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# Growth, Mortality and Yield per Recruit of *Johnieops vogleri* (Bleeker) from Mumbai Waters

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Growth, mortality and yield-per-recruit of sharp toothed hammer croaker, *Johnieops vogleri* (Bleeker) is studied. L∞ and K were estimated as 374 mm and 0.73/year. Z, M and F were estimated as 4.13, 1.27 and 2.86 respectively. The length at first capture was 170 mm. Phi prime was calculated as 6.94. This species with Z/K ratio of 5.65 has high mortality. The yield isopleth diagram shows that optimum yield can be obtained at Lc/ L∞ value of 0.45 and E of 0.65. This shows that the fish belongs to quadrant "C" of 'yield isopleth' diagram where fishery is well developed and large sized fish can be caught at higher efforts. However, it may deplete the stock. Thus in order to sustain the catch, it is better to continue fishing at the present level of efforts.

**Key words:** ***Johnieops vogleri*, mortality, growth, exploitation, stock assessment**

Sciaenids are one of the important multispecies groups landed as by-catch of shrimp trawlers. Nearly a dozen species of lesser Sciaenids are landed at Mumbai coast, of which, at least six species contribute substantially to the fishery. The estimated annual average landing of Sciaenids in India was 1,54,795 t for the years 1990-2000 (Anon, 1990-2000a,b). Among the lesser Sciaenids *Johnieops vogleri* (Bleeker) is one of the major contributors. The biology, growth and stock assessment of this species has been reported by Muthiah (1982), Rao *et al.* (1992), Chakraborty (1993) and Chakraborty *et al.* (1996 & 2000). As most of the earlier studies pertain to 1972-1995 period, the present study was undertaken to investigate the status of the species in the changing scenario of increased effort and expanse of the operation of shrimp trawlers into deeper waters.

## Materials and Methods

The length frequency for *Johnieops vogleri* was collected once a week from New Ferry Wharf landing centre of Greater Mumbai from shrimp trawlers. The total weight of the sample thus measured was also taken at the landing centre itself. The total landing of this species on the day of observation was also made. The length frequency was distributed in 10 mm class intervals. The days catch was divided by the sample weight and the resultant factor was multiplied by the actual number of fish measured in each length group. This way the catch was raised for the day of observation. The raised frequencies of all the four days were added. The raising factor for the month was obtained by the following formula

$$\text{Raising factor of the month} = \frac{\text{Average catch of four days} \times \text{No. of fishing days of the month}}{\text{Total catch for four days}}$$

The sum of raised numbers of all the four days was multiplied by this raising factor to get the raised number for the month. These raised numbers formed the basic data for the growth, mortality and population parameters. This method of raising the numbers for the day and subsequently for the month was done following Sekharan (1962).

The growth was estimated by ELEFAN following Gayanilo *et al.* (1996) and by combination of Bhattacharya/ Gulland & Holt plot. The total mortality coefficient was estimated by length converted catch curve of Pauly (1984), given as

$$\ln (N/\Delta t) = a + b.t$$

Where, 'b' with sign changed is the estimate of total mortality coefficient 'Z'.

Here only the descending right limb is taken for the estimation of Z as that represents the fully recruited class which is vulnerable to the gear. The natural mortality coefficient 'M' was calculated by Pauly's (1980) emperical formula as

$$\ln M = -0.0152-0.279 (\ln L\infty) + 0.6543 (\ln K) + 0.463 (\ln T)$$

Where L∞ is in cm, K is annual and temperature is in degree Celsius. The natural mortality coefficient was also calculated by Rikhter and Effanov's (1976) formula, given as

$$M = (1.521/tm_{50}^{-0.72}) - 0.155 \text{ / year}$$

Where, tm is the age of massive maturation, usually the length at which 50% of the fish become mature.

The relative yield per recruit model developed by Beverton & Holt (1966) was employed here which requires less number of parameters. The formula is given as

$$(Y/R)' = E\, U^{m/k} \left\{ 1 - \frac{(3U)}{1+m} - \frac{(3U^2)}{1+2m} - \frac{(U^3)}{1+3m} \right\}$$

$$\text{Where } m = \frac{1-E}{M/K} = K/Z$$

U = 1-Lc/ L∞, the fraction of growth to be completed after entering the exploited phase.

E = F/Z, exploitation ratio or the fraction of death caused by fishing.

A separate estimate of K is not required as input and the equation of relative yield-per-recruit is based on length (L∞ and Lc in U) rather than age. Y/R' can be calculated for a given input of M/K, L∞, and Lc values of E ranging from 0-1. The yield–isopleth diagram was computed to work out the eumetric fishing by inserting the isovalues of L∞/Lc on Y- axis and E or F on the X-axis. Comparison of growth parameters was made by phi prime (ϕ) formula given by Munro and Pauly (1983) as

$$\phi = \ln (K) + 2 \ln (L\infty)$$

Where K is annual and L∞ is in cm. All these analysis was carried out employing FiSAT programme developed by Gayanilo *et al.* (1996). The length frequency data of three years i.e. from April 2000-March 2003 was pooled and it formed the basic data for all the analyses.

## Results and Discussion

The annual average catch of lesser sciaenids during 1995-96 to 2001-2002 periods in Maharashtra was 19,325 t. The minimum catch during this period was16410 t in 2000-01 and the maximum was 21880 t in 1999-2000 (Anon 1990-2000a,b). Species wise catch details is not available. However, based on the estimates made on days of observation it was found that nearly 25% of the catch consists of *J. vogleri.*

Using ELEFAN programme, the L∞ and K were estimated as 370mm and 0.72/year respectively. Employing Bhattacharya/ Gulland & Holt plot the L∞ and K were estimated as 374 mm and 0.72/year respectively. The asymptotic length and K estimated by the latter method was taken for further calculation. The third parameter of VBGF was taken as zero (Fig.1). Taking this L∞ and K, length attained by the fish at the end of I-III years of life was calculated as 193, 289, and 333 mm respectively. The largest

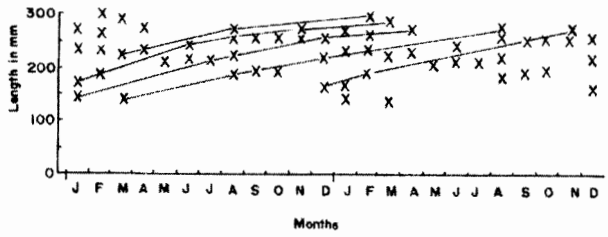


Fig. 1. Mean length of assumed cohorts connected for Bhattacharya analysis

fish observed during the present investigation was 340 mm. Using VBGF, the age of the largest fish was worked out to be 3.33 years. The calculated growth curve of this species is presented in Fig 2.

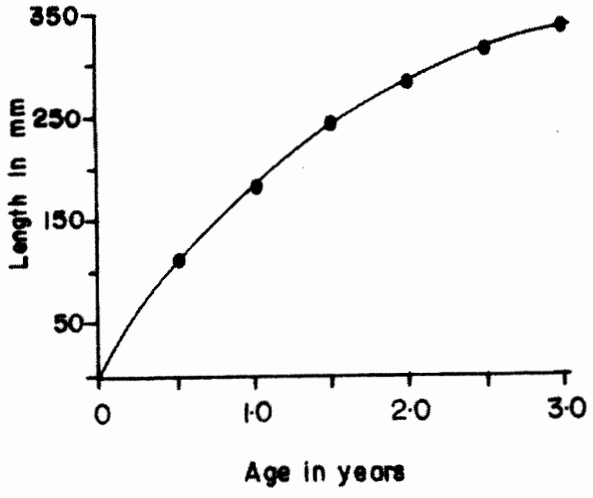


Fig. 2. Calculated growth curve

The phi prime was calculated as 6.93. The total mortality coefficient (Z) was calculated as 4.13 (Fig. 3) and the natural mortality coefficient was calculated as 1.27. The fishing mortality coefficient obtained by substracting M from Z was 2.86.The exploitation ratio and exploitation rate were calculated as 0.69 and 0.67, respectively. The Z/K ratio was found to be 5.65. The length at which 50% of fish becomes vulnerable to the gear (Lc50) was found to be 170 mm. The Lc/ L∞ value was obtained as 0.45 and the M/K value was 1.76. The latter two parameters formed the basic input for selection ogive and the yield isopleth diagram. By

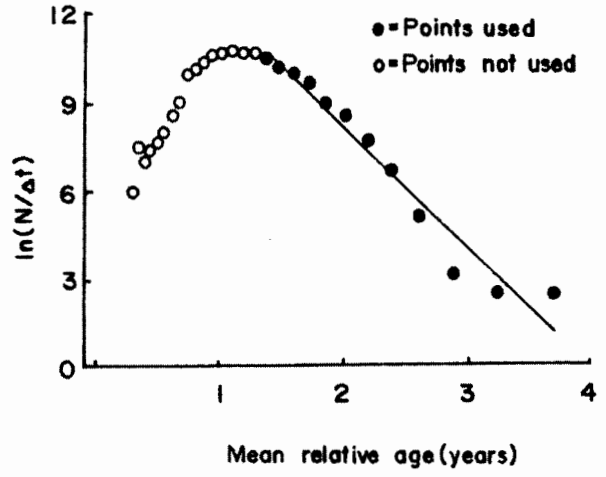


Fig. 3. Length converted catch curve for the estimation of 'Z'

selection ogive the Emax was obtained as 0.59 (Fig. 4). The yield isopleth diagram indicates that optimum yield can be obtained at E of 0.65 with Lc/ L∞ value of 0.45 (Fig. 5).

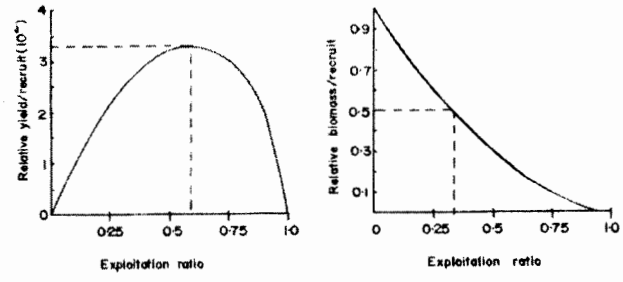


Fig. 4. Relative yield-per-recruit and biomass-per-recruit by selection ogive

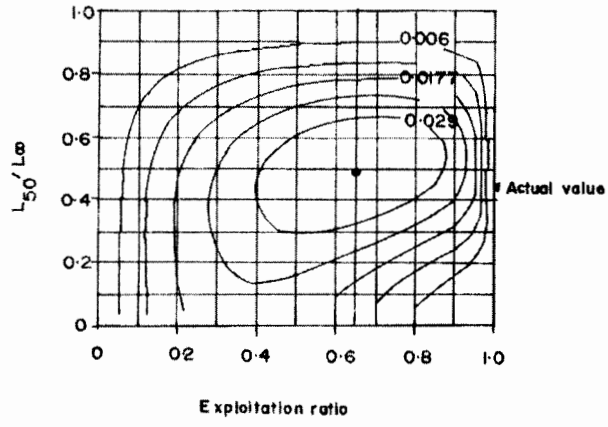


Fig. 5. Yield isopleth diagram

A number of researchers have studied the growth and related parameters of *Johnieops vogleri* (Muthiah, 1982, Rao *et al.*, 1992; Chakraborty *et al.*, 1996, 2000). Except for Muthiah (1982) who used the annuli on scales for the growth studies in addition to length frequency data, all other authors used only length frequency for the determination of age. While Muthiah (1982) and Chakraborty (1993) used the model progression analysis manually, the rest of the authors used computer based programme like ELEFAN or FiSAT. The rate of growth obtained by Muthiah (1982) and Chakraborty (1993) happened to be slow. For comparison of growth obtained by various authors phi prime ($\phi$) was used, which is usually constant for a species, family or closely related taxonomic groups. The phi prime ranged from 6.45-6.78 (Table 1). In the case of Chakraborty (1993) the phi prime is low where the 'K' appears to be underestimated. The total mortality coefficient of 4.13 estimated in the present study is higher as compared to 2.17 obtained by Chakraborty (1993). Subsequent workers have recorded higher values of Z and E for this species. Rao *et al.* (1992) have estimated the E and Z as 0.69 and 3.58 respectively. Whereas Chakraborty *et al.* (2000) have recorded E and Z as 0.66 and 3.79 respectively. The higher Z and E in the subsequent studies are due to the higher rates of exploitation in the later years.

Table 1. Phi prime ($\phi$) estimated for *J. vogleri* based on $L\infty$ and K estimated by different authors

| Investigators | $L\infty$ (mm) | K | ($\phi$) |
|---|---|---|---|
| Rao *et al.*, 1992 | 345 | 0.72 | 6.75 |
| Chakraborty, 1993 | 353 | 0.5077 | 6.45 |
| Chakraborty *et al.*, 1996 | 345 | 0.72 | 6.75 |
| Chakraborty *et al.*, 2000 | 350 | 0.72 | 6.78 |
| Present study 2005 | 374 | 0.73 | 6.93 |

'M' is one of the most difficult parameters in the tropics as time series data on the Z and efforts is not available. Even if they are available, apportioning of efforts in a multi species, multi gear fishery is difficult. Thus, the most reliable method of estimation of M *i.e.* a plot of Z against efforts (Paloheimo, 1958) cannot be used. It is for this reason a number of methods used to arrive at a reasonable estimate of 'M'. In spite of using so many methods ultimately the reliability of 'M' thus estimated is judged by the M/K ratio, which usually falls in the range if 1-2.5 (Beverton & Holt, 1959). In the present investigation the M/K was 1.74, which is well within the range.

The knife-edge procedure gave $E_{max}$ of 0.69 whereas by selection ogive the $E_{max}$ was estimated as 0.59. In knife-edge selection it is generally assumed that the fish below that length will not be retained by the trap while selection ogive method assumes that the probability of capture of a fish is a function of its length. In general selection ogive appears to be more realistic. As the Y/R analysis showed that $E_{max}$ is to be maintained at 0.59 by following selection ogive while the present E is 0.69, therefore, fishing effort need to be reduced.

The yield isopleth diagram shows that optimum yield can be obtained at Lc/L value of 0.45 and E of 0.65. Thus, the E obtained is less than that of 0.69 obtained by knife-edge and slightly higher than 0.59 obtained by selection ogive. According to Pauly & Soriano (1986) the yield isopleth contours with Lc/L of nearly 0.5 consists of four quadrants. Accordingly, *J. vogleri* belongs to quadrant 'C' where fishery is well developed and large sized fish can be caught at higher efforts. As the exploitation ratio/ rates, fishing as well as total mortalities have gone up in the recent years, reduction in the efforts in the form of reduction of boats or increase of cod end mesh size is suggested.

However, to what extent, the same is possible in the multispecies multigear fishery where the target is shrimp, and croakers are landed as by catch.

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