The Journal of the Oceanological Society of Korea
Vol. 8, No. 2, p. 68-74, December 1973

AGE STUDIES ON THE BUTTER FISH POPULATION FROM SOUTHWESTERN WATERS OF KOREA

Pyung Chin Han

Department of Oceanography, College of Liberal Arts & Sciences,
Seoul National University

ABSTRACT

The present paper concerns the age determination and growth of butter fish, *Pampus argenteus*, from the southwestern waters of Korea by otolith reading. 743 specimens taken by stow-net in the southern part of the Yellow Sea and northeastern part of the East China Sea during the period from October 1972 to September 1973 were examined.

Results of the study are summarized as follows:

1. Sex ratio of females to males was found to be 2 : 1.
2. Ring marks on the otolith were found to be formed twice a year, once during the period of January-May and the other time in September.
3. The Lee's phenomenon was observed on the otolith sample.
4. The relationship between the radius of otolith (R) and fork length (L) was found to be as follows:

$$R=0.3069+0.0133L.$$

5. Calculated fork length at the time of otolith ring formation are found to be as follows: I-ring, 71.67mm; II-ring, 125.05mm; III-ring, 168.65mm; IV-ring, 201.74 mm; V-ring, 225.80mm; VI-ring, 240.84 mm.
6. Maximum fork length calculated according to the diagram of Walford's growth transformation was found to be 281.5 mm.
7. Growth curve, when related to the von Bertalanffy's equation, was laid out as

$$L_t=281.5\ [1-e^{-0.674(t-0.128)}]$$

INTRODUCTION

The butter fish, *Pampus argenteus* (EUPHRASEN), is a shapely compressed fish belonging to the Family Pampidae. It is a salt water fish that habits in coastal and offshore waters near southwestern part of Korea, southern part of Japan and northeastern part of the East China Sea. In Korea, it is caught mainly by stow-net in the southwestern waters.

The butter fish are known to migrate from East China Sea to Yellow Sea during May-October for spawning and have several subpopulations. But these facts are out of scope in the present study.

In Korea, age studies on the butter fish seems to have never been performed, except Choo (1971) had dealt with butter fish statistics. The present study, therefore, was undertaken to find out a suitable method of age determination and growth.

An investigation of annual markings demonstrated that the otolith provided satisfactory indicators of age and growth in the present study.

MATERIALS AND METHODS

The materials used in this study were collected from the Inchun Fish Market at monthly interval during the twelve month period (Oct. 1972-Sep. 1973). The amount of sampling reflected the general fishing condition; many in summer and fall, and few in winter and spring. In Korea, most of them are caught by stow-net in the southwestern waters adjacent to East China Sea. The data for this study were taken from 743 fishes consisted with 488 females, 244 males and 11 undetermined sex.

After being brought to the laboratory, each fish was weighed on the spring scale graduated in five grams. Its fork length was measured, from the tip of the snout to the middle rays at the fork of the tail, to the nearest millimeter. Scales were collected from the area under pectoral fin and placed on the slide glass for preparation (präparat) without washing or any treatment. Otoliths were collected after the fish had been measured and weighed. Sex was determined after otolith had been collected. Otoliths were collected from the cranial cavity posterior to the hind brain on each side of the split head with a pair of forceps. The sacculus that covering the otolith was cleaned off by rubbing gently with fingers so that it would not dry on the otolith. The otolith samples in this study were stored dry in small vials on which the corresponding fish numbers were recorded. This method of storage was satisfactory because there were no considerable breakage occurrence.

Scales of butter fish were examined on the Profile-projector using transmitted light with the magnification of 100 diameters. But it varies extremely in radius between the scales from the same fiish, so it could not be used as the age determination character in the present study.

Butter fish otoliths require neither grinding nor polishing prior to an examination. They were examined by being placed in absolute alcohol (refractive index; 1.36) in a black concavity watch glass under a dissecting microscope using reflected light (side illumination).

Otolith measurements were taken at a magnification of 31.5 diameters. Each micrometer division corresponded to 0.0625 mm with the magnification used.

The otolith radius was measured in a straight line from the center of the otolith to the marginal edge of the otolith, and ring radius was measured from the center of the otolith to the inner edge of the hyaline zone. In the present study, otoliths from 743 fishes were examined of which approximately 3.1% were unreadable because of breakage or granular structure, so the percentage readability was 96.9% (720 among 743).

RESULTS

Seasonal formation of alternate zones in otoliths

The formation of opaque and hyaline zones in the otolith can be studied at intervals for a year to determine when a particular zone is formed. Since the otolith grows by fusion and accretion (Bélanger, 1960), the alternate opaque and hyaline zones may be observed in the margin of the otolith according to the season.

The occurrence of hyaline and opaque zones in the otolith was studied at monthly intervals for a year to determine when a particular zone is formed. That the hyaline zone in butter fish otolith seems to be formed once during the months of January to May and the other time in September has been found in the analyses of monthly variation of otolith margins (Fig. 1).

By examining the marginal area of these otoliths, it could be ascertained whether the zones laid during a particular month were hyaline or opaque. Most of otoliths at least showed faint hyaline margins.

The percentage composition of the monthly variation in the occurence of hyaline and opaque margins in otolith is shown in Figure 1, in

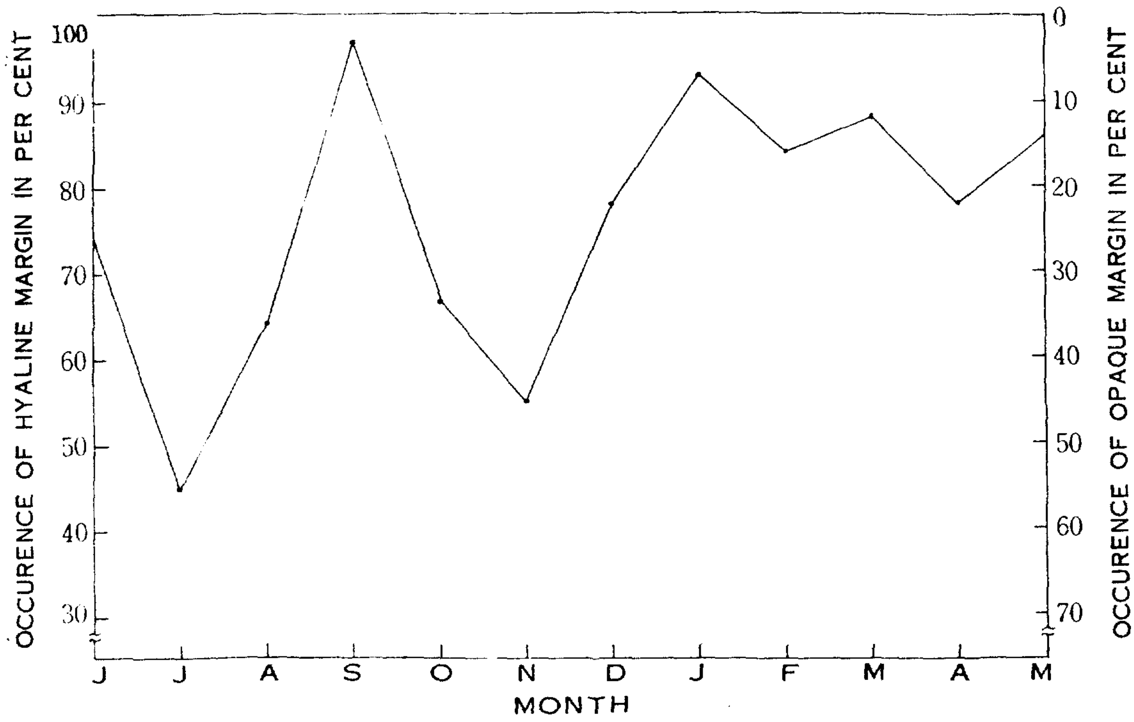

Fig. 1. Monthly variation in occurrence of hyaline and opaque margins in otolith.

which two clear peaks in the percentage occurrence of hyaline margin are evident.

It is reasonable, therefore, to assume that two hyaline zones in butter fish otolith are formed annualy, one during the winter months, and the other during the late summer and early autumn months.

Lee's phenomenon and its correction

Distribution of number of ring marks and ring radius frequencies is shown in Figure 2. According to this figure, the first ring mark and the second ring mark are well distiguished, but the second ring mark and the third or the higher number of ring mark are often overlapped so that it is very difficult to distinguish the second, the third or the higher ring mark from the third, fourth or the higher number of ring mark.

To test the existance of Lee's phenomenon, the mean size of ring mark on otolith in each mark group (Table 1) and each ring mark size were plotted on the semi-logarithmic graph (Fig. 3). Each point occurs almost straight in figure 3 and the older fish shows the smaller ring radius, *i.e* it shows the Lee's phenomenon fairly well.

Table 1. Mean size of Ring radius.

No. of mark	No. of fish examined	Radius of ring mark (mm)					
		r_1	r_2	r_3	r_4	r_5	r_6
I	14	1.40					
II	71	1.02	2.22				
III	277	0.86	1.72	2.60			
IV	258	0.83	1.55	2.26	2.88		
V	79	0.66	1.23	1.93	2.65	3.21	
VI	10	0.63	1.27	1.86	1.45	2.99	3.47

To correct Lee's phenomenon, calculation of the growth rate of ring mark on otolith in each mark group, given by ratio of $(r_i-r_{i-1})/(r_{i-1}-r_{i-2})$ was performed. The result was 0.974 (Table 2).

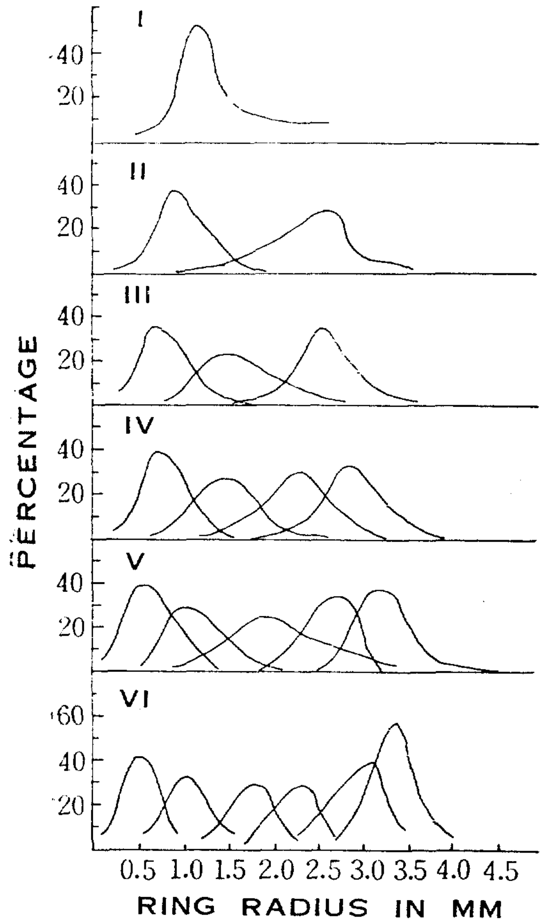

Fig. 2. Composition of otolith radii for each annual ring group.

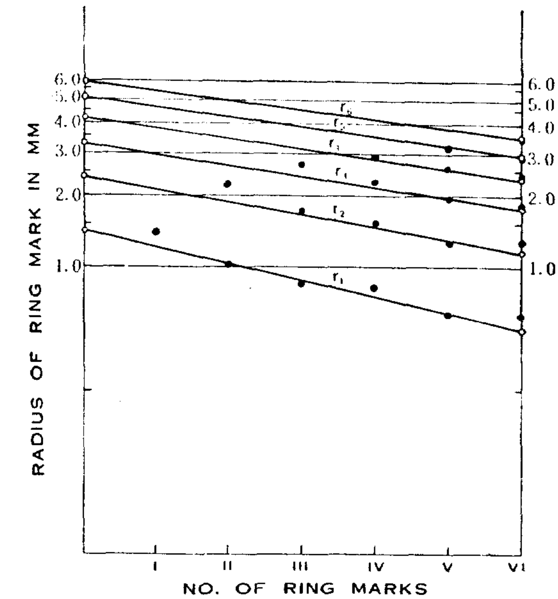

Fig. 3. Semi-logarithmic diagram showing Lee's phenomenon observed on otoliths for each annual ring group.

Table 2. Growth rate of ring marks.

No. of marks	r_3-r_2/r_2-r_1	r_4-r_3/r_3-r_2	r_5-r_4/r_4-r_3	r_6-r_5/r_5-r_4	Mean
III	1.024				1.024
IV	0.995	0.862			0.929
V	1.211	1.046	0.766		1.008
VI	0.913	1.011	0.905	0.901	0.933
Mean	1.036	0.973	0.836	0.901	0.974

As shown in Figure 3, regression curve of r_1 intersects the left end vertical axis(0th ring mark) at value of 1.41 mm and the right end vertical axis (6 th ring mark) at value of 0.54 mm. As the same method r_3 intersects 3.31mm (left end), 1.78mm (right end). It is assumed that in the case of left end vertical axis, r_2 lies between r_1 and r_3, and r_4, r_5, r_6, grows proportionally to the given growth rate of 0.974 per every ring mark. The results are as follows; $0r_1=1.41$ mm, $0r_2=2.37$ mm, $0r_3=3.31$ mm, $0r_4=4.23$ mm, $0r_5=5.13$ mm, $0r_6=6.00$mm. Naturally, it can be likewise applied for the case of right end vertical axis. The results are as follows; $6r_1=0.54$mm, $6r_2=1.17$mm, $6r_3=1.78$ mm, $6r_4=2.37$mm, $6r_5=2.95$mm, $6r_6=3.51$mm. The straight lines, which connects the corresponding points from right end to left end, are regression lines of $r_1 \sim r_6$.

With these results, it can be calculated that the real size of ring marks in otolith at the time of its formation is obtained theoretically by the transformation of semi-logarithmic diagram on ordinary section paper. Real size of each mark at the time of its formation is diagramatically shown at an intersecting point of trend lines r_i ($i=1, 2, \ldots 6$) with the I, II...VI-axis of ordinates. As a result of this transformation calculated otolith length is obtained (Table 3).

A prerequisite to the correct application of the back calculation method is an accurate knowledge of relationship between the otolith and fish length. The data were analyzed by the method of least squares, and the following equation for the regression of fork length(L) in mm on otolith length(R) in mm was derived (Fig. 4):

$$R=0.3069+0.0133\,L\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Table 3. Calculated radii of otolith ring marks. (unit : mm)

r_1	r_2	r_3	r_4	r_5	r_6
1.26	1.97	2.55	2.99	3.31	3.51

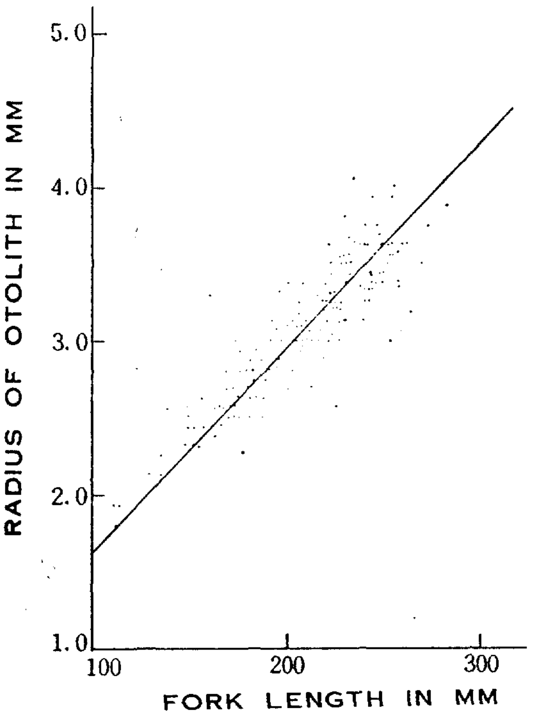

Fig. 4. The relationship between radius of otolith and fork length.

Fork length at the time of ring mark formation on otolith, which was obtained by substituting $r_i(i=1, 2, \ldots 6)$ in Table 3 for R in equation(1), is shown in Table 4.

Table 4. Calculated fork length during the period. (unit : mm)

L_1	L_2	L_3	L_4	L_5	L_6
71.67	125.05	168.65	201.74	225.80	240.84

Growth equation

It is possible to say that the number of hyaline zones symbolized by even number 2, 4 and 6 represents approximately one, two and three years of growth respectively. Thus the result of Walford's growth transformation of fork length, based upon the data shown in Table 4, is obtained as a fairly straight line(Fig. 5). The equation of regression line of this plot is

$$L_{n+1}=0.5098\,L_n+137.9849$$

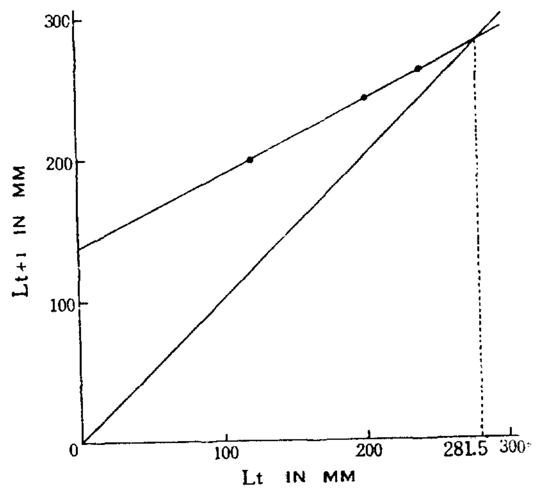

Fig. 5. Walford's growth transformation of fork length.

In this formula, a constant proportion to the coefficient of catabolism K was obtained as 0.674. And asymptotic length L was obtained as 281.5mm.

To fit this result for von Bertalanffy's growth equation,

$$L_t=L\ [1-e^{-k(t-t_0)}],$$

the equation with the fitted constants becomes as follows;

$$L_t=281.5\ [1-e^{-0.674(t-0.128)}]\ \ldots\ldots\ldots(2)$$

Growth curve

Growth curve (Fig. 6) was obtained by substituting the age (0,1,2,3,) for t in equation (2), and comparison between observed length

Table 5. Comparison of observed fork length and calculated fork length (unit : mm)

t (age in year)		0	1	2	3	4	5
L_t(mm)	Calculated	−25.3	125.1	201.9	240.8	260.8	270.9
	Observed	—	125.1	201.7	240.9	—	—

(represented L_2, L_4, anb L_6 in Table 4) and calculated length obtained from the growth curve was performed(Table 5). It shows a moderately good fit of observed length for calculated length.

The asymptotic length (theoretial maximum length) was 281.5mm and the real size of fork length of largest fish that had collected for this study was 295 mm.

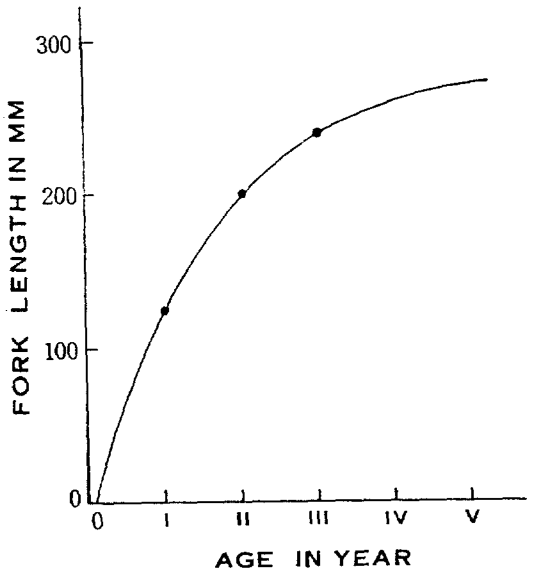

Fig. 6. Growth in fork length from one to five years. (Solid circles indicate observed values as shown in Table 5).

CONCLUSION

On the basis of the foregoing studies, it is possible to draw the following conclusion;

1. Scales of butter fish showed extreme variation in size between the scales from the same fish so that it could not be used as age determination character.

2. Butter fish otoliths had given a satisfactory results in otolith reading for age determination.

3. Growth curve derived from the von Bertalanffy's growth equation coincides with the observed fork length of each age group very well.

4. The maximum observed fork length was 295 mm which was longer than the theoretical maximum length of 281.5 mm, but except only one fish lengths of all specimens appeared shorter than 281.5 mm.

5. It could be said that the butter fish of southwestern waters of Korea is a relatively fast growing stock.

ACKNOWLEDGEMENT

This study was performed under the supervision of Dr. Wan Soo Kim, professor of the Department of Oceanography, Seoul National University, to whom the author wishes to express his gratitude for the valuable guidance in all phases of the work. He wishes to thank Dr. Jong Wha Lee of K.O.R.D.I. for his valuable suggestions and criticism.

Special thanks and acknowledgement are extended to the "Inchon Memorial Foundation" for its constant encouragement and granting scholarship during the conduct of the studies.

Thanks are extended to Mr. Yong Soo Kim, Yong Sik Kim, Do Young Maeng, Eun Ho Park and Miss Hyo Jin Kim, for their help through the whole process of the study.

LITERATURE CITED

Bélanger, L. F. 1960. Development, structure, and composition of the otolithic organs of the rat. In Calcification in biological systems, Pub. No. 64 of the Amer. Asso. Adv. Sci., 151-162, Washington, D.C.

Choo, W.I. 1971. A study on stow-net fishery resources on the Korean West Coast. Bull. Fish. Res. Dev, 7, 79-92.

Chung, M. K. 1961. Illustrated Encyclopedia of the fauna of Korea (2)-Fishes. Ministry of Education, 861 p.

Hagerman, F.B. 1952. The bilolgy of the Dover Sole, *Microstomus pacificus* (Lockington). California. Dept. of Fish and Game, Fish Bull., (85), 48.

Year book of Fisheries statistics. 1970. office of Fisheries Republic of Korea, 196 p.