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Stock assessment of big eye croaker *Pennahia macrophthalamus* (Bleeker) (Pisces/ Perciformes /Sciaenidae) from Bombay waters

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Growth, mortality and stock assessment of big eye croaker *Pennahia macrophthalamus*(Bleeker) is reported in the present communication.The asymptotic length of this species is estimated as 260mm and growth coefficient 1.20 per year.The total, natural and fishing mortalities were estimated as 3.24, 2.81 and 0.43 respectively.The stock assessment studies were carried out using length cohort and Thompson & Bell model. The result of this study shows that there is no decline in the catch of this species at the present level of exploitation. However, it is observed that even if the fishing efforts are doubled the catch can go up by only 12.74%.Therefore, further increase in the efforts is detrimental to the stock of *P.macrophthalamus* and the returns may not be remunerative.

Landing as by-catch of shrimp trawl,sciaenids form one of the important components of trawl fishery in Bombay.The total annual average catch of croakers at all India level was 1,06,757 tons during 1985-92 period.This group as a whole contributed 7.02% to total fish catch at the all India level.Maharashtra, with annual average catch of 22,751 tons during the 1985-92 period ranked second among the maritime states of India as far as the landing of sciaenids are concerned.The chief states in order of abundance contributing to the croaker catch are Gujarat,Maharashtra,Tamil Nadu, Andhra Pradesh and Kerala.

Stock assessment studies on a number of species of croakers have been worked out from Bombay waters[1-4]. Big eye croaker *Pennahia macrophthalamus* is however, a minor species forming only 4-5% of the croaker catch in Bombay.Growth, mortality and stock assessment studies of this species has not been reported from the west coast of India. Based on the data collected from 1989-91 from New Ferry Wharf and Sassoon Docks landing centres of Greater Bombay, the growth, mortality and stock assessment of this species is described in the present communication.

Materials and Methods

Weekly measurements on the length frequency was made at S.Docks and N.F.Wharf landing centre of Greater Bombay. They were recorded in the length range of 82-249 mm.The length data was grouped into 10 mm class intervals and raised for the day's catch and subsequently for the months' catch following Sekharan[5].Twentyseven months' data spread over for three years were pooled.No measurements of this species could be taken in July and September as they were not represented in catch during these months. Age was determined by three different methods[6-9]. Total and natural mortality coefficients were estimated[10,11]. The T_{max} was calculated as per Beverton & Holt[12]. The length weight relationship was calculated as $W = a.L^b$ where L is length in cm and W is weight in g and "a" and "b" are constants. The stock estimate were done by length-cohort[13] and Thompson & Bell[14] method employing Length Based Fish Stock Assessment package developed by Sparre *et al.*[15]. The phi factor (ϕ) was worked out as per Pauly & Munro[16].

Results and Discussion

During this period in the length range of 82 to 249 mm, 2,308 specimens were measured. More number of specimen were measured in April and June. The asymptotic length (L_∞) and growth coefficient (K) estimated by three different methods have been presented in Table 1. It is observed that L_∞ estimated by Bhattacharya/Gulland & Holt plot[6,7],

ELEFAN[8], Wetherall *et al.*[9] was 260, 255 and 254 mm and the K was estimated as 1.20 and 1.12 per year by Bhattacharya/Gulland-Holt plot and ELEFAN method. Wetherall *et al.*, plot gives an estimate of Z/K only. Thus, there was only minor differences in the estimates of L_∞ and K arrived at by three methods. However, for further calculations the L_∞ and K of 1.20 per year estimated by Bhattacharya and Gulland-Holt plot was taken into consideration (Fig. 1).

The L_∞ of 260 mm is close to the largest fish of 249 mm observed in the catch. Based on the L_∞ and K the length at the age of I and II years were calculated as 182 and 237.5 mm respectively. The von Bertalanffy's growth formula (VBGF) for this species could thus be written as

$$Lt = 260\ 1\text{-}e^{K\,(t\,\text{-to})}$$

The length weight formula for this species was obtained as

$$\text{Log } W = 0.0184255 + \text{Log } L^{2.906661}\ (r^2 = 0.99455)$$

Table 1—Growth parameters of *P.macrophthalamus* as estimated by different methods.

Method employed	L_∞	K/year	Z/K
ELEFAN[8]	255	1.12	—
Bhattacharya/ Gulland-Holt plot[6,7]	260	1.2	—
Wetherall *et al.*[9]	254	—	3.17

L_∞ = Asymptotic length, K = growth coefficient
Z/K = ratio of total mortality & growth coefficient.

Table 2—Input parameters used for the length cohort analysis.

L_∞	K	M	F/Z	q inW=qL^b	b inW=qL^b
260	1.2	2.81	0.55	0.0184255	2.906666

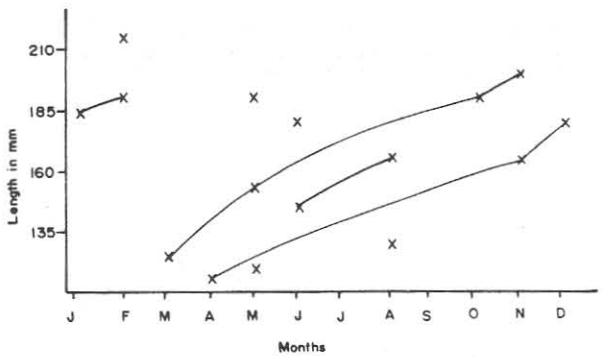

Fig.1—Mean length of assumed cohorts connected for Bhattacharya analysis

Table 3—Length-cohort analysis of *P. macrophthalamus*

Interval	C	X	N	F/Z	F	Z	W+	Mean N	Mean N* W	C*W
84.5	124280	1.069	36250000000	0.0843	0.2588	3.0688	7546.42	480237.72	3624.06	937.87
94.5	121925	1.073	9362497	0.0901	0.2784	3.0884	10406.92	437984.35	4558.06	1268.86
104.5	415493	1.078	8009836	0.2754	1.068	3.878	13901.51	389052.15	5408.41	5775.96
114.5	693683	1.084	6501106	0.4309	2.2179	4.9379	18090.43	325986.65	5897.24	12549.02
124.5	606825	1.091	4891401	0.4543	2.3396	5.1496	23033.37	259370.83	5974.18	13977.22
134.5	315850	1.098	3555744	0.3528	1.5316	4.3416	28789.59	206219.31	5936.98	9093.19
144.5	215810	1.107	2660417	0.3149	1.2916	4.1016	35417.88	167083.72	5917.75	7643.53
154.5	205967	1.118	1975102	0.3555	1.5503	4.3603	42976.65	132860.11	5907.88	8851.77
164.5	125989	1.131	1395798	0.3025	1.2185	4.0285	51523.85	103400.54	5327.59	6491.43
174.5	172876	1.147	979254	0.4471	2.2724	5.0824	61117.12	76075.27	4649.51	10565.68
184.5	115998	1.169	592606	0.449	2.29	5.1	71813.87	50654.12	3637.67	8330.27
194.5	87647	1.198	334270	0.5024	2.8371	5.6471	83671.14	30893.36	2584.88	7333.52
204.5	59139	1.238	159813	0.5725	3.7626	6.5726	96745.5	15717.59	1520.61	5721.43
214.5	20781	1.298	56507	0.5328	3.2051	6.0151	111093.5	6483.83	720.32	2308.63
224.5	11966	1.401	17507	0.6987	6.5171	9.3271	126771.6	1676.42	212.52	1516.95
234.5	210	0	382	0.55	3.4344	6.2444	143655.2	61.15	8.79	30.17
Total	102395.5							Total	61688.43	102395.54

X=((L_∞–L(i))/(L_∞–L(i+1))) ^(M/2K), C=Numbers caught, N=Numbers of survivors, F/Z=Exploitation rate, F=Fishing mortality, Z=Total mortality, W=Body weight in tons.

Employing this formula the asymptotic weight (W_∞) at asymptotic length (L_∞) was calculated as 244g.

Using Beverton & Holt's[11] formula the maximum age (T_{max}) for the species was calculated as 2.63 years . The total mortality (Z) and the natural mortality (M) were calculated as 3.24 and 2.81 respectively The fishing mortality coefficient (F) was calculated as

$F = Z - M = 0.43$

The terminal value of F/Z was assumed as 0.55.

The length cohort analysis formed the basis of the length based Thompson & Bell analysis. It is evident from Thompson & Bell[14] analysis (Table 4) that at the present level of fishing (X = 1) the average catch of *P.macrophthalamus* is 102 tons and the mean biomass is 61 tons . There is no decline in the catch at the present level of fishing .It also shows that even if the fishing efforts are doubled (X=2) the catch would go up only by 13 tons (i.e. an increase by 12.74%) but at the same time the mean biomass would go down to 39 tons.

Table 4—Results of Thompson & Bell long term forecast for *P.macrophthalamus*

X	Yield*	Mean biomass
0	0	135.6
0.2	45.43	108.26
0.4	70.46	90.7
0.6	85.61	78.23
0.8	95.41	68.85
1.0	102.04	61.48
1.2	106.65	55.52
1.4	109.92	50.6
1.6	112.25	46.47
1.8	113.9	42.96
2.0	115.06	39.94

Maximum sustainable yield (MSY) of 116.81 tons is obtained at X = 3.01 ; *Yield and biomass area in tons

The input parameters used for the length cohort analysis are presented in Table 2.Results of the length cohort[13] and Thompson & Bell[14]are presented in Tables 3 and 4 respectively.The fishing mortality increased to a maximum of 9.32 at 224.5mm followed by a decline at 234.5 mm and above size group.The mean fishing mortality for the fully recruited group (larger than 184.5mm)was 3.47 and the mean total mortality (Z) for the fully recruited group was 6.48.

Maximum sustainable yield (MSY) of 116 tons can be obtained by nearly increasing the fishing efforts more than three times (X= 3.015). The phi factor was calculated as 2.91.

To the best of author's knowledge there is no report on the growth , mortality and stock assessment of this species from the west coast of India. A species growing to almost same length *Johnieops sina* has been worked out[4]. The asymptotic length and the growth coefficient for this species has been estimated as 266mm and 0.91 per year.The largest specimen recorded for this species is 243 mm which is very close to that of *P.macrophthalamus* (249 mm).

Work on this species has been reported from Philippines[16,17] and Malayasia[18].The growth, mortality and phi factor for this species shows that there is little agreement between the two results obtained from Philippines waters (Table 5). The growth coefficient appears to be very low from San Miguel Bay [17]in spite of having a low L_∞, though as a rule the lower the L_∞ the higher is the K. The asymptotic length estimated from Malayasia[18] appears to be very high as compared to the maximum length (L_{max}) observed in the catch and consequently the K is very low.The largest fish of

Table 5—Comparison of growth and related parameters of *P.macrophthalamus* from other localities of Asia

Area	L_∞	Annual K	Z	M	E	phi factor
Manila Bay[16] Philippines	26.5	1.4	5.55	2.3	0.58	2.99
San Miguel[17] Bay Philippines	20.0	0.6	2.28	1.4	0.37	2.28
Penang & Perak[18] Malaysia	34.2	0.4	10.26	5.5	0.84	2.67
Bombay waters (Present study)	26.0	1.2	3.24	2.8	0.13	2.91

K = Growth coefficient, Z and M = Total and natural mortalities, E = Exploitation ratio

250 mm recorded in the catches in Malayasia is same that of 249 mm recorded from Bombay. If we assumed that the L_∞ of *P. macrophthalamus* from Malayasia as 265mm and K as 1.1 then the phi factor would be 2.90 which is very close to that of the same species in Bombay.

Stock assessment studies indicate that the yield can be increased by 12.74% by doubling the efforts . But this appears to be impractical as the biomass would be depleted resulting in a drastic decline in the catch per unit of effort. Though studies on the catch per unit of efforts have not been done ,indirect inferences can be drawn based on the status of mean biomass.It is evident from Table 4 that if the efforts are doubled the catches would increase by 13.01 tons but the mean biomass would decline from 61 to 39 tons. As it is always better to be on the left hand side of the maximum sustainable yield (MSY) on the yield curve , for the benefit of the stock it is better if the fishing efforts are maintained at the present level only.

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