

Growth parameters and mortality rates of the blue swimming crab, *Portunus segnis* (Forskal, 1775) in coastal waters of Persian Gulf and Gulf of Oman, Iran

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ABSTRACT

Population parameters of the blue swimming crab, *Portunus segnis* in coastal waters of the Persian Gulf and the Gulf of Oman (Hormozgan Province) were estimated using the swept area method. Sampling was carried out monthly from May 2010 to October 2011. The carapace width and weight relationship demonstrated that growth in both sexes is allometric ($p < 0.05$). The asymptotic carapace width (CW_{∞}) was estimated as 191 mm for males and 185 mm for females. The growth parameter K was calculated as 1.7 yr^{-1} for males and 1.6 yr^{-1} for females. The total mortality, natural mortality and fishing mortality rates were estimated as 5.97, 1.47 and 4.50 for males and 3.94, 1.42 and 2.52 for females, respectively. The exploitation rate was 0.75 for males and 0.64 for females.

Keywords: Growth parameters, Iran, Mortality rates, *Portunus segnis*

Introduction

Decapod crustaceans form a major component of commercial fisheries in the Indo-Pacific region. Different groups of decapod crustaceans exist in the Persian Gulf and Gulf of Oman (Hormozgan Province) and are caught during the shrimp fishing season. Crabs are mainly caught as bycatch in bottom trawls (targeted for shrimps and fishes), operated in depths up to 50 m. The crab fishery here is dominated by members of a single family, Portunidae and include four species of mud crabs (genus *Scylla* De Haan, 1833), blue swimming crabs *Portunus pelagicus* (Linnaeus, 1758), *Portunus segnis* (Forskal, 1775) and the gazami crabs *Portunus trituberculatus* (Miers, 1876) (Lai *et al.*, 2010).

Lai *et al.* (2010) described the morphological differences between *P. segnis* and *P. pelagicus*. The frontal median teeth are minute and inconspicuous, almost obsolete, or if present, always small in *P. segnis*, while small but conspicuous in *P. pelagicus*; the carapace region is relatively poorly defined and branchial regions are not as swollen as in *P. pelagicus* (Fig. 1). Distribution of this species extends along the western Indian Ocean, western Indian Sub-continent, Pakistan, Persian Gulf, Red Sea, Mediterranean Sea and East coast of Africa (Lai *et al.*, 2010). In spite of the abundance and commercial importance of blue swimming crabs, there is a paucity of information on the population dynamics of *P. segnis*.

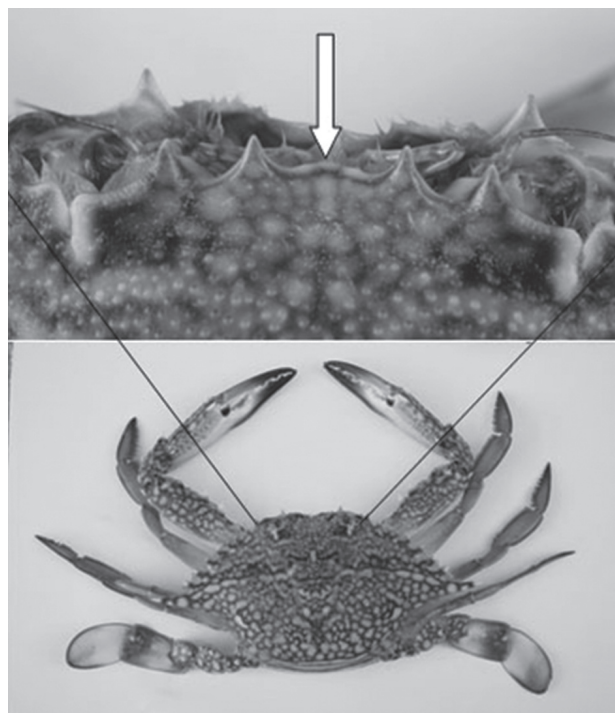


Fig.1. *Portunus segnis* (female) and frontal margin (enhanced view)

Therefore, the present study was carried out to throw light on the mortality and growth parameters of this species.

Materials and methods

The study area extends from 26° 25' E to 27° 07' E and 57° 29' N to 56° 06' N. Stratified sampling was done using a shrimp bottom trawling net with a 20 mm mesh size at the cod end. The sampled area was divided into three strata of 2–5, 5–10, and 10–20 m (Fig. 2). Samples were collected each month from May 2010 to October 2011. In all, 1,839 male and 1,769 female crab samples were caught and stored in a deep freezer onboard for preservation pending further analysis. Each crab was measured and the carapace width, body weight as well as sex were recorded. The carapace width (CW) measurement was taken to the nearest millimeter across tips of epibranchial spines and individual wet weights of crabs were recorded to the nearest gram.

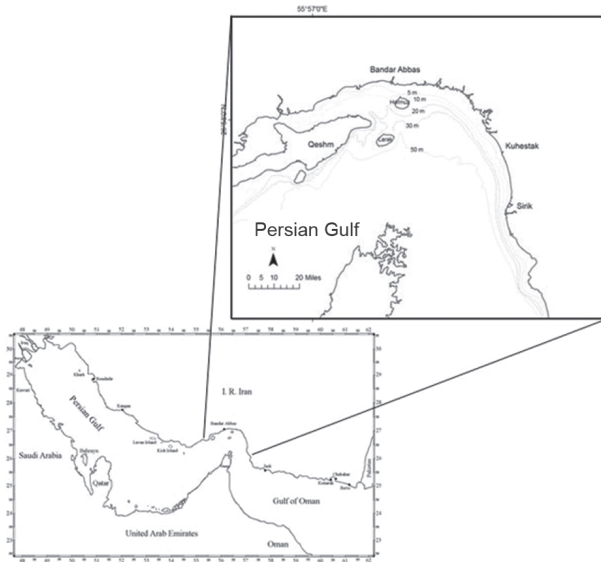


Fig. 2. Locations of sampling sites for *Portunus segnis* in Persian Gulf and Gulf of Oman, Iran

To establish the carapace width-weight relationship, the commonly used relationship $W = aCW^b$ was applied (Pauly, 1983), where W is the weight (g), CW is the carapace width (mm), a is the intercept (condition factor) and b is the slope (growth coefficient). A linear equation ($\log W = \log a + b \log CW$) was fitted to the log-transformed data. Deviation of the estimated ' b ' value from the isometric value of 3 was tested using t test:

$$t = \frac{s.d(CW)}{s.d(w)} \times \frac{|b-3|}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

where $s.d(CW)$ is the standard deviation of the log CW values, and $s.d(w)$ the standard deviation of the log W values, n being the number of crabs used in the computation. The value b is different from 3 if t is greater

than the table value of t for $n - 2$ d.f. (Pauly, 1983). Input data were separated by sex and values of K and CW_∞ were estimated for each sex by the von Bertalanffy growth equation:

$$L_t = L_\infty (1 - \exp^{-K(t-t_0)})$$

where, L_t is the carapace width at time t , L_∞ is the asymptotic length, K is the growth coefficient, and t_0 is the hypothetical age when the size of the crab is zero. Using input data from length frequencies and the ELEFAN1 program, asymptotic length (CW_∞) and growth coefficients (K) were estimated for both males and females. To find the best growth curve passing through the maximum number of peaks, different starting samples and starting lengths were subjected to goodness-of-fit tests by assessing the ESP/ASP ratio (R_n).

The growth performance index ϕ' was estimated following Pauly and Munro (1984). Mortality parameters were estimated using the FiSAT II program. The instantaneous rate of natural mortality (M) was obtained using Pauly's empirical formula (1980):

$$\ln M = -0.0152 - 0.279 \times \ln L_\infty + 0.6543 \times \ln K + 0.463 \times \ln T$$

where, the mean water temperature in the distribution area of *P. segnis*, T was 26.5 °C. From estimates of growth parameters (K , L_∞), the instantaneous rate of total mortality (Z) was estimated using the length converted catch equation (Pauly, 1983). For an estimate of total mortality, calculations were based on the length composition obtained by the research vessel, under the assumption that they were representative of commercial fisheries.

The fishing mortality (F) was estimated as:

$$F = Z - M$$

The exploitation rate E was estimated as:

$$E = F/Z.$$

Results and discussion

The carapace width to weight relationship of *P. segnis* had a high R^2 value and the exponent was significantly different from 3 ($p < 0.05$). Therefore, it was assumed that growth of this species is allometric (Table 1).

Growth parameters and growth curve of *P. segnis* in coastal areas estimated by ELEFAN-I are presented in Table 2 and Fig. 3 and 4 for both sexes. The estimated growth for males revealed a CW_∞ of 191 mm and K was 1.7 yr⁻¹ while for females CW_∞ was 185 mm and K was 1.6 yr⁻¹. The growth performance index ϕ' was 11.04 for males and 10.91 for females. The difference of maximum carapace width (CW_∞) between males and females was 6 mm, indicating differential growth rates in males and females.

Table 1. Carapace width-weight relationships of *P. segnis* in the Persian Gulf and Gulf of Oman, Iran

Sex	Carapace width-weight equation	R ²	N
Male	$W = 0.00003 \times CW^{3.214}$	0.96	1839
Female	$W = 0.00001 \times CW^{3.299}$	0.84	1769
Pooled	$W = 0.00002 \times CW^{3.232}$	0.89	3608

Short-lived animals like crabs reach their asymptotic lengths in the first or second years of their life span and are characterised by a high *K*-value (Garcia and Le Reste, 1981). In this study, *P. segnis* exhibited differential growth rates between sexes throughout the year. Males and females have at least two cohorts in most months of a year (Fig. 3 and 4). The *K*-value was higher in males than in females. The value of *K* obtained in this study was similar to that estimated for *P. pelagicus* from Thailand, but the

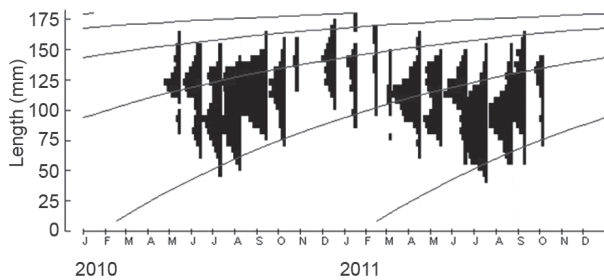
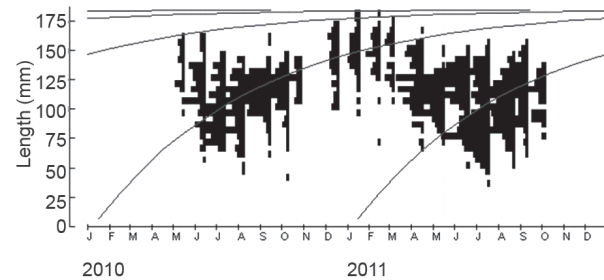
value of CW_{∞} of males and females in this study are higher than those reported from Thailand (Sawusdee and Songrak, 2009). Studies on *P. pelagicus* from India have also reported differential growth between sexes. (Sukumaran and Neelakantan, 1997; Josileen and Menon, 2007). From Persian Gulf waters, Kamrani *et al.* (2010) estimated lower CW_{∞} and *K* values for both sexes of *P. pelagicus* (Table 3).

Table 2. Estimated growth parameters of *P. segnis* in the Persian Gulf and Gulf of Oman.

Sex	CW_{∞} (mm)	<i>K</i> (yr ⁻¹)	Rn	<i>t</i> ₀
Male	191	1.7	0.111	-0.055
Female	185	1.6	0.144	-0.059

Mean $\emptyset'$ values for studies in Thailand and India were 10.45–11.04 for both sexes, and were similar to the findings in this study, suggesting that these estimates of the von Bertalanffy growth parameters are reliable (Table 3). The maximum age for males (18 months) and females (19 months) and CW_{∞} for both sexes obtained in this study were similar to those estimated for *P. pelagicus* from Thailand (Sawusdee and Songrak, 2009).

The natural mortality rate (*M*) of *P. segnis* were calculated to be 1.47 and 1.42 for males and females respectively. The annual total mortality rate (*Z*) was 5.97 for males and 3.94 for females. The fishing mortality rate (*F*) was 4.50 for male crabs and 2.52 for females. The exploitation rate (*E*) was 0.75 and 0.64 for males and females respectively. *E* being more than 0.50, indicates that *P. segnis* stock is currently being overexploited from the Persian Gulf and Gulf of Oman waters (Table 4; Fig. 5 and 6).

Fig. 3. Carapace width frequency distribution with growth curves of male *P. segnis* from the Persian Gulf and Gulf of OmanFig. 4. Carapace width frequency distribution with growth curves of female *P. segnis* from the Persian Gulf and Gulf of OmanTable 3. Comparison of growth parameters and $\emptyset'$ of *P. segnis* from Iran and *P. pelagicus* from other countries.

Area and source	Species	Sex	<i>K</i> (yr ⁻¹)	CW_{∞} (mm)	$\emptyset'$
Thailand, Sawusdee and Songrak, 2009	<i>P. pelagicus</i>	Male	1.5	179	10.78
		Female	1.6	171	10.75
India, Josileen and Menon, 2007	<i>P. pelagicus</i>	Male	0.95 -1.68	191.9-199.4	10.45-11.02
		Female	1 – 1.42	190.4 -196.9	10.50-10.92
India, Sukumaran and Neelakantan, 1997	<i>P. pelagicus</i>	Male	1.14	211	10.83
		Female	0.97	204	10.61
Iran, Kamrani <i>et al.</i> , 2010	<i>P. pelagicus</i>	Male	1.2	168	10.43
		Female	1.1	177.9	10.46
India, Present study	<i>P. segnis</i>	Male	1.7	191	11.04
		Female	1.6	185	10.91

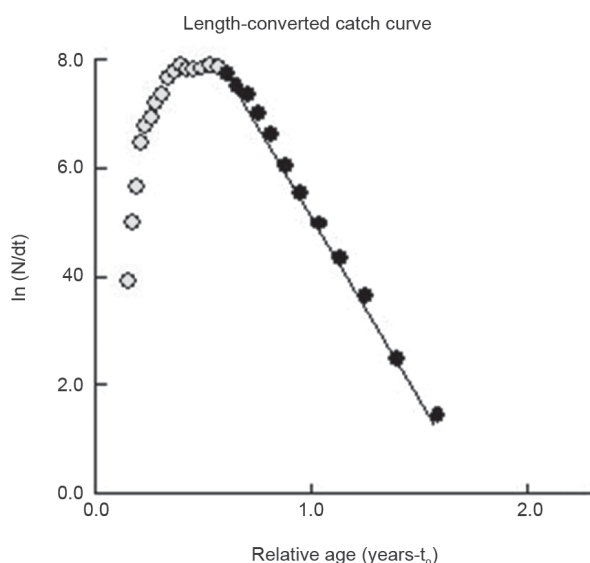
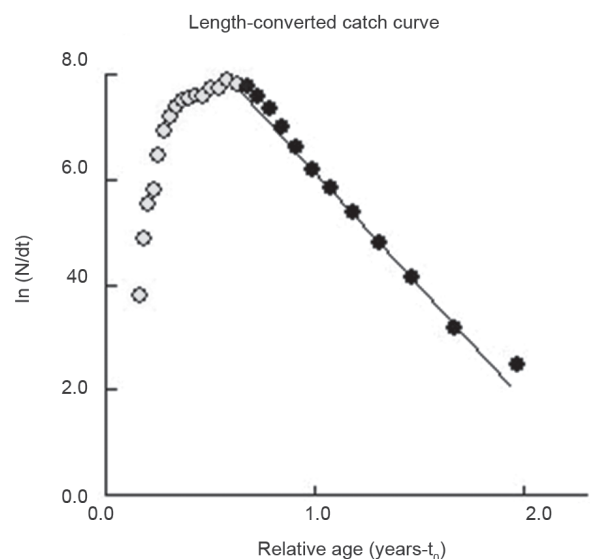
Table 4. Mortality and exploitation rates of *P. segnis* in the Persian Gulf and the Gulf of Oman

Sex	Z	M	F	E
Male	5.97	1.47	4.50	0.75
Female	3.94	1.42	2.52	0.64

The estimated natural mortality rate for *P. segnis* for both sexes in this study was less than estimated values reported for *P. pelagicus* by Sawusdee and Songrak (2009). Kamrani *et al.* (2010) also estimated lower mortality values for both sexes of *P. pelagicus* from the Persian Gulf. In most short-lived species, it is difficult to identify component

age groups and estimate numbers at each age. In length converted catch curve analysis for estimations of total mortality, the initial ascending data points are not included in the regression (Fig. 5 and 6). These points represent younger age groups, which are subjected to lower fishing mortality because they are either not fully recruited or not fully vulnerable to the fishing gear used (King, 1995). Perhaps only a proportion of each of the younger age classes have moved from nursery areas and been recruited to adult stocks in fishing grounds. However, some juveniles may have reached fishing grounds, but remain small enough to escape through the mesh of the trawling net.

In the marine environment many factors act to reduce survival rates of individuals in a population (King, 1995). These factors include adverse conditions, lack of food, competition and perhaps most important of all, predation. Natural mortality rates vary from year to year, because of environmental factors and are especially affected by the relative abundance of predators in the area. Fishing mortality, natural mortality and environmental factors all affect longevity. In species with long life span, fishing pressure over long periods reduces longevity. But for crabs it is likely that effects of predators and environmental factors are important regulators of longevity. The added effect of fishing pressure have a greater impact on the population, resulting in overexploitation of the stock, as is seen in the present study. Exploitation rate of >0.50 obtained in this study indicates the need for application of suitable management of the blue swimming crab fishery in the waters of the Persian Gulf and Gulf of Oman.

Fig. 5. Length-converted catch curve of male *P. segnis* from the Persian Gulf and Gulf of Oman, Iran (2010-2011)Fig. 6. Length-converted catch curve of female *P. segnis* from the Persian Gulf and Gulf of Oman, Iran (2010-2011)

References

- Garcia, S. and Le Resete, L. 1981. Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stock. *FAO Fish. Tech. Pap.*, 203: 215 pp.
- Gayanilo F. C. Jr., Sparre, P. and Pauly, D. 1996. FAO-ICLARM Stock Assessment Tools (FiSAT) User's Guide. *FAO Comp. Info. Ser. (Fish.)*, 8, Rome, FAO, 126 pp.
- Gayanilo, F. Jr. and Pauly, D. 1997. FAO/ICLARM Stock Assessment Tools (FiSAT). Reference manual. *FAO Comp. Info. Ser. (Fish.)* 8: 262 pp.
- Josileen, J. and Menon, N. G. 2007. Fishery and growth parameters of the blue swimmer crab *Portunus pelagicus* (Linnaeus, 1758) along the Mandapam coast, India, *J. Mar. Biol. Ass. India*, 49(2): 159–165.
- Kamrani, E., Sabili, A. N. and Yahyavi, M. 2010. Stock assessment and reproductive biology of the blue swimming crab, *Portunus pelagicus* in Bandar Abbas coastal waters Northern Persian Gulf, *J. Persian Gulf*, 1(2): 11-22.
- King, M. 1995. *Fisheries biology, assessment and management*. Fishing News Books. Blackwell Science Ltd., Oxford, UK, 342 pp.

- Lai, J. C. Y., Ng, P. K. L. and Davie, P. J. F. 2010. A Revision of the *Portunus pelagicus* (Linnaeus, 1758) species complex (Crustacea: Brachura: Portunidae), with the recognition of four species, *The Raffles Bull. Zool.*, 58(2): 199–237.
- Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *Journal du Conseil International pour l'Exploration de la mer*, 39 (2): 175– 192.
- Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, 234: 52 pp.
- Pauly, D. and Munro, J. L. 1984. Once more on the growth comparison in fish and invertebrates. *Fishbyte*, 2: 21 pp.
- Sawusdee, A. and Songrak, A. 2009. Population dynamics and stock assessment of blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) in the coastal area of Trang province, Thailand, *Walailak J. Sc. & Tech.*, 6(2): 189-202.
- Sparre, P. and Venema, S. C. 1992. Introduction to tropical fish stock assessment, Part I: Manual. *FAO Fish. Tech. Pap. Rev.*, 306 (1): 376 pp.
- Sudtongkong, C. 2006. *Reproductive biology of P. pelagicus Linnaeus in Sikao Bay, southern Thailand*, Department of Marine Science Rajamangala University, Thailand, 221 pp.
- Sukumaran, K. K. and Neelakantan, B. 1997. Age and growth in two marine portunid crabs, *Portunus (Portunus) sanguinolentus* (Herbst) and *Portunus (Portunus) pelagicus* (Linnaeus) along the south-west coast of India, *Indian J. Fish.*, 44(2): 111-131.