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Age and growth of butterfish, *Poronotus triacanthus* (Peck) in ICNAF Subarea 5 and Statistical Area 6

by

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Introduction

Butterfish is found on the continental shelf from Newfoundland to the Gulf of Mexico. Fishing grounds are located between Georges Bank and Cape Hatteras (ICNAF Subarea 5 and Statistical Area 6).

According to Waring (1975), total landings from several countries averaged 5,350 tons during the period 1963-68. During the period 1920-1963 the total catch (entirely by the USA) averaged 3,500 tons per year. The total annual landings from 1969 to 1975 averaged more than 10,000 tons with considerable fluctuation between years.

Monthly distribution of Japanese butterfish catch shows distinct seasonality. (Fig. 1). The fishing grounds for butterfish and long-finned squids by Japanese fleets are along the outer edge of the continental shelf from November to March (Fig. 2). On the other hand, USA inshore fishery takes butterfish primarily from May to November.

In this paper, age and growth of butterfish in SA 5 and 6 are investigated using otoliths.

Materials and Methods

Since the scales exfoliate off when butterfish are taken, the otoliths are used for age determination. 3,850 individuals were sexed and measured (fork length to the nearest mm) at sea and in the laboratory (Table 1). Otoliths were kept in 50 percent aqueous solution of glycerin with thymol saturated.

The otolith of the butterfish is oval in shape and rather thin with an incision and irregular margin (Fig. 3). The central part of larger otoliths are opague with alternating hyaline and opague zones radiating outward from the center. Otoliths were viewed with a x20-powered stereoscopic microscope using reflected light. Measurements were made from the center of the otolith to the outermost margin of each hyaline zone ($_{V}n$) and to the outermost edge of the otolith(R).

Relationship between fork length and otolith radius

Otolith radius was plotted against the fork length by sex (Fig. 4 and Fig. 5). Using the method of least squares, the following equations are obtained,

$$\text{male;} \quad R_{(mm)} = 0.01580 \times FL_{(mm)} + 0.4346$$

$$\text{female;} \quad R_{(mm)} = 6.01549 \times FL_{(mm)} + 0.4759$$

The analysis of covariance shows that the mean square of residuals is not significant. Therefore, the regression line with sexes combined is calcaluted as follows,

$$R_{(mm)} = 0.01559 \times FL_{(mm)} + 0.4630$$

Formation of year mark

Among 3,850 butterfish sampled, 3,343 could be aged. The difficulty in age determination increases in proportion to the size of butterfish.

Four mark groups with 0 to 3 year marks were observed. The mean radius and standard deviation of year marks are shown in Table 2. Mean radius in female is larger than that in male. Also younger individuals have larger mean radius than older ones.

To estimate the time of turning of hyaline zone into opaque zone (year mark), monthly change of relative marginal increment (R.M.I.) are used,

$$R.M.I. = (R - V_n) / (V_n - V_{n-1})$$

where, R: radius of otolith

V_n: radius of nth year mark

V_{n-1}: radius of (n-1)th year mark, and

$V_{n-1} = 0$ in one year mark group

R.M.I. is high in winter and spring, while it is low in summer and autumn (Fig. 6). Therefore, the year mark formation is estimated to occurred once in a year from May to July.

Back-calculation of fork length from otolith

Using the mean radius of year mark and the relationship between otolith radius and fork length, the fork length at the time of annual mark formation was calculated (Table 3).

The calculated fork length is larger in female and in younger individuals due to the larger mean radius of year mark.

Spawning season

Fig. 7 shows the monthly change of gonad weight against the fork length. Gonad weight of butterfish more than about 15 cm increases in March and April, and reaches its maximum in May to July. In autumn and winter, gonad weight is diminished.

Hildebrand and Schroeder (1928) reported the spawning occurred during June and July, and that the minimum size of spawning fish was 15 cm in Chesapeake Bay. Bigelow and Schroeder (1953) report that the spawning season was from June to August in Gulf of Maine. Herman (1963) reported butterfish eggs were found only in June to August in Narragansett Bay. However, based on the data presented in this paper it is possible that the spawning period extends from April or May to August.

Calculation of growth equation

The parameters of a growth equations were estimated by the Walford method (Fig. 8). Assuming that spawning and mark formation are made on June 1, occur on June 1, the von Bertalanffy growth equations are calculated as follows (Fig. 9),

$$\text{male;} \quad l_t = 226.5 \, (1 - e^{-0.5784 \, (t + 0.3963)})$$

$$\text{female;} \quad l_t = 206.7 \, (1 - e^{-0.9747 \, (t - 0.0158)})$$

$$\text{sexes combined;} \quad l_t = 210.2 \, (1 - e^{-0.8618 \, (t + 0.0699)})$$

Relationship between fork length and body weight are found to be (Fig. 10),

$$BW_{(g)} = 1.635 \times 10^{-6} \times FL_{(mm)}^{3.4920}$$

Consequently estimated growth equation is weight with sexes combined is as follows (Fig. 11),

$$BWt_{(9g)} = 210.9\ (1 - e^{-0.8618\ (t + 0.0699)})$$

Discussion

In order to test the validy of ages from otolith, monthly length distributions of butterfish taken by Japanese trawlers in 1968-1976 are used (Fig. 12). Examination of length distributions mostly reveals two modes at 12-14 cm and 16-18 cm from February to July and modes at 12 cm and 14-15 cm for September to November.

Growth curve estimated in this paper almost agrees with the modes after the first birthday. However, in the early growth, no coincidence is seen between them.

Since young butterfish are associate with jellyfishes. It is expected that butterfish has different growth pattern in their early life stage. In this paper, therefore, the von Bertalanffy growth equation should be applied after the first birthday.

Table 4 shows the age-length key of butterfish in SA 5 and 6, years and sexes combined. Judging from the age-length key and length distribution, the stock of butterfish mainly consist of two age groups and the majority of individuals spawn at two years old.

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Table 1 Data on materials for age determination of butterfish in SA 5 and 6.

date	division	depth(m)	number
Oct. 1, 1970	5Ze	-	42
Aug. 2, 1971	5 A	108	98
Oct. 10,	6 C	103	96
Apr. 3, 1972	6 B	130	93
27,	5Zw	141	86
Dec. 8,	6 B	115	20
11-31,	6 A	82-140	399
16-23,	5Ze	103-160	219
18,	5Zw	122	20
Jan. 15-31, 1973	5Ze	118-124	100
17-29,	6 A	78-129	721
Feb. 1, 3,	5Ze	153, -	170
Mar. 20,	6 B	94	60
Feb. 24, 1974	5Ze	111	7
25,	5Zw	115,122	100
Mar. 2,	6 B	126,163	101
4-31,	6 A	81-154	344
6-18,	5Zw	92-134	302
15-20,	5Ze	115-146	84
Apr. 1-19,	6 B	116-223	260
11,14,	6 A	116,118	85
Sep. 13,	6 B	120	111
Jun. 10, 1976	6 A	155	3
11-24,	6 B	121-145	131
Jul. 6,	6 B	160	88
13,	6 A	153	110
total			3850

Table 2 Mean radius and standard deviation of year mark of butterfish in SA 5 and 6.

year mark	sex	number	$\bar{r}_1$	σ_{r_1}	$\bar{r}_2$	σ_{r_2}	$\bar{r}_3$	σ_{r_3}
0	♂	696						
	♀	705						
1	♂	556	2.435	0.2643				
	♀	718	2.478	0.2662				
2	♂	98	2.335	0.2645	3.116	0.2072		
	♀	243	2.375	0.3172	3.233	0.2076		
3	♂	11	2.168	0.3408	3.073	0.2218	3.500	0.1962
	♀	29	2.374	0.2327	3.111	0.1699	3.509	0.1708
total	♂	1361	2.419	0.2687	3.112	0.2081	3.500	0.1962
	♀	1695	2.450	0.2822	3.220	0.2071	3.509	0.1708
total		3056	2.437	0.2772	3.189	0.2128	3.507	0.1756

Table 3 Calculated fork length of butterfish in SA 5 and 6 at the time of year mark formation.

year mark	sex	l_1	l_2	l_3
1	♂	126.5		
	♀	129.2		
2	♂	121.4	170.2	
	♀	122.6	177.7	
3	♂	109.4	167.4	194.8
	♀	122.6	169.9	195.4
total	♂	125.5	169.9	194.8
	♀	127.5	176.8	195.4
total		126.6	174.9	195.3

Table 4 Age-length key of butterfish in SA 5 and 6, years and sexes combined.

month	Jan. - Mar.				
age	0	1	2	3	total
FL(cm)					
8- 9	2				2
9	40				40
10	111				111
11	144				144
12	132				132
13	179	3			182
14	143	24			167
15	85	125	3		213
16	11	188	6		205
17	2	152	22		176
18		103	53	1	157
19		41	71	3	115
20		9	60	6	75
21			20	14	34
22			3	4	7
23				1	1
24					
total	849	645	238	29	1761

month	Apr. - Jun.				
age	0	1	2	3	total
FL(cm)					
8- 9					
9					
10	5				5
11	17				17
12	37				37
13	51				51
14	89	3			92
15	66	29			95
16	15	80	2		97
17		64	8		72
18		36	16		52
19		6	22	1	29
20		1	5	2	8
21			4		4
22					
23					
24					
total	280	219	57	3	559

month	Jul. - Sep.				
age	0	1	2	3	total
FL(cm)					
8- 9					
9					
10					
11		1			1
12		54			54
13		49			49
14		51			51
15		74	10		84
16		12	31		43
17			30	1	31
18			2		2
19			1		1
20					
21					
22					
23					
24					
total		241	74	1	316

month	Oct. - Dec.				
age	0	1	2	3	total
FL(cm)					
8- 9					
9	12				12
10	27				27
11	54				54
12	73				73
13	68				68
14	56	24			80
15	15	74	1		90
16	7	91	4		102
17		69	4		73
18		58	9		67
19		19	21	1	41
20		1	10	2	13
21			1	4	5
22				2	2
23					
24					
total	312	336	50	9	707

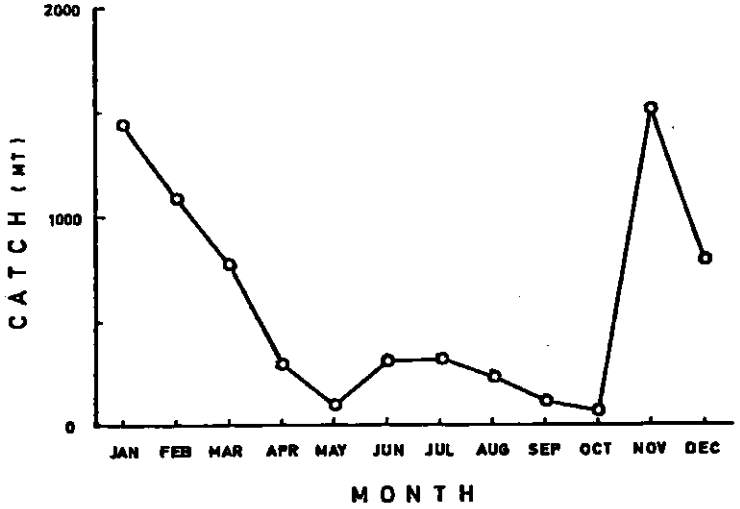

Fig. 1 Monthly distribution of average Japanese catch of butterfish in SA 5 and 6 during the period 1970-74.

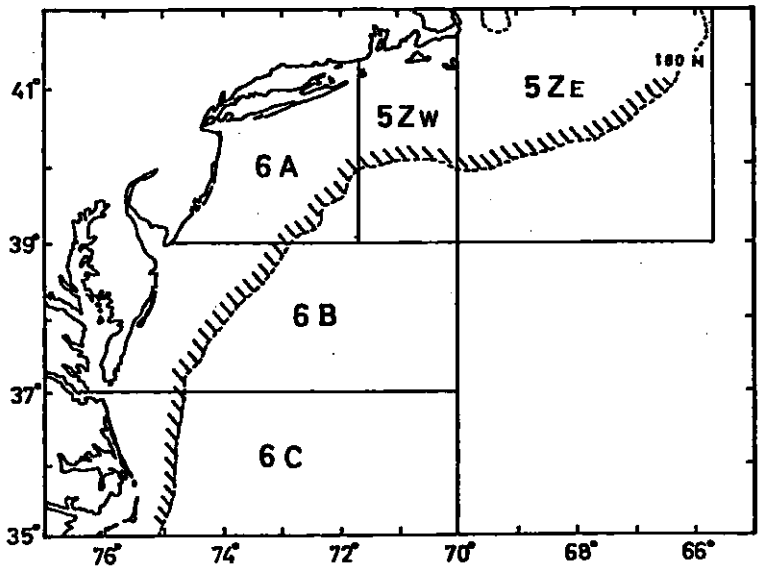

Fig. 2 Fishing grounds for butterfish in winter.

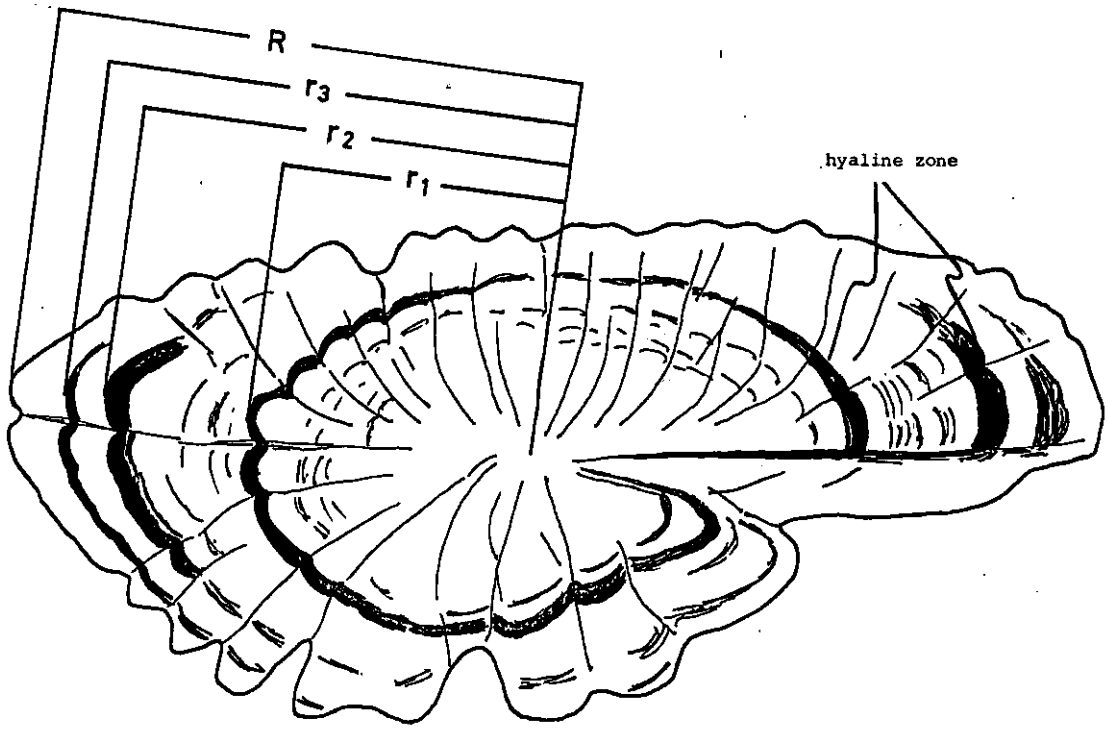

Fig. 3. Diagram of butterfish otolith showing notation for measurement.

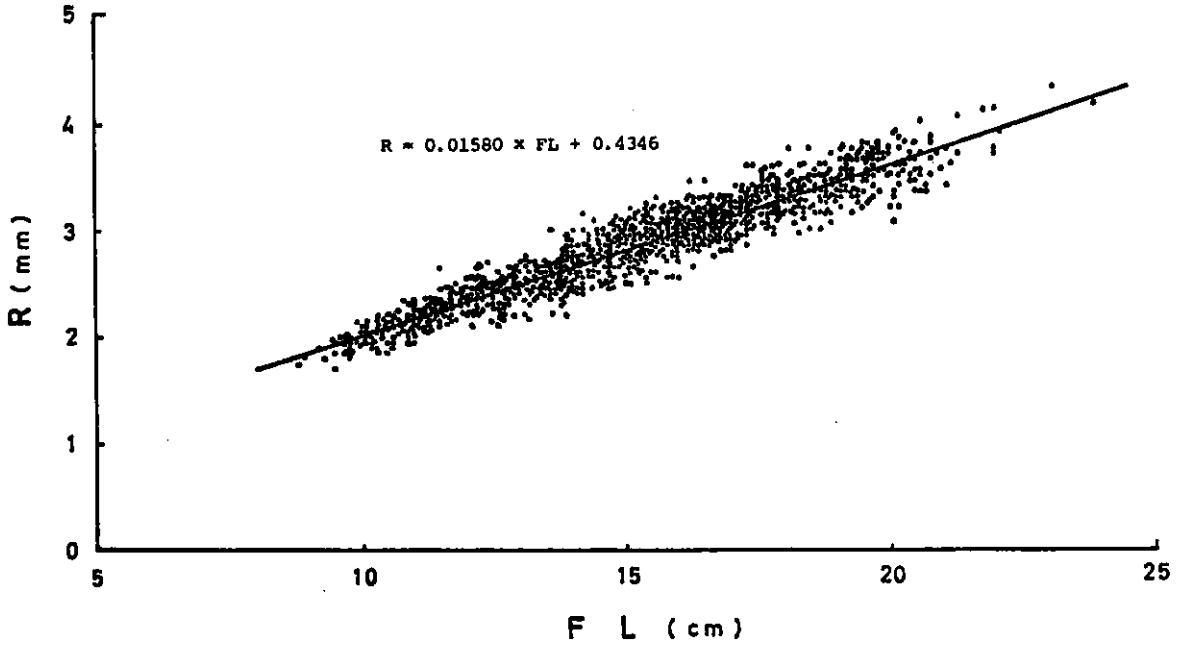

Fig. 4 Relationship between fork length (FL) and otolith radius (R) of male butterfish.

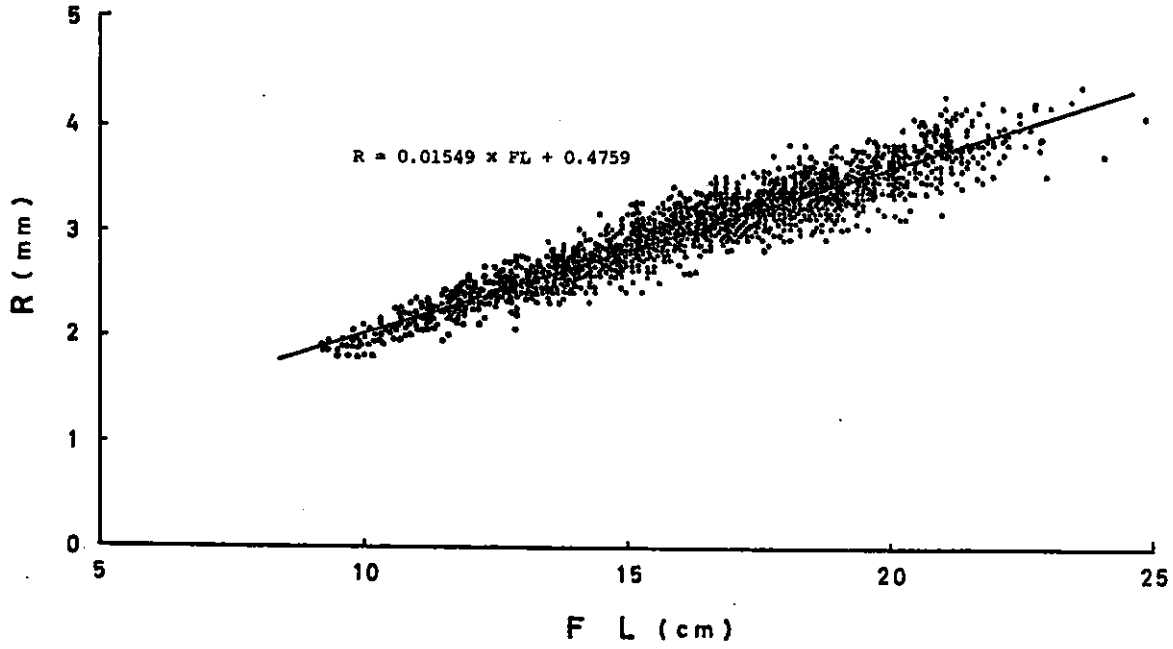

Fig. 5 Relationship between fork length (FL) and otolith radius (R) of female butterfish.

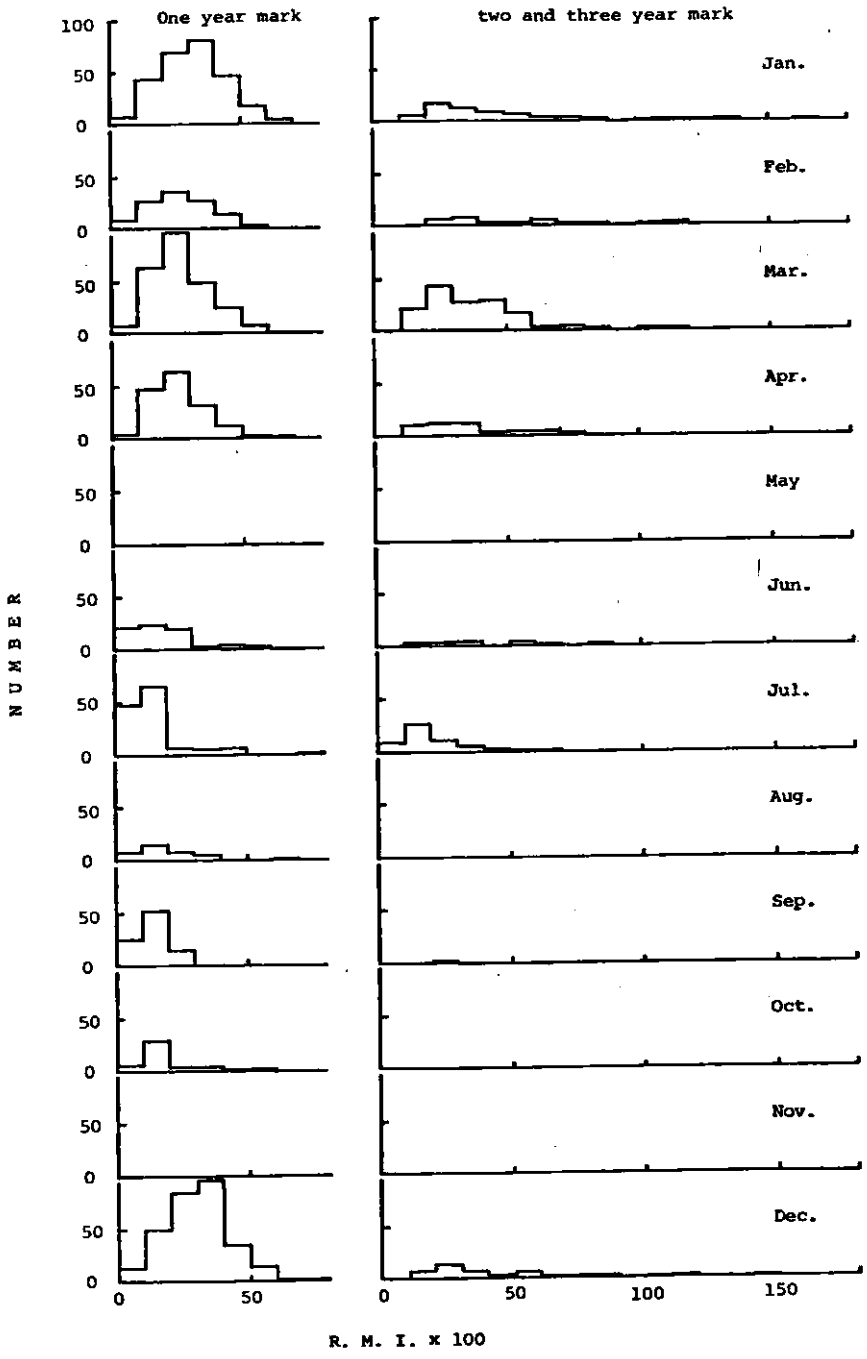

Fig. 6 Monthly change of relative marginal increment (R.M.I.) of butterfish in SA 5 and 6. R.M.I. = $R - r_n / r_n - r_{n-1}$

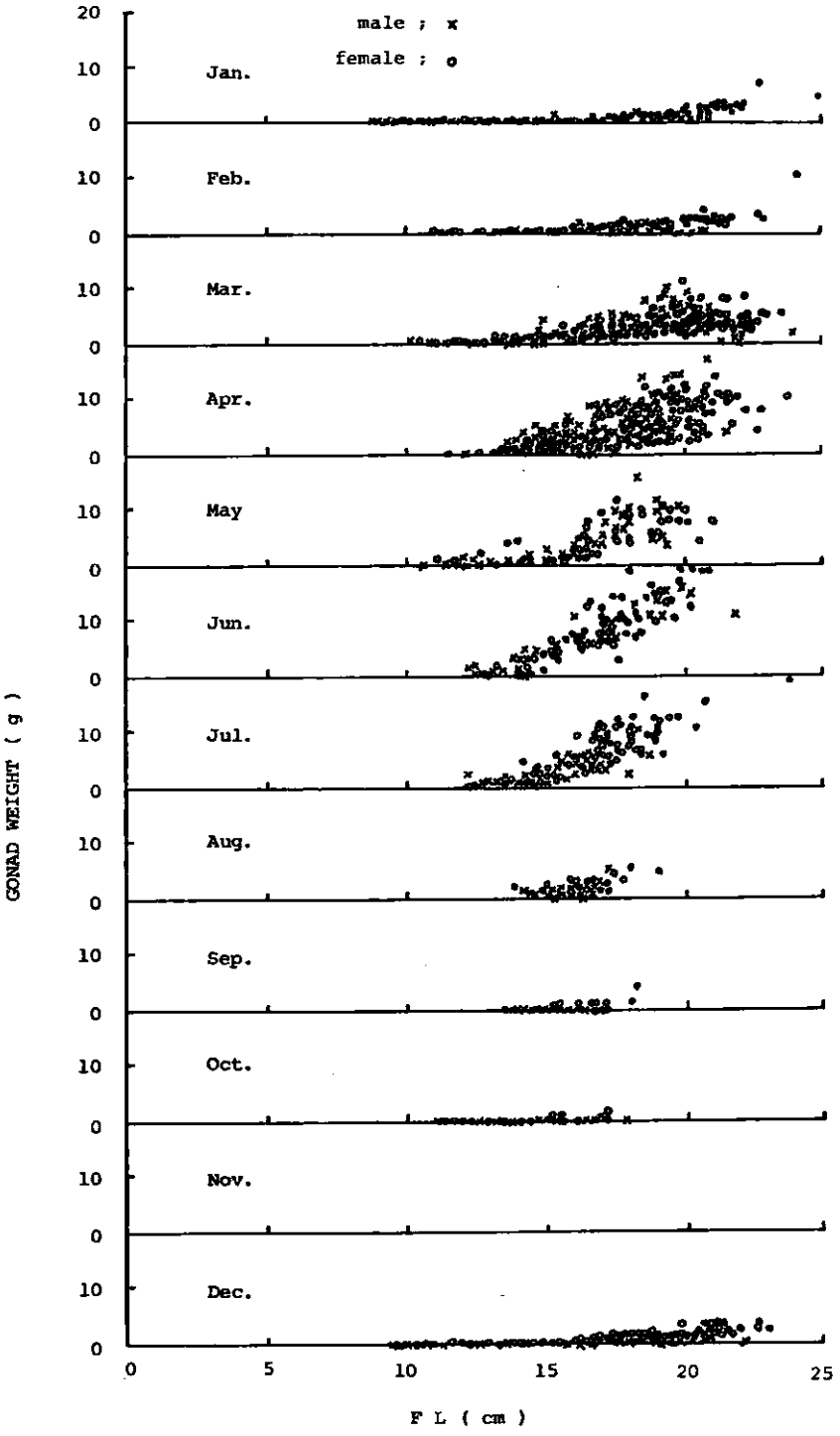

Fig. 7 Monthly gonad weight of butterfish in SA 5 and 6 by sex.

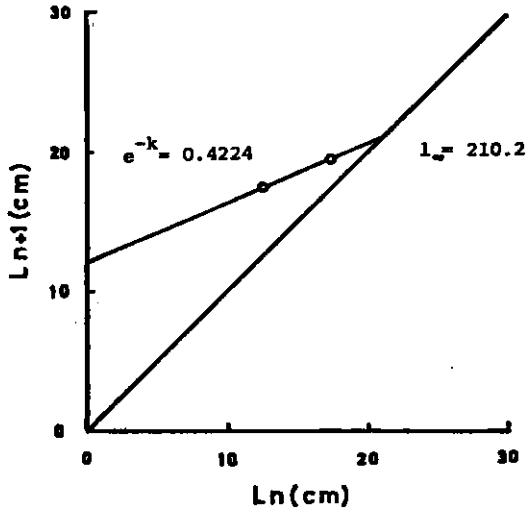

Fig. 8 Walford graph for fork length of butterfish in SA 5 and 6, sexes combibed.

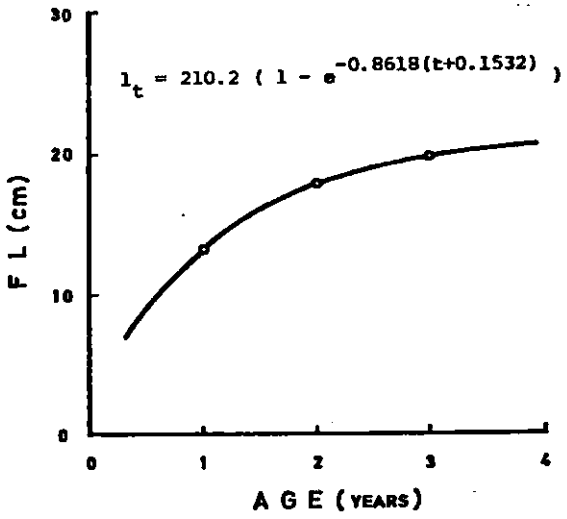

Fig. 9 Growth curve of butterfish in SA 5 and 6, sexes combined.

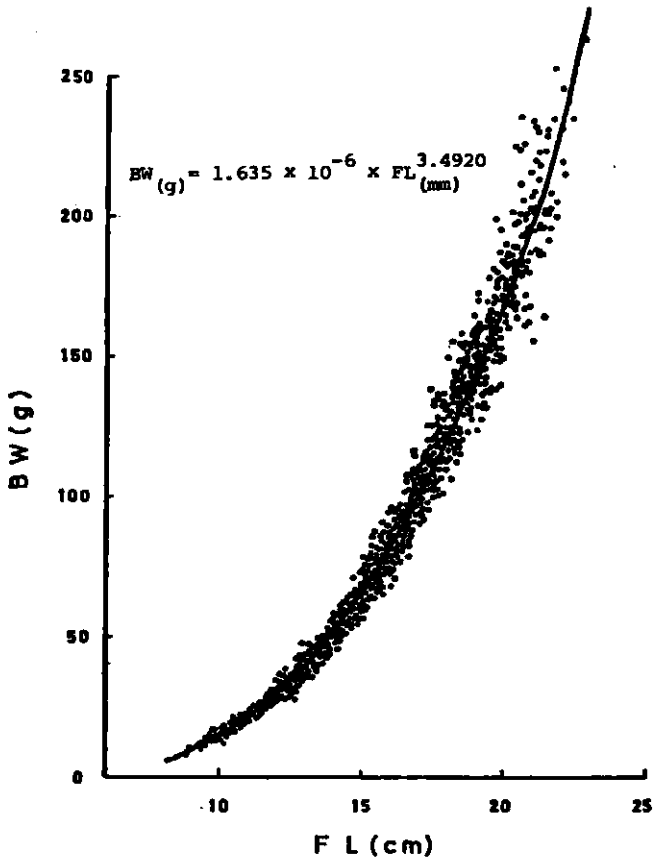

Fig. 10 Relationship between fork length and body weight of butterfish in SA 5 and 6, sexes combined.

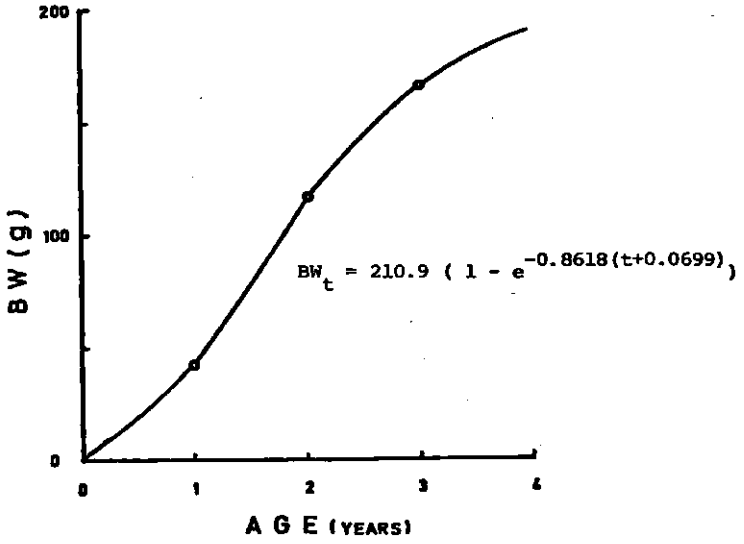

Fig. 11 Growth curve of butterfish in weight in SA 5 and 6, sexes combined.

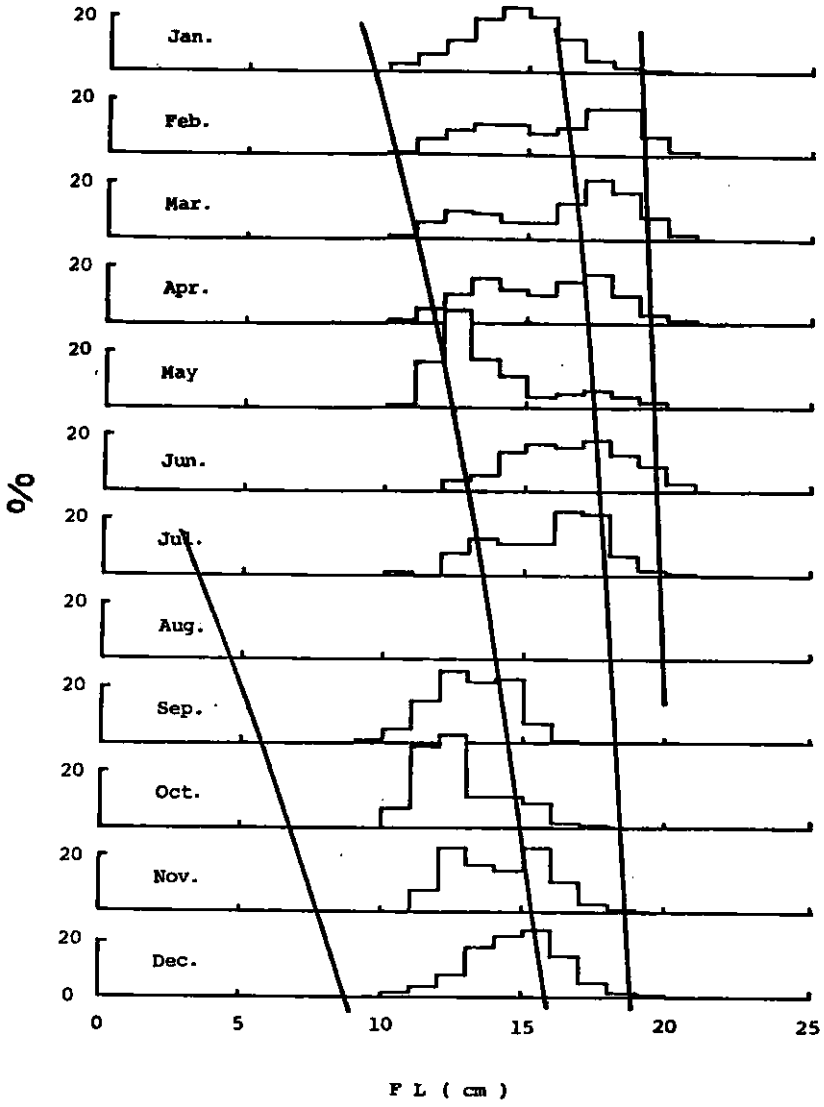

Fig. 12 Monthly length distributions of butterfish in SA 5 and 6, and growth curve estimated in this paper.