THE STATUS OF CORAL REEFS IN SUDAN - 2000

Nicolas Pilcher[1] & Dirar Nasr[2]

[1]Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia Email: nick@tualang.unimas.my
[2]PERSGA, P.O. Box 53662, Jeddah, 21583, Kingdom of Saudi Arabia. Email: dirar.nasr@PERSGA.org

Executive Summary

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. There are three primary coral habitats along the Sudanese coastline: barrier reefs, fringing reefs and Sanganeb, an oceanic atoll.

The primary industries are maritime shipping and port-related activities, but tourism and fisheries have significant growth potential. 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, and further fishery development at present is negligible. Fisheries are believed to have great potential, but face logistical problems such as refrigeration, transport and markets for product.

The coral reefs are considered to be in moderate to good health, despite recent reports of extensive coverage of algae over a high proportion of the fringing reefs. The reefs are patchy at depths < 10 m, with average live coral cover ranging from 5 to 75 %. Below 10 m, the reefs contain healthy colonies of framework corals. Fish fauna health was considered good, and that overfishing not a severe problem at the coral reefs. Key indicator species were abundant and diversity appeared high relative to other Red Sea sites. The Crown of thorns *Acantaster planci* was not recorded in plague numbers at any of the Sudan 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.

The most severe threats to reefs come from maritime shipping and dredging. The tourism sector contributes to damage of reefs by anchor and flipper damage. An additional problem is that of the shark fishery by foreign vessels. 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.

Although Sudan has ratified a number of international Conventions and Protocols which are relevant to the protection of the environment in general, only the regional Jeddah Convention for the Conservation of the Red Sea and Gulf of Aden Environment is concerned with the marine environment. The national legal framework for the protection of the environment in the Sudan is weak; a new framework umbrella law for the environment has been submitted to the Ministry of Justice but is not yet enacted and there is no comprehensive maritime law.

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 which takes into consideration shipping, coastal development, pollution and natural resources, along with effective and enforced implementation, should cater to most of the above.

1. 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. 1). 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, there is occasional freshwater influx into the Red Sea. In most parts of the Sudanese Red Sea water transparency is very high, reaching up to 70 m. Surface temperatures range between 26.2 and 30.5 °C, and salinity is high (39 - 41 ppt). From May to October, surface currents flow in a southerly direction, for the rest of the year they flow northwards.

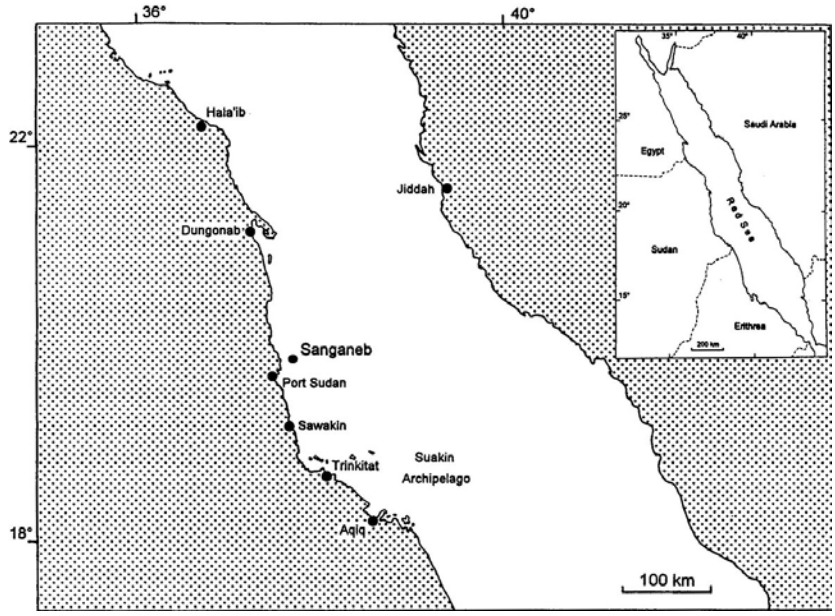

Fig. 1: The Sudanese coast of the Red Sea.

Three primary coral habitats along the Sudanese Red Sea coast are barrier reefs, fringing reefs and Sanganeb, an oceanic atoll (Fig. 2). Most of the coast is bordered by fringing reefs 1 - 3 km wide which are separated by deep channels from a barrier reef of 1 - 14 km offshore. The outer barrier drops steeply to several hundred meters depth. 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. 1993, Ormond 1980, 1987, Schroeder, 1981, Schroeder et al. 1985, Vine & Vine 1980 and 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 sea-floor of more than 800 m.

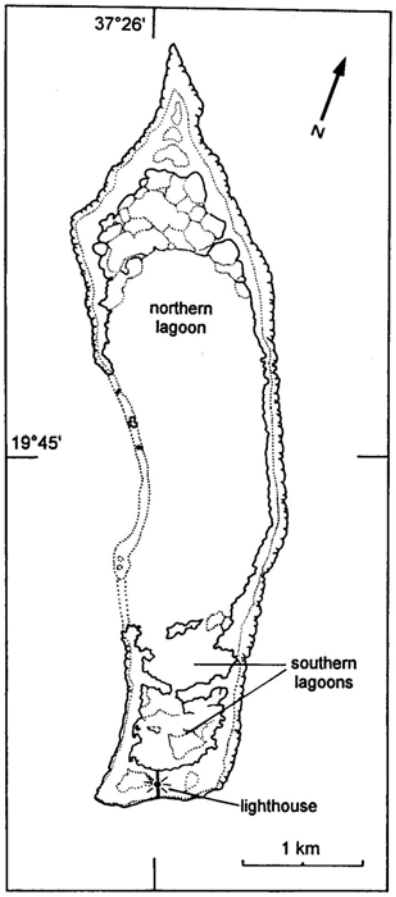

Fig. 2: Sanganeb atoll, off Port Sudan.

Port Sudan is the largest coastal city with a population of ca. 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 and the contribution of fisheries and tourism to the GNP is < 3 %, and subsistence fisheries are only locally important. The primary industries are maritime shipping and port-related activities. Tourism and fisheries have a 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 coastal area. Non living resources from the coastal area include metalliferous muds and oil and gas. Natural gas was found in the 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. The development of a Strategic Action Programme (SAP) co-ordinated by the Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is geared to the conservation of all aquatic resources, including coral reefs. This status report has been developed to provide a baseline on which future studies may be based, to detect changes in environmental quality over time.

2. Methods

i. Geographical Scope

Recent surveys on Sudanese corals were carried out by D. Nasr and K. Al-Sheikh in 1999, at three sites (Abu Hanish Jetty, Bashear Port and Arous). A more thorough survey was carried out in 1997 by Hunting Aquatic Resources, under contract to PERSGA, covering the coastal area from Port Sudan to Suakin.

ii. Survey Techniques

Reef check methods (see Hodgson 1999) were followed to determine percent cover of Hard, Soft and Dead corals and to obtain a general assessment of reef health in the 1999 surveys, while 10 m quadrat analysis and 20-minute timed swims (see English et al. 1997 For methodology). During these surveys the percentage cover of different life forms was determined (English et al. 1997), along with counts for indicator species such as butterfly and angel fishes, the Humphead Wrasse *Cheilinius undulatus*, and several commercial fishes.

4. Status of Coral Reefs – Benthos and Fish

i. Summary

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. An algal film covered a large proportion of the shallow corals, but was not found to affect those > 10 m. The reefs are patchy in depths < 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, fish fauna health was considered good, and that overfishing is 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 > 20 grouper in more than half of the 20-minute swim samples recording. Key indicator species were abundant and diversity appeared high relative to other Red Sea sites.

Anthropogenic pressures on the reefs are low, with those highest 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 > 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 *Acantaster planci* was not recorded in plague numbers at any of the Sudan reefs.

ii. 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 - 95 %, n = 54 sites; PERSGA 1998). Live coral cover ranged from 5 to 60 % (mean = 25.3 %, n = 25 sites). Dead coral coverage of > 1 % was only noted at five sites (Appendix III). The dominant substrate cover at depths < 10 m was algal film. The origin of the high algal film cover was attributed to a thermal event, possibly though runoff of high temperature waters from the lagoon. The die-off event is consistent with reports of similar events in Saudi Arabia and Eritrea at the same time (PERSGA 1998). The algae cover did not affect larger colonies, and it was suggested that the reef may recover from this within a span of decades, rather than centuries.

Additional surveys by Nasr & Al-Sheikh (2000) at Abu Hashish Jetty, where the reef extends to about 800 m with an average depth of 2 m followed by a steep drop-off to a depth of 10, found that the percentage of hard live coral (HC) ranged from 23.5 % at 10 m depth and 50 % at 5 m, while dead coral (DC) ranged from 2.5 % at 10 m depth and 0 % at 5 m depth suggesting that the area was comparatively healthy. At Bashaer 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 and no bleaching was observed below 4 m. Bleached corals were observed at the top of the fringing reef at 2 m (Fig. 3; see also Appendix VII). Overall bleached corals were estimated to cover 14 % of the substrate.

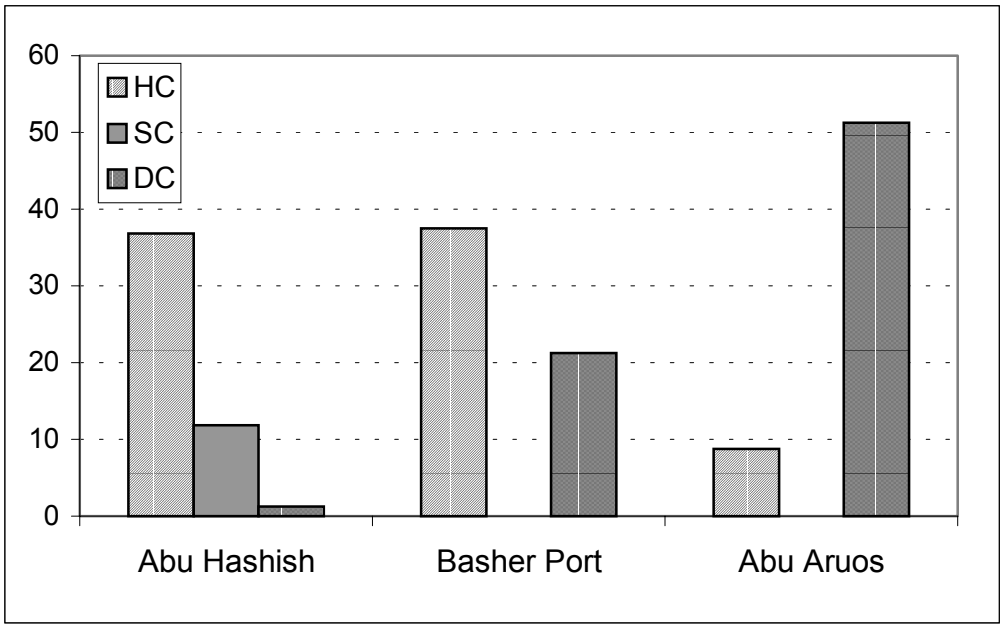

Fig. 3. Average percentage of coral cover in the three selected sites in the Sudanese Red Sea coast (Source: Nasr & Al-Sheikh 2000) **.**

iii. Fish Communities

Based on the results of the 1997 surveys (PERSGA 1998), fish communities were considered healthy and abundant. The Humphead Wrasse *Cheilinius undulatus*, 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 (Balistodiae) 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 > 20 individuals; Similarly, snappers (Lutjanidae) were recorded at 24 of the 25 sites, with a maximum count of 212 and at four sites > 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 found at all sites. Sharks were reported at three sites. Surveys in 1997 revealed the abundance of *Chaetodontidae semilarvatus*, which was not found in 1981 (Edwards & Rosewell, 1981), but did not record the presence of *C. pausifasciatus* which was frequently found around Port Sudan at that time.

Selected non-piscivore fauna was counted during timed swims, and distribution was normal (Appendix IV). Studies have been carried out for the distribution of polycheats and crabs at Sanganeb, and mangrove fauna along the Sudanese coastline (see Krupp et al. 1994).

5. Status of Coral Reef Fisheries

i. Summary

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, and 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.

ii. Artisanal Fishery Resources

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 - 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 include that for Trochus (*Trochus dentatus*) and sea cucumber (*Holothuria* sp.). Annual export rates of Trochus during 1991 to 1995 varied between 306 and 535 mt. 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.

iii. Fishery Trends and Composition

All the shallow water areas (mersas) along the Sudanese coast are potential spawning grounds. The only spawning ground for oysters is Dongonab Bay, where there are 8 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 and estimated 400 small fishing boats in Sudan and about 300 slightly larger boats of 9 - 10 m (4 - 5 crew). Fish is 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 (1489 mt) and have gradually decreased by 30 % since that time (Fig. 4; PERSGA 1997). 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 had been developed. At the same time, fuel and maintenance costs increased, and fishermen have reverted to sailing dugouts from modern outboard-powered craft.

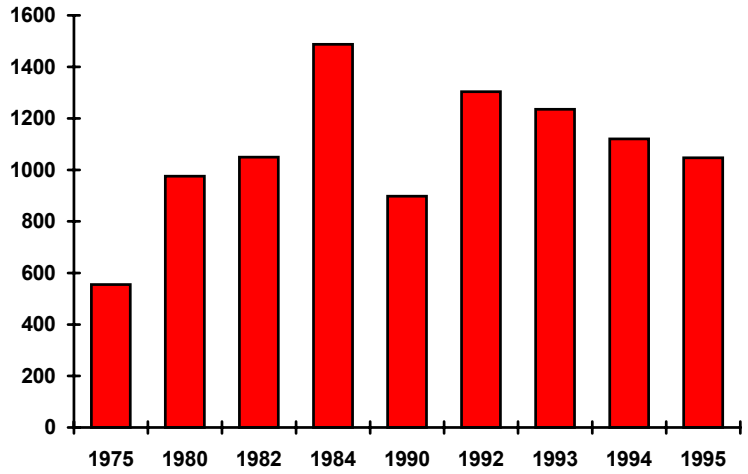

Fig. 4: Artisanal finfish landings in metric tonnes between 1975 and 1995 (Source: PERSGA 1997).

Catches of bohar, farasi and korаib (*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 underexploited. Several ventures have carried out trial trawls in Sudan's 700 km^2 of trawling grounds, landing a catch which 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 a potential for purse seine fisheries, and present landings amount to some 1300 mt, with an estimated maximum sustainable yield of 2300 mt.

Two other important fishery resources are kokian (Trochus shell) and Sadaf (pearl oysters). 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 priced 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 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 6000 oysters each and are supervised by scientists. Improved growth rates allowed for partial cropping after only two years, rather than 3 - 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/FAO 1985, Mishrigi 1993).

6. Threats to Coral Reef Biodiversity

i. Summary

Due to the limited industrial development along the Sudanese coastline, threats are localised at the few urban centers. The most severe threats come from maritime shipping and dredging and land filling, although the tourism sector contributes to damage of reefs by anchor and flipper damage. An additional problem which 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.

ii. Maritime Transport

Port Sudan is the Sudan's 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 (eg 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 of 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 problems to navigation. Combined with heavy maritime traffic and limited navigational devices, there is a constant risks 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 ship discharges of solid waste 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 marine environment.

iii. Tourism

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

iv. Coastal Development

Habitat destruction as a result of coastal development is localised. The extension of Port Sudan and the port of 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 and 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 - 8 ha of land will be land-filled for the

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

The establishment of proposed a Economic Free Zone (EFZ), which will cover 600 km² between Port Sudan and Suakin, may also impact diverse coral reefs at Towartit, which are located immediately in front of the planned EFZ. Heavy industries, petrochemical industries, fish processing factories, slaughter houses with a capacity of 3000 heads per day, tanneries, and warehouses will be established in the area.

v. Ecological Changes

At present shark resources are depleting and catches by local fishermen are declining rapidly due to large-scale shark fisheries by foreign vessels from the Region for the East-Asian shark fin market. A portion of these fishermen operate with licences, but many fish illegally. Sharks are caught by hook and line and nets, damaging coral reefs. The fins are cut of, usually while the shark is still alive. Large amounts of bycatch, 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. The Government has been recently decided to stop commercial shark fisheries and no new licences will be issued.

vi. Petroleum Industry Development and Transport

There is a constant threat of oil spills. Oil leaks occur on a regular base 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, affects the productivity and the fauna in the harbour area. At some sites intertidal biota disappeared completely (Abu Bakr 1995).

A new joint venture company, the Greater Nile Petroleum Operating Company (GNPOC), has been formed to manage a pipeline which will transport crude oil 1,500 km from the Heglig and Adariel oil fields to the Sudanese coast for export. The site for the new Bashayir oil terminal is Gezirat Abd Alla, about 24 km south of Port Sudan. GNPOC has engaged a consultant firm to carry out an environmental impact assessment (EIA) of the project and to recommend appropriate environmental controls. 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 Bashayir, a National Oil Spill Contingency Plan for Sudan has been prepared by PERSGA and submitted to the Government of Sudan. 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 includes internal waters including ports, harbours, estuaries, bays and lagoons. On land, it includes the foreshore and any adjacent land affected by an oil spill.

vii. Industrial Activities

Primary industry is located in the vicinity of Port Sudan. The chronic release of industrial pollutants results in 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 ITMD tyre manufacturing company also 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.

The proposed Economic Free Zone covering 600 km^2 between Port Sudan and Suakin will pose significant risks to both the terrestrial and marine environment. The development should therefore be subject to strict Environmental Impact Assessment studies to ensure that risks are clearly identified and that pollution control and other abatement measures are properly implemented.

7. Marine Protected Areas (MPAs) and Level of Management

i. Summary

Given Sudan's relatively small coastline, two important protected areas exist, with Sanganeb being a world-renown marine protectorate. Sanganeb has yielded a wealth of information on Sudan's marine habitat, and is the center of much of the country's research into coral reef ecosystems. Four other areas have been proposed as protectorates, and await government decisions and implementation.

ii. 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 an 12 km^2 atoll with highly diverse and complex coral reefs, diverse reef-associated fauna (see Appendices V and VI), sharks, marine mammals and manta rays, and is the only typical atoll in the Red Sea. Current threats come from recreational diving practices, including anchor and flipper damage.

iii. *de facto* and Planned MPAs

There are five proposed marine protected areas, of which four contain coral reefs: Shuab Rami, which covers ca. 4 km^2 and contains highly diverse coral reefs with unique associated fauna including sharks and marine mammals; Mukkawar Island and Dungonab Bay, which cover ca. 300 km^2 and are home to coral reefs, whale sharks, and the largest aggregations of mata rays in the Red Sea; Suakin archipelago, which contains coral reefs with a diverse fish fauna, and is nesting site for marine turtles and sea birds, and; Abu Hashish, which covers ca. 5 km^2 and also contains diverse coral reefs and associated fauna.

8. Current and Potential Climate Change Impacts

At present there is limited information on the effects of climate change on Sudanese reefs. No bleaching was reported by PERSGA (1998), but coral die-off events were observed on shallow reefs. The report suggested that these reefs exhibit potential for recovery if development in the region is well managed. A wide spread die-off of reefs at shallow depths was also mentioned in the Sudan Country Report in the framework of the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden (PERSGA, 1996). 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 14 % of the substrate (Nasr & Al-Sheikh 2000). At Bashaer 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 of the 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 "as if covered with a white cloth" and suggested that corals were bleached. Tourist operators indicated bleached corals in the southern Sudanese Red Sea could amount to 30 % of cover, with *Platygyra* sp. being the most afflicted.

9. Current Monitoring and Management Capacity to Conserve Coral Reef Resources

i. Summary

Sudan has much of the infrastructure needed for regular monitoring and effective management of coral reef resources. There exist a number of research organisations (based at the universities) that have carried out research on reefs in the past, and government agencies (such as the Navy0 which provide a limited degree of enforcement. Many of the present problems can be attributed to a widespread lack of law enforcement, 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.

ii. Monitoring Capacity

Little or no temporal studies are carried out in the country. What monitoring occurs 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) is an institution with representatives from all government institutions, the private sector, and NGOs concerned with the Red Sea environment. It played an important role in raising awareness and in formulating regulations, particularly in the 1970s.

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

The University of Khartoum has a laboratory in Suakin. The Departments of Zoology, Botany and Geology train students and conduct research in the Red Sea area. 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 lab 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: These 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 with offices in Port Sudan and Tokar.

iii. Management Capacity
Coral reefs are only indirectly managed 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 planning and promotion of tourism; 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; and the Wildlife Research Centre, in charge of providing the scientific background for wildlife conservation and management.

The Ministry of Transport: Includes the The Sea Ports Corporation, which is in charge of all aspects of maritime transport and is linked to the Maritime Administration, responsible for the implementation of Coastal Zone Management Plan.

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. The Navy 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.

10. Government Legislation, Strategies and Policy Pertinent to Reef Conservation

i. Summary
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.

ii. International Agreements
Sudan has ratified the following Conventions and Protocols: Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of

Hazardous Wastes within Africa (1993); Convention Concerning the Protection of the World Cultural and Natural Heritage (1974); Convention on Biological Diversity (1995); Convention on International Trade in Endangered Species of Wild Fauna and Flora (1982); Protocol Concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1984); Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (1984); United Nations Convention on the Law of the Sea (1985). Apart from the regional Jeddah Convention, none of these treaties are concerned with protection of the marine environment. Even the Law of the Sea Convention does not provide either obligations or the benefits of those international treaties which are specifically focused on the marine environment. MARPOL has not yet been ratified, because of a lack of port reception facilities.

iii. 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, including oil, into the sea and the collection of corals, shells and aquarium fish.

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

Marine Fisheries Ordinance: Givs 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 awaiting approval and implementation.

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

11. Gaps in Capacity and Requirements for Improved Conservation

i. Summary
A major problem in conservation of reef resources is funding for research and management efforts. The recent revival of PERSGA and the injection of GEF funding means there will be research and training, but enforcement will remain at its present state. 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:

ii. 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.

iii. 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 Center. To date, only a limited oil-spill response plan has been developed, and only for the Port of Sudan area.

iv. 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.

12. Recommendations to Improve the Conservation of Coral Reef Resources

i. Summary
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 which takes into consideration shipping, coastal development, pollution and natural resources, along with effective and enforced implementation, should cater to most of the above. Specifically:

ii. 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) 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 Civil Liability Convention (1969); the International Oil Pollution Compensation Fund; 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); and the Ramsar Convention on Internationally Important Wetlands.

iii. 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 which forms part of a regional network of MPAs.

A set of guidelines for visitors to coral reef areas should 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.

iv. Maritime Transport and Industrial Activities

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

Port Sudan refinery should take steps to repair the skimmer system at its lagoon and reduce discharges of highly contaminated drainage water on to the beach. Action should be taken immediately by the main electricity power station to prevent continuing oil discharges, possibly through the addition of a separator unit.

It is essential for the Bashayir Oil Terminal operators to carry out a full risk assessment of their operations and to prepare a local oil pollution emergency plan, backed by an oil spill response organisation and an adequate level of oil spill combating equipment.

The Ministry of Environment and Tourism should ensure that the development of the proposed 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.

The ITMD tyre manufacturing company should address the problems with the 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. The principles of the local oil pollution emergency plan for Port Sudan harbour should be updated in the light of decisions on the NOSCP.

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

v. Information

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

Appendix I – References

Abu Bakr, O.A. 1995. The Effect of Waste Oil Disposal into the Red Sea. M.Sc. Thesis, Institute of Environmental Studies, University of Khartoum.

Edwards, A. & J. Roswell, 1981. Vertical zonation of coral reef fishes in the Sudanese Red Sea. Hydrobiologica 79: 21-31.

English, S., C. Wilkinson & V. Baker, 1997. Survey manual for tropical marine resources. 2nd ed. Australian Institute of Marine Science, Townsville. 368 pp.

FRC/IDRC, 1985. Sudan IDRC Oyster Culture Research Project. Phase II Proposal. Fisheries Research Centre, Khartoum. 26 pp.

Head, S.M., 1980. The ecology of corals in the Sudanese Red Sea. Ph.D. Thesis, University of Cambridge, U.K.

Hodson, G., 1999. A global coral reef assessment. Mar. Poll. Bull. 38(5): 345-355.

IUCN/UNEP, 1985. Management and Conservation of renewable marine resources in the Red Sea and Gulf of Aden Region. UNEP Regional Seas Reports and Studies No. 64.

Krupp, F., 1990. Sanganeb - ein Unterwasser Nationalpaerk im Roten Meer. Natur und Museum 120: 405-409.

Krupp, F., M. Türkay, A.G. El Hag and D.H. Nasr, 1994. Comparative ecological analysis of biota and habitats in littoral and sublittoral waters of the Sudanese Red Sea, based on the study of marine fauna and flora. Report for the period of April 1991 to December 1993. Forschungsinstitut Senckenberg, Frankfurt and Faculty of Marine Science and Fisheries, Sudan. 89 pp..

Krupp, F., T. Paulus & D. Nasr, 1994. Coral Reef Fish Survey. In Comparative ecological analysis of biota and habitats in littoral and shallow sublittoral waters of the Sudanese Red Sea (F. Krupp, M. Türkay, A.G.D. El Hag & D. Nasr eds.). Forchungsinstitut Senckenberg, Frankfurt. 63-82.

Mishrigi, S.Y. 1993. Identification Study for Sudan Red Sea Fisheries. Ministry of Economic Planning and Investment (MEPI) Project Preparation Unit. Khartoum. 240 pp.

Nasr, D. & K. Al-Sheikh, 2000. Assessment of coral reefs in the Sudanese Red Sea in the context of coral bleaching. In Proceedings of the International Workshop on the Extent and Impact of Coral Bleaching in the Arabian Region (H. Tatwany, ed.). National Commission for Wildlife Conservation and Development, Riyadh.

Ormond, R.F.G., 1980. Management and conservation of Red Sea habitats. Proc. Symp. Coast. Mar. Environ. Red Sea and Gulf of Aden and Tropical Western Indian Ocean. University of Khartoum, Sudan. 2: 137-162.

Ormond, R.F.G., 1987. Conservation and Management. In: The Red Sea (Edwards, A.J. and Head, S.M. eds). Pergamon Press: 405-423.

PERSGA, 1997. Draft Country Report: Republic of the Sudan. Strategic Action Programme for the Red Sea and Gulf of Aden. Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden. 14 pp.

PERSGA, 1998. Surveys of natural habitats and plans for their protection in Sudan. Hunting Aquatic Resources, London, Draft Final Report.

Sanders, M.J. & S.M. Kedidi, 1981. Summary Review of the Red Sea Commercial Catch and Stock Assessments, Including Maps of Actual and Potential Fishing Grounds. UNDP/FAO, RAB/77/008/19. 49 pp.

Schroeder, J.H.. 1981. Man versus reefs in the Sudan: threats, destruction, protection. Proceedings of the 4th International Coral Reef Symposium, Manila. 1: 252-253.

Schroeder, J.H. & D.H. Nasr, 1983. The fringing reefs of Port Sudan, Sudan. 1. Morphology, Sedimentology, Zonation. Esser. Geogr. Arb. 6: 29-44.

Vine, P.J. & M.P. Vine, 1980. Ecology of Sudanese coral reefs with particular reference to reef morphology and distribution of fishes. Proc. Symp. Coast. Mar. Environ. Red Sea and Gulf of Aden and Tropical Western Indian Ocean. University of Khartoum, Sudan. 2:87-140.

Vine, P.J., 1985. The Red Sea. Immel Publishing, London and Jeddah. 128 pp.

Appendix II – Names and Addresses of Key Contacts for Sudan

Dr. Abdel Gadir D. Elhag
Vice Chancellor
Red Sea University
P.O. Box 24,
Port Sudan
Sudan

Fax: (249311) 27778

Dr. Ahmed Suleiman El-Wakeel
Project Co-ordinator, HCENR
National Biodiversity Strategy and Action Plan project
P.O. Box 10488
Khartoum
Sudan Email: balgis@yahoo.com
nbasb@yahoo.com

Dr. Dirar Nasr
Regional Organisation for the Conservation of the Environment
of the Red Sea and the Gulf of Aden
P.O. Box 53662
Jeddah 21583,
Kingdom of Saudi Arabia

Email: dirar.nasr@PERSGA.org

Mr. Mohammed Younis
Regional Organisation for the Conservation of the Environment
of the Red Sea and the Gulf of Aden
P.O. Box 53662
Jeddah 21583,
Kingdom of Saudi Arabia

Email: mohammed.younis@PERSGA.org

Mr. Mohamed Mustafa Eltayeb
Faculty of Marine Sciences and Fisheries
Red Sea University,
P.O. Box: 24,
Port Sudan,
Sudan

E-mail: mohamedeltayeb@hotmail.com

Dr. Nadir M. Awad
Higher Council for Environmental Protection and Natural Resources
P.O. Box 10488
Khartoum
Sudan

Fax: (24911) 787611

Ms. Hanan El Amin Muddathir
PERSGA National Specialist
c/o Ministry of Environment & Tourism
P.O. Box 1920
Khartoum
Sudan

E-mail: hanan-muddathir@hotmail.com

Eng. Mahgoub Hassan
National Programme Coordinator
PERSGA / SAP
P.O. Box 1333
Port Sudan
Sudan

Email: mahgoub.Hassan@usa.net

Dr. Alec Dawson-Shepherd
Hunting Aquatic Resources
Innovation Centre, York Science Park
University Road
Heslington
York YO1 5DG, U.K.

Email: coracil1@rad.net.id

Capt. Abdel Halim
P.O. Box 125
Port Sudan

Tel: 249 31122649

Mr. Muhammad Amin Hamza
Institute of Marine research
P.O. Box 24
Port Sudan
Sudan

Tel: 249 3112509

Dr. Eisa M. Abdellatif
Department of Zoology
University of Khartoum
P.O. Box 321
Khartoum
Sudan

Fax: 249 11 777017

M.O.H. El-Dardiry
Director

Dr. Yousif B. Abu Gideiri
Director, Institute of Environmental Studies

Marine Fisheries Administration
P.O. Box 260
Port Sudan
Sudan

Tel: 249 31126162
Mr. Taha El Tahir Bedawai
Sudanese Ecological Society
General Secretary of Ecological Congress
Red Sea State
Port Sudan
Sudan

Fax: (24931) 3051

University of Khartoum
P.O. Box 321
Khartoum
Sudan

Fax: 249 11 773807
Khalda M. Abuzaid
Sudanese Environment Conservation Society
P.O. Box 44266
Khartoum
Sudan

Fax: 249 11 777107

Appendix III: Substrate cover at fifty four Sudan coral reef sites.

Site ID	*Location Name*	*Lat N*		*Long E*		*AF*	*CA*	*DC*	*DA*	*HC*	*SC*	*S*	*GR*	*OT*
		(deg)	*(min)*	*(deg)*	*(min)*									
781	Hardaweb Spit	19	21.248	37	21.248	70	0	0	0	10	0	20	0	0
783	Hardaweb Spit	19	21.248	37	21.248	30	20	0	5	10	0	30	0	5
857	Wingate Reefs	19	37.111	37	17.229	30	10	0	30	30	0	0	0	0
859	Wingate Reefs	19	37.203	37	17.236	0	10	0	0	30	30	30	0	0
860	Wingate Reefs	19	37.966	37	17.609	30	0	0	5	20	20	20	5	0
862	Wingate Reefs	19	38.073	37	17.687	20	0	0	0	30	20	20	10	0
863	Umbria	19	38.073	37	17.687	65	0	0	5	15	15	0	0	0
864	Wingate Reefs	19	38.200	37	17.408	15	20	0	20	40	5	0	0	0
866	Wingate Reefs	19	38.659	37	17.372	30	0	0	0	20	20	20	10	0
867	Port Sudan	19	38.320	37	15.144	60	10	0	0	20	10	0	0	0
869	Port Sudan	19	38.409	37	15.004	50	0	0	0	30	10	0	10	0
870	Port Sudan	19	36.660	37	14.645	70	10	0	10	10	0	0	0	0
872	Port Sudan	19	36.591	37	14.548	80	10	0	0	10	0	0	0	0
876	Lighthouse	19	35.364	37	14.986	80	0	0	15	5	0	0	0	0
878	Lighthouse	19	35.437	37	14.887	85	0	0	10	5	0	0	0	0
879	Wreck N of Towartit	19	31.934	37	16.135	90	0	0	5	5	0	0	0	0
881	Wreck N of Towartit	19	31.895	37	16.215	75	5	0	5	15	0	0	0	0
882	Towartit Elbow	19	29.414	37	17.892	60	5	0	15	20	0	0	0	0
884	Towartit Elbow	19	29.294	37	17.930	30	40	0	5	20	5	0	0	0
885	Towartit Reef (hut)	19	28.791	37	19.744	15	10	0	5	60	0	5	5	0
887	Towartit Reef (hut)	19	28.928	37	19.716	50	5	0	5	30	0	0	0	5
888	North Towartit Reef	19	28.886	37	21.939	70	10	0	10	30	0	20	20	0
890	Towartit North Reef	19	28.895	37	21.889	10	5	0	5	20	0	0	0	0
891	Towartit North Reef	19	30.286	37	20.659	20	15	0	10	35	5	10	5	0
893	Towartit North Reef	19	30.370	37	20.674	20	5	0	5	70	0	0	0	0
894	Towartit North Reef	19	30.830	37	19.932	40	0	0	5	30	0	50	20	0
896	Towartit North Reef	19	30.984	37	19.886	55	10	0	5	20	0	0	10	0
897	Graham Pt.	19	8.457	37	21.932	50	10	0	10	30	0	0	0	0
899	Graham Pt.	19	8.563	37	21.982	50	10	0	10	20	10	0	0	0
900	Marsa Kuwai	19	12.434	37	20.738	75	5	0	0	20	0	0	0	0
902	Marsa Kuwai	19	12.264	37	20.740	65	5	0	10	20	0	0	0	0
903	Al Mansooriya	19	13.293	37	23.129	20	10	0	0	20	45	5	0	0
905	Al Mansooriya	19	13.345	37	23.187	15	10	0	0	75	0	0	0	0
906	Al Mansooriya	19	11.952	37	24.000	0	20	0	0	50	15	0	15	0
908	Al Mansooriya	19	11.870	37	24.087	60	0	0	0	30	10	0	0	0
909	Fikheeb	19	9.583	37	24.907	0	5	0	10	60	15	0	10	0
911	Fikheeb	19	9.583	37	24.907	20	40	0	0	20	20	0	0	0
912	Fikheeb	19	9.583	37	24.907	0	30	0	0	60	5	5	0	0
913	Fasmat Al Waladab	19	6.352	37	27.593	30	40	0	0	30	0	0	0	0
915	Fasmat Al Waladab	19	6.352	37	27.593	10	40	0	10	20	20	0	0	0
916	Fasmat Al Waladab	19	3.340	37	26.705	0	0	0	0	40	15	20	0	25
918	Fasmat Al Waladab	19	3.340	37	26.705	0	20	0	0	40	20	0	0	20
919	Fasmat Al Waladab	19	3.340	37	26.705	95	0	0	0	5	0	0	0	0
920	Fasmat Al Waladab	19	3.340	37	26.705	10	5	0	0	35	5	25	20	0
922	Fasmat Al Waladab	19	3.340	37	26.705	10	10	0	0	40	0	30	10	0
923	Al Waladah Al Beadh	19	3.534	37	21.141	0	0	0	10	30	0	30	30	0
925	Al Waladah Al Beadh	19	3.534	37	21.141	60	5	0	0	25	0	5	5	0
926	Al Waladah Al Beadh	19	3.534	37	21.141	0	10	0	0	10	5	30	25	20

927	Graham Pt.	19	5.976	37	23.382	40	10	0	10	35	5	0	0	0
929	Graham Pt.	19	5.976	37	23.382	0	20	0	5	50	5	0	20	0
930	Graham Pt.	19	7.834	37	22.371	65	10	0	0	20	5	0	0	0
932	Graham Pt.	19	7.834	37	22.371	70	0	0	0	25	0	5	0	0
933	Marsa Agwetay	19	26.632	37	18.165	50	0	0	0	40	10	0	0	0
935	Marsa Agwetay	19	26.632	37	18.165	60	10	0	0	25	0	0	0	0

Note: AF = Algal Film, CA = Coralline Algae, DC = Dead Coral, DA = Dead coral with Algae, HC = Living Hard Coral, SC = Soft Coral, S = Sand, GR = Gravel, OT = Other

Source: Adapted from tables in PERSGA (1998).

Appendix IV: Counts for selected benthic organisms during 20-minute swims.

Site ID	*Location Name*	*Lat N*		*Long E*		*AN*	*COT*	*GC*	*LOB*	*SCU*	*DIA*	*SPU*	*TS*
		(deg)	*(min)*	*(deg)*	*(min)*								
782	Hadraweb Spit	19	21.423	37	19.371	0	0	17	0	0	0	0	0
858	Wingate Reefs	19	37.203	37	17.236	0	0	12	0	0	0	0	0
861	Wingate Reefs	19	38.073	37	17.687	3	3	78	0	1	22	0	0
865	Wingate Reefs	19	38.758	37	17.347	0	8	65	0	3	6	0	0
868	Port Sudan	19	38.409	37	15.004	8	1	42	0	3	1	0	0
871	Port Sudan	19	36.660	37	14.645	0	2	13	0	0	0	0	0
877	Lighthouse	19	35.364	37	14.986	0	0	45	0	0	1	0	0
880	Wreck N of Towartit	19	31.934	37	16.135	5	0	170	0	0	0	0	0
883	Towartit elbow	19	29.414	37	17.892	1	0	7	0	0	0	0	0
886	North Towartit Reef (hut)	19	28.791	37	19.744	0	1	73	0	13	3	0	0
889	Towartit North Reef	19	28.886	37	21.939	3	1	70	0	14	0	0	0
892	Towartit North Reef	19	30.286	37	20.659	0	0	27	0	0	0	0	0
895	Towartit North Reef	19	30.894	37	19.886	0	0	35	0	12	0	0	0
898	Graham Point	19	8.457	37	21.932	0	0	7	0	0	0	0	0
901	Marsa Kuwai	19	12.434	37	20.738	0	0	12	0	17	0	0	0
904	Al Mansooriya	19	13.293	37	23.129	3	2	80	0	0	0	0	0
907	Al Mansooriya	19	11.870	37	24.087	0	6	77	0	0	0	0	0
910	Fikheeb	19	9.583	37	24.907	0	0	33	0	0	0	0	0
914	Fasmat Al Waladab	19	6.352	37	27.539	0	0	63	0	0	0	0	0
917	Fasmat Al Waladab	19	3.340	37	26.705	0	1	110	0	0	0	0	0
921	Fasmat Al Waladab	19	3.340	37	26.705	0	0	48	0	0	0	3	0
924	Al Waladah Al Beadh	19	3.534	37	24.141	0	2	22	0	0	0	0	0
928	Graham Point	19	5.976	37	23.382	0	0	12	0	0	1	0	0
931	Graham Point	19	7.834	37	22.371	0	0	27	0	0	0	0	0
934	Marsa Agwetay	19	26.632	37	18.165	1	0	4	0	0	0	0	0

Note: AN = Anenome; COT = Crown of Thorns starfish; GC = Giant Clams; LOB = Lobster; SCU = Sea Cucumber; DIA = Diadema sea urchins; SPU = Slate Pencil Urchins; TS = Top Shells.

Source: Adapted from PERSGA (1998).

Appendix V: List of fish species recorded from Sanganeb.

Carcharhinidae
Carcharhinus albimarginatus *
Carcharhinus amblyrhynchos ∗
Carcharhinus melanopterus +
Triaenodon obesus +

Sphyrnidae
Sphyrna lewini +

Torpedidae
Torpedo sp. ∗

Myliobatidae
Aetobatus narinari +

Mobulidae
Manta birostris *

Dasyatididae
Taeniura lymma ∗ #

Synodontidae
Saurida gracilis ∗
Synodus variegatus ∗

Muraenidae
Gymnothorax javanicus ∗ #
Siderea grisea *

Ophichthidae
Callechelys striata #

Clupeidae
Spratelloides sp. ∗ #
Herklotsichthys quadrimaculatus *

Belonidae
Tylosurus choram ∗ #

Hemiramphidae
Hyporamphus gambarur ∗ #

Atherinidae
Atherinomorus lacunosus ∗

Syngnathidae
Corythoichthys flavofasciatus ∗
Corythoichthys nigripectus ∗ #
Corythoichthys schultzi ∗ #

Ophidiidae
Brotula multibarbata #

Antennariidae
Histrio histrio #

Holocentridae
Neoniphon sammara ∗ #
Myripristis murdjan ∗ #
Sargocentron caudimaculatus * #
Sargocentron ruber ∗
Sargocentron spinifer ∗ #

Scorpaenidae
Pterois radiata ∗
Pterois volitans ∗
Pterois sp. ∗
Scorpaenopsis barbatus ∗
Synanceia verrucosa #

Platycephalidae
Onigocia oligolepis #

Serranidae
Aethaloperca rogaa ∗ #
Cephalopholis argus ∗
*Cephalopholis hemistikto*s ∗
Cephalopholis miniata ∗
Epinephelus fuscoguttatus ∗ #
Epinephelus tauvina ∗
Plectropomus areolatus *
Plectropomus pessuliferus ∗
Variola louti *
Pseudanthias fasciatus ∗
Pseudanthias lunulatus ∗ #
Pseudanthias squamipinnis ∗ #
Pseudanthias taeniatus *

Grammistidae
Grammistes sexlineatus +
Diploprion drachi ∗

Cirrhitidae
Cirrhitichthys oxycephalus ∗ #
Paracirrhites forsteri ∗
Cirrhitus pinnulatus # ∗
Oxycirrhites typus ∗

Pseudochromidae
Pseudochromis flavivertex ∗
Pseudochromis fridmani ∗
Pseudochromis olivaceus ∗
Pseudochromis dixurus ∗
Pseudochromis sp. ∗

Apogonidae
Apogon annularis ∗
Apogon aureus ∗
Apogon exostigma ∗ #
Apogon cf. *frenatus* ∗
Apogon cf. *coccineus* +
Apogon kallopterus *
Apogon leptocanthus ∗
Archamia fucata +
Cheilodipterus macrodon ∗
Cheilodipterus bipunctatus #
Cheilodipterus lineatus *
Cheilodipterus quinquelineatus ∗

Carangidae
Caranx sexfasciatus ∗
Caranx melampygus ∗
Caranx cf. *sexfasciatus* ∗
Carangoides bajad ∗ #
Carangoides fulvoguttatus ∗

Lutjanidae
Lutjanus argentimaculatus *
Lutjanus caeruleolineatus *
Lutjanus kasmira ∗
Lutjanus fulviflamma ∗
Lutjanus gibbus *
Lutjanus monostigma ∗
Lutjanus bohar ∗
Macolor niger ∗

Caesionidae
Caesio lunaris +
Caesio striatus ∗
Caesio suevicus ∗
Caesio varilineata *

Haemulidae
Plectorhynchus gaterinus ∗ #

Lethrinidae
Lethrinus nebulosus +
Monotaxis grandoculis ∗

Nemipteridae
Scolopsis ghanam ∗
Nemipterus sp. *

Ephippidae
Platax orbicularis ∗ #

Kyphosidae
Kyphosus vaigiensis ∗
Kyphosus cinerascens ∗

Monodactylidae
Monodactylus argenteus ∗

Pempheridae
Parapriacanthus guentheri ∗
Pempheris vanicolensis ∗

Bothidae
Bothus pantherinus #

Soleidae
Pardachirus marmoratus +

Mullidae
Mulloides vanicolensis *
Mulloides flavolineatus *
Parupeneus cyclostomus ∗
Parupeneus forsskali ∗
Parupeneus macronema ∗

Malacanthidae
Malacanthus latovittatus ∗ #

Mugiloididae
Parapercis hexophthalma ∗

Echeneidae
Echeneis naucratus ∗

Mugilidae
Crenimugil crenilabis ∗
Oedalechilus labiosus ∗

Sphyraenidae
Sphyraena barracuda ∗
Sphyraena jello +
Sphyraena qenie ∗

Pomacentridae
Amblyglyphidodon flavilatus ∗
Amblyglyphidodon leucogaster ∗
A*budefduf vaigiensis* ∗
Abudefduf sexfasciatus ∗
Abudefduf sordidus ∗
Amphiprion bicinctus ∗
Chromis caerulea ∗

Siganidae

Chromis dimidiata ∗
Chromis ternatensis ∗
Chromis trialpha +

Chromis weberi ∗
Chromis pembae *
Chrysiptera unimaculata ∗
Dascyllus aruanus ∗ #
Dascyllus trimaculatus ∗
Neopomacentrus miryae +
Neopomacentrus xanthurus ∗
Paraglyphidodon melas ∗
Plectoglyphiodon lacrymatus ∗
Plectoglyphiodon leucozona +
Pomacentrus leptus +
Pomacentrus sulfureus ∗
Pomacentrus trichourus ∗
Pomacentrus trilineatus +

Labridae
Anampses twistii +
Bodianus anthioides *
Bodianus axillaris *
Bodianus diana ∗
Cheilinus digrammus ∗
Cheilinus fasciatus ∗
Cheilinus lunulatus ∗
Cheilinus mentalis ∗
Cheilinus undulatus ∗
Cheilinus sp.
Coris aygula ∗
Coris africana *
Epibulus insidiator ∗
Gomphosus caeruleus ∗
Halichoeres hortulanus ∗
Halichoeres nebulosus *
Halichoeres scapularis ∗
Halichoeres marginatus ∗
Hemigymnosus fasciatus +
Hologymnosus annulatus ∗
Labroides dimidiatus ∗
Larabicus quadrilineatus ∗
Pseudocheilinus evanidus ∗
Pseudocheilinus hexataenia *
Cirrhilabrus blatteus *
Pseudodax moluccanus ∗
Thalassoma klunzingeri ∗ #
Thalassoma lunare ∗ #
Thalassoma purpureum ∗ #
Thalassoma sp. +
Minilabrus striatus +

Valenciennea sp. ∗

Scaridae
Hipposcarus harid ∗
Cetoscarus bicolor ∗

Bolbometopon muricatum ∗
Scarus genazonatus *
Scarus sordidus *
Scarus gibbus *
Scarus ferrugineus *
Scarus fuscopurpureus *
Scarus niger *

Congrogadidae
Haliophis guttatus #

Chaetodontidae
Chaetodon auriga # ∗
Chaetodon austriacus ∗
Chaetodon fasciatus # ∗
Chaetodon lineolatus ∗
Chaetodon melannotus ∗
Chaetodon paucifascitus ∗
Chaetodon semilarvatus ∗
Chaetodon mesoleucos ∗
Gonochaetodon larvatus ∗
Megaprotodon trifascialis ∗
Heniochus diphreutes ∗
Heniochus intermedius *

Pomacanthidae
Pomacanthus imperator ∗
Pomacanthus maculosus ∗
Pomacanthus asfur ∗
Centropyge multispinis ∗
Apolemichthys xanthotis *
Pygoplites diacanthus ∗
Genicanthus caudovittatus ∗

Acanthuridae
Acanthurus gahham ∗
Acanthurus nigrofuscus ∗
Acanthurus sohal ∗ #
Ctenochaetus striatus ∗
Naso hexacanthus ∗
Naso unicornis ∗
Naso brevirostris ∗
Naso lituratus ∗
Zebrasoma veliferum ∗
Zebrasoma xanthurum ∗

Monacanthidae

Siganus luridus +
Siganus stellatus ∗

Blenniidae
Cirripectes sp. ∗
Exallias brevis ∗
Ecsenius frontalis ∗
Ecsenius midas ∗ #
Ecsenius nalolo ∗
Ecsenius cf. *aroni* +
Ecsenius gravieri *
Meiacanthus nigrolineatus ∗
Plagiotremus tapeinosoma ∗

Gobiidae
Istiogobius decoratus *
Cryptocentrus lutheri +
Cryptocentrus caeruleopunctatus ∗
Ctenogobiops maculosus #
Amblyeleotris steinitzi +
Asterropteryx semipunctatus +
Ptereleotris microlepis ∗
Ptereleotris evides ∗
Nemateleotris sp. ∗
Amblygobius albimaculatus #
Amblygobius hectory * #
Gobiodon citrinus ∗
Gobiodon sp. ∗ #
Eviota sebrei *
Bryaninops sp. 1 ∗
Bryaninops sp. 2 ∗
Bryaninops sp. 3 ∗

Balistidae
Balistapus undulatus ∗
Pseudobalistes fuscus ∗
Rhinecanthus assasi ∗
Sufflamen albicaudatus ∗
Odonus niger ∗
Balistoides viridescens ∗
Oxymonacanthus halli ∗

Ostraciidae
Ostracion cyanurus ∗
Ostracion cubicus ∗

Tetraodontidae
Arothron diadematus ∗
Arothron hispidus ∗
Canthigaster margaritata *
Canthigaster pygmaea ∗

Diodontidae
Diodon hystrix ∗ #

* photographic record
# specimen
+ visual record

Source: Krupp et al. (1994).

Appendix VI: List of the 31 most common fish species recorded in Sudan (in % of the total records). * - Species which occurred on all transects.

Pseudanthias squamipinnis	43.63 %	*Chromis weberi*	0.72 %
Chromis dimidiata *	19.45 %	*Thalassoma klunzingeri* *	0.65 %
Chromis ternatensis	5.20 %	*Labroides dimidiatus* *	0.61 %
Pseudochromis fridmani	3.36 %	*Halichoeres hortulanus* *	0.57 %
Ctenochaetus striatus *	2.73 %	*Pomacentrus leptus*	0.54 %
Chromis caerulea	2.61 %	*Plectorhynchus gaterinus*	0.40 %
Parapriacanthus guentheri	1.65 %	*Parupeneus forsskali*	0.40 %
Caesio suevicus	1.45 %	*Paracirrhites forsteri*	0.35 %
Cephalopholis hemistiktos *	1.17 %	*Centropyge multispinis* *	0.33 %
Amblyglyphidodon flavilatus	1.11 %	*Cephalopholis miniata*	0.33 %
Myripristis murdjan *	1.08 %	*Scarus fuscopurpureus*	0.32 %
Pomacentrus trichourus *	0.92 %	*Pseudocheilinus evanidus*	0.32 %
Amblyglyphidodon leucogaster	0.85 %	*Pseudocheilinus hexataenia* *	0.31 %
Caesio lunaris	0.77 %	*Thalassoma lunare*	0.31 %
Pomacentrus sulfureus	0.75 %	*Scarus ferrugineus*	0.31 %
Gomphosus caeruleus *	0.74 %	Remaining 90 species	6.06 %

Source: Krupp et al. (1994).

Appendix VII: Mean percentage of coral cover in Sudan, 1999.

Area	*HC*	*SC*	*DC*
Abu Hashish	36.88	11.88	1.25
Bashaer Port	37.5	0	21.25
Arous Village	8.75	0	51.25

HC = Hard coral, SC = Soft Coral, DC = Dead Coral

Source: Nasr & Al-Sheikh (2000).

Appendix VIII - Acknowledgements

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