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Seasonal variations in catch composition from the *Nematopalaemon* shrimp fishery in Okoro river estuary, southeastern Nigeria

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Abstract
Wet and dry season variations in shrimps and bycatch compositions were surveyed in the *Nematopalaemon* shrimp fishery in the near shore water (<35 m depth and <5 nautical miles) in the Okoro River estuary, Southeastern Nigeria. The catch composition included: 46 species from 27 families in the wet season and 35 species from 23 families in the dry season. Total catch consisted 39.3% shrimp, 7.55% bycatch, 0.15% crabs/squids in the wet season and 46.37% shrimp, 6.61% bycatch and 0.05% crabs/squids in the dry season. Finfish, crabs and squids were higher in wet season than dry season, while shrimp catch was higher in the dry season than wet season. Significant variabilities in shrimp and bycatch compositions were detected at these temporal scales, shrimps-bycatch ratio of 5: 1 and 7:1 were obtained respectively at wet and dry seasons. Bycatch species were juveniles with a total length range of 4 to 30 cm in the wet season and 4 to 56 cm in the dry season. Majority of the bycatch species occurs throughout the year, few have seasonal occurrence and showed progressive increase in mean total lengths and weight from wet to dry season; *Arius latiscutatus, Trachinotus teraia, Alpheus pontederiae and Callinectes amnicola* in the wet season while *Sardinella aurita, Chloroscumbrus chrysurus* and *Pseudotolithus typus* showed progressive increase in mean total and weight from dry to wet season. The comparison of multi-species composition of the fishery revealed that only 15 out of the 48 species recorded showed significant difference between seasons (p<0.05). These species are: *N. hastatus*, *P. atlantica*, *Pellonula leonesis*, *Pseudotolithus elongates*, *Trichurus lepturus*, *Lutjanus endecacanthus*, and *Ethmalosa fimbriataa*. The total quantity of shrimps and bycatch landings combined were significantly higher in dry season (39,164.73kg) than in wet season (34,798.15kg) (p<0.005). The *Nematopalaemon* shrimp fishery is characterized by wet and dry season variations in catch composition. Thus, pragmatic management strategy is hereby recommended to reduce bycatch problems in the artisanal shrimp fishery.

Keywords: Seasonal variations, Catch composition, Shrimp-bycatch ratio, *Nematopalaemon* shrimp fishery, Okoro River estuary, Southeastern Nigeria.

1. Introduction
The *Nematopalaemon* shrimp fishery constitutes an important component of the artisanal shrimp fishery in Nigeria. It is a daily fishery and is carried out all-year around in Okoro river estuary. However, wet and dry seasonal variations in the catch composition have been recorded. Marioghae (1981) [1] had reported the peak catch of this species to be the early and late rains and poor harvest in between July and September. In the New Calabar estuary of the Niger Delta, Marioghae (1981) [1] had also found that poor catches for the shrimp fishery occurred in the middle of rainy season (June – September). Moses (1989) [2] had reported that catches of *N. hastatus* fishery in the Niger Delta were highest between March and May and Enin *et al. (*1989) [3] have recorded peak catch rates in the early rains and late rains (April-June) and poor harvest between July and September in the Cross River estuary. According to Enin *et al.* (1991) [4] catch peaks for *N. hastatus* between March and June with a secondary peak in October/November and the poorest catch in the middle of the rainy months of July and September. Ambrose (2004) [5] had reported that in the coastal artisanal shrimp beam trawl fisheries off Lagos coast, Nigeria, the total quantity of shrimps and bycatch combined per landings were higher in wet season than dry season. In the outer Cross River estuary, Ofor and Kunzel (2009) [6] have recorded peak CPUE for *N. hastatus* fishery in May and November and a trough in July. In Casamance estuary, Senegal, the catch peak was recorded at the height of the dry season, when the estuary had the highest salinity (Le Reste 1992) [7]. Large seasonal

and spatial variations of fish and shrimp biomass have been documented in the nearby Gambia River (Guillard *et al.*, 2004) [8]. The authors also recorded two peaks in the artisanal catches in Gambia estuary, West Africa, the largest one around October-November right after the rain (June to September) and a smaller one in February-March. Artisanal fisheries account for more than 95% of fishers in the world, especially in developing countries (Pauly, 2006) [9], thus a large number of species (both protected and unprotected), are severely threatened due to unmanaged fisheries (Lewison *et al.*, 2004) [10]. In terms of species composition, Powell (1982) [11] had discovered that three-quarters of the *Nematopalaemon* shrimp fishery is dominated by *N. hastatus*, followed by *P. atlantica* in the Bonny area of the Niger Delta, Nigeria. Enin *et al.* (1991) [4] have recorded three shrimp species in samples collected from the Cross River estuary with the estuarine prawn, *N. hastatus* accounting for 81.5% by weight and 91.9% by number. FDF (1990) [12] reported a similar proportion in the catches from the mid-western area of Nigeria. The *Nematopalaemon* shrimp fishery of the Cross River was also investigated by Ofor and Kunzel (2009) [6] who showed that *N. hastatus*, *P. atlantica* and *E. hastatoides* were the major components of the catch with mean catch composition by weight of 70%, 14%, 3% respectively, and 14% fish by-catch.

Generally, the artisanal shrimp fisheries exploit the juveniles of pelagics like *Ethmalosa fimbrata* (bonga), and *Sardinella* spp (sardines) together with some demersals like *Pseudotolithus* spp as by-catch. Other species that support a thriving artisanal shrimp fishery include the juveniles of the following species: *Polydactylis* spp, *Sphyraena* spp (baraccudas), *Trichuirus spp* and the swimming crab, *Callinectes amnicola* (Enin *et al*. 1991) [4]. These species are widely distributed in the estuarine waters of Nigeria (Ambrose, 2004) [5]. Moreover, accurate data on the species composition of landings is needed to assess the status of the stocks and manage it properly (FAO 2000) [13] and yet very little attention has been given to the extent of bycatch in artisanal shrimp fisheries in Nigeria. Thus, this study was formulated to determine the monthly abundance of caught species, and seasonality of catches by-catch: shrimp weight ratios to estimate the magnitude of the incidental catch, and to describe species composition for 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 (4º 30' 47 42"N, 7º 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) [14]. 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 [15]. AKUTEC, 2006) [16]. The mean water temperature of the study area is 28.2 ºC Udoidiong (2005) [17].

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 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) [15]. Artisanal shrimping is a subsistent enterprise in the area, it is done on the muddy-sandy bottom of the estuary with depth ranging from 16.8m to 38.2m. 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) [18]. FAO (1981) [19] and Schneider (1990) [20] 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) [21] 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.

2.5 Ratio Estimation

Two sets of ratios were calculated for all the samples: shrimp: total bycatch and shrimp: crabs/squids (Froese and Pauly 2013) [22].

2.6 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) [23]. Student's t-test (Snedecor and Cochran, 1980) [24]. Was employed to test the hypothesis that the weight of total catch in the dry season and wet season do not differ. 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

Monthly abundance of species in the Nematopalaemon shrimp fishery is presented in Fig. 1. A total of 15098 individuals were collected between April 2011 and March 2012 with a gross total weight of 73, 962.88g (73.9kg). Population was found to be bigger in the dry season (8085 individuals) than in the wet season (7155 individuals). The total quantity of shrimps and bycatch landings combined were significantly higher in dry season (39,164.73kg) than in wet season (34,798.15kg) (t_{12}=2.64 p=0.011). Seasonal abundance and dynamics of the shrimp and by-catch community in the *Nematopalemon* shrimp fishery of Okoro River estuary are shown in Table 1. In the wet season, the shrimp was composed of the following species in decreasing order of abundance (by number): *N. hastatus*=18.65%, *P. atlantica*=10.60%, *P. kerathurus*=5.16%; *P. setiferus* =3.39%, *P. sculptilis* =1.21%, *E. hastatoides* = 0.57%, *P.monodon* = 0.05%, bycatch = 7.16% while in the dry season, the order was *N. hastatus* =26.37%, *P. atlantica* =6.73%, *P. setiferus* =4.59%, *P. sculptilis* =4.02%, *P. kerathurus* =3.81%; *E. hastatoides* =0.27%, *P.monodon* =0.06%, bycatch = 6.97%

In terms of percentage by weight in the wet season (Fig.2), the order was: *N. hastatus* =12.33%, *P. atlantica* =11.65%, *P. kerathurus* = 3.90%; *P. setiferus* =1.06%, *E. hastatoides* = 0.40%, *P.monodon* = 0.39%, *P. sculptilis* =0.13%, bycatch = 17.08% while in the dry season, the order was *N. hastatus* =17.44%, *P. atlantica* =7.40%, *P. sculptilis* =4.36%, *P. kerathurus* = 2.87%; *P. setiferus* =1.57%, *P.monodon* = 1.02%, *E. hastatoides* = 0.19%, bycatch = 17. 82%. The estuarine prawn *N. hastatus* was higher, both numerically and gravimetrically in the catches of Okoro River estuary between April 2011 to March 2012, accounting for about 45.02% by number and 29.77% by weight. The guinea shrimp (*P. atlantica*) was next with average compositions of 17.33% by number and 19.05% by weight, followed by the zebra shrimp (*P. kerathurus*) with 8.97% and 6.77% by number and weight respectively. *Penaeus setiferus* had 7.98% by number and 2.63% by weight. *P. sculptilis* recorded 5.23% by number and 4.49% by weight, while *P. monodon* had 0.11% by number and 1.41% by weight. The companion shrimp (*E. hastatoides)* accounted for 0.84% by number and 0.59% by weight. The bycatch accounted for 14.14% by number and 34.9% by weight. The lowest percentage species composition was recorded in July 2011 (peak of the rain), while the highest percentage was recorded in dry season month of January, 2012. The catch composition comprised: 46 species from 27 families in the wet season and 35 species from 23 families in the dry season. Total catch consisted 39.3% shrimp, 7.55% bycatch and 0.15% crabs/squids in the wet season and 46.37% shrimp, 6.61% bycatch and 0.05% crabs/squids in the dry season. Finfish, crabs and squids are higher in wet season than dry season, while shrimp catch was higher in the dry season than wet season (Table 1). Significant variability in shrimp and bycatch compositions were detected at these temporal scales, shrimps-bycatch ratio of 5: 1 and 7:1 were obtained respectively at wet and dry seasons.

Majority of the bycatch species occurs throughout the year, few have seasonal occurrence. Higher number of individuals were caught in the dry season months for most species except for *P. atlantica, P. kerathurus, Pellonula leonensis, Polydactylus quadrifilis, Callinectes marginatus, Callinectes amnicola, Corythoichtys schultzi, Onychoteuthis antillarium, Pota saltadora and Pontocaris lacazei Trachinotus teraia, Syngnathus abaster, Hemiramphusbalao, Lutjanus endecacanthus,, Lutjanus gorensis, Pomadasys peroteti, Epinephelu saeneus, Liza falcipinnis and Hepsetus akawo* which indicate that the spawning season of these species may be in the wet season.

The comparison of multi-species composition of the *Nematopalaemon* shrimp fishery of the Okoro River estuary revealed that 15 species out of the 48 recorded showed

significant difference between seasons ($p<0.05$). These species are: *N. hastatus, P. atlantica Pseudotholithus elongates Illisha africana, Ethmalosa fimbriata, Pellonula leonensis, Pentanerus quinquarius, Callinectes marginatus, Callinectes amnicola,* and *Corythoichthys schultzi. Pellonula leonesis, Pseudotolithus elongates, Trichurus lepturus, Lutjanus endecacanthus* and *Alpheus pontederiae.* Other species showed no significant differences between seasons ($p>0.05$). The *Nematopalaemon* shrimp fishery is characterized by wet and dry season variations in catch composition. 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 mean sizes of individual species changes with season. Penaeidae, Portunidae and Ommastrephidae showed progressive increase in mean total lengths/weight from wet to dry season. Bycatch species were juveniles with a total range of 4 to 30 cm in the wet season and 4 to 56 cm in the dry season. Swimming crabs, *Calinectes*, dominated the catches in the wet season. Seventy percent of *Pseudotolitus elongatus* was also caught at an essentially smaller size than the maximum size 45 cm.

The results indicate that the smaller-sized fishes were caught in the wet season while larger-sized were caught in the dry season. However, Palaemonidae, Sciaenidae and Polynemidae showed a reverse trend with larger sized individual caught in the wet season. Thus, the species are vulnerable to growth and recruitment over fishing particularly during the wet season months

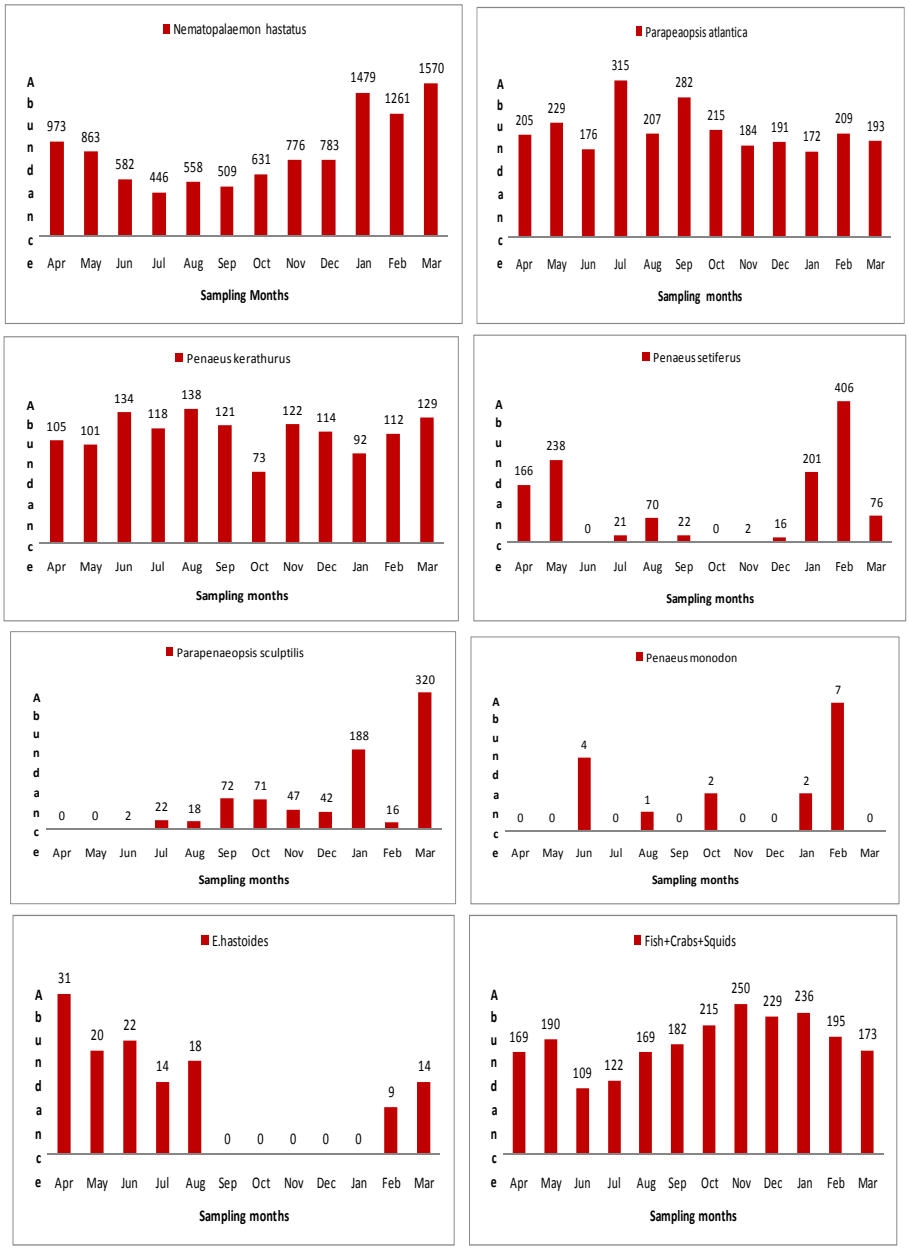


Fig 1: Monthly abundance of shrimps and bycatch component in the *Nematopalaemon* shrimp fishery of Okoro River estuary, Southeastern Nigeria

Table 1: Seasonal frequency of species occurrence

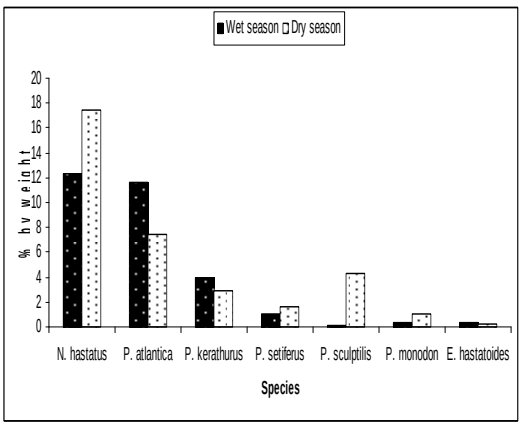
		Wet season (Apr-Oct)				Dry season (Nov-Mar)				Test of Significance	
Family	**Species**	**N**	**%**	**WT (g)**	**%**	**N**	**%**	**WT (g)**	**%**	**T-values**	**p**
Palaemonidae	*Nematopalaemon hastatus*	2842	18.65	9122.56	12.33	4020	26.37	12904.4	17.44	2.18	0.023*
Penaeidae	*Parapenaeopsis atlantica*	1616	10.60	8613.28	11.65	1027	6.738	5473.91	7.40	2.197	0.027*
	Penaeus kerathurus	786	5.157	2884.62	3.90	580	3.805	2128.6	2.87	1.153	0.241
	Penaeus setiferus	517	3.392	791.11	1.06	701	4.599	1166.14	1.57	0.333	0.749
	Parapenaeopsis sculptilis	185	1.213	98.74	0.13	613	4.022	3225.57	4.36	1.174	0.284
	Penaeus monodon	7	0.045	291.72	0.394	9	0.059	754.59	1.02	0.244	0.815
Hippolytidae	*Exhippolysmata hastatoides*	87	0.571	297.54	0.40	41	0.269	140.22	0.189	0.44	0.79
Sombridae	*Sarda sarda*	49	0.321	417.77	0.56	48	0.314	820.10	1.10	0.042	0.967
Clupeidae	*Pellonula leonesis*	199	1.305	672.25	0.91	81	0.531	239.76	0.32	2.206	0.052*
	Ethmalosa fimbriata	74	0.485	968.72	1.31	95	0.623	1581.65	2.13	0.573	0.582
	Illisha africana	38	0.249	521.52	0.71	63	0.413	758.21	1.03	0.547	0.608
	Sardinella aurita	51	0.334	494.19	0.66	66	0.433	639.54	0.86		
	Sardinella maderensis	20	0.131	182.37	0.25	19	0.125	195.01	0.26	0.071	0.945
Sciaenidae	*Pseudotolithus elongates*	256	1.679	1681.37	2.27	341	2.237	2523.84	3.41	2.925	0.026*
	Pseudotolithus senegalensis	157	1.030	2904.5	3.93	170	1.115	3145.0	4.25	0.183	0.861
Polynemidae	*Galeodes decadactylus*	29	0.190	314.71	0.42	18	0.118	209.16	0.28	0.972	0.368
	Pentanemus quinquarius	33	0.216	167.64	0.22	15	0.098	76.2	0.10	0.79	0.39
	Polydactylus quadrifilis	18	0.118	283.14	0.38	13	0.085	204.49	0.27	2.27	0.03
Portunidae	*Callinectes marginatus*	20	0.131	288.10	0.39	7	0.045	141.25	0.19	5.61	0.001
	Callinectes amnicola	26	0.171	1009.06	1.36	0	0	0.00	0.00	4.04	0.006
Trichiuridae	*Trichurus lepturus*	13	0.085	173.81	0.23	52	0.34	1024.64	1.38	2.501	0.051*
Tetraodontidae	*Sphoeroides pachygaster*	15	0.098	158.60	0.21	31	0.203	375.08	0.51	0.806	0.450
Syngnathidae	*Syngnathus abaster*	1	0.006	0.61	0.0008	0	0	0.00	0.00	1.001	0.355
Carangidae	*Hemicaranx bicolor*	3	0.019	42.64	0.05	5	0.032	60.69	0.08	0.547	0.603
Carangidae	*Chloroscombrus chrysurus*	17		82.24	0.11	3	0.019	17.96	0.02	1.468	0.192
	Trachinotus teraia	4	0.026	253.73	0.34	0	0	0.00	0.00	1.33	0.230
Elopidae	*Elops lacerta*	3	0.019	64.28	0.08	2	0.013	139.81	0.19	0.547	0.603
Bothidae	*Citharichthys stamflii*	10	0.065	113.55	0.15	17		189.59	0.25	0.794	0.452
Ariidae	*Arius gigas*	4	0.026	394.10	0.53	2	0.013	78.2	0.10	0.794	0.457
Monodactylidae	*Psettias sebae*	19	0.12	1102.05	1.49	10	0.065	448.05	0.61	0.668	0.528
Hemiramphidae	*Hemiramphus balao*	1	0.006	12.83	0.01	0	0	0.00	0.00	1.000	0.355
Lutjanidae	*Lutjanus endecacanthus*	3	0.019	42.18	0.05	0	0	0.00	0.00	2.219	0.05*
Lutjanidae	*Lutjanus gorensis*	1	0.006	8.20	0.01	0	0	0.00	0.00	1.000	0.355
Haemulidae	*Pomadasys peroteti*	1	0.006	10.78	0.02	0	0	0.00	0.00	1.000	0.355
Serranidae	*Epinephelus aeneus*	2	0.013	11.34	0.02	0	0	0.00	0.00	1.000	0.355
Mugilidae	*Liza falcipinnis*	1	0.006	31.45	0.04	0	0	0.00	0.00	1.000	0.355
Haemulidae	*Hepsetus akawo*	1	0.006	33.23	0.05	0	0	0.00	0.00	1.000	0.355
Sphyraenidae	*Sphyraena guachancho*	1	0.006	47.60	0.06	8	0.052	222.37	0.30	1.621	0.156
Ophichthidae	*Dalophis cephalopeltis*	2	0.013	39.05	0.05	2	0.013	10.33	0.01	1.000	0.355

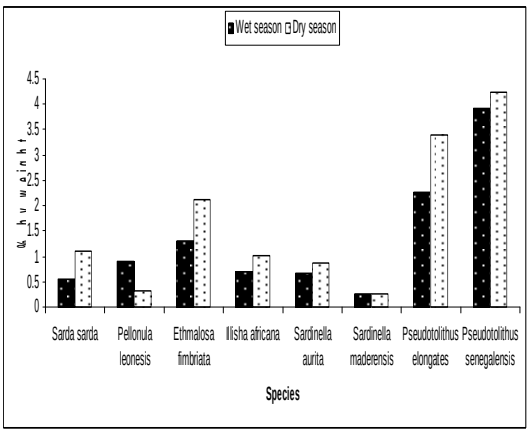
Drepanidae	*Drepane africana*	0	0	0.00	0.00	1	0.006	32.63	0.04	1.000	0.355
Gerreidae	*Eucinostomus melanopterus*	0	0	0.00	0.00	6	0.039	61.08	0.08	1.261	0.253
Squillidae	*Squlla aculeatacalmani*	2	0.013	16.35	0.022	5	0.032	29.64	0.04	0.625	0.554
Alpheidae	*Alpheus pontederiae*	6	0.039	16.2	0.02	0	0	0.00	0.00	2.521	0.045*
Sphyraenidae	*Sphyraena barracuda*	4	0.026	33.08	0.04	12		139.2		1.12	0.35
Corythoichthydae	*Corythoichthys schultzi*	21	0.13	76.02	0.10	0	0	0.00	0.00	2.96	0.02
Ommastrephidae	*Onychoteuthis antillarum*	5	0.032	10.65	0.01	0	0	0.00	0.00	1.50	0.182
Ommastrephidae *Ommastrephes bartrami*	*Ommastrephes bartrami*	3	0.019	9.03	0.01	1	0.006	3.01	0.004	0.794	0.45
Crangonidae	*Pontocaris lacazei*	2	0.013	9.64	0.01	1	0.006	4.82	0.006	0.547	0.603
Total		7155		34.798.15		8085		39164.73			

Table 2: Species Composition and seasonal size structure in the *Nematopalaemon* shrimp fishery of Okoro River Estuary, Southeastern Nigeria

				Wet season		**Dry season**	
Family	**Species**	**Common name**	**Authority**	**Weight±SE (g) (min –max)**	**Length ±SE (min-max)**	**Weight±SE (g) (min-max)**	**LENGTH ±SE (min –max)**
Palaemonidae	*Nematopalaemon hastatus*	Estuarine prawn	Aurivillus,1898	0.47± 0.03 (0.21- 0.79)	45.15± 1.20 (36.25- 59.4)	49.76 ± 0.98 (27.45-	0.60 ± 0.03 (0.17- 1.25)
Penaeidae	*Parapenaeopsis atlantica*	Guinea shrimp	Balss,1914	5.47±0.06 (0.38-23.18)	87.22±0.36 (37.2-143.25)	4.81±0.05 (0.22-13.82)	84.40±0.36 (31.85-128.30)
	Penaeus kerathurus	Zebra shrimp	Forskal,1975	3.23± 0.09 (0.63-12.44)	74.32± 0.67 (44.35-116.2)	3.18± 0.09 (0.81- 11.99)	74.57± 0.65 (48.55- 113.95)
	Penaeus setiferus	White shrimp	(Herbst, 1793)	1.62± 0.02 (0.13-14.23)	64.58± 0.29 (31.2-120.55)	1.33 ± 0.16 (0.32-8.45)	57.87± 1.32 (36.35- 100.45)
	Parapenaeopsis sculptilis	Rainbow shrimp	(Heller, 1862)	5.92± 0.14 (0.57-22.85)	90.22 ± 0.79 (40.7-140.3)	3.96 ± 0.11 (0.73-11.62)	78.96± 0.70 (46.5-104.6)
	Penaeus monodon	Black tiger prawn	(Fabricius, 1798)	73.69 ± 23.23 (13.18- 128.76)	195.22± 24.78 (121.35-	61.62 ± 6.49 (27.0 -90.73)	190.67 ± 10.09 (113.25- 222.05)
Hippolytidae	*Exhippolysmata hastatoides*	Common shrimp (Red-tailed)	Balss,1914	3.81±0.16 (0.57-78.6)	43.89±5.64 (9.58-78.4)	3.62±0.13 (0.57-76.2)	39.81±3.64 (9.58-77.4)
Sombridae	*Sarda sarda*	Atlantic bonito	(Bloch, 1793)	18.73±1.41 (3.46-44.4)	13.63±0.38 (7.3-19.3)	17.08±1.41 (4.79-41.82)	13.48±0.38 (9.3-19.4)
Clupeidae	*Pellonula leonesis*	Guinean sprat	(Boulenger, 1916)	3.42± 0.38 (0.66-42.93)	7.11± 0.16 (4.6-20.1)	2.82±0.19 (1.31-5.69)	7.26±0.14 (6.1-8.9)
	Ethmalosa fimbriata	Bonga shad	(Bowdich, 1825)	9.88±1.11 (3.55-42.57)	10.09± 0.33 (3.71-17.2)	20.94±5.37 (5.73-172.05)	12.17±0.65 (8.7-28.1)
	Illisha africana	West African illisha	(Bloch 1795)	15.82±8.33 (3.06-56.07)	11.2±1.75 (7.1-19.9)	10.34±0.98 (7.71-12.66)	11.3±0.34 (10.5-12.1)
	Sardinella aurita	Sardine	Valenciennes,1833	4.62±0.12 (1.12-8.12)	8.75± 1.23 (5.9-11.6)	5.12±0.12 (1.12-9.12)	9.55± 1.23 (5.9-13.6)
	Sardinella maderensis	Madeiransardinella	(Lowe, 1839)	9.11±1.44 (1.51-21.08)	9.6±0.41 (7.1-13.2)	10.30±0.92 (5.58-21.75)	10.16±0.24 (8.7-12.5)
Sciaenidae	*Pseudotolithus elongates*	Bobo croaker	(Bowdich, 1825)	4.32±0.93 (0.74-44.27)	7.91±0.37 (3.2-17.7)	13.58±1.85 (4.61-38.01)	12.26±0.48 (8.9-18.1)
	Pseudotolithus senegalensis	Normal croaker	Valenciennes,1833	5.26±0.28 (0.71-9.82)	7.45±1.03 (4.6-10.3)	6.11±0.26 (0.95-11.82)	8.55±1.08 (4.6-12.3)
Polynemidae	*Galeodes decadactylus*	African threadfin	(Bloch, 1795)	10.85±1.53 (1.58-29.12)	9.62± 0.45 (5.8-14.3)	11.62±1.62 (1.51-31.34)	10.53±0.55 (6.1-17.2)
	Pentanemus quinquarius	Royal threadfin	Linnaeus,1758	3.45±0.45 (0.83-6.08)	6.41±0.23 (4.6-8.21)	4.15±0.55 (1.83-8.18)	7.46±0.23 (5.6-10.23)
	Polydactylus quadrifilis	Threadfin	Cuvier,1829	2.68±0.34 (2.05-3.31)	6.88±1.01 (4.0-7.6)	3.88±0.44 (3.45-5.33)	7.78±1.01 (5.0-9.6)
Portunidae	*Callinectes marginatus*	Marble swimcrab	(A. Milne Edwards, 1861)	96.14±13.87 (75.11- 122.33)	123.35± 3.61 (118.8- 130.5)(CW)	20.17±14.25 (2.91-105.36)	60.07±10.8 (41.25- 124.4)(CW)
	Callinectes amnicola	Swimming crab	DeRocheburne, 1883	22.61±3.22 (3.01-39.85)	6.77±2.33 (4.95- 9.53)(CW)	20.41±3.21 (2.01-38.81)	5.74±2.13 (3.95- 7.52)(CW)
Trichiuridae	*Trichurus lepturus*	Largeheadhairtail	(Linnaeus, 1758)	13.46±1.28 (8.14-17.47)	28.06±0.81 (24.9-30.4)	19.71± 1.94 (2.93-62.34)	31.47±1.03 (12.9-46.1)

Tetraodontidae	*Sphoeroides pachygaster*	Blunthead puffer	(Muller &Troschel, 1848)	9.88±1.72 (1.96-18.66)	9.45±0.91 (4.1-12.2)	12.41±1.43 (2.28-26.25)	10.38±0.51 (4.7-13.4)
Syngnathidae	*Syngnathus abaster*	Black-striped pipefish	(Risso, 1827)	0.61	11.00		
Carangidae	*Hemicaranx bicolor*	Two-colour jack	(Gunther, 1860)	14.21± 0.58 (13.05-14.94)	9.81±0.81 (8.2-10.7)	13.29±3.24 (6.27-18.96)	10.1±0.81 (8.1-11.3)
Carangidae	*Chloroscombrus chrysurus*	Atlantic bumper	(Cuvier, 1833)	4.83± 0.33 (3.06-7.91)	8.15±0.15 (7.1-9.5)	5.98±0.71 (5.13-7.14)	8.31±0.21 (8.1-8.7)
	Trachinotus teraia	Terai pompano	(Cuvier, 1832)				
Elopidae	*Elops lacerta*	West African ladyfish	(Valencies, 1846)	21.42±9.94 (2.35-35.82)	13.6±3.43 (6.8-17.9)	69.91±23.16 (46.74-93.07)	23.1±2.5 (20.5-25.5)
Bothidae	*Citharichthys stamflii*	Smooth flounder	(Steindachner, 1894)	13.35±3.14 (7.18-17.53)	11.13±1.01 (9.1-12.2)	12.83± 1.63 (9.96-19.07)	10.96±0.38 (10.2-12.3)
Ariidae	*Arius gigas*	Giant sea catfish	(Boulenger, 1911)	67.00±5.03 (3.03-273.79)	16.6± 6.02 (7.1-43.1)		
Monodactylidae	*Psettias sebae*	African moony	(Cuvier,1831)	56.91±7.82 (28.34-84.62)	12.68± 0.69 (10.1-15.1)	52.35±3.83 (22.16-79.46)	12.35±0.31 (9.5-14.5)
Hemiramphidae	*Hemiramphus balao*	Balae halfbeak	(Le Sueur,1825)	12.83	18.90		
Lutjanidae	*Lutjanus endecacanthus*	Guinea snapper	(Bleeker, 1863)	15.05±1.75 (13.3-18.55)	22.61±6.21 (10.2-28.82)		
Lutjanidae	*Lutjanus gorensis*	Gorean snapper	(Valenciennes, 1830)	8.20	7.80	-	-
Haemulidae	*Pomadasys peroteti*	Pigsnout grunt	(cuvier, 1830)	10.78	9.00	-	-
Serranidae	*Epinephelus aeneus*	White grouper	(Hilaire, 1809)	5.67± 0.22 (5.28-6.06)	7.81± 0.11 (7.6-8.1)	-	-
Mugilidae	*Liza falcipinnis*	Sickle fin mullet	(Valenciennes, 1836)	31.45	14.70	-	-
Haemulidae	*Hepsetus akawo*	Parrot grunt	(Cuvier, 1830)	33.23	6.50		
Sphyraenidae	*Sphyraena guachancho*	Guachanche baracuda	(Cuvier, 1829)	-	-	26.54±9.08 (4.87-86.95)	17.86±1.85 (11.2-28.6)
Ophichthidae	*Dalophis cephalopeltis*	Worm/Sneak eel	(Bleeker, 1863)	19.52±8.92 (10.6-28.45)	42.1±2.8 (40.1-44.6)	5.16±0.59 (4.57-5.76)	19.8±0.91 (18.9-20.7)
Drepanidae	*Drepane africana*	African sicklefish	(Osorio, 1892)	32.63	11.10	-	-
Gerreidae	*Eucinostomus melanopterus*	Flagfinmojarra	(Bleeker, 1863)	10.18±0.56 (7.84-11.53)	9.75±0.30 (8.5-10.5)	-	-
Squillidae	*Squlla aculeatacalmani*	Guinean mantis shrimp	(Holthius, 1959)	8.17±3.07 (5.1-11.25)	8.05±0.21 (7.85-8.25)	5.92±3.31 (2.01-19.16)	7.26±1.23 (5.5-12.1)
Alpheidae	*Alpheus pontederiae*	Pistol shrimp	(Crosnier and Forest, 1966)	0.27±0.08 (0.1-0.53)	22.43± 2.02 (15.25-27.9)	-	-
Sphyraenidae	*Sphyraena barracuda*	Senects	Walbaum,1792	6.31±1.75 (0.34-12.28)	9.37±0.20 (4.41-14.2)	7.34±1.65 (0.44-14.22)	10.77±0.20 (4.41-16.1)
Corythoichthydae	*Corythoichthys schultzi*	Gilded pipefish	Herald,1953	2.95±0.82 (1.68-4.21)	3.28±1.82 (1.23-5.34)	3.55±0.82 (1.88-5.23)	3.88±1.82 (1.23-6.33)
Ommastrephidae	*Onychoteuthis antillarum*	Squid	LeSueur,1821	1.63±0.01 (0.13-3.12)	2.45±0.14 (0.32-2.13)	1.33±0.01 (0.13-2.12)	2.15±0.14 (0.22-2.03)
Ommastrephidae *Ommastrephes bartrami*	*Ommastrephes bartrami*	Squid	Adam,1941	1.51±0.11 (0.67-2.34)	1.82±0.44 (0.67-2.97)	1.51±0.11 (0.67-2.34)	1.22±0.14 (0.61-2.27)
Crangonidae	*Pontocaris lacazei*	Hard shell	Gourret,1887	3.44±1.2 (2.66-6.32)	3.11± 1.22 (1.77-5.94)	4.84±1.2 (2.96-6.71)	3.71± 1.22 (1.76-5.64)





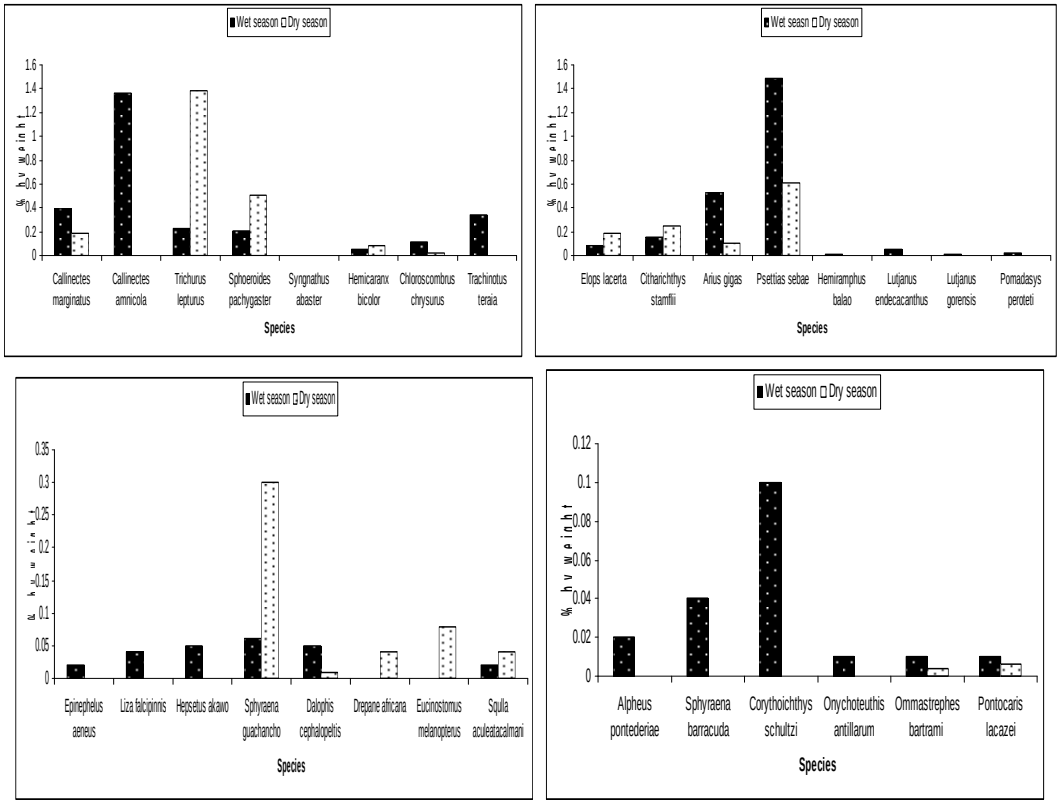


Fig 2: Species seasonal frequency by weight

4. Discussion

The shrimp species recorded in the present study are similar to that recorded by Ajayi *et al.* (1997) in the Imo River estuary, except *Penaeus setiferus* and *Parapenaeopsis sculptilis*. The higher percentage of *N. hastatus* recorded in the dry season is similar to the report of Olawusi-Peters and Ajibare (2014) [26]. who reported 84.34% of *N. hastatus* in November-December in the coastal waters of Ondo State, Nigeria. Peneaidae had the highest number of species in the shrimp catch of Okoro River estuary. These species included *Parapenaeopsis atlantica, Parapenaeopsis sculptilis, Penaeus kerathurus, Penaeus setiferus* and *Penaeus monodon.* Garcia (1988) [27] had stated that penaeid shrimps can withstand and tolerate both the estuarine and sea water salinity. Therefore, the encounter of peneaid species in this study confirms the philosophy that penaeid shrimps are marine species but with estuarine residence where the juveniles are boren and bred. Most of the penaeids spend their life cycle in estuarine zone (Garcia 1989) [28] and reproduce in the estuarine zone. This indicated that the life cycle of penaeid shrimps can be affected by seasonal or inter- annual fluctuations of environmental factors that modify fishing seasons and abundance. This study also recorded the abundance of penaeid shrimps in the wet season than the dry season. Teikwa and Mgaya (2003) [29] had reported that at Bagamoyo coastal waters, Tanzania, *P. monodon* was dominant in the wet season months (April October). Babatunde (2010) [30] recorded the smallest fin fish size of 5.1cm (2.96g) for *S. melanotheron*. From Lagos Lagoon, Nigeria This size is bigger than *Onychoteuthis antillarium* (2.13 cmTL; 2.34 gTW) recorded as the smallest fish in the catch of Okoro River estuary. The smallest size structure indicates that exploitation of by catch species is severe in Okoro River estuary. The differences in size structure may be accounted for by spatial variation in factors affecting growth of fish and gear selection. According to (Pauly, 1987) [31], size structure and composition of the stock change with the amount of fishing pressure (effort) applied.

The catch compositions comprised: 46 species from 27 families in the wet season and 35 species from 23 families in the dry season, thus wet season recorded more by-catch than dry season. This is higher than 10 fish by-catch species reported by Enin *et al.* (1991) [4]. In the *N. hastatus* fishery of the outer estuarine region of Cross River, Nigeria, 28 species recorded by Etim *et al.* (1994) [32]. In the artisanal fishery of Cross River estuary, 17 species recorded by Ajayi *et al.* (1997) [25]. In Imo River estuary, 9 fish species recorded by Ofor (2002) [33] in the Cross River estuary, 23 fish species recorded Ofor and Kunzel (2009) [6]. In the Cross River estuary, 20 families and 25 species recorded by Ambrose (2004) [5]. In the coastal artisanal shrimp beam trawl fisheries off Lagos coast, Nigeria and 21 species recorded by Olawusi-Peters and Ajibare (2014) [26] in coastal waters of Ondo State, Nigeria. The higher abundance of species recorded in the Okoro River estuary may be due to higher productivity of the estuary and its proximity to the Atlantic Ocean. The dominant of *Calinectes* in the wet season is also similar to other reports Etim *et al.* (1994) [32], Ajayi *et al.* (1997) [25], Ofor and Kunzel 2009 [6], Ambrose (2004) [5]. And Olawusi-Peters and Ajibare (2014) [26].

Species that occurred only in the wet season include: *Callinectes marginatus*, *Callinectes amnicola,* and *Illisha africana.* This corroborates the findings of Ambrose (2004) [5]. that these species are wet season species. The genus *Pseudotolithus* constituted the highest percentage of by-catch composition by number and by weight. This is similar to the findings of Ajayi *et al.* (1997) [25]. (Imo River estuary) Ambrose (2004) [5]. (Lagos coast), Nwosu (2009) [34]. (Cross River estuary) and Olawusi-Peters and Ajibare (2014) [26]. (Coastal waters, Ondo State Nigeria).

Other fish by-catch species recorded in this study was: *Trichiurus lepturus, Sardinella aurita, Ethmalosa fimbriata* and many others. The presence of these species is as a result of

the trophic structure in the estuarine system as reported by Marioghae (1989) [35]. Thus, this study established the fact that the trophic structure in the Okoro River estuary provides routes for species interactions. These interactions assure the flow and distribution of energy in an estuarine ecosystem. In this study, the quantity of shrimps and by-catch (wet weight) caught was more in the dry season than in the wet season ($p > 0.05$) and higher numbers of individuals were caught in the dry for most species. This is at variance with the report of Ambrose (2004) [5] who had recorded higher preponderance of shrimp and by-catch in the wet season in the Lagos Lagoon, Nigeria. The seasonal variation in the catch composition could be attributed to rainfall pattern and salinity gradient which may influence the distribution and abundance of species in both estuaries. Rainfall can influence tidal flooding and micro-topographic mounds resulting from deposition of sediments, accumulation of wrack and entrapment of debris which could facilitate the migration of less flood tolerant species. Also, salinity is an ecological factor of considerable importance, influencing the type of organisms that reside in the estuarine water. Thus, species distribution and abundance are to a large extent dependent on the hydrodynamics of the estuarine ecosystem. The shrimp-by-catch ratio of 5:1 and 7:1 for wet and dry seasons respectively indicates that wet season fishing generate more bycatch relative to the quantity of shrimps per landing. This implies that rainy season is profitable and environmentally friendly for the bycatch species

The shrimp-by-catch ratio obtained in the wet and dry seasons in this study is at variance with the ratio of 14:1 and 6;1 reported for wet and dry seasons by Ambrose (2004) off the coast of Lagos, Nigeria. However, the dominance of the shrimp species in the catch composition of Okoro river estuary may be due to the large expanse of the mangrove ecosystem that serves as breeding grounds for various shrimp species. This result contrasts with other reports outside the coast of Nigeria. Slavin (1982) [36]. Hall, *et al*., (2000) [37]. Have recorded shrimp-by-catch of 1:5 in temperate region, while Andrew and Pepperell (1992) [38] have reported an alarming ratio of 1:10 in the tropics. These alarming ratios reported by these authors in favour of by-catch component however may not hold in all cases of artisanal shrimp fisheries across the globe as evident in this study.

5. Conclusion

Majority of the by-catch species occur throughout the year, but few have seasonal occurrence. Seasonal incursions of species add to the permanent presence of fish by-catch in the estuary. The artisanal shrimp fishery of Okoro River estuary is a major source of food, income and employment for rural dwellers. The need for income, employment and food security of the population of the coastal fishing communities should not be allowed to run counter to habitat preservation and resource sustainability. Artisanal fishery still has a good potential of becoming a beneficial and ecological sustainable export product but a possibility of a scientifically based effort regulation is required.

6. References

1. Marioghae IE, The Commercial Fishery of Nematopalaemon hastatus in Nigeria Paper Presented at the National Conference on Agriculture, River State University of Science and Technology, Port Harcourt, 1981, 31.
2. Moses BS. The Status of Artisanal Fisheries and Fish Resources Conservation in South Eastern Nigerian. Conf. of the Nig. Soc. For Biol. Cons., University of Cross River State, Uyo, Nigeria, 1989; 22:28-30.
3. Enin UI, Lowenberg U, Kunzel T. The Artisanal Inshore Shrimp Fishery off the Cross River Estuary, Nigeria, Fishbyte, 1989, 6-10.
4. Enin UI, Lowenberg U, Kunzel T. The Nematopalaemon hastatus (Estuarine Prawn) Fishery in the Outer Estuarine Region of the Cross River, Nigeria. Archives for Fischereiwissenschaft, 1991; 41(1):67-88.
5. Ambrose E. Seasonal Variations in shrimp, Nematopalaemon hastatus and Bycatch Compositions from Coastal Artisanal Shrimp Beam Trawl Fisheries off Lagos Coast and Management Implications. Afri. Jour. of Appl. Zoo. And Environ. Bio. 2004; 6:1-5.
6. Ofor CO, Kunzel T. Fisheries and Reproduction of Nematopalaemon hastatus Aurivillius, 1898 (Crustacea palaemonidae) in the Cross River Estuary Nigeria. Jour of Sust. Agric. and the Envir, 2009; 11(1/2):61-74.
7. Le Reste L. Pluviométrie et captures des crevettes Penaeus notialis dans léstuaire de la Casamance (Sénégal) entre 1962 et 1984 Aquatic living resources, nr 5 1992, 1995, 233-248.
8. Guillard J, Albaret JJ, Simier M, Sow I, Raffray J, Tito de Morais L. Spatio-temporal variability of fish assemblages in the Gambia Estuary (West Africa) observed by two vertical hydro acoustic methods: Moored and mobile sampling. Aquatic Living Resources 2004; 17:45-55.
9. Pauly D. Major trends in small-scale fisheries, with emphasis on developing countries, and some implications for the social sciences. Maritime Studies, 2006; 4:7-22.
10. Lewison RL, Crowder LB, Read AJ, Freeman SA. Understanding impacts of fisheries bycatch on marine megafauna. Trends. in Eco. and Evol., 2004; 19:598-604.
11. Powell CB. Fresh and Brackish Water Shrimps of Economic Importance in the Niger Delta. Proceedings of the 2nd Annual Conference of Fisheries Society of Nigeria. Calabar, 1982, 254-285.
12. Federal Department of Fisheries (FDF) Fisheries Statistics of Nigeria (1st Edition). FDF, Logos, 1990, 32.
13. FAO. Fisheries Department, Fisheries Infomration, Data Statistics Unit, FAO. Rome, 2000.
14. NEDECO. The waters of the Niger Delta. Reports of investigation by NEDECO (Netherlands Engineering Consultants), The Hague, 1961.
15. Gibo AE. Relationship between rainfall trends and flooding in the Niger-Benue River basin. J Meterol. 1988; 13:132-133.
16. AKUTEC. Final Report for the Implementation of Akwa Ibom State University, Nigeria, 2006, 202.
17. Udoidiong OM. Studies of the Impact of Nipa Palm (Nypa fruticans Wurmb) on the Epibenthic Communities of Mangrove Swamps of Eastern Obolo, 2005.
18. Powell CB. Key to Shrimps and Prawns (Crustracesa: Decapoda, Natantia) of the Niger Delta Basin Development Authority Area. Consultancy Report, 5. Local Government Area, Akwa Ibom State, Nigeria. Ph.D. Thesis: Department of Animal and Environmental Biology, University of Port Harcourt, Nigeria. 1980, 235,
19. FAO Species Identification Sheets for Fisheries Purposes on Eastern Central Atlantic Fishing Areas 34,47 edited (in part) by Fisher, W; Branch, G; Scott, W. B (eds) 1981. Canada Funds-in-Trust Ottawa, Department of Fisheries and Oceans Canada by Arrangement with the Food and

Agriculture organization of the United Nations, 1981, 1-7.
20. Schneider W. Field guide to the Commercial Marine Resources of the Gulf of Guinea FAO Species Identification Sheets for Fishery Purposes Food and Agriculture Organization of the United Nations, Rome: FADR/ FUGO/ Z, 1990.
21. FAO Fisheries Technical Paper Introduction to tropical fish stock assessment: Part I - Manual, 306/1, rev. 1, edited by Sparre, P. and Venema, S.C, 1992.
22. Froese R, Pauly D. Fish Stocks. In Simon Levin (ed.). Encyclopedia of biodiversity. 2013; 3:477-487. Academic Press, 5504 p., ISBN-978-0-12-384719-5 DOC
23. Sokal RR, Rohlf EKJ. Biometry, W. H. Freamson Francisco, California: List, 1981, 859.
24. Snedecor GW, Cochran WG. Statistical Methods. Seven Edition. The LOWA State University Press, USA, 1980, 509.
25. Ajayi TO, Anyanwu AO, Adetayo JA, Abohweyere PO, Isebor CE, Abass MA, et al., Fisheries Survey of Brackish and Inshore Coastal Waters. Mar. Fish. Re.s, 1997, 1-5.
26. Olawusi-Peters OO, Ajibare AO. Species Abundance and Distribution Patterns of some Shellfishes in Coastal waters of Ondo State,Southwest of Nigeria. Inter Jour. of Fua. and Biol. Stud, 2014; 1(4):19-24.
27. Garcia S. Tropical Penaeid Prawn. In: Fish Population Dynamics, J. A. Gulland (ed.) (2nd ed.), John Wiley and Sons, London 1988, 212-249.
28. Garcia S. Life Cycle, Dynamics Exploitation and Management of Coastal Peneaid Shrimp stocks, FAO Fish. Technical Paper, 1989; 30:203 -215.
29. Babatunde EE, First Observation on Shrimp Fishery Using Brackish Water Fern Acrostichum aurem Traps in a Tropical Lagoon, Southwestern Nigeria. Report and Opinion 2010; 2(3):111-115.
30. Teikwa ED, Mgaya YD. Abundance and Reproductives Biology of the penaeid prawns of Bagamoyo coastal water, Tanzania. Western Indian Ocean Journal of Marine Sciences. 2003; 2(2):117-126.
31. Pauly D. A Review of the ELEFAN system for Analysis of Length- Frequency Data. In Fish and Aquatic Invertebrates In: Pauly, D and G. G. Morgan (Eds).Length-Based Methods in Fisheries Research. ICLARM Conference Proceedings 1987; 13:7-34.
32. Etim L, Uwe-Bassey BU, Brey T. Population Dynamics of the West African Croaker Pseudotolithus elongatus in the Cross River Estuary, Nigeria. Mar. Sc, 1994; 58(4):315-321.
33. Ofor CO. Exploitation Rate and By-catch of Nematopalaemon hastatus (Crustacea palaemonidae (Aurivillius, 1998) Fishery in the Cross River Estuary, Nigeria. Jour. of Aquat. Sc. 2002; 17(1):13-16.
34. Nwosu FM. Population Dynamics of the Exploited Peneaid Shrimp, Penaeus (Farfantepenaeus) notialis in the Cross River Estuary, Nigeria. Jour. of Fish. Inter. 2009; 4(4):62-67 doi: 10.3923/jfish. 2009.62.67.
35. Marioghae IE. Trophic Relationships of the White Estuarine Prawn, Nematopalaemon hastatus (Aurivillius, 1898) (Decapoda, Palacmonidae). Rev. Hydrobiol. Trop. 1989; 22(4):289-294.
36. Slavin JW. The Utilization of Shrimp By-catch. In Fish By-catch. Bonus from the Sea. Report of a Technical Consultation in Shrimp by-catch Utilization Held in Georgetown, Guyana, 27-30 October, 1981. Ohawa, IDRC (IDRC-198), 1982, 21-28.
37. Hall MA, Alverson DL, Metuzals KI. By-catch: Problems and Solutions. Edited by G. R. Sheppard, Seas at the Millennium; An Environmental Evaluation. Vol. III, Global Issue and Processes, 2000, 131-151.
38. Andrew NL, Pepperell JB. The By-catch of Shrimp Trawls Fisheries. Oceanosr. Mar. Biol. Ann. Rev, 1992; 30(5):27-565.