

## GROWTH AND MORTALITY PARAMETERS OF MANGO TILAPIA (*SAROTHERODON GALILAEUS*, LINNAEUS, 1758) IN IKERE-GORGE, OYO STATE, NIGERIA

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### ABSTRACT

Fish population is majorly regulated by the growth and mortality of fish species in aquatic ecosystems. This study is aimed to examine the growth and mortality parameters of *Sarotherodon galilaeus* of Ikere-gorge. The fish were sampled between January 2017 and December 2018. The total length was measured using a measuring board. The FAO-ICLARM Stock Assessment Tool (FiSAT II) software was used for data analysis. A total number of 1,388 mango tilapia were sampled with their length ranging from 7 to 31 cm. The estimated growth parameters were: asymptotic length ( $L_{\infty}$ ) was 32.55 cm; growth coefficient (K) was 1.6 year<sup>-1</sup>; growth performance ( $\Theta$ ) was 3.23; length at maturity ( $L_m$ ) was 19.05 cm; reproductive load ( $L_m/L_{\infty}$ ) was 0.58 and optimum length ( $L_{opt}$ ) was 20.04 cm. Likewise, natural, fishing and total mortalities were 2.38, 3.74, and 6.08 respectively. The values of the exploitation rate (0.61) and the ratio of total mortality and growth coefficient (3.80) showed that the mango tilapia is a highly exploited fish species in Ikere-gorge. But, the sustainable maximum exploitation rate ( $E_{max}$ ) was 0.48 which implies that the present exploitation rate of mango tilapia in Ikere-gorge should be reduced by 27.08 % to attain sustainability in Ikere-gorge. Therefore, appropriate fishing regulations should be enforced to regulate fishing gears and mesh size that will fish mango tilapia at an optimum length of 20.04 cm.

**Keywords:** *Exploitation; length; maturity; overfishing; recruitments; reproductive load Sarotherodon galilaeus.*

### INTRODUCTION

The study of the dynamics of the fish population helps fishery managers to estimate the number of fish in a particular aquatic ecosystem. Fish population is regulated by recruitment, migration, and mortality of fish; so if any of these factors is altered, the population will change with a corresponding magnitude (Rios, 2017). Recruitment is the number of fish that arrive in the fishing area for the first time in the exploitable phase. These individuals grow, spawn at least once or several times, and die (Cadima, 2003). Different valid models are used in fisheries

biology for the exploitable phase of the resource and the most wellknown is the von Bertalanffy Model (1938). Fish increase in length as they grow older and most growth and mortality parameters are length dependent. Likewise, length has another advantage over weight in fisheries science, because fish rarely lose length but fish can lose weight easily due to sickness or lack of food supply (Mathews and Samuel, 1990). Therefore, length, based on von Bertalanffy's growth equation has become one of the cornerstones in fishery biology and it is preferred by most authors to estimate growth

and mortality parameters (Sparre and Venema, 1998).

The growth parameters of fish are assessed with different types of length variations along its growth phase such as asymptotic length, optimum length, length at first catch, and length at first maturity. Each of these lengths provides management information for the sustainability of fisheries. Asymptotic length ( $L_{\infty}$ ) in cm is the parameter of the von Bertalanffy growth function (VBGF), which is the mean length that the fish would reach if they were to grow indefinitely. The mean length at which fish of a given population become sexually mature for the first time ( $L_m$ ) is an important management parameter used to monitor whether enough juveniles in an exploited stock mature and spawn (Froese and Binohlan, 2000). The optimum length ( $L_{opt}$ ) of the fish is the maximum possible yield per recruit obtainable at an intermediate age  $t_{opt}$ . The product of the number of surviving fish individuals multiplied by their average weight results in the highest biomass, usually corresponding to the highest egg production (Holt, 1958; Beverton, 1992). Length-at-first capture  $L_{50}$  or  $L_c$  (cm) is the length at which fish are vulnerable to fish gears.

Among fish population parameters, mortality is an essential parameter in understanding the dynamics of fish population. It is usually divided into two; natural and fishing mortality such that the sum of these gives total mortality. Natural mortality is the loss of fish in a population from natural sources such as predation, disease, and old age. Fishing mortality is the loss of fish in a population due to the exploitation of fish with various gears and methods (Simpfendorfer *et al.* 2005). Mortality is a function of size or age. Small or young fish are more vulnerable to a natural mortality than big or old fish because they

have low resistance to unfavorable environmental factors and more predators can eat them. However, small or young fish are less vulnerable to fishing mortality than big or old fish because they either have not yet migrated to the fishing ground or escape through the meshes of the gears (Sparre and Venema, 1998). Excessive mortality of both small (young) and big (old) may lead to growth and recruitment overfishing respectively. Growth overfishing occurs when fishing mortality is greater than that required to attain the maximum yield per recruit but recruitment overfishing is associated with fishing at a level that greatly reduces spawning potential and reproductive capacity (Cadima, 2003; Goethel *et al.* 2012). Therefore, this study aimed to examine the growth and mortality parameters and assess the sustainability of fishing mortality of the Mango tilapia of Ikere-gorge.

## MATERIALS AND METHODS

*Sarotherodon galilaeus* of Ikere-gorge (Ajagbe *et al.* 2020) were sampled monthly for twenty-four months (January 2017 and December 2018). Mango tilapia were randomly sampled from the catches of commercial artisanal fishermen using different fishing gears. The fish samples were sorted and identified to the species level using the guides provided by Adesulu and Sydenham, (2007). The total length of individual fish was measured with fish measuring board to the nearest 0.01 cm.

Means of the two years (from May 2021 to April 2023) monthly length-frequency distribution of *Sarotherodon galilaeus* were analyzed using the procedure of Gayanilo Jr. *et al.* (2005) of the FiSAT II (version 1.2.2) computer software package of fish stock assessment. ELEFAN I (nonparametric scoring of VBGF Fit) and II subroutines of the

software were used to estimate von Bertalanffy growth and mortality parameters, recruitment patterns and probability of capture. The equation for growth in length is given by,

$L_t = L_\infty [1 - \exp\{-K(t - t_0)\}]$  (1) Where:  $L_t$  is the estimated length at age  $t$ ;  $L_\infty$  (cm) is the asymptotic length in cm;  $K$  is a growth coefficient; ' $t_0$ ' is the theoretical age at which fish would have had zero length (Pauly 1986; Abdul *et al.* 2012).

The overall growth performances index ( $\emptyset'$ ) for the selected fish species were computed using the Pauly and Munro (1984):  $\emptyset' = \log_{10} K + 2 \log_{10} L_\infty$  (2)

Natural mortality was estimated using Pauly (1980)

$$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.06543 \ln K + 0.4634 \ln \check{T} \quad (3)$$

Where:  $M$  is the natural mortality;  $\check{T}$  is the Annual mean surface water temperature (°C) for the Ikere gorge was 28.14 °C.

The total mortality,  $Z$ , was obtained according to the model proposed by Ssentongo and Larkin (1973):

$$Z = (nK/(n+1)) (\ln(L_\infty - L_c) (L_\infty - \check{L}))^{-1} \quad (4)$$

Where:  $n$  is the number of fishes sampled;  $L_c$  is the length of the smallest fish in the sample;  $\check{L}$  is the average length in the samples

But, total fishing mortality is:

$$Z = F + M \quad (5)$$

Therefore, fishing mortality ( $F$ ) can be estimated as:

$$F = Z - M \quad (6)$$

Therefore, exploitation rate ( $E$ ) which is the mortality rate due to fishing activities can be estimated as:

$$E = F/F+M = F/Z \quad (7)$$

Length-at-first-maturity,  $L_m$  was estimated as:

$$\log L_m = 0.8776 \log L_\infty - 0.38 \quad (8)$$

Longevity was obtained from the following equation (Pauly 1983):

$$t_{max} = t_0 + 3/K \quad (9)$$

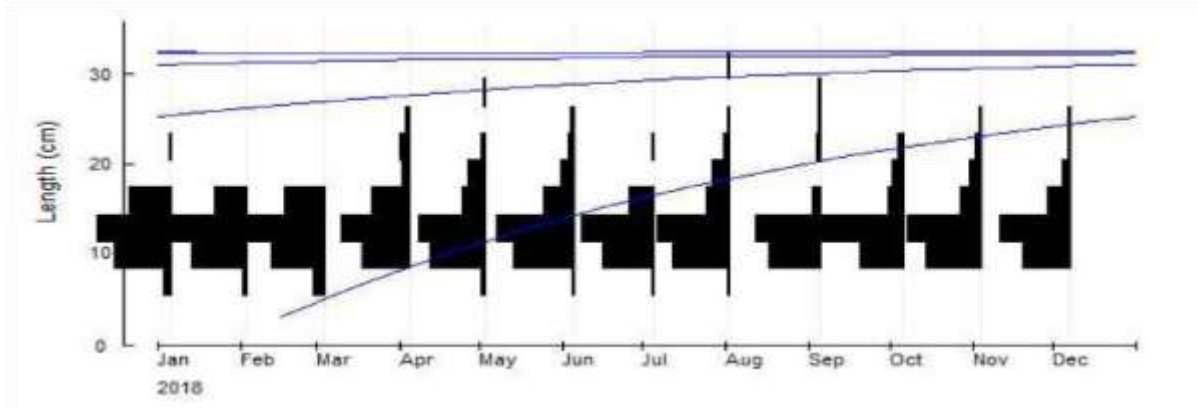
Where:  $t_{max}$  is the approximate maximum age the fish of a given population would reach.

## RESULT

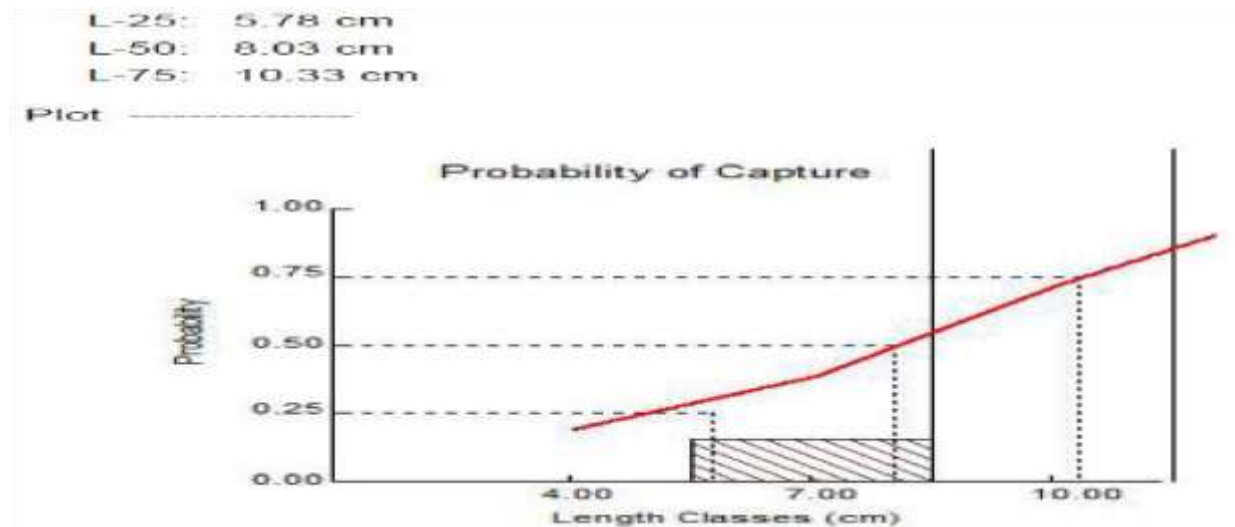
The total number of *Sarotherodon galilaeus* (Mango tilapia) sampled in Ikere-gorge was 1,388, and their size distribution varied between 7 and 31 cm with a mean of 14.2–2.98 cm. Figure 1 shows the von Bertalanffy growth function curves of Mango tilapia. The estimated growth parameters for Mango tilapia are the asymptotic length or the theoretical maximum length a fish species would reach if it lived indefinitely ( $L_\infty$ ) was 32.55 cm; the growth coefficient or the rate at which a fish species attained its maximum length ( $K$ ) was 1.6 year<sup>-1</sup>; and the value of  $K$ -scan or surface response ( $R_n$ ) was 0.18. The growth performance ( $\emptyset'$ ) was 3.23 and the longevity was 1.88 years. Figure 2 shows the probability of capture of Mango tilapia. It shows that the length at first capture or 50 % of the stock vulnerable to fishing gear ( $L_{50}$ ) was 8.03 cm. The length at first maturity of Mango tilapia was  $L_m$  was 19.1 cm; the reproductive load ( $L_c/L_\infty$ ) was 0.58 while the optimum length ( $L_{opt}$ ) which is the length at which the total biomass of a year-class reaches a maximum value was 20.04 cm. The recruitment patterns of mango tilapia in Ikere-gorge (Fig. 3) show two recruitment cycles

per year. The first recruitment occurred between January and April with a peak in

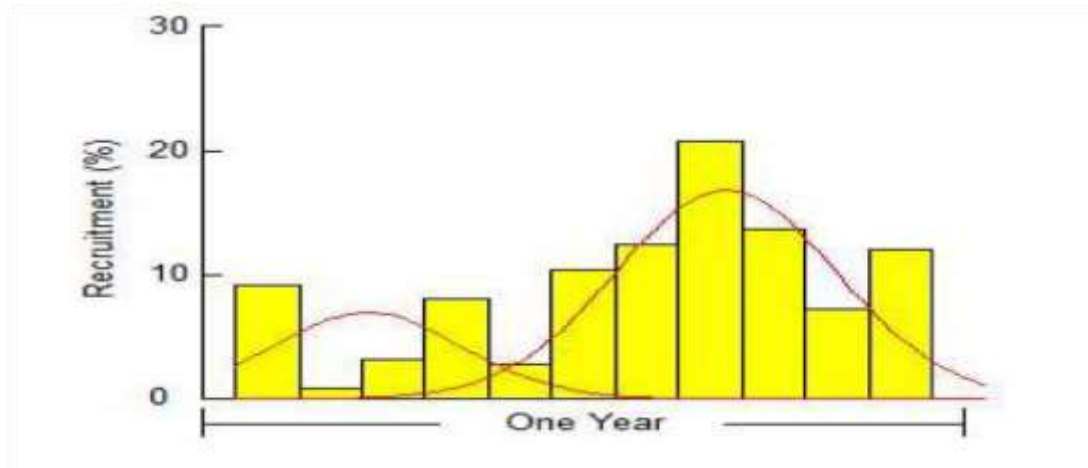
January. The second recruitment period occurred between June and November with a peak in August.



**Figure 1: The von Bertalanffy growth function curves of mango tilapia on Ikere-gorge**

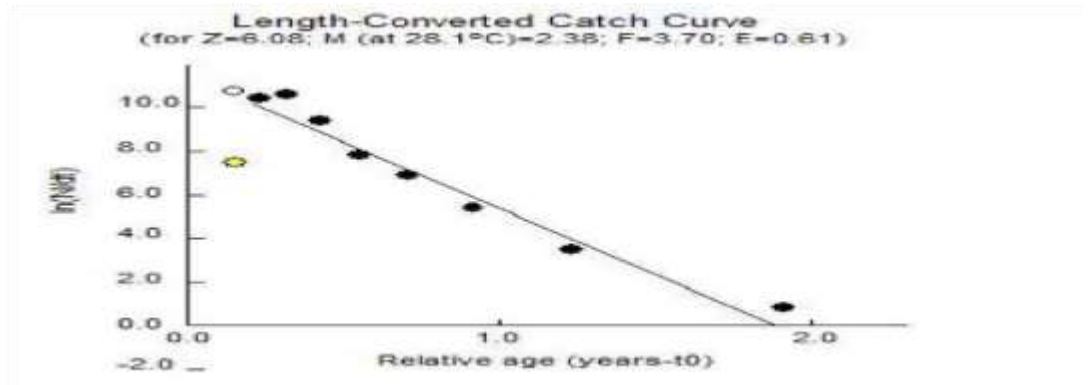


**Figure 2: The probability of capture of mango tilapia in Ikere-gorge**

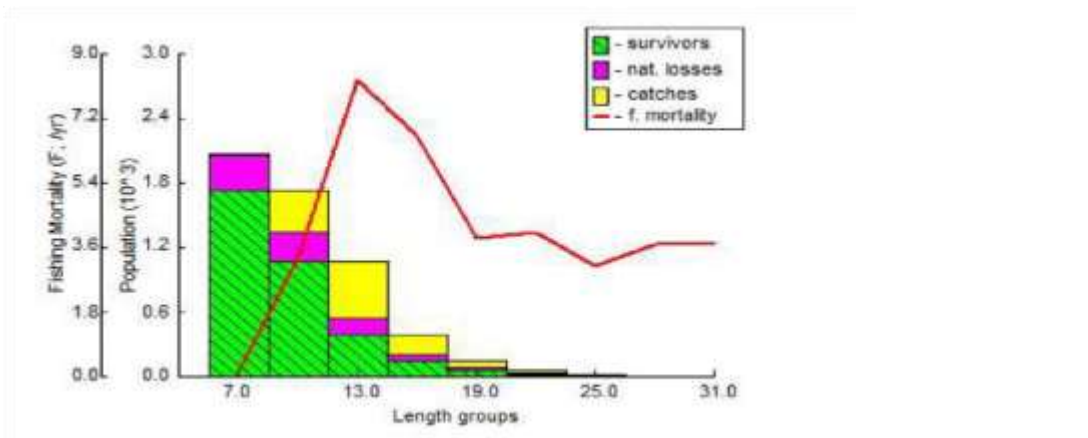


**Figure 3: The recruitment pattern of mango tilapia in Ikere-gorge.**

Figure 4 shows the length converted catch curve of Mango tilapia in Ikere-gorge. The unselected points revealed the stock that is yet to be recruited into the population. The



**Figure 4: The length converted catch curve of mango tilapia in Ikere-gorge**



**Figure 5: Virtual population analysis of mango tilapia in Ikere-gorge.**

estimated rate of instantaneous total mortality per year ( $Z$ ) of Mango tilapia in Ikere-gorge was  $6.08 \text{ year}^{-1}$ , the natural mortality was  $2.38 \text{ year}^{-1}$ , the fishing mortality was  $3.70 \text{ year}^{-1}$  and the exploitation rate was 0.61 at  $28.14^\circ\text{C}$  local temperature of Ikere-gorge. The virtual population of mango tilapia in Ikere-gorge showed that fishing mortality was high between the length range of 13 and 18 cm (Fig. 5). This is the length range of Mango tilapia that is heavily exploited in Ikeregorge. Figure 5 shows that natural mortality (as a

**DISCUSSION**

Fish growth and mortality parameters give a clear picture of the state of sustainability of exploitation of the resource in an aquatic ecosystem. It gives a basis for comparing the dynamic structure of the fish population.

The length range of Mango tilapia obtained in this study is lower than 11.0 – 41.9 cm reported by Abdul *et al.* (2019) for mango tilapia in Tropical Coastal Estuary, Nigeria; but greater than 9.5 and 22.5 cm reported by El-Bokhty (2006) for mango tilapia in Lake Manzala, Egypt. The asymptotic length obtained in this study is lower than 37.39 cm reported by Mahmoud *et al.* (2013) for mango tilapia in Nozha Hydrodrome, Alexandria, Egypt; but greater than 23.63 cm reported by El-Bokhty (2006) for mango tilapia inhabiting Lake Manzala, Egypt. The variation in the values of asymptotic lengths may be due to the variations in the environmental conditions among different geographical localities and the method of sampling of the calculated biological parameters (Mahmoud *et al.* 2013).

The rate at which fishes approach their asymptotic length is the growth coefficient ( $K$ ). It is used to estimate longevity or life expectancy for individual fish. The  $K$ -value of

result of predatory, diseases, etc.) predominates the length range of Mango tilapia between 0 and 7 cm. This represents the unexploited length range. However, fishing mortality begins to grow steadily from a length range above 8 cm and predominates at a length range of 13 cm. There is full exploitation at size 19 cm and above. The virtual population diagram suggested that there is growth in the overfishing of mango tilapia in Ikere-gorge.

mango tilapia obtained in this study is consistent with Pauly *et al.* (1984) in  $K$  values for tropical fish stock fall between 0.39 and 1.6 per year. The result shows that mango tilapia has the highest  $K$ -value of  $1.6 \text{ year}^{-1}$ , and with longevity of 1.88 years. However, Abdul *et al.* (2019) reported that mango tilapia in Tropical Coastal Estuary, Nigeria has a growth rate ( $K$ ) of 0.81 per year and longevity of 3.70 years. This shows that there is an inverse relationship between  $K$ -values and longevity. That is, as the  $K$  value increases, the longevity decreases, and vice versa. This observation confirmed the report of Sparre and Venema (1998) that fish with high  $K$ -value is short-lived almost reaching their  $L_\infty$  in a year or two; while fish species with low  $K$ -value need many years to reach their  $L_\infty$ . Length at first maturity is used to monitor whether enough juveniles in an exploited stock mature and spawn (Froese and Binohlan, 2000). Typically, fish are expected to spawn at least once before becoming vulnerable to fishing gear.

However, the Mango tilapia of Ikere Gorge are vulnerable to fishing gear before reaching that size. It is observed that the length ( $L_c$ ) at which 50 % of the fish become vulnerable to capture is less than the length ( $L_m$ ) at which the fish reaches its first sexual maturation

(Abdul *et al.* 2019; El-Bokhty 2006). However, this is not sustainable; it is very important to maintain and keep the spawning of the fish population. El-Halfawy *et al.* (2007) reported that the length at first sexual maturity of female *Saurida undosquamis* is determined at the length of 18.1 cm, which corresponds to an age of two years.

The instantaneous total mortality (Z), natural mortality (M), fishing mortality (F), and exploitation rate obtained in this study showed that mango tilapia is overexploited in Ikere-gorge. But, Abdul *et al.* (2019) and El-Bokhty (2006) reported that the exploitation rate (E) of mango tilapia was less than the optimum exploitation of 0.5 in their respective studies and they concluded that its exploitation was still below optimum; suggesting that mango tilapia is under fished in their study areas. Likewise, the value of Z/K is greater than 1 which is an indication that the stock is most exploited and dominated by mortality (Udoh *et al.* 2015; Ahmad *et al.* 2018). The high natural mortality recorded by mango tilapia corresponds to the result obtained from the virtual population analysis of the species. Nevertheless, the maximum sustainable exploitation rate obtained in this study was greater than what was reported by Gheshlaghi *et al.* (2012) for *Rutilus frisii kutum*, in the Southern parts of the Caspian Sea.

## CONCLUSION

The growth and mortality parameters of mango tilapia obtained in this study show that the stock is overexploited in Ikeregorge. The mango tilapia of Ikere-gorge has a high K-value and short longevity. It is heavily exploited at lower size before its length at maturity. Likewise, high natural mortality and the value of Z/K greater than 1 corresponds to

the result obtained from virtual population analysis of the species which indicated that mango tilapia of Ikeregorge is overexploited. The fishing pressure and the present level of exploitation are not sustainable and therefore should be reduced to the optimum level for the stock to be sustainable. There should be regulation of appropriate fishing gear and mesh size that will fish mango tilapia at an optimum length of 20.04 cm.

## REFERENCES

- Abdul, W. O., Omoniyil, I. T., AkegbejoSamsons, Y., Akinyemi, A. A., Agbon, A. O. and Adeosun, F. I. 2012. Management Indicators and Growth Performance Index of *Tilapia zillii* in a Tropical Coastal Estuary. *Journal of Agricultural Science*, 4(11): 66 – 77.
- Abdul, W. O., Omoniyi, I. T., Bashir, A. O., Makinde, A. A., Adekoya, E. O., Owoade, T. and Oriyomi, J. T. 2019. “Length Base Structure and Growth Parameters of *Sarotherodon galilaeus* (Pisces: Cichlidae) in Tropical Coastal Estuary, Nigeria”. *Pacific Journal of Science and Technology*, 20(1): 289-297.
- Adesulu, E. A. and Sydenham, D. H. J. 2007. The freshwater fishes and fisheries of Nigeria. Published by Macmillan Nigeria Publishers Limited. Printed by Foludex Press Limited, Ibadan, 85p
- Ahmad, I. M., Yola, I. D. and Suleiman, N. 2018. Mortality and Exploitation Rates of Challawa Gorge Dam

- Fishes, Kano State, Nigeria. *Journal of Fisheries and Livestock Production*, 6: 262. doi: 10.4172/2332-2608.1000262
- Ajagbe, S. O., Ajagbe, R. O., Ariwoola, O. S., Abdulazeez, I. F., Oloba, O. G., Oyewole, O. O., Kareem, A. T., Ojubolamo, M. T., Olomola, A. O., and Oke, O. S. (2020). Effect of fishing activities on fishery resources in Ikere-gorge, Iseyin, Oyo State, Nigeria. *Nigerian Agricultural Journal* 51(1): 79 – 86. ISSN: 0300-368X  
<http://www.ajol.info/index.php/na>
- Beverton, R. H. J. 1992. Pattern of reproductive strategy parameters in some marine teleost fishes. *Journal of Fish Biology*, 41(13): 137-160.
- Cadima, E. L. 2003. Fish stock assessment manual. *FAO Fisheries Technical Paper*. No. 393. Rome, FAO. 161p.
- El-Bokhty, E. E. B. 2006. Assessment of Family Cichlidae Inhabiting Lake Manzala, Egypt. *Egypt Journal Aquatic Biology and Fisheries* 10(4): 85 – 106.
- El-Halfawy, M. M., Amin, A. M., & Ramadan, A. M. (2007). Growth and Reproduction of Female Brushtooth Lizardfish *Saurida undosquamis* (Richardson) from the Gulf of Suez, Egypt. *Ege Journal of Fisheries and Aquatic Sciences*, 24(1): 143-148.
- Froese, R., and Binohlan, C. 2000. Empirical relationship to estimate asymptotic length, length-at-first maturity, and length maximum yield per recruit in fishes, with a simple method to evaluate frequency data. *Journal of Fish Biology*, 56: 758773.
- Gayanilo, F. C. Jr. Sparre, P.; Pauly, D. 2005. FAO-ICLARM Stock Assessment Tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8, Revised version. Rome, FAO. 2005. 168 p. (Includes a CD-ROM with the software).
- Gheshlaghi P., Vahabnezhad A. and Taghavi-Motlagh S. A. 2012. Growth parameters, mortality rates, yield per recruit, biomass, and MSY of *Rutilus frisii kutum*, using length frequency analysis in the Southern parts of the Caspian Sea. *Iranian Journal of Fisheries Sciences*, 11(1): 48-62
- Goethel, D. R., Cadrin, S. X. and Rothschild, B. J. 2012. Reconsidering Historical Definitions of Overfishing and the Balance between Sustainable Use and Overexploitation. ICES ASC Bergen, Pp 19.
- Holt, S. J. 1958. The evaluation of fisheries resources by the dynamic analysis of stocks, and notes on the time factors involved. *ICNAF Special Publication* I, 77–95.
- Mahmoud, H. H., Ezzat, A. A., Ali, T. E. and El Samman, A. 2013. Fisheries management of cichlid fishes in Nozha Hydrodrome, Alexandria, Egypt. *Egyptian Journal of Aquatic Research*, 39: 283–289

- Mathews, C. P. and Samuel, M. 1990. Using the growth performance index  $\Theta$  to choose species aquaculture: An example from Kuwait. *Aquabyte*, 3(2): 1–4.
- Pauly, D. and Munro, J. L. 1984. Once more, on the composition of growth in fish and in vertebrates. *Fishbyte*, 2(1): 21.
- Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 Fish stocks. *Journal du Conseil / Conseil Permanent International pour l'Exploration de la Mer*, 39: 175-192.
- Pauly, D., 1986. On improving operation and use of the ELEFAN programmes. Part II. Improving the estimation of L4. *Fishbyte*, 4: 18-20.
- Pauly, D., Ingles, J. And Neal, R. 1984. Application of objective methods for the estimation of growth, mortality, and recruitment-related parameters of shrimp stocks from lengthfrequency data Elefan 1 And 2 Pp 220 – 234. In *Gulland, J. A. and Rothschild B. J. Editors Penaeid shrimp: Their Biology and Management*. Fishing News (Book) Survey.
- Rios, A. 2017. Introduction to population dynamics and stock assessments. MREP USVI, South East Fisheries Science Center, NOAA Fisheries, Pp 56.
- Simpfendorfer, C. A., Bonfil, R. and Latour, R. J. 2005. Mortality estimation. In: (eds) *Musick, J. A. and Bonfil, R. 2005. Management techniques for elasmobranch fisheries*. FAO Fisheries Technical Paper. No. 474. Rome, FAO. 251p.
- Sparre, P. and Venema, S. C. 1998. Introduction to tropical fish stock assessment. Part 1. Manual. FAO. *Fisheries Technical Paper*. No. 1. 306 Rev 2. Rome. FAO. 407p
- Ssentongo, G. W. and Larkin, P. A. 1973. Some Simple Methods of Estimating Mortality Rates of Exploited Fish Populations. *Journal of the Fisheries Research Board of Canada*, 30(5): 695-698
- Udoh, J. P., Ukpatu, J. E. and Udoidiong, O. M. 2015. Population dynamics of *Chrysichthys nigrodigitatus* (Lacepede, 1803) in the Lower Cross River, Nigeria. *Croatian Journal of Fisheries*, 73, 103 – 114.
- Von Bertalanffy, A., 1938. A quantitative theory of organic growth. *Human Biology*, 10 (2): 181–182.