



ASSESSMENT OF THE PRESENT STATE OF THE ENVIRONMENT; IN PORT SUDAN HARBOUR AREA

Item Type	Report
Publisher	Red Sea University
Download date	31/12/2023 03:29:59
Item License	http://creativecommons.org/licenses/by-nc/3.0/
Link to Item	http://hdl.handle.net/1834/5081

**ASSESSMENT OF THE PRESENT STATE
OF THE ENVIRONMENT IN
PORT SUDAN HARBOUR AREA**

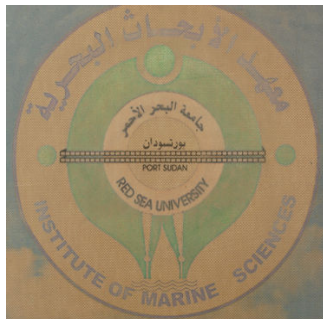
CONDUTED BY

INSTITUTE OF MARINE RESEARCH

(IMR)

RED SEA UNIVERSITY (RSU)

**A STUDY SUBMITTED TO
THE CHAIRMAN OF THE
TECHNICAL COMMITTEE
KHARTOUM — SUDAN**



NOVEMBER 2008



CONTENTS

	<u>Page</u>
1. General introduction	1
2. Objectives	2
3. Approach & Methodology	3
3.1: Description of location of the study area	3
3.2: Work plan	3
3.3: Assessment of related environmental physical features	3
3.3.1: Climatic conditions:	3
3.3.2: Oceanographic conditions:	5
3.3.3: Topography & Bathymetry:	5
3.4: Inventory & Evaluation of coastal / marine resources:	5
3.5: Main sources of environmental impacts	5
3.6: Institutional legal and frame-work	5
4. Findings & Observations:	7
4.1: Environmental conditions:	7
• Air temperature:	7
• Rainfall:	7
• Humidity:	7
• Evaporation:	8
• Winds:	8
• Air quality:	8
4.2: Oceanographic conditions:	10
• Water temperature (°C):	10
• Salinity: (S ‰):	10
• Transperancy:	11
• Tides:	11
• Water currents:	11
• Dissolved Oxygen (DO ₂):	11

• Nutrients (inorganic salts):	12
4.3: Topography & bathymetry:	12
4.4.: Coastal & Marine Resources	14
4.4.1: Coastal vegetation:	14
• Mangroves:	14
• Halophytes:	16
• Terrestrial vegetation (inland):	16
4.4.2: Marine vegetation:	18
4.4.3: Marine Invertebrates fauna:	21
• Corals:	21
• Invertebrates:	24
4.4.4: Marine vertebrate fauna:	27
• Fishes:	27
• Mammals:	36
• Turtles:	36
• Sea birds:	36
4.5: Other Marine Resources	38
5. Main sources of environmental impacts	39
5.1: Land-filling and dredging:	39
5.2: Oil pollution:	39
5.3: Chemical and thermal pollution:	41
5.4: Wastes disposal:	42
5.5: Other sources of impacts:	42
6. Institutional & Legal Framework:	44
7. Recommendations & Conclusions:	48
References	50
Appendices	52

Assessment of the present state of the environment in Port Sudan Harbour Area

1. General introduction:

The Red Sea since ancient times is considered as a vital trade maritime route and an important source of food and livelihood for many coastal inhabitants. Its geographical location (in an arid zone area) geological structure and semi- enclosed nature, have created peculiar characteristic features manifested in a broad spectrum of complex habitats with high biological diversity. It is, therefore, described as one of the most important repositories and centre of biodiversity in the world (Ormond, 1986, Krupp etal, 1994).

The Sudanese Red Sea (about 750 km or more) which is located at the central part of the Red Sea conforms to such patterns. It is particularly famous of its exceptionally unique and varied habitats with rich biological communities, especially coral reefs. Its productive and highly sensitive coastal and marine habitats (coastal halophytes, mangroves, seagrasses / algal beds and coral reefs) harbour enormous counts of ecologically and commercially important fisheries resources. This is in addition to rare mammals, turtles and birds.

Port Sudan harbour which is the main maritime port of Sudan, has witnessed remarkable expansions and notable innovations within the Sea Port Development Phased –Plan which started since 1999 and planned to continue until 2020.

As a result several new platforms and oil terminals with advanced machineries have been constructed in the southern and northern parts of the harbour, with the intention of increasing its carrying capacity and handling efficiency. This is inorder to meet the over growing exports & imports demands of the country.

However, such current and future planned coastal & marine activities in and around Port Sudan harbour area are expected to have their adverse (negative) impacts on the marine and coastal environments and their resources, unless proper mitigation measures are considered. Therefore, it is thought more appropriate to evaluate the

present status of coastal and marine environments and living resources in the port area. This will facilitate identification & assessment of levels of environmental impacts arising from coastal and marine activities and the suitable protection procedures to be applied.

2. Objectives:

The environmental study aims at:

- Description and evaluation of the existing conditions of land / coastal and marine environments in Port Sudan harbour area.
- Inventory and assessment of coastal and marine resources and species diversity in the main port area.
- Provision of adequate environmental base-line data, fundamental for identifying and assessing levels and magnitudes of any resultant environmental impacts arising from land /sea activities in the area.
- Providing advice and recommendations for setting up appropriate environmental protection and management plans for attaining sustainable development in the whole Sudanese coastal zone area.

3. Approach & Methodology:

The Institute of Marine Research (IMR) / Red Sea University (RSU) has been assigned to perform an environmental base-line study in Port Sudan harbour area that will provide basic environmental, oceanographic and biological data, pre- requisite for describing the current state of the environment and facilitating evaluation of any resultant negative impacts in the area.

3.1: Description and location of the study area:

Port Sudan harbour which is the main natural Port of Sudan, is located on the western side of the central Red Sea, at L at: 19°38 N and Longit: 37°13 E. It is a semi- enclosed, elongated bay, extending from the sea inland to about 5.5 km long and approximately 1.0 km wide (at the main basin) and terminates into a shallow lagoon (≤ 500 m wide).

Its inlet which is bordered by fringing reefs on either side is almost 300m wide and about 60 m deep. The water depth being ≤ 25 m at the main basin and decreases steadily and gradually inland to ≤ 10 m till it reaches ≤ 5.0 m at the terminal (Fig .1).

3.2: Work Plan:

A working plan has been set up to involve:

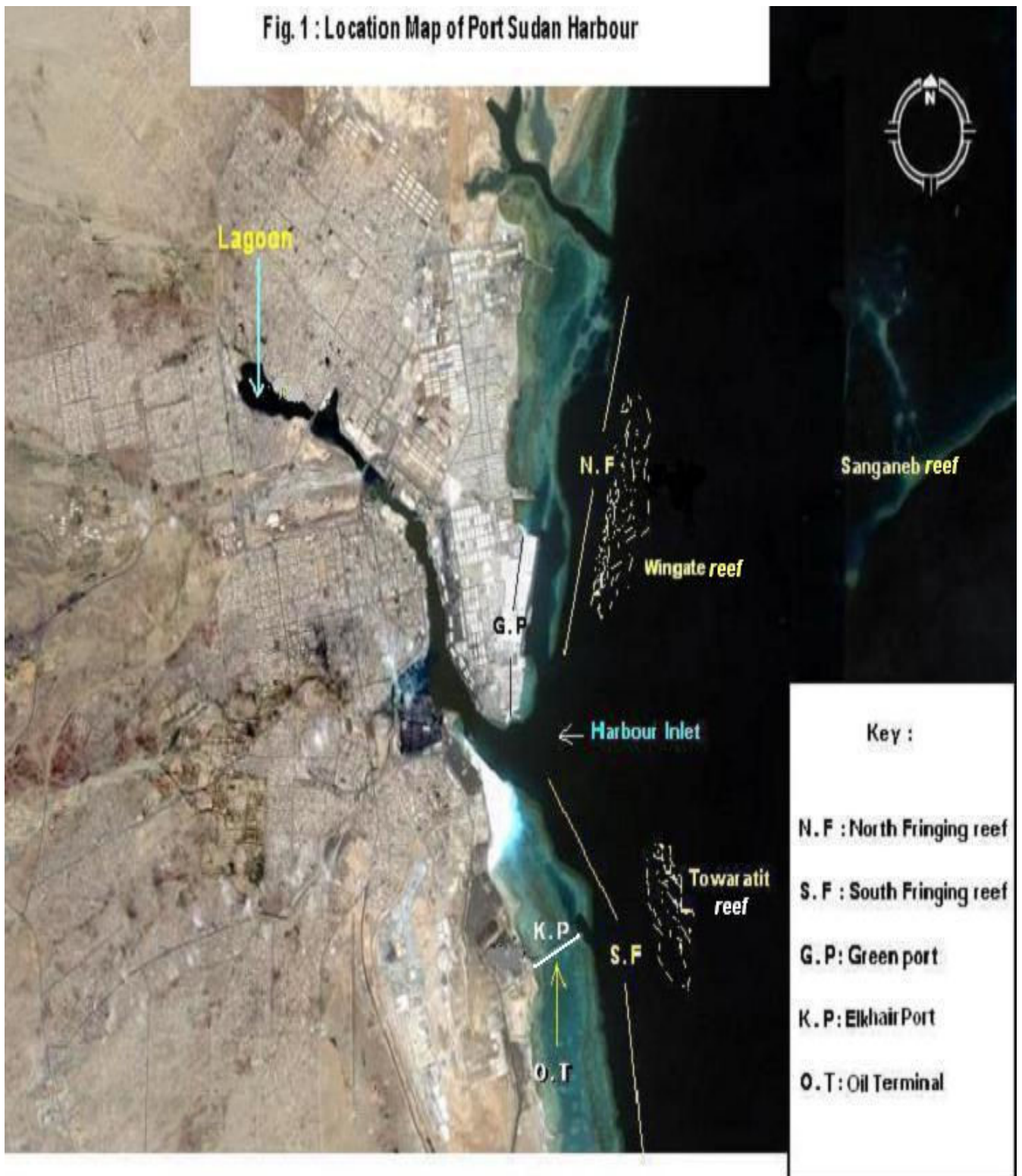
- 3.2.1:** Selection of the working professionals and supporting staff.
- 3.2.2:** Rapid assessment survey, to the study area for certain in-situ measurements and photography.
- 3.2.3:** Collection of all relevant data and reports from related sources, pertaining to the environmental evaluation study.
- 3.2.4:** Time schedule for data processing, assessment, drafting and finalizing of report.

3.3: Assessment of related environmental physical features.

3.3.1: Climatic conditions:

- Temperature.
- Rainfall.
- Humidity
- Evaporation

Fig. 1 : Location Map of Port Sudan Harbour



- Winds
- Air quality

3.3.2: Oceanographic conditions:

- Water temperature (°C).
- Salinity (S ‰)
- Transparency (m)
- Tides
- Water currents
- Oxygen (O₂)
- Nutrients (NO₃, PO₄ & SiO₃)

3.3.3: Topography & Bathymetry:

3.4: Inventory & Evaluation of coastal / marine resources:

a. Living resources:

- Coastal vegetation (mangroves ,halophytes & inland plants)
- Marine vegetation / (sea grasses & seaweeds).
- Coral reefs and associated marine organisms.
- invertebrates
- Fisheries (vertebrates).
- Marine mammals (ie Dugong – Dugon & Dolphins)
- Turtles
- Birds

b. Non – living marine resources:

- Minerals
- Oil & gases
- Table salt
- Freshwater

3.5: Identification of the main sources of environmental impacts in the area.

3.6: International and National Conventions, guidelines, legal and institutional frame-work for environmental protection in Sudan.

3.7: Recommendations & Conclusions.

3.8: References

3.9: Appendices.

Fig. 2 : Range of Air Temperatures in Port sudan area (1976-2008)

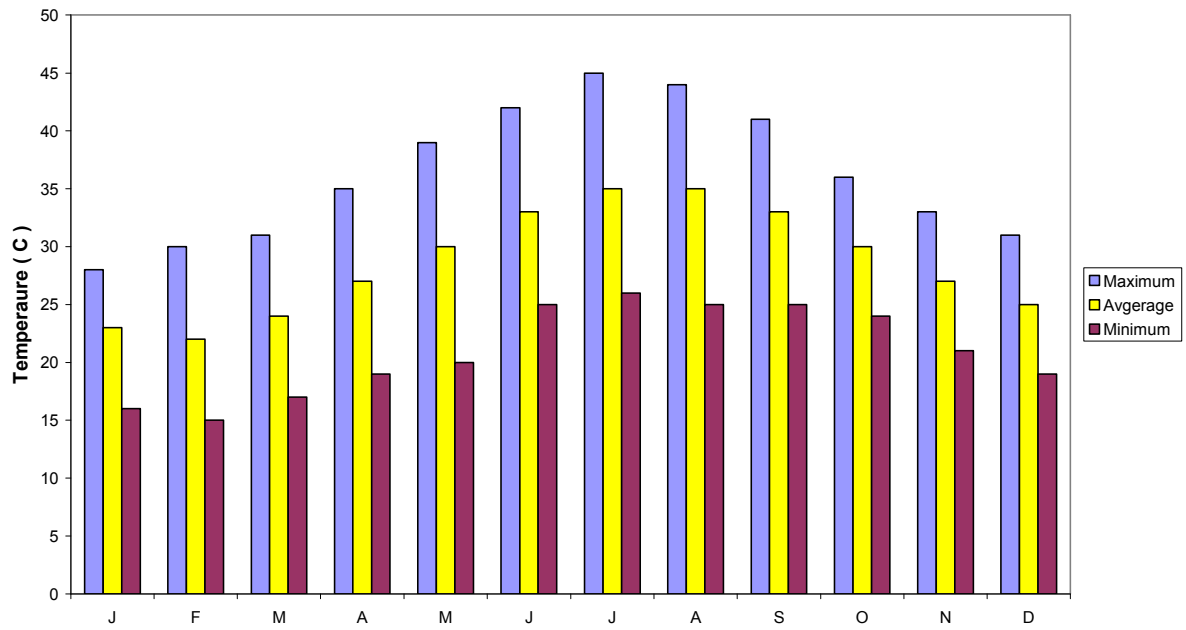
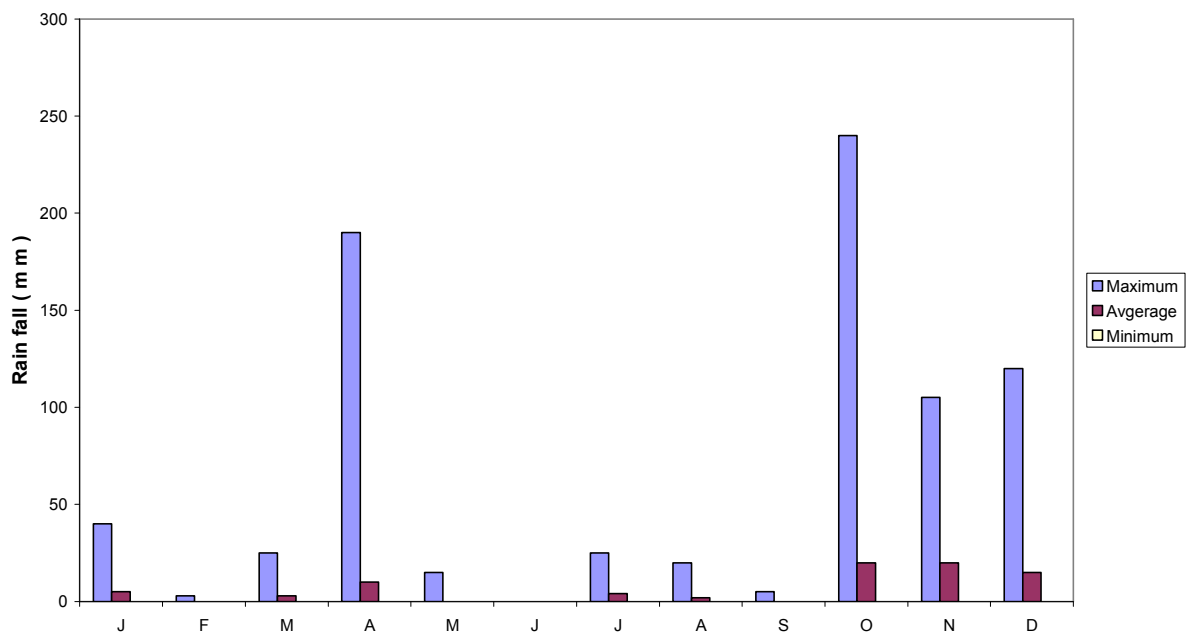


Fig. 3 : Rain fall range in Port Sudan Area (1976-2008)



4. Findings & Observations:

The following pertinent environmental, oceanographic, habitats and biological characteristics, which are important in describing the state of environment and resources in the area, are assessed and evaluated.

The results presented in the preset study are based on in-situ, recent and early surveys conducted by the Institute of Marine Research / Red Sea University, as well as from other previous records.

4.1: Environmental conditions:

Climatic conditions of the Red Sea area are generally classified as a typical arid zone environment with higher temperature, low rainfall, high humidity & evaporation rates. These climatic conditions which are strictly controlled and determined by natural effects of the sea and Red Sea HILLS include:

- **Air temperature:**

It generally fluctuates in the range 30 – 47 °C during summer May – September and $\leq 20 - 27.0^{\circ}\text{C}$ during winter (October – January) at Port Sudan.

However, long-term temperature records of Port Sudan taken from the Meteorological Administration, generally indicate no significant spatial variations in temperature, though values decrease northward (Fig. 2).

- **Rainfall:**

The rainfall is generally scarce throughout the Red Sea coastal zone (average annual of 55 mm) increasing southward. In the Sudanese Red Sea. The average annual rainfall ranges between 34 – 240 mm, being mainly during winter (October – December), occurring as torrential rains.

However, more than 30 years records from the Meteorological Authority (1976 – 2005) revealed that maximum, average and minimum annual rainfalls in Port Sudan ranged between a minimum of 25 mm at the extreme north and a maximum of 250 mm over the hills, increasing southwards (Fig. 3).

- **Humidity:**

The relative humidity of the Red Sea coastal fringe is mainly due to the effect of sea and of moisture from saturated trade winds. The humidity in Port Sudan ranges from 42 – 76 % with the maximum range of 72 – 76 % being reported

during winter (Oct – Jan) while the minimum mean levels (36-65%) were recorded during summer (June – July).

However, maximum average & minimum records (from Meteorological Department) in Port Sudan reflected the relatively high humidity, as expected for a coastal area particularly in October (Fig. 4).

- **Evaporation:**

Evaporation rate in Port Sudan is generally high with the maximum of 9.1 mm / day reported in July – August and lowest rate is about 3 mm / day, being detected during Dec – Jan (Fig. 5).

- **Winds:**

The Red Sea is directly influenced by the relatively low pressure system in winter (Siraj, 1988) and southwest monsoon in summer (Morcos, 1970). The wind direction in the Sudanese Coast is almost northerly and northwesterly throughout the year. The northeastern trade winds, blow during winter (November – March) at a speed range of 50 – 80 km / hr while (relatively at much lower speed) the northwestern winds (at relatively much lower speed), locally known as "Haror", prevail during summer months (June – August). The wind rose for 30 years of Port Sudan records (1976 – 2005) showed that wind in Port Sudan area is mostly north, northeast or northwest, being strongest (≥ 80 km / hr) during winter.

- **Air quality:**

Ambient air quality data has been collected and analyzed and the main air pollutants were identified in Port Sudan area (Environmental base line study / 2007 & 2008).

Results of the major air pollution parameters measured (Table 1) revealed that the levels of gases emissions from the various pollution sources in the area were insignificant except for suspended particulate matter arising from seasonal dust storms that usually occur (during summer) in the southern coast.

Other parameters such as hydrocarbons were shown to have no levels in Port Sudan & Bashair harbour. The ambient air quality monitoring may well indicate that pollution of the air environment in the study area is almost negligible at present.

Fig. 4 : Humidity of typical year records in Port Sudan area (1976-2008)

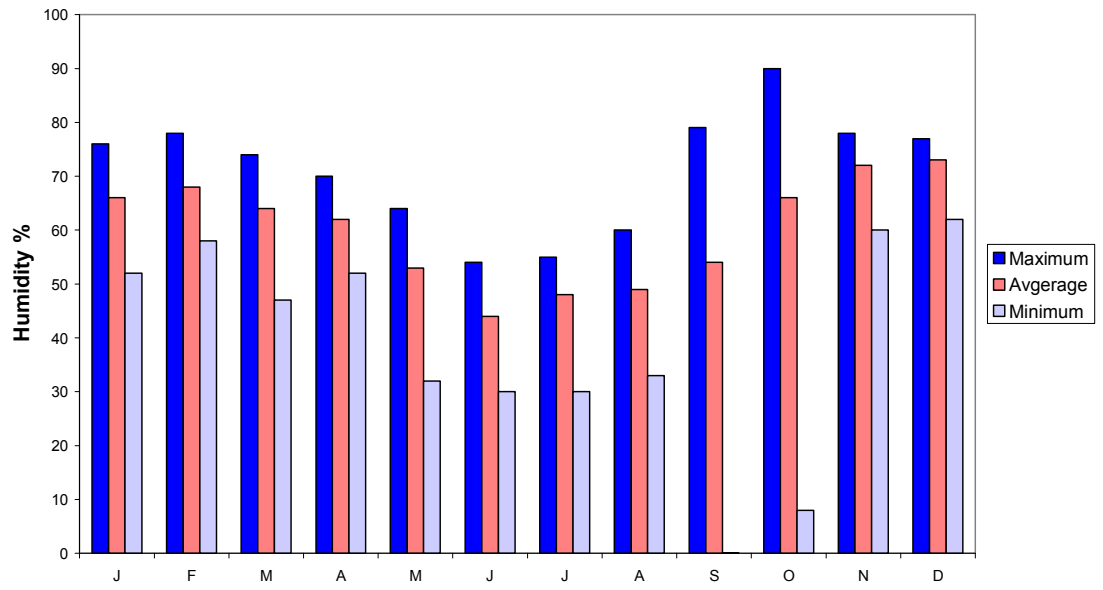


Fig. 5 : Evaporation rates in Port Sudan area (1976-2008)

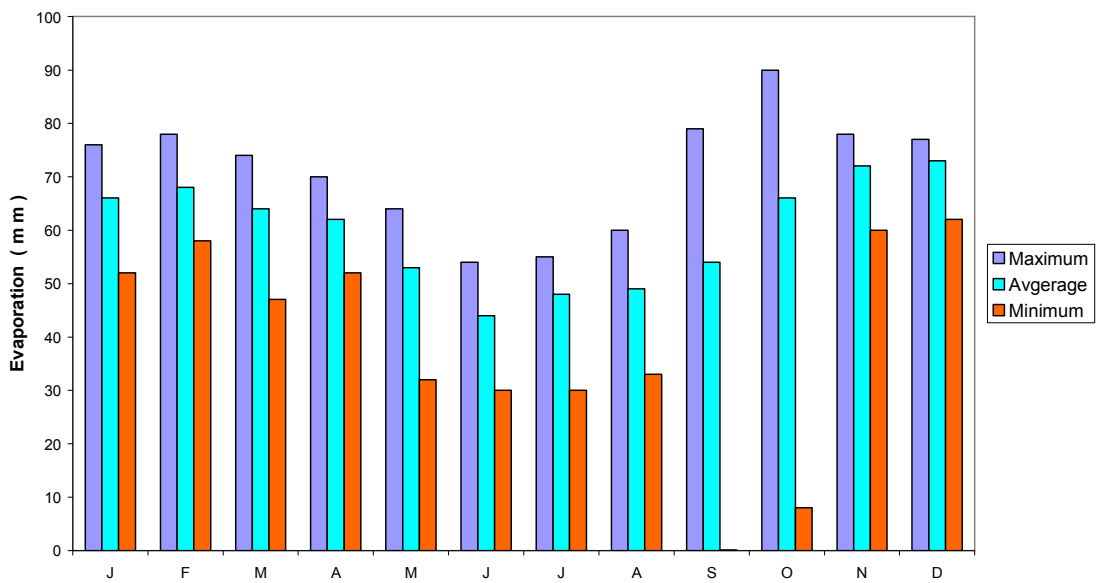


Table (1): Ambient Air Quality Parameters in Port Sudan area:

Elements	NO ₂ (ppm)	H ₂ S (ppm)	SO ₂ (ppm)	CO (ppm)	NH ₃ (ppm)	PM Mg / m ³
Range	0.0	0.0	0.03 -0.0	9 - 1	1.43– 0.0	15.0-0.0
Average	0.0	0.0	0.003	7	0.2	5

NO₂: Nitrogen oxide

H₂ S: Hydrogen sulfide

SO₂: Sulfur dioxide

CO: Carbon monoxide

NH₃: Ammonia

PM: Particulate matter

PPM: Part Per Million

4.2: Oceanographic conditions:

- **Water temperature (°C):**

Surface water temperature was recorded at various sites in coastal and offshore waters in the study area. Temperature values were found in the range 26.0 – 28.0 °C in shallow and deep water (open sea), indicating winter conditions. However water temperature records during summer were found to fluctuate between 29.5 – 32.0 °C in shallow coastal waters, especially lagoons. There are however a general northward decrease in temperature along the coast.

It is noteworthy to indicate that subsurface temperature (though not measured) below 200 m depth tends to be uniform through the water column (\approx 21.5 °C) but usually increases appreciably at greater depths (\geq 600 – 1000 m) amounting to 50.°0 C or more in the central trough (\geq 2500 m deep).

- **Salinity: (S ‰):**

Salinity (salt content) measured in-situ, in Port Sudan harbour and surrounding areas was relatively high (39.00 – 41.00 ‰) characteristic of the Red Sea waters with insignificant variations.

It is relevant to mention that, surface salinity, in reverse to water temperature increases northwards along the Sudanese Red Sea which is characterized by its strong halocline. Deepwater layers (below 200 m) are found to be isohaline

with an identical salinity value ($\approx 40.60 \text{ ‰}$) indicating stability of the water column especially during summer.

- **Transparency:**

Transparency (visibility) was recorded (in-situ) in inshore and offshore waters in and around Port Sudan harbour area. Values ranged between 4.0 – 8.0 m and 13.0 – 25.0 m in the former (inshore) and latter (offshore) waters respectively.

However water Transparency (clarity) normally increases appreciably during summer (climax August) to more than 50 m in offshore (deep) waters. The high water clarity is a good indication of the pristine water conditions in the area.

- **Tides:**

Tides in the Red Sea are generally semi-diurnal varying within a small average spring (winter) range of about 50 cm and mean sea level of up to 100 cm high, increasing southwards.

Tidal range in the Sudanese coast is small compared to southern and northern parts of the Red Sea, fluctuating around 50 cm or less (during summer) and about 90 cm or less, during winter.

- **Water currents:**

The Red Sea is regarded to be a semi-enclosed water body with high density surface water as a result of high rate of evaporation ($200 \text{ cm}^3 / \text{yr}$) which exceeds precipitation (Techemia, 1980).

The overall circulation of the Red Sea is influenced by the monsoon winds. Surface currents during winter (October – April) flow from the Indian Ocean northwards throughout the Red Sea while the direction of currents during summer (May – September), is reversed i.e flowing southwards to the Indian Ocean as deep currents.

There are, in addition, nearshore currents, in the area generally follow the local wind pattern (wind driven currents).

- **Dissolved Oxygen (DO₂):**

Surface dissolved oxygen level was assessed in the study area and areas in vicinity. It was found to be relatively high ranging between 4.9 – 5.4 ml O₂ / l, which falls well within the saturated values range (4.80 – 6.50 ml O₂ / l) stated for the Red Sea region (UNEP, 1997).

It is pertinent to mention that oxygen saturated larger in the Red Sea generally extends down to ~ 100 m depth and drops gradually below forming an oxygen minimum larger (≥ 3.0 mlO₂ / l) at deeper waters (300 – 500 m deep).

- **Nutrients (inorganic salts):**

Inorganic minerals including mainly, nitrate (NO₃ – N) Nitrite (NO₂ – N) and phosphate (PO₄ – P), measured in the study area (in both coastal & offshore waters), seemed to be generally low values within the range 0.35 – 0.55 µg – at / l, 0.24 – 0.40 µg – at / l and 0.15 – 0.30 µg – at / l were detected for nitrate, nitrite & phosphate respectively, reflecting small or insignificant variation in the area.

The detected nutrients levels were observed to be within the low detectable limits of oligotrophic waters (low fertility), characteristic of the Red Sea (Theil et al, 1986). So any abnormal rise in levels of these essential chemical parameters can cause eutrophication problems which may adversely affect the sensitive habitats and marine resources in the study area.

4.3: Topography & bathymetry:

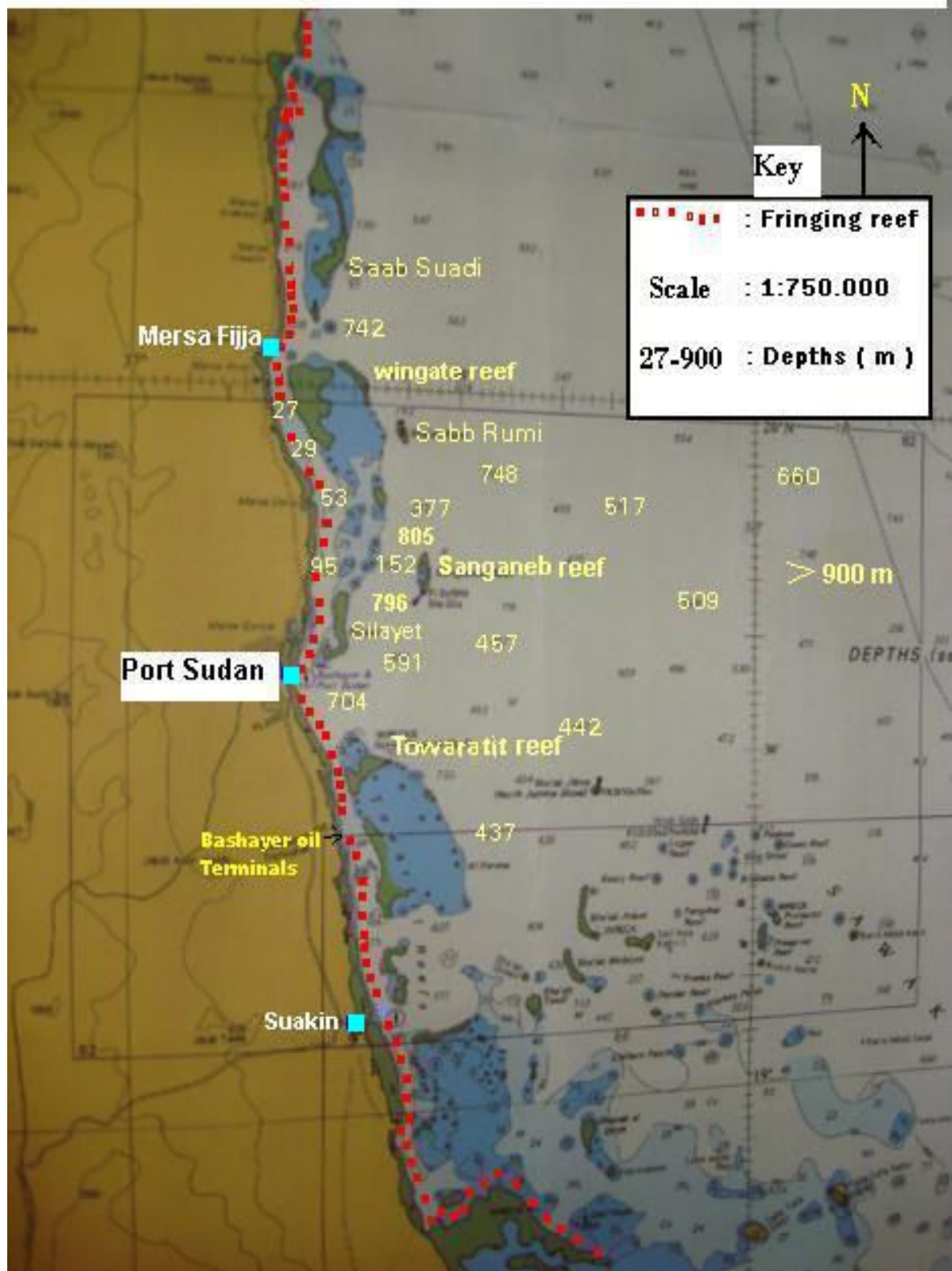
The Red Sea which is considered as a rift valley, separating landmasses of Africa & Arabia, is \simeq 2000 km long, 280 km wide and narrows at its most southern part (at Bab El Mandab) to 27 km wide with a shallow sill of about 100 m deep.

It is generally characterized by its irregular topography & bathymetry and hence being categorized into main three photographic zones:

- i. Coastal shelves located from the shore (0 – 200m) down to depths of 300 – 600 m
- ii. Irregular broken floor of the main trough ranging between 600 – 1500 m and more.
- iii. The axial (central) trough with continuous depth > 2500 m located in the middle of the Red Sea (where Sudanese Red Sea is located) as indicated in Fig. 6.

The Sudanese Red Sea is characterized by its numerous bays (Mersas) , including Port Sudan harbour as well as traversed by several khors (mainly Arbaat & Baraka) and seasonal streams draining into the Sea.

Fig.6 : Types of reefs around Port Sudan area



The coastline and the Red Sea Hills which bound the study area from its eastern and western sides respectively, form a semi – desert strip of land (coastal plain) 20 – 30 km wide.

4.4: Coastal & Marine Resources: (living resources)

The Red Sea is considered as a semi-enclosed elongated basin (2000 km long & 280 km wide), located in an arid zone area with irregular topography and bathymetry such peculiar features create a wide array of highly sensitive and productive habitats including, coastal vegetation, mangroves, seagrasses / algal, coral reefs and offshore islands.

These habitats which encompass a vast number of diverse living organisms, as important food and economic resources, are mainly located in the narrow strip of the coastal zone area.

The coastal and marine living resources together with non-living resources, existing in the study area will be cited in the following:

4.4.1: Coastal vegetation:

Mangroves:

Mangroves are the main conspicuous coastal vegetation (macro-halophytes) that constitute a characteristic feature of the Sudanese Red Sea coast. They are highly productive habitats (500 – 4000 mg C / m² / day) favorable for fishery activities, as nurseries for many commercially important fishes (mollusca, crustaceans & finfishes) and breeding sites for various seabirds. These trees are generally found (as stands or patches), at the coastline, at edges or around bays (mersas) and some offshore islands.

About 13 mangroves stands with varying sizes and density cover had been reported along the Sudanese Coast, mainly located south of Port Sudan & Suakin areas (Wilkei, 1995).

However, *Avicennia marina* is found to be the only predominant species in the area, forming mangroves mono-stands.

It is relevant to mention that when the present findings are compared with previous studies in the area, noticeable degradation in several



Mangrove

(نباتات ملحية)

Halophytes

mangroves stands (or patches), distributed along the coast could be observed mainly in the north and just south of Port Sudan and Suakin harbours. This might be attributed mainly to increasing coastal activities and other environmental influences (grazing, felling, damming high salinity and land – filling).

Halophytes:

These salt tolerant plants form a prominent feature of coastal vegetation, in the Sudanese coast, characteristic of arid zones. Various types of halophytes (ephemerals, annuals & perennials) of different sizes ($\leq 2.0 - 60$ cm high) occur just above the coastline (supralittoral zone), fringing much of the coast (1 – 3m wide) with varying densities. Their growth becomes more prolific and dense in the southern parts of the coast than in its northern parts where the coastal plain tends to be narrower and the rainfall gets relatively scarce.

The dominant halophytes in the study and surrounding areas are low succulent (fleshy) shrubs ($\leq 20 - 60$ cm high), including several species mainly of *Suaeda*, *Zygophyllum* spp, *Arthrochemum* spp, *Halopeplis* sp, *Limonium* sp as well as small herbs, grasses and creeping forms.

The various common and/or dominant halophytes which form an important grazing ground and source of freshwater, (mainly to camels) in the area, are as listed in Appendix 1. However such coastal vegetation, primarily *Suaeda* spp are also found to predominate several offshore islands, located north and south of the coast.

Terrestrial vegetation (inland):

The landscape of the Red Sea in general is a low scrubland, characteristic of tropical arid zone areas. Recent inland surveys were carried out along the coast (at, north & south Port Sudan harbour) for assessment and inventory of inland (or terrestrial) flora (freshwater dependent plants).

Results indicate that terrestrial vegetation in the area is typified by a mixture of grasses, herbs, shrubs and trees (up to 2 – 3m or more in height, including mainly, *Acacia* spp & *Prosopis* sp "Mesquite") interspersed with bare areas.



Some land vegetation

Both density and diversity of the inland flora, increase westward towards the Red Sea Hills (≤ 40 km distance), mainly located in Khors and Wadies where more freshwater is drained during the rainy season. It is also noted that the plant cover and biodiversity increase southward and decrease northward, along the coast depending on availability of freshwater.

Frequency of occurrence and species composition of the major terrestrial (freshwater-dependent) vegetation, reported in the area, are as shown in Table 2.

4.4.2: Marine vegetation :(Seagrasses / Seaweeds)

Seagrasses (marine plants) and seaweeds (macro algal) form one of the most highly productive habitats in marine (offshore islands) and coastal environments – Beside their biological and economical importance in maintaining potential fishery resources (fishes, molluscs & crustacean including shrimps), they are considered as important nursery grounds for enormous herbivorous fishes and food for key species such as Dugongs & turtles as well as providing shelter for most of these marine resources (particularly seagrasses).

Seagrasses are soft – bottom (muddy / sandy) communities, usually grow in sheltered waters, behind fringing reefs with coastal lagoons (≥ 20 m deep) and around offshore islands. Correspondingly seaweeds are considered as hard – bottom communities, inhabiting shallow coastal waters, fringing reefs, outer reefs and offshore (submersed) coral islands. They are mainly influenced by substratum, location and coastal activities (dredging, land-filling & hot effluents)

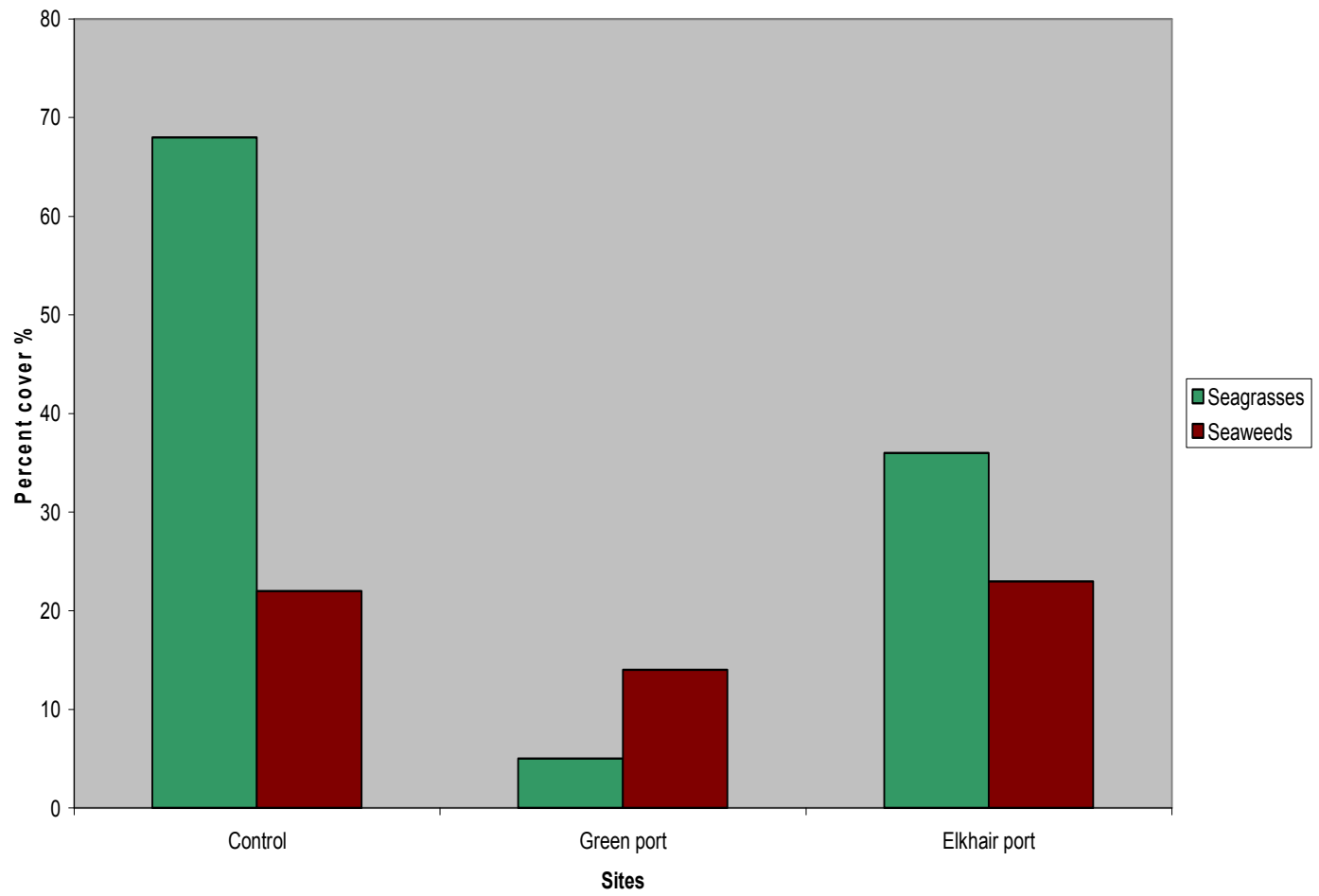
The density cover (%) of sea vegetation estimated in the area varies between moderately low (5.0 – 32.7 %) to moderate (10.0 – 45.0 %) and with mean average cover of 28.0 % and 15.0 % for seagrasses & seaweeds respectively.

Variations in density cover and species composition of the sea vegetation in the area were as illustrated in Fig.7 & Appendix 2.

Table (2): Occurrence of the main terrestrial flora around Port Sudan area

No.	Family	Species name (Latin name)	Arabic Name
1	Asclepiadaceae	<i>Calotropis procera</i> <i>Leptadinia pyrotechnica</i>	Usher Marakh
2	Caesapliniaceae	<i>Tamarindus indica</i>	Aradib
3	Capparidaceae	<i>Boscia angustifolia</i> <i>Capparis deciduas</i> <i>Maerua crassifolia</i>	Shajaratalmafi Tundub Sarah
4	Graminae	<i>Panicum turgidum</i>	Tumam
5	Loranthaceae	<i>Loranthus curviflorus</i>	Anab
6	Mimosaceae	<i>Acacia nilotica</i> <i>A. melifera</i> <i>A. radiana</i> <i>A. spirocarba</i> <i>A. tortilis</i> <i>Prosopis chilensis</i>	Sunut Kitir Samar Sanganeid Samar Mesquite
7	Palmae(palmaceae)	<i>Phoenix dactylifera</i> <i>Hyphaene thebaica</i>	Nakheil Dome
8	Papilionaceae	<i>Indigofera oblongifolia</i>	Dahaseir
9	Rhamniaceae	<i>Zigphus spina christi</i>	Sidir
10	Salvadoraceae	<i>Salvadora persica</i>	Arak
11	Simarubaceae	<i>Balanites aegyptiaca</i>	Hjlij
Total number of pant species in each site			

Fig. 7 : Average density cover (%) of sea vegetation in the study area



However previous records of sea vegetation especially seagrasses inside the harbour area prior to Port expansions and several coastal constructions that took place, showed extensive growth, forming seagrass beds and seaweeds belts in the shallow coastal waters on either side of the Port.

This may well indicate the influence of the coastal activities occurred in the area which has have resulted in destruction of suitable habitats for these important resources.

4.4.3: Marine Invertebrates fauna:

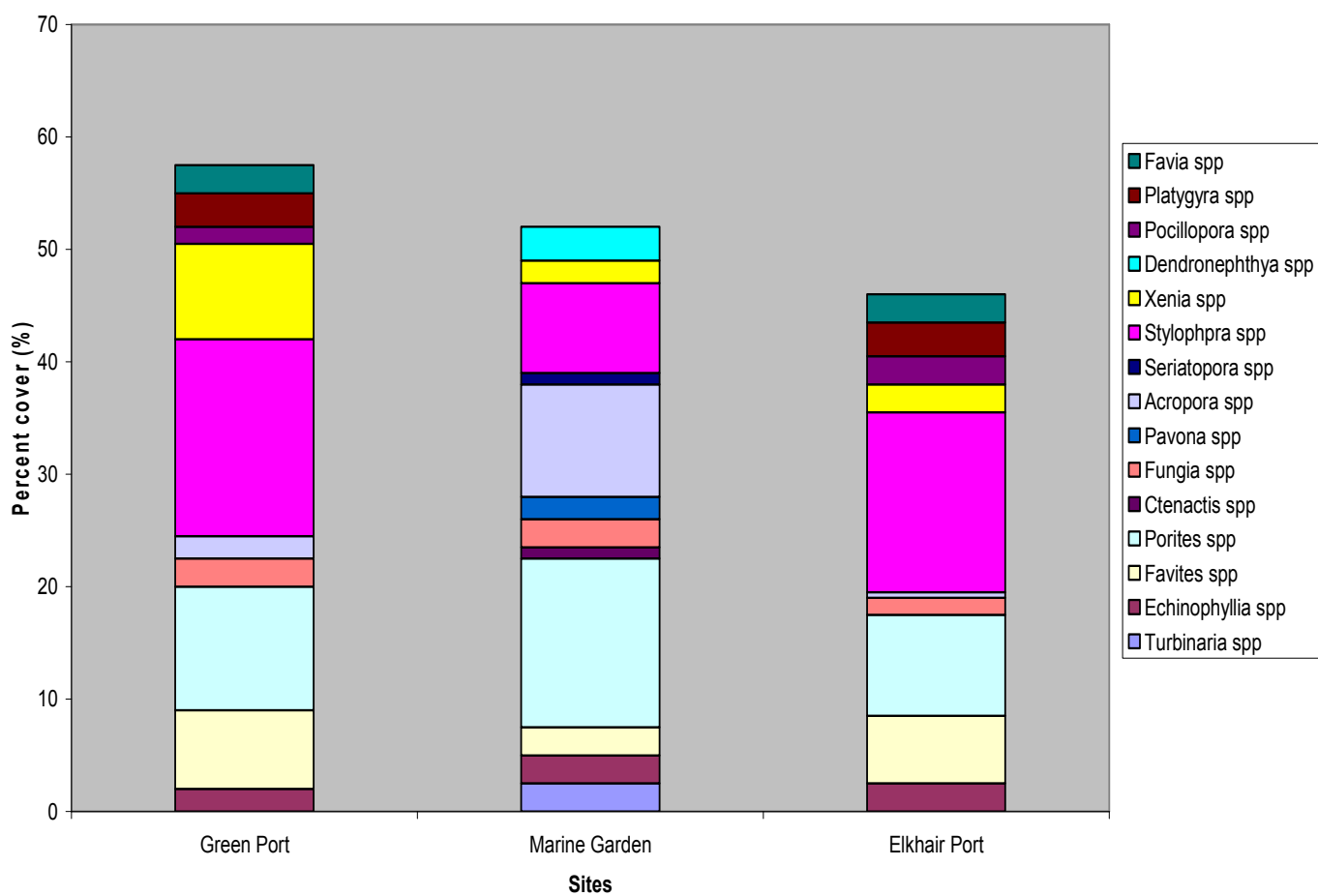
- **Corals:**

Corals are important benthic (sessile) marine organisms which form various and complex types of reefs including, fringing, barrier and atoll reefs (Fig. 6) Coral reefs are considered a characteristic feature of the Sudanese Red Sea which has some of the richest and diverse coral reefs in the world (Ormond, 1986). Such productive and more sensitive habitats, harbour vast numbers of important associated marine organisms with the optimum degree of species biodiversity. In addition to their ecological and economic importance, coral reefs form a major shelter against wave action and coastal erosion.

Three types of reefs exist in the Sudanese coast, particularly at Port Sudan including:

- Fringing reefs: They are parallel and almost continues reefs (1 – 3 km wide) except when interrupted by inlets leading to coastal lagoons (Mersas), including Port Sudan harbour.
- Barrier reefs: These are about 1-14 km in width such as Towartit (south) and Wingate (east to Port Sudan harbour) reefs and are usually separated from the fringing reefs by deep channels (100 – 400 m deep). Both reefs have been proposed as Marine Protected Areas (MPA'S).
- Atoll reefs: They are located offshore (north – east Port Sudan harbour) known as Sanganeb atoll reefs which arise from a steep sea – floor of more than 800 m depth. Due to the unique structure and coral diversity Sanganeb atoll (reefs) has been declared as MPA since 1990 (Fig. 6).

Fig.8 : Average density cover of dominant corals in Port Sudan harbour





Some types of corals

The aforementioned reefs, particularly, Sanganeb reefs composed of unique and highly diverse corals (≥ 150 species) and enormous associated marine life.

The estimated average coral cover (hard & soft) which is the living cover was found to range between $\leq 20 - 80$ % with lowest / moderate and highest cover in the range being reported at the reefs fringing the harbour and Sanganeb reefs respectively. The living cover of the dominant corals is presented in Fig. 8.

It can be observed from the present study and some other recent marine surveys carried out in Port Sudan harbour and surrounding areas that:

- Coral reefs and corals are relatively better developed and diverse in the outer (barrier) and offshore (Sanganeb) reefs than at the fringing reefs bordering the harbour.
- Almost all the hard (stony) corals encountered in the area are of hermatypic type (reef – building), contributing significantly in the reefs formation.
- Corals, reef types and coral diversity encountered in the study area, are characteristic of the central Red Sea which is globally famous of its highest marine biodiversity and hence one of the best SCUBA diving destinations in the world (Sheer and Pillii, 1983, Sheppard, et al. 1992).
- The common corals identified in the area (≥ 150 species belonging to more than 30 genera) indicate relatively high level of corals diversity in the area, particularly north of Port Sudan harbour

▪ **Invertebrates:**

The main macro benthic (motile) organisms assessed during the present study and from previous records, mainly at the fringing reef on the northern (Green Port) and southern (Elkhair Port) parts of the main harbour, included in terms of abundance:

Tridacna sp (Giant Clam – Mollusca)

Sea urchins (*Echinoderms*)

Sea cucumber (Echinoderms – "Aliseri")

Trochus sp (Mollusca – "kokian")

Strompus sp (Gastropods – "Abzrumback")

Triton (Gastropods)



Some Molluscs (رخويات)



Echinoderms (شوكيات الجلد)

Starfishes (*Acanthaster planci* – COT)

Their distribution and population density were as shown in Fig. 9. It was noted that both density and diversity of the above benthic fauna were generally low to moderate in the harbour area particularly *Trochus* sp, Sea cucumbers, *Strompus* and Trion. Earlier studies conducted in the northern and southern parts of the main harbour (before the recent ports expansions & marine constructions) showed relative abundance and high diversity of marine invertebrates in the area especially *Trochus* & Sea cucumber in addition to *Strompus* (Eltyeb, 1999, Ibraheem, 2000 & Elhag et al, 2007).

Such low density and diversity of these economic and ecologically important invertebrate groups (particularly the latter ones) can be attributed to environmental impacts as a result of the coastal activities, took place in the area beside over-fishing or collection of these organisms, mainly for trade.

However marine invertebrates (from previous and recent records) were noted to be more abundant and diverse in the outer (barrier) reefs (Towartit & Wingate) of Port Sudan harbour indicating relatively less coastal influences.

It is relevant to mention that, the Sudanese Red Sea in general, notably its northern part (Port Sudan harbour area and further north) is considered to be the most favourable fishing grounds for these commercially important shellfishes.

4.4.4: Marine vertebrate fauna:

▪ Fishes:

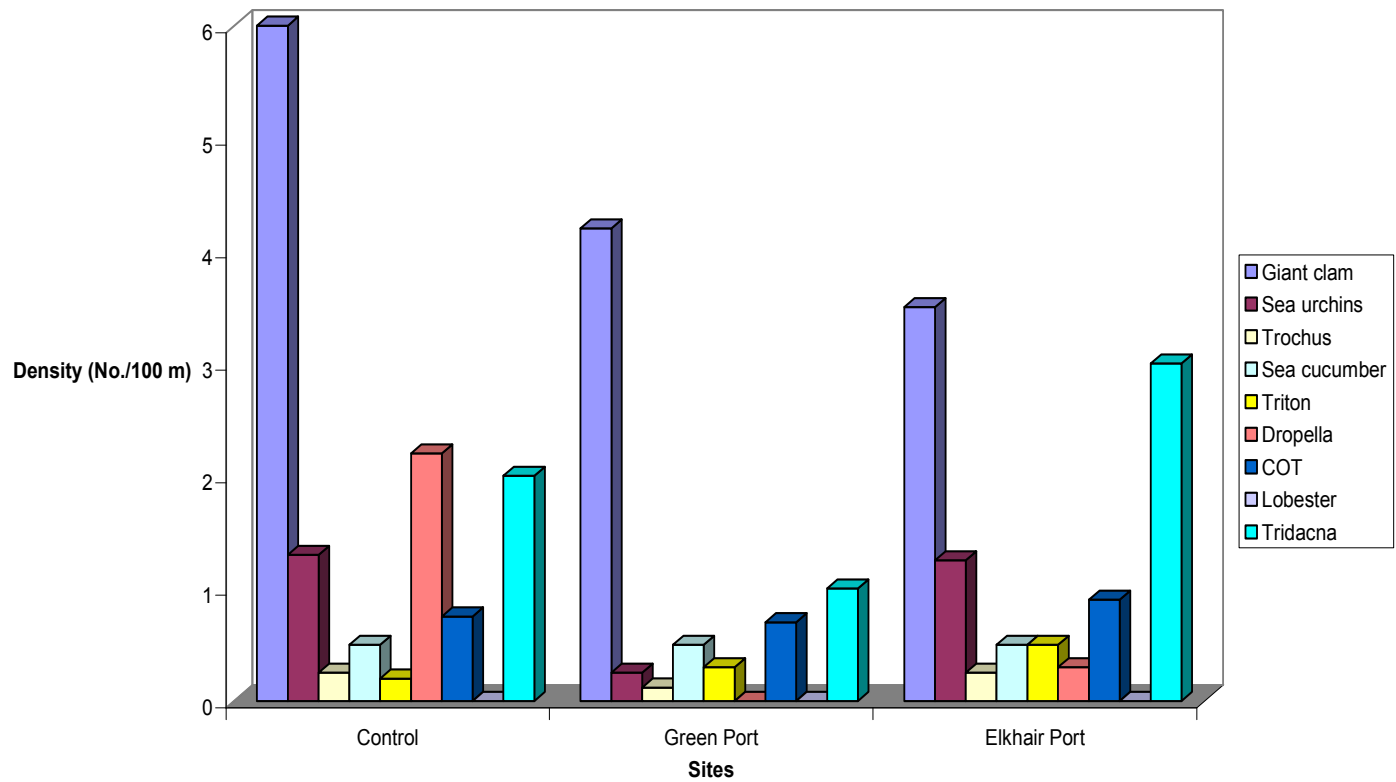
1. Reef fishes:

Coral reef finfishes have been assessed and identified mainly in the northern and southern fringing reefs bordering the harbour. They are primarily reef associated fishes of variable sizes (≤ 10 – ≥ 30 cm), encountered at the reef crest and reef slope.

Relative abundance and variations of the main coral reefs groups (including fancy (exotic) fishes) were as presented in Fig. 10 & 11

It can be noted from the results that the population densities of the different coral reef fish communities reported in the harbour area are low

Fig. 9: Population density and variation of invertebrates in Port Sudan area :





Some coloured reef fishes

to moderate. On the other hand, their biodiversity is relatively high (particularly fancy fishes) as more than 50 species and genera, belonging to more than 20 families have been identified (Appendix 3). The various associated coral fishes species registered which include relatively larger groupers ie Plectropomus (Najil), snappers (Bohar) and relatively small to medium fish forms (mainly fancy fishes), including Butterfly fishes, Angel fishes, damselfishes, sweetlips small grouper & snappers are important economic fisheries potential in the area.

They are considered as valuable indicators in assessing reef finfishes in the Sudanese Red Sea (Najil & Bohar). Other reef associated fishes (fancy fishes) are also regarded as useful indicators of conditions of reefs systems as well as important index of high endemism and biodiversity in the area (Sale, 1971, Reese, 1978, & Krupp et al, 1994).

However population densities and diversity of the coral reefs fishes were assessed in the outer barrier (Towartit & Wingate) and offshore (Sanganeb atoll) reefs, located within Port Sudan harbour area (during previous surveys (2005 / 2006). Results revealed relatively more abundance and high diversity of coral reefs fishes in these locations compared to those reported in coral reefs fringing the harbour. This may well be attributed to impacts of coastal activities (Port expansion & marine construction) took place inside the harbour area.

2. Demersal & Pelagic fishes:

The main common coastal (demersal) and pelagic (open waters) commercial fishes reported (or sighted) in the present study as well as from records provided by the Marine Fisheries Department and from local fishermen are as listed in Table 3.

It is more relevant to mention that about 35 % of the total fish catch of the Sudanese Red Sea comes from its northern part (including Port Sudan area) which may well illustrate the relatively high fisheries potentials in such area

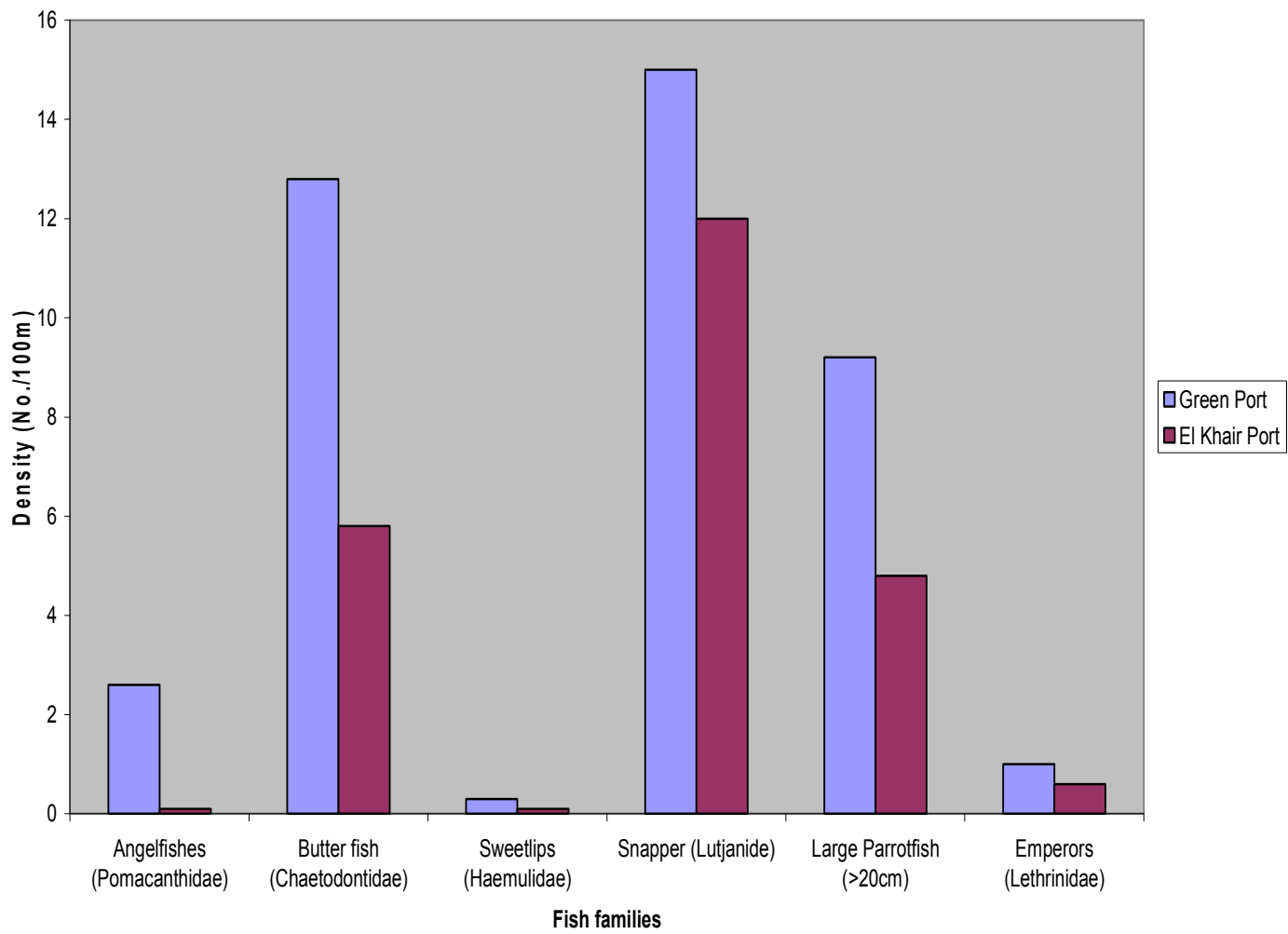
Table (3): list of important common fish species available in the study area

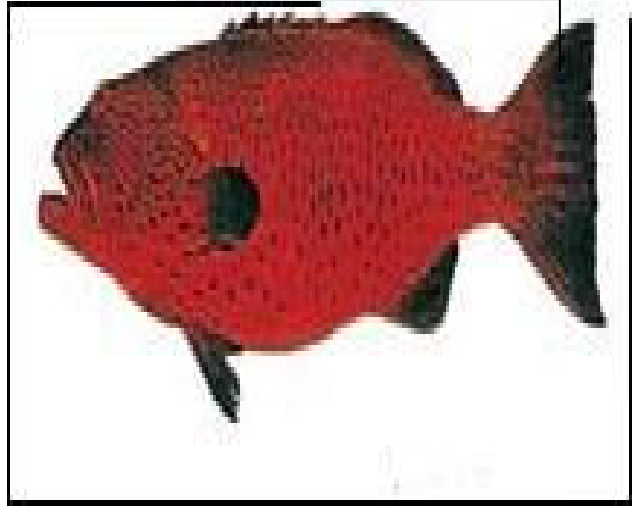
Local name	English name	Scientific name
Bounouk	Tarpon or Bone fish	<i>Albula vulpes</i>
Shagool	Giant Herring	<i>Elops machnata</i>
Salamani or Bunji	Salmon herring or Milk fish	<i>Chanos chanos</i>
Abusive	Wolf Herring	<i>Chirocentrus dorab</i>
Kombir	Gar fish or needle fish	<i>Tylosurus crocodiles</i>
Jajaloom	Soldier fish	<i>Holocentrum spp</i>
Betel	Google-eye	<i>Pricanthus hamrur</i>
Najil	Coral Trout	<i>Plectropomus maculates</i>
Kutrouban	Rock code	<i>Cephalophollis rogaa</i>
Goholab	Round- tailed Rock code	<i>Cephalophollis spp</i>
Rishal	Moon –tail code	<i>Variola louti</i>
Ghoushar shooni	Spotted Rock code	<i>Epinephelus aerolatus</i>
Tauwina	Grooper or merous	<i>Epinephelus tauvina</i>
Bayad or girim	Giant trevally	<i>Caranx spp</i>
Seleikh	Banded trevally	<i>Caranx emburi</i>
Bayad Goutar	Yellow spotted trevally	<i>Caranx fulvoguttatus</i>
Habot	Finletted trevally	<i>Caranx mate</i>
Kortom	Torpedo fish	<i>Melalaspis cordyla</i>
Shawish	Plumed trevally	<i>Alectis indica</i>
Teeman	Swallow tail	<i>Trachinotus bailoni</i>
Teeman	Pompano	<i>Trachinotus bailoni</i>
Shirwi	Leather skin	<i>Horinemus lysan</i>
Kanaf	Bat fish	<i>Blatax orbicularis</i>
Kaham	Ring –tailed surgeon fish	<i>Acanthurus gahm</i>
Abu- garin	Unicorn fish	<i>Nasaso uni cornis</i>
Farsi	Red snapper	<i>Aprion spp</i>
Hamroon	Red snapper	<i>Etelis carbunculus</i>
Koreib	Red snapper	<i>Pristi pomoides</i>
Fofal	Spiny snapper	<i>Argyrops spinifer</i>
Bohar	Red Bass	<i>Lutjanus bohar</i>
Safin	Mangroove Jack	<i>Lutjanus argentimaculatus</i>

Table (3): Conted

Asmoot	Scarlet Perch or Paddle-tailed	<i>Lutjanus gibbus</i>
Ablein asfar	Blue Banded Perch	<i>Lutjanus kasmira</i>
Hababir	Finger Mark Perch	<i>Lutjanus fulviflamma</i>
Kut	Balck Perch	<i>Macolor niger</i>
Telham	Rubber lip	<i>Gaterin schotaf</i>
Gadrenb or gattrin	Yellow –finned Rubber	
Fateletta or shikfa	Sweet lip	<i>Plectrorhynchus pictus</i>
Ko koi	Grunter Bream	<i>Pomadasys opercularis</i>
oor•Sha	Emperor or red mouth bream	<i>Lutjanus spp</i>
Agous	School Barracuda	<i>Sphyraena jello</i>
Faras elbhar	Sail fish	<i>Istiophorus gladius</i>
Umm falloos	Dolphin fish	<i>Coryphaena hippurus</i>
Arabi	Mullet	<i>Mugil spp</i>
Zerigan	Striped pike	<i>Sphyraena obstusaa</i>
Abu shenab	Goat fish or red mullet	<i>Mugil spp</i>
Sijan	Spine foot	<i>Siganus spp</i>
Silinty	Half beaks	<i>Hemiramphus spp</i>

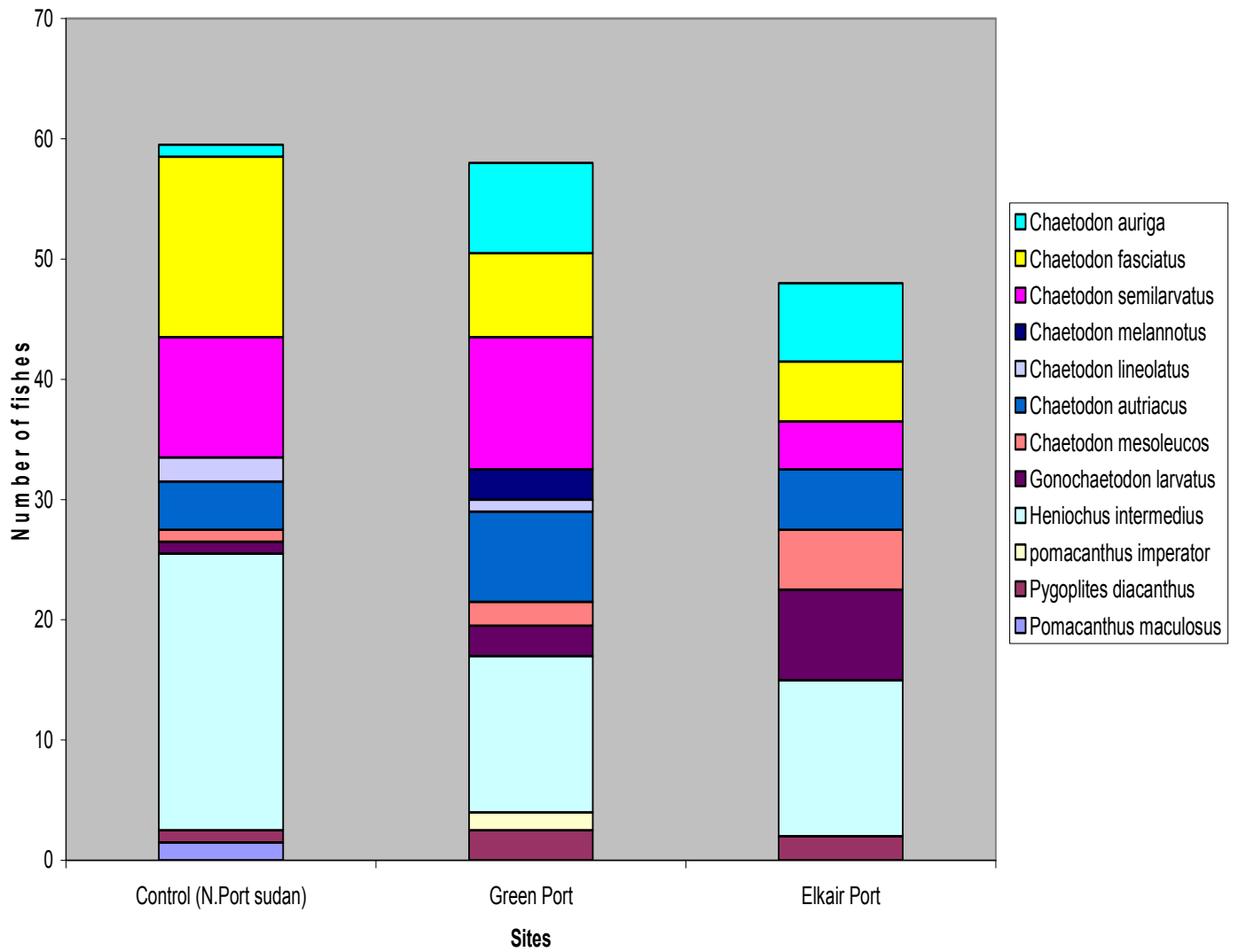
Fig.10 : Density and variations of dominant fish families in Port Sudan area





Some common Fishes

Fig.11 : Relative abundance and variations of butterfly fishes and angel fishes in the study area



- **Mammals:**

- i. **Dolphins (Cetaceans):**

Several species of dolphins occur regularly in the area including mainly bottlenose (Tursiops truncata) and the common dolphins (Delphinus delphis). They are sighted at several coastal and offshore waters of Port Sudan and several north and south areas along the Sudanese coast.

- ii. **Dugongs (Sirenia):**

The dugongs (Dugong-dugon) which are globally endangered species are generally found in few numbers throughout the Red Sea (≥ 220 populations).

However about 20 – 40 distinct population of dugongs were encountered in the Sudanese Red Sea (Ormond, 1980), but such number seemed to have declined appreciably. This might be due to increased accidental capture to these endangered key species. However, according to IUCN Red List of Threatened Species, dugongs, common dolphins and the Pilot Whale (Globicephala) are classified as endangered or threatened species.

- **Turtles:**

Four out of five pantropical turtles recorded in the Red Sea are common in the Sudanese Red Sea, including:

Hawksbill, Green, Loggerhead and Leatherback turtles. However, Hawksbills and Green turtles were observed to be the commonest species in the area mainly south, north offshore islands and fringing reefs areas (Gasparetti et al, 1993 & Al Mansi et al, 2003). Both types are categorized as endangered amphibians in the IUCN Red List of Threatened species.

- **Sea birds:**

Birds of the Sudanese Red Sea which form a prominent feature along the coast, notably at its northern part, are generally of tropical Indian Ocean origin.

Abundance and species composition of seabirds encountered in the Sudanese coast had been made by several investigations (Cooper et al, 1989 & PERSGA / GEF, 2000) and recent marine survey-carried out in the area (Elhag et al, 2008).



Some common sea birds

The various seabirds identified along coastal and offshore islands of the Sudanese Red Sea (> 20 species) were as listed in Table 4. Most of these listed species were reported north and north-east off coast of Port Sudan area.

4.5: Other Marine Resources : (Non – living)

These are non – living resources which can be summarized in the following:

- i. Piolet exploration studies of mineral resources (metalliferous deposits) in Sudanese / Saudi Arabia territorial waters (Atlantis II Deep – hot brines area) as a joint investment project between the two countries. The main minerals metals explored include gold, silver, Cu, Zn, Mg & Mn. However all the baseline studies have been completed just awaiting commercial exploitation of such resources.
- ii. Onshore and offshore oil/gas exploration and production in the mid and southern parts of Sudanese Red Sea (Block 15, Red Sea) operated since 2007 by Red Sea Petroleum Co. LTD (RESPOC).
- iii. Offshore seismic operations for oil exploration and production in the northern part of the coast (Block 13, Sudan) started this year (2008) by Coral Petroleum Operating Co. LTD (CPOC).
- iv. Freshwater is produced from limited desalination plants, belonging to private and public sectors. Plans are underway to install several plants mainly in Port Sudan & Suakin harbour areas.
- v. Table salt is produced at relatively large scale (for local consumption and for export) from natural and constructed saltpans located mainly, north and south of Port Sudan harbour.

5. Main sources of environmental impacts:

The Sudanese Red Sea environment is still considered in largely pristine conditions compared to other parts of the Red Sea region and pollution is mainly confined to Port Sudan harbour area. Nevertheless, both coastal and marine environments and their resources are becoming vulnerable to various environmental threats due to increasing urban, industrial & recreational development and other marine practices in coastal and marine environments especially around Port Sudan harbour area.

Such environmental hazards are expected to augment (increase) and spread along the coast as further unplanned coastal development continues to occur (MEPA, 1989). That will eventually lead to degradation of the environment and depletion of resources. The main environmental impacts in the area which usually originate from land-based and marine-based sources can be summarized as follows:

5.1: Land-filling and dredging:

Such destructive practices are considered one of the main environmental problems related to the present coastal land uses and human activities. They are usually carried out in nearshore and shallow coastal waters for marine constructions and therefore result in destruction and loss of a number of biologically productive habitats, including coastal vegetation, mangroves, seagrasses, coral reefs and associated fisheries. These activities have increased appreciably in the Sudanese Red Sea Coast; especially in Port Sudan & Suakin areas where port expansion and construction works took place. As a result important habitats such as fringing reefs & seagrasses together with their associated marine organisms were seriously affected at the two harbours.

The situation may become more serious when more port expansions & construction operations continue at the existing harbours as well as new (O'seif) and proposed ones north of Port Sudan (Arakiyai) and south of Suakin (Trinkitat & Agig) .

5.2: Oil pollution:

Oil is becoming the main source of pollution in the Red Sea which occurs as a result of improper handling at oil terminals or accidental spills and discharges due to navigation risks. Oil pollution has serious direct or indirect effects to marine habitats and their associated marine living resources and other marine activities. It could hamper coastal and offshore constructions & operations.

Table (4): Sea birds species common in Port Sudan area:

Common Name	Latin Name
Brown Booby	<i>Sula Leucogaster</i>
Western Reef Heron	<i>Egretta gularis</i>
Osprey	<i>Pandion haelietus</i>
Saker Falcon	<i>Falco cherrug</i>
Demoiselle Crane	<i>Anthropoides vergo</i>
Terck sandpliper	<i>Xenus cinerus</i>
Sooty Gull	<i>Larus hemprcchii</i>
White – eyed Gull	<i>L. leucaphthalmus</i>
Black – Ground Sparrow	<i>Eremopterisc nigriceps</i>
Caspian Tern	<i>Sterna caspia</i>
White – cheeked Tern	<i>Sterna repressa</i>
Sooty tern	<i>Sterna fuscata</i>
Bridled Tern	<i>Sterna anaethetus</i>
Pink – backed Pelican	<i>Pelecanus rufescens</i>
Little Green Heron	<i>Butorides striatus</i>
Goliath Heron	<i>Ardea goliath</i>
Spoonbill	<i>Platalea Leucorodia</i>
Crab Plover	<i>Dromas ardeola</i>
Sooty Falcon (terrestrial)	<i>Falco concolor</i>
Clamorous Reed Warbler (terrestrial)	<i>Acrocephalus stentoreus</i>
Graceful Prinia (terrestrial)	<i>Prinia haesitata</i>

Oil pollution in the Sudanese Red Sea which was (few years ago) mainly restricted to Port Sudan close waters, it is at present becoming a serious problem to marine environment and its resources. This is due to construction and operation of two oil exporting ports (Bashair 1 & 2) which have been in operation since 2006 /2007 (located just south of the main harbour). There are already evidences of oil pollution, along several parts of the coast north & south of Port Sudan. Sources of pollution in the area come mainly from crude (or refined) oil leakages during loading and unloading, accidental spills due to navigation risks as well as dispersal of used engine oil from land-based facilities and anchored ships. This is in addition to discharges of oily ballast water from coming in or passing by oil tankers which often occur. However relatively major oil spills have recently been reported from the existing two oil exporting Ports.

Also in view of the increasing rate of hydrocarbons (oil / gas) exploitation production in the Sudanese Red Sea onshore and offshore waters already started (2007 / 2008) covering almost 75 % of the coast; much stresses on environment and resources are expected.

Therefore mitigation measures, such as oil contingency plan ought to be taken in order to meet these challenges

5.3: Chemical and thermal pollution:

The main sources of such types of pollution originate from various industrial plants i.e Oil Refinery, Power Plants, oil terminals, Flour Mill Factory, Tyre Factory (not operating) & Desalination Plants. The major pollutants include almost every category namely, oily waste (crude, refined and used oil), chemicals, detergents, heated water effluents and some organic contaminants (insecticides). All the wastes (solid or liquid) and cooling water generated from these facilities are directly discharged into the sea (untreated or treated). So such existing plants are considered to be responsible for the continuous deterioration of the environmental and degradation of both quantity and quality of marine life.

However more exhaustion and depreciation of marine environment and marine living resources are expected in the area, due to petro-chemical industry (in the economic Free-Zone Area 600 km², located between Port Sudan & Suakin) and other coastal developments, planned along the coast.

5.4: Wastes disposal:

It is another source of pollution which, at present, poses a real problem facing the coastal zone area environment. Both solid (plastics, tins, pesticides, fertilizers, chemicals and other garbage or litter) and liquid (industrial & municipals effluents) wastes exist.

Waste management in or around Port Sudan is largely uncontrolled though there is a regular system of garbage collection. Thousands tons of solid wastes are collected daily from the town (and the port area) and dumped out at the outskirts (open dumping).

Discharge of untreated sewage directly into the Sea, from land-based sources, though limited, also occurs (mainly in Port Sudan area).

However with the noticeable accelerating rate of urbanization and industrialization in the coastal zone area, in (already) absence of adequate facilities for collection, treatment and proper disposal of industrial, domestic and municipal wastes, more deterioration and degradation of the environment and marine living resources in the coastal zone area are expected (particularly Port Sudan area).

5.5: Other sources of impacts:

There are certain existing and expected other indirect sources of environmental threats to land / sea resources. These can be summarized in the following:

- Over-grazing and exploitation of natural resources due to increased human activities along several parts of the coast, coupled with poor planning and management. Such activities will result in serious reduction of land and coastal vegetation cover that will lead to deforestation (especially mangroves) and desertification in the coastal zone area.

The direct impact will be erosion and increased sedimentation (sedimentation) which adversely affect the marine environment and cause damage to or loss of sensitive habitats (seagrasses & coral reefs) and their associated marine fisheries.

- Roads building: Construction of permanent roads such as that made between Port Sudan – Suakin (main high way) and Suakin / Tokar (≈150 km) along the southern coast have their direct influence on the coastal and marine habitats.

Appreciable habitat loss and fragmentation to terrestrial (land) and coastal (mainly mangroves) plants have already been noticed in the area. However more pressure and negative impacts on the coastal / marine vegetation environment and biodiversity are anticipated along the entire coast as a result of construction of a permanent road (well underway) from Port Sudan till the Egyptian borders in the north ($\approx \geq 220$ km long).

- Agricultural & mining activities: Extensive use of pesticides, insecticides and herbicides for agricultural purposes mainly at Delta Tokar (southern coast) as well as mining for gold and gypsum production (in areas north and south-east Port Sudan), will impact land / coastal environments and habitats (especially terrestrial / coastal vegetation & fauna).

6. Institutional & Legal Framework:

a. Institutional arrangements:

According to the Quarter Century National Strategy (up to 2020). Sudan is committed to the pursuit of sustainable development and environmentally sound resources management. To this effect, the following Institutions are involved in the use and management of coastal & marine resources.

- The Ministry of Environment and Physical Development (established since 1994) with the mandate of coordinating environmental protection and resources management.
- The Higher Council for the Environment and National Resources (HCENR) – is the technical branch body in charge of coordination, policy making and international cooperation.
- Ministry of Environment and the Higher Council of environment in the Red Sea State (newly established).
- The Ministry of Energy and Mining, coordinates coastal & marine activities, regarding gas and oil explorations matters.
- The Marine Fisheries Administration & Fisheries Research Centre – Ministry of Animal Wealth, manage fisheries resources and control fishing and observe Fisheries regulation as well as consultation on shell fisheries culture areas and any fisheries related activities.
- Sea Port Cooperation (SPC), responsible for managing the ports of Port Sudan / Suakin & Oseif. It is also responsible for marine operation and Maritime Administration Directorate.
- Institute of Marine Research (IMR) & Faculty of Marine Sciences & Fisheries (FMSF) / Red Sea University (RSU) – regular monitoring to coastal / marine environments, coastal & marine research, training and provision of scientific advice on environmental & sustainable management matters.
- A national Marine Conservation Committee (MCC) and several NGOS, are active in the Red Sea State working in various social works including rehabilitation, health, nutrition and education. This is in addition to environmental conservation, management and governing regulations.

Sudan as a country member in the Regional Organization for the Protection of Environmental of the Red Sea & Gulf of Aden (PERSGA) is party to a number of principal international and regional conventions as outlined in Table 5.

b. Legal Framework:

Numerous environmentally related laws, legislations and regulations have been endorsed and in effect – which include:

- Environmental protection Act 2001: The Environmental protection Act is the basic environmental law in Sudan and provides an umbrella for general principles to be considered in conducting EIA studies, to assess potential environmental impacts (both + ve & - ve impacts) and provide recommendations for mitigation measures.
- **Environmental Protection Act:** Ministry of Environment and Tourism – Red Sea State (endorsed in 2006).
- **Environmental Health Act 1975: The Public Health Act 1975:**
These laws prepare & implement a scheme for the safe drainage and disposal of wastes and effluents of the quality permitted under the rules or the bye-laws. Also they ensure the correct calculation, reporting and payment of pollution charges by polluting / industrial units.
- **Industrial Safety Act 1976:** Prohibits industrial, atmospheric, water and soil pollution and regulates working conditions in factories.
- **Petroleum Wealth Act 1998:** It is a basic law which regulates the Oil & Gas sector in Sudan. Environmental health, safety precautions and measures to safeguard against environmental pollution due to such activities.
- **Petroleum Concession Agreements:** Legal context signed between Ministry of Energy & Mining (MEM) & oil operating Companies in the Protection Health Act (1998).
- **Regulations for the protection of the Environment 2007 (amended 2005).**
- **Wildlife Protection and National Parks Act. 1986:** Issued to provide protection, conservation and management of Wildlife and setting of national resources or parks (including marine protected area)
- **Forests and Renewable Natural Resources Act 1989 (amended 2002).**

Table (5): Regional and International Conventions

Title of Convention	Situation
Bamako convention on the ban of the import into Africa and the control of transboundary movement & management of Hazardous wastes in Africa.	Ratified
Basel convention on the control and transboundary hazardous wastes and their disposal movement.	No action
Convention concerning the protection of the world's culture and natural heritage.	Ratified
Convention on Biological Diversity.	Signed, ratified and entered into force
Convention on international trade in endangered species of wild fauna and flora.	ratified and entered into force
Convention on nuclear safety	Signed
Convention on the conservation of migratory species of wild animals.	No action
Protocol concerning regional co-operation in combating pollution by oil and other harmful substances in cases of emergency.	Signed and ratified
Ramsar convention on wetlands of international especially as wetland habitat.	No action
Regional convention for the conservation of the Red Sea and Gulf of Aden environment.	Signed and ratified
United Nations convention on law of the Sea	Signed, ratified and entered into force
United Nations convention to combat desertification.	Signed and ratified
United Nations framework convention on climate change.	No action
Vienna convention for protection of the Ozone layer.	ratified and entered into force

- **Port regulation, 1937 & Port Sudan Harbour General Bye – laws, 1979:** The Port regulations touch upon pollution matters to a limited degree.
- **The Marine Fisheries Ordinance, 1937 (amended in 1975 and has been recently revised and updated):** It deals with protection and conservation of marine environments & marine organisms – including forbidding and use of spear guns & prohibition of shells and corals collection, as well as endangered or threatened key species.
- **Integrated Coastal Zone Management Plan (ICZM):** It was endorsed in 2005 and jointly sponsored by the Federal Ministry of Environmental & Physical Development and Ministry of Environment and Tourism in the Red Sea Sate (RSS).
- **Red Sea State Local Laws & Guidelines:** Various decrees, laws and regulations related to environmental protection, including Decree of the establishment of the State Council for Environment and Natural Resources (1999), industrial Development and Regular Law, 1998, Public and Environmental Health Law 2001. However, the Environmental Protection Act for the Red State (as stated above) has been eventually endorsed by the RSS Government (2006) in accordance with the National Environmental Protection Act (2001).

7. Recommendations & Conclusions:

In view of the main sources of environmental impacts identified and assessed, which are considered as priority issues of major threats to marine environment & resources in the area – the following mitigation measures and management strategies are recommended:

- Development and enforcement of a contingency plan for emergency responses to any minor or major disasters (national or incidental) for abrupt control of any resultant contamination (or damage) to the marine environment and marine life in Port Sudan harbour area especially oil spills).
- Establishment of an effective reception facilities plant in the main harbour for proper handling, treatment and appropriate disposal of wastes (solid & liquid) collected from anchored ships and land-based sources.
- Development and implementation of effective control of dredging and filling of coastal areas for urban, industrial development, port construction and dredging of navigational channels.
- Establishment and implementation of waste water treatment and industrial discharges coupled with effluent monitoring program to ensure compliance with the stated criteria and standards.
- Development of natural integrated coastal zone management plan (ICZMP) with a view to regulate and control coastal activities within coastal and marine areas.
- Enforcement Environmental Impact Assessment (EIA) studies for all coastal and marine development projects prior to implementation.
- Establishment of regular advanced monitoring system for continuous assessment and evaluation of the state of environment with respect to & water quality, marine resources and biodiversity in coastal & marine areas. This will facilitate detection of any expected resultant impacts in such area.
- Strengthening and enforcement of updated existing laws, regulations and legislations related to marine protection and management of coastal & marine areas.
- Identification and establishment of more protected areas and reserves along the Sudanese Coast, to maintain the integrity and biodiversity of habitats.

However the success of execution of the afore mentioned strategies and mitigation programs depends mainly on:

- i. Strengthening the legal & institutional capacities of the country to enable implementation of the programs.
- ii. Strengthening capacity of local scientists and technicians to deal with different aspects relevant to the strategies and programs.
- iii. Establishing an effective environmental protection system and strengthening the existing national institutions in order to improve efficiency in enforcing national & regional legislations.
- iv. Establishing mechanisms by the Government which integrate all the policies relating to the protection of the coastal and marine environment at both national and regional levels.

Conclusions:

Sudanese Red Sea Coast is considered to be comparatively conservative i.e in rather pristine conditions. Nevertheless, in view of the rapid increase in coastal & marine activities due to expanding industrialization and urbanization developments in the area, such characteristic conditions will no longer exist.

More deterioration and degradation of coastal / marine environments and living resources are expected with further developments unless proper setting, planning, mitigation and management strategies & programs are considered.

The central issue is how to plan and manage present and future coastal and marine uses in an environmentally sound manner. Doing so, will eventually achieve sustainable development along the Sudanese Coast and hence keep providing valuable assets for the present and future coming generations.

References:

Al- Mansi, A.M, Suzan, A.B, Ehab, O.A, Sheikheldin, A. M. (2003):

The marine turtles in the Republic of the Sudan: Their Biology
and conservation, Report, pp 25.

Cooper, J, Williams, A.J. & Britton, P.L. (1984): Distribution, population sizes
and conservation of breeding sea birds in the afro tropical region.
Tech. Pub. No.2: 403 – 419.

El hag etal (2007 / 2008): Baseline and Environmental Impact Assessment Studies
in the southern & northern parts of the Sudanese Red Sea –
RESPOC. 2007 / SV 007 & CPOC / 2008 / HSE – 001 Reports.

Eltyeb, M.M (1999):Studies on biology, ecology and fisheries of *Trochus*
dentatus (kokian)
in the Sudanese Red Sea – M.Sc dissertation.

Gasparette, J, Simposon, A, Miller, J, Ross, P & Gasparette, P. (1993).
Turtles of Arabia. 13, p 170 - 367.

Ibrahim, M.Y. (2000): Studies on some Holothurians of Sudanese Red Sea.
M.Sc dissertation.

Krupp, F. H. Paulus, J & Nasr, D. (1994): Coral reef fish survey – Sanganeb Atoll in:
A report on Comparative
Ecological Analysis of Biota and Habitats in Littoral and Shallow
Sub-littoral Waters of the Sudanese Red Sea. P 63 – 82.

MEPA (1989): Environmental Protection Standards: MEPA Document, 1409 – 01

Marcos, S.A. (1970): Physical and chemical oceanography of the Red Sea. Oceanogr.
Mar. Biol. Ann. Rev. 8: 73 – 202.

Ormond, R. F.G. (1980): Occurrences and feeding behavior of the Red Sea coral
fisheries. Proc. Symp. Coastal and marine environment of the Red Sea,
Gulf of Aden and Trop. W. Indian Ocean. Khartoum, 2: 327 - 372.

- Ormond, R.F.G. (1986):** Distribution and status of Critical habitats in the Indian Ocean region. In: Pro. IOC/UNESCO Workshop on regional cooperation in marine science in central Indian Ocean and adjacent Seas and Gulfs, Colombo, IOC Workshop, Rep. 37. p 167 - 193.
- PERSGE / GEF (2002, b):** The Red Sea & Gulf of Aden Regional Network & marine protected areas. Regional Master Plan. PERSGA Techni series No, 1. PERSGA, Jeddah. 82 pp.
- Reese, E. S. (1977):** Co - evaluation of corals and coral feeding of the family chaetodontidae. Proc. Of third Intern. Coral reef Symp. Miami, 1 267 – 274.
- Sheer, G & Pillai, C.S.G. (1983):** Report on the stony corals from the Red Sea Zoologia 133: p 1 - 198.
- Sheppard, C. R.C, Price, A. R. G & Roberts, C.M. (1992):** Marine Ecology of the Arabian Region: Academic Press, London. 359 pp.
in extreme tropical environments
- Siraj, A. (1988):** Climate of Saudi Arabia. Climatological features of Saudi Arabia. Fauna of Saudi Arabia 6: 32 - 52.
- Techemia, P. (1980):** Descriptive Oceanography, Pergamum, London.
- Theil, H. H. Weikert, H and Karbe. L. (1986).** Risk assessment for mining metalliferous muds in the Deep Red Sea.
Ambio 15: 34 - 41.
Assessment of land-based sources and activities affecting the marine environment in the Red Sea & Gulf of Aden Rs – Report No. 166.
- Wilke, M.I(1995):** Mangroves Conservation & management in the Sudan
FO. GCP / SUD / 047 / NET: 92 pp

Appendix (1): Composition of the dominant coastal vegetation in the Study Area

No.	Family	Species name (Latin name)	Arabic name
1	Amaranthaceae	1) <i>Aerva javanica</i> 2) <i>A. lanata</i>	Ras alshaib
2	Asclepiadaceae	3) <i>Calotropis procera</i> 4) <i>Caralluma vittata</i> 5) <i>Leptadinia pyrotechnica</i>	Usher Shaob Marakh
3	Boraginaceae	6) <i>Arnebia hispidissima</i> 7) <i>Heliotropium aegyptiacum</i> 8) <i>H. logiflorum</i> 9) <i>H. strigosum</i> 10) <i>H. sudanicum</i>	— Ghurira Ghurira Ghurira Danab alagrab
4	Caesapliniaceae	11) <i>Cassia italica</i> 12) <i>C.senna</i> 13) <i>Tamarindus indica</i>	Sana Sanamaka Aradib
5	Capparidaceae	14) <i>Boscia angustifolia</i> 15) <i>Cadopa rotundifolia</i> 16) <i>Capparis decidua</i> 17) <i>C. spinosa</i> 18) <i>Cleome brachycarpa</i> 19) <i>Cleome paradoxa</i> 20) <i>Maerua crassifolia</i>	Shajarat almafin Kurmut Tundub Lasaf Abu liqaita Na'na'a Sarah
6	Chenopodiaceae	21) <i>Arhochemum glucum</i> 22) <i>Atriplex farinosa</i>	Shinan Hantal

	Chenopoliaceae	23) <i>Suaeda fruticosa</i> 24) <i>S. monica</i> 25) <i>S. vermiculata</i>	Suwaida Adlib Suwaida
7	Compositae	26) <i>Launaea goraensis</i> 27) <i>Pulicaria crispa</i>	Gathgath
8	Convolvulaceae	28) <i>Cressa cretica</i> 29) <i>Ipomoea blepharosepala</i> 30) <i>Seddera latifolia</i>	Mulaih Hantual Ahtirj
9	Cucurbitaceae	31) <i>Coccinia gradis</i> 32) <i>Colocynthis vulgaris</i>	Mugud Handal
10	Cyperaceae	33) <i>Cyperus conglomeratus</i> 34) <i>C. rotundus</i>	Ushb Najil
11	Euphorbiaceae	35) <i>Euphorbia granulata</i> 36) <i>Ricinus communis</i>	Libbina Khirwi'
12	Graminae	37) <i>Aeluropus lagopoides</i> 38) <i>Aristida mutabilis</i> 39) <i>Cynodan dactylon</i> 40) <i>Dactyloctenium aegyptium</i> 41) <i>D. aristatum</i> 42) <i>Echinochla colonum</i> 43) <i>Panicum turgidum</i> 45) <i>Lasiurus hirsultus</i> 45) <i>Sporobolus spicatus</i>	Najil Umm shera Najil Umm asaba' Okunish Difara Tumam Hada Najil

13	Illecebraceae	46) <i>Cometes abyssinica</i>	Dign alshaikh
14	Loranthaceae	47) <i>Loranthus curviflorus</i>	Anab
15	Mimosaceae	48) <i>Acacia nilotica</i> 49) <i>A. melifera</i> 50) <i>A. radiana</i> 51) <i>A. spirocarba</i> 52) <i>A. tortilis</i> 53) <i>Prosopis chilensis</i>	Sunut Kitir Samar Sanganeid Samar Mesquite
16	Molluginaceae	54) <i>Mollugo cerviana</i> 55) <i>Mollugo nudicaulis</i>	— —
17	Palmae(palmaceae)	56) <i>Phoenix dactyl lifera</i> 57) <i>Hyphaene thebaica</i>	Nakheil Dome
18	Papilionaceae	58) <i>Indigofera oblongifolia</i>	Dahaseir
19	Plummbaginaceae	59) <i>Limonium axillare</i>	Shalil
20	Portulacaceae	60) <i>Portudaca oleracea</i>	Rejla
21	Resedaceae	60) <i>Ochradenus baccatus</i>	Jurdi
22	Rhaminaceae	62) <i>Zigphus spina christi</i>	Sidir
23	Salvadoraceae	63) <i>Salvadora persica</i>	Arak
24	Simarubaceae	64) <i>Balanites aegyptiaca</i>	Hlijj
25	Tiliaceae	65) <i>Corchorus depressus</i>	Molokhia

			66) <i>C. tridens</i> 67) <i>C. trilocularis</i>	Molokhia Molokhia
26	Urticaceae		68) <i>Forsskalea tenacissima</i>	Lussig
27	Verbenaceae		69) <i>Avicennia marina</i>	Shura
28	Zygophyllaceae		70) <i>Tribulus pentandus</i> 71) <i>Zygophyllum album</i> 72) <i>Z. coccineum</i> 73) <i>Z. simplex</i>	Dirsesa Bawwal/Gurir a Bawal Jarmal
29	Zonichelliaceae		74) <i>Cymodocea ciliata</i> 75) <i>C. rotundata</i> 76) <i>Diplanthera uninervis</i>	Kanaf — Elal
Total number of pant species in each site				

Appendix (2): List of various sea vegetation species in the Port area:

a) Sea grasses:

Thalassia hermprichii
Halophila ovalis
Halodule stipulacea
Halodule uninervis
Cymodocea rotundata
Cymodocea serrulata
Syringodium isoetifolium
Enhalus Acoroides

b): Seaweeds (Algae):

Cyanophyta (Blue-green)

Lyngbya sp
Oscillatoria sp.

Chlorophyta (green)

Halimeda opuntia
Halimeda macroloba
Halimeda tuna
Caluerpa racemosa
Caulerpa serrulata
Caulerpa spp (2)
Bryopsis sp
Cladophora spp (3)
Enteromorpha sp.1
Enteromorpha sp.2
Udotea sp.
Chaetomorpha sp
Valonia sp
Dictyosphaeria sp

Phaeophyta (Brown)

Sargassum spp (4)

Cystoseira spp (3)

Turbinaria spp (3)

Padina pavonica

Padina spp (2)

Dictyota dichotoma

Dictyota spp (2)

Rhodophyta (Red)

Jania spp (2)

Hpynea spp (2)

Laurencia spp (4)

Gracilaria spp (3)

Gelidiella sp

Corralina (spp (3)

Number in Parenthesis (-): No of species

Appendix (3) :Fish families and species composition in Port Sudan area

Families	Speices
Serranidae	
	<i>Cephalopholis hemistiktos</i>
Pseudochromidae	
	<i>Pseudochromis sankeyi</i>
Lutjanidae	
	<i>Lutjanus ehrenberg</i>
	<i>Lutjanus fulviflamma</i>
	<i>Lutjanus spp</i>
Lethrinidae	
	<i>Lethrinus harak</i>
	<i>Lethrinus spp</i>
Pomacentridae	
	<i>Abudefduf saxatilis</i>
	<i>Abudefduf sexfasciatus</i>
	<i>Chromis careuleua</i>
	<i>Chromis dimidiatus</i>
	<i>Chromis atripectoralis</i>
	<i>Dascyllus aruanus</i>
	<i>Neopomacentrus xanthuru</i>
	<i>Plectroglyphidodon lecozona</i>
	<i>Pomacentrus sulfureus</i>
	<i>Stegastes nigricans</i>
Labridae	
	<i>Halichoereus hortulanus</i>
	<i>Halichoereus scapularis</i>
	<i>Halichoereus spp</i>
	<i>Thalassoma klunzingeri</i>
	<i>Gomphosus coeruleus</i>
Scaridae	
	<i>Cetoscarus bicolor</i>
	<i>Scarus collana</i>
	<i>Scarus ferrugineus</i>
	<i>Scarus frenatus</i>
Acanthuridae	
	<i>Acanthurus nigrofusus</i>
	<i>Acanthurus nigricans</i>
	<i>Acanthurus sohal</i>
	<i>Naso unicornis</i>
Balastidae	
	<i>Rhinecathus assasi</i>
Siganidae	
	<i>Siganus rivulatus</i>
Gobiidae	
	<i>Cryptocentrus spp</i>

Conted.....

Carangidae	
	<i>Carangoides bajad</i>
	<i>Caranx spp</i>
Chaetodonidae	
	<i>Chaetodon auriga</i>
	<i>Chaetodon austriacus</i>
	<i>Chaetodon lineoltus</i>
	<i>Chaetodon fasciatus</i>
	<i>Chaetodon semilarvatus</i>
	<i>Gonochaetodon larvtus</i>
	<i>Heniochus intermedius</i>
	<i>Megaprotodon trifascialis</i>
Pomacanthidae	
	<i>Pygoplites diacanthus</i>
Mullidae	
	<i>Parupeneus forsskali</i>
	<i>Parupeneus macronema</i>
Sparidae	
	<i>Acanthopagrus bifasiatum</i>
	<i>Rhabdosargus sarba</i>
Mugilidae	
	<i>Valamugil seheli</i>
Haemulidae	
	<i>Plectrohynchus gaterinus</i>
Dasyatididae	
	<i>Dasyatis urnak</i>
Sphyraenidae	
	<i>Sphyraena quenie</i>

Appendix (4): Staff Involved:

a. Professionals:

- 1. Prof. A'Gadir Dafalla Elhag:**
environmental

Marine biology and

sciences specialist –
(Director of IMR / RSU
– the Team Leader).

- 2. Prof. Amin Musa Elhag:**

economic and maritime
transport studies
specialist (Faculty of
Economic and
Administrative
Sciences – RSU).

- 3. Prof. Mohamed Al – Amin Hamza:**
specialist

Fisheries & mariculture

(Faculty of Sciences &
Fisheries / RSU – Vice
Chancellor of RSU).

b. Supporting technical & secretariat staff.