EGYPTIAN JOURNAL OF AQUATIC RESEARCH ISSN: 1687-4285
VOL. 35 NO. 1, 2009: 177-191

POPULATION CHARACTERISTICS OF *TILAPIA ZILLII* (GERVAIS, 1848) IN LAKE TIMSAH, SUEZ CANAL, EGYPT.

AZZA A. EL-GANAINY AND MANAL M. M. SABRA

National Institute of Oceanography and Fisheries, Suez Branch,
P.O. Box 182, Suez, Egypt.
Tel: +20643366172
Fax: +20623360016
E-mail address: azzaelgan@yahoo.com

Keywords: Tilapia zillii, Lake Timsah, age, growth, mortality, yield per recruit.

ABSTRACT

The population parameters of *Tilapia zillii* from Lake Timsah were studied. 1638 specimens with total length ranging from 7.5 to 21.3 cm were collected monthly from the small scale fishery of Lake Timsah during the period from October 2002 through February 2004. The length weight relationship was calculated to be $W = 0.0217\ L^{2.9555}$. The oldest age stimated from otolith reading was 4 year. Age group one was the most predominant in the catch represented by about 73.0 % of the individuals. The parameters of von Bertalanffy growth equation were L_∞= 21.87 cm, K= 0.46 year^{-1} and t_o= -0.499 year. The values of natural mortality (M), total mortality (Z) and fishing mortality rates were 0.712, 2.260 and 1.548 Y^{-1} respectively. The fishing mortality rate was substantially greater than both the target (F_{opt} = 0.356/yr) and limit (F_{limit} = 0.474/yr) biological reference points. Analysis of the yield per recruit postulated that the fishing pressure exerted in Lake Timsah has exceeded the critical level, and that juvenile individuals are the target of the fishery. This implies that the stock dynamics of this species would be seriously affected. Reductions in the fishing effort and mesh size regulations are required for the protection of the resource.

1. INTRODUCTION

Lake Timsah is a small lake (2262 acre) which lies in the middle of Suez Canal (Fig 1). The lake is considered as an important fisheries resource for the Suez Canal sector in Egypt, it produces about 2000 tons of fish and shell fish per year (GAFRD, 2007). In spite of the small area of the lake, it is characterized by the high abundance and diversity of fishes. About 35 fish species were recorded in the lake, 17 of them are Mediterranean species and 18 are Red Sea species (EL-Etreby, 1986). The small scale fishery in the lake depends on small non-mechanized boats (3-6 m in length), with two to three fishermen working on each boat. Four fishing nets are employed in the fishery; there are gillnets, trammel nets, cast nets and encircling nets. Fishermen in there manipulation of trammel nets, they beat the water with wooden poles to drive fish towards the nets.

The tilapia fishes are the most popular components of tropical fresh and brackish water ecosystems. They are economically important, and are widely exploited and cultured. They are abundant in all Egyptian lakes and inexpensive, and easily afforded by the low-income portion of the population. *Tilapia spp*. constitute about 21% of the total lake Timsah production. Three tilapine yeeies are present in Lake Timsah, namely; (*Tilapia zillii*, *Oreochromis niloticus*, and *Oreochromis aureus*) of which *Tilapia zillii* is the most abundant, contributing by about 70% of the cichlid species (Table 1).

Tilapia zillii has not yet been extensively cultured in ponds like other tilapine fish (Pullin and Lowe-McConneli, 1982) probably because of the inadequate information on its biology. Intensive biological studies were undertaken on tilapia spp. in different water bodies in Egypt (Bayoumi and Khalil, 1988; Abdel-Aziz *et al.,* 1990; El-Haweet, 1991; El-Shazly, 1993; Abdalla, 1995; Shenouda *et al*., 1995; Abdalla and Talaat, 2000; Khalifa *et a*l., 2000; Akel, 2005 and 2007).

Biological information and appropriate statistical records for Lake Timsah fishery are still lacking. Total landed catch by family is the only available record for the evaluation of the fishery. This study is the first attempt to investigate the essential biological and dynamic parameters that would help in the proper management of one of the most abundant cichlid species, *Tilapia zillii,* in Lake Timsah.

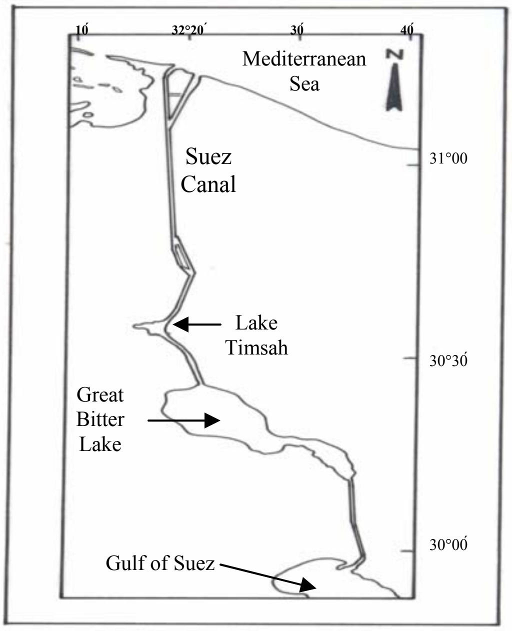

Fig (1): Map showing Lake Timsah at the middle of Suez Canal.

Table (1): Annual total tilapia catch and *Tilapia zillii* catch from Lake Timsah.

Year	Tilapia catch	Zillii catch
2000	300	210
2001	315	221
2002	255	179
2003	236	165
2004	231	161
2005	284	199
2006	264	185
2007	220	154

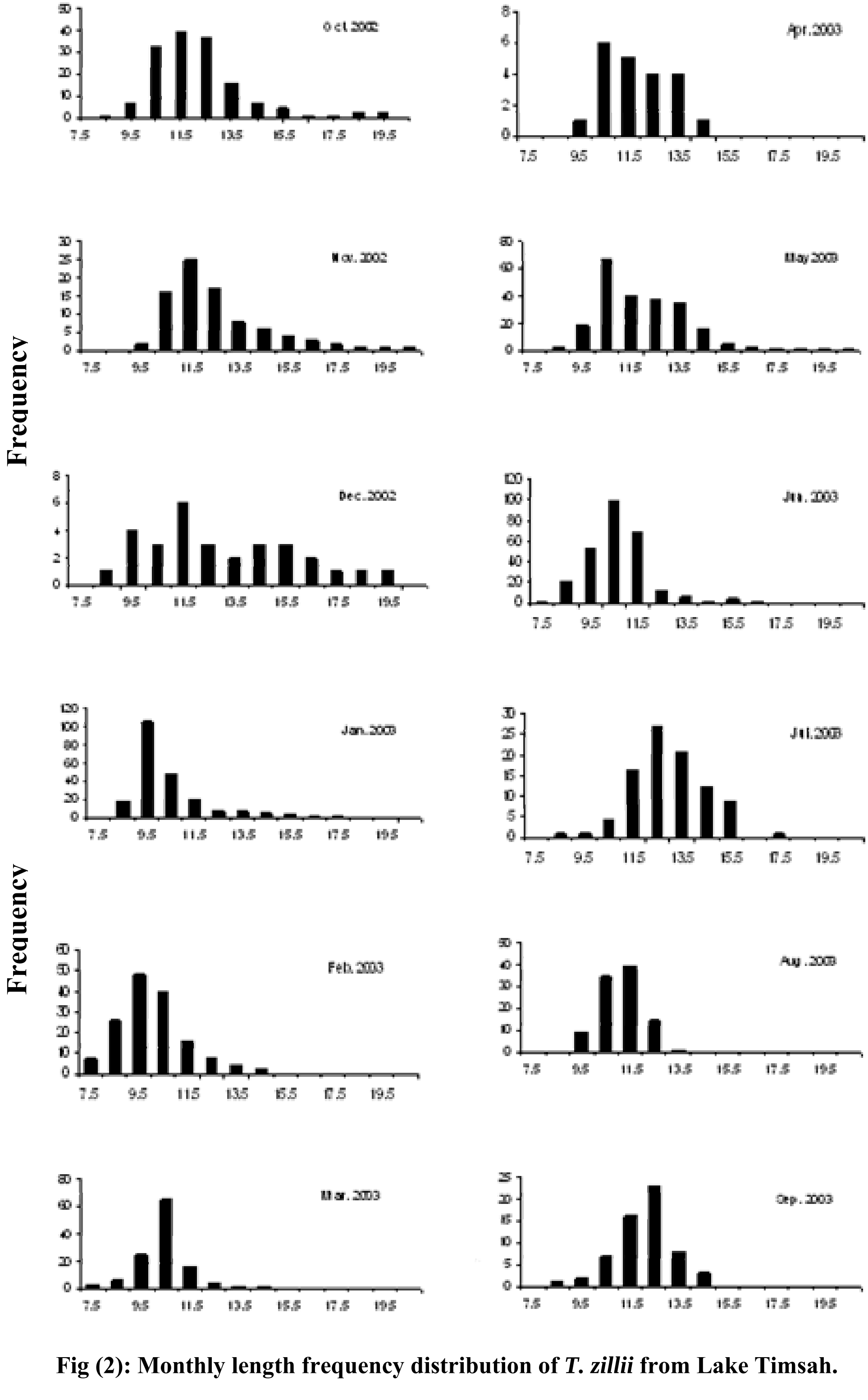

Fig (2): Monthly length frequency distribution of *T. zillii* from Lake Timsah.

2. MATERIAL AND METHODS

Samples of *Tilapia zillii* were collected monthly during the period from October 2002 through February 2004 from the commercial catch of the main landing site in Timsah Lake.The used fishing gear for catching tilapia is trammel net with mesh size of 7 cm for the outer layers and 2.5 cm for the inner layer. In the laboratory each specimen was measured to the nearest cm and weighed to the nearest gram. The length frequency distributions were determined at 1.0 cm. length intervals. Age was determined by otolith reading. The estimation of growth parameters was performed through a non-linear least square technique (Prager *et al.,* 1989); the mean square error was used as an index of goodness of fit. The mathematical relationship between length and weight was described by the common equation $W = a L^b$ (Ricker, 1975), where W is the total weight in gm, L is the total length in cm, and a and b are constants.

The annual instantaneous rate of total mortality (Z) was estimated by the length converted catch curve method described by Pauly (1983). Pooled length frequency samples were converted into relative age-frequency distributions by using parameters of the von Bertalanffy growth function. The natural logarithm of the number of fish in each relative age group divided by the change in relative age was plotted against the relative age, and Z (± 95% CI) was estimated from the descending slope of the best fitt line with least squares linear regression. Estimates of the survival rate (S) was then calculated by $S = e^{-Z}$ (Ricker, 1975). These rates were converted into percentages by using the formulae:

$$\text{Percentage mortality} = 100\,(1- e^{-Z}),\ \text{and}$$
$$\text{percentage survival} = 100\, e^{-Z}.$$

The annual instantaneous rate of natural mortality (M) was computed using Hoenig (1983) empirical equation; and Alagaraja longevity formulae (1984). The instantaneous rate of fishing mortality (F) was extracted as $F = Z\text{-}M$. The exploitation ratio (E) was calculated as equal to the fraction of death caused by fishing $E = F/Z$. Precautionary target biological reference points, optimum fishing mortality (F_{opt}) and Limit fishing mortality (F_{lim}) were calculated as 0.5 and 2/3 M respectively (Patterson, 1992) and were compared with the estimated fishing mortality.

The probability of capture data were estimated from the backwards extrapolation of the length converted catch curve (Pauly, 1984). Selectivity curve was generated by fitting a logistic function to the plot of the probability of capture against size, from which values of the parameters L_{50}, L_{75}, and the size at which fish were fully recruited to the fishery (L_{100}) were obtained using FiSAT program (Gayanilo et al., 1995). The recruitment pattern was obtained by projecting the length frequency data backward onto the time axis using the growth parameters to show the number of recruitment pulses per year (Pauly, 1984) by normal separation.

The relative yield per recruit analyses was used to assess the fishery. Beverton & Holt (1966) relative yield per recruit model was applied, assuming a knife-edge selection. Growth (L_∞ and K), mortality (M), and selectivity (L_{50}) parameters were the model input values. The maximum exploitation rate (E_{max}) associated with relative maximum yield per recruit was then estimated, along with $E_{0.1}$, the rate at which the marginal increase of Y`/R is 1/10 of its value at E = 0. The size that generates maximum yield per recruit was estimated by Froese and Binohlan (2000) empirical equation, then the yield per recruit model was used to predict the effect of increasing the mean size at first capture (L_{50}) to the mean size at first sexual maturity (L_m) and that at which yield per recruit would be maximized (L_{max}).

3. RESULTS

3.1 Growth in Length

The monthly length frequency distributions (Fig. 2) show that the smallest fish (< 9.0 cm) younger than one year old represented about 24% of the total catch. Most of these individuals were caught during February and March, referring that recruitment to the fishery occurs during these months.

Total length measurements ranged from 7.3 cm. to 21.3 cm. with an average of 12.30 ± 2.41 cm while the total weight measurements varied from 9.6 to 174.1 gm. with an average of 40.51 ± 25.83 gm. The length weight relationship (Fig. 3) was calculated to be $W = 0.0217\ L^{2.9555}$ (ANOVA, $F = 8648.01$, $P < 0.01$) by: ($r^2 = 0.972$, $2 = 452$, $SE_a = 0.079$, $SE_b = 0.032$). The growth of weight relative to length was almost isometric ($b = 2.955$; 95% CI: 2.893-3.018) since the obtained isometric index value (b) was not significantly different from 3 (Student's *t*-test; $P = 0.461$).

3.2. Age and growth

The otoliths of 560 specimens were used in age determination, of which 548 were successfully aged. Alternating translucent and opaque zones were observed in the otoliths of *T. zillii*, one growth ring consisting of an opaque and translucent zone was formed annually. The validity of the annulus as a true year mark was tested by: (1) The relationship between the total fish length and number of rings showed a good correlation ($r^2 = 0.976$), and (2) The close agreement between the observed and calculated lengths at age ($P = 0.00033$).

The maximum age observed from otolith readings was 4 years. Age group one was the most dominant (Fig. 4) representing about 73.0 % of the catch of this species. The mean estimated lengths at age (Table 2) indicated rapid growth in the 1st year of life with the fish attaining almost 50 % of its maximum size, whereas in the following years the rate of growth slows down. The mean lengths at age for all aged specimens were used for fitting the growth curve (Fig 5) and estimating the von Bertalanffy growth parameters. The resulting VBGF parameters are L_∞= 21.87 cm (SE= 1.152), K= 0.46 year^1 (SE= 0.092) and t_o= -0.499 year (SE= 0.359).

3.3. Mortality and selectivity

Total annual mortality rate (*Z*) was estimated using the length converted catch curve (Fig.6) without the extreme age groups (>4 yr) and those not fully recruited (zero group). The estimated (Z) value was 2.26 year^{-1} with a range of 2.17-2.36 and r^2 = 0.9678 and the survival rate *S* was determined to be 0.10. The percentage of total mortality was 89.6% and the percentage of survival was 10.4%. The estimated mean natural mortality rate, *M,* was 0.712/yr. Fishing mortality rate was in excess of the natural mortality rate, accounting for 68% of the total mortality. The estimated fishing mortality (F = 1.548/yr) was substantially greater than both the target (F_{opt} = 0.356/yr) and limit (F_{limit} = 0.474/yr) biological reference points (Table 3).

The selectivity range derived from the probability of capture at size plot was 3.0 cm (7.5-10.5) (Fig.7). Values of the sizes where the probability of capture was 50% (L_{50}), 75% (L_{75}) and 100% (L_{100}) are 7.5, 8.5, and 10.5 respectively. The obtained length at first capture which is the selection length (Gulland 1969 and Ricker, 1975) was 8.5 cm.

3.4. Recruitment pattern

The recruitment pattern of *T. zillii* in Lake Timsah was plotted in relation to the percentage of recruitment vs. time (projecting a set of length frequency backward onto 1-year time axis). There was continuous recruitment throughout the year, with a peak during May and June (Fig. 8).

3.5. Assessment of the fishery

The estimated length that generates the maximum possible yield (L_{opt}) was 13.3 cm (CI of 12.1-14.6); this value is considerably greater than the mean size at first capture (L_c = 8.5 cm) and the mean size at first sexual maturity (L_m = 9.2 cm as reported by Akel and Moharram, 2007) (Fig 9).

The Y`/R was computed as a function of different values of exploitation ratio (E) and length at first capture (L_c), length at first sexual maturity (L_m) and that at which yield per recruit would be maximized (L_{max}). The results (Fig. 10) indicate that at the present value of length at first capture (L_c = 8.5) and the current natural mortality (M = 0.712), the present value of the exploitation ratio is higher than that associated with the maximum relative yield per recruit (E_{max} = 0.587). The yield per recruit function also indicated that an increase in the size at first capture to that which would give maximum yield per recruit would be associated with a substantial increase in yield at the current level of exploitation. An increase in the size at first capture to that at which sexual maturity occurs was also predicted to be associated with an increase in yield, although to a lesser degree (Table 3).

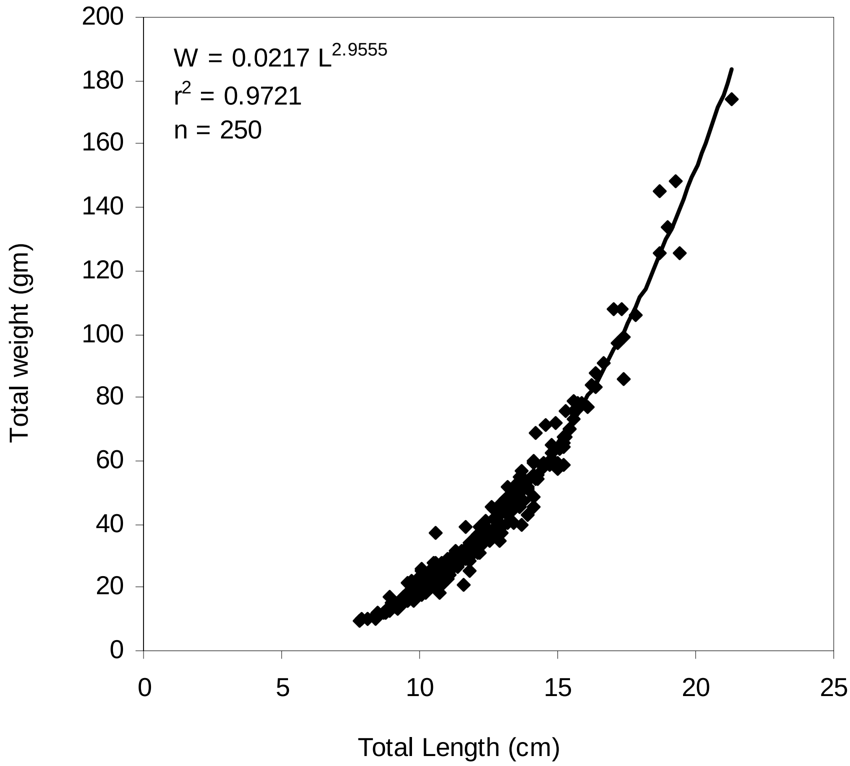

Fig (3) Length weight relationship of *Tilapia zillii* from Lake Timsah.

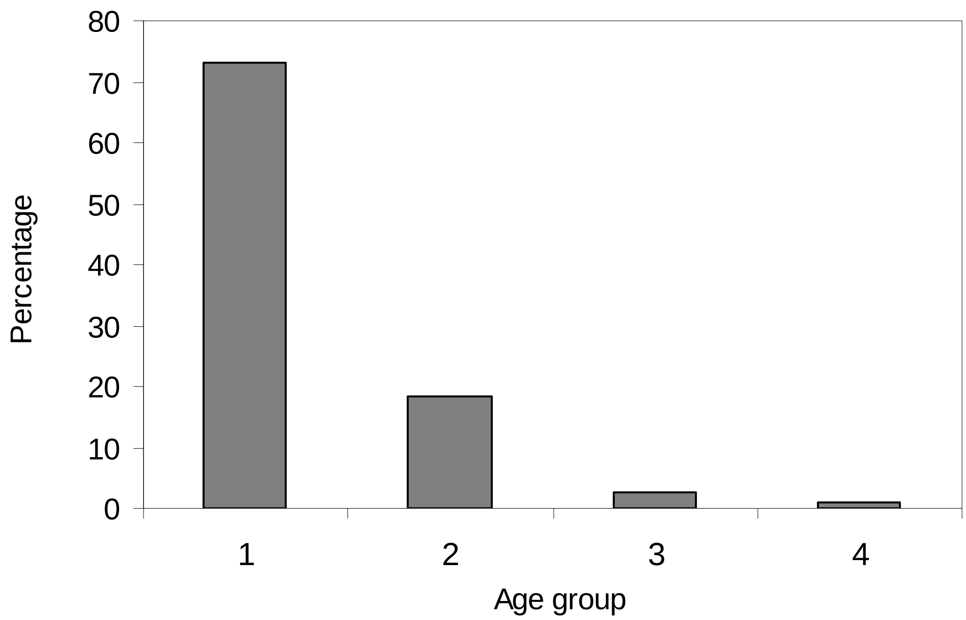

Fig (4) Age composition of *Tilapia zillii* in Lake Timsah.

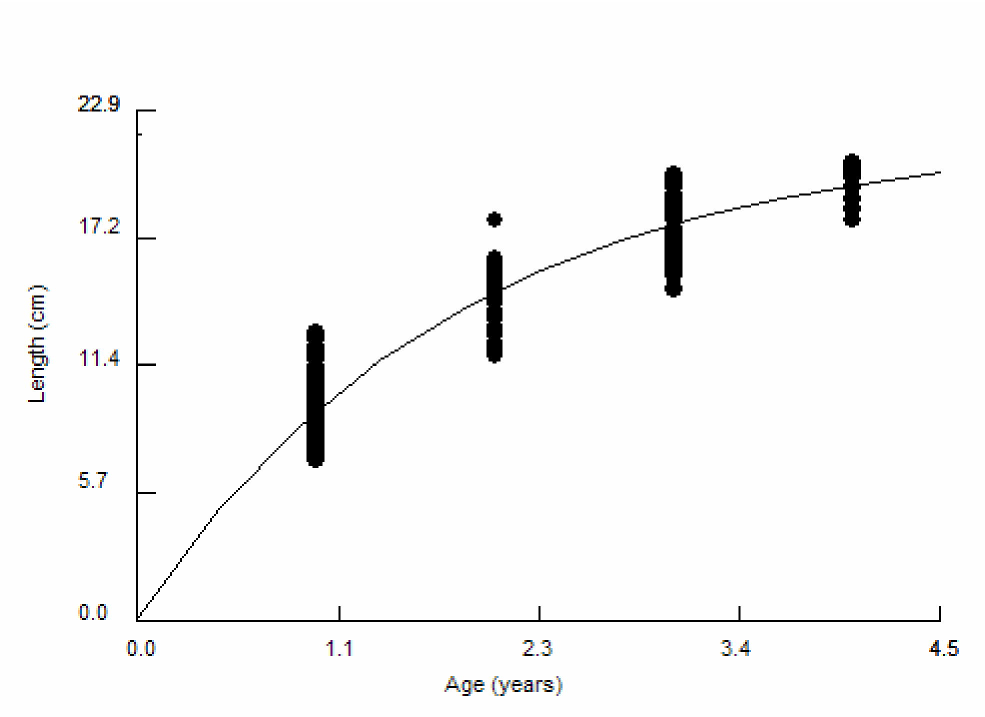

Fig (5): Length at age of *T. zillii* from Lake Timsah.

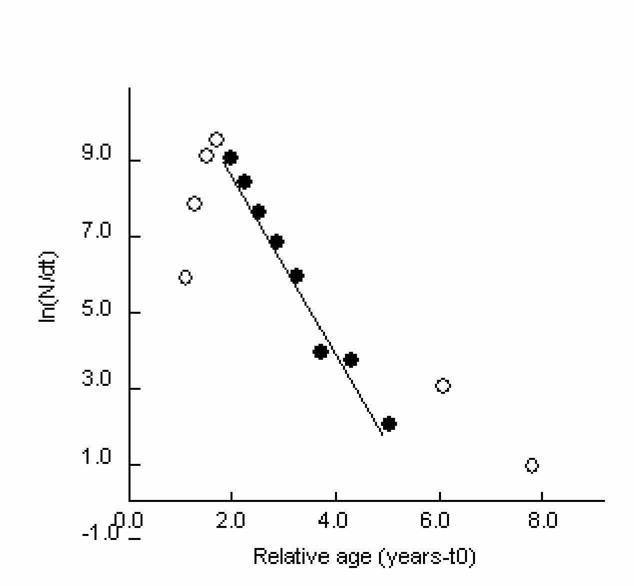

Fig (6): Length converted catch curve for estimating total mortality of *T. zillii* from Lake Timsah.

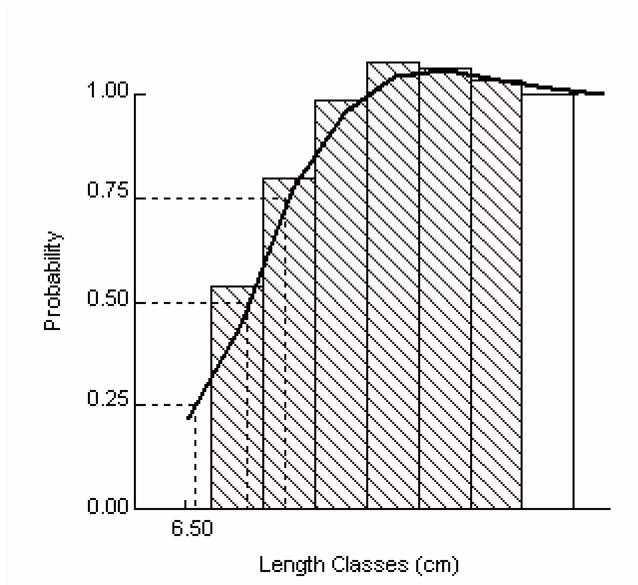

Fig (7): Probability of capture of *T. zillii* from Lake Timsah.

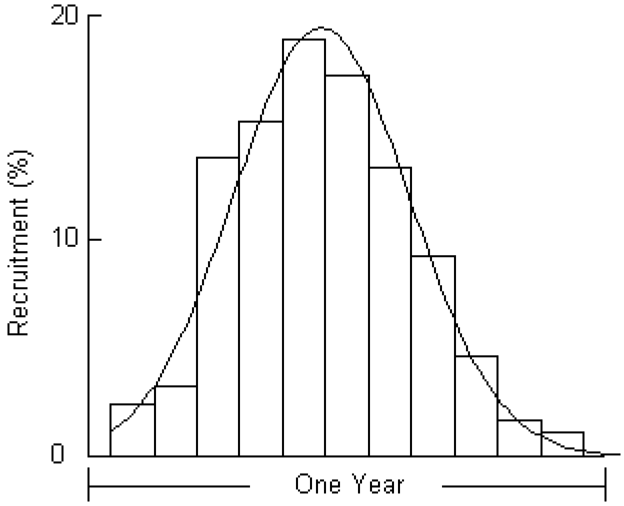

Fig (8) Recruitment pattern of *T. zillii* from Lake Timsah.

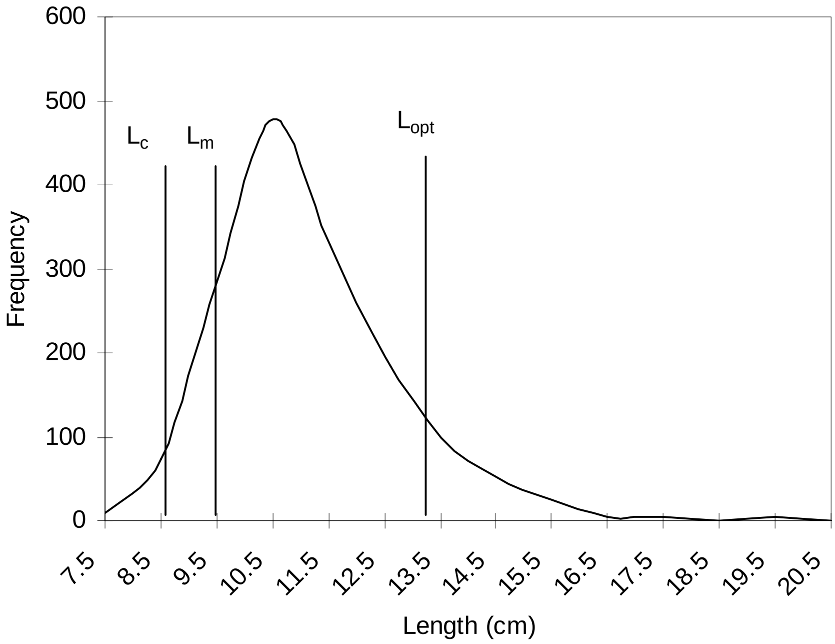

Fig (9) Total length frequency composition of *T. zillii* indicating the length at first capture (L_c), length at first maturity (L_m) and the optimum length (L_{opt}).

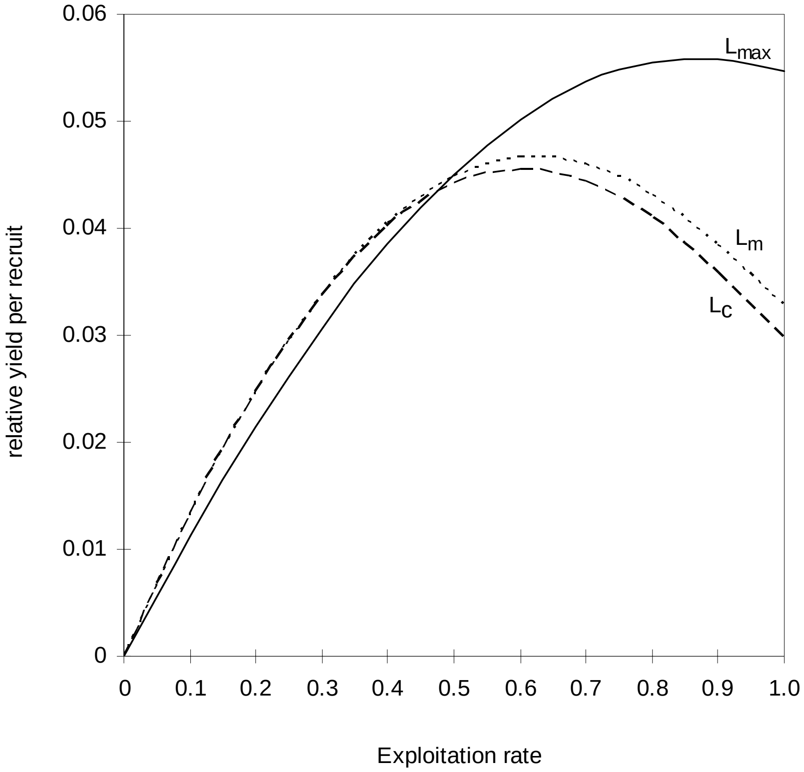

Fig (10) Relative yield per recruit for *Tilapia zillii* in lake Timsah in relation to different exploitation rates.

Table (2) Mean lengths at age based on otolith readings of *T. zillii* from Lake Timsah.

Age group	Number of fish	Length range	Mean length	S.D.
I	400	9.8 - 12.0	10.52	0.748
II	127	11.0 - 15.1	14.31	0.653
III	15	15.7 - 17.9	16.77	0.213
V	6	17.8 - 21.3	18.5	0.198

Table (3): Estimated values of natural mortality (M) and subsequent estimations for the different models used.

	Alagaraja (1984)	Hoenig (1983)	Mean M
M	0.706	0.719	0.712
Z	2.260	2.260	2.260
F	1.554	1.541	1.548
E	0.688	0.682	0.685
F_{opt}	0.353	0.359	0.356
F_{lim}	0.471	0.479	0.474

Table (4): Exploitation rates at length at first capture, length at first maturity and length that maximize yield per recruit.

Item	$L_c = 8.5$	$L_m = 9.2$	$L_{max} = 13.3$
$E_{0.1}$	0.505	0.514	0.770
$E_{0.5}$	0.327	0.336	0.393
E_{max}	0.587	0.617	0.879

4. DISCUSSION

Tilapias support an important commercial fishery of Timsah Lake, contributing by about 21% of the total lake production during the last ten years. Sampling species composition showed that *Tilapia zillii* is the most abundant, contributing by about 70% of the cichlid species. The coefficient (b) of the total length–weight relationship of *T. zillii* showed that the growth of weight relative to length is almost isometric (b = 2.955), this value is lower than that reported by El-Haweet (1991), who described the length-weight relationship for *T. zillii* from Lake Burollus with the equation $W = 0.0143 L^{3.103}$. On the other hand Abd-Alla & Talaat (2000) and Akel (2005) obtained lower values of b = 2.687 and 2.848, respectively from Lake Edku and Abu Qir Bay. These discrepancies in the values of b between different authors and various locations be due to the difference of environmental conditions, particularly the salinity, between lakes or due to discrepancies in data collection.

The existence of alternating hyaline and opaque zones with an annual deposition pattern makes the otoliths suitable for age determination of *T. zillii*. The maximum observed age in the present study (4 years) is less than that reported by El-Haweet (1991); Abd-Alla and Talaat (2000) and Akel (2005) who found a maximum age of 5 years for this species in the Egyptian lakes, Lake Burollus, Lake Edku and and Abu Qir Bay, respectively. Leveque (1997) recorded a higher maximum age (7 years) in Lake Kinnereth in Israel. The growth parameters of *T. zillii* have been reported from several localities in Egypt and Africa (Table 5); it seems that there is no agreement in the growth pattern estimated by the different authors. The high growth rate of *T. zillii* in Lake Timsah may be attributed to the high productivity of the Lake. However, the present estimates of L_∞ and K generally agree with many of the recorded parameters (de Merona, 1983; Abd-Alla and Talaat, 2000; Akel, 2005). The calculated longevity (t_{max}) of the studied species is about 6 years indicating that they are short-lived. However, the age composition showed that most of the fish caught were one year of age, implying that they are normally caught before they grow large enough to contribute substantially to the stock biomass; this is an indicative of growth over-fishing.

Tilapia zillii in Lake Timsah seems to be a relatively fast-growing fish, with high rate of natural mortality (M = 0.712). The natural mortality was estimated by applying two different models then the mean of the two methods was used. The reliability of the estimated natural mortality rate was ascertained using the M/K ratio. Beverton and Holt (1957) reported that the M/K value for most fishes lies in the range 1.12-2.5. The value of M/K ratio for the present fish under study was 1.548. The estimated M was in accord with that reported by many authors, it was 0.646 (El-Haweet, 1991) and it was 0.667 (Abd-Alla and Talaat, 2000) and 0.74 (Akel, 2005). The estimated fishing mortality (F=1.548/yr) was much greater than both the target (F_{opt}) and limit (F_{limit}) biological reference points. Walters and Martell (2002) reported that any value of F_{opt} above 0.5M needs to be carefully justified. Patterson (1992) reported that limit of fishing mortality rates above (2/3) M is often associated with stock declines. These results clearly indicate growth overfishing. The estimated exploitation ratio was beyond the expected optimal exploitation level, E_{opt} = 0.5 (Gulland, 1971), indicating over-exploitation of this resource. This was confirmed by the analysis of the yield per recruit which postulated that the fishing pressure exerted in Lake Timsah has exceeded the critical level. The estimated length at first capture (L_c=8.5 cm) is less than the length at first sexual maturity 9.2 cm (Akel and Moharram, 2007). This implies that juvenile individuals are the target of the fishery, and the stock dynamics of this species would be seriously affected. Thus, the protection of juveniles is probably the key factor for the sustainability of the resource; through periodic spatial closure of the spawning and nursery areas. The results indicate that reductions in the fishing effort and mesh size regulations are required for the protection of this resource. Also, the catch and effort records system should be improved.

Table (5): summary of the estimated growth parameters of *T. zillii* in different localities.

Locality	L_∞	K	Φ	Source
Egypt				
Lake Manzala (Male)	28.1	0.503	2.60	Iles (1971)
(Female)	21.1	0.659	2.47	Iles (1971)
Nozha Hydrodrome	32.1	0.334	2.25	Iles (1971)
Lake Qarun	17.0	0.66	2.28	Moreau et al (1986)
Lake Brollus	25.3	0.231	2.17	El-Haweet (1991)
Lake Edko	22.5	0.266	2.13	Abdalla and Talaat (2000)
Abu Kir Bay	22.0	0.276	2.13	Akel (2005)
Other localities				
River Niger	21.9	0.603	2.46	de Merona (1983)
Lake Tiberias	26.3	0.234	2.21	Pauly (1978)
Lake Kainji	27.4	0.63	2.68	Kapetsky and Petr (1984)
Lake Timsah	21.87	0.46	2.34	**Present study**

REFERENCES

Abd-Alla, A.: 1995, Age, growth and population dynamics of tilapia species in the Egyptian inland waters, Lake Edku. Ph. D. Thesis submitted to Sohag Faculty of Science Assuit University.

Abd-Alla, A. and Talaat, K.M.: 2000, Growth and dynamics of Tilapias in Edku Lake, *Egypt. J. of aquatic Res.*, A. R. E., 26: 183-196.

Abdel-Aziz, E.H.; Ezzat, A.A. and El-Bassir, M.A.: 1990, Growth assessment of cichlid fish, *Oreochromis niloticus* (L.) from the Egyptian and Sudanese inland waters. Proceeding of International Symposium of Biology and Culture of tilapias. Oct. 1990, Alexendria, Egypt.

Akel, E.H.Kh.: 2005, Growth, mortalities and yield per recruit of *Tilapia zillii* (Gervais) (Pisces, Fam. Cichlidae) from Abu Kir Bay-Estern Alexandria, Egypt. *Journal of Egyptian Academic Society of Environmental Development (D-Environmental Studies)* 6: 17-31.

Akel, E.H.Kh. and Moharram, S.G.: 2007, Reproductive biology of *Tilapia zillii* (Gerv., 1848) from Abu Kir Bay, Egypt. *Egyptian Journal of Aquatic Research*, 33: 379-394.

Alagaraja, K.: 1984, Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries,* 31: 177–208.

Bayoumi, A.R. and Khalil, M.T.: 1988, Tilapia fisheries in Lake Manzala. Egypt. *Egyptian Journal of Aquatic Research*, A. R. E. 14: 87-99.

Beverton, R.J.H. and Holt, S.J.: 1957, On the dynamics of exploited fish populations. *Fisheries Investigation. Ministery of Agriculture and Fish Food* G. B., series II, 19: 533 p.

Beverton, R.J.H. and Holt, S.J.: 1966, Manual of methods for fish stock assessment. Part 2.Tables of yield functions. *FAO Fish. Technical Papers,* 1: 67 p.

de Merona, B.: 1983, Modèle d'estimation rapide de la croissance des poissons. Application aux poissons d'eau douce d'Afrique. Rev. *Hydrobiol. Trop.*, 16:103-113.

El-Etreby, S.G.: 1986, Fishes of Suez Canal. II Survey and ecological study of fish of Timsah Lake. *Proceedings of Zoological Society of Egypt*, 12: 199-214.

El-Haweet, A.A.K.: 1991, Biological studies of some cichlid species in Lake Borollus. M. Sc. Thesis submitted to Faculty of Science Alexandria University.

El-Shazly, A.: 1993, Biological studies on four cichlid fishes (*Tilapia nilotica, Tilapia galilae, Tilapia zillii, Tilapia aurea*), M. Sc. Thesis submitted to Faculty of Science Zagazig University.

Froese, R. and Binohlan, C.: 2000, Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes with a simple method to evaluate length frequency data. *Journal of Fish Biology,* 56: 758-773.

GAFRD,- 2007. Annual report of the General Authority of fish development Resources for fisheries statistics in Egypt.

Gayanilo, F.C. Jr.;P. Sparre, and Pauly, D.: 1995, The FiSAT user's guide. FAO computerized information series fisheries. 99, ICLARM, DIFMAR, Rome.

Gulland, J.A.: 1969, Manual of methods for fish stock assessment. Part 1. Fish population analysis.

Gulland, J.A.: 1971, The fish resources of the ocean. *FAO Fish Tech. Pap.*, (97): 425p.

Hoenig, J.M.: 1983, Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin*, 82: 898-903.

Iles, T.D.: 1971, Ecological aspects of growth in African cichlid fishes. *Journal de Conservation et Exploration International de Mer*, 33: 363-385.

Kapetsky, J.M. and Petr, T.: 1984, Status of African reservoir of fisheries. *CIFA Technical Papers,* 10: 326 p.

Khalifa, U. S. A.; Agaypi, M.Z. and Adam, H.A.: 2000, Population dynamics of *Oreochromis niloticus* L. and *Sarotherodon galilaeus* Art. 97-90. In: Sustainable fish production in Lake Nasser: Ecological Basis and Management Policy. *ICLARM Conference Proceedings*, 61: 184p.

Lévêque, C.L.: 1997, Biodiversity dynamics and conservation: the freshwater fish of tropical Africa. ORSTOM. Cambridge University Press U.K.

Moreau, J.C. Bambino and Pauly, D.: 1986, Indices of overall growth performance of 100 tilapia (Cichlidae) populations. p. 201-206. In: J.L. Maclean, L.B. Dizon & L.V. Hosillos (eds.) The First Asian Fisheries Forumn 727 p. Asian Fisheries Society, Manila, Philippines.

Patterson, K.: 1992, Fisheries for small pelagic species: an empirical approach to management targets. *Review of Fish Biology and Fisheries,* 2: 321-338.

Pauly, D.: 1978, A preliminary compilation of fish length growth parameters. *Berlin Institute. Meereskd. Christian-Albrechts-University Kiel*, 55:1-200.

Pauly, D.: 1979, Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian demersal fisheries. *ICLARM Review Studies*, 1: 35p.

Pauly, D.: 1983, Some simple methods for the assessment of tropical fish stocks. *FAO Fisheries Technical Papers*, 234: 52 p.

Pauly, D.: 1984, Fish population dynamics in tropical waters: a manual for use with programmable calculators. *ICLARM Review Studies,* 8: 325p.

Prager, M.H.; Saila, S.B. and Recksiek, C.W.: 1989, FISHPARM: a microcomputer program for parameter estimation of nonlinear models in fishery science. 2nd ed. Old Dominion University. *Oceanography Technical Reports,* 87: 1-18.

Pullin, K.S.V. and Lowe-McConnell, R.H.: 1982, The biology and culture of tilapias. *ICLARM Conference Proceedings*, 7: 432 p.

Ricker, W.E.: 1975, Computation and interpretation of biological statistics of fish population. *Bulletin of Fisheries Research. Board of Canada,* 191: 382 p.

Shenouda, T. S.; Azim, M.E.; Abbas, F.F. and Adam, E.A.: 1995, Comparative age and growth studies on two tilapia species from the High Dam Lake within twenty years and signs of their overfishing. *Journal of Egyptian German Society of Zoology*, 18: 15-44.

Walters, C. and Martell, J.D.: 2002, Stock assessment for sustainable fisheries management. *Bulletin of Marine Science,* 70: 629-638.