

Biology and exploitation of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758), from south Karnataka coast, India

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ABSTRACT

Portunus pelagicus supports indigenous as well as mechanised fishery of Karnataka coast. Trawlers accounted for 98% of the landing and the highest landing was observed during 2001-2002 (403 t). The peak fishing season for crabs was during December-June. Size range observed in the fishery was 56 to 165 mm in males and 61 to 170 mm in females. The homogeneity of sex ratio (χ^2 test) obtained for the years 1998-2005 was 1:1. Peak spawning activity occurred during February-March. Size at maturity (50%) of females was estimated at 96 mm carapace width. Growth was isometric and males were heavier than females of similar size. By von Bertalanffy's growth plot, it was estimated that males and females reach 123 and 128 mm (CW) respectively at the end of one year and reach 156 and 160 mm respectively in two years. Longevity of *P. pelagicus* is estimated as 3 years in both sexes. The total mortality coefficient (Z), natural mortality coefficient (M) and fishing mortality coefficient (F) values estimated for the species were 6.3, 2.2 and 4.1 respectively. The exploitation ratio (E) was 0.65 and L_c was estimated at 87.7 mm. MSY was estimated as 367 t against the present annual average yield of 333 t. From Thompson and Bell yield prediction analysis it is seen that any additional 10% effort from the present level will yield only less than 10% additional catch, indicating that increasing the effort will not be economical. Restricting the catch to MSY level (367 t) is suggested as a suitable management option for the sustainability of *P. pelagicus* fishery from the coast.

Introduction

The blue swimmer crab (*Portunus pelagicus*) supports substantial commercial fishery and is an important component of traditional fisheries in Karnataka and other parts of the country. Though the commercial catches of *P. pelagicus* in Karnataka was growing rapidly from 86 t in 1980-1981 to 403 t in 2001-2002, the catch rate (catch per hour) during 1980-1981 was 0.44 (Sukumaran and Neelakantan, 1996), whereas during 2001-2002 it was reduced to 0.11. Due to the high demand in local market, the species is exploited heavily from estuaries, inshore waters as well as off shore waters. The species is also identified as a candidate for culture, domestication and stock enhancement (Williams and Primavera, 2001; Josileen and Menon, 2004).

Although the species is having wide distribution in near shore marine and estuarine waters throughout Indo-west Pacific (Stephenson, 1962), most of the studies pertaining to its biology and stock parameters were limited to the population from estuarine and embankment areas (Kangas, 2000). In India, George and Naik (1962) and Sukumaran and Neelakantan (1996 a) described the crab fishery of Karnataka coast. Sukumaran and Neelakantan (1996 a,b,c; 1997 a,b) conducted elaborate studies on the crab fishery and biology along Karnataka coast during early

nineties. During late nineties, significant changes have occurred in the trawl fishery in terms of depth, extend and period of operation and these developments might have put heavy stress on the stock of the resources. Despite the economic significance, the population dynamics of the species remain poorly understood and it was felt necessary to conduct a detailed study on the fishery, size distribution, sex-ratio, maturity, spawning season, growth and stock parameters to understand the impact of these on the stock.

Materials and methods

Data on crab catch and effort were collected from Mangalore and Malpe fishing harbours on an average of 8 days per month (2 days a week) during 1998-2005. Detailed studies on catch, effort and size range of *P. pelagicus* were carried out during this period with the help of catch and effort data and data on carapace width and body weight. Maturity stages of females were determined by classifying the females into five categories namely, immature, early maturing, late maturing, mature and spent based on the fullness of ovary. Berried females were found to occur predominantly with spent and early maturing females (Ryan, 1967). The size at first maturity was found out by plotting logistic curve (King, 1995). Percentage of matured females (beyond late maturing stage) was calculated for each 1mm carapace width size class and

logistic curve was fitted. The length corresponding to 50% of the physiological maturity was taken as size at maturity (50%). Homogeneity of the sex ratio over the years was tested using χ^2 test (Snedecor and Cochran, 1967).

For deriving carapace width-weight relationship, linear equation ($\log W = \log a + b \log L$) was fitted for the log transformed data. Regression analysis was performed to determine the constants a and b and relationship between carapace width and weight. Analysis of covariance (Snedecor and Cochran, 1967) technique was used to test for any significant difference in the relationship in the above parameters between the sexes at 1% level.

Data on carapace width-frequency distribution for a period of five years from January, 2001 to December, 2005 were used for the growth and stock assessment studies. Length frequency data (carapace width) were grouped into 5 mm class interval. The growth parameters were initially estimated by Powell-Wetherall plot, followed by ELEFAN I routine from FiSAT software (Gayaniilo and Pauly, 1997). Since ELEFAN I method is described as more reliable and highly recommended objective method for studying single species dynamics in a multispecies context (Pauly, 1982), the values obtained by this method were used to describe the growth of *P. pelagicus*. t_0 was calculated by Pauly's empirical equation (Pauly, 1979), $\log(-t_0) = -0.392 - 0.275 \log L_\infty - 1.038K$. Growth was calculated using von Bertalanffy's growth formula. Since the growth parameters of both sexes did not vary much, stock assessment of the species was conducted using sex pooled data for the period 2001-2005. The total mortality coefficient (Z) was estimated using length-converted catch curve method of Pauly (1983) and natural mortality coefficient (M) was calculated by Srinath's (1990) empirical formula. The result of cohort analysis of length-frequency data was used as inputs for finding the yield and effort relationship in Thompson and Bell model. Biological reference points E_{max} , $E_{0.1}$ and $E_{0.5}$ were estimated by Beverton and Holt's 'relative yield/recruit model'.

Results and discussion

The fishing ground exploited by indigenous gears are mostly restricted to shallow water region of the coast up to 15 m depth and trawl fishing in deeper waters extends up to 100 m. The fishing ground is generally characterized by muddy or loamy bottom. Indigenous gears like '*matabale*', '*beenibale*', and '*jeppubale*' are operated mainly during the monsoon season, but a few like '*kairampani*' and castnets are operated throughout the year along south Karnataka coast. Since these were operated as a subsistence fishery from different fishing villages, estimation of the catch was not possible. However, when these operations were done in an organized manner during the monsoon months, about 90% of the catch was formed by *P. pelagicus*. Along Mangalore-Malpe coast, maximum catch (12t) was recorded during 2004-2005.

Landing by trawlers

During 1998-2005, fishery was constituted by *P. pelagicus*, *P. sanguinolentus* and *Charybdis feriatus*. The annual *P. pelagicus* catch, total crab catch and other details are given in Table 1. During 1985-1986 the landing of *P. pelagicus* by trawlers at Mangalore-Malpe fisheries harbours was 473 t, which was landed by an effort of less than five lakh trawling hours i.e., 4,78,126 h (Sukumaran and Neelakantan, 1996a) whereas in 2001-2002, fishing hours operated was about four times (18,48,191 h).

Seasonal abundance

Month-wise landing of the species at Mangalore and Malpe fishing harbours (pooled) is given in Fig.1. Even though the trawling season is extended from September to June, peak fishing season for crabs was during December-June. It was reported that *P. pelagicus* migrate to open ocean when the salinity in the coastal water comes down and come near shore when the salinity of the coastal waters become normal (Potter *et al.*, 1983; 1998). In light of this finding, it can be assumed that salinity related off shore migration of the species takes place along Karnataka coast also. Salinity

Table 1. *P. pelagicus* catch (t) at Mangalore and Malpe fisheries harbours (pooled) during 1998-2005

Year	Effort		<i>P. pelagicus</i>		Total crab catch (t)	Catch per unit (kg)	Catch per hour (kg)
	Units	Hours	Catch (t)	%			
1998-1999	58882	1499416	92.00	29.40	313.59	1.56	0.06
1999-2000	53763	1485752	242.10	30.60	792.39	4.50	0.16
2000-2001	65522	1826090	253.10	35.90	705.15	3.86	0.14
2001-2002	62314	1848191	403.10	25.00	1609.51	6.47	0.22
2002-2003	58140	1770223	338.10	38.80	870.85	5.81	0.19
2003-2004	59024	1967472	381.70	34.80	1098.53	6.47	0.19
2004-2005	47213	2215158	219.50	37.50	585.79	4.65	0.10
Average	57837	1801757	275.66	33.14	853.69	4.76	0.15

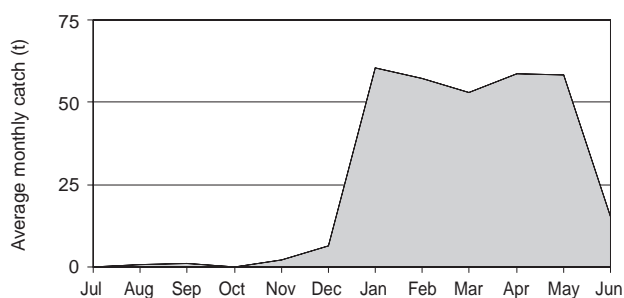


Fig. 1. Seasonal landing pattern of *P. pelagicus* at Mangalore and Malpe fisheries harbours (pooled) during 1998-2005.

of coastal waters of Karnataka during July to September is comparatively low i.e., < 31 ppt (Krishnakumar and Bhat, 2008) as a result of the freshwater influx from monsoon rains and salinity regains normalcy by November-December.

Size range and mean size

Along the coast, size range observed in the fishery was 56 to 165 mm in males and 61 to 170 mm in females. Mean size ranged from 93 to 112 mm. No inverse relationship with the catch and mean size was observed even during the highest landing (2001-2002).

Sex ratio

Male to female sex ratio in *P. pelagicus* for the period 1998-2005 was 51: 49 at both fisheries harbours. Homogeneity of the sex ratio (χ^2 test) of pooled data of both fishing harbours for these period showed that the

proportion conform to 1:1 ratio. However, in Mangalore significant variation of sex ratio (at 1% level) was observed during 1999-2000, 2001-2002 and 2002-2003 (Table 2). In *P. pelagicus* depth-wise and substratum-wise sexual segregation and wide variation in sex ratio was reported by various workers (Potter *et al.*, 1983; Sumpton *et al.*, 1994). Since fishing area for crab fishery off Karnataka coast is extended up to 100 m depth and the crab catch from all the depth zones were landed simultaneously, depth-wise species composition could not be derived from the study.

Maturity and spawning

Mature and berried females were found throughout the fishing period. Studies on the percentage of occurrence of females of advanced ovarian maturity and berried females in the fishery revealed that occurrence of late maturing and matured females were high during February–March every year, confirming that peak spawning occurs during these months. A minor peak was also observed during the end of the trawl fishing season i.e., May–June.

Size at maturity

Size at maturity of females was estimated at 96 mm carapace width. Size at maturity of crabs was found to vary considerably with latitude and location (Campbell and Fielder, 1986; Sukumaran and Neelakantan, 1996a). Potter *et al.* (1998) stated that 50% of the crabs become mature at 98 mm in Peel-Harvey Estuary, and at 97 mm at Leschenault Estuary, Australia. Present study indicated that *P. pelagicus*, reaches sexual maturity within one year

Table 2. Annual sex ratio and test of variation from homogeneity in sex ratio of *P. pelagicus*.

Mangalore Year/sex	Estimated No.		Percentage		χ^2 value
	Male (%)	Female (%)	Male (%)	Female (%)	
1998-99	97090	72640	57	43	2.07
1999-00*	1578600	1056790	60	40	3.92*
2000-01	997560	783790	56	44	1.44
2001-02*	1068680	1664510	39	61	4.75*
2002-03*	378780	545070	41	59	3.24*
2003-04	2167760	2001000	52	48	0.16
2004-05	1125600	920940	55	45	1.00
Total	7414070	7044740	51	49	0.07
Malpe					
1998-99	204050	186100	52	48	0.21
1999-2000	827490	933120	47	53	0.36
2000-01	479510	386030	55	45	1.17
2001-02	1100910	899110	55	45	1.22
2002-03	580240	628590	48	52	0.16
2003-04	733680	733680	50	50	0.00
2004-05	858280	824620	51	49	0.04
Total	4784160	4591250	51	49	0.04

* Significant at 1% level

(8 months) which agrees with the finding of Smith (1982) and Sukumaran and Neelakantan (1996 b).

Carapace width - weight relationship

Carapace width-weight relationship for male ($n=156$) was $W=aL^b$ i.e., $W=0.020056CW^{3.4864}$ ($r=0.992$) and that for females ($n=158$) was, $W=0.02852 CW^{3.22063}$ ($r=0.969$), where W is the weight (in g) and CW the carapace width (in cm).

The regression equations between male and female tested for equality through analysis of covariance showed that the values of slope and elevation differ significantly at 1% level. Present results indicated the tendency of males being heavier than females in this species which is in conformity with earlier observation by Sukumaran and Neelakantan (1997a).

In order to use in the stock assessment studies of the species, carapace width-body weight relations using sex-pooled data were also analysed. Carapace width-weight relation for the sex pooled data ($n=314$) was $W=0.023433CW^{3.36126}$ ($r=0.955$), where W is the weight (in g) and CW the carapace width (in cm).

Growth parameters

The estimated values for L_∞ and K during 2001-2005 period for males were 169 mm and 1.3 yr^{-1} respectively and for the females were 170 mm and 1.4 yr^{-1} . t_0 values estimated by Pauly's (1979) empirical equation for males and females were -0.0428 and -0.0384 respectively. During the present study, comparatively higher K values for females than males was observed, which confirms the findings of Sumpton *et al.* (1994) on the species from Australian waters, which reported values of 1.597 yr^{-1} for males and 1.613 yr^{-1} for females. By von Bertalanffy's growth plot (Fig. 2), it was estimated that males reach 123 mm (CW) in the end of first year, 156 mm (CW) in second year and 166 mm (CW) in third year. Females reached 128 mm in the first year, 160 mm in second year and 167 mm in the

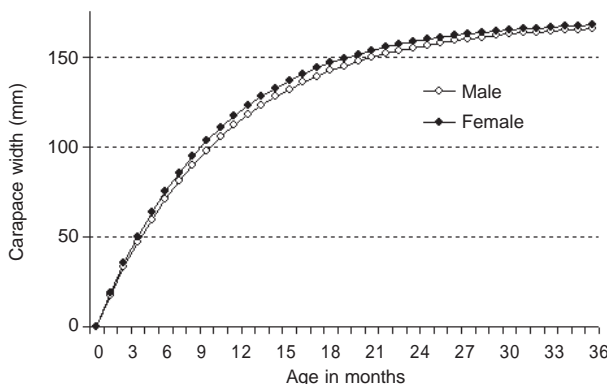


Fig. 2. Von Bertalanffy's growth curve for *P. pelagicus*.

third year. Sukumaran and Neelakantan (1997b) estimated that males reach 145 mm (L_∞ 204 mm; K , 0.97 yr^{-1} and t_0 -0.0691) along Karnataka coast, which is much higher when compared with the present findings. They reported that females reach 132.5 mm (L_∞ 211 mm; K , 1.14 yr^{-1} and t_0 -0.0194) at the end of first year which is in agreement with the findings of the present study. Longevity of the species for males and females were estimated to be 3 years whereas Sukumaran and Neelakantan (1997c) estimated the same as 2 1/2 years. Smith and Sumpton (1987) estimated 3 years as the age of the largest crabs caught from Australian waters.

Stock assessment

The estimated values for L_∞ and K for the period was 174 mm and 1.2 yr^{-1} . t_0 values estimated by Pauly's (1979) empirical equation was -0.0470.

Mortality and selection parameters

The total mortality coefficient (Z) estimated by 'linearized length-converted catch curve' was 6.30. The natural mortality coefficient (M) estimated by Srinath's (1990) formula was 2.2 and fishing mortality coefficient (F) estimated was 4.10. The exploitation ratio (E) was 0.65 (Fig. 3). The results of the length-converted catch curve method were used for the estimation of probabilities of capture and l_c . The selection parameters obtained for *P. pelagicus* by the probability of capture method were $L_{25} = 79.6 \text{ mm}$, $L_{50} = 87.7 \text{ mm}$ and $L_{75} = 93.5 \text{ mm}$.

Using the results obtained from length structured 'virtual population analysis' as input, maximum sustainable yield was calculated from Thomson and Bell prediction

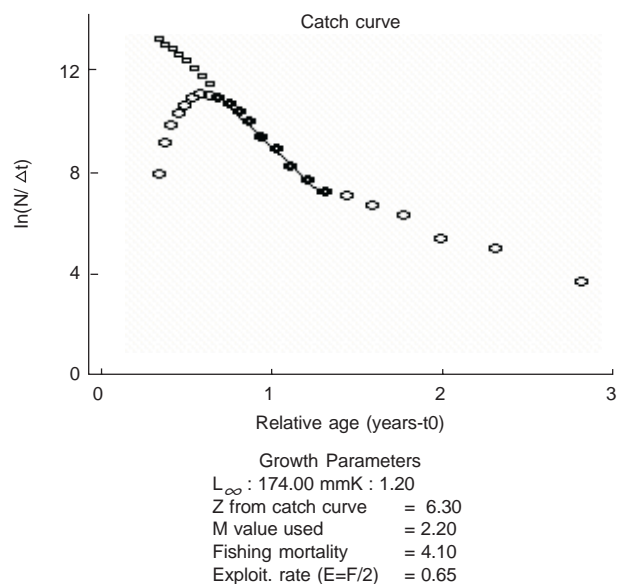


Fig. 3. Length-converted catch curve of *P. pelagicus*.

model (Fig. 4). MSY was estimated as 367 t against the present annual average yield of 333 t. It is observed that during the years 2002 and 2003 the catch was higher than MSY (423 and 404 t respectively) and the fishing beyond MSY level during this period might have caused sudden

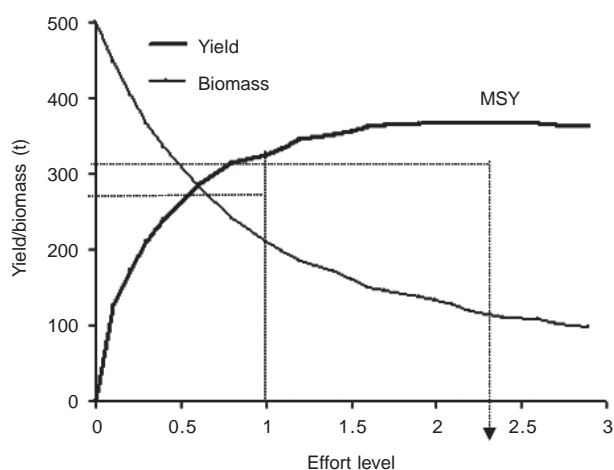


Fig. 4. Thompson and Bell plot for yield and biomass prediction.

reduction of the fishery in 2004 (221 t). Sukumaran and Neelakantan (1996c), while assessing the stock of *P. pelagicus* stated that during 1993-1994 period, the landing is near the MSY level and the effort should be restricted to the average effort level which prevailed during that period (10,32,000 h) to obtain biologically optimum yield. But by 2005, the fishing hours operated became more than double (23,62,000 h) which might have exerted heavy pressure on the stock resulting in wide fluctuations in *P. pelagicus* landing. E_{max} was estimated as 0.73 (Fig.5) and $E_{0.1}$ and $E_{0.5}$ were 0.66 and 0.36 respectively. Thompson and Bell yield prediction analysis showed that any additional 10% effort from the present level will yield only

less than 10% additional catch indicating that increase in the effort for better catch of the resource will not be economical. It is practically difficult to suggest cut off points in exploitation of the species, since the trawling is targeted for many other commercial species and also the fishing ground is being extended every year. However, looking at all the stock parameters available to predict the fishery, it can be suggested that restricting the fishery to MSY level (367 t) will be a suitable management option for sustainable production of the species from the coast.

Acknowledgements

The authors are thankful to Prof. (Dr.) Mohan Joseph Modayil, Director, Central Marine Fisheries Research Institute, Cochin, Dr. E.V. Radhakrishnan, Head, Crustacean Fisheries Division, CMFRI, Dr. Mary. K. Manissery, Principal Scientist CMFRI and Dr. C. Muthiah, Principal Scientist and Scientist-in-charge of Mangalore Research Centre of CMFRI for their constant encouragement and support.

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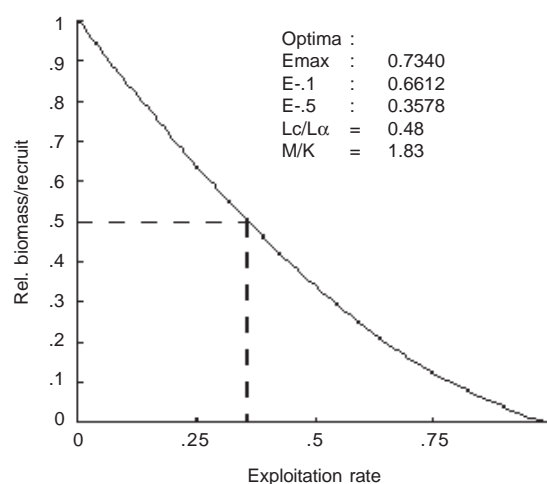
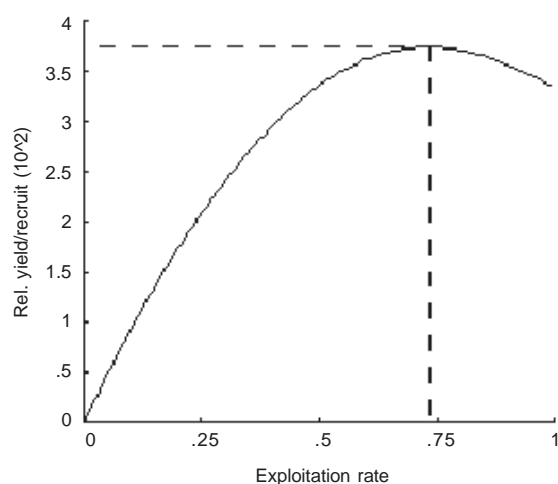


Fig. 5. Yield per recruit analysis of *P. pelagicus*.

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