International Journal of Fisheries and Aquaculture Research
Vol.5, No.3, pp.9-18, August 2019
Published by European Centre for Research Training and Development UK (www.eajournals.org)

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

Elsayed Farrag*; Ahmed Al-Zaaby; Eisa Alyafei and Mustafa Alshaer

Marine Environment Research Department, Ministry of Climate Change and Environment.
P.O. Box 1509, Dubai, United Arab Emirates.

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, 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 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,

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

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

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

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 ^{o}C 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.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

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.

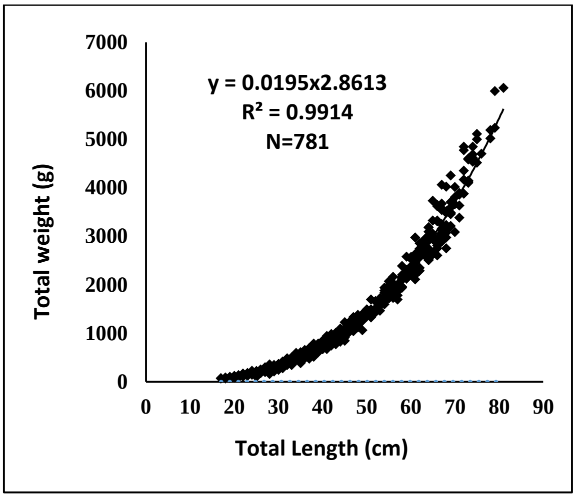

Figure 2. Length-Weight relationship of *G.speciosus*

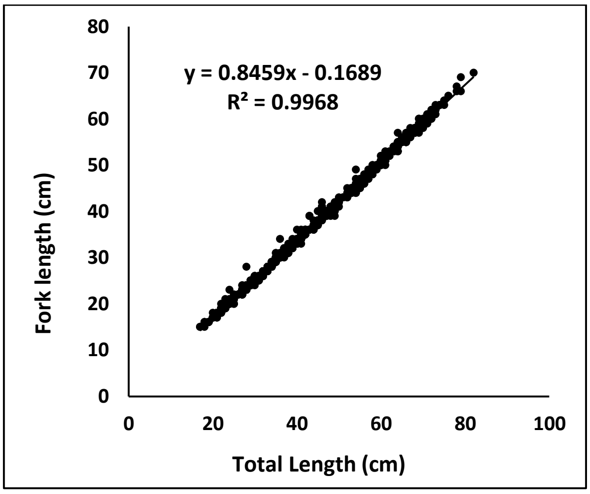

Figure 3. Total-Fork length relationships of *G.speciosus*

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.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

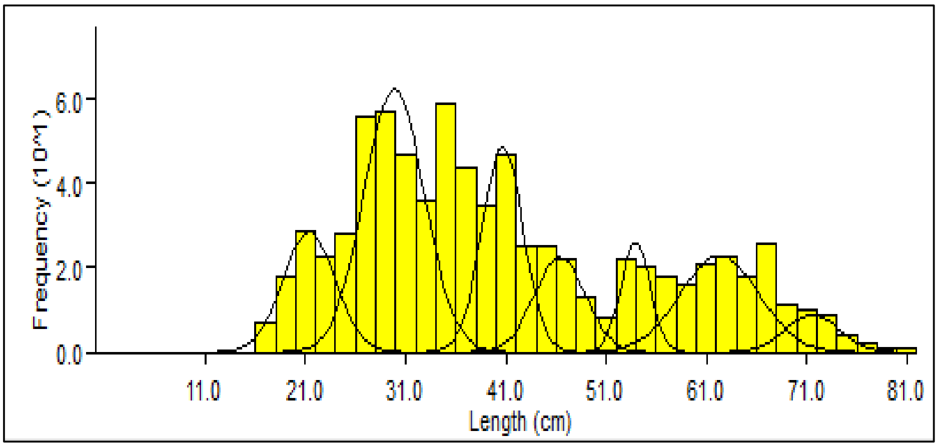

Figure 4. Length frequency distribution for *G.speciosus* using Bhattacharya's method

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.

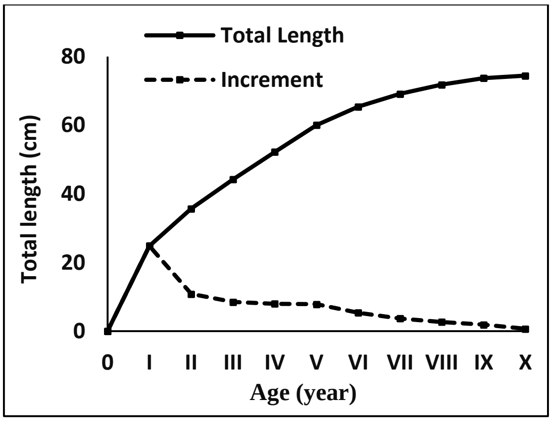

Figure. 5. Growth in length and increment of *G.speciosus*

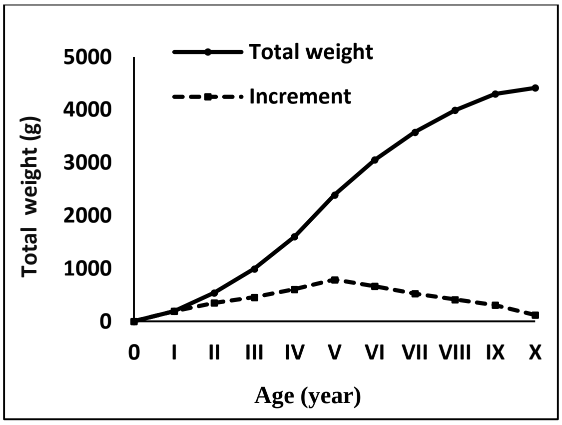

Figure. 6. Growth in length and increment of *G.speciosus*

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,

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

consequently, length-based methods were used to establish growth parameters were: k= 0.514 year^{-1}, L_∞=72.33 cm (*LF*), t_o =−0.70 years.

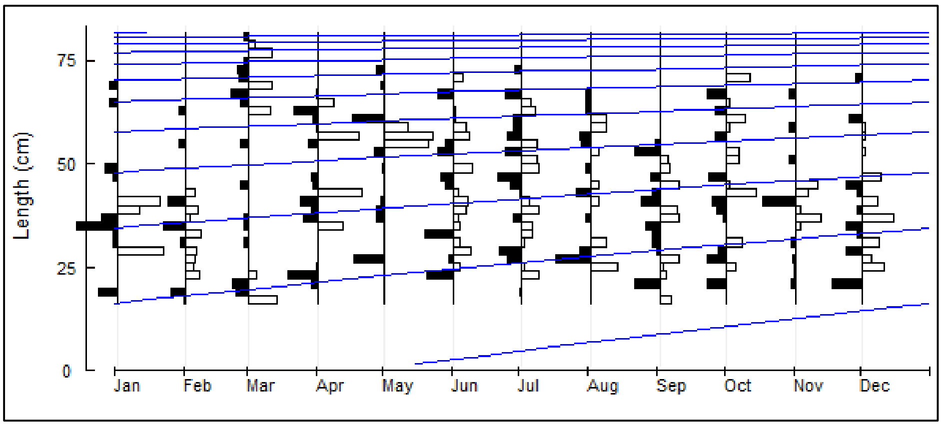

Figure 7. Von Bertalanffy growth curve of *G.speciosus* fitted by ELEFAN technique.

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 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.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

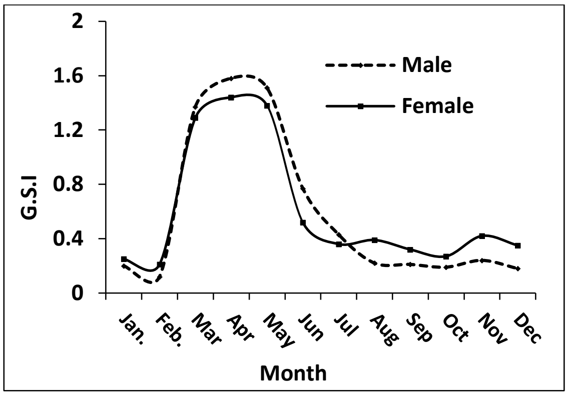

Figure 8. Mean monthly Gonado-Somatic index for *G.speciosus*.

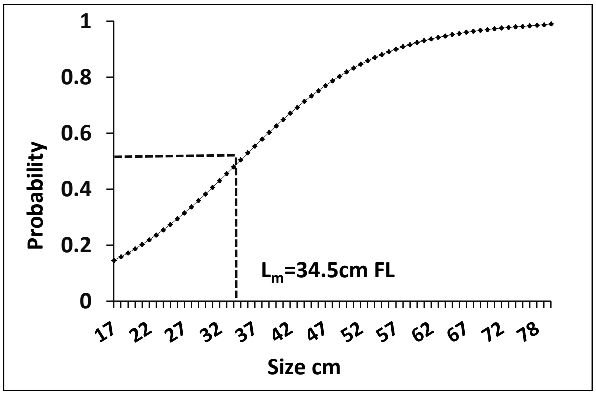

Figure 9. Size at first sexual maturity of *G.speciosus*

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.

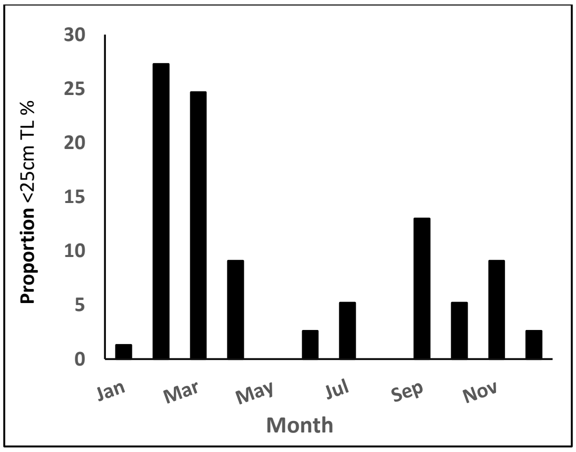

Figure. 10. Recruitment pattern of *G.speciosus*

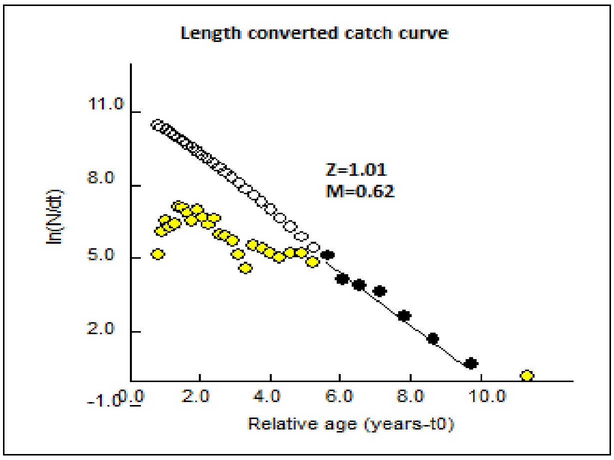

Figure. 11. Length converted catch curve of *G.speciosus*

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.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

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).

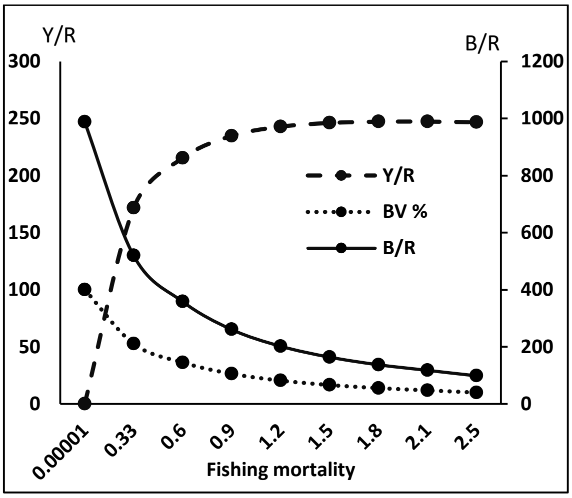

Figure 12. Yield per recruit and Biomass per recruit of *G.speciosus*

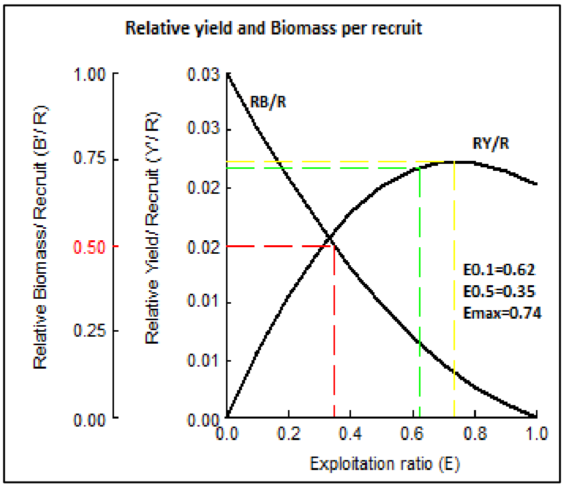

Figure 13. Relative yield per recruit and biomass per recruit of *G.speciosus*

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.

Acknowledgment

The authors sincerely thank the Fisheries Department in the Ministry of Climate change and Environment for all facilities it offered during the work. Thanks are also due to the sampling collectors in the Marine Environment Research Department for their great effort in obtaining the samples.

References

Allen, G.R., Steene, R.C. 1988. Fishes of Christmas Island Indian Ocean, Christmas Island Natural History Association, Christmas Island, Indian Ocean, 6798, Australia.

Al-Rasady, I., Govender, A. and Al-Jufail, S.M. 2013. Age and growth of longnose trevally *Carangoides chrysophrys* in the Arabian Sea. J.Appl. Ichthyol. 1-5.

Beverton R.J.H. 1992. Patterns of Reproductive strategy parameters in some marine teleost fishes. J. Fish Biol. 4 (B):106-137.

Beverton, R.J.H. and Holt, S.J.H. 1957. On the dynamics of exploited fish populations. Fishery investigations, London Series II. 19:533p.

Bhattacharya, C.G. 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics, 23: 115-135.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

Corpuz, A., Saeger, J. and Sambilay, V. 1985. Population Parameters of Commercially Important Fishes in Philippine Waters, Technical Report of the University of Philippines, Department of Marine Fisheries. 6.

Crabtree, R.E., Hood, P.B. and Snodgrass, D. 2002. Age, growth, and reproduction of permit (*Trachinotus falcatus*) in Florida waters. Fish. Bull. 100, 26–34.

Edwards, R.R.C., Bakhader, A. and Shaher, S.1985. Growth, mortality, age composition and fishery yields of fish from the Gulf of Aden. J. Fish Biol.; 27,13–21.

Ford, E. 1933. An account of the herring investigations conducted at Plymouth during the years from 1924 B.J. Mar. Biol. Assoc. U.K.; 19: 305B 384p.

Froese, R. and Binohlan, C. 2000. Empirical relationship to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes with a simple method to evaluate length frequency data. J.Fish.Biol., 56:758-772.

Fry, G.C., Brewer, D.T. and Venables, W.N., 2006. Vulnerability of deepwater demersal fishes to commercial fishing: evidence from a study around a tropical volcanic seamount in Papua, New Guinea. Fish. Res. 81,126–141.

Gayanilo Jr, F.C. and Pauly, D. 1997. FAO–ICLARM Stock Assessment Tools. Reference manual. ICLARM International Centre for Living Aquatic Resources Management, Food and Agricultural Organization of the United Nations, Rome.

Grandcourt, E.M., Al Abdessalaam, T.Z., Francis, F. and Al Shamsi, A. 2004. Population biology and assessment of representatives of the family Carangidae *Carangoides bajad* and *Gnathanodon speciosus* (Forsskal, 1775), in the Southern Arabian Gulf. Fisheries Research. 69: 331–341.

Griffiths, S.P., Fry, G.C. and van der Velde, T.D. 2006. Population dynamics and fishery benefits of a large legal size of a pelagic sportfish, the Talang queenfish, *Scomberoides commersonnianus*, in northern Australia. Fish. Res. 82; 74–86.

Hilborn, R. and Walters, C.J., 1992. Quantitative fisheries stock assessment. In: Choice, Dynamics and Uncertainty. Chapman and Hall, London.

Hoening, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin US, 82: 898-902.

Le-Cren, E.D. 1951. The length weight relationships and seasonal cycle in gonad weight and condition in perch *Perce fluviatilis*. J.Anim.Ecol. 20:201-219

Lee, R.M. 1920. A review of the methods of age and growth determination in fishes by means of scales. Fish Invest. London, Ser.; 4 (2):1-32.

Metin, G. and Ilkyaz, A.T. 2008. Use of otolith length and weight in age determination of poor cod (trisopterus minutus Linn., 1758). Tur.J.Zool. 32: 293-297.

Montgomery, W.L. and Galzin, R., 1993. Seasonality in gonads, fat deposits and condition of tropical surgeonfishes (Teleostei: Acanthuridae). Mar. Biol. 115, 529–536.

Morales-Nin, B. and Ralston, S. 1990. Age and growth of *Lutjanus kasmira* (Forsskal) in Hawaiian waters. J. Fish Biol. 36, 191–203.

Nelson, J.S. 1994. Fishes of the world, 3rd edn., John Wiley and Sons, Inc., New York.

Patterson, K. 1992. Fisheries for small pelagic species: an empirical approach to management targets. Reviews in Fish Biology and Fisheries. 2:321-338.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Conserv. 39:175–199.

Pauly D. 1983. Length converted catch curves. A powerful tool for fisheries research in tropics (Part-1), ICLARM Fishbyte; 1:9-13.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776

Pauly D. 1984. Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Stud.&Rev. 8. ICLARM, Manila. 325.

Pauly, D. and Munro, J.L. 1984. Once more on the comparison of growth in fish and invertebrates. ICLARM Fish byte, 2:21.

Powell, D.G. 1979. Estimation of mortality and growth parameters from the length frequency of a catch. Rapp. P.-v. Reun. CIEM, 175: 167-169.

Randall, J.E. 1995. Coastal Fishes of Oman. University of Hawaii Press, Honolulu, Hawaii.

Randall, J.E., Allen, G.R. and Steene, R.C. 1997. Fishes of the Great Barrier Reef and Coral Sea. University of Hawaii Press, Honolulu, Hawaii.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board can.; 191: 382p.

Rikhter, V.A. and V.N. Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc., 76(VI/8): 12.

Robertson, D.R., 1990. Differences in the seasonality of spawning and recruitment of some small neotropical reef fishes. J. Exp. Mar. Biol. Fish. 9, 193–223.

Smith-Vaniz, W.F. 1984. Carangidae. In: Fischer, W., Bianchi, G. (Eds.), FAO Species Identification Sheets for Fishery Purposes. Western Indian Ocean Fishing Area 51 FAO, Rome; vol. 1.

Smith-Vaniz, W.F. 1995. Carangidae. Jureles, pámpanos, cojinúas, zapateros, cocineros, casabes, macarelas, chicharros, jorobados, medregales, pez pilota. p. 940-986. In W. Fischer, F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter and V. Niem (eds.) Guia FAO para Identification de Especies para lo Fines de la Pesca. Pacifico Centro-Oriental. 3 Vols. FAO, Rome.

Von Bertalanffy, L. 1938. A quantitative theory of organic growth. Hum. Biol. 10: 181–213.

Walford, L.A. 1946. A new graphic method of describing the growth of animals. Biol. Bull. Mar. Biol. Lab. Woods Hole, 7:90B, 141p.

Wetherall, J.A. 1986. A new method for estimating growth and mortality parameters from length frequency data. ICLARM Fishbyte, 4 (1): 12-14.

Print ISSN: ISSN 2397-7507, Online ISSN: ISSN 2397-776