Growth, mortality and recruitment of Nile perch *Lates niloticus* (L. Centropomidae) in the Nyanza Gulf of Lake Victoria: an evaluation update

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Abstract

A reassessment of the estimates of growth, mortality and recruitment patterns of Nile Perch, *Lates niloticus* was made based on data from commercial landings collected during the Catch Assessment Survey Programme. Two sets of length frequency data, one each from beach seining and hook and line fisheries, were analyzed. Values of L_∞ = 169 and 230 (cm TL) and K= 0.18 yr^{-1} and 0.195 yr^{-1} were obtained. The total mortality estimates from the catch curve analysis were Z = 0.72 yr^{-1} and 0.94 yr^{-1}, respectively, with a natural mortality M of about 0.35 for a mean environmental temperature of 27°C. The highest peak for recruitment was in November, December and January with a minor one in June, indicating recruitment of two cohorts per year. These results are discussed and compared to previously available information on *L. niloticus* in Lake Victoria.

Introduction

The Kenyan portion of Lake Victoria is a narrow and shallow gulf, known by several names: Victoria Nyanza (Graham 1929), Kavirondo Gulf (Copley 1953; Muller and Benda 1981), Nyanza Gulf (Rinne and Wanjala 1982; Ogari and Dadzie 1988) and Winam Gulf (Okach 1982) (Fig. 1). It comprises only 6 per cent (4 100 km^2) of the entire lake (68 000 km^2). The gulf has an average depth of 6 to 8 m and an elevation of a 1 136 m above sea level. The maximum depth is about 43 m and the shoreline is about 500 km with flat sandy and muddy beaches, the latter found mostly in sheltered bays (Okach and Dadzie 1988).

The fishery of the Nyanza Gulf is multi-species and is dominated by the Nile perch, *Lates niloticus* (60 per cent), *Rastrineobola argentea* (30 per cent), and Tilapiines (5.5 per cent) (Ogari 1985; CIFA 1987; Asila and Ogari 1988; Rabuor 1991).

Length-frequency analyses on Nile perch specimens from Lake Victoria have been done by Acere (1985) in the Uganda sector. In the Nyanza Gulf, growth parameters and mortality rates have been estimated only by Asila and Ogari (1988) from samples obtained between October 1978 and February 1984. The aim of this study is to update our knowledge of the demographic situation of the stock of Nile perch in the Nyanza Gulf and re-estimate its growth parameters, mortality rates and recruitment patterns.

Fig. 1. Lake Victoria (Kenya) showing some of the major landing beaches

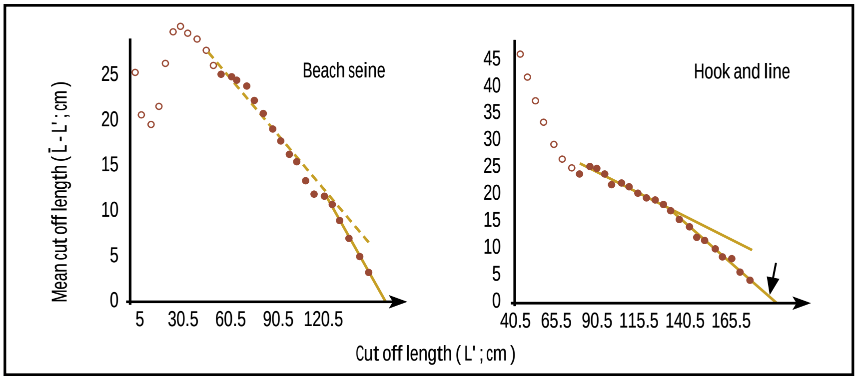

Fig. 2. Preliminary estimates of L_∞ and Z/K obtained from length-frequency data using the Wetherall's method (1986)

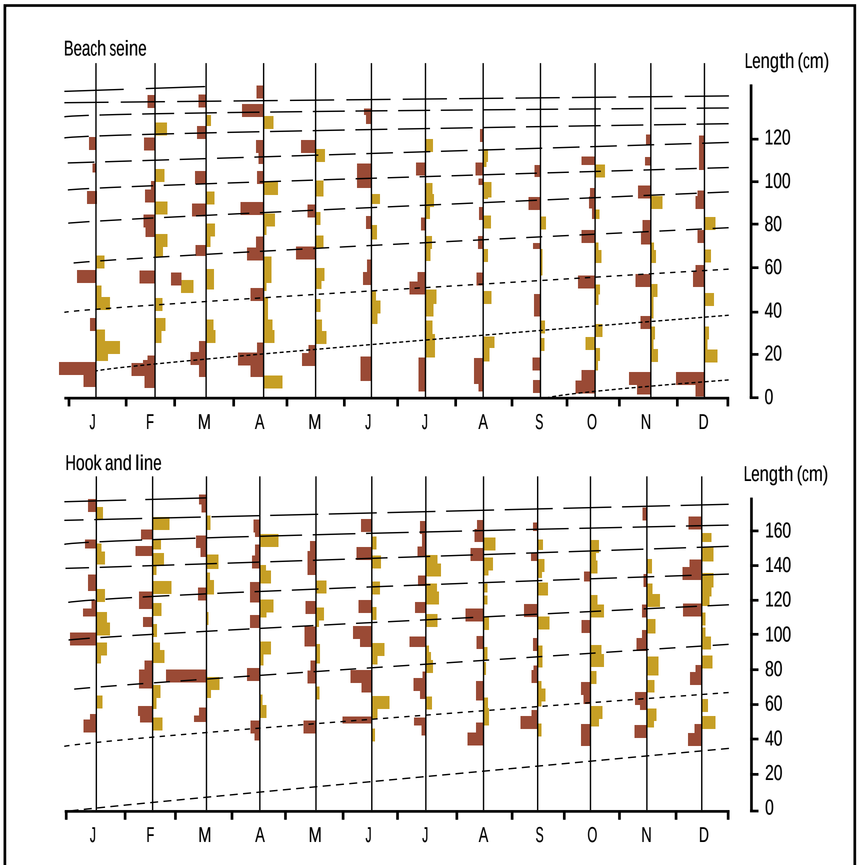

Fig. 3. Evaluation of the growth of *Lates niloticus* in Nyanza Gulf, Lake Victoria, using ELEFAN 1 on length-frequency data (L_∞=228cm, K=0.185)

Materials and methods

Sampling methodology

Length-frequency data for the Nile perch was obtained through the routine Catch Assessment Survey Programme conducted on a monthly basis at 22 fish landing beaches. Two sets of data, both obtained in 1991, were used: one from littoral beach seining and the other one from hook and line fisheries. These were analyzed separately. The purpose of using the two different sets of data was to point out possible differences in the dynamics of *L. niloticus* according to the range of sizes and location in the lake. The samples were grouped into 5 cm length groups, ranging from 3 to 168 cm, based on total length (TL) measurements.

Data analysis

The "COMPLEAT ELEFAN" (Electronic Length Frequency Analysis) software developed by Gayanilo et al. (1991) for IBM/PC compatible microcomputers was used for the analysis of the length frequency data in the following way:

i. ELEFAN 0 was used to create and modify the length frequency data for use with the remaining parts of the program.

ii. ELEFAN I was used to estimate the **growth parameters** based on the Von Bertalanffy Growth Formula (VBGF) expressed in the form (Pauly and Gaschutz 1979):

$$L_t = (L_\infty [1 - e^{-K(t-t_0)}]) \qquad (1)$$

where:

L_t is the predicted length at age t.
L_∞ is the asymptotic length or mean length the fish of a given stock would reach if they were to grow forever.
K is a growth constant, also called "stress factor" by Pauly (1980).
t_0 is the "age" the fish would have been at zero length.

Given the data and the ecological conditions of the lake, no seasonality could be taken into account.

iii. ELEFAN II was used to estimate the **instantaneous total mortality** coefficient Z via a "length-converted catch-curve" analysis as described by Pauly (1984). To compute the natural mortality coefficient M, Pauly (1980) developed an empirical formula using the multiple regression indicated below:

$$\log_{10} M = -0.0152 - 0.279 \log_{10} L_\infty + 0.65431 \log_{10} K + 0.463 \log_{10} T^{o}C \qquad (2)$$

This formula was used to obtain the estimate of M, given L_∞ (total length in cm), K (the growth constant), and T (the mean environmental temperature °C). Once Z and M were obtained, then fishing mortality (F) was derived from the relationship:

$$F = Z - M \qquad (3)$$

And the exploitation rate (E) was obtained by the relationship:

$$E = F/Z = F/(F + M) \quad (4)$$

iv. ELEFAN II was further used to obtain expressions of the **seasonal changes in recruitment patterns** displayed in a graphical form. It was subdivided into normally distributed recruitment pulses, suggestive of the recruitment seasons for an arbitrary year. Growth parameter estimates L_∞ and K were used as inputs in this analysis in application of the NORMSEP program in ELEFAN II.

v. ELEFAN II has a routine that was used to get preliminary estimates of L_∞ and of the ratio Z/K using the method of Wetherall (1986) as modified by Pauly (1986).

Results

Preliminary estimates of L_∞ using the method of Wetherall (1986) gave the following values: 168 cm for beach seine samples and 211 cm for the hook and line samples (Fig. 2). With ELEFAN 1, the growth parameter estimates are L_∞ = 169 cm and 223 cm, respectively, and K = 0.0195 yr^{1} and 0.180 yr^{1}, respectively (Fig. 3).

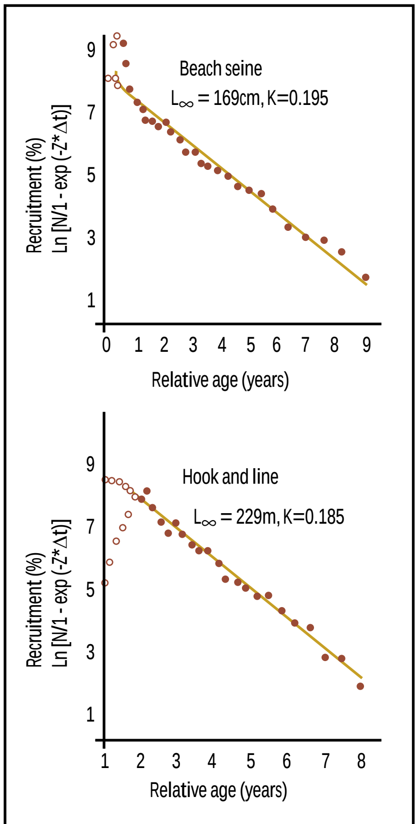

Fig. 4. Length converted catch curve analysis operated using ELEFAN 11 on length-frequency data

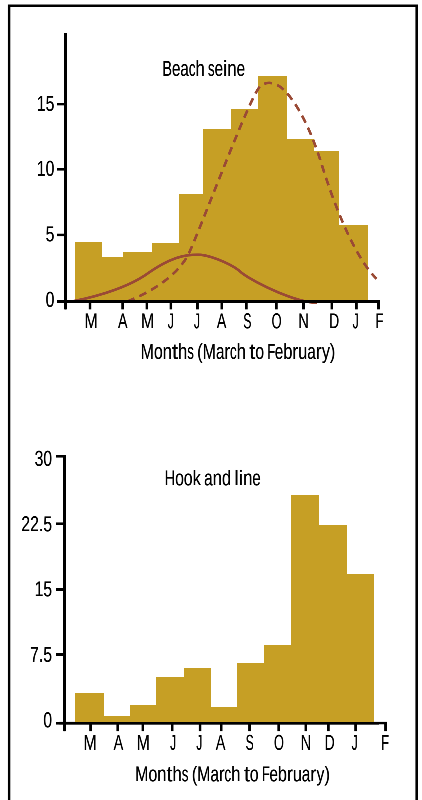

Fig. 5. Recruitment pattern of *Lates niloticus* in Nyanza Gulf, Lake Victoria as provided by ELEFAN 11 using length-frequency data

The length–converted catch–curve analysis produced total mortality estimates of Z = 0.724yr^{1} and 0.975yr^{1}, respectively, in the same ranges of age: 2 to 9 (Fig. 4). The natural mortality estimates were 0.372 yr^{1} and 0.324 yr^{1}, leading to fishing mortality values of 0.352 and 0.633, respectively.

The recruitment pattern (Fig. 5) for *L. niloticus* in the Nyanza Gulf suggests a major peak recruitment from August to December from beach seine data and from October to January from the hook and line data, with a minor one in June in both cases. This suggests two cohorts per year, with one being poorly pronounced.

Discussion

The estimates of the growth parameters are in the range of already available values from the literature (Moreau 1982). Acere (1985) obtained L_∞ = 251 cm and K = 0.091yr^{1} for Nile perch from the Uganda waters of Lake Victoria using the probability paper method. Asila and Ogari (1988) obtained L_∞ = 205 and K = 0.19 yr^{1} for Nile perch in the Nyanza Gulf using the Bhattacharya (1967) and Gulland and Holt (1956) plots. Moreover, the data of Acere (1985) allowed a fitting with the VBGF as modified by Soriano et al. (1992) taking into account a two phase growth curve for juveniles and adults as shown on Fig. 6a. This new curve can be assumed to result from two different growth patterns as shown in Fig. 6b. It shows that the combination of L_∞ and K values obtained in the current study from the beach seining samples are similar to those of juveniles in Fig. 6b. The combination of L_∞ and K values obtained from the samples from hook and line fishing are similar to the ones for adults shown in Fig. 6b. This indicates that the difference between growth parameters calculated from the two sets of length frequency data are acceptable as they can be assumed to come from two slightly different stocks: one living in the littoral areas and exploited by beach seines and one living in more open and deep waters and exploited by hook and line. Those two stocks can also be assumed to have different feeding habits as assumed by Soriano et al. (1992) in their model. The large *L. niloticus* are known to be more piscivorous that the small ones (Ogari and Dadzie 1988) in Lake Victoria.

Concerning total mortality, Acere (1985) provided values of Z that decreased from 2.6 to 0.85 between 1964 and 1977. Similarly, Asila and Ogari (1988) obtained total mortality estimates of Z = 2.2 to 1.6 in 1978 and 1984, respectively. In Uganda, the period of the study of Acere (1985) was one of strong development of the population of *L. niloticus* with a very high initial turnover (e.g. P/B or Z value), which progressively declined after some years. The same situation probably occurred during the study of Asila and Ogari (1988) between 1978 and 1984 when catches of *L. niloticus* increased enormously in the Nyanza Gulf (Ogari 1985; Rabuor 1991). After a similar high turnover (Z = 2.2.), Z tends to decrease to the low values observed in this study (0.72 to 0.96). Note that, even with these low values of Z, the exploitation rate is high: 0.486 in the littoral areas and 0.663 for the hook and lines fishery. This last value is similar to the one estimated by Asila and Ogari (1988).

The period of the main recruitment pulse lasts from September to January of the following year. A minor pulse takes place in June. This is supportive of Gee (1964, 1965) who suggested that Nile perch in Lake Victoria probably spawn twice a year. Gee (1964) suggests that the spawning periods are mainly in the rainy seasons. This is true for the main pulse, which occurs before and during the short rainy season (October to December).

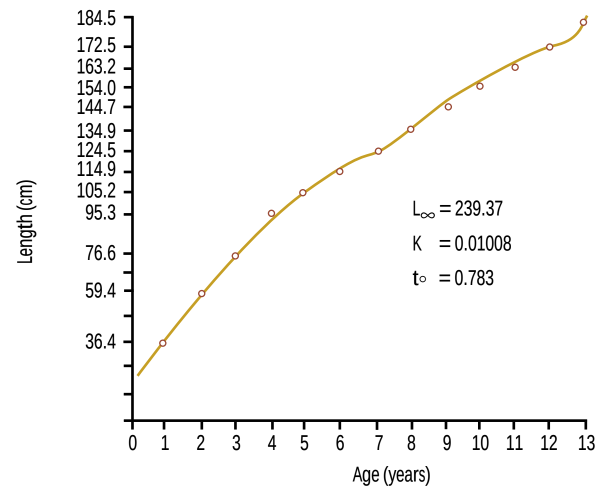

Fig. 6(a). Mean length at age of Nile perch in Lake Victoria: fitted growth curve using the biphasic model of Soriano, (1992)

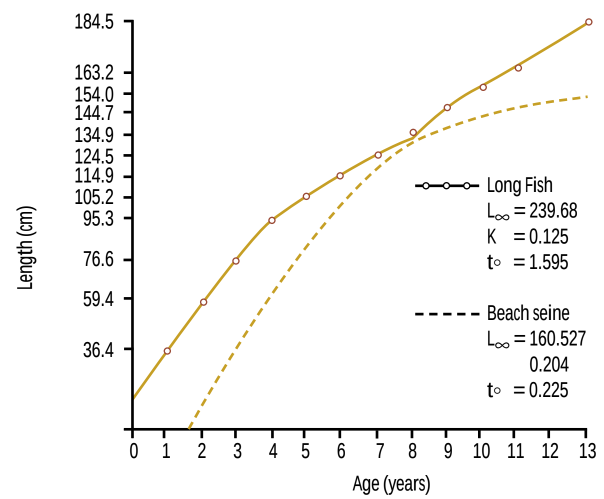

Fig. 6(b). Ordinary Von Bertalanffy growth curves fitted separately for juveniles and adults

Conclusion

It is the first time that a length frequency analysis of *L. niloticus* from Lake Victoria has been made based on two sets of data from two different fisheries. The results suggest different demographic situations for the two sub-stocks concerned. Moreover, low turnover (i.e. low value of Z) means that, after a phase of strong development, this population may now be in some kind of demographic equilibrium. However, further investigations are needed to monitor its demographic evolution and possible over-fishing, as has already been observed in some parts of the Uganda littoral areas of Lake Victoria (A. Kudhogania pers. comm. to Jacques Moreau in 1994).

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References

Acere, T.O. 1985. Observations on the biology of the Nile perch (*L. niloticus*) and growth of its fishery in the northern waters of Lake Victoria. FAO Fish. Rep. 335:42–61.

Asila, A.A. and J. Ogari. 1988. Growth parameters and mortality rates of Nile perch (*Lates niloticus*) estimated from length–frequency data in Nyanza Gulf (Lake Victoria). FAO Fish. Rep. 389:272-287.

Bhattacharya, C.G. 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics 23: 115–135.

CIFA (Committee for Inland Fisheries of Africa). 1988. Report of the fourth session of the sub-committee for the development and management of the fisheries of Lake Victoria, Kisumu, Kenya, 6-10 April 1987. FAO Fish. Rep. 388:112.

Copley, H. 1953. The tilapia fishery of the Kavirondo Gulf. J.E. African Nat. Hist. Soc. 94:1-5.

Gee, J.M. 1964. Nile perch investigations. EAFFRO Annual Report 1962/63: 14–24.

Gee, J.M. 1965. Nile perch investigations. EAFFRO Annual Report 1964:13–27.

Gayanilo F., M. Soriano and D. Pauly. 1991. A draft Guide to the Compleate

ELEFAN. ICLARM Software 2, 70 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Graham, M. 1929. The Victoria Nyanza and its fisheries. Crown Agents, London.

Gulland, T.A. and S.J. Holt. 1956. Estimation of growth parameters for data at unequal time intervals. J. Cons. Int. Explor. Mer. 25(2):215–222.

Moreau J. 1982. Exposé synoptique de données biologiques sur *Lates niloticus* L. FAO Fish Synopsis Mer. 132:39 p.

Muller, R.G. and R.S. Benda. 1981. A comparison of bottom trawl stock densities in the inner Kavirondo Gulf of Lake Victoria. J. Fish. Biol. 19: 399–401.

Ogari, T. 1985. Distribution, food and feeding habits of *Lates niloticus* (L.) in Nyanza Gulf of Lake Victoria (Kenya). FAO. Fish. Rep. 335:68–80.

Ogari, J. and S. Dadzie. 1988. The food of the Nile perch, *Lates niloticus* L. after the disappearance of the haplodichromine cichlids in the Nyanza Gulf of Lake Victoria (Kenya). J. Fish. Biol. 32:571–577.

Okach, J. I. O. 1982. Reproductive biology and feeding of Siluroid catfish *Bagrus docmac* Forskal (Pisces: Bagridae) in the Winam Gulf of L.Victoria, East Africa. University of Nairobi, MSc Thesis

Okach, J.I.O. and S. Dadzie. 1988. The food, feeding habits and distribution of a Siluroid catfish, *Bagrus docmac* (Forskal) in Kenyan waters of Lake Victoria. J. Fish Biol. 32:21–26.

Pauly, D. and G. Gaschutz. 1979. A simple method fitting oscillating length growth data, with a program for pocket calculator. ICES CM 1979/G : 24 Demersal Fish Ctee, 26 p.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. FAO. Fish. Circ. No. 729.

Pauly, D. 1984. Length converted catch-curves. A powerful tool for fisheries research in the tropics (part 3). ICLARM Fishbyte 2(3):9–10.

Pauly, D. 1986. On improving operation and use of the ELEFAN programs. Part II. Improving the estimation of L_∞ Fishbyte 4(1):18–20.

Rabuor, C.O. 1991. Catch and effort sampling techniques and their application in freshwater fisheries management: with specific reference to Lake Victoria, Kenya waters, p. 373–381. *In* I.G. Cowx (ed.) Catch effort sampling strategies. 420 p.

Rinne, J.N. and B. Wanjala. 1982. Observations on movement patterns of Tilapia spp. in Nyanza Gulf, Lake Victoria, East Africa. J. Fish. Biol. 20: 317–332.

Soriano M., J. Moreau, J.M. Hoenig and D. Pauly. 1992. New functions for the analysis of two phase growth of juvenile and adult fishes, with application to Nile perch. Trans. Amer. Fish. Soc. 121:486–493.

Wetherall J.A. 1986. A new method for estimating growth and mortality parameters from length frequency data. Fishbyte 4(1):12–14.

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