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Research Article

STOCK STATUS OF *LABEO SENEGALENSIS* (VALENCIENNES, 1842) FOR CONSERVATION AND MANAGEMENT STRATEGIES IN OGUTA LAKE, IMO STATE, NIGERIA

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ABSTRACT
Stock status (age, growth rates, Recruitment, Mortality and Exploitation rate) of African carp: *Labeo senegalensis* in Oguta Lake was investigated from September 2023 to April 2024. Assorted fishing gears were used to catch fish by professional fishers' folks in designated sampling stations of the lake. Standard lengths of *L. Senegalensis were* measured to the nearest centimeter (cm). The length data obtained were analyzed with Electronic Length Frequency Analysis (ELEFAN II) and Von Bertalanffy Growth Model (VBGM). The ELEFAN II plot showed 8-year classes and the VBGM was $L_{(t)} = 63[1 - e^{-0.13(t - 0.621)}]$.The estimated length infinity (L_∞) was 63cm, Total Mortality (Z) = 2.688yr^{-1}, Natural Mortality (M) = 0.393yr^{-1}, Fishing Mortality (F) = 2.283yr^{-1}, and Exploitation rate (E) = 0.853yr^{-1}. The fishery is not operating at its Maximum Sustainable Yield (MSY). *Labeo senegalensis* is experiencing over exploitation and over fishing in Oguta Lake. The recommended management strategies are a). Restriction on the use of small mesh sizes; b) Restriction on the catching of sexually immature individuals (*i.e.,* those below the length of 42cm) and; c) Closing of fishing on the identified recruitment peak periods of the month of April yearly to ensure the conservation of *L. senegalensis* and avoid the collapse of its fishery in Oguta Lake.

Keywords*: L. senegalensis, Oguta, Status, Mortality, Management*

INTRODUCTION
A good understanding of fish stock status (i.e., how age, growth, recruitment, and mortality interact to affect abundance) is needed to inform conservation and management policies for sustainable yield (Enyenihi *et al.*, 2017). According to WWF (2016), population dynamics describes how a given population grows and shrinks over time, controlled by birth, death, and migration. It is the basis for understanding changing fishery patterns and issues such as habitat destruction, predation, and optimal harvesting rates (Olurin & Aderibigbe, 2017). FAO (2018) noted that freshwater fish stocks are in a state of crisis worldwide due to a perceived increase caused by changes in the monitoring and measuring, rather than the actual changes in fisheries production. *Labeo senegalensis* is one of the common species of the Genus *Labeo,* found in Africa (Nelson, 2006), and is a highly valued food fish. It is of commercial importance in artisanal Fisheries in Nigeria and other West African Countries (Ogueri, 2004; Montchowui *et al*., 2008). *L. senegalensis* belongs to the family CYPRINIDAE, and they make the largest part of the

biomass in most water bodies except for fast-flowing rivers (Turan *et al*., 2013). CYPRINIDAE constitute the carp, true minnows, and their relatives, commonly referred to as the carp family, and the largest family of vertebrate animals in the Genera taxon (Adeyemi & Akombo, 2012).

Oguta Lake is the largest lacustrine ecosystem in South-East Nigeria (Wikipedia, 2025) and serves as a source of water for domestic use, income, plant and fish species to the innumerable communities close to the Lake. Over the years, the lake has experienced habitat degradation due to local sand mining and Government authorized dredging. *L. senegalensis* is relatively abundant in Oguta Lake (Okogwu& Ugwumba, 2012). Navarro – Ortega *et al.* (2022) postulated that anthropogenic pressure causes changes in the physical, chemical and/or biological component of freshwater ecosystems when the carrying capacity of ecosystem decreases below the ability to absorb stress. As deduced by WWF (2016) the current rate of Fish population decline in Freshwater systems is double the rate for marine systems.

On the IUCN (2024) Red List, *L. senegalensis* is listed as "Least concern" since 2019 when it was the last time the species was assessed. However, Fish Base (2024) noted that conservation statuses can change over time due to environmental and anthropogenic factors. Therefore, ongoing monitoring and research are essential for effective conservation efforts. Works on *L. senegalensis* and Oguta Lake abound (Okogwu & Ugwumba, 2010; Turan *et al*., 2013; David, 2014; Olurin & Aderibigbe, 2017; Kakioi & Nawa 2019; Ukagwu & Okeke, 2024) but no published works on the stock assessment of the species in the Lake.The aim of this study is therefore, to investigate the stock status of *L. senegalensis*in Oguta Lake in view of providing baseline information useful in formulating management strategies for the species conservation and sustainable Yield of the Fishery in the Lake.

MATERIALS AND METHODS

Four sites in the main basin of Oguta Lake (Fig. 1) were designated as sampling stations. The sites were selected for easy access and proximate to the major fish landing areas of the Lake. Catching of fish was done by professional fisher folks using assorted fishing gears: (Mesh sizes 15 – 25mm) hooks and line, traps and baskets. Fishing was done forthrightly from September 2023 to April 2024 corresponding to period of high water volume (September - December) and low water volume (January – April).

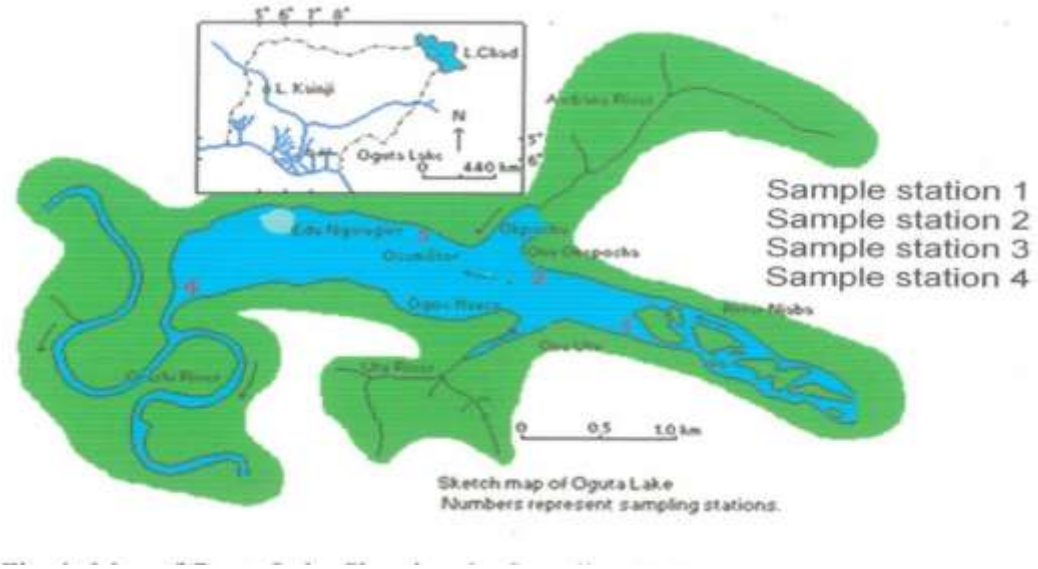

Figure1:Map of Oguta Lake showing the sampling stations with numbers

Fish species were identified with identification keys of Paugy 2003 and Adesulu & Sydenhan (2007) standard length (from snout to caudal peduncle) of *L. senegalensis*were measured to the nearest centimeter (cm). The length data obtained were grouped into 1-cm class intervals and analyzed with

Electronic Length Frequency Analysis II (ELEFAN II) of FISAT II (FAO – ICLARM stock assessment) tools as explained in details by Gayanilo *et. al*., (2025). The FISAT II makes use of the Von Bertalanffy Growth Model (VBGM):

$L_{(t)} = L_{\infty}[1 - e^{-k(t - to)}]$

Where,

$L_{(t)}$ = Length of fish at time, t

L_{∞}= Length infinity (Asymptotic length maximum length the fish can reach at the ecosystem)

K = Growth curvature to which the first tends to grow to L_{∞}

t = Age of fish at time, t (In years)

t_o = time the length of fish is zero

The total mortality rate (Z) was determined by the length-converted catch curve and the natural mortality (M) calculated using Pauly's empirical formula (Pauly, 1984) incorporated in the FISAT tools.

The Fishing Mortality (F) was computed by the difference, F = Z – M. The exploitation rate (E) was derived from the quotient: E = F/Z.

The length at First maturity (L_m) was estimated as $L_m = \frac{2*L\infty}{3}$ (Hoggarth *et al*., 2006)

Relative Yield per Recruit (Y^1/R) and Relative Biomass per Recruit (B^1/R) were determined using the model as modified by Pauly& Soriano (1986) also incorporated in the FISAT II.

L_c is deduced from the ELEFAN II plot which is the minimum length in the catch.

The maximum Sustainable Yield MSY is extrapolated from Y'/R, using FAO (2011):

$Y^1/R = 1$. Indicates the fishery is operating at its maximum sustainable Yield (MSY)

$Y^1/R < 1$. Indicates that the fishery is not operating at its MSY and needs room for improvement.

$Y^1/R > 1$. Is not biologically possible as it is an indication of the fishing producing more Yield than is sustainable.

The Reproductive load was calculated from $Lc/L\infty$ (Froese, 2006) and interpreted thus:

$Lc/L\infty < 0.5$. Shows over-fishing as fish are being caught before they reach half their maximum potential size

$0.5 \leq Lc/L\infty < 0.7$.Suggests moderate fishing pressure with fish being caught between half and 2/3rd of their maximum potential size.

$Lc/L\infty > 0.7$. Indicates sustainable fishery practices as fish is being caught closer to the maximum potential size.

RESULTS

A total of 32,451 specimens of *L. senegalensis* were examined ranging in size from 7 to 62cm with mean ± standard deviation (33.5 ± 15.6cm 95% CL). In Fig.1 is the ELEFAN II plot of *L. senegalensis*. The figure combines the length Frequency distribution plot (the vertical bar segments) with the Von Bertalanffy growth curve (the continuous blue lines) fitted to the data

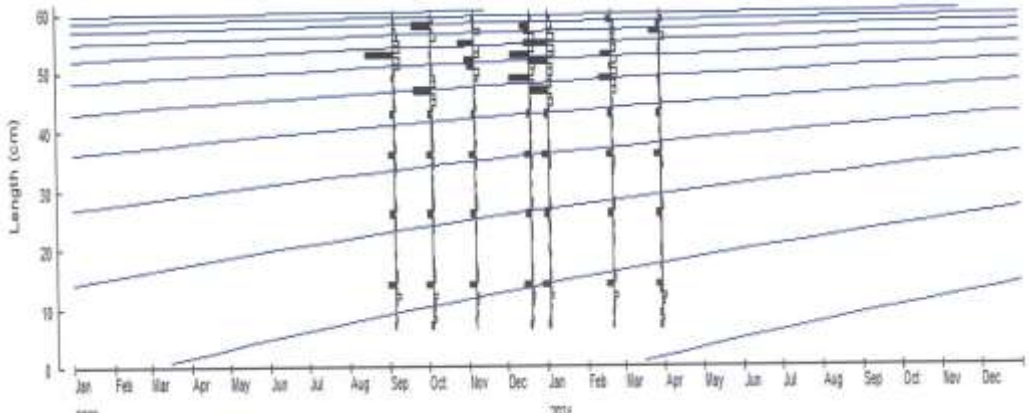

Figure 2: ELEFAN II plot of *L. senegalensis* In Oguta Lake.

The Length Frequency bars show multiple modes of peaks, indicating different age/sizes classes present in the population over the sampling period from September 2023 to April 2024. The seasonal pattern with higher frequencies of smaller lengths observed around April – June each year likely representing recruitment of new cohorts of young fish. The Von Bertalanffy growth curve models capture the over-all growth trajectory, showing asymptotic approach towards maximum length as the fish get older. The gap between the upper and lower blue curve represents the variation or confidence intervals around the predicted lengths at each age (1 – 8) for the species.

The VBGM estimated was:

$$L_t = 63\ [1 - e^{-0.13(t - 0.621)}]$$

In Table 1 is shown the length-at-age growth rate of the fish during the period of observation

Table 1. Length-at-age and Growth rate of *L. senegalensis* in Oguta Lake

Age	Length (cm)	Growth rate (cm/yr)
1	27.15	
		10.60[a]
2	37.81	
		7.02[b]
3	44.88	
		5.23[c]
4	50.11	
		4.08[d]
5	54.19	
		3.7[d]
6	57.89	
		1.4[e]
7	59.29	
		1.12[e]
8	60.41	

Footnote: Values with different superscript show significant difference ($p < 0.05$)

The highest growth rate in the Table is between the Age 0 and 1 (27.15 cm/yr) with the least growth rate recorded between age 7 and 8; at the older age there appears to be an insignificant difference ($p > 0.05$) in the growth rates.

In Fig.3 is presented the Length-converted catch curve. The X-axis shows the relative age the fish expressed 10 years multiplied by 10 (10 years -10). The Y-axis represents the natural logarithm of the catch or abundance of each age group.

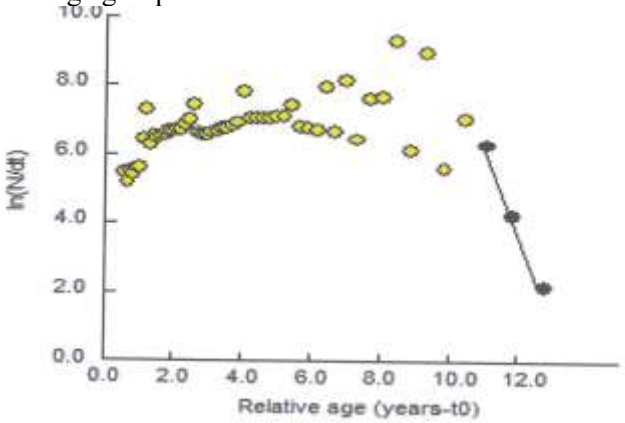

Figure 3: The Length converted catch curve of *L. senegalensis* in Oguta Lake

The catch curve (Fig. 3) shows a generally descending pattern as age increases, which is expected due to natural mortality and Fishing pressure reducing the abundance of older ages. There appears to be two distinct segments in the curve – a relatively flat portion for younger ages (up to around 4 years)followed by a steeper decline for older age groups. The flatter group for younger ages shows reduced mortality for those age classes. The steeper decline in the upper part of the curve suggests higher mortality rates, likely due to a combination of natural causes and fishing pressure on the older, larger individuals. The points marked in black towards the end of the curve represent the oldest age group and may be subject to higher uncertainties due to fewer individuals remaining at those advanced ages.

The Total Mortality (Z) estimated was 2.688$yr^{=1}$, Natural Mortality (M) = 0.393yr^{-1}, Fishing Mortality (F) = 2.283$yr^{-1}$and Exploitation rate (E) = 0.853yr^{-1}. The length at first sexual maturity (L_m) = 42cm.

In Fig. 4 is shown the Recruitment rate of *L. senegalensis*. The Figure has a pyramidal shape with higher rates at intermediate lengths/ages and lower rates at smallest and largest size classes

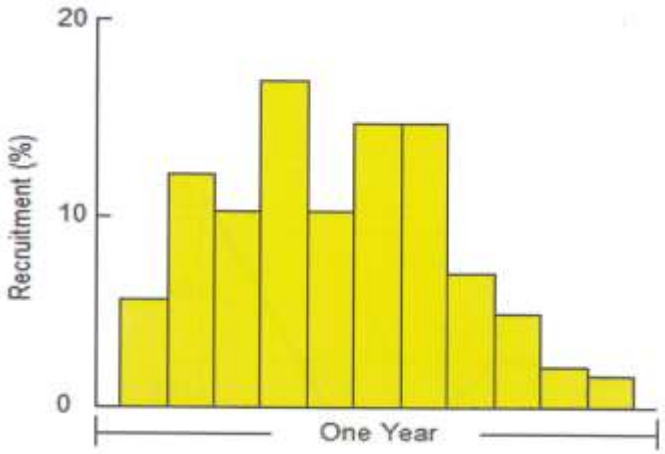

Figure 4: Recruitment Rates per year of *L. senegalensis* in Oguta Lake

The peak recruitment as seen on Fig. 4 occurs around the middle of the size range, which shows the age/ size/ April at which most successful reproduction and survival of juveniles occur. There is a steady decline in recruitment towards both the smallest and largest size classes represented on the bar graph.

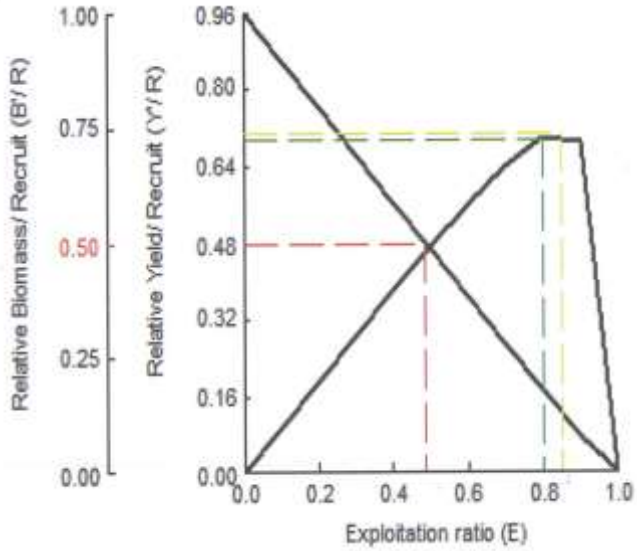

Figure 5: Stock status of *L. senegalensis* in Oguta Lake

Fig. 5 depicts the stock status of *L. senegalensis*. The maximum Yield per Recruit (Y^1/R) occurs at an Exploitation ratio of around 0.5, as indicated by the peak of the red curve. The Biomass-per-recruit (B^1/R) curve (green line) is initially flat, then start declining sharply beyond an exploitation ratio of around 0.8.
The intersection of the Y^1/R and B^1/R curve occurs at an exploitation ratio of approximately 0.56 that represents the reference the point for Maximum Sustainable Yield (MSY). The Exploitation rate appears around 0.85(indicated by the vertical yellow line which falls to the right of the MSY reference point. At the exploitation level (E = 0.85) the relative yield per recruit is slightly lower than the maximum possible while the relative biomass per recruit has declined from its initial level. This indicates that the fishing is not operating at its MSY.
The Reproductive Load ($Lc/L\infty$) computed was $0.111yr^{-1}$ which is lesser than 0.5 indicates over-fishing.

DISCUSSION

The stock assessment of *L. senegalensis* in Oguta Lake were estimated with ELEFAN II and VBGM. The findings provided baseline information on the ages, growth rates, mortality rates, exploitation rates and recruitment dynamics of this commercially important fish species that can inform effective management strategies. The L_∞ (63cm) estimated in this study compared similarly to other studies. Kakior & Nawa (2019) observed 63.5cm in the Volta Basin while Abobi &Ekau (2015) recorded 67.2cm in the Cross-River estuary. The estimated age classes in Oguta Lake were 8 years. In Sudan, Mutasim *et al*., (2024) estimated 5.604 years while L_∞ = 42cm. All the aforementioned studies relied on ELEFAN and VBGM but the difference in the estimated parameters were due to the different number of samples examined and the different ecological habitat.*L.senegalensis* grows faster at younger ages than at older ages which is common to many fish species (Neumann *et al*., 2012).

The length-frequency data and VBGM curves revealed distinct modes representing different age/size classes with evidence of seasonal recruitment patterns. The presence of multiple cohorts and the ability to track their progression over time is crucial for understanding the population's age structure and dynamics (Ecoutin *et. al*., 2005). The length-converted catch curve (Fig. 3) provided valuable insights into the mortality rates and exploitation patterns of *L. senegalensis* in Oguta Lake. The descending trend in the catch curve, particularly at the older age groups indicated the combined effects of natural and fishing mortality on the population (Graves & Macdowell, 2006). As reported by Entsua-Mensah*et al.* (2016) the flatter portion of the curve for younger ages could be attributed to higher recruitment success or reduced mortality during early life stages.

Total Mortality (Z) = $2.688yr^{-1}$, Natural Mortality (M) = $0.393\ yr^{-1}$ and fishing Mortality (F) = $2.283yr^{-1}$ indicates that of the total mortality, Natural mortality contributed a paltry 14.62% of death while death due to fishing mortality contributed a whopping 84.93%. This calls for concern. Optimal fishing is when M = N = F = $0.5yr^{-1}$ (Hilborn *et al*., 2001). In Oguta Lake, the F estimated was $2{,}283yr^{-1}$, a clear indication of over-fishing.

The Exploitation rate ($0.85yr^{—1}$) far exceeds the MSY in Fig.5 and also the Y^1/R values fall below 1. All showing that the *L. senegalensis* is not operating at its MSY.
The reproductive load ($Lc/L\infty$) of $0.111yr^{-1}$ is below $0.5yr^{-1}$ which shows over-fishing (Froese, 2016) and the fish being caught before they reach their maximum potential size. Morgan (2008) postulated that Reproductive Load is a critical component of fish stock assessment as it helps to ensure the long-term sustainability of fish population and ecosystem they inhabit. The length at first sexual maturity observed in this study was 42cm while the mean length was 33.5cm showing that most individuals were caught before they reach sexual maturity. This is referred to as "Recruitment over fishing" (Gallagher 2013); which takes place where adult population (spawning biomass) is depleted to a level where it no longer has the reproductive capacity to replenish itself, in other words, Sufficient adults are not available to produce offspring.

CONCLUSION AND RECOMMENDATIONS

Using ELEFAN II and VBGM, it has been established that *L. senegalensis* is experiencing over–exploitation and over fishing in Oguta Lake and management strategies should include:

1. Engaging the relevant stakeholders to ensure there is restriction on small mesh sizes as many small – sized individuals are dominant in the catches.
2. Restricting the catching of sexually immature individuals (*i.e*., those less than 42cm)
3. Closing the fishing season at the identified recruitment period on April every year and closure of fishing in spawning areas as means of attaining conservation measures of *L. senegalensis* and avoid the collapse of its Fishery in Oguta Lake,

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