International Journal of Fisheries and Aquaculture Research
Vol.3, No.2, pp.10-18, July 2017
Published by European Centre for Research Training and Development UK (www.eajournals.org)

RECRUITMENT PATTERN AND LENGTH-AT-FIRST-CAPTURE OF THE SILVER CATFISH *CHRYSICHTHYS NIGRODIGITATUS* LACÉPÈDE: CLAROTEIDAE IN LOWER CROSS RIVER, SOUTHEAST NIGERIA

Okon M udoidiong, John E. Ukpatu and James P. Udoh*

Department of Fisheries and Aquatic Environmental Management, Faculty of Agriculture, University of Uyo, Uyo, Nigeria.

ABSTRACT: *The recruitment pattern and lengt:h-at-first-capture of Chrysichthys nigrodigitatus from lower Cross River, Nigeria, were derived from 12 consecutive months length - frequency samples (October 2011 to November 2012) using FAO – ICLARM Stock Assessment Tools (FiSAT II) software. Recruitment was continuous all year-around with two peaks of unequal pulses: the major in March-April (15.19-15.32%) and minor in July-August (11.10-13.16%), apparently occurring during rainy and early dry seasons, respectively; while no recruitment was observed in October. The recruitment pattern observed is consistent with the general spawning pattern of the species (April - August) reported by earlier researchers. The probability of capture routine estimated the mean length-at-first-capture, L_c = 36.24 cm. The mean ratio of length-at- first-capture (L_c) to asymptotic (L_∞) was 0.309 indicating the length at-first-capture is quite low for the population indicating higher fishing pressure on the stock, thereby endangering the health status of the resource.*

KEYWORDS: Artisanal Fishery, Fishing Season, Logit Transformation, Resource Sustainability, Running Average.

INTRODUCTION

Recruitment is the entrance of young fish into the exploited fishing area where they become liable to capture by the fishing gear [1]. It also refers to the addition of new fish to the vulnerable population by growth from among smaller-sized individuals [2]. This may involve an actual movement in which young fishes move from nursery area into the main fishing ground [3]. Thus, recruitment is a major source of variability in fish population.

The mean age of fish at recruitment [4] and recruitment pattern generally depend on the type of gear used in fishing. The recruitment pattern affords the identification of the number of recruitment pulses per year and their relative importance to each other. General a recruitment curve is derived from a proper knowledge of the biology of the species concerned and estimation of the recruitment pattern based on size composition of actual catches with known selectivity of gear. Recruitment is also a very crucial phenomenon in fisheries as it determines the magnitude of catch that can be taken year to year from a fish stock [3,5].

Changes in length-at-first-capture (L_c) predict the response of relative yield-per-recruit of the species. Hence, it is an important input in the computation of the potential yield of a fishery (relative yield -per- recruit or relative biomass-per-recruit) and the exploitation level that produces the maximum yield-per-recruit (E_{max}). In addition, the L_c is a very vital parameter when used along with length-at-first-maturity as an indication of the health status of the resource.

ISSN 2397-7507(Print), ISSN 2397-7760(online)

Chrysichthys nigrodigitatus (Lacépède, 1803) is of great economic importance and drives ecological structure in the Lower Cross River ecosystem. It is a valuable commodity in rural communities of Nigeria and it forms the bulk of economic rent of the rural households. The livelihood of the artisanal fishers therefore depends on the harvest capacity of this resource. Intensive fishing activity has impacted on size of the species as they are not allowed to grow to maximum size [6]. The species belongs to the family Claroteidae and has been described in Northern part of Nigeria [7]. The population dynamics (growth, mortality and exploitation rate) of the species has been reported for Lake Volta, Ghana; Nun River and Andoni River in the Niger Delta, Nigeria [8,9,10], respectively. Other aspects of its biology studied include age and growth in the Cross River [11] (Ezenwa and Ikusemiju, 1981); condition factor, diet and reproductive biology in the Cross River estuary [12] and diseases [13]. Two recruitment peaks per year (highest in September and lowest in June) have also been reported in a coastal shrimp fishery in Bangladesh [14]. The two major recruitment events suggest that two cohorts are possibly produced in a year in Bangladeshi water system. This study will add to the body of data in providing vital scientific information on recruitment pattern and length-at-first-capture of *C. nigrodigitatus* to aid its sustainable management in the Lower Cross River, Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted within the Itu bridgehead axis (4°25′ – 7°01′ N; 7°15′ – 9°3′ E; Fig. 1), approximately 40 km along of Lower Cross River, southeast Nigeria. The area lies within the rain forest belt with an annual rainfall of up to 2500 mm; wet season spans April to mid-November [15]; average water depth is 4m (dry season) to 14m (rainy season); mean annual temperature is about 27°C, approximately 30°C maximum April or May, and 22°C minimum in January, giving a narrow range of about 8°C [16,17,18]. The river floods its banks in July to October [19].

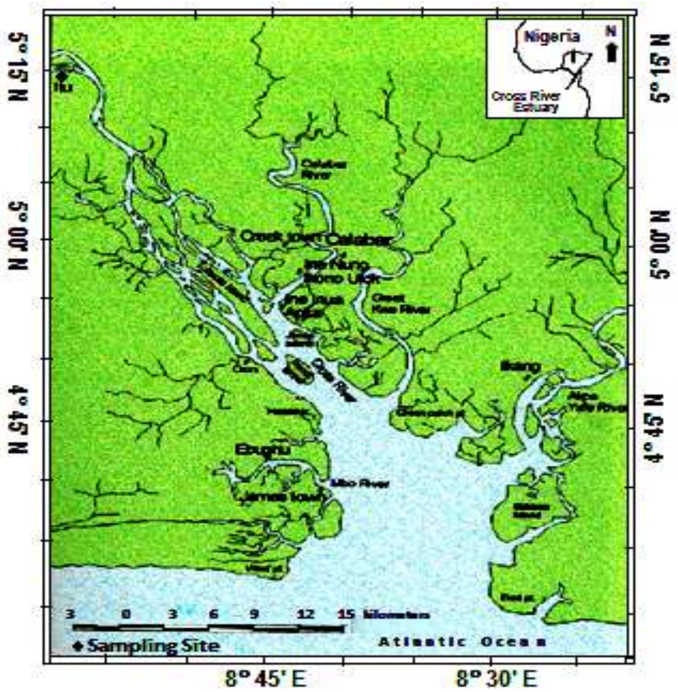

Fig. 1: The Cross River Estuary, southeast Nigeria showing the sampling station – Itu

Field sampling

A total of 6637 specimens of *C. nigrodigitatus* were randomly sampled from October 2011 to November 2011 from the fish catch of artisanal fishers using dug-out canoes (pirogue) at Itu beach near Calabar. The species was identified using FAO species identification sheet [20,21]. The total length (TL) of each was taken to the nearest 0.01 cm with a measuring board and recorded. The monthly length data were combined into a single pool in groups with 10 cm size class interval, representing one theoretical annual cycle and analyzed accordingly. For a proper implementation of the FiSAT analysis, the length-classes must be above 10 [22].

Estimation of the Parameters of von Bertalanffy growth function (VBGF)

The parameters of the von Bertalanffy growth function (VBGF): asymptotic length (L_∞) and growth coefficient (K) were estimated using ELEFAN-1 routine [23] incorporated in the FiSAT II software. The index of goodness-of-fit (Rn) was calculated as

$$Rn = 10^{(ESP/ASP)}/10 \quad (1)$$

Here ASP (available sum of peaks) is the sum of all values of available peaks while ESP (expected sums of peaks) is the sum of all peaks and troughs which the growth curves pass through. The residual of the Gulland and Holt plot from the length-at-age derived from the linking of cohort means, gave the value of the amplitude of growth oscillation and the winter point, WP (the point at which growth is slowest).

Growth Performance Index (Ø')

The estimated L_∞ and K were used to calculate the growth performance index (Ø') of *C. nigrodigitatus* using the equation [24]:

$$(Ø') = 2 \log L_\infty + \log K \quad (2)$$

where L_∞ is the asymptotic length in (cm) and K is the growth coefficient expressed in (yr^{-1}). The growth performance index assesses the reliability of L_∞ and K.

Probability of Capture

The probability of capture *P* of each size class *i* was estimated from the ascending left arm of the length-converted catch curve procedure [25]. The method involves dividing the numbers actually sampled by the expected numbers obtained by backward extrapolation of the straight portion or the right descending part of the catch curve in each length class of the ascending part of the catch curve. The plot of the cumulative probability of capture against mid length, a resultant curve was obtained; smoothed using the logit transformation. From this curve, the length-at-first-capture (L_c) was taken as corresponding to the cumulative probability at 50%.

Seasonal Recruitment Pattern

The seasonal recruitment pattern of the stock was reconstructed using the entire restructured length-frequency data set. This entails back projecting, along a trajectory defined by the VBGF, all the length-frequency data onto a one-year time scale [25]. Then using the maximum likelihood approach, the Gaussian distribution was fitted to the back projected data and decomposed using normal separation (NORMSEP) procedure [23]. The routine reconstructs the recruitment pulse from a time series of length frequency data to determine the number of pulses per year and the relative strength of each pulse. Input parameters were asymptotic length (L_∞) and growth coefficient (K).

RESULTS

Length-frequency Distribution and von Bertalanffy parameters

The monthly length-frequency data used in the present analysis (Table 1) consist of 6,846 of *C. nigrodigitatus* measurements collected for 12 consecutive months. The length-frequency distribution (Fig. 2) showed that the 44.5 mid length class was the dominant size group and constituted 23.11% of the population, while the least value of 0.12% was observed at 104.5 mid length class. The best values of the seasonalized VBGF are: K = 1.5yr^{-1}, L_∞ = 120.23 cm, C= 0.75, WP= 0.50; the response surface (Rn) = 0.234 and Ø' = 4.045

Recruitment Pattern

The recruitment pattern (Fig. 3a,b) of *C. nigrodigitatus* indicates continuous recruitment with many micro cohorts and two unequal peaks/pulses, major in March-April (15.19-15.32%) and minor in July-August (11.10-13.16%); while no recruitment was observed in the 12th month of sampling - October (Table 2).

Probability of Capture (Length at first capture)

The probability of capture (Fig.4) estimated the length-at-first-capture of *C. nigrodigitatus* L_{50}, L_{25} and L_{75} as 37.22, 30.56 and 43.37 cm by Logit transformation and 34.54, 26.88 and 43.24 cm by Running average routines, respectively. The mean length-at-first-capture, L_c = 36.24 cm (Table 3).

Table 1. Length – frequency data of *C. nigrodigitatus* from lower Cross River, Nigeria between November 2011-0ctober 2012; n = 6,846, size class=10cm

Mid length	Nov.	Dec.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total	% Total
14.5						2	20	14	24	13			73	1.1
24.5	26	2	4	3	27	12	76	148	88	31		4	421	6.34
34.5	116	14	24	8	116	14	148	222	122	20	51	24	879	13.24
44.5	201	181	144	17	211	18	135	248	148	128	73	30	534	23.11
54.5	108	188	181	133	148	188	44	117	118	45	46	114	430	21.55
64.5	140	178	18	118	122	149	35	187	113	56	35	19	170	17.63
74.5	110	111	3	122	59	49	10	30	20	54	23	10	601	9.06
84.5	95	71	2	92	30	38	9	17	4	23	9	8	398	6
94.5	38	3	1	41	4	2	7	14	4	9			123	1.85
104.5	2	1		4					1				8	0.12
SUM	**836**	**586**	**559**	**588**	**828**	**472**	**484**	**997**	**632**	**379**	**276**	**209**	**6637**	**100.00**

ISSN 2397-7507(Print), ISSN 2397-7760(online)

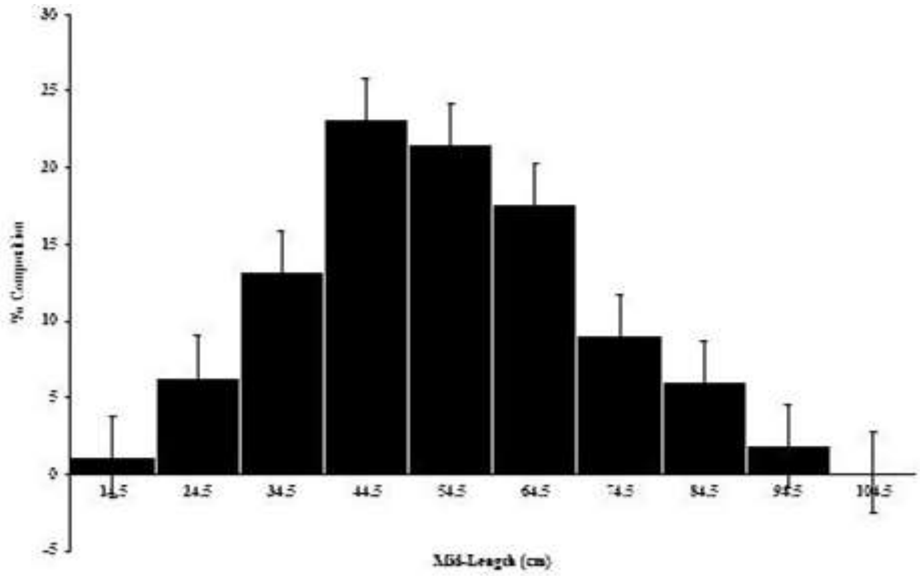

Fig. 2. The length-frequency of *C. nigrodigitatus* from artisanal landings of the Lower Cross River at Itu, Nigeria

Table 2. Recruitment Pattern for *C. nigrodigitatus*

Cohorts*	Relative	%	Cohorts	Relative	%
1	Nov, 2011	4.63	7	May, 2012	10.11
2	Dec, 2011	4.68	8	Jun, 2012	6.99
3	Jan, 2012	2.80	9	Jul, 2012	11.10
4	Feb, 2012	9.41	10	Aug, 2012	13.16
5	Mar, 2012	15.19	11	Sep, 2012	6.60
6	Apr, 2012	15.32	12	Oct, 2012	0.00

*Relative Months

Table 3: Estimate of length-at-fist-capture for *C. nigrodigitatus* using both the logits and running average routines

Routine	L_{25}	L_{50} or L_c	L_{75}
Logits	30.56	37.22	43.87
Running Average	26.88	34.54	43.24
Mean	28.72	35.88	43.555

ISSN 2397-7507(Print), ISSN 2397-7760(online)

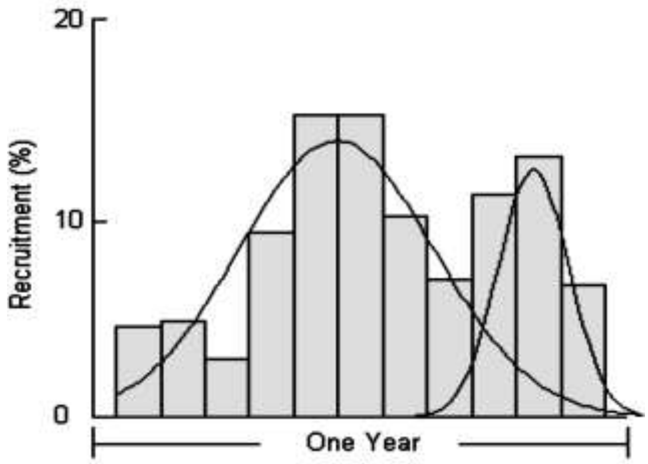

Figure 3. Backward projection of the restructured VBGF length frequency data of *C. nigrodigitatus* onto an arbitrary one-year time scale with the superimposed recruitment pattern decomposed into pulses exhibiting two peaks of unequal pulse strength

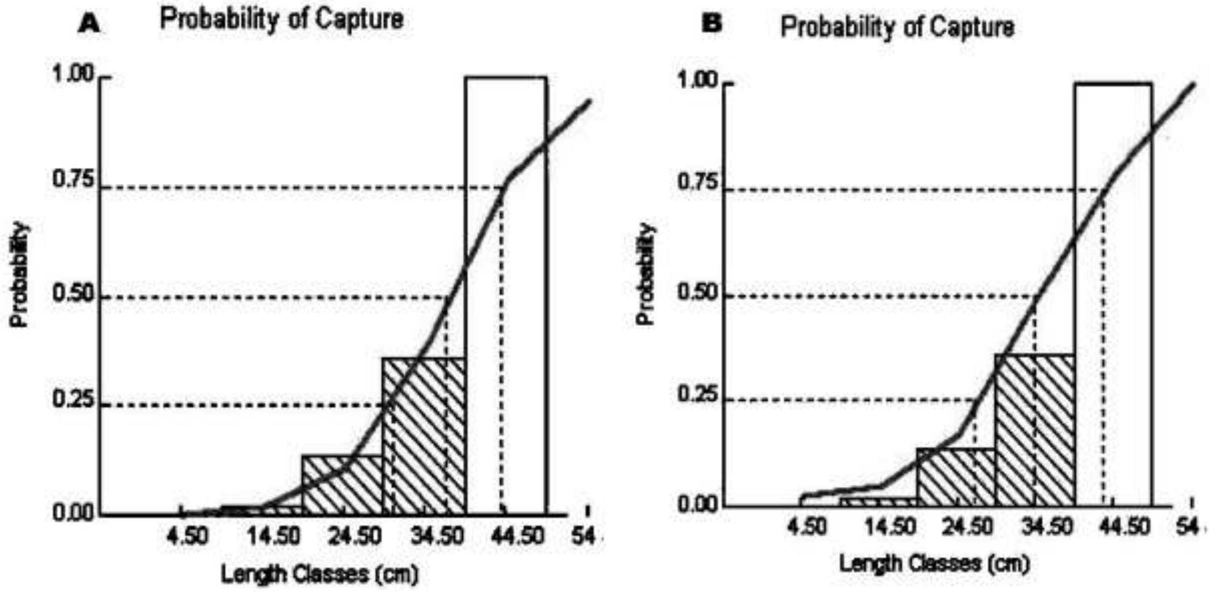

Figure 4. Probability of capture by length class of *C. nigrodigitatus* estimated from the ascending arm of the catch curve showing the length at first capture L_{50} = 37.22, L_{25} = 30.56, L_{75} = 43.37 by Logistic transformation (a); and L_{50} = 34.54, L_{25} = 26.88, L_{75} = 43.24 by Running average routine (b) estimated from the dotted lines at the middle. It is one of the inputs in computing the relative yield- per- recruit, relative biomass- per – recruit and plotting of the yield isopleths

DISCUSSION

Recruitment Pattern

Major peak in recruitment occur during wet season months (April - August) coincide with breeding period [12] when the rainfall in the area remains above average. Hence, juvenile

ISSN 2397-7507(Print), ISSN 2397-7760(online)

abundance relates well with flood regime; and there is linear relationship between the inter-annual variations in the hydro-regime and the yearly fluctuations in the population structure of some coastal and estuarine fishes like *C. nigrodigitatus* of the Lower Cross River, Nigeria [26]. The major recruitment peak is also in close agreement with that established for tropical species [27]. The year-round recruitment observed in this study, has been described to be a normal phenomenon for tropical fish [28,29,30] and for short-lived species [27] while the double peaks observed could be adduced to influence of environmental factors prevailing in the study area. Generally, the abundance and productivity of commercial fish stocks vary on inter-annual and inter-decadal time scale as a result of environmental variations, species interactions and fishing [31]. Moreover, the zero theoretical age parameter, t_o, of the von Bertallanffy growth model could not be estimated length frequency data alone, thus, the months of the year corresponding to the peaks of recruitment could not be calculated directly. However, the recruitment pattern (Fig. 2) indicates the peaks of the smaller sized the fish between April and August; corresponding closely to the spawning pattern of the species.

The recruitment pattern of the *C. nigrodigitatus* also corroborate the species depends to a large extent on the flooding of the river system as influenced by rainfall during the wet season months. During these months, rainfall and river discharge (runoff) bring into the system nutrients (organic detritus) which may stimulate the rapid growth of microorganisms and hence of invertebrates which may be fed upon directly by the fish. Also, as the water expands into the forest of the flood plain, it engulfs animals (insects, insect larvae, earthworms, snails, etc.), as well as plant materials and planktonic organisms, which can provide increased food for the fish during the wet season. High trophic flexibility enables the switching from one diet to another according to availability and this is good for the transfer of fuel in the ecosystem [26].

Besides the leaves, branches and stems of the macrophyte provide sufficient cover for eggs, larvae and juvenile of *C. nigrodigitatus,* thereby reducing the amount of predation and natural mortality. Thus, the wet season appears to be the main growth and fattening season for this species and this season influences the reproductive successes and recruitment strength of the silver catfish in the Lower Cross River, Nigeria. Therefore, food availability, spawning pattern, nature of breeding grounds and breeding habits coupled with shelter, hydrological regime, vegetation cover and migration pattern are major influencing factors affecting the distribution and abundance of *C. nigrodigitatus* of the Lower Cross River, Nigeria [12,26].

Length at-first –capture (L_c)

The L_c for *C. nigrodigitatus* were 37.22 cm and 34.54 cm using the logits transformation and running average methods, respectively (Table 3); implying that the smallest size susceptible to the exploitation method is juvenile. The mean ratio of length-at- first-capture (L_c) to asymptotic (L_∞) was 0.309 indicating the length at-first-capture is quite low for the population. From the management point of view, this is not a healthy trend for the resource and as such calls for a management strategy that will allow the escape of such sizes from the gear used in the resource exploitation. Probability of capture analysis by extrapolation of the length-converted catch curve provides reasonable estimates of mesh size at first capture. The logistic curves assume selection is symmetrical or nearly so, while the running averages smoothen the data sets by interpolating the selection parameters. The L_c serves as a biological index and vital parameter that indicates the health status of the resource and should be considered along with length at first maturity in the management of fisheries resource.

ISSN 2397-7507(Print), ISSN 2397-7760(online)

CONCLUSION

C. nigrodigitatus in the Lower Cross River exhibit two recruitment peaks of un-equal strengths, the major in March-April and minor in July-August. The length-at- first-capture is quite low for the population; which may be attributed to higher fishing pressure on the stock. For sustainability of this resource, exploitation should be avoided in the months of June-August, the major breeding season of the stock; to allow young recruits to grow and reproduce thereby ensuring resource sustainability.

REFERENCES

[1] Gulland, J. A. 1971. *The fish resources of the oceans*. Farnham: Fishing News, Farnham.
[2] Gayanilo Jr. F. C. and D. Pauly (1997) (eds.). The FAO-ICLARM Stock Assessment Tools (FISAT) reference manual, FAO Computerized Information. Series 8, (Fisheries), (FAO. Rome), 1997. 262 p.
[3] Pauly, D. (1984). Fish population dynamics in tropical waters: A manual for use with programmable calculators. *ICLARM, Studies and Reviews* 8, 325p.
[4] Abowei, J. F. N. A. O. Davies and S. A. Ngodigha (2008). The recruitment patterns of two palaemon shrimps and some physicochemical characteristics in the River Nun estuary. *Nigeria Int. J. Nat. Appl. Sci.*, 4 (4): 396-401.
[5] Biswas, S. P. (1993). *Manual of Methods in Fish Biology*. New Delhi: South Asian Publishers, 157 p.
[6] Atobatele, O.E and Ugwumba, A.O (2011). Condition factor and diet of *Chrysichthys nigradigitatus* and *Chrysichthys auratus* (Silurifomes: Bagridea) from Aiba reservoir, Iwo, Nigeria. *Revista de Biologia Tropical* 59(3):212-220.
[7] Reed, W. Burchard, T., Hopkin, A. J., Jenness, J. and Yaro, I. (1967). Fish and fisheries of Northern Nigeria. Ministry of Agriculture, Northern Nigeria, 226p.
[8] Ofori-Danson,P.K; de Graaf G. J ; Vanderpuye C. J (2002). Population Parameter Estimated for *Chrysichthys auratus and Chrysichthys nigrodigitatus* (Pisces: Claroteidae) in Lake Volta, Ghana. *Fisheries Research* 54(2): 267-277.
[9] Abowei, J. F.N and Hart, A. I (2007). Size Composition, Age, Growth, Mortality and Exploitation Rate of *Chrysichthys nigrodigitatus* from Nun River, Niger Delta, Nigeria. *African Journal of Applied Zoology and Environmental Biology*, 9: 44-50.
[10] Francis, A and Samuel, E. E (2010). Fish Mortalities and Management Measures of Fish Species of the Andoni River, Niger Delta, Nigeria. *Research Journal of Biological Sciences*, 5 (2): 171-176
[11] Ezenwa, C. I. O. and Ikusemiju, K (1981). Age and growth determinations in the catfish, *Chrysichthys nigrodigitatus (*Lacépède) by use of the dorsal spine. *Journal of Fish Biology*, 19 (3):345-351.
[12] Offem, B.O; Akebejo- Samsons, Y and Omoniyi, I. T. (2008). Diet, Size and Reproductive Biology of the silver catfish, *Chrysichthys nigrodigitaus* Siluriformes: Bagridae) in the Cross River, Nigeria. *Revista de Biology Tropical* 56(4):166-178.
[13] Obiekezie, A. I., Moer, H. and Anders, K. (1988). Diseases of the African estuarine catfish *Chrysichthys nigrodigitatus (*Lacépède) from the Cross River estuary, Nigeria. *Journal of Fish Biology*, 32 (2):207-221.
[14] Zafar, M., Mustafa, M. G. and Amin, S. M. N. (1998). Population dynamics of *Acetes chinensis* in the Kutubdia channel of Bangladesh coastal waters. *Indian Journal of Fisheries*, 45 (2)) 121-127.

ISSN 2397-7507(Print), ISSN 2397-7760(online)

[15] Ekanem, E. M. (2010): Climate characteristics. pp. 91-101. In Usoro, E. J. and P. A. Akpan (eds.). Akwa Ibom State: A geographical perspective. A special publication of the Department of Geography and Regional Planning, University of Uyo, Nigeria.
[16] Etim, L and Enyenihi, U. K (1991). Annual Cycle of Condition and Flood Season Spawning in Galatea paradoxa (Born 1777) from the Cross River in Nigeria. *Tropical Freshwater Biology*, 2: 234-248.
[17] Etim, L and Brey T (1994). Growth, Productivity and Significance for Fishing of the bivalve Egeria radiate (Donacidae) of the Cross river Nigeria. *Archives of Fisheries and Marine Research*, 42(1): 63 – 75. 42(1): 63-74.
[18] Etim, L; Uwe-Bassey, B. U. and Brey, T. (1994). Population Dynamics of the West African Croaker *Pseudotolithus elongatus* in the Cross River Estuary, Nigeria. *Marine Sciences* 58 (4): 315-321.
[19] Moses, B. S. (1987). The Influence of Flood Regime on Fish Catch and Fish Communities of the Cross River Flood-Plain Ecosystem, Nigeria. *Environmental Biology of Fish*, 18: 51-65.
[20] Fisher, W. and Bianchi, G. (1984). FAO Species Identification Sheets for Fishery Area, 34, 47 p.
[21] Olaosebikan, B. D. and Raji, A. (1988). Field guide to Nigerian freshwater fisheries. Federal College of Freshwater Fisheries Technology. New Bussa, Niger State, Nigeria.
[22] Gayanilo, F. C., Spare, P and Pauly, D (2002). The FAO – CLARM stock Assessment Tools (FISAT-11) User's guide. Computerized Information series FAO, Rome Italy.
[23] Pauly, D and David, N, (1981). ELEFAN-1 BASIC Program for the Objective Extraction of Growth Parameters from Length Frequency Data. *Meereforsch* 28(4):205-211.
[24] Pauly, D. and Munro J. L. (1984). Once more on the comparison of growth in fish and invertebrates. *Fishbyte* 2(1):21
[25] Pauly, D. (1987). Length-Based Methods in Fisheries Research. *ICLARM Conference Proceedings* 13:7-34.
[26] Moses, B.S. (2001). The Influence of Hydroregime on Catch Abundance and Recruitment of the Catfish, *Chrysichthys nigrodigitatus* (Bagridae) and the bonga, *Ethmalosa fimbriata* (Clupeidae) of Southeastern Nigeria's Inshore Waters. *Environmental Biology of Fishes* 61: 99-109.
[27] Pauly, D. and Navaluna N. A. (1983). Monsoon-induced Seasonality in Recruitment of Philippine Fishes FAO Fish Rep. 3 (291): 823-833.
[28] Qasim, S. Z. (1973). Some Implications of the Problem of Age and Growth in Marine Fishes from Indian waters. *Indian Journal of Fisheries*, 20 (3): 351-371.
[29] Weber, W. (1976). The Influence of Hydrographic Factors in the Spawning Time of Tropical Fish. In Fisheries Resources and their Management in Southeast Asia (Tiews, K., ed.) 269-281.pp.
[30] Pauly, D. (1982). Fish population dynamics in tropical waters: a manual for use with programmable calculators. *ICLARM, Studies and Reviews* 8:325.
[31] Mueter, F. J., Boldet, J. L., Megrey, B. A. and Peterman, R. M. (2007). Recruitment and Survival of Northeast Pacific Ocean Fisk Stocks: Temporal trends, Covariation and Regime Shifts. *Canadian Journal of Fisheries and Aquatic Science* 6:911-927.

ISSN 2397-7507(Print), ISSN 2397-7760(online)