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REPRODUCTION, AGE AND GROWTH OF THE INDIAN MACKEREL, *Rastrelliger kanagurta* (Cuvier, 1816) FROM SOFALA BANK, MOZAMBIQUE

by

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ABSTRACT

Studies on reproduction, age, growth and mortality of indian mackerel, Rastrelliger kanagurta are presented. They are based on material collected since 1979 from industrial commercial trawlers operating mainly in Sofala Bank. Informations from surveys were also included.

Indian mackerel has a long spawning season which lasts from August to March or April, ocurring the spawning peak in December or January.

Growth curves based on both otolith readings and length frequency distributions were estimated. As no confidence limits can be calculated for the estimated growth parameters it is impossible to tell whether the curves differ significantly from each other or not.

Total mortality, Z, was given by Elefan II. The values for 1979, 1980 and 1981 are very high. This fact may be due to migration of big fish away from the fishing area or to the decrease of their catchability with length.

RESUMO

Apresentam-se os estudos feitos sobre reprodução, idade, crescimento e mortalidade da cavala, Rastrelliger kanagurta. O material de estudo foi colhido desde 1979, nos arrastões de pesca industrial que operam principalmente no Banco de Sofala. Também se inclui a informação proveniente dos cruzeiros de investigação.

A cavala tem um periodo de desova longo, de Agosto a Março ou Abril, com um pico de desova em Dezembro ou Janeiro.

Foram estimadas as curvas de crescimento baseadas nas leituras de otólitos e nas distribuições de frequências de comprimentos. Como não se podem calcular limites de confiança para os parâmetros de crescimento estimados, não é possivel confirmar se as curvas obtidas são significativamente diferentes ou não. Os valores de mortalidade total, Z, dados pelo Elefan II, para os anos de 1979, 1980 e 1981 são muito altos. Este facto pode ser devido

à migração de peixes grandes para fora da área de pesca ou à redução da capturabilidade com o tamanho.

0 - INTRODUCTION

Since 1977 the indian mackerel, Rastrelliger kanagurta (Cuvier, 1816) have been caught by industrial bottom trawlers operating mainly at Sofala Bank. This species contributes with 14 percent of the catch. Besides it is caught by artisanal fishermen close to the shore and by industrial shrimp trawlers.

The species has been reported in both acoustic and bottom trawl surveys (V. Budnitchenko, 1977; R. Saetre, 1979; L. Brinca et al. 1984; I. Timochin et al., in prep.), where it was found from Boa Paz to Angoche at depths above 200 meters. It has also been reported from other parts of the Indian Ocean and the Western Central Pacific e g by Jones and Rosa (1965), Menon and Radhakrishnan (1974), Losse (1974) and Ronquillo (1974).

This paper is based on material collected at Sofala Bank and Boa Paz onboard commercial bottom trawlers and research vessels. It describes the results obtained in terms of age, growth, reproduction and other biological characteristics.

I - MATERIALS AND METHODS

Collection of data

Since 1979 samples for analysis of species composition, length measurements, gonad development and extraction of otoliths have been collected onboard the commercial trawlers on a daily basis. The vessels, of 1900 GRT and 1000 HP, use bottom trawl nets with a horizontal opening of 13 - 18 m and a vertical opening of 21 m. The mesh size of the cod end is 20 mm.

In addition samples have been collected during several surveys.

From 1979 to June 1983 a total of 31811 individuals of R. kanagurta from Sofala Bank were measured and grouped in 0.5 cm length groups. In the same period 1952 individuals of mackerel were sampled from Boa Paz.

Individual length measurement, weight, sex and maturity stages were recorded for 10383 mackerel by use of the methodology described by Gjosaeter and Sousa (1983, p. 87).

Extraction and preparation of otoliths

Otoliths were extracted in the way described by Gjosaeter and Sousa (1983, p. 87). A total of 62 otoliths of a size range of 4.5 to 20.6 cm were collected for growth studies.

The otoliths were dipped in water and ground on both sides on a grindstone. When the rings were visible under a microscope the otoliths were cleared with a drop of 1% HCl for 5-10 seconds to remove particles from the ground surface. Afterwards they were rinsed in water and mounted in DPX mounting medium.

The method for reading the otoliths was described by Gjosaeter and Sousa (1983, p. 88).

Otoliths of indian mackerel are thin and about 5-6 mm long in medium sized fish. They have a rostrum and a smaller antirostrum and the opposite edge is rounded.

Fitting of growth equations

Data on length distributions of R. kanagurta for the period 1979 to 1981 were sent to Dr. D. Pauly, ICLARM, Philippines, where the Elefan II computer program was used to estimate growth parameters, total mortality and recruitment pattern. The program is described in D. Pauly et al. (1981).

Initial estimates of growth parameters based on otolith readings were obtained by graphical methods. Later these estimates were improved by a least squares technique.

Gonad development and size at first maturity

Gonad development was studied by maturity stages and gonadosomatic index, GSI (Gjosaeter and Sousa, 1983).

The size at first maturity was estimated from the percentage of females in maturity stage V (spawning) in each length group during the main spawning season.

An s-shaped curve passing through most of the points was drawn by hand from which the size at first maturity was read as the size at which 50% of females were found in spawning.

II - RESULTS

1. Reproduction

A good correspondance was found between the maturity stages and the gonadosomatic index (GSI). The highest value of GSI was found in stage IV (mature) in both sexes (Fig. 1). Stage V (spawning) had a lower index, indicating that the sexual products had at least partly been expelled.

At Sofala Bank high percentages of individuals in spawning (stage V) were observed from August to March or April (Table 1).

Within this period the highest percentages were found in February-March 1980, November 1980 and December 1981 and 1982.

The highest value of GSI was always observed in December (Fig. 2). The results thus show that R. kanagurta has a long spawning period lasting from August to March or April with one spawning peak probably located in December or January. The results from the surveys (Tables 2 and 3) support this conclusion.

The same period of spawning was observed at Boa Paz although spawning peak seems to occur one or two months later (Tables 4 and 5 and Fig. 3).

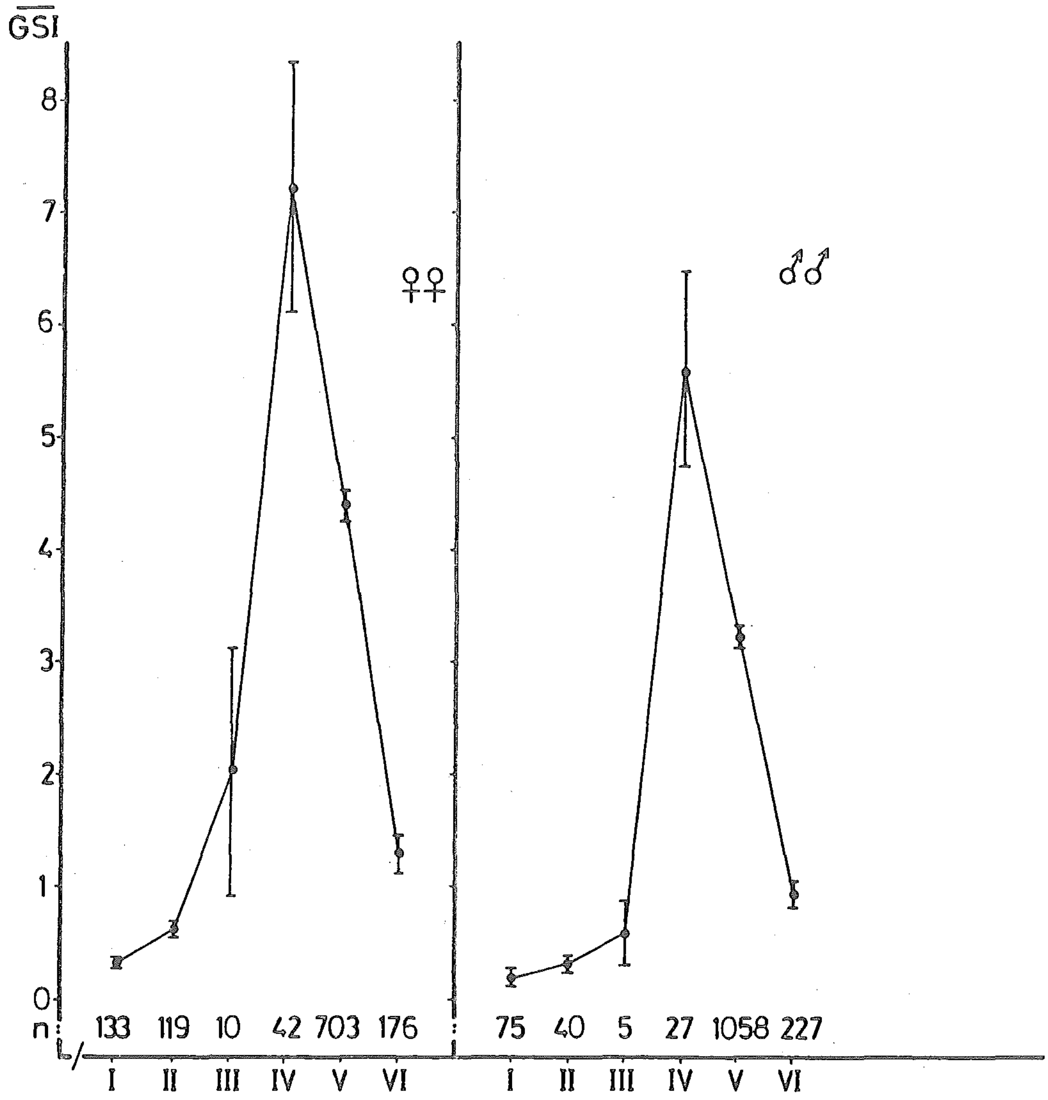

Fig. 1. Average gonadosomatic index of each maturity stage for females males (vertical bars indicate 95% confidence limits).

The size at first maturity was estimated by use of the data collected from November to February in 1980, 1981 and 1982.

The length at which 50 percent of the females were in spawning was found to be between 20 and 21 cm (Fig. 4).

Table 1. Maturity stages (percent) collected on board the commercial vessels at Sofala Bank. Period 1979- June 1983.

MONTH	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
1979														
Jan														
Feb														
Mar	5.2	10.4	15.6	10.4	58.3		96	9.4	13.9	10.5	2.6	63.2	0.4	266
Apr	25.0			50.0	25.0		4	28.6		14.3	14.3	42.9		7
May														
Jun	0.8	6.8	0.4		10.5	81.6	266	20.3	18.9	0.5		26.9	33.5	212
Jul		1.8	0.4	0.7	14.0	83.2	279		16.5	0.8		42.5	40.2	254
Aug					57.3	42.7	75	1.0	2.0	1.0		68.0	28.0	100
Sep														
Oct														
Nov														
Dec	1.7	2.9	9.2	37.4	47.7	1.2	174	1.4	2.9	2.9	24.5	66.8	1.4	200
1980														
Jan														
Feb		1.0	1.0	0.5	80.2	17.4	207					96.7	3.3	214
Mar		2.3			84.4	13.3	128					89.6	10.4	182
Apr	38.9	1.9			47.2	12.0	108	14.4			0.7	61.9	23.0	139
May														
Jun	21.3	63.9			8.2	6.6	61	28.1	27.0		1.1	9.0	34.8	89
Jul	17.8	43.8	3.4	1.4	6.9	26.7	146	19.0	10.7	4.1		22.3	43.8	121
Aug	17.0	6.6			50.9	25.5	106	4.3	0.7		2.9	77.9	14.3	140
Sep	26.3	1.7		3.4	61.9	6.8	118	3.0	3.0		1.5	79.6	12.9	132
Oct	2.0		0.7	7.2	77.1	13.1	153	0.6			1.7	80.8	16.9	172
Nov	1.5		1.5	6.0	86.6	4.5	67	2.0			8.2	84.7	5.1	98
Dec	2.2		1.1	22.0	64.8	9.9	91	5.1			6.4	76.3	12.2	156
1981														
Jan	13.6			8.0	67.1	11.4	88	7.6	0.8		7.6	64.9	19.1	131
Feb	60.9	1.6		3.1	31.3	3.1	64	24.2	9.5	3.2		48.4	14.7	95
Mar														
Apr														
May	65.3	5.1			4.1	25.5	196	45.6	1.8	0.6		6.5	45.6	169
Jun														
Jul														
Aug		3.7	0.5	8.5	63.0	24.3	189	0.6	1.3		3.1	90.0	5.0	160
Sep		3.5		8.6	81.0	6.9	58	2.6			3.9	92.2	1.3	77
Oct														
Nov														
Dec		3.7		2.2	91.9	2.2	135		1.2		0.6	96.9	1.2	163
1982														
Jan		1.7			45.8	52.5	59		7.4			62.1	30.5	95
Feb		21.5			33.9	44.6	130		3.1	1.0		82.3	13.5	96
Mar		55.7	0.9		8.5	34.9	106		20.9			49.3	29.9	67
Apr														
May														
Jun		41.5	15.1	1.9	9.4	32.1	53		27.0	5.4		37.8	29.7	37
Jul		45.1	7.3	0.7	13.6	33.3	273	0.6	16.1	7.7	1.2	49.5	24.8	323
Aug		31.0	4.2	14.1	24.7	26.1	142		6.4		4.8	54.8	33.9	124
Sep														
Oct														
Nov														
Dec		16.5	3.8	1.3	77.2	1.3	79		0.8		0.8	90.0	8.3	120
1983														
Jan		29.6	1.4	1.8	56.3	10.8	277		13.3		1.7	79.6	5.5	181
Feb														
Mar														
Apr		25.8	3.2	3.2	35.5	32.3	31		8.6		5.7	65.7	20.0	35
May		61.5	11.5		15.4	11.5	26		33.3	9.5		47.6	9.5	21
Jun	23.3	30.2	2.3		7.0	37.2	43	13.0	32.6	15.2		23.9	15.2	46

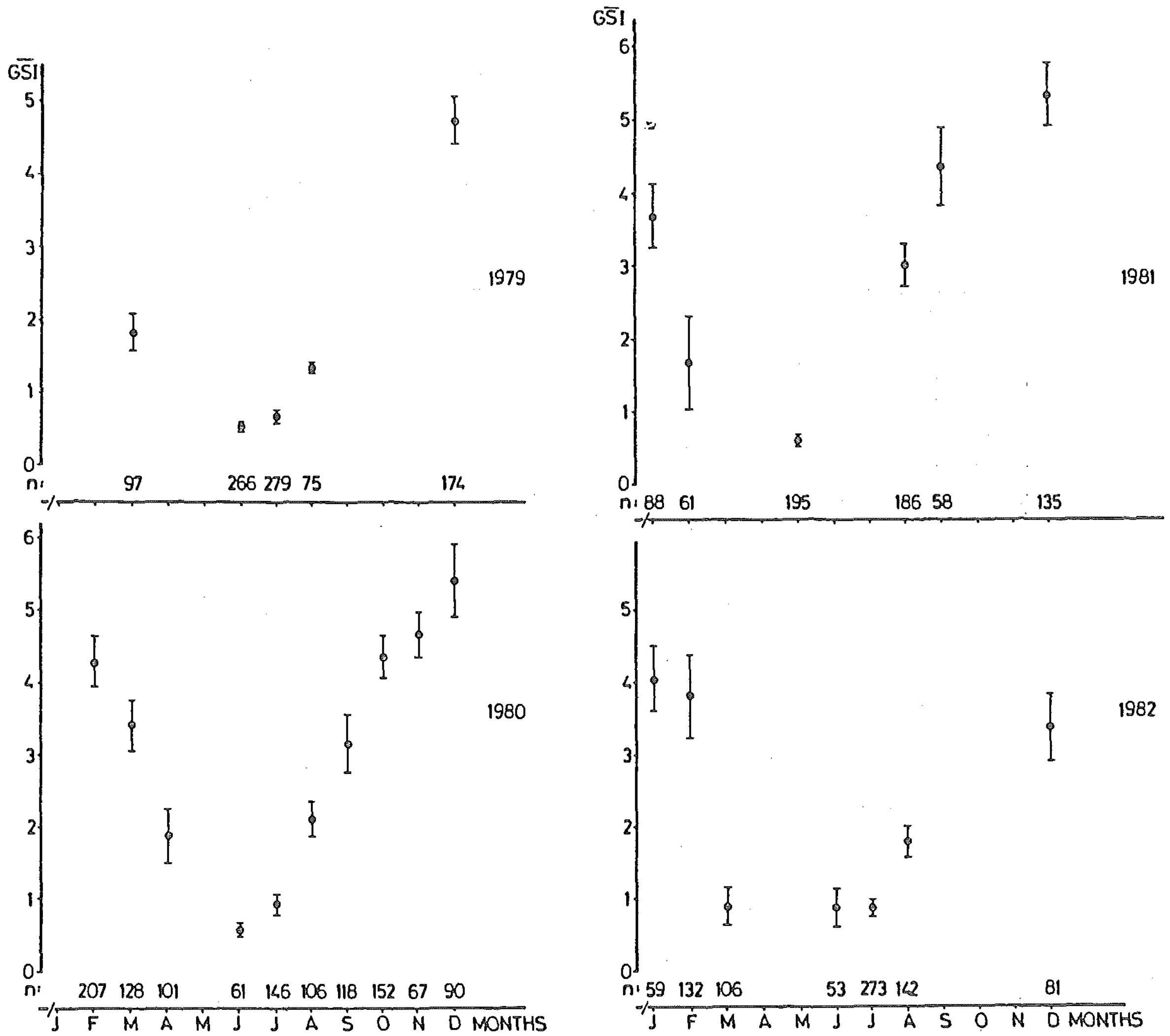

Fig. 2. Average monthly value of gonadosomatic index for females (vertical bars indicate 95% confidence limits) at Sofala Bank. Period 1979-82.

Table 2 - Maturity stages (percent) collected during the surveys at Sofala Bank. Period 1981-83

	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
1981														
S. KADANCHIK (21/04-17/05)	50.4	13.2	0.9	0.4	10.7	24.4	234	31.9	5.2	-	0.5	23.8	38.6	210
PEGAGO IV (22/05-12/06)	87.2	11.1			1.7		117	82.1	3.6	0.9		0.9	12.5	112
PANTIKAPEY (7/06-23/06)	75.5	12.7	5.5	0.9	0.9	5.5	110	68.0	5.8	-	1.9	3.9	20.4	103
PANTIKAPEY (21/07-5/08)	15.2	26.7	13.3	1.9	37.1	5.7	105	13.8	12.9	2.6	1.7	44.0	25.0	116
1982														
FR. NANSEN (29/08-30/09)			8.9	42.9	46.4	1.8	56				1.5	95.6	2.9	68
S. RYBAK (25/09-27/10)		3.4	55.2	41.4			29			50.0	50.0			20
S.RYBAK (9/11-18/12)		13.4		13.4	70.7	2.4	82		6.7		6.7	85.6	1.1	90
1983														
FR. NANSEN (29/05-8/06)	5.5	29.5	30.6	4.9	25.1	4.4	183	19.6	26.6	7.0	1.4	28.0	17.5	143

Table 3. Average value of gonadosomatic index for females collected during surveys at Sofala Bank. Period 1981-83.

	n	$\overline{GSI}$	s
1981			
S. KADANCHIK (21/04-17/05)	231	0.86	1.043
PEGAGO IV (22/05-12/06)	117	0.31	0.213
PANTIKAPEY (7/06-23/06)	110	0.51	0.550
PANTIKAPEY (21/07-5/08)	105	1.89	1.471
1982			
S. RYBAK (9/11-18/12)	43	5.35	2.469
1983			
FR. NANSEN (29/05-8/06)	41	1.00	0.877

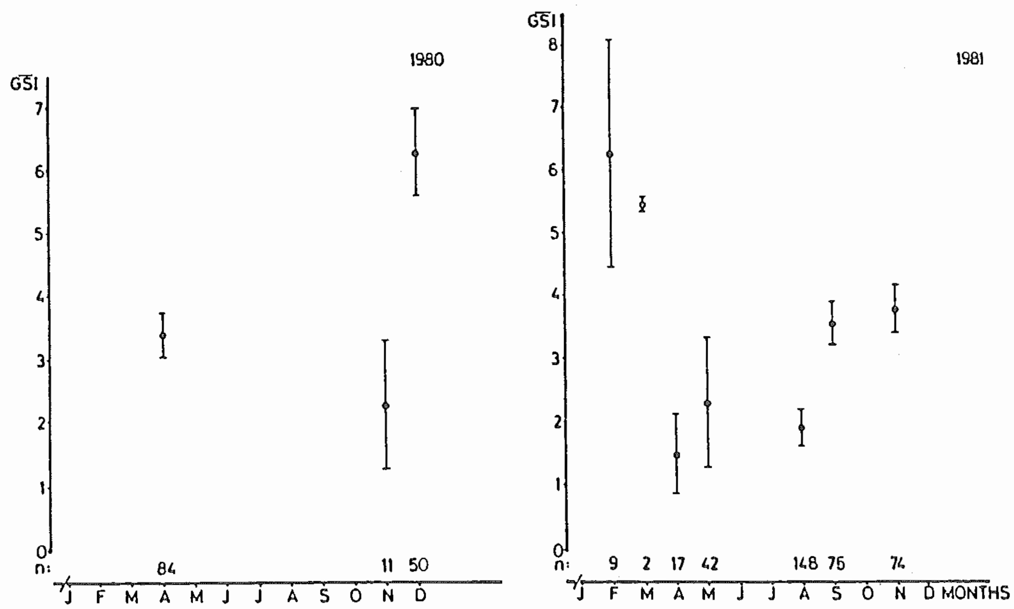

Fig. 3 - Average monthly value of gonadosomatic index for females (vertical bars indicate 95% confidence limits) at Boa-Paz. Period 1980-81.

Table 4 - Maturity stages (percent) collected on board the commercial vessels at Boa Paz. Period 1980-81

MONTH	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
1980														
Jan														
Feb														
Mar														
Apr	3.5			4.6	76.7	15.1	86	1.3			2.7	70.7	25.3	75
May														
Jun														
Jul														
Aug														
Sep														
Oct														
Nov	18.2				45.5	36.4	11					71.4	28.6	7
Dec				30.0	70.0		50	3.5			20.7	75.9		29
1981														
Jan														
Feb				22.2	77.8		9					90.9	9.1	11
Mar					100.0		2					83.3	16.7	6
Apr	35.3				41.2	23.5	17					45.4	54.6	11
May	44.2	7.0	2.3	9.3	30.2	7.0	43	50.0				10.0	40.0	30
Jun														
Jul														
Aug		8.8		5.4	47.3	38.5	148		4.0		1.3	80.3	14.5	76
Sep		2.5		15.2	78.5	3.8	79				3.7	94.4	1.9	54
Oct														
Nov		2.0		7.8	86.9	3.3	153		1.4		1.4	93.2	4.1	146

Table 5 - Maturity stages (percent) collected during the surveys at Boa Paz. Period 1981-82

	FEMALES							MALES						
	I	II	III	IV	V	VI	n	I	II	III	IV	V	VI	n
<u>1981</u>														
PRIMORETS (27/03-11/05)		47.8	13.0	39.1			23		19.4	5.6	16.7	58.3		36
PANTIKAPEY (30/06-15/07)	62.8	17.4	4.1	1.6	10.7	3.3	121	29.9	10.3	0.9	0.9	24.3	33.6	107
<u>1982</u>														
S. RYBAK (16-19/09)					100.0		5				37.5	75.0		8

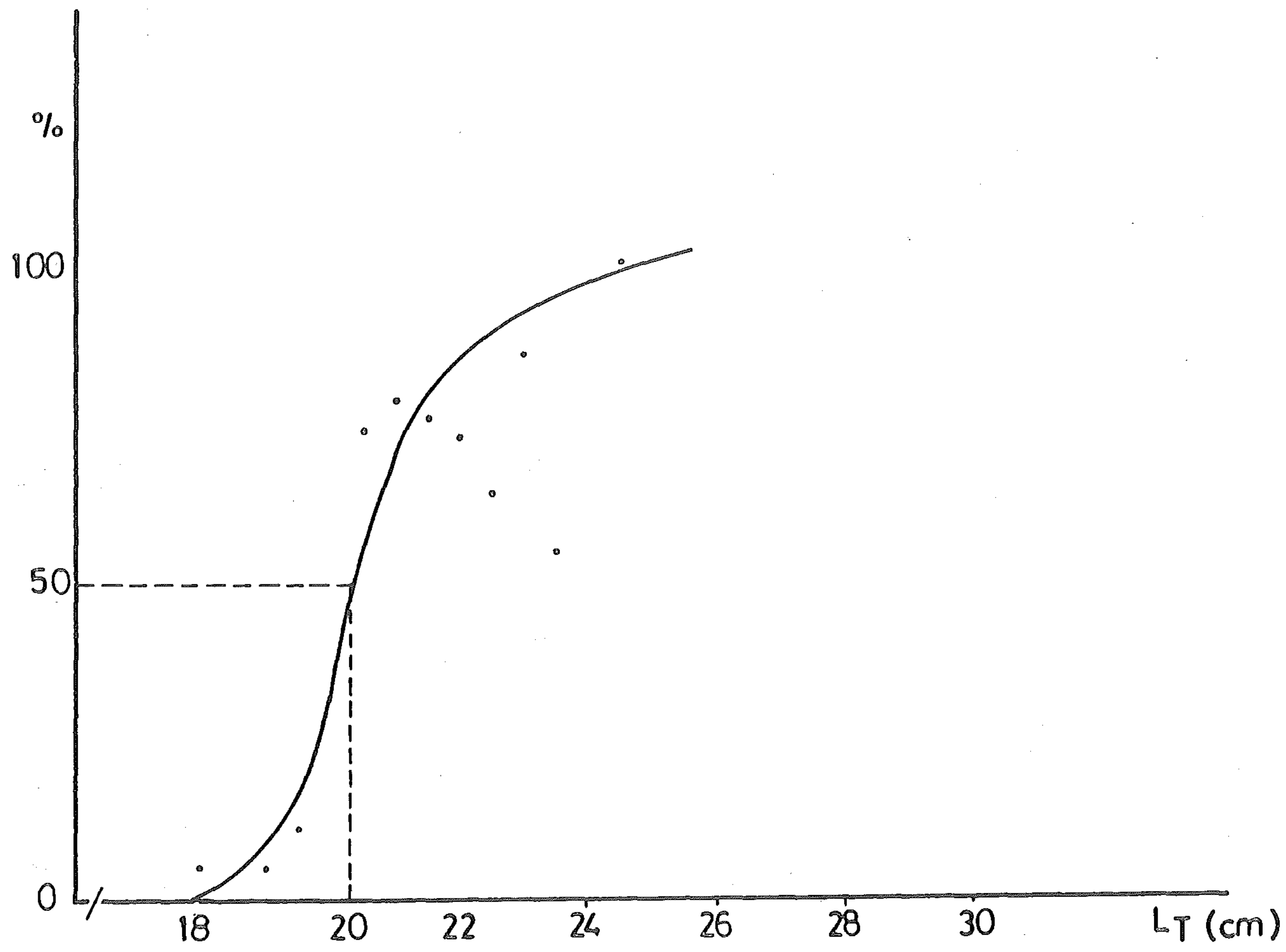

Fig. 4 - Size at first maturity (at 50%) of females

2. Length-weight relationship

The length-weight relationship was studied for 2464 individuals collected during 1980 from commercial catches.

Table 6. presents monthly values of a and b of the predictive regression equation

$$\log W = a + b \log L$$

where W is total weight in grams and L total length in centimeters. One common regression line based on all the material was derived:

$$\log W = 3.304 \log L - 2.385$$

with correlation coefficient $r = 0.928$ and 95% confidence limits of the regression coefficient are 3.251 and 3.356.

Table 6. Length-weight relationship from commercial catches 1980. Parameters a and b from the predictive regression $\log W = a + b \log L$ and the corresponding correlation coefficient r.

MONTH	n	a	b	r	SIZE RANGE (cm)
January					
February	428	-2.544	3.434	0.977	17.3 - 23.0
March	313	-2.755	3.579	0.960	15.9 - 24.1
April	245	-2.341	3.256	0.956	13.9 - 23.6
May					
June	149	-1.899	2.939	0.921	17.3 - 21.8
July	266	-1.968	2.989	0.918	16.2 - 25.0
August	248	-2.815	3.644	0.919	18.3 - 22.6
September	251	-2.491	3.397	0.926	18.2 - 24.0
October	248	-2.067	3.053	0.858	19.5 - 24.0
November	106	-1.559	2.688	0.853	19.1 - 22.0
December	210	-2.484	3.359	0.875	16.1 - 23.3
TOTAL	2464	-2.385	3.304	0.928	13.9 - 25.0

3. Age and growth

a) Ageing by counting daily growth rings in otoliths

Around the nucleous 80-120 primary growth rings are deposited in regular groups of 2-3 rings. After this pattern alternating light and dark bands are seen each containing 7, 14 or 28 primary growth rings. The change from the first to the second part is very abrupt. The number of rings is most easily estimated by counting the bands and multiplying by the number of primary rings in each. These bands are observed until 2/3 of the size of the otolith. The last third is composed of very thin primary rings not disposed in bands and laid down very close to each other. No spawning rings were seen.

Initial estimates of growth parameters were made by use of individual readings grouped in monthly age groups in order to minimize possible errors in the individual age readings.

Graphical methods were applied (Beverton and Holt, 1957) to estimate the growth parameters of the von Bertalanffy growth equation and the following result obtained:

$$L_t = 28.51 \ (1-e^{-0.722 \ (t - 0.15)})$$

where L_t is total length in centimeters and t the time at length L_t.

Later the estimates were improved by use of a least squares technique. As the age readings probably show a greater variation than the length measurements, the growth equation was first transformed to:

$$t = t_o - \frac{1}{K} \ln \frac{(L_\infty - L_t)}{L_\infty}$$

which has the advantage that L_t becomes the independent variate and t the dependent.

Furthermore it can be solved as a linear regression equation:

$$y = a + bx$$

by inserting individual L_t at time t and a first guess of L_∞. Different values of L_∞ were tried and the value which minimized the sum of squares of the difference between observed time and estimated time was adopted.

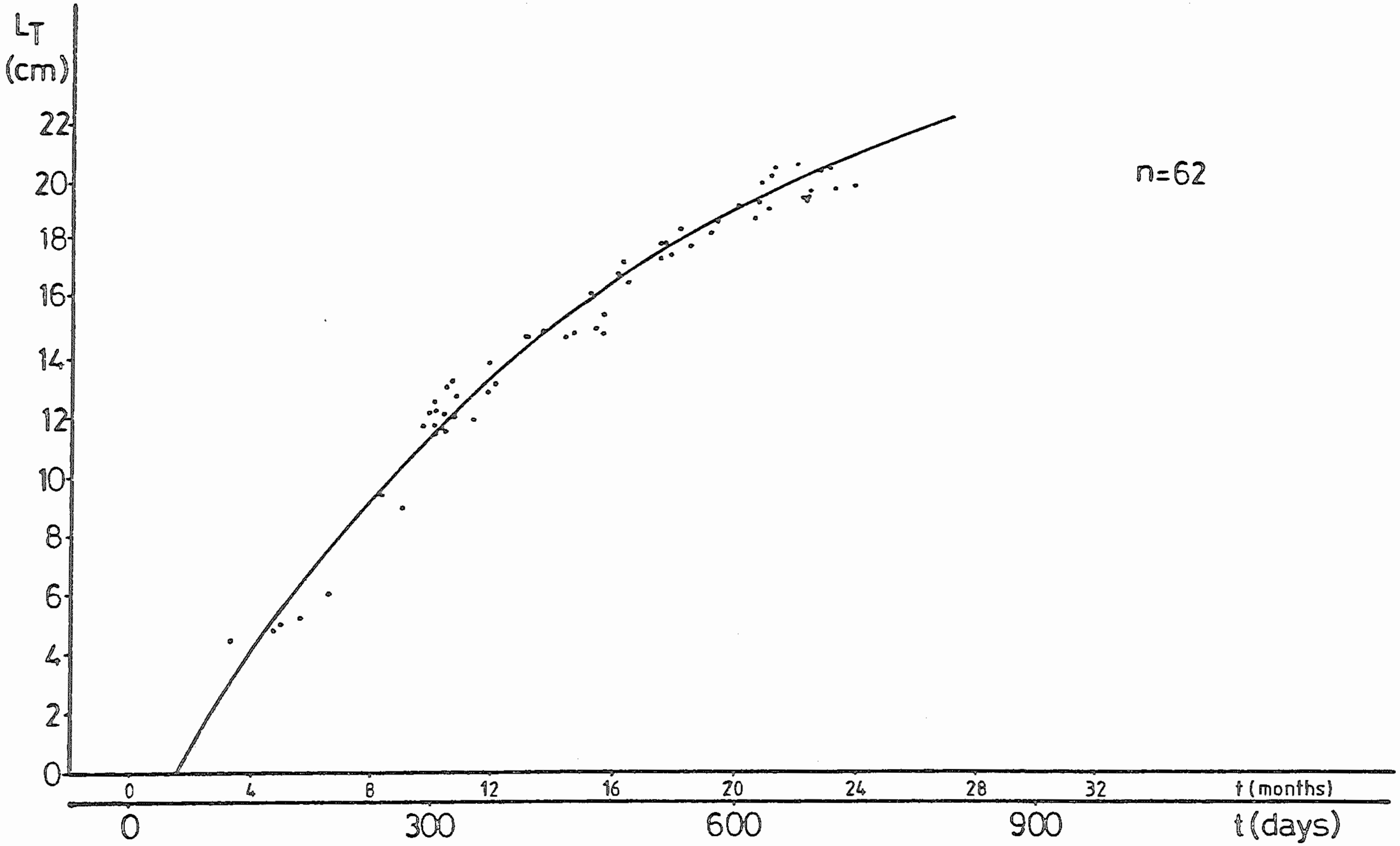

Fig. 5. Growth curve of R. kanagurta based on otolith readings .

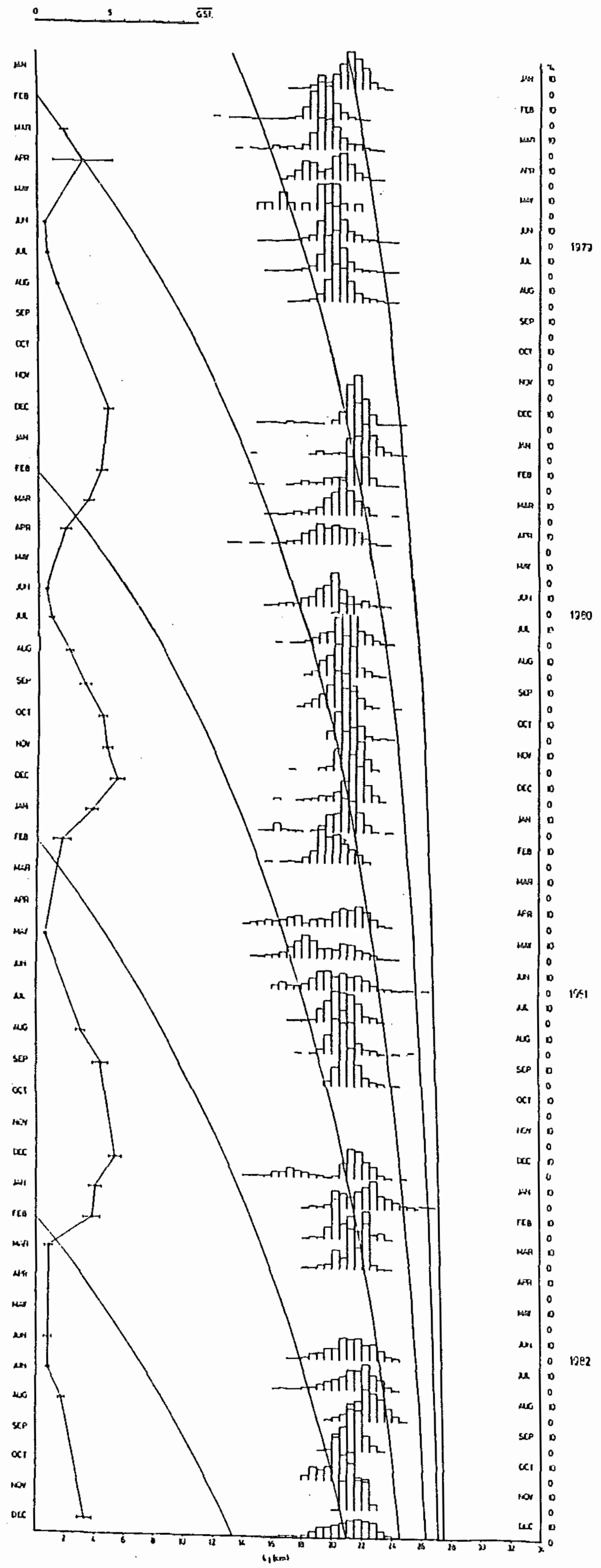

Fig. 6 - Growth curves based on otolith readings, monthly length distributions and average monthly value of gonadosomatic index for females. Period 1979-82.

The results were (Fig. 5):

$$L_\infty = 27.8 \text{ cm}$$
$$K = 0.753 \text{ year}^{-1}$$
$$t_o = 0.128 \text{ year}$$

Fig. 6 presents growth curves using these parameters and assuming that the birthdate of R. kanagurta is the first of January. Monthly length distributions for the period 1979 to 1982 and mean monthly gonadosomatic index of females are also presented.

In general the curve is passing through most of the modes of the length distributions. The highest gonadosomatic index observed coincides with the time the big fish are dominating the catches. No correlation between GSI and length was however performed.

b) Estimating growth parameters from length-frequency data

Monthly length compositions of R. kanagurta from 1979, 1980 and 1981 were used to estimate growth parameters by Elefan II (Pauly, David and Ingles, 1981) (Fig. 7).

The following equation was used:

$$L_t = L_\infty \left(1 - e^{-k(t - t_o) + C \frac{K}{2\pi} \sin(2\pi (t - WP + 0.5))}\right)$$

where L_∞ , K and t_o are the parameters of the von Bertalanffy growth equation and C and WP the parameters introduced to take seasonal oscillations of growth into account.

For each year a set of growth parameters was estimated. The results were:

	1979	1980	1981
L_∞	29.5	28.5	30.5
K	0.850	0.825	0.900
C	0.4	0.4+	0.4
WP	0.7	0.7	0.6

+ value fixed before iteration, ie not estimated from the data.

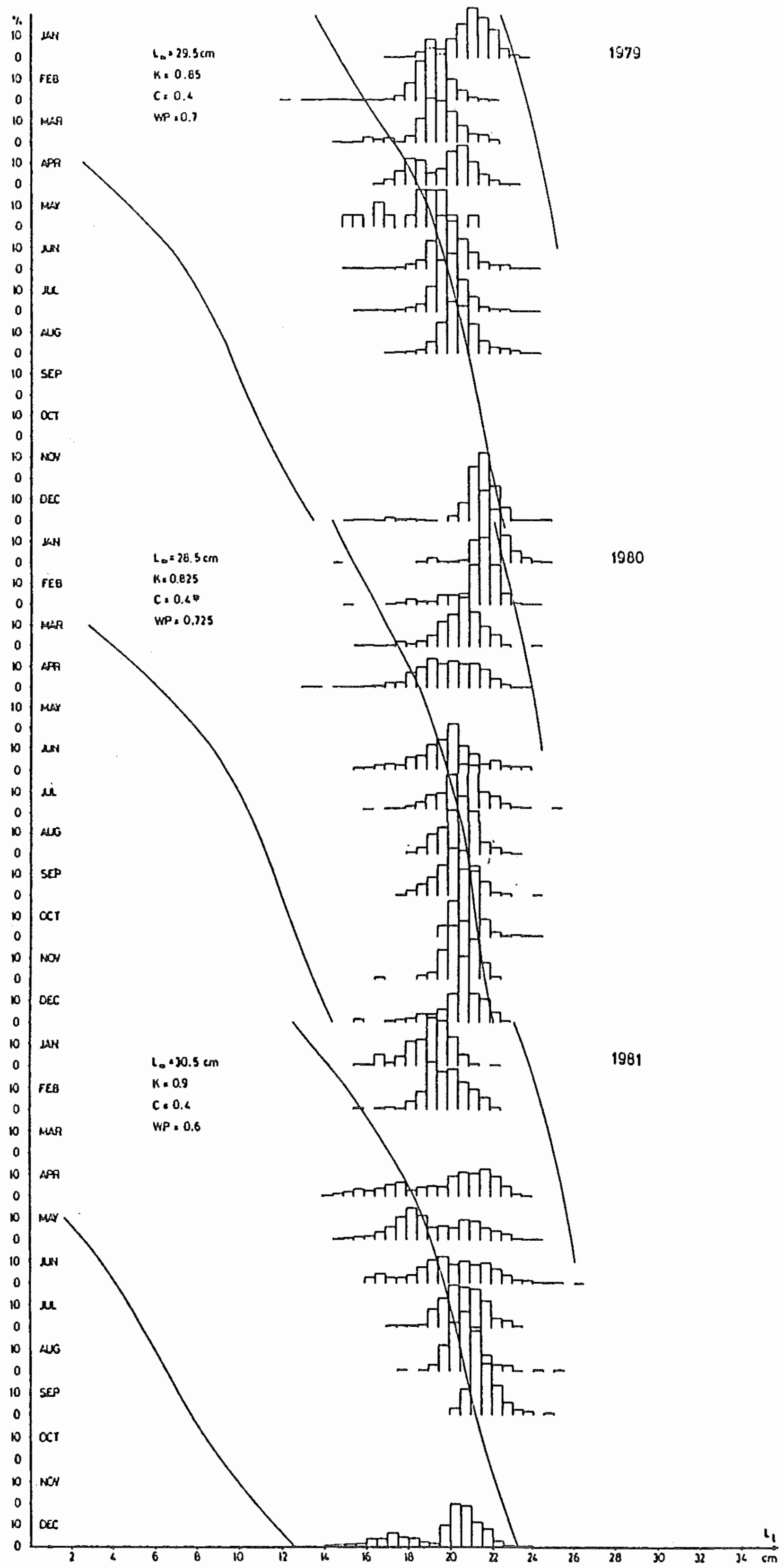

Fig. 7 - Growth curves estimated by Elefan II. Period 1979-81.

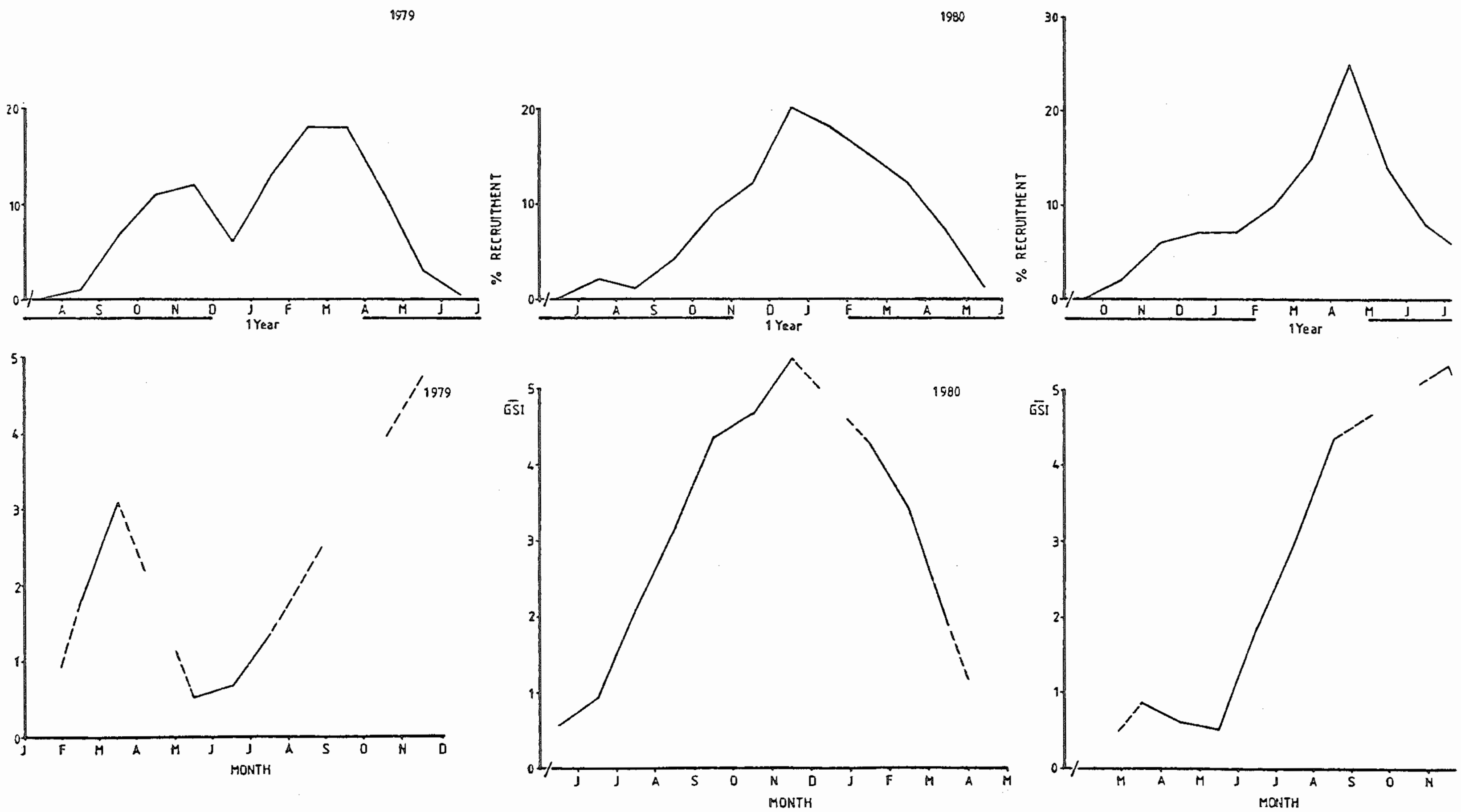

Fig. 8 - Recruitment patterns derived from Elefan II. Period 1979-81

Estimates of t_o were obtained by inserting the length at age from the otolith readings into the equations. For each year a mean t_o was calculated. The results were 0.35, 0.27 and 0.44 for 1979, 1980 and 1981, respectively.

Elefan II also generated recruitment patterns. Fig. 8 shows recruitment patterns of indian mackerel for 1979, 1980 and 1981 and the pattern obtained by plotting mean gonadosomatic index of females against time.

Adjusting to real time by means of t_o the recruitment peaks obtained by Elefan II corresponds nicely to the spawning peaks obtained from the gonadosomatic index.

4. Total mortality

The total mortality, Z, was also estimated by ELEFAN II by the construction of catch curves from length frequency data and growth parameters. Fig. 9 presents for 1979, 1980 and 1981 plots of natural logarithm of number caught against age. The slope of the regression line passing through the points of the descending part of the curve is equal to minus Z. The values of Z obtained, 9.98, 8.86 and 9.29 for 1979, 1980 and 1981, respectively are very high.

Other methods of estimating total mortality, such as Jones and Zalinge (1981) and individual estimates of Z by length groups have also been tried but the results are in the same range as the values presented here (Borges et al, 1984). The explanation could be the emigration of big fish away from the fishing grounds or a decrease in their catchability with length.

III - DISCUSSION

Both the maturity stages and the gonadosomatic index show that R. kanagurta has a long spawning season which lasts from August to March or April at Sofala Bank. Within this period it is common to find samples where more than 50% of the individuals are in stage V, spawning. As all of the samples used in this study were collected within the fishing area which only covers

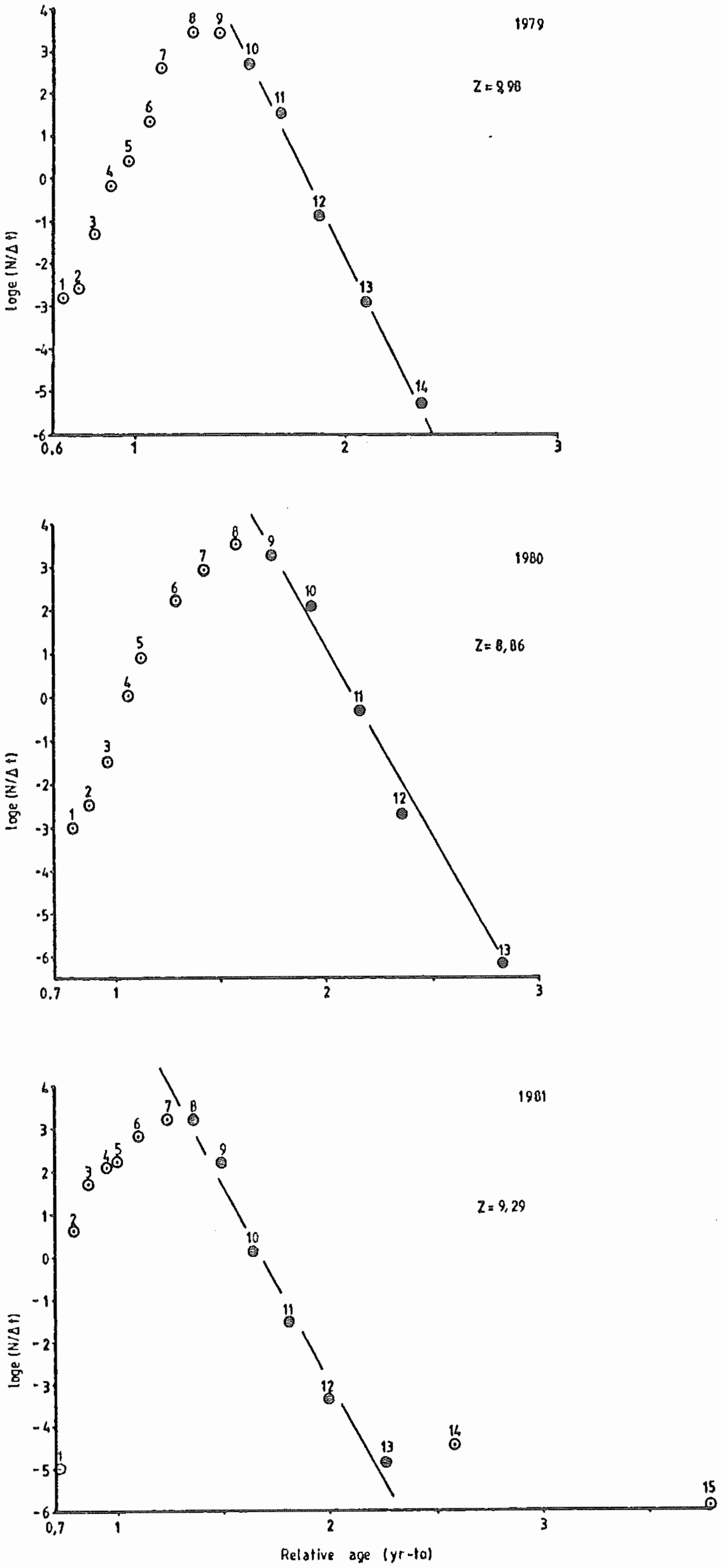

Fig. 9 - Total mortality, Z, estimated by Elefan II. Period 1979-81.

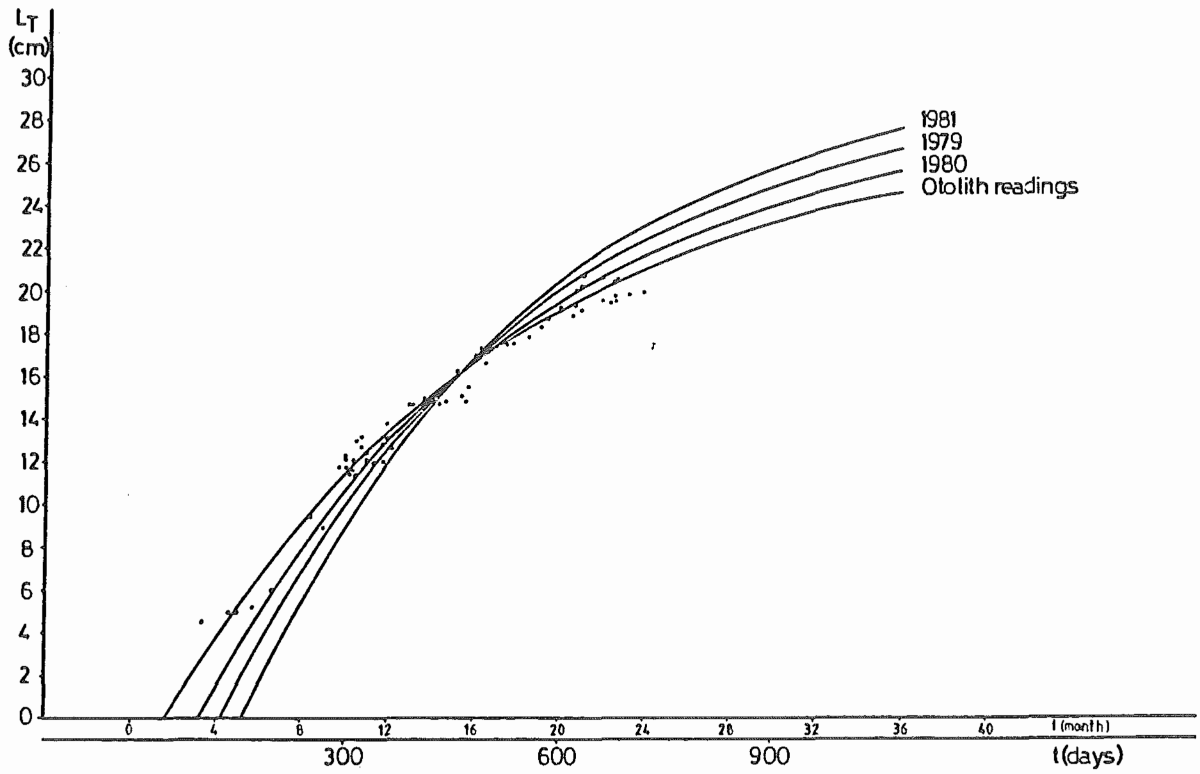

Fig. 10 - Growth curves based on otolith readings and by use of Elefan II.

a small part of the total distribution area one may speculate whether such high percentages of fish in spawning are due to a continuous influx of spawners into the area or to repeated spawning by the same group of fish. Other information suggest that the last possibility is the most likely. Pradhan (1956), Sekharan (1958) and Radnakrishnan (1965) concluded from studies of the development of eggs in the ovaries of R. kanagurta caught at Karwar, India, that the eggs are released in several small batches over an extended period. In addition spawners have been found outside the fishing area during research surveys. Unfortunately these samples are too few to show the extent of the total spawning area.

Fig. 10 presents the growth curves estimated from otolith readings and by the use of ELEFAN II. As no confidence limits can be calculated for the estimated growth parameters it is impossible to tell whether the curves differ significantly from each other or not. If they do the reason may be problems with the interpretation of the primary rings of the otoliths. Another possibility is that length frequencies used as input to the ELEFAN II are biased because of migrations to and from the fishing area.

It is tempting, but perhaps a bit premature to try to relate the three secondary zones observed in the otoliths to the life history of R. kanagurta. During research surveys juveniles were caught by pelagic trawl in the so-called "untrawlable" area outside Beira. At a length of approx. 12 cm, corresponding to an age of 11 months, they start to recruit to the bottom trawl fishery.

Maturity is reached at a length of 20-21 cm at an age of approx. two years. Only very few fish are caught which are more than three years old. The explanation is probably that they have migrated to other areas. Returning to the otoliths it seems thus as if the two innermost zones are formed in the juvenile phase and that the commencement of the third may be connected with the recruitment to the fishing area. This hypothesis should however be checked by further observations.

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V - REFERENCES

BEVERTON, R.F.H. and S.J. HOLT - On the dynamics of exploited fish
1957 populations. Fish.Invest. (Ser.2), U.K. Min.Agric.Fish, (19)533 p.

BORGES, F., H. GISLASON and M.I. SOUSA - A preliminary assessment of the
1984 scad and mackerel stocks at Sofala Bank, Mozambique. Rev. Inv.Pesq., (12):37-107

BRINCA, L. et al. - A survey on the marine fish resources of Mozambique,
1981 Oct.-Nov. 1980. Rep.Surv.R/V Dr.F.Nansen, Maputo, IDP / Bergen, IMP. 58 p

BRINCA, L. et al. - A survey on the fish resources at Sofala Bank,
1983 Mozambique, September 1982. Rep.Surv.R/V Dr.F.Nansen, Maputo, IIP / Bergen, IMR. 70 + 15 p

BRINCA, L. et al. - A survey on the fish resources at Sofala Bank,
1984 Mozambique, May-June 1983. Rep.Surv.R/V Dr.F.Nansen, Maputo, IIP / Bergen, IMR. 90 p

BUDNITCHENKO, V. - Recursos de peixes de águas da plataforma continental,
1979 adjacentes à República Popular de Moçambique: com base nos resultados da análise da pesca industrial dos navios soviéticos de 1977 e 1978 (manuscript)

__________ - Características das áreas de pesca com base na análise das
1980 capturas dos barcos soviéticos de pesca em 1979 (manuscript)

GJOSAETER, J. and M.I. SOUSA - Reproduction, age and growth of the
1983 Russell's scad, _Decapterus russellii_ (Ruppel, 1828) (Carangidae) from Sofala Bank, Mozambique. _Rev.Inv.Pesq._, (8):83-107

JONES, S. and H. ROSA JR. - Synopsis of biological data on indian mackerel,
1965 _Rastrelliger kanagurta_ (Cuvier) 1817 and short - bodied _Rastrelliger brachysoma_ (Bleeker) 1851. Rome, _FAO Fish. Syn._, (29)

JONES, R. and N.P. van ZALINGE - Estimates of mortality rate and population
1981 size for shrimp in Kuwait waters. _Kuwait Bull.Mar.Sci._ (2): 273-288

LOSSE, G.F. - Description of the indian mackerel _Rastrelliger kanagurta_
1974 (Cuvier) from East African waters with preliminary notes on the biology and fishery. _East Afr.Mar.Fish.Res.Org.Rep._, (L1)

MENON, M. and N. RADHAKRISHNAN - Present status of knowledge regarding the
1974 biology of indian mackerel, _Rastrelliger kanagurta_ (Cuvier). _IPFC Proces._ 15(3):343-350

PAULY, D., N. DAVID and J. INGLES - Elefan II: User's instructions and
1981 program listing. Mimeo. pag. var.

PRADHAN, L.B. - Mackerel fishery of Karwar. _Indian J. Fish._, 3 (1):141-185
1956

RADHAKRISHNAN, N. - Observations on the maturity and spawning of Indian
1965 mackerel, _Rastrelliger kanagurta_ (Cuvier) at Karwar. _Indian J. Fish._, 9(2) A:512-514

RONQUILLO, I.A. - A review of the roundscad fishery in the Philippines.
1974 _IPFC Procs._, 15(3):351-375

SEKHARAN, K.V. - On the south Kanara coastal fishery for mackerel,
1958 _Rastrelliger kanagurta_ (Cuvier) together with notes on the biology of the fish. _Indian J. Fish._, 5:1-31

SAETRE, R. and R.P. SILVA - The marine fish resources of Mozambique.
1979 Rep.Surv.R/V Dr.F.Nansen, SIP, Maputo / IMR, Bergen.

SOUSA, M.I. - Relatório do cruzeiro realizado no Banco de Sofala pelo
1983 navio "Pantikapey" de 7 a 23 de Junho de 1981 - Peixes pelágicos e fauna acompanhante de carapau e cavala. Rev.Inv.Pesq., (4):33-66

SOUSA, M.I. - Relatório do cruzeiro realizado no Banco de Sofala pelo
1983 navio "Pantikapey" de 4 de Julho a 7 de Agosto de 1981 - Peixes pelágicos e fauna acompanhante de carapau e cavala. Rev.Inv.Pesq., (4):67-97

TIMOCHIN, I. et al. - Report on the cruises conducted by "S. Rybak" at Sofala Bank from September to December 1982 (in prep.)