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Stock assessment of the penaeid prawn *Metapenaeus dobsoni* (Miers) along the Indian coast

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ABSTRACT

The annual production of *M. dobsoni* showed an increasing trend with an annual average of 22 370 t during 1985-89. It formed 15.7% of the penaeid prawn landings in the country. West coast contributed 69.9% to the annual yield of this prawn. Kerala ranked first (51.4%) in *M. dobsoni* production followed by Tamil Nadu. Shrimp trawl alone caught 54% of the landings. $L\infty$ and K were 139 mm and 2.4 for males, and 145 mm and 2.76 for females respectively. The instantaneous mortality coefficient (Z) ranged between 16.47 and 25.29 in males, and between 16.21 and 20.97 in females. The natural mortality coefficient (M) was 2.3 for both the sexes. The yield per recruit (Yw/R) increased steadily to maximum values (MSY/R) in both the sexes at Emax ranging between 0.2 and 0.4. It marginally reduced at the present E between 0.8 and 0.9 suggesting that the resource is overexploited and the current effort is far higher than the effort required to harvest optimum yields. Although the average annual catch by shrimp trawls (12 189 t) is lower than MSY (13 965 t), the annual effort of 6 920 tpd or 1 488 000 bd (F= 17.8 and E = 0.89) is far beyond f_{msy}. Considering the fact that this prawn is also exploited by other gears with an annual average of 10 180 t during 1985-89, a conservative estimate of 25 000 t as potential stock for the whole country is made.

The commercial exploitation of penaeid prawns is ever on the increase due to the great demand in the external and internal markets. Among the penaeids, the flower-tail shrimp (*Metapenaeus dobsoni* (Miers)), an important species under the genus *Metapenaeus*, is caught from south of Goa on the west coast through southeast coast to south of Visakhapatnam on the east coast. This species is intensively exploited both by mechanized and non-mechanized sectors from the coastal inshore waters, besides being fished by traditional gears operating in the backwaters and estuaries.

Our present knowledge on *M.dobsoni* is limited to the works of Menon (1951, 1955, 1957) on bionomics; Banerji and George (1965) on growth; George (1964) and Rao (1970) on breeding; George and Rao (1965) on sex distribution; Kurup and Rao (1974) on population characteristics; George *et al.* (1963), Ramamurthy *et al.* (1978) and Ramamurthy and Sukumaran (1984) on fishery and biology; Alagaraja *et al.* (1986), George *et al.* (1988), Silas *et al.* (1984) and Paralkar Smitha and Devaraj (1990) on stock assessment. George (1970) summed up the biological and fishery importance of the species. Later the fishery and biology of the species was also studied

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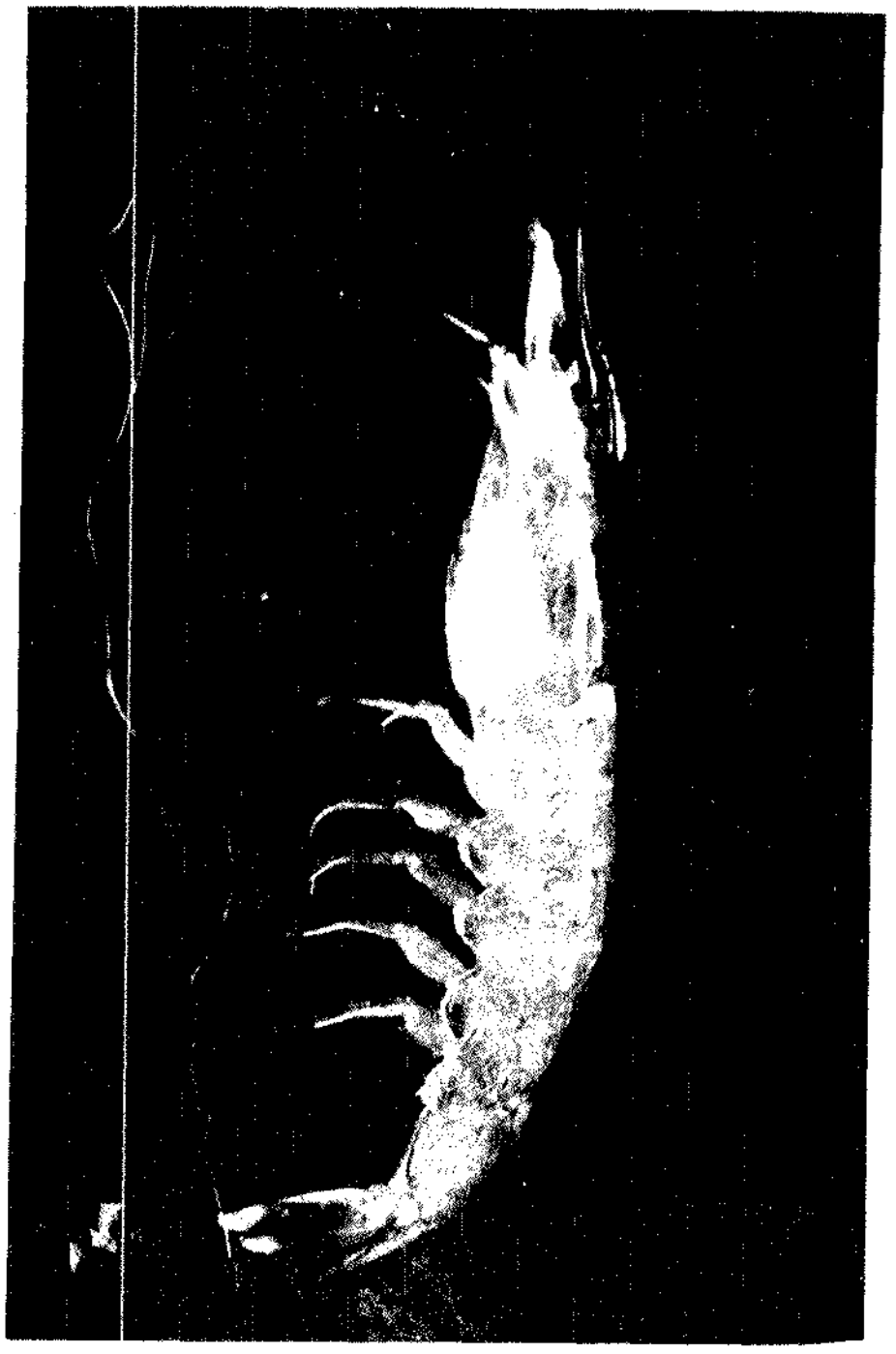

Metapenaeus [illegible] (Miers)

in the All-India Co-ordinated Research Project on Marine Prawn Biology and Resources (CMFRI 1975). Kurien and Sebastian (1975) brought out a review of prawn fishery of the country.

Interestingly all these studies pertain to the species distributed in the west coast of India. In the present paper an attempt is made for the first time to study the resource on an all-India basis based on the investigations carried out at various Research Centres of the Central Marine Fisheries Research Institute during 1985-89. This would help in understanding the population dynamics together with the evaluation of the present state of the stock and the potential besides suggesting measures for its rational exploitation.

Data base

The catch and effort along with the length frequency and maturity data of *M. dobsoni* landed by shrimp trawlers at Karwar, Mangalore, Calicut, Cochin, Munambam and Madras, and the annual prawn landings at Goa, Karnataka, Kerala, Tamil Nadu, Pondicherry and Andhra Pradesh by mechanized and traditional sectors during 1985-89 form the basis of the present study.

METHODS

The state-wise annual catch of *M. dobsoni* for 1985-89 was obtained from the estimated total penaeid prawn catch of the state for trawl and indigenous gears separately on the basis of its mean percentage contribution at the major centres of the respective states. Since the present stock assessment studies are based on trawl data, all the catch landed by indigenous gears and purse seine are grouped under other gears. By pooling the gear-wise landing figures for different states all-India production figure was obtained. Each boat trip of 6-8 hr duration is considered as 1 boat day (bd) in respect of trawl in the present study.

For length frequency studies, total length (measured from tip of rostrum to tip of telson) measurements were taken and grouped into 5-mm size intervals and raised to the catch of respective days and later to the month. The raised length frequency data in respect of trawl for males and females for 1985-89 pertaining to each centre were brought down to thousands and pooled month-wise for estimating the growth parameters like $L\infty$ and K using ELEFAN I (Pauly and David 1981). Instantaneous total mortality coefficient (Z) was estimated from the length frequency data (Beverton and Holt 1956) with the help of a computer.

Natural mortality coefficient (M) was calculated using Sekharan's method (1974).

Instantaneous fishing mortality coefficient (F) was found out from the relation $Z = M + F$. The yield recruit (Y/R), annual average stock (Y/U) and maximum sustainable yield (MSY) and standing stock (Y/F) were estimated for Mangalore, Cochin and Madras, by using Beverton and Holt yield per recruit model with the help of a computer. From the yield per recruit and MSY recruit values, the standing stock, annual average stock and MSY for the respective states were estimated, from which all-India estimates were obtained. Since the above values were not available for Goa and Andhra Pradesh, the values of the neighbouring states were used.

Fishing seasons and craft and gear employed

Shrimp trawl formed the major single gear employed in the exploitation of this prawn. Plank-built boats of varying size

(8.4-10.8 m) and power (20-96 HP) are employed to operate shrimp trawl with cod-end mesh varying from 10 to 25 mm along the west and east coasts of India. The size and power of the boat and dimensions of the trawl net vary from centre to centre.

The fishing season of this species by this gear is extended from September to May along the west coast, while it is continuous along the east coast.

M. dobsoni is also being caught in considerable quantities by traditional gears particularly during monsoon months. Occurrence of mud banks along some parts of Kerala coast during the south-west monsoon period is associated with heavy catches of this prawn. The major indigenous gears exploiting this resource are 'matabala', shore seine, gill net and cast net in Karnataka and Goa, ring seine (earlier boat seine) in Kerala and seines in Tamil Nadu and Andhra Pradesh. Along the west coast, the fishing season by indigenous gears is mainly restricted to monsoon months whereas it is continued all through the year along the east coast.

All-India production

The annual average production of *M. dobsoni* during 1985-89 was 22 370 t forming around 15.7% of the penaeid prawn landings in the country. The annual yield showed an increasing trend over the years.

Landings along the West and East coasts of India

The annual production from the west coast alone accounted for 69.9% of the total *M. dobsoni* landings in the country. Of this the bulk of the catch was realized from Kerala (73.8% of the west coast catch) and the rest from Karnataka and Goa. The east coast accounts for 30.1% of the annual average production of *M. dobsoni* in the country. Of this production, 61% was realized from Tamil Nadu and Pondicherry, and the rest (39%) from Andhra Pradesh.

State-wise production

Kerala alone accounted for 51.4% of the total *M. dobsoni* catch in the country, followed by Tamil Nadu (20.3%), Karnataka (11.6%), Andhra Pradesh (9.8%) and Goa (6.8%).

GEAR-WISE PRODUCTION TRENDS

Landings by indigenous gears and purse seines

M. dobsoni catch by indigenous gears together with purse seine accounted for 45.5% of the annual average production of the species in the country. The average annual catch for 1985-89 was highest in Kerala (61.1%) followed by those in Andhra Pradesh (17.8%), Karnataka (9.0%) and Tamil Nadu (8.8%). The landings by traditional gears showed an increasing trend in all the states particularly in Kerala where it surpassed even the trawl catch obtained in 1988 and 1989. This may be attributed to the bumper catch of this prawn by ring seines when mud banks are formed along the Kerala coast during south-west monsoon period.

Landings by shrimp trawls

During 1985-89 the trawl fishery accounted for 54.5% of the *M. dobsoni* landings in the country. The annual catch for the whole country showed an increasing trend. Bulk of the catch was landed in Kerala (43.3%), followed by those in Tamil Nadu (29.9%), Karnataka (14.0%), Goa (9.8%) and Andhra Pradesh (3.0%). The annual catch, the average annual catch and the annual effort are given in Table 1.

Table 1. Catch (tonnes) effort (boat days) and catch rate (in kg) of *Metapenaeus dobsoni* by shrimp trawlers in different states during 1985-1989

		1985	1986	1987	1988	1989	Average
Karnataka	Catch	1 375	1 848	2 168	1 603	1 475	1 694
	Effort	138 875	174 499	300 149	222 208	214 021	209 950 (976)
	C/u.	9.9	10.5	7.2	7.2	6.9	8.1
Kerala	Catch	5 033	2 825	5 909	4916	7 714	5 279
	Effort	370 176	402 563	586 515	863 274	595 301	563 565 (2621)
	C/u	13.6	7.0	10.0	5.7	13.0	9.4
Tamil Nadu	Catch	1896	2 700	4 800	3 660	5 160	3 643
Pondichery	Effort	411 906	567 487	474 163	460 431	444 560	471 709 (2194)
	C/u	4.6	4.8	10.0	7.9	11.6	7.7
Andhra Pradesh	Catch	336	626	482	210	219	375
	Effort	105 234	116 418	98 214	103 286	88576	102 346 (476)
	C/u	3.2	5.4	4.9	2.0	2.4	3.7
Goa	Catch	1 108	1 774	1 366	859	884	1 198
	Effort	109 237	160 531	185 287	118 840	128 267	140 653
	C/u	10.1	11.0	7.4	7.2	6.9	8.5
	Total (All Indian)	9748	9773	14 725	11 188	15 452	12 189
	Effort	1 135 428 (5 281)	1 421 498 (6 611)	1 644 328 (7 648)	1 768 039 (8 223)	1 470 725 (6 840)	1 488 002 (6 920)
	C/u	8.5	6.9	9.0	6.3	10.5	8.2

Trawl per day (tpd) in given in parenthesis.

Quarter-wise trends in various states

Peak landings of *M. dobsoni* were recorded in the first (January-March) and second (April-June) quarters in Karnataka when effort expended was also maximum.

In Kerala also peak landings were recorded in the first and second quarters even though maximum effort was expended in the second quarter followed by third quarter (July-September).

In Tamil Nadu, contribution of this species was maximum in the first quarter when effort expended was also relatively more.

Maximum catch of *M. dobsoni* was available in the third quarter in Andhra Pradesh.

Biology

Life-history: The species is present in the juvenile stages in most of the estuaries and backwaters along the coast line and adults are in inshore areas up to 40 m depth with muddy bottom. The species is heterosexual. The minimum size at maturity of the female is 64 mm in total length. The species breeds in the sea within 25 m depth zone. Individual prawn spawns 5 times during its life time with an interval of 2 months between 2 successive spawnings (Rao 1970). Fecundity ranges from 35 500 eggs at 70 mm to 160 000 eggs at 120 mm (Rao 1970). Larval development undergoes 5 nauplial, 3 protozoal and 3 myses stages. Eggs and larvae occur in appreciable numbers in the

inshore waters. Late mysis and post-larval stages migrate to estuaries and backwaters where they spend a part of their life and migrate back to the sea before the onset of maturity. Maturity of gonads in female is attained in the sea.

Spawning season: Breeding period from September to March or April along the Malabar coast (Menon 1955). George (1964) and Rao (1960) reported year-round spawning in the species with peaks during June-August and October-December in the Cochin area. The species breeds throughout the year with peaks during April-June and October-December at Ambalapuzha (Kerala; Kurup and Rao 1974). Ramamurthy *et al.* (1978) observed peak spawning during April-May and November-December along the Mangalore coast. Protracted spawning was noticed by George *et al.* (1988) along the Karnataka coast with maximum intensity during March-September at Mangalore, and during January-May and August-November at Karwar. Although *M. dobsoni* breeds all through the year, the peak spawning seasons, on the basis of percentage distribution of mature females in different months in the fishery at different regions during 1985-89, are found during November-February at Cochin; November-January and April-May at Calicut; March-April at Mangalore; February-April, July-August and November-December at Karwar and during February-March, August and November at Madras.

Sex ratio: The proportion of females was slightly higher in the species along the Malabar coast (Menon 1955). George and Rao (1965) observed that the sex ratio is significantly different from 1:1 and the ratio of males is high in the fishing grounds in June and November-December. They opined that the differential sex ratio in the fishing ground might have been brought about by the segregated sex movements for breeding. Higher proportion of males in the lower size groups was found by Kurup and Rao (1974) at Ambalapuzha. They suggested that the preponderance of females in the population and disparity in sex ratio in different size groups were due to the reproductive activities and differential growth rates in sexes. Ramamurthy *et al.* (1978) observed that females predominated in the fishery during April-May and November-December coinciding with intensive breeding.

Age and growth: Menon(1955) estimated that males and females of *M. dobsoni* attain, respectively, 70 and 75-80 mm, 90-95 and 100-105 mm; and 110 and 120 mm at the end of first, second and third years of its life. Off Cochin the species attain 95, 114 and 118 mm at the end of first, second and third year respectively (Banerji and George 1965). According to Kurup and Rao (1974) males and females of the species grow to a size of 97 and 115 mm at the end of first year, and 122 and 138 mm at the end of second year. Ramamurthy *et al.* (1978) found that the species reaches a length of 85 and 95 mm, and 105 and 120 mm on completion of first and second year, respectively, in males and females at Mangalore. Paralkar Smitha and Devaraj (1990) opined that *M. dobsoni* grows to 54.1 mm at the end of first year, 96.4 mm at the end of second year and 120 mm at the end of third year. The growth rates obtained by various authors are tabulated in Table 2.

RESULTS

Length-weight relationship

The length-weight relationship in

Table 2. Growth (mm) in *M. dobsoni* obtained by various authors at the end of first, second and third years at various localities

Author/s	Year	Sex	First year	Second year	Third year	Areas of study
Menon	1955	Male	70	90.95	110	Malabar coast
		Female	75-80	100-105	120	
Banerji and George	1965		95	114	118	Cochin
Kurup and Rao	1974	Male	97	122	-	Ambalapuzha (Kerala)
Ramamurthy	1978	Male	85	105	-	Mangalore
		Female	95	120	-	
Paralkar Smitha and Devaraj	1990		54.1	96.4	120	Entire west coast

M. dobsoni was studied at Mangalore, Cochin and Madras. The relationship for males and females at these centres are given below.

Mangalore

Males : Log W = -4.907 + 2.8208 log L (r = 0.81)

Females : Log W = -6.3502 + 3.5643 log L (r = 0.88)

Cochin

Males : Log W = -5.08518 + 2.91356 log L (r = 0.97)

Females : Log W = -5.7007 + 3.25937 log L (r = 0.99)

Madras

Males : Log W = -4.9618 + 2.9952 log L (r = 0.99)

Females : Log W = -5.0806 + 3.0671 log L (r = 0.99)

Growth parameters

The growth parameters, $L\infty$ and K in respect of males and females of *M. dobsoni* were determined by analysing the length frequency data by employing the computerised model ELEFAN I (Pauly and David 1981), studying the growth schedule obtained from it, and by comparing with the results of earlier studies. The L and K (annual) considered in the present study are 139 mm and 2.4 for males, and 145 mm and 2.76 for females. The growth parameters of VBGF like L_∞, K, t_o and W_∞ of *M. dobsoni* estimated by different authors earlier from various regions are given along with the present values in Table 3. $L\infty$ values ranged between 128.9 and 139 mm in males, while it was around 145 mm in females at all the centres. K values also showed marginal variation from centre to centre (annual value: 2.4 for male and 2.76 for female), and these are in conformity with the values obtained by Alagaraja *et al.* (1986).

Employing these growth parameters in von Bertalanffy's growth formula, mean age at lengths was determined and growth curves were drawn for males and females separately (Fig.1). Our studies indicated that this species attains around 90 mm in males and 100 mm in females on completion of 6 months, and 120 and 130 mm at the end of first year. Growth during the rest of the period is negligible. Paralkar Smitha and Devaraj (1990) observed that this species

Table 3. Estimation of growth parameters of *M.dobsoni* by various authors from different areas.

Author		L_∞ (mm)	K	t_0	W_∞	Area
Kurup and Rao (1974)	Male	128.9	0.1268	09660	-	Ambalapuzha (Kerala)
	Female	144.6	0.1280	0.3946	-	Ambalapuzha (Kerala)
Algaraja *et al.* (1986)	Male	139	0.20	-	18	Cochin
	Female	145	0.23	-	20	Cochin
George *et al.* (1988)	Male	135	0.41	-	18	Mangalore Karwar
	Female	145	0.29	-	20	
The present study	Male	139	2.4*	-	14.4	West coast
	Female	145	2.76*	-	22.1	and east coast

* Annual
Other K values monthly

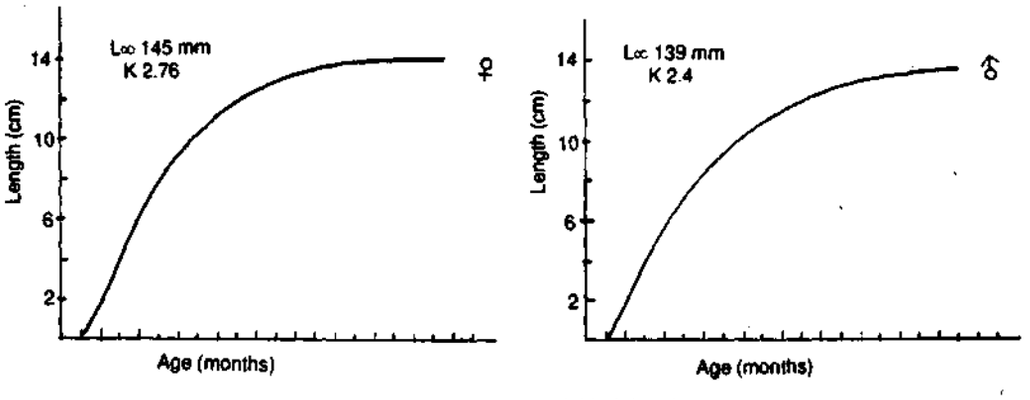

Fig.1. Growth curve of *M. dobsoni*

attains 54.1 mm, 96.4 mm and 120 mm at the end of first, second and third years respectively. These estimates are much lower than observed in the present studies and studies made by Muthu *et al.* (1981) who found that this species grows to 63 mm in 4 months itself in the culture ponds.

Mortality

The instantaneous total mortality coefficient (Z) estimated for males and females of *M. dobsoni* using Beverton and Holt (1956) formula for various centres are given in Table 4 along with the results obtained by earlier workers. The values in the present study ranged between 16.47 and 25.29 in males and between 16.21 and 20.47** in females. The Z values estimated by Alagaraja *et al.*(1986) in this species from Cochin was around 1.0 (monthly), while George *et al.* (1988) found the values near 1.2-1.6 (monthly) for the same species from Karnataka. Paralkar Smitha and Devaraj (1990) computed an annual Z of 3.4-5.3 for the entire south-west coast for *M. dobsoni.*

The present studies indicated that the

Table 4. Estimates of Z, M, F and C of *M.dobsoni* by various authors from different areas

			Z	M	F	E	C	Area
Alagaraja *et al*[1].	1986	Male	1.0	0.20	0.80	0.80	0.58	Cochin
		Female	1.02	0.23	0.79	0.77	0.61	Cochin
George *et al*[2].	1988	Male	1.26	0.41	0.85	0.70	0.56	Mangalore
		Female	1.21	0.29	0.92	0.75	0.62	Mangalore
George *et al.*		Male	1.60	0.51	1.09	0.70	0.56	Karwar
		Female	1.03	0.29	0.74	0.70	0.62	Karwar
Paralkar Smitha and		Male	3.44	2.3				
Devaraja (1990)		Female	5.31					
Present study[3]		Male	20.12	2.3	17.82	0.88	0.45	Cochin
		Female	16.21	2.3	13.91	0.86	0.50	
		Male	25.29	2.3	22.99	0.91	0.52	Mangalore
		Female	19.60	2.3	17.30	0.88	0.60	Mangalore
		Male	16.47	2.3	14.17	0.86	0.52	Madras
		Female	20.47	2.3	18.67	0.89	0.53	

1. Z, M and F values are in monthly
2. Z, M, F values are in bimonthly
3. Z, M, F values are in annual.

life span of the prawn is around 2 years. Assuming that the mortality is at least 99.0% by the time this age is reached in the unexploited state as suggested by Sekharan (1974), we get a natural mortality coefficient (M) of 2.3. Since the life span of male and female is the same, a single value of M was taken in the present study. Alagaraja *et al.* (1986) estimated an M of 0.2 (monthly) for this species for the Cochin area (Table 4). A value of M ranging between 0.3 and 0.5 (monthly) was found by George *et al.* (1988) for the whole Karnataka coast. Paralkar Smitha and Devaraj (1990) estimated an annual M of 2.3 for the entire west coast.

Yield per recruit (Y/R)

The yield per recruit (Yw/R) has been calculated from the observed age at first capture (t_c) for males and females of *M. dobsoni* for M = 2.3 as a function of exploitation ratio (E) in respect of Mangalore, Cochin and Madras, and the estimates are given in Table 5.

At Mangalore, the Yw/R at M = 2.3 and t_c =0.31 year (l_c= 72.5 mm) is 1.62 g for the present F of 22.99 (E =0.91). The

Table 5. Annual average yield, standing stock, average annual stock, MSY/R, present Y/R average recruits in numbers (Re) and MSY estimated for *M. dobsoni* at Mangalore, Cochin and Madras

Centre	Sex	Annual average yield(t)	Standing stock(t) Y/F	Annual average stock (t) Y/U	MSY/R (g)	Present Y/R (g)	Re (10^6)	MSY (t)
Mangalore	Male	159.6	6.94	175.5	1.878	1.617	98.69	185.4
	Female	378.8	21.86	429.2	3.483	3.325	113.92	386.8
Cochin	Male	323.4	18.15	365.13	1.731	1.370	236.06	408.6
	Female	557.8	40.10	650.00	3.005	2.613	213.47	641.5
madras	Male	148.9	10.51	173.1	2.083	1.901	78.33	163.1
	Female	256.9	13.76	288.6	3.526	3.085	83.27	293.6

Yw/R for the F_{max} of 4.91 (E=0.19) was 1.88 g. MSY is estimated at 185.4 t for males. For females, the Yw/R is 3.325 g for the present F of 17.3 (E=0.88) when M = 2.3 and t_c-0.34 year (l_c =72.5 mm). For F_{max} of 6.86 (E_{max} = 0.35) the Yw/R is 3.48 g. The MSY is estimated at 396.8 t for females at this centre (Fig. 3).

At Cochin, the Yw/R at M=2.3 and t_c=0.25 year (l_c =62.5 mm) is 1.731 g at F_{max} =3.73 (E_{max}=0.19) for *M. dobsoni* males (Fig. 2). It is seen that for the present F of 17.82 (E=0.89) the Yw/R is only 1.37 g. The MSY is estimated at 408.6 t. At the same centre, the Yw/R at M=2.3 at t_c=0.25 year (l_c=72.5 mm) is 2.613 g for the present F of 13.91 (E=0.86) for females. For the F_{max} of 4.34 (E=0.27) the Yw/R is 3.0 g. MSY is estimated at 641.5 t.

At Madras, the Yw/R at M=2.3 and t_c=0.31 year (l_c =72.5mm) is 2.083 g for a F_{max} of 4.95 (E_{max} =0.3) for *M.dobsoni* males. For the present F of 14.17 (E=0.86) the Yw/R is 1.9 g (Fig.4). For males, at M =2.3 and t_c =0.28 year (l_c =77.5 mm), the Yw/R is 3.08 g for the present F of 18.67 (E=0.91). An Yw/R of 3.52 g is obtained for a F_{max} of 4.94 (E_{max}=0.24). The MSY is estimated to be 163.1 t for males and 293.6 t for females.

Keeping M at 2.3, the Yw/R has been calculated for different values of t_c for the prevailing E in respect of *M. dobsoni* males and females for Mangalore, Cochin and Madras (Table 6). At the present level of fishing intensity (E=0.91 or F=22.99) the MSY level could be increased by 1.1 times by increasing the mesh size by 1.06 times so as to have C=0.56 (l_c=77.5 mm, t_c=0.34 year) instead of the present C=0.56 (l_c=72.5 mm or t_c=0.31 year) in *M. dobsoni* males at Mangalore. For females at the same centre,

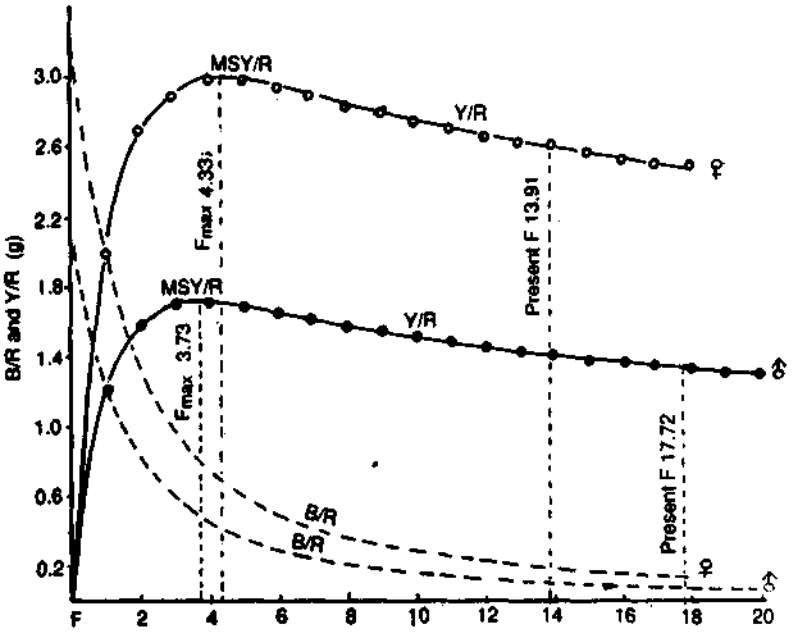

Fig 2. Yield per recruit and biomass per recruit at different levels of F in *M. dobsoni* at Cochin.

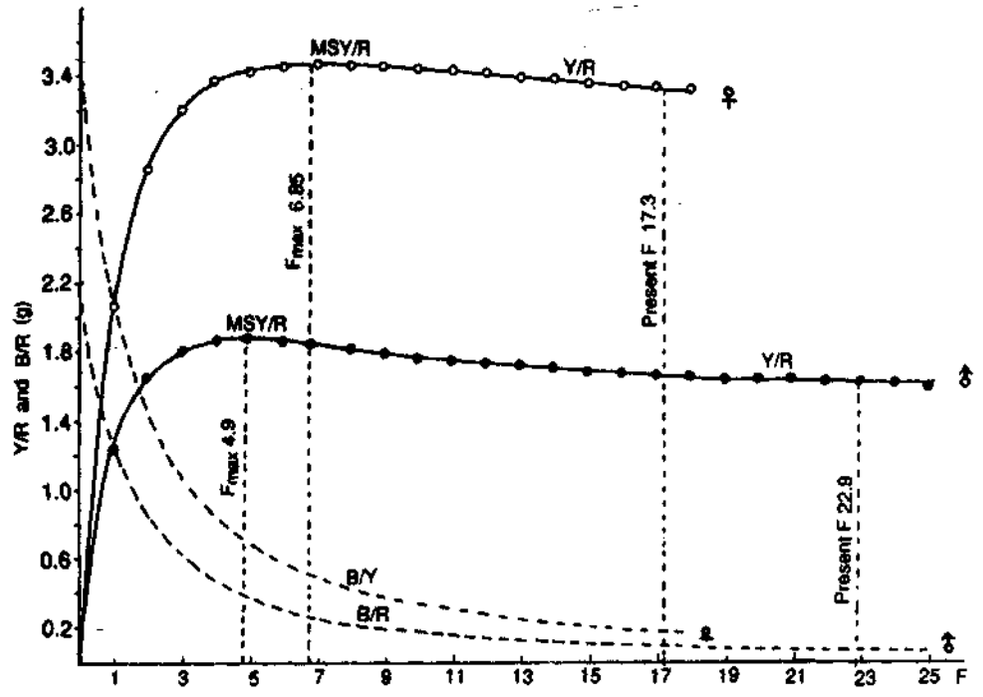

Fig.3. Yiled per recruit and biomass per recruit at different levels of F in *M. dobsoni* at Mangalore.

Table 6. Yield per recruit at different age at capture (t_c) in *M.dobsoni* males and females at Mangalore, Cochin and Madras

	Male				Female			
	Age at capture (t_c)				Age at capture (t_c)			
Centre	Present F	0.25 (62.5 mm) C=0.45	0.31 C=0.52	0.34 (77.5 mm) C=0.56	Present F	0.25 (72.5 mm) C=0.50	0.28 C=0.53	0.34 (87.5 mm) C=0.60
Mangalore	22.99 E=0.91	1.29	1.69*	1.77	17.3 E=0.88	2.59	2.92	1.32*
Cochin	17.82 E=0.89	1.37*	1.68	1.81	13.91 E=0.86	2.61*	2.84	3.25
Madras	14.17 E=0.86	1.58	1.92*	2.05	18.67 E=0.9	2.64	3.08*	3.62

Yield per recruit at the present t_c is indicated by astericks. Maximum yield per recruit for the present F is underlined. Length at captrue (l_c) is given in parentheses C= l_c/L_∞

it is seen that the MSY level is available at the present C=0.6 (l_c=87.5 mm, t_c=0.34 year) itself at the prevailing fishing intensity.

At Cochin, in *M. dobsoni* males, at the present level of fishing intensity (E==0.89, F =17.82), the MSY level can be increased by 1.32 times by increasing the mesh size by 1.24 times so as to have C=0.56 (l_c=77.5 mm, t_c=0.34 year instead of the present C =0.45 (l_c=62.5 mm, t_c=0.25 year). In

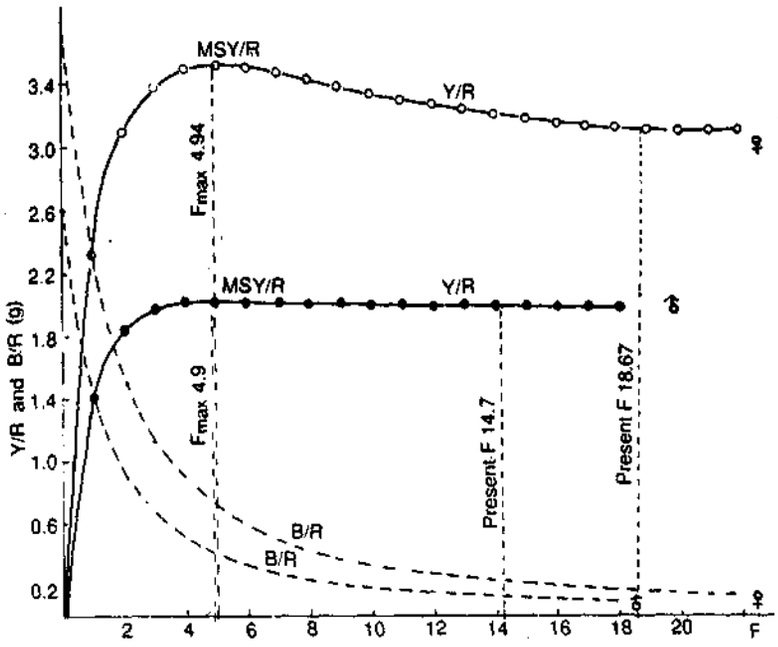

Fig 4. Yield per recruit and biomass per recruit at different levels of F in *M. dobsoni* at Madras.

females, at the same centre, the MSY level can be enhanced by 1.24 times by increasing the mesh size by 1.21 times so that l_c could be at 87.5 mm (t_c =0.34 year, C=0.6) instead of the present l_c=72.5 mm (t_c=0.25 year, C=0.5) for the present fishing intensity.

At Madras also, in males and females, the MSY level can be increased by 1.07 times and 1.18 times by increasing the mesh size by 1.07 times and 1.13 times, respectively, so as to have C=0.56 (l_c=77.5 mm, t_c=0.34 year) and C=0.6 (l_c=87.5 mm, t_c=0.34 year) at the present level of fishing intensity.

It is apparent that increasing the mesh size is advantageous to the fishery at all centres.

Stock assessment

Average annual yield, standing stock (Y/F), average annual stock (Y/U) and MSY estimated for males and females of *M. dobsoni* in respect of various states are given in Table 7. The standing stock in males was highest in Kerala followed by those in Tamil Nadu, Karnataka, Goa, Pondicherry and Andhra Pradesh.

DISCUSSION

The life span of *M. dobsoni* is around 2 years in both sexes and females grown to larger lengths. It is therefore reasonable to believe that the growth rate is faster in females than in males resulting in higher K values in females. The K values of 1 and 1.2 for males and females, respectively, gave relatively good fit but these values may not represent the actual growth complement as in the growth of penaeid prawns there are two distinct phases. In the first phase, the

Table 7. Annual average yield, standing stock (Y/F), average annual stock (Y/U) and MSY of *M.dobsoni* exploited by shrimp trawls estimated for various states

States	Sex	Annual average yield (t)	Standing Stock (t)	Annual average stock (t)	MSY (t)
Goa	Males	440	19.1	484.0	511.2
	Females	758	43.8	858.8	793.9
Karnataka	Males	622	27.0	684.2	772.6
	Females	1 072	62.0	1 214.6	1 122.8
Kerala	Males	1 937	109.0	2 187.0	2 447.0
	Females	3 442	240.2	3 894.6	3 843.8
Tamil Nadu and Pondicherry	Males	1 337	94.3	1 554.0	1 465.0
	Females	2 306	123.5	2 590.1	2 635.6
Andhra Pradesh	Males	138	9.7	160.3	151.2
	Females	237	12.7	266.2	270.9
All India	Males	4 474	259.1	5 069.5	5 297.0
	Females	7 715	482.2	8 824.3	8 667.0
	Male and Female pooled	12 189	741.3	13 893.8	13 965.0

prawn registers faster growth rate in the early part of life, whereas in the second phase, the growth slows down drastically on attaining maturity. The data analysed for the present length frequency studies mostly composed of prawns belonging to the second phase resulting in low K values. Considering the short life span and fast growth rate in the early part of life, K values of 2.4 for males and 2.76 for females considered in the present study gave reasonable good result. Further, these values are in conformity with the K values obtained by Alagaraja *et al.* (1986).

Garcia (1981) opined that for penaeids with a maximum age of about 2 years, the M value would be between 2 to 3/year. In the present study M of 2.3 was estimated, while Paralkar Smitha and Devaraj (1990) gave a similar value for M.

At the present level of exploitation (E=0.88) for an effort of 148 800 bd (6 920 trawls/day) for an annual average of 215 fishing days an annual average yield of 12 189 t of *M. dobsoni* was obtained. This was lower than the MSY of 13 965 t estimated for shrimp trawls. However, the annual yield for 1987 and 1989 (14 725 t and 15 452 t respectively) far exceeded MSY level.

Yield per recruit studies indicated that the present effort of 14 88 000 bd (equivalent to 6 920 tpd) is much beyond the effort required to harvest optimum yields (Figs 9, 10, 11). Hence it is suggested that the effort may be drastically reduced to 50% of the present level (3 360 tpd equivalent to 7 44 000 bd) along with marginal increase in cod-end mesh size to 25 mm would be beneficial to the fishery to obtain sustainable yields.

The steady increase in annual production over the years suggests that the current exploitation has not resulted in any apparent reduction of the resource as the stock is being replenished by new recruits entering the inshore fishery periodically after successful spawning. However, the fishery may be closely watched so as to enable to suggest measures for conservation and management of the resource.

Considering the fact that this species is

exploited by shrimp trawls as well as traditional gears, the estimation of the potential stock of *M. dobsoni* in the coastal waters has become very difficult. Shrimp trawls being the single major gear exploiting more than 50% of the annual landings of *M. dobsoni* in the country, the present stock assessment studies are made exclusively based on trawl data, even though it represents only a segment of the population. For a comprehensive picture of the potential stock in the coastal waters the stock assessment studies have to be carried out on data pertaining to other gears also after standardizing them and collecting additional data. Coupled with this, suitable statistical models have to be developed for assessing the stock.

MSY based on trawl data (13 965 t) does not indicate the actual potential stock position, as it is far below the annual average yield of 22 370 t during 1985-89 (12 189 t by trawl + 10 181 t by other gears) and the 1989 catch of 31 213 t (15 452 t by trawl + 15 761 by other gears). Considering all these facts, a reasonable estimate of the potential stock can be arrived at by adding the MSY of trawl (13 965 t) and the annual average catch of other gears (10 181 t). As such, a conservative estimate of 25 000 t can be safely taken as the potential stock of *M. dobsoni* for the entire country.

It is suggested that the indigenous gears may be encouraged for exploiting this coastal species, particularly during monsoon months as trawling within 20 km from the shore is banned in Kerala during this period.

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