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THE YIELD AND OPTIMUM FISHING EFFORT PREDICTION FOR TILAPIA (OREOCHROMIS NILOTICUS LINNAEUS, 1758) STOCK OF LAKE CHAMO, ETHIOPIA

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ABSTRACT

Tilapia (Oreochromis niloticus) is the major commercially exploited species contributes more than 85% of the total annual landings from Lake Chamo, Ethiopia. On the other hand, its potential is not studied in detail from the lakes of Ethiopia. In the present study, the Schaefer and Fox models were used to predict the Maximum Sustainable yield (MSY) and fishing effort maximum sustainable yield (fMSY) of Tilapia in Lake Chamo using catch effort data collected over a period of 5years (2011-2015). The MSY of Tilapia in Lake Chamo is about 2319 tons/year and the optimum level of fishing effort to be expanded on the stock should be below 1219 gill nets per day. The current yield estimate is more than that of the actual yield. According to the data collected, it shows that Tilapia in Lake Chamo is not overfished, and that the yield may marginally increase if mesh size regulations are enforced and the number of gill nets is restricted.

Keywords: Tilapia, Lake Chamo, stock assessment, Schaefer-Fox models, maximum sustainable yield, fishing effort maximum sustainable yield

INTRODUCTION

Ethiopia has remarkable diversity of lakes which differ considerable in size, shape, depth stratification and biotic diversity. The country has an inland water spread area of about 7,444 km2 (Abebe and Geheb, 2003) and the estimated fish yield from such water bodies is about 51,481 tons/annum. However, the current level of fish production is around 10,000 tons/year (LFDP, 1997) which is below 1/5th of the potential yield. The riverine fishery in Ethiopia is still untapped and the present level of exploitation is from the main rivers. On the other hand, the commercial fishery of most Ethiopian lakes has tremendously increased to the extent that some commercially important fish species have already been over exploited.

Lake Chamo is one of the most overexploited lakes in the country. In this lake, fishing effort has increased by five folds and landings nearly ten folds since the last three decades. For example during the early 1980’s, the fishing effort in the case of Tilapia was below 250 nets per day, where as in the 1990’s, it increased to about 350 nets per day (LFDP, 1993) and currently 1219 nets are being used per day to exploit the fish stock. The impact of this alarming rate of fishing pressure is further worsened by progressively decreasing the mesh size of the nets especially to catch Tilapia in Lake Chamo.The recommended minimum Tilapia gill net mesh size is 17 to 25cm (LFDP, 1994), but now mostly the mesh size is 9cm. Besides this, there is widespread illegal fishing practices are found in Lake Chamo. In view of this alarming rate of fishing pressure, there is an urgent need to follow sound management practices and this requires knowledge about the exploitation potentials of the stocks mainly Tilapia.

The present work is therefore an attempt to estimate the maximum sustainable yield (MSY) of Tilapia in Lake Chamo as well as the optimum level of fishing effort to be expanded on the Tilapia stock of the lake. Accordingly, catch and effort data collected over a period of 5 years (2011-2015) have been used to predict the exploitable potentials of the stock.

2. MATERIALS AND METHODS

2.1 Description of the study area and fishery

Lake Chamo is situated at 5040'N, 37037'E at an altitude of 1282m (Fig. 1). It has a surface area of about 350 km2 with a depth of 13 m. The dominant vegetation along the shores constitutes paprus and ambach trees. The most economically important fish species of the lake are Nile perch *(Lates niloticus*), Tilapia *(Oreochromi sniloticus*), Bagrus (*Bagrus docmak*) and African catfish (*Clarias garipenus)*. Fishing is almost exclusively conducted using surface gillnet although long –lines are also used to some extent to catch Catfish. The fishing gears are set in the afternoon and checked early in the subsequent morning. Tilapia is the major target species because catch rates of Nile perch has been reduced.

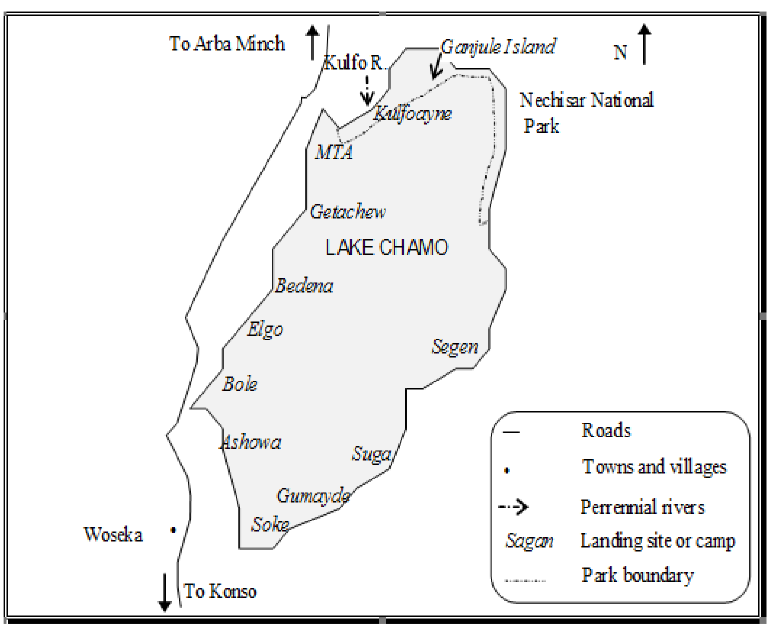


Fig 1: The map of Lake Chamo in the Ethiopian part of the eastern great Rift valley of Africa

2.2 Methods of data collection and analysis

The Tilapia catch and effort data were collected from 20 randomly sampled boats for five days per month at five major landing sites (4 boats in each landing site). Spring balance was used to take the total weight of the catch. The gillnets at operation were counted during every sampling occasion. Similarly, a gillnet inventory of all boats was done every month. Catch per Unit Effort (CPUE) was obtained by dividing sample catch by sample effort. Total catch was obtained by multiplying the average CPUE of the month by the total effort (number of nets set) and number of working days per month. Accordingly, the annual catch and effort of the respective year was obtained by summing up the monthly total catch and effort data. The Maximum Sustainable Yield (MSY) of Tilapia was estimated using Schaefer and Fox models (Schaefer, 1954; 1957., Fox, 1970).

Schaefer parabola yield model: $Yi=afi+bfi^2$
Fox parabola yield model: Yi=fi *ea+bfi
Where,
Yi = The total annual yield of Tilapia during year i
(tons/year)
fi= The total annual effort expanded by the fishery during year i (no of gill nets/year)
a and b are constants of the relationship
The above parabola yield equations were transformed into
linear form as follows
Schaefer Linearized equation: Yi/fi=a+bfi
Fox linearized equation: Ln(Yi/fi)=a+bfi
Where,
Yi/fi = Catch per unit effort (tons/net) of the respective year
fi= The total annual effort expanded by the fishery during year
i (No. of gill nets/year)
a and b are constants of the relationship
Accordingly a linear regression was established between Yi/fi and fi (Schaefer model) and between Ln(Yi/fi) and fi (Fox model) and the corresponding intercept (a) and slope (b)values were estimated. Hence, from the above relationship the maximum Sustainable yield (MSY) and optimum fishing effort level that gives the maximum sustainable yield(fMSY)were estimated as follows (Schaefer, 1954, 1957; Fox, 1970; Ricker, 1975; Caddy, 1980; Pauly, 1984; Schnute,1985).
Schaefer model
$MSY = a^2/4b$
fMSY= a/2b

Fox model
MSY = -(1/b) * e(a-1)
fMSY= -1/b

Where,
MSY is the maximum sustainable yield of Tilapia (tones/year)and fMSY is the fishing effort that should be expanded on the Tilapia stock per year to get the maximum sustainable yield(gill nets/ year).

3. RESULTS AND DISCUSSION

Annual Tilapia yield and effort level expanded by the fishery

Total annual yield of Tilapia (tones/year) and annual effort (number of gill nets per year) expanded on the Tilapia fishery of Lake Chamo between the years 2011 up to 2015 are shown in Table 1. Accordingly, on average an estimated number of gill nets 414494 were expanded by the fishery annually during the mentioned five years and this gave an average of about 1840 tonnes of Tilapia/ per year. This means an average of about 1135 nets were set per day during the said period. The number of gillnets given in the table from 2011-2015 shows that there is fishing pressure in Tilapia fishery on lake Chamo.

Table 1: Total annual effort (gillnets/year) and annual yield (ton/year) of Tilapia caught from Lake Chamo between 2011 and 2015.
CPUE and Ln (CPUE) values prepared for Schaefer and Fox yield model, respectively

Year	effort	Yield	cpue	Ln(cpue)
2011	144175	1921	0.013324	-4.31818
2012	214985	1530	0.007117	-4.9453
2013	328135	1402.5	0.004274	-5.45517
2014	458075	2078.2	0.004537	-5.39553
2015	927100	2269.5	0.002448	-6.0125
average	414494	1840.21		

3.1 Yield estimation

Based on the Schaefer model, the equation that expresses the CPUE (Yi/fi) of Tilapia in Lake Chamo as a function of fishing effort is given as follows (Fig. 2a).
Yi/fi = 0. -0. 0.010**-** 0.01057984fi

From this, the corresponding parabola yield equation for the Tilapia of the Lake Chamo fishery is expressed as follows (Figure 3a)

Yi = $0.010fi – 0.01057984fi^2$

Accordingly, values of the intercept (a) and the slope (b) are

.

Similarly, the linearized as well as the parabola yield equation for the Tilapia of Lake Chamo based on the Fox model are expressed as follows.

Ln(Yi/fi) = - 4.480 – 0.000002 fi Linear form **(Fig. 2b)**

Yi = fi *e-4.480 –– 0.000002fi Parabola form **(Fig. 3b)** From the above expression, values of the intercept (a) and the slope (b) are given as -4.480 and -0.000002, respectively. Hence, based on the above, the MSY and fMSY values are estimated as follows

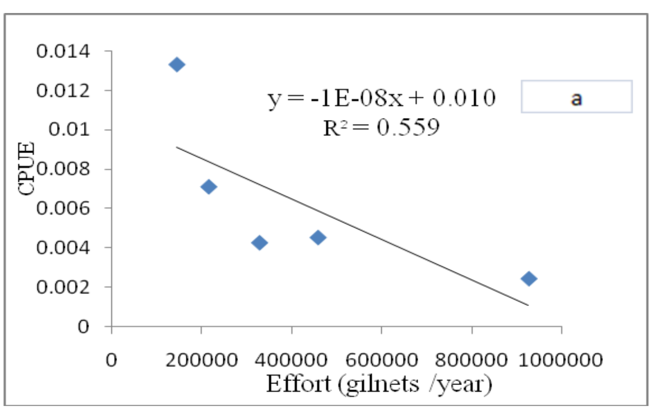
Schaefer model MSY = 2736 tones/year, fMSY = 517146 gillnet**s**/year

Fox model MSY =, 2319 tones/year **fMSY =** 556223 gillnets/year

As shown above, both models gave the fishing effort maximum sustainable yield (fMSY) for the Tillapia of Lake Chamo. Since the R^2 of the Fox model is greater than that of the Schaefer model therefore, the estimated MSY and fMSY of the Fox model is taken. i.e., 2319 t/year and 556223 nets per year. Hence, on a daily basis an effort level of about 1524 nets. The yield estimates obtained shows that 2319 tones of Tilapia can be harvested sustainably from Lake Chamo but this figure is to be seen as a long term average. As per the recommendation of Sparre and Venema (1992) , safe level of exploitation (i.e., optimum fishing effort) is 20% less than the fishing effort that gives the maximum sustainable yield (fMSY). Taking 80% of the fMSY obtained in this study (1524 nets /day), gives 1219 gillnets /day, so the optimum level of fishing to be expanded on the Tilapia of Lake Chamo should not exceed 1219 gill nets/day.

The yield estimates obtained in this study (2319 tons/year) is close to the safe level of exploitation recommended by Reyintijens Dirk and Tesfaye Wudineh (1998) which is 2325 tons/year. The estimated optimum effort level in the present study for the Tilapia stock of Lake Chamo is close to 1219 gillnets/day is higher than the recommended safe level of fishing estimated by Reyintijens Dirk and Tesfaye Wudineh. (1998) as 900 nets/day.

Schaefer model



Fox model

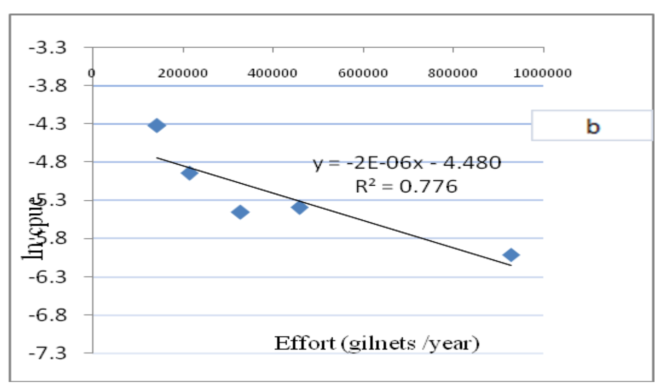


Fig 2: Yield per unit effort (tons/gillnet) of Tilapia caught from Lake Chamo between 2011 and 2015 and Natural log values of Yield per unit effort expressed as a function of total annual effort.

Schaefer model **Fox model**

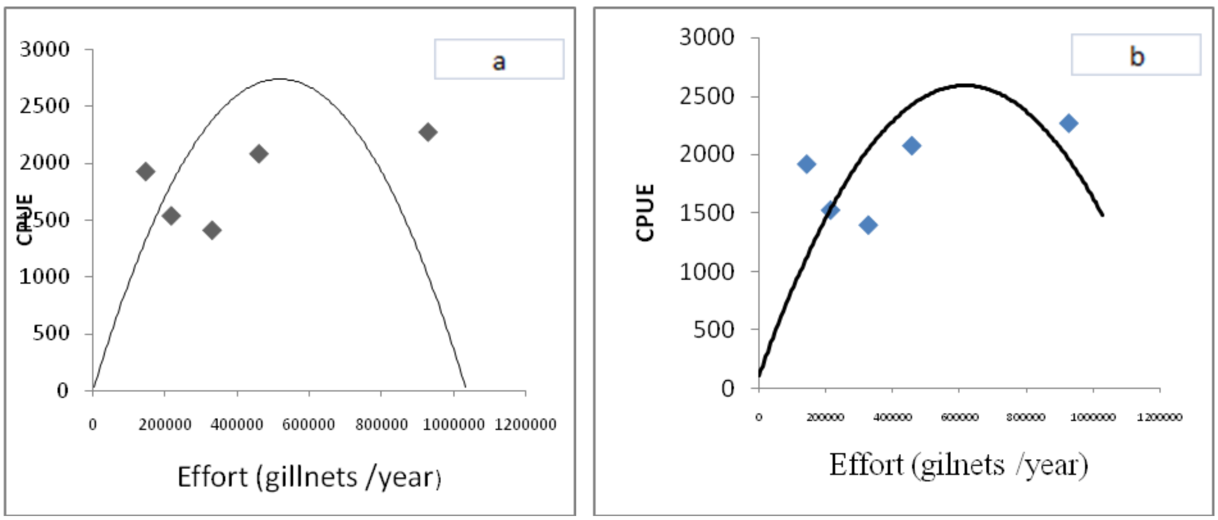


Fig 3: Total annual yield (ton/year) as a function of fishing effort for the Tilapia stock of Lake Chamo Schaefer and Fox parabola yield curves are fitted to the data and shown with the respective equation

4. CONCLUSION

The yield estimate obtained in the present study was higher than that of the yield estimate 1800 tons/year based on data collected between 1992-1994 (LFDP, 1994). According to the present study, the lake is not overfished and it can catch more Tilapia, if the number of gillnets is reduced and reducing the mesh size of the gill nets. So it is recommended not to reduce the mesh size of the gill net and not to add the number of the gill nets.

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