Accepted: 20 February 2018
DOI: 10.1111/lre.12203

ORIGINAL ARTICLE

WILEY Lakes & Reservoirs

Growth, mortality and recruitment of Nile perch (*Lates niloticus*) in Lake Victoria, Kenya

Edwine Yongo[1] | **Simon Agembe**[1] | **Nicholas Outa**[2] | **Monica Owili**[3]

[1]Department of Fisheries and Aquatic Sciences, University of Eldoret, Eldoret, Kenya

[2]Department of Biological Sciences, Egerton University, Egerton, Kenya

[3]Kenya Marine and Fisheries Research Institute (KMFRI), Kisumu, Kenya

Correspondence
Edwine Yongo, Department of Fisheries and Aquatic Sciences, University of Eldoret, Eldoret, Kenya.
Email: edwineyongo@gmail.com

Abstract

This study investigated the growth, mortality and recruitment of *Lates niloticus* in Lake Victoria basis on length–frequency data collected during the period 2014-2015. The asymptotic length (L_∞) had a value of 124 cm TL, growth curvature (K) of 0.22 year^{-1}, total mortality (Z) of 0.96 year^{-1}, a natural mortality (M) of 0.42 year^{-1}, a fishing mortality (F) of 0.54 year^{-1}, an exploitation rate (E) of 0.57 and a growth performance index (Ø) of 3.53. Logistic selection model showed that 50% of fish of 46.09 cm TL encountering the gear are retained. There were two peak recruitment periods, a minor one in March and a major one in July, accounting for 12.04% and 22.04%, respectively, of the total fish catch. The Beverton and Holt's relative yield-per-recruit model indicated the indices for sustainable yields are 0.32 for optimum sustainable yield ($E_{0.5}$), 0.60 for maximum sustainable yield (E_{max}) and 0.51 for economic yield ($E_{0.1}$). Compared to previous findings, there is a great decline in the sizes of Nile perch stocks in Lake Victoria. Thus, managing the fishery requires strict adherence to the slot size of 50–85 cm TL, and restrictions on illegal gear and methods, by the devolved governments through monitoring, control and surveillance in liaison with the Beach Management Units (BMUs).

KEYWORDS
growth, mortality, Nile perch, recruitment

1 | INTRODUCTION

The Nile perch (*Lates niloticus*) is widely distributed in Africa, occurring in the Congo, Niger, Volta and Senegal Rivers, and Lakes Chad and Turkana. It was introduced into Lakes Victoria, Kyoga and Nabugabo from Lake Albert during the 1950s and early 1960s (Pringle, 2005). The fish can grow to a length of 2 m, weigh up to 200 kg and live up to 16 years (Ogutu-Ohwayo, 2004). Nile perch introduction into Lake Victoria was meant to convert the large biomass of the indigenous small bony haplochromine cichlids into a less productive, but more valuable commodity (Pringle, 2005). Fisheries production from Lake Victoria increased from around 100,000 t per annum in 1980 to about 1,000,000 t at present, largely because of Nile perch introduction (Marshall & Mkumbo, 2011). It is estimated the Lake Victoria fisheries as a whole support about 40 million people, with Nile perch now being an important export commodity with exports, mainly to Europe, worth about US 350 million annually (Mkumbo & Marshall, 2015).

Up to the 1970s, Lake Victoria supported a multispecies fishery dominated by the tilapiines *Oreochromis esculentus* (Graham) and *Oreochromis variabilis* (Boulenger), and more than 500 species of haplochromine cichlids (Ogutu-Ohwayo, 1990a). Other important species included *Rastrineobola argentea* (Pellegrin), *Protopterus aethiopicus* (Heckel), *Bagrus docmak* (Forsskåll), *Clarias gariepinus* (Burchell), *Schilbe intermedius* (Rüppell), various *Barbus* species, and *mormyrid* species. Haplochromine cichlids were the dominant fish in Lake Victoria during those periods, forming the major prey for Nile perch (Ogutu-Ohwayo, 1990a, 1990b). However, a dramatic

Nile perch boom in the 1980s (Goudswaard, Witte, & Katunzi, 2008) coincided with the disappearance of about 40% of the 500+ endemic haplochromine cichlid species (Witte et al., 1992). After depletion of the haplochromine stocks in Lake Victoria at the end of the 1980s, Nile perch shifted to feeding on shrimp *Caridina nilotica*, juvenile Nile Perch, *Oreochromis niloticus* and *Rastrineobola argentea* (Katunzi, Van Densen, Wanink, & Witte, 2006; Ogutu-Ohwayo, 2004; Outa, Yongo, & Jameslast, 2017).

Since the mid-1990s, Nile perch yields have been declining, and some haplochromine species has resurged in certain parts of Lake Victoria (Balirwa et al., 2003; Downing et al., 2014). Accordingly, haplochromines are again the major prey of Nile perch in Lake Victoria (Budeba & Cowx, 2007; Kishe-Machumu, Witte, Wanink, & Katunzi, 2012; Ngupula & Mlaponi, 2010; Nkalubo, Chapman, & Muyodi, 2014). Thus, there are concerns that the Nile perch are being overfished, based on the fluctuations of the catches and changes in population size-structure, combined with the recovery of haplochromine cichlids (Kishe-Machumu et al., 2012). The average fish size decreased rapidly in 2007, when the stock biomass fell by 50% (Mkumbo & Marshall, 2015). They argued that fishers have increasingly abandoned large-meshed gillnets in favour of small hooks on long lines, allowing prey species *(Rastrineobola argentea* [Pellegrin] and haplochromines) to increase, shifting the fishery to one dominated by species at lower trophic levels. Fishing for *R. argentea* in shallow areas less than 5 m deep with 5-mm mesh nets could have some adverse effects on the Nile perch stock because this method is unselective, capturing juvenile fish of all species, thereby endangering recruitment (Njiru et al., 2009). In addition, the high cost of the legal fishing gears has resulted in the use of illegal fishing gear, and methods such as cast nets and beach seines (Muhoozi, 2002).

As a result of its influences on resource availability and diet, eutrophication is attributed to the changes in Nile perch stocks and population dynamics (Downing, van Nes, van de Wolfshaar, Scheffer, & Mooij, 2013). The shallow nearshore waters, which are preferred breeding and nursery grounds for Nile perch in Lake Victoria, are particularly sensitive to the effects of pollution and eutrophication. According to Mkumbo and Marshall (2015), however, changes in population size-structure of Nile perch do not reflect deterioration in the environment because evidence suggests conditions in the lake have improved, and prey species sensitive to deoxygenation have increased. Although Nile perch is no longer the dominant species in the fishery in terms of weight, having been replaced by small pelagic species, it is still the most important in terms of value, accounting for about 60% of the total landed value of fish from Lake Victoria in 2011 (LVFO, 2011). Considering its high societal and economic importance, it is important to manage the Nile perch fishery effectively and prevent its collapse. This study was undertaken to provide useful information on the growth, mortality and recruitment of Nile perch in the Kenyan waters of Lake Victoria to enhance management of the fishery.

2 | MATERIALS AND METHODS

Lake Victoria, with an area of 68,800 km^2, is the second largest freshwater lake in the world, being shared by Kenya, Uganda and Tanzania in the ratios of 6%, 45% and 49% of its surface area, respectively (Johnson, Kelts, & Odada, 2000). It stretches 412 km from north to south between 0°30′N and 3°12′S, and 355 km from west to east between 31°37′ and 34°53′E. It lies across the equator at an altitude of 1,135 m above sea level. Nyanza Gulf is a large inlet from Lake Victoria that extends into Kenya, being comparatively shallow, with a maximum and average depth of 68 and 6 m, respectively. The Gulf constitutes the major portion of the Kenyan part of Lake Victoria. Nile perch samples (6,361) were obtained monthly from commercial catches between June 2014 and June 2015 at two landing sites within the Kenyan waters of Lake Victoria (Wichlum site GPS coordinates: 0°14021.4″S, 34°12034.3″E; Honge site GPS coordinates: 0°02037″S, 34°00048.6″E). Both shallow (Wichlum) and deep-water (Honge) sites were represented. The fish were measured (total length, TL) in the field using a measuring board to the nearest centimetre (cm). Data analysis was based on length–frequency distribution analysis.

The electronic length frequency analysis (ELEFAN I in FAO ICLRAM Stock Assessment Tool [FISAT]; Gayanilo, Sparre, & Pauly, 1996; Pauly, 1987) was used to estimate population parameters.

2.1 | Growth, mortality and probability of capture

Estimates of the growth parameters were based on the von Bertalanffy growth formula (VBGF), as follows:

$$L_t = L_\infty(1 - \exp(-K(t - t_0))), \tag{1}$$

where L_t = predicted length at age t; L_∞ = asymptotic length; K = growth curvature; and t_o = age the fish would have been at zero length.

The total mortality (Z) was estimated using a length-converted catch curve. The coefficient of natural mortality (M) was estimated with K (year^{-1}), L_∞ (cm) and T (mean annual water temperature of 24°C), following Pauly' s empirical formula (Pauly, 1980), as follows:

$$\mathrm{Ln}(M) = -0.0152 - 0.279\ln(L_\infty) + 0.6543\ln(K) + 0.463\ln(T). \tag{2}$$

The fishing mortality (F) was computed from the relationship:

$$F = Z - M. \tag{3}$$

The exploitation rate (E) was calculated from the relationship:

$$E = \frac{F}{Z} = \frac{F}{F+M}. \tag{4}$$

The growth performance index (Ø) was computed, according to Pauly and Munro (1984), as follows:

$$Ø = \mathrm{Ln}(K) + 2(L_\infty). \tag{5}$$

TABLE 1 Monthly composite length frequency data of *Lates niloticus* representing samples collected from 2014 to 2015 pooled together

Length-class TL (cm)	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
<30	5	5	1	5	2	1	49	11	5	1	60	2
30–40	9	6	9	11	9	9	39	14	11	6	20	0
40–50	30	58	45	52	39	154	132	122	184	102	147	28
50–60	213	346	293	264	254	262	526	324	403	342	333	122
60–70	37	79	75	76	56	54	119	86	105	86	51	28
70–80	14	26	17	14	8	19	42	29	25	15	32	10
80–90	8	10	7	8	3	9	19	8	11	15	11	5
90–100	5	4	3	3	1	6	9	3	2	4	8	0
100–110	3	0	1	0	0	3	1	3	2	1	2	1
110–120	0	1	1	2	1	1	1	1	0	1	2	0
120–130	0	0	0	2	0	0	1	0	0	0	0	0
Total	324	535	452	437	373	518	938	601	748	573	666	196

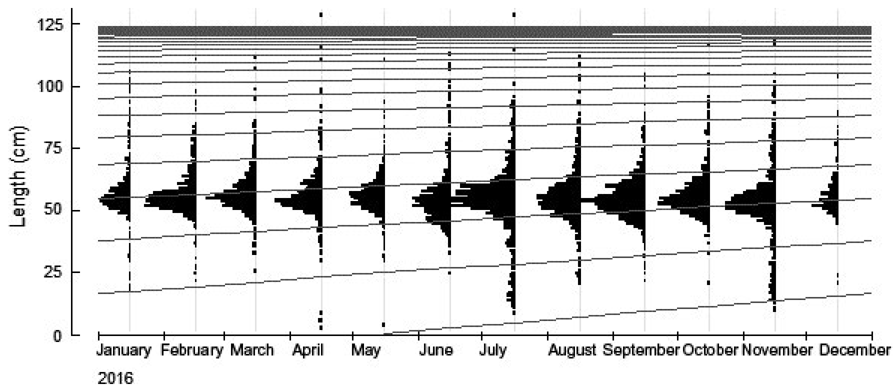

FIGURE 1 von Bertalanffy growth function and length frequency for *Lates niloticus* from Lake Victoria, Kenya

The probability of capture was obtained from the backward extrapolation of the length-converted catch curve, according to Pauly, Ingles, and Neal (1984).

2.2 | Recruitment pattern

Growth parameters L_∞ and K were used as inputs, by backward projection, along a trajectory defined by the VBGF, of the frequencies onto the time axis of a time-series of samples. Plots illustrating the seasonal recruitment patterns were obtained in this manner.

2.3 | Beverton and Holt's *Y/R* and *B/R* analyses

The relative yield-per-recruit model used was based on the Beverton and Holt (1966) model, as modified by Pauly and Soriano (1986). The options assuming knife-edge selection was utilized, using probabilities of capture. L_c/L_∞ and M/K ratios as inputs.

Relative yield-per-recruit (Y'/R) was computed from the relationship:

$$\frac{Y'}{R} = EU^{M/K}\left\{1 - \frac{3U}{(1+m)} - \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)}\right\}, \quad (6)$$

where $U = 1 - (L_c/L_\infty)$; $m = (1 - E)/(M/K) = (K/Z)$; and $E = F/Z$.

Relative biomass per recruit (B'/R) was estimated from the relationship:

$$\frac{B'}{R} = \frac{(Y'/R)}{F}. \quad (7)$$

While E_{max}, $E_{0.1}$ and $E_{0.5}$ were estimated using the first derivative of this function, E_{max} is the exploitation rate at maximum sustainable yield (MSY), $E_{0.1}$ is the rate at maximum economic yield (MEY), and $E_{0.5}$ is the optimum exploitation rate.

3 | RESULTS

3.1 | Growth parameters

The samples for each month from 2014 to 2015, combined to form a composite sample for this study, are presented in Table 1. The K-scan technique indicated a symptotic length (L_∞) of 124 cm TL and a growth curvature (K) value of 0.22 year^{-1}. These results indicate a growth performance index (Ø) of 3.53 for *L. niloticus* in Lake Victoria. The seasonalized von Bertalanffy growth curve resulting from a combination of

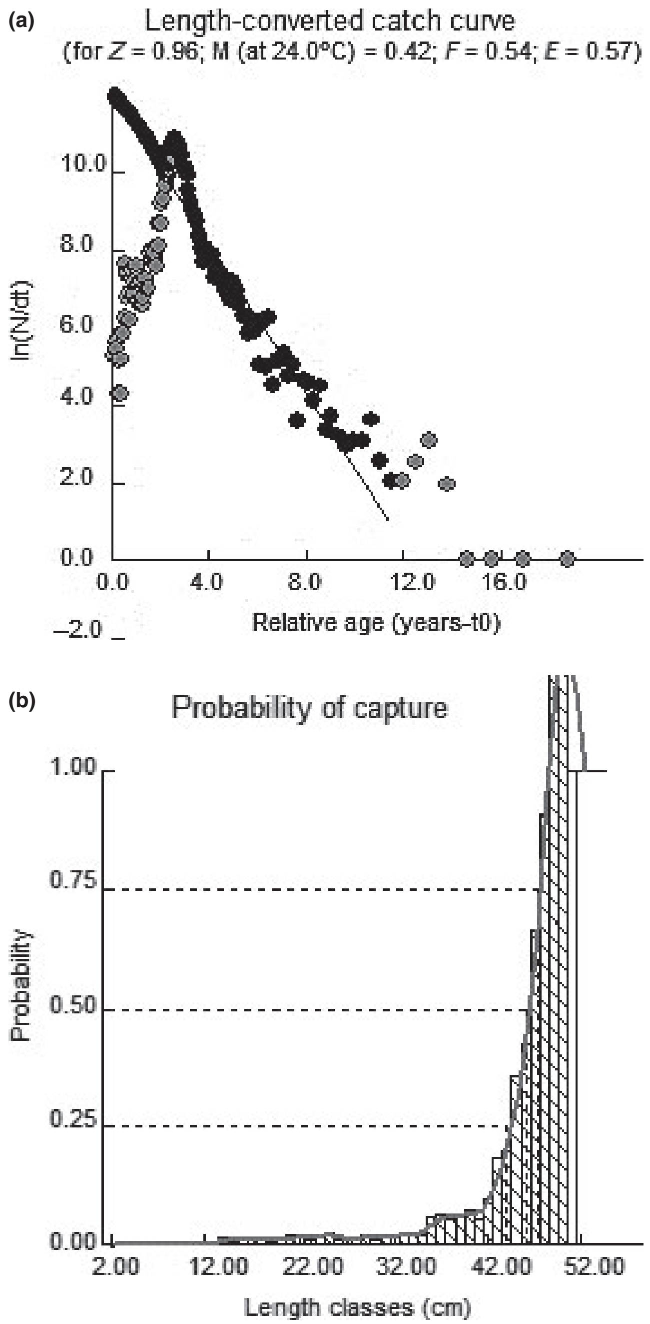

FIGURE 2 (a) Values of total mortality (Z), natural mortality (M), fishing mortality (F) coefficients and exploitation rates (E) from length-converted catch curve in Lake Victoria, Kenya. (b) Logistic curve showing 25%, 50% and 75% capture length (cm TL) of *Lates niloticus* (broken lines) from Lake Victoria, Kenya

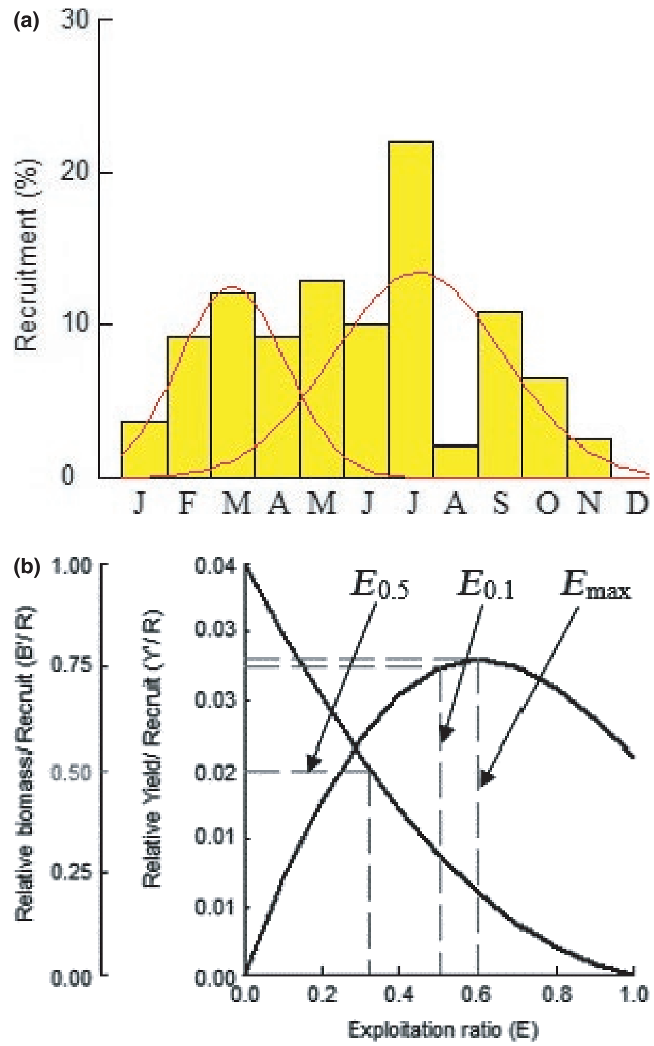

FIGURE 3 (a) Estimated percentage recruitment. (b) Beverton & Holt's relative yield per recruit and average biomass per recruit models, showing levels of yield indices: $E_{0.5}$—optimum sustainable yield, $E_{0.1}$—maximum economic yield and E_{max}—maximum sustainable yield

124 cm TL asymptotic length and growth curvature of 0.22 year^{-1} is shown in Figure 1.

3.2 | Mortality estimates and probability of capture

The total mortality coefficient (Z) of *L. niloticus* from length-converted catch curve indicated an annual estimate of 0.96 year^{-1}, with a confidence interval from 0.89 to 1.03 year^{-1}. Natural mortality (M), fishing mortality (F) and exploitation rate (E) were found to be 0.42, 0.54 and 0.57 year^{-1}, respectively (Figure 2a). The probability of capture indicated at least 25% of fish of 44.01 cm TL, 50% of the fish of 46.09 cm TL and 75% of all fish of 47.29 cm TL are retained on encounter with the gear (Figure 2b). All fish above 50 cm TL are retained with the gear.

3.3 | Recruitment pattern and relative yield per recruit/biomass per recruit

Recruitment pattern indicated two peak recruitment periods, a minor one in March, accounting for 12.04%, and a major peak in July, accounting for 22.04%, of the total annual recruitment (Figure 3a). The Beverton and Holt's relative yield-per-recruit model (Figure 3b)

TABLE 2 Changes in growth and population parameters of *Lates niloticus* in Lake Victoria, 1991–2015

Lake & period	L_∞ (cm TL)	K (year^{-1})	Z (year^{-1})	F (year^{-1})	E F/Z	Lm_{50} Male	Lm_{50} Female	Source
Victoria (Kenya)—1988	205	0.19	1.60	1.26	0.78	74	102	Njiru et al. (2008)
Victoria (Tanzania)—1990	185	0.17				60	110	Njiru et al. (2008)
Nyanza Gulf (Kenya)—1991	169	0.18	0.72	0.35				Rabuor et al. (2003)
Victoria (Uganda)—2002	256	0.29	1.91	1.44	0.75	64	73	Njiru et al. (2008)
Victoria (Tanzania)—2002	216	0.19	1.93	1.64	0.85	54	77	Njiru et al. (2008)
Victoria (Kenya)—2002	204	0.21	1.78	1.42	0.80	55	78	Njiru et al. (2008)
Victoria (Uganda)—2003	221	0.17	2.18	1.88	0.86	57	76	Njiru et al. (2008)
Victoria (Tanzania)—2006	178	0.20	2.17	1.81	0.83	60	85	Njiru et al. (2008)
Victoria (Uganda)—2006	153	0.24	2.12	1.88	0.89	58	70	Njiru et al. (2008)
Victoria (Kenya)—2006	145	0.24	1.91	1.71	0.89	55	62	Njiru et al. (2008)
Victoria (Kenya)—2015	124	0.22	0.96	0.54	0.57			This study

indicated the indices for sustainable yields are 0.32 for optimum sustainable yield ($E_{0.5}$), 0.60 for the maximum sustainable yield (E_{max}) and 0.51 for economic yield ($E_{0.1}$).

4 | DISCUSSION

The changes in growth and population parameters of *L. niloticus* in Lake Victoria between 1991 and 2015 are presented in Table 2.

It is evident from the findings of the present study that the asymptotic length (L_∞) of 124 cm TL of *L. niloticus* caught from Lake Victoria has been greatly reduced over the past years. Similarly, there was a sharp decrease in the numbers of fish above the slot size of 50–85 cm TL, based on the length frequency distribution. Njiru et al. (2009) reported that fish below and above the slot size has continued being caught and processed, thereby confirming the slot size is hardly adhered to by both the fishers and the processors. Reductions in the sizes of *L. niloticus* are likely attributed to the illegal gears and methods used in the fishery (Yongo et al., 2017). Fishers in Lake Victoria have increasingly abandoned large-meshed gillnets in favour of small hooks on long lines (Mkumbo & Marshall, 2015), which largely targets small size Nile perch. They added that the readily availability of Nile perch <50 cm TL in local markets around the lake confirms the existence of an extensive illegal fishery that may be having an impact on the stocks. When the Nile perch fishery in Lake Victoria began, gillnets (90 m in length) were the principal type of fishing gear, and authorities established a minimum mesh size of 5 inches (125 mm) in an attempt to ensure fish smaller than 50 cm TL were not caught. Illegal nets, however, have evolved over time. According to reports of the Lake Victoria Frame Survey on the Kenyan side, the number of undersized (<5 inch or 127 mm) gillnets increased from 54,085 in 2012 to 75,205 in 2014. Long-line hooks, a fishing gear that specifically targets Nile perch, the number of the smallest hooks (size > 10) was reported to be 1,586,512 in 2014. Although this has not been very successful, the co-management approach via the establishment of Beach Management units (BMUs) has at least help reduce illegal gear and the capture of undersized fish in Lake Victoria.

The natural mortality coefficient (*M*) of 0.42 reported in the present study is comparable with the value of 0.37 reported by Rabuor, Gichuki, and Moreau (2003) in their study on Nile perch in the Nyanza Gulf of Lake Victoria. Natural fish mortality is attributable to factors not associated with fishing, including predation, competition, cannibalism, diseases, spawning stress, starvation and pollution stress (Yongo & Outa, 2016). The present study reported a 50% probability of capture of the fish of 46.09 cm TL, which is lower than its length at first maturity (Lm_{50}) in Lake Victoria (Njiru, Kazungu, Ngugi, Gichuki, & Muhoozi, 2008; Table 2). This implies the fishing gears are catching high proportions of immature fish. The recruitment peaks showed by Nile perch in the months of March and July actually coincide with the rainy seasons along the Lake Victoria basin. Thus, recruitment of Nile perch could be influenced by food availability and favourable environmental conditions. Rabuor et al. (2003) observed the highest peak for recruitment of Nile perch in November, December and January in the Nyanza Gulf of Lake Victoria, with a minor one in June, indicating recruitment of two cohorts per year. According to Kishe-Machumu et al. (2012), the apparent preference for haplochromines as prey has considerably reduced the degree of cannibalism, which may have a positive impact on Nile perch recruitment. The impact of population parameters on the biomass and yield is best reflected in the Beverton and Holt's yield-per-recruit model (Beverton & Holt, 1966). At the current mortality rates, the observed exploitation rate (*E*) of 0.57 is less than optimum sustainable yield ($E_{0.5}$) of 0.32, but not much different from maximum sustainable yield (E_{max}) 0.60 and economic yield ($E_{0.1}$) of 0.51. These results agree with Rabuor et al. (2003), who reported the Nile perch population in the Nyanza Gulf may now be exhibiting some kind of demographic equilibrium.

In conclusion, there is a great decline in the sizes of Nile perch stocks in Lake Victoria, compared to the situation in the past. Thus, managing the fishery requires strict adherence to the slot size of 50–85 cm TL, and a restriction on illegal gear and methods, by the devolved government through monitoring, control and surveillance, in liaison with the BMUs.

ORCID

Edwine Yongo http://orcid.org/0000-0001-8843-6113

REFERENCES

Balirwa, J. S., Chapman, C. A., Chapman, L. J., Cowx, I. G., Geheb, K., Kaufman, L., … Witte, F. (2003). Biodiversity and fishery sustainability in the Lake Victoria basin: An unexpected marriage? *BioScience*, *53*(8), 703–715. https://doi.org/10.1641/0006-3568(2003)053[0703:BAFSIT]2.0.CO;2

Beverton, R. J. H., & Holt, S. J. (1966). Manual of methods for fish stock assessment. Part II. Tables of yield function. FAO Fish. Biol. Techn. Pap. 38, 10 (Ver. 1): 1–67.

Budeba, Y. L., & Cowx, I. G. (2007). The role of the freshwater shrimp *Caridina nilotica* (Roux) in the diet of the major commercial fish species in Lake Victoria, Tanzania. *Aquatic Ecosystem Health & Management*, *10*, 368–380. https://doi.org/10.1080/14634980701703876

Downing, A. S., Van Nes, E., Balirwa, J., Beuving, J., Bwathondi, P., Chapman, L. J., … Janse, J. H. (2014). Coupled human and natural system dynamics as key to the sustainability of Lake Victoria's ecosystem services. *Ecology and Society*, *19*(4), 31. https://doi.org/10.5751/ES-06965-190431

Downing, A. S., van Nes, E. H., van de Wolfshaar, K. E., Scheffer, M., & Mooij, W. (2013). Effects of resources and mortality on the growth and reproduction of Nile perch in Lake Victoria. *Freshwater Biology*, *58*(4), 828–840. https://doi.org/10.1111/fwb.12089

Gayanilo, F. C., Sparre, P., & Pauly, D. (1996). FAO-ICLARM stock assessment tools (FISAT), Rome (126 pp., +3 diskettes).

Goudswaard, K., Witte, F., & Katunzi, E. F. B. (2008). The invasion of an introduced predator, Nile perch (*Lates niloticus*, *L.*) in Lake Victoria (East Africa): Chronology and causes. *Environmental Biology of Fishes*, *81*(2), 127–139.

Johnson, T. C., Kelts, K., & Odada, E. (2000). The holocene history of Lake Victoria. *Ambio*, *29*(1), 2–11. https://doi.org/10.1579/0044-7447-29.1.2

Katunzi, E. F. B., Van Densen, W. L. T., Wanink, J. H., & Witte, F. (2006). Spatial and seasonal patterns in the feeding habits of juvenile *Lates niloticus* (*L.*), in the Mwanza Gulf of Lake Victoria. *Hydrobiologia*, *568*, 121–133. https://doi.org/10.1007/s10750-006-0033-3

Kishe-Machumu, M. A., Witte, F., Wanink, J. H., & Katunzi, E. F. (2012). The diet of Nile perch, *Lates niloticus* (L.) after resurgence of haplochromine cichlids in the Mwanza Gulf of Lake Victoria. *Hydrobiologia*, *682*(1), 111–119. https://doi.org/10.1007/s10750-011-0822-1

LVFO (2011). *Technical report: Stock assessment regional working group* (28 pp.). Jinja, Uganda: Lake Victoria Fisheries Organization.

Marshall, B. E., & Mkumbo, O. C. (2011). The fisheries of Lake Victoria: Past present and future. *Nature & Fauna*, *26*, 8–13. FAO, Rome.

Mkumbo, O. C., & Marshall, B. E. (2015). The Nile perch fishery of Lake Victoria: Current status and management challenges. *Fisheries Management and Ecology*, *22*, 56–63. https://doi.org/10.1111/fme.12084

Muhoozi, L. I. (2002). *Exploitation and management of the artisanal fisheries in the Ugandan waters of Lake Victoria*. PhD Thesis. University of Hull, Hull, UK.

Ngupula, G. W., & Mlaponi, E. (2010). Changes in the abundance of Nile shrimp, *Caridina nilotica* (*Roux*) following the decline of Nile perch and recovery of native haplochromine fishes, Lake Victoria, Tanzanian waters. *Aquatic Ecosystem Health & Management*, *13*, 196–202. https://doi.org/10.1080/14634988.2010.483188

Njiru, M., Getabu, A., Taabu, A. M., Mlaponi, E., Muhoozi, L., & Mkumbo, O. C. (2009). Managing Nile perch using slot size: Is it possible? *African Journal of Tropical Hydrobiology and Fisheries*, *12*(1), 9–14.

Njiru, M., Kazungu, J., Ngugi, C. C., Gichuki, J., & Muhoozi, L. (2008). Management of Lake Victoria fishery an overview of the current status of Lake Victoria fishery: Opportunities, challenges and management strategies. *Lakes & Reservoirs: Research & Management*, *13*, 1–12. https://doi.org/10.1111/j.1440-1770.2007.00358.x

Nkalubo, W., Chapman, L., & Muyodi, F. (2014). Feeding ecology of the intensively fished Nile Perch, *Lates niloticus*, in Lake Victoria, Uganda. *Aquatic Ecosystem Health & Management*, *17*(1), 62–69. https://doi.org/10.1080/14634988.2014.880639

Ogutu-Ohwayo, R. (1990a). The decline of the native fishes of Lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus* and the Nile tilapia, *Oreochromis niloticus*. *Environmental Biology of Fishes*, *27*, 1–96.

Ogutu-Ohwayo, R. (1990b). Changes in the prey ingested and the variations in the Nile perch and other fish stocks of Lake Kyoga and the northern waters of Lake Victoria (Uganda). *Journal of Fish Biology.*, *37*, 55–63. https://doi.org/10.1111/j.1095-8649.1990.tb05926.x

Ogutu-Ohwayo, R. (2004). Management of the Nile perch, *Lates niloticus* fishery in Lake Victoria in light of the changes in its life history characteristics. *African Journal of Ecology*, *42*, 306–314. https://doi.org/10.1111/j.1365-2028.2004.00527.x

Outa, N. O., Yongo, E., & Jameslast, A. K. (2017). Ontogenic changes in prey ingested by Nile perch (*Lates niloticus*) caught in Nyanza Gulf of Lake Victoria, Kenya. *Lakes & Reservoirs: Research & Management*, *2017*(20), 1–5.

Pauly, D. (1980). On the interrelationship between natural mortality, growth parameters, mean environmental temperature in 175 fish stock. *Journal du Conseil. Conseil Permanent International Pour L'exploration de la mer*, *39*, 175–192. https://doi.org/10.1093/icesjms/39.2.175

Pauly, D. (1987). A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates. In D. Pauly & G. R. Morgan (Eds.), *Proceedings*, *length-based methods in fisheries research ICLARM Conference* 13 (486, pp. 7–34).

Pauly, D., Ingles, J., & Neal, R. (1984). Application to shrimp stocks of objective methods for the estimation of growth, mortality and recruitment-related parameters from length-frequency data (ELEFAN I and II). In J. A. Gulland & B. I. Rothschild (Eds.), *Penaeid shrimps - Their biology and management* (pp. 220–234, 312). Farnham, UK: Fishing News Books.

Pauly, D., & Munro, J. L. (1984). Once more on growth comparison in fish and invertebrates. *Fish Bytes*, *2*, 21.

Pauly, D., & Soriano, M. L. (1986). Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In J. L. Maclean, L. B. Dizon, & L. V. Hosillo (Eds.), *The first Asian fisheries forum* (pp. 491–496). Manila, Philippines: Asian Fisheries Society.

Pringle, R. M. (2005). The origins of the Nile Perch in Lake Victoria. *BioScience*, *55*(9), 780–787. https://doi.org/10.1641/0006-3568(2005)055[0780:TOOTNP]2.0.CO;2

Rabuor, C. O., Gichuki, J., & Moreau, J. (2003). Growth, mortality and recruitment of Nile perch *Lates niloticus* (L. Centropomidae) in the Nyanza Gulf of Lake Victoria: An evaluation update. *Naga*, *WorldFish Center Quarterly*, *26*(4), 8–12.

Witte, F., Goldschmidt, T., Wanink, J., van Oijen, M., Goudswaard, K., Witte-Maas, E., & Bouton, N. (1992). The destruction of an endemic species flock: Quantitative data on the decline of the haplochromine cichlids of Lake Victoria. *Environmental Biology of Fishes*, *34*, 1–28. https://doi.org/10.1007/BF00004782

Yongo, E., & Outa, N. (2016). Growth and population parameters of Nile tilapia, *Oreochromis niloticus* (L.) in the open waters of Lake Victoria, Kenya. *Lakes & Reservoirs: Research & Management*, *21*(4), 375–379. https://doi.org/10.1111/lre.12154

Yongo, E., Outa, N., Kito, K., & Matsushita, Y. (2017). Some aspects of the biology of Nile perch, Lates niloticus, in the open waters of Lake Victoria, kenya. *Lakes & Reservoirs: Research & Management*, *20*, 1–6.

How to cite this article: Yongo E, Agembe S, Outa N, Owili M. Growth, mortality and recruitment of Nile perch (*Lates niloticus*) in Lake Victoria, Kenya. *Lakes & Reserv*. 2018;23:17–23. https://doi.org/10.1111/lre.12203