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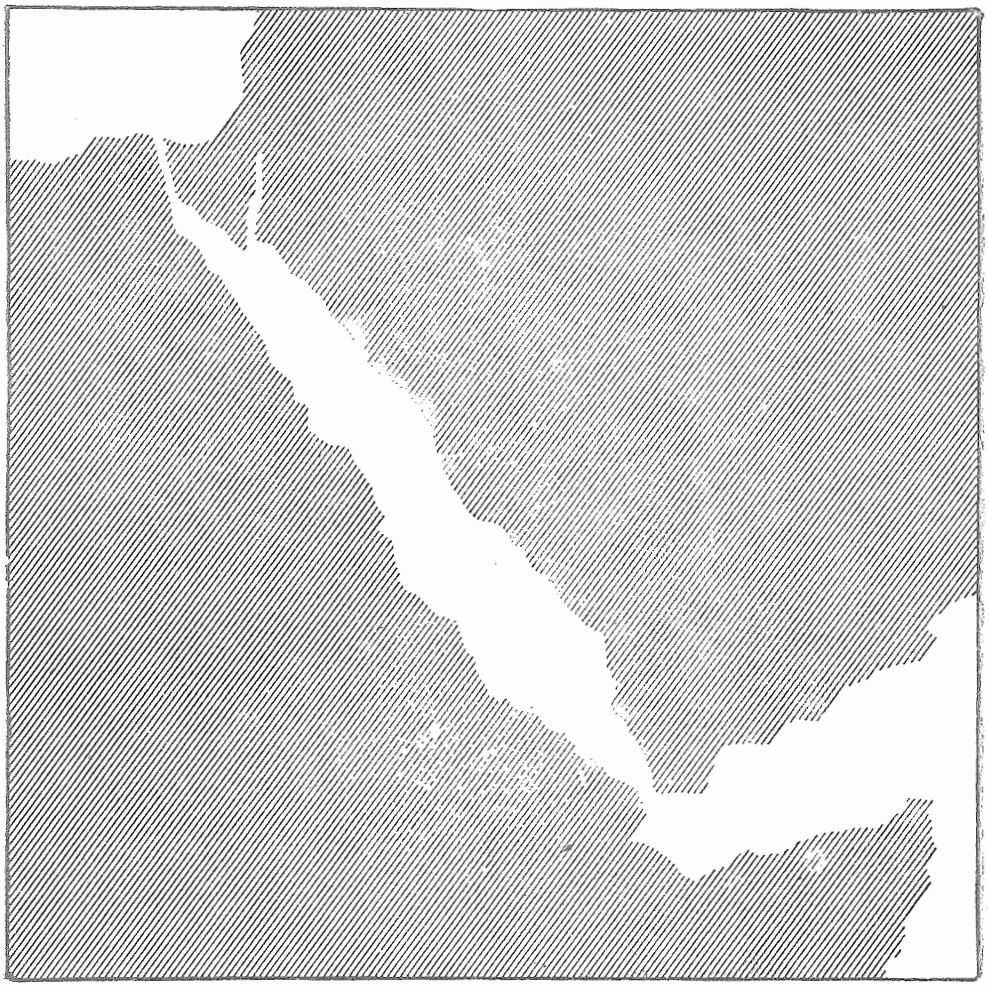
DEVELOPMENT OF FISHERIES IN AREAS OF THE RED SEA AND GULF OF ADEN

Report on a survey of some sites in and around Hodeidah, Yemen Arab Republic, with a view to assessing their suitability for aquaculture development



UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Report on a survey of some sites in and around Hodeidah, Yemen Arab Republic, with a view to assessing their suitability for aquaculture development

by
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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATION

Project for Development of Fisheries in Areas of the Red Sea & Gulf of Aden

Summary

This report examines the possibilities of developing aquaculture in the Yemen Arab Republic. Although the physical conditions along the country's Red Sea coastline are not particularly favourable to such development, two areas are identified as being suitable for limited pond culture. Other areas are considered suitable for pen and cage culture. A number of species occur in the capture fisheries which would be suitable for aquaculture. It is pointed out that investigations are required to ascertain the availability of juveniles of species intended for culture and of fish feed constituents. Trained personnel and facilities are also essential. A preliminary action plan for aquaculture development over a four-year period is outlined, giving estimated expenditures and possible revenues. However, it is recommended that, before any activities are commenced, a further survey by a multidisciplinary team be carried out.

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1. INTRODUCTION

1.1 Context of the Report

During the past decade the Government of the Yemen Arab Republic has been giving increasing importance to the exploitation of its fishery resources. Mechanization of traditional sambuks, improved fishing techniques and commercial trawler operations have increased the total annual production from 7,500 tonnes in 1973 (Agger, 1973) to 12,000 tonnes in 1979 (FAO/39/79/YAR 6,1979). The activities of the recently established autonomous General Corporation for the Development of Fishery Resources (GCDFR), management of the traditional fisheries and shrimp capture operations are expected to result in landings of 20000 tonnes of fish and 3000 tonnes of shrimp. In keeping with the overall aim of developing the potential for fish production in Y.A.R., the Government also wished to look into the possibility of initiating aquaculture development and, accordingly, requested the Food and Agriculture Organization of the United Nations to send a mission to examine certain water bodies in and near Hodeidah. The F.A.O. assigned T.Gottfried Pillai as Aquaculture Consultant to carry out this task under the auspices of the Project for Development of Fisheries in areas of the Red Sea and Gulf of Aden,RAB/81/002 , and the present report is based on his mission to the Yemen Arab Republic.

1.2 Terms of Reference

To carry out a reconnaissance survey of the aquaculture potential of two water bodies in North Yemen. One of the two is a 250 ha brackish water lake located close to Hodeidah, the other is a lagoon, reported to be small and close to Taif. The objectives of the survey are to appraise the possibilities of aquaculture in the two water bodies and, if these are believed to be good :

(1) tentatively to identify the species which would be most suitable for culture from a technical, economic and social point of view ;

(2) to propose additional investigations, if any, which would have to be carried out to determine technical feasibility of the "most suitable" species;

(3) to outline a short-term action plan aimed at appraising the economic viability and social relevance of the " most suitable " species.

To discuss findings, conclusions and recommendations with Government authorities concerned.

1.3 Places visited

Details of the itinerary, places visited and persons met during the visit to Y.A.R. from the 15th of March to the 15th of April, 1982 are given in Appendices 1 and 2.

1.4 Acknowledgements

Gratitude is expressed to the Chairman and staff of the Fisheries Corporation in Hodeidah for the assistance given in various ways during the consultancy; also to the Faculty of Science, University of Sana'a for determining the salinity of the water samples.

2. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The lagoon opposite the Fisheries Corporation in Hodeidah, some locations along the road to Taif, and the cove where the Fisheries Corporation's prawn trawlers are moored in Al Salif were visited with a view to assessing their suitability for aquaculture.

It was observed that, in almost all the places visited, there is no scope for fish culture in earth ponds because the soil is too sandy or silty for dike construction. Only in two places was there some limited scope for pond culture. The first is in the Wadi creek behind Imam Ahmed's old house located about 23 km from Hodeidah along the road to Taif. The other is in Muandar where some earth ponds for preliminary fish culture experiments and raising fish shrimp seed could be constructed. There is no permanent lake in Taif and the lagoon opposite the Fisheries Corporation in Hodeidah becomes one continuous mass of water with the Harbour during the spring tides. Fish culture in ponds is not possible in this lagoon because of poor soil conditions and the water is too shallow for culture in floating cages. However, pen culture is possible in this lagoon. Another place of interest is the sheltered cove near the cement factory in Al Salif, where trials on fish culture in floating cages can be carried out.

As regards the current status of aquaculture development in Y.A.R., it is going to be an entirely new activity. There are no trained officers for aquaculture development and there is no available background information on the seasons and locations of occurrence of fry and fingerlings of culturable species, such as grey mullets, milkfish, rabbitfish and prawns.

Hence it is advisable that aquaculture development should proceed in a stepwise manner as follows :-

(i) Assign the following full-time government staff for aquaculture development :

(a) at least one Aquaculturist (Biologist) ;
(b) two aquaculture technicians;
(c) one driver and two fishermen.

(ii) Purchase a full-time vehicle and equipment such as nets and materials required for studies pertaining to aquaculture;

(iii) Seek the assistance of an expert in tropical marine and brackish water aquaculture ;

(iv) Commence surveys on the seasons, locations and relative abundance of occurrence of the fry and fingerlings of species suitable for aquaculture, such as grey mullets, milkfish, rabbitfish and prawns. Also collect data on the occurrence of mature adults and breeding seasons of the above species, since they will be useful if breeding in hatcheries is considered at some future date

(v) Carry out preliminary trials in aquaculture ;

(vi) Further training of aquaculturists and technicians ;

(vii) Pilot scale aquaculture activities and feasibility studies for commercial scale activities ;

(viii) Expansion into commercial scale activities.

3. BACKGROUND

3.1 Geography

Situated along the south western side of the Arabian Peninsula, the Yemen Arab Republic has about 500 km of Red Sea coastline. A stretch of semi-desert flat land called the Tihama, varying in width between a few hundred metres near Bah-el Mandah to over sixty km further north separates the central mountainous parts of the country from the sea. Rainfall over the Tihama is very low, varying between 64.0 and 84.7 mm in Hodeidah. Thus, there are no perennial rivers bringing in a steady flow of fresh water into the Red Sea. Waters resulting from occasional heavy showers flow into the sea across the Tihama through temporary rivers or Wadis. The Tihama abounds in under-ground water which is fresh and potable in several locations, sometimes even just a few metres away from the sea shore. While air temperatures range from about 16-40°C, that of water in the open sea, during summer, ranges from 31-32°C, and may reach even 37-40°C in shallow, sheltered tide pools. Winds are strongest in winter,

and even during other periods of the year reach gale force, causing waves to reach an amplitude of 2 metres in the Hodeidah region.

According to the 1982 tide tables for Y.A.R., the highest tides range between 1.1 -1.4m being over 1.0m for about 228 days of the year. The lowest tides range between 0.0-0.3m reach 0.0m during about 23 days of the years.

The coastline itself is characterized by wide sandy or silty beaches, which are mere extensions of the coastal sand-dune areas right down to the sea shore. Large areas of tidal flat, which are exposed at low-tide, are composed of such soil and are generally unsuitable for earth pond dike construction. Coastal sea-bed changes occur due to the combined effect of littoral sand movements in the sea, which cause the formation of shifting sand banks as well as the deposition of sand and dust blown from the coastal sand dunes, especially during sand storms.

Mangrove vegetation is relatively scarce. From ancient times they were cropped for poles to build houses, for scaffolding and for firewood. Macnae (1974) mentions that the Red Sea coastline was colonized by various species of mangroves wherever conditions were suitable for their growth, but that they were removed at an early date, and only isolated patches of the relatively useless Avicinnia Marina persist, often in most unlikely places.

3.2 Fishery

The total annual fish production was estimated at 7,500 tonnes in 1973 (Agger, 1973) and 12,000 in 1979 (FAO/World Bank 1979). Based on the latter and a total population of 5.5 million in 1979, the per caput consumption of fish is around 2.2 kg (wet weight) per annum. About 3,900 fishermen, among a total population of 30,000 distributed in some 40 fishing villages along the coast of Y.A.R, are engaged in marine fishing. They are organized under the leadership of a village headman and an elderly fisherman each (FAO/World Bank Report, 1979). Aquaculture, however, is unknown to these fishermen and has still to be carried out even on an experimental basis in Y.A.R.

3.3 Personnel for Aquaculture:

As regards availability of technical personnel trained in marine and brackishwater aquaculture, there is none at present in the Y.A.R.

4. THE LAGOON OPPOSITE THE FISHERIES CORPORATION IN HODEIDAH

4.1 General description and tides

This is one of the two main water bodies investigated during the present consultancy. Sketches of this lagoon are given in Appendices 3 and 4 and this so-called "Lake" (L) is a variable water area, depending on the tides, but its average area at low-tide is arount 250 ha. It is connected with the main Hodeidah Harbour through a canal (C) which varies between 25 and 50m in width at low-tide when the lagoon itself is partly separated from the harbour by a sandy stretch over 1.5 km across from the point S1 along the road leading to Ras Katib to point S3 near the canal and another 250-300 m of sandy area from points S4 to S5 near the oil storage tanks and the mosque nearby. However, as was observed during the high-tides, between the 26th March and 12th April, 1982, the entire area A,L, S-S5 and H was under water and there was no indication of a lagoon or lake separate from the harbour and the sea. On 30/3/82 the tide table figures were as follows :

Time	Tide levels (m)
0441	1.2
1058	0.4
1700	1.1
2324	0.3

The condition of the lagoon around 11.30 a.m during low tide is shown in Appendix 4. The so-called lake area was clearly separated from the channel C and considerably reduced in size. Depths within this area range from 0.5 - 3.0 metres. Marine flora such a Enhalus, Halophila and Haledule spp. were exposed during the low tide. As already stated in the introduction the highest tides range between 1.1-1.4 m and are over 1.0 m for about 228 days of the year, which indicates that the lagoon is likely to be indistinguishable from the Hodeidah harbour during a greater part of the year. Some arrangement for enclosing the lagoon should be installed if the entire area is used for aqua-culture. As regards the total number of days in the year (1982) in which the lagoon is likely to be visible as a water body isolated from the Hodeidah harbour at low-tide, it is around 221, low-tide levels dropping to 0.3m on 87 days, 0.2 m on 76 days, 0.1m on 35 days and 0.0m on 23 days.

4.2 Soil conditions

The soil is quite sandy or with soft silt in areas A, S, S1-S5. It is somewhat muddier in the canal area C and

most of the lagoon area L itself. On the whole the soil is unsuitable for pond dike construction. In this connection it would be interesting to note that FAO/World Bank (1979) considered this lagoon for a fishery harbour and concluded that " the nature of the soil makes the site unsuitable for economical construction purposes and the basin and shallow lagoon entrance would need frequent dredging ". Another important point that report mentions is that there is a fuel pipeline installed across the entrance to the lagoon site. However, this pipeline was not exposed during the lowest tides in March 1982, and is unlikely to affect aquaculture activities that may be carried out in the area.

4.3 Salinity

Salinity values of water samples collected on 20/3/82 from the lagoon site and compared with that of the open sea are as follows :

Stations	Salinity
	P.P.t
X1	38.45
X2	38.59
X3 (sea)	37.35
X4	38.59
X5	39.19

As is to be expected, the salinity of the water in the lagoon site is slightly higher than that of the sea.

4.4 Species of fish

As regards the main species of fish occurring in this site, examination of local fishermen's catches revealed the presence of the following : small barracuda (Sphyraena sp.), Jaabul (Therapon sp.), Grunters (Pomadasys sp.), Threadfin travally (Alectis Indicus) and arabi (Mugil spp.)

4.5 Examination of possibilities for using this lagoon for aquaculture.

4.5.1 Aquaculture in earth ponds

4.5.1.1 Soil

The soil is not compact enough to make earth dikes, being too sandy in most places, too silty in the others. Dikes constructed out of this soil are likely to be completely destroyed by the tides before a single growing period of any cultured species.

4.5.1.2 Drainability

It is not possible to drain area L at low-tide. This is very important for culturing species such as shrimps and grey mullets (Mugil spp.,), especially for eradicating predatory fish and pests. The use of chemicals as an alternative will be impractical and uneconomical.

4.5.1.3 Conclusions

The site is unsuitable for sub-division into ponds with earthen dikes.

4.5.2 Possibilities for using the entire area L as a single unit for aquaculture.

4.5.2.1 In its present state but with a one-way arrangement for entry of fish through canal C.

It is unsuitable for intensive stocking through human efforts, since the fish or prawn seed stocked will find their way to the sea through the area S1 - S3 during the next spring-tide. Predatory fish as juveniles of the cultured species will also enter from the sea through this area. There is a likelihood of the fish leaving the lagoon as they grow older unless there is a means of preventing their escape across S1-S5.

4.5.2.2 Closure of area S1-S5 with an earth or cement dike and a one-way arrangement for fish in Canal C.

An earth dike is not feasible for reasons mentioned under section 4.1.1.1.

A cemented dike will be about 1.5 km long and is likely to cost about 3 to 4 million Rials, and there is no evidence at this stage that this will be economically feasible for the Fisheries Corporation to construct.

Moreover, as mentioned earlier, the problem of eradicating fish species remains if species such as shrimps and/or grey mullets are to be intensively stocked for culture.

4.5.2.3 Enclosure of the entire area L with plastic " Netlon " netting across from S1 - S5 with a one-way arrangement for fish in Canal C.

This will permit a simple type of aquaculture. Young fish will be able to enter the lagoon through the meshes of the "Netlon" whenever the area S1-S5 is covered at high-tide, some of them will return to the sea through the meshes; but those that remain and grow will not be able to pass through the meshes. If they attempt to leave through the channel they will be captured in a bordigue arrangement there.

4.5.2.4 Cage culture, pen culture

In a shallow lagoon like this the culture of fish in pens will be more appropriate and more likely to be economically viable than culture in cages. But any large scale operation has to be preceded by surveys for the occurrence of juveniles of species projected for pen culture and adequate experimentation.

5. OTHER AREAS VISITED

5.1 Some areas en route to and beyond Taif were visited and their soil and other conditions examined.

5.1.2 Road to Gholeifikah/Taif

There are a number of sandy bays and tidal flats along the road from Hodeidah to Taif and Gholeifikah. Accessibility of sites beyond about 20km. from Hodeidah along this route becomes a problem during the rainy season when even 4-wheel drive vehicles tend to get stuck in the soft sand.

5.1.1 Goleifikah

This is a fairly large bay which is separated from the sea by a sand-bar, There were indications that sea water flows over the sand bar into the bay during the highest tides or during rough weather. On the land side of the bay there is a steep drop from the sand dunes to the shores of the bay below.

The sandy tidal flats around the bay are unsuitable for pond fish culture. A fishery for shrimps and fish exists in the bay, as well as in the open sea. It would seem more profitable to concentrate on the fishery than to start aqua-culture in such a difficult location.

5.1.2 Taif

This place is located about 25-30 km from Hodeidah. No lakes as such were observed in and around Taif during four visits to the area.

5.1.3 Bay near Imam Ahmed's ancient residence. The old house said to have belonged to Imam Ahmed is located about 23 km from Hodeidah along the route to Taif behind an ancient house believed to have been built by Imam Ahmed (Appendix 6). Water is always present in the creek since the area is somewhat deeper than the tidal flat in the bay itself. Juvenile grey mullets and penaeid shrimps were observed in the creek.

5.1.4 Wadi creek near Imam Ahmed's old house . This is located about 23 km from Hodeidah along the route to Taif behind an ancient house believed to have been built by Imam Ahmed (Appendix 5). Water is always present in the creek since the area is somewhat deeper than the tidal flat in the bay itself. Juvenile grey mullets and penaeid shrimps were observed in the creek.

An area of about 2.0-2.5 ha can be used for some preliminary experiments on farming mullets and/or penaeid shrimps after a dike AB and sluice S are constructed. The salinity of the water on 25/3/82 was 38.15 at point A and 38.45 at point B. There is much underground fresh water in the area, even as close as a few metres from the sea shore.

5.1.5 Yondoh

This place is located about 17 km from Hodeidah. A vast tidal flat is exposed at low-tide. Mullet fingerlings were observed in the tidal channels traversing the tidal flats. The soil here also is too sandy or silty for earth pond dike construction.

5.1.6 Muandar solar salt pond area

This is located about 6-7 km from Hodeidah along the route to Taif. The local villagers operate small-sized irregularly constructed solar salt ponds here. Sea water is let into the ponds during the spring tides along long narrow canals which have been dug for this purpose.

The soil here is somewhat more compact and better for constructing earth ponds than observed elsewhere along the route to Taif. Some of the salt ponds which were filled with fresh water during the recent rains showed a rich micro-algal bloom. The site could be useful for initial experiments on fish culture and for raising fish fingerlings for pen culture.

5.1.7 Al Salif

The relatively calm cove opposite the cement factory where the Fisheries Corporations prawn trawlers are usually moored is a suitable area for conducting experiments in floating cages. Much trash fish is presently discarded, which could be used to raise good quality fish in floating cages. Such floating cages need to be adequately covered with netting to prevent the large number of sea gulls, which presently thrive on the discarded trash fish, from getting at the cultured fish.

6. SPECIES SUITABLE FOR AQUACULTURE

Among the species which occur in the capture fisheries and which are of immediate interest for aquaculture in Y.A.R., from a technical and economical point of view, are the following:

Common names	Arabic Names
Grey Mullets (Mujilidae)	Arabi, Budjem, Bugan, Ora,
Milk Fish (Chanos)	Kumba, Muref
Rabbit Fish (Siganids)	Sigan, Zikan, Sisan, Kizan
Sea Breams (Sparidae)	-
Cat Fish	Kumal
Penaeid Shrimps	Gembedi

Althouh no information is available on the seasons, locations and relative occurrence of the juveniles of the well-known culturable species such as Grey Mullets, Milkfish, Rabbit fish and Penaeid Shrimps, much useful information is provided by Walczak (1977) on the species composition and biology of the shrimps obtained in the commercial catches off the coast of Y.A.R. He reports the following species :

Penaeus semisulcatus - 79-100% throughout the year.
Penaeus indicus - increase in abundance from March to July, peak in May.
Penaeus Japonicus - few
Metapenaeus monoceros - occurs irregularly, never more than 16% of the catches.

According to his studies on P.semisulcatus from Ras Katib ground, females with ripe or nearly ripe ovaries occurred throughout the year increasing from October to May, then decreasing rapidly and remaining less than 15% of the sample during the summer. Some information on sex ratios of the P.semisulcatus, P. indicus and M. monoceros is also provided.

Trawler catches of prawns brought to the Corporation's office in Hodeidah for sale were examined during the present consultancy. A key to the identification of the species reported in local commercial trawler catches is provided in Appendix 6.

7. INVESTIGATIONS REQUIRED

Aquaculture, whether in ponds and other enclosed water bodies or cages and pens, will depend on other important factors besides suitable locations. The more important ones are:

(i) Availability of juveniles of the species projected for culture, in adequate numbers for the scale in which it is intended to carry out experimental and, eventually, commercial culture operations. For example, if it is intended to have an experimental farm with 5 ha of production ponds producing 2 tonnes of grey mullets (Arabi) per hectare with an avergage weight of 330 gr. each,(or 3 fish to a kilogram) the number of grey mullet young that should survive and grow to this size will be 6,000 per hectare. About 10-25% more should be added to compensate for mortalities, which brings the total to 33,000-37,500 fingerlings for the 5 ha production area.

For extensive culture of penaeid prawns, such as P.semisulcatus or P.indicus, the numbers need to be higher. If a production of 0.5 tonnes per ha of prawns weighing about 20 to a kilogramme is projected, the numbers surviving per ha would be about 10,000. For a 5 ha production area the number surviving would be 50.000. Mortality rates for prawns are often higher

than for fish. About 25% more need to be added to compensate for this, bringing the total to 62,500 for the 5 ha production area. Thus, for commercial production of, say, 25 tonnes of grey mullet and 10 tonnes of penaeid shrimp through aquaculture, the numbers of juvenile fish and shrimps required would be 82,500 -93,750 mullets and 250,000 prawns.

Although methods for breeding these species in special hatcheries are known, initial experiments can be carried out more easily and often without much expenditure with juveniles collected from the natural environment. For this certain studies and surveys are necessary. Even development of hatcheries for breeding them would depend very much on such surveys and studies.

(ii) Like all farmed animals, fish also need to be fed, especially when stocking intensities are high. A good proportion of normal fish feeds are derived from agro by - products. Since there is very little agricultural activity in the Tihama areas, there are hardly any agro by-products available. They have to be brought from the agricultural areas of the hill country. Fish feeds normally include animal protein, the proportion depending on the species of fish being farmed. Among sources of animal protein for fish feed are trash fish and fish waste which can be converted to fish meal, and blood from slaughter houses. An inventory needs to be made of the kinds and locations of availability of such fish feed constituents, cost of purchase and transport and, finally, converting them into fish feed.

(iii) Investigation and studies relating to aquaculture, and the subsequent experimental and pilot-scale aquaculture, will require trained technical personnel and facilities on a full-time basis, since there has been no past experience in brackish water or marine aquaculture in Y.A.R. and there are no trained technical personnel in this area. The provision of trained full-time aquaculturists should receive priority in order to carry out the necessary studies and lay the foundations for aquaculture development in the future.

8. GENERAL CONCLUSIONS REGARDING THE AQUACULTURE POTENTIAL IN THE AREAS VISITED

(i) The number of places where aquaculture activities could be carried out in Hodeidah and along the route to Taif are very limited. The bays and tidal flats along the route to Taif are exposed to the open sea, and the soil in most places is unsuitable for earth pond construction. Floating cages and pens are not feasible in most places. They have to be installed very far from the shore in order to have sufficient depth of water since the water recedes more than a kilometre during the low-tides. The rough weather that can prevail, especially in exposed areas, has already been dealt with in the introduction.

(ii) There are two places of some interest, however, along the road to Taif: One is the Wadi creek located about 23 km from Hodeidah behind the old house said to belong to Imam Ahmed. An area of about 2.5 ha of the bay can be cheaply enclosed and used for preliminary fish/shrimp culture experiments. The ancient house, itself, is unoccupied and could be used for stationing staff. However, the site is often inaccessible, even by 4-wheel drive vehicle, during the rains.

The other is in Muandar, 6-7 km from Hodeidah, where solar salt ponds are operated by the villagers. The soil here is somewhat better for earth pond construction than in all the other places visited. Ponds constructed here could be used for initial fish culture experiment and for holding and raising fry and fingerlings of species to be cultured in pens.

(iii) The shallow lagoon opposite the Fisheries Corporation in Hodeidah is more suitable for pen culture than for pond culture or cage culture. Some experimental fishing with French fish traps called ' trabaques ' is likely to yield some useful information as to whether a more permanent fish trap called a 'bordique' could be operated in the channel.

(iv) Preliminary experiments on the culture of fish in floating cages could be carried out in the sheltered cove opposite the cement factory in Al Salif, where the Fisheries Corporation's prawn trawlers are usually moored.

9. A PRELIMINARY ACTION PLAN FOR AQUACULTURE DEVELOPMENT

According to discussions held with Fisheries Corporation officials, the development of aquaculture is under consideration because of the increasing fishing pressures on the limited naturally occurring stocks in the southern areas of the Red Sea, and with the future in view.

However, there is no past or present experience in aquaculture, necessary background information on culturable species is lacking, and there are at present no personnel trained in, or specially assigned to, aquaculture development.

The present report is based on a limited survey of coastal areas in and around Hodeidah. It is therefore recommended that a further survey be carried out, preferably by a multi-disciplinary team, to determine whether there are other and better sites for aquaculture development before commencing aquaculture activities.

Whatever the sites that may eventually be selected, the following action plan is proposed for carrying out the preliminary surveys, studies, experiments and economic assessments required, upon which a longer term programme for aquaculture development could be based.

9.1 Staff, Expertise and Equipment

In order to gather the necessary data on the occurrence of fry, fingerlings and adults of species suitable for aquaculture, and to carry out the preliminary studies and culture trials, it is necessary that full-time staff, equipment and other facilities be provided as follows :

9.1.1 Staff

i) One aquaculturist (biologist)
ii) Two aquaculture technicians
iii) Two fishermen/field workers
iv) One driver

9.1.2 Expertise

Since there is no person with adequate experience in mariculture in Y.A.R. it would be necessary to recruit one. Under his guidance the national aquaculturist and aquaculture technicians could undertake the surveys, studies and experiments necessary to formulate a sound programme for aquaculture development.

9.1.3 Equipment and materials

i) A four wheel drive vehicle
ii) Nets, fish seed, containers, laboratory and other equipment.
iii) Fry /fingerling ponds, fertilizers, fish feeds

9.2 Surveys for fish seed

Surveys on the seasons, locations and relative abundance of the fry and fingerlings of culturable species such as grey mullets, milkfish, rabbit fish, catfish, seabreams and prawns need to be carried out. The results of these surveys will indicate the extent to which aquaculture can depend on naturally occurring fish seed.

9.2.1 Surveys for mature broodstock

Information on the breeding seasons and sources of mature broodstock of culturable species will be useful, in case naturally occurring seed are insufficient or uneconomical

to collect, since the feasibility of breeding them in special hatcheries could be examined.

9.3 Preliminary trials on aquaculture

9.3.1 Ponds for holding fry and fingerlings

Important for aquaculture are ponds for holding and raising fish or shrimp seed. As stated in Section 5.1.6, the soil in Muandar is somewhat more compact than elsewhere along the route from Hodeidah to Taif. Ponds could be constructed here for experimental rearing of fry and fingerlings obtained during the surveys. Additional ponds can be constructed in due course for large-scale raising of fry and fingerlings.

9.3.2 Pen culture

In view of the poor soil conditions along most of the coast of Y.A.R., culture in pens and cages has more potential for future expansion than culture in earth ponds. Pen culture can be carried out using fish or a combination of non-carnivourous fish with shrimps.

If adequate numbers of fry and fingerlings are obtainable from the natural environment, it would be cheaper to use them for the initial experiments than to establish, staff and operate special hatcheries for this purpose.

From the point of view of convenience for supervision and management and the fact that the area is relatively less exposed to bad weather than most of the other sites visited along the route from Hodeidah to Taif, the lagoon opposite the Fisheries Corporation in Hodeidah appears suitable for the initial experiments on pen culture. Muandar is also a short distance from here for raising the fry and fingerlings required in ponds. Except for these ponds and a field office/laboratory/watch hut no expensive buildings would be required for the initial experiments.

9.3.3 Culture in floating cages

Although far from the Fisheries Corporation's office in Hodeidah, experiments on the culture of fish in floating cages could be commenced in the sheltered cove opposite the cement factory in Al Salif. The more suitable species are rabbit fish (siganids) and catfish, The former could be fed with algae while the latter could be fed with trash fish from the Corporation's fishing boats which land their fish in this cove. At present large quantities of trash fish are discarded.

9.3.4 Experimental use of fish traps (trabaques) in the lagoon opposite the Corporation.

The experimental use of about 5 French fish traps known as trabaques will give an indication of the species and relative quantities of fish that occur in this lagoon. The number of traps can be gradually increased to about ten, if the catches indicate that it would be profitable to do so.

9.3.5 Netlon netting enclosure for the lagoon opposite the Corporation.

If the experiments with trabaques prove successful a simple form of aquaculture using the entire lagoon area opposite the Fisheries Corporation could be practised. For this,a well supported "netlon" screen needs to be erected from S1 - S5 (Appendices 3 and 4) and a one-way arrangement for fish called a "bordigue" installed in the channel C from S3 - S4. Fish fry will be able to enter or leave through the meshes of the " netlon ", but those that remain and grow will be captured in the bordigue if they try to escape through the channel. Both juveniles and older fish will be able to enter the lagoon through the one-way arrangement in the bordigue.

9.3.6 Use of the entire area of the lagoon plus expansion of pen culture

Depending on the availability of fish/prawn fry and fingerlings, the area used for pen culture can be increased. At the same time the rest of the lagoon, enclosed with""netlon", will support a simple form of aquaculture.

Since pen culture is a form of aquaculture involving large numbers of the cultured species in a limited area, it would be necessary to provide them with suitable feeds in adequate quantities

9.4 Training of Aquaculturist and Aquaculture Technicians.

After a year or so of in-service training under the guidance of the Mariculture Expert, the Aquaculturist and Technicians appointed by the Corporation should be provided with opportunities for training abroad :

i) In Tunisia for the construction, installation and operation of bordigues and management of lagoon fisheries, and the culture of grey mullet, sea bream, molluscs and prawns.

ii) In the Philippines for the culture of fish in pens (milkfish, grey mullets, shrimps and molluscs).

9.5 Pilot scale operations

Based on the results of preliminary experiments, plans for pilot scale pen culture and cage culture operations could be prepared and implemented. At least two years will be required.

9.6 Based on the results of pilot scale operations, and with due consideration to aspects such as the availability of adequate fish seed, feed, personnel and economic viability, aquaculture activities could be expanded into commercial scale operations.

10. ESTIMATED EXPENDITURE	US $
10.1 First year	
10.1.1 Expertise	
- One Mariculture Expert with at least seven years experience in the successful operation of tropical commercial fish and shrimp farms	60,000
- Consultancy in mariculture fish pond engineering	
Two man-months, for drawing up plans and estimates for nursery ponds and provision for fish/prawn hatchery	10,000
10.1.2 Equipment for fry and fingerling surveys	
- 1 four - wheel drive vehicle with power winch and trailer attachment	12,000
- 1 trailer for 5-6 metre fibre glass boat	2,000
- 1 Fibre glass boat, 5-6m long	5,000
- 2 twenty h.p. outboard motors	3,000
- Various fishing gear	7,000
- Containers, oxygen cylinders, etc. for live fish transport	5,000
- 2 tents and camping equipment	5,000
- Laboratory equipment and chemicals	7,000
- Miscellaneous	4,000
Total US $	120,000

10.1.3	Government staff	Rials
	One Aquaculturist (Marine Biologist) Two aquaculture technicians Two Fishermen/Field Workers One Driver	
10.1.4	Fuel for vehicle and boat, allowances for field surveys, miscellaneous expenses	
	Total : Rials	50,000
10.2	Second Year	US $
10.2.1	Expertise	
	- Extension of Mariculture Expert 12m/m	65,000
	- Consultancies 1 m/m	5,000
10.2.2	Equipment	
	- Netting for 10 experimental fish culture pens in the lagoon opposite the Fisheries Corporation in Hodeidah. Each pen 100 m^2 consisting of netting, float line and floats, sinker chain/ weighted ropes	5,000
	- Five fish trabaques, complete with 2m x 50m guide netting, for experimental fishing in the above lagoon	4,000
	- For cage culture trials in Al Salif 5 floating cages 5m x 5m x 2m (h), 1.5 cm^2 mesh complete with cover net, floats, ropes, anchors and anti-fouling treatment (Bridport-Gundry, Skretting).	3,000
	- 5 floating cages 5m x 5m x 2m and 2.0 cm^2 mesh as above	3,000
	- Miscellaneous items of equipment	15,000
	Total US $	100,000
10.2.3	Construction works	Rials
	Construction of a total of one hectare of nursery and rearing experimental ponds, complete with sluices and supply canal from the sea as follows :	

			Rials
	- 10 ponds 10m x 25m (250m^2 each), total 2500m^2.		
	- 5 ponds 20m x 25m (500m^2 each), total 2500m^2.		
	- 5 ponds 40m x 25m (100m^2 each), total 500m^2.		
	- Field laboratory, office, store and watch house.		
		Total Rials	75,000
10.2.4	Government staff		
	- Staff as in 10.1.3		
	- Operation and maintenance of vehicles, per diem for surveys, miscellaneous		
	- For cage culture experiments in Al Salif one Fisherman/Watchman		55.000
		Total Rials	130,000
10.3	Third Year		US $
10.3.1	Expertise		
	- Mariculture Expert	12 m/m	65,000
	- Consultancies	1 m/m	5,000
10.3.2	Equipment		
	- Netting for 20 more fish culture pens as under section 10.2.2		
	- 20 floating cages as under Section 10.2.2.		
	- Miscellaneous items of equipment		
	- Fish feeds, fertilizers		45,000
		Total US $	115.000
10.3.3	Construction Works		Rials
	- If surveys indicate that it is uneconomical to capture fry and fingerlings of species to be cultured from the natural environment and if mature adults of grey mullets, prawns and sea breams (*Sparus spp.*) can be obtained, a hatchery can be established in Muandar or other location if more suitable. Stage I	C/F	150,000

		Rials
	B/F	150,000
10.3.4	Government staff as in Section 10.1.3	
	- Operation and maintenance of vehicle, boat.	
	- Travel allowances for field surveys miscellaneous expenses	60,000
	Total Rials	210,000

10.4 Fourth Year

		US $
10.4.1	Expertise	
	- Mariculture Expert - Consultancies 2 m/m	80,000
10.4.2	Equipment	
	- 20 additional fish culture pens - 25 additional fish culture cages - Miscellaneous hatchery equipment, feeds, fertilizers	30,000
	Total US $	110,000

		Rials
10.4.3	Construction works	
	- Phase 2 of hatchery - Expansion of earth pond area in Muandar by 1 ha	100,000
10.4.4	Government staff as in Section 10.1.3 and 10.2.4	
	- Operation and maintenance of vehicle, boat - Per diem for field surveys, capture of fry fingerlings, broodstock	60,000
	Total Rials	160,000

10.5 Summary of Estimated Expenditure for Four years

Year	Y.A.R. Rials	US $
First year	50,000	120,000
Second year	130,000	100,000
Third year	210,000	115,000
Fourth year	160,000	110,000
Total	550,000	445,000

11. ROUGH ESTIMATES OF PRODUCTION AND RETURNS

Appendix 7 shows a rough estimate of production and gross returns through the first four years of aquaculture development, assuming that the required numbers of fry and fingerlings are available from the natural environment or through breeding in special hatcheries or both, and based on conservative production figures per unit area or volume. Only gross returns are estimated for this period since much of estimated expenditure is for surveys, research, experimentation and development of facilities which normally precede aquaculture development activities, and which have to commence with regard to mariculture in Y.A.R.

However, assuming that the required logistical support is available, it could be expected that necessary surveys, research and experimentation could be completed by the fourth year, and that pilot scale operations could commence by the fifth year.

11.1 Rough estimates for pilot scale pen culture and cage culture operations

11.1.1 Equipment :

Quantity	Description	Price US $	Price Rials
50 cages	37.5m^3 at approx US $ 500 each	15,000	69,000
20 pens	25m x 20m x2m(h) at approx.$700 each	14,000	64,400
		Total	133,400 Rials

11.1.2 Estimated production

Activity	Production (kg)	Rate	Sale value (Rials) (Rials 15 per kg)
Cage culture (Al Salif)	9,375	5 kg/m^3	140,625
Pen Culture	10,00	1 kg/m^2	150,000
		Total	290,625

11.1.3 Estimated profitability

The cost of cages and pens for the pilot phase, 133,400 rials, can be amortized over a period of two years, at the rate of 66,700 rials per annum. The salaries of staff connected with these activities is estimated around 36,000 rials per annum, while fish feeds and other related expenses would be around 50,000 rials per annum.

	Rials (per annum)	
Proceeds from sale of harvests	290,625	+
Salaries of staff	36,000	-
Fish feeds, etc	50,000	-
Amortization of equipment	66,700	-
Estimated profit	137,925	

11.2 Expansion into commercial phase

It will therefore be seen that subject to the natural availability and/or production of adequage numbers of fry and fingerlings of the cultured species, which is indeed likely to be a critical factor, pen culture and cage culture activities can be profitably expanded several-fold.

12. ENCLOSURE OF THE LAGOON OPPOSITE THE FISHERIES CORPORATION

This has been referred to in Section 9.3.6. The experimental fishing with trabaques as suggested in Section 9.3.4. will indicate whether it will be feasible to do so. Meanwhile, even at a conservative estimate of 20 kg/ha/annum, the 200 ha lagoon could produce 4,000 kg of fish worth 60,000 rials per annum. The production is likely to be higher because large numbers of juvenile fish are likely to be attracted into the lagoon by the feed given to the fish being cultured in pens. Additional fish will also be caught as they enter the lagoon through the bordigue.

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Appendix 1

Itinerary

March 1982

Saturday 13 - Dar Es Salaam-Jeddah
Monday 15 - Jeddah - Sana'a
Tuesday 16 - Sana'a
Wednesday17 - Sana'a - Hodeidah
Thursday 18-Tuesday 23-Hodeidah, Fisheries Corporation, observations on Lake opposite the Corporation
Wednesday 24 - Visit to Al Salif with Mr.A.Hayel of the Fisheries Corporation and Mr. Bouhlel of the Red Sea Fishery Project (RAB/81/002)
Thursday 25 - Visit to Taif with Mr. A.Hayel and Mr.A.R.Jaffer of the Fisheries Corporation
Friday 26 - - ditto- -ditto-
Saturday 27 - Hodeidah, Fisheries Corporation, lake opposite Corporation
Sunday 28 - Hodeidah, Fisheries Corporation, fish market
Monday 29 - Visit to Ras Katib and Hodeidah harbour area
Tuesday 30 - Hodeidah, measurements and study of lake opposite Corporation
Wednesday 31 - Hodeidah

April 1982:

Tuesday 6 - Hodeidah
Wednesday 7 - Discussions with Chairman and General Manager of the Fisheries Corporation and other officials
Thursday 8 - Hodeidah
Sunday 11 -
Monday 12 - Visit to Taif, Goleifikah
Tuesday 13 - Visit to Muandar (Taif)
Wednesday14 -
Thursday 15 - Hodeidah, Discussions with Chairman and General Manager of the Fisheries Corporation and other officials
Friday 16 - Departure for Cairo.

Appendix 2

Persons Met

March 1982 :

15th : Sana'a

UNDP : Mr. Jacques Godfrin - Deputy Resident Representative
Mr. Yusuf A. Abdalleh - Programme Officer
Mr. Fuad F. Shomali - Administrative Officer

FAO : Mr. Mohammed Jama - FAO Representative
Mr. I.A. Abdul-Zahab, Programme Officer.

18th-31st Hodeidah

Fisheries Corporation

Mr. Ahmed Taleb, General Manager
Mr. Abdul Rahman Hayel, Chief, Statistic and Studies
Mr. Mohammed Alawi Madari, Manager, Administration
Mr. Abdul Rahman Jaffer, Master Fisherman
Mr. Abdulkader Yusuf Ali
Mr. Ali Issa Shanu, Marketing Officer and Cold Storekeeper

Consultant to the Fisheries Corporation

Mr. Knud Larsen, Partner, Hastrup Schultz and Sorensen, Copenhagen

RAB/81/002

Mr. M.J. Sanders, Senior Fishery Biologist
Mr. M. Bouhlel, Biologist

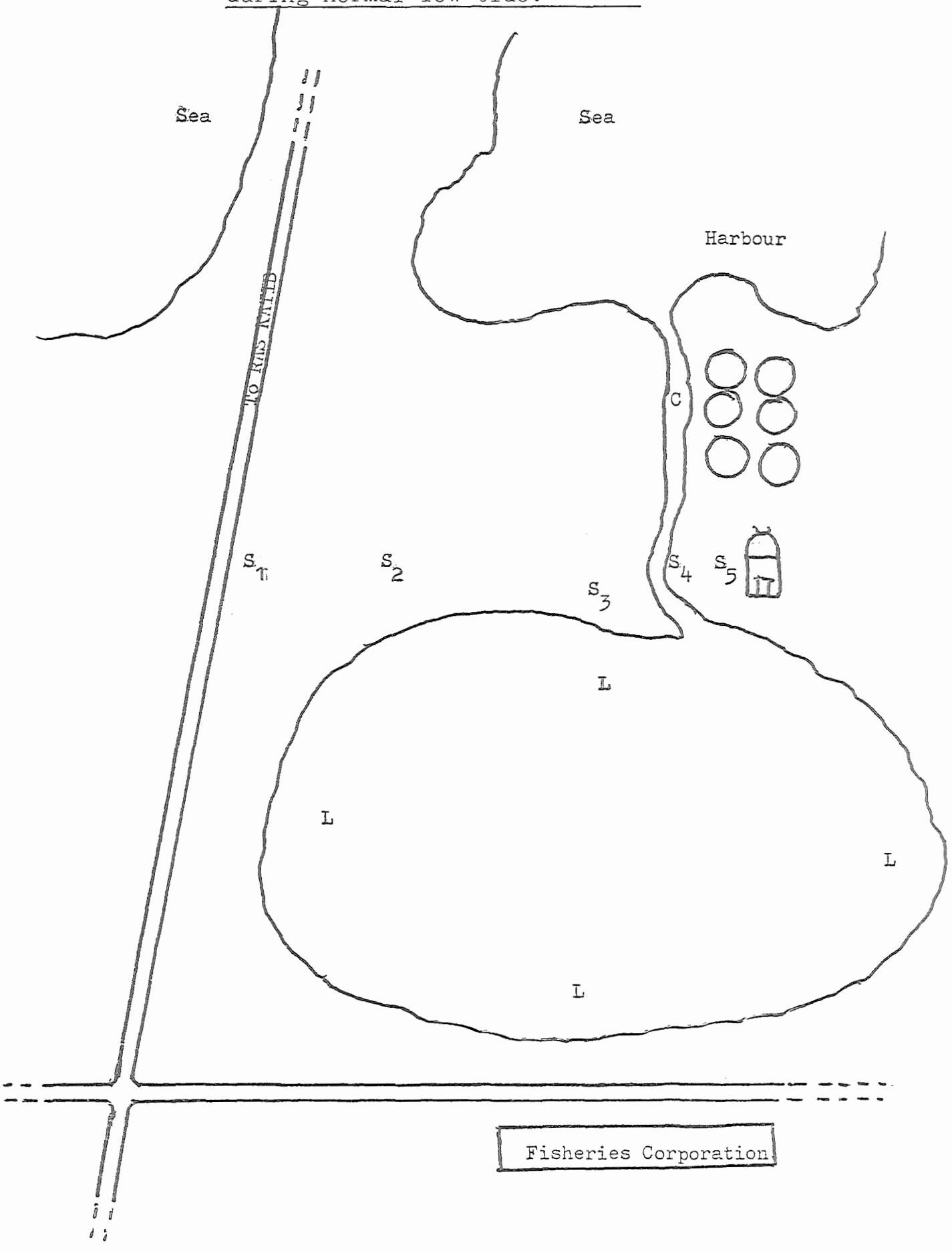
April 1982

1st-15th Hodeidah

Mr. Husein Lou Lou, Chairman, Fisheries Corporation
Mr. Husein Al Safargal, Director of Marketing and Sales, Ministry of Agriculture, Sana'a.

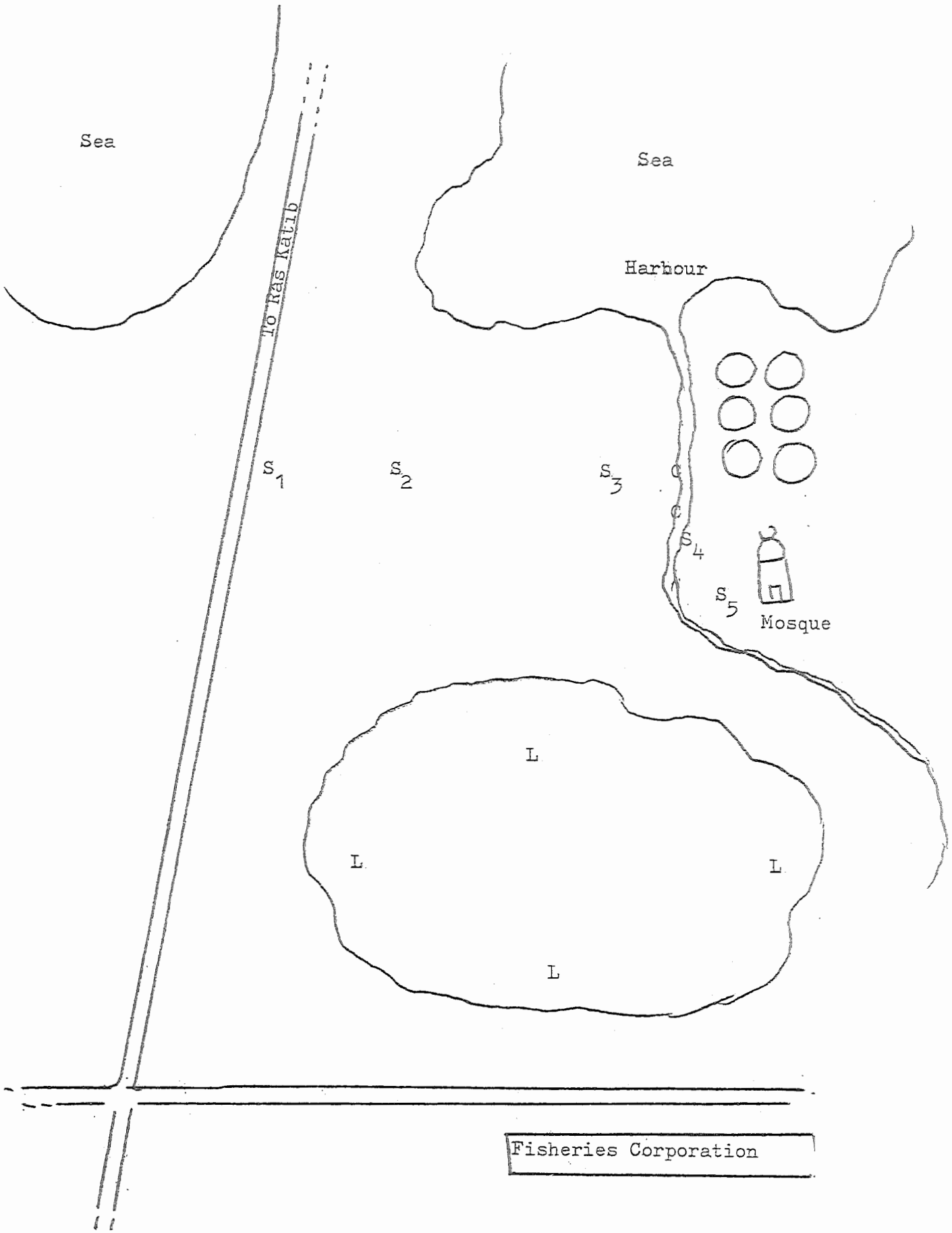
Appendix 3

Sketch of the lagoon opposite the Fisheries Corporation in Hodeidah showing condition during normal low-tide.



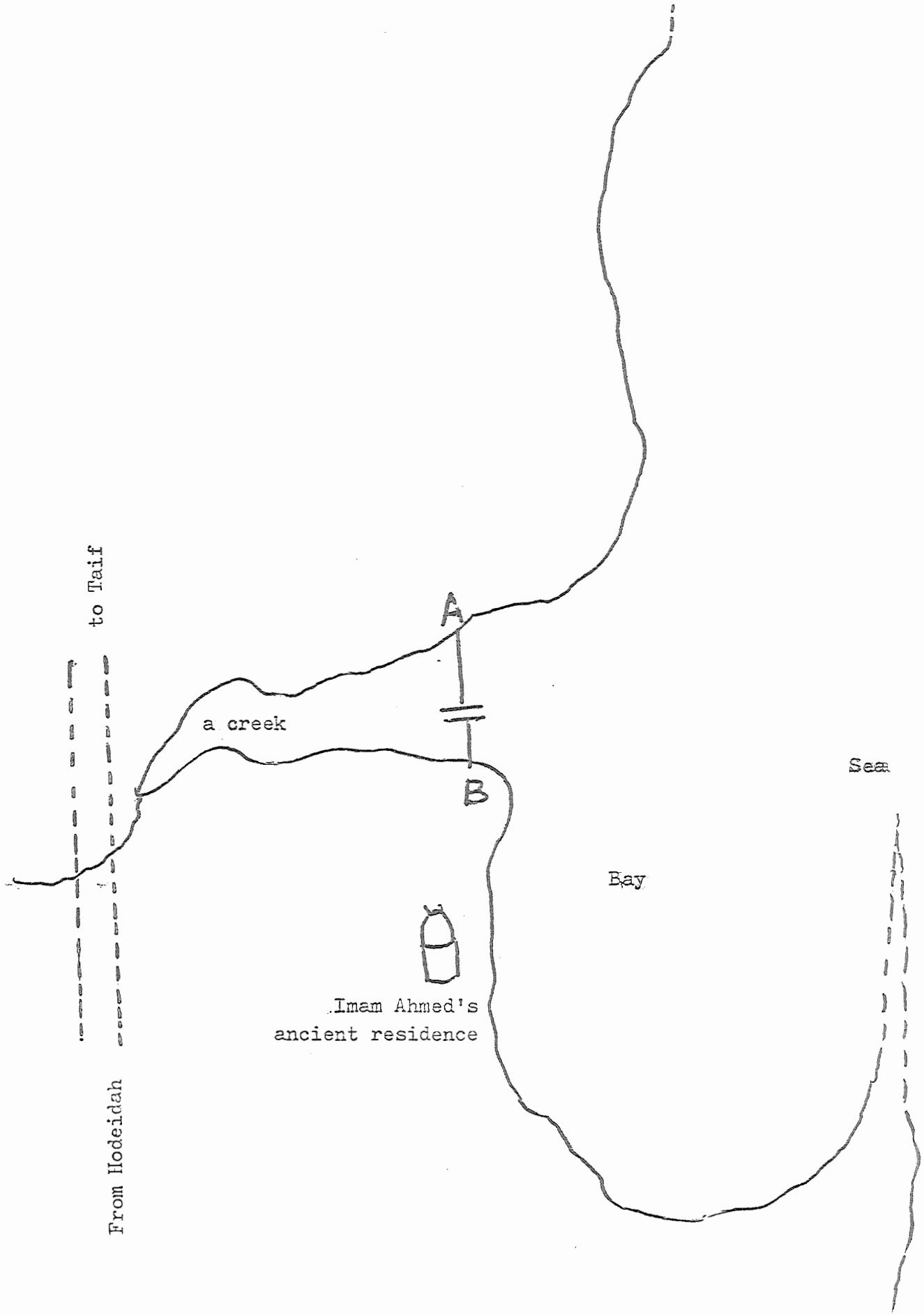
Appendix 4

Sketch of the lagoon opposite the Fisheries Corporation in Hodeidah showing condition during the lowest tides



APPENDIX 5

Sketch of the Wadi Creek near
Imam Ahmed's old house



Appendix 6

KEY TO THE IDENTITY OF PENAEID PRAWNS OBTAINED IN COMMERCIAL TRAWLER CATCHES OF YEMEN ARAB REPUBLIC

1. i) Exoskeleton rough to touch;
Rostrum without ventral spines;
In male: 5th walking leg (pereiopod)
with characteristic spur;
Petasma whitish, stiff like cartilage,
longer than exopodite of 1st pleopod ....
..... Matapenaesu monoceros
(Fabricius)

ii) Exoskeleton smooth to touch;
Rostrum with ventral spines;
In male: 5th pereiopod without spur;
Petasma pinkish, shorter than
exopodite of first pleopod: 2

2. i) Telson armed with paired spinules:.. Penaeus japonicus Bate

ii) Telson without paired spinules: 3

3. i) Outer antennule equal to or longer
than peduncle or squame;
In fresh specimens, antennae white,
uropods with yellow coloration:..Penaeus indicus Milne-Edwards

ii) Outer antennule shorter than
peduncle or squame ;
In fresh specimens, antennae buff to
reddish-brown, uropods without yellow coloration ...4

4. i) 5th pereiopod with small exopodite;
Post-rostral carina deeply grooved:... Penaeus semisulcatus
De Haan

ii) 5th pereiopod without exopodite post-rostral
carina without distinct groove:... Penaeus Monodon
Febricius

TABLE SHOWING ESTIMATED PRODUCTION AND RETURNS THROUGH AQUACULTURE (At selling price of 15R/kg)

	1st Year		2nd Year		3rd Year		4th Year		Overall Potential	
1. Pen culture In Hodeidah	weight (kg)	value (Rials)	weight (kg)	value (Rials)	weight (kg)	value (Rials)	weig (kg)	value (Rials)	weight (kg)	value (Rials)
a) 10 pens x 100m^2 at 1kg/m^2/a			1 000	15 000	-	-	-	-	-	-
b) 30 pens x 100 m^2 at 1kg/m^2/a			-	-	3 000	45 000	-	-	-	-
c) 50 pens at 100m^2 at 1kg/m^2/a			-	-	-	-	5 000	75 000	-	-
d) At least 10 ha at 1kg/m^2/a			-	-	-	-	-	-	100 000	1500 000
2. Cage culture in Al Salif										
a) 10 cages 37.5m^3 x 5kg/m^3/a			1 875	28 125	-	-	-	-	-	-
b) 30 cages 37.5m x 5kg/m^3/a			-	-	5 625	84 375	-	-	-	-
c) 50 cages 37.5m x 5kg/m^3/a			-	-	-	-	9 375	140 375	-	-
d) d) 250 cages 37.5m^3 x 5 kg/m^3/a			-	-	-	-	-	-	46 875	703 125