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Stock assessment of *Metapenaeus monoceros* (Fabricius) from Cochin waters, Kerala

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ABSTRACT

Based on the catch and effort, and length distribution data of *Metapenaeus monoceros* landed by shrimp trawlers at Cochin Fisheries Harbour during 1991 - 93, an attempt has been made to assess the stock of this species in the Cochin waters. The average annual instantaneous rate of total mortality was estimated 7.06 and 7.75 for females and males respectively. The estimated value of annual natural mortality (M) was 2.35 and it was assumed to be the same for both sexes. The estimate of fishing mortality rate (F) was 4.71 for females and 5.40 for males of *M. monoceros.* The average rate of exploitation (E) was 0.70 and 0.67 respectively for males and females. The average standing stock size of *M. monoceros* for the period under study was 10.55 t for males and 28.65 t for females. The Thomson and Bell and the Beverton and Holt yield per recruit routines in the LFSA are used to explain the present status of fishery which shows that there is no adverse effect of fishing on the exploited stock of *M. monoceros* from the southwest coast off Cochin.

Introduction

Knowledge of the growth and mortality rates is essential for assessment of the status of the exploited stock. Among the exploited marine fishery resources in India, the penaeid prawns occupy a premier position primarily due to their high export value. Development of the marine fisheries in India is characterised by its bias towards this valuable resource. The penaeid prawn fishery in the country is a multispecies one supported by more than a dozen species of which *Metapenaeus monoceros* is an important component. There has been only a few studies on the dynamics of the exploited stocks of this species (Lalitha Devi, 1987; George *et al.*, 1988; Sukumaran *et al.*, 1993; Rao, 1994). The present study is the maiden attempt along the Kerala coast on the dynamics of this resource. This paper provides information on the estimates of the mortality rates, rate of exploitation and stock size. Effect of fishing on the stock is also dealt with.

Database and methods

The catch and effort data along with the length-frequency distribution of *M. monoceros* landed by the shrimp trawlers at the Cochin Fisheries Harbour during 1991 - 1993 formed the data base. The fishing ground covered for the study extends from Thottappally in the south to Ponnani in the north at a depth range of 30 - 60m [Lat. 09° 15'N -10° 46'N and Long. 75° 33'E - 75° 45'E (north) and 75° 52'E -76° 12'E (south)]. The monthly and the annual length-frequency distributions

have been arrived at following the procedure given by Alagaraja (1984). It is assumed that the growth in length (total length) follows the von Bertalanfy's Growth Formula (vBGF), and the estimated values of growth parameters *(L°°* and k) obtained by Nandakumar (MS) are taken as inputs for the present study. The FISAT and the LFSA packages were used for data analysis. To estimate the instantaneous rate of total mortality (Z) four estimation procedures as given in FISAT and LFSA were followed. They were (i) the length converted catch curve method (LCC), (ii) the cumulative catch curve method (CC), (hi) Wetherall method (WPR) and (iv) the Beverton and Holt method (BH). The instantaneous rate of natural mortality (M) was estimated following Rikhter and Efanov (1976).

The standing stock, recruitment and the length group-wise mortality rates were estimated using the length cohort analysis routine as given in the LFSA. The annual stock size and the standing stock under steady state conditions were estimated using the Baranov's catch equation. The effect of fishing was explained using the Thompson and Bell and the Beverton and Holt yield per recruit routines in the LFSA.

Results and discussion

The estimated value of the annual natural mortality (M) was 2.35 and it was assumed to be the same for both the sexes in the absence of the knowledge to the contrary. The estimated values of Z obtained by the four methods separately for the sexes are presented in Table 1. There is no con-cordance in the value obtained by the different methods. In general, the estimates of Z during 1992 were higher than those in the other two years. Ideally one would expect that the estimates of Z to be more or less of the same magnitude obtained from the different methods. However, the reason for the variability between the estimates obtained from the four methods could be attributed perhaps to the sampling variability. The pooled values of Z for both the sexes were obtained by simple average of the estimates obtained by the four methods. It would have been more appropriate to obtain a weighed average, the weights being functions of the variability in Z obtained from the respective methods. In the absence of such information for the last two methods, only simple averaging was resorted to. The average annual Z thus estimated were 7.06 and 7.75 respectively

TABLE 1. *Estimates of Z and F for females and lies of* M. monoceros

	Females				Males			
	(L<=° = 204mm	k (yr[1]) = 1.8) (z)			: 170mm	Wyr[1] == 1.5) (z)		
Method	1991	1992	1993		1991	1992	1993	
Lcc	6.77	8.92	6.96		6.67	8.96	7.85	
cc	7.28	9.36	7.41		6.74	9.43	7.90	
BH	6.07	7.54	5.72		7.29	9.45	6.86	
WPR	5.52	7.60	5.59		6.35	7.12	8.41	
Pooled (Z)	6.41	8.36	6.42	7.06	6.76	8.74	7.76	7.75
F	4.06	6.01	4.07	4.71	4.41	6.39	5.41	5.40

(M = 2.35, assumed to be the same for both the saxes).

for females and males. The corresponding estimates of fishing mortality rates (F) were 4.71 and 5.40.

The length-cohort analysis was carried out separately for the sexes using the average annual length-frequency data collected during 1991-'93. The results are summarised in Tables 2 and 3. The estimated number of recruits for females was about 58.2 million and for males it was 45.6 million indicating predominance of the females. The average fishing mortality rates weighted by the stock numbers were 4.08 and 5.16

TABLE 2. *The yield and average biomass of* M.monoceros *females for the period 1991 '93 in Jone's length based cohort analysis*

Lower limit mm	Number caught (000') C	Number of survivors (000') N	F/Z	F	Z	Mean N*)	Mean N*W	C*W
65	3.931	58187.46	0.0014	0.0034	2.3534	1156.3309	837.0971	2.8458
70	15.907	55466.15	0.0059	0.0139	2.3639	1143.0166	1034.5385	14.3973
75	58.800	52764.15	0.0217	0.0521	2.4021	1128.7488	1258.4958	65.5589
80	108.602	50052.79	0.0399	0.0976	2.4476	1113.0551	1509.0092	147.2357
85	191.527	47328.51	0.0693	0.1749	2.5249	1095.3593	1785.1428	312.1378
90	169.279	44562.89	0.0627	0.1573	2.5073	1076.4105	2087.4082	328.2711
95	353.084	41864.05	0.1247	0.3347	2.6847	1054.7748	2411.7832	807.3402
100	560.437	39032.24	0.1884	0.5456	2.8956	1027.2327	2746.7986	1498.5969
105	970.196	36057.81	0.2943	0.9799	3.3299	990.0895	3073.1338	3011.3867
110	1388.297	32760.90	0.3861	1.4778	3.8278	939.4398	3361.9243	4968.2261
115	1777.632	29164.92	0.4639	2.0331	4.3831	874.3314	3585.2878	7289.3662
120	1946.319	25332.61	0.5095	2.4406	4.7906	797.4698	3725.8989	9093.4941
125	2369.874	21512.24	0.5879	3.3527	5.7027	706.8472	3743.2410	12550.1094
130	2184.072	17481.27	0.6046	3.5932	5.9432	607.8330	3630.9705	13046.8408
135	1870.692	13868.79	0.6077	3.6402	5.9902	513.8914	3447.3918	12549.3584
140	1712.443	10790.46	0.6316	4.0297	6.3797	424.9563	3188.2114	12847.5098
145	1567.880	8079.37	0.6638	4.6403	6.9903	337.8854	2824.1167	13104.6680
150	1721.550	5717.46	0.7495	7.0315	9.3815	244.8327	2271.5930	12972.7920
155	932.553	3420.55	0.7077	5.6902	8.0402	163.8869	1682.2566	9572.4150
160	576.621	2102.86	0.6870	5.1573	7.5073	111.8078	1265.7177	6527.6260
165	365.414	1263.49	0.6750	4.8817	7.2317	74.8533	931.7610	4548.6113
170	243.137	722.17	0.6857	5.1270	7.4770	47.4233	647.2950	3318.6511
175	131.788	367.59	0.6692	4.7533	7.1033	27.7255	413.8706	1967.2562
180	72.850	170.65	0.6783	4.9543	7.3043	14.7044	239.4570	1185.3460
185	17.995	63.24	0.5064	2.4106	4.7606	7.3611	130.4662	318.9397
190	13.853	27.71	0.5000	2.3500	4.7000	5.8949	113.3953	266.4790
Total		598162.30				51946.2656	135316.4530	

*) mean N(i) = (N(i)-N(i+1))/Z(i) Mean F(L) = 125) : 4.0845 (Weighted by stock number)

These results were obtained using the parameters :

L^{∞} (L - infinity)	204	Terminal exploitation rate	0.5
K (curvature parameter)	1.8	M/2K	0.652
M (natural mortality)	2.35	q in $w = q L^{A}b$ (g, cm)	3.958E-06
		b in $W = q L^{A}b$	3.1341

TABLE 3. *The estimation yield and average biomass of* M. monoceros *(Males) for the period 1991 - '93 in Jone's length based cohort analysis*

Lower limit mm	Number caught (000') C	Number of survivors (000') N	F/Z	F	Z	Mean N*)	Mean N*W	C*W
70	3.974	45621.42	0.0011	0.0027	2.3527	1498.9440	1385.8839	3.6743
75	23.894	42094.93	0.0069	0.0164	2.3664	1454.3936	1630.9961	26.7954
80	44.522	38653.21	0.0133	0.0136	2.3816	1408.0542	1892.3301	59.8346
85	260.166	35299.76	0.0755	0.1919	2.5419	1355.8953	2160.7202	414.5939
90	368.363	31853.24	0.1079	0.2843	2.6343	1295.7698	2425.4641	689.5139
95	594.998	28439.82	0.1711	0.4851	2.8351	1226.5583	2674.1138	1297.2009
100	1708.335	24962.41	0.3929	1.5207	3.8707	1123.3756	2830.9775	4305.1123
105	2780.132	20614.14	0.5515	2.8902	5.2402	961.9331	2782.8215	8042.7754
110	2573.560	15573.46	0.5864	3.3321	5.6821	772.3535	2548.9792	8493.4570
115	3112.024	11184.87	0.7010	5.5089	7.8589	564.9044	2114.7107	11649.8125
120	1831.812	6745.32	0.6752	4.8848	7.2348	375.0056	1584.0264	7737.5869
125	1152.690	4032.25	0.6661	4.6878	7.0378	245.8936	1166.3397	5467.5205
130	829.316	2301.71	0.7020	5.5347	7.8847	149.8390	794.5511	4397.6133
135	363.296	1120.27	0.6461	4.2894	6.6394	84.6955	500.0177	2144.7930
140	245.546	557.94	0.6986	5.4463	7.7963	45.0848	295.2018	1607.7631
145	96.479	206.45	0.6798	4.9902	7.3402	19.3336	139.8996	698.1318
150	17.625	64.53	0.4702	2.0858	4.4358	8.3346	66.4291	140.4762
155	13.525	27.05	0.5000	2.3500	4.7000	5.7553	50.3336	118.2839
Total		309352.80				27043.7969	57294.9375	

*) mean N(i) = (N(i)-N(i+1))/Z(i) Mean F(L) = 115) : 5.1554 (Weighted by stock number)

These results were obtained using the parameters :

Loo (L - infinity)	170	Terminal exploitation rate	0.5
K (curvature parameter)	1.5	M/2K	0.783
M (natural mortality)	2.35	q in w = q L^Ab (g, cm)	1.099 BE-05
		b in W = q L^Ab	2.9004

for the fully exploited length ranges which were assumed to be 125 and 115 mm respectively for females and males. The average fishing morta-lity rates unweighted by the stock numbers for the fully exploited length range were 4.74 and 5.10 respectively. The values derived from the average Z values (Table 1) were 4.71 and 5.40 which were in close agreement with those obtained from the length-cohort analysis.

The average rate of exploitation (E) was 0.70 and 0.67 respectively for males and females (Table 4). The standing stock for males ranged from 7.2 to 14.05t

TABLE 4 *Estimates of rate of exploitation (E), annual exploitation ratio (U) and standing stock obtained from the Baranov's catch equation*

Year	Yield (t)	E	Standing stock (t)
		Males	
1991	62	0.65	14.05
1992	46	0.73	7.2
1993	63	0.70	11.65
Average	57	0.70	10.55
		Females	
1991	144	0.63	35.49
1992	108	0.72	17.98
1993	153	0.63	37.59
Average	135	0.67	28.65

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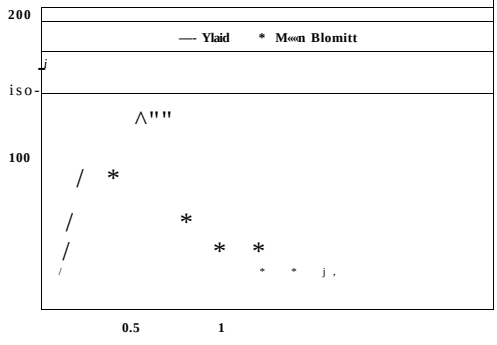
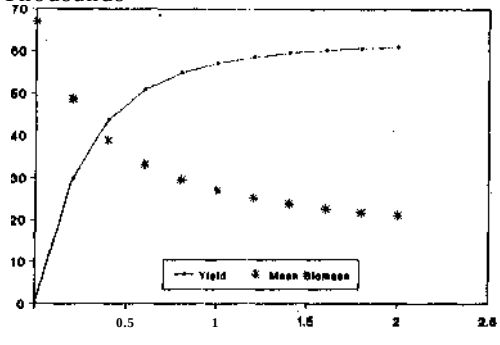
For the same period the standing stock
Thousands



Effort multiplier

Fig.l. Thomson and Bell long term forecast for females of *M. monoceros.*

Thousands



Effort multiplier

Fig.2. Thomson and Bell long term forecast for males of *M. monoceros.*

Thousands

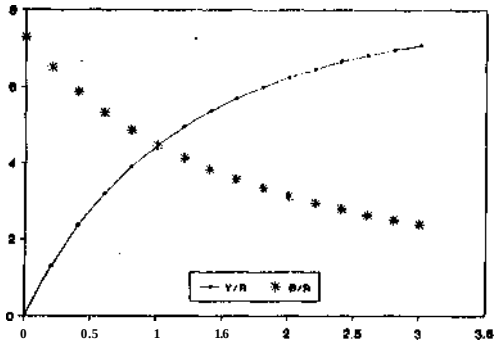


Fig.3. Beverton and Holt yield per recruit for females of *M. monoceros.*

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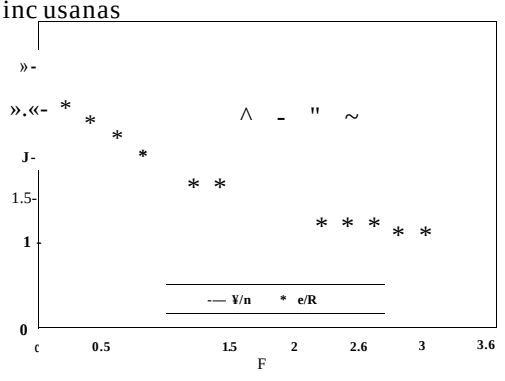

Fig.4. Beverton and Holt yield per recruit for males of *M. monoceros.*

of females ranged from 1798 t in 1992 to 37.591 in 1993 yielding 108 to 1531. The average standing stock sizes for the period under study were 10.55 and 28.65 t respectively for males and females. The corresponding estimates for the fully vulnerable length range obtained from the length cohort analysis were 11.2 t and 27.3 t respectively.

The Thompson and Bell analysis revealed that for females, the maximum yield could be obtained by increasing the fishing mortality by 40% (Fig. 1); whereas for males, a 400% increase in the fishing mortality was suggested to get the maximum yield (Fig. 2). The Beverton and Holt yield per recruit analysis indicated that the (Y/R) max would be attained at a fishing level 12 times the present value for the females (Fig. 3), whereas the Y/R curve for males had no maximum (Fig. 4).

It can be seen from the Table 1 that the total mortality Z for males was estimated to be higher than that for the females. This was in agreement with similar observation made by Lalitha Devi (1987); Sukumaran *et al.* (1993) and Rao (1994). The natural mortality rate of 2.35 for both the sexes was also

in concordance with the estimates obtained by Rao (1994). The average annual fishing mortality during the period was 5.40 and 4.71 respectively for males and females, the average rate of exploitation being 0.70 and 0.67, indicating that the major source of mortality was due to fishing. The standing stocks of 10.55 and 28.65 t respectively for the males and females (Table 4) yielded an annual average catch of about 57 and 135 t and these values are also in close agreement with the corresponding values obtained from the length cohort analysis (Table 2 and 3).

In a multispecies fishery and also for those stocks which don't form a significant magnitude of the exploited resource assemblage, it is rather difficult to suggest harvesting strategies exclusive to a particular stock. However, it is imperative and advisable to monitor from time to time the trend in the landings from the exploited stocks of multispecies fishery in order to assess the status. Besides, if reliable estimates of population parameters could be made, then more accurate information on the status ofstocks could be obtained through application of analytical tools and suggest a first approximation to the effect of fishing on the exploited stocks. This paper is thus an attempt in that direction. The analysis revealed that there was no adverse effect of fishing on the exploited stocks of *M. monoceros* from the southwest coast of India off Cochin.

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