Analysis Of Shrimp Bycatch In The *Nematopalaemon* Shrimp Fishery Of Okoro River Estuary, Southeastern Nigeria

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Abstract: The species composition, size structure, length frequency and length at first maturity (L_{50}) of shrimps and bycatch in the *Nematopalaemon* shrimp fishery in the fishing grounds of Okoro River estuary, Southeastern, Nigeria were studied for 12 consecutive months (April 2011 to March 2012). Seven (7) shrimp species belonging to three (3) families were identified in the catch, while forty-one (41) species belonging to 29 families of fishes constituted the bycatch species and are juveniles with a total length range of 0.32 to 46 cm. The catch composition comprised palaemonidae, penaeidae, hyppolytidae, teleostei, elasmobranch and invertebrate families. Sciaenidae and clupeidae recorded the most abundant families in the bycatch component, while the squids are mainly of the family, Ommastrophedae. Total catch consisted of 85% shrimp, 14% bycatch and 0.81% crabs/squids. Shrimp to bycatch ratio was calculated as 6:1, while crabs to squids ratio was 7:1. One sample t-test found a significant difference ($p<0.05$) between mean length (Lmean) and length at maturity (Lm) for 16 species. Maturity length (Lm) value was significantly greater than mean length (Lmean) for 30 out of the 41 bycatch species analyzed, indicating that young and immature fishes were harvested. There is a danger that too many fish may be caught before they could spawn and replace themselves. The results can be interpreted as an important tool in monitoring of artisanal shrimp fishery and in the evaluation of bycatch component.
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Key Words: bycatch-to-shrimp ratio, Lmean/Lm ratio, shrimp trawl fisheries, Okoro River estuary, Southeastern Nigeria

1. Introduction

The species of flora and fauna that are not targets of any fishery is known throughout the world as "bycatch" or as "non-target" species (FAO 2005). Shrimp bycatch (SBC) has become a global fisheries management problem (FAO, 1999) because shrimp fisheries across the globe produce a large by-catch of fish resulting in large amounts of discard. This by-catch is composed of small shrimp and fish mainly juveniles, in addition to shellfish, plants, jellyfish, crustaceans, crabs, turtles and non-living material. FAO (2005) reported that the overall discard rates have dropped to 8%, mainly because of larger bycatch utilization. However, tropical shrimp fisheries still have the world's highest rates of bycatch, mostly varying between 60% and 80% (Kelleher 2005).

Finfish weight to shrimp weight ratios have been used to estimate quantities of by-catch in shrimp fisheries in several locations: in the northern coast of Venezuela (Griffiths and Simpson, 1972), in the South Carolina offshore shrimp fishery (Keiser, 1976), in the north central Gulf of Mexico(Slavin,1982), in the artisanal trawl shrimp fishery operating along the northern coast of Brazil (Dragovich and Villegas 1983) and in the coastal artisanal shrimp beam trawl fisheries off Lagos coast, Nigeria (Ambrose,2004). Hall *et al*. (2000) reported that coastal shrimp trawl fishery generate more bycatch than any known world fishery and presented an averaged shrimps-bycatch ratio of 1:3 to 1:15 in the tropic. Other studies on bycatch from shrimp trawling have also given alarming shrimp-by catch ratios of 1:5 in temperate and sub-topical regions and 1:10 in the tropic (Slavin, 1982; Andrew and Pepperall, 1992). Ambrose, 2004 recorded a shrimp-bycatch ratio of 14:1 and 6:1 for wet and dry seasons in the artisanal shrimp beam trawl fisheries off Lagos coast, Nigeria.

Artisanal shrimp trawling is generally regarded as one of the least selective fishing methods because the bycatch may consist of over several hundred teleost species (Kelleher 2005; Eayrs 2007). The bycatch component of the *Nematopalaemon* shrimp fishery is a common source of livelihood in Okoro River estuary, Southeastern Nigeria, but no information is available about the species composition, by-catch: shrimp weight ratios length frequency and length at maturity of the large rates of bycatch caught in the *Nematopalaemon* shrimp fishery. Thus, this study provided a seminal recorded of species composition, bycatch component and compared fish length with length at maturity of some species for the purpose of recommending pragmatic

management approach to tackle bycatch problems in the *Nematopalaemon* shrimp fishery of Okoro River estuary, Southeastern, Nigeria.

2. Materials And Methods:

2.1 Description of the study area:

The study was carried out in Okoro River estuary, Southeastern Nigeria located on (4° 30' 47 42"N, 7° 38' 25 28"E) about 650 m above sea level in the tropical mangrove forest belt east of the Niger Delta between the lower Imo and Qua Iboe River estuaries (Fig. 1). The tidal range in the area is about 0.8 m at neap tides and 2.20 m during spring tides with little fresh water input joined by numerous tributaries as they empty into the Atlantic Ocean (NEDECO, 1961). The climate of the area is tropical with distinct rainy (April to October) and dry seasons (October to May) with a high annual rainfall averaging 2500 mm (Gibo 1988; AKUTEC, 2006). The mean water temperature of the study area is 28.2°C (Udoidiong, 2005).

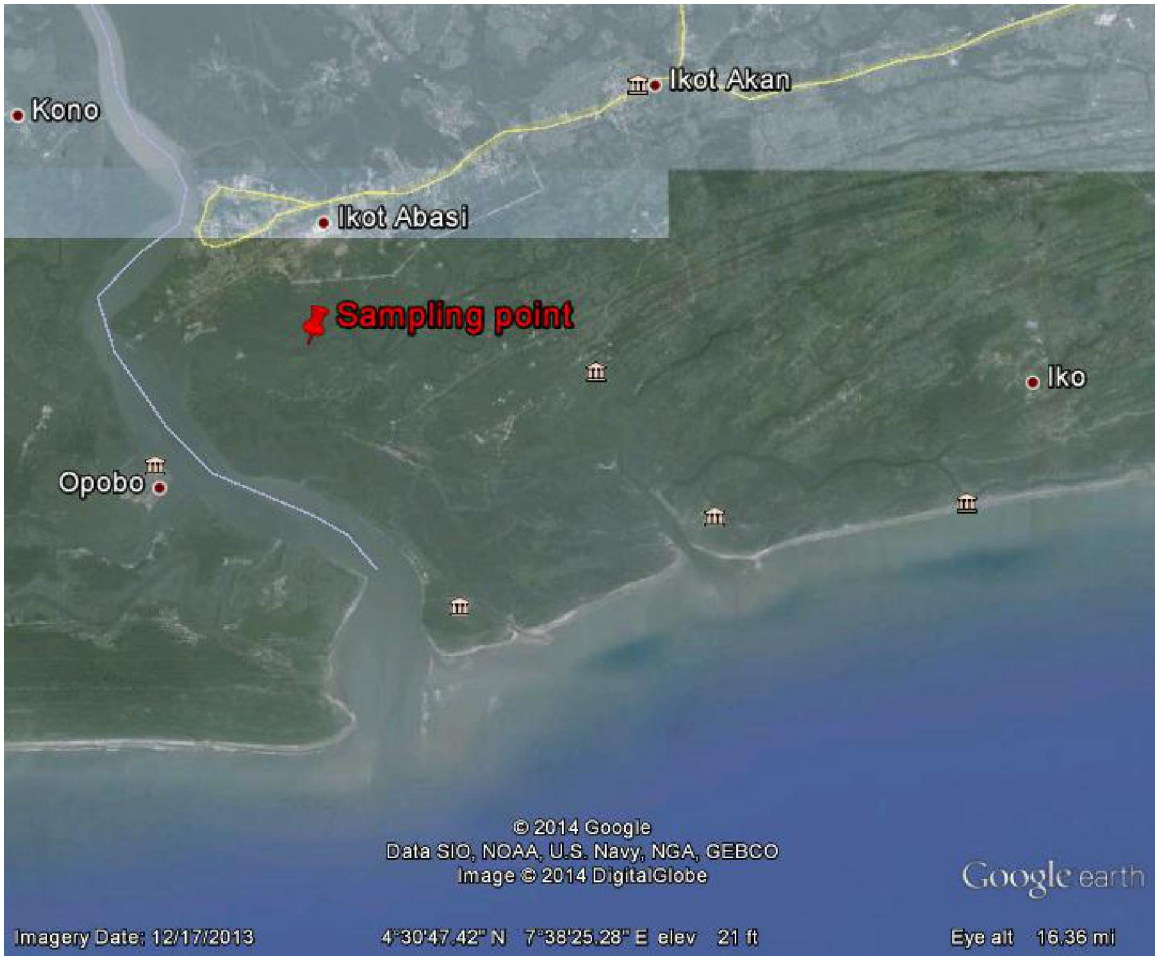


Fig. 1 Okoro River estuary, Southeastern Nigeria (Source: Google earth)

2.2 Vegetation and Mineral Resources

The area is characterized by an expensive mangrove swamp dominated with mangrove species: *Rhizohora racemosa, Avicennia germinas, Conocarpus eractus*, interspersed with *Nypa fruticans* with inter-tidal mud flats influenced by the semi-durnal tidal regime of the estuary. Fishing and farming are the main economic activities in this study area. Oil palm (*Elaeis guineensis*) and coconut palm (*Cocus mueifera*) are also widely distributed in the surrounding villages. The area is also an oil-producing area with several oil exploration wells and oil pipelines.

2.3 Fishing activities

The brackish water ecosystem of Okoro River is an important component of Nigeria's artisanal fisheries resources. 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 (AKUTEC, 2006). Artisanal and 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.

2.4 Collection of Shrimp Specimens and Analysis of By-catch Composition

Samples were collected for 12 consecutive months (March 2011 to April 2012) from the artisinal shrimp fishers who used conical trap nets (*Anyima*) to collect samples from Okoro River estuary between 16.8-38.2 m water depths. The trap is a conical bag net of nylon materials, with a rectangular opening. The mouth of the net is 2.5 m wide and 2.0 m high. The net is about 7- 8.5 m long with mesh size varying from 0.9 mm at the cod-end to about 2.8 cm near the mouth. On each trip to the Elekpon Okoro fishing settlement, random sampling technique was applied to collect two and half kilogram (2.5kg) weight of fresh samples from at least 15 operational canoes. The collected specimens were washed with clean estuarine water and fixed in 5% formalin solution and taken to the laboratory. In the laboratory, shrimp specimens were sorted, identified and sexed using the keys of Powell (1980), FAO (1981) and Schneider (1990) and separated into species. Total length (TL-mm) was taken from the tip of the rostrum to the tip of the telson to the nearest 0.1mm using the vernier calipers. Total weight was measured using an electronic weighing balance with a sensitivity of 0.01g.

All the fish species in the catch were also identified using the FAO, 1992 keys and photographs and were further sorted into families. Weight of fish by-catch was taken using weighing balance and length of each specimen in the by-catch was taken using a meter rule fixed to a measuring board.

Length at first maturity

The length at first maturity (L_{50}) was estimated by fitting a logistic model described by equation 1 to the cumulative frequency of mature specimens using the logistic model in PAST statistical software, version 20.0 (Hammer, Harper and Ryan, 2001).

$P = 1/ (1 + \exp. (-r (TL – Lm))$ ……..…..1

Where P is the percentage of gravid females in a given length class, r is the slope, TL is the total length and L_M is the size at first maturity (Dall *et al.,* 1990; Sobrino and Garcia, 2007; Dineshbabu and Manissery, 2008). The mean length (Lmean) of all species was calculated then the Lmean/Lm ratio recorded and plotted for all species (Froese and Pauly 2013).

Ratio Estimation

Two sets of ratios were calculated monthly for all the samples: shrimp: total bycatch, and crabs: squids (Froese and Pauly 2013).

2.4 **Statistical Analysis**

Elementary techniques of descriptive statistics (ratio, mean, standard deviation, range and percentages) were employed to analyze the catch and biological data according to the approach of Sokal and Rohlf (1981). The one sample t-test (Snedecor and Cochran, 1980) was used to compare Lmean and Lm for all species. The significant difference was tested at $p < 0.05$. The analysis was done using the Statistical Package for Social Science (SPSS, version 19.0) for Window Software. The Microsoft Excel 2007 was used for the graphical presentation of data.

3. Results

Seven (7) shrimp species belonging to three (3) families were identified in the catch. The size of individual shrimp species (Table 2) showed mean total lengths of *P. monodon* (192.09 mm) > *P. scuptilis* (86.46mm) > *P. atlantica* (86.02 mm) > *P. kerathurus* (74.43 mm) > *E. hastatoides* (64.36 mm) > *P. setiferus* (64.20 mm) > *N. hastatus* (48.53 mm). The largest shrimp sample was *P. monodon,* while *N. hastatus* was the smallest. Forty-one (41) species belonging to 29 families of fishes constituted the bycatch species and are juveniles with a total length range of 0.32 to 46 cm (Table 1). Among the by-catch species, *Trichiurus lepturus* (46.00cmTL) was the longest fish, followed by *Dalophis cphaloptlis* (44.10cmTL). The squid, *Onychoteuthis antillarium* (2.13 cmTL; 2.34 gTW) was the smallest fish in the catch, followed by *Ommastrephes bartrami* (2.97 cmTL; 3.12 gTW). In terms of gross weight of individual fish; *Trachinotus teraia* (148.47gTW) had the highest weight, followed by *Callinectes marginatus* with (122.33gTWg). The shrimp (Fig. 1) was composed of the following species in decreasing order of abundance: *Nematopalaemon hastatus* = 44.78%, *Parapenaeopsis atlantica* = 17.1%, *Penaeus kerathurus* = 9.01%, *Penaeus setiferus* = 8.06%, *Parapenaeopsis sculptilis* =5.28%, *Exippolysmata hastatoides* = 0.85% and *Penaeus monodon* = 0.11%.

The by-catch was composed of the following families in decreasing order of abundance: Sciaenidae: (*Pseudotolithus elongatus, Pseudotolithus senegalensis)* = 5.95%; Clupeidae: (*Illisha africana, Ethmalosa fimbriata*, *Pellonula leonensis, Sardinella aurita)* = 4.54%; Trichiuridae: *(Trichiurus lepturus)* = 0.91%; Polynemidae*:* (*Galeodes decadactylus*, *Pentanemus quinquarius, Polydactylus quadrifilis*) = 0.52%; as well as two swimming crabs of the genus *Callinectes*: (*C. marginatus* and *C. amnicola*) = 0.36%. Others were: Tetraodontidae: (*Sphoeroides pachygaster)* = 0.3%, Bothidae: (*Citharichythys stampflii*) = 0.15%, Corythoichydae (*Corythoichyths schultzi*) = 0.13%; Sphyraenidae: (*Sphyraena barracuda)* = 0.11%. Squids (*Onychoteuthis antillarium* and *Ommastrephes bartrami*) were also

part of the by-catch and constituted about 0.05% by number.

The catch composition comprised palaemonidae, penaeidae, hyppolytidae, teleostei, elasmobranch and invertebrate families. Sciaenidae and clupeidae recorded the most abundant families in the bycatch component, while the squids are mainly of the family, Ommastrophedae. Total catch consisted of 85% shrimp, 14% bycatch and 0.81% crabs/squids. Shrimp to byctch ratio was calculated as 6:1, while crabs to squids ratio was 7:1. One sample t-test found a significant difference ($p<0.05$) between mean length (Lmean) and length at maturity (Lm) for 16 species. Maturity length (Lm) value was greater than mean length (Lmean) for 30 out of the 41 bycatch species analyzed, indicating that young and immature fishes were harvested.

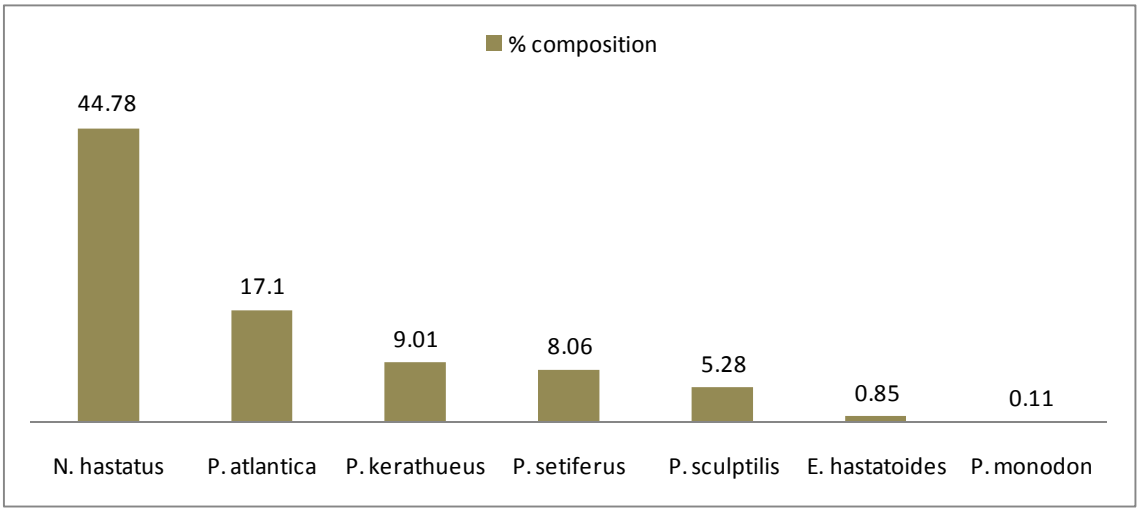
Table 1. **Species Composition and size structure in the *Nematopalaemon* shrimp fishery of Okoro River Estuary, Southeastern Nigeria**

	Species	**Common name**	**Authority**	**WEIGHT (MIN-MAX) (g)**	Mean WEIGHT±SE (cm)	LENGTH(MIN-MAX)	Mean LENGTH ±SE	Length at maturity(L_{50})
Palaemonidae	*Nematopalaemon hastatus*	Estuarine prawn	Aurivillus,1898	0.12-5.34	2.73± 0.12	7.23-76.68mm	48.53± 0.81	40.2+
Penaeidae	*Parapenaeopsis atlantica*	Guinea shrimp	Balss,1914	0.22 - 23.18	5.22± 0.04	12.8-164.2mm	86.52±7.54	73.4+
	Penaeus kerathurus	Zebra shrimp	Forskal,1975	0.21 - 12.44	3.21± 0.21	11.5-141.5mm	74.43± 0.47	79.7*
	Penaeus setiferus	White shrimp	(Herbst, 1793)	0.13 - 14.23	3.6± 1.3	31.20 - 120.55	64.20± 2.3	62.01*
	Parapenaeopsis sculptilis	Rainbow shrimp	(Heller, 1862)	0.57 - 22.85	5.27± 0.45	20.70 - 140.30	80.51±4.23	88.51*
	Penaeus monodon	Black tiger prawn	(Fabricius, 1798)	13.18 - 128.76	65.39± 8.15	38.30 - 251.15mm	144.7±91.1	168.75*
Hippolytidae	*Exhippolysmata hastatoides*	Common shrimp (Red-tailed)	Balss,1914	0.56-6.87	3.71± 0.15	9.58-78.4mm	43.99±5.64	40.2+
Sombridae	*Sarda sarda*	Atlantic bonito	(Bloch, 1793)	3.46 - 44.40	17.91±0.99	7.3 - 19.40	13.56± 0.27	13.71*
Clupeidae	*Pellonula leonesis*	Guinean sprat	(Boulenger, 1916)	0.66 - 42.93	3.29±0.30	4.60 - 20.10	7.14±0.13	8.06*
	Ethmalosa fimbriata	Bonga shad	(Bowdich, 1825)	3.55 - 172.05	14.57±2.43	3.70 - 28.00	10.97±0.35	12.5*
	Illisha africana	West African illisha	(Bloch 1795)	3.06 - 56.07	13.33±4.45	7.10 - 19.00	11.13±0.92	11.5*
	Sardinella aurita	Sardine	Valenciennes,1833	1.12-8.12	4.62	5.9-11.6cm	8.75	10.81*
	Sardinella maderensis	Madeiransardinella	(Lowe, 1839)	1.51 - 21.75	9.69±0.86	7.00 - 13.20	9.91± 0.24	9.95*
Sciaenidae	*Pseudotolithus elongates*	Bobo croaker	(Bowdich, 1825)	0.74 - 44.27	5.74±1.14	3.20 - 18.00	8.51±0.42	9.51*
	Pseudotolithus senegalensis	Normal croaker	Valenciennes,1833	0.71-9.82	5.26	4.6- 10.3cm	7.45	8.56*
Polynemidae	*Galeodes decadactylus*	African threadfin	(Bloch, 1795)	1.50 - 31.34	11.14±1.12	5.80 - 17.20	9.97±0.35	10.5*
	Pentanemus quinquarius	Royal threadfin	Linnaeus,1758	0.83-6.08	3.45	4.6-8.2cm	6.41	7.18*
	Polydactylus quadrifilis	Threadfin	Cuvier,1829	2.05-3.31	2.68± 0.34	6.0-7.6 cm	6.88	7.32*
Portunidae	*Callinectes marginatus*	Marble swimcrab	(A. Milne Edwards, 1861)	2.91 - 122.33	42.96±15.56	41.25 - 130.50	79.06±12.21	72.5+
	Callinectes amnicola	Swimming crab	DeRocheburne, 1883	2.01-38.81	20.41± 3.21	3.95-7.52 (CW)	5.74	6.12*
Trichiuridae	*Trichurus lepturus*	Largeheadhairtail	(Linnaeus, 1758)	2.93 - 62.34	18.96±1.73	12.90 - 46.00	31.06±0.92	34.75*
Tetraodontidae	*Sphoeroides pachygaster*	Blunthead puffer	(Muller &Troschel, 1848)	1.96 - 26.25	11.6±1.12	4.10 - 13.40	10.08±0.45	9.51+
Syngnathidae	*Syngnathus abaster*	Black-striped pipefish	(Risso, 1827)	0.61-0.61	0.61	11.00 - 11.00	11.00	-
Carangidae	*Hemicaranx bicolor*	Two-colour jack	(Gunther, 1860)	6.27 - 18.96	13.68±1.76	8.00 - 11.30	9.91±0.52	9.82+
	Chloroscombrus chrysurus	Atlantic bumper	(Cuvier, 1833)	3.06 - 7.91	5.01±0.31	7.10 - 9.50	8.17±0.13	8.18*
	Trachinotus teraia	Terai pompano	(Cuvier, 1832)	18.6 - 148.47	85.9± 34.53	9.70 - 23.00	18.80±3.14	15.25+
Elopidae	*Elops lacerta*	West African ladyfish	(Valencies, 1846)	2.35 - 93.07	40.81±14.97	6.80 - 25.50	17.36±3.07	18.5*
Bothidae	*Citharichthys stamflii*	Smooth flounder	(Steindachner, 1894)	7.18 - 19.07	13.02±1.42	9.10 - 12.30	11.02±0.40	11.5*
Ariidae	*Arius gigas*	Giant sea catfish	(Boulenger, 1911)	3.03 - 273.70	67.0±5.04	7.10 - 43.11	16.60±6.02	18.2*
Monodactylidae	*Psettias sebae*	African moony	(Cuvier,1831)	22.16 - 84.62	53.45±3.41	9.50 - 15.10	12.43±0.28	12.65*
Hemiramphidae	*Hemiramphus balao*	Balae halfbeak	(Le Sueur,1825)	12.83-12.83	12.83	18.90 - 18.90	18.90	-
Lutjanidae	*Lutjanus endecacanthus*	Guinea snapper	(Bleeker, 1863)	10.33 - 18.55	15.5±1.75	10.2 - 28.82	22.61±6.20	24.43*
	Lutjanus gorensis	Gorean snapper	(Valenciennes, 1830)	8.20-8.20	8.2	7.80 - 7.80	7.80	-
Haemulidae	*Pomadasys peroteti*	Pigsnout grunt	(cuvier, 1830)	10.78-10.78	10.78	10.78 - 10.78	10.78	-
Serranidae	*Epinephelus aeneus*	White grouper	(Hilaire, 1809)	5.28 - 6.06	5.67	7.60 - 8.00	7.80	-
Mugilidae	*Liza falcipinnis*	Sickle fin mullet	(Valenciennes, 1836)	31.45-31.45	31.45	14.70 - 14.70	14.70	-
Haemulidae	*Hepsetu sakawo*	Parrot grunt	(Cuvier, 1830)	33.23-33.23	33.23	6.50 - 6.50	6.50	-
Sphyraenidae	*Sphyraena guachancho*	Guachanche baracuda	(Cuvier, 1829)	4.87 - 86.95	28.88±8.34	11.12 - 28.60	17.22±6.23	21.5*

Ophichthidae	*Dalophis cephalopeltis*	Worm/Sneak eel	(Bleeker, 1863)	4.57 - 28.45	12.34 ±5.52	18.90 - 44.10	30.95±6.49	39.75*
Drepanidae	*Drepane africana*	African sicklefish	(Osorio, 1892)	32.63-32.63	32.63	11.10 - 11.0	11.10	-
Gerreidae	*Eucinostomus melanopterus*	Flagfinmojarra	(Bleeker, 1863)	7.84 - 11.53	10.18±0.56	8.50 - 10.50	9.75±0.38	9.93*
Squillidae	*Squlla aculeatacalmani*	Guinean mantis shrimp	(Holthius, 1959)	2.01 - 19.16	6.57± 2.42	5.50 - 12.10	7.48±0.86	8.22*
Alpheidae	*Alpheus pontederiae*	Pistol shrimp	(Crosnier and Forest, 1966)	21.85-27.90	0.81±0.02	15.25 - 27.90	22.43±2.02	24.87*
Sphyraenidae	*Sphyraena barracuda*	Senects	Walbaum,1792	0.34-12.28	6.31	4.4-14.2cm	9.37	10.2*
Corythoichthydae	*Corythoichthys schultzi*	Gilded pipefish	Herald,1953	1.68-4.21	2.95	1.23-5.34cm	3.28	4.21*
Ommastrephidae *Ommastrephes bartrami*	*Onychoteuthis antillarum*	Squid	LeSueur,1821	0.13-3.12	1.63	0.32-2.13cm	2.45	3.33*
	Ommastrephes bartrami	Squid	Adam,1941	0.67-2.34	1.51	0.67-2.97cm	1.82	2.25*
Crangonidae	*Pontocaris lacazei*	Hard shell	Gourret,1887	2.96-6.71	4.84	1.76-5.64cm	3.71	4.41*

Keys for L_{50}: * = Lm > meamL, + = Lm < mean L, - = sample not enough to determine Lm

(a)



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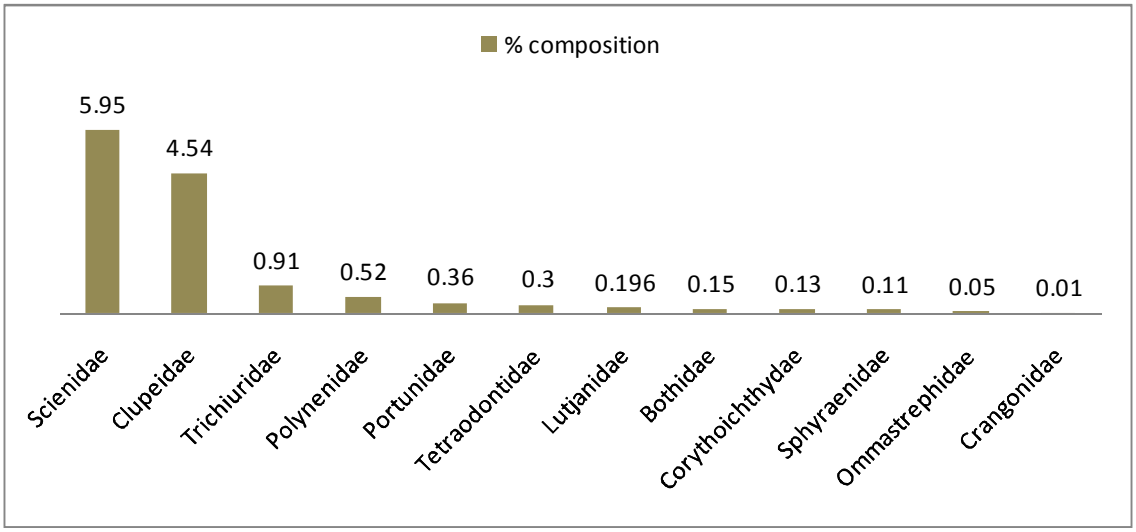

Figure 1: Percentage composition of shrimp and byctch in the Nematopalaemon shrimp fishery of Okoro River estuary, Southeastern Nigeria (a) shrimp species (b) most abundance families

4. Discussion

The results of this study showed that the weight and length of *P. monodon*, *P. atlantica* > *P. kerathurus, P. sculptilis, P. setiferus* > *E. hastatoides* > *N. hastatus*. The observed significantly higher size structure of Penaeid shrimps may be attributed to their ability to grow bigger and faster than *N. hastatus.* Marioghae (1989) reported that the Penaeid shrimps feed on *N. hastatus*. This could be one of the reasons for the larger size of the Penaeid shrimps. Five penaeid species have been identified in the shrimp fishery of Okoro River estuary, Southeastern Nigeria: *Parapaeneopsis atlantica (*Guinea shrimp), *Penaeus keraturus (*Zebra shrimp), *Penaeus setiferus (*White shrimp), *Parapenaeopsis sculptilis (*Rainbow shrimp) and *Penaeus monodon (*Black tiger prawn). In the coastal areas of Tanzania, five penaeid species was also identified (Jidawi and Ohman, 2002) in the artisanal shrimp fishery. These included: *Penaeus indicus* (white prawn), *Penaeus monodon* (giant prawn), *Penaeus semisulcatus* (tiger prawn), *Metapenaus monoecros* (brown prawn) and *Penaeus japonicus* (flower prawn). The species composition recorded in this study is higher than the findings of Enin *et al.* (1991) who reported 9 families, 3 shrimp species and 10 fish by-catch species in the *N. hastatus* fishery of the outer estuarine region of Cross River, Nigeria. It is also different from the result of Ofor (2002) who recorded 7 families: 3 shrimp species and 9 fish species in the Cross River estuary. The reason for the sharp difference is that Enin *et al.* (1991) recorded the anchored trap net (*Esik*) as the only fishing gear used in the *Nematopalaemon* shrimp fishery of the Cross River estuary, compared to four gear types reported in this study. Thus, this study established that multi-specific gear influences multi-species composition. However, a decade after Enin's work, Ofor and Kunzel (2009) recorded the gear used in the *Nematopalaemon* shrimp fishery in the Cross River estuary to include the "*Onyimba*" or bag net, "*Akokobi*" or basket net and the *Iseke* nets, yet their record of species composition was lower than that of Enin *et al.* (1991) and quite lower than the result of this study. The dynamics between the result of Ofor and Kunzel (2009) and this study may be due to the geographic location of sampling area. The issue of geographic location of sampling area could inform the differences in species composition as reported by Oribhabor and Ezenwa (2005) in the Lagos Lagoon, Nigeria.

The species composition of *Nematopalaemon* shrimp fishery presented in this report indicates that *N. hastatus* dominated the species composition. The dominance of *N. hastatus* in the artisanal shrimp fisheries of Nigeria has been documented by various studies. Enin *et al.* (1991) reported that *N. hastatus* was the most dominant in landings off Cross River Estuary, Nigeria and contributed about 89.8% by number. Ajayi *et al.* (1997) recorded > 80% by weight in the shrimp catch of Imo River estuary. In the outer Cross River Estuary, Ofor and Kunzel (2009) reported *N. hastatus* as the dominant species but with 70% by number, while Olawusi-Peters and Ajibare (2014) reported 71.93% in coastal waters of Ondo State, Nigeria. The presence of penaeid shrimps in the catch composition of Okoro River estuary supports the findings of Garcia (1988) that marine penaeid shrimps use estuaries as nursery for their post-larvae, which then migrate out to the sea on maturation. These species are trapped in the traditional beam trawl nets and float/anchored nets on their seaward migration from production grounds and form part of the *Nematopalaemon* shrimp fishery in the estuaries. Nawa (1984) reported 14.6% composition of the peneaid shrimp (*Penaeus kerathurus*) in the *Nematopalaemon* shrimp fishery of the Cross River, Nigeria.

The value of 0.59 % by weight of *E. hastatoides* recorded in this study is greater than 0.5% recorded by Powell (1982) for the Bonny River of the Niger Delta and 0.3% by weight recorded by Ajayi *et al.* (1997) in Imo River estuary.

The 41 species belonging to 31 families of bycatch recorded in this study is higher than 25 species belonging to 20 families recorded by Ambrose 2004 in the catch composition from the coastal artisanal shrimp beam trawl fisheries off Lagos coast, Nigeria. Also four fish species: *Sphyraena barracuda, Citharichtys stampfli, Callinectes amnicala* and *Ommastrephes bartrami* recorded in the study area were not recorded by Enin *et al* (1991) and were not also recorded by Ofor and Kunzel (2009) in the Cross River estuary. This result however supports the finding of Oribhabor and Ezenwa (2005) who also recorded *Sphyraena barracuda*, *Citharichthys stampfli* and *Callinectes amnicola* in the Lagos Lagoon, Nigeria.

The total weight of shrimp trawled in the *Nematopalaemon* shrimp fishery of Okoro River estuary exceeds the total weight of bycatch. The ratio of shrimp to bycatch in this fishery compares favourably with reports from other locations. For instance, the weight of prawns trawled in the Clarence estuary, Australia (Liggis and Kennelly, 1996) and in the Lagos coast of Nigeria (Ambrose, 2004) exceeds the weight of bycatch.

Many of the bycatch species live in the shrimp fishing grounds of the Okoro River estuary and shrimp trawling threatens species that are smaller than their length at maturity (Lm) every year. Lm is

defined as the length at which fish of a given population develop ripe gonad or mature for the first time (Froese and Pauly 2013). Similar threats to finfishes in the shrimp fishing grounds of the Persian Gulf were reported by (Eighani and Paighambari, 2013). Again, most juveniles migrate up the river to feed in the protected and nutritious mangrove habitats of the estuary until they reach mature size, after which they start migrating back to the offshore spawning grounds (Garcia 1989).

Maturity length (Lm) value was significantly greater than mean length (Lmean) for 31 out of the 41 bycatch species analyzed, indicating that young and immature fishes were harvested before they could mature for the first time. The result indicated that a large number of specimens encountered in the catch are juveniles. This is an indirect indication of the fact that the inshore area serves as the nursery grounds for almost all species, accounting for the abundance of immature finfishes, crabs and squids in the Okoro River estuary. The matured specimens encountered in the catch must be those that enter the inshore waters along with currents during their breeding season. Specimen caught below their mature length cannot grow bigger. This is bad for the fishery and also has a negative impact on fish species of OkoroRiver estuary. In coastal areas of Tanzania, most by-catch comprises small specimen of about the same size as the target shrimp species (Brewer *et al*. 1998).

The total length range of 0.32 cm to 20 cm dominated the catch in which 20 to 80 individual fishes constituted 1kg weight. This is difference from the inshore/offshore industrial shrimp trawling in which an individual bycatch species can measure between 1kg and 10kg by weight (Brewer *et al*. 1998). Therefore, the bycatch species are all juveniles. However, artisanal shrimp fishery still has a good potential of becoming a beneficial and ecological sustainable fishery if the catch of small size is minimized.

5. Conclusion

The artisanal bycatch species was dominated by mostly juvenile fish species, squid and swimming crabs. Recruitment overfishing influenced the by-catch composition of the artisanal shrimp fishery of the Okoro River estuary, Southeastern, Nigeria. There is a danger that too many fish may be caught before they could spawn and replace themselves. Therefore, it is very important to analyse the composition of by-catch, size distribution of juvenile shrimp and juvenile fish so as to measure and verify the effects of the anchored trap nets on the catch composition. Results of quantitative and qualitative studies of the catch composition of the artisanal shrimp fishery can provide basic information for sustainable fisheries management of the Okoro River estuary, Southeastern, Nigeria.

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