

Use of Length–Frequency Analysis for Stock Status, Growth and Mortality Estimation of the Striped Eel Catfish *Plotosus lineatus* (Thunberg 1787) from Gulf of Aqaba, Egypt

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ABSTRACT

The present study aimed to determine the age composition, growth parameters, natural and fishing mortality coefficients and level of exploitation of the striped eel catfish (*Plotosus lineatus*) from the Gulf of Aqaba, Egypt. To assess the population status, the length frequency data were analyzed using the FiSAT computer program. The parameters of the von Bertalanffy growth curve were $TL_{\infty} = 31.36, 29.29$ and 32.52 cm for males, females and sexes combined respectively, while the obtained K values were $0.41, 0.50$ and 0.45 y^{-1} for males, females and sexes combined respectively. The instantaneous mortality coefficients of the whole population were estimated as follows: total mortality (Z) = 1.26 y^{-1} ; natural mortality (M) = 0.74 y^{-1} , and fishing mortality (F) = 0.52 . The stock showed a growth performance (ϕ) value of 2.68 . The current exploitation rate of the species was calculated as 0.41 . The analysis of relative yield per recruitment and relative biomass per recruitment showed that the maximum allowable exploitation rate at maximum sustainable yield (MSY) for the striped eel catfish fishery in the Gulf of Aqaba is 1.0 which is more than the currently observed exploitation rate. The results suggest that the striped eel catfish stock in the Gulf of Aqaba is not overfished and is within safe exploitation limits. It is recommended that a regular monitoring program for the stock should be in place, and any proposal for a change in exploitation rate should be assessed according to the stock status at that point of time.

INTRODUCTION

The Gulf of Aqaba (Fig. 1) is among the important fisheries resources in Egypt; however, it is still unexploited. The Gulf ($28^{\circ}45'N$ $34^{\circ}45'E$ / $28.750^{\circ}N$ $34.750^{\circ}E$) is a semi-enclosed, deep, narrow body of water of approximately 180km long, stretching from the Protectorate of Ras Mohammed in the south to Taba in the north (Hamouda & El-Gharabawy, 2019). It has a maximum width of 24km and a depth of $1,850\text{m}$ at its deepest point, with a surface area of 239km^2 . The Gulf houses more than 100 coral species, 800 fish species as well as several species of crustaceans and mollusks. Moreover, many species of marine mammals including dolphins, whales, dugongs and whale sharks are found in the Gulf. The present annual fish yield of the Egyptian coast of

Aqaba Gulf is 46 ton (GAFRD, 2020), which is very low in respect to the fishing area of the Gulf. Commercial fish populations in the Egyptian sector of the Gulf showed a seasonal variation in terms of dominant species and catch composition.



Fig. 1. The Gulf of Aqaba (study area)

Striped eel catfish, *Plotosus lineatus* of the family Plotosidae is one of the target species by small-scale in the Gulf of Aqaba. As an important fishery resource, the fish is traditionally and nationally traded across the Egyptian markets and serves as an important source of protein for many coastal communities. Striped eel catfish contains highly essential amino acid nutrients for human health (Manikandarajan *et al.*, 2014). Among these essentials, monounsaturated fatty acid (MUFA), 1.37%; polyunsaturated fatty acids (PUFAs ω -6), 18.0%; PUFA ω -3, 32.0% (Osman *et al.*, 2001; Sahena *et al.*, 2009); and other PUFAs, 34.0 are considered. These essential amino acids have important roles and usages in pharmaceutical products, food additives, food supplements and antioxidants (Ray *et al.*, 2014). In addition, eel catfish meat contains carbonate 3.26 mg g⁻¹, protein 14.69 mg g⁻¹ and fat 1.48 mg g⁻¹ (Suganthi *et al.*, 2015). In the Egyptian waters, striped eel catfish have been exploited by fishermen for decades without any significant importance for the species. In the recent years, the current high level of exploitation due to the increasing demand has reduced the wild fish populations of the common species. Several fish species began to be common and exploited in acceptable prices from which the striped eel catfish. Such a condition requires proper resource management strategies to ecologically and economically maintain the population of the fish. These efforts need essential information on the dynamic population of the species including its size structure

and growth parameters for effective management of the fish. Currently available literature and research about the striped eel catfish are rare in the Egyptian waters. Thus, this study tried to fill the gap of knowledge by investigating the size structure, growth parameters and mortality and exploitation levels of striped eel catfish in the Gulf of Aqaba for the first time in the area. The obtained results serve as important an baseline information in managing striped eel catfish resources in the Gulf of Aqaba.

MATERIALS AND METHODS

The catch data from landing points along the fishing area from south Taba to Nuwaibaa was monthly recorded from September 2021 to February 2023. Boats were randomly selected at the landing points along the area from Taba to Nweibaa, and all catch of these boats was taken. The selected species was measured for its total length nearest to 0.1cm and weighed nearest to 0.1g. The length measurements were grouped into one cm length classes for the construction of monthly length distribution for the study period. The resulting length frequency distribution was then used to estimate the population parameters, viz. growth, mortality rates and relative yield per recruit. To describe the growth of eel catfish, von Bertalanffy Growth Function (VBGF) was applied to estimate the three parameters; the asymptotic length L_{∞} , the growth coefficient K and the theoretical age at length zero t_0 . These parameters were determined by using FAO FiSAT-II program (**Gayanilo et al., 2005**). The initial value of L_{∞} was estimated by Powell-Wetherall plot, and the age modes were resolved by subjecting the annual length frequency distribution to the analysis of **Bhattacharya (1967)**. Total mortality coefficient (Z) was estimated by Pauly's catch curve (**Pauly, 1983**). The cumulative catch curve was assessed in accordance to **Jones and van Zalinge (1981)**; natural mortality was determined using the formulae of **Alverson and Carney (1975)** and **Lorenzen (1996)**. The growth performance index (ϕ') was calculated using **Pauly and Munero's (1984)** formula ($\phi' = \text{Log}K + 2\text{Log} L_{\infty}$). The length at first capture L_c was estimated using catch curve analysis (**Pauly, 1984**). Relative yield per-recruitment (Y/R) and relative biomass-per recruitment (B/R) values as a function of E (exploitation rate) of the species was estimated using the model of **Beverton and Holt (1966)** as modified by **Pauly and Soriano (1986)** and incorporated into the FAO FiSAT II program (**Gayanilo et al., 2005**).

RESULTS AND DISCUSSION

1. Size structure

The total number of striped eel catfish caught during the study was 1860 individuals consisting of 832 males and 1028 females, with an overall sex ratio of 1.24. The length and weight of males ranges were 20 - 28 cm and 90 - 155 g, respectively. The length and weight of females ranges were 18 - 26 cm and 80 -145 g, respectively. The

fish were grouped into one cm- sized groups (Fig. 2). The group sizes of 22 and 23 cm were the most dominant (65.7%) than the other groups for females, and group sizes of 25 and 26 cm were the most dominant (55.6%) for males. The mean TL of male populations (25.35 ± 1.16 cm) was significantly higher than female population (23.26 ± 1.24 cm) (independent t-test, $P \leq 0.01$), indicating that the stock is composed of larger sized males and dominated females in number. The fish size grouping based on the Bhattacharya method showed that the striped eel catfish population in Aqaba Gulf was divided into three size groups or cohorts for females and four cohorts for males.

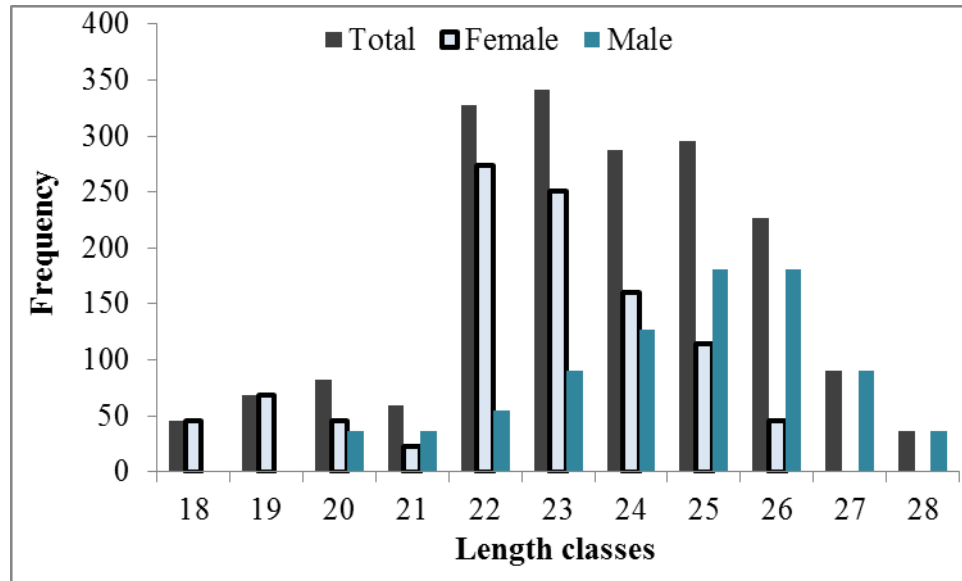


Fig. 2. Length frequency distribution of *Plotosus lineatus* in the Gulf of Aqaba

2. Growth parameters

Wetherall (1986) plot gave TL_{∞} estimates of 31.36, 29.29 and 32.52 cm for males, females and sexes combined, respectively (Fig. 3). These values were then applied to a von Bertalanffy plot to estimate the growth parameter K. The obtained K values were 0.41, 0.50 and 0.45 y^{-1} . ELEFAN I program (Pauly, 1987), giving $TL_{\infty} = 31.05$ cm and $K = 0.44 \text{ y}^{-1}$ for males, $TL_{\infty} = 29.40$ cm and $K = 0.48 \text{ y}^{-1}$ for females and 31.82 cm and $K = 0.40 \text{ y}^{-1}$ for combined sexes (Fig. 4). Males have higher TL_{∞} and slightly lower K value than females since males attained higher maximum observed length than females. The values of estimated growth parameters (K and TL_{∞}) of *P. lineatus* from the Gulf of Aqaba indicate a short longevity and fast growth rate of this species. Lifespan estimated using Bhattacharya method was four and three years for males and females, respectively. The growth parameters of the sexes combined ($K = 0.45 \text{ y}^{-1}$, and $L_{\infty} = 32.52$ cm) were used for further analysis.

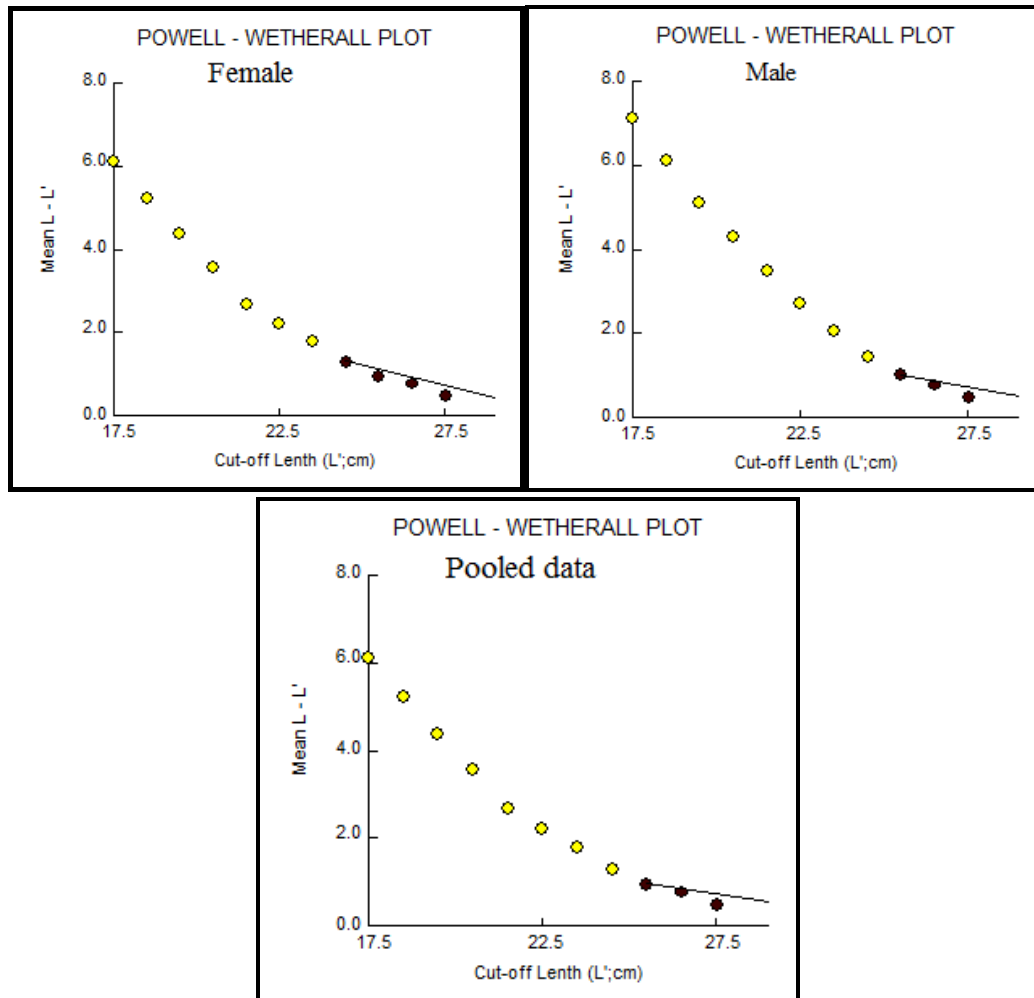


Fig. 3. Powell-Wetherall plot for estimation L_{∞} and Z/K of *Plotosus lineatus* from Gulf of Aqaba

3. Mortality and exploitation rates

The mean value of the total mortality coefficient (Z) estimated from the two different methods was 1.15, 1.61 and 1.26 y^{-1} for males, females and sexes combined, respectively. While, the geometric mean of natural mortality coefficient (M) for males, females and sexes combined was 0.61, 0.87 and 0.74 y^{-1} , respectively, and the respective values of fishing mortality coefficient (F) were 0.54, 0.74 and 0.52 y^{-1} . Accordingly, the exploitation rate (E) was computed as 0.47, 0.46 and 0.41 for males, females and sexes combined, respectively. The M was found to be higher in females compared to males; whereas, the current values of Z and F were lower in males compared to females. The F (0.54 y^{-1} for males and 0.74 y^{-1} for females) observed in the present study, was lower than M (0.61 y^{-1} for males and 0.87 y^{-1} for females) as a result of which E_{cur} (0.47 and 0.46 for males and females respectively) was found to be lower than the optimum exploitation rate (0.5), as reported in the study of **Gulland (1971)**. Thus, the current values of exploitation rate and fishing

mortality revealed that the striped eel catfish fishery in the Gulf of Aqaba is in a healthy condition. This is logic due to the fact that the Gulf of Aqaba in Egypt hasn't been rationally exploited and needs a proper management plan for its sustainability.

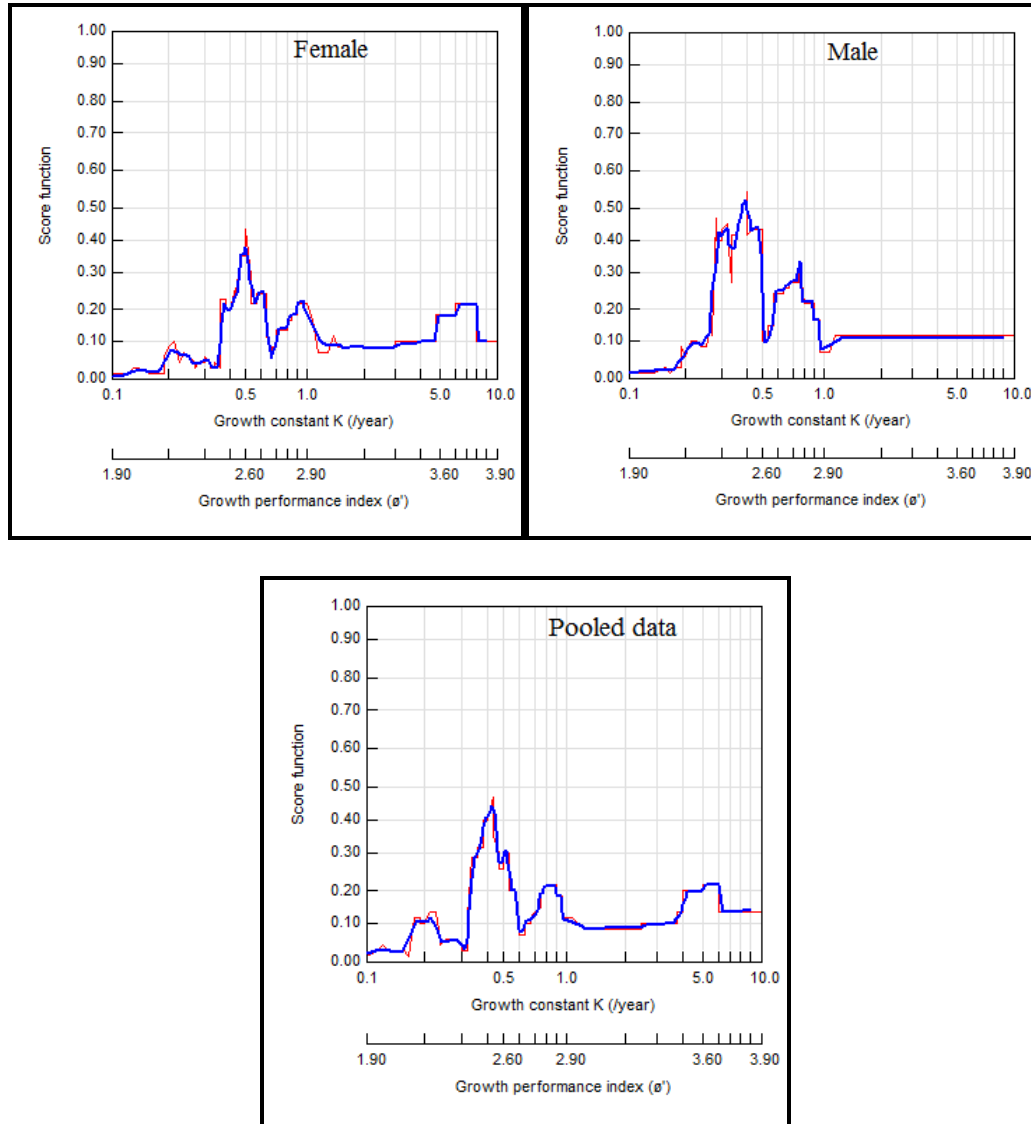


Fig. 4. ELEFAN I for K-scan of *Plotosus lineatus*

In the present study, the high values of M were correlated with the high K values of *P. lineatus*. **Beverton and Holt (1957,1959)** found that, the fast growing fish species of high K - values have high values of natural mortality. The M/K ratio for males, females and sexes combined of *P. lineatus* from the Gulf of Aqaba were in the range of 1.5 - 2.5 reported in the study of **Beverton and Holt (1959)**. Mortality coefficients and current exploitation rate for pooled data will

be considered in the yield per recruit analysis.

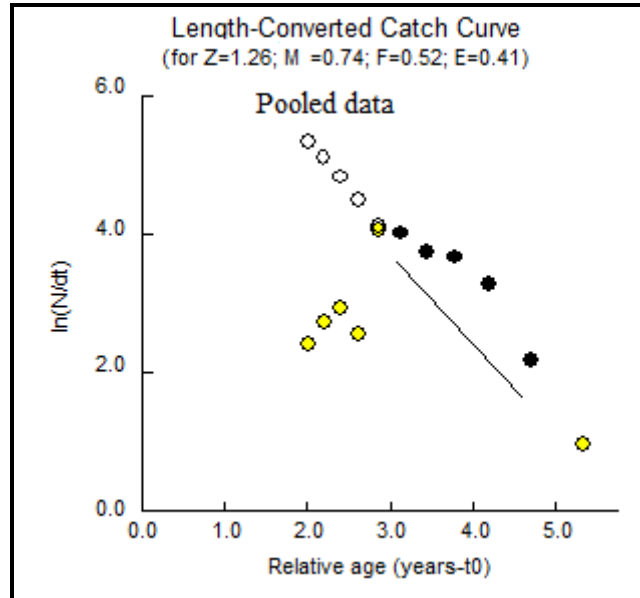


Fig. 5. Mortality and exploitation rates for pooled data of *Plotosus lineatus*

4. Length at first capture (L_c)

The total length at first capture (the length at which 50% of the fish are vulnerable to capture) was estimated as a component of the length converted catch curve analysis. The values of TL_c obtained were 22.33, 20.56 and 20.95 cm for males, females and sexes combined, respectively. The estimated L_c for *Plotosus lineatus* in the Gulf of Aqaba is relatively high, indicating an under-exploitation situation.

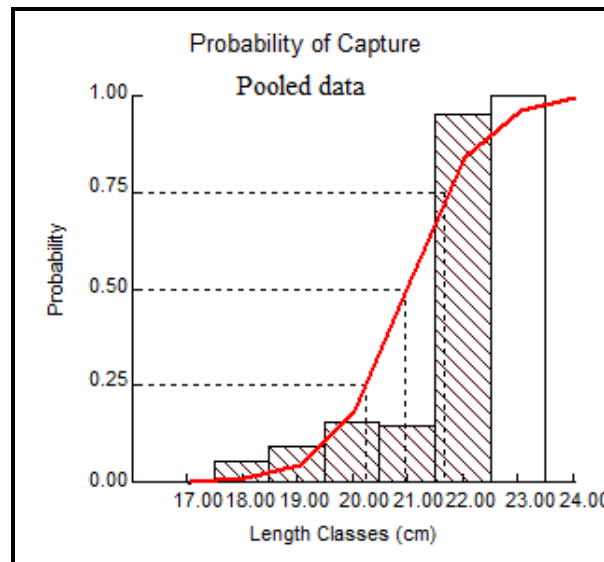


Fig. 6. L_c estimation for pooled data of *Plotosus lineatus*

5. Relative yield per recruit analysis

Based on the obtained results (Fig. 7), a higher catch of eel catfish could be achieved with the increase of fishing effort along the Egyptian coast of the Gulf of Aqaba. The analysis showed that maximum relative Y/R could be obtained at E_{\max} of one suggesting scope for the increase in exploitation rate (Fig. 7). However, the results should be carefully evaluated since the analysis does not consider the spawning stock biomass, which is essential for maintaining the recruitment in the future. Moreover, under the present conditions of the Gulf, such an increase in fishing effort may not adversely affect the stock of striped eel catfish but will affect the other commercial stocks of finfish in the Gulf. As a result, it could be said that, presently, the stock of striped eel catfish is underexploited and one possible management policy towards obtaining better catches might be to suggest a specific fishing method for it with suitable mesh sizes to conserve the young stages.

$E_{0.5}$ represents exploitation rate at which B/R reduces by 50% compared to virgin stock, i.e. to the level which theoretically maximizes surplus production (Pauly, 1984) and can be used as a proxy for the optimum sustainable yield (OSY) (Dadzie *et al.*, 2005). In the present study, the optimum biomass of *P. lineatus* can be maintained at $E_{0.5}$ of 0.41, which is equal to the current E.

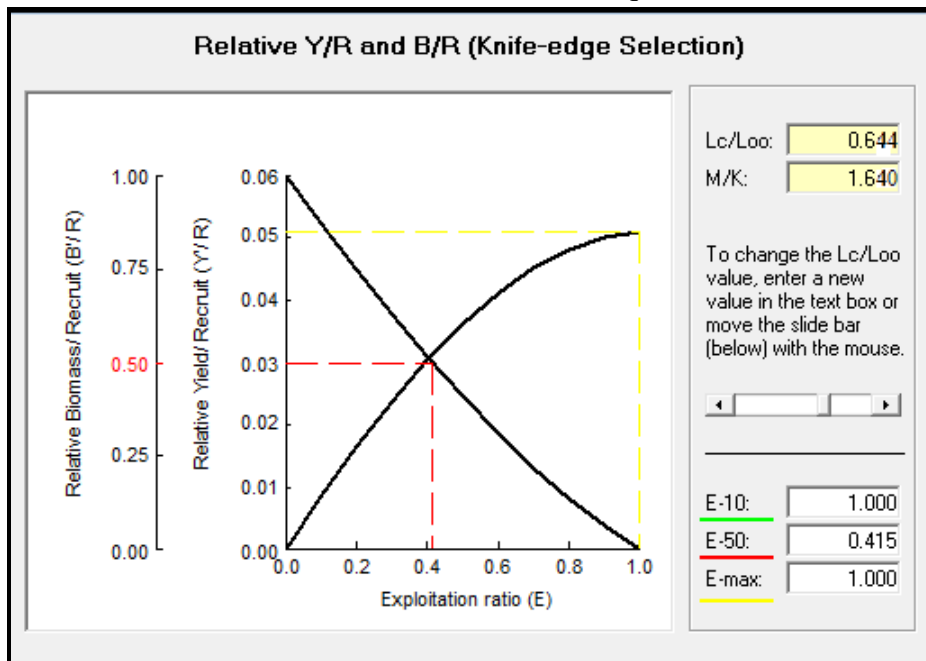


Fig. 7. Relative yield per recruit analysis of *Plotosus lineatus* in the Gulf of Aqaba

CONCLUSION

In conclusion, the results of this study showed that striped eel catfish fishery in the Gulf of Aqaba is exploited under its optimum level, and there is a scope for a considerable extension of the fishery. But any recommendation to increase the effort in a multi-species fishery should consider all the components of that fishery. Additionally, before any advice to increase the fishing effort, more precise assessment would be required, and a sampling programme for the commercial landings should be established to provide total catches by size groups. Furthermore, an investigation on the impact of the fishery independent factors such as predation and other changes in environmental parameters on the growth and recruitment should be conducted. Finally, improving the catch statistics recording system to cover all species caught from the Gulf should be considered. The unreported and unregulated harvest of all species exploited in the Gulf should also be monitored and controlled. Further research is recommended to develop the fishing fleet and fishing techniques to achieve the rational exploitation of this important area.

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