THE BIOLOGY AND AVAILABILITY OF THE SPINY LOBSTER PALINURUS DELAGOAE BARNARD, OFF THE COAST OF MOZAMBIQUE

by

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1. INTRODUCTION

The work reported in the present paper was carried out on board of a commercial vessel. Catch and effort data and some biological characteristics of the deep water spiny lobster Palinurus delagoae Barnard was regularly collected between August 1980 and December 1981.

2. FISHING GEAR

The fishing gear consists of lines of traps. The vessel normally uses 13 long-lines each with 600 traps, 18 meters apart, baited with scad which are laid in different fishing grounds. As only two long-lines are hauled up each day the gear lays in each fishing ground from 1 to 5 days depending on the time available, weather conditions and level of catches.

3. FISHING AREAS

Fishing takes place from 22° 00'S and 26° 40'S and normally at depths between 340 and 380 m. The principal fishing grounds are Barra Falsa, East of Boa Paz Bank, South-West of Boa Paz Bank and Inhaca (Fig. 1).

4. ANALYSIS OF CATCH AND EFFORT DATA

4.1 - Data available

The data analysed in this section are based on information recorded in log books. When each long-line is hauled up the position and depth are recorded. The catch is processed into the following commercial groups:

Whole cooked lobster
Whole uncooked lobster
Soft lobster
Lobster tail
Slipper lobster tail
Crabs

In order to compute values of catch from this data the production of headless lobster was multiplied by 100/45 to compensate the loss in weight of ≈ 45% when the head is taken off.

The weight of cooked lobster was not converted to the weight of uncooked lobster because a conversion factor was not available.

Due to the lack of reliable conversion factors there are a lot of uncertainties connected with the conversion of production to catch.

4.2 - Monthly distribution of catches

Table 1 shows total monthly catches of the deep water spiny lobster *Palinurus delagoae* Barnard, the slipper lobster (a species belonging to the *Scyllaridae* family) and the deep-water crab *Geryon quinquedens*.

Palinurus delagoae dominates the catches. During the period of time considered in the present report 90% of the total catch was the deep-water spiny lobster.

5. MORPHOMETRIC RELATIONSHIPS

The relations between carapace length and total length and carapace length and total weight were determined for both sexes separately. Regressions were calculated by the method of least squares.

a) Carapace length/total weight (Fig. 2 and Fig. 3)

This relationship was computed applying the formula $y = ax^b$.

Mean weight of monthly samples was computed by 0.5 cm classes of carapace length. Predictive regression was applied with both variables transformed to logarithms.

As this relationship for females should show an increase in weight at the time of egg-bearing this relationship was computed separately for the two periods: August-December 1980 and January-May 1981.

The following regression equations were computed:

Females:

August-December/1980

n= 64 (N= 2790)

log w= 2.52866 log LC - 2.71500

r= 0.9975

January-May/1981

n= 49 (N= 2772)

log w= 2.61164 log LC - 2.77417

r= 0.9978

Males:

August-December/1980

n= 61 (N= 2365)

log w= 2.59496 log LC - 2.78283

r= 0.99583

January-May/1981

n= 63 (N= 2737)

log w= 2.64236 log LC - 2.82520

r= 0.9983

Comparing the two regression lines from males and females it can be seen that the two regression lines of the females are different. This can show that the weight of the eggs increase the weight of the females at the time of egg-bearing.

For commercial purposes, the following regression lines were computed for the whole year (January-December 1981)

Females:

n= 140 (N= 7535)

log WT = 2.60971 log LC - 2.78278

r= 0.9972

Males:

n= 154 (N= 7922)
log WT= 2.59962 log LC - 2.79091
r= 0.9971

Females and Males Combined:

n= 294 (N= 15457)
log WT= 2.59339 log LC - 2.77713
r= 0.99682

b) Total length/Carapace length (Fig. 4)

To make computation easier mean total length of monthly samples of a year was computed by 0.5 cm classes of carapace length.

Predictive regression was applied with both variables transformed to logarithms.

The following regression equations were computed for the period January--December 1981.

Females:

n= 140 (N= 7535)
log LT= 0.84380 log LC + 0.62372
r= 0.9958

Males:

n= 154 (N= 7922)
log LT= 0.79536 log LC + 0.65491
r= 0.9976

Females and Males Combined:

n= 294 (N= 15457)
log LT= 0.80882 log LC + 0.64840
r= 0.9942

6. SOME BIOLOGICAL CHARACTERISTICS

6.1 - Methods

One long-line per day was analysed. The catch of the first or second trap was sorted and whenever possible a total of 100 specimens were examined. These specimens were sorted by sexes, grouped in 0.5 cm classes of carapace length and the weight of each class recorded. For each specimen the following parameters were recorded:

- total length
- moulting stages
- maturity stages only for the females
- egg-bearing females.

Length measurements, scale of moulting stages and scale of maturity stages used were described by Berry (1973).

6.2 - Characteristics of the population

Interpretation of the population structure of this species is limited to the type of fishing gear used and its selectivity. Moreover as fishing took place at depths between 340 and 380 meters, sampling was only confined to a section of the population and the segregational behaviour and movement could not be observed.

According to Berry (1973) "... a tendency for small sexually immature spiny lobster to occur in the deepest extreme of the depth range was evident, whereas sexually mature animals and particularly dense aggregations of egg-bearing females tended to occur in shallower water just over the edge of the continental shelf ...".

This segregational behaviour is partly confirmed by the sampling programme carried out on board of a research vessel operating with a different fishing gear and at depths between 235 and 535 meters on the period August to February (Table 2). Bigger individuals were found on shallower waters but individuals occuring at depths between 350 and 535 meters, although smaller than the previous ones had more or less the same distribution and the same mode already found on the catches of the commercial vessel. The tendency of the small individuals described by Berry (1973) could not be observed in this investigation probably due to the fact that the work has not been carried out during a whole year and possibly small individuals does not appear in the area in this period.

6.3 - Size frequency distribution

The size frequency distribution of males and females on a monthly basis are presented in Fig.5 which illustrates little variation in composition of samples and a general tendency of skewness to the left with the modal size class remaining fairly constant.

The size frequency distributions of the total catch of males and females taken over an entire year are presented in Fig. 6 which show that about 60% of the individuals (males and females) occur between 6.0-6.5 to 7.0-7.5 cm size classes.

The absence of juvenile specimens smaller than 5.0-5.5 cm size suggests that they have a different distribution or occur in a different habitat (Berry, 1973).

6.4 - Sex ratio

The sex ratio in each size class in the combined year samples show an aproximate 50/50 ratio over most of the size range (Table 3). However, in the 12.0-12.4 size class and those above the larger size attained by males results in a sudden increase in their proportion and their exclusive occurrence (although numbers are small).

The sex ratio on a monthly basis incorporating the entire size range, shows little fluctuation and aproximates closely to a 50/50 ratio (Fig. 7).

6.5 - Size range, mean carapace length and mean weight

Fig. 5 shows size range on a monthly basis. Over the entire period sampled the carapace length of males ranged from 5.0-5.5 cm size class to 14.0--14.5 cm size class.

The mean carapace length is presented in Table 4 and again reflects little variation of the catch composition. The mean carapace length of males ranged from 6.35 to 7.62 cm and in females from 6.30 to 7.55 cm.

The mean weight is also presented in Table 4. The mean weight of males ranged from 0.178 to 0.315 grams and in females from 0.180 to 0.298 grams.

6.6 - Attainment of sexual maturity

Females

A female able to spawn and carry her eggs was regarded as being sexually mature.

The frequency of specimens with reproductively active ovaries (stages 2-5) in each size class was determined for the period when females showed the highest percentage of ripe ovaries (August 1980 to January 1981 and June 1981 to December 1981). Figure 8 shows that the smallest females with active ovaries had a carapace length of 5.5 cm but sexual maturity appears only to be attained by over 50 percent of the population at a size of 6.5 cm.

The incidence of egg-bearing in each size class was determined over the peak months of breeding (November 1980 to May 1981 and October 1981 to December 1981). Figure 9 shows that the smallest berried female obtained had a carapace length of 6.0 cm. A gradual increase in the frequency of egg-bearing is evident. However, as the maximum percentage of any size class in berry was 28 per cent, it was considered that at a carapace length of 7.0 cm a better approximation of attainment of sexual maturity is achieved. This is a larger size than is indicated using the incidence of active ovaries as a criterion, but it can be attributed to moulting and subsequent growth prior to mating and oviposition (Berry, P.F. 1973).

Males

As sexual development was not investigated, it was considered that sexual maturity of males is attained with the same size found for females.

6.7 - The reproductive cycle

Frequency of egg-bearing

The frequency of egg-bearing was expressed as a percentage of the total number of sexually mature females each month.

Figure 10 shows that breeding starts at October-November and egg-bearing build ups to a small peak in December-January and a bigger peak probably in March-April. In May there is a sharp decline in the incidence of egg--bearing presumably due to hatching of the eggs which appears to continue at a very low level until July. The same pattern is found for the periods August 1979 to June 1980 and April 1982 to July 1982. The small peak in June 1981 is probably the result of inadequate data which is confirmed by data of other years.

Figure 10 shows that the incidence of egg-bearing females is low when compared with the frequencies obtained in samples from trawl catches (Berry, 1973). The highest percentage (70%) was obtained in 1980. This can probably be explained by the low availability of adult females during the egg-bearing cycle (Fig. 11). The low availability can be either the result of a possible migration to grounds outside those normally fished or the decrease of catchability associated with a tendency of egg-bearing females to concentrate in small areas. The second assumption is supported by data from one area (between 22° 10'S - 24° 30'S) for the period February to April 1980. During the egg-bearing period a small number of traps was found with high percentages of berried females (Fig. 12) and Fig. 13 show a preponderence of males in the traps with 15% to 30% of egg-bearing females and a preponderence of females when more than 70% of egg-bearing females was found in the traps.

A similar pattern of availability was found for adult males (Fig. 11). It was not possible to relate availability with the reproductive cycle of males. However it seems reasonable to assume that males have the same behavioural pattern as females during the egg-bearing cycle.

Ovarian cycle

The percentage of sexually mature specimens in each stage of ovary development was determined. Monthly frequencies of active and ripe ovaries (stages 4 and 5 combined)is presented in Fig. 14. An increase in the percentage of the ripe ovaries was recorded from May-June until a peak in August and a progressive decrease was recorded from September until April--May coincident with the egg-bearing cycle. This progressive variation suggests a gradual development of the ovaries.

6.8 - Moulting

The moulting cycle was divided into four macroscopically distinguishable stages (Berry, 1973).

The frequencies of animals immediately before and after ecdysis (stages D and A) are very low probably because feeding and ecdysis are correlated.

Monthly frequencies of sexually mature lobsters (with a carapace length of 6.5 cm and greater) in stage A is shown in Fig. 15. Moulting occurs all over the year with two peaks - in April and September.

The results suggest that adult lobsters moult twice per year. The smaller peaks abtained in December and July probably represent a continuation of the moulting occured in September and April.

Although the incidence of newly-moulted animals is much lower in April than in September, the examination of monthly frequencies of animals in stages B (incompletely hardened shells) and C (hard shells) seems to indicate that moulting should have occurred in April (Fig. 16). The lower incidence could be explained by the decrease of adult animals in the catches (Fig. 11), which means that a decline in the availability of these size-groups takes place in April-May. This is probably the result of a decrease of catchability or a possible migration to grounds outside those normally fished.

7. CATCH PER UNIT OF EFFORT AND AVAILABILITY

Figure 17 shows C.P.U.E. expressed in kilograms per fishing day, kg per long-line and kg per trap.

With these different units of effort the C.P.U.E. show similar trends because the vessel normally hauls up two long-lines per day and each long--line normally has 600 traps. For further analysis C.P.U.E. expressed in kilograms per trap will be used.

There is a seasonal pattern of C.P.U.E.. The catch per trap tend to increase from March-April until October when the highest values are obtained. After that the catches decrease to a minimum value in February-March.

The seasonal variation of catches seems to be related with the moulting cycle. Figure 18 suggests that the newly-moulted animals do not feed. After a period of starvation feeding recommences. The period of starvation seems to be one month (September-October/80, April-May/81 and September-October/81) or less than one month (December/80 and July/81). The peak of moulting of April has a small influence in catch per unit of effort expressed in kg/trap because during April and May there is a decline in the availability of the larger size-groups (Fig. 11).

The decrease of availability between November and February-March can be related with the benavioural pattern of the adult population during the breeding season (see section 6.7).

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TABLE 1 - Monthly distribution of catches (kg)

Year	Month	Spiny lobster	Slipper lobster	Crabs
1980	August	20.359	91	552
	September	14.195	1.352	72
	October	30.006	424	288
	November	28.863	30	5.064
	December	14.780	111	396
1981	January	30.047	171	10.386
	February	7.413	192	-
	March	-	-	-
	April	9.055	767	336
	May	43.633	292	14.076
	June	8.838	20	672
	July	55.338	909	2.292
	August	16.355	1.442	12
	September	39.202	552	432
	October	48.898	162	144
	November	19.833	-	3.372
	December	56.072	293	2.856

TABLE 2 - Frequency of males and females per size classe and by depth intervals of the combined samples taken on the period August to February on board the R/V Ernst Haeckel

Depth	Total length (cm)															Total Number
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
235-350			0.8	2.4	4.7	11.8	16.5	22.0	16.5	11.8	5.5	3.9	2.4	1.6		127
350-450	0.2	5.3	27.9	38.3	21.2	4.8	1.2	0.2	0.2	-	-	0.2	0.2			433
450-535	0.4	7.6	31.6	41.4	13.5	4.2	1.3									237

TABLE 3 - The sex-ratio in each size class based on the combined monthly samples (Jan-Dec. 1981)

Size class	Numbers		Percentages	
	Males	Females	Males	Females
5.0- 5.4	19	30	38.8	61.2
5.5- 5.9	552	824	40.1	59.9
6.0- 6.4	2065	2083	49.8	50.2
6.5- 6.9	1779	1397	56.0	44.0
7.0- 7.4	1307	963	57.6	42.4
7.5- 7.9	871	748	54.0	46.0
8.0- 8.4	612	669	47.8	52.2
8.5- 8.9	360	422	46.0	54.0
9.0- 9.4	140	219	39.0	61.0
9.5- 9.9	80	92	46.5	53.5
10.0-10.4	36	38	48.6	51.4
10.5-10.9	28	18	60.9	39.1
11.0-11.4	18	13	58.1	41.9
11.5-11.9	13	10	56.5	43.5
12.0-12.4	17	5	77.3	22.7
12.5-12.9	6	1	85.7	14.3
13.0-13.4	9	2	81.8	18.2
13.5-13.9	5	-	100.0	-
14.0-14.4	3	1	75.0	25.0
14.5-14.9	2	-	100.0	-

TABLE 4 - Mean carapace length and mean weight on a monthly basis

	Males			Females		
	N°.	$\bar{L}$ (cm)	$\bar{W}$ (g)	N°.	$\bar{L}$ (cm)	$\bar{W}$ (g)
August 1980	167	6.35	0.178	453	7.12	0.264
September	177	6.73	0.207	238	7.07	0.256
October	587	7.27	0.272	568	7.20	0.268
November	940	6.94	0.230	1 095	7.07	0.250
December	596	7.28	0.271	438	7.03	0.254
January 1981	1 261	7.10	0.248	1 237	7.19	0.277
February	565	7.56	0.315	389	6.93	0.246
March	-	-	-	-	-	-
April	147	6.79	0.236	164	6.62	0.219
May	764	6.57	0.205	982	6.30	0.180
June	106	7.62	0.315	95	7.38	0.297
July	1 023	6.86	0.222	1 092	6.91	0.239
August	345	6.91	0.228	456	7.28	0.284
September	839	6.91	0.226	830	7.12	0.257
October	812	7.47	0.279	716	7.55	0.298
November	582	7.16	0.249	439	6.99	0.245
December	1 478	7.33	0.263	1 136	7.41	0.289

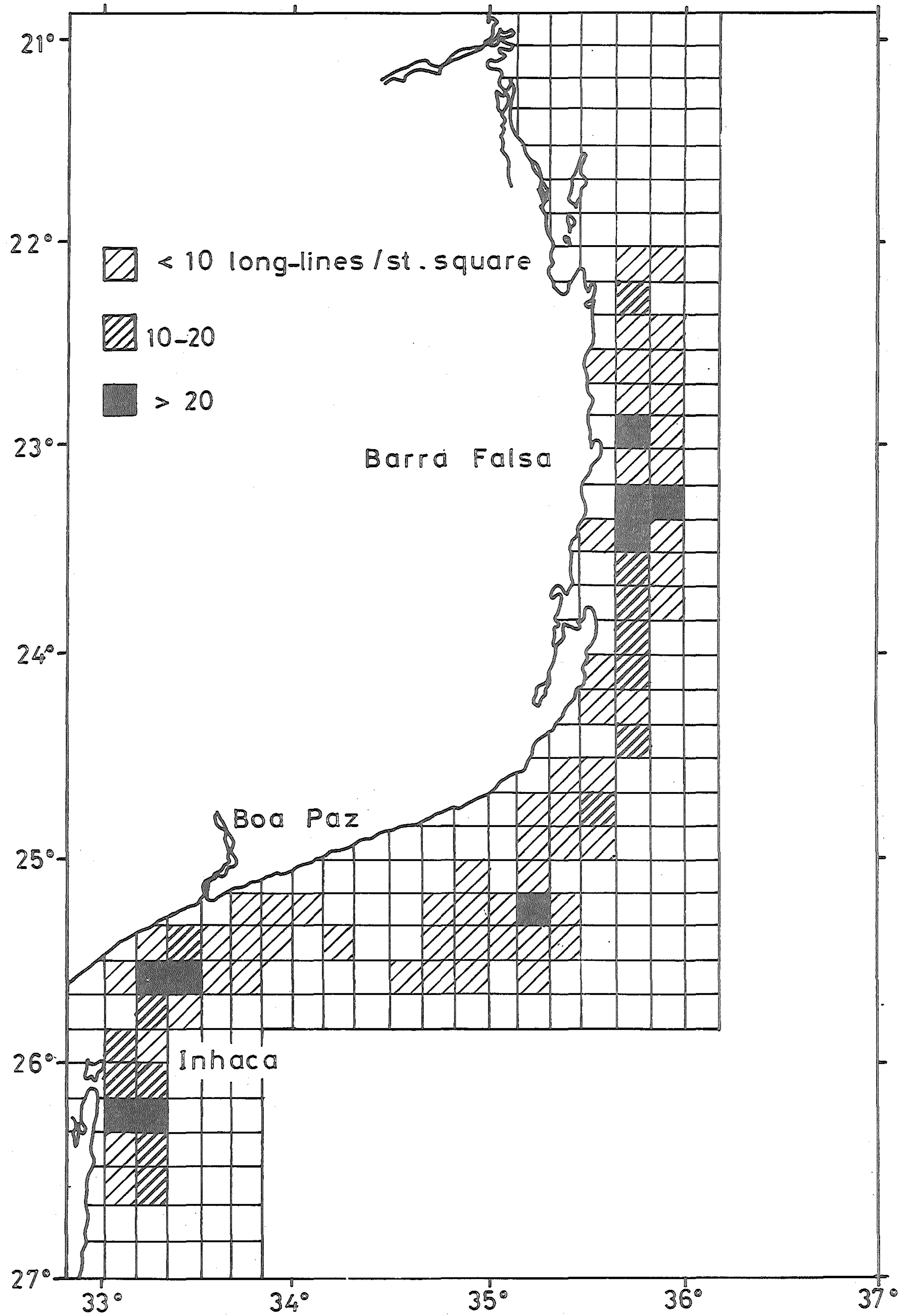

Fig. 1- August 1980 to December 1981. Number of long-lines per 10 x 10 nm squares

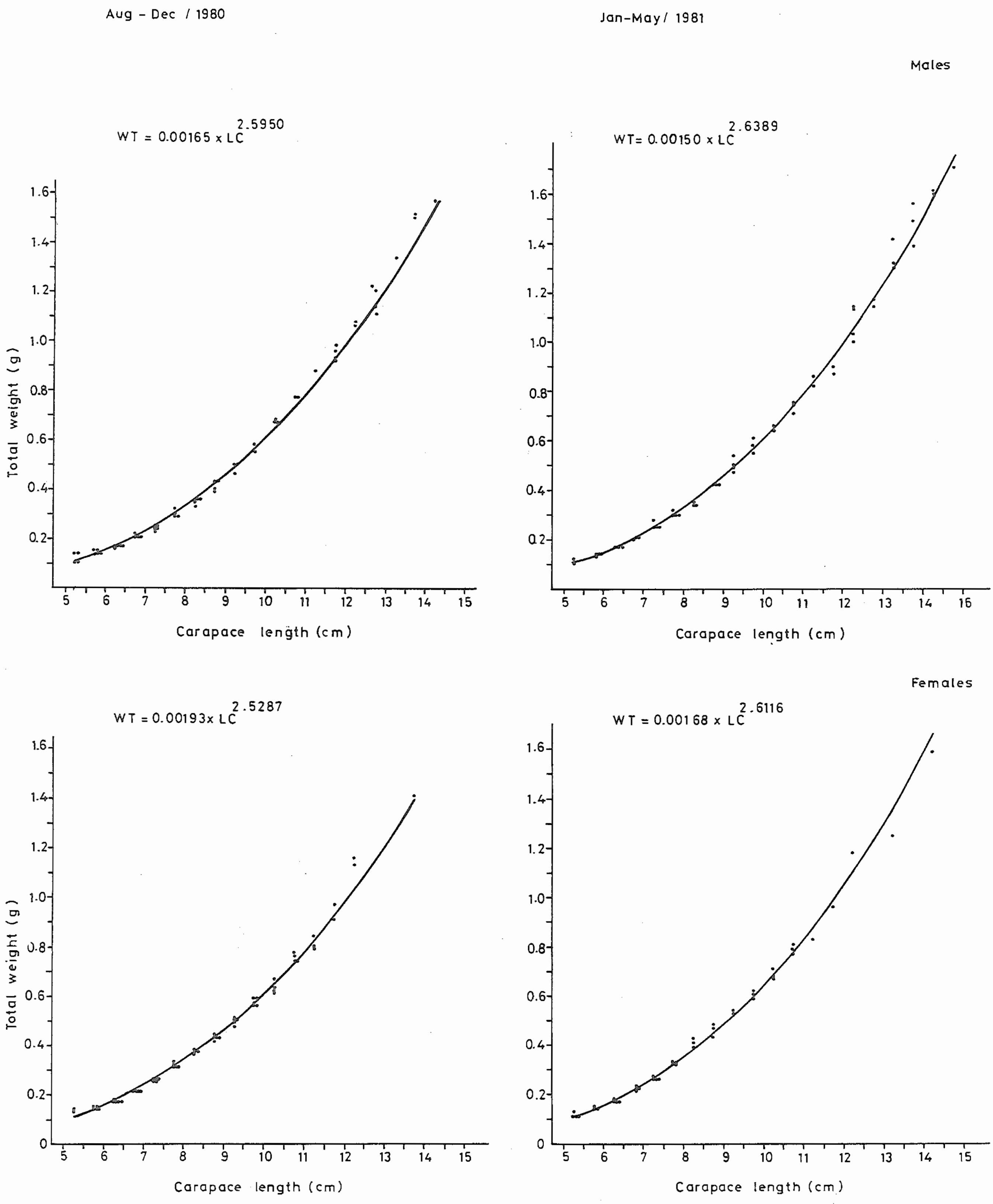

Fig. 2 Relationship between carapace length and total weight in males and females

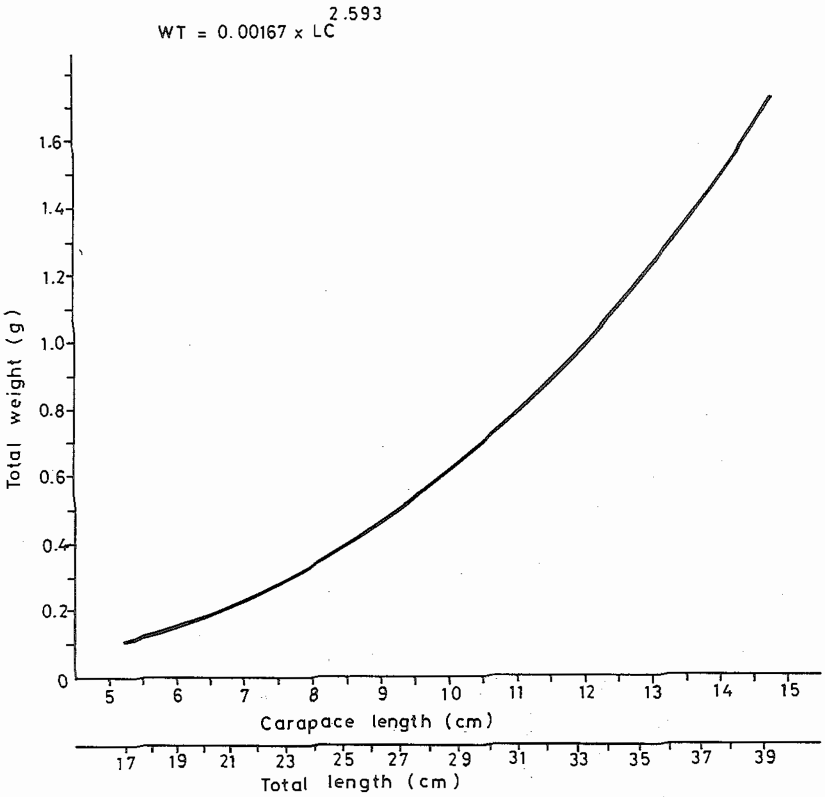

Fig. 3 Relationship between carapace length (total length) and total weight for males and females for the period January-December 1981.

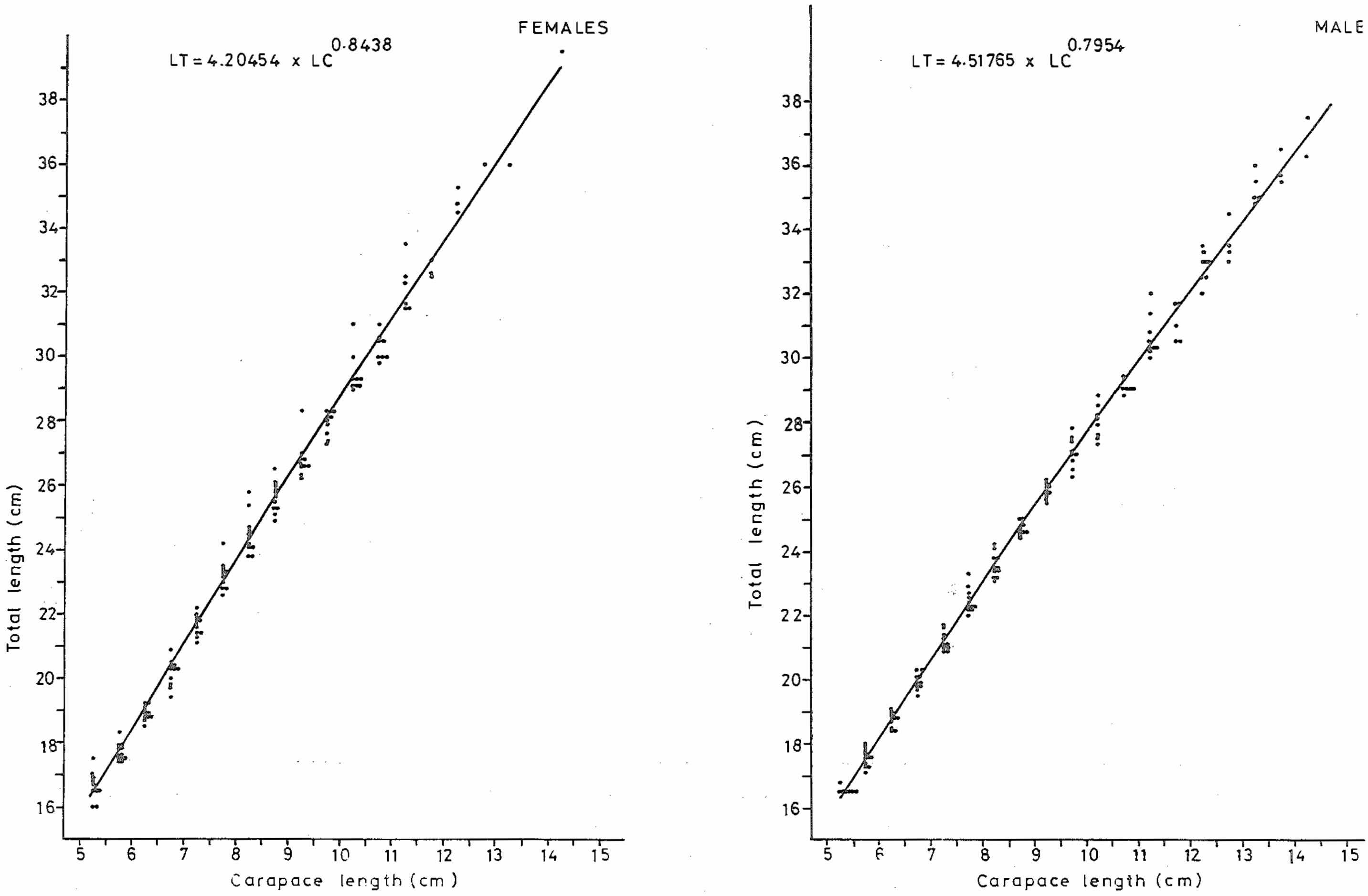

Fig. 4 Relationship between carapace length and total length in males and females.

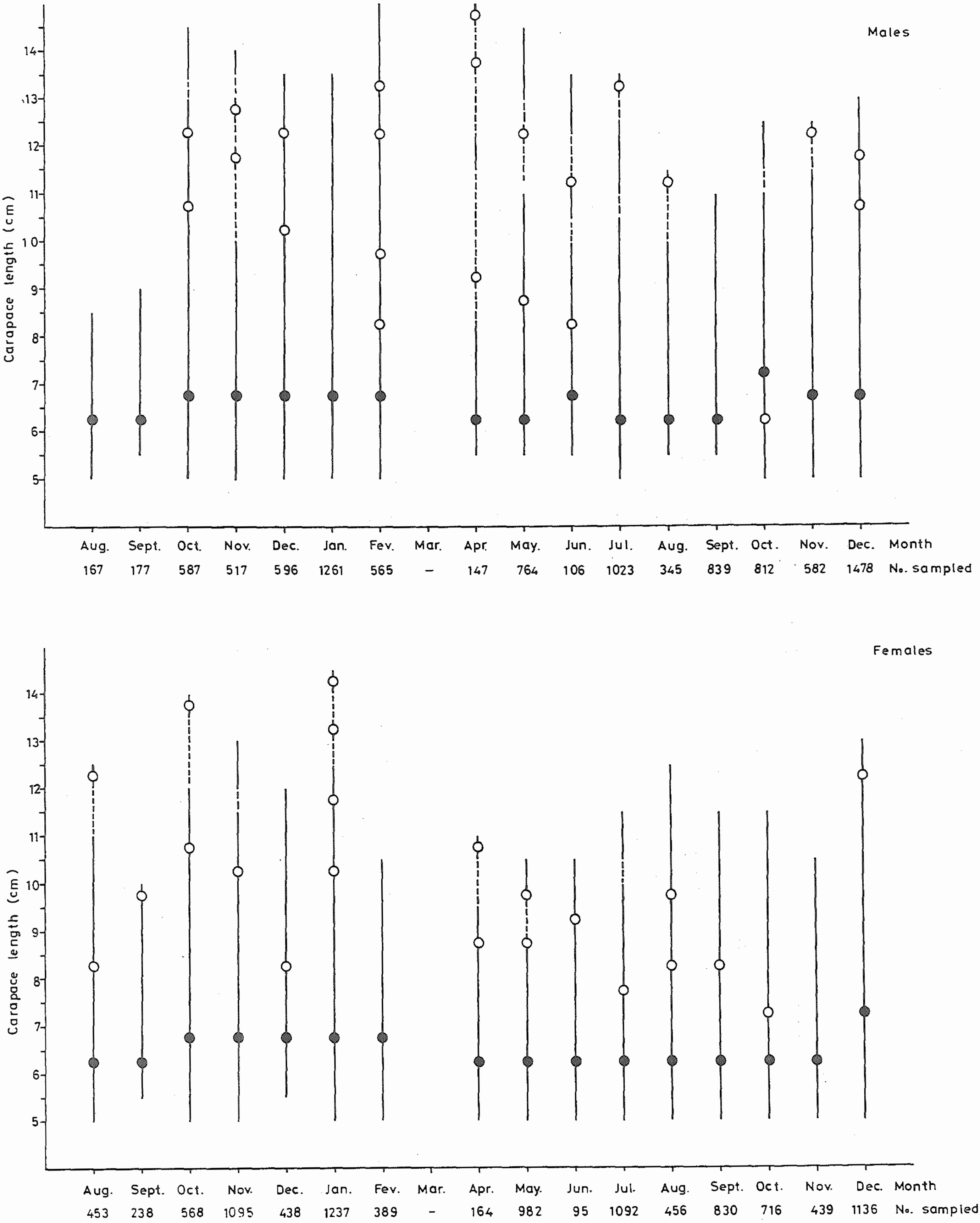

Fig. 5 Size Frequency distribution on a monthly basis.

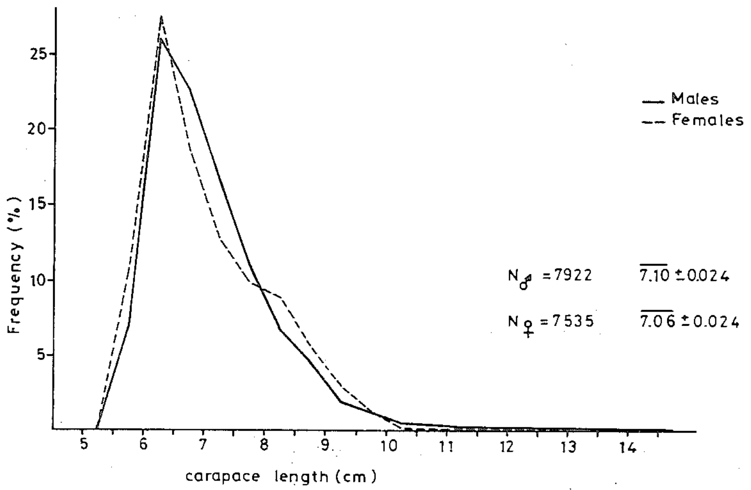

Fig. 6 Size frequency distributions of males and females in the combined monthly samples (January - December 1981)

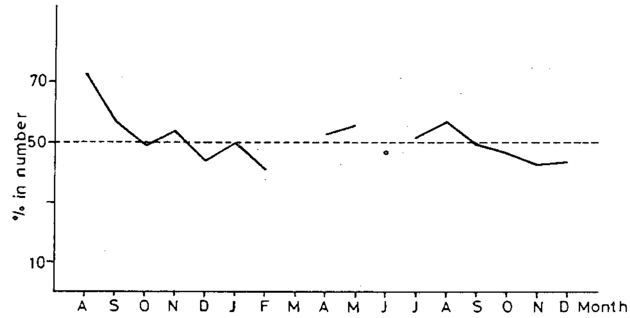

Fig. 7 Monthly variations of the sex-ratio (percentage of females)

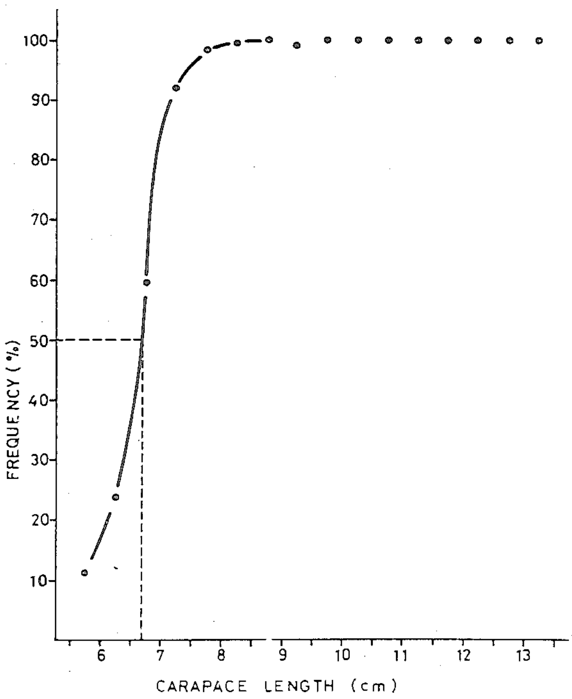

Fig. 8 - Percentage of females with reproductively active ovaries in each size class during the periods August 1980 to January 1981 and June 1981 to December 1981.

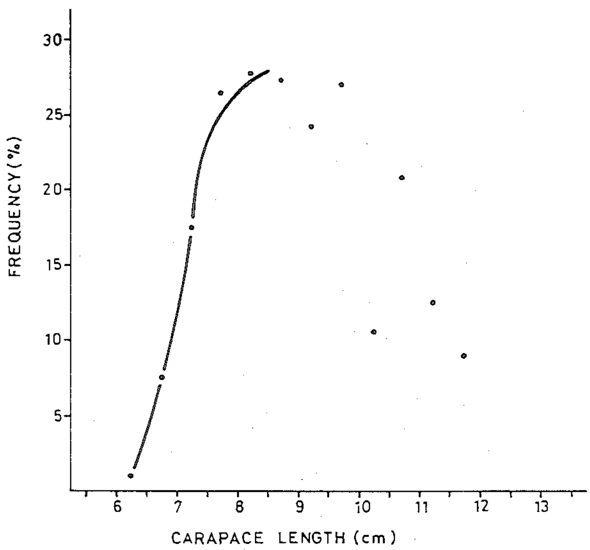

Fig. 9 - Percentage of egg-bearing females in each size class during the periods November 1980 to May 1981 and October 1981 to December 1981.

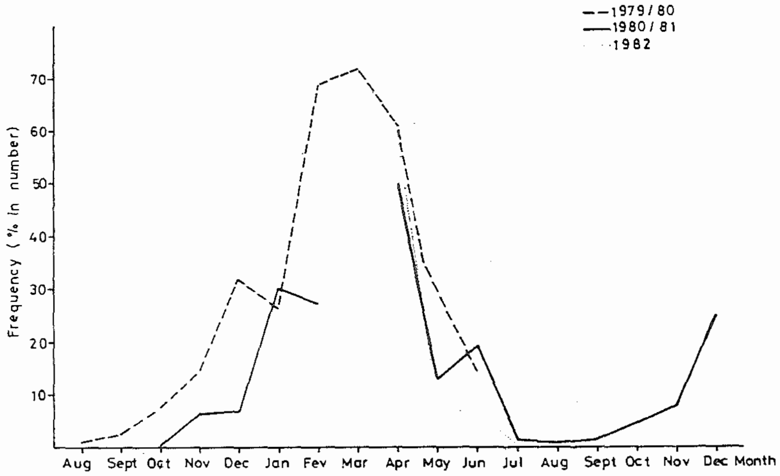

Fig. 10 Frequency of egg-bearing females in monthly samples

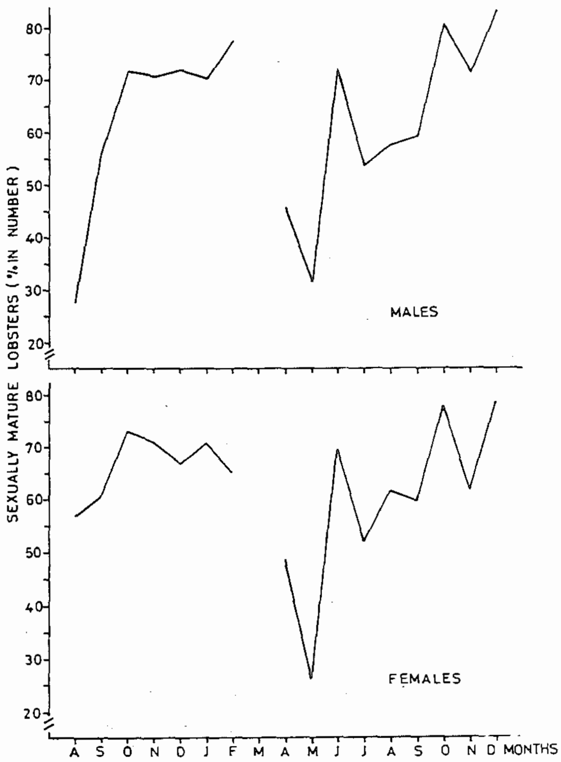

Fig. 11 Monthly frequency of sexually mature lobsters

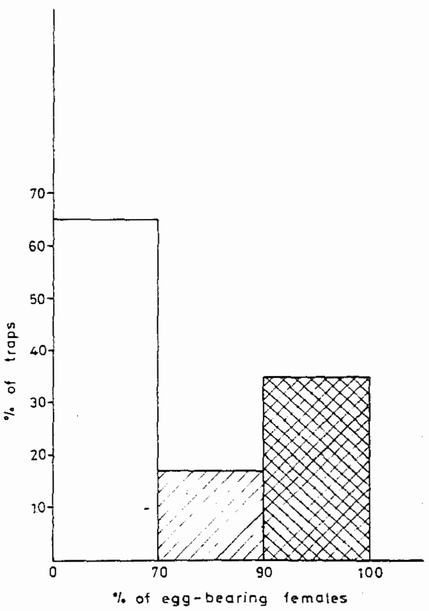

Fig. 12 - Ocurrence of egg-bearing females in the traps.

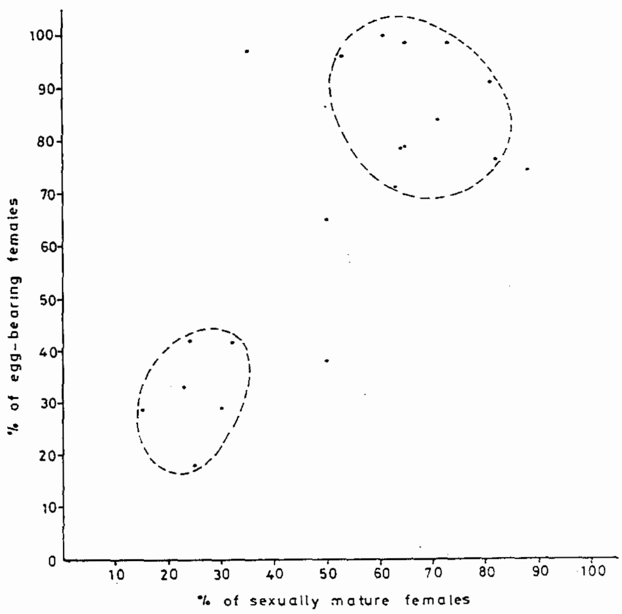

Fig. 13 - Relation between incidence of egg-bearing females and percentage of mature females. Each point corresponds to a single trap

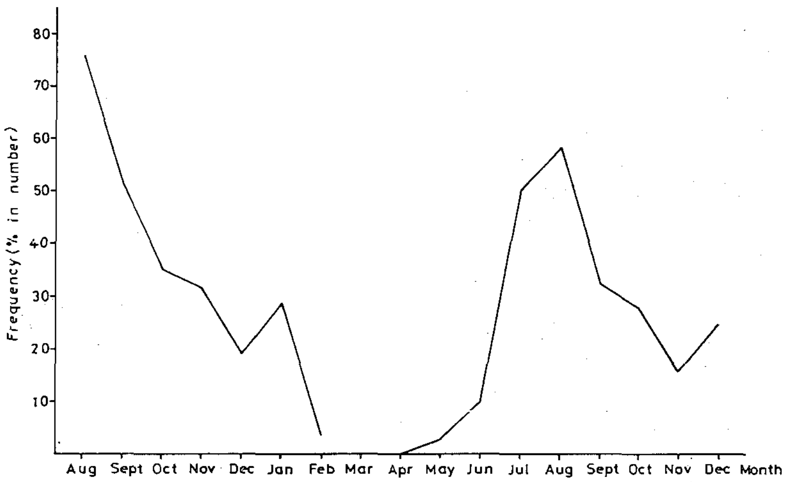

Fig. 14 Frequency of active and ripe females combined in monthly samples

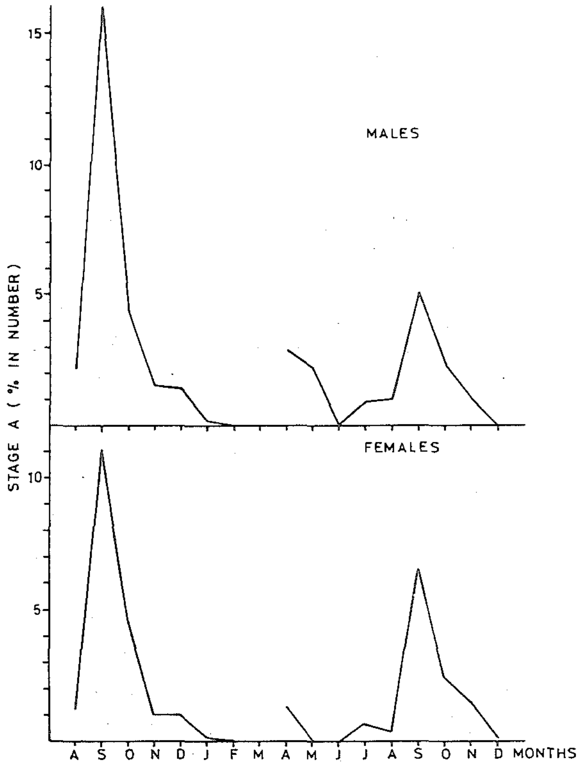

Fig. 15 - Frequency of sexually mature lobsters in moulting each month

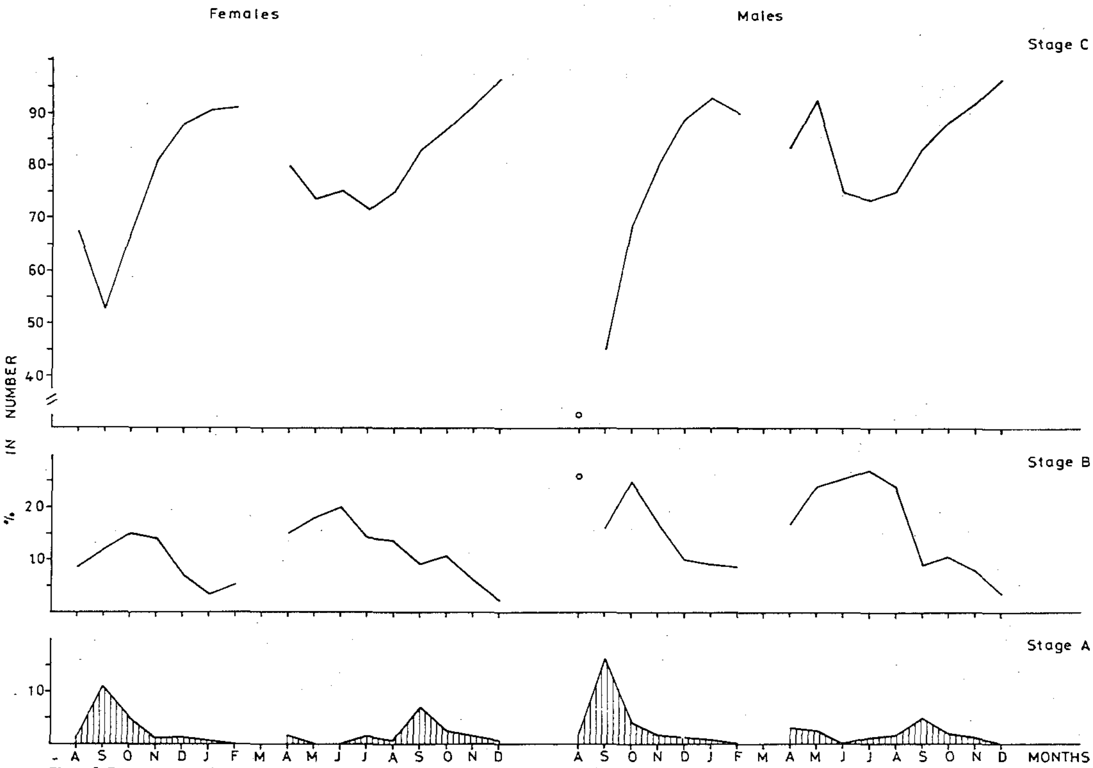

Fig. 16 Frequency of sexually mature lobsters in different maulting stages each month

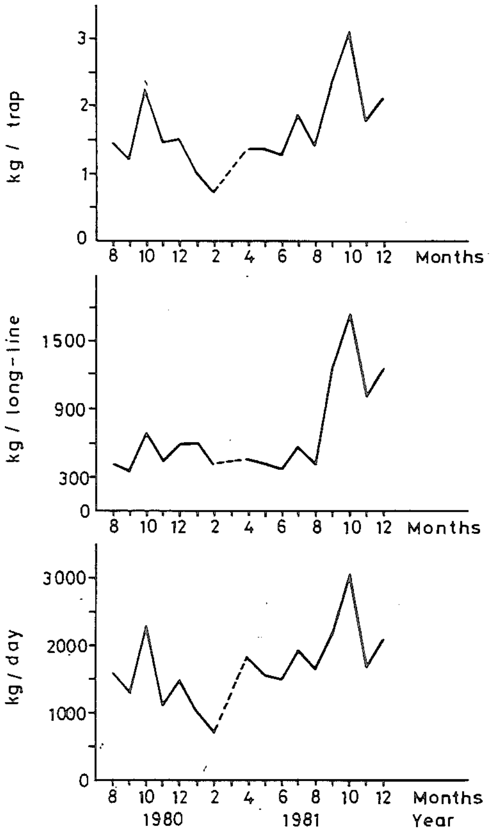

Fig. 17 Monthly catch per unit of effort expressed in kg / trap, kg / long-line and kg / day.

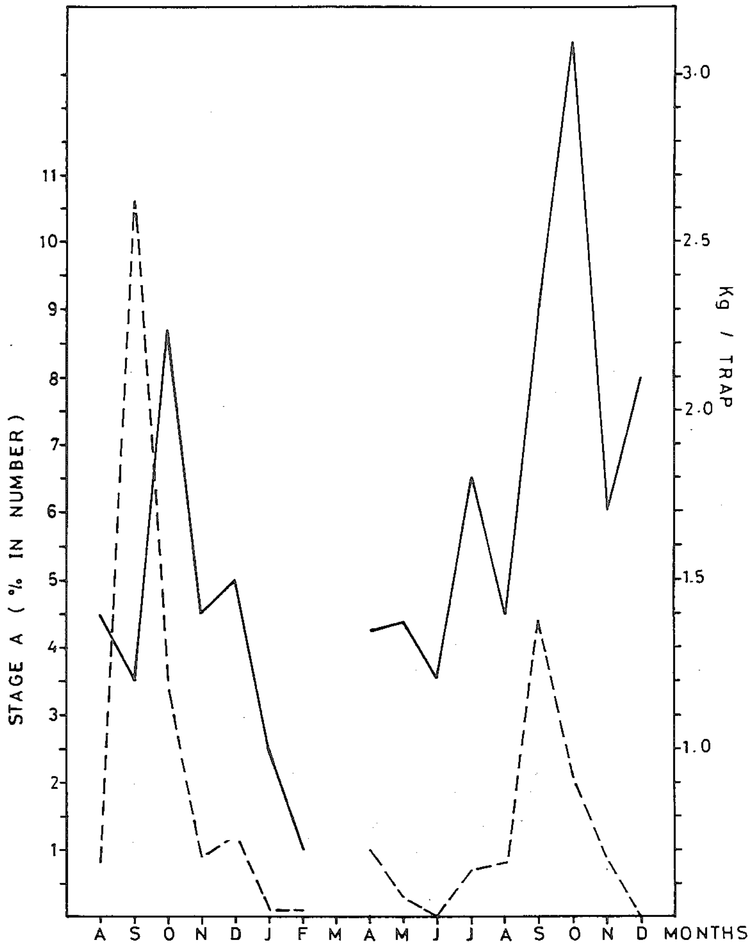

Fig. 18 Relation between monthly catch per unit of effort (solid line) and frequency of moulting