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First record of artisanal fishing effort and characteristics of the *Nematopalaemon* shrimp fishery in the Okoro river estuary, southeastern Nigeria

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Abstract
Frame surveys were carried out in April 2011 to March 2012 to assess the effort statistics of the *Nematopaleamon* shrimp fishery of Okoro River estuary, Southeastern Nigeria. The survey covered the entire estuary from head to mouth. A total of 26 fishing villages were found in the study area. The effort units were run by a work force of 4457 fishers. The mean number of fishers per fishing community was 171. The mean number of crew men per canoe was 3±1. The total number of canoes was 1539 canoes, while the mean number of canoe per fishing community was 59±5. The ratio of operational to non-operational canoes averaged 4:1. Correlation between fishing inputs and environmental factors revealed how the environment and fishing effort governed the yield of the fishery. A total of 9 different fishing gears were in use in the area with fish weir (6%), traditional crayfish beam trawl (16%), stake / stow net (27.2%) and float / anchored trap nets (50.8%) being the most widely used. The study recorded an average of 10±5 nets per canoe unit. Anchored trap net was found to be the only unit of exploitation of the fishery that showed constancy and consistency. The fishing crafts were mainly dug-out motorized canoes (12m long) equipped with 8-45 Hp and non-motorized (8m long) canoes equipped with 3x3x3 polythene sail and paddles. This study recorded a mean value of 4±2 trips per week. The 1539 fishing canoes with 4457 fishers' work force indicated heavy pressure on shrimp resources. Excessive effort should be reduced for optimal management and sustainability of the *Nematopaleamon* shrimp fishery in the Okoro River estuary Southeastern of Nigeria.

Keywords: Artisanal fishing, Effort statistics, *Nematopaleamon* fishery, Dugout canoes, Okoro river, Southeastern Nigeria.

1. Introduction
Fishing effort consist of the number of fishing trips made and the power exerted to harvest fish per unit time. Effort could be measured in terms of number of fishers or fishing units (Gulland 1983; McCluskey and Lewison, 2008) [1, 2]. or measure in terms of the amount of fishing capacity and activity. There are two general categories of fishing effort: nominal and effective. Nominal fishing effort describes the effort allocated to fishing, such as time (days or hours fished), capacity (number of vessels, length or horsepower of vessel), labour (number of persons or number of crew) or gear (mesh size). Nominal fishing effort can also be considered as a measure of fishing power, ie the capacity of a fishery to produce a potential yield. Effective fishing effort is a standardized measure of effort, such as the rate of fish capture (Maunder and Punt, 2004) [3]. Effort information is needed to interpret changes in the amount of catch (stock abundance) and to regulate fishing efficiency to maximize profit and minimize over fishing Branch *et al.,* (2006) [4]. Knowledge of the amount of fishing effort used together with the corresponding catch could enable the computation of an index of abundance of a given shrimp fishery (Holden and Reed, 1972; Holden and Raitt, 1974) [5, 6]. Also, excessive fishing effort is one of the prime problems in many cases where resource over-exploitation occurs (ACMRR, 1993; Young *at al.* 2006) [7, 8]. In estimating the fishing effort of the artisanal fleet in the Cross River estuary, Nigeria, Holzloeliner *et al*., (2004) [9]. Reported a total 87,990 fishers and 19,023 canoes operating in the inner and outer estuary. In the coastal areas in Spain, Otero *et al.* (2005) [10] have reported that about 5000 vessels operate in the artisanal fleet off the coast of Galicia, Spain in 2004. Also, half a million small scale or artisanal vessels were reported to operate in Indonesia and Malaysia between 1998 -2000 (FAO, 2006) [11]. Federal Department of Statistics (FDF, 2008) [12]. Reported had that there are about 166

million artisanal fishers in Nigeria: out of this 984,434 operate full time, 681,973 part-time and the rest occasional. Etim (2010) [13]. stated that artisanal fishery contributes 82% to domestic fish production in Nigeria and that the sector is capable of generating 10,000 jobs for rural dwellers annually. According to FAO (1969) [14]. an effective method for assessing the fishing effort in an area or for a given fishery is by undertaking an inventory, usually through a frame survey in order to assess whether the fishery is sustainable. Again, regulation of fishing effort (e.g reduction of number of boats, number of fishers and type of gears, time of fishing, mesh size regulation etc) is an important management approach for global sustainable development of any given fishery as recommended by (Enin *et al.*, (1991) [15]. As Gulland (1983) [1] puts it, measures such as number of fishers or fishing units, recorded perhaps once a year, can be used as a measure of fishing effort.

In the Okoro River estuary, Southeastern region of Nigeria, the *Nematopaleamon* shrimp fishery is concentrated in shallow waters especially in the estuarine areas were fishers use a multiplicity of gears, with heavy concentration on near shore areas where abundance and availability of shrimp are highest. The *Nematopalaemon* shrimp fishery is carried out using a specific traditional shrimp conical trawl net with dug-out canoes. The artisanal shrimp fleet in this area is increasing tremendously in recent years and these vessels exploit shrimp resources in large quantities in Okoro River estuary, Southeastern Nigeria and yet no scientific information on the effort statistics of the shrimp fishery in this area. Thus, the study was conducted to provide baseline and comprehensive effort data and characteristics of the *Nematopalaemon* shrimp fishery in the Okoro River estuary and its adjourning floodplains.

2. Materials and Methods

2.1 Geographical Location and Hydrology

The Okoro River estuary is located in the Southeastern of Nigeria on latitude 4º 33^{1}N and 4 º 55^{1}N and longitude 7º45^{1}E and 7^{0}55^{1}E. (Fig. 1) It has an area of about 1000km^2 with a range length of 132-135 km and width range of 65-105 km (NEDECO, 1961) [16]. The maximum depth of the river is approximately 58.2m and is connected with the open sea (Atlantic ocean) at three different locations: Ebong Aquan Iko, Ebong Aquan Emereoke and Ebong Aqua Obianga. It is joined with 13 creeks and 22 tributaries (Udoidiong, 2005) [17]. The creeks are tide dominated embayment with little fresh water input thus, creating a complex habitat that sustains rich aquatic ecosystem locally.

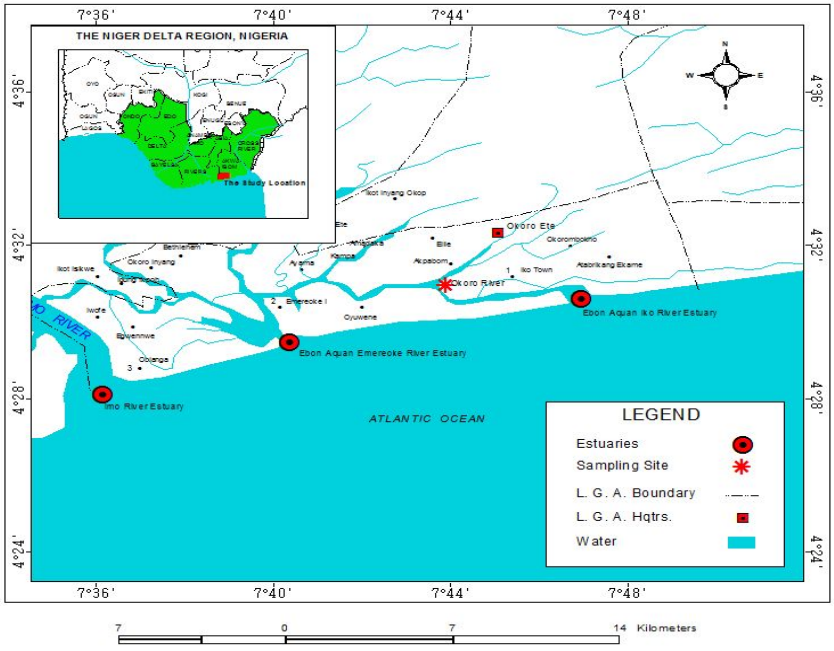

Fig 1: Location of sampling site on the map of Eastern Obolo, Akwa Ibom State, Southeastern Nigeria

2.2 Vegetation

The vegetation is dominated by managrove species: *Rhizophora racemosa* (red mangrove) and *Avicennia germinas* (white mangrove). These constitute part of the biggest mangrove ecosystem of the West African coast. In some parts of the estuary, the Indo-west pacific palm, *Nypa fruticans* introduced into West African coast from Singapore in 1906, flanked both sides of the shores (Udoidiong, 2005) [17]. In other areas, the black mangrove, *A. africana* is interspersed with *Nypa fruticans.* Oil palm (*Elaeis guineensis*) and coconut palm (*Cocus mueifera*) are also widely distributed in the surrounding villages. The low inter-tidal zone is usually bare of vegetation, with clay, peat and sand deposit.

2.3 Tidal Regime

The area is an estuarine environment, characterized by extensive mangrove swamp, tidal flats and semi- diurnal tidal regime. Tidal oscillations of 4m and predominant east-west winds create strong tidal currents which facilitate water mixture, leading to a uniform vertical distribution of the main oceanographic parameters.

The salinity fluctuates with season and tidal oscillations. The tidal range in the area is about 0.8m at neap tides and 2.20m during spring tides (NEDECO, 1961) [16]. Significant dilution of sea water by fresh water takes place at the estuary mouth. This ensures that annual fresh water loss through evaporation is equal annual freshwater gain through rain and river discharge.

2.4 Climate: The climate is tropical with a distinct rainy season (April to October) and dry season (November – March). The weather is warm humid. The mean annual rainfall is 250mm and the mean annual temperature of about 28ºC (Udoidiong, 2005) [17].

2.5 Sediment: The sediment morphology is that of sandy mud to the organic rich muddy sediments, which makes it an ideal habitat for shrimps and prawns. The muddy sediments are sustained by regular tropical runoff and river discharge.

2.6 Fishing Activities: The brackish water ecosystem of Okoro River is an important component of Nigeria's artisanal fisheries resources. Most of the fishing activities take place within 2000km^2 of the Exclusive Economic Zone (EEZ). The inshore zone is officially dedicated for artisanal fishing and it extends up to 5 nautical miles from the baseline, while beyond 5m is exclusive for commercial trawlers. Commercial and artisanal subsistent shrimping in the area is done on the muddy-sandy bottom with the depth of 16.8m – 38.2m in the estuary. Several fishing villages/ communities are located on both sides of the estuary. Fishers devoted to shrimping within and outside the estuary are dominated by the Obolos, Andonis, Yorubas, Ibibios and Ijaws.

2.7 Natural Resources

The area is one of the ecologically and economically rich marine ecosystems in the Niger Delta region of Nigeria providing breeding grounds for a variety of fish and shrimp species. It is rich in biodiversity. It falls within the oil producing area called the Niger Delta region which is often referred to as the richest part of Nigeria in terms of natural resources endowment. Oil refinery, flow stations and terminals dominate the study area. The area is extensively used by fishing boats, sea trucks and oil tankers and sea vessels, hence, numerous activities such as oil exploration and exploitation. Fisheries activities and energy production (fuel wood exploitation) dominate the study area.

2.8 Sampling Design and Analytical Procedures

FAO (1980) [18] ground survey method was employed to survey the fishing villages/landing sites. The fishing villages were visited for 12 consecutive months (April 2011- March 2012). For each trip to the fishing villages, number of motorized and non-motorized canoes that had landed with catch, number of motorized and non-motorized canoes that did not go out for that day's fishing, types of gears used for fishing, numbers of canoes, no of fishers, crew size and fishing methods in the surveyed fishing villages and settlements were noted and recorded *in-situ*. The intensity of fishery activity was measured by the ratio of operational to non-operational canoe. Identification and classification of canoes into motorized and non-motorized were done according to the size and the physical features attached to each canoe according to the method of Anderson (1986) [19]. Additional information were obtained using the interaction method, personal contacts, direct observation, discussions and interview with the canoe owners in the fishing villages and landing sites. Photographs of the craft and gear identified were taken with digital camera (aqua sprite water camera model DC/1318 mega pixel). Special trips were undertaken with the fishers to ascertain their fishing grounds and fishing methods. The depths of the fishing area were determined by measuring the length of anchor head rope used by the fishers according to the methods of Campanis, 2007; [20]. Campanis and Thompson, (2007) [22].

Elementary techniques of descriptive statistics (ratio, mean, standard deviation, range and percentages) were employed to analyze the data according to the approach of Sokal and Rohlf (1981) [22]. Correlation analysis was employed to establish the degree of association between fishing effort and environmental factors.

3. Results

A total of 26 fishing settlements were found in the study area. Table 1

Showed number of canoes, average number of nets per canoe, crew size and number of fishers per fishing settlement. There were 4457 fishers (part-time and full time) and numerous auxiliary workers and 1539 fishing units. Fishing expedition consisted of a three-man crew. For each canoe, the canoe owners used an average of 15±5 nets each while the crew used an average of 5±2 nets each with an average of 10±2 per canoe. The mean number of fishers per settlement was 171± 16. Table 2 shows occurrence and spatial distribution of fishing gears, fishing depth per gear and fishing methods in the surveyed fishing villages and settlements. Different types of rudimentary and modern gears are used to exploit shrimp resources in the area. Correlation between fishing inputs and environmental factors is presented in Table 3. This explained how the environment and fishing effort govern the yield of the fishery. Rainfall pattern influenced fishing inputs and CPUE negatively, while estuarine temperature and salinity regime had positive influence on fishing inputs and yield. Table 4 showed the summary of shrimp fisheries characteristics. The mean ratio of operational to non-operational boats was 4:1. Fishing is carried out from dug-out canoes. These vary in length from 6 - 8 m and 8.5 - 12.5 m for the non-motorized and the motorized canoes, respectively. The canoes have 1.2 – 1.7 m mid ship beam and 0.4 – 0.7 m mid ship depth. The dugout canoes are built locally using either of the trunks of silk cotton tree (*Ceiba pentandra)*, iron wood (*Lopheria alata*), Mahogany species (*Khaya norensis)* or Obeche *(Triplochiton scleroxylon)*. The non-motorized canoes are propelled by paddles and polythene sails (3 x 3 x 3 m), while the motorized are equipped with outboard engines ranging from 8 to 45 Hp. Fishing is all year-round except on Sundays, fishing festival days and rainy days. Off fishing days are also caused by roughness of the sea, and poor catches in the previous days. Usually, each boat and crew goes fishing once a day. The fishers fished on the average of 24±4 days per month during the peak-fishing season (October - March) and 14±4 days per month during the off-fishing season (July – September), with the mean active fishing days of 21±4 days per month. Fishing takes place in the day time. No night fishing is carried out, and mostly one tide is exploited per day by a given fisher. This study recorded 4-6 trips per week with a mean value of 4±2 trips per week. There is increasing use of sophisticated gear in the Okoro River estuary, Southeastern Nigeria. Altogether nine (9) types of gears were identified, only four (4) are widely distributed in the fishing villages and settlements viz: fish weir (*edek*), stake and stow net (*Anyima*), float and anchored trap net (*Nkoto*) and traditional crayfish beam trawl (*Uduut*). More than half (50.8%) of the fishers use the float/anchored trap nets, 27.2% use the stake/stow nets, 16% use the traditional crayfish trawl net while 6% use the fish weir (Fig.1). However, there are clear differences in size structure and operational efficiency.

Table 1: Okoro fishing villages and fishing effort statistics

S/N	Fishing villages	No. of crew/canoe	Fishing Units (No. of canoes)	No. of fishers	Ave no of nets/canoe	Total no. of nets
1.	Edwink	3	88	264	10	880
2.	Ebon Awan Iko	3	94	282	9	846
3.	Elekpon-Okoro	3	137	412	15	1918
4.	Akpabom	3	96	288	7	672
5.	Otuawaji	3	38	114	8	304
6.	Utiat	2	46	92	11	506
7.	Nlokot	3	60	180	7	420
8.	Emeroeke	2	100	207	12	1200
9.	Otunene	3	58	116	7	348
10.	Agansa	3	36	108	10	360
11.	Isotoyo	2	42	126	9	378
12.	Amanwon	2	54	162	13	702
13.	Okwan Obolo	2	28	84	7	196
14.	Amadede	3	30	92	8	240
15.	Ama –Stephen	2	36	72	7	216
16.	Obianga	3	92	346	12	1104
17	Iwofe	3	42	126	10	420
18	Aganzat	3	46	138	9	414
19	Emerememem	2	71	213	8	568
20	Utibi-Izong	3	64	192	7	448
21	Etize	3	48	144	9	432
22	Udum Unene	2	39	117	11	429
23	Otobo	2	33	99	10	330
24	Okokung	3	66	198	7	462
25	Lagos	2	57	171	9	513
26	Ebon-Gom	3	38	114	8	304
Total		**68**	**1539**	**4457**	**240**	**14610**
Mean		**3±1 (2-3)**	**59±5 (28-137)**	**171±16 (72-412)**	**10±2 (7-15)**	**561±73 (196-1918)**

Table 2: Identification and spatial distribution of gear type in the study area

S/N	Gear Type in Use		No. of Fishers with Particular Gear Type	Rank	% of Total	Fishing Depth	Type of Technology	Fishing Method	Peculiar Fishing Settlements
	English Name	Local Name (Obolo)							
1	Fish weir	*Edek*	170	4th	6.2	Shallow water (6-8 m)	Ancient technology	Fence method	Nlokot Otunene Isotoyo
2	Stake/ stow net	*Anyima*	764	2nd	27.6	Semi-shallow (8-10 m)	Traditional modified Ancient	Trapping method	All fishing locations
3	Float/ anchored trap	*Nkoto*	1336	1st	50.30	Deep water (16.8 m)	Modern technology	Anchoring method	All fishing communities
4	Crayfish beam trawl	*Udut*	440	3rd	16.0	Deeper waters (>16.8 m)	Modern technology	Trawling method	Lagos/Obianga Ebon Awan, Iko, Emereoke, Elekpon Okoro
			Total = 2610		100				

Table 3: Pearson correlation between fisheries inputs and environmental factors

Parameter	RNF	NOPC	TC	NTPM	SAL	CPUE	NON	DPT	TEMP
RNF	1.000								
NOPC	-.853**	1.000							
TC	-.424*	.627*	1.000						
NTPM	-.746**	.830**	.473*	1.000					
SAL	-.637**	.494	.099	.688*	1.000				
CPUE	-.453*	.779**	.805**	.540*	.134	1.000			
NON	-.082	-.035	.545*	.002	-.031	-.053	1.000		
DPT	-.425	.949**	.586*	.931**	.631*	.747**	-.075	1.000	
TEMP	-.437	.328	.185	.651**	.764**	.231	.231	.471*	1.000

RNF=Rainfall pattern, NOPC= No. of operational canoes, TC= Total catch, NTPM=No. of trips per month, SAL=Salinity, CPUE=Catch perunit effort, NON= No.of nets, DPT=Durationpertrip, TEMP=Temperature*=Significant at $p<0.05$, **= Significant at $p<0.001$

Table 4: Summary of shrimp fisheries characteristics in Okoro River estuary, Southeastern Nigeria

S/N	Parameters	Figures	Unit
1	Number of fishing villages	26	
2	Number of fishers	4457	
3	Mean number of fishers per fishing community	171	
4	Number of canoes	1539	
5	Mean number of canoes per fishing community	59	
6	Ratio of operational to non-operational canoes	4:1	
7	Length of motorized canoe	12	m
8	Length of non-motorized canoe	8	m
9	Length of mid ship beam	1.2-1.7	m
10	Mid ship depth	0.4-0.7	m
11	Horsepower	8-45	HP
12	Dimension of polythene sail	3x3x3	m
13	Mean active fishing days	21	days
14	Mean value of fishing trip per week	4	days
15	Gear types	9	
16	Crew size	3	
17	Life span of craft (Canoe)	4-6	years
18	Duration per fishing trip/day	9	hours
19	Average number of nets per canoe	10	

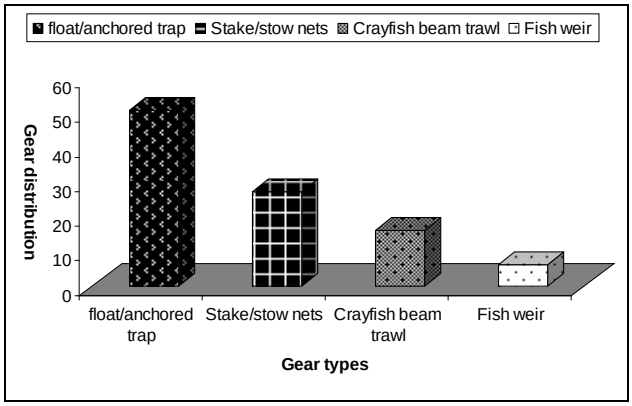

Fig 1: Distribution of Gear Types in Okoro River estuary, Southeastern Nigeria

The fish weir (*Edek*) encountered in the study area was about 6 to 7m in diameter and a mesh size of 1.8 mm. This device was deployed in shallow waters of the estuary. It consisted of a line of stakes closely aligned across shallow channels. The stakes served as supporting structures for the screens (nets) of 1.8mm mesh size that retained shrimps and by-catch in their seaward emigration. The screens are locally sourced raffia bamboo fronds, fabricated with mesh size decreasing toward the end of the enclosures. The bark and carcass of raphia palm or wood were arranged diagonally around the stake with openings and mesh size of 1.8mm at the bedroom. During high tide, shrimp and fish of different species were trapped in the enclosures or local fish ponds, and during low tide, the shrimp and fish species trapped are harvested with basket or hand nets. The position of the weir is maintained for ages. It is inherited from progenitors and is visited more frequently. But the most frequented fishing ground is more prolific of food than the same extent of richest farm land. The stakes are driven into the sea bed manually. The stakes are constructed in V-shaped fences leading to heart shaped enclosures of woven mats. The screen is made with raffia strips. However, conflicts do arose especially between those using the stationary enclosures for permanent position. The float anchored trap nets (*Nkoto*) encountered is in the form of conical bag nets made of nylon material. The net is 7 m long with a rectangular opening. The mouth of the net is 2.5 m wide (horizontal length) and 2.0 m high (vertical length) with the net opening coefficient of 0.8. Stretched mesh size varies from 0.9 cm at the cod-end to about 2.8 cm near the mouth. The net is placed in the direction of the strong tidal currents which enable the conical trap nets to sustain horizontally. The nets are set and anchored to the bottom in the direction of the ocean current and it sweeps in a large swarm of shrimp into the net including by – catch that prey on the shrimp. The nets were manually hauled in just before the direction of tidal flow reverses. The net is oriented to filter the oncoming currents and it is capable of trapping shrimps in their seaward emigration. The position of the net is marked at the surface mostly with brightly coloured inflatable floats. These were linked to the nets with nylon ropes of about 16.8m-32.4m. The length of these ropes when stretched tout during fishing, was measured to determine the depth of the fishing ground.

The stake/stow nets (*Anyima*) are conical bag nets of 8.5m long (Fig.2). The mouth of the net is about 3.5 m wide (horizontal length) and 3.0 m high (vertical length) with the net opening coefficient of 0.86. Stretched mesh size varies from 0.9cm at the cod-end to about 3.2cm near the mouth. The mouth measured 2.5m x 1.8m, and is held open with stakes. The stakes are constructed using red mangrove tree (*Rhizohora mangle*). The traps are placed along the migratory channels and they are capable of trapping shrimps and fishes in their seaward movement. They are set at the low tide and normally soaked for 24 hours (soak time). The nets are not anchored but tied to stakes in the direction of sea current. The traditional crayfish beam trawl (*Udut*)(Fig. 3) has the same features as the anchored trap net. However, the differences between the two nets is in terms of operational efficiency or the "power factor" The traditional crayfish beam trawl (*Udut*) is not anchored but tied to an engine boat, and they are powered by 8-45Hp. The nets are propelled (drifted) against sea current by the engine boat, similar to the method used by the sea trawlers that operate beyond the 5 nautical miles (5nm).The study revealed that fishers operated more than one gear type at any time.

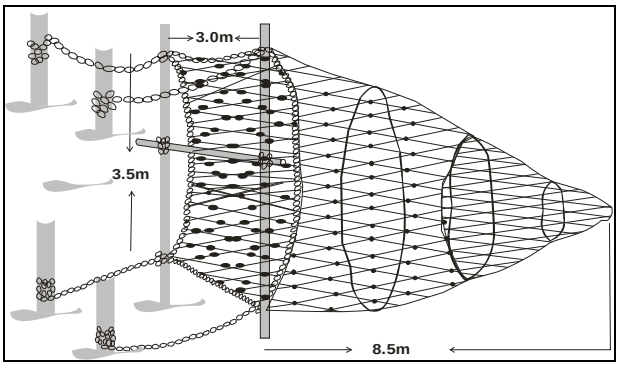

Fig 2: Stake/stow net (*Anyima*) used in the Okoro River estuary, Southeastern, Nigeria

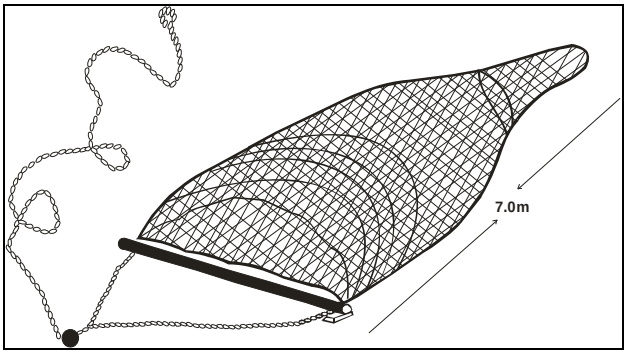

Fig 3: Traditional beam trawl net (*Uduut*) used in the Okoro River estuary, Southeastern, Nigeria

4. Discussion

On-the-spot survey is one of the major ways of acquiring the basic fisheries statistics by the inventory of various fisheries components. The result of this study revealed that canoe, outboard engine, nets and number of fishers were the most critical items of artisanal shrimp production. The canoe is the most important asset upon which the livelihood of fishers depend, thus it is the most valuable input. Measures such as number of fishers or fishing units, recorded even once a year, can be used as a measure of fishing effort (Gulland, 1983) [1]. The measure of fishing effort once a month in this study were an attempt toward recording fishing effort statistics and accounting for inter-settlement migration of fishers. This is different from Gulland's (1983) [1] recommendation of perhaps once a year. Furthermore, the study estimated about ten thousand (10,000) or (0.01 million) people that are engaged directly or secondarily in the Okoro shrimp fishing sub sector. This figure apart from part-time and full time fishers includes those involved in processing, marketing, mending of fishing nets, canoe builders, sail constructors, outboard engine repairers, etc. This implies that artisanal shrimp fishing sub sector of Okoro River estuary employs directly or indirectly about ten thousand people of Nigeria. The result agrees with the findings of Otero *et al.* (2005) [10]. FAO (2006) [11]. and Etim (2010) [13]. that artisanal fisheries provide employment to the rural dwellers. The result is also in strong agreement with the findings of (FAO, 2003 [23]. Pauly *et al*., (2005) [24]. that an artisanal fishery ensures employment and food security for the coastal communities around the globe. However, the total number of active fishers (4457) indicates heavy pressure on shrimp resources. This result is in consonance with the report of ACMRR (1993) [7] that excessive fishing effort is one of the prime problems leading to resource over-exploitation. Besides, the *Nematopalaemon* shrimp fishery of Okoro River had been operating on ancient gear, but today due to technological advancement, there is development of modern gear which has enhanced excessive exploitation of the resources. The results of Kingdom and Kwen (2009) [25]. have showed that the commonest gear used in the Lower Taylor Creek Area, Bayelsa State is trap nets (50%). The 50.8% recorded for float and anchored trap net in this study is closer to Kingdom and Kwen's report. Therefore, the dominance of float / anchored trap net (50.8%) recorded in this study may not be unconnected with lesser effort involved in the operation of the net as well as flexibility in the direction of the current. The fish weir (*Edek*) has apparent advantages over the other nets. Its operation requires less effort, its yields are higher and it is more selective with higher gear longevity of over 10 years. However, major disadvantages include high building cost (e.g. US $356.81 or N 57,091 in 2011) per enclosure and a limited number of employment opportunities for rural dwellers and the time it takes to build one enclosure. Further, this study observed that passive gear like float/ anchored trap net recorded less by-catch than active gear (Cray-fish beam trawls). This is in accord with Kingdom and Kwen (2009) [25]. who had stated that the commonest gear in Taylor Creek of Bayelsa State are all passive and are known to have lower rates of by-catch. Again, fishing gear has generally undergone a lot of modifications and improvements in Okoro River estuary in consonance with advances in modern technology. However, the basic principle of encircling, scooping and filtering can still be detected despite the advances in fishing gear and methods. This finding supports Enin *et al.,* (1989) [26]. observation that crud technology was part of the shrimp fishery in the Cross River, Nigeria. The results of this study is also similar to the report of Kingdom and Kwen (2009) [25]. Who had listed fishing gear used in the Lower Taylor Creek Area of Bayelsa State, Nigeria to include: entangling nets, trawls, trap nets and drift nets? Nwosu (2010) [27]. had also listed trap net, beach seine and push net as fishing gear used in the *Macrobrachium* fishery of the Cross River Estuary, Nigeria. However, this study observed that more than 75% of fishers have more than one type of fishing gear in use at any given time. The gear types encountered indicate increased local technological innovations and modifications in the use of ancient and modern gear in recent times, but have an impact on the exploitation of multi-species shrimp assemblages.

The result of this study also showed that three fishers (crew men) on the average operate in each fishing unit (canoe). The three-man crew recorded in this study is different from the report of (Enin *et al*. 1989 Ofor, 2002 [] and Ofor and Kunzel, 2009) [26, 28, 29] who recorded four-man crew for the *Nematopalaemon* shrimp fishery of the Cross River estuary, Nigeria. The differences in the number of crew men may be due to the differences in the number of nets (25-40) used per canoe in the Cross River estuary as compared to 7-15 nets/canoe employed in the Okoro River estuary. This study also recorded an average of 10 nets per canoe. This is also different from an average of 33/nets/canoe and 30/nets/canoe recorded in the Cross River estuary by Enin *et al.* (1991) [15] and Ofor and Kunzel (2009) [29]. The differences are also as a result of modern technological innovations of gear in Okoro River estuary which do not require higher number of nets. For instance, the traditional beam trawl net (*Uduut*) propelled by an outboard engine has replaced the low yielding traditional trap nets (Nkoto) that requires higher number of nets as reported by (Enin *et al.* 1991, Ofor and Kunzel 2009) [15, 29].

The ratio of operational to non-operational canoes of 4:1 found in this study is controlled by the quantity of previous catch or weather condition which indicate the productivity level of the fishing ground. In rough weather conditions, fewer boats fish close to near shore areas. This rough weather also resulted in loss of effort and loss of investment in the rough period. This is the reason for higher number of non-operational canoes recorded in the peak of the rainy season. Also, the mean active fishing days was recorded as 21 days per month with minimum in July and September and maximum in May. This is also different from the report of Enin *et al.* (1989) [26]. who reported that fishermen were not fishing on only 4 days per month in the Cross River estuary, Nigeria. The higher active fishing days (26) reported by Enin *et al*. (1989) [26]. may be due to the fact that fishers in the Cross River estuary fish sometimes on Sundays. Again, in respect of the minimum fishing days in the rainy season, fishermen explained that during heavy rains, the speed of ebb tide currents becomes extremely fast leading to displacement and loss of nets or mixing up of nets of different fishermen in the sea. The implications of these are loss of investment and generation of dispute among fisher folks.

This study also recorded 8-45 HP outboard engines as the fishing power used and 4-6 trips per week with a mean value of 4 trips per week. The finding is in consonance with FAO (2004 [30] 2005) [31] report that fishing effort is the number of fishing trips done and fishing power used to harvest fish during a given period of time. However, the result of this study is different from the findings of other researchers. For instance, in the analysis of artisanal fishing in the south Agro-ecological zone of Delta State, Nigeria, Inoni and Oyaide (2007) [32] have reported the number of fishing trips per week as between 2-5, with a mean value of 3 trips per week. Nevertheless, increasing fishing frequency reported in this study may be an indication of dwindling and intensive exploitation of the shrimp stock.

5. Conclusion

The result of the survey presented here will be the first reference material for future studies in Okoro River estuary. This survey documented the variety of fishing gear operating in the Okoro River estuary. It has also recorded the number of fishers and number of fishing unit (canoes). Number of fishing boats is a constant parameter in the analyses of the *Nematopalaemon* shrimp fishery. The *Nematopalaemon* shrimp fishery of Okoro River is a multispecies fishery with multispecific gears. However, these statistics are subject to changes, increase or decrease based on a number of factors including rural migration of fishers and modification of fishing methods. The changes are rapid in recent years and thus a re-survey at least five-year interval is recommended. This will always bring an up-to-date record, among others on the state of the fishery and the fishing effort in the area.

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