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Population Dynamics of Sardinella maderensis in Lagos Lagoon, South-West, Nigeria

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ABSTRACT
Stock assessment gives important scientific information for conservation and management of fish stocks. The study assessed stock and population dynamics of Sardinella maderensis in Lagos Lagoon for one year with monthly sampling. Commercial catches from fishermen were randomly sampled during fishing on the lagoon. Data on catch, distribution and abundance, physical and chemical parameters of water, length-weight relationship and population parameters of Sardinella maderensis were obtained from three zones divided at 3km intervals. FISAT 11, was used to analyse the data collected during the study. The total of 2,575 specimens were sampled. Mean TL ranged from 10.51±1.39 to 11.38±1.75 with corresponding mean weight of 17.28±3.11 and 1.8.11±2.05. The results showed that, the growth performance index (φ') and initial condition parameters (t0) were 2.91 and -0.007 years, respectively. Sardinella maderensis showed a b-value of 2.78 (CL95 = 2.65 – 2.79). The study concluded that exploitation of Sardinella maderensis was high and posed a threat to its population due to higher ratio of male to female.
KEYWORDS: Population dynamics, Lagos Lagoon, Stock Assessment, Fish.

I. INTRODUCTION

The Lagos Lagoon Complex is the largest lagoon system along West Africa's Gulf of Guinea coast. With the exception of some dredging areas, particularly near the Lagos harbour, the Lagoon is typically shallow, with a depth range between 0.3 and 3.2 m. The study area for this project was the coast of the Lagos Lagoon. Seasonal variations in salinity are a defining feature of the lagoons in south-western Nigeria (Olaniyan, 1957; Hill and Webb, 1958). Salinity was proposed by Olaniyan (1969) as an ecological element in the Lagos Lagoon. Several more studies on the fisheries of the Lagoon are Lawal-Are (2001), Lawal-Are and Kusemiju (2000), and Soyinka et al (2010). The actual capture of fish and its composition, however, have altered throughout time in the lagoons for a number of reasons. For the vast majority of species that spend their first developmental stages close to the coast, estuary, brackish, or freshwater, coastal degradation now poses a threat to the sustainability of lagoon fisheries. The Lagos lagoons provide a broad variety of biological material, including both plant and wildlife (Amadi, 1990). Due to their influence on the distribution and quantity of other creatures in the water they live in, fish are useful indicators of trends in the aquatic environment (Olopade, 2001). Hence, this study was aimed to assess population dynamics of Sardinella maderensis in the Lagos Lagoon.

II. Materials and Methods

Description of the study Area

The Lagos lagoon is part of the continuous system of lagoons and creeks that are found along the coast of Nigeria from the border with the Republic of Benin to Niger-Delta. This lagoon bordering the Lagos Island is located between longitude 3º22' E and 3º4' E and latitude 6º17' N and 6º28' N (Oluwajoba et al., 2018). It stretches for about 257 km from Cotonou in the Republic of Benin to the Western edge of the Niger-Delta. Lagos lagoon boarders the forest belt and receives input from a number of important large rivers draining more than 103,626 km of the country (Lawson, 2010) (Figure 1).

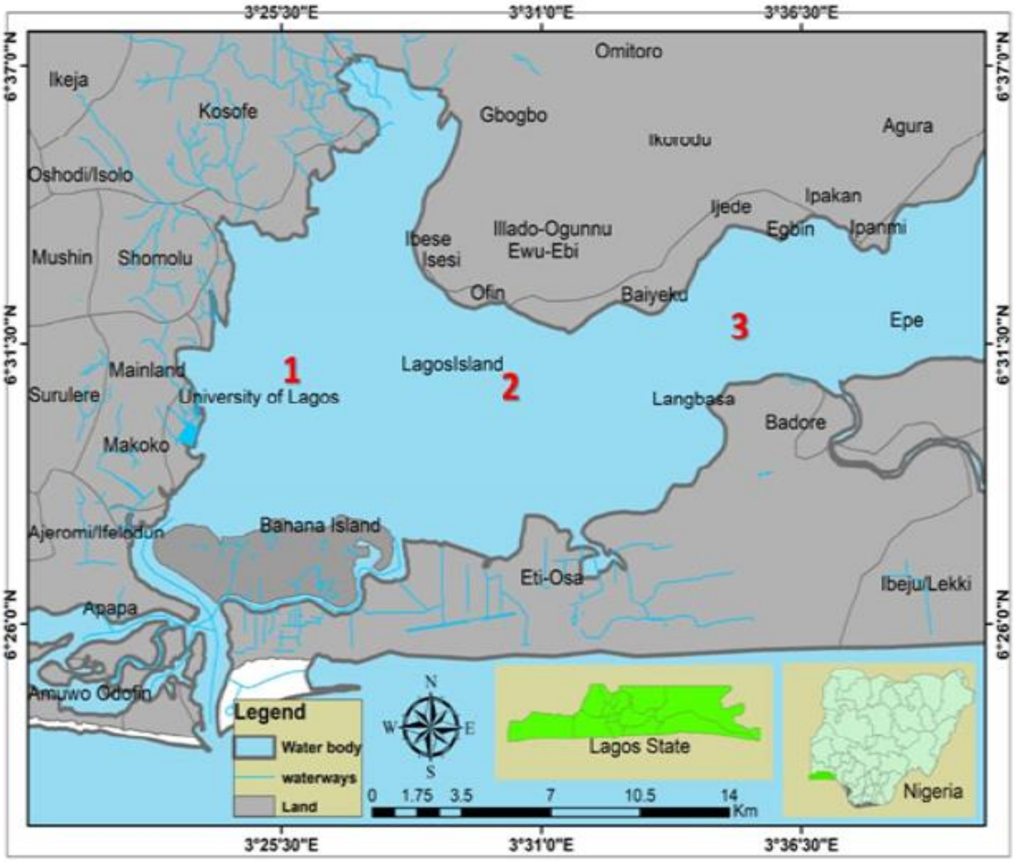

Figure 1: Sampling stations along the Lagos Lagoon

Collection of samples

Sampling was done monthly for one year, comprised of one dry (November-March) and one wet (April- October) seasons following standard protocol accordimg to FAO (2004). At the laboratory, fish samples were sorted into species and counted, Routine morphometric measurements were taken, Total length (cm) of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board to the nearest 0.1cm. Body weight was measured in gram (0.1g) using a top loading Metler balance. The length measurements were converted into length-frequencies with 1.0cm class intervals. The mean lengths and weights of the classes were used for data analysis. The data from the zones were then pooled on monthly basis. These subsequently were grouped into length classes by 1cm interval. Data was analyzed using the SPSS and FiSAT II software's. The SPSS software was used to analyse monthly condition factors while the FiSAT II was used to analyse annual length-weight relationship of population parameters.

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)

III. RESULTS

Population parameters and Growth parameters of *S. maderensis* in year 2014

Monthly distribution and mean weight of *S. maderensis* in the study area are shown in Table 1. The highest mean weight 20.17±1.35 was recorded in November while the lowest 14.11±4.85 was recorded in October. Total mean length was 10.29±2.18.

Population parameters of *S. maderensis* from length converted curve and empirical models of FiSAT II (2014) is shown in Table 2. The ELEFAN-I program estimated asymptotic length (L∞) and growth co-efficient (K) of the von Bertalanffy Growth Equation (VBGF) for *S. maderensis* were estimated as 18.9 cm and 2.3/year respectively with its longevity (tmax) as 1.20 years. The computed growth curve with these parameters is superimposed over the restructured length distribution in Figure 2.

The growth performance index (φ') and initial condition parameters (t0) were estimated at 2.91 and -0.007 years. Using the estimated growth parameters (L∞, K and t0), the VBGF for length at time (t) for the species is expressed as: SLt=18.9 (1-e-2.3 (t-(-0.007)). The estimated mortality parameters for *S. maderensis* as shown in Table 2 and that total mortality (Z) was 5.47/year, natural mortality (M) was 3.54/year while fishing mortality as 1.93/year.

The dark circles in the figure (Figure 3) represent the points used in calculating (Z) through least squares regression method. The yellow circles represent frequencies of fishes either not fully recruited or approaching (L∞), and hence discarded from the calculation. The values of M/K and Z/K ratio were 2.38 and 1.54 respectively.

The probability of capture and length at first maturity for *S. maderensis* in 2014

The probability of capture and length at first maturity for *S. maderensis* in 2014 are shown in Figure 4.

The probability of capture at 25%, 50% and 75% were estimated to be 10.04 cm, 10.89 cm and 11.74 cm respectively. The length at first maturity (Lc50) was estimated at 12.6 cm. The estimated Lc/L∞ ratio using the relationship between the Length at first maturity (Lc50) and the asymptotic length (L∞) for the species was 0.64.

Relative yield per recruit analysis of *S. maderensis* in Lagos Lagoon in 2014

The exploitation rates based on the Beverton and Holt relative yield per recruit model for *S. maderensis* in year 2014 are presented in Figure 5. Emax which implies exploitation rate producing maximum yield (yellow dashes), E0.1 suggesting exploitation rate at which the marginal increase of Y'/R is 10% of its virgin stock (green dashes) and E0.5 indicating exploitation rate under which the stock is reduced to half its virgin biomass (red dashes) of *S. maderensis* were estimated as E0.1=0.801, E0.5=0.405 and Emax=0.955 respectively.

Table 1: Monthly distribution and mean weight of *S. maderensis* in the Lagos lagoon (2014)

LENGTH CLASS	Jan 2014	Feb 2014	Mar 2014	April 2014	Oct 2014	Nov 2014	Dec 2014	Total	Mean Wt.(g)
7-8	6	0	18	0	0	0	0	24	4.12
8-9	24	19	7	54	2	48	15	169	6.37
9-10	12	83	45	31	7	26	36	240	7.42
10-11	96	113	23	42	31	78	44	427	9.62
11-12	78	54	33	45	18	21	56	305	10.17
12-13	23	94	42	46	14	126	27	372	12.01
13-14	14	49	84	20	1	63	25	256	12.41
14-15	107	28	101	15	4	24	9	288	16.89
15-16	12	105	23	39	7	56	19	261	17.28
16-17	3	0	118	19	0	15	0	155	19.04
17-18	6	3	17	4	0	5	12	47	21.11
18-19	3	12	5	2	0	9	0	31	23.09
Total	**384**	**560**	**516**	**317**	**84**	**471**	**243**	**2575**	
MeanL(cm)	**10.51±1.39**	**10.37±1.49**	**11.01±2.17**	**10.42±2.02**	**10.56±2.34**	**13.07±3.04**	**11.38±1.75**	**10.29±2.18**	
MeanW(g)	**17.28±3.11**	**16.01±5.31**	**18.54±4.19**	**16.40±3.17**	**14.11±4.85**	**20.17±1.35**	**18.11±2.05**		**15.04±3.43**

Table 2: Population parameters of *S. maderensis* in Lagos Lagoon in 2014

Population Parameters	Values
Asymptotic Length, L∞(cm)	18.9
Growth rate, K(/year)	2.3
Initial hypothetical age t_0(year)	- 0.007
Natural mortality rate M(/year)	3.54
Fishing mortality rate F(/year)	1.93
Total mortality rate Z(/year)	5.47
Growth performance index(Φ^1)	2.91
Theoretical longevity Tmax(/year)	1.20
Exploitation rate E(/year)	0.35
Z/K	2.38
M/K	1.54

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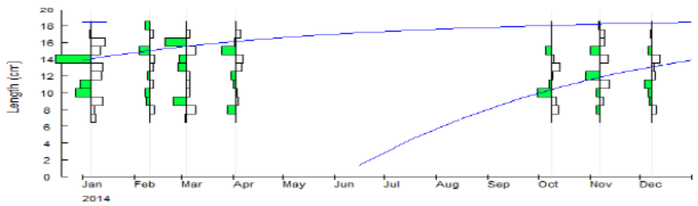

Figure 2: Restructured frequency distribution output from FiSAT II with superimposed growth curves for *Sardinella maderensis* in the study area in 2014

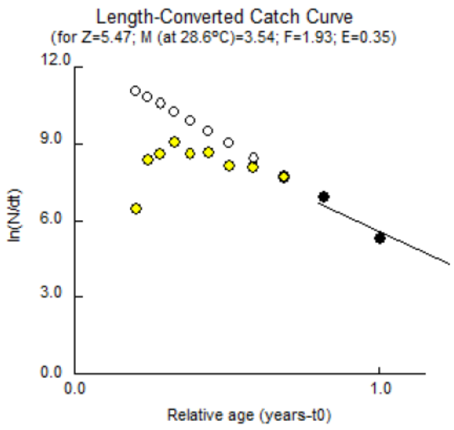

Figure 3: Length-converted catch curve using length frequency data for Sardinella maderensis in 2014

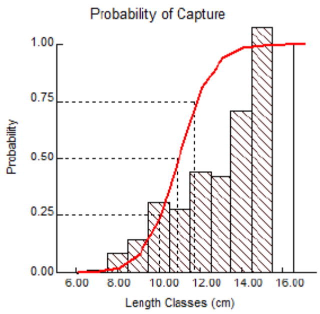

Figure 4: FiSAT II output of the probability of capture of Sardinella maderensis respectively in the study area (0.2, 0.50 and 0.75 relates to 25%, 50% and 75% respectively) in year 2014

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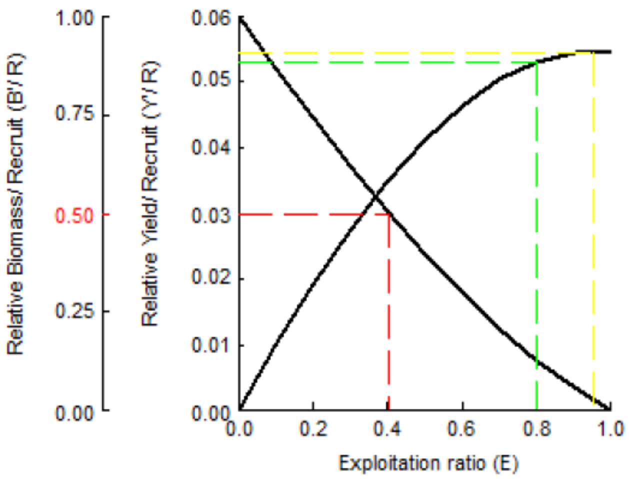

Figure 5: Relative yield per recruit analysis using knife-edge selection of Sardinella. maderensis in the study area in 2014

IV. DISCUSSION

The sustainability of population fishes in providing valuable services in food and sustenance for people the world over is jeopardized in the face of diverse and interacting threats. In the traditional single-species stock assessment, catch, abundance, and life history data are used to construct models that are used to establish allowable harvest quotas (Copps et al., 2007). The difference in abundance of the stocks of the two species in the Lagos lagoon for the two years studied has implications for management decisions. Primarily, the stock abundance corroborates that natural disturbances, such as floods, droughts, or fires, and anthropogenic changes, such as new fishing technologies, regulation changes, or non-native fish introductions, introduction of effluents into the ecosystem, runoff, etc can alter fish populations. Growth rates are used in analytical stock assessments to model the average changes in fish size with age. In length-based approaches, growth rates are required to partition the length composition into ages to estimate mortality rates. Growth of fish is commonly indexed with various coefficients of the von Bertalanffy growth model which is widely used to describe the lifetime pattern of somatic growth of organisms, such as fish, with indeterminate growth (Ricker, 1975). ELEFAN 1 and FISAT 11 model is one of the most commonly used methods for studying theoretical growth in fishery biology. $L\infty$, K and Φ1 values in this study indicated that the fish stock is a good candidate for aquaculture unlike the values estimated for same species in freshwater environment in Ghana ($L\infty$ = 36.75cm, K = 0.2/yr) (Kwarfo-Apegyah et al., 2009). Also, it was better than the values provided for similar species, S. melanotheron ($L\infty$ = 21.3cm, K = 0.60/yr) from Bontanga Reservoir, Ghana (Ofori-Danson, and Apegyah, 2008). Higher value of natural mortality M, in this study might have resulted from intense predation which is a consequence of low population of the stock in the estuary. Biro et al. (2003) asserted that low population level affects scale formation time and size resulting into high predation. This could be used to corroborate the low annual survival (10.9%) of the stock in the estuary. Population parameters such as asymptotic length ($L\infty$) and growth coefficient (k), mortality rates and exploitation level were studied with the major objective of rational management and resource conservation (Nasser et al., 2002; Goethel et al., 2011b). Growth information provides a lot of tools that are used in fishery management. The data on the age of a fish can provide tools in fishery management such as the general background information needed for management decisions. It aids in the diagnosis of management needs such as the recognition of overcrowding and stunting (Edmond et al., 2017; Dipanoto et al., 2019). Fish grows throughout its life and its growth is largely a function of specific endogen factors (genetic luggage) and exogenous factors that consist of abiotic characteristics (temperature, dissolved oxygen) and biotic characteristics (availability of food resources, feeding, intra- or interspecific competition) (de Merona et al., 2005; Panfili et al., 2005). Growth rates are used in analytical stock assessments to model the average changes in fish size with age. In length-based approaches, growth rates are required to partition the length composition into ages to estimate mortality rates. Findings from this study reveal that growth rates of fish in a population are intricately linked with mortality and recruitment rates. It could also be inferred that growth rate influences survival and age at sexual maturity

In this study, the value of φ' in Sardinella maderensis in 2014 was 2.91. The φ' (2.90) values obtained in Nigeria's estuary (Stokholm and Isebor, 1993; King and Udo, 1997) are slightly similar to what was found in the present study. The values of growth performance indexes can be attributed to food unavailability, unfavorable environmental conditions. Specifically, the growth performance index recorded in this study was similar to the result obtained by Bedia et al. (2020) who recorded a growth performance index of 2.62 for E. fimbriata in Ebrie Lagoon, Cote d'Ivoire. In this study, it was observed that the value of asymptotic Length, L∞ was higher in 2014, whereas the value of growth rate (K) was lower in 2014. This was in agreement with Beverton and Holt (1957) who pointed that the two parameters of growth are inversely proportionally to each other. The growth performance index of S. maderensis recorded in this study for the sampling year were higher than the values obtained by Olopade et al. (2019) in Sombreiro River, Nigeria and Amponsah et al. (2018) in coastal waters of Ghana. The growth performance index is in line with the report of Sossoukpe et al., (2016) in the nearshore waters of Benin (West Africa) and Wehye et al. (2017) in the Liberian coastal waters Olopade et al. (2019) attributed the lower values of growth performance index (ϕ') to the poor state of water quality in the study area as a result oil pollution and other human activities in and around the Sombreiro River. The values of ϕ' in the present study falls within the range of 2.65 -3.32 estimated for some important fishes in Africa (Baijot and Moreau, 1997). Sossoukpe et al. (2016) concluded that the growth performance index indicates the important availability of food and other favourable environmental conditions. S. maderensis in the sampling year was greater than the fishing mortality (F=1.93 year-1). This was in line with the report of Wehye et al. (2017) who recorded more natural mortality than fishing mortality, but contrary to estimates reported by Sossoukpe et al. (2016) from Benin. Wehye et al. (2017) resolved that the observation could be due to the fact that S. maderensis stock in Liberian coastal waters is more susceptible to natural mortality conditions than to fishing gears. The length at first capture (L25) of S. maderensis recorded in the sampling year in this present study was higher than the values obtained by Amponsah et al. (2018) but lower than the values reported by Olopade et al. (2019) for same fish species. The difference can be attributed to the fishing pressure, suitability of the aquatic environment in the different regions. The exploitation rate (Emax) of S. maderensis obtained for the sampling year was higher than the values obtained by Wehye et al. (2017) in the Liberian coastal waters, and Olopade et al. (2019) in the Sombreiro River of Niger Delta, Nigeria. Also, Sossoukpe et al., (2016) from the coastal waters of Benin reported a similar finding. This is an indication that the level of exploitation of this species is very high in the study area. The exploitation rate was relatively higher than the optimum level of 0.5, showing the existence of over-exploitation within the fishery of S. maderensis (Pauly, 1980). In addition, the observed lower estimated exploitation rate (E) compared to the maximum exploitation rate (Emax) was in agreement with the report of Wehye et al. (2017) who reported that the exploitation rate (E) of S. maderensis in Liberian coastal waters was lower than the maximum exploitation rate (Emax). On the contrary, Amponsah et al. (2018) recorded an exploitation rate (E) that was higher than the maximum exploitation rate (Emax). Therefore, the intensity of exploitation on any fish species could be assigned to factors including geographical locations, the degree of dependency on it as a source of protein, especially in coastal communities as well as the nature of the fishing industry (Amponsah et al., 2018).

REFERENCES

[1]. Amadi AA (1990). A Comparative Ecology of Estuaries in Nigeria. Hydrobiol. Amponsah, S. K. K., Ofori-Danson, P. K., Nunoo, F. K. E., & Ameyaw, G. A. (2018). Estimates of Population parameters of the Flat sardine, Sardinella maderensis (Lowe, 1838) in the coastal waters of Ghana. Greener Journal of Agriculture Sciences, 9 (1), 23-37.doi.org/10.15580/GJAS.2019.1.011719017.

[2]. Baijot, E., and Moreau, J.(1997). Biology and demographic status of the main fidh species in the reservoirs of Burkina-Faso. In: Baijot, E., Moreau,J., Bouda, S.(Eds.), hydro biological aspects of fisheries in small reservoirs in the Sachel Region. Technical centre for the European communitiers, Wageningen, the Netherlands, pp. 79-109.

[3]. Bédia, T. A., C. Bakari, R. N. Etilé, P. E. Kouamelan, V. N'douba, (2020). Growth and exploitation parameters of Ethmalosa

fimbriata (Bowdich, 1825) (Clupeidae) in a Tropical Coastal Lagoon: Ebrié Lagoon (Aghien-Potou Sector, Côte d'Ivoire). International Journal of Fisheries and Aquatic Research, 5(2): 32-37.

[4]. Beverton RJH, Holt SJ. (1957). On the dynamic of exploited fish populations. Fishery Investment. London, 2(19):1- 533.

[5]. Biro, P. A., J. R. Post, and E. A. Parkinson. 2003. Population consequences of a predator-induced habitat shift by trout in whole-lake experiments. Ecology 84(3):691-700.

[6]. Copps, S. L., M. M. Yoklavich, G. Parkes, W. W. Wakefield, A. Bailey, H. G. Greene, C. Goldfinger, and R. Burns. 2007. Applying marine habitat data to fishery management on the US west coast: initiating a policy-science feedback loop. J Mapping the seafloor for habitat characterization: 451-462.

[7]. De Merona, B., R. Vigouroux, and F. L. Tejerina-Garro. 2005. Alteration of fish diversity downstream from Petit-Saut Dam in French Guiana. Implication of ecological strategies of fish species. Hydrobiologia 551(1):33-47.

[8]. Dipanoto, A., M. L. Syamsuddin, Z. Anna, and I. Izza. 2019. The estimation of bigeye tuna (Thunnus obesus, (Lowe, 1839)) fishing season in the East Indies Ocean which is disembarked in Benoa Port, Bali. World Scientific News 115:1-14.

[9]. Edmond, S., A. S. Wilfrid, and F. E. Didier. 2017. Growth, Mortality Parameters and Exploitation Rate of West African Ilisha (Ilisha africana Bloch, 1795, Clupeidae) off Benin Coastal Waters (West Africa): Implications for Management and Conservation. Open Journal of Marine Science 7(03):327.

[10]. F.A.O. (2004). The state of World Fisheries and Aquaculture Report (http: //www.fao.org)

[11]. Froese, R. & C. Binohlan. 2000. Empirical relationships to estimate asymptotic length, length at first maturity, and length at maximum yield per recruit in fishes. J. Fish Biol. (in press). Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22, 241–253.

[12]. Goethel, D.R., Quinn, T.J.,II, Cadrin,S.X.,2011.Incorporating spatial structure in stock assessment: movement modelling in marine fish population dynamics. Rev. Fish.Sci.19 (2), 119-136.

[13]. Hill, M. B. and Webb, J. E. (1958). The topography and physical features of the Lagos harbour and Lagos Lagoon. Phil. Trans. R. Soc. Lond. B., 683: 307- 419.

[14]. King, R., and L. Etim. 2004. Reproduction, growth, mortality and yield of Tilapia mariae Boulenger 1899 (Cichlidae) in a Nigerian rainforest wetland stream. Journal of Applied Ichthyology 20(6):502-510.

[15]. Kwarfo-Apegyah, K., P. Ofori-Danson, and F. Nunoo. 2009. Exploitation rates and management implications for the fisheries of Bontanga Reservoir in the Northern region of Ghana. West African Journal of Applied Ecology 14(1)

[16]. Lawal-Are, A. O. (2001). Aspects of the biology of the Lagoon crab, Callinectes amnicola (De Rocheburne) in Badagry, Lagos and Lekki Lagoons, Nigeria pp 215-220 In: Eyo, A. A. and Ajao, E. A., (eds). Proceedings of the 16th Annual Conference of Fisheries Society of Nigeria.

[17]. Lawal-Are, A. O. and Kusemiju, K. (2000). Size composition, growth pattern and feeding habits of the Blue crab, Callinectes amnicola (De Rocheburne) in the Badagry Lagoon, Nigeria. J. Sci. Res. Dev. 5: 169-176.

[18]. Lawson, E. O. 2010. Maturation and Histological characteristics of ovaries in Mudskipper, Periophthalmus papilio from Lagos lagoon, Nigeria. Journal of American Science 6(11):965-976.

[19]. Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in Gonad weight and condition in the perch (Perca fluviatilis). Journal of animal ecology. Vol.20, NO.2(Nov.,1951), pp.201-219.

[20]. Nasser, A., M. Sivadas, P. Pillai, and G. Gopakumar. 2002. Tuna live-bait fishes-their exploitation, conservation and management in Lakshadweep. Management of Scombroid Fisheries:148-154.

[21]. Olopade OA (2001). Biodiversity and conservation of marine fish beels of the coastal wetlands of Ogun state, Nigeria. Ph.D Thesis, University of Ibadan p.205.

[22]. Olopade, O.A., Dienye, H.E., & Bamidele, N.A. (2019). Some population parameters of the Sardinella maderensis (Lowe, 1838) in the Sombreiro River of Niger Delta, Nigeria. Acta Aquatica Turcica, 15(3), 354-364. https://doi.org/10.22392/actaquatr.532284

[23]. Oluwajoba E.O., Fakayode Oluwafemi., Oluboba T.F., Ukaonu S.U and Fola-Mattews O.O. (2018). Seasonal Variation in Species Abundance, Diversity and Composition of Fish Fauna in Lagos Lagoon, Nigeria. 14(9):1281-1288

[24]. Panfili, J., J.-D. Durand, K. Diop, B. Gourène, and M. Simier. 2005. Fluctuating asymmetry in fish otoliths and heterozygosity in stressful estuarine environments (West Africa). Marine Freshwater Research 56(5):505-516.

[25]. Pauly DA (1980). Selection of simple methods for the assessment of tropical fish stocks. FAO Fisheries Circular 729, FAO, Rome. Pepin, P. 1995. An analysis of the length-weight relationship of larval fish: limitations of the general allometric model. Fishery Bulletin 93(2):419-426.

[26]. Ricker, W. E., 1975: Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can.191, 1-382.

[27]. Sossoukpe E, Djidohokpin G, Fiogbe ED (2016) Demographic parameters and exploitation rate of Sardinella maderensis (Pisces: Lowe 1838) in the nearshore waters of Benin (West Africa) and their implication for management and conservation. Fish Res 4: 165-171.

[28]. Soyinka, O. O., M. P. Kuton, and C. I. Ayo-Olalusi. 2010. Seasonal distribution and richness of fish species in the Badagry Lagoon, south-west Nigeria. Estonian Journal of Ecology 59(2) Stamatopoulos, C. 2002. Sample-based fishery surveys. A technical handbook. FAO. Soyinka,O. O., Kuton, M. P. and Ayo-Olalusi, C. I. (2010). Seasonal distribution and richness of fish species in the Badagry Lagoon, South-west Nigeria. Estonian Journal of Ecology. 59(2):147-157.208: 27 -28.

[29]. Stokholm, H., and C. Isebor. 1993. The fishery of Ilisha africana in the coastal waters of Republic of Benin and Lagos State, Nigeria. Wehye AS, Amponsah SKK, Jueseah AS (2017) Growth, Mortality and Exploitation of Sardinella maderensis (Lowe, 1838) in the Liberian coastal waters. Fish Aqua J 8: 189. doi:10.4172/2150-3508.1000189