continuously with two peaks of activity around April and October. In addition, we note that the mean lengths of the cohorts given in Table 1 correspond to relative ages of between 1 and 2 years. This indicates that the fishery depends mainly on 1-year old fish.

Currently, there is concern about the fishing pressure being exerted on juvenile sardines. The gillnets utilized by most fishermen appear to help avoid growth overfishing and to allow sufficient escapement of spawners (Boely 1979). However, the beach seines currently in use in nursery grounds, as well as the purse seines in use further offshore, do not allow young fish to escape from the nets. These practices, combined with strong fishing effort, may lead to overfishing of the stock.

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References

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

Boely, T. 1979. Biologie de deux espèces de sardinelles (*Sardinella aurita* Valenciennes 1847 et *Sardinella maderensis* Lowe 1841) des côtes sénégalaises. Pêche maritime, Juillet 1979.

Gulland, J.A. and S.J. Holt. 1959. Estimation of growth parameters for data at unequal time intervals. J. Cons. CIEM 25(1):47-49.

Gulland, J.A. 1983. Fish stock assessment. FAO/Wiley Series on Food and Agric. Vol. 1.

Marcus, O. 1984. Annual report. Nigerian Institute for Oceanography and Marine Research, Lagos.

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Pap. No. 234.

Pauly, D. and J. Munro. 1984. Once more on growth comparison in fish and invertebrates. Fishbyte 2(1):21.

Sparre, P. 1985. Introduction to tropical fish stock assessment. FI: GCP/INT/392/ DEN, Rome. 338 p.

Management of Catfish (*Bagrus meridionalis* Günther) in Southern Lake Malaŵi

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Introduction

The catfish *Bagrus meridionalis* Günther, locally known as *kampango*, is a predator endemic to Lake Malaŵi where it lives in deeper water and feeds mainly on small bottom-living cichlid species. Some notes on its biology were given by Jackson et al. (1963). Substantial quantities of *kampango* are caught in gillnets and longlines by artisanal fishermen. The fish also occur as bycatch in the demersal commercial trawlers in southern Lake Malaŵi.

FAO (1976) reported declining catfish catch rates from gillnet and longline fisheries in southern Lake Malaŵi from the early 1950s to the early 1970s. Since *kampango* is one of the valued food and commercial fish species in Malaŵi, measures to control its exploitation should be taken. This paper assessess the yield of the fish using a dynamic pool model with the aim of giving advice on the rational exploitation of the fish.

Materials and Methods

The dynamic pool model of Beverton and Holt (1957) was used to calculate values of yield per recruit. Data concering the growth of *kampango* which were required in fitting the model were taken from the study carried out by Tweddle (1975). The natural mortality (M) was estimated from the equation of Pauly (1980).

During January to March 1987, bottom trawling was carried out in the north of fishing area B (Fig. 1) using the 88 hp research vessel "Ethelwyn

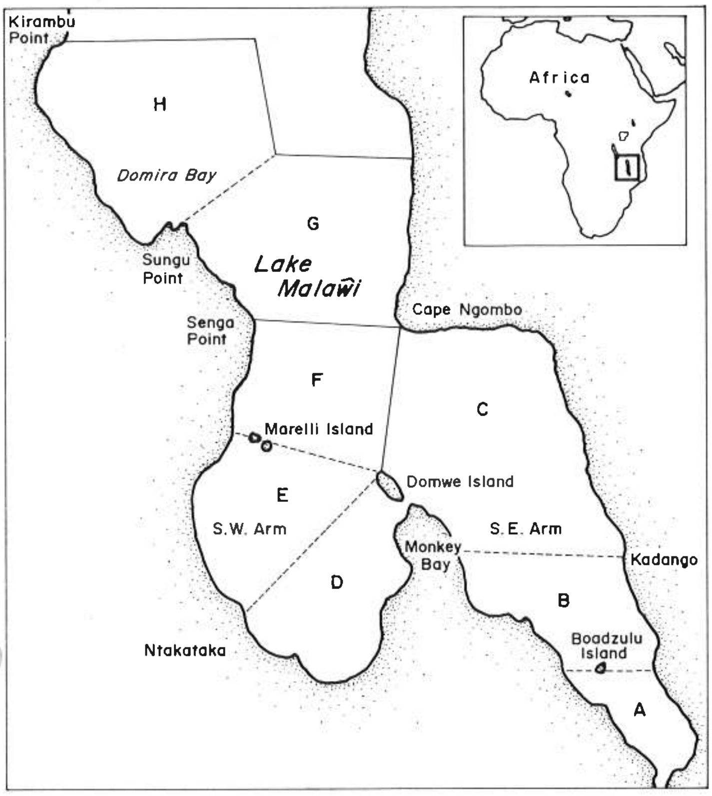

Fig. 1. Commercial fishing areas in southern Lake Malaŵi.

Trewavas". Samples of fish were collected using a trawl net of codend mesh size 38 mm. These samples were used to estimate the parameters of a length-weight relationship, based on 883 fish, as well as to construct a catch curve for estimation of Z.

Results and Discussion

Tweddle (1975) gave separate estimates of L_∞ and K for females and males. The means of his values were 107 cm and 0.0915 year^{-1} for L_∞ and K, respectively.

The other parameters given by Tweddle (1975) are t_o = - 0.02 and age at recruitment t_r = 2.5 year. The estimated length-weight relationship was:

$$\ln(W) = 3.1512 \times \ln(L) - 5.6094 \qquad \text{... 1)}$$

where W is the live weight in g and L the length in cm. Hence, the asymptotic weight corresponding to L_∞ is W_∞ = 9096 g.

An estimate of t_{max}, the maximum age of fish in the stock, was obtained by solving the VBGF

$$L_t = 107(1-\exp(-0.0915(t+0.02))) \qquad \text{... 2)}$$

for 90 cm, the most common length among the largest fish in Tweddle's samples from the Southwest area of Lake Malaŵi, which had never been fished at the time (the largest males and females were 90 and 97 cm, respectively).

The estimate of t_{max} was equal to 20 years. The value of M estimated from Pauly's equation was 0.25 year^{-1}, based on a mean water temperature of 26°C.

Fig. 2 shows the age-frequency distribution of *B. meridionalis*, as derived by conversion of length to age using equation (2). The natural logarithms of the frequencies were used to estimate Z = 1.11 year^{-1} for age 5-10; this, given the value of M derived above, gives F = 1.11 - 0.25 = 0.85 year^{-1}.

Fig. 3 shows the yield-per-recruit isopleth diagram for *kampango*. As might be seen, peak yield per recruit is about 340 g, for $t_c \approx 8$ years and high values of F.

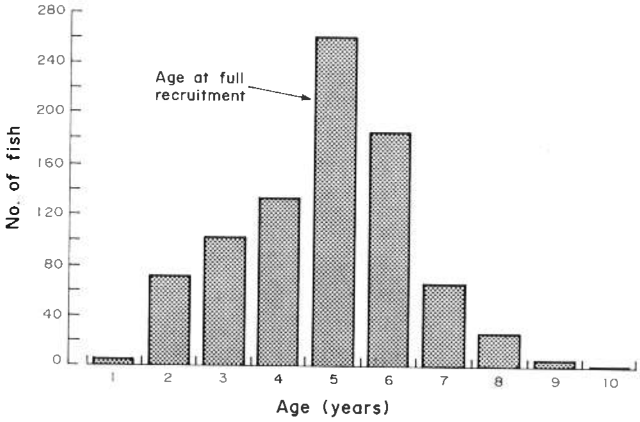

Fig. 2. Age frequency plot of *kampango (B. meridionalis)* from fishing area B of southern Lake Malaŵi.

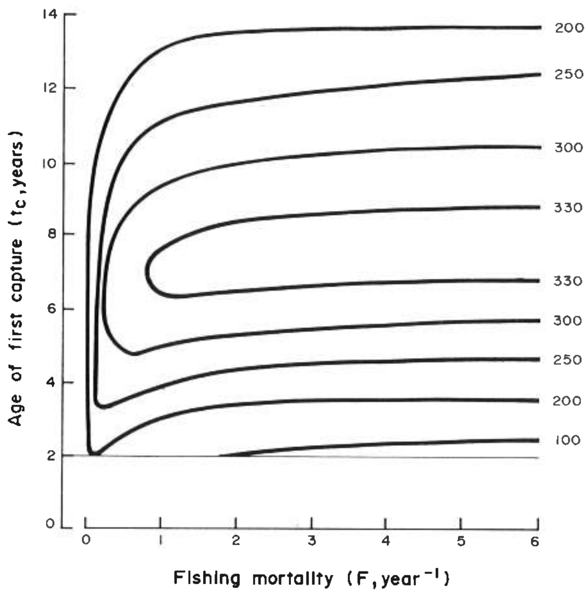

Fig. 3. Yield-per-recruit contours for *kampango, Bagrus meridionalis* from Lake Malaŵi derived from the Beverton and Holt (1957) model.

The graph suggests that yield per recruit could be increased by augmenting t_c, presently less than 5 years to about 8 years. This would also stabilize the stock itself, since $t_c \approx 8$ years correspond to 50-60 cm, well beyond the size at first maturity of 37 cm (Tweddle 1975).

Jackson et al. (1963), in their study in northern Lake Malaŵi, found that of the series of gillnet mesh sizes they tried, the 5-inch (12.7 cm) meshed nets caught the largest amount of fish and 75% of the catch was *B. meridionalis*. In a later study by Tweddle (1982) in northern Lake Malaŵi, a fleet of gillnets of mesh sizes ranging from 6.4 cm to 17.8 cm was used. It was found that, while adult *B. meridionalis* were caught in the mesh sizes from 8.9 cm and up, the catch of the 12.7 cm mesh gillnets was composed mainly of fish of lengths between 50 cm and 65 cm, the sizes at which *kampango* are most valued. Since this range of size is close to the optimum size at first capture, it would appear that the gillnet mesh size that would be suitable for optimizing the age of the fish at first capture and hence, optimizing the yield is 12.7 cm.

McKaye (1986) considers that the growth rate of *kampango* may be slightly faster than was documented by Tweddle (1975). If this is true, then the yield surface outlined in Fig. 3 will only shift slightly and horizontally to the right so that the management recommendations then given will essentially be the same as those outlined here.

Yield isopleth diagrams based on the Beverton and Holt model often have their maximum at very high levels of fishing. However, for practical management purposes, fishing mortality can be set depending on what percentage of the maximum yield per recruit has been selected (Pitcher and Hart 1982). The diagram in Fig. 3 suggests that if fishing mortality is set at 1.0 $year^{-1}$ and fishing gears are used that leave out all fish younger than 8 years from the catch, then a yield per recruit which is not very different from the maximum can be achieved.

Fryer (1984) expressed concern over the diminishing numbers of *Bagrus meridionalis* in the demersal trawl catches in southern Lake Malaŵi and attributed this decline to the trawlers catching immature fish and to heavy fishing by artisanal fishermen, mostly using gillnets and longlines, before trawling began. While this may be true for the other fishing areas in southern Lake Malaŵi, it does not seem to apply to Area C and the northern part of Area B. These areas are at present lightly fished by both trawlers and artisanal gillnets and longlines. The present analysis shows that the fishing mortality in the northern part of Area B is less of the optimum mortality suggested above and that the trawl catches do not include many fish younger than the age at first maturity (four years). Trawl samples similar to those collected from the north of Area B should be collected from the other fishing areas to enable determination of fishing mortality rates and of the age structure of the fish populations. In addition to this, the longline fisheries in the various areas should be studied to determine the fishing strategy that should be employed to obtain the optimum yield from *kampango*. These analyses would give an indication of the position of the fisheries in those areas and should lead to the formulation of improved management recommendations.

References

Beverton R.J.H. and S.J. Holt. 1957. On the dynamics of exploited fish populations. Fish. Invest. London, Ser. II 19:1-533.

FAO. 1976. An analysis of the various fisheries of Lake Malaŵi. Promotion of Integrated Fishery Development. Tech. Rep. FI: DP/MLW/71/516.

Fryer, G. 1984. The conservation and rational exploitation of the biota of Africa's great lakes. S. Afr. Nat. Sci. Prog. Rep. No. 92:135-154.

Jackson, P.B.N., T.D. Iles, D. Harding and G. Fryer. 1963. Report on the survey of northern Lake Nyasa, 1954-1955. J.F.R.O. Govt. Print., Zomba, Malaŵi.

McKaye, K.R. 1986. Trophic egg and parental foraging for young by the catfish *Bagrus meridionalis* of Lake Malaŵi, Africa. Oecologia 69(3):367-369.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM 39(2):175-192.

Pitcher, T.J. and P.J.B. Hart. 1982. Fisheries ecology, Croom Helm, London.

Tweddle, D. 1975. Age and growth of the catfish *Bagrus meridionalis* Günther in southern Lake Malaŵi. J. Fish Biol. 7:677-685.

Tweddle, D. 1982. A comparison of gillnet mounting techniques and different mesh sizes in northern Lake Malaŵi. Luso: J. Sci.Tech. (Malaŵi) 3(2):47-65.