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The Determination of the Age and Growth of *Gnathagnus elongatus* (TEMMINCK et SCHLEGEL)

SHIN-ICHI MIO

Gnathagnus elongatus has a wide distribution in the coastal waters of Japan and in the East China and Yellow Seas. The materials for this study was the samples taken from commercial catches by the Japanese trawls in the East China Sea, during the period from April 1959 to December 1960. Six hundred and fifteen specimens were divided into two groups with their fishing areas, that is, one group of specimens was caught in the northern East China Sea, off southern Shantung Peninsula (No. 361, 351, 180 and 169 in statistical fishing ground blocks represented by number), and another group in the central East China Sea, off the estuary of the Yangtze River (No. 328, 330, 340, 360 and 290 statistical fishing ground blocks). As the large number of specimens belonged to the latter group, age of *Gnathagnus elongatus* in this paper was determined with data based on the fishes from the central East China Sea and the remaining were used as reference. All fish were measured in millimeter from the tip of the snout to the longest ray of the caudal fin and, the body and gonad weights were recorded to the nearest gramme.

I. Age

Age of the fish can be estimated mainly from the growth mark on the otolith, the scale and the skeletal structures. For this species, however, only the otoliths provided the reliable results, since the scales were vestigial and the growth zones in the skeletal structures were rather difficult to read.

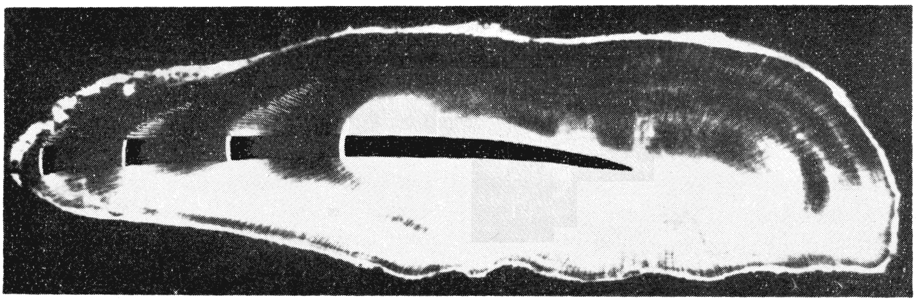

Fig. 1 Transverse section of a otolith of 355mm long *Gnathagnus elongatus* showing measuring axis

Otoliths removed from the fishes were made into transverse sections by the following procedure. All remnants of tissue were removed from otoliths and a cross line was drawn on otoliths with a pencil to indicate the exact position of the origin of growth. This otolith was embedded in a capsule filled with liquid acrylic resin. When the resin was quite dry and hard, the grinding could begin with carborundum stone of the simple electric grinding machine. At first the grinding was continued down to the pencil mark at one end. After a piece of the resin containing the otolith was fixed with a temporary stopping to hold it at the grinding face, the other end of the resin block was also rubbed down to obtain a sufficiently thin section (0.1- 0.3 mm). The transverse section was fixed on the microscope slide with Canada balsam. Otolith-size and mark-size on the major axis of the otolith section were measured with a projector under the magnification of 50 times natural size (Fig.1).

No significant differences in the mark formation were found between the right and the left otolith, that is, *similarity* of mark-sizes were well recognized. The relationship between total-length (L) and otolith-size (R) was found to be linear and could be expressed by the equation (Fig.2).

$$L=89.3\,\hat{R}+11.8 \qquad \cdots\cdots 1)$$

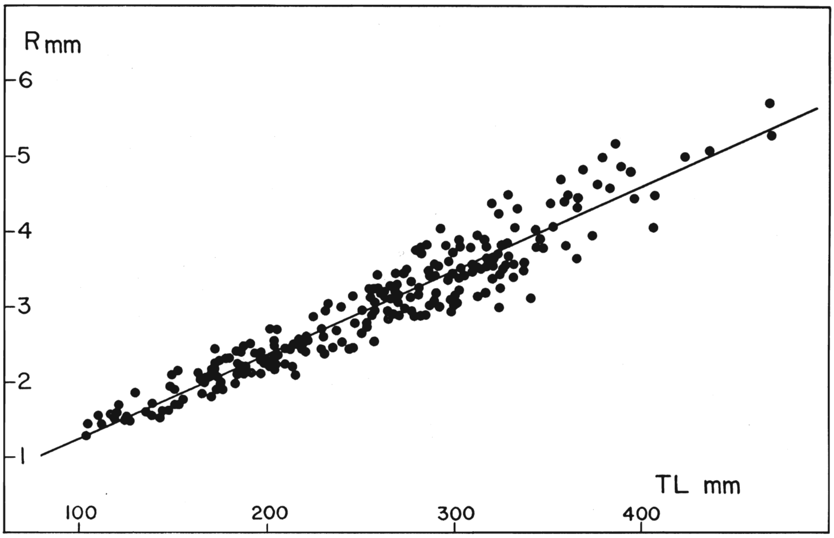

Fig. 2 Relationship between total-length (TL) and otolith-size (R)

To take away the variation of the mark-size resulting from the difference of otolith-size in the same total-length group of samples the measurements of otolith-size and mark-size were standardized by multiplying with the factor, $\hat{R}/R$, since this regression was attended with considerable variation in plotting of otolith-size against total-length and *similarity* was recognizable between otolith-size and mark-size.

Sampling of specimens is accompanied inevitably by the following three objections for age determination : a) Abundant young fish is sampled, but the observations on the old fish are scanty, bcause the size composition of the samples reflects the size frequency distribution of the commercial catch, b) the frequency distribution of total-length in the same age group fluctuates irregularly in each season, c) the number of samples in every month is not the same. On the other hand, it is found in the relationship between mark-size and total-length that in the same age class the mark-size of small fish is formed in small size and one of the large fish have large size. Therefore, combining the phenomena and these three objections the mode of mark-size frequency distribution results in obscurity. However, the relationship between otolith-size (R) and mark-size (r_n) for each month data was found to be intermittent with several short linear regressions and by the intermittent parts along the ordinates each individuals for each month data was divided into each successive age class (Fig.3). The standard mark-size representing this species was more accurately obtained from the relationship between total-length (L) and mark-size (r_n) at each age group divided by the intermittent part in each month data (Fig. 4). Hence, the back calculated total-length (ℓ) at the time

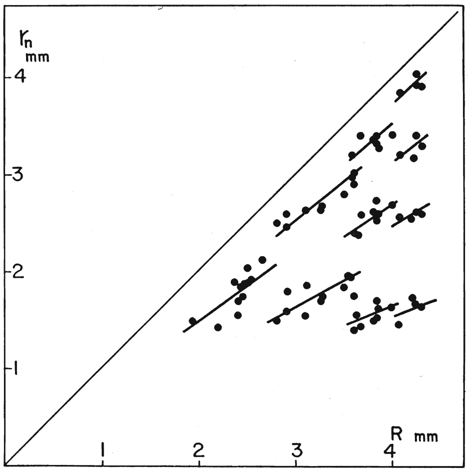

Fig. 3 Relationship between otolith-size (R) and mark-size (r) in May

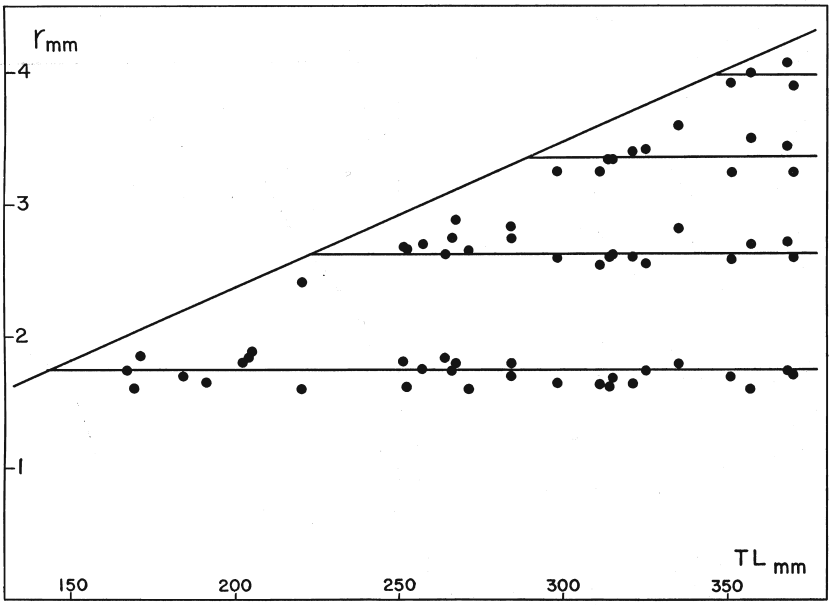

Fig. 4 Relationship between total-length (TL) and mark-size (r) derived from each age class and month data

of formation of the different marks were estimated from the equation 1) and the standard mark-size (Table 1).

WALFORD plot for standard mark-size was found to be a linear regression with excellent results and indicated the following equation (Fig.5).

$$r_{n+1}=0.828\ r_n+1.19 \cdots\cdots\cdots\cdots\cdots\cdots 2)$$

It was, therefore, estimated that these marks were formed at an equal time interval.

The evidence that the seasonal change of the marginal growth rate

Table 1 The mark size represented from the data in monthly age group and the back calculated total–length (mm).

	R	r_1	r_2	r_3	r_4
Jan.	2.12	1.87			
	3.00	1.76	2.70		
Feb.	2.20	1.70			
	3.16	1.60	2.66		
	3.64	1.68	2.62	3.34	
	4.10	1.60	2.70	3.50	4.00
Apr.	2.04	1.60			
May.	2.42	1.84			
	3.10	1.74	2.76		
	3.74	1.74	2.56	3.42	
	4.24	1.72	2.60	3.24	3.90
Jun.	2.42	1.88			
	3.30	1.80	2.75		
Jul.	2.06	1.80			
	2.60	1.60	2.40		
	4.04	1.70	2.58	3.24	3.92
Aug.	2.94	1.82	2.68		
	3.46	1.66	2.60	3.24	
Sep.	3.12	1.80	2.88		
	3.70	1.64	2.60	3.40	
Oct.	2.02	1.74			
	3.30	1.70	2.84		
	3.86	1.80	2.86	3.60	
Nov.	2.40	1.80			
	3.08	1.84	2.62		
	3.62	1.62	2.62	3.36	
Dec.	2.28	1.66			
	2.96	1.62	2.66		
	3.60	1.64	2.54	3.24	
	4.22	1.74	2.72	3.44	4.06
mean	—	1.74	2.64	3.36	3.98
ℓ	—	144	225	290	346

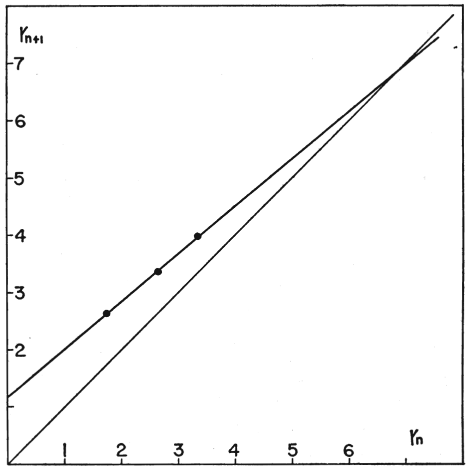

Fig. 5 Walford plot of growth in standard mark–sizes

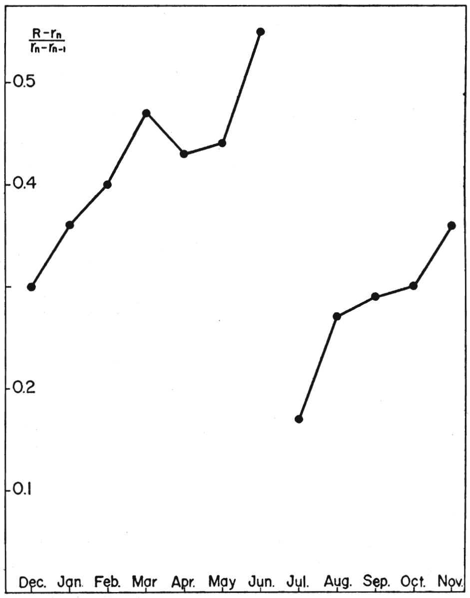

Fig. 6 Monthly change in marginal growth rate $(R-r_n/r_n-r_{n-1})$

$(R-r_n/r_n-r_{n-1})$ attained the minimum value in July was accepted as the sufficient proof of the fact that the main formation of these marks occurred in July every year (Fig. 6).

II. Growth

Plotting the total-length at age n on the x axis against total-length at age $n+1$ on the y axis respectively, these points fell along a straight line which was expressed by the equation,

$$\ell_{n+1}=0.828\ \ell_n+105\cdots\cdots\cdots\cdots\cdots 3)$$

From the monthly change of the maturity index (GW/TL^3) it was found that the species had a restricted spawning season during the months of August to October, its peak being in September (Fig. 7).
The first mark just formed was attained in July in the 1-age. Thus, putting $t=0$ at the spawning time, the growth in length was given by the equation,

$$L_t=612\ (1-e^{-0.187t+0.039})\cdots\cdots\cdots 4)$$

where L_t was the total-length in millimeter at age t years after spawning.

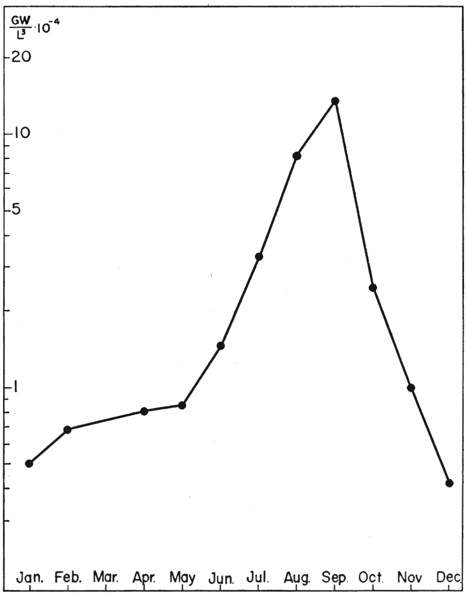

Fig. 7 Monthly change in maturity index (GW/L^3)

The relationship between the body weight and the cube of total-length in this species conformed to the linear regression (Fig. 8).

$$W=1.28\cdot L^3\cdot 10^{-2}\cdots\cdots\cdots\cdots\cdots\cdots\cdots 5)$$

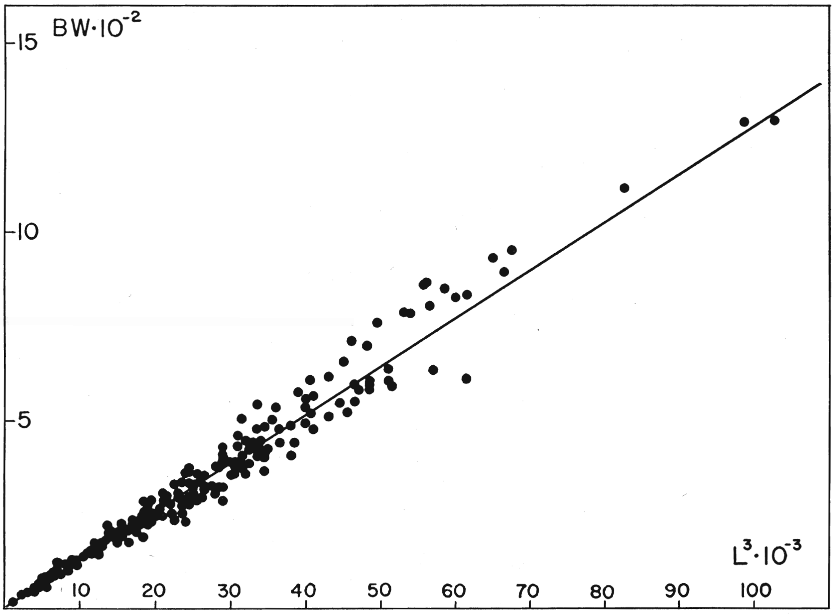

Fig. 8 Relationship between body weight (BW) and cube of total-length (L^3)

The coefficient of fatness of this species was constant without distinction of age. The growth in body weight was derived from the equations 4) and 5).

$$W_t = 2934\ (1 - e^{-0.187t+0.069})^3 \cdots\cdots\cdots\cdots\cdots\cdots 6)$$

where W_t was the body weight in gram at age t years after spawning. The time of the maximum growth rate in this species was 6.23 years after spawning (TL ; 408mm, BW ; 870 g.).

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アオミシマ (***Gnathagnus elongatus*** (TEMMINCK et SCHLEGEL)) の年令および成長

三　尾　真　一

1959年4月から1960年12月にわたって以西底びき網漁船によって漁獲され，福岡市場に水揚げされたアオミシマから615尾の資料を採集した．各資料はその漁場によって山東半島南部沖と楊子江河口沖の2つの群にわけられるが，後者から漁獲された資料が大部分を占めているので，楊子江河口沖の群集についての年令と成長について調べた．

年令査定のための形質として耳石を用いた．各魚体から採集された耳石をアクリル樹脂に包埋し，電動グラインダーで両側から削り，耳石の中心を通る横断切片を作り．長軸上の年令標示および耳石径を計測した．全長と耳石径とは直線関係で示される．計測された各標示径は係数 $\hat{R}/R$ で標準化された．

月別に求められた耳石径と標示径との関係における各標示の回帰線に基づいて各個体を年級群に分け，月別・年級群別に各標示の代表値を求めた．その代表値と全長との関係から，この種を代表する標準標示径を求めた．

WALFORD の成長転換法によって標準標示径を検討すると，得られた各点は一直線上によく乗り，この標示は周期的に形成されていると推定された．そこで縁辺成長率 $(R - r_n/r_n - r_{n-1})$ の季節変化を調べると7月に最小値が得られ，この標示は毎年7月を盛期として形成されていることがわかった．

産卵は9月を盛期として8～10月にわたって行なわれる．産卵盛期の9月を $t=0$ として成長および増重をそれぞれ PÜTTER–BERTALANFFY, BUCH–ANDRESSEN–FISCHER の式で示した．また，体重と全長の3乗値との関係は一直線で示され，肥満度は年令に関係なく一定の値を示す．