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POPULATION DYNAMICS AND ASSESSMENT OF GOLDEN TREVALLY, *GNATHONODON SPECIOSUS* (FORSSKÅL, 1775), IN THE SOUTHERN ARABIAN GULF OFF THE UNITED ARAB EMIRATES

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ABSTRACT: *The population dynamics of Gnathonodon speciosus from the southern Arabian Gulf off the United Arab Emirates was investigated based on direct and indirect methods to validate the age. The average growth parameters based on the methods were estimated as* L_∞*=84.52cm TL, K=0.28 and* t_o*=-0.45years. The fitted Von Bertalnaffy's growth equation for G.speciosus was* L_t*=84.52*[1–exp-0.28*(t+0.45)]. The estimated growth performance index Ø was 3.30 while the estimated life spans close to 11.0 years. The instantaneous coefficient rates of total mortality Z estimated by length converted catch curve was* $1.01yr^{-1}$*. Natural mortality M estimated by pauly, Rikhter&Efanov and Hoeing methods were 0.62, 1.02 and* $0.41yr^{-1}$ *respectively with average* $0.68yr^{-1}$ *for further analysis. Peaks in spawning occurred during March, April and May. Yield per recruit Y/R and biomass per recruit B/R were estimated as 171.7&520.3g respectively at current* $F=0.33year^{-1}$ *and* T_c*=1.59 year. Estimates of relative yield per recruit and relative biomass per recruit were* $E_{0.1}$*=0.62,* $E_{0.5}$*=0.35 and* E_{max}*=0.74 indicates the stock of G.speciosus is under-exploited.*

KEYWORDS: *Gnathonodon speciosus*, Growth, Mortality, yield per recruit and spawning season

INTRODUCTION

Carangidae are a large family, comprises about 32 genera and 140 species in the world oceans (Nelson, 1994). Among the carangids, the genus Carangoides represented by 11 species in the Arabian Gulf and Sea of Oman. Being well represented in all tropical and subtropical seas (Randall *et al.,* 1997; Smith-Vaniz, 1984). The Golden Trevally, *Gnathanodon speciosus* (Forsskål, 1775), occurs throughout the Indo-Pacific: from Kwazulu-Natal (South Africa), north to Mie Prefecture, Japan and East to southwestern Coast of Baja California Sur, Mexico and Gulf of California to Ecuador (Smith-Vaniz, 1995). *G.speciosus* is a large species attaining a maximum size of 120 cm total length (Randall, 1995) and 15.0 kg total weight (Allen and Steene, 1988). Age determination in fish can be carried out with direct (zonation on hard parts) or indirect (length frequency, marking and recapture etc.) methods (Morales-Nin & Ralston, 1992). Age determination using sagittal otolith has been problematic with tropical carangids (Griffith *et al.,* 2006), with the alternating translucent and opaque bands often being absent or difficult to discern. Grandcourt *et al.,* 2004 were unable to distinguish annuli in burnt sagittal otolith of two tropical carangids; *Gnathonodon speciosus* and *Carangoides bajad* (Al-Rasady *et al.,* 2013). Similar problem was encountered in studies of the carangid *Trachinotus falcatus* from Florida waters (Crabtree *et al.,* 2002). Fry *et al.,* 2006 concluded the direct age validation of growth increments in shallow water fast growing carangids such as *Caranx tille* and *Caranx*

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lugubris was impracticable. Metin and Ilkyaz, 2008 declared there is no age determination has yet accomplished by direct method without applying any additional techniques before reading, is due to difficulty related to ageing by otolith reading. Alternative methods requiring less effort and delivering large precision are sought for determining the age of fish. One of these methods is the length frequency distribution, in the present study, using the length frequency data in conjunction of annual rings on the hard parts an attempt to estimate age, growth and stock status for *Gnathonodon speciosus* in the southern Arabian Gulf off the United Arab Emirates to help develop a management plan for sustainable exploitation

MATERIALS AND METHODS

Specimens of *Gnathonodon speciosus* were collected monthly from commercial catches landed at the main landing sites; Ras El-Kheima, Umm Al-Qwain, Ajman and Sharjah (United Arab Emirates) Fig.1 between January and December 2014. Total length L_T, Fork length L_F and standard length L_S were recorded to the nearest 0.1cm using a measuring board. The weight was measured using the electronic weighing scale to the nearest 0.01g. Fish were sexed by macroscopic examination of the gonad and weighed to 0.1g using electronic balance.

Figure 1. Map showing the sampling sites

Length- weight relationship was calculated using the power equation $W=aL^b$ (Le Cren, 1951) where: *W* is the total weight in g; *L* is the total length in cm; *a* is the intercept and *b* is the slope of the equation. In order to verify if calculated *b* was significantly different from 3, the Students t-test was employed (Pauly, 1984). The linear equation $FL=a+b*TL$ was utilized for total length-fork length relationship where: *FL* is the fork length, *TL* is the total length and *a&b* are constants. The condition factor $K=W/L^3*100$ was calculated according to Le-Cren, 1951.

Otoliths were used to determine fish age, the relationship between the otolith radius and fish total length was determined by the following equation : $L=a+b*OR$ where : *L* is the total fish length and *OR* is the otolith radius and *a&b* are constants. The length at different ages were back calculated using Lee's method (1920). Growth parameters were estimated by fitting Ford (1933) and Walford (1946) plot and by using the Von Bertalanffy Growth function, 1938 fitted in FISAT II. According to VBGF, individual fishes grow on average towards the asymptotic length at an instantaneous growth rate *K* with length at time *t* following the expression: $L_t=L_\infty*1-exp^{-k(t-to)}$ Where L_t is the total fish length at age *t*, L_∞ is the maximum attainable length, *k* is the growth coefficient and t_o is the hypothetical age at zero length and was estimated by employing the equation of Pauly (1980): $Log(-t_o)=-0.3922-0.2752LogL_\infty-1.038LogK$. The longevity T_{max} was estimated as $T_{max}=3/K$ (Beverton, 1992). The mean asymptotic length, growth coefficient and age at length zero were estimated to the following calculation. The overall growth performance index for *G.speciosus* was calculated using the formula of Pauly and Munro, (1984) $\varphi=LogK+2LogL_\infty$.

The spawning season was determined by the monthly average values of Gonado-Somatic Index (GSI) where: *GSI=Gonad Wt/Gutted Wt *100*. The mean size at first sexual maturity L_m was estimated for *G.speciosus* by fitting the logistic function to the proportion of mature fish in 1.0cm size categories. The mean size at first maturity was taken as that which 50% of individuals were mature. The corresponding age at sexual maturity was estimated as: $T_m=-1/k*L_n\ (L-L_m/L_\infty)+t_o$ (Hilborn and Walters, 1992). The mean size at first sexual maturity was taken as that at which 50% of individuals were mature (stage III and above). Sex ratios (male:femal) were also calculated.

The instantaneous total mortality *Z* of fish was calculated by length converted catch curve method (Pauly, 1983) using the routine provided in the LFDA. Natural mortality coefficient *M* was estimated by three different empirical methods (Rikhter and Efanove, 1976; pauly, 1980 and Hoeing's, 1983) and the average *M* was taken for further analysis. In the empirical method of pauly 1980, temperature was taken as 27.5 ^oC that represents the mean temperature in the southern Arabian Gulf (Internal report). In the Rikhter and Efanov's method, 1976, the formula, $M=1.521/tm^{0.72}-0.155$ was used, where, t_m is the age at which 50% of the population matures. The formula used by Hoeing's, 1983 was: $\ln(M)=1.44-0.984*\ln(t_{max})$. The fishing mortality *F* was computed by subtraction natural mortality from total mortality as, $F=Z-M$. The exploitation rate E was estimated from *Z* and *F* values as defined by the equation (Ricker, 1975) as: $E=F/Z$.

The biological reference point *BRP* was estimated by the equations of Patterson, 1992 as, $F_{opt}=0.5*M$ and $F_{limit}=2/3*M$ where *M* is the natural mortality. The optimum length of exploitation was estimated empirically from the equation (Froese and Binohlan, 2000) as, $L_{opt}=3*L\infty/3+M/K$ where L_{opt} denotes the optimum length of exploitation. The length at first capture *Lc* was calculated by plotting cumulative percentage of fish against length classes. The age at first capture was calculated according to the equation of Beverton and Holt, 1957. The length and age at first recruitment were estimated. The relative biomass per recruit *(B'/R)* was estimated as $B'/R = (Y'/R)/F$. The exploitation rate producing maximum yield E_{max}, $E_{0.1}$ highlighting exploitation rate at which the marginal increase of *Y'/R* is 10% of its virgin population and $E_{0.5}$ indicating exploitation rate under which the population is reduced to half its virgin biomass were computed using the procedure incorporated using the Knife-edge option fitted in the FiSAT II Tool, Gayanilo and pauly, 1997.

RESULTS AND DISCUSSION

Age and growth

The linear regression analysis of the length-weight data allowed the estimation of the constants, *a* and *b* of the length–weight relationship (Fig.2) explained by the equation $W=0.0195L^{2.8613}$ provided a good fit to length and weight data for species $(r^2=0.99)$. The growth of weight relative to length was allometric growth (*b*=2.861). As the obtained isometric index value (*b*) was insignificantly different from 3 (Student's t-test < t critical). Grandcourt *et al.,* 2004 in southern Arabian Gulf off Emirate Abu Dhabi estimates the *b* value of length-weight relationship as 2.867. The total length and fork length relationship was expressed as $FL=0.8459TL–0.1689$ with $r^2=0.997$ (Fig. 3). The ratio for TL: FL was 1.0 : 1.19.

The monthly variations of condition factor ranged from 1.08 to 1.29 with average 1.19 in males, while in females ranged from 1.06 to 1.29 with average 1.17. On the other hand, the highest values of condition factor for both sexes was 1.29 during January and February for females and males respectively. While the lowest values 1.08 and 1.06 were recorded during September and October for males and females respectively. There was no significant difference in the mean condition factor of *G.speciosus*.

Age was determined using 781 specimens of *G.speciosus* sorted into different length groups with length interval of 2.0 cm for length frequency analysis, in addition to reading of 230 otoliths for validation of the age. Fig 4. Shows the length frequency analysis using Bhattacharya's method (1967) and showed 7th years old.

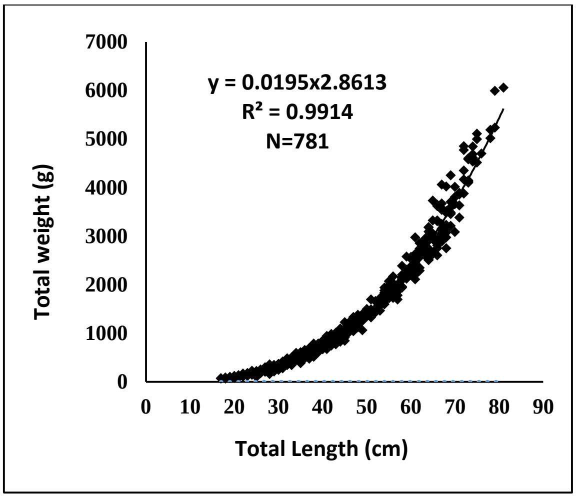

Figure 2. Length-Weight relationship of *G.speciosus*

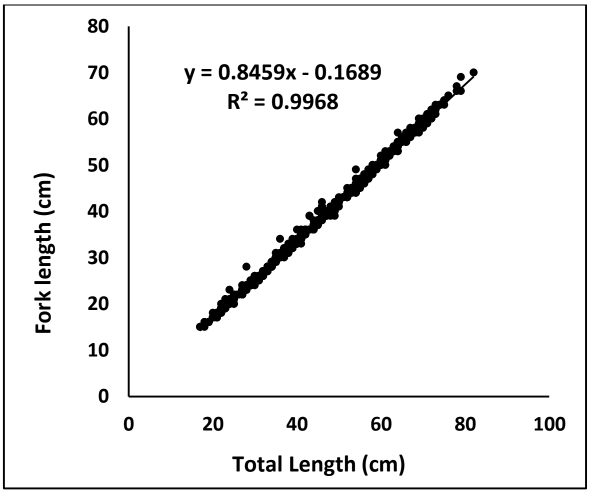

Figure 3. Total-Fork length relationships of *G.speciosus*

The back calculated length at the end of different years of life, for the *G.speciosus* based on otolith reading revealed the presence of age groups 0-10. There was a general decrease in the rate of growth as the fish increases. The fish attained lengths of 24.85, 35.69 and 44.19cm at the end of the first, second and third years of life respectively, while the fish attained the length of 74.40cm at the end of tenth year.

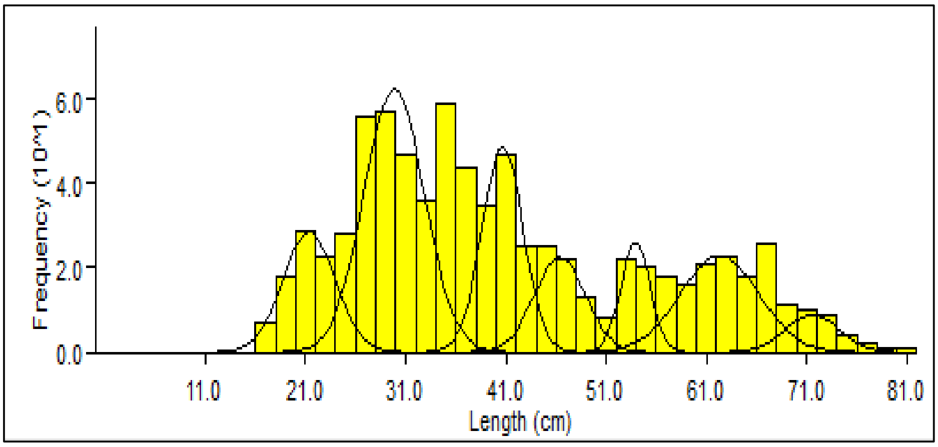

Figure 4. Length frequency distribution for *G.speciosus* using Bhattacharya's method

The results of growth in length revealed that, the maximum increment of the linear growth occurred by the end of the first year of life (24.85 cm), after which a gradual decrease in annual increments with a further increase in age was observed. The calculated weights by the end of each year of life were estimated. It was noticed that, the annual increment of growth in weight increases with a further increase in age until it reaches its maximum value at age group V (789.0 g), after which it shows a gradual decrease with a further increase in age. Figures 5 and 6.

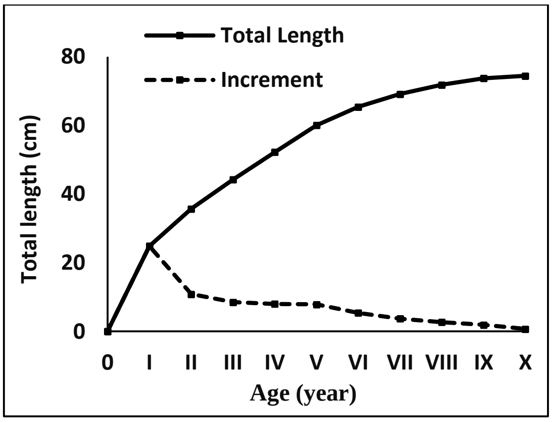

Figure. 5. Growth in length and increment of *G.speciosus*

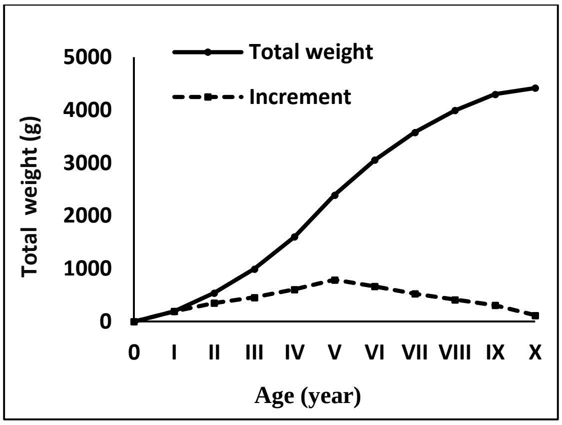

Figure. 6. Growth in length and increment of *G.speciosus*

The growth parameters, L_∞ and *Z/K* estimated using Powell (1979) –Wetherall (1986) plot were 85.01cm and 3.28 with r=0.96. The additional estimates of L_∞ and *K* obtained by ELEFAN were 85.05cm and 0.31year^{-1} respectively with R_n value of 0.36.

Figure 7 shows the restricted length frequency histogram with growth curves for *G.speciosus*. In the present study, the average growth parameters calculated by hard parts and ELEFAN methods are used for further analysis were; L_∞= 84.52cmTL, K=0.28year^{-1} and the value of t_o was taken as -0.45year. The resultant Von Bertalanffy growth equations for *G.speciosus* were:

For growth in length: L_t=84.52*(1-exp-0.28(t-(-0.45)). For growth in weight: W_t=6361.7*(1–exp-0.28(t-(-0.45))$^{2.8613}$. Grandcourt *et al.,* 2004 declared that, for the absence of suitable structural increments precluded the development of an ageing method using sagittal otoliths, consequently, length-based methods were used to establish growth parameters were: k= 0.514 year^{-1}, L_∞=72.33 cm (*L*F), t_o =−0.70 years.

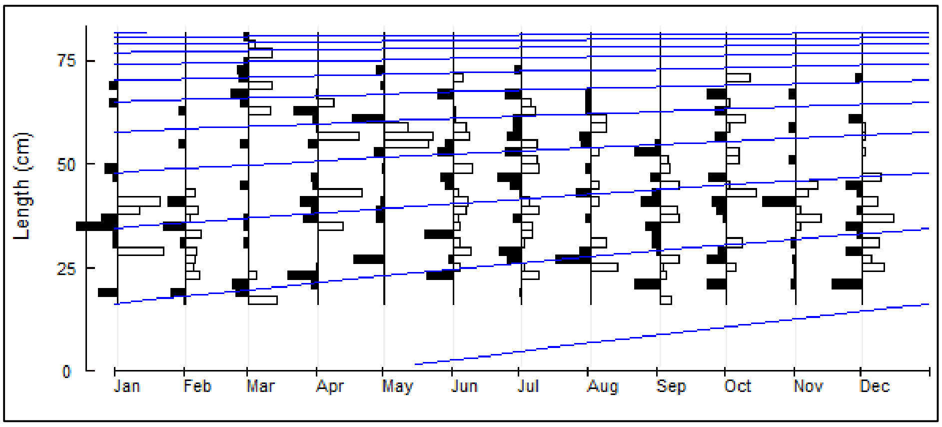

Figure 7. Von Bertalanffy growth curve of *G.speciosus* fitted by ELEFAN technique.

The longevity T_{max} was calculated as approximately 11.0years. The growth performance index *Ø* was found to be 3.30. A method of validating growth parameters involves the comparison of growth performance indices in terms of growth in length or weight with estimates obtained for similar species (Gayanilo and Pauly, 1997). Values of *Ø* for representative Carangids range from 2.5 for *Carangoides armatus* (Corpuz *et al.*, 1985) to 3.45 for *G.speciosus* (Edwards *et al.*, 1985). the growth performance indices *Ø* of *G. speciosus* was 3.43 in Grandcourt *et al.,* 2004.The result of growth performance would suggest that the growth parameters estimated here are of the right order and support the contention that Carangids are relatively fast growing fishes.

Reproduction

Figure 8 shows the monthly changes in GSI values of individuals of *G.speciosus* from this figure its appear that, the GSI values began to increase from March to May then began to decrease indicating that its breeding season during spring, this result coincide with the results declared by Grandcourt *et al.,* 2004 and support the view that seasonal reproductive cycles are common among tropical fishes (Robertson, 1990; Montgomery and Galzin, 1993). The mean size at first maturity L_m was estimated at 34.5cm FL and correspond to 1.43year at first maturity Figure 9.

The length at first capture L_{50} (the length at which 50% of the fish are first exposed to capture) was estimated as a component of cumulative catch curve was found to be 30.9cm FL which correspond to 1.18 years. The mean size at first sexual maturity of *G.speciosus* was estimated as 32.5cmFL and was higher than the length at first capture as reported by Grandcourt *et al.,* 2004. Sex ratio was close to unity being 1:1.5 was not significantly different(P>0.05). The proportion of immature fish in aggregated size frequency samples that were below the mean

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size at first sexual maturity (juvenile retention rate) 58.4%. Grandcourt *et al.*, 2004 mentioned that the sex ratio was 1:1.1 and juvenile retention rate was 70.7%. There were two defined peaks in recruitment to the fishery; the first peak in February, March and April while the second peak defined during September, October and November Figure 10.

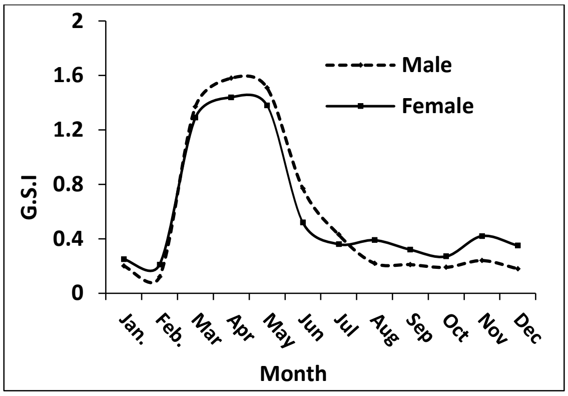

Figure 8. Mean monthly Gonado-Somatic index for *G.speciosus*.

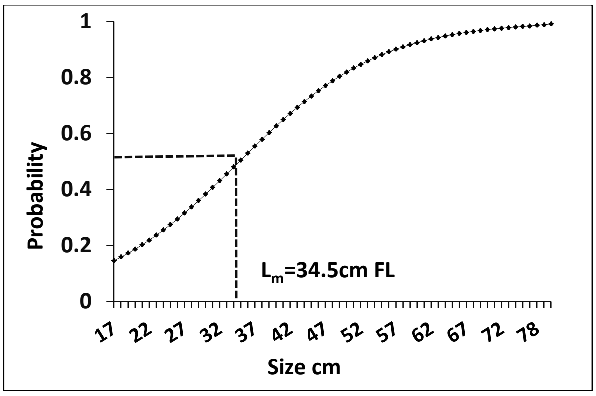

Figure 9. Size at first sexual maturity of *G.speciosus*

Mortality parameters

The length converted catch curve Fig.11 gave Z value of 1.01yr-1 (confidence interval of Z=0.81-1.22; standard deviation of the slope=0.084; r=-0.98). The natural mortality M calculated by empirical methods of pauly, Rikhter&Efanov and Hoeing's were 0.62, 1.02 and 0.41yr-1 respectively with the average of 0.68yr-1. Therefore, the computed instantaneous fishing mortality coefficient F was estimated as 0.33yr-1 and almost equal the target fishing mortality F_{opt}=0.34 biological reference point. Total, natural and fishing mortalities were calculated according to Grandcourt *et al.*, 2004 as:1.834, 0.896 and 0.94yr-1 respectively in the Coast of the Emirate of Abu-Dhabi. The exploitation rate E calculated as 0.32 indicated the stock of *G.soeciosus* is under-exploited. The fraction of growth to be completed by the fish after entry into the exploitation phase U=0.57. The optimum length of exploitation L_{opt} estimated was 46.5cm TL and the value of L_{opt}/L_{∞} calculated was 0.55.

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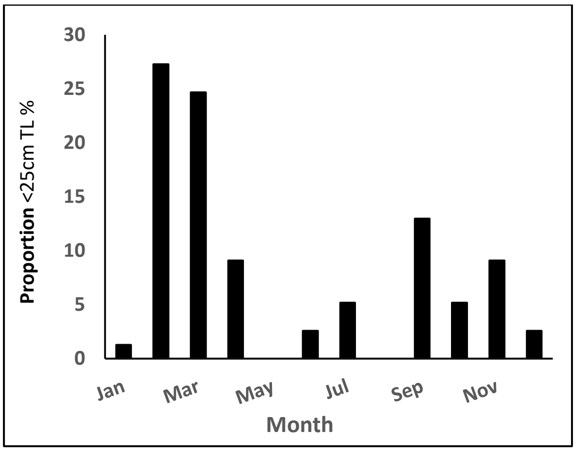

Figure. 10. Recruitment pattern of *G.speciosus*

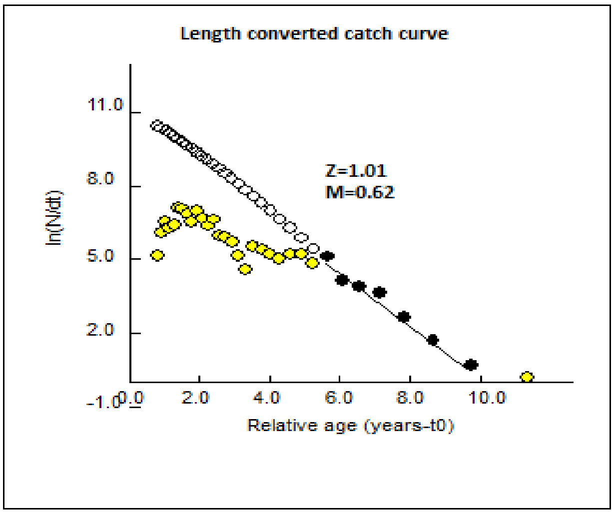

Figure. 11. Length converted catch curve of *G.speciosus*

Yield per recruit

The length and age at first capture (L_c&T_c) were estimated as 36.7cm and 1.59 year respectively. While the length and age at recruitment (L_r&T_r) were estimated as 17.0cm and 0.36 year respectively. Using W_∞=6362.0g, yield and biomass per recruit *Y/R* and *B/R* were estimated as 171.7 & 520.3g respectively at current F= 0.33 year^{-1} and T_c = 1.59year Fig. 12.

The maximum yield per recruit was 247.4g it is estimated at fishing mortality 2.1 year^{-1} which is higher than current fishing mortality. Estimates of relative yield per recruit and relative biomass per recruit as graphically represented in Fig. 13, were $E_{0.1}$=0.62, $E_{0.5}$=0.35 and E_{max}=0.74. Comparatively, $E_{current}$ (0.32) was lower than E_{max}(0.74).

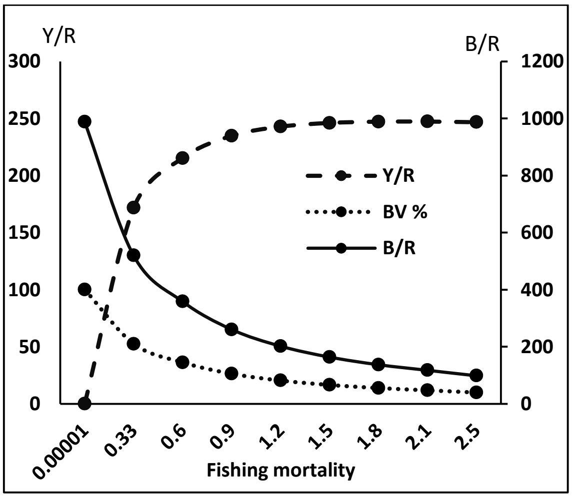

Figure 12. Yield per recruit and Biomass per recruit of *G.speciosus*

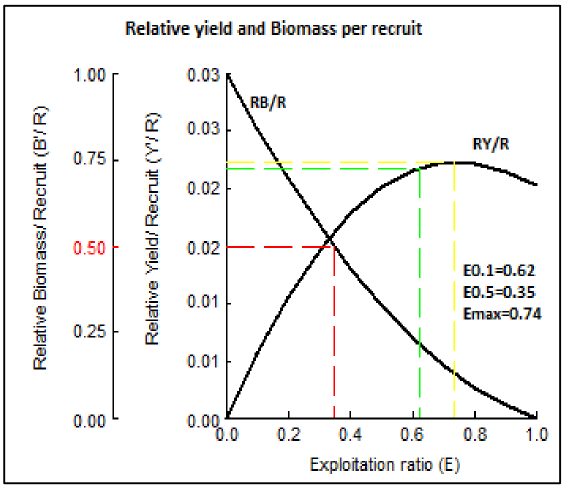

Figure 13. Relative yield per recruit and biomass per recruit of *G.speciosus*

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CONCLUSION

In conclusion, the paper provides the basic information on growth, mortality and stock status of *G.speciosus* in the southern part of the Arabian Gulf off the United Arab Emirates. This information is required by most of the models of stock assessment to estimate fishing mortality, population of cohorts and population of spawning stock.

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