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Stock Assessment of Blue Swimming Crab *Portunus pelagicus* (Linnaeus, 1758) from Pakistani Waters (Northern, Arabian Sea)

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A B S T R A C T

Length frequency distribution data of blue swimming crab *Portunus pelagicus* (Linnaeus, 1766) from Pakistani waters were used to estimate the growth and mortality parameters during 2015. The combined length frequency data of *P. pelagicus* were n= 1459. The data were measured in carapace width (CW) in cm. The analyses were based on FiSAT stock assessment computer software package. The von Bertalanffy growth function parameters CW_∞=17.85 cm (CW) and K =1.700 year^{-1} (using ELEFAN method) and the t_0 value was calculated at -0.975. Based on the VBGF growth parameters the total, natural and fishing mortality were calculated at 4.60, 1.684 and 2.915 year^{-1}, respectively. The yield per recruit described that when t_c was assumed to be 2, F_{max} was estimated 2.2 and $F_{0.1}$ as 3 and when t_c was assumed to be 1, F_{max} as estimated at 2.15 and $F_{0.1}$ at 3. Currently we assume that the age of fish t_c at first capture is about 1 year and $F_{current}$ was 2.915, therefore $F_{current}$ was greater than $F_{0.1}$ and F_{max} which shows that the current status of blue swimming crab is in overexploitation state. Furthermore, when using Guland (1971) biological reference points F_{opt} was equal to M (1.685) the current fishing mortality rate is 2.915 was greater than biological reference point. The exploitation rate (E) was calculated at 0.633. In the light of above results we may assume that the *P. pelagicus* fishery from Pakistani waters are was in overexploited state. We may recommend that some management steps should be taken to maintain the blue swimming crab fishery stock from Pakistani waters for the future.

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Authors' Contributions
MAK supervised and designed the study. ZA executed the experimental work, analyzed the data and wrote the article, MAB, AN, FS, AH and IA helped in collecting and analysing the samples.

Key words:
Blue swimming crab, Stock assessment, Mortality, Overexploitation

INTRODUCTION

Pakistani waters are located at Northern part of the Arabian Sea and marine fisheries sector is the back bone of national economy, Pakistan coastline divided into Sindh and Balochistan coastline about 1120 km from the northwest Iranian border and southwest Indian borders, from which Sindh coastline comprises about 348 km and Balochistan coastline about 772 km within this the Pakistan's continental shelf limits extended from 200 to 350 nautical miles (NM) and the Exclusive Economic Zone (EEZ) also increased from 250,000 Km^2 at present about 290, 000 km^2 (UN commission March 2015) from which Pakistan can explore and exploited their marine resources. At this time about 57% of total fish landing is only from marine sector and during 2006 Pakistan's fishery product value was about US$ 196 million (FAO, 2009).

According to the FAO (2009) fisheries statistics data the trend of increasing fishing efforts from Pakistani waters since 1999 causes the decreasing trend of fish stock. The Pakistani marine waters area located at tropical region and are rich in marine diversity and comprises about more than 250 demersal fish, 20 large pelagic fish, 50 small pelagic fish and 15 medium sized pelagic and about 17 different crab, Lobster, squid, cuttlefish and octopus, 15 commercially shrimp species were found from Pakistani waters from which most of these species have commercial importance edible and highly export to different part of the world (FAO, 2009).

About 4500 crab species found all over the world, and more than 200 crab species have been reported from Pakistani waters (Kazmi, 2003), out of 200 species only five species are edible from which *Portunus pelagicus* (Linnaeus, 1785) and *Portunus sanguinolentus* (Herbst, 1783) are most dominant species from Pakistan and others are *Scylla tranquebarica* (Fabricius, 1798), *S. olivacea* (Herbst, 1796) and *Charybdis feriatus* (Linnaeus, 1785).

Portunus pelagicus (Linnaeus, 1758) is portunid crab belonging to family Portunidae and this group of

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family and commonly known as blue swimming crabs (Stephenson, 1972; Carpenter *et al*., 1997) or flower crab (Carpenter and Niem, 1998) due to the appearance.

P. pelagicus distributed throughout the Indo-West Pacific and contribute and important fishery and plays an important role in different regions (Stephenson, 1962; Potter *et al*., 1983; Kailola *et al*., 1993; Bryars and Havenhand, 2004). *P. pelagicus* mostly found in different habitats mostly at estuaries to the open sea salinity ranges from about 30 to 40 ppt (Potter *et al*., 1983; Romano and Zeng, 2006), found at sandy or muddy bottom at seagrass and algal areas depth around 50-65 m depth (Williams, 1982; Abdel_Razak, 1987; Sumpton *et al*., 1989; Edgar, 1990).

The previous studies *i.e*. food and feeding habits of blue swimming crab was considered as benthic or bottom feeder carnivorous and scavengers and mostly eat on sessile mollusks and other invertebrate bivalves but they also prey on gobbies and mostly active in sunset and diet of the crab also changes due to increase of size (Williams, 1982; Grove-Jones, 1987; Smith and Sumpton, 1987; Wessenberg and Hill, 1987; Potter and deLestang, 2000). The different studies have been conducted in different parts of the world such as Indian fishery and biology of the blue swimming crab (Prasad and Tampi, 1951, 1953; Rahman, 1967; Pillai and Nair (1968, 1971, 1973, 1976), work on reproductive cycle and biological changes in gonads, ecology and fishery (Dhawan *et al*., 1976), food and feeding habit, length weight relationship, sex ratio and fecundity from Indian water (Sukumaran and Neelakantan, 1996a,b,c). The number of studies on population dynamics have been done from different area like from Persian Gulf (Kamrani *et al*., 2010; Mehanna *et al*., 2013; Safaie *et al*., 2013), from India (Sukumaran and Neelakantan, 1996, 1997; Josileen and Menon, 2007; Denishbabu *et al*., 2008), from Thailand (Sawusdee and Songrak, 2009; Kunsook *et al*., 2014a,b), from Australia (Potter *et al*., 2001), from Indonesia (Kembaren *et al*., 2012; Sunarto, 2012; Ernawati, 2013; Ihsan *et al*., 2014).

It was observed that the peak fishing seasons of blue swimming crab were from December to January and June to July and peak spawning seasons were from December to June (Kunsook *et al*., 2014a). *P. pelagicus* is found in a variety of habitats and distributes from the intertidal zone to depth of around 50-65 m and estuaries to the open sea, it is also prefers to live on muddy or sandy bottoms or algal and seagrass habitat (Williams, 1982; Sumpton *et al*., 1989; Edgar, 1990).

There is only limited work done on the taxonomy, morphology, reproductive biology of the blue swimming crab (Hashmi, 1963; Khan, 1975; Khan and Ahmed, 1975; Mustaquim and Rabbani, 1976; Tirmizi and Kazmi, 1996; Sddiquie *et al*., 1987; Takween and Qureshi, 2001, 2005). No work has however, been done on the stock assessment of blue swimming crab fishery from Pakistani waters. The population dynamics parameters are more effective for better fishery management and fishery managers rely on those paramters (Fakhri *et al*., 2011; Kunsook, 2011; Sugilar *et al*., 2012).

Mostly the stock assessment were based on the age-structure data, or length frequency data especially in tropical waters where age determination through otolith is not easy to study and is more laborious to read the annuli on the hard parts of the species (Sparre and Venema, 1998).

Limited work has been done on the stock assessement of a single fish species like Bombay duck (Kalhoro *et al*., 2013), *Saurida tumbil* (Kalhoro *et al*., 2015), *Saurida undosquamis*, *Nemipterus japonicas* (Kalhoro *et al*., 2014a, b), Indian squid (Soomro *et al*., 2015) and *Lepturacanthus savala* (Memon *et al*., 2016) from Pakistani waters and little is known about the management steps taken to maintain the fish stock of these species for future.

The present study is aimed at recording the growth, mortality and exploitation rate of blue swimming crab from Pakistani waters which may be helpful in better management of this species in Pakistani waters.

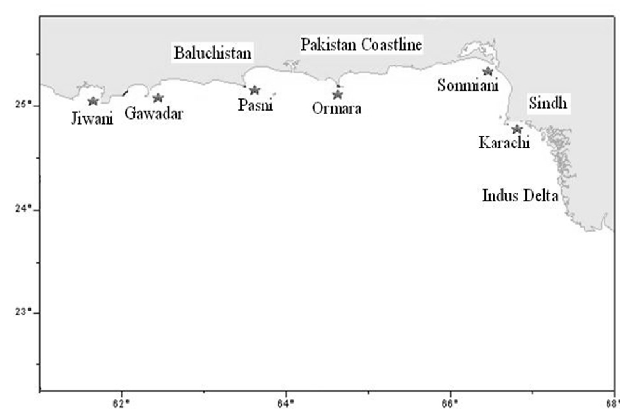

Fig. 1. Fish landing sites along the Pakistan coast (Northern Arabian Sea).

MATERIALS AND METHODS

Data collection

The length frequency data were collected on weekly basis from January 2015 to November 2015 from Pakistani waters. A total of 1459 length frequency data were measured; 155 in January, 125 in February, 157 in

March, 132 in April, 153 in May, 125 in June, 101 in August, 120 in September, 221 in October and 170 in November. The crab samples were measured in CW (carapace width) in cm. The stock assessment parameters study was carried out by using FiSATII computer program for fish stock assessment (Gayanilo *et al*., 2003).

Growth parameters

The von Bertalanffy growth function (VBGF) were used to estimate growth parameters by fitting the length frequency distribution the formula is as given below;

$$CW_t = CW_\infty\ (1\text{-exp}\ (-k\ (t\text{-}t_0)))$$

Where CW_t Is the carapace width in cm is, CW_∞ is the carapace asymptotic width in cm, K is the VBGF growth coefficient ($year^{-1}$), t_0 is the theoretical age in years at which length of the fish equal to zero (usually negative) as estimated by the Pauly's equation (Pauly, 1984) as:

$$\log_{10}(-t_0) = -0.3922\text{-}0.275\log_{10} CW_\infty \text{-}1.038\log_{10} K$$

Mortality rate

The total mortality rate (Z) was estimated by length converted catch curve analysis method (Pauly, 1983). The natural mortality (M) was calculated from Alverson and Carney (1975).

$$(M = 3^*K / [\exp\ (t_{max} {}^*0.38^*\ K)\ \text{-}1])$$

while fishing mortality (F) was calculated by $F=Z\text{-}M$ and the exploitation rate (E) was calculated from $E=F/Z$.

Biological reference points

Gulland (1969) method were used to calculate the biological reference points, the optimum fishing mortality is

$$F_{opt} = \text{M}$$

Yield per recruit analysis

Beverton-Holt model were used to estimate the yield per recruit of blue swimming crab from Pakistani water by the formula:

$$Y_w / R = FW_\infty e^{M(t_c - t_r)} \sum_{n=0}^{3} \frac{Q_n e^{-nK(t_c - t_0)}}{F + M + nK} (1 - e^{-(F+M+nK)(t_\lambda - t_c)})$$

Where Y_w / R is the yield per recruit, t_c is the mean age of the fish at first capture, t_γ is the recruitment age, t_λ is the asymptotic age, Q is a constant value and equals to 1, -3, 3 and -1 when n is 0, 1, 2 and 3 respectively (Pitcher and Hart, 1982).

Growth performance index

By the input values of VBGF growth parameters (CW_∞, and K) were used to calculate the growth performance index, given by Pauly and Munro (1984):

$$\acute{\O} = \log_{10} K + 2\log_{10} CW_\infty$$

which is available in FiSAT computer software program.

Virtual population analysis

The length-structured Virtual Population Analysis (VPA) for the blue swimming crab from Pakistani waters was estimated from input values of growth, natural and fishing mortality into FiSAT computer software package which is normally used for the length frequency structured data.

RESULTS

Length frequency distribution

Total of 1459 length frequency distributions were measured during present study from January to November 2015. The length ranged were from 7 to 17 cm (CW) with the dominant length range of blue swimming crab were from 8 to 12 cm (CW) (Fig. 2).

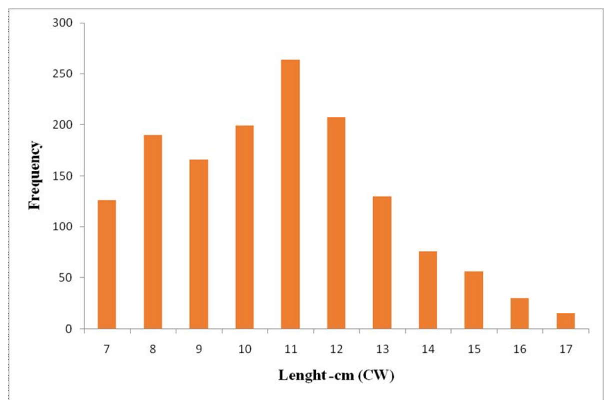

Fig. 2. Length frequency distribution (n=1459) of blue swimming crab from Pakistani waters during 2015.

Growth parameters

The ELEFAN method were used to estimate the growth parameters from a total of 1459 length frequency of fish collected from fish landing sites during January 2015 to November 2015. The von Bertalanffy growth parameters of blue swimming crab were at CW_∞ =17.85 cm (CW) and K=1.700 year^{-1} (Fig.3) and the t_0 value was calculated by Pauly's equation t_0 = -0.975 and the goodness of fit was R_n = 0.276.

Mortality rate

The total mortality of blue swimming crab from Pakistani waters were at Z=4.60 with 95% confidential interval of Z were (CI of Z 3.75-5.44) using length converted catch curve with the input values of growth rate (CW_∞ = 17.85 and K=1.700 year^{-1}) (Fig.4). The natural mortality was calculated as M=1.684, thus the fishing mortality was calculated at $F=Z-M=2.915$ year^{-1} and the exploitation rate (E) was obtained from $E=F/Z=0.633$ year^{-1}.

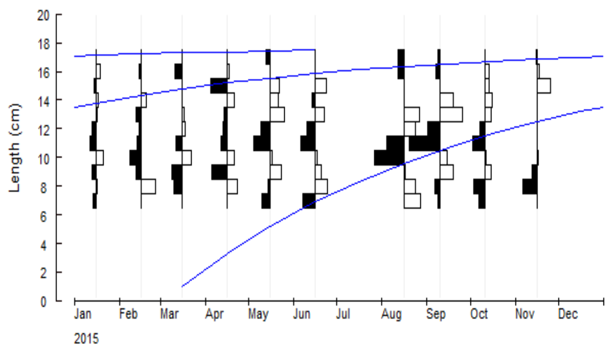

Fig. 3. Length frequency distribution (n=1459) the growth rate were estimated by ELEFAN method where (CW_{∞}= 17.85 (cm) and K=1.700 year^{-1}) with Rn= 0.29, (goodness of fit) from Pakistani waters during 2015.

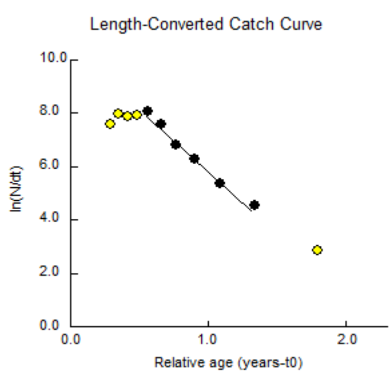

Fig. 4. Length converted catch curve were used to estimate Total mortality of blue swimming crab with input value of VBGF growth parameters (CW_{∞}=17.85 cm (CW) and K=1.700), only the black dotes were considered for total mortality estimation, where Z=4.60 year^{-1} with CI of Z (3.75-5.44) from Pakistani waters during 2015.

Yield per recruit analysis

The yield per recruit contour map in Figure 5 shows that when t_c was assumed to be 2, F_{max} was estimated 2.2 and $F_{0.1}$ as 3 and when t_c was assumed to be 1, F_{max} as estimated at 2.15 and $F_{0.1}$ at 3. Currently we assume that the age of fish t_c at first capture is about 1 year and $F_{current}$ was 2.915, therefore $F_{current}$ was greater than $F_{0.1}$ and F_{max} which shows that the current status of blue swimming crab is in overexploitation state. Furthermore, when using Guland (1971) biological reference points F_{opt} was equal to M (1.685) the current fishing mortality rate is 2.915 was greater than biological reference point.

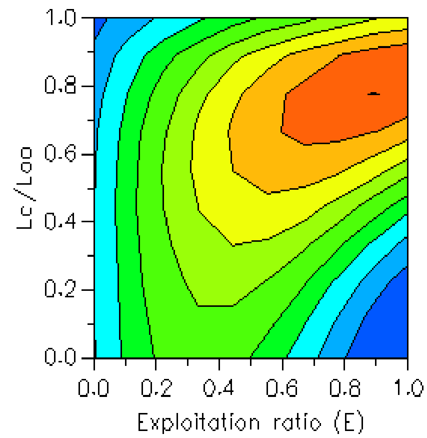

Fig. 5. The yield per recruit analysis contour map of *P. pelagicus* from Pakistani waters during 2015

Growth performance index

The growth performance index (Ǿ) of blue swimming crab was estimated at 2.734 from Pakistani waters during present study.

Virtual population analysis

The length frequency distribution data were used to estimate virtual population analysis (VPA) with the input values of length weight and growth parameters and it shows that the high fishing mortality ranges from 10 cm to 13 cm (CW) (Fig.6). VPA is great tool for the stock assessment. It is to estimate the standing stock (in numbers) and fishing mortality by length classes. If also determines the size length which has high fishing mortality.

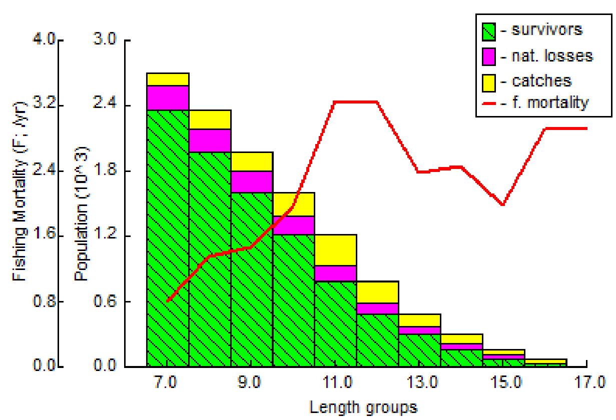

Fig. 6. Virtual population analysis shows the maximum fishing pressure on length class of 10 to 13 cm (CW) of *P. pelagicus* fishery from Pakistani water during 2015.

DISCUSSION

Growth

The length frequency distribution data were used to analyze the VBGF growth parameters such as growth coefficient (K year^{-1}) and asymptotic length (CW_∞) and the age at length zero (hypothetical age usually negative). The results from present study (CW_∞=17.85, K=1.700 year^{-1}) were compared with previous studies from the different area (Table I).

The growth parameters and asymptotic length of male and female from different waters of the India such as CW_∞=21.10, K=1.14 year^{-1}; CW_∞=20.40, K=0.95 year^{-1} (Sukumaran, 1995); CW_∞=21.98, K=1.82 year^{-1}; CW_∞=21.18, 1.70 year^{-1} (Josileen and Menon, 2004); CW_∞ =22.30, K= 0.95 year^{-1}; CW_∞=19.51, 1.00 year^{-1} (Josileen and Menon, 2007) were higher than the present study. However, some values of blue swimming crab of male and female from Iran, Oman, Australia, and Egypt were lower than the present study such as: CW_∞=16.80, K=1.20 year^{-1}; CW_∞=17.79, 1.10 year^{-1} (Kamrani *et al*., 2010); CW_∞=10.28, K=1.85 year^{-1}; CW_∞=10.95, 1.68 year^{-1} and both sexes were CW_∞=10.84, K=1.68 year^{-1} (Mehanna *et al*., 2013); CW_∞=11.91, K=3.11 year^{-1}; CW_∞=12.47, 2.60 year^{-1} (Potter *et al*., 2001); CW_∞=8.38, K=2.04 year^{-1} (Mehanna and Al-Aiatt, 2011), respectively. Some values of the growth parameters from Australia CW_∞=17.50, K=1.60 year^{-1}; CW_∞=17.00, 1.61 year^{-1} (Sumpton *et al*., 1994); CW_∞=17.50, K=1.62 year^{-1}; CW_∞=17.70, 1.61 year^{-1} (Sumpton *et al*., 2003), from Thailand CW_∞=17.90, K = 1.50 year^{-1}; CW_∞= 17.10, 1.60 year^{-1} (Sawusdee and Songrak, 2009) and Indonesia were CW_∞=17.38, K=1.20 year^{-1}; CW_∞=18.63, 1.50 year^{-1} (Ihsan *et al*., 2014) and CW_∞=15.20, K=0.93 year^{-1}; CW_∞=17.30, 0.86 year^{-1} (Hamid *et al*., 2015a,b) were observed to be the same or close to the present values.

Though, t_0 values from the present study (-0.975) were close to values from Indonesia t_0= -0.963 and -0.837, (Hamid *et al*., 2015a,b) which also shows the similarity with present study. The positive t_0 values shows that the juveniles were slow grower while negative t_0 values indicated that crab species were fast grower during juvenile stage (King, 1995, 2007; Sparre and Venema, 1998).

The difference between these values were may be because of different factors affecting the growth parameters because of methods by which crabs were caught in those localities, in addition to ecological and environmental factors affect the growth rate. The growth rate also differ from stock to stock (Adam, 1980; Devaraj, 1981; Sparre *et al*., 1992). It was observed that the growth parameters were correlated with each other which means that higher the K values lower the CW_∞ values and vice versa (Pauly and Morgan, 1987) (Table I).

In this study the VBGF growth coefficient parameters were estimated using non-parametric methods which are commonly used for the length frequency analysis. It is basically an ad hoc method and does not depend on estimating the cohort distribution parameters directly. This makes only weak hypothesis about the distribution of size classes within the cohorts. The length model of each cohort are fixed to lie upon a curve described by growth models such as von Bertalanffy growth model, this it makes a strong assumption about growth (Pitcher, 2002).

Mortality

There are different causes of mortality such as predation by large animals (Otobo, 1993), aging factor (King, 1991), parasites and diseases (Landau, 1979), environmental factors (Chapman and Van Well, 1978). In this study the mortality rate of blue swimming crab were estimated using length-converted catch curve using input values of VBGF growth parameters. Length converted catch curve is normally used when age-structure data were not available. In the present study the total, natural and fishing mortality of blue swimming crab were estimated at 4.60, 1.684 and 2.915 year^{-1}, respectively. The mortality rate of the blue swimming crab from the different area of the world are also shown in Table II, which shows that overall values are closer to the present study. The values of total, natural and fishing mortality and exploitation rate of male and female from Indian water were 6.20, 2.20, 4.10 and 0.65; 4.54, 2.76, 2.45 and 0.54, respectively (Dineshbabu *et al*., 2008) and from Oman these values were 7.85, 3.15, 4.70, 0.60, respectively (Mehanna *et al.*, 2013).

Table II shows that overall values from other parts of the world were closer or higher than the present study. It shows that the blue swimming crab has high commercial demand in the market. The exploitation rate (E) from Pakistani waters were 0.663. Gulland (1971, 1979) described that if exploitation rate is greater than 0.5 it may be assumed that the stock in the water body is in overexploitation state, and according to the Patterson (1992) exploitation rate should be not greater than 0.4 for the sustainable state, but according to our result the exploitation rate is greater than 0.4 and 0.5. It may show that the stock of blue swimming crab fishery from Pakistani waters is in stress and is in overexploited state.

Regarding present study, we may suggest that the fishery managers should take some serious steps to save this commercially important crab species from Pakistani waters for future and should maintain the stock of crab fishery so that share holders can get more benefit from the stock.

Table I. Growth parameter of blue swimming crab and comparison results of present study with previous studies during 2015.

Area	Sex	$K\ year^{-1}$	CW_{∞}	References
Bandar Abas, Persian Bay	Male	1.20	16.80	Kamrani *et al*., 2010
	Female	1.10	17.79	
Oman coast, Oman	Male	1.85	10.28	Mehanna *et al*., 2013
	Female	1.68	10.95	
	Both	1.68	10.84	
Persian Gulf and Oman, Iran	Male	1.70	19.10	Safaie *et al*., 2013
	Female	1.60	18.50	
Karnataka Coast, India	Male	1.14	21.10	Sukumaran, 1995
	Female	0.95	20.40	
Karnataka Coast, India	Male	1.30	11.69	Dineshbabu *et al.*, 2008
	Female	1.40	17.00	
Mandapan Coast, India	Male	0.95	22.30	Josileen and Menon, 2007
	Female	1.00	19.51	
Western Australia	Male	3.11	11.91	Potter *et al*., 2001
	Female	2.60	12.47	
Australia	Male	1.60	17.50	Sumpton *et al*., 1994
	Female	1.61	17.00	
Australia	Male	1.62	17.50	Sumpton *et al*., 2003
	Female	1.61	17.70	
India	Male	1.14	21.10	Sukumaran and Neelakandan, 1997a,b
	Female	0.97	20.40	
India	Male	1.82	21.98	Josileen and Menon, 2004
	Female	1.70	21.18	
Egypt	Male	1.73	10.40	Mehanna, 2005
	Female	1.61	9.80	
	Both	1.67	10.50	
Egypt	Both	2.04	8.38	Mehanna and Al-Aiatt, 2011
Thailand	Male	1.50	17.90	Sawusdee and Songrak, 2009
	Female	1.60	17.10	
Thailand	Male	2.75	14.26	Kunsook, 2011
	Female	1.13	16.73	
Indonesia	Male	1.20	8.13	Sunarto, 2012
	Female	0.78	8.11	
Indonesia	Male	1.37	15.90	Kembaren *et al.*, 2012
	Female	1.08	15.40	
Indonesia	Male	1.26	18.50	Ernawati, 2013
	Female	1.13	18.70	
Indonesia	Male	1.20	17.38	Ihsan *et al*., 2014
	Female	1.50	18.63	
Indonesia	Male	0.93	15.20	Hamid and Wardiatno, 2015
	Female	0.68	17.30	
Pakistan, Arabian Sea	Both	1.70	17.85	Present study

K year^{-1}, is the growth coefficient, CW_{∞} is the carapace asymptotic width (cm).

Biological reference points

The biological reference points (BRF) is important to know for the long term fishery management objectives using the length frequency data. The $F_{0.1}$ and F_{max} are two biological reference points (BRP) which are usually used for the fisheries management in the world (Deriso, 1987; Hilborn and Walters, 1992). These were estimated from length frequency data or age-structure data for better fishery management for the future (Caddy, 1998).

Basically $F_{0.1}$ describes that fishing mortality rate at which marginal increase in yield per recruit (YPR) is 10% of F 0 and F_{max} is the fishing mortality rate when maximum YPR value is attained (Deriso, 1987; Hilborn and Walters, 1992).

Figure 5 of the yield per recruit shows that the when t_c was assumed to be 2, F_{max} was estimated to be 2.2 and

Table II.- Comparison results of mortality rate of blue swimming crab from previous studies.

Area	Sex	Z	M	F	E	References
Bandar Abas, Persian Bay	Male	2.48	1.21	1.27	0.51	Kamrani *et al*., 2010
	Female	2.44	1.13	1.31	0.54	
Oman coast, Oman	Male	7.85	3.15	4.70	0.60	Mehanna *et al*., 2013
Persian Gulf and Oman, Iran	Male	5.97	1.47	4.50	0.75	Safaie *et al*., 2013
	Female	3.94	1.42	2.52	0.64	
Karnataka Coast, India	Male	5.60	1.70	3.90	0.53	Sukumaran, 1995
	Female	4.90	1.60	3.20	-	
Karnataka Coast	Male	6.20	2.20	4.10	0.65	Dineshbabu *et al*., 2008
Mandapan Coast, India	Male	4.54	2.76	2.45	0.54	Josileen and Menon 2007
	Female	3.03	2.11	1.57	0.52	
Thailand	Male	9.25	1.61	7.62	0.83	Sawusdee and Songrak, 2009
	Female	8.85	1.61	7.24	0.82	
	Both	8.96	1.61	7.35	0.82	
Thailand	Male	8.15	3.98	4.53	0.56	Kunsook, 2011
	Female	6.95	2.07	4.88	0.70	
Indonesia	Male	2.52	1.53	0.98	0.39	Sunarto, 2012
Indonesia	Male	9.21	1.33	7.88	0.86	Kembaren *et al*., 2012
	Female	6.90	1.21	5.69	0.82	
Indonesia	Male	6.24	1.27	4.97	0.80	Ernawati, 2013
	Female	6.19	1.18	5.01	0.81	
Indonesia	Male	2.53	1.44	1.09	0.43	Ihsan *et al*., 2014
	Female	3.22	1.27	1.95	0.60	
Indonesia	Male	2.80	1.09	1.71	0.61	Hamid and Wardiatno, 2015c
	Female	2.95	0.86	2.09	0.71	
Pakistan, Arabian Sea	Both	4.60	1.684	2.915	0.633	Present study

Z, total mortality; M = natural mortality; F, fishing mortality; E, Exploitation rate.

$F_{0.1}$ as 3 and when t_c was assumed to be 1, F_{max} was estimated at 2.15 and $F_{0.1}$ at 3. Currently we assume that the age of fish t_c at first capture is about 1 year and $F_{current}$ was 2.915, therefore $F_{current}$ was greater than $F_{0.1}$ and F_{max} which shows that the current status of blue swimming crab is in overexploitation state. Furthermore, when using Gulland (1971) biological reference points F_{opt} was equal to M (1.685). The current fishing mortality rate is 2.915 which was greater than biological reference point.

Growth performance index

Estimation of growth performance index is also important for the stock assessment for any fishery (Pauly and Munro, 1984; Sparre and Venema, 1998). Growth performance values may be different because of input values of growth parameters and some ecological and geological conditions (Deveraj, 1981). In the present studies $\acute{\varnothing}$ = 2.734 shows that the environmental conditions were favorable for the growth of blue swimming crab in Pakistani waters.

CONCLUSIONS

In conclusion the length frequency data used in the present study represent the full length class of blue swimming crab species and provide the best management for the stock assessment because length frequency data gives valuable information about growth, mortality and life history parameters of this species. The reliability depends on the sampling strategies, environmental and ecological factors. In the light of above results we may suggest that the blue swimming crab fishery was overexploited during present study. We suggest ban on the spawning season, unreported trawl and on catch of berried females. Replace the trawl nets by traps with appropriate holes in all fishing grounds along Pakistan coast to conserve the reproduction of species in the population and declare the Marine Protected Areas for the blue swimming crab fishery during their breeding season to maintain the stock of blue swimming fishery from Pakistani waters.

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Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Abdel-Razek, F.A., 1987. Crab fishery of the Egyptian waters with notes on the bionomics of *Portunus pelagicus* (L.). *Acta Adriat.*, **28**: 143-154.

Adam, P., 1980. Life history pattern in marine fishes and their consequences for fisheriesmanagement. *Fish. Bull.*, **78:** 1-12.

Alverson, D.L. and Carney, M.J., 1975. A graphic review of the growth and decay of population cohorts. *Journal du Conseil International pour l'Exploration de la Mer* **36**:133–143.

Bryars, S.R. and Havenhand, J.N., 2004**.** Temporal and spatial distribution and abundance of blue swimmer crab (*Portunus pelagicus*) larvae in a temperate gulf. *Mar. Freshw. Res*., **55**: 809-818.

Caddy, J., 1998. A short review of precautionary reference points and some proposals for their use in data-poor situations. *FAO Fish. Tech. Pap*., 379.

Carpenter, K.E. and Niem, V.H., 1998. *The living marine resources of the Western Central Pacific. Volume 2. Cephalopods, crustaceans, holuthurians and sharks*. FAO Species Identification Guide for Fishery Purposes. FAO, Rome.

Carpenter, K.E., Krupp, F., Jones, D.A. and Zajonz, U., 1997**.** *Living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates*. FAOION. Rome, pp. 293.

Chapman, D.W. and VanWell, P., 1978**.** Growth and mortality of *Stolothrissa tangenicae*. *Trans. Am. Fish. Soc.*, **2107:** 26- 35.

Deriso, R.B., 1987. Optimal $F_{0.1}$ criteria and their relationship to maximum sustainable yield. *Can. J. Fish. aquat. Sci*., **44 (suppl. 2):** 339-348.

Devaraj, M., 1981. Age and growth of the three species of seerfishes *Scombermorus commerson, S. guttatus, S. lineolatus*. *Indian J. Fish.*, **28**: 104-127.

Dhawan, R.M., Dwivedi, S.N. and Rajamanickam, G.V., 1976. Ecology of the blue crab *Portunus pelagicus* (Linnaeus) and its potential fishery in Zuari estuary. *Indian J. Fish*., **23:** 57-64.

Dineshbabu, A.P., Shridhara, B. and Muniyappa, Y., 2008. Biology and exploitation of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758), from south Karnataka Coast, India, Mangalore Research Centre of Central Marine Fisheries Research Institute, Mangalore - 575 001. *Indian J. Fish,* **55:** 215-220.

Edgar, G.J., 1990. Predator-prey interactions in sea grass beds. II. Distribution and diet of theblue manna crab *Portunus pelagicus* Linnaeus at Cliff head, Western Australia. *J. exp. Mar. Biol. Ecol.,* **139**: 23-32.

Ernawati, T., 2013. *Population dynamics and stock assessment of blue swimmer crab* (Portunus pelagicus *Linnaeus*) *resource in Pati and adjacent waters*]. Master thesis, Bogor Agricultural University, Bogor, Indonesia, pp. 80 [in Indonesian].

Fakhri, A., Hajed, P., Shadi, A., Kamalifar, R. and Mirza, R., 2011**.** Growth parameters and mortality rates of Javelin Grunter, *Pomadasys kaakan*, in the Persian Gulf. *World J. Fish. mar. Sci*., **3:** 346-350.

FAO, 2009. *Fishery and aquaculture profile*. FAO's Fisheries Department, Rome, pp. 1-18.

Gayanilo, F.C., Sparre, P. and Pauly, D., 2003.*FAO-ICLARM stock assessment tool* (FiSAT II) User's Guide, FAO Computerized Information Series (Fisheries). No. 8, Rome, FAO, pp. 266.

Grove-Jones, R., 1987. Catch and effort in the South Australian blue crab (*Portunus pelagicus*) fishery. South Australian Department of Fisheries, discussion paper, September 1987, pp. 45.

Gulland, J.A., 1969. *Manual of Methods for Fish Stock Assessment. Part 1. Fish population analysis*. Fishery Resources and Exploitation Division, FAO, Rome, pp. 154.

Gulland, J.A., 1979**.** *Report of FAO/IOP workshop on the fishery resources of the western Indian Ocean South of the Equator*. FAO, Rome, IOFC/DEV/79/45, pp. 1-37.

Gulland, J.A., 1971. *Fish resources of the ocean. FAO Fisheries Technical Paper* (97). West Byfleet, Survey, Fishing News Books Ltd. pp. 425.

Hamid. A. and Wardiatno, Y., 2015. Population dynamics of the blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) in Lasongko Bay, Central Buton, and Indonesia. *AACL Bioflux*., 8: 729-739.

Hamid, A., Wardiatno, Y., Djamar, T.F.L.B. and Riani, E., 2015a. Fecundity and gonad maturity stages of ovigerous female blue swimming crab (*Portunus pelagicus*) in Lasongko bay, Southeast Sulawesi]. *Bawal* **7**: 43-50 [in

Indonesian].

Hamid, A., Wardiatno, Y., Djamar, T.F L B. and Riani, E., 2015b. Changes in proximate and fatty acids of the eggs during embryo development in the blue swimming crab, *Portunus pelagicus* (Linnaeus 1758) at Lasongko bay, Southeast Sulawesi, Indonesia. *Indian J. Sci. Tech*., **8**: 501-509.

Hashmi, S.S., 1963. Carcinological fauna of Karachi. *Agric. Pak.*, **14**: 237-243.

Hilborn, R. and Walters, C.J., 1992. *Quantitative fisheries stock assessment: Choice, dynamics, and uncertainty*. Chapman and Hall, New York, pp. 570.

Ihsan, Wiyono E.S., Wisudo, S.H. and Haluan, J., 2014. A study of biological potential and sustainability of swimming crab population in the waters of Pangkep Regency South Sulawesi Province. International Journal of Sciences: *Basic appl. Res.*, **16**: 351-363.

Josileen, J. and Menon N.G., 2004. Larval stages of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura). *Crustaceana*, **77**: 785-803.

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. Assoc. India*, **49**: 159-165.

Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., Mcnee, A. and Grieve, C., 1993. *Australian fisheries resources*. Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation, Canberra, Australia.

Kalhoro, M.A., Liu, Q., Memon, K.H., Chang, M.S. and Jat, A.N., 2013. Estimation of Maximum Sustainable Yield of Bombay duck *Harpadon nehereus* fishery in Pakistan using the CEDA and ASPIC packages. *Pakistan J. Zool.*, **45:** 1757-1764.

Kalhoro, M.A., Liu, Q., Waryani, B., Panhwar, S.K. and Memon, K.H., 2014a. Growth and mortality of brushtooth lizardfish *Saurida undosquamis* from Pakistani waters. *Pakistan J. Zool.*, **46:** 139-151.

Kalhoro, M.A., Liu, Q., Memon, K.H., Chang, M.S. and Zhang, K., 2014b. Population dynamics of Japanese threadfin bream *Nemipterus japonicus* from Pakistani waters. *Acta Oceanol. Sin.*, **33**: 1-9.

Kalhoro, M.A., Liu, Q., Memon, K.H., Waryani, B. and Soomro, S.H., 2015. Maximum sustainable yield of Greater lizardfish *Saurida tumbil* fishery in Pakistan using CEDA and ASPIC packages. *Acta Oceanol. Sin*., **34:** 68-73.

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 (Mar. Sci.)*, **1**: 11-22.

Kazmi, Q.B., 2003. *Taxonomic studies of crustaceans in Pakistan*. Global Taxonomy Institute in Asia (ed. J. Shimura), pp. 230-248.

Kembaren, D.D., Ernawati, T. and Suprapto, 2012. Biology and population parameters of blue swimming crab (*Portunus pelagicus*) in the Bone Bay and adjacent waters. *J. Penelitian Perikanan Indonesia*, **18**:273-281 [in Indonesian].

Khan, M.A., 1975. Portunidae of Pakistan. *Agric. Pakistan*, **26**: 377–392.

Khan, M.A. and Ahmed, M.F., 1975. A checklist of *Brachyura* of Karachi coasts.

King, M., 1995. *Fisheries biology, assessment and management*. Blackwell Science Ltd, London, UK. Fishing News Book, pp. 341.

King, M., 2007. *Fisheries biology, assessment and management*. Fishing News Book, Oxford, UK, Wiley-Blackwell Publishing. London, pp. 342.

King, R.P.L., 1991**.** Some aspects of the reproductive strategy of *Ilisha africana* (Bloch, 1795) (Teleost, Clupeidae) in Qua Iboe Estuary, Nigeria. *Cymbium*, **15**: 239-251.

Kunsook, C., 2011. *Assessment of stock and movement pattern for sustainable management of blue swimming crab* Portunus pelagicus *(Linnaeus, 1758): Case study in Kung Krabaen Bay, Chanthaburi Province, Thailand*. Ph.D thesis, Chulalongkorn University, Bangkok, Thailand, pp. 166.

Kunsook, C., Gajaseni, N. and Paphavasit, N., 2014a. A stock Assessment of the blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) for sustainable management in Kung Krabaen Bay, Gulf of Thailand. *Trop. Life Sci. Res*., **25**: 41–59.

Kunsook, C., Gajaseni, N. and Paphavasit, N., 2014b. The feeding ecology of the blue swimming crab, *Portunus pelagicus* (Linnaeus, 1758), at Kung Krabaen Bay, Chanthaburi Province, Thailand. *Trop. Life Sci. Res.*, **25:** 13–27.

Landau, R., 1979. *Fisheries biology, assessment and management*. Fishing News Books, Blackwell Science, Osney Mead, Oxford OX2 OEL, England, pp.341.

Mehanna, S.F., 2005. Stock assessment of the blue swimmer crab *Portunus pelagicus* (Linnaeus, 1766) at Bitter Lakes, Suez Canal, Egypt. *Egyp. J. aquat. Biol. Fish*., **9:** 187-213.

Mehanna, S.F. and El-Aiatt, A., 2011. *Fisheries characteristics and population dynamics of the blue swimmer crab* Portunus pelagicus *(Linnaeus, 1766) from Bardawil lagoon*. Proceeding of 4th International Conference on Fisheries and Aquaculture. Cairo, Egypt.

Mehanna, S.F., Khvorov, S., Al-Sinawy, M., Al-Nadabi, Y.S., Mohamed, N. and Al-Mosharafi, H.N., 2013**.** Stock assessment of the blue swimmer crab *Portunus pelagicus* (Linnaeus, 1766) from the Oman coastal waters. *Int. J. Fish. aquat. Sci*., **2**: 1-8.

Mustaquim, J. and Rabbani, M.M., 1976. Species of portunid crabs (Decapoda: Brachyura) from Karachi. *Pakistan J. scient. indust. Res.*, **19**: 161–164.

Otobo, A.J.T., 1993**.** *The ecology and fishery of the pygmy herring*, Sierrathensa loenensis *(Thysvan Den Audenaerde, 1969) in the Num River and Taylor Creek of the Niger Delta*. Ph.D. thesis, University of Port Harcourt, pp. 298.

Patterson, K., 1992. Fisheries for small pelagic species: An empirical approach to *Portunus pelagicus* (Linnaeus) with a note on the zcea of Thalamita crenata Latreille. *J. Bomb. nat. Hist. Soc.*, **51**: 674-89.

Pauly, D. and Munro, J.I., 1984. Once more on the comparison of growth in fish and invertebrates. *Fish Byte*, **2**: 21-23.

Pauly, D., 1983**.** Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, **234:** 1-52.

Pauly, D., 1984. Length-converted catch curves: A powerful tool for fisheries research in the tropics (part II). *ICLARM Fishbyte*, **2**: 17-19.

Pauly, D. and Morgan, G.R., 1987**.** *Length-based methods in fisheries research.* ICLARM Conference Proceedings 13. Int. Cent. Living Aquat. Resourc. Manage., Manila, Philippines, and Kuwait Inst. Sci. Res., Safat, Kuwait, pp. 468.

Picther, T.J. and Hart, P.J.B., 1982. *Fisheries ecology*. Croom Helm, London, pp. 250-292.

Pillai, K.K. and Nair, N.B., 1968. Observations on the reproductive cycle of some crabs from the southwest coast of India*. Mar. Biol. Assoc. India***, 10**: 384-385.

Pillai, K.K. and Nair, N.B., 1971. The annual reproductive cycles of *Uca annulipes*, *Portunus pelagicus* and *Metapenaeus affinis* (Decapoda: Crustacea) from the South-west coast of India. *Mar. Biol.*, **11:** 152-166.

Pillai, K.K. and Nair, N.B., 1973. Observations on the biochemical changes in gonads and other organs of *Uca annulipes*, *Portunus pelagicus* and *Metapenaeus affinis* (Decapoda: Crustacea) during reproductive cycle. *Mar. Biol*., **18:** 167-198.

Pillai, K.K. and Nair, N.B., 1976**.** Observations on the breeding biology of some crabs from the southwest coast of India. *J. mar. biol. Assoc. India*, **15**: 754-770.

Pitcher, T.J., 2002**.** A bumpy old road: size-base methods in fisheries assessment. In: *Handbook of fish biology and fisheries* (eds. P.J.B. Hart and J.D. Reynold), Vol. 2, Fisheries. Blackwell Publishing, Oxford, pp. 189-210.

Potter, I.C., Chrystal, P.J. and Loneragan, N.R., 1983**.** The biology of the blue manna crab *P. pelagicus* in an Australian estuary. *Mar. Biol.*, **78**: 75-85.

Potter, I.C. and deLestang, S., 2000**.** Biology of the blue swimmer crab *Portunus pelagicus* in Leschenault Estuary and Koombana Bay, south-western Australia. *J. R. Soc. W. Aust.* **83**: 443-458.

Potter, I.C., deLestang, S. and Melville-Smith, R., 2001. *The collection of biological data required for management of the blue swimmer crab fishery in the central and lower west coasts of Australia*. Centre for Fish and Fisheries Research, Murdoch University, Murdoch, Australia, pp. 56.

Prasad, R.R. and Tampi, P.R.S., 1951**.** An account of the fishery and fishing methods for *Neptunus pelagicus* (Linnaeus) near Mandapam. *J. zool. Soc India*, **3:** 335-39.

Prasad, R.R. and Tampi, R.S., 1953**.** A contribution to the biology of blue swimming crab, *Neptunus pelagicus* (Linnaeus), with a note on the zoea of Tha/amita crenata Latrelle. *1. Bombay nat. Hist. Soc.*, **51**: 674-689.

Rahaman, A.A., 1967. Reproductive and nutritional cycles in the crab, *Portunus pelagicus* (Linnaeus) (Decapoda: Brachyura) of the Madras coast. *Proc. Indian Acad.*, **65**: 76-82.

Romano, N., Zeng, C., 2006. The effects of salinity on the survival, growth and haemolymph osmolality of early juvenile blue swimmer crabs, *Portunus pelagicus*. *Aquaculture*, **260**:151–162.

Safaie, M., Pazooki, J., Kiabi, B. and Shokri, M.R., 2013. Reproductive biology of blue swimming crab, *Portunus segnis* (Forskal, 1775) in coastal waters of Persian Gulf and Oman Sea, Iran. *Iranian J. Fish. Sci.*, **12**: 430-444.

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. Sci. Technol*., **6:** 189-202.

Siddiquie, P.J.A., Akbar, Z. and Quasim, R., 1987. Biochemical composition and calorific values of the three edible species of portunid crabs from Karachi. *Pak. J. scient. indust. Res.*, **30**: 119-122.

Smith, G.S. and Sumpton, W.D., 1987. Sand crabs a valuable fishery in southeast Queensland. *Queensl. Fisher.*, **5**: 13-15.

Soomro, S.H., Qun, L., Kalhoro, M.A., Memon, K.H., Zhang, K. and Liao, B., 2015. Growth and mortality parameters of Indian squid *Uroteuthis* (*Photoligo*) *duvaucelii* (D'Orbigny, 1835) from Pakistani waters (Arabian Sea) based on length frequency data. *Indian J. Geo-Mar. Sci.*, **44**: 1598-1603.

Sparre, P., Ursin, E. and Venema, S.C., 1992. *Introduction of tropical fish stock assessment, Part 1 Manual*, FAO Fisheries Technical Paper No. 306/1, Italy, Rome. FAO, pp. 337.

Sparre, P. and Venema, S.C., 1998. *Introduction to the tropical fish stock assessment*. Manual. FAO Fisheries Technical Report, 306, Rev. 2, Rome, pp. 407.

Stephenson, W., 1962**.** Evolution and ecology of portunid crabs, with special reference to Australian species. In: *The evolution of living organisms* (ed. G.W. Leeper), Melbourne University Press, Melbourne, pp. 311-327.

Stephenson, W., 1972**.** An annotated check list and key to the Indo-Pacific swimming crabs (Crustacea: Decapoda, Portunidae). *Bull. R. Soc. N. Z.*, **10:** 1-64.

Sugilar, H., Park, Y.C., Lee, N.H., Han, D.W. and Han, K.N., 2012. Population dynamics of the swimming crab *Portunus trituberculatus* (Miers, 1876) (Brachyura, Portunidae) from the West Sea of Korea. *Int. J. Oceanog. Mar. ecol. Syst.*, **1:** 36-49.

Sukumaran, K.K., 1995. *Fishery, biology and population dynamics of the marine crabs,* Portunus (Portunus) sanguinolentus *(Herbst) and* Portunus (Portunus) Pelagicus *(Linnaeus) along the Karnataka Coast*. Ph.D thesis, School of Ocean Sciences, Karnataka University, Karwar, India, pp. 403.

Sukumaran, K.K. and Neelakantan, B., 1996. Mortality and stock assessment of two marine portunid crabs, *Portunus (Portunus) sanguinolentus* (Herbst) and *Portunus (Portunus*) *pelagicus* (Linnaeus) along the Southwest Coast of India. *Indian J. Fish.*, **43**: 225-240.

Sukumaran, K.K. and Neelakantan, B., 1997a. Length–weight relationship in two marine portunid crabs, *Portunus (Portunus) sanguinolentus* (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus) from the Karnataka coast. *Indian J. mar. Sci.,* **26**: 39-42.

Sukumaran, K.K. and Neelakantan, B., 1997b. Age and growth of two marine portunid crabs *Portunus* (*Portunus*) sanguinolentus (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus), along south-west coast of India. *Indian J. Fish*., **44**: 111-131.

Sukumaran, K.K. and Neelakantan, B., 1996a. Marine crab fishery of Karnataka. *Seafood Exp. J.,* **27**: 5-14.

Sukumaran, K.K. and Neelakantan, B., 1996b. Relative growth and sexual maturity in the marine crabs, *Portunus* (*Portunus*) *sanguinolentus* (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus), along south - west coast of India. *Indian J. Fish*., **43**: 215-223.

Sukumaran, K.K. and Neelakantan, B., 1996c. Morality and stock assessment of two marine portunid crabs *Portunus* (*Portunus*) *sanguinolentus* (Herbst) and *Portunus* (*Portunus*) *pelagicus* (Linnaeus), along south-west coast of India. *Indian J. Fish*., **43**: 225-240.

Sumpton, W., Gaddes, S., McLennan, M., Campbell, M., Tonks, M., Good, N., Hagedoorn, W. and Skilleter, G., 2003. *Fisheries biology and assessment of the blue swimmer crab* (Portunus pelagicus) *in Queensland*. Proj. No., **98:** 170.

Sumpton, W.D., Potter, M.A. and Smith, G.S., 1989**.** The commercial pot and trawl fisheries for sand crabs (*Portunus pelagicus*) in Moreton Bay, Queensland. *Proc. R. Soc. Queensl*., **100**: 89-100.

Sumpton, W.D., Potter, M.A. and Smith, G.S., 1994. Reproduction and growth of the commercial sand crab, *Portunus pelagicus* (L.) in Moreton Bay, Queensland. *Asian Fish. Sci*., **7**: 103-113.

Sunarto, 2012. *Bioecology characteristics of blue swimming crab* (Portunus pelagicus) *in Bebes waters*. Ph.D. thesis, Bogor Agricultural University, Bogor, Indonesia, pp. 175 [in Indonesian].

Takween, W. and Qureshi, N.A., 2001**.** Distribution, abundance and diversity indices of Portunid crabs (swimming crabs) from the coastal areas of Pakistan. *Pak. J. mar. Biol.*, **7**: 49-59.

Takween, W. and Qureshi, N.A., 2005**.** Population structure and reproductive biology of four species of swimming crabs (Crustacea: Brachyura: Portunidae) from coastal area of Karachi, Pakistan. *Pakistan J. mar. Sci*., **14:** 107-121.

Tirmizi, N.M. and Kazmi, Q.B., 1996. *Marine fauna of Pakistan, 6: Crustacea: Brachyura, Brachyrhyncha, Part 2: Portunidae*. Marine Reference Collection Centre, University of Karachi, pp.72.

Wassenberg, T.J. and Hill, B.J., 1987. Feeding by the sand crab *P. pelagicus* on material discarded from prawn trawlers in Moreton Bay, Australia*. Mar. Biol.*, **95:** 387-393.

Williams, M.J., 1982. Natural food and feeding in the commercial sand crab *P. pelagicus* Linnaeus, 1766 (Crustacea: Decapoda: Portunidae) in Moreton Bay, Queensland. *J. exp. Mar. Biol. Ecol.*, **59:** 165-176.