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Seasonal changes in fish catch and environmental variables in a large Tropical Lake, Volta, Ghana

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Abstract

Fish species assemblage and selected environmental variables were monitored in Lake Volta from September 2014 to August 2016 to determine seasonal variability in species composition, catch and environmental variables that determine the structure of the fish community. A total of 1,557 individual fish belonging to 41 species, 25 genera and 13 families were recorded. The important fish species with respect to frequency of occurrence, abundance and weight, respectively, were as follows: *Chrysichthys* (100%; 43.03%; 17.93%), tilapias (100%; 28.97%; 17.86%), *Alestes* (100%; 14.13%; 32.10%) and *Bagrus* (91.67%; 5.65%; 12.80%) in that order. The composition of fish species and their temporal variation in experimental catches were similar to that of commercial catches. There were no significant differences ($p > 0.05$) in species abundance, weight and diversity indices between the dry and wet seasons. The modal class of length frequency distribution of the dominant species in the catch, *Chrysichthys*, reduced from 125 mm in 2006 to 95 mm in the current study indicating overfishing. Environmental variables considered showed little variation and within optimal ranges for fish survival and did not differ significantly between seasons. Canonical Correspondence Analysis showed that environmental variables explained 43.30% of the variation in species abundance with Lake water level, nitrite-nitrogen and total dissolved solids being the main environmental factors influencing the structure of the fish community.

Entre septembre 2014 et août 2016, nous avons suivi des assemblages d'espèces de poissons et certaines variables environnementales dans le lac Volta afin de déterminer la variabilité saisonnière de la composition des espèces, des prises et des variables environnementales qui déterminent la structure de la communauté de poissons. Nous avons enregistré un total de 1557 individus appartenant à 41 espèces, 25 genres et 13 familles. Les espèces importantes au point de vue de leur fréquence, abondance et poids étaient respectivement *Chrysichthys* (100% ; 43,03% ; 17,93%), tilapias (100% ; 28,97% ; 17,86%), *Alestes* (100% ; 14,13% ; 32,10%) et *Bagrus* (91,67% ; 5,65% ; 12,80%). La composition des espèces de poissons et les variations dans le temps étaient comparables à celles des prises commerciales. Il n'y avait pas de différences significatives ($p<0,05$) dans l'abondance des espèces, leur poids et les indices de diversité entre les saisons sèches et les saisons des pluies. La classe modale de la distribution longueur-fréquence de l'espèce dominante des prises,

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Chrysichthys, a été réduite de 125 mm en 2006 à 95 mm lors de notre étude, signe de surpêche. Les variables environnementales considérées présentaient peu de variation et se trouvaient dans les limites optimales pour la survie des poissons ; elles ne différaient pas significativement entre les saisons. Une Analyse de correspondance canonique a montré que les variables environnementales expliquaient 43,30% de la variation de l'abondance des espèces : le niveau de l'eau du lac, l'azote des nitrites et le total des solides dissous dans l'eau sont les principaux facteurs environnementaux qui influencent la structure de la communauté de poissons.

KEYWORDS
Chrysichthys, environmental variables, fish species, species diversity, tilapias

1 | INTRODUCTION

Large inland tropical lakes have an enormous importance for food supply, but also invaluable economic importance to human populations not only on a local but also on a regional and in some cases a national scale (FAO, 2011). Therefore, any new knowledge concerning seasonal changes in fish composition and abundance in combination with effects of environmental variables to the fishery is of great importance not only to fishery managers but also to fishermen in order to undertake sustainable fishery.

Lake Volta is the largest lake in Ghana and one of the largest man-made lakes in the world. The lake, which was primarily created for hydropower generation, is also the main source of inland freshwater fisheries, potable water to many of the inhabitants and home to unique aquatic and terrestrial species (Barry, Obuobie, Andreini, Andah, & Pluquet, 2005; Béné, 2007; van Zwieten, Béné, Kolding, Brummett, & Valbo-Jørgensen, 2011).

The Lake accounts for 15% of the total domestic fish production and 85% of inland fish production estimated at 86.27 metric tons annually (Ministry of Fisheries and Aquaculture Development, MOFAD, 2015). Since the creation of the lake in 1964, there has been an increase in human population and anthropogenic activities such as pollution and habitat alteration which have resulted in decrease fisheries resources availability and reduction in biodiversity (Braimah, 1995; Ntow, 2003).

It is widely accepted that environmental variations play an important role in the organization of lacustrine fish communities (Amarasinghe & Welcomme, 2002; Cheng, Lek, Loot, Lek-Ang, & Li, 2010). However, the most important factors determining species composition differ between water bodies, ranging from physical, chemical and biological factors (Amarasinghe & Welcomme, 2002; Cheng et al., 2010; Zhao, Fang, Peng, Tang, & Piao, 2006). Fish population changes due to environmental factors such as temperature, nutrient availability can affect the growth and development of young fish, the migratory routes of certain species, changes in the food habit and competition rendering weaker and juvenile fish more vulnerable to predators and leading to poor recruitment success (Chapman, 2009).

Apart from these environmental variables, Lévêque and Quensiérie (1988) have ranked hydrological regime among the important factors affecting yields and community structure in shallow lakes. A significant correlation between water levels and catches has been reported by Stauch (1977) in Lake Chad, van Zwieten and Njaya (2003) and Furse, Kirk, Morgan, and Tweddle (1979) in Lake Chilwa (Malawi), Kolding (1989, 1992) in Lake Turkana and Dankwa, Agyakwah, Agbogah, Abban, and Kolding (2011) in Lake Volta. In all these studies, changes in catches were, largely, influenced by seasonal changes in environmental variables. However, correlations between catch and water level can be an artefact of climate change in combination with changing fishing effort.

Most studies conducted on the management of fisheries in the lake have focused on fishing pressure (Braimah, 1995; Dankwa et al., 2011; Ministry of Food and Agriculture, MOFA, 2003) with only limited focus on seasonal variability and environmental parameters affecting the changes in stocks. Studies of whether observed changes in fish composition and fish stocks are environmental or seasonal driven is key knowledge to sustainable management of the fish stocks of Lake Volta, particularly also in a climate change perspective which poses a threat to fisheries (Daw, Adger, Brown, & Badjeck, 2009).

The aim of this study was to determine the seasonal variability in fish species composition in the Lake and possible environmental variables that influence the structure of the fish community.

2 | MATERIALS AND METHODS

2.1 | The study area

Lake Volta is one of the world's largest reservoirs whose major tributaries are the Rivers White and Black Volta and Rivers Oti and Afram (Abban & Dankwa, 2006) which drain from the north, west, east and south, respectively, into the Lake. The lake has been partitioned based on its ecology into eight strata for stock assessment purposes (Abban & Dankwa, 2006; Béné et al., 2009). It lies within a tropical zone characterized by two major seasons: the wet season which occurs when the warm and humid maritime air blows over Ghana which is characterized by rainfall (moderate to high) and the dry season which occurs when the hot and dry continental air dominates (van Zwieten et al., 2011). The annual temperature ranges between 26°C and 30°C with high temperatures in the dry season. Besides increase in temperature, global warming is also leading to more extreme weather, which is likely to have different impact on fisheries.

This study was undertaken in Stratum III of the Lake at Kpando Torkor, one of the major fish landing sites around the Lake (Figure 1). It is located within longitudes 0° 19′E and 0° 02′W and latitudes 6° 45′N and 7° 17′N with a total catchment area of 1,191.9 km². Stratum III is designated as the most lacustrine segment of the Lake characterized by submerged and exposed tree stumps (Béné et al., 2009).

It was observed during the study, that the most frequent fishing gears used were gill nets, bamboo pipes and basket traps. Hook and line, seine and cast nets are less commonly used in the shallower parts of the Lake. Fishing activity on the Lake is predominantly performed in relatively shallow areas (less than 20 m) where gill nets are stretched between the flooded trees and shrubs at the banks while traps are set at the bottom close to the shore. The major fishing craft used are made of wooden planks, which may be motorized.

2.2 | Fish catch assessment

Fish were sampled monthly from September 2014 to August 2016 using two different experimental gill nets made up of mono- and multifilaments. The monofilament nets had two each of twelve different mesh sizes; 38.1, 50.8, 63.5, 76.2, 88.9, 101.6, 114.3, 127.0, 139.7, 152.4, 165.1 and177.8 mm (stretched mesh). Each of them measured 25 m × 4 m. The multifilament nets each of which measured 25 m × 2 m had two each of six different mesh sizes; 12.5, 15.0, 20.0, 25.0, 30.0 and 40.0 mm (stretched mesh). One each of the mesh sizes from the monofilament and multifilament were grouped together to constitute a series or battery of nets. The two series of nets were deployed overnight (approximately from 5 pm to 6 am the following morning) one series at inshore (about half a kilometre from the shore) and the other offshore (about 2 km from the shore) for two nights on each sampling occasion.

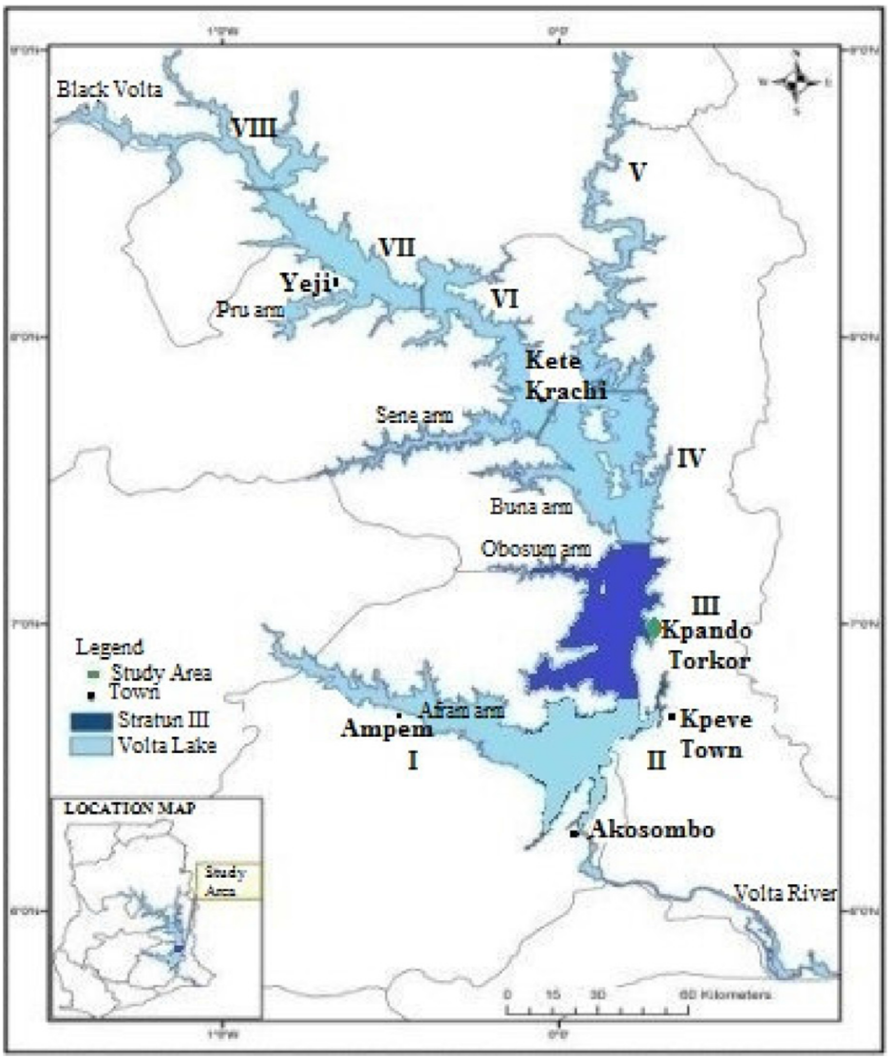

FIGURE 1 Map of Lake Volta showing the study area, Stratum III

Fishes caught were identified to species level based on keys of Paugy, Leveque, and Teugels (2003a,b) and Dankwa, Abban, and Teugels (1999). The standard length (SL) and total length (TL) of each individual were measured (to the nearest ± 1.0 mm) and weighed (to the nearest ± 0.1 g) using a measuring board and an electronic scale (model KERN EMB 500-1), respectively. Species belonging to the same family were pooled together. Fish families appearing less than five times in samples were pooled together as "*Others*." Fish catch was grouped into two hydrological seasons: the dry (November–February) and wet seasons (March–October).

In addition, the species composition in commercial catches for each month was estimated using the average of their proportional representation, in numbers, from catches of a number of fishers. This was performed in order to compare experimental and commercial catches to ensure whether experimental catch was a true reflection of the fishery.

Standard length measurements made in the current study for *Chrysichthys* species were used to determine the length frequency distribution by grouping the length measurements into 10 mm length classes. The modal length class was compared with that obtained for *Chrysichthys* species using the same set of experimental gill nets in the study area in 2006 and 2011. Length data for the other species were not sufficient for such comparison.

2.3 | Determination of environmental variables

Ten environmental variables known to influence fish productivity in water bodies (Chapman, 2009; Cheng et al., 2010) were measured on a monthly basis on the day of fish sampling. Surface water temperature, turbidity, total dissolved solids and water level were physical parameters considered. Chemical parameters measured were dissolved oxygen and nutrients (nitrite-nitrogen, nitrate-nitrogen, ammonia-nitrogen and orthophosphate). In addition chlorophyll-a which is vital for photosynthesis was measured and used as a surrogate for primary production (Balmer & Downing, 2011).

Water samples for determination of the environmental variables were collected at 8:00 in the morning into precleaned 1 L Nalgene sample bottles using a Van-dorn water sampler. Samples for dissolved oxygen were carefully collected in 250 ml precleaned light bottles. Two-ml magnesium sulphate and 2-ml alkali-iodide-azide were added immediately to fix the oxygen.

Water temperature, turbidity and total dissolved solids (TDS) were measured using a temperature probe (Testo 110), Turbimeter (Palintest® v5.06) and TDS metre (HACH-DR/2000), respectively. At the Water Research Institute's environmental chemistry laboratory, dissolved oxygen was measured with the Azide modification of the Winkler method and nutrients were determined using the following standard methods described in APHA, AWWA, WEF (2012). Nitrate-nitrogen was determined by hydrazine reduction method, nitrite-nitrogen by diazotization, ammonia-nitrogen by direct nesslerization method and orthophosphate by stannous chloride method. Chlorophyll-*a* was determined using the spectrophotometric method after acetone extraction (APHA, AWWA, WEF, 2012). The lake water level readings were obtained from the Volta River Authority.

2.4 | Data analyses

2.4.1 | Fish catch assessment

Fish catch composition in terms of abundance and weight by family was presented graphically in pie charts, with area graphs to present trends in monthly catch using Microsoft Excel® 2013 version. The Catch per Unit of Effort (CPUE) which was determined as the total number (CPUEn) and weight (CPUEb) of fish caught by the two series of nets deployed for the two nights was used as a measure of the relative abundance and biomass for comparison among the different months and seasons.

In order to determine the differences in average fish catches between the dry and wet seasons, the catch data were subjected to a Mann–Whitney test at 95% confidence level using PAST v. 3 statistical package (Hammer, Harper, & Ryan, 2001). The species diversity for each season was determined using three different indices: diversity (Shannon–Wiener), species richness (Simpson's Index) and evenness (Pielou's Index) from fish abundance data using PAST to determine differences in fish diversity.

Shannon–Wiener Index (H') which considers both the number of species and the distribution of individuals among species was calculated as follows:

$$H' = -\sum Pi\ (\ln Pi) \tag{1}$$

(Shannon & Wiener, 1963) where Pi = proportion of each species in a sample and ln = natural logarithm

Simpson's Index (D) was calculated using the formula:

$$D = \sum\left(\frac{n}{N}\right)^2 \tag{2}$$

(Simpson, 1949) where n = number of species in sample; N = number of individuals in sample.

Pielous Index (J) for evenness was estimated using the equation:

$$J = H'/\ln * S \tag{3}$$

(Pielou, 1969) where H' is the species diversity index, and S is the number of species.

2.4.2 | Environmental variables

In order to determine the best environmental variables that explained the variations in the species abundance and monthly data, the data were subjected to Canonical Correspondence Analysis (CCA) using XLSTAT statistical package. Species captured less than 5 times of the total of 24 samples were omitted from the analysis because rare species typically have a minor influence on results of multivariate statistics and can be perceived as outliers in ordinations (Ibanez et al., 2007). The effect of extreme values was minimized by log transforming the species abundance data and the environmental variables prior to analysis. In all, 22 fish species and 10 environmental variables were used in the analysis.

3 | RESULTS

3.1 | Fish catch composition and trend

A total of 1,557 individual fish comprising 41 species, 27 genera and 13 families were caught during the sampling period. Five genera, namely *Chrysichthys*, Tilapias, *Alestes*, *Bagrus* and *Mormyrus*, dominated the catches. They contributed more than 91.8% and 92.6% by number and weight, respectively, of the total catch. The total catch was dominated by *Chrysichthys* (43% and 18% by number and weight, respectively) followed by the tilapias (29%, 18%), *Alestes* (14%, 32%) and *Bagrus* (6%, 13%) (Figure 2a). Species grouped as "*Others*" included *Clupeids*, *Cyprinids*, *Schilbeids* formed less than 2% and 6% of the total number and weight, respectively. The frequency of occurrence of the species in the catch revealed that, *Chrysichthys*, the tilapias, *Alestes* and *Bagrus* appeared in all the samples (Figure 3) as compared to the other species.

The composition of the total catch by the local fishermen within the study period also showed similar pattern as that of the experimental catch: *Chrysichthys* (44%), tilapias (34%), *Bagrus* (9%) and *Alestes* (7%) (Figure 2b).

3.2 | Seasonal variation in fish catch

The Catch per Unit Effort (CPUEn and CPUEb) and diversity indices determined for both seasons and years are shown in Table 1. Both years showed similar patterns in CPUE values lower CPUEs being recorded in the dry seasons but the differences were not significant ($p > 0.05$). Species diversity, richness and evenness determined were all slightly higher in the dry seasons than in the wet seasons for both years. They were, however, not significantly different ($p > 0.05$).

3.3 | Length frequency of *Chrysichthys*

The length frequency distributions of *Chrysichthys* sampled during the experimental period and previous studies in 2006 (Agyakwah, 2010) and 2011 (van Zwieten et al., 2011) were compared. The mode of length frequency distribution was 120-130 (125) mm (22%) in 2006, 80-90 (85) mm (38%) in 2011 and 90-100 (95) mm (17%) in 2016, the current study. This shows a reduction in the length of the modal class from 2006 to 2016.

3.4 | Environmental variables

Surface water temperature throughout the sampling period ranged between 28.0 and 31.1°C with a minimal variation of 0.05°C between the seasons. Dissolved oxygen levels in the lake were above 5.0 mg/L for both wet and dry seasons, while turbidity and total dissolved solids levels ranged from 1 to 7 NTU and 27.8 to 45.6 mg/L, respectively. Nutrients (nitrite-nitrogen, nitrate-nitrogen, ammonia-nitrogen and orthophosphate) level showed minimal variations and nonsignificant differences among the seasons. There were fluctuations in chlorophyll a concentrations throughout the sampling period with values ranging from 1.2 to 7.9 μg/L. Mean concentrations for the wet and dry seasons were 4.30 ± 2.10 μg/L and 3.15 ± 0.19 μ/L, respectively. The lake's average level over the sampling period was 73.67 ± 1.27 m.

3.5 | Relationship between fish catch and environmental variables

The CCA plot showing the relationships between species abundance and environmental variables is presented in Figure 4. The first and second axes together explained 43.3% of the fish community structure with the first axis explaining 24.94% and the second axis explaining 18.37%. The major environmental variables influencing

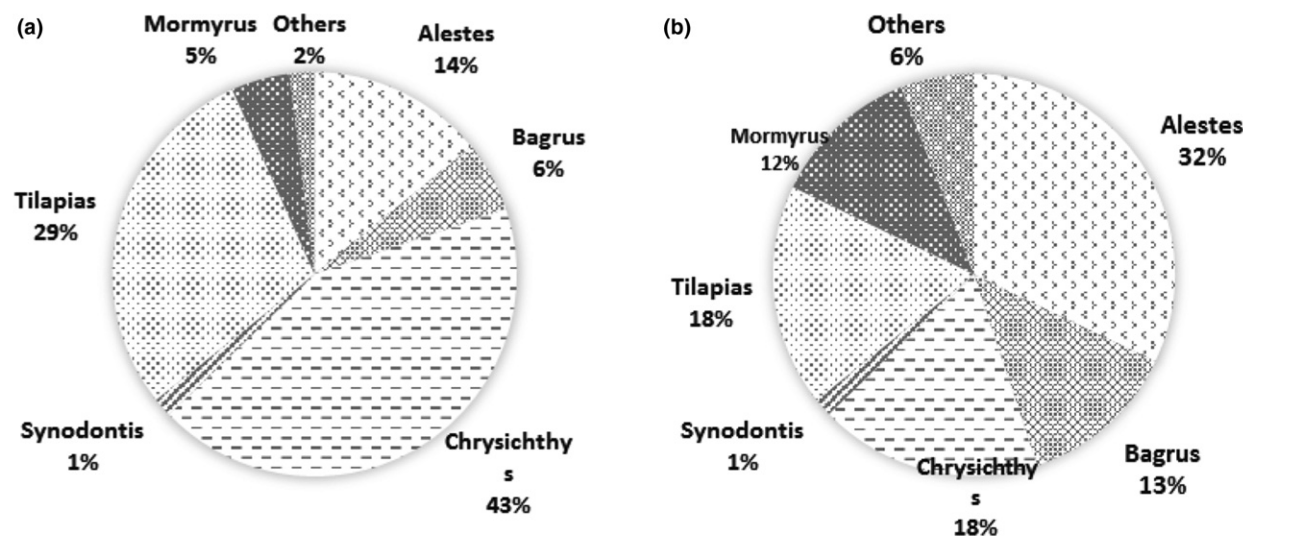

FIGURE 2 Fish catch composition in numbers in experimental (a) and local fishermen (b) sampled at Kpando Torkor from September 2014 to August 2016

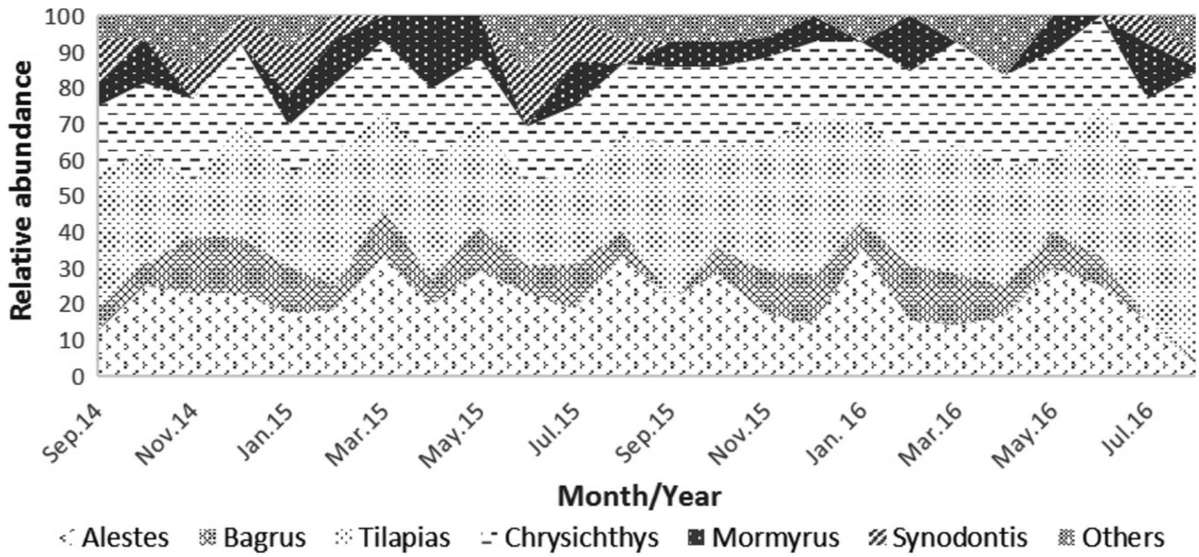

FIGURE 3 Monthly trend in relative abundance of fish species in Lake Volta at Kpando Torkor, from September 2014 to August 2016

TABLE 1 Catch per unit of effort (abundance and weight) in mean values with standard deviation and Diversity indices of fish species sampled in the dry and wet seasons in Stratum III

	Year 1		Year 2	
	Dry season	Wet season	Dry season	Wet season
(CPUEn)	66.40 ± 20.08	69.86 ± 11.22	58.02 ± 23.47	63.57 ± 22.09
(CPUEb) (kg)	3.60 ± 1.01	4.65 ± 1.26	3.10 ± 1.75	4.94 ± 3.05
Simpson (*d*)	0.741	0.706	0.709	0.65
Shannon (*H′*)	1.556	1.442	1.386	1.289
Evenness (*J*)	0.677	0.604	0.666	0.519

the fish community structure are water level, nitrite-nitrogen, orthophosphate and nitrate-nitrogen as indicated by their vectors and closeness to the first axis. Other variables of importance in determining the structure of the fish community in the Lake are TDS and turbidity as shown by their vectors and closeness to the second axis.

Four main groups of species were distinguished in the CCA plot. Species such as *Brycinus leuciscus* and *Bagrus bayad* with positive score on axis 1 and negative scores on axis 2 are highly influenced by water level. The abundance of *Alestes baremose*, *Tilapia zillii*, *Sarotherodon galileus Hemichromis fasciatus* and *Hydrocynus forskalii* with positive scores on both axes was influenced by nitrite-nitrogen concentration while TDS influenced the abundance of *Tilapia dageti*, *Alestes dentex* and *Steatocranus irvinei* with negative scores on axis 1 and positive score on axis 2. Species with negative scores on both axes such as *Chrysichthys maurus*, *Hemichromis bimaculatus*, *Mormyrops anguilloides*, *Petrocephalus bovei* and *Synodontis ocellifer* were not influenced by any of the environmental variables considered.

Even though there was no clear aggregation of the samples according to seasons, the wet season samples aggregated more at the top left while the dry season samples mainly aggregated at the bottom right of the plot (Figure 5).

4 | DISCUSSION

The number of species encountered in the present study, 41 was higher than 32 species reported in both Strata II and III using the same experimental gill nets and information from local fishermen's catch (Dankwa et al., 2011, 2014), although both studies recorded 13 families. The increase in number of fish species may probably be due to migration of some species into the stratum to take advantage of favourable environmental conditions (such as temperature, dissolved oxygen) for survival or spawning and also due to the duration of the sampling period. Béné et al. (2009) in a study on the improvement of fisheries productivity in Lake Volta also attributed increase in species abundance to favourable environmental conditions. The Lake Volta, although described as mesotrophic (Karikari, Akpabey, & Abban, 2013) is rich in fish biodiversity (Dankwa et al., 1999; van Zwieten et al., 2011). Dankwa et al. (1999) and Braimah (2001) listed 121 and 140 fish species, respectively, for the whole Lake. The number of species may, however, vary from one stratum to another due to ecological differences such as hydrological conditions.

The temporal trend in catch composition prominently featured *Chrysichthys*, Tilapia, *Alestes* and *Bagrus* species. Previous studies by Braimah (1995), Abban (1999), Ministry of Food and Agriculture,

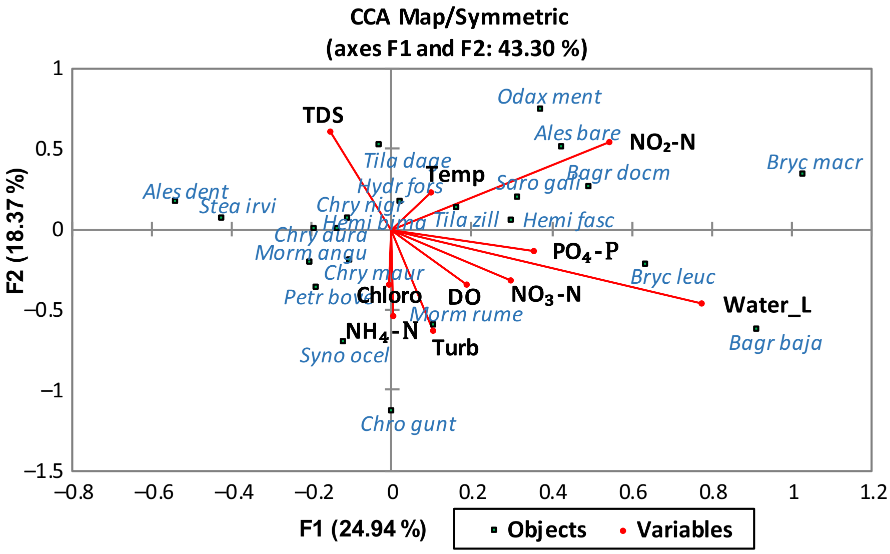

FIGURE 4 Ordination plot for fish species and environmental variables sampled in Stratum III, Kpando Torkor from September 2014 to August 2016

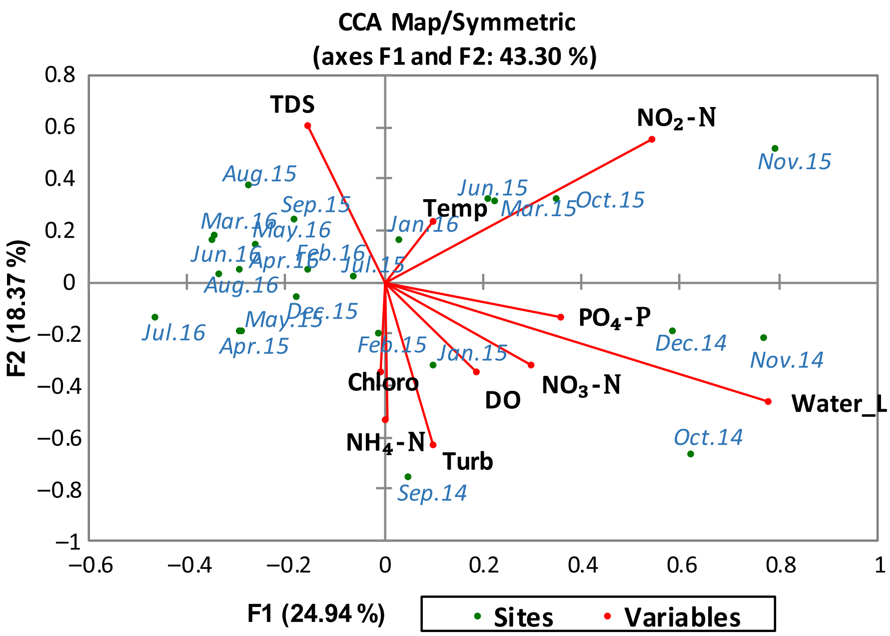

FIGURE 5 Ordination plot for total catch and month sampled in Stratum III, Kpando Torkor from September 2014 to August 2016

MOFA (2003) and Dankwa et al. (2011) indicated a similar trend in catch composition throughout the Lake. The omnivorous feeding habits of *Chrysichthys* and the numerous brush parks established in the Lake, which provide refuge and good feeding grounds in terms of attached algae for Tilapias may explain the dominance of *Chrysichthys* and Tilapias in the Lake (Dankwa, Agbogah, Amerdome, & Amegbe, 2009). In a previous study by Dankwa et al. (2014), Tilapias were found to constitute between 94 and 98% of catches from brush parks in the Lake. The Lake may still be undergoing changes with respect to species composition as some of the species, for example *Hydrocynus* spp and *Synodontis* spp which were among the five top species in a study conducted in the same area from 2007 to 2008 (Dankwa et al., 2011) are no more in the current five top species. Also in the 1990s *Synodontis* spp and *Labeo* spp formed a substantial percentage, 20% and 14%, respectively, of the catches (MOFA, 2003); however, their catches have also declined.

Experimental catches which used only gill nets proved to be a good indicator of trends in commercial catches, although locally evolved traps such as bamboo and basket traps are used mostly in fishing and are skewed towards the catch of few species such as *Chrysichthys* spp which could be attributed to the selectivity of the gear. This was also observed by Béné et al. (2009).

The higher catches in the wet season corroborates the findings of de-Graaf and Ofori-Danson (1997) who reported that CPUE was positively correlated to water level. They attributed this to increased turbidity, which resulted in high catchability of the nets. In this study, the TDS and turbidity recorded in the wet season was higher than that in the dry season and may have contributed to the supposed inability of fishes to detect nets in turbid waters. This contradicts a study by Ayanwale et al. (2013) in Lake Tagwai, Minna, Nigeria. They recorded low catches in the wet season and ascribe this to the large volume of water, which made fishing more difficult as fish dispersed into a wider area.

Seasonal differences in species diversity indices were not significant. This indicates that species were fairly distributed and stable throughout the seasons and as reported by Alhassan (2013), this could be attributable to uniform or minimal changes in biophysical conditions. Environmental characteristics as well as resource availability are believed to be among the main determinants of species distribution (Grenouillet, Pont, & Seip, 2002), species interaction (Deus & Petrere-Junior, 2003) and habitat adaptations (Mérigoux, Dolédec, & Statzner, 2001; Poff & Allan, 1995).

The reduction in length frequency distribution shown by *Chrysichthys* species from experimental fishing and previous studies may be an indication of overfishing (possibly growth overfishing) as fish are caught too early and the growth potential is not optimally used (de-Graaf & Ofori-Danson, 1997). This may be the same for the other species as local fishers have also reported declining sizes of fish caught.

The fish community, in general, showed little variation as depicted by the CCA plots. This is evident by the fact that most of the species clustered in the middle of the plot and the fact that the whole community was dominated by a few species, which occurred in almost all the samples. The relatively small variations in the number of species caught and diversity indices in both seasons lend further support to this assertion.

This variation in the community structure can be linked to, a large extent, water level and nitrite-nitrogen, total dissolved solids concentrations as these environmental factors are the most closely correlated with the first and second ordination axis, respectively, hence the principal gradients affecting the fish assemblage. The fact that water level is an important environmental variable influencing fish catch in the Lake has been reported in previous studies by Braimah (1995) and Dankwa et al. (2011). Various authors have also reported similar findings of the effect of water level on fish catches from other Lakes. Stauch (1977) found a significant inverse correlation between falling lake levels and increased catches in Lake Chad during the drought between 1969 and 1974. This was attributed to the concentration of the fish and increasing ease of their capture. van Zwieten and Njaya (2003) also corroborated this trend during their work in Lake Chilwa (Malawi). In both cases, yields fell sharply during the following years. Furse et al. (1979) also found that the yields and species composition in the shallow Lake Chilwa varied as a function of the lake level. High water levels that allow floodplains to be inundated provide abundant food and refuge for recruits and results in high recruitment success, which reflects in good catches either the same year or the ensuing year (Kolding, 1989, 1992).

The levels of nutrients (nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen and orthophosphates) measured were low throughout the study. This may be due to relatively low leaching and overland flow into the lake, high water volumes causing dilution and low in situ production of these nutrients in the catchment areas (Antwi, 1990; Béné et al., 2009). Although nutrients level were found to be low, orthophosphates, nitrate-nitrogen and nitrite-nitrogen are important for primary production, which form the basis of the food chain in aquatic ecosystems and a major source of food for herbivorous fishes, for example Tilapias, which are a major component of the fish catch in the Lake. These nutrients, from the plot, also contributed in influencing the fish community. Previously established relationships for large, highly productive aquatic ecosystems suggest that a 20% decrease in primary productivity would reduce fisheries yields about 30% (Nixon, 1988).

Total dissolved solids have significant effects on community dynamics when they interfere with light transmission because of turbidity (Kerr, 1995). The suspended solids may have significant effects on succession due to shading, abrasive action, habitat alteration and sedimentation, hence its influence in the fish community structure.

The distribution, abundance and migration of aquatic organisms are also influenced by temperature and dissolved oxygen concentration (Alhassan, 2013). In this study, temperature and dissolved oxygen did not play any major role in structuring the fish community because both variables of the Lake were relatively stable with narrow seasonal variations. The Lake has been found to show little or no thermal stratification probably due to wind induced mixing hence any heat received is evenly distributed (Karikari et al., 2013; Ofori-Danson & Ntow, 2005).

5 | CONCLUSION

The fish community showed little variation and dominated by a few species (*Chrysichthys* spp, Tilapias, *Alestes* spp, *Bagrus* spp) throughout the seasons. Fluctuations in the environmental variables between the seasons were minimal. Water level appeared to be a major environmental gradient determining the structure of the fish species community hence any climatic changes that will impact the hydrology of the Lake are likely to affect the fish community and consequently catches.

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