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ESTIMATES OF THE STOCKS OF THE SPINY LOBSTER *PANULIRUS POLYPHAGUS* (HERBST) IN THE TRAWLING GROUNDS OFF BOMBAY*

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ABSTRACT

Panulirus polyphagus is one of the major species contributing about 87.2% to the average annual landings of 341 tonnes of the spiny lobsters landed at 6 selected lobster landing centres of this country during 1978-85. This particular species is landed in 4 of those selected centres and among them Bombay contributed as much as 63.67% to it.

Stock studies reveal that total mortality coefficient 'Z' is 1.76 for males and 1.15 for females. Growth parameters determined by Kagwade (1987 a) are made use of in estimating the natural mortality coefficient 'M', the values of which are 0.33 for males and 0.35 for females. The fishing mortality coefficient 'F' deduced from these, equals 1.43 for males and 0.80 for females. The total stock estimated is 452.66 t, the standing stock is 271.12 t, and the maximum sustainable yield is 168.42 t.

INTRODUCTION

THE SPINY LOBSTER *Panulirus polyphagus* belongs to the species that have fisheries of low density, a character typical to tropical species. This species is gregarious and is known to inhabit the waters upto 70 metres. Among the 6 species of Paniluridae common to Indian waters, *P. polyphagus* is the major one meeting the ever growing demand of the export market. The six selected lobster landing centres - Veraval, Bombay, Calicut, Cochin, Tuticorin and Madras have shown that *P. polyphagus* is the most dominant of all other species, its average annual catch has been 341 tonnes forming 87.2% during the period 1978-85 and it has occurred in fisheries abundance in the four centres of Veraval, Bombay, Calicut and Madras among which Bombay alone has contributed as much as 63.67% to it (Kagwade *et al.*, MS).

No work on population dynamics is available so far for any of the lobster species in India. An attempt is made here to study the same in respect to *P. polyphagus* in the trawling grounds off Bombay.

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DATA BASE

P. polyphagus are landed as by-catch in the shrimp and fish trawl nets at the two major landing centres of Sassoon Docks and New Ferry Wharf in Bombay. The fishing grounds have been between 17°N and 20°N upto the

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depth of 70 metres. Data used for this paper are from these sources and pertain to the period 1976-86. Using the length weight relationships

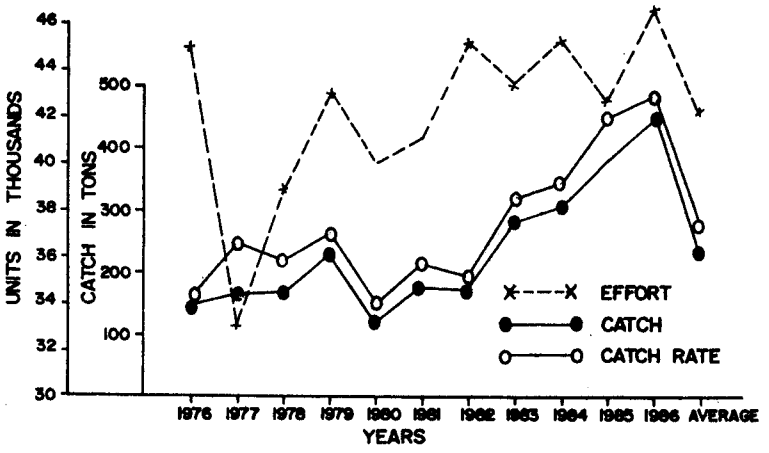

FIG. 1. Annual catch, effort and catch rate of lobsters during 1976-86.

(Kagwade, 1987 a), weight of the sampled landings are estimated and further the length frequency distribution of the total landings for each month is calculated separately for males and females.

CATCH ABUNDANCE

The annual catch of *P. polyphagus* at Bombay as seen in Fig. 1, fluctuates between 119 t at the rate of 2.98 kg/unit in 1980 and 450 t at the rate of 9.68 kg/unit in 1986, giving an average annual catch of 236 t at the rate of 5.38 kg/unit. The catch as well as catch rate were above the average annual values after 1982. Except for the 4 years 1977, 1978, 1980 and 1981, however, the number of units operated (effort) are above the average annual value in all the years. The fishery presents a picture of a steady increase over the years.

GROWTH PARAMETERS

Growth in *P. polyphagus* has been described by Kagwade (1987 b) who has pointed out that the growth in the juvenile phase lasting for 3 years in the case of females and 4 years in the case of males is constant at the rate of 60 mm per year, thus demonstrating Arithmetic growth while the growth in the adults is retrogressive geometric growth. Because of this peculiar nature of growth which is common to all crustaceans, Kagwade (1987 b) has been able to apply the von Bertalanffy's growth formula to only the adults as they form bulk of the fishery and also as they alone record successive decrease in the annual growth increments, a pre-requisite condition required for this formula and estimated the following growth parameters for this species from the equation —

$$L_t = L_\infty [\, 1 - e^{-k(t-t_0)} \,]$$

		Males	Females
L_∞	...	537 mm	443 mm
K	...	0.2	0.2231
t_0	...	0.6037	0.1985

STOCK ESTIMATION

(i) Estimation of 'Z', the instantaneous rate of total mortality :

Using the length frequency distribution the instantaneous rate of total mortality 'Z' is estimated by the method described by Alagaraja (1984) for each of the 11 years from 1976 to 1986 for males and females separately. The formula used in this method is —

$$Log\ (N_t + \Delta_t N_t) = \frac{Z}{K} = log_e \frac{L\infty - Lt + \Delta t}{L\infty - Lt}$$

$$M = Z = \frac{1}{t_{max-1}}\ log_e \frac{Nt}{Nt_{max}}$$

where t_{max} = maximum age which is 15 years for males and 14 years for females.

Nt = number of one year old

Nt_{max} = number at the maximum age in the population.

TABLE 1. *Annual sex-wise 'Z' value and the standard error for* P. polyphagus *during 1976-86*

Year	Male		Female	
	Z	Std. error	Z	Std. error
1976	1.64	0.3725	1.05	0.2060
1977	1.48	0.2344	0.96	0.2054
1978	1.50	0.5727	1.34	0.2960
1979	1.44	0.3536	1.03	0.2285
1980	1.65	0.5526	1.21	0.3003
1981	1.94	0.3410	1.29	0.3060
1982	2.41	0.7758	1.43	0.4436
1983	1.70	0.5215	0.97	0.3401
1984	1.95	0.5654	1.22	0.4183
1985	2.23	0.5075	1.38	0.4726
1986	1.41	0.4068	0.77	0.2885
Average	1.76		1.15	

Three point moving average are made use of in the analysis. Portion of the length frequency distribution resembling the right limb of the catch curve alone is considered for the estimation of 'Z'. Multiplying $\bar{Z}/K$ by the growth parameter K, the values of 'Z' and the standard error are estimated for *P. polyphagus*. Table 1 shows the values of 'Z' and the standard error for different years for males and females. The average annual value estimated for 'Z' is 1.76 for males and 1.15 for females.

(ii) Estimation of 'M', the instantaneous natural mortality rate :

The various methods employed to estimate the value of 'M' have shown that the value arrived at by Cushing (1968) is more appropriate in view of the higher longevity of the species and the formula used for it is —

From the above it is noted that M = 0.33 for males and 0.35 for females.

(iii) Deduction of 'F', the instantaneous fishing mortality rate :

F = Z - M
= 1.76 - 0.33
= 1.43 for males and
= 1.15 - 0.35
= 0.8 for females.

Thus the mortality parameters for the two sexes are :

		Males	Females
Z	=	1.76	1.15
M	=	0.33	0.35
F	=	1.43	0.80

RESULTS AND DISCUSSION

The exploitation rate U $= \frac{F}{Z}(1 - e^{-z})\,1$

Total stock $= \frac{Y}{U}$

Standing crop $= \frac{Y}{P}$

Exploitation ratio E $= \frac{F}{Z}$

have been calculated for the annual catch (Y in tonnes) by making use of the growth and mortality parameters for the period 1976 to '86 and presented in Tables 2 and 3 for males and females of *P. polyphagus* respectively.

In the case of lightly exploited stock for calculating MSY, the maximum sustainable yield, Gulland (1979) gave the expression :

$$MSY = Z_t\ 0.5.Bt$$

where Zt = total mortality at the time t and Bt = standing stock.

Lobster being a by-catch in the fish and shrimp trawl, it is assumed to be not so heavily exploited in the present study. Hence, making use of the above formula the annual MSY for males and females are worked out and incorporated in Tables 2 and 3 respectively.

It is seen from Table 2 that the average annual MSY for the period 1976 to '86 for males is 68.08 tonnes which is far below the average annual yield of 109.5 tonnes and the average annual exploitation ratio is as high as 0.81. The average annual MSY for females (Table 3) is 100.34 tonnes which again is far below the average annual yield of 134 tonnes while the average annual exploitation ratio is slightly lower being 0.68.

TABLE 2. *Annual estimated total stock, standing stock, exploitation rate, exploitation ratio and MSY for male* P. polyphagus *during 1976-1986*

Year	Yield Y(tonnes)	Exploitation rate (U)	Total stock P(tonnes)	Standing stock (tonnes)	Exploitation ratio - E	MSY (tonnes)
1976	75.1	0.64	117.28	57.30	0.80	46.99
1977	79.6	0.60	132.67	69.22	0.78	51.22
1978	82.1	0.61	134.54	70.14	0.78	52.60
1979	105.3	0.59	178.46	94.86	0.77	68.30
1980	87.6	0.65	134.78	66.37	0.80	54.75
1981	76.0	0.71	107.03	47.20	0.83	45.78
1982	75.1	0.78	96.28	36.11	0.86	43.51
1983	135.9	0.66	205.88	99.18	0.81	84.30
1984	132.3	0.71	186.30	81.65	0.83	79.61
1985	162.1	0.76	213.32	85.33	0.85	95.14
1986	194.0	0.58	334.53	179.66	0.76	126.66
Average	109.5	0.66	167.37	80.64	0.81	68.08

This study demonstrates that the MSY for females is 1.5 times that for males. Kagwade (1987 b) has reported that between 210 and 330 mm, the size contributing to bulk of the fishery, the females preponderate and this observation further supports the view that the total stock of the females is larger than that of males.

The combined average annual stock of males and females estimated is very low against the yield (Table 4) and this forewarns the signal to be cautious in the exploitation of this species from the trawling grounds off Bombay in spite

of a sound picture of steady rise in the yield mentioned earlier. Gulland (1971) assumes that when F = M, the sustainable yield is optimum at the exploitation ratio of 0.5. Hoever, in the present study, the exploitation ratio estimated is very much higher than 0.5 for both the sexes

The spiny lobster fisheries of the West coast of Africa, New Zealand and Western Australia have declined over the years (Cobb and Phillips, 1980) due to heavy exploitation. Some of them have introduced legal minimum size for capture, decreased the fishing effort

TABLE 3. *Annual estimated total stock, standing stock, exploitation rate, exploitation ratio and MSY for female* P. polyphagus *during 1976-1986*

Year	Yield Y (tonnes)	Exploitation rate U	Total stock P (tonnes)	Standing stock (tonnes)	Exploitation ratio - E	MSY (tonnes)
1976	70.1	0.43	162.93	100.09	0.67	52.55
1977	83.9	0.39	215.03	137.47	0.63	65.99
1978	86.9	0.54	160.93	87.78	0.74	58.81
1979	119.5	0.42	284.48	175.71	0.66	90.49
1980	111.7	0.50	223.48	129.93	0.71	78.61
1981	100.3	0.53	189.34	106.75	0.73	68.85
1982	100.8	0.57	176.93	93.38	0.75	66.77
1983	146.4	0.40	365.92	236.08	0.64	114.50
1984	176.5	0.50	353.10	202.93	0.71	123.79
1985	221.9	0.56	396.23	215.43	0.75	148.65
1986	256.1	0.29	609.69	609.79	0.54	234.77
Average	134.0	0.47	285.29	190.48	0.68	100.34

TABLE 4. *Average annual stock estimates in tonnes of* P. polyphagus *during 1976-1986*

Sex	Yield	Total stock	Standing stock	MSY
Male	109.5	167.37	80.64	68.08
Female	134.0	285.29	190.48	100.34
	243.5	452.66	271.12	168.42

and hence the species requires careful monitoring to know its fishing trend.

Kagwade (1988) has reported that the percentages of ovigerous females of *P. polyphagus* ranged between 24.8 and 40.7 during 1976-1985 giving an average of 33.4% per year. It is noticed during the course of this study that the percentage of ovigerous females have come down to 28.9 in 1986 and to 15.3 in 1987 till the month of November. This drastic fall in the percentage of females may further add to the deterioration of the stock which is already under stress.

by reducing the number of licensed vessels, protected ovigerous females by throwing back into the sea and also have closed the fishing season. However, *P. polyphagus* is only a by-catch in the fish or shrimp trawl nets contributing to less than 0.2 to 0.3% anually to the all fish catch (Kagwade *et al.*, MS), in India. Hence, introducing any managerial measure will be difficult at the expense of other major fisheries from the trawling grounds off Bombay. Under the circumstances, the only measure left is to release the ovigerous females back into the sea by carefully handling, so that

their appendages are kept intact in order to increase their survival rate. The present study is the first of its kind in the population dynamics of this species. The fact that this is a luxury item, much sought after by the public for consumption and the traders for earning a foreign exchange, great care must be taken at every stage to protect this species by keeping a close watch on its population dynamics and also on the dynamics of reproduction.

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