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Research Article

Population dynamics of Gray eel catfish (*Plotosus canius* Hamilton, 1822) at mangrove estuary in Bangladesh

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Abstract

Present study emphasizing the population dynamics parameters of Gray eel catfish (*Plotosus canius*) that was scrutinized based on monthly length frequency data collected from mangrove estuary, Bangladesh from January 2017 to December 2018. A total amount of 1298 specimens was collected to estimate the total length (*TL*) and weight (*W*) of *P. canius* ranged from 13.3cm to 87.4cm and 28g to 5200g respectively. The length-weight relationship was $W=0.006\ L^{2.95}$ with R^2=0.972 for both sexes. The von Bertalanffy growth function parameters were $L\infty$=93.25cm and K=0.28yr^{-1}, hypothetical age at zero length of t_0=0.059 year and goodness of the fit of R_n=0.494. The growth performances indices for L_∞ *and* W_∞ were computed as $Ø'$=3.386 *and* $Ø$=1.84 respectively. The natural mortality was 0.51yr^{-1} at average annual water surface temperature as 22°C. The total instantaneous mortality was 1.24yr^{-1} at $CI_{95\%}$ of 1.05–1.42 (r^2=0.986). While fishing mortality was 0.73yr^{-1} and the current exploitation ratio as 0.59. The recruitment was continued throughout the year with one major peak during June-July was 17.20-17.96%. The Beverton-Holt yield per recruit model was analyzed by FiSAT-II, when t_c was at 1.443 yr, the F_{max} was estimated as 0.6yr^{-1} and $F_{0.1}$ was 0.33yr^{-1}. At the age of 0.6 year, $F_{current}$ was 0.74yr^{-1} that is beyond the $F_{0.1}$ that specified the current stock of *P. canius* of Bangladesh was over-exploited.

Keywords: *Plotosus canius*, Mangrove estuary, Asymptotic length, Growth, Mortality, Bangladesh

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Introduction

The amphidromous gray eel catfish, *Plotosus canius*, Belong to the family Plotosidae is one of the near threaten catfish of Bangladesh (IUCN, 2015). This canine catfish most commonly distributed in the estuarine region, particularly on the south west coast of the country and the mangrove areas (Islam, 2007). *P. canius* was primarily found in marine habitats but sometimes caught in brackish or freshwater habitats (Riede, 2004). Kottelat (2001) finds out that, *P. canius* arise in coastal seas and fresh or brackish waters. Juveniles are commonly found to form compact aggregates, thus resulting in very tight shoals with about 50 juvenile fish (Mohsin *et al.*, 1993; Ambak, 2010). Riede (2004) described that, *P. canius* has been observing to live on or near the bottom of the sea and migrate between the sea and freshwater. Canine catfish is a less common species and its population abundance shows a declining trend in Bangladesh. Moreover, the estimated extent of occurrence (46,947.01 km^2) and area of occupancy (10,178.31 km^2) are above the threshold values for any IUCN threatened category but the fish are impacted by some major threats, including the destruction of habitat and over-exploitation and poses a risk for its extinction in future (IUCN, 2015). *P canius* is one of the essential catfish on the west coast of Peninsular Malaysia, contributed 0.21% (1,541 tonnes) of the annual commercial fish landings in 2009 (Leh, 2012). However, *P canius* stocks have declined in nature due to over fishing, illegal fishing, indiscriminate fishing of brood stocks and Juveniles, rapid degradation of marine habitat, agricultural activities (Khan *et al*., 2002), Although, it has been declared as a near threatened catfish for Bangladesh (IUCN, 2015).

Information on the biology of catfishes plays a significant role for conservation and management (Usman, 2016). Therefore, this study represents the information on asymptotic length (L_∞) and growth coefficient (K), mortality coefficients (natural, fishing, and total) and exploitation level (E) of *P. canius* from Mangrove estuary, Bangladesh for the first time.

Materials and methods

Major samples of *P. canius* both sexes were collected from commercial barrier trap nets of 20-24-mm mesh size between the periods of January 2017 to December 2018 from three estuarine mangrove areas (Fig.1). Best efforts were given in sample identification and data recorded. After collection, samples were fixed in 10% formalin solution in the field and analyzed after 2-3 days of preservation. Total length and weight of 1298 specimens of *P. canius* were measured

Monthly length-frequency data was used for estimating the growth parameters, L_∞ (asymptotic length) and K (growth coefficient) through the von Bertalanffy growth function (VBGF) by the ELEFAN I routine incorporated with the FiSAT II software (FAO-ICLARM stock assessment tool) (Gayanilo *et al.*, 2005; Gayanilo and

Pauly, 1997). For estimating length-weight relationship (LWR), the following formula was modified by Le Cren (1951) as $W=aL^b$, Where L is the total length (cm), W is the body wet weight (gm), 'a' is the intercept of the regression and 'b' is the regression coefficient. The equation $W=aL^b$ can be linearly represented as $Log\ W=Log\ a+b\ Log\ L$. The values of 'b' and '$Log\ a$' in the equation were estimated the using least square regression method.

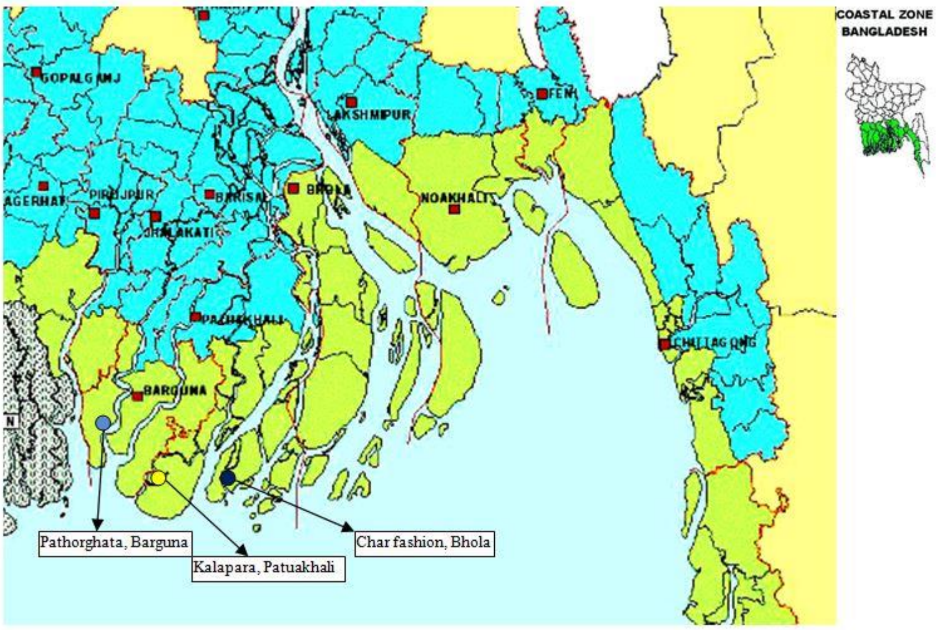


Figure 1: Map of Coastal areas of Bangladesh showing locations where the specimens of *P. canius* were collected.

In the von Bertalanffy equation as $L_t = L_\infty (1 - exp^{-K(t-t0)})$, where L_t is the length at time t, L_∞ is the asymptotic length, K is the growth coefficient and t_0 is the hypothetical age or time when length was equal to zero. The additional estimated value of t_0 was introduced by Pauly (1980):

$$log_{10}(-t_0) = -0.3922 - 0.275\ log_{10}L_\infty - 1.038\ log_{10}K.$$

The estimated growth parameters values of L_∞ (asymptotic length) and K (growth constant) were used to determine the growth performance index (Phi prime $Ø$). Following the equations of Pauly and Munro (1984) as:

$Ø' = log10\ K + 2\ log10 L_\infty$ and $\Phi = log10\ K + 2/3\ log10 W_\infty$.

Pauly (1980) described that the length converted catch curve method was used for estimating the total mortality rate (Z). Additional parameters of M and F (natural mortality and fishing mortality) were also calculated. The F (Fishing mortality) was evaluated by using the relationship of subtracting $F=Z-M$. The regression formula for Z is $L_n (N_t) = L_n (N_0) - Z_t$, where N_t is the population size at age t and N_0 is population size at zero. For calculating natural mortality

(M), an equation was developed by Pauly (1980) as:

$$\log_{10}M = 0.0066 - 0.279 \log_{10}L_\infty + 0.654 \log_{10}K + 0.4634 \log_{10}T.$$

T equals to 22°C that was the average annual surface temperature of water where the stock of *P. canius* distributed. Exploitation ratio (E) was evaluated by using the formula as: $E=F/Z=F/(F+M)$. The recruitment pattern of the stock was determined by backward projection on the length axis of the set of available length frequency data as described in FiSAT II (Pauly, 1980). This routine reconstructs the recruitment pulse from a time series of length frequency data to determine the number of pulses per year and the relative strength of each pulse. Input parameters were L_∞, K and t_0. The normal distribution of the recruitment pattern was determined by NORMSEP (Nikolskiii, 1980).

The Length structured virtual population analysis (VPA) for *P. canius* was carried out with the input values of LWR parameters intercept (a), slope (b), growth parameters values of asymptotic length (L_∞), growth coefficient (K) and mortality parameters values of natural mortality (M) and terminal fishing mortality(F_t) to evaluate the fishing mortalities per length class. The t_0 value was taken in which length at age zero (Sparre *et al*., 1989).

Gulland (1971a) estimated the optimal fishing mortality rate $F_{opt}=M$ was determined as the limit of biological reference points (BRP) for *P. canius* in the mangrove estuary, Bangladesh.

Thompson and Bell (1934) introduced the equilibrium yield such as catch (Y) and revenue (*Taka*) and standing stock biomass (B) at different fishing levels were predicted using length-frequency data. Thompson and Bell bio-economic model as:

For the ith length class was: $(L_i - L_{i+1})$

Total mortality sequence was:

$Z_i=M+xF_i$

Where x is the multiplier used to raise or reduce the fishing mortality rates sequence, x=1 for the current level of exploitation

Population size of successive classes was:

$$H_i = \left(\frac{L\infty - Li}{L\infty - Li+1}\right)^{M/2K}$$

$$N_{i+1} = N_i \left(\frac{1/Hi - x(Fi/Zi)}{Hi - x(Fi/Zi)}\right)$$

Catch for each class was $C_i = (N_i - N_{i+1})\ x\ (F_i/Z_i)$

$$\overline{W_I} = a\left(\frac{Li + Li+1}{2}\right)^b$$

Average weight for each length class was; $Yi=C_i\ W_I$

Yield for each different length class was; $Vi=YiVi$

Value for each length class was;

$$Ni = \frac{Ni - Ni+1}{Zt\Delta ti}$$

The Beverton-Holt yield per recruit model (1957) the equation as:

$$Y/R = F * e^{-M(tc-tr)} * W_\infty * \left(\frac{1}{Z} - \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} - \frac{S^3}{Z+3K}\right) \text{ and } S=e^{-k(tc-t0)}$$

(Y/R) was the yield per recruitment. Where K and t_0 was von Bertalanffy growth parameter, t_c was the average age of the first capture, t_r was the age of recruitment, W_∞ was asymptotic body weight, F was fishing mortality and $Z=F+M$ was total mortality. E_{max}, $E_{0.1}$, and $E_{0.5}$ were estimated by using the derivative of this function. E_{max} is the exploitation rate at Maximum Sustainable Yield (MSY), $E_{0.1}$ is the exploitation rate at which the marginal increase of relative yield/recruit is 1/10th, and $E_{0.5}$ is the value of E under which the stock has been reduced to 50% of its unexploited biomass. The data from the above stock assessment models were used to forecast the biological reference points (BRPs) for the sustainable exploitation of the Gray eel catfish.

Results

In current study, the total length range for *P. canius* was between 13.3 to 87.4 cm at average length 49.3±23.38cm and weight varied from 28 to 5200gm at average 568.74±343.76gm. The length-weight relationship of both sexes for *P. canius* was estimated as $W=0.006\ L^{2.95}$ and R^2=0.972 (Fig. 2). The dominant length group was ranged from17 to 27cm *(TL)* (Fig. 3).

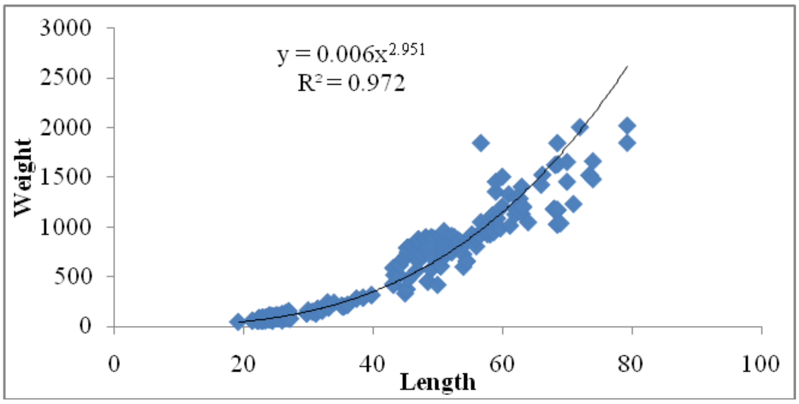


Figure 2: Length- weight relationship for combined sex of *P. canius* (2017-2018).

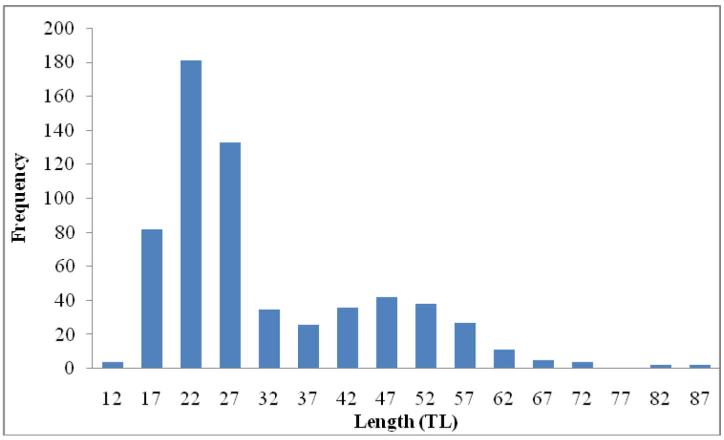
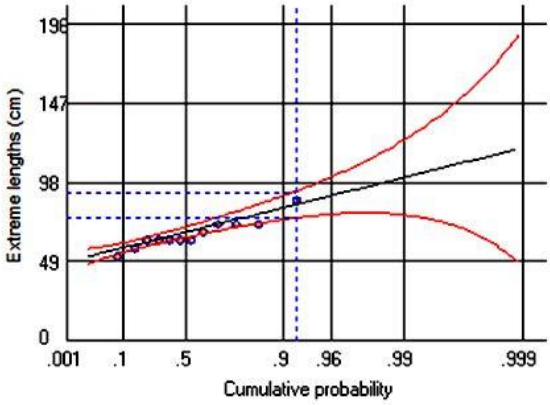


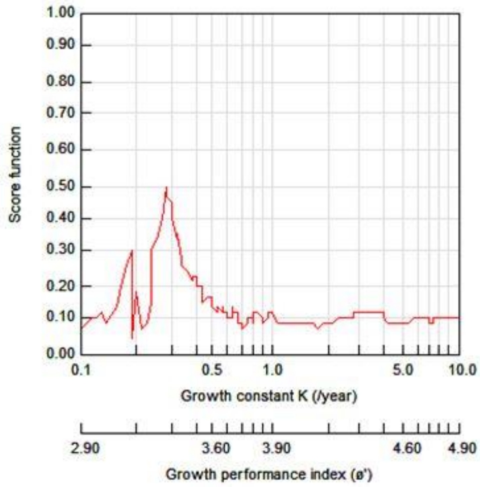
Figure 3: length frequency distribution (n=1298) ranging between 12-87 cm (*TL*) for both sexes of *P. canius* using the landing data from estuarine mangrove areas, Bangladesh during January 2017- December 2018.

The initial extreme length value Fig 4a was used in ELEFAN-I, incorporated in FiSAT package for producing the optimum growth curve. The VBGF growth coefficient (*K*) was 0.28 yr^{-1}. The goodness fit index of the ELEFAN-I routine (*Rn*) was 0.494, consider as the best combination of growth parameters *L∞* (asymptotic length)=93.25cm and *K* (growth coefficient)=0.28 yr^{-1}. Hypothetical age at zero length was estimated as t_0=0.059 year.

The von Bertalanffy growth parameters of *L∞* and *K* were used to estimate the growth performance indices (phi prime or index *Ø' and Ø*) for *P. canius* of the estuarine mangrove areas, Bangladesh as *Ø'*=3.386 and *Ø*=1.84 respectively (Fig 4b). VBGF curve through graphical representations is shown in Figure 5.



4 (a)



4 (b)

Figure 4: (a) Predicted maximum length of *P. canius* based on extreme value theory with a 95% confidence interval, obtained from the intersection of overall maximum length. (b): K-scan routine for determining the best growth curvature which giving the best value of asymptotic length with growth performance indices *Ø'* for *P. canius* in estuarine mangrove areas of Bangladesh.

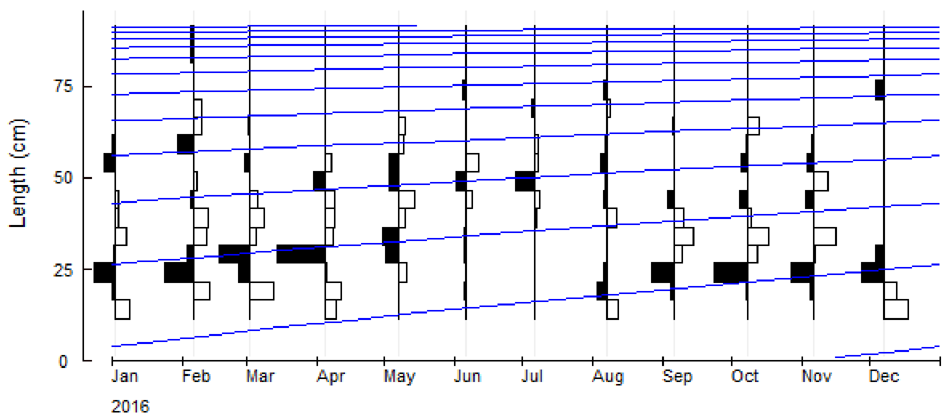


Figure 5: ELEFAN–I assessment revealed the growth curves for *P. canius* where L_∞ *and K* were 93.25cm, 0.28yr^{-1}, respectively.

The maximum length (L_{max}) was estimated 87.4 cm in the current study. Consequently, the sizes attained by *P. canius* were 10.83cm, 21.59cm, 39.10cm, 52.32cm, 62.32cm at the end of 0.5, 1, 2, 3 and 4 years of age respectively. The absolute increase is presented in Figure 6. Calculated growth of *P. canius* was 11.55 cm from 1 to 6 months of age; the estimated growth increment was 17.50 cm and 13.23cm from 1st to 2nd and 2nd to 3rd year, respectively.

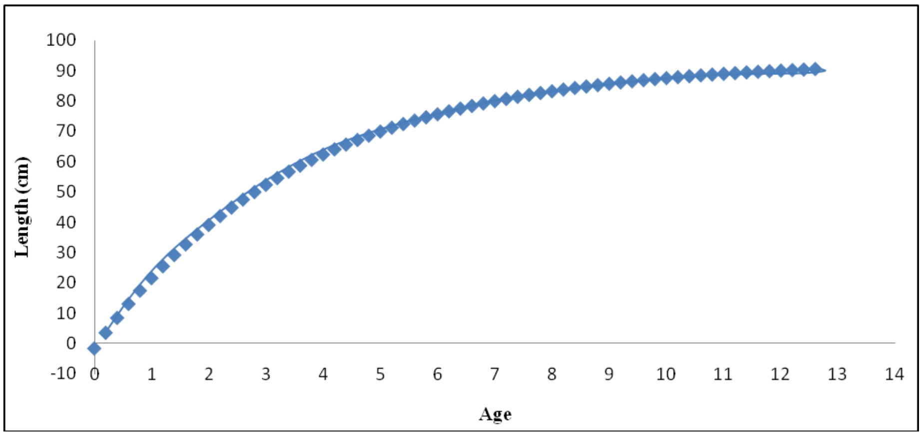


Figure 6: Age and growth of *P. canius* in year wise based on computed growth parameters (L_∞ and *K*).

The total mortality (*Z*) was 1.24 year^{-1} with *CI* $_{95\%}$ of 1.05–1.42 (r^2=0.986) assembled from the input values of VBGF growth parameters (L_∞ and *K*) in the length converted catch curve model (Fig. 7 and Table 1).

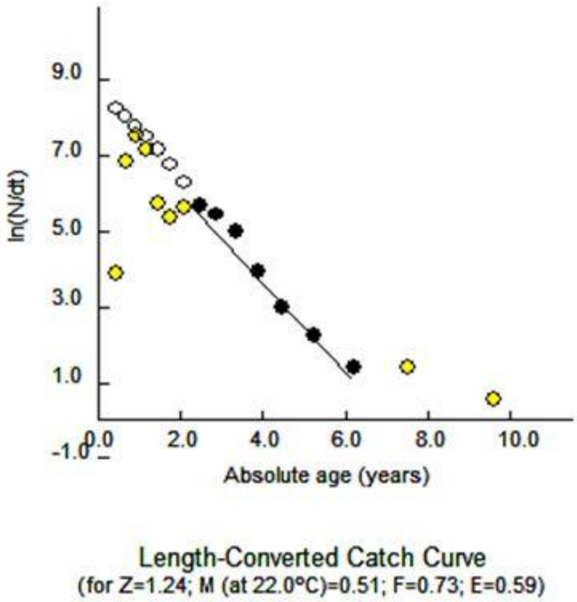


Figure 7: Mortality parameters *viz. M. F, Z* and *E* of *P. canius* applying growth parameter ($L\infty$=93.25cm and *K*=0.28yr^{-1}).

Table 1: Estimated key parameter of growth, mortality, exploitation and yield of *P. canius*, estuarine mangrove areas of Bangladesh during January 2017 to December 2018.

Population parameters	*P. canius* of estuarine rivers mangrove areas
Intercept (*a*)	0.006
Exponent (*b*)	2.951
Coefficient of determination (R^2)	0.972
Asymptotic length ($L\infty$)	93.25cm
Growth coefficient (*K*)	0.28 yr^{-1}
Theoretically age(t) at zero length (t_0)	0.059 year
Goodness of fit (R_n)	0.494
Total mortality (*Z*)	1.24yr^{-1} at $CI_{95\%}$ of 1.05–1.42
Natural mortality (*M*)	0.51yr^{-1}
Fishing mortality (*F*) $F=Z-M=$	0.73yr^{-1}
Exploitation ratio (*E*) $E=F/Z=$	0.59
Mean water temperature of estuarine mangrove areas of Bangladesh	22^0C
GPI Ø′ ($L\infty$)	3.386
GPI Ø ($W\infty$)	1.84
Dominant length range (cm)	17-27cm
Dominant weight range (g)	25.66 to 254.63g
Sample size (n)	1298

The natural mortality (*M*) was 0.51$year^{-1}$. Consequently, fishing mortality (*F*) found out by subtracting of natural mortality from total mortality ($F=Z-M$) as F=0.71$year^{-1}$ and the ratio of exploitation (*E*) was obtained ($E= F/Z$) as E=0.59. The recruitment pattern (Fig. 8) shows solo annual peak recruitment per year through input values of VBGF growth parameters.

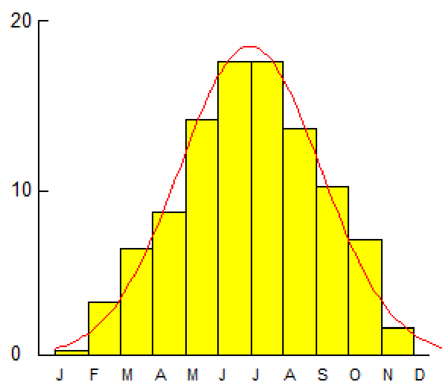


Figure 8: Recruitment pattern of *P. canius* in estuarine mangrove areas of Bangladesh.

The highest peak (June-July) was 17.20-17.96%, probably due to the recruitment of migrant breeding stock. Probability of capture was estimated from the type of net (commercial barrier trap nets) used for fishing. It was estimated that the length of the first capture (L_c) was 29.95cm.

The length at recruitment (L_r) for *P. canius* was found to be 7.8 cm. Logistic regression of the probability of capture for sequential length classes obtained from length converted catch curve analysis revealed that 50% of the *P. canius* become vulnerable to gear at the total length of 29.95cm (L_{50}) (Fig. 9). The L_{25} and L_{75} were also calculated as 25.19 cm and 34.71cm, respectively.

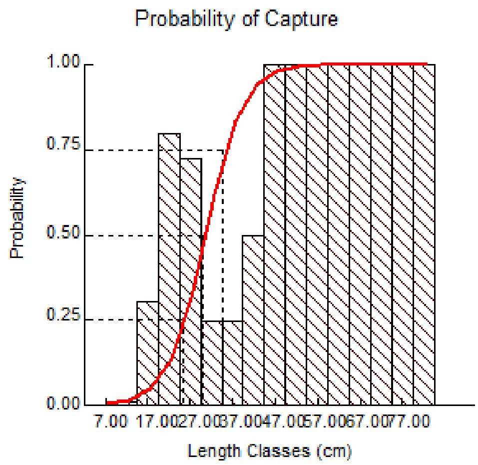


Figure 9: Length at capture *(L_{50})* of *P. canius* in estuarine mangrove areas of Bangladesh.

The von Bertalanffy growth parameters (L_∞ and K), natural mortality (M), terminal F/Z (F_t) assumed to be 0.5 and length-weight relationship parameters (a and b) were used to form the length structured virtual population analysis (LVPA) for P. canius in the estuarine mangrove areas of Bangladesh. Cohort analysis to output graphics for LVPA was done by FiSAT-II (Fig. 10). The length of the higher fishing mortality was observed in 22 to 27cm range.

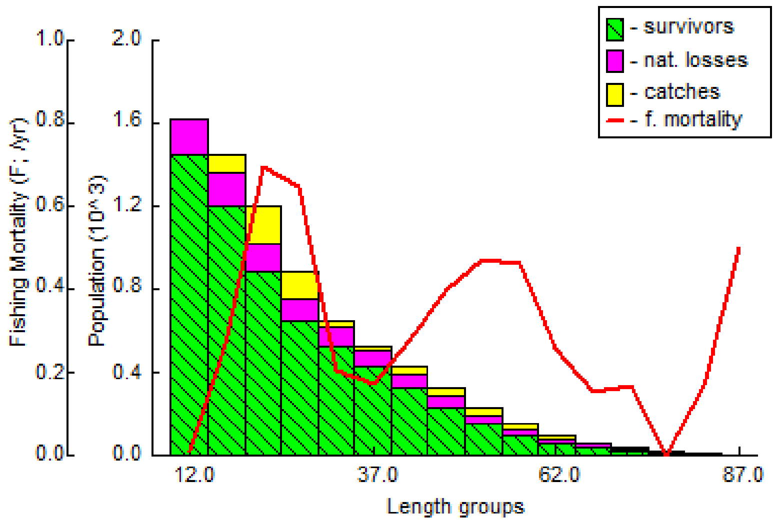


Figure 10: Length-Structured Virtual Population Analysis (LVPA) of *P. Canius.*

Bio-economic analysis was predicted by Thompson and Bell prediction model (1934). In the present fishing situation, the Stock biomass, Maximum Sustainable Yield (MSY) and value of *P. canius* were 395.40 tons, 154.81tons and Bangladeshi Taka (BDT) 5.30 crores, respectively (Fig. 11).

However, the mean biomass would be drastically decreased from 1104.37 tons at F-factor 0.25 to 28.97 tons at F-factor 5.25. The predicted Maximum Sustainable Economic Yield, MEY of *P. canius* would be a projected BDT 5.3 crores if the fishing effort remained at F-factor 1. However, *P. canius* was near threatened species in Bangladesh, so fishing effort should be kept in an unchanged state.

Yield per recruitment was estimated by Beverton-Holt yield equation, the response of a population to fishing mortality on a per-recruit basis depends on natural mortality (*M*), fishing mortality (*F*), growth rate (*K*, from the von Bertalanffy growth equation), age at first recruitment (t_r) and the age (t_c) at first capture (depends on gear selectivity). In graphical representation showed that when the age (t_c) at first capture was 1.443 the estimated Maximum Sustainable Yield per recruitment (MSY/R) for the assessed stock was 256.88 grams/recruitment and Maximum sustainable biomass per recruitment (MSB/R) was 428.13 grams/recruitment at F_{msy}=0.6 (Fig. 12).

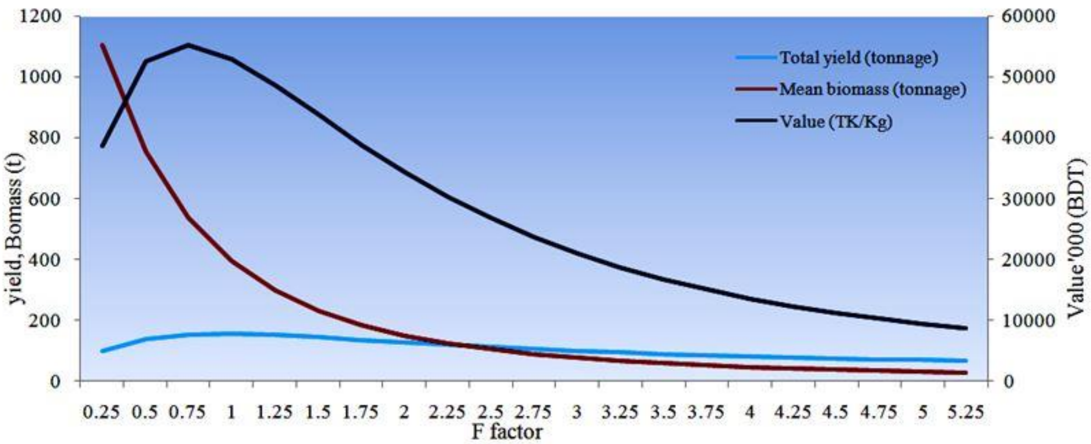


Figure 11: Stock status of *P. canius* using Thompson and Bell analysis.

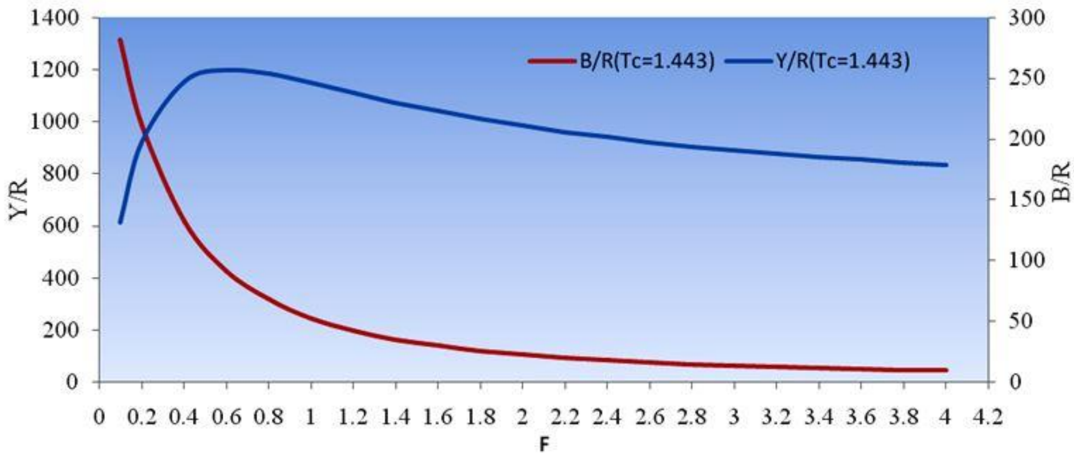
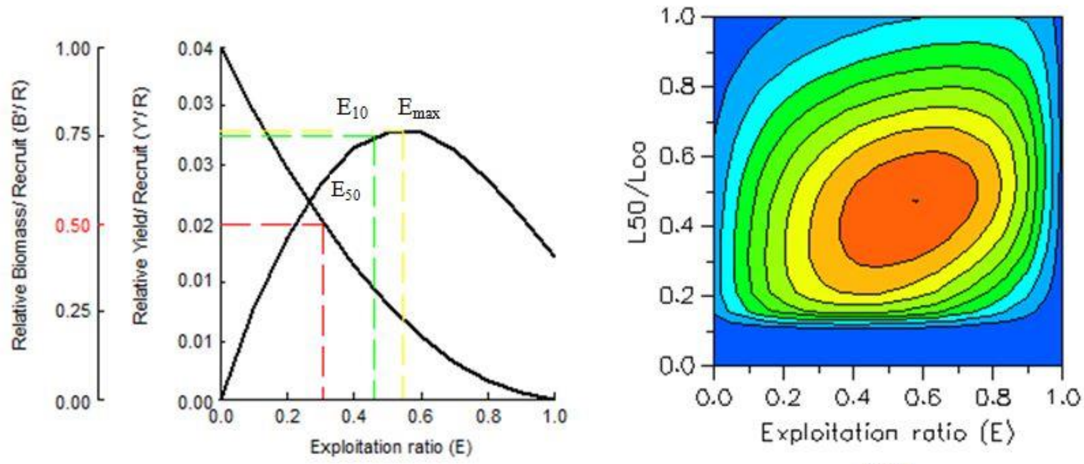


Figure 12: Y/R and B/R of *P. canius* as a function of F at estuarine mangrove areas of Bangladesh.

When age at first capture t_c was assumed at 1.443 year the F_{max} and $F_{0.1}$ were evaluated as 0.6 year^{-1} and 0.33year^{-1} respectively for pooled sexes by yield per recruit analysis. The current fishing mortality was 0.73 year-1, that was beyond to the biological reference points (BRP) and cross the F_{max} and $F_{0.1}$ specified that the stock of *P. canius* is overexploited in the mangrove estuary.

The relative Y/R and B/R analysis of *P. canius* were estimated using knife-edge procedure of FiSAT II (Fig. 13a]. Isopleths deliberate by selection ogive shows the optimum fishing activity

(Fig. 13b). L_{50}/L_∞ of 0.321 and M/K of 1.821 were used as the input parameter for the analysis.



13(a) 13(b)

Figure 13: (a) Stock status of *P. canius* using Beverton and Holt's relative Y/R analysis using knife edge; 13(b) Isopleths estimated by selection ogive, showing optimum fishing activity both in terms of fishing effort and size of first capture (depicted with a star in the central curve) for *P. Canius.*

The relative Y/R and B/R analysis of *P. canius* were estimated using knife edge selection and

The assessment revealed that, the maximum exploitation rate (E_{max}) was 0.544. $E_{0.1}$ was estimated to be 0.46. The exploitation level, which will be resulted in the reduction of B/R to 50% compared to virgin biomass ($E_{0.5}$), was 0.31 (Fig.13a). The present exploitation rate, E=0.59 was above the E-max (0.54) which indicated the fish was over exploited in the mangrove estuary as Gulland (1971) stated that E value above 0.5 indicates over fishing of a species in an area.

Discussion

The present study represents the first attempt to analyze the population dynamic parameters of *P. canius*, near threatened catfish species at estuarine mangrove areas in Bangladesh. Gayanilo and Pauly (1997) believed length frequency distribution analysis could be used for the resource evaluation and management of the fish population.

The coefficient of determination (R^2) of *P. canius* was 0.972 for LWR that showed a close relationship between length and weight. Khan *et al*. (2002) discovered the coefficient of determination (R^2) was 0.80 in Paikgacha, Khulna. Amornsakun *et al*. (2018) found the coefficient of determination (R^2) was 0.82 in Pattani Bay, Thailand. Usman *et al*. (2016) established the coefficient of determination (R^2) value as 0.95 in Port Dickson, Peninsular Malaysia. Absar (1997) revealed the coefficient of determination (R^2) for pool sexes was 0.949 in Chittagong, Bangladesh.

Present study showed highest correlation from previous findings. Usman *et al*. (2016) described the "*b*" value for combined sex of *P. canius* 2.71 that showed negative allometric growth, present study concordant with these findings. Gomon (1983) found "b" value 2.75 for male and 2.83 for female based on LWR of this species. Absar (1997) found out the regression coefficient "b" value for males and females of *P. canius* were 3.10 and 3.11 respectively justified isometric growth. As recommended by Petrakis and Stergiou (1995) the use of these LWR should be strictly restricted to the observed length ranges used in the estimation of the linear regression. Present study revealed the asymptotic length (L_∞), growth rate (*K*), and age at zero length (t_0) of *P. canius* for pool sexes were 93.25 cm, 0.28 year$^{-1,}$ and 0.059 year respectively. Usman and Amin (2014) revealed that asymptotic length ($L\infty$) and growth coefficient (*K*) were 67.20 cm and 0.95yr^{-1} respectively in the port Dickson, Malaysia. Usman *et al*. (2019) reported that, the sexual maturity of male was between 44-48 cm and 40-44 cm total length for female in the coastal waters of port Dickson, Malaysia.

There is no previous record on the VBGF parameters of *P. canius* of the Bay of Bengal, mangrove estuary, Bangladesh and the other adjacent coasts. Vijaykumaran (1997) reckon asymptotic length (L_∞), growth rate (*K*), and t_0 for *Plotosus lineatus* as 243.73mm, 1.369 year$^{-1,}$ and 0.0085 year respectively. Beverton and Holt (1957) suggested that the coefficient of natural mortality (*M*) is proportional to the growth coefficient *K* of a fish and inversely proportional to the length of the asymptotic L_∞ and longevity. The present study found total mortality; natural mortality and fishing mortality of *P. canius* were 1.24 year^{-1}, 0.51year^{-1} and 0.73year^{-1} respectively. Usman and Amin (2014) found out total mortality (Z), natural mortality (M) and fishing mortality (F) of *P. canius* were 2.73yr-1, 1.43yr-1, and 1.31yr-1 respectively. Current study concludes that natural mortality rate was less than fishing mortality in mangrove estuary of Bangladesh. Natural mortality rate mostly depends on some factors, i.e. predation, old age, environmental stress, and parasitic affects or disease (Gatabu, 1992).

Karim *et al*. (2017) described that the comparison of the growth rates is a matter of multiple factors of the growth rate (*K*) and the asymptotic length ($L\infty$). As the growth performance index (*Ø'*) response to von Bertalanffy growth parameters criteria, it is easy to express the slight difference when compared to other alternatives indicators (Etim *et al*., 1999; Hilborn and Walters, 1992). Usman and Amin (2014) found the growth performance index, GPI (*Ø'*) as 3.63 in the coastal waters of port Dickson, Malaysia. Present study found the value of GPI for combine sex was 3.386 considered slow growth. Pauly and Munro (1984) stated that parameter Phi prime (*Ø'*) as an indicator of the inconsistency on the accuracy of the estimated growth parameters of the same or related species of stocks. GPI compares the growth performance of the fish species with different populations of the same or different environmental fish populations and higher values indicate higher growth. This index is also endorsed by the von Bertalanffy growth parameters ($L\infty$ and K) because it facilitates the program between the species and growth (Devadoss, 1989). Apart from the genetic structure, determining the growth potential of a species, overfishing, dietary patterns, and their utilization may affect in terms of growth performance of a specific species (Mommsen, 1968). Present study described the Thompson and Bell prediction model that provides the current fishing level. If the fishing effort was increasing and crossed the maximum limit, the yield and biomass were drastically reduced (Sawusdee and Songrak, 2009). Moreover, the study revealed that present MSY and MEY of *P. canius* were higher than the MSY and MEY generated from the information collected from the fishers directly because the length-based Thompson and Bell Analysis proceeds successively from the youngest to the oldest age classes and number of recruits.

Biological reference points are usually a combination of several elements such as the stock dynamic, growth, recruitment, and mortality. They can give a key philosophy about the status of the fish stock due to meaningful and significant character (King, 1997). Exploitation ratio is one of basic elements to justify the level of utilization of the fishery. The optimum value of utilization is that the fishing mortality rate is equivalent to the natural mortality rate (Gulland, 1971a). Usman and Amin (2014**)** revealed the exploitation level (E) of *P. canius* was 0.48. Gullan (1971a) illustrated that, when the exploitation ratio exceeds 0.5 then the stock is considered as overfished or overexploited. Present study calculates the exploitation rate as 0.59, indicated that the *P. canius* stock was overexploited, so that if we will not take any initiatives in near future it might be vulnerable or near extinct. The level of fishing mortality is now widely used for the conservation and management of fisheries resources (Gatabu, 1992). $F_{0.1}$ and F_{max} are most commonly used in fisheries management (King, 1997). The target biological reference point F_{max} is the F, which produces the maximum value of yield per recruit (Y/R). $F_{0.1}$ is another target reference point denoted that, at which the marginal gain in Y/R decreased to an arbitrary 10% from that at F=0 (Zero) (Sparre *et al*., 1989; Haddon, 2011; Hilborn and Walters, 1992). Consequently, Larkin (1977) shared practical experience as fishery management has cast doubts on the usefulness of MSY as a safe TRP (target reference point). However, the analysis does not give any consideration to the biomass; it is advisable to use a considerably safer management reference point (Clark, 1991). Biological reference point (BRP) from the measures F_{opt} by Patterson (1992) which is F_{opt}=0.56. Since the age of the first capture during the current study was approximately 0.6 year, the current fishing mortality rate ($F_{current}$) was 0.73yr^{-1} which beyond to the F_{opt} , F_{max} and $F_{0.1}$, indicating overexploitation. For safer management reference points such as $E_{0.1}$ is the level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of *E* (Purushottama *et al*., 2017). E_{curr} was 0.59 for *P. canius* but $E_{0.1}$ was 0.46, found to be higher than $E_{0.1}$ concluding that current exploitation exceeds the target reference point (TRP). Hence, the fishing pressure on the stock is excessive. More yields could be obtained by a reasonable decrease in the effort without necessarily leading to overexploitation.

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