ENVIRONMENTAL IMPACT ASSESSEMENT (EIA)

IN OSMAN DIGNA (SUAKIN) HARBOUR

INSTITUTE OF MARINE RESEARCH
RED SEA UNIVERSITY

A STUDY SUBMITTED TO
SEA PORT CORPORATION
PORT SUDAN

MAY / 2007

CONTENTS

INTRODUCTION

Sudanese coast, stretching for about – 750 km is well recognized by its unique and diverse habitats including pelagic realm , coral reefs , seagrasses / algal beds and mangroves . They harbour potential coastal and marine resources comprising enormous commercially important finfishes fisheries, turtles, rare mammals and seabirds – which exhibit a high degree of biodiversity and endemism (Krupp et al 1994).

Such ecologically and economically valuable biological systems particularly coral reefs have become vulnerable to various types of pollutants. These arise mainly from oil leaks, industrial wastes, garbage heated effluents physical destruction and alteration of habitats, as a result of increasing coastal activities including ports development.

Suakin (Osman Digna) Port which is considered now the second harbour of Sudan has undergone notable rehabilitation during Sea Port Corporation development phased - plan which started since (1999 / 2000).

The development process involved dredging and widening of the harbour inlet and construction of platforms to receive passenger's ships. This was in addition to installation of a natural gas terminal.

Moreover, several new platforms will be constructed during this and next year (2007 / 008) in the same harbour with the intension of increasing its handling capacity to receive different cargo ships. This is inorder to meet the demands of the over growing levels of exports and imports of the country.

However such current and any other future planned coastal activities in the Port area expected to have their adverse impacts on the marine environment and eventually lead to deterioration and exhaustion of its potential living resources.

Accordingly, appropriate necessary precautions and measures should be under taken to mitigate any negative influences arising from such coastal activities on the ecosystem.

Objectives of the study:

The present work which is concerned which conduction of an environmental impact assessment study in Suakin (Osman Digna) Port, in relation to construction of new platforms contains the following objectives:

- Provision of base-line data to evaluate the status of marine environment and is resources prior to construction of the new platforms in the Port basin.
- Identification and assessment of magnitude and levels of coastal impacts on the environment and marine life in the area.
- Evaluation of methodology adopted during construction operations and provision of alternative options hat may assist in minimizing negative effects during and after construction of the platforms.
- High light the importance of sustainable use of coastal and marine resources and provide advice and recommendations that may help in avoiding or mitigating depletion of marine resources.
- Provision of advice and recommendations as guidelines for setting up appropriate environmental protection and management plans to attain sustainable development in the whole coastal zone area.

MATERIALS & METHODS

The Institute of Marine Research (Red Sea University) in collaboration with Faculty of marine Sciences & Fisheries , has been assigned by Sea Port Corporation to perform an environmental assessment study (EIAS) , preceding construction of more than ten platforms in Osman Digna (Suakin) Port. The study involves the relevant environmental biological and geological properties of the marine aquatic system. Such parameters will provide the base-line data pre- requisite for describing the state of the environment prior to platforms construction and help in evaluation of any resultant negative impacts on the area.

1. Description of the study area:

Suakin Port (later renamed Osman Digna Port) is a natural harbour located at the western side of the Red Sea (Lat. 19º 15ó N and Longit. 37° 22ó E).

Its inlet which is fringed by corals on either side is about 250 – 300 m wide, extending from the sea to about 3- 5km inland and terminates into a lagoon (2-3 km wide) surrounding old coral buildings (coral island) as shown in Fig.(.1)

1.1: Locating of study sites:

Six location sites (as transects or point stations) were selected at different parts of the harbour as follows:

- **i.** Stations 1,2,&3 (as transects) , were selected in the northern side of the harbour basin where more than ten new platforms (about 2.5 km long & 15- 20m deep) will be constructed Fig.(1&2.).
- **ii.** Station 4 (as transect station) located at the coast line just out side the harbour basin.

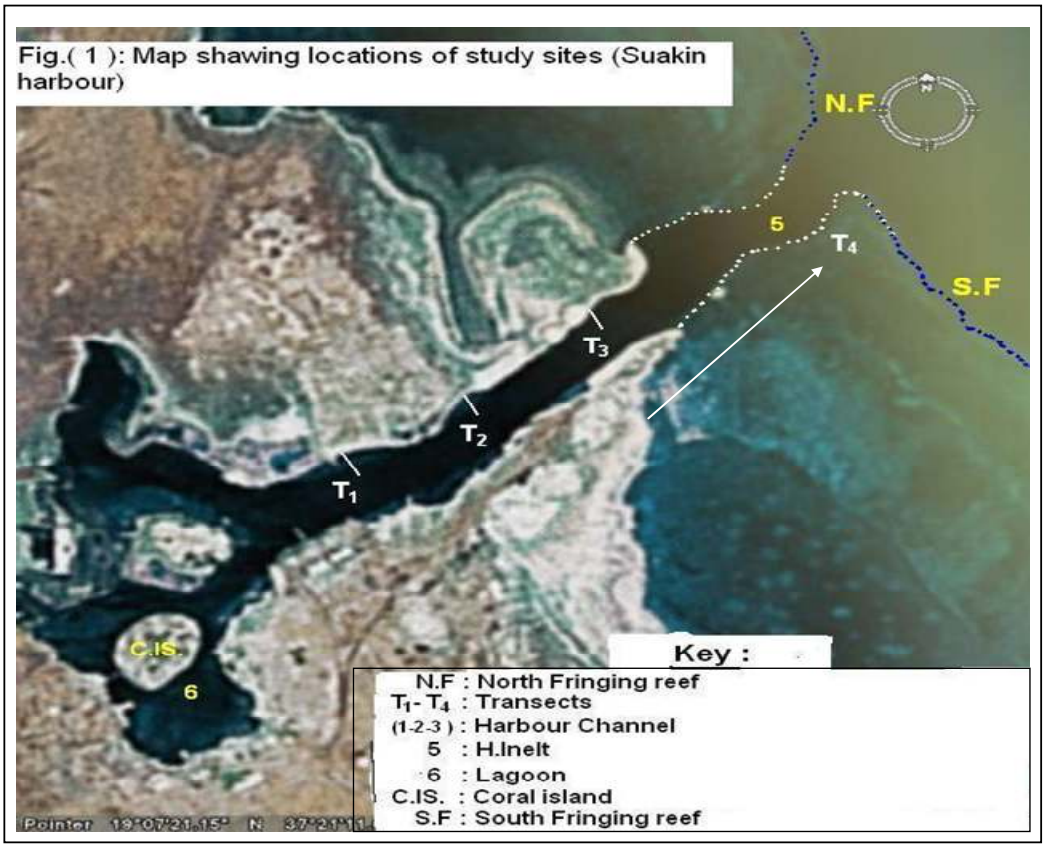
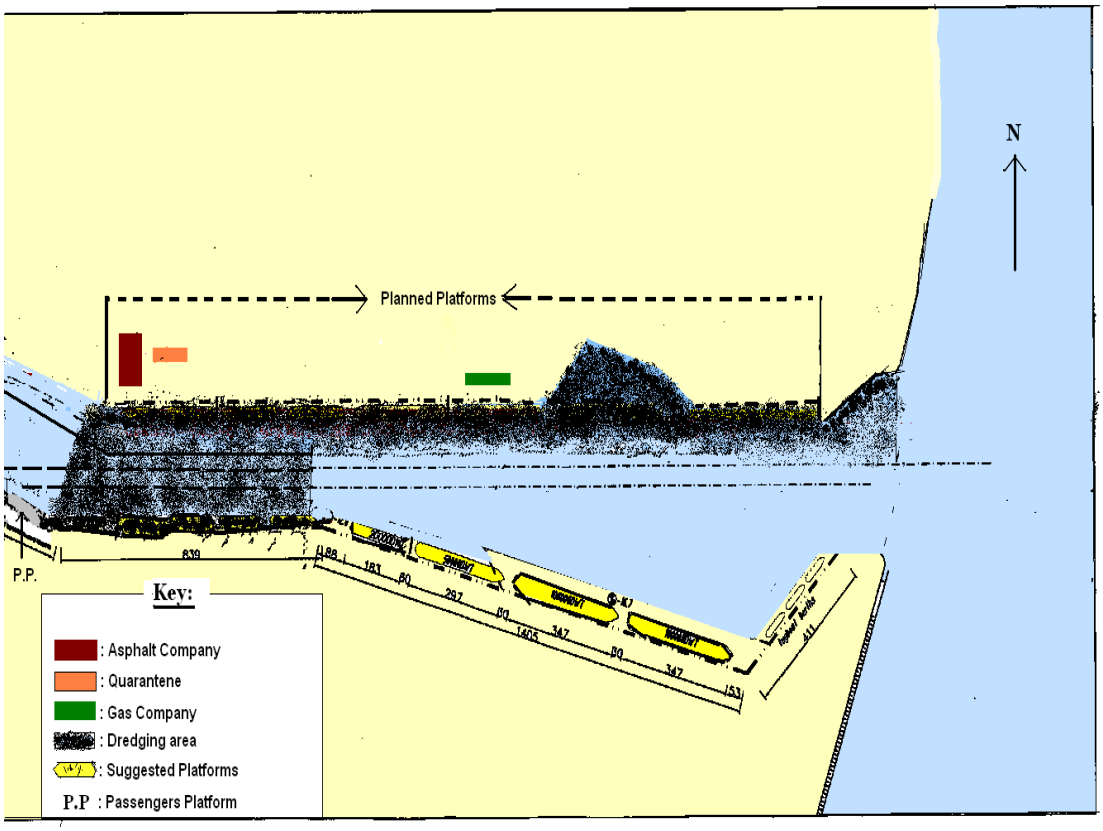


Fig.(1): Map shawing locations of study sites (Suakin harbour)
N.F
5
T4
S.F
T3
T2
T1
C.IS.
6
Key :
N.F : North Fringing reef
T1- T4 : Transects
(1-2-3) : Harbour Channel
5 : H.Inelt
6 : Lagoon
C.IS. : Coral island
S.F : South Fringing reef

Fig. (2): A sketch Map showing location of the Planned Platforms in the study area



iii. Stations 5&6 (as point stations) were chosen, one at the outer inlet (st. 5) and the other (st.6) at the innermost part of the basin (lagoon) as shown in Fig.(1) .

2. Work plan:

A work plan has been set up involving preparation and calibrations of field and laboratory equipments required for the following in-situ and laboratory analyses.

2.1: Physical parameters:

2.1.1: Air / water temperature (Cº) – measured by an ordinary Centigrade Thermometer (0º - 50 Cº).

2.1.2: Transparency (visibility) – measured by an enamelled metal Secchi Disk (diameter: 30 cm).

2.1.3: Salinity (S‰) – assessed by using a refractometer (rang: 0.0 – 50.0‰).

2.1.4: pH (hydrogen ion concentration) – using a battery – operated , portable pH Meter.

2.2: Chemical variables:

2.2.1: Dissolved Oxygen (DO_2) – applying Winkler Method as modified by Grasshoff (1983).

2.2.2 Inorganic nutrients including **:**

- Nitrite – Nitrogen (NO_2- N)
- Nitrate – Nitrogen. (NO_3-N).
- Phosphate – Phosphorus (PO_4 – P).

These were determined according to the modified Method of Strickland and Parson, 1965**).**

2.3: Geological studies:

2.3.1: Mapping and locating study sites

2.3.2: Thickness and classification of bottom sediments.

2.4: Biological characteristics:

2.4.1 Distribution ,density cover and biodiversity of coral reefs and reef formations inside and outside harbour basin

According to the Reef – check method cited in Standard Survey Methods (PERSGA, 2004).

2.4.2: Distribution, relative abundance and biodiversity or (composition) of invertebrate and vertebrate fauna, including mainly Molluska, Crustaceans, finfishes and coral reef fishes.

2.4.3: Ecology, density cover and biodiversity of sea vegetation (seaweeds & seagrasses) – adopting Standard Survey Methods of PERSGA (2004).

2.4.4: Plankton biomass assessment – according to Method of Lovegrove (1966).

RESULTS & OBSERVATIONS

Field surveys were carried out in Suakin (Osman Digna) port along selected stations (transects. 1, 2 &3), in the northern part of the harbour, where the planned platforms will be constructed. Other stations as transect (St.4) or as point (St**.** 5 & 6) stations were chosen in and outside the harbour.

The following pertinent parameters including, physico–chemical, biological and geological parameters have been analyzed.

1. Physical parameters:

1.1: Air temperature (C^{o}):

Air temperature measured (before noon) in the various stations (or transects) could be correlated with the water temperature although relatively higher. It was recorded within a narrow range of 25.5 – 26.0^{o}C reflecting winter conditions (Table 1).

1.2: Water temperature(C^{o}):

Water temperature records in the inner most (lagoon), mid and upper parts of the deep channel (stations 1, 2 &3) and outer part of the harbour basin (inlet) were found to vary between a similarly narrow range (23.0 – 23.5 C) as shown in Table (1) & Fig (3)**.**

1.3: Transparency (meters):

Water visibility in the main basin and the outer inlet of the harbour ranged between 4.0m – 10m, with the highest value being recorded at the inlet and the lowest one in the innermost part of the harbour (lagoon). Such findings may well indicate very low rate of resuspended sediments in mid. and outerparts of the harbour (deep channel).

On the other hand, the relatively low transparency value in the lagoon may reflect increase rate of suspended sediments and other particles, which is mostly due to coastal influences (Table (1) & Fig (4).

Table (1): Physico – Chemical variables in the study area (Suakin harbor)

Variables / Stations		Air temp(ºC)	Water temp (ºC)	Transperancy (meter)	pH	Salinity ‰	DO_2 (ml\l)	PO_4-P (µg-at/l)	NO (µg-
Inlet	5	26.0	23.0	10.0	8.6	40	4.72	0.98	
Harbor channel	1	26.0	23.0	7.5	8.58	40	4.68	0.58	
	2	26.0	23.0	8.0	8.6	40	4.58	0.56	
	3	26.0	23.0	8.3	8.58	39.8	4.63	0.56	
Island (lagoon)	6	25.5	23.5	4.0	8.6	39.5	4.80	1.00	

Fig.(3) Variation of surface temperature in the study area

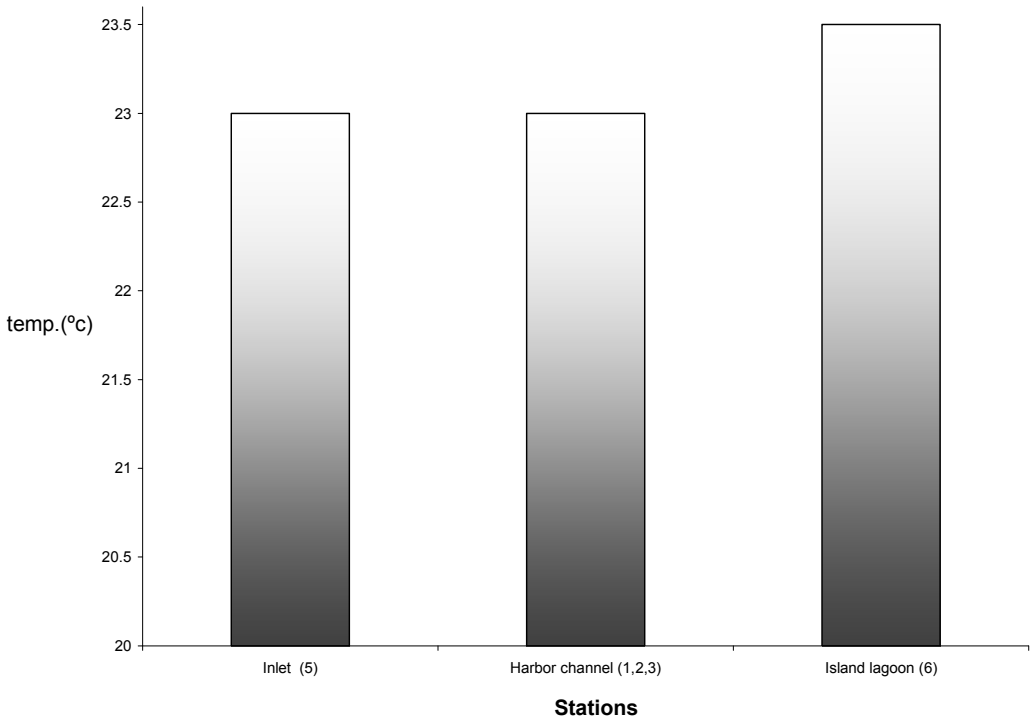
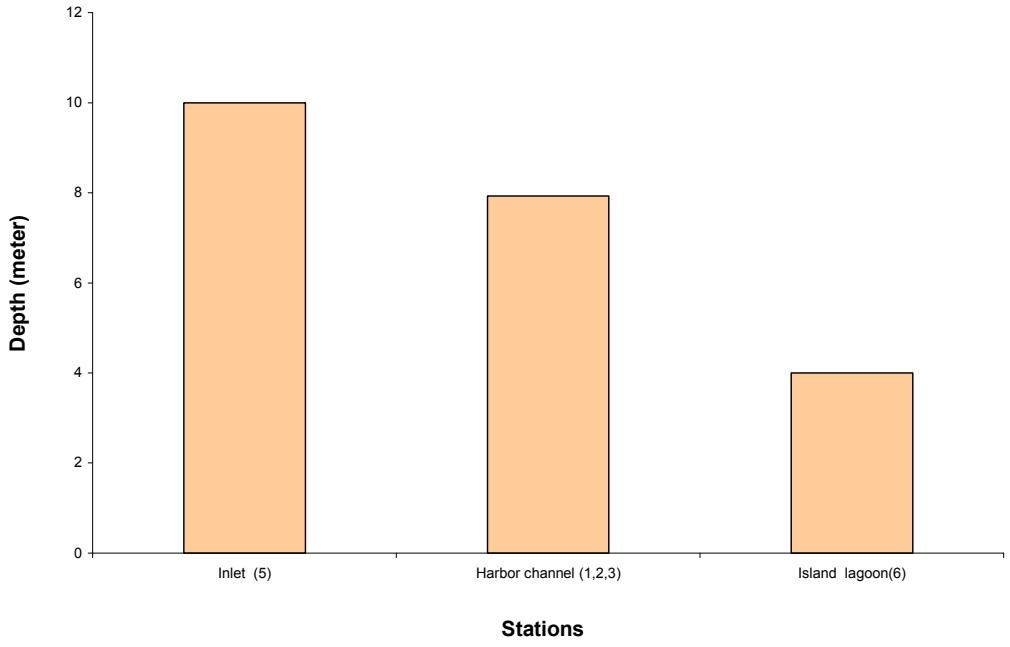


Fig. (4):Variation of transperancy in the study area



1.4: Salinity (S‰)

The salt content of the water in the different locations showed insignificant variation (39.00 – 40.oo ‰), indicating the conservative property of seawater. The salinity values estimated are within the normal limits reported in other areas just south and north of the coast.

1.5: pH (Hydrogen – ion concentration)

Almost similar pH values, with no apparent variations were registered and noted in the various surveyed locations, being in the rang of 8.58 - 8.6 (Table1 & Fig 5). It appears that the recorded pH range is on the alkaline side which furnishes optimum conditions for various biological processes.

2. Chemical variables :

2.1: Dissolved Oxygen (DO_2):

The oxygen content varied slightly in the harbour at the selected stations with concentrations found to be below or just at the limit of saturation values, ranging between 4.58 – 4.80 mlO_2 /l (Table1 & Fig 6). The relatively highest oxygen level (4.80 ml/l) just at the lower limit of saturation value was recorded at the lagoon which is a coastal station. This may indicate an increase in rate of primary production in this location.

...2.2: Nutrients:

2.2.1: Phosphate (PO_4 - P):

It can be noticed that phosphate level showed appreciable variations in the different selected stations (0.56–1.00 µg–at/l) being highest at the lagoon station and relatively moderate at the upper mid parts of the basin (St.2&3) and at the inlet station (Table1 & Fig 7). The higher phosphate concentration recorded at the lagoon may be attributed to anthropogenic imputes from coastal activities.

Fig.(5): Variation of pH in the study area

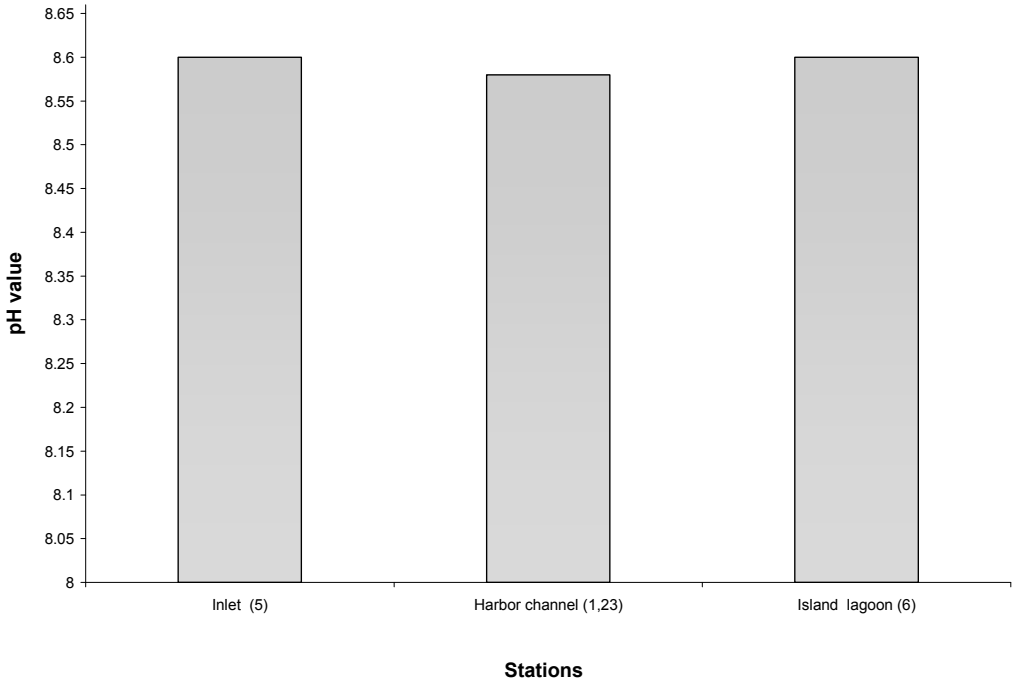


Fig.(6):Variation of dissolved oxygen in the study area

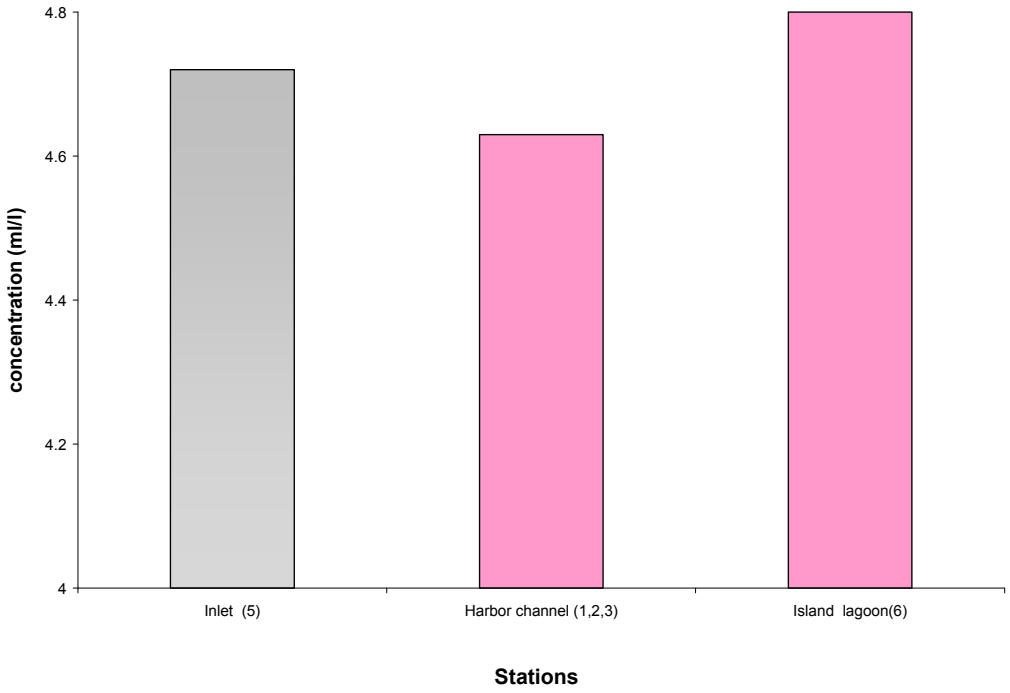
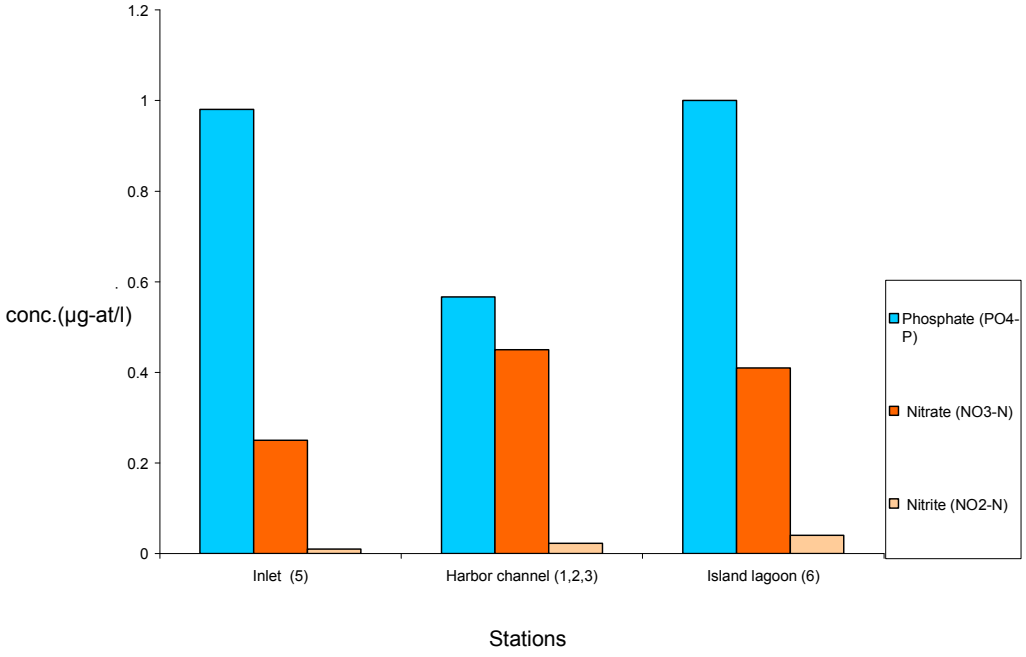


Fig.(7):Variations of nutrients in the study area



2.2.2: Nitrate (NO_3 – N):

Nitrate was detected at relatively low to moderate levels at the surveyed sites in the harbour with values varying between 0.20 – 0.41 µg–at/l (Table1 & Fig7). The relatively higher nitrate concentration in the range was similarly reported at the lagoon station which may reflect nutrient enrichment in this location.

2.2.3: Nitrite (NO_2 – N):

The nitrite recorded in the study sites exhibited very low concentration fluctuating in the range of 0.01 – 0.05 µg–at/l, with small variations (Table1 & Fig7). Such lower levels of nitrite may well indicate low bacterial activities in the area.

3. Geological Studies:

3.1: Maps:

A satellite image in addition to a magnified sketch map have been presented showing the various selected locations in the study area Fig (1 &2).

3.2: Substratum:

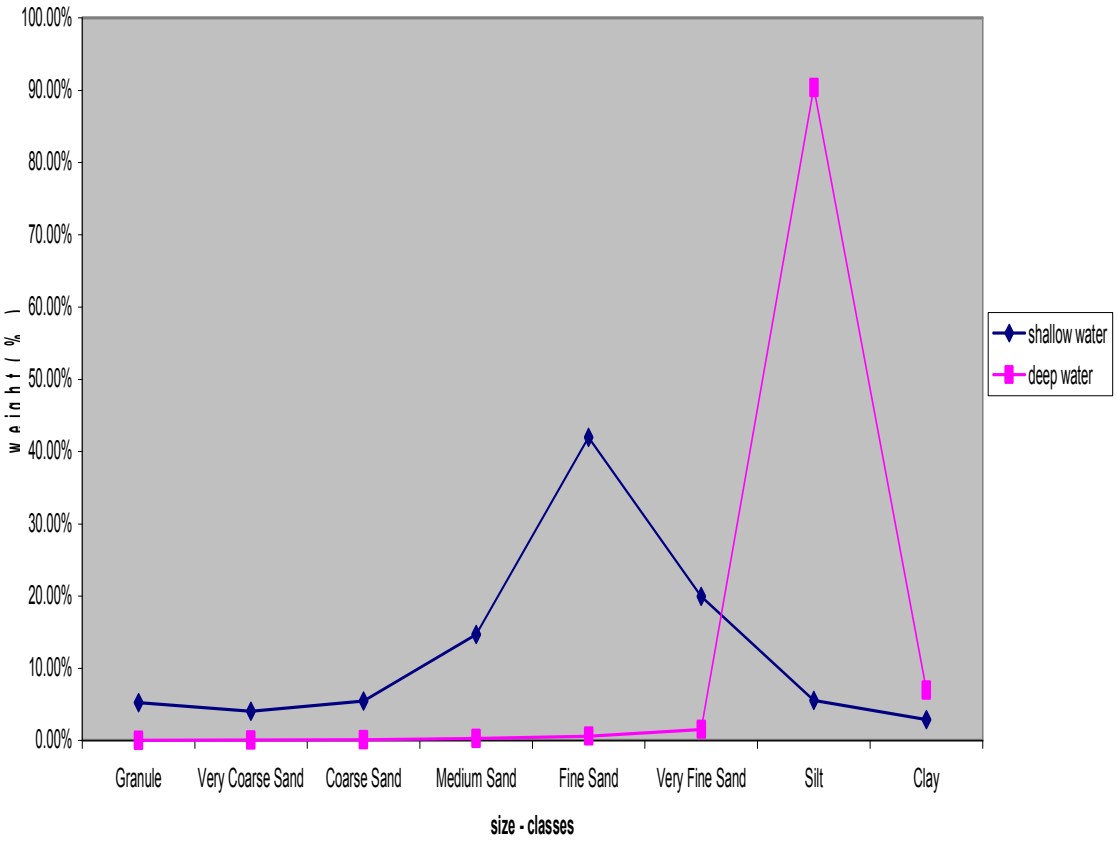
Nature of sea bottom and sediments composition have been analyzed and categorized in the main harbour basin and outside it, just at the inlet.

Result of the analysis revealed variations of different size classes of sediments and their relative composition in the various selected stations (Table 2 & Fig 8). It is noted that shallow sea bottom inside the harbour was composed mainly of fine sand , followed by very fine and medium sand , constituting 42.0%, 20% and 15% substratum . On the other hand, sediments composition at sea bottom in the deep channel

Table (2): Size - classes of bottom sediments in the harbour area:

Size Classes		Mean average (Weight %)	
		Shallow water	Deep water
Granule		5.28 %	0.00 %
Very Coarse Sand		4.05 %	0.08 %
Coarse Sand		5.48 %	0.13 %
Medium Sand		14.68 %	0.29 %
Fine Sand		41.97 %	0.60 %
Very Fine Sand		19.97 %	1.54 %
Mud	Silt	5.51 %	90.38 %
	Clay	2.88 %	6.98 %

Fig. (8) :Variations of size- classes composition of bottom sediments in the study area.



including the harbour inlet consisted mainly of mud forming 97.3 % of bottom sediments (Table 2 & Fig 9).

The muddy and fine sand structure of substratum in the study sites may be attributed mainly to the early dredging activities took place in the Port area.

4. Biological characteristics:

4.1: Sea vegetation (seagrasses /seaweeds):

Seagrasses and seaweeds constitute one of the most highly productive habitats in the coastal environment. In addition to their ecological and economical value, they are considered as important feeding and nursery grounds for enormous marine organisms including fishes turtles, mammals, shellfishes, shrimps and other economically valuable, benthic fauna. Such biologically important marine plants which also provide shelter for most fish juveniles & benthos are influenced by type of substratum, water quality, location, and coastal activities.

Variation of density cover (as %) and composition of sea vegetation were assessed along selected transects (1, 2, 3 & 4) in the study area (Fig 10).

4.1.1: Seagrasses:

It is apparent from Fig (10) that density cover (as %) of seagrasses estimated at the different selected transects (1, 2, 3 & 4) was found to be sparse or absent (0 – 3.0%) at the inner transects (1, 2, & 3) located on the northern side of the harbour basin. Correspondingly, seagrasses were abundant at the outer transect (4), forming meadows with a mean density cover amounting to 53% (Fig10).

Scarcity or absence of seagrasses inside the harbour (T_1 - T_3 may be due mainly to loose sandy and or muddy substratum resulting from dredging processes that occurred previously in the harbour.

Fig. (9) : Percentage composition sediments in the harbar area .

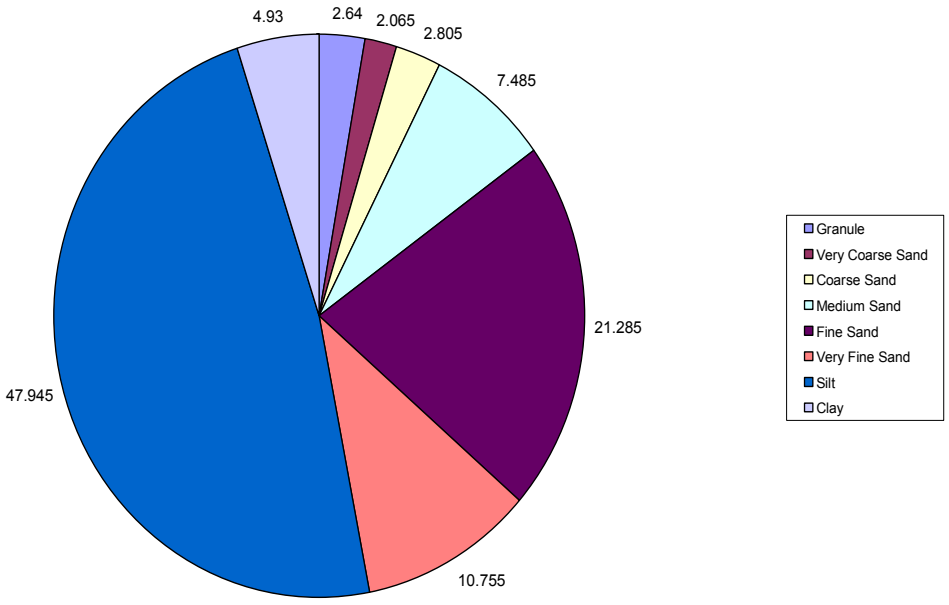
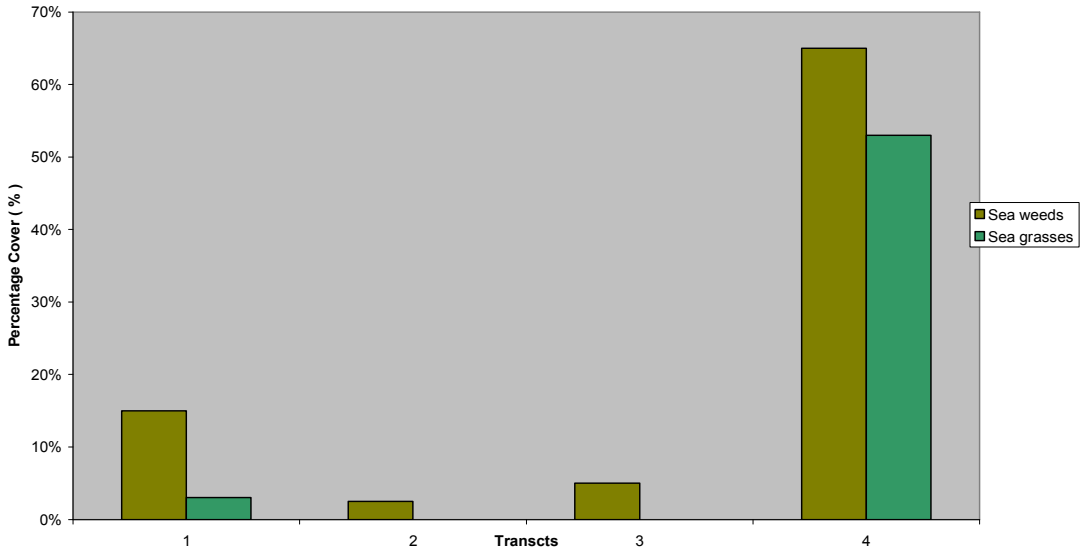


Fig. (10) : Relative abundance (%) of Sea Vegetation in the study area



On the other hand, the rich plant cover recorded at the outer station (T_4) just at the coast line may be attributed mainly to the favourable substratum (less fine sediment load).

Species composition of seagrasses varied significantly in the studied sites being mainly encountered in the outer transect. The various seagrasses genera and / or species registered in the area in terms of abundance included**:** *Halodule uninervis, Thalassia hemprichii, Halophila ovalis, Cymodocea serrulata* & *Cymodocea rotundata*.

4.1.2: Seaweeds:

Seaweeds surveyed at the chosen transects (1, 2, 3 & 4) in and out side the harbour basin showed lower density cover in the inner transects (1,2 &3) ranging between 3 – 15 % .

Correspondingly, prolific growth and much higher density cover of seaweeds (65%) were observed or estimated in the outer transect (4) extending from the shore line up to the fringing reef (Fig 10)**.**

The low density cover and low diversity of seaweeds in the inner studied transects, compared to the highest density cover & higher diversity in the outer one may be due mainly to the suitability of substratum (bottom) in such sites.

The main seaweeds encountered and identified in the study sites comprised more than 25 genera and species belonging in term of abundance to the following groups**:** *Phaeophyta* (brown algae) – 13 species, *Rhodophyta* (red algae) – 11 species, *Chlorophyta* (green algae) – 4 species & *Cyanophyta* (blue-greens) – 2 species (Table 3)**.**

4.2: Plankton biomass:

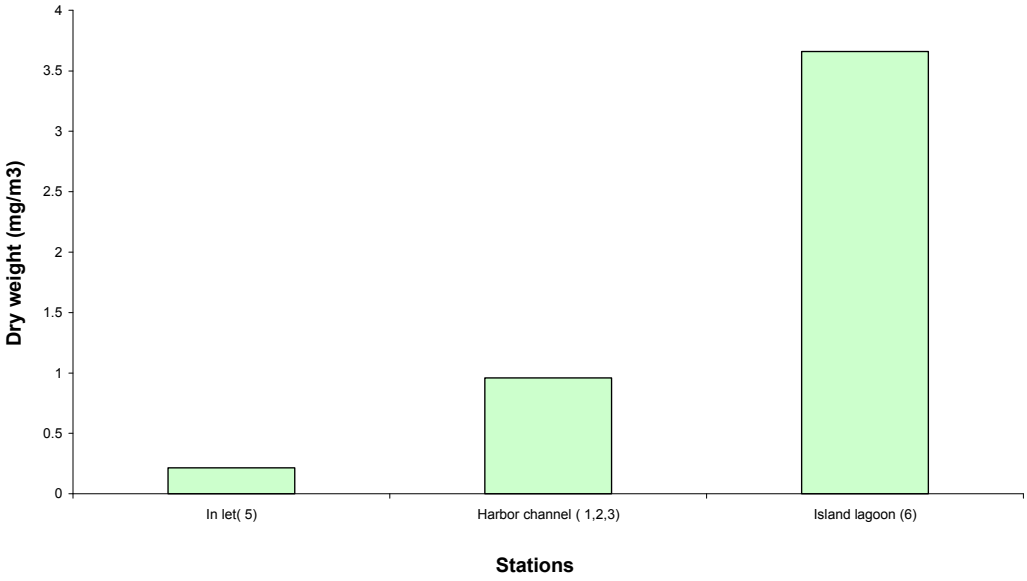
Plankton biomass was assessed in terms of plankton dry weight /m^3 as an index of water productivity in the area. Results of plankton biomass and variation in the selected sites in the harbour were presented in Fig (11)**.**

Table (3): Occurrence and biodiversity of seaweeds in the study area

Stations / Seaweeds	1	2	3	4
Chlorophyceae (Green algae)				
Halimeda opuntia	+	-	-	+
Caulerpa serrulata	+	-	-	+
Dictyosphaeria sp	-	-	+	+
Enteromorpha sp	-	-	-	+
Phaeophyceae (Brown algae)				
Sargassum spp	-	-	-	+ + +
Cystoseira spp	-	-	-	+ + + +
Turbinaria sp	+	+	+	+ +
Padina sp	+	-	-	+ +
Dictyota spp		-	-	+ +
Rhodophyceae (Red algae)				
Jani sp	+	-	-	+ + +
Coralline sp	-	-	-	+
Galaxauria sp	-	+	-	+
Digenia sp	-	-	+	+
Cyanophyceae (blue – green algae)				
Lyngbya sp		-	-	+ +
Oscillataria sp	+	-	-	+

+ + + + =dominant
+ + + = abundant
+ + = frequent
+ =present
- = absent

Fig.(11): Variation of planktonic biomass (dry weight) in the study area



The biomass weight determined in the respective sites was generally low to moderate, ranging between 0.23 – 3.38 mg / m³, with the relatively highest value being obtained in the lagoon (station 6) while the lowest one in the range was recorded just outside the harbour inlet (open sea). The highest planktonic biomass may indicate more water fertility in the most inner (coastal) part of the harbour basin compared to low water productivity in the outer part of the harbour (offshore).

4.3: Coral reefs:

Sudanese Coast is famous of its unique and diverse coral reefs compared to other parts of the Red Sea. These productive habitats are more sensitive to various coastal and marine impacts which are accelerating rapidly. Coral reefs, in addition to their economical and ecological significance, support a vast number of diverse marine organisms, including finefishes, shellfishes crustaceans and other benthic fauna.

Most of the coastline is bordered by fringing reefs except at intervals leading to mersas (bays) including Suakin (Digna) harbour.
Relative abundance (as % cover) and variations of the main coral species or genera were assessed at selected sites (St**.** 1, 2, 3 & 4) as shown in Fig (12) **.**

Coral reefs surveyed along transects in the first three stations (1, 2 &3), located on the northern side of the harbour, were observed as coral patches growing on a discontinuous narrow band (10 – 20 m wide) fringing the harbour deep channel**.**

On the other hand, corals at the inlet site, just outside the harbour basin, were relatively rich and diverse forming a continuous strip fringing the inlet passage up to the fringing reef**.**

The living coral cover estimated (as % cover) in the study area was found to be low to moderate (30.0 – 43.0%) inside the harbour (St. 1, 2 &3) while moderately high (56.2%) at the outer inlet (4) site or transect showing a progressive increase towards the outer site (Fig12)**.** It seems that corals growth and biodiversity have been greatly influenced

Fig. (12): Relative abundance (% cover) of corals in the study sites

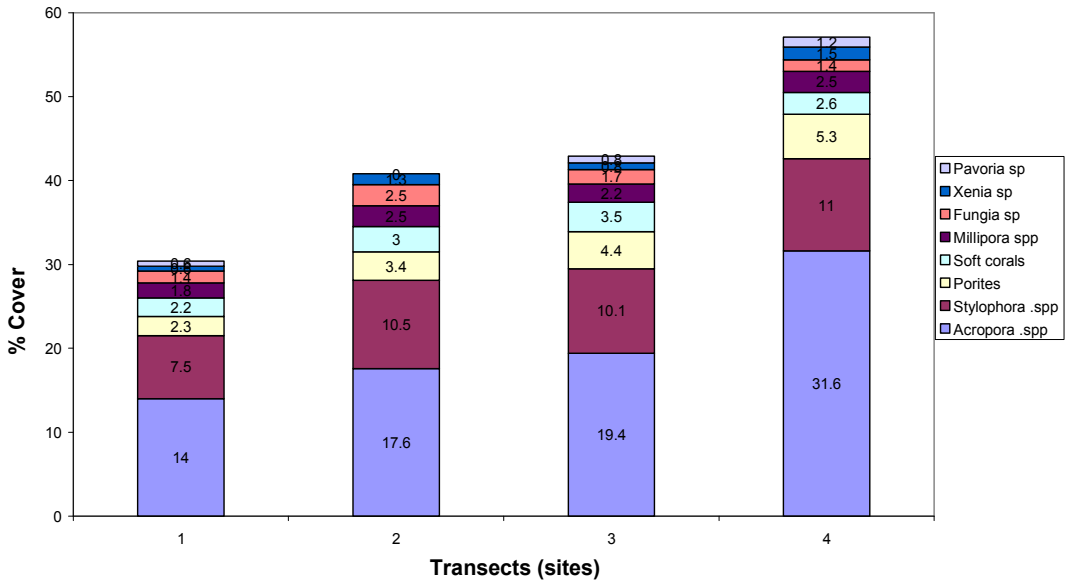


Table (4)**: Relative occurrences of invertebrates in the study area**

Sites / General species	1	2	3	4
Diadema sestosum (Sea urchin)	+ + +	+ + +	+	+ +
Tridacna sp (giant clam)	-	-	+	+ +
Brittle stars (Echinoderms)	+	+	+	+
Starfish (Astropecten sp)	-	+	+	+
Strombus sp	-	+	+	+
Sea cucumber (black)	-	+	+	+ +
Trochus sp (Cockian)	-	-	+	+
Sponges (red , black , white)	+	+	+ +	+ +
Sea anemones	-	+	-	-

+ + + = abundant
+ + = frequent
+ = absent
- = not recorded (rare)

by the previous dredging & excavation activities took place in the harbour where considerable portions of coral reefs or patch corals have been removed especially in the inner sites.

Nevertheless, massive growth of certain corals (i.e. *Acropora spp*- table forms) and marked signs of regeneration (*Stylophora sp*& Porites) were observed, particularly at the outer site.

The most common corals encountered at the selected sites in terms of abundance**:** *Acropora spp*, *Stylophora* spp, *Porites*, soft corals *(sarcophyten sp), Millipora spp, Fungia spp, Xenia sp and Pavoria sp .*

4.4: Invertebrates:

Both density and diversity of invertebrates assessed in the surveyed sites in the harbour area were found generally low or moderate. The more common benthic fauna encountered included**:** Sea Urchins, *Tridacna sp*, Sponges (red, black, & white), Sea cucumbers (black)*, Starfishes (Astropecten), Strombus spp*, Trochus sp, Brittle stars & Sea anemones.

The above invertebrate genera or species were reported at varying degrees and some of them were absent in the selected sites (1, 2, 3 &4) as shown in Table (4).

The relatively low density or scarcity of these invertebrate fauna, particularly, Sea cucumbers (white) *Strombus sp* & Trochus sp may indicate over – collection or most probably removal or burial during previous dredging activities that occurred in the harbour area.

4.5: Vertebrates (Fishes):

Vertebrate fishes have been assessed and identified in the study sites along several transects (stations 1, 2, 3 &4) in the harbour area, mainly in the fringing or patch reefs. The major coral fishes encountered inside the harbour basin and at the inlet, just outside the basin, according to the degree of their occurrence were: Angel fishes, Butterfly fishes, Snappers, Sweetlips, Emperor fish, Groupers, Parrot fishes, Trigger fishes & Morays**.** Their relative abundance and variations in the study sites were as shown in Table (5)**.**

Table (5): Fish families & species encountered in the study area

Transects / Fish families	1	2	3	4
Sparidae (*Crenidens*)	_	_	_	+
Lethrinidae (*Lehthrinus sp*)	_	_	_	+
Siganidae (*Siganus sp*)	_	_	_	+
Gerreide (*Gerres sp-Mojarra sp)*	_	_	_	+
Dasyatidae (*Taeniura sp*) (Stingray)	+	+	_	+
Lutjanidae (*Lutjanus sp*)(snapper)	_	_	+	+
Globidae (Gobis)	_	_	+	+
Chaetodonidae (butter fly)	_	_	_	+
Pomacentridae (*Chromis sp*), (*dascyllus sp*) ,(*abudefduf sp*)	+	+	+	+
Labridae (Wrasses)	_	_	_	+
Haemulidae (*Plectrohynchus sp*) (Grunt)	_	_	+	+
Acanthuridae (*Acanthurus sp*)	_	_	_	+
Pseudochromidae (Dotty backs)	_	_	_	+
Muraenidae (Gymnthorax) , (morays)	_	_	_	+
Balistidae (Triggerfishes)	_	_	_	+
Scaridae (Scarus (parrot fish))	+	+	+	+

+ = recorded
- = not recorded

Table (6): List of important fish species common in the study area

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

Table (6): …….Conted.

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

It is observed that most of the coral fishes detected are smaller (fancy fishes) to medium size i.e. Parrot fishes; Trigger & Acanthurus (~ 20 - 30 cm) and few relatively larger fishes (Groupers).

However, fish density and diversity in the study area were low to moderate in side the harbour basin while moderate to relatively higher at the outer site, just at the fringing reef.

Due to the difficulty encountered in counting larger (or small) demersal fishes (particularly , commercial fishes) a general list of fishes known to be common in the study and surrounding areas was provided by Department of Fisheries & local fishermen Table (6).

5. Expected environmental effects:

a) During construction operations:

More than ten platforms (~ 2.5 km long) will be constructed along most of the northern side of the harbour during this year (2007) as the first phase.

Such marine constructions mainly involve dredging, excavations land- filling and concrete building operations. They are therefore, expected to have their major impacts on the aquatic environment and associated marine living resources.

The anticipated adverse effects will be mainly manifested in physical damage and alteration of habitats and resultant high rate of sedimentation.

The marine habitats that are most likely to be seriously affected as a result of such environmental hazards include:

- Coral patches fringing the inner harbour channel on both sides mainly the northern one.
- Fringing reefs with associated marine organisms, located south and north of the main harbour.
- Marine benthic fauna (invertebrates), vertebrate fauna (finfishes & ray fishes) and sea vegetation (seagrasses & seaweeds) inhabiting the study area and areas in vicinity.
- The Pilot Desalination Plant installed inside the harbour.

b) Post marine constructions:

- Risks and incidents that may incur during anchoring, loading and unloading of different types of bulk or contained cargo as a result of mishandling**.**
- Environmental and health hazards emanating from gases emissions and asphalt leaks as well as dusts arising from bulk cement & grains**.**

CONCLUDING REMARKS

An environmental impact assessment study was conducted before dredging and establishment of about ten or more new platforms (~ 2.5 km long) at the southern side of Suakin (Digna) Port for receiving medium to big cargo ships. The platforms will be constructed during this year (2007) in addition to several other platforms planned to be built up in the harbour next year (2008).

- An execution plan was set up for the present study which involved necessary field and laboratory preparations, working staff and a time schedule.
- Pertinent physico – chemical, biological and geological characteristics were assessed in the study area, in order to evaluate the current state of the environment before construction of platforms.
- Limits of physical (temperature, salinity, pH & transparency) and chemical (oxygen & nutrients i.e. phosphate, nitrate & nitrite) properties determined at the various sites of the study area were found to be generally within the normal levels except phosphate, being reported at relatively higher values.
- Bottom sediments in the study area were mainly composed of fine to slightly coarse sand particularly in the main harbour basin. This might most probably be attributed to the previous dredging activities took place in the area.

  However, transparency values recorded during the present study reflect good visibility, indicating relatively reduced rate of sedimentation especially outside the harbour.
- Sea vegetation (seaweeds & seagrasses) cover and biodiversity estimated in the study area were relatively more rich and diverse in the outer harbour basin site (4) while much lower at the inner study sites (1, 2 & 3). The relatively low density cover & composition of seaweeds & seagrasses inside the harbour may be mainly due to the unsuitable substratum (loose

sandy / muddy) resulting from the preceded marine constructions occurred in the area.

- The living corals cover estimated in the study area was noticed to be moderate to moderately high, although corals have been greatly influenced by previous dredging and exaction operations took place in the area (1999 / 2000). This may well indicate a good sign of regeneration of these biologically important systems over the years.

- Density and diversity of invertebrate fauna assessed in the surveyed area, particularly shell fishes (*Strombus*, Trochus) and *echinoderms* (Sea cucumbers) were observed to be relatively low to moderate. The comparatively lower population of shellfishes and some echinoderms inside the harbour sites (1, 2 & 3) may indicate their over – collection and most probably their removal or burial during the early dredging activities happened in the area. However, there are indications of more invertebrates recovery (shell fisheries) especially outside the harbour basin towards the fringing reef.

- The vertebrate fishes, including fancy fishes were mainly encountered in the fringing reef and coral patches inside the harbour with various sizes.

- Fishes density and diversity in the study area were low to moderate in the inner surveyed sites while moderate to high in the outer site towards the fringing reef.

- A general list of demersal & pelagic fishes known to be common in the area is provided, reflecting high density and diversity of such commercially important fish species.

RECOMMENDATIONS

The following mitigation options and environmental management plan related to construction of several new platforms in Osman Digna (Suakin) Port are recommended:

- Sediments should de disposed off, above the shore line during dredging and excavation operations in the northern side of the main harbour where the planned platforms are to be built up.
- Construction of a gravel (or concrete) curb along the northern shore- line inorder to prevent or minimize dispersal of sediments back to the harbour basin and limit their spread over to the surrounding fringing reef.
- The well developed and regenerating corals located on the northern side of the harbour as a narrow band fringing the slope of the deep channel (observed from about ≥ 10 m depth) especially at site 2 & 3, are strongly advised to be left intact or at least part of them. These may provide protection for the platforms against strong waves during high tides as well as conserving biodiversity in the area.
- Appropriate controlling measures are required to contain any environmental hazards to human & marine life i.e. gases fumes & fine dusts arising from liquid & bulk cargo.
- Formulation of a contingency plan for emergency responses to minor or major disasters, being natural or incidental that may cause damage to marine environment and marine life in the harbour area.

  The plan should also contain stringent security measures to ensure that any potential issues that may cause pollution hazards in the harbour area are avoided.
- Development of an effective reception facilities in the main harbour for proper handling and appropriate treatment and disposal of solid or liquid wastes collected from anchored ships and land-based sources.
- Revising of existing regulations governing health, safety and environment to comply with regional and international standards.

- Necessity of undertaking regular monitoring programs in the area for evaluation of the current state of the environment and detection of any expected impacts that may arise from coastal and marine activities.
- Importance of conducting environmental impact assessment studies prior to implementation of any coastal or marine development projects in the area inorder to avoid any environmental problems and ensure sustainability of these projects.
- Adoption of an effective, endorsed intergrated coastal zone management plan for co-ordination of coastal and marine activities in order to achieve sustainable development in the area and along the Sudanese Coast.

REFERENCES

1. Grasshoff, K. (1983)**:** Determination of Oxygen. In: Grasshoff et. al Method of analysis, Vertag. Chemie Wanhuim, P. 61 – 71.

2. Krupp, F. et. al (1994)**:** Coral reef fish survey – Sanganeb Atoll. In: A report on comparative ecological analysis of biota and habitats in littoral and shallow Sublittoral waters of the Sudanese Red Sea P. 63 – 82.

3. Lovegrove, G (1966)**:** Determination of plankton Biomass- In: Barnes, H . some Contemporary Studies in Marine Sciences, P.29 – 467.

4. PERSGA (2004)**:** Standard Survey Methods for Key Habitats & Key Species in the Red Sea and Gulf of Aden. Tech. series No. 10.

5. Strickland, J.D.H & Parsons, T.R. (1965)**:** Manual of Seawater Analysis, USA, UK.

APPENDIX

Scientists & technical staff involved:

1. Prof**.** A'Gadir. D. El – Hag**:** (Marine biology) / IMR * - leader of the group.

2- Dr**.** Mohammed El – Amin Hamza**:** (Marine biology / fisheries) / RSU*

3- Mr. Abdel. Moneim. K. Gaiballa**:** (Marine biology) / Lecturer – FMSF*.

4- Mr. Khalid Al – Wali. Kunda**:** Senior technician / IMR.

5- Mr. Salah Omer Mohammed**:** Senior technician / FMSF.

6- Mr. Ali Osman**:** technician / FMSF.

*** IMR:** Institute of Marine Research (RSU).

*** RSU:** Red Sea University

*** FMSF:** Faculty of Marine Sciences & Fisheries (RSU).