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"Preliminary results on age and growth of <u>Sardina</u>
<u>pilchardus</u> (WALB.) in sub-area IXa"

by

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SUMMARY

The age of the Atlantic sardine, (Sardina pilchardus (WALB.) was
determined based on otoliths collected from commercial fish samples during
1979.

The relationship between fish length and otolith radius can be
expressed by a linear regression equation

Results concerning Center and Southern zones are presented separately.

The von Bertalanffy's growth equations obtained by back calculation
on otolith readings were:

Center Zone: $L_t = 23,79 \left[1 - e^{-0,5292 (t+0,6939)} \right]$

Southern Zone: $L_t = 23,55 \left[1 - e^{-0,4866 (t+0,5365)} \right]$

SOMMAIRE

On présente les résultats préliminaires de l'évaluation des paramè-

tres de croissance de l'équation de von Bertalanffy concernant Sardina pil-
chardus (WALB.) de la côte portugaise.

Ces paramètres ont été déterminés par l'examen des otolithes. Les échantillons
ont été recueillis dans les zones Centre et Sud de la côte et les résultats
sont présentés séparément.

$$\text{Zone Centre} \quad L_t \doteq 23.79 \left[1 - e^{-0.5292 \ (t+0.6939)} \right]$$

$$\text{Zone Sud} \quad L_t = 23.55 \left[1 - e^{-0.4866 \ (t+0.5365)} \right]$$

1 - INTRODUCTION

The pilchard (Sardina pilchardus WALB.) is one of the most important
fishries of the portuguese coast with 57% of the total landed during the
period 1975-1978.

The most common gear is the purse-seine, responsable for 97% of the
landings in the same period.

The present paper is an attempt to estimate growth parameters of the von
Bertalanffy equation based on the otolith observations.

As for the portuguese coast this is the first study on pilchard growth
based on the otoliths and as the data concern only one year, these results
must be considered as preliminary.

2 - MATERIAL AND METHODS

Every month from January to December 1979, two purse seine landings at
Center zone (Peniche) and two every week at Southern zone (Olhão) were
sampled for total length measurements (0.5 cm below) and weight/length
relationship.

Otoliths were collected from 939 pilchards at the Center Zone and from
905 at Southern Zone. Each individual fish was measured weighted and
sexed. The sexual maturity and degree of adiposity were also registered.

The otoliths were examined using a stereomicroscop (x20 magnification) under reflected light, in a petri dish with ethanol, against a dark background.

Measurements of the otoliths were made with a micrometer eyepiece.

Fig.1 shows the way those measurements were made.

The age of the sardines was determined by counting the translucent zones, assuming that an opaque and a translucent zones are formed during an year growth.

For the age group determination the birthday was allocated as 1stJanuary.

3 - <u>RESULTS AND DISCUSSION</u>

3.1 - <u>Rings formation</u>

We observed the edge of all otoliths collected in order to establish the annual periodicity of the growth zones formation. Figs. 2a and 2b show the seasonal changes in marginal characters of the otoliths. The seasonal pattern of the two zones formation is clear in spite of the occurrence of the opaque and hyaline edge all along the year. We can presume that an hyaline zone and an opaque zone are formed respectively in the winter and summer.

3.2 - <u>Back calculation of the growth</u>

The length of fish at the time of rings formation was calculated using otolith radius (RO) / total body length (L_t) relationship, represented by the following equations (Figs 3a and 3b):

$$\text{Center Zone} \quad RO = 0.1093 + 0.0067 \, L_t$$
$$r = 0.9954$$

$$\text{Southern Zone} \quad RO = 0.2110 + 0.0064 \, L_t$$
$$r = 0.9925$$

The TAB.I shows, for each age group the mean distance of annuli measurements, r_n (from otolith center to the inner limite of opaque zone).

TAB.I - Mean distance (mm) of hyaline zones from otolith center

Age group	Center Zone r_n	Southern Zone r_n
I	1.052	1.007
II	1.327	1.285
III	1.453	1.445
IV	1.550	1.556
V	1.625	

For the calculation of the fish length at annulus formation the data of the TAB.I were substituted on the equations indicated above.

TAB.II - Calculated and observed length and annual increment

Age group	Center Zone			Southern Zone		
	L_t calc. (cm)	Inc (cm)	L_t obs. (cm)	L_t calc. (cm)	Inc (cm)	L_t obs. (cm)
I	14.15		16.73	12.42		14.46
		4.14			4.33	
II	18.29		19.09	16.75		17.83
		1.88			2.50	
III	20.17		21.28	19.25		20.03
		1.46			1.73	
IV	21.63		21.73	20.98		21.16
		1.12				
V	22.75		22.75	-		-

We can observe comparing the data of the TAB.II that for the same age group the pilchards of center zone are greater than that of Southern zone.

A rapid growth for the younger fishes was also observed for both zones.

The parameters L_∞ and K of von Bertalanffy equation

$$L_t = L_\infty \left[1-e^{-k(t-t_o)}\right]$$

were determined from the Walford plot, (Fig. 4a and 5a) and t_o was calculated by the method described by Gulland (1965) resulting the following equations:

Center Zone: $L_t = 23.79 \left[1-e^{-0.5292(t+0.6939)}\right]$

Southern Zone: $L_t = 23.55 \left[1-e^{-0.4866(t+0.5365)}\right]$

The *length* of the pilchard from the two considered geographic zones (TAB.IV) was calculated from the above equations (Fig. 4b and 5b)

TAB.IV.Pilchard *length* in Center and Southern Zones:

Age Group	I	II	III	IV	V
Center Zone	14.08	18.07	20.43	21.81	22.63
Southern Zone	12.40	16.69	19.33	21.00	-

The data of TAB.V were used to calculate the weight/length relationship which can be expressed by the following equations:

Center Zone $W = 0.0033\ L^{3.2914}$ $r=0.998$

Southern Zone $W = 0.0056\ L^{3.1346}$ $r=0.999$

resulting:

Center Zone $W_\infty = 111.91$ g

Southern Zone $W_\infty = 111.06$ g

The growth in weight by age can therefore be expressed as follows:

Center Zone : $W_t = 111.91 \left[1-e^{-0.5292(t+0.6939)}\right]^{3.2914}$

Southern Zone: $W_t = 111.06 \left[1-e^{-0.4866(t+0.5365)}\right]^{3.1346}$

TAB. V - Weight/length relationship

Length (cm)	Center Zone mean weight (g)[x]	Southern Zone mean weight (g)[x]
7.25	(2.0)	
7.75	(2.7)	2.8
8.25	-	3.8
8.75	-	4.6
9.25	-	5.7
9.75	-	6.8
10.25	(6.5)	7.9
10.75	-	9.0
11.25	8.85	10.3
11.75	10.85	11.7
12.25	12.47	13.3
12.75	13.75	15.1
13.25	16.30	17.3
13.75	17.62	19.4
14.25	20.20	21.8
14.75	23.34	24.3
15.25	26.50	26.8
15.75	29.15	29.4
16.25	33.04	32.2
16.75	38.62	35.3
17.25	41.92	38.3
17.75	45.45	41.9
18.25	49.78	47.1
18.75	53.48	52.0
19.25	56.66	57.3
19.75	61.74	62.3
20.25	65.61	67.8
20.75	72.47	74.2
21.25	75.83	79.9
21.75	81.76	88.2
22.25	84.15	93.0
22.75	93.97	102.9
23.25	91.88	99.6
23.75	109.85	(108.0)
24.25	(110.00)	

x - The mean weight into brackets were not considered
   in the calculs because they were obtained from
   only one fish.

TAB. VI - Calculated mean weight values (g) by age group

Age Group	I	II	III	IV	V
Center Zone	19.93	45.28	67.71	84.02	94.81
Southern Zone	14.87	37.78	59.87	77.08	-

TAB. VII shows different growth equations in length of
Sardina pilchardus (WALB.) obtained by different authors.

TAB. VII - Different growth equations in length of Sardina pilchardus
(WALB.)

ZONE	METHOD*	EQUATION	AUTHOR
MARRUECOS	L.D.E.	$L_t = 21.63 \left[1-e^{-0.49(t+1.07)}\right]$	BELVEZE, 1972 **
SAHARA ESP.	L.D.O.	$L_t = 22.96 \left[1-e^{-0.517(t+0.84)}\right]$	KRZEPTOWSKI, 1975 **
SAHARA ESP.	L.D.O.	$L_t = 24.62 \left[1-e^{-0.371(t+1.32)}\right]$	KRZEPTOWSKI, 1978 **
AL HOCEIMA	L.D.E.	$L_t = 20.19 \left[1-e^{-0.476(t+1.69)}\right]$	BELVEZE
SAFI-AGADIR	L.D.E.	$L_t = 21.23 \left[1-e^{-0.680(t+1.33)}\right]$	et
AGADIR	E.E.	$L_t = 20.27 \left[1-e^{-0.981(t-0.02)}\right]$	RAMI, 1978
P^{ta} STAFFORD	E.E.	$L_t = 20.25 \left[1-e^{-0.926(t-0.06)}\right]$	**
CABO BLANCO	E.E.	$L_t = 22.81 \left[1-e^{-0.946(t-0.22)}\right]$	
GALICIA	L.D.E.	$L_t = 23.0 \left[1-e^{-0.5(t+0.96)}\right]$	LOPEZ VEIGA, 1978
CANARY ISLAND	L.D.O.	$L_t = 21.58 \left[1-e^{-0.82(t+1.29)}\right]$	BRAVO de LAGUNA
	E.E.	$L_t = 21.93 \left[1-e^{-0.80(t+0.38)}\right]$	et al, 1979
PORTUGAL CENTER ZONE	B.O.	$L_t = 23.79 \left[1-e^{-0.5292(t+0.6939)}\right]$	Present
SOUTHERN ZONE	B.O.	$L_t = 23.55 \left[1-e^{-0.4866(t+0.5365)}\right]$	paper

* L.D.E. - Direct readings on scales
  L.D.O. - Direct readings on otoliths
    E.E. - Scalimetry
    B.O. - Backcalculation on otoliths readings
** Ref. by BRAVO de LAGUNA et al, 1979

Comparing the data of TAB. VII we can observe that Portugal results are more similar with those from Galicia.

TAB. VIIIa and VIIIb represent the length age keys for the two considered geographic zones.

4 - CONCLUSIONS

We can assume that:

1 - The formation of an opaque and an hyaline zones corresponds to an year growth.

2 - The weight/length relationship can be expressed by

Center Zone $\quad W = 0.0033 \, L^{3.2914}$

Southern Zone $\quad W = 0.0056 \, L^{3.1346}$

3 - The otolith radius/total length relationship for the two zones are:

Center Zone $\quad RO = 0.1093 + 0.0067 \, L_t$

Southern Zone $\quad Ro = 0.2110 + 0.0064 \, L_t$

4 - The growth equations in length are:

Center Zone $\quad L_t = 23.79 \left[1 - e^{-0.5292 \, (t+0.6939)} \right]$

Southern Zone $\quad L_t = 23.55 \left[1 - e^{-0.4866 \, (t+0.5365)} \right]$

5 - The growth equations in weight are:

Center Zone: $\quad W_t = 111.91 \left[1 - e^{-0.5292 \, (t+0.6939)} \right]^{3.2914}$

Southern Zone: $\quad W_t = 111.06 \left[1 - e^{-0.4866 \, (t+0.5365)} \right]^{3.1346}$

REFERENCES

BRAVO de LAGUNA et al, 1979 - Growth studies of Sardina pilchardus (WALB.)
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GULLAND, J.A., 1965 - Manual of methods for fish stock assessement Part I.
Fish population analysis. FAO Manuals in Fisheries Science Nº4.

LOPEZ VEIGA, E.C., 1978 - Parâmetros poblacionales de la sardina (Sardina
pilchardus) de la Galicia. Inv. Pesq. 42 (2)

RICKER, W.E., 1958 - Handbook of computations for biological statistics of
fish population. Bull. Fish. Res. Bd. Can. Nº 119

Note: This results were presented by the authors at the meeting of "Working
Group for the Appraisal of Sardine Stocks in Divisions VIIIc and IXa"
in Vigo (Spain) 1980.

TABLE VIIIa — Age length key of sardine from Center Zone

Lt. Cm	Age length key							TOTAL
	0	I	II	III	IV	V	VI	
7.25	1							1
7.75	1							1
8.25	—							—
8.75	—							—
9.25	—							—
9.75	—							—
10.25	1							1
10.75	—							—
11.25	—	1						1
11.75	—	2						2
12.25	1	4						5
12.75	—	5						5
13.25	3	4						7
13.75	3	5						8
14.25	6	8						14
14.75	7	10						17
15.25	5	14						19
15.75	1	25						26
16.25	3	30						33
16.75	2	34	6					42
17.25		28	20					48
17.75		16	27					43
18.25		10	38					48
18.75		11	51					62
19.25		10	41	2				53
19.75		11	46	2				59
20.25		9	30	4	2			45
20.75		2	13	9	3			27
21.25		1	14	6	4			25
21.75		2	5	12	5			24
22.25				6	7	1		14
22.75				2	2	1		5
23.25				1	—	1		2
23.75					1		1	2
TOTAL	34	242	291	44	24	3	1	639

TABLE VIIIb — Age length key of sardine from Southern Zone

| Lt. Cm | Age length key | | | | | | | TOTAL |
	0	I	II	III	IV	V	VI	
8.25	1							1
8.75	4							4
9.25	5	3						8
9.75	9	4						13
10.25	11	5						16
10.75	11	9						20
11.25	11	17						28
11.75	17	20						37
12.25	18	19						37
12.75	17	19						36
13.25	16	19						35
13.75	9	28						37
14.25	9	32						41
14.75	3	38	2					43
15.25	4	39	1					44
15.75	1	27	15					43
16.25		23	19					42
16.75		30	21					51
17.25		17	31	1				49
17.75		13	30	2				45
18.25		6	35	4				45
18.75		5	32	7				44
19.25			17	18				35
19.75			10	20	5			35
20.25			7	21	7			35
20.75			3	14	10	1		28
21.25				17	7	1		25
21.75				3	8	1		12
22.25				–	4	3	1	8
22.75				1	2	1	–	4
23.25					1	1	1	3
23.75					1			1
TOTAL	146	373	223	108	45	8	2	905
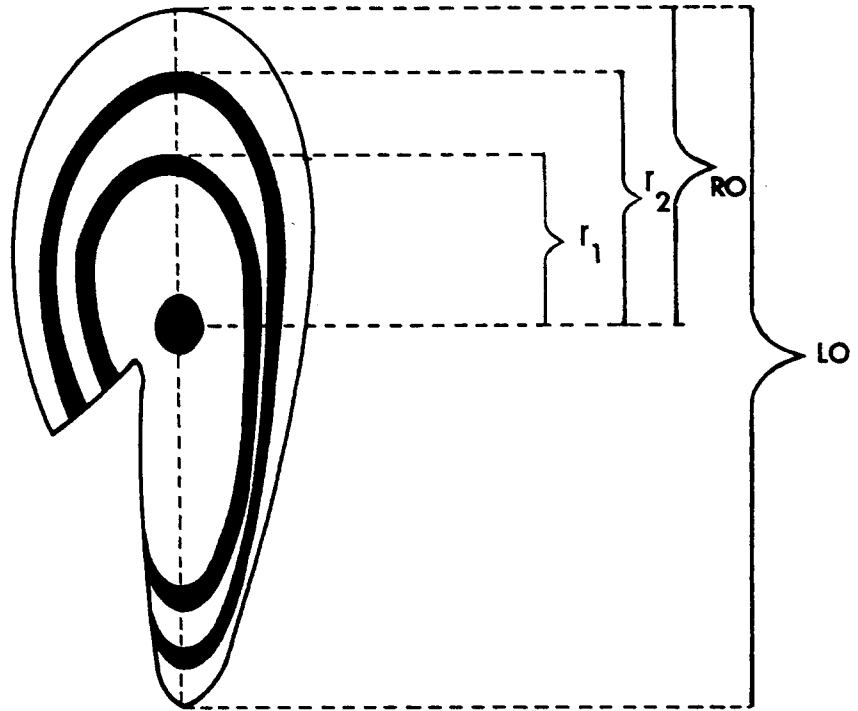
Posterior edge

Anterior edge

Fig. 1 — Schematic drawing showing otolith measurements

Fig. 2 a — Seasonal changes in marginal character of otoliths of sardines from Center Zone
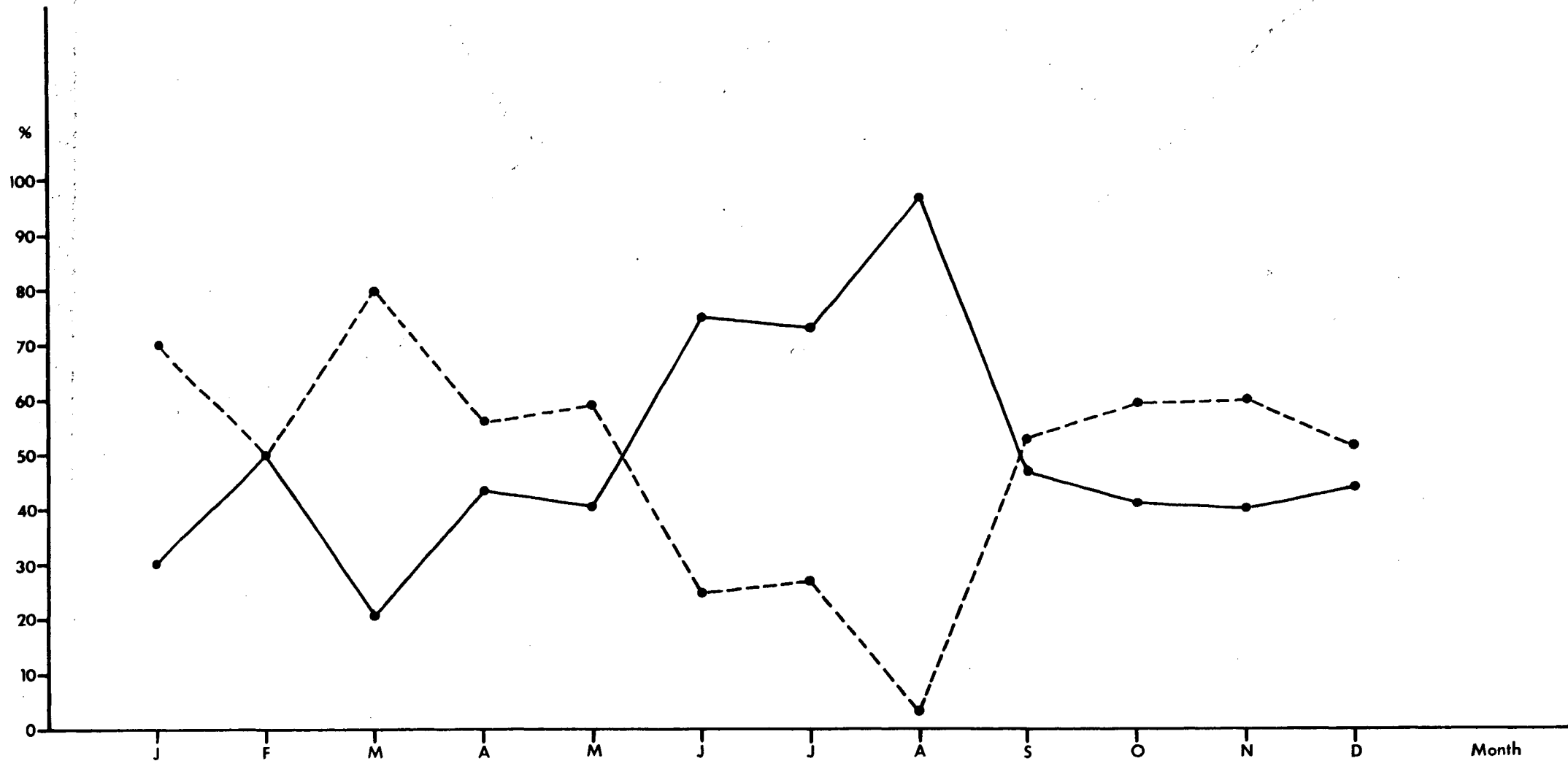opaque edge (————); hialine edge (— — — —)

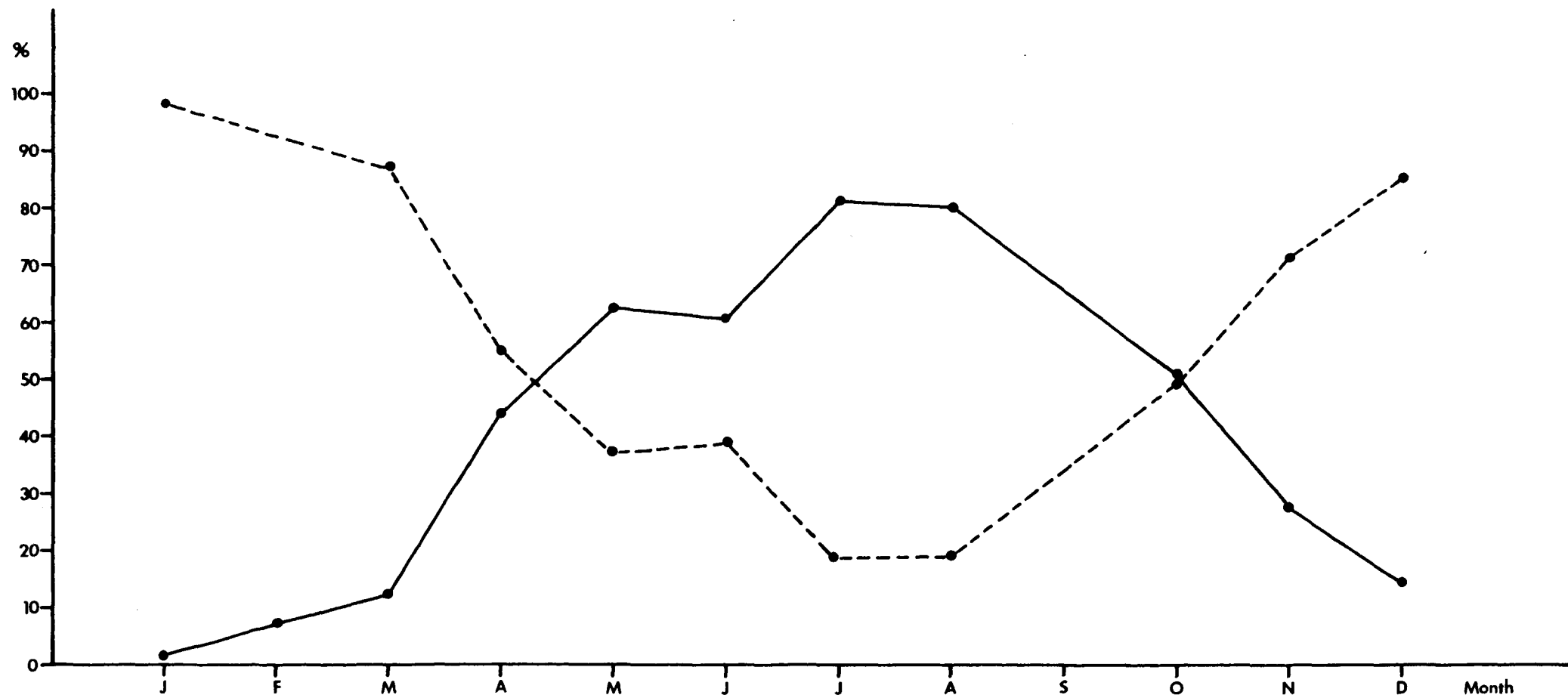Fig. 2 b – Seasonal changes in marginal character of otoliths of sardines from Sowthern Zone opaque edge (————); hialine edge (— — — —)

Fig. 3 a — Otolith radius (RO)/Body length (L$_t$) relationship of sardines from Center Zone

| — Mean and 2 standerd deviations either side of mean

$$\overline{RO} = 0.1093 + 0.0067\ L_t$$
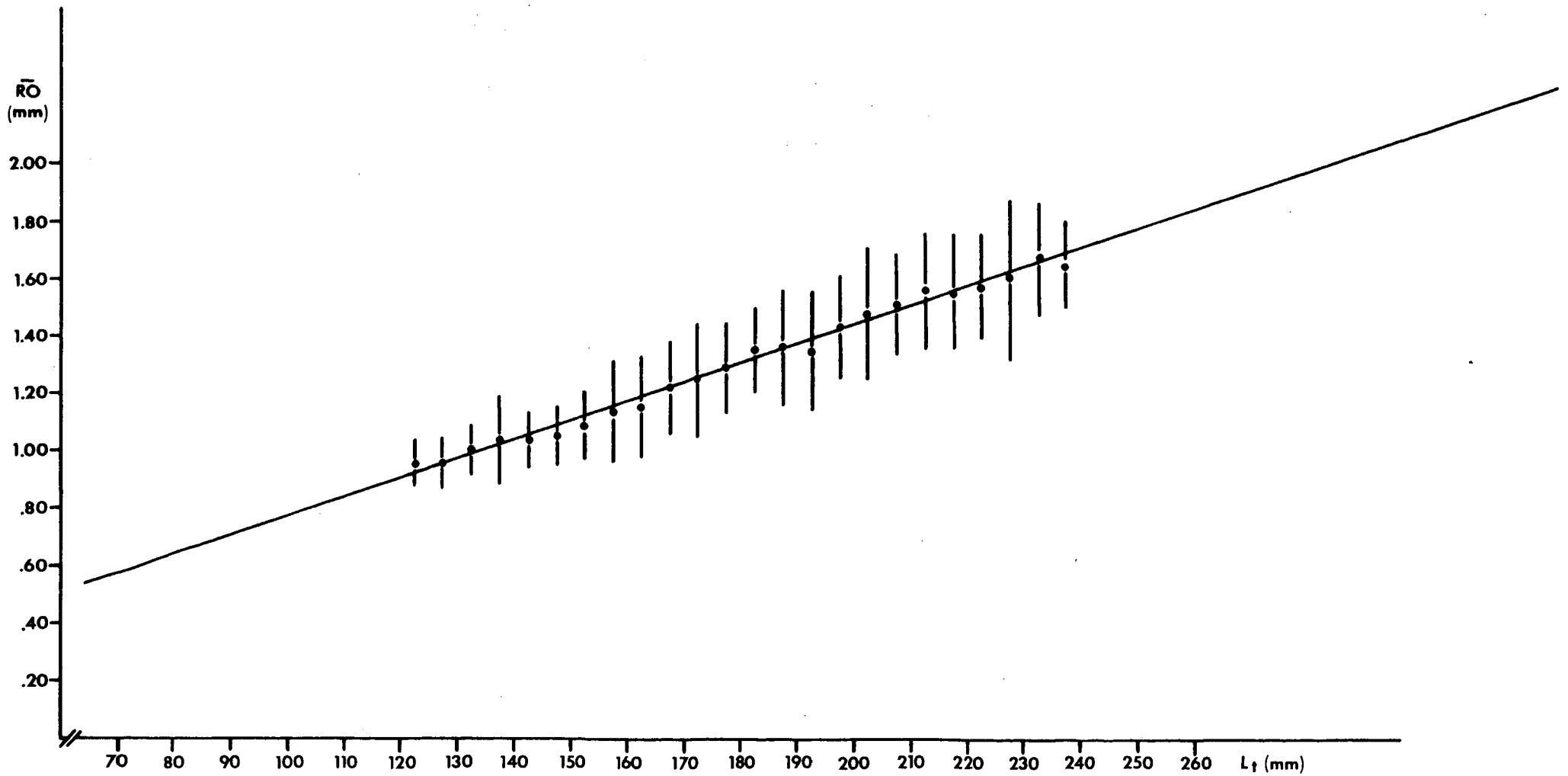
Fig. 3 b — Otolith radius (RO)/Body length (L₄) relationship of sardines from Sowthern Zone

| — Mean and 2 standerd deviations either side of mean

$$\overline{RO} = 0.2110 + 0.0064\ L_f$$
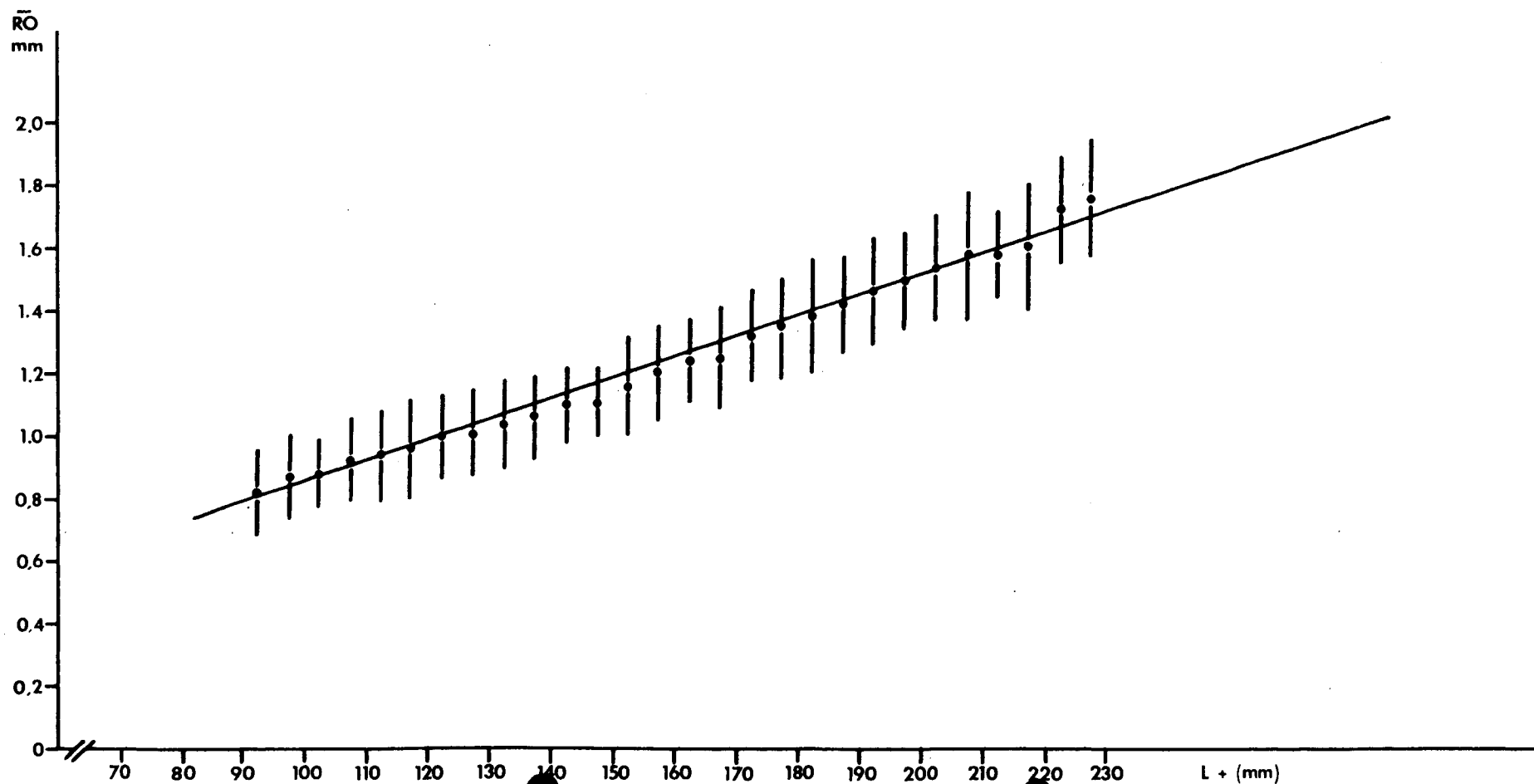
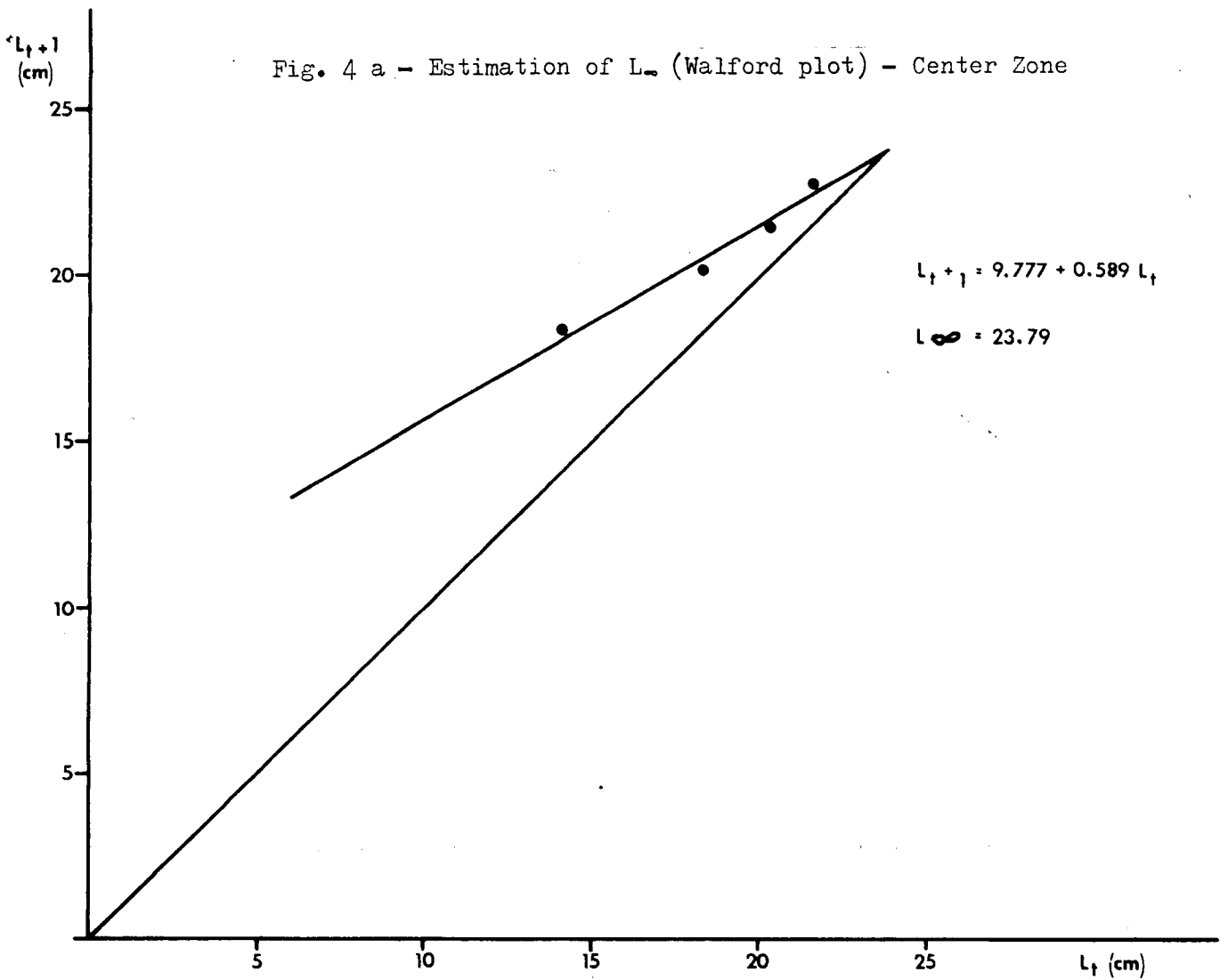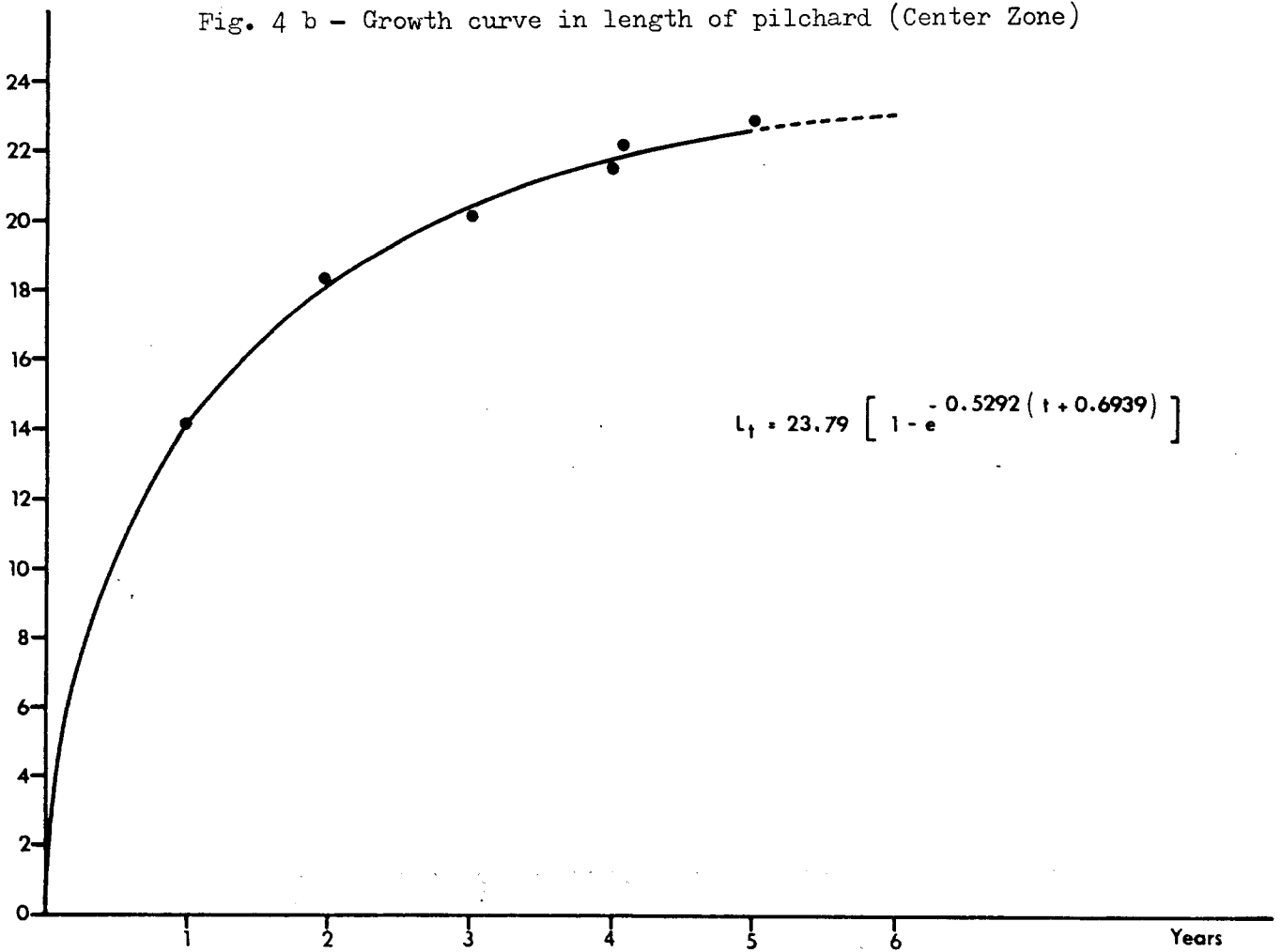Fig. 4 a — Estimation of L∞ (Walford plot) — Center Zone

$$L_{t+1} = 9.777 + 0.589 \, L_t$$

$$L\infty = 23.79$$

Fig. 4 b — Growth curve in length of pilchard (Center Zone)

$$L_t = 23.79 \left[1 - e^{-0.5292 \, (t + 0.6939)} \right]$$

Years

$$L_{t+1} = 9.0723 + 0.6147 \; L_g$$

$$L_{\infty} = 23.55$$
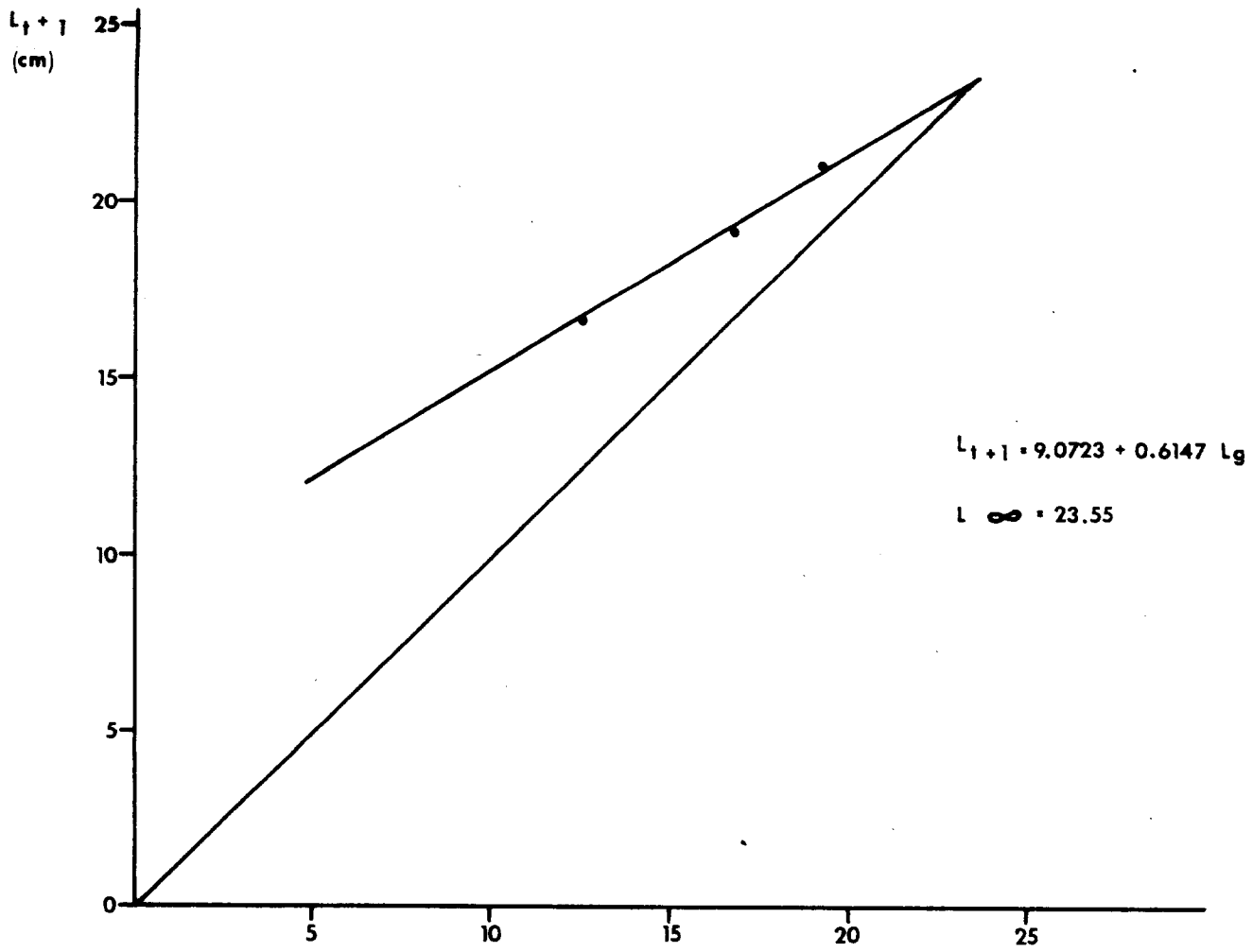
Fig. 5 a — Estimation of L_{∞} (Walford plot) — Sowthern Zone

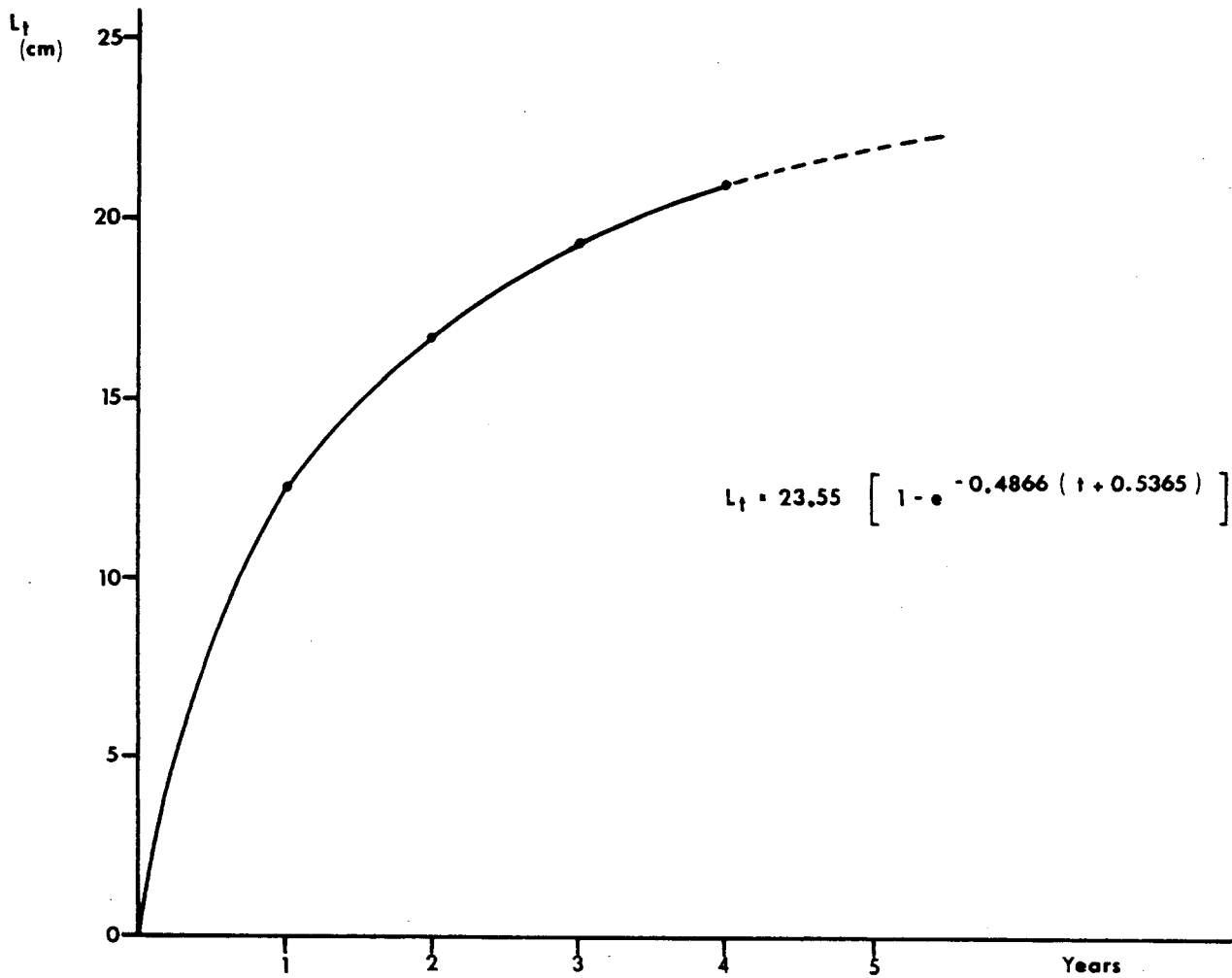$$L_t = 23.55 \left[1 - e^{-0.4866 \, (t + 0.5365)} \right]$$

Fig. 5 b — Growth curve in length of pilchard (Sowthern Zone)