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Fishery Biology and Population Structure of the Blue Swimmer Crab, *Portunus pelagicus*, from the Red Sea, Egypt

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ABSTRACT

More than 300 MT of blue swimmer crabs (BSC), *Portunus pelagicus*, are annually captured from the fisheries of the Egyptian Red Sea waters. During the last 20 years, a decline has been witnessed in the production of this species. For management purposes, information about the fishery's biology and population structure is required. Hence, monthly samples of *P. pelagicus* were collected from the commercial catch of Hurghada landing site, Red Sea, Egypt during the period from November 2017 to October 2018. A number of 1190 specimens were measured for morphometric relationships, sex ratio, age determination using carapace width frequency, population structure, mortality rate and exploitation ratio. The study revealed that *P. plagicus* was targeted by trammel nets and caught by a small bottom trawler as a by-catch. Carapace width- total weight relationship showed positive allometric growth (***b***-value= 3.10). Higher condition factors were observed in the small individuals. Four age groups were determined and age group +I was dominant by number (60.6%). Parameters of the von Bertalanffy equation were 21.19 cm, 0.414 year^{-1}, and -0.998 year for CW_∞, K and t_o, respectively. The carapace width at first capture was estimated (CW_{50} = 8.7 mm). The mortality rates were calculated as 2.929, 1.285 and 1.644 year^{-1} for total, natural and fishing mortalities, respectively. The blue swimmer crab fisheries on the Red Sea is over-exploited (E= 0.65) by the trammel net. Some management measures were suggested to maintain its stock for sustainability.

INTRODUCTION

Blue swimmer crab (BSC), *Portunus pelagicus*, is a tropical species belonging to family Portunidae and is found in estuaries and inshore marine waters. It is widely distributed in the Indian and the Pacific oceans **(Svane & Hooper, 2014)**. It can be found in different water depths across many countries in Asia, Australia and Africa **(La Sara *et al.*, 2017)**. The blue swimming crab is a large commercially valuable crab found within tropical and subtropical regions of the Indo-West Pacific. Over 80 species are encountered under the genus *Portunus* worldwide **(Stephenson, 1972)**. Globally, it was estimated that *P. pelagicus* contributed with about 0.4% (298 thousand MT) of the world total capture production, representing about 5.0% of the global crustacean fisheries **(FAO, 2020)**. In Egypt, specifically the last 20 years, the trend of the blue swimmer crab catch in the Red Sea witnessed a decline from more than 2000 MT in 2000 and 2003 to only 300 MT in 2019 (Fig. 1) with respect to the estimates of **GAFRD (2021)**.

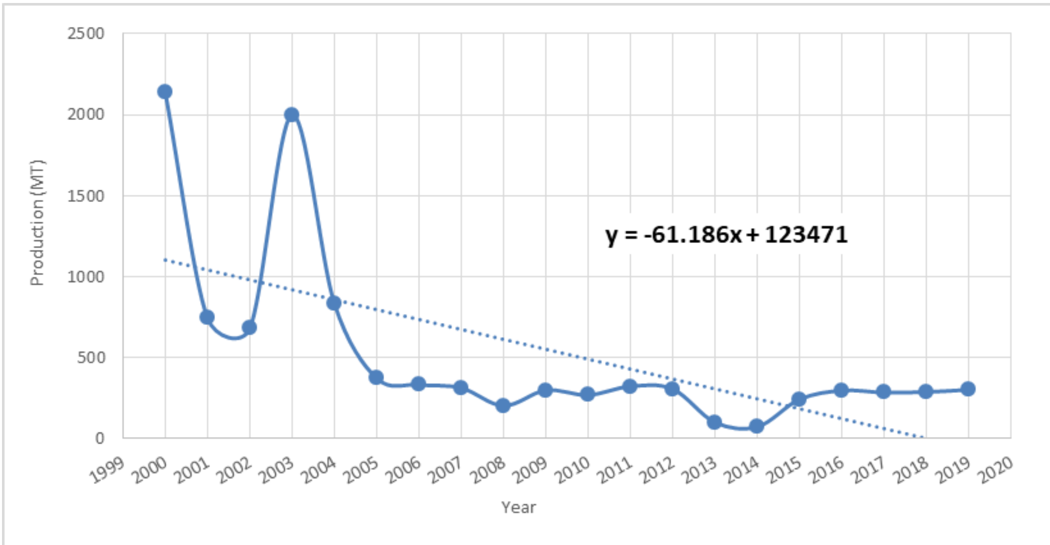

Fig. 1. Blue swimmer crab capture trend during the last 20 years (**GAFRD, 2000-2018)**

The BSC possess a high potential in boosting economics with high prices. Nevertheless, selling this species at high price can cause a continuous catch by fishermen and may also trigger overfishing in its habitat. Overfishing is attributed to the lack of information with regard to the biological developmental phases, and to some extent, it can be considered an outcome of the limitated recruitment analylitics. Subsequently, the afore- mentioned conditions have led to a decrease in the BSC in nature **(Santoso *et al.*, 2016)**. Notably, few studies have been conducted on the fisheries' biology of BSC in the Egyptian sector of the Red Sea. Therefore, this study was focused to determine the biological characters and population structure of *P. pelagicus*. to enrich the literature with information required for the implementation of a sustainable policy for the welfare of the blue swimming crabs' fishery in the Egyptian Red Sea waters.

MATERIALS AND METHODS

Random samples of blue swimmer crab, *Protunus plagicus* were monthly collected from the commercial catch of trammel nets at Hurghada area in the Red Sea (Fig. 2) during the period from November 2017 to October 2018. A number of 1190 BSC specimens were measured for morphometric and biological estimations. For each specimen, the carapace width (CW), carapace length (CL), frontal marginal length (FML) and caudal length (CaL) were measured using digital caliper to the nearest 0.1 mm, while the total body weight (Wt) was recorded to the nearest 0.01 g. Morphometric relationships, their regressions and statistics were formulated using MS excel Version 2016 and SPSS (Ver. 20). The condition factor (K) is calculated by the following formula: $K = 100\ W / CW^3$ **(Le-Cren, 1951)**. The values of CW_∞ (Theoretical maximum expected carapace width) and K (Coefficient of growth) were estimated from the linear regression between (CW_t) and (CW_{t+1}) using the least square method as follows: $CW_\infty = a / (1- b)$, and $K = - \ln b$, where; a and b are the intercept and the slope of the regression, respectively. t_o (age at **CW** zero) is estimated according to the method of **Pauly (1984)** where; $t_o = (a - \ln CW_\infty) / K$. Depending on ELEFAN 1 using carapace width frequencies, FiSAT II **(Gayanilo *et al.*, 2005)** program was applied for age determination. Total mortality (Z) was estimated from length-converted catch curve. Natural mortality (M) was calculated according to **Pauly (1983)**; $\ln (M) = -0.0152 - 0.279 \ln (L_\infty) + 0.6543 \ln (K) + 0.463 \ln (T)$ where; T is the water temperature. Fishing mortality is estimated by the successive equation: (F)= Z- M. Relative yield and biomass per recruit and the virtual population analyses were evaluated using FiSAT II program. Carapace width at first capture (CW_{50}) was assessed using the accumulation proportion curve **(Pauly, 1985)**.

Fig. 2. A map of Egypt showing Hurghada area in the Red Sea (area of study).

RESULTS

Samples of 1190 random specimens (682 males and 508 females) of BSC (Fig. 3) were collected from the commercial fisheries of the Red Sea, during the period from November 2017 to October 2018. The BSC carapace width ranged from 5.25 to 14.1 cm (males; from 5.25 to 14.0 cm and females; from 5.32 to 14.1 cm). For males, the total weight ranged from 11.5 to 225.0 g, the carapace length ranged from 2.5 to 7.7 cm, the frontal marginal length ranged from 1.7 to 3.95 cm, and the caudal length ranged from

1.65 to 3.79 cm. For females, the total weight ranged from 14.5 to 228.0 g, the carapace length ranged from 2.5 to 7.6 cm, the frontal marginal length ranged from 1.47 to 3.75 cm and the caudal length ranged from 1.49 to 3.9 cm.

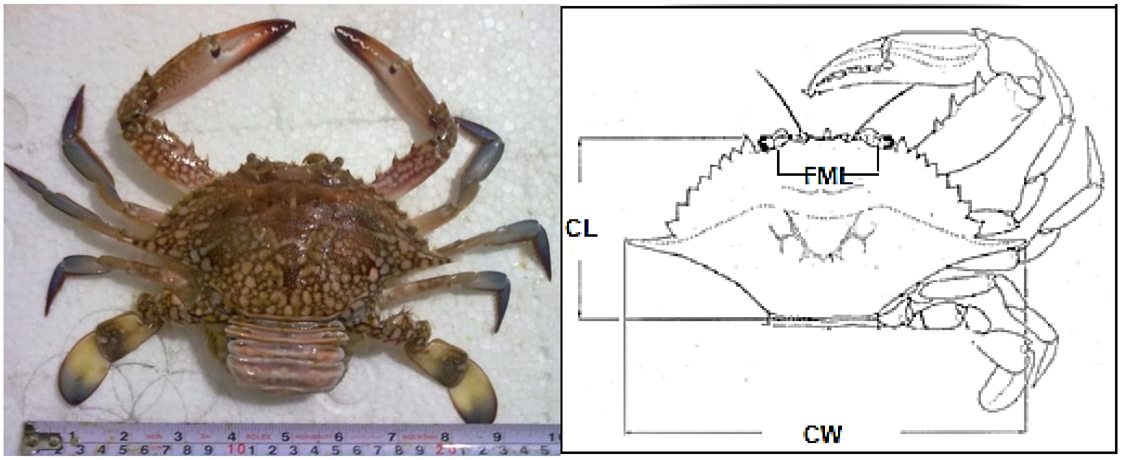

Fig. 3. Blue Swimmer crab, *P. pelagicus*, from the Red Sea; Photograph (left slide) and morphometric dimensions (right slide). CW, carapace width; CL, carapace length and FML, frontal marginal length

1- Frequency distribution:

Fig. (4) shows the carapace width frequencies' distribution of blue swimmer crab in the Red Sea catch. The peak was recorded at a length of 9.0 cm, and the number of males were close to that of females at carapace width from 10.0 to 13.0 cm. On the other hand, monthly frequencies' distribution was recorded for males and females during 12 subsequent months. In all samples, males' frequencies were relatively higher than those of females except in April.

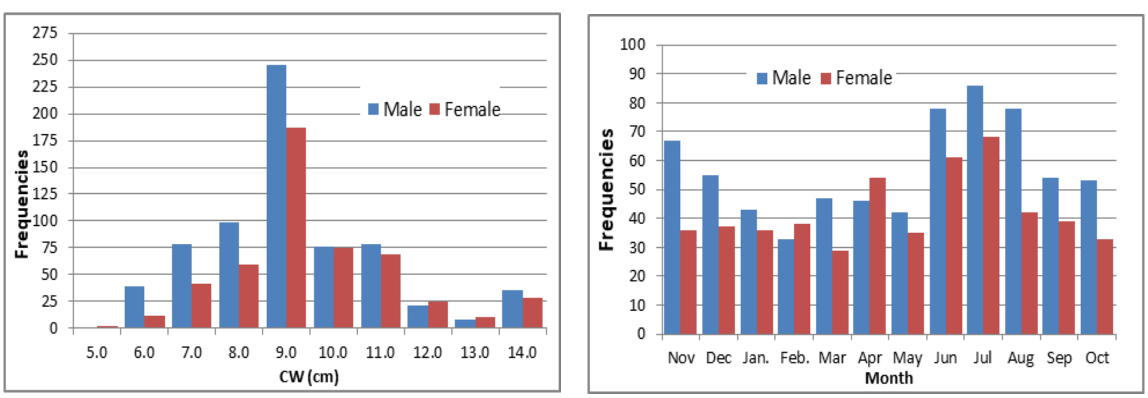

Fig. 4. frequency distribution of males and females of *P. pelagicus* from the Red Sea fisheries during the period of study; (left) according to crab carapace width and (right) according to month.

2- Morphometric measurements

For each specimen, the carapace width (CW), total weight (Wt), carapace length (CL), frontal marginal length (FML) and caudal length (CaL) were measured. The relationships between the carapace width and other measurements were obtained regarding to the best fit regression and higher regression coefficient (Table 1).

- *Carapace width (CW) – total weight (W) relationship*: the relation is represented by a power regression as follows:

$Wt = 0.0513\ CW^{3.1281}$ ($R^2 = 0.8815$) for males,

$Wt = 0.0574\ CW^{3.0709}$ ($R^2 = 0.8458$) for females and

$Wt = 0.0513\ CW^{3.1012}$ ($R^2 = 0.8680$) for combined sexes.

- *Carapace width (CW) - carapace length (CL) relationship*: the regression was represented by the following equations;

$CL = 0.0769 + 0.5083\ CW$ ($R^2 = 0.9743$), for males,

CL=0.153+b.4991CW ($R^2 = 0.9709$) for females, and

$CL = 0.1119 + 0.504 * CW$ ($R^2 = 0.9726$) for combined sex

- *Carapace width (CW) – frontal marginal length (FML) relationship* where;

$FML = 0.5113 CW^{0.7865}$ ($R^2 = 0.9264$) for males,

$FML = 0.4262\ CW^{0.867}$ ($R^2 = 0.9052$) for females, and

$FML = 0.468 CW^{0.8255}$ ($R^2 = 0.9129$) for combined.

- *Carapace width (CW) - caudal length (CaL) relationship*; the relation was represented by the equations for males, females and combined sex, respectively.

$CaL = 0.5203 CW^{0.788}$ ($R^2 = 0.8903$),

$CaL = 0.4567 CW^{0.8483}$ ($R^2 = 0.8674$), and

$CaL = 0.4886\ CW^{0.817}$ ($R^2 =$ 0. 0.8771).

Table 1. Relationship between carapace width (CW) with total weight (Wt), carapace length (CL), frontal marginal length (FML) and caudal length (CaL) of *P. pelagicus* in the Red Sea during study period; a & b: constants in equations; R^2: regression coefficient & STD: standard deviation.

Relation	Equation	*A*	*B*	R^2	*STD*
Males					
CW-Wt	$Wt=a*CW^b$	0.0513	3.1281	0.8815	42.413
CW-CL	$C.L=a+b*CW$	0.0769	0.5083	0.9743	0.959
CW- FML	$IOD=a*CW^b$	0.5113	0.7865	0.9264	1.437
CW-CaL	$Ca.L=a*CW^b$	0.5203	0.788	0.8903	1.445
Females					
CW-Wt	$Wt=a*CW^b$	0.0574	3.009	0.8459	43.788
CW-CL	$C.L=a+b*CW$	0.153	0.4991	0.9709	0.971
CW- FML	$IOD=a*CW^b$	0.4262	0.867	0.9052	1.405
CW-CaL	$Ca.L=a*CW^b$	0.4567	0.8483	0.8674	1.421
Combined sexes					
CW-Wt	$Wt=a*CW^b$	0.0541	3.1012	0.868	43.078
CW-CL	$C.L=a+b*CW$	0.1119	0.504	0.9726	0.970
CW- FML	$IOD=a*CW^b$	0.468	0.8255	0.9129	1.429
CW-CaL	$Ca.L=a*CW^b$	0.4886	0.817	0.8771	1.440

a & b: constants in equations; R^2: regression coefficient & STD: standard deviation.

3- Condition factor

For male, the condition factor was ranged from 1.836 to 14.305 with an average of 6.950 (STD ±1.406). On the other hand, the condition factor of females ranged from 1.516 to 12.381 with an average of 6.904 (STD ±1.496). In whole sample, the average condition factor of *P. pelagicus* in the Red Sea was 6.9305 (STD ±1.445) during the period of study. The condition factor variation was estimated according to crab carapace width and according to month (Fig. 5).

Condition factor variation according to carapace width in both male and females had the same trend in the relation between the condition factor and the carapace width. The condition factor sharply decreased from carapace width 5.0 cm (9.675, 11.095 and 10.622 for males, females and combined sex) to 7.0 cm (6.604, 6.588 and 6.599 for males, females and combined sex) carapace width, then it slightly increased in carapace width of 14.0 cm (7.610, 7.757 and 7.674 for males, females and combined sex).

Monthly variation in condition factor (Fig. 2b): lower K-values (6.5258 for males, 6.0125 for females and 6.2919 for combined sex) were recorded during January will higher values were recorded during March (7.485, 7.533 and 7.503 for males, females and combines sex respectively) and June (males; 7.441, females; 7.507 and combined sex; 7.389).

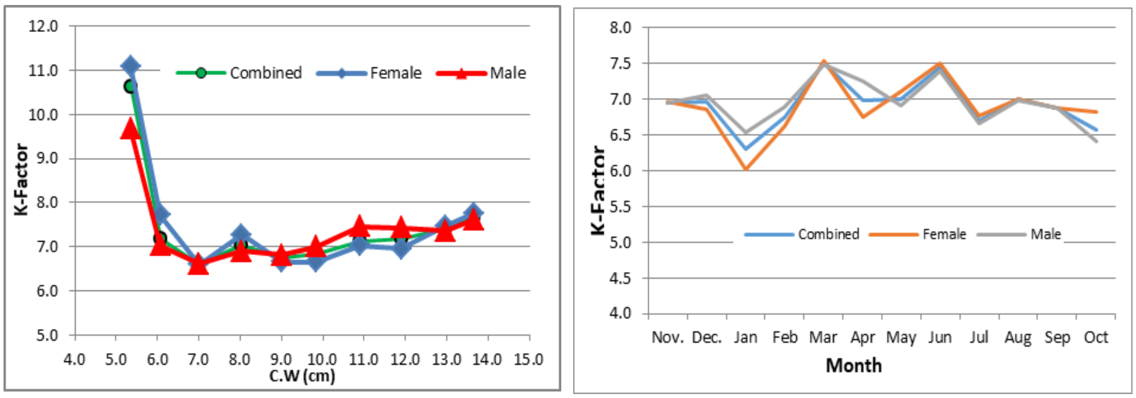

Fig. 5: Variation of K-factor values of *P. pelagicus* from the Red Sea fisheries during the period of study according to carapace width (left) and according to month (right).

4- Age determination

Using FiSAT II program based on carapace width frequencies, five age groups were determined in BSC in the present study. About 6.1 % of the total crab number (1.8 % of the sample weight) was belonging to age group (0+) with individuals less than 67.4 cm carapace width. Age group (I+) represented by about 60.6 % of sample individuals (41.4 % of the sample weight) including crabs from 6.7 to 9.6 cm carapace width. Individuals with carapace width ranged from 9.62 to 12.0 cm are categorized in age group (II+) that represented by 24.7% of crab number (32.9% of the sample weight). Age group (III+) was represented by 7.9% of crab number (21.9% of the sample weight) and was ranged from 12.01 to 13.9 cm carapace width. Individuals larger than 13.9 cm carapace width (about 0.7 % in number and 2.1% in the sample weight) were belonged to age group (IV+). The average weights of age group (0+), group (I+), group (II+), group (III+) and group (IV+) were 18.1, 43.3, 84.3, 175.4 and 198.1g respectively (Table, 2). The growth parameters were estimated; Sympathetic carapace width (CW_∞) = 21.19 cm, growth coefficient (K) = 0.414 year^{-1} and age at zero size (t_o)= -0.998 year.

Table 2: Blue swimmer crab, *P. pelagicus*, age groups, carapace width, number, frequency %, average weight, total weight percentage in the Red Sea during the period of study.

Age-gp	CW (mm)	Fish No.	Frequency %	Av. wt (g)	T.Wt %
0	< 67.4	73	6.1%	18.13	1.8%
I	67.4	721	60.6%	43.30	41.4%
II	96.2	294	24.7%	84.30	32.9%
III	120.1	94	7.9%	175.39	21.9%
IV	139.0	8	0.7%	198.13	2.1%
Total		**1190**	**100.0%**	**75405**	**100.0%**

5- Population structure:

Population parameters of blue swimmer crab in the Red Sea were determined using random sample of 1190 specimens with 5.25, 14.1 and 9.3 cm minimum, maximum and average of carapace width respectively. Carapace width at first capture (CW_c) was estimated from the catch cumulated carve as 8.7 cm. The total mortality (Z) was estimated from length converted catch curve (Fig., 6) based in age as 2.929 $year^{-1}$. The nature mortality (M) was estimated from Pauly (1995) equation using the growth parameters (CW_∞ and K) and average water temperature (T= 23.16 C^o) as 0.1.011. The fishing mortality (F) calculated to be 1.918 $year^{-1}$ and the exploitation ratio (E) was 0.655 (over-exploited). Blue swimmer crab catch in the Red Sea was 300 MT during the period of study and the stock [P (stock)= C (catch)/E (exploitation rate), Richer (1975)] is estimated to be about 103.5 MT.

6- Virtual population analysis (VPA)

Data of the carapace width frequency distribution with estimated values of carapace width-weight, growth parameters and mortalities rates were used to estimate the virtual population analysis (VPA). The analysis showed that the high fishing mortality ranges from 9.0 cm to 11 cm carapace width (Fig., 8). VPA is great tool for the stock assessment where it estimates the standing stock (in numbers) and fishing mortality by length classes. Probability of capture was applied in FiSAT II program using carapace width structure. In general, the population number and natural crab losses are increased as their size get larger. Values of CW_{25}, CW_{50} and CW_{75} were estimated to be 7.44, 8.22 and 9.05 cm respectively, as shown in Figure (6).

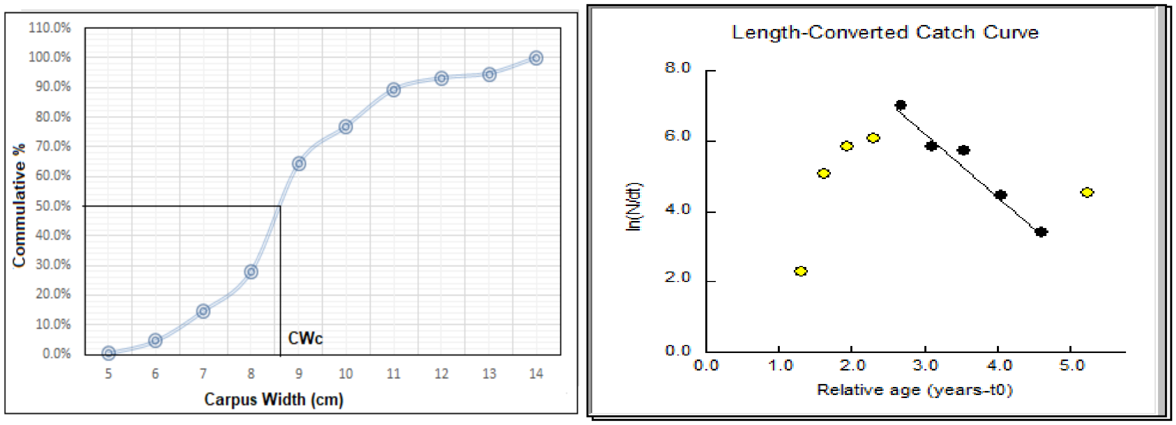

Fig. 6: Catch cumulative curve for determination of CW at first capture (left) and length converted catch curve (right) for estimation of the total mortality of *P. pelagicus* in the Red Sea during the period of study.

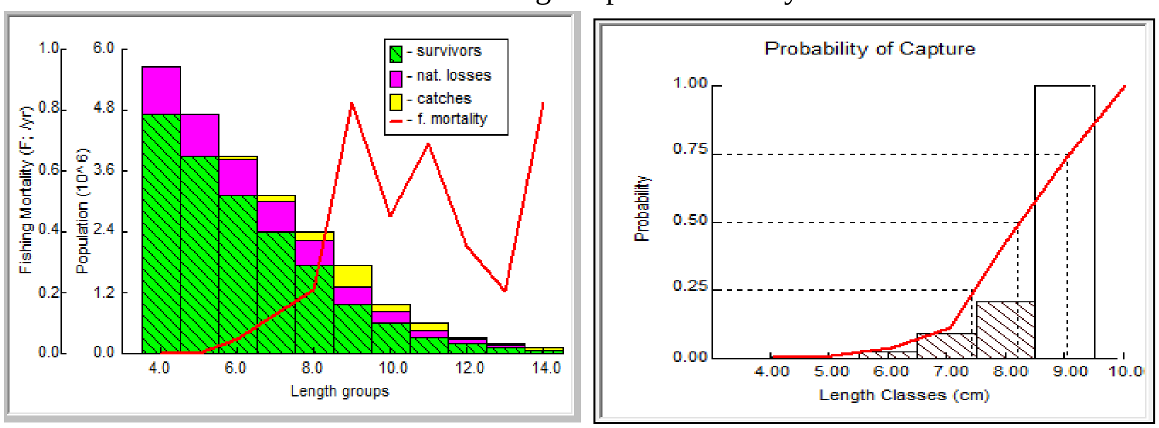

Fig. 7: Virtual population analysis based on carapace width class (left) and probability of capture at different levels of *P. pelajecus* from Red Sea during the period of study.

DISCUSSION

Morphometric analysis is a valuable supplement to genetic and environmental stock identification in population research **(Cadrin, 2000)**, and the relationship between length and the weight allow the conversion of growth-in-length equations to growth-in-weight equations for use in a stock assessment model **(Moutopolos & Stergiou, 2002)**. Information about individual body weight-length/width relationships in populations is important for estimating the population size, specifically for the purpose of its exploitation. For evaluating crustacean populations, the width or length-weight relationships are regarded as more suitable **(Atar & Sector, 2003; Gorce *et al.*, 2006; Sangun *et al.*, 2009)**. The interrelationships between various morphometric characters, such as carapace width with carapace length, body weight, frontal marginal length, and caudal length were analysed in the present study. High correlation coefficient (R^2 ranged from 0.846 to 0.974) were recorded for all relationship regressions. The value of exponent ***'b'*** was found to be 3.13, 3.01 and 3.10 in carapace width-weight relationship of male, female and combined sexes, respectively. They were slightly positive allometric growth and males are heavier than females at a given carapace width against weight. The relationships between carapace width and body weight is used as indicators of condition, biomass calculation and comparison between populations (**Lagler, 1968; Binohlan & Pauly 2000)**. Comparing to others studies from different locations, *b*-values in the present study is falling in the range e.g. in India **(Dineshbabu, 2008)**, in Egypt **(Mehanna and Al-Aiatt, 2011; El-Far *et al.*, 2018; Abdel Razek *et al.*, 2019)**, in Iran **(Safaie *et al.*, 2013)**, in Indonesia **(Hamid and Wardialno, 2015)** and in Pakistan **(Afzaal *et al.*, 2016)**.

The carapace width frequency distribution data were used to determine the VBGF growth parameters (CW_∞ and K). The current study results (CW_∞= 21.19 cm and K= 0.414 $year^{-1}$) were compared to previous studies from different areas (Table, 3). 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 differs 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). Value of t_o (-0.998 year) from the present study was close to values from Indonesia t_o= -0.963, **(Hamid *et al.*, 2015)** and India t_o= -0.975 **(Afzaal *et al.*, 2016).** The positive t_o values shows that the juveniles were slow grower while negative t_o values indicated that crab species were fast grower during juvenile stage **(Sparre and Venema, 1998; King, 2007)**.

For any fishery, the estimation of growth performance index is important for the stock assessment as stated by Pauly & Munro (1984) and Sparre & Venema (1998). In the present studiesy Ǿ = 2.0 shows that the environmental conditions of the Red Sea waters were suitable for the growth of BSC. Growth performance values may be different because of the ecological and geological conditions as well as input values of growth parameters **(Deveraj, 1981)**.

Fish natural mortality is caused by many reasons such as parasites and diseases **(Landau, 1979)**, aging factor **(King, 1991)**, predation by large animals **(Otobo, 1993)** and environmental factors **(Chapman and Van Well, 1978)**. In the present study, the total mortality rate of BSC was estimated using length-converted catch curve based on values of VBGF growth parameters. The total, natural and fishing mortality of blue swimming crab were estimated at 2.929, 1.285 and 1.644 year-1, respectively. The mortality rates of the BSCs from different area showed that overall values are closer or higher than that of the present study. Nearby values were estimated by **(Kamrani *et al.*, 2010), (Sunarto, 2012), (Ihsan *et al.*, 2014),** and **(Hamid & Wardiatno, 2015c)**. On the other hand, higher values were reported by (**Dineshbabu et al., 2008)**, **(Kunsook, 2011)**, **(Kembaren *et al*., 2012), (Ernawati, 2013),** and **(Mehanna *et al.*, 2013).** The BSC resources are overexploited by trammel net in the Red Sea (E = 0.65) as in most of the previous studies in many areas. According to the Patterson (1992), exploitation rate should not be greater than 0.4 for the sustainability of the resource. The carapace width at first capture (CW_c =8.7 cm) and the VPA indicated that the catch went to the small length which smaller than the reported (CW_m > 9.0 cm) length at first sexual maturity **(Mesa *et al.*, 2018; Abdel Razek *et al.*, 2019).**

Table (3): Comparison of Growth parameter (CW_∞ and K) with some of the previous studies in different locations

Author	Sex	CW_∞	K	Location
Sukumaran (1995)	Male	21.1	1.14	Karnataka coast, India
	Female	20.4	0.95	
Sumpton *et al.*, (2003)	Male	17.5	1.62	Queensland, Australia
	Female	17.7	1.61	
Josileen and Menon (2007)	Male	22.3	0.95	Mandapam coast, India
	Female	19.51	1	
Sawusdee and Songrak, (2009)	Male	17.9	1.5	Trang coast, Thailand
	Female	17.1	1.6	
Mehanna and Al-Aiatt, (2011)	Both	8.38	2.04	Bardawil Lagoon, Egypt
Mehanna *et al.*, (2013)	Male	10.84	1.68	Oman coastal water
Safiie *et al.*, (2013)	Male	19.1	1.7	Coastal water, Persian Gulf
	Female	18.5	1.6	
lhsan *et al.*, (2014)	Male	17.38	1.2	Pangkep Regency, Indonesia
	Female	18.63	1.5	
Hamid and Wardiatno, (2015)	Male	15.2	0.93	Lasongko Bay, Indonesia
	Female	17.3	0.68	
Afzaal *et al.*, (2016)	Both	17.85	1.7	Northern Arabian Sea, Pakistan
El-Far *et al.*, (2018)	Both	18.3	0.27	Mediterranean coast, Egypt
Present Study	Both	21.19	0.414	Hurghada region, Egypt

CONCLUSION

Length frequency data used in the present study gives valuable information about growth, mortality and life history parameters of blue swimmer crab, *P. pelajecus*. In the light of above results, the BSC fishery was overexploited by the trammel net in the Red Sea water during present study. Regarding to the present study, we may suggest that the fishery managers should take some serious steps to save this commercially important crab species in Red Sea waters for future and should maintain the stock of crab fishery so that shareholders can get more benefit from the stock. Some measures could be considering e.g. minimum landing size (greater than 9.0 cm carapace width) and control the fishing effort.

REFERENCES

Abdel Razek, F; Farghaly, M; Sorour, J. and Attia A. (2019). Population Characteristics, Maturation and Spawning of the Blue Swimmer Crab *Portunus pelagicus* in Eastern Mediterranean Sea, Egypt. Asian Journal of Biological Sciences, 12: 626-636. ISSN 1996-3351. DOI: 10.3923/ajbs.2019.626.636.

Adam, P. (1980). Life history pattern in marine fishes and their consequences for fisheries management. Fish. Bull., 78: 1-12.

Afzaal, Z.; Kalhoro, M.; Buzdar, M.; Nadeem, A.; Saeed, F.; Haroon, A. and Ahmed, I (2016). Stock Assessment of Blue Swimming Crab Portunus pelagicus (Linnaeus, 1758) from Pakistani Waters (Northern, Arabian Sea). Pakistan J. Zool., 48(5):1531-1541.

Atar, H. and Seçer, S. (2003). Width/length-weight relationships of the blue crab (Callinectes sapidus Rathbun, 1896) population living in Beymelek Lagoon Lake. Turkish Journal of Veterinary and Animal Sciences, 27: 443-447.

Binohlan, C. and Pauly, D. (2000). The length-weight table, In: Fishbase 2000: concepts, design and data sources, Froese R. & D. Pauly, (Eds), 121-123, ICLARM, ISBN 971-8709-99-1, Manila, Philippines.

Claxton, W.; Govind, K. and Elner, R. (1994). Chela function, morphometric maturity, and the mating embrace in male snow crab, *Chionoecetes opilio*. Canadian Journal of Fisheries and Aquatic Sciences, 51:1110-1118.

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

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

Dineshbabu, A.; 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.

El-Far, A.; El-Kasheif, M and Habashy, M. (2018) Fisheries Biology of Blue Swimmer Crab, *Portunus Pelagicus*, In The Mediterranean Water Front Egypt. FishForum, Proc. Rome, Italy. 222pp.

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, 80pp.

FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en.

GAFRD (2021). Fish statistics book year 2019 of General Authority for fish Resources Development on Fishery Egyptian, Cairo: 112p.

Gayanilo, F.; Sparre, P. and Pauly, D. (2005). *FAO-ICLARM stock assessment tool* (FiSAT II) User's Guide, FAO Computerized Information Series (Fisheries). No. 8, Rome, FAO, 266pp.

Gorce, G.; Erguden, D.; Sangun, L.; Cekic, M. and Alagoz, S. (2006). Width/length and relationships of the blue crab (*Callinectes sapidus* Rathbun, 1986) population living in Camlik Lagoon Lake (Yumurtalik). Pakistan Journ. biol. Sci. 9(8): 1460-1464.

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. and Riani, E. (2015). Fecundity and gonad maturity stages of ovigerous female blue swimming crab (*Portunus pelagicus*) in Lasongko bay, Southeast Sulawesi]. *Bawal* 7: 43-50.

Josileen, J. and Menon, N. (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.

Ihsan; Wiyono E.; Wisudo, S. 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.

Kamrani, E.; Sabili, A. 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.

Kembaren, 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.

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

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

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

La Sara; Muskita, W.; Astuti, O. and Safilu (2017). Some population parameters of blue swimming crab (*Portunus pelagicus*) in Southeast Sulawesi waters, Indonesia. AACL Bioflux, 10(3): 587-601.

Kunsook, C.; Gajaseni, N. and Paphavasit, N. (2014). 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.

Lagler, K. (1968). Capture, sampling and examination of fishes. In: W.E., Ricker (Ed.). Methods for Assessment of Fish Production in Freshwaters. IBP, Handbook-III, 7-45.

Le Cren, E. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol., 20(2): 201-219.

Mehanna, S. 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.; hvorov, S.; Al-Sinawy, M.; Al-Nadabi, Y.; Mohamed, N. and Al-Mosharafi, H. (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.

Mesa, Sh.; Bayate, D. and Guanco, M. (2018) Blue Swimming Crab Stock Assessment in the Western Visayan Sea. The Philippine Journal of Fisheries 25 (1): 77-94. DOI 10.31398/tpjf/25.1.2017C0008.

Moutopoulos, D. and Stergiou, K. (2002). Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). J. Appl. Ichthyol. 18: 200-203.

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. (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 Fisheries Technical Paper, No. 243, Rome, Italy, 52pp.

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, 468pp.

Otobo, A. (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, 298pp.

Ricker, W. E. (1975): Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Canada, 191: 382 pp.

Safaie, M.; Pazooki, J.; Kiabi, B. and Shokri, M. (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.

Sangun, L.; Tureli, C.; Akamca, E. and Duysak, O. (2009). Width/length-weight and width length relationships for 8 crab species from North-Mediterranean coast of Turkey. J Animal and Vet Advanc. 8(1): 75-79.

Santoso, D.; Karnan, L. and Raksun (2016). Bio-ecological characteristic of blue swimming crab (*Portunus pelagicus*) at Dusun Ujung water, East Lombok Jurnal Biologi Tropis 16 (2): 94-105.

Svane, I. and Hooper, GE. (2004). Blue Crab (*Portunus pelagicus*) Fishery. Fishery Assessment Report to PIRSA for the Blue Crab Management Committee. South Australian Research and Development Institute (Aquatic Science), Adelaide. RD 03/02742.

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

Stephenson, W. (1972). An annotated check list and key to the Indo-West-Pacific swimming crabs (Crustacea: Decapoda: Portunidae). Royal Society of New Zealand, 1: 3-63.

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, 403pp.

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.

Sunarto, (2012). Bio-ecology characteristics of blue swimming crab (*Portunus pelagicus*) in Bebes waters. Ph.D. thesis, Bogor Agricultural University, Bogor, Indonesia, 175pp.