

Growth, Mortality and Sustainable Exploitation of the Shrimp (*Penaeus semisulcatus*) Fishery in the Jizan Area (Red Sea Coast, Saudi Arabia)

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Abstract. Population characteristics of green tiger prawns, *Penaeus semisulcatus* taken by shrimp trawlers in Jizan area was investigated during the period from August 2002 to July 2003. Monthly length-frequency data were used to estimate the growth curves and related parameters for both females and males. The mean asymptotic carapace length (L_{∞}), growth constant (K), amplitude of growth (C) and winter point (WP) were respectively, 58.5 mm, 0.8 year⁻¹, 0.100 and 0.800 for females and 44.9 mm, 0.7 year⁻¹, 0.400 & 0.100 for males. The annual mortality coefficients and current exploitation rate for females were estimated at slightly higher values ($Z = 3.937$ year⁻¹, $M = 1.649$ year⁻¹, $F = 2.288$ year⁻¹ and $E_{\text{current}} = 0.581$) than those of males ($Z = 3.599$ year⁻¹, $M = 1.588$ year⁻¹, $F = 2.011$ year⁻¹ and $E_{\text{current}} = 0.550$).

Maximum exploitation rate for females and males of *Penaeus semisulcatus* was estimated as 0.583 and 0.695 respectively.

Keywords: Tiger shrimp, *Penaeus semisulcatus*, maximum sustainable yield, growth, mortality, fisheries, Red Sea.

Introduction

The green tiger shrimp *Penaeus semisulcatus* that dominates the commercial catches was taken by bottom trawlers operated in the Red Sea. Six shrimp

species were recorded by Abdallah and Abushusha (2003) in the commercial landings of Jizan region.

Little information is available on *Penaeus semisulcatus* in the Red Sea (Ghamrawy, 1988 & 1990; Abdallah & Abushusha, 2003). Abdallah and Abushusha, in their study on this species indicated that its fishery in the area of study was overexploited during the year 2000.

A set of precautionary management measures including changing the length and the commencement date of the closed season, were accordingly applied by the Saudi government to approach sustainable exploitation of shrimp fishery. In this context, the present study was undertaken mainly to monitor the status of shrimp fishery and provide information required for its management in the area of study.

Materials and Methods

Sampling and Data Collection

Biological data on spawning season, sex and length frequency were obtained by sampling the catch of shrimp trawlers at Jizan landing site two times per month during the study period (Aug 2002 – July 2003). Samples were obtained during the closed season on board of a trawler hired by the Ministry of Agriculture and Waters.

A total of 15027 specimens were collected, weighted, sexed and measured. Length frequencies were recorded by measuring the carapace length, the length from the rostral cleft to the posterior border of the carapace, generally using a vernier caliper.

Data Analysis

Carapace length-frequency data for both males and females *P. semisulcatus* was analyzed using FiSAT (Gayanilo *et al.*, 1995). Growth estimates including asymptotic carapace length L_{∞} , growth constant K, amplitude of growth C and winter point WP were obtained using the ELEFAN I routine (Pauly and David, 1981).

The Phi-prime index, ϕ' (Munru and Pauly, 1983; Moreau *et al.*, 1986) was used to compare the growth performance of *P. semisulcatus* with that estimated by other authors.

Estimates of total mortality (Z) were derived from Jones and van Zalinge (1981) plot produced by the ELEFAN II routines in FiSAT. Natural mortality (M) was derived through the equation of Pauly (1980) considering the mean annual temperature as 28°C (Morcos, 1970). Fishing mortality (F) was extracted as $F = Z - M$.

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 by using the relevant formulas developed by Abdallah and Abushusha (2003).

According to Pauly and Soriano, (1986) ELEFAN II was used to calculate relative yield-per-recruit (Y'/R) and biomass-per-recruit (B'/R).

Results

Growth Parameters

Figure 1 shows the restructured carapace length frequency for females and males *P. semisulcatus*, with superimposed growth curves. The growth parameters were estimated as $L_{\infty} = 58.5$ mm, $K = 0.8$ year⁻¹, $C = 0.100$ & $WP = 0.800$ for females and $L_{\infty} = 44.9$ mm, $K = 0.7$ year⁻¹, $C = 0.400$ and $WP = 0.100$ for males. Growth performance index ϕ' was estimated as 3.437 and 3.150 for females and males respectively.

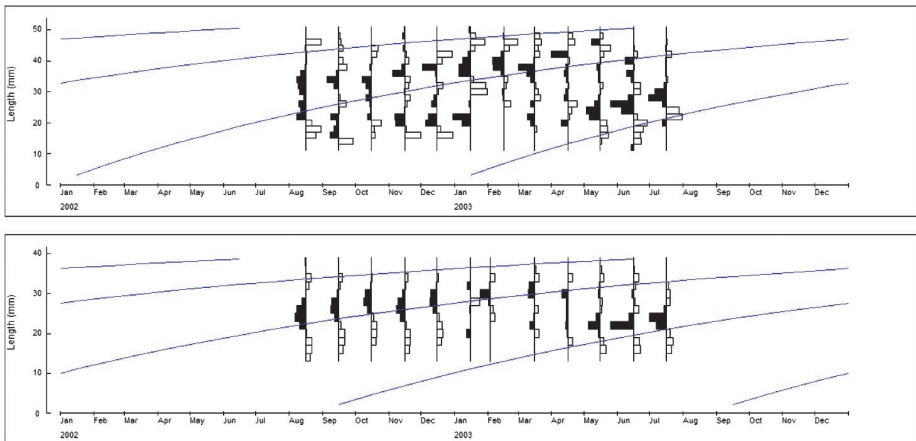


Fig. 1. Growth curve for females (above) and males (below) *P. semisulcatus* superimposed over restructured length frequency data.

Mortality Coefficients and Current Exploitation Rate

Figure 2 shows Jones and van Zalinge (1981) plots used to estimate the total mortalities coefficients for females and males. It was found that, the annual mortality coefficients and current exploitation rate for females ($Z = 3.937$ year⁻¹, $M = 1.649$ year⁻¹, $F = 2.288$ year⁻¹ & $E_{\text{current}} = 0.581$) were slightly higher than those of males ($Z = 3.599$ year⁻¹, $M = 1.588$ year⁻¹, $F = 2.011$ year⁻¹ & $E_{\text{current}} = 0.550$).

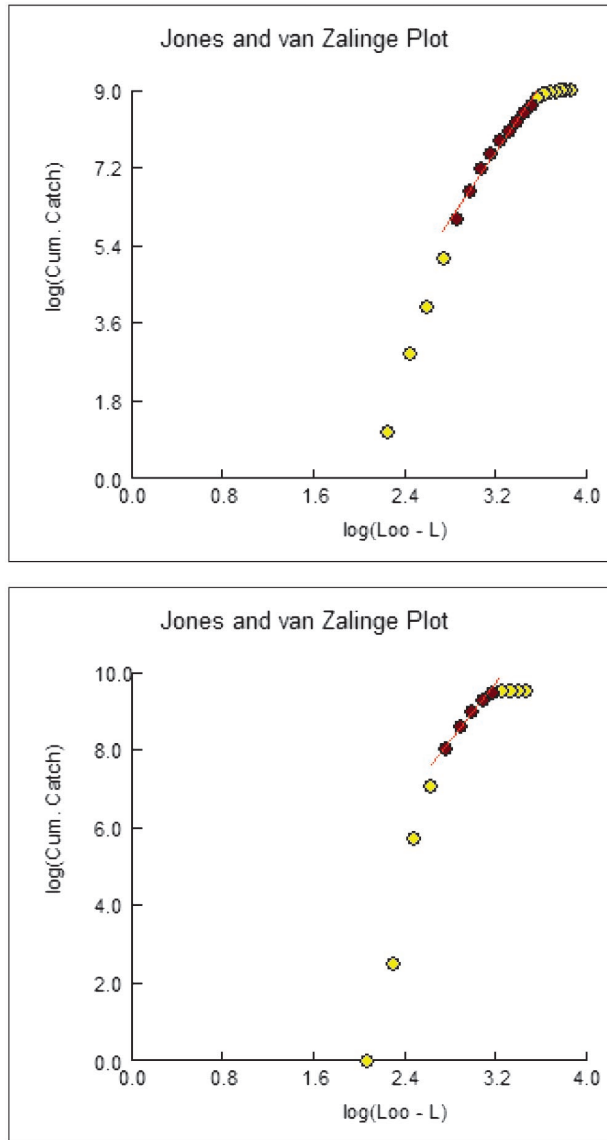


Fig. 2. Jones and van Zalinge plots for females (above) and males (below) *P. semisulcatus*.

Length at First Capture

The carapace length at first capture L_{50} (the carapace length at which 50% of the fish at that size are vulnerable to capture) was estimated as 20.30 mm for females and 18.79 mm for males (Fig. 3) which correspond to total lengths of 23.56 cm and 19.7 cm respectively.

Exploitation Rates - Relative Yield per Recruit (Y'/R) and Relative Biomass per Recruit (B'/R)

Estimates of (Y'/R) and (B'/R) were graphically represented in Fig. 4. Relevant values of exploitation rates for females ($E_{10} = 0.453$, $E_{50} = 0.316$ & $E_{\max} = 0.583$) were slightly lower than those of males ($E_{10} = 0.555$, $E_{50} = 0.341$ & $E_{\max} = 0.695$) where;

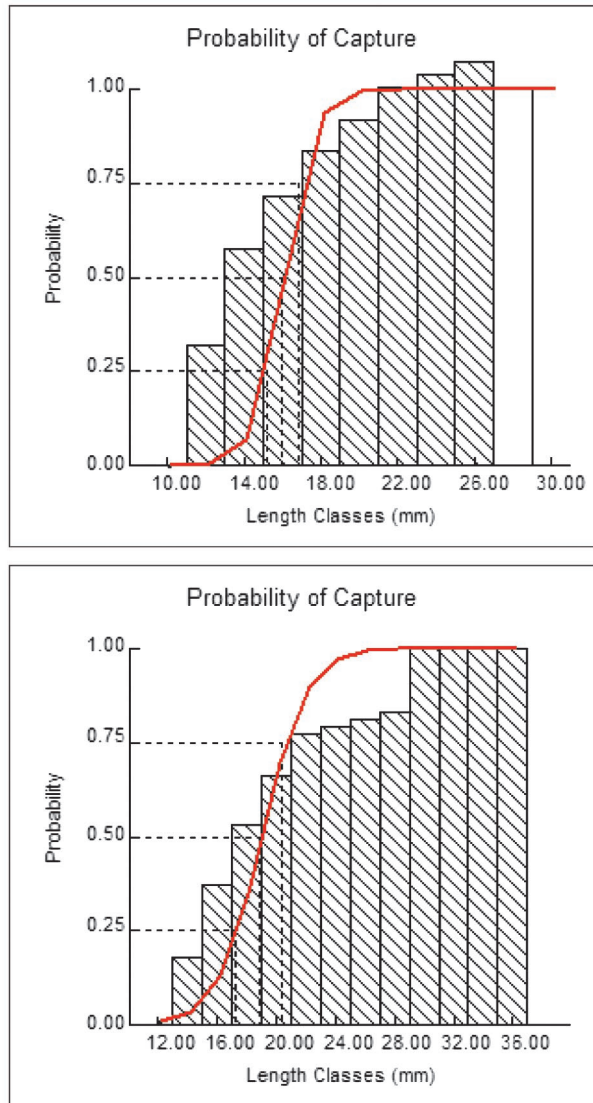


Fig. 3. Length at first capture for females (above) and males (below) *P. semisulcatus*.

E_{10} is the exploitation rate at which the marginal increase of Y'/R is 1/10 of its value at $E = 0$;

E_{50} is the exploitation rate under which the stock has been reduced to 50% of its unexploited biomass; and

E_{max} is the exploitation rate which produces maximum yield.

The results indicated that, $E_{current}$ (0.581) of females was slightly lower than E_{max} (0.583) and higher than its optimal level ($E_{10} = 0.316$) while, $E_{current}$ (0.55) of males was lower than E_{max} (0.695) and equaled its optimal level ($E_{10} = 0.55$).

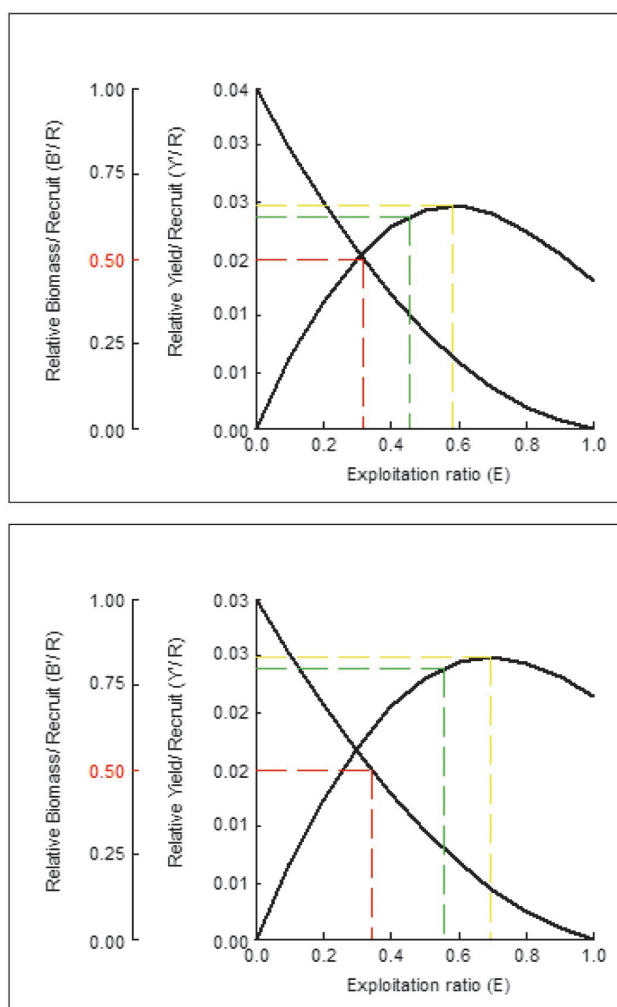


Fig. 4. Relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) for females (above) and males (below) *P. semisulcatus*.

Discussion

The asymptotic carapace lengths for females and males ($L_{\infty} = 58.5, 44.9$ mm) were higher than most of the corresponding values (54.3, 37.0 mm during the fishing season 1985/86; 49.5, 36.1 mm during 1986/87; 52.1, 36.8 mm during 1987/88; 50.9, 37.1 mm during 1988/89 & 49.0, 36.1 mm during 1989/90) as estimated by Hussain *et al.*, 1996. This can be attributed to that maximum size of shrimp caught in this study were greatly higher than those of other localities.

The estimated growth performance indices, ϕ of females (3.437) and males (3.150) confirm the corresponding values (3.68 & 3.25) and (3.647 & 3.364) that were recorded respectively by Xu and Mohamed, 1996 in Kuwait waters and Abdallah and Abushusha, 2003 in the same area of study.

Because of the size difference of females and males, different values of mortality coefficients and exploitation rates have been obtained. This is reflecting the comparatively higher fishing pressure on females than males.

Estimation of the relative yield per recruit (Y'/R) indicated that the current exploitation rate is lower than E_{\max} which generates the maximum yield for both females and males. It is indicated also that males were optimally exploited while females were fully exploited.

Comparing with the recent study (Abdallah and Abushusha, 2003) who mentioned the overexploitation of tiger shrimp stock in the same area during the year 2000, this study indicates its recovery and the effectiveness of the closed season being applied of 133 days long.

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معاملات النمو والنفوق والاستغلال الأمثل لمصائد الروبيان أم نعيه (بينوس سميلكيتس) في منطقة جيزان (ساحل البحر الأحمر، المملكة العربية السعودية)

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المستخلص. يتناول هذا البحث تحديد العمر و معدلات النمو والنفوق والإنتاج لمصائد الروبيان أم نعيه (بينوس سميلكيتس) بناء على العينات التي تم تجميعها من منطقة جيزان (البحر الأحمر، المملكة العربية السعودية) خلال الفترة من أغسطس ٢٠٠٢م إلى يوليو ٢٠٠٣م. تم استخدام بيانات التكرار الطولي للعينات الشهرية في تحديد أنماط النمو المعاملات المرتبطة بها لكل من الذكور والإناث. كما تم تحديد ثوابت معادلة فون بورتلانفي، وطول الدرقة اللانهائي (L_∞)، ومعامل النمو (K)، ونطاق النمو (C)، والمعامل الشتوي (WP) على التوالي ٥٨,٥ مم، و ٠,٨، و سنه^{-١} ١٠,٠، و ٠,٨٠ للإناث والتسوالي ٤٤,٩ مم، و ٠,٧، و سنه^{-١} ٤٠,٠، و ٠,١٠ للذكور. قد تم تعيين معدل النفوق الكلي بمقدار ٣,٩٣٧ والنفوق الطبيعي ١,٦٤٩، والنفوق نتيجة عمليات الصيد ٢,٢٨٨ (عام)^{-١} للإناث حيث ظهرت أعلى من القيم المناظرة للذكور (٣,٥٩٩، و ٥٨٨، و ١,٠١١ (عام)^{-١}) على التوالي. كما أوضحت الدراسة أن معدل الاستهلاك الحالي للإناث (٠,٥٨١) والذكور (٠,٥٥) بينما معامل الاستغلال الأمثل هو ٠,٥٨٣ للإناث و ٠,٦٩٥ للذكور.