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Fishery and stock assessment of *Portunus sanguinolentus* (Herbst) from south Karnataka coast, India

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Abstract

The study on the exploited fishery of *Portunus sanguinolentus* off south Karnataka coast during 1998-2005, revealed that it contributed to 46% of the average annual crab landing with peak in May. The carapace width (CW) varied from 61 to170 mm in males and 56 to 160 mm in females. Percentage of females in advanced maturity stage was high during January-March. Size at maturity of females was 90 mm (CW). Carapace width-weight relationship indicated that males are heavier than females and the growth is positive isometric. The longevity of the species was estimated as 2 ½ years and males and females reach 137 mm (CW) at the end of the first year and 163 mm (CW) in two years. Females reached sexual maturity in 6 months. L_∞ and K were estimated as 175 mm and 1.7 year^{-1} respectively. The estimated total mortality coefficient (Z) was 7.15 and fishing mortality coefficient (F) 4.18. The exploitation ratio (E) was 0.58. Size at capture (L_{50}) was 79.2 mm. Estimated total stock was 852 t standing stock was 118 t and the MSY was 544 t. An increase in fishing effort by 10 to 20 % may enhance the catch only by 3 to 4%. It is suggested that for sustaining the fishery, the fishing effort (in hours) may be reduced by 30 to 40% from the present level of exploitation.

Key words: Crabs, *Portunus sanguinolentus*, fishery, stock assessment, Karnataka

Introduction

Introduction of mechanized trawling in the early sixties revolutionized the marine fisheries sector of Karnataka. Till the early nineties, the crab landing of Karnataka was supported by two species, *viz.*, *Portunus pelagicus* and *P. sanguinolentus*. After the introduction of multiday trawling, the crab fishery improved substantially with the addition of other species such as *P. gracillimanus, Charybdis feriatus*, *C. smithi* etc. George and Naik (1962) described the crab fishery of Karnataka coast. Menon (1952), Sukumaran and Neelakantan (1996 a, 1996 b, 1996 c, 1997 a, 1997 b) conducted studies on the fishery and biology of *P. sanguinolentus* from the southwest coast of India. In the present study, the population dynamics of *P. sanguinolentus* was investigated and compared with earlier studies from Karnataka coast.

Materials and Methods

Data on crab catches and effort were collected from Mangalore and Malpe Fishing Harbours for two days a week or for 8 days in a month during 1998-2005. Two categories of trawlers, single day fishing fleet (SDF) and multiday fishing fleet (MDF) were in operation. Samples of *P. sanguinolentus* were collected and carapace width measured. Monthly estimates of catch and effort were made based on the method described by Alagaraja (1984).

Maturity stages of females were determined by classifying them into five categories namely, immature, early maturing, late maturing, mature and spent. Breeding season and annual fluctuation in the breeding season were found out by estimating the monthly percentage of females with mature and late maturing ovaries. The size at first maturity was determined by plotting logistic curve (King,

1995) of percentage mature crabs against the carapace width. Homogeneity of sex ratio over the years was tested using χ^2 test (Snedecor and Cochran, 1967).

Data on frequency distribution of carapace width collected for a period of five years from January 2001 to December 2005 were used for growth and stock assessment studies. The data were grouped into 5 mm class interval. Monthly size frequency data were analysed using Powel-Wetherall plot followed by ELEFAN I module of FiSAT software to get a preliminary estimate of L_∞ and K. These growth parameters were further refined and re-estimated using the data corrected for gear selection. Using L_∞ and K derived from ELEFAN I routine, t_0 was calculated following Pauly's (1979) equation and growth by von Bertalanffy's growth formula. To test the growth parameters for their reliability by comparing them with the available growth studies of the same species and with related species in the same family, empirically derived growth performance index (phi prime index, Φ') expressed by the equation $\Phi' = \log_{10} K + 2\log_{10} L_\infty$ (Longhurst and Pauly, 1987) was used. 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.

Since the growth parameters were almost similar in both males and females, growth parameters derived from sex pooled data were used for stock assessment studies. The results of cohort analysis were used as inputs for finding the yield and effort relationship in Thompson and Bell (1934) model. The annual stock and standing stock under steady state conditions were calculated from yield and mortality parameters using the equations given by Beverton and Holt (1957).

Results and discussion

Crab fishery: During 1998-2005, about 40,000 to 60,000 trawl units were operated. The number of units was the low during 2004-2005 (47,213), but the number of fishing hours showed an increase over the years. In 1998-1999, the average fishing hours by a trawler was 26 hours, which increased to 50 hours in 2004-2005. The average annual crab landing was 850 t, with the highest in 2001-2002 (1,610 t) and the lowest in 1998-1999 (314 t). The crab landing showed a declining trend from 2001 to 2005. Commercial crab fishery was constituted by three species, *viz.*, *P. sanguinolentus, P. pelagicus* and *Charybdis feriatus.* The major contributor to the fishery was *P. sanguinolentus* forming 46% of the crab catch with an average annual catch of 416 t. Details of the annual catch and effort and its percentage in total crab landing are given in Table 1. The catch per unit increased from 2.5 kg in 1998-1999 to 5.6 kg in 2004-2005. However, the catch per hour did not show considerable increase, which indicated that the increase in catch was mainly due to increase in fishing hours.

During 1980 - 1994 (Sukumaran and Neelakantan,1997 c), the annual average landing of *P. sanguinolentus* was 225.8 t forming 50% of the total crab landing and the average annual catch per hour was above 0.35 kg. This showed that even though the total catch showed 100% increase over the last decade, the catch per hour was decreasing.

Seasonal abundance: Trawling season was generally from September to June. Catch of *P. sanguinolentus* was poor during September-November. Major fishing season for the species was during December-June with the highest landing in May (Fig. 1).

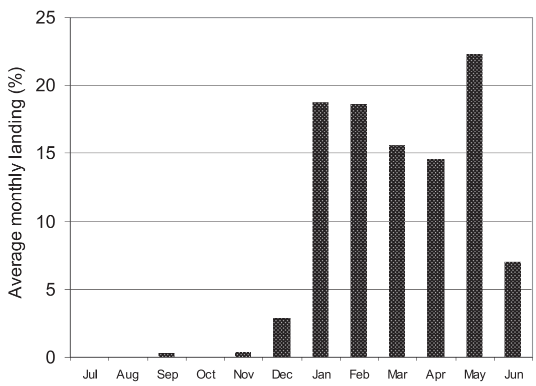

Fig. 1. Monthly landing (% of annual landing) pattern of *P. sanguinolentus* at Mangalore and Malpe Fisheries Harbours during 1998-2005

Table 1. *Trawl effort and crab catch (kg) landed at Mangalore and Malpe Fisheries Harbours during 1998-2005*

Year	Effort		*P. sanguinolentus*		Total crab catch	Catch per unit	Catch per hour
	Units	Hours	Catch	%			
1998-1999	58882	1499416	148416	47.3	313589	2.52	0.10
1999-2000	53763	1485752	267886	33.8	792391	4.98	0.18
2000-2001	65522	1826090	308988	43.8	705149	4.72	0.17
2001-2002	62314	1848191	1076565	66.9	1609514	17.28	0.58
2002-2003	58140	1770223	340915	39.1	870847	5.86	0.19
2003-2004	59024	1967472	509062	46.5	1098530	8.62	0.26
2004-2005	47213	2215158	263021	44.9	585786	5.57	0.12
Average	57836	1801757	416407	48.8	853686	7.20	0.23

Size range and mean size: Size range, modal class, and mean size of the species caught during 1998-2005 are given in Table 2. The carapace width (CW) in males was 61 to 170 mm and in females 56 to 160 mm. The mean size ranged from 93.3 to 108.1 mm in male and from 88.5 to 106.5 mm in female. No conspicuous difference was noticed in the mean size over the years. Sukumaran and Neelakantan (1996 a) reported that the largest crab caught during 1979-1982 was 145 mm and in the present study, crabs bigger than 145 mm (CW) were caught in good quantity. It is possible that the crabs move out to deeper waters during post monsoon season perhaps after mating. The non-availability of crabs during post monsoon and their reappearance from December onwards in the inshore areas strengthen the view that crabs may be undertaking offshore-inshore movement regularly. It appears that the larger sized crabs observed in the present study may be due to the extension of fishing operation to the deeper grounds.

Sex ratio: Male to female sex ratio was 50:50 at Mangalore and 53:47 at Malpe. Test of homogeneity showed that the annual sex ratios did not significantly differ from 1:1 ratio.

Maturity and spawning: Berried females and females in advanced maturity stage were found throughout the period of fishery. The number of late maturing and mature females of *P. sanguinolentus* was high during January-March every year and it confirms the suggestion that the peak spawning in crabs occurs during these months (Fig. 2). Size at maturity (50%) of females was estimated at 90 mm (CW) (Fig. 3) which agrees with the finding of Lee and Hsu (2003) from Taiwanese waters. In the present study, the smallest mature female was 82 mm (CW) whereas Menon (1952) and Sukumaran and Neelakantan (1996 a) observed mature and ovigerous females at 78 mm (CW) from the west coast of India.

Carapace width-total weight relationship: Since the carapace width distribution was used for growth and stock estimates, carapace width-weight relationships for males and females were found out.

The CW-weight relationship for male (n=184) in the form of $W=aL^b$ is as follows:

$W = 0.04274156CW^{3.122}$ ($r^2 = 0.988$) where, W is the weight (g) and CW the carapace width (cm).

The length-weight relationship for females (n = 189) is

$W = 0.046713956CW^{3.0540}$ ($r^2 = 0.982$)

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

Table 2. *Carapace width (mm) of* P. sanguinolentus *landed at Mangalore and Malpe Fisheries Harbours during 1998-2005*

Year	Sex	Mangalore			Malpe		
		Range	Modal class	Mean	Range	Modal class	Mean
1998-1999	M	66-160	81-85	99.46	61-140	96-100	103.11
	F	61-150	106-110	98.38	76-140	106-110	104.76
1999-2000	M	61-160	85-90	98.43	56-160	86-90	93.20
	F	61-140	91-95	97.18	61-160	91-95	97.68
2000-2001	M	61-155	96-110	95.03	66-165	96-100	101.1
	F	61-160	101-105	94.45	61-160	96-100	99.98
2001-2002	M	61-155	96-110	100.55	66-165	96-100	108.12
	F	66-150	101-105	94.92	61-160	106-110	106.48
2002-2003	M	61-170	86-90	99.46	66-155	96-100	93.35
	F	66-150	106-110	98.38	66-135	96-100	97.96
2003-2004	M	61-155	76-80	92.94	61-160	91-95	101.2
	F	56-145	81-85	90.46	56-145	81-85	98.87
2004-2005	M	66-150	96-100	96.57	61-155	91-95	93.71
	F	61-145	81-85	97.13	61-150	91-95	94.28

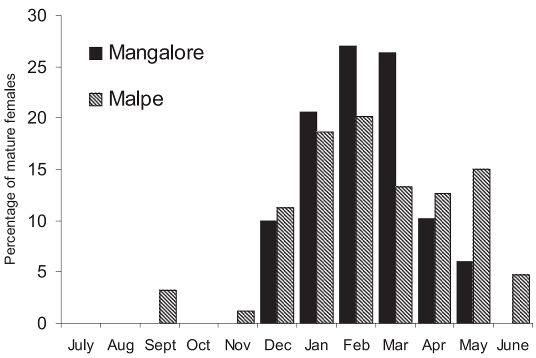

Fig. 2. Monthly occurrence (% of annual occurrence) of mature females of *P. sanguinolentus* observed at Mangalore and Malpe Fisheries Harbours during 1998-2005

Growth parameters: In the case of males, the estimated L_∞ and K were 169 mm and 1.6yr^{-1} respectively and for females, the values were 170 mm and 1.6 yr^{-1}. By using Longhurst and Pauly (1987) formula, the Φ' values were 2.63 for both the sexes. By von Bertalanffy's growth formula, it was estimated that the crab reaches 137 mm (CW) at the end of first year and 163 mm (CW) in two years. Sukumaran and Neelakantan (1997c) observed that the males and females attain CW of 124.1 mm (L_∞ : 195 mm; K: 0.99yr^{-1} and $t_{0:}$ -0.013) and 112.5 mm (L_∞ : 188 mm; K: 0.82yr^{-1} and t_0 : 0.098) respectively at the end of first year, which is low compared to the present estimation. However, their assumption of longevity of the species (2 ½ years) holds good in the present context also. In the Taiwanese waters, Lee and Hsu (2003) estimated higher L_∞ values (205 mm for males and 194 mm for females) for *P. sanguinolentus* on the basis of their studies on the population in which males of CW as large as 193 mm and females of 182 mm were recorded. The largest size observed for males and females off south Karnataka were much smaller (168 mm and 160 mm respectively) and on the basis of the size distribution of the stock, the estimated L_∞ appears reasonable for the present stock. In all the three studies, the growth performance indices were within a reasonable range (2 Φ 3).

Mortality parameters: The total mortality coefficient (Z) was estimated separately for the period 2001-2005 by the 'linearized length-converted catch curve' method (Pauly, 1983). The *Z* values obtained for males and females were 5.96 and 6.84 respectively. The natural mortality coefficient values estimated by Srinath (1990) formula was 2.80. The fishing mortality coefficient (*F*) values were 3.2 and 4.0 respectively. The exploitation ratio (*E*) was 0.53 for males and 0.59 for females. The results of the length-converted catch curve method were used for the estimation of probabilities of capture.

Stock assessment: The CW and weight relationship and growth parameters were revised using sex-pooled data. The carapace width and weight relationship for the sex pooled data (n = 373) was

$W = 0.047439941CW^{3.062}$ ($r^2 = 0.965$) where W is the weight (g) and CW the carapace width (cm).

The growth parameters L_∞ and *K* for the sex-pooled data were 175 mm and 1.7 yr^{-1} respectively (Fig. 4). By using these parameters as input in Pauly's equation (Pauly, 1979), the value of t_0 for both sexes were calculated as -0.033 year. The total mortality coefficient (*Z*) for the period was 7.15. The natural mortality was 2.97 and fishing mortality coefficient (*F*) was 4.18. The exploitation ratio (*E*) was 0.58 (Fig. 5). The results of the length-converted

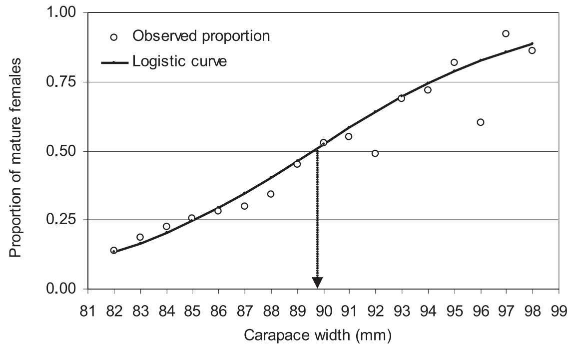

Fig. 3. Size at maturity (50%) of females of *P. sanguinolentus*

catch curve method were used for the estimation of probabilities of capture (l_c). The selection values obtained by the probability of capture were L_{25} = 72.5 mm, L_{50} = 79.2 mm and L_{75}= 84.6 mm.

The details of length-cohort studies are given in Table 3. Total stock and standing stock was estimated as 852 t and 118 t respectively. The MSY was calculated as 544 t with Thompson and Bell plot (Fig. 6). It is assumed that the yield increases with increasing effort, but an increase of fishing effort by 10 to 20 % from the present level will additionally yield only 3 to 4% indicating that any increase in effort level may not be economical. It is difficult to suggest cut off points in exploitation when the fishing ground is being

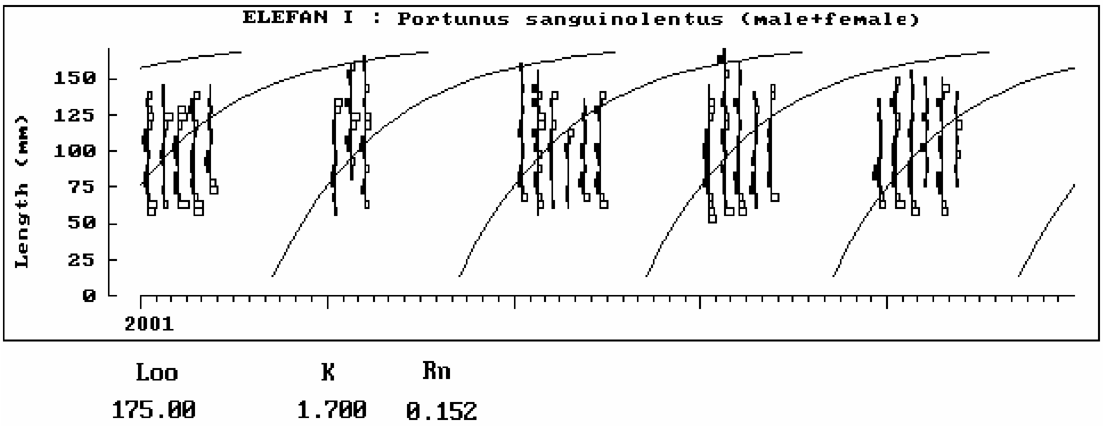

Fig. 4. Estimation of L_∞ of *P. sanguinolentus* (sex pooled data) using ELEFAN I method

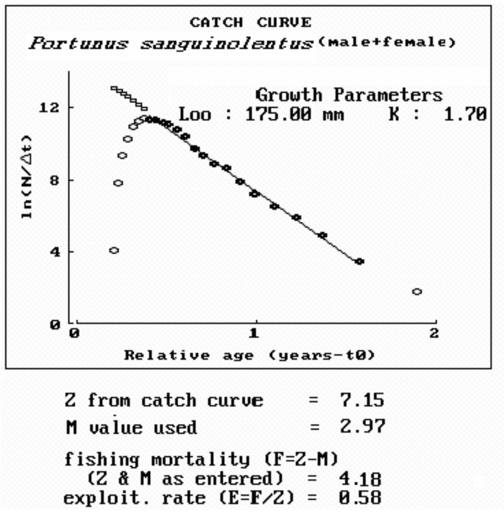

Fig. 5. Estimation of mortality and exploitation rate of *P. sanguinolentus* (sex-pooled data) using Pauly's linearised length-converted catch curve method

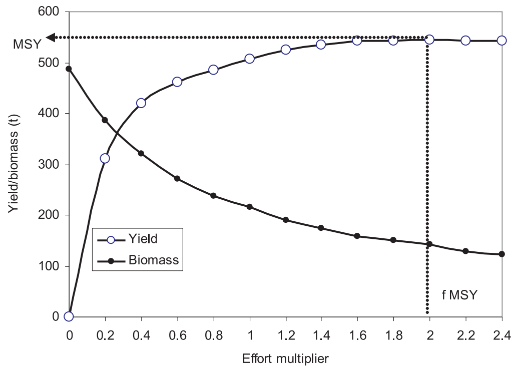

Fig. 6. Thompson and Bell plot for yield and biomass prediction with different effort levels

extended every year. However, it is suggested that for sustaining the fishery the fishing effort (in hours) may be reduced by 30 to 40% from the present level of exploitation.

Table 3. *Annual average yield and biomass of* P. sanguinolentus *for the period 2001-2005 estimated from length based cohort analysis*

CW mid point(cm)	Number caught	Number of survivors	Fishing mortality (F)	Mean number (N)	Biomass (t)	Yield (t)
5.8	1606	24714041	0.0027	598710	6.20	0.02
6.3	32054	22934259	0.0553	579055	7.72	0.43
6.8	167006	21182416	0.2999	556951	9.38	2.81
7.3	388606	19361259	0.7338	529605	11.08	8.13
7.8	608086	17399722	1.2272	495495	12.69	15.58
8.3	779678	15320011	1.7137	454969	14.10	24.16
8.8	771293	13189070	1.8749	411382	15.25	28.58
9.3	846610	11195976	2.3136	365922	16.06	37.16
9.8	1004045	9262577	3.1834	315397	16.25	51.73
10.3	739039	7321302	2.7710	266705	16.00	44.34
10.8	824472	5790648	3.7433	220254	15.28	57.19
11.3	502829	4312023	2.8092	178995	14.26	40.06
11.8	390756	3277577	2.6610	146849	13.36	35.55
12.3	272062	2450673	2.2662	120050	12.40	28.10
12.8	283894	1822063	2.9797	92275	11.12	33.13
13.3	193819	1255204	2.6661	72696	9.54	25.43
13.8	123974	845475	2.2510	55073	8.09	18.21
14.3	119429	557936	3.0245	39487	6.47	19.57
14.8	109814	321229	4.5992	23876	4.35	19.99
>15.3	85381	140507	4.6000	18561	3.74	17.20
					223.37	507.37

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