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ORIGINAL PAPER

Population dynamics of *Trichiurus lepturus* (Linnaeus 1758) from the coast of Ghana

Dynamique des populations de *Trichiurus lepturus* (Linnaeus, 1758) dees côtes du Ghana

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Abstract One of commercially significant marine fish species in Ghana, Ribbonfish (*Trichiurus lepturus*) is currently exhibiting a population decline due to overexploitation. Samples of the assessed fish species was obtained from four fishing communities along the coast of Ghana. The total length of 626 individuals of the species was recorded and analyzed for growth, mortality and exploitation rates using FAO ICLARM statistical Tool II (FISAT II). From the FISAT II, growth equation was **Lt = 77.7 (1 – exp 0.67 (t + 0.18))**, with a growth rate and asymptotic length of 0.67 per year and 77.7 cm respectively. Size at first capture (Lc) and maturity (Lm) was 26.8 cm TL and 41.6 cm respectively, suggesting the possible existence of recruitment overfishing. The total mortality rate (Z), natural mortality rate (M), and fishing mortality rate (F) were 2.69, 1.07, and 1.62 per year respectively. The exploitation rate was estimated to be 0.60, exceeding the optimum level 0.5. This implied that individuals of the sampled fish species resident in the coastal waters of Ghana are experiencing overexploitation. The exploitation rate at maximum sustainable yield (E_{max}) was slightly lower than the current exploitation rate, which suggests possible collapse of the fishery, especially in the absence of proper management measures. Based on the outcome of the study, it is recommended that species specific measures be instituted including minimum landing size, reduction in fishing efforts among others.

Key words : Growth parameters, Mortality parameters, Length at capture, Length at maturity Ghana.

Résumé L'une des espèces de poissons marins d'importance commerciale au Ghana, le poisson-ruban (*Trichiurus lepturus*) présente actuellement un déclin de population en raison de la surexploitation. Des échantillons de l'espèce de poisson évaluée ont été obtenus auprès de quatre communautés de pêcheurs le long de la côte du Ghana. La longueur totale de 626 individus de l'espèce a été enregistrée et analysée pour la croissance, la mortalité et les taux d'exploitation à l'aide de l'outil statistique FAO ICLARM II (FISAT II). D'après le FISAT II, l'équation de croissance était **Lt = 77,7 (1 - exp 0,67 (t + 0,18))** avec un taux de croissance et une longueur asymptotique de 0,67 par an et 77,7 cm respectivement. La taille à la première capture (Lc) et à la maturité (Lm) était de 26,8 cm LT et 41,6 cm respectivement, suggérant l'existence possible d'une surpêche du recrutement. Le taux de mortalité totale (Z), le taux de mortalité naturelle (M) et le taux de mortalité par pêche (F) étaient respectivement de 2,69, 1,07 et 1,62 par an. Le taux d'exploitation a été estimé à 0,60, dépassant le niveau optimal de 0,5. Cela implique que les individus des espèces de poissons échantillonnées résidant dans les eaux côtières du Ghana sont surexploités. Le taux d'exploitation au rendement maximal durable (E_{max}) était légèrement inférieur au taux d'exploitation actuel, ce qui suggère un possible effondrement de la pêcherie, notamment en l'absence de mesures de gestion appropriées. Sur la base des résultats de l'étude, il est recommandé de mettre en place des mesures spécifiques aux espèces, notamment une taille minimale de débarquement et une réduction de l'effort de pêche.

Mots clés : Paramètres de croissance, Paramètres de mortalité, Longueur à la capture, Longueur à maturité, Ghana.

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Introduction

According to Amador & Aggrey-Fynn (2020), ribbonfishes (*Trichiurus lepturus*) are members of the Trichiuridae family. The cosmopolitan ribbonfish is typically found in shelf waters that are warm or warm-temperate (Martins & Haimovici, 2000). Although *T. lepturus* has been described as a global species, it is currently only certain to exist in the West Atlantic and Indo-West Pacific (Collette *et al.,* 2015). Depending on its life cycle stages and dietary requirements, species move between estuary and marine habitats. They are found in shallow and inshore seas as well as offshore areas down to around 350 meters. In tropical to temperate waters, they are mainly found in dense schools along continental coasts (Al-Nahdi *et al.,* 2009).

In Ghana, individuals of this species are captured using beach seines and bottom trawls (Kwei and Ofori-Adu, 2005). *T. lepturus* is a valuable pelagic fish that contributes significantly to food and nutritional security by supporting fishermen's livelihoods and being a part of Ghana's marine resources (Amador & Aggrey-Fynn, 2020). In Ghana, *T. lepturus* is generally smoked for consumption and its tasty flesh makes it highly patronized by direct and indirect consumers in Ghanaian fishing communities (Kwei & Ofori-Adu, 2005). Despite the economic and nutrition importance of this commercially important fish species, the current capture production (i.e., 3082 metric tons in 2023) is less than half of the production in 2015 (i.e., 7905 metric tons) as shown in Figure 1. The decline in production coupled with existing overexploitation of marine fishes in Ghana may result in collapse of this important marine fish. This may result in severe ramifications on dependent households in Ghana including nutrition and economic resilience, hence the need for proper management to ensure its sustainability.

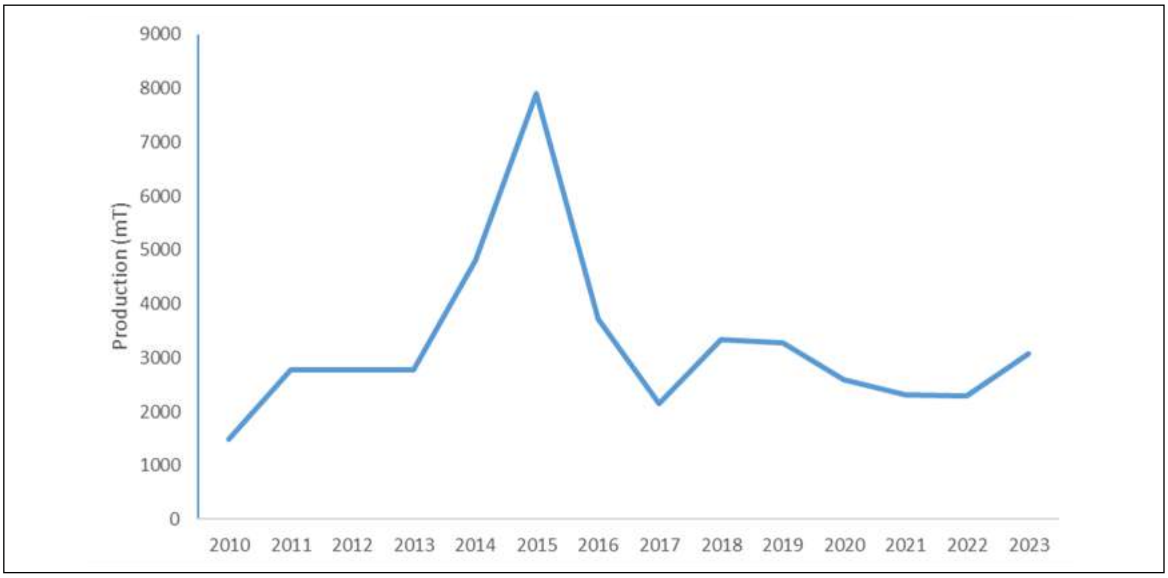

Figure 1: Production trend of *Trichiurus lepturus* from 2010 to 2023 from the coast of Ghana (FAO 2025)

Owing to the substantial contribution to fisheries, several studies have been done in other locations for sustainable management of the sampled fish species. These studies include Abdussamad *et al.*, (2006); Ghosh *et al.,* (2009); Avinashi *et al.,* (2014); Rajesh *et al.,* (2015); Cheng *et al.*, (2013); reproductive studies in India; Ghosh *et al.,* 2014; and in the Philippines (Guillena, 2018); ecological aspects in Mexico (Cruz-Torres *et al.,* 2014) and morphometric variation in Kenyan waters (Mwakiti *et al.*, 2016); age structure in China (Sun *et al.,* 2015). However, in Ghana only one study on the species and feeding habits (Udo et al., 2014) has been conducted (Amador & Aggrey-Fynn, 2020). Their study revealed that individuals of this species from the coast of Ghana are currently prone to overfishing. However, paucity of scientific information on this commercially important species limits the efficiency of any management measures geared towards its sustainable management. Therefore, the study aimed to evaluate the growth, mortality, and exploitation rate of the *Trichiurus lepturus* in Ghanaian coastal waters. Scientific information from the study will supplement limited scientific information essential for improving our understanding of and ability to manage this commercially important fishery resource.

Materials and Methods

Study area

Four coastal communities along the coast of Ghana were the study sites. The selection of these sites was based on their level of fishing activity and geographical location. These sampling locations were Sekondi (4°55'45.74"N, 1°43'22.75"W), Sakumono (5°36'40.50"N, 0° 2'41.13" W), Keta (5°53'34.41"N, 0°59'36.22"E) and Apam (5°16'59.24"N, 0°44'9.96"W) as shown in Figure 2. The most engaged sources of income for people in the selected study sites were fishing and farming.

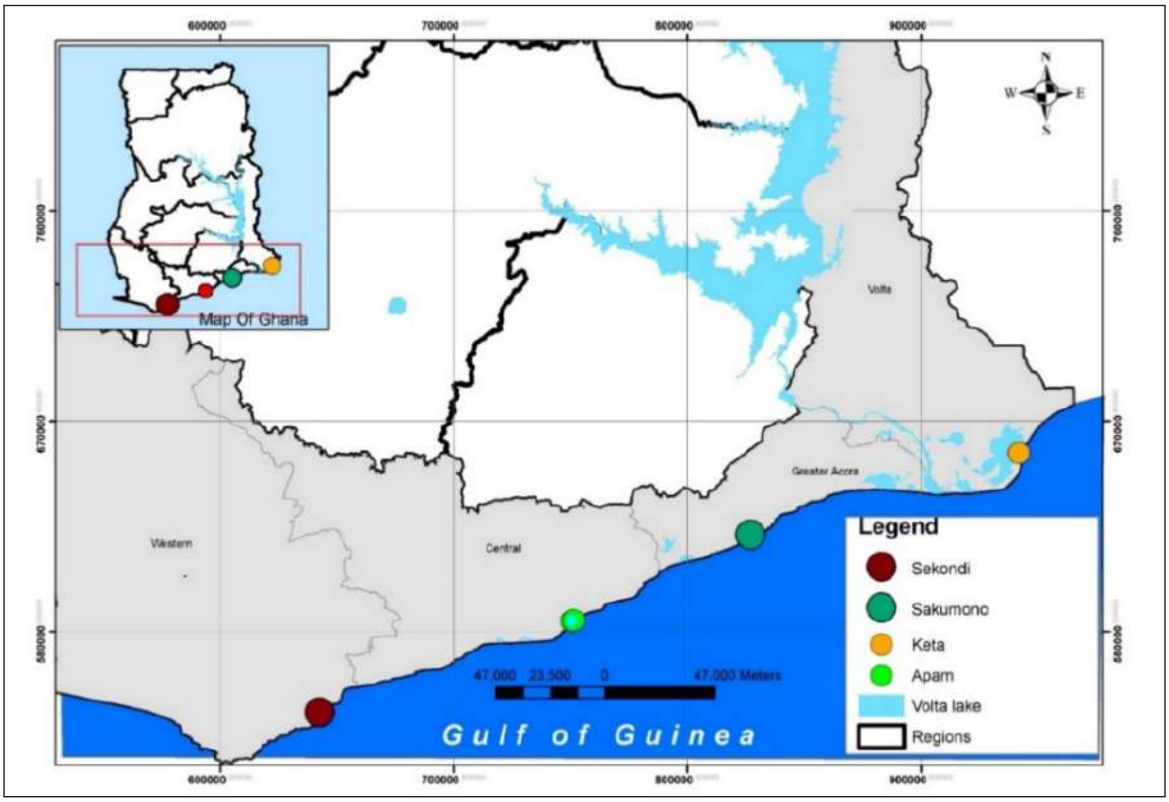

Figure 2 : Map showing the sampling locations for the study

Data collection

A total of 626 samples of *T. lepturus* from the coast of Ghana were obtained monthly from commercial fishermen between January and December 2021. Samples obtained were identified using Kwei & Ofori-Adu (2005) identification keys and transported on ice to the Department of Marine and Fisheries Science laboratory, University of Ghana for further analysis. At the laboratory, samples obtained were measured to the nearest centimeter for total length (TL) using a 100 cm graduated wooden measuring board and weighed to the nearest gram using an electronic balance.

Growth parameters

The Electronic Length Frequency Analysis (ELEFAN) option of FiSAT II Tool was used to determine the growth parameters (Pauly, 1980):

$TL_t = TL_\infty (1 - e^{-K(t - t_o)})$,

where L_t is the total length, is the asymptotic length, K is the growth rate and is the age at zero length.

Longevity (T_{max}) of the species was determined following the equation:

$T_{max} = 3/K$ (Pauly, 1983).

The growth performance index was estimated as:

$2\log L\infty + \log K$ (Munro & Pauly, 1984).

The theoretical age at length zero (t_0) followed the equation:

$\text{Log}_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$ (Pauly, 1979).

Length at first capture

The downward side of length converted catch curve was applied in calculating the length at first capture (Lc_{50}). In addition, the lengths at both 25 and 75 percent capture which corresponds to 25% and 75% respectively were estimated (Pauly, 1984).

Length at first maturity

The length at first maturity (Lm_{50}) was estimated as Log Lm_{50} = 0.8979*Log_{10}(L∞) - 0.0782 (Froese & Binohlan, 2000).

Mortality parameters

The total mortality rate (Z) was estimated from the descending arm of the length converted catch curve (LCC). Natural mortality rate (M) at a temperature of 28.9 °C was computed using a multiple regression formula sourced from Pauly (1980): ln M = – 0.0152 - 0.279 * ln L∞ + 0.6543 * ln k + 0.463 * ln T, where M = natural mortality; T = annual mean temperature (in °C) of the seawater.

The fishing mortality rate (F) followed the formula: F= Z–M (Pauly, 1983). The exploitation rate (E) was determined as E= F/Z. (Pauly, 1983).

Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)'

The data of Lc/Linf and M/K values were used to estimate both exploitation at E_{max}, $E_{0.1}$, and $E_{0.5}$.

Data analysis

Length measurement data was pooled together at 5 cm interval and analyzed for population parameters including growth, mortality and exploitation rates using FISAT II software (Gayanilo *et al.*, 1996). Charts and tables were generated for easy understanding of output from software used.

Results

Length distribution

From 626 individuals of *T. lepturus* obtained during the study, the mean length was 37.6 ± 8.13 cm (Figure 3. The length obtained ranged between 14.8 cm to 69.1 cm with the modal mid-length as 42 cm (Figure 3).

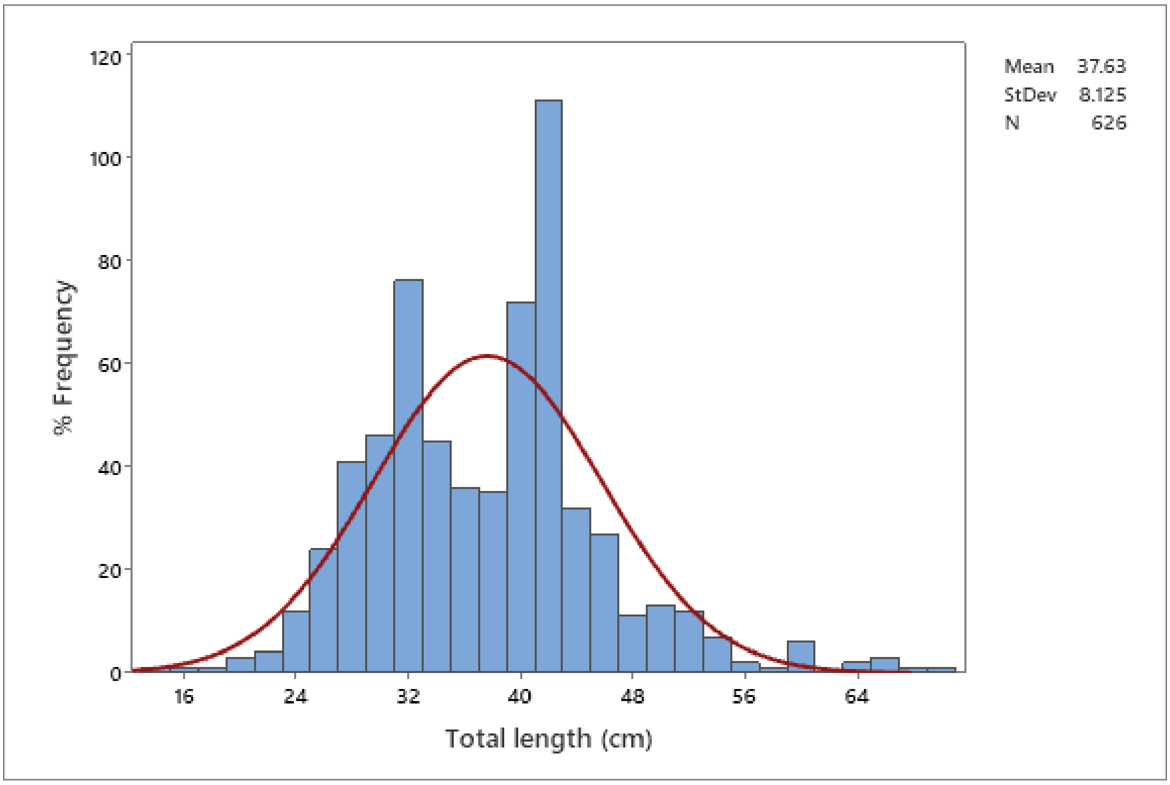

Figure 3 : Length distribution of *Trichiurus lepturus* from the coast of Ghana

Growth parameters

The asymptotic length and growth rate of *Trichiurus lepturus* was 77.7 cm, K = 0.67 $year^{-1}$ respectively (Figure. 4). The age at length zero and growth performance index were -0.18 year and Ø' was 3.607 respectively with a goodness of fit as 0.35.

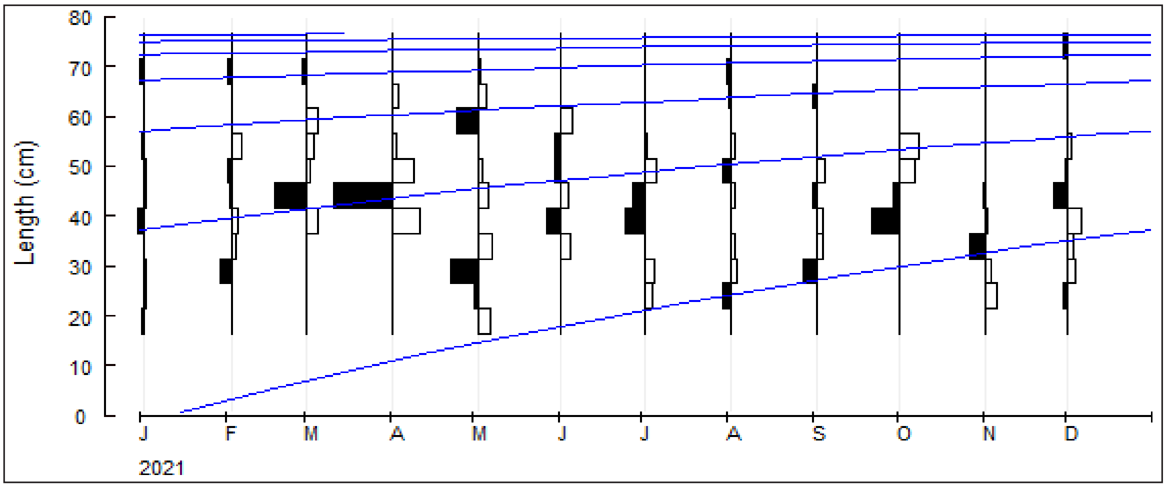

Figure 4 Length based distribution with growth curves of *Trichiurus lepturus*

Mortality parameters

The total mortality rate (Z) for *T. lepturus* was Z = 2.69 $year^{-1}$ (Figure 5). The natural mortality (M) and fishing mortality, rates were 1.07 $year^{-1}$ and 1.62 $year^{-1}$ respectively. The exploitation rate was 0.60.

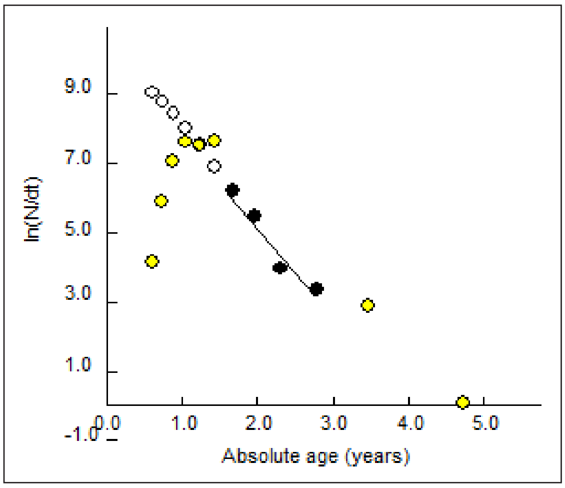

Figure 5 Length Converted Catch curve (LCC) of *Trichiurus lepturus*

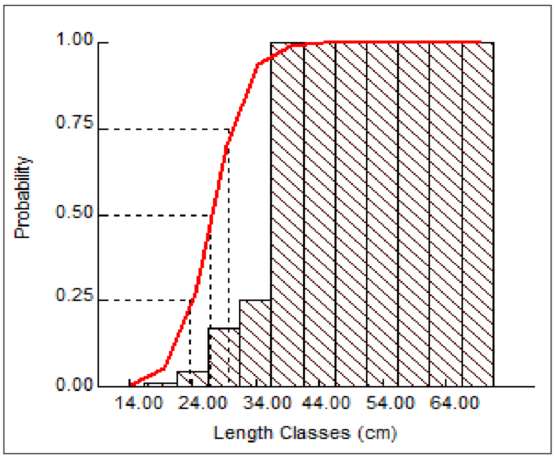

Figure 6 Length at capture of *Trichiurus lepturus*

Length of capture

The lengths at capture were 23.7 cm, 26.7 cm and 29.7 cm at 25%, 50% and 75%, respectively (Figure 6). The length at first capture was 26.7 cm. The size at first maturity was 41.6 cm.

Yield per recruit analysis

The exploitation rate at 10%, 50 %, and the maximum level was 0.456, 0.313 and 0.544, respectively (Figure 7).

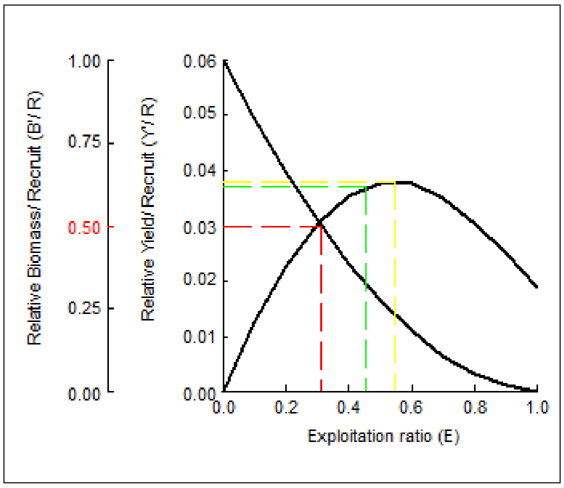

Figure 7 : Yield per recruit analysis of *Trichiurus lepturus* in the present study

Discussion

Growth parameters are important in determining the population parameters of fish (Shojaei *et al.*, 2007). The recorded asymptotic length documented in the present study was lower than that documented by other researchers including Amador & Aggrey-Fynn (2020) and Ghosh *et al.* (2024) who reported 133.7 cm and 143.8 cm from the coast of Ghana and Nigeria, respectively.

In contrast, growth rate from the study was higher than that recorded by these scholars from various geographical locations. Amador & Aggrey-Fynn (2020) and Ghosh *et al.* (2009) recorded 0.46 per year and 0.48 per year respectively. The variation in growth rate and asymptotic lengths in relation to other studies may be due to drivers such as method of computation, length classes of individuals obtained and sampling approach used (Neves *et al.*, 2022). In addition, relatively changes in asymptotic length distribution potentially indicates presence of small-sized individuals of sampled species from the coastal waters of Ghana (Zan-Bi *et al.*, 2022).

Growth performance index recorded from the present study was lower than values provided by Amador & Aggrey-Fynn (2020) and Taghavi Motlagh *et al.* (2021) who documented 3.92 and 4.18 from the Persian Gulf and Oman Sea. Comparatively, variation in values of growth performance index may be aligned with factors such as changes in environmental conditions, availability of prey, and pressure from human activities (Hakimelahi *et al.*, 2010; Khadem *et al.*, 2020). According to Sparre & Venema (1998) and King (2013), environmental parameters, including temperature, have influence on species population parameters.

Following results from the study, the size at capture (Lc_{50}) was less than that recorded by Amador & Aggrey-Fynn (2020) and Taghavi Motlagh *et al.* (2021) who reported 47.1 cm and 70.9 cm respectively. This suggests that individuals of *T. lepturus* from the coast of Ghana are largely small-sized individuals, which potentially reflects existence of high fishing pressure on the stock. According to Pauly & Soriano (1986), small-sized individuals are present when the critical length at capture (Lc) is less than 0.5.

Similarly, the length at maturity (i.e., 70.5 cm and 75.4 cm) recorded by Amador & Aggrey-Fynn (2020) and Ghosh *et al.* (2024) was greater than that obtained from the current study. The reduced length at maturity could be due to the sizes utilized in the present estimation. In contrast to results from other regions, environmental variation might be a contributing factor. Length at first maturity from the study was comparably lower than length at capture, which was favourable with estimates by Amador & Aggrey-Fynn (2020). This biological condition facilitated by high fishing pressure and other unconducive environmental factors may suggest that individuals of sampled species from the coast of Ghana become prone to the fishing gears before maturing. Consequently, this may lead to distortion in ensuring constant recruitment into the stock, with potential collapse if proper management are not implemented (Ben-Hasan *et al.*, 2021).

Fishing mortality rate from the study was less than estimates by Amador & Aggrey-Fynn (2020) and Ojelade *et al.* (2019) whose studies reported fishing mortality rate of 2.03 per year and 2.80 per year from the coast of Ghana and Nigeria, respectively. Difference in computational methods, size obtained and environmental temperature may be factors influencing the variation in fishing mortality rates (Huynh *et al.*, 2018). In addition, the fishing mortality rate reported in the current study was greater than the natural mortality rate, a similar situation has been reported by other scholars including Prihatiningsih *et al.* (2025) from the coast of Indonesia. The high fishing pressure on the species may attest to the key role fishing activities plays role in supporting dependent nutritional and economic needs of dependent households. The reported high fishing mortality could have also translated into high exploitation rate observed in the current study.

Similarly, the exploitation rate from the study was lower than that recorded by other fisheries scholars. Amador & Aggrey-Fynn (2020) and Ojelade *et al.* (2019) documented exploitation rates of 0.75 and 0.73 respectively. Comparatively, the variation in exploitation rate may be reliant on the degree of fishing efforts and patronage of the species for consumption and other economic benefits. According to Chakrabarty (1990), fish stocks do not exhibit any discernible consequences of fishing pressure if the species subjected to exploitation rate (E) is up to 0.5, known as optimal exploitation rate (E_{opt}).

However, the exploitation rate from the study was marginally higher than the optimal level which suggests that the sampled species is highly vulnerable to overexploitation. In addition, the rate of exploitation (E) was greater than the maximum exploitation rate (E_{max}) from the current study. Abdussamad *et al.* (2006) reported similar situation, where the rate of exploitation (E = 0.77) was higher than maximum exploitation rate (E_{max} = 0.53). This finding does not only buttress the earlier claim that the sampled species is overexploited but also indicates significant reduction of the stock resident in the coast of Ghana evidenced by reduction in mean body size, increased fishing mortality, exploitation rate, and target and limit reference points (Chakrabarty, 1990). According to Khadem *et al.* (2020), overfishing prevents the commercially important stock from recovering regularly. The inability of overfished fish stocks from ensuring sustainable production could negatively affect nutrition and economic prowess of dependent household.

Conclusion

The study shed light on the dynamics of the *Trichiurus. lepturus* in the coast of Ghana. According to the study, *T. lepturus* exhibited signs of fast growth, recruitment overfishing and overexploitation. These signs place individuals of the sampled species at risk of future depletion. To protect this commercially important species, it is recommended that the minimum landing size be adjusted by institutionalization mesh size regulation measures. Reducing fishing capacity is also necessary to protect the resources from further depletion.

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