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KNOWLEDGE AND PRACTICES OF *CHRYSICHTHYS NIGRODIGATATUS* FISHERY OF THE NEW CALABAR RIVER AND IMPLICATIONS FOR CONSERVATION

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ABSTRACT

The Silver catfish, *Chrysichthys nigrodigitatus* is of major economic importance in Nigeria. This species has been harvested for decades; however, the inability to spawn in captivity and the availability of fry is still a limiting factor in aquaculture of the species. Thus, it has been subjected to over-harvesting and posing a threat to the population in many water bodies. The aim of this research was to study the knowledge and practice of *Chrysichthys nigrodigitatus* fishery of the New Calabar River and discuss the implications for conservation. We carried out a survey of fishermen and the fishery characteristics of *C. nigrodigitatus* of the New Calabar River using questionnaires containing closed-ended items, direct observations, and interviews. The results indicate that the fishing of the species was dominated by males, as it was an all-male affair. Additionally, the average household size was 5.57±persons. The fishermen identified two species of *Chrysichthys* in the river. The drum trapping was the most practiced method of fishing, and the fishery was unregulated. The fishermen demonstrated good knowledge of the breeding characteristics of the species which was the reason the fish could be easily trapped in drums. The adoption of drum trapping is going to be essential in developing captive breeding of the species because it is non-invasive.

***Keywords*:** *Chrysichthys nigrodigitatus* Fishery, Knowledge, Practice, New Calabar River, Conservation

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1. INTRODUCTION

The silver catfish, *Chrysichthys nigrodigitatus* (Lacépède 1803) belongs to the Claroteidae. The genus comprises 5 species in Nigerian waters, namely *C. nigrodigitatus*, *C. furcatus*, *C. aluuensis*, *C. walker*, and *C. auratus*. The species *C. nigrodigitatus* is naturally distributed in most of tropical Africa including Nigeria, Senegal, Gambia, Ivory Coast, Liberia, Zaire, and Gabon (Ezenwa 1981), occurring abundantly in natural water bodies such as mangrove habitats, coastal lagoons, estuaries, freshwater lakes, creeks, streams and rivers where the stock is currently declining due to environmental degradations and overfishing (Adite et al. 2017). *C. nigrodigitatus* is a benthic euryhaline teleost fish migrating to freshwater for spawning but spends most of its life in estuaries.

All through the species distribution range, it supports an important and thriving commercial fishery, being priced for its firm and tasty flesh. In coastal and riverine communities of the Niger Delta Region, *Chrysichthys* is one of the most important food fish and its fisheries provide employment to the population, thereby enhancing the socioeconomic status of the people (Ama-Abasi and Uyoh 2020).

The New Calabar River is described as a black water type and among the important water resources in the Niger Delta region of southern Nigeria (Abu and Agarin 2016; Dienye and Woke 2015; Orajiaka-Uchegbu et al. 2020). The entire river course is situated between longitude 7˚60'E and latitude 5˚45'N in the coastal area of the Niger Delta, emptying itself into some creeks and coastal lagoon bordering the Atlantic Ocean. The river region has an annual rainfall between 2000-3000mm. It is fresh and acidic at the source but brackish and tidal at the mouth (Dienye and Woke 2015; Simeon et al. 2019). Presently, the river is highly stressed because of its strategic economic importance as a means of transporting industrial raw materials - numerous oil wells, flow stations, oil pipelines, oil servicing companies, food processing companies, agricultural farms, fish farms, and hydraulic sand mining sites are located within the precincts of the river (Uzukwu et al. 2014; Nwawuike and Ishiga 2019).

The fish resources of the New Calabar River include many species belonging to the families Lutjanidae, Clupeidae, Cichlidae, and Claroteidae with the Claroteidae (silver catfish) and Cichlidae (tilapias) dominating (Francis and Elenwo 2012). Thus, the fishery is exploited by artisanal fisherfolks, and it is characterized by the use of different types of traditional fishing gear. These include pipe and drum traps, gills, and cast nets, while the craft

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in use is an unmotorized dugout canoe and paddle (Francis and Elewuo 2012). The upper reach of the New Calabar River is rich in *C. nigrodigitatus* broodfish (Uzukwu et al. 2014). Given the current picture of the environment such as climate change, pollution, other anthropogenic activities, and migratory behavior in response to seasonal rainfall and salinity changes, *Chrysichthys nigrodigitatus* of the river may be highly exposed and impacted (Ganesh et al. 2022; Onyena et al. 2023). IUCN has indicated that the species is generally threatened. da Costa et al. (2010) and Ama-Abasi and Uyoh (2020) reported very low genetic diversity of the species in the Cross River Estuary. Put together, there is the need for constant monitoring and assessment of the species' status given the increasing impact of climate change and environmental variability.

Therefore, the aim of this research was to assess the knowledge and practice of *Chrysichthys nigrodigitatus* fishery of the New Calabar River and discuss the implications for conservation. We carried out a survey of fisherfolks and the fishery characteristics of *C. nigrodigitatus* of the New Calabar River using questionnaires containing closed-ended items, direct observations, and interviews.

2. MATERIALS AND METHODS

The study was conducted in the Aluu and Choba Axis of the New Calabar River. The survey was conducted during a 2-week period in July 2021. Aluu is the main fishing area while most of the sales take place at Choba by the East-west Road bridge (Fig. 1). A snowball approach was used in identifying 15 fishermen. Data was collected through i) interviews ii) administration of questionnaires, and iii) direct observations. Data collected include species of *Chrysichthys* in the river, condition of *Chrysichthys* at capture, threats to the *Chrysichthys* fishery, fishing seasons, and suggestions for the conservation of the fishery.

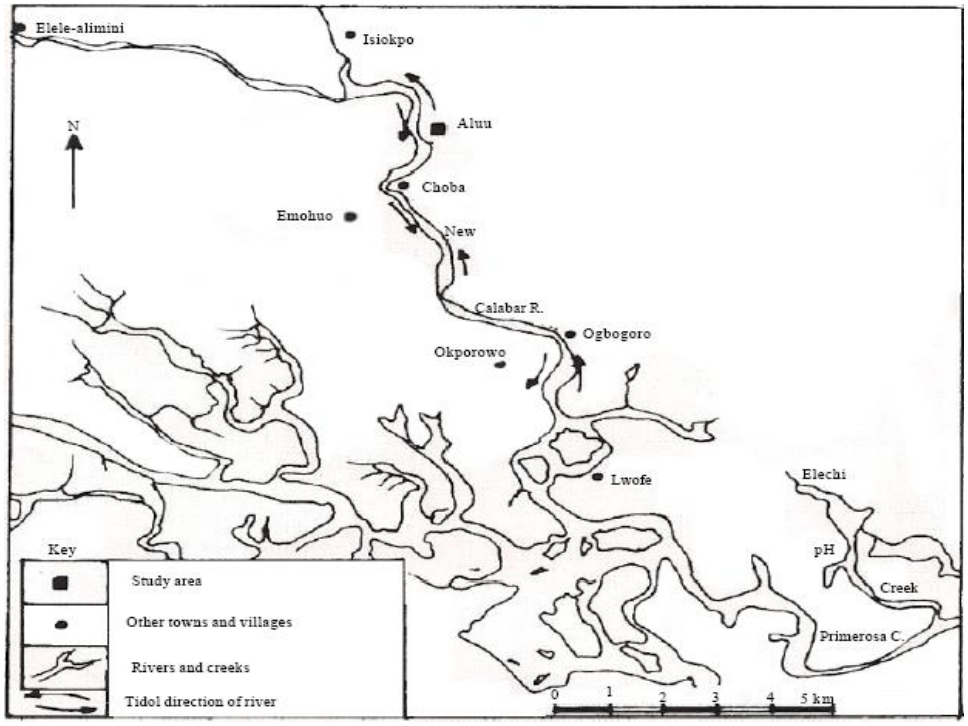

Fig. 1: Map of the New Calabar River showing the location of Aluu as the study area.

3. RESULTS AND DISCUSSION

3.1. Socio-economic Characteristics

There were five socio-demographic characteristics, which include gender, level of education, religion, number of households, and marital status in this study. The survey questionnaire was distributed to 15 fish-folks of the New Calabar River with household size ranging from 3-9 persons. The mean actual household size was 5.57 persons. All the respondents were married and male. Only one of the respondents had primary education (6.67%) with the majority holding secondary school certification (93.33%). The level of education has been shown elsewhere to play a major role in the perception and practice of fishing methods deployed by the fishermen (Wagner et al. 1999; Munyi 2009; Tawari and Davies 2009). The majority of them were Christians (86.67%) while 13.33% practice traditional religion. The role of religion in the mainstream of natural resource conservation and management is well documented with suggestions that religious beliefs including myths, norms totems, and taboos should be embedded

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in conventional conservation principles for long-term benefits (Negi 2005; Ngara and Mangizvo 2013; Nkama et al. 2022). The fishermen recorded were from Rivers State (Ahaoda, Degema, Kalabar, and Ogbia in Bayelsa State). The majority do not belong to any association or cooperative except two individuals (13.33%). Cooperative Society involves social participation that helps farmers pool their resources, have access to fisheries inputs, and have insights into their fishing issues. Memberships of cooperative societies are therefore a factor that influences the adoption of improved fisheries technologies and poverty alleviation.

3.2. Identification of *Chrysichthys*

The respondents were asked i) if they specialized in catching only *Chrysichtys* species and ii) 'how many species of *Chrysichthys* occur in the New Calabar River 12 of the respondents (80%) specialized in the fishing of *C. nigrodigitatus*. The other three engaged in mixed fishing. Most of the respondents (86.67%) identified only two species of *Chrysichthys* in the New Calabar River while two were not sure. Bwala et al. (2010) reported that fishermen of Kainji Lake were able to name fish species of the lake on the basis of morphological characteristics. The species literacy level of the fishermen of the New Calabar River is high and could aid communication and awareness creation. In fact, there are only two species of *Chrysichthys* in the New Calabar River. *Chrysichthys aluuensis* of minor fishery significance was recently identified. The ability of the fishermen to identify the *Chrysichthys* species would add value to the management of the species and would guide resource managers. The ability of artisanal fishermen to name fish species is crucial to conservation efforts and the effective implementation of regulations pertaining to species of fish caught in the river (Nwafili and Gao 2017).

3.3. Fishing methods

The fisherfolks deploy a diversity of fishing gears in the New Calabar River for *Chrysichthys nigrodigitatus* (Fig. 2). The species was trapped mostly using drum taps (100%). However, other methods of capturing the fish were as shown in Table 1. It can be seen from Table 1 that drum trapping was the most practiced method of fishing the silver catfish. The drum trap is a passive fishing gear. It is a metal cylindrical drum with a round opening (an area to allow fish species to go into the drum) at one of its bases, and a net is attached to the round opening in such a way that it forms a funnel entrance into the drum which will inhibit the escape of fish species that go into the drum (Nwankwoala and Angaya 2017; Akankali et al. 2018).

Other gears include the use of nets of different kinds (40%), PVC (20%), dynamiting, and hook (13.33% each). Dynamiting has grave implications for the aquatic environment because it destroys habitat, including spawning areas.

Fig. 2: Captured *Chrysichthys nigrodigitatus* (silver catfish) from the New Calabar River.

Table 1: Practice of *Chrysichthys nigrodigitatus* fishing method in the New Calabar River

Fishing Method	Respondents	Frequency	%
Drum trap	15	15	100
Netting	6	6	40.0
Pipe (PVC)	3	3	20.0
Dynamiting	2	2	13.33
Hook	2	2	13.33

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Typically, the drum traps (Fig. 3) we encountered were measured as follows:

i) Diameter of the drum = 22.5inches = 57.15cm
ii) Height of the drum = 34.5inches = 87.63cm
iii) Curved surface area of a cylinder = $2\pi rh$
iv) Total surface area of a cylinder = $2\pi r^2 + 2\pi rh = 2\pi r(r+h)$
v) Volume of a cylinder = $\pi r^2 h$

Where $\pi = 3.14$

i) Radius of catchments area = $\frac{diameter}{2} = \frac{23cm}{2} = 11.5cm$
Radius of drum = $\frac{diameter}{2} = \frac{57.15cm}{2} = 28.58cm$
ii) Curved surface area of catchments area = 2×3.14×11.5cm×87.63cm = 6,328.64cm^2
iii) Curved surface area of drum = 2×3.14×28.58cm×87.63cm = 15,728.04cm^2
iv) Total surface area of drum = 2×3.14×28.58cm (28.58cm+87.63cm) = 179.48cm (116.21cm) = 20,857.37cm^2
v) Volume of drum= 3.14× (28.58cm)^2 × 87.63cm = 3.14 × 816.82cm^2 × 87.63cm = 224,754.72cm^3

So, the volume of a typical drum trap was in the neighborhood of 224,754.72cm^3

The fishing drums are properly and skillfully set in the river (to avoid ghost fishing) by the fisher folks and are left for some days to capture fish. *Chrysichthys nigrodigitatus* breed in quiet waters and the drum trap is an innovation that mimics such habitat. Therefore, the fishermen were knowledgeable of the habitat requirements and the reproductive behavior of the species. Among the reasons adduced for preference of the drum trap include i) non-invasive capture, ii) efficiency, and iii) fish is captured without injuries or bruises.

Fig. 4 showed that fishing occurred more during the rainy season from April to September, representing 86.67% of the fishermen. This is in agreement with the reproductive cycle of the fish, making it more abundant and available for fishing during the rainy season (Ezenwa 1981; Adite et al. 2017; Tiogue et al. 2020). Thus, fishermen exploit its vulnerability during the season which coincides with the breeding season. However, only 33.33% fish throughout the year.

The fishermen observed that most times breeding pairs or couples were attracted to the drum. The fisherfolks use different types of bait as attractants. All fishers use baits. Types of baits used include small mobile fish (100%), cassava waste (86.67%), palm fruits (40%), other fruits (66.67%), soap (0.00%), and fish wastes (0.00%). The fishing drum could be adopted as an innovative trap essential to developing captive breeding of the species since it does not cause any injuries.

Fig. 3: A drum trap encountered on the shore of New Calabar River.

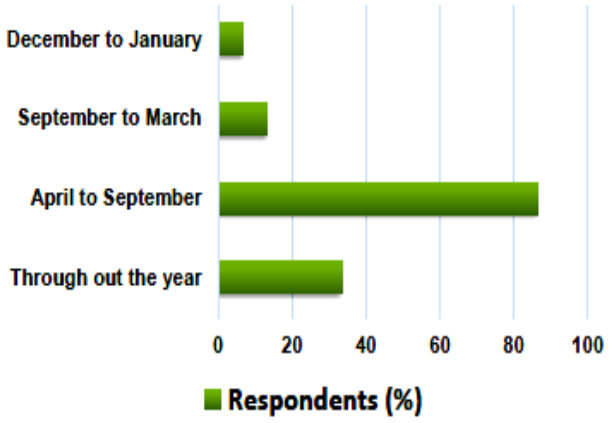

Fig. 4: Fishermen's knowledge of the fishing season of *Chrysichthys nigrodigitatus* in the New Calabar River identifies.

3.4. Biological Condition and Characteristics of Pairs in Drums

The biological conditions of *Chrysichthys* caught in the drums, they were caught in pairs (66.67% of the fishermen). Some of the individuals were gravid (80% of the fishermen) while 80% of the fishermen had encountered or seen fingerlings swimming in the drums. The catfish were captured inside traps in pairs. According to 53.33% of the fishermen, the species were entrapped in pairs while 80% said it could occur in any number. Some of the fishers have observed that during the season, some members of the pair carry eggs, and sometimes young

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individuals can be found in the drums swimming around. Fishing is carried out throughout the year. However, 50% of the respondent's fish throughout the year while another 50% only fish during the rainy season. The opinion of the fishermen appears to agree with the findings of Ekanem (2000), Offem et al. (2008), and Tiogue et al. (2020) which confirmed the peak breeding period observed between April and June in Rivers in Nigeria and Cameroun. The species is therefore not a particular target during the dry season but undertakes short migration for breeding during the rainy season. This is why there is plenty brood stock in the upper reaches of the New Calabar River during the rains (Erondu 1997; Uzukwu et al. 2004). There is no regulation of the fishery. Studies have shown that *C, nigrodigitatus* are more vulnerable to the drum trap. The drum trap is a recent introduction into the Niger Delta.

3.5. Threats to the *Chrysichthys nigrodigitatus* Fishery of New Calabar River

Evidence of declining importance of the fishery: The fishermen agreed that the fishery is declining in importance due to decreasing catch. The number of hours spent fishing has continued to increase according to 13 individuals interviewed. All the fishermen agreed that pollutants from artisanal crude oil refining and products from industries operating in the vicinity of the river released into the environment were the major cause of the decline. Large-scale habitat loss environmental degradation from sand extraction for the construction of roads and buildings and water pollution are common features in the vicinity of the river (Horsefall and Spiff 1998; Ajana 2003; Douglas 2018; Umeoguaju et al. 2022).

Only 53.33% agreed that their method of fishing may be contributing to the declining fishery. They were not aware of the dangers of capturing gravid males and females during the breeding season. All these put together, demonstrate that the fishermen were not in tandem with conservation and best fishing practices, making the need for awareness creation and environmental education urgent.

The following are threat characteristics to which the fishery is exposed:

i) Unsustainable fishing and exploitation.
ii) The use of explosives such as dynamiting destroys both the habitat and spawning areas.
iii) The species spawn in highly restricted and quiet areas, making them vulnerable to fishing during the breeding season. Thus, targeting of brooding pairs with drum traps is a major threat to recruitment.
iv) Lack of regulation or restriction of fishing during the breeding season. 100% of the respondents said there is no policy or law preventing them from fishing or restricting them to any season or period. The Inland Fisheries Decree 1992 aims to regulate inland fisheries in Nigeria. However, the laws and regulations are ineffective. In many cases, there are no personnel to enforce the laws.
v) The absence of fisheries management service in the New Calabar River has created a gap that must be urgently addressed to conserve the *Chrysichthys* fishery. The prospect for the sustainable exploitation of the *Chrysichthys* resource of the New Calabar River is to start with awareness creation and education of the users of the New Calabar River resources. FGDs targeted at all stakeholders including industries, operators of different businesses around the vicinity of the river, oil companies, locals, etc. must be thoroughly engaged.

3.6. Pollution

The New Calabar River is located in a State where oil exploration and spillage is one of the greatest challenges. The New Calabar River is in particular surrounded by various industries and markets making pollution from both organic and inorganic waste a common occurrence (Fig. 5). The river receives pollutants from abattoirs and markets, untreated industrial effluents, municipal wastewater, run-off from agricultural fertilizers and pesticides, surface run-off resulting from soil erosion, lumbering activities, forestry operations, dredging activities, domestic sewage, human and animal waste (Gideon and Chidiebere 2008; Okparanma et al. 2016; Otene et al. 2023). The pollution level of the New Calabar River has made the river unsafe for the domestic, recreational, and agricultural purposes it serves the communities around it.

3.7. Kpofire and Hydrocarbon Pollution

Oil spill incidents as a result of oil theft/vandalism and Kpofire are common features around the river (Amnesty International 2009). Kpofire is the corrupt form of illegal crude oil refining outlets scattered in the Niger Delta (Fig. 6). It is a crude technology based on the principles of fractional distillation and it results in a significant quantity of waste (about 55% of the products) which is often discarded surrounding environment - farms, mangroves, creeks, streams, and rivers (SDN 2013). The facilities deployed in the operations were grossly inefficient and crude, resulting in aquatic, terrestrial, and atmospheric pollution. It is one of the most important threats to biodiversity in the region in recent years. Consequently, aquatic life is destroyed because of changes in the physicochemical properties of water and the direct impact of biodiversity loss (Adewale 1985; Anejionu et al. 2015; Albert et al. 2018).

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Fig. 5: Illustration of the current pollution status of the New Calabar River

Fig. 6: Illegal oil mining site (Kpofire) in Niger Delta Region (The Guardian).

3.8. Suggested Strategies for Management and Conservation of *C. nigrodigitatus* in New Calabar River

The *Chrysichthys* fishery across Nigeria is facing similar challenges. Ama-Abasi and Uyoh (2020) listed conservation and management measures to halt the decline in the Chrysichthys population. Thus, the same strategies for management and conservation should apply. The strategies for the management and conservation of *C. nigrodigitatus* in the river must take cognizance of those factors affecting the fishery negatively. These include environmental deterioration of the New Calabar River, overfishing, and hazardous fishing and trapping of breeding pairs which have led to a noticeable decline and crash of the silver catfish catch. Efforts should be made to halt the degradation of the environment through habitat restoration.

The drum trap could become an innovative strategy for protecting breeding pairs. Suitable spawning substrates should be placed in the drum traps to take advantage of the habit/habitat of migrating reproductive behavior of *C. nigrodigitatus* to permit spawning and hatching of eggs on traps and to develop spawning grounds to breed and protect silver catfish resources. However, the success of this strategy will depend on creating the awareness necessary to introduce this novel method which will facilitate the spawning of more eggs and recruitment. Besides, regulatory measures including closing the fishery during the breeding season must be enforced and enacted. Thus, there must be rapport or cooperation among stakeholders. More so, registration of fishing gear and security patrol against illegal fishing and legislation must be given priority attention. The Aluu section of the river is the breeding ground of the species in the New Calabar River. In order to sustain the fishery, the section must be declared a protected area, and captive breeding research must commence using the traditional drum to trap brood fish.

4. Conclusion

The livelihood of some fishermen along the river depends on the fish resource of *Chrisichthys spp*., thus, the continual availability of the resource will depend on good management and sustainable exploitation. The fishermen

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were very knowledgeable about the ecological and biological characteristics of *C. nigrodigitaus* because of the deployment of drum traps targeting the species. The environmental issues and other anthropogenic activities in and around the vicinity of the New Calabar River constitute a great challenge to the sustainability of the *C. nigrodigtatus* fishery. Conservation measures must urgently be designed and adopted to restore the status of the species, with fisheries management plans directed at tackling the rapid decline in abundance. Since the breeding area is well-demarcated in the New Calabar River, it should be designated a protected area closed to fishing, especially during the breeding season.

Concerned Government authorities or agencies must implement projects targeted at conserving the silver catfish including research monitoring and raising awareness. Awareness and education of fishermen are measures that need to be taken to prevent destructive and unsustainable fishing activities in the river. Regulations on fishing gear, fishing grounds, and seasons should be taken into consideration to protect and conserve the resources. The drum trap must be adopted trapping because it is environmentally friendly and going to be essential in developing the captive breeding program of the species.

Conflict of interest: There is no conflict of interest.

Contribution by Authors: The authors contributed equally to the manuscript. Nwafili SA designed the questionnaire and wrote the Manuscript. Olumati distributed the questionnaire, interviewed the fisherfolks, and assembled the data.

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REFERENCES

Abu OMG and Agarin OJ, 2016. Length-Weight relationship and condition factor of silver catfish (Chrysichthys nigrodigitatus) from the lower reaches of the New Calabar River Niger Delta. International Journal of Innovative Studies in Aquatic Biology and Fisheries 2(4): 1-7.

Adewale O, 1985. Judicial attitude to environmental hazards in Nigerian oil industry: Proceedings of An International Seminar on the Petroleum Industry and Nigeria Environment, Port Harcourt, pp: 35-40.

Adite A, Gbaguidi HM and Ategbo JM, 2017. Reproductive biology and life history patterns of the Claroteid, Chrysichthys nigrodigitatus (Lacépède: 1803) from a Man-made lake in Southern Benin. Journal of Fisheries and Aquatic Science 12: 106-116. https://doi.org/10.3923/jfas.2017.106.116

Ajana AM, 2003. Economic development of the Niger Delta: The role of fisheries. A paper presented at the first Niger Delta stakeholders' Agricultural forum, organized by Niger Delta Development Commission, Port-Harcourt.

Akankali JA, Davies IC and Nwafili SA, 2018. Heavy metal concentration in Grey mullets (Mugil cephalus) and New Calabar River, Iwofe, Niger Delta of Nigeria. Nigerian Journal of Fisheries and Aquaculture 6 (2), 43-50.

Albert ON, Amaratunga D and Haigh RP, 2018. Evaluation of the impacts of oil spill disaster on communities and its influence on restiveness in Niger Delta, Nigeria. Procedia Engineering 212: 1054-1061. https://doi.org/10.1016/j.proeng.2018.01.136

Ama-Abasi D and Uyoh EA, 2020. Ecology and population dynamics of silver catfish, Chrysichthys nigrodigitatus (Siluriformes: Claroteidae), of the Cross River, Nigeria. Global Journal of Agricultural Sciences 19: 71-82.

Amnesty International, 2009. Petroleum, pollution, and poverty in the Niger Delta. London.

Anejionu OC, Ahiarammunnah PA and Nri-ezedi CJ, 2015. Hydrocarbon pollution in the Niger Delta: Geographies of impacts and appraisal of lapses in extant legal framework. Resources Policy 45: 65-77.

Bwala RL, Sule AM, Yem IY, Ndakotsu S and Adedeji R, 2010. Indigenous fish identification methods in lakes Kainji and Jebba, Nigeria. Report and Opinion 2(6): 16-22.

da Costa LM, Abdelhamid A, Lalaye P and Moelants T, 2010. Chrysichthys nigrodigitatus. The IUCN Red list of Threatened Species: e.10.2305/IUCN.UK.2010- 3.RLTS.T182997A801953.en. Accessed: 20 April 2020.

Dienye HE and Woke GN, 2015. Physico-chemical parameters of the upper and lower reach of the New Calabar River. Journal of Fisheries and Livestock Production 3: 154.

Douglas SE, 2018. Effect of illegally refined crude oil ("kpo- fire") residue on soil fungi. International Journal of Current Microbiology and Applied Sciences 7(12): 3309-3316.

Ekanem S, 2000. Some reproductive aspects of Chrysichthys nigrodigitatus (Lacepede) from cross river Nigeria. Naga ICLARM 2(2): 2000.

Erondu ES, 1997. Aspect of the Biology of Chrysichthys nigrodigitatus (Lacepede) in The New Calabar River and Its Aquaculture Potentials. PhD Thesis, University of Nigeria, Nsukka, Nigeria, pp: 165.

Ezenwa B, 1981. A study of the reproductive biology of the catfish Chrysichthys nigrodigitatus (Lacepede) in Nigeria. University of Lagos, Lagos, Nigeria.

Francis A and Elewuo U, 2012, Aspects of the biology of trap caught Chrysichthys nigrodigitatus (Lacepede: 1803) from the New Calabar River, Nigeria. International Journal of Fisheries and Aquaculture 4(6): 99-104.

Ganesh G, Philominal P, Naga Mahesh LV and Sravya P, 2022. Impact of heavy metal pollution on fish health and its consequent effect on human health. Journal of Experimental Zoology India 25(1).

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Gideon OA and Chidiebere E, 2008. The current pollution status of the New Calabar River in the Niger Delta region of southern Nigeria: A survey of antibiogram profiles of its bacterial isolates. African Journal of Environmental Science and Technology 2(6): 134-141.

Horsefall MJ and Spiff AT, 1998. Principles of Environmental Pollution. 1st Ed. Metro Prints, Port Harcourt, pp: 212-217.

Munyi F, 2009. The Social and Economic Dimensions of Destructive Fishing Activities in the South coast of Kenya. Western Indian Ocean Marine Science Association. Report No. WIOMSA/MARG-I/2009 –01.

Negi CS, 2005. Religion and biodiversity conservation: not a mere analogy. International Journal of Biodiversity Science & Management 2: 85-96. https://doi.org/10.1080/17451590509618083

Ngara R and Mangizvo RV, 2013. Indigenous Knowledge Systems and the Conservation of Natural Resources in the Shangwe Community in Gokwe District, Zimbabwe. International journal of Asian Social Sciences 3: 20-28.

Nkama CL, Kingsley NO and Emmanuel E, 2022. Eco-Preservation through the Lens of Igbo Beliefs and Practices: A Re-Imagination. Religions 13: 1066. https://doi.org/10.3390/rel13111066

Nwafili SA and Gao TX, 2017. Genetic diversity in the mtDNA control region and population structure of Chrysichthys nigrodigitatus from selected Nigerian rivers: Implications for conservation and aquaculture. Archives of Polish Fisheries 24(2): 86-97. https://doi.org/10.1515/aopf-2016-0010

Nwankwoala HO and Angaya YB, 2017. An evaluation of heavy metals concentration in the Choba section of the New Calabar River, Eastern Niger Delta. Biodiversity International Journal 1(6): 62-68.

Nwawuike N and Ishiga H, 2019. Comparative Assessment of Heavy Metal Concentrations, Environmental Risks and Phytoremediation Potentials of R. racemosa and A. germinans in Mangroves of Niger Delta, Nigeria. Asian Journal of Environment & Ecology 8(3): 1-3.

Offem OB, Akegbejo YS and Omoniyi TI, 2008. Diet, size and reproductive biology of the silver catfish, Chrysichthys nigrodigitatus (Siluriformes; Bagridae) in the cross river, Nigeria. Review Biology in Tropics 56(4): 1785-1799. https://doi.org/10.15517/rbt.v56i4.5759

Okparanma RN, Jumbo RB and Chukwu FN, 2016. Combined effects of municipal and industrial wastes on the quality of the new northern Calabar River, Nigeria. International Journal of Water Resources and Environmental Engineering 8(8): 103-112.

Onyena AP, Folorunso OM, Nwanganga N, Udom GJ, Ekhator OC, Frazzoli C, Ruggieri F, Bocca B and Orisakwe OE, 2023. Engaging One Health in Heavy Metal Pollution in Some Selected Nigerian Niger Delta Cities. A Systematic Review of Pervasiveness, Bioaccumulation and Subduing Environmental Health Challenges. Biological Trace Element Research, https://doi.org/10.1007/s12011-023-03762-5

Orajiaka-Uchegbu C, Patrick-Iwuanyanwu CK, Ogbo BA and Egbuna C, 2020. Bioaccumulation of heavy metals and potential health risk through consumption of seafoods from selected creeks in rivers state, Nigeria. Egyptian Journal of Aquatic Biology and Fisheries 24(7-Special issue): 1033-1053.

Otene BB, Thornhill I and Amadi J, 2023. A comparison of the water quality and plankton diversity of the Okamini Stream to the freshwater systems within the New Calabar River catchment, Port Harcourt, Nigeria. African Journal of Aquatic Science 48(1): 97-104.

SDN, 2013. Communities not Criminals: Illegal Oil Refining in the Niger Delta. http://www.stakeholderdemocracy.org/wp.content/uploads/2015/04/CommunitiesNotCriminals.pdf

Simeon EO, Idomo KB and Chioma F, 2019. Physicochemical Characteristics of Surface Water and Sediment of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. American Journal of Environmental Science and Engineering3(2): 39-46.

Tawari CC and Davies OA, 2009. The Relationship of Fisherfolks Characteristics to Technologies Adoption in Niger Delta, Nigeria. Ozean Journal of Applied Sciences 2(4): 361-368.

Tiogue CT, Zebaze BT, Zango P, Tomedi-Tabi ME, 2020. Reproductive Strategy of Chrysichthys nigrodigitatus (Lacepede, 1803) in a Natural Environment in the Nkam River, Littoral Cameroon. International Journal of Zoology 2020: 1-8.

Umeoguaju FU, Akaninwor JO, Essien EB and Amadi BA, 2022. Heavy metal profile of surface and ground water samples from the Niger Delta region of Nigeria: a systematic review and meta-analysis. Environmental Monitoring and Assessment 194: 46. https://doi.org/10.1007/s10661-021-09688-6

Uzukwu PU, Leton TG and Jamabo NA, 2014. Survey of the physical characteristics of the upper reaches of the New Calabar River, Niger Delta, Nigeria. Trends in Applied Sciences Research 9(9): 494-502.

Wagner GM, Mallya U, Juma S, Mgaya YD, Wahure O, Mahika G and Wagner SM, 1999. A preliminary investigation for an integrated, community-based approach to conservation and restoration on marine ecosystems along the Dares Salaam coast. African Development Foundation, Dares Salaam, pp: 124.