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TRADITIONAL FISHERIES ASSESSMENT PROJECT (MG/ODA)

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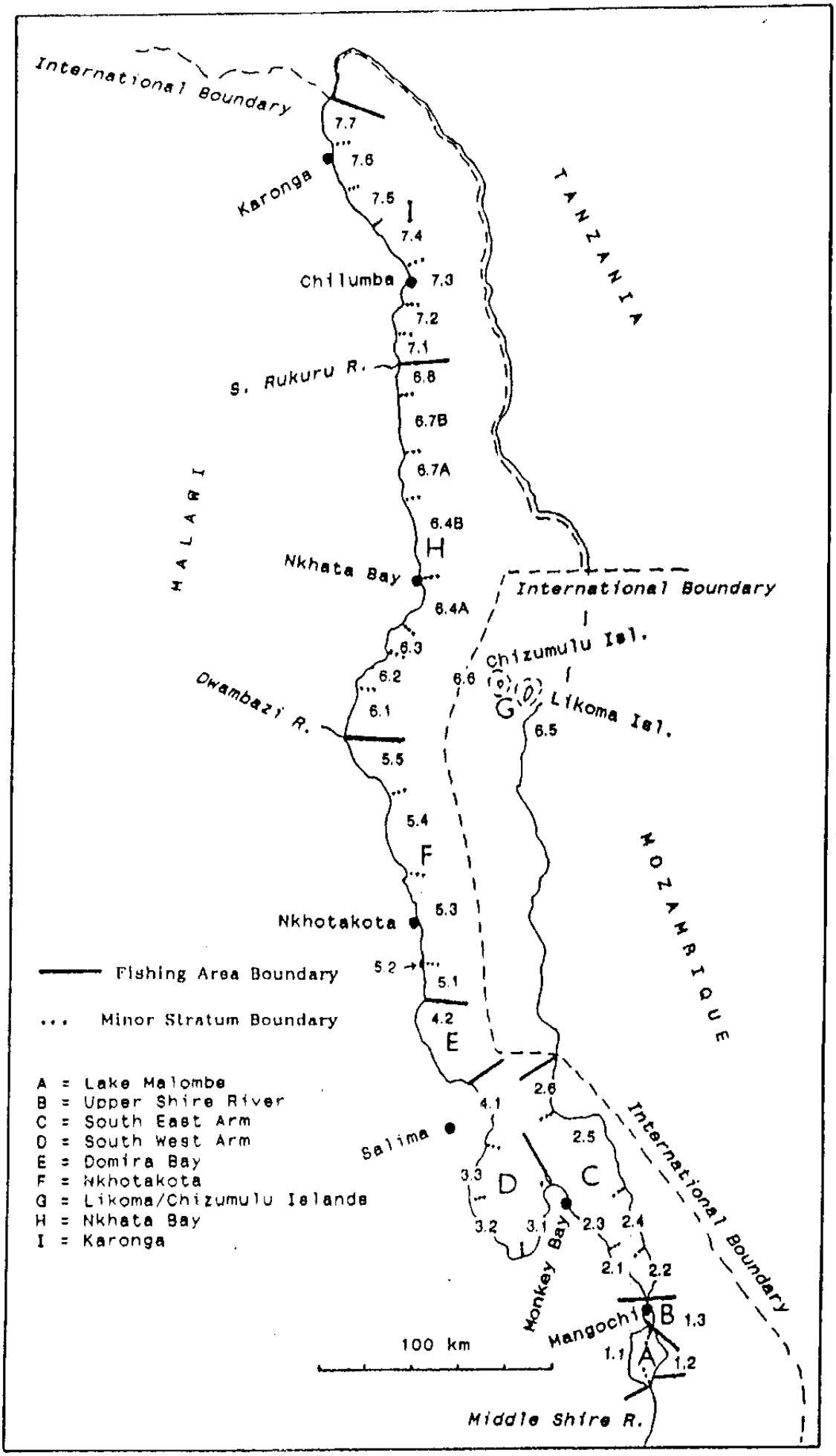

International Boundary
Karonga
Chilumba
S. Rukuru R.
MALAWI
TANZANIA
Nkhata Bay
International Boundary
Chizumulu Isl.
Likoma Isl.
Dwambazi R.
MOZAMBIQUE
Nkhotakota
Fishing Area Boundary
Minor Stratum Boundary
A = Lake Malombe
B = Upper Shire River
C = South East Arm
D = South West Arm
E = Domira Bay
F = Nkhotakota
G = Likoma/Chizumulu Islands
H = Nkhata Bay
I = Karonga
Salima
Monkey Bay
Mangochi
International Boundary
100 km
Middle Shire R.

Figure 1

INTRODUCTION

The Shire River flows from the southern tip of Lake Malawi for about 12km before widening to form Lake Malombe, a lake 30km long by 15km wide with a maximum depth of only 5m (Fig. 1). At times of low level in Lake Malawi such as the first 35 years of this century, Lake Malombe does not exist and its bed is rich farmland. The lake is fed by the most eutrophic water in Lake Malawi, the South East Arm, and is further enriched by streams flowing into the lake from its highly-populated catchment area and by recycling of nutrients in sediments as a result of the shallowness of the lake. Malombe is therefore much more productive than Lake Malawi, though detailed limnological investigations have not yet been made.

Fishing only started on anything greater than a subsistence level in the 1960s after the destruction of the large crocodile population (A.J.P. Mzumara, pers. comm.). In the 1940s the lake was very heavily overgrown with weeds (R. H. Lowe-McConnell, pers. comm.). By the 1970s, catches reached over 5,000 tonnes annually with the bulk of the catch consisting of high value Chambo (*Oreochromis* spp.).

Gillnets were the main gear used and Chambo were frightened into the nets by the fishermen beating the water with clubs. Seining was hampered by dense weed beds and shoreline reeds. The weeds also prevented trawling from developing, though experimental tows in the early 1970s produced high yields dominated by the small cichlid species *Placidochromis longimanus* in the short spells before weeds blocked the nets (J. Tarbit, pers. comm.). In the 1970s and 1980s, however, seining grew to dominate the fishery as weeds were cleared.

In the 1989 annual frame survey, 2,768 fishermen were recorded operating on Lake Malombe (Fig. 1). The number of fishing craft recorded on the lake in annual frame surveys has fluctuated from year to year, probably as a result of fishermen moving freely back and forth through the River Shire to Lake Malawi, but has nevertheless shown a steady upward trend in numbers (Fig. 2). In 1989, 642 craft, of which only 21 were dugout canoes, were operating on the lake. No outboard engines were in use, a remarkable change from the 221 engines present in 1980.

METHODS OF DATA COLLECTION

Statistical data on the traditional fisheries are collected and analysed using methods developed by Bazigos (1972) and implemented by Walker (1974; 1976). A description of the methods of collecting data and the associated problems has been presented elsewhere (Alimoso, 1988). Total catch and fishing effort for each area are estimated by combining data obtained in monthly catch assessment surveys (CAS) and in annual frame surveys. The data are presented here by gear and by species group.

DATA ANALYSIS

The total estimated annual catch in the period covered here ranged from 2,917 to 12,936 tonnes (mean = 8,245 tonnes) (Fig. 3 and Appendix). In general, catches doubled from the 1970s to the 1980s but are now showing signs of decline. Chambo (*Oreochromis* spp.) comprised 54% of the catch over the whole 14 year period (Fig. 4), while Kambuzi (haplochromines) were also very important (31% of total). Kambuzi increased steadily in importance from 1981 (Fig. 3), while catches of minor species also improved in the 1980s (Fig. 5).

Figure 1. Lakes Malawi and Malombe, showing the areas into which the lakes have been divided for data analysis.

Three gears, gillnets, Chambo seines and Kambuzi seines, caught 99% of the total estimated catch (Figs. 6 and 7). Other gears may therefore be regarded as being of negligible importance for stock assessment. It should be noted that although nkacha nets (which developed in the 1970s as a method of seining offshore) have been included on the recording forms since 1983, the recorders have continued to record nkacha effort data under Kambuzi seines and occasionally under chirimilas. Because of this it has been necessary to lump all data for these gears together under the general heading of Kambuzi seine. The Kambuzi seine is a beach seine with small meshes to catch small haplochromine cichlids known collectively as Kambuzi. While the legal minimum mesh size is 19mm, much smaller meshes are now commonly being used, and the lengths of almost all nets exceed the maximum permissible length of 100m. The nkacha net is similar in appearance to the Kambuzi seine but is generally smaller. It is set in a circle offshore and divers pull the bottom of the net together and tie the weights to effectively 'purse' the net. While Kambuzi seines themselves tend to have higher cpue than nkacha nets, the number of such seines is small (only 27 on the lake in the 1988 survey) and unlikely to drastically influence the results. The Kambuzi seine/nkacha net fishery has increased greatly in importance in the 1980s (Fig. 6). The extent of the nkacha and seine net fisheries of Lake Malombe has been documented elsewhere (Alimoso and Tweddle, 1991).

Two methods of assessing the state of the fisheries are presented in this report, (1) analysis by gear, concentrating on each of the three gears of importance in the lake's fisheries, and (2) analysis by species, concentrating on the Chambo fishery. Chambo are exploited by gillnets, Chambo seines and, to a lesser extent, Kambuzi seines. Thus an analysis of catches of this species group, combining catches of all gears, provides a valuable comparison with the separate analysis by gear.

ANALYSIS BY GEAR

Gillnets

In Lake Malombe gillnets are actively fished with the aim of catching Chambo, which comprise 85% of the catch by weight. The fish are driven into the nets at night by fishermen, who beat the water to frighten the fish into the gear, hence catch per unit effort (cpue) figures are very high in comparison to those of passively fished nets.

The number of gillnets owned by Lake Malombe fishermen has declined steadily since 1978 (Fig. 8). Figs. 9 to 11 show the catch, effort and cpue data for the gillnet fishery over the 14 year period 1976-1989. Annual effort levels were generally in agreement with gillnet ownership though there were some discrepancies. In 1979 and 1980, effort was much lower than would be expected from the number of nets present, while in two recent years, 1986 and 1989, estimated effort exceeded the total possible if all nets were fished every night. Biased recording, due to beach selection in favour of beaches where gillnetting is the dominant activity, or under-recording of actual ownership of gillnets may be the reason. Approximately 700 nets would be necessary to achieve the recorded effort of 1989.

Figure 2. Changes in the number of fishing craft of different types owned by Lake Malombe fishermen, based on annual frame surveys.

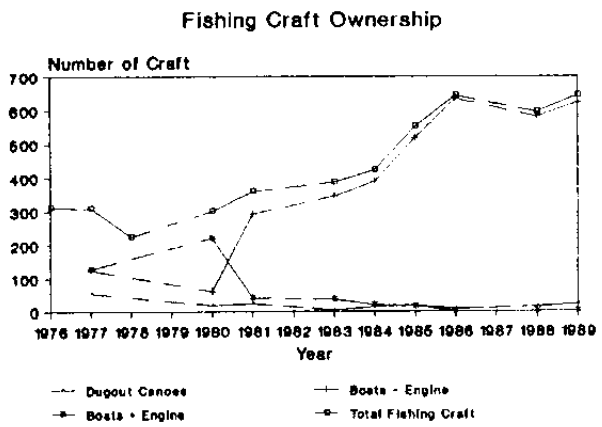
Figure 3. Annual catches from Lake Malombe, showing the contribution to the catches of the different species groups.

Figure 4. Contribution of the different species groups to the total catch over the 14 year period 1976-1989.

Figure 5. Annual catches of the minor species in the catches, showing the improvement in catches in the 1980s.

Figure 6. Contribution of the different fishing gears to the annual catches, showing the increasing importance of Kambuzi nets in recent years.

Figure 7. Contribution of the different fishing gears to the total catch over the 14 year period 1976-1989



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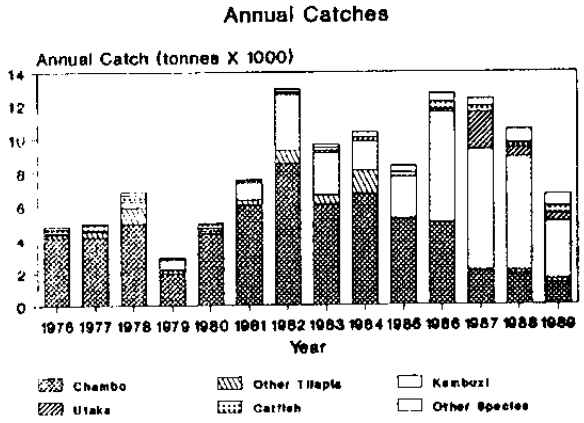

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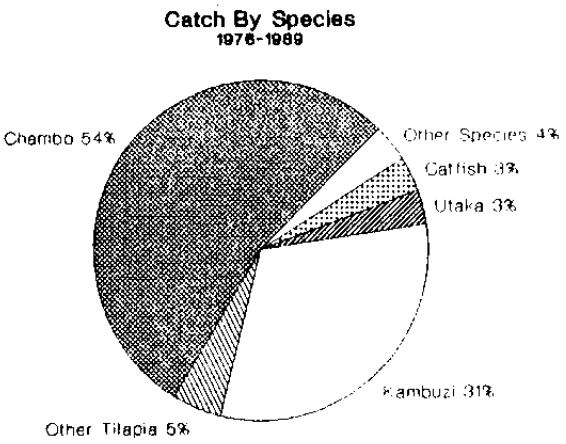

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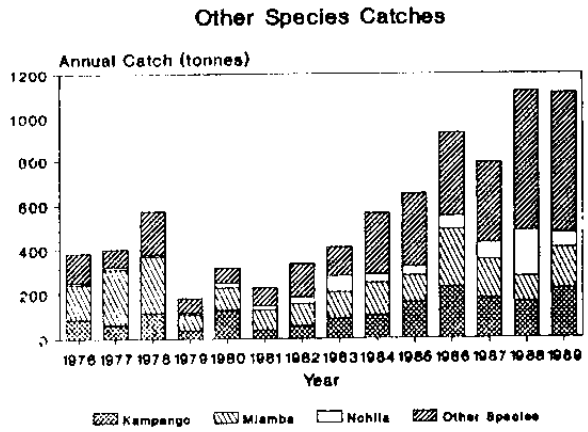

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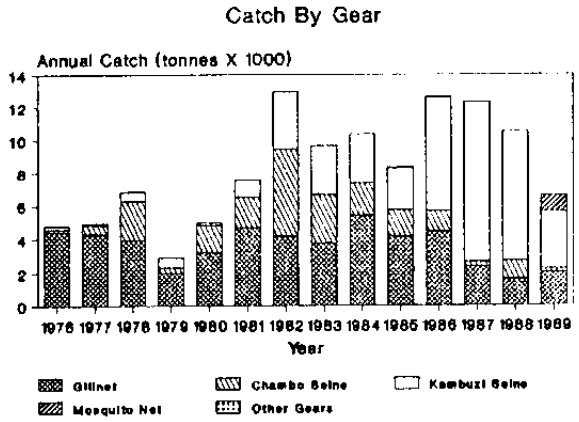

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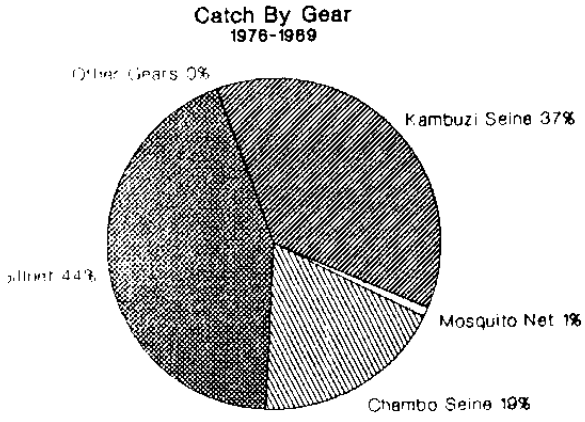


Figure 7

The exponential regression of cpue on effort was highly significant ($r = 0.644$, $P=0.013$). The correlation was similar when Gulland's (1961) method of averaging fishing effort of the current year with that of previous years was used, e.g. for a two-year mean of effort $r = 0.647$, $P = 0.012$. The good correlation suggests that the abundance of fish stocks exploited by the gillnets may be little affected by other activities and may be treated as a management unit. This is discussed further later in this report under the section on Chambo seines. The Fox (1970) yield model (which gave a better fit to the data than Schaefer's (1954) model) was applied to the data using the two-year mean of effort, a combination which has proved suitable in other Lake Malawi fisheries (FAO, 1976; Tweddle and Magasa, 1989; Tweddle *et al.*, 1991). The model suggests a maximum sustainable annual yield (MSY) of 4,250 tonnes at an effort level of 475,000 net nights (Fig. 12A).

Walter's (1986) graphical method for obtaining equilibrium yield curves, based on changes in cpue from year to year, has also been applied to these data. Before 1987, this method produced good results with the best fit to the data being identical to that of the Fox model if this is recalculated using the pre-1987 data only. This curve is also shown in Fig. 12 and shows that optimum effort is much lower than calculated with the Fox model using all available data. Only one point (1977) did not fit the Walter model, and this point was very close to the fitted curve. However, the data since 1987 do not fit the model, with cpue declining every year despite lower effort levels, suggesting there are now other factors influencing this fishery. The Fox model assumes a fishery in equilibrium with the stock. The change in the fishery since 1986 suggests that this assumption no longer holds and that the Fox model should only be used for the fishery pre-1987. The recent changes in the fishery are discussed in detail later.

For most of the period examined, effort has been in the optimum region of around 200,000 net nights annually (Fig. 12), but it appears to have been excessive from 1976 to 1978. After effort was cut back from 1979, there was a steady improvement in catches not only of Chambo but also of other species which make up a lesser proportion of the catch. The improvement in catches of Kampango (*Bagrus meridionalis*), Mlamba (*Clarias gariepinus*), Nchila (*Labeo mesops*) and 'others' is shown in Fig. 13. Chambo, however, showed a major decline after 1986.

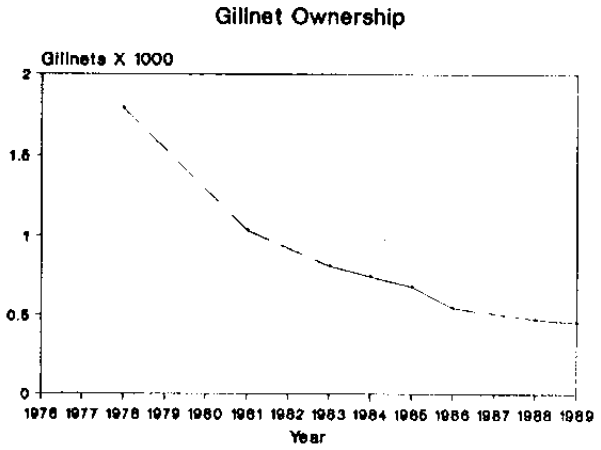
Figure 8. Changes in the number of gillnets owned by Lake Malombe fishermen, based on annual frame surveys.

Figure 9. Annual catches made by gillnets by species groups.

Figure 10. Annual effort for gillnets (1 gillnet night = 1 x 100yd (91m) stretched length gillnet set for 1 night).

Figure 11. Changes in cpue in gillnets from year to year.

Figure 12. Estimate of maximum sustainable yield (MSY) for the gillnet fishery. The figure shows both the Fox yield curve based on the regression in part B of the figure, and the Walter curve, based on the changes in catch per unit effort (cpue) from year to year. The direction of each annual change in cpue is shown by arrows on the data points. Up arrows indicate improved cpue in following year, down arrows falling cpue and absence of an arrow unchanged cpue. The Walter curve is based on the data to 1987 only, as the post-1987 data show a marked change in pattern from the earlier years. If the Fox model is recalculated using only the data to 1987, it gives an identical picture to that shown in the walter curve in the figure. For more details see text.



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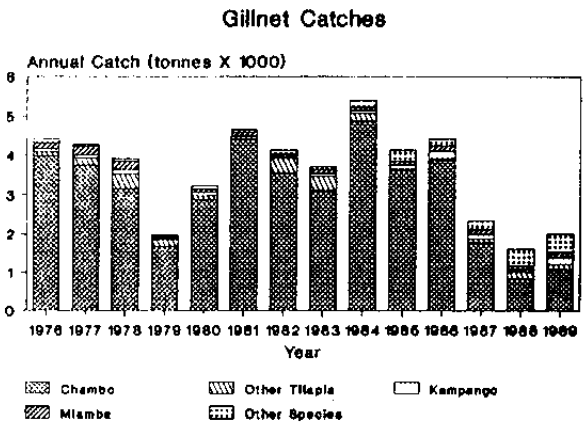

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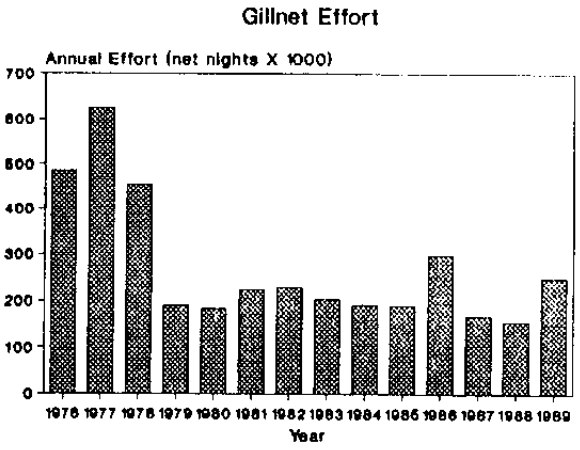

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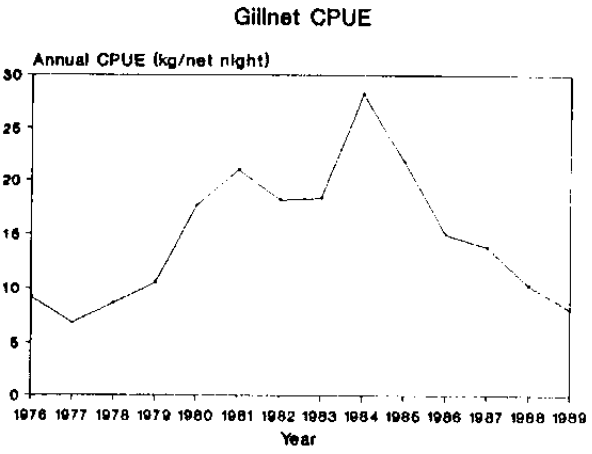

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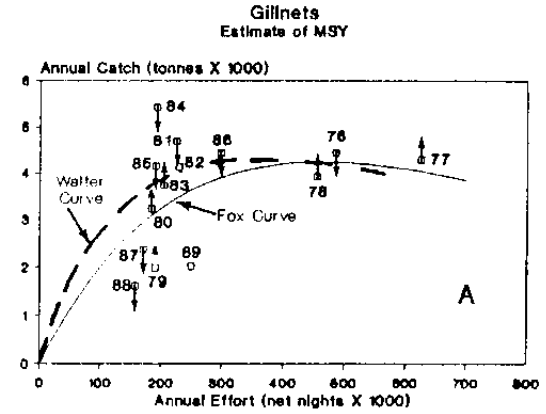


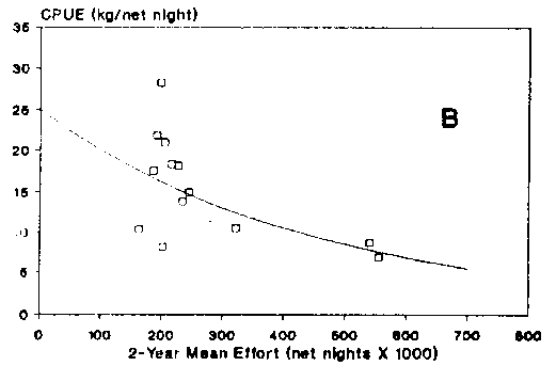


Figure 12

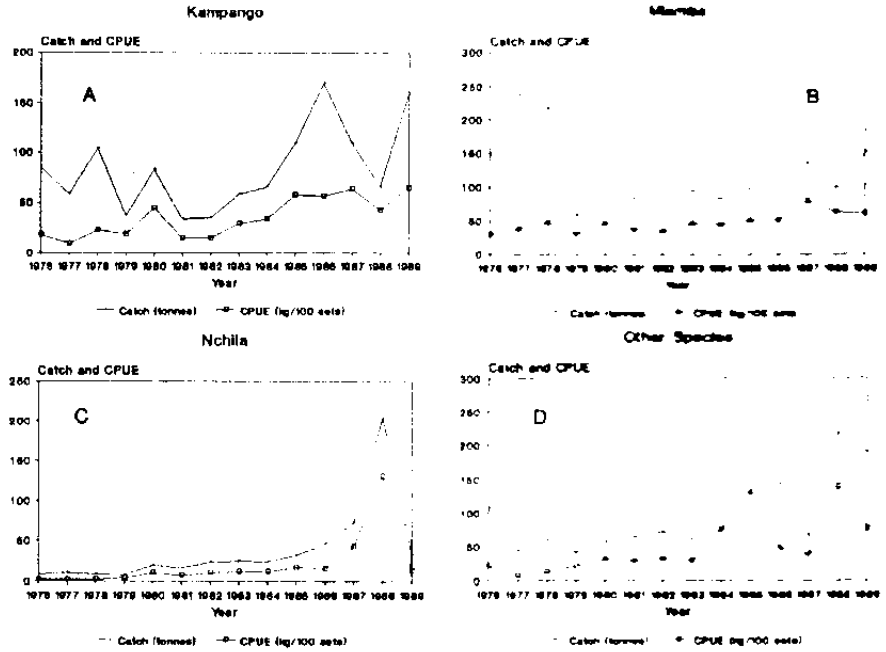


Figure 13. Gillnet catch and cpue for the less abundant species in the gillnet catches, showing the improvement in cpue in particular in the 1980s. Note the 100 net scale for cpue, used in order to fit the catch and cpue data on the same graph.

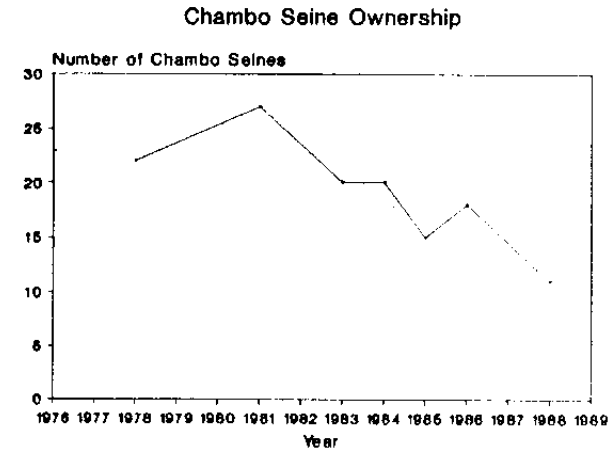
Figure 14. Changes in the number of Chambo seines owned by Lake Malombe fishermen, based on annual frame surveys.

Figure 15. Annual catches of Chambo seines in Lake Malombe, showing the contribution of different species groups to the catches.

Figure 16. Annual effort for Chambo seines, expressed in numbers of pulls.

Figure 17. Changes in cpue from year to year in Chambo seines.

Figure 18. The relationships between catch (Fig. A) and cpue (Fig. B) and effort for the Chambo seine fishery.



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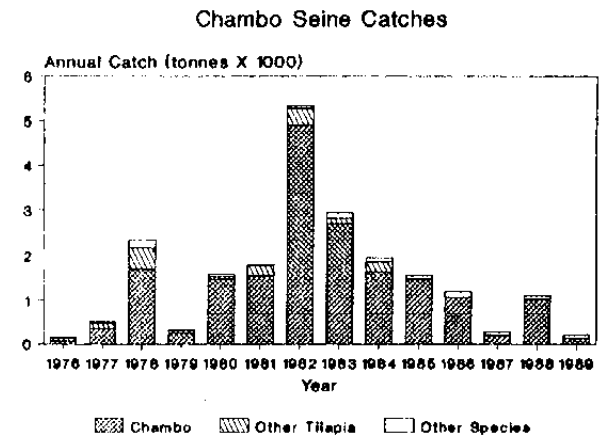

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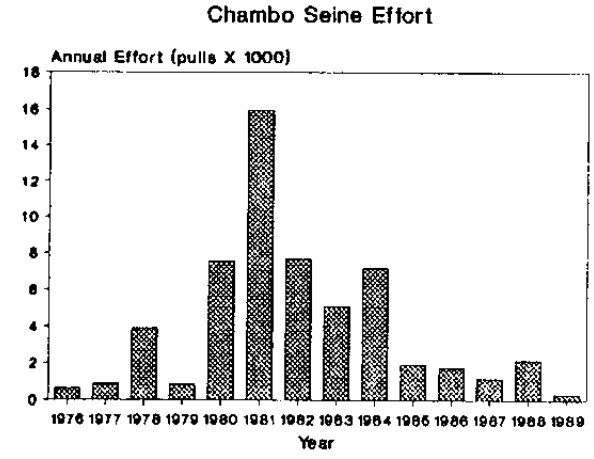

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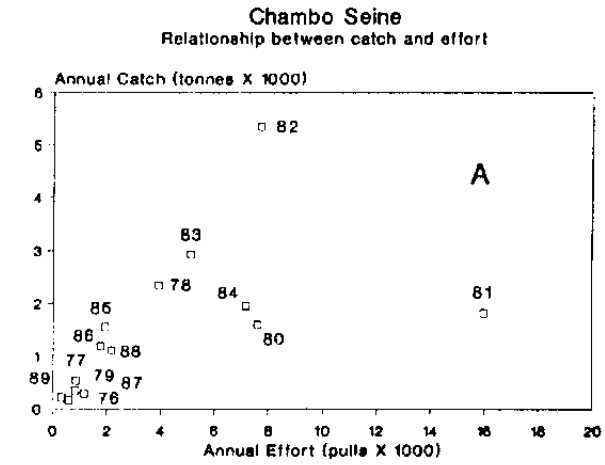

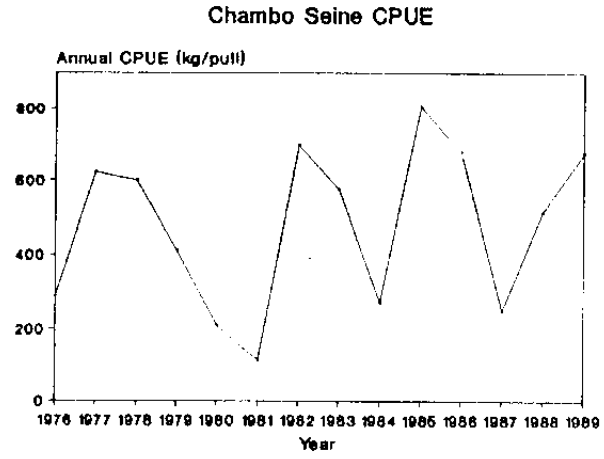

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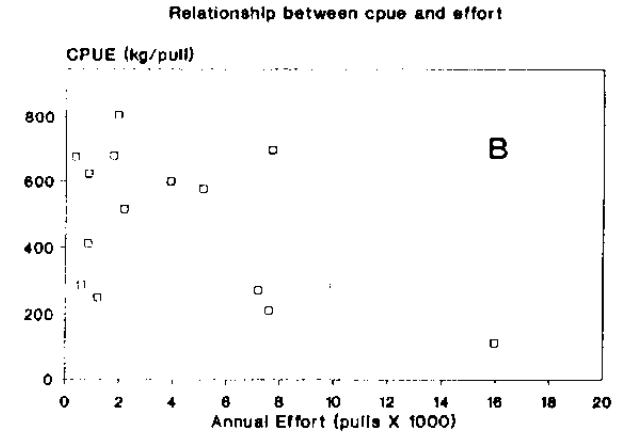


Figure 18

Chambo seine

The Chambo seine is a very long net, up to 1km or more, with a legal minimum mesh size of 76mm. This net is usually fished at night and takes several hours to haul. The target species are Chambo. As this fishery exploits Chambo almost exclusively, it would be expected that cpue trends would closely parallel those of the gillnet Chambo fishery, which presumably exploits the same stocks. In Lake Malombe there can be little spatial and no depth segregation of Chambo species as occurs in Lake Malawi, and the open water species *Oreochromis lidole* is rare in Lake Malombe (Lowe 1952 and personal observations). However, cpue in the Chambo seine appears to be very erratic and the relationship between gillnet and Chambo seine cpue is not significant (linear regression $r = 0.248$).

The number of Chambo seines operational on the lake has declined in recent years (Fig. 14). Catch, effort and cpue data for the twelve year period are shown in Figs. 15 to 17. The relationship between cpue and effort is not as clear as in the gillnet fishery, though it is significant (exponential regression: $r = -0.620$; $P = 0.018$) (Fig. 18) when using cpue and effort data for the same year only. However, if Gulland's method, averaging effort over two years as above, is used, there is no correlation ($r = -0.361$; $P = 0.226$). As we are dealing with fish which are exploited over more than one year, one would expect stock levels and hence cpue to be affected by the amount of fishing in the previous year. Thus, the loss of correlation when dealing with averaged data shows that the use of surplus production stock assessment models based on the apparent correlation between cpue and effort in the same year cannot be justified.

The relatively poor correlation between cpue and effort in this fishery has several possible explanations and is most likely due to a combination of all. Data are affected by (A) greater potential fluctuation in cpue (0-1,000kg cf. 0-30kg in gillnets), associated with (B) smaller recorded sample sizes, which greatly increase variance. (C) Seines catch whole or part shoals of fish. Hence (i) there is a great potential for fluctuations in cpue, as noted in (A) above, and (ii) the cpue may not be closely related to the actual abundance of the fish. (D) Sampled beaches around the lake are changed each year, being randomly chosen based on the results of the annual frame surveys. Thus there is a distinct possibility that in one year an important Chambo seining beach will be recorded, while in other years chosen beaches are not used by Chambo seiners. This will exaggerate the problem noted in (B) above. As an example, the high effort recorded in 1981 exceeds the maximum possible if all recorded Chambo seines on the lake (Fig. 14) were fished daily. Such an error can arise from a beach selection bias in favour of important Chambo seining beaches. (E) Chambo seines are often hauled at night when the beach recorder is absent, hence effort may be under-recorded, while cpue is accurate, being based on actual landed samples. (F) As Chambo seine nets are actively operated, catches are influenced by human variability. (G) Variations in individual net lengths may influence catch rates. Results from an ongoing survey into the seine fisheries of Lake Malombe show that the data collected under the regular sampling system are erratic. For example, the regular system reported nil returns from the Chambo seine fishery from May 1988 to December 1988 whereas the parallel survey recorded catches in all those months except the November and December close season (Alimoso and Tweddle, 1991).

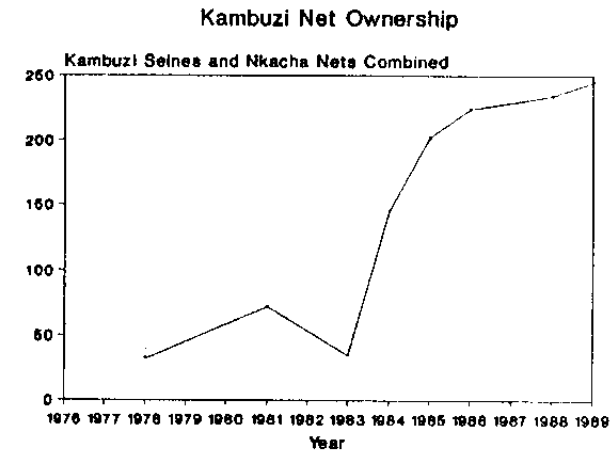
Figure 19. Changes in the number of Kambuzi nets (both Kambuzi seines and nkacha nets) owned by Lake Malombe fishermen, based on annual frame surveys.

Figure 20. Annual catches of Kambuzi nets in Lake Malombe, showing the contribution of different species groups to the catches.

Figure 21. Annual effort for Kambuzi nets, expressed in numbers of pulls.

Figure 22. Changes in cpue from year to year in Kambuzi nets.

Figure 23. Estimate of maximum sustainable yield (MSY) for the Kambuzi net fishery. The figure shows the Fox yield curve based on the regression in part B of the figure. The arrows on data points show the direction of annual changes in cpue, as described in the Figure 12 caption.



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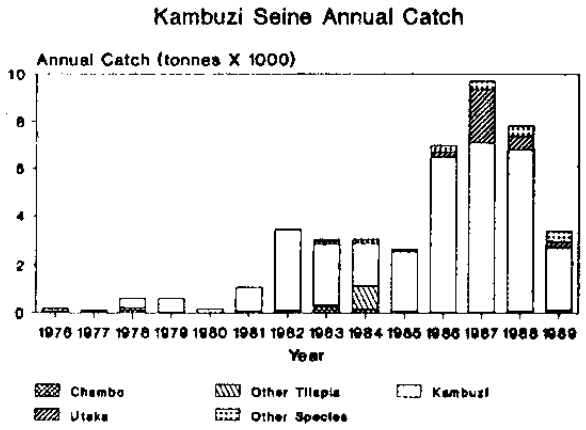

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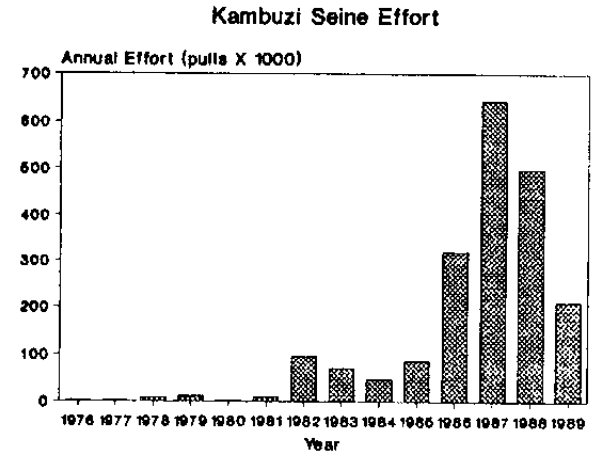

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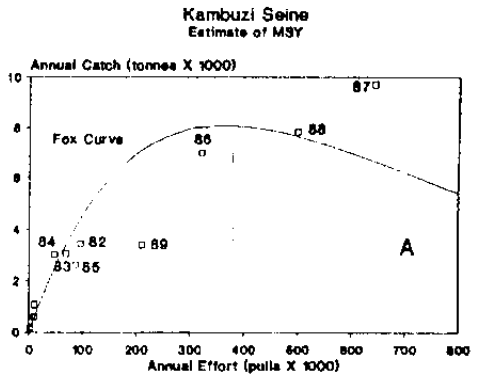

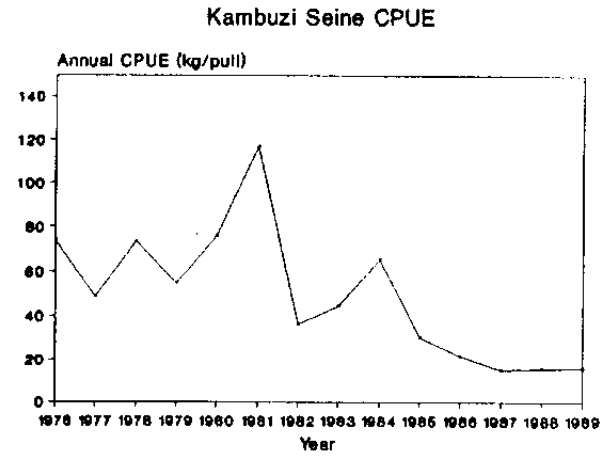

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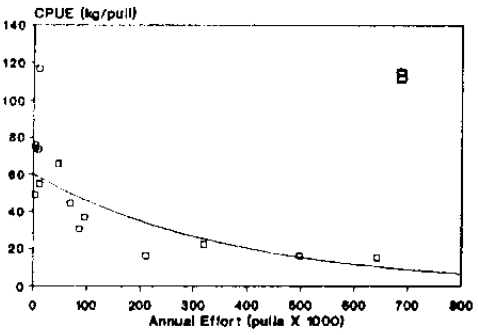

Figure 23

The very poor correlation also explains why there is no apparent correlation between the catch rates of gillnets and Chambo seines despite the fact they are almost certainly exploiting the same stocks.

Kambuzi seine

Kambuzi is a local collective name for the many small haplochromine species that are caught together in small meshed seine nets from Lake Malombe. Kambuzi seines (together with nkacha nets) contributed 37% on average of the total annual catch from the lake, approximately 3,050 tonnes (Fig. 7). 91% of the catch was recorded as Kambuzi (including the other small cichlid categories 'Utaka' and 'Chisawasawa'). Figure 19 shows changes in the number of Kambuzi nets (i.e. seines and Nkacha nets) on Lake Malombe from 1978 to 1989.

Catch, effort and cpue figures for the fourteen year period are shown in Figs. 20 to 22.

Cpue in this fishery has declined over time with increasing effort (Fig. 22). The decline is significant (exponential regression; $r = 0.805$; $P < 0.001$). The effort increase was a result of the expansion of the nkacha net fishery. The increase in recorded effort is reflected in a doubling in the number of craft and eightfold increase in the number of Kambuzi nets (i.e. seines and nkacha nets) on Lake Malombe (Fig. 19).

A certain amount of caution is advisable in interpreting the data for two reasons. (1) The nkacha fishery was already active in the mid-1970s and an independent estimate (A.G. Seymour, pers. comm.) suggested a yield of 5,000 tonnes in 1977. (2) The apparent effort increase in 1986 and 1987 is excessive. An independent survey (Alimoso and Tweddle, 1991) has shown that 202 nkacha nets were operating on the lake in 1988, fishing an average of 6 hauls a day for 5 days a week. Thirty hauls per week for 39 weeks a year (January to March is a close season) equals 1,170 hauls, giving a maximum of about 240,000 pulls per year for all nets on the lake. The 1987 estimate is nearly three times this figure and there is clearly a statistical error. Nkacha nets use at least two boats, hence it is possible that effort could be over-estimated if both boats were recorded as units when going out fishing. This would increase the raising factors, which are based on the proportion of boats out fishing on each day. However, examination of a selection of the raw data shows that two boat units are being correctly recorded as one fishing unit. Thus double recording is not a major factor in the apparent error. A contributing factor to the error may be a bias in favour of important nkacha beaches, as noted above for the 1981 Chambo seine data. By 1989 effort was down to the level expected from the number of nets operating on the lake and their fishing patterns.

For these reasons, any estimate of MSY can only be used as a rough guide and cannot be used in isolation to guide the management of the fishery. However, we can make a tentative assessment of the fishery by using a combination of methods and comparing results.

Fox's model: Fig. 23 shows the calculations of MSY using the Fox model with the original data. MSY is calculated at 8,080 tonnes at an effort level of 370,000 pulls. Using two and three year means of effort in Gulland's (1961) method also gave significant results. The Fox method may be giving a reasonable estimate of the amount of effort which may be allowed, though the actual sustainable yield may not become apparent until a few more years' data are available.

Walter's (1986) method: The data are insufficient to make actual effort recommendations using this method. The stable, but low, cpue from 1987 to 1989 make it impossible to fit a realistic yield curve to the data.

Comparison with Lake Malawi cichlid fisheries: The Kambuzi fishery exploits a multi-species stock of small cichlids which has many similarities to the species group exploited by the trawl fishery of the southern tip of Lake Malawi, south of Boadzulu Island. This fishery has been closely monitored from the start and stock assessments made (Turner, 1977b; Tweddle and Magasa, 1989). In this fishery, the analyses to date suggest that cpue when the fishery is fully exploited is half that of the virgin fishery. Assuming that the cichlid stocks of Lake Malombe and southern Lake Malawi have similar characteristics (life histories, species interactions, etc.), the knowledge gained from the Lake Malawi trawl fishery may be applied to make a rough assessment of the Lake Malombe Kambuzi fishery. The cpue of the lightly exploited stocks of Lake Malombe in the 1970s averaged 65kg pull, hence at full exploitation a cpue of about 35kg/pull might be expected. Using the exponential regression of cpue against effort ($r = -0.841$), the cpue of 35kg/pull is equivalent to an effort of 300,000 pulls. If each nkacha net is fished 30 times a week for 39 weeks this is equivalent to 170 nets, which would yield

about 7,000 tonnes. It must be stressed that this is a very rough estimate and is given here simply to support other evidence which points to the existence of overfishing in this fishery.

Summary: All methods discussed above suggest that overfishing has occurred in this fishery, though the data are still inadequate to provide reliable recommendations for long-term management. Present management options are discussed later in this report.

ANALYSIS BY SPECIES

As 85% of the Lake Malombe catch consists of two species groups only, Kambuzi and Chambo (Fig. 4), and since Kambuzi have been effectively covered above under Kambuzi seine nets, this section covers Chambo only. This group formed the highest proportion of the total Lake Malombe catch over the 14 years, it is of great economic importance in Malawi and it is caught in virtually all gears, hence further analysis has been made of the fishing impact on this species group.

Chambo fishery

Three species of *Oreochromis* are included in this group in the southern part of Lake Malawi, and of these only two, *Oreochromis saka* (Lowe) and *Oreochromis squamipinnis* (Günther) are considered to be of importance in Lake Malombe (Lowe, 1952 and personal observations). Fig. 24 shows fluctuations in the catch of Chambo from year to year.

Standardisation of fishing effort in a multi-gear fishery is required before the combined effects on the fish stock of fishing with various gears can be assessed. In analysing the Chambo fishery of the South East Arm of Lake Malawi, Alimoso (1986) was unsuccessful in standardising fishing effort from different gears when using relative fishing power calculated from gear cpue. Hence the method chosen was to standardise fishing effort in terms of the cpue of the dominant gear, assuming that this was the best representative of the index of abundance of the fish stock, with the advantage that the larger database available reduces statistical errors inherent in small, often erratic, samples. Tweddle and Magasa (1989) adopted a similar approach in assessing the commercial scale Chambo fishery of Lake Malawi.

In Lake Malombe trends in cpue of the three main gears were not significantly related. Since gillnets contributed most of the total Chambo catch, total annual standardised fishing effort was calculated in gillnet- equivalents by dividing total annual catch by annual gillnet cpue (Fig. 25). The results are shown in scatter diagrams in Fig. 26. There was too great a scatter to obtain meaningful results by calculating a yield curve. For instance, with Fox's surplus yield model, using a two year mean of effort as in the gillnet fishery calculations above, the correlation coefficient between cpue and effort was not significant ($r = -0.360$; $P = 0.227$).

Visual inspection of the graphs in Fig. 26 suggests that the lake, if managed to optimise Chambo catches, could produce about 5-6,000 tonnes on average, with a combined effort of about 3-400,000 gillnet nights.

DISCUSSION

The fisheries of Lake Malombe have undergone marked changes over the fourteen year period. When recording started, gillnetting was the most important fishing method (Fig. 6), but this has been altered by the development of the nkacha fishery for Kambuzi. The development of this fishery was accompanied by a big increase in the number of non-engined wooden planked boats, necessary to handle the relatively bulky nets. Relatively short distances to the fishing grounds, together with large increases in the cost of outboard engines, spares and fuel, resulted in the complete disappearance by 1989 of the 221 outboard engines present in 1980 (Fig. 2). While the number of Kambuzi nets has increased eightfold, the number of gillnets and Chambo seines engaged in the fishery has declined considerably.

The decline in gillnet effort resulted in increases in cpue for all gillnet- caught species. However, in the most recent years, chambo have suffered a major decline while the other species catches remained high. With the decline in chambo, the 1989 and 1990 gillnet data do not fit the pattern which existed previously (Fig. 12).

The decline in Chambo coincided with the big increase in Kambuzi fishing. The Kambuzi fishery expanded in 1986 and overall Chambo catches showed a marked decline in the following year (Fig. 3). There is, therefore, a possibility that the capture of immature Chambo, known as Kasawala, by the Kambuzi nets has depressed the Chambo stocks. If this is the case, the fishery is now in an unhealthy state. Overall catches, which for most of the 1980s were approximately double those of the 1970s, were in 1989 back down to earlier levels (Fig. 3). The 1989 catches, however, were mainly of low-valued Kambuzi while the high-priced Chambo which formed most of the 1970s catches now comprised a much smaller proportion overall. While catches are back to 1970s levels, the number of fishermen and craft has doubled, hence individual catches and profitability are now much lower.

In 1989, mosquito nets suddenly appeared in the records, catching almost 1,000 tonnes (Fig. 6). In Lake Malawi, such nets are used almost entirely for Usipa (see other TFAP Working Papers) but in Lake Malombe they were used for Kambuzi. Over 19 tonnes of Chambo were also taken in the mosquito nets in 1989. Recent observations have shown that nets lined with cloth are being commonly used, catching cichlid fry. An increase in use of such gears would have a devastating effect on the fishery.

Because of the domination of three gears and two species groups discussed above, management emphasis should be concentrated on these major fisheries, though monitoring of minor fisheries should continue.

The gillnet fishery needs close monitoring to ensure that fishing effort does not return to or exceed the levels of the late 1970s. A limit on number of gillnet licences issued, together with effective enforcement, will have to be considered. While economic factors (lower cpue at high effort levels) may cause the fishery to be self-regulating, this cannot be relied on.

The Kambuzi fishery is difficult to quantify, largely because of (i) statistical inaccuracies, (ii) the major increase in activity in recent years, and (iii) the confusion between catches of the Kambuzi seines and nkacha nets. However, whichever method of analysis is used, and allowing for gross inaccuracies in the data, it is clear that the optimum effort was exceeded by 1987 and that effort must be reduced.

Mixed cichlid species fisheries are resilient and recover rapidly from overfishing (Lewis, 1986; Tweddle and Magasa, 1989), hence an immediate drastic cut in effort is not essential. Reduction in the scale of the fishery can be achieved over a number of years. This has the advantage of allowing more data to be collected, on which regulations for optimal control of the fishery can be based. Recommendations are made below for control of the fishery.

No prediction of MSY is being put forward here for the Kambuzi fishery. Given the size and relatively high productivity of the lake, however, an annual yield of about 5,000 tonnes of Kambuzi seems reasonable. The 1989 data suggest that the Fox model estimate of 8,080 tonnes (Fig. 23) is over-optimistic.

Figure 24. Fluctuations in the catches of Chambo from year to year.

Figure 25. Annual effort expended in catching Chambo in Lake Malombe expressed in gillnet-equivalents, calculated as explained in the text.

Figure 26. The relationships between (A) catch and effort, and (B) cpue and effort for the Chambo fishery of Lake Malombe.

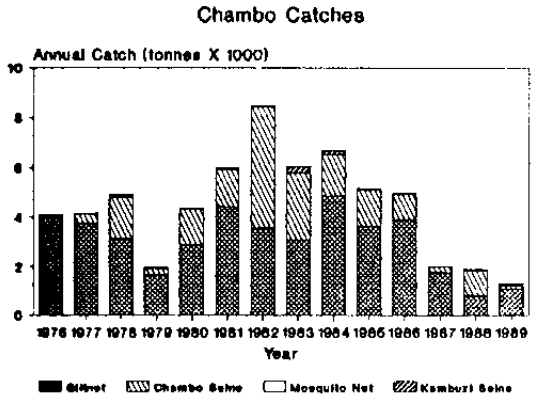

Figure 24

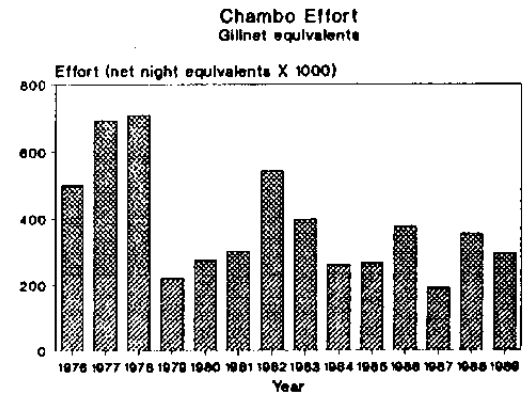

Figure 25

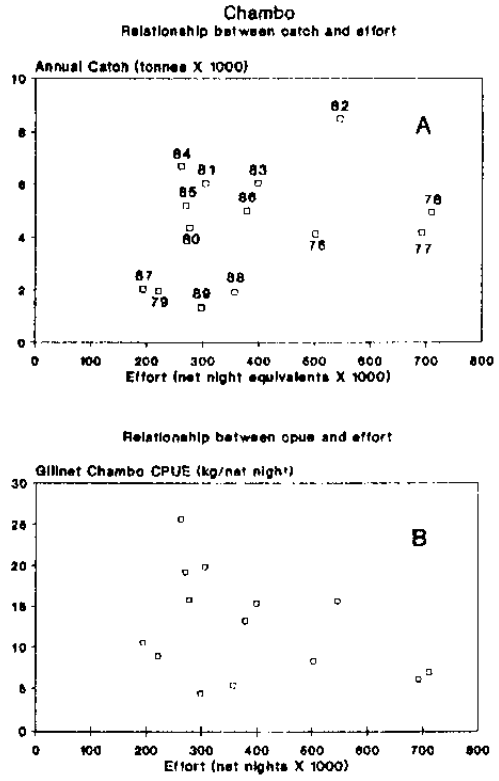

Figure 26

With the negligible contribution of other gears, Lake Malombe may be expected to sustain fisheries producing about 10-12,000 tonnes annually, assuming that recent environmental patterns remain consistent. Tweddle (1987) and Tweddle and Magasa (1989) have demonstrated relationships between environmental factors and recruitment in different Lake Malawi fisheries, and the shallow Lake Malombe can be expected to show proportionally greater responses to environmental fluctuations. The large fluctuations in Chambo catches may be evidence of this, though changes in the fishery must also have affected stocks, as discussed above. Variations from the calculated yields, even if the fisheries are perfectly controlled, may be the rule rather than the exception. The Lake Malombe yields suggested above cannot, therefore, be taken for granted, but may be viewed as reasonable guidelines.

The annual yield estimate of 10-12,000 tonnes is close to the maximum produced from the fishery in the 1980s. Lower yields in the first few years of recording, particularly for Chambo, may be attributed to a degree of overfishing, which may have been cured by fishermen switching to the lucrative Kambuzi fishery (83% of Chambo seine fishermen also own Kambuzi nets). However, as the Kambuzi fishery expanded further, it began to have a marked adverse effect on the Chambo stocks as a result of its impact on the juveniles.

RECOMMENDATIONS

1) There should be an immediate, effectively enforced ban on mosquito- netting and cloth nets. Usipa annual catches in Lake Malombe have never exceeded 9 tonnes, hence there is no justification for allowing the use of a gear which can have devastating effects on the juveniles of important commercial species.

2) The cichlid species flock exploited by the nkacha nets has many similarities to that fished by the pair trawlers in the shallow waters of the South East Arm of Lake Malawi. *Copadichromis* cf. *mloto*, *Placidochromis longimanus* and several *Lethrinops* spp., for example, are common in both fisheries. The 38mm minimum stretched mesh used by the pair trawlers should be made the legal minimum mesh size for the nkacha nets also.

3) The effort expended in the Kambuzi fishery should be limited. A reduction in effort may be achieved by a combination of (i) limiting the number of licenses issued for these gears and (ii) strict enforcement of the fishery regulations. In the first instance, a limit of 170 nkacha net licences is recommended for a period of three years. If cpue declines in that time, a further reduction will be necessary. It must be stressed, however, that should there be an accelerated decline in cpue, an immediate and drastic cut in effort will be essential.

4) The Kambuzi seine often catches quantities of Kasawala, while Kasawala do not seem to be as commonly caught in the offshore nkacha nets. This point needs to be followed up in more detail because of the recent decline in overall Chambo catches. The Kambuzi beach seines should be eliminated and the fishermen encouraged to switch to offshore methods which are less damaging to the immature Chambo stocks.

5) With the reduction in effort in the gillnet fishery, cpue and total catch for all species improved steadily, showing that effort until 1978 was excessive. The optimum effort appears to be about 200,000 net nights per year. Approximately 700 nets would be necessary to produce such an effort level. It is recommended (1) that the number of gillnets licenced for Lake Malombe be limited to 700, (2) that licencing be fully and effectively enforced, and (3) that the 76mm minimum mesh size be enforced.

6) The present management regulations for the Chambo seines should be rigorously enforced, particularly the minimum mesh size. The number of seines is not excessive at present, but if there should be an increase in future, the effects will have to be closely monitored.

7) If, despite the effective enforcement of these proposed and already existing regulations, Chambo stocks do not recover and the Kambuzi fishery does not sustain the high catch levels of the 1980s, further measures will be necessary to alter the balance back in favour of the high-valued Chambo. It is first necessary to ascertain the effects of the small-meshed nets on the immature Chambo stocks before deciding whether to limit the small mesh fishery much more drastically and enforce mesh size and close season regulations firmly to allow recovery of the Chambo stocks.

8) The large fluctuations in the data for the Chambo seines show that the present data collection system does not effectively monitor such fisheries. The limited number of seining beaches and the selection of beaches for recording on an annual basis by random sampling results in inconsistent coverage. Our recommendation that the system be modified to achieve more consistent coverage has already been implemented by the FAO/Malawi Government Chambo Project. It is important that the system which is finally implemented should be financially sustainable by the Malawi Government after the end of the FAO project.

REFERENCES

Alimoso, S.B. (1986) An assessment of yield in the chambo (Oreochromis sp.) fishery in southern Lake Malawi. M.Sc. thesis, University of Wales, Bangor.

Alimoso, S.B. (1988) A review of the present system of collecting fisheries statistics from Malawi waters. *In* Report of SADCC Fisheries Statistics Workshop, Zambia - 25th-29th April, 1988, 20 p.

Alimoso, S.B. and D. Tweddle (1991) Seine net fisheries of Lake Malombe. Malawi Fisheries Department, Traditional Fisheries Assessment Project Working Paper, TFAP/11.

Bazigos, G.P. (1972) The improvement of the Malawian fisheries statistical system. Rome, FAO, FAO/MLW/16:23 pp.

Eccles, D H. and D.S.C. Lewis (1977) A taxonomic study of the genus Lethrinops Regan (Pisces: Cichlidae) from Lake Malawi, Part 1. *Ichthyol.Bull.Rhodes Univ.*, 36:1-12.

FAO (1976) An analysis of the various fisheries of Lake Malawi, based on the work of J. Turner. Rome, FAO, FI:DP/MLW/71/516, Technical Report 1, 73 pp.

Fox, W.W. (1970) An exponential surplus yield model for optimising by exploited fish populations. *Trans.Amer.Fish.Soc.*, 99:80-88.

Gulland, J.A. (1961) Fishing and the fish stocks at Iceland. *Fishery Invest., Lond., Ser.*2, 23:1-52.

Lewis, D.S.C. (1986) A review of the research conducted on "Chambo" and the chambo fisheries of Lakes Malawi and Malombe, 1859-1985. Malawi Fisheries Dept. report, 36 pp.

Lowe, R.H. (1952) Report on the *Tilapia* and other fish and fisheries of Lake Nyasa 1945-1947. *Colon.Off.Fish.Publ.*, 1:1-126.

Schaefer, M.B. (1954) Some aspects of the dynamics of populations important to the management of commercial marine fisheries. *Bull.inter-Am.trop. Tuna Comm.*, 1:27-56.

Turner, J.L. (1977a) Changes in the size structure of cichlid populations of Lake Malawi resulting from bottom trawling. *J.Fish.Res.Bd.Can.*, 34:232-238.

Turner, J.L. (1977b) Some effects of demersal trawling in Lake Malawi (Lake Nyasa) from 1968 to 1974. *J.Fish Biol.*, 10:261-271

Tweddle, D. (1987) An assessment of the growth rate of mpasa, *Opsaridium microlepis* (Gunther, 1864) (Pisces : Cyprinidae), by length frequency analysis. *J.Limnol.Soc.sth.Afr.*, 13(2):52-57.

Tweddle, D. and J.H. Magasa (1989) Assessment of multispecies cichlid fisheries of the Southeast Arm of Lake Malawi, Africa. *J.Cons.int. Explor.Mer*, 45

Tweddle, D., S.B. Alimoso and G. Sodzapanja (1991). Analysis of catch and effort data for the fisheries of the South East Arm of Lake Malawi, 1976-1987, with a discussion of earlier data and the interrelationships with the commercial fisheries. Malawi Fisheries Department, Traditional Fisheries Assessment Project Working Paper, TFAP/2.

Walker, R.S. (1974) Collection of catch assessment data in tropical fisheries (inland waters). Notes for Malawi Fisheries Dept use, 6 pp.

Walker, R.S. (1976). The processing and checking of field forms used for the catch assessment surveys of the waters of Malawi. FAO/Malawi Fisheries Dept. mimeographed report, 8pp.

Walter, G.G. (1986) A robust approach to equilibrium yield curves. *Can.J.Fish.aquat.Sci.*, 43:1332-1339.

APPENDIX I

LAKE MALOMBE

ANNUAL CATCH AND EFFORT DATA SUMMARIES

1976-1989

NOTES ON MONTHLY DATA SUMMARIES

The data in this report are presented by species group and by gear. The species groups listed by column are as follows:-

chambo	=	*Oreochromis* spp., excluding *O. shiranus*.
other tilapia	=	*O. shiranus* and *Tilapia rendalli*.
kambuzi	=	inshore cichlid (haplochromine) species.
utaka	=	*Copadichromis* spp.
chisawasawa	=	offshore, demersal haplochromines.
kampango	=	*Bagrus meridionalis* Günther.
mlamba	=	clariid catfishes.
usipa	=	*Engraulicypris sardella* Günther.
nchila	=	*Labeo mesops* Günther.
others	=	species not included in above categories, including mormyrids and some cyprinid species.

The gears are listed by row, with catch, effort and catch per unit effort (cpue) shown for each gear.

Catch is expressed in metric tonnes in all cases.

Effort is expressed as follows:-

gillnets	:	number of sets of 91 m (stretched length) net.
longlines	:	number of sets of 100 hooks.
chambo seines	:	number of hauls.
kambuzi seines	:	number of hauls.
chirmila nets	:	number of hauls.
mosquito nets	:	number of hauls.
fish traps	:	number of traps set.
handlines	:	number of hauls.
cast nets	:	number of hauls.
scoop nets	:	number of hauls.
mbacha nets	:	number of hauls.

Cpue is expressed in catch (in kg) per unit of effort as defined above.

ADJUSTMENTS FOR MISSING DATA

Where data are unavailable because of no recording in a month, estimates have been made based on catch rates in the area before and after the month for which the data are missing. Estimates are based on the mean effort and cpue for each species group and gear category for the month preceding and the month following the data gap. Total catches in the month are then estimated by multiplying mean cpue by mean effort.

In Lake Malombe, catches have been estimated as above for the following months:

1977	Both minor strata	August
1978	Both minor strata	August.
1988	Minor Stratum 1.2	February

In 1976, the first year of recording, both January and February data are unavailable. Estimates for these months have been made based on average monthly catch and effort over the rest of the year. Details are presented in the note below the annual summary for 1976.

ANNUAL SUMMARY FOR THE YEAR 1976

	chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
catch	3991.73	90.30	0.00	0.00	0.00	85.25	146.15	0.00	9.38	107.12	4429.93
effort	485016	485016	485016	485016	485016	485016	485016	485016	485016	485016	485016
cpue	8.23	0.19	0.00	0.00	0.00	0.18	0.30	0.00	0.02	0.22	9.13
catch	0.00	0.00	0.00	0.00	0.00	2.24	1.81	0.00	0.00	0.34	4.39
effort	3870	3870	3870	3870	3870	3870	3870	3870	3870	3870	3870
cpue	0.00	0.00	0.00	0.00	0.00	0.58	0.47	0.00	0.00	0.09	1.13
catch	70.49	73.78	0.00	0.00	0.00	0.94	0.69	0.00	0.00	21.35	167.24
effort	583	583	583	583	583	583	583	583	583	583	583
cpue	121.01	126.65	0.00	0.00	0.00	1.61	1.18	0.00	0.00	36.65	287.10
catch	55.62	17.93	89.87	0.00	0.00	0.56	3.23	0.00	0.00	4.73	171.94
effort	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326	2326
cpue	23.91	7.71	38.64	0.00	0.00	0.24	1.39	0.00	0.00	2.03	73.92
catch	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
effort	31	31	31	31	31	31	31	31	31	31	31
cpue	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
catch	0.00	0.00	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70
effort	1561	1561	1561	1561	1561	1561	1561	1561	1561	1561	1561
pue	0.00	0.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73
TOTAL CATCH	4117.84	182.01	92.59	0.00	0.00	88.99	151.88	0.00	9.38	133.54	4776.22

The above annual summary incorporates estimates for missing January and February data.
Estimates are based on average monthly catch and effort data for the rest of the year.
Close seasons for seine nets have been taken into consideration in the revised estimates.
For Chambo Seine, therefore, (close season November and December) catch estimates are increased by 25%.
For Kambuzi Seine (close season January to March), no upward adjustment is necessary.
All other gears are adjusted upwards by 20%.

ANNUAL SUMMARY FOR THE YEAR 1977

	chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
catch	3756.16	183.45	0.00	0.00	0.00	58.59	237.63	0.00	9.50	43.67	4289.00
effort	624230	624230	624230	624230	624230	624230	624230	624230	624230	624230	624230
cpue	6.02	0.29	0.00	0.00	0.00	0.09	0.38	0.00	0.02	0.07	6.87
catch	372.37	109.95	0.00	0.00	0.00	3.21	8.71	0.00	2.42	29.14	525.80
effort	845	845	845	845	845	845	845	845	845	845	845
cpue	440.93	130.20	0.00	0.00	0.00	3.80	10.32	0.00	2.87	34.50	622.62
catch	32.19	7.69	7.14	0.00	0.00	0.23	2.34	0.00	0.00	2.08	51.66
effort	367	367	367	367	367	367	367	367	367	367	367
cpue	87.82	20.97	19.48	0.00	0.00	0.63	6.38	0.00	0.00	5.66	140.94
catch	0.00	0.00	67.74	0.00	0.00	0.00	0.14	0.00	0.00	2.69	70.56
effort	2144	2144	2144	2144	2144	2144	2144	2144	2144	2144	2144
cpue	0.00	0.00	31.60	0.00	0.00	0.00	0.06	0.00	0.00	1.25	32.92
TOTAL CATCH	4160.71	301.09	74.88	0.00	0.00	62.03	248.82	0.00	11.92	77.57	4937.02

ANNUAL SUMMARY FOR THE YEAR 1978

	chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
catch	3150.44	375.85	0.00	0.00	0.00	104.40	216.67	0.00	8.50	59.69	3915.56
effort	454078	454078	454078	454078	454078	454078	454078	454078	454078	454078	454078
cpue	6.94	0.83	0.00	0.00	0.00	0.23	0.48	0.00	0.02	0.13	8.62
catch	0.00	0.00	0.00	0.00	0.00	0.00	8.14	0.00	0.00	0.00	8.14
effort	21441	21441	21441	21441	21441	21441	21441	21441	21441	21441	21441
cpue	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.38
catch	1685.29	482.97	0.00	0.00	0.00	9.23	28.71	0.00	0.15	129.23	2335.59
effort	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904	3904
cpue	431.68	123.71	0.00	0.00	0.00	2.36	7.36	0.00	0.04	33.10	598.26
catch	85.61	113.98	376.13	0.00	0.00	1.23	0.99	1.07	0.00	3.01	582.10
effort	7922	7922	7922	7922	7922	7922	7922	7922	7922	7922	7922
cpue	10.81	14.39	47.48	0.00	0.00	0.15	0.12	0.13	0.00	0.38	73.48
TOTAL CATCH	4921.35	972.80	376.13	0.00	0.00	114.86	254.51	1.07	8.65	191.94	6841.38

ANNUAL SUMMARY FOR THE YEAR 1979

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	1675.55	162.67	1.10	0.00	0.00	36.82	51.00	0.00	8.48	41.98	983.60
	effort	189092	189092	189092	189092	189092	189092	189092	189092	189092	189092	189092
	cpue	8.86	0.86	0.01	0.00	0.00	0.19	0.00	0.00	0.04	0.22	10.49
long line	catch	0.00	0.00	0.00	0.00	0.00	0.00	5.97	0.00	0.00	0.10	6.07
	effort	503	503	503	503	503	503	503	503	503	503	503
	cpue	0.00	0.00	0.00	0.00	0.00	0.00	11.87	0.00	0.00	0.20	12.07
chambo seine	catch	266.50	57.83	0.00	0.00	0.00	0.62	4.33	0.00	0.02	8.21	337.51
	effort	821	821	821	821	821	821	821	821	821	821	821
	cpue	324.60	70.44	0.00	0.00	0.00	0.76	5.27	0.00	0.02	10.00	411.10
kambuzi seine	catch	13.80	14.40	545.31	0.37	0.00	0.76	1.55	0.00	0.06	13.13	589.38
	effort	10774	10774	10774	10774	10774	10774	10774	10774	10774	10774	10774
	cpue	1.28	1.34	50.61	0.03	0.00	0.07	0.14	0.00	0.01	1.22	54.70
	TOTAL CATCH	1955.85	234.90	546.41	0.37	0.00	38.20	68.85	0.00	8.56	63.42	2916.56

ANNUAL SUMMARY FOR THE YEAR 1980

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	2875.24	96.09	0.00	0.00	0.00	82.79	85.35	0.00	18.76	57.13	3215.36
	effort	183084	183084	183084	183084	183084	183084	183084	183084	183084	183084	183084
	cpue	15.70	0.52	0.00	0.00	0.00	0.45	0.47	0.00	0.10	0.31	17.56
chambo seine	catch	1468.72	56.32	0.00	0.00	0.00	42.56	14.56	0.00	1.47	8.35	1591.98
	effort	7588	7588	7588	7588	7588	7588	7588	7588	7588	7588	7588
	cpue	193.56	7.42	0.00	0.00	0.00	5.61	1.92	0.00	0.19	1.10	209.80
kambuzi seine	catch	0.35	0.73	155.43	0.76	0.00	0.34	2.01	0.00	0.38	1.78	161.78
	effort	2132	2132	2132	2132	2132	2132	2132	2132	2132	2132	2132
	cpue	0.16	0.34	2.90	0.36	0.00	0.16	0.94	0.00	0.18	0.83	75.88
	TOTAL CATCH	4344.31	153.14	155.43	0.76	0.00	125.69	101.92	0.00	20.61	67.26	4969.12

ANNUAL SUMMARY FOR THE YEAR 1981

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	4416.86	62.49	0.00	0.00	0.00	34.24	82.60	0.00	15.56	63.66	4675.41
	effort	223114	223114	223114	223114	223114	223114	223114	223114	223114	223114	223114
	cpue	19.80	0.28	0.00	0.00	0.00	0.15	0.37	0.00	0.07	0.29	20.96
chambo seine	catch	1545.60	235.01	0.00	0.00	0.00	4.29	4.27	0.00	0.18	17.74	1807.09
	effort	15962	15962	15962	15962	15962	15962	15962	15962	15962	15962	15962
	cpue	96.83	14.72	0.00	0.00	0.00	0.27	0.27	0.00	0.01	1.11	113.21
kambuzi seine	catch	55.46	11.31	1005.24	0.00	0.00	0.03	0.68	0.00	0.00	4.01	1076.73
	effort	9218	9218	9218	9218	9218	9218	9218	9218	9218	9218	9218
	cpue	6.02	1.23	109.05	0.00	0.00	0.00	0.07	0.00	0.00	0.44	116.81
	TOTAL CATCH	6017.92	308.81	1005.24	0.00	0.00	38.56	87.55	0.00	15.74	85.41	7559.23

ANNUAL SUMMARY FOR THE YEAR 1982

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	3555.21	372.81	0.00	0.00	0.00	34.85	76.43	0.00	23.35	71.91	4134.56
	effort	228093	228093	228093	228093	228093	228093	228093	228093	228093	228093	228093
	cpue	15.59	1.63	0.00	0.00	0.00	0.15	0.34	0.00	0.10	0.32	18.13
chambo seine	catch	4904.33	374.75	0.00	0.00	0.00	12.40	13.46	0.00	5.00	37.32	5347.26
	effort	7677	7677	7677	7677	7677	7677	7677	7677	7677	7677	7677
	cpue	638.83	48.81	0.00	0.00	0.00	1.62	1.75	0.00	0.65	4.86	696.53
kambuzi seine	catch	25.17	75.45	3130.09	0.00	0.00	6.64	7.45	0.00	0.22	37.86	3282.88
	effort	84148	84148	84148	84148	84148	84148	84148	84148	84148	84148	84148
	cpue	0.30	0.90	37.20	0.00	0.00	0.08	0.09	0.00	0.00	0.45	39.01
chiri' mila	catch	0.00	0.00	166.27	0.00	0.00	1.26	1.08	0.00	0.00	2.86	171.47
	effort	10758	10758	10758	10758	10758	10758	10758	10758	10758	10758	10758
	cpue	0.00	0.00	15.46	0.00	0.00	0.12	0.10	0.00	0.00	0.27	15.94
	TOTAL CATCH	8484.71	823.01	3296.36	0.00	0.00	55.15	98.42	0.00	28.57	49.95	12936.17

ANNUAL SUMMARY FOR THE YEAR 1983

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	3099.11	377.58	0.00	0.00	0.00	58.98	94.07	0.00	25.17	59.72	3714.63
	effort	203330	203330	203330	203330	203330	203330	203330	203330	203330	203330	203330
	cpue	15.24	1.86	0.00	0.00	0.00	0.29	0.46	0.00	0.12	0.29	18.27
chambo seine	catch	2708.59	112.16	0.00	0.00	0.00	15.74	15.11	0.00	41.77	33.55	2926.92
	effort	5095	5095	5095	5095	5095	5095	5095	5095	5095	5095	5095
	cpue	531.62	22.01	0.00	0.00	0.00	3.09	2.97	0.00	8.20	6.58	574.47
kambuzi seine	catch	174.35	54.07	1292.71	150.73	0.00	8.37	5.64	0.00	3.23	25.07	1714.17
	effort	26568	26568	26568	26568	26568	26568	26568	26568	26568	26568	26568
	cpue	6.56	2.04	48.66	5.67	0.00	0.32	0.21	0.00	0.12	0.94	64.52
ch'sawa mosquito	catch	0.00	0.00	23.87	0.00	0.00	0.08	0.08	0.00	0.00	0.12	24.15
	effort	1045	1045	1045	1045	1045	1045	1045	1045	1045	1045	1045
	cpue	0.00	0.00	22.84	0.00	0.00	0.08	0.08	0.00	0.00	0.11	23.11
utaka mosquito	catch	73.30	0.47	1202.60	0.00	0.00	4.46	3.80	0.00	0.00	12.27	1296.90
	effort	40925	40925	40925	40925	40925	40925	40925	40925	40925	40925	40925
	cpue	1.79	0.01	29.39	0.00	0.00	0.11	0.09	0.00	0.00	0.30	31.69
	TOTAL CATCH	6055.35	544.28	2519.18	150.73	0.00	87.63	118.70	0.00	70.17	130.73	9676.77

ANNUAL SUMMARY FOR THE YEAR 1984

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	4889.37	198.83	0.00	0.00	0.00	65.76	83.30	0.00	23.70	143.14	5404.10
	effort	191371	191371	191371	191371	191371	191371	191371	191371	191371	191371	191371
	cpue	25.55	1.04	0.00	0.00	0.00	0.34	0.44	0.00	0.12	0.75	28.24
long line	catch	0.00	0.00	0.00	0.00	0.00	0.15	0.30	0.00	0.00	0.17	0.62
	effort	33	33	33	33	33	33	33	33	33	33	33
	cpue	0.00	0.00	0.00	0.00	0.00	4.55	9.09	0.00	0.00	5.15	18.79
chambo seine	catch	1631.85	233.62	0.00	0.00	0.00	13.01	20.75	0.00	10.48	37.05	1946.76
	effort	7166	7166	7166	7166	7166	7166	7166	7166	7166	7166	7166
	cpue	227.74	32.60	0.00	0.00	0.00	1.82	2.90	0.00	1.46	5.17	271.69
kambuzi seine	catch	157.17	957.55	1115.90	5.01	0.00	22.30	40.51	0.00	3.77	89.26	2391.47
	effort	39445	39445	39445	39445	39445	39445	39445	39445	39445	39445	39445
	cpue	3.98	24.28	28.29	0.13	0.00	0.57	1.03	0.00	0.10	2.26	60.63
utaka mosquito	catch	0.00	0.74	624.50	0.00	0.00	0.59	1.21	0.00	0.00	4.87	631.91
	effort	6704	6704	6704	6704	6704	6704	6704	6704	6704	6704	6704
	cpue	0.00	0.11	93.15	0.00	0.00	0.09	0.18	0.00	0.00	0.73	94.26
	TOTAL CATCH	6678.39	1390.74	1740.40	5.01	0.00	101.81	146.07	0.00	37.95	274.49	10374.86

ANNUAL SUMMARY FOR THE YEAR 1985

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	3638.79	14.02	0.00	0.00	0.00	109.20	96.48	0.00	31.73	249.75	4139.97
	effort	189707	189707	189707	189707	189707	189707	189707	189707	189707	189707	189707
	cpue	19.18	0.07	0.00	0.00	0.00	0.58	0.51	0.00	0.17	1.32	21.82
long line	catch	0.00	0.00	0.00	0.00	0.00	0.40	7.54	0.00	0.00	0.00	7.94
	effort	50	50	50	50	50	50	50	50	50	50	50
	cpue	0.00	0.00	0.00	0.00	0.00	8.00	150.80	0.00	0.00	0.00	158.80
chambo seine	catch	1461.87	17.82	0.00	0.00	0.00	34.82	6.71	0.00	1.04	31.20	1554.18
	effort	1932	1932	1932	1932	1932	1932	1932	1932	1932	1932	1932
	cpue	756.66	9.22	0.00	0.00	0.00	18.02	3.47	0.00	0.54	16.15	804.44
kambuzi seine	catch	57.99	0.97	2474.58	0.00	0.00	15.04	11.26	0.00	6.59	45.20	2611.63
	effort	85777	85777	85777	85777	85777	85777	85777	85777	85777	85777	85777
	cpue	0.68	0.01	28.85	0.00	0.00	0.18	0.13	0.00	0.08	0.53	30.45
	TOTAL CATCH	5158.65	32.81	2474.58	0.00	0.00	159.46	121.99	0.00	39.36	326.15	8313.72

ANNUAL SUMMARY FOR THE YEAR 1986

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	3908.65	19.93	0.00	0.00	0.00	169.75	150.90	0.00	45.72	143.49	4438
	effort	297010	297010	297010	297010	297010	297010	297010	297010	297010	297010	2970
	cpue	13.16	0.07	0.00	0.00	0.00	0.57	0.51	0.00	0.15	0.48	14
long line	catch	0.00	0.00	0.00	0.00	0.00	0.39	16.51	0.00	0.00	0.30	17
	ffort	98	98	98	98	98	98	98	98	98	98	
	cpue	0.00	0.00	0.00	0.00	0.00	3.98	168.47	0.00	0.00	3.06	175
chambo seine	catch	1056.07	0.00	0.00	0.00	0.00	34.37	50.87	0.00	0.22	48.15	1189
	effort	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	17
	cpue	602.78	0.00	0.00	0.00	0.00	19.62	29.04	0.00	0.13	27.48	679
kambuzi seine	catch	2.70	0.44	6232.66	0.00	0.00	19.29	35.17	0.00	15.02	162.58	6467
	effort	292959	292959	292959	292959	292959	292959	292959	292959	292959	292959	2929
	cpue	0.01	0.00	21.27	0.00	0.00	0.07	0.12	0.00	0.05	0.55	22
chiri' mila	catch	0.00	0.00	262.08	206.55	0.00	3.30	5.63	0.00	0.45	25.44	503
	effort	25879	25879	25879	25879	25879	25879	25879	25879	25879	25879	258
	cpue	0.00	0.00	10.13	7.98	0.00	0.13	0.22	0.00	0.02	0.98	19
nkacha net	catch	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
	effort	750	750	750	750	750	750	750	750	750	750	7
	cpue	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
	TOTAL CATCH	4968.50	20.37	6494.74	206.55	0.00	227.10	259.08	0.00	61.41	379.96	12617

ANNUAL SUMMARY FOR THE YEAR 1987

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	1772.94	108.12	82.49	0.00	0.00	108.86	135.26	0.00	73.11	63.63	2344
	effort	169071	169071	169071	169071	169071	169071	169071	169071	169071	169071	169
	cpue	10.49	0.64	0.49	0.00	0.00	0.64	0.80	0.00	0.43	0.38	13
chambo seine	catch	228.05	0.00	12.42	0.00	0.00	43.66	0.79	0.00	0.00	6.01	290
	effort	1165	1165	1165	1165	1165	1165	1165	1165	1165	1165	1
	cpue	195.75	0.00	10.66	0.00	0.00	37.48	0.68	0.00	0.00	5.16	249
kambuzi seine	catch	22.07	0.00	7069.59	2245.71	2.33	25.10	38.25	4.45	0.50	287.05	9695
	effort	642053	642053	642053	642053	642053	642053	642053	642053	642053	642053	642
	cpue	0.03	0.00	11.01	3.50	0.00	0.04	0.06	0.01	0.00	0.45	15
	TOTAL CATCH	2023.06	108.12	7164.50	2245.71	2.33	177.62	174.30	4.45	73.61	356.69	12330

ANNUAL SUMMARY FOR THE YEAR 1988

Gear		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
gill net	catch	832.51	189.70	0.00	0.00	0.00	66.30	98.02	0.00	204.37	218.53	1609
	effort	155851	155851	155851	155851	155851	155851	155851	155851	155851	155851	155
	cpue	5.34	1.22	0.00	0.00	0.00	0.43	0.63	0.00	1.31	1.40	10
chambo seine	catch	1012.41	0.00	0.00	0.00	0.00	46.01	0.00	0.00	0.00	52.52	1110
	effort	2167	2167	2167	2167	2167	2167	2167	2167	2167	2167	2
	cpue	467.19	0.00	0.00	0.00	0.00	21.23	0.00	0.00	0.00	24.24	512
kambuzi seine	catch	55.54	5.40	6732.43	590.96	1.03	47.47	15.74	8.74	0.80	356.22	7814
	effort	498426	498426	498426	498426	498426	498426	498426	498426	498426	498426	498
	cpue	0.11	0.01	13.51	1.19	0.00	0.10	0.03	0.02	0.00	0.71	15
	TOTAL CATCH	1900.46	195.10	6732.43	590.96	1.03	159.78	113.76	8.74	205.17	627.27	10534

ANNUAL SUMMARY FOR THE YEAR 1989

TOTAL	[illegible]		chambo	other tilapia	kambuzi	utaka	ch'sawa	k'pango	mlamba	usipa	nchila	others	TOTAL
4438.44		catch	1082.26	151.83	0.00	241.88	0 00	160.24	151 44	0.00	31.69	188.79	2008.13
297010		effort	247973	247973	247973	247973	247973	247973	247973	247973	247973	247973	247973
14.94		cpue	4.36	0.61	0.00	0.98	0 00	0 65	0.61	0.00	0.13	0.76	8.10
17.20	[illegible]mbo	catch	150.20	0.00	0.00	0.00	0.00	25.89	0.00	0.00	0.00	41.77	217.86
98	[illegible]e	effort	323	323	323	323	323	323	323	323	323	323	323
175 51		cpue	465.02	0.00	0.00	0.00	0.00	80.15	0.00	0.00	0.00	129 32	674.49
1189.68	[illegible]buzi	catch	42.20	76.38	2194.45	278.65	1.58	23.49	18.67	4.35	5.92	284.53	2930.22
1752	[illegible]e	effort	160328	160328	160328	160328	160328	160328	160328	160328	160328	160328	160328
679.04		cpue	0.26	0.48	13.69	1.74	0.01	0.15	0.12	0.03	0.04	1.77	18 28
6467.86	[illegible]uto	catch	19.46	0.27	860.56	12.13	0.00	4.33	7.59	2.46	0.00	90.09	996.91
292959	[illegible]	effort	50343	50343	50343	50343	50343	50343	50343	50343	50343	50343	50343
22.08		cpue	0.39	0.01	17.09	0.24	0.00	0.09	0.15	0.05	0.00	1.79	19.80
503.45	[illegible]cha	catch	0.55	0.00	379.09	7.94	0.00	3.07	5.04	2.35	27.64	28.22	453.90
25879	[illegible]	effort	49418	49418	49418	49418	49418	49418	49418	49418	49418	49418	49418
19.45		cpue	0.01	0.00	7.67	0.16	0.00	0.06	0.10	0.05	0.56	0.57	9.18
1.08		TOTAL CATCH	1294.67	228.48	3434.10	540.60	1.58	217.02	182.74	9.18	65.25	633.40	6607.02
750													
1.44													
12617.71													

TOTAL
2344.41
169071
13.87
290.93
1165
249.73
9695.05
642053
15.10
12330.39

TOTAL
1609.43
155851
10.33
1110.94
2167
512.66
7814.33
498426
15.68
10534.70