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Fish species diversity, abundance and distribution in the major water bodies in Akwa Ibom state, Nigeria

Abstract

Akwa Ibom State is one of the largest oil producing States in Nigeria. Unfortunately, this State like every other Niger Delta region has gone through devastation and marginalization over the years; a consequent of exploration and its attendant oil spillage, gas flaring and climate change. A review of fish composition, diversity and distribution of the major water bodies in Akwa Ibom State was carried out on spatial and temporal scales, with a view to assessment of the fisheries. Water bodies reviewed were of Cross River, Imo River and Qua Iboe River Eco-zones. The review revealed that Cross River is richer when compared to either Imo or Qua Iboe Rivers. However, a careful management strategy and routine monitoring are critical for the improvement and sustenance of the fisheries

Keywords: South eastern Nigeria, physico-chemical parameters, climate change, fish species composition and distribution

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Introduction

The occurrence and distribution of macro vertebrates and vertebrates are governed mostly by the physical and chemical quality parameters as well as the immediate substrate of occupation.1 The use of these macro vertebrates and vertebrates diversity for bio-assessment therefore provides a simpler approach compared to other environmental quality assessment procedures.1 According to Adakole et al.,2 macroinvertebrate and vertebrates can be sampled quantitatively, and the relative sensitivity and tolerance of some of them to contamination is deciphered. The degree of tolerance of these species to pollution is obviously shown in the reduction of species diversity.3,4 According to Khan et al.,5 biodiversity is defined as diversity of organisms of the world or the variability among world's living organisms. Ekpo6 showed that hundreds of thousands of the earth's species have become extinct in the last 50 years because of destroying their natural habitats and excessively depleting their populations. The South Eastern Nigeria in general and the Niger Delta in particular which consist of mangrove swamps and riparian forests have come under threat in the last six decades as a result of environmental pollution arising from oil exploration, drilling and transportation of the products7 and this is also applicable to fish.8 Knowledge of status of the fauna and flora of the ecosystem is important in the development and management of conservation measures.9 Monitoring the physico-chemical parameters is very important for studying the influence of these parameters on the distribution of various components of biodiversity in headwater stream.4 Water quality is influenced by geological, hydrological, climatic and anthropogenic factors.10

Nigeria lies between Longitudes 2°49'E and 14°37'E and Latitudes 4°16'N and 13°52' North of the Equator. The climate is tropical, characterized by high temperatures and humidity as well as marked wet and dry seasons, though there are variations between South and North. Total rainfall decreases from the coast northwards. The South (below Latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme North between 500 and 1000 mm.11 Nigeria is blessed with a vast expanse of inland freshwater and brackish ecosystems. Their full extent cannot be accurately stated as it varies with season and from year to year depending on rainfall. However, these water resources are spread all over the country from the coastal region to the arid zone of the Lake Chad Basin.11 The country has an extensive mangrove ecosystem of which a great proportion lies within the Niger Delta (South Eastern Nigeria) and are also found mostly in Rivers, Delta, Cross River, Akwa Ibom, Lagos and Ondo States. They lie between Latitudes 3° and 7° 6' north and are estimated to cover between 500,000 and 885,000 ha. Freshwaters start at the northern limit of the mangrove ecosystems and extend to the Sahelian region.11 Deltas and estuaries, with their saline wetlands have a total surface area of 858,000 ha, while freshwaters cover about 3,221,500 ha.11 But the purpose of this work, we will be narrowing our discussion to the three major rivers in the South Eastern Nigeria; Cross river, Imo river and Qua Iboe River (Table 1).

Table 1 Distribution and extent of Nigerian brackish and fresh water bodies

Types of wetland and distribution	Approximate size (ha)	References
Deltas and Estuaries		
i) Niger Delta	617,000	Scott (1966)
ii) Cross River estuary	95,000	Ita11
iii) Imo and Qua Iboe estuary	36,000	ENPLAN (1974)
iv) Others	110,000	Ita11
Sub-Total	858,000	Ita11

Survey sites

Cross River

The Cross River hydrological basin surrounds an area of about 44, 000 miles of which approximately 31,000 miles is located within Nigeria geographic territory and 13,000 miles stretched into the neighboring Cameroon Republic.[12] The Cross River system lies between latitude 4°00'

and 8°00' N and longitude 7°20' and 10°00' E. It rises from the Cameroon Mountains and flows westwards into Nigeria at about 40 km upstream of Ikom and southwards through a network of brackish water channels before finally discharging into the Atlantic Ocean at the bight of Bonny.[13] According to Asuquo et al.,[14] Cross River estuary is considered the largest in Africa. This estuary receives inlands drainage from Calabar, Mbo, Great Kwa and Akpayefe Rivers.[12] Estimates of potential fish yield from the Cross River and its wetlands have been attempted by Moses.[15] Using Welcomme's[16] formula for quick approximation of possible yields from rivers he arrived at estimates ranging between 7,790 and 17,140 mt per year with a mean of 12,405 tonnes. However, he accepted the lower limit of 7,790 tonnes as the approximate potential yield considering the low fish production of the river (about 10 kg/ha/y).

Moses15 also attempted to extrapolate the catch from the Cross River floodplains, based on the influence of the flood regime, and arrived at a mean annual catch of 4,791 tonnes over a period of twelve years (1972–1983).

According Ita,[11] statistical frame and catch assessment surveys of the artisanal fisheries were conducted between 1985 and 1986 with the objective of substantiating these theoretical estimates and providing a working data base for the management and control of the fisheries and the population of fishermen. A total of 811 boats and 2,214 fishermen were counted along the eastern shore in 43 fishing camps, 29 fishing villages and one resettlement village (Table 1). Along the western shore a total of 929 boats were counted with 2,665 fishermen giving an average of two to three fishermen per boat for the river stretch. The mean of monthly landings for the flood season was about 153 mt for the western shore and 216.3 mt for the eastern shore giving an overall total for the flood season of 368.9 mt. Thus the total landing for the flood season extending between May to October was about 2,213.4 mt, while that of the dry season was estimated at 2,534.4 mt giving a total annual fish landing of about 4,747.8 mt for the freshwater zone of the river.

The above estimates exclude landings along the brackish water areas extending from Calabar creeks on the eastern shore and Oron along the western shore to the confluence towns of Obioko and Effiong Oron on the eastern and western shores respectively. Estimated landings at Calcemco Beach (Calabar Town) in June 1985 gave average monthly landings of 31.2 mt for the flood season. These estimates confirm Moses15 conclusion that the lower figure of 7,790 tonnes is preferable to his upper estimate of 17,140 tonnes. However, in view of the limited number of boats operating along the brackish water area the lower limit of 7,790 tonnes is a good approximation of the total fish landings along this whole river stretch. The composition of the catch for the two consecutive seasons is shown in Table 2. *Chrysichthys* made up the bulk of the commercial landings both in June 1985 and April 1986, followed by *Clarias* and *Tilapia* in June 1985 and *Clarias, Lutjanus* and tilapia in April 1986. There was more species diversity in June, possibly as a result of the influx of migratory spawners with the early flood waters, than in April at the peak of the dry season.

Table 2 Catch composition from commercial landings along the cross river

Species	Jun-85					Apr-86					Moses17	
	No.	Wt. (kg)	Mean Wt. (g)	% No.	% Wt.	No.	Wt. (kg)	Mean Wt. (g)	% No.	% Wt.	Mean catch (x104kg)	%
Chrysichthys sp.	123	121.8	990	24.1	44.5	172	113.7	661	36.8	36.4	42.7	12.2
Clarias sp.	55	53.6	975	10.8	19.6	67	41.5	619	14.1	13.3	50.5	14.4
Tilapia sp.	107	34.5	332	21	12.6	134	39.7	296	28.3	12.7	81.8	23.3
Alestes sp.	78	17.2	221	15.3	16.3	-	-	-	-	-	2.7	0.8*
Mormyrids	13	16.5	1259	2.5	6	35	18.2	506	7.6	5.8	56.6	16.1
Synodontis sp.	35	15.7	449	6.9	5.7	-	-	-	-	-	-	-
Hydrocynus sp.	28	7.1	254	5.5	2.6	-	-	-	-	-	-	-
Auchenoglanis sp.	18	6.4	356	3.5	2.3	-	-	-	-	-	-	-
Physailia sp.	53	1	19	10.4	0.4	-	-	-	-	-	-	-
Labeo sp.	-	-	-	-	-	47	16.2	345	9.9	5.2	-	-
Lutjanus sp.	-	-	-	-	-	18	83.2	4622	3.8	26.6	-	-
Others	-	-	-	-	-	-	-	-	-	-	116.4	32.2*
Total	510	273.8	-	-	-	474	312.5	-	-	-	350.7	100

Moses[17] gave a more comprehensive checklist of commercial landings, comprising both freshwater and marine species possible caught along the brackish water zones of the Cross River, which were not sampled during the current survey.[11] His data comprise landings, recorded between 1972 and 1975 with tilapias topping the list (Table 2), and followed by *mormyrids*, *Clarias* and *Chrysichthys* alongside others. The mean weights of the four major species identified during the two surveys according to Ita[11] were higher in June samples than in April, indicative of bigger spawning populations during the flood season. Ichthyofaunal survey by Udo18 in Ikpa River; a perennial tributary stream of the Cross River recorded 19 species belonging to 16 genera representing 13 families. Malapteruridae was the dominant family (46 fauna constituting15.4%) while *Malapterurus electricus* the dominant species (48 fauna constituting 15.4%).

Ofem et al.,[9] also recorded a total of 548 fish representing 13 species from 5 families during the dry and wet seasons, with only one family being restricted to the wet season, which was of very rare taxa (Table 3). The number of taxa, and relative proportion of each species present,

upstream, midstream and downstream reaches are shown in Table 4. Cichlidae, Clariidae and Cyprinidae were the most abundant families accounting for 56.7% of the total catch. *Tilapia zillii, Clarias gariepinus* and *Labeo coubie* dominated overall catch constituting 45.5%. Among the three dominant species, two benthic fishes (*L. coubie* and *C. gariepinus*) showed inverse distributional patterns. Clariid fish (*C. gariepinus*) was most abundant downstream and least represented, upstream. Cyprinid (*L.coubie*), on the other hand, dominated the upstream reaches and scarce downstream. According to Ofem and Ikpi (2012), five species were site specific because of the association with the midstream portion of the river *(L. senegalensis*) and downstream reaches (*A. occidentalis, H. longifilis, H. fasciatus* and *C. nigrodigitatus*), while distribution of other species revealed no distinct trends.

Table 3 Relative proportions of fish species for the three reaches (January 2006 to December, 2007)

Reaches up Family/species	River mid pi	River down pi	River up pi
Cichlidae			
Oreochromis niloticus	0.042	0.038	0.004
Tilapia zilli	0.1100.238	0.098	0
Hemichromis fasciatus	0	0	0.011
Pelmatochromis guntheri	0.01	0.006	0.024
Clariidae:			
Clarias anguillaris	0.031	0.005	0.057
Clarias gariepinus	0.023	0.014	0.315
Heterobranchus longifilis	0	0	0.111
Bagridae:			
Chrysichthys nigrodigitatus	0	0	0.013
Auchenoglanis occidentalis	0	0	0.003
Mochokidae:			
Synodontis clarias	0.015	0.004	0.018
Cyprinidae:			
Labeocoubie	0.388	0.121	0.003
Labeo senegalensis	0	0.044	0
Barbus occidentalis	0.034	0.003	0.001

Ofem et al.[9]

However, water depth, water discharge, water velocity and dissolved oxygen varied significantly between reaches ($p > 0.05$) (Table 4) and all biological species studied correlated negatively with water discharge and water velocity except the Cyprinids (Table 5). On the other hand, all the species correlated positively with dissolved oxygen apart from annelids and the marginal vegetation.[9]

Seasonal differentiation evident in higher number of species and individuals caught during wet months of the study period, agree with other results which described larger ichthyofaunal densities in water bodies in Grahamstown in the rainy season.[9,19,20] This was also attributed to seasonal differences in dissolved oxygen concentration in the system, both at low water and during the floods; this factor appears to have played an essential role in determining the distribution of fish within the system.[9] In general the more active the species the more it tends to avoid de-oxygenated areas.[21] Most species encountered downstream during dry season have adaptation for survival in low dissolved oxygen conditions like presence of external gills (*Clarias, Heterobranchus*). These species form a group that is well adapted to swamps life and tend to concentrate in the more de-oxygenated small pools and swamps of the floodplain during lowwater, when other more active species like Tilapia and carp are to be found in the mid-stream (water fall) and upstream respectively.[9]

Although on a community basis the three reaches did not separate out, some species when analysed individually revealed specific range preferences. Two heterologous species between two genera, *C. gariepinus* and *L. coubie*, the two most common and economically viable benthic fishes found in this study, demonstrated opposite habitat preference, with *C. gariepinus* dominating the lower reach and *L. coubie* more abundant in the upper reach.[9] This opposing habitat preference and the attendant ecological and trophic heterogeneity reduce competition, and may be responsible for the overwhelming success of the two species in the Agbokum waterfalls.[9] The relatively higher number of *C. gariepinus* in the lower reach during this study according to Ofem et al.,[9] may be due to the fact that being mud-dwelling species, most individuals found their natural habitat downstream. The common carp, *L. coubie* adapted to live in shallow rocky bottom, assemble in the rocky upstream. Another dominant freshwater species (*T. zilli)* demonstrated great preference to the turbulent well aerated midstream reaches. This distributional trend, in a similar study(Tumwesigwe, Yusuf, and Makanga, 2000) was attributed to several factors including fast water current, suitable breeding area, marginal vegetation and the absence of competitors and piscivorous predators.[9]

Table 4 Mean variation and F-values of the analysis of variance (ANOVA) of physico-chemical parameters of water measured at three sampling sites. I: Upriver,II: Mid-river, III: Downriver

Properties	Upriver	Midriver	Downriver	Properties	F-value ANOVA
Physical Conductivity (uScm-1)	36.6 ± 11.0	38.1 ± 11.5	25.3 ± 58.2	0.77	p > 0.05
Water temperature (°C)	28.0 ± 1.1	26.6 ± 1.2	27.2 ± 0.8	3.36	p > 0.05
Water depth (m)	1.4 ± 0.7	2.2 ± 0.5	4.8 ± 0.6	4.32	p > 0.05
Water discharge (m3s-1)	156.71 ± 12	1496.46 ± 82	189.8 ± 13	5.8	p > 0.05
Water velocity (m/s)	1.94 ± 0.25	1.01 ± 0.3	0.5 ± 0.14	4.32	p > 0.05
Transparency (cm)	26.6 ± 13.9	29.5 ± 14	28.8 ± 13.4	1.56	p > 0.05
Physical Conductivity (uScm-1)	36.6 ± 11.0	38.1 ± 11.5	25.3 - 58.2	0.77	p > 0.05
Water temperature (°C)	28.0 ± 1.1	26.6 ± 1.2	27.2 ± 0.8	3.36	p > 0.05
Chemical					
Dissolved oxygen (mg/l)	6.6 ± 0.3	9.61 ± 0.2	4.34 ± 0.5	3.98	p > 0.05
pH	7.0 ± 0.2	7.0 ± 0.2	7.1 ± 0.2	1.43	p > 0.05

Ofem et al.[9]

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Table 5 Results of Pearson correlation analysis using physico-chemcal and biological parameters from Agbokum waterfalls

Item	Water depth	Water discharge	Water velocity	Dissolved °2
Chlorophytes	-0.675	-0.564	-0.654	0.654
Cyanophyceae	-0.766	-0.843	-0.321	0.435
Rotifers	-0.492	-0.477	-0.765	0.755
Cladocerans	-0.566	-0.777	-0.465	0.665
Cichlids	0.586	-0.345	-0.234	0.788
Cichlids	0.897	-0.657	-0.654	0.234
Cyprinids	0.675	0.768	0.876	0.888
Decapods	0.456	-0.543	-0.287	0.654
Annelids	0.654	-0.254	-0.432	-0.765
Azolla	-0.564	-0.671	-0.654	-0.234
Nympha	-0.444	-0.876	-0.324	0.564
Commelina	0.398	-0.432	-0.487	-0.675

Ofem et al.[9]

Imo River

The Imo Basin is located south of the Okigwe Hills from where it rises between latitudes 4° 45' and 6° 17'N and longitudes 6° 35' and 8° 10'E. The major tributaries of the Imo River include the Rivers Ibu, Iyiba, Uchu, Anamiri, Iyeachara, Eme and Otamiri and all these tributary rivers are perennial.[11] This basin is located in the rain forest zone with adequate rainfall. The rainy season begins in April and lasts for seven months up to October. The inundated soils are composed of clay with a good water retention capacity and hence several flood ponds are left behind after the flood season.[11] Along the Imo River Basin, the Oguta/Egbema plain is flooded seasonally by overflow from the Niger and Ulasi rivers which flow parallel to each other. Other floodplains exist all along the course of the Imo River.

The fish production potential of the Anambra/Imo River Basins was estimated at 10,000 mt by the Overseas Development Administration (ODA) for the former East Central State (now Anambra, Enugu, Imo and Abia States). The yield from the rivers is low hence fishermen resort to exploiting the flood ponds.[11]

Ikenna et al.,[1] also reported a total of 129 benthic fish fauna belonging to 5 species and 4 families in Otamiri River (Table 6). *Chrysichthys nigrodigitatus* was the most abundant species (32.65%) while the least abundant species was *Synodontis soloni* (2.18%).

Table 6 Species composition and percentage abundance of fish fauna in Otamiri River

Family	Species	S1 (%)	S2 (%)	S3 (%)	Otamiri River (%)
Mochokidae	*Synodontis budgetti*	8(80)	5(45.5)	7(6.5)	20(15.5)
Mochokidae	*S. soloni*	2(0.0)	3(27.3)	0(0.0)	5(3.9)
Calroteidae	*Chrysichthys nigrodigitatus*	0(0.0)	0(0.0)	83(77.9)	83(64.3)
Clariidae	*Clarias gariepinus*	0(0.0)	2(18.2)	11(10.2)	13(10.1)
Notopteridae	*Papyrocranus afer*	0(0.0)	1(9.1)	7(6.5)	8(6.2)
		10(7.8)	11(8.5)	108(83.7)	129(100)

Ikenna et al.,[1] S1 = station 1, S2 = station 2 and S3 = station 3

According to Ikenna et al.,[1] the abundance of the fish fauna in Otamiri River was dependent on season as more fishes were captured in dry season than in wet season. More species were also recorded and with high diversity indices in the dry season than in the wet season in all the stations, Ikenna et al.[1] Ikenna et al.,[1] Pearson correlation analysis of fish species abundance with some physicochemical parameters showed a significant positive linear relationship between abundance of *S. budgetti, C. nigrodigitatus and P. affer and* water temperature (r = 0.6996, 0.473 and 0.530 respectively). There was significant negative relationship between abundance of *S. budgetti, C. gariepinus* and water depth (r = -0.615 and - 0.481 respectively) and only *S. budgetti* abundance had a significantly positive linear relationship with turbidity ($r = 0.595$, $p < 0.01$).[1]

The Authors however attributed the dominance of *C. nigrodigitatus* at station 3 over stations to pollution, stress and high level of anthropogenic activities such as sand dredging, mining and waste disposal, in stations 1 and 2. This assertion was in line with the report of Nwankwo et al.,[22] that also attributed low species abundance and diversity at some sites in a river in South Eastern Nigeria to pollution of such sites. Ikenna et al.,[1] noted that parameters such as temperature, depth, DO and turbidity had influence on the community composition of Otamiri River. This supports the claims by Brown et al.,[23] that the abundance and diversity of benhic fauna are generally affected by the physical and chemical characteristics of water, availability of food and substrate quality. Finally, Ikenna et al.,[1] noted that anthropogenic activities at Otamiri River affected the fish diversity of the area. Meanwhile, Okereke[24] also recorded 46 fish species from 20 families in Otamiri River.

Assessment of fish landing by artisanal fishers in Imo River at Owerri-Nta was also conducted from January-December, 2013.[25] Nine fish species belonging to seven families were identified in the fisher's catch on the river during the survey as shown on Table 7, while their relative abundance is shown on Table 8. The fish species *Tilapia zillii*, a cichlid was the most dominant with a total value of 3,342 and 22.87 % in terms of numbers and percentage abundance respectively. The *Chrysichthys nigrodigitatus*, with 13.08 % percentage abundance, was the species of the highest market value and based on the catch composition, the river was productive and comparable with other smaller but productive Nigeria Rivers, reservoirs and lakes.[25]

Table 7 List of fish families and species identified in Imo River at Owerri-Nta, Abia state

Fish families/species	Common name	Local name
Alestidae		
Alestes macrophthalmus	Tiger fish	Sako
Cichlidae		
Hemichromics fasciatus	Tiliapa	Atabala
Tilapia guineensis	Tiliapa	Atabala
Tilapia zilli	Tiliapa	Atabala
Claroteidae		
Chrysichthys nigrodigitatus	Cat fish	Okpor
Channidae		
Parachanna obscura	Snakehead	Snakehead
Hepsetidae		
Hepsetus odae	Tiger fish	Sako
Malapterutridae		

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Table Continues...

Fish families/species	Common name	Local name
Malapterurus electricus	Electric catfish	Eruru
Polypteridae		
Erpethoichthys calabaricus	Rope fish	Iroro

Adaka et al.[25]

Table 8 Fish species composition and their percentage abundance in the total catch during the twelve months of catch assessment

Fish families/species	Common name	Local name
Alestidae		
Alestes macrophthalmus	Tiger fish	Sako
Cichlidae		
Hemichromics fasciatus	Tiliapa	Atabala
Tilapia guineensis	Tiliapa	Atabala
Tilapia zilli	Tiliapa	Atabala
Claroteidae		
Chrysichthys nigrodigitatus	Cat fish	Okpor
Channidae		
Parachanna obscura	Snakehead	Snakehead
Hepsetidae		
Hepsetus odae	Tiger fish	Sako
Malapterutridae		
Malapterurus electricus	Electric catfish	Eruru
Polypteridae		
Erpethoichthys calabaricus	Rope fish	Iroro

Adaka et al.[25]

Qua Iboe River

Qua Iboe River lies within the tropical region in the South Eastern Nigeria. It is located at latitude 4° 39^1 and 27° 61^1 N and longitude 7° 52^1 and 42° 18^1 E is the dominant hydrographic feature in AkwaIbom State, Nigeria. It drains it catchment area of about 7. 092 km^2 and the river course covers a distance of 151 km from its source at Umunike in Imo State to where it discharges in to the Atlantic Ocean at the Bight of Bonny close to Ibeno. There are two predominant season (wet and dry seasons) in the zone. The dry season spans between November and April, while the wet season spans between May and October. Rainfall is significantly lower at the head water, but increases downstream. Qua Iboe River basin is subject to heavy rainfall with concomitant changes in the physical characteristics of the water.[26] The heavy rainfall in the River basin results in substantial leaching of the soil nutrients and the transport of large amount of allochthonous organic matter in to the river. Rainfall is therefore the most important hydro-meteorological variable that affects its physical hydrology.[27]

According to Ekpo et al.,[26] However some work on the species distribution on some streams and rivers on the Qua Iboe River basin has been reported although with more emphasis have been on the trophic spectra. Udo et al.,[26] reported 13 species from Obio Akpa Stream; a tributary of the lower reach of the Qua Iboe River. The most abundant fish species was *Tilapia dubia* (111.11%) followed by *Clarias anguilaries* (10.56%) and *Heterobranchus* sp and *Ophiocephalus* sp with 9.44% respectively while the least abundant species was *Calamoichthys* sp and *Notopterus* sp with 5.5% respectively. Ekpo et al.,[27] also recorded 356 fishes comprising 20 species belonging to 12 families in Qua Iboe (Table 9). The most abundant fish was *Barbuscallipterus* (35.11%) fowed by *Bienomyrusbrachyistus* (12.64%), *Malapterurus electricus* (8.4%) while *Xenomystus nigri* and *Anqspidoglanis fasciatus* having 0.28% abundant each.

The report of Ekpo et al.,[28] in Qua Iboe River estuary also recorded 187 fishes comprising 17 species belonging to 10 families.Mugilidae recorded the highest percentage abundance (58.30) followed by Trachinidae (12.84), Sciaenidae (9.09) while Sphyraenidae and Serranidae recorded the lowest percentage abundance with 0.53 each. However, the species *Liza grandisquamis* recorded the highest abundant with 27.80% of the total species assemblages. The general observation is that Imo River and Qua Iboe River Basins are comparatively poor when compared to Cross River Basin. According the report of Ambrose et al.,[29] revealed that the smallest size of matured female of *Pseudotolithus elongatus* (22.5 cm) in Cross River Estuary was relatively larger than earlier report by Akpan et al.,[27] which noted that the smallest matured female of the species in Qua Iboe River and Imo River Estuaries were 21.4 cm and 18.8 cm respectively. Ambrose et al.,[29] added that the fecundity of fish increases with size and also noted that the high fecundity of P. elongates in the Cross River Estuary ensures that in spite of the fluctuating physicochemical ambience, a majority of the newly spawned fish have a huge chance of survival. Ekpo et al.,[30] estimated about 77 species distributed into 52 genera, 29 families and 9 orders, with averagely one to three species per genus in the lower Cross River flood plain. This is however the largest that has been recorded in the course of this review

Table 9 Families, species and total number of specimens caught in Qua Ibe River, Nigeria

Family	Fish species	Number
Polypteridae	*Erpetoichthyscalabaricu*	24
Notopteridae	*Xenomystusnigri*	1
Mormyridae	*Bienomyrusbrachyistus*	45
	Isichthyshenrgii	3
Characidae	*Brycinuslongipinnis*	20
Cyprnidae	*Barbuscallipterus*	125
Bagridae	*Anqspidoglanisfasciatus*	1
	A. akiri	7
	Chrysichthysaluuencis	7
Malapterinidae	*Malapteruruselectricus*	30
Cyprinodontidae	*Epiplatysbifasciatus*	9
	E. sexfasciatus	21
Cichlidae	*Thysochromisansorgii*	6
	Hemichromisfasciatus	12
	Chromidontilipiagunteri	18
	Tilapia mariae	12
	Pelvicachromispulcher	4
Channidae	*Parachannaafricana*	6
Anabantidae	*Ctenepomanebulosum*	3
Nandidae	*Polycentopsisabbreviata*	2
		356

Source: Ekpo et al.[30]

The water quality assessment of these river basins have also been

studied; Williams et al.,[12] considered the hydrological characteristics of Cross River and Qua Iboe River estuaries and noted the following; i)Qua Iboe River is more saline at where it empties into the Atlantic Ocean ii) there was an increased concentration of sulphate and chloride; in which the Author attributed to inputs from human-induced activity such as agricultural production, and municipal influences iii) the turbidity levels in these estuaries were consistently higher during the wet season and there was a direct correlation between turbidity and total suspended solids in the two estuaries. BOD indicated a clean system in the estuaries except for Qua Iboe River estuary during the dry season; which showed a moderately polluted estuary.[31] iv) Cross River appears to have more uptake of anthropogenic carbon dioxide from the atmosphere than Qua Iboe River estuary and this was attributed to decreased surface pH as reported by Offiong et al.[32]

According to Ikenna et al.,[1] anthropogenic activities at Otamiri River (a tributary of Imo River) affected the faunal diversity of the area. Okorafor, James and Udoh also noted that the ecological capacity of the lower Qua Iboe River has largely been diminished due to industrialization. Based on the foregoing, a careful management strategy and routine monitoring of the anthropogenic activities around these Ecozones are required to check its excesses. Only then will these great Rivers along with her numerous resources be sustainable.[33]

Conclusion and Recommendations

The findings presented in the current survey demonstrated that, the three major ecosystems in the region are capable of a pronounced fishery. This can be achieved through regular/consistent restocking regimes with adequate and suitable fish seed. Decline in the fish species on the other hand was found to be arising from a combination of many factors including, climate change, poor management etc. Cross River was pointed out to be very productive having higher species evenness and diversity basically because of limited anthropogenic activities on the fishery. These findings relate to the importance of these fisheries in the conservation of biodiversity. Proper management guidelines such as mesh sizes, closed fishing seasons and banning of fishing in the breeding grounds must therefore be enforced to regulate and control the fishing activities in these water bodies. The survey also revealed that these water bodies are in accordance with other Nigerian water bodies where cichlids dominate the catch composition. However, there was no great difference amongst the investigated localities regarding the values of diversity indices, reason being that the distance between localities is not so great. The rich assemblage of fish species as evidenced in the survey indicates that these water bodies have the great potential for fish production if properly managed. It is hoped that the information gathered will be useful for future planning and management of the fisheries resources of the named ecosystems and others elsewhere.

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Conflicts of interest

The author declares there are no conflicts of interest.

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