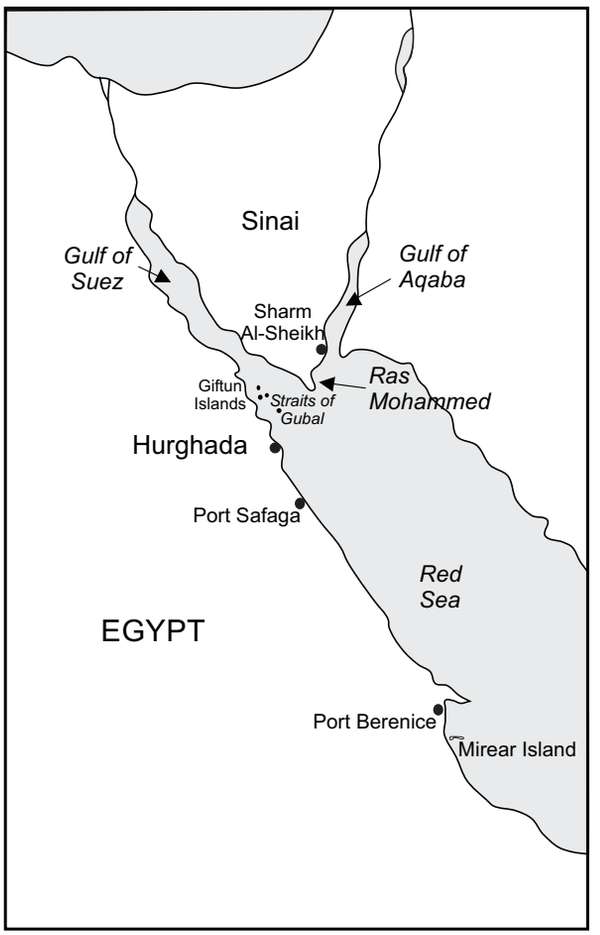

Fig. 1: The major features of the Egyptian coastline

Matters pertaining to the conservation and management of coral reefs are the responsibility of the Egyptian Environmental Affairs Agency (EEAA).

Rapid development over the last few decades has resulted in a number of new anthropogenic threats to the reefs, including high sedimentation rates, dredging, destructive fishing, tourism and curio trading. Resort development is proceeding rapidly, threatening the valuable coral reef resources (JAMESON et al. 1995). The reefs in the Hurghada area, for instance, are under significant stress through anchor and fin damage (JAMESON & SMITH 1997) and an initiative funded by USAID has provided a number of permanent mooring buoys to mitigate these effects. Non-anthropogenic threats include flood run-off, infestations by the crown-of-thorns starfish *Acanthaster planci* and high sea temperatures, resulting in severe bleaching.

Egypt has subdivided the future requirements for coral reef conservation into three major categories:

- information requirements,
- development challenges and
- public awareness.

Under information requirements, it is recommended that advanced mapping techniques be employed to update data on the extent of current reefs. Reef monitoring must be

prioritised in areas of recreational and industrial use and must be continued and incorporated into coastal management plans. Development challenges include improving sewage treatment and outfalls, including collection and recycling of solid wastes, testing and implementing the national Oil Spill Pollution Response Protocol, developing flood control mechanisms, minimising siltation and careful planning of tourism operations within the coastal zone. Finally, it is recognised that there is a need for heightened and improved information dissemination through various media, including workshops, seminars, and academic programmes, and a need for co-operation between the tourism and government sectors.

The most northerly reefs lie near Suez. Along the eastern coast of the Gulf of Suez, patch reefs are small and occur in depths of 1 to 5 m, resting on calcareous sandy substrates. On the western coast of the Gulf of Suez reefs are more developed, forming a fringing reef that stretches from 50 km south of Suez to Ain-Sukhna, extending 30 to 40 m offshore and sloping from 1 to 5 m in depth. There are extensive reefs in the southern Gulf of Suez, on the Sinai Peninsula at Ras Mohammed and surrounding the Ashrafi Islands close to the western shores of the Gulf. In the Gulf of Aqaba there are narrow fringing reefs along the steep cliffs of both shores. At the mouths of *wadis* (river valleys) and across bays the fringing reefs extend outwards for up to 1 km from the shore. In the Red Sea proper, fringing reefs extend from Gubal in the north nearly continuously to Halaib, at the border with Sudan. These reefs are 25 to 150 m wide at the northern end, increasing to 500 m wide from Marsa Alam to Shalatein. At Shalatein, the reef extends up to 12 km from the shore to Mirear Island, decreasing in width (to 50 m) southwards to Abu Ramad.

Surveys

Geographical Scope and Survey Techniques

Surveys were carried out from Hurghada to Shakateen by staff from the Suez Canal University and the Al-Azhar University between 1997 and 1999. The surveys examined 130 reef sites to evaluate the status of coral reefs and associated communities. In addition, more detailed studies were carried out at 11 sites close to Hurghada to assess the impact of recreational diving on reef habitats. ABOU ZAID (2000) summarised data collected by the Egyptian Red Sea Coastal and Marine Resources Management Project, the Ecological Sustainable Tourism Project and the Coral Reef Biodiversity Project to provide a recent overview of reef status. Rapid Environmental Assessments (REAs) were made at 48 frequently visited dive sites as part of the Environmentally Sustainable Tourism Project (JAMESON et al. 1997).

Survey methodology generally followed that outlined in ENGLISH et al. (1997). At the detailed study sites, 10 replicates of a 4 m^2 quadrat were used at 5 m and 10 m intervals to assess coral and fish community structures, comparing heavy and moderately dived sites with control sites at which no diving occurred. In the REA project, quadrat sampling over a one hour period at each of 43 sites yielded data on the percentage of life-form coverage, while the IUCN quantitative line transect method (Pernetta 1993) was used to obtain detailed data at five heavily used sites.

Coral Reefs – Benthos and Fish

Coral Diversity

Reefs in the north and central Red Sea were more diverse than those in the south, with nearly

Region	Genera	Species
Gulf of Aqaba	47	120
Gulf of Suez	25	47
North Red Sea	45	128
Central Red Sea	49	143
South Red Sea	31	74

Table 1: Number of genera and species of reef building corals in the Egyptian Red Sea (ABOU ZAID 2000)

double the number of coral species (Table 1). The distribution and development of reef-building corals was believed to be restricted by several physico-chemical parameters, including temperature, sediment load, salinity and light.

Coral Cover

The percentage of live coral cover generally ranged from 11 to 35 % in the reef flat areas (Table 2), while the highest cover was found along the reef walls (ranging from 12 to 85 %) and reef slopes (5 to 62 %). Variation in coral cover was attributed to siltation, caused by flooding and mining activities, and to recreational SCUBA diving.

Overall there has been a decline in coral cover at most sites in the Egyptian Red Sea (Table 3). Coral cover has decreased by 20 to 30 % and the percentage of recently dead coral (normally through anchor and fin damage) has increased by several factors. Surveys by the

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

Table 2: Average percentage of live coral cover in different reef zones along the Egyptian coastline (GEF 1977)

	Al Aruk		Small Giftun		El Erg 3	
	1987	1996	1987	1996	1987	1996
Hard coral	36.8	24.1	49.9	22.0	60.9	49.2
Soft coral	23.6	15.6	12.5	3.1	16.6	19.8
Rubble	1.7	5.0	3.6	3.6	0	1.5
Recently broken coral	10.9	0	9.2	0	0.2	0.2
Recently dead coral	0	5.5	1.3	3.5	0.5	6.0

Table 3: Historical comparison of reef composition (percentage cover) at three dives sites in the northern Red Sea (adapted from JAMESON et al. 1997)

Marine Conservation Society also indicate deteriorating trends between 1981 and 1996 at Shaab Fanadir and Giftun Saghir (WOOD et al. 1996).

Over 40 % of dive sites had less than 30 % hard coral cover, of which more than one third had significant levels of broken coral (JAMESON et al. 1997).

Fish Communities

ABOU ZAID (2000) reported a total of 261 fish species representing 89 genera from 46 families. He also noted that southern reefs housed a greater diversity of fish species than northern reefs. Exposed reefs contained a higher diversity of fishes than sheltered reefs, which was attributed to the lower incidence of divers and fishermen in these areas. The most abundant family was the Pomacentridae (damselfishes), represented by 16 to 26 species across all sites, followed by the Labridae (wrasses), represented by 20 species. The most common damselfish was *Chromis dimidiata* and the most common wrasse was *Labricus quadrilineatus*. The least abundant family was the Scaridae (parrotfishes), represented by only nine species, of which *Hipposcarus harid* and *Scarus ferrugineus* were the most common. Among the Acanthuridae (surgeonfishes), *Naso literatus, Acanthurus negrifuscus* and *Acanthurus sohal* were the most common species. Chaetodontidae (butterflyfishes) diversity increased in the north, with *Chaetodon larvatus, C. auriga* and *C. fasciatus* being among the most common.

Coral Reef Fisheries

The Red Sea fisheries contribute approximately 11 to 14 % of the total annual Egyptian fish production including aquaculture, and nearly 16 % of the marine fisheries. Of these, 44 % of fish landings are coral reef-based. Fishery activities are regulated by the General Authority for Fish Resources Development (GAFRD) of the Ministry of Agriculture.

Over 7 % of the national workforce is involved in fisheries of one kind or another (GAFRD 1989). Highest landings are reported at the port of Suez (78 % of the total), but most of the fishing boats landing their catch in Suez actually fish further south, in central and southern areas of the Red Sea.

The total number of commercial coral reef fish species is 27. Five species make up over 48 % of the total landings, amounting to slightly over 22,800 tonnes per annum. The balance of the catch is made up of crustaceans, offshore pelagic fishes and demersal fishes (in equal proportions). Fishery landings have decreased steadily since 1994, after a peak in 1993 that consisted of record landings of Indian and other mackerel, and of sardines (PERSGA/GEF 2001). GAFRD aims to increase fish catches to 70,000 tonnes by 2017.

Threats to Coral Reef Biodiversity

Coral reefs are affected by a wide range of anthropogenic impacts. Oil spills, land reclamation and sedimentation are responsible for a large proportion of the damage. Recreational SCUBA diving practices, which also include anchor damage, is also considered significant. Urban garbage, especially plastic, is becoming increasingly prevalent on reefs. A number of natural phenomena, including flooding, disease and predator outbreaks also affect coral reef habitats. It is not understood how much these phenomena are the indirect effect of anthropogenic inputs.

Floods and Earthquakes

Heavy rainfall causes floods from wadis (dry river beds), which increase sediment loads and reduce salinity levels. These effects may extend several kilometres offshore depending on the substrate type and the severity of the flood.

Disease

A number of coral diseases prevalent in the Red Sea have been found in Egyptian waters. Most important of these are black band and white band diseases which are believed to be the result of cumulative stresses from anthropogenic impacts such as high nutrient (chemical) and sediment (physical) loads.

Predator Outbreaks

Major outbreaks include infestations of the crown-of-thorns starfish (*Acanthaster planci*), sea urchins (*Diadema* sp.) and gastropod snails (*Coralliophila* sp. and *Drupa* sp.). *Coralliophila violacea* was found to feed intensely on *Porites* sp. at several sites along the Red Sea (ABOU ZAID et al. in press). *Acanthaster planci* was rarely observed prior to the 1990s. In 1994 there was a moderate outbreak (200 individuals) at Ras Mohammed in south Sinai. It was estimated that the 20 to 30 cm sized starfish caused a loss of 20 to 30 % of total live coral cover. From 1995 to 1998 the populations of starfish appeared to increase in density, with records of up to five starfish per 10 m^2 (Salem 1999). In 1998 a further outbreak of approximately 250 to 300 small (7 to 15 cm) individuals occurred at Ras Mohammed, but the greatest outbreak (10,000 individuals) occurred around Gordon Reef, near Tiran Island. The EEAA have reduced the impact to the reefs by organising the removal of over 60,000 starfish between 1998 and 1999.

Sedimentation and Siltation

Siltation of Egyptian reefs is invariably the result of poorly planned and implemented construction. Dredging and land reclamation (land-filling) activities have resulted in the loss of numerous reef habitats. In Hurghada, a 2,900,000 m^2 reef flat was land-filled, and the sediment plume from this activity extended several kilometres from shore between 1994 and 1997. Mandatory environmental impact assessment studies have curtailed land-filling operations since then.

Nutrient Enrichment

Sewage and phosphate ore washing (such as that at Qusseyr and El-Hamrawain) are the principal sources of nutrient enrichment along the Egyptian coastline. Sewage, high in coliform bacteria and suspended solids, is normally untreated and discharged into the intertidal zones. The effect of these nutrient loads on coral habitats is not fully understood, although it is believed that they result in higher turbidity and sedimentation and reduce coral reproductive capacity.

Salinity Changes

The most important human-induced salinity changes are those caused by discharges from desalination plants. The higher salinity discharges increase coral mucous production and result in the expulsion of zooxanthellae. This leads to bleaching and growth of algae over coral colonies. Efforts to mitigate these effects have been undertaken by the EEAA to enforce the dilution of the brine prior to reintroduction to the sea.

Destructive Fisheries

Unsustainable fishery practices include spear fishing, the use of closed mesh nets and dynamite (blast) fishing, all of which have been reported to occur along the Egyptian coastline (REIGL & LUKE 1998). These practices remove many reef herbivores, resulting in changes (such as algal blooms) to natural ecological processes on the reef.

Bleaching

Rising sea surface temperatures, especially the above-normal warm period between 1997 and 1998, are believed to have resulted in the large scale bleaching and mortality of many scleractinian corals. During the summer months water temperatures increased to 35 ºC, particularly on shallow reef flats (30 to 50 cm deep).

Curio Collecting

Considerable quantities of coral, molluscs and fish are collected for the curio and aquarium trades.

Recreational SCUBA Diving

Major effects of the recreational SCUBA industry include anchor, trampling and fin damage (JAMESON et al. 1999).

Oil and other Hydrocarbons

The danger from oil pollution comes not only from exploration activities but also from transport. Up to 100 million tonnes of oil may pass through Egyptian Red Sea waters each year. Oil and gas exploration are concentrated in the Gulf of Suez, with the main sources of pollution being from Ras Ghariba, Ras Shoukier, Abu Rudees and Abu Zenimah through the inefficient operation of equipment, illegal discharges and lack of monitoring. More than 20 oil spills have occurred along the Red Sea since 1982 (Table 4). The spills involve a number of pollutants, which smother corals and poison them through hydrocarbon absorption. Seismic blasts from oil exploration are also a threat to coral reefs (FOUDA 1983).

Location	Date	Vessel	Spill	Cause
Gulf of Suez	1982	Unknown	Crude oil	Collision
Gulf of Suez	1989	Mbuy Samba	Crude oil	Collision
Suez Canal	1989	Lauber Horn	Crude oil	Grounding
Safaga Island	1991	Salem Express	Fuel	Sinking
Ras Gharib	1992	Samah	Fuel	Sinking
Baranis (Berenice)	1993	Hamad	PVC and fuel	Sinking
Gulf of Suez	1993	Gele 15	Crude oil	Collision
Gulf of Suez	1993	Mega Biolot	Crude oil	Unknown
Suez Harbour	1994	Salam 91	Detergent	Collision
Ras Nasrami	1994	Baltabs Kiazori	Fuel	Grounding
Suez Harbour	1994	Itab	Fuel	Bunkering
Sharm El-Sheikh	1994	Balmeera	Bilges	Malfunction
Ras Shukheir	1994	Meraw	Crude oil	Collision
Ras Shukheir	1994	Hazzam	Chemicals	Discharging
Suez Harbour	1994	Rafah	Bilges	Discharging
Ras Shukheir	1994	Ocean Spirit	Ballast water	Discharging
Sharm El-Sheikh	1994	Unknown	Crude oil	Unknown
Suez Harbour	1994	GPC	Crude oil	Pipe leak

Table 4: Shipping accidents along the Egyptian coastline (1982-1994) resulting in hydrocarbon contamination (ABOU ZAID 2000)

Marine Protected Areas and Level of Management

The Government is committed to a management programme to arrest environmental degradation and to improve environmental quality. Egypt currently has four marine protected areas that include coral reefs, and another two in which coral reefs are not present. The majority of these protected areas have been established around the Sinai Peninsula at sites where recreational SCUBA diving is common and the threat from anchor and fin damage is considered high. In total, Egypt has legally protected over 37,000 km^2. There are seven additional areas that have been proposed or suggested to the Government for protected status. The major implementing and funding bodies in each case involve GEF-Egypt and USAID projects.

MPAs Declared

Ras Mohammed National Park: Established by Prime Minister's Decree No. 1068 in 1983, the Park occupies part of the southern portion of the Sinai Peninsula (27°44'N 34°15'E), now extending to and including Senafir and Tiran Islands, and covering an area exceeding 480 km^2. The Park has a particularly high diversity of flora and fauna, including coral reefs, seaweed and seagrass beds, mudflats, mangroves and other halophytic vegetation. The management plan, developed with financial and technical assistance from the European Commission, includes the development of infrastructure and training for rangers and scientific staff. The Park is an important sea turtle developmental habitat and serves as Egypt's major marine environmental education centre.

***Nabq*:** Occupying another 600 km^2 of the southern Sinai Peninsula, the Nabq Multiple Use Management Area (28°15'N 34°24'E) was established by Prime Minister's Decree No. 1511 in 1992. It encompasses a number of marine and terrestrial ecosystems (seagrass beds, coral reef) and is an important habitat for resident and migratory birds. The mangroves within Nabq represent the northern limit of their extent in the Red Sea. Threats include recreational diving-related damage and uncontrolled output from a shrimp farm.

***Abu Galum*:** Also established by Prime Minister's Decree No. 1511 in 1992, the Abu Galum Multiple Use Management Area occupies part of the Sinai Peninsula extending into the Gulf of Aqaba (28°41'N 34°34'E) and covers an area of roughly 400 km^2. Biologically rich in both flora and fauna, Abu Galum traverses several mountain ranges and wadi systems, freshwater springs and sand dunes. The coral reefs form one of the main SCUBA diving attractions in the region. In addition to coral reefs, the Area contains seagrass beds that support a significant amount of marine life.

***Elba*:** The Elba protectorate (declared in 1986) is by far the largest in Egypt, encompassing 35,000 km^2 of the Doaib, Gebel Elba and Abraq regions (22°10'N 36°19'E). The protectorate is home to large mangrove communities, which serve as important bird breeding sites, and extensive fringing reefs along the mainland and 22 offshore islands. The main threats within the MPA are extensive fishing activities.

The protected areas at El-Zaranik (700 km^2) and Ashtom El-Gamil (1200 km^2) established in 1985 and 1988 respectively, include wetlands and sandy shores but do not have coral reef habitats.

De facto and Planned MPAs

The area that each of the seven proposed MPAs will cover has not yet been defined.

***Giftun Islands and Straits of Gubal*:** This MPA has been proposed to the Egyptian government based on the well-developed and diverse coral reefs and rich reef-associated fauna. The islands are also important sea turtle and seabird nesting areas. Current threats include recreation pressure, anchor damage and fishing.

***Safaga Island*:** Small patches of coral reef surround the mangrove-lined island, which is also a seabird nesting site. Current threats include shipping and a small-scale fishery.

***Sharm al-Lulu*:** This is a small bay lined with coral on both sides. Threats to the area are tourism related.

***Dedalus Island*:** The island lies some 40 km offshore and is mostly affected by recreational SCUBA diving and anchor damage.

***Zabareged (Zabargad) Island*:** This is a small sea turtle nesting island 40 km offshore surrounded by coral reefs. Threats here also include recreational SCUBA diving and anchor damage.

***Brother Islands*:** The coralline islands support extensive and well-developed coral reefs on which extensive diving takes place.

***El-Quseir Reef Complex*:** Extensive and complex submerged offshore reefs with a diverse reef-associated fauna. Threats identified include damage from anchors, SCUBA diving and coral collection.

***Wadi Gamal*:** A large terrestrial area, with coastal wetland, mangroves, islands and migratory birds; there are no coral reefs present.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

Several institutions carry out monitoring activities along the Egyptian coastline. The Egyptian Environmental Affairs Agency (EEAA) is responsible for monitoring pollution and damage to coastal environments. The National Institute of Oceanography and Fisheries (NIOF) has carried out investigations of fisheries and corals and associated fauna in the Hurghada region for 70 years. In addition, staff from the Al-Azhar University and Suez Canal University carry out research and monitoring of coral reef habitats.

There are three organisations in charge of the management of coral reef resources: the Tourism Development Agency (TDA), the Egyptian Environmental Affairs Agency (EEAA), and local governments through three Red Sea Governorates (RSG). The primary role of the TDA is to support the private sector tourism industry and to develop an institutional framework for environmentally sound tourism development. This includes developing guidelines for hotel management and the follow-up of environmental regulations and procedures. The EEAA is tasked with developing environmental preservation policy and legislation and with reviewing environmental impact assessment studies. The EEAA is also responsible for the control of pollution, National Park and coastal zone management, including law enforcement for coastal recreational activities. In addition, the EEAA recommends the accession to regional and international conventions related to the environment. The RSGs are responsible for promoting tourism and regulating land allocation and hotel construction within city limits through zoning and the issue of permits.

In addition to the three primary organisations, several secondary agencies play a role in environmental management. The

Egyptian General Petroleum Corporation (EGPC), which is responsible for oil and gas exploration, controls the activities of international oil companies and has developed an oil spill response capability in Ras Gharib on the Gulf of Suez. At present, the equipment available for tackling oil spills is only suitable for small spills in good weather. The National Committee for Integrated Coastal Zone Management (NCICZM) co-ordinates coastal activities among competent authorities by developing guidelines for all activities, including EIAs. The NCICZM is responsible for harmonizing development with the carrying capacity of coastal ecosystems, and for co-ordinating and specifying mandates for authorities in the coastal area.

Finally, a number of tertiary agencies are also responsible for the protection of the marine environment. These include the Port and Lighthouse Authority, the Suez Canal Authority, Suez Port Authority, GAFRD, and the General Organization for Coastal Protection.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

Egypt is a signatory to a number of international conventions under which the conservation of coral reef resources is stipulated or indirectly addressed. At the same time, since the early 1980s the country has enacted a number of laws and presidential decrees through which coral reefs receive direct or indirect protection.

International Agreements

Egypt has acceded to the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment and to the Protocol for Regional Cooperation for Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982). It is a signatory to the MARPOL Convention, the Convention on Wetlands of International Importance (RAMSAR), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the African Agreement for the Conservation of Nature and Natural Resources (Algiers 1988) and the Convention on Biological Diversity (CBD).

National Legislation

A number of Presidential decrees and Public laws have been formulated dealing with oil and other forms of pollution, coastal development and tourism, through which coral reefs receive direct and indirect protection (Table 5).

Gaps in Capacity and Requirements for Improved Conservation

One of the major gaps identified in the process of coral reef conservation is that of *appropriate* information. While there are several hundred publications on Red Sea coral reefs, few of these address specific problems and offer management solutions. There is currently no water quality database on which repeated measurements can be based and compared. There is also a need to establish detailed, refereed species lists for each area covering corals, their associated fauna, and the fishery resources. It is also necessary for Egypt to participate in regional and global information networks and to develop national training and education programmes through the use of local and international experts.

Research

Research needs to be carried out in order to establish baseline environmental conditions and follow-up monitoring should refer to these baselines to detect changes in environmental quality.

Law, Ordinance, Regulation	Year	Implementation
Public Law No. 280	1960	Ministry of Defence
MoD Decree No. 56	1962	Ministry of Defence
Presidential Decree No. 1984	1965	Ministry of Petroleum
Public Law No. 72	1968	Ministry of Tourism
Presidential Decree No. 691	1972	Ministry of Tourism
Establishment of Protectorates Law No. 102	1983	Ministry of Environmental Affairs
Prime Minister's Decree No. 1068 (Ras Mohammed National Park)	1983	Ministry of Environmental Affairs
Prime Minister's Decree No. 1429	1985	Ministry of Environmental Affairs
Presidential Decree No. 152	1986	Ministry of Environmental Affairs
Prime Minister's Decree No. 450	1986	Ministry of Environmental Affairs
Prime Minister's Decree No. 1186	1986	Ministry of Environmental Affairs
Prime Minister's Decree No. 459	1988	Ministry of Environmental Affairs
Presidential Decree No. 478	1988	Ministry of Environmental Affairs
National Environmental Action Plan	1991	Ministry of Environmental Affairs
Prime Minister's Decree No. 1511	1992	EEAA
Public Law No. 4	1994	EEAA
Prime Minister's Decree declaring 22 islands and mangrove areas as protected areas	1995	Ministry of Environment

Table 5: National laws and decrees that affect coral reef protection directly or indirectly, and the date when they came into effect

Networking

There is a need to integrate current research into global initiatives such as the International Coral Reef Initiative (ICRI) and the Global Coral Reef Monitoring Network (GCRMN).

Training

There is a need for training in the use of modern technology, including SCUBA, Remotely Operated Vehicles, side-scan sonar, satellite mapping and Geographical Information Systems (GIS).

Planning

Direct use and indirect development activities that affect reef systems need to be carefully evaluated in the design stages and be subject to continued monitoring through the implementation stages.

Community Education

There is a need to develop community education programmes that highlight the impact of communities on reef ecology, including degradation.

Recommendations to Improve the Conservation of Coral Reef Resources

A number of actions are needed to improve Egypt's current response to and mitigation of natural and anthropogenic threats. These involve the collection of baseline information for sound decision making, the development of an integrated coastal area management plan, the review and upgrading of existing regulations and more efficient monitoring and control of pollution sources and coastal development.

Zonation and Protection

Key marine areas should be assigned extra protection through strict planning. A comprehensive coastal zoning scheme is needed in which four land classes are recognised:

- Urban and development areas in which commercial and industrial development assessments should be carried out.
- Standard areas where normal planning regulations apply and in which EIAs should be carried out.
- Multiple Use Management Areas in which development is restricted but traditional uses continue.
- Marine Parks and Reserves that afford complete protection to species and habitats.

Coastal Zone Management

A comprehensive, integrated plan is needed to address development along coastal areas and to harmonize existing conservation projects.

Pollution Control

Local and regional pollution monitoring units should be established, along with the provision of adequate reception facilities for petroleum wastes, guidelines for the use of dispersants, a review of existing pollution control regulations and the development of a contingency plan for pollution control. Also needed are improved sewage treatment facilities, diversion of outfalls away from reef habitats and effective collection and recycling of solid wastes. To reduce sedimentation, silt curtains, berms and other mechanical aids should be used around coastal construction.

Geographical and Biological Data Sets

Complete, up-to-date data sets on the biological components of the coastal zone are needed for effective management. These should include fishery stock assessments, shoreline profiles, land use patterns and coral reef resources.

Information

National training programmes are needed to raise institutional capacities of key agencies involved in coral reef management, linking decision makers with the facts needed for sound environmental management decisions.

Coral Reefs of Sudan

Introduction

The Sudanese Red Sea coast is approximately 750 km long inclusive of bays and inlets, extending from 18ºN at the Eritrean border to 22ºN at the Egyptian border (Fig. 2). Average annual rainfall is 111 mm (varying from 36 mm at Halaib to 164 mm at Suakin) and the coastal plain is very dry. Sudan lies within the desert and semi-desert sub-zone and there is no perennial water flow to the sea. Only after torrential rains, which occur mainly in November and December, is there occasional freshwater influx. In most parts of the Sudanese Red Sea water transparency is very high, reaching up to 70 m. Surface temperatures range from 26.2 to 30.5 °C, and salinity is high (39 to 41 ppt). From May to October, surface currents flow in a southerly direction, for the rest of the year they flow northwards.

The primary coral habitats along the Sudanese Red Sea coast are barrier reefs, fringing reefs and one oceanic atoll, Sanganeb (Fig. 3). Most of the coast is bordered by fringing reefs 1 to 3 km wide, which are separated by deep channels from a barrier reef 1 to 14 km offshore. The outer barrier drops steeply to a depth of several hundred metres. Previous studies along these reefs suggested they are among the most diverse and spectacular in the Red Sea (Head 1980; IUCN/UNEP 1985; Krupp et al. 1994; Ormond 1980, 1987; Schroeder 1981; Schroeder & Nasr 1983; Vine & Vine 1980; Vine 1985). One of the most unique reef structures in the Sudanese Red Sea is Sanganeb atoll (Krupp 1990), whose steep slopes rise from a seafloor at more than 800 m depth.

Port Sudan is the largest coastal city with a population of about 390,000. At present the natural resources of the Red Sea are under-exploited due to a lack of marketing, transport facilities and cold storage. There is no offshore oil exploitation, the contribution of fisheries and tourism to the GNP is less than 3 % and subsistence fisheries are only locally important. The primary industries are maritime shipping and port-related activities. Tourism and fisheries have great growth potential, as does shrimp aquaculture.

At present fisheries play a minor role in the economy at the national level, but are important at a subsistence level along the coast. Non-living resources from the coastal area include metalliferous muds, oil and gas. Natural gas was found in Tokar and Suakin, while offshore reserves are located in the Suakin archipelago. Present exploitation amounts to 16.1 million cubic feet per day.

While large parts of the Red Sea region are still in a pristine state, environmental threats, notably from habitat destruction, over-exploitation and pollution, are increasing rapidly, requiring immediate action to protect the region's coastal and marine environment.

Surveys

Geographical Scope and Survey Techniques

D. NASR and K. AL-SHEIKH carried out surveys on Sudanese corals in 1999 at three sites (Abu Hashish Jetty, Bashayer Port and Arous Tourist Village). Hunting Aquatic Resources (HAR), under contract to PERSGA, carried out a more thorough survey in 1997, covering the coastal area from Port Sudan to Suakin.

In the 1999 surveys, Reef Check methods (HODGSON 1999) were followed to determine percentage cover of hard, soft and dead corals and to obtain a general assessment of reef health, while 10 m quadrat analysis and 20-minute timed swims (ENGLISH et al. 1997) were used by HAR. During these surveys the percentage cover of different life forms was determined along with counts for indicator species such as butterfly and angelfishes, the humphead wrasse *Cheilinus undulatus* and several commercial fishes.

Coral Reefs – Benthos and Fish

The coral reefs of the Sudan are considered to be in moderate to good health, despite an extensive coverage of algae over a high proportion of the fringing reefs surveyed. An algal film covered a large proportion of the shallow corals, but was not found to affect those more than 10 m deep. The reefs are patchy in depths less than 10 m, with average live coral cover ranging from 5 % to 75 %. Below 10 m, the reefs contain healthy colonies of framework corals. In general, the status of the fish fauna was considered good, and overfishing not a severe problem at the coral reefs. As an example, grouper counts were high relative to assessments in other parts of the Red Sea, with more than 20 groupers in over half of the 20-minute swim samples recorded. Key indicator species were abundant and diversity appeared high relative to other Red Sea sites.

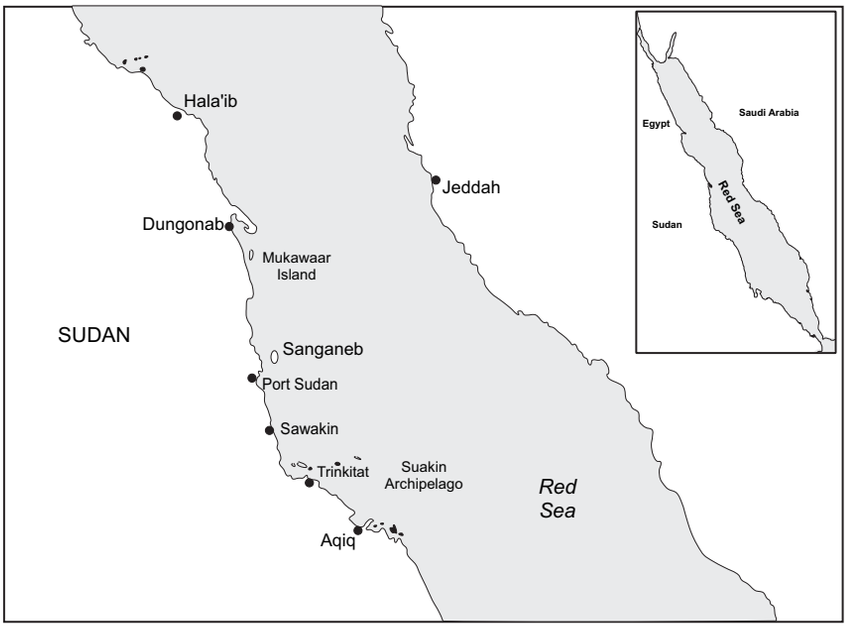

Fig. 2: The Sudanese coast of the Red Sea

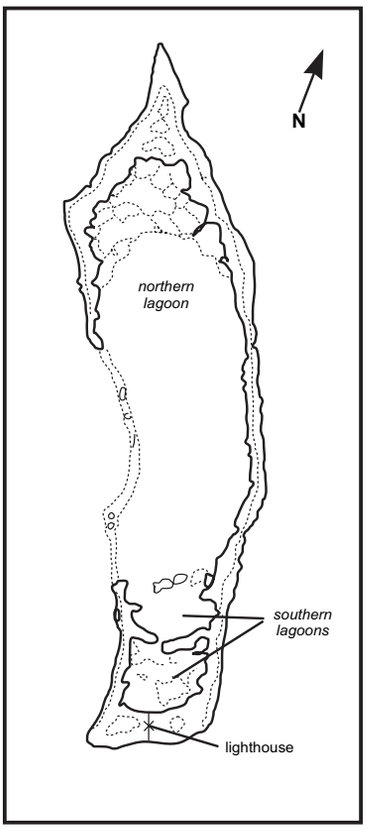

Fig. 3: Sanganeb atoll, off Port Sudan

Anthropogenic pressures on the reefs are low, with those most affected being the fringing reefs along the coast in the vicinity of Port Sudan and Suakin. Framework corals are still intact and large colonies of *Acropora* and *Porites* survive at depths in excess of 10 m. Those shallower than 10 m are affected by an algal cover believed to be the result of thermal influences. The crown-of-thorns, *Acanthaster planci,* was not recorded in plague numbers on any of the Sudanese reefs.

Coral Cover

Over 80 % of the coastal fringing coral reef sites surveyed in 1997 had a high percentage of thin algal film cover, averaging 28.8 % (range 5 to 95 %, n = 54 sites; PERSGA/ALECSO in press). Live coral cover ranged from 5 to 60 % (mean = 25.3 %, n = 25 sites). Dead coral cover exceeding 1 % was only noted at five sites. The dominant substrate cover at depths shallower than 10 m was algal film. The origin of the high algal film cover was attributed to a thermal event, possibly through runoff of high temperature waters from a lagoon. The die-off event is consistent with reports of similar events in Saudi Arabia and Eritrea at the same time. The algal cover did not affect larger colonies and it was suggested that the reef might recover from this within a span of decades, rather than centuries (PERSGA/ALECSO in press).

At Abu Hashish Jetty the reef extends about 800 m with an average depth of 2 m followed by a steep drop-off to a depth of 10 m. Surveys by Nasr & Al-Sheikh (2000) found that the percentage of hard live coral (HC) ranged upwards from 23.5 % at 10 m deep and 50 % at 5 m, while dead coral (DC) ranged from 2.5 % at 10 m deep and 0 % at 5 m, suggesting that the area was comparatively healthy. At Bashayer Oil Exporting Port, where the area between the shoreline and the fringing reef is shallow (0.5 to 3.5 m) with a muddy sand bottom, HC covered 37.5 % while DC covered 21.25 % of the substrate. At 2 m a large number of corals were dead and covered with algae indicating that a coral die-off had recently taken place. This observation was supported by the results of interviews with scientists from the Institute of Marine Science of the Red Sea University and divers in the area. They reported that during the summer of 1998, when the water level was exceptionally low, the corals in the barrier reef 2 km away were white in colour 'as if covered with a white cloth' i.e. corals were bleached. At Arous, a small tourist village where coral damage by tourist activities is noticeable, dead corals covered 51.25 % of the substrate but no bleaching was observed below 4 m. Bleached corals were observed at the top of the fringing reef at 2 m (Fig. 4). Overall, bleached corals were estimated to cover 14 % of the substrate.

Fish Communities

Based on the results of the 1997 surveys (PERSGA/ALECSO in press), fish communities were considered healthy and abundant. The humphead wrasse, currently considered endangered throughout its range, was found in three of the 25 timed swims. Angelfish (Pomacanthidae) were observed at all but one site, with 15 sites recording more than 10 angelfish; butterflyfish (Chaetodontidae) were recorded at all sites, of which 19 contained more than 50 individuals; triggerfish (Balistidae) were only recorded at seven sites, with a maximum of two at any site; groupers (Serranidae) were recorded at all sites, and 13 sites contained more than 20 individuals; similarly, snappers (Lutjanidae) were recorded at 24 of the 25 sites, with a maximum count of 212 and at four sites more than 100; surgeonfish (Acanthuridae), in particular the endemic *Acanthurus sohal* and *Ctenochaetus striatus*, were noted at all sites and a number of indicator wrasses (Labridae) were also found at all sites. Sharks were reported at three sites. The surveys in 1997 recorded an abundance of Chaetodon semilarvatus, which was not found in 1981

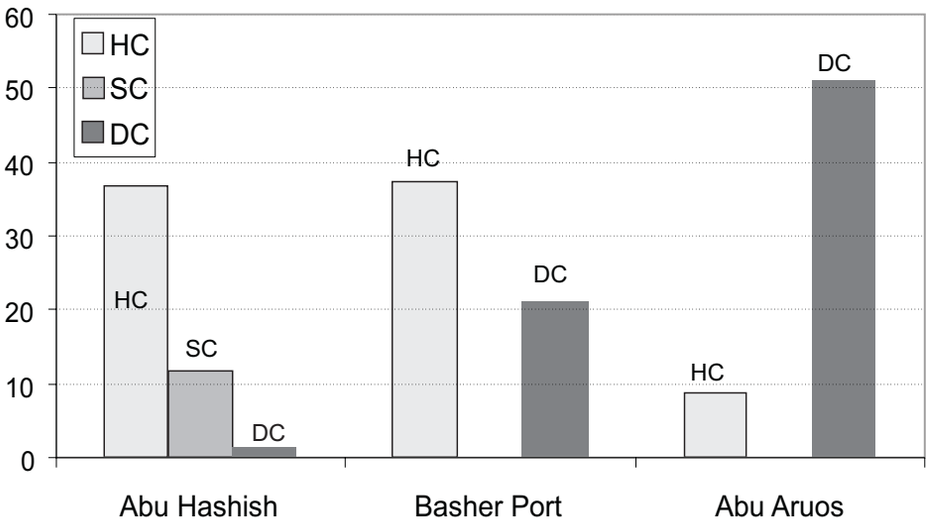

Fig. 4. Average percentage of coral cover from three selected sites, Sudanese Red Sea coast (NASR & AL-SHEIKH 2000)
HC = live hard coral, SC = soft coral, DC = dead coral

(EDWARDS & ROSEWELL 1981), but they did not record the presence of *C. pausifasciatus*, which was found frequently around Port Sudan at that time. A list of fish species recorded from Sanganeb can be found in KRUPP et al. 1994.

Selected non-piscivore fauna were counted during timed swims and distribution was normal (PERSGA/ALECSO in press). Studies were undertaken on the distribution of polychaetes and crabs at Sanganeb, and on the mangrove fauna along the Sudanese coastline by KRUPP et al. (1994).

Coral Reef Fisheries

At present fisheries play a minor role in the economy at the national level, but are important at a subsistence level along the coast. Neither commercial nor artisanal landings reach the estimated maximum sustainable yields but further fishery development at present is negligible. Fisheries are believed to have great potential in Sudan, but face logistical problems such as refrigeration and transport.

SANDERS & KEDIDI (1981) and MISHRIGI (1993) report about 65 species of economically important bony fishes, in addition to sharks, rays, shrimps, lobsters, crabs, molluscs and sea cucumber. In artisanal fisheries, the nine following taxa account for 60 to 70 % of the catches: gushar (*Epinephelus spp.*), bohar (*Lutjanus bohar*), asmoot (*Lutjanus gibbus*), shaoor (*Lethrinus spp.*), bayad (*Carangidae*), najil (*Plectropomus maculatus*), farisi (*Aprion sp.*), abu garin (*Naso unicornis*), arabi (*Valamugil seheli*) and sharks (mainly Carcharhinidae and Sphyrnidae).

Other reef-based fisheries involve the reef mollusc, trochus (*Trochus dentatus*), and sea cucumber (*Holothuria sp.*) and the pearl oyster (*Pinctada margaritifera*).

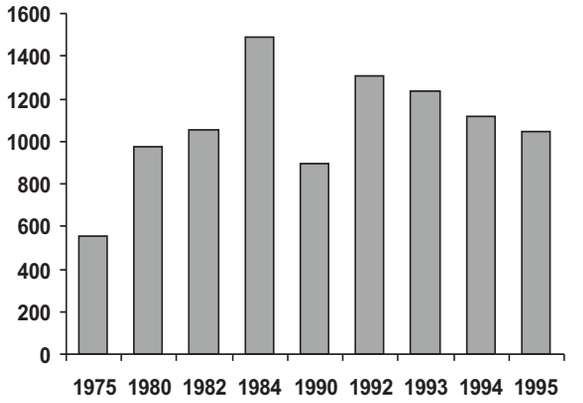

Fig. 5: Artisanal finfish landings in metric tonnes between 1975 and 1995 (PERSGA/GEF 2001)

All the shallow water areas (mersas) along the Sudanese coast are potential spawning grounds. The only spawning ground for oysters is Dungonab Bay, where there are eight oyster farms producing mother-of-pearl for export. The only areas where trawl fishing is carried out are the Tokar Delta in the south and Ofoul Bay in the north. Over 80 % of fish are caught with hook and line. There are an estimated 400 small fishing boats in Sudan and about 300 slightly larger boats of 9 to 10 m (4 to 5 crew). Fish are exported from Port Sudan to Saudi Arabia about every 10 days. A DANIDA study in 1989 estimated that there were about 1,500 artisanal fishermen in Sudan.

The Fisheries Administration of Sudan suggests that the maximum sustainable yield from artisanal fisheries is around 10,000 mt. Present annual production is 1,200 mt, more than double that of 1975 (555 mt). Peak landings occurred in 1984 (1,489 mt) and have gradually decreased by 30 % since that time (Fig. 5; PERSGA/GEF 2001). Over the last two decades two major fishery development projects were phased out (FAO 1980 to 1985 and ODA 1975 to 1990), whereupon financial support to the artisanal fisheries was discontinued and no other financing mechanisms have been developed. At the same time, fuel and maintenance costs increased, and fishermen have reverted from modern outboard-powered craft to sailing dugouts.

Catches of bohar, farasi and koraib (*Pristipomoides filamentosius*) have decreased by 50 %. Shark catches, which presently represent a small sector of the artisanal fishery, decreased from 90 mt in 1982 to 13 mt in 1992. No figures are available for catches by foreign vessels (MISHRIGI 1993).

Commercial fisheries are currently under-exploited. Several ventures have carried out trial trawls in Sudan's 700 km^2 of trawling grounds, landing a catch that was composed primarily of lizard fish (75 %). Shrimp catches were not considered economically viable and most trawlers have moved away from the area. Offshore there is the potential for purse seine fisheries and present landings amount to some 1,300 mt, with an estimated maximum sustainable yield of 2,300 mt.

Three other important fishery resources are kokian (trochus shell) and sadaf (pearl oysters) and sea cucumber (*Holothuria* sp.). Traditionally, the Suakin area was the centre of kokian (*Trochus dentatus*) fisheries, but the fishery recently shifted to Mohammed Gol. Annual exports of kokian from 1991 to 1995 varied between 306 and 535 mt. The pearl oyster (*Pinctada margaritifera*) is a highly prized resource, based at Dungonab and Mohammed Gol. The average annual landing declined from a peak in 1971 of 118 mt to 25 mt in subsequent years. Oyster farming has flourished in Dungonab with up to 65 family farms. Large-scale farming ceased in 1969 following mass mortality events but export continued from wild populations. Between 1966 and 1989, the average annual export rate was 37 mt. Since 1998 the Dungonab oyster culture scheme has been revived, and there are now 36 farms in Dungonab and 15 in Mohammed Gol. The farms grow some 6,000 oysters each and are supervised by scientists. Improved growth rates allowed for partial cropping after only two years, rather than 3 to 4 years as used to be the

case. However, mortality is still high (up to 50 %). OXFAM UK/Ireland presently funds oyster farms under the supervision of the Marine Fisheries Research Centre as part of a community development project (FRC/IDRC 1985, MISHRIGI 1993). In 1981, 15 mt of dried sea cucumber were exported and thereafter production ceased due to low prices and difficulties in collecting. Sea cucumber exploitation recently resumed in the Marsa Ashat area south of Suakin.

Threats to Coral Reef Biodiversity

Due to the limited scale of industrial development along the Sudanese coastline, threats are localised at the few urban centres. The most severe threats come from maritime shipping, dredging and land-filling, although the tourism sector contributes to reef damage through physical contact from anchors and divers' fins. An additional problem that will involve an international solution is that of the shark fishery, which may lead to ecological changes on the coral reefs through the removal of top level carnivores.

Maritime Transport

Port Sudan is the largest port and accounts for the bulk of the country's import and export trade with about 1,000 ship-calls per annum. Apart from ship-related pollution risks (e.g. discharges of garbage and oily wastes; bunkering activities), Port Sudan handles approximately 1.5 million tonnes of petroleum products annually and accidents involving tankers, together with discharges from unloading operations, constitute a serious pollution risk.

Physical damage to coral reefs is caused by anchors. Wingate and Towartit Reefs are the main anchorage areas for large vessels waiting to enter the port. There is an urgent need for moorings at these two locations. There are also signs of coral die-off at several sites on the fringing reef near Wingate, believed to be caused by vessel discharges.

The coral reef systems also pose several hazards to navigation. Combined with heavy maritime traffic and limited navigational devices, there is a constant risk of ship collisions and groundings. This is particularly severe near the ports of Port Sudan and Suakin, both of which have to be approached through channels among large reef complexes.

Vessel sewage and discharges of solid waste from ships pose additional threats. Without waste reception facilities at the ports, ships dispose their waste directly into the sea. Vessels are reported to throw large garbage bags overboard once they reach international waters. Once these break, they release their contents into the sea.

Tourist boats also damage reefs with anchors, and there is a need for moorings at popular diving destinations.

Coastal Development

Habitat destruction as a result of coastal development is localised. The extension of Port Sudan and the port at Suakin, which involved dredging and land-filling, resulted in severe sedimentation pressure on coral reefs. In Suakin, parts of the coastal fringing reef have been removed for the extension of the port. A new port has been constructed at O'Seif, while a fourth one is planned at Agig and further reef damage is expected at these locations. The implementation of the Sudan Integrated Fisheries Project is also expected to destroy coastal habitats: at the entrance of Port Sudan harbour 5 to 8 ha of land will be land-filled for

the construction of industrial processing plants. This will cause damage to the coral reefs at Wingate and Towartit.

The establishment of the Economic Free Zone (EFZ), which covers 600 km² between Port Sudan and Suakin, may also impact the diverse coral reefs at Towartit, which are located immediately offshore. Heavy industries, petrochemical industries, fish processing factories, slaughter houses with a capacity of 3,000 heads per day, tanneries and warehouses are expected to be established in the area.

Destructive Fisheries

At present shark resources are being depleted and catches by local fishermen are declining rapidly due to large-scale shark fisheries by foreign vessels for the East-Asian shark fin market. A proportion of these fishermen operate with licences, but many fish illegally. Sharks are caught by hook and line, and with nets, the latter damaging coral reefs. Large amounts of bye-catch, including turtles, dolphins and fin-fish are discarded, invariably dead. The capture of top-level predators and the accidental mortalities that are associated with the trade may irreversibly alter the ecological balance of the reef ecosystems. Recently the Government has decided to stop commercial shark fisheries and no new licences will be issued.

Petroleum Industry Development and Transport

There is a constant threat of oil spills. Oil leaks occur regularly from the oil terminal and tankers in Port Sudan Harbour and the Port is already heavily polluted by oil. The oil film extends as far as the edge of Wingate reef and this affects the productivity and the fauna in the harbour area. At some sites intertidal biota have disappeared completely (Abu Bakr 1995).

A new joint venture company, the Greater Nile Petroleum Operating Company (GNPOC), has been formed to manage a pipeline that will transport crude oil 1,500 km from the Heglig and Adariel oil fields to the Sudanese coast for export. The new Bashayer oil terminal is located at Gezirat Abd Alla, about 24 km south of Port Sudan. Gezirat Abd Alla is in the present anchorage area between the shoreline and Towartit Reef. It has deep water and is sheltered from prevailing winds.

With the gradually increasing volume of shipping using Port Sudan and the development of the new oil terminal at Bashayer, a National Oil Spill Contingency Plan for Sudan has been prepared. This contingency plan describes the policy and procedures for the response to oil spills in the coastal waters of the Sudan, including the organisational relationship of the various bodies involved. The scope of the plan covers internal waters including ports, harbours, estuaries, bays and lagoons. On land, it includes the foreshore and any adjacent land affected by an oil spill.

Industrial Activities

Primary industry is located in the vicinity of Port Sudan. The chronic release of industrial pollutants has caused a decline in water quality. Among these are the oily discharges from Port Sudan refinery, which are discharged without treatment or analysis. A major source of oil pollution is the power station, which is in the innermost part of Port Sudan Harbour. The International Tyre Manufacturing Distribution Co. Ltd. (ITMD) has problems with management of its solid wastes, in particular the disposal of carbon residue, of which loose discharges constitute a significant health hazard and also pollute the beach.

Bleaching

No bleaching was reported by PERSGA/ALECSO (1998), but coral die-off events were observed on shallow reefs. The report suggested that these reefs exhibit the potential for recovery if development in the region is well managed. A widespread die-off of reefs at shallow depths was also mentioned in the Sudan Country Report (PERSGA/GEF 2001). The coral die-off event in the fringing reef was attributed to coastal developmental activities, but no explanation was given to those occurring in the offshore reefs and the report called for further investigation.

In July 1998, a survey on the western side of Sanganeb atoll indicated that reefs were relatively healthy, supporting a diverse fish population, and bleached corals covered only 14 % of the substrate (NASR & AL-SHEIKH 2000). At Bashayer Oil Exporting Port a large number of corals were dead and covered with algae, indicating that a coral die-off had recently taken place. Observations by scientists at the Institute of Marine Science (Red Sea University) and divers in the area indicated that when the water level was exceptionally low they had noticed that corals in the barrier reef were white in colour and suggested that corals were bleached. Tourist operators reported that bleached corals in the southern Sudanese Red Sea could amount to 30 % of cover, with *Platygyra* sp. being the most affected.

Marine Protected Areas and Level of Management

MPAs Declared

The only Marine Protected Area in Sudan is the Sanganeb Marine National Park (19°45'N 37°25'E), established in 1990. This is a 12 km^2 atoll with highly diverse and complex coral reefs, diverse reef-associated fauna, sharks, marine mammals and manta rays (KRUPP et al. 1994) and is the only typical atoll in the Red Sea. Current threats come from recreational diving practices, including anchor and fin damage.

De facto and Planned MPAs

There are five proposed Marine Protected Areas, of which four contain coral reefs:

- Shuab Rami, which covers about 4 km^2 and contains highly diverse coral reefs with unique associated fauna including sharks and marine mammals,
- Mukawwar Island and Dungonab Bay, which cover about 300 km^2 and are home to coral reefs, whale sharks and the largest aggregations of manta rays in the Red Sea,
- the Suakin archipelago, which contains coral reefs with a diverse fish fauna and is a nesting site for marine turtles and sea birds,
- Abu Hashish, which covers about 5 km^2 and also contains diverse coral reefs and associated fauna.
- The proposed Khor Kilab Bird Sanctuary (2 km^2) is an estuarine area with mangrove and salt marsh, important for migratory birds.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

Sudan has much of the infrastructure needed for regular monitoring and effective management of coral reef resources. A number of research organisations (based at the universities) have carried out research on reefs

in the past, while government agencies (such as the Navy) provide a limited degree of enforcement. Many of the present problems can be attributed to a widespread lack of law enforcement activities, a lack of awareness among law enforcement authorities, a weak legal framework and the absence of surveillance. Recently, power was transferred from the central government to federal states. The new system is not yet well established, resulting in an unsatisfactory legal situation and inadequate enforcement of existing regulations.

Monitoring Capacity

Monitoring is carried out primarily through research projects based at the universities and through external research groups. The most recent research has been carried out by staff from the Red Sea University. The following organisations collect information on coral reef ecosystems:

- **The Sudan Marine Conservation Committee** (SMCC): This institution includes representatives from all government institutions, the private sector and NGOs concerned with the Red Sea environment. It has played an important role in raising awareness and in formulating regulations, particularly in the 1970s.

- **The Red Sea University at Port Sudan**: Founded in 1993, two of its sub-units are active in marine research and education. These are the Faculty of Marine Sciences and Fisheries that trains undergraduate students in marine and fisheries sciences, and the Marine Research Institute that is being established to revive the research activities of the former Institute of Oceanography.

- **The University of Khartoum**: The Departments of Zoology, Botany and Geology train students and conduct research on the Red Sea. The Suakin Marine Biological Laboratory is engaged in marine biological research and training of undergraduate and graduate students from the Universities of Khartoum, Juba, El Nilein and Umdurman Ahlia. The laboratory has reasonable facilities but no resident research staff because of a lack of research funding. The Institute of Environmental Studies conducts research on environmental issues and supervises graduate students.

- **NGOs**: include the **Sudanese Environment Conservation Society**, which has branches at Port Sudan and Suakin, the **Sea Friends Association** at Port Sudan, and **OXFAM** U.K./Ireland which has offices in Port Sudan and Tokar.

Management Capacity

Coral reefs are only managed indirectly through government institutions and regulations, with the exception of the Sanganeb National Park. The following institutions are involved in management of coastal and marine areas and resources:

- **The Ministry of Environment and Tourism:** Established in 1994 with the mandate of co-ordinating environmental conservation and promoting tourism. Under its umbrella it includes the *Higher Council for the Environment and Natural Resources* (HCENR), which is the technical branch in charge of co-ordination, policy making and international co-operation; the *National Tourism Corporation*, which is responsible for the planning and promotion of tourism; and the *General Administration for Wildlife Conservation*, which is charged with the protection and management of wildlife, including protected areas.

- **The Ministry of Animal Wealth:** In charge of animal production and fisheries, and includes the *Marine Fisheries Administration*, which manages fisheries resources and controls the observation of fisheries regulations; the *Marine Fisheries Research Centre*, which provides scientific information for the management of fisheries resources; the *Wildlife Research Centre*, in charge of providing the scientific background for wildlife conservation and management.

- **The Ministry of Transport:** Includes the *Sea Ports Corporation*, which takes responsibility for all ports, maritime transport and the *Maritime Administration Directorate*.

- **The Ministry of Energy and Mining:** Co-ordinates coastal and marine mining activities, oil and gas explorations.

- **The Ministry of Defence:** Is in charge of the Naval Forces in the Red Sea area. The Navy is responsible for the security in the coastal and marine areas. It has a boat and two soldiers stationed at Sanganeb Marine National Park.

- **The Ministry of Interior:** Is in charge of the Police Forces. The *Wildlife Force* is under administrative supervision of this Ministry.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

Sudan is a signatory to a number of international conventions and agreements that promote the protection of coral reefs. National legislation in Sudan does not address coral reefs *per se*, but indirectly supports pollution control measures that affect coral reefs. It is suggested that the demarcation and enforcement of Marine Protected Areas will strengthen national legislation.

International Agreements

Sudan has ratified the following Conventions and Protocols (adoption date / ratification date): Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa (1991/1993); Convention Concerning the Protection of the World Cultural and Natural Heritage (-/1974); Convention on Biological Diversity (1992/1995); Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973/1982); Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (1982/1984); Protocol Concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982/1984); United Nations Convention on the Law of the Sea (1982/1985). MARPOL has not yet been ratified, because of a lack of port reception facilities.

National Legislation

Several national legislative frameworks are in place that relate to coral reefs:

- **Sudanese Fishery Ordinances and Regulations:** Dates back to 1937 and was amended in 1975 and 1978. Prohibits overfishing, dumping of refuse and oil into the sea and the collection of corals, shells and aquarium fish.

- **Environmental Health Act:** Established in 1975. Prohibits the dumping into the sea of any item that is harmful to humans or animals.

- **Marine Fisheries Ordinance:** Gives police, customs officers and local authorities the right to board and search a vessel and detain any craft accused of violating the above regulations.

- **Maritime Law:** Drafted by the Maritime Administration and waiting approval and implementation.

- **Comprehensive National Strategy:** Through this, Sudan is committed to the pursuit of sustainable development and environmentally sound resource management.

Gaps in Capacity and Requirements for Improved Conservation

A major problem in the conservation of reef resources is funding for research and management efforts. Additionally, there are political obstacles within the government: the General Administration for Wildlife Conservation is charged with the protection and management of wildlife, including protected areas. However, it is still lacking experience in the marine field and its efficiency is hampered by the fact that it is technically under the Ministry of Environment and Tourism, but administratively under the Ministry of Interior (employees are part of the police force). Finally, there are a number of logistical constraints, which combine to make coral reef conservation ineffective:

Legislation

A number of important legal instruments still await ratification, for instance the National Maritime Law and the marine conservation laws drafted by the Sudan Marine Conservation Committee.

Communication

The communication network between all ports and the headquarters of the Port Commission is not yet operational. Similarly, the Coastal Survey and Monitoring Unit, which will patrol the Sudanese coast, has yet to be equipped with fixed or mobile radar. Both of these are needed for the operation of a Rescue Co-ordination Centre.

Research

Since 1992 the Faculty of Marine Science and Fisheries of the Red Sea University and the Suakin Marine Laboratory have conducted research programmes on oil pollution and coral reefs, but these projects are limited in scope and intermittent. No temporal studies take place in Sudan, providing little indication of changes to the environment over time.

Recommendations to Improve the Conservation of Coral Reef Resources

Several legislative decisions are needed at both national and international levels. These would strengthen Sudan's legal framework, benefiting coral reefs. At the same time, there is a need for further, continued research on coral reefs and an information dissemination programme to enhance community participation and awareness. An integrated coastal management plan that takes into consideration shipping, coastal development, pollution and natural resources, along with effective and enforced implementation, should cater to most of the above. Specifically:

Legislation

The National Maritime Law, which is presently being drafted, should be ratified and implemented. Related laws and regulations, including the Marine Fisheries Ordinances and Regulations, should be revised within the context of the Environmental Policy Act, which has been drafted by the Higher Council for the Environment and Natural Resources.

To combat oil pollution at an international level, it is recommended that the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/78) be ratified. The following related conventions should also be considered: The International Convention on Oil Pollution Preparedness, Response and Co-operation (1990); the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969); the International Convention on Civil Liability for Oil Pollution Damage (1969); the International Oil Pollution Compensation Fund (1971); the International Convention on Hazardous and Noxious Substances and Limitation of Liability (1996); the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972); and the RAMSAR Convention on Internationally Important Wetlands (1971).

Institutional Framework

A National Integrated Coastal Zone Management Plan is urgently needed that pays special attention to urban planning. Institutions involved in the management of coastal and marine resources and in law enforcement need strengthening.

An integrated management programme should be developed for Marine Protected Areas under which Sanganeb should be given highest priority. Management should then be extended to other protected areas within a national system that forms part of a regional network of MPAs.

A set of guidelines for visitors to coral reef areas should be developed. This should include maps, permanent moorings and guidelines for boats. A guide to coral reef areas and major dive sites might be a way of achieving part of this effort.

A Fisheries Management Plan is needed that takes into consideration marketing, cold storage and transport. The fisheries management programme, which should include sharks, shellfish and sea cucumbers, must be based on comprehensive stock assessments for each commodity.

Maritime Transport and Industrial Activities

There is a need to upgrade current monitoring of vessels passing through Sudanese waters. Navigational markers along major shipping channels need to be installed and maintained.

The Port Sudan refinery should take steps to repair the skimmer system at its lagoon and reduce discharges of highly contaminated drainage water onto the beach.

It is essential for the Bashayer Oil Terminal operators to prepare a local oil pollution emergency plan, backed by an oil spill response organisation and an adequate level of oil spill clean-up equipment.

The Ministry of Environment and Tourism should ensure that the development of the Economic Free Zone is subject to a strict Environmental Impact Assessment to ensure that all risks to the terrestrial and marine environment are clearly identified and that pollution control and other abatement measures are properly implemented.

It is recommended that the ITMD tyre manufacturing company address the problems with regard to management of its solid wastes, in particular the handling of carbon black to remove the hazards to occupational health and the pollution of adjacent beaches.

The Government of the Sudan is recommended to seek international funds to map comprehensively all known data about fishing activities.

Waste reception facilities need to be upgraded/installed at ports. A feasibility study on waste management and the development of port reception facilities is urgently needed.

Information

Finally, an environmental awareness and education programme for various target groups is urgently needed to enhance public participation in environmental initiatives.

Coral Reefs of Djibouti

Introduction

Djibouti has a coastline of 372 km fringed, in places, by extensive coral reefs. The northern coast near Eritrea faces the Straits of Bab al-Mandab and is generally shallow and sandy, with coral outcrops at Ras Siyyan and Kadda Gueini. The Sawabi (Iles des Sept Frères) archipelago east of Ras Siyyan is also fringed by coral reefs. The southern coast towards Somalia is shallow with several estuaries and poorly developed coral reefs, due to the cold water upwelling from the Indian Ocean. Most of the coast of Djibouti lies along the deep (883 m) Gulf of Tadjoura. Ghoubbet al-Kharab, a shallow semi-enclosed basin separated from the Gulf of Tadjoura by a narrow opening, contains low diversity coral reefs. At the entrance of the Gulf of Tadjoura, north of Djibouti city, are Iles Moucha and Maskali, surrounded by extensive coral reefs (Fig. 6).

At the confluence of three biogeographic zones, Djibouti is home to a unique assemblage of coral reef species. The combination of tropical warm-water biota (from the Indian Ocean and Red Sea) with cold water habitats (from the Somali and Arabian regions) is unusual, and found in few other parts of the world.

Djibouti lies in a hot and semi-arid zone where the weather is influenced by the Indian Ocean monsoon. Mean air temperatures vary between 25 ºC in the winter to 35 ºC in the summer. Annual rainfall ranges from 50 to 215 mm. During the south-west monsoon, from June to September, northerly winds move surface waters from the Gulf of Aden out into the Arabian Sea. This is reversed during October to May, bringing cooler waters into nearshore areas. Salinity ranges from 36 to 39 ppt, increasing during south-west monsoon periods, and water temperature ranges from 25 to 29 ºC.

Agriculture, cattle breeding and fisheries contribute less than 2.5 % to the national income. The international port of Djibouti contributes significantly to the national economy.

At the confluence of three biogeographic zones, Djibouti is home to a unique assemblage of coral reef species. Ecologically, the confluence of warm-water tropical biota (from the Indian Ocean and Red Sea) with cold water upwelling habitats (from the Somali and Arabian regions) is notable at the Iles des Sept Frères, and resembles marine conditions seen in only a few other parts of the world.

Current threats to coral reefs come from shipping, coastal development and tourism, though marine tourism is still in its infancy. A GEF supported project is underway to prepare an action plan for the conservation of national biodiversity, both terrestrial and marine.

Surveys

Geographical Scope and Survey Techniques

In 1998 a national team led by David Obura surveyed Iles Moucha and Maskali, Khor Ambado, Les Trois Plages, Sable Blanc, Ras Duan, Iles des Sept Frères, Recif d'Ambouli and a site off Tadjoura (OBURA & DJAMA 2000). A separate survey by Hunting Aquatic Resources on behalf of PERSGA surveyed coastal and marine resources at Iles Moucha and Maskali, Khor Ambado, Djibouti City, Sable Blanc, Godoria, Khor Angar, Iles des Sept Frères and Ras Siyyan in April 1998, during which a total of 185 locations were sampled examined (PERSGA /ALECSO 2003). Obura also carried out a detailed study was also carried out at 21 sites between November and December 1998, covering the Gulf of Tadjoura, the Iles Moucha and Maskali and the Iles des Sept Frères in the north. Benthic cover and reef fish statistics are given in OBURA 1998.

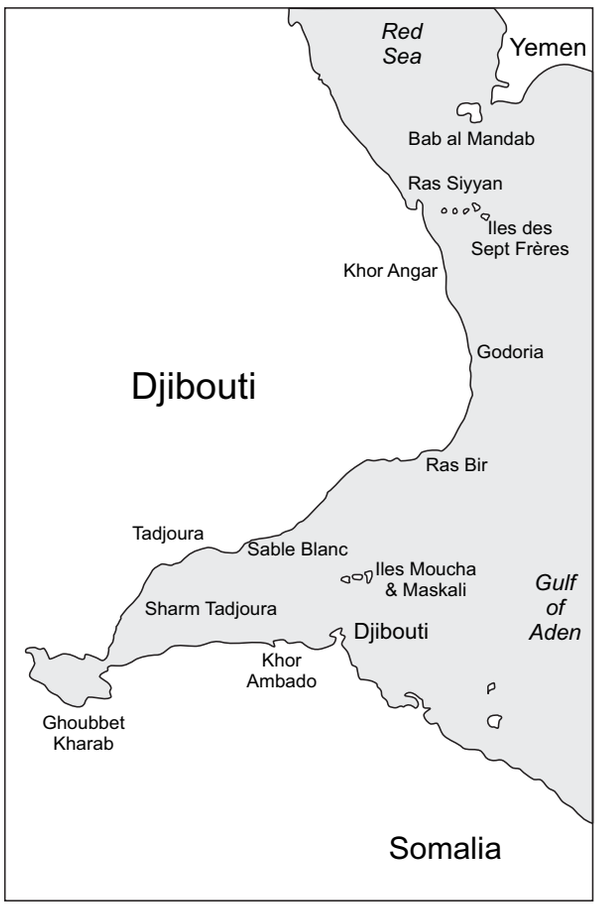

Fig. 6: Map of the Republic of Djibouti illustrating the location of major marine areas.

OBURA & DJAMA (2000) measured the percentage cover of soft and hard corals, and made counts of major invertebrates using circular plots at random locations. The status of corals was assessed and any evidence of algal blooms was recorded.

In the PERSGA/ALECSO study, visual assessment by snorkel of 10 m × 10 m quadrats, centred on a demarcating line between the reef edge and the reef face, was used to assess principal sessile and anthropogenic features on the reef. In addition, timed 20-minute swims were made by snorkel along the line of the reef edge. These started and ended at quadrat sample sites and were used to assess percentage cover of different life forms within a 10 m band transect. Counts were also made for indicator species such as butterflyfish and angelfish, the humphead wrasse *Cheilinus undulatus* and several commercial fishes. Benthic features were assessed for percentage cover following English et al. (1997), with the exception of 'algal turf', which was a generic term used to cover all forms of non-calcareous algae that were too small to distinguish with the unaided eye. Certain features were counted rather than listed as percentage cover, in particular macro-invertebrates such as lobsters and crown-of-thorns starfish, *Acanthaster planci* (COTS). A number of indicator fish species were counted following methods in ENGLISH et al. (1997).

OBURA (1998) collected data by snorkelling in water less than 5 m deep and by SCUBA diving in depths exceeding 5 m. Circles were used covering 100 m^2, marked by a radial line of 5.6 m. Estimates were made of the percentage cover of three types of bottom

substrate and six types of living cover. Broad 10-percentile ranges (i.e. 10 %, 30 %, 90 %, etc.) were used, with additional categories for low-cover presence indicated by categories of 1 % and 5 %. The principal objective of the method was to sample large areas of the bottom rapidly rather than obtain detailed measurements of small areas, as provided by line transect and quadrat techniques.

Coral Reefs – Benthos and Fish

The reefs off the main beach of Ile Maskali (currently demarcated by mooring buoys) are were in a very poor condition. Towards the south-western tip of Maskali, near the navigation beacon, the reefs are were also very poor and turbidity is was very high. In contrast, most of the other reefs off Iles Moucha and Maskali had moderate to very good live coral cover (estimated at > 30 %). Sample sites on patch reefs, and coral gardens to the south of Ile Maskali, had good live coral coverage with associated fish populations. Live coral cover on the fringing reefs to the north of Iles Moucha and Maskali was moderate to good (25 to 40 %) and framework corals at these sites appeared substantive and robust. Additionally, the patch reefs in the channel between Iles Maskali and Moucha are were reasonably well developed. The fringing reefs to the north of Iles Moucha and Maskali had a relatively high cover of broken *Acropora*, now colonised by coralline algae. This was possibly a result of a bleaching event, with most breakage subsequently occurring due to wave action. However, living substrate cover at these sites is was substantive and may have been indicative of a regenerating system.

The fringing reefs of Khor Ambado had an average, living, hard coral cover of 52 %. This was high compared to many other sites in Djibouti and elsewhere in the Red Sea, despite very turbid conditions at the time of the survey. Species diversity of benthic and sessile organisms was low relative to other study sites visited, and *Porites* and *Pocillopora* were the dominant reef- forming corals on the reef edge and reef slope. Coral and other fauna were relatively rare on the back reef and reef flat. The fringing reef directly offshore from the tourist beach at Sable Blanc had large *Porites* coral cascades on a steep reef slope that dropped off to sand at approximately 20 m. Most colonies exhibited signs of minor impact, possibly due to disease or sedimentation damage.

Eastwards along the coast, the reef was in moderate to good condition with coral cover within samples of up to 80 %. The influence of localised factors such as wadi (dry river beds) out-washing and run-off, rather than visitor pressure appeared to dictate the overall reef condition.

The reef flat at Sable Blanc exhibits exhibited a greater array of small coral colonies and living substrate cover than the reef at Khor Ambado. Observations indicated that the predominant coral species on the reef flat was *Pocillopora*. Small colonies of *Acropora* were also present on the reef flat, particularly to the west of the main tourist beach. No significant signs of recent bleaching, other than COTS feeding scars, were recorded on the reef face or reef flat.

The reefs of Djibouti are under pressure from many human activities. Despite these threats, the living hard coral cover averaged 39 %, with a maximum of 80 % (predominantly *Pocillopora*). Water turbidity was high at all sites. Patches of coral substrate were widely spaced and interspersed with mud and soft sediment. However, living coral is are able to persist in small patches around the capital and very close to the port area.

The status of the coral habitats at Iles des Sept Frères is was good. Live coral cover for the islands averaged 34 %, and although not very high, observations of general substrate diversity indicated that most parts of the archipelago had balanced and healthy reefs. Impact was difficult to attribute to any specific cause and possibly reflects long-term environmental disturbance. No indications of a COTS epidemics, either current or recent, were recorded during the 1998 study. Most of the reefs located in the Gulf of Tadjoura showed no signs of bleaching. In some areas, such as the offshore Ile Maskali, degraded reefs were observed, but the causes of degradation could not be determined. The only sites with notable bleaching are were the Iles des Sept Frères located in the Red Sea portion of Djiboutian waters. These islands are quite unique because rising cold waters contribute to higher ecosystem productivity (hence important fishing grounds). The Trois Plages was in a pristine state and had extensive reefs containing one of the highest numbers of butterflyfish species recorded in the survey (OBURA & DJAMA 2000).

Coral Diversity

A total of 167 coral species (including three species of black coral) were identified in 1998 (OBURA 1998), dominated by *Acropora hemprichii, Echinopora fruticulosa* and *Porites nodifera*. Only 10 % of species were found at all sites, while 40 % were present at several sites. Nearly 50 % of the coral species were restricted to a handful of sites. *Acropora* sp. suffered high mortality in Khor Ambado and off Maskali.

In 1998, Obura identified the highest diversity (93) at Arta Plage. Grande Isle in the Iles des Sept Frères had the second highest

Region	Site	# species	Sample time (min)
Iles des Sept Frères	Ile Grande	84	45
Tadjoura, south	Trois Plages	75	55
Iles des Sept Frères	Ile Sud	71	100
Tadjoura, south	Arta Est	70	45
Iles des Sept Frères	Ile Est	69	35
Iles Moucha and Maskali	Moucha Est	67	35
Tadjoura, south	Arta Ouest	66	20
Iles Moucha and Maskali	Maskali Buoy	64	40
Tadjoura, south	Khor Ambado	64	45
Tadjoura, north	Ras Duan-flat	63	30
Iles Moucha and Maskali	Maskali Lighthouse	62	40
Tadjoura, north	Sable Blanc	58	40
Tadjoura, north	Ras Duan-Fringing Reef	57	35
Iles des Sept Frères	Ile Double	52	60
Tadjoura, north	Tadjoura	49	25
Iles Moucha and Maskali	Moucha N	43	30
Iles Moucha and Maskali	Moucha S	21	30
Iles Moucha and Maskali	Maskali S	19	20

Table 6: Coral species diversity and length of survey at each site (OBURA 1998)

diversity of corals (84 species), followed by Trois Plages in the Gulf of Tadjoura (75 species) (Tables 6 & 7). Only one coral species was recorded at every site, *Porites lutea*, and only 10 % of the species identified were recorded at 14 or more sites.

Coral Cover

Seventy-two quadrats (10 m by 10 m) were assessed visually for percentage cover of various life forms and abiota. Living hard coral was absent from only two of the 72 quadrats. Percentage cover ranged from 5 % (offshore of the main tourist beach on Ile Maskali) to 90 % (at Hamra Island, Iles des Sept Frères). At this latter site the dominant coral was *Acropora*, forming a coral garden. In 26 samples, percentage cover of live hard coral was equal to, or greater than, 50 %. In reef edge swims, percentage cover of living hard coral ranged from 5 % to 70 %, and exceeded 20 % in all but three samples (PERSGA/ALECSO 2003).

Macroalgae were recorded in 38 of 72 reef assessment quadrats. The percentage cover in a quadrat ranged from 1 % at Sable Blanc to 60 % at the Fish Market site, Djibouti City. A cover of 50 % was recorded in the vicinity of Ile Moucha at two sites. No macroalgae were recorded during quadrat assessments performed around Iles des Sept Frères. Algal turf was observed in 13 of 72 quadrats. Percentage cover ranged from 5 % (at Khor Angar) to 25 % (at the Radio Mast site at by Djibouti City). Coralline algae were observed in 62 of 72 quadrats. Values ranged from 5 % (at 17 sites) to a maximum percentage cover of 60 %. In reef edge swims, macroalgae were recorded in 24 of the 34 reef edge assessments. Percentage cover ranged from 1 % at Sable Blanc to 60 % at a site near the Navigation Buoy off Ile Maskali. Macroalgae were not recorded during reef edge swims at Iles des Sept Frères. Algal turf was observed in six of the 34 reef edge assessment swims, with percentage cover ranging from 5 % (at Khor Angar) to 20 % (Fish Market, Djibouti City). Coralline algae were observed in 27 of 34 reef edge swims. The highest percentage cover recorded was 48 % (at Sable Blanc). A further 13 reef edge swims had a percentage cover of 20 % or more (PERSGA/ALECSO 2003).

Dead coral was observed in only one sample quadrat. However, dead coral with a covering of algae was observed in 25 quadrats. Values ranged from 4 % to 20 %. Dead coral was observed in only one reef edge swim (at Sable

Region	Site	# species	Sample time (min)
Tadjoura, south	Arta	93	65
Tadjoura, north	Ras Duan	90	65
Iles des Sept Frères	Grande	84	45
Moucha and Maskali	Ile Maskali	84	100
Moucha and Maskali	Ile Moucha	82	95
Tadjoura, south	Trois Plages	75	55
Iles des Sept Frères	Sud	73	100
Iles des Sept Frères	Est	69	35
Tadjoura, south	Khor Ambado	64	45
Tadjoura, north	Sable Blanc	62	40
Iles des Sept Frères	Double	52	60
Tadjoura, north	Tadjoura	49	25

Table 7: Coral species diversity and length of survey for each area (OBURA 1998)

Blanc). However, dead coral with algae was noted in 21 reef edge swims, with percentage cover ranging from 5 % to 25 % (at Khor Ambado) (PERSGA/ALECSO 2003).

Soft coral was observed in 19 reef quadrat samples. The maximum cover was 40 % (at Kadda Dabali and Rhounda Dabali). In the reef edge swims, soft coral was observed in 10 samples. Percentage cover ranged from 1 % (at Ile Moucha) to 35 % (at Rhounda Komayto, Iles des Sept Frères) (PERSGA/ALECSO 2003).

Fish communities

Sharks were observed at in six of the samplessurvey sites. Four sharks were sighted at Hamra Island, Iles des Sept Frères and single individuals were observed in the remaining samples.

Angelfish were observed at all sites. Counts ranged from six to 31 (around Ile Moucha). Twenty-eight samples contained 10 or more angelfish. *Holocanthus xanthotis* and *Pomacanthus imperator* were observed at three and five sites respectively. *H. xanthotis* was observed in a group of 11 individuals at Rhounda Komayto, Iles des Sept Frères. *P imperator* was only observed as single individuals. *Genicanthus caudovittatus* was not observed at any site. *Pomacanthus asfur* was observed at all but one site (at Kadda Dabali, Iles des Sept Frères). Counts ranged from one to 20 (at Ile Maskali). *Pomacanthus maculosus* was observed in 31 of 34 samples. Counts ranged from one to 15 (at Godoria), but 21 samples contained less than 10 individuals. *Pygoplites diacanthus* was observed in 21 samples. Counts ranged from one to 15, with 14 samples containing less than 10 individuals.

Total butterflyfish counts (i.e. the sum of counts for all species) ranged from eight (at Sable Blanc and Fish Market, Djibouti City) to 110 (at Ile Moucha). Fifty or more butterflyfish were observed in 15 of 34 samples. The most frequently observed butterflyfish were *Gonochaetodon larvatus* (a total of 510 individuals) and *Heniochus intermedius* (a total of 45 individuals). *H. intermedius* was also observed in all samples. Counts ranged from one (at Fish Market, Djibouti City) to 48 (at Hamra Island, Iles des Sept Frères). Eighteen samples contained 10 or more individuals, while six samples contained more than 20 individuals. *Chaetodon semilarvatus* was observed in all samples, with counts ranging from one to 65 (at Ile Moucha). Twenty-two samples contained 10 or more fish, and nine samples contained more than 20 individuals. *Chaetodon auriga* and *Chaetodon austriacus* were not observed in any samples (PERSGA/ALECSO 2003).

The total number of groupers observed (i.e. sum of all counts for grouper species) ranged from zero (at Fish Market, Djibouti City) to 56 (at Godoria). Twenty-eight samples contained 10 or more groupers, while 17 samples contained 20 or more. Two species of grouper of commercial interest, *Variola louti* and *Plectropomus truncatus*, were not observed in any sample. *Cephalopholis miniata* was only observed in one sample at Khor Ambado, while a fourth species, *Epinephelus tauvina*, was only observed in two samples (at Rhounda Komayto, Iles des Sept Frères and Sable Blanc). No species was ubiquitous to all samples. The most frequently observed species, both in number of samples it occurred in and total number of individuals, was *Cephalopholis hemistiktos*. This species was absent from only two samples (at Ile Moucha and the Fish Market, Djibouti City). Counts of *C. hemistiktos* ranged from two to 27.

Six species of snapper were assessed numerically during the PERSGA/ALECSO survey. One species, *Lutjanus argentimaculatus*, was not recorded in any sample, while *Macolor niger* was only observed in one sample (at Ile Maskali). *Lutjanus kasmira* was observed in 20 assessments and counts ranged from one to 260 individuals (at Ile Maskali). *Lutjanus monostigma* was observed in 29 samples. Counts ranged from one individual (at Ile Moucha) to a maximum count of nearly 2000 (at Kadda Dabali, Iles des Sept Frères). A further sample (at Hamra Island, Iles des Sept Frères) also contained more than 1000 individuals; 10 swims recorded counts above 100.

Only one species of wrasse, the humphead *Cheilinus undulatus*, was assessed numerically. This fish was recorded in 14 samples. The highest count was five, observed at Ile Maskali. In total 28 individuals were observed during all of the 34 reef edge assessment surveys. Pre-spawning of this species was observed in the vicinity of the Maskali reserve.

Thirteen species of wrasse were recorded as present or absent. Of those, three species, *Gomphosus caeruleus*, *Thalassoma lunare* and *Larabicus quadrilineatus*, were present in all samples and *Halichoeres hortulanus* was absent from only two samples. In contrast, *Thalassoma klunzingeri* and *Macropharyngodon bipartitus* were absent from all samples. Although *Halichoeres marginatus* was only present in 15 samples, the remainder of the species were recorded in more than 20 swims (PERSGA/ALECSO 2003).

One species of sparid, *Acanthopagrus bifasciatus*, was assessed numerically. This species was observed in nine samples. Counts never exceeded 10 individuals in a single assessment swim. The maximum of 10 was recorded at Ile Moucha. The total number of sparids for all assessments was only 31 (PERSGA/ALECSO 2003).

The presence or absence of six species of damselfish was noted in reef assessment swims. *Plectroglyphidodon* spp. were not observed in any sample. *Chromis dimidiata* was only observed in one sample at Hamra Island, Iles des Sept Frères. The most frequently observed damselfish were *Abudefduf* spp., which were present in all assessments.

Five parrotfish species were assessed for presence or absence. *Scarus ferrugineus* was present in all samples and *Scarus sordidus* was absent from only one sample (Rhounda Komayto, Iles des Sept Frères). *Scarus frenatus* was absent from all samples. *Scarus niger* was observed in 26 samples and *Cetoscarus bicolour* was present in 20 samples.

Of the four species of surgeonfish recorded for presence-absence one species, *Zebrasoma xanthurum,* was ubiquitous,. while *Zebrasoma veliferum* was found in all but three samples. *Ctenochaetus striatus* and *Acanthurus sohal* were recorded as present in 31 and 18 reef edge assessment swims respectively.

Invertebrate Communities

Anemones were observed in 13 samples but the number of anemones was low (a maximum of seven at Rhounda Dabali at Iles des Sept Frères). The number of crown-of-thorns starfish was also low. Aggregations of COTS were not observed. The maximum number of COTS found was 14 (Ile Moucha), with 12 individuals in Rhounda Dabali, Iles des Sept Frères. Eleven starfish were observed in a further three samples. In total, 96 crown-of-thorns starfish were observed in 34 reef assessment swims. Giant clams were observed in all but three samples. Samples from Godoria, Djibouti City South, Fish Market and Djibouti City did not contain giant clams. The number of clams ranged from 1 to 52 (Sable Blanc). Thirteen samples contained more than 10 clams and in

total 348 clams were observed in the swims. In total, 15 lobsters were were observed in six swims. The maximum number observed in any sample was six (Hamra Island, Iles des Sept Frères). Sea cucumbers were observed in all but three swims and 10 swims recorded 10 or more. Counts ranged from one to 30 (Ile Moucha). In total, 284 sea cucumbers were observed during the swims. The highest recorded count for the long-spined (or needle spined) sea urchin *(Diadema)* was 81 individuals (Radio Mast, Djibouti City). A further 80 individuals were also recorded during a reef swim at Sable Blanc. A total of 374 urchins was observed during reef edge assessment swims. No large aggregations of *Diadema* were observed. Slate pencil urchins (*Heterocentrotus*) were recorded in only five of 34 samples. A maximum of 17 slate pencil urchins was counted at the Navigation Beacon on Ile Maskali. A further 11 were counted at Sable Blanc. Nine urchins were distributed between the remaining three samples. Top shells were absent from all but one sample, at Ile Maskali, which contained two shells (PERSGA-ALECSO 2003).

Coral Reef Fisheries

The major economic sectors in the coastal zone are maritime transport and port-related activities. At present, fisheries play a limited role, although subsistence fisheries are locally important. There are about 90 artisanal fishing boats, of which 75 are small open boats (6 to 8 m) powered by outboard engines. Each boat operates with an average of three fishermen on one-day trips. Some 15 of the boats are longer (10 to 14 m) and equipped with inboard engines. These carry an average of five fishermen each, and go out for four days. Most of the fisheries are at subsistence level and fishing effort is generally low.

The majority of the catch is landed by hook and line. To a lesser extent gill nets and throwing nets are used. Catches consist almost entirely of large food fish, which are marketed fresh. There is no processing of any significance. About 75 % of the catch is landed at Boulaos. Other small landing places are Escale (5 %), Tadjoura (5 %) and Obock (10 %). Club Nautique is entirely used by sport fishermen, and accounts for 3 % of landings. The remaining 2 % are consumed on board.

Catches are composed of grouper (23 %), Spanish mackerel (14 %), red snapper (13 %), antak (12 %), blackspot snapper (10 %), bonito (5 %) and jack (4 %). All other species are of less importance. Fisheries production increased from 200 tonnes in 1980 to 400 tonnes in 1984 and 700 tonnes in 1988. Between 1988 and 1991 the increase in production slowed down due to poor marketing efforts. From 1991 to 1994 the production decreased dramatically, due to political unrest in the north of the country.

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BARRATT & MEDLEY (1988) indicated that there is a substantial market for aquarium fish from the Red Sea and Western Indian Ocean waters of Djibouti, with the USA, Hong Kong, Germany, Japan and other European countries as the main export markets. No major trade exists at present.

Threats to Coral Reef Biodiversity

Although parts of the coast and territorial waters are still in a largely pristine state, the few studies that have been conducted show indicate that in several areas there are alarming signs of degradation and threats are increasing rapidly. Pressure from humans is particularly severe in the vicinity of the capital. The major threats to reefs in Djibouti are tourism and sewage discharges. Coral bleaching needs to be monitored more closely to determine its impact on reefs.

Habitat Destruction

Extensive coastal development, which includes dredging and landfilling, destroys large tracts of coral reefs. Urban, industrial and port development takes place with inadequate environmental planning and little or no environmental assessment. The lack of management and awareness, in addition to lack of enforcement of regulations, results in physical damage to coral reefs, a loss of coral habitat and a decline in reef-associated fauna. This is also brought about by anchor damage, ship groundings and tourism related activities. Poor navigational control systems and a lack of moorings throughout the area compound these problems.

Damage to corals that was unequivocally caused by anchoring was noted in nine reef edge assessments in 1998. Two of these sites were around Ile Maskali; three were off the beach at Sable Blanc; three were situated around Ile Moucha and signs of minor anchor damage were noted at Rhounda Dabali, Iles des Sept Frères. Suspected damage from small anchors was also observed outside the samples at locations to the south of Iles Maskali and Moucha, and the reef flat at Sable Blanc exhibited damage most likely to have been caused by small anchors or trampling.

Exploitation of Living Marine Resources

There is potential overfishing of game fish resulting in a decrease in average catch size, as the level of fishing effort exceeds the Maximum Sustainable Yield. The lack of surveillance and enforcement of existing regulations, such as that regulating the use of spearguns in capital around urban areas and in MPAs is widespread. In addition, the fisheries data collection system collapsed in late 1990, holding back the development of any fisheries management plans. The illegal shark fishery supplying the Oriental shark fin market has resulted in a decline in shark stocks. There is also a large bye-catch of turtles, manta rays, dolphins, dugongs and finfish, and damage to reefs from nets.

Navigation and Maritime Risks

Maritime transport is a major commercial sector in Djibouti. Activities at Djibouti Port have developed rapidly. The port offers container-handling facilities at two berths with a total length of 400 m and with depths alongside of up to 12 m. A 780 km railway links Djibouti with Addis Ababa and goods coming from and going to Ethiopia are shipped via Djibouti. The income of the International Autonomous Port of Djibouti is a very important contribution to the national economy.

There are risks of ship collisions and groundings due to limited navigational control devices and poorly separated traffic. Maritime traffic is heavy and the area has complex navigational hazards, the extensive coral reef systems at the entrance to the port being one example. Marine vessel sewage and discharge of solid waste is localized, washing up on the shores and along the mangroves. There is inadequate on-board treatment, a lack of port reception and disposal facilities, and inadequate surveillance and enforcement throughout the area.

Petroleum Development and Transport

Small oil spills (< 20 tons) cause beach contamination and damage to the coastal and marine biota. These occur from underground pipelines or from the discharge of ballast and bilge water, waste oil, or bunker oil spills. The lack of reception facilities at the port, inadequate control and lack of enforcement compound the problem.

Medium oil spills (20 to 100 tons) also cause beach contamination and damage coastal and marine biota. These occur through discharges from terminals and small accidents at sea. There is inadequate control and monitoring of procedures, equipment, personnel and training.

Large oil spills could cause widespread destruction of coastal and marine habitats and biota and devastation to beach habitats. These could occur with the rupture of oil tanks through collision or wreckage. Poor navigation aids are a major contributory factor.

Industrial Activities

Excessive exploitation of surface and groundwater for industrial use and excessive pumping, coupled with inadequate concern for water conservation and poor regulation of water exploitation could affect natural water discharge patterns. Industrial pollution has led to a decline in water quality through the chronic release of pollutants; lack of enforcement and inadequate technology compound the problem.

Urban Development

The discharge of untreated or insufficiently treated sewage in coastal areas alters the marine environment and is a threat to public health. The lack of sewage treatment plants, lack of maintenance of existing plants and inadequate pollution control regulations, monitoring and enforcement result in severe damage to coastal and marine life. Sewage discharges may cause algal booms.

Natural Predators

In early May 2000, large numbers of crown-of-thorns starfish were found at Khor Ambado. A survey of an area about 5000 m^2 at Ile Moucha also found large numbers of COTs. However, at present it was not believed that these were in plague densities at the time, and their impact on the reefs is was minimal.

Bleaching

Most of the reefs in the Gulf of Tadjoura showed no signs of bleaching. At Ile Maskali, degraded reefs were encountered in 1998 (OBURA & DJAMA 2000) but the causes of degradation could not be determined. The only site with significant bleaching was at Iles des Sept Frères, in Djibouti's Red Sea waters. In early 1998 there was no evidence Obura and Djama did not find any of evidence of bleaching at any of the survey sites, either inshore or offshore (OBURA & DJAMA 2000). In late 1998 at the same sites, coral mortality was estimated at 30 % at Iles des Sept Frères, but there was no mortality at other sites. Observations by recreational SCUBA divers since that time (early 1999) suggest that bleaching mortality has increased to 40 % at Iles des Sept Frères, affecting principally tabular corals in the shallow water zones that are not affected by longshore currents. However, OBURA (1998) found a low incidence of bleached corals in late 1998; less than 1 % at the Iles des Sept Frères, none in the Gulf of Tadjoura or around Iles Moucha and Maskali.

Marine Protected Areas and Level of Management

Djibouti has two declared Marine Protected Areas, which have been established for more than ten years. There are several additional areas proposed for protected status, one of which is of regional importance.

MPAs Declared

Moucha Territorial Park: Established in 1972 by regulation 72-1363/SG/CG, the Park covers an area of about 10 km^2 at 11°43'N 43°12'E and includes extensive coral reefs, a rich reef-associated fish and invertebrate fauna, and mangroves. The regulation prohibits the collection of corals and molluscs.

Decree 80/062/PR/MCTT (1980) extended the protection to the Maskali reserve. This latter Decree was then modified by Decree 85/103/PR/AG (1985) to strengthen conservation of the two areas. The South Maskali Islands Integral Reserve covers an area of about 3 km^2 at 11°40'N 43°10'E and contains coral reefs and rich reef-associated fish and invertebrate fauna (PERSGA/GEF 2001).

Only artisanal fisheries of edible species are allowed in these zones. Protection is supposed to prevent all extractive utilization except for artisanal fishing, which is defined as fishing using traditional techniques on trips not longer than a day or two.

The islands and reefs within and outside the reserves are used extensively for weekend recreation, including picnicking, swimming, snorkelling, diving, water-skiing and camping. There are severe pressures from reef trampling, collection of souvenirs and spearfishing.

De facto and Planned MPAs

***Godoriya*:** This is an extensive mangrove area (*Rhizophora* and *Avicennia*), rich in mangrove-associated fauna. There are no coral reefs within the proposed area.

***Iles des Sept Frères and Ras Siyyan*:** Lying at the junction of the Red Sea and the Gulf of Aden, this is a group of high-aspect islands and an adjacent coastal stretch with a mangrove-fringed bay. There are diverse coral reefs and rich reef-associated fish and invertebrate fauna. There is a significant level of recreation, fishing-related pressure, and sedimentation from nearby shipping activities.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

At present the number of environmental initiatives in Djibouti is limited. The most important ones are a contingency plan for the Gulf of Aden developed in 1990, through which an oil spill response centre was established for Djibouti, Yemen and Somalia; and the rules for the management of marine protected areas and the exploitation of reef associated species, issued in 1992 by the Maritime Administration.

Several institutions in Djibouti are involved with coastal and marine area and resource management. These are:

- the Ministry of Agriculture and Hydraulic through the Directorate of Stock-farming and Fisheries,
- the Ministry of Transport and Telecommunications through its Directorate of Maritime Affairs,
- the National Office for Tourism, Arts and Crafts,
- the Presidency of the Republic, through the Institute of Higher Studies, Scientific and Technical Research,

- the Service for Management and Environment, the Inter-ministerial Co-ordination Commission on the Protection of the Marine Fauna and the Seabed and

- the National Council of the Sea.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

The Republic of Djibouti is a signatory to a number of international conventions for the protection of the marine environment and for the prevention of pollution, and it has enacted several national instruments through which conservation and management of coral reefs are directly or indirectly addressed.

International Agreements

The Republic of Djibouti is a signatory to the London Convention (modified 1954) which is applicable through National Law No. 64/83. The following were approved by National Law No 94/AN/89 2ºL in 1989:

- the London Convention (1971) on international compensation funds,

- the London Convention (1973, modified 1978) with the exception of annexes (III, IV, & V) and

- the Brussels Convention (1969) on intervention on the High Seas.

The Republic of Djibouti is a signatory to the United Nations Convention on the Law of the Sea (UNCLOS 1982).

The Republic of Djibouti is also a signatory to the CITES Convention. Decree 80-62/PR/MCTT of 25 May 1980 provides for the protection of the seabed and the marine fauna, whereby the capture of marine mammals and turtles is illegal, as well as the trade with or export of these animals. Spearfishing is also illegal in Djibouti.

At the regional level, an agreement was signed by Yemen, Djibouti and Somalia on the establishment of a centre to combat oil pollution in the Gulf of Aden. Oil spill response equipment is stored at facilities in Djibouti. Yemen and Djibouti are currently negotiating a bilateral agreement regarding the use of this equipment. On 20 January 1986 Djibouti and Somalia signed a bilateral fishing agreement.

National Legislation

National regulations on the protection of the marine environment include provisions on marine pollution, protection of endangered species and the creation of protected areas (summarised in Table 8). Regulations on the prevention and combat of marine pollution include:

- Law 76-599 (1976) - Enacted by regulation 675/SELAG concerning ship- and aircraft aircraft-based pollution, as well as the combat of accidental marine pollution.

- Law 76-600 (1976) - Enacted by regulation 676/SELAG regarding pollution by incineration operations.

- Laws 9/AN/82 (1982) and 137/AN/85 1ºL (1985) on oil pollution.

- Ordinance 86-042/PR/PM (1986) containing regulations on action to be

taken in case of abandonment of ships that pose a threat to the environment in territorial waters.

- Decree 89-085/PR/AE (1990) providing for the implementation of a contingency plan in the case of pollution by oil spills.

- Decree 89-085/PR/PM (1989) and Regulation 90-0534/MPAM (1990) concerning the passage of foreign ships through territorial waters in order to prevent pollution and the dumping of hazardous wastes.

- Code of Maritime Administration - The present fisheries law was drafted before independence, with the exception of some articles, and is now part of the Code. Articles 148, 149 and 220 to 225 (enacted by law 212/AN/82) and Articles 16 to 19 of Law No. 52/AN/78 (1979) regulate the fishery. Certain fishing techniques, such as the use of explosives and poisons, are illegal. They determine the conditions for the exploitation of fishery resources including fishing zones and closed seasons. They also include sanctions in case of violation of these regulations by fishermen.

- National Law No. 64/83 (1983) includes the approval of four international conventions on maritime navigation.

- Coastal Zone Regulations: Regulation 86-0717/PR/MCTT (1986) concerns the waste from camping on islands and beaches; Ordinance 77-038/PR (1977) regulates registration of pleasure boats;

Law, Ordinance, Regulation	Year (in force)	Government Agency Concerned
Regulation 72-1363/SG/CG, establishment of Moucha Territorial Park	1972	Maritime Administration
Law 76-599 on ship based pollution	1976	Maritime Administration
Law 76-600 on pollution caused by combustion	1976	Maritime Administration
Ordinance 77-038/PR on registration of pleasure boats	1977	Maritime Administration
Law 52/AN/78 article 16-19, fisheries regulations	1979	Maritime Administration
Decree 80-062/PR/MCTT on protection of the seabed and the marine fauna, establishment of South Maskali Islands Integral Reserve	1980	MCTT
Law 9/AN/82, on hydrocarbon pollution	1982	Maritime Administration
Law 212/AN/82, fisheries regulations	1982	Maritime Administration
Law 137/AN/85, on hydrocarbon pollution	1985	Maritime Administration
Regulation 84-0969/PR/PM, on security of pleasure boating	1984	Maritime Administration
Decree 85/103/PR/AG on Marine Protected Areas	1985	Maritime Administration
Ordinance 86-042PR/PM, regulating abandoned ships	1986	Maritime Administration
Regulation 86/0717/PR/MCTT on camping huts on beaches and islands	1986	National Office for Tourism, Arts and Crafts
Decree 89-085/PR/PM on passage of foreign vessels	1989	Maritime Administration
Decree 89-085/PR/AE on oil spill response	1990	Maritime Administration
Regulation 90-0534/MPAM on passage of foreign vessels	1990	Maritime Administration

Table 8: National laws and regulations related to coastal and marine environments and resources (PERSGA 2001)

and Regulation 84-0969/PR/PM (1984) concerns security of pleasure boating and beach activities.

Gaps in Capacity and Requirements for Improved Conservation

The two major requirements in Djibouti are staff (with expertise in coral reef biology and ecology, and an understanding of research and monitoring practices), and funding to undertake conservation work. The lack of trained staff stems largely from the lack of a higher education system and the funding avenues for post-graduate study of Djiboutian nationals.

Institutional Capacity

Only a few personnel are qualified for managing marine resources. Recently the PERSGA/ALECSO-funded project and the National Biodiversity Project have initiated training of national counterparts in coral reef survey techniques. At present there are no monitoring or conservation programmes for coral reefs. The Environment Department was created recently (1996) and finalised the National Environmental Action Plan (NEAP) in April 2000 and a National Strategy for Biodiversity Conservation with financial support from the GEF. These include a National Framework Law, which will require Environmental Impact Assessments for all projects concerning the marine environment. It is assumed that with the adoption of the NEAP and Biodiversity Strategy, the Environment Department will be involved in all development projects. There is a need for the managerial staff of the key national institutions to be trained in coral reef survey techniques and the biology and ecology of coral reef ecosystems.

Financial

Financial constraints are a major obstacle to the conservation of coral reefs. There have been no funds for surveys to assess the status and health of coral reefs in Djibouti, except for foreign-based research. The Environment Department has had to rely on the GEF and financial support through PERSGA to conduct the first assessments of coral reefs since 1988. It is possible that financial resources could be raised through levying of fines and fees for infringements of national laws. The NEAP calls for the creation of an Environmental Fund, which should be established in the near future. It is expected that this fund will be used for conservation of key ecosystems such as coral reefs.

Recommendations to Improve the Conservation of Coral Reef Resources

Natural and anthropogenic stresses on corals in Djibouti are limited in extent and scope. Several key actions at the national level in the form of legislation and implementation could reduce the risks of ship-based pollution and oil spills. A dedicated research and monitoring programme that fed back into coastal area management plans would contribute greatly to efficient conservation actions.

Legislation

It is recommended that decrees on biodiversity conservation and protected areas should be put into force. Related laws and regulations should also be revised. It is important to strengthen enforcement of existing regulations relating to the management of coastal and marine areas and resources. A national Integrated Coastal Zone Management Plan is urgently needed. Annexes III, IV, and V of the MARPOL Convention 73/78 should be ratified to bring Djibouti into line with international efforts at combating oil pollution.

Coastal Area Management

Institutions involved in the management of coastal and marine resources and in law enforcement need support. A framework and programme for visitors to coral reef areas has to be developed. This will should include guidelines and moorings for boats.

Reef Conservation

A coral reef monitoring, protection and management programme should be developed. Management programmes should be developed for the existing Marine Protected Areas and a feasibility study for the conservation and management of additional marine protected areas should be conducted. These might include Iles des Sept Frères and Ras Siyyan. Stocks of reef fish populations should be assessed properly before the collection of ornamental fish for the aquarium trade is developed commercially.

Research and Monitoring

Marine habitats and biota should be studied and monitored on a regular basis. The establishment of a marine biology department and the training of Djiboutians in marine biology is recommended once a university is established. An environmental data base containing information on biological resources should be developed. A monitoring programme should be set up to support management and enforcement activities. Institutions involved in applied research need strengthening.

Shipping and Navigation

Monitoring of vessels passing through territorial waters of Djibouti, communication with vessels and the installation of navigational markers, particularly along major shipping channels, should be improved. The national oil spill response contingency plan should be updated and implemented. The response capacity needs to be upgraded and waste reception facilities installed at ports. A feasibility study on waste management and the development of port reception facilities and waste management systems are also needed.

Récifs Coralliens à Djibouti

Introduction

Djibouti possède 372 kilomètres de côtes bordées en certains endroits de vastes récifs coralliens. La côte nord, près de l'Érythrée, fait face au détroit de Bab el-Mandeb; côte sablonneuse aux eaux généralement peu profondes, elle présente des formations coralliennes à Ras Siyyan et à Kadda Gueini. L'archipel des Sawabi (Sept Frères), à l'est de Ras Siyyan, est également entouré de récifs frangeants. La côte du sud-est vers la Somalie, a des eaux peu profondes, avec plusieurs estuaires et des récifs coralliens peu développés en raison des remontées d'eaux froides (upwelling) qui proviennent de l'océan Indien. La majeure partie du littoral djiboutien se trouve le long du profond golfe de Tadjourah (883 m). Le Ghoubbet al-Kharab, bassin semi-fermé de faible profondeur séparé du golfe de Tadjourah avec lequel il communique par une passe étroite, contient des récifs coralliens de faible diversité. À l'entrée du golfe de Tadjourah, au nord de Djibouti-ville, se trouvent les îles Moucha et Maskali, qui sont entourées d'importants récifs coralliens (Figure 7).

Situé à la convergence de trois zones biogéographiques, Djibouti possède un assemblage unique de récifs coralliens de diverses espèces. La combinaison de biotes d'eaux tropicales chaudes de l'océan Indien et de la mer Rouge et des habitats d'eaux froides, des régions somalienne et arabe est inhabituelle et rare sont les points du globe où elles se trouvent.

Djibouti est située dans une zone chaude semi-aride où le climat subit l'influence de la mousson de l'océan Indien. Les températures atmosphériques moyennes vont de 25 ºC en hiver à 35 ºC en été. Les précipitations annuelles varient de 50 à 215 mm. Au cours de la mousson du sud-est, de juin à septembre, les vents du nord poussent les eaux de surface du golfe d'Aden dans la mer d'Arabie. Le phénomène s'inverse d'octobre à mai pour ramener des eaux froides à proximité des côtes. Le taux de salinité varie de 36 à 39 ppt, avec des augmentations pendant la mousson du sud-ouest, et la température de l'eau varie de 25 ºC à 29 ºC.

L'agriculture, l'élevage et la pêche apportent moins de 2,5 % au revenu national. La contribution du port international de Djibouti à l'économie nationale, en revanche, est significative.

Les menaces qui pèsent actuellement sur les récifs coralliens proviennent du trafic maritime, du développement du littoral et du tourisme, ce dernier étant toutefois encore à un stade embryonnaire. Un plan d'action pour la conservation de la biodiversité nationale, tant terrestre que marine, a été préparé dans le cadre d'un projet appuyé par le FEM.

Études

En 1998, une équipe nationale dirigée par David Obura a étudié les îles Moucha et Maskali, Khor Ambado, les Trois Plages, Sable Blanc, Ras Duan, les Sept Frères, le récif

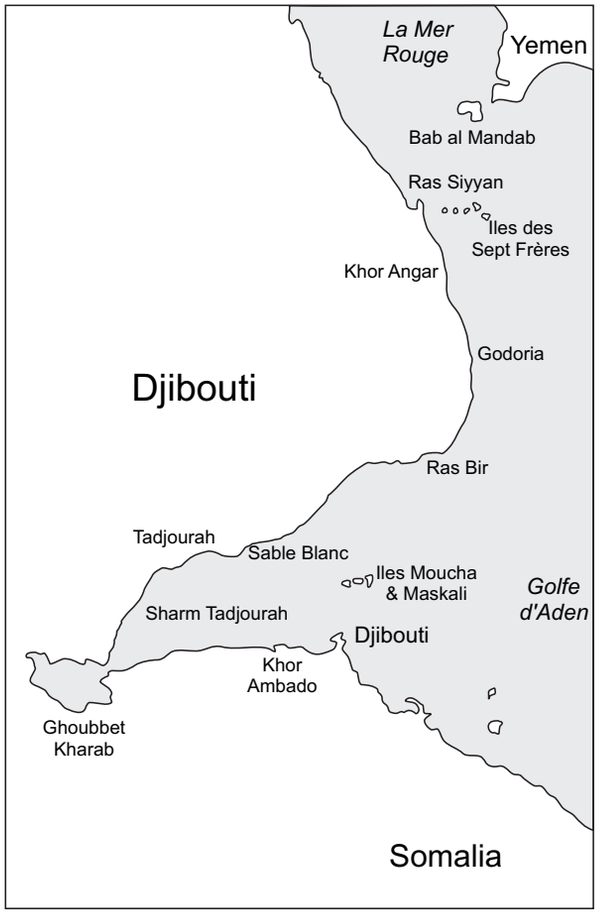

Figure 7: Carte de la République de Djibouti indiquant l'emplacement des principales aires marines.

d'Ambouli et un site au large de Tadjourah (OBURA & DJAMA 2000). Une étude distincte menée en avril 1998 par Hunting Aquatic Resources pour le PERSGA a porté sur les ressources côtières et marines des îles Moucha et Maskali, de Khor Ambado, de Djibouti-ville, de Sable Blanc, de Godoria, de Khor Angar, des îles des Sept Frères et de Ras Siyyan, où un total de 185 sites ont été examinés (PERSGA/ALECSO). Une étude plus détaillée a également été réalisée de novembre à décembre 1998 sur 21 sites du golfe Tadjourah, des îles Moucha et Maskali et des îles des Sept Frères dans le nord (OBURA 1998).

Dans l'étude d'Obura & Djama, le nombre et le pourcentage de couverture des coraux mous et durs a été évalué a l'aide de quadrants circulaires, et il a été procédé à des dénombrements des principaux invertébrés. Tous les signes de prolifération algale ont été notés.

Dans l'étude PERSGA/ALECSO, il a été procédé à des évaluations visuelles par plongée en apnée sur des quadrats de 10 × 10 m, centrés sur une ligne de démarcation entre le bord des récifs et la face récifale, pour déterminer l'état des principaux invertébrés sessiles et évaluer les impacts des activites humaines. En outre, des observations de la périphérie à la nage pendant 20 minutes ont été effectuées le long des récifs entre les quadrats d'échantillonnage, pour évaluer le taux de couverture des différents organismes sur une bande de 10 m de large. Des dénombrements ont également été effectués pour des espèces indicatrices telles que les poissons-papillons, les poissons-anges, le napoléon *Cheilinus undulatus* et plusieurs espèces commerciales.

Les caractéristiques des espèces benthiques ont été évaluées pour déterminer le taux de couverture, selon ENGLISH et al. (1997), à l'exception de la « pellicule algale » terme générique désignant toutes les formes d'algues non calcaires trop petites pour être distinguées à l'œil nu. Certaines composantes ont été comptées au lieu d'indiquer leur pourcentage de couverture, en particulier les macro-invertébrés tels que les langoustes et les couronnes d'épines (*Acanthaster planci)*. Un certain nombre d'espèces indicateurs de poissons ont été dénombrées selon les méthodes d'ENGLISH et al. (1997).

Dans l'étude réalisée par Obura à la fin de l'annee 1998, des données ont été recueillies par plongée en apnée dans les eaux de moins de 5 m de profondeur et en plongée avec bouteille dans les profondeurs de plus de 5 m. Les zones

d'échantillonnages étaient des quadrants circulaires d'un rayon de 5,6 m (superficie de 100 m^2). Le pourcentage de couverture a été estimé pour trois types de substrats et six types de couvert biologique. L'objectif principal ainsi visé était de procéder à des relevés rapides sur les fonds et non pas d'obtenir des mesures détaillées sur de petites superficies, comme en fournissent les techniques des transects et des quadrats.

Récifs coralliens – Benthos

Les récifs situés au large de la grande plage de Maskali (actuellement démarqués par des bouées de mouillage) étaient en très mauvais état. Vers la pointe sud-ouest de l'île, près du phare de navigation, les récifs étaient aussi en piètre état et la turbidité très élevée. En revanche, la plupart des autres récifs au large de Moucha et de Maskali présentaient une très bonne couverture de coraux vivants (estimée à plus de 30 %). Les sites d'échantillonnage sur les platiers de corail et les bancs coralliens au sud de Maskali avaient eux aussi une très bonne couverture de coraux vivants avec leur faune ichtyologique associée. La couverture de coraux vivants des récifs frangeants au nord de Moucha et Maskali était de modérée à bonne (25 à 40 %) et la structure corallienne paraissait robuste. Par ailleurs, les platiers de coraux étaient raisonnablement bien développés dans le chenal séparant Maskali et Moucha. Les récifs frangeants au nord de Moucha et Maskali présentaient une couverture relativement élevée d'*Acropora* brisés maintenant colonisés par des algues coralliennes, qui est peut-être le résultat d'un épisode de blanchissement, suivi de la cassuré des coraux sous l'effet des vagues. La présence d'un substrat vivant important constatée sur ces sites peut indiquer un processus de régénération.

La couverture des coraux durs des récifs frangeants de Khor Ambado était de 52 %, taux élevé par rapport à nombre d'autres sites à Djibouti et ailleurs dans la mer Rouge, malgré une forte turbidité au moment de l'observation. La diversité des espèces benthiques et sessiles était faible par comparaison aux autres sites étudiés, et *Porites* et *Pocillopora* étaient les coraux bâtisseurs dominants en bordure et sur les pentes des récifs. Les coraux et autres espèces fauniques étaient relativement rares sur l'arrière-récif et le platier. Le récif frangeant situé en face de la plage touristique de Sable Blanc présentait de vastes cascades de *Porites* sur une pente récifale abrupte descendant jusqu'à un fond sablonneux à environ 20 m de profondeur. Il a été relevé des signes d'impacts mineurs sur la plupart des colonies, ce qui peut être dû à la maladie ou à la sédimentation.

Vers l'est, le long de la côte, l'état du récif était de modéré à bon avec une couverture corallienne atteignant 80 % dans les zones d'échantillonnage. L'état général du récif semble conditionné davantage par des facteurs extérieurs tels que l'épandage de matériaux et le ruissellement d'eau des pluies en provenance des wadis (rivière non permanente) que par les pressions des visiteurs.

Le platier de Sable Blanc présentait une gamme plus large de petites colonies coralliennes et de substrats vivants que le récif de Khor Ambado. L'espèce de corail dominante observée sur le platier était *Pocillopora.* Il a également été noté la présence de petites colonies d'*Acropora* sur le platier, en particulier à l'ouest de la principale plage touristique. S'il n'y avait pas de signes notables de blanchissement récents, des cicatrices de couronnes d'épines ont été relevées sur la face récifale et le platier.

Les récifs de Djibouti sont soumis à des pressions provenant de nombreuses activités humaines. Malgré cela, le couvert de coraux durs vivants s'établit en moyenne à 39 %, avec

un maximum de 80 % (avec dominance de *Pocillopora)*. La turbidité de l'eau était élevée sur tous les sites. On observe des platiers de substrat corallien largement espacés, séparés par de la vase et autres sédiments mous. Néanmoins, les coraux vivants persistent en petites formations aux environs de la capitale et à proximité immédiate de la zone portuaire.

L'état des habitats coralliens aux Sept Frères était bon. La couverture corallienne vivante des îles était en moyenne de 34 % et les observations de la diversité générale du substrat ont indiqué que la majorité de l'archipel possédait des récifs équilibrés et sains. Il est difficile d'attribuer les impacts à une cause précise quelconque et il s'agit peut-être de perturbations environne-mentales à long terme. Il n'a pas été constaté d'indications d'épidémies de couronnes d'épines actuelles ou récentes lors de l'étude de 1998. La plupart des récifs du golfe de Tadjourah ne présentaient pas de signes de blanchissement. Dans certaines zones, notamment au large de l'île Maskali, on a constaté la présence de récifs dégradés, mais sans que l'on puisse déterminer les causes de cette dégradation. Les seuls sites où il a été relevé des signes de blanchissement notables sont les îles des Sept Frères situées dans les eaux djiboutiennes de la mer Rouge. Ces îles doivent leur spécificité aux remontées d'eau froide qui contribuent à accroître la productivité des écosystèmes (et elles constituent de ce fait des zones halieutiques importantes). Le site des Trois Plages était remarquablement intact et possédait de vastes récifs contenant l'un des plus grands nombres d'espèces de poissons-papillons relevés au cours de l'étude (OBURA & DJAMA 2000).

Diversité des coraux

Au total, l'étude de 1998 a recensé 167 espèces de coraux, dominés par *Acropora*

Région	Site	Nbre d'espèces	Temps d'échantillonnage (mn)
Sept Frères	I. Grande	84	45
Tadjourah, sud	Trois Plages	75	55
Sept Frères	I. Sud	71	100
Tadjourah, sud	Arta Est	70	45
Sept Frères	I. Est	69	35
Moucha et Maskali	Moucha Est	67	35
Tadjourah, sud	Arta Ouest	66	20
Moucha et Maskali	Maskali Buoy	64	40
Tadjourah, sud	Khor Ambado	64	45
Tadjourah, nord	Ras Duan-Platier	63	30
Moucha et Maskali	Phare de Maskali	62	40
Tadjourah, nord	Sable Blanc	58	40
Tadjourah, nord	Ras Duan-Récif frangeant	57	35
Sept Frères	I. Double	52	60
Tadjourah, nord	Tadjourah	49	25
Moucha et Maskali	Moucha N	43	30
Moucha et Maskali	Moucha S	21	30
Moucha et Maskali	Maskali S	19	20

Tableau 9 : Diversité des espèces coralliennes et temps d'échantillonnage sur chaque site (OBURA 1998)

hemprichii, Echinopora fruticulosa et Porites nodifera. Seules 10 % d'entre elles étaient présentes sur tous les sites; 40 % étaient présentes sur plusieurs sites et près de 50 % étaient limitées à quelques sites.

Un total de 167 espèces de coraux (dont trois espèces de corail noir) ont été identifiées en 1998 (OBURA 1998). La plus forte diversité a été enregistrée à Arta Plage (93), Grande Ile dans l'archipel des Sept Frères se plaçant au second rang (84 espèces), suivie par les Trois Plages dans le golfe de Tadjourah (75 espèces) (tableaux 9 et 10). Seule une espèce de coraux, *Porites lutea*, a été identifiée sur tous les sites et 10 % seulement des espèces identifiés ont été recensées sur 14 sites ou plus.

Couverture corallienne

Soixante-douze quadrats de 10 sur 10 m ont fait l'objet d'une évaluation visuelle pour déterminer les taux de couverture par diverses composantes biotiques et non biotiques. Les coraux vivants durs n'étaient absents que deux des 72 quadrats, leurs taux de couverture variant de 5 % (au large de la grande plage touristique de Maskali) à 93% (sur l'île Hamra des Sept Frères). Sur ce dernier site, le corail dominant était *Acropora*. Sur 26 sites-échantillons, le taux de couverture de coraux vivant était égal ou supérieur à 50 %. Les taux de couverture des coraux durs vivants relevés lors des observations à la nage sur les périphéries des récifs varient de 5 % à 70 % et dépassaient 20 % sur tous les sites observés sauf trois (PERSGA/ALECSO).

La présence de macroalgues a été notée dans 38 des 72 quadrats évalués, avec un taux de couverture par quadrat variant de 1 % à Sable Blanc à 60 % au site du marché au poisson à Djibouti-ville. Un taux de 50 % a été noté près de Moucha sur deux sites. Il n'a pas été observé de macroalgues au cours des évaluations de quadrats autour des Sept Frères. La présence d'une pellicule algale a été observée dans 13 des 72 quadrats, avec un taux de couverture variant de 5 % (à Khor Angar) à 25 % (au site de

Région	Site	Nbre d'espèces	Temps d'échantillonnage (mn)
Tadjourah, sud	Arta	93	65
Tadjourah, nord	Ras Duan	90	65
Sept Frères	Grande	84	45
Moucha et Maskali	Maskali	84	100
Moucha et Maskali	Moucha	82	95
Tadjourah, sud	Trois Plages	75	55
Sept Frères	Sud	73	100
Est Sept Frères	Est	69	35
Tadjourah, sud	Khor Ambado	64	45
Tadjourah, nord	Sable Blanc	62	40
Sept Frères	Double	52	60
Tadjourah, nord	Tadjourah	49	25

Tableau 10 : Diversité des espèces coralliennes et temps d'échantillonnage dans chaque zone (OBURA 1998)

l'antenne radio près de Djibouti-ville). Des algues coralliennes ont été observées dans 62 des 72 quadrats, le taux de couverture variant de 5 % (sur 17 sites) à un maximum de 60 %. Lors des observations sur le bord des récifs, la présence de macroalgues a été constatée sur 24 des 34 évaluations. Le taux de couverture va de 1 % à Sable Blanc à 60 % sur un site proche du phare de navigation de Maskali. Il n'a pas été vu de macroalgues lors des observations à la nage le long de la périphérie des récifs aux Sept Frères. La présence d'une pellicule algale a été constatée lors de six des 34 évaluations des bords des récifs, les taux de couverture allant de 5 % (à Khor Angar) à 20 % (marché au poisson, Djibouti-ville). Des algues coralliennes ont été observées dans de 27 de ces 34 évaluations. Le taux de couverture le plus élevé qui ait été constaté était de 48 % à Sable Blanc et dans 13 autres de ces évaluations à la périphérie des récifs, le taux de couverture atteignait ou dépassait 20 % (PERSGA/ALECSO en préparation).

Il n'a été observé de coraux morts que dans un seul quadrat. En revanche, la présence de coraux morts couverts d'algues a été relevée dans 25 quadrats, à des taux variant de 4 % à 20 %. Lors des observations à la périphérie des récifs, il n'a été vu de coraux morts qu'à Sable Blanc. En revanche des coraux morts couverts d'algues ont été observés lors de 21 évaluations à la périphérie de récifs, à des taux allant de 5 % à 25 % à Khor Ambado (PERSGA/ALECSO en préparation).

Des coraux mous ont été observés dans 19 quadrats, avec un taux de couverture maximum de 40 % (à Kadda Dabali et à Rhounda Dabali). La présence de coraux mous a été constatée lors de 10 observations en bordure des récifs, à des taux de couverture allant de 1 (à Moucha) à 35 % (à Rhounda Komayto, Sept Frères) (PERSGA/ALECSO).

Peuplement ichtyologique

Des requins ont été observés sur six des sites étudiés. Quatre requins ont été vus à l'île Hamra (Sept Frères) et des individus solitaires ont été observés sur les autres sites.

Des poissons-anges ont été observés sur tous les sites, leur nombre allant de six à 31 (Moucha). Vingt-huit sites contenaient 10 poissons-anges ou plus. *Holocanthus xanthotis* et *Pomacanthus imperator* ont été observés sur trois et cinq sites respectivement. *H. xanthotis* a été observé dans un groupe de 11 individus à Rhounda Komayto (Sept Frères). Seuls des individus isolés de *P. imperator* ont été observés. *Genicanthus caudovittatus* n'a été vu sur aucun site. *Pomacanthus asfur* a été observé sur tous les sites sauf un (Kadda Dabali, Sept Frères), en nombres variant de un à 20 (Maskali). *Pomacanthus maculosus* a été observé dans 31 sites-échantillons sur 34. Les nombres relevés varient de un à 15 (à Godoria), mais 21 sites contenaient moins de 10 individus. *Pygoplites diacanthus* a été observé sur 21 sites-échantillons, en nombres variant de un à 15, avec 14 sites contenant moins de 10 individus.

Le nombre total de poissons-papillons observés (à savoir la somme des dénombrements pour toutes les espèces) varie de huit (à Sable Blanc et au marché au poisson de Djibouti-ville) à 110 (à Moucha). Sur 15 des 34 sites-échantillons, il a été observé 50 poissons-papillons ou plus. L'espèce la plus fréquemment observée est *Gonochaetodon larvatus* (510 individus au total) et *Heniochus intermedius* (45 individus au total). *H. intermedius* a également été observé sur tous les sites, ses nombres allant de un (au marché au poisson à Djibouti-ville) à 48 (à l'île Hamra des Sept Frères). Dix-huit sites échantillons contenaient 10 individus ou plus et six sites échantillons en contiennent plus de 20. *Chaetodon semilarvatus* a été observé sur tous les sites, ses nombres allant de un à 65 (à Moucha); 22 sites contenaient 10 individus ou plus et neuf sites plus de 20 individus.

Chaetodon auriga et *Chaetodon austriacus* n'ont été vus sur aucun site (PERSGA/ALECSO).

Le nombre total de mérous observés (toutes espèces confondues) va de zéro (au marché au poisson) à 56 (à Godoria). Vingt-huit sites contenaient 10 mérous ou plus et 17 sites en contenaient 20 ou plus. Deux espèces de mérou commerciales, *Variola louti* and *Plectropomus truncatus,* n'ont été observées sur aucun site. *Cephalopholis miniata* n'a été observé qu'à Khor Ambado et une quatrième espèce, *Epinephelus tauvina,* ne l'a été que sur deux sites (Rhounda Komayto, Sept Frères ; et Sable Blanc). Aucune espèce n'est pésente sur tous les sites. L'espèce la plus fréquemment rencontrée, par le nombre de sites où elle est présente et le nombre total d'individus observés, était *Cephalopholis hemistiktos.* Cette espèce n'était absente que de deux sites (Moucha et le marché au poisson). Les nombres de *C. hemistiktos* observés varient de 2 à 27.

Six espèces de vivaneaux ont fait l'objet d'une évaluation numérique au cours de l'étude PERSGA/ALECSO. Une espèce, *Lutjanus argentimaculatus,* n'a été observée dans aucun site et un seul individu de *Macolor niger* l'a été (à Maskali). *Lutjanus kasmira* a été observé dans 20 sites, en nombres variant de 1 à 260 individus (Maskali). *Lutjanus monostigma* a été observé dans 29 sites, en nombres allant de un (à Moucha) à près de 2 000 (à Kadda Dabali, Sept Frères). Un autre site (Hamra, Sept Frères) contenait plus de 1 000 individus et dix observations à la nage en ont relevé plus de 100.

Une seule espèce de labre, le Napoléon, *Cheilinus undulatus,* a fait l'objet d'une évaluation numérique. Sa présence a été notée dans 14 sites. C'est à Maskali qu'il en a été observé le plus grand nombre (cinq individus), un total de 28 ayant été observé dans les 34 évaluations de la périphérie des récifs. Des activités de pré-fraye de cette espèce ont été observés aux environs de la réserve de Maskali.

Une espèce de sparidés, *Acanthopagrus bifasciatus,* a fait l'objet d'une évaluation numérique. Elle a été observée dans neuf sites. Les nombres observés ne dépassent pas 10 individus au cours de la même sortie d'évaluation. Ce nombre maximum a été relevé à Moucha. Le nombre total de sparidés recensés pour toutes les évaluations effectuées n'a atteint que 31 (PERSGA/ ALECSO).

La présence/absence de six espèces de demoiselles a été notée lors des évaluations des récifs à la nage. *Plectroglyphidodon* spp. n'a été observé nulle part. *Chromis dimidiata* n'a été observé qu'à Hamra, aux Sept Frères. L'espèce de demoiselle la plus fréquemment observée a été *Abudefduf* spp., qui était présente dans tous les sites.

Cinq poissons perroquets ont fait l'objet d'évaluations pour déterminer leur présence/absence. *Scarus ferrugineus* était présent dans tous les sites et *Scarus sordidus* n'était absent que dans un site (Rhounda Komayto, Sept Frères). *Scarus frenatus* était absent de tous les sites. *Scarus niger* a été observé que dans 26 et sites *Cetoscarus bicolour* dans 20 sites.

Sur les quatre espèces de poissons-chirurgiens dont la présence/absence ont été déterminées, une seule, *Zebrasoma xanthurum,* était présente dans tous les sites, et *Zebrasoma veliferum* dans tous les sites sauf trois. La présence de *Ctenochaetus striatus* et *Acanthurus sohal* a été notée dans 31 sites et lors de 18 évaluations à la nage à la périphérie de récifs.

Treize espèces de labres ont fait l'objet d'évaluations pour déterminer leur présence/absence. Trois de ces espèces, *Gomphosus caeruleus, Thalassoma lunare* et *Larabicus quadrilineatus,* étaient présentes dans tous les sites et *Halichoeres hortulanus* n'était absent que dans deux sites. En revanche, *Thalassoma klunzingeri* et *Macropharyngodon bipartitus* étaient absents dans tous les sites.

Bien que la présence de *Halichoeres marginatus* n'ait été observé que dans 15 sites, les autres espèces ont été observée lors de plus de 20 observations à la nage à la périphérie de récifs (PERSGA/ALECSO).

Peuplements d'invertébrés

Des anémones ont été observées dans 13 sites-échantillons, mais leur nombre était bas (avec un maximum de = sept à Rhounda Dabali). Le nombre de couronnes d'épines (CdE) était bas lui aussi. Il n'a pas été vu d'agrégats de CdE et le nombre maximum d'individus observés est de 14 (Moucha). Douze CdE ont été observées à Rhounda Dabali, aux Sept Frères, et 11 sur trois autres sites-échantillons. Au total, il a été dénombré 96 CdE lors des 34 évaluations de récifs. Des tridacnes géants ont été observés dans tous les sites sauf trois. Les sites de Godoria, Djibouti-ville sud, marché au poisson et Djibouti-ville n'en contenaient pas. Le nombre d'individus observés va de un à 52 (Sable Blanc). Treize sites contenaient plus de 10 individus et un total de 348 tridacnes ont été observés lors des évaluations à la périphérie des récifs. Un total de 15 langoustes a été observé lors de six observations à la nage; le nombre maximum observé dans tous les sites est de six (Hamra). Des concombres de mer ont été observés lors de toutes les observations à la nage sauf trois et dans 10 sorties, il en a été observé 10 ou plus. Les nombres vont de un à 30 (Moucha). Au total, 284 concombres de mer ont été observés lors des sorties à la nage. Le nombre maximum d'oursins-diadèmes observés est de 81 (antenne radio, Djibouti-ville). Également, lors d'une évaluation en bordure de récif à Sable Blanc, il en a été dénombré 80; un total de 374 oursins a été observé lors de ces évaluations à la nage, sans que soient observés de grands agrégats de cette espèce. La présence d'oursins crayons (*Heterocentrotus*) n'a été relevée que sur cinq sites sur 34. Un maximum de 17 oursins crayons a été dénombré à la balise de Maskali et 11 à Sable Blanc. Neuf oursins étaient répartis entre les trois autres sites. Les troches étaient absents de tous les sites-échantillons sauf un, Maskali, où il en a été observé deux (PERSGA/ ALECSO en préparation).

Pêcheries des récifs coralliens

Les principaux secteurs d'activité économique dans la zone côtière sont les transports maritimes et les activités portuaires connexes. Les pêcheries ne jouent actuellement qu'un rôle limité, mais la pêche de subsistance est importante au niveau local. Il y a environ 90 bateaux de pêche artisanale, dont 75 sont de petites embarcations non pontées de 6 à 8 m, propulsées par un moteur hors-bord. Ces bateaux ont un équipage de trois hommes en moyenne et sortent pour la journée. La flottille compte également une quinzaine de bateaux de 10 à 14 m, dotés de moteurs in-bord Ces bateaux ont généralement un équipage de cinq hommes et effectuent des sorties de quatre jours. La plupart des activités de pêche se situent au niveau de la subsistance et l'effort de pêche est généralement bas.

La pêche se fait en majorité à la ligne, les filets maillants et les éperviers étant également utilisés mais dans une moindre mesure. Les prises consistent pour leur quasi totalité de poissons comestibles de grande taille qui sont commercialisés frais. Il n'existe pas de traitement significatif. Il n'y a aucun traitment d'importance. Environ 75 % des prises sont débarquées à Boulaos, les autres points de débarquement étant Escale (5 %), Tadjourah (5 %) et Obock (10 %). Le Club Nautique est utilisé exclusivement pour la pêche sportive et représente 3 % des débarquements. Les 2 % restants sont consommés à bord.

Les prises se composent de mérous (23 %), thazards (14 %), rougets (13 %), antaks (12 %), dorades (10 %), bonites (5 %) et

carangues (4 %). Les autres espèces sont de moindre importance. La production halieutique a connu une progression, 200 tonnes en 1980, 400 tonnes en 1984 et 700 tonnes in 1988. De 1988 à 1991, cette progression a marqué un ralentissement, du fait de la médiocrité des efforts de commercialisation. De 1991 à 1994, la production a connu une diminution substantielle causée par les troubles politiques dans le nord du pays.

La pêche est pratiquée essentiellement à la ligne et, dans une moindre mesure, au filet maillant et à l'épervier. Les prises consistent presque entièrement de grands poissons comestibles qui sont commercialisés à l'état frais. Il n'existe pas d'activités de traitement significatives. La production halieutique atteint son maximum en mai-juin et en septembre. Au cours de la période de cinq ans de 1986 à 1990, où la production a été relativement stable, les plus hauts rendements ont été enregistrés en mai (44,522 tonnes) et les plus bas en février (25,110 tonnes).

BARRATT & MEDLEY (1988) indiquent qu'il existe un important marché d'aquariophilie pour les poissons de la mer Rouge et de l'océan Indien occidental. Les principaux importateurs étant les États-Unis, Hong-Kong, l'Allemagne, le Japon et divers pays européens, mais il n'y pas actuellement d'échanges commerciaux importants dans ce domaine.

Menaces pour la biodiversité des récifs coralliens

Bien que certaines parties des eaux côtières et territoriales soient encore essentiellement intactes, les quelques études qui ont été effectuées indiquent qu'il existe des signes alarmants de dégradation et de menaces en rapide expansion. Les pressions anthropiques sont particulièrement intenses aux alentours de la capitale. Les principales menaces qui pèsent sur les récifs djiboutiens sont le tourisme et les rejets d'eaux usées. Il faut également surveiller plus attentivement le blanchissement des coraux afin de déterminer l'impact du phénomène sur les récifs.

Destruction des habitats

Un développement intensif du littoral, avec dragage et remblayage, détruit de vastes superficies de récifs coralliens Les travaux d'aménagement urbain, industriel et portuaires sont effectués avec une planification environnementale insuffisante et des évaluations environnementales limitées, voire inexistantes. L'absence de gestion et de sensibilisation, en sus de la non-application des règlements, a pour effet d'infliger des dégâts aux récifs qui se traduisent par des pertes d'habitats coralliens et une diminution de la faune récifale. Les dégâts causés par les ancres, les échouages de navires et les activités liées au tourisme ont le même effet. La médiocrité des systèmes de contrôle de la navigation et l'insuffisance de mouillages viennent aggraver le problème.

Neuf évaluations coralliens en bordure de récifs effectuées en 1998 ont noté des dégâts causés incontestablement par les ancres. Les sites sont les suivants:

- deux sites près de Maskali,
- trois au large de la plage de Sable Blanc,
- trois aux alentours de Moucha et
- des dégâts mineurs ont été relevés à Rhounda Dabali, aux Sept Frères.

Il est également suspecté que des dégâts observés hors des sites d'échantillonnage au sud de Maskali et de Moucha sont dus à de petites ancres, de plus le platier récifal de Sable Blanc présente des zones vraisemblablement endommagées par de petites ancres ou par piétinement.

Exploitation des ressources marines biologiques

Il y a un danger de surpêche espèces de poissons ciblé par la pêche sportive, et l'on note une réduction de la taille moyenne des prises indiquant que l'effort de pêche dépasse le rendement maximal soutenu. L'absence de surveillance et la non-application des règlements, notamment l'interdiction des fusils de plongée aux environs des zones urbaines et dans les AMP, sont en cause. En outre, le système de collecte de données sur les pêcheries est devenu inopérant à la fin des années 1990 ce qui constitue un obstacle à l'élaboration de tout plan de gestion dans le domaine. La pêche illicite de requins a destination du marché oriental des ailerons de requins s'est traduite par une diminution des stocks. Il y a également d'importantes prises accessoires de tortues, de raies manta, de dauphins, de lamantins et de poissons et des dégâts causés aux récifs du fait de l'emploi de filets.

Activités et risques liés à la navigation

Le transport maritime est un important secteur commercial à Djibouti. Les activités du Port de Djibouti se sont développées rapidement. Le port possède des installations de manutention de conteneurs à deux postes d'accostage d'une longueur totale de 400 m et d'une profondeur de quai de 12 m. Une voie ferroviaire relie Djibouti à Addis-Abeba et les marchandises venant d'Éthiopie ou destinées à ce pays transitent par Djibouti. Les recettes du Port international autonome de Djibouti constituent un apport très important pour l'économie nationale.

Il y a des risques de collision et d'échouage des navires en raison de l'insuffisance des aides à la navigation et de la séparation du trafic. Le trafic maritime est intense et les problèmes de navigation sont complexes : la présence d'un récif corallien à l'entrée du port en étant un exemple. Les rejets d'eaux usées et de déchets solides provenant des navires sont localisés, mais polluent les rivages et menacent les mangroves. Ces problèmes sont dus aux insuffisances du traitement des déchets à bord, à l'absence des déchets d'installations portuaires de réception et de mise au rebut des déchets, et de la surveillance et de l'application des règlements dans toute la région.

Exploitation et transport des hydrocarbures

De petits déversements (moins de 20 tonnes) causent une contamination des plages et occasionnent des dégâts aux biotes côtiers et marins. Ils se produisent à partir de canalisations souterraines ou du fait du rejet des eaux de ballast et de cale, des huiles usées, ou de déversements de fuel de soute. L'absence d'installations portuaires de réception des déchets et l'insuffisance de la surveillance et de l'application des règlements compliquent le problème.

Il se produit aussi des déversements de taille moyenne du fait de rejets aux terminaux pétroliers et de petits accidents en mer. Le contrôle et la surveillance des procédures en vigueur présentent des faiblesses.

De grands déversements d'hydro-carbures pourraient provoquer une destruction généralisée des habitats et biotes marins et dévaster les plages. Ces accidents peuvent être causés par la rupture de réservoirs consécutive aux collisions ou aux naufrages. L'insuffisance des aides à la navigation constitue un facteur de risque majeur.

Activité industrielle

La consommation excessive des eaux de surface et souterraines à des fins industriels et les prélèvements excessifs couplés à un manque d'attention portée à la conservation de l'eau et aux carences de la réglementation relative à sa consommation pourraient se répercuter sur les caractéristiques du régime hydrographique naturel. La pollution industrielle s'est traduite par une baisse de la qualité de l'eau du fait du rejet chronique de polluants; la non-application

des règlements. Les insuffisances technologiques viennent aggraver le problème.

Développement urbain

Les rejets d'eaux usées non traitées ou insuffisamment traitées dans les zones côtières portent atteinte à l'environnement marin et constituent une menace pour la santé publique. Le manque de stations d'épuration, les carences de l'entretien de la station existante, de surveillance et de l'absence d'application des règlements relatifs à la lutte contre la pollution infligent de graves dommages à la faune et à la flore côtière et marine. Les rejets d'eaux usées provoquent la prolifération d'algues.

Prédateurs naturels

Au début de mai 2000, on a constaté la présence en grands nombres d'étoiles de mer (couronne d'épines CdE) à Khor Ambado. La même constatation a été faite lors d'une étude d'une zone d'environ 5 000 m^2 aux îles Moucha. Toutefois, au vu des densités relevés, il ne s'agissait pas là d'un phénomène d'infestation caractérisée et l'impact des CdE sur les récifs était minime.

Aires marines protégées et niveau de gestion

Djibouti possède deux aires marines protégées (AMP) qui ont été établies il y a plus de dix ans. Il existe plusieurs autres zones qu'il est envisagé de déclarer également, dont l'une est d'importance régionale.

AMP déclarées

L'AMP de Moucha a été établie la première par le règlement 72-1363/SG/CG (1972), qui interdit le prélèvement de coraux et de mollusques. Le décret 80/062/PR/MCTT (1980) a étendu cette protection à la réserve de Maskali. Ce décret a été modifié par le décret 85/103/PR/AG (1985) qui renforce la conservation de ces deux aires. La protection vise à prévenir toute utilisation extractive des ressources, à la seule exception de la pêche artisanale d'espèces comestibles, celle-ci étant définie comme la pêche pratiquée selon des méthodes traditionnelles avec des sorties ne dépassant pas un jour ou deux. Les îles et récifs situés dans les réserves et hors des réserves sont très fréquentés en fin de semaine et font l'objet d'une utilisation récréative : pique-niques, baignade, plongée en apnée ou avec des bouteilles, ski nautique et camping.

Parc territorial de Moucha : Établi en 1972, il est situé à 11°43' N et 43°12' E et couvre une superficie d'environ 10 km^2; il comprend de vastes récifs coralliens avec leurs riches peuplements de poissons et d'invertébrés et de mangroves. Il subit de graves pressions du fait du piétinement des récifs, du prélèvement de souvenirs et de la pêche sportive au harpon.

Réserve intégrale de Maskali sud : Établie en 1980, la réserve est située à 11°40' N et 43°10' E et couvre environ. **3** km^2; elle contient des récifs coralliens et leur riches peuplements de poissons et d'invertébrés. Elle subit de graves pressions du fait du piétinement des récifs, du prélèvement de souvenirs et de la pêche sportive au fusil de plongée.

AMP potentielles

Godoriya : Il s'agit d'une vaste zone de mangrove et de la faune qui y est associée, mais il n'y a pas de récifs coralliens dans cette AMP proposée.

***Iles des Sept Frères et Ras Siyyan* :** Situé à la jonction de la mer Rouge et du golfe d'Aden, cette future AMP est un groupe d'îles à haut relief et de la côte continentale adjacente, avec une baie bordée de mangroves. Elle possède des récifs coralliens diversifiés avec de riches peuplements de poissons et d'invertébrés. La

zone fait l'objet de pressions résultant d'importantes activités récréatives et de pêche, et l'on y relève une sédimentation résultant des activités de transport maritime.

Impacts actuels et potentiels des changements climatiques

Il n'existe pas de signes de blanchissement des coraux dans le golfe de Tadjourah. À Maskali, des récifs dégradés ont été signalés en 1998 (OBURA & DJAMA 2000) mais les causes de la dégradation n'ont pas pu être déterminées. Le seul site où des signes importants de blanchissement ont été relevé est celui des Sept Frères, dans les eaux djiboutiennes de la mer Rouge. Au début 1998, il n'y avait de signe de blanchissement sur aucun des sites étudiés, ni sur les côtes, ni au large (OBURA & DJAMA 2000). À la fin 1998, sur les mêmes sites, la mortalité corallienne était estimée à 30 % aux Sept Frères, mais seuls les sites des Sept Frères étaient touchés. Les observations d'amateurs de plongée sous-marine depuis cette époque (début 1999) suggèrent que le blanchissement et la mortalité ont augmenté et atteignent 40 % aux Sept Frères, où ils touchent principalement les coraux tabulaires des zones de faible profondeurs qui ne subissent pas l'influence des courants côtiers. En revanche, à la fin 1998, Obura a constaté une faible incidence de blanchissement corallien (OBURA 1998).

Capacités actuelles de suivi et de gestion pour la conservation des ressources des récifs coralliens

Les initiatives environnementales sont actuellement en nombre limité à Djibouti. Les plus importantes d'entre elles sont un plan d'urgence national de lutte contre la pollution par les hydrocarbures pour le golfe d'Aden, élaboré en 1990, grâce auquel un centre d'intervention en cas de déversements d'hydrocarbures a été institué pour Djibouti, le Yémen et la Somalie, et des règles de gestion des aires marines protégées et d'exploitation des espèces récifales associées, ont été émises par l'Administration maritime en 1992.

Plusieurs institutions de Djibouti prennent part à la gestion des ressources des aires marines. Ce sont le ministère de l'Agriculture et de l'Hydraulique par l'entremise de la Direction de la Pêche, le Ministère des Transports et des Télécommunications par l'intermédiaire de sa Direction des Affaires maritimes; l'Office national du Tourisme, des Arts et de l'Artisanat, la Présidence de la République par l'intermédiaire du Centre de Recherche de Djibouti et le Ministere charge de l'Environnement par l'intermediaire de la Direction de l'Aménagement du Territoire et de l'Environnement.

Législation, stratégies et politiques relatives à la conservation des récifs

La République de Djibouti est signataire de plusieurs conventions internationales pour la protection de l'environnement marin et la prévention de la pollution et a adopté plusieurs instruments nationaux visant directement ou indirectement la conservation et la gestion des récifs coralliens.

Accords internationaux

La République de Djibouti est signataire de la Convention de Londres de 1954 (modifiée) applicable sur son territoire en vertu de la Loi nationale 64/83. Les conventions suivantes ont été approuvées par

- la Loi nationale 94/AN/89 2º L en 1989,
- la Convention de Londres de 1971 sur le fonds international d'indemnisation,

Loi, ordonnance, règlement	Année d'entrée en vigueur	Organisme gouvernemental concerné
Règlement 72-1363/SG/CG, portant création du Parc territorial de Moucha	1972	Administration maritime
Loi 76-599 sur la pollution en provenance des navires	1976	Administration maritime
Loi 76-600 sur la pollution causée par l'incinération	1976	Administration maritime
Ordonnance 77-038/PR sur l'inscription des embarcations de plaisance	1977	Administration maritime
Loi 52/AN/78, articles 16-19, réglementant les pêcheries	1979	Administration maritime
Décret 80-062/PR/MCTT sur la protection de la faune et des fonds sous-marins, établissant la Réserve intégrale de Maskali sud	1980	MCTT
Loi 9/AN/82 sur la pollution par les hydrocarbures	1982	Administration maritime
Loi 212/AN/82, réglementant les pêcheries	1982	Administration maritime
Loi 137/AN/85 sur la pollution par les hydrocarbures	1985	Administration maritime
Règlement 84-0969/PR/PM sur la sécurité de la navigation de plaisance	1984	Administration maritime
Décret 85/103/PR/AG sur les Aires marines protégées	1985	Administration maritime
Ordonnance 86-042PR/PM réglementant les navires abandonnés	1986	Administration maritime
Règlement 86/0717/PR/MCTT sur les cabines de camping sur les plages et les îles	1986	Office national du tourisme de Djibouti
Décret 89-085/PR/PM sur le passage des navires étrangers	1989	Administration maritime
Décret 89-085/PR/AE sur le déversement d'hydrocarbures	1990	Administration maritime
Règlement 90-0534/MPAM sur le passage des navires étrangers	1990	Administration maritime

Tableau 11 : Lois et règlements nationaux relatifs à l'environnement et aux ressources côtières et marines (PERSGA 2001)

- la Convention de Londres de 1973 modifiée en 1978, à l'exception des annexes III, IV et V et
- la Convention de Bruxelles de 1969 sur l'intervention en haute mer.

La République de Djibouti est signataire de la Convention des Nations Unies sur le droit de la mer (UNCLOS 1982).

La République de Djibouti et également signataire de la Convention CITES. Le Décret 80-62/PR/MCTT du 25 mai 1980 porte sur la protection de la faune et des fonds sousmarins et interdit la capture de mammifères marins et de tortues, et le commerce ou l'exportation de ces animaux. La chasse sousmarine au fusil de plongée est également interdite à Djibouti.

Au niveau régional, un accord a été conclu par le Yémen, Djibouti et la Somalie concernant l'établissement d'un centre d'intervention régional pour lutter contre la pollution en cas de déversement d'hydrocarbures dans le golfe d'Aden. Le matériel d'intervention est stocké à Djibouti. Une évaluation technique et financière

de ce centre a été réalisée par la composante Réduction des Risques de la Navigation et Djibouti et a été soumis au Conseil des Ministres du PERSGA pour approbation. Aucune decision n'a ete prise a ce sujet. Le 20 janvier 1986, Djibouti et la Somalie ont conclu un accord de pêche bilatéral.

Législation nationale

Les différentes dispositions législatives et réglementaires visant la protection de l'environnement marin portent sur la pollution marine, la protection des espèces menacées et la création d'aires protégées (voir le sommaire tableau 11). Parmi les textes relatifs à la prévention de la pollution marine et à la lutte contre cette pollution figurent :

- La Loi 76-599 (1976), promulguée par l'arrêté 675/SELAG, relative à la pollution par les navires et les avions, ainsi qu'à la pollution marine accidentelle.

- La Loi 76-600 (1976), promulguée par l'Arrêté 676/SELAG, relative à la pollution causée par les opérations d'incinération.

- Les Lois 9/AN/82 (1982) et 137/AN/85 1º L (1985) relatives à la pollution par les hydrocarbures.

- L'Ordonnance 86-042/PR/PM (1986) portant réglementation des dispositions à prendre en cas d'abandon de navires présentant un danger pour l'environnement marin dans les eaux territoriales.

- Le Décret 89-085/PR/AE (1990) concernant la mise en œuvre d'un plan Polmer en cas de pollution accidentelle résultant d'un déversement d'hydro-carbures.

- Le Décret 89-085/PR/PM (1989) et l'Arrêté 90-0534/MPAM (1990) relatifs au passage des navires étrangers dans les eaux territoriales visant à prévenir la pollution marine et le déversement de déchets dangereux.

Le Code de l'Administration maritime constitue l'actuelle loi portant code des Affaires Maritimes. Hormis certains articles, cette loi a été élaborée avant l'indépendance. Les articles 148, 149 et 220 à 225 (promulgués par la loi 212/AN/82) et les articles 16 à 19 de la loi 52/AN/78 (1979) régissent l'exercice de la pêche. Certaines techniques de pêche, tels que l'usage d'explosifs et de poison, sont interdites. Ces dispositions prévoient les conditions de l'exploitation des ressources halieutiques et définissent les zones et les saisons de pêche. Elles prévoient également des sanctions applicables en cas de violation des règlements par les pêcheurs.

- La Loi nationale 64/83 (1983) porte approbation de quatre conventions internationales sur la navigation maritime.

Plusieurs règlements concernent également la zone côtière :

- le Règlement 86-0717/PR/MCTT (1986) porte sur les déchets **provenant des visiteurs des** îles et des plages,

- l'Ordonnance 77-038/PR (1977) concerne l'inscription des embarcations de plaisance et

- le Règlement 84-0969/PR/PM (1984) porte sur la sécurité de la navigation de plaisance et des activités sur les plages.

Manques de capacités et ressources nécessaires pour améliorer la conservation

Djibouti a besoin de ressources humaines (personnel spécialisé en biologie et écologie des récifs coralliens et comprenant les pratiques en matière de recherches et de suivi) et de ressources financières pour entreprendre les activités de conservation. La pénurie de personnel formé provient essentiellement des faiblesses de l'enseignement supérieur à Djibouti et de la non disponibilité de fonds pour permettre aux ressortissants djiboutiens diplômés de poursuivre des études avancées.

Capacités institutionnelles

Djibouti manque de personnel pour assurer la gestion des ressources marines. Récemment, toutefois, le projet financé par PERSGA/ALECSO et le projet de la biodiversité nationale ont entrepris la formation d'homologues nationaux aux techniques d'étude des récifs coralliens. Il n'y a pas actuellement de programmes de suivi ou de conservation de ces écosystèmes. Le Département de l'Environnement a été créé récemment (1996) et a élaboré le Plan d'Action National pour l'Environnement (PANE) en avril 2000 et une Stratégie nationale pour la conservation de la biodiversité avec l'appui financier du FEM. Ces dispositions comprennent notamment une loi-cadre qui exigera que des études d'évaluations d'impact environnemental soient menées pour tous les projets touchant à l'environnement marin. Avec l'adoption du PANE et de la Stratégie sur la biodiversité, il est à prévoir que le Département de l'Environnement sera associé à tous les projets de développement. Il est donc nécessaire de former du personnel de gestion au sein des institutions nationales clés dans les domaines des techniques d'étude des récifs coralliens et de la biologie et de l'écologie de ces écosystèmes.

Ressources financières

Il n'y a pas de fonds disponible pour financer les études de courte durée visant à évaluer l'état et la santé des récifs coralliens de Djibouti. Le Département de l'Environnement a dû recourir au FEM et à l'appui financier du PERSGA pour effectuer les premières évaluations des récifs coralliens depuis 1988. On pourrait envisager de mobiliser des ressources financières par le biais d'amendes et de redevances imposées en cas de violation des lois nationales. Le PANE prévoit la création d'un Fonds environnemental, qui devrait être établi dans un avenir proche. Les ressources de ce fonds seront utilisées selon toute vraisemblance pour la conservation des écosystèmes **clés** tels que les récifs coralliens.

Recommandations pour l'amélioration de la conservation des ressources des récifs coralliens

Les pressions naturelles et anthropiques qui s'exercent à Djibouti sur les coraux sont de portée limitée. Plusieurs mesures clés prises au niveau national sous forme de législation et de dispositions d'application pourraient réduire les risques de la pollution provenant des navires et de déversements d'hydrocarbures. Un programme de recherches et de suivi spécialisé dont les données serviraient le plans de gestion à élaborer des plans de gestion.

Il conviendrait spécifiquement de prendre les mesures suivantes :

Mesures législatives

Il est recommandé de veiller à l'application de décrets sur la conservation de la biodiversité et **des** aires protégées. Les lois et règlements visant ces domaines devraient également être révisés. Il est important de renforcer l'application des règlements existants relatifs à la gestion des zones et des ressources côtières et marines. Il faut également formuler et adopter

d'urgence un plan de gestion intégrée de la zone côtière. Il conviendrait aussi de ratifier les annexes III, IV et V de la Convention MARPOL 73/78, de manière à ce que Djibouti aligne ses efforts sur ceux qui sont déployés au niveau international pour lutter contre la pollution par les hydrocarbures.

Gestion de la zone côtière

Les institutions associées à la gestion des ressources côtières et marines et à l'application des dispositions législatives et réglementaires doivent bénéficier d'un appui. Il faut élaborer un cadre et un programme à l'intention des visiteurs qui se rendent dans les zones des récifs coralliens, avec notamment la formulation de directives et l'**installation** de mouillages pour les bateaux.

Conservation des récifs

Il conviendrait d'élaborer un programme de suivi, protection et gestion des récifs coralliens. Il faudrait formuler des programmes de gestion pour les Aires marines protégées actuelles et mener une étude de faisabilité sur la conservation et la gestion d'Aires marines protégées supplémentaires, lesquelles pourraient comprendre les Îles des Sept Frères et Ras Siyyan. Les peuplements de l'ichtyofaune récifale Les populations de l'ichtyofaune récifale devraient faire l'objet d'une évaluation en bonne et due forme avant que soit formulé et mis en œuvre un programme de prélèvement de poissons d'ornement pour le marché de l'aquariophilie.

Recherche et suivi

Les habitats et les biotes marins devraient être étudiés et suivis périodiquement. Il est recommandé, une fois qu'une université aura été fondée, d'établir un département de biologie marine et de former des Djiboutiens dans ce domaine. Il conviendra d'établir une base de données environnementales sur les ressources biologiques. Un programme de suivi devrait être mis en place pour appuyer les activités de gestion et d'application des règlements. Les institutions qui mènent des activités de recherche appliquée doivent être renforcées.

Transport maritime et navigation

La surveillance des navires qui transitent par les eaux territoriales de Djibouti, les communications avec les navires et le système de balisage, notamment le long des grandes voies de navigation, devraient être améliorés. Le plan national d'intervention en cas de déversement d'hydrocarbures devrait être actualisé et mis en application. Les capacités d'intervention doivent également être renforcées et les ports doivent être dotés d'installations de réception des déchets. Il conviendra aussi de mener des études de faisabilité sur la gestion des déchets, l'établissement d'installations portuaires de réception des déchets et la mise en place de systèmes de gestion des déchets.

Coral Reefs along the Northern Coast of Somalia

Introduction

Somalia has 3,300 km of coastline, of which 1,300 km face the Gulf of Aden from Ras Aser (or Raas Casayr in Somali) in the east to the border with Djibouti. The coast to the west between Zeila (Saylac) and Berbera is shallow with exposed, high-energy sandy beaches. The central portion between Berbera and Bosaso (Boosaaso) consists mainly of shallow, sandy shorelines, broken occasionally by protruding rocky outcrops and cliffs that extend into the shallow water. Along the eastern section between Bosaso and Ras Aser, high mountains meet the sea. The area is characterised by rocky shores with steep cliffs, often interspersed with short segments of narrow sandy beaches.

There are no perennial rivers along the northern coast and freshwater reaches the sea only during irregular flash floods following torrential rains. The surface run-off from land has no significant influence on the marine environment. Most nearshore subtidal areas are shallow with sandy substrate, occasionally interspersed with fields of cobbles or boulders and by rocky outcrops. Steep rocky cliffs usually give way to shallow sandy areas under the water surface. Coral growth is limited, partly by a lack of suitable substrates and partly by hydrographic conditions. However occasional coral growth has been observed in both the eastern and western part of the coastline. Extensive coral reefs, possibly the largest in the Gulf of Aden, occur in the vicinity of Sa'adadin Island (Sacdadiin). Smaller coral reef areas exist west of Xabo and between Buruc and Bosaso.

The continental shelf rarely exceeds 15 km in width, except at the extreme north-western section near the border with Djibouti, where it is much wider. There are only two island groups along the Gulf of Aden shore of Somalia. The Sa'adadin group near Zeila consists of six small, low-lying, exposed islands with sandy beaches. Mait Island (Jazirat Maydh), in the central part near Ras Khatib, is a steep-faced rock a little over 1.5 km in length and with an average height of 100 m.

The climate is arid with an average annual rainfall less than 300 mm. Seasonal variation is mainly influenced by the monsoon winds, which also determine the coastal currents. From May to August, the south-west monsoon drives a strong current from the vicinity of Socotra (Yemen) to the east. It influences the water masses in the Gulf of Aden where, during this period, the main current direction is eastwards. Along the north-eastern coast however there is a counter-current that flows westwards, fed by water passing between Socotra and the mainland into the Gulf of Aden. From October to March, during the north-east monsoon, waters flow from the Arabian Sea into the Gulf of Aden. The main current direction along the Somali coast is westwards, but in the north-east there is a counter-current that flows east.

During the south-west monsoon there are upwellings of cold water in the north-east that are rich in nutrients, but generally low in oxygen. These upwellings generate phyto- and zooplankton blooms. They break down during the north-east monsoon when the water in the area is warmer, less nutrient-rich and saturated

with oxygen (SWALLOW 1991). Nutrient levels are largely determined by variable current patterns and annual fluctuations in upwelling intensity. In terms of primary productivity, the area is thought to fall in a transition zone between the richly productive water to the north-east and the East African shelf environment to the west.

Along the Gulf of Aden coast three areas have been proposed for protection. The Daloh Forest Reserve (terrestrial), which lies to the north of Erigavo; Mait Island, which lies adjacent to Daloh Forest Reserve; and Aibat (Ceebaad), Sa'adadin and Saba-wanag (Sabawanaag) - two islands and an adjacent stretch of coastline near Zeila. This latter area has the largest mangrove stands and coral reefs along the entire Gulf of Aden coast of Somalia.

The largest town on the coast is Berbera. Other larger settlements along the coast are Zeila, Las Korey (Laas Qoray), Qandala (Candala), Xabo and Alula (Caluula). Despite rich living marine resources, fisheries account for only a very small percentage (2%) of GDP (PERSGA/GEF 2001). Other marine based activities, such as tourism and maritime transport, are even less important.

Surveys

Three short surveys were carried out between 1996 and 1999 on the north coast of Somalia.

Geographical Scope and Survey Techniques

In April and May 1996, representatives from the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) carried out a rapid assessment of the marine habitats of Somalia, which included coral reef investigations (PERSGA/GEF 2001).

In 1997, a rapid ecological assessment of the Saardin Islands (Aibat, Sa'adadin and reefs) in north-west Somalia was carried out by IUCN. The objectives of this survey were:

- to provide a preliminary assessment of the ecological status,
- to identify and describe the principal terrestrial and marine habitats and ecological indicator species,

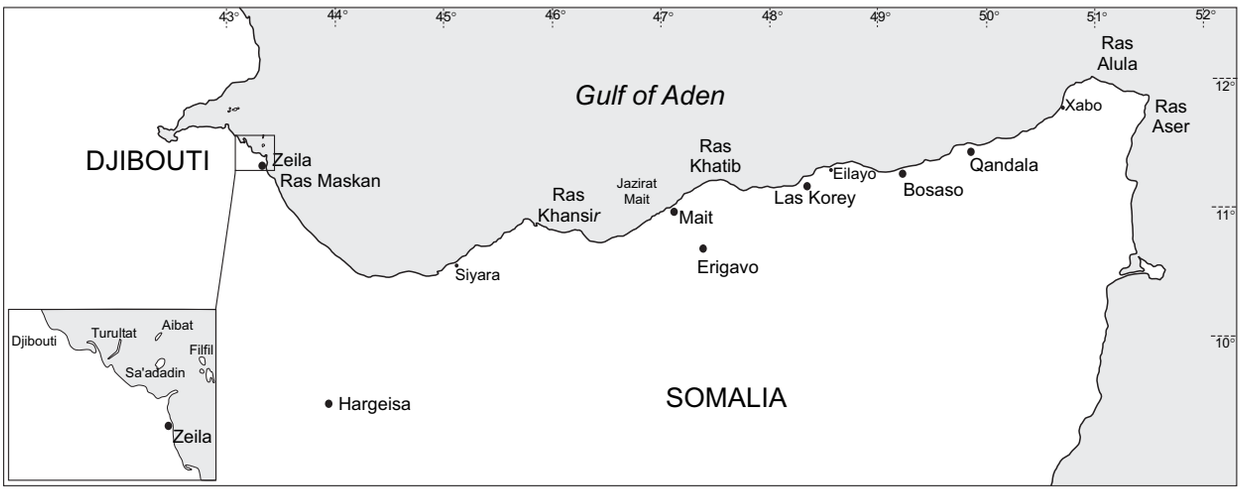

Fig. 8: Map of Somalia indicating location of major urban areas and coral reefs

- to identify any human-based utilization of resources,

- to quantify fish and coral diversity, including commercial and conservation value (IUCN 1997).

General observations were made of coral reef and soft substrate habitats, and of reef development and health. Quantitative assessments of biodiversity were made for scleractinian corals and bony fish using underwater visual census techniques. For corals, species sightings were recorded in six 5-minute intervals to give a measure of frequency at location, with a varying period of time used to search for new species records. Fish species were recorded during 15-minute interval samples, with two to three replicate intervals recorded at each site (IUCN 1997).

In 1999, a coastal biodiversity survey was undertaken on the northern Somali coast from 15 km west of Berbera to the mangrove known as Khoor Shoora approximately 150 km to the east. The aims of this survey were to determine the status of the marine resources in the region, the threats to the biodiversity, and thus determine appropriate measures for the sustainable use and conservation of the resources (SCHLEYER & BALDWIN 1999). Data were collected on the nature and biodiversity of the shoreline, mangrove, seaweed, coral reef and pelagic environments. A record was also kept on the abundance of turtles, dolphins and seabirds, as well as of the extent of turtle nesting on beaches.

Coral Reefs – Benthos and Fish

There are coral reefs of limited extent near Ras Khansir (Raas Khansiir), of fairly limited extent at Ras Cuuda and Siyara, and of considerable extent off El Girdi and west of Berbera. Reefs formed on fossilised beach rock were found at depths from 1 to 10 m. The coral communities on the reefs varied considerably in condition. All had been affected by bleaching to some degree. The shallow reefs (1 to 2 m) to the west of Berbera were slightly bleached and those in water less than 1 m deep appeared to have died from tidal exposure. The shallow reefs to the east of Berbera were affected far more severely by bleaching and, in many instances, had suffered nearly total mortality. Deeper reefs (2 to 5 m) were in better condition. Patchy reefs subject to sedimentation were dominated by Faviids, while more established reefs were dominated by *Porites* spp. Foliose *Montipora* spp. and *Astreopora* spp. were conspicuous on the deepest reefs (5 to 10 m). A total of 69 species of scleractinian coral, 11 species of alcyonacean coral and two species of fire coral were found along the north shore reefs (SCHLEYER & BALDWIN 1999). It is suggested that a more thorough coral-dedicated survey would substantially increase this number. In general, the area is both productive and relatively pristine apart from the harmful effects of coral bleaching and, to a lesser extent, predation by COTS on the coral reefs.

At Sa'adadin the structure and complexity of reefs was high. Scleractinian coral and fish diversity and abundance were found to be extremely high, comparable to the healthiest reefs seen in the western Indian Ocean and the Red Sea, potentially with higher diversity due to the mixing of species from different origins (Table 12). It is possible that the Sa'adadin Islands have a unique coral reef fauna and flora, at the mixing point of three regions - the Indian Ocean, Red Sea and Arabian Sea (IUCN 1997). As a result of low demand and low fishing pressure on coral reef fish, populations and individual fish sizes were large.

Coral Diversity

A total of 74 species of scleractinian coral, 11 species of alcyonacean (soft) coral and two species of fire coral were found during the 1999

Sites	Exposure/Water Clarity	Coral Species No. per 30 minutes	Fish Species No. per 30 minutes	Total Species
Aibat	Windward/high	61.0	66.5	127.5
	Leeward/low	55.0	51.5	106.5
Eilfil	Windward/High	51.0	62.5	113.5
	Leeward/High	46.0	53.0	99.0
Sa'adadin	Windward/Low	21.0	49.3	70.3
	Leeward/Low	35.0	49.7	84.7
Turultat	Windward/Low	37.0		
Average	Windward	44.3	59.4	103.8
	Leeward	45.3	51.4	96.7

Table 12: Number of species of coral and coral reef-associated fauna at Sa'adadin reefs (IUCN 1997)

survey (SCHLEYER & BALDWIN 1999). Other reef organisms encountered during the survey were sparse and included only five *Panulirus versicolor,* two specimens of two species of anemones, five specimens of *Tridacna* spp. and various sponges, ascidians, holothurians, echinoids, crinoids, molluscs and zoanthids. (See also IUCN 1997 for a record of coral species encountered.)

Coral Cover

Living coral cover varied from zero to 80 % on reefs affected by the bleaching and COTS phenomena, the average being between 2 and 5 %. Reefs not affected by bleaching had a coral cover ranging between 60 and 80 %. These constituted a fairly narrow fringing band on the outer perimeter of the reefs and there was relatively little healthy coral.

Fish Communities

Reef fish were diverse and the presence of large schools of fish, as well as an abundance of large fishes, indicated a relatively un-exploited resource and pristine environment (SCHLEYER & BALDWIN 1999, FAO 1996). The reef fish community differed considerably from that of the eastern Arabian Peninsula to the north, the fish communities of eastern Africa to the south, and the Red Sea to the west, particularly regarding the Chaetodontidae, Acanthuridae and Balistidae.

Compared to areas with a rocky or sandy substratum, or algal dominated assemblages, the coral reef environments showed the greatest diversity of fish fauna (140 species), the presence of large schools (Lutjanidae and Carangidae) and an abundance of large individuals (Serranidae and Plectorhynchidae). Degraded reefs colonised by filamentous and coralline algae had a greater proportion of herbivorous fish which, in some instances, were numerous and formed large shoals. Surgeonfishes were conspicuous in this regard. (Also see IUCN 1997 for list of coral reef fish, presence and abundance.)

The following are generalised site descriptions from SCHLEYER & BALDWIN 1999:

Berbera Harbour (10º 24.88'N 44º 57.55'E): low cliffs (2 to 3 m), with a shoreline of fossilized seabed; subtidally, rock boulders and rubble with scattered coral communities and algal beds at 1 m to 4.5 m, sloping gently to sand. Up to 32 species of corals, scattered and mostly dead with a maximum of 5 % live cover of small colonies (most being < 20 cm in diameter). Silt conditions favouring Faviids,

which were dominant. Coral rubble included *Acropora* cf. *formosa* (or *A. nobilis*). Fish were notably abundant (32 species), mostly *Scarus* and *Epinephelus*. Invertebrates: *Xestospongia* sp., *Dysidea* cf. *herbacea, Cryptodendron adhaesivum, Palythoa* cf. *natalensis, Lambis truncata, Pinctada margaritifera.* Turtles: one green *Chelonia mydas* and one hawksbill *Eretmochelys imbricata*.

Ras Khansir (10º 49.01'N 45º 44.79'E) approximately 1 km west of Karin village: a scattered *Porites* 'bommie' field on sand at a depth of 2 to 4 m, apparently extending westwards from Karin to the next headland and possibly beyond. Corals scattered on a sandy substratum, with a maximum of eight species representing 5 % live cover. *Porites solida* formed small bommies under silted conditions. Fishes were notably abundant, but low in diversity (17 species).

Ras Cuuda (10º 42.98'N 45º 33.37'E): a reef comprising a flat and algal covered area interspersed with mats of pale and dark zoanthids (*Zoanthus sansibaricus*); some appeared a deep blue in the dim light. Corals very sparse in their distribution and small in size, with a few Faviids and *Stylophora pistillata*. A relatively productive area with regard to fishes; extremely abundant juvenile *Lutjanus* sp., two sandbar sharks (*Carcharhinus plumbeus*) and one guitar shark (*Rhynchobates* sp.). Other invertebrates: *Xestospongia s*p., *Zoanthus sansibaricus*.

1 km west of Ras Cuuda (10º 42.21'N 45º 31.30'E): shallow reef composed largely of stands of *Millepora squanrosa* and *Porites lutea* bommies ranging from 0.54 m in diameter; also considerable *Pocillopora verrucosa*. Most of the coral (27 species) was dead apparently from bleaching, and the mortality ranged from 60 to 100 %. *Millepora* and *Porites* were 99 % dead, apparently from a bleaching event. Two small *Acropora* colonies were totally bleached and a colony of *Galaxea* and a small *Montipora colony* were partially bleached. Fish were relatively abundant (35 species). Other invertebrates included *Xestospongia* sp., *Acanthella* sp., *Dysidea* cf *herbacea, Panulirus versicolor* (4), *Palythoa* sp. and a single *Tridacna sp.*

From 10º 41.55'N 45º 31.46'E to 10º 40.63'N 45º28.37'E: sparse rubble (with very few corals - only eight species) interspersed with sand inhabited by numerous holothurians at a depth of 4 to 5 m. A few live and dead specimens (40 cm) of *Lobophyllia* cf. *corymbosa* were conspicuous. One *Acanthaster planci* (40 cm) was observed under a small bommie and one (30 cm) was moving rapidly across the sand. A large, almost mono-specific stand of *Pocillopora verrucosa* with some *Porites lutea* ranged in depth from 2 to 5 m. Patches were dead and overgrown with turf algae; the average cover being + or - 60 %. A single *A. planci* (35 cm) was associated with a dead patch but no feeding scars were observed. The approximate size of the outcrop was 50 m x 50 m. The outcrop was inhabited by a rich fish fauna. It gave way to a shallower (1 to 2 m) area of broken reef consisting almost entirely of dead coral with very few faviids, a single *Stylophora pistillata, a* few specimens of *Montipora stellata* and sponge *(Haliclona* sp.*).* The dead coral community was mixed but mostly unidentifiable as it was largely encrusted by coralline algae.

Between Ras Cuuda and Ras Xaatib (10º 39'91'N 45º 25'27'E): coral and rock rubble, with some bedrock under coarse sand veneer at a depth of 6.5 m. Very scattered live corals, including *Platygyra daedalea, Favia* sp., *Porites solida, P. lutea, Coscinarea* sp. Fishes were *v*ery abundant (particularly *Sphyraena* sp.*),* but low in diversity (7 species). Invertebrates included *Dysidea* sp., *Plakortis* sp., *Xestospongia* sp. and *Sepia pharaonis*.

Between Ras Cuuda and Ras Xaatib (10º 39'65'N 45º 25'04'E): coral rock rubble at 2 to 3 m (14 species). Scattered live corals forming a maximum 1 to 2 % live cover in very silted conditions; abundant fish life (28 species). Invertebrates included *Holothuria edulis, Sepia pharaonis* and unidentified sponges.

Siyara (10º 36.09'N 45º 15.85'E): a reef off the village at the base of a cliff. The reef commenced with exposed rock immediately offshore from Siyara and sloped to a depth of 10 m where the substratum again became sand. The reef covered more than 40 % of the seafloor and generally consisted of boulders overgrown with coral and small bommies. The rocks at a depth of 1 to 3 m had a few encrusting algae and sponges. Scattered sponges and some *Litophyton* cf. *iiltveldi* were found up to a depth of 6 m with a number of hard corals, the average coral cover being 40 %. The extent of the rock cover decreased from 6 to 10 m, averaging 30 % of the seafloor, with a coral cover greater than 40 %. The coral cover was diverse (33 species) and uniformly mixed up to 6 to 7 m, whereafter *Astreopora* mounds with a few *Montipora* plates were conspicuous. Many of the former bore old COTS feeding scars; those that had not been entirely eaten were showing good recovery. Fish life was abundant and diverse (70 species). Invertebrates included *Xestospongia, Dysidea* cf. *herbacea* and *Palythoa* cf. *natalensis.*

El Girdi (10º 33.65'N 45º 13.1 5'E): a reef adjacent to a narrow dune belt on the shore backed by a steeply sloping mountain. The subtidal sand gradually gave way to broken, submerged rock that developed into reef, approximately 11 km^2 in extent. From 1 to 2 m to the reef top, the reef consisted of regular spurs raised up to 2 m above the intervening patches of sand. The rock had been overgrown by coral so that the reef tops were flat and the sides vertical. The deeper margin of the reef (23 m to the reef top) formed a complete fringing reef that gave way to patch reef, with *Porites* and *Astreopora* bommies ranging in depth from 5 to 10 m, giving way to sand. The shallower regions of the reef were almost entirely dead and encrusted and accreted with coralline algae. There were only very few small fragments of *Montipora stellata* on the reef and isolated colonies of *Pocillopora* and *Stylophora.* The mortality was uniform and complete, and probably resulted from bleaching at an earlier date. More coral had survived on the outer fringe of the reef and *Porites* bommies of up to 3 m were conspicuous. These gave way to a coral community similar to that found in the deeper water at Siyara. Plates of *Montipora* were more conspicuous and there were no COTS feeding scars. The reef cover ranged from 40 to 100 % and the average coral cover on the reef ranged from 0 to 60 %. Fish fauna was diverse and abundant (65 species), especially surgeonfishes and parrotfishes. Invertebrates included *Tridacna* sp., *Holothuria scabra,* grey holothurian, *Haliclona* cf. *tulearensis* and several large *Lambis truncata*.

Coral Reef Fisheries

Artisanal fisheries have a long tradition in Somalia. Important landing sites along the coast are Alula, Xabo, Qandala, Las-Korey, Berbera, Lughaye and Zeila. Though still underdeveloped, artisanal fisheries are essential for the livelihood of a large portion of the coastal population (PERSGA/GEF 2002). Most commercial operations are carried out by foreign vessels (mainly from Yemen) that provide no catch or effort statistics. Reports of up to 70 boats at a time in the Zeila region alone suggest that this is a widespread occurrence. Somali fishermen target a limited number of demersal stocks (constrained by fishing gear limitations), and a range of coral reef fish.

The northern Somali fishing industry is centred at Berbera, with Siyara and Karin participating at a smaller scale. At Karin, a temporary fishing village, fishing is carried out in small canoes which either set a limited number of 7, 15, or 30 cm stretched mesh size gill nets or, occasionally, using handlines. Only 20 canoes were reported to operate between Zeila and Karin (SCHLEYER & BALDWIN 1999). Turtles are harvested opportunistically, both by jigging and harpooning at sea and through the capture of nesting turtles. Gill nets are permanently set around the coral reefs at Siyara, targeting sharks. Sharks are landed at Zeila and on Aibat Island. Fishermen report landing sharks of 3 to 4 m TL [total length], but carcasses littering the beaches rarely exceed 1 m (IUCN 1997). Throughout the summer, intensive shark fishing takes place at the following sites: Xabo, Butiyalo and Hantara in the eastern (Bari) region, Eilayo (Ceelayo), Las Korey and Mait in the central (Sanag) region, and Geeri and Lughaye in the western (Awdal and Sahil) regions.

Much of the commercial catch is made up of shark for the sharkfin industry. No total catch records exist, but up to 800 kg per month (300 kg of fins, wet weight) are caught in the Zeila district alone. Other catches include up to 10 mt of Spanish mackerel, 12 mt of assorted benthic species, 50 kg of crabs, 100 kg of lobster and a number of sea cucumbers, clams and oysters (IUCN 1997). Major sharks and rays targeted by the fisheries include hammerhead sharks (Sphyrnidae), largetooth sawfish (*Pristis pectinata*), whitetip shark (*Triaenodon obesus*), tiger shark (*Galeocerdo cuvier*) and guitarfishes (Rhinobatidae). Spanish mackerel, tuna (yellowfin, skipjack and frigate), jacks and trevallys are also sought. Benthic catches include parrotfish, snappers, goatfish, sardines and groupers. The most abundant species is the Indian oil sardine (*Sardinella longiceps*). The highest concentrations are found in the Ras Aser area, while stocks decrease gradually westwards. Round herring (*Etrumeus teres*), anchovies (Engraulididae) and scads (*Alepes* spp., *Atule mate*) are important resources that are fished seasonally in the Gulf of Aden. For the entire Somali coast the MSY [maximum sustainable yield] of small pelagics has been estimated at 70,000 to 100,000 mt. In addition, up to 200 turtles are caught each month during the nesting season.

Threats to Coral Reef Biodiversity

The area is productive and relatively unspoiled. However, there has been coral bleaching and COTS predation on the coral reefs. The effects of human activity on the environment appear to be minimal, the only exceptions being the relatively heavy, opportunistic exploitation of turtles and sharks. Fisheries and transport are only a small component of the national economy, and are not significant threats to coral reefs. Other coastal activities, such as salt mining and the collection of guano are only of local importance. There is neither oil nor gas exploitation nor tourism in the area. Given the above, this section identifies potential rather than actual threats to coral reefs.

Urban Development

Berbera and Bosaso are the two main ports along the Gulf of Aden coast. The urban population is growing rapidly and is largely uncontrolled. Adjacent to major population centres, domestic sewage is a locally significant source of marine pollution. In the absence of any monitoring, it is not possible to estimate the amount of toxic leachates and pathogenic organisms entering coastal waters. It is suggested that at present coral reefs are not overtly threatened. However, the pressures from expanding urban settlements close to coral reefs are expected to increase.

Oil and Gas Exploration

During the 1980s offshore oil exploration was conducted and results indicated that the continental shelf of Somalia may contain oil and gas reserves. Elf-Somalia and Agip were granted concessions for the eastern and central parts of the Gulf of Aden coast. No reserves of economic importance have been found so far and at present there is no exploitation of oil or gas. Should this come about however, there would be risks of spills and coastal contamination, in addition to the increase in population and related pressures that would occur.

Marine and Coastal Tourism

Tourism has never played an important role in Somalia, even though the five-year development plan (1982-86) placed an emphasis on the development of a tourism infrastructure (SHEPPARD & WELLS 1988). There is considerable potential for the development of tourism in Somalia, including coastal and marine activities which, with sufficient attention to conservation aspects, could contribute significantly to the economy.

Habitat Degradation and Destruction

Physical damage to coral reefs, which results in the loss of coral habitat and decline of reef associated fauna, is low. In the north-west, corals are collected occasionally and shipped to Djibouti for sale to tourists, but the extent of this activity is not known. The establishment of collecting stations for reef fishes is presently being considered by a private entrepreneur. If not managed properly, this may have negative effects on the reef habitat.

Marine Protected Areas and Level of Management

Three areas have been proposed for protection along the Gulf of Aden coast. However, only one of these (the Aibat, Sa'adadin and Saba-wanag area) encompasses significant coral growth, the others (the Daloh Forest Reserve and Mait Island) being chosen more for their terrestrial and wildlife attributes.

MPAs Declared

There are no declared marine protected areas in Somalia.

***De facto* and Planned MPAs**

Aibat and Sa'adadin Islands, Sabah Wanak: Extending over an area of some 300 km^2, the proposed protected area encompasses low lying mangrove islands with possibly the largest coral reef area in the Gulf of Aden. It is an important nesting site for marine turtles and seabirds, which are currently threatened through collection of eggs. Corals are also collected from the area.

Mait Island, (about 1 km^2) is a rock island with up 100,000 breeding seabirds, notably noddy terns.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

Regional and District Councils, and Councils of Elders have taken up the role of principal co-ordinating organisations for the inflow of aid to their respective jurisdictions. International agencies and NGOs work in co-ordination with the Councils of Elders in the development of a sustainable institutional base. Institutional co-ordination is achieved through the District and Regional Councils to ensure a reasonable level of public accountability. In the case of research, extension or credit accountability has to be established. One of the

institutions of North West Somalia is called the Ministry of Fisheries and Coastal Development. Created in 1993, this Ministry is in charge of encouraging public and private investment for the exploitation of marine resources; increasing fisheries production within the MSY; protection of the coastline and sea from environmental degradation; initiation and development of research and training facilities for the fisheries sector; and the development of employment opportunities in the marine sector.

Monitoring Capacity

There are currently no long-term monitoring programmes in Somalia.

Management Capacity

In the present political situation the national laws and regulations are not enforced and the national institutions are not operational. However, in 1988, prior to the current political situation, there were a number of institutions charged with activities that indirectly addressed coral reef protection. It is hoped that with continued stability these institutions will be re-established.

- **National Marine Affairs Committee**: Established to oversee the overall development of the maritime sector. The Committee included Minerals and Water Resources, Fisheries and Marine Resources, Foreign Affairs, Education and Defence Ministries.

- **Ministry of Marine Transport and Ports**: Mandated with the development of maritime transport and the improvement of port facilities, and responsible for environmental control of coastal areas including ports, prevention of marine pollution and safety of navigation. The Ministry was responsible for the implementation of the Maritime Code, other laws and regulations related to the marine environment applicable to ships in ports, and the implementation of regional and international conventions.

- **Ministry of Fisheries and Marine Resources**: Established in 1977 to develop and manage Somalia's fisheries resources. Basic marine fisheries legislation is contained in the Maritime Code of 1959.

- **National Range Agency and Ministry of Tourism**: Responsible for National Parks and establishing MPAs. Legislation was prepared for a network of protected areas before the political unrest.

Government Legislation, Strategies and Policies Pertinent to Reef Conservation

Although signatory to a host of international agreements and protocols, Somalia's ability to effectively implement them is limited.

International Agreements

Somalia is a signatory to the Bamako Convention on the Ban of the Import into Africa and the Control of Trans-boundary Movement and Management of Hazardous Wastes within Africa (1993)[1] and has ratified the following conventions and protocols which are relevant to the marine environment:

- Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (1988),

[1] Year in brackets gives the date Somalia became a Party to the Convention.

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (1985); the Convention on the Conservation of Migratory Species of Wild Animals (1986),

- Protocol Concerning Co-operation in Combating Marine Pollution in Cases of Emergency in the Eastern African Region (1988); the Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region (1988),

- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (1988),

- Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1988), and the

- United Nations Convention on the Law of the Sea (1989).

National Legislation

National environmental legislation is poorly developed and inadequate for environmental management and conservation. Somalia has not formulated a national policy for the exploitation of marine resources.

Gaps in Capacity and Requirements for Improved Conservation

The two key requirements for improved conservation are funding and personnel. There is a clear need for strengthening the skills of the manpower base to improve assessment, planning and management of coastal and marine environments. Manpower development must be an integral component of all conservation activities. Long-term research, monitoring and conservation activities will not take place without first, or simultaneously, addressing the poverty and socio-economic situation faced by the people of Somalia.

Recommendations to Improve the Conservation of Coral Reef Resources

Conservation of coral reefs in Somalia is currently given a lower priority than the rebuilding of the nation and the eradication of poverty. However, if measures can be implemented in tandem with this development, coral reefs will not be lost to future generations. These include the development of a system of marine protected areas, the adoption of oil spill response measures, broad-scale environmental education and continued research and monitoring for early detection of reef deterioration.

Establishment of MPAs

The establishment of other small reserves or Marine Protected Areas between Ras Xaatib and Ras Cuuda, west of the lighthouse near Berbera Airport and around the coral reefs opposite Siyara, would provide protection for representative coral reefs and turtle nesting beaches.

Research and Monitoring

A more detailed investigation is needed to assess marine resources, in particular those of coral reefs and their exploitation. This should be carried out in collaboration with the local fishermen to develop an understanding of seasonal exploitation, ultimately leading to resource management procedures. Monitoring of the coral reefs for further deterioration, or recovery from COTS outbreaks and bleaching, should be carried out on a regular timeframe. Studies should expand the coral reef and turtle surveys to both the west and east, further investigate the biodiversity of the reef fishes,

and extend the work into a regional study of their zoogeography. There is also a need for baseline surveys upon which to base the effects of oil, toxic chemicals, pathogens and other forms of pollution. A database containing information on biological resources and environmental information should be developed.

Review of Legal and Institutional Framework

There is a need to review existing legal and institutional mechanisms that address coral reef conservation and management. These should make provision for co-operation between government, non-government and private sectors. There must be a review of relevant international and regional conventions and the options for participation in international and regional initiatives. The existing environmental impact assessment policies concerning the marine and coastal environment need to be reviewed, developed and implemented.

Environmental Education

There is a need to integrate environmental education into existing community and educational programmes and curricula. An environmental education programme targeted towards all levels of society is needed to increase public awareness of the value, interest and vulnerability of the Somali coastal and marine environment, and to promote public participation in environmental initiatives.

Funding

Adequate funding mechanisms need to be developed for biodiversity conservation efforts in Somalia, which take into account the present political environment and the socio-economic conditions under which the people of Somalia live.

Pollution Control

An oil spill response contingency plan needs to be developed and implemented with reference to the Oil Spill Response Stockpile held in Djibouti.

Coral Reefs of Yemen

Introduction

The Republic of Yemen lies in the south-western corner of the Arabian Peninsula and includes the Socotra Island Group (Suqutra). The coastline is about 2,200 km long, roughly one third of which faces the Red Sea and the remaining two-thirds the Gulf of Aden (Fig. 9).

Along the Red Sea, the climate is dry with an average annual rainfall of 100 to 200 mm and a humidity of about 60 %. No perennial surface streams discharge into the Sea. However, flash floods are a widespread feature following torrential rains. The Gulf of Aden is dominated by the Indian Ocean monsoon system. The highest annual rainfall occurs between January and March (north-east monsoon). Between May and September the south-west monsoon generates winds blowing in a north-easterly direction and the relatively warm surface water of the north-eastern Gulf of Aden and Arabian Sea is blown offshore and replaced by cooler, nutrient-rich waters from deeper layers, limiting coral growth.

True coral reefs developed on biogenic calcium carbonate are most widely distributed in the Red Sea, fringing the mainland coast and offshore islands. The southern Red Sea reefs have a markedly different geomorphology to those of the northern and central Red Sea, with comparatively limited reef development resulting from differences in bathymetry, topography, turbidity and sea temperature. The Gulf of Aden and Socotra have even less Holocene reef development than the southern Red Sea, mostly supporting coral communities developed directly on non-reef substrates or relict reef deposits.

Coral growth along Yemen's Red Sea coast is found both as coral reefs and as coral communities on a variety of substrates. There are two principal reef types:

- fringing reefs of the southern Red Sea coast and some offshore islands, and
- semi-submerged patch reefs, found west of Al Hodeidah and south of the Ras Isa peninsula.

Yemeni reefs and coral communities have developed in some of the most extreme environments known for corals, ranging from high sea temperatures, minimal tidal movement and relatively calm sea conditions in the southern Red Sea, to seasonal cool water upwelling and large oceanic waves in parts of the Gulf of Aden and Arabian Sea. Areas exposed to the upwelling share a unique mix of tropical and temperate species and have highly productive fisheries.

About 75 % of the coastline consists of soft sediments and more than half of the shores are covered by sabkhas (dried mud flats) and salt marshes. The scarcity of hard substrates and the high turbidity along the wide and shallow continental shelf create unfavourable conditions for coral growth and only about 25 % of the mainland coastline supports coral reefs. South of Al Khaukha, nearshore reefs are more

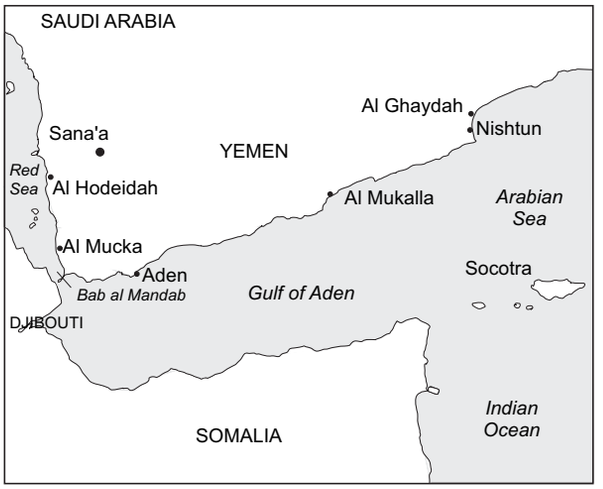

Fig. 9: Map showing major urban areas and coastline of Yemen

extensive and diverse than further north. The best-developed reefs occur offshore, mainly in the vicinity of the large number of islands that characterise the Yemeni Red Sea (IUCN 1987, SHEPPARD & WELLS 1987, SHEPPARD et al. 1992).

The Gulf of Aden coast has a length of about 1,400 km and a continental shelf area of 20,225 km². The southern extent is characterised by rocky cliffs that normally terminate in shallow water, alternating with stretches of sandy beaches. Seasonally low temperatures, as a result of the upwellings, and large expanses of unfavourable sandy substrate limit coral growth. Only 5 % of the coast is known to support fringing coral communities or reefs. Corals have been reported at Perim Island, near Aden (Khor Umairah, Little Aden), Ghuraira and Shuqra. More extensive areas of coral growth occur further east, towards Al Mukalla, particularly at Belhaf and Burum, and a group of six small islands lying off Bir Ali (WATT 1996, DEVANTIER & HARIRI in press).

The Socotra Island Group has long been isolated from the mainland, surrounded by deep waters, in places exceeding 3,000 m in depth. It lies 400 km south of the Arabian Peninsula and is highly exposed to the monsoon climate of the Indian Ocean. Annual rainfall is around 200 mm, mainly falling in June, November and December. Average air temperature ranges from 17 °C in January to 37 °C in July. Most of the coast consists of cliffs or sandy beaches, with occasional gravel shorelines. Corals are widespread throughout the archipelago, with cover varying from less than 5 to 80 % (UNDP/GEF 1996). Most of the coastal and marine areas surrounding these islands are still in a pristine state and, in 1996, the Government of Yemen declared Socotra a special natural area in need of protection.

Surveys

Several major projects have recently assessed the distribution, composition and status of living marine resources around much of the coastline; the Red Sea coast (TURAK & BRODIE 1999), the Gulf of Aden (WATT 1996) and the Socotra Island Group (CHEUNG et al. in press). Additional studies at key sites along the Gulf of Aden and Red Sea have been undertaken by members of the Arabian Seas Expedition (J. KEMP, U. ZAJONZ pers. comm.) and as part of smaller projects (e.g. assessment of coral bleaching in the north-east Gulf of Aden; DEVANTIER and HARIRI in press).

Survey Techniques

Methods have ranged from remote sensing using satellite imagery (Socotra), rapid ecological and impact assessments (Red Sea, Gulf of Aden and Socotra), to more detailed biodiversity studies (Red Sea and Socotra). Most recently, these studies have culminated in the initiation of long-term monitoring programmes at selected sites in the Red Sea and Socotra Island Group.

Remote Sensing: Distribution and composition of coastal and marine biotopes around Socotra were assessed using Landsat images, combined with extensive ground-truthing. These data have been used to provide unsupervised and supervised biotope classifications of the coastal and marine habitats of Socotra (J. TURNER & R. KLAUS pers. comm.). In combination with biodiversity data (see later) the biotope classifications were used in planning the zone boundaries of the recently proclaimed Socotra Multiple Use Marine Protected Area.

Rapid Ecological Assessment: The broad distribution of different coastal and marine habitat types along Yemen's Red Sea, Gulf of Aden and Socotra coastlines has been documented using several rapid assessment methods (MACALISTER ELLIOT & PARTNERS 1996, WATT 1996, TURAK & BRODIE 1999, DEVANTIER et al. in press a-c). These and other ongoing studies have begun to fill the previously large gaps in knowledge of Yemen's coastal and marine habitats (SHEPPARD & SHEPPARD 1991).

The biological resources, resource uses and impacts along the 1,365 km coastline of southern Yemen were assessed at 91 geographically discrete sites (MACALISTER ELLIOT & PARTNERS 1996, WATT 1996). The sites were selected every 15 km along the shoreline, from west to east, on 1:100,000 scale topographical maps. Sites were located using GPS (WGS 84 map datum; EC/MFW 1995). Each sample comprised a 500 m × 500 m quadrat bisecting the beach, covering the immediate terrestrial, supratidal, intertidal and immediate subtidal zones. Within the quadrat, the abundance or magnitude of biological resources and resource uses/impacts were estimated and recorded semi-quantitatively. The abundance of biological resources were scored using a ranked 0 to 6 scale and scores were based on estimates of the relative abundance within each quadrat.

A rapid assessment was also made of the coastal and marine environments of the Socotra Island Group in 1995 (MACALISTER ELLIOT & PARTNERS 1996, KEMP 1998). The subtidal appraisal, conducted using snorkel or SCUBA, included general observations of benthic cover and more detailed assessments of coral and fish biodiversity (KEMP 1998). A 9-point habitat code was used to classify sublittoral habitats, with observations of the dominant biota providing an overview of the distribution and composition of coral and fish communities.

Further rapid assessments have been undertaken since 1995. These include assessments of levels of reef development, benthic cover and various environmental attributes on the Socotra Island Group (DEVANTIER et al. in press a) and in the Red Sea (TURAK & BRODIE 1999). The surveys were conducted at 65 sites around the coasts of Socotra and adjacent islands and 51 sites along the Red Sea coast and offshore islands. In meandering SCUBA swims of 30 to 45 minutes duration, ecological and substratum attributes were assigned to standard ranked categories, based on an assessment integrated over the length of the swim (see DEVANTIER et al. 1998 for details).

Biodiversity Assessment: Taxonomic inventories of some key elements of reef fauna and flora have been undertaken in the Red Sea (corals: TURAK & BRODIE 1999; fish: BRODIE et al. 1998, 1999), Gulf of Aden (corals: DEVANTIER & HARIRI in press; fish: ARABIAN SEAS EXPEDITION, J. KEMP pers. comm., KEMP & BENZONI 2000) and Socotra Island Group (fish: KEMP 1998, F. KRUPP, U. ZAJONZ pers. comm.; corals: DEVANTIER et al. in review; crustaceans, molluscs and other fauna and algae, various authors in GEF-UNDP Socotra Biodiversity Project Progress Reports).

For corals, bio-inventories of the Socotra and Red Sea fauna were undertaken during SCUBA swim searches at each site. Each organism was identified to species level whenever possible and to genus and growth-form for taxonomically difficult species. Stony corals that could not be readily identified in the field were photographed, collected and bleached for detailed study.

Reef fish composition and abundance in the Red Sea, Gulf of Aden and Socotra Island Group have been assessed using both quantitative (belt transects, collecting stations) and semi-quantitative (visual census) field methods (KEMP 1998, BRODIE et al. 1998, 1999; U. ZAJONZ pers. comm.).

For quantitative assessments, numbers and/or log abundance estimates and/or sizes of fishes were made in single or replicated belt transects of known volume (e.g. 50 m length, 5 m width, 5 m height above sea bed). In Socotra, fish surveys were undertaken jointly with the coral surveys, allowing combined community analyses. Fish species composition around the Socotra Island Group was also assessed at point sampling stations, where the fish-narcotizing agent, Rotenone, was used to collect fishes (U. ZAJONZ pers. comm.).

For semi-quantitative assessments, fish species lists and abundance estimates were compiled at point census stations or during SCUBA swims, using standard rapid assessment methods (see ENGLISH et al. 1997).

Sea Surface Temperature Studies - Red Sea

As part of the GEF-UNDP Yemen Red Sea Project, a sea temperature monitoring programme was established in 1998. The programme is presently monitoring sea surface temperature using submerged temperature loggers (Dataflow 392 loggers). These have been deployed at Mayun Island near the entrance to the Red Sea and a further two loggers were deployed near Al Luhayyah in the north, recording temperature every 30 minutes (ROUPHAEL et al. 1999, M. AL SAFANI pers. comm.).

Benthos and Fish Monitoring - Socotra Island Group

A long-term monitoring programme was established around the Socotra Island Group in the year 2000. Selection of monitoring sites was based on initial surveys of benthos and fish conducted in 1999. The 11 monitoring sites that were selected are distributed widely around the archipelago, with seven sites on Socotra Island and one site each on four of the smaller outer islands of Abd Al Kuri, Samha, Darsa and Kal Farun. The sites were located in a variety of benthic community types, from those dominated by mono-specific coral stands to those supporting diverse coral assemblages to those dominated by macroalgae with sparse corals. These communities had been affected to varying degrees in 1998 by the global coral bleaching event. Several of the sites had experienced major bleaching-induced declines in cover and shifts in community composition whereas others had been little- or unaffected, and represented near-pristine reef habitats in terms of cover and community structure.

Field methods followed Global Coral Reef Monitoring Network (GCRMN) standards, employing sets of replicated line intercept transects (5 x 20 m length for benthos) and belt transects (3 x 50 m length, 5 m width and height for fish). The special nature of coral habitats around the Socotra Island Group, with little true reef development and often small coral patches with little or no reef slope, required modification of the GCRMN protocol. The lack of reef slope precluded establishment of two sets

of transects (at two depths) per site. Instead each site was at a single depth range (3 to 5 m or 8 to 11 m). Further, transects were aligned roughly parallel to each other approximately 15 m apart.

Coral Reefs - Benthos and Fish

More than 300 species of reef building corals and more than 600 species of reef-associated fishes have been identified from Yemen's reefs and coral communities. In particular, coral and fish communities of the Socotra Island Group are surprisingly diverse given that there is little reef development. The islands lie at a crossroads between different faunal provinces and sub-provinces, and the coral and fish fauna show biogeographic affinities with Arabia, east Africa and the greater Indian and Indo-Pacific regions.

Some of Yemen's reefs have been adversely affected by various disturbances over the past decade. This has caused major declines in living coral cover and shifts in community composition at the worst affected sites which are located in the northern part of the Yemeni Red Sea (Turak & Brodie 1999), the north-east Gulf of Aden (DeVantier & Hariri in press), and along the north coast of Socotra (DeVantier et al. in press b). Bleaching has adversely affected reefs and coral communities in all three areas, most recently during 1998. Other more localised disturbances include predation by the crown-of-thorns starfish and gastropod snails, sedimentation, storm damage and flood run-off. Although these disturbances have had adverse impacts in some locations particularly in the Red Sea, other Yemeni reefs in more exposed clear water areas of the southern Red Sea and the outer islands of the Socotra group remain in good to excellent condition, with little or no local human impact.

In Socotra, preliminary results indicate that there had been little change in coral cover or community composition from 1999 to 2000, other than an apparent increase in coral recruitment at sites badly impacted by bleaching in 1998. The rapid growth of coral recruits suggests that very small juvenile corals survived the 1998 bleaching-induced mortality. Some recent (post-bleaching) coral mortality had occurred at several sites, possibly caused by flood run-off during intense rains in December 1999. Most outer island sites were in good to excellent condition, and presently have low levels of human use. These sites give the Socotra islands international importance as a coral reef monitoring centre, as such sites are becoming rare in many countries with coral reefs, where human impacts are causing loss of valued reef attributes.

Coral Diversity

Yemen's reefs support some 300 species of scleractinian stony corals from 60 genera and 16 families (Sheppard & Sheppard 1991, Sheppard 1997, Turak & Brodie 1999, DeVantier et al. in review), the high richness reflecting the wide range of habitat types, oceanographic and environmental conditions.

A total of about 176 species of stony corals are presently known to occur in Yemen's Red Sea (Turak & Brodie 1999). Richness at individual sites ranged from 1 to 76 species. Of 51 Red Sea bio-inventory sites, almost 50 % had more than 40 coral species and 12 % of sites had over 50 species, similar to counts at reefs in the central and northern Red Sea (DeVantier et al. 2000). Turak & Brodie (1999) identified at least 19 new distribution records for the southern Red Sea, based on the list compiled by Sheppard & Sheppard (1991) and further coral specimens await identification.

Diversity appears to be lower along the mainland Gulf of Aden coast, which is thought to support some 100 coral species (SHEPPARD & SHEPPARD 1991, DEVANTIER & HARIRI in press), but remains relatively poorly studied. By contrast, the Socotra Island Group supports a diverse fauna of about 250 stony coral species, placing it among the richest sites in the western Indian Ocean (Table 13). The high diversity is related to the co-occurrence of a composite coral fauna from different biogeographic provinces and sub-provinces, including species with wide Indo-Pacific ranges, species from the Indian Ocean, species previously known only from East Africa, Arabia or the Red Sea (DEVANTIER et al. in press) and species not yet described (VERON 2000, DEVANTIER et al. in review).

A high degree of similarity in stony coral richness and composition between the Red Sea and Socotra Island Group exists at family and generic levels, whereas the Gulf of Aden is relatively depauperate at generic and species levels (Table 13). At individual sites in the Red Sea, Gulf of Aden and Socotra, coral richness ranges from less than 5 species to more than 70 species. Low diversity sites include those composed of large monospecific coral stands (covering thousands of square metres), sites on coralline algal reefs, or sites where environmental characteristics are suitable only for tolerant corals (SHEPPARD & SHEPPARD 1991, TURAK & BRODIE 1999). Sparse coral assemblages (with several notable diverse exceptions) are common along the exposed southern coastlines of the Socotra Island Group, where monsoon upwelling and high biomass of macroalgae and other benthos tend to limit coral growth. High diversity assemblages are more commonly found in areas of moderate water movement and clarity, notably on the offshore islands of the Red Sea (TURAK & BRODIE 1999), north-east Gulf of Aden and protected northern coasts of the Socotra Island Group.

Reef distribution and coral communities

For Red Sea coastal and island fringing reefs, live coral cover was generally higher (about 10 %) in the south than in most of the northern and central areas (TURAK & BRODIE 1999). There were more large colonies (up to 3 to 4 m diameter) at the southern end of Saba Island in the Zubayr group and at Mayun Island in the straits of Bab al Mandab. There is a long fringing reef from just north of Al Khawthah down the coast to opposite Mayun Island. This reef continues in patches around the rocky headland on the Gulf of Aden coast. The width varies from less than 100 m to more than 1 km enclosing a shallow lagoon (0.2 to l.5 m deep). Observations showed that the seaward margin typically dropped to around 3 m, except south of Al Mulbah, where there was a healthy patch of *Platygyra* colonies on a sandy bottom at depths of 5 to 6 m. *Acropora* spp. were more evident than farther north and formed stands of branching colonies. *Porites* spp. and S*tylophora pistillata* colonies were found at all sites. Other common species were *Montipora* spp., *Acropora valida* and *A. humilis, Porites nodifera, Pavona cactus, Galaxea ascicularis, Acanthastrea echinata, Hydnophora* spp., *Favia favus, Goniastrea retiformis, Platygyra daedalea, Leptastrea purpurea* and *Echinopora gemmacea* (TURAK & BRODIE 1999).

Fringing reefs around the islands were in the form of extensive patches with gradual slopes and intermittent sand areas. Some of the coral patches and ridges were formed by coral rubble accumulations from storm activities. These rubble ridges were often covered with thick mats of the brown alga *Dictyota* sp. In addition to *Stylophora pistillata* and *Porites* spp., *Psammocora contigua* was very common on one reef. Most *Acropora* corals were dead, including numerous tabular colonies.

Taxonomic level	Red Sea	NE Gulf of Aden	Socotra islands
Family	14	14	16
Genus	56	38	58
Species	176	100	253

Table 13: Species diversity of reef-building stony corals from Yemen's Red Sea, (TURAK & BRODIE 1999), N.E. Gulf of Aden (DEVANTIER & HARIRI in press) and Socotra Island Group (DEVANTIER et al. in review)

Mayun Island, at the mouth of the straits of Bab al Mandab and subject to the effects of periodic nutrient-rich cold water upwelling from the Indian Ocean, had distinct coral reef formations. The island is of volcanic origin with reef growth on basal volcanic rock. On the northern side, extensive reef flats with diverse and healthy coral growth had developed. The eastern and western sides support predominantly monospecific *Stylophora* communities. Bays on the southern side had healthy growth of corals dominated by large *Porites* colonies up to 4 to 5 m in diameter, all of which survived the 1997/1998 bleaching event (TURAK & BRODIE 1999).

Red Sea Submerged Patch Reefs: In terms of surface and volume, these reefs may be the most dominant (TURAK & BRODIE 1999). Large patches are found west of Al Hodeidah, south of the Ras Isa peninsula and scattered in the southern Farasan Islands in the inter-island waters. The shallower parts generally are 6 to 8 m deep, although some reefs in the southern Farasan group grow to just below sea surface. Several large patches appeared not to be marked on current hydrographic charts. The dominant corals were *Porites* spp.

Red Algal Reefs and Associated Coral Communities: Red algal reefs occur in the shallow coastal waters from the Saudi Arabian border south to the Ras Isa peninsula and around many nearshore islands, in waters less than 6 m (typically 2 to 4 m deep). On these reefs coral growth ranged from a few small colonies of some hardy species to extensive coral communities with high substrate cover. These reefs were essentially built by red coralline algae of the genera *Porolithon* and *Lithothamnium*, and supported limited coral reef development (SHEPPARD & SHEPPARD 1991, TURAK & BRODIE 1999). They were generally found in semi-sheltered, low energy environments with high temperature, salinity and sedimentation levels. The corals more tolerant to these conditions were the Pocilloporidae, *Porites* spp. (massive growth forms) and *Siderastrea savignyana*. Coral colonies on these reefs do not attain large sizes, reaching a maximum of around 50 cm diameter. In addition to corals, fleshy macroalgae were also associated with the coralline algal reefs. The main algae were *Caulerpa* sp., *Sargassum* sp. and *Padina* sp.. At times dense *Sargassum* mats, which could have fronds growing more than 2 m long totally obscured the underlying coralline red algal growth.

Coral Communities on Volcanic Rock: The offshore islands of the Hanish and Zubayr groups and At Tair Island supported some areas of extensive coral development and a high diversity of scleractinian corals (TURAK & BRODIE 1999). *Porites* species were the dominant corals. A similar diversity of hard coral species was also found in coral communities on mid water pinnacles of volcanic origin, such as Six Foot Rocks south of Tiqfash Island and Avocet Rock south of Al Hodeidah. These pinnacles, rising from 40 to 60 m, support rich and abundant fish fauna. The highest recorded coral species diversity (76 species, TURAK & BRODIE 1999) was at a community on Six Foot Rocks and was comparable to diversity levels in other areas of the Red Sea.

Around At Tair and islands of the Zubayr group, small coral colonies of massive growth form, mostly *Porites*, grew unattached to the flat volcanic rock. Other common corals were massive *Goniastrea retiformis,* encrusting *Acropora*, *Montipora* and *Leptastrea* and *Cyphastrea* species. Under the volcanic ash cliffs of At Tair Island, where fine sediments predominated, very large *Siderastrea savignyana* colonies were developed, reaching several metres in diameter and typically partially buried in shifting sediments.

Although Yemen's Red Sea reefs have proven surprisingly diverse in species composition, the main structural elements are massive corals of the genus *Porites.* These are by far the most common genus of reef-building coral and the main reef framework builder of contemporary coral reefs in this region. The other two most common corals are *Stylophora pistillata* and *Platygyra daedalea,* both species found in a wide range of habitats.

Gulf of Aden: Until recently, descriptions of coral communities from the northern coast of the Gulf of Aden were sparse (SHEPPARD & SHEPPARD 1991). More recent surveys have demonstrated that there are at least six discrete areas where coral communities are developed along the Gulf of Aden coast, concentrated from the entrance of the Red Sea to Aden in the west and from Belhaf to Al Mukalla in the east. Coral diversity is higher to the west of Al Mukalla where there are approximately 40 genera (Table 13). East of this point growth is limited to isolated colonies of a few genera, principally the more hardy or massive forms such as *Stylophora*, *Porites* and various faviids, a finding echoed by studies in southern Oman (SHEPPARD & SHEPPARD 1991). Low sea water temperatures associated with upwelling and competition for light from algae probably limit growth, while grazing by urchins and herbivorous fish are important in determining larval settlement rates.

Generally, coral communities in the Gulf of Aden grow as a veneer over a rocky substrate of inorganic origin, usually discernible between colonies. Thus these are coral communities rather than true reefs. Cold water upwelling and the limited distribution of available habitat are the two principal factors limiting coral diversity and growth in the area, although other factors such as turbidity and scouring also may be important.

Along the north-west Gulf of Aden coast, key sites include:

- **Khor Umairah:** This is a semi-enclosed lagoon cut off from the sea by a large spit and an ideal habitat for seagrasses (HIRTH et al. 1973). Large coral areas occur in the lagoon, where the sheltered conditions favour coral growth by reducing wave energy.

- **Crater, Aden:** The coral fauna at this site forms a veneer over steeply sloping volcanic rocks and boulders down to 8 m deep, where a gently sloping sandy bottom prevents further colonisation. Live coral cover is high on average (30 to 50 %) although it reaches 100 % in places. Massive growth forms of *Porites* colonies dominate and at least 20 other genera were also present, including large colonies of *Lobophyllia*, *Galaxea*, the solitary coral *Fungia,* and *Turbinaria* in deeper water. ROSEN (1971) reports a total of 32 genera for the Aden area.

- **Shuara:** The area is relatively diverse and supports two examples of a larger reef complex. Corals at the Shuara site showed evidence of forming a true fringing reef (typical reef profile with reef flat, reef crest and slope; the development of a massive, wave-resistant structure composed of biogenic carbonate). Live coral cover ranged from below 5 % on the reef flat, to 30 to 40 %

at the sample site 20 km east of Shuara. Both sites were dominated by *Stylophora* and *Porites*, with a range of other genera in lower abundances, with faviids and acroporids being well represented.

Further to the east, in the north-east Gulf of Aden, coral communities are developed from Belhaf to Al Mukalla, and including the islands offshore from Bir Ali. These coral communities are of moderate to high diversity (about 100 spp. Scleractinia) with a wide range of coral cover (< 10 to > 75 %, DEVANTIER & HARIRI in press).

Community structure at individual sites ranges from monospecific coral stands (including *Pocillopora damicornis, Stylophora pistillata, Goniastrea retiformis, Porites* spp., KEMP & BENZONI 1999, DEVANTIER & HARIRI in press) to moderately diverse assemblages of tabular and branching acroporids, massive and encrusting faviids, mussids and poritids. Despite the general lack of reef development, the area supports some large corals estimated to be centuries old.

- **Belhaf:** The area around Belhaf is volcanic with extensive lava fields leading to the coast in places and providing a suitable substrate for coral colonisation. Conditions are favourable for reef formation and have resulted in the growth of a mature fringing reef, dominated by *Porites* colonies and occasional large *Acropora* tables, staghorn beds and foliose *Montipora* stands. This site was particularly badly affected by coral bleaching in 1998, with major reduction in living coral cover (KEMP & BENZONI 2000, DEVANTIER & HARIRI in press).

- **Bir Ali and Offshore Islands:** The Bir Ali area supports the most concentrated distribution of coral communities known from the northern Gulf of Aden, with large coral patches developed offshore from the village and coral communities fringing the offshore islands. Community structure at individual sites varies from large monospecific stands of pocilloporids, faviids and poritids to moderately diverse assemblages (about 50 spp. Scleractinia). Coral and fish communities on the islands offshore from Bir Ali are particularly well developed, share interesting biogeographic affinities and may be important in maintaining gene flow along the Gulf of Aden coast (KEMP & BENZONI 2000).

- **Burum:** Coral growth forms only a veneer over the volcanic outcrop and boulders in the shallow sublittoral. At this site the more fragile foliaceous and branching forms of *Montipora* dominate the live coral cover. *Porites* and other massive corals also contribute significantly. Wave energy significantly influences the composition of coral assemblages along this stretch of coast.

- **Al Mukalla:** The area supports both shallow (1 to 10 m) and deep water (15 to 25 m) coral communities, mostly developed directly on terrigenous rock. Shallow water assemblages were composed of massive poritids, faviids and mussids and tabular *Acropora* spp., with cover of live coral approaching 50 % at several locations. These assemblages were adversely affected by bleaching in June 1998, with the loss of around half the live coral cover at the worst affected sites. Deeper assemblages, composed predominantly of encrusting and massive faviids, mussids and siderastreids, were less affected by the bleaching event, with living coral cover remaining at about 10 %.

- **Ras Fartak and Ras Fantas:** The area around Ras Fartak and Ras Fantas is influenced by seasonal upwelling. The sublittoral epifauna is dominated by ascidians, sponges and large populations of urchins. Small encrusting coral colonies covered 1 to 5 % of the substrate, composed mainly of faviids, *Porites* and *Stylophora* species and small branching colonies of *Acropora*.

- **Socotra Island Group:** Coral communities are distributed patchily around the islands, with most extensive development on the northern coasts. The southern coasts are more strongly dominated by macroalgae, although some sites supported assemblages of stony and soft corals interspersed among macroalgae, turf and coralline algae and/or barrel-foliose sponges (e.g. Socotra: Qatanin, Qaara, Bidholan; Abd Al Kuri: Bandar Salih, east Ras Lubaynah 'Trident Bay'; and south-west Samha). Trident Bay, south-west Abd Al Kuri, was exceptional for a south coast location in terms of the cover and species richness of the coral assemblage and sizes of individual coral colonies.

The communities were developed from low tide level to depths exceeding 20 m, with most occurring on gentle slopes (less than ten degrees to the horizontal), and usually surrounded by sand or merging into sand at their deeper extent. With some exceptions on the northern coasts, the communities were small (1 to 5 ha). Most communities occurred in semi-sheltered environments, although they were distributed over the full range of exposures, from sheltered to highly exposed (south coasts).

At most sites there was little to no recent (Holocene) reef development. Around two-thirds of sites were classified as incipient reefs with some accretion and one third as coral communities developed directly on rock, sand or rubble (mostly on the south coasts). Some communities were growing on relict 'spur and groove' structures that probably represent earlier (pre-Holocene) periods of reef development.

There was great variety in the coral community structure around the archipelago. Individual sites were characterized by low to high coral diversity (13 to 90 spp. Scleractinia) and variable coral cover (< 1 to > 75 %, average 22 %). Most coral communities were small (1 to 5 ha) and developed on the north coasts. Coral cover and diversity were higher than in macroalgal dominated south coast locations (north coasts average 27 % coral cover, 46 spp.; south coasts average 5 %, 35 spp.).

The outer islands (Abd Al Kuri, Samha, Darsa and Kal Farun) were on average more diverse than Socotra for both corals and fish. As with the Gulf of Aden, some corals attained great size, although there is little recent biogenic reef accretion. The lack of Holocene reef development is likely to be related to recurrent mass mortality from intense monsoon upwelling or ENSO (El Niño Southern Oscillation) events, competition with macroalgae, episodic burial under sediments, high rates of bio-erosion and the recent initiation of reef growth late in the Holocene. Some communities, notably on the northern coast of Socotra Island and north-east Gulf of Aden, were adversely affected by elevated sea temperatures (> 31 °C) in May to July 1998. This caused mass coral bleaching and mortality and resulted in major reductions in cover and shifts in community composition at the worst-affected sites (DeVantier & Hariri in press, DeVantier et al. in press b). Other sites, particularly on the outer islands of the Socotra group, were little affected, exhibiting high living cover and little damage. These communities also support other reef-associated species of high conservation value and/or economic importance.

Coral Cover

Cover of stony corals, dead corals, soft corals and algae were all highly variable among different sites within the Red Sea, Gulf of Aden and Socotra Island Group. Ratios of live to dead coral cover at individual sites ranged from strongly positive to negative, related largely to the differential effects of recent disturbance, notably coral bleaching in 1998.

Red Sea: In the northern Yemeni Red Sea, extensive coral mortality over the past decade (probably caused by elevated sea temperatures and predation by crown-of-thorns starfish) had resulted in major reductions in living coral cover on some reefs (TURAK & BRODIE 1999). Reefs of the southern Red Sea, and those fringing offshore islands, were less disturbed, supporting higher living coral cover.

When surveyed in the mid-1990s, semi-protected island reefs in Yemen's northern Red Sea had, on average, low live-coral cover (17 %), high dead-coral cover (34 %) and high macroalgae cover (20 %). These reefs had relatively high average species richness (44 spp.). The northern and central Yemen coast and nearshore islands, from north of Al Khawkhah to Midi near the border with Saudi Arabia, had very low live-coral cover (3 %) and very high dead standing coral cover (averaging 34 %). Macroalgal cover was also high (average 34 %) with *Sargassum, Turbinaria, Padina* and *Dictyota* spp. being dominant. These communities were also characterized by very low coral species richness (average 9 spp.).

Clear water communities facing the open sea - the Zubayr group, At Tair in the north, and Mayun Island in the south - had the highest live coral cover (29 %) and lowest dead coral cover (14 %). Macroalgal cover was also among the lowest, while coral species diversity was high (46 spp.) with some of the largest colonies encountered in the surveys. Deep water pinnacles and submerged patch reefs had high overall coral cover (average 52 %), with similar levels of live (24 %) and dead coral (28 %). Outbreaks of the crown-of-thorns starfish may have caused this extensive mortality. The most common distinguishing characteristic of these sites was high coral species richness (56 spp.) including 76 species at one site.

Most exposed reefs with algal crests and monospecific stands of coral also had high cover of dead coral, often in the form of mounds or ridges of branching coral rubble but also dead massive and tabular *Acropora* colonies. Reefs in this group had a very high percentage of total coral cover (averaging over 50 %), although it was mostly dead standing coral (average 44 %) at the time of survey. Southern fringing reefs (south of Yakhtul to Dhubab) also had higher average cover of dead corals (23 %) than live corals (15 %) and substantial cover of macroalgae (average 14 %).

Gulf of Aden: Despite the lack of major biogenic reef accretion, some sites support high live-coral cover (> 50 %, and large sizes of individual coral colonies). Examples include the islands offshore from Bir Ali. These sites have high regional significance, as communities with high coral cover (whether forming true reefs or not) are known to occur only very rarely in the Arabian Sea (SHEPPARD & SHEPPARD 1991, SHEPPARD et al. 1992, WATT 1996, KEMP & BENZONI 2000).

Socotra: Cover of stony corals (including the reef-building hydrozoan 'fire coral' *Millepora*) ranged from less than 1 % to more than 75 %, and in large patches (about 1,000 m^2) attained about 100 %. When assessed over all sites, living stony coral cover averaged about 20 %, with highest cover (about 35 %) on the Brothers (Samhah, Darsa and including

Sabuniyah Rocks). Stony coral cover was much higher on the north coasts (about 25 %) than on the south coasts (about 5 %).

Sites of high stony coral cover (> 50 %) included Medina (north-west Socotra - large monospecific beds of *Pavona maldivensis* and *Goniopora stokesi*), Ras Anjara Bay (east of Abd Al Kuri: tabular and staghorn *Acropora* spp., massive and encrusting faviids, poritids, mussids), north Samha (large monospecific beds of staghorn *Acropora formosa*), and north-east Samha (tabular and staghorn *Acropora* spp., massive and encrusting faviids, poritids, mussids). Other notable locations were Diham-Qubbah and Hawlaf Port (Socotra) and the small outer island rock stacks of Kal Farun and Sabuniyah Rocks, all with living coral cover (about 50 %), composed predominantly by large (1 to 4 m diameter) massive corals of the genera *Porites* or *Galaxea*.

All the above sites remained largely unaffected by the mass coral bleaching event that caused major reductions in live cover at other sites in May and June 1998. Most south coast sites had stony coral cover less than 10 %, being dominated by macroalgae, with the notable exception of south-west Abd Al Kuri. Here cover of both living and dead corals was each about 20 %, composed predominantly of massive corals, some of which had dead colony surfaces consistent with injury during the 1998 bleaching event.

Previous coral surveys reported that most sites were in good to excellent condition (MacAlister Elliott and Partners 1996, see also Kemp 1998). Although high cover of dead *Acropora* spp. (about 50 %) was reported from one site on the north-east coast of Socotra, no cause of the mortality was identified. Coral mortality following bleaching in 1998, particularly among tabular and staghorn *Acropora*, foliose *Montipora*, fire corals and soft corals, caused reductions in average coral cover from about 50 to about 20 % at some locations. Following the 1998 bleaching event, overall dead coral cover averaged 8 %, with little variability among islands. Cover of dead corals was lowest at the Brothers (about 5 %) and on the southern coasts, reflecting the generally low coral cover there.

Special Characteristics of Yemeni Reefs

One of the important features of most Yemeni Red Sea coral reefs is the very limited or complete lack of an intertidal zone. The main tidal movements in the Red Sea are diurnal tides of limited magnitude, seasonal tides of more significance and, at times most importantly, sea level fluctuations due to strong persistent onshore winds (Edwards 1987). Most reefs in the Yemeni Red Sea either do not have an intertidal reef flat development or they are devoid of live corals.

From the shallow coastal waters of southern Saudi Arabia, Sheppard (1985) described reef formations built essentially of crustose red algae and named them Algal Reefs. Such formations also occur along the north coast of Yemen and south to A1 Urj. Algal reefs also occur in the shallow nearshore waters north of Al Hodeidah. They are often covered by dense macroalgal growth and may also be surrounded by seagrass beds. Associated biota are usually poor and may include some sea urchins and a variety of algal species. Fish diversity and abundance were generally low.

Coral communities of the Socotra Island Group and north-east Gulf of Aden were notable for the occasional co-occurrence of large monospecific coral stands immediately adjacent to highly diverse coral assemblages, developed in similar environmental conditions of depth, light, sea temperature, and sediment type.

Coral Reef Fisheries

Fishing is a traditional profession for thousands of Yemenis. Total annual catches vary between 90,000 and 95,000 mt. Most of the landings come from trawling in the Red Sea and the pelagics fishery in the Gulf of Aden. Reef-based fisheries are, for the most part, underdeveloped and at a subsistence level.

Fishery Distribution

Coral reef fisheries are based primarily in the Red Sea and around the Socotra Island Group. There are five main landing centres on the Red Sea coast: Midi, Khoba, Hodeidah, Khaukha and Mokha. Reef-based fisheries in the Gulf of Aden are minor, with the majority of the fishing industry targeting pelagics. On Socotra, reef-based fishing activities take place along the entire coastline, but only one processing plant exists to market catches on a commercial scale. Other catches are predominantly at a subsistence level. The trawling grounds of the Red Sea cover about 6,200 km^2 of which 550 km^2 are shrimp fishery areas (SANDERS & KEDIDI 1981).

Fishery Composition and Trends

For the Red Sea, data date back to the 1970s and early 1980s and focus on demersal fishes and shrimps. SANDERS & MORGAN (1989) estimated the standing stocks in the Yemeni Red Sea at roughly 23,000 to 32,000 mt. No more recent data on stocks are available. Statistics are generally unreliable because catches are auctioned and sold as individual fishes (for large species), or in bundles for fish of smaller size, often without being weighed. Furthermore, there are no accurate figures on fishing effort.

In the Gulf of Aden several surveys have provided valuable resource information on demersal and pelagic stocks, but little on artisanal fisheries. Among the exploitable stocks, pelagics are more abundant than demersal resources. Large pelagics include tunas, Spanish mackerels, sharks, jacks and marlins. Data on the distribution of demersal stocks and their densities are given in EDWARDS et al. (1984). Catches of the Spanish mackerel *Scomberomorus commersoni* amount to about 1,000 mt annually; horse mackerels (*Trachurus* and *Decapterus* sp.) ranged between 5,000 to 8,000 mt annually during the 1980s. There has been a slow but gradual decline in catches of pelagic species following a peak in 1989, while demersal fish stocks have been declining sharply since 1987. Sharks (mostly Carcharinidae and Sphyrnidae) are also fished, using trolling and surface long-lining. During the 1980s annual catches were in the order of 7,000 mt.

There is an artisanal fishery for spiny lobsters (*Panulirus* spp.) in Hadhramut and Mahra and around the Socotra Island Group. Catches were about 200 mt between 1972 and 1983, rose to a peak of 1,150 mt in 1987 and dropped to around 600 to 700 mt 1991. Only 5 % came from Socotra. Management measures since 1970 have restricted the lobster fishing season to the period between October and April, limited tail lengths to greater than 7 cm and catching females with eggs was forbidden. Since 1983 fishermen have been encouraged to use lobster traps, which have now largely replaced nets.

Resource surveys in the 1960s and 1970s reported rich fishery resources in the waters surrounding the Socotra Island Group. KESTEVEN et al. (1981) estimated biomass for demersal resources at 55,000 to 116,000 mt and for pelagics at 112,000 to 24,000 mt, with yield estimates of 10,000 to 20,000 mt and 39,000 to 78,000 mt respectively. Fish, turtles and lobsters are important resources in the archipelago and abalone is a resource of potential future exploitation. More recent information is provided in UNDP/GEF (1996).

Threats to Coral Reef Biodiversity

Coral reefs have not ranked highly on the protection agenda in Yemen. Development of urban centres and industry carry a higher priority, and only in recent years has the protection of coral reefs been addressed. Threats to Yemen's reefs include those from oil and oil-related industries, shipping and harbour activities, ballast water discharge, fishing, urban development and sewage discharge, litter, catchment pollution and sedimentation, chemical pollution, tourism, coastal industries, coral predators and global climate change (PERSGA/GEF 2001, BRODIE & TURAK 1999). Threats to biodiversity range from local (e.g. coral collecting), regional (e.g. bleaching) to global (e.g. changes in ocean alkalinity from increasing atmospheric carbon dioxide). A fledgling tourism industry poses a small threat to reefs from anchor or diver damage.

Coastal Development

Coastal cities and towns are expanding at accelerating rates and unplanned settlements around cities such as Al Hodeidah may result in the loss of coral reefs. The proposed development of Aden Port and Aden Free Zone are expected to have a major impact on the environment. Reclamation for port development and expansion and for construction of industrial areas is already underway in Aden, where lagoons and intertidal areas are being reclaimed. In Socotra, harbour and airport development are planned. Unless appropriate environmental precautions are taken, this development is likely to cause considerable local adverse environmental impact.

Tourism

Reef-based tourism is still in its infancy and impacts on the reefs by visitors are low. This might become an important issue in the Gulf of Aden where corals are already under stressful conditions and particularly sensitive to disturbance.

Shipping and Navigation

Yemeni waters are major shipping routes. About 16,000 ships pass through the Straits of Bab al Mandab each year and many call at Yemen's main ports (Table 14; ADEN PORT DEVELOPMENT 1996). Ships are known to dump their wastes and ballast water into Yemeni waters. Ballast waters result in the formation of tar balls, which have been found all along the coastline of the Gulf of Aden (EC/MFW 1995) and some parts of the Red Sea coast (RUSHDI et al. 1991). Additionally, solid waste from ship-based sources may be found on beaches. The potential threat of a major accident is significant and may result in major habitat destruction and oil pollution. Main ports lack reception facilities and there is limited oil spill contingency planning.

Port	1994		1995		First half 1996	
	number of ships	Oil cargo	number of ships	Oil cargo	number of ships	Oil cargo
Aden	878	2,548,563	1164	4,201,809	696	4,112,120
Al Hodeidah	523	1,350,524	583	1,326,711	392	108,807
Al Mucka	84	263,447	97	230,254	159	19,304
Mukalla	224	229,100	186	248,404	183	116,084
Ras Isa	83	7,639,899	84	7,411,011	46	3,543,541

Table 14: Number of ships calling at Yemeni ports and volume of oil cargo in metric tonnes (PERSGA 1997)

Shark Fishery

Catches of sharks from the Red Sea increased to 1993 (peak of 6,537 mt) and dropped gradually to 3,556 mt in 1996. Sharks are mainly caught for their fins, which are exported and fetch high prices on international markets.

Oil Pollution

Oil and oil-related industries pose a threat to coral reef biodiversity. Oil originates from ballast water discharge or from spills while loading or unloading. A 409,000 tonnes deadweight, floating storage and off-loading vessel is moored 4.8 nautical miles offshore from Ras Isa on the Al Salif Peninsula. This ship is supplied with crude oil by a pipeline from the shore, which is then transferred to crude oil tankers. Oil spill risks associated with these procedures are considered significant. Over 200 tar balls per 10 m transect were recorded at Bandar east of Aden (RUSHDI et al. 1991). Current daily bunker supplies in the Port of Aden are around 40,000 mt. Poor maintenance has resulted in low level, but locally significant, leaks from bunkering facilities into the port. One bunker barge sank in 1995, causing considerable localized oil pollution in the Tawahi area (ADEN PORT DEVELOPMENT 1996), and a thick layer of oil covering the intertidal and lower supralittoral zones is still evident.

Bleaching

Bleaching has caused extensive recent coral mortality on many Yemeni reefs, including those in the northern nearshore area of the Red Sea (since 1990), in the southern Red Sea (within the last 2 to 4 years), and Socotra Island Group and north east Gulf of Aden (1998). A number of the Red Sea sites with near total mortality had been reported as having healthy coral growth in the 1980s (IUCN 1987).

Bleaching effects in 1998 were patchily distributed around the Socotra Island Group and north-east Gulf of Aden. At the worst affected sites, more than half of the species were injured and about half of the live coral cover was killed. Species were affected differentially. Pocilloporids, table and branching *Acropora* spp. and fire corals *Millepora* sp. were the most badly affected and changes occurred in species composition and relative abundance.

The bleaching followed a period of elevated sea surface temperatures greater than 1 °C above mean monthly averages (as derived from NOAA 'hotspot' satellite imagery). On the north coast of Socotra, sea surface temperatures were warmer than 31 °C in May to June 1998, followed by rapid cooling (< 24 °C) in July 1998 (DEVANTIER et al. in press b). Warming occurred in June in the north-east Gulf of Aden.

Crown-of-Thorns Starfish - Offshore Red Sea Reefs

Recent extensive coral mortality on offshore Red Sea reefs was similar in appearance to that following outbreaks of crown-of-thorns starfish. Nearly all the acroporid corals, the preferred food of *Acanthaster planci*, were dead, including large (4 to 5 m diameter) colonies. Some starfish remained feeding in the area. Small scale starfish outbreaks have also been reported previously from other parts of the Red Sea and it is believed that the present level of damage is comparable to that caused by *A. planci* in Sudan in the late 1960s (ORMOND & CAMPBELL 1974).

***Drupella* Mortality**

The coral-feeding snails *Drupella* were present at most Red Sea and Socotra sites. They occurred with a varying degree of abundance, most commonly on compact branching forms of *Acropora*, tabular *Acropora* and pocilloporids, in order of preference. Generally damage was at a sub-lethal level, with most infected corals showing partial mortality ranging from 10 to 70 % of the colony.

Bio-Erosion

The urchins *Echinometra* and *Diadema* spp. occur in moderate to high abundance (> 10 m^2) at some sites and, with the grazing parrot fishes (Scaridae) and boring sponges, are major contributors to bio-erosion of the reef substrate. Bio-erosion was particularly noticeable at sites badly affected by the 1998 bleaching event.

Storm Waves

Coral assemblages at some sites around Socotra had been affected by storm waves. Large tabular colonies of *Acropora clathrata* had been overturned or toppled and some branching corals had been fragmented. Dead corals that had been killed by the 1998 bleaching or other agents, and where the skeletons had been weakened by bio-erosion, were particularly susceptible to breakage.

Coral Diseases

There is little known of the distribution and effects of coral diseases in Yemeni waters. In the northern Red Sea several diseases have been identified as killing or injuring corals. In the Socotra Island Group, diseased corals were uncommon or absent from most sites, although 'white band' disease was causing injury to tabular colonies of *Acropora clathrata,* a species badly affected by the 1998 bleaching event.

Coral Collecting

Coral collecting for lime and building materials (indicated by piles of coral boulders on the coast) occurs at many locations around the Socotra Island Group. However, most collecting is of dead corals that have been deposited on beaches by storms. At present there is little evidence of subtidal collecting of live corals from any of the islands. However, increasing export demand may prompt live coral collecting in the future.

Overfishing

Overfishing of reef-associated species has the potential to produce secondary effects on the ecosystem. Shark resources are depleting and catches by local fishermen are declining due to large-scale shark fishing. Outbreaks of crown-of-thorns starfish are suspected to be caused by overfishing of reef-associated fish predators in the families Lethrinidae, Balistidae and Tetraodontidae (ORMOND et al. 1990).

Aquarium Trade

At present two companies are licensed to collect coral reef fishes for the aquarium trade, and more licences are expected to be issued in the future. There are limited catch records. Fish collecting for the aquarium trade should be monitored carefully to prevent damage to the reef habitat and decline in reef-associated fauna.

Industrial and Urban Development

Waste waters from the main coastal cities and industries are discharged directly into the sea. Only about 30 to 40 % of large coastal cities are served by public sewage networks. In Aden, raw organic matter is discharged directly into the sea, and problems of bacterial contamination are apparent (EC/MFW 1995). In Mukalla and the smaller towns, sewage is also directly discharged into the sea without any treatment. Power stations at Mokha, Ras Katheeb and Hiswa (Aden) discharge saline high-temperature water directly into the sea causing temperature increases in surrounding waters.

Marine Protected Areas and Level of Management

There is one marine protected area in Yemen. Six other areas have been proposed for protected area status. The establishment of marine protected areas is a relatively new process in Yemen, with funding and technical

input from IUCN, the Global Environment Facility and PERSGA.

MPAs Declared

Socotra Islands Group: The archipelago occupies some 3,625 km^2 and is home to diverse terrestrial plant and animal life with a high degree of endemism. Socotra (12°30'N 54°00'E) is the main island, the others being Abd Al Kuri, Samha and Darsa. There are also smaller rock islets, Kal Farun and Sabuniya. Funding and logistical support has been provided through the GEF-Socotra Biodiversity Project. It was established as a protected area in 1996.

De facto and Planned MPAs

Belhaf and Bir Ali Area: This is a coastal stretch and group of high aspect islands with extensive fringing coral reefs and rich fishing areas (14°00'N 48°10'E). The area is also an important seabird and marine turtle nesting site, and contains a saltwater crater with fringing mangroves.

Ras Isa and Kamaran Island: The headland/island complex (15°16'N 42°44'E) contains mangroves and coral reefs with diverse associated fauna. Habitats are threatened by chronic pollution from the nearby oil terminal, and reef fisheries for the aquarium trade.

Khor Umaira: Mixed seagrass and coral reef habitat; the area is a semi-enclosed lagoon that supports marine turtle feeding grounds (12°40'N 44°10'E). There are no coral reefs.

Ras Sharma: Important (regionally and possibly globally) nesting site for green turtles (13°00'N 43°40'E). There are no coral reefs.

Dhobba (Shihr): Considered as it is a marine turtle nesting site (14°45'N 49°40'E). There are no coral reefs.

Bab al Mandab and Perim Island: Contains extensive seagrass beds and mangrove stands, and is an important waterway feeding the Red Sea (12°30'N 43°30'E). There are no coral reefs.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

Monitoring Capacity

The Department of Oceanography, University of Sana'a, which was established in the late 1970s, has more than 10 staff members specialized in marine ecology, chemistry, geology, and fish biology. Its main responsibilities are teaching, research and advising the government on marine issues. It has a capacity for and is carrying out research and training in coastal surveys, pollution monitoring and analysis. The University of Aden, with colleges in Hodeidah and Mukalla, also has several departments which are involved in research and training in marine sciences. In 1996, this university organised the first international symposium on Socotra Island.

The Marine Science Research and Resources Centre (MSRRC) in Aden is the advisory body to the Ministry of Fish Wealth (MFW). The centre advises the ministry on aspects of fish stock assessment and management, data on fish landing, fishing seasons etc. It consists of Fisheries, Oceanography and Benthos departments and has a newly established small pollution control centre at Al Buriekah (Little Aden), an experimental mariculture station, and a small laboratory in Mukalla. The MSRRC operates a

37 m research vessel, which is currently in need of maintenance. The centre receives some technical assistance from Yemen's Fourth Fisheries Development Project and has collaborated in the execution of a coastal habitat survey of the Gulf of Aden.

Staff from the Socotra Biodiversity Project undertake annual monitoring of coral and fish communities around the archipelago.

Management Capacity

A number of governmental agencies have responsibility for the coastal and marine areas. There is no authority solely in charge of the management of the coastal zone in Yemen.

- **Environment Protection Council (EPC):** The EPC was established in 1990 by Prime Ministerial Decree 94/1990. The Technical Secretariat (TS) co-ordinates and monitors the planning and implementation of environmental protection policies. Implementation at field level is under the responsibility of the line ministries. There are three departments under the TS: Environment Protection, Planning and Data, and Administration and Financial Affairs. The EPC is the official government agency in charge of the development and implementation of national environmental protection and control policies. (The EPC has now been renamed as the Environment Protection Agency.)

- **Ministry of Fish Wealth (MFW):** The MFW regulates fishing, issues licences and supervises processing and marketing of fish and fisheries products for local consumption and export. Imports and/or manufacturing of fishing gear and other relevant equipment must be in accordance with specifications of the MFW. The ministry is responsible for the management and development of Yemen's fish resources. The MFW, through the Department of Monitoring and Surveillance, is responsible for the enforcement of laws and regulations concerning marine resources.

- **Public Corporation for Maritime Affairs (PCMA):** This is the main governmental body concerned with maritime safety and marine pollution control. It also plays an important role in developing a legislative framework to protect the marine environment.

- **Maritime Training Centre:** The Centre was established in Aden in 1989. It conducts training courses in port operations and maritime transport, maritime safety and pollution control. It offers courses on the MARPOL Convention and oil spill response. It currently receives assistance from UNDP.

- **General Tourism Authority (GTA):** The GTA is responsible for tourism activities throughout the country including eco-tourism. Permission for building tourist villages along the coast or on islands is issued by the GTA. In 1995, the GTA issued a set of regulations and guidelines for tourists while snorkelling or/and diving.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

The Republic of Yemen is a party to international conventions, agreements and treaties that have implications for the marine environment. Similarly, a number of national instruments exist at various government levels, which concern coral reefs either directly or indirectly.

International Agreements

Treaties or conventions that were signed by ex-YAR and ex-PDRY Yemen are still in force according to the unification decree. Yemen is party to The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (1982); the Protocol Concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982); the United Nations Convention on the Law of the Sea (1982); the Vienna Convention for the Protection of the Ozone Layer (1985); the Montreal Protocol on Substances that Deplete the Ozone Layer (1987); the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989); the Convention on Biological Diversity (1992); and the United Nations Framework Convention on Climate Change (1992).

Yemen has signed, but not yet ratified the MARPOL Convention due to lack of funds to purchase the necessary port waste reception facilities. At present Yemen co-operates with Djibouti and Somalia in combating oil spills. Oil pollution control equipment for the Gulf of Aden area (Yemen, Somalia and Djibouti) has been stored at facilities in Djibouti. Yemen and Djibouti are currently negotiating a bilateral agreement regarding the use of these facilities.

National Legislation

In recent years Yemen has established a number of significant instruments, laws and regulations, which concern coral reefs (Table 15). These include:

- **Prime Ministerial Decree No. 4 (1996):** Established Socotra as a protected area and developed a High Committee for Development of Socotra headed by the Deputy Prime Minister and Minister of Planning and Development.

- **Law No. 11 (1993):** Established for the protection of the sea from pollution, it is mainly concerned with pollution by oil and pollution from passing ships. The law determines procedures for prosecuting, penalizing and requesting compensation from ships that violate the law. It gives the Public Corporation for Maritime Affairs the legislative power to deal with oil pollution at sea. In its Article No. 35, the law prohibits any form of discharge of pollutants of any kind and from any source into the sea without prior treatment.

- **Law No. 4, Article 10(d) (1993):** Prohibits any activities or practices carried out in contradiction to special directives regarding the protection of the environment.

- **Fisheries Law No. 42 (1991):** This is the main legal framework for organisation, exploitation and protection of fishing and aquatic resources. This law deals with the protection of fisheries resources and regulation of fishing activities. The law prohibits the use of destructive fishing methods such as poisons, chemicals, etc. The law also indicates means of limiting and/or dealing with pollution.

- **Law No. 37 (1991):** Defines the territorial waters, the boundaries of the islands, and the exclusive economic zone of 200 nautical miles. It also regulates free passage in the Straits of Bab al Mandab. It emphasizes the prohibition of dumping any wastes into these zones.

Law, Ordinance, Regulation	Year	Government Agency concerned
Presidential Resolution on the Territorial Sea, Adjacent Waters, the Exclusive Economic Zone and the Continental Shelf (Law No. 37)	1991	Ministry of Defence, MFW
Presidential Resolution on Fishing, Exploitation and Protection of Living Aquatic Resources (Law No. 42)	1991	Ministry of Fish Wealth
Free Zone Law (Law No. 4)	1993	Free Zone Authority
Protection of the Marine Environment from Pollution (Presidential Decree No. 11)	1993	Public Corporation for Maritime Affairs
The Maritime Law for the Republic of Yemen (Presidential Decree No. 5)	1995	Public Corporation for Maritime Affairs
Environment Protection Law	1995	Environment Protection Council
Ministerial Decree for Specifications of Fishing Vessels and Gear (No. 101)	1995	Ministry of Fish Wealth
Prime Ministerial Decree No. 4 of 1996 establishing Socotra as a protected area	1996	Ministry of Planning and Development

Table 15: National Laws and Regulations related to Coastal and Marine Environments and Resources

Gaps in Capacity and Requirements for Improved Conservation

The major gap in effective coral reef conservation is the lack of funding to establish and implement regulations in marine protected areas. These will also need strict enforcement and further research to acquire baseline information. There is a general lack of funding for marine research activities and most research is currently funded through GEF, World Bank or UNDP projects. Specifically, the Republic of Yemen needs to address the following issues:

Research

Research needs to be carried out in order to update baseline environmental conditions and follow-up monitoring should refer to these baselines to detect changes in environmental quality.

Networking

There is a need to integrate current research into global initiatives such as ICRI (International Coral Reef Initiative) and GCRMN (Global Coral Reef Monitoring Network) and regionally among the PERSGA member states.

Planning and Coastal Development

Direct use and indirect development activities that affect reef systems need to be carefully evaluated in the design stages and be subject to continued monitoring through the implementation stages.

Community Education

There is a need to develop community education programmes that highlight the role of people play in reef ecology, including reef degradation.

Legislation

Yemen needs to take further steps in the establishment of marine protected areas and to monitor the implementation of legislation concerning these areas with special regard to coastal development, fisheries and tourism.

Funding and Expertise

A larger proportion of funds allocated to protected areas and environmental research needs to be appropriated for marine conservation efforts. With the EPC for instance, this would also require the expansion of marine research and conservation activities.

Recommendations to Improve the Conservation of Coral Reef Resources

The key recommendations are centred around the development of national capacity for planning and implementation of relevant control mechanisms, be they legislative or procedural. This would include development of maritime laws, ICZM plans, EIA methods, port facilities, pollution management strategies and applied research activities.

Legislation

Develop the regulations and human resources to implement the existing Maritime Law and the Law for the Protection of the Marine Environment from Pollution. This should take place alongside the development and implementation of environmental assessment procedures and guidelines, including those that develop and implement a protected area law.

Institutional Strengthening

Strengthen the institutional capacity of the Environmental Protection Council to co-ordinate and monitor activities affecting the marine environment. Strengthen the capacity of the Public Corporation for Maritime Affairs to enable it to carry out its duties in the fields of protecting the marine environment from pollution, safety of shipping, including Port and Flag State Control duties. Strengthen institutional capacity for the enforcement of environmental and fisheries regulations.

Environmental Management

Develop and implement a master plan for conservation and sustainable development of the Socotra Island Group. Prepare and implement a coastal zone management plan. Strengthen the capacity of GTA and the Free Zone Authority for environmental management. Develop and establish a system of marine protected areas with effectively implemented management plans.

Habitat Conservation

Design and conduct inventory surveys, habitat mapping and sensitivity analyses of the entire coastline including distribution of rare and endangered species.

Petroleum Development and Transport

Develop and implement an oil spill contingency plan.

Industrial Development

Establish a framework for development and operation of the Aden Free Zone in an environmentally sound manner. Develop and implement a port reception facilities plan.

Urban Development

Upgrade the waste-water collection and treatment in coastal areas, including Aden, Hodeidah and Mukalla. Upgrade solid waste management and disposal in coastal areas, including Aden, Hodeidah and Mukalla.

Applied Research

Develop a database of biological resources and environmental information and establish a

monitoring programme to support operations and enforcement activities. Develop training programmes for marine resource surveys, monitoring and management and GIS applications. Design and implement a programme to evaluate potential impacts from agricultural chemicals on the Tihama coastal zone.

Environmental Education and Public Participation

Conduct public awareness and environmental education programmes for all levels of the coastal population. Promote the broad-based participation of NGOs.

Coral Reefs of Saudi Arabia

Introduction

Saudi Arabia's Red Sea coastline extends southwards approximately 1,840 km from the Jordanian border north of Haql (29°30'N) to the border with Yemen at Oreste Point (16°22'N). The continental shelf extends offshore for distances of < 1 km in the Gulf of Aqaba to > 100 km on the Farasan Bank.

The climate is extremely arid and much of Saudi Arabia's biological productivity is confined to a narrow coastal strip where coral reefs, mangroves and seagrass communities predominate. Average rainfall is less than 70 mm/year along the broad coastal Tihama plains of the Red Sea (Al-Wajh: 16 mm/year; Jeddah: 63 mm/year; Jizan: 63 mm/year). Inland, above the coastal escarpment, it may exceed 200 mm/year.

Over 15 % of the population lives in the Red Sea coastal zone; urban and industrial development have had severe impacts on the coastal lands and waters, particularly adjacent to the major coastal towns and cities. Much of this development involved extensive landfill sites and dredging, which has destroyed substantial areas of the intertidal and subtidal nearshore habitats (CHIFFINGS 1989). In Jeddah, the Corniche development and other urban expansion projects continue this destruction of habitat and natural resources (CHILD & GRAINGER 1990).

The central Red Sea, including the Outer Farasan Bank, contains many species that are absent from the northern and southern reaches of the Red Sea. There is evidence that coral abundances and temperature regimes are important in explaining species distribution in this zone. The southern Red Sea has many species that are more suited to sediment-loaded waters, which occur because of terrigenous input and water mixing across the wide shallow coastal shelf. The highest sea temperatures are found in this zone restricting coral development.

The Red Sea coast and islands support a variety of coastal and marine habitats, related largely to oceanographic regime, degree of exposure and particularly to topographic features which support the development of coral reefs, mangrove stands and seagrass beds. The area has a complex tectonic history of uplift and subsidence, related to the rift development of the Red Sea from the movements of the Arabian and African tectonic plates. The present series of living coral reefs are the latest in a chronological sequence of raised (uplifted) and submerged reefs that have developed at various times over the past several hundred millennia. In many cases the present reefs are developed on earlier reef structures. Detailed descriptions of the geology, physical environment, climate, hydrology, oceanography and habitats of the Red Sea and wider Arabian Region are presented by FISHELSON (1971), MERGNER (1971), SCHEER (1971), ORMOND et al. (1984a), EDWARDS & HEAD (1987), CROSSLAND et al. (1987), IUCN/UNEP (1988), BENTHOUX (1988), SHEPPARD & SHEPPARD (1985, 1991), BEHAIRY et al. (1992) and SHEPPARD et al. (1992), PURSER & BOSENCE (1998).

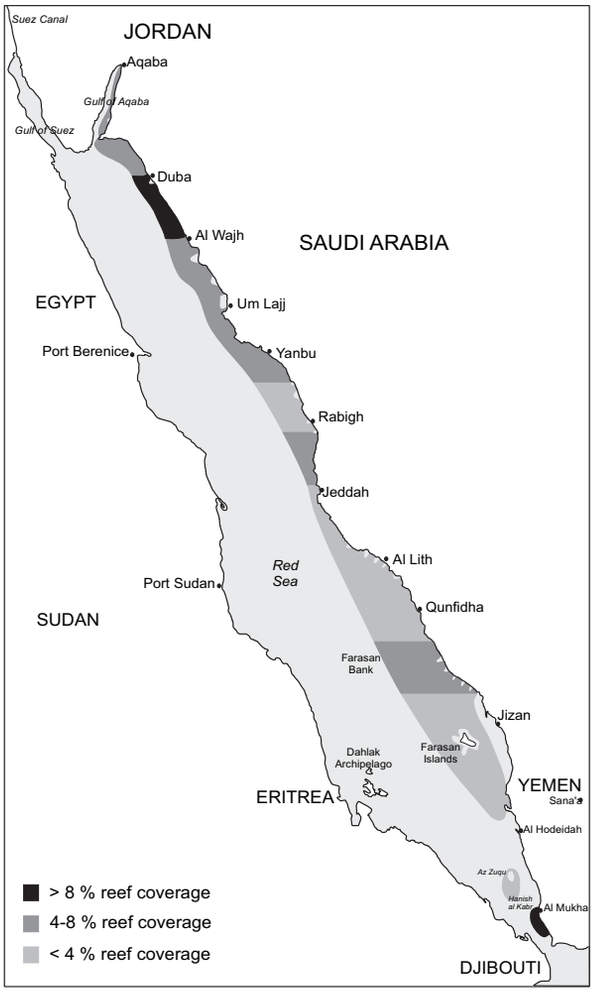

Fig. 10: Map of the Saudi Arabian Red Sea coast indicating coral reef densities: shading represents areas of a 500 m by 500 m quadrat which was reef, (MEPA/IUCN 1992b)

The Saudi Arabian Red Sea coast is divisible into three relatively homogenous areas in terms of the variety and distribution of coastal and marine habitats and reefs:

- the Gulf of Aqaba in the north,
- the northern-central section from immediately south of the Gulf of Aqaba to Jeddah,
- the central-southern region from south of Jeddah to the border of Yemen and including the Farasan Bank and Islands.

The Gulf of Aqaba is deep and relatively narrow. It is characterised by its geographical isolation and the number of species that are either restricted to or from the area, including several species of reef-building corals and fish. The extreme north of the Gulf contains species presently known from nowhere else in the Red Sea (MEPA/IUCN 1987). A dispersal bottle-neck into and out of the Straits of Tiran and cool sea temperatures may be important factors in these species distributions. Reefs are typically narrow, fringing the steep mainland coast.

The northern-central Red Sea has a much higher diversity of reef and coastal habitat types than the Gulf of Aqaba. It has large expanses of coastal marshes (sabkha), seagrasses, macro-algae, mangrove stands and reefs that fringe the mainland, islands, offshore patch and barrier reefs. The area is renowned for the presence of the Al-Wajh Bank, a large, relatively shallow area bordered by a barrier reef system on its seaward edge and incorporating many islands and reefs. The Bank is unique in several respects and is the current focus of marine protected area planning by the National Commission for Wildlife Conservation and Development (NCWCD). With the exception of reefs in the vicinity of coastal towns and cities, most remain in good condition (NCWCD-JICA 2000, DeVantier et al. in press).

The central-southern area, including the Outer Farasan Bank and islands, has a different bio-physical and geomorphological character to the northern area and Gulf of Aqaba. It contains species that are better suited to more turbid, sediment-loaded waters that occur here because of terrigenous input and water mixing across the wide, shallow, coastal shelf. The highest sea temperatures are found in this zone and coral development is restricted. The Farasan Islands and surrounding waters and reefs have been designated as a protected area.

Coral reefs fringe much of the entire length of the Saudi Arabian Red Sea coastline and the offshore islands (Fig. 10) and are generally in good condition, with the exception of those near Jeddah and Yanbu (PERSGA 1998). Five areas in particular have been noted for their coral reefs: the Tiran Islands, the Al-Wajh Bank, the reefs north of Yanbu, the reefs between Obhur and Thuwal north of Jeddah, and the outer Farasan Bank (MEPA/IUCN 1987b).

The near-continuous coral reef tract of the Red Sea has high local, regional and global conservation significance. With the exception of reefs in the immediate vicinity of coastal cities and towns (particularly Jeddah and Yanbu), these reefs generally have low levels of human use and impact. The region includes most of the world's major reef types, including mainland fringing reefs, island fringing reefs, platform patch reefs, pinnacles and barrier reefs. Reefs are often developed in sharms along the mainland coast, a characteristic reef-form largely restricted to the Red Sea. Most of the reefs are actively accretional. The level of reef development varies widely. There are subsurface patch reefs with no reef flat (mostly in the Al-Wajh Bank and southern area), narrow contour fringing reefs with reef flats < 30 m wide (in the Gulf of Aqaba), large platform and barrier reefs with reef flats often > 100 m wide and tower reefs similar to atolls (on the Farasan Bank). These reef types support coral communities with highly variable levels of live coral cover and species diversity. There are unique communities including species endemic to the region and others not yet described. The communities support other reef-associated species of high conservation value and/or economic importance.

Surveys

Geographical Scope

Several major research initiatives have been carried out over the past few decades (see MERGNER 1984, SHEPPARD et al. 1992 for reviews). The first major broad-scale surveys of coastal and marine habitat types and biodiversity of the Red Sea coast were undertaken in the 1980s (ORMOND et al. 1984 a-c). These surveys identified about 70 key sites for conservation and recommended the establishment of five larger, multiple-use, marine protected areas (MPAs) in the Gulf of Aqaba, the Tiran Island chain, the Wedj Bank (herein Al-Wajh Bank), the Outer Farasan Bank and part of the Farasan Islands. To date, only the Farasan Islands have been designated as a MPA.

Reef types and composition of the coral fauna of the Saudi Arabian Red Sea were assessed in the early to mid 1980s (SHEPPARD & SHEPPARD 1985, 1991, ANTONIUS et al. 1990), producing a comprehensive coral species inventory for the Saudi Arabian Red Sea. Subsequently, during 1987-88, a monitoring programme was conducted investigating coral reef health and surrounding water quality along the Red Sea coast (AWAD 2000). Black and white band diseases, shut-down-reaction and tissue bleaching were taken as pathogenic indicators, while more than twenty hydrographic, chemical and pollution parameters were used for describing the surrounding environment.

More recently (1997-99), the distribution and composition of coastal and marine habitats of the central-northern Red Sea were assessed, from north of Jeddah to Haql in the Gulf of Aqaba. A joint study was conducted between the National Commission for Wildlife Conservation and Development (NCWCD) and the Japanese International Co-operation Agency (JICA). This

study produced detailed site bio-inventories for corals, fish, other benthos, algae, seagrass, coastal vegetation and birds, and assessed the distribution and abundance of marine mammals and turtles. Combined with socio-economic assessments of patterns of human use and detailed habitat mapping prepared from aerial photos and satellite images, the data were used to define key reefs and larger reef areas of high conservation significance for MPA planning (NCWCD-JICA 2000, DeVantier et al. in press).

Further south in the Farasan Islands Marine Protected Area (FIMPA), abundances of live coral, dead coral, coral-feeding Crown-of-Thorns starfish *Acanthaster planci* and muricid snails *Drupella* spp.. were assessed in 1999 (Al-Yami & Rouphael 2000).

Survey Techniques

Methods have ranged from broad scale habitat mapping using colour aerial photos and satellite imagery, rapid ecological and impact assessments, biodiversity studies of a variety of taxonomic groups and studies of coral cover, abundances of predators and diseases.

Habitat Mapping: Distribution and composition of coastal and marine habitats of the central-northern Red Sea were assessed using high-resolution aerial photos and satellite images, combined with extensive ground-truthing (Ormond et al. 1984a-c, NCWCD-JICA 2000). The NCWCD-JICA data were incorporated into detailed GIS habitat maps of the distribution of coral reefs, seagrass and algal beds, mangroves and sabkha along the central-northern Red Sea coast and offshore islands.

Rapid Ecological Assessment: The distribution of different coastal and marine habitat types, including coral reefs, along the Red Sea has been documented using several rapid assessment methods (IUCN 1984, Dawson Shepherd & Ormond 1987, Price et al. 1998, Rouphael & Al-Yami 1999, DeVantier et al. in press).

The biological resources, uses of the resources and any impacts along the coastline were assessed at about 1400 geographically discrete coastal and offshore sites (Price et al. 1998). The sites were selected at 10 km intervals along the shoreline and offshore islands. Each site comprised a 500 m by 500 m quadrat bisecting the beach, covering the immediate terrestrial, supratidal, intertidal and immediate subtidal zones. Within the quadrat, the abundance of ecosystems and species groups and the magnitude of resource uses or impacts was estimated and recorded semi-quantitatively on ranked scales. The abundance of biological resources was also scored using a ranked 0 to 6 scale and scores were based on estimates of the relative abundance within each quadrat. Similar methods were used subsequently on the Yemeni Red Sea and Gulf of Aden coasts, providing a uniform broad-scale assessment.

Further rapid assessments of coral reefs (levels of reef development, benthic cover and various environmental attributes) of the Red Sea were undertaken in 1998-99 (DeVantier et al. in press). The surveys were conducted at 145 sites along the central-northern Red Sea coast and offshore islands. In meandering SCUBA swims of 30 to 45 minutes duration at each site, ecological and substratum attributes were assigned to standard ranked cover categories (see DeVantier et al. in press for details).

Distribution and status of coral reefs around the Farasan Islands were assessed using semi-quantitative methods in the early 1990s. The aim was to develop a management plan for the

Farasan Islands MPA (GLADSTONE 1994a). Follow-up surveys of the reefs in the area were undertaken in 1999 (ROUPHAEL & AL-YAMI 1999).

Biodiversity Assessment: Taxonomic inventories of some key elements of reef fauna and flora have been undertaken in the Red Sea (e.g. corals - SHEPPARD & SHEPPARD 1991, DEVANTIER et al. in press).

SHEPPARD & SHEPPARD (1991) compiled a comprehensive inventory (including a taxonomic revision of previous records and synonymies) of corals in the Saudi Arabian Red Sea. These authors made extensive field collections and reviewed the many previous taxonomic lists published from the broader Red Sea (e.g. SCHEER & PILLAI 1983). More recently, further coral bio-inventories were compiled in the central-northern Red Sea (DEVANTIER et al. in press). Inventories of reef-associated fish, benthos, algae and seagrass were also made in 1998-99 (NCWCD-JICA 2000). Reef fish composition and abundance have been assessed using both quantitative (belt transects, collecting stations) and semi-quantitative (visual census) field methods (ORMOND et al. 1984a-c, NCWCD-JICA 2000). In the quantitative assessments, numbers and-or log abundance estimates and/or sizes of fishes were made in single or replicated belt transects of known volume. In the semi-quantitative assessments, fish species lists and abundance estimates were compiled at point census stations or during SCUBA swims, using standard rapid assessment methods (e.g. ENGLISH et al. 1997).

Long-term Monitoring: Baseline quantitative data on percentage live and dead coral cover (replicated line transects) and fish abundances (replicated belt transects) were collected using the Reef Check protocol (HODGSON 1999) in the Al-Wajh Bank in 1999 (NCWCD-JICA 2000, DEVANTIER et al. in press). Follow-up monitoring surveys will be undertaken at these sites by NCWCD in the future. GLADSTONE (1994b) made recommendations for the development of a monitoring programme in the Farasan Islands. ROUPHAEL & AL-YAMI (pers. comm.) plan to establish baseline monitoring stations using replicated line transects (benthos) and belt transects (fish) in the area.

Coral Reefs – Benthos and Fish

In 1998-99, living cover of reef-building corals at individual reefs ranged from < 10 to > 75 %, while soft corals ranged up to 50 % cover. High percentage cover of dead coral (> 20 %) occurred on some reefs following coral bleaching or predation. High percentage cover of living corals was associated with reefs of relatively high exposure to wave energy and high water clarity. High percentage coral cover was usually present on the shallow reef slopes of exposed fringing, patch and barrier reefs. With some important exceptions, deeper reef slopes (> 10 m), in low wave energy environments and reefs with low water clarity usually had a lower percentage living coral cover than their shallow, more exposed counterparts.

The Red Sea coral communities were composed of at least 260 species of reef-building stony corals from 68 genera in 16 families of Scleractinia. The coral communities were composed predominantly, both in terms of composition and percentage cover, by the families Acroporidae, Faviidae and Poritidae. A diverse mix of soft corals, hydrozoan fire corals, corallimorpharians, gorgonians and zoanthids were also present.

Species diversity of scleractinian stony corals at individual sites in the central-northern Red Sea ranged from about 20 to 100 species (the regional average was 61 species). There

were four major coral community types, predominantly related to the degree of wave exposure, water clarity, depth and steepness of reef slope. Notably, there was only minor variability in species composition among the assemblages. The entire region exhibited a high degree of homogeneity in terms of coral community composition, both latitudinally and longitudinally.

Reefs with moderate to high species diversity and abundance and percentage living coral cover were widely distributed, with no clear latitudinal or longitudinal trends. Such reefs have high significance for replenishment because of their potential as sources of large numbers of propagules of coral and other reef-associated taxa.

Disturbances

Overall, most reefs of the central-northern Red Sea of Saudi Arabia were in good to excellent condition in 1998-99 (DeVantier et al. in press). There was little to no direct human impact (e.g. destructive fishing, anchor damage, coral mining or pollution) on the great majority of reefs. The exceptions were the reefs in urban areas, which were subject to reef fishing, land reclamation, urban run-off or littering. Coral communities on some reefs (about 10 % of those surveyed) had also been adversely affected to a greater or lesser extent by coral bleaching or predation.

Bleaching was patchy and highly variable in intensity. It was most intense on reefs near Rabigh, where more than two thirds of total coral cover was bleached or recently dead (about 20 to 40 % cover). On worst affected reefs, bleaching occurred to the base of the reef-slopes (> 20 m depth), but was usually most intense in depths < 6 m, where more than half of all coral species had been affected. High mortality (> 90 %) occurred within the most susceptible taxa, notably fire-corals *Millepora* spp., soft corals and a wide variety of stony coral taxa (DeVantier et al. 2000).

The bleaching occurred in July to September 1998, when sea surface temperatures were elevated by > 1 ºC above mean monthly averages for a period of about one month (NOAA 'Hotspots' satellite imagery). Patterns of mortality to upper coral colony surfaces suggest that radiation effects may also have been implicated at some locations.

Other forms of recent coral mortality in the Saudi Arabian Red Sea included predation by crown-of-thorns starfish and muricid snails. Such predation had no noticeable effect on coral cover or community composition on most reefs, where starfish and snail populations were at low levels. However, coral cover and community structure had been affected by larger populations of the starfish on some patch reefs on the Al-Wajh Bank and Farasan Islands. The larger starfish population on the Al-Wajh Bank may be related to over-fishing of predatory fishes in the families Lethrinidae, Balistidae, Labridae, Serranidae and Lutjanidae.

Conservation Value

On a global scale, the area spanning the Farasan Islands to Haql in the Gulf of Aqaba is one of the most important coral reef areas for marine protected area management. At present, there is little local human impact in most of the region, other than in the vicinity of coastal cities and towns as mentioned.

The Red Sea has many reefs with a high conservation value in terms of uniqueness, quality and those which are representative of the area (i.e. reefs with high species diversity, high percentage coral cover and those important as reservoirs of biodiversity and replenishment).

The reefs are widely distributed, from the Gulf of Aqaba and Tiran areas in the north, Duba to Al-Wajh, the Al-Wajh Bank, Umluj (Umm Lajj) to Ras Baridi, Yanbu to Rabigh and the Farasan Bank in the south.

Four sub-regions are of special conservation importance:

- **The Gulf of Aqaba:** The Gulf is noted for its high levels of percentage coral cover and species diversity, including species that are rare or apparently absent from other parts of the region (e.g. *Cantharellus doerderleini*, *Caulastrea tumida*). Of particular note are the characteristic narrow contour reefs (< 50 m wide) which are present on steep coastal slopes. These narrow reefs are among the most species-rich of the entire region. The high species diversity is particularly significant given the restricted reef area, cool sea temperatures and that the Gulf of Aqaba is at the north-westernmost extent of reef development in the Indo-Pacific region.

- **The Tiran Area:** This area extends from the mainland coast north of Duba to the entrance to the Gulf of Aqaba It is important for the wide variety of different biotopes and reef types, forming unique reef complexes with high zoogeographical significance. These reef complexes support a high species diversity including Red Sea endemic corals, presently undescribed coral species and species with restricted distributions which are otherwise rare or absent in the Red Sea.

- **The Al-Wajh Bank:** This bank supports the greatest range of reef types (and other marine and coastal habitats) in the region. As with the Tiran area, reefs of the Al-Wajh Bank support Red Sea endemic corals, undescribed coral species and species with apparently restricted distributions. The size of the Bank, the diversity of reef habitats and likely high level of ecological connection in terms of larval dispersal in ocean currents, both within the Bank and with other parts of the Red Sea, afford it great conservation significance.

- **The Farasan Islands and Farasan Bank:** This area supports a wide variety of reef types, including tower reefs (ORMOND et al. 1984a) and other marine and coastal habitats not present in other areas.

Reef Distribution

The central-northern area of the Red Sea, from north of Jeddah to Haql in the Gulf of Aqaba supports a near-continuous coral reef tract composed of a wide range of reef types. The area supports relatively complex reef geomorphology. It is comprised of mainland and island fringing reefs and various forms of patch reef, coral pinnacles and ribbon barrier reefs (ORMOND et al. 1984a, provide a review of the geomorphology and distribution of these reef types).

Mainland fringing reefs are distributed along much of the coastline and are often developed in the entrances and on the sides of sharms, a characteristic reef-form largely restricted to the Red Sea (ORMOND et al. 1984c). Extensive mainland fringing reefs occur around Rabigh, Ras Baridi, Umluj, Al-Wajh to Duba and in the Gulf of Aqaba, the latter often being narrow (< 30 m wide), developed as contours on the relatively steep sub-littoral topography (FISHELSON 1973). Island fringing reefs are commonly developed in the Tiran area and from Duba to Al-Wajh Bank to Umluj.

Circular/elongate patch reefs are also widespread in offshore waters (< 50 m deep). Some patch reefs support sand-coral islands (cays), while others are submerged and resemble coral carpets (RIEGL & PILLER 1999). Both forms are common in the Al-Wajh Bank and south from Umluj to Rabigh. 'Reticulate' patch reefs ('labyrinths / mazes' ORMOND et al. 1984a), composed of interconnected networks of reef matrix separated by sand and forming intricate reticulate patterns, are particularly well developed in shallow waters (< 10 m deep) of the Tiran area and southern Al-Wajh Bank. Pinnacles (individual corals and coral 'bommies' surrounded by sand) are present in shallow waters (< 10 m deep), particularly in the Al-Wajh Bank and Tiran areas (DEVANTIER et al. in press).

Barrier reefs composed of platform and ribbon reef structures are developed further offshore, on the edge of the continental slope, where water depths increase from < 50 to > 200 m. The best-developed barrier reef system occurs along the seaward margin of the Al-Wajh Bank. The barrier is composed of a continuous line of reefs stretching for about 100 km and separated by several narrow (< 200 m wide) channels (ORMOND et al. 1984a, DEVANTIER et al. in press). Another barrier reef system of different gross geomorphological structure, the 'Little Barrier Reef', occurs further south near Yanbu (ORMOND et al. 1984a, SHEPPARD & SHEPPARD 1985). The central-northern Red Sea in Saudi Arabia does not support atoll-like or tower reefs, more characteristic of southern areas and the outer Farasan Bank (ORMOND et al. 1984a).

South of Jeddah, reefs become less well developed along the mainland coast. Differences in topographic features, sediment and turbidity tend to restrict coastal reef growth progressively towards the Yemen border (PRICE et al. 1998). Further offshore however, complex reef structures are developed on the Farasan Bank and islands (ORMOND et al. 1984a). These include tower reefs which are similar in gross geomorphology to atolls and are rare or absent in other areas of the Saudi Arabian Red Sea.

Levels of reef accretion among the various reef types range from small (< 1 ha) subsurface patch reefs and thin coral layers which blanket wide areas with no reef flat, to narrow fringing reefs with reef flats < 50 m wide, and large fringing, platform and barrier reefs with reef flats often > 100 m wide.

Coral Diversity

SHEPPARD & SHEPPARD (1985) identified 116 coral species or species groups in 13 coral assemblages in the central-northern area of the Red Sea. The most distinctive assemblages from exposed locations dominated by species of *Acropora* and from sheltered locations dominated by species of *Porites* (see also ANTONIUS et al. 1990). Reefs around Yanbu were notable in supporting both a higher coral diversity and number of assemblage types than had previously been reported from the Red Sea. In the early 1980s, 194 species of corals were recorded from the entire Saudi Arabian Red Sea coast, with the greatest diversity in the central portion (MEPA/IUCN 1987). SHEPPARD & SHEPPARD (1991) and SHEPPARD (1997) revised this species list, recording 140 species from the Gulfs of Aqaba and Suez (54 genera, 15 families) and 150 species (49 genera, 14 families) from the central Red Sea.

More recent surveys have expanded this list substantially, with approximately 260 species in 68 genera of 16 families of reef-building Scleractinia now known to occur in Saudi Arabian Red Sea waters (Table 16). Of these, 26 species were previously undescribed (VERON 2000) and about 50 species were distribution range extensions into the Red Sea. Several additional species had been described from the

Red Sea in the 19th century, but had either been synonymised or lost from recent species lists, for example the branching *Acropora variolosa* (KLUNZINGER 1879), *Favites vasta* (KLUNZINGER, 1879) and *Echinopora forskaliana* (MILNE EDWARDS & HAIME, 1849, WALLACE 1999, VERON 2000). A further 16 species synonymised by SHEPPARD & SHEPPARD (1991) are considered herein as valid species in the Red Sea (VERON 2000, DEVANTIER et al. in press).

About a further 30 taxa of soft corals, fire corals, zoanthids and gorgonians were recorded in the NCWCD-JICA study (2000). However, because of difficulties of field identification and lack of taxonomic expertise in the non-scleractinian taxa, actual species diversity is substantially higher (DEVANTIER pers. obs., and see REINICKE 1998 for comprehensive review of the soft coral family Xeniidae). At individual sites in the central-northern Red Sea, stony coral species richness ranges from about 20 to 100 species, with a further 5 to 15 non-scleractinian taxa (DEVANTIER et al. in press). Average diversity for scleractinian corals per site was 61 species, with deep sites usually slightly more species-rich than shallow sites.

There were no clear latitudinal or longitudinal trends, although reefs in the northern Gulf of Aqaba were particularly rich given their high latitude location at the extreme north-west of reef distribution in the Indo-Pacific Region (along with the adjacent Gulf of Suez). Some species in the coral assemblages have very widespread Indo-Pacific distributions, others appear restricted to the Red Sea (VERON 1986, 1993, 1995, 2000; HOEKSEMA 1989, 1993; SHEPPARD & SHEPPARD 1991, SHEPPARD 1997, WALLACE 1999). The Saudi Arabian Red Sea supports a unique composite fauna of coral

Family	**Species**					
	N - C Red Sea	Red Sea	N - C Red Sea *	N - C Red Sea	Red Sea	N - C Red Sea *
Astrocoeniidae	1	1	1	2	2	2
Pocilloporidae	4	4	4	8	8	11
Acroporidae	4	4	4	32	32	64
Poritidae	4	4	3	10	10	27
Siderastreidae	4	4	4	6	7	10
Agariciidae	4	4	4	16	16	21
Fungiidae	6	6	7	21	21	26
Oculinidae	1	1	1	1	1	2
Pectinidae	3	3	3	3	3	7
Mussidae	5	5	5	8	8	15
Merulinidae	2	2	2	3	3	3
Faviidae	15	15	16	40	41	61
Caryophylliidae	6	8	2	6	9	2
Dendrophylliidae	4	4	3	6	7	10
Trachyphylliidae	1	1	0	1	1	0
Rhizangiidae	2	2	0	2	2	0
Total	66	68	59	174	180	261

Table 1: Taxonomic composition of Red Sea scleractinian coral fauna, based on SHEPPARD & SHEPPARD (1991), SHEPPARD (1997) and the NCWCD-JICA study (2000) (source: DEVANTIER et al. in press).

species known from the following biogeographic provinces or sub-provinces:

- Widespread across the entire Indo-Pacific, e.g. *Pocillopora damicornis* and *Gardineroseris planulata,*
- Widespread in the Indo-west Pacific, e.g. *Stylophora pistillata, Acropora muricata* (previously *A. formosa*, WALLACE 1999),
- Previously known only from the Pacific Ocean, e.g. *Cantharellus noumeae,*
- Widespread in the Indian Ocean, e.g. *Coscinaraea monile* and *Siderastrea savignyana,*
- Widespread in the western Indian Ocean, e.g. *Acropora hemprichii,*
- Red Sea endemics, e.g. *Symphyllia erythraea, Merulina scheeri* and *Cantharellus doederleini,*
- Species not yet described.

Several corals thought to be endemic to the Red Sea are well represented and widely distributed within the central-northern area notably *Echinopora fruticulosa*, *Echinopora forskaliana, Merulina scheeri, Stylophora wellsi*, *Symphyllia erythraea* and *Acropora variolosa* (SHEPPARD & SHEPPARD 1991, DEVANTIER et al. in press); all occurred at more than a third of sites (DEVANTIER et al. in press). Others were relatively uncommon (at about 10 % of sites: *Stylophora mammilata*, *Favites vasta* and *Erythrastrea flabellata*) or rare (< 2 % of sites: *Cantharellus doerdeleini* and *Alveopora ocellata*).

Some of these differences in abundance may be explained by habitat preferences. For example, *S. mammilata* prefers reef slopes > 20 m deep which have not been extensively sampled. *Erythrastrea flabellata* was found only in the northern area (north of Umluj), consistent with previous studies (although one colony has been reported from the Gulf of Aden, SHEPPARD & SHEPPARD 1991). *Cantharellus doederleini* is considered endemic to the northern Red Sea (CHADWICK-FURMAN & LOYA 1992, HOEKSEMA 1993). *Alveopora ocellata* was recorded from the Al-Wajh Bank and adjacent waters. Three of these species (*Stylophora wellsi, Favites vasta* and *Symphyllia erythraea*) are now known to occur outside the Red Sea, their distribution extending into the Arabian Sea (DEVANTIER pers. obs., VERON 2000). Conversely, most of the undescribed species are presently known only from the central-northern Red Sea (VERON 2000), although further work in the larger Arabian and western Indian Ocean regions may extend their distribution ranges.

Coral Communities

Within the central-northern Red Sea region, 10 coral communities encompassing about 20 coral assemblage types have been described (Table 17, SHEPPARD & SHEPPARD 1991). The authors, whilst differentiating these assemblage types, noted a high degree of similarity in species composition within the region. Species at most individual reefs were a subset of the larger regional species-pool.

More recent studies in the area (DEVANTIER et al. in press) have confirmed the high degree of homogeneity in species composition within the region. There were, however, major differences in abundance of particular taxa in certain biotopes, and thus clear zonation patterns in the structure of coral communities. These were related largely to the degree of physical exposure, water clarity (irradiance), depth and steepness of reef slope (DONE 1982, SHEPPARD 1982). Most of the assemblage types previously described for the central-northern Red Sea (Table 17) are represented in the four major community types described above (Reef Distribution). These community types form part

Reef type, exposure and habitat	Dominant coral species	Location in Red Sea	Characteristic Assemblages
Shallow patch reef, exposed in sandy plain	*Acropora horrida, A. formosa*	Suez	None
Shallow exposed fore-reef slopes	*Acropora hyacinthus, A. humulis*	North - central	None
Shallow - mid - depths, moderate exposure	None	North	None
Sheltered fringing reefs, backs of patch reefs	*Porites lutea*	North - central	None
Shallow - mid - depths in north, mid - deep in central region, moderate exposure	None	North - central	A) *Millepora,* B) None, C) *Goniopora*
Moderately turbid and exposed mid-depths	None	North - south	None
Mid-depths, patch-reefs in sand	*Pocillopora damicornis, Acropora eurystoma, A. clathrata*	Central	None
Patch and barrier reefs, mid-depths	*Pocillopora verrucosa, Acropora hemprichi*	Central	None
Barrier and exposed fringing reefs, shallow	*Acropora hyacinthus, A. digitifera, A. humilis A. danai,A. hemprichi, Pocillopora verrucosa*	Central	*A. hyacinthus, A. danai, P. verrucosa*
Barrier, patch and fringing reefs, mid-depths	*Porites*	Central - south	*Montipora circumvallata Goniastrea pectinata*

Table 17: Major coral communities of northern-central Red Sea (source: SHEPPARD & SHEPPARD 1991)

of a continuum, with particular species exhibiting differences in occurrence and abundance related to site-specific habitat characteristics and disturbance histories.

Coral Cover

There is considerable variability in percentage cover of stony and soft corals in response to reef-specific characteristics and disturbance histories, and species-specific tolerances to stress, particularly exposure, levels of sedimentation, turbidity and illumination.

In 1998-99 in the central-northern Red Sea, percentage cover of living stony corals (including *Millepora* spp.) ranged from < 10 % to > 75 %, with an average of about 35 % (DEVANTIER et al. in press). Approximately 17 % of sites had high percentage cover of living stony coral (> 50 %), particularly on shallow reef slopes, where large mono and multi-specific stands of *Acropora*, *Porites* and *Millepora* were often conspicuous. Percentage cover usually declined on the deeper slopes.

Dead standing corals and rubble were relatively minor components of cover at most sites (average about 7 %). Highest levels of dead coral (30 %) occurred following intense coral bleaching in August-September 1998 (DEVANTIER et al. 2000). Mass coral mortality following the bleaching was patchy and restricted to < 10 % of reefs surveyed. Bleaching and subsequent coral mortality were

most intense on reefs near the town of Rabigh, where up to 90 % of total coral cover was bleached or recently dead (20 to 40 % absolute cover). Bleaching occurred down to the base of the reef-slopes (> 20 m), but was most intense at depths < 6 m, where more than half the coral species had been affected (DEVANTIER et al. 2000). Further high coral mortality occurred on patch reefs in the Al-Wajh Bank following predation by crown-of-thorns starfish (DEVANTIER et al. in press).

Cover of soft corals in the central-northern Red Sea ranged up to 50 %, but was usually less than 30 % (average about 9 %). Large beds of *Xenia* spp. and stands of *Sinularia cf. capitalis,* covering hundreds of square metres, were characteristic features of some sites. *Sinularia cf. capitalis* formed large tree-like colonies up to 2 m in height and contributed substantially to reef accretion (also see REINECKE 1998, SCHUHMACHER 1997). Cover of turf including coralline and macro-algae was usually low (< 10 %) in these coral dominated areas. Cover of algae usually increased on the inner reef flats.

Some reefs with a high percentage of living coral cover occurred in sheltered habitats, particularly subsurface patch reefs on the Al-Wajh Bank. However, high percentage cover of stony corals, soft corals and crustose coralline algae were all most common on shallow reefs with high exposure, steep slopes and high water clarity.

Further south, in the Farasan Islands Marine Protected Area, abundances of live coral, dead coral and other benthic life-forms also varied greatly among sites. Percentage cover of live *Acropora*, *Porites* and other corals increased with distance from the mainland, while abundance of dead coral declined with distance from the mainland (AL-YAMI & ROUPHAEL 2000). Significant levels of coral mortality were observed close to the mainland. For example, coral coverage at the Abalat Islands declined from approximately 80 % in 1993 to about 10 % in 1999. *Porites* colonies, some in excess of 1.5 m in diameter, suffered 100 % mortality. Mean monthly sea surface temperatures were found to be unusually high (> 32 ºC) three months prior to the first report of coral mortality in 1996.

Damage and Coral Mortality

Overall, most reefs (about 90 %) of the central-northern Red Sea were in good to excellent condition in terms of the ratio of live to dead coral cover and levels of injury to coral species in 1998-99 (DEVANTIER et al. in press). There was little to no direct human impact (e.g. destructive fishing, anchor damage, coral mining or pollution) on the great majority of reefs. The exceptions were reefs in urban areas, which were subject to land reclamation, urban run-off and pollution or littering. Most damaged reefs occur in the immediate vicinity of the major coastal cities and towns.

At most sites outside these areas, levels of injury and death of corals were low (< 10 % cover of dead corals), with < 20 % of species present exhibiting injury and < 20 % average injury to those species. Coral communities on about 10 % of reefs surveyed had been adversely affected by bleaching, by coral predation (mostly by crown-of-thorns starfish) or by sedimentation (DEVANTIER et al. in press).

Coral Bleaching: No evidence of mass bleaching or other forms of major coral mortality were found during surveys in the central-northern Red Sea in May to June 1998. Most reefs appeared to be in good condition. No bleaching was reported from other areas of Saudi Arabia at the time, although reefs further to the south in the Arabian Sea and greater Indian Ocean had already been bleached

extensively (WILKINSON et al. 1999). By October 1998, bleaching was patchily distributed throughout the Saudi Arabian Red Sea, extending north from the Farasan Islands to reefs around Jeddah and Yanbu (NCWCD pers. comm.). Reefs offshore from Rabigh and north to Yanbu experienced intense bleaching, causing high levels of coral mortality, while others (Ras Baridi, Al-Wajh Bank, Gulf of Aqaba) were little affected or unaffected possibly due to coastal upwelling of cooler water. Minor bleaching occurred at some locations near Haql in the Gulf of Aqaba, and minor to moderate bleaching occurred in the Tiran area near Jazirat Muksoor. Bleaching was most widespread and intense in the shallower coral communities (depths < 6 m), where recently dead and bleached corals accounted for up to 90 % of the total cover of hard corals, soft corals and fire-corals (*Millepora* spp). Deeper communities had also been affected, with coral mortality of about 15 % of the species present (DEVANTIER et al. 2000).

Of the 325 zooxanthellate anthozoan taxa recorded during the pre- and post-bleaching surveys in May to June and September to October 1998, 124 taxa exhibited injury at one or more of the sites (84 species pre-bleaching and 101 species post-bleaching). Both the proportion of coral species with injury and the level of average injury per species increased from the pre to post-bleaching surveys. As with coral cover, levels of injury to individual species were most intense on reefs around Rabigh, where over half of all species had been affected, with coincident high mortality (about 90 %) to the worst affected taxa (DEVANTIER et al. 2000). Coral species that were worst affected by bleaching-related injury represented a wide range of genera and growth forms. Many of the worst affected taxa were uncommon, occurring at low abundance in few sites. Such species may be particularly susceptible to local extinction.

Extensive coral bleaching was reported to have occurred on reefs of the Farasan Islands, although the level of subsequent mortality and species affected are not known at present (NCWCD, pers. comm.). Precise timing of the bleaching at the Farasan Islands is not known. ROUPHAEL & AL-YAMI (1999) suggested that extensive coral mortality in the nearshore Abalat Islands occurred in 1996, following elevated sea surface temperatures.

Coral Predation: Predation by crown-of-thorns starfish and muricid snails had no noticeable effect on percentage coral cover or community composition on most reefs in the Saudi Arabian Red Sea, where starfish and snail populations were at low levels. However, coral cover and community structure has been adversely affected by larger populations of the starfish (about 100 *A. planci* ha^{-1}) on patch reefs in the Al-Wajh Bank (DEVANTIER et al. in press). At the patch reef sites in the Al-Wajh Bank, the starfish had caused substantial reductions in living coral cover and coincident increases in dead coral cover and shifts in relative abundance and community structure. Starfish and snails were also implicated in coral mortality in the Farasan Islands (ROUPHAEL & AL-YAMI 1999).

Fish Communities

Numerous studies have documented species composition and abundance of reef fishes in the Red Sea. Recent diversity estimates vary greatly. RANDALL (1983) lists 325 species, although this was not a comprehensive systematic account, rather a pictorial account of common taxa. ORMOND & EDWARDS (1987) recorded 508 species, substantially less than BOTROS (1971) with 776 species, DOR (1984) with 1,000 species or GOREN & DOR (1994) with 1,248 species. Differences among these various estimates are in part due to distinctions in the definition of reef fishes. Although many Red Sea reef fishes have distribution ranges that extend outside the Red Sea, to the Gulf of Aden,

Arabian Sea and greater Indian Ocean and Indo-Pacific regions, others are presently considered endemic to the Red Sea (KLAUSEWITZ 1987). Levels of endemism vary among different groups of fishes, being particularly notable in the Chaetodontidae. These endemics and other Arabian and western Indian Ocean species give a characteristic structure to Red Sea reef fish assemblages in comparison with their central Indo-Pacific and eastern Pacific counterparts.

Coral Reef Fisheries

Until 1981, artisanal fishermen from small boats and larger sambouks exploited Saudi Arabia's fishery almost exclusively. Saudi Fisheries, an industrial fishery company established in 1991, currently lands around 1,500 metric tonnes of shrimp and a similar amount of finfish. Despite this, landings remain dominated by the artisanal sector.

Location	Number of Boats
Tabuk	16
Wejh	50
Umm Lajj	199
Yanbu	259
Rabigh	215
Jeddah	254
Al-Lith	95
Qunfudhah	117
Jizan	470
Total	1675

Table 18. Distribution of fishing boats along the Saudi Arabian coast in 1983/84

Coral reef-based fisheries are distributed along the length of the Red Sea, with the highest proportion of fishing boats being based in the south (Table 18). It must be noted, however, that the greater number of boats in the south does not represent an increase in fishing pressure on coral reefs, rather it represents the greater number of trawlers that make up the prawn and non-coral reef-based fisheries.

Region	Number of Fishermen	Annual Landings (tonnes)	Catch per Unit Effort (tonnes per fisherman per year)	Production (tonnes per km of shoreline)
Haql - Duba	29	80	2.758	0.3
Duba - Wejh	39	90	2.307	0.6
Wejh - Umm Lajj	86	250	2.903	1.4
Umm Lajj - Yanbu	225	670	2.978	4.4
Yanbu - Rabigh	320	1,030	3.218	5.9
Rabigh - Jeddah	303	880	2.904	6.1
Jeddah	284	1,180	4.140	---
Jeddah - Lith	174	460	2.644	4.1
Lith - Qunfudhah	176	580	3.294	6.6
Qunfudhah - Suquayq	156	1,030	6.606	7.3
Suquayq -Jizan	50	320	6.400	2.9
Jizan - Yemen Border	371	2,390	6.442	35.7
Farasan Islands	195	1,250	6.441	7.7
Total/Average	2,408	10,210	4.08	10.72

Table 19: Distribution of Red Sea catch and effort (source: KEDIDI et al. 1984)

Although fishery statistics have been analysed for different sectors (Table 19), differences between the various sources do not allow for standardisation or comparisons. A significant problem is that fishery statistics are normally aggregated for both the Red Sea and Arabian Gulf fisheries. A reliable long-term series of catch and effort data, required for specific management suggestions, is not presently available.

There is an increasing trend in productivity from north to south. Over 74 % of the annual Red Sea landings come from the southern section between Al-Lith and the Yemen border (MAW 1989). This is indicated both by increasing production per km of shoreline and per fisherman. This increase is based on productivity and size of the fishing grounds.

Red Sea landings are evenly divided between benthic species associated with coral reefs and the continental shelf and pelagic species (Table 20).

Major threats to diversity and abundance of fishes in the Red Sea include increasing fishing pressure and development pressures near coastal towns and cities.

Threats to Coral Reef Biodiversity

Local threats to Saudi Arabia's coral reefs originate primarily through industrial development and maritime transport. With these are associated risks of oil spills, land-filling, pollutant discharges, effluents from desalination activities and a number of other major impacts. Most acute damage to reefs is localised and restricted to and around major urban areas. Global threats include potential mass bleaching events associated with a global warming trend (WILKINSON et al. 1999) and possible reductions in reef building through loss of calcification linked with changes in ocean alkalinity from carbon dioxide increases (KLEYPAS et al. 1999).

Oil Pollution

Physico-chemical, chemical and pollution levels in water and sediment, oil and its derivatives (persistent carcinogens) were correlated with coral disease in the Red Sea. Coral reef health was not affected south of Jeddah but to the north there were significant levels of diseases, especially black band disease (AWAD 2000).

Industrial Development

Along the Red Sea coast, industrial development is concentrated at Jeddah, Yanbu, Rabigh and Jizan. Oil refineries and other petroleum facilities have been constructed at

Species	Percentage of Total Landings	Species	Percentage of Total Landings
Spanish Mackerel	30.4	Sharks	2.0
Jacks	12.0	Mullets	2.0
Cutlass Fish	3.0	Parrotfishes	1.0
Cobia	0.1	Wrasses	0.1
Indian Mackerel	3.0	Sea Breams	0.03
Emperors	13.9	Surgeon Fish	0.02
Groupers	13.0	Rabbit Fish	0.02
Snappers	8.0	Goat Fish	0.01
Barracudas	7.0	Miscellaneous	4.4

Table 20: Species composition of Saudi Arabian Red Sea landings (source: MAW 1996)

Yanbu where the Trans-Arabian Pipeline (TAPLINE) terminates. Desalination, waste-water treatment, cement, and power plants are sited intermittently along the coast.

Marine Transportation

An estimated 25,000 to 30,000 ships transit the Red Sea annually (LINTNER et al. 1995). Much of this is associated with transport of crude oil and petrochemical products between the northern Red Sea port of Yanbu, the Suez Canal and the Egyptian oil pipeline from the Gulf of Suez to the Mediterranean. The Red Sea receives many times more pollution from marine transport and refinery inputs than the global average. It is inherently dangerous to maritime traffic because of its narrow and congested navigation routes, which are bounded on either side by very restricted anchorages and coral reefs. Shipwrecks and collisions continue, despite advances in safety and navigational systems. Even at a major port such as Jeddah, 5 to 10 spills and maritime accidents occur annually.

Commercial and Residential Development

Commercial and residential development is clustered around urban areas. On the Red Sea coast, the expansion of urban or residential areas also has a considerable effect on the coastline. The major areas of urban and related development are found around Jeddah, Yanbu, Rabigh and Jizan.

Land-filling

Land-filling is one of the most disruptive activities to coastal and marine resources. Land-filling has caused severe and permanent destruction of coastal habitats and has changed sedimentation patterns that have damaged adjacent resources. Changes in water circulation caused by land-filling have altered the distribution of plant and animal communities. On the Red Sea coast the seabed drops off to over 20 m immediately following the reef edge, creating a boundary for fill operations. However, land-filling has taken place mostly around Jeddah (causing the death of large tracts of fringing reefs), Yanbu and Jizan.

Dredging

Dredging causes destruction of the resources in the dredged area and often has indirect impacts from increased sedimentation. On the Red Sea coast, dredging has been concentrated around Jeddah, Yanbu and in Sharm Jubba (north of Duba).

Water Pollution

There are numerous sources of coastal water pollution, including discharges of oil and other chemicals, and effluents from industrial and residential sources. Some urban areas have waste-water treatment facilities, but in many places these are inadequate or non-existent. On the Red Sea coast, Jeddah, Yanbu and Rabigh are the main areas with pollution problems.

Desalination

There is extensive use of desalinated water to meet demands of the population and industry. As of 1992 there were eighteen desalination plants operating along Saudi Arabia's Red Sea coast (Table 21), with a total combined capacity of 726,343 m^3/day (SWCC 1992). In Jeddah the desalination plant produces a major portion of the NO_2 and SO_2 emissions and contributes heavily to the particulate and trace metal emissions load. Discharges into the marine environment from the Jeddah plants include chorine and anti-scaling chemicals and 1.73 billion m^3 of brine at 51 ppm and 41 °C.

Recreation and Tourism Activities

Recreation and tourism have caused significant disturbances to coastal and marine habitats. Collection of corals and other souvenir species, a widespread practice in the 1970s and 1980s, has contributed to the loss of coral reef-

Location	Capacity m3/day	Start Up Date	Location	Capacity m3/day	Start Up Date
Haql	3,785	1989	Jeddah II	37,850	1978
Duba	3,785	1989	Jeddah III	75,700	1979
Al-Wajh II	473	1979	Jeddah IV	189,250	1982
Al-Wajh IIa	825	1986	Jeddah ROI	48,827	1989
Al-Wajh IIb	1,032	1989	Shu'aybah	181,800	1989
Umm Lajj	3,785	1986	Al-Birk	1,952	1984
Yanbu	95,000	1980	Assir	75,700	1989
Rabigh	1,204	1982	Farasan Isl.	430	1979
Aziziah	3,870	1987	Farasan Isl.	1,075	1989

Table 21: Seawater desalination plants on the Red Sea coast of Saudi Arabia (source: PERSGA 1998)

associated fauna. Along parts of the Saudi Arabian Red Sea coast, particularly near Jeddah and Yanbu, the reefs have been damaged by extensive food and souvenir collecting and by spearfishing.

Bleaching

As discussed, the most recent mass bleaching event in 1997-98, the largest ever recorded, affected reefs world-wide. There are now widespread concerns that the incidence and intensity of bleaching are increasing, perhaps linked with a trend in global warming (HOEGH-GULDBERG 1999, TIMMERMAN et al. 1999, WILKINSON et al. 1999).

Marine Protected Areas and Level of Management

The Kingdom of Saudi Arabia has established a number of extensive terrestrial protected areas, but lags behind in the development and implementation of marine protected areas. Many areas have been proposed and suggested, dating back to the mid and late 1980s, and remain that way to date. With the exception of the Farasan Islands, protected in 1996, no other marine protected areas have been established.

Background

Protection of marine habitats in Saudi Arabia has a fairly recent history. In 1977, the small island of Umm al-Qamari was given *de facto* protected area status by the national hunting regulations of 1977. The Ministry of Agriculture and Water (MAW) established Asir National Park in 1981 (CHILD & GRAINGER 1990). Following this, MEPA identified 46 coastal areas for inclusion in a system of coastal protected areas (MEPA/IUCN 1987). Under Saudi Arabia's Environmental Protection Coordinating Committee (EPCCOM) these were designated Environmentally Sensitive Areas. In 1987, the National Commission for Wildlife Conservation and Development (NCWCD) was formed with the express mission of handling the Kingdom's wildlife and conservation management issues, using its own classification system (Table 22).

By 1989, this programme had placed 2.4 % of Saudi Arabia's total area (51,405 km^2) under protected status, none of which encompassed marine habitats. In 1990, the NCWCD published its 'Plan to Protect Areas in Saudi Arabia' that presented a system of protected areas, which, if designated, would place 12.8 % of Saudi Arabia's land-mass under conservation management.

NCWCD Category	IUCN Equivalent(s)
Special Natural Reserves	1. Strict Nature Reserve/Scientific Park 2. National Park 4. Nature Conservation Reserve or Managed Reserve/Wildlife Sanctuary
Natural Reserves	1. National Park 4. Nature Conservation Reserve or Managed Reserve/Wildlife Sanctuary
Biological Reserves	1. Strict Nature Reserve/Scientific Park 4. Managed Reserve
Resource Use Reserves	5. Protected Landscape or Seascape 6. Resource Reserve 8. Multiple Use Management Area/Managed Resource Area. 9. Biosphere Reserve
Controlled Hunting Reserves	8. Managed Resource Area.

Table 22: NCWCD conservation categories and their IUCN equivalents (source: CHILD & GRAINGER 1990)

MPAs Declared

Yanbu Royal Commission Protected Area: Protected by the Royal Commission through an agreement with the Meteorological and Environmental Protection Administration (MEPA). It covers an area of about 5 km^2 and encompasses fringing reefs, mangroves and seabird nesting sites, including ospreys.

Umm al Qamari: Established in 1977 and covering an area of only 2 km^2, this small protected area in the southern Red Sea has two islands with surrounding fringing reefs and is an important habitat for thousands of seabirds especially doves, herons, pelicans, gulls and sooty falcons.

Farasan Islands: Established in 1996 and covering an area of 3,310 km^2, this terrestrial and coastal reserve is an archipelago of small islands at the southern extreme of Saudi Arabia's Red Sea shores. It supports several important habitats and species, including mangroves, seagrass, coral reefs with high biological diversity, marine mammals, marine turtles, seabirds and endemic gazelle. It is threatened by fishing, development and recreation activities.

De facto and Planned MPAs

Straits of Tiran: Straddling the Saudi Arabia/Egypt border, it encompasses islands and extensive coral reefs with diverse reef-associated fauna in the transition area between the Gulf of Aqaba and the Red Sea. It is an important habitat for marine turtles and dugong. There is tourist activity on the Egyptian side.

Ras Suwayhil: Proposed to cover an area of 267 km^2, the site encompasses pristine and diverse coral reefs and reef-associated fauna and is a prime example of the Gulf of Aqaba reefs and high cliffs. It provides habitat for seabirds and dugong.

Sharm Zubayr: Proposed to cover 80 km^2, the area encloses open coastline and a sharm with fossil reef cliffs, narrow fringing reefs and the northernmost mangroves in Saudi Arabia. A causeway has been proposed to cut through the area.

Ghubbat Bal'aksh: Covering 33 km^2, this is a sharm and open coastline with coral reefs with particularly high species diversity, seagrass beds and seabirds, but is subject to unregulated recreation activities.

Sharm Dumagyh and Sharm Antar: Covering an area of 70 km^2, these two inlets contain fringing reefs, seagrass beds, and mangroves and are habitats for green and hawksbill turtles and seabirds. The area is subject to fishing and recreation pressures.

Al-Wajh Bank: Including Sharm Habban and Sharm Munaybirah, this protected area will cover 2,840 km^2. It is home to the most extensive coral reef system of the entire Red Sea, diverse reef-associated fauna, seagrass beds and mangroves. It is inhabited by marine turtles and seabirds and is a key area for dugong.

Qalib Islands: Actually included in the Al-Wajh Bank, these islands are surrounded by fringing reefs and are important nesting sites for seabirds and marine turtles.

Al-Hasani and Libanah Islands: These are high-aspect islands with extensive fringing coral reefs and are important nesting sites for seabirds and marine turtles.

Ras Abu Madd and Sharm Hasi: These are scenic sharms and have high quality fringing coral reefs, fossil reef terraces and are an important seabird area. To be combined with the Al-Hasani and Libanah Island protected area. They are threatened by fishing activities.

Ras Baridi and Sharm Al-Khawr: The area (30 km^2) encompasses sand beaches, small islands, high quality coral reefs and seagrass beds. It is the most important marine turtle nesting site in the Red Sea. It is threatened by unchecked fallout from a nearby cement factory.

Sharm Yanbu: Enclosing 50 km^2, the sharm is a deep, bi-lobed lagoon that contains mangrove and seagrass beds and fringing reefs and is an important seabird area.

Shi'b al-Qirin: Extending over 15 km^2, this is a high quality inshore reef complex that is also an important seabird area.

Marsa as-Sarraj: Proposed to cover 200 km^2, this is the largest land-locked lagoon on the Saudi Arabian Red Sea coast. Seasonally inundated, it contains mangroves, halophytes, seagrass beds and high quality coral reefs. It is threatened by agricultural development and fishing activities.

Ras Hatiba: Covering about 450 km^2, this is a large shallow lagoon with sandy and coralline spits, small mangrove stands, extensive offshore reefs and is a prime site for environmental and education programmes. It is currently threatened by recreation and unregulated development.

Jeddah Salt Marsh: Proposed to cover 100 km^2, this is a marshland area with extensive offshore reefs, but is threatened by oil pollution and other waste disposal.

Ash-Shu'aybah and Mastaba: Proposed to cover about 100 km^2, this is a large lagoon with extensive mangroves, fossil reef terraces and good quality offshore reefs. It is a key site for seabirds, but is threatened by unregulated development, mangrove felling and a possible major highway project.

Qishran: A complex of coral reefs, coral spits, seagrass beds and extensive mangroves. It provides important seabird and dugong habitat.

Outer Farasan Bank: A major reef and island system contiguous with the Farasan Islands. It has diverse mangrove, seagrass and coral reef habitats, and is an important turtle and seabird nesting area.

Khawr Nahoud: Proposed to cover about 33 km^2, this is a lagoon with fringing corals, seagrass beds and mangroves. It provides important dugong and seabird habitat.

Khawr Itwad: Proposed to cover about 70 km^2, this is a lagoon with fringing corals, seagrass beds and mangroves.

Shi'b Abu al-Liqa and Shi'b al-Kabir: Proposed to cover about 140 km^2, these are two lagoons with abundant fringing corals and mangroves.

Other proposed sites include the Inner Farasan Bank, Marsa al-Usalla and Marsa Tawil, Mastura beach, Marsa Umm Misk and Haramil Island, Marka Island, Ras Tarfa, Khawr Wahlan, Duwayyimah, and Khawr Amiq. These areas do not contain important coral reef sites, but have been selected for their halophytes, mangroves, seagrass beds or their importance for species such as dugongs or turtles.

Monitoring and Management Capacity to Conserve Coral Reef Resources

Monitoring Capacity

Faculty of Marine Science, King Abdul Aziz University: The objectives are teaching and research. The main geographic area of research is the Red Sea. Research is practical in nature and relates to resource exploitation, including fisheries, aquaculture, mangroves, microfaunal distribution, coastal processes, pollution, circulation, mixing and fronts and other related subjects. The faculty has sites at Obhur on the Red Sea coast north of Jeddah and on the University campus. Facilities include research laboratories (3,000 m^2), aquarium (17 tanks), a small museum, workshop, computers, a research vessel, a well-established library and teaching facilities.

King Fahd University of Petroleum and Minerals Research Institute: This university carries out research projects related to the protection of the Saudi Arabian environment. These include research and studies of the ecology of the marine environment. Facilities include laboratory space (2,200 m^2), research vessels, aquarium, museum, library and teaching facilities. The Arabian Journal of Science and Engineering is published by the University (four issues a year). It has cooperative programmes with many institutions including the Austrian Academy of Science, Kuwait Institute of Science and Research (KISR), MEPA/ROPME and UNESCO.

The geographic scale of the reef tracts of Saudi Arabia (both in the Red Sea and Arabian Gulf) are such that an adequate long-term monitoring programme would require a minimum of four dedicated NCWCD personnel. Following training and technology transfer (DeVantier et al. in press, Vogt & Al Shaikh 2000, Rouphael & Al-Yami pers. comm.), sufficient expertise exists within the NCWCD to develop such a team. This would facilitate coral reef monitoring and research within the Kingdom, essential adjuncts to future MPA management.

Management Capacity

The key to any efforts to reconcile environmental concerns with economic and population expansion in Saudi Arabia will be the establishment of the institutional basis for co-ordination and implementation of necessary economic expansion in a sustainable manner.

Several institutions in the Kingdom are mandated through a variety of mechanisms to carry out conservation tasks that in one way or another impact coral reefs:

- **National Commission for Wildlife Conservation and Development (NCWCD):** NCWCD is responsible for the management of protected areas (Royal Decree No. M/22, dated 12/9/1406). The NCWCD's main role is to preserve, protect and develop the wildlife within the Kingdom. Specific objectives are to develop and implement projects to protect wildlife and their habitats, conduct surveys and promote research and public interest in environmental issues related to the wildlife in Saudi Arabia and co-ordinate different ministries, authorities and national and international institutions to accomplish these objectives.

- **Meteorology and Environmental Protection Administration (MEPA):** Established by Council of Ministers decision No. 157, Dated 20/11/1411 and Royal Decree No. 7/505M, dated 28/3/1406, MEPA has jurisdiction for the prevention of pollution in the territorial seas. MEPA is the central environmental agency in the Kingdom of Saudi Arabia. However, the Kingdom distinguishes between the establishment of environmental criteria, such as standards, and actual operational management. Thus operational agencies such as the Ministry of Petroleum, Ministry of Agriculture, and Ministry of Industry and Electricity retain regulatory control over activities carried out under their respective mandates. MEPA sets environmental performance standards, monitors the activities of operational agencies and serves as a co-ordinator for environmental management, including coastal zone management. Despite this, institutionalisation of authority for centralised coastal zone management has not been achieved, and each individual agency operates under its own specific mandate and numerous overlaps and potential conflicts abound. Day-to-day co-ordination mechanisms and a central planning authority specific to the coastal zone are lacking. MEPA also has jurisdiction for oil spill response (co-ordination mechanism established under Royal Decree 7/B/13307, dated 22/7/1411) and for prevention of pollution including effluent from landfills (Royal Decree No. 7/505M, dated 28/3/1406). MEPA is responsible for setting standards for the environment (Royal Decree No. 7/M/8903, dated 2/14/1401) and for carrying out a programme of environmental impact assessment. It is also the designated coastal zone management agency.

- **Saudi Arabian Coast Guard:** Established by Royal Decree No. 33, dated 27/7/1377, the coast Guard has jurisdiction between the border of the territorial seas (12 miles offshore) and 10 km inland.

- **Ministry of Transport:** Has responsibility for marine navigation in territorial waters.

- **Sea Ports Authority:** Has responsibility for ports (Royal Decree No. 7/505M, dated 28/3/1406) and has been directed by Royal Decrees to enforce a moratorium on landfill in ports (Royal Decree No. M/9, dated 27/3/1408).

- **Ministry of Agriculture:** Has jurisdiction over fishery activities (Royal Decree No. 7/505M, dated 28/3/1406).

- **Royal Commission for Jubail and Yanbu:** Responsible for industrial development within the two industrial cities. It is also responsible (under a

memorandum of understanding with MEPA) for environmental management within the two industrial cities.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

Saudi Arabia is signatory to regional and international agreements that place obligations upon it for the prevention of pollution and protection of resources, including coral reefs. Among these are a number of international agreements and memoranda of understanding and a series of national laws and royal decrees that are pertinent to coral reef conservation.

International Agreements

Among others the Kingdom of Saudi Arabia is a signatory to:

- the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (1982)
- the Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982)

National Legislation

A number of national decrees and laws affect coral reef conservation measures in the Kingdom, including:

- Environmental Protection Standards Document No. 1401-01 (1402 H)
- National Oil Spill and Hazardous Substances Contingency Plan
- resolutions adopted by EPCCOM and proposed to the Council of Ministers for their consideration (in particular those concerning the designation of coral and sandy islands as marine protectorates)
- Council of Ministers Decision No. 271 (23.11.1404) obliging the use of best available technology to reduce pollutant emissions (such as cement dust)
- Rules and Regulations for Saudi Arabian Seaports
- draft national Fisheries Regulations
- establishment of the National Commission for Wildlife Conservation and Development (NCWCD)
- Royal Decree 7/B/13307 (22/7/1411) concerning oil spill response activities
- Royal Decree No. 7/505M (28/3/1406) concerning effluent from landfill ports
- Royal Decree No. 7/M/8903 (2/14/1401) concerning standards for the environment
- Royal Decree No. M/9 (27/3/1408) establishing a moratorium on land-filling in port areas
- Royal Decree for jurisdiction of fishery activities.

Gaps in Capacity and Requirements for Improved Conservation

Many of the environmental problems facing the Kingdom require an integrated approach to provide a solution. Such an approach has been difficult due to the strongly sectoral organisation of its government. Recent efforts in creating advisory councils and a national coastal zone management plan may begin to address this issue.

Research

Research needs to be carried out in order to update baseline environmental conditions, and follow-up monitoring should refer to these baselines to detect changes in environmental quality.

Networking

There is a need to integrate current research into global initiatives such as ICRI and GCRMN, and regionally among the PERSGA Member States.

Planning and Coastal Development

Direct use and indirect development activities that affect reef systems need to be carefully evaluated in the design stages and be subject to continued monitoring through the implementation stages.

Community Education

There is a need to develop community education programmes that highlight the role of communities in reef ecology, including degradation.

Legislation

The Kingdom needs to take bold steps in the establishment of marine protected areas and monitor the implementation of legislation concerning these areas with regard to coastal development, fisheries and tourism. The designation of marine protectorates needs to become a priority issue within the country.

Funding and Expertise

A larger proportion of funds allocated to protected areas and environmental research needs to be appropriated for marine conservation efforts. Within the NCWCD for instance, this would also require the expansion of the Marine Department, which is currently staffed by only three people with limited research funds and equipment.

Recommendations to Improve the Conservation of Coral Reef Resources

Saudi Arabia has carried out a number of programmes and adopted a number of legal measures to conserve coral reefs. These include laws on pollution discharges and the establishment of protected areas. However, a number of issues remain unresolved or poorly addressed. Foremost, these include the enforcement of existing emission standards, control over industrial development, which includes land-filling, and integration of the public and private sectors in reef conservation.

The Kingdom would also see a marked improvement in the conservation of coral reefs through a comprehensive system of marine protected areas. This will need strict enforcement and further research and monitoring to acquire or update baseline information.

Legislation and Environmental Management

There is a need to strengthen enforcement of legislation related to management of coastal and marine areas. The Kingdom must effectively implement the Coastal Zone Management Plan; improve mechanisms for co-ordination of environmental activities among sectoral ministries and review each institution's mandates; and expand the EIA requirements for

industrial, municipal and private sectors.

Habitat and Biodiversity Conservation

Saudi Arabia must implement a management programme for the Farasan Islands and develop and implement a management programme for marine protected areas at Al-Wajh Bank, the Straits of Tiran and other areas in the Red Sea. For coral reef resources, the Kingdom must establish measures to control spearfishing and intensive collection of fish and invertebrates on reef flats. It also needs to update its current fisheries management programme.

Tourism Management

Saudi Arabia should further enforce regulations and develop public awareness programmes for coral reef conservation, including control of overfishing, anchor damage, littering and souvenir collection.

Navigation Risks

There is a need to improve navigational aids and radio communication in Saudi Arabian waters, especially on major shipping channels, and to implement the current Oil Spill Contingency Plan. This should include the development of site-specific plans, improvement in the capacity to respond to spills of oil and other hazardous materials, and include a review and upgrading of port reception facilities for solid and liquid waste.

Industrial Development

Saudi Arabia needs to improve the management of air pollution, brine disposal and thermal discharges (from desalination plants) and improve the control of emissions from cement plants such as the one at Ras Baridi. There is a need to control dredging and land-filling in the development of ports.

Research

Saudi Arabia should strengthen its current programme for development of a national database of biological resources and environmental information, and further strengthen and expand monitoring programmes to support operations and enforcement activities.

Environmental Education

There is a need to expand environmental education activities in both public and private sectors, and to encourage public participation in conservation efforts, as they were invited to participate in wildlife rescue efforts after the 1991 Gulf War.

Coral Reefs of Jordan

Introduction

The coastline of the Hashemite Kingdom of Jordan extends approximately 27 km along the north-eastern reaches of the Gulf of Aqaba (Fig. 11). The climate in the region is arid, with an annual rainfall of 20 to 30 mm and mean daily air temperatures ranging from 14 to 32 ºC. The Gulf of Aqaba is a semi-enclosed system with limited water circulation (residence time of two to three years). The coast is home to Jordan's only seaport and is a centre of industry, tourism and transportation. Approximately 30 % of the coast is used for port facilities.

Fringing reefs border up to 50 % of the coast and support a high diversity of coral and associated fauna. It has been reported that the reefs support 158 coral species from 51 genera (AL-MOGHRABI 2000) and over 280 species of fish (PERSGA/GEF 2001). Overall, Jordan's coral reefs are in good condition supporting up to 90 % cover of scleractinian corals. No bleaching events were recorded following the 1997-98 global warming event, possibly due to the extreme northern latitude.

Pollution from industry, primarily in the form of phosphates and fertilisers, constitutes the major threat to coral reefs. The influx of nutrients smothers the coral polyps and promotes the growth of opportunistic species such as *Stylophora pistillata*, which ultimately alters the ecological balance on the reefs. The slow water circulation patterns in the Gulf of Aqaba exacerbate these problems.

Natural impacts on coral reefs include predation, such as that from the snail, *Drupella cornus*, disease and extreme low tides.

There are currently no official marine protected areas in Jordan, although one is proposed that will encompass coral reefs at the northern tip of the Gulf of Aqaba, through funding by a GEF-Jordan initiative.

Several efforts are underway to develop regulatory and institutional mechanisms for promoting sustainable development in the Aqaba region, however, coral reef conservation in the Gulf of Aqaba will only come about by limiting the effects of industry, maritime activities and tourism.

Surveys

Current research involves studies on the coral communities near the fertiliser factories (a critical site), and along the entire coastline (a national programme). This involves the monitoring of biological and physical characteristics including currents, temperature and nutrients levels. Studies are also aimed at identifying temporal and spatial changes in reef structure, coral coverage, fish population diversity and density, and addressing the impacts of industry, diving and tourism.

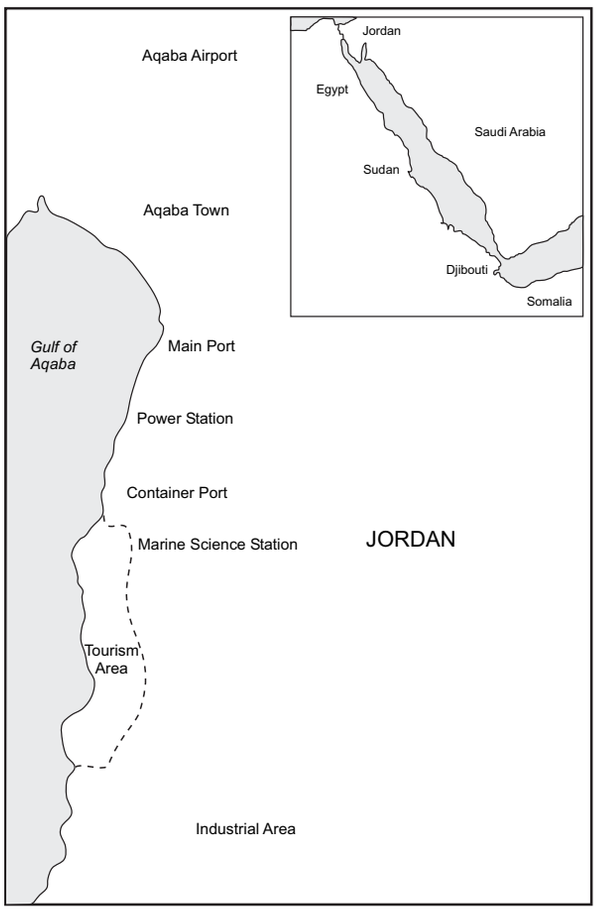

Fig. 11: Map showing the coastline of Jordan in the Gulf of Aqaba

Coral Reefs – Benthos and Fish

Information for this review is drawn primarily from AL MOGHRABI 2000 and PERSGA/GEF 2001. These reports indicate that reefs are in relatively good condition, with over 90 % coral cover with no evidence of bleaching observed after the 1997-98 climatic event.

Coral Health

A high number (212/m^2) of muricid gastropod, *Drupella cornus,* was recorded in 1994. Black band disease was also found to infect 61 colonies in a survey area of 10 m diameter at reefs near the Industrial Area, and only six colonies in a similar sample in the *de facto* protected area immediately offshore from the Marine Science Station in 1997. The reef flats are subjected to extreme low tides that dry out the entire zone during February and September each year.

Coral Cover

An estimated 50% of the shoreline is fringed with coral reefs (PERSGA/GEF 2001).

Fish Communities

According to conservative accounts, 268 species of tropical and semi-tropical fish are found in the Gulf of Aqaba but the actual number could be as high as 1,000 species. Blacktip, hammerhead and whale sharks as well as pelagic fish species including skipjack tuna and bonito can be found in the Gulf of Aqaba's open waters (PERSGA/GEF 2001). It is interesting to note that, in general, Gulf of Aqaba fish assemblages are unique in comparison to other neighbouring regions (SHEPPARD et al. 1992). For example, a number of deep water fishes found elsewhere in the Red Sea are found living close to the surface in the Gulf of Aqaba (e.g. the flashlight fish, *Photobleraphon palpebratus*), while many shallow water species are found closer to the surface in the Gulf than elsewhere. In addition, species resident at the mouth of the Gulf appear unable to live within it. Furthermore, there are species in the Gulf not found in any other part of the Red Sea/Gulf complex. These changes in ecological structure have been attributed to differing temperature regimes (ORMOND et al. 1984), although the argument is still under debate (SHEPPARD et al. 1992).

Coral Reef Fisheries

The fishing industry in Aqaba is small and artisanal, consisting of approximately 85 fishermen and 40 boats (1995 data). Total catch in 1995 was 15 metric tonnes, down from the 103 metric tonnes recorded for 1993 and the

maximum of 194 metric tonnes in 1966. There are no cold storage facilities and catches are sold upon landing (PERSGA/GEF 2001). Recreational SCUBA divers are reported to collect a small number of aquarium fish, but no data regarding volume are available.

Threats to Coral Reef Biodiversity

The Gulf of Aqaba is highly susceptible to pollution. At present, however, pollution is limited and localised. The main threats are oil spills, industrial discharges, municipal and ship-based sewage, and solid waste. The development of the tourism sector may threaten coral reef habitats in the future.

Fertiliser Discharges

Aqaba's main manufacturing facility is the Jordan Phosphate Mines Company fertiliser plant in the Industrial Area, producing 740,000 metric tonnes (mt) of diammonium phosphate (DAP) and 432,000 metric tonnes of phosphoric acid annually. The fertilisers account for 10 % of Jordan's annual export commodities. A second plant is under construction (Nippon Jordan Fertiliser Company), which will increase this industry sector significantly, with an estimated production of 300,000 metric tonnes of nitrogen-phosphorus-potassium fertiliser (NPK) destined for the Japanese market. A concern is the cooling discharge (warm, chlorinated brine) which is released 140 m from shore at a depth of 30 m. Small quantities of sulphur and DAP are routinely spilled during ship loading operations.

Power Generation

The Jordan Electrical Authority operates two power stations (260 megawatts and 14 megawatts) and is constructing a third (130 megawatts). The primary concern with these power generation installations is the high volume of cooling water discharges (warm, chlorinated brine). At present some 38,000 cubic metres per hour are discharged 200m from shore at a depth of 20 m. Discharge water is 3 ºC above ambient temperature.

Port Related Activities

The Port of Aqaba is a major regional shipping centre (second only to Suez and Jeddah), and exports from 1989 to 1993 ranged from 6.6 to 10 million metric tons per year (PERSGA/GEF 2001). During this period, more than 2,300 vessels entered the port and plans aimed to double the volume by 2000. Rock phosphate is the primary export, ranging from 3.6 to 6.4 million metric tonnes (mt) between 1989 to 1993. In the same period, 1.2 to 1.4 million mt of potash and 0.4 to 0.7 million mt of phosphate fertiliser were also handled. One concern is the possibility of reef-damaging runoff from an accumulated stockpile of fluorine-containing gypsum during flash floods. Waste oil is occasionally discharged from bulk cargo transport trucks in sensitive tidal areas, eventually reaching the sea.

Tourism

Tourism is an important sector of Jordan’s economy. The number of tourists has risen steadily over the last two decades, with over 1.5 million people in 1995. Although tourism has not reached the levels attained in neighbouring Egypt and Israel, the number of divers rises steadily each year. Current operations are able to handle 160 divers per day, with direct destruction occurring through walking on exposed reefs, souvenir collection, aquarium fish collection, fin and anchor damage.

Oil Pollution

The ports in Aqaba have no reception facilities for oil-contaminated bilge or ballast water. Contamination risks from small spills come from:

- bilge or ballast water from freighters (0 to 2 mt),
- spills from bilge or ballast water from oil tankers (2 to 20 mt),
- release of oil as a result of defective equipment or procedures (100 mt); major spills from a bunker tank rupture (> 500 mt),
- complete sinking of a cargo vessel (> 1,500 mt),
- tanker collisions (> 7,500 mt) and
- wreckage and loss of a fully loaded tanker (>100,000 mt).

Given the slow cycling period for water in the Gulf of Aqaba, oil spills might remain for several years, with a severe risk to coral reefs through smothering or the uptake of hydrocarbons by polyps.

Sewage

Discharges into the Gulf of Aqaba have resulted in the proliferation of algae, limiting coral growth in the northern reefs. Sewage from the 1.2 million passengers who use the Arab Bridge Marine Company vessels is discharged directly to the sea.

Bleaching

No evidence of bleaching was observed after the 1997-98 climatic event, and the northern latitudes of the region were considered to have moderated to some degree any surface water warming. However, the generally rising sea surface temperatures, may at some point result in bleaching and mortality of scleractinian corals, which could compound anthropogenic effects on coral reef environments. The slowly rising sea levels may also affect a coral reef's ability to act as a natural erosion barrier, given that current models indicate the upward growth of low lying coral cays is insufficient to keep pace with predicted rates of sea level rise.

Marine Protected Areas and Level of Management

An initial feasibility study for the establishment of a MPA was carried out by IUCN through PERSGA in the late 1980's and a management plan developed following a series of studies and consultations. The official designation and establishment of the Aqaba Marine Park (AMP) was issued on 29 July 1997 by Decree No. 5 of the Aqaba Regional Authority Board of Directors.

The AMP is located in the southern portion of the Jordanian Gulf of Aqaba. It extends north to south for approximately 7 km, from the southern boundary of the passenger terminal to the southern boundary of the Public Security Officer's Club, equivalent to the stretch marked 'Tourism Area' on the previous map. Its development has been supported by the Global Environment Facility.

Current Monitoring and Management Capacity to Conserve Coral Reef Resources

Monitoring Capacity

The Water Authority of Jordan (WAJ) is responsible for monitoring industrial discharges on a semi-monthly basis to ensure compliance with Jordan Standard Specifications (JSS) 212.

To date, monitoring has not taken place at this frequency and enforcement actions based on JSS 212 are rare. At present, no standards or guidelines are currently in force regarding the treatment of sewage sludge under JSS 893, which sets maximum limits for pollutants in sewage plant discharges.

The Aqaba Marine Science Station (MSS) monitors trends on coral reefs and provides facilities for training and research. Studies are conducted on water quality, impacts of pollutants and baseline coral reef ecology. MSS also administers the Aqaba Marine Science Centre, which occupies 500 m of the coastline (*de facto* protected).

Three NGOs also address marine environmental concerns in Aqaba: The Royal Society for the Conservation of Nature, which funds an inspector to patrol merchant vessels; the Jordan Environment Society, which introduces awareness programmes, and the Jordan Royal Ecological Diving Society, which organises underwater clean-ups, awareness programmes and monitoring of coral reefs.

Management Capacity

The responsibility for development of the Aqaba region is borne by the Aqaba Regional Authority (ARA), with conservation works carried out through the ARA Environment Unit (established in 1994). ARA supervises town planning, tenders and public works, finance, administration, regional planning and research and studies.

The Ports Commission is responsible for the construction, operation and maintenance of Aqaba port facilities. The commission also addresses environmental protection concerns and, through its Marine Department, the safety of shipping operations. This department does not monitor environmental law compliance of ships, but if ships are observed discharging oil, the Department works with the Royal Jordanian Navy (which patrols port areas and anchorage areas) to keep vessels in custody until the case is heard in a court of law. Court hearings invariably take place within 48 hours but fines only range from USD 1,000 to 16,000. No cases were heard between 1993 and 1995.

Government Legislation, Strategies and Policy Pertinent to Reef Conservation

In recent years Jordan has improved the legal and regulatory framework for environmental protection at a national and international level. The country is party to eight international conventions or treaties that directly or indirectly have an impact on the conservation of coral reefs.

International Agreements

Jordan is party to eight international conventions that are relevant to the conservation of coral reef resources. These are the International Convention for the Prevention of Pollution of the Sea by Oil, the Convention on the Prevention of Marine Pollution by Dumping Wastes and other Matter (London Convention), the Convention on International Trade in Endangered Species of Wild Fauna or Flora (CITES), the International Convention for the Prevention of Pollution from Ships (MARPOL); the Regional Convention for the Conservation of the Red Sea and the Gulf of Aden Environment (Jeddah Convention) and Protocol; the Convention for the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (Basel Convention); the United Nations Convention on Biological Diversity (CBD); and the United Nations Framework Convention on Climate Change.

National Laws and Regulations	Year (in force)	Government Agency Concerned
Shipping Law No. 51	1961	Ports Corporation
Aqaba Port Quarantine Law No. 32	1972	Ports Corporation
Agricultural Law No. 20	1973	Ministry of Agriculture
Port Services Fees Law No. 49	1976	Ports Corporation
Jordan Standard Specifications No. 212	1982	Water Authority of Jordan
Law of the Aqaba Region Authority No. 7	1987	Aqaba Regional Authority
Port Services Fees Law No. 20	1987	Ports Corporation
Jordan Standard Specifications No. 893	1994	Water Authority of Jordan
Law of the Environmental Protection No. 12	1995	Higher Council for Environmental Protection General Corporation for Environmental Protection

Table 23: National Laws and Regulations pertinent to coral reefs (PERSGA/GEF 2001)

National Legislation

Several national laws exist that are either directly or indirectly relevant to reef conservation (Table 23), in particular the Law of Environmental Protection.

- Law of the Aqaba Regional Authority No. 7 (1987) - delegates the power to plan and execute tourism, industrial and agricultural projects in the region. The Law has been the key instrument for strengthening environmental controls including the use of EIAs and coastal zone management guidelines. Regulations for the Jordanian Red Sea Marine Park are being developed under this Law.

- Law of Environmental Protection No. 12 (1995) - establishes a national framework for environmental policy, including the formation of a Higher Council for Environmental Protection (HCEP). The HCEP sets national environmental policy and reviews proposed laws, specifications and standards prepared by the General Corporation for Environmental Protection (GCEP). The GCEP implements pollution prevention regulations including inspection and monitoring. The Law also harmonises existing laws and settles jurisdictional conflicts.

- Law of Environmental Protection (Article 35) - bans the removal, damage to and use of corals and shellfish from the Gulf of Aqaba.

- Jordan Standard Specifications No. 212 (1982 updated 1991) - establishes maximum allowable limits for pollutant discharges into streams, wadis or the sea, and includes standards for the protection of aquatic life.

- Jordan Standard Specifications No. 893 (1994 updated 1995) - sets maximum limits for pollutants in sewage plant discharges, which include publicly owned waste water works operated by the WAJ.

- Shipping Law No. 51 (1961) - bans ships from dumping soils, stones, sand, scum, toxic and chemical waste or any other material into the sea. Spills that occur during the loading and unloading of ships are also classified under this Law.

- Aqaba Port Quarantine Law No. 32 (1972) - bans the discharge of ship-based pollution including bilge water. The Law may impose fines and order remediation works.

- Agricultural Law No. 20 (1973) - issues fishing licences and prohibits the removal of corals.

Gaps in Capacity and Requirements for Improved Conservation

Most of Jordan's departments and organisations appear to be well staffed. Certain areas, including coastal zone management and computerisation, need to be strengthened to meet the demands of effective development and implementation of legislature, and for the establishment of a marine park.

Institutional Capacity Building

A training programme should be developed and implemented to strengthen the capacity to regulate industrial performance. Essential for the development of this programme are an industrial pollution prevention specialist and an environmental monitoring technician. The industrial pollution prevention specialist will implement the new permitting process, conduct facility inspections and review specific industry documents and practices relevant to the control of industrial pollution. The environmental monitoring technician will be responsible for the collection and analysis of both air and water samples. At the same time, coastal zone management efforts need strengthening to integrate current conservation measures with development plans.

Computer/GIS Database Capability

There is a need to determine the information technology appropriate to support the work of the Aqaba Regional Authority (ARA) Environment Unit. The information technology system chosen must be designed to promote planning, monitoring and enforcement actions. This initiative must acquire a computer/GIS system and conduct staff training in information technology applications for specific projects.

Recommendations to Improve the Conservation of Coral Reef Resources

The institutional capacity of Jordanian government agencies could be strengthened by the hiring and training of extra staff, the full implementation of environmental protection laws, and enhanced regional coordination. Jordan has improved its capacity for environmental protection through the establishment of the new national environmental law, and the creation of the ARA Environment Unit. Several additional measures are needed if coral reefs are to be protected, including the development of an integrated coastal zone management strategy, capacity building at the legislative, management and operational levels, the establishment of a marine protected area and the harmonisation of existing regulations at the national and international level.

Pollution

To meet its obligations under MARPOL, Jordan is expected to develop and implement standards and regulations for management of oily waste (bilge and ballast water and tank washings), noxious liquid substances, solid waste and sewage. The option of establishing a coordinated (Jordan-Egypt-Israel) waste oil recovery scheme should be assessed.

Oil Spills

The present contingency project, targeting spills of up to 600 metric tonnes of oil, does not address the risk of potentially catastrophic spills (up to 150,000 metric tonnes) from tanker collision or grounding.

Coastal Zone Management Plan Implementation

Regulations, standards, coastal zone management and environmental auditing procedures should be implemented for coastal industries, including the adoption and implementation of guidelines for industrial pollution prevention. This effort should monitor air and water discharges, compile and analyse inspection data, review industrial emergency preparedness plans and assist industries in the preparation of industrial environmental audits.

Monitoring Marine Water Quality

A monitoring project is needed to assess current marine water quality and to establish measures for maintaining and improving water quality. The monitoring programme must include monthly baseline testing to assess the horizontal and vertical distribution and movement of nutrients, inorganic components, algae, oxygen, salinity and other parameters.

Legislation and Implementation

Coastal Zone Management and Environmental Impact Assessment procedures need to be implemented as do guidelines for new construction, coordinated with requirements that may be developed by the GCEP. The capacity to implement new regulations needs to be developed.

Gulf of Aqaba Marine Park

Legislation for Park management has been drafted. It is anticipated (March 2000) that a new bye-law will be passed based on Environment Law No. 12. This will create a legal mandate for management. The Park management plan includes regulations governing different user activities (e.g. motorised and non-motorised boating, SCUBA diving, snorkelling, swimming, fishing, beach recreation); installation of boundary demarcations for different user zones within the marine park, including mooring and marker buoys (AL-SAIFI 2000).

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وقد تم اقتراح عدة مناطق كمحميات بحرية ، وتعود هذه الاقتراحات إلى أواسط وأواخر الثمانينات . وباستثناء جزر فرسان التي تم إعلانها كمحمية في عام 1996، لم يتم الإعلان عن أي منطقه محمية بحريه أخرى على ساحل البحر الأحمر في المملكة العربية السعودية .

لقد قامت المملكة العربية السعودية بتنفيذ عدد من البرامج وتبنت عدداً من التدابير القانونية للمحافظة على الشعاب المرجانية . وتتضمن هذه التشريعات قوانين على تصريف الملوثات والعمل على إنشاء مناطق محمية. غير أن عدداً من هذه المواضيع لم يتم البت فيها أو لم يتم تناولها بقوة ؛ وعلى وجه الخصوص تطبيق المعايير القياسية الحالية للأشياء المنبعثة ، والتطور الصناعي (وبخاصة أعمال الردم)، وعملية التكامل بين القطاع العام والخاص للمحافظة على الشعاب المرجانية.

الأردن

يمتد الساحل الأردني حوالي 27 كيلو متراً على طول الشاطئ الشمالي الشرقي لخليج العقبة ، وتقريباً يتم استخدام حوالي 30% من الشاطئ فى نشاطات الميناء. وتحد الشعاب المرجانية الهدبية حوالي 50% من الشاطئ لتدعم التنوع العالي الموجود من المرجان والحيوانات البحرية المرتبطة بها (158 نوعاً من المرجان في 51 جنساً وما يزيد عن 280 نوعاً من الأسماك) .

الشعاب المرجانية في الأردن في حالة جيدة وتدعم حوالي 90% من الغطاء المرجاني. ولم يتم تسجيل أي حوادث لظاهرة ابيضاض المرجان في عام 1998، وربما كان ذلك نتيجة للموقع الجغرافي للأردن الذي يتوغل نحو الشمال. ولا يوجد أي مناطق محمية رسمياً مع أن المنطقة التى تقع ضمن أرض المحطة البحرية معروفة باسم منطقه الشعاب المرجانية المحمية في العقبة؛ وهي في الحقيقة المنطقة المحمية الوحيدة المقترحة في الأردن .
لقد قام الأردن بمراجعة الأطر القانونية والتنظيمية فيما يخص الحماية البيئية على المستوى الوطني والدولي؛ والأردن طرف في ثمانية اتفاقيات أو معاهدات دوليه لها تأثير مباشر أو غير مباشر على صون الشعاب المرجانية

إن خليج العقبة معرض بشده للتلوث وهو في الوقت الراهن محدود ويتمركز حول أماكن معينة . والتهديدات الرئيسية هي تسرب النفط والتصريفات الصناعية والبلدية ومياه الصرف الصحي من البلديات والسفن والنفايات الصلبة. كما أن تطوير قطاع السياحة يضيف خطراً جديداً على الشعاب المرجانية .

ولتحسين وضع المحافظة على الشعاب المرجانية فإن هناك حاجة لتقوية القدرات المؤسسية العامة للمؤسسات الحكومية؛ ويمكن إنجاز ذلك من خلال تعيين وتدريب الموظفين وتنفيذ التشريعات والقوانين الخاصة بالحماية البيئية ، وتحسين التعاون الإقليمي لتنسيق وتعزيز الجهود التي تبذلها الشعوب المحيطة بخليج العقبة. وهناك حاجة أيضاً لعدة إجراءات إضافية من ضمنها تطوير استراتيجية للإدارة المتكاملة للمنطقة الساحلية، بناء القدرات في المستويات الإدارية والتشريعية والتنفيذية، إنشاء المناطق البحرية المحمية، والتوفيق بين التشريعات الموجودة حالياً على المستويين الوطني والدولي.

حوالي 100%. وبشكل إجمالى كان متوسط الغطاء المرجاني الحجري الحي حوالي 20% مع غطاء أعلى (حوالى 35%) فى الجزر الخارجية .

وقد تلاحظ تأثير ابيضاض المرجان في عام 1998 على شكل رقع موزعة حول مجموعة جزر سقطرى وشمال شرق خليج عدن؛ وفي المواقع الأكثر تأثراً أصيب أكثر من نصف الأنواع الحية كما مات حوالي نصف الغطاء المرجاني الحي. وكان من بين أكثر الأنواع تضرراً فصائل بوسيلوبوردس واكروبورا (المنضدة والمتفرع) والمرجان الناري ميلبورا.

إن صيد الأسماك هو مهنه تقليديه لآلاف اليمنيين، ويتراوح المجموع السنوي للصيد ما بين 90000 و 95000 طن متري؛ غير أن مصايد الأسماك والتي تكون الشعاب المرجانية قاعدة لها فهي في معظمها غير متطورة.

تم تناول موضوع حماية الشعاب المرجانية في السنوات الأخيرة فقط ؛ فهناك منطقه واحدة تم إعلانها رسمياً كمنطقة بحرية محمية وهي مجموعة جزر سقطرى، وتم اقتراح ست محميات أخرى . وتشكل عمليات التنمية الساحلية وصناعة النفط وعمليات الشحن البحرية خطراً داهماً على الشعاب المرجانية حيث تكون فى شكل مياه الصرف الصحي غير المعالجة وأعمال الردم والتلوث الهيدروكربوني.

المملكة العربية السعودية

يبلغ طول الشريط الساحلي للمملكة العربية السعودية على البحر الأحمر تقريباً 1840 كيلو متر توازيها الشعاب المرجانية الهدبية والتي تحف أيضاً بالجزر البعيدة عن الشاطئ. لقد تم إجراء عدة مسوحات على طول الساحل في الثمانينات والتسعينات وكان آخرها المسح الذى قامت به الهيئة الوطنية لحماية الحياة الفطرية وإنمائها بالتعاون مع الوكالة اليابانية للتعاون الدولي. وعموماً تبدو في حالة جيدة باستثناء الشعاب الموجودة بالقرب من جده وينبع. وفى أوائل الثمانينات تم تسجيل 194 نوعاً من المرجان مع تنوع أكبر فى الجزء الأوسط.

لقد تسببت ظاهرة ابيضاض الشعاب المرجانية فى الموت الجماعي للمرجان في الوسط الشمالي للبحر الأحمر في المملكة العربية السعودية في أواخر عام 1998. وكان الابيضاض موزعاً على شكل رقع ويختلف جدا في الكثافة. وكانت ظاهرة الابيضاض أكثر كثافة بالقرب من رابغ ، حيث ابيض أكثر من 65% من مجموع الغطاء المرجاني أو مات حديثاً. كما تمت ملاحظة مستويات مهمة من الموت المرجاني على طول البحر الأحمر الجنوبي ، حيث تدنى مستوى الغطاء المرجاني الحي في بعض المواقع (مثل جزر عبلات) من 80% في عام 1993 إلى حوالي 10% في عام 1999. ووجد أن متوسط درجة الحرارة الشهرية للمياه السطحية كان عالياً على غير العادة (> من 32ْ مئوية) وذلك قبل ثلاثة أشهر من أول تقرير عن موت المرجان .

تنشأ المخاطر التي تهدد الشعاب المرجانية بشكل أساسي من التطور الصناعي والنقل البحري بما في ذلك تسرب الزيت وأعمال الردم والتصريفات الملوثة والبقايا المتدفقة من عملية تحلية المياه. ونجد أن اكثر الأخطار حدة على الشعاب المرجانية تتمركز حول مناطق المدن الرئيسية .

اليمن

تقع الجمهورية اليمنية في الزاوية الجنوبية الغربية لشبه الجزيرة العربية ، وتضمن مجموعة جزر سقطرى. ويبلغ الشريط الساحلي حوالي 2200 كيلومتر تقريباً ثلثه في البحر الأحمر والثلثين الباقيين فى خليج عدن . ويساند حوالي 25% فقط من الشريط الساحلي اليمني على البحر الأحمر الشعاب المرجانية. وتقع الشعاب المرجانية الأكثر تطوراً بعيداً عن الشاطئ وحول العديد من الجزر التي تميز جنوب البحر الأحمر ؛ كما نجد أن نسبة 5% فقط من خليج عدن تساند إما المجتمعات المرجانية الهدبية أو الشعاب بينما نجد نمواً مرجانياً شاملاً حول مجموعة جزر سقطرى .

قامت مؤخراً بضعة مشاريع رئيسيه بتقييم التوزيع والتركيب والوضع الراهن للموارد البحرية الحية حول الشريط الساحلي اليمني؛ وتم التعرف على اكثر من 300 نوعاً من المرجان الباني للشعاب المرجانية واكثر من 600 نوعاً من الأسماك المرتبطة بالشعاب المرجانية في الشعاب المرجانية اليمنية والمجتمعات المرجانية. وعلى وجه الخصوص فإن المجتمعات المرجانية والأسماك تتنوع بشكل شديد حول مجموعة جزر سقطرى.

وقد تم تسجيل حوالي 176 نوعاً من المرجان الحجري فى الشاطئ اليمني على البحر الأحمر ، مع وفرة فى المواقع الفردية تتراوح من 1- 76 نوعاً، وقد تم تصنيف 19 تسجيلاً جديداً على الأقل في جنوب البحر الأحمر . وقد كان التنوع بحد أدنى على طول ساحل خليج عدن والذى يعتقد بأنه يدعم حوالي 100 نوعاً من المرجان ؛ غير أن المنطقة ما زالت نسبياً غير مدروسة جيداً. أما منطقه بلحاف بير علي فإنها تدعم المجموعة الأكثر تركيزاً من مجموعات المرجان المعروفة في شمالي خليج عدن مع رقع مرجانية كبيرة تطورت بعيداً عن شواطئ قرية بير علي ومجتمعات مرجانية تحف بالجزر البعيدة. وتعرض هذه المجتمعات المرجانية تنوعاً يتراوح بين المعتدل والعالي ومدى واسع من الغطاء المرجاني (> 10 الى <75%) .

تدعم مجموعة جزر سقطرى مجموعات حيوانية متنوعة بحوالي 250 نوعاً من المرجان الحجري مما يضعها بين أغنى المواقع في المحيط الهندي . وقد وجد اكثر المرجان تطوراً في الشمال مواجهاً للشواطئ حيث كان الغطاء المرجاني والتنوع أعلى من الساحل الجنوبي حيث تسوده الطحالب الكبيرة وحيث تكون أكثر تعرضاً إلى الرياح الموسمية الجنوبية الغربية .

لقد كان التباين كبيراً الغطاء المكون من المرجان الحجري والمرجان الميت والمرجان الطري والطحالب بين مختلف المواقع ضمن البحر الأحمر وخليج عدن ومجموعة جزر سقطرى . وتعزى النسب بين الغطاء المرجاني الحي والغطاء المرجاني الميت في المواقع الفردية إلى التأثيرات المتباينة للاضطرابات الحديثة مثل الابيضاض المرجاني الملاحظ في عام 1998. وقد أظهرت الشعاب المرجانية في شمال البحر الأحمر اليمني غطاءاً مرجانياً حياً منخفضاً (بمعدل 17%) وغطاءاً مرجانياً ميتاً عالياً (بمعدل 34%) وكذلك نسبة عالية من الطحالب الكبيرة (20%). كما نجد أن الساحل اليمني الشمالي والأوسط والجزر القريبة من الشاطىء تحتوي على غطاء مرجاني حي منخفض جداً (3%) وغطاء مرجاني ميت عال (بمعدل 34%). أما حول مجموعة جزر سقطرى فإن الغطاء المرجاني الحجري يتراوح بين أقل من 1% وأكثر من 75% وفى الرقع الكبيرة (حوالي 1000 متر مربع) يبلغ

وقد تم جمع المعلومات الحالية حول وضع الشعاب المرجانية من ثلاث عمليات مسح على طول هذا الشاطئ ما بين عامي 1996 و 1999 حيث تم استخدم طريقه بسيطة وسريعة المعلومات الحالية حول وضع الشعاب المرجانية للتقييم.

تقع الشعاب المرجانية ذات التطور المحدود بالقرب من راس خنزير وراس كودا وسيارا قبالة الجردي والى الغرب من بربرة . وهذه الشعاب المرجانية ضحلة (من 1- 10 متر) وقد نمت على صخور متحجرة. وتتباين المجموعات المرجانية على الشعاب بشكل كبير في حالتها العامة إلا أن معظمها قد تأثر بظاهرة ابيضاض الشعاب المرجانية إلى حد ما . فالشعاب المرجانية الضحلة إلى الشرق من بربرة قد قاست الكثير تقريبا من موت كلي. أما الشعاب المرجانية فى المناطق الأعمق منها (من 2 الى 5 متر) فقد كانت في وضع أحسن . و نجد في جزر سعد الدين أن التنوع المرجاني، وأعداد الأسماك وأحجام الأفراد منها ضخما؛ وقد تم تسجيل 69 نوعاً من مرجان (سكليراكتنين) و11 نوعاً من مرجان (السيوناسين) ونوعين من المرجان الناري في دراسة واحدة. وعموما فإن المنطقة تعتبر عموماً منتجة ولا تزال نسبيا على طبيعتها، بغض النظر ظاهرة الابيضاض المرجاني والى درجة أقل الضرر الذي تسببه نجمة البحر ذات الإكليل الشوكي على الشعاب المرجانية.

إن صيادي الأسماك الصوماليين يستهدفون نسبياً عدداً محدوداً من المخزون السمكي مرتبطين بإمكانيات الصيد المحدودة ومدى الأسماك الموجودة على الشعاب المرجانية. ويعتبر صيد الأسماك الذي يقوم به الشعب الصومالي محدوداً وعبارة عن حرفة تقليدية تقريباً؛ وبما أن مصايد الأسماك ما زالت بدائية فإنها ضرورية لحياة جزء كبير من السكان الذين يعيشون على الساحل . أما معظم العمليات التجارية فى الساحل الشمالي فتقوم بها سفن أجنبية.

تم اقتراح ثلاث مناطق على طول الشاطئ الشمالي للحماية، منها ثلاث مناطق فقط تضمن شعاب مرجانيه هي: منطقه عيبات وسعدالدين وسباونك (جزيرتان وشريط ساحلي مجاور بالقرب من زيلع) . ويبدو أن تأثير النشاط البشري على البيئة ضئيل جداً باستثناء استغلال السلاحف وأسماك القرش بشدة نسبياً. وحيث أن مصايد الأسماك ووسائل النقل يكونان جزءاً يسيراً من الاقتصاد الوطني فإنهما لا يمثلان تهديداً حقيقياً على الشعاب المرجانية .

ومع أن الصومال موقعة على عدة اتفاقيات وبروتوكلات فإن قدرتها على تنفيذ التشريعات الدولية أو الوطنية تبقى محدودة.

إن المطلبين الرئيسيين لتحسين صون الشعاب المرجانية هما التمويل والموظفين. غير أن المحافظة على الشعاب المرجانية في الوقت الحالي نالت أولوية أدنى مقارنة بأولويات بناء الأمة الصومالية واستئصال الفقر. وتظل الحاجة ماسة لتطوير نظام من المناطق المحمية البحرية وتبني معايير الاستجابة في حالات تسرب النفط وتبني تعليم بيئى ذى نطاق واسع؛ وكذلك تبني استمرارية للبحوث والمراقبة للكشف المبكر عن تدهور حالة الشعاب المرجانية.

الهندي . إن معظم الشواطئ والمياه الإقليمية في جيبوتي لاتزال الى حد كبير محتفظه بطبيعتها البدائية والأصيلة ولكن علامات التآكل والتدهور والمخاطر على البيئة تتزايد بسرعة .

في عام 1998 تم تقديم تقريرين قصيرين ولكن شاملين عن تقييم للشعاب المرجانية تبعهما مسح شامل في عام 1999 حيث وفرت هذه التقارير ثروة من المعلومات عن الشعاب المرجانية في جيبوتي. فعلى قمة جزيرة ماسكالي في الجنوب الغربي كانت درجة العكارة عالية والشعاب المرجانية هزيلة جداً .

وفي جزر ماسكالي وموشا كان الغطاء المرجاني الحي من معتدل الى جيد (>30%) . وكان المرجان الحي على الشعاب في شمال موشا وماسكالي في حالة معتدلة إلى جيدة (من 25 الى 40% غطاء مرجاني)؛ بينما كان للشعاب في خور امبادو معدل من الغطاء المرجاني الصخرى حوالي 52%. إن التنوع بالنسبة لأنواع الكائنات الحيه والثابتة كانت منخفضة؛ وكان المرجان من نوع البورايتس والبوسيلوبورا هي المهيمنة في المرجانيات المكونة للشعاب المرجانية وذلك على حافة الشعاب ومنحدراتها؛ بينما كان المرجان والحيوانات الأخرى نادرة نسبياً على الشعاب الخلفية المسطحة . وشرقا من خور أمبادو كانت الشعاب المرجانية في حالة معتدلة إلى جيده اذ يبلغ الغطاء المرجاني حوالى 80% . أما وضع الشعاب المرجانية في جزر الأخوة السبعة فقد كان جيداً (حيث كان معدل الغطاء 34%) ؛ وفى معظم الأرخبيل كانت توجد شعاب مرجانية متوازية وصحية. هذا ولم يتم تسجيل أي علامات مهمة عن ابيضاض مرجاني حديث لا على وجه الشعاب المرجانية أو الشعاب المسطحة. وفي عام 1998 تم تسجيل 166 نوعاً من المرجان.

إن الشعاب المرجانية في جيبوتي واقعة تحت ضغوط من عدة مصادر بشرية، وبشكل رئيسي من السياحة ومياه الصرف الصحي. والقطاعات الاقتصادية الرئيسية في المنطقة الساحلية هي النقل البحري والأنشطة المرتبطة بالميناء . ويبدو الضغط عالياً خصوصا في منطقه العاصمة. هذا وتلعب مصايد الأسماك دوراً محدوداً مع أن هذه المصايد على المستوى المحلي مهمة من الناحية المعيشية.

أعلنت جيبوتي عن منطقتين بحريتين محميتين ، بينما تم اقتراح منطقتين إضافيتين للحماية إحداهما ذات أهمية إقليمية . وهناك عدة أعمال رئيسيه على المستوى الوطنى فى هيئة تشريعات وتطبيق قد تخفف من مخاطر التلوث التي تسببها السفن أو التسرب النفطي . إن برامج المراقبة والأبحاث المتخصصة التى تزود خطط إدارة المناطق الساحلية بالمعلومات قد تساهم كثيراً في أعمال الصون الفاعلة .

الصومال، الساحل الشمالي

يتميز الساحل الشمالي بشكل عام بالضحالة مع شواطئ رمليه معرضة لحركة الأمواج. ويتكون الجزء الأوسط من شواطئ رمليه ضحلة مع وجود نتوءات أحياناً ومنحدرات صخرية قد تمتد إلى داخل المياه الضحلة .

السودان

يبلغ طول ساحل البحر الأحمر السودانيّ 750 كيلومتراً تقريباً شاملا للخلجان والمداخل ؛ ويتضمن ثلاثة مواطن أساسية للمرجان : شعاب حاجزة ، شعاب هدبية ، والشعاب الدائرية فى سنقنيب. وتشير المسوحات التي تمت خلال عامي 1997 و1999 إلى أن الشعاب المرجانية تعتبر بصحة معتدلة إلى جيدة ، وذلك بالرّغم من تقارير حديثة عن تغطية شاملة للطحالب لجزء كبير من الشعاب الهدبية. وتنتشر الشعاب المتفرقة في أعماق أكثر من 10 متر ، مع غطاء مرجاني حي يتراوح بين 5 إلى 75%. وتحتوي الشعاب ، تحت العشرة أمتار ، على مستعمرات صحية من النظم المرجانية . واعتبرت التقارير أن صحة الأسماك جيدة وأن الصيد المتزايد لا يسبب مشكلة حادة بالنسبة للشعاب المرجانية . وكذلك فإن المؤشرات الرئيسية من الأنواع كثيرة وأن التنوع يبدو عالياً مقارنة بمواقع أخرى في البحر الأحمر . أما نجمة البحر ذات الإكليل الشوكي فلم تظهر في أرقام عالية تجعلها وباءا في أي من الشعاب المرجانية السودانية . وفي عام 1999 تم تقدير المرجان المصاب بالابيضاض بحوالي 14 %من الطبقة القاعية . وتوجد منطقة واحدة محمية معروفة وهي متنزه سنقنيب البحري القومي ؛ وقد تم اقتراح أربع محميات أخرى فى انتظار قرار الحكومة بإعلانها ثم تنفيذ القرار .

يُمَثِّلُ صيد الأسماك دورا ثانويّا في الاقتصاد ، لكنه هامّ على المستوى المعيشي . غير أنه لا صيد الأسماك التجاري ولا الحرفي يصل إلى أقصى حدود الإنتاج المقدرة . ويتقد أن مصايد الأسماك تتمتع بإمكانيات تطور هائلة غير أنها تواجه مشاكل لوجستية مثل التبريد والمواصلات والأسواق .

تَجِيءُ أكثر التهديدات حدة للشعاب المرجانية مِن الملاحة وعمليات التجريف لإنشاء الموانىء والتنمية التحتية . ومع أن آثاره محدود فى الوقت الراهن فإن لقطاع السياحة تأثيرات سلبية على الشعاب المرجانية بواسطة المرساة وحركة زعانف الغواصين والتى تساهم فى إحداث أضرار بالشعاب .

لدى اَلسُّودَان الكثير من البنية التحتية المطلوبة للرصد والمراقبة المنتظمة وإلى الإدارة الفاعلة لموارد الشعاب المرجانية ، غير أن العديد من المشاكل الحالية بالنسبة للمحافظة على الشعاب المرجانية تعزى إلى غياب تطبيق القانون ، وإلى القصور فى التوعية العامة ، وإلى ضعف الإطار القانوني ، والقصور فى نظم المراقبة .

وإن وجود خطة إدارية متكاملة للسواحل تأخذ في الاعتبار عمليات الملاحة , والتنمية الساحلية ، والتلوث والموارد الطبيعية إلى جانب التطبيق الفاعل والمدعوم سوف تقدم الحلول لمعظم المواضيع المطروحة .

جيبوتي

يبلغ طول الشريط الساحلي فى جيبوتى 372 كيلومتراً . وبينما يوصف الشاطئ الشمالي بأنه ضحل ورملي بشكل عام مع وجود بروز مرجانية أحياناً ، تحف الشعاب المرجانية أرخبيل سوابي شرق رأس سيان . أما الساحل الجنوبي فهو ضحل مع وجود شعاب مرجانية بالكاد تكون متطورة لاتصالها بالمياه الباردة القادمة من المحيط

وحتى تتحسن عملية صون الشعاب المرجانية وتَكُونَ فاعلة في الإقليم ، فإن هناك حاجة لمَزيد من التوعية العامة، ومزيد من تنفيذ وفرض للآلية القانونيّة الدوليّة؛ وتنفيذ خطط الإدارة الساحلية التي تأخذ فى الاعتبار التنمية الساحلية، والتحكم في التَلَوُّث، والسياحة مع صيانة النوعيّة البيئيّة في المواطن الطبيعية البحريّة.

مصر

تعتبر جمهوريّة مصر العربيّة الموطن لأكثر من 1800 كيلومتر من الشعاب المرجانية المتنوعة على الجانب الغربي لساحل البحر الأحمر وفي خليجي السويس و العقبة. وقد تم أخذ المعلومات من دراسات المسح التي قام بها بعض أعضاء هيئة التدريس من جامعتي قناة السويس والأزهر خلال الفترة 1997 - 1999 ، وهي مراجعة حديثة لحالة الشعاب المرجانية وتقييم بيئي سريع للعديد من مواقع الغطس التي كانت محط زيارات دائمة .

وصلت نسبة الغطاء المرجاني لحوالي 55% في المناطق المكشوفة و85% في المناطق المحمية. وقد كَانَتْ نسبة الغطاء المرجانيّ الحيّ متغيرة جدا على طول الساحل على أن أعلى نسبة كانت تقع على جدران الشعاب المرجانية وحافتها الأمامية . ووجد أن الشعاب الجنوبيّة تحتوي على تنوع أكثر لأنواع الأسماك مقارنة بالشعاب الشماليّة. كما أن الشعاب المكشوفة تحتوي على تنوع اكثر للأسماك منها في الشعاب المحمية . وحتى وقت قريب كانت الشعاب المرجانية تعتبر بصحة جيدة وخالية من التأثيرات البشرية الرئيسية؛ ولكن وجد أن الرسوبيات الناتجة عن أعمال استصلاح الأراضي، وتسرب النفط وتحطيم المرجان من جراء الغوص الترفيهي باستعمال معدات الغوص أخذت دورها فى تدهور الشعاب المرجانية ؛ وأصبح الغطاء المرجاني في كثير من الأماكن متضررا وهبط إلى نسبة 30 في المائة . أما الأخطار الطبيعية فتتضمن الفيضانات والأمراض وتكاثر الحيوانات المفترسة، وازدهار أعداد النجمة البحرية ذات الإكليل الشوكي.

لدى مصر الآن أربع مناطق محميّة بحريّة ، والتى تُضَمِّ شعاب مرجانية ، تم إنشاؤها حول شبه جزيرة سيناء . وقد تم اقتراح سبع مناطق إضافيّة على الحكومة لتأخذ وضع المحميات . وتعنى ثلاث مؤسّسات وطنية بإدارة موارد الشعاب المرجانية وهي هيئة تطوير السياحة وجهاز شئون البيئة المصرية والحكومات المحلية من خلال ثلاث محافظات للبحر الأحمر. علاوة على ذلك فان عدّة وكالات ثانويّة تلْعَبْ دَوْرَاً في الإدارة البيئيّة ، بما في ذلك الهيئة العامة للبترول واللجنة الوطنية للإدارة المتكاملة للمناطق الساحلية بالإضافة إلى عد د من الوكالات الثلاثية المسؤولة أيضاً عن حماية البيئة البحرية.

إن جمهورية مصر العربية قد قامت بالتوقيع على عدد من الاتفاقيات الدولية والتي في ظلها يتم ، بشكل مباشر أو غير مباشر ، صون موارد الشعاب المرجانية. وقد أصدرت مصر عدد من القوانين والقرارات الجمهورية والتي تعطي الشعاب المرجانية الحماية المباشرة وغير المباشرة . وحتى نحسن ردود الفعل الجارية على الأخطار الطبيعية والبشرية أو التخفيف منها، فإن الأمر يتطلب تطوير خطة إدارية متكاملة للمنطقة الساحلية ومراجعة وتحديث القوانين الحالية والمراقبة الفاعلة والتحكم فى مصادر التلوث والتنمية الساحلية.

ملخص تنفيذي

يستعرض هذا التقرير الوضع الراهن للشعاب المرجانيّة في مصر، والسودان ، وجيبوتي، والصُّومَال ، اليمن ، والمملكة العربية السعودية والاردن وقد تم جمعه وترتيبه من أعمال مسح تمت في التسعينات.

يُوجَدُ المرجان في هذه المنطقة بشكل رئيسي فى المناطق التالية:

- **الشعاب الهدبية المتواجدة على طول الساحل وحوالي الجزر؛**
- **الشعاب الحاجزة ؛**
- **قمم الصخور المرجانيّة؛**
- **الشعاب الدائرية.**

وتَشْتَمِلُ عدّة مواطن طبيعية أخرى على المرجان بما في ذلك:

- **الشعاب المتفرقة المغمورة بالماء،**
- **مسطحات الطحالب الحمراء الكلسية؛**
- **بقايا تكوينات الشعاب؛**
- **تدفقات الصخور البركانية.**

وعموما، ، فإن صحّة الشعاب المرجانية تعتبر جيدة مع وجود 30% إلى 50% غطاء مرجانيّ حيّ في أكثر المواقع وأكثر من 50% كغطاء إجمالي في المعدل العام. إن التنوع المرجانيّ والحيوانات المرتبطة بالشعاب المرجانية يعتبر ضمن الأعلى في منطقة المحيط الهندي. وقد تسَبَّبَ ابيضاض المرجان في موت شامل في الجزء الأوسط الشمالي من البحر الأحمر في عام 1998 ، وعلى الساحل السودانيّ كان يوجد طبقة رقيقة من الطحالب الحمراء على معظم الشعاب المرجانية الضَحلة.

ومن ضمن التهديدات الأساسية الأخرى للشعاب المرجانية:

- **أعمال الردم والتجريف في مشاريع التوسع الساحلي ؛**
- **طرق صَيْد الأسماك المدمرة ؛**
- **الملاحة و الأنشطة البحريّة ؛**
- **الضرر من صناعة الغوص الترفيهية؛**
- **عدم التطبيق الكافي للتشريعات ذات التأثير على صون الشعاب المرجانية.**

قامت دول الإقليم بالتوقع على عدد من الاتفاقيات الإقليميّة والدوليّة والثنائية والمتعدّدة الأطراف ، وغيرها من الآليات القانونية. كما يَمْتَلِكُ كلّ بلد أيضًا مجموعة كاملة نسبياً من القوانين الوطنيّة و التشريعات. و مع ذلك،فإن تَطْبيقها لهذه التشريعات يبقى ضعيفا فى العادة وفي بعض الحالات لا يكون هناك أي تَطْبيق أو تنفيذ للقانون.

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 فى القاهرة فى سبتمبر 1995 حيث تتخذ من مدينة جدة مقراً لها. تضم الهيئة في عضويتها كل من الاردن ، جيبوتي ، السعودية ، السودان ، الصومال ، مصر واليمن .

عنوان الهيئة : ص ب 53662 جدة 21583 المملكة العربية السعودية

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وقد جرى العمل لإعداد هذه الوثيقة ضمن أنشطة مكون صون المواطن الطبيعية والتنوع الحيوي فى إطار تنفيذ برنامج العمل الاستراتيجى للبحر الأحمر وخليج عدن والذى يموله مرفق البيئة العالمى بشركائه الثلاثة: برنامج الأمم المتحدة الإنمائى و برنامج الأمم المتحدة للبيئة والبنك الدولى ، وبتمويل إضافى من البنك الإسلامى للتنمية .

الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن

الشعاب المرجانية فى البحر الأحمر وخليج عدن

مسوحات الفترة 1990 – 2000

ملخص وتوصيات