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Coastal Survey as a Tool in Marine Environment Protection, Gulf of Suez, Red Sea

A.E. RIFAAT, KH. A. MOUSSA, A.I. BELTAGY and A.A. EL-SHAZLY
National Institute of Oceanography and Fisheries, Alexandria, Egypt

ABSTRACT. As part of the National Program for Surveying the Egyptian Coastal Areas, National Institute of Oceanography & Fisheries, Alexandria, Egypt, surveyed the coastal zone of the central part of Gulf of Suez to collect data on the nature of the beach and inter-tidal zones, beach morphology, sediments' types, degree of pollution, and the probable land use for each part of the area.

The survey showed that sands cover most of the coastal zone in the study area whereas rocky flats and cliffs are of frequent occurrence. The beaches are sometimes clean but the majority of the coastal zone is subjected to varying degrees of pollution with oil and litter. Oil patches, and tar balls of different sizes and ages cover approximately the entire area. The litter consist of plastics, glass, cans, and wood in addition to other wastes.

The field survey revealed that, recreation and camping villages, marinas-fishery ports, and fish food processing are the appropriate types of activities for the area. Adequate measures should be applied to protect the near shore environment. These measures include, establishment of waste water processing units, waste recycling systems and controlled dumping units for any of the proposed projects of negative environmental impact.

Introduction

The proper management of the coasts is of prime importance in exploiting these natural resources especially if environmental issues are considered. The survey of the coastal areas before planning and construction of industrial and other projects is very essential to determine the environmental sensitivity of these areas. Consequently, for each coastal part, the appropriate project can be defined and the environment impact can be minimized. Furthermore, the results of these surveys may help decision makers to decide upon the validity of the economic project in relation to protection of the coastal environment.

The coastal zone is a geographical concept. Its predominant physical characteristic is the shoreline where land, sea, and air join to form a triple interface. This zone is continuum of geographical regions; each is characterized by its own pattern of economic and social activities, which relate to the distribution and availability of resources. Furthermore, the manner and rate of resource utilization may affect the stability of the constituent geological, biological and meteorological subsystems interacting and in a dynamic balance against their respective environmental requirements. The many and diverse human activities involved in the use of the coastal zone constitute imposing, excessive, and competitive demands on the limited resources; consequently they often critically affect regional ecological systems (Peel Brahtz, 1972). Yet, despite increasing concern over the state of the world's coastal environments, knowledge of the connection between non-living, biological and human domains is still far from complete (McGlade, 1989). Priory detailed resources mapping constitutes a tool for managed development of the coastal zone; the case that minimizes the drastic effect on the coastal zone ecosystems and by which sustainable development could be implemented.

The Gulf Of Suez (GOS) has significant strategic and economic value. Suez port is the gateway to the Red Sea from the Suez Canal. Commercial activity at this port has increased dramatically in recent years. There is also a rapidly expanding tourist haven, attracting hundreds of thousands of visitors annually.

Unmanaged development may threaten the Gulf's fragile marine ecology. The environmental pressures imposed by various human activities may cause significant destruction of coral along the stretches of the shoreline. Also, improper designs of coastal engineering structures may alter the stability of the coastal zone leading to shore erosion, lowering the landscape absorptivity (Mann, 1993) and consequently to diminishing economic value. Therefore, the objective of this study is to:

1 – Assessing the environmental settings, including environmental sensitivity index, of the coastal zone before exploitation.

2 – Assigning the most appropriate activity compatible with CZU (Site Alignment and Selection).

3 – Determining Zones of Special Environmental Importance ZSEI in which no development should be implemented.

4 – Laying out the Site Planning Procedure considering the environmental settings.

Area of Study

The area of study lies on the central part of the western coast of the Gulf of Suez (Fig. 1). No studies were conducted in this area because of the extensive existence of minefields along the shore which hinder the accessibility to the beach zone. Those minefields are now being cleared by the Egyptian Ministry of Defence. The Gulf is a semi-enclosed sea just 280 km long and 20-40 km wide. It occupies a wide valley and is bordered by the wide plains of low relief of the Eastern Desert and Sinai Peninsula. It has no significant terrestrial input of water. The mean monthly air temperature at Suez Meteorological Station (average of records of 1989, 1990, 1991) varies between 14°C in January and 30°C in August. The atmospheric pressure increases gradually from 1007 mb in July to 1020 mb in January and decreases afterwards until July. The mean wind speed is minimum (3.5-6 knot) in January and December and maximum in August and September (7-11 knot). However, local storms are frequently occurring. The dominant wind direction is north and northwest. The sea surface temperature in the Gulf ranges between 19.3°C in winter and 26.2°C in summer. Horizontal declination of water temperatures from south to north and from east to west is a pronounced feature of the Gulf and is due to cooling effect by the north and from east to west is a pronounced feature of the Gulf and is due to cooling effect by the north and northwest winds. The north-south increase in water temperature is associated with decrease in water salinity (4.25% at north and 4.05% at south). According to Shepard *et al.* (1992), the rapid cooling of surface water in winter and the increased evaporation helps to increase the salinity causing a steep salinity gradient along the Gulf. The regional current system in the Gulf is characterized by northerly flowing surface waters and a southerly flowing bottom waters except near the shore where it has a gyratory character.

The bottom topography of the Gulf is almost flat with a maximum depth of 70 m at its southern end. The near shore zone is almost occupied by coral reefs. The Gulf appears to be spreading and exhibits normal faulting. The bottom sediments are predominantly sands and silty sands. They are composed of calcareous debris of corals, coralline algae, molluscan shell fragments and others; terrestrial deposits are minor (Shepard *et al.*, 1992).

Field Survey and Methods of Analyses

The area of study (Fig. 1) was surveyed comprehensively. The data collected comprised :

1 – Geomorphology of the coastal zone

The geomorphological features of the coastal stretch, located between the water mark and Suez-Ras Garib main road, were identified. The locations were fixed using the Magellan PRO 1000 GPS and Magnavix MX 100 GPS instruments. The accuracy of the positioning instruments is 5 m when the differential method is applied.

2 – Biological communities

Representative samples of the drifted and underwater benthic biological communities (down to a depth of 5 m) were collected by snorkeling and preserved in 5% formaline solution for later identification in the laboratory.

3 – Pollution with litter and oil

The semiquantitative method for the estimation of the surface distribution of tar balls using the random quadrate technique (PARCOM, 1988) was applied. The method involves the estimation of the percentage coverage of 1 m × 1 m surface area of the beach (determined using 1 m square steel frame) with tar balls. The touch of the tar balls/flakes determines whether they are relatively fresh or aged.

4 – Sediments' types

Representative samples of the surface one centimeter sediment layer from the beach and intertidal zones were collected. The laboratory size analysis were applied following the method of Folk (1974) after removing the gravel fraction of the samples. The nomenclature of the sediment samples is basing on the visual observation in the field not on the nomenclature

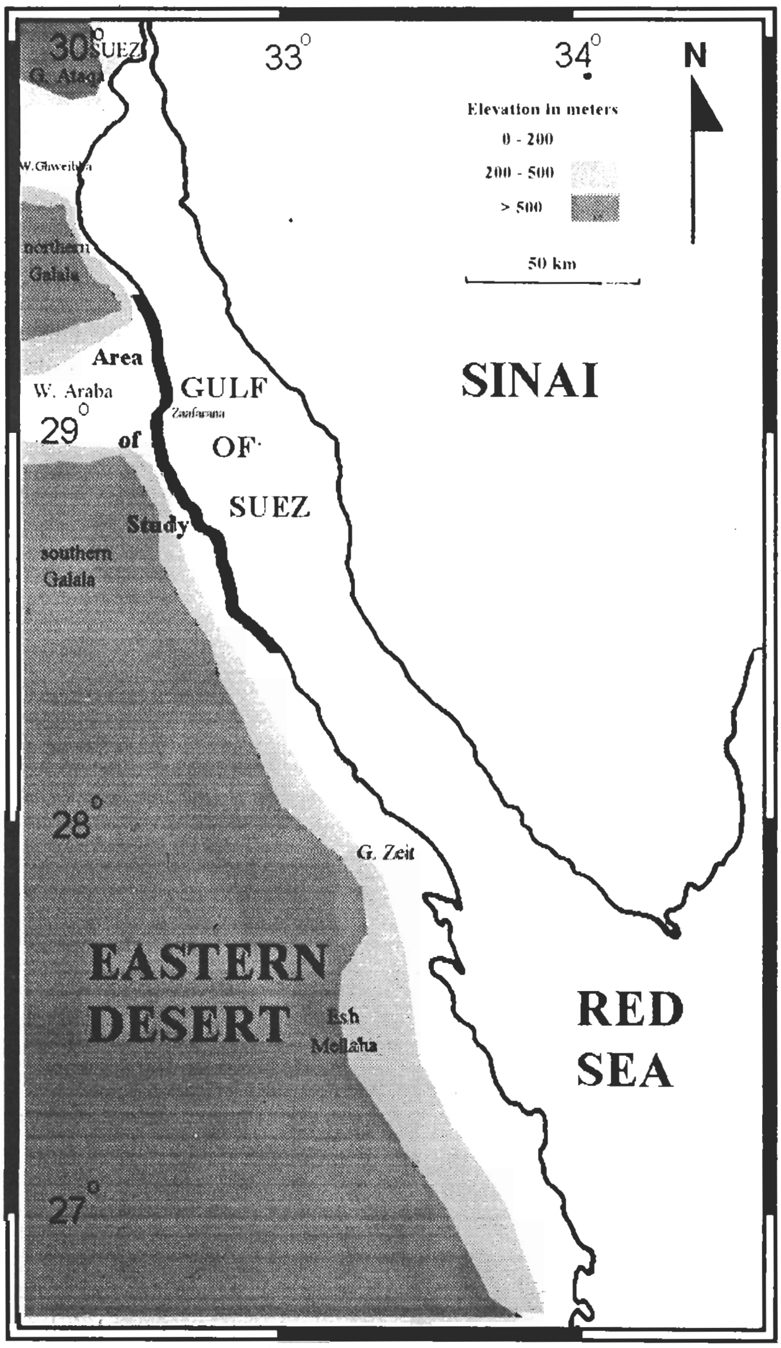

FIG 1. Area of study.

of sediment after Shepard (1954) or Folk (1974).

5 – *Present activities:* including demography, socio-economic aspects, ... etc.:

The two populated sites, namely Zaafarana village and Mersa Thelemet fishery port, along the study area were visited to collect information on demography, social and economical activities.

On the basis of the field observations and laboratory data, the probable land use activity was assigned for each Coastal Zone Unit (CZU). All the collected environmental data and assigned activity were quantified, *i.e.* a numerical value was assigned to each parameter, this value has a negative or a positive sign based on the environmental impact of the parameter and the Multi-layer Overlaying Technique (MOT).

The MOT is a technique modified following the principles of the various procedures mentioned in Kenchington and Hudson (1988) for the coral reef management and in Bashat (1992) for environmental management. The economic value (constructive) for each assigned activity and its environmental impact (destructive) were quantified and considered in the analysis. The integrated analysis of environmental and economic exploitation aspects helps in subdividing the coastal zone into subunits based on the best exploitation method (with or without precautions); in other words the objective of the analysis is to reach the best sustainable managed development for the coastal zone.

Results and Discussion

The study area is bordered from north by the northern Galala which is a great massif that is rising in parts over 1000 m above sea level (Fig. 1). While its center still preserves the plateau character, its edges are cut by numerous wadis. To the north it ends in the vertical cliffs overlooking the Ghweibba plain. On the east its escarpment ends abruptly on the shore of the GOS leaving hardly any coastal strip. To the south a similar scarp borders the north side of Wadi Araba. South of the northern Galala massif, and separating it from the blocks of southern Galala, is the wide valley of Wadi Araba which measures 30 km from north to south and reaches westward to the central limestone plateau of the eastern desert. The rocks that crop out in Wadi Araba are chiefly the lower Cretaceous Nubia sandstones; and the center there are exposed fossiliferous beds of Carboniferous age. An elongated scarp similar to the one on its northern side borders Wadi Araba on the south; it also rises to heights over 1200 m above sea level in its eastern end, but gradually sinks to the west where it merges into the central plateau of the eastern desert. This escarpment in the northern limit of the southern Galala Plateau which, like the northern Galala, is made of Eocene limestones with Cretaceous rocks showing in the lower half of its bounding cliffs. To the south of this highly broken massif the coastal plain becomes wider. About 40 km south of Zaafarana the main Red Sea hills begin to appear and the monotony of the plain is broken further south by the appearance of the Gebel Zeit and Esh-Mellaha ridges which form conspicuous topographical features between the coast of GOS and the main Red Sea hills. These ridges are separated by a plain which forms the southern extension of the main coastal plain to the north (Hussien, 1991; Said, 1962; Mostafa, 1985; Wally, 1984; Abu Koffa, 1981).

At the end of the surveyed area (Fig. 2a, b) the beach is generally flat and is covered by sandy sediments. It is relatively wide being blanketed with sand sediments at its most parts except at two small regions where rocks and rocky patches intervened with sands are found. The distribution of tar balls and litter varies from scarce to moderate depending on the beach direction and configuration. To the North, the beach is occupied by small-sized sand dunes that are covered with desert plants. The beach width in this area fluctuates between narrow and wide and is entirely covered by sand sediments except at one location where rocky patches intervened with sands exists. The area is lightly to densely polluted with litter and oil with a general increasing trend due north. Further north, a long stretch of the shore area is occupied by small-sized sand dunes that are covered with desert plants. At the northern limit of the surveyed area, the shore area is mostly formed by rocky cliffs and huge sand dunes bordering the beach zone that is relatively wide and is covered by sandy sediments. The litter and oil pollution vary from relatively clean to moderately polluted being clean in its most parts (Table 1). Most of the sediments covering the beaches of the study area along the GOS are of Pliocene-Recent age (Said, 1962 & Abu Koffa, 1981).

The coastal zone is characterized by distinguished landscape and underwater corals. The existence of mountainous regions bordering the coast and the coral reefs assemblages parallel to the coast (Fig. 2a, b), besides, the fish species richness and high diversity, give the area a high environmental sensitivity attribute. Reefs on the western coast of the Gulf of Suez are better developed than those on the East. At the area of study the reef flat extends 30-40 m offshore and is followed by a gentle slope to a sandy bottom at 4-5 m deep. The communities at the outer slope are dominated by *Porites, Acropora* and *Stylophora* (Sheppard *et al.,* 1992). The relative low sea water temperature and turbidity caused by resuspension of bottom sediments restrict the further development of reefs.

Along the shore of the study area over 160 species of anthozoans, echinoderms, demospogians, decapods, cephalopods, bivalves, and gastropods are recorded by the authors. Most of these species are marine and few are terrestrial. The diversity is relatively very high although the population densities are low. The diversity in marine biota is typical of the Red Sea environment. Seagrasses are relatively diverse (8 species) while the shore vegetation is scarce and dominated by 3 species (*Hamada scoparia, Suaeda* sp. and *Halocnenum strobilaceum*).

The distribution of fish species richness along the Gulf of Suez shows a relative decline from 85 species at north to 70 species at south being about 80 fish species

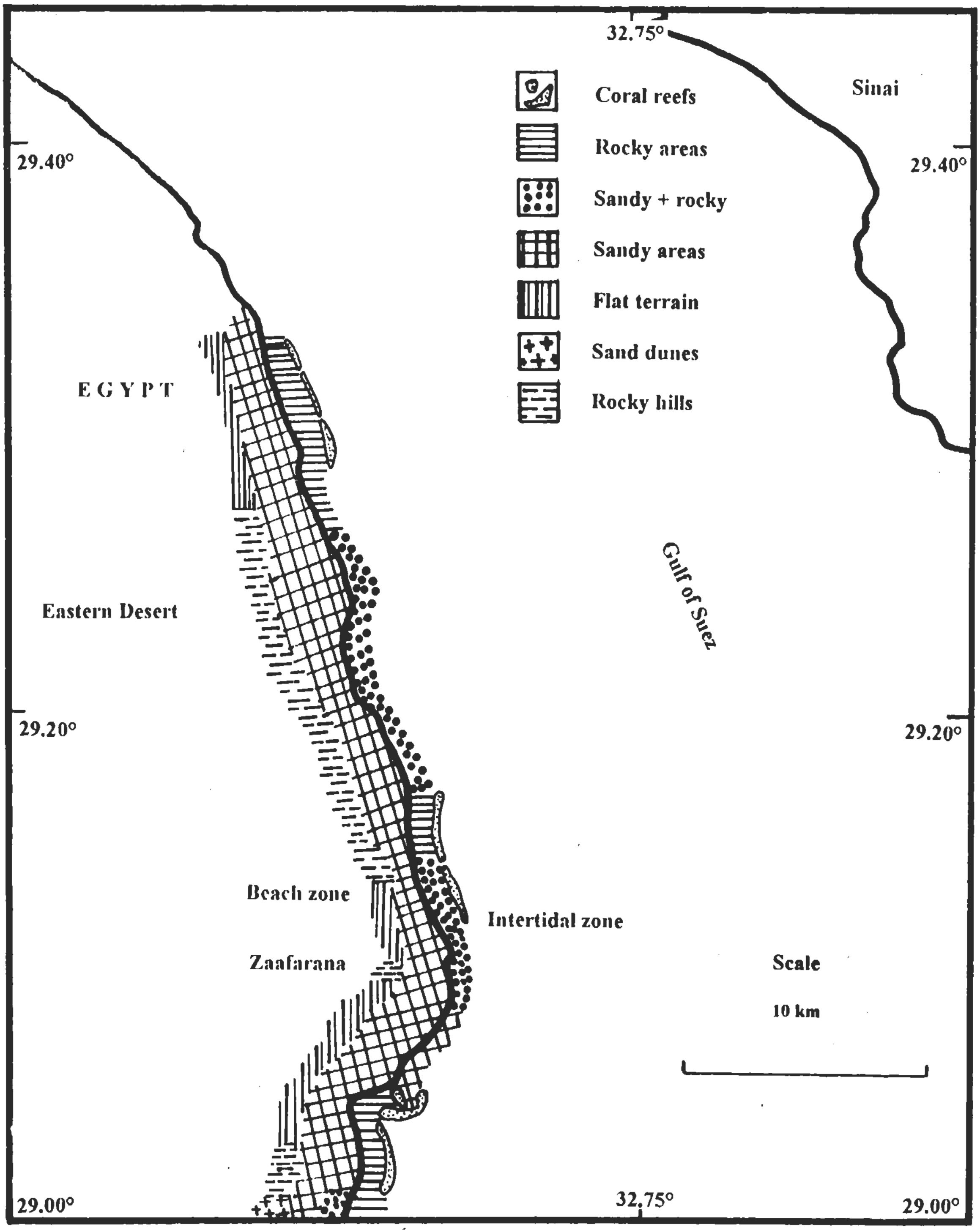

FIG 2a. Geomorphology of the northern coastal zone of the study area, Gulf of Suez (see Fig. 1).

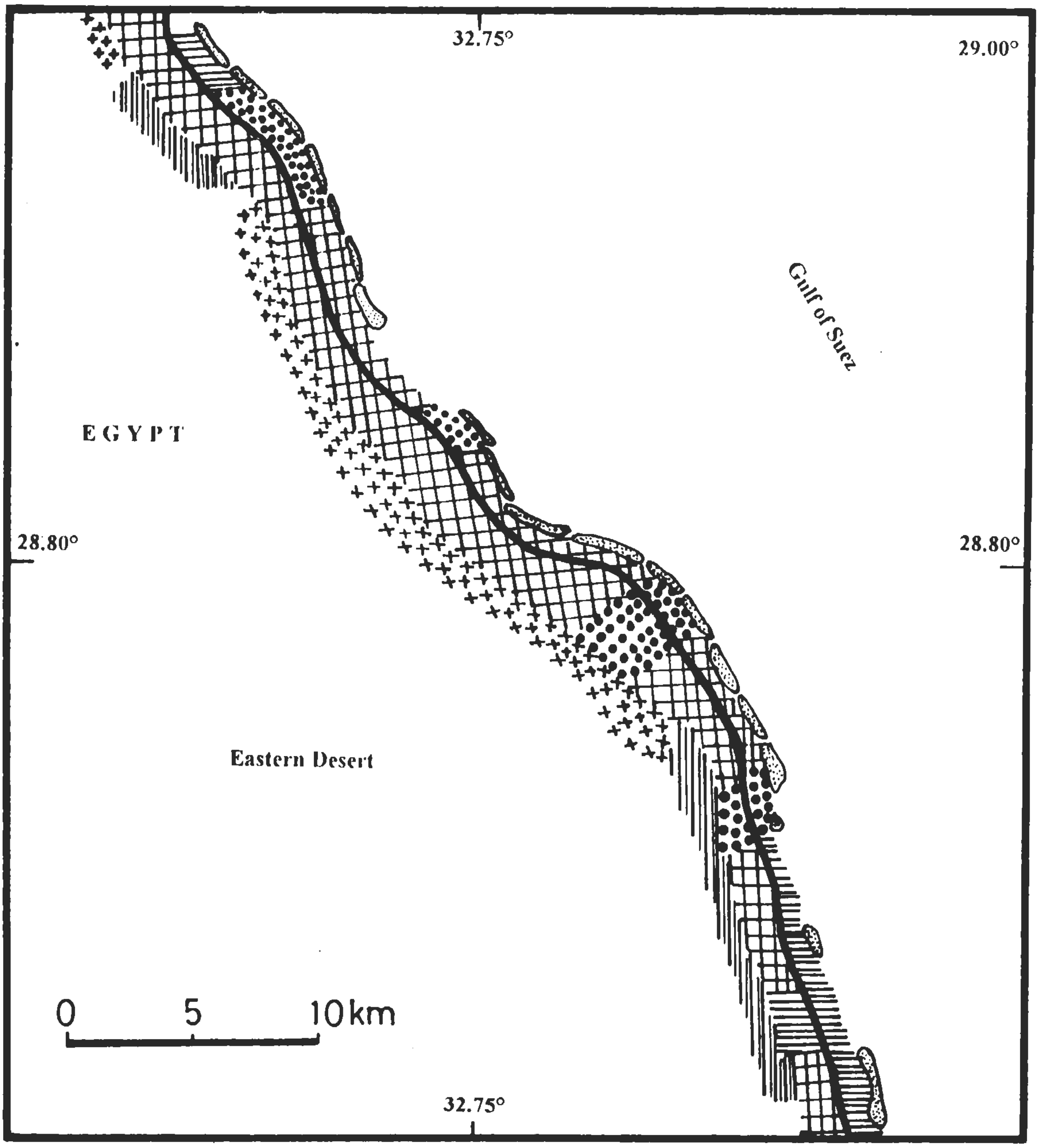

FIG 2b. Geomorphology of the southern coastal zone of the study area, Gulf of Suez (see Fig. 2a for legend).

at the area of study. The abundant species include *Epinephelus chlorostigma, E. summana, Chaetodon larvatus, Minilabrus striatus, Pseudochromis flaviertex,* and *Chaetodon paucifasciatus.* Most of the commercial fish and shrimp catch fleet in the area of study operate as trawlers by day and purse seiners at night (Sanders and Kedidi, 1984).

The populated sites along the coast of the study area are Zaafarana village, Mersa Thelemet, North Amer collecting station, and PETROJET installations. Zaafarana village is the only administrative unit along the coast. Its population is 150 individual. The population at Mersa Thelemet is 20 individuals. However, the only activity at those two sites is fishing. At very limited areas, the beach is used for recreation occasionally but the existence of extensive minefields (relics of the past war) restrict this activity to a large extent.

Proposed Development Activities

The proposed land use map (Fig. 3) designed based on the MOT results (Table 2), shows that tourism-recreational villages, fishery harbours and marinas, oil

TABLE 1. Features of the studied area along the Gulf of Suez.

Coastal zone unit	Coast	Beach zone width	Sediment type**	Pollution degree*	
				oil	litter
U1	Flat	wide	gravelly sand	clean	clean
U2	,,	,,	rocky	moderate	,,
U3	,,	,,	,,	,,	moderate
U4	,,	,,	gravelly sand	,,	clean
U5	,,	,,	,,	light	,,
U6	,,	,,	g. sand + rocky	moderate	moderate
U7	,,	narrow	,,	,,	,,
U8	Flat + dunes	wide	gravelly sand	light	light
U9	,,	,,	,,	moderate	moderate
U10	,,	narrow	g. sand + rocky	heavy	heavy
U11	,,	,,	sand	,,	,,
U12	,,	wide	gravelly sand	light	light
U13	,,	,,	sand	,,	heavy
U14	,,	narrow	,,	moderate	,,
U15	,,	wide	,,	light	light
U16	,,	narrow	,,	,,	,,
U17	,,	wide	,,	moderate	moderate
U18	Flat	narrow	,,	heavy	heavy
U19	Flat + dunes	wide	,,	clean	clean
U20	,,	,,	sand + rocky	,,	,,
U21	Hills	,,	rocky	,,	,,
U22	Flat	,,	sand	,,	,,
U23	Flat	,,	,,	,,	,,
U24	Composite	,,	sand + rocky	moderate	moderate
U25	Flat	,,	sand	heavy	heavy
U26	Hills	narrow	sand dunes	moderate	moderate
U27	Hills	,,	sand dunes + rocky	,,	,,

*Estimated using the method mentioned in PARCOM (1988) **Field observation.

exploration-production industry and fish processing factories (canning, freezing, ... , etc.) are the most probable activities suitable for the area at the locations shown on the map. The restriction on construction of Marinas and harbours (fishery) arises from the existence of offshore corals communities. The engineering structures accompanying the installations destroy permanently the offshore corals. Therefore, where corals are absent and the substrate of the beach and intertidal zones is rocky, Marinas and Harbours are assigned as Best Activity for this CZU if 1) controlled dumping of wastes are considered and 2) the landscape absorptivity is high. The term absorptivity is a measure for the capacity of any landscape to absorb build introductions (Mann, 1993). The tourism and recreational villages and resorts are convenient for the entire area except at locations marked with asterisks (*). The construction design of such villages and camps should; 1) Consider a clear or buffer zone measuring at least 200 m from the high water mark, 2) Avoid altering the present shore features such as landscape, 3) Avoid clearing of the sand dunes that are the shore stability factors, 4) Include waste and wastewater processing units to ensure clean dumping to the adjacent marine area, and 5) To ensure presenting EIA prior to the construction of any project (Low of the environment, 1994). The locations marked with asterisks(*) are areas of high diversity and very high landscape features that should be protected against alteration by human activities. These areas are Zones of Special Environmental Importance (ZSEI) in which development should not occur at all. Oil exploration-production industry is mostly allowed along the entire area but in the offshore zone (beyond the corals stretches) with precautions toward leakage and catastrophic spill accidents. The onshore oil collecting units and the bottom oil pipelines should be installed away from the corals communities and seagrass beds. Other industrial activities are strictly prohibited due to 1) the unexpected effects of industrial discharges (even if properly treated) on the marine environment especially the biological communities and 2) the relative small volume of the Gulf of Suez and its semi-enclosed nature.

Conclusion

Coastal survey is an important procedure to protect the coastal zone environment. Its importance arises

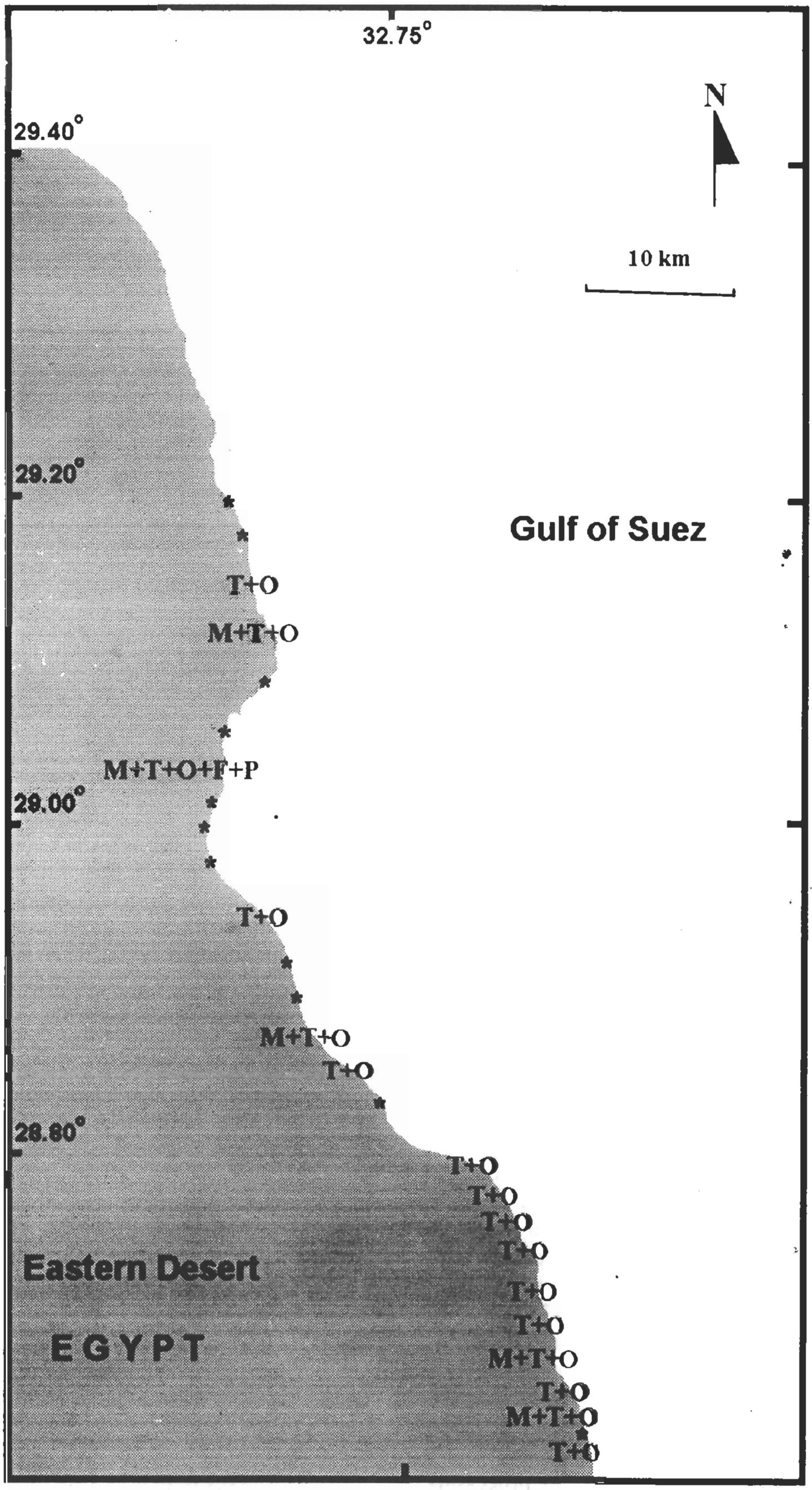

FIG. 3. Assigned activities along the studied area (see Table 2 for legend).

TABLE 2. Results of Multi-layer Overlaying Technique (MOT).

Coastal zone unit from south to north	Lat. N	Long. E	Environmental sensitivity index	Exploitation impact index	Net impact	Managed activity
U1	28° 36.6618′	32° 51.7630′	6	10	− 4	T + O
U2	28° 37.9358′	32° 51.5630′	5	20	− 15	*
U3	28° 39.1107′	32° 51.2139′	10	5	5	M + T + O
U4	28° 39.3643′	32° 50.5367′	6	10	− 4	T + O
U5	28° 41.4305′	32° 50.3202′	6	5	1	M + T + O
U6	28° 42.5753′	32° 43.7632′	5	10	− 5	T + O
U7	28° 43.6438′	32° 49.8773′	6	10	− 4	T + O
U8	28° 44.7317′	32° 32.4352′	7	10	− 3	T + O
U9	28° 45.8111′	32° 48.7356′	8	10	− 2	T + O
U10	28° 46.9301′	32° 48.0343′	8	10	− 2	T + O
U11	28° 47.3342′	32° 46.1269′	6	10	− 4	T + O
U12	28° 49.0582′	32° 44.1571′	6	20	− 14	*
U13	28° 50.1414′	32° 43.7103′	7	10	− 3	T + O
U14	28° 51.2491′	32° 42.1375′	7	5	2	M + T + O
U15	28° 52.3304′	32° 41.1973′	5	20	− 15	*
U16	28° 53.7018′	32° 40.7673′	6	20	− 14	*
U17	28° 55.0181′	32° 40.3255′	7	10	− 3	T + O
U18	28° 57.7558′	32° 38.0985′	5	20	− 15	*
U19	28° 59.0844′	32° 37.2525′	4	20	− 16	*
U20	29° 00.4422′	32° 37.3492′	5	20	− 15	*
U21	29° 01.8032′	32° 37.8939′	13	0	13	M + T + O + F + P
U22	29° 03.1881′	32° 37.4117′	3	20	− 17	*
U23	29° 04.5543′	32° 39.1190′	1	20	− 19	*
U24	29° 05.9240′	32° 40.0061′	9	5	4	M + T + O
U25	29° 07.6690′	32° 39.1127′	5	10	− 5	T + O
U26	29° 09.3044′	32° 38.7889′	8	20	− 12	*
U27	29° 11.0000′	32° 38.3881′	11	20	− 9	*

Sensitivity Index 1 = high sensitivity 13 = low sensitivity
Impact Index 0 = low effect 20 = high effect
M = Marina, T = Tourism, O = Oil Industry, F = Fishery Harbour,
P = Fish Processing Industry

from the need of finding a formula to balance between the economic development along the coasts and the environment conservation. Many industries could be established along the GOS coasts. If it is executed with appropriate care and deliberation with respect to site selection, site planning, viewshed exposure, and design parameters, the managed development in certain regions of the Gulf's coast or any coastal zone area can meet the intended objectives without diminishing the value of the resources.

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المسح الساحلي كوسيلة لحماية البيئة البحرية، خليج السويس، البحر الأحمر

أحمد السيد رفعت، خالد عبد العال موسى، علي إبراهيم بلتاجي، عبد الرحمن أحمد الشاذلي

المعهد القومى لعلوم البحار والمصايد - الأسكندرية - مصر

المستخلص: فى إطار البرنامج القومى لمسح الشواطىء المصرية والذى قام به المعهد القومى لعلوم البحار والمصايد تم مسح المنطقة الساحلية الوسطى لغرب خليج السويس لجمع البيانات المتعلقة بطبيعة الشواطىء ونطاق المد والجزر وشكل وتضاريس الشواطىء ونوعية الرسوبيات ودرجة التلوث والاحتمالات الأفضل لاستغلال المنطقة الشاطئية .

وقد أظهرت نتيجة المسح أن معظم الشواطىء مغطاة بالرمال باستثناء بعض المناطق ذات الطبيعة الصخرية المنبسطة أو الجبلية ، وبالرغم من أن معظم المنطقة الشاطئية قد تعرضت لدرجات متفاوتة من التلوث بالبترول والفضلات المبعثرة فإن ذلك لم يمنع تواجد بعض المناطق الخالية تقريبا من التلوث. ويتمثل التلوث بالبترول فى بقع الزيت السائلة وكرات القار ذات الأحجام والطبيعة المتفاوتة والتى تسود تقريبا معظم شواطىء منطقة الدراسة. وتشمل الفضلات المبعثرة البلاستيك بأنواعه والزجاج والعلب المعدنية والأخشاب والمخلفات الأخرى .

بينت الدراسة إمكانية استغلال المنطقة الساحلية فى أنشطة مثل القرى والمعسكرات السياحية والموانىء وإنشاء مراسي مراكب الصيد واليخوت وكذلك فى إنشاء الصناعات المتعلقة بالأسماك مثل التعليب والتجفيف والتجميد مع الأخذ في الاعتبار اتباع الاجراءات الكافية لحماية البيئة البحرية المتاخمة لمنطقة الاستغلال مثل إنشاء محطات معالجة أو إعادة استخدام المخلفات الصلبة ومياه الصرف ووحدات التحكم في الصرف إلى المياه الساحلية .