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STUDIES ON GROWTH AND STOCK ASSESSMENT OF GOLD-SADDLE GOATFISH *Parupeneus cyclostomus* (LACEPÈDE, 1801) ALONG THE EASTERN COASTLINE OF THE UNITED ARAB EMIRATES

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Abstract: A total of 899 samples of *Parupeneus cylostomus* were collected from landing sites of eastern coastline of the United Arab Emirates from January to December 2017. Total length of individual fish samples was measured and analyzed using FiSAT II software. Von Bertalanffy growth parameters were estimated at asymptotic length L_∞ = 43.29 cm, growth rate K = 0.47 per year, the theoretical age at length zero t_o = −0.30 year and growth performance index Φ=2.63. The length at first capture was estimated at 23.17 cm. The estimated value of total mortality based on length converted catch curve is Z = 1.86 per year. Natural mortality based on growth parameters and mean environmental temperature estimated at M = 0.98 per year. Furthermore, the annual instantaneous fishing mortality rate of 0.88 per year was by far in excess of the precautionary target F_{opt} = 0.39 per year and limit F_{limit} = 0.65 per year biological reference points, indicating that the resource was over-exploited. The exploitation ratio E = 0.47 is higher than the exploitation which maintain the 50% of the stock $E_{0.5}$.

Keywords: Exploitation rate; Growth parameters; Mullidae; Mortality; *Parupeneus cyclostomus*.

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INTRODUCTION

Goatfishes are tropical marine perciform fish of the family Mullidae. Goatfishes are most associated with the reefs. Within the family there are approximately 6 genera and 70 species (Randall 2004; Uiblein and Heemstra 2010). Goatfish are valued food fish in many countries. Goatfish are tireless benthic feeders, using a pair of long chemosensory barbels protruding from their chins to rifle through the sediments in search of a meal. Like goats, they seek anything edible; worms, crustaceans, mollusks and other small invertebrates. Many goatfish form large schools: these aggregates may contain both conspecifics and hetero-specific. For example, the Gold-saddle goatfish *Parupeneus cyclostomus* is congregating with bigeye trevally *Caranx sexfasciatus* (Rajan *et al.,* 2012). Most goatfish inhabit inshore areas and are commercially important throughout their distribution. Due to their economic value, goatfish have been the subject of rather intense biological and taxonomic studies in different areas (Lee, 1974; Munro, 1976; Papaconstantinou *et al.,* 1981; Sorden, 1983; Gosline, 1984; Wahbeh, 1992a,b; Golani, 1994). The taxonomy of Mullidae in the Red Sea has received considerable attention (Dor and Ben-Tuvia, 1984; Al-Absey, 1988; Ben-Tuvia and Kissil, 1988). *Parupeneus cyclostomus* is an important species of family Mullidae. It is existing in Indo-Pacific: Red Sea and east coast of Africa south to Durban, South Africa, east to the Hawaiian Islands, islands of French Polynesia and the Pitcairn Islands, north to the Ryukyu Islands and Ogasawara Islands, Japan south to Australia. The maximum length of *P. cyclostomus* reaches to 50.0cm (Sommer *et al.,* 1996). The common

length: 35.0cm; maximum published weight: 2.3kg (Honebrink, 1990). *P.cyclostomus* found on coral (Broad, 2003), rocky or rubble bottoms of reef flats, lagoons, and seaward reefs (Mundy, 2005), benthopelagic (Randall, 1985). Juveniles form schools, adults usually solitary. Feed primarily on small fishes, crustaceans, worms, shrimps, crabs, and small gastropods during the day (Mundy, 2005).

Figure 1. Sampeling Location: Map shows the landing sites where samples collected

EXPERIMENTAL

Length frequency data for the present study was collected from the eastern coastline of the United Arab Emirates comprising of four landing sites namely; Kalba, Fujairah, Khor Fakkan and Dibba Alhisn (Figure 1), from January to December 2017. The fishes were measured nearest 1.0cm (fork length) and the pooled length data were grouped into 1.0cm size groups. The data analyzed using the FAO ICLARM Stock Assessment Tools II (Gayanilo and Pauly, 1997).

The growth parameters L_∞ (asymptotic length) and K (growth coefficient) were estimated based on K technique (ELEFAN I and Shepherd's method) computer program of FiSAT (Gayanilo *et al.,* 1996). The preliminary estimation of the L_∞ and Z/K were obtained using Powell (1979) and Wetherall Method (1986), the average of growth parameters used to the subsequently calculations.

The theoretical age at birth t_o was calculated using the empirical formula (Pauly, 1984):

$$Log_{10}(-t_o) = -0.3922 - 0.275 * log_{10} L_\infty - 1.038 * log_{10} K$$

The equation for growth in length is given by:

$$L_t = L_\infty * [1 - exp - k(t - t_o)]$$

Where, L_t is the length at age t, L_∞ is the asymptotic length; K is the growth rate and t_o is the age at length zero.

Growth performance index φ in terms of growth in length was estimated to validate the growth parameters using the equation of Pauly and Munro (1984):

$$\varphi = log_{10} K + 2\ log_{10} L_\infty$$

The potential longevity T_{max} was estimated using the formula of Pauly and Munro (1984):

$$T_{max} = 3/K$$

The instantaneous rate of total mortality Z was estimated using the Length converted catch curve method mentioned by Pauly (1983).

Natural mortality rate M was estimated by empirical equation of Pauly (1980) expressed below using a mean surface temperature T of 27.5°C:

$$LogM = -0.0066 - 0.279\ log\ L\infty + 0.6543\ logK + 0.4634\ logT$$

Where M is the natural mortality, L_∞ is the asymptotic length, T is the mean surface temperature and K refers to the growth rate coefficient of the VBGF.

The extrapolated points will be used to approximate the probability of capture of 0.5 (L_{50}), 0.75 (L_{75}). The length at optimum yield L_{opt} was estimated as follows (Beverton, 1992):

$$L_{opt} = (3/(3+M/K))*L_{\infty}$$

Fishing mortality F was calculated using the relationship (Gulland, 1971):

$$F=Z-M$$

Where Z is the total mortality rate, F the fishing mortality rate and M is the natural mortality rate. Limiting fishing mortality F_{limit} and the optimum fishing mortality F_{opt} which forms the precautionary target were calculated as $F_{opt}=0.4*M$ (Pauly, 1983) and $F_{limit}= 2/3*M$ (Patterson, 1992). The exploitation rate (the fraction of death caused by fishing) was obtained using the relationship: E = F/Z (Gulland, 1969). The recruitment pattern was computed following the method described in the FiSAT routine (Gayanilo *et al.,* 2005). The relative yield-per-recruit Y'/R and Relative biomass per recruit B'/R were estimated using the Beverton and Holt model (1964) as modified by Pauly and Soriano (1986). The computed exploitation rate was compared with the expected values of E_{max} (the value of exploitation rate giving maximum relative yield-perrecruit), $E_{0.1}$ (the value of E at which marginal increase in Y/R is10% of its value at E=0) and $E_{0.5}$ (value of E at 50% of the unexploited relative biomass-per-recruit) (Sparre and Venema 1992; Gayanilo and Pauly, 1997) as reference points.

RESULTS AND DISCUSSION

A total of 899 specimens were collected (Figure 2) ranging in size from 20.0 to 40.0 cm FL. The mean fork length was estimated 26.7±3.53 cm (±SD), with the highest frequency in length group 25.0cm (13.13%). First estimates of the asymptotic length L∞ and the ratio between the coefficients of total mortality and growth Z/K obtained from Powell-Wetherall plot were 45.87cm and 4.988 (Figure 3). Thereafter the estimates of L∞ and K were estimated by K-scan in ELEFAN I and Shepherd methods and the results are 42.0cm, 0.71 per year and 42.0cm, 0.23 per year respectively. The mean lengths of growth parameters were L∞=43.29cm and K=0.23per year with a life span T_{max} of 6.4 years. Figure 4 shows the restricted length frequency data superimposed with the estimated growth curve. The growth performance index φ of 2.63 was estimated for *P. cyclostomus.* The estimated to value was 0.30 per year. The VBGF for length at time t was expressed as:

$$Lt = 43.29 * [1-exp-0.47*(t + 0.30)$$

The estimate of the instantaneous total mortality Z from the length converted catch curve was 1.86 per year (Figure 5). The natural mortality rate M =0.98 per year and fishing mortality rate F=0.88 per year was considerably greater than the target (F_{opt} = 0.39) and limit (F_{limit} = 0.65) biological reference points, suggesting that the stock is over-exploited. The current exploitation rate was estimated as E=0.47. The length at first capture (the length at which 50% of the fishes are vulnerable to capture) was estimated as a component of the length converted catch curve analysis (Figure 6). The values of L_c obtained were 23.17 cm FL. On the other hand, the probability of capture of L_{25} and L_{75} were 22.32 and 24.01 cm respectively. The optimum length was estimated at 25.5cm FL.

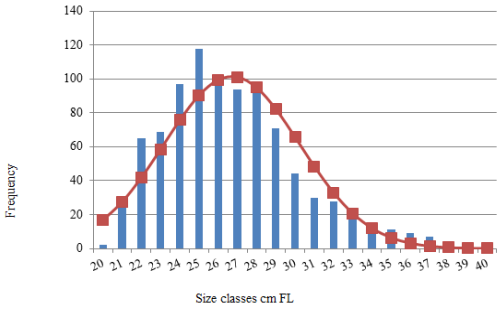

Figure 2. Length frequency distribution of *P. cyclostomus* in the Eastern area of the UAE

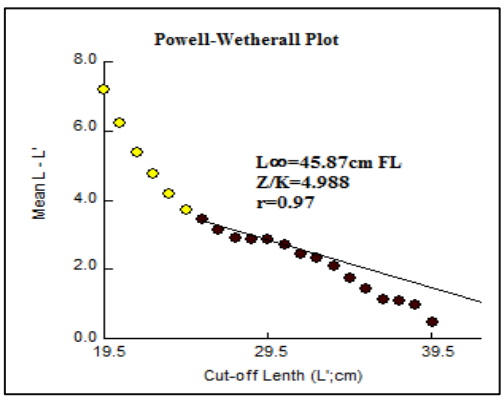

Figure 3. Powell-wetherall plot of *P. cyclostomus*: Estimated Values L∞=45.87 and K=0.28

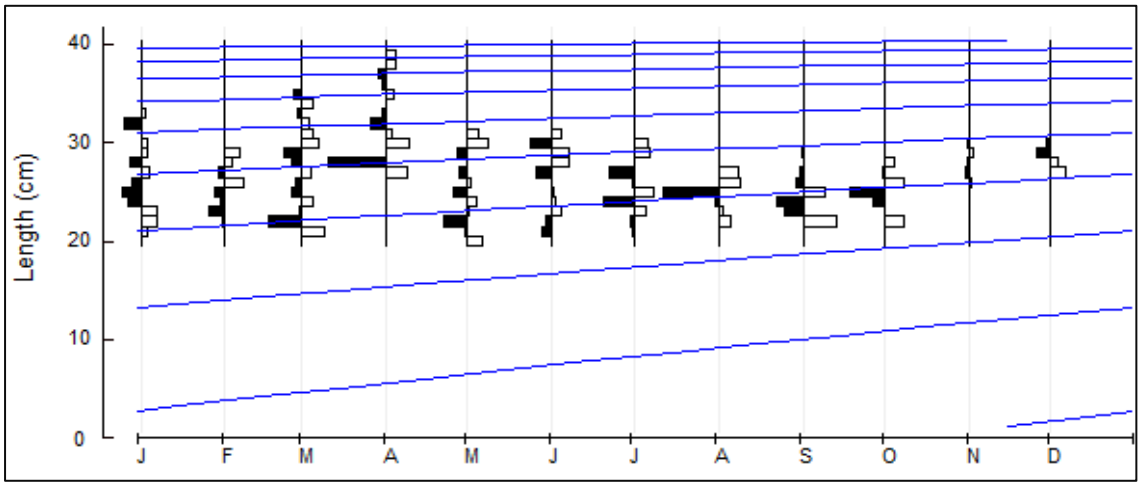

Figure 4. ELEFAN growth curve of *P. cyclostomus*

The recruitment pattern (Figure 7) shows double annual peak recruitment per year, the first peak (February) with recruitment strength of 12.16% while the second peak in October with recruitment strength of 14.77%. The Beverton and Holt (1959) relative yield per recruit estimated using the knife-edge method is given in Figurer 8, the optimum exploitation rates were estimated as; E_{max} = *0.89*, $E_{0.1}$=*0.76* and $E_{0.5}$=*0.38*. The current value of exploitation E_{curr} *(0.47)* was lower than that which gives the maximum *Y'/R* by about 89% but the raise of the current exploitation rate to this level will be associated with a negligible increase in *Y'/R*. Both of $E_{0.1}$ (level of exploitation at which the marginal increase in yield per recruit reaches *1/10* of the marginal increase in its value of *E*) and $E_{0.5}$ (exploitation level which will result in a reduction of the unexploited biomass by 50%) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.76 and 0.38 respectively. It is obvious that the current *E* is higher than the exploitation rate $E_{0.5}$ which maintains 50% of the stock biomass. For management purposes, the exploitation rate of *P. cyclostomus* should be reduced from 0.47 to 0.38 (19%) to maintain a sufficient spawning biomass since the maximum Y'/R is not the target point but the maximum constant yield (maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass) is the target reference point for fisheries management (Caddy and Mahon, 1995). Besides, it is always safe to be on the left of the maximum *Y'/R* than to use its current value.

The size range of fish in the commercial catches in the present study ranged between 20.0 and 40.0cm of FL. The highest frequency of catches belonged to the length of class 25.0cm (13.13%) while the terminal length groups are the lowest. Maximum size of individuals of *P. cyclostomus* indicated in the FishBase (Sommer *et al.,* 1996) and registered in Somalia is 50cm TL. The proportion of fish in aggregated length frequency samples that were below the optimum length was calculated about 52.8 %. Length based stock assessment showed an asymptotic length L_∞ of 43.29 cm FL and growth coefficient *K* of 0.47per year with a life span T_{max} of 6.4 years. Age at length zero was estimated as -0.30. The VBGF for length at time *t* was expressed as:

$$L_t = 43.29 * [1-exp-0.47*(t + 0.30)].$$

The growth performance index (phi prime index, Ø) for *P. cyclostomus* from the eastern area of the United Arab Emirates was 2.63. The annual instantaneous total mortality coefficient *Z* of *P. cyclostomus* estimated by length converted catch curve method in the present investigation was 1.86 per year. The natural mortality rate *M* estimated based on the growth parameters and temperature was 0.98 per year. The high *M* value can be explained as when the fish grow fast (high K) are likely to attain higher natural mortality rate as compared to fishes that grow slow and consequently with lower *M* (Gulland, 1969). The *M/K* ratio usually

ranges between 1 and 2.5 (Beverton and Holt, 1959). In the present study, the *M/K* ratio for *P.cyclostomus* was calculated to be 2.09. The estimated fishing mortality *F=0.88* was close to the value of *M* during the study period. The exploitation rate *E* generally indicates the state of exploitation of a stock under exploitation assuming that the optimal value of E≈0.5, which in turn assumes that the sustainable yield is optimized when F≈M (Gulland, 1971). In the present study, as the estimate of *F* is slightly lower than the *M* and the calculated *E* was 0.47 which is almost close to the optimum level. The current fishing effort was considerably greater than the target (F_{opt}=0.39) and limit (F_{limit}=0.65) biological reference points, suggesting that the stock is over-exploited. Results obtained from the length converted catch curve analysis suggested 25% of fish of 22.32 cm FL, 50% of the fish of 23.17 cm FL and 75% of all fish of 24.01 cm FL. The recruitment pattern shows two peaks recruitment per year, the first peak in February with recruitment strength of 12.16% while the second peak in October with recruitment strength of 14.77%. As per Beverton and Holt (1959) relative yield per recruit indicated that the current value of exploitation E_{curr} = 0.47 was lower than that which gives the maximum *Y'/R* by about 85%, but the raise of the current exploitation rate to this level will be associated with a negligible increase in Y'/R. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.76 and 0.38, respectively. It is obvious that the current *E* is higher than the exploitation rate $E_{0.5}$ which maintains 50% of the stock biomass. For management purposes, the exploitation rate of *P. cyclostomus* should be reduced by 19% to maintain a sufficient spawning biomass.

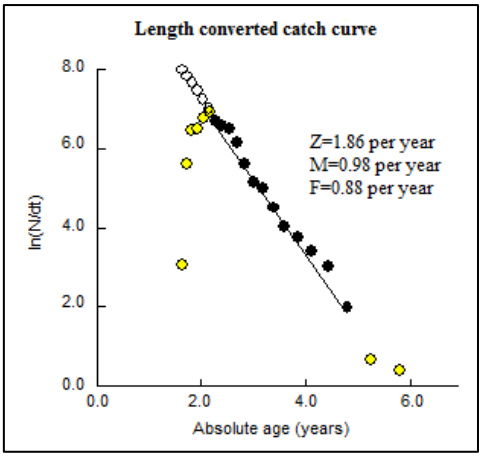

Figure 5. Linearized length converted catch curve of *P.cyclostomus*. Estimated Z=1.86

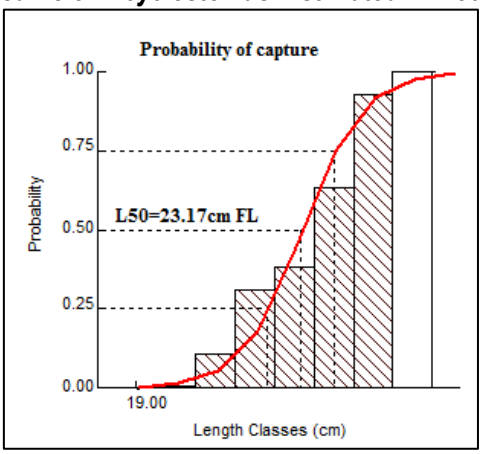

Figure 6. FISAT II output of probability of capture for *P. cyclostomus*

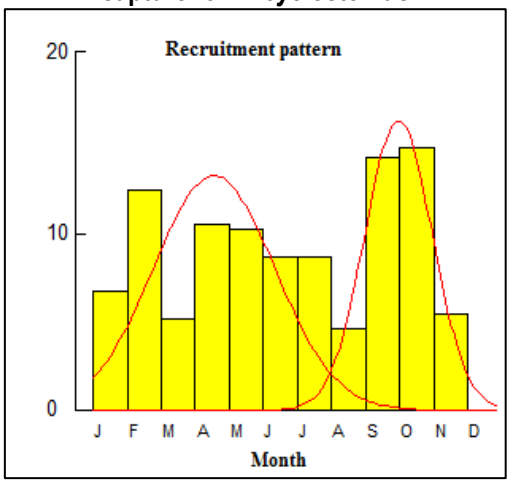

Figure 7. Recruitment pattern of *P. cyclostomus* obtained by FiSAT II

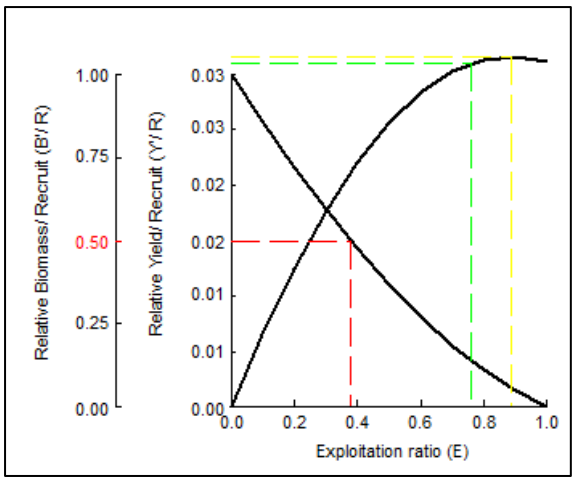

Figure 8. Relative Y/R and relative B/R as computed using the knife-edge method

CONCLUSION

The results of yield per recruit analysis showed that, the present level of exploitation is higher than the rate which maintains 50% of the stock biomass. Reducing the current exploitation by 19.0% will maintain a sufficient spawning biomass. Therefore, monitoring the fishing effort and mesh size regulation is needed to safeguard the commercial important species along the East Coast of the United Arab Emirates.

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