SOME POPULATION PARAMETERS AND EXPLOITATION RATE OF *ETHMALOSA FIMBRIATA* (PISCES: CLUPEIDAE) IN THE COASTAL MARINE HABITAT OF OGUN STATE, SOUTH-WEST, NIGERIA

OJELADE, O.C.*, I.T. OMONIYI, W.O. ABDUL, I. ABDULRAHEEM and F.I. ADEOSUN
Department of Aquaculture and Fisheries Management, Federal University of Agriculture, Abeokuta
*Corresponding author: ojeladeoc@funaab.edu.ng, +2348032255000

ABSTRACT
Most aquatic ecosystem services are in a state of decline and the harmful consequences of this decline could grow significantly worse if efficient management strategies and policies are not put in place. The growth and mortality parameters as well as exploitation rate of 2,121 Ethmalosa fimbriata were collected between February 2015 and January 2017 from Ogun marine coastal water for management and conservation studies. Growth parameters and performance index estimated based on the Von Bertalanffy model using routines in ELEFAN1 FiSAT II gave the asymptotic length (L∞) of 32.6cm, the growth coefficient (K) of 0.65yr^{-1}, the theoretical age at length zero 0.35^{-1} and the performance index ϕ of 2.8^{-1}. E. fimbriata grew allometrically (negative) with an abundance of medium size specimens. This species indicated a bi-modal distribution of two cohorts within the population structure. The estimated average value of instantaneous rate of total mortality was 2.69^{-1}, natural mortality was 1.33^{-1}, giving fishing mortality of 1.36y^{-1} and the rate of exploitation, E at 0.51yr^{-1} indicating over-exploitation of the stock of this species. Therefore, some management actions are considered necessary for sustainable exploitation and conservation of this commercially important species of fish.

Keywords: Mortality, Extinction, Exploitation rate, *Ethmalosafimbriata*.

INTRODUCTION

Several benefits such as direct consumption of seafood, storm prediction and recreation are being derived from marine and coastal ecosystems on a daily basis (Guerry *et al.,* 2011). However, other non-direct benefits include sequestering of carbon and other regulatory processes as reported by Mark *et al.* (2012). Hence, the coastal ecosystems play an important role in the economy of any nation by providing services that directly or indirectly benefit humans (Fisher *et al*., 2009). However, there is growing evidence that these ecosystems are being negatively affected by anthropogenic pressures such as overfishing, eutrophication, toxic pollution and habitat degradation among others (Karr *et al*, 2006). The most prominent anthropogenic effect on the marine ecosystem is overfishing and most marine fisheries are suffering from this due to over capacity of fishing fleets (Clark 2006). Regardless of the declining fish stock, most Nigerian artisanal fishermen use increased fishing effort to get the available catch which is still below the demand of Nigerians population. The fear now is that the unsatisfied demand would continue to be met through fish importation unless policies and actions are geared towards improving the domestic production from the artisanal sector in a sustainable way (Fafioye and Oluajo, 2005). The detrimental effect of this continuous fish decline in coastal and marine ecosystems calls for an urgent need to remedy these impacts through the implementation of appropriate restoration measures (Agboola *et al*., 2008).

A larger percentage of the landings of the Nigerian coastal artisanal fisheries is composed of clupeids which include *Ethmalosa fimbriata* (Bonga shad), *Ilisha africana* (West African Shad), *and Sardinella marderensis* (Sardine) among others (Ajah *et al.,* 2006). These species represent one of the most important fish species inhabiting the coastal water off the Gulf of Guinea, hence the reason for their commercial relevance in the fishing industry. It plays important role in the livelihood of fisherfolks who depend on fishing for their sustenance.

Bonga shad (*E. fimbriata*) is a coastal clupeid that is abundant in the 15km coastline of Ogun State, Nigeria (Odulate *et al.*, 2012). This fish is consumed fresh or processed, and it is reported to constitute the second most abundant fish species caught in Nigerian coastal waters (FDF, 2007). The biology and population parameters of clupeids including *E. fimbriata* have been studied extensively along Nigeria coastline (Kusemiju and Onadeko, 1990; Essen, 1995; Ama-Abasi, 2002; Ama-Abasi *et al.*, 2004 and Ambrose and Udo, 2015). However, there is dearth of information on studies related to the determination of growth parameters and exploitation rate from size frequency distribution of *E. fimbriata* in Ogun Coastal waters. Hence, this study on some population parameters and exploitation rate of the species could provide scientific evidence necessary for the implementation of its management and conservation plans in Ogun Coastal marine habitat.

MATERIALS AND METHODS

Description of the Study Area

This study was carried out in the Coastal marine water of Ogun State which covers an area of about 6,032km^2 with a 15km coastline off Nigeria on the Bight of Benin (Olopade, 2001). The study area is bounded in the West by Ijebu-East Local Government Area and Lekki Lagoon, in North and East by Ondo state and in the South by Lagos State and Bight of Benin (Atlantic Ocean) (Figure 1). It is predominantly a rural settlement and the indigenes are mainly Ijebus, other inhabitants are Ikales and Ilajes (Ojelade *et al*., 2016). The area comprises over 50 towns and villages and the Headquarter is at Abigi, with a population of 72,935 (NPC, 2006). Ogun coastal area is situated in the rainforest belt of Nigeria with an annual rainfall of 125-150cm as reported by (Oluwalana, 1997). The area is characterised by two distinct dry and wet season with relative humidity of above 80% and 60-80% respectively.

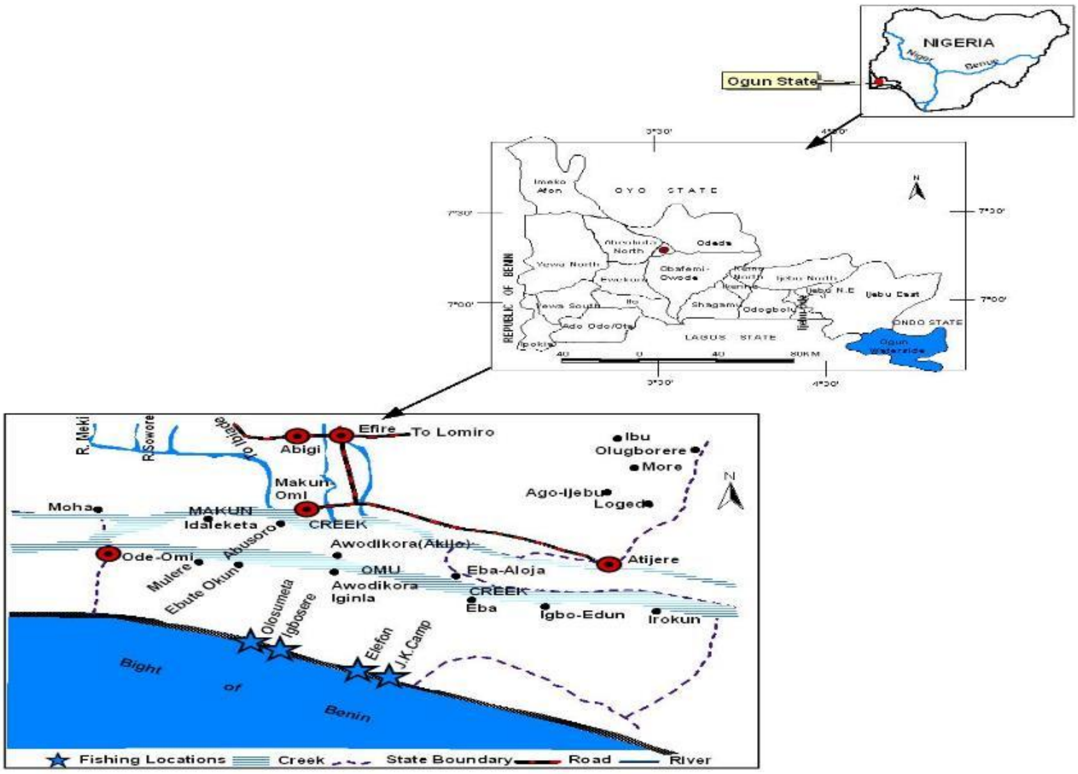


Figure 1: Map of Ogun coastal marine habitat

Fish Sampling

Specimens of *E. fimbriata* were collected on a monthly basis in the study area from February 2015 to January 2017. A graded monofilament gillnet of varying mesh sizes (18, 22, 26, 30, 40, 45, 50, 65, 70, 75, 80 and 90 mm, knot-to-knot) was used to assess the fish catch. The nets were set at a distance of 300m to the shore at late afternoon (1800 to 2000hours) and retrieved the following morning (0600 to 0800hours). Specimens of *E. fimbriata* were sorted and preserved in ice-chest for subsequent analysis in the laboratory.

Laboratory Procedure

The specimens were drained of excessive water using a pile of filter papers. Total Length TL (distance from the snout with the mouth closed to the tip of the caudal fin) and Standard Length SL (distance from the snout to the caudal peduncle) were measured with a measuring board to the nearest 0.1cm for each specimen while the ungutted body weight (BW) was measured with a Mettler balance (Model 1106) to the nearest 0.01g. The sex of the fish was determined using the methods described by Ama-Abasi (2002) and the sex ratio was recorded on a monthly basis.

Total length and frequency distribution of the caught *E. fimbriata* was analyzed at a class interval of 2cm using histogram to determine the type of distribution, which characterized the population structure of the fish species in the study area.

The Length-Weight Relationship (LWR) of the fish was estimated using the equation: $W = a L^b$, where a is the intercept and b is the allometry coefficient. Parameters a and b were determined using least–square linear regression method (Zar, 1999). The value of b gives information on the growth pattern of fish: growth is isometric if $b = 3$ and the growth is allometric if $b \neq 3$ (negative allometric if $b < 3$ and positive allometric if $b > 3$).

$W=aL^b$ represented linearly by logarithms transformation as given:

$$\text{Log } W = \text{Log } a + b \text{ Log } L.$$

Where, W = body weight of fish in grams (g)

L = standard length of fish in centimetres (cm)
a = regression constant
b = regression coefficient.

Growth and Mortality Parameters

The length weight data were subjected to length-frequency analysis in ELEFAN FiSAT II (Version 2.2) to obtain the asymptotic length ($L\infty$) which is the theoretical maximum length that the species would reach if it lived indefinitely in cm, and the growth curvature (K); a measure of the rate at which the maximum size is attained (yr^{-1}) using the formula $Lt = L\infty\ [-\ \exp(-K(t-\ t0))]$ as described in Von Bertalanffy (1938). The estimates of $L\infty$ and K were used to compute the growth performance index φ' (in terms of length) of the species (Pauly and Munro, 1984): $\varphi' = \mathrm{Log10}\ (K) + 2\mathrm{Log10}\ (L\infty)$. The fitting of the best growth curve was based on ELEFAN I (Pauly and David, 1981), which allows the fitted curve through the maximum number of peaks of the length–frequency distribution. The annual instantaneous rate of total mortality, Z, was estimated by constructing linearized length-converted catch curves. Instant natural mortality rates, M, were computed using the empirical equation and mean annual surface temperature (T) using the formula:

$$\mathrm{Log10}\ (M) = -0.0066 - 0.279\ \mathrm{Log10}\ (L\infty) + 0.6543\ \mathrm{Log10}\ (K) + 0.463\ \mathrm{Log10}\ (T).$$

The instant fishing mortality rate, F, was calculated as Z–M (Sparre and Venema, 1992). The exploitation rate (E) was derived using FISAT II from the linearized length-converted catch curve of the species using E = F/Z where F= fishing mortality and Z= total mortality.

The condition factor which represents the state of the general well-being of the fish was analysed in relation to size and this was estimated using Fulton's equation:

$K = 100\ W/L^3$

Where, K = condition factor
L = standard length in centimetres (cm);
W = weight in grams (g). Le Cren (1951)

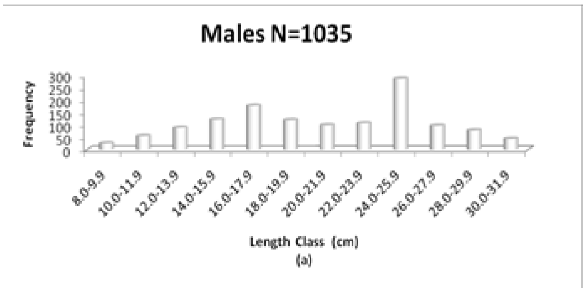
The data were analysed using descriptive and inferential statistical tools.

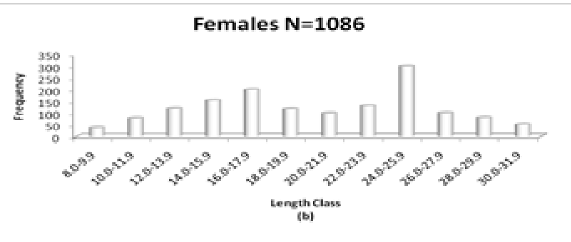
RESULT

A total of 2,121 fish specimens was recorded during the study period, which consisted of 1035 males (48.8%) and 1,086 females (51.2%) as presented in Table 1. The sex ratio of male to female was 1:1.1, indicating that females were slightly more than the males in the habitat. The ranges of standard length and body weight are also indicated in Table 1. The population structure of *E. fimbriata* in the study area showed a bimodal distribution with respective modal class at 16.0-17.9cm and 24.0-25.9cm as shown in Figure 1.

Table 1: Standard length, ungutted weight and sex ratio of *E. fimbriata* in Ogun coastal water

Gender	Number	Range of Standard Length in cm (Mean)	Range of Weight in grammes (Mean)
Males	1035	9.4-29.8 (25.2±0.06)	14.93-58.6 (90.3±2.51)
Females	1086	8.0-31.9 (26.4±0.04)	15.1-261.42 (128.4±1.77)
Combined Males and Females	2121 (1.0:1.1)	8.0-31.9(26.1±0.02)	54.93-61.42 (116.5±1.98)





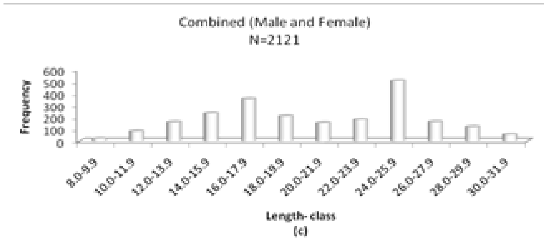


Figure 2: Population structure of males (a), females (b) and combined sexes (c) of *Ethmalosa fimbriata* in Ogun coastal water.

Estimates of LWR showed that there was a positive relationship between the weight and total length of the fish species in Ogun coastal water as shown in Table 2, which indicated that *E. fimbriata* increased in weight with their corresponding increase in length. The LWR for the combined male and female sample is presented in Fig. 3. The body weight was strongly correlated with standard length

(SL) ($r^2 = 0.93$) for pooled samples. The "b-value of 2.92, was not significantly different from 3, hence the species exhibited isometric growth in the habitat.

Table 2: Length–weight relationship parameters of males, females and both males and females of *E. fimbriata* in Ogun coastal water

Gender	DF	Slope (b-value)	Intercept	r^2	Linear model	Curvature model
Male	1034	2.95	0.0297	0.951	LogW=2.95L-log1.39	W=0.0297L2.96
Female	1086	2.89	0.0291	0.899	LogW=2.89L-log1.34	W=0.0291L2.88
Combined	2120	2.92	0.0284	0.967	LogW=2.92L-log1.29	W=0.0284L2.92

DF = Degree of freedom and r^2 = regression coefficient

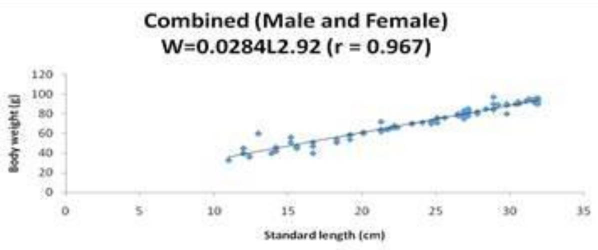


Figure 3: Length weight relationship for both males and females *Ethmalosa fimbriata* in Ogun Coastal Water

Figure 4 shows the linearized length-converted catch curve which was used to extrapolate the average annual total mortality rate, Z, 2.69yr^{-1}. The estimated instantaneous fishing mortality rate F = 1.36yr^{-1}, and the natural mortality (M) of 1.33yr^{-1} was recorded for *E. fimbriata* in the study area with an exploitation rate, E, of 0.51yr^{-1}.

The length frequency distribution with the superimposed growth curve output for the twenty-four successive months from the FiSAT analyses for *E. fimbriata* is shown in Figure 5. The estimated growth parameters of *E. fimbriata* on the Gulf of Guinea were TL∞ (cm) = 32.57, K (yr−1) = 0.65, t_0 = 0.35yr^{-1} and ϕ' = 2.84. The equation of Von Bertalanffy function of this species was TL = 32.6{1 – exp [-0.65(t-0.240)]}.

Figure 6 depicts the condition factor K for *E. fimbriata* in the study area. The condition factor fluctuated throughout the sampling months. It ranged from 1.3 in September to 1.76 in April.

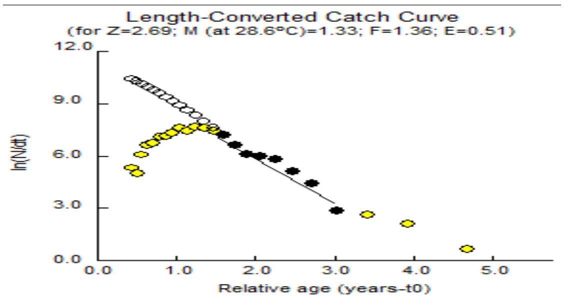


Figure 4. FiSAT output of linearized length-converted catch curve for *Ethmalosa fimbriata* in Ogun coastal water.

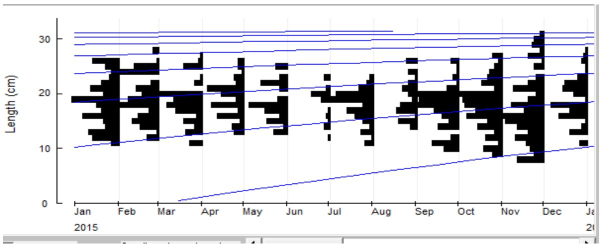


Figure 5. Length-frequency distribution output from FiSAT with superimposed growth curves for *Ethmalosa fimbriata* in Ogun coastal water

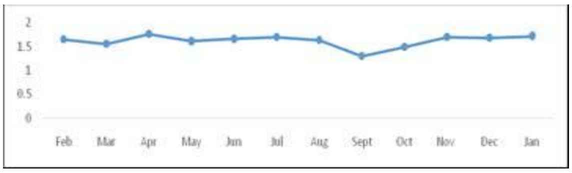


Figure 6. Mean Monthly Condition Factors of *Ethmalosa fimbriata* in Ogun coastal water

Discussion

The high population of *E. fimbriata* recorded in this study indicate the preponderance of the species which corroborated the report of (Odulate *et al.*, 2014) in Ogun marine water of Nigeria. The length frequency distribution of the species in Ogun Coastal water showed a bi-modal distribution which implied that these species showed an even temporal distribution across the study area and throughout the sampling period (Figure 2). The length frequency distribution showed a bi-modal distribution which indicated probably the existence of two cohorts within the population. LWR of *E. fimbriata* showed that there were several size groups of the species in marine coastal water of Ogun State and the size group 16-17.9cm and 24.0-25.9cm were predominant (Table 2). This observation confirmed the availability of juveniles, post-juvenile and adults in the coastal water while the variations recorded in the fish sizes indicated that the fish population ranged from immature specimens to fully matured ones earlier reported by Jones (2002). The total length of *E. fimbriata* which ranged between 8.0cm and 31.9cm, was in agreement with the findings of Sossoukpe *et al.*, (2016) in their study off Benin West Africa where a size range of 7.2-30.6cm was recorded for *S. marderensis*, but *E. fimbriata* grew bigger in this study area. The wide range of TL could also be attributed to variation in the mesh sizes of gillnet used during the study. The estimated theoretical length at infinity ($L\infty$) of 32.57cm in this study suggested that the stock of *E. fimbriata* being exploited was mostly the medium-sized individuals as larger Sardines with $L\infty$ of 43.0cm have been reported in Delta, Nigeria (Marcus 1989). It has, however, been reported that the maximum size attainable in fishes is location-specific according to Frota *et al.*, (2004). The length-weight data for *E. fimbriata* in this study was similar to those reported by Ecoutin and Albaret (2003), Konan *et al.*, (2007) and Omogoriola *et al.*, (2011) in West African waters. However, it has been reported that parameters of length-weight relationships are affected by several factors which include the season of the year, sample size, habitat, sex, diet, health, fish activities among others (Bagenal and Tesch, 1978; Pauly and Munro, 1984).

The regression co-efficient "b" value represents the body form of a fish species. It is directly related to the weight which is affected by temperature, food supply and spawning conditions as reported by Offem *et al*., (2008). The regression co-efficient of 2.92 recorded for this fish species agreed with the findings of Pauly and Gayanilo (1997) that b-values usually range between 2.5 and 3.5. The b-values was not significantly ($P<0.05$) different from 3; which showed a negative allometric growth pattern. This finding corroborated the report of Ama-Abasi *et al.*, (2004) who also reported a negative allometric growth pattern for the same species of fish in Cross River estuary. Several authors have reported both positive and negative allometric growth patterns for different fish species from various water bodies. Fafioye and Oluajo (2005) reported similar observation on some related fish species in Epe Lagoon, Nigeria. Abdul *et al.*, (2016) also reported b-value range of 2.53 to 3.35 for some fish species in coastal estuary of Ogun State. Abowei (2009), Nieto-Navarro *et al.*, (2010) and Kamaruddin *et.al.* (2011), also observed negative allometric growth pattern for some fish species in their various habitats.

This result also conformed views of Abdul *et al*. (2015) and Sossoukpe *et al*. (2016), who reported that fish do not retain the same size throughout their life span.

The correlation co-efficient (r^2) recorded for *E. fimbriata* in this study was relatively high which implied an increase in length with increase in weight. This result agreed with the findings of Kohler *et. al.* (2000) and Konan *et. al.* (2007) on some fish species from different water bodies.

The mean condition factor which indicated the suitability of the aquatic ecosystem for the growth of *E. fimbriata* was 1.62 while the mean monthly condition factor ranged from 1.3 in September to 1.76 in April. These results varied slightly from the condition factor (K) of between 0.77 – 0.81 reported by Abowei (2009) in Niger-Delta, which showed that the species were in good condition in the study area. However, the condition factor reported in this study was higher than the report of other authors including Odulate *et al.*, (2014) who reported mean condition factor of 1.21 for some species in the Gulf of Guinea. K values less than 1 implies that a fish species is in a poor state of well-being within its habitat while values greater than 1 implies that fishes are in good physiological state of well-being within their habitat. The K-values of *E. fimbriata* in this study were mostly greater than 1 which implied that the species was in good condition in Ogun coastal marine water.

The estimated mortality parameters of this species indicated an over-exploitation of the fish in the study area. A high ($>1yr^{-1}$) fishing mortality rate for *E. fimbriata* affirmed the high economic value of this fish species. Moreover, the exploitation rate ($E>0.51yr^{-1}$) for this species indicated that *E. fimbriata* was under ecological threat of extinction in Ogun coastal water.

Conclusion

Mortality parameters of the fish species indicated an over-exploitation of the stock of *E. fimbriata* in Ogun Coastal water. Despite the economic importance of this species to the fisherfolks in the study area, the study showed that the existence of, *E. fimbriata* was under ecological threat of extinction in Ogun marine coastal water. Thus, management actions such as mesh size regulation and closed season/areas are considered necessary for sustainable exploitation and conservation of *E. fimbriata* in the study area.

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