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Species richness, diversity and abundance of some Decapod Crustaceans in coastal waters of Ondo State, South West, Nigeria

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Abstract
The richness, diversity and abundance of some shellfishes of the coastal waters bordering Ayetoro, Bijimi, Asumogha and Idiogba of Ondo States, Nigeria were studied from September to December, 2011. Specimens were collected monthly with artisanal fishing boat. Seven species belonging to four families were captured throughout the sampling period and ranged from three (3) to five (5) per trip. The abundance and diversity were determined using Margalef's diversity index, Shannon-Wiener index, Pielou's measure of evenness, Berger- Parker dominance Index, Sorensen's index and the Number of Occurrence Index (NOI). *Nematopalaemon hastatus*, *Farfantepenaeus notialis*, *Parapenaeopsis atlantica* and *Portunus validus* occurred at the four sampling stations throughout the sampling period. *Macrobrachium macrobrachion* was not caught in December while *Ocypode africana* was caught once during the sampling period (in November). All the indices considered showed no significant differences among all the stations except for Margalef's diversity index (*d*) and Barger-Parker Dominance index (*D*) which showed significant difference ($P<0.05$) between Idiogba and Asumogha. The study revealed that there was a generally high similarity among the crustaceans' communities in the four sampling stations.

Keywords: Margalef's diversity index, Sorensen's index, Number of Occurrence Index (NOI), Shannon-Wiener index, Pielou's measure of evenness and Berger- Parker dominance Index.

1. Introduction
Ondo State is located in South Western Nigeria and has coastal areas estimated to be about 60,000 hectares which have rich biodiversity that contains diverse assemblage of fish, shellfish (shrimps, crabs, lobster, gastropods and cephalopoda), reptiles and other organisms [1]. Shellfish harvested by the artisanal fisheries include white shrimps (*Nematopalaemon hastatus*, Aurivillius, 1898), brackish river prawn (*Macrobrachium macrobrachion*, Herklots, 1851), Africa river prawn (*Macrobrachium vollenhovenii*, Herklots, 1857), West Africa freshwater crab (*Brachyodontes niger*), Tiger prawn (*Penaeus monodon*, Fabricius, 1798) and pink shrimps (*Farfantepenaeus notialis*, Perez-Farfante, 1967) [2].
Shellfish have been found out to be of very great commercial importance in Nigeria territorial waters and the exploitation has been on the increase due to increasing population and demand for protein sources by man [3]. Nwosu [4] reported that there has been significant reduction of the natural stock of shrimps in Nigerian coastal waters (probably due to environmental degradation which is detrimental to the abundance and life cycle of the shrimp species) while Deekae and Abowei [5] stated that the unfriendly fishing methods of local fishers who use poisons and chemicals are affecting the shrimp catch.
Extensive researches have been carried out in the coastal waters of Ondo State: Akegbejo-Samson [6] on the ecology of the fisheries resources of coastal wetlands of Ondo State and its management implications; Asaolu [7] on the chemical pollution studies of coastal waters of Ondo State; Adeparusi [8] on smoke-curing of fish by artisanal fisher folks in Ilaje, Ondo State, Nigeria; Adebowale [9] impacts of natural and anthropogenic multiple sources of pollution on the environmental conditions of Ondo State coastal water; Abdus-Salam [10] on physicochemical assessment of water quality of oil producing areas of Ilaje, Ondo State; Bayode [11] on the environmental implications of oil exploration and exploitation in the coastal region of Ondo State, Nigeria; Olawusi-Peters [12] on the length-weight relationship and condition factor of shrimps in coastal waters of Ondo State; however, the species abundance and diversity of shellfishes in Ondo State are yet to be investigated. Hence, this study is expected to bridge the existing gap in research and to provide information on the species

richness, diversity and abundance of some decapods crustaceans needed for efficient and effective management, utilization, and conservation in coastal waters of Ondo State.
This research was designed to provide answers to the following questions:

1. Which species of decapod crustaceans are in the coastal waters of Ondo State?
2. Which species are most abundant in the artisanal fisheries of the study area?
3. Is there any similarity in the species diversity of the decapod crustaceans in the four stations?

2. Materials and Methods

Description of Study Area

The study was carried out in Ilaje Local Government Area (ILGA) (Fig. 1) in the coastal area of Ondo State from September to December, 2011. ILGA is at the extreme southern part of Ondo State. ILGA shares boundaries with Okitipupa Local Government Area in the North; the Atlantic Ocean in the South; Ijebu Waterside Local Government Area (Ogun State) in the West and Delta state in the East. It comprises of several fishing communities located within the river tributaries discharging into the Atlantic and those along the coastline [8]. The coastal areas of Ondo State consist of over five hundred settlements spreading over 3,000 km^2. ILGA has the longest coastline in Nigeria (about 78 km) with long history in fishing dating back to the pre-colonial days [8, 11]. The study area falls within Latitudes 6.00° and 6° 30' north and Longitudes 4° 45' and 5° 45' east of the Greenwich Meridian. The area is positioned within the equatorial evergreen swamp forest. There are over 80 fishing communities along the coastline and are the major fish producers in Ondo State [6]. A few of them (Ayetoro, Bijimi, Idiogba, and Asumogha) were purposely selected for this study based on extensive fishing activities in the towns and accessibility.

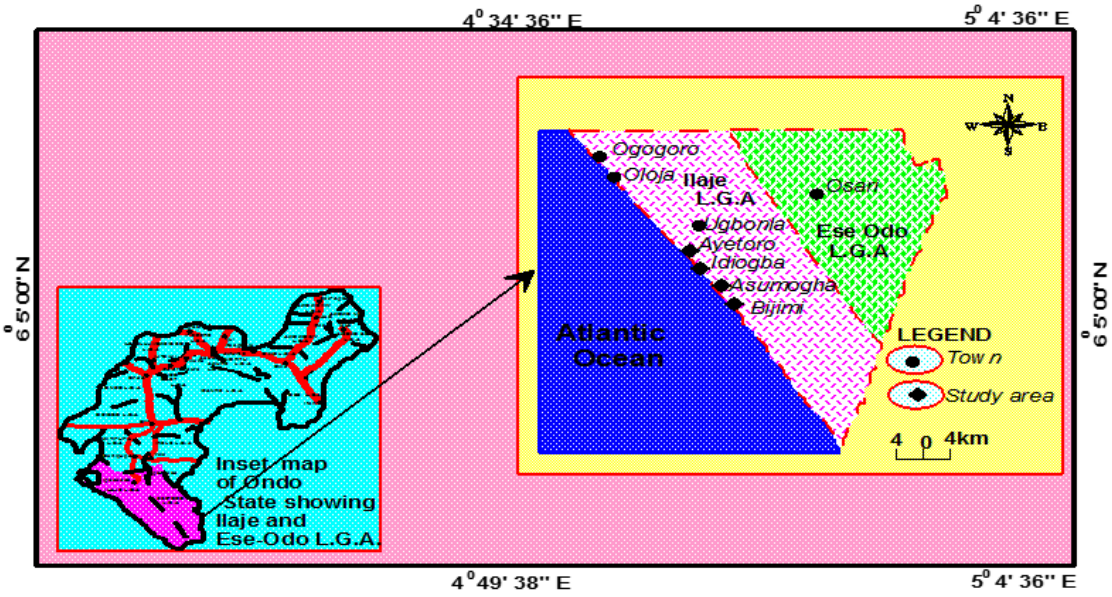

Fig 1: Coastal waters of Ondo State

Catching of Shrimps

The shrimps were collected on monthly basis from September to December 2011, with the assistance of artisanal fishermen. The Shrimpers used boats with sizes ranging from 5 to 12m long. The boats were powered by small outboard engines and manned by an average of two men per boat, to which the shrimping nets are attached for fifteen minutes. The specimens were immediately preserved in iced packed cooler and transferred to the Fisheries and Aquaculture Laboratory, Federal University of Technology, Akure where they were frozen at -4^{o}C before they were used for the research work.

Species Identification

The specimens were identified to specific level using the FAO Species Identification Sheets, (Volume VI) [13].

Data Analysis

The data were analysed using the Margalef's diversity index, Shannon-Wiener index, Pielou's measure of evenness, Berger-Parker dominance Index, Sorensen's index and the Number of Occurrence Index (NOI). The data were further subjected to one-way analysis of variance (ANOVA) to compare the variations in parameters among stations over time, using statistical package for social science (SPSS) 16.0

Margalef's diversity index

Margalef's diversity index is calculated by using the formula according to Margalef [14]:

$$d = \frac{S-1}{log_e N}$$

Where, d = Margalef's diversity index
S = number of species
N = number of individuals

Shannon-Wiener index [15]

Measures the average diversity of a sample and is given by equation:

$$H' = (-P_1 lnP_1) + (-P_2 lnP_2) + \cdots$$

Where *H'* = Shannon-Wiener index
P = total proportion of each species in sample

Pielou's measure of evenness [16]
Measures evenness with which individuals were distributed among the species.

$$J = \frac{H'}{log_{(S)}}$$

Where S = number of observed species.
H'= Shannon-Wiener index.

Berger- Parker Dominance Index
Relates the species richness and abundance. It takes into account only the commonest species in the sample and is calculated as:

$$D = \frac{N_{max}}{S}$$

Where N_{max} = the number of individuals of the most abundant species,
S = the total number of observed species.

Sorensen's similarity index
This is the degree of similarity between the fish communities in the different locations. It is expressed according to Krebs [17] as:

$$C_S = \frac{2j}{a+b}$$

Where *Cs* is Sorensen's index,
j is the number of species common to a given pair of locations,
a and *b* are the number of species occurring in either of the two locations.

Number of Occurrence Index **(NOI)**
This is the total number of individual of each species in a catch, expressed as a percentage of the total number of individual of all species in the catch.

$$NOI = \frac{C}{D} \times 100$$

Where, C = number of individual of each species in the catch,
D = total number of individual of all species in the catch.

3. Results and Discussion
Table 1 shows that seven species belonging to four families were captured in the study area. The families include; Penaeidae (*Farfantepenaeus notialis*, Perez-Farfante, 1967 and *Holthuispenaeopsis atlantica*, Balss, 1914); Palaemonidae (*Nematopalaemon hastatus*, Aurivillius, 1898 and *Macrobrachium macrobrachion*, Herklots, 1851), Portunidae (*Sanquerus validus*, Herklots, 1851 and *Callinectes Marginatus*, A. Milne-Edwards, 1861) and Ocypodidae (*Ocypode africana*, De Man, 1881). The occurrence of the crustaceans in the sampled stations is shown in Table 2. The table shows that *N. hastatus*, *F. notialis*, and *P. atlantica* was caught in all stations throughout the sampling period, while *S. validus* was caught throughout the study period in both Bijimi and Asumogha but was not caught in Ayetoro and Idiogba in October and December respectively. *M. macrobrachion* was caught from September to November in Bijimi; in September and October in Ayetoro and in October in Idiogba, but was not caught in Asumogha. Also, *C. marginatus* was caught in Asumogha in both September and December, while *O. africana* was only caught in Asumogha in November.

Table 3 shows the Number of Occurrence Index (NOI) of species in all the sampling stations. The result showed that *N. hastatus* was the most abundant species in the four sampled stations throughout the study with 83.05% (n=98), 76.47% (n=117), 72.50% (n=58) and 71.67% (n=86) in September; 76.82% (n=106), 79.04% (n=132), 71.93% (n=82) and 70.7% (n=111) in October; 85.36% (n=140), 86.96% (n=180) 94.68% (n=178) and 86.17% (n=162) in November; 91.46% (n=182), 93.99% (n=172), 83.76% (n=98) and 84.34% (n=97) in December (in Ayetoro, Idiogba, Asumogha and Bijimi, respectively).
The table further reveals that *F. notialis* had 9.32% (n=1), 11.67% (n= 14), 20% (n= 16) and 18.3% (n= 28) in September; 10.86% (n= 15), 10.83% (n= 17), 17.54% (n= 20) and 11.38% (n= 19) in October; 8.54% (n= 14), 4.79% (n= 9), 2.13% (n= 4), 8.70% (n= 18) in November; 5.53% (n= 11), 6.96% (n= 8), 11.11% (n= 13) and 4.37% (n= 8) in December at Ayetoro, Bijimi, Asumogha and Idiogba respectively.
The NOI of *P. atlantica* for the month of September were 2.54% (n= 3), 15% (n= 18), 5% (n= 16) and 4.58% (n= 7) in Ayetoro, Bijimi, Asumogha and Idiogba respectively, while the month of October were 5.8% (n= 8), 14.65% (n= 23), 7.89% (n= 9) and 6.58% (n= 11) at Ayetoro, Bijimi, Asumogha and Idiogba respectively. Also, *P. atlantica* had 4.88% (n= 8), 5.85% (n= 11), 1.06% (n= 3) and 3.86% (n= 8) in November; 2.51% (n= 5), 7.83% (n= 9), 3.43% (n= 4) and 1.64% (n= 3) in December at Ayetoro, Bijimi, Asumogha and Idiogba respectively.
Moreover, *S. validus* had 1.7% (n= 2), 0.83% (n= 1), 1.25% (n= 1) and 0.65% (n= 1) in September; 0% (n= 0), 1.27% (n= 2), 2.64% (n= 3) and 0.6% (n= 1) in October; 1.22% (n= 2), 0.53% (n= 1), 0.53% (n= 1) and 0.48% (n= 1) in November; 0.50% (n= 1), 0.87% (n= 1), 0.85% (n= 1) and 0% (n= 0) in December Ayetoro, Bijimi, Asumogha and Idiogba respectively. *M. macrobrachion* was only caught in Ayetoro (3.39% / n= 4) and Bijimi (0.83% / n= 1) in September and in Ayetoro (6.52% / n= 9), Bijimi (2.55% / n= 4) and Idiogba (2.4% / n= 4) in October. It further contributed 2.66% (n= 5) to the NOI of Bijimi in November while none was caught in all the stations in December. *C. marginatus* also contributed to the species richness of Asumogha with NOI of 1.25% (n= 1) and 0.85% (n= 1) in September and December respectively, while *O. africana* had NOI of 1.06% (n= 2) also at Asumogha in November.

Table 1: Composition of decapod crustaceans caught in coastal water of Ondo state from September to December, 2011

Common Name	Species	Descriptor	Year	Family	Super Family
Estuarine Prawn or White Shrimps	*Nematopalaemon hastatus*	Aurivillius	1898	Palaemonidae	Palaemonoidea
Brackish River Prawn	*Macrobrachium macrobrachion*	Herklots	1851	Palaemonidae	Palaemonoidea
Southern Pink Shrimps	*Farfantepenaeus notialis*	Perez-Farfante	1967	Penaeidae	Penaeoidea
Guinea Shrimp	*Holthuispenaeopsis atlantica*	Balss	1914	Penaeidae	Penaeoidea
Smooth Swim Crabs	*Sanquerus validus*	Herklots	1851	Portunidae	Portunoidea
Marbled Swim Crab	*Callinectes Marginatus*	A. Milne-Edwards	1861	Portunidae	Portunoidea
African Ghost Crab	*Ocypode africana*	De Man	1881	Ocypodidae	Ocypodoidea

Table 2: Occurrence of decapod crustaceans in coastal waters of Ondo State, from September to December, 2011.

Months	Species	Ayetoro	Bijimi	Asumogha	Idiogba
September	*N. hastatus*	+	+	+	+
	M. macrobrachion	+	+	-	-
	F. notialis	+	+	+	+
	P. atlantica	+	+	+	+
	P. validus	+	+	+	+
	C. marginata	-	-	+	-
	O. africana	-	-	-	-
October	*N. hastatus*	+	+	+	+
	M. macrobrachion	+	+	-	+
	F. notialis	+	+	+	+
	P. atlantica	+	+	+	+
	P. validus	-	+	+	+
	C. marginata	-	-	-	-
	O. africana	-	-	-	-
November	*N. hastatus*	+	+	+	+
	M. macrobrachion	-	+	-	-
	F. notialis	+	+	+	+
	P. atlantica	+	+	+	+
	P. validus	+	+	+	+
	C. marginata	-	-	-	-
	O. africana	-	-	+	-
December	*N. hastatus*	+	+	+	+
	M. macrobrachion	-	-	-	-
	F. notialis	+	+	+	+
	P. atlantica	+	+	+	+
	P. validus	+	+	+	-
	C. marginata	-	-	+	-
	O. africana	-	-	-	-
+ indicates present; - indicates absent					

Table 4 presents the biodiversity index of decapods crustaceans in coastal waters of Ondo state Nigeria. Number of species (*N*) caught across the four stations throughout the study period were not statistically different ($p<0.05$) with number of species ranging from 3 (Idiogba in December) to 5 (Ayetoro in September; Bijimi in September, October and November; Asumogha in September, November and December). The table also shows that the Margalef's diversity index (*d*) of the crustaceans ranged between 0.38 (Idiogba in December) and 0.91 (Asumogha in September). The Margalef's diversity index also showed significant difference between Asumogha (0.79) and Idiogba (0.58) while Ayetoro (0.65) and Bijimi (0.76) were not significantly different from Idiogba and Asumogha.

The Shannon-Wiener index (H_s) of the decapod crustaceans collected from the four stations range from 0.26 (Idiogba in December) to 0.92 (Bijimi in October) and there were no significant difference ($P<0.05$) among the four sampling stations. Also, table 3 further presents the Pielou's measure of evenness (*J'*) for the four stations. This shows that *J'* ranged from 0.17 to 0.60 in Asumogha in November and October respectively.

The Barger-Parker Dominance index (*D*) for the species collected in the study area showed significant difference ($P<0.05$) between Idiogba (39.50) and Asumogha (21.83) while Bijimi (24.01) and Ayetoro (31.65) were statistically not different from Idiogba and Asumogha. Table 5 shows that Sorensen's similarity index (*Cs*) values ranged from 0.38 to 0.50.

A total of seven species belonging to four families were recorded across the four stations. The species richness were not significantly different across the four stations. The reason for this might not be unconnected with the speciation due to physical, ecological and climatological barriers. Akegbejo-Samson [6] and Ogaga [18] also reported similar results. However, Ogaga [18] observed a sharp drop in the diversity of fin-fishes and attributed it to problems such as extinction, pollution and overfishing. Yem [19] also reported extinction of threatened fishes and succession in Kanji Dam as a result of impoundment.

Table 3: Number of Occurrence Index (% and n) of decapod crustaceans in coastal waters of Ondo State, from September to December, 2011.

Month	Species	Ayetoro		Bijimi		Asumogha		Idiogba	
		%	n	%	n	%	n	%	n
September	*N. hastatus*	83.05	98	71.67	86	72.50	58	76.47	117
	M. macrobrachion	3.39	4	0.83	1	0	0	0	0
	F. notialis	9.32	11	11.67	14	20.00	16	18.30	28
	P. atlantica	2.54	3	15.00	18	5.00	4	4.58	7
	S. validus	1.70	2	0.83	1	1.25	1	0.65	1
	C. marginatus	0	0	0	0	1.25	1	0	0
October	*N. hastatus*	76.82	106	70.70	111	71.93	82	79.04	132
	M. macrobrachion	6.52	9	2.55	4	0	0	2.4	4
	F. notialis	10.86	15	10.83	17	17.54	20	11.38	19
	P. atlantica	5.8	8	14.65	23	7.89	9	6.58	11
	S. validus	0	0	1.27	2	2.64	3	0.6	1
November	*N. hastatus*	85.36	140	86.17	162	94.68	178	86.96	180
	M. macrobrachion	0	0	2.66	5	0	0	0	0
	F. notialis	8.54	14	4.79	9	2.13	4	8.7	18
	P. atlantica	4.88	8	5.85	11	1.06	3	3.86	8
	S. validus	1.22	2	0.53	1	0.53	1	0.48	1
	O. africana	0	0	0	0	1.06	2	0	0
December	*N. hastatus*	91.46	182	84.34	97	83.76	98	93.99	172
	F. notialis	5.53	11	6.96	8	11.11	13	4.37	8
	P. atlantica	2.51	5	7.83	9	3.43	4	1.64	3
	S. validus	0.50	1	0.87	1	0.85	1	0	0
	C. marginatus	0	0	0	0	0.85	1	0	0
%= percentage. n = frequency									

Table 4: Biodiversity index of decapods crustaceans in coastal waters of Ondo state from September to December, 2011

Month	Ayetoro					Bijimi					Asumogha					Idiogba				
	N	d	Hs	J'	D	N	d	Hs	J'	D	N	d	Hs	J'	D	N	d	Hs	J'	D
September	5	0.84	0.65	0.41	19.60	5	0.84	0.85	0.53	17.20	5	0.91	0.81	0.51	11.60	4	0.60	0.69	0.50	29.25
October	4	0.61	0.79	0.57	26.50	5	0.79	0.92	0.57	22.20	4	0.63	0.84	0.60	20.50	5	0.78	0.73	0.46	26.40
November	4	0.59	0.55	0.39	35.00	5	0.76	0.56	0.35	32.40	5	0.76	0.28	0.17	35.60	4	0.56	0.49	0.35	45.00
December	4	0.57	0.36	0.26	45.50	4	0.63	0.57	0.41	24.25	5	0.84	0.59	0.37	19.60	3	0.38	0.26	0.24	57.33
Overall	4.25^{a}	0.65^{ab}	0.59^{a}	0.41^{a}	31.65^{ab}	4.75^{a}	0.76^{ab}	0.73^{a}	0.47^{a}	24.01^{ab}	4.75^{a}	0.79^{b}	0.63^{a}	0.41^{a}	21.83^{a}	4.00^{a}	0.58^{a}	0.54^{a}	0.39^{a}	39.50^{b}

Table 5: Sorensen's similarity index for the pairs of shellfish communities

Month	Station	Ayetoro	Bijimi	Asumogha	Idiogba
September	Ayetoro	0			
	Bijimi	0.50	0		
	Asumogha	0.40	0.40	0	
	Idiogba	0.44	0.44	0.44	0
October	Ayetoro	0			
	Bijimi	0.44	0		
	Asumogha	0.38	0.44	0	
	Idiogba	0.44	0.50	0.44	0
November	Ayetoro	0			
	Bijimi	0.44	0		
	Asumogha	0.44	0.40	0	
	Idiogba	0.50	0.44	0.44	0
December	Ayetoro	0			
	Bijimi	0.50	0		
	Asumogha	0.44	0.44	0	
	Idiogba	0.43	0.43	0.38	0

The results showed that *N. hastatus*, *F. notialis*, and *P. atlantica* were captured throughout the sampling period and in all stations, while *S. validus* was captured throughout the sampling period in both Bijimi and Asumogha and was not captured once in both Ayetoro and Idiogba in September and December respectively. *C. marginatus* and *O. africana* were only captured in September and November respectively. This abundance was in line with the work of Ofor [20] and Zabbey [21] which stated that *N. hastatus* dominate artisanal catches from coastal waters and in estuaries, together with *F. notialis*, *P. kerathurus* and *P. atlantica* as the major representatives in small-scale catches.

The result obtained in this study was similar to the results of Enin [22] who studied *N. hastatus* fishery in the outer estuarine region of Cross River, Nigeria and Powel [23] who reported that *P. atlantica* is of secondary importance to *F. notialis* and *N. hastatus* in the river mouth fisheries. Also, according to Mariogha e[24] *N. hastatus* (which he called the "tiny shrimp" in distinction from penaeid shrimps) makes up three-quarters of the catch of filter traps or nets, while, Marioghae [25] made estimates of catches which give a figure of about 35kg of *N. hastatus* per fisherman per day and the catch is sun-dried or smoked, and marketed over much of inland Nigeria as "crayfish", which is ground and used as a condiment in cooking.

The result revealed that *S. validus*, *O. africana* and *C. marginatus* occurred in low numbers during the study and this was referred to as 'bycatch' by Zabbey [21] who stated that the composition of 'bycatch' observed during shrimping ranged from jellyfishes to finfish and occasionally gastropod molluscs. Bycatch may be defined as anything the fisherman does not intend to catch and may include the turtles, fish, crabs, sharks, weed and seabed debris [26].

Species diversity is a useful parameter for the comparison of communities under the influence of biotic disturbances or to know the state of succession and stability in the community. Relative species abundance in a community is another factor that affects diversity. Species richness, or the number of species, is currently the most widely used diversity measure. Stirling and Wilsey [27] opined that diversity (or biodiversity) is typically measured by species count (richness) and sometimes with an evenness index. The species count/richness in this study revealed seven different species throughout the sampling period and ranged from three (3) to five (5) per trip. This showed that the coastal water of Ondo state is relatively rich in terms of decapod crustaceans. However, The pielou's measure of evenness showed that the four stations had low evenness or high single-species dominance as the values were closer to zero (0) than to one (1).

The Shannon-weinner index (*H'*) and Sorensen's similarity (*Cs*) values suggest a generally high similarity among the shellfish communities in the study area. The closeness of the diversity indices is reflected in the communities being very similar and this is buttressed by the similarity index values. Balloch [28] found the diversity index to be a suitable indicator for water quality. Hughes [29] also concluded that this index was useful for community structure, but could not stand alone for assessing environmental quality. Costa and Fransozo [30] reported that the important factors that affect distribution and abundance of shrimps in the tropical region are water quality (temperature, salinity), nourishment and substrates. Thus, this finding could be as a result of the prevailing highly similar environmental conditions as reported by Ekta [31].

The Barger-Parker Dominance index (*D*) and Margalef's diversity index (*d*) indicates little difference in the species diversity of the shellfish communities. The statistical variation obtained between Asumogha and Idiogba could be attributed to differences in the level of pollution or anthropogenic activities that occur in the areas. Dance and Hynes [32] stated some important factors governing the abundance and distribution of aquatic communities to include water quality, immediate substrates for occupation and food availability. Thus, any ecological imbalance arising from any severe alterations of these factors may affect the environment. Also, Kennish [33] noted that anthropogenic activities could lead to the periodic or permanent elimination of estuarine dependent fish species from individual estuarine systems.

Therefore, the relatively low evenness or high single-species dominance, composition and diversity obtained in this study may be as a result of stress imposed by land based pollutants, as well as substrate instability possibly arising from frequent anthropogenic activities in the area. Similar observations were made by Ajao and Fagade [34] on the western industrialised parts of Lagos Lagoon which received a complex mixture of domestic and industrial wastes.

4. Conclusion

It could be concluded that *N. hastatus* (which makes up about three-quarter of the total catch in the study area), followed by F. *notialis* and *P. atlantica* were very abundant in small-scale catches in the coastal waters of Ondo state and were widely distributed. The distribution of *M. macrobrachion, O. africana* and *C. marginata* was limited in the study area as they were scarcely caught in the study period. Also, there was a generally high similarity among the shellfish communities in the four sampling stations. However, the relatively low evenness or high single-species dominance calls for further research on the ecosystem condition especially in terms of pollution status. There is hence an urgent and serious need for the monitoring and control of pollution in coastal area of developing nations to further analyse its sustainability of biodiversity.

5. References

1. Solarin BB, Williams AB, Hamzat MB, Rabiu A., Oguntade OR, Bolaji DA *et al*. Report on survey of fish and other living resources of the Nigerian coastal waters conducted between 14th April and 6th June 2009. NIOMR, Lagos, 2010, 57.
2. Tobor JG. Fin and Shellfish of Conservation Interest in Nigeria. Paper Presented at the 1st National conference on Conservation of Aquatic Resources, Calabar 11th – 14th May, 1992, 17.
3. Bankole MY. Some Aspects of The Reproductive Biology of Freshwater Prawn (*Macrobrachium vollenhovenii*) and Brackish Water Prawn (*Macrobrachium macrobrachion*). M.TECH Thesis, The Federal University of Technology Akure, Nigeria, 2007, 14-17.
4. Nwosu F. The Problem of By Catch Associated with Industrial Shrimping: Implications for Inshore Demersal Fisheries in the Niger Delta. In: Zabbey (Ed.), Small Scale Shrimp Fisheries in Nigeria. Centre for Environment, Human Rights and Rural Development (CEHRD), Eleme, Rivers State Cehrd/Tech/Conserv/01/2007, 32-48.
5. Deekae SN, Abowei JFN. *Macrobrachium macrobrachion* (Herklots, 1851) Length-Weight Relationship and Fulton's Condition Factor in Luubara Creek, Ogoni Land, Niger Delta, Nigeria. Int J Anim Vet Adv 2010; 2(4):155-162.
6. Akegbejo-Samson Y. Ecology of the Fisheries Resources of Coastal Wetlands of Ondo State and Its Management Implications. Ph.D. Thesis, Federal University of Technology, Akure, 1995, 297.
7. Asaolu SS. Chemical pollution studies of coastal waters of Ondo State. Ph.D Thesis, Federal University of Technology, Akure, 1998, 15-17.
8. Adeparusi EO, Ajibefun AI, Akeremale EO. Smoke-Curing of Fish by Artisanal Fisher Folks in Ilaje, Ondo State, Nigeria. UNAAB 2003. ASSET Ser. A. 2003; 3(4):101-109.
9. Adebowale KO, Agunbiade FO, Olu-Owolabi BI. Impacts of Natural and Anthropogenic Multiple Sources of Pollution on the Environmental Conditions of Ondo State Coastal Water, Nigeria. Elect. J Env Agric Food Chem, 2008.
10. Abdus-Salam N, Adekola FA, Apata AO. A Physicochemical Assessment of Water Quality of Oil Producing Areas of Ilaje, Nigeria. Adv. Nat Appl Sci 2010; 4(3):333-344.
11. Bayode OJ, Adewunmi EA, Odunwole S. Environmental Implications of Oil Exploration and Exploitation in the Coastal region of Ondo State, Nigeria: A regional planning appraisal. J Geog Reg Plann 2011; 4(3):110-121.
12. Olawusi-Peters OO, Ajibare AO, Bello-Olusoji OA. Length-weight relationship and condition factor of shrimps in coastal waters of Ondo state, South West, Nigeria. International Journal of Fisheries and Aquatic Studies 2014; 1(3):137-142.
13. FAO. Species Identification Sheets. Food and Agricultural Organization of the United Nations, (Volume VI). Department of Fisheries and Oceans, Canada, 1981, 7-35.
14. Margalef R. Perspective in Ecological Theory, Uni. of Chicago Press, 1968, 112.
15. Shannon CE, Weaver W. The mathematical theory of communication. University Illinois Press, Urbana, IL, 1963.
16. Pielou EC. Species diversity and pattern diversity in the study of ecological succession. J Theor Biol 1966; 10:370–383.
17. Krebs CJ. Ecological Methodology. Canada: Addison-Welsey Educational Publishers, 1999, 620.
18. Ogaga AA. Fish species composition and diversity of Warri River, Niger Delta, Nigeria. Proceedings of the 26th Annual Conference of Fisheries Society of Nigeria, 2012, 112-114.
19. Yem IY, Bankole ON, Ibrahim A. Fish Species succession and disappearance in Kainji Lake, Nigeria. 27th Annual Conference of Fisheries Society of Nigeria, 2013, 98-101.
20. Ofor CO. Exploitation Rate and By-Catch of *Nematopalaemon hastatus* (Crustacean: Palaemonidae) Arivillius, 1898). Fishery in the Cross River Estuary, Nigeria. J Aqua Sci 2002; 17(1):13-16.
21. Zabbey N. Small scale shrimp fisheries in Nigeria Centre for Environment, Human Rights and Development, Eleme, Rivers State. Technical Report, Cehrd /Tesh/Conserv/01/2007, 64.
22. Enin UI, Lowenberg U, Kunzel T. The *Nematopaleamon hastatus* (Estuarine prawn) Fishery in the Outer Estuarine Region of The Cross River, Nigeria. Archiv fur Fischereiwissenschaft 1991; 41:67-88.
23. Powell CB. Fresh and Brackish Water Shrimps of Economic Importance in the Niger Delta. In proceedings of the 2nd Annual conference of the Fisheries Society of Nigeria, Calabar, 24-27-January 1982, 27.
24. Marioghae IE. The Ecology and Commercial Fishery of *Palaemon (Nematopalaemon) hastatus,* Aurivillius, 1888. pp. 11-12 in Nigerian Institute for Oceanography and Marine Research 1980 Annual Report, 1981.
25. Marioghae IE. The ecology and commercial fishery of *Palaemon (Nematopalaemon*) *hastatus* Aurivillius, 1898. M.Sc. Dissertation, University of Port Harcourt. 1980, 78.
26. Eayrs S. A Guide to Bycatch Reduction in Tropical Shrimp-Trawl Fisheries. Food and Agricultural Organization (FAO) of the United Nations, Rome, Italy, 2005, 231-239.

27. Stirling G, Wilsey B. Empirical Relationships between Species Richness, Evenness, and Proportional Diversity. Am Nat 2001; 3(158):286–299.
28. Balloch D, Davies CE, Jones FH. Biological assessment of water quality in three British rivers: the North Esk (Scotland), the Ivel (England) and the Taff (Wales). J Water Pollut Control 1976; 75:92–114.
29. Hughes BD. The influence of factors other than pollution on the value of Shannon's diversity index for benthic macroinvertebrates in streams. J Water Res 1978; 12:359–364.
30. Costa RC, Fransozo A. Abundance and ecologic distribution of the shrimp *Rimapenacus constrictus* (Crustacea: Penaeidae) in the northern coast of Sao Paulo, Brazil. J Nat History 2004; 38(7):901-912.
31. Ekta S. Comparative Analysis of Diversity and Similarity Indices with Special Relevance to Vegetations around Sewage Drains. World Acade. Sci Eng Tech 2012; 69:735-737
32. Dance KW, Hynes HBN. Some effects of agricultural land use on stream insect communities. Envi Poll Ser A 1980; 22:19–28.
33. Kennish MJ. Environmental threats and environmental future of estuaries. J Envi Conserv 2002; 29(1):78-107.
34. Ajao EA, Fagade SO. A study of sediment and communities in Lagos Lagoon, Nigeria. Oil and Chemical Pollution 1990.