Growth, Mortality and Exploitation of *Penaeus semisulcatus* in Jizan Fisheries, Saudi Arabia

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Abstract. The growth parameters, mortality coefficients and exploitation rate of *Penaeus semisulcatus* in Jizan fisheries were determined during the fishing season 2015 / 2016. The growth curves and parameters were estimated using length-frequency data for combined sexes (pooled data). The growth parameters (L_{∞} , K & t_0) for the sexes combined are estimated as $L_{\infty} = 94.40$ mm, $K = 0.81 \text{ year}^{-1}$, $t_0 = -0.20$ year, $M = 1.634 \text{ year}^{-1}$, $Z = 3.124 \text{ year}^{-1}$, and $F = 1.961 \text{ year}^{-1}$. The results indicated that, the current exploitation rate ' $E_{cur} = 0.628$ ' was higher than that required to get the maximum sustainable yield per recruit ' $E_{max} = 0.581$ '. In the present study B/R was found 5.98 gm. The current biomass per recruit ratio indicates that the current exploitation rate is not suitable for maintaining a sufficient spawning stock biomass of *P. semisulcatus* in Jizan area which indicates that the stock status of fisheries is currently overexploited.

Keywords: Red Sea, *Penaeus semisulcatus*, growth, mortality, fisheries. Jizan.

Introduction

Six shrimp species were recorded in the commercial landings of Jizan region (Abdallah and Abushusha 2003, PERSGA/GEF. 2002). The green tiger shrimp *Penaeus semisulcatus* is the most dominant species constituting between 85-90% of the commercial catches taken by bottom trawlers operated in the Red Sea coast of Saudi Arabia (Abdallah & Abushusha, 2003). Due to the highest market value, the Red Sea fishing fleet targets mainly *P. semisulcatus*. This species is widely distributed in the Indo-Pacific region (Holthuis, 1980), and is fished commercially from Southeast coast of India to the Arabian Gulf and the Red Sea. In the Red Sea waters, the distribution of *P. semisulcatus* is associated with the extension of the continental shelf where the bottom is muddy, especially in three regions; Jizan area in the

south, Al-Qunfedah area, and in Al-Khoribah area in the far north. The Jizan region is by far the most important fishing ground where more than 90% of the shrimp trawlers operate (Abdallah and Abu-Shoushah 2003).

However, limited data are available on *P. semisulcatus* in the Red Sea indicated that the stock of the green tiger prawn fishery in the Jizan was overexploited during the fishing season 2000. Therefore, this study aims mainly to assess the fishery status of *P. semisulcatus* in Jizan fisheries (Ghamrawy, 1988, 1990; Abdallah and Abushusha, 2003). Previous work carried out by Abdallah and Abushusha (2003).

Materials and Methods

Sampling:

Samples were collected twice monthly (first and third week of the month) from the landed

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catch of shrimp trawlers at Jizan landing site during the study period (Aug 2015–Mar 2016). Shrimp species were identified according to FAO species identification sheets, for shrimp trawl catch (Fischer and Blanchiceds, 1984). Species composition of the commercial landing of shrimp trawl in Jizan region was determined and the samples of *P. semisulcatus*

were separated to take the different measurements (Figs.1-2). Females and males were determined. For all individuals, Vernier calipers were used to measure lengths to the nearest 0.1 mm, and weight measurements were recorded using a digital balance having a sensitivity of 0.01g.

Fig. 1. The trawl fishing in Jizan area.

Fig. 2. The catch of trawl net in Jizan area.

Data Analysis

The FiSAT II software was used to estimate growth parameters through the analysis of length-frequency of *P. semisulcatus*. The maximum theoretical length L_{∞} , growth coefficient K , growth amplitude C , and winter point WP were estimated in the ELEFAN I routine (Pauly and David 1981). The instantaneous total mortality coefficient (Z) was estimated using Jones and van Zalinge (1981) plot implemented in the ELEFAN II routines of the FiSAT II Package. The coefficient of natural mortality (M) was estimated by the method of Pauly (1980) considering the mean annual temperature as 28°C (Morcos, 1970). The Fishing mortality coefficient (F) was considered as the difference between Z and M .

Carapace length at first capture (L_{50}) was estimated using the plot of probability of capture by length (Pauly, 1984). Total length at first capture was derived from the estimated carapace length according to Pauly and Soriano, (1986). ELEFAN II program was used to calculate the relative yield-per-recruit (Y'/R) and biomass-per-recruit (B'/R).

$$“Y'/R” = E U M/K [1 - (3U / (1 + m)) + (3U^2 / (1 + 2m)) - (U^3 / (1 + 3m))].$$

$$\text{Where: } m = K / Z = \left(\frac{1 - E}{M/K} \right)$$

$$U = 1 - (L_c / L_{\infty}) \quad E = F / Z$$

K = von Bertalanffy growth parameter.

Z = Total mortality coefficient.

F = Fishing mortality coefficient.

L_{∞} = von Bertalanffy constant

‘ L_c ’, the length at first capture, the length at which all fish of that length and longer are under full recruitment.

The relative biomass per recruit was computed as:

$$“B'/R” = “Y'/R” / F.$$

The exploitation ratios E_{10} , E_{50} and $E_{\max}$ were determined by using FiSAT software program.

Results

Growth Parameters

The restructured carapace length frequency of *P. semisulcatus* is shown in Figure (3), with superimposed growth curves. The monthly length frequency distributions were analyzed by ELEFAN program (Pauly and David 1981) incorporated in LFDA software for the estimation of growth parameters (L_{∞} , K & t_0) for the sexes combined. Where L_{∞} is the asymptotic total length, K is the curvature parameter and t_0 is the Age at length zero. They are estimated as $L_{\infty} = 94.40$ mm, $t_{\max} = 3.70$ year, $K = 0.81 \text{ year}^{-1}$ and $t_0 = -0.20$ year.

Fig. 3. Growth parameters (L_{∞} , K & t_0) of *P. semisulcatus* in Jizan area (output of the LFDA software).

Mortalities rates:

Fishing mortality coefficient was calculated as a result of subtraction of $M=1.163 \text{ year}^{-1}$, $F=1.961 \text{ year}^{-1}$, and $Z= 3.124 \text{ year}^{-1}$ from

(Beverton and Holt, 1957). This was found to be 1.961 year^{-1} .

Fig. 4. Jones and van Zalinge plot for *P. semisulcatus*.

Carapace length and age at first capture:

The corresponding age at first capture “ t_c ” was calculated by the following equation (Beverton & Holt, 1957):

$$t_c = (-1 / K) (\ln ((1 - L_c / L_\infty) + t_0))$$

Where “ K , L_∞ & t_0 ” are the Von Bertalanffy constants and “ L_c ” is the length at first capture.

The carapace length at first capture L_{50} (the carapace length at which 50% of individuals at that size are vulnerable to capture) was estimated as 35.73 mm for combined sexes, and the corresponding age at first capture (t_c) was 0.387 year.

Relative yield / recruit (Y'/R), relative biomass / recruit (B'/R)

The plot of relative yield per recruit “ Y'/R ” and relative biomass per recruit “ B'/R ” of *P.*

semisulcatus in Jizan fisheries against the exploitation rate “ E ” are graphically represented in fig. (5) and tabl (1).

The yield-based biological reference points E-10 (the exploitation rate at which the marginal increase of Y'/R is 1/10 of its value at $E=0$), E-50 (the exploitation rate under which the stock has been reduced to 50% of its unexploited biomass), and E-max (the exploitation rate which produces maximum yield per recruit) of exploitation rates were found to be E-10 = 0.502, E-50=0.328 and E-max = 0.581 year⁻¹. The current level of exploitation E-cur was estimated to be 0.628 year⁻¹, and both E-10 and E-max are lower than the current exploitation rate.

Fig. 5. Relative yield / recruit (Y'/R) , and relative biomass / recruit (B'/R) for *P. semisulcatus* in Jizan fisheries.

Table 1. Yield / recruit and average biomass / recruit of *P. semisulcatus* as a function of fishing mortality.

F	Y/R	B/R	% Bv
0.000	0.0000	33.477	100.00
0.845 (0.1)	10.8808	12.880	38.46
1.000	11.2999	11.300	33.75
1.200	11.6149	9.680	28.91
1.601	11.8040	7.373	22.02
1.607 (max)	11.8041	7.345	21.94
1.612	11.8040	7.323	21.87
1.800	11.7770	6.543	19.54
1.961 (cur)	11.7230	5.979	17.86
2.500	11.4340	4.574	13.66
3.000	11.1160	3.705	11.07

Discussion

Due to the developing technology and fishing equipment, the fishing effort exerted on fishery resources has been increasingly modified leading to overfishing problems which may result in reducing fish stocks to biologically and ecologically harmful levels. Investigating the population dynamics such as age, growth and mortalities are very important to assess the current status of any given population.

In the present study, the asymptotic total length for combined sexes ($L_{\infty} = 94.4\text{mm}$) was higher than those estimated in previous study reported by Hussain et. al. (1996) in Jizan area for females and males, respectively (54.3mm and 37.0 mm during the fishing season 1985/1986; 49.5mm and 36.1mm during 1986/1987; 52.1mm and 36.8mm during 1987/1988; 50.9mm and 37.1mm during 1988/1989, and 49.0mm and 36.1mm during 1989/1990).

The above mentioned different values of asymptotic carapace lengths for females and males may be attributed to the excess fishing effort exerted by trawling on the stock of this species in Jizan fisheries. In the present study, the growth coefficient “K” of *P. semisulcatus* in Jizan area during the fishing season 2015/2016 was found to be 0.81. Hotzhausen and Kirchner (2001) reported that as the value of “K” increases the rate of growth increases. This would explain the higher growth rate of *P. semisulcatus*. Abdul-Wahab (2014) studied the population dynamics of *P. semisulcatus* in the Yemeni Red Sea water, and found that the current exploitation rate, E, is the best compromise resulting in higher stock biomass and higher catch rate than that obtained at $E_{\max}$ and $E_{0.1}$. In the present study, results of the relative yield per recruit (Y'/R) indicated that the current exploitation rate is higher than $E_{\max}$ which generates the maximum yield per recruit. In addition, the current values of “E” are higher than the values of “ $E_{0.5}$ ” which consider the exploitation level that maintains

the spawning stock biomass at 50% of the virgin spawning stock biomass for the species under study. The current biomass per recruit ratio indicates that the current exploitation rate is not suitable for maintaining a sufficient spawning stock biomass of *P. semisulcatus* in Jizan area. **Conclusion,** Based on that, this study recommended the reduction of exploitation rate from $E_{\text{cur}} = 0.628$ to $E_{10} = 0.502 \text{ yr}^{-1}$ and further monitoring and management through estimation of the optimal exploitation rates, female spawner relative stock biomass as targeted reference points.

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النمو والنفوق والاستغلال لمصايد روبيان أم نعيرة (بينبوس سميسلكيتس) في مصايد جيزان، المملكة العربية السعودية

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المستخلص. تناولت هذه الدراسة تحديد معدلات النفوق والنمو والإنتاج لمصائد الروبيان أم نعيرة (بينبوس سميسلكيتس)، وذلك من خلال تحليل عينات تم جمعها من منطقة جيزان (البحر الأحمر، المنطقة الجنوبية للمملكة العربية السعودية) خلال الفترة من أغسطس ٢٠١٥ وحتى مارس ٢٠١٦م. تم استخدام بيانات التكرار الطولي للعينات الشهرية، وذلك لتحديد أنماط النمو والمعاملات المرتبطة بها، طول الدقة النهائي، معامل النمو. من الدراسة كان طول الدقة النهائي ٩٤,٤٠ مم ومعامل النمو ٠,٨١ سنة^{-١} والعمر ٠,٢٠ سنة، النفوق الطبيعي = ١,٦٣٤ سنة^{-١}، النفوق بسبب الصيد = ١,٩٦١ سنة^{-١}، والنفوق الكلي = ٣,١٢٤ سنة^{-١}. معامل الاستغلال الحالي بلغ ٠,٦٢٨. في حين إن الاستغلال الأمثل للجمبري ٠,٥٨١. من الدراسة الحالية معدل نسبة الكتلة إلى الأجيال الجديدة ٥,٩٨ جرام. الاستغلال الحالي غير يؤدي إلى ضعف إمكانية دخول أجيال جديدة لمنطقة المصيد مما يعني أن مخزون بينبوس سميسلكيتس الحالي تحت الصيد الجائر.

الكلمات الدالة: روبيان أم نعيرة، بينبوس سميسلكيتس، النمو، الفقد، المصائد، جيزان، البحر الأحمر.