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Assessment of *Oreochromis niloticus* Caught off Lake Borollus, Egypt

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Abstract: Evaluation of *Oreochromis niloticus* caught from LakeBorollus was studied based on the length-frequency samples collected by different fishing gears. Analysis of the pooled data using (FiSAT) computer program returned the estimate of the von Bertalanffy's growth curve parameters as: L_∞ = 26.29 cm (total length); k = 0.81year^{-1}. Very narrow selection ranges were observed and recorded corresponding to the different fishing gears. The total mortality coefficient "Z" was found to be 3.43 year^{-1}. Also, the invariant measure of effort, the fishing rate (F), was estimated to be 1.99 year^{-1}. The estimated exploitation rate "E" was 0.58 which coincides with the maximum exploitation as revealed by Beverton and Holt's model. Their relative yield and relative biomass per recruit analysis showed that the stock of *O. niloticus* is over exploited. Howbeit, larger mesh sizes of fishing nets should be used to increase the mean lengths at first capture and their marketable sizes leading to more economic returns and also to conserve the spawning stock part of *O. niloticus* population instead of lowering the effort exerted which seems to be difficult to apply due to the social concerns of fishermen.

Key words: Selection Range · Fishing Methods · *Oreochromis niloticus* · Lake Borollus · Egypt

INTRODUCTION

Egypt has various inland resources, include the NileRiver with many irrigation canals, six northern coastal lagoons (Mariut, Edku, Borollus, Manzalah, Port Fouad and Bardawil). All of these lakes, with the exception of LakeMariut, are directly connected to the sea, El-Ganainy, [1].

Fishing activity has been proposed as the first major human disturbance to coastal areas Jackson *et al*. [2] and evidence of fishing activity going back to ancient times. BurollusLake, is a region of outstanding importance in terms of its participation of fish food security. It is located at the north of the Delta region and connected with the Mediterranean Sea via outlets. The annual fish production of this lake during 2009 was found to be 53401 tons representing about 47.2% of the northern Nile Delta lakes. Tilapia fish species represented the majority of the catch (38.81 %), followed by catfish (21.74%) and mugilid species (14.44) according to GAFRD [3].

Tilapia species in LakeBorollus are represented mainly by; *Oreochromis niloticus, Oreochromis aureus*, *Sarotherodongalilaeus* and *Tilapia zillii*. Both of the passive and active fishing gears are used in the lake. From the passive gears, basket traps, gill and trammel nets, while the active gears were mainly represented by the dragged or towed gears such as Lokaffa and Alqerba (Local names).

Various aspects of the biology of Cichlids of commercial importance have been studied by many authors e.g. Khalifa *et al*. [4], Abd-Alla and Talaat [5], Khallaf *et al.* [6] and Khallaf [7]. Fishing gear researches were conducted by Al-Sayes [8-10] and El-Bokhty [11]. While little studies concerning the fishing gear impacts on fish populations that dominate the Delta Lakes. (Ishak *et al*. [12], El-Bokhty [13, 14, 15]. It was shown by Kaiser *et al.* [16], Gislason [17] and Agardy [18] that capture fisheries impact target resources. They reduce their abundance, spawning potential and, possibly, population parameters (growth, maturation, etc.). They modify age and size structure, sex ratio, genetics and species composition of the target resources, as well as of their associated and dependent species. When poorly controlled, fisheries develop excessive fishing capacity, leading to overfishing, with major ecosystem, social and economic consequences. Also, it was shown that industrial fishing has been identified as a cause for life history changes in many harvested stocks, mainly

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because of the intense fishing mortality and its size-selectivity, Jørgensen *et al.* [19]. The present study is an endeavor to estimate the effect of different fishing techniques on the selection ranges and population parameters of *Oreochromis niloticus* stocks in the LakeBorollus, by using the length frequency data collected from the commercial catch of such gears, which may help for its sustainable management in the lake.

MATERIALS AND METHODS

Fish samples of the commercial catch of *Oreochromis niloticus* taken by various fishing gears working at Lake Borollus was undertaken during 2002-2003. The pooled length frequency distributions of *Oreochromis niloticus* were analyzed using the appropriate routines and subroutines of the "FiSAT" computer program according Gayanilo *et al.* [20] to stand on the fishery status of the population of this species. Also, the length frequency data of each fishing method was dealt separately to reveal the selection ranges as estimated from the probability of capture and corresponding to each fishing gear. An estimate of the asymptotic length (L_∞) and the growth coefficient (K) were obtained by the method of Wetherall [21]. The parameters were then used as seed values in ELEFAN I routine according to Pauly [22, 23] for estimating the best combination of L_∞ and K.

The instantaneous rate of total mortality (Z) was derived from the length converted catch curve method described by Pauly [24]. The instantaneous rate of natural mortality (M) was computed from the empirical equation of Pauly [25] considering the mean annual temperature of the lake as 22°C. The instantaneous rate of fishing mortality (F) was extracted as F=Z–M. The exploitation ratio was calculated as E= F/Z. The length at first capture "L_c" was derived from probabilitiesof capture generated from the catchcurve analysis. according to Pauly [24].

The relative yield per recruit (Y/R) and relative biomass per recruit (B/R)' were estimated by using the model of Beverton and Holt [26] as modified by Pauly and Soriano [27] and incorporated in the FiSat software package.

Statistical analysis was carried out using minitab-15 computer program in order to get the most suitable and best-fitting relationships to study time series trends of the major catch components (Total catch, Tilapia, Catfish and Mullets) of the lake.

RESULTS AND DISCUSSION

Lake Fisherycharacteristics: The total annual catch of Tilapia from LakeBorollus during the period 2000-2009 according to GAFRD [3] fluctuated between a minimum catch of 51768 ton in 2000 and a maximum catch of 59785 ton in 2002 with an average of 55207 ton showing a tendency of oscillation with a decreasing trend (Table, 1 and Fig. 1-a).

Tilapia fish formed the majority of fish catch from the lake (38.81 %) followed by catfish (21.74 %) while the mullets represented only 14.44 % in year 2009. Recently, the decline in the landed catch of tilapia fish (Fig. 1-b) was in parallel with an increase of both catfish (Fig. 1-c), mullets (Fig. 1-d) and other groups. Hence, the lake total fish catch seems nearly steady withslightlydecrease during the last few years. Unfortunately, the species constituents of tilapia fish were not identified by GAFRD estimates. It was found that *Oreochromis aureus* and *Oreochromis niloticus* dominated the catch of most of the fishing methods in the lake in numerical order, while *O. niloticus* dominated by weight over the others Al-Sayes [10].

Length Frequency Distribution: The length distribution of *O. niloticus* caught from the commercial catch of the different fishing gears (Figure 2) varied from one to another. The length ranges of fish caught by these nets were found to be as follows:

From 4.5 cm to 21.5 cm with an average length 11.3 cm for the dragged net Lokkaffa, from 8.5 cm to 15.5 cm with an average length 10.9 cm for those caught off dragged Al-Qerba, from 9.5 cm to 26.5 cm with an average length 13.6 cm for basket traps, from 9.5 cm to 20.5 cm for trammel nets and from 8.5 cm to 26.5 cm for seine net (El-Ganeb) with an average length 13.6 cm.

Table 1: Total fish catch landed from LakeBorollus during 2000-2009

Year	Total Catch (ton)
2000	51768
2001	59200
2002	59785
2003	55500
2004	55000
2005	53909
2006	52956
2007	58291
2008	52260
2009	53401
Av. Catch	55207

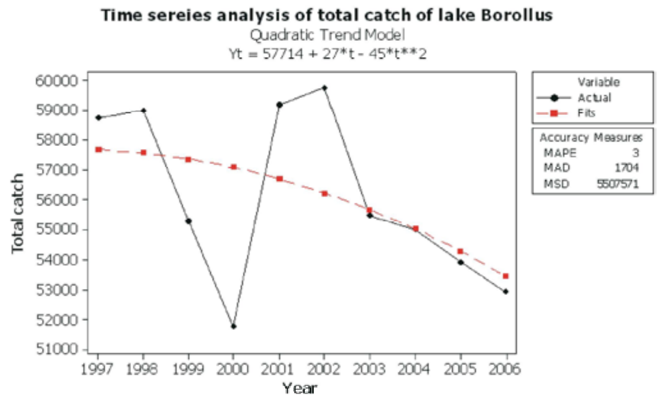


Fig. 1-a: Trend of total fish catch of Lake Borollus

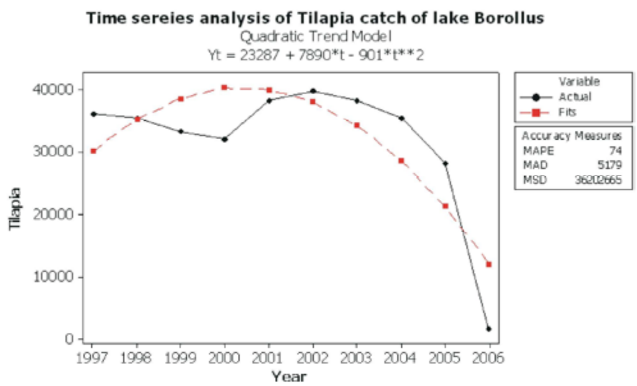


Fig. 1-b: Trend of Tilapia fish catch of LakeBorollus

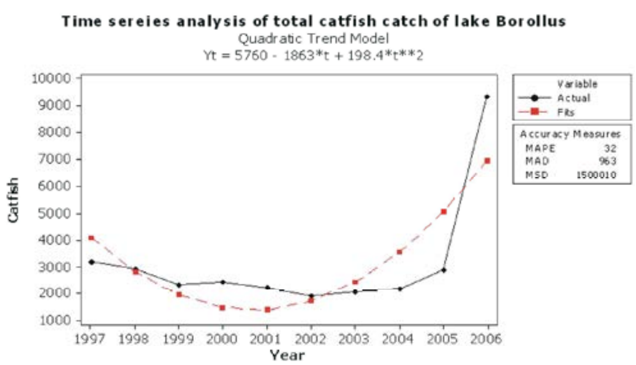


Fig. 1-c: Trend of Catfish fish catch of LakeBorollus

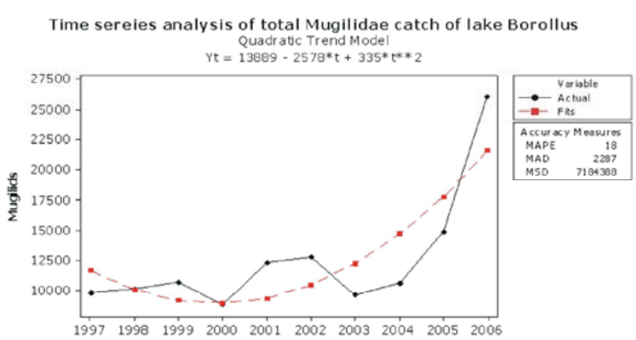


Fig. 1-d: Trend of Mugillid (Mullet) fish catch of LakeBorollus

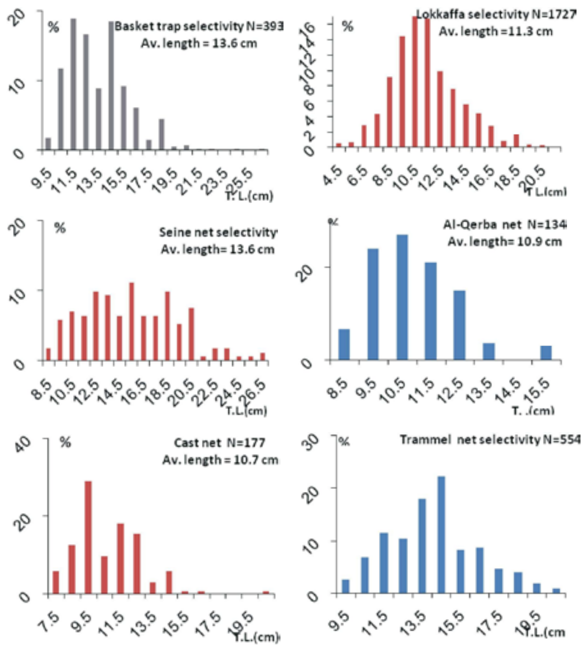


Fig. 2: Length frequency distribution of *O. niloticus* caught by different fishing gears, Lake Borollus

Table 2: Estimated vital population parameters for *Oreochromis niloticus* caught by different fishing gears, lakeBorollus

Fishing Method	L_∞	K	Z	R^2(Z)	M	F	E
Lokaffa	24.02	0.40	1.66	0.9781	0.93	0.73	0.44
B. traps	26.12	0.33	1.45	0.9250	0.79	0.66	0.46
Cast net	22.0	0.24	1.45	0.9384	0.69	0.77	0.53
AlQerba	16.82	0.37	1.49	0.9580	0.98	0.51	0.34
Total *O. niloticus* population	26.29	0.81	3.43	0.9453	1.44	1.99	0.58

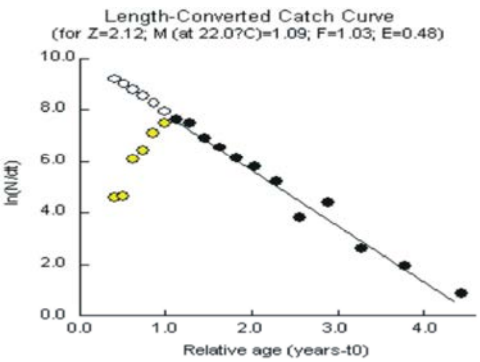
Z: estimated from length converted catch curve, F = Z – M, E = F/ Z

R^2 (Z): determination coefficient of Z

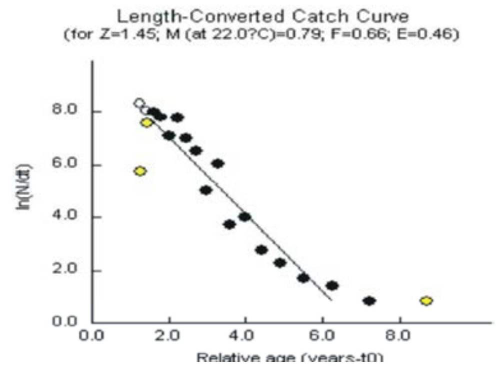
Mortality Estimates: Estimation of different mortality parameters are used to characterize the state of various fish populations and as input variables for bio-demographic models like those of Beverton and Holt [26] and Pet *et al*. [28]. These models are applied to predict consequences of management measures, like changes in effort and mesh size, on the yield. The data was pooled together to estimate the population parameters corresponding the stock of *O. niloticus* because selectivity of each gear may cause distorted or biased estimates of even the simplest type of parameters because the sample collected will not be representative for the whole population, Mattson, [29]. The estimated vital population parameters of *Oreochromis niloticus* are summarized in Table (2).

Total Mortality Rates: An estimate of the total mortality coefficient (Z) for *O. niloticus* from the descending portion of catch curve (Fig. 3, a-e) was found to be 1.66, 1.45, 1.45, 1.49 y^{-1} and 3.43 y^{-1} for the whole population of that species. The total value of Z (3.43y^{-1}) was found more than that recorded by Ishak*et al*. [12] (2.626 y^{-1}). Also, this value is higher than that estimated by Dowidar *et al*. [30] (2.2 y^{-1}) and near that recorded by El-Bokhty, [13] (3.38 y^{-1}) who revealed that this species is overexploited in LakeManzalah. Meanwhile, the natural mortality rates (M) as determined from Pauly's equation [25] were computed as 0.93, 0.79, 0.69, 0.98 and 1.44y^{-1} for the total population. The fishing mortality (F) is simply defined as the fraction of the average population taken by fishing. In other words, F can be considered as an invariant measure of effort Rothchild [31]. It was computed as 0.73, 0.66, 0.77,0.51 and 1.99 y^{-1} (total value) corresponding to the fishing methods in respective order (Table 2). The differences between these rates could be attributed to the differences in sample variations between the fishing gears according to Dalzell [32] as some may catch a wide variety of sizes and species, while others (such as gill and trammel nets) may be very size selective taking only a relatively narrow ranges of lengths depending on the size of the mesh Acosta [33].

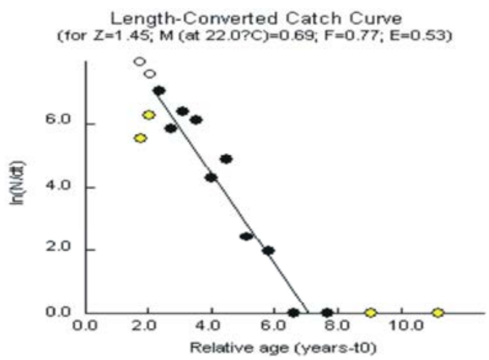
Exploitation Rate: The exploitation rates (E) of *O. niloticus* were determined by using the formula of Gulland [34] and were found to be 0.44, 0.46, 0.53, 0.34 corresponding to the fore-mentioned fishing gears respectively and 0.58 for the whole *O. niloticus* population. It was shown by Misund *et al.* [35] that, in many small-scale artisanal freshwater fisheries, a multitude of fishing techniques are used, some of which are technically illegal such as small mesh sizes, barriers and seines, in order to take advantage of all productive parts of the system they exploit. As a result of the multi-gear, multi-mesh situation they generate an overall fishing pattern which has a relatively uniform selectivity over a large range of the organisms and sizes. While they are generally condemned and persecuted for using such 'harmful' and 'unselective' fishing practices, the actual result on the community is a fishing pattern close to the theoretical optimal (Misund *et al.* [35]. The situation is true for *O. niloticus* population as they appeared as moderately exploited corresponding to most of the gears separately, but the whole picture is the species suffering of overexploitation. According to Gulland [34] who suggested that in an optimally exploited stock fishing



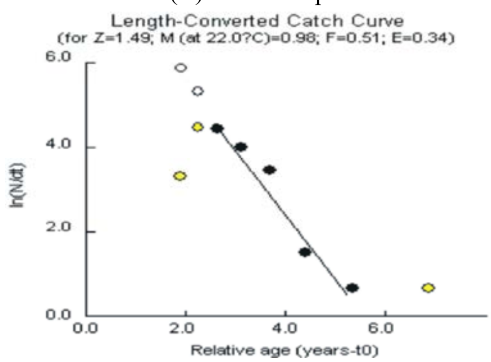
(A) Lokaffa



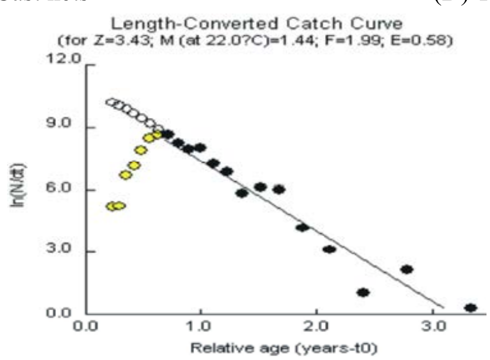
(B) Basket traps



(C) Cast nets



(D) Trawl (Al-qerba) net



(E) Total *O. niloticus*

Fig. 3A-E: Length converted catch curves of *O. niloticus*caught by different fishing methods, LakeBorollus

mortality should be equal to natural mortality, resulting in a fixed $E_{opt} = 0.5$. Thus, it was found that the stock of *O. niloticus* is overexploited comparedwiththe optimum level (E= 0.50).

Selection Ranges and Length at First Capture (L_{50}): The length at first capture is strongly correlated with the mesh size of the net used. It was estimated as a component of the length-converted catch curve analysis. L_{50} values at which 50% of the fish that become vulnerable to capture were estimated to be 8.98, 10.3, 8.64, 9.49 and 9.47 cm for *O. niloticus*caught by lokaffa, basket traps, cast net, al-qerba and for the total respectively. This means that *O. niloticus*is caught before being given the chance to grow even to their first size at maturing or to reach the best marketable size by most of these fishing methods (Table 3).

The selection range (S.R.) fluctuated between 7.9 cm and 9.9 cm total length for *O. niloticus*caught by lokaffa nets. Also, the lower limits of selection ranges were 9.6, 7.9 and 8.7 cm for Basket traps, cast net and Al-qerba respectively. While the upper limit (L_{75}) didn't exceed 11.1 cm (in case of basket traps). Consequently, very narrow ranges were observed between these values (Table 3).

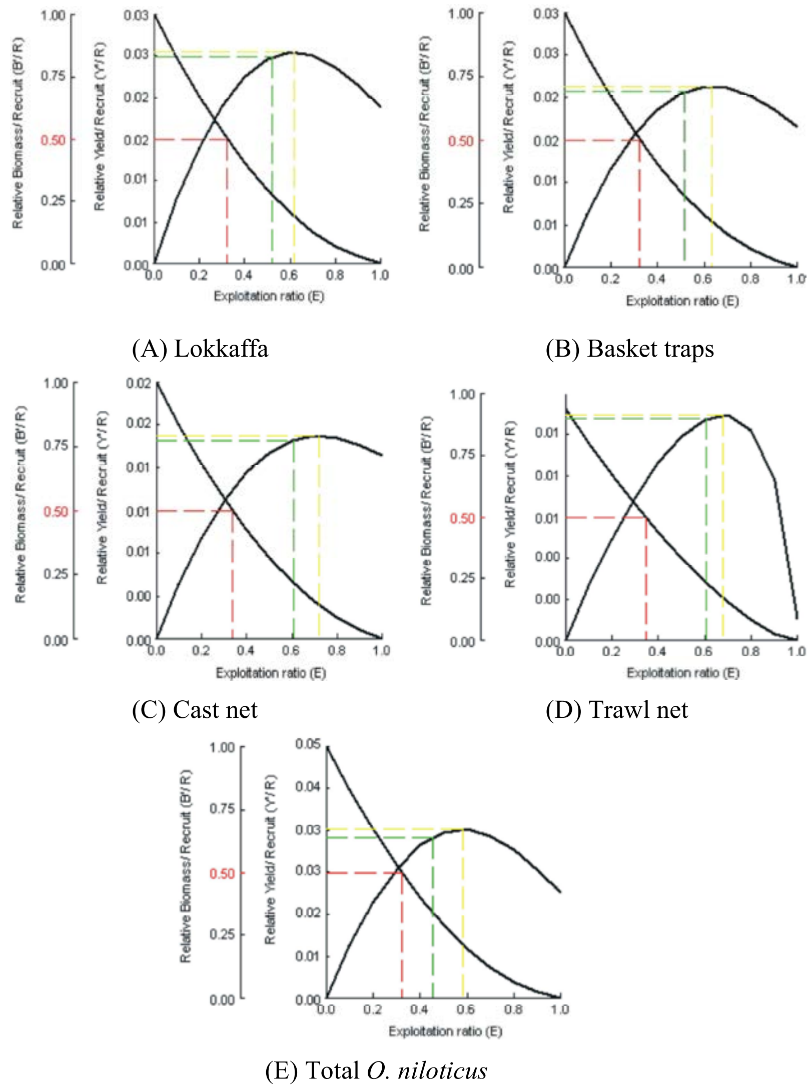


Fig. 3A-E: Relative yield per recruit (Y/R)' and biomass per recruit (B/R)'of*O. niloticus*, corresponding to different gears, LakeBorollus

Table 3: Probability of capture and selection ranges of *O. niloticus* caught by different fishing gears, Lake Borollus

Fishing Method	L_{25} (cm)	L_{50} (cm)	L_{75} (cm)	Range (S.R.) (cm)
Lokaffa	7.9	8.9	9.9	2
B. Traps	9.6	10.3	11.1	1.5
Cast net	7.9	8.6	9.5	1.6
Al-Qerba	8.7	9.5	10.3	1.6
Total *O. niloticus*	8.36	9.47	10.44	2.08

Relative Yield per Recruit (Y/R)' and Relative Biomass per Recruit (B/R)': As shown in Figures 3a-e, the relative yield per recruit and relative biomass per recruit of *Oreochromis niloticus* were estimated. It was found that the level of exploitation rate for the whole data (0.58) was higher than that of the optimum value by nearly 10 %. This result agree with those estimated by Hashem *et al.* [36].

The exploitation rates ($E_{0.1}$, which the increase in relative yield per recruit is one tenth of its value, corresponding to the different fishing techniques) were found higher than those estimated from the catch curves. Therefore, efforts should be reduced to reach these values and at the same time, larger mesh sized nets should be used in assembling the different fishing gears so as to increase the lower limits of selection ranges as well as the mean catchable lengths and to conserve the reproducible part or the growing portion of the population.

CONCLUSION

Results indicated that the stock of *O. niloticus* caught off Lake Borollus could be considered as overexploited. For fishery management of this resource, the fishing pressure should be lowered orat least maintained at the present level of exploitationas the exploitation rate coincide with that corresponding to the maximum exploitation ($E_{max.}$= 0.58) as revealed by Beverton and Holt model. The use of illegal mesh sizes and other destructive fishing methods need to be urgently addressed, especially those towed types which destroy the bottom habitat and alter the physical properties of water, by the authorities concerned as well as raising the mesh sizes of nets used to increase the lower limits of selection ranges corresponding to each fishing gear, to increase the potential capacity of smaller fishes to grow and get higher marketable sizes and also to keep breeding and saving stock biomass of that species. Increasing the legal lower limit of tilapia to reach 15cm is encouraged to get higher marketable sizes.

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