J. mar. biol. Ass. India, 1998, **40** (1 & 2) : 125 – 132

AGE AND GROWTH OF MALABAR SOLE *CYNOGLOSSUS MACROSTOMUS* NORMAN OFF KERALA COAST

A.A. JAYAPRAKASH

Central Marine Fisheries Research Institute, Cochin

AND

N.D. INASU

Post-Graduate and Research Dept. Zoology, Christ College, Iringalakuda, Kerala

ABSTRACT

The age and growth of the Malabar sole, *Cynoglossus macrostomus* Norman occurring along the coastal seas off Kerala were studied. The length frequency studies indicated that the fish attained 114.0 mm, 136.5 mm, 152.5 mm and 159.5 mm at the end of 1 to 4 years. The growth rings on scales showed that the fish attained 118.7 mm, 134.8 mm and 150.3 mm when I to III rings are formed on scales. The time of formation of the rings on scales was found to be during October-December and February-April. The growth parameters were determined by the von Bertalanffy growth formula, Ford-Walford graph and by the Gulland and Holt plot. The values obtained were L_{∞} = 166 mm and K = 0.714/year.

INTRODUCTION

IN MODERN fisheries research, ageing of fishes is considered very important because it has been realised that a knowledge of the age and growth rate of fishes is a prerequisite for many practical and scientific questions related to management and conservation. Through age determinations we have the means to identify the age composition of a fish population, and it can be determined to which degree the various age classes are utilised by the fishery against time. Once the addition (weight) in a fish stock in relation to time is determined, the optimum size at age can be fixed for rational exploitation of a fishery. Further, the loss in given fish stock due to natural and fishing mortality is to be estimated for arriving at maximum sustainable yield and biomass estimation. Thus a knowledge of the size (age) structure and growth rate and other related growth parameters is an essential pre-requisite for successful fishery management.

The studies on the age and growth in flatfishes in India are limited to the work of Seshappa and Bhimachar (1951) who showed the utility of scales of Malabar sole *C. semifasciatus Day* (= *C. macrostomus* Norman) as age indicators. Seshappa and Bhimachar (1954, 1955) studied the age and growth of *C.semifasciatus* by length frequency and scale methods. Krishnankutty (1967) and Seshappa (1974) studied the growth rings on scales of *C. macrolepidotus* and *C. dubius* respectively. The growth rings on scales of *Cynoglossus* spp. have been indicated by Seshappa (1981). Feroz Khan and Nandakumaran (1993) studied the age and growth of *C. macrostomus* along Calicut coast, by length frequency studies.

The Malabar sole *C.macrostomus* though distributed along both the coasts of India supports a single species fishery of commercial importance along the south west coast of India and is invariably an essential bycatch in shrimp trawls. The annual landings of this species have gone up with increasing operation of the shrimp trawls during the past decades. Since most of the past works pertained to the early post independence period it was felt necessary to study the biology of the species in the changing scenario of exploitation. The present account elucidates various aspects of the age and growth of this species.

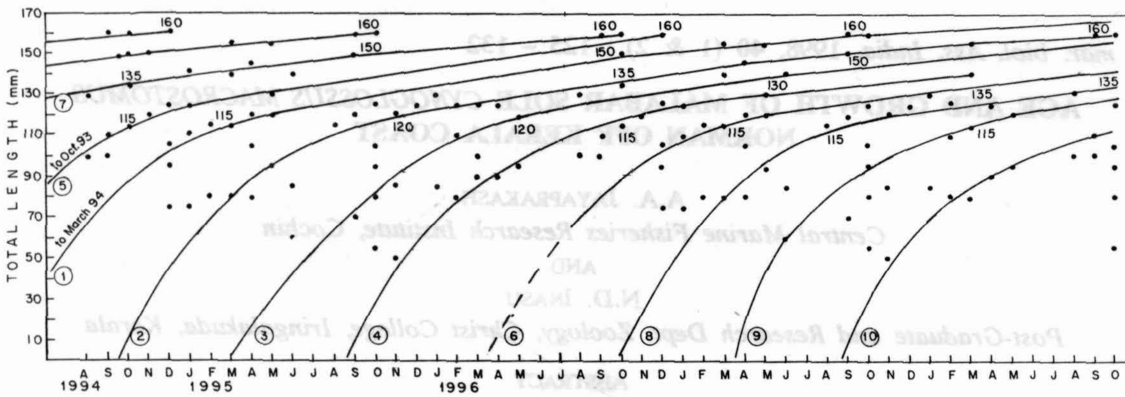

FIG. 1. *Monthly modal progression by scatter diagram of modal lengths for* C.macrostomus *at Cochin*

The first author is very grateful to late Prof. A.G. Govindankutty for suggesting the problem and to Rev. Fr. Jose Chittilappilly, Principal, Christ College Iringalakuda for providing facilities to carryout the work in the Zoology Dept. of this College. He is also thankful to the Director CMFRI for granting study leave during which period the work was conducted and to Dr. M. Srinath.

MATERIAL AND METHODS

Age determination of the Malabar sole, *Cynoglossus macrostomus* was done by the length frequency analysis, from the growth checks on scales and by the ELEFAN Method (Pauly and David 1981). The results of these studies were then compared.

Length frequency analysis

The material for the study was collected from the trawl landings at Fisheries Harbours at Cochin and Neendakara (Quilon) and from the minitrawl catch at Ambalapuzha. Weekly trips were made to the Cochin Fisheries Harbour and fortnightly trips to Neendakara (Quilon) and Ambalapuzha. During each trip on an average 200 fishes were measured for total lengths as indicated below.

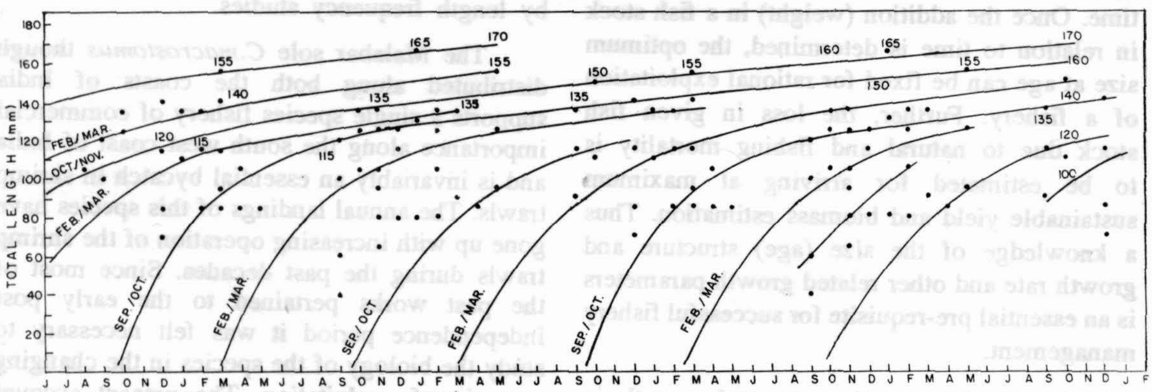

FIG. 2. *Monthly modal progression by scatter diagram of modal lengths for* C.macrostomus *at Neendakara*

Database

Centre	Gear	No.of specimen	Period	Monthly av. Nos.
Cochin	Trawls	9032	Aug. 94 to Oct. 96	335
Neendakara	Trawls	8067	Aug. 94 to Oct. 96	298
Ambala-puzha	Minitrawl	9633	Nov. 94 to Oct. 96	401

The monthly length data were grouped into 5 mm class intervals separately for the three centres. Based on the scatter diagram of modes observed during successive months, the trend lines tracing the growth of successive broods by means of modal progression through time were fitted free hand. These lines were extrapolated (with reference to the growth lines for younger broods) to intersect the time axis in order to resolve the periodicity and frequency of brood production during each spawning season and also the growth of various broods through successive months. The mean length at time were then worked out.

Scales

The study was based on the examination of scales from 648 males and 585 females of the size range 44 to 162 mm in total length. From each fish 5-10 scales were taken out from the pectoral region just below the lateral line. After mounting between glass slides they were observed under a monocular microscope (eye piece 10x and objective 5x). A micrometer was utilised to measure the radius (length) of the scale and also the radius between successive growth checks. Each micrometer division is equivalent to 0.0286 mm.

Based on the results obtained from the length frequency and scale studies, the growth parameters were determined by von Bertalanffy growth equation, Ford-Walford plot (1946) and Gulland and Holt Plot (1959). The length data were also analysed by computer based ELEFAN method (COMPLEAT ELEFAN Package) as described by Gayanilo *et al* (1988) and Pauly and David 1981 to obtain growth parameters.

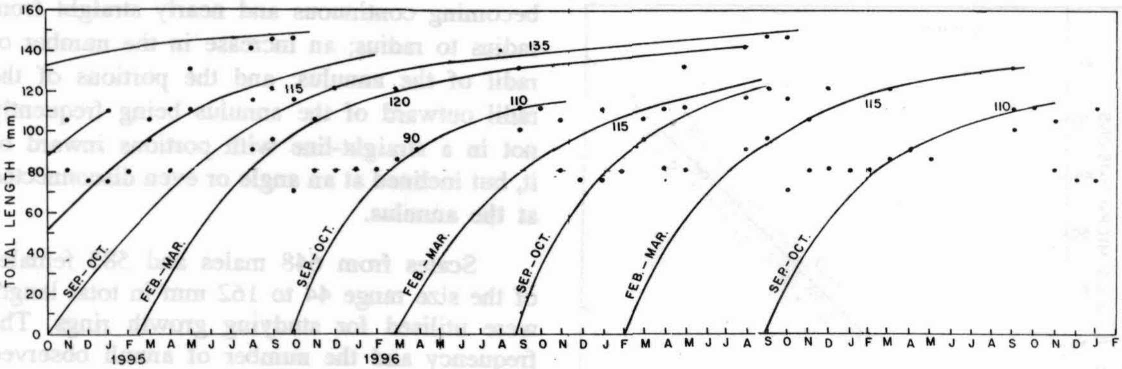

FIG. 3. *Monthly modal progression by scatter diagram of modal lengths for* C.macrostomus *at Ambalapuzha*

RESULTS

Age determination by length frequency studies

The dominant modes were noted from the monthly length frequency distribution of Malabar sole collected from Cochin, Neendakara and Ambalapuzha. Figure 1 gives the scatter diagram of modes at Cochin, Figure 2 from Neendakara and Figure 3 from Ambalapuzha.

The mean length at age was calculated taking into account the modal values. Based on this the length at age in each successive quarters were worked out for Cochin. Thus, the fish was found to attain a total length of 72.5, 87.5, 101.5, 114.0, 122.0, 126.5, 131.5, 136.5, 141.5, 145.5, 149.0, 152.5, 154.5, 158.0, 159.5 and 161.0 mm at the end of 1st to the 16 quarters respectively. The yearly growth in length attained has been found to be 114.0 mm, 136.5 mm, 152.5 mm and 159.5 mm at the end of 1 to IV years at Cochin compared to 115, 135, 150 and 160 mm respectively at Neendakara.

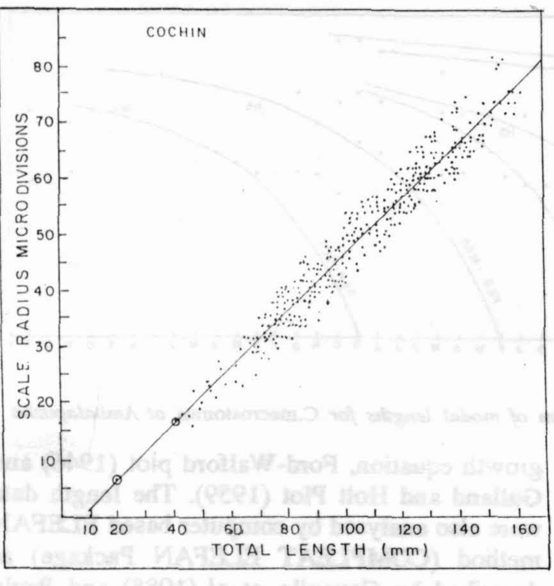

FIG. 4. *Relation between scale radius and fish lengths in Malabar sole*

Age determination of Malabar sole by scales

Relation between fish length and scale length (radius)

The Malabar sole has prominent ctenoid scales which are longer than wide. The scale lengths of 363 fishes ranging in total length from 44 to 162 mm were plotted against fish lengths as in Figure 4. The scatter of the points clearly showed that the relationship between them is linear and of the form L = a + b S where L = fish length in mm, S = scale length (radius) in m.d., and 'a' and 'b' are constants. The regression equation calculated by the method of least squares is

$$L = 23.881 + 2.0134\ S$$

Growth checks on scales

The annuli or growth checks on scales of Malabar sole are characterised by the narrowing of the sclerites and the closing up of the intervals between successive sclerites; the sclerites are wavy and broken up elsewhere, becoming continuous and nearly straight from radius to radius; an increase in the number of radii of the annulus; and the portions of the radii outward of the annulus being frequently not in a straight-line with portions inward of it, but inclined at an angle or even disconnected at the annulus.

Scales from 648 males and 585 females of the size range 44 to 162 mm in total length were utilised for studying growth rings. The frequency and the number of annuli observed on scales were then plotted against the class intervals and mean fish size was calculated. Out of 584 females, 163 specimens had no rings on scales, 115 showed 2 rings and 25 fishes had 3 rings. In males, out of 648 specimens examined, no rings were observed in the scales of 228 fishes, 290 fishes had one ring, 106 had 2 rings and 24 fishes showed 3 rings. The mean fish length (TL mm) worked out for one to three rings in the scales of males were 118.4, 134.4 and 149.4 mm respectively. For females it was 118.7 mm, 134.8 mm and 150.3 mm respectively. The growth pattern in males and females were similar showing no difference in the growth.

Scale radius to different growth rings

While taking the scale length (radius) measurements, radius of the scale upto the Ist and subsequent growth checks were also measured to find out the mean scale radius to successive growth rings. The mean scale radius for 1 to 3 rings was found to be 41.4 m.d, 54.2 m.d and 63.4 m.d respectively.

Back calculation of fish length from scales

For each scale studied, back calculation was done by using the corrected Lee (1920) formula based on the fish length scale length relationship.

$$L_t = L\ S_t/S + a\ (1\text{-}S_t/S)$$

where L and S are lengths of the fish and scale respectively, L_t is the calculated length at age t and S_t is the length of the scale upto t^{th} annual ring, 'a' is the constant in the equation for regression denoting the length of the fish when the scales are formed.

Back calculation of fish length from scales was also done using Bagenal (1974) formula

$$\text{Log } L_n = \text{Log } L_t + b \times \text{Log } rn - \text{Log } R_t$$

where L_t = length at capture, b = regression coefficient, R_t = scale radius at capture and Rn = scale radius at age n. The mean length of fish calculated from the scales for 1 to 3 rings by Lee's method was 114.9, 134.0 and 150.2 mm respectively. The corresponding values obtained from Begenal method was 115.3, 134.3, and 150.5 mm respectively. The values obtained by the two methods were similar and agreed with the results obtained from length frequency studies. This indicated that the growth checks on scales are annual in nature.

Time of formation of growth checks

This study was based on the width of the scales in the terminal zone. The width of the margin from the last ring to the edge of the scale (the increment of the last ring) should be at a maximum immediately before, at a minimum just at or after the formation of the last ring. Monthly scale samples from 771 fishes were studied for this purpose. The study showed that the time formation of the annuli is during October-November and March-May (Fig. 5).

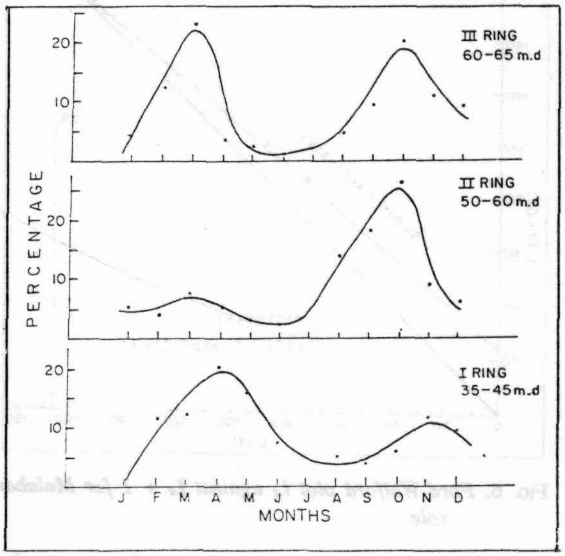

FIG. 5. *Time of formation of the I, II and III annual growth checks on scales of Malabar sole (Based on the minimum width in the terminal zone of successive growth checks)*

Factors inducing formation of growth checks on scales

The study indicated that the time of ring formation is during October-November and then in March-April-May. Studies have shown that the spawning of this species takes place during October-November and again in February-March-April. Malabar sole is not a multiple spawner. The spawners during the above two spawning periods are different. Consequently there are two broods in an year, one that of the October-November spawning and the other pertaining to the February-March spawning. Fishes with the Ist ring formed during October-November represent the broods of the previous year October-November period. Likewise fishes with one ring formed in their scales during February-March represent broods of the previous February-March period. These

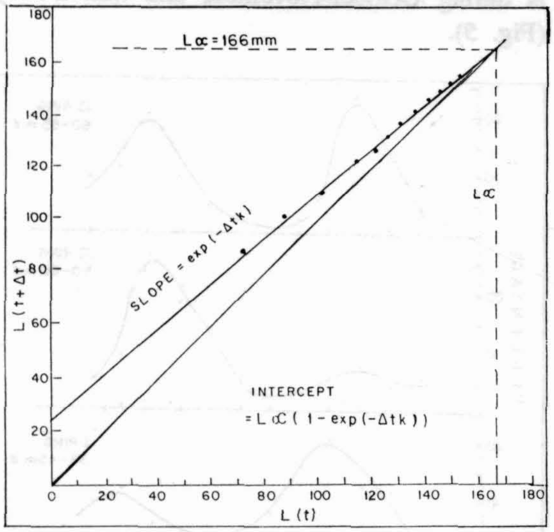

FIG. 6. *Ford-Walford plot L_t against $L_t + 1$ for Malabar sole*

two broods spawn after the end or at the completion of one year growth during the respective periods. Since there is remarkable

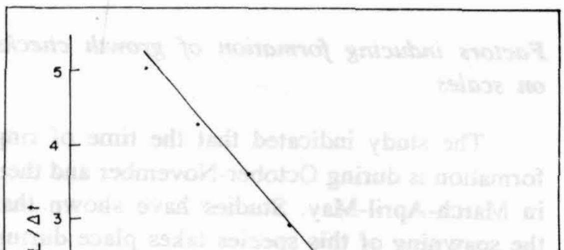

FIG. 7. *Gulland and Holt plot for finding L_{∞} of Malabar sole*

coincidence in the timings of the ring formation with that of the spawning time, the causative factor in all probability could be the spawning stress.

Estimation of growth parameters

The growth parameters such as the maximum size attainable (L_{00}), the coefficient *K* and the arbitrary origin of growth t_0 were estimated using the quarterly length increments in Malabar sole by the Ford-Walford graph (Fig. 6), Gulland and Holt plot (Fig. 7) and by the von Bertalanffy growth formula. The value of t_o was derived by the formula

$$t_o = t1 + \frac{1}{K} * \ln\left(1 - L\frac{(t1)}{L_{00}}\right)$$

Based on the formula the average value of t_o calculated for different ages were -5.63626 (/month), -1.87875 (/quarter), and - 0.46968 (/year). Thus the values were substituted in the VBG equation as

$$L_t = 166\left\{1-e^{-0.061227\ (t-(-5.63626))}\right\}$$

The von Bertalanffy growth curve and the regression analysis are indicated in Fig. 8 and Fig. 9 respectively.

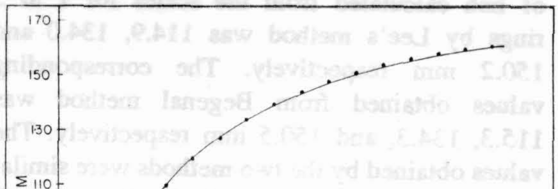

FIG. 8. *von Bertalanffy growth curve for Malabar sole based on quarterwise growth increments*

Fitting growth curves by means of Computer Programme

Data on Malabar sole at Cochin from August 1994 to October 1996 and data from Neendakara (1994 to 1996) have been analysed

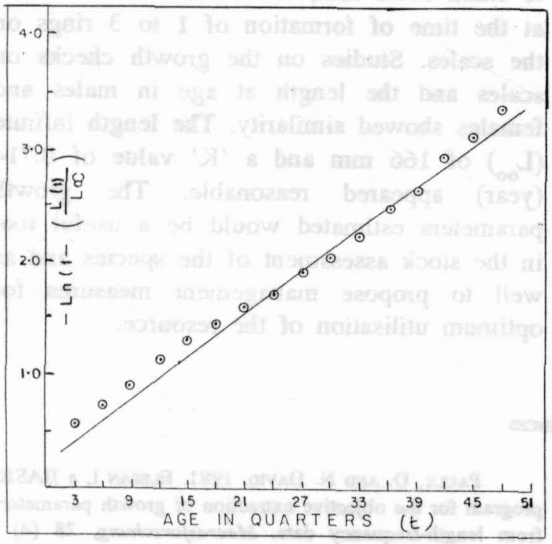

FIG. 9. *Regression for the von Bertalanffy plot for Malabar sole. The slope indicate K and t_o = -a/b*

by ELEFAN - 1 programme (Pauly and David, 1981). The growth parameters was found to be L_{∞} 170 mm and K = 0.9. at Cochin as indicated in Figure. 10.

DISCUSSION

The age and growth studies by Seshappa and Bhimachar (1951) using the growth checks on scales and by length frequency methods indicated that the Malabar sole attained a length of 100-129 mm in the first year, 140-149 mm and 170-180 mm in the second and third years respectively. Ferozkhan and Nandakumaran (1993) indicated that the species attained 106 mm in the first and 131 mm in the second year.

The present study showed that growth was fast in the early part of the life. The fish attained 72.5 mm by the end of three months itself showing an average growth of 24.2 mm per month. Further, the growth was found to slow down. The fish attained 87.5 mm at the end of 6 months. During this three months the average monthly growth was 5 mm compared to 24.2 mm per month in the initial three months. At the end of 9 months the fish attained 101.5 mm. The average monthly growth from 6th to 9th month was 4.7 mm and in the next 3 months the growth was 4.2 mm per month.

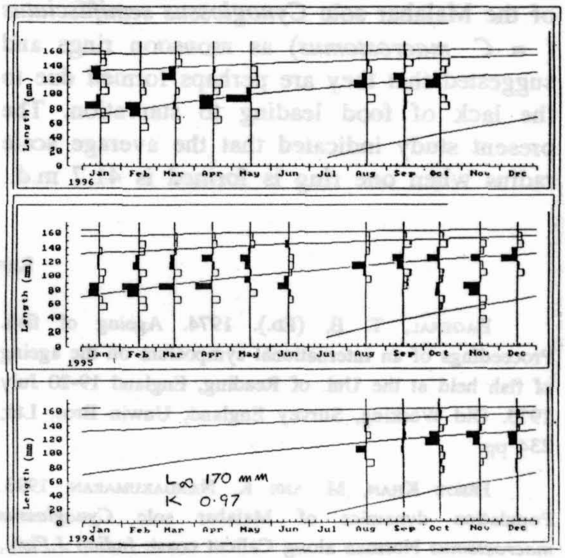

FIG. 10. *Growth curve of Malabar sole identified by ELEFAN (Based on combined length frequency data from Cochin, Neendakara and Ambalapuzha)*

The fish attained 114 mm at the end of 12 months indicating an average monthly growth of 9.5 mm during the first year. The fish attained 136.5 mm at the end of 2nd year. The growth during the second year was 1.9 mm per month. During the third year the average monthly growth was 1.3 mm. It is to be noted here that the size at maturity of the fish is 97 mm. The maximum growth took place before the attainment of maturity. After an initial fast rate the growth slowed down after 6 months, mostly due to energy investment in maturation and gonadal development. A uniform growth of 5 mm per quarter was observed from 21st to 27th month. Again, the quarterly growth was uniform during the 33 to 36th months. Analysis showed that these periods of uniform growth mostly coincided with the time immediately after the spawning. This indicated the recovery of the fishes from the spawning stress. But again the growth in length slackened due to energy diversion for maturation and subsequent spawning.

Seshappa and Bhimachar (1951, 1954, 1955) termed that the rings seen in the scales of the Malabar sole *Cynoglossus semifasciatus* (= *C macrostomus*) as monsoon rings and suggested that they are perhaps formed due to the lack of food leading to starvation. The present study indicated that the average scale radius when one ring is formed is 41.7 m.d. The scales of the new recruits of February-March will not attain that radius by September, but do attain by next February-March period when they complete one year. Hence the factors responsible for the formation of these growth checks appear to be the spawning stress. The fish has been found to attain 118.5 mm, 134.6 mm and 149.8 mm at the time of formation of 1 to 3 rings on the scales. Studies on the growth checks on scales and the length at age in males and females showed similarity. The length infinite (L_{oo}) of 166 mm and a 'K' value of 0.714 (year) appeared reasonable. The growth parameters estimated would be a useful tool in the stock assessment of the species and as well to propose management measures for optimum utilisation of the resource.

References

BAGENAL, T. B. (ED.). 1974. Ageing of fish. Proceedings of an international symposium on the ageing of fish held at the Uni. of Reading, England 19-20 July 1973. Old Working, Survey England, Unwin Bros. Ltd; 234 pp.

FEROZ KHAN, M. AND K. NANDAKUMARAN, 1993. Population dynamics of Malabar sole *Cynoglossus macrostomus* Norman along Calicut coast. *Indian J.Fish.*, **40** (4) : 225-230.

GAYANILO Jr, F. C., M. SORIANO AND D. PAULY. 1988. A draft guide to the *COMPLEAT ELEFAN. ICLARM Software Project* **2** : 65 p. and 10 diskettes (5.25 inches, 360 k).

GULLAND, J. A. AND S. J. HOLT.1959 Estimation of growth parameters for data at unequal time intervals. *J.Cons. CIEM*, **24** (1) ; 47-49.

KRISHNANKUTTY, M. 1967. Observations on the growth and mortality of the large-scaled tongue-sole, *Cynoglossus macrolepidotus* (Bleeker). *Proc. Nat. Inst. Sci. India*, **33** B (1 & 2) : 94-110.

LEE, R. M. 1920. A review of the methods of age and growth determination in fishes by means of scales. *Fish. Invest. Min. Agric. Fish., Lond., Ser.* 11, **4** (2).

PAULY, D. AND N. DAVID. 1981. ELEFAN I, a BASIC program for the objective extraction of growth parameters from length-frequency data. *Meeresforschung*, **28** (4) : 205-11.

SESHAPPA, G. 1974. On the fishery and biology of the large Tongue sole *Cynoglossus dubius* Day, at Calicut, Kerala. *Indian J. Fish.*, 21 (1) : 345-357.

________ 1981. Observations on the size distribution and occurrence of growth rings in scales of three species of *Cynoglossus* at Calicut. *Ibid*; **25** (1&2): 186-196.

________ AND B. S. BHIMACHAR. 1951. Age determination studies in fishes by means of scales with special reference to the Malabar sole. *Curr. Sci.*, **20** : 260-262.

________ AND B. S. BHIMACHAR. 1954. Studies on the age and growth of the Malabar sole, *Cynoglossus semifasciatus* Day. *Indian J.Fish*; **1** : 145-162

________ AND B. S. BHIMACHAR. 1955. Studies on the fishery and biology of the Malabar sole *Cynoglossus semifasciatus* Day. *Ibid;* **II** (2) : 180-230.

WALFORD, L. A. 1946. A new graphic method of describing the growth of animals. *Biol. lab. Woods Hole*, **90** : 141-7.