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POPULATION DYNAMICS AND GILLNETS SELECTIVITY OF *Chrysichthys nigrodigitatus* (Lalepede 1803) IN LOWER REACHES OF THE CROSS RIVER ESTUARY, NIGERIA.

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Abstract

Population Dynamics and gillnet selectivity of Chrysichthys nigrodigitatus (Lalepede 1803) in the lower reaches of the Cross River estuary of Nigeria was studied for two years (January 2008 – December 2009), with respect to selectivity, gillnet sizes and population of the species based on length frequency analysis. Estimates of growth parameters, asymptotic length (L∞) = 98.25cm and growth constant (K/year) = 0.96yr-1. Total mortality rate (Z) was 6.27 yr-1, natural mortality (M) = 1.22 yr-1, Fishing mortality (F) = 5.05 yr-1 and Exploitation rate (E) = 0.81. Significant correlation (r = 0.9140 – 0.9770 and r = 0.976 – 0.977). (P < Z0.05) was observed between mesh sizes of gillnets and mean values of the morphometric characteristics (such as half-circumference, total length and total weight) of the fish. There is low percentage frequency range of the number of fish caught in different mesh sizes, possibly with low hanging coefficient range (0.4-0.5). Gilling, snagging, wedging, entangling were observed in the selection of the fishes. In conclusion, selectivity in Chrysichthys nigrodigitatus gillnet fishery in the Cross River estuary may be moderately adequate despite the influence of several other factors. The selection distribution curve using 17.5cm estimated modal total length recommends the usage of 50mm mesh size and above for exploitation of the species.

Keywords: *Gillnet, Selectivity, Mortality, Length, Population*

Introduction

In the Cross River estuary, *Chrysichthys nigrodigitatus* constitutes 66% by weight and 81% by number in the landings of the artisanal fishery, (Moses, 1987), confirming their dominant position as the target species are fished all the year round but with peak catches during the rainy months from May to October, which constitutes the main fishing season (Moses, 1987). Spawning and recruitment of the species also takes place all year round but with seasonal pulses. The major spawning peak occurs between July and September, and a secondary peak in January, while recruitment peak occur in May and December (Moses, 1987).

In describing the population dynamics of an exploited aquatic resource, a fundamental concept is that of stock. The stock is a group of organisms of one species having the same stock parameters and is victim of mortality and physiological features. Population dynamics is very important aspect of fisheries which becomes a welcome tool for management and conservatory measures (Begon *et al.,* 1990). One essential feature of a stock is that the population parameters remain constant over the distribution area of the stock, so the stock parameters are operationally convenient in assessing the population dynamics of a given species (Mosepele, 2000). The primary objective of population dynamics is to provide advice on the optimum exploitation of aquatic living resources such as fish and shrimps. Since these resources are limited but renewable, a fish stock assessment may be obtained as a search for the exploitation level, which in the long run gives the maximum yield (Hovgard *et al.,* 1999). The stocks targeted for this study which is *Chrysichthys nigrodigitatus* is commercial specie which is easily acceptable in the diet table of Nigerians. The result is that different fishing gears have been used in their exploitation, which result in non-fishable sizes seen in our Nigerian markets (Moses, 1987).

Gillnet fishing technique which is the most selective method of fishing worldwide and incidentally one of the most popular fishing techniques other than cast-netting in the study area is investigated. The selective capability of gillnets is afforded by the "mesh" which is the functional unit of the net. Different sizes of mesh determine different sizes of fish to be caught. Therefore, selectivity of gillnet can best be defined as the ability of the net to select different sizes of fish in

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preference to others (Helser *et al.,* 1991). The introduction of fine synthetic fishes such as nylon in the construction of fishing gear marked expansion in the commercial use of gillnets. The materials were cheaper and easier to handle, lasted longer and required less maintenance than natural fibres. Fibres such as nylon monofilaments become almost invisible in water, so nets made with synthetic twines generally caught greater numbers of fish than natural fibre nets used in comparable situations (Appelberg, 2000). Nylon is highly resistant to abrasion; hence the netting has the potential to last for many years if it is not recovered (Moses, 1988). Gillnet is a clear water fishery. In too deep water, the hydrostatic pressure can compress the usual floats of cork or plastic to such an extent that they lose their buoyancy and the gear can no longer function. With suitable floats, gillnets can be operated at a depth of 150m and more (Brandt, 1972).

The consumption of animal protein enhances health, (FAO, 1981). Over 40% of the animal protein consumed in Nigeria comes from fish and contributes over 35% to the total quantity of fish available for consumption in the country (Olawuyi, 1992). Regulating and selecting the sizes of target fish is of primary concern in the conservation of the stock. The exploitation of *Chrysichthys nigrodigitatus* is an important fishery in the Cross River System. *Chrysichthys nigrodigitatus* is more abundant in the East and south-South Nigeria where the bottom deposits consists of soft and hard substrate. This work was aimed at ascertaining the population dynamics and gillnets selectivity of *Chrysichthys nigrodigitatus* in lower reaches of the Cross River estuary, Nigeria.

Study area

The study area in South-South Nigeria is defined here is the coastal zone lying between the Cross River at the Cameroun border (approximately longitudes 70°5" – 80°35"E and latitudes 3°45" – 5°30"N) and encompassing Akwa Ibom, a fraction of the Rivers State East of the Niger Delta (Figure 1).

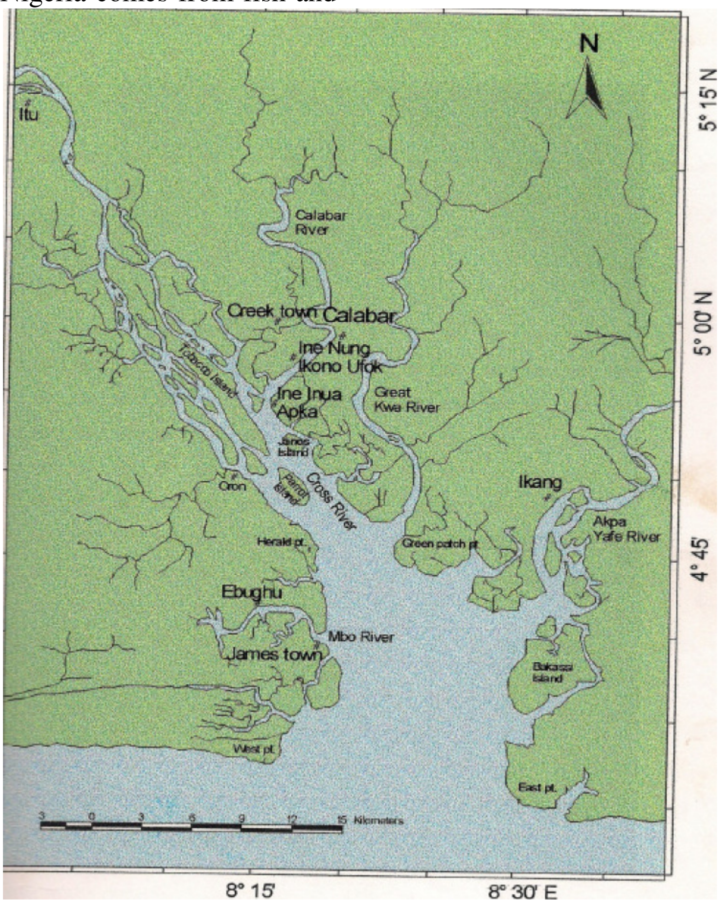

Figure 1 Cross River Estuary

Fishing is always an important occupation of the people of South-South Nigeria. The climate of the study area is divided into a distinct wet season (April – October, with rainfall of 211 – 431mm per month) and dry season (November – March, with rainfall of 32 – 156mm per month); 55% of the annual precipitation occurs between June and September (Moses, 1990).

Materials and Methods

Samples Collection

Sampling stations were selected at Mbo River, Itu beach and Calabar beach. Samples were collected bi-monthly. They were sorted into size categories. Each sample was obtained from total catch of known weight by mesh size. Samples were measured; length and weight measurements. Samples from all different mesh sizes were weighed for each gillnet and then pooled to length-frequency analysis. Different gillnets with different mesh sizes were used – 30mm, 40mm, 50mm, 60mm, 70mm, 80mm, 100mm. the length measurement were taken according to conventional method, that is, "nearest unit below" to 0.1mm precision for total length using a ruler. Girth was measured by using a simple tape measure or a string that is inelastic but calibrated.

The nets are set and checked at interval of 3-6 hours during day time but usually anchored and set in the evening and checked at dawn. Mesh size of the net which was measured as the distance between two opposite knots of a mesh when fully, stretched in a normal direction (Allcom, 1999).

Hanging coefficient (E) or ratios of the gillnet type (monofilament or multifilament) were obtained according to FAO (1978) as the ratio of length of the stapling rope to the number of meshes and mesh size hang on it. Frequency of occurrence, total length (TL cm), weight (kg) and the girth or circumference (O^{ce}) of the head around the operculum was obtained. The girth of individual fish caught by different mesh sizes were obtained with the aid of a flexible thin rope (0=0.01m) tied around the head – operculuon or deepest part of the body and recorded in millimeters (mm).

Data analysis

A software package, FAO/ICLARM Stock assessment tools (FiSAT) (Pauly 1983) was used for length-frequency analysis. This composition incorporated ELEFAN O routine for data entry; ELEFAN I routine for estimating the growth curvature parameter (K). Also incorporated in ELEFAN I is the routine for plotting the length-converted catch curves for estimating total mortality (Z). ELEFAN II programme of this FiSAT package is used to obtain recruitment pattern within a year, while ELEFAN III programme performs virtual population analysis (VPA).

ELEFAN I routine allows the estimation of von Bertalanffy growth parameter without knowing the age of the individuals was used to obtain L∞ and K. Von Bertallanffy growth equation below was used:

$$L_t = L\infty\ (1-e^{-k(t-to) + (ck/2x)\sin(2x(t-ts)})$$

Where L_t = mean length at age t.

L∞ = asymptotic length

k = growth constant

t_o = age at zero length

c = constant expressing amplitude of seasonal oscillations in growth

t_s = phase of oscillations.

Pauly (1984a) demonstrated that in nature, the oldest fish of a stock grow to about 95% of the asymptotic length. L∞ ≈ Lmax/0.95. Where Lmax is the maximum length observed in sample from the population. However, the longetivity of fishes were estimated from the relationship by Pauly (1980c) tmax ≈ $^3/_{IL.}$ Instantaneous rate of total mortality (Z) was calculated from length converted catch curve analysis method incorporated in FiSAT package with the option accounting for seasonal growth (Gayanilo and Pauly, 1997). Using Pauly's empirical formula (Pauly 1980b) natural mortality (M) was calculated with aid of length frequency data obtained. Upon the estimation of Z and M, the F-values were computed from the relationship F = Z-M. And exploitation (E) = E = $^F/_Z$. Mean half Circumference ($^1/_2 0^{ce}$). This was adopted in assumption that half the measured length of the circumference of the fish could approximate the mesh size (stretched) of the gillnet that length it (Erzini and Castro, 1998). Calculation was based on the mean, of the smallest and largest circumference range obtained from the fish caught by a particular mesh size. Circumference of fish girth measured could be assumed to be equal to the circumference of given mesh when cut and fully stretched. $(0^{ce})F = (0^{ce})$ M. F and M represents fish and mesh respectively. Mean total weight was obtained by finding the average (i.e.

dividing total weight of catches by total number of fish caught in a particular mesh size). Length frequency data obtained from catches of various mesh sizes were grouped according to length ranges of 2cm intervals of their total length (TL). A selection distribution curve was obtained by plotting mesh size against percentage retention of the fish.

Results

Total length measurements of 7,852 specimens of *Chrysichthys nigrodigitatus* used are shown in Table 1 and Table 2. Seeding the preliminary values into ELEFAN I, a seasonalized growth curve was obtained with the following parameters L∞ = 98.25cm, K = 0.96 yr^{-1} amplitude of oscillation (C) = 0.15, winter point (WP) = 0.15, growth performance index (φ) = 3.08 fig. 1. Z = 6.27 yr^{-1} and M = 1.22 yr^{-1}.

Yield per Recruit and Biomass per Recruit.

The Length at first Capture (Lc) L0.50 = 46.53cm L = 40.54cm and L0.75 = 50.19cm. Confidence Limit (CI) range of -1.33 to 12.88 gave a relative age of approximately. The knife-edge selection procedure (Figure 2) assumes that C. *nigrodigitatus* smaller than LC (46.53cm) is not captured by gear (Figure 3). The selection Ogive approach assumes that the probability of capturing any fish is proportional to its length. The knife-edge procedure gave the following results:

Emax = 0.661, E0.1 = 0.568, E0.5 = 0.358 plot of exploitation rate (E) against Relative yield/Recruit (Y/R) and Relative Biomass/Recruit (B/R) (Figure 4) indicated that increased exploitation rate (E) resulted in increased yield/Recruit and subsequent decrease in Biomass/Recruit. The specie exhibits two recruitment pulses in a year, peaks of unequal magnitude (Figure 5). A selection distribution curve of percentage retention and the mesh sizes is normally distributed and peaked at 60mm mesh size (Figure 6).

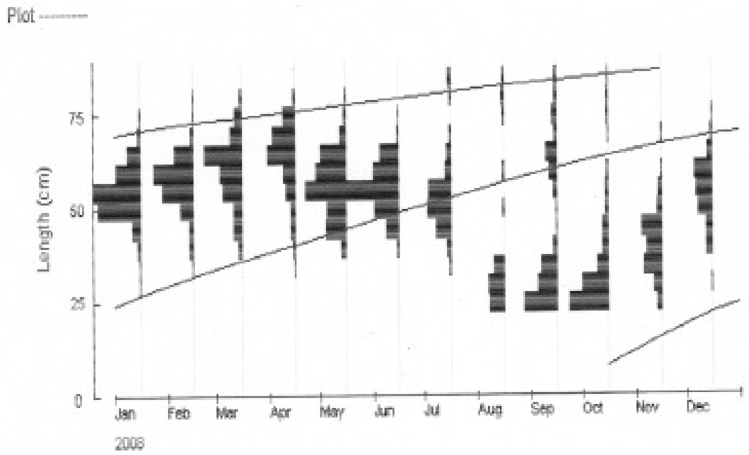

Figure 2 Growth curve of *C. nigrodigitatus* of the cross river reaches (L∞=98.25cm, k=0.96year⁻¹, C=0.15, wp=0.15, rn=0.205) superimposed on length-frequency data restructined by ELEFAN 1 programme.

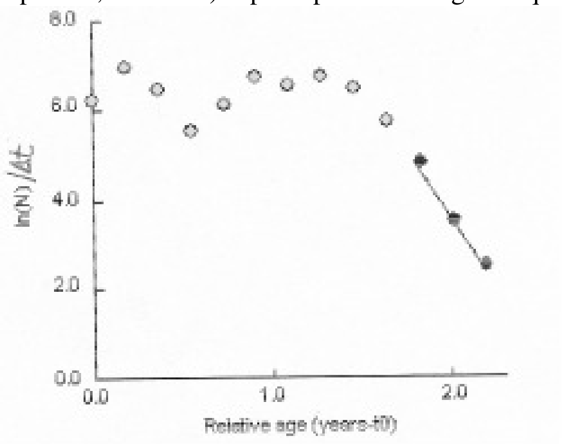

Figure 3 Length-converted catch curve of *C.nigrodigitatus* of the Cross River Reaches. Estimated z=6.27year⁻¹.

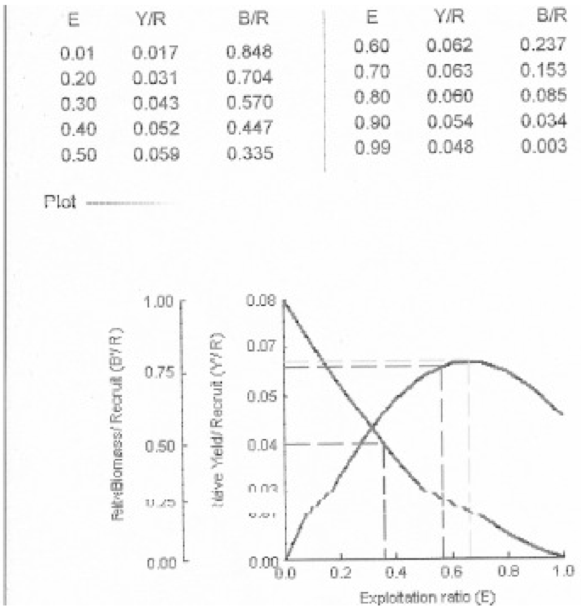

Figure 4 Related yield/Recruit Analysis (knife-edge) of C. *nigrodigitatus* of the Cross River Reaches. E0.1=0.568, E0.5 =0.358 Emaxa=0.661.

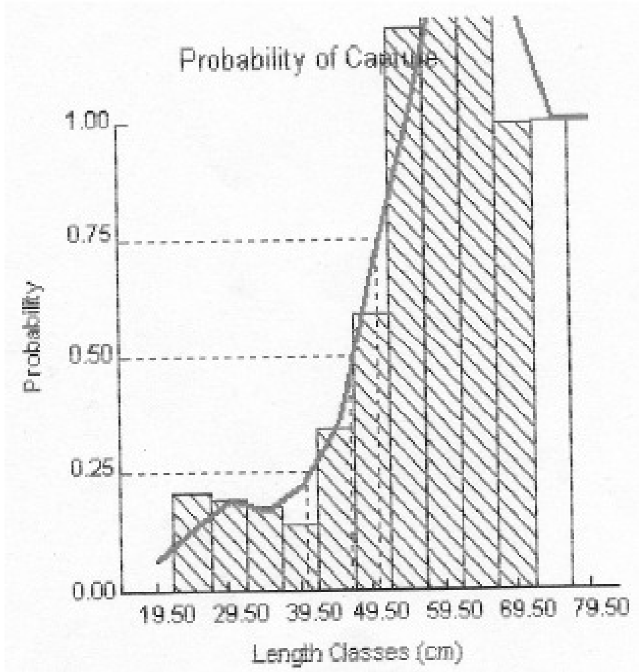

Figure 5 Probability of capture of *C. nigrodigitatus* as estimated from the ascending arm of the catch curve. The length at first capture (46.53cm).

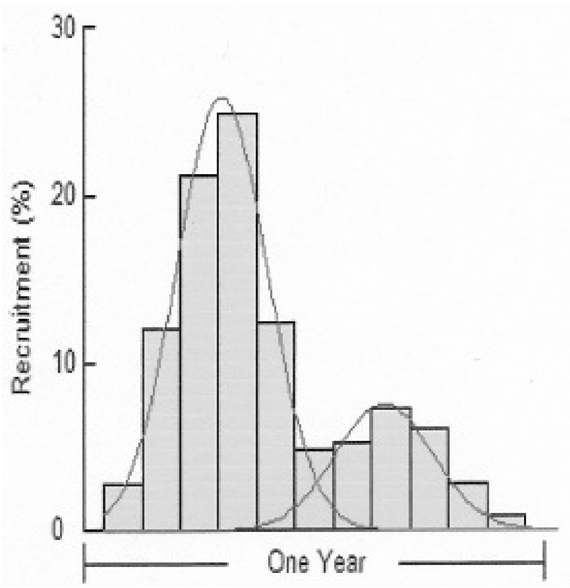

Figure 6 Recruitment pattern of *C. nigrodigitatus* of the Cross River Reaches, indicating two peaks of unequal magnitude within an arbitrary year.

Table 1 Total length (TL) frequency data of *Chrysichthys nigrodigitatus* taken from the reaches of the Cross River, Nigeria from January to December, 2008. ML = Mid Length of class interval.

ML/Date	01/8 Jan	02/08 Feb	03/08 Mar	04/08 April	05/08 May	06/08 June	07/08 July	08/08 Aug	09/08 Sept.	10/08 Oct	11/08 Nov	12/08 Dec	
24.5	-	-	-	-	-	-	-	90	217	263	23	-	
29.5	1	-	-	-	-	-	-	102	128	172	46	3	
34.5	1	3	-	2	-	-	7	61	103	70	114	-	
39.5	8	27	12	8	27	8	18	0	16	32	92	33	
44.5	50	24	50	19	131	84	93	0	5	28	125	39	
49.5	277	82	51	23	126	163	154	8	1	14	26	93	
54.5	322	203	122	59	266	390	141	-	22	16	14	111	
59.5	153	263	137	71	197	173	33	1	41	6	1	118	
64.5	80	124	243	179	166	124	22	-	68	0	0	29	
69.5	11	15	70	143	34	13	3	-	15	3	1	12	
74.5	3	5	38	74	11	1	0	7	27	9	-	1	
79.5	-	1	6	5	2	-	9	16	13	5	-	-	
84.5	-	-	-	-	-	-	12	8	11	1	-	-	
89.5	-	-	-	-	-	-	1	8	4	6	-	-	
	906	747	729	583	960	956	493	301	671	625	442	439	=7,852

Table 2: Length frequencies, weight and mean half circumference of girth of *Chrysichthys nigrodigitatus* caught in gill nets of various mesh sizes in the study area

Mean Weight (g)	Mean ½Ōce (mm)	Mean Total Length (mm)	MESH SIZES OF GILL NETS 30		40		50		60		70		80		100		Log Mean Weight (g)	Log Mean ½Ōce (mm)	Log Mean Total Length (mm)
			Freq (n)	% Freq.	Freq (n)	% Freq.	Freq (n)	% Freq.	Freq (n)	% Freq.	Freq (n)	% Freq.	Freq (n)	% Freq.	Freq (n)	% Freq.			
14.4	22.4	110	124	12.1													1.16	1.35	2.04
15.6	24	130	188	18.4	62	7.1											1.19	1.38	2.11
26.3	29.3	150	180	17.6	76	8.7											1.42	1.47	2.18
39.4	32.3	170	258	25.3	84	9.6	32	5.8									1.60	1.51	2.23
55.3	38.6	190	172	16.8	102	11.6	35	6.4	20	3.9							1.74	1.59	2.28
70.1	42.6	210	90	8.8	130	14.8	62	11.3	26	5.1							1.85	1.63	2.32
94.3	46.5	230	0	0.0	238	27.1	84	15.3	34	6.7							1.97	1.67	2.36
180.6	55.3	250	0	0.0	82	9.3	112	20.4	38	7.5	17	2.9					2.26	1.74	2.40
186.4	60.3	270	0	0.0	52	5.9	78	14.2	70	13.8	34	5.7					2.27	1.78	2.43
203	65.3	290	0	0.0	30	3.4	42	7.6	160	31.6	42	7.1					2.31	1.81	2.46
205	68.6	310	5	0.5	14	1.6	30	5.5	62	12.2	66	11.1					2.31	1.84	2.49
210	75	330	3	0.3	6	0.7	24	4.4	38	7.5	86	14.5	6	2.2			2.32	1.88	2.52
253	68.6	350	0	0.0	0	0.0	20	3.6	22	4.3	142	23.9	12	4.4			2.40	1.84	2.54
301	75.7	370	0	0.0	0	0.0	16	2.9	18	3.6	73	12.3	34	12.5			2.48	1.88	2.57
302	74	390	0	0.0	0	0.0	10	1.8	9	1.8	40	6.7	48	17.6			2.48	1.87	2.59
342	77.9	410	0	0.0	0	0.0	4	0.7	6	1.2	30	5.1	58	21.3			2.53	1.89	2.61
352	80	430	1	0.1	0	0.0			2	0.4	22	3.7	64	23.5	38	18.1	2.55	1.90	2.63
610	95.6	450			2	0.2			1	0.2	14	2.4	18	6.6	43	20.5	2.79	1.98	2.65
675	103.6	470					1	0.2	0	0.0	14	2.4	18	6.6	56	26.7	2.83	2.02	2.67
750	106.9	490							1	0.2	14	2.4	14	5.1	73	34.8	2.88	2.03	2.69
Total number of fish			**1021**	**100**	**878**	**100**	**550**	**100**	**507**	**100**	**594**	**100**	**272**	**100**	**210**	**100**			
Total weight (kg)			14.72		24.22		29.32		35.2		40.11		39.2		30.51				
Mean total length (mm)			114		143		173		205		241		303		331				
Range of ½Ōce (mm)			29.3		42.6		60.3		68.6		75.7		95		106.9				

Discussion

The growth curves estimated indicates a seasonal growth, and that growth drastically slows down in certain period of the year C = 0.15 in *Chrysichthys nigrodigitatus*. Winter point (WP) of 0.15 implies that the poorest growth occurs in July. The month of February and March are about the warmest in the year, with surface temperatures generally above 30^{o}C. Hovard *et al.,* (1999) noted that in temperate waters feeding often slow down or ceases in the summer, when temperatures reaches 29^{o}C or higher. This will affect the gillnet selectivity as it becomes difficult for a reasonable catch to be observed. The twine diameter increased especially monofilament nets. Gillnet of 30mm is best used during this period as increase in twine diameter will not be too large.

The poorest growth in July may be associated with their reproductive activities in the period. They spawn in the estuary but this comes to a peak in July to September (Offem, *et al.,* 2008). The poor growth in this month of July had earlier been noted by Atobatele and Ugwumba (2011). The estimated value of the growth coefficient (K) of 0.96yr^{-1} fall within the estimated value for Cynodrontis spp stocks by Pauly *et al.* (1984). The $L\infty$ estimation of 98.25cm is compared with maximum length of 120cm observed for species in the Lagos lagoon (Mairoghae, 1982). The presence of two recruitment peaks per year is in accordance with earlier results on prawns in tropical regions (Pauly *et al.,* 1984), and confirms the assertion of Pauly (1980b), and Dwiponggo *et al.* (1986) that the two recruitment pulses per year may be typical of tropical fish and invertebrate stocks.

Instantaneous rate of total mortality (Z) of 6.27yr^{-1} and exploitation rate of 0.81, shows there is fishing pressure on *Chrysichthys nigrodigitatus*. This is based on the assumption of Gulland (1971) that in an optimally exploited stocks, the natural and the fishing mortalities should be equal i.e. E = F/Z = 0.5. Comparing this result with the relative yield-per-recruit analysis would seem to confirm this assertion that the *Chrysichthys nigrodigitatus* populations are over fished with gillnet of mesh sizes of 30mm and 40mm.

The monofilament surface driftnets are preferred because of their reduced visibility in water (Brandt, 1972). Morphometric relationship of the catches in different mesh sizes of the gillnet shows a significant correlation range (r = 0.9140-0.9970), indicating fish size (circumference, total length and weight) selected by the gear depended on the mesh sizes of the net used. This is in line with the work of Udolisa *et al.* (1979) in the Cross River Nigeria. The ratio of 1.4/2.5 circumference by weight obtained from the log-log transformations of total length with circumference and weight signify a higher increase rate in weight than circumference per unit increase in length. While circumference increases, this being one of the factors that control selectivity by gilling and enmeshment weight increase attains an allometirc rate (2.5). The value 2.5 obtained from computation falls within the limits of 2.0-3.5 range (Beverton and Bolts, 1957; 2.5-3.5 range. Carlender, 1969; 2.5-4.0 range. Lagter *et al.,* 1997) which shows that no fish actually grow isometrically due to differences in the condition factor of the fish. However, growth of fish is isometric at the early age (to) and allometric at later age (max) (Begenal and Tesch, 1979). The low hanging coefficient of gillnet result in entangling of a wider size range of the species by a particular mesh size. Aside gilling, some were wedge (caught at the targets body depth) and snagged. Shape and behaviour of the fish could be contributive factors that moderate selectivity of the net (Anyanwu, 1991). Others include net construction and visibility of the net in water (Brazil and Wolters, 2002).

The selection distribution curve obtained from the estimated modal total length of a 98.25cm is the combined effect of gilling, wedging, snagging and entangling which did not deviate from the normal dumbbell shape curve of gillnet selectivity. This means gilling which is the catching patterns that dominate all others in effect of mesh size alone. Selectivity in *Chrysichthys nigrodigitatus* gillnet fishery in the Cross River estuary may be moderately adequate despite the influence of several other factors. There are selectivity deviations in some gillnet fishery. Mohanty (2004), noted such deviation in the exploitation of *Chrysichthys nigrodigitatus* in lower Cross River, Nigeria.

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