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Stock status of *Hepsetus odoe* (Bloch 1974) in river Imo, Nigeria, for conservation and management strategies for sustainability

Estado de la población de *Hepsetus odoe* (Bloch 1974) en el río Imo, Nigeria, para estrategias de conservación y gestión sostenibles

C. Ogueri[1]; C. N. Anyanwu[1]; G. S. Adaka[1]; M. N. O. Ajima[1]; C. Utah[1]; D. Nwaka[1]; C. F. Ezeafulukwe[1]; P. O. Oguleru[1]; B. Alabi[2]; E. T. Adebayo[3] *

1 Department of Fisheries and Aquaculture Technology (FAT), School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology, Owerri.
2 Department of Surveying and Geoinformatics, Federal University of Technology, Owerri.
3 Department of Biosciences and Biotechnology, Faculty of Science, University of Medical Sciences Ondo City, Ondo State.

* Autor corresponsal: tadebayo@unimed.edu.ng / adebayotemitope.et@gmail.com (E. T. Adebayo).

ORCID de los autores:
C. Ogueri: https://orcid.org/0009-0007-4904-6869
G. S. Adaka: https://orcid.org/0000-0001-6070-071X
E. T. Adebayo: https://orcid.org/0009-0004-2675-0325

ABSTRACT

The fisheries stock status: growth, recruitment rates, Maximum Sustainable Yield (MSY), Mortality and Exploitation rate of *Hepsetus odoe* in river Imo, Nigeria were investigated. Assorted fishing gears with mesh sizes (15 – 30 mm) were used to catch fish in designated 4 sampling stations of River Imo from January to July 2023. Standard lengths (S.L.) of 131,226 specimens of *H. odoe* were taken to the nearest centimeter (cm) and analyzed with Electronic Length Frequency Analysis (ELEFAN II) then fitted into the Von Bertalanffy Growth Model (VBGM). The estimated VBGM was $L_{(t)} = 55.65[1 - e^{-0.24(t-0.9)}]$. The estimated growth parameters value was for $L_\infty = 55.65$ cm; Total Mortality (Z) = 1.21 yr^{-1}, Natural Mortality (M) = 0.52 yr^{-1}, Fishing Mortality (F) = 0.69 yr^{-1} and Exploitation rate (E) = 0.57 yr^{-1}. *H. odoe* was slightly over-exploited in River Imo, being that estimated Exploitation maximum (Emax) was 0.52 yr^{-1}. The Relative Yield per Recruitment (Y'/R) indicates that the fishery is not operating at its MSY. The Reproductive load indicated over-fishing. There should be restrictions on the mesh sizes in use and closed fishing season of *H. odoe* in the identified recruitment peak of the month of June, every year to avoid the collapse of the species' fishery in River Imo which may threaten the current conservation status of the species by International Union for Conservation of Nature (IUCN).

Keywords: *H. odoe*, river Imo; mortality; exploitation; conservation; sustainable yield; strategies.

RESUMEN

Se investigó en este estudio el estado de las existencias pesqueras: crecimiento, tasas de reclutamiento, rendimiento máximo sostenible (RMS), mortalidad y tasa de explotación de *Hepsetus odoe* en el río Imo, Nigeria. Se utilizaron diversos aparejos de pesca con tamaños de malla (15 - 30 mm) para capturar peces en 4 estaciones de muestreo designadas en el río Imo de enero a julio de 2023. Las longitudes estándar (LE) de 131226 especímenes de *H. odoe* se redondearon al centímetro (cm) más cercano y se analizaron con análisis electrónico de frecuencia de longitud (ELEFAN II) y luego se ajustaron al modelo de crecimiento de von Bertalanffy (VBGM). El VBGM estimado fue $L_{(t)} = 55,65[1 - e^{-0,24(t-0,9)}]$. El valor estimado de los parámetros de crecimiento fue para $L_\infty = 55,65$ cm; Mortalidad total (Z) = 1,21 $año^{-1}$, Mortalidad natural (M) = 0,52 $año^{-1}$, Mortalidad por pesca (F) = 0,69 $año^{-1}$ y Tasa de explotación (E) = 0,57 $año^{-1}$. *H. odoe* fue ligeramente sobreexplotado en el río Imo, siendo que la máxima explotación estimada (Emax) fue de 0,52 $año^{-1}$. El rendimiento relativo por reclutamiento (Y'/R) indica que la pesquería no está operando a su RMS. La carga reproductiva indicó sobrepesca. Debería haber restricciones en los tamaños de malla en uso y una temporada de pesca cerrada de *H. odoe* en el pico de reclutamiento identificado del mes de junio, cada año para evitar el colapso de la pesquería de la especie en el río Imo que puede amenazar el estado de conservación actual de la especie por la Unión Internacional para la Conservación de la Naturaleza (UICN).

Keywords: *H. odoe*, río Imo; mortalidad; explotación; conservación; rendimiento sostenible; estrategias.

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INTRODUCTION

Age and growth studies are of practical importance for describing the status of fish population and for predicting the potential of Fisheries (Hillborn & Walters, 2013). Hossain et al. (2009) stated that information on population parameters i.e. growth, reproduction, recruitment as well as mortality of fish is vital to the implementation of sustainable management strategies for their better conservation.

Hepsetus odoe, commonly known as African pike, is a freshwater fish species distributed across west and central Africa. It was formerly believed to be the only species in the genus (Stewart, 2003) and widespread in sub-Saharan Africa (Nelson, 2006) but studies in 2011 – 2013 (Charles & Favour, 2013) found that there are several species recognized as *H. cuvier, H. Kingsleyae, H. Lineata and H. occidentalis*. This true *H. odoe* is restricted to West and Central Africa (Myers et al., 2025).

H. odoe is abundant and constitute important commercial fish species in Nigeria's Rivers and streams including River Imo (Olatubuson & Raji, 2005). River Imo is ranked a major River in Nigeria with a distance of 240 km from its source in Isuochi, Okigwe to Atlantic Ocean (Figure 1). The significance of the river is highlighted in Afigbo (2005).

Recent publications on *H. Odoe* focus on the biology of the species. Idowu (2023) reported that *H. Odoe* exhibited allometric growth in Ado Ekiti Reservoir, Nigeria, with four distinct age groups using length frequency distribution method of age and growth determination.

H. odoe inhabited vegetated environment river back waters, lagoons and sluggish tributaries as small-sized *Hepsetus* fed heavily on small mochokid catfishes, *synodontis* spp while the adult are mostly Piscivorous (Winemiller & Winemiller, 1994).

H. odoe faces significant environmental threat in Alape River, Nigeria. Observation by Awugo & Igejongbo, (2024) indicates that the order of concentration of Heavy metals in *H. odoe* is as follows: Fe (2.26 mg/kg) > Ni (0.37 mg/kg) > Cu (0.23 mg/kg) > Mn (0.27 mg/kg) > Pb (0.05 mg/kg) > Cd (0.01 mg/kg) with higher concentrations observed in the gills and intestines around May and June.

According to Nuonagnom et al. (2025) in the length – weight relationship of *H. odoe* the b-values varied between 2.91 for males and 3.51 for females with mean value of 3.43 indicating positive allometric growth. The conservation status of *H. odoe* is currently listed as "Least Concern" on the IUCN (2024) Red list which indicates that the species is not considered to be threatened with extinction at the global level. However, it is essential to note that conservation statuses can change over time and local populations may still face threats or vulnerabilities (IUCN. op. cit).

In spite of several studies on *H. odoe* (Stewart, 2003; Stiassny & Teugels, 2007; Beyer, 2009; Decru et al., 2013), no published work is available on the stock status of *H. odoe* in River Imo. To fill this gap, this study is aimed at providing baseline information in stock status; growth, recruitment, mortality, reproductive Load, Maximum Sustainable Yield (MSY) and Exploitation rate of *H. odoe* in river Imo for conservation of the species and management strategies to ensure the sustainability of its fishery.

METHODOLOGY

Four areas within the main course of River Imo were designated as Sampling Stations (Figure 1). The sites were selected for easy accessibility and being major landing sites proximate to the River. Assorted Fishing gears; with mesh sizes: 15 to 30mm, hooks and line, basket and traps, were used to capture fish forthrightly by seasoned fisherfolks from January to July, 2023. Catches of fish mongers were also examined. The catches were sorted into their different species using identification keys of Paugy (2003) and Adesulu and Sydenham (2007). The Standard Length of the samples were taken to the nearest centimetre (cm) and grouped at 1 - cm interval, monthly. The length Data were analyzed with Electronic Length Frequency Analysis (ELEFAN II) of the FAO – ICLARM (FISAT) Assessment Tools as explained in details by Gayanilo *et al*. (2005) and then fitted into the Von Bertalanffy Growth Model (VBGM):

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

Where, $L_{t)}$ = Length of fish at age, t; L_∞ = Asymptotic Length (Maximum Length the fish will attain at that particular ecosystem); K = growth coefficient or the growth curvature to which the fish reaches L_∞; t_o = theoretical time when the fish length is zero; t = age of the fish in years.

The total mortality (Z) was estimated by the length-converted catch curve (Pauly, 1984) incorporated into FISAT II software. Natural Mortality (M) was also estimated by using Pauly's empirical formula. The Fishing Mortality (F) was calculated by F = Z - M. The Exploitation rate (E) was derived from the quotient E = F/Z and the isopleths from the FISAT II software. The length at first capture (Lc) was read from the ELEFAN II Plot. The probability of capture is determined from the probability of capture curve, thus.

L_{25} = probability of 25% fish capture

L_{50} = probability of 50% fish capture

L_{75} = probability of 75% fish capture

At first sexual maturity (L_m) was computed as $L_m = \frac{2 * L\infty}{3}$ (Hoggarth et al. 2006).

Relative Yield per recruitment (Y'/R) was Estimated as modified by Pauly and Soriano (1986). The Maximum Sustainable Yield (MSY) is extrapolated from the Y'/R using FAO (2011):

Y'/R = 1 indicates that the fishing is operating at its Maximum Sustainable Yield (MSY).

Y'/R < 1 indicates that the fishing is not operating at its MSY and needs room for improvement.

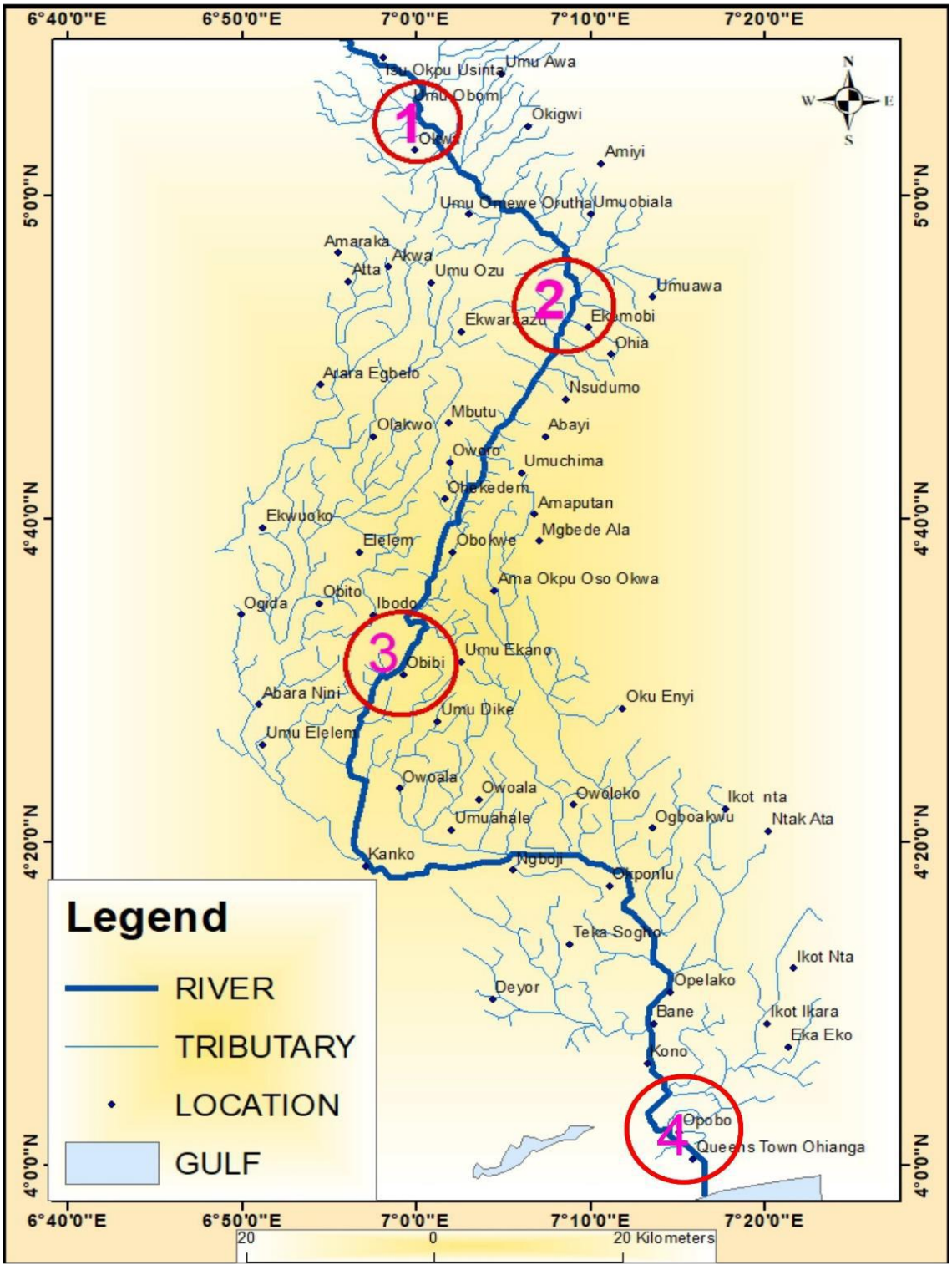

Figure 1. Map of River Imo showing the sampling stations indicated with numbers.

$Y/R > 1$ is not biologically possible as it would indicate that fishing is producing more yield than is sustainable.

The Reproductive load was derived from L_c/L_∞ (Froese, 2006) and applied thus:

$L_c/L_\infty < 0.5$ indicates overfishing as fish are being caught before they reach half their maximum potential size.

$0.5 \leq L_c/L_\infty < 0.7$ suggests moderate fishing pressure with fish being caught between half and 2/3rd of the maximum potential size.

$L_c/L_\infty \geq 0.7$ indicates sustainable fishing practices as fish are being captured closer to their maximum potential size.

RESULTS AND DISCUSSION

The total number of 131,226 specimens of *H. odoe* was examined ranging from 9 to 53 cm with mean ± s.d (35.5 ± 16.74).

The growth of a population or an individual is often represented by mathematical models describing the average change per unit of time (Conquest et al., 2015). According to Orians (2010), most of the variables in analytic population dynamics are defined as rates, e.g. changes in length or weight, changes in numbers, changes in biomass or Yield. They are all values per unit time. In this study, the method for analysis was ELEFAN II and Von Bertalanffy Growth Model (VBGM) which were chosen for handling large samples and easy computation. *H. odoe* was growing faster at younger ages than older ages and estimated to live up to 6 years. The asymptotic Length (L_∞) which refers to the largest theoretical length the fish could attain in its natural habitat assuming the fish grows throughout its life (Abobi & Ekan, 2018) was estimated at 55.65 cm. Stewart (2003) recorded maximum length of 47 cm in physical description but not of a particular freshwater body. Which means *H. Odoe* grows too big in river Imo. Also, Stewart (2003) estimated 5 years as the Average life span but the predictive life span in river Imo is between 6 and 7 years (Tabla 1). The discrepancies could be because of the number of samples observed and the different research methods/models applied in both studies and finally the water body.

The total mortality (Z) was 1.21 yr^{-1} while M = 0.52 yr^{-1} and fishing mortality (F) = 0.69 yr^{-1} predicting that the mortality of *H. odoe* is more from the fishing (57%) than of natural mortality (43%).

Fish species are optimally exploited where E = 0.5 (Pauly & Soriano, 1986). From the knife – edge method. The Emax was 0.52 yr^{-1} whereas the exploitation rate estimated was 0.57 yr^{-1}, which shows that *H. Odoe* in river Imo is slightly over-exploited. The yield per Recruit (Y^1/R) was less than 1 also indicated that the fishery is not operating at its MSY.

Reproductive load is a critical component of fish stock assessment as it helps to ensure the long-term sustainability of the fish population and ecosystem they inhabit. (Morgan, 2008). In this study, the Reproductive Load (L_c/L_∞) was 0.16 which was less than 0.5. Going by Froese (2006) measure, *H. Odoe* was undergoing over-fishing during the period of study and the fish are being caught before they reach half their maximum potential size. Ogueri (2004) noted that high catching of *H. Odoe* may be since the species is known to have a good taste and also increasing cost of living may force fishermen to harvest this fish heavily and make use of the wrong nets in order to sustain themselves.

Table 1
Length at-age and growth rates of *H. odoe* in river Imo from January to July 2023

Age (yr)	Length (cm)	Growth rate (cm/yr)
1	29.49	
		8.90[a]
2	38.39	
		5.57[b]
3	43.96	
		3.89[c]
4	47.85	
		2.79[c]
5	50.64	
		1.62[d]
6	52.31	
		1.11[d]
7	53.42	

Footnote: values with the same superscripts are not significantly different ($p > 0.05$).

The length at first maturity (L_m) was 37.1cm while the length at 50% capture was 50.05cm, which means that most of the sexually immature individuals were caught before they reach sexual maturity. This could be referred to as "Recruitment Over-fishing". Gallagher (2013) postulated that Recruitment over-fishing happens when the mature adult population (Spawning biomass) is depleted to a level where it no longer has the reproductive capacity to replenish itself. There are not enough adults to produce offspring.

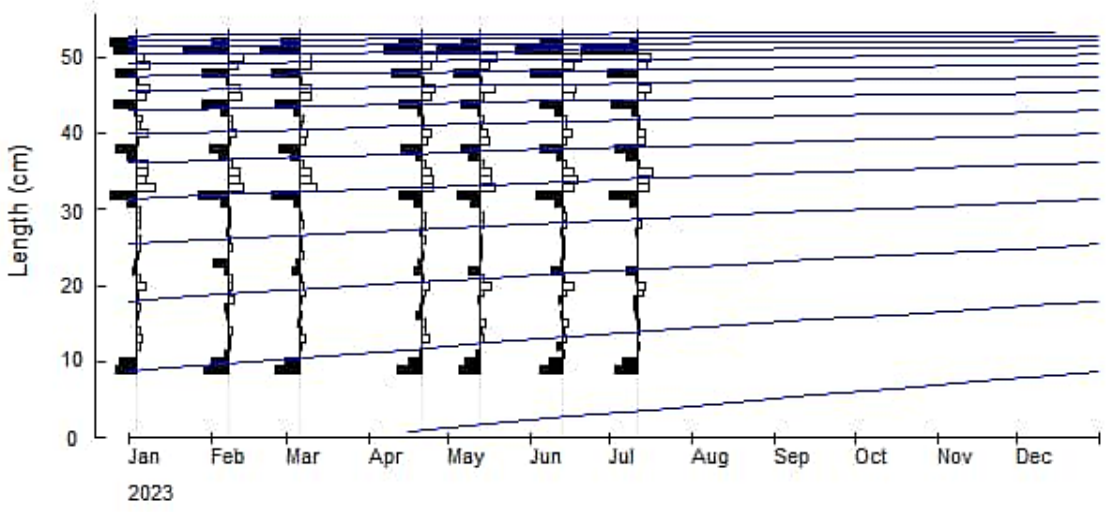

Figure 2. ELEFAN II plot of *H. odoe* in River Imo from January to July, 2023.

The growth rate was highest between zero and 1 year followed by between 1 year and 2 years and then lesser at older Ages. The probability of capture obtained from the Probability of Capture Curve in Figure 3: showing L_{25} = 49.21 cm, L_{50} = 50.05 cm and L_{75} = 50.94cm. The L_m = 37.1cm. Note that the L_{50} is greater than the L_m. The VBGM was:

$$L_{(t)} = 55.65[1 - e^{-0.24(t-0.9)}]$$

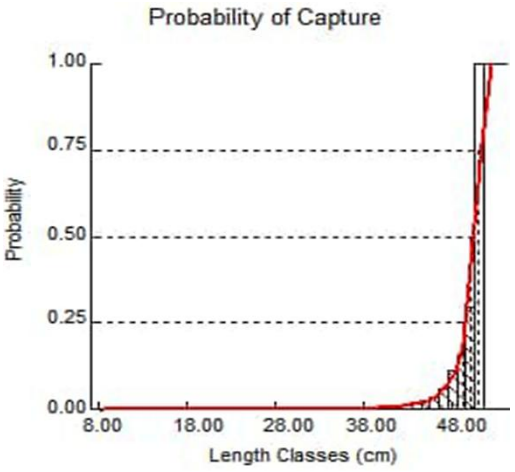

Figure 3. The probability curve of capture of *H. Odoe* in Imo River.

The Length-converted catch curve in Figure 4 shows Regression statistics: y -intercept, a = -9.54; slope, b = 1.26; r = 0.89; n = 34, F = 0.69, M = 0.52, Z = 1.98 yr^{-1}, and E = 0.15 yr^{-1}. The yellow spots showed individuals that were fully exploited.

Individuals that were not fully recruited to the catches were represented with dark spots. The slope of the regression analysis suggested a total mortality rate of 1.21 yr^{-1} of *H. odoe* in River Imo. The recruitment rate per year was shown in Figure 5. The highest recruitment per year was in the month of June. The Recruitment rate shows the age of length the fishes start entering the catches.

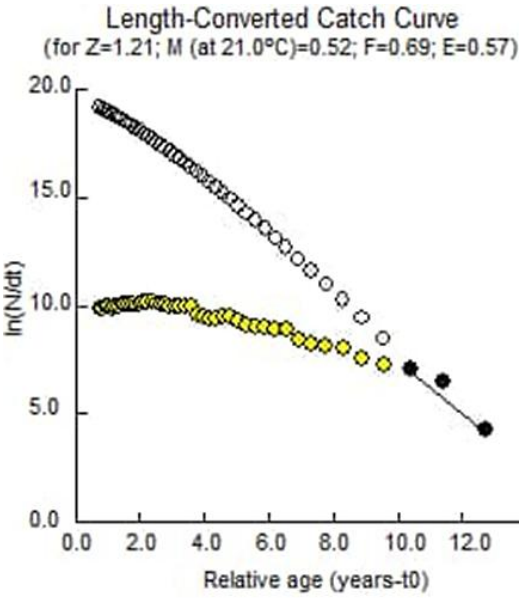

Figure 4. The length converted cash curve of *H. Odoe* in Imo River.

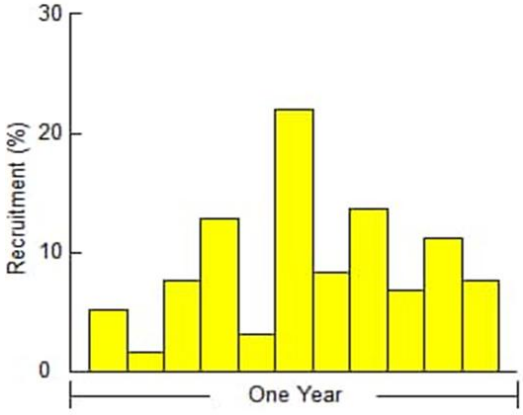

Figure 5. Recruitment rate of *H. Odoe* in Imo river from January to July 2023.

CONCLUSIONS

Fisheries parameters of *H. Odoe* were investigated by employing Von Bertalanffy Growth Model (VBGM) which indicated Fishing Mortality (F = 0.69 yr^{-1}), Natural mortality (M = 0.52 yr^{-1}), Total Mortality (Z = 1.98 yr^{-1}) and exploitation ratio (E = 0.59 yr^{-1}). In optimal fishing; F = E = 0.5 yr^{-1} but since the values of F and E are higher in this study, that means the fish species is experiencing over fishing and over exploitation.

There should be tight restriction on the use of small mesh sizes in the catching of *H. Odoe* in the River. The length of first sexual maturity was L_m = 37.1 cm and there were Preponderance of individuals below the L_m. It is, therefore, recommended that no *H. Odoe* below the length of 37.1cm is to be caught to avoid the depletion of the spawning stock. There should be no fishing of *H. Odoe* within the identified Recruitment period of the month of June every year to ensure the conservation and sustainability of the species in Imo River.

Further Research should focus on identification of the spawning/breeding areas of *H. odoe* in Imo River so that those areas will be closed for fishing of *H. odoe* to allow their rapid re-population before *H. odoe* fishery collapses in the river.

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