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; Shaikhmohmad 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 Mistry, 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.

The help extended by Shri R. Thiagarajan in the statistical analysing, Shri A. Y. Mistry in the collection of biological data, Shri P. Ramdoss in the preparation of illustrations, Mrs. Rosy Joachim and Shri S. K. Murali in the secretarial work are gratefully acknowledged.

**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):

\[ a = \frac{1}{2}lv \]

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

\[ d = \frac{y}{e} \cdot a \]

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

\[ B = dA \]

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 stylifera* 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

$$ \ln W = \ln a + b \ln L $$

where $\ln W$ is the dependent variable ($Y$), $\ln L$ 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 to 0.82 t/km² in January and September respectively which provides a biomass of 7860 and 20,540 t.

**Species Composition**

The fishery is one of multispecies. The yearly landing of different species, their CPUE and percentage composition during 1979–’85 are represented in Table 2. Based on the annual average catch, the order of abundance of

<table>
<thead>
<tr>
<th>Year</th>
<th>Effort in 100 Hours</th>
<th>Catch (1000 t)</th>
<th>C/hr (kg)</th>
<th>% in all fish</th>
<th>Density (kg/ha)</th>
<th>Biomass (1000 t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978-79</td>
<td>990.1</td>
<td>8.24</td>
<td>8.3</td>
<td>26.6</td>
<td>5.93</td>
<td>14.82</td>
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<td>1979-80</td>
<td>1043.5</td>
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<td>37.8</td>
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<tr>
<td>1984-85</td>
<td>1246.1</td>
<td>12.13-</td>
<td>9.7</td>
<td>32.7</td>
<td>6.93</td>
<td>17.32</td>
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**Average**

<table>
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<tr>
<th>Effort in 100 Hours</th>
<th>Catch (1000 t)</th>
<th>C/hr (kg)</th>
<th>% in all fish</th>
<th>Density (kg/ha)</th>
<th>Biomass (1000 t)</th>
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<td>1158.9</td>
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<td>7.1</td>
<td>28.0</td>
<td>5.11</td>
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**Fig. 2.** Monthly variations in the catch of different commercial species during 1979-85.
<table>
<thead>
<tr>
<th>Year</th>
<th>M. affinis</th>
<th>M. monacera</th>
<th>M. brevicornis</th>
<th>P. stylirostra</th>
<th>P. hardwickii</th>
<th>S. crassicornis</th>
<th>Penaeus spp.</th>
<th>M. stridulans</th>
<th>Other penaeid</th>
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<tr>
<td>1979-80</td>
<td>1086.1</td>
<td>467.0</td>
<td>74.1</td>
<td>1993.4</td>
<td>179.5</td>
<td>1460.7</td>
<td>114.5</td>
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<td>42.0</td>
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<tr>
<td>%</td>
<td>20.0</td>
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<td>1.4</td>
<td>3.6</td>
<td>3.3</td>
<td>26.9</td>
<td>2.1</td>
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<td>0.8</td>
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<td>1980-81</td>
<td>1492.7</td>
<td>631.6</td>
<td>151.8</td>
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<td>212.7</td>
<td>1417.5</td>
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<tr>
<td>%</td>
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<td>17.8</td>
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<td>0.1</td>
<td>0.4</td>
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<td>1981-82</td>
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<td>396.3</td>
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<td>178.4</td>
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<tr>
<td>%</td>
<td>20.3</td>
<td>24.6</td>
<td>2.2</td>
<td>2.4</td>
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<td>15.1</td>
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<tr>
<td>1983-84</td>
<td>1933.8</td>
<td>1409.0</td>
<td>98.3</td>
<td>3593.1</td>
<td>217.6</td>
<td>770.0</td>
<td>365.5</td>
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<td>186.0</td>
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<tr>
<td>%</td>
<td>21.3</td>
<td>15.5</td>
<td>1.1</td>
<td>3.9</td>
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<td>8.5</td>
<td>4.0</td>
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<td>2.0</td>
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<td>1984-85</td>
<td>2221.2</td>
<td>970.8</td>
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<td>5664.8</td>
<td>503.3</td>
<td>1039.4</td>
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<td>96.5</td>
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<tr>
<td>%</td>
<td>18.3</td>
<td>8.0</td>
<td>2.3</td>
<td>4.6</td>
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<td>3.8</td>
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<tr>
<td>Average</td>
<td>1621.5</td>
<td>1050.4</td>
<td>142.4</td>
<td>3218.5</td>
<td>279.8</td>
<td>1295.2</td>
<td>265.7</td>
<td>360.0</td>
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</tr>
<tr>
<td>%</td>
<td>19.6</td>
<td>12.7</td>
<td>1.7</td>
<td>3.8</td>
<td>3.4</td>
<td>15.6</td>
<td>3.2</td>
<td>4.3</td>
<td>0.7</td>
</tr>
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</table>
different species was *Parapeneaepsis stylifera*, *Metapeneaepsis affinis*, *Solenocera crassicornis*, *M. monoceros*, *Metapeneaepsis 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 *Trachypenea curvirostris* and *Parapeneaepsis 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 lien 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 (Subrahmanyan, 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 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 (Shaikhmammad 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 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 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. styliifera*: For males the monthly mean length ranged from 76.5 to 107.8 mm and for 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 second 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

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

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<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
<td>M</td>
<td>F</td>
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<tr>
<td><em>M. affinis</em></td>
<td>113.2</td>
<td>130.6</td>
<td>117.5</td>
<td>123.7</td>
<td>121.2</td>
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<td><em>M. monoceros</em></td>
<td>124.1</td>
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<td>87.6</td>
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<td><em>S. crassicornis</em></td>
<td>68.8</td>
<td>92.5</td>
<td>65.9</td>
<td>85.8</td>
<td>65.2</td>
<td>82.7</td>
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APRIL — MAY (RamaMurthy, 1980). Along the Malabar Coast, it was during OCTOBER — DECEMBER (Menon, 1953). At Cochin, NOVEMBER — JANUARY and APRIL are the peak 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 lien. 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 panaeids 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 a 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>
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<th>Species</th>
<th>Male</th>
<th>Female</th>
<th>Significance at 1% Level</th>
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<tbody>
<tr>
<td>M. affinis</td>
<td>( W = 0.000002114 \ L^2.2336 )</td>
<td>( W = 0.000001093 \ L^3.3402 )</td>
<td>Significant</td>
</tr>
<tr>
<td>M. monoceros</td>
<td>( W = 0.000004248 \ L^2.6288 )</td>
<td>( W = 0.000000808 \ L^3.4502 )</td>
<td>Significant</td>
</tr>
<tr>
<td>P. styliifera</td>
<td>( W = 0.00003652 \ L^2.5978 )</td>
<td>( W = 0.00000281 \ L^3.1668 )</td>
<td>Not Significant</td>
</tr>
<tr>
<td>S. crassicornis</td>
<td>( W = 0.00051502 \ L^2.0495 )</td>
<td>( W = 0.04460042 \ L^1.1455 )</td>
<td>Significant</td>
</tr>
</tbody>
</table>

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.

Shaikhamrud 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 up to 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


