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POPULATION DYNAMICS OF PENAEID PRAWN *PENAEUS MERGUIENSIS* OFF MUMBAI COAST

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ABSTRACT

Stock dynamics of *Penaeus merguiensis* was studied using length composition data collected seperately for males and females during the period 1995-1998, at New Ferry Warf landing, centre in Greater Mumbai. Food and feeding, sex ratio, facundity and length-weight relationships were worked out on a representative sub-sample. Asymptotic length ($L\infty$) and growth coefficient (K) were estimated to be 220 mm and 1.80 per annum respectively for males. These parameters were respectively 281 mm and 1.72 per annum in the case of females. The instantaneous rate of total mortality coefficient (Z) was found to be 9.79 and 7.44 per annum for males and females respectively. The annual natural mortality coefficient (M) was estimated to be 2.80 for males and 2.60 for females. As the exploitation ratio exceeded 0.5 in the case of both the males and females, the study suggests the necessity for reduction in fishing pressure in order to achieve Maximum Sustainable Yield (MSY).

Keywords - Banana Shrimp, mortality, Stock assessment, MSY.

INTRODUCTION

Penaeid prawn landings in India varied between 1.79,143 and 2,03,401 t with average landings of about 1,90,200 t during 1995 to 1997 and contributed about 63% to the total prawn landings. About 75% the total penaeid landings of the country came from the west coast and Kerala contributed about 36% followed by Maharashtra (32%) and Gujarat (24%) in 1997. Along the west coast trawlers accounted for about 83% of the total penaeid prawn landings.

Next to the tiger prawn, *Penaeus monodon*, the white or the banana prawn, *Penaeus merguiensis*, is commercially the most important prawn which supports the export industry. It is generally confined to shallow coastal areas upto 40 m depth. Investigations on *P. merguiensis* in India have been carried out among others by Raje and Ranade (1972) and Hameed Ali (1981). Based on the data collected from New Ferry Wharf landing centre of Greater Mumbai during 1995 to 1998, the food and feeding, reproduction, growth, mortality and stock assessment of *P. merguiensis* are reported in the present paper.

MATERIAL AND METHODS

Weekly visits were made during 1995-1998 to the New Ferry Wharf landing centre in Greater Mumbai to collect length and species composition data. These weekly samples were later pooled to obtain monthly data. A representive sample was also brought to the laboratory for biological studies. Length measurements were taken for males and females separately from tip of the rostrum to the tip of the telson, keeping the prawn dorsoventrally flattened on a scale graduated at 1 mm intervals. Length and corresponding weight were taken for males and females separately for calculating length-weight relationship. The prawns were grouped into 10 mm class intervals and raised for the day and subsequently for the month. Thirty one months data was then pooled for estimation of assumptotic length ($L\infty$) and the annual growth coefficient (K). Length-cohort analysis was also carried out. Analyses were carried out using LFSA package developed by Sparre (1987) and FiSAT package (Gayanilo,et al 1996) developed jointly by the ICLARM and FAO of United Nations. The total mortality was estimated by length-converted catch curve (Pauly, 1983) and Jones and van Zalinge's method (Jones and van Zalinge, 1981) while the natural mortality was estimated using Cushing (1968) and Pauly's formula (Pauly, 1980).

RESULTS

Food and feeding :

Specimen of *P. merguiensis* with lengths varying from 90 mm to 280 mm were collected for biological studies. A total of 271 specimens of various size groups comprising 121 males and 150 females were examined separately. Food items encountered in the guts were grouped into 10 groups viz. decapods, copepods, unidentified crustaceans, debris, fish, vegetable matters, molluscs, polychaetes, sand and miscellaneous (Table 1). Sand particles might have got accidentally in the gut in course of feeding.

Tablel 1 : Gut contents of 271 specimens of *P. merguiensis*

Sl. No.	Food Items	Male & Female (N=271)	Male (N=150)	Female (N=121)
1	Decapod	252 (92.99)	135 (90.00)	117 (96.69)
2	Copepod	66 (24.35)	39 (26.00)	27 (22.31)
3	Unidentified Crustacea	115 (42.44)	59 (39.33)	56 (46.28)
4	Debris	242 (89.30)	129 (86.00)	113 (93.39)
5	Fish	128 (47.23)	67 (44.67)	61 (50.41)
6	Vegetable matters	267 (98.52)	147 (98.00)	120 (99.17)
7	Molluscs	101 (37.27)	32 (21.33)	69 (57.02)
8	Polychaetes	212 (78.23)	121 (80.67)	91 (75.21)
9	Sand	198 (73.06)	105 (70.00)	93 (76.86)
10	Miscellaneous	122 (45.02)	65 (43.33)	57 (47.11)

N = No. of gut studied; figures in brackets show the respective percentage.

Sex ratio :

The male : female ratio in the population varied from a minimum 1 : 1.03 in February and 1 : 1.26 in December to a maximum 1 : 4.11 in the month of September, showing apparently that the females are always dominating in the catch during May to November which coincides with the breeding season. The disparity between sexes are low in February and December and very high in September (Fig. 1).

Spawning and fecundity :

The lowest fecundity has been found to be 59,449 eggs in a ovary weighing 0.54 g and the prawn was 110 mm in length weighing 15.35 g. The highest of 4,74,085 eggs were found in the 3.84 g ovary of a 197 mm long specimen weighing 84.10 g. The number of eggs increased with the size of the prawns . The relationship between the length of the prawn and the fecundity is presented below :

$$\text{Log } F = -2.4991 + 63.5629 \text{ Log } L$$

The Gonado Somatic Index (G.S.I.) study for 12 specimen are presented in Table 2.

Length-weight relationship :

The length-weight relationship (g-cm) is based on 165 specimens and the results are presented below :

Males :$\text{Log } W = -5.0523 + 3.0650 \text{ Log } L$

Females :$\text{Log } W = -5.2132 + 3.0262 \text{ Log } L$

Weight and size at first maturity :

The size at first maturity in this prawn was calculated to be 120 mm in males and 160 mm in females at about an age of 4-5 months and the weight is 20.9 g in males and 28.6 g in females.

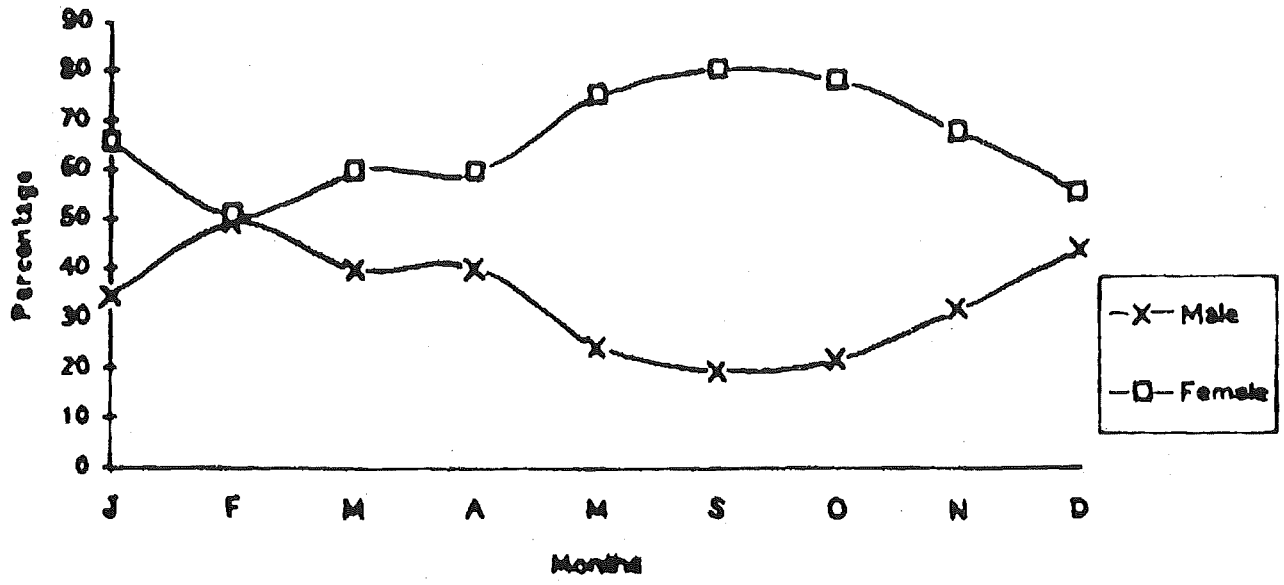

Fig 1 : Month-wise sex ratio of P.merguiensis.

Tablel 2 : Gonado Somatic Index of 12 specimens of *P. merguiensis*

Sl. No.	Total Length (mm)	Total Weight (g)	Weight of Ovary (g)	G.S.I.
1	132	15.38	0.59	3.84
2	137	28.13	2.44	8.67
3	143	22.08	1.86	8.42
4	146	24.25	2.75	11.34
5	147	26.47	3.30	12.47
6	149	26.82	0.94	3.50
7	153	27.20	1.30	4.78
8	155	31.32	4.22	13.47
9	157	33.15	5.02	15.14
10	161	35.45	4.23	11.93
11	164	36.93	2.56	6.93
12	172	38.02	2.50	6.58

Growth parameters :

The $L\infty$ was calculated as 220.48 mm say 220 mm for males and 280.76 mm say 281 mm for females. The annual growth coefficient (K) was calculated as 1.80 and 1.72 for males and females respectively (Fig. 2 & 3). At the end of one year the males grow to a length of 190 mm and the females 230 mm. This species moults 11-12 times during its growth from 0.30 mm (Nauplius-I) to 6.0 mm (Post Larva-I).

Mortality :

Table 3 gives year-wise Z values of males and females for 1995-98.The average instantaneous rate of total mortality coefficient (Z) for males and females estimated by length-converted catch curve method was 9.79 and 7.44 respectively (Fig. 4 & 5). Jones and van Zalinge's method gave Z value of 7.41 and 7.21 respectively for males and females. The overall average value of Z obtained by these two methods

Table 3 : Z values for males and females by length-converted catch curve method

Year	Male	Female
1995-96	10.64	7.60
1996-97	8.21	7.19
1997-98	7.07	6.32
Pooled	9.79	7.44

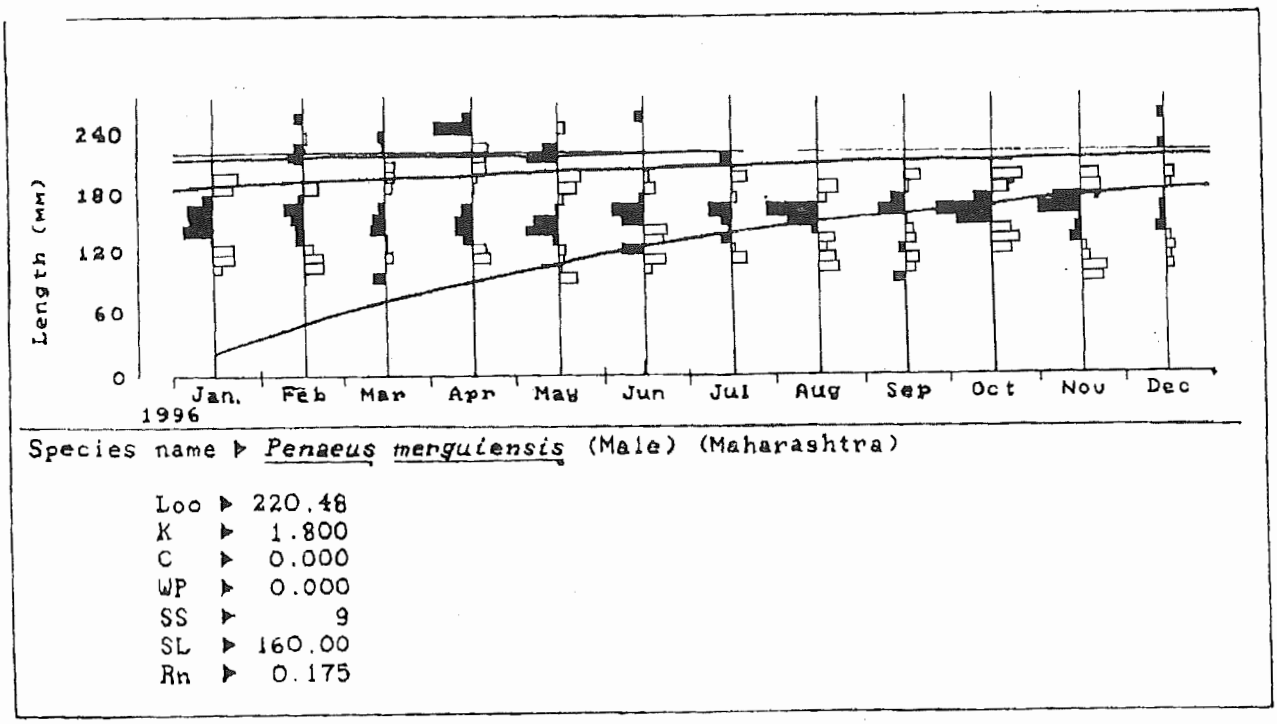

Fig 2 : Growth curve of P. merguiensis (male) as estimated using ELEFAN I module of FiSAT programme.

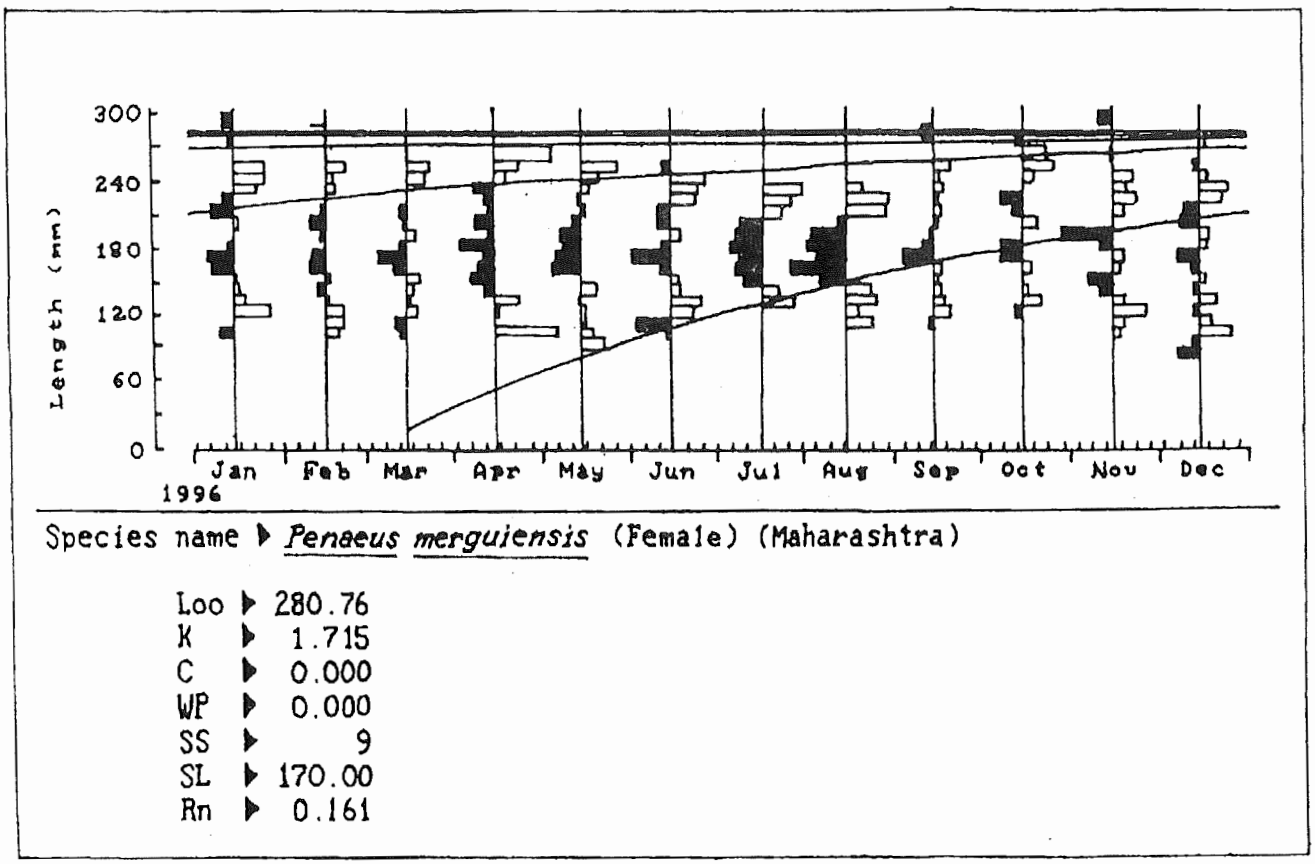

Fig 3 : Growth curve of P.merguiensis (female) as estimated using ELEFAN I module of FiSAT programme.

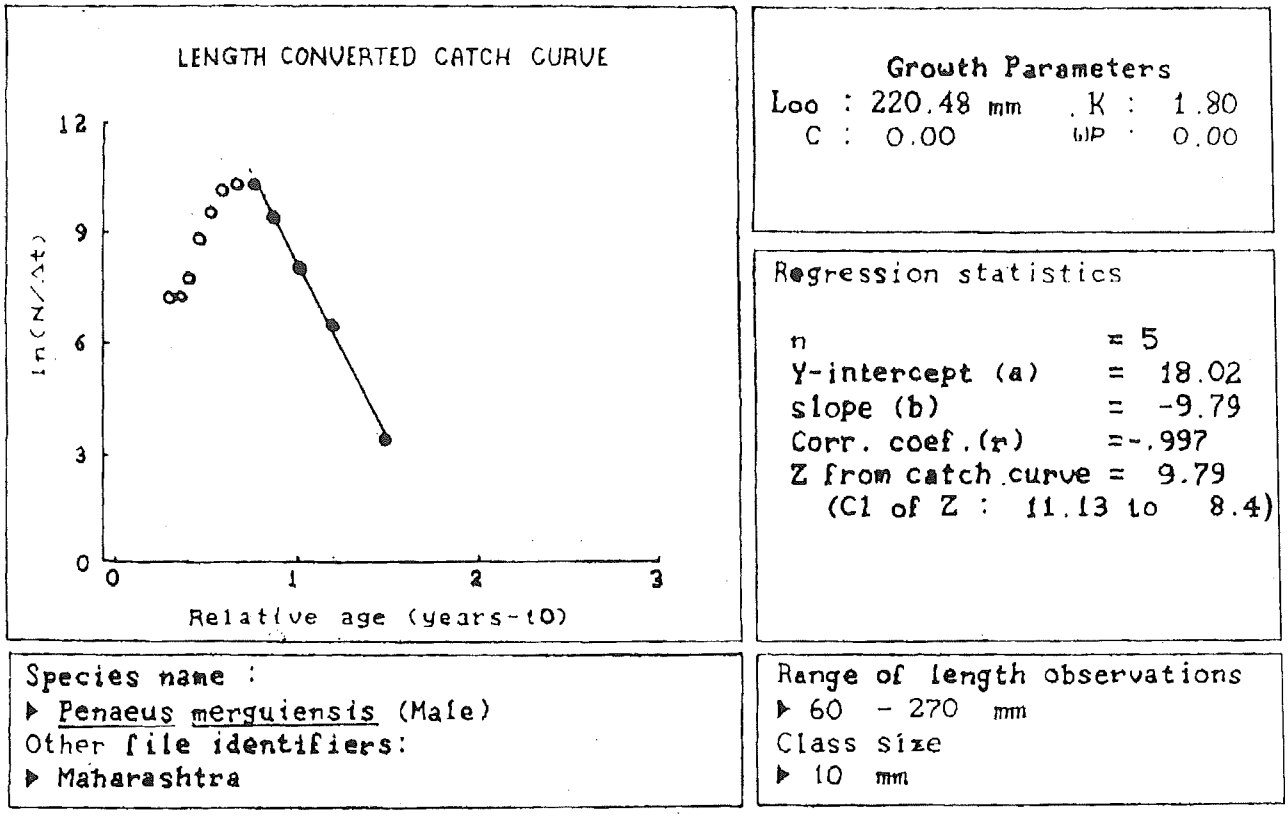

Fig 4 : Length-converted catch curve for estimation of Z for P.merguiensis (male).

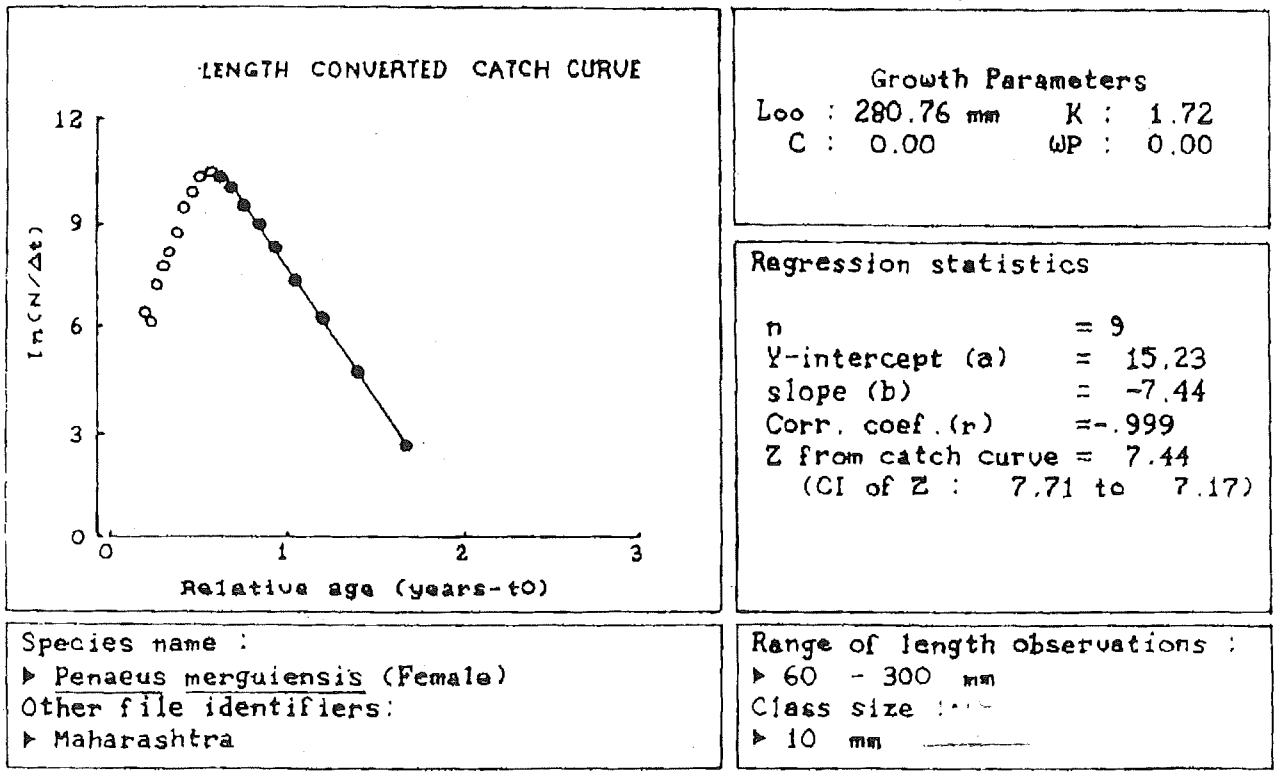

Fig 5 : Length-converted catch curve for estimation of Z for P.merguiensis (female).

works out to 8.60 and 7.33 respectively for males and females. The average lifespan of this prawn was estimated as 1.71 years. Assuming that atleast 99% of the fish die by the time they reached the Tmax in the unexploited state, M value obtained by Cushing's method were 2.76 for males and 2.63 for females. M obtained by Pauly's formula with temperature of 28°C were 2.86 for males and 2.59 for females. It is observed that M values obtained by both the methods are very close. Average values of these two methods were used as estimates of M in further calculations i.e. M = 2.8 and 2.6 for males and females respectively.

Length cohort analysis :

Cohort analysis indicated that fishing mortality is more or less stable for larger specimen beyond 170 mm in case of females (Fig. 7). However, in case of males fishing mortality decreased between 170 to 190 mm and rose abruptly later for specimen of 200 mm (Fig. 6). This phenomenon observed in males needs further explaination. It may be either to due migration of males of this length group out of the fishing grounds or may be due to the failure of commercial fishery to sample this part of the population for some reason or the other.

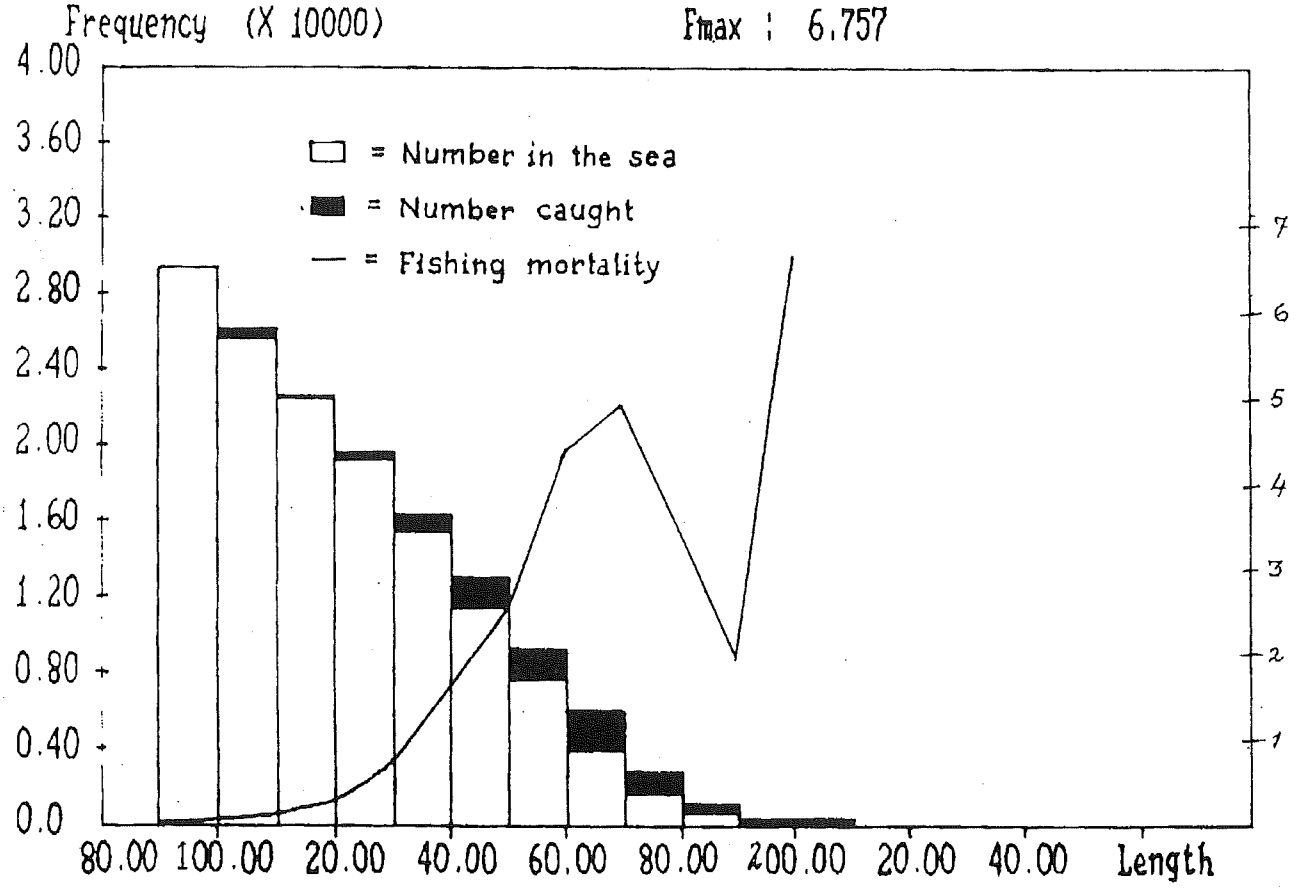

Fig 6 : Length cohort analysis for P. merguiensis (male).

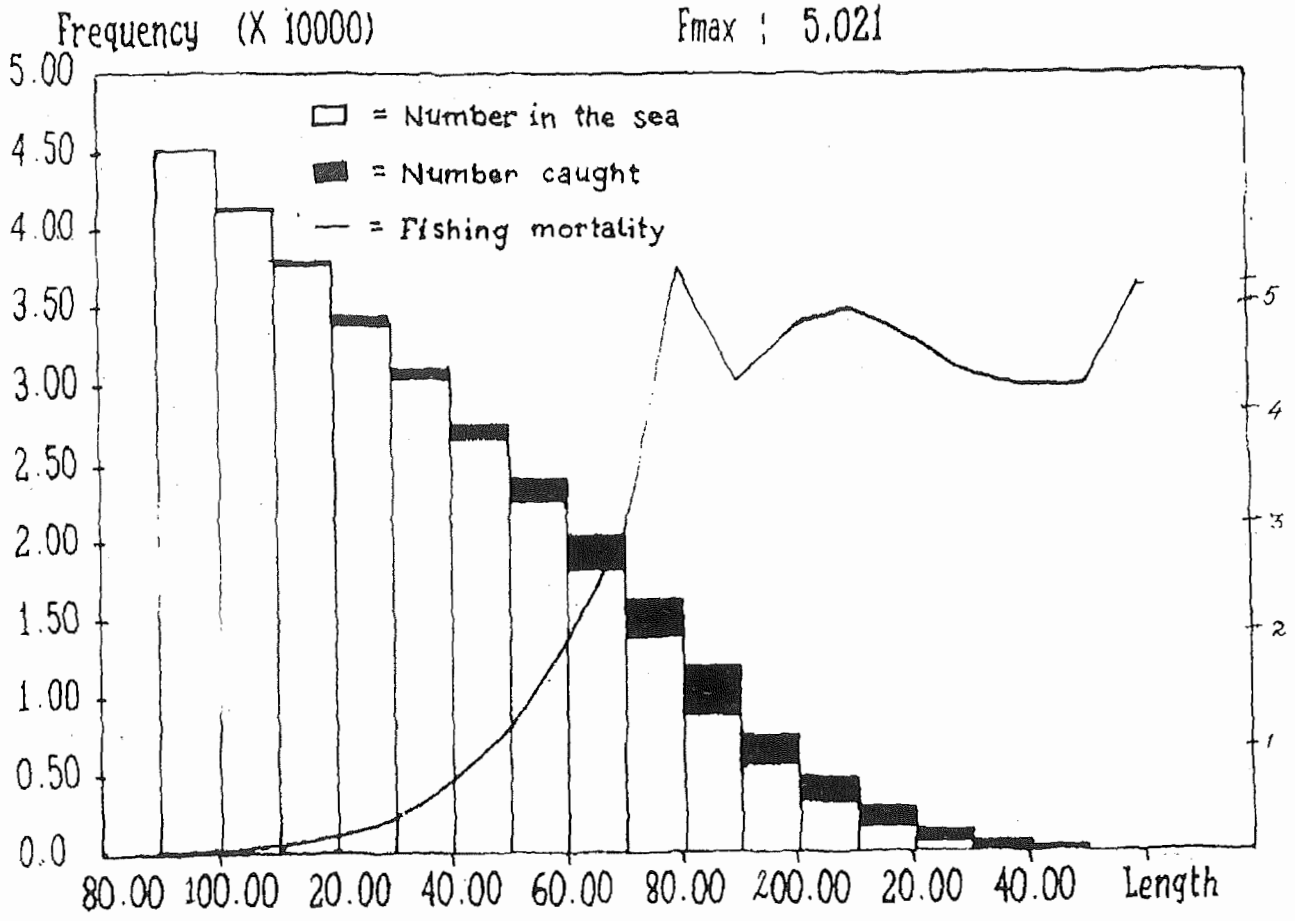

Fig 7 : Length cohort analysis for P. merguiensis (female).

Table 4 : Input parameters used for length cohort analysis and Thompson & Bell model of *P. merguiensis*

Parameters	Male	Female
Asymptotic length (mm)	220.00	281.00
Growth coefficient/year	1.80	1.72
Natural mortality	2.80	2.60
Terminal F/Z	0.70	0.65
Constant 'a' (g cm)	5.0523	5.2132
Constant 'b' (g cm)	3.065	3.0262

Constants 'a' and 'b' are from the length-weight relationship.

The input parameters used for the length cohort analysis and Thompson and Bell analysis are presented in Table 4. At the present level of F the yield is 3,098 t for males and 7,279 t for females (Figure 8 & 9). The MSY was obtained at F of 5.42 in males and 3.02 in females. By doubling the effort the catch may go upto 3,488 t (12.59%) in males and 7,681 t (5.52%) in females. Correspondingly biomass is expected to decline by more than 20% to achieve this and hence, it would not be advisable to increase the effort further since in the long run it may be detrimental to the stock.

Maximum Sustainable Yield (MSY) :

The maximum sustainable yield (MSY) for males and females was estimated to be 3630 t and 7640 t respectively.

DISCUSSION

The industrial fishing concentrates on the areas where highest returns per hour of trawling are obtained. Therefore, as fishing pressure increases fishing intensifies more and more on small sizes and during the recruitment period. In India,

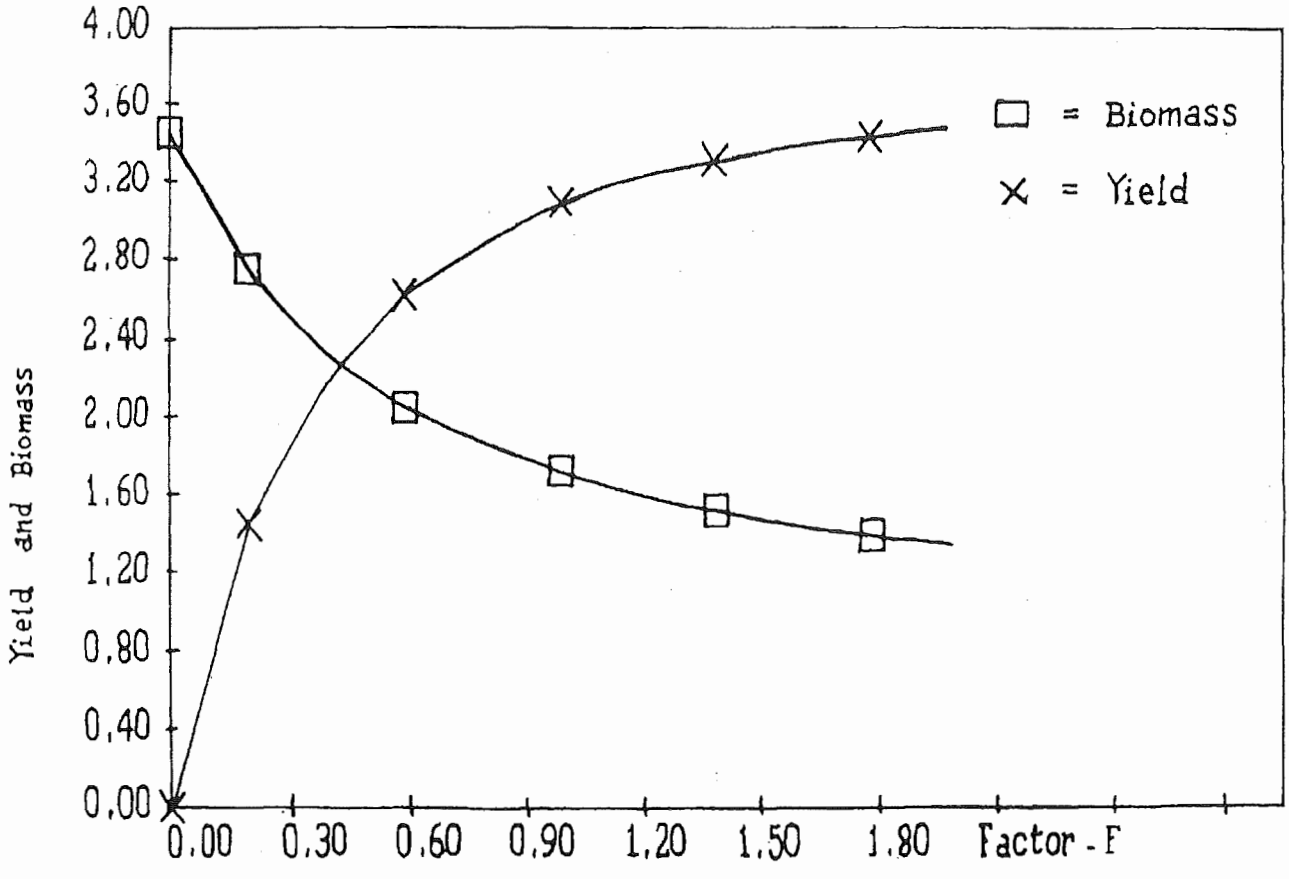

Fig 8 : Estimation of yield and biomass by length based on Thompson & Bell model : P. merguiensis (male).

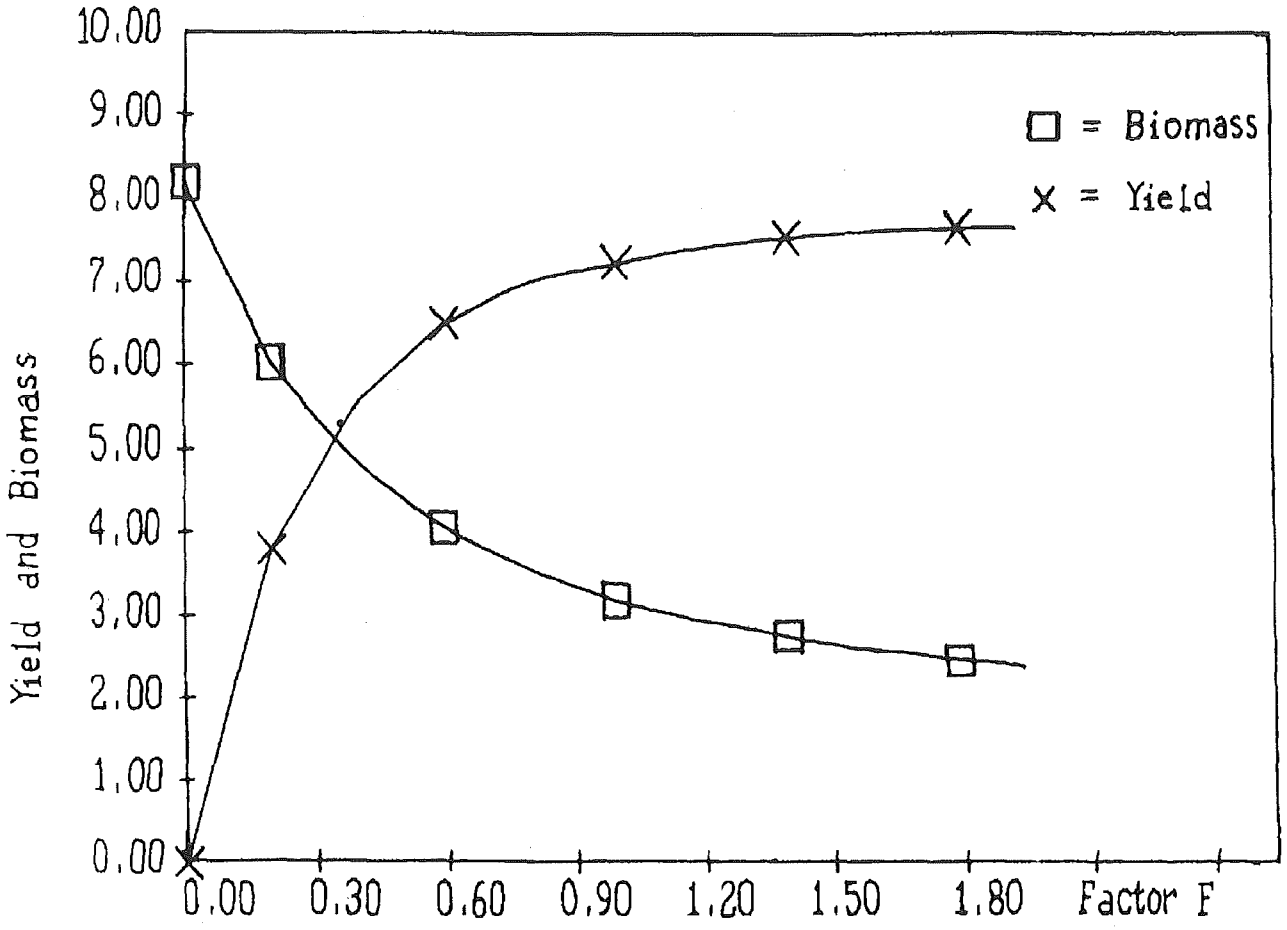

Fig 9 : Estimation of yield and biomass by length based on Thompson & Bell model : P. merguiensis (female).

commercial trawl fishery for prawns registered a considerable expansion in the recent years with the addition of more and more boats, particularly larger trawlers, at selected landing centres and the number of trawlers in Maharashtra has been increased by 18-19% (Chakraborty *et al.*, 1997). Consequently with the increasing fishing activities, particularly during night, the percentage contribution of the species in the all India landings of penaeid prawns over the years has increased from 1,79,143 t to 2,03,401 t during 1995-1997.

P. merguiensis, males attained 130 mm and 190 mm and females 170 mm and 230 mm on completion of 6 and 12 months respectively, thus showing a sex-wise differential growth. This differential growth is much pronounced in case penaeid prawns. The males usually grow less than that of females and $L\infty$ of males is distinctly lower than that of females. Consequently in prawns there is a predominance of females beyond a certain size (Table 5). These data have sometimes been used for other marine species to infer a lower life span for males (Beverton & Holt, 1959 and Holt, 1962).

In the present study, the $L\infty$ value is 220 mm for males and 281 mm for females, while an annual K value of 1.80 for males and 1.72 for females were registered.

Table 5 : Sex ratio of *P. merguiensis* by length groups

Size group	Males		Females		Total	Male : Female
	No.	(%)	No.	(%)		
80-89	00	0.00	49	100.00	49	
90-99	02	4.55	42	95.45	44	1 : 21
100-109	09	33.33	18	66.67	27	1 : 2
110-119	40	44.94	49	55.06	89	1 : 1.23
120-129	121	47.08	136	52.92	257	1 : 1.21
130-139	306	72.68	115	27.32	421	1 : 0.38
140-149	513	65.69	268	34.31	781	1 : 0.52
150-159	566	61.39	356	38.61	922	1 : 0.63
160-169	484	47.36	538	52.64	1022	1 : 1.11
170-179	395	33.93	769	66.07	1164	1 : 1.95
180-189	121	17.56	568	82.44	689	1 : 4.69
190-199	61	8.87	627	91.13	688	1 : 10.27
200-209	09	1.86	476	98.14	485	1 : 52.89
210-219	04	1.02	388	98.98	392	1 : 97
220-229	10	4.81	198	95.19	208	1 : 19.80
230-239			117	100.00	117	
240-249			68	100.00	68	
250-259			38	100.00	38	
260-269			02	100.00	02	
270-279						
280-289			01	100.00	01	
290-299			03	100.00	03	
300-309			05	100.00	05	

The total mortality coefficient estimated for males and females in *P. merguiensis* were 9.79 and 7.44 respectively. This lower value of Z in females may be due to its relatively larger fishable life span.

The average natural mortality rate for penaeids is of the order of 2.4 + 0.3 per year for adult (Garcia, 1985). In the present study, natural mortality was estimated as 2.8 and 2.6 for males and females which is in line with the range suggested by Garcia (1985). Holt (1962) advocated comparative studies between the essential biological parameters (life, growth, mortality and maturation) within groups of species in order to determine those parameters for closely related groups which are comparatively less known.

Fishing mortality in fairly well developed fisheries (where catch and effort have been stable for a long time after an initial period of rapid increase) has been found to be around 1.6 + 0.3 per year (Garcia, 1985). This average value, considered close to the traditional FMSY, refers to fisheries where effort has sufficiently increased to have caused substantial decrease in catch per unit effort (CPUE), but where overall abundance is still high enough to allow for some fishing all year round. For instance, in the Gulf of Carpentaria (Australia) fishing on white banana prawns, *P. merguiensis* has reached such a level that the fishing season lasts only a few weeks. There, fishing mortality has been estimated as 0.9 - 1.4 per month equivalent, if sustained, to 10.8 - 16.8 per year (Lucas *et al.,* 1979). Therefore, values of fishing mortality (F) largely in excess of M are possible in fisheries where total catch has remained constant despite very substantial increase in fishing effort and where fishing is heavily concentrated on recruitment early in the biological year. The present study shows that the F value in *P. merguiensis* is relatively higher for males (5.80) than for females (4.73), suggesting that the males are subjected to slightly more fishing pressure (E=0.68) as compared to females (E=0.65). As the exploitation ratio is more than 0.5 in the case of both the males and females, fishing effort needs to be reduced to obtain MSY and to avoid deleterious effects on the stock.

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