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POPULATION DYNAMICS AND STOCK ASSESSMENT OF HERMAPHRODITE PRAWN *EXHIPPOLYSMATA ENSIROSTRIS* KEMP, AT NAWABUNDER, GUJARAT*

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ABSTRACT

Exhippolysmata ensirostris formed 27% of the non-penaeid prawn landings at Nawabunder, a major dol net centre in Saurashtra. The peak landing period is from October-December with an annual landing of 302.2 t during the period 1983-86. The growth parameters are L_∞ 105.84 mm, t_0 = —0.09 month and K = 0.193 on monthly basis. The total mortality coefficient, 'Z' for the three year period varied from 8.39 to 11.35. The natural mortality] coefficient, is 3.2. The MSY, calculated from the yield per recruit analysis is 334.6 t which is close to the present yield and the exploitation rate is 0.69. In spite of high exploitation rate, the fishery has sustained as the exploited stock consists of large size adults with size at capture (lc = 73.0 mm) which is much higher than the size at 50% maturity (Lt_m 50 = 58 mm).

INTRODUCTION

NON-PENAEID prawns are one of the commercially important groups of crustacean supporting the 'dol' net fishery along the northwest coast of India. Among the non-penaeid prawns *Exhippolysmata ensirostris* (Kemp), is a fairly good sized prawn occurring in good quantities along the Saurashtra Coast of Gujarat. The species is hermaphrodite in nature (Sukumaran, 1973; Kagwade, 1981) and the available information on it includes larval and life history investigations (Bensam and Kartha, 1967; Pillai, 1973) and fishery and biology studies from Bombay waters (Kunju, 1967; Sukumaran, 1979; Kagwade, 1980, 1984). There is little information on its fishery and biology from the Saurashtra waters.

The investigations on population characteristics, dynamics and stock are essential for the rational exploitation of the stock. This is particularly true in the case of caridean prawns which unlike penaeid prawns, have limited fecundity. Due to this fact, the caridean prawns are probably incapable of recovering from heavy fishing mortality (Neal and Maris, 1983). With this in view, it is attempted to study dynamics and assess the stock of *E. ensirostris* from Nawabunder fishing center, one of the major fish landing centers in Gujarat.

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MATERIAL AND METHODS

Six days observations were made at regular interval in a month at Nawabunder landing center. The sampling days, total catch and

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species composition of non-penaeid prawns were recorded. Monthly estimates were made as per the method given by Sekharan and Dhulkhed (1963) and the effort in hauls was standardised as given by Khan (1986). 3-4 samples of *E. ensirostris* were collected every month and total length and maturity stages, as described by Sukumaran (1981), were noted. The length frequency distribution collected on the observation days were raised to day's catch and were further raised to get monthly length composition of the catch. Since the species is hermaphrodite throughout its life (Kagwade, 1981), the individuals were not sexed.

The growth in length was estimated on the basis of monthly modal class progression using scatter diagram technique (Devaraj, 1982). By employing Ford-Walford method (Gulland, 1969) the parameters $L\infty$, K and t_o of the von Bertalanffy growth function were estimated.

For size at 50% maturity, cumulative percentage of individuals in late maturing, matured, ovigerous and in cemented conditions were used.

The total mortality coefficient, Z, was estimated using the method given by Srinath (1986) and the natural mortality coefficient 'M' was calculated by employing Rikhter and Efanov method (1976) using the expression :

$$M = \frac{1.521}{(t_m\ 50)^{0.72}} - 0.155$$

where t_m 50 is age at 50% maturity of the species. For fitting the yield-per-recruit model of Beverton and Holt (1957), the weight asymptote, $W\infty$, was calculated as the weight in grammes at $L\infty$, using length-weight relationship. The age at first capture (t_c), of the exploited phase of population into fishery, was calculated from the 50% cumulative frequency upto the first mode. The age of recruitment (tr) was estimated from the smallest prawn (lower limit of that class interval) observed in the samples.

The maximum substainable yield (MSY) was estimated by obtaining F max and finding the corresponding yield (Corten, 1974).

Results

Fishery : At Nawabunder and practically all along the Saurashtra Coast, the fishing season is from September-October to the end of May, the period between June and September is closed due to monsoon conditions. During the three year period between 1983-86, average landings of non-penaeid prawns were 1119.54 tonnes in which *E. ensirostris* formed 27.02% of the catch (Table 1). *E. ensirostris* occurs throughout the fishing season with maximum landings in November-December, when nearly 60% of the annual catch is landed.

TABLE 1. *Catch, effort and catch per unit effort of* E. ensirostris *during 1983-'86.*

Year	*Efforts (hauls)*	*Catch of* E. ensirostris	*% in total non-penaeid prawns*	*c.p.u.e. (Kg/haul)*
1983-84	59,666	287,210	35.58	4.814
1984-85	78,466	415,364	24.53	5.281
1985-86	70,786	205,078	23.91	2.897
Average	69,639	302,551	27.02	4.345

Growth : During the period, 4,300 specimens were measured ranging in size from 38-98 mm. The modes obtained by the length frequency were plotted against each month and by connecting maximum number of modes it was possible to trace 7 growth curves. The lengths attained at monthly interval from each curve were averaged and from these, parameters of von Bartalanffy growth formula were estimated by employing Ford-Walford graph. The growth parameters are $L\infty$ 105.84 mm, K = 0.193 on monthly basis and t_o = —0.09 months.

From the growth parameters it is seen that *E. ensirostris* attains 71.22 mm and 95.15 mm at the end of 6 months and one year of the age respectively. These findings differ from the studies on growth reported earlier from Bombay waters. Kagwade (1984) concluded that the species attains 60 mm at the end of one year and 90 mm at the end of the 2nd year. Sukumaran (1979) however, stated that 78 mm sized specimen are one year old and the fishery is mostly constituted by O year class.

Length-weight relation: For length-weight relationship 292 specimens ranging in size from 38 mm to 98 mm were measured and weighed with an accuracy of 0.01 g. The relationship is :

$$W = 0.0000155 + L^{2.8522}$$

Using this reltionship the weight asymptote, W∞, was found to be 6.875g.

Fecundity of 30 specimens found out by counting the ova from ovigerous individuals, ranged from 757 to 10,078, in a size range of 49 to 96 mm. The logarithmic linear relationship between size and the fecundity is :

$$\text{Log } Y = 4.2970 + 4.221 \log X$$

where Y is number of eggs and X is total length. The sizes between 68 mm and 83 mm formed the mainstay of the fishery at Nawabunder hence the average fecundity varied between 2740 and 6360.

Mortality estimates: The values of total mortality coefficient Z, for the three years are given in Table 2.

The age of *E. ensirostris* at 50% maturity is 0.35 years and therefore the natural mortality coefficient 'M' by Rikhter and Efanov's method (1976) is 3.08 on annual basis. The fishing mortality coefficient obtained by subs-

TABLE 2. *Mortality coefficients and the stock of* E. ensirostris *at Nawabunder, Gujarat during the period* 1983-86

Year	Z	M	F	U	Yield in kg	Total stock in kg	Standing stock in kg
1983-84 ..	8.39 ± 0.02	3.08	5.31	0.633	287,210	453,728	45,089
1984-85 ..	11.35 ± 0.61	3.08	8.27	0.729	415,364	569,772	50,225
1985-86 ..	10.05 ± 0.19	3.08	6.97	0.694	205,078	295,501	29,423
Mean ..	9.93	3.08	6.85	0.685	302,551	439,667	44,579

Spawning, maturity and fecundity: The spawning of *E. ensirostris* is almost throughout the period with peak during January-March. The population in the exploited stock consists of adult prawns with more than 50% of the exploited prawns in matured and ovigerous condition. The size at first maturity is 58 mm. and the smallest matured specimen was 42 mm. This is in close agreement with Sukumaran (1979) and Kagwade (1980).

tracting the natural mortality from total mortality for the three year period is given in Table 2. The exploitation rate $U = F/Z \, (1 - e^{-z})$ is also given in Table 2. The present average annual yield of *E. ensirostris* is 302.55 tonnes hence the standing stock (Y/F) and total annual stock (Y/U) are 44.579 and 439.667 tonnes respectively.

Yield-per-recruit: Dol net, with 15-20 mm cod end mesh size, is a nonselective gear, therefore for fitting the yield per recruit model of Beverton and Holt (1957), the length at first capture (lc) is derived by taking the 50% length of the selection curve. The lc is found to be 73 mm and correspondingly the age (tc) is 0.502 years. The smallest prawn observed in the catch was 38 mm therefore age at recruitment (tr) is calculated for its lower limit of its size group *i.e.* 36 mm. The age at recruitment (tr) is thus 0.172 years.

is estimated at a point at which the slope of the Yw/R curve is one-tenth of the slope at the origin (Zuboy and Jones, 1980). The value of F max thus obtained is 22.59 and the corresponding Yw/R is 0.8136. With the present average yield of 302.55 tonnes the Yw/R is 0.7357g therefore maximum sustainable yield (MSY), at F max works out to 334.6 tonnes. This is close to the present average yield of 302.55 tonnes.

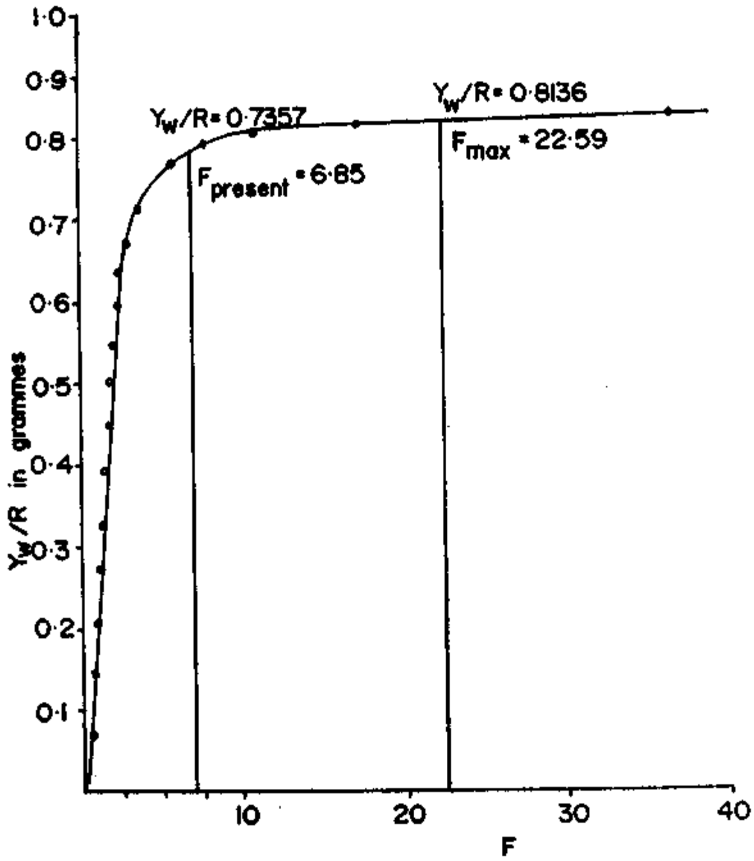

Fig. 1. Yield per recruit curve of *E. ensirostris*.

Yield per recruit (Yw/R) as a function of fishing mortality (F), with 'M' at 3.08 and tc at 0.502 year, shows a flat topped curve without an indication of a peak or decline with any further increase in 'F' (Fig. 1). Under such conditions the F max or optimum 'F'

DISCUSSION

The shape of a yield per recruit curve is largely determined by the growth and natural mortality coefficients of the stock (Beverton and Holt, 1957). The stock of *E. ensirostris* at Nawabunder, exhibits growth coefficient which is relatively lower (K = 0.193) than the natural mortality coefficient (0.252). Due to this the yield per recruit curve is flat-topped without a clearly defined maximum point (F max) on the curve. This may suggest that there cannot be reduction in yield even at higher fishing intensity. It may further imply that stock can sustain high fishing mortality without fear of overfishing. But under such circumstances only species with high biotic potential could sustain the stock. Silas *et al.* (1983) suggested that penaeid prawns are annual stocks with high natural mortality and it would be advisable to fish them hard. The penaeid prawns with very high fecundity coupled with multiple spawning have tremendous biotic potential (Etzold and Christmas, 1977); their recruitment to the fishery is independent of the spawning stock and relatively few individuals of the spawning stock left can replenish the stock (Garcia and Le Reste, 1981). However, the penaeid prawns have long larval life-cycle and they have to pass through several larval phases. The carideans, on the contrary, have abbreviated larval life, but relatively less fecundity (Neal and Maris, 1983).

E. ensirostris, a caridean prawn with fecundity limited to 3000-6000, is a continuous spawner. However, larval life-cycle of this species is very critical unlike other carideans. During the larval metamorphosis of it from Zoea III onwards, heavy mortality occurs owing to highly elongated 5th pereopod in subsequent larval forms (Pillai, 1974). Thus, *E. ensirostris* with low fecundity and critical larval life has poor biotic potential when compared with the penaeid prawns. Therefore in this context, the exploitation rate of 0.69 can be considered very high. Obviously stock of this prawn has a danger of being overfished to the extent of total depletion, if the fishing intensity is increased indiscriminately as indicated by the Yw/R curve.

The Yw/R curve shows that the 'F max' is 22.59 and the corresponding yield would be 334.6 tonnes whereas the present 'F' is 6.85 and the yield is 302.5 tonnes. This indicates that by increasing the effort by nearly three times the present level, the yield would increase by 10.6 % only, which could be an unattainable management goal due to economical reasons. Further, *E. ensirostris* is the bycatch in dol nets, the target species for the dol net fishery at Nawabunder being Bombay duck *Harpodon nehereus*. The present yield of Bombay duck has already reached the MSY level (Khan, 1986), hence further increase in effort would not be advisable for increasing the yield of *E. ensirostris*. However, it is noteworthy that the effort in terms of number of hauls has been showing increasing trend from 37,108 in 1976-77 (Khan, 1986) to the present level of 69, 639 hauls.

At present, in spite of high exploitation of *E. ensirostris* at Nawabunder, the stock is maintained and does not show signs of depletion. This can be largely attributed to the fact that the size at first capture is much higher (tc = 73 mm) than the size at first maturity (tm 50 = 58 mm). Owing to this, before the stock reaches the exploitate size, well over 80% of the stock gets a chance of breeding, as a result perpetuation of species and recruitment occurs and the stock remain unaffected. Secondly, the fishing at Nawabunder is closed during monsoon. Sukumaran (1979) has observed that monsoon is the peak breeding period of this species in Bomaby waters. If the same is true for Nawabunder, then the species gets protection during its breeding period also. The stock may however, get affected, in future, if the size at first capture is smaller than the size at first maturity, by reducing the cod end mesh size, coupled with nonclosure of the fishing activity in the monsoon months.

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