Journal of Limnology and Freshwater Fisheries Research

http://www.limnofish.org

Stock Assessment Indicators for Sustainable Exploitation of *Chrysichthys walkeri* in Lake Volta, Ghana, West Africa

Samuel K. K. AMPONSAH[1]*

[1] Department of Fisheries and Water Resources, University of Energy and Natural Resources, Ghana

ABSTRACT

The biological indicators of *Chrysichthys walkeri* (Claroteid catfishes) in lake Volta were investigated for their sustainable management. A total of 846 samples were collected from the lake from March to December 2020. The recorded total length of the fish samples was analyzed using *TropFishR*. The von Bertalanffy parameters including asymptotic length (L_∞), growth rate (K), and growth performance index (Φ) were estimated as 28.88 cm, 0.42 per year, and 2.54 respectively. Mortality parameters were calculated as total mortality rate (Z) = 2.56 per year, natural mortality rate (M) = 0.91 per year and fishing mortality rate (F) = 1.65 per year. The exploitation rate (E) was 0.64. From the study, it was concluded that the population of the species *C. walkeri* from the Lake Volta is overexploited. There is the need to ensure continuous monitoring of fishing effort to ensure the sustainable exploitation and management of *C. walkeri.*

Keywords: *Chrysichthys walkeri*, growth, mortality, *TropFishR*, Lake Volta, Ghana

ARTICLE INFO

REVIEW

Received : 15.12.2021
Revised : 14.02.2022
Accepted : 25.05.2022
Published : 30.12.2022

DOI:10.17216/LimnoFish.1037218

*** CORRESPONDING AUTHOR**

samuel.amponsah@uenr.edu.gh
Phone : +233 556184236

How to Cite
Amponsah SKK. 2022. Stock Assessment Indicators for Sustainable Exploitation of *Chrysichthys walkeri* in Lake Volta, Ghana, West Africa LimnoFish. 8(3): 226-234. doi: 10.17216/LimnoFish.1037218

Introduction

Lake Volta occupies about 4% of the area of Ghana. It was recorded as the largest man- made Lake, which is the largest of its kind and has provided enormous biological and socio-economic benefit like generation of electricity (1060 MW) at Akosombo and Kpong dam (Fobil and Attuquayefio 2003). The Lake Volta is a highly significant water body richly surrounded by Togo, Cote d΄Ivoire, Mali, Benin and Burkina Faso distributing the largest drains in the Lake Basin (Bene 2007). It is drained by several major rivers: the Mouhoun (Black Volta), the Nakambe (White Volta) with the Nazinon (Red Volta) as its tributary, the Oti River and the Lower Volta (Bene 2007). It is estimated that a total of 300.000 people depends on the lake for their livelihood of which 80.000 are fishers and 20.000 fish processors and traders (Braimah 1995). The fishery is solely artisanal with about 17.500 canoes actively fishing in the Lake operating from about 2.000 fishing villages. More than 90% of the inland fresh water fish are produced from the Volta Lake (Béné 2007). Study by Dankwa et al. (1999) and Briamah (2001) revealed the existence of 121 and 140 fish species for the whole Lake Volta respectively. Some of the dominant species recorded from the Lake include *Chrysichthys* sp., *Sierathrissa* sp., *Tilapia* sp., and others (Ofori-Danson 1999).

Belonging to the family Claroteidae, *Chrysichthys walkeri* is one of the five species belonging to the genus Chrysichthys in freshwaters of Ghana (Okyere and Boahemaa-Kobil 2020). It is an endangered fish species said to be endemic to the Pra Basin in Ghana (Lalèyè et al 2021; Froese and Pauly 2020). However, other studies on the species suggest its presence in Nigeria as well (Taiwo and Aransiola 2003; Ikusemiju and Olaniyan 1977; Nwafili1 et al. 2012). According to Nwafili1 et al. (2012), *C. walkeri* is almost indistinguishable from its counterpart *Chrysichthys nigrodigitatus* and is considered as an important commercial value fish, desirable for human consumption (Olopade et al. 2015). This species is of food and commercial importance with high culture potential (Dankwa et al. 1999).

There are few studies on the species and these include studies on its food and feeding habits (Ikusemiju and Olaniyan 1977), its length-weight relationship, condition factors and fecundity (Taiwo and Aransiola 2003) and its proximate composition consumption (Olopade et al. 2015). In Ghana, there are even fewer references on *C. walkeri,* with such reference including the study on changes in the fish community of the Kpong Headpond, lower Volta River (Quarcoopome 2011) and life history of Chrysichthys catfish in Volta Lake, Ghana (Vanderpuye 1979). It is therefore evident that, there is a paucity of information on population indicators for the sustainable management of *C. walkeri*.

The sustainable management of fisheries is a multi-dimensional and multi-level activity, that deals with a wide range of considerations including survival of the fish stocks and the fisheries (FAO 1999). It is an activity requiring reliable and invaluable information such as biological indicators. According to Hoggarth et al. (2005), biological indicators monitor the current status of a fishery and determines if fishery objectives are being achieved. Encompassing the categories of catch of fish, size of fish stock and amount of fishing, biological indicators serve as important tools of stock assessment (Hoggarth et al. 2005). They are therefore invaluable, to ensuring the sustainable management of important fisheries resources such as the stocks of *C. walkeri*.

This study was undertaken to address the knowledge gap concerning information on some population parameters such as growth rates, mortality rate and exploitation rates for sustainable management of *C. walkeri*. It focuses on the indicators such as growth parameters, mortality parameters and exploitation rate.

Materials and Methods

Study Area

Four landing communities within the Stratum VII of the Lake Volta, which lies between longitude 0º10’ and 1º05W and latitude 8º8’ and 8º20’N, and extends 60 km south and 50 km north of Yeji, were selected. These communities were Tonka, Vutideke, Brekente and Fante Akura which are all landing sites within the Stratum VII of Lake Volta (Figure 1). Yeji is the capital of Pru District in the Brong-Ahafo region with a population of 28.515 (GSS 2014). Selection of these sampling inland fishing communities was based on two-stage stratified sampling criteria, which were geographical isolation and the level of fishing activities based on the number of fishing boats.

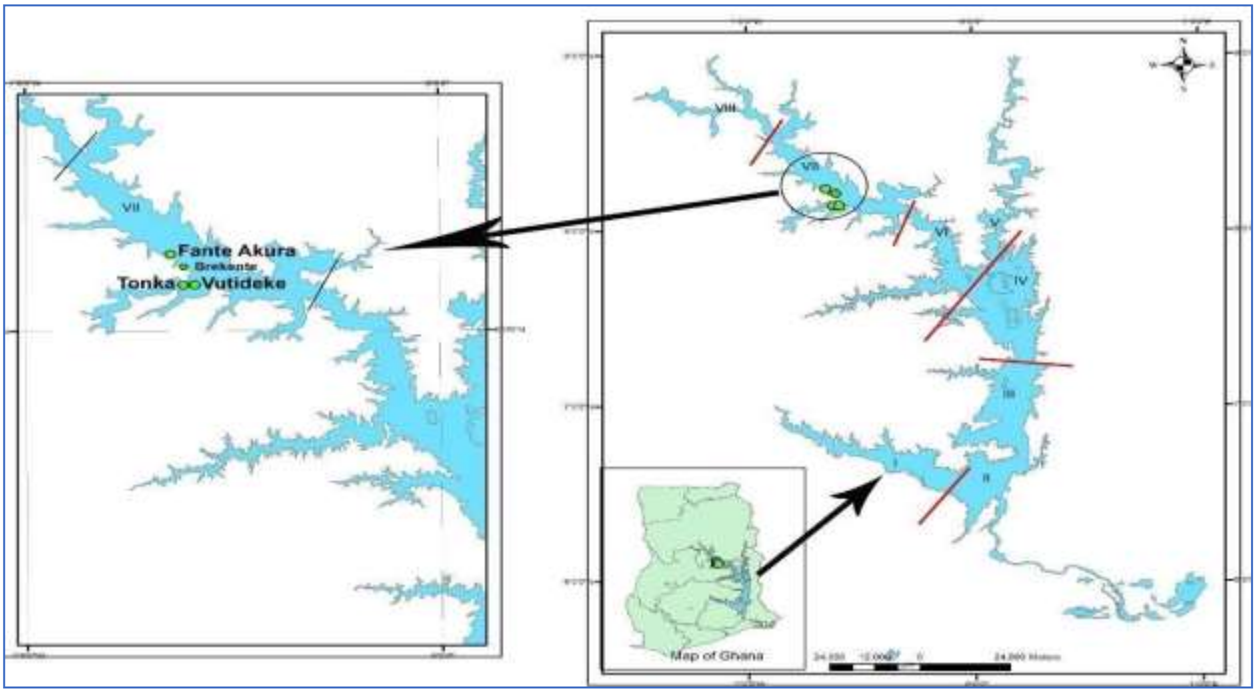

Figure 1. Map showing the study areas within Stratum VII of the Volta Lake, Ghana

Data Collection

Samples of *C. walkeri* from the Volta Lake, Ghana were obtained from randomly selected fishermen who apply multifilament fishing gears in their fishing activities. Samples were obtained over a ten (10) month period (i.e., March 2020 to December, 2020) and were identified at the sampling sites using the taxonomic identification keys by Lowe-McConnell and Wuddah (1972). Measurements of length and weight were performed using a 100 cm graduated wooden measuring board and to the nearest gram 0.1 g using the digital balance.

Estimation of Parameters

Growth parameters

Growth parameters which follow the Von Bertalanffy Growth Function (*VBGF*) including growth rate (*K*) and asymptotic length (L_∞) were estimated using the ELEFAN_ SA. Estimation of longevity (t_{max}) of the species was done using the method:

$t_{max} = 3/K$ (Anato 1999)

The growth performance index was calculated using the formula:

$\Phi' = 2logL_\infty + log\ K$ (Pauly and Munro 1984)

The theoretical age at length zero (t_o) followed the equation:

$Log_{10}(-t_0) = -0.3922 - 0.2752\ log_{10} L_\infty - 1.038 log_{10} K$ (Pauly 1979)

Mortality Parameters

The total mortality (*Z*) was computed using linearized length-converted catch curve (Pauly and David 1981; Sparre and Venema 1992)

The natural mortality rate (*M*) was calculated using:

$M = 4.118K^{0.73}L\infty^{-0.333}$ (Then et al. 2015)

Fishing mortality (*F*) was calculated as:

$F = Z – M$ (Qamar et al. 2016)

The exploitation rate (*E*) was computed using:

$E = F/Z$ (Georgiev and Kolarov 1962)

Length at First Capture (Lc_{50})

Using a backwards extrapolation of the descending limb of the length-converted catch curve, the probability of capture was estimated. A selectivity curve was generated using linear regression fitted to the ascending data points from a plot of the probability of capture against length, which was used to derive values of the lengths at capture at probabilities of 25%, 50% and 75% (Pauly 1987).

Virtual Population Analysis (*VPA*)

VPA is a method that allows for the reconstruction of the population from total catch data by age or length. The initial step was to estimate the terminal population (*Nt*), followed by the successive estimation of F values and finally, the population sizes are computed for each length class (midpoint). These procedures were estimated using the method developed by Pope (Pope 1972).

Yield Per Recruit

The relative yield-per-recruit (*Y/R*) was estimated using the knife-edge method (Beverton and Holt 1957).

Results

Length Distribution

Table 1 shows the length distribution and catch composition of *C. walkeri* obtained during the study period. The length interval ranged from 5.5 cm - 27.5 with the highest number of specimens obtained during periods of August and September and the least during Mar - Apr, 2020 (Table 1). In all, a total of 846 specimen of *C. walkeri* were sampled for the study.

Table 1. Catch composition and length distribution of *C. walkeri* obtained from March - December, 2020

lengthClass	2020									
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.5	4									
6.5	4					1	2			
7.5	2					3	4	2	1	1
8.5	5		1	1		7	12	9	4	2
9.5	4	3		1		6	44	15	9	9
10.5	6	1	4	3	5	24	50	11	3	4
11.5		6	9	3	11	17	54	11	9	14
12.5		6	8	1	9	12	16	6	3	8
13.5	2	4	5	2	14	11	6	5	3	4
14.5	1	7	12	6	15	18	6	5	4	2
15.5	2	6	12	8	14	5	3	5	5	6
16.5	4	6	4	8	16	7	4	11	5	3
17.5	3	3	4	6	10	3	2	6	1	2
18.5	2	2	1	8		4		3		
19.5	1			10		3			2	2
20.5	1	1	1	1	1	1			1	
21.5	1	1	3	1					2	
22.5				2		1				
23.5				2		1				
24.5	1	1		1				1		
25.5		1		1	1					
26.5				1						
27.5	1	1		1						
Total	44	49	64	67	96	124	203	90	52	57

Reconstructed length frequency of *C. walkeri* with superimposed growth curves is shown in Figure 2. The asymptotic length (L_∞) was 28.88 cm with a growth rate (K) of 0.42 per year. Growth performance index (Φ') was 2.54. The longevity (t_{max}) was approximately seven (7) years. The age at zero length (t_o) was estimated as - 0.40 years.

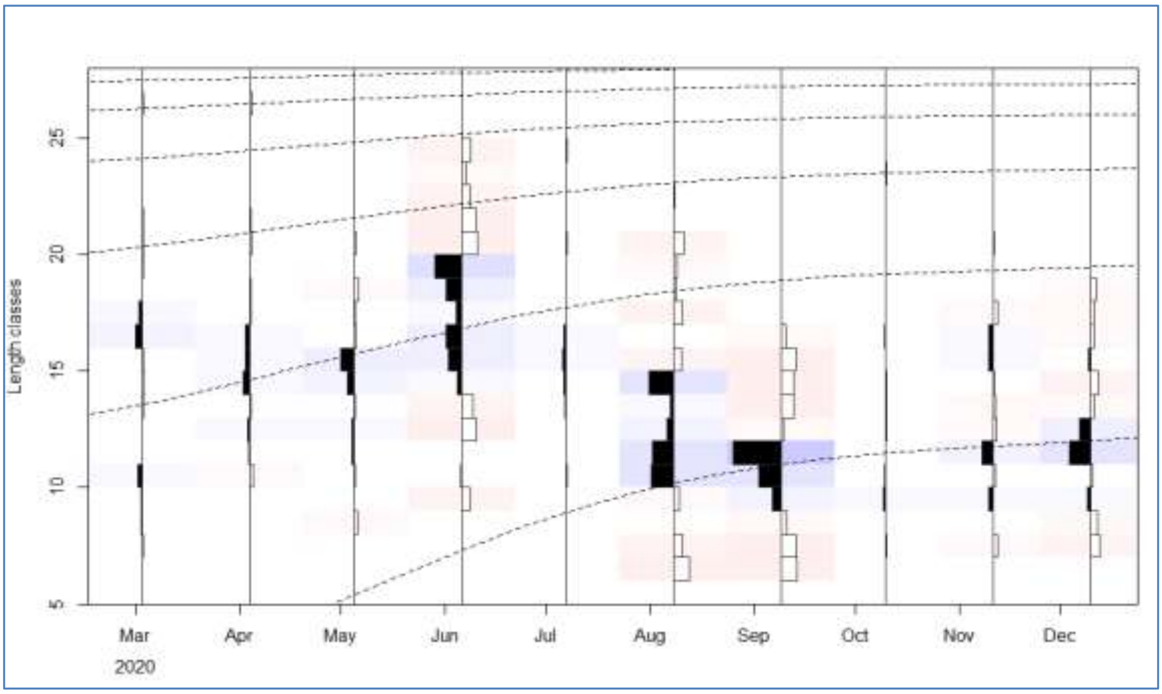

Figure 2. Reconstructed length-frequency distribution with growth curves.

Mortality Parameters

The linearized length-converted catch curve was used for the estimation of instantaneous total mortality (Z) as shown in Figure 3. The total mortality rate (Z) was calculated as 2.56 per year. The natural and fishing mortality rates were estimated at M = 0.91 per year and F = 1.65 per year respectively. The current exploitation rate (E) was obtained at 0.64.

Length at First Capture

The corresponding lengths at capture (Lc) for *C. walkeri* were estimated as Lc_{75} = 3.27 cm, Lc_{50} = 4.80 cm and Lc_{75} = 6.33 cm (Figure 3).

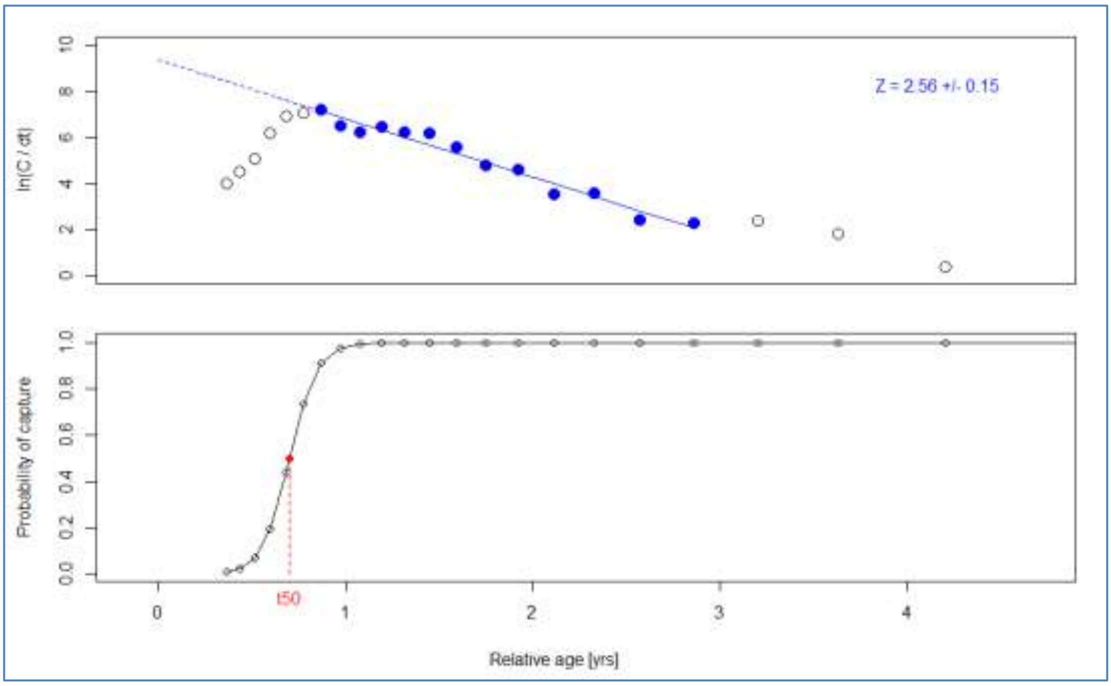

Figure 3. Linearized length-converted catch curve.

Virtual Population Analysis

The virtual population analysis of *C. walkeri* is shown in Figure 4. Individuals within the range of 11 - 12 cm experienced the highest level of exploitation (catch = 13400 per year). Natural losses were highest among individuals within the length range of 6 cm – 8 cm. Surviving individuals in the stock exhibited a declining trend with increased rate of fishing pressure. The highest number of survivors (692421) in the stock was observed in the length range of 6 – 7 cm whereas the lowest number of survivors (1078.38) was observed for individuals at a length range of 27 – 28 cm. Fishing effort was highest (F = 0.32 per year) on individuals within the length range of 11 – 12 cm and lowest (F = 0.006 per year) on individuals at length range of 6 – 7 cm.

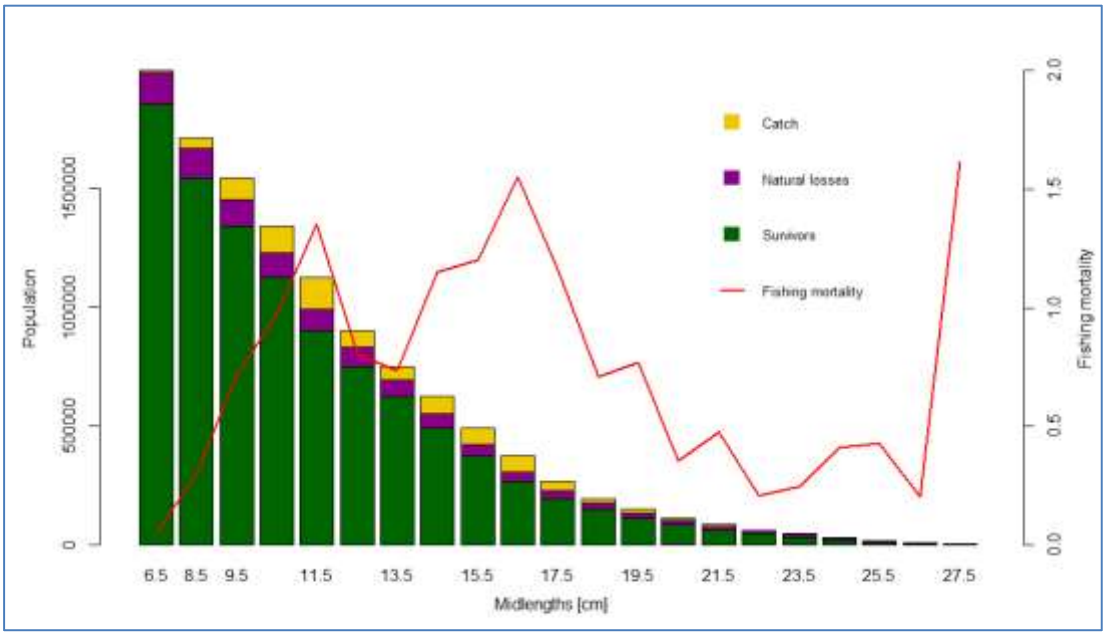

Figure 4. Length structured virtual population analysis of *C. walker* in Lake Volta

Relative Yield Per Recruit

The plot of relative yield per recruit against fishing mortality showed that the indices for sustainable yield were 0.8 for $F_{0.5}$ and 2.5 for F_{msy} as indicated in Figure 5.

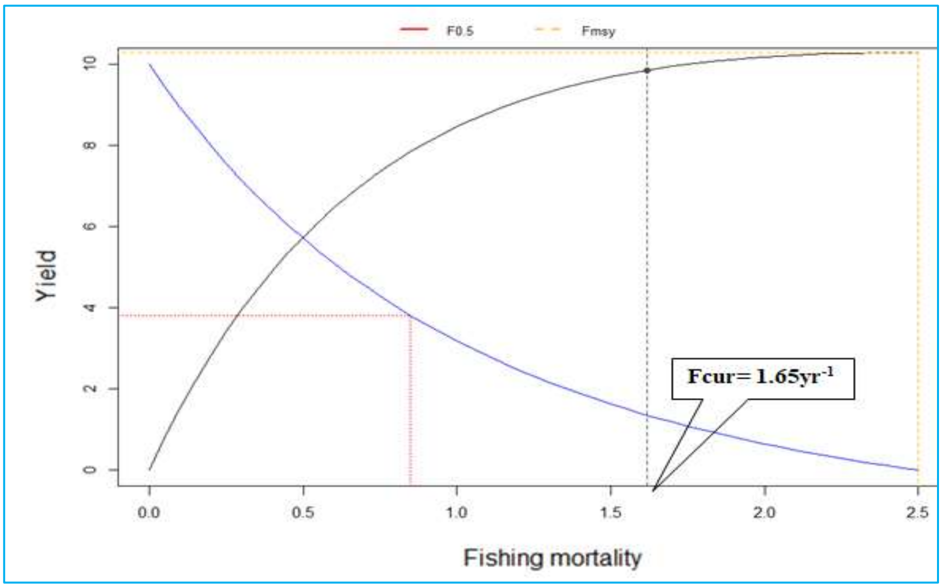

Figure 5. Yield-per-recruit plot of *C. walkeri* in the Lake Volta. The black dot represents yield under the current fishing pressure. The yellow and red lines represent maximum allowable fishing mortality and fishing mortality with a 50% reduction related to the virgin biomass.

Discussion

There is little information on the population dynamics of *C. walkeri* and hence, the present study compares the information obtained on *C. walkeri* with its almost indistinguishable counterpart *C. nigrodigitatus* (Olopade et al. 2015). The present study will provide baseline information for the sustainable management of *C. walkeri* in the Lake Volta.

The growth rate for *C. walkeri* estimated for the study was 0.420 per year. This was lower than the estimates for *C. nigrodigitatus* from Ghana (0.65 per year) (Ofori-Danson et al. 2002), Nigeria's Nun River (0.538 per year) (Abowei and Hart 2007) and Nigeria's lower cross river (1.50) (Udoh et al. 2015). Variations in growth rate of this study compared to others may be is a result of influences of gonad maturity, sex, growth phase, habitat, fish adaptive life pattern, location, food abundance or number of sampled specimen (Froese 2006; Qamar et al. 2016). The growth rate from the present study (0.420 per year) signified that *C. walkeri* in Lake Volta is a slow-growing species, characterized by its longevity period (t_{max}) of seven (7) years. The asymptotic length (L_∞) for the present study was 28.88 cm which is relatively lower when compared to the asymptotic length (L_∞) of the *C. nigrodigitatus*. The differences in asymptotic length may be are results of the differences in environmental factors, productivity, length of the largest species, the age analysis method utilized and fishing pressure (Park et al. 2008; Sequeira et al. 2009; Wehye et al. 2017).

Growth performance index is a function of the asymptotic length and it is used in comparing the growth curves between populations of the same species and/or different species that belong to the same family (Park et al. 2013). It can be affected by determinants of the growth potential of species such as genetic make-up, overfishing and the diet of the fish species (Sambo and Haruna 2012). The growth performance index for *C. walkeri* for the present study (2.54) was lower than estimates by Ofori-Danson et al. (2002) (3.12), Abowei and Hart (2007) (2.63) and Udoh et al. (2015) (4.31) for the related species, *C. nigrodigitatus*. Differences in growth performance indexes may be due to the differences in environmental factors, such as temperature, salinity of study water and variability in the lifespan between study areas (Park et al. 2013).

The total mortality rate estimated from the current study was 2.56 per year. This was found to be lower than estimates by Ofori-Danson et al. (2002) (3.77 per year) and Udoh et al. (2015) (4.31 per year) but higher than estimate by Abowei and Hart (2007) (1.68 per year). The variation in total mortality estimates in relation to the current study could be a result of differences in environmental parameters and the level of fishing effort. The natural mortality rate estimated from the present study was 0.91 per year which was lower than estimates of mortality rate by Ofori-Danson et al. (2002) (1.24 per year) and Udoh et al. (2015) (1.38 per year) for *C. nigrodigitatus* but higher than the estimate of natural mortality rate by Abowei and Hart (2007) (0.70 per year) for *C. nigrodigitatus*. From the present study, the fishing mortality rate (F = 1.65 per year) was greater than the natural mortality rate (M = 0.91 per year). This estimate suggests that for *C. walkeri* species in Lake Volta, fishing mortality is the most important form of mortality confronting this species, as the impact of fishing activities on the decline of *C. walkeri* is superior to natural mortality induced conditions (de Costa et al. 2018). The fishing mortality rate for *C. walkeri* was however, lower than the fishing mortality rate required at the maximum sustainable yield (F_{msy}). The exploitation rate from the present study was 0.64, which is lower than the value provided by Ofori-Danson et al. (2002) (0.65) but higher than provided by Abowei and Hart (2007) (0.58) and Udoh et al. (2015) (0.62) for *C. nigrodigitatus*. The exploitation rate of *C. walkeri* in Lake Volta was above the optimum of 0.5, and this suggests that the species is overexploited (Gulland 1971).

The estimated length at first capture from the current study for *C. walkeri* was 4.80 cm. This estimate was less than the value recorded by Udoh et al. (2015) from Nigeria for *C. nigrodigitatus* (i.e., 36.3 cm). The potential reason for this variation in estimates could be linked to the type and mesh size of fishing gear, time, duration of sampling, fish landing site sampled (Ofori-Danson et al. 2018).

Length-based VPA provides a medium for estimating fishing pressure on various length groups using fish landings from fishing operations (Neethiselvan and Venkataramani 2002). The high fishing mortality on a large-sized individual was experienced by individuals within the interval of 11 cm - 12 cm. Also, the number of individuals of the species subjected to natural losses as well as the number of survivors declined as they matured.

In conclusion, *C. walkeri* from Lake Volta is a slow-growing species with a growth rate of 0.42 per year. The exploitation rate (E = 0.64) was above the optimum level of 0.5 indicating that this species is overexploited in Ghana's Lake Volta. There is therefore the need to reduce the fishing effort through the implementation of closed fishing season, alternative livelihoods for fisher folks and the application of sustainable fishing practices. In addition, the continuous monitoring of the above stated fishing management practices for sustainable exploitation of *C. walkeri* is essential for the achievement of *SDGs* 1, 2 and 14.

References

Abowei JFN, Hart AI. 2007. Size composition, age, growth, mortality and exploitation rate of *Chrysichthys nigrodigitatus* from Nun River, Niger Delta, Nigeria. Afr J App Zoo & Env Bio. 9:44-50.

Anato CB. 1999. Les Sparidae des côtes béninoises: Milieu de vie, pêche, présentation des espèces et biologie de Dentex angolensis Poll et Maul, 1953 [PhD Thesis]. Faculté des Sciences de Tunis. 277 p.

Beverton RJH, Holt SJ. 1957. On the dynamics of exploited fish populations. London: Chapman and Hall 179 p.

Béné, C. 2007. Diagnostic study of the Volta Basin fisheries Part 1: Overview of the fisheries resources, 33p.

Braimah, LI. 1995. Recent developments in the fisheries of Volta Lake (Ghana). CIFA Technical Paper, FAO, 30 pp.

Braimah, LI. 2001. Volta Lake fisheries management plan. Fisheries Subsector Capacity Building Project the Department of Fisheries, 160p.

Dankwa, H.R., Abban, E.K. and Teugels, G.G. 1999. Freshwater fishes of Ghana: identification, distribution, ecological and economic importance. Annales Sciences Zoologiques, 283: 53pp.

da Costa MR, Tubino RDA, Monteiro-Neto C. 2018. Length-based estimates of growth parameters and mortality rates of fish populations from a coastal zone in the Southeastern Brazil. Zoologia. 35:1-8. doi: 10.3897/zoologia.35.e22235

Froese R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. J Appl Ichthyol. 22(4):241-253. doi: 10.1111/j.1439-0426.2006.00805.x

Froese R, Pauly D. 2020. FishBase, World Wide Web electronic publication; [cited 2022 May 20]. Available from http://www.fishbase.org(12/2020)

Georgiev ZM, Kolarov P. 1962. On the migration and distribution of horse mackerel (Trachurus ponticus Aleev) in the western part of Black Sea. Arbeiten des Zentralen Forschungsinstitutes Fur Fishzught und Fisherei Varna. 11:148-172.

GSS (Ghana Statistical Service). 2014. District Analytical Report, Pru District. [cited 2022 May 20]. Available from https://www2.statsghana.gov.gh/docfiles/2010_District_Report/Brong%20Ahafo/Pru.pdf

Gulland JA. 1971. The fish resources of the oceans. West Byfleet, the UK: Fishing News (Books) Ltd 255 p.

Hoggarth DD, Mees CC, O'Neill C, Hindson J, Krishna M. 2005. A guide to Fisheries Stock assessment using FMSP tools. London/Ahmedabad: Marine Resources Assessment Group (MRAG), Centre for Environment Education, Scales Consulting Ltd 26 p.

Ikusemiju K, Olaniyan CIO. 1977. Food and feeding habits of catfishes *Chrysichthys walkeri* (Gunther), *Chrysichthys filamentosus* (Boulenger) and *Chrysichthys nigrodigitatus* (Lacepede) in Lekki Lagoon, Nigeria. J Fish Biol. 10(2):105-112. doi: 10.1111/j.1095-8649.1977.tb04047.x

Lalèyè, P., Olaosebikan, D. B., Dankwa, H., Schmidt, R. C., Diallo, I., & Darwall, W. R. 2021. The status and distribution of freshwater fishes in western Africa. Identification and Validation of Western African Freshwater Key Biodiversity Areas, 22.FAO 1999. Food and Agriculture Organization. Indicators for sustainable development of marine capture fisheries: [cited 2022 May 20]. Available from https://www.fao.org/in-action/globefish/publications/details-publication/en/c/344016/Fobil, J. N., and Attuquayefio, D. K. 2003. Remediation of the environmental impacts of the Akosombo and Kpong dams. Horizon International, Yale University, Yale.

Lowe-McConnell RH, Wuddah AA. 1972. Keys for the field identification of freshwater fishes likely to occur in or above the new man-made lakes, Lake Volta in Ghana and the Kainji Lake on the River Niger in Nigeria. Accra: Ghana Universities Press 22 p.

Neethiselvan N, Ventaramani VK. 2002. Population dynamics of siboga squid *Doryteuthis sibogae* (Cephalopoda / Teuthoidae) in Thoothukkudi (Tuticorin) coast, Southeast of India. Indian J Mar Sci. 31(3):213-217.

Nwafili SA, Soyinka OO, Gao TX. 2012. Levels and patterns of genetic diversity in wild *Chrysichthys nigrodigitatus* in the Lagos Lagoon complex. Afr J Biotechnol. 11(91):15748-15754. doi: 10.5897/AJB10.1258

Ofori-Danson, P.K. 1999. Stock assessment of the five major commercial fish species in Yeji area (Stratum VII) of the Volta Lake. PhD Thesis, University of Ghana, Legon, p. 189.

Ofori-Danson PK, de Graaf GJ, Vanderpuye CJ. 2002. Population parameter estimated for *Chrysichthys auratus* and *Chrysichthys nigrodigitatus* (Pisces:Claroteidae) in Lake Volta, Ghana. Fisheries Research. 54(2):267-277. doi: 10.1016/S0165-7836(00)00292-7

Ofori-Danson PK, Addo S, Animah CA, Abdulhakim A, Nyarko JO. 2018. Length at first capture (LC_{50}) of *Sardinella aurita* and *Sardinella maderensis* landed from purse seines at the Tema fishing habour, Ghana. International Journal of Fisheries and Aquatic Research.3(3):8-13.

Okyere I, Boahemaa-Kobil EE. 2020. Occurrence and food habits of the bagrid catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) in the Pra River Estuary, Ghana. Journal of Fisheries and Coastal Management. 1:29-34. doi: 10.5455/jfcom.20190315071516

Olopade OA, Taiwo IO, Adetimilehin FB. 2015. Comparative Study on the Proximate Composition of *Chrysichthys nigrodigitatus* and *Chrysichthys walkeri* (Family Claroteidae) from Oyan Lake. Food Science and Quality Management. 42:1-4.

Park JM, Hashimoto H, Jeong JM, Kim HJ, Baeck GW. 2013 Age and growth of the robust tonguefish *Cynoglossus robustus* in the Seto Inland Sea, Japan. Anim Cells Syst. 17(4):290-297. doi:10.1080/19768354.2013.826281

Park KD, Kim JK, Chang DS, Kim JI, Oh CW. 2008. Age and growth of the mudskipper, *Scartelaos gigas* (Perciformes, Gobiidae) from Korea. Anim Cells Syst. 12(4):305-311. doi: 10.1080/19768354.2008.9647186

Pauly D. 1979. Theory and Management of Tropical Multi-Species Stocks: A Re-view, with Emphasis on the Southeast Asian Demersal Fisheries. Manila, Philippines: International Center for Living Aquatic Resources Management 35 p.

Pauly D, Munro JL. 1984. Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte. 2(1):1-21.

Pauly D. 1987. A Review of the ELEFAN System for Analysis of Length-Frequency Data in Fish and Aquatic Invertebrates. In: Pauly D, Morgan GR, editors. Length-Based Methods in Fisheries Research. Manila, Philippines: Intemational Center for Living Aquatic Resources Management; Kuwait Institute for Scientific Research. p. 7-34.

Pauly D, David N. 1981. ELEFAN 1, a BASIC Program for the Objective Extraction of Growth Parameters from Length-Frequency Data. Ber Deut Wiss Komm. 28(4):205-211.

Pope JG. 1972. An investigation in the accuracy of the Virtual Population Analysis using cohort analysis. Res Bull Int Comm Northwest Atlantic Fish. 9:65-74.

Qamar N, Panhwar SK, Brouwer S. 2016. Population Characteristics and Biological Reference Point Estimates for Two Carangid Fishes, *Megalaspis cordyla* and *Scomberoides tol*, in the Northern Arabian Sea Coast of Pakistan. Pakistan J Zool. 48(3):869-874.

Quarcoopome T, Amevenku F, Ofori-Danson P. 2011. Changes in the fish community of the Kpong Headpond, lower Volta River, Ghana after 25 years of impoundment. Rev Biol Trop. 59(4):1685-1696.

Sambo F, Haruna M. 2012. Some aspects of the growth parameters of the fishes of Ibrahim Adamu Lake, Kazaure Jigawa state, Nigeria. Bayero Journal of Pure and Applied Sciences. 5(1):175-181. doi: 10.4314/bajopas.v5i1.31

Sequeira V, Neves A, Vieira AR, Figueiredo I, Gordo LS. 2009. Age and growth of bluemouth, Helicolenus dactylopterus, from the Portuguese continental slope. ICES J Mar Sci. 66(3):524-531. doi: 10.1093/icesjms/fsp010

Sparre P, Venema SC. 1992. Introduction to Tropical Fish Stock Assessment Part 1 Manual, FAO Fisheries Technical Paper. Rome: FAO. Report No.:306/1.

Taiwo IO, Aransiola MO. 2003. Length weight relationship, condition factors and fecundity of *Chrysichthys nigrodigitatus* and *Chrysichthys walkeri* in Asejire Lake. Paper presented at: 16th Annual Conference of the Fisheries Society of Nigeria (FISON); Maiduguri, Nigeria.

Then AY, Hoenig JM, Hall NG, Hewitt DA. 2015. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES J Mar Sci. 72(1):82-92. doi: 10.1093/icesjms/fsu136

Udoh JP, Ukpatu JE, Udoidiong OM. 2015. Population dynamics of *Chrysichthys nigrodigitatus* (Lacepède, 1803) in the lower cross river Nigeria. Croatian Journal of Fisheries. 73(3):103-114. doi: 10.14798/73.3.834

Vanderpuye CJ. 1979. Life history of Chrysichthys catfish in Volta Lake, Ghana. [PhD Thesis]. Iowa State University. 140 p.

Wehye AS, Ofori-Danson PK, Lamptey AM. 2017. Population dynamics of *Pseudotolithus senegalensis* and *Pseudotolithus typus* and their implications for the management and conservation within the coastal waters of Liberia. Fisheries and Aquaculture Journal. 8(2):1-9. doi:10.4172/2150-3508.1000201