Length Base Structure and Growth Parameters of *Sarotherodon galilaeus* (Pisces: Cichlidae) in Tropical Coastal Estuary, Nigeria

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ABSTRACT

Population dynamics and length frequency distribution of *Sarotherodon galilaeus* was investigated from commercial fishermen operating within Iken brushpark in the Ogun coastal estuary of Nigeria. The study was necessitated to provide information on *S. galilaeus* that has been listed in the IUNC as a threatened species. A total of 1,938 specimens with total length range of 11.0 – 11.9 to 41.0-41.9 cm and corresponding weights of 27 g to 1,345 g were sampled. Mean TL ranged from 26.96±0.58 cm in February to 31.08±0.41 cm in June with corresponding mean weight of 517.20±26.45 g and 766.12±26.04 g. In terms of abundance, the month of April ranked as the highest (492) and the least abundance was observed in February (252).

The contribution of size class 31.0-31.9cm dominates the stock. Bhattacharya's Modal Class Progression Analyses depicts four distinct peaks representing age groups 1+ to 4+. The highest value of the exponent "b" of length-weight relationship and condition factor "K" was recorded in male fish. K value showed significant difference ($p<0.05$) within sex. The estimated growth parameters values using Von Bertalanffy Growth Equation from age lengths key data were: Asymptotic length (L_∞) = 43.58 cm, Growth rate (K) = 0.81 yr-1, Total mortality (Z) = 2.64 yr-1, Natural mortality (M) = 1.42 yr-1, Fishing mortality (F) = 1.22 yr-1, Exploitation rate (E) = 0.46, longevity (Tmax) = 3.70 years, Length-at-optimum yield (Lopt) = 25.02 cm and Length-at-first maturity (L50) = 11.43 cm. Overview of the growth parameters analysis suggest that *S. galilaeus* is still under exploit and it longevity is also above the recommended limit of cichlids.

(Keywords: Bhattacharya's, length distribution, growth index, Sarotherodon galilaeus, tropical, fisheries, stock assessment, cichlids, big man fish)

INTRODUCTION

Length-base stock assessments form the basis for the management of many fish species (Hilborn and Walters, 1992; Campana, 2001). Accurate age estimates are critical as underestimation of age, with resultant overestimation of growth can, lead to the collapse of major commercial fisheries (Campana et al., 1990; Beamish and McFarlane, 1983). Knowing the age of a fish provides a clue to its longevity, age at first maturity, age of recruitment, and growth (Summerfelt and Hall, 1987); moreover, the length base approach data, allows the development of catch curves from which the annual mortality rates can be calculated. So ageing fish accurately is indispensable to the understanding of the dynamics of their stocks (Beamish and McFarlane, 1987; Meunier, 1988).

Bhattacharya's method is useful for splitting a composite distribution into separate normal distributions when there are several fish cohorts (age groups; age-years classes) in the same sample. The application of LFA analysis relies on the availability and quality of data and could be proposed just for cases with a large sample represented with as much as possible a higher number of age classes Mees et al. (1994). Sparre and Venema (1992) stated that one of the weaknesses of this method is in choosing how many points will each lie on a straight line (age classes) and which points can or cannot be included in one or another line since they are based on subjective selection. In the first few regression analyses (age classes) these mistakes were not so common as later on, when the points were not distributed as clearly on the lines and each author had to make an independent decision of what would be calculated in each regression analysis.

Cichlids are one of the most endemic species caught in Iken brushpark fish aggregating device in Ogun State coastal estuary (Abdul et al 2011). *S. galiliaeus* commonly referred to as "big man fish" has high potential of larger sizes (length and weight) when harvested. The declaration of IUNC red list of threatened species in Africa waters (Bailliet et al., 2004) on *S. galilaeus* lead to the investigation of age structure and length distribution pattern of *S. galilaeus* in tropical coastal estuary Nigeria.

MATERIALS AND METHODS

The study was carried out in Ogun State coastal estuary, Ogun Waterside Local Government Area of Ogun State, Nigeria. The Local Government is one of the twenty local government areas of Ogun State. The estuary is located between latitudes 6°20′N - 6°45′N and longitudes 4°15′E - 4°30′E (Figure 1) and covers an area of 26 km2 (Ssetengo et al., 1983). It empties into the Atlantic Ocean via Lagos harbor. It falls into the western littoral area.

The wet season (April – October) and dry season (November – March) are the two distinct seasons experienced in the area with an average rainfall that ranges from 500 mm to 1,800 mm, most of which falls between April and October. Vegetation in the estuary forms a coastal belt of mangrove swamp forests. The estuary is essential freshwater all year round as the mean salinity is estimated to be 0.37±0.0210/00 (Abdul et al., 2010).

Some of the fish fauna in the estuary include *Tilapia zillii* (*Coptodon zillii*), *Tilapia mariae* (*Pelmatolapia mariae*) reclassified by Dunz and Schliewen (2013), *Sarotherodon galilaeus*, *Chrysichthys nigrodigitatus*, *Chrysichthys auratus*, *Mormyrus rume*, *Elops lacerta*, *Hydrocynus forskalis*, *Hepsetus odoe*, *Chana obscura*, *Polypterus senegalus*, *Cynoglossus senegalensis*, and others (Abdul, 2012).

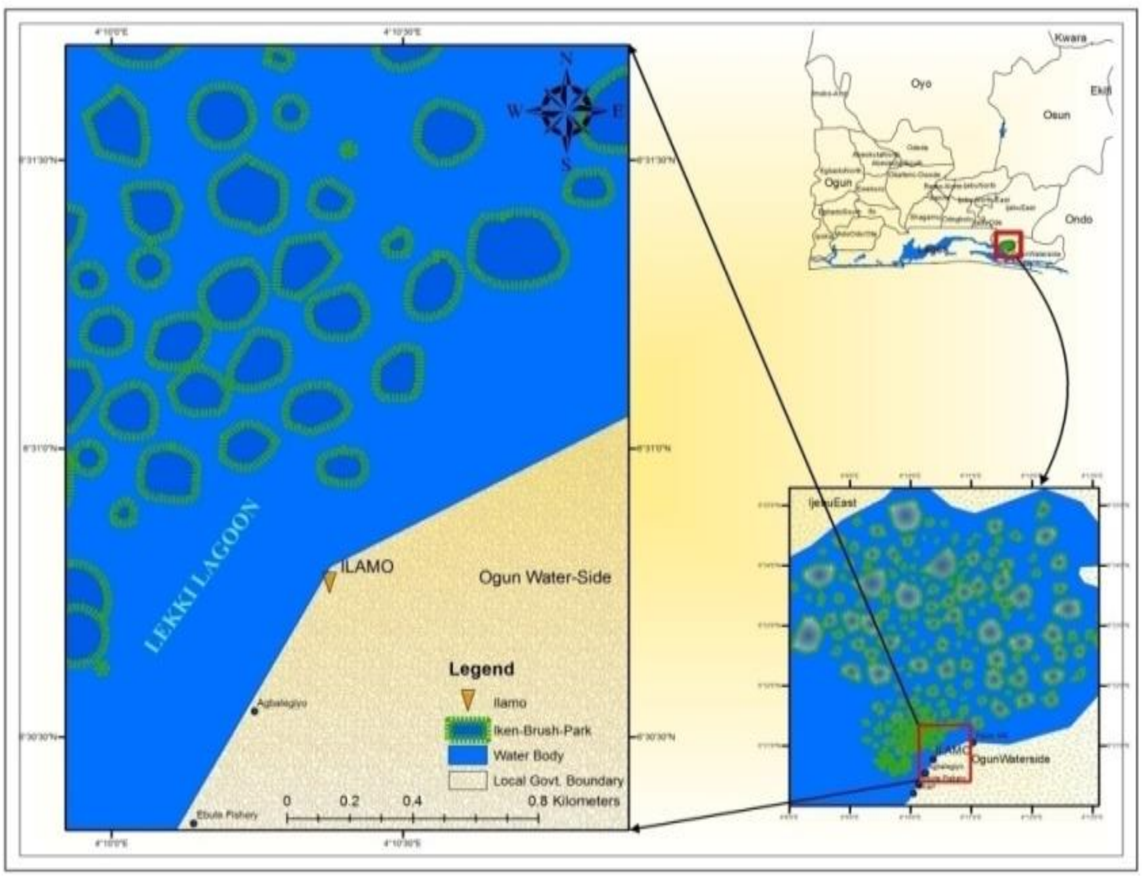

Figure 1: Map of Ogun State Coastal Estuary showing Brushpark as the Sampling Zone.

Collection of Fish Samples

Fish samples were randomly collected on a monthly basis (February-July 2015) from commercial fishermen operating in Iken brushpark on the water. Total length (cm) of sample was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board, Body weight was measured to the nearest gram using an electronic sensitive weighing balance (Model: EK3250).

Length Group Structure

1938 samples of *S. galilaeus* from length frequency distribution data were used to group the population into classes using 1 cm class interval as required for ELEFAN 0, a sub-routine of FISAT II version 2.1 for fish stock assessment.

Length-Weight Relationship and Condition Factor

The length-weight relationship (LWR) was estimated by using the equation:

W= aLb (Le Cren, 1951).

Where W is the Body weight in grams and L is Total length of fish in (cm). The values of constant 'a' and 'b 'were estimated from the log - transformed relationship of LWR:

LogW= Loga + bLogL…………………… **(1)**

Parameter b was used to determine the growth pattern of the fish at 95% confidence limit.

Condition factor (K) was estimated as:

K = 100× W / L3,

where W is the total weight in g and L is the total length in cm (Bagenal 1978).

Growth Parameters Estimation

Sub-routines of FiSAT II (version 2.10), ELEFAN 0 – II, were used to estimate the growth parameters of S. galilaeus. A non-seasonalized Von Bertalanffy Growth Function (VBGF) was used to estimate the Asymptotic length L∞, Natural mortality, M and Exploitation rate, E was estimated from length-converted catch curve Pauly (1979).

Some Growth parameters Index were estimated as follows:

Growth performance index, Φ1:

Φ1= log10 K + 2 log10 L∞…………….. **(2)**
(Pauly and Munro 1984)

Longevity tmax:

Tmax = 3/K ………………………………. **(3)**
(Pauly, 1984)

Length- at-optimum yield, Lopt:

Lopt = L∞ (3/ (3+ M/K)) ………………… **(4)**

Length-at-first maturity:

Log L50 = 0.8776 Log L∞ - 0.38 …... **(5)**
L50 (Froese and Binohlam, 2000)

RESULTS

Length Distribution Pattern and Age Structure

Length-frequency distribution of *S. galilaeus* in Ogun State coastal estuary is illustrated in Figure 1. The distribution was polymodal with peak at 31-31.9 cm with a frequency of 189. Size classes 12-12.9 cm, 17-17.9 cm, 21-12.9 cm, and 40-40.9 cm were not represented. In all, a total of 1,938 specimens with total length range of 11.0 – 11.9 to 41.0- 41.9 cm and corresponding weights of 27 g to 1345 g were sampled. Mean TL ranged from 26.96±0.58 cm in February to 31.08±0.41 cm in June with corresponding mean weight of 517.20±26.45 g and 766.12±26.04 g. During March and April, total mean length and weight were 27.19±0.35 cm, 519.0±15.86 g, and 29.83±0.32 cm and 694.82±17.98 g, respectively. However, for May and July the means of total length were 30.02±0.43 cm and 30.42±0.50 cm with corresponding mean weights of 651.92±21.91 g and 671.97±24.06 g, respectively.

The fish was most abundant, in April (492) and least abundant in February (252). Size class 31.0-31.9cm contributed most (189) while size classes 11.0-11.9, 13.0-13.9, 15.0-15.9 and 39.0-39.9 cm contributed least (3 in each case). Four distinct peaks were separated by Bhattacharya's using length frequency data (Figure 2).

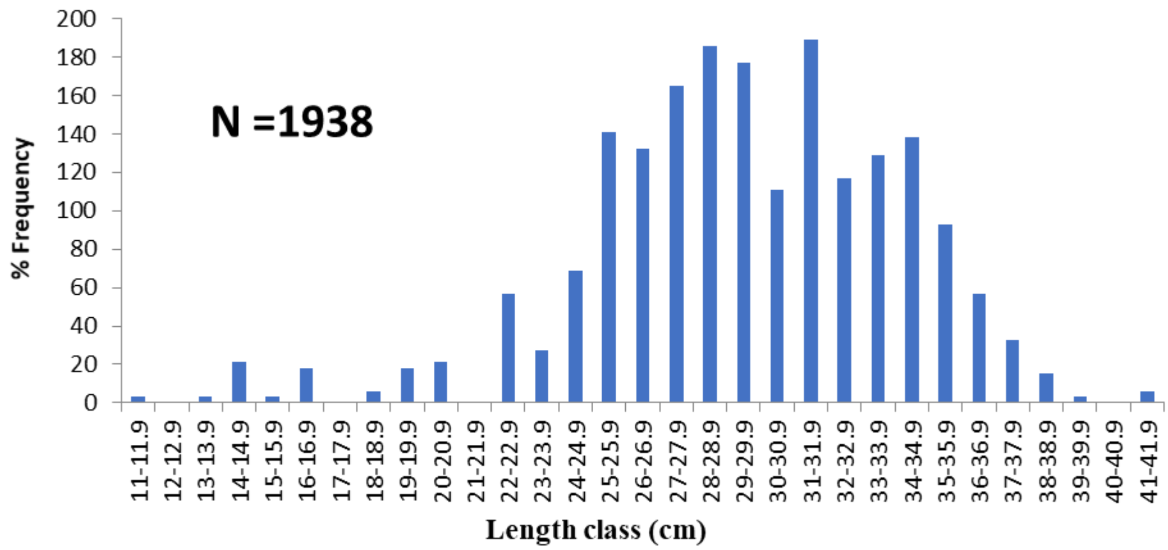

Figure 1: Length-Frequency Distribution of *Sarotherodon galilaeus* in Ogun State Coastal Estuary.

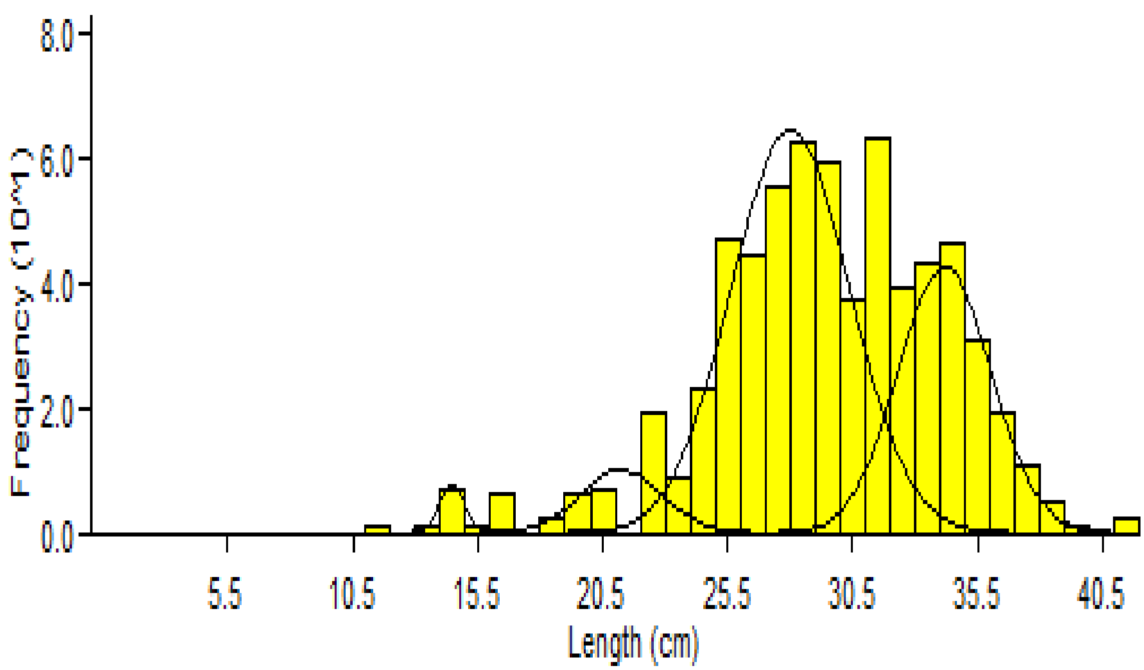

Figure 2: Length Distribution of *Sarotherodon galilaeus* Separated by Bhattacharya method.

Mean lengths of the cohort age group were 14.50, 21.26, 28.00 and 34.18 cm for age 1+ to 4+ respectively (Table 1). Age group 3+ dominated followed by age group 2+ while age group 1+ was the least.

Length-Weight Relationship and Condition Factor

The mean logarithmic transformation of length and weight of Male and Female *S. galilaeus* is estimated as: Log W=1.125 + 2.846 logL, r = 0.943; Log W =1.194 + 2.826 logL, r = 0.894. Variance test (t- test) showed that 'b' values of both sex were not significantly (p> 0.05) different from 3.0. Also, the higher mean condition factor (K) was recorded in male fish than the female counterpart. However, Analysis of variance (t-test) showed that condition factor of male stock was significantly (p<0.05) higher than that of female stock in the fishery during the study period Table 2.

Table 1: Computed Mean Length at Age Separated by Bhattacharya's Method.

Age groups	Computed Mean Length (cm)	S.D.	Population	S.I.
I	14.5	0.51	28.69	Na
II	21.26	1.61	121.75	2.62
III	28	2.37	1144.33	2.24
IV	34.18	2.14	636.14	2.11

S.D= Standard deviation, S.I= Separation Index and Na= Not Available.

Table 2: Simple Linear Regression.

	A	b	r^2	Equation	K
Male	0.051±0.01	2.846±0.09*	0.887±0.03	LogW= 1.125+2.846LogL	2.242±0.01*
Female	0.077±0.05	2.826±0.17*	0.803±0.06	LogW= 1.194+2.826LogL	2.102±0.32**

Mean values with the double sign indicate significantly ($p < 0.05$) different.

Growth Parameters Estimation

The estimated growth parameters values using Von Bertalanffy Growth Equation from length frequency data were: Asymptotic length (L_∞) = 43.58 cm, Growth rate (K) = 0.81 yr-1, Total mortality (Z) = 2.64yr-1, Natural mortality (M) = 1.42yr-1, Fishing mortality (F) = 1.22yr-1, Exploitation rate (E) = 0.46, longevity (Tmax) =3.70 years, Length- at-optimum yield (Lopt) =25.02 cm and Length-at-first maturity (L50) = 11.43 cm. The length converted catch curve is illustrated in Figure 3.

DISCUSSION

Length frequency distribution data and population dynamics have been used as a tool to identify and predict species at greater risk of endangered. The range of sizes of *S. galilaeus* from Ogun coastal estuary measured 11 to 41 cm. Ebenezer (2010) reported size range of 7.0 to 33.3 cm for *S. galilaeus* in Weija reservoir Ghana. Abdul et al. (2011) also reported a size range of 22-34 cm for *S. galilaeus* from the same water body when investigating the impact of Iken brushpark on the species. Sample method could be attributed to sizes variation.

Bhattacharya's method is useful for splitting a composite distribution into separate normal distributions when there are several fish cohorts (age groups; age-years classes) in the same sample (Sparre and Venema, 1992). Analysis of length frequency data using Bhattacharya separation model four peaks was observed and this implies that four age groups were present. Separation of the peaks might be made distinct as a result of three major changes in the environment namely: increase in photoperiod, beginning of rainy season and lowering of pH suggested by Idodo-Umeh (2003).

Sahin et al. (1998) recorded similar result in *Anadara cornea* using Bhattacharya separation in eastern Black sea of Turkey. The curvilinear relationship between the length and weight of the species is common among fishes (King, 1996). For an ideal fish that shows isometric growth, the regression co-efficient is 3.0 (Allen, 1978; Bagenal and Tesch, 1978; Dalzell, 1987) and populations in which the exponent differs significantly from 3.0 exhibits allometric growth.

The regression coefficient of 2.85 (male) and 2.83 (female) indicated isometric growth in the species and was similar to what has been reported for growth of *Sarotherodon galilaeus* in Opa Reservoir Nigeria by Arawomo (1981). Njiru et al. (2006), however, observed positive allometric growth in both males and females of the species in Lake Victoria, Kenya. The isometric growth pattern exhibited by both sex in the estuary might be attributed to abundant food supply and suitable environmental conditions.

The mean condition value of *S. galilaeus* for male and females were in agreement with values of most tropical fishes. The K values indicated that they were in a very good condition (K >1). This was based on the hypothesis stated by Bagenal and Tesch (1978) that heavier fish of a given length have better condition.

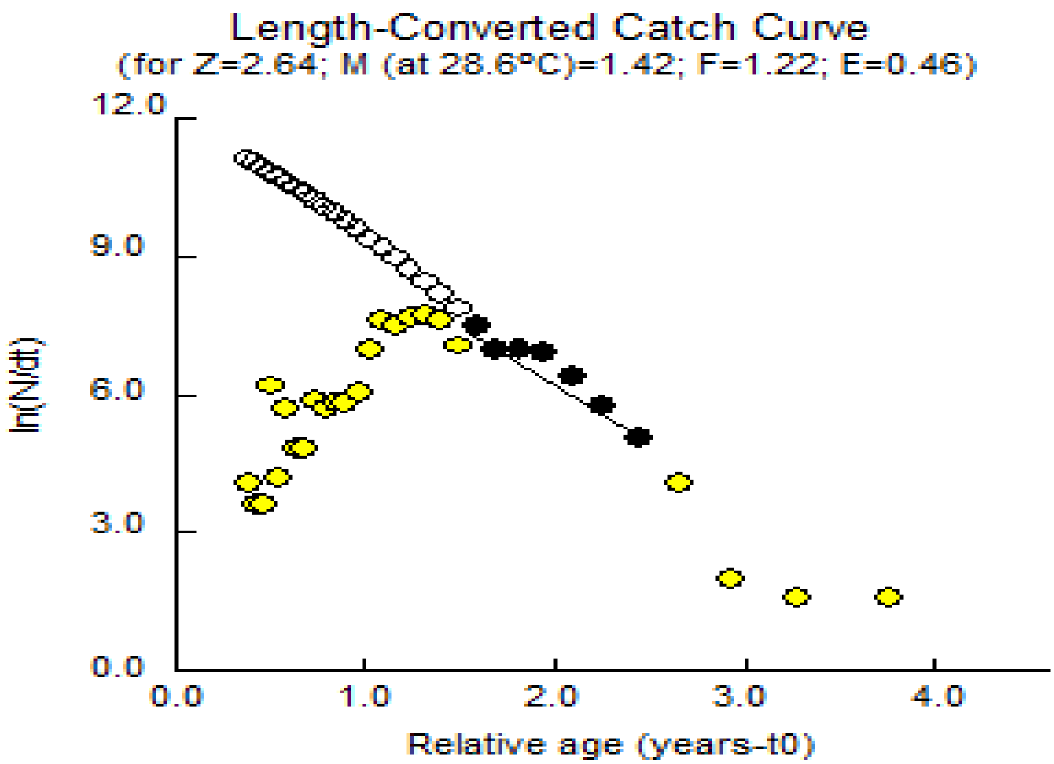

Figure 3: Length-Converted Catch Curve from LFD.

Low condition factor in females might encourage atresia and significantly reduce egg production or some mature female stock skip spawning (Abdul, 2015). Similar result has been reported by (Stone, 1980; Behrends, 1983; Eknath et al., 1993; and Bentsen et al., 1998). The difference in growth of both sexes observed in the present study might also be attributed to genetic differences between the males and the females as suggested by Pagan (1970) and Tave (1980).

L∞ value was higher in this study than the work of Tim du fen (1995) in Kainji lake. This may be attributed to the difference in size of collected sample and ecological environment of both habitats. Growth rate expresses how fast fish approaches its L∞ indicating a directly relationship between K and L∞. Spare et al (1989) stated that K values greater than or equal to 1 are short-lived species.

Cichlids have been studied to have age limits or longevity of 36 months and above Taylor (1960). This value reflects the impact that fishing has on tilapia individual growth and consequently on the population structure, that do not surpass the two year and a half age. Higher longevity value depicted that the environment was good to support the growth of the fish population in the estuary.

Apegyah et al (2008) recorded higher longevity value of 10 years in Bontanga reservoir Ghana. The difference between the present work (0.81) and Apegyah (0.26) study lies in the K values of the two ecosystems.

Moreau et al. (1995) estimate higher natural mortality value of 1.63 and 1.54 in Fleuve Senegal and Lac Ramitinga Bukina Faso, respectively. This indicates that *S. galilaeus* was subjected to lower mortality levels. Beverton and Holt (1957) pointed out that the natural mortality coefficient is inversely related to the asymptotic length (L∞) and the life span longevity.

Exploitation rate is an index of growth extinction as stated by Gulland (1971) that when E is below 0.5 the stock is under exploited, above 0.5 indicate over fishing and equal to 0.5 mean optimal or fixed rate. Meanwhile, exploitation was still below optimum (0.46) suggesting that *S. galiliaeus* is under fished in the study area.

Lopt which indicates the length in a population that more of the fish would get to its maximum sustainable yield (MSY). The value obtained in this study was higher than the value observed by Abdul et al., (2012) in the same water body for *T. zillii*. Exploiting 13% of the total population below Lopt value shows that *S. galilaeus* is still under fished.

Sparre and Venema (1992) stated that Φ1 is an index of growth potential and has minimum variance. Φ1 value range of 2.65-3.32 were estimated for the following fish species *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Brycinus nurses*, and *Clarias gariepinus* in most west African rivers (Baijot et al., 1994). This implies that values lower than 2.62 indicate low growth performance and potential fishes.

The length at first maturity (L50) of fish population is a function of their size. L50 value estimated in this study was higher than the work of Abdul et al (2012) for *T. zillii* in Ogun Coastal estuary, Nigeria. All the estimated growth parameter and LFD indicates that *S. galilaeus* is still underexploited and should not be categorizes as a threatened or endangered species as listed in IUNC 2004. However, the estuary should be continually monitored against pollution, anoxia, and atresia condition and size selectivity for future extinction risks.

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SUGGESTED CITATION

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