ISSN 1110-0354
Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E., Vol. (27) 2001: 13 - 44

DEVELOPMENT OF JEDDAH DURING THE PAST 20 YEARS AND ITS IMPACT ON THE MARINE ENVIRONMENT

By

A.E. RIFAAT*, A.S. BASAHAM, H.A. AL-WASHMI, R. A. BANTAN AND S. M. EL-NADIE

**Faculty of Marine Science, KAAU, 80207, Jeddah 21589*

Key words:

ABSTRACT

In 1983 the authors visited the Jeddah Corniche. At that time most of the coastal area of Jeddah City was natural and sandy beaches were present along the entire shore except at limited locations where the coastal road was constructed at the northern and middle part of the city. In 1999, the authors revisited the coastal zone and noticed a great variation. The Corniche extended further south, most of the natural beaches are filled, removed or replaced by constructions and resorts. The reef flats were filled and the land was cut for the purpose of beautification and resort construction. Also, the sewage plants started dumping into the sea at some locations along the shore. The industrial discharges are poured into the sea. Therefore, it was necessary to assess the impact of these activities on the near-shore marine environment off Jeddah. The success in implementing the national development programs, although adds economic benefits to the nations, it exert a great load on the environment. The strategy of the study based on two approaches. The first was to collect information on the present status of the near-shore marine environment, shore occupation and activities and to define the marine environment quality off Jeddah as reflected on the sediment composition. The second approach is to analyze the collected information, integrate them into one map using what is known as Geographic Information System or GIS and measure the impact of human activities on the marine environment off Jeddah. The result is a one-frame, multiple map, geographically linked data presentation

that reveals the locations that are affected by human activities and the size of the impact. The present study has shown that the marine ecosystem off Jeddah City is greatly disturbed by: 1) Construction processes of the coastal road, onshore facilities etc. 2) Reconfiguration processes of the shore including filling operations. 3) Sewage dumping. 4)Industrial wastes dumping to the sea at the southern part of the city. 5) Shipment operations of industrial imports and exports especially oil.

The study revealed, also, that there is a shrink in the coral cover off Jeddah between the years 1986 and 2000. This decrease in coral cover is accompanied, undoubtedly, by decrease in the number of habitats dwelling the coral environment. The causes of such decrease are the increase in water turbidity, depletion of dissolved oxygen resulting from dumping of municipal and industrial wastes and blooming of algal mats.

INTRODUCTION

Since the stress on the environment increases with the success in implementing the national development plans. It is obvious; from the achievements in implementing the national development plans in the Kingdom of Saudi Arabia (KSA) (UNDP/CSD, 1997), that the KSA has gone so far in implementing the development plans. As a result the rapid growth in industry, agriculture, urban, ...etc, has exerted a huge stress on the environment. The controversy DEVELOPMENT VERSUS ENVIRONMENT is a major problem during the development stage of nations. And, KSA is no exception.

Jeddah, the western coast major city of Saudi Arabia has grown very fast during the past decades in all aspects of life. The urban area is greatly increased. The industry, transportation, trade, ...etc, has been, and are being, developed so fast that its effect on the environment especially air and sea are very prominent. Therefore, it was necessary to assess the present status of the marine environment and determine the degree of impact of development plans on the marine ecosystem off Jeddah. Studies on the marine environment off Jeddah and vicinity include those carried out by DurgaPrasadaRao & Behairy (1982), Osman (1982), El-Rayis *et al.* (1982), Dowidar (1983), Beltagi (1983), Behairy & El-Sayed (1983), Meshal *et al.* (1983), Behairy *et al.* (1983), El-

Sayed (1985), Basaham & El-Shater (1994), Basaham (1998a,b), and El-Sayed and Niaz (1999). All these studies are scattered and dealt with the environmental aspects individually. Non of these studies subjected to the impact of tourism and urban development on the marine environment. In the last two decades, the technique of satellite image processing and GIS, together with ground studies have been used to evaluate the status of the environment. This technique is used successfully to compose geographic information maps that hold all the variables of the environment in one easily identifiable frame. These maps could be used not only to identify the environmental problem but also to display the size and source of it. This may help in planning sustainable and environmentally safe development programs. The study's primary goal is to prevent further loss of marine environment and coastal biodiversity of the Red Sea, focusing on the near-shore marine environment along Jeddah City. This could be reached by viewing the sources and impacts of human activities on the marine environment off Jeddah and suggesting possible solutions.

JEDDAH

The Red Sea port of Jeddah, located mid-way along the Western coast of the Kingdom, is a bustling, thriving city and seaport. Its location on the ancient trade routes and its status as the seaport and airport for pilgrims visiting the Holy Cities of Makkah and Madinah have ensured that Jeddah is the most cosmopolitan of all Saudi Arabia's cities. By the end of the 1970 (1391 AH), the population of Jeddah was estimated to be close to one million. By 1986 (1406/07 AH), the estimated population was 1.4 million. With an estimated growth rate in excess of 10%, the population by 1993 (1413/14AH) had passed the two million mark. The extraordinary growth of Jeddah, demanded by the Kingdom's development programs, has been achieved in a remarkably short period. (The expansion of the sea port's capacity is a case study of what can be achieved if the will, the management and the resources are available.). At the same time, aesthetic considerations have not been ignored. Jeddah now boasts some of the most beautiful examples of modern architecture in the world. Tree-lined avenues and the generous distribution of bronze sculptures attest to the success of the city's beautification program. The Jeddah Islamic Port is the busiest of all the Kingdom's ports. It is the principal commercial port and the main port of entry for pilgrims on their way to the Holy Cities of Makkah and Madinah. In 1975 (1395 AH), Jeddah imported 2,811,000 tons, which represented almost half of all imports to the Kingdom in that year. In 1984 (1404/05 AH), the volume of imports reached a peak of 20,762,000 tons. In

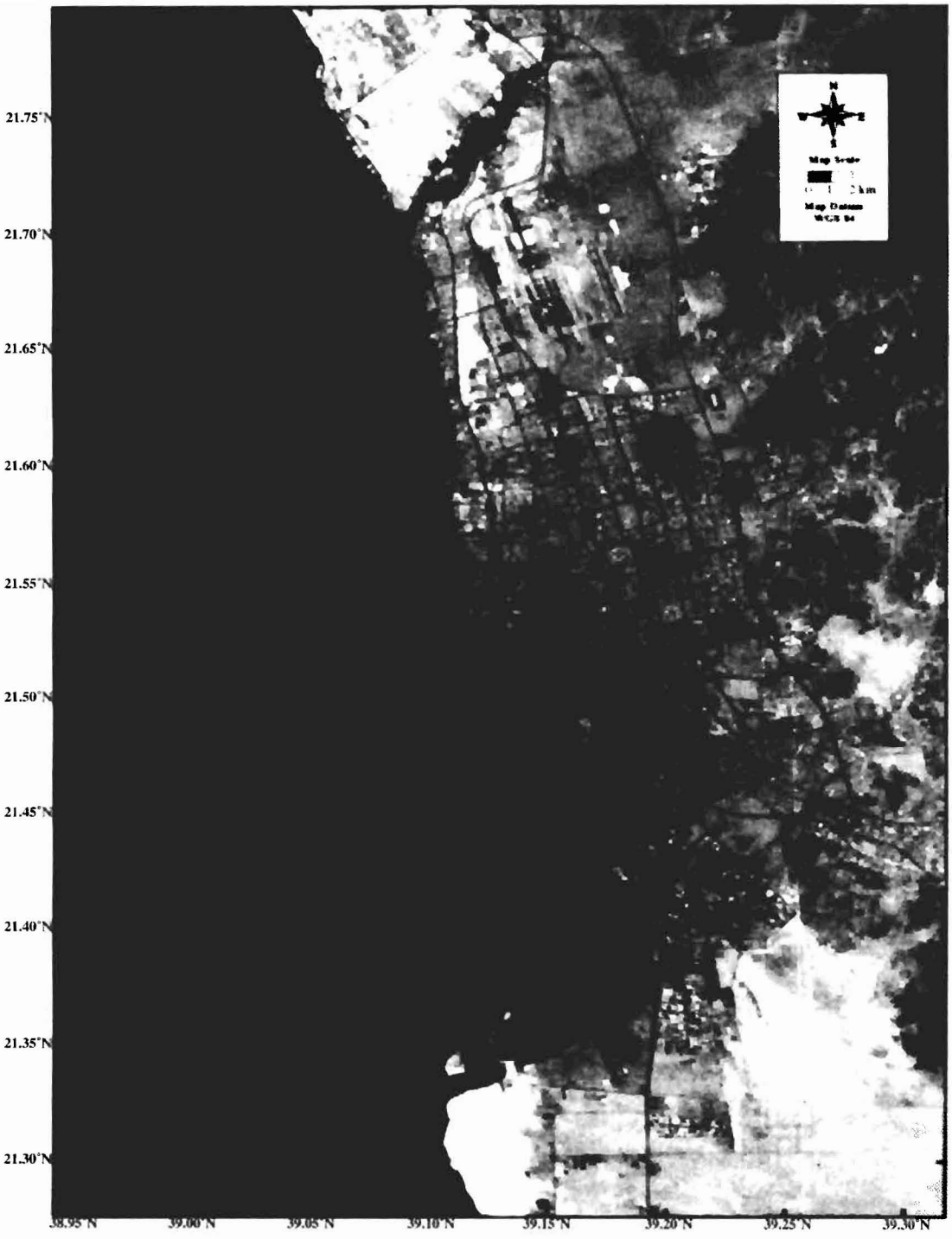


Figure (1) Landsat TM 2000 image showing the study area.

Current speed and direction were taken from five stations at the surface and 10 meters depth (Tables 1-3). This stations covered the area extended from 21°21'23.9", 39°07'15.5" to 21°43'08.5", 39°04'35.2" with a distance of about 40 km. Between the first station (station no. 1) and the last station (station no.5) (Fig. 2).

FIELD RECONNAISSANCE AND SAMPLING

A long-shore reconnaissance survey was conducted to recognize the coastal features and to decide the sampling sites. The urban activities and coastal installations were recorded and photographed using a stand still camera and a Global Positioning System (GPS) to fix the geographic positions. Since sediments are the final sink of all solid materials that enter the marine environment, they are a reflection of the environmental quality; therefore, bottom sediments along Jeddah shore were collected to determine their contaminants' content. A number of sites that cover the study area were selected for sampling of off shore bottom sediments.

A total of 9 samples (Fig. 2), were collected from the selected sampling sites. In very shallow sites, samples were manually collected using a plastic scope. In deeper waters samples were collected using grab sampler.

SEDIMENT CHARACTERIZATION

TEXTURE

In order to determine the relative proportions of gravel, sand and mud in the samples, a representative dried sub-sample was taken from each and wet sieved using a 2 and 0.063 mm standard sieves.

ORGANIC MATTER DETERMINATION

The O.C. determination is carried out using dried sub-samples powdered in agate mortar and sieved to pass 200 mesh to ensure a complete homogeneity.

Organic carbon was measured using the sulphuric acid-dichromate wet oxidation method firstly proposed by Walkely and Black (1934).

SATELLITE IMAGE PROCESSING

The satellite images for Jeddah city LandSat TM (7 bands) for the years 1986 and 2000 were processed to extract the information on the changes occurred to the coastal area between the respective years. The proces

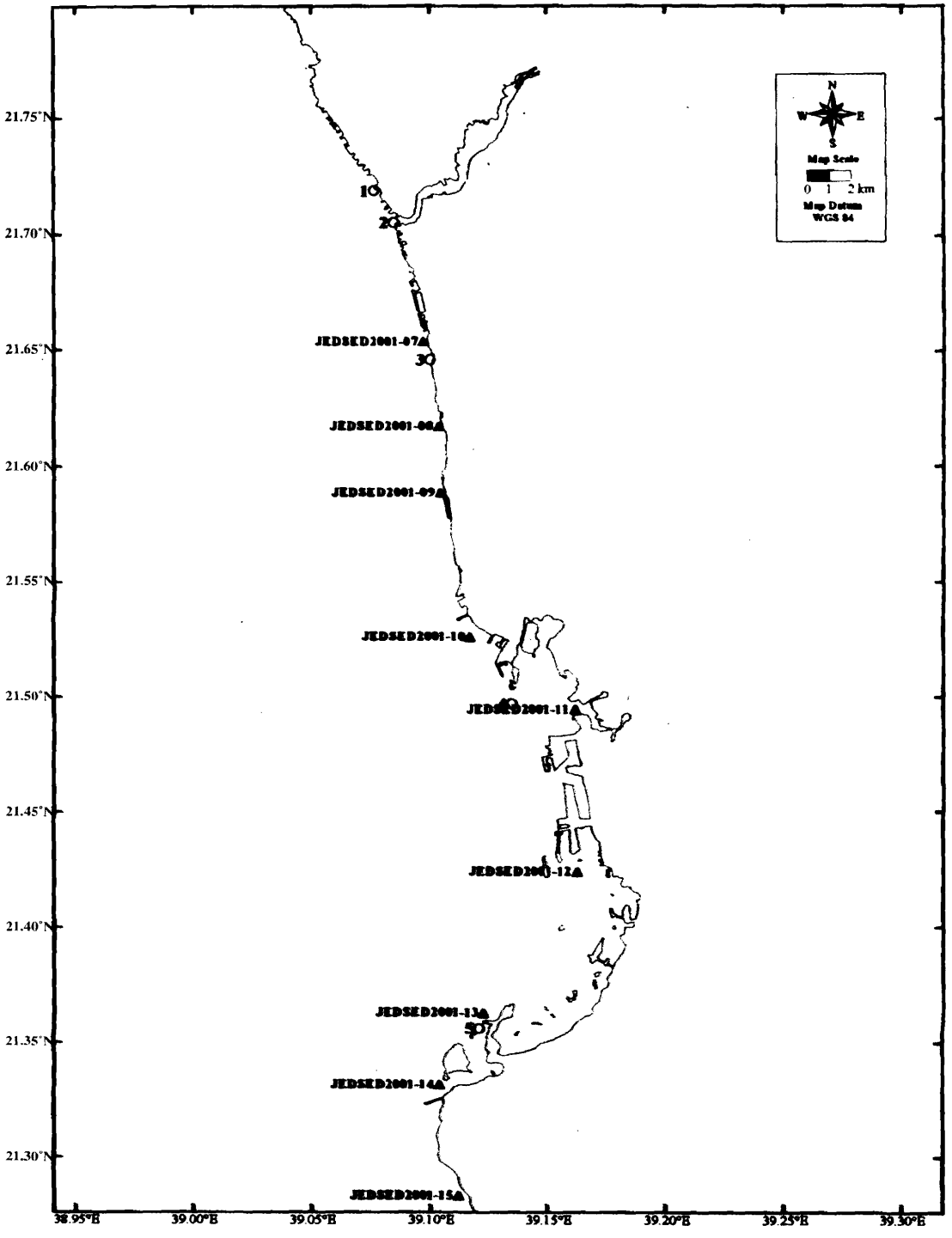


Figure (2) Location of current measurement stations (dots) and sediment sampling sites (triangles).

Table (1): Stations location of the current measurements.

Station number	Latitude	Longitude
01	21°43'08.5''	39°04'35.2''
02	21°42'19.4''	39°05'05.2''
03	21°38'44.8''	39°05'59.7''
04	21°29'50.2''	39°08'05.1''
05	21°21'23.9''	39°07'15.2''

Table (2): Currents speed and direction during February, 2001.

Station number	Depth (m)	Speed (m. s^{-1})	Direction (degrees)
01	0	0.104	355
	10	0.029	224
02	0	0.225	022
	10	0.062	062
03	0	0.314	334
	10	0.074	053
04	0	0.351	313
	10	0.081	302
05	0	0.521	347
	10	0.411	329

Table (3): Currents speed and direction during August, 2001.

Stations number	Depth (m)	Speed (m.s^{-1})	Direction (degrees)
01	0	0.204	129
	10	0.078	158
02	0	0.292	104
	10	0.063	098
03	0	0.367	141
	10	0.092	119
04	0	0.410	232
	10	0.066	177
05	0	0.481	207
	10	0.353	139

comprised rectification of the images so as to define the exact coordinates. The rectification and processing steps went as follows:

- The LandSat TM image for Jeddah city (1986) was first rectified using a set of admiralty charts.

- The LandSat TM image for Jeddah city (2000) was then rectified using image to image rectification to realize complete matching of the coordinate systems for the 1986 and 2000 images.

- The high-resolution vector maps was digitized after the rectified images of 1986 and 2000 and digital high resolution vector outline maps for the shores of Jeddah City was compiled.

- Basing on area calculation the shoreline changes between 1986 and 2000 were delimited.

- The growth in the metropolitan area of Jeddah between 1986 and 2000 was outlined.

RESULTS AND DISCUSSIONS

THE COASTAL AREA SETTINGS

The eastern coast of the Red Sea is approximately 2000 Km long, about ninety per cent of which belong to the Kingdom of Saudi Arabia. Its coral reef community is one of the most diverse in the world. The importance of the coral reef as suitable environment for feeding, breeding and nursery ground for a vast variety of marine organisms has been recognized by several ecologists (Odum and Odum, 1955; Veron, 1986). However, coral reefs are seriously endangered, particularly in the developing countries, due to intensive wastewater dumping in the coastal waters.

The city of Jeddah is situated at the central part of the Red Sea eastern coast; it is the most important urban agglomeration. Since the seventies oil crisis, the city is suffering an immense economic and population growth, three hundred thousand inhabitants in 1979, its population is more than two millions at present. Industrial activity is also expanding and includes, in addition to

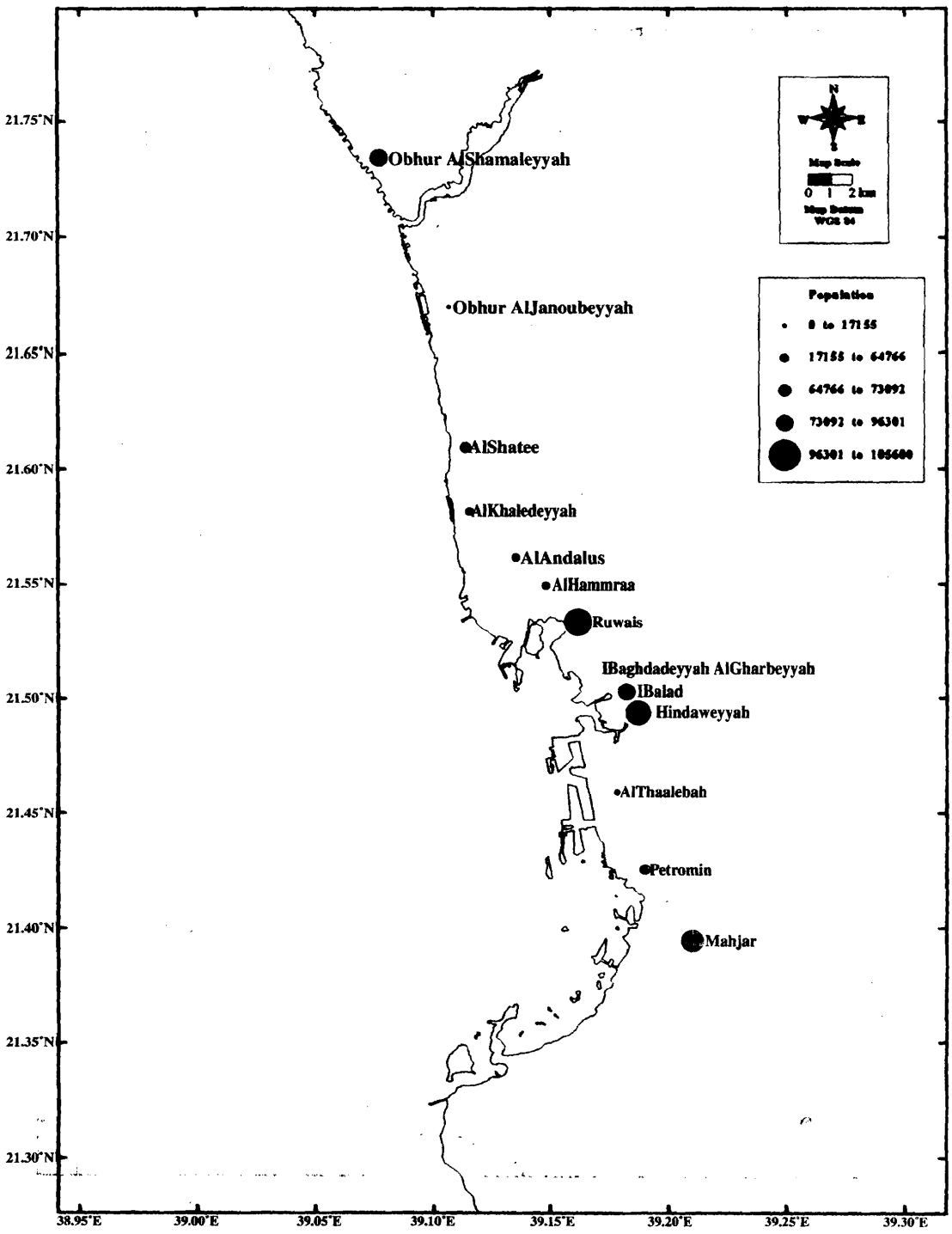


Figure (3) Population at each district.

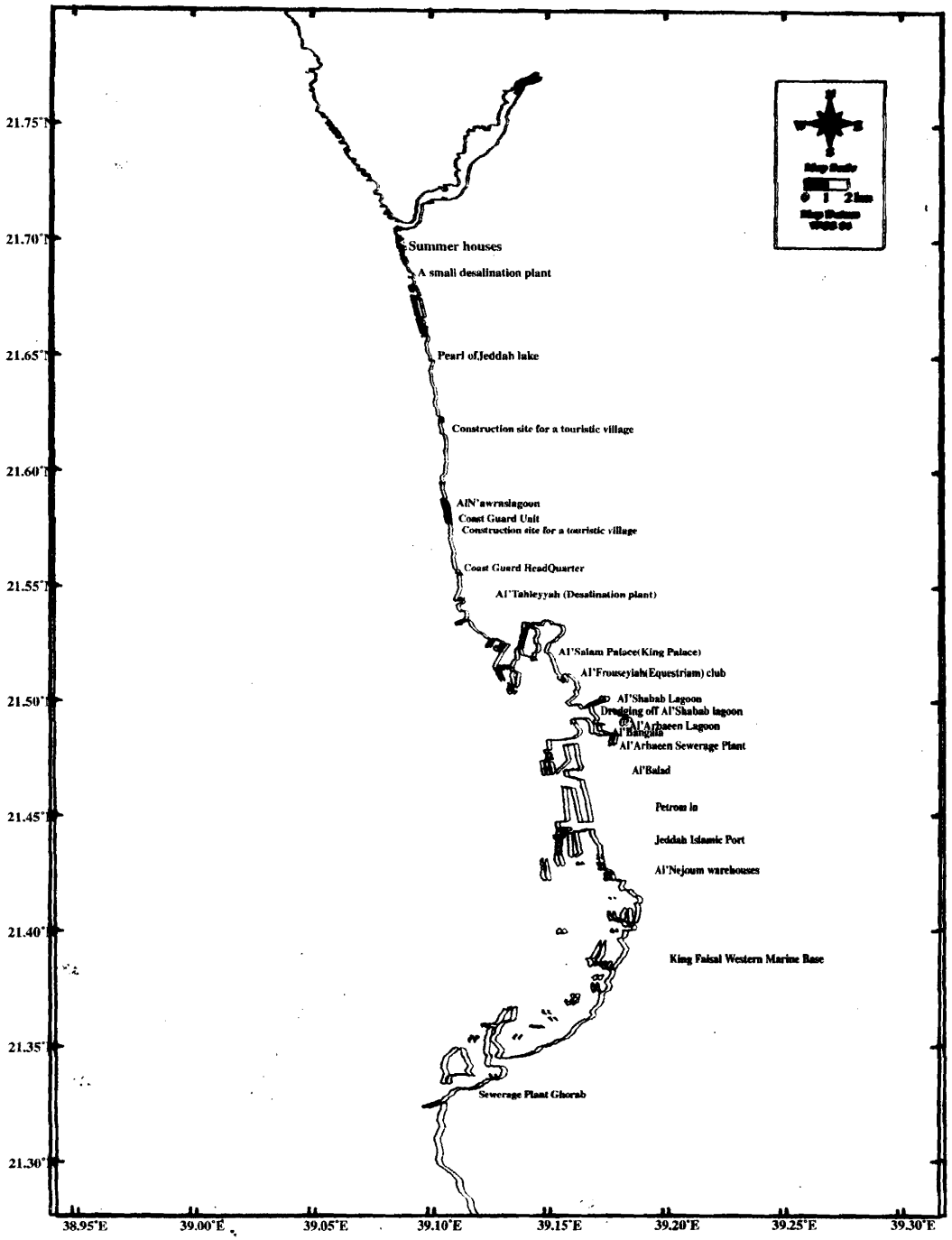


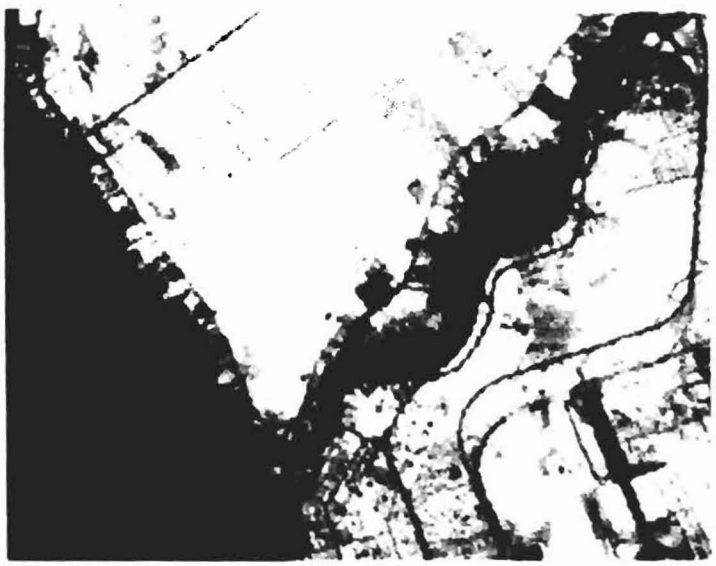
Figure (4) Shore occupation along Jeddah coast.

Table (4): Districts occupying the coastal zone of Jeddah.

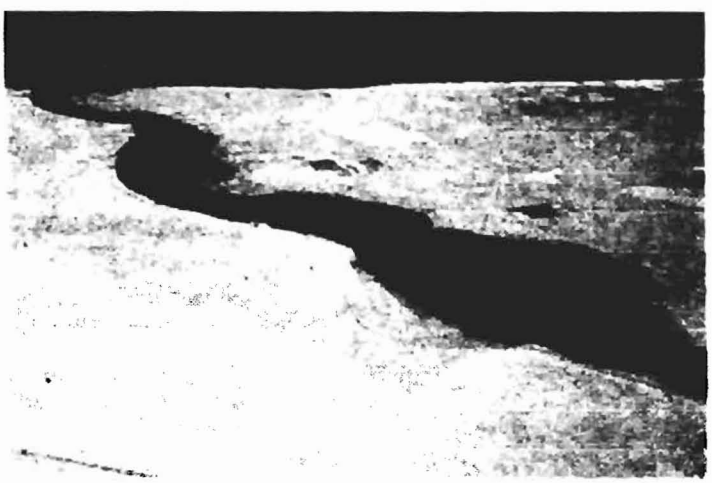
District from south to North	Area square meters	Population+	Area square km	Population density/km2
Al'Mahjar	7,704,158	96,301	7.704158	12,500
Petromin	2,725,848	68,146	2.725848	25,000
Al'Thaalebah	632,476	5,155	0.632476	8,151
Al'Hindaweyyah	2,197,557	96,926	2.197557	44,106
Al'Balad	3,016,238	90,487	3.016238	30,000
Al'Baghdadeyyah Al'Gharbeyyah	3,812,389	95,309	3.812389	25,000
Al'Ruwais	4,223,399	105,584	4.223399	25,000
Al'Hammra'a	5,718,510	17,155	5.71851	3,000
Al'Andalus	5,181,313	64,766	5.181313	12,500
Al'Khaledeyyah	5,047,762	20,191	5.047762	4,000
Al'Shate'e	16,258,497	65,033	16.258497	4,000
O'bhur Al'Janoubeyyah	29,435,434	Not specified	29.435434	-
O'bhur Al'Shamaleyyah	73,092,416	731,092	73.092416	10,002

+ thousands For location see figure (2)

The coastal area was subjected to several processes of reconfiguration and reconstruction. In 1978 (Plate 1) most of the coastal are was natural and due to the increasing demand for tourism and recreation facilities, the government has been obliged to fill part of the near-shore zone so as to increase the aesthetic value and beautify the landscape. To protect the coastal road against erosion the seaward margin was reinforced with boulders and blocks. The filling, reconstruction and reconfiguration processes have affected, undoubtedly, the nearby marine ecosystem leading to deterioration of the marine environment. The area of filling as calculated from the satellite images between 1986 and 2000 is about 1335 square meters along the entire coastal area. Figure (5) shows areas of filling between 1986 and 2000 as digitized from the satellite images for the respective years. As a demand for the increasing urban and industrial development, four wastewater treatment plants were established to serve the city. Al Khumra station of water treatment is the most important.



Sharm Obhur north of Jeddah
2000
Landsat TM 2000



Sharm Obhur north of Jeddah
1978
Aerial photograph (Bemert and Ormond 1981)

Plate (1) The plate shows the increase in urban areas at Sharm Obhur north of Jeddah between 1978 and 2000.

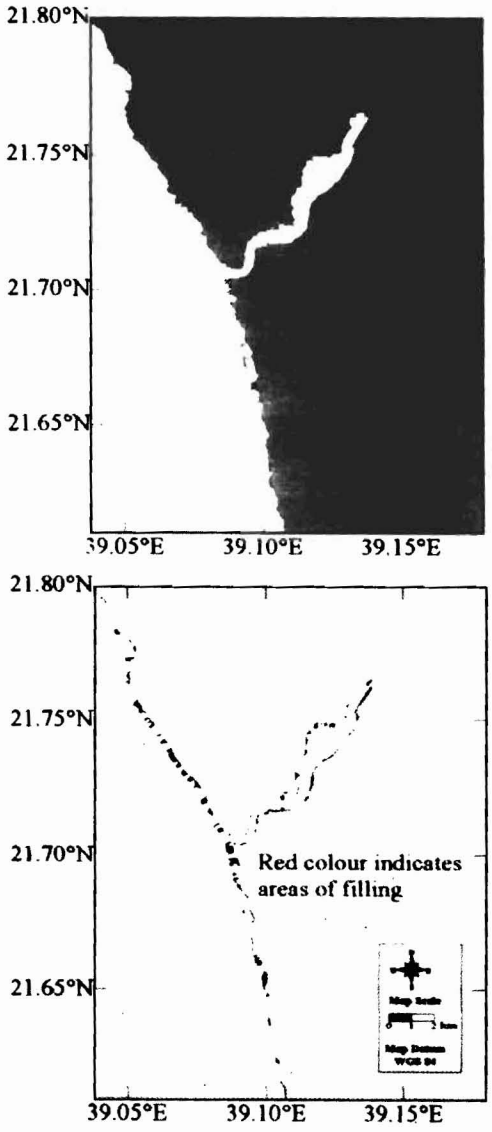


Figure (5) The areas of filling and cuttings along the northern Corniche between 1986 and 2000.

It was constructed at the southern end of the city at Ghorab island to receive 40,000 cubic meters per day of wastewater. Due to the increase of the population the capacity of the station has recently been increased to receive 80,000 cubic meters. However, the station is actually receiving more than its capacity (>120,000 cubic meters daily; El-Sayed and Niaz, 1999) and at least 20 to 80 thousand cubic meters are daily by-passed without any treatment. The mixture of treated and untreated sewage is dumped into the coastal area south of the city .The dumping site is bordered southwards by natural islets and artificial sand barrier which forces the effluent water to disperse westward towards the open water. In a recent study (El Sayed and Niaz, 1999), it has been shown that the waste effluent carries daily approximately nine tons of suspended solids that carry great amounts of metallic and organic (organic detritus, aromatic hydrocarbons) contaminants. In addition to that, Al'Arbaeen lagoon wastewater treatment plant discharges large amount of untreated sewage to the lagoon causing a disastrous effect on the marine environment. A local less sewage outlets are distributed along the northern part of the coastal road to serve hotels, restaurants, resorts and the private summerhouses. Al'Tahleyyah (Desalination) Plant pours its water directly to the sea. This high saline, high temperature and highly turbid water changes the physical properties of the near-shore environment and affects the entire marine habitats. Jeddah Islamic Port, which is the most important and active port along the entire Red Sea, receives and exports huge quantities of materials, goods and oil. The shipping and loading activities result in discharging large amounts of contaminants to the marine environment falling during the shipment operations, in addition to the ship's garbage dumped to the sea regardless of regulations concerning this aspect.

SURFACE CURRENT STUDIES

The surface flow and its variability in the Red Sea is, one of the desirable field of research.

This surface flow in most of time and in many places, coincides well with the wind regime. The water exchange between the Red Sea and the Mediterranean Sea via the Suez Canal is insignificant, while the exchange between the Red Sea and Gulf of Aden through the Strait of Bab El'Mandab is significant. This exchange is not a simple, its very complicated by the wind

over the Red Sea & Gulf of Aden, and the water specifications of this two basins (Quadfasal and Baunder, 1993).

North of latitude 20°N, the surface flow was to the north-northwest direction, only in winter, i.e. against the wind direction (Patzert, 1972). Thompson, (1939) emphasized that the shifting wind field over the Red Sea has the greatest influence on its circulation. Neumann and McGill, (1962) suggested that evaporation is the major factor affecting circulation especially in early summer. Morcos (1970) stated that, the currents of the Red Sea are weaker at the times of change of the monsoons, April, May and October, where at this time there is a little or no flow through the Strait of Bab El'Mandab. Except during the transitional months, the currents in the Southern Red Sea are always greater than that in the Northern Red Sea.

During February 1963, Maillard (1971) analyzed the lateral and longitudinal hydrographic structure of the Red Sea, she concluded that the circulation at that time consisted of series of large eddies, causing strong cross currents. During summer season, a northward flow exists along the Arabian Coast in the Northern part, and a southward flow exists along the African Coast (Gerges and Soliman, 1987). Hassan and El–Nadie, (1994) showed from the computations of geostrophic currents during early summer in the Red Sea that a surface layer of depth 50 meters flow northward along the Eastern Arabian Coast of the Sea with an average velocity of about 0.27 $m.s^{-1}$, and in the same layer another southward flow of average velocity 0.39 $m.s^{-1}$, was observed along the African Coast. The current speed and direction at the two levels are shown by the length and direction of the arrows in the area (Figs. 6, 7, 8, and 9). It is seen that the surface currents in February, 2001 is directed to northwest at stations 3, 4, and 5 while it is directed to north and northeast at the stations 1 and 2 respectively. The average velocity of that currents covering this area is of about 0.3 $m.s^{-1}$ (Fig. 6). The current at 10 meters depth (Fig. 7) directed to northwest at the stations 4 & 5 and variable at the other three stations (northwest and southwest). During August 2001 the surface currents oscillated between southwest and southeast directions (Fig. 8), while directed to south-southeast at 10 meters depth (Fig. 9). It is observed that the current velocities at the southern stations is greater than that at the northern stations. The average velocities in summer is of about 0.35 $m.s^{-1}$ greater than that in winter. The results of the measured currents in winter approximately compatible with the general accepted circulation in the Red Sea during this period, while in summer season the

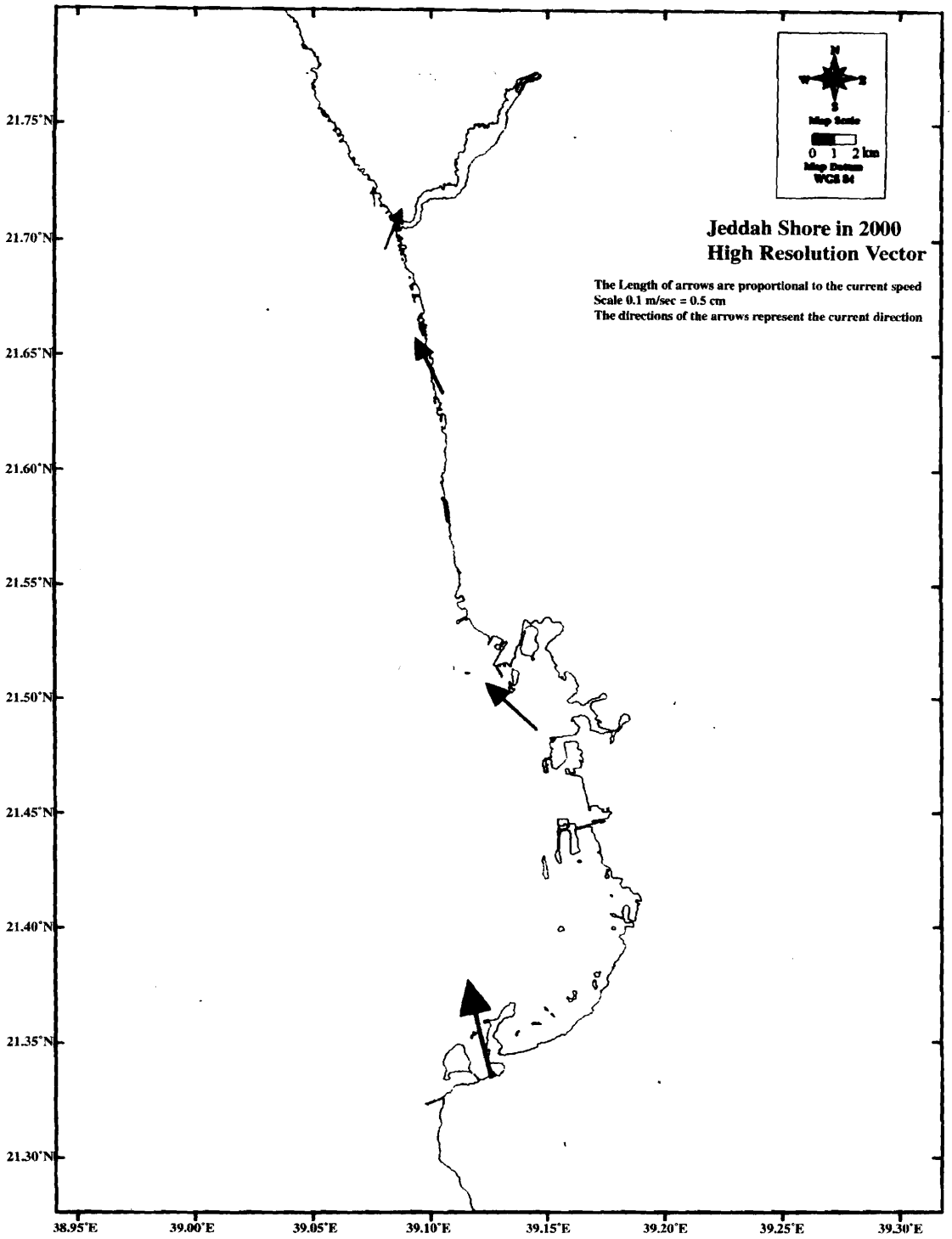


Figure (6). Current speed and direction at the surface during February 2001 (winter season).

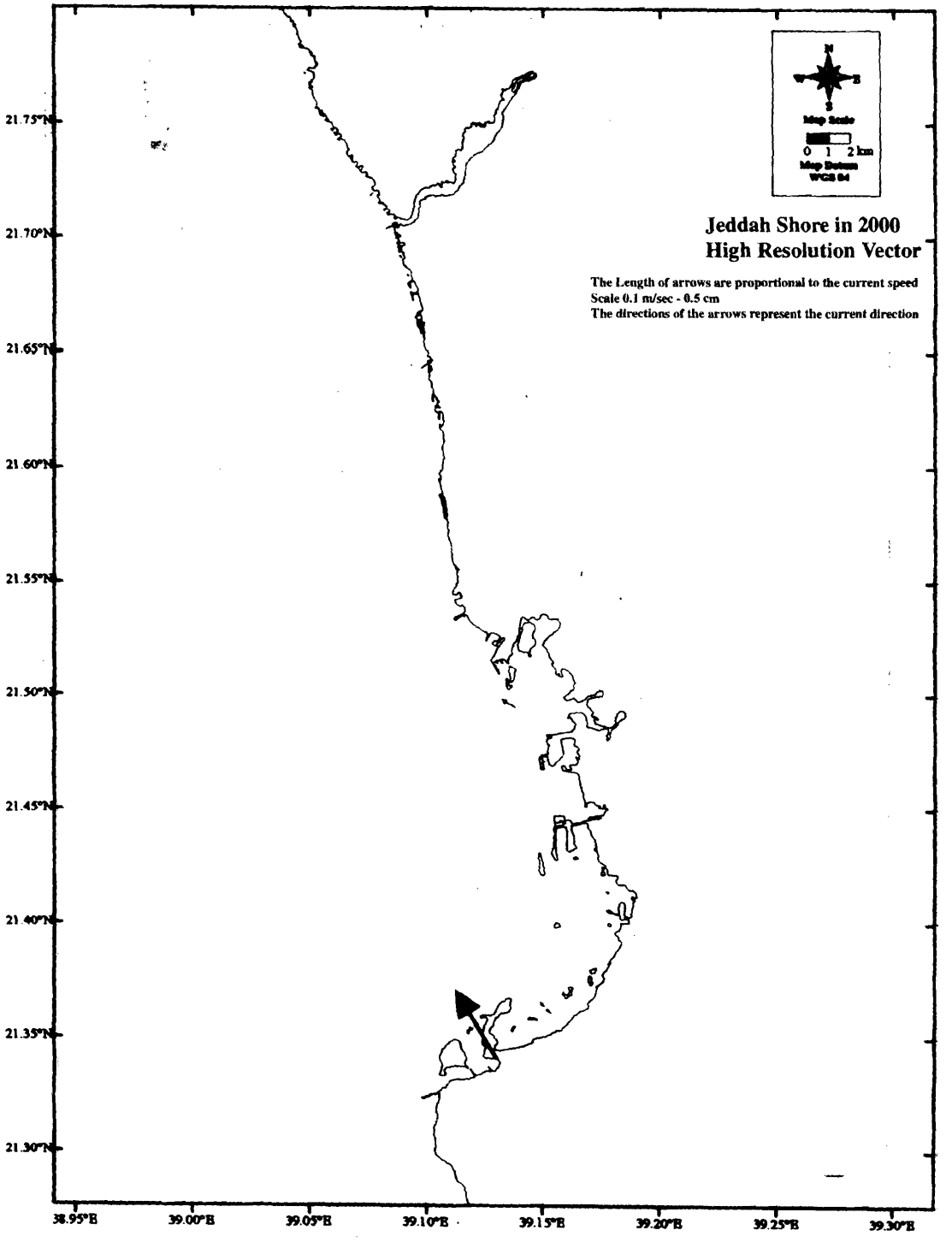


Figure (7). Current speed and direction at 10 m depth during February (winter season).

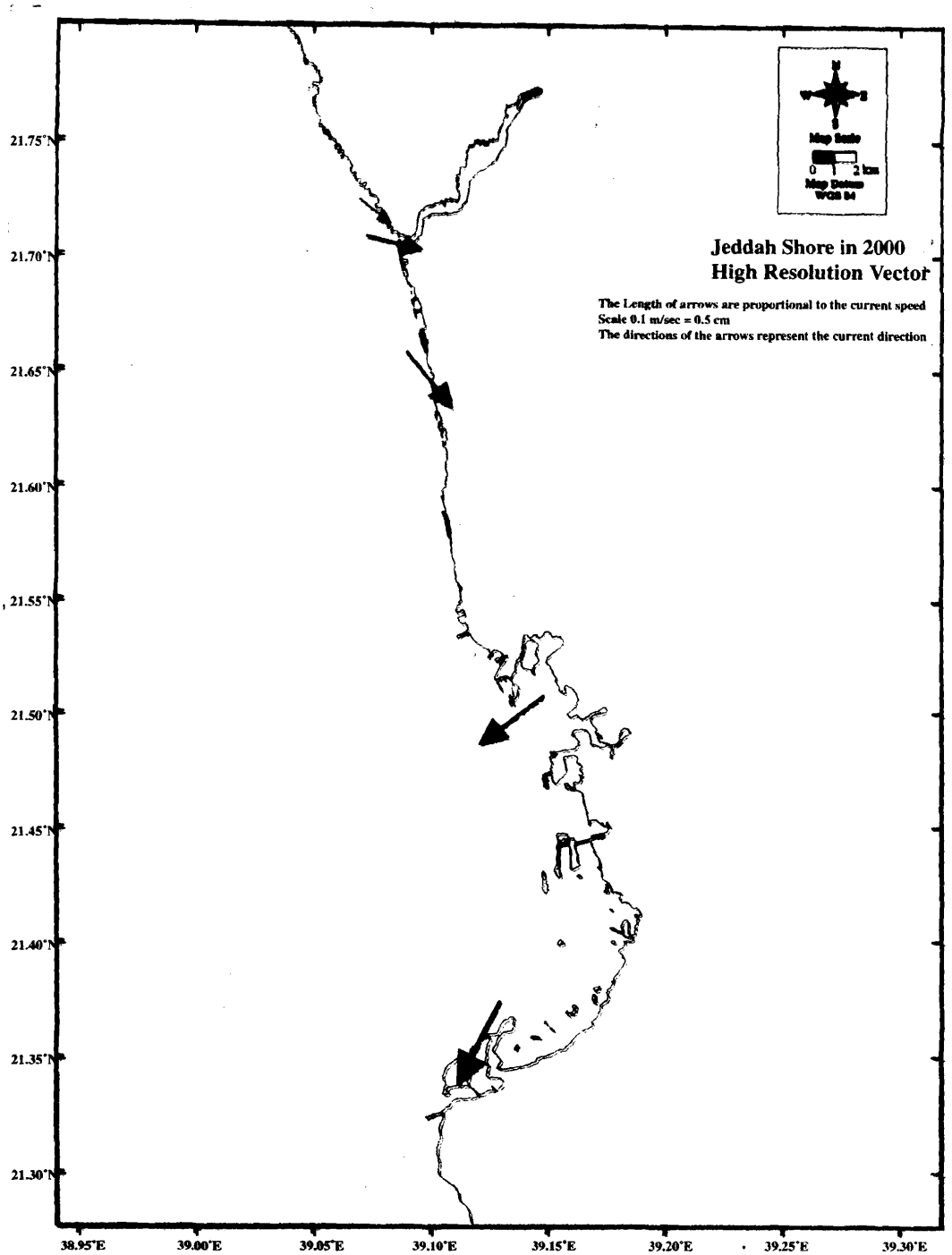


Figure (8). Current speed and direction at the surface during August 2001 (summer season).

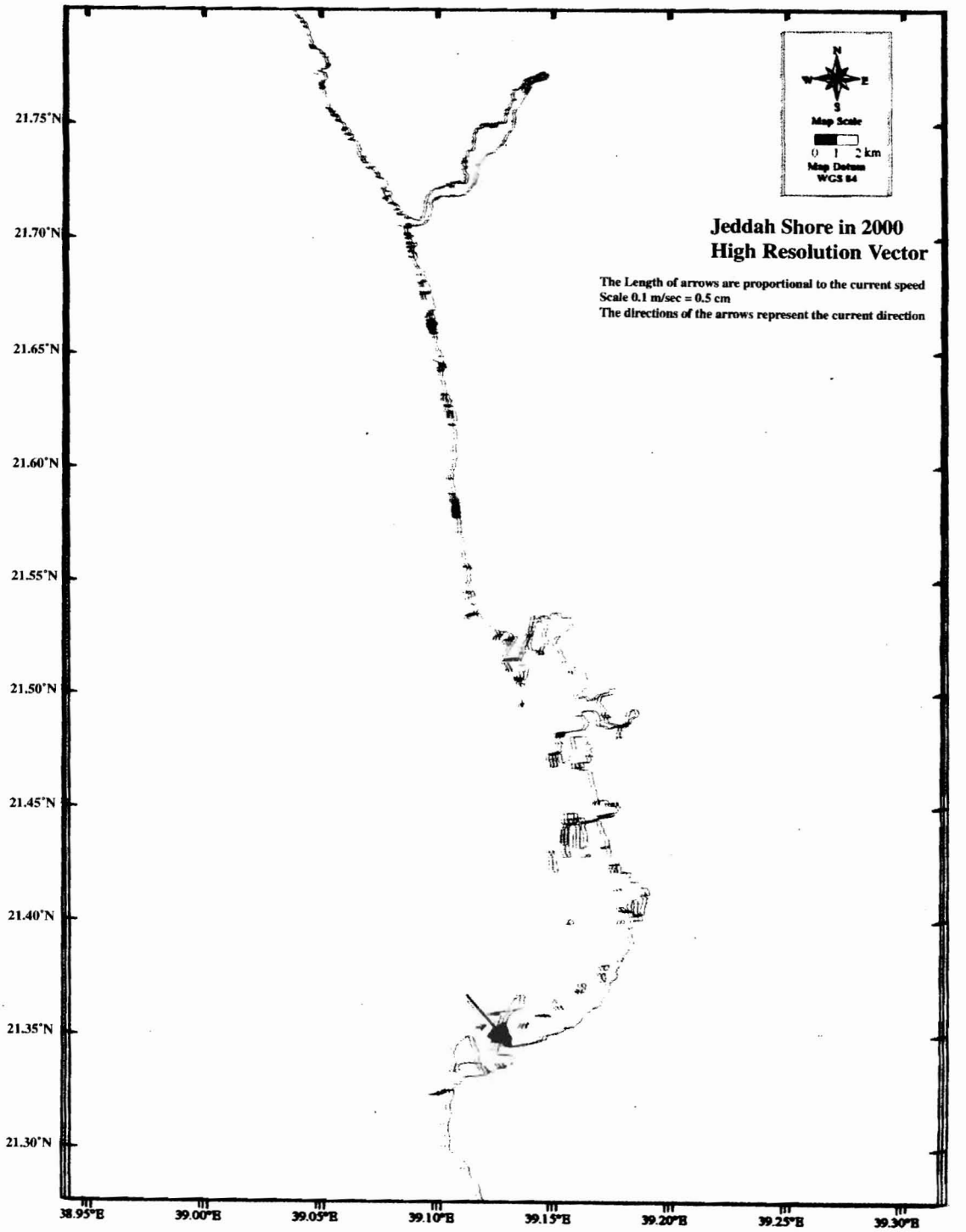


Figure (9). Current speed and direction at 10 m depth during August 2001 (summer season).

picture is different where there no systematic pattern of current is observed because of the local winds covering the area or from the coast configurations.

It needs a comprehensive continuous record of the current data to explain clearly surface flow in that area.

THE MARINE ENVIRONMENT OFF JEDDAH

The coral reef environment along Jeddah coast is a typical fringing reef (Montaggioni *et al.*, 1986). The typical fringing reef consists of a series of distinct zones at different depths and positions across the reef.

THE ENVIRONMENT QUALITY

SEDIMENT DESCRIPTION

Sand sized materials are predominant in the southern and northern Corniche areas (average 82 and 86 % respectively). On the other hand, mud rich sediments are mostly found in the relatively sheltered areas. Supply of sand and gravel along Jeddah shore zone is the product of extensive erosion of reefal limestone offshore barrier and coastal terraces bordering the coastline. Microscopic examination of the coarse grained fraction showed that it is generally composed of benthic foraminifera, shell fragments of mollusks, coral fragments, peloids, red and green algae in addition to detrital material composed essentially of quartz, feldspars and some heavy minerals.

ORGANIC MATTER CONTENT

Organic matter accumulating in marine sediments is the result of the balance between organic matter production and mineralization. The oligotrophic nature of the Red Sea results in a low organic productivity. Therefore, when the carbon cycle is not disturbed, low carbon content is expected to accumulate in the bottom sediments. This is evidently the case in the northern Corniche area where the organic carbon content of the sediments has values of 0.28%-0.35% (Table 5). This area is characterized by rather sandy deposits and is free of any appreciable organic matter input but the natural production. Therefore, oxic respiration is dominant and helps in the reduction of the organic content of the sediments. The values encountered in the northern Corniche are comparable to figures presented by other investigators in different Red Sea environments (Mohamed, 1949; El-Sayed and Hosny, 1980; Behairy *et al.*, 1983). In the disturbed ecosystems like the southern Corniche and the other areas where sewage dumping is effective, carbon fixation is enhanced due to nutrients'

input. Organic matter accumulation is therefore increased by the direct input from sewage discharge and by a second source, more or less important according to some local physical and hydrological conditions, which is the potential organic matter that could be built by algae and phytoplankton due to nutrient enrichment. The environment may turn to anoxic respiration when organic matter accumulation is fast enough to provoke oxygen depletion Anoxic respiration is less efficient than the oxic mineralization of organic matter. It results in the formation of hydrogen sulphide.

Table (5) Texture and organic carbon in marine sediments off Jeddah.

Station	Gravel%	Sand%	Mud%	OC%
7	9	88	3	0.35
8	12	74	14	0.32
9	9	89	2	0 28
10		34	65	0.86
11	Sludge	Material		25.56
12	1	10	89	1.82
13	0	83	17	0.91
14	5	88	7	0.91
15	3	71	26	0.87

For location see figure (2)

Despite the comparability of their textural composition. the southern Corniche sediments contain more than double organic carbon (0.87%-0.91%) as the northern Corniche. The highest organic carbon concentrations (average 25.56%) were recorded in the Al'Arbaeen lagoon and Al'Bankalah sediments (Fig. 10). Here the environment has turned completely anoxic and tremendous amounts of organic matter are contributed from the fish market and the sewage dumping station.

Apparently, the marine environment off Jeddah could be classified into uncontaminated area, the northern Corniche and Southern part of Jeddah: and heavily contaminated area, Al'Arbaeen lagoon, Al'Shabab lagoon and Al'Bangalah.

This classification is strictly applied to the areas represented by our sampling network. It is evident that the southern Corniche deserves a special

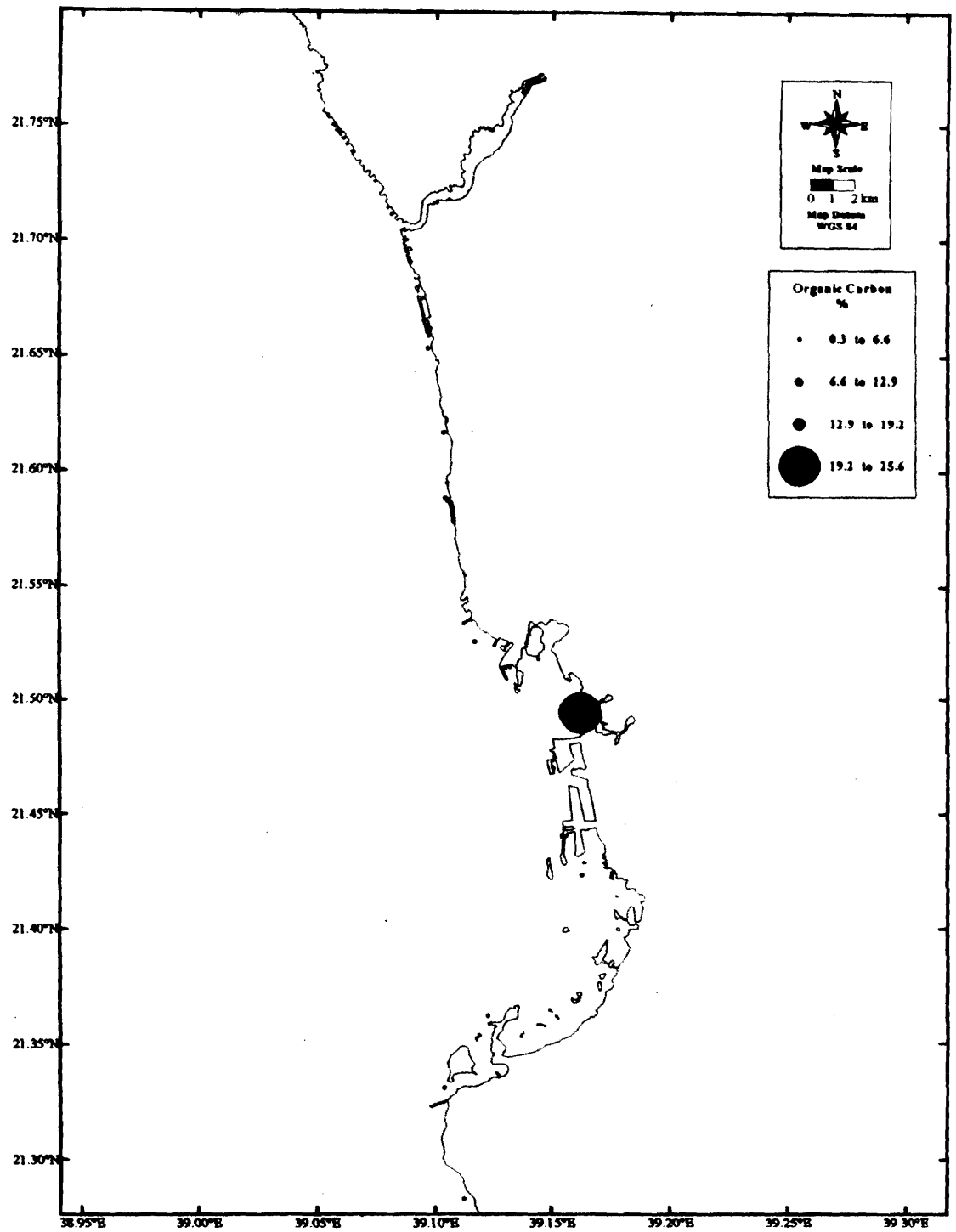


Figure (10) Organic carbon content in marine sediments off Jeddah.

research program to study the composition, flux and dispersion of the sewage effluent.

SATELLITE IMAGE DATA

The coral reef environment off Jeddah was once very highly diverse and unique. Figure (11) shows the percentage coral cover off Ghorab island, Jeddah center and the northern Corniche. The coral cover percentage off southern Jeddah is 11%. This is higher than that off Jeddah center (5%) and the northern Corniche (3%). Many coral species and other associated habitats were dwelling the near shore fringing reef zone off Jeddah. Due to the continuous and rapid industrial and urban development, coral reef cover has been decreased dramatically. Figure (12) shows the shrinkage in coral cover area between the years 1986 and 2000 at Ghorab Island south of Jeddah. Obviously, a subsequent decrease in the coral communities, and a simultaneous decrease in the habitats dwelling the coral reef environment should accompany the decrease in coral cover. The effect of sewage dumping is very strong on the near-shore marine environment off Jeddah as previously mentioned. The increase in water turbidity, pollutants and organic matter content of the bottom sediment halted the growth of the corals by shielding the light and depleting the dissolved oxygen required for the growth of corals and coral habitats. Furthermore, the algal mats grown as a result of increased dumping of sewage to the sea have covered the surface water at many places along the shore off Jeddah especially at Ghorab, Al'Arabaeen lagoon, Al'Shabab, Al'Frusiyah and Al'Salam lagoons.

These algal mats cause eutrophication and could hinder and may kill the existing corals by consuming the dissolved oxygen and preventing the light penetration. The coast of Jeddah has lost all the aspects of the natural shore.

The sandy beaches have been diminished and replaced by artificially man-made beaches. The back-reef zone and part of the reef-flat has disappeared.

The continuous dumping of either treated or untreated sewage and other similar effluents, the insistence on constructing the coastal roads (e.g. Corniche road) so close to the seawater limit and on the rocky ground of the reef zone, filling the coastal lagoons and reconfiguring the natural shore line will lead to the complete diminish of the coral reef zone and its habitats.

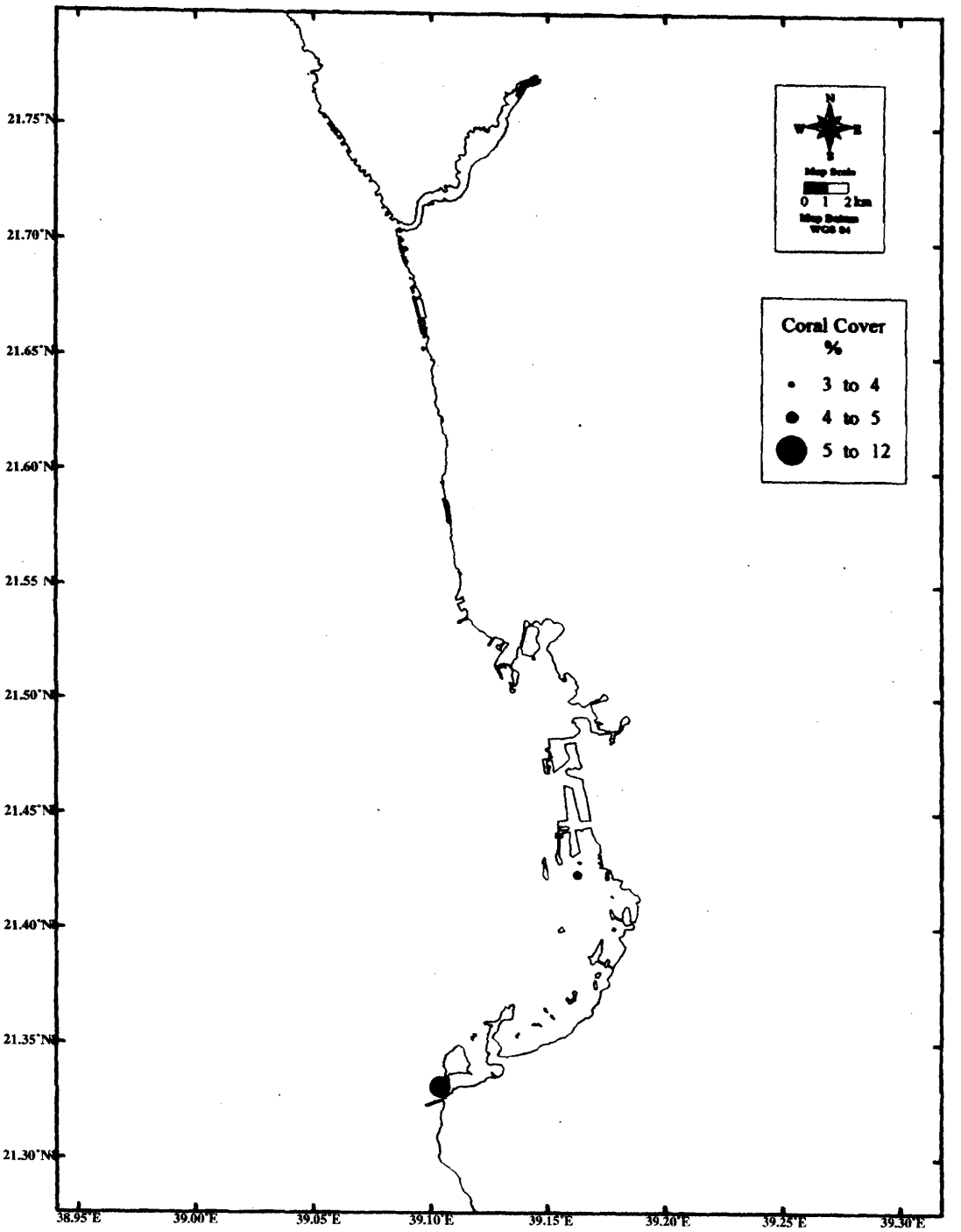


Figure (11) Percentages of coral cover off Jeddah. calculated from Landsat TM image 2000

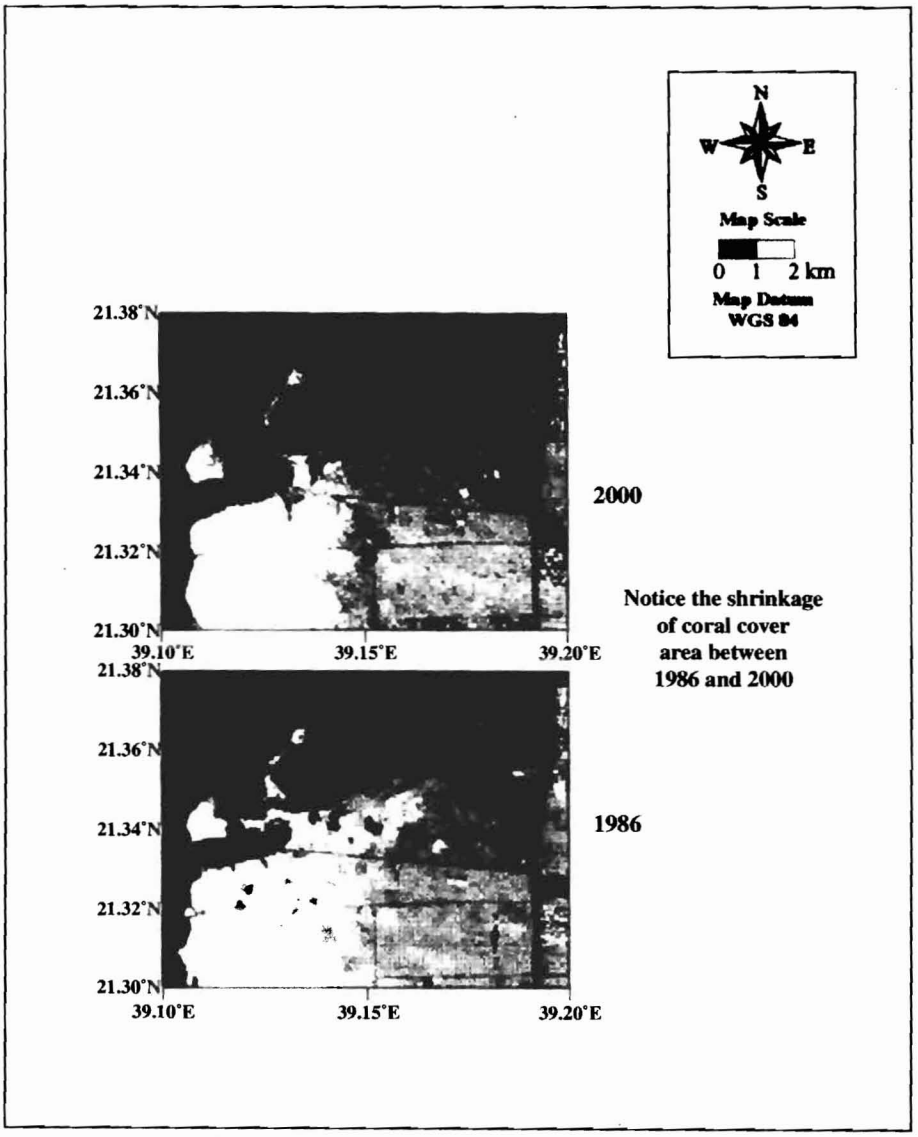


Figure (12) Variation in the coral cover between 1986 and 2000 Ghorab Island south of Jeddah

In addition, the increase in the urban, tourism and recreational activities along the shore with the subsequent dumping process of sewage effluents, swimming, diving and other water recreational sports may disturb the coral ecosystem leading to the disintegration of many habitats. The situation is disastrous and needs rapid act and further comprehensive studies. Environmental studies should be conducted on how to rehabilitate the coral reef ecosystem.

CONCLUSIONS

The study revealed that the marine ecosystem off Jeddah City is greatly disturbed by:

1- Construction processes of the coastal road and on shore facilities, recreational villages, amenity beaches, hotels, installations along the whole coastal area and port development. In addition to the anchor damage caused by boats and yachts at the numerous Marinas along the northern part of the city coast.

2- Reconfiguration processes of the shore including filling the coastal lagoon and intertidal flats and land cuttings-dredging at the northern part of the city.

3- Sewage dumping from the city main sewage treatment units and the local outlets of the on-shore recreational villages, resorts and summer houses along the whole coastal area.

4- Industrial wastes dumping to the sea at the southern part of the city.

5- Shipment operations of industrial imports and exports especially oil.

It has been shown that Al'Arbaeen lagoon and Al'Bangalah are highly polluted. The sediments of the most northern and southern sites seem undisturbed for the time being. However, the area of the southern Corniche deserves a particular attention due to the important quantities of mixed industrial and urban wastes that it receives daily. The fine-grained particles are favorable sites for the fixation of the organic matter. The study revealed, also, that there is a shrink in the coral cover off Jeddah between the years 1986 and

2000. This decrease in coral cover is accompanied, undoubtedly, by decrease in the number of habitats dwelling the coral environment. The causes of such decrease are the increase in water turbidity, depletion of dissolved oxygen resulting from dumping of municipal and industrial wastes and blooming of algal mats. Therefore, the present study recommends that rapid measures should be applied, these are:

1- Enforcement of legislation related to management of coastal and marine areas.
2- Carry out rehabilitation studies and programs of mangrove and coral reefs.
3- Measures to control collection of corals and shells from the reef flats
4- Enforcement of public awareness activities for coral reef conservation
5- Improved management of pollution, brine and thermal discharges from desalination plants
6- Effective control of dredging and filling
7- Upgrading of wastewater collection and treatment.

Unless a rapid action is taken it is expected that the coral reef environment and its habitats off Jeddah would be extinct.

ACKNOWLEGEMENT

This research was financially granted by King AbdulAziz University, Scientific Research Council, Grant No. 252/421. King AbdulAziz City for Science and Technology is acknowledged for providing the satellite images used in this study.

REFERENCES

Basaham, A. S., 1998a. Distribution and behavior of some heavy metals in the surface sediments of Al Arbaeen lagoon, Jeddah, Red Sea coast. J. K. A. U., Earth Sci. (accepted).

Basaham, A. S., 1998b. The composition and diagenetic features of the inland Quaternary coralline limestone, south Sharm Obhur , Red Sea coastal plain of Saudi Arabia. J. K. A. U. Mar. Sci., 9: 75-87.

Basaham, A.S. & El-Shater, A., 1994. Textural and mineralogical characteristics of the surficial sediments of Sharm Obhur, Red Sea coast of Saudi Arabia. J. KAU Mar. Sc., 5:51-71.

Behairy, A. K. A; EL-Rayis, 0. A. and Ibrahim, A. M.; 1983. Preliminary investigations of some heavy metals in water, sediments and plankton in Obhur Creek (Eastern Red Sea). J. Fac. Mar. Sci. K. A. A. U., 3: 129-139.

Behairy, A.K.A. & El-Sayed, M.Kh., 1983. Bathymetry and bottom relief beyond the reef complex off Jeddah, Red Sea. J. Fac. Mar. Sc., KAU, 3:73-80.

Behairy, A.K.A.; El-Rayis, O.A. & Ibrahim, A.M.; 1983. Preliminary investigation of some heavy metals in water, sediments and plankton in Obhur creek (eastern Red Sea). J. Fac. Mar. Sc., KAU, 3:129-139.

Beltagi, S., 1983. Anapertus trifurcatus Nov. Sp. (Archoophora: Anaperidae): A new species of Acoelan turbellaria from the Red Sea. J. Fac. Mar. Sc., KAU, 3:49-71.

Bemert, G. and Ormond, R. 1981. Red Sea corals. Kegan Paul Internat. Ltd., London, pp. 193.

Dowidar, N.M., 1983. The genus Ceratium form the Red Sea. J. Fac. Mar. Sc., KAU, 3:5-37.

DurgaPrasadaRao, N.V.N. & Behairy, A.K.A, 1982. Erosion and sedimentation: Vital factors in the Jeddah coastal management. J. Fac. Mar. Sc., KAU, 2:11-25.

El-Rayis, O.A., Abbas, M.M. & Qurashi, A.A., 1982. Distribution of chemical pollutants in Jeddah coastal waters, Red Sea: I- Phosphate and silicate. J. Fac. Mar. Sc., KAU, 2:73-80.

El-Sayed M. Kh. and Hosny, Ch. F. 1980. sediments of the intertidal zone off Ghardaqa, Red Sea, Egypt. proceeding of the Symposium on the Coastal and Marine Environments of the Red Sea, Khartoum 2. ALESCO / UNESCO, RSC, University of Khartoum, pp 3-15.

El-Sayed, M.A. and Niaz G. R., 1999. Study of sewage pollution profile along the southern coast of Jeddah, study of some organic and inorganic pollutants. Report, KAU, SRC, pp. 111.

El-Sayed, M.M., 1985. Distribution and concentration of dissolved organic matter along the eastern coast of the Red Sea between Jeddah and Yanbu. Saudi Arabia. J. Fac. Mar. Sc., KAU, 4:113-129.

Gerges, M. A. and Soliman, G. F. 1987 : Principal of circulation in the Red Sea obtained from two – layer numerical model, Bulletino di Oceanologica Teoricaed Aplicata, 5, 4, 261 – 276.

Hassan, H. M. and El–Nadie, S. M. 1994: New geostrophic studies on currents in the central part of the Red Sea. Bulletin of National Institute of Oceanography and Fisheries, 20, 2. 1 – 14.

Meshal, A.h., Osman M.M. & Behairy, A.K.A., 1983. Comparison of evaporation rates between coastal and open waters of the central zone of the Red Sea. J. Fac. Mar. Sc., KAU, 3:95-104.

Maillard, C., 1971 : Etude hydrologique et dynamique de la Mer Rouge en hiver, Ann. Inst. Oceangr., 498, 2, 113 – 1140.

Mohamed, A. F., 1949. The distribution of organic matter in sediments from the northern Red Sea. Amer. J. Sci. 247: 116-127.

Montaggioni, L.F., A.K.A. Behairy, M.Kh. El-Sayed and N. Yusuf 1986. The modern reef complex, Jeddah area, Red Sea: a facies model for carbonate sedimentation on embryonic passive margin. Coral reefs, 5:127-150.

Morcos, S. A., 1970. Physical and chemical oceanography of the Red Sea. Oceanogr. Mar. biol. Ann. Rev., 8: 73-207.

Neumann, A. C. and McGill. D. A., 1962. Circulation of the Red Sea in early summer, Deep – Sea Res., 8, 223 – 235.

Odum, H.T., and Odum, E.P., 1955. Trophic structure and productivity of a windward coral reef community of Eniwetok Atoll. Ecol. Monogr., 25:291-320.

Osman, M.M., 1982. Marine meteorological considerations for rational planning and management of coastal resources. J. Fac. Mar. Sc., KAU, 2:69-72.

Patzert, W. C., 1972. Seasonal variation in structure and circulation in the Red Sea, Hawaii Inst. Geophys. Rep. No. Hig. 72, 13, 58 pp.

Patzert, W.C., 1974. Wind induced reversal in Red Sea circulation. Deep Sea Res. 21: 109-121.

Quadfasal, D. and Baudner, H., 1993. Gyre – Scale circulation cells in the Red Sea, Oceanologica. Acta. 16, 3, 221 – 229.

UNDP/CSD 1997. Kingdom of Saudi Arabia, Country Profile, Report, UNDP Publ., electronic format documents, pp. 55.

UNEP/IUCN 1988. Coral reefs of the world. Vol. 2, Indian ocean. Red Sea and Gulf. UK/UNEP Nairobi, Kenya, pp. 389.

Veron, J.E.N., 1986. Corals of Australia and the Indo-Pacific. Angus & Robertson Publ., Sydney, pp. 644.

Walkely, A. and Black, I. A. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29- 38.