

## Stock assessment of the penaeid prawn *Metapenaeus monoceros* Fabricius along the Indian coast

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### ABSTRACT

The annual average production of *Metapenaeus monoceros* during 1985-89 was 10 286 tonnes, nearly 7.2% of the penaeid prawn landings in the country. The west coast accounted for 71.2% and the east coast for the rest. Among the maritime states, Maharashtra ranked first in production (27.2%) followed by Karnataka (22.3%) and Andhra Pradesh (21.3 %). The estimates of von Bertalanffy growth parameters,  $L_{\infty}$  and K (annual) were 180 mm and 1.8 for males, and 210 mm and 1.8 for females. This prawn attained a size of 149 mm and 173 mm in males and females, respectively, at the end of 1 year. The instantaneous total mortality coefficient (Z) ranged between 4.28 and 8.05 in males, and between 4.17 and 6.33 in females. Natural mortality coefficient (M) was 1.8 in both the sexes. Yield per recruit studies indicated that for an age of 0.59 year at first capture the fishery generated a steadily increasing yield up to 10 000 tonnes for an annual effort of 1 578 000 boat trips (16 670 000 fishing hours) at which the annual fishing mortality (F) is 3.76 and the exploitation ratio (E) is 0.67. Beyond this level of exploitation the increase in yield was only marginal. Even though the average annual yield during 1985-89 was marginally lower than the maximum sustainable yield (MSY) of 10 993 t, the catch during 1987 and 1988 exceeded MSY level. Hence the desirability of maintaining the effort at the present level to obtain sustainable yields is mentioned.

The brown shrimp, *Metapenaeus monoceros*, is a commercially important prawn in the backwaters and estuaries, and up to about 75 m depth in the continental shelf region.

Our knowledge on the resource of *M. monoceros* is limited to the works of George (1959) on bionomics; George *et al.* (1968) and Rao (1987, 1988) on fishery and biology; Mohamed and Rao (1972) on estuarine phase; Rao (1973) on larval

development; Subramaniam (1973) on the fishery and biology from the estuary; George (1974), Kuttiyamma (1974) and Rao (1988) on food and feeding; Rao and Krishnamoorthy (1990) on growth; Nalini (1976) and Rao (1989) on reproductive biology; and George *et al.* (1988), Lalitha Devi (1987) and Rao (in Press) on stock assessment. In addition, George (1970) summed up all the available information on the fishery and biology up to 1970 in the species synopsis.

All these informations were mostly based on the studies conducted either at Cochin or at Kakinaçã. A comprehensive account on the fishery, biology and population dynamics of the resource on an all-India basis is still lacking. The present study was conducted to understand the

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present stock position of the resource besides its population dynamics on an all-India basis.

#### MATERIALS AND METHODS

##### *Data base*

The catch and effort, length distribution and maturity data of *M. monoceros* landed by shrimp trawlers at Bombay, Veraval and Visakhapatnam, and annual prawn landings at Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh by mechanized trawlers during 1985-89 formed the basis of the present study.

##### *Methods*

The state-wise annual catch of *M. monoceros* for 1985-89 was calculated from the estimated total penaeid prawn catch of the state by mechanized trawlers on the basis of its mean percentage contribution at major centres of the respective states. By pooling the catch data for different states the All-India figure was obtained.

The duration of each boat trip (bt) varied from centre to centre considerably and hence the actual fishing hour (fh) was considered as the unit of effort in the present study. The number of units (fishing trips) for various states was supplied by Fishery Resources Assessment Division of CMFRI. Actual fishing hours available for major centres in all states were utilized to estimate the effort in fishing hours in respect of various states.

Total length (from tip of rostrum to tip of telson) was measured and the catch grouped into 5 mm class intervals and raised to the catch in weight of respective days of observation and later to the month. The raised length frequency data for males and females for 1984-88 in respect of each centre were brought down to thousands and pooled month-wise. Estimates of von Bertalanffy

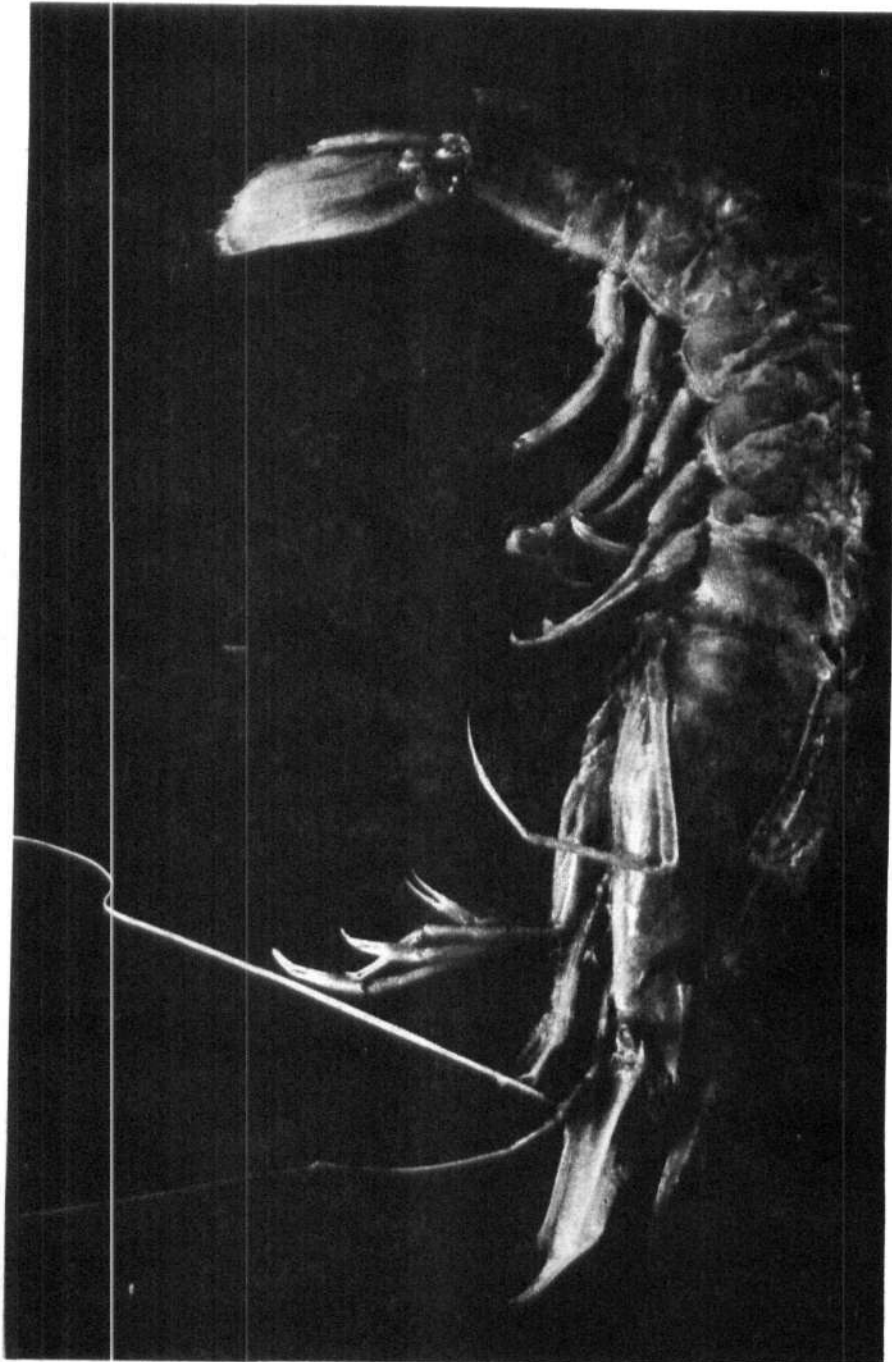
growth parameters ( $L_{\infty}$  and  $K$ ) were derived by applying ELEFAN I programme to length frequency data with the aid of a computer. Instantaneous total mortality coefficient ( $Z$ ) was estimated from the length frequency distribution (converted to weight) using the following Beverton and Holt (1956) formula,

$$Z = K \frac{L - \bar{L}}{\bar{L} - L}$$

where,  $\bar{L}$  is the mean length of length  $L'$  and longer, while  $L'$  is some length for which all prawn of that length and longer are under full exploitation. Natural mortality ( $M$ ) was calculated (Sekharan 1974) and fishing mortality ( $F$ ) was found out from the relation,  $Z = M + F$ . Weight infinity ( $W_{\infty}$ ) corresponding to length infinity ( $L_{\infty}$ ) was calculated from the length-weight relationship (Rao 1988) in this species from Kakinada. The yield per recruit ( $Y/R$ ) and maximum sustainable yield per recruit ( $MSY/R$ ), standing stock ( $Y/F$ ), annual average stock ( $Y/U$ ), and maximum sustainable yield ( $MSY$ ) were computed for Visakhapatnam, Bombay and Veraval using Beverton and Holt (1957) yield per recruit model. From these values, the standing stock, annual average stock and  $MSY$  for respective states were computed (for Karnataka and Kerala the Bombay values were used and for Tamil Nadu, Visakhapatnam values were used) from which all India figures were obtained.

##### *Craft and gear and fishing season*

Apart from the traditional fishery in the backwaters, estuaries and inshore areas for juvenile prawns, this resource is exploited by plank-built boats of small and medium sizes (9-17 m) fitted with diesel engines of varying HP. These boats operate shrimp trawls of varying dimensions, up to 70-75 m



*Metapenaeus monoceros* Fabricius

depth along the west and the east coast of India. A good number of large steel vessels (OAL up to 24 m with 380 HP engine) fitted with modern fishing aids are in operation at certain centres and during night operate for shrimp. Small trawlers make 2-5 days cruise, while the larger boats stay at sea for 18-23 days.

The dimensions of the boats and trawl net including the mesh size at cod end vary from centre to centre.

The fishing season extends from November to May along the west coast, and throughout the year along the east coast.

#### *All-India production*

The average annual production of *M. monoceros* for 1985-89 was 10 286 tonnes forming 7.2% of the total average production of penaeids in the country. After realizing a moderate catch of 7 729 t in 1985, the annual production increased over the years, reaching an all-time high of 12 377 t in 1988 and subsequently decreased to 10 913 tonnes in 1980 (Table 1).

#### *Production along the west and east coasts*

Even though the species is caught all along the Indian coast, bulk of the catch was obtained from the west coast (71.2%). The east coast contributed only to 28.8%. About 38.2% of the west coast catch was realized from Maharashtra, followed by Karnataka (31.2%), Kerala (11.3%) and Gujarat (11.2%). Nearly 74.1% of *M. monoceros* catch obtained from the east coast was landed in Andhra Pradesh. Tamil Nadu contributed only 25.9%.

#### *Production in different states*

The average annual catch of *M. monoceros*, fishing hours and fishing trips in the different states are given in Table 1. The annual production contributed up to

27.2, 6.2, 3.9 and 9.1 of the total penaeid prawns in Andhra Pradesh, Tamil Nadu, Kerala and Maharashtra respectively.

#### *Seasonal fluctuations*

The peak season of the fishery was in first quarter (January-March), followed by fourth quarter (October-December) in Andhra Pradesh; fourth quarter followed by third quarter (July-September) in Tamil Nadu; second quarter (April-June) and fourth quarter in Kerala; first quarter followed by fourth quarter in Karnataka; third quarter followed by fourth quarter in Maharashtra; and fourth quarter followed by first quarter in Gujarat.

#### *Biology*

Although *M. monoceros* inhabits the marine environment during its adult phase, the juveniles are found in the estuaries, backwaters and the upper reaches of the estuaries where salinity is considerably low. It is distributed all along the west and the east coasts of India up to 100 m depth. The species is heterosexual and females grow to larger size.

#### *Growth*

The species grows @ 7.63-10 mm/month in the estuary and attains a size of 106-110 mm at the end of 1 year (George 1959). Rate of growth varies from 6.25 to 10.25 (average of 7.98 mm/month) in the rearing experiments conducted in the laboratory. The species moults 32 times during its growth from 3 mm to 100 mm. This species does not breed in the backwaters and migrates to the sea on attaining a size of 100 mm (George 1959). Generally the species measuring more than 120 mm are not available in the backwaters. On the basis of these informations, George (1959) concluded that the fishery in the backwaters

Table 1. Catch (t), effort and catch rate (kg) of *M. monoceros* in different states during 1985-89

	Years					Average
	1985	1986	1987	1988	1989	
<b>Andhra Pradesh</b>						
Catch	2 188	2 668	2 555	1 729	1 809	2 190
Effort (bt)	105 234	116 418	98 214	103 286	88 576	102 346
(fh)	1 052 000	1 478 000	1 198 000	1 363 000	1 169 000	1 252 000
Catch/hr	2.08	1.80	2.13	1.27	1.55	1.75
<b>Tamil Nadu</b>						
Catch	528	788	833	841	835	765
Effort (bt)	284 616	411 797	453 458	443 618	426 982	424 094
(fh)	2 047 000	3 037 000	3 344 000	3 271 000	3 680 000	3 076 000
Catch/hr	0.26	0.26	0.25	0.26	0.23	0.25
<b>Kerala</b>						
Catch	281	527	1944	2533	1806	1418
Effort (bt)	370 176	402 563	586 515	863 274	229 556	490 417
(fh)	1592 000	1691 000	3 050 000	4 057 000	1 080 000	2 294 000
Catch/hr	0.18	0.31	0.64	0.62	1.67	0.62
<b>Karnataka</b>						
Catch	998	635	2858	4154	2842	2291
Effort (bt)	138 875	174 499	300 149	222 208	214 021	209 950
(fh)	1 042 000	1 221 000	2 821 000	2 444 000	2 354 000	1 997 000
Catch/hr	0.96	0.56	1.01	1.70	1.21	1.16
<b>Maharashtra</b>						
Catch	3 070	2 768	3 061	3 261	2 832	2 798
Effort (bt)	176 635	206 539	244 594	229 911	171 690	205 874
(fh)	5 652 000	5 969 000	8 316 000	7 495 000	5 597 000	6 588 000
Catch/hr	0.54	0.46	0.37	0.30	0.51	0.42
<b>Gujarat</b>						
Catch	664	753	1057	859	789	824
Effort (bt)	90128	87 549	96 895	319 392	137 560	146 305
(fh)	1 030 000	1 007 000	1 114 000	3 673 000	1 582 000	1 682 000
Catch/hr	0.64	0.74	0.95	0.23	0.50	0.49
<b>All India Catch</b>						
Effort (bt)	7 729	8 139	12 308	12 377	10 913	10 286
(fh)	12 65 664	13 99 365	1 779 825	2 181 689	1 268 385	1 577 986
Catch/hr	0.62	0.56	0.62	0.55	0.71	0.62

is supported by 0-year class. Subramaniam (1973) recorded a growth of 5-15 mm/month in the Godavary estuary with an average of 13 mm/month between 4 mm and 101 mm lengths in the species. Rao and Krishnamoorthy (1990) found that the species grows to 95 mm and 105 mm at the end of 6 months, 142 mm and 162 mm at the end of 12 months, and 163 mm and 187 mm at the end of 18 months (Table 2).

Studying the length-weight relationship

in *M. monoceros* exploited from Cochin, George (1959) computed the following relationship.

$$W = 0.01989 L^{2.7603}$$

Recently, Rao (1988) estimated the relationship between length and weight for males and females of the population caught off Kakinada separately as given below.

Males :  $\log W = -5.0895 + 2.9521 \log L$   
 Females :  $\log W = -5.4649 + 3.1509 \log L$

Table 2. Growth in *M. monoceros* obtained by various authors at different ages from various localities.

Author's	Year	Sex	6 months	12 months	18 months	2 years	3 years	Area
George	1959			106-110		131-135	156-160	Cochin
Rao and Krishnamoorthy	1990	Male	95	142	163			Kakinada
		Female	105	162	187			
Present study		Male	105	149				All
		Female	120	173				India

#### Food and feeding

George (1974) observed that the food of juveniles largely consisted of small crustaceans. He further observed that 50% of the gut content in small prawns (below 50 mm) obtained from backwaters of Cochin consisted of unrecognizable material inclusive of mud and detritus. Subramanian (1973) recorded small crustaceans, algae, foraminiferans, small molluscan shells and organic detritus in the estuarine population of River Godavary, while those inhabiting in marine regions in that area subsisted mainly on small crustaceans. Kuttyamma (1974) found that the species showed a preference to vegetable matter, mainly seaweed and algae, during greater part of the year. The food also included diatoms, crustaceans and detritus. The food of *M. monoceros* in the inshore waters mainly comprised other crustaceans (30 %), polychaetes (19.1%), prawns (17.5 %) and detritus (10.6 %). The backwater samples comprised detritus (36.8%), other crustaceans (15.5 %) and algae (11.6 %) in the Kakinada area (Rao 1988).

**Sex ratio:** George (1959) found slightly higher percentage of females in *M. monoceros* in the Cochin area. According to Subramanian (1973), in the backwaters and inshore waters, females were more, while in the offshore waters males outnumbered females in this species in the Kakinada coast. He also observed that the overall sex ratio is almost equal in all these

environments. Rao (1989) observed that the sex ratio deviated from binomial distribution due to sex-wise distribution.

**Size at first maturity:** According to Rao (1989) the size at first maturity in this prawn was 96 mm in males and 115-116 mm in females in the Kakinada area. Nalini (1976) observed that the minimum size at maturity in this species by least-square method was at 118 mm. George (1970) recorded that the prawn matures when it attains a size of 120 mm. The size at first maturity at 50 % level was 135.5 mm in this species in the Karwar area (George *et al.* 1988).

**Spawning:** Rao (1989) recognized 5 maturity stages depending on size and colour of the ovaries, and size of ova in this species as in other prawns from Kakinada area.

George (1959, 1962) opined that breeding takes place more or less throughout the year with two peaks, first in July-August and second in November-December in the Cochin area. From the same area Nalini (1976) reported that the species breeds throughout the year with peaks during October-April. However, the secondary peak recorded by George (1962) was not observed by Nalini (1976). Srivastava (1953) indicated that the spawning season extended from February to April in the Gulf of Kutch. In Taiwan waters, the species breeds actively from August to October (Liao *et al.*, 1969).

The present study indicated that the species breeds throughout the year with

peaks during January-March at Veraval, March-June, August and February at Bombay, and during January-April at Visakhapatnam.

Rao (1989) opined that most females of 113-178 mm length form the spawning population. Nalini (1976) recorded mature prawns in all size groups above 116-120 mm, but majority fell between 131 and 165 mm.

Rao (1989) also found that the individual prawns attain ripe stage at least 5 times in their life time.

George and George (1964) located a spawning ground of the species at 50-60 m depth off Cochin.

**Fecundity:** The number of eggs produced by females 146-175 mm long varies between 155 000 and 338 000 in the Cochin area. The number of eggs increases with the size of the prawn (Nalini 1976). The relationship between the length of the prawn and fecundity is,

$$\log W = -4.21938 + 4.3509 \log L$$

Rao (1989) observed that the fecundity ranged between 53 684 ova (113 mm) and 416 273 ova (181mm) in *M. monoceros* in the Kakinada area.

#### Growth parameters

For the present study a single value

each for  $L_{\infty}$  and  $K$  in respect of males and females were taken after carefully studying the monthly sequence of lengths obtained through the application of ELEFAN I programme to the length frequency data as well as checking up with earlier studies. The  $L_{\infty}$  and  $K$  (annual) values obtained from the present study are 180 mm and 1.8 for males and 210 mm and 1.8 for females. The growth parameters of VBGF by earlier workers are given in Table 3 along with the present values.

By employing the present values of  $L_{\infty}$  and  $K$  in VBGF, the mean age at different lengths was determined for males and females, and a growth curve drawn (Fig.1). It is seen that males and females attain, respectively, 105 mm and 120 mm at the end of 6 months and 149 mm and 173 mm at the end of 1 year.

#### Mortality

The instantaneous total mortality coefficient ( $Z$ ) for males and females obtained from the present study are given in Table 4 along with the results obtained by earlier workers for this species.

#### Natural mortality coefficient ( $M$ )

It is reasonable to assume that the life span of the prawn is around  $2\frac{1}{2}$  years. Assuming that the mortality is at least 99%

Table 3. Estimates of  $L_{\infty}$  and  $K$  annual,  $t_0$ , and  $W_{\infty}$  obtained by various authors from different localities

Author(s)	Year	Sex	$L_{\infty}$	$K$	$t_0$	$W_{\infty}$	Area
George <i>et al.</i>	1988	Male	190 mm	0.47*			Karwar
		Female	225	0.45*			
Rao and Krishnamoorthy	1990	Male	178.4	1.68	0.048		Kakinada
		Female	207.3	1.62	0.666		
Lalithadevi	1987	Male	208.4	0.972	-0.063		Kakinada
		Female	216.2	0.996	-0.044		
Present study		Male	180	1.8		37.0g	All India
		Female	210	1.8		71.1g	

\* Quarterly

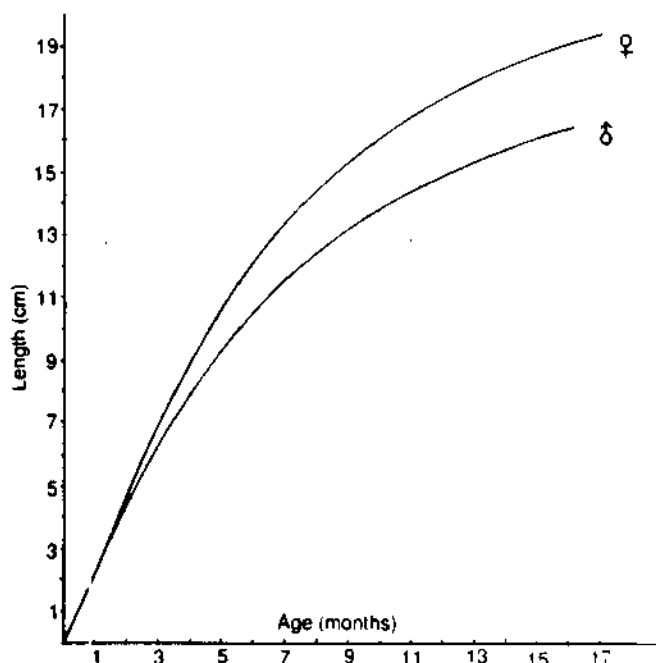


Fig.1. Growth curve of *M. monoceros* determined by von Bertalanffy growth formula.;

Table 4. Estimates of Z, M, F, E and C by various authors from different localities

Author(s)	Year	Sex	Z	M	F	E	C*	Area
George <i>et al.</i>	1988	Male	3.16	0.47	2.69	0.85	0.40	Karwar
		Female	1.06	0.45	0.61	0.60	0.56	
Lalithadevi	1988	Male	7.98	1.81	6.17	0.66	0.45	Kakinada
		Female	5.49	1.84	3.65	0.77	0.42	
Rao M S		Male	4.36	2.42	1.94	0.60		Kakinada
		Female	3.66	2.32	1.44	0.55		
Present study		Male	8.05	1.8	6.25	0.7764	0.71	Visakhapatnam
		Female	6.33	1.8	4.53	0.7156	0.70	
		Male	4.28	1.8	2.48	0.5794	0.74	Veraval
		Female	4.17	1.8	2.37	0.5683	0.70	
		Male	5.85	1.8	4.05	0.6925	0.65	Bombay
		Female	4.68	1.8	2.88	0.6154	0.61	

\* C =  $10/L_{\infty}$

Z, M, F, Values are given in annual basis.

by the time this age is reached in the unexploited state, a M value of 1.8 is obtained.

*Yield per recruit (Y/R)*

The yield per recruit in weight (Yw/R) was calculated for the observed age at



capture ( $t_c$ ) for males and females for  $M = 1.8$  as a function of exploitation ratio ( $E$ ) in respect of Veraval, Bombay and Visakhapatnam centres (Table 5).

in weight ( $Yw/R$ ) at  $M/K = 1$  and  $t_c = 0.68$  year ( length at capture,  $t_c = 127.5$  mm) was 5.80 g at  $F_{max} = 21.77$  for *M. monoceros* males (Fig. 2). For the present  $F$  of 6.25 ( $E = 0.78$ ) the  $Yw/R$  was 5.608. Maximum

At Visakhapatnam, the yield per recruit

Table 5. Annual average yield average standing stock, average annual stock, MSY/R, Y/R, recruits and MSY of *Metapenaeus monoceros* for Visakhapatnam, Veraval and Bombay

Centre	Sex	Annual average yield (t)	Standing stock Y/F (t)	Annual average stock Y/U	MSY/R (g)	Present Y/R (g)	Re* (10 <sup>6</sup> )	MSY (in t)
Visakhapatnam	Male	108.6	17.4	139.9	5.806	5.608	19.365	112.4
	Female	163.0	36.0	227.8	10.394	9.739	16.737	174.0
Veraval	Male	94.3	38.0	165.0	7.387	5.817	16.2111	119.8
	Female	141.5	59.7	252.9	11.993	9.770	14.483	173.7
Bombay	Male	421.0	104.0	609.9	5.875	5.645	74.579	438.2
	Female	631.8	219.4	1036.2	10.072	9.492	66.561	670.4

\* Recruits in number.

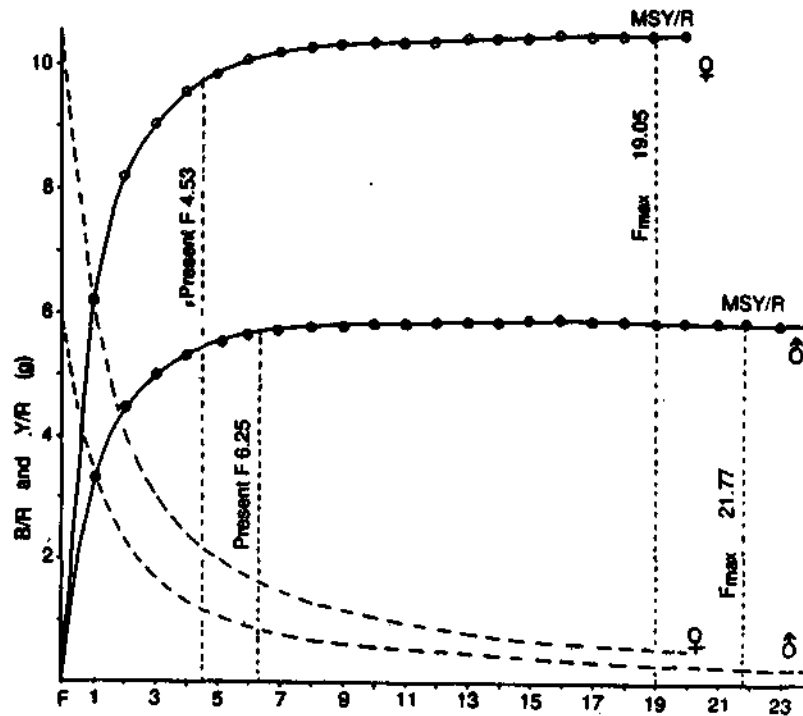


Fig.2. Yield per recruit and biomass per recruit at different levels of  $F$  in *M. monoceros* at Visakhapatnam.

sustainable yield (MSY) was estimated at 112.4 t. At the same centre, the Yw/R at M/K = 1 and  $t_c = 0.67$  year ( $l_c = 147.5$  mm) was 9 739 g for the present F of 4.53 (E = 0.72). For the  $F_{max}$  of 19.056 the Yw/R was 10.39 g and the MSY was estimated at 174.0 t.

At Bombay, the Yw/R for the present F of 4.05 (E=0.69) was 5.645 g for *M. monoceros* males, at M/K = 1 and  $t_c = 0.59$  year ( $l_c = 117.5$  mm). At the same centre

for females, the Yw/R at M/K = 1 and  $t_c = 0.52$  ( $l_c = 127.5$  mm) at the present F of 2.88 (E=0.62) was 9.492 g. The Yw/R at the respective M/K and  $t_c$  values at  $F_{max}$  9.326 and  $F_{max}$  6.31 were 5.875 g and 10.072 g for males and females respectively. The MSY was estimated at 438.2 t for males and 670.1 t for females (Fig. 3).

At Veraval, for males, the Yw/R at M/K = 1 and  $t_c = 0.74$  year ( $l_c = 132.5$  mm) was 5.817 g at the present F of 2.48

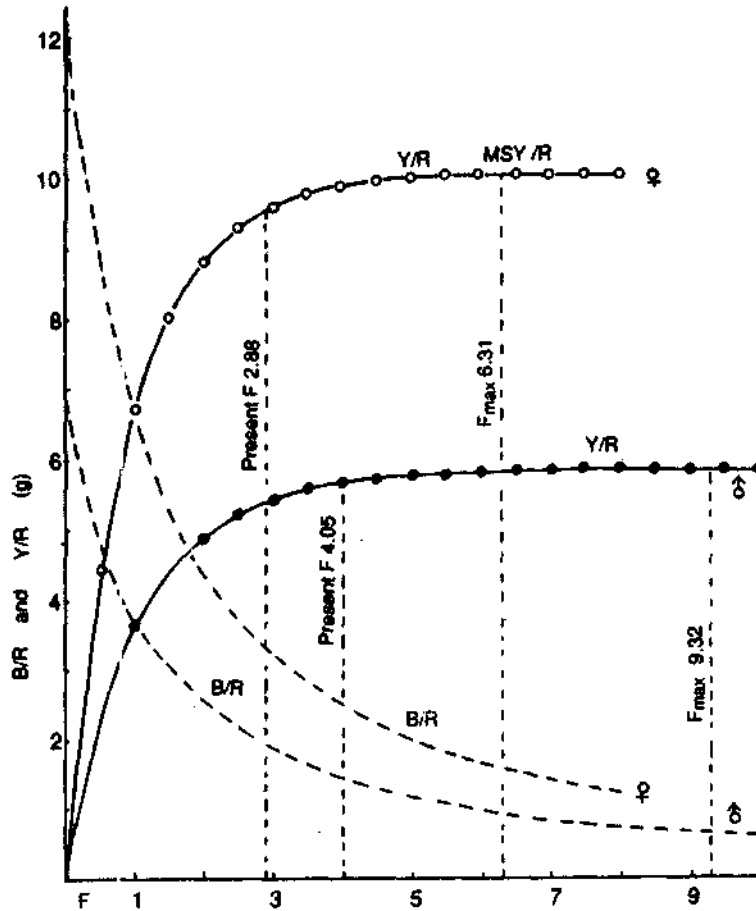


Fig.3. Yield per recruit and biomass per recruit at different levels of F in *M. monoceros* at Bombay.

( $E=0.58$ ). At  $F_{max}$  65.06 ( $E=0.97$ ) the  $Yw/R$  was 7.387 g. The MSY was estimated at 119.8 t. For females, the  $Yw/R$  at  $M/K = 1$  and  $t_c = 0.67$  ( $l_c = 147.5$  mm) at the prevailing  $F$  of 2.37 ( $E=0.57$ ) was 9.77 g and at  $F_{max}$  of 19.056 was 11.99g. The MSY was estimated at 173.7 t (Fig. 4).

To examine the impact of changing the size at first capture on the yield of the resource under study,  $Yw/R$  was calculated for different values of  $t_c$  keeping  $M/K$  and  $E$  at the present level for various centres (Table 6). The MSY level can be obtained at the present  $C = 0.71$  ( $l_c = 127.5$  mm or  $t_c = 0.68$  year) itself at the current rate of fishing pressure ( $E=0.78$  or  $F = 6.25$ ) for

*M.monoceros* males at Visakhapatnam. At the same centre for females for this species, MSY level can be increased by 1.08 times by reducing the mesh size by 0.93 time so as to have  $C=0.65$  ( $l_c = 137.5$  mm or  $t_c = 0.59$  year) instead of the present  $C = 0.7$  ( $l_c = 147.5$  mm or  $t_c = 0.67$  year) at the prevailing rate of fishing intensity ( $E=0.72$  or  $F = 4.53$ ).

At Veraval, at the present fishing intensity ( $E = 0.58$  or  $F=2.48$ ) the level of MSY can be increased by 1.08 times for *M. monoceros* males by reducing the mesh size by 0.89 time so as to have  $C = 0.65$  ( $l_c = 117.5$  mm or  $t_c=0.59$  year) instead of the present  $C = 0.74$  ( $l_c = 132.5$  mm or

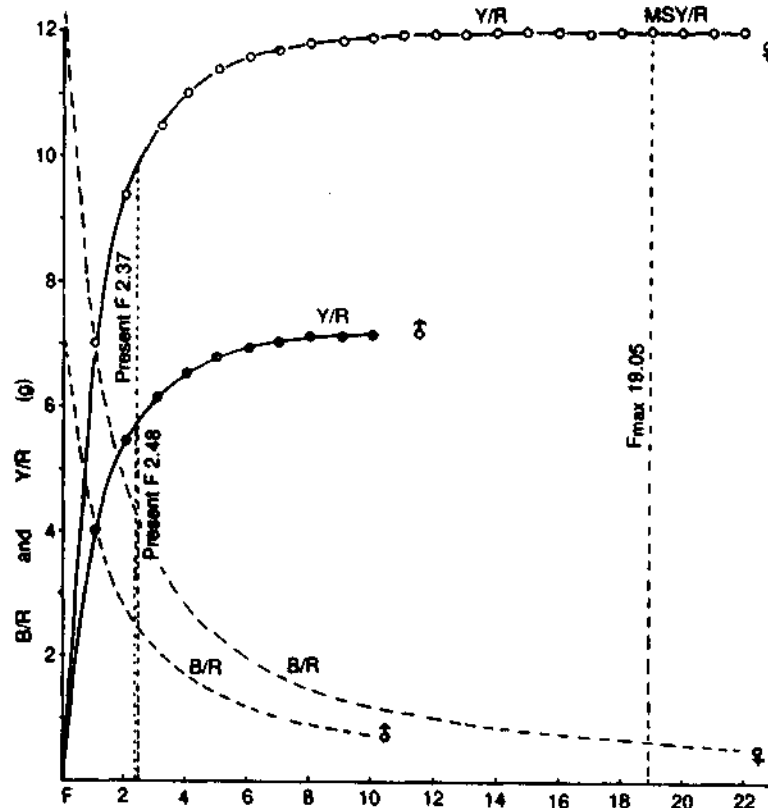


Fig.4. Yield per recruit and biomass per recruit at different levels of  $F$  in *M. monoceros* at Veraval.

Table 6. Yield per recruit in *M. monoceros* males and females at varying age at capture ( $t_c$ ) at the present level of fishing intensity at Veraval, Bombay and Visakhapatnam

Centre	Male				Female			
	Present F	Age at capture ( $t_c$ )/ $l_c$			Present F	Age at capture ( $t_c$ ) / $l_c$		
		0.74 (132.5 mm)	0.59 (117.5 mm)	0.68 (127.5 mm)		0.67 (147.5 mm)	0.52 (127.5 mm)	0.59 (137.5 mm)
Veraval	2.48 (E=0.58)	1.82*	6.26	6.07	2.37 (E=0.57)	9.77*	10.23	10.16
Bombay	4.05 (E=0.57)	5.45	5.65*	5.58	2.88 (E=0.62)	9.31	9.49*	9.52
Visakhapatnam	6.25 (E=0.78)	5.52	5.59	5.61*	4.53 (E=0.72)	9.74*	9.67	9.82

Yield per recruit at the present  $t_c$  is indicated by asterisk  
Maximum Y/R values in respect of each centre is underlined.

$t_c=0.74$  year). In females MSY level can be increased by 1.05 times by reducing the mesh size by 0.85 times so as to have  $C=0.61$  ( $l_c=127.5$  mm or  $t_c=0.52$ ) instead of the prevailing  $C=0.7$  ( $l_c=147.5$  mm or  $t_c=0.67$  year) at the current fishing pressure ( $E=0.57$  or  $F=2.37$ ).

At Bombay, for *M. monoceros* males, at the present F of 4.05 ( $E=0.69$ ) MSY levels could be obtained at the prevailing  $C=0.65$  ( $l_c=117.5$  mm or  $t_c=0.59$  year) itself. For females MSY levels could be marginally increased by increasing the mesh size by 1.08 times so as to have  $C=0.65$  ( $l_c=137.5$  mm or  $t_c=0.59$  year) instead of the present  $C=0.61$  ( $l_c=127.5$  mm or  $t_c=0.52$  year) at the current fishing intensity ( $E=0.62$  or  $F=2.88$ ). From this, it is seen that marginal reduction of mesh size is advantageous to males and females of *M. monoceros* at Veraval, and only for females at Visakhapatnam.

#### Stock assessment

The average annual yield, average standing stock (Y/F), average annual stock (Y/U) and the maximum sustainable yield (MSY) estimated for males and females for

various states are given in Table 7. Average standing stock and average annual stock values were relatively higher in females than in males in all states. Maximum sustainable yield (MSY) for *M. monoceros* for the whole country and the states was estimated (Table 7).

#### DISCUSSION

Commercial trawl fishery for prawns registered considerable expansion in recent years with the addition of more and more boats, particularly larger trawlers, at selected centres. Consequently, this species is exploited both from the inshore waters and offshore regions extending up to 100 m depth in the continental shelf. Earlier when day fishing was predominant, the contribution of the species was relatively low. With increasing fishing activities, particularly during night, the percentage contribution of the species increased and often it formed up to 92 % of the prawn catch landed by medium trawlers operating beyond 30 m depth off Mangalore (Rao *et al.* in press). Due to this, there has been steady increase in the landing of this species up to 1988.

Table 7. Annual average yield, average standing stock, average annual stock and MSY of *M. monoceros* estimated for different maritime states

States		Average annual yield (t)	Average standing stock (Y/F) (t)	Average annual stock (Y/U) (t)	MSY (t)
Andhra Pradesh	Male	876	140	1 128	907
	Female	1 314	290	1 836	1 402
Tamil Nadu	Male	304	49	392	315
	Female	459	101	641	490
Gujarat	Male	330	133	558	419
	Female	494	208	883	607
Maharashtra	Male	1 119	276	1 622	1 165
	Female	1 679	584	2 755	1 782
Karnataka	Male	916	226	1 327	953
	Female	1 375	478	2 255	1 459
Kerala	Male	567	140	821	590
	Female	851	202	1 396	904
All India	Male	4 114	964	5848	4 349
	Female	6 172	1 863	9 766	6 644
Combined		10286	2827	15 614	10 993

Even though there has been appreciable increase in the all-India landings of this prawn over the years (from 7 729 t in 1985 to 12 377 t in 1988), the catch rate showed a marginal fall from 0.62 kg/hr in 1985 to 0.55 kg/hr in 1988 with increased effort, suggesting an overall exploitation stress on the stock. This was more predominant in Andhra Pradesh where the catch and catch rate decreased although there was increase in fishing effort (Table 1). In Tamil Nadu, even though there was marginal increase in catch in 1989 with additional effort, the catch rate remained more or less at the same level. In Kerala and Karnataka, on the other hand, the catch and catch rate both showed increase with the additional effort (Table 1). In Maharashtra, even though the catch showed an increasing trend with the addition of effort, the catch rate decreased during 1985-1988. In Gujarat also, the catch and catch rate registered

improvement up to 1987 and thereafter declined.

While studying the growth of *M. monoceros*, Rao and Krishnamoorthy (1990) found that males and females of the species attain a length of 95 and 105 mm, 142 and 162 mm, and 163 and 187 mm on completion of 6, 12 and 18 months, respectively, thereby registering a sex-wise difference in growth of the order of 10 mm at 6 months, 20 mm at 12 months, and 24 mm at 18 months in males and females. Similarly, in the present study, males and females of this prawn attained 105 and 120 mm, and 149 and 173 mm on completion of 6 and 12 months, respectively, thus showing a growth difference of 15 mm at 6 months and 24 mm at 12 months of age. Kurup and Rao (1974) and Ramamurthy *et al.* (1978) observed that the difference in growth in males and females of *Metapenaeus dobsoni* was 10 mm at 12

months of age although a difference of 15-16 mm was recorded at the same age earlier. Relatively wider difference was observed in the growth rate between males and females of *M. monoceros* as compared to the coexisting species such as *M. dobsoni*, *Parapenaeopsis stylifera*, *Metapenaeus affinis* and *Penaeus indicus*.

Average Z values for males and females in *M. monoceros* were 6.1 and 5.1 whereas in the allied species, *M. dobsoni*, these values were as high as 20.6 and 18.9 respectively. The higher Z values in *M. dobsoni* may be attributed to its shorter fishable life span and heavy fishing pressure ( $E=0.89$  for males and  $E=0.88$  for females) to which the resource is subjected to by various types of gears operating in the coastal waters, whereas the lower values of Z in *M. monoceros* may be due to its relatively longer fishable life span as well as lesser fishing pressure since it is a relatively deep water species.

This study also showed that the average F value in *M. monoceros* is relatively higher for males (4.26) than for females (3.26), suggesting that males are subjected to more fishing pressure ( $E=0.7$ ) as compared to females ( $E=0.64$ ) even though both sexes are exploited from the same ground together. This may possibly be due to the migratory behaviour of females out of the present fishing ground for spawning thereby exposed to lesser fishing mortality than males.

The  $L_{\infty}$  values ranged between 178.4 and 190 mm in males and 207.3 and 225 mm in females (Table 3). The present values were 180 mm in males and 210 mm in females, and are in conformity with the values obtained by Rao and Krishnamoorthy (1990) in this species from Kakinada. Lalithadevi (1987) computed a K value of 0.972 for males and 0.996 for females, from the

same area. Rao and Krishnamoorthy (1990) estimated a K value of 1.68 for males and 1.62 for females, while in the present study a K value of 1.8 was computed for both sexes.

Even though the present catch is below MSY level, further addition of effort may generate only marginal increase in catch. To obtain MSY level, the present yield has to be increased by around 7% for which the effort has to be increased by over 100%. This may not be remunerative to the industry (Figs 2-4). Hence it is desirable to maintain the fishing effort and mesh size at the present level in all states except in Gujarat, Tamil Nadu and Andhra Pradesh where the mesh size can be reduced to 25 mm without any increase in fishing effort for obtaining optimum yields from the present fishing grounds.

#### ACKNOWLEDGEMENTS

We thank Dr P S B R James, Director, for encouragement and Dr P Vedvayasa Rao, Principal Scientist of this Institute for his valuable suggestions.

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