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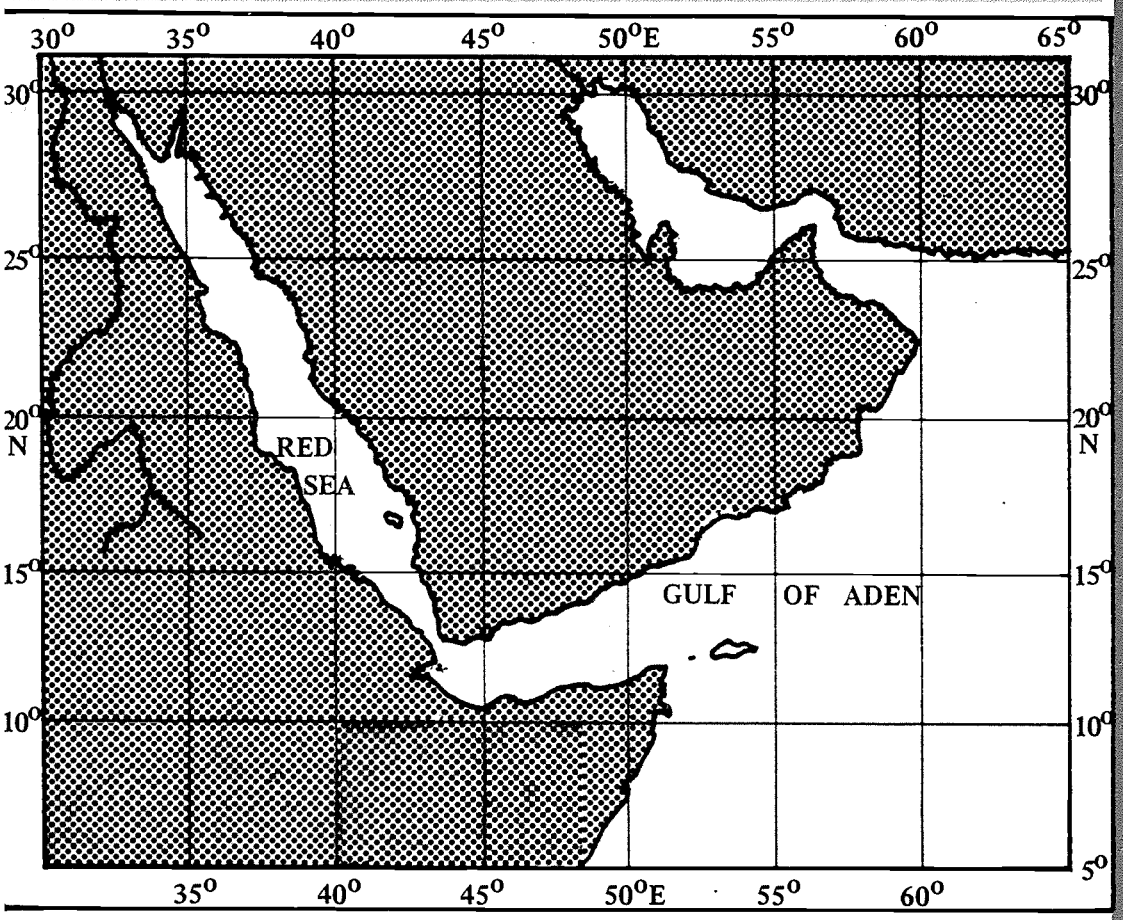

FOOD
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Review of the fisheries resources of the Red Sea and Gulf of Aden

by
M.J. Sanders
Regional Fisheries Development
and Management
for the South West Indian Ocean (SWIO)
Unity House, P.O. Box 487
Victoria, Mahé
Seychelles

and

G.R. Morgan
Mariculture and Fisheries Department
Kuwait Institute for Scientific Research (KISR)
P.O. Box 24885
13109 Safat
Kuwait

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Rome, 1989

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M-43
ISBN 92-5-102832-X

PREPARATION OF THIS DOCUMENT

This document has been prepared as part of FAO's Regular Programme activities, and is intended to provide a background on the state of the fisheries resources of the Red Sea and Gulf of Aden against which fishery development can be planned, and against which the needs for future research and management might be gauged.

The report concentrates on summarizing the published and unpublished material, generated mainly during the past two decades. Inevitably a considerable amount of data and information has been left aside in producing these summaries and therefore it is strongly recommended that, as far as possible, the original reports cited in the text also be consulted.

The review has been limited to the crustacean, molluscan and finfish resources exploited in the region. The potentially significant but as yet unfished resource of mesopelagic fishes (Fam. Myctophidae) have been included; but the marine mammals, reptiles and algae have not.

Distribution:

FAO Fisheries Department
FAO Regional Fisheries Officers
Marine Sciences (general)

Sanders, M.J.; Morgan, G.R.
Review of the fisheries resources of the Red Sea and Gulf of Aden.
FAO Fisheries Technical Paper. No. 304. Rome, FAO. 1989. 138p.

ABSTRACT

The ten countries which border the Red Sea and Gulf of Aden depend to varying degrees on the area for their fish supplies with some countries such as South Yemen being totally dependent on the fish resources while to others, such as Israel and Jordan, the area is of minor importance.

Catches of all fish species have been increasing slowly in recent years and in 1986 totalled 60.9 thousand tons from the Red Sea and 99.4 thousand tons from the Gulf of Aden. After reviewing the resource assessment and survey work which has been carried out in the area it was concluded that further increases in landings could be achieved on a sustainable basis. However such increases will come from the development of new fisheries and the expansion of the areas presently fished rather than from traditional fisheries which are, in general, fully exploited. Utilization and marketing problems, particularly with small pelagic and mesopelagic species, however need to be addressed for the full potential of the area to be realized.

CONTENTS

1. INTRODUCTION

The Fisheries resources of the Red Sea and Gulf of Aden (Figure 1) support marine fisheries in ten countries, viz. Egypt, Israel, Jordan, Sudan, Saudi Arabia, Yemen Arab Republic (North Yemen), Djibouti and Ethiopia which border the Red Sea and Somalia and Democratic Peoples Republic of Yemen (South Yemen) which border the Gulf of Aden. The importance of these marine resources to the total fish supply in the countries varies widely and ranges from total dependence in the case of South Yemen and Djibouti to only minor importance as with Sudan (Table 1). Of the ten countries, only South Yemen is able to achieve full self-sufficiency in fisheries products combined with a high per capita consumption of fish. As is shown in Table 1, half of the countries import a significant proportion of their total fish supplies whereas others such as as Sudan and Ethiopia experience shortages of hard currency with which to pay for imported fish as a supplement to local supplies. Per capita consumption in these countries is, as a consequence, extremely low.

Aquaculture development has proceeded slowly in all ten countries with only Egypt and Israel having a significant proportion of their total fish supplies being derived from aquaculture. Such aquaculture, however, is relatively low technology, involving pond culture of tilapia and carp species and is a traditional feature of fish production particularly along the river Nile. There is, however, considerable scope for increased production from these facilities with proper management (Infosamak, 1987). Marine fish farming is not undertaken in the region with the exception of small pilot-scale commercial production of penaeid shrimp in Saudi Arabia and Israel and although modest expansion of both shrimp and marine fish culture is a likely development within the next decade or so, it is not expected to contribute significantly to fish supplies in any country of the region.

The resources of the Red Sea and Gulf of Aden are therefore not only of immediate importance in supplying the marine fish resources for the bordering countries but their development and management could contribute significantly in the future to both reducing dependence on imported fish and increasing per capita fish consumption. Such development objectives will naturally differ between countries although the implementation of both objectives depends on the orderly development of the various fish resources of the area and regional co-operation in their management.

Various estimates of the total potential annual landings from the Red Sea and Gulf of Aden have been made and range up to 360 x 10^3 t for the Red Sea (Gulland, 1971) and 267-414 x 10^3 t for the Gulf of Aden (Kesteven et al, 1981). The latter value does not include the mesopelagic fishes found to be particularly abundant throughout the Arabian Sea, including the Gulf of Aden. The potential yield of the

Table 1. Sources of fish supply (food and non-food) for countries bordering the Red Sea and Gulf of Aden together with per capita annual fish consumption (kg) and current (1986) landings from the Red Sea/Gulf of Aden

Country	Percentage of fish supply from:					1986 Red Sea Gulf of Aden Landings (t)	Per capita consumption (kg) 1982-1984 average
	Red Sea/ Gulf of Aden	Other Marine	Inland Fisheries	Aquaculture	Imports		
Egypt	8	12	27	20	33	13908	5.5
Israel	<1	5	2	11	82	150	14.2
Jordan	<1	-	-	-	99	65	4.0
Sudan	6	-	91	1	2	1190	1.4
Saudi Arabia	13	12	-	1	74	22700	9.9
Yemen, A.R.	73	-	-	-	27	22341	3.4
Djibouti	100	-	-	-	-	385	6.2
Ethiopia	15	-	84	-	1	600	0.1
Yemen, P.D.R.	100	-	-	-	-	91216	25.1
Somalia	50	50	-	-	-	8250	2.0

Source FAO (1988)

mesopelagics from the Gulf of Aden has been estimated at 20 x 10^6 t (Gjosaeter, 1983) although significant technological and economic problems of catching, handling and marketing these fish remain to be solved. It is therefore apparent that there may be considerable opportunity for increasing the present landings from the area on a sustainable basis.

This report examines the available information, including catches, of the major fish and crustacean stocks of the Red Sea and Gulf of Aden together with the various assessments of these major stocks which have been made both by national institutions and by the FAO Red Sea Project which operated in the area between 1979 and 1984. An attempt has been made, where necessary, to reconcile the various assessments in the context of recent data collected on the stocks and the developments which have occurred in the various fisheries. In addition, consideration has been given to the most appropriate methods of further developing the fisheries of the area in accordance with the constraints imposed not only by the resource availability and markets but also by the support facilities and services available in the various countries. Finally, recommendations regarding management of the major stocks are considered with particular emphasis on the stocks for which regional co-operation is a necessary requirement.

2. GEOGRAPHY, CLIMATE, HYDROLOGY AND PRODUCTIVITY

The Red Sea (Figure 1) is a long narrow basin extending NNW-SSE between 30°N and 12°31'N. Its total length is about 2000 km and its average breadth 280 km. The maximum breadth is 306 km in the southern sector near Massawa (Ethiopia) while it attains a minimum breadth of only 26 km near its entrance to the Gulf of Aden at Bab-el-Mandab.

The Sinai Peninsula divides the northern extremity into the shallow Gulf of Suez and the deep Gulf of Aqaba. These two Gulfs differ markedly in geographical features with the Gulf of Suez being flat-bottomed with a depth of 30-40 m in the north, gradually increasing towards the south to about 70-80 m. By contrast, the Gulf of Aqaba is a deep basin with narrow shelves which reaches depths in excess of 1000 m.

The area of the Red Sea is variously reported as about 440,000 km^2 and the volume as about 240,000 km^3. Its continental shelf area to 200 m depth is 180,000 km^2, comprising some 41% of the total area. The average depth of the Red Sea is about 500 m with the greatest depths being over 2500 m in the axial trough between 22°N and 19°N. The geographical separation of the Red Sea from the Gulf of Aden is via a 100 m deep sill about 125 Km north of Bab-el-Mandab.

Important features, particularly in the Red Sea proper, are the vigorous coral reefs occurring in depths less than 50 m. Typically the shore is fringed by shallow reefs of a width varying from a few

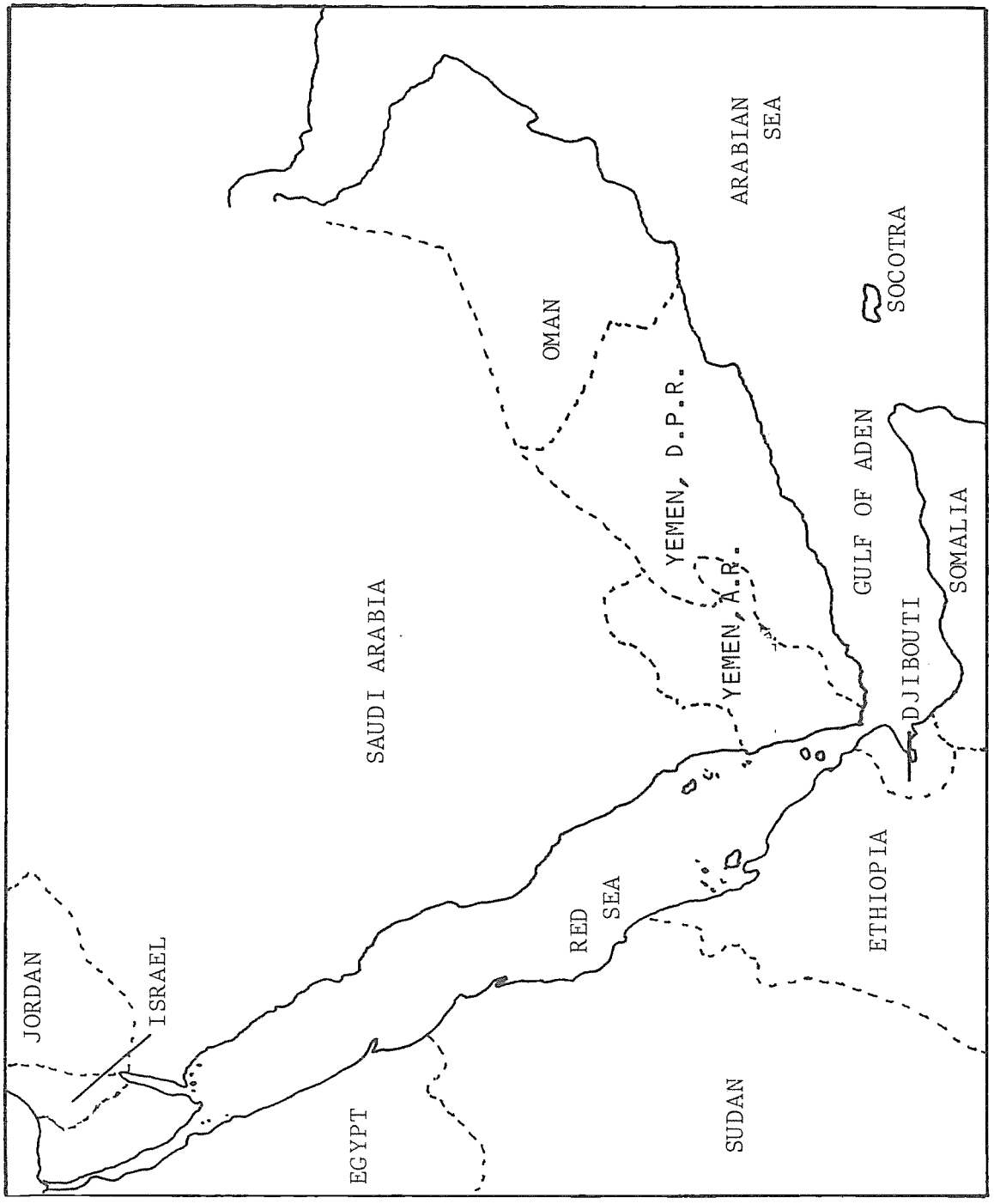

Figure 1 Map of the Red Sea and Gulf of Aden area

metres to half a kilometre or more. The outer edge of these fringing reefs is just covered at low water and may slope steeply to the deep water of the open sea, or more gently into lagoons bordered by outer reefs. The depths of those lagoons are commonly 10 to 40 m.

Reefs of all types are common in the southern part of the Red Sea extending far out on both sides leaving only a relatively narrow but deep passage in the middle clear for navigation. The northern half has fewer reefs with the 200 m contour occurring close to shore. The exceptions are the many reefs and islands adjacent to both the Gulfs of Suez and Aqaba, and the narrow fringing reefs within the Gulfs.

The Gulf of Aden extends eastward from the Red Sea, to a line between Ras Fartak (South Yemen) and Ras Asir (Somalia). In this review Socotra and the adjacent islands are also included as part of the Gulf of Aden. Its continental shelf area is 50,000 km^2 (to 200 m depth).

The coastline consists of a series of sandy beaches, broken at intervals by rock outcrops which often extend into the shallow waters. There are no fringing coral reefs because of the seasonal occurrence of cold and turbid water from the areas of upwelling. The exceptions are in the extreme western part adjacent to the Gulf of Tadjura and Perim Island. The presence of offshore islands is limited to Perim Island and the Socotra group (Figure 1).

The seabed slopes steeply from the coast and the continental shelf is relatively narrow. The main shallow-water banks are adjacent to, and east of Aden, and extend to about 30 km offshore. Small banks within the 200 m contour are also present off the Somali coast at Mait and Alula. Water depths in the Gulf of Aden vary as a result of a series of ridges and trenches running NE-SW with the principal ridge near Ras Fartah having a depth of 1280-1460 m while the trench on the eastern side of this ridge reaches 3660 m.

The region of the Red Sea and Gulf of Aden is characterized by high air temperatures (averaging 40-43^{o}C in summer) and high evaporation rates which results in surface waters with high temperatures and high salinities (Morcos, 1970). There are no major river inflows and evaporation far exceeds precipitation. In the Red Sea, the loss of water through evaporation is approximately equal to the nett inflow through the Strait of Bab-el-Mandab while water inflow through the Suez Canal is small and has a negligible influence on the water and salt budgets of the Red Sea (Morcos, 1970).

Surface temperatures in the Red Sea generally increase southwards before decreasing again near the Strait of Bab-el-Mandab (Morcos, 1970) with this trend being most noticeable in winter (Table 2 and Figures 2-5). Surface temperatures in the Gulf of Aden are lower than the Red Sea (Wyrtki, 1971) and exhibit maxima twice annually in

Table 2. Annual variation of average sea temperatures (°C) for the period 1855-1943 recorded by ships passing down the Red Sea and through the Gulf of Aqaba. Values are arithmetic means of 146 to 802 observations. (Unpublished by G.A. Tunnell); from Morcos (1970)

Lat. °N.	28-30	26-28	24-26	22-24	20-22	18-20	16-18	14-16	12-14	12-14	12-14	12-14	10-12	10-12
Long. °E.	32-34	33-35	34-36	37-39	38-40	38-40	40-43	42-44	42-44	44-46	46-48	48-50	50-52	52-54
	Gulf of Suez	Red Sea proper							Bab-el-Mandab	Gulf of Aden				
Month														
January	18.4	21.9	22.7	24.8	25.8	26.6	25.7	25.1+	24.9+	24.9+	24.8+	24.6+	24.9	25.1
February	17.9	21.3+	22.3+	24.0+	24.9+	25.6+	25.4+	25.1+	25.1	25.2	24.9	24.9	25.2	25.3
March	18.2	21.7	22.7	24.3	25.3	26.1	26.2	25.9	25.9	26.1	25.8	25.8	26.2	26.4
April	20.0	22.7	23.8	25.3	26.6	27.2	27.6	27.2	27.3	27.5	27.4	27.3	27.5t	28.0t
May	22.1	24.4	25.6	27.3	28.3	29.0	29.4	29.3	29.2	29.5	29.2	29.2	28.2t	28.4t
June	23.8	25.4	26.7	27.9	28.8	29.6	30.5	31.0	29.9	30.0	30.1	30.1	24.7	25.6
July	25.2	26.6	27.9	29.4	30.1	30.2	31.1	31.1	29.3	27.7	29.0	29.1	23.9	23.4
August	26.5t	27.9t	29.1t	30.3t	30.9t	30.7t	30.9t	31.3t	29.2t	26.4t	28.2t	28.7t	23.4+	23.1+
September	25.7	26.8	28.3	29.8	30.6	30.9t	31.7t	31.9t	30.4t	29.2t	29.7t	29.6t	24.3	23.9
October	24.6	26.2	27.3	29.3	30.3	30.8	30.9	30.1	28.9	28.7	28.6	27.9	25.9	26.1
November	23.1	25.2	25.9	28.1	28.9	29.3	28.4	27.3	26.7	26.8	26.6	26.2	25.8	26.2
December	20.4	23.1	24.1	26.1	27.1	27.6	26.8	25.8	25.6	25.7	25.5	25.3	25.3	25.6
Annual mean	22.4	24.4	25.5	27.2	28.1	28.6	28.7	28.4	27.5	27.3	27.5	27.4	25.4	25.6

t = maximum values; + = minimum values.

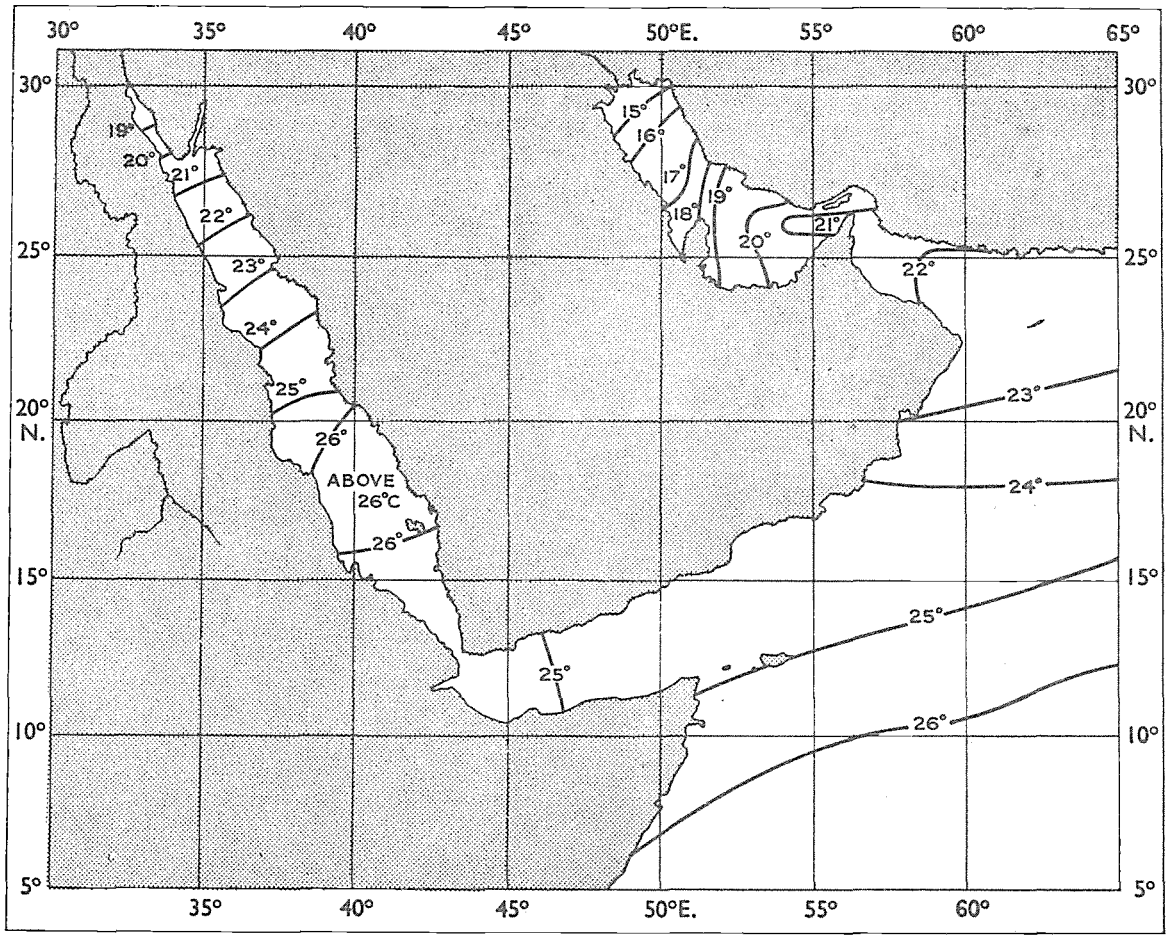

Figure 2 Mean Sea Surface Temperature (^{o}C) in the Red Sea and Gulf of Aden during February

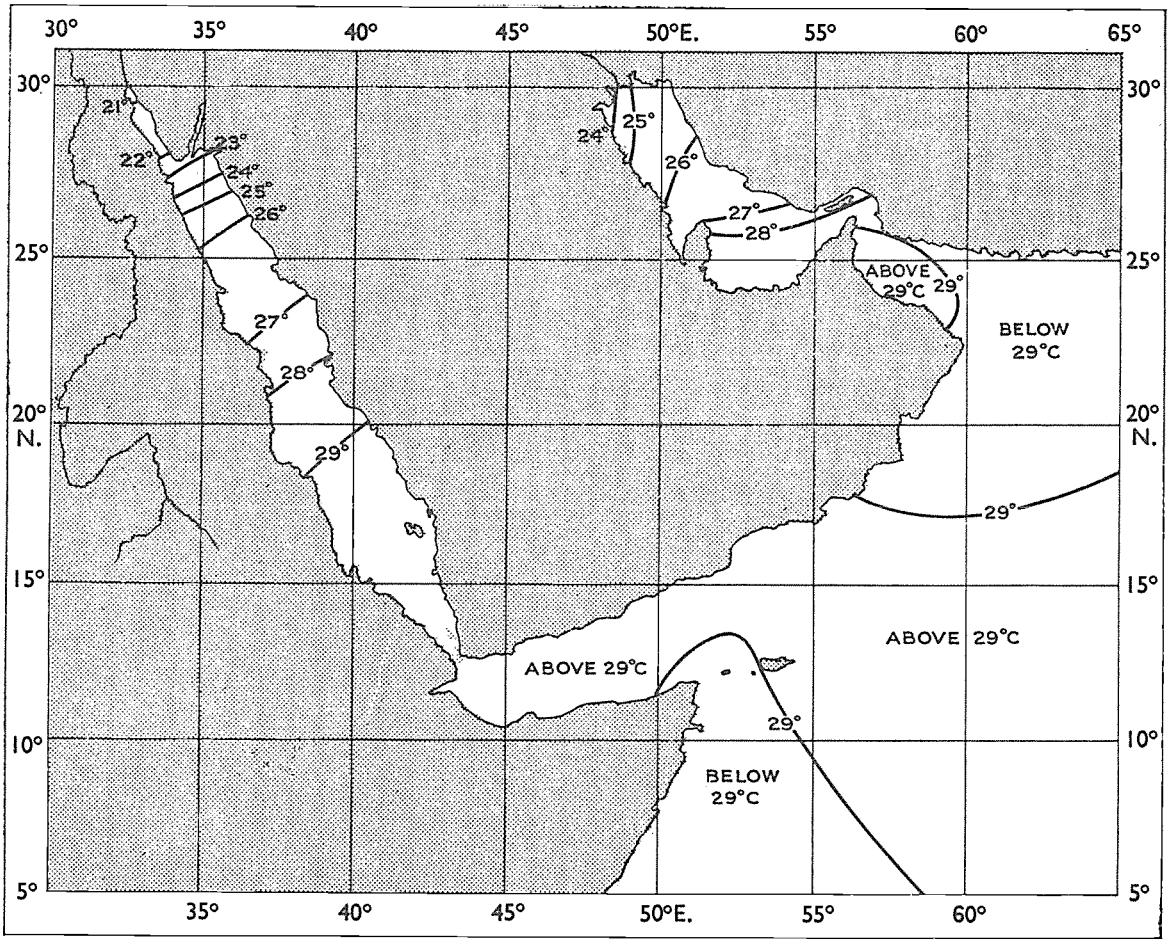

Figure 3 Mean sea surface temperature (^{o}C) in the Red Sea and Gulf of Aden during May

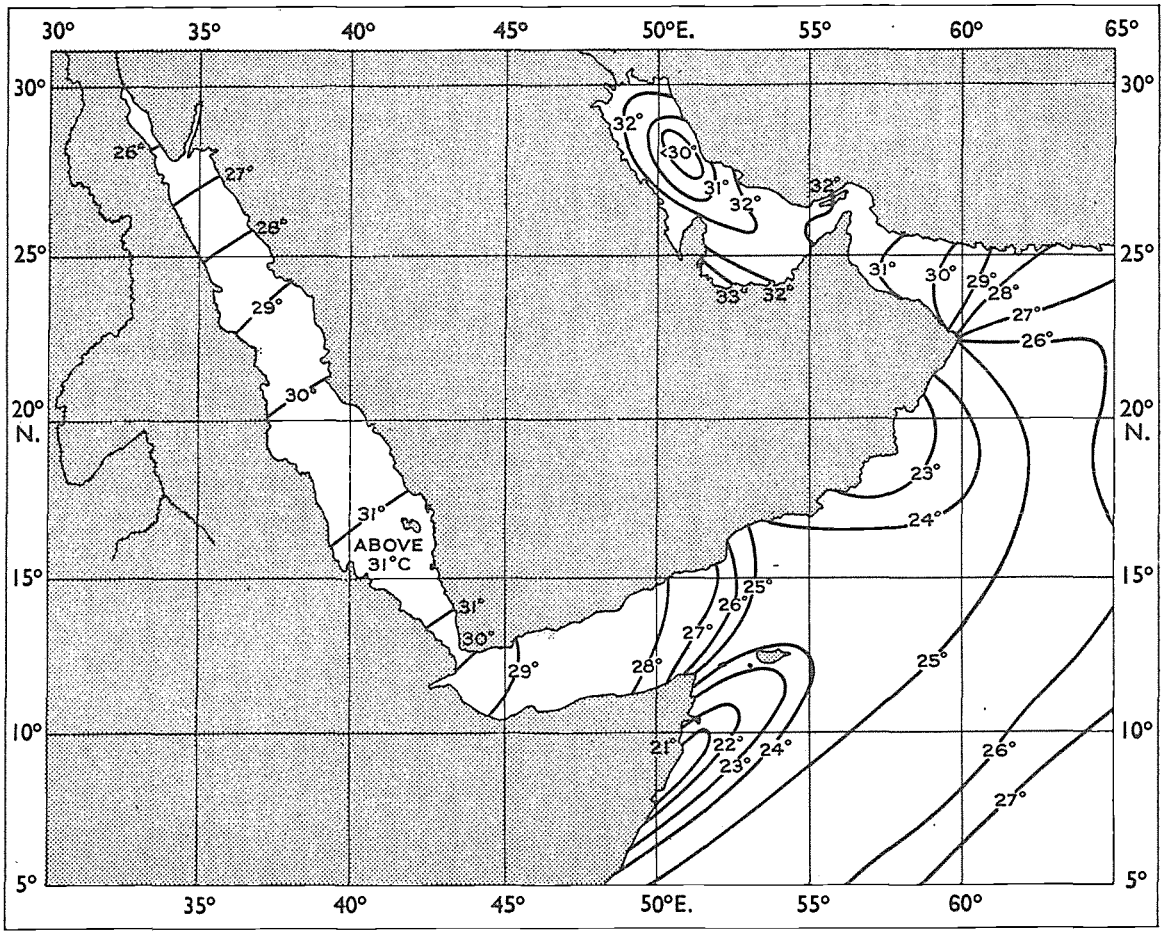

Figure 4 Mean sea surface temperature (^{o}C) in the Red Sea and the Gulf of Aden during August

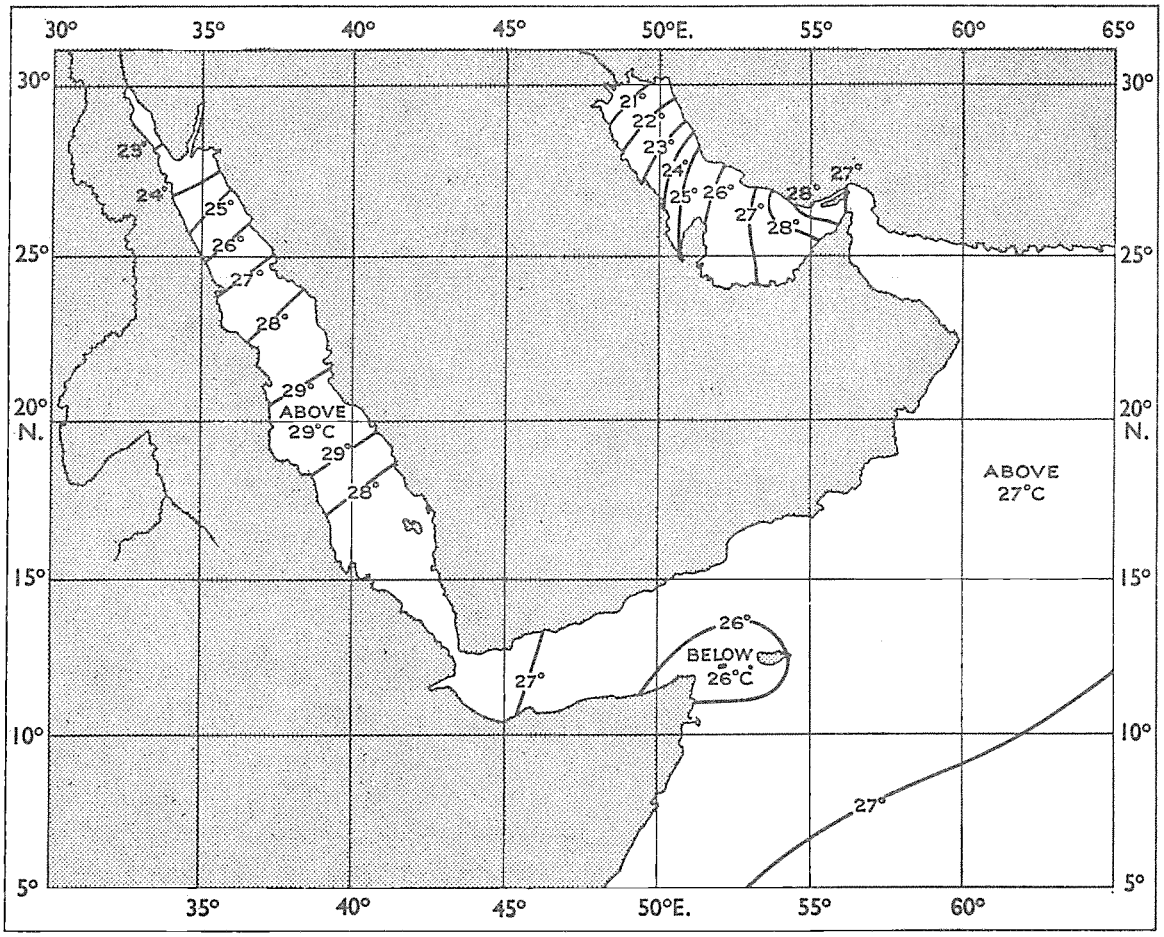

Figure 5 Mean sea surface temperature (^{o}C) in the Red Sea and the Gulf of Aden during November

contrast to the Red Sea where maximum temperatures occur in August/September and minimum temperatures in February. This bi-modality of surface temperatures in the Gulf of Aden occurs in spring (May/June) and autumn (September/October) and is a consequence of the monsoonal activity in the area and particularly of the extensive upwellings associated with the southwest monsoon in autumn.

The principal upwelling areas are south of Socotra Island (and adjacent to the east coast of Somalia), between Salalah and Masirah (both in southwest Oman), and to a lesser extent east of Bab-el-Mandab. In these areas the water temperature is highly variable. Differences in mean temperatures between May and July/August are substantial; up to 7°C near Bab-el-Mandab, 8° between Salalah and Masirah and 10°C south of Socotra. Mass mortalities of fish have been reported at the times of upwelling.

The prevailing winds are north and northwest in the northern part of the Red Sea. These winds also extend over the southern part during June to August while the remaining months the prevailing winds in the southern part are from the southeast and east. Also during these months the central part of the Red Sea is characterized by relatively low pressure calms.

In the Gulf of Aden the wind directions are more directly related to the monsoons, being east to northeast during the northeast monsoon in October to April, and from the southwest during the southwest monsoon in May to September. Generally the wind strengths are highest during the southwest monsoon.

The predominant flow of the surface water currents generally reflects the prevailing wind direction although modified by coastline and offshore island and reef configuration. In the Red Sea the currents generally do not exceed 1 knot (1.8 km/h) and very rarely 2 knots (3.7 km/h) in the southern parts. During the northeast monsoon the majority of currents in the Gulf of Aden are less than 1 knot. About half the currents exceed 2 knots during the southwest monsoon, and can reach about 3 knots (5.6 km/h) in July and August.

The tide system within the Red Sea is generally semi-diurnal with a difference of about six hours in the time of high water between the north and the south. The tidal range is low. The average spring range is 0.5 m in both the north and the south, decreasing from both ends to where there is no appreciable semi-diurnal range near Port Sudan and Jeddah (Saudi Arabia). Another negligible tide area is just north of Bab-el-Mandab. South at Perim Island the spring range increases to 1 m.

In the Gulf of Aden the tide is generally diurnal, with the extreme range being about 3 m at Aden and Djibouti. Eastward the tide

system becomes more semi-diurnal, though the diurnal inequality remains great, with ranges up to 3 m.

In the northern part of the Red Sea the characteristics of the water mass are generally uniform below 200 m depth as a consequence of the dense surface layer sinking during winter. Very high salinities prevail to the greatest depths (salinity 40.6°/oo, temperature 21.6°C). In the southern part, temperatures decrease slightly with depth, and the salinities increase with depth (from about 36°/oo at the surface to 40°/oo beyond 100 m). Unusually high temperatures (50 to 60°C) and salinities (>30.0°/oo) have been found in several deep trenches along the axis of the Red Sea.

The water column in the Gulf of Aden is characterized by a well mixed surface layer, separated from the sub-surface waters by a highly stable boundary layer at about 100 m in depth. During the southwest monsoon this thermocline rises to less than 25 m and strengthens. While the surface layers are generally characterized by high temperatures and salinities, and oxygen contents above saturation levels, the sub-surface waters are much cooler, lower in salinity and having extremely low oxygen levels.

The above is complicated by the flow of waters between the Gulf and the Red Sea. During the summer, surface water and a layer of highly saline bottom water flows from the Red Sea, and between these layers a counter current of Indian Ocean waters flows into the Red Sea. In winter, surface waters enter the Red Sea from the Gulf of Aden, but Red Sea water continues to discharge at depth. The water carried by the bottom current is believed to have sunk and formed in the northern part of the Red Sea in winter, and has a high salinity and temperature and a low concentration of dissolved oxygen.

The primary productivity (phytoplankton) of the Red Sea is low throughout most of the year (Halim, 1984) and throughout most of the basin, and consequently so is the secondary production (zooplankton). The plankton diversity and biomass fluctuations are closely related to the surface circulation, which is itself governed by the wind system and the inflow of nutrient rich Indian Ocean water from the Gulf of Aden. Productivity increases from north to south (Halim, 1984) both in the main basin and the Gulf of Aqaba. It is also higher in the reef-bound coastal zone than offshore. Both the Gulfs of Suez and Aqaba have plankton communities which are less diverse than the Red Sea proper although the diversities increase significantly in winter (Halim, 1984).

In contrast to the Red Sea, the western part of the Arabian Sea including much of the Gulf of Aden, is claimed as one of the more productive parts of the World Ocean. Its mean productivity, up to several hundred miles koffshore, is as high or higher than that found in other upwelling areas such as the eastern boundary currents off the

coast of Peru or off West Africa (Krey and Babenard, 1976; Wooster et al, 1967). In terms of sector biomass, the highest productivities (>900 mg/m^3) are observed around August during the latter part of the southwest monsoon while the lowest values (<400 mg/m^3) are found in January during the northeast monsoon. The highest productivities (> 1000 mg/m^3) are observed adjacent to the sites of upwelling.

3. FISHERY DESCRIPTIONS, STATISTICS AND RESOURCE ASSESSMENT

Most of the fish landings in the Red Sea and Gulf of Aden (Table 1) originate with small scale, artisanal fishermen exploiting inshore coastal waters although some large scale industrial fishing is also undertaken, particularly in the People's Democratic Republic of Yemen where various joint venture arrangements with other countries exist. There is little mixing of national fleets and most fishermen operate exclusively within the territorial waters of their own country. Fisheries statistics are collected by most countries in the region although the reliability of such statistics varies significantly not only between countries but also with time as a result of economic and political changes in the region. A summary of recent marine landings in the Red Sea and Gulf of Aden by each country is given in Table 3, based partly on FAO statistics, and this indicates that landings from the region as a whole have remained relatively stable over the years despite significant changes in the industrial fisheries. Details of the present status of each country's fishing industry and recent trends in landings are given below together with a summary of resource assessment work which has been carried out on the various stocks.

Resource assessment of the major commercial stocks in the region has been undertaken both by FAO and by national institutions. However, the relatively recent attention to resource assessment as an ongoing activity in many countries, together with the general lack of an adequate time series of detailed landings and effort statistics has meant that the precision of most resource assessments which have been undertaken could be improved. In addition, little is known about the distribution and extent of inter-dependence of many of the major commercial species so that, while assessments of the fish species resources have been carried out at a national level, some consideration needs to be given to the interactions between stocks on a regional level. Unfortunately, in most instances, there is insufficient data to allow this to be done and hence assessments reported here do not address the question of interaction between stocks within the region and it is therefore assumed that the fisheries resources within the territorial waters of each country can be assessed, and managed, independently of other countries. As the extent of knowledge of the stocks increases and the various fisheries developed, such interaction will need to be addressed and regional co-operation in management of the stocks initiated. Such co-operation will most likely be of significant importance in the assessment and management of some of the pelagic stocks of the region such as the

various Sardinella species, Indian mackerel (Rastrelliger kanagurta) and horse mackerel (Trachurus indicus).

3.1 Egypt

3.1.1 Fishery Description and Statistics

The most productive fishing grounds are within and adjacent to the Gulf of Suez. This is believed to be due to the relatively shallow depths (about 70 m maximum) and generally flat mud-sand seabed conducive to a range of fishing methods, including purse seining trawling and longlining. Its 8,400 km^2 continental shelf area (to 200 m depth) is about the same as for the remainder of the Egyptian coastline within the Red Sea.

Outside the Gulf the fishing opportunities are restricted by both the narrowness of the shelf, and its heavy covering of coral reefs. There is however an extensive area of shallow waters within and south of Foul Bay on both sides of the Border with Sudan. This area including the Sudanese waters is fished almost exclusively by Egyptian fishermen (Barrania and El Shennawi, 1979).

Comprehensive statistics of landings and fishing efforts are collected for Ataka and Port Tawfik within the Gulf of Suez, and the landing sites within Hurgharda. These result from the activities of enumerators employed by the Suez and Hurgharda branches of the Department of Agriculture complemented by the routine interviewing of sample groups of fishermen. Occasional and incomplete statistics are collected for the other landing sites.

Of the recent total marine landings in the Red Sea and Gulf of Suez, (Table 3), about 80% originates from the Gulf of Suez, 17% from within and adjacent to Foul Bay and the rest from other locations, including the eastern coastline of the Sinai Peninsula (Chakraborty, 1984a).

Purse seining is the most productive method accounting for about 60 percent of the landings, mostly from the Gulf of Suez. The fishery is seasonal (October or November through May) and based from the landing sites of Ataka (near Suez) and Sakalla (within Hurgharda).

Fishing takes place at night and involves the use of lighted dinghies, pre-positioned for attracting concentrations of fish. All fishing stops during an approximately ten day period in each month when the moon is full. The attraction to the lighted dinghies is much less at these times.

The nets are actually 'ring nets', having lengths of about 200 to 300 m and depths of 50 to 80 m. They are hauled manually, which accounts in large part for the crews being of around 25 to 30 persons

Table 3. Total marine landings (10^3 t) for the Red Sea and Gulf of Aden
(Source FAO, 1988 with added information)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Egypt	9.3	7.9	9.1	17.5	14.8	15.8	13.4	13.6	13.7	13.8	13.9
Sudan	0.8	0.6	0.8	0.7	1.0	0.9	1.1	4.4	4.4	1.2	1.2
Ethiopia	1.0	0.2	0.2	0.2	0.4	0.3	0.4	2.0	0.8	0.6	0.6
YAR	16.5	17.5	19.3	18.0	17.0	16.0$_R$	14.0$_R$	18.0$_R$	18.6$_R$	20.6	22.3
Saudi Arabia[a]	11.6	11.7	13.3	13.1	13.2	13.2^R	13.2^R	13.2^R	13.2^R	21.8	22.7
Jordan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Israel	0.0	0.0	0.0	0.3	0.3	0.3	0.1	0.1	0.1	-	-
Red Sea	39.4	38.1	42.9	50.0	47.0	46.9	42.6	51.7	50.8	58.2	60.9
Djibouti	0.2	0.2^R	0.2^R	0.2^R	0.3	0.4	0.4	0.4^R	0.4^R	0.4	0.4
Somalia[b]	4.1	4.9	4.6	5.5	7.2	7.5	7.4	7.8	7.6	8.2	8.2
South Yemen	64.1	64.0	48.1	51.6	89.7	78.0	69.7	74.1	84.1	85.2	91.2
Gulf of Aden	68.2	68.9	52.7	57.1	96.9	85.5	77.1	81.9	91.7	93.4	99.4

Notes

R Repetition of previous years figures
a Half the total Saudi Arabian landings
b North coast of Somalia

including skipper and engineer (Awadallah, 1982a). Fishing trips within the Gulf of Suez are commonly of 2 to 5 days duration, while when operating within or adjacent to Foul Bay a single trip may last twenty days.

The mean annual landings from the purse seine vessels during 1979-82 was 13.9 thousand tons, (Sanders et al., 1984a) consisting of 11.1 thousand tons (80%) from the Gulf of Suez, 2.5 thousand tons (18%) from within and adjacent to Foul Bay, and the rest from immediately adjacent to the Gulf. Some sixty percent of the Gulf of Suez landings are made within the first three months of each season. The mean annual catches per unit effort for the Gulf are about the same as for within and adjacent to Foul Bay (Tables 4 and 5).

The important species groups from the Gulf of Suez are horse mackerels and scads (around 50-60%; and principally Trachurus indicus and Decapterus maruadsi), the round herring (around 20-40%; and principally Etrumeus teres), and the sardinellas (around 5-10%; and principally Sardinella gibbosa).

Those from within and adjacent to Foul Bay are the spotted sardinella (around 45-50%; and principally Sardinella sirm), the Indian mackerel (around 10-20%; and principally Rastrelliger kanagurta), the goldstripe sardinella (around 10-20%; and principally Sardinella gibbosa), and the horse mackerels and scads (around 10%; and principally Decapterus maruadsi).

Trawling is the next most productive method accounting for more than 20 percent of the landings. Most of the catches are made within the Gulf of Suez. The fishery is seasonal, commencing in September and ceasing at the end of May. Almost all the trawl catches are landed at Ataka. Fishing trips are commonly of about five days duration.

The trawl nets used are of the Mediterranean type, with headline lengths of about 20 to 30 m. The vessels, similar to those used for purse seining, are almost invariably wooden, and about 20 to 30 m in length. They are equipped with winches, and some are fitted with echo-sounders, principally for the determination of depth rather than fish finding. Crew numbers are generally about 10 to 15 persons including the skipper and engineer (Awadallah, 1982b).

The mean annual landings during the three seasons commencing in 1979-80 is reported as 5.6 thousand tons (Sanders et al. 1984b). This includes 5.0 thousand tons (89%) from the Gulf of Suez, 0.5 thousand tons (9%) from within and adjacent to Foul Bay, and the rest from immediately adjacent to the Gulf. Like the purse seine fishery, about 50% of the Gulf of Suez landings are during the first three months of each season (Table 6). Landings per unit effort at mid-season and

Table 4. Landings, effort and landings per unit effort for the Egyptian purse seine fishery within the Gulf of Suez (from Sanders et al, 1984a)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
					Landings (tons)					
1979/80	4,930	3,033	2,272	1,528	1,130	670	458	392	-	14,404
1980/81	1,622	1,625	1,820	1,352	875	459	268	631	-	9,652
1981/82	-	1,632	3,000	1,442	1,034	735	751	578	119	9,290
					Effort (Fishing days)					
1979/80	1,854	1,621	963	955	1,326	563	303	316	-	7,901
1980/81	1,419	917	1,412	1,204	1,525	843	333	480	-	8,133
1981/82	-	631	1,460	1,204	886	587	458	497	67	5,790
					Landings/effort (kg/day)					
1979/80	2,659	1,871	2,359	1,600	845	1,190	1,513	1,193	-	1,823
1980/81	1,143	2,863	1,289	1,123	574	545	804	1,314	-	1,187
1981/82	-	2,586	2,055	1,197	1,167	1,251	1,641	1,163	1,775	1,605

Table 5. Landings effort and landings per unit effort for the Egyptian purse seine fishery within and adjacent to Foul Bay (from Sanders et al, 1984a)

Year	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
						Landings (ton)							
1979/80	-	-	-	-	-	330	336	373	535	320	39	-	1,932
1980/81	3	-	360	291	328	270	221	377	695	408	46	-	2,999
1981/82	-	-	95	516	252	206	182	254	336	376	42	15	2,272
1982/83	-	-	144	102	175	328	-	-	-	-	-	-	749
						Effort (fishing days)							
1979/80	-	-	-	-	-	200	132	220	356	217	95	-	1,220
1980/81	1	-	171	87	123	83	66	122	513	416	15	-	1,596
1981/82	-	-	108	271	158	119	88	257	284	224	71	(10)	1,590
1982/83	-	-	(68)	43	87	(154)	-	-	-	-	-	-	352
						Landings/effort (kg/day)							
1979/80	-	-	-	-	-	1,653	2,548	1,694	1,501	1,475	406	-	1,584
1980/81	2,700	-	2,108	3,349	2,662	3,264	3,341	3,084	1,355	979	3,121	-	1,876
1981/82	-	-	881	1,901	1,594	1,732	2,069	988	1,183	1,678	584	-	1,429
1982/83	-	-	(2,118)	2,376	2,009	(2,130)	-	-	-	-	-	-	2,131

Note: Figures in brackets are estimates

Table 6. Landings, effort and landings per unit effort for the Egyptian trawl fishery within the Gulf of Suez (from Sanders et al, 1984b)

Year	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
					Landings (tons)					
1979/80	945	879	564	529	357	232	252	235	266	4,259
1980/81	1,136	850	781	640	494	364	305	369	346	5,284
1981/82	592	1,270	908	721	541	311	360	340	334	5,377
					Effort (fishing days)					
1979/80	1,980	1,841	1,272	1,135	1,346	780	854	709	644	10,563
1980/81	1,782	1,621	1,571	1,558	1,546	1,023	1,120	1,193	938	12,352
1981/82	712	1,550	1,513	1,374	1,440	1,094	1,650	1,156	1,244	11,733
					Landings/effort (kg/day)					
1979/80	477	477	443	466	266	297	295	332	413	403
1980/81	637	524	497	411	319	356	272	309	369	428
1981/82	832	819	600	525	375	284	218	294	269	458

later are generally about half that applying in the beginning of season months.

The important species groups from the Gulf of Suez are lizardfish (around 30-50%; and principally Saurida undosquamis), the striped snappers (around 10-15%; and principally Lutjanus lineolatus), the threadfin breams (around 5-10%; and principally Nemipterus japonicus), and the 'large' shrimps (around 10%; and principally Penaeus semisulcatus, P. latisulcatus and P. japonicus). Very similar species compositions occur in the landings from within and adjacent to Foul Bay, except for the absence of shrimps.

The catching of reef associated species, typically involving the use of motorized launches of 6 to 12 m in length accounts for about 10 percent of the total landings. Some 90 percent of these landings are taken from within and adjacent to the Gulf of Suez and nearby Hurgharda.

The principal method is handlining. Longlining is also important within the Gulf of Suez, while gillnetting and the use of trammel nets are important both within and outside the Gulf. Commonly several methods are used during a single fishing trip. The fishermen also use seines and cast nets for catching bait. Crew numbers are about 5 to 10 persons (including skipper).

The landings of reef-associated species during 1979-82 (Sanders et al, 1984c) indicated a mean of 2.2 thousand tons annually; consisting of 0.9 thousand tons (48%) from the Gulf of Suez, 0.7 thousand tons (39%) from immediately adjacent to the Gulf, and the rest from more southern grounds and the eastern Sinai Peninsula.

The landings are generally highest in the April through July period (Tables 7 and 8). The annual mean catches per unit effort are slightly higher for the Gulf of Suez apart from the third year when the value is the same for adjacent to the Gulf.

The important species groups from the Gulf of Suez are the groupers (around 35-40%; and principally Epinephelus areolatus, E. chlorostigma and E. summana), the emperors (around 20-30%; and principally Lethrinus nebulosus and L. mahsena), and the longspine bream (around 5%; and mainly Argyrops spinifer, Evynnis cardinalis, and Sparus major). At least another twenty species group categories comprise the rest.

Landings from adjacent to the Gulf include the emperors (around 40%; mainly Lethrinus nebulosus), groupers (around 15-20%; and principally Epinephelus areolatus, E. summana, E. tauvina, E. megachir, Plectropomus maculatus, and Variola louti), parrotfish (around 5-10%; and principally Scarus ghobban and S. hareed), and the jacks (around 5%; from the family Carangidae).

Table 7. Landings, effort and landings per unit effort for the Egyptian fishery for reef associated species in the Gulf of Suez (from Sanders et al, 1984c)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
						Landings (tons)							
1979/80	58	37	56	55	47	47	27	82	80	86	48	48	671
1980/81	18	32	40	48	41	55	33	46	60	84	29	31	518
1981/82	59	44	72	55	53	64	51	102	74	67	57	28	725
						Effort (fishing days)							
1979/80	275	288	294	477	596	424	250	351	332	567	650	149	4,653
1980/81	111	184	287	288	464	387	274	291	422	1,005	215	170	4,098
1981/82	204	586	679	1,022	1,037	1,065	1,200	216	358	656	395	207	7,625
						Landings/effort (kg/day)							
1979/80	211	127	192	116	78	111	106	234	241	152	74	323	144
1980/81	159	171	140	165	89	143	120	158	143	84	135	184	126
1981/82	289	75	106	53	51	60	42	473	210	103	145	135	95

Table 8. Landings, effort and landings per unit effort for the Egyptian fishery for reef associated species adjacent to the Gulf of Suez (from Sanders et al, 1984c)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
						Landings (tons)							
1980	37	25	13	35	119	106	32	29	35	40	56	35	562
1981	22	29	40	71	197	119	93	47	45	66	55	39	823
1982	38	19	22	28	169	158	87	59	53	55	41	25	753
						Effort (fishing days)							
1980	719	218	277	321	585	1,333	468	199	229	481	743	409	5,982
1981	413	266	766	942	1,132	826	537	486	278	633	1,106	1,062	8,447
1982	400	515	149	571	741	1,083	1,022	962	1,021	875	243	326	7,908
						Landings/effort (kg/day)							
1980	51	116	46	108	203	80	68	146	155	82	75	86	94
1981	54	109	52	75	175	144	172	96	162	104	50	37	97
1982	95	37	146	48	229	145	85	61	52	62	171	76	95

Most of the remaining landings come from seines, gillnets and trammel nets used close to the landing sites for small pelagic and demersal species. Amongst the many landing sites, those of principal importance are Port Tawfik within the Gulf of Suez, Hurgharda and Quseir. The boats used are of about 5 m in length, and are referred to as fellucas. Often they are equipped with outboard motors; otherwise they are propelled by sail. Unfortunately reliable estimates for the landings of small pelagic and demersal species from fellucas operating adjacent to the landing sites are not available.

3.1.2 Resource Assessment

Several assessments of the coastal fisheries resources of Egypt have been undertaken and range from exploratory fishing ventures to detailed biological and population dynamics studies. The most comprehensive of these studies were those undertaken as part of the FAO Red Sea Project from 1979 to 1981 and which included assessments of all of the major existing fisheries. In addition, assessments of the resources which are presently not fished or are only lightly exploited have been undertaken utilizing various survey techniques including echoacoustics.

Purse Seine Fishery

In November and December 1964, three vessels of the Azcherno Expedition (Azcherniro, 1966) were engaged in light assisted purse seining within the Gulf of Suez. Their overall catch was 10.5 t from 72 sets, equivalent to 145 kg/set (Table 9) with the lower range of catch rates being attributable to moving to less productive fishing grounds.

The principal species groups found in the purse seine catches were the goldstripe sardinella (Sardinella gibbosa) 42.5%, and the horse mackerel and round scad (Trachurus indicus and Decapterus maruadsi) 46.9%. The spotted sardinella (Sardinella sirm) was absent from these catches.

The same three vessels were engaged in 'light assisted' purse seining in the northern part of Foul Bay during January and February 1965. During 20 days fishing, the overall catch was 12.3 tons from 104 sets; equivalent to 119 kg/set (Table 10). This catch per set was less than obtained for the Gulf of Suez, and less than expected from the abundance of fish observed to accumulate adjacent to the lights. The lower catching success during February was attributed to the fish moving off the fishing ground.

The principal species in these purse seine catches were the spotted sardinella (Sardinella sirm) 32.4%, the goldstripe sardinella (Sardinella gibbosa) 29.0%, rainbow sardine (Dussumieria sp) 15.8%, scad (probably Decapterus maruadsi) 10.6%, and the Indian mackerel

Table 9. Catches by exploratory purse seine vessels in the Gulf of Suez, November-December 1964 (from Azcherniro, 1966)

Vessel identity	November 25-December 7, 1964			December 8-31 1964			Combined		
	Total catch (kg)	Number of net shots	Catch per net shot (kg)	Total catch (kg)	Number of net shots	Catch per net shot (kg)	Total catch (kg)	Number of net shots	Catch per net shot (kg)
C4C - 1 182	2,347	13	181	1,397	14	100	3,744	27	139
C4C - 1 178	1,460	7	209	345	10	35	1,805	17	106
C4C - 1 173	3,080	11	280	1,833	17	108	4,913	28	175
Combined	6,887	31	222	3,575	41	87	10,462	72	145

Table 10. Catches by exploratory purse seine vessels in the northern part of Foul Bay, Egypt, January-February 1965 (from Azcherniro, 1966)

Vessel identity	January 4-31 1965			February 1-22 1965			Combined		
	Total catch (kg)	Number of net shots	Catch per net shot (kg)	Total catch (kg)	Number of net shots	Catch per net shot (kg)	Total catch (kg)	Number of net shots	Catch per net shot (kg)
C4C - 1 182	3,040	24	127	361	14	26	3,411	38	90
C4C - 1 178	3,107	21	148	539	11	49	3,646	32	114
C4C - 1 173	3,630	22	165	1,656	12	138	5,286	34	155
Combined	9,777	67	146	2,556	37	69	12,333	104	119

(Rastrelliger kanagurta) 7.9%. The horse mackerel Trachurus indicus was absent from the catches.

It was concluded from the Expedition findings that some minor increase in total catch was possible from within the Gulf of Suez and that considerable increases could be obtained from the more southern grounds, particularly from Foul Bay. Purse seine catches in 1962 were reported (Azcherniro, 1966) as 17.7 thousand tons from the Gulf of Suez and 2-2.5 thousand tons from the area around Foul Bay. Despite these assessments, landings have therefore decreased since 1962 in the Gulf of Suez to around 9 thousand tons in 1982/82 (Table 4) while landings from Foul Bay have remained at about the same level at 2.3 thousand tons (Table 5). More recent landings (FAO, 1988) are apparently a little less than 1981/82.

Detailed assessments of the major purse seine species were carried out as part of the FAO Red Sea Project with the priority species from the purse seine landings including the horse mackerel (Trachurus indicus), round scad (Decapterus maruadsi), round herring (Etrumeus teres), goldstripe sardinella (Sardinella gibbosa), spotted sardinella (Sardinella sirm), and the Indian mackerel (Rastrelliger kanagurta).

Stock assessment parameters were estimated for these species (Sanders et al, 1984d; 1984e; 1984f; 1984g; 1984h; 1984i) and included growth, mortality, recruitment, sexual maturity and other biological parameters. A summary of the growth, mortality and recruitment parameters are given in Table 11 while Table 12 presents data on biological parameters of these species.

The stock assessment parameters were utilized in a 'Thompson and Bell' type yield per recruit model. This allowed some consideration of the likely consequences on future yields (and economic benefits) of altering the magnitude of the fishing effort applying in the fisheries, the durations and timing of the fishing seasons, and the lengths at which the fish are first liable to capture.

In respect to the species important in the Gulf of Suez purse seine landings, the yields per recruit were converted to yields (Figure 6) on the basis of their annual recruit numbers (Table 11). These four species represent about 80 percent of the purse seine landings from the Gulf.

On the basis of the plots it was concluded that the 1981/82 fishing effort (21 000 net shots) was producing close to the maximum yields or beyond the maximum yield with respect to Etrumeus teres. In the context of future management, the more important observation was that a fifty percent reduction in fishing effort would result in only a small reduction in yield. It was suggested (Awadallah, 1982a) that if fishing effort reduction were associated with commensurate

Table 11. Growth, Recruitment and Mortality Parameters for the Major Species in the Purse Seine Fishery from the Gulf of Suez and Within and Adjacent to Foul Bay. Summarized from Various Publications of Sanders et al (1984)

Species	GROWTH				RECRUITMENT			MORTALITY		
	K	L_{oo}	t_o	Birthday	t_c	l_c	R	M	F	q
Trachurus indicus[c]	0.19	24.2	-1.82	Jul. 1	1.2	10.6	219	0.5	1.2[a]	4.83[a]
Etrumeus teres	0.81	26.8	0.55	Apr. 1	1.5	14.7	52	1.1	2.2[a]	13.9[a]
Decapterus maruadsi	0.41	25.0	-0.45	Jul. 1	1.2	12.5	108[a]	0.7	1.6[a]	7.6[a]
							18[b]		0.7[b]	15.6[b]
Sardinella gibbosa	0.40	22.1	-0.80	Jul. 1	1.2	12.5	54[a]	0.8	1.4[a]	6.7[a]
Sardinella sirm	0.38	26.1	-0.27	Jan. 1	1.9	13.7	61[b]	0.8	0.8[b]	17.5[b]
Rastrelliger kanagurta	0.23	40.0	-0.76	Jan. 1	1.9	18.5	-	0.5	-	-

L_{oo} in cm total length

t_o in years

t_c (age at recruitment) in years

l_c (size at recruitment) in years

R is millions of recruits of age t_c in 1981/82.

M is natural mortality

F is fishing mortality in 1981/82

q is catchability coefficient x 10^5 when effort is measured in net shots

Notes [a] Gulf of Suez

[b] Foul Bay

[c] Trachurus indicus is also captured by trawl nets and hence mortality estimates here only refer to the purse seine fishery.

Table 12. Length-Weight, Maturity and Maximum Size Parameters for the Major Species in the Purse Seine Fishery of the Gulf of Suez and Within and Adjacent to Foul Bay. Summarized from Various Publications of Sanders et al (1984)

Species	Length-Weight		Size at Maturity				Spawning Season		
	a	b	Males		Females				
			l_m	t_m	l_m	t_m		l_{max}	t_{max}
Trachurus indicus	8.26	3.15	13.1	2.2	12.2	1.8	Jan-May	23	13
Etrumeus teres	5.93	3.16	16.2	1.7	16.4	1.7	Jan-May	26	5
Decapterus maruadsi	8.41	3.03	-	-	-	-	-	23	9
Sardinella gibbosa	6.71	3.11	-	-	-	-	-	21	7
Sardinella sirm	3.71	3.36	-	-	-	-	-	26	8
Rastrelliger kanagurta	4.04	3.33	-	-	-	-	-	36	15

Length-weight relationship of $W=aL^b$ where W is in gms. and L in cms.

l_m and t_m are lengths (cm) and ages (years) at 50% maturity

l_{max} is observed maximum length in the catch

t_{max} is maximum age in the catch

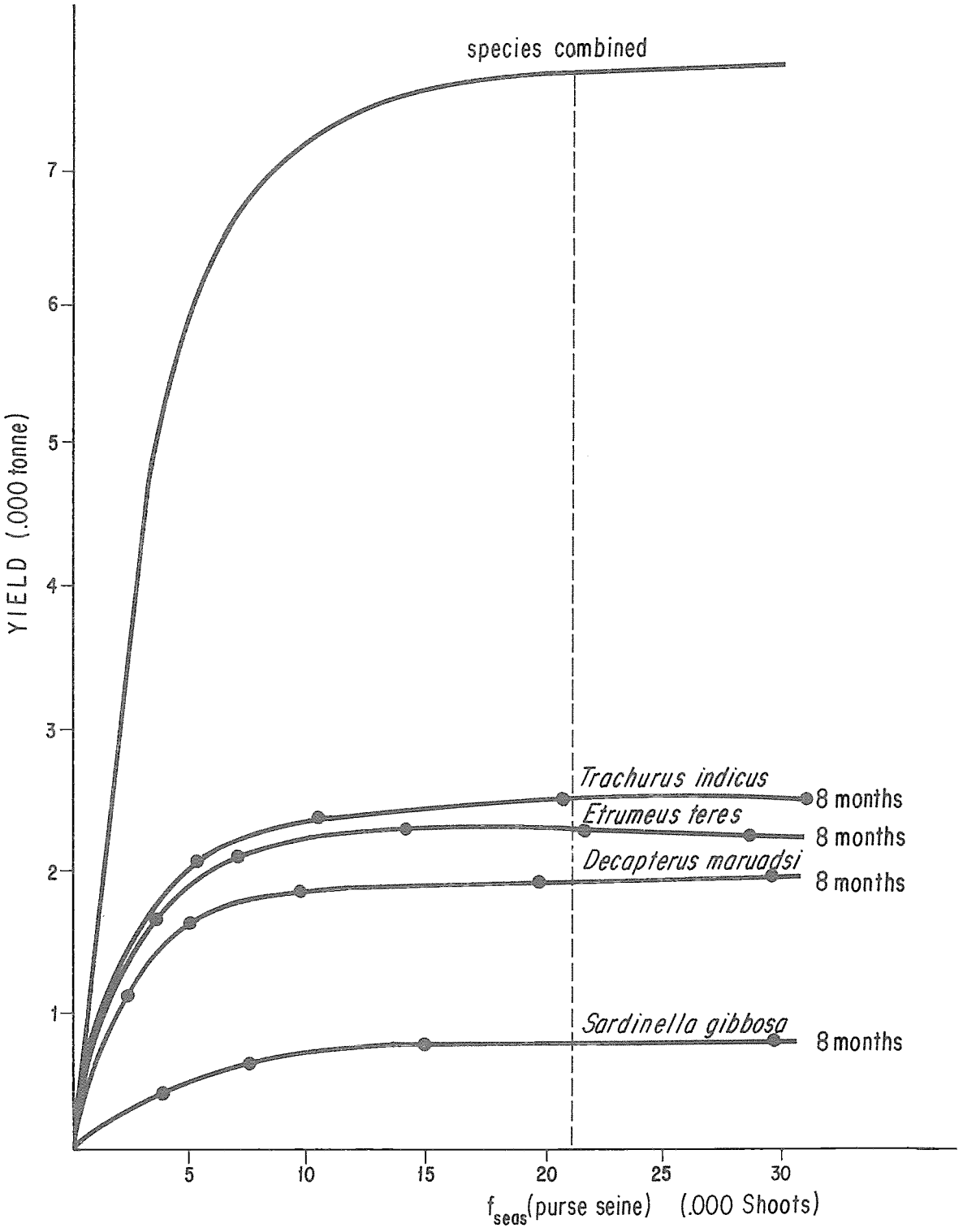

Figure 6 The relationship between annual yield and fishing effort for species landed by the Egyptian purse seine fishery in the Gulf of Suez. The broken line indicates the 1981-82 fishing effort level. (From Sanders et al., 1984)

reductions in fishing costs (e.g. by lowering the vessel numbers), such action might lead to substantially increased profits.

Although not shown in Figure 6, the yield per recruit analyses indicated that increases in yields could not be achieved by changing the fishing season duration (while maintaining the same seasonal fishing mortality). Decreasing the season duration was identified as a possible means of reducing fishing effort, although such action was judged as likely to have little affect on fishing costs and hence profits from the Gulf of Suez fishery.

Similar relationships between estimated yields and fishing efforts were plotted in respect to the purse seine species landed from within and adjacent to Foul Bay (Figure 7). Although estimates of the fishing mortality coefficients were not available for Sardinella gibbosa and Rastrelliger kanagurta, these species were included in the Figure on the assumption that they share the same catchability coefficient as Sardinella sirm.

The annual recruitment numbers that were used to estimate the yields are $R = 61 \times 10^6$ for S. sirm, $R = 35 \times 10^6$ for S. gibbosa, $R = 18 \times 10^6$ for D. maruadsi, and $R = 6 \times 10^6$ for R. kanagurta. These four species account for generally more than 90 percent of the purse seine catch from within and adjacent to Foul Bay.

The plots show that the estimated yields at the 1981/82 level of fishing effort (4 400 net shots) are marginally less than the maximum yields for each of the species. The exception is Rastrelliger kanagurta for which the value is very close to the maximum. Realising the additional yield potential is suggested as likely to be economically justifiable (Awadallah, 1982a) only if the fishing effort were able to be increased without an associated increase in fishery costs. This might be possible through diverting excess effort from the Gulf of Suez fishery.

The results of these detailed assessments confirm the broad conclusion reached earlier (Azcherniro, 1966) that the species captured by purse seine in the Gulf of Suez are more heavily exploited than those of Foul Bay and that while there is little opportunity for increasing landings from the Gulf of Suez, same increase might be expected from the Foul Bay fishery. The potential increase in landings from the Foul Bay area has been estimated on the basis of a comparison between the productivity of the Gulf of Suez and Foul Bay (Sanders and Kedidi, 1981). They considered that a total catch of 4.6 thousand tons could be taken from the Foul Bay purse seine fishery, an increase of 2.1 thousand tons over the average catches for 1979/80-1981/82 (Table 5). Similarly, Sanders and Kedidi (1981) estimated that a maximum value for the potential mean annual landings from purse seining outside but adjacent to the Gulf of Suez was 1.0 thousand

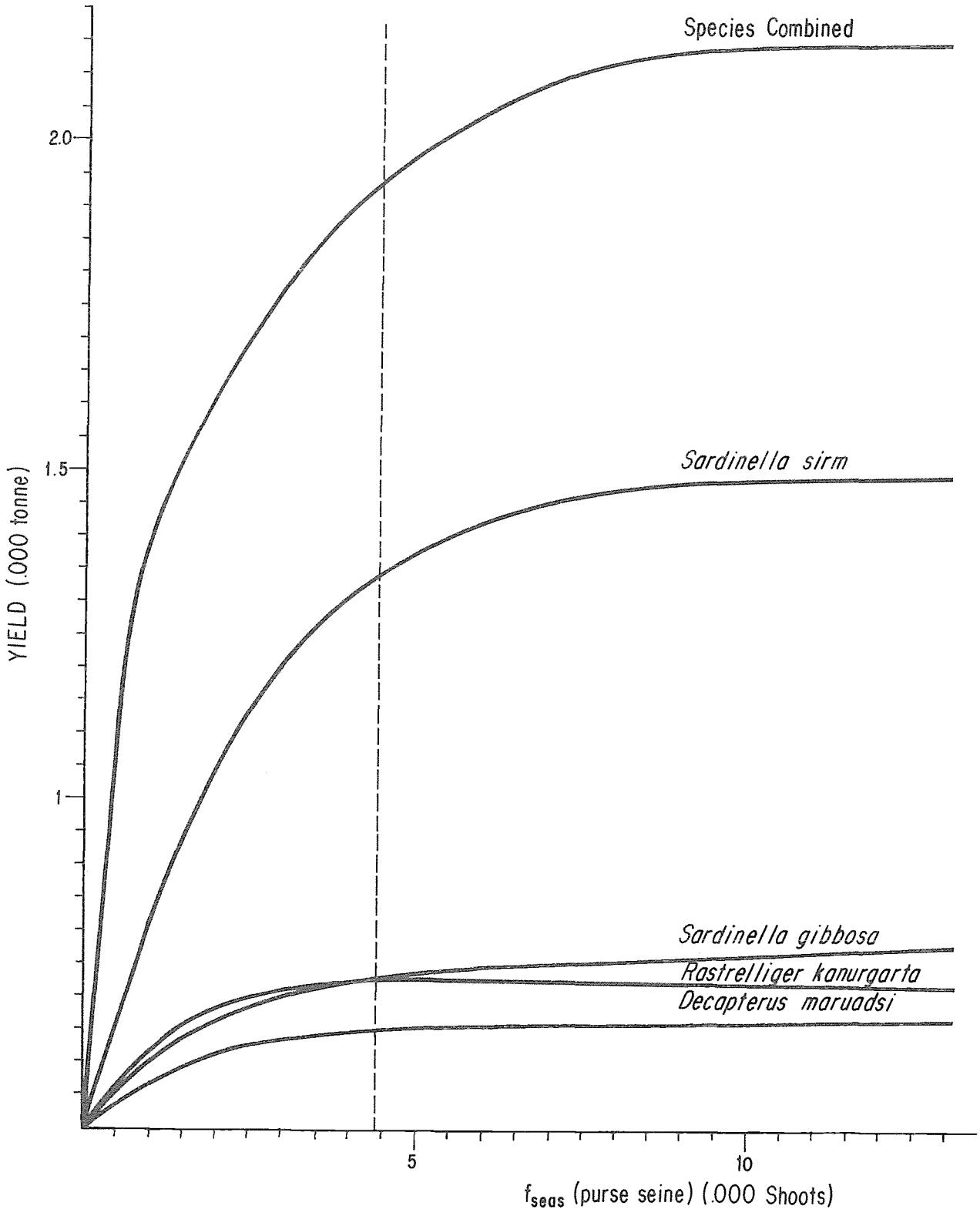

Figure 7 The relationship between annual yield and fishing effort for species landed by the Egyptian purse seine fishery within and adjacent to Foul Bay. The broken line indicates the 1981-82 fishing effort level. (From Sanders et al., 1984a)

tons, some 0.8 thousand tons more than the average 1979/80-1981/82 landings.

Trawl Fishery

The trawl fishery is second in importance only to the purse seine fishery with landings in 1981/82 being around 5.0 thousand tons (23% of total landings) compared with 13.6 thousand tons (62% of landings) for the purse seine fishery.

Resource assessment of the species taken by demersal trawls was undertaken in November and December 1964 and later in March and April 1965 in the Gulf of Suez by the R.V. Ikhtiology (Azcherniro, 1966). All trawling was done in depths between 40 m and 70 m, generally with a net of 27.1 m horizontal opening and 7 m vertical height.

During the earlier period the total catch was 2 197 kg equivalent to 125.4 kg/hr and 62.8 kg/shot. The catch in the latter period, after excluding an abnormal catch of sardine, was 792 kg, equivalent to 107.2 kg/hr and 52.8 kg/shot. Catch rates tended to increase towards the southern part of the Gulf.

The principal species groups landed were the lizard fish (Saurida undosquamis) horse mackerel and round scad (Trachurus indicus and Decapterus maruadsi), the goldstripe sardinella (Sardinella gibbosa), anchovy (fam. Engraulidae), and small barracuda (Fam. Sphyraenidae).

The R/V 'Ikhtiolog' was also used during January through March 1965 in exploratory trawling in more southern Egyptian waters. This involved a total of 15 demersal trawl shots, nine in the northern part of Foul Bay adjacent to Berenice, one shot in Safaga Bay, and five shots near Hurgharda.

The overall catch was 1 008 kg, equivalent to 134.8 kg/hr and 67.2 kg/shot, with the mean catch rates at the three locations being approximately the same. The lizardfish was consistently the principal species found in the catches (23.4%).

While catch rates (in kg/hour) from this Expedition cannot be directly compared with later commercial catch rates (in kg/day, see Table 6), average commercial rates of around 420 kg/day during the period 1979-80 - 1981/82 are not inconsistent with the results obtained from the R.V. Ikhtiology. The commercial trawl catch in 1962 was reported (Azcherniro, 1966) as 4.4 thousand tons, about the same as in 1979/80 - 1981/82 (Table 6).

Later assessment of the trawl fishery was carried out between 1979 and 1982 (Sanders et al, 1984b; 1984j; 1984k) with particular emphasis on the major components of the catch, viz. the brushtooth

lizardfish (Saurida undosquamis), bigeye snapper (Lutjanus lineolatus) and horse mackerel (Trachurus indicus).

Stock assessment parameters were estimated for these species and included growth, mortality, recruitment, sexual maturity and other biological parameters. A summary of the growth, mortality and recruitment parameters are given in Table 13 while Table 14 presents data on biological parameters of these species. Yields per recruit were converted to yields on the basis of the annual recruitments for Saurida undosquamis and Lutjanus lineolatus being $R = 134 \times 10^6$ and $R = 41 \times 10^6$ respectively. These species together contribute roughly 50 percent to the landed weight, and about the same percentage value. The shrimps, for which no assessments have been undertaken, represent some 30 to 40 percent of the value of the trawl landings (Awadallah, 1982b).

The plots of the yields against fishing effort (Figure 8) suggest that the 1981/82 fishing effort was providing close to the maximum yield (about 10 to 15 percent less) for each of the species. It is suggested that because the effort would need to be at least doubled to obtain the maximum yield, the economic justification for doing so is doubtful since increasing effort would be associated with increased fishing costs.

While not indicated in Figure 8, the yield per recruit analyses indicated that increasing the length at first capture was not likely to lead to increased yields. The fish caught would be of a larger mean size, however, which was suggested as having management significance if this were in turn associated with attracting higher prices.

While no direct assessment of the trawl fishery within and adjacent to Foul Bay has been made, Sanders and Kedidi (1981) estimated that the area suitable for trawling in that locality was 1491 km^2 compared with 6671 km^2 in the Gulf of Suez. The potential annual landings from the Foul Bay grounds was therefore estimated as 1.1 thousand tons, some 0.4 thousand tons more than the 1982/83 landings. Sanders and Kedidi (1981) and Sanders et al (1984b) indicated that much higher catch rates are associated with the grounds within and adjacent to Foul Bay - some four times greater than those in the Gulf of Suez during the period 1979/80 - 1981/82. Despite this, the skippers preferred operating in the Gulf of Suez, probably as a result of the near absence of high value shrimp in the catches outside the Gulf of Suez.

Reef Associated Species

Of the reef associated species captured by handlines, longlines etc. (see Section 3.1.1, only Lethrinus nebulosus has been subjected to detailed resource assessment studies (Sanders et al, 1984l). This

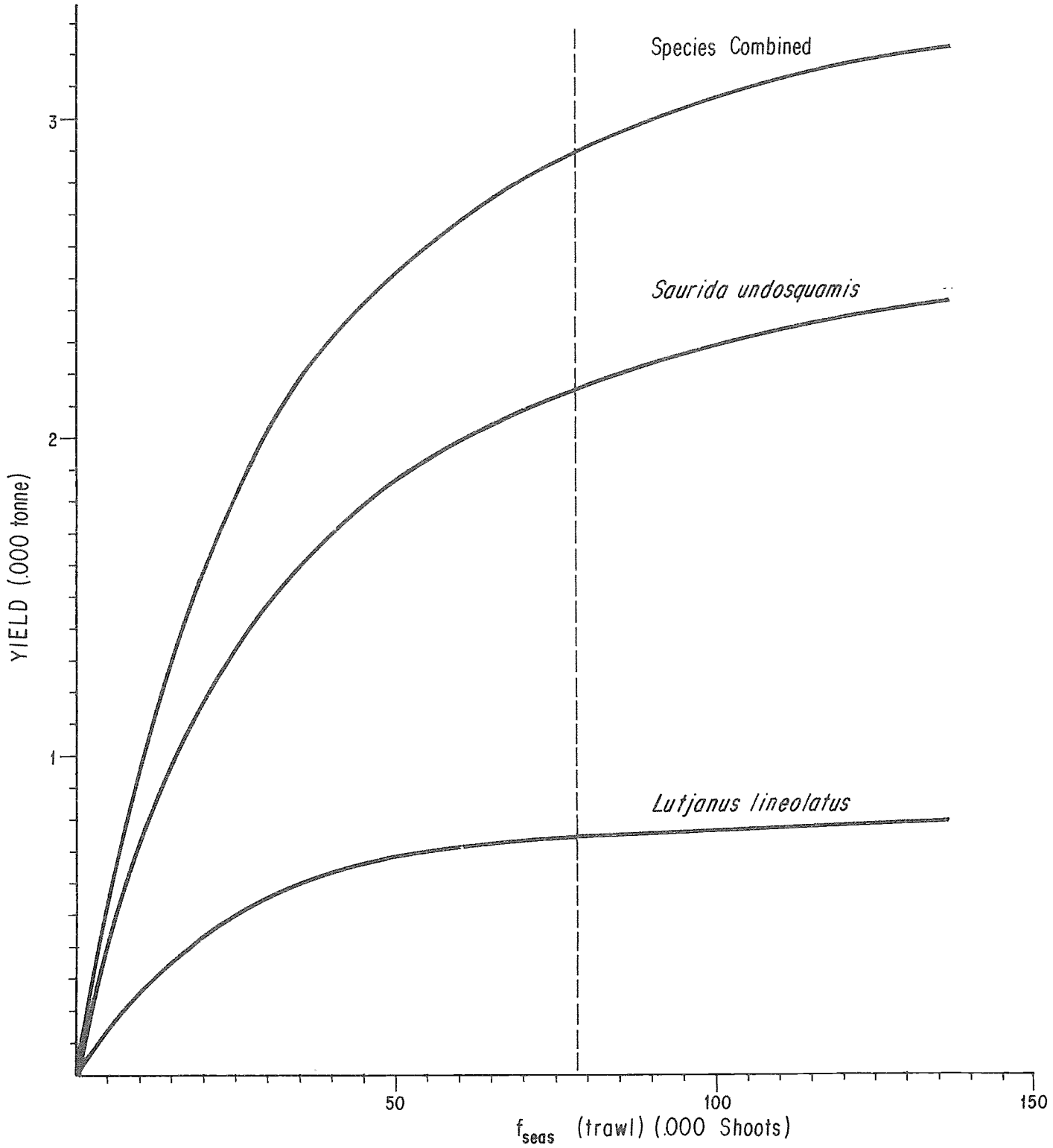

Figure 8 The relationship between Annual Yield and Fishing Effort for species landed by the Egyptian Trawl Fishery in the Gulf of Suez. The broken line indicates the 1981-82 Fishing Effort level. (From Sanders et al 1984b)

Table 13. Growth, Recruitment and Mortality Parameters for the Major Species in the Gulf of Suez Trawl Fishery. Summarized from Various Publications of Sanders et al (1984)

Species	GROWTH				RECRUITMENT			MORTALITY		
	K	L_{oo}	t_o	Birthday	t_c	l_c	R	M	F	q
Saurida undosquamis										
males	0.25	36.0	-0.60	Jul. 1	1.2	13.8)		0.85	0.61	7.8
females	0.39	37.0	-0.34	Jul. 1	0.7	13.3)	134		0.37	4.7
Trachurus indicus	0.19	24.2	-1.82	Jul. 1	1.2	10.6	219	0.5	0.1	1.1
Lutjanus lineolatus	0.14	22.0	-3.4	Apr. 1	1.4	11.0	41	0.5	1.0	12.8

L_{oo} in cm. total length

t_o in years

t_c (age at recruitment) in years

l_c (size at recruitment) in years

R is recruitment in millions at age t_c in 1981/82

M is natural mortality

F is fishing mortality in 1981/82

q is catchability coefficient x 10^6 when effort is measured in number of shots

Table 14. Length-Weight, Maturity and Maximum Size Parameters for the Major Species in the Gulf of Suez Trawl Fishery. Summarized from Various Publications of Sanders et al (1984)

Species	Length-Weight		Size at Maturity				Spawning Season		
	a	b	Males		Females				
			l_m	t_m	l_m	t_m		l_{max}	t_{max}
Saurida undosquamis	5.34	2.08	17.0	1.8	16.6	1.1	Apr.-Jun.	31[a]	7[a]
								35[b]	8[b]
Trachurus indicus	8.26	3.15	13.1	2.2	12.2	1.8	Jan.-May	23	13
Lutjanus lineolatus	14.07	3.04	10.2	0.7	10.6	0.9	Mar.-May	19.5	14

Length-Weight relationship of $W = aL^b$ where W is in gms. and L in cms.

l_m and t_m are lengths (cm.) and ages (years) at 50% maturity

l_{max} is observed maximum length in the catch

t_{max} is the maximum age in the catch

Notes (a) males

(b) females

species, which is taken from within and adjacent to the Gulf of Suez comprises about 30% of the landings of reef associated species in the area. Some 70% of the landings of this species are taken in May and June which may be due to increased vulnerability during the spawning season. Stock assessment parameters, which are summarized in Table 15, were utilized in a Beverton and Holt (1957) yield per recruit analysis. This analysis showed that the yield per recruit at the 1981/82 level of fishing effort was about 7% less than the maximum yield. However, since reaching this maximum yield would require a three fold increase in fishing effort this was judged not to be justified on economic grounds (Sanders et al 1984l). The yield per recruit analysis also showed that the present length at first capture was about optimal for the prevailing level of fishing effort.

Based on a value of productivity for the Gulf of Suez of 305 kg/km^2 for the commercial fishery, Sanders and Kedidi (1981) and Sanders et al (1984c) estimated that potential annual landings as 0.3 thousand tons for the area south of Hurgharda to Ras Banas, 1.2 thousand tons for within and adjacent to Foul Bay and 0.1 thousand tons for the eastern Sinai Peninsula. The Gulf of Suez was considered fully exploited at the 1981/82 catch of 1.6 thousand tons.

The estimate of annual landings from all grounds during the period 1979/80 - 1981/82 was estimated at 2.2 thousand tons (Sanders et al, 1984c), some 1.0 thousand tons less than the estimated potential landings with the area within and adjacent to Foul Bay having the greatest unrealized potential.

Other Species

During March and April 1982, deep water gillnetting was undertaken adjacent to Quseir (Bean, 1982). Multi-monofilament nets of mesh sizes 4 1/4" (11 cm), 5 1/4" (13 cm), and 6 1/4" (16 cm) were used. The nets used were 30 meshes in height, 200 m in length and having fifty percent slackness. They were generally set in water depths of 100 to 250 m, at the foot of the steep slope, found close to the shore along the Egyptian Red Sea coast, south of the Gulf of Suez.

The catch taken during 28 fishing days was 2725 kg; including 527 kg of snappers, 1602 kg of sharks and 596 kg of other species. Amongst the snappers, two species predominated, Etelis carbunculus and Pristipomoides multidens. These were usually caught at individual weights of 3 to 10 kg. The nets of 6 1/4" (16 cm) mesh size were considered the most effective for catching fish of these sizes. The distribution or potential of the resource is not known.

Acoustic surveys for small pelagic fish were undertaken by the R.V. Dr. Fridtjof Nansen in the Gulf of Suez and along the Egyptian Red Sea Coast during March 1981. The acoustic survey commenced just south of Quseir, however the coverage north to Hurgharda was slight.

Table 15. Stock Assessment Parameters for the Spangled Emperor (Lethrinus nebulosus) Within and Adjacent to the Gulf of Suez. From Sanders et al (1984l). Definition of symbols is given in Tables 13 and 14

Growth Parameters

L_∞ = 86.0 cm total length
K = 0.11
t_o = -1.09 years
Birthday = July 1

Recruitment Parameters

l_c = 42.1 cm
t_c = 5.1 years
R^a = 4.02×10^5

Maturity Parameters

l_m (males) = 40.0 cm
t_m (males) = 4.6 years
l_m (females) = 45.6 cm
t_m (females) = 5.9 years

Mortality Parameters

M = 0.3
F^a = 0.6
q = 4.65×10^{-5}
When effort is in fishing days

Length-Weight Parameters

$W = aL^b$
a = 16.09×10^{-3}
b = 2.97
where L is in cm. and W in gms

Maximum Size

l_{max} = 83 cm
t_{max} = 19 years

Notes
[a] Average values for the period 1979/80 - 1981/82

A more complete coverage was achieved adjacent to the Gulf of Suez, particularly the Shadwan Channel on the western side, and again within the northern half of the Gulf. A total of eleven pelagic trawl shots and three demersal trawl shots were undertaken.

Pelagic fish were not found in the southern region up to Hurgharda. Some small pelagic fish were encountered in the Shadwan Channel. In the southern part of the Gulf few fish recordings were observed, while in the northern part from Ras Mal'ab good recordings were made, with the denser concentrations near Ras El Sudr (Aglen and Myklevall, 1982).

The biomass of small pelagic fish determined for the Gulf of Suez is 127 thousand tons, with over ninety percent north of Ras Mal'ab (Table 16). The only substantial catch with the pelagic trawl (700 kg in a half hour shot) contained about 95 percent of anchovy (Stolephorus spp). This species comprises only a negligible component of the landings of small pelagics from the Gulf, because of its low commercial value.

The acoustic recording of demersal fish, and the demersal trawl catches during the survey were very low and no biomass estimate was attempted.

3.2 Sudan

3.2.1 Fishery Description and Statistics

The 9 800 km^2 of continental shelf of Sudan is characterized by numerous inlets and both nearshore and offshore coral reefs. The latter are separated from the mainland by channels of some 50 to 150 m in depth and 5 to 10 km in width. The most productive grounds for the handline fishermen are the inner edges of these offshore reefs. The outer edges generally mark the commencement of the continental slope.

Handlining is the principal fishing method, and claimed to account for some 80 percent of the landings (Table 3). Each line is typically rigged with 1 to 3 hooks. Stones are used as sinkers. The most popular baits are sardines and to a lesser extent grey mullets. These are usually caught in the inlets by fishermen using cast nets. The inlets are also very important as anchorages for the fishing boats.

The principal species caught are the groupers (Variola louti, Epinephelus aereolatus, E. tauvina, Cephalopolis sp.), emperors (Lethrinus mahsena, L. miniata, L. harak, L. lentjan), the blue-spotted seabass (Plectropomus leopardus) and the two spot red snapper (Lutjanus bohar). Spanish mackerel (Scomberomorus commerson) barracuda (Sphyraena sp.), trevallies and jacks (Caranx sp.) are also caught by

Table 16. Estimates of abundance for small pelagic fish in Egyptian Waters, 1981 (from Aglen and Myklevoll, 1982)

Subarea	Area of fish distribution $n.mile^2$	Fish biomass tons
Suez - Ras Mal'ab 29°15'N	430 (576)	86,000 (115,000)
Ras Mal'ab - Ras Sheratib 29°15'N 28°35'N	736 (902)	5,000 (6,000)
Ras Sheratib - Strait of Gubal 28°35'N 27°50'N	688 (890)	2,500 (3,000)
Shadwan Channel	122	2,500
Total	1,976 (2,490)	96,000 (127,000)

N.B. The values in parenthesis are based on the assumption that the fish density in depths shallower than 20 m is the same as the average fish density whithin the observed fish distribution area.

trolling when traveling to and from the fishing grounds (Kedidi, 1984a).

The handline fishermen operate in all depths up to about 100 m. Those fishing from canoes and small houris mainly operate close to shore. When using the larger sailing and mechanized sambuks the fishing occurs adjacent to the offshore reefs, and the shallow banks closer to shore. Up to four fishermen operate from each boat and fishing trips can be of about five days in duration.

A small number of fishermen based at the principal landing sites of Suakin and Port Sudan also use gillnets usually during daytime in very shallow waters where the fish can be surrounded prior to meshing. Sometimes the nets are set in a fixed position and hauled several hours later.

The species most commonly caught by these methods include the rabbitfish (Siganus rivulatus), unicorn fish (Naso unicornis), grey mullets (Mugil sp.), trevally and jacks (Caranx sp.), and the hump-headed wrasse (Cheilinus undulatus).

The quantities being landed overall by the small-scale and artisanal fishermen are not well known, due to the absence of any comprehensive system for collecting fisheries statistics. The landings in 1981 were estimated by White (undated) as 1579 t (Table 17). This is based on the annual catch rates being taken as 3 t for the unpowered canoes and feluccas, 6 t for the feluccas with outboards, 16 t for the small motor launches, and 55 t for the large motor launches. A summary of other estimates is given in Table 18.

Subsequent to the discovery of a shrimp resource off the Tokar delta (adjacent to the mouth of the Baraka river) there has been intermittent trawling by licensed foreign vessels. The Italian trawler F/V Omarazo Torzo was operated on these grounds from January 31 to April 27 1981 for a reported catch of 26.36 t of shrimp (tails?). It was suggested that the actual catch was higher. Some 13 t of fish were also landed for local sale. The more recent trawl catches from other vessels have not been reported.

Although not reflected in the fisheries statistics for Sudan, about 2.5 thousand tons of small pelagic fish (mainly Sardinella sirm, Rastrelliger kanagurta, Sardinella gibbosa and Decapterus maruadsi) are caught annually by Egyptian purse seine fishermen operating adjacent to the border. It has been claimed (Barrania, 1979a) that about half of these catches come from Sudanese waters.

Previously the Egyptian fishermen were also substantially engaged in catching grey mullets (Mugil sp.) along the coast of Sudan, and sometimes from Ethiopian waters. The fishing method was by veranda nets set usually in water depths of less than two meters. The fish

Table 17. Estimated landings, numbers of fishermen and fishing boats in Sudanese waters in 1981. From White (undated)

Location	Unpowered canoes & felukas	Felukas with outboards	Small motor launches	Large motor launches	Number of fishermen	Fish catch (tons)
North of Port Sudan						
Halib	3	0	0	0	6	5
Dongonab	7	0	0	0	14	14
Muhamed Qui	6	0	6	0	36	60
Aruus	8	0	2	0	24	32
Aruus	4 part time				4	4
Darur	5	0	0	0	10	15
Halot	8	4	0	0	24	48
El Regeba	5	0	0	0	10	15
					total	193
Port Sudan						
Salabona	5	1	0	0	12	21
Abu Hashish	21	10	0	0	72	123
Khor Kelab	11	7	10	1	87	280
Drake	11	1	0	0	25	39
Al Kharbai	9	0	0	0	18	27
Kilo 8	0	3 part time	0	0	3	3
					total	493
Port Sudan to Suakin						
Tawartit	14	12	0	0	64	114
Damat	1	1	0	0	5	9
					total	123
Suakin and South						
Suakin	21	8	26	3	182	645
Entabeeb	15	2	2	0	44	87
Heidub	2	0	0	0	4	6
Kishay Dama	2 (nets)	0	0	0	6	12
Sheik Ibrahim	2	0	0	0	4	6
Mersa Ashat	2 (nets)	0	0	0	6	12
Aqiq	2	0	0	0	4	2
					total	770

Table 18. Summary of estimated annual landings in Sudan by small-scale and traditional fishing methods, from various sources

Year	Estimated landings (t)	Source
1976	671	White (undated)
1979	500	Barrania (1979a)
1979	300	Keleshis (1979)
1979	1,041	White (undated)
1979	792	Chakraborty (1984b)
1980	996	Chakraborty (1984b)
1981	1,579	White (undated)
1982	1,192	Kedidi (1984a)
1983	1,442	Kedidi (1984a)
1983	1,350	Chakraborty (1984a)

attempt to jump over these nets when avoiding capture and are caught in that part set horizontally at the water surface.

Catches of up to a thousand tons of grey mullets landed in Egypt have been claimed in the past. Presently with the general exclusion of foreign fishermen this form of fishing has almost ceased.

Similarly a substantial fishery for trochus shell (Trochus dentatus) and the black lipped pearl oyster (Pinctada margaritifera) existed in the past (FAO, 1962). These were taken mainly in Donganab Bay by divers (usually of foreign origin). Exports are reported to have reached 2 130 t of trochus shell (1946) and 288 t of oyster shell (1947).

The fishery is now much reduced with a reported production in 1982 of 600 t of trochus shell and 5 t of oyster shell. The Government pearl oyster farm commenced in 1959 has been closed. The abundance of oysters is claimed to have declined substantially as the consequence of disease.

3.2.2 Resource Assessment

Of the major commercial fish species of Sudan, only the Red Spot Emperor (Lethrinus lentjan) has been the subject of detailed resource assessment studies (Kedidi, 1984b; Kedidi et al 1984a). Based on sampling carried out at Suakin and Mohamed Qal during 1982/83 and 1983/84, growth and mortality parameters were estimated and utilized in a Beverton and Holt (1957) yield per recruit analysis. Growth parameters used were $K = 0.17$, $L_{oo} = 51.1$ cm, $t_o = 0.86$ years while the natural mortality value used of $M = 0.4$ was taken from a study of the same species in Saudi Arabia (Kedidi et al, 1984a). The analysis indicated that the stocks adjacent to both landing sites were fully exploited although some increase in yield per recruit could be achieved at Mohamed Qal with increased fishing effort. In contrast, increased fishing effort at Suakin would be expected to lead to significant reductions in yield per recruit. Kedidi et al (1984a, 1984b) suggested that this situation may not be generally applicable to the commercial stocks along the Sudanese coast.

Based on productivity data from the Gulf of Suez (0.50 t/km^2) and the north coast of Saudi Arabia (0.41 t/km^2), Sanders and Kedidi (1981) estimated the potential annual yield from the 10,125 km^2 of Sudanese fishing grounds to be 4.0-5.0 thousand tons.

Other Species

Bean (1985a) conducting experimental gill netting trials in Sudanese waters during March 1985. The nets of multi-mono nylon were set in water of usually between 200 to 400 m depth along the inner edge of the outer reef adjacent to Suakin. Each net was about 100 m

in length (equivalent to 200 m at 50 percent slackness) and 30 meshes deep. The mesh size used was 5 1/4 inch (135 mm).

The overall catch during the period was reported as 1 699 kg, including 200 kg of red snappers, 209 kg of other fish, and 1 290 kg of shark. The principal species of interest because of their high value, were the red snappers Etelis carbunculus and Pristipomoides multidens.

The hard ground along the face of the 'drop offs' were suggested to be the most productive for catching the red snappers. Very high catches of shark occurred when the nets were set on the fine silt adjacent to the bottom of the slopes. The results were believed to be sufficiently encouraging as to justify feasibility commercial fishing, particularly if markets can be arranged for the shark.

Ross Seafoods International (1979) conducted exploratory shrimp trawling off southern Sudan between June 1978 and March 1979 despite the general unsuitability of the coast for trawling with the exception of an area of about 710 km^2 off the southern coast near the Baraka River.

Mexican flat trawls were used having 16.8 m headline and 18.3 m leadline lengths, and a try net of 3 m headrope length. The normal trawling speed of the vessel was described as four knots (7.4 km/hr).

The survey effort during the period was 659 trawling hours, mainly in the central and northwest area off the Delta. More than ninety percent of this effort was applied during night time and twilight. Much lower catch rates were experienced during day light hours.

Penaeus semisulcatus (67%), P. latisulcatus (13%) and Metapenaeus monoceros (14%) were the principal shrimp species encountered although the latter was considered uncommercial because of its small size. The by-catch included gobies, Gobius sp (45%); pony fish Gazza sp (12%); lizard fish Saurida sp (12%); spade fish, Cheitodipterus spp (9%); and sweetlips, mainly Pomadasys hasta (8%).

In November 1978 fishing was undertaken during the full 24-hour period so as to investigate the relationships between catch rates and time of day. At that time the catchability of the shrimp increased substantially from about 30 min. after sunset and they ceased to be caught about 30 min. before sunrise. Very limited amount of daylight fishing were undertaken in other months with similar results, except during July 1978 when reasonable catch rates were obtained in the daytime.

Overall mean catch rates of 12.6 kg/hr of shrimp (whole weight) and 122 kg/hr of by-catch were reported. Highest catch rates of

shrimp were obtained from the Gulf of Aqiq and the southern stretches of the Tokar Delta. The means were 18.3 kg/hr and 18.2 kg/hr respectively. Highest sustained catch rates occurred in January, February and March off the southern Tokar Delta when a mean of 21.3 kg/hr was obtained.

The company concluded that a vessel similar to the survey vessel could be expected to land 30 t (whole weight) of shrimp annually. They considered this insufficient to justify a commercial venture. The by-catch was regarded as having no value.

Using the same data Branford (1979) has described the monnthly catches to be expected from a smaller single rigged vessel equipped with a 16.8 m trawl. The annual catch was estimated at 14.7 t of shrimp and 115 t of by-catch per vessel. The months of June, July and half of August were allocated for vessel refit. It was suggested that no market presently existed for the by-catch, but that the small quantities of lobster Thenus orientalis and squid, and some fish might be sold.

During August and September 1973, personnel from the Cambridge Coral/Starfish Research Group undertook a survey (Roads, 1974) of the lobster resources between Abu Ramat and Ras Kasar. This involved observations made by divers assisted by underwater lights, and catches made at night by persons holding paraffin lamps and wading on the partially exposed reef platforms. Some fifty five reefs were sampled.

Maximum densities of lobsters were recorded from the fringing reefs around the islands south of Suakin. High mean densities were also observed on the outer reefs off the north coast. In those areas where the lobster were abundant catch rates of at least ten individuals per man hour of wading were attained.

The species Panulirus penicillatus was described as sufficiently abundant to justify commercial exploitation. Small numbers of P. versicolor and P. ornatus were also reported.

Reference was made to an existing commercial fishery, based on the collection of lobsters at night in the shallow waters over the partially exposed reef platforms. Catch rates reaching 500 individuals per week per crew were indicated.

3.3 Ethiopia

3.3.1 Fishery Description and Statistics

Ethiopian fisheries were active in the 1950's with annual landings of more than 25,000 t reported from its 52,500 km^2 continental shelf area to 200 m depth. (Aubrey, 1975; FAO, 1983). About 85 percent of this production consisted of small coastal

pelagics, mainly the sardine (Herklotsichthys punctata) and the anchovies (Stolephorus heterolobus and Thrissocles baelama). These were processed for sale as fishmeal in Europe, and sun-dried for markets in the Far East.

In those years there were six fishmeal plants operating in Massawa. The fishing was done along the shore between Massawa and Assab and around the islands of the Dahlak Archipelago mainly between October and April. The fishermen are claimed to have been from Yemen, and of Yemenite extraction but settled in Ethiopia.

The overall production of 21,000 t (fresh weight) in 1966/67 dropped to 14,000 t in the next year due to the closure of the Suez Canal which prevented the export of fishmeal. In 1972-73 civil war and the subsequent instability caused a further decrease in landings, down to 4000 t (Table 19). This trend continued with landings of 300 to 400 t in 1980-81, then increasing to about 2,000 t in 1983 (Guidicelli, 1984). Present landings are still small and are shown in Table 3.

The capture of small pelagic species is now avoided (Guidicelli, 1984) and the incidental catches of tunas, jacks, rays etc. are discarded due to marketing difficulties. Much of the fish that is landed is sold in North Yemen. The species most sought after are the more valuable reef fish such as snappers (Lutjanus spp), emperors (Lethrinus spp) and groupers (Epinephelus spp). Present catch rates are claimed to be about 10 to 25 t/boat (houri)/year.

The fishermen have experience in using beach seines, handlines, gillnets, trolling lines and shark longlines. The beach seines were most commonly used during the early years when fishermen gave priority to catching the small pelagics. Now handlines and gillnets are the most frequently used gears. The traditional boat types continue to be used, mainly houris (6 m length) and dhows (10 to 15 m length).

A trawler fleet is reported to have existing in the 1960's (Ben Yami, 1964, 1975) including four inshore trawlers (50 to 125 HP) engaged in catching shrimp near Massawa, and up to five offshore trawlers (150 to 240 HP). Typical Mediterranean trawl nets were used. All were operated by Israeli interests, with the production from the vessels consisting mainly of fish being exported to Eilat.

Total annual landings from the trawlers were reported to have been 1,200 to 1,500 t including about 30 t (whole weight) of shrimps with catch rates from a 240 HP offshore trawler being between 200 and 280 kg of saleable fish per trawling hour. These mainly consisted of the lizardfish (Saurida undosquamis and S. tumbil) and the threadfin bream (Nemipterus japonicus). About 30 to 50 percent of the catches were discarded (Grofit, 1971).

Table 19. Estimated Red Sea fish production (thousands of tons) from Ethiopean Fisheries 1965/66-1979/80. Source FAO (1982)

Species groups	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80
Pelagic fish	19.7	18	7	9	13	19	11	2	3.5	2	.25	-	-	-	.289
Demersal fish	1.3	1.2	1.2	1.5	.1	1.2	1.2	1	.6	.4	.6	.154	.015	-	.073
Shark	1.1	1.3	5.5	1.9	1.5	2.3	1.1	.4	.5	.03	.1	.014	-	-	-
Lobster/shrimp/ crab	.009	-	-	.1	.08	.03	.03	-	-	-	.02	-	-	-	.045
Shells	.15	.2	.2	1.2	.4	.4	.5	.3	.3	-	-	.004	-	-	-
Total	22.26	20.7	13.9	13.7	16.08	22.93	13.83	3.7	4.9	2.43	.97	.172	.015	-	.407

On the inshore trawling grounds daily fish and shrimp landings of 50 to 200 kg were reported, consisting of about 10% - 20% shrimp (Penaeus semisulcatus, P. japonicus, P. latisulcatus and Metapenaeus monoceros). The discarded portion of the catches was reported as about 90 percent.

About 3,200 km^2 of trawling grounds are known to exist on the shelf. The principal inshore grounds are in Hargigo Bay while much of the offshore trawling was done adjacent and south of Massawa to Assad. Potential unexplored trawling ground was claimed to exist south of Assab. Also 17,000 km^2 of continental slope (200 to 550 m depth) was suggested as worthy of survey.

3.3.2 Resource Assessment

Pelagic Resources

Although the pelagic fisheries resources are, based on past landings (Table 19), the most important component of Ethiopia's fisheries resources, little information is available on the distribution, biomass or potential catches. Limited acoustic surveys undertaken in March 1984 by the R.V. Dr. Fridtjof Nansen (Institute of Marine Research, Bergen, 1984) in areas further than 3 nm (5.6 Km) from shore indicated a very low abundance. Only few scattered schools of fish were recorded with the densest concentrations being offshore from Assab and midway between Assab and Massawa. Although no pelagic trawling was conducted at these localities, the acoustic recordings indicated that the fish were of a very small size. Given the past importance of the pelagic fishery in Ethiopia, it is highly probable that this survey was undertaken either at a time or in locations where abundance of pelagic fish was low. As such it probably does not represent a realistic assessment of the pelagic stocks in Ethiopian waters.

Exploratory fishing for large pelagic species was undertaken in 1962 and 1964 (Ben Yami, 1964) using a purse seine net. Eight purse seine sets were made during February 1962 and resulted in small catches of little tuna (Euthynnus affinis), longtail tuna (Thunnus tonggol) and possibly yellowfin tuna (Thunnus albacares).

Larger catches per set were taken in April-June 1964 (after some modification to the purse seine net) with eight of the 35 sets resulting in catches of 150-800 kg. In addition to longtail tuna and little tuna, several sets produced good catches (400-800 kg) of milkfish (Chanos chanos). Small quantities of spanish mackerel (Scomberomorus commerson) and indian mackerel (Rastelliger kanagurta) were also taken. Based on these catches and on sightings, it was concluded that schools of the major large pelagic species were small with most being below 1-2 ton.

Guidicelli (1984) estimated that, based on productivity data from North Yemen, the potential catch of large pelagic species in Ethiopian waters could reach 5000 t per year although since the basis of this estimate was not Ethiopian data, it should be treated with some caution.

Guidicelli (1984) estimated the potential annual yield of pelagic species from Ethiopian waters at 25.0-50.0 thousand tons per year although his estimates were based on extrapolation of productivity from other areas and not on survey data. Atkins and Partners (1965), Ben Yami (1964) and Grofit (1971) also arrived at similar figures although, again, none were based on actual surveys. There is no indication that the annual catches of the 1950's and 1960's of 20-25 thousand tons were not sustainable although, like many fisheries for small pelagic species, the limitation to development is just as much market-orientated as it is dependent on the availability of the resources.

Demersal Resources

Again, little survey or assessment work of the demersal stocks in Ethiopian waters has been carried out. In 1957/58, a 14-month survey was carried out by a 23 m demersal trawler (Israel, Ministry of Agriculture, 1959) which resulted in an overall catch rate of 290 kg/hour of saleable fish from the trawling grounds off Massawa. The catch consisted mainly of lizardfish (Saurida undosquamis) and S. tumbil) and threadfin bream (Nemipterus japonicus).

The survey results led to the immediate development of a commercial fishery. Subsequently on the basis of the data from the commercial fleet, it was suggested (Ben Yami, 1964) that the potential landings from the known grounds is 10,000 t. The offshore trawl grounds were judged as capable of supporting at least 15 trawlers of 240 HP each.

Although acoustic surveys in 1984 by the R.V. Dr. Fridtjof Nansen (Institute of Marine Research, Bergen, 1984) indicated that demersal resources were small in areas around Massawa and Assab, the results of 25 demersal trawl shots were more encouraging with 6073 kg of fish being caught at a mean rate of 486 kg/hour (all species). Again, lizardfish and threadfin bream were the dominant species particularly in inshore areas.

Three 240 HP steel stern trawlers were intermittently used in 1969/70 in exploratory shrimp trawling to about 20 fathom (36 m) between Ras Harb to south of Assab (Laor, 1969; Porat, 1970). During a thirty day period in December/January 5,956 kg (whole weight) of shrimp were caught at a mean catch rate of 24.8 kg/hour. Fishing was undertaken during the night time when best catch rates could be obtained.

The fishing locations during this period were reported as mainly in Massawa Bay to Ras Harb, and off Um Es Saaig. The catch rates were generally uniform throughout the survey area.

Much lower catch rates were obtained during surveys in each of April 1969 and April/May 1970 (Grofit, 1970). Again night time fishing was the most productive. Five trawl shots off Gorgasum in 12 to 20 m depth gave 9.1 kg (tails)/hour, 13 shots off Assab gave 3.5 kg/hour, and 2.8 kg/hr came from 11 shots off Um Es Saaig.

According to these results supported by observations on the commercial fishery, it is concluded that shrimp are available in the shallow waters along much of the coastline. Also the winter months are the most productive, with highest catch rates being achieved from night time fishing.

Because of the general absence of data on the distribution and abundance of commercial demersal resources in Ethiopia, assessment of their potential is difficult. Using data on the productivity of demersal fishing grounds in North Yemen (Walczak, 1977), Giudicelli (1984) calculated the annual potential yield of demersal fish in Ethiopian waters at around 18,000 t comprising 3000-8500 t of reef associated species (caught by handlines and gillnets) and 7000-10000 t of demersal trawl species. In addition, he calculated the potential yield of spiny lobsters (Panulirus spp) as between 500 and 1000 t per year. This estimate was based on observations that lobster are occasionally taken by divers in shallow waters and the unsubstantiated belief that abundance would increase with depth. These values for the demersal fish potential are very much greater than actual landings (even in the most productive year of 1969/70 when 1500 t of demersal fish were landed) and should be treated with some caution.

3.4 Jordan

3.4.1 Fishery Description, Statistics and Resource Assessment

The coastline of Jordan within the Red Sea extends for some 25 km at the northern and eastern tip of the Gulf of Aqaba. During the period 1972-1978 annual fish landings at the port of Aqaba declined from around 143 t to 30 t (Table 20). In 1983, landings were reported as 17 t (Chakraborty, 1984a) although present landings (1986) have increased to around 65 t (Table 1), mainly as a result of expansion of the fishery into Saudi Arabian waters.

Most fishing is done in Saudi Arabian waters within about 300 miles of Aqaba and is in accordance with a fishing agreement concluded between the two countries. Fishing trips to the more distant grounds last 12-15 days.

Table 20. Monthly landings in kg at the port of Aqaba, Jordan, 1972-1978. From Barrania (1979b)

Year / Month	1972	1973	1974	1975	1976	1977	1978
January	13,566	2,930	2,326	20,643	5,250	3,150	N/A
February	26,816	5,580	3,876	11,030	4,050	4,500	2,138
March	17,079	3,569	6,585	5,210	4,538	3,486	3,255
April	14,299	7,098	10,018	7,099	3,626	2,850	5,632
May	17,160	13,454	9,271	12,438	5,854	6,600	3,970
June	14,721	9,195	13,784	4,361	4,000	3,270	910
July	5,535	13,905	9,584	6,159	3,000	1,500	3,450
August	6,240	6,900	6,345	5,486	3,500	3,000	2,220
September	1,620	8,269	6,720	3,830	3,946	2,400	1,150
October	5,952	9.892	12,845	3,675	4,946	-	3,720
November	9,345	4,766	10,777	7,299	5,850	-	1,180
December	10,368	7,364	10,518	3,057	600	-	3,325
Total	142,701	92,922	102,649	90,287	49,160	30,756	30,950

The boats are of about 9 m in length and powered with inboard diesels of 25 to 45 HP. The number of these boats operating in 1979 was 18 (Barrania, 1979b) each manned by some 3 to 4 persons. Another 12 boats of 3 to 5 m length operated on a day trip basis close to Aqaba.

Handlines are the preferred fishing gear, with 2 to 3 hooks per line for depths less than 100 m, and 10-12 hooks per line when operating in deeper waters. The catches comprise mainly of the reef associated species such as snappers, emperors and groupers.

Although there has been no assessment of the fish resources within Jordanian waters, the limited fishing area available (including the narrow continental shelf in the northern waters of Saudi Arabia) means that the potential yield from the fish resources in these waters is limited. There does not appear to be any significant potential for expansion of the local fishery to take new species and it is likely that landings will continue to be derived from artisanal fishermen taking reef associated species in Jordanian and northern Saudi Arabian waters.

3.5 Saudi Arabia

3.5.1 Fishery Description and Statistics

Although Saudi Arabia has access to both Red Sea waters on its west coast and Gulf waters on its east coast, about half (or perhaps a little more) of its total fish landings are derived from the Red Sea area. In addition the Red Sea coast appars to offer greater potential for future development of fisheries than the more heavily exploited fisheries of the Gulf (Morgan, 1985). The continental shelf to 200 m depth of Saudi Arabia's Red Sea coast is relatively large at about 70,000 km^2.

Although narrow to a maximum width of 40 km in the north, it broadens out south of Jeddah to widths of 150 km from the coast. Accordingly much of the landings come from these southern grounds, particularly adjacent to the Farasan Banks.

The latter contains an inner passage having a soft flat seabed of 15 to 50 m depth. The water here is turbid which has generally restricted the growth of corals. At its northern end the inner passage is 10 to 20 km wide, and increases towards the south to about 35 km. On the seaward side it is bordered by extensive coral reefs and islands for almost all its length.

Fisheries production from the Red Sea coast of Saudi Arabia has increased significantly in recent years (Table 3) from around 13,000 t to 23,000 t in 1986. These landings are taken both by artisanal fishermen who operate small sambuks, houris, katiras and speedboats

and other traditional vessels and by larger industrial vessels which undertake demersal trawling for both shrimp and fish and which mainly operate from Gizan near the border with the Yemen Arab Republic. Although statistics are not collected on a regular basis from the artisanal fishermen (who operate a variety of fishing gears including gill nets, handlines, fish traps and trolling) Peacock (1978) and Peacock and Alam (1977) estimated that this sector landed around 10,200 t of fish in 1967/77 and employed 2400 fishermen distributed along the coast at 72 localities. Table 21 provides details of the distribution of the artisanal catch in 1976/77 while Figure 9 shows the location of the various fishing centres. A later estimate for the artisanal catch in 1983 (Chakraborty, 1984a) indicated that annual landings had not changed significantly and now amounted to around 10,700 t. Table 22 provides the details of this later survey including the species composition of the catch. As can be seen from Table 22, mackerels and jacks dominate the landings, accounting for around 46% of the total. The mackerel species are principally Scomberomorus commerson and Rastrelliger kanagurta while Caranx fulvoguttatus, C. sexfasciatus and C. ignobilis dominated the jack catches. These species are mainly taken on the southern grounds including the Farasan Bank.

The catches from the northern grounds include substantial quantities of mullets (Valamugil seheli and Crenimugil crenilabrus) and groupers (Plectropomus maculatus, Epinephalus microdon, E. tauvina, E. areolatus, and Variola louti). Snappers (Lutjanus bohar, L. gibbus and L. johni), jacks, groupers and emperors (Lethrinus lentjan, L. harak, L. miniatus, L. mahsena and L. nebulosus) are the important species from the central grounds.

Prior to 1981, the artisanal fishery was the only source of landings from Saudi Arabian waters. However in 1981 with the formation of the Saudi Fisheries Company, industrial trawlers began operating from Gizan to take shrimp (mainly Penaeus semisulcatus). Initially this trawling was undertaken by Thai vessels operating under contract to the Saudi Fisheries Company although with the development of their own fleet of trawlers, fishing is now undertaken by vessels owned and operated by the Company. Initial landings in 1982 were 466 t of shrimp (whole weight) in addition to 703 t of fish.

This industrial fishery has expanded significantly in recent years and now lands around 2500 t of fish and 500 t of shrimp annually. Processing facilities and other infrastructural support has also been established at Gizan and other centres and provides the basis for further expansion and development of other fisheries resources.

The artisanal gill net fishery has also expanded dramatically since about 1983 with the introduction of specialized fibreglass

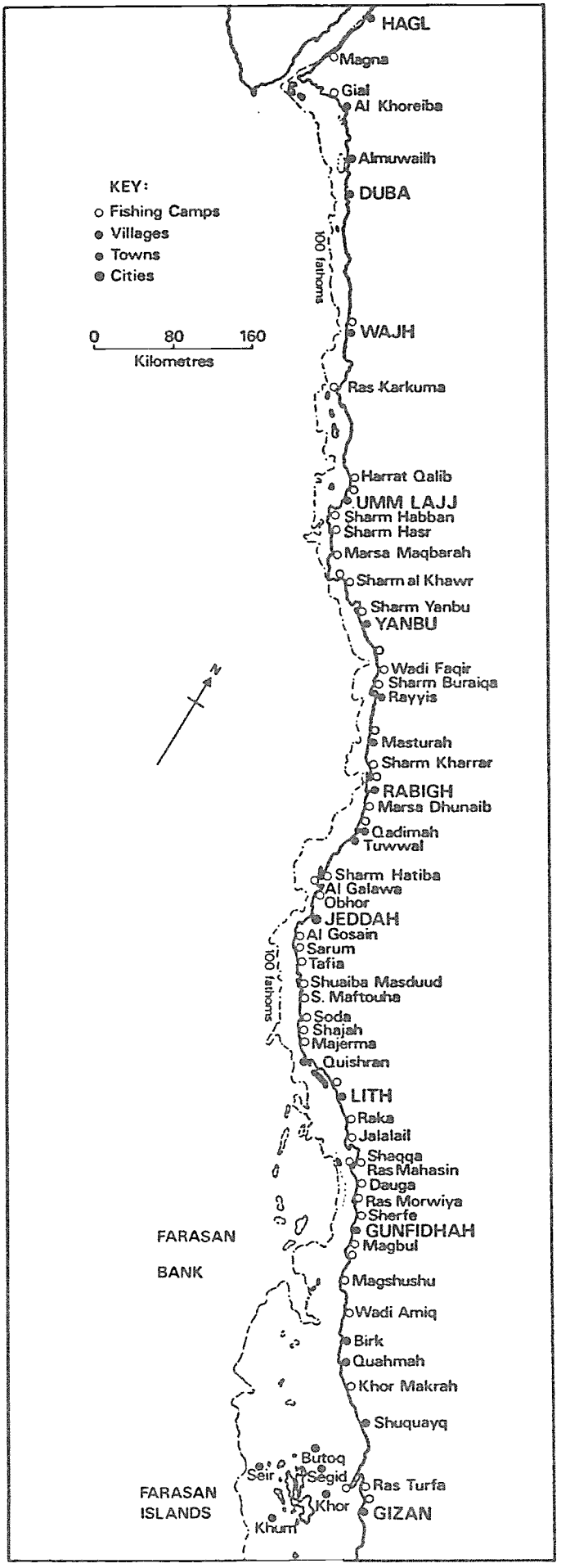

Figure 9 Fishing communities along the Red Sea coast of Saudi Arabia. (From Peacock, 1978)

Table 21. Estimates of landings (t), fishing effort and numbers of fishermen in various areas of Saudi Arabia. From Peacock (1978)

Region	Quantity of effort[b] Sambuks	Quantity of effort[b] unit Katiras	Annual landings estimate[c,d]	Number of fishermen	Unit Katira per km of coastline	Production per km of coastline
Hagl-Duba	-	11	80	29	~0	0.3 t
Duba-Wajh	-	13	90	39	0.1	0.6
Wajh-Umm Lajj	-	36	250	86	0.2	1.4
Umm Lajj-Yanbu	-	97	670	225	0.6	4.4
Yanbu-Rabigh	-	147	1,030	320	0.8	5.9
Rabigh-Jeddah	-	127	880	303	0.9	6.1
Jeddah	26[d]	53	810+370	284	-	-
Jeddah-Lith	-	67	460	174	0.6	4.1
Lith-Qunfidha	-	84	580	176	0.9	6.6
Qunfidha-Shuquayq	-	76	1,030	156	0.5	7.3
Shuquayq-Gizan	-	24	320	50	0.2	2.9
Gizan-Yemen Border	-	177	2,390	371	2.6	35.7
Farasan Islands	-	93	1,250	195	~0.5	~7.1
	26	1,010	10,200	2,400		

[a] Each region is inclusive of the first naded community, but exclusive of the latter.

[b] 1 'Unit Katira' is the fishing effort exerted by 1 typical Katira and is equivalent to 0.4 Zerog or 3.1 Houris.

[c] 1 'Unit Katira' catches 6.9 tons annually in the coastal diverse fishery from Lith to Hagl, and 13.5 tons annually in the Farasan Bank fishery from Qunfidha to Gizan.

[d] One Sambuk catches 31 tons annually. Although this is landed at Jeddah, as the table shows, it is caught in the Lith and Qunfidha sectors, and is consequently accredited to these sectors for the calculation of Effort and Production per unit Coastline.

Table 22. Species composition of small-scale fishery landings (t) in Saudi Arabia for 1983; from Chakraborty (1984a)

Species	Northern	Central	Southern	Total
Mackerels	127	97	3,029	3,253
Jacks	74	196	1,419	1,689
Snappers	121	402	-	523
Groupers	580	165	200	945
Mullets	402	73	-	475
Emperors	110	104	406	620
Tunas	-	83	513	596
Sharks & Rays	59	24	741	824
Parrotfish/wrasses	217	149	-	366
Barracudas	32	29	627	688
Others	271	299	193	763
Total	1,993	1,621	7,128	10,742

Notes:

Northern Sector: Hagl - Rabigh
Central Sector: Rabigh - Lith
Southern Sector: Lith - Yemen Border

netting vessels up to 10 m in length and this sector now accounts for the majority of the 23,000 t annual production from the Red Sea.

3.5.2 Resource Assessment

Some assessment work on individual fish stocks has been carried out in the past by a number of institutions and organizations and together these assessments provide an adequate overall picture of the fishing intensity and development prospects of the fisheries resources. However, most of the assessment work has been orientated towards those species which are important components of the artisanal fishery and, as a result, assessments of the major species of interest to the industrial fishery, including shrimp and lobster, have not yet been undertaken. Considering the recent development of this industrial fishery, such work would be desirable to guide future development plans.

Fish Stocks North of Lith

Results from a two year study (Kedidi, et al 1984b) indicated the annual landings for the approximately 700 km^2 of fishing grounds adjacent to Tuwwal as 266 t (1981) and 286 t (1982). This represented an annual productivity of the grounds of 0.38 t/km^2 and 0.41 t/km^2 respectively.

The principal species included were the jacks (Carangoides bajad), emperors (Lethrinus lentjan), groupers (Plectropomus maculatus and Epinephelus areolatus), barracudas (Sphyraena jello), sardines (Sardinella sirm) and Indian mackerel (Rastrelliger kanagurta).

On the assumption that the grounds adjacent to Tuwwal are fully exploited, and have the same productivity as all the grounds north of Lith (to the border with Jordan) an estimate was obtained for the potential yield from the latter grounds.

The total area of the grounds north of Lith were determined as 10,500 km^2, which when multiplied by 0.4 t/km^2 gives a potential yield of 4,200 t per year. This is indicated as about the same as the present annual landings, implying that the stocks available to the small-scale fishermen are fully exploited.

Assessment for the Redspot Emperor (Lethrinus lentjan)

The landings of small-scale fishermen operating adjacent to Tuwwal were sampled continuously during 1981 and 1982 (Kedidi et al 1984a). The lengths of redspot emperor were measured, some were aged, and the gonads examined in respect to studying sexual maturity and spawning seasons. The stock assessment parameters relevant to describing growth, mortalities and sexual maturity were determined (Table 23).

Table 23. Stock assessment parameters for the redspot emperor adjacent to Tuwwal; from Kedidi et al (1984a)

Lethrinus lentjan	L_{oo} = 51.1 cm		l_c = 24.9 cm		M = 0.45
	K = 0.1743		t_c = 3.0 yr		F = 0.70
	t_o = 0.855 yr		l_m = 28.4 cm		
	L_{oo}' = 56.6 cm		t_m = 3.8 yr		
	K' = 0.1341		t_{max} = 9 yr (observed)		
	t_o' = 1.345		t_{max} = 12 to 13 yr (estimated)		
	Birthday July 1				
	Length-weight relationship of $W = aL^b$:				
	a = 10.7×10^{-3}				
	b = 3.090				
	when L is in cm and W in gms.				
	Spawning season annual (April to June)				

These were used in yield per recruit analyses with the 'Beverton and Holt' type model. It was indicated that at the contemporary level of exploitation the length at which the fish are first liable to capture is about optimal. Also any attempts to maximize the yields would result in only about 10 percent increase in landings. The justification for such action is claimed to be low, as at least 100 percent increase in fishing effort would be required.

The landings of this species were determined as 21.4 t (1981) and 28.4 t (1982) representing nearly ten percent of the total landings at this location.

1977-1979 Fishery Resources Survey

Exploratory fishing surveys were undertaken during the period from February 1977 through October 1979 (Peacock, 1978; Peacock, 1980). This mainly involved the 35 m R/V 'Ibn Majid' using a Mediterranean trawl (50 m footrope length and 42 m headrope length) when operating in depths less than 100 m, and a Granton trawl (38 m footrope and 24 m headrope) when in deeper waters. The survey area was divided into nine zones, and some were further sub-divided into inner and outer sub-zones.

Within the Farasan Bank inner passage, the mean catch rates achieved with the Mediterranean trawl ranged between 115 and 1,198 kg/hr, with an overall mean of 427 kg/hr of which 15 kg/hr (or 3.5 percent) are described as 'prime' species (Table 24).

About 45 percent of the catches consisted of ponyfish (Leiognathus bindus, L. leucisus). The other industrial species included the silverfish (Gerres filamentosus), lizardfish (Saurida tumbil and S. undosquamis), goatfish (Upeneus moluccensis), and threadfin bream (Nemipterus japonicus). Sharks and rays comprised about 10 percent.

Shrimps, principally Penaeus semisulcatus and Metapenaeus ensis were caught in small localized areas adjacent to sites of flash flood runoff. Mean nocturnal catch rates ranged from about 8 to 14 kg/hr (whole weight), although use of a tickler chain occasionally achieved much higher rates of 30 kg/hr or more. These productive grounds were considered to be small in area, and capable of supporting only one or two boats fishing for shrimps during part of the year.

The assessment of stock biomass for the inner passage ground was made on the basis of an estimate of 0.142 km^2/hr being the swept area for the Mediterranean trawl (horizontal trawl width 24 m x mean towing speed of 5.93 km/hr). This value was used to convert the mean catches per hour to catches per area, which when multiplied by the trawlable area was taken as an estimate of the biomass (Table 25).

Table 24. Catch rates achieved with the Mediterranean trawl in the Farasan Bank inner passage, Saudi Arabia. From Peacock (1980)

	Zones						Means
	1	3	4	5	6	8	
Effort (trawling hours)	17.9	3.5	1.4	11.3	3.0	8.2	
Prime fish (kg/hr)	18	0[a]	2	22	31	2	15
All fish (kg/hr)	171	0[a]	1198	335	318	115	427
Depth (metres)	16	31	37	24	18	62	31

[a] Trawl filled with mud

Table 25. Estimate of standing stock for inner passage trawl ground, Farasan Bank, Saudi Arabia. From Peacock (1980)

Zones	1	3	4	5	6	Total
Area (km^2)	2,110	1,700	690	870	170	5,540
Catch (kg/hr) rate	230	300	1,200	340	320	
Standing stock per unit area (t/km^2)	1.62	2.11	8.43	2.39	2.25	
Standing stock (ton)	3,420	3,590	5,820	2,080	380	15,000

This is based on the assumption of the trawl being 100 percent efficient.

It was suggested that the potential yield would be between about 10,000-14,000 t annually. This is based on the assumption that the exploitation rate would be 0.7 and the biomass would be replaced annually (because it comprises of fish having lifespans of little more than one year).

Additional productive ground was found on the western edge of the Farasan Bank. This was surveyed mainly with the Granton trawl. A mean catch rate of 526 kg/hr was obtained from Zone 2, in depths of about 200 m (Table 26). The catches comprised 49 percent mackerel (Scomber australasicus) and scad (Decapterus maruadsi) and about 40 percent of the industrial species common on the inner passage grounds. The mackerel were present during the summer and autumn months only, while the scad were present during all months. The catches were reported as also regularly containing the snapper (Pristipomoides typus) which was caught at an average rate of 47 kg/hr.

The area of the above-mentioned ground was determined as 1100 km^2, and the swept area of the Granton trawl as 0.169 km^2/hr (horizontal trawl width 28.5 m x mean towing speed of 5.93 km/hr). Using the mean catch rates of 258 kg/hr of mackerel and scad, and 47 kg/hr of snapper gave an initial estimate of the standing stocks of 1,700 t and 300 t respectively. Again this is based on the assumption that the trawl was 100 percent efficient.

These values are suggested as being under-estimates, due to the mean height of the schools above the seabed being about 6 to 7 m (indicated by the echosounder) while the headrope height of the trawl was believed not to exceed 1.7 m.

The mackerel and scad stock was thought more likely to be ten times the initial estimate; that is up to 10,000 to 15,000 t. The associated annual potential yield was proposed as 4,000 to 5,000 t.

In the case of the deep water snapper it was noted that these are normally most abundant along the vertical edge of the upper continental slope, where trawling is not usually possible. A limited survey with single hook handlines and 15 hook droplines was undertaken at six locations along the outer edge of the Farasan Bank. The catch rates from an effort of 50 line hours was 8.4 kg/line/hr and 17 kg/line/hr with the two types of gear respectively.

Most of the lining was done at night, dusk and dawn, while the previously mentioned trawling had been done during the daytime. The species caught, apart from the snapper, were those typical of the catches from shallower waters.

Table 26. Catch rates achieved with the Granton trawl in the mainly offshore grounds of Farasan Bank, Saudi Arabia. From Peacock (1980)

	Zones					
	1	2	4(out)	5(out)	6(in)	9
Effort (trawling hours)	17.1	67.6	2.0	5.5	5.7	0.5
Prime fish (kg/hr)	22	294	0	0	3	0
All fish (kg/hr)	289	526	350	107	86	161
Depth (metres)	35	230	230	270	75	325

A more comprehensive handline survey was undertaken of the nearshore fish stocks. A total of 2,978 line hours were spent for a catch of 15 t of prime fish, at an average rate of 5 kg/line/hr (Table 27). The handlining was generally done at night from the deck of the 'Ibn Majid'. It was suggested that the catch rates obtained were likely to be an underestimate of those possible from smaller commercial boats.

The most important species in the catches were the snappers (Lutjanus bohar, L. sebae, L. gibbus), groupers (Ephinephelus tauvina, E. chlorostigma, E. merra and E. microdon), barracuda (Sphyraena jello), emperors (Lethrinus miniatus, L. lentjan and L. mahsena) and jacks (Caranx sexfaciatus). The pelagic species tended to be from inshore in Zone 1 and 3 to 6 (inner) whereas the demersal species were most abundant offshore in Zone 2 and 3 to 6 (outer). Catch rates were poor in the inner passage of the Farasan Bank, and this was suggested to be due to the already high level of commercial exploitation, and the lesser abundance of coral structures.

The surveys also included the use of demersal gillnets, which were fished overnight usually in lengths of 300 m. Using 100 m as the basic unit of length, a total of 361 lengths were fished for a catch of 14.5 t. The average catch rates ranged from 35 to 105 kg/100 m/night. The gillnets most frequently used were green monofilament of 40 meshes depth, and mesh size (stretched) of 12.7 cm.

The gillnet catches were dominated by sharks and rays, which contributed roughly 70 percent of the total in all zones. The pelagic species included the mackerels (Scomberomorus commerson) and jacks (Carangoides bajad, Trachinotus blochi and Scomberoides commersoniannus) while the most abundant demersal species in the catches was the snapper (Lutjanus bohar).

Estimates of the stock biomass and potential yields were made for the reef associated species, principally on the basis of extrapolation from the fishery landings and knowledge of the areas of both the exploited and unexploited portions of the grounds.

The stocks north of Lith to Hagl were claimed as already near fully exploited. Apart from the outer edge of the Wajh Bank (which was then not being exploited) all other grounds are fished. The Farasan Bank is suggested however as being underexploited, with substantial stocks beyond the present range of the small-scale fishermen. A tentative estimate of the potential yield is given as 11,000 t annually, compared to the then contemporary annual yield of 6,000 t.

Mention is made of stocks for which no quantitative data were collected. Schools of Sardinella were sighted, and attracted to the lights of the 'Ibn Majid' during night-time mainly at the Farasan

Table 27. Catch rates achieved with handlines Farasan Bank, Saudi Arabia. From Peacock (1980)

	1	2	3		4		5		6		7	8	9	Means
			In	Out	In	Out	In	Out	In	Out				
Total effort (line hours)	99	1,024	99	130	410	103	244	136	141	142	62	213	41	
Av. catch/unit effort (kg/hr)	1.7	7.2	2.0	10.1	4.5	3.9	3.1	4.4	2.2	4.6	1.1	2.9	1.6	3.8
Catch Composition	%	%	%	%	%	%	%	%	%	%	a/	%	%	%
Sharks and rays	3	5	5	2	13	24	13	2	10	14		10	0	9
Barracuda	27	11	33	2	13	5	20	2	20	4		5	2	12
Jacks	20	14	18	8	19	5	16	8	16	6		10	0	12
Mackerel	14	4	8	0	9	2	3	0	0	0		0	0	3
Grouper	19	4	8	3	8	14	10	30	14	24		33	46	17
Snapper	0	50	22	83	33	45	30	53	33	49		28	6	36
Emperor	11	10	4	2	4	4	5	5	7	3		14	25	8
Others	3	2	3	0	1	1	3	0	0	0		0	21	3

a/ Sample too small to analyse

Bank inner passage, but also off Umm Lajj. Small tuna (probably Auxis sp and Euthynnus sp.) were also sighted, although very rarely.

Experimental Deep Water Gillnetting

During five days in March 1985 demersal gillnetting was undertaken (Bean, 1985b) adjacent to Tuwwal, principally for the snappers Etelis carbunculus and Pristipomoides multidens. The nets with 50 percent slackness were 100 m long when rigged, and 30 meshes deep. The mesh size of the netting was 5 1/4" (13.3 cm) stretched.

Highest catch rates of 10-30 kg per net day were reported for the two days when the nets were set on the slope about 20 km offshore in 140-200 m depth. These fish had mean weights of about 3-4 kg. Catches of shark were also reported at rates about the same as for the snappers.

3.6 Israel

3.6.1 Fishery Description, Statistics and Resource Assessment

The Red Sea fisheries of Israel are small and contribute only about 150 t per year to fisheries supply in the country (Table 3) with imports providing most of the additional supply needed.

There are three main sources of fish production in Israel viz. intensive fish culture in ponds, long distance fishing in the southeast Atlantic and coastal fishing in inland waters (mainly Lake Kineret), the Mediterranean Sea and the Red Sea. Of these, the fishery in the Red Sea is by far the smallest and accounts for only about 3% of the total marine landings of some 4200 t.

The fishery in the Red Sea is conducted by small craft, powered either by inboard or outboard engines. They fish with bottom-set longlines and with bottom-set or floating gill and trammel nets to take a variety of coastal species such as snappers and grunts. In addition, some pelagic fishing for sardines has been carried out using small pure seine vessels as well as distant water fishing in other parts of the Red Sea, particularly Ethiopia (e.g. Ben Yami, 1964).

No resource assessment of fish stocks within Israeli Red Sea waters has been carried out although given the very small area of the available coastal shelf, it is extremely unlikely that a potential beyond the present landings exists.

3.7 Yemen Arab Republic (North Yemen)

3.7.1 Fishery Description and Statistics

The 11,200 km^2 (to 200 m depth) of continental shelf is relatively productive. This is presumed to be due to much of it being shallow, and also having higher nutrient levels from water exchange with the Gulf of Aden.

The fishery is entirely artisanal in nature and is carried out from small sambuks of 10-15 m overall length and smaller houris of 4-7 m.

They are either powered by sails, inboard motors in the case of the sambuks or by outboard motors. Crew numbers range from 5 to 12 persons on the sambuks and from 1 to 7 persons on the houris. Overnight trips of less than 24 hours are most common, except when using the larger sambuks for which trips of several days duration are more usual. The principal landing sites are Hodeidah, Al Khoba, Klauka, Khataba and Mocha.

Previously, in the years 1970 through 1974, a fleet of twin-rigged shrimp trawlers originating from Kuwait operated in the coastal waters of North Yemen. During the peak of activity the number of vessels engaged is claimed to have reached 39, and the annual landings to have exceeded 600 t of shrimp tails.

The trawling for shrimp was recommenced from 1980, using small local vessels including modified sambuks. This activity is administered through the General Corporation for the Development of Fishery Resources. It is claimed that seven boats landed about 20 t (whole weight) of shrimp (and about five tons of fish) for each of 1981 and 1982. The monthly landings data show that January through March and August through September are the most productive periods for shrimp. Penaeus semisulcatus is the principal species landed.

Catches of shrimp have increased dramatically in recent years from 17 t in 1984 to 432 t in 1986.

Total landings from the Yemen Arab Republic have apparently increased in recent years (Table 3) although the reliability of statistics prior to about 1983 is questionable. The increase in recent years, from 17,000 t in 1984 to 22,300 t in 1986 (part of which may be an artefact brought about by the improved collection of statistics) is primarily a result of three factors:

a. The landing of fish species which were not previously landed. This is particularly noticeable with the so-called 'third rate' species such as catfish, sharks and some of the smaller grunts.

b. The increased catches in the last few years of the pelagic species, the most important of which is the Indian Mackerel which, at 4,929 tonnes in 1986 (Table 27) is by far the biggest single component of the catch. The catches of larger pelagics, such as spanish mackerel and cobia have also increased in recent years.

c. The increased catches from the shrimp fishery which have increased from 17 t in 1984 to 432 t in 1986.

With the exception of the shrimp fishery, these increases have apparently occurred without significantly increased fishing effort, although effort statistics by stock are not readily available. What is apparent from the statistics being collected is that the number of vessels (all small scale fisheries) has not increased markedly since 1984. More vessels, however, are now equipped with shrimp trawling gear and are able to undertake trawling in addition to other fishing methods for fish species. The implementation of a closed season for shrimp from April 1 to August 31 has also had a major impact on shrimp catches by increasing the size of first caputre of Penaeus semisulcatus (the major species) and therefore leading to a significantly improved yield per recruit. It is also apparent that the areas now being fished for shrimp are much greater than previously although the small scale fishermen are limited by their gear to fishing in depths shallower than about 8 metres. No shrimp fishing occurs in waters deeper than this.

Apart from the trend of landing species which were previously discarded, there does not appear to have been any major changes in the fishery for species other than shrimp. The major component of the catch, the Indian mackerel, recovered to near 5000 t in 1986 after a series of declining years, culminating in a 2200 t catch in 1985.

Demand for all fish and shrimp species landed has increased in recent years with wholesale prices doubling in some instances in the period 1984-1986. As previously, the entire catch is consumed within Y.A.R. (apart from a small quantity which is transported to Qizan in Saudi Arabia) and a comprehensive road transport system exists to supply inland cities and villages, including Sanna'a, with fish supplies.

A summary of the catches, by species, for the years 1983-1986 is shown in Table 28.

A comprehensive system of fisheries data collection is now well established and is based on an interview sampling technique. Eight landing places were being sampled in 1987, accounting for over 70% of the landings made in the Yemen Arab Republic. Data on catches per boat, species, fishing method, landing place and time are collected together with wholesale price and transportation details.

Table 28. Catches (t) by species in Yemen Arab Republic for the years 1983-1986

Species	1983	1984	1985	1986
Shrimp	17	239	320	432
King Fish	2788	3115	2351	2673
Cobia	43	183	966	570
Queen Fish	-	339	666	329
Emperor	1902	1754	2268	2454
Big Eye Tuna	724	678	840	307
Barracuda	519	1173	1386	1052
Sea Bass	951	550	1239	811
Indian Mackerel	7211	4214	2246	4929
Other Mullet	-	476	420	920
Grey Mullet	193	440	42	416
Jacks	1157	672	1365	1095
Goggle eye	-	466	378	438
Red-striped seabream	-	-	1286	1336
Red snapper	-	678	903	876
Spotted grunts	-	-	168	153
Small queen fish	-	-	-	329
Sharks	1361	448	1407	1030
Catfish	79	-	57	548
Others	1994	2840	1890	1643
Total	18030	18566	20598	22341

3.7.2 Resource Assessment

Almost all of the resource assessment work which has been carried out in North Yemen has been related to the demersal fish and shrimp stocks with no analysis of the pelagic or reef associated species having been undertaken. This is, however, currently being addressed with an ongoing research programme on some of the more important pelagic stocks, (particularly the Indian mackerel, Rastrelliger kanagurta) being undertaken by the Ministry of Agriculture and Fisheries in Hodeidah.

Details of the demersal and shrimp resource assessments which have been undertaken are as follows:

Feasibility Trawling 1973-1977

A total of 472 hauls were made from the F/V 'Orion' during the period from July 1973 through January 1977. The great majority of these (71%) were on the Ras Katib grounds adjacent to Hodeidah (Walczak, 1972).

Of the four bottom trawls the Gulf of Mexico Shrimp trawl (18.3 m headline length and opening height of 60-105 cm), and the Thailand trawl (40.3 m headline length and 2.5 m opening height) were most commonly used. A trial shrimp trawl (9 m headline length and opening height of 40 to 80 cm) was used until February 1975 and an Icelandic trawl was sometimes used although it was considered relatively ineffective.

The catch rates were lowest with the Thailand trawl, although the extent of difference was less when considering only the marketable species (Table 28). When using this gear the mean catch rates from the various grounds ranged from 124 to 658 kg/hr (all species) and 83 to 244 kg/hr (marketable species). Highest catch rates were generally achieved during the winter months, and at shallow water depths, particularly in the 31 to 50 m range in the case of the marketable species. Very little trawling was done in depths greater than 50 m.

The principal species caught with the Thailand trawl were the jacks/trevally (16%), threadfin breams (15%), rays (14%) and lizardfish (12%) whereas shrimps comprised only a small part (3.5%) of the catches (Table 29). The Gulf of Mexico trawl was much more effective in catching shrimp. The species were mainly Penaeus semisulcatus (70 to 100%), followed by P. indicus.

The catch rates were used to estimate the standing stock (= biomass) from the relationship:

$$\text{standing stock} = 1/q \cdot \frac{\text{catch/hr}}{\text{swept area/hr}} \cdot \text{area of fishing grounds}$$

Table 29. Catches, fishing efforts and catches per fishing effort by fishing location and gear from R.V. Orion surveys, North Yemen 1973-1977. From Walczak (1977)

Fishing Location	Thailand trawl				Gulf of Mexico Trawl				Shrimp trial trawl				Icelandic trawl			
	Effort (No. hauls)	Total catch (tons)	All sp. (kg/hr)	Marketable sp.[1] (kg/hr)	Effort (No. hauls)	Total catch (tons)	All sp. (kg/hr)	Marketable sp.[1] (kg/hr)	Effort (No. hauls)	Total catch (tons)	All sp. (kg/hr)	Marketable sp.[1] (kg/hr)	Effort (No. hauls)	Total catch (tons)	All sp. (kg/hr)	Marketable sp.[1] (kg/hr)
Ras Katib	82	65.37	658	143	208	40.56	194	86	34	6.73	192	63	5	0.11	82	21
Ras Mujamila	22	2.33	124	83	3	0.14	247	48	7	0.87	128	29				
Salif Areas	12	4.38	304	244	3	0.09	68	24	6	0.29	71	21	5	0.06	65	23
Rhisa Areas	44	11.33	265	128												
Mocha & Khauka	14	(3.43)	245	131												
North of Kamaran & Khoba	18	2.93	171	73					9	1.10	122	47				

[1] Marketable catch includes shrimp

Total number of hauls: 472
Total catch : 139.72 t

The trawl efficiency coefficient was taken as q = 0.5, except in respect to the shrimp catches with the Thailand trawl when q = 0.3 was used. The values for the swept areas were previously determined as 0.075 km^2/hr for the Thailand trawl, 0.030 km^2/hr for the Gulf of Mexico trawl, and 0.015 km^2/hr for the trial trawl.

Estimates of the potential yield were in turn determined from the estimates of standing stock and the relationship MSY = 0.5 M B_o. The natural mortality coefficient was taken as M = 1. The potential yield was determined as 7,386 t when considering all the species, and 3,431 t for the saleable species (Table 30). These are the weighted means of the separate estimates determined for each trawl net type and fishing location.

Similar calculations led to an estimate of 805 t (whole weight) as the potentital yield for shrimps (Table 31). These are suggested as being very tentative, due to the uneven distribution of the survey effort. Estimates for the areas north of Kamaran and Khoba are based on only 9 hauls with the shrimp try net and 18 hauls with the Thailand trawl.

Commercial Trawling off North Yemen during 1971 and 1972

The 35 m long stern trawler F/V 'Tareq II' having a main engine of 939 hp was engaged in commercial trawling from April 1971 through June 1972 (FAO, 1978). It was equipped with a French (Granton) trawl with a headrope length of 25.6 m and a codend mesh size of 70 mm (stretched). The horizontal opening of the net was claimed to be 17 m.

The vessel was operated for 266 days during which the mean trawling effort per day was 5.3 hours. The quantity of catch subsequently landed in Jordan was 198 t. The associated catch rates (of marketable fish) were 743.1 kg/day and 139.4 kg/hr. The mean catch rates in each month ranged from about 100 to 200 kg/hr without any apparent seasonal trend. The fishing locations were mainly in depths greater than 20 m.

More detailed data are described relevant to a five day cruise from May 29 to June 3 on the fishing grounds adjacent to Hodeidah. Twenty hauls equivalent to a fishing effort of 70 trawling hours resulted in a catch of 17.2 t. A mean catch rate (all species) of 246 kg/hr was achieved, of which the landings represented 132 kg/hr. It is suggested that on the basis of six hauls of 3.5 hr duration a catch of 4 t/day of saleable fish could have been attained.

The landings were of relatively large fish, including the grey skin (Spilotichthys pictus), the emperor (Lethrinus nebulosus) and the snapper (Lutjanus sanguineus), which together represented 68 percent

Table 30. Species compositions of marketable portion of the catches from R.V. Orion surveys, North Yemen 1973-1977. From Walczak (1977)

English Name	Scientific Name	Thailand trawl		Gulf of Mexico trawl		Shrimp trial trawl		Icelandic shrimp trawl	
		kg	%	kg	%	kg	%	kg	%
Sharks	Selachii	189	0.9	20	0.1	24	1.0	4.0	5.7
Guitarfish	Rhynchobatus sp.	657	2.8	33	0.2	88	3.7	-	0
Stingrays	Dasyatidae	3,296	14.2	1,455	10.7	17	0.7	-	0
Sardines, anchovies	Clupeidae, Engraulidae	219	0.9	39	0.3	99	4.2	-	0
Indian mackerel	Rastrelliger kanagurta	85	0.4	855	6.3	206	8.6	-	0
Spanish mackerel (Kingfish)	Scomberomorus commersoni	170	0.7	4	0	13	0.5	6.0	8.6
Jacks/trevally	Carangidae	3,746	16.1	130	1.0	10	0.4	13.0	18.7
Barracuda	Sphyraena sp.	1,050	4.5	103	0.8	1,235	51.8	2.5	3.5
Snappers	Lutjanus sp.	832	3.6	1	0	20	0.8	-	0
Empreror breams	Lethrinidae	158	0.7	2	0	2	0.1	-	0
Groupers	Serranidae	76	0.3	-	0	45	1.9	-	0
Monocle breams	Scolopsis phaeops	46	0.2	-	0	12	0.5	-	0
Threadfin breams	Nemipterus sp.	3,481	15.0	21	0.2	151	6.3	0.5	0.7
Indian halibut	Psettodes erumei	171	0.7	77	0.6	5	0.2	-	0
Mojarras	Gerridae mainly G. oyena	293	1.2	55	0.4	-	0	1.0	1.4
Lizardfish	Saurida tumbil	2,784	12.0	52	0.4	6	0.3	-	0
Sweetlips	Plectorhynchus sp.	142	0.6	-	0	-	0	-	0
Spotted grunts	Pomadasys sperculare	1,540	6.6	1,522	11.2	59	2.4	-	0
Other fish	Other fish	2,930	12.6	861	6.3	-	0	36.5	52.5
Spiny Lobster and sand lobster	Palinuridae and Thenus orientalis	56	0.2	1	0	206	8.6	-	0
Shrimp	mainly Penaeus semisulcatus	838	3.6	7,555	55.4	105	4.4	4.0	5.8
Blue swimming crabs	Lupa pelagica	353	1.5	508	3.7	62	2.6	1.0	1.4
Squid, cuttlefish	Cephalopoda	100	0.4	345	2.5	17	0.7	1.0	1.4

Table 31. Estimates of standing stock and maximum sustainable yield of demersal fish from R.V. Orion surveys, 1973-1977. From Walczak (1977)
(Values in parenthesis represent numbers of hauls. GMT = Gulf of Mexico Trawl, STT = Shrimp Try Trawl, TT = Thailand Trawl)

	Area (km^2)	Standing stock (tons)			Maximum sustainable yield (by gear) (tons)			Maximum sustainable yield	
		GMT	STT	TT	GMT	STT	TT	Total	Marketable
Ras Katib	182	(208)	(34)	(82)					
Total		2,350	4,600	3,200	1,175	2,300	1,600	1,400	
Marketable		1,735	252	403	867	126	201		621
Ras Mujamila	432	(3)	(7)	(22)					
Total		7,113	7,372	1,428	3,500	3,686	704	1,618	
Marketable		1,382	1,670	956	690	835	478		576
Salif area	141	(3)	(6)	(12)					
Total		640	1,334	1,143	320	667	1,070	848	
Marketable		225	394	917	112	197	460		335
Rhisa area	420	(0)	(0)	(44)					
Total				2,296			1,150	1,150	
Marketable				1,433			715		715
Mocha & Khauka	260	(0)	(0)	(14)					
Total				1,700			850	850	
Marketable				908			454		454
North of Kamaran/Khoba	356	(0)	(9)	(18)					
Total			5,790	1,664		2,895	832	1,520	
Marketable			2,230	693		1,115	346		730
		(214)	(56)	(192)					
Totals	1,791	-	-	11,431	-	-	5,715	7,386	
Marketable				4,949			2,475		3,431

of the total. Amongst the discards were rays, catfish, sharks, horse mackerels, goatfish, threadfin breams and many other species.

The biomass was estimated as 12,000 t of saleable fish based on a mean catch rate of 200 kg/hr, an effective swept area of 0.10 km^2/hr (with the trawling efficiency assumed to be 100 percent), and 6,200 km^2 as the area of the trawl grounds. The potential yield was assumed to be half the biomass and hence 6,000 t.

Feasibility Shrimp Trawling 1977

The twin-rigged shrimp trawler F/V 'Newebe IV' was operated for eight months from April through December (FAO, 1978). The nets used were Star Shrimp Trawls of 68.5' (20.9 m) headrope and 82.5' (25.1 m) footrope lengths. Locating concentrations of shrimp involved the use of a try net of 12' (3.7 m) headrope length.

Subsequent to the orientation cruises, 9.3 t of shrimp tails resulted from an effort of 228 trawling hours, equivalent to a mean catch rate of 41 kg/hr. The grounds adjacent to Hodeidah were reported as the most productive. Here 4.2 t of tails were caught at a rate of 139 kg/hr. Included in this was a catch of 1,520 kg taken during 2 hr. 22 min. of trawling.

The trawling operations were generally restricted to the daylight hours. The small number of night-time shots conducted furing June gave substantially higher catch rates than had been obtained during the daytime. In respect to fishing depths, these were described as usually less than 40 m. Maximum catch rates were obtained in the 8 to 9 m range, with a sudden drop in catch rates with increasing depth. The coverage with time was judged as insufficient from which to determine the seasonality of catch rates.

Penaeus semisulcatus was reported as the most abundant and widely distributed species. In the northern part of the survey area P. indicus was found in very shallow water (4 to 8 m depth) at catch rates up to 600 kg (tails)/hr, however elsewhere it comprised less than one percent of the catches. P. japonicus is described as occurring in depths shallower than 12 m, and P. monodon in depths mainly between 35 to 40 m although never in abundance.

A total of 107 t of by-catch (all species) was taken during the survey period. The mean catch rate was 326 kg/hour with the Star Shrimp Trawl. Highest catch rates were achieved during November and December, and in water depths of 35 to 40 m (no trawling was done at depths greater than 40 m). It was suggested that the saleable fish might represent some 35 percent of the catches.

On the basis of these results the contractors concluded that an identical commercial vessel operating 14 hours/day, 22 days/month and

10 months/year should obtain an annual catch rate of 82.5 t of shrimp tails. They suggested an optimal fleet size of six vessels, giving a projected annual catch of 500 t of tails. In addition they estimated an annual by-catch from the fleet of 440 t of saleable fish.

An alternative assessment from the same data is described. This is based on estimating the mean catch rates in each 3 x 3 n.mile (5.56 x 5.56 km) sub-area. These were then converted to densities on the basis of 0.058 km^2 being the effective area covered during an hour of trawling (a 50% catching efficiency was assumed).

The overall biomass (FAO, 1978) was determined as 1,067 t of shrimp tails. The potential yield was assumed to equal to half the biomass, giving 533 t of tails (equivalent to 850 t of whole shrimp).

Assessment Based on Commercial Fishing of Shrimp 1970-1974

Gulf Fisheries Pty Ltd. based in Kuwait operated a fleet of shrimp trawlers in North Yemen from February 1970 to May 1974. Operations commenced with six vessels and rapidly expanded to 20 vessels for the last three months of 1970. During 1971 the numbers of vessels is reported (FAO, 1978) as reaching 39, consisting of at least 30 of 25 m (overall) length, seven smaller vessels and two mothership. The fleet number dropped to less than ten during September 1972 and stayed below this figure until operations were terminated in May 1974.

All the vessels were twin-rigged and equipped with the Gulf of Mexico type trawls. Each net had a ground rope length of 41 m. Fishing was described (FAO, 1978) as generally taking place in water depths of less than 18 m. The productive Ras Katib grounds are 9 to 13 m depth. Highest catch rates were achieved during the periods of dawn and just before sunset. Satisfactory catch rates were also achieved during daytime. It is understood that no fishing was done between sunset to before dawn.

The fishing locations were described as including the sheltered waters inside Kamaran Island, inside Salif Bay, between the islands north of Kamaran Island, and off Luhelya as far north as Zurbat Island as well as the sheltered waters around the Ras Katib Peninsula. Some fishing was also done around the inshore waters of Ras Mujamila, although catches there were generally low. Catches were also claimed as generally poor north of Zurbat Island to the Saudi Arabiaan border.

The monthly catches of shrimp were reported by Gulf Fisheries as generally highest during 1971 when 614.9 t of tails were landed (Table 32). It was during this time that the vessel numbers were greatest. The mean catch rates per vessel are shown to have ranged between 1 to 4 ton/month and highest during October through March.

Table 32. Estimates of standing stock and maximum sustainable yield for shrimps based on surveys by R.V. Orian in North Yemen, 1973-1977. From Walczak (1977)

Fishing Locations	Trawlable area (km^2)	Area with shrimp (km^2)	Fishing effort (hauls)			Standing stock (tons)			Maximum sustainable yield (tons)			
			GMT	STT	TT	GMT	STT	TT	GMT	STT	TT	Average
Ras Katib	182	30	208	34	82	85	180	28	43	90	14	50
Ras Mujamila	432	20	3	7	22	8	5	0	4	2	0	5
Salif	141	141	3	6	12	425	846	131	212	423	65	250
Rhisa	420	0	0	0	44	-	-	0	-	-	0	0
Mocha & Khauka	260	0	0	0	14	-	-	0	-	-	0	0
North of Kamaran & Khoba	356	356	0	9	18	-	2,136	332	-	1,070	166	500?
	1,791	547	214	56	192	518	3,167	491	259	1,585	805	

A rearrangement of these data (Walczak, 1977) were used in a 'Schaefer' type model to estimate a maximum sustainable yield of 800 t (whole weight) of shrimp. The fishing effort required to take this yield was determined as 300 boat months. (Figure 10). In the belief that there had been some incorrect reporting of data, the assessment was repeated after increasing the fishing efforts in the first two years to 286 boat months. This provided a maximum sustainable yield estimate of 1000 t (whole weight), related to a fishing effort of about 400 boat months.

Exploratory Survey of Lobster Resources, 1981

During six days in June 1981 a survey (Atkins, 1982) was undertaken by diving in water depths up to 5 m. Adjacent to Salif no lobster or suitable habitat for lobster were seen. Seven lobster (Panulirus versicolor) were observed during one and a half hours diving off Ras Khatib. However the extent of suitable habitat was judged as very limited. At Ras Isa ten lobster were observed in one and a half hours diving along the offshore edge of the fringing reef.

No lobster were sighted at Khataba, although the habitat seemed suitable. At Ras Katenib, and between Khataba to Maushij lobster were absent or rare. The reefs at Al Mulk were reported as exploited by fishermen from Djibouti who take lobster by diving. However unfavourable diving conditions prevented any lobster being observed during the survey dive. Three 40 m tangle nets set over one night at this location also failed to catch any lobster.

Observations at the fish markets and landing sites, complemented by interviews conducted with the fishermen led to the conclusion that lobster are rarely landed in the YAR.

3.8 Djibouti

3.8.1 Fishery Description and Statistics

Present landings in Djibouti (Table 3) are in excess of 400 t per year, having increased slowly since the late 1970's. The relatively small landings are related to the short coastline (about 280 km long) and the associated narrow continental shelf. The width of this shelf to 200 m depth varies from 2 to 28 km with an area of about 2280 km^2.

The fishing grounds are located to the north and south of the Gulf of Tadjura (Figure 11). Those in the north are considered the most productive and least exploited. The latter is due to the northern region not having fish storage capacity, and being distant from the main population in Djibouti (City) where most of the fish is sold.

Table 33. Catches (in tons) and catches per boat for the Gulf Fisheries operating in North Yemen, 1970-1974. From Walczak (1977)

Month	1970		1971		1972		1973		1974	
	Total	Per boat	Total	Per boat	Total	Per boat	Total	Per boat	Total	Per boat
January	-	-	82.0	3.28	48.8	2.12	23.8	2.65	19.2	3.84
February	89.2	4.87	82.4	4.58	55.0	2.39	33.0	6.61	22.8	4.56
March	84.1	5.61	46.6	2.33	32.1	1.78	35.2	3.52	23.0	4.60
April	24.0	1.20	31.5	2.62	25.6	1.42	36.4	4.04	19.5	3.25
May	0.0	-	18.4	1.67	8.7	0.48	3.5	0.43	-	-
June	0.0	-	39.9	1.73	0.0	-	-	-	-	-
July	5.9	0.35	12.9	0.56	3.7	0.34	-	-	-	-
August	35.9	2.11	74.7	3.25	-	-	7.1	1.78?	-	-
September	74.7	4.15	86.7	3.77	1.0	0.25	11.1	2.78?	-	-
October	42.7	1.78	27.5	1.19	11.7	1.95	20.0	5.00?	-	-
November	30.6	1.17	55.1	2.39	21.2	5.33	11.6	2.32?	-	-
December	94.0	3.48	57.2	2.49	44.5	4.45	29.6	4.94?	-	-
Total	481.1		614.9		252.0		210.0		84.6	

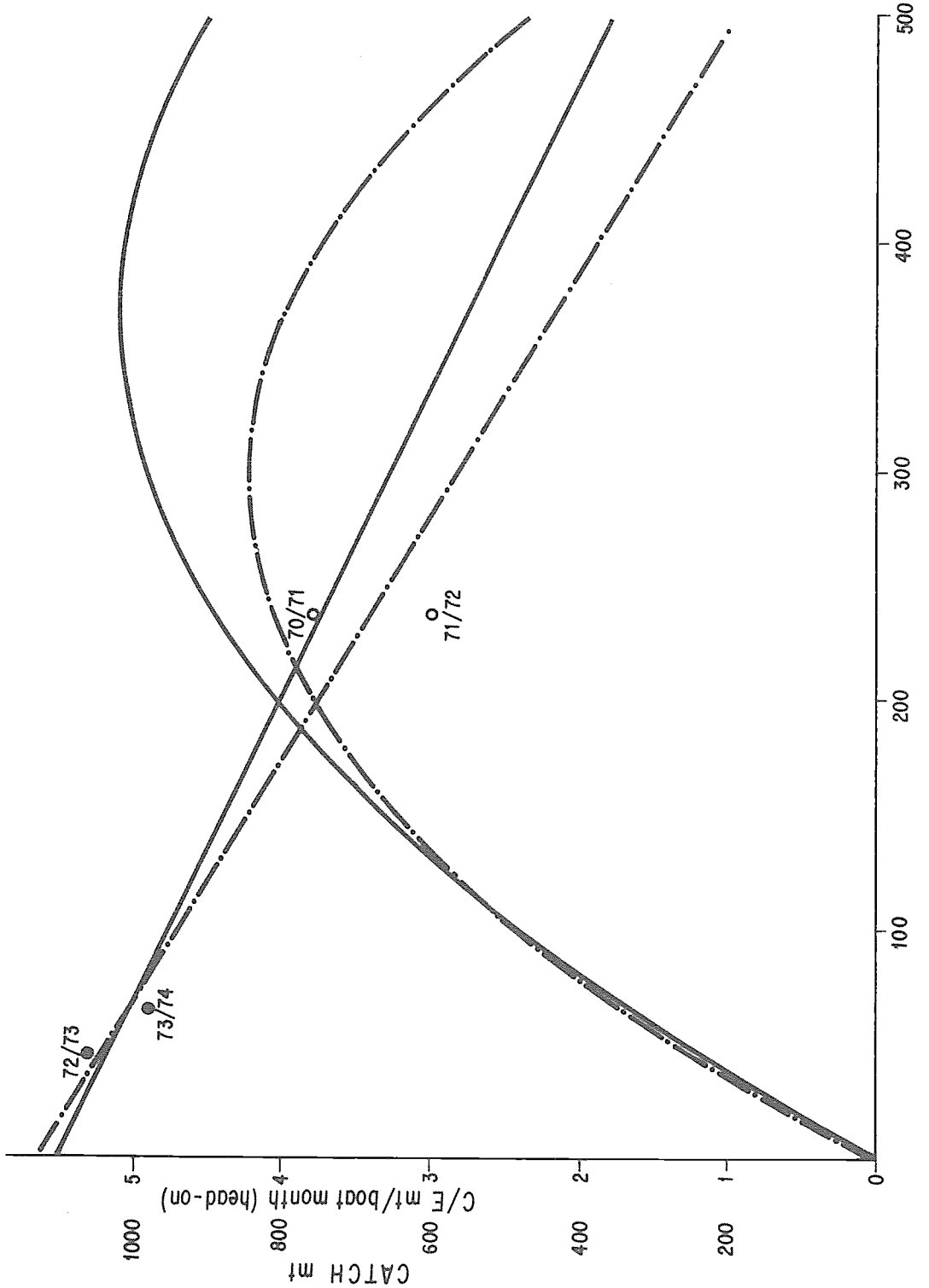

Figure 10 The observed relationships between Annual Catch (and Catch Rate) and Fishing Effort for the Shrimp Fishery of Yemen Arab Republic (from Walczak, 1977)

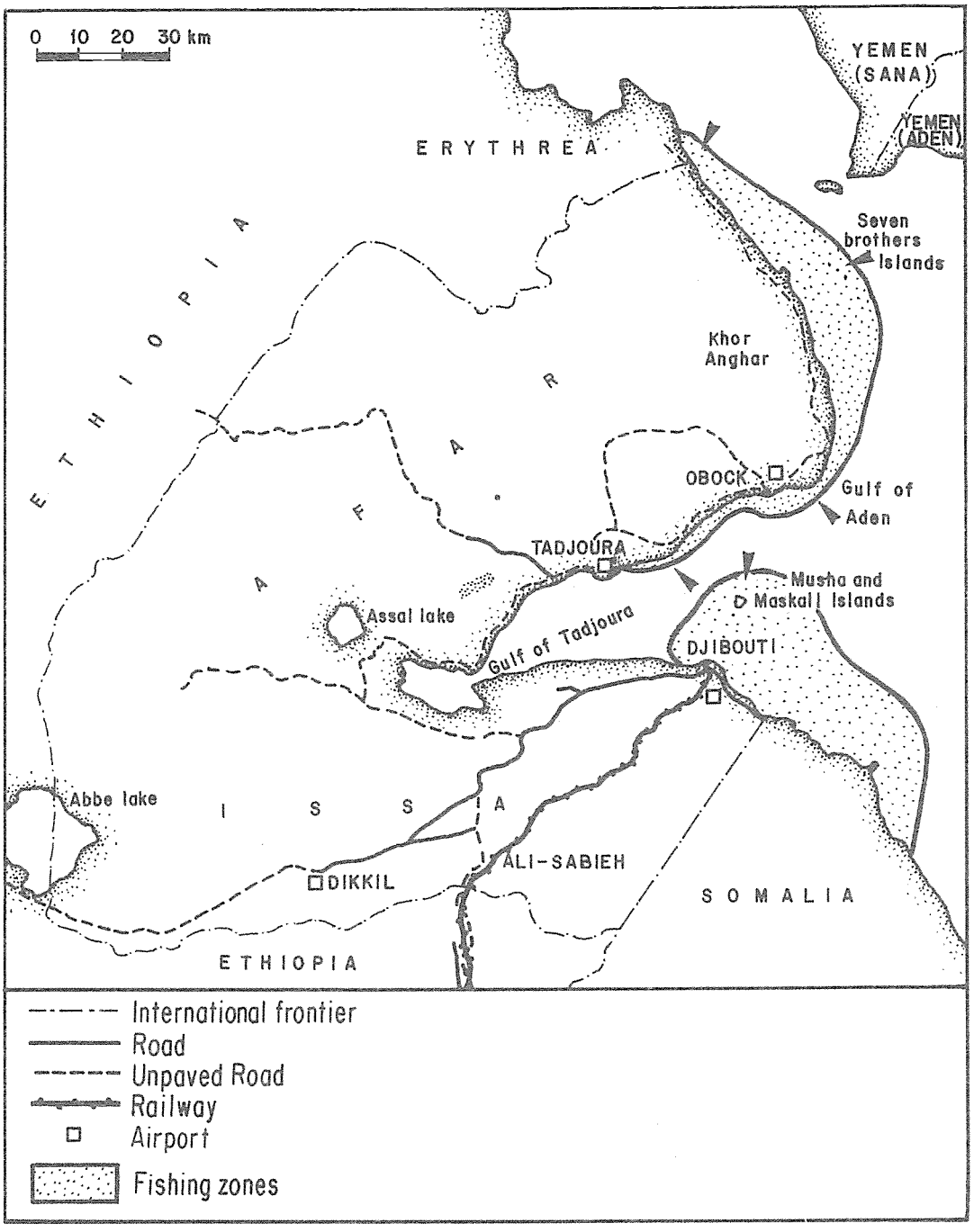

Figure 11 General location of fishing grounds of Djibouti

Fishing is entirely small-scale, with the preferred gears being ring nets handlines and troll lines. Some fish are also caught by gillnets and castnets, and lobster are caught by diving. The total population of artisanal fishermen (boatowners, family members engaged in fishing and hired crew) was determined as hardly exceeding 230 persons in 1983. (Bjoerklund and Walter-Dehnert, 1983).

Most of the fishing is from houris of 6 to 10 m length, equipped with 6 to 25 HP outboard motors. A small number of dhows are also engaged in drift gillnetting. The latter are usually manned by about five persons, have lengths of 12 to 15 m and are powered by 35 to 80 HP inboard motors.

Of the total landings in Djibouti, the majority are marketed by the Association Cooperative des Pecheurs Maritimes (ACPM) with 77% of the catch passing through the cooperative in 1983 (Table 34).

Species composition of the landings received at ACPM in 1982/83 (Bjoerklund and Walter-Dehnert, 1983) indicated that the red snappers (principally Lutjanus bohar, L. sanguineus, L. marabaricus and L. argentimaculatus) dominated the catch accounting for 23% of the annual landings. Jacks (Caranx ignobilis, Scomberoides lysan), kingfish (Scomberomorus commerson), barracuda (Sphyraena barracuda), groupers (Epinephalus tauvina, E. chlorostigma, E. areolatus) and small tunas (Euthynnus affinis, Katsuwonus pelamis) were also important components of the catch.

The rock lobster fishery for Panulirus ornatus is an important, high value fishery where landings have increased to around 4 t in recent years.

3.8.2 Resource Assessment

Limited assessment of the resources of Djibouti have been undertaken although the work that has been undertaken has concentrated on the stocks of the various important snapper species.

The catches of blood snapper (Lutjanus sanguineus) and longface emperor (Lethrinus miniatus) were sampled each month during 1982/83 at the principal landing site in Djibouti (City) (Kedidi and Bouhlel, 1985a, 1985b). Fish were measured for length on almost a daily basis. Sub-samples of fish were measured for length and weight, and aged. The latter involved examining burnt vertebrae, and also scales removed from the pectoral fin region. The stock assessment parameters relevant to describing growth, mortalities and recruitment were determined by applying a variety of methods (Table 35).

Yields per (nominal) recruit were determined using the Beverton and Holt (1957) model and plotted against both the fishing mortalities and fishing effort. The results for the blood snapper were

Table 34. Production of fish in Djibouti; from FAO (1984)

Year	ACPM (kg)	Total (kg)	Observations
1979	164,883	214,345	March till December only
1980	209,126	272,921	
1981	296,937	386,018	
1982	298,891	387,457	
1983	282,812	367,655	

Table 35. Stock assessment parameters for the blood snapper and longface emperor in Djiboutian waters; from Kedidi and Bouhlel (1985a and 1985b)

Lutjanus sanguineus	L_{oo} = 89 cm	l_c = 58.7 cm		M = 0.5
	K = 0.236	t_c = 4.3 yr		F = 0.5
	t_o = 0.281 yr	t_{max} = 13 yr (estimated)		q = 1.45×10^{-4}
	L_{oo}' = 94 cm	l_{max} = 86 cm (observed)		when f in
	K' = 0.184			fishing days
	t_o' = -1.063			
	Birthday January 1			
	Length-weight relationship ($W = aL^b$):			
	a = 9.078×10^{-3}			
	b = 3.090			
	when L in cm and W in g			

Lethrinus miniatus	L_{oo} = 82 cm	l_c = 39.3 cm		M = 0.4
	K = 0.213	t_c = 3.25 yr		Z = 0.8
	t_o = 0.183 yr	t_{max} = 14.3 yr (estimated)		q = 1.15×10^{-4}
	L_{oo}' = 90.0 cm	l_{max} = 85 cm (observed)		when f in
	K' = 0.160			fishing days
	t_o' = -0.297 yr			
	Birthday October 1			
	Length-weight relationship ($W = aL^b$)			
	a = 23.0×10^{-3}			
	b = 2.888			
	when L in cm and W in g			

interpreted as indicating that the annual catch could be moderately increased from both an increase in the fishing effort and a reduction in the length at first capture.

The possible yield increases for this species were estimated as 22 percent if the contemporary fishing effort were doubled (while keeping 1_c constant); 32 percent if the length at first capture were reduced to 1_c 40 cm (while keeping the fishing effort constant); and 42 percent if the length at first capture were reduced to 1_c = 45 cm and the fishing effort were increased to 50 percent above the contemporary value.

In respect to the longface emperor it was concluded that both the prevailing fishing effort and length at first capture were about optimal. The yield per recruit was shown as likely to increase by only some 12.5 percent from a more than 100 percent increase in fishing effort (while keeping 1_c constant). Any change in the length at first capture (while keeping the fishing effort constant) was shown to result in less yield.

The pelagic resources of Djibouti have been little investigated apart from a single exploratory cruise undertaken by the R.V. Fridtjof Nansen during a three day period in March 1981 (Myklevoll, 1982).

The survey included the entrance and the inner part of the Gulf of Tadjura, the plateau between Djibouti harbour and Musha Islands, and the continental shelf and adjacent waters between Ras Bir and the northern border. The area to the east of Ras Bir was not surveyed. A total of nine pelagic trawl shots and three demersal trawl shots were undertaken.

The main objective of the survey was to determine whether migratory small pelagic species had arrived in Djibouti waters and the equipment was accordingly set to record within the upper 200 m. The fish were scattered. No schools were recorded on the equipment, nor were any observed visually on the surface. According to the local participants the cruise had been scheduled too early and the absence of fish was not surprising. Dense concentrations of mesopelagic fish were however encountered.

The catches with the two pelagic trawls (area of opening 30 x 30 m and 25.5 x 25.5 m) were small. They ranged on an hourly rate from almost zero to 97 kg/hr (Table 36). Better catch rates up to 1030 kg/hr were achieved with the demersal trawl (Table 37).

The principal species caught were pony fish (Fam. Leiognathidae), threadfin breams (Fam. Nemipteridae) and lizardfish (Fam. Synodontidae). Small quantities of large shrimp (Penaeus sp) were taken between Djibouti Harbour and the Musha Islands.

Table 36. Pelagic trawl catches in March 1981 from Djibouti Waters. From Myklevoll (1982)

Station number (trawl type)	105(H)	106(K)	107(H)	109(H)	110(K)	111(K)	112(K)	113(K)	115(K)
Date	2.3	3.3	3.3	3.3	3.3	4.3	4.3	4.3	4.3
Hour start	2345	0110	0440	2005	2300	0125	0350	1035	1845
Towing time (minutes)	30	30	30	30	30	30	40	15	30
Position N	$11^{0}38'$	$11^{0}48'$	$11^{0}46'$	$12^{0}08'$	$12^{0}12'$	$12^{0}16'$	$12^{0}18'$	$12^{0}35'$	$11^{0}59'$
E	$42^{0}47'$	$42^{0}49'$	$42^{0}59$	$43^{0}27'$	$43^{0}39'$	$43^{0}45'$	$43^{0}27'$	$43^{0}16'$	$43^{0}28'$
Gear depth (headrope) (m)	0	50	0	0	25	30	25	25	30
Bottom depth (m)	225	?	50-166	28-78	360	312	39	43	?
Catch per hour (kg)	3.2	76.0	6.0	0.2	34.0	22.4	3.15	24.4	97.0
Total catch (kg)	1.6	38.0	3.0	0.1	17.0	11.2	2.1	6.1	48.5

Table 37. Bottom trawl catches in March 1981 from Djibouti Waters. From Myklevoll (1982)

Station Number	108	114	116
Date	3.3	4.3	4.3
Hour start (30 minutes hauls)	0735	1020	2305
Position N	$11^{o}38'$	$12^{o}35'$	$11^{o}38'$
E	$43^{o}13'$	$43^{o}15'$	$43^{o}14'$
Depth (m)	29	41	29
Catch per hour (kg)	1030	180	428
Total catch (kg)	515	90	214

A report by IFAD (1980) refers to an estimated potential yield of 5,000 t of sardines and an annual catch of 200 t from Djibouti waters by Yemeni fishermen but the basis for these figures is not reported.

The only other resource assessment work which has been carried out in Djibouti was experimental fishing undertaken in 1964/65 by the Institut Scientifique et Technique des Peche Maritimes (ISTPM, 1965; ISTPM, 1966).

Small purse seines (150 x 40 m and 220 x 45 m) were used from a small boat (13 m) and a longer pole and line boat (150 t) in 1964-65. The trials with the small net resulted in very little catch. The technique had been to locate concentrations of fish with the echo-sounder and to aggregate them near the surface by chumming.

The results with the larger net were better but still poor. Sixty percent of the sets were unsuccessful and the catch rate per fishing day averaged 104 kg. This time the operations took place during the night with the fish being concentrated through the use of lights.

During the same period experimental fishing with a beam trawl also gave generally poor catch rates. Subsequent trials in 1973-74 using a high opening net from the same 13 m boat gave catches of 30 to 350 kg/hr. The mean was reported as 120 kg/hr.

The grounds available for trawling were identified as 100 n.mile^2 (343 km^2) in extent. They were also the same as utilized by the fishermen using traditional gears. The conclusion from the experimental trawling was that it might be viable but should not be encouraged.

Trolling was reported as extensively tested, with catch rates of 40 to 150 kg/day. An average fishing day was defined as 8 hours trolling with 6 to 8 lines. A great variation in areas and seasons was observed. It was concluded to be a viable secondary method of fishing.

The principal method handlining was also tested during trial fishing. Catch rates of 0 to 300 kg/line day were reported. The possibility of lining normally demersal species in mid-water was noted.

A few trials with fish traps also occurred during 1974-75. The catches ranged from a few to 150 kg for an immersion time of up to two days. These results were judged as encouraging and further trials recommended.

Resource assessment work and marketing studies are continuing in Djibouti with assistance from various countries and particular emphasis is being placed on the pelagic and demersal stocks. There

has also been some examination of the potential for aquaculture development in the country with experiments being undertaken on edible oyster production.

3.9 Peoples Democratic Republic of Yemen (South Yemen)

3.9.1 Fishery Description and Statistics

Of the countries considered in this review, the marine fish landings of South Yemen are by far the largest, reaching around 91,000 t in 1986 (Table 3). The catch is taken along a coastline of some 1550 km with a continental shelf area of 20,255 km^2 to 200 m depth (Chakraborty, 1984c).

The fisheries are principally limited to the shelf waters, although deep sea lobster (Puerulus sewelli) and shrimps are caught along the slope in water depths to 500 m. The most productive grounds are considered to be east of Mukalla, and this is presumed to relate to the influence of local upwelling caused by the southwest monsoon.

Reasonably comprehensive statistics are provided to the the Ministry of Fish Wealth by all industrial vessels including those fishing under licence. These statistics are based on daily radio reports and give details of position, catch by species and fishing effort information. The data is collated and summarized by the Marine Science Centre in Aden and Mukhalla and used as the basis for subsequent publication of the country's fisheries statistics. Table 38 gives catches for 1986 for the industrial fleet and includes both mid-water and demersal trawling activities. Statistics from the artisanal sector are less reliable and are based on reports provided by the various cooperatives. However, it is apparent that much fish (particularly sardines) is sold outside the cooperative system and is not recorded in any statistics.

The small-scale fishing methods include the use of cast nets and seines for catching the small pelagic species, principally the Indian oil sardine (Sardinella longiceps); and mesh nets and seines for catching the larger pelagic fish, such as kingfish (Scomberomorus commerson), queenfish (Scomberoides lysan), tunas (incl. Euthynnus affinis) and the Indian mackerel (Rastrelliger kanagurta).

The reef associated species such as groupers (Fam. Epinephalidae), snappers (Fam. Lutjanidae) and emperors (Fam. Lethrinidae), and the sharks, are mainly caught by handlines and longlines.

The most productive of the small-scale fisheries is for the sardine (mainly Sardinella longiceps) in the nearshore waters east of Mukhalla. It has traditionally involved the use of cast nets, of about 12 m in diameter, which are manually thrown over near surface

schools of fish. This is done from boats of about seven metres in length powered by small outboard motors, each manned by 2 to 6 persons.

The use of small purse seines by these fishermen commenced generally during 1980-81. These nets are about 150 to 200 m in length, 7 m in depth and require to be operated from a pair of boats (of the size mentioned above). The crew number associated with each net is about eight persons, six in the boat used for shooting and recovery and two in the boat used for surrounding the fish.

Fishing for sardine by whichever method is on a daily basis. After being landed most of the catches are spread on the beach for sun drying. The dried fish is sold for use as a stock feed supplement, or as fertilizer. Only small quantities of catch are marketed fresh for human consumption.

After the fish meal plant closed in Mukhalla in 1980, the recorded catches of this species declined from around 18,000 t to about 10,000 t in 1983. The present catch is probably around the same figure with the majority coming from the traditional artisanal fisheries. The collection of statistics from this artisanal fishery is improving although it appears that a large proportion of the catch is sold outside the cooperative system or is used directly by the villagers for stock feed. Recorded cooperative production in 1985 amounted to only 1659 t and is evidently only a small proportion of the total artisanal catch.

Statistics from the Soviet industrial vessels show an increased production from 186 t in 1981 to 1272 in 1986. This however, is only a small proportion of the total production. All of the Soviet vessel's catch of sardines is frozen and marketed for human consumption. There is, at present, little or no reduction to fish meal.

During the period 1972/73 to the end of the 1980/81 season, the sardine stocks were also exploited for use as fish meal. Some twelve purse seine vessels of 25 to 30 m in length having winches and power blocks, and powered by motors of about 400 to 800 hp, were involved in supplying a floating fish meal factory at Mukalla. The fish schools were located with the assistance of sonar, and caught using nets of about 800 m in length and 80 m in depth. The number of crew on each vessel was typically about 16 persons, and fishing trips were generally of several days duration.

Prior to the demise of the large vessel purse seine fishery with the closing of the floating fish meal factory at Mukhalla, the annual landings of sardine from this source is reported as about 8000 tons. Some nine vessels were involved during these years. The mean landings

per unit effort applying to the vessels is reported as usually ranging between 10 to 20 ton/shot (Sanders and Bouhlel, 1984a).

The most important small-scale fishery in terms of its hard currency earnings is based on the rock lobster (Panulirus homarus). It is also situated along the coastline east of Mukhalla (and at Socotra Island). The fishery is seasonal, from October through April.

Although mesh nets were the traditional method of capturing lobsters, traps were introduced into the fishery in about 1985 and are now the most common fishing method. Catches in 1987 were around 400 t whole weight with the majority being processed by the Mukhalla and Dhabut Cold Stores. Most of the catch is taken in coastal areas east of Mukhalla to the Yemen-Oman border with the island of Socotra apparently being only lightly fished. An indication of the size composition of the catch can be had from the distribution of tail weights processed at the Mukhalla Cold Stores. These data, shown in Table 39, indicate that in the years 1972/73-1982/83, the fishery was exploited at a level which made further development possible and it was on the basis of these data that Sanders and Bouhlel (1984b) suggested a maximum annual yield of around 400 t whole weight.

Amongst the industrial fisheries the most important until very recently is that for the cuttlefish Sepia pharaonis. Again this is caught principally in the waters east of Mukhalla, in depths to about 120 m, although mainly in less than 50 m. The fishing season has generally been from around April through October, and the method of capture is by demersal trawling.

The vessels engaged range in lengths from 30 to 50m and include SRTM and RTM types. They include vessels operated by the Yemen Fishing Corporation, and the PDRY-USSR (Joint Venture) Expedition as well as licensed Japanese and Soviet vessels.

Annual landings had declined from a peak of over 10,000 t to some 2,200 t in 1983 amid concern that recruitment was being adversely affected by fishing activities (Sanders, 1979). However, management measures introduced in the fishery have resulted in an increase in the landings to 3850 t in 1985 and 4090 t in 1986 (Table 38). The number of vessels and number of fishing days in 1985 and 1986 are significantly less than in 1983, resulting in a marked increase in catch per vessel.

Many of the above-mentioned industrial trawlers are also engaged in catching the deep sea lobster (Puerulus sewelli) and shrimps along the outer edge of the continental shelf, at depths between 200 to 600 m. This fishery is seasonal, usually from September or October through April, largely as a consequence of a preference to deploying the vessels in catching cuttlefish during the other months (Sanders,

Table 38. Catch of Soviet-Yemeni Expedition Vessels for 1986 (Kg) Fishing in South Yemen Waters

Species	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Sepia pharaonis	3420	1170	2280	—	7140	444480	398430	459210	471930	317630	104770	12360	2222820
Peurulus sewelli	16164	25300	26226	12834	1728	13605	5283	4887	—	—	9795	76770	192592
Deepsea shrimps	59040	18972	31918	44616	15702	3004	3102	5502	—	—	13914	38944	234714
Selar sp., Decaptrus sp.	—	—	—	1290	3429	2310	870	1380	10350	489	—	—	20118
Scomber japanicus	—	—	—	1260	1404	8679	3687	1080	1500	8040	90	—	25740
Fishes grade 1	71579	31903	53286	73146	102685	4533	270	16155	27765	25018	19840	210	426390
Fishes grade 2	77838	62325	71833	126983	194450	107650	160688	106233	40931	84633	47500	1560	1082624
Fishes grade 3	20229	24054	9955	26455	33175	3683	993	4203	7752	19325	6600	210	156634
Coastal shrimp	—	—	—	—	—	—	—	32740	21787	6720	2296	528	64071
Total	248270	163724	195498	286584	359713	587944	573323	631390	582015	461855	204805	130582	4425703

Catch of Soviet-Yemeni Corporation Vessels in 1986 (kg) Fishing South Yemen Waters

Species	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Sepia pharaonis	590	—	2038	—	74753	604737	462375	372435	224180	94160	23190	8760	1867218
Peurulus sewelli	—	—	—	—	—	—	—	—	—	—	—	—	—
Deepsea shrimps	—	—	—	—	—	—	—	—	—	—	—	—	—
Selar sp., Decapterus sp.	2470	24984	1044	—	—	—	—	—	—	—	—	—	28498
Scomber japonicus	333540	89696	194680	—	—	8950	—	—	—	11928	380426	204726	1331946
Fishes grade 1	61098	21840	58932	35192	15829	590	150	22973	16853	28685	62231	111710	436083
Fishes grade 2	72982	16225	128490	70827	228156	103810	55080	182467	33363	42867	65285	101210	1100762
Fishes grade 3	65993	10485	49933	27433	29017	14180	41260	51214	5721	28906	41161	68370	433673
Coastal shrimp	—	—	—	—	—	—	—	—	1958	4076	—	—	6034
Total	536673	163230	435117	133452	347755	732267	558865	629089	282075	318622	572293	494776	5204214

1981b). The vessels are single rigged and tow nets typically with a headline length of about 55 m.

Like the cuttlefish stocks, the deepsea lobster catches have increased from 38 t in 1982 to 178 t in 1985 to 193 t in 1986 (Table 38). Again, this increase is attributable to management measures introduced to control the numbers and areas of operation of the vessels.

One result of the limitation of fishing area has been a significant decline in the catch of deepwater shrimp which has declined from 1500 t in 1983 to 235 t in 1986 (Table 38). While part of this decline is evidently related to fishing area restriction, the contribution of lower abundance to the decline is not known.

3.9.2 Resource Assessment

Reasonably comprehensive assessments have been undertaken in recent years for each of the major single species fisheries of South Yemen and these have been the basis of management measures introduced to control exploitation of the fisheries. With stocks such as the cuttlefish, the management measures have been shown to be markedly successful in increasing landings. A summary and synthesis of stock assessment work which has been carried out on the major species is as follows:

Cuttlefish (Sepia pharaonis)

Based on catch sampling data collected between 1980 and 1983, Sanders (1979, 1981a) using a yield per recruit analysis, concluded that the cuttlefish stocks were overexploited and that substantial increases in yield were likely to result from increasing the length at first capture (as much as 40 percent when l_c = 19 cm and 60 percent at l_c = 22 cm; when the sexes are considered together). The contribution from the males was identified as considerably more than the females due to their greater longevity.

In respect to the consequences on yields of changing the level of fishing mortality, it was concluded that much the same yields were available for annual fishing mortality coefficients above F = 1.0. The males were shown as greater contributors to the yields when the fishing mortalities are low, and the males and females were roughtly equal contributors when the fishing mortalities are hight.

Substantial yield benefits were shown as likely to result from delaying the commencement of the fishing season. When considering the sexes combined, the benefit was determined as 20 percent if the season was started on July 1st, and 40 percent if started on September 1st. In each case it was assumed that the same annual fishing mortalities applied, and that the season finished on October 31st.

The possibility of increasing the yields of cuttlefish by increasing the size at which they are first liable to capture, led to the conduct of mesh selection trials. (Sanders and Bouhlel, 1981, 1982a, 1982b, 1983a, 1983b). Three cruises involving the R/V 'Ibn Majid' took place, during March 1981, October/November 1981, and April 1983. The cod-end mesh sizes that were tested ranged from about 10 cm to 17 cm (as determined by an ICES measuring gauge).

The linear relationship obtained between the 50 percent selection lengths and the cod-end mesh sizes was given by

50% selection length (cm) = 2.15 x mesh size (cm) - 9.34

A plot of this relationship is given in Figure 12. On the assumption that the length at first capture for cuttlefish should be 20 cm, the relationship indicated 13.6 cm as the most appropriate cod-end mesh size.

The following relationship was also established which provided a method of forecasting the annual catch of cuttlefish from the beginning of the season catch per unit effort.

Annual catch ($\times 10^3$ t) = 1.8 + 0.5 catch per effort in May (t/st. fishing day).

This is plotted (Figure 13) and was derived for a period during which the annual fishing effort was roughly constant (Sanders and Bouhlel, 1982b).

The relationship was used to forecast annual catches of 8.2 thousand tons in 1980, 3.9 thousand tons in 1981 and 5.0 thousand tons in 1982. Corrections were made in anticipation of lower fishing efforts being applied in the latter two years. The catches actually reported for the three years were respectively 8.7 thousand tons, 2.5 thousand tons and 1.9 thousand tons.

Subsequent management of the cuttlefish stocks by restriction on the number of vessels and precise control of their areas and times of operation (Section 3.9.1) has resulted not only in a reduction in fishing effort since 1985 but also an indirect control of the size at first capture, a restriction on fishing of spawning cuttlefish and a closure of areas where the demersal eggs have been deposited. As a result of these measures, landings have increased as expected.

Deep Sea Lobster (Puerulus sewelli)

Again based on data from commercial catch sampling, Sanders (1981b), using a yield per recruit analysis, concluded that the potential yield of deep sea lobster was around 250 t of tails, some 50 t more than the 1980 landings of 200 t. Since achieving these

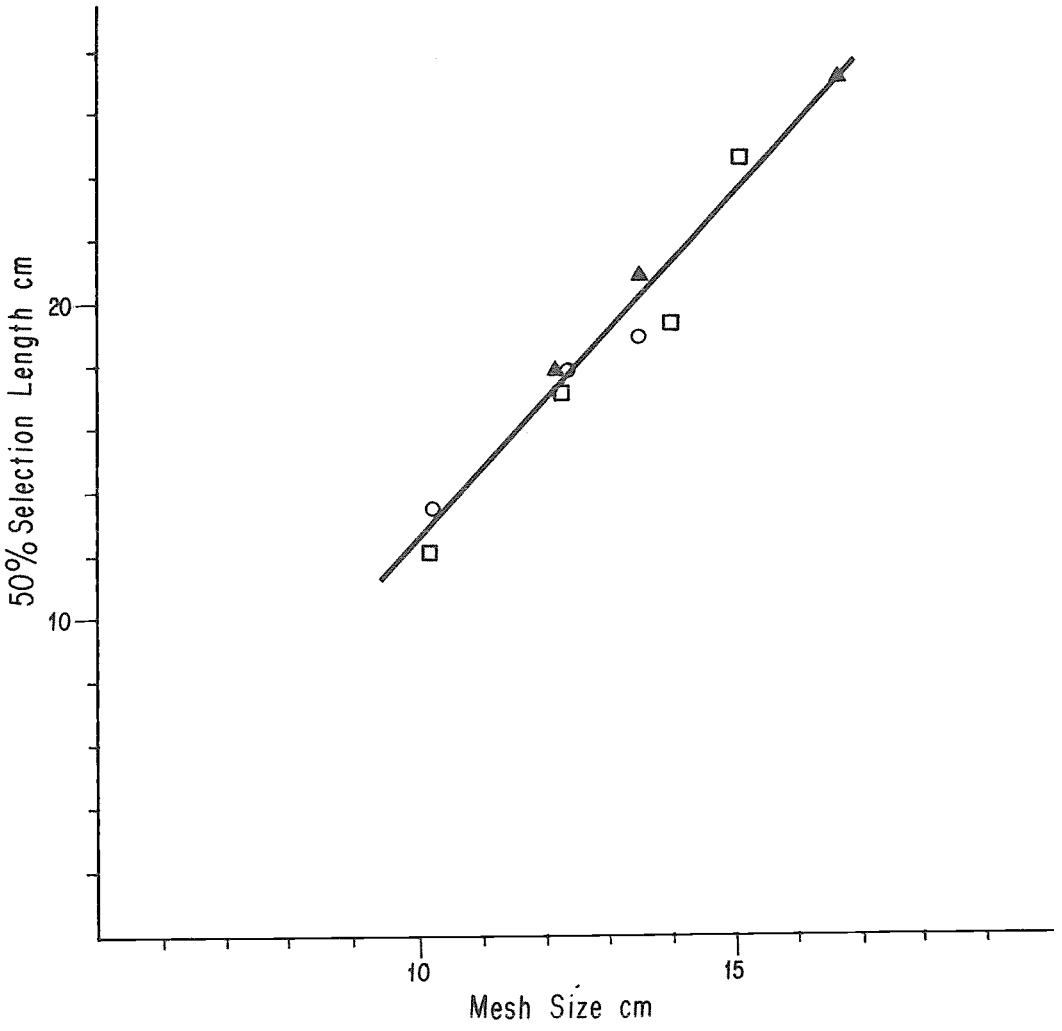

Figure 12 The relationship between the 50% selection length and cod end mesh size for the cuttlefish (Sepia pharaonis) stocks of South Yemen. (From Sanders and Bouhlel, 1983a)

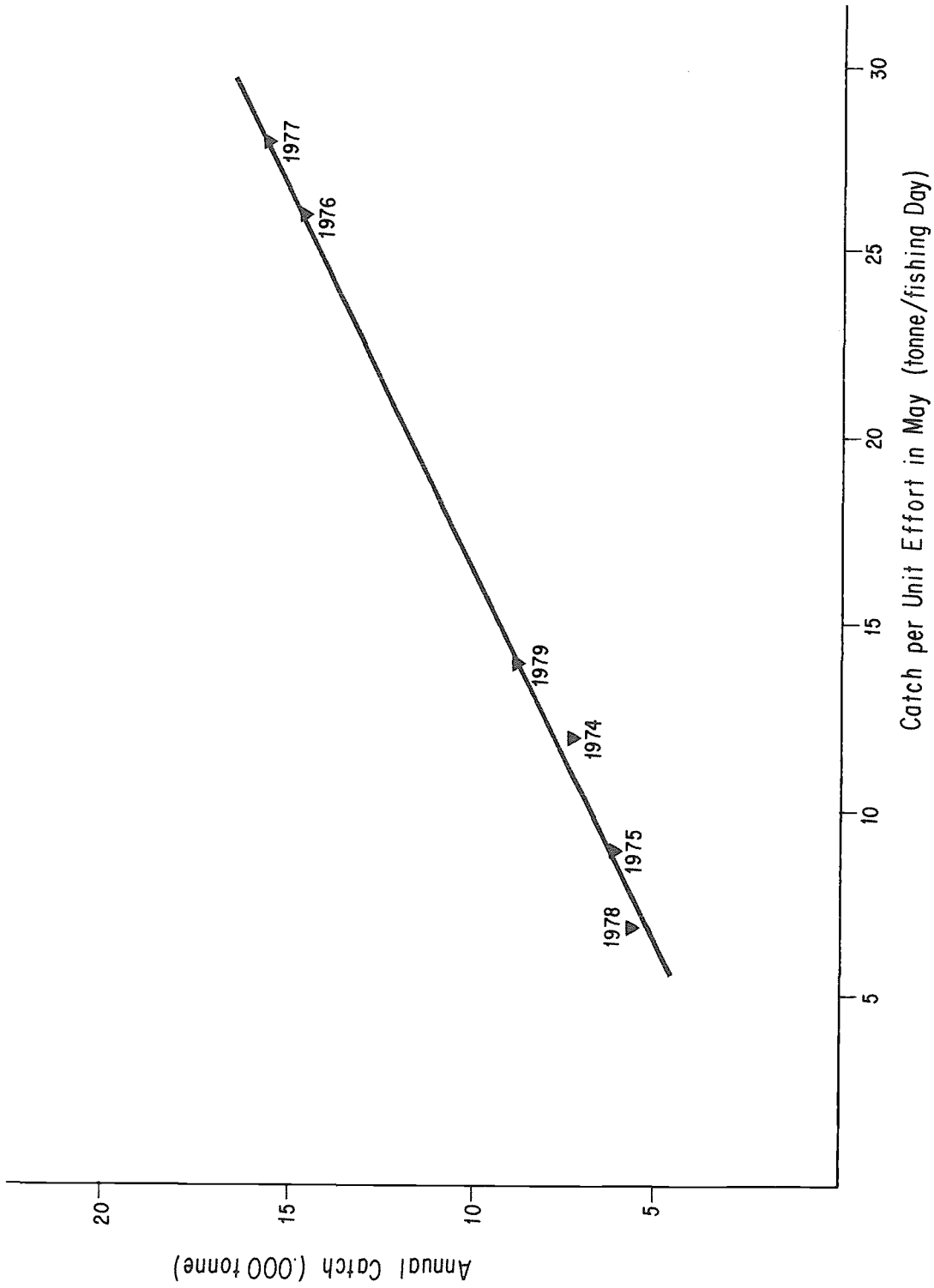

Figure 13 The relationship between annual catches of the cuttlefish (Sepia pharaonis) in South Yemen and the catch rate at the beginning of the season in May for the years 1974-79. (From Sanders, 1981a)

additional landings would require a four-fold increase in fishing effort, the practical realization of this potential was considered unlikely. The existing length at first capture was considered optimal.

The available commercial fisheries statistics were also used (Sanders, 1981b) to establish a linear relationship (Figure 14) between catch rate (in tons/standard fishing day) and the mean fishing effort, in standard fishing days, averaged over the same and the previous two years. This relationship of

$$\text{Catch rate} = 0.862 - 60.5 \times 10^{-5} \times \text{fishing effort}$$

was used to calculate the relationship between catch and fishing effort, also shown in Figure 14, which indicated a maximum yield of around 300 t at a little over 700 days fishing. A reduction in fishing effort from the 1978-1980 levels was therefore indicated. Subsequent implementation of management measures in 1985 to control the number of vessels and the areas of operation has resulted in such a reduction in fishing effort. As a result of these management measures, catches have increased in recent years (Table 38).

Indian Oil Sardine (Sardinella longiceps)

Several acoustic surveys and exploratory fishing ventures have been undertaken in South Yemen waters to assess the extent and distribution of the stocks of sardine in addition to use of commercial fisheries data in various stock assessment models.

There have been seven separate acoustic surveys involving the R/V Dr Fridtjof Nansen in each of March/April 1975 (cruise 1), September/October 1975 (cruise 2), January/February 1976 (cruise 3), April/May 1976 (cruise 4), September/October 1976 (cruise 5), March 1984 (cruise 6), and August/September 1984 (cruise 7). The extent of the study area covered during each cruise was about the same. The principle exceptions are that during the last survey there was no coverage west of Aden nor adjacent to Socotra, and a substantially greater coverage than previously in offshore waters beyond the continental shelf. This was also the only survey during the southwest monsoon.

Preliminary (FAO/NORAD, 1984) and revised (Kesteven et al, 1981) biomass estimates for cruises 1-5 in 1975/76 have been published with the later analysis indicating a biomass of 376-495 thousand tons of small pelagics on the mainland shelf together with 164-238 thousand tons of demersal species (Table 40). Potential yields for the small pelagic species were estimated (Kesteven et al, 1981) as 132-173 thousand tons for the mainland areas and 39-78 thousand tons for the area around Socotra Island.

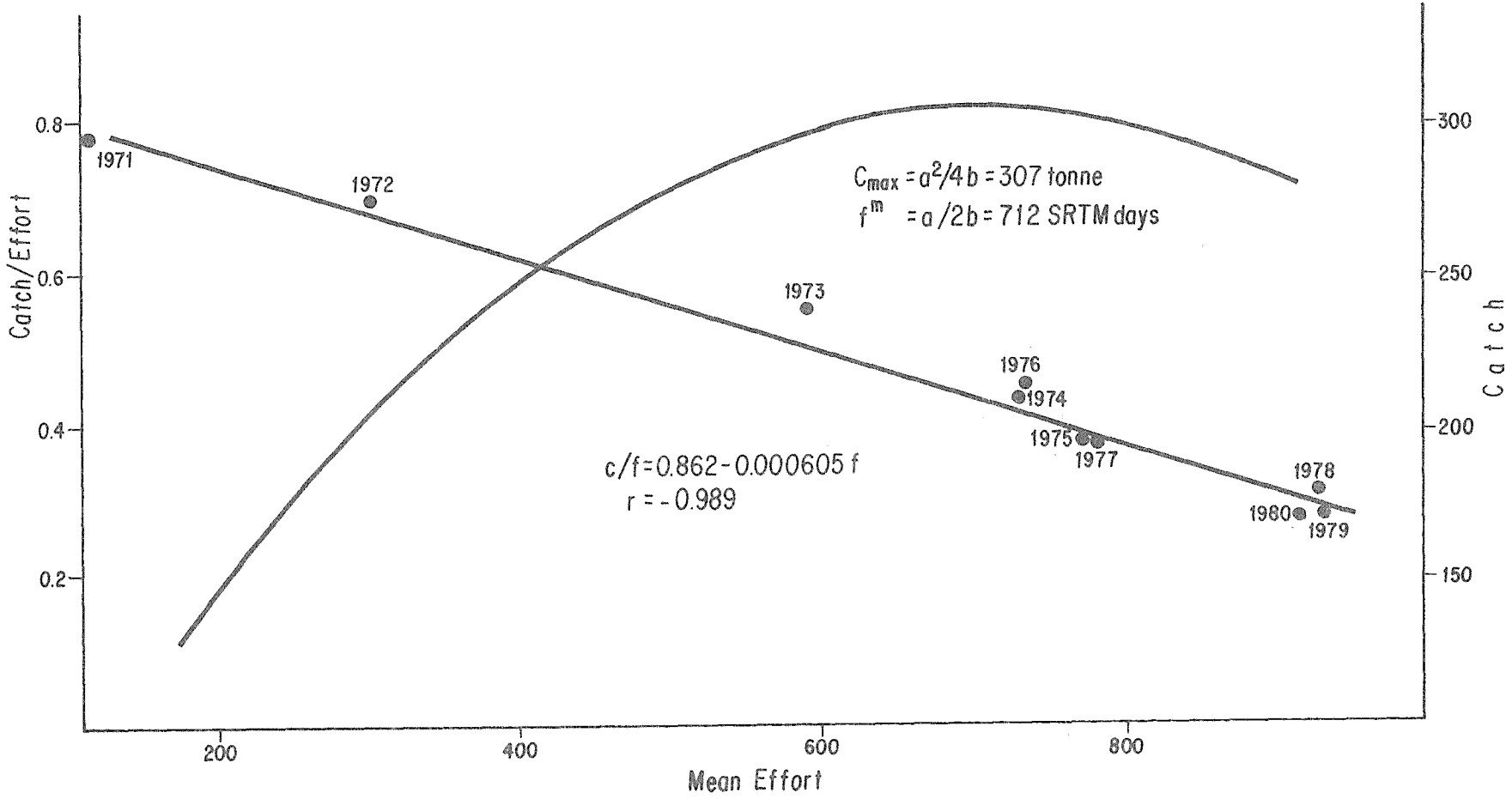

Figure 14 The relationship between annual catch (and catch rate) and mean fishing effort averaged over three years for the deep-sea lobster (Puerulus sewelli) stocks of South Yemen. (From Sanders, 1981b)

Table 39. Weights of rock lobster (P. homarus) tails packaged at the Mukalla Cold Store, South Yemen by tail weight grade and year; from Sanders and Bouhlel (1984a)

Years	Tail weight grades											Totals
	1	2	3	4	5	6	7	8	9	10	11	
	(kg)											
1972/73	5940	14720	26460	27360	23000	19200	16860	10870	13280	8040	710	166440
1973/74	6980	9450	16040	16760	16720	10500	7300	4130	4800	2820	340	95840
1974/75	12860	10770	14950	14600	15860	11040	7300	3650	3710	1870	30	96640
1975/76	12140	10930	14620	16550	13990	9390	6190	4060	2470	1060	200	91600
1976/77	4730	4530	6660	7430	9020	6190	5970	4550	2260	1480		52820
1977/78	1020	1180	2320	4970	7730	6400	7040	6500	3730	2310		44250
1978/79	1440	1880	2570	5950	7180	4620	3810	3480	2540	2850		37040
1979/80	2740	5750	5950	7730	7740	6850	5320	4050	2270	2920		51329
1980/81	2940	3180	3700	7620	9070	7170	4500	3180	1620	2280		45260
1981/82	2870	2670	3610	5220	6030	5060	4010	3510	2310	2720		38010
1982/83	6180	5620	6550	8220	8850	5580	3860	3810	1400	2210		52280

Table 40. Estimates of (maximum) biomass and potential yields for South Yemen from acoustic surveys in 1975 and 1976; from Kesteven et al (1981)

		Demersal species ('000 tons)		Pelagic species ('000 tons)	
		min.	max.	min.	max.
Yemen mainland	max. biomass	164	238	376	495
	pot. yield	29	42	132	173
Socotra	max. biomass	55	116	112	224
	pot. yield	10	20	39	78

(The maximum biomass were taken as related to the pre-exploitation values by $B_o = 0.7\ B_{max}$; and the potential yields were determined according to $MSY = 0.5\ M\ B_o$, with values for the natural mortality coefficient of $M = 0.5$ for the demersal species and $M = 1.0$ for the pelagics).

During the first of the 1984 cruises (Stromme, 1984) the schools of small pelagic fish were observed to be small and scattered. The largest and densest concentration was recorded off Aden. Ninety percent of the catch from pelagic trawling at this locality were Decapterus russelli (synonym of D. maruadsi), Rastrelliger kanagurta and Sardinella longiceps were also present.

Only very scattered recordings of demersal fish were observed, indicating a generally low abundance. Highest concentrations were found off the northeast coast of Socotra, where the extent of trawl ground is considered to be very limited due to the rough bottom. The predominant species taken in two hauls with the demersal trawl at this location were from the families Sparidae, Lethrinidae and Lutjanidae.

During the second survey period in 1984 (involving the use of higher efficiency acoustic equipment) several inshore concentrations of small pelagic fish were located, east and west of the Ras Fartak and Mukhalla upwelling areas, and east of Aden. Concentrations were also located in the offshore waters adjacent to Mukhalla. It was suggested that the latter might be a consequence of the relatively low oxygen levels in the inshore waters at this time, causing the fish to move further offshore.

The estimates obtained (Stromme, 1984) for the biomass of small pelagic fish during August/September 1984 were 125,000 t for the shelf waters and 140,000 t for the offshore waters. The latter is suggested as being an underestimate as schools were also observed in the surface waters for which the acoustic equipment is relatively inefficient. These are equivalent to potential yields of 62,500 t and 70,000 t, on the assumption of being half the biomass.

Demersal fish were detected acoustically (during August/September 1984) only in very scattered and restricted distributions, below the threshold for which reliable biomass estimations could be made. The 35 demersal trawl shots, which were distributed in a 'semi-random' pattern indicated overall mean density of 9.9 t/sq.n.m. (9 t/km^2). This was estimated on the basis of the horizontal width between the wings of the net being 18.5 m, and the catching efficiency as 100 percent.

Of the exploratory fishing trials which have been undertaken, the first was that using the R.V. Rizq-al-Bar in purse seining demonstrations between October 1970 and including a survey in the Mukhalla area in 1971 (Zupanovic, 1972), November 1972 (FAO 1973a, 1973b). A total of 867.5 t of small pelagic fish (mostly Sardinella longiceps) were landed from 291 fishing days and 125 purse seine sets. Tunas and other large pelagic species were also sighted. Potential annual yields of small pelagics were given as 280,000 t although the estimates related not only to the mainland shelf area of South Yemen

and Socotra Island but also to the northeast coast of Somalia and the southern coast of Oman.

The F/V 'Dhab Dhab' was engaged in feasibility purse seining adjacent to Mukhalla from September through December 1975 (Ellingsen, 1975). The vessel was fitted with a Simrad SK3 sonar having a searching range of 750 m. The net initially used was 220 x 37 fathom (402 x 67.7 m). An extra 22 fathom (40 m) was added partway through the trials.

The net was set 85 times during 51 active fishing days. This resulted in 2,015 t being landed, mainly Sardinalla longiceps. The overall landings per unit effort were 39.5 t/fishing day and 23.7 t/set. In addition to the quantity landed, an equal quantity was claimed to have been surrounded and then lost due to operational difficulties. The fish were most abundant just west of Mukhalla and adjacent to Ras Kalb.

The sardine were described as appearing to migrate from the direction of SSW (offshore) and thereafter to generally move northward along the coast against the prevailing current. During the daylight hours the fish were most often scattered and unable to be seined in quantity. Concentration into shallow water schools took place shortly after dark, followed by dispersion then another period of concentration during the early morning.

Sets were made in depths of 4 to 95 fathom (7 to 174 m), with some 84 percent in the range of 10 to 20 fathom (18 to 37 m). A total of 200,000 t of small pelagics are claimed to have been present during the trial period. It is reported that several times schools estimated at 100 to 200 t were observed concentrated in shallow water at night. On one occasion a concentration of "at least 50,000 t" was seen.

Assessments of the stocks of sardine based on commercial fisheries data were carried out by Sanders and Bouhlel (1984a) and related particularly to the stocks located between just west of Mukhalla and Ras Sharma.

Plots of yields per recruit against fishing mortality coefficients for S. longiceps indicated that the stock had been near fully exploited prior to the cessation of the 'large' vessel purse seining in April 1980. Increasing the fishing mortality coefficient to F = 2 (from F = 1.7 for the inshore small-scale fishery and F = 0.6 for the 'large' vessel purse seine fishery) was shown likely to produce only an additional 3,000 t above the combined annual landings of about 18,000 t (prior to April 1980).

The stock assessment parameters were also used to estimate a mean annual biomass of 21 thousand tons having a within year range between 32 thousand tons in October to 12 thousand tons in April. These

values are significantly less than the biomass estimates obtained from acoustic surveys in the same region (see above) during earlier years. This difference probably reflects not only changes in abundance and distribution of the sardine but also the fact that the acoustic surveys included other species.

With respect to comparing the affects of changing the duration of the fishing season (while maintaining the same within season fishing effort) it was determined (Sanders and Bouhlel, 1984a) that an eight months season should provide a greater yield than a five months season. Similarly, allowing the length at first capture to remain at the prevailing l_c = 14.4 cm was shown likely to be associated with higher yields than changing to l_c = 16 cm or l_c = 18 cm.

Given the high biomass estimates from acoustic surveys, the high catch rates achieved with exploratory fishing and the reduction in fishing effort on the sardine stocks as a result of the cessation of large scale industrial fishing in 1980, it is apparent that the stocks are only lightly exploited at the present time and that Sanders and Bouhlel's (1984a) estimate of an annual sustainable catch of 21,000 t would be readily achievable. However, the fishery is presently limited in its development potential by the lack of an adequate market for a product for human consumption and by the lack of an economically viable fish meal plant for industrial production. Until these constraints are overcome, the fishery is likely to remain underexploited, supplying an important stock feed source for the coastal villages of both South Yemen and Oman.

Rock Lobster

Although a survey of the rock lobster resources of South Yemen undertaken in 1963 (FAO, 1963) indicated a potential annual yield of 113-227 t whole weight for the area between Bir Ali and Qusaiyir, detailed assessments based on commercial landings data were not undertaken until 1980-1983 (Sanders and Bouhlel, 1984b). Their analysis indicated that a small (about 8%) increase in annual landings over the 1982/83 figure of around 220 t whole weight should be achievable although this would require an 85% increase in fishing effort. Fishing mortality rates were estimated as 1.2 for females and 1.5 for males compared with a value of 2.5 which would maximize yield per recruit. It was also concluded that the same yields would be obtained for any choice of tail length at first capture between 10 cm and 12 cm.

Although the assessment was based on data from the area just west of Mukhalla to Ras Fartak, an attempt was made to extrapolate the results to the other stock east of Ras Fartak, as well as to the stock at Socotra and the nearby islands. It was assumed that the productivities per length of coastline were the same for each.

In respect to the stock west of Ras Fartak, the mean annual landing during the study period was 138 t whole weight from 358 km of coastline equivalent to 385 kg/km. The lengths of coastline associated with the other two stocks is 183 km and 325 km respectively. Accordingly the potential annual yield for the stock east of Ras Fartak was determined as 70 t (35 t less than the total of the landings reported for 1982/83), and 125 t for Socotra and the nearby islands (112 t more than the landings reported for 1982/83).

With the introduction of the more efficient traps in about 1985, fishing effort on the stocks has apparently increased although this is offset to some extent by the reduction in losses due to predation or death of net caught lobsters. As a result, catches have increased to around 400 t in 1987 which is a little more than the level estimated by Sanders and Bouhlel (1984b) as the sustainable catch from all areas.

The introduction of traps to the fishery has resulted in the ability to enforce management regulations such as protection of egg-bearing females and minimum size limits. Previously, such regulation was not possible since net-captured lobsters were invariably dead or nearly so when taken from the water. However, the introduction has also made fishing effort control measures more urgent since, without such control measures, it is likely that significant increases in fishing pressure on the stocks will result both as a result of greater efficiency of the traps and by attracting additional fishermen to the fishery.

Demersal Fish Resources

A trawling survey was undertaken during a four month period in 1983/84 from the R/V Ibn Majid (Edwards et al, 1984). The trawl shots were of 1 to 3 hours duration, and were taken in depths between 10 and 90 m. The trawl net was Japanese with a 28 m headline and 65 mm mesh in the cod-end. The towing speed was 3.6 knots (6.8 km/hr), giving a swept area of 12.8 hectares per hour. The catching efficiency was assumed as 50 percent.

An estimate for the trawl fish biomass was given as 109 thousand tonne. Using a value for the natural mortality coefficient of M = 0.3 in the relationship $Y = 0.5\ MB_o$, the annual sustainable yield was suggested as 16 thousand tonne. The catch composition on the eastern trawling grounds in depths of 20-40 m contained 30 to 40 percent of non-commercial species.

During the survey, length compositions were obtained for the more abundant species, and vertebrae were dissected for the subsequent determination of ages. The lengths and weights of individual fish were also taken. These data were used to obtain estimates of the von Bertalanffy growth constants, the constants in the length-weight

relationships, and of the natural mortality coefficients (Table 41, 42 and 43).

A trawling survey was undertaken from November 1979 through November 1971 using the 38 m long F/V 'Nisshin Maru No.52'. (FAO, 1973a, 1973b). The fishing effort during this period was 533 fishing days and 2107 trawling hours. Much of the continental shelf and some of the slope adjacent to the South Yemen mainland was surveyed as well as a small area of the north Somalia shelf adjacent to Ras Asir, off the southern coast of Oman and the shelf south of Socotra. Catch rates were found to be highest in the upwelling area adjacent to Ras Fartak, particularly for the valuable cuttlefish Sepia pharaonis.

The quantity of fish landed during the study period totalled 479 t. It was suggested that this value under-represents the potential landings, as all lizardfish, catfish and mullets were discarded at sea as also were the snappers, emperors and carangids whenever good catches of cuttlefish were being obtained. The area of the trawlable fishing ground was concluded as being 7,750 sq.n.mile (26,583 km^2).

Large Pelagic Resources

Although no stock assessment analyses have been undertaken on the large pelagic resources of South Yemen, numerous exploratory fishing ventures have indicated that high catch rates and landings are achievable. Losse (1975) reported catches of 1562 kg of tuna during longlining operations in 1966/67 with a catch rate of 1.53 fish per 100 hooks.

The principal species in the catches were yellow fin tuna Thunnus albacares (63 fish of 713.5 lb (323.6 kg)), and striped marlin Tetrapturus andax (26 fish of 2,894 lb (1312.7 kg)). No fish were caught during three days, and only shark on another three days. A total of 18 shark were caught, but were not weighed because of their relatively large size.

Exploratory fishing using tuna longlines was also conducted (FAO, 1964) during the seven months from August 1962 through February 1963. Fishing locations were generally along the 100 fathom (183 m) depth contour, off the Yemen mainland from west of Aden to east of Mukhalla.

Some 1,536 tuna or tuna-like species were caught from a total of 7,349 hooks, equivalent to 20.9 fish per 100 hooks. The principal species was yellowfin tuna Thunnus albacares (sizes between 92.5 and 97.5 cm), with some bigeye tuna Thunnus obesus also being caught. The catches were considered sufficiently encouraging to justify further investigations.

Gillnetting and pelagic longlining surveys for large pelagics were carried out (FAO, 1973a, 1973b) during the fourteen months from

Table 41. Estimated von Bertalanffy growth parameters for fish species taken during trawling operations, South Yemen, 1984. From Edwards et al (1984)

Species	L_{oo}	K	t_o
Acanthopagrus bifasciatus (Forsskal)	29.8	0.25	-0.035
Alectis indicus (Ruppell)	105.0	0.17	+0.018
Argyrops spinifer (Forsskal)	57.8	0.21	+0.026
Carangoides ferdau (Forsskal)	77.3	0.21	+0.024
Cheimerus nufar	59.7	0.18	+0.022
Drepane punctata (Linnaeus)	46.5	0.19	+0.025
Epinephelus tauvina (Forsskal)	150.0	0.09	+0.007
Gnathanodon speciosus (Forsskal)	103.6	0.14	+0.015
Lethrinus nebulosus (Forsskal)	87.0	0.09	+0.540
Nemipterus japonicus (Bloch)	29.1	0.31	+0.048
Plectorhynchus pictus (Thunberg)	83.0	0.17	+0.025
Pomadasys maculatus (Bloch)	70.5	0.16	+0.019
Rachycentron canadus (Linnaeus)	160.0	0.09	+0.006
Saurida undosquamis (Richardson)	56.2	0.21	+0.026
Scomberomorus commerson (Lacepède)	230.3	0.12	+0.010
Sphyraena jello (Cuvier)	148.4	0.10	+0.009

Table 42. Estimated natural (M) and total (Z) mortality rates for fish species taken during trawling operations, South Yemen, 1984. From Edwards et al (1984)

Species	Z	M
Alectis indicus	0.35	0.40
Alepes mate	0.53	0.51
Argyrops spinifer	0.61	0.54
Drepane punctata	0.38	0.54
Epinephelus tauvina	0.31	0.24
Lethrinus nebulosus	0.44	0.44
Nemipterus japonicus	0.67	0.85
Plectorhynchus pictus	0.47	0.43
Pomadasys maculatus	0.45	0.43
Rachycentron canadus	0.48	0.24
Saurida undosquamis	0.40	0.24
Scomberomorus commerson	0.44	0.38

Table 43. Estimated length-weight parameters for the relationship $W=aL^b$ (where W is weight in gms and L is length in cm) for fish species taken during trawling operations, South Yemen, 1984. From Edwards et al (1984)

Species	Value of a	Value of b
Acanthopagrus bifasciatus	0.039	2.91
Alectis indicus	0.081	2.57
Alepes mate	0.049	2.67
Argyrops spinifer	0.111	2.54
Carangoides ferdau	0.130	2.46
Cheimerus nufar	0.044	2.80
Drepane punctata	0.040	2.91
Epinephelus tauvina	0.031	2.84
Gnathanodon speciosus	0.071	2.68
Lethrinus nebulosus	0.035	2.81
Nemipterus japonicus	0.025	2.87
Plectorhynchus pictus	0.144	2.42
Pomadasys maculatus	0.067	2.62
Rachycentron canadus	0.001	3.50
Saurida undosquamis	0.010	3.03
Scomberomorus commerson	0.011	2.85
Sphyraena jello	0.028	2.60

October 1970 with the vessels F/V 'Noqun', and F/V 'Southern Hope'. This involved 19 fishing cruises, from which 32 t of fish resulted from 1,420 gillnet sets and 5,100 hook sets. The main species landed were sharks, tuna (yellowfin tuna and bonito), kingfish, sailfish, swordfish, rock cod and others.

The biomass estimates based on combining the observations from all surveys totalled 2,307,000 t; including 1,200,000 t of small pelagics, 400,000 t of medium/large pelagics, and 600,000 t of demersal species. The potential yield is given as 360,000 t overall; comprising 280,000 t of small pelagics, 40,000 t of medium/large pelagics, and 69,000 t of demersal fish.

The above estimates relate not only to the continental shelfs along the Yemen mainland and adjacent to Socotra, but also along the northeast coast of Somalia and the southern coast of Oman.

Mesopelagic Resources

Both acoustic and exploratory fishing surveys have indicated an extremely large resource of mesopelagic fish in the Gulf of Aden and adjacent sea areas. This resource is, however, currently not exploited since no ready market presently exists for these species either in fresh or processed form.

Acoustic surveys undertaken by the R.V. Dr Fridtjof Nansen between 1975 and 1983 in the Gulf of Aden (Gjosaeter, 1983) indicated that mesopelagic species were abundant in depths greater than 150 m.

In the Gulf of Aden, Benthosema pterotum was reported as the most abundant species, although occassionally it was surpassed by B. fibulatum, Symbolophorus evermanni, Myctophum spinosum and Diaphus sp.

Whenever B. pterotum was dominant, the fish were observed to distribute during day time into an upper layer at about 150-200 m depth, with vertical extent of 20-40 m, and a lower layer centred at about 250 m depth, with a vertical extent of about 70-100 m. The distribution at night time was more diffuse, with an upper layer in the top 100 m depth, and a lower layer below 200 m depth.

In the inner Gulf of Aden the biomass of mesopelagics from the survey results ranged between 12 x 10^6 t in spring and autumn 1975, to 2 x 10^6 t in the summer 1976 (Table 44). The range in the outher Gulf was between 28 x 10^6 t in Spring 1975 and 2 x 10^6 t in the Summer 1979.

The stock densities were described as relatively high with two of the seven cruises providing stock density estimates of more than 100 g/m^2 (Table 44). The densities seem not to be related to the distance offshore. The highest values were found in the upper daytime layer,

Table 44. Abundances and mean densities of mesopelagic fish estimated for the Gulf of Aden; from Gjosaeter (1984)

	Spring 1975	Autumn 1975	Spring 1976	Summer 1976	Autumn 1976	Spring 1977	Summer 1979	Winter 1981	Winter 1983
Inner Gulf									
Abundance (10^6 t)	12	12	5	2	3	-	3	9	-
Densities (g/m^2)	120	120	50	20	30	-	25	90	-
Outer Gulf									
Abundance (10^6 t)	28	16	11	4	4	-	2	8	-
Densities (g/m^2)	187	107	73	27	27	-	11	53	-

and the greatest biomass in the lower daytime layer. At night the upper layer was most dense.

Pelagic trawling for mesopelagic resources was conducted in the nearby Gulf of Oman in 1979, 1981 and 1983 (Scharfe, 1983) and resulted in the majority of catches being in the range of 0-0.49 t/hour in 1979 and 1981 with the upper daytime layer providing the higher catch rates. After the trawl was modified for the 1983 surveys mean catch rates from 34 hauls increased to 4.7 t/hour with the upper daytime layer again providing the highest catch rates.

Stock assessment parameters have been determined for Benthosema pterotum (Dalpadado, 1983, Gjosaeter, 1981, Svasand, 1983, Sanders and Bouhlel, 1982c). This species is typically small, fast growing, and with a short lifespan of less than one year. Preliminary yield per recruit estimates from these parameters have been attempted by Sanders and Bouhlel (1982c) and Svasand (1983) with similar results.

Ages at first capture of t_c = 3 or 4 months were shown to provide highest potential yields when the fishing and natural mortality coeffcients are about equal. The associated annual yields were given as 15 x 10^6 t (for the Northwest Arabian Sea including the Gulf of Aden) by Sanders and Bouhlel (1982c) and about 10 x 10^6 t for the gulf of Oman (Svasand 1983).

It has been suggested (Sanders and Bouhlel, 1982c) that the most appropriate levels of future exploitation are likely to be considerably lower than the above, having in mind the commercial aspects such as the availability of markets, profitability, etc.

Of the other commercial fishing resources of South Yemen, no resource assessment has been undertaken apart from surveys of the potential for a bech-de-mer fishery (Gentle, 1985, Matthes, 1983). A potential yield of 55 t of dried product was estimated, based mainly on Holothuria scabra and various Actinopyga species. Some commercial exploitation of these species was reported (Gentle, 1985) during 1981-1984 when 120 t whole weight (equivalent to 12 t of dried product) was taken during 19 months fishing.

3.10 Somalia

3.10.1 Fishery Description and Statistics

The north coast of Somalia within the Gulf of Aden is some 900 km in length. It consists of a series of sandy bays interrupted by rocky promontories extending into the sea down to a shallow depth. There are neither fringing coral reefs nor bars. The continental shelf is narrow, generally only 6 km (to 200 m) except between Berbera and Zeila and northeast of Alula, where the widths reach 30 km (Figure

36). The uneven surface of the shelf is such that there are few trawlable areas, despite the general absence of coral formations.

The fishery is now almost all artisanal in nature although occasional industrial scale purse seining has been undertaken in the past (Pecker, 1982).

An artisanal tuna fishery has been conducted along the north coast for many years, producing both fresh fish for local consumption and a dried product for export to the Arabian Peninsula. During the 1930's small tuna canneries were established at Alula, Kandala and Habo. Canneries were also established at Bosaso, Elayu and Las Khoreh, but were closed after a short time due to lack of raw material. A freezing/storage facility was established near Filuch, but operated for only six months.

During the 1968/69 fishing season the canneries at Habo and Kandala were still operational (FAO, 1970). They were reported as supplied with some 621 tons (whole weight) of mainly yellowfin tuna (Thunnus albacares). This is indicated as lower than for some earlier years, such as 1962/63 when 2,523 tons were landed at the canneries by the small-scale fishermen.

During the poor tuna fishing seasons, the prices paid for dried tuna (at Aden and Mukhalla) is high with the fishermen preferring to sell to those markets rather than the canneries. It is claimed that (FAO, 1970) during the 1960s up to 80 percent of the landings were exported during poor seasons, and about 20 percent during good seasons.

The fishing gears used by the artisanal fishermen are mainly gillnets, trolling lines, short pelagic longlines and handlines. The gillnets are set across the current in water depths of 20 to 30 m. At Alula the nets may be operated all the year, whereas to the west the season is from September to May. Trolling is most successful at the beginning of the season (October) when the thermocline is shallow. Most of the fishing is done from dugout sailing canoes (houris) of 3 to 6 m length, and motorized sambuks of 8 to 10 m.

The species caught by gillnet in addition to yellowfin tuna are the longtail tuna (Thunnus tonggol), little tuna (Euthynnus affinis), kingfish (Scomberomorous commerson) and various species of sharks. East of Habo the yellowfin tuna are caught throughout the year including the southwest monsoon period. The best catch rates are reported for October and November and August in the case of the longtail tuna. The latter species is the most commonly caught by trolling.

The canneries at Kandala and Habo each operated a purse seine vessel during the 1970s mainly to provide bait for the tuna fishermen,

but also for canning and the production of fish meal during poor tuna fishing seasons. Landings of 0.5 to 1 or 2 t/boat/day are reported for November 1968/69 (FAO, 1970). Occasional sets resulting in more than 30 t exceeded the bait requirements and were not landed.

Fishing for the small pelagics is done at night around lighted dinghies. Common species in the catches are the sardines (Sardinella gibbosa, S. sirm, S. longiceps), round herring (Etrumeus teres), scads (Decapterus maruadsi) and horse mackerels (Trachurus indicus).

In addition, quantities of demersal fish are caught on the inshore grounds adjacent to Habo and Kandala. The main species are groupers (Epinephelus areolatus), snappers (including Etelis spp.), emperors (Lethrinus spp.) and various sharks. Much of the latter is dried and salted for export (Elmer, 1985).

Total landings of all species in Somalia was 16.4 thousand tons in 1986 which it is estimated that half, or 8.2 thousand tons, originated from the north coast in the Gulf of Aden (Table 3). Catches from this area, and from Somalia generally, have increased in recent years as a result of licencing of foreign fishing vessels, particularly demersal trawlers, to carry out fishing operations in the country.

3.10.2 Resource Assessment

Most of the limited resource assessment which has been carried out on Somalia's fisheries resources in the Gulf of Aden has involved exploratory fishing for tuna, beginning with a longlining survey in 1963/64 by the Italian General Fishing Company (FAO, 1970). This survey resulted in a total of 5,771 tuna being caught weighing approximately 60 t from 22,742 hooks net. The best catches were made along the edge of the continental shelf with the baits at a depth of 80 m.

Another longlining survey was conducted by the Somali Government in 1968/69 (FAO, 1970). The gear used was a short pelagic longline, with the snoods spaced at 10 to 12 m intervals along the mainline, and about 10 to 20 hooks between each buoy. The main purpose of the operation was to obtain tuna for tagging and biological studies.

The lines were set across the current direction generally adjacent to Kandala and Habo. The baits included the Indian oil sardine (Sardinella longiceps), scads (Decapterus maruadsi) and mackerels (Scomber japonicus). During the shooting operations quantities of dead baitfish were thrown into the water. The lines were constantly monitored, and whenever the buoys were noted to move or were dragged under, that section of the line was hand-hauled. This method was similar to that used by the indigenous fishermen.

The total catch from the eleven days fishing was 198 fish, including 184 yellowfin tuna (Thunnus albacares). The overall hook rate of yellowfin tuna was 13.2 percent and the average catch of fish per day was 16.7. The best tuna catches, at both Kandala and Habo, were made when the surface water temperature showed a slight rise from the previous days and the water transparency was low.

A tuna trolling survey was undertaken in 1952/53 by the F.V. Good Hope (FAO, 1970) and during 61 fishing days, 487 multiple trolling hours produced 2,998 fish weighing 12.9 t. The catches averaged 26.6 kg/trolling hour and 212.8 kg/trolling day. The little tuna (Euthynnus affinis) were most abundant in the catches which also included spanish mackerel (Scomberomorus commerson), longtail tuna (Thunnus tonggol), skipjack tuna (Katsuwonus pelamis), oriental bonito (Sarda orientalis), frigate mackerel (Auxis thazard) and yellowfin tuna (Thunnus albacares).

Pole and line live-bait fishing was also attempted. Schools of longtail tuna were 'raised' by chumming on several occasions, but no catches were made. The failure of the method was attributed to the behaviour of the fish and environmental conditions. Surface schools were rarely encountered and when present the fish (longtail tuna) sounded rapidly.

Japanese style pelagic longlines were tried during eight fishing days, when 39 fish weighing 3.8 t were caught. This included 18 shark weighing 3.6 t and eight yellowfin tuna. Other species of tuna were included in the remainder.

In 1970/71, a fishing survey using the R.V. Zheleznyakov was conducted in two parts (FAO, 1972) the first from August 1970 to April 1971 when 190 days were spent at sea. During most of this time the vessel was used as a tuna longliner. Some 3017 yellowfin tuna (Thunnus albacares) equivalent to about 21 t in weight were landed at a catch rate of generally less than 50 kg/100 hooks. The fishing locations were mainly within 40 n.miles (74 km) of the coast between Zeila and Cape Guardafui.

The vessel was also used for purse seining, mainly during the second phase from June to October 1971 when 89 days were spent at sea. In July, August and September 11.2 t were caught from 34 sets with the tuna purse seine (766 m long x 103 m height). Most of this catch was during September; 9.5 t from 23 sets. In September through November of the previous year, 2.1 t were taken in 15 sets.

The principal species were frigate mackerel (Auxis thazard), little tuna (Euthynnus affinis), longtail tuna (Thunnus tonggol) and skipjack tuna (Katsuwonus pelamis). These appeared to be most abundant in close proximity to the shore, particularly in the vicinity of capes.

In addition to the purse seining, experimental driftnetting was conducted on scattered concentrations of tuna during the second phase. A fleet of 30 driftnets (each of 30 m length x 12 m deep, with a hanging coefficient of 0.6, and stretched mesh sizes of 160, 180 and 200 mm) was set on nine occasions for a total catch of 289 kg. Included were a small number of little tuna (Euthynnus affinis) and yellowfin tuna (Thunnus albacares).

During August to November 1971 the vessel was used for trawling in the vicinity of the Ras Hafun Cape. Six shots in August with the 20 m trawl net in 18-53 m depth gave 3525 kg, including 2150 kg of "edible" fish. The catch from 4 shots in November gave 1192 kg.

These various exploratory fishing ventures for tuna do not indicate any significant unexploited resource since most of the catches were, as expected, of the same species that are presently landed. None of the surveys were of sufficient duration or geographical extent to be used for assessment of the available tuna and related large pelagic resources the north coast of Somalia. The past problems of the tuna canneries in Somalia in maintaining an adequate supply of raw material for processing may indicate, however, that these tuna resources are not large.

The only other resource assessment works reported off the north coast of Somalia were acoustic surveys and associated pelagic and demersal trawling by the R.V. Dr. Fridtjof Nansen in 1975/76 (Kesteven et al, 1981).

Five separate acoustic surveys were undertaken in the Gulf of Aden; in March/April 1975 (Cruise 1), September/October 1975 (Cruise 2) January/February 1976 (Cruise 3), April/May 1976 (Cruise 4), and September/October 1976 (Cruise 5). All included coverage of the shelf adjacent to north Somalia. The most recent of the two sets of biomass and potential yield estimates resulting from this work are shown in Table 45.

The maximum biomass estimates obtained are 67-128 thousand tons for demersal species and 128-225 thousand tons for the small pelagics. The respective potential yields were determined as 12-22 thousand tons and 45-79 thousand tons respectively. These estimates include all species, irrespective of commercial importance and density.

During all surveys the small pelagics were very scattered and the catch rates achieved with the pelagic trawl were low. It appeared that two periods of peak abundance occurs each year, with the most noticeable being during the northeast monsoon. The abundant species of interest in the catches were scad (Decapterus maruadsi) horse mackerels (Trachurus spp) and ponyfish (Leiognathus spp).

Table 45. Estimates of (maximum) biomass and potential yields for north Somalia from acoustic surveys in 1975 and 1976; from Kesteven et al (1981)

	Demersal species ($\times 10^3$ t)	Pelagic species ($\times 10^3$ t)	Combined ($\times 10^3$ t)
Maximum biomass (B_{max})	67–128	128–225	194–307
Potential yields	12–22	45–79	57–101

(The maximum biomass values were taken as related to the pre-exploitation values by $B_o = 0.7\ B_{max}$; and the potential yields were determined according to MSY = 0.5 MB, with values for the natural mortality coefficient of M = 0.5 for the demersal species and M = 1.0 for the pelagics)

Except for a single shot with the bottom trawl (when 2.2 t/hr was obtained) the catches of demersal species were also low. The steep bottom slope was described as providing poor conditions for trawling in most of the area. Ponyfish, lizardfish (Saurida spp) and trevally (Fam. Carangidae) were the most common in the catches.

These data indicate that, although the total biomass of small pelagic and demersal fish might be significant, there may be severe operational difficulties in catching and landing these fish in sufficient quantity.

4. CONCLUSIONS

The marine fisheries resources of the Red Sea and Gulf of Aden are an important component of fish supplies for the ten countries which border these sea areas and, in several cases, provide the sole source of fish. Although present total catches (Table 3) from the Red Sea and Gulf of Aden are significantly less than the various published estimates of maximum potential (e.g. Gulland, 1971 for the Red Sea and Kesteven et al, 1981 for the Gulf of Aden), the realization of these potentials must take into account not only the availability of resources but also the catching, marketing and infrastructure requirements for the development of these resources. In many countries bordering the Red Sea and Gulf of Aden these latter aspects are of greater importance than the availability of the fisheries resources.

The diverse physical and bathymetric structure of the two sea areas means that both areas support a wide range of demersal and pelagic marine resources, including such typical shallow water species as shrimp, reef associated demersal fish and lobster. Extensive upwelling areas, particularly in the eastern part of South Yemen, result in high productivity and an abundance of associated small pelagic species. These small pelagics, however, are lightly exploited and primarily support an artisanal fishery which utilizes the sundried fish for stock feed. The deeper water areas in both the Red Sea and the Gulf of Aden are apparently less productive although an important trawl fishery for deepwater lobster (Puerulus sewelli) and deepwater shrimp exists off South Yemen.

With a few notable exceptions, such as the various joint venture trawling and purse seining operations in South Yemen, the vast majority of fish are captured by artisanal fishermen using small vessels in inshore waters. There is little intraregional trade in fish and fish destined for human consumption is usually consumed in the country in which it was captured.

Assessments of the various major fish stocks which comprise the fisheries of the area indicate that, in general, the marine resources are not fully exploited and that additional catches can be taken.

However, this potential for increased catches varies greatly between species groups and many of the more important commercial species are near to their maximum potential yields.

The species with the greatest potential for increased catches are, by contrast, those small pelagic and mesopelagic species for which an industrial, rather than a food, use is the most appropriate method for their utilization. Capture of such species in the large quantities needed to justify industrial processing and marketing of the processed products currently involves significant difficulties and hence the realization of the potential of these species in an economically feasible way may present some problems.

A summary of the potential catches from available assessments of the major fish stocks in the area are as follows:

4.1. Egypt

Assessments of the major species which comprise the purse seine fishery indicate that, while the Gulf of Suez fishery is fully exploited, additional catches of about 2.9 thousand tons (principally of Sardinella species) could be taken from the area in and adjacent to Foul Bay. This increase is probably best achieved by diverting vessels from the Gulf of Suez.

Similarly, only small increases in catch can be expected from the demersal trawl fishery with the majority of this coming from the area within and adjacent to Foul Bay. Sanders and Kedidi (1981) estimated that an additional 0.4 thousand tons could be taken from this area over the 1982/83 landings of 0.7 thousand tons.

Of the reef associated species, which are mainly caught by handlining, assessment of one major species (Lethrinus nebulosus) by Sanders et al (1981) showed that, while little additional catch could be practically taken from this stock in the Gulf of Suez, both this and other species occurring in and adjacent to Foul Bay are probably capable of providing an additional 1.0 thousand tons over the 1979/80-1981/82 average annual catch of 2.2 thousand tons.

Of other species, acoustic surveys (Aglen and Myklevall, 1982) have indicated a biomass of small pelagic fish, apparently mainly Stelophorus species, of around 127 thousand tons while deepwater gillnetting surveys (Bean, 1982) have provided some indications of a resource of unknown potential south of the Gulf of Suez.

The development of these resources, however, presents difficulties from both a capture and utilization point of view and, while probably of future importance in fisheries development in Egypt, are unlikely to be of immediate relevance.

In summary, the potential for increasing catches from existing fisheries is small, amounting to additional landings of some 4 thousand tons. Most of this potential increase comes from the area in and adjacent to Foul Bay with the already important purse seine fishery contributing most of the increase through additional catches of Sardinella..

4.2 Sudan

The marine resources of Sudan are poorly known with only one species. Lutjanus lentjan, being the subject of a comprehensive stock assessment (Kedidi, 84b). Although this assessment indicated that stock of this species adjacent to the landing sites was fully exploited, areas further distant from the landing sites were considered to be capable of increased hield per recruit. This conclusion of a potential for increased catches was supported for the reef associated species as a whole by Sanders and Kedidl (1981) who showed that, by considering the average productivity of the area, the potential yield of these species was 4.0-5.0 thousand tons compared with the 1986 catch of around1.2 thousand tons (Table 1).

There is little information on which to judge the potential for development of other fisheries resources. Although commercial shrimp resources exist off southern Sudan, various attempts at their development have not been totally successful and it is likely that the resource is small. Similarly, lubster resources are both limited and are based on species which do not enter traps and, therefore, substantial development of this resource is unlikely. Bean (1985) recorded some success with deepwater gillnetting near Suakin although the development of this largely unknown resource will be difficult with the small vessels presently employed in the fishing industry. Given the present market situation for trochus shell and pearl oyster products, it is also unlikely that these resources will regain their previous importance. Perhaps the most appropriate avenue for immediate development is the diversion to Sudan of the catches of grey mullet and sardines which are presently made by Egyptian fishermen fishing on the Egyptian-Sudanese border. Such diversioncould be achieved either by development of a Sudanese capability to take these species or by appropriate economic incentives to encourage the Egyptian fishermen to land the catch in Sudan. This could contribute about an additional 1.0 thousand tons to fish supply in Sudan.

4.3. Ethiopia

Although the small pelagic fisheries resources are, based on past landings, the most important component of Ehtiopia's fisheries resources, the limitation to development of these resources is likely to be just as much market orientated as it is dependent on the availability of the resources. Accordingly, the various estimates of

potential yield (supported by data of past landings) of around 25.0 thousand tons are largely academic since development of the fishery must wait for a viable solution to product utilization to be developed.

There is apparently some potential for the further development of the fishery for large pelagic species with an upper estimate of around 5.0 thousand tons being suggested on the basis of the extrapolation of productivity data (Guidicelli, 1984). This extrapolation, however, was from an area of particularly high productivity (North Yemen) and hence this is likely to be an overestimate.

Again, extrapolation of productivity data from North Yemen (Giudicelli, 1984) has been used to estimate an annual potential yield of demersal fish of around 18.0 thousand tons, comprising 3.0-8.5 thousand tons of reef associated species and 7.0-10.0 thousand tons of demersal trawl species. This estimated potential, however, has not been supported by test fishing where catch rates were generally found to be rather modest, particularly for demersal trawling. Accordingly, it is likely that the actual potential of demersal species in Ethiopian waters is somewhat less although additional survey and assessment data is required to clearly delineate the potential.

Of other species, shrimp are known to occur along much of the coast although the lack of development of a fishery and the low catch rates from test fishing operations leads to the conclusion that the resource is not large. Likewise the significant development of the lobster resources in Ethiopia is unlikely since the fishery is based on species which do not enter traps. The fishery will therefore continue as a small scale enterprise using divers.

4.4 Jordan

Although there has been no resource assessment of the marine resources in Jordanian waters the limited fishing area available means that the potential for significantly increased catches is limited. There does not appear to be any significant potential for exapnsion of the local fishery to take new species and it is likely that landings will continue to be derived from artisanal fishermen taking reef associated species. Co-operative fishing agreements with other countries of the region (particularly Saudi Arabia) to allow Jordanian fishermen access to foreign waters appears to be the most likely and desirable development for the Jordanian marine fisheries industry.

4.5 Saudi Arabia

Fish landings have increased significantly in recent years having risen from around 13.0 thousand tons in 1983 to 22.7 thousand tons in 1986 (Table 3). Most of this increase has come from the development of a mechanized artisanal gill net fleet which takes a variety of

species including various species of jacks, emperors, groupers as well as Indian mackerel. Initial resource assessment work undertaken up to 1983 prior to the expansion of the landings, indicated that most stocks were then fully exploited with the exception of areas such as the Farasan Bank which were considered to be underexploited. The expansion of the fishery to more remote areas and the use of mechanized net and line hauling equipment has enable previously inaccessible or lightly exploited areas to be fished. The increased landings therefore appear to be a result of expansion of the fishing areas rather than increased exploitation of the stocks in previously fished waters. This increase is also consistent with the estimates made previously (e.g. Kedidi et al, 1985b, Peacock, 1978, Peacock, 1980) on the basis of extrapolation of productivity data and by considering the available areas of fishing ground. On these bases, a total potential catch of around 35.0 thousand tons was estimated compared with 1982 estimated artisanal landings of around 11.0 thousand tons. Most of the potential for increased landings was considered to be in the areas around the Farasan Bank and this is indeed where much of the increased landings have originated. Further expansion of the fishery into deeper waters is still possible and the earlier estimates of potential annual landings of around 35.0 thousand tons appear achievable with further development of the artisanal fleet.

The establishment of an industrial fishing fleet and associated processing and infrastructure facilities at Gizan has enabled the shrimp resources on the coast near to the border with Yemen Arab Republic to be exploited and catches are currently around 500 t per year. It is unlikely that significant increases in these landings can be achieved since comprehensive surveys by the fishing company operating the vessels have failed to find any additional shrimp resources in the area. Further development of the industrial fishery in the Gizan region will therefore need to rely on increased utilization of the demersal fish taken by the trawlers and development of other fisheries such as lobsters. These latter resources however are likely to be small.

4.6. Israel

The marine area in the Red Sea available to Israel is small and, as a consequence, the prospects for expansion of the landings derived from this source is limited. Some ongoing stock assessment work is carried out by national research institutions but this is mainly concentrated on the marine stocks in the Mediterranean. Israeli long distance fishing is carried out in Ethiopean waters. Similar co-operative fishing agreements with other countries in the Red Sea area appears to be the only opportunity for Israel to significantly expand its Red Sea landings.

4.7 Yemen Arab Republic

Almost all of the resource assessment work which has been carried out in North Yemen has been related to the demersal fish and shrimp stocks with no analysis of the pelagic or reef associated species having been undertaken. This is, however, currently being addressed with an ongoing research programme on some of the more important pelagic stocks (particularly the Indian mackerel Rastrelliger kanagurta) being undertaken by national research institutions.

The extent of the demersal stocks is reasonable well known to a depth of about 50 m as a consequence of trawl surveys and commercial fishing. This applies both to the fish and shrimp resources. The catch rates achieved from the various vessels when adjusted for the size of the nets were remarkably similar and, when also adjusted for the area of the trawling ground covered in the various surveys, indicate a potential yield of around 6.0 thousand tons of fish. This compares to 1986 catches of about 4.0 thousand tons of demersal trawl species.

The shrimp fishery based at Hodeidah has expanded significantly in recent years from landings of 17 t in 1984 to 432 t in 1986. Further development of this fishery is planned. Resource assessments carried out on the shrimp stocks, based both on previous commercial operations and on trawling surveys have indicated a potential annual yield of 800-1000 t. Since much of the present fishery is concentrated in shallow waters with the deeper water areas being virtually unfished, the potential landings are probably closer to the higher value of 1000 t.

Management measures of the shrimp resources have been introduced in the form of a closed season and it is likely that this managed exploitation will result in this potential catch being attained.

There have been no assessments of the pelagic or reef associated species which presently form the bulk of the 1986 landings of 22.3 thousand tons (Table 28). However, an extensive artisanal fishery exists to take these species and it is unlikely that the stocks are significantly under-exploited. Potential yields of these species are therefore probably not greatly different from present catches of some 17.0 thousand tons. However, actual landings could be increased to some extent by the landing of so-called 'third rate' species, the majority of which are presently discarded. These species comprise fish such as catfish, sharks and some of the smaller grunts. This trend is already apparent in the landings data of Yemen Arab Republic (Table 28) and should continue.

4.8 Djibouti

The limited resource assessment which has been undertaken on the fish stocks of Djibouti have concentrated on the reef associated species and acoustic surveys of the pelagic resources. Assessment of the various species of reef associated fish has indicated that in each case the resources have been capable of increased production with these potential increases averaging around 40% above the present landings. If this is applied to the total present landings of reef associated species of about 400 t, these analyses indicate a potential yield approaching 600 t. In addition to these fish, the lobster resources of Djibouti are worthy of further investigation although since the fishery is, like other countries of the region, based on species which does not enter traps, substantial development of the resource is unlikely.

Available trawling areas in Djibouti waters are limited to about 340 Km^2 and experimental demersal fishing has provided only low catch rates. The potential for such a demersal fishery would therefore appear to be limited.

Acoustic surveys of the small pelagic resources of Djibouti have been limited in extent and although they indicated that fish biomass and associated catch rates were low, their limited duration and coverage does not provide sufficient evidence for unequivocal assessment of the potential of the stock. However, even if the resources were available, the significant problem of appropriate utilization and marketing of the product would remain.

4.9 People's Democratic Republic of Yemen

Reasonably comprehensive fisheries assessments of the four major single species of South Yemen have been undertaken and, as a result of these assessments, management measures have been introduced to control exploitation of these stocks. With such suitable measures, the potential landings from the cuttlefish fishery has been estimated at around 10.0 thousand tons annually, compared with the 1986 landings of 4.1 thousand tons. These landings are increasing since reaching a low point in 1983 and it may be expected that with the continuation of the management regime in this fishery, the full potential of this fishery will be realized.

The potential landings of deep sea lobster (Puerulus sewelli) has similarly been estimated at around 250 tons and, with appropriate management measures now in place, the landings have increased from a low of 38 t in 1982 to 193 t in 1986. The maximum potential landings of 250 t therefore appears to be achievable with the current management strategy.

With the introduction of traps to the rock lobster fishery east of Mukhalla, fishing effort and landings have increased dramatically from about 240 t in 1983 to over 400 t whole weight in 1987. This latter figure is near to the maximum potential landings estimated in 1983 and hence further significant increases in landings are unlikely. In fact, an urgent management requirement in this fishery is for a mechanism for controlling fishing effort since the greater efficiency of the traps has resulted not only in high returns to the fishermen but has also attracted new entrants to the fishery on a large scale.

Althouth the most productive small scale fishery in South Yemen is the fishery for sardine, the estimated potential landings from this fishery is significantly less than present landings. This situation is unlikely to change in the near future unless an alternative use for the catch is developed. At present, the catch is dried and used as stock feed although there have been several, generally unsuccessful attempts at developing a fish meal industry based on this resource. Until such an alternative use for the resource is developed, catches are likely to remain at around the present level of some 10.0 thousand tons compared with an estimated potential of around 21.0 thousand tons.

Of the other species, there appears to be some potential for further development of the large pelagic resources of South Yemen with estimates of maximum landings being as high as 40.0 thousand tons compared with 1987 catches of around 14 thousand tons. In addition, a significant resource of small pelagic species (other than sardine) has been reported and apparently consists mainly of Decapterus russelli and Rastrelliger kanagurta. Landings of these species in 1987 were around 20.0 thousand tons compared with an estimated potential of some 40.0 thousand tons. A small shrimp fishery has developed west of Aden and catches in 1986 reached 66 t. There is apparently some scope for increased landings from this fishery although the resource is unlikely to be of major proportions.

A major unexploited resource in South Yemen are the stocks of mesopelagic fish east of Mukhalla and which are generally distributed in the sea areas off both the South Yemeni and Omani coasts. Acoustic surveys and test fishing have indicated a resource in the region of 17.0 million tons in the Gulf of Aden with catch rates being sufficiently encouraging to justify commercial exploitation. However, a major constraint to the development of this fishery is lack of markets for the fresh product and the difficulties of processing these fish for human consumption. Until these utilization aspects are solved, commercial exploitation of the resource is unlikely to be feasible.

4.10 Somalia

The important tuna fisheries of Somalia, which are mainly based on artisanal fishing activities have been the subject of various exploratory fishing ventures over a number of years. These surveys have not indicated any significant unexploited resource of tuna or other large pelagic species in Somali waters and this, combined with past problems of maintaining an adequate supply of fish for the tuna canneries, leads to the conclusion that there is little additional potential for increased catches from this fishery.

The inshore demersal fish species such as groupers and snappers are likewise probably fully exploited although there may be some potential for expanding the fishery into deeper, presently under-exploited areas. Demersal trawl fish provide greater potential with acoustic surveys (Kesteven et al, 1981) indicating a potential annual sustainable yield of 12-22 thousand tons. However, this includes all fish species and not only commercial species. Experimental demersal trawling produced only moderate catches of commercial species and this, combined with the difficult trawling conditions, would seem to limit the potential yields to the lower end of the suggested range at around 12 thousand tons annually. Various foreign vessels operating under licence and joint venture arrangements are currently engaged in this fishery.

While there has been no assessment of the rock lobster resources of Somalia, recent developments in fishing techniques adopted in Oman and South Yemen will most likely be also adopted in Somalia. This could not only increase the landings significantly from the present 1900 t but could lead to an urgent need for management of the fishery.

Of the other resources, only the small pelagics (principally Decapterus maruadsi, Trachurus spp. and Leiognathus spp.) appear to be underexploited with acoustic surveys indicating potential yields of 45-79 thousand tons annually. However, the usual problems of marketing and utilization of these resources are significant and, as a result, this potential is unlikely to be realized in the near future.

4.11 General Conclusions

In assessing the potential for further development of the marine fisheries resources of the Red Sea and Gulf of Aden, a prime consideration is not only the availability of resources but also the existing demand for specific species in the region and the ability of the local fishing fleets to take these species. With the exception of South Yemen where a major industrial fishing fleet is well established, most of the landings in the area originate with small scale artisanal fishermen. These fishermen commonly use gill nets, handlines and other fishing methods (although fish traps are curiously not a common method of fishing) to take their fish in inshore waters.

As a result of the sometimes intense exploitation on these stocks by these artisanal fishermen, there is very little potential for increased yields from these fisheries in any country of the region. What potential does exist (for example in Saudi Arabia, Ethiopia and Sudan) is dependent on expansion of the fishing areas and this, in turn, usually means the introduction of more advanced fishing methods in order to fish these areas. Such an introduction of mechanized net and line haulers in Saudi Arabia thus enabled artisanal landings to increase appreciably in recent years.

In terms of absolute landings, by far the greatest unrealized potential in the areas is for increased exploitation of small pelagic species. Such species (mainly Sardinella spp and Rastrelliger spp) provide a significant fishery only in South Yemen where, however, the stocks are grossly underexploited and the fish are used only as stock feed. Fish meal production from the resources has been carried out in the past in both South Yemen and in Ethiopia where it once constituted the major component of the fishery. Fish meal production is presently limited to a small production in South Yemen.

The constraints to the further development of a fishery on these resources is therefore very much linked to the processing and marketing of products derived from the resource since demand for the fresh product in the region is significantly less than the potential landings of the stocks.

Previous assessments of the potential of fisheries resources in the Red Sea and the Gulf of Aden have usually included these small pelagic resources and, accordingly, provided a somewhat over-optimistic view of the development prospects of fisheries in the region. Such development prospects certainly exist as indicated in detail above but their achievement will depend not only on providing the capability of exploiting the resources but also on the development of processing technology and markets for the product and establishment of suitable management measures for each fishery including, where appropriate, regional co-operation in resource management.

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M-43/T0152E/1/6.89/3000
ISBN 92-5-102832-X