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RESIPIENTVURDERING AV SJØOMRÅDET UTENFOR MOMBASA, KENYA

I. MARINE BIOLOGICAL RESOURCES IN THE MOMBASA AREA

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C O N T E N T S

FOREWORD

The present report has been sponsored by Norconsult A/S in connection with the Mombasa Water Pollution and Waste Disposal Study conducted for the Government of Kenya. The report is based on a 6 week study emphasizing collection of available information on marine biotas and biological resources of the project area. The work has included a 3 week tour to Mombasa for interviews with local expertise and authorities, besides introductory observations of the marine communities which may be affected by future sewage outfalls.

The account is based on literature studies, and in particular on interviews with personnel at the Fisheries Department of the Ministry of Tourism and Wildlife and research officers of the East African Marine Fisheries Research Organization (EAMFRO). Thanks are due to Ass. Director Peter Kamande, Mr. Allela, Mr. B.M. Ogilo, and Mr. E.J. Kimani (all of the Fisheries Department); Dr. A.J. Bruce, Mr. G.F. Losse, Mr. J. Wood, and Mr. L.A. Barron (all from EAMFRO), Mr. A. Dommasnes (Institute of Marine Research, Norway), and Mr. E. Jaasund (University of Tromsø, Norway).

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1. INTRODUCTION

The main objectives of the present report are:

a) To summarise existing information on marine biological resources which can be affected by future sewage outfalls.

b) To discuss the elements of biological field studies within the scope of the project and to outline alternative programs for such studies.

In addition to the main topics, the report comprises comments on water quality, present status of water pollution, and observations from introductory surveys in the project area. A few biological samples have been collected during the surveys, which have served as part of the basis for considerations of further investigations.

2. EXPLOITABLE ORGANISMS

The rich biological communities of the creek, lagoon and reef environments are exploitable in many ways and are consequently of economic as well as social importance. What is given below, is an account of present day status with respect to marine life as a source of food and organic material, with some consideration of potential value (as related to future improvement of catching methods, increased harvesting, and aquaculture).

2.1 Fish

Although the Mombasa region covers the smallest area of the four fishing regions of Kenya, about 30% of the total fish yield in tons is landed here (Tables 1 and 2). However, this also includes catches from outside the study area. The following is a summary of relevant information on fishing sites within the project area, number of people engaged in fishing and distribution, economic value, equipment, fishing methods, and the most important species caught in the lagoon/creeks and within about 5 miles off the reef. The results of a survey of ozio traps (tata-traps, stake traps, V-traps) are included. Some more information on these subjects will certainly result from the recent work of Kenya Coast Planners Ltd within the scope of the Kenya Beach Ecological Study, particularly from the aeroplane surveys of fishing boats, and from aerial photography.

2.1.1 Important fish species

Several hundred species are to be found at the fish market of Mombasa. Information on the catch, or estimates of population size of the individual species, are practically non-existent. Thus ranking according to commercial importance is difficult. A further difficulty in this respect is the problems of taxonomy, and the fact that one and the same common name is used to designate two or more species. The composition of catches will also vary through the year due to seasonal variation in hydrographical conditions, supply of food, life cycles, migration patterns, etc. Some information on ecology, seasonal abundance and distribution is to be found in Williams (1964) and Losse (1968).

Of pelagic fishes caught in the creeks and lagoons, the following deserve mentioning. (Where English and local names are included in the list these have been taken from the above publications. Particularly abundant species are underlined).

CLUPEOIDS:

Albula vulpes (Bone fish, Mnyimbi, Mborode)
Chironcentrus dorab (Wolf-herring, Panga, Bahanafu)
<u>Herklosichtys quadrimaculatus</u>[x] <u>(Common herring, Simu yate</u>)
Hilsa kelee (River shad, Makrenge)

[x] H. punctatus form B in Losse 1968.

Pellona ditchela (Ditchela, Simu, Simu koko)
Sardinella albella (Deep-bodied sardine, Simu koko)
Sardinella gibbosa (Common sardine, Simu ziwa)
Sardinella longiceps (Oil sardine, Simu ziwa)
Sardinella sirm (Arabian sardine, Simu arabuni)
Spratelloides delicatulus (Common sprat, Dagaa)
Spratellomorpha bianalis (Estuarine sprat, Dagaa)
Stolephorus buccaneeri (Round-head anchovy, Kumbu)
Stolephorus commersonii (Commersons's anchovy, Wali wa mpunga)
Stolephorus heterolobus (Long-head anchovy, Kumbu)
Thrissina baelama (Short-jaw anchovy, Malearenge)
Thryssa setirostris (Long-jaw anchovy, Malearenge)
Thryssa vitrirostris (Mustached anchovy, Malearenge)

SCOMBROIDS:

Caranx spp
Carangoides spp } (Horse mackerels, Karambezi, Kole kole)
Decapterus sp
Hemiramphus spp
Rastrelliger kanapuncta (Indian mackerel, Oona)
Scomberomorus commerson (Kingfish, Nguru)
Scomberomorus lineolatus (Kingfish, Kanadi, Barega)
Tylosurus sp.

Clupeoids are in general abundant from October through the Northeast monsoon period and during the heavy rains.

According to Losse (1968) Herklosichtys quadrimaculatus is mostly caught in shallow water close to the shore and is most abundant over muddy bottom. It is present the whole year, but may be extremely abundant during the northeast monsoon and the rainy seasons.

Sardinella gibbosa is the most abundant sardine of East African waters. (Losse 1968). It occurs throughout the year in bays and harbours, but has its peak abundance during the northeast monsoon, and during and following the rainy seasons.

Pellona ditchela is a species apparently confined to waters of lowered salinity (Losse 1968) - estuaries, mangroves, and occasionally in river water. Being abundant all year, the occurrence reaches a maximum during the southeast monsoon and the rainy seasons (then a little further offshore).

Among the demersal fishes caught in the lagoon and the creeks, perhaps the following may be regarded as most abundant:

Gazza minuta
Gerres spp.
Leignathus spp.
Lethrinus spp.
Lutianus argentimaculatus
Other Lutianidae (Snappers)
Mugilidae (Mullets)
Pellona sp.
Secutor sp.
A few Serranidae (Rock cods)

In addition to the above mentioned, Fisheries Department stressed the importance of the following (latin names not specified):
Grunters (Pamamba), Rays (Rai), Catfish (Fume), Sting rays (Taa), and Angel fish (Tuku).

Game fish are mostly caught off-shore and the species below are seasonally common within 5 miles outside the reef:

Acanthocybium solandri	(Wahoo, Nguru)
Auxis thazard	(Frigate mackerel, Sehewa)
Carcharinus spp.	

Coryphaena hippurus	(Dorado, Dolphin)
Elagatis bipinnulatus	(Rainbow runner)
Euthynnus affinis	(Bonito, Little tuna, Sehewa)
Istiophorus platypterus	(Sailfish)
Katuwonus pelamis	(Skipjack tuna, Sehewa)
Megalaspis cordyla	(Torpedo)
Scomberomorus commerson	(Kingfish, Nguru)
Scomberomorus lineolatus	(Kingfish, Kanadi, Barega)
Sphyrna spp.	(Hammerheads)
Tetrapturus audax	(Striped marlin)

2.1.2 Boats, equipment and catching methods

Sesse canoes and small sailing boats constitute the majority of the fishing crafts, but motor launches are used to some extent, particularly in off-reef fishing. Most game fishes are caught off-reef from rented boats.

The most common catching methods used by the indigenous fishermen are ozio traps, gill-netting, hand-lining, cast-netting and basket traps. The ozio traps may be regarded as most important. Statistics on catching by the various methods are not available, however.

2.1.3 Fishing sites

Apart from the easily observable ozio traps, exact knowledge of important fishing grounds must be based on interviews with local fishermen. Until it is possible to rank specific localities, all creek and lagoon waters probably ought to be regarded as of more or less equal importance. Exceptions to this are already polluted waters, e.g. parts of Kilindini Harbour, etc.

2.1.4 Number of people engaged in fishing and distribution

According to information from the Fisheries Department of the Ministry of Tourism and Wildlife, there are about 300 fishermen within the Mombasa area, delivering their catch to about 30 distributors.

2.1.5 Economic value

The yearly value of fish landed in Mombasa, and sold on the market, is about 3 mill. K.Sh. (Tables 1 and 2). The value of fish consumed by the fishermens' families or sold outside the market cannot be assessed, but should not be neglected by an overall socio-economic evaluation of the role of fisheries.

The potential yield of creek and lagoon fisheries is not likely to be much higher than the present output, even if some increase can be expected from gear improvement.

The total value of coastal fisheries in Kenya shows a remarkable decline from 1971 to 1973 (Table 3). The same trend seems to be valid for the Mombasa region (Tables 1 and 2), but data from more years have to be analyzed, this being outside the scope of this report.

(Courtesy of Ministry of
Tourism and Wildlife,
Fisheries Department)

Table 1. Production of marine fish and shellfish in the coastal regions of Kenya 1972.

SPECIES	LAMU		MALINDI		KILIFI		MOMBASA		SHIMONI		TOTAL	
	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.
FRESH WATER FISH	65	58733	977	978052	-	-	111	87238	-	-	1153	1124023
WET FISH												
Demersal fish	959	917999	504	786119	69	185669	775	1889512	1177	1933153	3484	5712451
Pelagic fish	171	192074	826	306531	23	64377	887	659999	110	235306	2017	1458287
Sharks	83	46717	87	112977	21	19505	244	324092	203	174125	638	677416
Others	5	9367	129	212239	59	79581	270	486874	709	123064	1172	911125
TOTAL	1218	1166157	1546	1417866	172	349131	2176	3360477	2199	2465648	7311	8759279
CRUSTACEA												
Spiny lobster	57	349753	2	12503	2	12834	17	154419	12	86421	90	615930
Prawns	9	17594	2	10664	2	11064	40	303041	30	121761	83	464124
Crabs				1921			-	-	12	18353	12	20274
TOTAL	66	367347	4	25088	4	23898	57	457460	54	226535	185	1100328
MISCELLANEOUS												
Game fish	3	6646	44	30096	16	48731	18	23701	27	37659	108	146833
Oysters	-	-	-	41118	-	-	1	15815	-	-	3	56933
Oyster shell grit	-	-	-	-	-	-	97	50263	4	1440	101	51703
Be-che-mer	8	3900	-	-	-	-	12	36430	-	-	120	40330
Green turtle	2	1033	-	-	-	-	-	-	-	-	2	1033
TOTAL	13	11597	46	71214	16	48731	128	126209	31	39099	234	296832
GRAND TOTAL	1362	1603816	2573	2492220	192	421760	2472	4031384	2284	2731282	8883	11280462

Table 2. Production of marine fish and shellfish in the coastal regions of Kenya 1973. (Courtesy of Ministry of Tourism and Wildlife, Fisheries Department)

SPECIES	LAMU		MALINDI		MOMBASA		SHIMONI		TOTAL	
	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.
FRESH WATER FISH	90	81304	813	813635	285	223981	-	-	1188	1129541
WET FISH										
Demersal fish	1091	1044305	258	402480	532	1297016	624	1024608	2505	3768409
Pelagic fish	4	4492	99	36729	165	122760	23	49207	291	213188
Sharks	29	16904	33	42850	149	197872	56	48037	267	305663
Others	2	3747	97	159565	235	423705	65	11284	399	598301
TOTAL	1126	1069448	487	641624	1081	2041353	768	1133136	3462	4885561
CRUSTACEA										
Spiny lobster	48	294528	2	12503	5	45415	6	43212	61	395650
Prawns	19	3745	5	26660	84	636384	23	93350	131	793539
Crabs	2	2200	1	1100	-	-	13	19877	16	23177
TOTAL	69	333873	8	40263	89	681799	42	156439	208	1212574
MISCELLANEOUS										
Game fish	-	-	57	21147	20	14880	8	17112	85	53139
Oysters	-	-	2	41118		11685	-	-	2	52803
Oyster shell grit	-	-	-	-	130	63236	-	-	130	63236
Beche-de-mer	49	457000	-	-	-	-	-	-	49	45700
Squid	1	2300	-	-	-	-	-	-	1	2300
TOTAL	50	48000	59	62265	150	89801	8	17112	267	217178
GRAND TOTAL	1335	1532645	1367	1557152	1605	3036934	818	1306687	5125	7444654

(Courtesy of Ministry of Tourism and Wildlife, Fisheries Department)

Table 3. Annual production of marine fish and shellfish in Kenya 1971-1973.

SPECIES	1971		1972		1973	
	M.TONS	SHS.	M.TONS	SHS.	M.TONS	SHS.
FRESH WATER FISH	1.822	1.752.962	1.153	1.124.023	1.188	1.129.541
MARINE FISH						
Demersal fish	3.919	11.217.817	3.484	5.712.451	2.505	3.768.409
Pelagic fish	519	1.195.070	2.017	1.458.287	291	213.188
Sharks	790	686.641	638	677.416	267	305.663
Mixed fish	1.231	1.309.319	1.172	911.125	399	598.301
TOTAL	6.457	14.408.847	7.311	8.759.279	3.462	4.885.561
CRUSTACEA						
Spiny lobsters	145	845.432	90	615.930	61	395.658
Prawns	124	527.375	83	464.124	131	793.539
Crabs	15	29.833	12	20.274	16	23.177
TOTAL	284	1.402.640	185	1.100.328	208	1.212.374
MISCELLANEOUS						
Game fish	102	228.684	108	146.833	85	53.139
Oysters	2	44.725	3	56.933	2	52.803
Oysters shell grit	133	60.374	101	51.703	130	63.236
Bech-de-mer	59	18.340	20	40.330	49	45.700
Turtles	4	5.850	2	1.033	-	-
Squid	-	-	-	-	1	2.300
TOTAL	300	357.973	234	296.832	267	217.178
GRAND TOTAL	8.863	17.922.422	8.883	11.280.462	5.125	7.444.654

2.1.6 Present distribution of ozio traps

On the 12th and 13th October 1974 a survey was carried out to check the present distribution of ozio traps as compared to information about trap locations given in chart no. 999 (Port Mombasa including Port Kilindini and Port Reitz, new ed., March 1966). The prime aim of the survey was to get a general view of creek and lagoon fishing grounds; it was not considered necessary to mark off the trap positions with the accuracy required for navigational purposes. At the same time note was taken of local fishing boats in activity. The observations were made in Port Reitz, Port Kilindini, Mueza Creek, Port Mombasa, Port Tudor, the lagoon coastline up to Mtwapa creek, and within this creek. (Makupa Creek was not accessible by boat). Owing to the risk of running aground, the innermost parts of the creeks could not be surveyed. As the study in part took place during low tide, some of the traps had to be observed from a far distance, making it difficult to decide whether they were in use or not. Merely in a rather few obvious cases old traps have been excluded.

The positions of trap grounds can be seen from Fig. 1. As the exact trap positions are of relatively minor importance in this connection, the localities have been encircled, with a figure indicating the number of traps. Table 4 gives the results from the respective subareas.

Table 4 Number of ozio traps in the Mombasa area and the various subareas

Area	Number of traps
Port Reitz (from Ras Kigangone)	35
Port Kilindini	22
Mueza Creek	5
Port Mombasa	5
Port Tudor (from Nyali Bridge)	3
Ras Kunwongbe - Cannon Pt.	5
Mtwapa Creek	13
Total	88

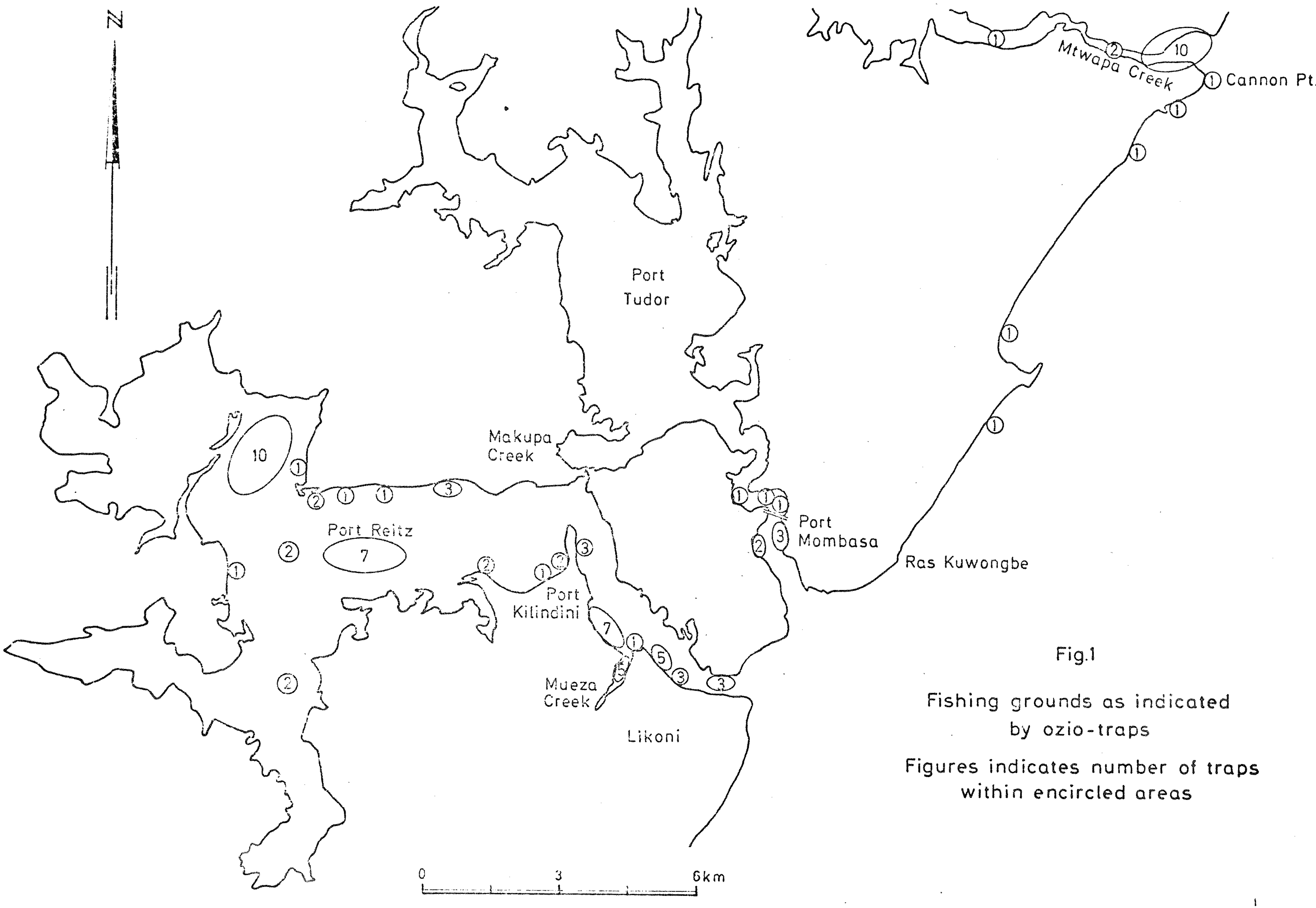

Fig.1

Fishing grounds as indicated by ozio-traps

Figures indicates number of traps within encircled areas

In Table 5 the results have been compared to numbers counted from chart no. 999 (new edition 1966). (Only parts of Port Reitz and Port Tudor are included on this chart).

Within the Port Kilindini/Port Tudor area about 40 fishing boats with 1-2 men were observed in activity (Saturday, 12th Oct.), whereas about 30 boats were observed (the following day) along the coast from Ras Kuwongbe to Mtwapa Creek (inclusive). Data are only approximate, and there was no close inspection of the activities.

Table 5 Ozio traps recorded in 1974 as compared to chart data from 1966.

Area	Number of traps 1974	1966
Port Reitz (part of)	21	37
Port Kilindini	22	26
Mueza Creek	5	13
Port Mombasa	5	8
Port Tudor (part of)	3	5
Coastline from Ras Kuwongbe (part of)	0	5
In all	56	94

The survey confirmed that extensive fishing goes on in the whole investigation area. As regards ozio traps, about 2/3 of them were recorded in Port Reitz, Port Kilindini and Mueza Creek. In Mtwapa Creek there was a concentration of traps in the inlet, whereas in Tudor Creek very few were registered inside Nyali Bridge. It would be premature, however, to rank the subareas with respect to importance on the above basis, as other catching methods also play a role.

Whether the chart data on ozio traps are directly comparable to the results of the survey is not quite clear. Presumably, traps out of function would have to be included on charts. It is not likely, however, that this can account for more than a part of the reduction in numbers of traps in the eight years from 1966. A few of the grounds may have been exploited for other purposes (as is the case in the vicinity of Ras Mkadirti and at Kenya State Beach). A third factor is that low tide prevented close inspection of some of the shallow mangrove areas.
All factors considered, it seems that a certain reduction has taken place. Nevertheless, the overall picture seems to be in reasonably good accordance with the 1966 data.

2.2 Crustaceans

Most important among the exploited crustaceans are prawns (Penaeidea) and spiny lobsters (Palinuridae), and to a lesser degree shrimps (Caridea) and crabs.

2.2.1 Commercial or otherwise important species

The species most frequently caught in the project area are:

PRAWNS

Penaeus	indicus	(Bananas)
"	japonicus	(Tiger prawns)
"	monodon	(Kings)
"	semisulcatus	(Kings)

SHRIMPS

Exhippolysmata tugelae
Palaemon tenuipes

SPINY LOBSTERS

Panulirus ornatus
" versicolor
Panulirus spp.

(The Swahilian name Kamba (or Kamba dogo) denotes both prawns and shrimps, whereas the name of spiny lobsters is Kamba wakuba - big prawns).

The staff of the Fisheries Department estimated that *Penaeus indicus* constitutes 40-50% of the total catch of prawns and shrimps, *P. monodon* 20-25%, the other species being of more variable occurrence.
P. japonicus was ranked as the rarest of the above mentioned.
On the other hand, Brusher (FAO 1971) states that juvenile *P. semisulcatus* seemed to be dominant in the Mombasa area.

As to the spiny lobsters, the Fisheries Department ranked *Panulirus ornatus* and *P. longipes* as most abundant, *P. versicolor* as variable and *P. penicillatus* as the rarest. In Brusher (FAO 1971) *P. ornatus* is said to be the dominant species along the Kenyan coasts.

Table 6 gives a more complete list of commercial or potentially exploitable East African species, many of which are occurring in the Mombasa region.

2.2.2 Habitats and life cycles

Most prawns live as adults and spawn offshore, preferring a relatively smooth, muddy or sandy bottom down to 30-40 m. Some species probably go deeper. According to Brusher (FAO, 1971), it is improbable that such habitats exist to any large extent along the Kenyan coast, except in the vicinity of Ungwana Bay and the Sabaki River outlet. Patchy occurrence of smaller localities in other places is to be expected, however. With respect to the project area, there is a rather steep dropoff outside the reef, reaching depths of more than 100 m 3-4 km offshore.

After spawning in open waters the postlarvae of prawns drift with currents to their nursery grounds in mangrove creeks or estuarine areas. The Mombasa region is rich in such environments.

Table 6. COMMERCIALLY IMPORTANT DECAPOD CRUSTACEA OF KENYA AND TANZANIA (Courtesy of Dr. A.J. Bruce, EAMFRO)

This list includes those species that are already of commercial importance, together with those that are of possible commercial significance and also those species that occur commonly in commercial catches.

** major commercial importance.
* lesser commercial importance.
+ deep water species.

Penaeidea

PENAEIDAE

Penaeus japonicus Bate *
" latisulcatus Kishinouye
" marginatus Randall +
" monodon Fabr. *
" semisulcatus de Haan **
" indicus Milne-Edwards **
Metapenaeus monoceros (Fabr.) **
stebbingi Nobili *
Parapenaeus longipes Alcoc
fissurus (Bate) +
Penaeopsis serratus (Bate)
Trachypenaeus curvirostris (Stimpson)
Trachypenaeopsis richtersii (Miers)
Parapenaeopsis acclivirostris Alcock
Metapenaeopsis mogiensis (Rathban)
" quinquedentata (De Man)
" hilarulus (De Man)
" coniger (Wood Mason)
" barbatus ?
" phillippii (Bate)
Solenocera pectinata (Bate)
" alticarinata Kubo
Aristeomorpha foliacea (Risso) +

SERGESTIDAE

Acetes indicus
" erythraeus Nobili

Caridea

PALAEMONIDAE

Palaemon tenuipes (Henderson)

HIPPOLYTIDAE

Exhippolysmata tugelae Stebbing

PANDALIDAE

Plesionika marita (A. Milne Edw.)+
Parapandalus sp. +
Heterocarpus woodjonesi Alcock +

Macrura

PALINURIDAE

Panulirus ornatus (Fabri.) **
" versicolar (Latri.)**
" homarus (L.) *
" dasypus (Milne-Edwards)
" longipes (Milne-Edwards) **
" penicillatus (Olivier)*
" polyphagus (Herbst) ?
L. somniosus Berry & George
Puerulus angulatus Bate +

SCYLLARIDAE

Thenus orientalis (Lund)
Ibacus incisus (Peron) +
Scyllarides squamosus Milne-Edward
" tridacnophagu Holthuis
Parribacus antarcticus Lund

NEPHROPIDAE

Metanephrops andamanicus (Wood-Mason) +
Enometoplus occidentalis (Randall)

Brachyura

PORTUNIDAE

Scylla serrata (Forsskål)

Stomatopoda

SQUILLIDAE

Oratosquallia investigatoris (Lloyd)

In the creeks the juveniles (25-90 mm) have good access to food, and grow rapidly until they return to the open sea as subadults, then having a size of 90-140 mm. Juveniles of P. latisulcatus have also been recorded in plenty in the lagoon environment.

In contrast to prawns, shrimps are mainly breeding in river mouths and bays, thus going through all their life stages inside the reef. The life cycle of prawns and shrimps is completed within one year.

With respect to food, there is reason to believe that small animals and dead organic matter of animalian origin are the main food sources for both shrimps and prawns. It is worth while noticing, however, that the productivity at all trophic levels of creek communities will greatly depend on the input of nutrient matter in the form of leaves shed by the mangroves. (An illustration of this for a Florida locality is given by Heald and Odum (1970)).

Spiny lobsters are commonly associated with reefs and rocky bottom, but their occurrence is not confined to such habitats. Some species are more often found on sand-covered rock or among higher plants and algae in lagoon areas, or even where there is a muddy bottom. According to Berry (1971) this is the case for P. ornatus. In the Mombasa region the exploited spiny lobster populations mostly live outside the fringing reefs or around patch reefs in the lagoon and creek environment down to about 10-15 m. The habitats vary for successive life stages, but juveniles of reef species can be found in the lagoon area. In anly case, the development is rather slow, and it takes 8-12 years before maturity is reached. In aquaria spiny lobsters seem to be practically omnivorous, indicating that they live as scavengers in nature, but also as predators.

Lastly, among the crustaceans, the mangrove crab (Scylla serrata) should be mentioned. It lives in holes among mangrove roots or on other muddy banks, feeding on dead as well as live animals.

2.2.3 Catching methods and sites

In the Mombasa area most prawns are taken in the creeks. Thus it is mainly postlarvae and subadults which are caught, i.e. specimens smaller than 140 mm. On the Kenyan coast as a whole ozio traps still supply the bulk of the prawn catch. Trawling is used in some districts, but only on a small scale in the Mombasa region. At least one reason for this is lack of sizable areas suitable for adult prawns. Juveniles and subadults are also caught in beach seines (hand nets drawn through the water) together with shrimps, the latter being too small for the ozio traps. This is probably the most abundant method in the creeks.

At present there is no satisfactory basis for emphasizing the importance of any particular fishing locality for prawns/shrimps. Neither is it possible to rank the creeks of the Mombasa area in this respect. It is presumed, however, that any ground associated with the mangrove belt is a favourable habitat.

Within the project area, most of the spiny lobsters are caught by goggling immediately outside the reef (down to about 10 m). Modern methods (trammel nets) have proved to be more efficient, but have only been adopted to a limited extent (Brusher, FAO 1971). The mangrove crab is caught by hand.

2.2.4 Yield and economic importance

Total landings of prawns and spiny lobsters in the Mombasa region are fluctuating; the prawn figures for 1972 and 1973 being 40 and above 80 metric tons respectively, which represents a value of 3-600,000 K.Sh. (Tables 1-2). Corresponding figures for spiny lobsters were 17 tons (150,000 K.Sh.) and 5 tons (45,000 K.Sh.). Information is not available as to how much of this was caught outside the project area.

Records are also lacking with respect to the exploitation of the mangrove crab and the small shrimp *Acetes* sp; the latter being a food source for the indigenous population.

Data from studies on the populations of juvenile and subadult prawns in the estuarine habitats of the Mombasa region have been too scarce to warrant conclusions as regards standing stock. Previous observations of catch efficiency (Brusher, FAO 1971) did not reveal any large potential, though. A monitoring program with registration of postlarvae of prawns at the entrance to Port Kilindini (at Likoni) has been carried out by the Fisheries Department since 1970, but the data requires further processing before presentation. From the initial results it appeared, however, that there is a seasonal variation in the prawn utilisation of estuarine environments, this being at its peak in the period December-March (Brusher, FAO 1971).

According to the Fisheries Department there are plans for cultivation of shrimps in Tudor Creek in the near future.

With regard to the potential spiny lobster production in the Mombasa region, this was estimated by Brusher (FAO, 1971) to be 43,000 tons per year. This figure is not in accordance with the declining trend in output (Tables 1, 2, 3). The discrepancy may be explainable by the combined effect of two factors: overharvesting at traditional fishing sites (cf. EAMFRO yearbook, 1972) and the very limited utilisation of modern techniques (trammel nets, tangle nets), which would permit the exploitation of virgin fishing grounds (below 5 fathoms).

There is reason to believe that the creeks represent environments suitable for lobster cultivation, but the possibilities have not been subject to evaluation.

As can be seen from Tables 1-2, crabs are not harvested to any significant extent in the Mombasa area. Neither has the potential crab production been investigated.

2.3 Other exploitable animals

The other animalian resources include rock oysters and other mussels, snails, sea cucumbers, and cephalopods.

2.3.1 Present harvesting of mussels

The rock or mangrove oyster (*Crassostrea cucullata*) is abundant on rock and concrete in the creeks, on the reef flats and on stems of mangroves. It grows up to the mean tide level and is harvested by means of hammer and chisel. All the creeks near Mombasa have large areas with suitable habitats, but the best beds are possibly at other localities (Kilifi creek, Mida Creek, Ras Ngomini). Further, it is probable that rock oyster beds in general are over-harvested (in relation to regrowth). This assumption is in the main based on the fact that growth rate is relatively slow, and on signs that supply cannot always meet demand. There is, however, a need for further documentation based on population studies. In this connection it may be pointed out that the output for the last two years only showed a small decline for the Mombasa region (Tables 1, 2) and no change for the Kenyan coast as a whole (Table 3).

The rock oyster seems to be a hardy species, tolerating a heavy natural load of organic matter (frequent in mangrove areas), and even being able to sustain periodic oil pollution. (Thus it is found in the innermost part of Kilindini Harbour).

The oysters are either used as bait or sold to restaurants and hotels. To what extent the species is a local food source is not known, but this is probably insignificant, oysters being a luxury article.

As can be seen from the Tables 1-2, the utilisation as raw material for shell grit is at present of greater economic importance than harvesting for food (50-60,000 K.Sh. as compared with about 15,000 K.Sh.).

Whether other mussels play any considerable part as food in local households, is not known.

2.3.2 Prospects for oyster farming

Experiments with culturing of the Pacific oyster (Crassostrea gigas) have been performed with suspended and anchored rafts (L.A. Barron, private comm.). The specimens were reared from a size of 1 cm. Growth rate was about 3 times that of the indigenous rock oyster. The results also compared favourably with growth rates recorded in Japan.

Except for areas polluted by noxious substances and/or fecalia, the creeks are regarded as excellent localities for farming. Thus there should be reason to believe that farming prospects are very good indeed. It is difficult to rank the creeks with respect to their suitability, however, as by nature all of them seem excellent for the purpose.

The Pacific oyster is a very adaptable species with regard to temperature and salinity. The death percentage was remarkably low during transportation of 1 cm animals from Scotland to Mombasa, no particular precautions being taken during the 72 hour journey. The rock oyster is also regarded as being suitable for culture purposes, but is less advantageous due to the markedly slower growth rate.

Oyster demand in Kenya is under the existing conditions (connoisseur market) estimated to be about 1 million per year. This quantity could be produced at a single farm. The firm Western Agriculture has shown interest in the prospects, and a pilot project is estimated to cost £15,000.

Small scale oyster culture (5,000 per year) is planned in connection with a local restaurant in the old port of Mombasa.

2.3.3 Cephalopods, sea cucumbers and snails

Octopuses are collected in rock pools in the lagoon and on the reef flats, and should not be overlooked as a local food source. Sea cucumbers are mostly exported (cf. beche de mer, Table 1), but they may also play some role as food for the indigenous population. In other parts of East Africa snails are collected for food purposes. Information is lacking as to whether this is the case to any significant extent within the project area.

2.4 Algae

Algological investigations in Kenya are rather few, although there is a rich algal flora (Isaac and Isaac 1968). Records of algae from the project area are even more scarce (Isaac 1967, 1968, 1971). In Tanzania the red seaweed *Eucheuma* is harvested and exported as raw material for the carrageenan industry. Several other algae may represent economic resources (e.g. *Digenea simplex*, *Turbinaria spp*, *Hypnea spp*). The occurrence and abundance of these and other potential algal resources in Kenya is unknown.

3. BIOLOGICAL COMMUNITIES AND AMENITIES

The Kenyan government has established an active conservation policy. Within the project area it is also obvious that economic interests are in partial agreement with the conservational view. The conservation interests of business can be illustrated by the extensive collecting of corals, shells and live (aquaria) fish for sales and exportation. The said organisms are at the same time symbols of coral reef life, which is a major asset in the advertising of Kenyan coastal holidays. Consequently, the present reef conditions are of key interest in case future sewage outfalls are expected to affect the reef communities in any deleterious way.

3.1 The coral reefs

Published data on the coral reefs of Kenya are very scarce (Khamala 1971, Brander & al. 1971). It is expected, however, that systematic information will be available through the work performed by Kenya Coast Planners Ltd within the scope of the "Kenya Beach Ecological Study" (part of the "Diani Resort Complex Study", sponsored by the Kenyan Ministry of Finance). Other reports or publications will result from the expeditions of the University College of Swansea, U.K. in 1973, 1974 and 1975. The latter studies are concerned with the past and present reef environment along the coast from Mombasa to Mtwapa Creek, and also include observations in the Likoni area. Contact has been established with this group of researchers with an intent to exchange data. More specifically, the studies will supply information on present sediment and substrate conditions, angiosperm distribution, and the principal locations of modern coral colonisation.

Until the above results are available, the status of reef conditions may be summarised as follows (based on diving observations by EAMFRO staff members):

Most of the corals within the boundaries of the project area are alive. At depths above about 90 feet there is no serious silting at the seaward side of the reefs, not even outside Fort Jesus, where the bottom at this depth consists of hard sand. From Bahari Club to Ras Junda (in Port Tudor) the bottom is practically bare rock.

Above depths of about 100 feet there seems to be a very rich coral fish community all along the fringing reefs. Among other animals, swamps are conspicuous, perhaps particularly in areas which for some reason have a high content of particulate organic matter.

There is even a very rich patch of reef within Kilindini Harbour (just outside the mouth of Mueza Creek).

The crown of thorns starfish (Acanthaster planci) - known to have caused extensive damage to coral reefs in Australia, Guam, etc. - also occurs in the Mombasa area. It is neither rare nor particularly abundant. So far no damage to East African reefs has been reported. It is said to have increased somewhat in numbers in the last 15 years, though.

3.2 The lagoon and mangrove environment

Published data from investigations of lagoon or mangrove areas in the vicinity of Mombasa seem to be rare or non-existent. Preliminary observations conform with the general account of main components of the marine plant communities given by Isaac and Isaac (1968) and F.M. Isaac (1968) for Kenyan coastal waters (extensive growth of *Cymodocea ciliata* in the lagoon area, etc.). Both the lagoon and the mangrove environments are of great scientific interest, and are at the same time integral parts of the coastal landscape and scenery.

3.3 State of water pollution

Water pollution, excepting oil, is not regarded as any large problem as yet. A shore survey, undertaken every second month through one year, at times showed an abundance of oil clumps on Tanzanian and Kenyan shores (L.A. Barron, EAMFRO, pers. communication). In one particular incident, 10 miles of shore-line were densely covered with fist-sized clumps of a mixture of tar-like material and sand, with a mean frequency of 1-200 clumps per 100 m. (Picture documentation is available from EAMFRO). Such heavy pollution has not been observed in the Mombasa region, however, and the conditions within this area generally seemed to be better than further north (Formosa, Lamu) or on southern shores (Tiwi, Diani). It may be mentioned that observation of oil pollution along a distance of about 2 km shoreline at Kenya Beach in October 1974, gave as a result about 60 more or less evenly distributed tar aggregates of size 5 cm or more. Numerous small tar clumps (pea size and smaller) had a more patchy distribution pattern. The probability is that the oil pollution is caused by dumping in offshore waters. Age determination of the oil clumps from the one-year survey indicated that the oil in the main was about three months old.

Large oil spills are not known to have occurred in the Mombasa area. Small scale dumping and spillage is nevertheless evident in the inner parts of Kilindini Harbour.

Polluting material may also be expected to result from the following activities in the area: the slaughter house of Kenya Meat Commission (Tudor Creek), the Bamburi Cement Factory, and the East African Oil Refineries. There have been no studies as to the possible effects on marine biotas or water quality, but the conditions around the outfall from the slaughter house are said to have improved in recent years.

3.4 Preliminary observations and sampling

The aim of the introductory surveys was to serve as a first information about the investigation area and its biological communities.

The reef flats have been observed twice, outside Fort Jesus and outside Kenya Beach Hotel. Samples of intertidal algae were collected at both localities. Further there has been some sampling in the lagoon area of Kenya Beach and a limited photo documentation is available. The subtidal reef has been observed once by scuba diving, in the inlet to Kilindini Harbour. The samples of algae have been analysed (by Mr. E. Jaasund), and the results can to some extent serve as reference material for future studies.

Samples of surface phytoplankton and particulate matter were collected by net and quantitatively in Port Reitz, Port Tudor, Mtwapa Creek and in the lagoon. Analysis of these samples will give introductory information about the plankton communities, nature of abundant mineral and organic particles, and possibly also of species that may serve as indicators of the present and future creek conditions. (This also applies to the reef flat algae, one of the recorded species being the green alga *Dictyosphaeria cavernosa*, which is known to have caused damage to coral reefs after invasion triggered off by eutrophic conditions (Johannes 1972)).

4. DISCUSSION OF PROGRAMS FOR MARINE BIOLOGICAL FIELD STUDIES

The purpose of the above review of existing information is to help in the decision as to whether and where domestic sewage can be let out into the sea. The intention is further to provide a basis for predictions as to possible damaging effects on biological or recreational resources. Primarily, proposals for field studies are justified to the extent that the anticipated results will contribute to improving of the basis for assessing these problems. Secondly, the field studies should provide reference data for future monitoring. As a last point it should be emphasised that the details of the investigation program cannot be fixed until the outfall sites have been proposed. Investigations would, for example, presumably be unnecessary with submersed outfalls situated outside the "drop-off" of the reef slope; the probability being that any amount of waste water would be sufficiently diluted and carried away by tides and currents to leave no traceable effects.

4.1 Reference studies

Time and cost limitations make it impossible to conduct baseline studies with the purpose of improving the basis for predictions of recipient response to municipal waste water. Such prognoses would require an intimate knowledge of the biological communities involved. To a certain degree better knowledge could be acquired within reasonable time with respect to benthic littoral flora and fauna and perhaps the plankton, but still the results would be largely inadequate, given the time limits of the project. With regard to bottom fauna, fishes and the subtidal coral reef community it would be even more difficult. Real baseline investigations must be long-term activities conducted by specialists on various groups. Useful data can nevertheless be expected from the studies of the above mentioned British university group, and further from the studies of Kenya Coast Planners Ltd. (cf. above), particularly with regard to the present status of the coral reefs. Attention is also drawn to the fact that the sewage outfalls will not come into function for several years. Thus there should be ample time for reference studies if considered necessary.

Within the scope of this project it seems reasonable to carry out the following tasks:

a) Seek access to and summarize relevant data from the studies of Kenya Coast Planners Ltd and the group of Dr. F.T. Banner, University College of Swansea, U.K.

b) Collect possible further information at the departments of zoology and botany of the University of Nairobi.

c) Evaluate the results of analyses of benthic algae samples from the reef flats, the lagoon and from the polluted part of Kilindini Harbour.

d) Analyse seston samples from creek, lagoon and harbour waters.

e) Perform further simple studies at a few localities, with documentation by photography and identification of main components of a selection of the following communities: phytoplankton of the creeks, benthic creek algae, lagoon algae and angiosperms, algae of the reef flats (and the slope if possible), corals and associated animals of patch reefs in the creeks and their inlets. Among the algae, particular attention should be paid to the Chlorophyceaen *Dictyosphaeria cavernosa* and other possible indicators of eutrophication.

There is a need for a similar study of creek fauna of soft bottom areas, as these communities are probably best suited for monitoring purposes, but the practical problems would be difficult to overcome within the time available.

Even with such a simple documentational study it will be necessary to concentrate on merely some of the above mentioned communities, and to restrict the number of sampling stations. The choice of study objects and sampling locations should be made in relation to the proposed outfall sites.

Analysis of the collected bacteriological samples will give a basis for evaluation of the hygienic standard of the recipient waters.

(Very little, if any evidence points towards municipal sewage as a cause of Acanthaster invasion of coral reefs. Thus the sole reason for conducting a study of the occurrence of the crown of thorns starfish would be to forestall unwanted speculations in the future.

4.2 Monitoring program

The object of monitoring is to ensure that any unwanted effects from the sewage outfalls can be revealed as soon as possible, preferably before any significant harm has been done. The program is to cover three different aspects: biological resources, hygienic conditions, and general amenities.

If the domestic waste water is disposed of in such a way that one may feel reasonably sure that no measureable interference with the marine environment will ensue, a monitoring program is not required. This would for instance be the case if the outfalls were placed in deep off-reef water (30-50 m), or if the sewage water was infiltrated on land.

Like the baseline studies, details of the monitoring program should be made dependent on outfall sites and proposed sewage treatment. Further, no single parameter or indicator organism will be relevant for all the above mentioned aspects of the problem.

Biological resources can be endangered either by silting (corals, some other benthic animals, higher plants, algae), by high counts of fecal bacteria (e.g. oysters and other edible animals) or more indirectly by various environmental changes following eutrophication or saprobisation.

Most of the recently exploited marine organisms - particularly fish - are not suitable as monitoring organisms. The main reason for this is that their occurrence and abundance largely depend upon factors such as annual variation in hydrographical conditions, harvesting, etc. Nevertheless, in case of disposal of large amounts of sewage into the creeks, supplementation of the running program of prawn larvae registration of the Fisheries Department should be considered.

The rock oyster is an exception to the unsuitability of exploited animals for monitoring purposes. Specimens from beds in the neighbourhood of sewage outfalls regularly ought to be analysed for indicators of fecalia (coliforms or colifage). (Assumably there is already a need for putting such a program into effect).

Corals are susceptible to damage by domestic sewage, primarily by silting, further by eutrophicational effects (algal blooms, increased turbidity, heavy growth of benthic algae, reduced oxygen content of the water, cf. Johannes, 1972). In the project area, it is to be supposed that patch reefs of the lagoon and creek environment will be most exposed to the various harmful agents. Consequently, a monitoring program should emphasise such habitats. Coral species differ in their tolerance to this type of environmental stress. Porites compressa is for example one of the more vulnerable species. If possible, such differences should be taken heed of from the start; reliable monitoring studies otherwise requiring considerable efforts by coral taxonomists.

When looking at the coral community, one should also make observations of a selection of species from the associated fauna, especially filter feeders such as mussels and swamps, and detritus eaters (sea cucumbers and others). Some representatives of these groups can be expected to be favoured by amounts of sewage water which are disadvantageous for certain corals. Again there is a difficulty that experience with the effects of sewage water on the indigenous fauna is largely lacking.

Algae are useful as indicators both of light and nutritional environment. By overloading with fertilising elements one may experience blooms by planktonic species, as well as changes in the composition of the algal communities in general; some species being known to thrive better than others under eutrophic conditions. As stated above, population explosion of the benthic green alga Dictyosphaeria cavernosa has occurred after discharge of sewage water into tropical salt waters. It is recommended that littoral algae are monitored at representative localities of the reef flat, lagoon and creek areas, choosing the sampling stations close to the future outfall sites, and focusing on Dictyosphaeria and other indicator species. Tidal flushing is probably too large to permit planktonic algae to develop concentrations significantly larger than today. Locally, however, this could possibly take place if large outfalls were situated in the innermost parts of the harbours/creeks. Otherwise, monitoring of phytoplankton would hardly be justified. A simple, not too laborious way to monitor plankton and other particulate matter is frequent filtration of a fixed volume of water with subsequent filing of the dried filters, which can be analysed under the microscope or weighed according to need.

As stated before, the fauna of soft bottom areas is well fitted for monitoring investigations; the chief reason being that the polluting material tends to accumulate at the bottom, either by direct sedimentation, or by way of increased productivity of the surface water. Secondly, many of the animals are sessile or move slowly. A third factor is the Possibility that relatively slow bottom water renewal will bring about significant decrease in the oxygen content. The net result is that the bottom fauna very well reflects the average living conditions of their particular surroundings. Provided that expertise is available, it is suggested that the community of soft bottom animals in the creeks is sampled and analysed each year.

Hygienic conditions are already being surveyed within the scope of the project, and it is recommended that a monitoring program be drawn up on the basis of the findings from this study. In this connection it should also be considered whether to replace the counting of coliforms with coli attacking virus (colifage), the latter sustaining saline environments better than the bacteria.

Recreational values are mainly connected to the water's appearance and its hygienic standard. The former parameter is not easy to describe adequately. One obvious way is recording of turbidity in terms of Secchi depth. Rapidly changing conditions necessitate frequent measurements, however, and to obtain reliable trends several years of observation are needed.

Under the circumstances, physical and chemical parameters are judged as less suited for monitoring, most of them being subject to rapid change with time. Oxygen concentration is a possible exception in locally isolated water bodies, if such areas are present.

The above suggestions aim at monitoring the effects of domestic sewage disposal. Control of the effectiveness of sewage treatment plants has not been considered. One of the useful ways to do this is by means of algal assay, i.e. to measure the growth potential of the plant influent and effluent.

Further, it has been taken for granted that toxic effluents from industry, etc. will not be connected to the sewerage system without due actions at the source. In connection with toxic material, it should also be warned against chlorination of the treatment plant effluent. Recent results indicate that effects on marine biotas of residual chlorine may be more far reaching than hitherto assumed.

Studies should if possible be conducted in cooperation with the planned East-African Regional Laboratory for Marine Water

Pollution Research. This scheme is co-sponsored by SIDA (Swedish International Development Aid) and FAO, and the laboratory presumably will be established with its main office in Mombasa. Likewise, it would be advisable to try to engage local experts, i.e. researchers connected with EAMFRO, the University of Nairobi and the Fisheries Department of the Ministry of Tourism and Wildlife, particularly if the investigation program also is to include studies of fishes, prawns or spiny lobsters.

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