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Growth Parameters and Exploitation of Endangered Lady Fish (*Elops lacerta* Valenciennes, 1847) in the Obuama Creek, Rivers State, Nigeria

Dienye, H.E.*, Olopade, O.A. and Amachree, E.T.

Department of Fisheries, Faculty of Agriculture,
University of Port Harcourt Choba Nigeria.P.M.B.5323
**Email: henry.dienye@uniport.edu.ng*

Abstract

This study examined the parameters of the growth, mortality, and exploitation of endangered ladyfish (*Elops lacerta*) in the Obuama Creek, Rivers State, Nigeria. Fish samples were collected monthly from the local fishermen using various fishing gears (gillnet, cast net and local traps). The samples were identified individually with fish identification keys and online guides. The von Bertalanffy's growth equation was used to examine growth parameters, the length-weight relationship (L.W.R.), and the condition factor and FiSAT II for fish exploitation ratio, mortality parameters, and relative yield per recruit of *Elops lacerta*. The correlation value (r) was estimated as 0.736 with regression equation Log W=0.0216 +2.53logL indicating a negative allometric growth pattern. A mean condition factor "k" value was 0.83±0.32, indicating that the species was not in a perfect state of well-being. The growth parameters revealed that *E. lacerta* had an asymptotic length (L∞) of 30.13cm, a growth coefficient (k) of 1.1/ yr. and the growth performance index (Ø) was 3.00. The total mortality (Z), natural (M) and fishing mortality rates (F) were 2.18, 1.93, and 0.25 per year, respectively. The length at first capture (L50) was 21.24cm and the yield per recruit reached a maximum at an exploitation rate (Emax) of 0.42. The length at first capture (Lc) estimated in this study showed that these species were dominated by small sizes Natural mortality was greater than the fishing mortality while exploitation rate (E) was less than 0.5, the species exhibited a negative allometric growth pattern. The results of this study also confirm that the stock of *E. lacerta* in the Creek is underexploited. However, *E. lacerta* stock may be unsustainable when fishery intensifies to meet consumers' demand unless proper action is taken to manage the stocks.

Keywords: Growth, Mortality, Exploitation, Recruitment, Allometry

1. Introduction

West African ladyfish *Elops lacerta* or ten-pounder, a member of the Family Elopidae (FAO, 1990), found in estuaries and coastal waters in the tropical and subtropical seas. Its juveniles have been found in marine and brackish environments. and freshwater off Lagos Coast, Lagos, and Lekki Lagoons in Nigeria (Ugwumba, 1984). The distribution of fish in the sea is related to certain physical and chemical parameters of the water (Hadzley, 1997). The fish reproduces in the sea, and the larvae disperse into estuarine environments that are declining and deteriorating in quality. The majority of ladyfish are now facing severe challenges as a result of anthropogenically induced habitat loss and changes, rendering them vulnerable to habitat destruction as well as overfishing. Biological data on fish in estuarine environments is lacking, despite a recent call for their protection. (Adams et al., 2013). Biological data on fish in estuarine environments is lacking despite a recent call for their protection (Adams et al., 2013).According to Adams et al. (2013), little is known about this species and the habitats upon which the fisheries it supports depends. Also, because of their low economic status, ladyfish is an example of a fish species that has undergone little study worldwide. (Levesque, 2010). This species uses estuarine areas and hypersaline lagoons; changes in the quality of these habitats may affect this species' population dynamic. Although this species may not be closely associated with any single habitat, it may be adversely affected by development and urbanisation. Fluctuations in fishing resources and production have been generally described by density-dependent methods and the effects of harvesting on fishing (Dwivedi, 2009). Fishing not only reduces ûsh stocks, but excessive ûshing pressure can also cause the collapse of ûsh populations and destabilisation of the ecosystem (Gislason et al., 2000; Hutchings, 2000). Due to the high demand for freshwater fish, several sorts of illegal, limited, and small mesh size gears have been erected on various rivers around the country, which caused the indiscriminate killing of all aquatic species. For stock assessment, studies on age, growth, death rate, and exploitation rate are essential (Dulcic et al., 2007). The growth characteristics and death rate are key tools for determining the extent to which pelagic species are exploited (Cadima, 2000). Fish stock evaluation, on the other hand, should be done for each stock independently because one of the most important characteristics of a stock is that its population parameters remain consistent throughout its distribution range (Kamukuru et al., 2005; Wang and Liu, 2006). Length-weight connections are useful in fisheries research because they allow for the conversion of growth in a length equation assessment model, the determination of biomass from length observations, and the calculation of the fish's condition. They are also valuable for comparing the life histories of different species across areas. (Moutopoulos and Stegious, 2000). Overfishing and poor management of Nigeria's coastal waters have resulted in a drop in fish

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from the catch fishery. For sustainability of fishing resources, documentation of the occurrences, distribution and condition of the fish species are important. Against this background, the growth parameters and exploitation rate of *Elops lacerta* were carried out in Obuama Creek.

2. Materials and Methods

2.1. Study Area

The study was carried out at Obuama Creek, Nigeria, covering two stations, station 1 (04°48’04’’N; 06°46’65’’E) and station 2 (04°48’03’’N; 06°46’23’’E). The Obuama Creek is an important tributary of the Sombriero River. East of the Orashi River is the Sombreiro River. It rises from the Niger River, travels south into the Niger Delta Basin, and empties into the Atlantic Ocean. The Obu-Ama Creek is located in the obuama community (Harris town) in Degema Local Government Rivers State. The Obuama Creek is a brackish water environment with different vegetation red (*Rhizophora mangle*) and white mangroves (*Avicenia* spp) (Fig. 1).

2.2. Data Collection

Fish samples were collected from the local fishers immediately after landing using various fishing gear types like gillnet, cast net and local traps (nets of different mesh sizes). The samples were also collected from two major landing sites in Obuama Creek.

The samples were identified individually with fish identification keys and online guides (Adesulu and Sydenham, 2007; Babatunde and Aminu, 2013). Fish samples were then preserved in a plastic carrier containing enough ice and taken to the laboratory for further analysis. The total count was estimated, and the fish were sorted into sizes. The total length (T.L.) in cm, standard length (S.L.) in cm, girth as well as weight (measured in grams) were obtained. Some snapshots were taken to capture their physical features.

2.3. Data Analysis

The length-weight connection, condition factor, exploitation, and recruitment were statistically analysed using FiSAT II (FAO-ICLARM Stock Assessment Tools) as detailed in detail by (Gayanilo et al., 2005). The analytical methods used include

Length – Weight Relationship (L.W.R.): $W = aL^b$ equation was used to calculate the length-weight relationship (Ricker, 1973),

Where W is the total body weight of the fish(g);

L is the total length(cm)

a is the intercept of the regression curve and

b is the regression coefficient. a and b values were estimated by the least square method**.**

Condition factor: The condition factor (K), which refers to the degree of well being of a fish, was recorded. The condition factor was calculated using the formula.

$$K = 100 \times \frac{W}{L3}$$

Where K = condition factor, W = body weight in grams and L = total length in centimeters.

Fulton’s condition factor (K.F.): This was calculated using the equation

$$K.F. = 100 \times \frac{W}{L3}$$

Where W= total body weight (Bw,g) L= total length (TL,cm)

Growth Parameters: According to the equation, the von Bertalanffy growth equation was applied to investigate growth in length and weight for *Elops lacerta* according to the equation: Lt = L∞ (1 – e-k(t-to)). Von Bertalanffy’s

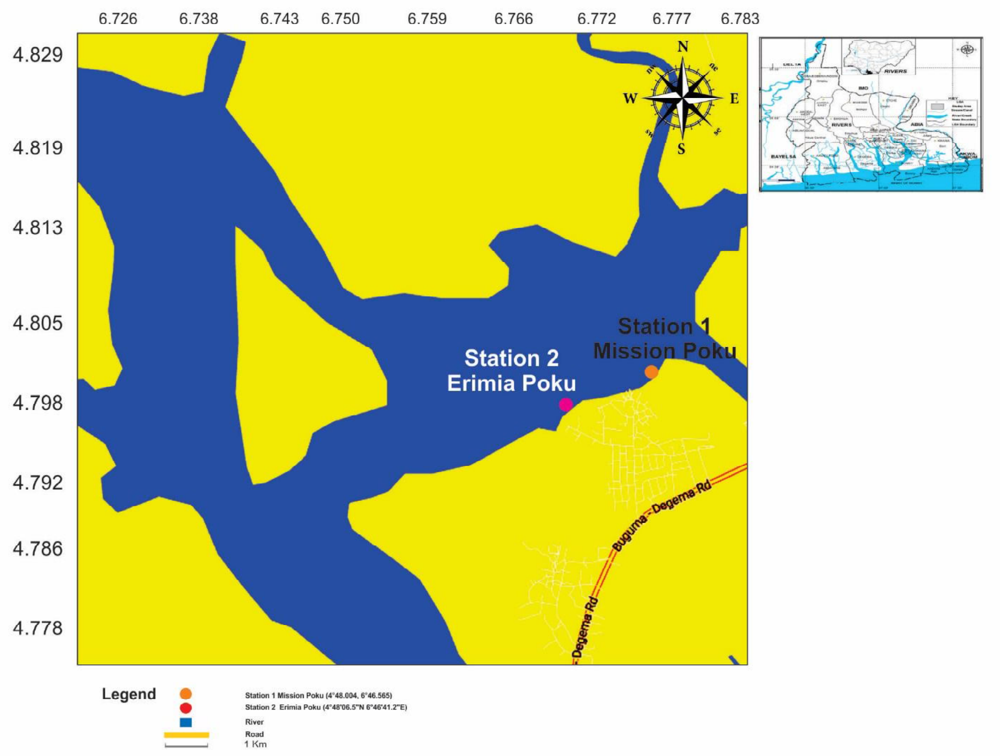

Fig. 1. Map of Obuama Creek, Nigeria showing the sampling sites

growth parameters L∞ and K were computed by ELEFAN-1 (Electronic Length Frequency Analysis)(Beverton and Holt, 1966).

Growth Performance Index (Ø): The growth performance index was computed according to the formula of Pauly and Munro (1984) as follows:

$$Ø = Log10\ K + 2\ Log10\ L_\infty$$

where: Ø = Phiprime, i.e. a length-based index of growth performance

Mortality Parameters (Z, M, F): Total mortality coefficient (Z) was estimated using the methods of Jones and Van Zalinge (1981), Pauly (1983) and Hoenig and Lawing (1982). The natural mortality coefficient (M) was estimated according to Taylor (1960), Ursin (1967), Rikhter and Efanovs Empirical Model (1976) and Pauly (1980). According to the equation: F = Z - M., the geometric means for calculating Z and M are then used to estimate the fishing mortality coefficient (F).

Exploitation Ratio (E): The recommended method was used to calculate the exploitation ratio (i.e. the percentage of deaths caused by fishing). by Gulland (1971) using: **E = F / Z**.

Probability Length at first capture (L50): Probability of capture against mid-length a resultant curve was used to compute the length at first capture (Lc50). The length at first maturity (Lm50) was estimated as Lm50 = (2 * L∞)/ 3 (Hoggarth et al., 2006)

Relative Yield per Recruit (Y/R): Relative yield per recruit (Y/R) was estimated using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in the FiSAT software package, as follows:

$$(Y/R)' = E\ U\ M/K\ [1 - (3U/1+m) + (3U2/1+2m) - (U3/1+3m)]$$

Where: m = (1-E)/(M/K) = (K/Z); U = 1 - (Lc/L∞).

3. Results

Table 1 showed the mean weight estimated was 70.12±21.14g, total length was 20.81±3.45cm, while the forked length and standard lengths were 16.67±2.81cm and 17.79±2.89cm, respectively. The length-weight relationship results revealed an exponent of (b) values of 2.53 and the coefficient of determination (r^2) of 0.736 (Table 2). The condition factor ranged from 0.36 to 2.20, and the mean value for condition factor (K) recorded was 0.83±0.32 (Table 3). The growth parameters estimated for *E. lacerta* using the length-frequency data revealed the best fit for L∞=30.13cm and k=1.1 per year while growth performance (Ø) was estimated as 3.00. The total mortality (Z) of *E. lacerta* estimated by the length converted catch curve was 2.18 (Table 4). The natural mortality (M/year) as per Pauly's empirical formula was found to be 1.93. The estimated fishing mortality (Z-M=F) stood at 0.25, as shown in Table 4. The logistic regression of the probability of capture routine values recorded for *E.lacerta* in Fig 4. The estimated L50 was 21.24 cm. The L25 was calculated as 19.36 cm, while L75 was 23.12cm. The Beverton Holtrelative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) were estimated using the selective Ogive procedure of FiSAT. The analysis indicated that the exploitation rate, which maximizes yield per recruit, produced values of Emax =0.42; E10 = 0.36 and E50 = 0.28 for *E. lacerta* (Fig. 5).

Table 1. The range for Weight, Total length, Standard length and Forked length including 95% CL for *E. lacerta*

Measurement	N	Min	Max	Mean±SD	CL95%
Weight (G)	216	33	165	70.12±21.14	67.29 - 72.96
Total Length (Cm)	216	13	27.5	20.81±3.45	20.35 - 21.27
Forked Length (Cm)	216	10	23.5	16.67±2.81	16.29 - 17.04
Standard Length (Cm)	216	11	24	17.79±2.89	17.40 - 18.18

Table 2. Length-weight relationship equation, the correlation coefficient for *E. lacerta*

Fish species	N	Regression equation	Correlation coefficient
E. lacerta	216	Log W=0.0216 +2.53logL	0.736

Table 3. Condition Factor of Elops lacerta from Obuama Creek

Condition factor	N	Min	Max	Mean±SD	CL95%
KF	216	0.36	2.2	0.83±0.32	0.79 - 0.87

Table 4. Growth Parameters of Elops lacerta from Obuama Creek

Von Bertalanffy's Growth parameters	*E.lacerta*
Growth performance index (Ø)	3
Von Bertalanffy's Growth parameters	ELEFAN-I
Asymptotic length (L∞, cm)	30.13
Growth coefficient (k)	1.1
Total mortality (Z)	2.18
Fishing mortality (F)	0.25
Natural mortality (M)	∞1.93

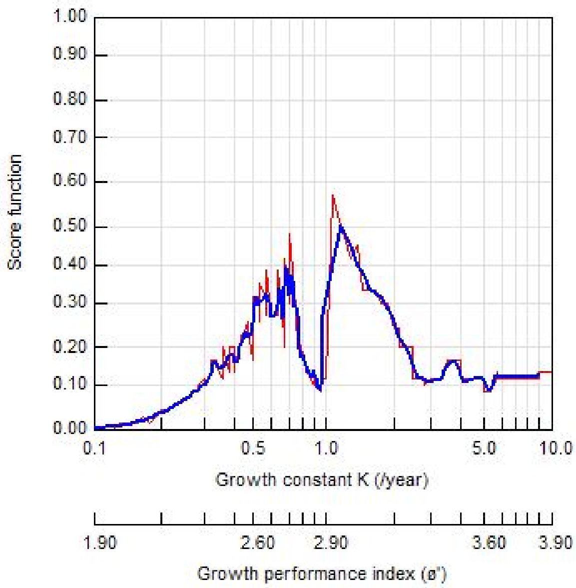

Fig. 2. Growth performance of *Elops lacerta*

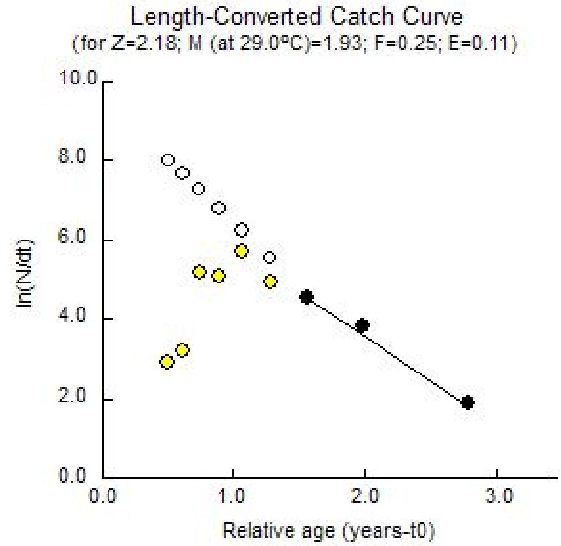

Fig. 3. Length-converted catch curves of the studied fish collected from Obuama Creek

4. Discussion

The total length of *E. lacerta* observed ranged from 13cm to 27.5cm with a mean total length value of 20.81±345cm, while the mean total weight recorded was 70.12±21.14g, with a range of 33g to 165g. Igejongbo *et al*. (2018) reported five growth categories of *Elops lacerta* viz., 10–15 cm (Immature), 15–20cm (Resting), 20-25cm (Maturing), 25-30cm (Ripe and Spawning) and 30 -35cm (Spent). This is in agreement with the findings of this study from the Obuama Creek. The results also corroborate the findings of Abdul *et al*. (2015), who recorded a range of 11cm-33cm for the total length of *E. lacerta* in Ogun state coastal Estuary and Abdul *et al*. (2016) with a total length range of 11.7cm-27.4cm.

The estimated b values of the regression for *E. lacerta* exhibited a negative allometric growth pattern (b<3) for this study (b = 2.53). Allen (1951) chose to keep the value of the b exponent constant at 3.0 for optimal fish growth. Tesch (1971) observed that the value of b remains constant during a given life phase but that b varies depending on environmental factors. Abdul *et al*. (2015) observed a negative allometric growth for *Elops lacerta* at the Ogun state coastal estuary (2.917). Lawson and Aguda (2010) also observed a negative allometric growth exhibited by the unsexed, male and female *Elops lacerta* at the Ologe lagoon, Lagos (b=2.40, 2.75 and 2.27 respectively). Lawson and Aguda (2010) further noted that the fish from his study became lighter for its length as it grew. Adesulu and Sydenham (2007) reported that condition factor in fish is mainly affected by the amount of food in the stomach and stage of egg development that will affect the weight of the body. Then the weight of fish is a function of condition factor in fish. The K factor of *Elops lacerta* was less than 1. The low K indicates that the fish are light for their length, which might be due to low feeding intensity and spawning activity (Lawson and Aguda, 2010). This low K value was also obtained for the species across stations 1 and 2. Furthermore, the condition

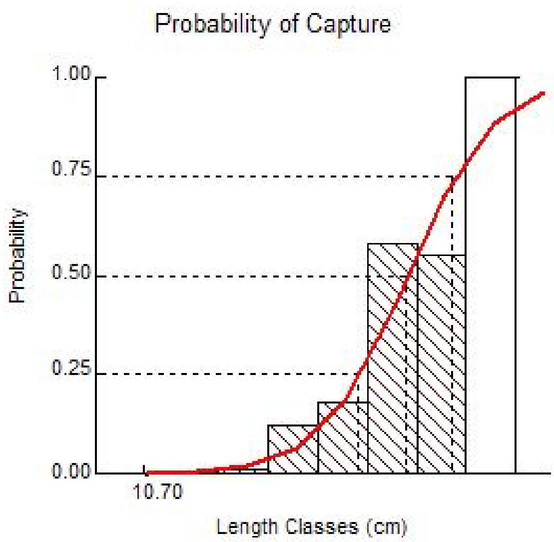

Fig. 4. The probability capture curve showing the L25, L50 and L75 of *Elops lacerta* from Obuama Creek

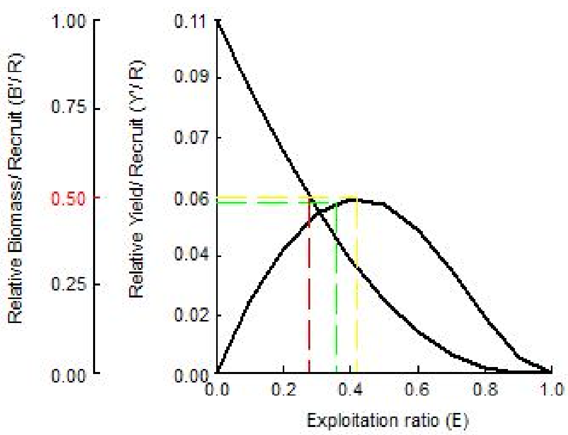

Fig. 5. Beverton and Holt'sHolt's relative yield per recruit and average biomass per recruit models, showing levels of yield indices of *Elops lacerta* from Obuama Creek

factor obtained ranged between 0.36 to 2.20. This variation in condition factors in a population may be attributed to sexual maturation and active spawning of the larger fish (El-Agami, 1988). The condition factor obtained is similar to that obtained by Lawson and Aguda (2010), which ranged between 0.8 and 2.0 at the Ologe lagoon, Lagos, and that of Abdul *et al.* (2015), which ranged between 0.649 and 1.14 on the same species at the Ogun state coastal estuary.

Abobi and Ekau (2013) opted that the asymptotic length ($L\infty$) is the largest theoretical mean length that a fish could attain in its natural habitat, assuming the fish grows throughout its life. The growth curvature (K) is the rate at which it grows towards this final size; (Etim *et al.*, 1999). The growth parameters in this study revealed that *Elops lacerta* had an asymptotic length ($L\infty$) of 30.13cm and a growth coefficient (k) of 1.1/yr. These values indicate that *Elops lacerta* grows at a fast rate. Abdul et al. (2015) recorded a higher $L\infty$ value (38.33cm) but a lower value of k (0.74/yr) for *Elops lacerta* in Ogun state coastal estuary. The growth performance index of *Elops lacerta* in this study 3.00. According to Baijot and Moreau (1997), the Ø mean values for some important fishes in Africa range of 2.65-3.32

The relative yield analysis showed that the exploitation rate, which maximises yield per recruit, produced values for E_{max}, E_{50}, and E_{10} of 0.42, 0.28 and 0.36. Based on the assumption that a stock is optimally exploited when F=M or E=0.5 (Gulland, 1971). The results of the present study indicate that the current exploitation rate is close to the maximum level of 0.5. The species is therefore not over-exploited in this creek. The probability of capture analysis showed the values of L_{25} as 19.36cm, L_{50} as 21.24 cm and L_{75} as 23.12 cm. The length at first capture (L_{50} = 21.24cm) falls within the range of the total length of *Elops lacerta* recorded in this study (13-27.5 cm). This implies that this fish species is not over-exploited. The value of L_{50} estimated in this study also shows that the smallest sizes susceptible to the exploitation method are juvenile fishes. Fish ageing (King, 1991), fish predation (Otobo, 1993), environmental conditions (Chapman and Van Well, 1978), parasites and diseases (Landau, 1979), and fishing activities are some of the reasons for fish death (King, 1991). The total mortality (Z), natural mortality (M/year), fishing mortality (F), and exploitation ratio (E) of *E. lacerta* were found to be 2.18, 1,93, 0.25 and 0.11. Therefore, the species of study is not over-exploited since the natural mortality (M= 1.93) is greater than the fishing mortality (F=0.25). Furthermore, Gulland (1971) assumed that a stock is optimally exploited when F=M or E=0.5. Comparing the optimum E value with the E value obtained from this study shows that *E. lacerta* is not overly exploited in the Obuama creek. The fact that samples were dominated by small-sized specimens implies management measures such as size-limit regulation by gradually increasing fishing gear mesh size (Sossoukpe et al., 2016).

5. Conclusion

The present study has provided information on the growth and population of endangered *Elops lacerta* that will help in the development of efficient management and conservation strategies. The length-weight relationship results revealed an exponent of (b) values of 2.53 and the coefficient of determination (r^2) of 0.736. The length at first capture (Lc) estimated in this study showed that small sizes dominated the se species. Natural mortality was greater than the fishing mortality, while exploitation rate (E) was less than 0.5, the species exhibited a negative allometric growth pattern. *E.lacerta* in the Creek is underexploited. However, unless sufficient effort is taken to control the stocks, the stock may become unsustainable as the fishing develops in the future to fulfil consumer demand.

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