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COASTAL MANAGEMENT IMPACT (1983) ON THE SUBLITTORAL ZONE OF THE JORDANIAN COAST OF THE GULF OF AQABA*

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INTRODUCTION

Jordan has a coastline of 25.6 km along the Gulf of Aqaba off the Red Sea. The shore of this coast is extremely narrow and borders on the northern and eastern side of the Gulf. The eastern shore is characterised by rich coral reef communities. Prevailing northern winds from Wadi Araba carry sand from the desert into the Gulf resulting in a northern shore composed of sandy bottom beaches. Situated on the interface between the northern beaches and reefs is the city of Aqaba, the only Jordanian port.

The entire Jordanian coastline on the Gulf is being modified by a variety of developments accompanying the enormous economic

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*This Study was carried out within the framework of the Jordanian French joint program of scientific cooperation.

growth in Jordan over the last ten years. To the north of Aqaba the sandy beaches are being developed as tourist resorts. To the east of Aqaba there is extensive industrial expansion including a fertilizer plant, power stations, wood industries and industrial jetties and piers.

More than any other city in Jordan, Aqaba has been greatly affected by the huge economic growth prevailing in Jordan for the last ten years. Accompanying economic development the population of Aqaba has increased from ten thousand in 1972 to forty thousand in 1982. Economic growth is reflected in a high rate of imports and exports, most of these are shipped through Aqaba. The results has been the construction of a large number of new berths, storage areas, parking places, harbours, jeties, etc. In addition, industrial expansion has taken place (e.g., fertilizer plant, power station, wood industry, etc.) Development has been wholly or partly at the expense of the sea floor.

It is well known that each construction destroys the benthic community of the area of sea floor it occupies. In addition, such construction leads to the damage of the neighbouring area (pollution induced by harbour activities, dredging, eutrophication of the closed waters, etc.). As the continental shelf of the Jordanian coast is extremely narrow, each construction on the sea floor reduces an important part of the natural surface of the benthic community.

The main aim of our study was to evaluate human impact on marine benthic life through inventories of sea floor constructions. Using the surface measurement of the construction and knowledge of the surface area of the sublittoral photosynthetic zone between 0 and 50 km, the impact of construction on the coastal zone can be evaluated. He hope this will give all concerned a definite idea of the need for coastal zone management. Such a plan must include a policy for the conservation of marine life.

In this respect, we may suggest plans that would limit the effect of sedimentation including the improvement of construction works, construction of coarse weave fabric boom and setting of sedimentation traps on either side, monitoring turbidity and separation of touristic from non-touristic areas.

METHODS

The Jordanian littoral zones on the Gulf of Aqaba has several different aspects. Our knowledge of the sublittoral zone in the area allowed us to divide the coast into three distinct zones (Figs. 1 and 2, Table 1).

Zone 1: From Wadi Araba to Military harbour (Fig. 1)
Zone 2: From the Navy Base to Yemenieh Point (Fig. 1)
Zone 3: From Yemenieh to the Jordanian-Saudi border (Fig.2)

Zone 1: - Oriented NW and is characterized by the presence of sandy beaches and sandy bottoms. Coral heads are rare and the substrate is covered with scattered beds of Halophila stipulacea (Forsskal), (Ascherson), to a depth of 42 m(Hulings and Kirkman, 1982).

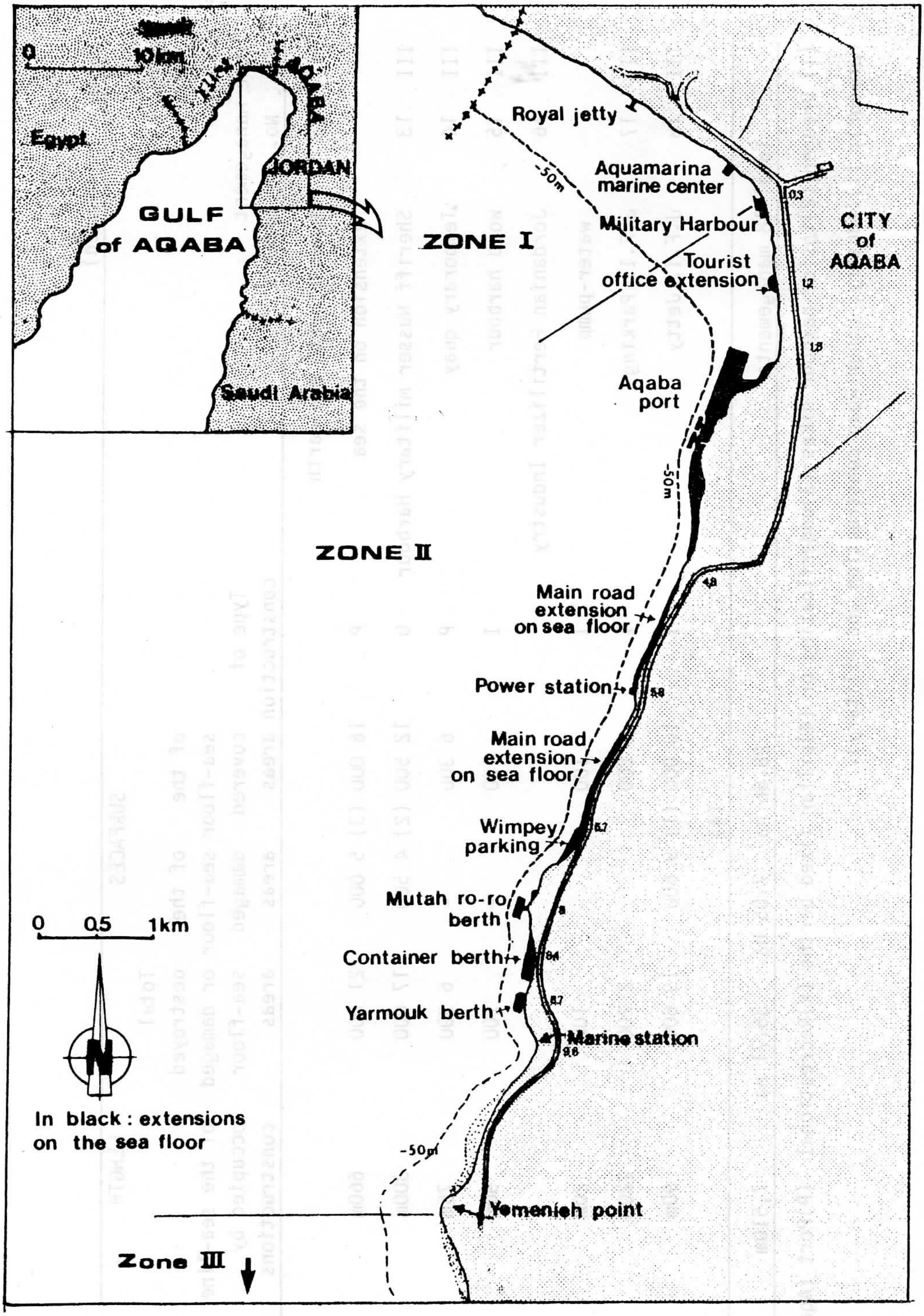
Table 1

Zone No.	Management No.	NAME	Type of construction	SURFACES: of the sea-floor covered areas	SURFACES: of the sea-floor damaged areas	SURFACES: Total destroyed or damaged sea-floor areas	LENGTH: of the sea-line occupied by constructions
I	1	Royal Jetty	R	2 800 m^2	-	2 800 m^2	50m
I	2	Aquamarine beach center	R	2 500	-	2500	35m
II	3	Navy base (Palm Beach)	O	7 900 (2)	6900 m^2	14 800	250m
II	4	Earth extension on the sea in front of the Castle	O	10 900	-	10 900	230m
II	5	Harbour of Aqaba	P	162 800 (1) (2) (3)	35 000	197 800	2,420m
II	6	Main Road extension on the sea	O	9 000	-	9 000	900m
II	7	Power station	I	2 000	-	2 000	100m
II	8	Main Road extension on the sea	O	8 000	-	8 000	800m
II	9	Wimpey Parking	P	6 500	-	6 500	450m
II	10	Mutah/Ro-Ro Berth and earth extension on the sea	P	9 000 (3)	5 000	14 000	580m
II	11	Container Berth	P	18 000 (1) (4)	4 500	22 500	280m

Table 1 (continued)

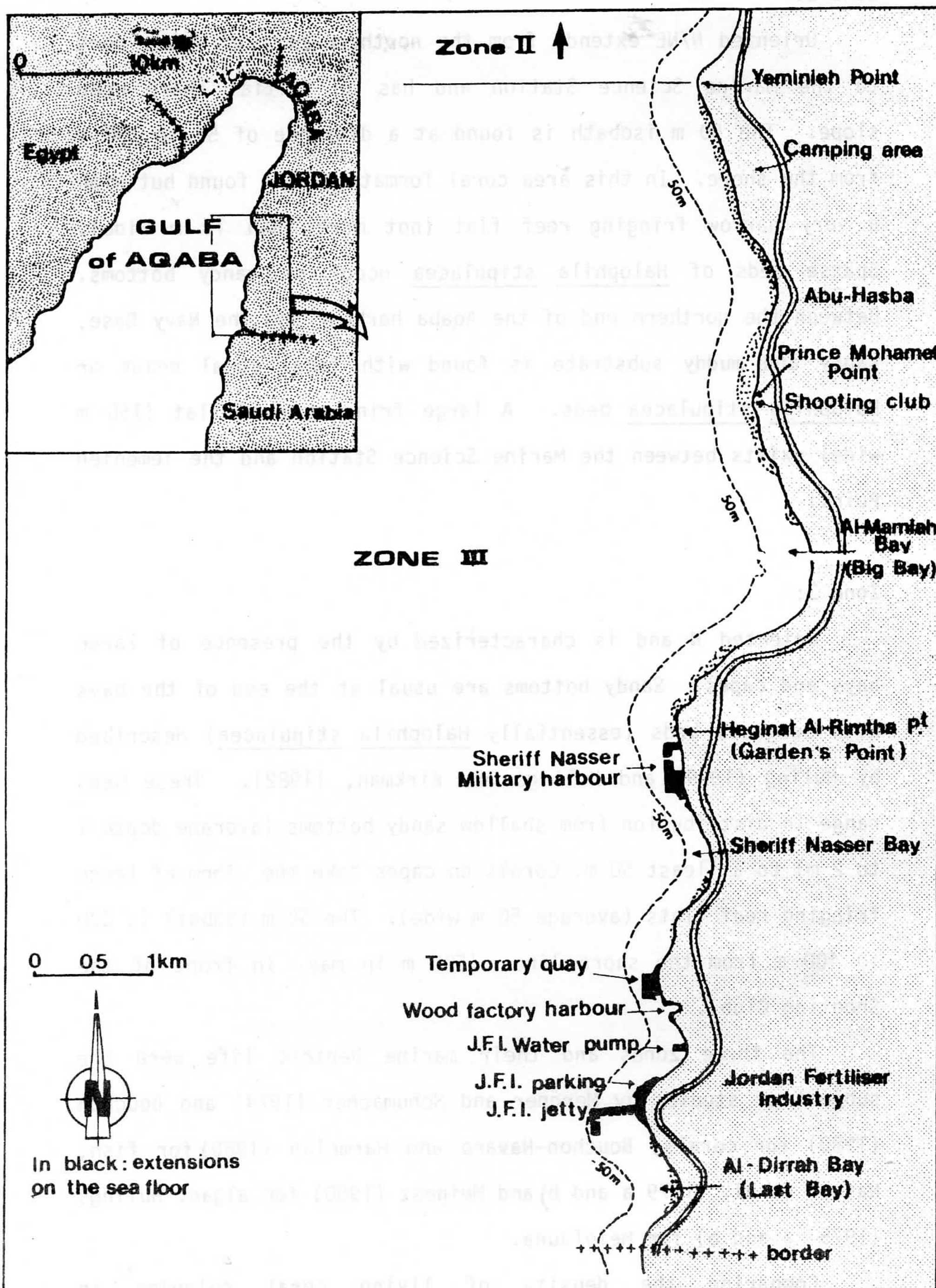
Zone No.	Management No.	NAME	Type of construction	SURFACES: of the sea-floor covered areas	SURFACES: of the sea-floor damaged areas	SURFACES: Total destroyed or damaged sea-floor areas	LENGTH: of the sea-line occupied by constructions
II	12	Yarmouk Berth and earth extension on the sea	P	16 000	(3) 5 000	21 000	660m
III	13	Sheriff Nasser Military Harbour	O	12 500	(2) 4 500	17 000	300m
III	14	Temporary quay	P	6 300	-	6 300	75m
III	15	Wood harbour	I	100	-	100	50m
III	16	Jordanian Fertilizer Industry water-pump	I	100		100	20m
III	17	J.F.I. Parking	I	2 200		2 200	220m
III	18	J.F.I. Jetty	I	10 000	(1) 9 600 (4)	19 600	90m
		Total 18 managements		28.66 ha	7.05 ha	35.71 ha	7,510m

(1) Dredged;(2)inside harbour dikes;(3)underfloating or (4)pillar fixed berths (R)Recreational (P)Port (Aqaba Harbour), (I)Industry; Other(Road construction and Military).



0
10km
Egypt
JORDAN
AQABA
GULF
of AQABA
Saudi Arabia
Royal jetty
-50m
Aquamarina
marine center
Military Harbour
Tourist
office extension
CITY
of
AQABA
ZONE I
Aqaba
port
ZONE II
Main road
extension
on sea floor
Power station
Main road
extension
on sea floor
Wimpey
parking
Mutah ro-ro
berth
Container berth
Yarmouk berth
Marine station
0 0.5 1km
In black : extensions
on the sea floor
-50m
Yemenieh point
Zone III

Fig. 1



0
10km
AQABA
Egypt
JORDAN
GULF
of AQABA
Saudi Arabia
Zone II
Yeminieh Point
Camping area
50m
Abu-Hasba
Prince Mohamed Point
Shooting club
50m
Al-Mamlah Bay (Big Bay)
ZONE III
Haqinat Al-Rimtha P^t (Garden's Point)
Sheriff Nasser Military harbour
50m
Sheriff Nasser Bay
0 05 1km
Temporary quay
Wood factory harbour
J.F.I. Water pump
J.F.I. parking
J.F.I. jetty
Jordan Fertiliser Industry
In black: extensions on the sea floor
50m
Al-Dirrah Bay (Last Bay)
border
SAUDI ARABIA

Fig. 2

Zone 2:

Oriented N/NE extends from the northern part of Aqaba port to the Marine Science Station and has an initial sharp deep slope. The 50 m isobath is found at a distance of 50 to 150 m from the shore. In this area coral formations are found but with a very narrow fringing reef flat (not more than 10 m wide). Sparse beds of _Halophila stipulacea_ occur on sandy bottoms. Between the northern end of the Aqaba harbour and the Navy Base, sandy and muddy substrate is found with local coral heads or _Halophila stipulacea_ beds. A large fringing reef flat (150 m wide) exists between the Marine Science Station and the Yemenieh Point.

Zone 3:

Oriented N and is characterized by the presence of large bays and capes. Sandy bottoms are usual at the end of the bays with seagrass beds (essentially _Halophila stipulacea_) described by Huling (1979) and Hulings and Kirkman, (1982). These beds range in distribution from shallow sandy bottoms (average depth 1 to 2 m) to at least 50 m. Corals on capes take the form of large fringing reef flats (average 50 m wide). The 50 m isobath is 300 to 400 m from the shore line (500 m in max. in front of the Shooting Club).

The three zones and their marine benthic life were the subject of studies by Mergner and Schumacher (1974) and Bouchon (1980) for corals, Bouchon-Navaro and Harmelan (1980) for fish, Natour et al. (1979 a and b) and Meinesz (1980) for algae. Hulings (1975 a and b) for Meiofauna.

Comparing the density of living coral colonies in previously investigated areas, it becomes apparent that there is a distinct decrease in the cover of hard corals. Such degeneration is accompanied by an increase in cover by soft corals and algae. The algal cover which normally recedes during summer, showed no denudation during our observations and seems to leave no place for settlement and development of new coral colonies due, probably, to the accumulation of sediment trapped by algae. In addition, an unusually large number of the urchin <u>Tripneustes</u> <u>gratilla</u> is readily observed together with its drastic effect on the overall seagrass cover of the sea bed.

Surface area measurement of the sublittoral zone between the seashore and 50 m depth was achieved by map measurement. Maps were 1:1000 scale from Yemanieh Point to Al-Dirrah Point on the Jordanian-Saudi Border and 1:25000 scale North Yemenieh to the end of the Jordanian coast. We devided the region between 0-50 m depth into four zones: 0 to 5 m, 5 to 10 m, 10 to 20 m and 20 to 50 m. Distinct communities live at the different depths (isobaths delimiting these areas are present on the maps we used for measurements). The surface projection of the bottom on a horizontal plane (as seen on maps) was measured. The original form of the seashore was used (i.e. our results deal with the initial sublittoral surface as it was prior to any coastal modification).

Coastal modifications were determined by study of aerial photographs (Institute Geographique National France), 11 sheets, Gulf of Aqaba, Jordan (1978), 1/12185, and 20 sheets, Gulf of Aqaba, Jordan (1981), 1/22656 and site visits. Only areas exceeding 100 m^2 development at the expense of the seafloor (harbours, berths, jetties, etc.) were taken into consideration. The inventory was done in March 1983 and any future projects, were not considered.

The length of the original coastline was determined from measurement of aerial photographs and maps. For transformed coastline the length of the preconstruction shore was used. Measurements of sea floor modification used drawings at a scale between 1:1000 and 1:5000. Measurement methods were those used in French Mediterranean coastal management impact studies (Meinesz and Lefevre, 1978; Meinesz et al., 1981.

RESULTS AND DISCUSSION

The sublittoral zone of the Jordanian coast between 0 and 50 m depth is 734.65 hectars (7.3 km^2, Table 1). On this restricted and narrow coastal zone eighteen developments resulted in the coverage and serious damage to 35.71 hectars. Most construction has only covered the first 5 meters of the sea floor. The percentage of the length of the coastline altered is 29.4%. Thus, 70.6% of the Jordanian coast is still in its natural state. Much of the destruction we measured was primary in nature. That is, the sea floor was covered over with jetties or pillars or dikes.

Each of the 18 major constructions have two classes of impact on the benthic marine life (Table 1). Eighty percent (28.66 hc) of the damaged surfaces are unavailable for marine life. The other 20% is available for recolonization and marine life but greatly modified because it is in closed waters (inside dikes) or in dredged areas under floating or stationary structures. The coral reef flat and the part of the reef slope between 0-20 meters depth have been most directly and seriously damaged. Approximately 10% of the shallow reef has been destroyed by a combination of destruction due directly to

Table 2: Distribution of damage in the three zones.

Zone	Surface	% the total damage
I	.53 hc	1.5%
II	30.65 hc	86%
III	4.53 hc	12.7%

building and secondary effects of silting and pollution.

Of the Jordanian portion of the Gulf of Aqaba, major damage to marine life has resulted from port developments (constructions 5, 9-12, and 14, Table 2). These structures account for 26.76 hc, 74.94% of the total damage (35.71 hc). Damage due to industrial facilities including parking areas (constructions 7, 15, 16-18) account for 2.4 hc, 6.72% of the total. In the other categories, road construction and the military harbour (3,4,6,8,13 Table 2) damaged an area of 5.9 hc (16.7% of the total). Recreational facilities have destroyed the least amount of natural coastline and account for 1.5% of the total damage (Tables 1 and 2).

Considering the damage by zone, zone 1 has the least damage, 53 hc = 1.5% of the total damage. The principal zone of damage (85.6% of the total damage) (Table 2) is between Aqaba Harbour and the Marine Science Station (Zone 2). In this zone more than 6.7 km of the coast is artificial (Quays, berths, parking, roads, Table 1). Between 0 and 20 m depth 21% of the shore in this region is permanently covered (under jetties and dikes) and another 63% has been disturbed. In contrast the 8 km stretch of coastline between the Marine Science Station south to Sherrif Nasser harbour is still in its natural state. In Zone 3 industrial development accounted for 12.7% of the total damage.

In this study we have not evaluated the effects of sewage discharge or thermal pollution. These types of pollution are known to modify main life at least in the neighbourhood of the discharge points (Walker and Ormond, 1982). Studies have described the effects of sediment pollution on coral reefs due to phosphate discharge and spillage during the loading of transport

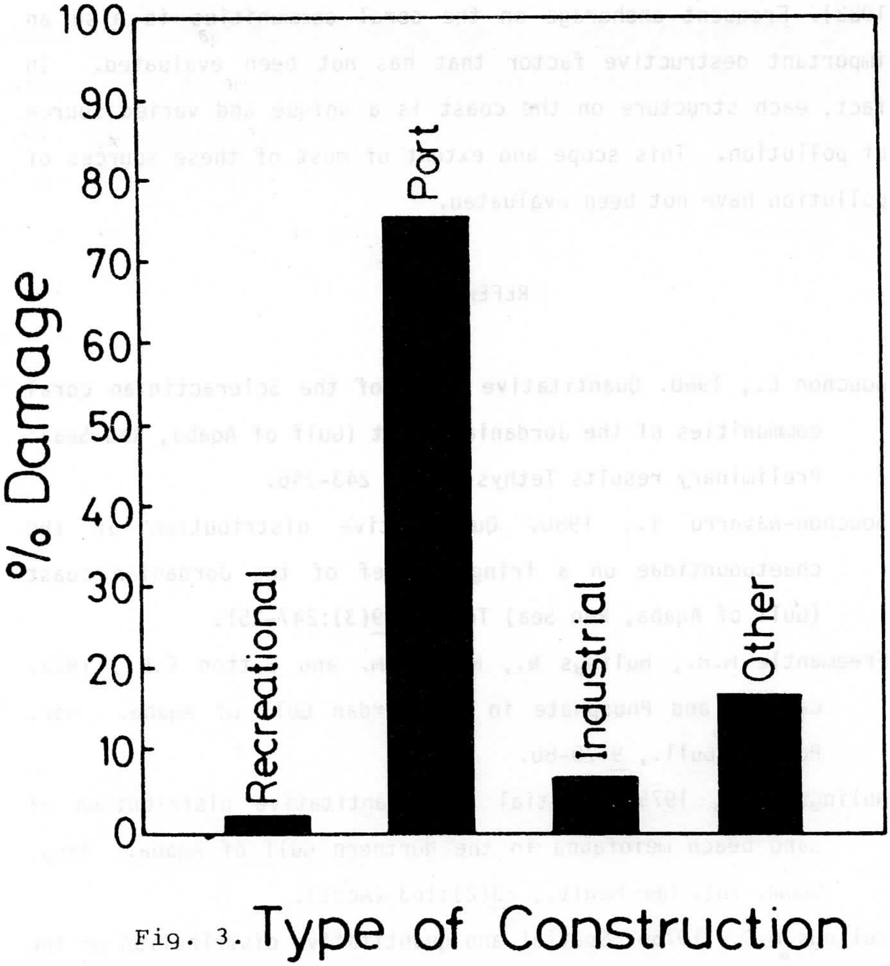

% Damage
100
90
80
70
60
50
40
30
20
10
0
Recreational
Port
Industrial
Other
Type of Construction

Fig. 3.

ships (Fee Mantle <u>et al</u>., 1978; Walker and Ormond, 1982; Hulings, 1982). Frequent anchorage on the coral communities is also an important destructive factor that has not been evaluated. In fact, each structure on the coast is a unique and varied source of pollution. This scope and extent of most of these sources of pollution have not been evaluated.

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