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Fish species composition and size structure exploited by gill net fishery in the New Calabar River, Nigeria

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Abstract

The purpose of this study was to investigate the species composition and size selectivity of gillnets commonly used by the artisanal fishers in the New Calabar River, Rivers State, Nigeria. The data were collected during February-July 2018 from 3 sampling stations: SI Choba, S2 Ogbogoro, and S3 Iwofe all along the stretch of the river. Twenty-eight fish species were found belonging to 15 families. The prevalent families were Cichlidae, Mugilidae and Clupeidae representing 32.22%, 30.36% and 10.23% of the total catch, respectively. The most dominant species in terms of number were *Liza falcipinnis* (12.58%) and *Mugil cephalous* (12.26%) while in terms of biomass, the most abundance species were *Xenomystus nigri (24.12%)* and *Lutjanus agennes* (12.50 %). The girth and total lengths of the fishes ranged from 5.20±0.20 to 21.00±0.00 cm and 8.85±0.15 to 28.19±1.13 cm respectively. The length at first capture (L50%) for the most abundant species (*Liza falcipinnis*) was calculated to be 14.13 cm while that of L25% and L75% were 12.70cm and 15.25cm respectively. It was concluded that the gill nets used in the New Calabar River exploit fish species of small sizes and the few medium sized specimens relative to species potential maximum size. It is therefore recommended that for an improved and sustainable exploitation fish stock of the New Calabar River, the use of gillnets of less than 25 mm-mesh sizes and "other gears" should be prohibited.

Keywords: gill nets; species composition; mesh size; selectivity; New Calabar River

1. Introduction

Niger delta is blessed with rivers, lagoons, creeks and their associated wetlands that are very rich in fish and other aquatic biodiversity. As a result of these numerous inland water bodies, fishing is the major tradition occupation in the region particularly for the people living in riverine areas. The vast water bodies support large freshwater small-scale artisanal fisheries that support livelihood gains and those that primarily support subsistence consumption activities. The capture from inland waters are multi-species and multi-gear with a great majority of fishers traditionally operate at small-scale level to exploit the natural fisheries resources in whatever means available to them (Olopade et al., 2017).

But over the past decades, these water bodies have come under increased pressure due largely to the heavy demand on freshwaters fishes, habitat degradation and water pollution. The increase in demand for freshwater fishes has led to increase in fishing effort and the use of destructive fishing gears and thus the consequent is stock depletion and over fishing.

Unfortunately, the management of inland fisheries in Nigeria for sustainable use is a difficult task even though the laws and regulations exist, but they are not enforced. For examples, the inland edit permits fishing gears with varied mesh sizes ranging from 3.8cm to 7.62cm (Inland Fishing Act, 1992). The local fishers are still involved in the use of gears and mesh sizes not sanctioned by government. Therefore, there is a need for effective and sustainable utilization of fish stocks through the evaluation of commonly used fishing gears and their impacts on fish species populations in the inland water fisheries.

Gill nets are widely used in artisanal fisheries in developing countries because they are efficiency, relatively inexpensive and capable of catching higher amount of commercially valuable species than another peasant (Valdez-Pizzini et al., 1992). Gill net selectivity has been defined as the probability that a fish of a given species and size will be caught when encountering a specified mesh size (Matsuoka et al., 1990). The spatial and temporal distribution of fish is one of the most important factors affecting the capture process of gillnets as it directly influences the probability of fish encountering a net (Dickson, 1989). Other factors such as hanging ratio and twine thickness affect gillnet catches and selectivity once fish have encountered a net.

Knowledge of gear selectivity is still essential in order to determine sizes vulnerable to fishing, determine fishing effort to maximize yield (the ultimate goal of both measures), and to monitor the size distribution of the fish stocks over time (Millar and Holst, 1997; Huse et al., 2000**).** Therefore, the estimation of selectivity parameters is needed to ensure a proper management of the commercial gillnet fishery. It is against this background th**is**

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study aimed at investigating the catch composition and size selectivity of gillnets in the New Calabar River.

2. Materials and methods

2.1. Fish sampling and data collection

Three sampling sites were selected each one with different habitat complexity and water quality characteristics. The sampling sites were at Choba (S1), Ogbogoro (S2) and Iwofe (S3) (Figure 1) all along the stretch of the New Calabar River longitude situated at 7°60'E and latitude 4°25'N. Fish sampling were conducted twice in a month for a period of six months (February - July, 2018), with the assistance of artisanal fishermen using gillnets of mesh sizes 15mm and 25mm (Table 1) which are the only mesh sizes used in this area.

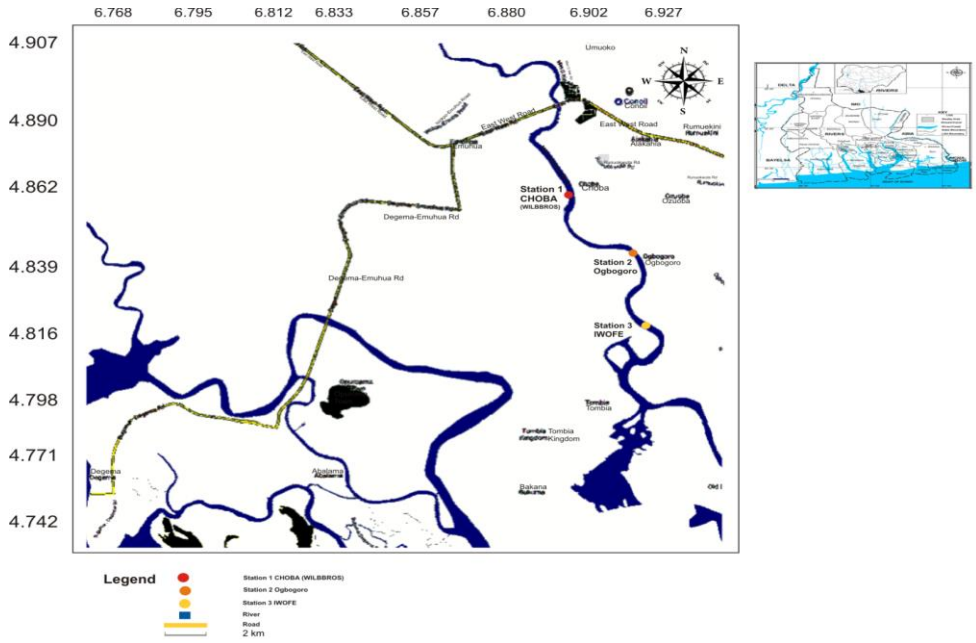

Figure 1. Sampling location.

Table 1.
Gill net specification

Design characteristics	Measurement and description	
	Mesh size 1	Mesh size 2
Mesh size	15mm	25mm
Length of net	100 m	100m
Height of net	2.74m	2.74m
Net structure	rectangular	rectangular
Sinker material	block	block
Floater material	rubber cock	rubber cock
Type of mesh	Knotted	Knotted
Gear colour	White	White
Netting material	Polyester	Polyester
Hanging ratio	0.2-0.5	0.2-0.5

The fishing gear was set during 5-6 p.m. and the fishermen came back the next day at 5-7 a.m. The fish samples collected were identified according to Adesulu and Sydenham (2007). Total length (TL) was measured from the most anterior part of the head to the tip of caudal fin with the mouth closed using a measuring board in cm. Total weight was recorded to nearest 0.1g and girth was measured to the nearest 0.01 cm with a caliper.

2.2. Data analysis

From the data collected from the samples, the following analytical method was used.

The relative species abundance % = (n/N) X 100

Where n is the number of samples in which the species was captured, and N is the total number of sampling events carried out in the study. An index of relative importance, IRI was calculated by Pinkas et al. (1971). T- test was used to analyse the means between the two mesh sizes and in order to determine the mean size at first capture (LC=L50%), the probability of capture estimated by backwards extrapolation of the descending limb of the catch curve to include younger age classes that were likely to be underrepresented in the catch, within the FiSAT II program (Gayanilo and Pauly, 1997).

3. Result and discussion

3.1. Result

The present study described total 28 species of fishes belonging to 15 families which presented in the Table 2. The fish family represented with the highest number species in the study was Cichlidae (32.22%) with eight species. This was followed by the Mugilidae (30.36%), Clupidae (10.23%), Alestidae (5.35%) with three species each. The family Carangidae was represented by two species. Other fish families include Eloetridae, Notopteridae, Monodactylidae, Claroteidae, Lutjanidae, Elopidae, Gerreidae, Sciaenidae, Sphyraenidae and Bothidae had one species each as shown in the Table 2. The most dominant species in terms of number were *Liza falcipinnis* with of about 12.58% of the total catch followed closely by *Mugil cephalous* (12.26%) and *Sarotherodon melanotheron* (8.69%). In terms of biomass, *Xenomystus nigri* (24.12%) had the highest followed by *Lutjanus agennes* (12.50 %) *and Chrysicthys nigrodigitatus* (8.66%).

The collected specimen of arrow bulleye *P. sagittarius* was 255 mm total length (TL) and 307 g weight (TW) (Figure 2). Body elongate; caudal fin slight rounded; Soft rays of dorsal and anal fins relatively long; Pectoral fins were relatively short and broadly pointed, shorter than pelvic spines.

Based on the index of relative importance (IRI) results in Figure 2 the following fish species were most important *Liza falcipinnis*, *Mugil cephalous* and *Chrysicthys nigrodigitatus* while *Brycinus longipillis* and *Pseudotholithus elongates* were the least important species.

Table 2.
Species composition of gill net in the New Calabar River.

Species	Frequency	%	Weigth (g)	%
ALESTIDAE				
Brycinus longipinnis	2	0.16	10	0.45
Brycinus macrolepidetus	18	1.46	42.78	1.91
Brycinus nurse	46	3.73	37.30	1.67
	66	**5.35**	**90.08**	**4.03**
CARANGIDAE				
Caranx hippos	47	3.81	29.21	1.30
Trachinotus teraia	13	1.06	30.62	1.37
	60	**4.87**	**59.83**	**2.67**
CICHLIDAE				
Coptodon dageti	34	2.76	55.65	2.49
Coptodon zillii	71	5.76	57.77	2.58
Coptodon guineensis	63	5.11	88.05	3.93
Sarotherodon melanotheron	107	8.69	72.02	3.22
Sarotherodon galileus	85	6.90	58.69	2.62
Chromidotilapia guntheri	30	2.43	84.46	3.77
Hemichromis fasciatus	7	0.57	135.71	6.06
	397	**32.22**	**552.35**	**24.67**
CLAROTEIDAE				
Chrysichthys nigrodigitatus	**68**	**5.52**	**193.94**	**8.66**
CLUPEIDAE				
Sardinella maderensis	58	4.71	16.67	0.74
Ethmalosa fimbriatta	27	2.19	10.41	0.46
Ilisha Africana	41	3.33	5.46	0.24
	126	**10.23**	**32.54**	**1.44**
ELEOTRIDAE				
Bostrychus africanus	**9**	**0.73**	**43.00**	**1.92**
ELOPIDAE				
Elops lacerta	**52**	**4.22**	**53**	**2.37**
GERREIDAE				
Eucinostomus melanopterus	**17**	**1.38**	**20.47**	**0.91**
LUTJANIDAE				
Lutjanus agennes	**3**	**0.24**	**280**	**12.50**
MUGILIDAE				
Liza falcipinnis	155	12.58	46.06	2.06
Liza grandisquamis	68	5.52	123.06	5.50
Mugil cephalus	151	12.26	45.73	2.04
	374	**30.36**	**214.85**	**9.60**
MONODACTYLIDAE				
Monodactylus sebae	**32**	**2.60**	**46.45**	**2.07**
NOTOPTERIDAE				
Xenomystus nigri	**1**	**0.08**	**540.00**	**24.12**
SCIAENIDAE				
Pseudotholitus elongates	**3**	**0.24**	**10**	**0.45**
BOTHIDAE				
Citharichthys spilopterus	**1**	**0.08**	**2**	**0.09**
SPHYRAENIDAE				
Sphyraena barracuda	**23**	**1.87**	**100.70**	**4.50**

Table 3 shows the variations in the number of individuals captured with the two mesh sizes and catch rate. The fish catches decreased in number as the mesh size increased from 15 mm to 25 mm. The gill net with mesh size 15mm recorded more individuals (760) and 21 species than the mesh size 25mm with 472 individuals and 11 species. Suggesting that majority of fish caught were juvenile and in-mature. The most susceptible species to mesh size 15mm were species from the Mugilidae family with the *Liza facipinnis* and *Mugil cephalous* accounting for 40.26% of total catch. While that of the 25mm caught more of the Cichlids with four species from this family accounting for 68.86%. The results in Table 4 are statistically significant ($t=-2.52$, $p<0.01$). The results revealed a statistically difference between the mesh sizes (15mm and 25mm) towards catch rate with mesh size 15mm recording more catch with a mean score of 16.208 as against the mesh size of 25mm with mean score of 15.16.

Table 3
Fish catch by different mesh size.

Species	25mm		15mm	
	Freq.	%	Freq.	%
Brycinus longipinnis	0	0.00	2	0.26
Brycinus macrolepidetus	0	0.00	18	2.37
Brycinus nurse	0	0.00	46	6.05
Caranx hippos	0	0.00	47	6.18
Chromidotilapia guntheri	27	5.72	3	0.39
Chrysicthys nigrodigitatus	68	14.41	0	0.00
Coptodon dageti	33	6.99	1	0.13
Coptodon guineensis	62	13.14	1	0.13
Coptodon zillii	71	15.04	0	0.00
Bostrychus africanus	9	1.91	0	0.00
Elops lacerta	0	0.00	52	6.84
Ethmalosa frimbiatta	0	0.00	27	3.55
Eucinostomus melanopterus	0	0.00	17	2.24
Citharichthys spilopterus	0	0.00	1	0.13
Hemichromis fasciatus	6	1.27	1	0.13
Ilisha africana	0	0.00	41	5.39
Liza facipinnis	0	0.00	155	20.39
Liza grandisquamis	0	0.00	68	8.95
Lutjanus agennes	3	0.64	0	0.00
Monodactylus sebae	0	0.00	32	4.21
Mugil cephalous	0	0.00	151	19.87
Pseudotholithus elongatus	0	0.00	3	0.39
Sardinella maderensis	0	0.00	58	7.63
Sarotherodon galileus	85	18.01	0	0.00
Sarotherodon melanotheron	107	22.67	0	0.00
Sphyraena barracuda	0	0.00	23	3.03
Trachinotus teraira	0	0.00	13	1.71
Xenomystus nigri	1	0.21	0	0.00
Total	472	100.00	760	100.00

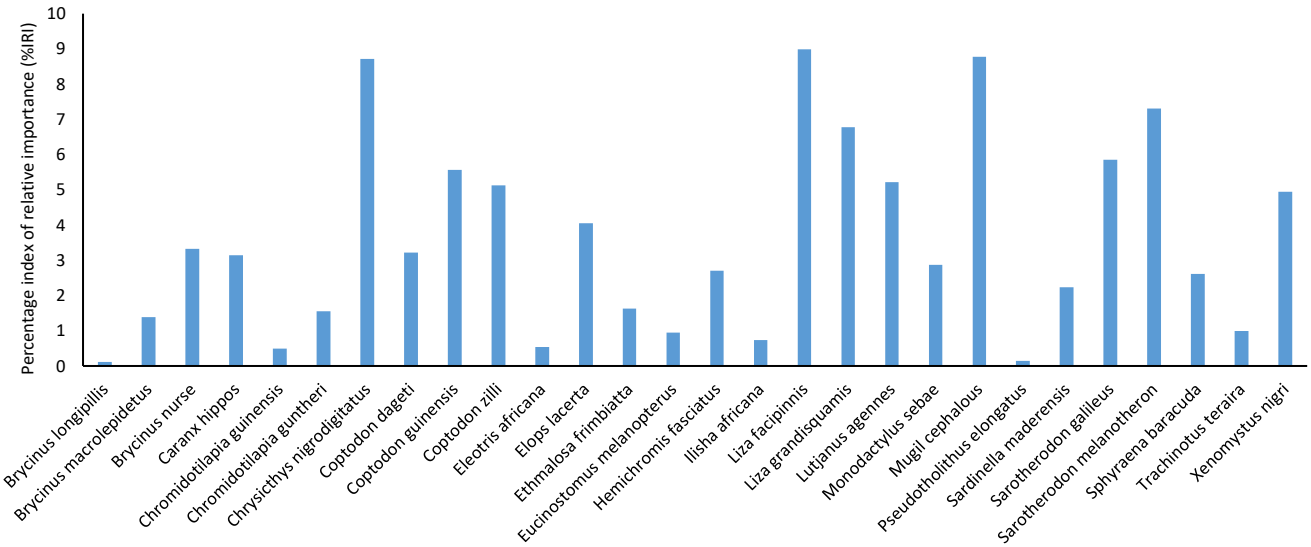

Figure 2. Percentage index of relative importance (% IRI) for each species.

Table 4
Summary of the t-test statistic between mesh sizes.

Mesh	N	Mean	Std. Deviation	F	P-value	T
25mm	472	15.1631	7.99873	190.20	0.00**	-2.52
15mm	759	16.2082	6.45474			

**Significant at p<0.01
N = the total number of individual fish caught by the mesh sizes

The mean girth, total length and mean weight of the fish species are shown in the Table 6 below the girth ranged from 5.20±0.20 to 21.00±0.00 cm recorded for *Brycinus longipinnis* and *Xenomystus nigri* respectively. The mean total lengths ranged from 8.85±0.15 cm recorded for *Brycinus longipinnis* to 28.19±1.13 cm recorded for *Chrysicthys nigrodigitatus* (Table 5).

Table 5
Girth and total length measurements of fish species caught by gill net.

Species	Girth (cm)		Total length (cm)	
	Mean±SE	Range	Range	Mean±SE
Brycinus longipinnis	5.20±0.20	5.00 - 5.40	7.00 - 7.50	8.85±0.15
Brycinus macrolepidetus	9.15±0.61	3.60 - 15.30	9.50 - 22.30	15.27±1.10
Brycinus nurse	7.89±0.29	2.60 - 12.00	5.50 - 95.00	13.11±0.42
Caranx hippos	6.86±0.19	2.10 - 10.00	4.90 - 10.50	11.53±1.91
Chromidotilapia geuntheri	8.64±0.59	3.50 - 17.00	4.80 - 15.00	13.77±2.49
Chrysichthys nigrodigitatus	13.09±0.55	2.80 - 24.00	10.50 - 33.50	28.19±1.13
Coptodon dageti	8.71±0.21	4.20 - 10.00	6.60 - 13.40	15.21±0.37
Coptodon guineensis	10.58±0.41	6.90 - 21.00	2.70 - 23.70	16.72±0.52
Coptodon zillii	9.73±0.31	4.00 - 20.00	6.00 - 17.00	15.03±0.29
Bostrychus africanus	6.80±1.05	2.50 - 12.00	7.50 - 18.00	13.87±1.44
Elops lacerta	8.19±0.47	4.80 - 16.20	10.50 - 23.60	19.03±0.52
Ethmalosa frimbiatta	5.49±0.33	1.30 - 8.40	2.10 - 12.30	8.81±0.42
Eucinostomus melanopterus	6.82±0.38	4.00 - 12.00	6.00 - 12.00	10.82±0.38
Citharichthys spilopterus	5.80±0.00	5.80 - 5.80	6.50 - 6.50	8.50±0.00
Hemichromis fasciatus	11.91±2.37	4.30 - 20.00	7.00 - 18.50	17.66±2.25
Ilisha africana	4.98±0.19	3.00 - 7.20	4.70 - 9.20	8.36±0.20
Liza falcipinnis	8.07±0.14	4.50 - 15.50	9.00 - 23.80	17.36±0.24
Liza grandisquamis	10.28±0.32	5.50 - 18.00	9.00 - 30.00	23.21±0.77
Lutjanus agennes	18.00±1.00	17.00 - 20.00	19.50 - 21.50	26.07±0.97
Monodactylus sebae	15.44±0.63	7.00 - 21.80	4.00 - 12.50	12.92±2.53
Mugil cephalous	7.83±0.12	2.40 - 12.00	4.80 - 22.50	17.01±0.28
Pseudotholithus elongates	7.67±0.13	7.40 - 7.80	11.00 - 12.00	15.33±0.07
Sardinella maderensis	6.51±0.64	1.20 - 35.00	2.30 - 10.20	9.46±0.29
Sarotherodon galileus	10.10±1.23	3.50 - 111.90	8.00 - 15.50	14.78±0.22
Sarotherodon melanotheron	10.06±0.24	5.00 - 18.90	8.00 - 17.00	15.62±0.23
Sphyraena barracuda	11.40±1.23	3.50 - 21.00	12.00 - 25.50	25.33±0.61
Trachinotus teraira	6.20±0.38	4.90 - 9.30	4.40 - 8.10	8.86±0.30
Xenomystus nigri	21.00±0.00	21.00 - 21.00	38.00 - 38.00	44.00±0.00

The selectivity of *Liza falcipinnis* was estimated for the most abundant species caught during the sampling period (Figure 3). The length at first capture (L50%) was calculated to be 14.13cm while that of L25% and L75% were 12.70cm and 15.25cm respectively.

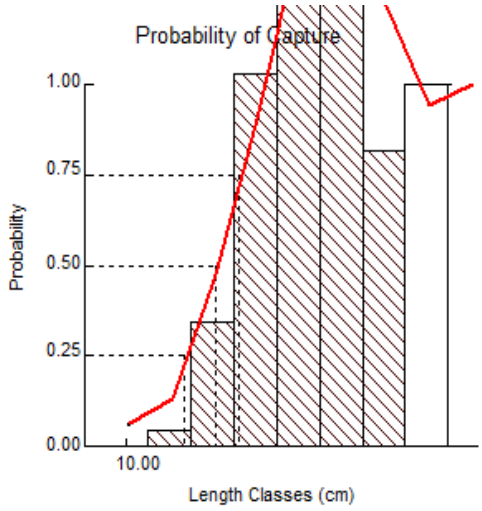

Figure 3. Probability of *Liza falcipinni*

3.2. Discussion

The fish fauna in the study area is typically diverse with 28 species belonging to 15 families. However, the number recorded in this study is lower than that recorded in the same river by earlier studies (Ibim et al., 2016). This can be attributed to the factors of sampling duration and selectivity of gear used in the present study. According to Olopade and Rufai (2014), species number will vary depending upon differences in sampling methods and sampling effort, as well as fish abundance. Hamley (1975) also reported that the probability of capture in gill net varies with the external characteristics of the fish, the material used, and the method of fishing. The fish fauna recorded in this study composed the freshwater and marine fish species with the most prevalent families were Mugilidae, Clupidae, Alestidae and Carangidae. Olopade et al. (2018) described the New Calabar River as a partially mixed estuary. It is believed that the New Calabar River is a distributary of River Niger that emptied into Atlantic Ocean saline as a result, their fish fauna is more related to the coastal and marine fishes than a typical Riverine fish fauna. Thirteen species in 28 were purely estuarine or marine fishes. This suggests that movement from one habitat to another is a continuum of survival of some fish species in the study area.

The dominant family was the cichlids, which had a total number of eight species while others fish families were represented with few species. This result can be closely related to the study carried out on the distribution and abundance of cichlids in the same river (Olopade and Dienye, 2018) which recorded ten cichlid species and also the research study on fish assemblage in the same river (Ibim et al., 2016) which recorded nine cichlid species. The dominance of the fish fauna of the river by the cichlids agrees with the findings of Nedelee and Prado (1990).The abundance of this fish family may be the result of natural history traits such as high reproduction rates, high rates of juvenile and adult survival or strong competitive abilities that allow them to dominate other species (Van Dyke, 2002). The relative abundance of species one is of the most fundamental aspects of community structure. The results of relative abundance and index of relative importance (IRI) revealed that the following fish species were most important *Liza falcipinnis, Mugil cephalous* and *Chrysichthys nigrodigitatus* while *Brycinus longipillis* and *Pseudotholithus elongates* were the least important species. Molles (2008) noted that in any community structure most species are moderately abundant; few are very abundant or extremely rare.

Expectedly, the fish catches decreased in number as the mesh size increased from 15 mm to 25 mm. The mesh size 15mm captured more individuals and almost all the species recorded during the study and the majority of the catch were at the juvenile stage. Reason for the large number of juveniles might be due to the size of the mesh of the nets used. Small mesh sizes catch small and in-mature fish (Ita and Machili, 1997). A minimum of 40mm stretch mesh is recommended for catching the larger fish specimen which brings high market value (Solarin and Kusemiju, 2003). The mechanical process of fish capture in a gill net depends on the relative geometry of the mesh and the

fish (Hamely, 1975). The most susceptible species to mesh size 15mm were species from the Mugilidae family while that of the 25mm caught more of the Cichlid species. This may be attributed to size and shape of the two fish families. It is well-established that gill nets are selective for particular sizes and species, although this depends on several biotic factors (Marais, 1985). Interspecific differences in behaviour, morphology, and even in the habitat each species occupies are factors that may account for the observed differences in mesh selectivity between species (Hickford et al., 1977).

The fish length and the fish girth are related to each other linearly. This relationship is also important because the fish girth is the main factor in determining the optimum mesh size (Hamley, 1975). Fish body length and girth are related to biological parameters such as condition and swimming capability and the different girth types determine the probability of different ways of capture by a fishing gear. In this study the fish fauna were characterized by small-sized specimens with the mean girths ranged from 5.20±0.20 cm to 21.00±0.00 cm and the mean total lengths ranged from 8.85±0.15cm to 28.19±1.13 cm. The gill net caught fishes of body girths range of 1.20-35.00 cm to 21.-21.00 cm and fishes with head and body girths smaller 1.20 cm which were not entangled escaped. Baranov (1948) showed how the size of mesh and the body form of the fish are very important in controlling the ability of an individual net to retain a particular fish.

The probability of capture was calculated for the most abundant species (*Liza falcipinnis*) during the sampling period. The length at which 50% of the species was retained and 50% escaped was estimated to be 14.13cm. This means at a length of 14.13cm, *Liza falicipinnis* was caught by the gill net. This revealed that smaller sizes are vulnerable to capture. This situation is also described by Froese (2004) as recruitment overfishing; when fishes are caught before they can realize their full potential.

4. Conclusion

This study revealed the diverse nature of the fish fauna and selectivity of gill nets used in the New Calabar River. The gill nets used by the fishers exploit fish species of small sizes and few medium sized specimens relative to species potential maximum size in the River because of small mesh sizes. Therefore, there is needed to ensure a proper management of gillnet fishery in the river by banning the use of gillnets of mesh size less than 25 mm for the fishing in the New Calabar River to optimize harvest and ensure sustainability safe guard the stock. In order to ensure adequate compliance an appropriate system for inspecting, monitoring, and tracking catches should be developed by the government. Also, better information should be provided to fishermen by government agents about fishing regulations, thereby decreasing the incidence of inadvertent violations

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