

PENAEID PRAWN FISHERIES OF THE NORTHWEST COAST OF INDIA*

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ABSTRACT

The present account is based on commercial trawler operations in the Northwest coast of India between 17° and 21°N — 71° and 73°E during 1978 - '85 covering an area of approximately 25,000 km². Penaeid prawns accounted for 8290 tonnes per year on an average constituting 28% of the trawl catch. A standing stock of 13,000 t of penaeid prawns has been estimated from this area based on the swept area method which indicates scope for increasing the fishing effort. *Parapenaeopsis stylifera*, *Metapenaeus affinis*, *Solenocera crassicornis* and *M. monoceros* were the major components.

The length-weight relationship of the major species has been worked out. No significant difference in the mean size of the species caught over the years was noticeable. Females always predominated over males among all the species almost throughout the season. The peak breeding period for most of the species was during August - November and March - April. However percentage of mature females was generally observed to be low in the population.

INTRODUCTION

PENAEID prawns are of great economic importance because of their value. The States of Maharashtra and Gujarat together have a coastline of about 2400 km with a shelf area of about 210,000 km², half of which only is exploited intensively at present. They account for about 38,000 t of penaeid prawns per annum, (Maharashtra's share being 76%) and constituted 9% of the all fish landings of this area and 35% of the total penaeid landings of India during 1970-'84. The annual average catch of 13,000 t from these States during 1961-'70 rose to 35,000 t during 1971-'80 and then the 43,500 t during 1980-'84. Improved methods of fishing like mechanisation of the craft and

gear particularly the trawlers which witnessed a multifold increase compared to sixties have played a pivotal role in the augmentation of the resource. The resultant fishing pressure coupled with increasing oil drilling and seismic activities on this coast warrant studies of this valuable resource and its management.

Earlier accounts on the prawn fisheries of the northwest coast, though there have been several (Rai, 1933; Shaikhmahmud and Tembe, 1960; Kagwade, 1967, 1980; Kunju, 1967, 1968; Mohamed, 1967; Ramamurthy, 1967; Raje and Ranade, 1972 a, b; Sukumaran, 1978; Sukumaran and Rajan, 1981; Nagabushanam and Kulkarni, 1982; Rajan *et al.*, 1982; Ramamurthy and Mestry, 1983, 1985) deal mostly with seasonal and spatial distribution of the resource and the species composition and some aspects of the biology of the species. Further most of these studies relate to the bag-net fishery.

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New Ferry Wharf in Greater Bombay is a major fish landing centre from which nearly 250 trawlers operate in the North Maharashtra and South Gujarat waters. The present account attempts to elucidate the status of the resource exploited from this region.

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MATERIAL AND METHODS

Fishing grounds extend from Ratnagiri in the south to Surat in the north in depths of 20 - 60 m (17° - 21°N) and 71° - 73° E (Fig. 1) covering an area of about 25,000 km². The nature of bottom is mostly muddy or sandy/muddy.

Trawling is carried out throughout the year. However, during the peak of southwest monsoon from June to August very few boats venture into the sea to fish and that too in comparatively shallow waters (20-30 m). The trawlers remain absent from the port for 2-3 days except during June - August when mostly daily trips are undertaken.

The data collected at the landing centre from July 1978 to June 1985 form the basis of this study. The primary data on catch and effort were taken from the Fishery Resources Assessment Division of the Central Marine Fisheries Research Institute. The C.P.U.E. is expressed as kg/hr.

The standing stock of penaeid prawns in the fishing ground covering an area of about 25,000 sq. km² (Fig. 1) was estimated by the swept area method following the formula as under (Siddeek, 1986) :

$$a = lv \dots \dots \dots 1$$

where 'a' is the area swept by the trawl per hour, 'l' is the length of effective horizontal opening of the trawl and 'v' is trawling speed (2 km/hr). The head rope length is 20 m and multiplying factor of 0.7 was used to calculate

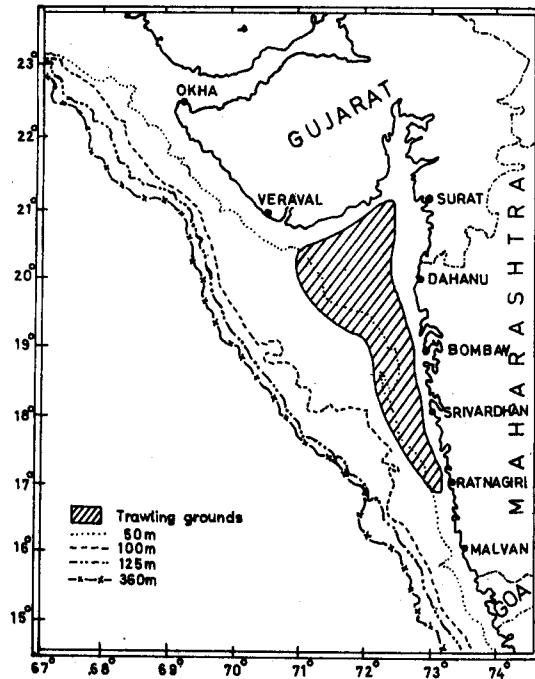


Fig. 1. Fishing grounds.

the effective horizontal opening of the trawl in order to avoid over-estimation of the stock

$$d = y/e. a \dots \dots \dots 2$$

where 'd' is density of prawns, 'y' is catch/hr and 'e' = 0.5 (trawl efficiency)

$$B = d.A. \dots \dots \dots 3$$

where 'B' is biomass and 'A' is total area fished by the trawlers.

The values obtained during June - August were excluded for density and biomass estimation since fishing was irregular during heavy monsoon period.

The species were sorted out by the fishermen before unloading at the wharf. *Metapenaeus affinis*, *M. monoceros*, *Parapenaeopsis styliifera* and *Solenocera crassicornis* were found to be commercially important. Random samples of the species for biological analysis were collected once a week. The sample weight was taken. Males and females were separated and length from the tip of telson measured. The estimation of prawns in a particular length group at 5 mm intervals and the CPUE in weight and numbers on each sampling day and for the month and the mean lengths for the month and year were determined as followed by Ramamurthy *et al.* (1975). The condition of gonads as visible externally and the number of impregnated females were noted among the different size groups. The monthly data were pooled and their percentage calculated.

The length weight relationship of prawns is expressed by the formula

$$W = aL^b$$

where W is weight in gm, L is total length in mm and a & b are constants.

Logarithmic transformation of the formula gives a straight line relationship

$$\text{Ln}W = \text{Ln}a + b \text{Ln}L$$

where LnW is the dependent variable (Y), LnL independent variable (X), b the regression coefficient or slope and Ln a the Y intercept. Ln a and b were estimated by the least squares method. The significance of the differences between the regression of slope (b) and elevation (a) were tested by the method of analysis of covariance.

CATCH AND EFFORT

During the sixties the trawlers contributed to only a small portion of the penaeid catch of Maharashtra, major part being accounted for by the bag-netters (Mohamed, 1967). With the

increase in the number of trawlers from a mere 60 in 1965 to over 1300 in 1983, it was noticed that the bulk of the penaeid fishery was contributed by this gear.

The catch and effort data during 1978-'85 at New Ferry Wharf are represented in Table 1. The annual effort remained more or less static with only marginal variations during 1978-82. During 1982-'83, the effort increased by 20% and remained at the same level during the subsequent years.

The annual average catch was 8290 t at a CPUE of 7.1 kg. The best catch and catch rate were obtained during 1984-'85 when the fishery recorded 1.5 fold increase over that of 1978-79. The catch in general indicated an upward trend during the period of study though a decline in the fishery was observed every alternate year.

As in the case of effort, the catch also remained poor during June - August ranging from 1 t in July 1982 to 980 t in August 1984. The CPUE was comparatively high during this period, maximum value occurring in August (39-177 kg/hr). However, these values, are not comparable with those of other months, since the effort level was at its ebb and the area of fishing was restricted. Barring this period the maximum catch and catch rate were observed in the postmonsoon period ranging from 930 t and 7.3 kg in October 1981 to 3450 t and 20.3 kg in September 1984 respectively. A secondary peak in the fishery and catch rate occurred during February - April.

STANDING STOCK

Table 1 gives the yearwise values of density and biomass of penaeid prawns in the fishing ground. The density was estimated to be within the range of 0.35 - 0.69 t/km² and the biomass 8750 to 17,250 t. The annual mean density was 0.51 t/km² and biomass 12,780 t.

The monthly density ranged from 0.16 t/km² in May 1982 to 1.45 t in September 1984, the respective biomass being 3930 t and 36,250 t. The mean monthly density varied from 0.31

SPECIES COMPOSITION

The fishery is one of multispecies. The yearly landing of different species, their CPUE

TABLE 1. Catch details at New Ferry Wharf and bio-mass estimates

Year	Effort in 100 Hours	Catch (1000 t)	C/hr (kg)	% in all fish	Density (kg/ha)	Biomass (1000 t)
1978-79	990.1	8.24	8.3	26.6	5.93	14.82
1979-80	1043.5	5.43	5.2	30.7	3.71	9.29
1980-81	1124.2	7.94	7.1	37.8	5.07	12.68
1981-82	1081.1	5.29	4.9	28.7	3.50	8.75
1982-83	1303.4	9.87	7.6	22.5	5.43	13.57
1983-84	1323.7	9.10	6.9	24.3	4.93	12.32
1984-85	1246.1	12.13	9.7	32.7	6.93	17.32
Average	1158.9	8.29	7.1	28.0	5.11	12.78

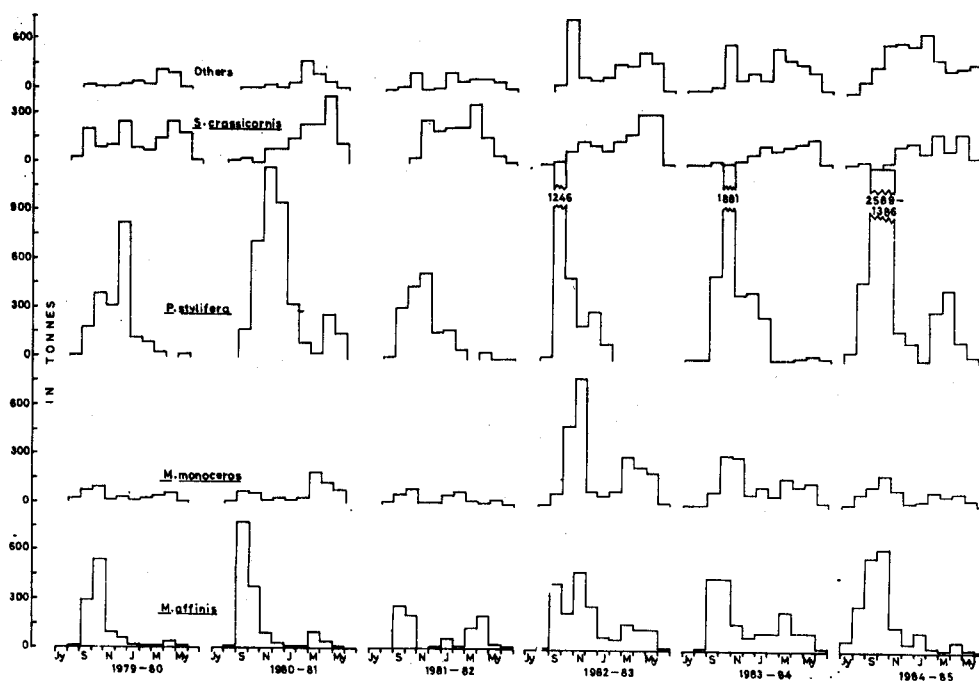


Fig. 2. Monthly variations in the catch of different commercial species during 1979-85.

to 0.82 t/km² in January and September respectively which provides a biomass of 7860 and 20,540 t.

and percentage composition during 1979-'85 are represented in Table 2. Based on the annual average catch, the order of abundance of

TABLE 2. Prawn species catch (t) and CPUJE (kg) in parentheses at New Ferry Wharf

Year	<i>M. affinis</i>	<i>M. monoceros</i>	<i>M. brevicornis</i>	<i>P. stylifera</i>	<i>P. hardwickii</i>	<i>S. crassicornis</i>	<i>Penaeus</i> spp.	<i>M. stridulans</i>	Other penaeids
1979-80	1086.1 (1.0)	467.0 (0.5)	74.1 (0.1)	1993.4 (2.0)	179.5 (0.2)	1460.7 (1.4)	114.5 (0.1)	8.0	42.0
%	20.0	8.6	1.4	36.8	3.3	26.9	2.1	0.1	0.8
1980-81	1492.7 (1.3)	631.6 (0.6)	151.8 (0.1)	3892.7 (3.5)	212.7 (0.2)	1417.5 (1.3)	132.9 (0.1)	4.0	8.6
%	18.8	8.0	1.9	49.0	2.7	17.8	1.7		0.1
1981-82	986.5 (0.9)	396.3 (0.4)	31.9	1772.4 (1.6)	169.8 (0.2)	1594.0 (1.5)	178.4 (0.2)	143.0 (0.1)	20.3
%	18.6	7.5	0.6	33.5	3.2	30.1	3.4	2.7	0.4
1982-83	2008.9 (1.5)	2427.10 (1.9)	216.7 (0.2)	2395.1 (1.8)	396.1 (0.3)	1589.7 (1.1)	340.7 (0.3)	591.6 (0.5)	7.0
%	20.3	24.6	2.2	24.2	4.0	15.1	3.5	6.0	0.1
1983-84	1933.8 (1.5)	1409.0 (1.1)	98.3	3593.1 (2.7)	217.6 (0.2)	770.0 (0.6)	365.5 (0.3)	522.6 (0.4)	186.0 (0.1)
%	21.3	15.5	1.1	39.5	2.4	8.5	4.0	5.7	2.0
1984-85	2221.2 (1.8)	970.8 (0.8)	281.5 (0.2)	5664.8 (4.5)	503.3 (0.4)	1039.4 (0.8)	461.7 (0.4)	890.6 (0.7)	96.5 (0.1)
%	18.3	8.0	2.3	46.7	4.2	8.6	3.8	7.3	0.8
Average	1621.5 (1.4)	1050.4 (0.9)	142.4 (0.1)	3218.5 (2.8)	279.8 (0.2)	1295.2 (1.1)	265.7 (0.2)	360.0 (0.3)	60.1 (0.1)
%	19.6	12.7	1.7	38.8	3.4	15.6	3.2	4.3	0.7

different species was *Parapenaeopsis stylifera*, *Metapenaeus affinis*, *Solenocera crassicornis*, *M. monoceros*, *Metapenaeopsis stridulans*, *P. hardwickii*, *Penaeus* spp. and *M. brevicornis*. Except *M. monoceros* and *S. crassicornis*, all the other species touched an all time high landing during 1984-'85.

The monthly variations of the commercial species are depicted in Fig. 2. All the species had the peak occurrence during September - October - November with a secondary peak during March - April except *S. crassicornis* which registered the peak during April - May and *P. hardwickii* and *M. brevicornis* during January - April.

P. stylifera : This was the dominant species in all the years except during 1982-83. The fluctuations in catch were of wide nature over the years. The best season was during 1984-'85 and the poorest during 1981-'82.

M. affinis : This occupied the second or third place in abundance during the different years. The fishery showed a steady improvement over the years except for a decline during 1981-'82.

S. crassicornis : This species formed a stabilised fishery during 1979-'83 with a peak generally occurring during April - May. In the following year, the catch dwindled to less than half relegating it to a fourth place in abundance. The fishery revived during the next year.

M. monoceros : Like *P. stylifera*, this species showed strong annual variations in catch. During 1982-'83 it attained the all time high to rank foremost in species composition closely preceding *P. stylifera*. Subsequently the fishery was on a gradual decline.

M. stridulans : One notable nature is that this species which was insignificant during 1979-'81

established itself as a fishery of considerable magnitude in the later years, showing a steady increase. It appeared in the fishery during the warm months of October - November and March - May.

P. hardwickii : This is also a seasonal species occurring during January - April.

Penaeus spp. : Three large sized species viz. *P. penicillatus*, *P. japonicus* and *P. monodon* occur throughout in the order of abundance. The fishery registered an upward trend with a substantial increase from 1982-'83.

M. brevicornis : Fairly good quantities were landed during 1980-'81, 1982-'83 and 1984-'85.

Other penaeids : These include *M. kutchensis* which occur during December - April and *Trachypenaeus curvirostris* and *Parapenaeus longipes* which appear in the fishery along with *M. stridulans* in varying quantities.

BIOLOGICAL CONSIDERATIONS

Four commercial species viz. *M. affinis*, *M. monoceros*, *P. stylifera* and *S. crassicornis* are considered here. The aspects covered relate to mean length, sex ratio, maturity and lengthweight relationship.

M. affinis : The monthly mean length ranged from 96.9 to 132.2 mm for males and 109.3 to 151.3 mm for females. The minimum mean length for either sexes occurred during August - November. The annual mean length (Table 3) was highest during 1981-'82 when the fishery was in and vice-versa during 1982-'83 when it was good. But the same relationship was not discernible during 1984-'85.

Females were always in excess of males (Fig. 3) except during January 1980 and April 1983. The percentage of mature (maturing and mature combined) and impregnated female was low ranging from 3.0 during 1984-'85 to 16.3 during 1979-'80 and 4.0 during 1980-'81 to

11.2 during 1979-'80 respectively. However, the maximum number of mature females was noticed in the size range of 123-143 mm. Impregnated females were also comparatively more in the same size range. The scarce occurrence of mature females on the whole during this study suggests that either fishing takes place outside the breeding grounds or the

November - January at Mangalore (Ramamurthy *et al.*, 1975), January to March at Calicut (Subrahmanyam, 1963) and October - March at Cochin (George, 1961; George *et al.*, 1968). In all these cases there is a gap in the knowledge of occurrence of maturity condition of the species during June - August, since fishing

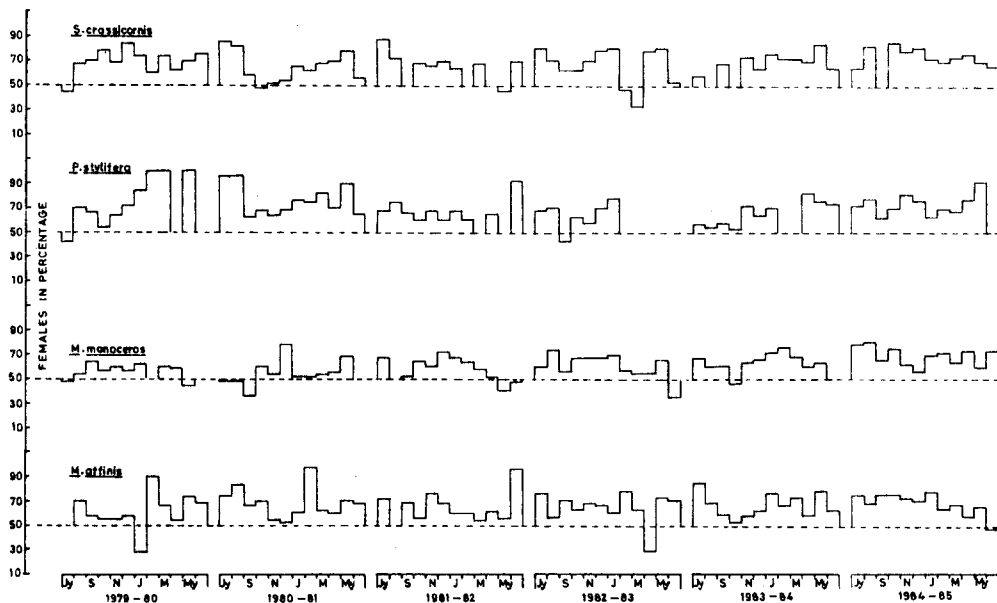


Fig. 3. Sex distribution of commercial species during 1979-85.

spawning season is June — August when fishing was restricted in time and space due to monsoon. The latter appears to be more probable since this period precedes the period of occurrence of minimum mean length of the species. This is further supported by the observations of Mohamed (1967) at Bombay.

Mature females occurred throughout the year indicating continuous breeding in the population. However their occurrence was relatively more during May - July and October. Breeding intensity was reported to be high during October - December and April - June at Bombay (Shaikhmahmud and Tembe, 1960),

remained almost suspended then due to inclement weather.

The smallest ripe female during the present study was 108 mm. The fishery currently exploited is mostly above this size. Juveniles perhaps inhabit areas closer to the shore which are not fished.

M. monoceros : The monthly mean length ranged from 105.2 to 149.2 mm for males and 96.5 to 167.4 mm for females. The minimum mean length occurred during October — December and March — April. The annual mean length was lowest during 1982-'83 (Table 3)

when the fishery was most successful. During other years also it tended to increase or decrease exhibiting a more or less inverse relation to the fluctuations of the fishery.

Females outnumbered males except in May — June or September — October (Fig. 3). The

this size is being exploited thus pointing to a possible removal of the potential spawners. This calls for a careful watch for management in future.

P. stylifera : For males the monthly mean length ranged from 76.5 to 107.8 mm and for

TABLE 3. Annual sexwise mean length (mm) of different species

Species	1979-'80		1980-'81		1981-'82		1982-'83		1983-'84		1984-'85	
	M	F	M	F	M	F	M	F	M	F	M	F
<i>M. affinis</i>	113.2	130.6	117.5	123.7	121.2	133.8	105.8	119.1	114.5	128.5	116.1	129.7
<i>M. monoceros</i>	124.1	143.3	122.4	139.2	124.7	137.5	112.4	126.0	121.0	138.3	121.8	136.6
<i>P. stylifera</i>	87.6	97.1	83.8	92.6	84.5	95.4	82.5	94.5	84.4	94.6	85.4	100.1
<i>S. crassicornis</i>	68.8	92.5	65.9	85.8	65.2	82.7	65.6	87.2	65.8	86.7	65.6	84.2

percentage of mature and impregnated females was low ranging from 0.5 during 1984-'85 to 6.1 during 1981-'82 and 1.6 during 1983-'84 to 6.1 during 1979-'80 respectively. The number of mature females was relatively more in the size range of 133-163 mm. There are indications of year round breeding with intense activity during January, May and August — October. Thus as in the case of *M. affinis*, peak spawning season appears to be during June — August. There however, seems to be a secondary spawning peak during January — March. George and George (1964) located a possible spawning ground in 50-60 mm depth off Cochin by collecting a good quantity of potential breeders during July - August. Based on the post-larval occurrence in the backwaters/estuaries, the breeding period was inferred to be November — December at Cochin (George, 1959) and January — June at Calicut (Menon, 1980).

The smallest mature female caught during the present study was 118 mm. During certain seasons the fishery with mean length below

females 83.8 to 115 mm. The minimum mean length was recorded during July — October and April — May. The annual mean length (Table 3) showed an inverse relation to the magnitude of the fishery till 1982-'83 after which the relationship was found to be direct.

Females preponderated throughout (Fig. 3) except in July 1979 and September 1982. As in the other species the percentage of mature females was low ranging from 0.3 during 1983-'84 to 5.3 during 1980-'81. Size range 98-113 mm had relatively more number of mature specimens.

The species breeds throughout the year, but the peak season seems to vary from place to place. The present study revealed two spawning periods, the main one during August–November and the secondary one during February — April as seen from the occurrence of mature females and younger size groups in the fishery. From the same area, Shaikhmahmed and Tembe (1961) observed the peak period during April — May and Mohamed (1967) from September to February. At Mangalore the peak was during November — December and

April — May (Ramamurthy, 1980). Along the Malabar Coast, it was during October — December (Menon, 1953). At Cochin, November — January and April are the peak

Females were preponderant except on a few occasions (Fig. 3). In the absence of any data on maturity in the present study the occurrence of younger size groups during

TABLE 4. *Biological characteristics of other penaeid prawns*

Species	Sex	Size range (mm)	Dominant groups (mm)	Sex ratio M : F	Smallest mature female (mm)	Dominant mature groups in mm (Female)	Peak period of mature females
<i>M. brevicornis</i>	M	68-123	83-98	1:3	—	—	—
	F	73-163	113-128		113	118-133	Dec.-Mar.
		(Mostly impregnated)					
<i>M. stridulans</i>	M	48-93	63-78	1:1.5	—	—	—
	F	53-113	68.83	—	—	—	—
<i>P. hardwickii</i>	M	58-103	63-78	1:1.9	—	—	—
	F	63-138	98-113	—	98	103-113	Mar.-Apr.
<i>P. penicillatus</i>	M	103-228	143-158	1:1.9	—	—	—
	F	103-293	108-173	—	108	163-193	Dec.-Mar.

spawning months (George *et al.*, 1968; Rao, 1968).

The size at maturity for females was observed to be 63.2 mm in the southwest coast of India (Rao, 1968). At Bombay, Kagwade (1980) found 105.5 mm as size at maturity from the bag-net fishery, though she recorded 76 mm as the minimum size of mature specimen. The smallest ripe female collected during this present study was 83 mm. There appears to be no threat of removal of potential spawners, since the mean length of the exploited population was above this size.

S. crassicornis : The monthly mean length ranged from 58.6 to 78.0 mm for males and 67.7 to 101.6 mm for females. The minimum mean length occurred during September — December. The annual mean length (Table 3) was lowest during 1981-'82 when the fishery was at its maximum. The reverse was not the case during 1983-'84 when the fishery was in. But during 1982-'83 and 1984-'85, the inverse relationship was perceptible.

September — December suggests peak spawning during June — August. Published accounts reveal that the peak spawning period in the Bombay waters was December and April (Kunju, 1967; Sukumaran, 1978) and December — May (Mohamed, 1967). Different values for size at first maturity for females ranging from 63 to 88 mm have been estimated (Kunju, 1968; Sukumaran, 1979; Kagwade, 1980) from the same area.

Certain biological observations on other species of penaeids are summarised in Table 4.

LENGTH — WEIGHT RELATION

The length weight relationships of the four commercial species were estimated for males and females separately (Table 5).

GENERAL REMARKS

Certain salient features emerge from this study. The fishing effort showed an increasing trend through the years, except for a slight

decline during 1981-'82 and 1984-'85. The catch also showed an increasing trend though there was a biennial decline as a result of the fluctuations in the constituent species. The biomass was estimated to be 1.35 to 1.8 times the exploited stock. There, thus seems to be

depth of 40 m, states that "the active spawning groups of penaeid prawns must be lying in the offshore areas and that thorough analysis of the trawl catches of these prawns would help to throw further light on this aspect". Though the present study is based on trawled material

TABLE 5. Length (mm) — Weight (gm) relationship of different species according to sex

Species	Male	Female	Significance at 1% Level
<i>M. affinis</i>	W = 0.000002114 L _{3.2306}	W = 0.000001093 L _{3.3892}	Significant
<i>M. monoceros</i>	W = 0.00004248 L _{2.6288}	W = 0.000000808 L _{3.4502}	Significant
<i>P. styliifera</i>	W = 0.00003652 L _{2.5978}	W = 0.00000281 L _{3.1688}	Not Significant
<i>S. crassicornis</i>	W = 0.00051502 L _{2.0495}	W = 0.04460042 L _{1.1455}	Significant

scope to increase the fishing effort. This is further supported by the fact that prawns being short lived (life span of 15-20 months), will be lost to the fishery if not harvested. Moreover mature females as well as undersized ones (juveniles) were not caught in any considerable quantities from the fishing grounds which indicate that the fishery is perhaps dependent upon recruitment from elsewhere. Actually during 1986-'87 the effort was reported to have reached the maximum (1545 thousand hours) and the catch of 9170 t of prawns was well above the annual average of 8290 t. The biomass being highest in September, exploitation can be increased during this month in particular.

The annual mean length of the species showed an inverse relation to the magnitude of the fishery in most of the years. It was found to be the lowest when the fishery was at its height which is indicative of better recruitment in those years.

Shaikhmahmud and Tembe (1960) from their observations at Bombay, state that "it is difficult to comment upon the breeding habits of penaeid prawns". Most of the species investigated by them from 10-20 m depth area were in immature stage. Kagwade (1980) who conducted studies on material collected upto a

from 20-60 m depth, the breeding habit of prawns is still a puzzle as it has not helped to indicate the spawning grounds. The occurrence of mature females was found to be generally poor. Majority of the specimens caught was in immature or early maturing stage. It may appear therefore that the spawning grounds are elsewhere, but not in the deeper areas since the trawling surveys conducted by the Indo-Polish vessel revealed very little prawn resource in 60-125 m depth (Bapat *et al.*, 1982).

Although all the species breed continuously they seem to have a spawning peak which occurs during the southwest monsoon period of June — September as seen from the distribution of monthly mean length. Majority size of the species caught is above the known size at maturity except in the case of *M. monoceros*. Thus in a large number of species, juveniles were not caught thereby affording a chance to grow to mature size.

Females preponderated almost throughout the period in the exploited population. This may be due to the death of males in large numbers after mating (Pope, 1984) and not due to sexual segregation as hitherto been indicated (George and Rao, 1965). This may also partly explain the existence of disparity in the maximum size attained by either sexes.

REFERENCES

- BAPAT, S. V. AND OTHERS 1982. Fishery resources of the Exclusive Economic Zone of the northwest coast of India. *CMFRI Bull.*, **33** : 1-86.
- GEORGE, M. J. 1959. Notes on the bionomics of the prawn *Metapenaeus monoceros* (Fabricius). *Indian J. Fish.*, **6** : 268-279.
- 1961. Studies on the prawn fishery of Cochin and Alleppey Coasts. *Ibid.*, **8** : 75-95.
- , K. RAMAN AND P. KARUNAKARAN NAIR 1968. Observations on the offshore prawn fishery of Cochin. *Ibid.*, **10** : 460-499.
- AND P. V. RAO 1965. Distribution of sex ratios of penaeid prawns in the trawl fishery off Cochin. *Proc. Symp. Crustacea, Mar. Biol. Ass. India*, **2** : 698-700.
- GEORGE, P. C. AND M. J. GEORGE 1964. On the location of a possible spawning area for the penaeid prawn *Metapenaeus monoceros* Fabricius off Cochin. *Curr. Sci.*, **33** (8) : 251 & 252.
- KAGWADE, P. V. 1967. Prawn catches by mechanised vessels in the trawling grounds of Bombay and Saurashtra. *Proc. Symp. Crustacea, Mar. Biol. Ass. India*, **4** : 1348-1381.
- 1980. Maturity size of the female population of certain commercial prawns from Bombay. *Indian J. Mar. Sci.*, **9** : 294-295.
- KUNJU, M. M. 1967. Observations on the prawn fishery of the Maharashtra Coast. *Proc. Symp. Crustacea, Mar. Biol. Ass. India*, **4** : 1382-1397.
- 1968. Some aspects of the biology of *Solenocera indica* Nataraj. *FAO. Fish. Rep.*, **57** (2) : 467-486.
- MENON, K. K. 1980. Observations on the occurrence of penaeid postlarvae in Korapuzha Estuary. *Indian J. Fish.*, **27** : 236-243.
- MENON, M. K. 1953. Notes on the bionomics and fishery of the prawn *Parapenaeopsis stylifera* (M. Edw.) in the Malabar Coast. *J. Zool. Soc. India*, **5** (1) : 153-162.
- MOHAMED, K. H. 1967. Penaeid prawns in the commercial shrimp fisheries of Bombay with notes on species and size fluctuations. *Proc. Symp. Crustacea, Mar. Biol. Ass. India*, **4** : 1408-1418.
- NAGABUSHANAM, R. AND G. K. KULKARNI 1982. Reproductive biology of the female *Parapenaeopsis hardwickii* (Miers). *Indian J. Fish.*, **29** : 151-159.
- POPE 1984. Notes on the scientific problems of TAC management. *FAO Fish. Rept.*, **289** suppl. **2** : 1-214.
- RAI, H. S. 1933. Shell fisheries of Bombay Presidency. *J. Bombay Nat. Hist. Soc.*, **36** (4) : 884-897.
- RAJE, P. C. AND M. C. RANADE 1972. Larval development of Indian penaeid shrimp : I. *Penaeus merguensis* De Man. *J. Indian Fish. Ass.*, **2** : 1-16.
- AND N. R. RANADE 1972. Larval development of Indian penaeid shrimp : II *Metapenaeus monoceros* (Fabricius). *Ibid.*, **2** : 38-40.
- RAJAN, K. N., K. K. SUKUMARAN AND S. K. PILLAI 1982. On the dol-net prawn fishery of Bombay during 1966-'76. *Indian J. Fish.*, **29** : 29-36.
- RAMAMURTHY, S. 1967. Studies on the prawn fishery of Kutch. *Proc. Symp. Crustacea, Mar. Biol. Ass. India*, **4** : 1424-1436.
- , N. S. KURUP AND G. G. ANNIGERI 1975. Studies on the fishery and biology of the penaeid prawn *Metapenaeus affinis* (M. Edw.) in the Mangalore Coast. *Ibid.*, **22** : 243-254.
- AND A. Y. MESTRY 1983. Unusual heavy landings of penaeid prawns at Bombay. *Mar. Fish. Infor. Serv. T & E Ser.*, **48** : 16.
- AND ——— 1985. Heavy landings of *Parapenaeopsis stylifera* (M. Edw.) at Bombay during postmonsoon, 1984. *Ibid.*, **65** : 18.
- RAO, P. V. 1968. Maturation and spawning of the penaeid prawns of the southwest coast of India. *FAO Fish. Rep.*, **57** (2) : 285-304.
- SHAIKHAHMUD, F. S. AND V. B. TEMBE 1960. Study of the Bombay prawns — the seasonal fluctuations and variations in abundance of the commercially important species of Bombay prawns with brief note on their size, state of maturity and sex ratio. *Indian J. Fish.*, **7** (1) : 69-81.
- AND ——— 1961. A brief account of the changes in the developing ovary of penaeid prawn *Parapenaeopsis stylifera* (M. Edw.) in relation to maturation and spawning cycle. *J. Bombay Univ.*, **29** (3 & 5) : 62-77.
- SIDDEEK, M. S. M. 1986. Studies on mesh selectivity and performance of the new fish cum prawn trawl at Pesalai, Sri Lanka. *BOBP/Misc/3*, Development of Small Scale Fisheries, Madras. pp. 1-25.
- SUBRAHMANYAM, C. B. 1963. Notes on the bionomics of the penaeid prawn *Metapenaeus affinis* (M. Edw.) of the Malabar Coast. *Indian J. Fish. J. Fish.* **10** (1) : 11-22.
- SUKUMARAN, K. K. 1978. Studies on the fishery and biology of *Solenocera crassicornis* (H. Milne Edw.) from Bombay waters. *J. mar. Biol. Ass. India*, **20** : 32-39.
- AND K. N. RAJAN 1981. Studies on the fishery and biology of *Parapenaeopsis hardwickii* (Miers) from Bombay area. *Indian J. Fish.*, **28** : 143-153.