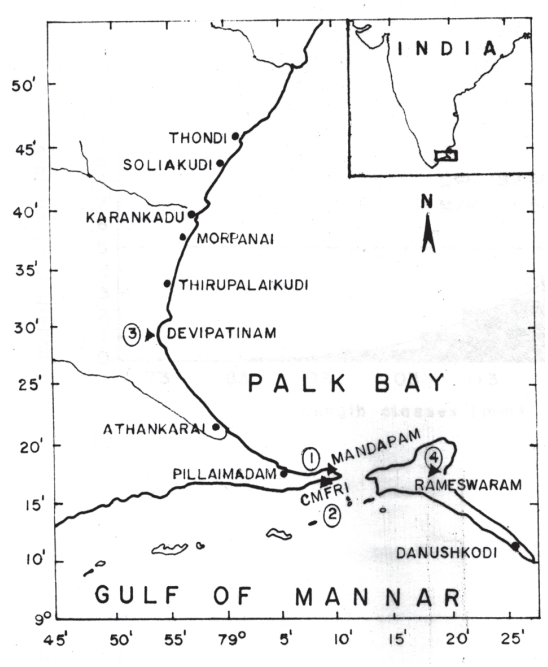

Fig. 1. Map showing sampling stations

to the number of fishing days to assess the monthly crab landings at each centre.

Statistical analyses: During the fortnightly sampling, the male and female crabs were separated and classified into 5 mm class intervals based on their carapace width(CW). Their frequencies in various classes were worked out. These frequencies were raised to the monthly catch estimates. This data was entered in the FiSAT computer programme (Sparre and Venema, 1998) for further analysis to estimate the growth parameters. The data pertaining to the trawl, the major gear in the exploitation of crabs, was used for the analyses.

Probability of capture analysis was carried out as follows:

1. Estimate of L_∞ by Powell-Wetherall method.
2. Correct length- frequencies for selection using the value 1.0 for the curvature parameter, K and the estimate of L_∞ obtained by stage-1.
3. Separate normally-distributed components by the Bhattacharya method from the corrected length-frequency distribution.
4. Use the estimated mean lengths of the components in modal progression analysis to estimate the growth parameters K and L_∞.
5. Estimate Z using length-converted catch curve analysis with the newly estimated growth parameters.

ELEFAN- routine in FiSAT was run to estimate the L_∞ and K, and after running different routines (Response Surface Analysis, Scan of K values and Automatic Search Routine), the parameter estimates with the highest Rn value were selected for males and females.

The growth increment data obtained by linking of means in modal progression analysis was used to run the Gulland & Holt plot, and the Munro and Faben method to find out the L_∞ and K values assuming that growth in carapace width followed the von Bertalanffy growth formula. From the parameters, estimates were selected based on comparison to the growth increments observed in the laboratory rearing experiments.

Relative yield-per-recruitment (Y/R) was estimated by Beverton and Holt (1964) method. The total instantaneous mortality coefficient (Z) was estimated for the sex from the length frequency based catch curve method. The instantaneous natural mortality coefficient (M) was estimated following the methods of Rikhter and Efanov (1976) and Pauly (1980). The instantaneous fishing mortality coefficient (F) was computed from the formula: F = Z – M. The exploitation rate (E) was computed from the formula: E = F/Z.

Results

Craft and gear: Trawling was a year round activity in Palk Bay while at Gulf of Mannar, it was restricted to October-March. The trawlers operated during day and night, or at night only. The fishing area was up to a maximum of 50 m depth but on most occasions, it was less than 25 m. Among the trawlers, majority (70%) were IB (in board) type or motorized boats with an overall length (OAL) of around 28-32' equipped with engine with horsepower of 48 to 58. Others were with outboard STB (Stern trawl boat) type with an

OAL ranging between 34' and 36' and engine hp of 68 to 88. The number of the crew was 4-5 per boat.

At Devipattinam and Thoppukadu, crab fishery was exclusively by a traditional set gillnet known as *nanduvalai*. A group of 3-5 fishermen participated in fishing in a country boat locally known as *Vathai*. The length of the craft was 25' m and *nanduvalai* is about 200m long and 1 m height. A single craft carried 15-25 nets depending on the number of crew. The webbing was made of high-density nylon mono-filament with a stretched mesh of 80 mm. The head rope was nylon with 1.5 cm thickness and small rubber floats were attached at intervals of about one and a half feet. The above descriptions pertain only to crab nets used at Devipattinam. Few variations were noticed in the specification of the crab nets used in adjacent localities. The entangled crabs are removed from the nets with much care and skill without damaging the appendages.

Total catch: For the 1995-98 period, the total estimated catch of *P. pelagicus* at Mandapam (Palk Bay) was 502.4 tonnes with an average CPUE (catch per unit effort) and CPH (catch per hour) of 4.2 kg and 0.3 kg respectively. In the Gulf of Mannar, the total landings for the 1995-98 period was 30.7 t with a CPUE of 1.2 kg. In the overall catch, *P. pelagicus* formed 4.4%. The catches were fluctuating and an average catch of 10 t/yr was recorded. In all the years, the maximum catch was recorded during June at Palk Bay while in the Gulf of Mannar, the maximum was in March during 1995-96 and in December in the following years. At Devipattinam, the estimated catch for the three years was 108.2 t with a CPUE of 13.3 kg and CPH of 4.4 kg. The maximum catch was during September in the first year, March in the second year and June in the last year. At Thoppukadu the estimated catch for three years was 17.2 t with an average of 5.4 t. CPUE and CPH were 2.01 kg and 0.67 kg respectively. The maximum catch of *P. pelagicus* was reported during July in the first year, March in the second year and May in the third year.

Size (carapace width) composition: At Mandapam (Palk Bay), the fishery was contributed by size ranging from 70-195 mm. The major portion of the catch was contributed by 105-170 mm group in both the sexes. At Mandapam (Gulf of Mannar), the fishery was contributed by crabs of size range 81-180 mm. The dominant size group during 1996-97 was 106-110 mm in males and 126-130 mm in females. At Devipattinam, the fishery was contributed by size range of 81-182 mm. The maximum recorded sizes for male and female were 182 and 176 mm respectively. In Thoppukadu,

Table 1. G*rowth parameters of* Portunus pelagicus

Method	L_∞ (mm)	K	Observed L_{max} (mm)	Growth Equation
		Male		
Gulland and Holt	199.4	1.56	195.0	$L_{(t)} = 199.4 \{1-\exp^{-1.56 (t- t_0)}\}$
Munro's	191.9	1.68		$L_{(t)} = 191.9 \{1-\exp^{-1.68 (t- t_0)}\}$
Fabens	195.0	1.71		$L_{(t)} = 195.0 \{1-\exp^{-1.71 (t- t_0)}\}$
ELEFAN	223.0	0.95		$L_{(t)} = 223.0 \{1-\exp^{-0.95 (t- t_0)}\}$
		Female		
Gulland and Holt	196.9	1.05	193.0	$L_{(t)} = 196.9 \{1-\exp^{-1.05 (t- t_0)}\}$
Munro's	190.4	1.37		$L_{(t)} = 190.4 \{1-\exp^{-1.37 (t- t_0)}\}$
Fabens	190.0	1.42		$L_{(t)} = 190.0 \{1-\exp^{-1.42 (t- t_0)}\}$
ELEFAN	195.1	1.00		$L_{(t)} = 195.1 \{1-\exp^{-1.00 (t- t_0)}\}$

the landed crabs were in the size range of 81-160 mm. The maximum sizes recorded for male and female were 156 and 159 mm respectively.

In females, the berried crabs were observed in the catch throughout the year in trawl catches, but the percentage was found fluctuating in different months in all the three years. However, during April-July 1997, bulk of the female population was in berried condition.

Probability of capture : In males, the L_{25}, L_{50} and L_{75} values were 115.2, 124.7 and 130.4 mm

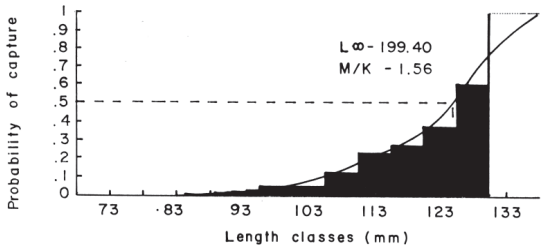

Fig. 2. Probability of capture analysis for *Portunus pelagicus* males

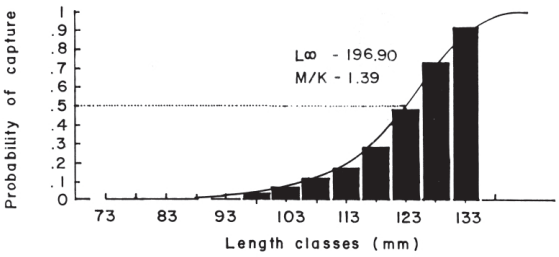

Fig. 3. Probability of capture analysis for in *Portunus pelagicus* females

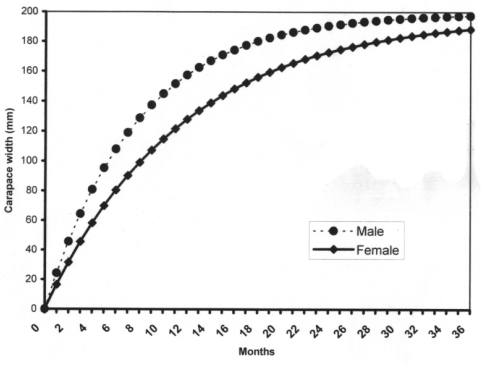

Fig. 4. von bertalanffy's growth curve for males and females of *Portunus pelagicus*

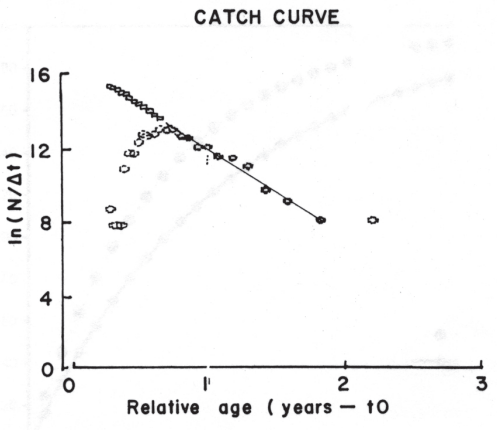

Fig. 5. Catch curve of *Portunus pelagicus* males; Cut off CW (L'):130.5mm; mean CW (from L'): 149.6 mm; Z from the catch curve: 4.54; Natural Mortality (M for t = 29°C): 2.72; M value used: 2.09; Fishing Mortality: 2.45; Exploitation rate: 0.54

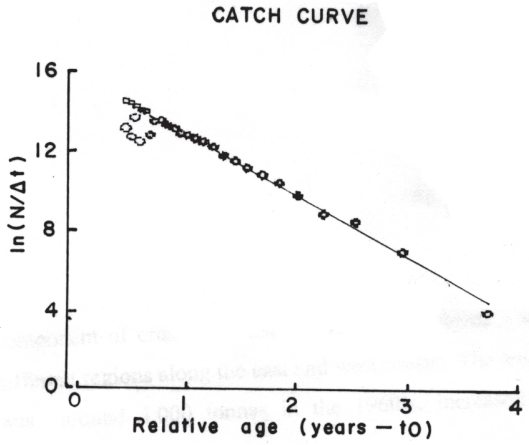

Fig. 6. Catch curve of *Portunus pelagicus* females; Cut off CW (L'): 90.5 mm; Mean CW (from L'): 120.5; Z from the catch curve: 3.03; Natural Mortality (M for T=29°C): 2.11; M value used: 1.46. Fishing Mortality: 1.57; Exploitation rate: 0.52

respectively (Fig. 2) and at carapace width (CW) of 137 mm and above, all the crabs were retained by the trawl. In females these values were 115.4, 122.9 and 129.0 mm respectively (Fig. 3) and at carapace width of 142 mm and above, all the crabs were retained by the trawl.

Growth parameters: For males, the L_{∞} estimated using different methods ranged between 191.9 and 223.0 mm and for females between 190.0 and 196.9 mm. The 'K' values were in a range of 0.95-1.71 and 1.00 –1.42 for males and females respectively. The growth parameters are given in Table 1.

The male crabs attained CW of 156.1-159.1 mm in the 1st year, 185.2-190.6 in the 2nd year and 190.6-197.5mm in the 3rd year. The females recorded a size of 128.0-144.1 mm in the 1st year, 172.8-178.9 mm in the 2nd year and 188.4-187.3 mm in the 3rd year. The growth curve by Gulland and Holt approach is presented in Fig. 4.

Mortality parameters: The total instantaneous mortality coefficient (Z) estimated by length converted catch curve method was 4.54 for males and 3.03 females. The instantaneous natural mortality coefficient (M) estimate for males by

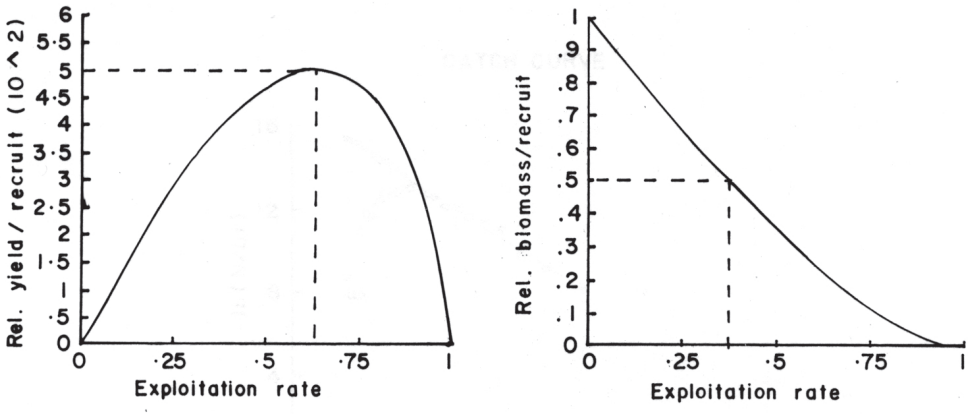

Fig. 7. Yield per recruitment analysis for *Portunus pelagicus* males

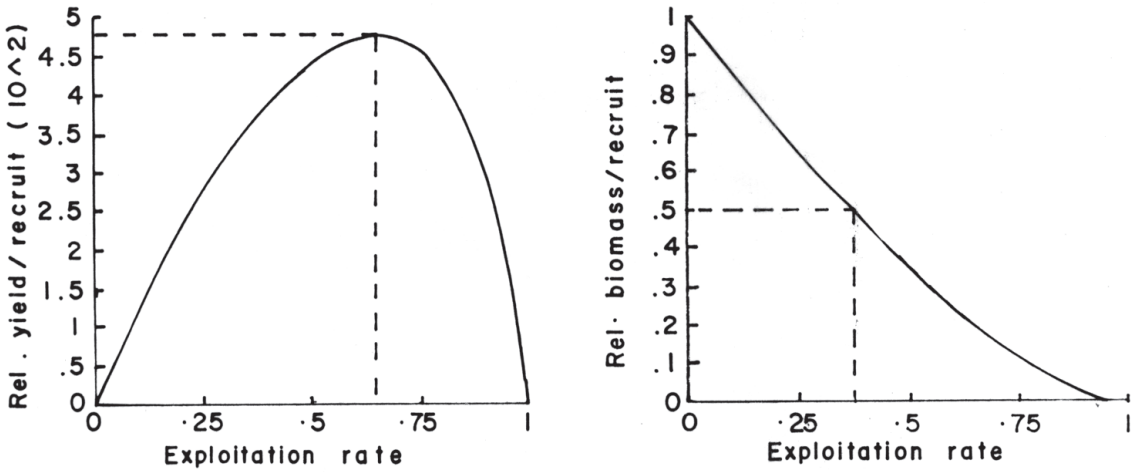

Fig. 8. Yield per recruitment analysis for *Portunus pelagicus* females

following Rikhter & Efanov and Pauly were 2.09 and 2.76. In females the M was 1.46 and 2.11 respectively by the two methods. The instantaneous fishing mortality coefficient (F) was 2.45 for males and 1.57 for females. The exploitation rate (E) was almost similar in males and females, *i.e.,* 0.54 and 0.52 respectively (Figs. 5 and 6).

Yield-per-recruit (Y/R): E_{max} was estimated as 0.64, $E_{0.1}$ as 0.62 and $E_{0.5}$ as 0.37 for males (Fig. 7) and 0.64, 0.61 and 0.38 respectively for females (Fig. 8).

Discussion

In India there is no organized fishery for the blue swimmer crab, even though good market demand exists in both domestic and export markets. A regular fishery exists at few places in the Palk Bay, Gulf of Mannar and off Mangalore. Bulk of the catch is landed by trawlers as a non-targeted bycatch.

Prasad and Tampi (1951) described the *nanduvalai* fishery for catching *Neptunus pelagicus* near Mandapam. This traditional gear, with minor modifications is in operation for more than five decades. It is evident from Ameer Hamsa (1978) that by 1970's trawling started for *P. pelagicus*. In Karnataka *P. pelagicus* was landed by trawlnets, minitrawl, shore seines, *Jebbubale* and *Kanthabale* (Sukumaran and Neelakantan, 1996). Fishing season was different at different places of the Indian coast (Jones and Sujansingani, 1952; Rao and Kathirvel, 1971; Dhawan *et al*., 1976; Kurup *et. al*., 1990; Sukumaran and Neelakantan, 1996). However, *P. pelagicus* was fished throughout the year by trawlers and gillnetters at Mandapam.

Ameer Hamsa (1978) reported that at Mandapam, annual CPUE ranged between 2.01-6.03 kg during1972-74 and in the present study it was between 3.4-4.8 kg. He has also reported the maximum cw of male and female as 209 and 204 mm respectively, stands to be a record size, whereas in the present study it was 195 and 193 mm respectively. It may be inferred that due to the present day intensified trawler operations, the maximum size of the crabs has reduced.

Campbell and Fielder (1986) have reported more than fifty per cent of the catch of adult females as being ovigerous during most of summer and autumn. Ameer Hamsa (1978) reported more number of berried crabs in trawl catches than in the gillnets, which is in conformity with the present study. *P. pelagicus* is a continuous breeder and berried crabs were caught in trawlnets throughout the year. But in *nanduvalai* berried crabs were not observed in all the months and the percentage was less even if they were present.

The exploitation rate of males (0.54) and females (0.52) was almost equal. These values are very close to the E_{max} level (males: 0.638; females:0.648) and well above the 50% exploitation level (males-0.371: females – 0.379). Since the current yield is close to the MSY level, it is suggested that the fishing effort may be maintained at the current level to obtain biologically optimum yield.

From the Gulland and Holt growth curve it is found that in the 3rd year male and female attain a respective carapace width of 197.5 mm and 188.4 mm. Hence it is reasonable to assume that the life span of these crabs may be around three years, although majority of the crabs is fished out by intensive trawling in the early part of their life (0-year class), leaving only a few to reach their maximum age.

At present, there is no ban on fishing the berried crabs and the minimum size at capture is not restricted in India. As a conservation measure, fishermen may be educated to release the berried and soft crabs to the sea while they are alive. The governments should take steps to implement ban during peak spawning seasons to prevent indiscriminate fishing. The best method to ensure a sustainable fishery throughout the year as well as to improve the quality of the yield is to ban fishing and marketing of berried crabs.

In this context, it is noteworthy to recall that the history and development of blue swimmer crab fishery in Australia, where the fishery has developed from what was a highly seasonal non-target fishery, into what today is a specialised fishery with specific

management regulations such as license for each gear, quota system, legal minimum size, ban on fishing berried females and closed seasons (Campbell and Broderick,1997; McDonald, 1997; Bellchambers *et al*., 2006; Anon., 2007). In India too, it is necessary to implement management measures for sustainable fishery of the blue swimmer crabs.

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