

**The Regional Organization
for the Conservation of the
Environment of the Red Sea
and Gulf of Aden (PERSGA)**

Strategic Action Programme (SAP)

**Stock Assessment and Fisheries Management
of Invertebrates and Impacts of Trawl Fishing
in the Yemeni Red Sea and Gulf of Aden Coast**

Final Report

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SUMMARY

Biological and statistical data were collected in 2003 for shrimps *Penaeus semisulcatus* and cuttlefish *Sepia pharaonis* in the Gulf of Aden.

Growth and natural mortality parameters were estimated for *P. semisulcatus* in Ghubbat Al Qamar area east of the Gulf of Aden. They were $L_{\infty} = 50.7$ mm (carapace length), $K = 1.875$ year⁻¹, $t_0 = -0.072$ and the natural mortality coefficient, $M = 2.9$ year⁻¹ for males and $L_{\infty} = 61.3$ mm, $K = 1.697$ year⁻¹, $t_0 = -0.075$ and $M = 2.7$ year⁻¹ for females.

Total mortality coefficient (Z) was estimated. The values were 5.7 and 5.0 year⁻¹ for males and females respectively.

Shrimp and cuttlefish stocks in Yemeni waters are under pressure. To allow the stocks and their habitat to recover management plans were suggested.

Total allowable catch of shrimp from Ghubbat Al Qamar area was estimated as 54 tons. Biomass of cuttlefish was estimated for 2003 fishing season by trawl survey in May 2003 as 22241-29630 tons. Cuttlefish stocks suffer from biological overfishing. Total annual allowable catch was estimated as 3000 – 5000 tons.

Based on the accumulated survey data from the Red Sea shrimp it is concluded that total allowable annual shrimp catch should be 800 tons.

The discards formed high quantity of the catches which reached 90% of shrimp total catch.

The impacts of trawl fishing were explained in the view of the conflict with the artisanal fishery and the damage of the spawning and nursery grounds.

1. BACKGROUND

The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) is executing the Strategic Action Programme (SAP). The SAP provides a cooperatively developed framework for the long-term conservation and management of the coastal and marine resources of the region.

A programme of activities is being carried out through six complementary components: reduction of navigation risks and maritime pollution, the promotion of integrated coast zone management, sustainable use of living marine resources, conservation of habitats and biodiversity, the establishment of marine protected areas, and the enhancement of public awareness and participation.

As part of the activities to promote sustainable use of living marine resources in the region, PERSGA wished to assess the stock of invertebrates particularly shrimp, its current and maximum sustainable exploitation rate and the impact of trawl fishing and propose a management plan for its fisheries in Yemeni Red Sea and Gulf of Aden Coast. This work has been carried out upon the contract between PERSGA and Marine Science and Resources Research Centre (MSRRC) in Aden.

2. INTRODUCTION

Republic of Yemen lies in the south western part of the Arabian Peninsula. It has a coast line of about 2500 kilometer. There is variety of marine species in Yemeni waters. Invertebrates, specially shrimps and cuttlefish have great importance in Yemeni fisheries (Tables 1, 2 and 3). They are caught by both artisanal and industrial fleets in the Red Sea and Gulf of Aden. Stock assessment work on cuttlefish was carried out in the seventies and eighties in the Gulf of Aden (Druzhinin 1973, Ayoma *et. Al.* 1979, Sanders 1979, Sanders 1981). Shrimp stock in the Gulf of Aden was first studied in 1986 (Abdul-Wahab 1989). In the Red Sea shrimp resource was studied in the seventies (Mizuishi and Kleijn 1978, Walczak 1977, Agger 1976).

This report presents the results of the work done on stock assessment of shrimps and cuttlefish in the Gulf of Aden and the Red Sea according to the Terms of References (Appendix 1) of PERSGA for national consultants to conduct a study on stock assessment and fisheries management of invertebrates with special reference to shrimp and the destructive impacts of trawl fishing in Yemeni Red Sea and Gulf of Aden.

3. MATERIALS AND METHODS

STUDY AREA

The study areas were Yemeni Red Sea and the eastern waters of the Gulf of Aden (main fishing grounds of shrimp and cuttlefish).

DATA SOURCE

Biological and statistical data were collected:

- Through monthly sampling onboard research and fishing vessels.
- Ministry of Fish Wealth, Aden Office
- Available previous reports and studies.

DATA COLLECTION, PROCESSING AND ANALYSIS

Biological and statistical data for shrimp and cuttlefish in the Gulf of Aden were collected according to the work plan using the forms which are shown in Appendix 2. Further catch and fishing effort statistics were compiled from the Ministry of Fish Wealth. These data were processed and analyzed using the FiSAT (FAO-ICLARM Stock Assessment Tools) package software.

Bhattacharya (1967) method was used for cohorts' analysis. Gulland and Holt (1959) plot was used to estimate growth parameters as follows

$$\Delta L/\Delta t = K * L_{\infty} - K * L(t)$$

Where, ΔL is the increment in length between two times

Δt is the time needed to grow by ΔL

K is curvature parameter (growth rate) and

L_{∞} is the asymptotic carapace length

t_0 , the initial condition parameter, was estimated using Pauly (1983) formula,

$$\log(-t_0) = -0.3922 - 0.2752 \log L_{\infty} - 1.038 \log K$$

Pauly (1980) formula was used to estimate natural mortality coefficient (M) as follows:

$$\log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log K + 0.4637 \log T$$

Where T is the mean annual sea water temperature.

Total mortality coefficient (Z) was estimated using length converted catch curve (Pauly, 1983a and 1984).

Swept area method, as described in Sparre and Venema (1992) was used to estimate cuttlefish biomass and total allowable catch.

The FAO species identification sheets (Fischer and Bianchi, 1984) were used for species identification.

4. RESULTS

GULF OF ADEN COASTAL SHRIMP

The main target species is *Penaeus semisulcatus*. It is caught by trawlers in the eastern waters of the country, in Al Mahara in the area between Lat. 15° 55'N, Long. 52° 15'E and Lat. 16° 05'N, Long. 52° 18'E (Figure 1). Total catches were 157.3 ton and 139.5 tons during 2001 and 2002 respectively (Tables 1 and 2) which represent 1.1 % and 0.9 % of total industrial catch in the Gulf of Aden. In value the export of shrimp in 2002 valued 398857 US\$, Table 3, which represents 4.9 % of the total export value. The fishery is characterized by seasonality. Fishing gear used are bottom double-rig trawlers with main engines powered by less than 1000 horse power.

4.1.1. Biology

Figures 2 and 3 show the carapace length frequencies of males and females shrimp during sampling months. For males two cohorts were identified in March, two cohorts in May and two cohorts in July. For females the identified cohorts were three in March, three in May and two in July. Table 4 shows the mean lengths of the identified cohorts.

Growth

Gulland and Holt (1959) plot was applied to estimate growth parameters to the mean carapace lengths of March and May cohorts of males and the first two cohorts in May and July and the third cohort in March and May for females (Figures 4a and 4b).

The von Bertalanffy's growth parameters were estimated as:

$L_{\infty} = 50.7\text{mm}$, $K = 1.875$ for males and $L_{\infty} = 61.3$, $K = 1.697$ for females.

t_0 was found to be -0.072 and -0.075 for males and females respectively. Figure 5 shows the growth curves of males and females.

Natural mortality coefficient (M)

The relationship between carapace length and total length was obtained for males and females to estimate the asymptotic total length (L_{∞}) to be used for M estimation.. The relationship was:

Total length (mm) = $a + b$ carapace length

Where the constants a and b were found to be $a = 34.937$, $b = 2.937$, with $n = 91$ and $r = 0.939$ for males and $a = 36.501$, $b = 2.796$, $n = 60$ and $r = 0.932$ for females.

Accordingly, L_{∞} (total length) for males = 183.8mm and L_{∞} (total length) for females = 207.3mm .

Inserting these values and mean annual water temperature 25°C , obtained during sampling months, into Pauly's formula, natural mortality coefficient was estimated as 2.9 and 2.70 year⁻¹ for males and females respectively.

Length- weight relationship

The standard equation, $W = a L^b$, fitted for carapace length and total weight, where W is total weight in gram, L is carapace length in millimeter and a and b constants. The values of a and b were estimated by Abdul-Wahab (1989) as follows, $a = 0.0086$ and $b = 2.347$ for males and $a = 0.0133$ and $b = 2.237$ for females. Figures 6 and 7 show these relationships.

Total mortality coefficient (Z) and exploitation rate (E)

The values of the total mortality coefficient (Z) were estimated as 5.7 for males and 5.0 for females (Figures 8 and 9). Using these values and the value of the natural mortality coefficient (M), the exploitation rate ($E = F/Z$) was estimated. The estimates were 0.49 and 0.47 for males and females respectively.

Exploitation

The fishery is characterized by its peak in August-September, sharp decline of the catch in November and almost disappearance of shrimp in December. Table 5 gives monthly catch and effort during 1986, 1987 and 2003 fishing seasons and table 6 gives total catch and effort during 1986, 1987 and 1988. Mature females were observed during all sampling months, the highest percentage were found in October and November (Abdul-Wahab, 1988).

Due to the lack of continuous catch, effort and biological data, total allowable catch was estimated by analyzing the available catch, effort and catch per unit effort as 54 tons

(Abdul-Wahab, 1989) at 135 fishing days from Ghubbat Al-Qamar area. Due to the disappearance of shrimps from the fishing grounds in December and observation of significant quantity of juvenile shrimps in June and July 2003, the fishing season should be limited for the period August – mid October.

Species composition

The following species of shrimp were present in the catches:

<i>Penaeus semisulcatus</i>	97.6 %
<i>Metapenaeus monoceros</i>	2.1 %
<i>Penaeus indicus</i>	rare
<i>Penaeus japonicus</i>	rare

Regulations

The main regulation currently applied to protect shrimp stock in the Gulf of Aden are the closed season during the period January – June and closed areas less than six nautical miles off the shore.

Discards

All fish caught with shrimps were discarded back to the sea. The discards were estimated to be more than 90 %. Samples were taken in July 2003 to estimate the quantity and the content of the discards of some shots by recording their weight and content. Trawling was taken place in the area between Al Ghaydah and Muhayfif in depths 8-15 m, the duration of the shot was 3 hours and the average number of shots per day was 6. Table 7 gives information of three samples.

4.2. RED SEA SHRIMP

4.2.1. Stock size, Maximum sustainable Yield (MSY), and exploitation

There is little detailed information about the Red Sea shrimp fishery. However, some surveys were carried out in the seventies which gave estimates of standing stock and the MSY. Fishing season extends from September to April. The productive areas were an area adjacent to Al Luhaiya and the waterway between Kamaran and Salif. The target species is *P. semisulcatus*, although *P. monodon*, *P. indicus*, *P. japonicus* and *Metapenaeus monoceros* are also present in small quantities.

Walczak (1977) estimated the MSY of 800 ton. Mitsuishi and Kleijn (1978) recommended an annual MSY of approximately 800 tons. Losse (1973) and Walczak and Gudmundsson (1975) estimated the MSY values of 500 – 1400 tons. Figure 10 shows the total catch of shrimp in the Red Sea during 1983 – 2002.

4.2.2. Regulations

The protective regulation here is the closed season between May to August.

4.2.3. Discards

The only information available on discards quoted from Macalister Elliot and Partner (1994) which is given in Table 8.

4.3. GULF OF ADEN CUTTLEFISH

Cuttlefish resources of the Gulf of Aden were discovered by Japanese trawlers in November 1966. Commercial exploitation using three trawlers began shortly after (Aoyama and Nguyen, 1979). Fishing has generally taken place from May to November. Nine species of cuttlefish were reported by Druzhinin (1973) of which 96 percent were *Sepia pharaonis*. Fishing grounds are between Mukalla and Al Ghayda. There are some isolated fishing grounds also west of Mukalla. The fishing method used is trawling. However, recently the species have been caught by traditional fishermen using traps.

4.3.1. Biology

The biology and stock assessment of *S. pharaonis* has been studied by Sanders (1979) and Sanders (1981). There are two spawning peaks, one in February/March and the other in September. Spawning takes place in shallow waters, usually less than 30m depth. Females die after spawning, von Bertalanffy growth parameters estimated by Sanders (1981) were $L_{\infty} = 38$ cm, $K = 0.9$ and $t_0 = 0.1$ yr⁻¹ in case of males and $L_{\infty} = 29$ cm, $K = 1.7$ and $t_0 = 0.1$ yr⁻¹ for females. Prior to spawning, the females are assumed to have the same natural mortality as the males, which is estimated by Sanders (1981) as 0.3

In 2003 monthly sampling programme was carried out in March, April, May, June and July to collect biological and statistical data. Figure 11 shows the length frequencies during these months. Bhattacharya (1967) method was used to identify the cohorts and their mean lengths. Table 9 gives the mean length of the identified cohorts.

4.3.2. Biomass and Sustainable Yield

Druzhinin (1973) estimated the stock size of cuttlefish as 100 thousand tons and the MSY as 10 thousand tons.

Based on trawl surveys by the Research vessel 'Ibn Majid' and the 'Dr. Fridtjof Nansen' between 1983 and 1985, Edwards *et. al.* (1986) estimated the stock of cuttlefish to be 10 thousand tons and the suggested MSY of 3000 – 4000 tons.

Sanders and Bouhleb (1982) established a mathematical relationship between the catch per unit effort at the commencement of the cuttlefish season in May and the subsequent season's landing. The relationship is

$$y = 1.8 + 0.5 x$$

where y is the annual catch in thousand tons and x is the May catch per unit effort in tons per standard fishing day. The estimated annual catch for 1982 season was about 5000 tons. However, Marine Science and Resources Research Center used to conduct a two week pre-season survey in May in the area between Lat. 15° 30'N, 52° 10'E and Long. 16° 30'N, 52° 30'E to estimate the biomass and total allowable catch for the season. The data were analyzed using 'Swept Area Method'. For 2003 fishing season the biomass estimate was 22241 – 29630 tons and the total allowable catch was 6672 – 8289 tons (Ali, 2003).

4.3.3. Exploitation

Total catch rose from about 4000 tons in 1967 to a peak of 15000 tons in 1976 and 1977 (Figure 11). Thereafter it fell sharply to about 2000 tons in 1983. It rose again to 5000 tons in 1986, but has subsequently fallen again to about 900 tons in 1991. Fishing effort was

recorded in number of vessels for the years 1967 – 1981 and in number of fishing days for the years 1982 – 1985 and 2001 -2002, Figure 12.

In 2001 the total catch was 7297 tons and it was 2808 tons in 2002 (Tables 1 and 2) which represent 51.3 % and 17.5 % respectively of the total catch of the industrial fleet in the Gulf of Aden.

4.3.4. Regulations

The protective regulation for cuttlefish are the closed season during the period November – May and during the spawning period from 20 August to the end of September and the closed areas upto six nautical miles off the shore.

4.3.5. Discards

All fish and other species were discarded. Samples were taken from some shots in May 2003 and estimates of discards were obtained (Table 10). The survey was taken place in the area between Lat. 15° 30' N, 52° 10' E and Long. 16° 30' N, 52° 30' E in depths 35-75m. The average number of shots per day was 8-9 and the duration of a shot was one hour.

5. TRAINING

A training course was held at MSRRC in Aden in Fish Stock Assessment during the period September 2002 – March 2003 for 15 participants with the purpose of training counterparts on species identification, sampling the catch, data collection, stock assessment methods and fisheries management. The references for that course were Gulland (1969) and Sparre and Venema (1992).

6. CONCLUSION

Although biological and statistical data were collected on almost monthly basis for shrimps and cuttlefish in the Gulf of Aden in 2003, still there is a need to continue data collection for further analysis to get more information for stock assessment purposes. In the Red Sea area data collection programme was not implemented due to the lack of cooperation of the Fish Wealth Office in Hudaida.

It is clear from the data and results obtained that shrimp and cuttlefish fisheries are under pressure. The estimates of stock sizes and annual allowable catches in the Red Sea and Gulf of Aden were bewildering, they based on different ways of calculation. However, it is possible to accumulate enough information to make some estimates for planning purposes until better estimates are available.

6.1. Gulf of Aden shrimps

Some biological parameters were obtained for the first time for shrimp species *P. semisulcatus* in Ghubbat Al Qamar in Al Mahara area. These parameters can be used for stock assessment in the future when more detailed information will be available. Total mortality coefficient (Z) and the exploitation rate (E) were low. That was due to the low fishing effort during the period March- July (Table 5) which is considered as closed season. The shrimp stock in Al Mahara area exists within the six nautical miles in depths 8- 15 m which is considered as closed area. Considering this regulation, this resource cannot be exploited although the shrimps from this area are of big sizes and have the highest price. It is recommended that instead of total banning of fishing some management

measures should be applied for the exploitation of shrimps. Taking into account the results obtained here such as the decline of the catch in November, high percentage of females in the last gonad maturity stage from which it can be concluded that the spawning season is December – March and the presence of juvenile shrimps in significant quantity in June and July. The following management plan can be considered:

- 1- Fishing season should be scheduled from 1st August to mid October.
- 2- Total allowable catch of 54 tons to be approached.
- 3- Fishing effort should be around 152 fishing days for the fleet.
- 4- Fishing should strictly prohibited out of the recommended fishing season.

6.2. Red Sea shrimp

In the Red Sea there is no detailed and accurate information on catch and effort. The estimate of annual sustainable catches is between 500 – 1400 tons. Currently shrimp stocks are already heavily exploited by industrial fleet and illegal foreign vessels. The following management plan is put until detailed information can be obtained:

- 1- Fishing season should be reduced to the period October – February.
- 2- Total allowable catch should be at 800 tons.
- 3- Number of fishing vessels should not exceed 20 vessels.
- 4- Fisheries data collection programme should be implemented urgently through sampling the catches onboard industrial fishing vessels.

6.3. Cuttlefish

Cuttlefish stocks have declined since the 1970's when more than 15000 tons of cuttlefish were caught in 1976 and 1977 fishing seasons. The catch ranged between 5000 tons to 8000 tons in the years 1997-2001. It declined again in 2002 to about 2800 tons. This year, 2003, information from the Ministry of Fish Wealth, Aden Office, indicates that the total catch of cuttlefish during the first half of the year reached 5000 tons, which means good season. It is obvious that this fishery have suffered from overfishing over the last 30 years. Based on trawl surveys of the cuttlefish stocks, it appears that total allowable catch should be between 3000-5000 tons each season. Fishery management plan should be introduced and effectively enforced to allow the stocks and their habitat to recover.

The following management plan should be considered :

- 1- Carrying on pre-season survey in May every year to estimate the biomass and total allowable catch.
- 2- Total annual catch to be between 3000 – 5000 tons.
- 3- Fishing season to start after the survey on the 1st. of June.
- 4- Fishing should be prohibited during the period 20 August – 30 September for spawning.
- 5- Trawling should be prohibited in depths less than 30 meters.
- 6- Fishing effort should not exceed 15 fishing vessels.

6.4 Monitoring control and surveillance and Fisheries Statistics

- There is a need to define new criteria for selection, recruitment and employment of inspectors placed on industrial vessels for reporting the catches and effort. Level of education, background and sense of responsibility should be taken into consideration.

- Present arrangements for fisheries data collection should be revised. Data should be collected to allow catch, effort and catch per unit effort analysis.
- Formal channels for information exchange should be established that clearly define the responsibilities as regards the various users of the data.

6.5 Impacts of trawl fishing

The impacts of trawl fishing can be seen clearly on the cuttlefish fishery. One of the most direct reasons for the decline of cuttlefish catches is the biological overfishing. Trawling in the shallow depths over the past thirty years has removed not only the hard structures that provide egg-deposition substrate for spawning, but also has damaged huge quantity of eggs.

Other impacts observed in the shrimp fisheries are the conflicts between the artisanal and industrial fisheries. Industrial trawlers are known to destroy stationary artisanal gear when they pass through inshore waters.

In addition the large amounts of trash fish that discarded at sea cause environmental pollution due to their decay and reduce the fish landings of the artisanal fleet.

To reduce these impacts the following should be considered:

- 1- Trawlers should have fish meal plants and should deliver the fish meal to the nearest fishing harbor or landing site.
- 2- Arrangements with local boats to collect the valuable discarded fish by-catch and deliver that to local fishermen villages.

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Table 1. Monthly catch, effort and catch per unit effort (c.p.u.e) of the industrial fleet in the Gulf of Aden in 2001 (from Kedidi,2002)

Month	Catch (kg)					Effort		c.p.u.e.						
	Fish	Cuttlefish*	Shrimp	Other Molluscs**	Total	Fishing days	Shots	Fi/day	Fi/shot	Cutt/day	Cutt/shot	Sh/day	Sh/shot	Tot/day
Jan	477648	99437	3797	15934	596816	218	986	2191.0	484.4	456.1	100.8	17.4	3.9	2738
Feb	401799	371730	0	4614	778143	227	1087	1770.0	369.6	1637.6	342.0	0	0	3428
Mar	324340	526114	12188	6865	869507	282	1363	1150.1	238.0	1865.7	386.0	43.2	8.9	3083
Apr	496261	339713	0	809	836783	277	1383	1791.6	358.8	1226.4	245.6	0	0	3021
May	238432	167823	0	584	406839	237	1054	1006.0	226.2	708.1	159.2	0	0	1717
Jun	280568	1597360	6316	384	1884628	486	2635	577.3	106.5	3286.7	606.2	13.0	2.4	3878
Jul	624176	1491867	6932	4632	2127607	549	2645	1136.9	236.0	2717.4	564.0	12.6	2.6	3875
Aug	481152	614016	20940	27185	1143293	553	2632	870.1	182.8	1110.3	233.3	37.9	8.0	2067
Sep	248589	483425	19868	38867	790749	343	1541	724.7	161.3	1409.4	313.7	57.9	12.9	2305
Oct	667576	1046134	38871	124632	1877213	680	3009	980.3	221.9	1536.2	347.7	57.1	12.9	2757
Nov	1244281	420532	14502	16278	1695593	644	1210	1932.1	1028.3	653.0	347.5	22.5	12.0	2633
Dec	1011920	138616	33854	39150	1223540	514	2631	1968.7	384.6	269.7	52.7	65.9	12.9	2380
Total	6496742	7296767	157268	279934	14230711	5011	22176	1296.5	292.96	1456.15	329.04	31.38	7.09	2839.89

* Cuttlefish, *Sepia pharaonis*

** Other mollusks: other cuttlefish species and squids

Table 2. Monthly catch, effort and catch per unit effort (c.p.u.e) of the industrial fleet in the Gulf of Aden in 2002

Month	Catch (kg)					Effort		c.p.u.e.						
	Fish	Cuttlefish*	Shrimp	Other Molluscs**	Total	Fishing days	Shots	Fi/day	Fi/shot	Cutt/day	Cutt/shot	Sh/day	Sh/shot	Tot/day
Jan	609463	341380	0	22220	973063	434	2586	1404.3	235.7	786.6	132.0	0	0	2242
Feb	915137	423482	0	21228	1359847	437	2616	2094.1	349.8	969.1	161.9	0	0	3112
Mar	1749136	162514	0	2958	1914608	535	2575	3269.4	679.3	303.8	63.1	0	0	3579
Apr	1380145	126467	0	1800	1508412	464	1963	2974.5	703.1	272.6	64.4	0	0	3251
May	934185	308133	0	1368	1243686	514	2255	1817.5	414.3	599.5	136.6	0	0	2420
Jun	1320825	651859	0	7176	1979860	697	3452	1895.0	382.6	935.2	188.8	0	0	2841
Jul	734996	130278	28071	7315	900660	605	3032	1214.9	242.4	215.3	43.0	46.4	9.3	1489
Aug	554644	74510	52305	13366	694825	569	2757	974.8	201.2	130.9	27.0	91.9	19.0	1221
Sep	653817	193382	22548	11711	881458	561	2411	1165.4	271.2	344.7	80.2	40.2	9.4	1571
Oct	1335156	146267	11498	52600	1545521	712	3408	1875.2	391.8	205.4	42.9	16.1	3.4	2171
Nov	1262189	205103	7021	18118	1492431	618	2944	2042.4	428.7	331.9	69.7	11.4	2.4	2415
Dec	1444034	44577	18036	25334	1531981	597	2735	2418.8	528	74.7	16.3	30.2	6.6	2566
Total	12893727	2807952	139479	185194	16026352	6743	32734	1912.2	393.9	416.4	85.8	20.7	4.3	2377

*Cuttlefish, *Sepia pharaonis*

** Other mollusks: other cuttlefish species and squids

Table 3. Exports of the companies worked according to quota system in 2002:

Company	Product								Total weight(kg)	Total value (\$)
	Frozen fish		Cuttlefish		Squid		Shrimp			
	weight(kg)	value (\$)	weight(kg)	value (\$)	weight(kg)	value (\$)	weight(kg)	value (\$)		
Chinese Company	2627846	1182531	853575	1536435	27447	49405	2070	16560	3510938	2784931
Nishtun Company	3608365	1623764	844413	1519943	11525	20745	1670	13360	4465973	3177812
Mayon Company	1111469	500161	657265	1183077	4419	7954	2090	16720	1775243	1707912
Economic Corporation	111590	50216	27482	49468	719	1294	14410	292505	154201	393483
Raydan Corporation	75	34	-	-	-	-	7464	59712	7539	59746
Total	7459345	3356706	2382735	4288923	44110	79398	27704	398857	9913894	8123884

Source: Ministry of Fish Wealth, Aden Office.

Table 4. Mean carapace length of the identified cohorts of *P. semisulcatus* during sampling months in 2003:

a. Male

Month	Cohort 1	Cohort 2	Cohort3
March	33.0 mm	42.2 mm	-
May	37.8 mm	44.5 mm	-
July	35.3 mm	43.2 mm	-

b. Female

Month	Cohort 1	Cohort 2	Cohort 3
March	32.0 mm	40.4 mm	53.3 mm
May	34.6 mm	41.6 mm	55.2 mm
July	41.1 mm	46.7 mm	-

Table 5. Monthly catch and effort during sampling months in 1986, 1987 and 2003:

Month	1986		1987		2003	
	Catch (t)	Fishing days	Catch (t)	Fishing days	Catch (t)	Fishing days
March					4.138	15
April						
May					3.64	10
June					2.238	7
July					8.345	16
August	34.5	49	13.5	38	2.822	11
September	21.6	65	12.3	40		
October	6.9	38	10.2	50		
November	2.5	17	1.5	20		

Table 6. Catch, effort and c.p.u.e of *P. semisulcatus* during 1986 -1988

Year	Catch (t)	No. of shots	Fishing days	c.p.u.e	
				ton/shot	ton/day
1986	65.5	1529	170	0.043	0.385
1987	49.4	1672	186	0.030	0.266
1988	31.4	446	50	0.070	0.628

Table 7. Catch composition of samples from three trawl shots of shrimps in July 2003

Species	Weight (kg)		
	Sample 1	Sample 2	Sample 3
Breams	7.400		
Grunts	2.750	1.000	5.500
Catfish	1.500	9.000	5.000
Sardines	2.250	4.000	3.500
Croakers	1.500	8.000	7.500
Lizardfish	1.000		3.000
Ponyfish	0.250		
Rays	1.500	0.500	1.000
Sailfish	0.500		
Crabs	5.250		
Mantis shrimp	0.700		
Cuttlefish	0.250		0.500
Flounder		4.000	2.500
Porcupinefish		4.000	3.000
Sharks		1.500	5.000
Hairtails		1.000	
Damaged fish	2.000	2.000	3.500
Sample weight	26.850	35.000	40.000
Total shrimp retained	5.000	64.000	56.000
Total weight discarded	200.000	500.000	700.000

Table 8. Catch composition (kg) of four trawl shots in three different areas in the Red Sea

(from MacAlister Elliott and Partners, 1994)

Area 1 - “Ghubb Dknan” (south of Salif), depth 30m.

Area 2 - North of Kadaman Island, depth 24m.

Area 3 - Northern approaches to Salif near Kamaran Island, depth 25m.

	Area 1	Area 1	Area 2	Area 3
Shrimp	133	84	107	180
Shrimp retained	100	67	80	130
Juvenile <i>Carangoides</i> (Dollarfish)	672	374	622	550
<i>Nemipterus</i> (Butterfly bream)	366	148	16	48
<i>Arius</i> (Catfish)	219	120	70	43
<i>Saurida</i> (Grinners)	61	64	114	98
<i>Pomadysis</i> (Janlin)	39	26	28	88
<i>Gerres owyena</i> (Silverbiddies)	12	15	32	150
<i>Terapon</i> (Grunts)	27	15	26	3
<i>Sphyaenella</i> (Pike)	47	25		
<i>Tetraodontids</i> (Puffer fish)	28	16	3	5
<i>Rastrelliger kanagurta</i> (Indian mackerel)	19	10		
Juvenile <i>Lethrinids</i> (Emperors)	5	3	6	3
Other fish	16	8	15	5
Fishe retained	15	12	15	50
Total fish	1562	836	947	1043
<i>Portunus pelagicus</i> (Blue crab)	5	5	40	68
<i>Sepia sp.</i> (Cuttlefish)	5	3	60	15
Total	1654	916	1154	1306

Table 9. Mean mantle length of the identified cohorts of *Sepia pharaonis* in 2003

Month	Mean length (cm)			
	Cohort 1	Cohort 2	Cohort 3	Cohort 4
March	11.4	18.0		
April	10.4	16.1	20.7	
May	14.8	20.7	26.5	33.8
June	18.1	28.7	33.3	36.7
July	17.2	21.2	30.9	

Table 10. Cuttlefish and discards weight (kg) of four shots in May 2003

	Shot 1	Shot 2	Shot 3	Shot 4
Cuttlefish	468	1150	850	1000
Discards	1032	1250	2150	3000

The discards consisted mainly of the following species:

- Hairtails (*Trichiuridae*)
- Breams (*Nemipteridae*)
- Seabreams (*Sparidae*)
- Croakers (*Sciaenidae*)
- Lizardfish (*Synodontidae*)
- Goatfish (*Mullidae*)
- Porcupinefish (*Diodontidae*)
- Crabs (*Portunidae*)

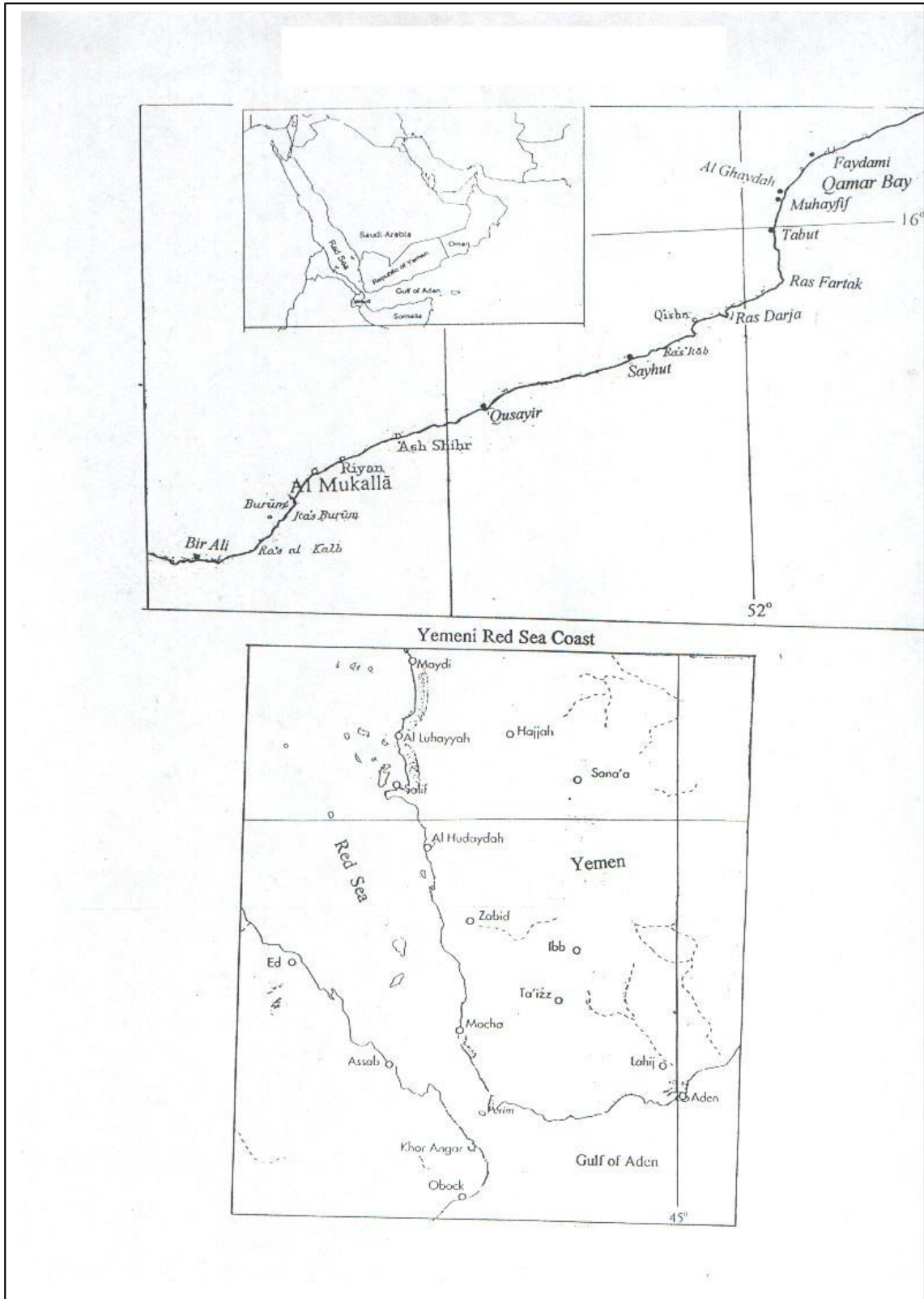


Figure 1. The Eastern Coastline of Yemen in the Gulf of Aden

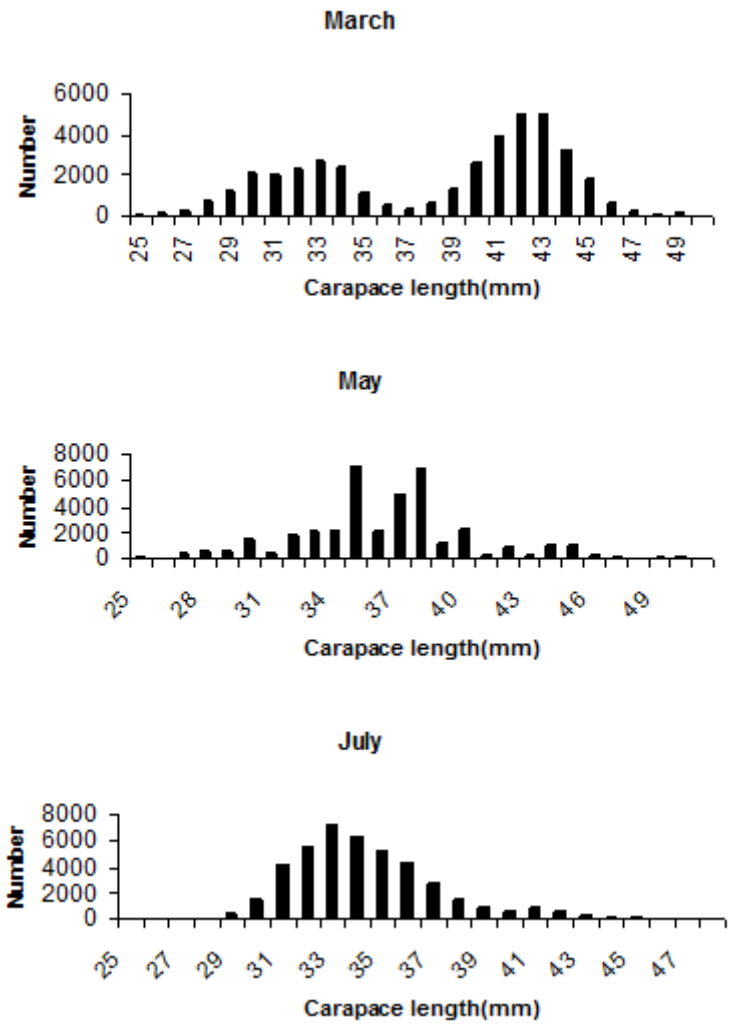


Figure 2. Length frequency of male *P. semisulcatus*

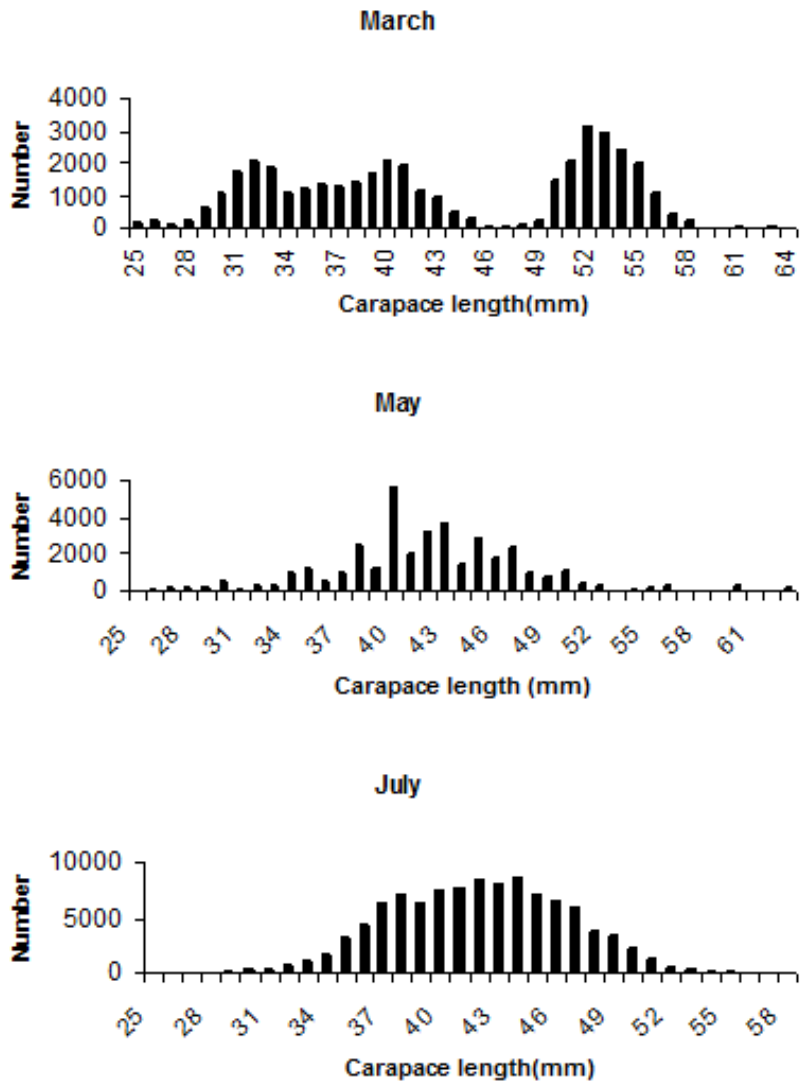


Figure 3. Length frequency of female *P. semisulcatus*

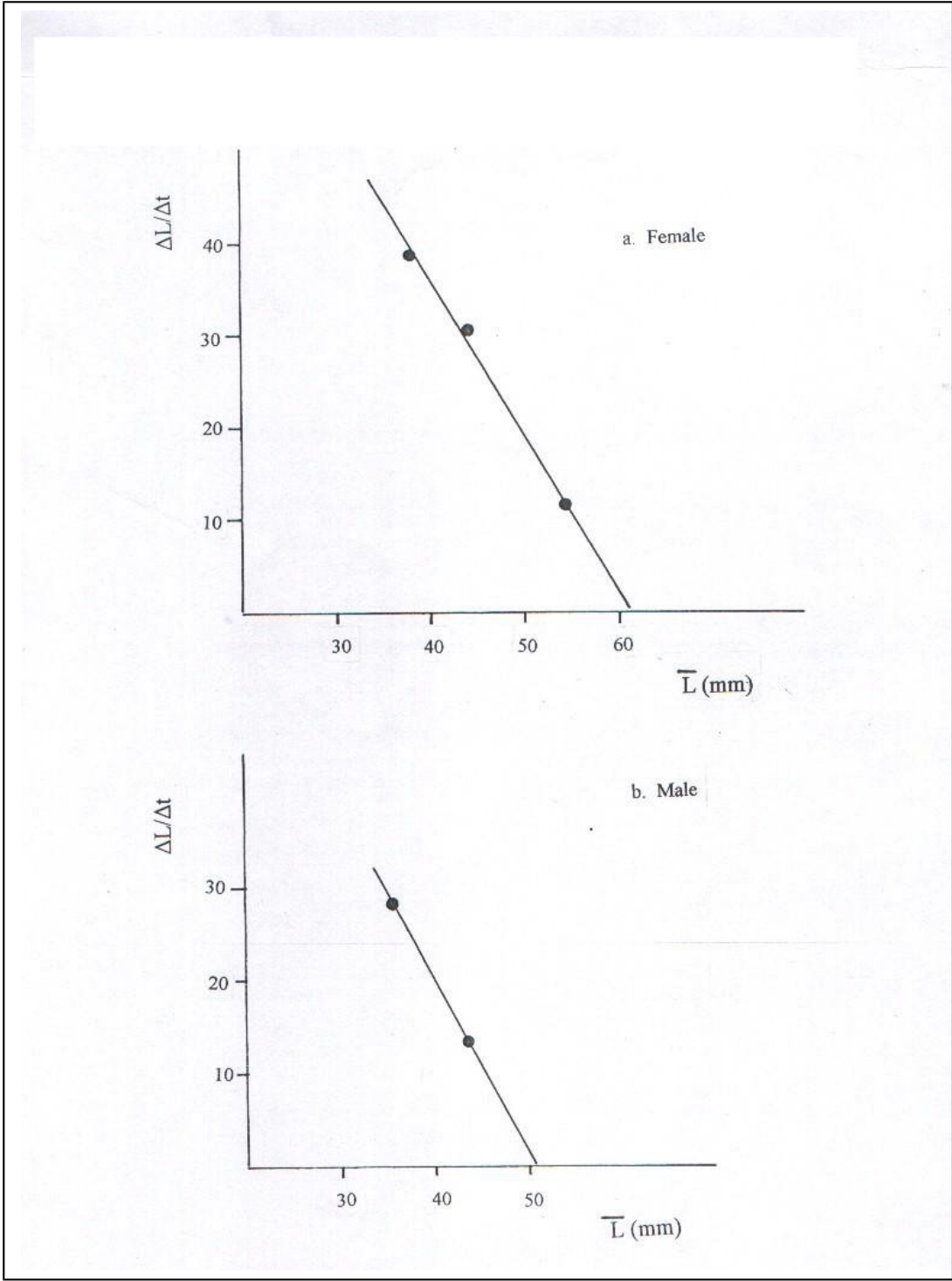
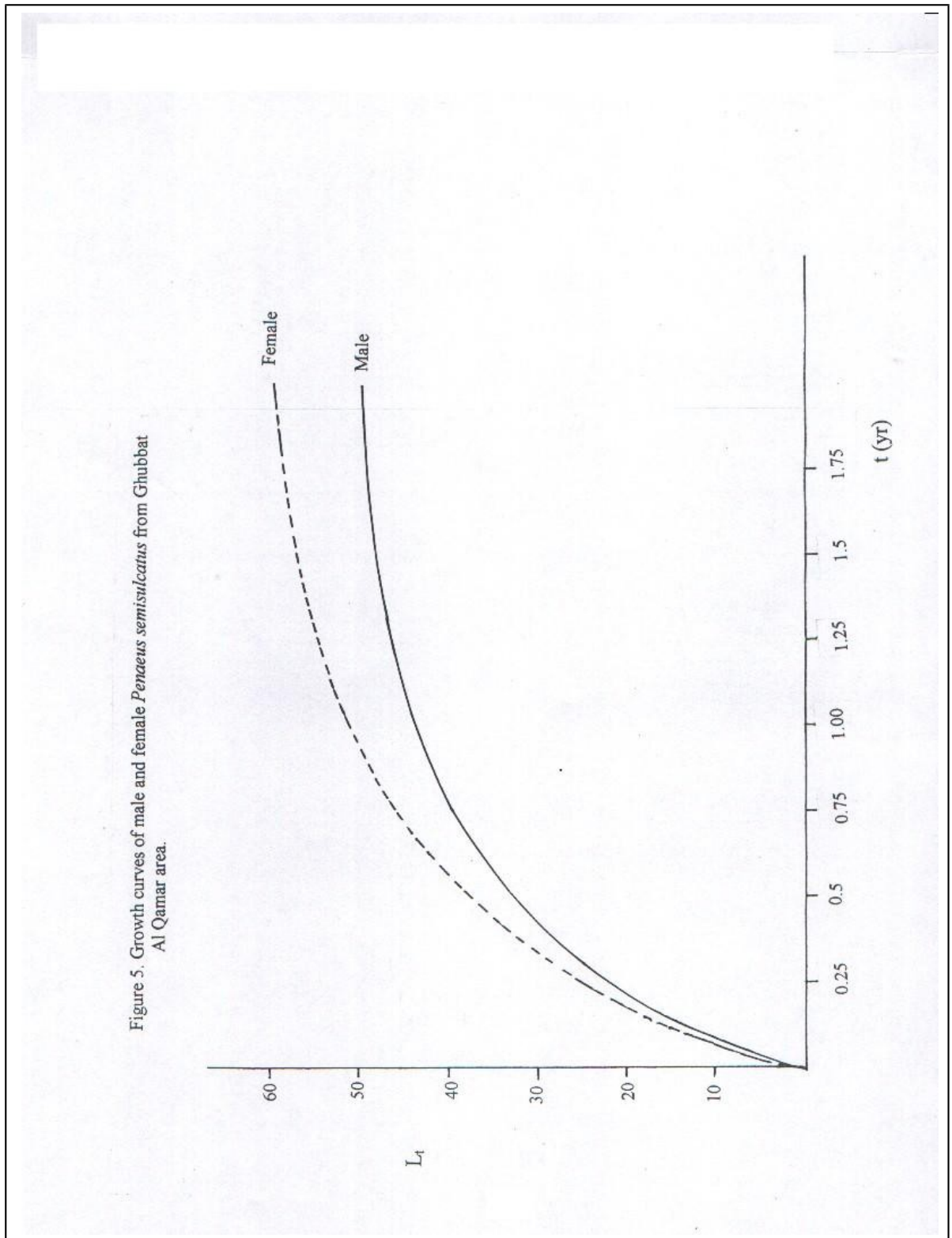


Figure 4. Gulland and Holt plot for female and male *P. semisulcatus*



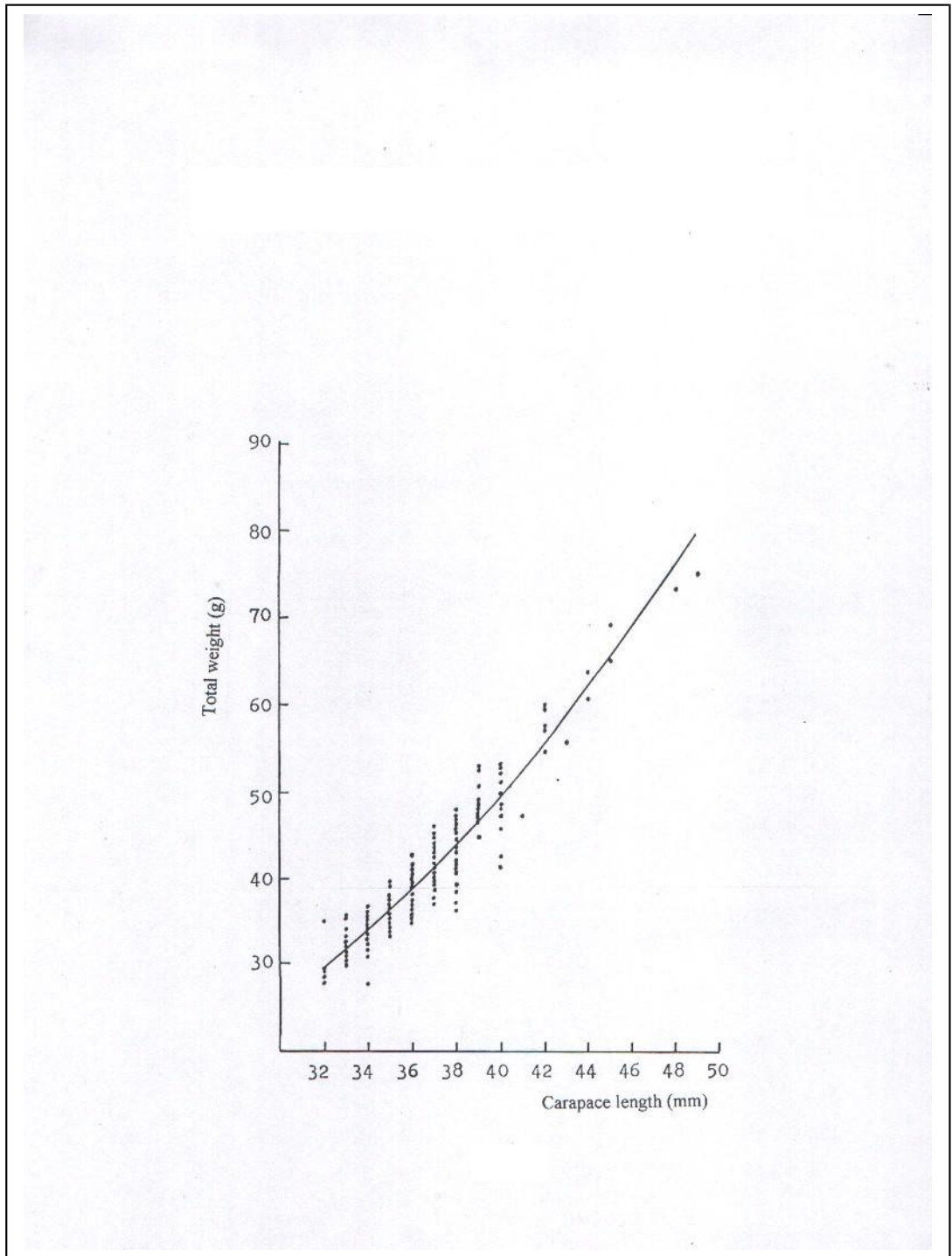


Figure 6. Total weight plotted against carapace length of male *P. semisulcatus*

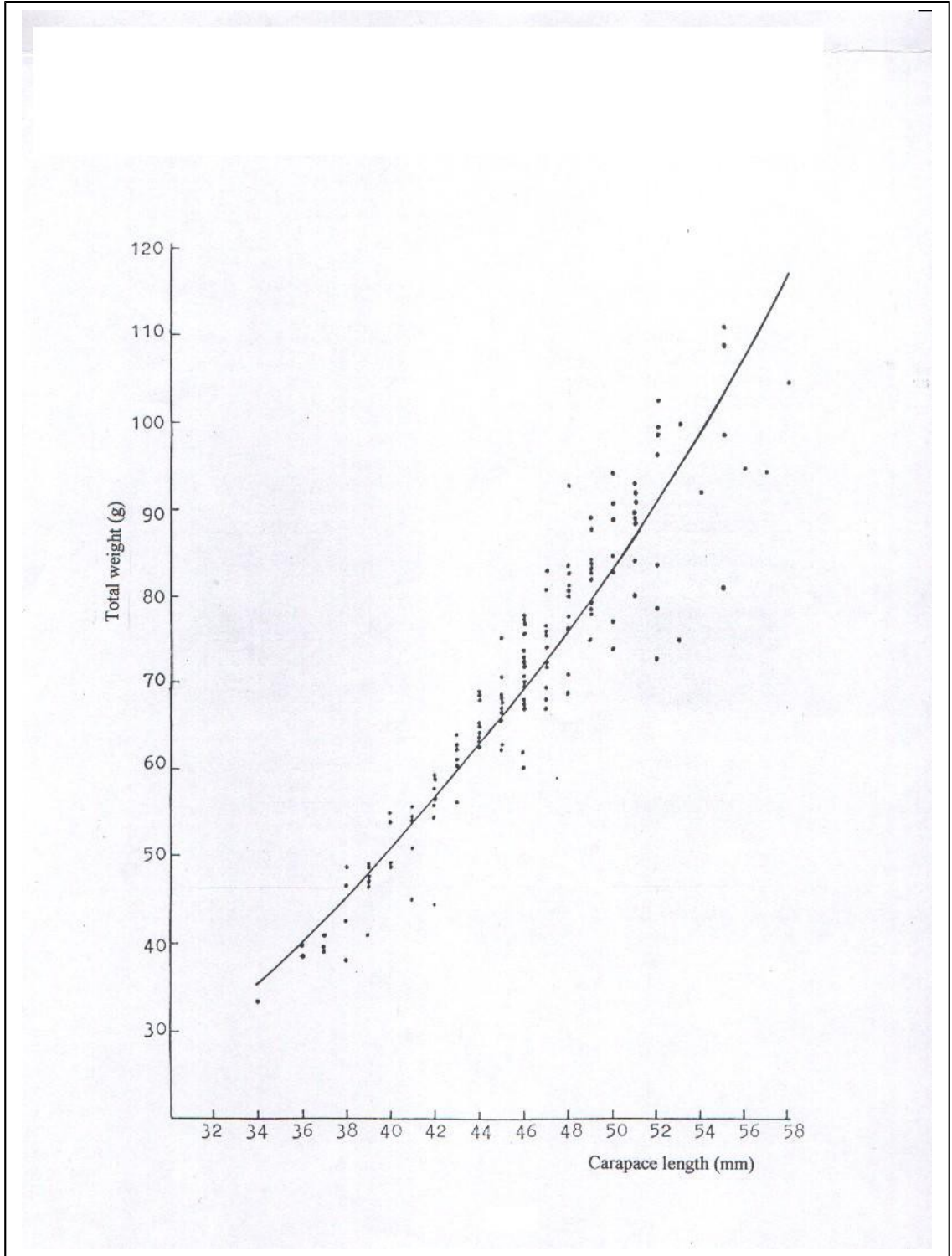


Figure 7. Total weight plotted against carapace length of female *P. semisulcatus*

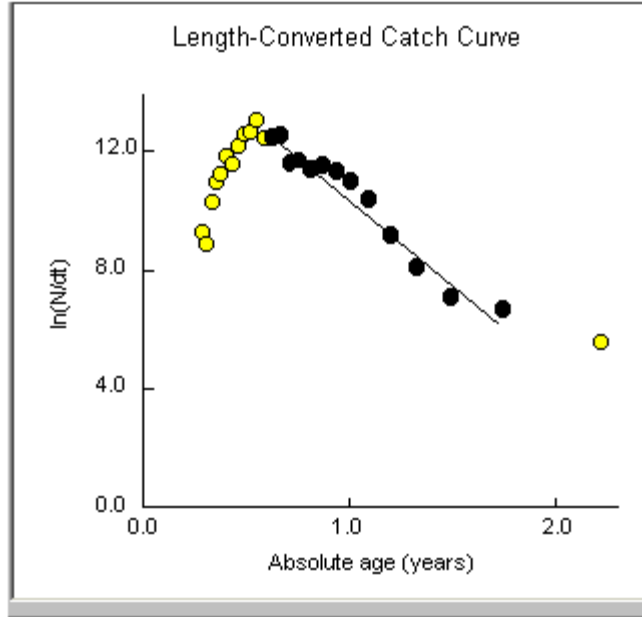


Figure 8. Length converted catch curve of male *P. semisulcatus* from the Gulf of Aden

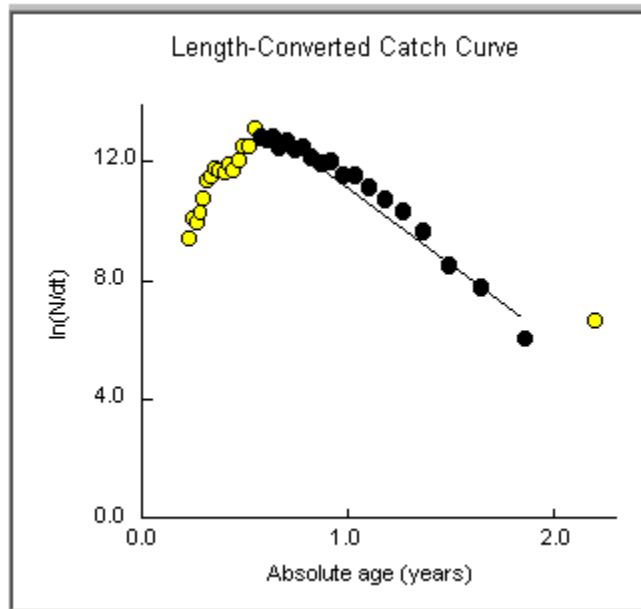


Figure 9. Length converted catch curve of female *P. semisulcatus* from the Gulf of Aden

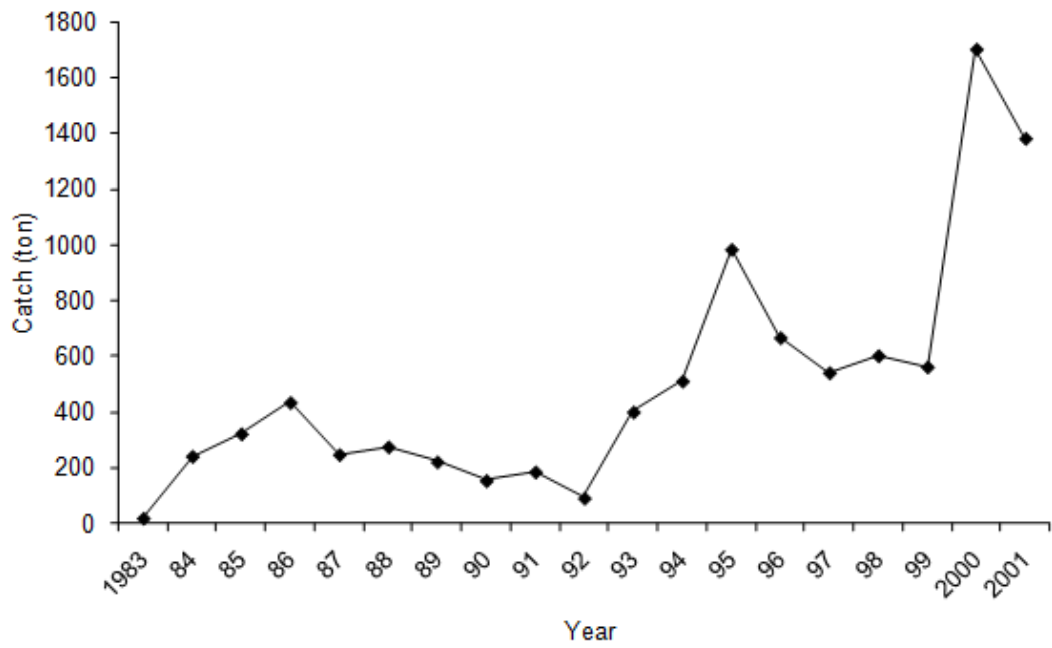


Figure 10. Total catch of shrimps in the Red Sea area during 1983-2002

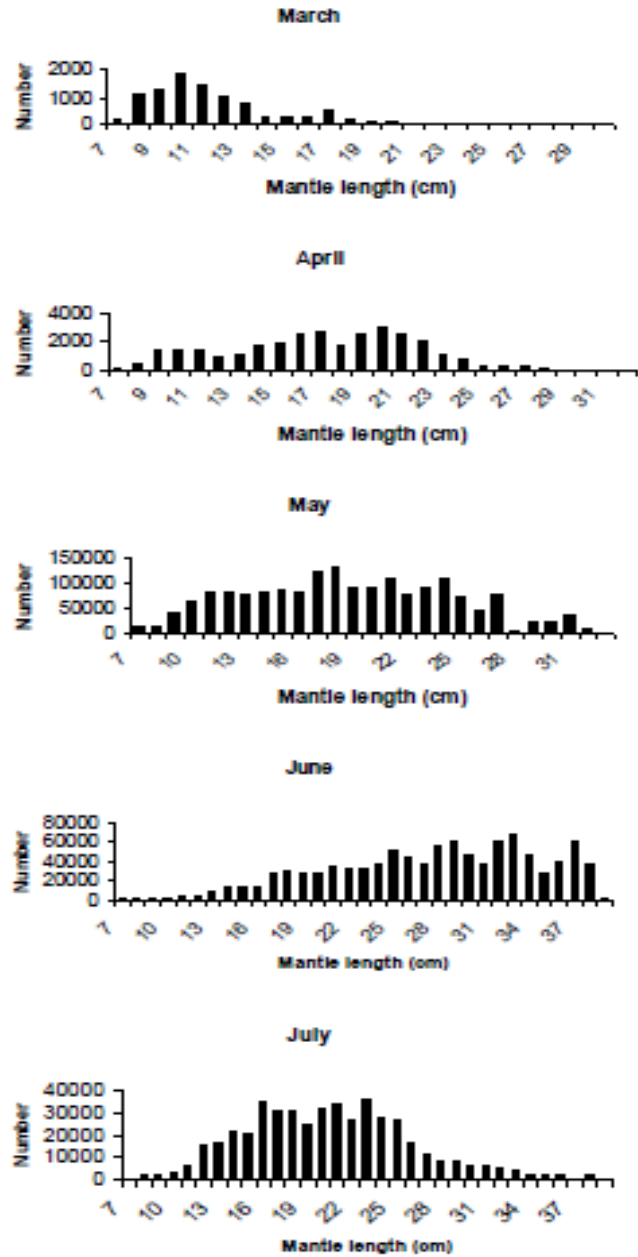


Figure 11. Length frequency of *Sepia pharaonis* during sampling months in 2003

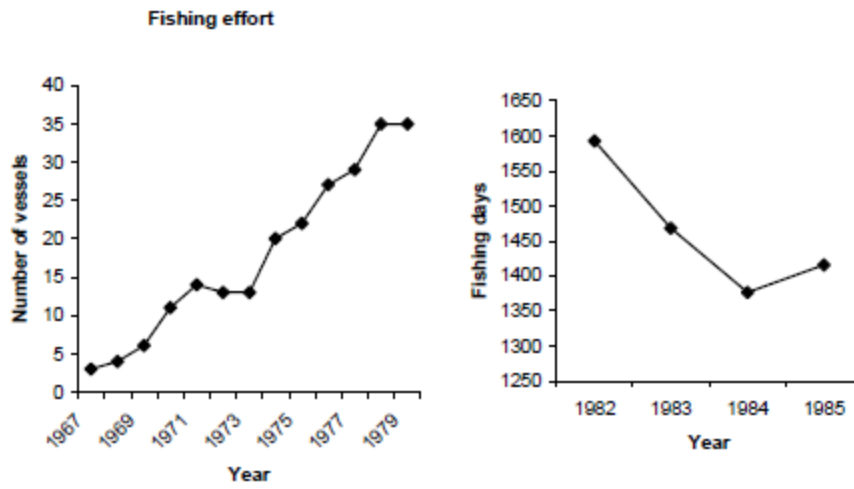
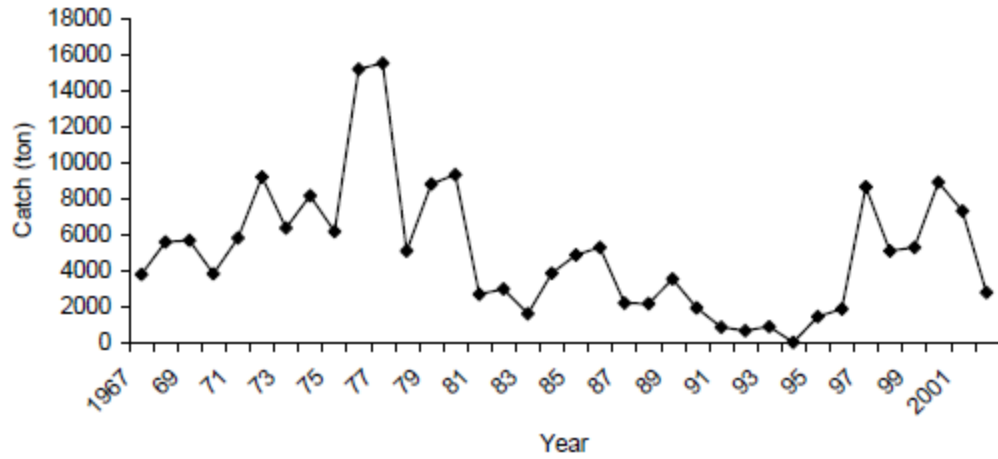


Figure 12. Total catch and effort of *S. pharaonis* from the Gulf of Aden during 1967-2002

Appendix DATA COLLECTION PROGRAMS

Data Collection Programme for Shrimps

Industrial Fishery:

Daily Sampling for Length Distribution:

Shrimps are sorted onboard fishing vessels into several commercial grades depends on their size. During fishing some of those grades were caught. Every day 4 kg of shrimp are sampled in the morning and 4 kg in the evening from each grade caught according to the following procedure:

- 1- Separating different species.
- 2- Separating males and females.
- 3- Recording carapace length in millimeters for each individual by sex.
- 4- Recording the following information:
 - Date, vessel name, fishing location, fishing depth, number of shots in the day, duration of the shot, total shrimp catch per day, total fish catch.

Half monthly sampling:

30 to 50 individuals of shrimps of each species by sex group are selected randomly and the following information are recorded for each individual:

- Carapace length (mm)
- Total length (mm)
- Total weight (g)
- Sex (male/female)
- Females gonad maturity stage

Female maturity stage determination:

		Stage
Immature	Ovaries empty, containing no eggs and whitish in colour.	1
Maturing	Ovaries are relatively small, yet colouring green to yellow indicating the presence of eggs.	2
Mature	Ovaries are large and containing many green to yellow eggs.	3

By- catch and discards:

The quantity of the by-catch and discards are recorded along with recording the species discarded.

Artisanal Fishery:

Here 10 kg of shrimps should be taken randomly on each sampling day (8 days per month) and the same procedures of the industrial fishery sampling should be followed.

Data Collection Programme for Cuttlefish

Aboard fishing vessels cuttlefish is sorted in trays. Each tray contains individuals of a particular grade according to their size. The grades are from the biggest EL, LL, L, M, S, SS, MT, ST and T.

Daily Sampling for Length:

On each day where possible, one tray sampled in the case of S, SS, MT, ST and T grades and two trays in the case of EL, LL, L and M grades in the morning time. The same thing is repeated in the evening.

The number of cuttlefish within each length group and the number of trays sampled for each grade are recorded on a recording sheet. The sample weight also recorded.

Monthly Sampling for Length, Weight, Sex etc.

On a monthly basis the length, weight, sex and gonad maturity stage are obtained for ten individual cuttlefish from each grade chosen randomly. The information is recorded on Form 2.

Length measurement:

The length taken must be the mantle length (see diagram) to the nearest centimeter using an ordinary plastic ruler.

Weight measurement:

The weight should be total weight to nearest 0.1 kg.

Determination of Sex:

The sex of cuttlefish is determined after dissection in a longitudinal direction through the ventral part of the mantle. Identifying the sexes requires visual observation of the presence of sperm sac in case of males and ovaries in the case of females.

Determination of Gonad Stage:

The following measures are used to assign the gonad stage:

Males:		Stage
Immature	Sperm sac without spermatophores	0
Maturing	Sperm sac with some spermatophores	1
Mature	Sperm sac filled with spermatophores	2
Spent	After release of spermatophores	3

Females:		Stage
Immature	No eggs visible in the ovaries	0
Maturing	Ovaries slightly enlarged with small opaque eggs	1
Mature	Ovaries enlarged considerably with large transparent eggs.	2
Spent	After release of eggs	3