

Stock Assessment and Reproductive Biology of the Blue Swimming Crab, *Portunus pelagicus* in Bandar Abbas Coastal Waters, Northern Persian Gulf

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Abstract

Stock assessment and reproductive biology of the blue swimming crab, *Portunus pelagicus*, in Bandar Abbas coastal waters was conducted from August 2006 to July 2007. A total of 424 male and 348 female crabs were taken to the laboratory for length, weight and reproductive biometry. Estimate of growth parameter of crab showed asymptotic carapace width (CW_{∞}) was 172.5 mm, the curvature parameter, $K(\text{year}^{-1})$ was 0.98, total mortality coefficient, $Z(\text{year}^{-1})$ was 2.13, natural mortality coefficient, $M(\text{year}^{-1})$ was 1.05 and the fishing mortality coefficient, $F(\text{year}^{-1})$ was 1.08 then the exploitation rate, $E(\text{year}^{-1})$ was 0.51. Results showed the sex ratio was 1:1.2 with 46.1% female throughout the year. All four stages of ovarian development were observed throughout the year. The Gonad Somatic Index (GSI) monthly mean values ranged between 2.05 to 2.97%. The highest values of GSI were recorded in December. Carapace width of ovigerous crabs varied from 32 to 173 mm. This crab spawned all year round with a spawning peak in December. The fecundity of ovigerous crabs ranged from 277421 to 1114348 eggs, with average fecundity of 662978 eggs. The minimum carapace width (CW) of sexually matured female crabs was 32-151 mm.

Keywords: *Portunus pelagicus*, Stock Assessment, Reproductive Biology, Fecundity, Gonad Somatic Index (GSI), The Persian Gulf.

1. Introduction

The blue swimming crab, *Portunus pelagicus* L. 1766, is an economically important species with high market demand. It inhabits a wide range of inshore and continental shelf areas, including sandy, muddy and sea grass habitats, from the intertidal zone to at least 50 m depth (Williams 1982; Edgar 1990; Clarke and Ryan, 2004). It is found in near-shore and

estuarine waters throughout the Indo-Pacific (Kailola et al. 1993; Clarke and Ryan, 2004).

Hormozgan Province is one of the three Iranian provinces bordering the Persian Gulf. Several marine species, including fishes, shrimps and crabs are harvested by local, small-scale fishermen in Hormozgan coastal waters, particularly in Bandar Abbas. (Fig.1). *Portunus pelagicus* is caught during shrimp harvesting and is exported since crab is not generally consumed in Iran.

Basic information on the population dynamics and

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biology of *P. pelagicus* is vital for policy makers and managers to establish regulation measures to conserve the population. Therefore, a study of reproductive biology, including sex ratio, gonad development, spawning season and fecundity of *P. pelagicus* was conducted. The results of this study will facilitate the management of *P. pelagicus* population in a wide range of locations.

2. Materials and methods

2.1 Study site

Bandar Abbas (25°24'N - 28°57'N and 53°41'E - 59°15'E) is located in Hormozgan province along The Persian Gulf coast line of Iran (Fig. 1). Hormozgan has a tropical climate. The average annual mean temperature of the study site is 26.9 °C. Local tides have a semi-diurnal regime with maximum amplitudes of 2.9 m.



Fig 1. Illustration of the study site; Bandar Abbas, Southern Iran

2.2 Sample collection

Portunus pelagicus were sampled at random from August 2006 to July 2007 from fishermen who collected this species in Bandar Abbas waters. A total of 424 male and 348 female crabs were taken to the laboratory and placed in a deep freezer until further analysis. Each crab was measured and recorded for its carapace width, its body weight and its sex. The carapace width (CW) was measured to the nearest millimeter across the tips of the

epibranchial spines, and individual wet weights of the crabs were recorded to the nearest gram. The number and carapace width (CW) of ovigerous females were also examined and recorded.

2.3 Stock Assessment

The relationship between carapace length and body weight can be represented by power curve equation:

$$W=aL^b$$

Where *b* is close to three in isometric growth, and *a* is a constant determined empirically (King, 2007). The parameters *L_∞* (total length, mm) and *K* (year⁻¹) of the von Bertalanffy growth equation (von Bertalanffy, 1938 and Beverton and Holt, 1957) were estimated using length distribution data for each of the selected species. This was done using the Powell-Wetherall method (Wetherall et al., 1987) and the ELEFAN I and II routines incorporated in the FiSAT software (Gayanilo and Pauly, 1997). The Powell-Wetherall method was used to provide an initial estimate of *L_∞*. This was necessary as for most species there a few estimates available and where available there is usually a considerable range of values. The estimates were verified by comparison with any available estimates for the species. After verification as a plausible estimate, this was then used as seed value for ELEFAN I analysis to determine the value of *K*. Minor adjustments to *L_∞* were made (and hence *K*) to maximize the “goodness of fit” criterion built into ELEFAN I. This led to a preliminary estimate of *L_∞* and *K* for each species that were used to derive probabilities of capture by length class using the routine in FISAT. These probabilities of capture were used to correct the length distribution data for the species to account for incomplete selection and recruitment. The final estimates of *L_∞* and *K* were obtained using these corrected length distribution data and ELEFAN I.

The growth performance index, $\phi' (= \log K + 2 \log L_{\infty})$ (Munro and Pauly, 1983; Pauly and Munro,

1984; Pauly, 1991 and Pauly, 1998), were computed using the L_{∞} and K values derived for each species. The number of recruitment peaks for each species was examined using “recruitment patterns” generated from the final estimates of L_{∞} and K and the length distribution data for the species. The mortality parameters of the exponential decay model (Beverton and Holt, 1957 and Beverton and Holt, 1966), depicting exponential decrease in population numbers through time, were estimated using the ELEFAN II routines in FiSAT (Gayanilo and Pauly, 1997). The total mortality coefficient, Z (year^{-1}), was estimated using the length-converted catch curve method in ELEFAN II, using the final estimates of L_{∞} and K and the length distribution data for the species. The natural mortality, M (year^{-1}), for each species was estimated using Pauly's (1980b) empirical equation relating M to L_{∞} , K and mean environmental temperature (taken as 26.32°C in this study). Differences in temperature are likely to have a minimal effect on estimates of M for these species, given the narrow temperature ranges. Fishing mortality, F (year^{-1}), was obtained by subtracting M from Z . The exploitation ratio, E , was computed by dividing F by Z . The parameter E expressed the proportion of a given cohort/population that ultimately died due to fishing given existing exploitation pressure (Beverton and Holt, 1966). The length-based methods within ELEFAN are similar to “non-parametric” statistical methods and therefore do not provide measures of confidence intervals or uncertainties.

2.4 Reproductive Biology

Monthly sex ratio was recorded using all crabs collected within each month. Chi-square analyses were used to compare male and female ratios for each monthly data set. Gonad Development was documented for the 348 females collected. The females were weighed. Their carapaces were opened

and the ovaries scored for their stage of maturity. Maturity stages fell into four classes following the procedure adopted by Kumar et al. (2000) and Delestang et al. (2003). Ovarian development was classified by size and color of the ovary as follows:

Stage 1- Gonad immature, ovary very thin and transparent (colorless).

Stage 2- Gonad maturing, ovary changed color to creamy, but not extending into hepatic region.

Stage 3- Gonad maturing, ovary became enlarge and changed color to yellow, extending some 1/3-1/4 of the hepatic region.

Stage 4- Gonad mature, the ovary covered most part of hepatic region, and turned orange or reddish orange.

The ovary was then removed and weighed. The Gonad Somatic Index (GSI) was calculated following Quinn and Kojis (1987):

$$\text{GSI} = \text{ovary weight} / \text{Total weight} * 100\%$$

Spawning season was forecast from the percentage of ovigerous females and GSI value in each month with the maximum values for both parameters occurring in the month of maximum spawning.

The size at sexual maturity was determined by examining the 59 ovigerous females and documenting the size of the smallest to carry eggs. Fecundity was calculated as the number of eggs carried externally by the female (Kumar et al., 2000). A separate sample of 43 ovigerous females was collected that covered a wide size range. CW of each females weighed their eggs to the nearest 0.001 g. At least 5% of total egg weight was sub-sampled and the number of eggs counted under a stereo microscope. This was then used to estimate the total number of eggs of each female.

3. Results and Discussion

The total number of 772 of blue swimming crab samples caught by shrimp trawl gear had a carapace width between 23-173 mm. The carapace width-

body-weight relationships (Table 1 and Figure 2) showed that the relationships for each sex and whole were isometric.

Table 1- Carapace width-weight relationship of blue swimming crab in Bandar Abbas.

Crab	Number	Length-Weight equation	R ²
Male	424	$Y = 0.0002 X^{2.757}$	0.93
Female	348	$Y = 0.0002 X^{2.748}$	0.88
Total	772	$Y = 0.0002 X^{2.762}$	0.91

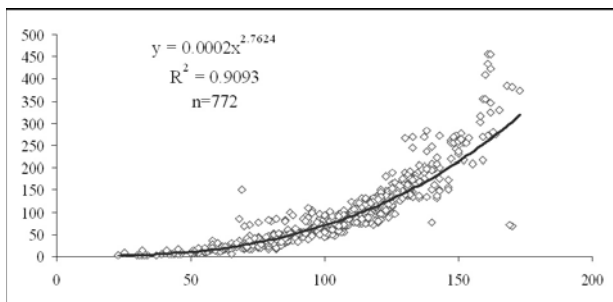


Fig 2. Carapace width (CW)-Body Weight Relationship of Total Blue Swimming Crabs in Bandar Abbas

The growth parameters of blue swimming crabs in Bandar Abbas by Bhattacharya's method (Powell, 1979), was used to separate the length frequency to determine the mean length of crab cohort. Consequently, model progression analysis was used to link the mean length of the same cohort which showed monthly growth progression. The line that was drawn to indicate the growth of the same cohort was further used to estimate the growth parameters (K and CW_{∞}) by using Gulland-Holt Plot (Beverton and Holt, 1957). The linking mean length of the same cohort showed the estimated parameter of $K = 0.98$ (year^{-1}) and $CW_{\infty} = 172.5$ mm. If divided according to sex, the male had the parameter of $K = 1.2$ (year^{-1}) and $CW_{\infty} = 168$ mm. and the female showed the parameter of $K = 1.1$ (year^{-1}) and $CW_{\infty} = 177.9$ mm (Table 2).

From the computation, the growth equation of blue swimming crab in Bandar Abbas based on Bertalanffy's model (von Bertalanffy, 1938) is shown in Table 3, Figures 3-5.

Table 2- Growth parameters of blue swimming crab in Bandar Abbas

Sexes	Carapace width (CW, mm)	Curvature growth, K (year^{-1})	ϕ'
Male	168	1.2	4.53
Female	177.9	1.1	4.5
Total	172.5	0.98	4.46

Table 3- Equation growth curve of blue swimming crab in Bandar Abbas.

Sexes	Growth Von Bertalanffy Equation
Male	$L_t = 168 \times (1 - \exp(-1.2 \times (t + 0.041)))$
Female	$L_t = 177.9 \times (1 - \exp(-1.1 \times (t + 0.041)))$
Total	$L_t = 172.5 \times (1 - \exp(-0.98 \times (t + 0.041)))$

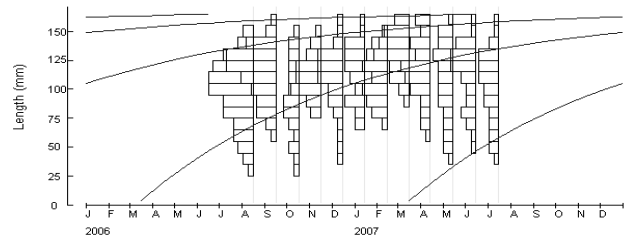


Fig 3. Frequency Distribution of Carapace Width (CW) and Growth Curve of Male Blue Swimming Crabs in Bandar Abbas.

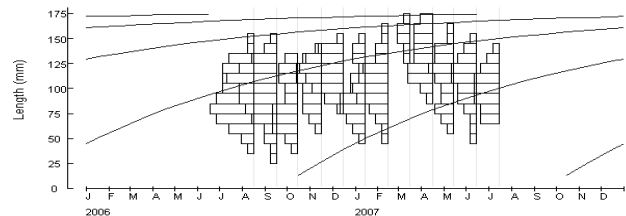


Fig 4. Frequency distribution of carapace width (CW) and growth curve of female blue swimming crabs in Bandar Abbas.

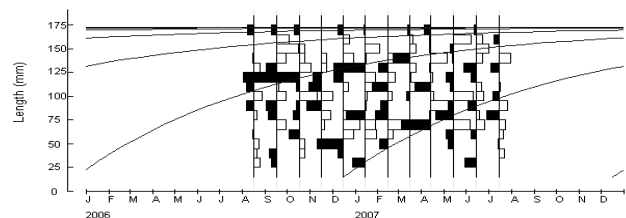


Fig 5. Frequency distribution of carapace width (CW) and growth curve of blue swimming crabs in Bandar Abbas.

The mortality parameters of capture blue swimming crabs in Bandar Abbas; the natural

mortality (M) of crabs (male and female) by Pauly's model (Nitiratsuwan, and Jantarachot, 2004), were 1.05 per year. The total mortality rate (Z) of crabs was 2.13, male crabs was 2.48 and female crabs was 2.44 per year respectively. The fishing mortality rates (F) of crabs, male crabs and female crabs were 1.08, 1.27 and 1.31 per year, respectively. The exploitation rate (E) of crabs was 0.51 (Table 4). This showed blue swimming crab were not overexploited.

Table 4- Mortality parameters and exploitation rate of blue swimming crab in Bandar Abbas.

Sexes	Z(year ⁻¹)	M(year ⁻¹)	F(year ⁻¹)	E = F/Z
Male	2.48	1.21	1.27	0.512
Female	2.44	1.13	1.31	0.536
Total	2.13	1.05	1.08	0.507

The exploitation rate of blue swimming crab for one year in Bandar Abbas, Hormozgan Province was used to find the numbers of blue swimming crab in each length interval for starting recruitment. This information was used to calculate the number of recruits of blue swimming crab by Jones' Length-Based Cohort Analysis. Actually, the recruitment of blue-swimming crab was continual and since Bandar Abbas is situated in tropical zone; thus, the spawning season was postulated to have occurred almost throughout the entire year.

At present, the exploitation of blue swimming crab in Bandar Abbas is near equal recruitment, so the sustainable utilization of blue swimming crab should be carried out under good management. In addition, the level of fishing effort should be maintained at the present levels.

Sex-ratio- The sex ratio of *P. pelagicus* populations has historically been used as an indicator of the population's ability to sustain ongoing recruitment (Ault et al, 1995). Here, we found the average sex ratio over the year to be 1:1.2 with a ratio of 46.1% females and 53.9% males. There was, however, a significant amount of variation in monthly sex ratios, ranging from 36.4 -

54.9% females (Chi-square: $P < 0.05$) (Table 5). The variation in the monthly sex ratios may be due to the migration of mature females at some periods of the year. Mature *P. pelagicus* display differences in habitat preferences for male and female crabs (Weng, 1992). Generally, females leave inshore estuarine areas and move offshore to spawn. This migration is thought to be necessary for the survival of the larvae due to lowered oxygen levels and lack of suitable food in estuaries (Meagher, 1971). Potter et al. (1983) revealed that female *P. pelagicus* were more abundant in shallow areas, particularly on the tops of sandbanks. Females are known to require sandy substrate for successful egg extrusion and attachment to the pleopods (Campbell 1984). Sumpton et al. (1994) stated that the migration of mature female *P. pelagicus* for egg extrusion might have been partly responsible for the variation of sex ratios in Moreton Bay just prior to the spawning season. In addition, female *P. pelagicus* on the west coast of Australia tended to emigrate from the estuaries to their spawning ground before their gonads were fully developed (Potter and de Lestang, 2000; de Lestang et al. 2003).

Table 5- Sex ratio of crabs harvested from Bandar Abbas

Month	male	female	male:female	% of female
Aug	63	48	1.3:1.0	43.2
Sep	54	48	1.1:1.0	47.1
Oct	23	28	.8:1.0	54.9
Nov	26	24	1.1:1.0	48
Dec	33	32	1.0:1.0	49.2
Jan	29	24	1.2:1.0	45.3
Feb	31	34	.9:1.0	52.3
Mar	35	20	1.7:1.0	36.4
Apr	37	27	1.3:1.0	42.2
May	31	26	1.2:1.0	45.6
Jun	31	25	1.2:1.0	44.6
Jul	31	25	1.2:1.0	44.6
Total	424	348	1.2:1.0	46.1

Gonad Development and Gonad Somatic Index (GSI)- All four stages of ovarian development were observed throughout the year (Fig. 6). The number of ovaries in stage 1 of development was higher during September (51.2%) and August (40%). December and April had very

low percentages in that stage. February, October and December had the highest percentage of individuals in maturity stage 2; 50%, 44% and 44%, respectively. Maturity stage 3 occurred in high percentages except in December (32%), while April had the highest percentage (39%) in this stage. March had the highest percentage (50 %) of crabs in maturity stage 4, despite the presence of this stage throughout the year. Maturity Stage 3 and 4 occurred throughout the year, indicating that mature females were actively breeding throughout the year.

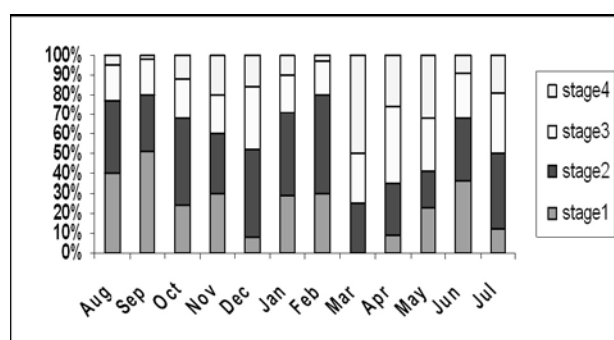


Fig 6. All maturity stages of female *P. pelagicus* sampled from Bandar Abbas.

These results are similar to the findings of Kumar et al. (2000) that *P. pelagicus* in South Australia have all stages of ovarian development throughout the year. In tropical regions, *P. pelagicus* breeds throughout the year (Batoiy et al. 1987), whereas reproduction is restricted to the warmer months in temperate regions (Smith 1982). In temperate regions, female crabs suspend ovary development during winter, but do not regress ovaries already completed the previous autumn. Svane and Hooper (2004) reported that the fourth stage of ovarian development of *P. pelagicus* was observed in late October to November in conjunction with rising seawater temperature.

The Gonad Somatic Index in stage 1 of ovarian development was higher during June (0.97%) and March (0.81%). March had the highest percentage of GSI in maturity stage 2 (1.65 %). The GSI values of stage 3 and 4 were high throughout the year. The highest GSI value of ovarian stage 3 occurred in

April with the value of 3.14, while December had the highest percentage of GSI in maturity Stage 4 (7.98%). The monthly mean values fell within the range of 2.05-2.97%. The peak of mean GSI occurred in December, with the highest value of 2.97% (Table 6; Fig 7).

Table 6- Gonad-Somatic Index in female *Portunus pelagicus* from Bandar Abbas

Month	%GSI in each gonad development stage				Mean GSI
	stage 1	stage 2	stage 3	stage 4	
Aug	0.40	0.96	3.12	6.81	2.82
Sep	0.56	0.62	2.12	5.94	2.31
Oct	0.20	0.85	2.01	5.14	2.05
Nov	0.49	1.03	2.14	5.78	2.36
Dec	0.41	0.89	2.63	7.98	2.98
Jan	0.68	0.76	2.43	5.97	2.46
Feb	0.61	0.92	2.66	6.03	2.56
Mar	0.81	1.65	2.68	6.10	2.81
Apr	0.80	1.51	3.14	5.21	2.67
May	0.79	1.49	2.22	6.40	2.73
Jun	0.97	1.34	2.35	6.75	2.85
Jul	0.31	0.95	2.98	6.84	2.77

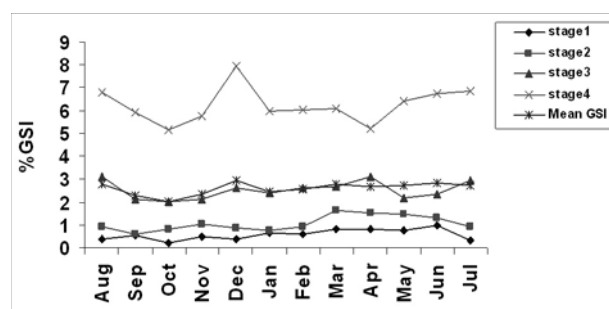


Fig 7. Percentage of GSI in each gonad development stage

Ovigerous females were present throughout the year, but the highest proportion occurred in March, with 42.8% of all females being ovigerous in this month. By contrast, the proportion of ovigerous females was lowest in October, with 10.7% of female catches having eggs (Table 7). This finding is similar to research conducted in Australia, which indicated that most ovigerous crabs are caught during the period November to January (Penn 1977, Smith 1982). Larval sampling in the St Vincent Gulf, South Australia indicated that the main hatching period of *P. pelagicus* extends from November to March (Bryars, 1997). Gaughan and

Potter (1994) found larvae of *P. pelagicus* in the lower Swan Estuary between the months of September and April, with a peak in January and February. De Lestang et al. (2003) stated that the development of ovaries and eggs in *P. pelagicus* is controlled by water temperature. In South Australian waters, berried females (females carrying eggs externally) very rarely appear in the commercial catch between April and September, when the temperature is relatively low. The peak period for ovary maturation and spawning starts in October, with peak proportions of berried females occurring in November-December (Clarke and Ryan, 2004). For example, the numbers of egg-bearing females were highest in Koombana Bay between October and January and highest in the Leschenault Estuary in December and January (Potter and de Lestang, 2000). The high proportion of ovigerous females in Bandar Abbas during August and July may indicate the influence of water temperature on ovulation and egg development of *P. pelagicus*.

Table 7- Number of ovigerous females sampled from Bandar Abbas

Month	Female	Ovigerous Female	% Ovigerous Female
Aug	48	8	16.7
Sep	48	7	14.6
Oct	28	3	10.7
Nov	24	4	16.7
Dec	32	7	21.9
Jan	24	3	12.5
Feb	34	4	11.8
Mar	20	3	15
Apr	27	4	14.8
May	26	4	15.4
Jun	25	3	12
Jul	25	9	36

Monthly variation in gonad development and ovigerous female *P. pelagicus* are shown in Figs. 8 and 9. It is clear that these crabs breed throughout the year but have a breeding peak in December and July, when the percentages of ovigerous crabs were highest.

This is comparable with Australian breeding crabs in which the periods of reproduction of *P.*

pelagicus have traditionally been in October-March (Kumar, 1999). Clarke and Ryan (2004) showed that female egg-bearing crabs occur throughout the year, with the proportion of females bearing egg masses being greatest during August and October. In tropical climates where water temperature is traditionally higher, *P. pelagicus* generally experiences constant reproduction, with peaks occurring in those months with higher temperatures. It is now clear that water temperature is the primary environmental factor influencing reproduction in *P. pelagicus* (Potter et al., 1998).

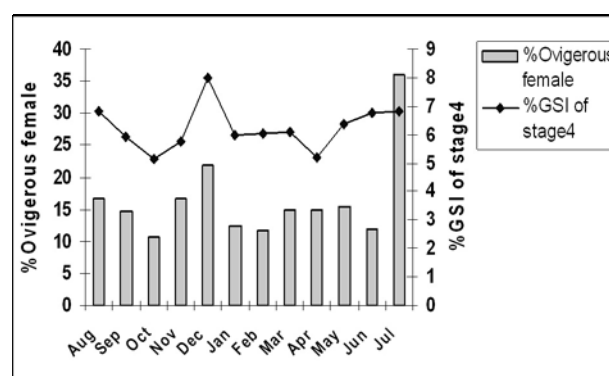


Fig 8. The comparison between Gonad-Somatic Index and percentage of ovigerous. females

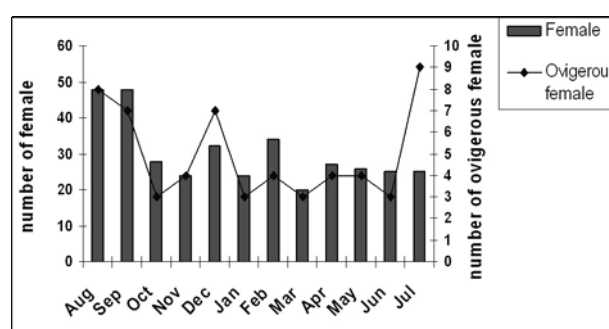


Fig 9. The relative abundance of ovigerous crabs sampled monthly

Salinity is potentially also important. In tropical regions like Bandar Abbas, the salinity of shallow coastal areas normally decreases in the rainy season due to the great amount of water runoff and this is unsuitable for *P. pelagicus*. In the Peel-Harvey Estuary, Australia, crabs were not found in winter when rainfall reduces the salinity

to less than 10‰ (Potter et al.1983). Meagher (1971) noted that *P. pelagicus* preferred salinity levels between 30 and 40 ppt. Moreover, the larvae need to grow and survive in stable and high salinity conditions. Females *P. pelagicus* therefore prefer to spawn in the dry period of the year when salinity is high and stable. A high percentage of ovigerous female occurred in the dry season, December, suggesting that temperature and salinity play an important role in affecting the timing of the reproductive cycle.

Reproductive female size ranged from 32-173 mm, with average size of mature females at 96 ± 0.6 mm. The smallest reproductively active females were 32mm in carapace width (Table 8).

Table 8- Carapace width of size at first sexual maturity of female

Month	Carapace width (mm) of ovigerous	Size at first sexual maturity (mm)
Aug	81-170	81
Sep	33-131	33
Oct	114-169	114
Nov	89-130	89
Dec	105-139	105
Jan	122-141	122
Feb	96-142	96
Mar	151-154	151
Apr	133-173	133
May	122-149	122
Jun	81-160	81
Jul	32-133	32

P. pelagicus mature at about one year of age (Smith, 1982). The size at which maturity occurs varies with latitude and location (Campbell and Fielder 1986, Sukumaran and Neelakantan 1996) and between individuals at any location. For example, the minimum carapace widths (CW) of female crabs that reach sexual maturity ranged from 61 mm in both the Peel-Harvey Estuary and Shark Bay to 84 mm in the Leschenault Estuary (de Lestang et al. 2003). Clarke and Ryan (2004) stated that about 82 mm CW females in Australia can become sexually mature. In India, males may reach sexual maturity at a CW ranging between 85 and 90 mm, and females at 80-90 mm CW (Sukumaran and Neelakantan 1996). Moreover, the carapace width at which *P. pelagicus* reaches sexual maturity vary depending on growth rate,

which is a direct function of temperature. For example, the carapace width at which 50% of both males and females reach sexual maturity in Cockburn Sound, Western Australia is 97mm, while in the Philippines, 50% of females reach sexual maturity at 106 mm carapace width (Sukumaran and Neelakantan, 1997). The size at first maturity of female *P. pelagicus* in Bandar Abbas is unusually small.

Females with carapace widths ranging from 32-173mm produce from 277,421 to 1,114,348 eggs. Mean fecundity was found to be 662978 eggs. This finding is similar to the result of Kumar et al. (2000), who found that a female *P. pelagicus* can produce between 650,000 to 1,760,000 eggs per spawning. Generally, female *P. pelagicus* may spawn up to two million eggs per batch, but the number of eggs produced by females varies with the size of the individual as well as between individuals of a similar size (Yatsuzuka 1962; Clarke and Ryan, 2004; Svane and Hooper, 2004).

The fecundity or number of eggs produced is directly related to the size of the individual (Kumar et al, 1999). In Cockburn Sound, Australia, the number of eggs recorded for a single batch of eggs ranged from 68,450 in a crab with a CW of 8.4 cm to 324,440 in a crab with a CW of 15.4 cm (de Lestang et al., 2003) Kumar et al. (2003) found that the fecundity of female crabs is size-dependent. Fecundity increased by 83.9% with an increase of carapace width from 105 mm to 125 mm, implying that a single large female could produce as many eggs as two small females. Ingles and Braum (1989) determined the relationship between weight (W) and fecundity (F) for *P. pelagicus* in the Philippines to be $F=972.75 W^{1.23}$. Here we found a strong relationship between carapace width and fecundity with $R^2=0.88$ (Figure 10). High fecundity was found in larger crab because of a longer inter molt period between population and egg extrusion than small crab (eight versus four months). They have longer period to accumulate the energy reserves

required to produce eggs (de Lestang et al., 2003).

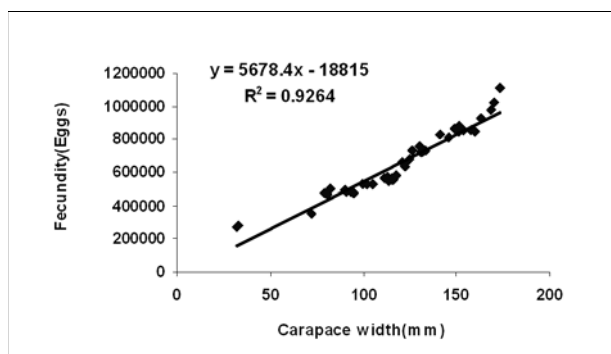


Fig 10- Relationship between carapace width and fecundity

4. Conclusions

The examination of the reproductive biology of blue swimming crab, *P. pelagicus*, in Bandar Abbas, Southern Iran provided useful information for the management of this species. For example, prohibition on the capture of ovigerous female crabs; a minimum size limit on the take of female crabs; and prohibited fishing in the spawning season should be instituted in this area.

At present, the exploitation of blue swimming crab in Bandar Abbas is near equal recruitment, so the sustainable utilization of blue swimming crab should be carried out under good management. In addition, the level of fishing effort should be kept at the present levels.

The management measures for blue swimming crab in Bandar Abbas, Hormozgan Province as suggested by stock assessment in fishery are to freeze the number of fishing gears of small-scale fishermen at present levels.

The decision-making on blue swimming crab management cannot use only biological information, thus, the socioeconomic condition of small-scale fishermen in Bandar Abbas, Hormozgan Province should be considered to achieve sustainable management of blue swimming crab resources and also to ensure fairness to all stakeholders.

5. Acknowledgements

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