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In the analysis of the catch and effort data, standard methods have been applied. For the details of the methodology a reference is made to Sparre and Venema's Introduction to Tropical Fish Stock Assessment (FAO 1992), where treatment of catch and effort data as well as surplus production models are explained in detail.

Contents

Preface

Executive summary 1

1. Introduction 3

2. Trends in fisheries 5

2.1 Lake Malawi 5

2.1.1 Traditional fisheries 5

2.1.2 Commercial fisheries 8

2.1.3 Semi-commercial fisheries 11

2.2 Upper Shire River 13

2.3 Lake Malombe 15

2.4 Lake Chilwa 16

2.5 Lake Chiuta 17

2.6 Lower Shire River 18

2.7 Trends in total catch 18

3. Status of some commercially important fish stocks 20

3.1 Chambo 20

3.1.1 Spawning seasonality 20

3.1.2 Length at maturity 21

3.1.3 Length distribution of catches 21

3.1.4 Catch and effort in Lakes Malawi and Malombe 21

3.1.5 Surplus production in Lake Malawi 23

3.1.6. Management recommendations 24

3.2 Kampango 25

3.2.1 Length at maturity 25

3.2.2 Length distribution of catches 25

3.2.3 Catch and effort in Lake Malawi 26

3.2.4 Surplus production in Lake Malawi 26

3.3 Bombe 27

3.3.1 Length at maturity 27

3.3.2 Length distribution of catches 28

3.3.3 Catch and effort in Lake Malawi 28
3.3.4 Surplus production in Lake Malawi 29
3.4 Utaka 30
3.4.1 Length distribution of catches 30
3.4.2 Catch and effort in Lake Malawi 30
3.5 Kambuzi 31
3.5.1 Catch and effort in Lake Malawi 31
3.6 Usipa 32
3.6.1 Catch and effort in Lake Malawi 32
3.7 Demersal monitoring surveys 1994-99 33
4. Current management measures 35
5. Short-term management recommendations 35
6. Medium and long-term management considerations 37
7. Names of fish species 39
8. Appendix: Tables 1, 3-12 and 14-24 40

Executive summary

The findings on stock sizes presented in the report are primarily based on data collected during 1976-96 within the Fisheries Research Unit (FRU) of the Fisheries Department. In agreement with current practices in fisheries management an attempt is made to apply the principles of the so-called precautionary approach. The FAO Code of Conduct for Responsible Fisheries, adopted in 1995, stipulates in article 7.5: "States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures."

Precautionary approach makes use of so-called precautionary reference points which represent estimated values derived through an agreed scientific procedure which corresponds to the state of the resource and of the fishery, and which can be used as a guide for fisheries management. Most precautionary reference points are based on time series of age dependent models which are presently not applicable to Malawian fish stocks due to lack of age based data. In situations of limited data alternative biomass estimates can be used, such as CPUE (**C**atch **P**er **U**nit of **E**ffort) as an estimator of stock size or biomass.

According to the annual Frame Surveys of Malawian fisheries dugout canoes operating in the waters of Malawi counted 9111-9821 during 1990-93 but increased gradually to 11800 until 1997, i.e. an increase of approximately 20%. The number of plank boats without engine has remained rather stable or in the range 2164-2787 boats. It is concluded that the number of plank boats with engine has increased considerably during the period 1990-97, or by some 25% (from a mean of 375 in 1990-92 to a mean of 468 in 1995-97).

The most common fishing gears in Malawian waters are gillnets and fish traps, the latter mainly being used in Lake Chilwa. The number of gillnets increased markedly in 1995-97 from some 20 thousand gillnets to 38 thousand, whereas traps fluctuated in numbers. Long lines, hand lines, chilimira seines and kambuzi seines are gears of intermediate importance in terms of numbers, counting up to 6000 sets for each gear type. These gears, except kambuzi seines, show an increasing trend in numbers during the period 1990-97.

Malawian fisheries have experienced considerable decline in the 1990s after a relative stability in preceding years. This decline is mainly caused by declining fisheries in the smaller waterbodies, such as Lakes Malombe and in the Upper and Lower Shire. The drying up of Lake Chilwa had also a great effect on catches in 1995 and 1996. The commercial fisheries in Lake Malawi have also declined in recent years.

CPUE has declined substantially in most of the smaller waterbodies. The status of the fisheries in Lakes Malombe, Chiuta and in the Upper Shire appears to be particularily serious and precautionary management actions are needed. The chambo stocks in Lake Malombe and the Upper Shire River are considered as collapsed. The restoration of these resources must be regarded as a task of major economic importance for Malawian fisheries.

The status of the traditional fisheries in Lake Malawi appears considerably better than in the smaller waterbodies. Thus, the CPUE of the fishery in the SE-Arm appears stable. In the SW-Arm, on the other hand, reduction in CPUE has been observed. However, although the fisheries appear relatively stable when treated as a whole, the state of individual stocks may differ markedly. Thus, the available results indicate a declining status of the chambo stocks in Lake Malawi and an urgent need for precautionary actions. Declining CPUE is observed for the stocks of bombe and utaka, but precautionary management actions are not recommended. The kampango stock has declined slightly below B_{pa}. The fisheries for kambuzi and usipa, on the other hand, are apparently in a healthy state and no precautionary action seems to be required. The status of the commercial fisheries seems more stable than the traditional fisheries in Lake Malawi, and no precautionary management measures are recommended

Malawian fisheries are subject to a rather extensive arsenal of management measures, such as technical restriction of fishing gears, i.e. gear mesh size or size of gear (e.g. head line length) and restrictions of fishing areas or fishing times. In view of the current status of fisheries and fish stocks in Malawian waters the effectiveness of these measures appears to be limited, mainly due to the "open-entry" nature of the traditional fisheries, and ineffective enforcement of regulations. Efficient management of Malawian fisheries requires a stringent control of effort.

In summary, recommended precautionary management actions are as follows:

- Lake Malawi traditional fishery: In order to restore the chambo stocks, a total ban on chambo seines and a ban on chilimira/kauni in area A is recommended.
- Lake Malombe fishery: To restore chambo stocks a total ban on gill nets and chambo seines will be necessary. To maintain the kambuzi stocks effort limitations in the nkacha net and kambuzi seine fisheries need to be undertaken, by denying new entries.
- Lake Chiuta fishery: To restore stocks a reduction in effort is recommended.
- Upper Shire fishery: To restore stocks a total ban on seines and gillnets is recommended.

The scientific basis of fisheries management in Malawian waters is basically limited to catch-effort data as well as some fish ecology data such as spawning seasonality or maturity ogives. In addition, monitoring surveys have been conducted annually in southern Lake Malawi since 1989. There is an urgent need to improve this basis in order to implement efficient management of the fish resources. This can be done by extending the monitoring survey to cover the lake as a whole. Annual monitoring surveys should also be conducted in the smaller waterbodies using traditional gears. Furthermore, age based methods in fish stock assessment should be introduced for selected, long-lived species such as chambo, kampango and bombe. These species happen to be among the most important fish stocks in Malawian waters and the need for more precise information on their status is essential for their comprehensive management in the near future.

1. Introduction

The fish stocks of Malawian waters are, undoubtedly, among the most important natural resources of Malawi. A common statement as to the importance of this resource is the "fact" that fish provides some 70% of animal protein in Malawi. It is generally assumed that Malawian fish stocks have declined in recent years. This assumption is confirmed in this report. The main reason for this decline is probably excessive fishing effort. Another relevant cause can be sought in destructive fishing practices such as use of small meshed gears and fishing for juveniles. The decline of the fisheries has stressed the need for efficient fisheries management, based on scientific knowledge. The aim of this resource report is to present this knowledge base as far as possible under the present conditions.

The findings presented in the report are, unless stated otherwise, based on data collected during 1976-96 within the Fisheries Research Unit (FRU) of the Fisheries Department. Unfortunately, data for 1997 and 1998 are not yet available to be included in the report's findings. Due to this limitation, analyses of the current state of the fisheries as well as management recommendations may fall short of the real situation. In the analysis of the catch and effort data, standard methods have been applied. For the details of the methodology a reference is made to Sparre and Venema's Introduction to Tropical Fish Stock Assessment (FAO 1992), where treatment of catch and effort data as well as surplus production models are explained in detail. Other methods of data analysis used in the report are not expected to warrant further explanation.

In agreement with current practices in fisheries management an attempt is made to apply the principles of the precautionary approach. The FAO Code of Conduct for Responsible Fisheries, adopted in 1995, stipulates in article 7.5: "States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures." And in Paragraph 12.13 of Article 12: "States should promote the use of research results as a basis for the setting of management objectives, reference points and performance criteria as well as for ensuring adequate linkage between applied research and fisheries management".

"A precautionary reference point is an estimated value derived through an agreed scientific procedure which corresponds to the state of the resource and of the fishery, and which can be used as a guide for fisheries management" (UN Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks).

Most precautionary reference points are based on time series of age dependent models which are presently not applicable to Malawian fish stocks due to lack of age-based data. Examples of such reference points are various levels of fishing mortality (F) such as $F_{0.1}$, F_{MSY}, F_{med}, F_{high} or different levels of biomass (B).

However, in situations of limited data alternative biomass estimates can be used, such as CPUE (**C**atch **P**er **U**nit of **E**ffort), as an estimator of stock size or biomass. A simple

approach in this case is to select a given CPUE value as a reference point. In the absence of virgin biomass this can be the maximum CPUE observed during past years or, preferably, the mean CPUE over a period of relatively high CPUE. This value is referred to as B_{max} in this report. The next step is to define a biomass limit (B_{lim}) below which the stock would be considered seriously depleted and even in danger of a collapse and, therefore, which should be avoided with very high probability. The choice of this point is rather subjective and a value of 20% of B_{max} is suggested.

Since there should be a high probability of staying away from the B_{lim} level, another value is needed at which a precautionary management approach must be undertaken in order to avoid the stock dropping below B_{lim}. This value, B_{pa} (pa=precautionary approach) can be calculated as, $B_{pa} = B_{lim} \exp(2*\sigma)$ where σ is a measure of uncertainty in the biomass estimate and the constant 2 reflects the approximate 95% confidence. The value of σ is usually taken as 0.2-0.3. However, in view of the high uncertainty in stock size estimates for Malawian fisheries a value of 0.4 is suggested. This results in a $B_{pa} = 0.45$, i.e. 45% of B_{max}.

Thus, when the stock appears to drop below B_{pa} a recommendation should be made to reduce fishing effort. The extent of the effort reduction should be in accordance with how close the point estimate of biomass is to B_{pa} and B_{lim}. The closer the point estimate is to B_{lim} the more reduction in effort should be recommended. If the point estimate is at or even below B_{lim} a closure of the fishery would seem the only realistic action.

The point estimate of a stock, B_{cur} (%), is defined as the current level of the biomass (CPUE) relative to B_{max}. In this report the reference years for calculation of a mean B_{cur} are the last 3 years available in the data series, usually the years 1994-96.

In view of the actual values chosen for B_{lim} and B_{pa} various criteria should be considered, such as uncertainties in size and productivity of the stocks. This uncertainty, although difficult to quantify, must be regarded as high for Malawian stocks due to limited and unreliable data. Furthermore, most Malawian fish stocks are characterised by low fecundity and therefore more vulnerable to excessive fishing pressure than more fecund stocks. In view of this a B_{pa} less than 45% of B_{max} would be regarded as inappropriate. (For further details of this subject a reference is made to: ICES CM 1997/Assess:7. Report of the study group on the precautionary approach to fisheries management. International Council for the Exploration of the Sea, Copenhagen. Available at the FRU library).

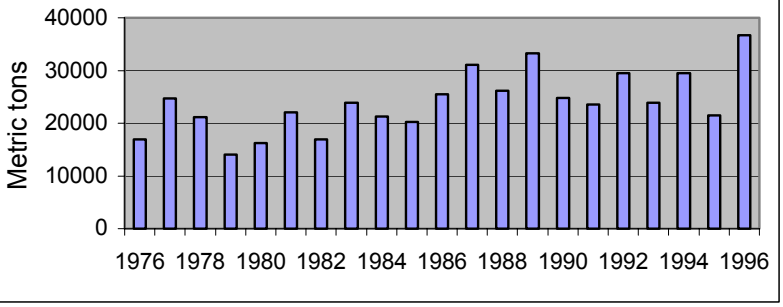
2. Trends in the fisheries

2.1 Lake Malawi

2.1.1 Traditional fisheries

Total catches in the traditional fisheries in Lake Malawi in 1976-96 are shown in Fig. 1 and Table 1 in appendix. A clear increasing trend is observed in catches during the first 10 years to a peak of more than 30 thousand tons in 1987 and 1989. In later years catches have fluctuated from year to year, but without any apparent trend. The highest catch, 36700 tons, was recorded in 1996.

Fig. 1. Total traditional catch in Lake Malawi 1976-96



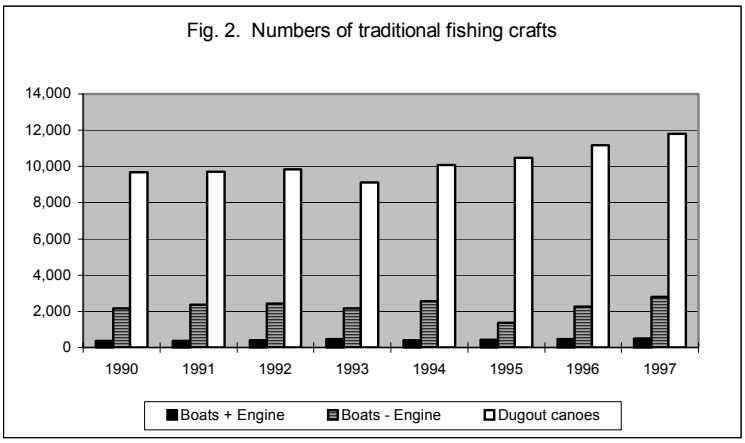
The average traditional catch is composed of 9 main species or groups of species (Table 2) of which utaka is a dominating group with 34.1% of the average total catch 1976-96, followed by usipa (19.7%) and chambo (17.8%). These three species-groups yield 71.6% of the average total catch. The catfish species, kampango and bombe, as well as kambuzi species, yield 5.2-7.4% and other groups around one percent or less. The coefficient of variation (CV = standard deviation/mean) indicates the degree of fluctuation in the catch figures. The usipa and some of the small cichlids (chisawasawa and kambuzi), as well as nchila, flucutuate most, whereas catfish and chambo catches are relatively stable.

Table 2. Average, annual traditional catch (metric tons and %) and CV in Lake Malawi 1976-96 by species or groups of species (metric tons). For local and scientific names of fish species, see page 39.

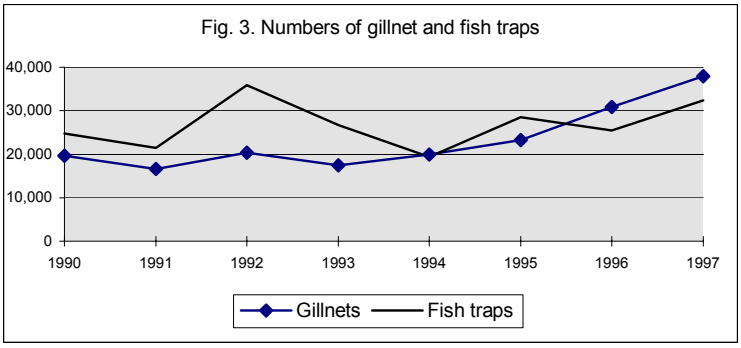
	Utaka	Usipa	Chambo	Kambuzi	Kampango	Bombe	Other tilapia	Nchila	Chisawa sawa	Others	Total
Mean	8168	4722	4258	1774	1686	1236	317	137	104	1506	23939
%	34.1	19.7	17.8	7.4	7.0	5.2	1.3	0.6	0.4	6.3	100.0
CV	0.41	0.98	0.36	0.69	0.33	0.26	0.51	0.91	0.81	0.38	0.24

Dugout canoes operating in the waters of Malawi counted 9111-9821 during 1990-93 but increased gradually to 11800 until 1997, i.e. an increase of approximately 20% (Fig. 2, Table 3). The number of plank boats without engine has remained rather stable or in the range 2164-2787 boats, except in 1995 when only 1361 boats were recorded. Obviously, this must be regarded as an error (incorrect census or erroneous data processing), since a change of such scale is by no means plausible. The number of plank boats with engine was 360-397 during 1990-92, 449 in 1993, 393 in 1994 and in

the range of 441-502 boats in 1995-97. The figures for 1993 and 1994 are probably errors, since an increase or decrease of the order of 50 boats in one year is highly unlikely. However, it can be concluded that the number of plank boats with engine has increased considerably during the period 1990-97, or by some 25% (from a mean of 375 in 1990-92 to a mean of 468 in 1995-97).



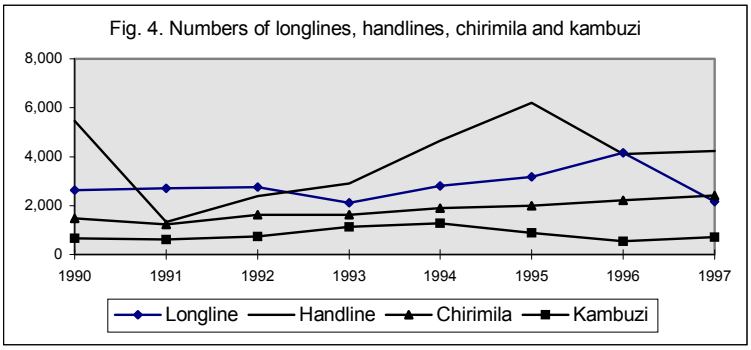
The most important fishing gears in Malawian waters are gillnets and fish traps, the latter mainly being used in Lake Chilwa (Fig. 3, Table 3). The number of gillnets increased markedly in 1995-97 from some 20 thousand gillnets to 38 thousand. The number of fish traps fluctuated considerably, but did not show an apparent trend in time.



Long lines, hand lines, chilimira seines and kambuzi seines are gears of intermediate importance in terms of numbers, counting up to 6000 sets each gear type (Fig. 4). These gears, except kambuzi, show an increasing trend in numbers during the period 1990-97. A number of other gears are used in Malawian waters and their total number was 883-2535 in 1990-97.

Catch, effort and CPUE in the South East Arm traditional fishery is shown in Fig. 6 and Table 4. In this report, effort, unless otherwise stated, refers to the so-called relative, normalised effort where all fishing gears have been standardised to a common effort unit. CPUE refers to the so-called weighted, relative CPUE where relative CPUE of each gear has been weighted by the catch taken by that gear (For further details see:

Sparre, P. & Venema, S.C., 1992. Introduction to tropical fish stock assessment. Part I - Manual. FAO Fisheries Technical Paper, 306/1, 376pp).



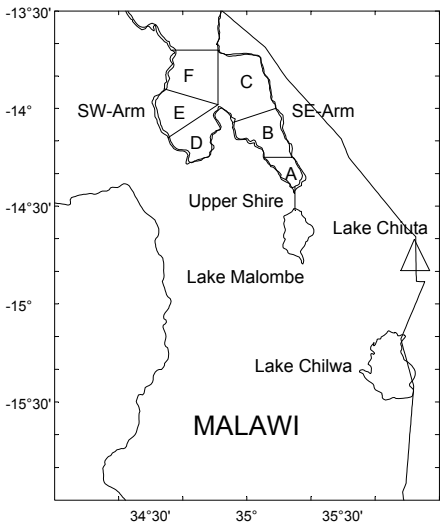
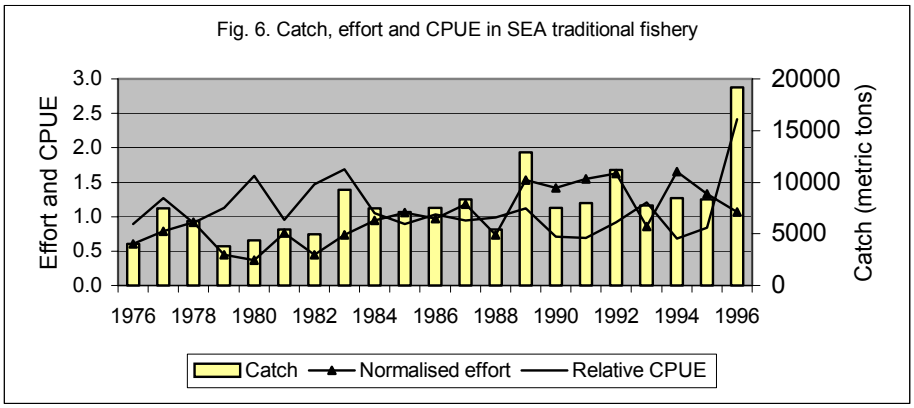
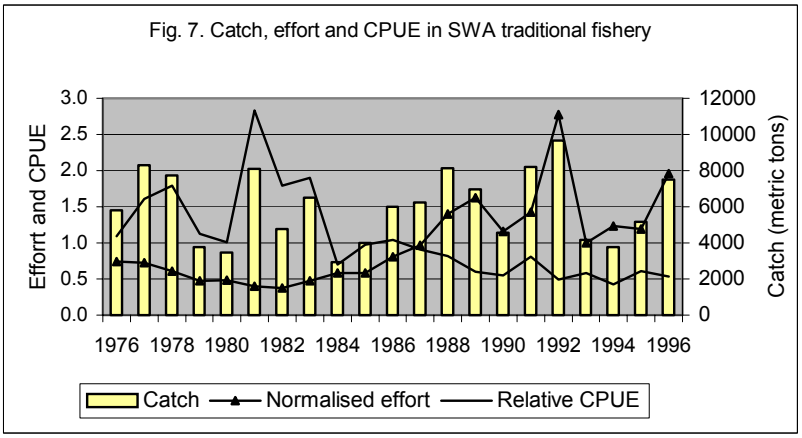


Fig. 5. Southern Lake Malawi with area division in SE- and SW-Arms. Lakes Malombe, Chilwa and Chiuta and Upper Shire River.

Catches fluctuated around some 5000 tons during 1976-82, increasing in later years to an average of some 8000 tons during 1983-95. In 1996 a sudden increase to 19000 tons was recorded, largely as a result of high usipa catches. Effort increased in the mid 1980s and has been at a relatively high level in the 1990s. CPUE shows basically a reverse trend, except for an extreme high value in 1996. Thus, B_{cur} is 111% of B_{max} (mean over 1976-85).

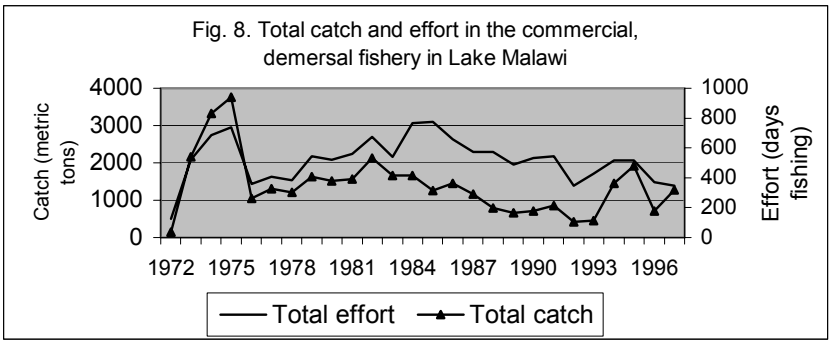


Catch, effort and CPUE in the South West Arm traditional fishery is shown in Fig. 7 and Table 5. Catches have fluctuated greatly throughout the period, around a mean catch of some 6000 tons. Effort was low until in the mid 1980s when it increased substantially and remained high, but fluctuating, in the 1990s. CPUE shows approximately the reverse trend. It was high and variable in the late 1970s, declined markedly in the early 1980s, and has remained at a low level in the 1990s. B_{cur} is 35% of B_{max} (1976-85).



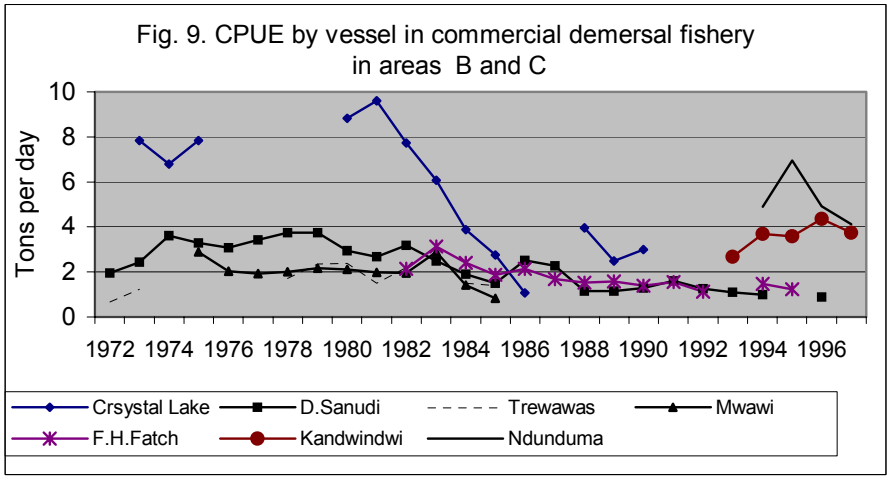
2.1.2. The commercial fisheries

Total catch and effort in the commercial, demersal stern trawler fishery in Lake Malawi 1972-97 is shown in Fig. 8. Catches peaked at almost 4000 tons in 1975 but declined sharply in 1976 to some 1000 tons. During the next years catches were in the range of 1000-2000 tons and declined below 1000 tons in 1988. In the mid 1990s, as the new and powerful vessels, Kandwindwi and Ndunduma, entered the fishery, catches

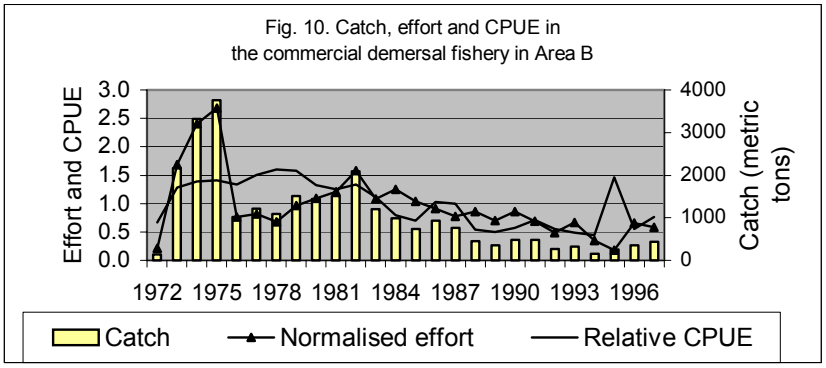


exceeded 1000 tons again and peaked at 1920 tons in 1995. Total effort, in number of boat-days fishing, has followed the pattern of catch rather closely. However, it should be noted that the effort of the different fishing units is not standardised in this case.

Trends in the CPUE (metric tons per day fishing) for individual commercial vessels are shown in Fig. 9 for areas B and C combined. There is a clear declining trend in the CPUE of the vessels over the 26 years as well as clear differences in fishing power. For Crystal Lake and D. Sanudi the CPUE is down to less than half of the initial CPUE. The CPUE of Mwawi and F.H. Fatch seems to have declined less. Kandwindwi and Ndunduma entered the fishery in the mid 1990s and their fishing power, and hence CPUE, is markedly higher compared to the other vessels at that time.

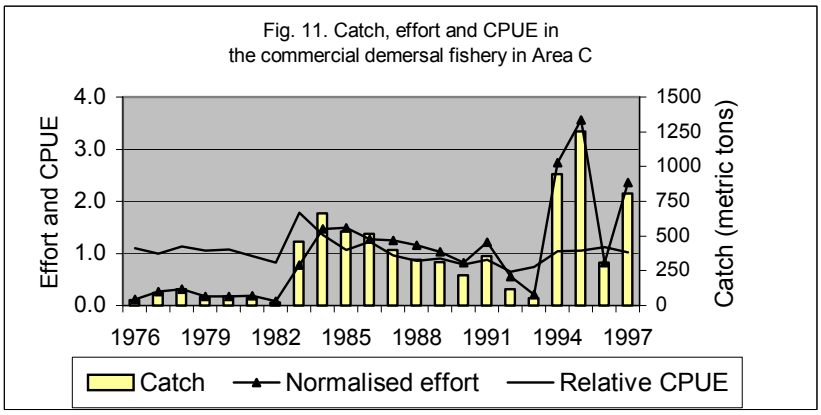


The commercial fishery in area B started in 1968 but yielded less than 50 tons annually until D. Sanudi entered the fishery in 1972 and Crystal Lake in 1973. Catches rose sharply in the next years to a peak of more than 3000 tons in 1974 and 1975. In 1975 Crystal Lake caught 2560 tons in the demersal fishery in area B. Catches fell abruptly to around 1000 tons in 1976 when Crystal Lake left the demersal fishery. During the 1980s catches declined to a level of less than 500 tons per year (Fig. 10, Table 6). A close correlation is seen between catch and effort ($p<0.05$, $r^2=0.91$). CPUE was relatively high and stable in the 1970s but declined to a markedly lower level during the 1980s. The high CPUE value observed in 1995 is due to very high CPUE of Ndunduma in that year. Because of the increased efficiency of the new vessels introduced in 1995,

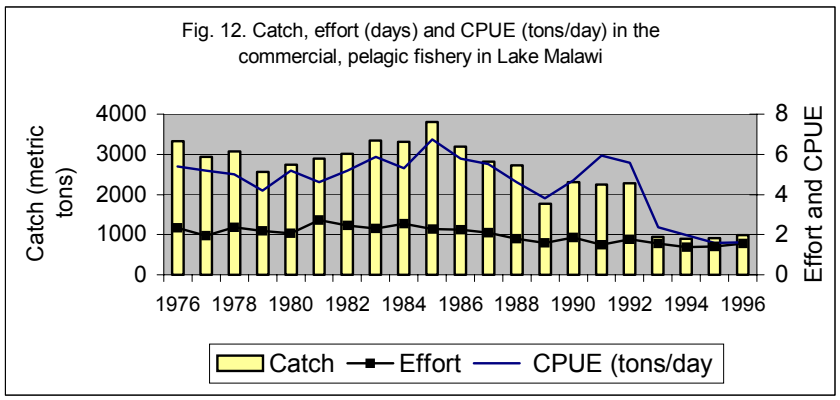


B_{cur} is calculated for 2 periods. B_{cur} (1991-93) is 42% of B_{max} (1973-82) but B_{cur} (1995-97) is 65% of the same B_{max}. Thus, the new vessels increased this value by more than 50%. Although the catch of the commercial fishery in Area B is primarily dictated by effort it is also seen that CPUE has been at a markedly lower level in recent years compared to the 1970s. This indicates that biomass may have been reduced in spite of declining effort. Therefore, increase in effort from the current level would not seem advisable unless a clear recovery in CPUE is observed.

The commercial fishery in Area C shows a very different trend to that of Area B, and it can be divided in 3 distinctive time intervals. During the first 7 years Mwawi and Trewavas were the only vessels operating in the area and catches were usually less than 100 tons a year (Fig 11, Table 7). In 1983 F.H. Fatch entered the fishery which resulted in a marked increase to a peak of 660 tons in 1984. Until 1992 catches declined to some 100 tons. In 1993 Kandwindwi entered the fishery and Ndunduma in 1994, which was the last year of F.H. Fatch. This resulted in a peak catch of 1240 tons in 1995. Catches



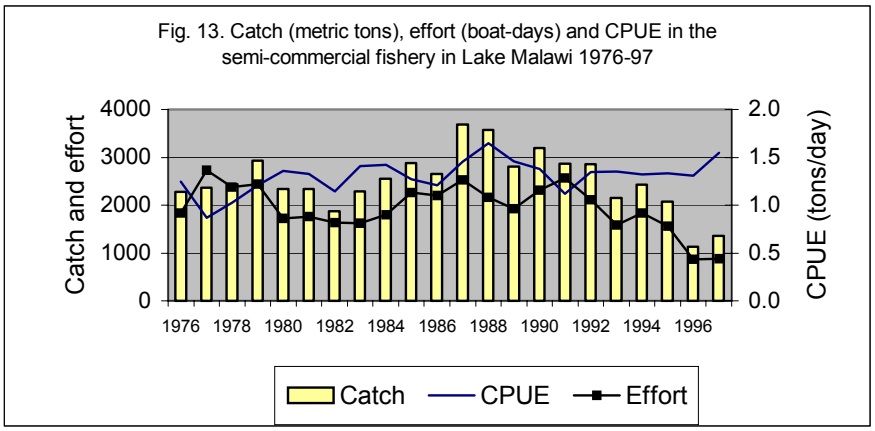
are highly correlated with effort ($p<0.01$, $r^2=0.94$), as can be seen in Fig. 11. CPUE has remained stable throughout the period. B_{cur} is calculated for 2 periods due to the same reasons as in area B. B_{cur} 1995-97 is 88% of B_{max} (1983-88) but B_{cur} 1991-93 is 63% of the same B_{max}. In either case, there is no indication of overfishing in the commercial fishery in Area C. However, it should be noted that this conclusion refers to total biomass only. Possible changes in biomass of individual fish species could not be determined from the data.



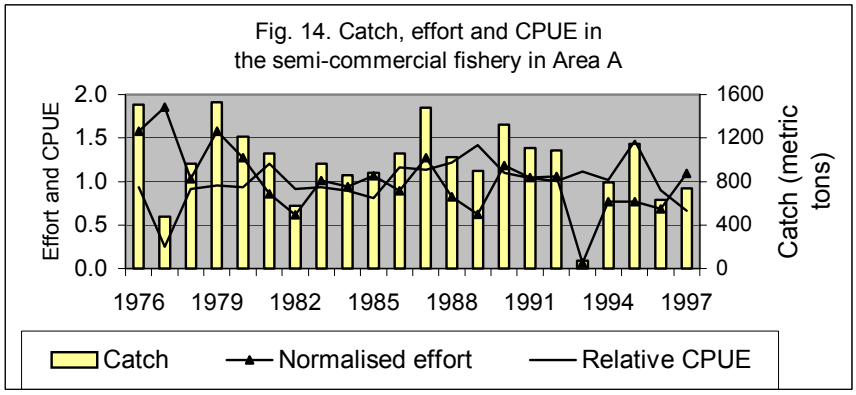
The commercial pelagic fishery is conducted in the SE Arm of Lake Malawi and uses ringnets and pelagic trawl. Chambo is the target species of the fishery and yielded 60-80% of the catch until 1992. During 1993-96 a rapid decline in the chambo catch was observed to less than 10% of the total catch in 1996. The total catch in the fishery was approximately 3000 tons per year until 1989 when it declined to some 2000 tons. In 1993 it declined further to some 1000 tons and has remained at that level (Fig. 12, Table 8). Effort has remained relatively stable throughout the period. CPUE fluctuated between 4 and 6 tons per day until 1993 when it declined below 2 tons per day in 1994-96. B_{cur} is 31% of B_{max} (1983-88) with respect to total CPUE.

2.1.3. The semi-commercial fishery

The semi-commercial fishery is a demersal, trawl fishery operating on pair-trawling plank boat units. A plot of total catches (metric tons) and total effort (boat-days) in the semi-commercial fishery 1976-97 shows a significant correlation ($p<0.05$, $r^2=0.65$).

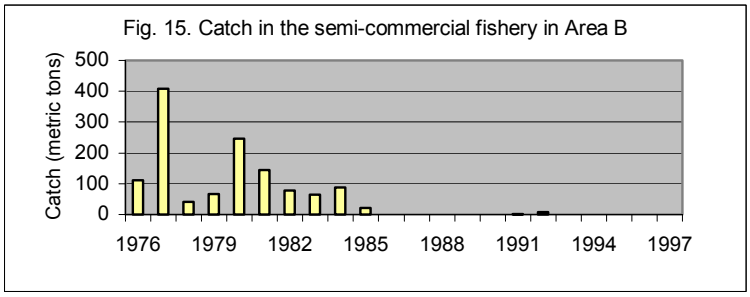


The catch reached a peak of 3680 tons in 1987 at an effort of 2531 boat-days (Fig. 13). Catch remained around 3000 tons until 1992 and has declined since then to a current level of some 1300 tons. Effort has declined to a level of 900 boat-days. For the semi-commercial fishery as a whole this indicates that declining catches are primarily dicated by declining effort in this fishery. As a consequence, CPUE has remained relatively stable throughout the period.

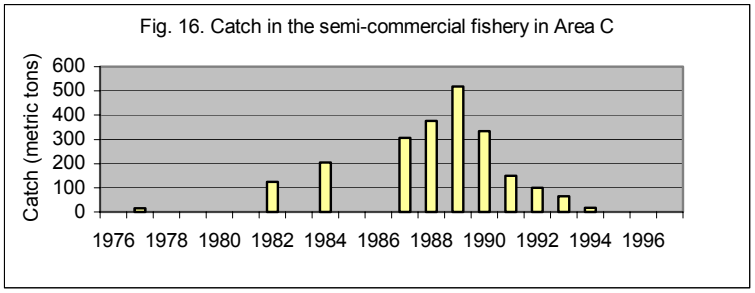


Catch, effort and CPUE of the semi-commercial fishery in Area A is shown in Fig. 14 and Table 9. Catches and effort fluctuated considerably, without trend in time, over the period and are significantly correlated ($p<0.05$, $r^2=0.64$). Maximum catch was around 1500 metric tons. CPUE, on the other hand, remained relatively stable over the whole period and B_{cur} is 84% B_{max} (1986-90).

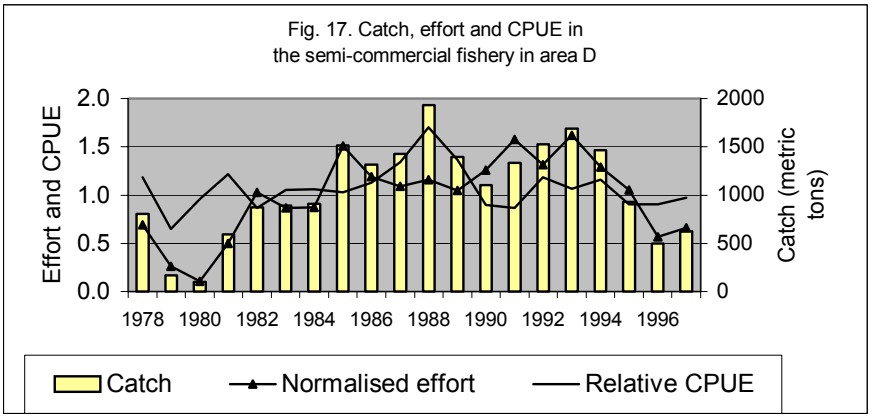
A limited semi-commercial fishery was conducted in Area B during 1976-85 with peak catch of some 400 tons in 1977 (Fig. 15).



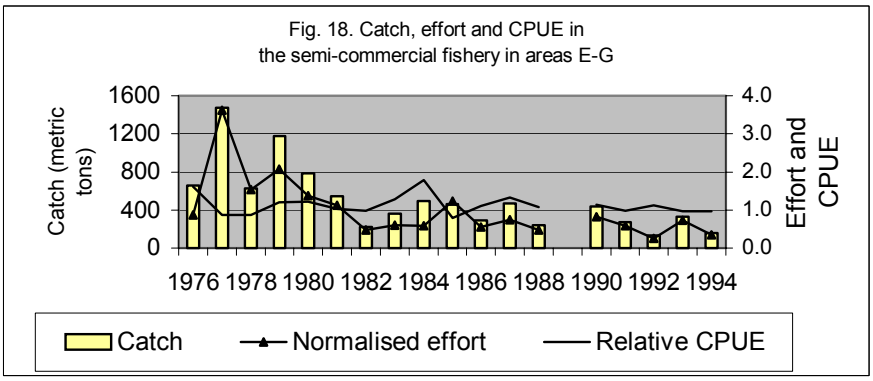
In Area C hardly any semi-commercial fishery took place until 1982 (Fig. 16). Catches of 300-500 tons were reached in 1987-90. This fishery came to an end in 1995.



The most important semi-commercial fishery has been conducted in Area D, with peak catch of some 1900 tons in 1988 and catches of around 1500 tons during 1985-94 (Fig. 17, Table 10). A close correlation is seen between catch and effort ($p<0.05$, $r^2=0.84$).



Since 1994 catch has declined markedly to a current level of some 600 tons. CPUE has remained relatively stable and B_{cur} is 72% of B_{max} (1986-90).



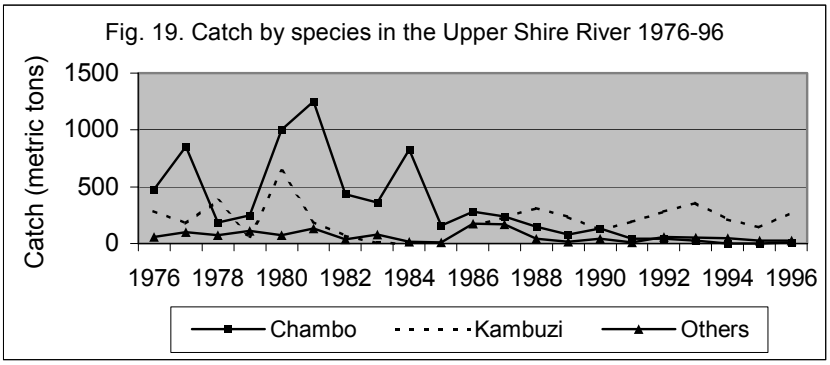
In areas E-G catches peaked at some 1500 tons in 1977 and declined in following years to a level of some 400 tons (Fig. 18). Effort has fluctuated in line with catch and a significant correlation exists between catch and effort ($p<0.05$, $r^2=0.87$). CPUE remained relatively stable throughout the period. This fishery came to an end in 1995.

The semi-commercial fisheries in areas A and D are the most important ones in this sector and dictate the overall picture as described earlier for the fishery as a whole. The fisheries in both areas show a significant correlation between catch and effort and catches in both areas have declined in recent years due to declining effort. On the other hand, no signs of declining CPUE, which would indicate deteriorating status of the fish stocks, can be detected. Thus, it must be concluded there should be scope for increased catches in the semi-commercial fisheries in all areas, as long as these are not conducted in competition with the traditional fisheries.

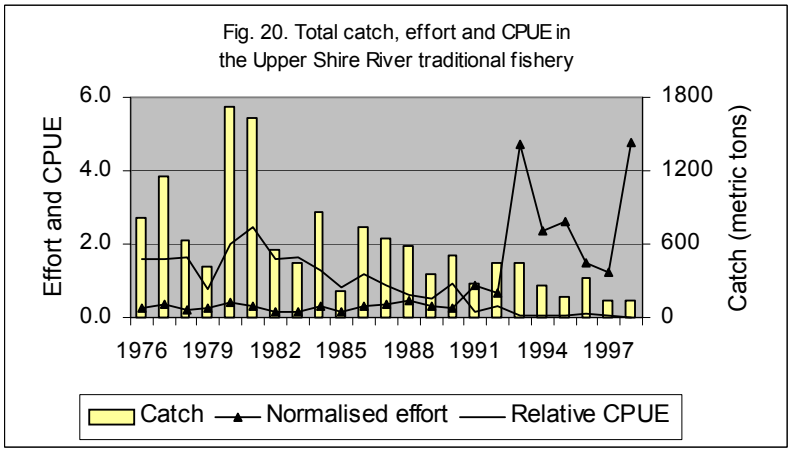
2.2 Upper Shire

The main gears in the Upper Shire fishery are chambo seine (44.6% of the recorded catch 1976-96), kambuzi seine (24.4%), gillnet (13.7%), nkacha net (11.2%) and mosquito net (5.9%). Nkacha net was introduced in 1991 and has been the main gear since that time, yielding some 69% of the total catch during 1991-96. However, much of the nkacha catch recorded in the Shire is actually caught in Lake Malombe.

Chambo was the main species in the Upper Shire River traditional fishery during the late 1970s and the early 1980s (Fig. 19). In the late 1980s the chambo catch was serverely reduced and has been at a very low level in the 1990s. The chambo stocks in the Upper Shire must be classified as collapsed. Following the collapse of the chambo stocks kambuzi has been the main species group of the fishery. However, the total catch is greatly reduced compared to previous years.

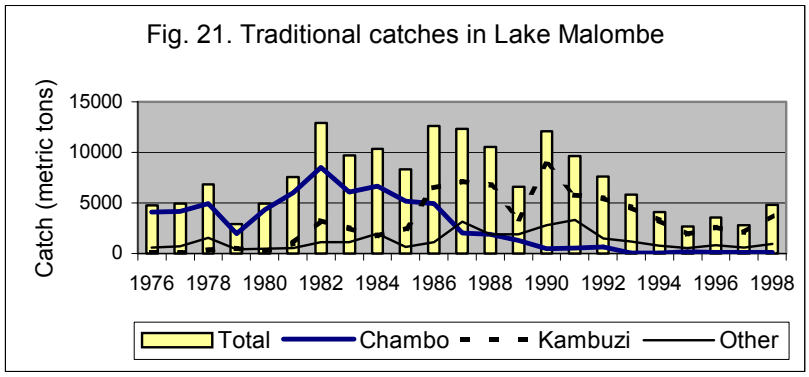


Catch, effort and CPUE in the Upper Shire River is shown in Fig. 20 and Table 11. Total catch peaked at 1700 tons in 1980 and declined in following years to less than 500 tons in the 1990s. Effort has fluctuated without a trend but CPUE has declined in line with catches. The decline in catch and CPUE indicates that the fishery has deteriorated in recent years and B_{cur} is down to 25% of B_{max} (1976-83). In view of this firm precautionary measures should be taken to reverse this trend. This should include a total ban of fishing with seines and gillnets.

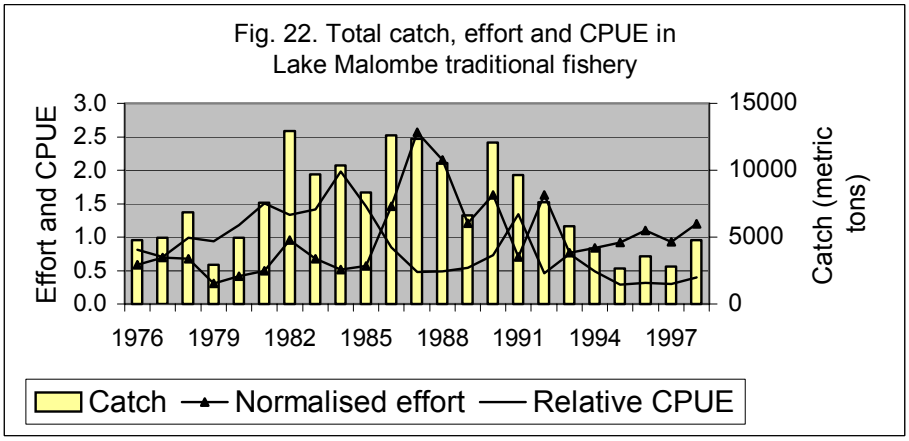


2.3 Lake Malombe

The composition of the traditional catch in Lake Malombe 1976-98 is shown in Fig. 21. Chambo was the main species in the 1970s, increasing to a level of more than 6000 tons in the early 1980s, and declining to very low level by the late 1980s. In the mid 1980s kambuzi species became the dominating catch and attained a level of more than 6000 tons in the early 1990s. Between 1994 and 1998 the kambuzi catch has fluctuated between 2000 and 4000 tons.



The total catch was at a level of some 10 thousand tons or more in most years in the 1980s and declined to some 3000 tons in the mid 1990s. However, in 1998 the total catch increased by 2000 tons to a total of some 5000 tons. Trends in total catch, effort and CPUE in Lake Malombe fisheries are shown in Fig. 22 and Table 12. CPUE increased markedly in the early 1980s with increasing chambo catches, but declined rapidly in the mid 1980s with increasing effort. CPUE has remained at a low level since that time, reaching an all time low in 1996. By 1998, there was a slight increase in CPUE but B_{cur} is still only 27% of B_{max} (1980-85) or close to B_{lim}. Effort was relatively low in the late 1970s into the mid 1980s and increased abruptly to a maximum in 1987. Effort declined in the following years and has been at a rather stable, intermediate level in the 1990s. However, there have been drastic changes in the gears used on the lake. In the late 1970s and early 1980s the fishery was dominated by gill nets and chambo seines. By the mid 1980s the use of chambo seines had declined dramatically to 38% of earlier effort levels and the fishery was now dominated by gill nets and Kambuzi seines. By the early 1990s nkacha nets increased in use and the present fishery is dominated by gill nets and nkacha nets.



The fish stocks of Lake Malombe have been subject to drastic changes in the last 2 decades. The fate of the chambo stocks is well known and will be analysed further in section 3.1. The current situation of very low CPUE and relatively high effort is unlikely to to facilitate a recovery of the chambo stocks on Lake Malombe. The FAO (1993) report attributed the decline in chambo stocks to increased use of kambuzi seines and nkacha nets. A drastic reduction in effort should therefore be considered for

Lake Malombe. While the kambuzi stocks seem relatively stable (section 3.5), the effect of the main harvesting gears (kambuzi seines and nkacha nets) on the chambo stocks has to be taken into consideration. Given the reduction of nkacha and kambuzi seine effort in Lake Malombe in recent years, effort limitations for these fisheries are recommended by denying new entries. In addition, the kambuzi and nkacha seine fisheries should be closely monitored to assess the effect of gear changes on the kambuzi stocks.

2.4 Lake Chilwa

The traditional catch in Lake Chilwa mainly consists of matemba (43.9% of the average catch), followed by makumba and mlamba (Table 13)

Fig. 23. Catch, effort and CPUE in Lake Chilwa traditional fishery

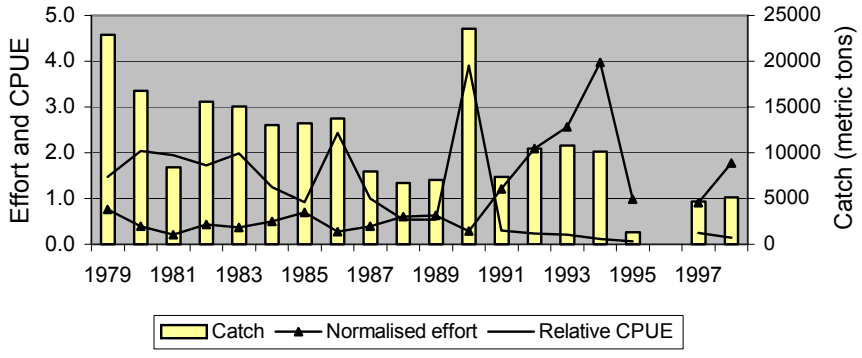


Table 13. Average catch by species in Lake Chilwa 1979-94 (metric tons).

	Matemba	Makumba	Mlamba	Others	Total
Mean	5677	3283	1810	2152	12923
%	43.9	25.4	14.0	16.7	100.0

Trends in catch, effort and CPUE are shown in Fig. 23 and Table 14. Catch records for 1997 and 1998 are only available for a part of the years. Therefore, total annual catch 1997-98 was calculated by raising the available catch records, on a monthly basis for each gear, to the whole year (see Table 14 for details). The lake gradually dried up during late 1994 and during 1995 and no fishing operations were carried out in 1996. Fishing operations started again in April 1997. In 1997 many beaches were deserted as a consequence of adverse conditions caused by the drought.

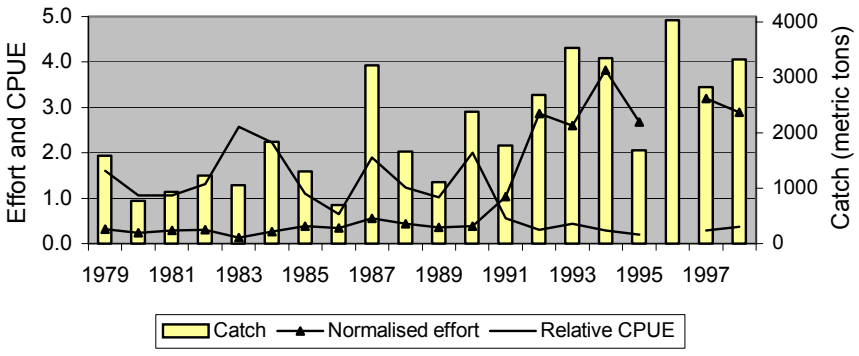
Catches were relatively high and stable during 1976-86 or around 15 thousand tons. In later years catches were markedly lower, with exception of record catch of 24 thousand tons in 1990. Effort remained low until in the 1990s when a rapid increase to much higher level was observed. Apparently, effort has declined following the drying up of the lake in 1995 and 1996. CPUE showed basically a reverse trend and has been at a very low level in the 1990s. B_{cur} is 11% of B_{max} (1979-83). However, the drying up of the lake in 1995 and 1996 and the limitations of data for later years prevents any

sensible assessment of the current status of fish stocks in Lake Chilwa. No recommendations are, therefore, made for this fishery.

2.5 Lake Chiuta

The traditional fishery in Lake Chiuta is mainly carried out using gillnets (48.2% of recorded catches 1979-95 were taken by that gear), matemba seines (37.3%) and fishtraps (10.5%). The catch is composed of 3 main species, i.e. makumba (64.1% of the total recorded catch 1979-95), mlamba (8.4%) and matemba (8.3%).

Fig. 24. Catch, effort and CPUE in Lake Chiuta traditional fishery



Trends in catch, effort and CPUE are shown in Fig. 24 and Table 15. Catch records for 1995, 1997 and 1998 are only available for a part of the years. Therefore, total annual catch was calculated by raising the available catch records, on a monthly basis for each gear, to the whole year (see Table 15 for details). Effort records for 1996 are not available and, therefore, CPUE and effort could not be calculated. Catches increased in the late 1980s and remained high in the 1990s with exception of 1995 when an abrupt decline was observed. Mozambican catch statistics are not available. Effort remained at a low level until in the 1990s when it increased to much higher level. CPUE, on the other hand, showed an inverse trend and B_{cur} is 21% of B_{max} (1979-85). In spite of low CPUE, catches have remained high due to high effort. However, this level of exploitation may not be sustainable. Therefore, a reduction in effort is recommended.

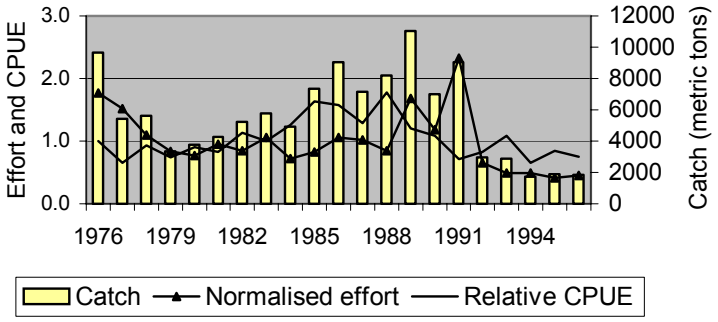
2.6 Lower Shire

The traditional catch in the Lower Shire River consists of 3 main species, i.e. mphende (41.1% of the total recorded catch 1976-96), mlamba (32.5%) and chikano (13.4%).

Trends in catch, effort and CPUE are shown in Fig. 25 and Table 16. Catches increased in the early 1980s to a maximum of 11 thousand tons in 1989 and declined in following years. Since 1994 catches have been around 2 thousand tons. Effort was relatively stable until 1989 when it increased considerably. Since 1991 effort has been at a markedly lower level than before. CPUE increased with increasing catch in the early 1980s and declined again in the late 1980s. In the 1990s CPUE has been at a similar level as in the late 1970s but considerably lower that B_{max} since B_{cur} is 51% of B_{max}

(1984-89) and therefore slightly above B_{pa}. Thus, reduced catches in the 1990s seem to be primarily due to reduced effort. If effort remains at this level catch and CPUE would be expected to increase. However, in flood plain fisheries many fish stocks are affected by various environmental factors such as flooding, which are not currently assessed.

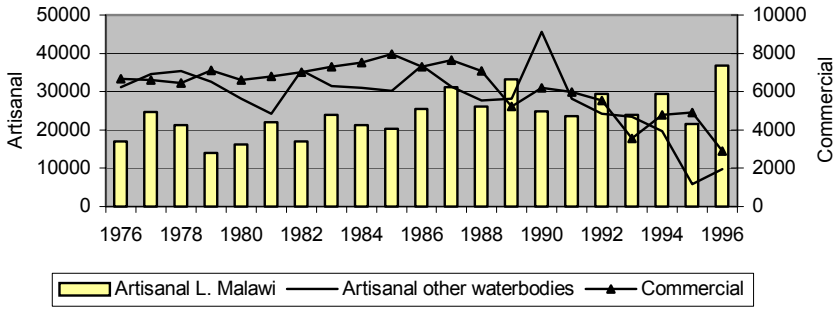
Fig. 25. Total catch, effort and CPUE in the Lower Shire River traditional fishery



2.7 Trends in total catch

Trends in total catches are shown in Fig. 26 for three main fisheries, i..e the artisanal fishery in Lake Malawi, the artisanal fisheries in other waterbodies and the commercial fishery in Lake Malawi. Traditional catches in Lake Malawi increased into the late 1980s to a peak of 33 thousand tons. In later years the catches have fluctuated considerably without a trend. The highest catch in Lake Malawi traditional fisheries was recorded in 1996 (37 thousand tons).

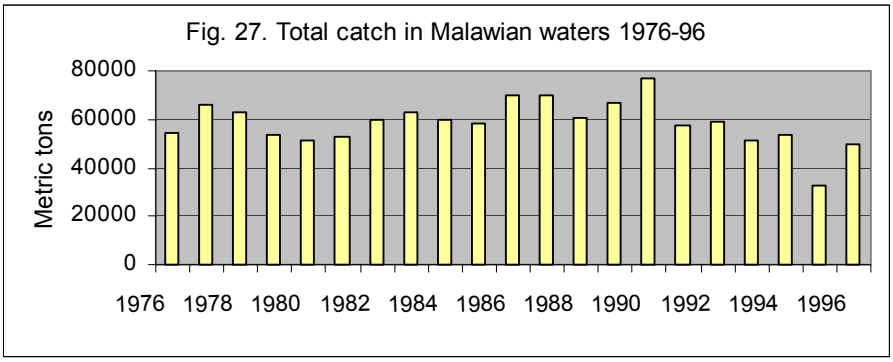
Fig. 26. Trends in total catches of main fisheries



The traditional fisheries in other water bodies than Lake Malawi remained relatively stable, close to or above 30 thousand tons, until in 1991 with a peak catch of 45 thousand tons in 1990. However, by 1994 the catches had declined to 20 thousand tons and they plummeted to 6-10 thousand tons in 1995-96. The very low catches in 1995 and 1996 are primarily due to low or zero catches in Lake Chilwa.

Commercial catches increased gradually into mid 1980s from 6500 tons in the late 1970s to a peak of 7948 tons in 1985. In later years the catches have declined substantially and reached a low at 2900 tons in 1996. During 1976-85 commercial catches were above 30% of total catches in Lake Malawi (average 34.5%), except in 1977 (27%). During 1986-91 the commercial catches were 25-29%, except in 1989 when the percentage was 16% (average 24.0%). Finally, during 1992-96 commercial catches were down to 8-23% of the total catch (average 15.4%), the lowest percentage (8%) was recorded in 1996.

Total catches in Malawian waters fluctuated between 51 and 66 thousand tons during 1976- 86 (Fig. 27). During 1987-91 the catch was 60-76 thousand tons. In the early 1990s a decline occurred to a minimum catch of 32271 tons in 1995. In 1996, however, catches recovered to 49 thousand tons, which to considerable extend is explained by good usipa catches in Lake Malawi. As seen in Fig. 26 this decline in total catches is primarily caused by the negative catch trends in other water bodies than Lake Malawi, in particular in Lake Chilwa, but also in Lakes Malombe and Chiuta and in the Lower Shire. Furthermore, reduced catches in the commercial fisheries contribute somewhat to this decline.



3. Status of some commercially important fish stocks

3.1. Chambo

3.1.1. Spawning seasonality

Turner and Mwanyama (1992) studied the spawning seasonality of Chambo in 1990-91 in Lake Malombe and in the south-east arm of Lake Malawi (Figs. 28 a-c). Peak spawning of *O. karongae* occurrs in July-October in Lake Malombe. *O. squamipinnis* peaks in December-March. In Lake Malawi Area A (south of Boadzulu Island) limited spawning seems to take place. Peak spawning of *O. squamipinnis* is observed in January-February but the other species are rarely observed in ripe condition. In Area B (north of Boadzulu Island) more intense spawning activity is observed with peak spawning of *O. karongae* in August-October as well as a second but lower peak in December-March. *O. squamipinnis* peaks in January-February and *O. lidole* in October-November although some spawning is also observed in September as well as December-February. In general, the spawning seasons of the three species occur in the same period in the different areas, although their length seems to more prolonged in Lake Malombe than in Lake Malawi.

Fig. 28 a. Chambo spawning seasonality in Lake Malombe

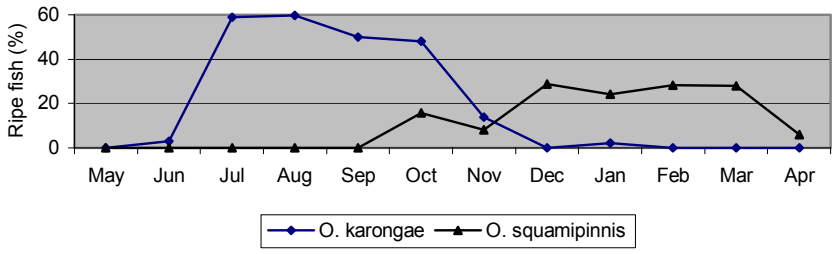


Fig. 28 b. Chambo spawning seasonality in Lake Malawi Area A

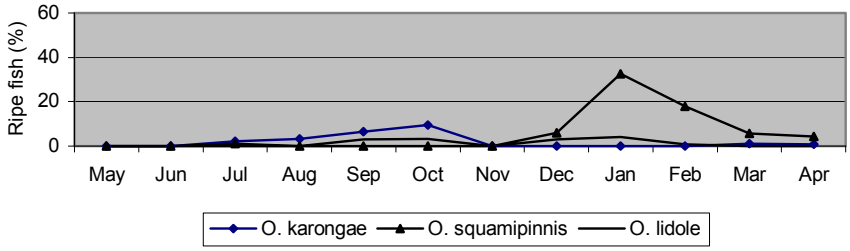
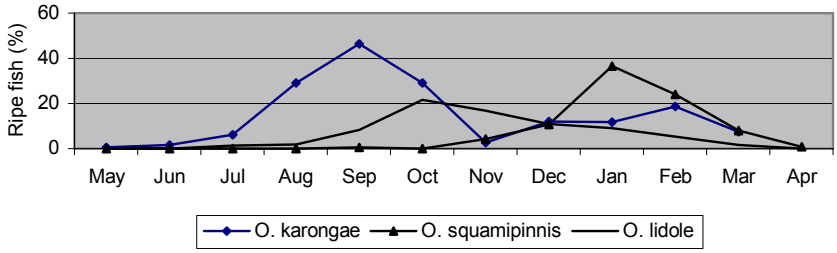
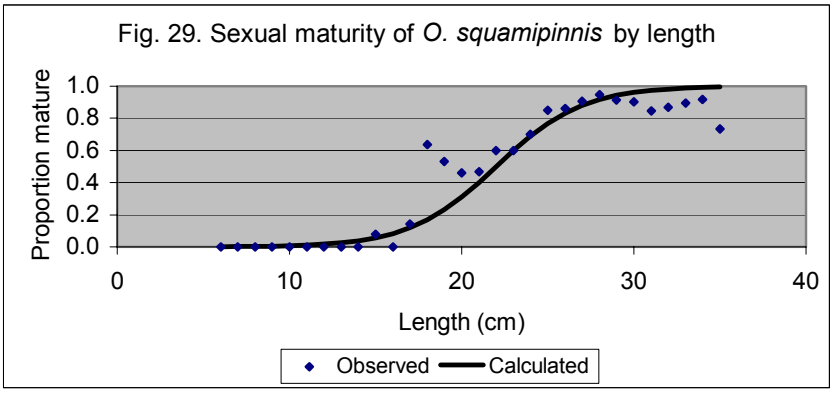


Fig. 28 c. Chambo spawning seasonality in Lake Malawi Area B



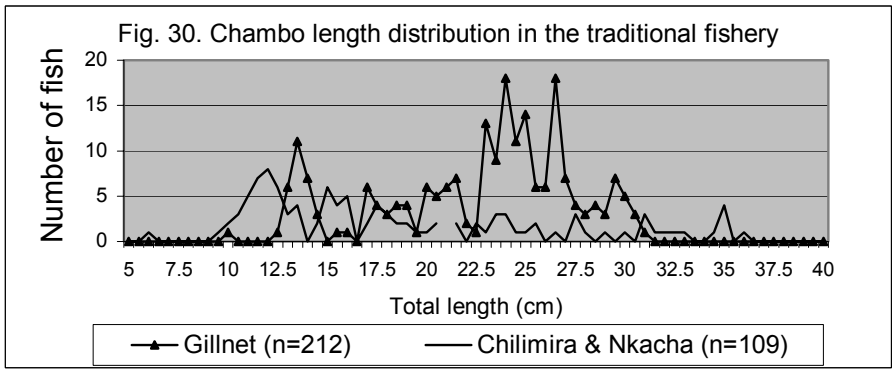
3.1.2. Length at maturity

According to observations made by Bertram et al. (1942) the onset of maturity of *O squamipinnis* is at 15 cm. The proportion mature at length increases rapidly and most fish are mature at 25 cm total length (TL). The calculated length of *O squamipinnis* at 50% maturity is 20.3 cm (Fig 29). Data are not available on maturity at length of other chambo species.



3.1.3. Length distribution of catches

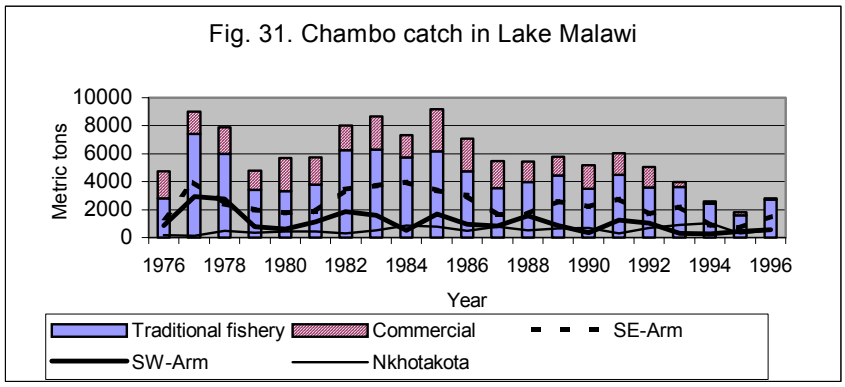
Length distributions of chambo (*O. squamipinnis* and *O. karongae*), collected from the traditional fishery in Lake Malawi in 1997 and 1998, are shown in Fig. 30. The bulk of the chambo caught in gillnets was in the length range 23-27 cm. Most of the gillnets had mesh size close to 90 mm, but some 37 mm mesh size. The proportion of fish smaller than 20.5 cm (size at 50% maturity) was 93% by number in the 37 mm gillnets but 23% in larger meshed gillnets. The mesh size of the chilimira was only 6 mm and that of the nkacha seines 27 mm. Markedly smaller fish was caught in the chilimira and nkacha seines than in larger gillnets, since 66% of the fish was smaller than 20.5 cm.



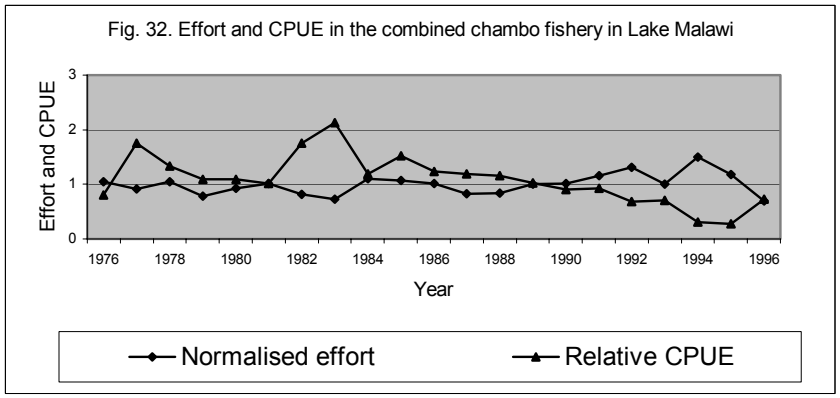
3.1.4. Catch and effort in Lakes Malawi and Malombe

Catches of chambo (*Oreochromis spp*.) in Lake Malawi peaked at 8-9000 tons in the late 1970s and in the mid-1980s (Fig. 31) but declined in 1986-87. Catches were relatively stable at 5-6000 tons during 1986-92 and declined to 1800-2800 tons in recent years. The bulk of the catches has been taken in the traditional fishery, mainly in gillnets (51% of the catch 1976-96), chambo seine (11%), kambuzi seine (5%) and chilimira (2%). The catch of the commercial fishery was in the range of 20-40% of the total catch (average 29%) until 1992, after which time this fishery came virtually to an end. Most of the traditional catches are taken in the SE-Arm (40% of the total catch in Lake Malawi 1976-96) and a significant catch is taken in the SE-Arm (19%). Much less

is caught in Nkhotakota (9%), but catches have remained more stable there than in the south.

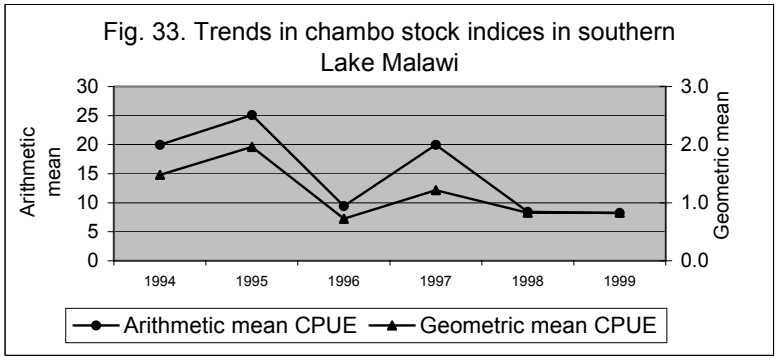


Effort and CPUE in the chambo fishery in Lake Malawi as a whole is shown in Fig. 32 and Table 17. In general effort remained fairly stable throughout the period, although a slight increase can be detected during 1992-94.

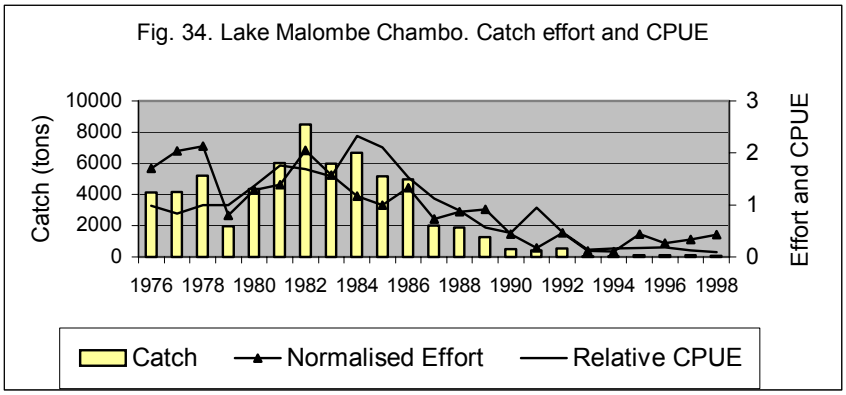


CPUE fluctuated somewhat during 1976-91, without a trend, and declined in the early 1990s to a minimum level in 1994-95. The trend in CPUE follows the same trend as catches and is seen as an indication of declining stock size in the 1990s and even longer. B_{cur} is 32% of B_{max} (1980-86) indicating a need for firm precautionary action to be taken.

Results from the monitoring surveys in southern Lake Malawi in 1994-99 are shown in Fig. 33. It is seen that chambo stock indices have declined during the period. The average stock index over the years 1997-99 is 67 % and 69% of the average 1994-96 for arithmetic and geometric mean respectively. Thus, the declining trend of chambo in southern Lake Malawi has continued since 1994-96, the last years of the catch-effort data series.



In Lake Malombe chambo catches were around 4000 tons in the late 1970s and increased to 6000 tons and more in the early 1980s (Fig. 34, Table 18). In the late 1980s a drastic decline was observed in catches to less than 600 tons per year since 1990.

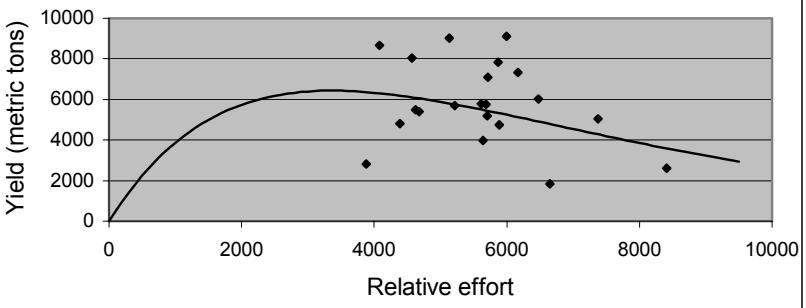


Effort and CPUE have followed a similar trend during the whole period. The status of the chambo stocks in Lake Malombe is clear: The stocks have been in a state of collapse or near collapse during the entire 1990s and B_{cur} (1996-98) is down to 8% of B_{max} (1980-86). The restoration of the stocks may not be a simple task under the present situation. However, it should be considered a matter of greatest importance in view of the economic value of the chambo.

3.1.5. Surplus production in Lake Malawi

A surplus production model (Fox) of CPUE and effort of chambo in Lake Malawi gives a significant plot ($p<0.05$, $r^2=0.41$). The resulting catch-effort plot is shown in Fig. 35.

Fig. 35. Surplus production plot of chambo in Lake Malawi



A cluster of 7 data points above 7000 tons shows the values of high catches in the late 1970s and mid 1980s. MSY is approximately 6400 tons and is reached at 3400 relative effort units. However, at 2500 effort units the calculated sustained yield is 6200 metric tons, which is virtually the same yield at a markedly (27%) reduced effort. During the whole period relative effort has been above FMSY of 3400. This indicates that excessive effort in the chambo fisheries may be a primary factor in view of the declining chambo catches in recent years in Lake Malawi.

3.1.6. Management recommendations

In view of the above findings, effort in the chambo fishery in Lake Malawi should be reduced significantly, in order to restore the stocks to previous levels, and thereby, increase the production of the chambo stocks. In order to achive this the following recommendations are made:

- Total ban on fishing with chambo seine in Lake Malawi.
- Ban on fishing with chilimira/kauni in area A (minor strata 2.1 and 2.2) of the south east arm of Lake Malawi.

These measures should be enforced until a clear recovery of the stocks is verified. The measures are expected to reduce the chambo catch in Lake Malawi by 400-500 metric tons per year and reduce effort by approximately 20%. In addition, a reduction in usipa catch in area A of approximately 500 tons is anticipated due to the chilimira/kauni restriction.

Fishing of chambo in Lake Malombe should be totally banned, in order to restore the depleted stocks. Since gill nets are the main gear catching chambo, the following recommendation is made:

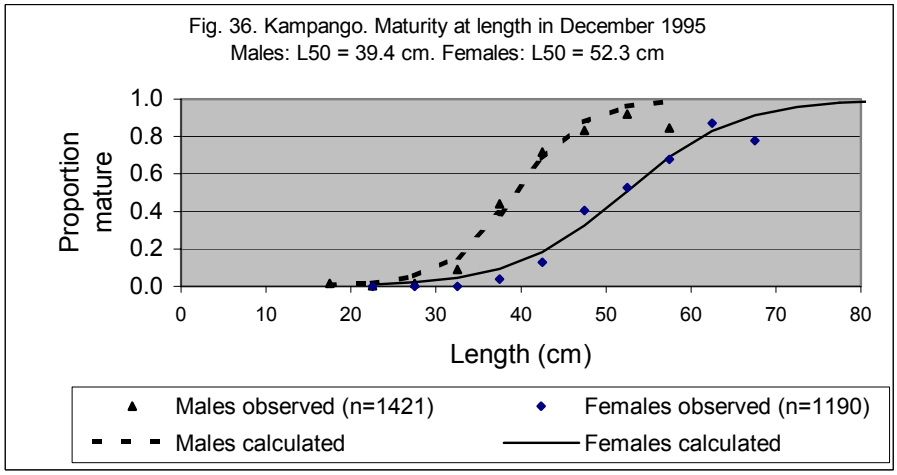
- Total ban on gill nets and chambo seines in Lake Malombe.

The total catch of chambo is only approximately 100 metric tons per year in Lake Malombe. The restoration of the stocks, therefore, cannot be expected to succeed unless a total ban on chambo fishing is sustained during a period of several years.

3.2. Kampango

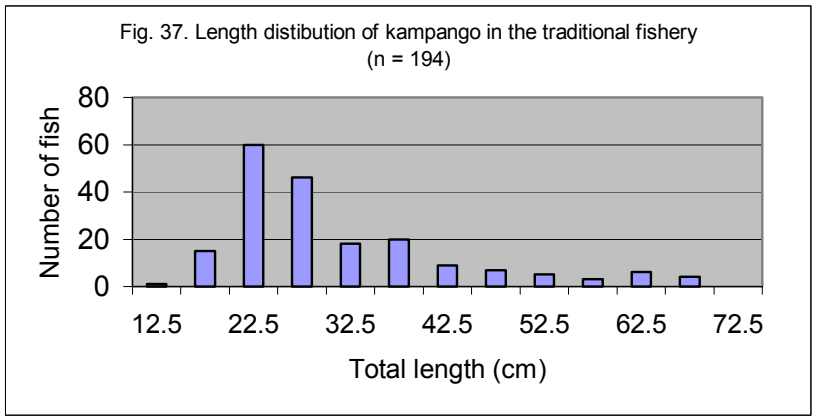
3.2.1. Length at maturity

Maturity ogives of kampango (*Bagrus merdionalis*) show a clear difference by sex in the onset of sexual maturity (Fig. 36). Maturity of males commences at around 30 cm total length and length at 50% maturity is 39.4 cm. Female maturity, on the other hand, commences around 40 cm and 50% maturity is reached at 52.3 cm.

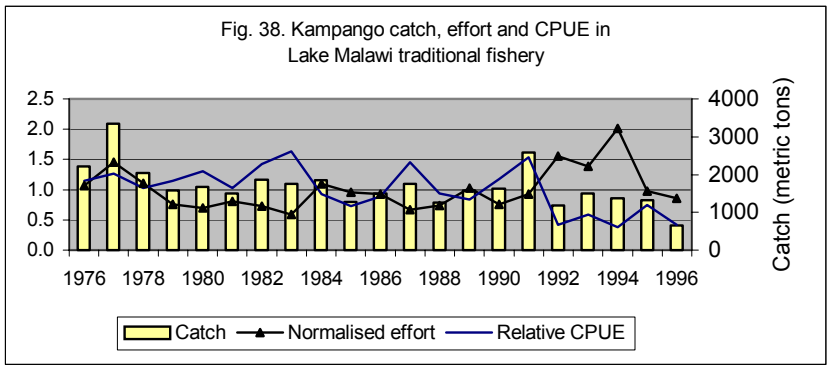


3.2.2. Length distribution of catches

The length distribution of kampango based on data collected from an ongoing survey of the traditional fishery in Lake Malawi in 1997-98 (mainly gillnets) is shown in Fig. 37. A large part of the fish (63%) is below the approximate length at first maturity (30 cm) and 82% is below the length of males at 50% maturity (40 cm). This is to be expected in view of gillnet mesh size and the fact that kampango is a relatively large fish compared to other species targeted by the gillnet fishery. Nevertheless, this must be considered as a compromising situation in terms of optimal exploitation of the stock.

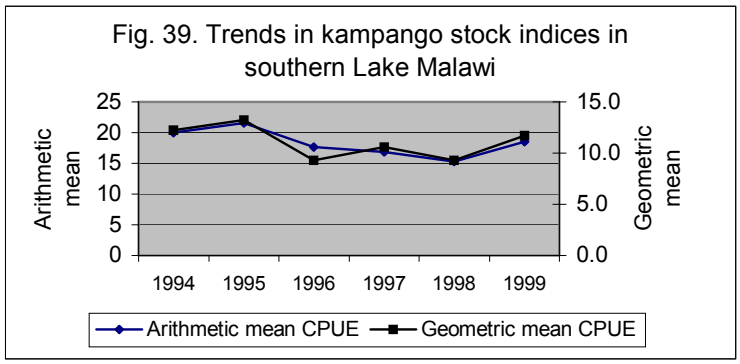


3.2.3. Catch and effort in Lake Malawi



Kampango is mainly taken in gillnets in the traditional fishery (87.3% of the recorded catches in Lake Malawi 1976-96). The catch of the commercial fisheries amounted to 4% of the total. The average annual catch over the period 1976-96 was 875 tons in SE- and SW-arms and 471 tons in Domira and Nkhotakota. The average catch in Lake Malawi traditional fisheries as a whole was 1686 tons. Trends in the traditional fishery for kampango in Lake Malawi as a whole are shown in Fig. 38 and Table 19. Clear declining trends are observed for catch and CPUE and B_{cur} is 43% of B_{max} (1976-84). Effort, on the other hand, has remained more stable with the exception of the years 1992-94 when relatively high effort was recorded.

Results from the monitoring surveys in southern Lake Malawi in 1994-99 are shown in Fig. 39. It is seen that kampango in southern Lake Malawi has remained relatively stable during the period. The average stock index 1997-99 was 85% and 91% of the average 1994-96 for arithmetic and geometric mean respectively.

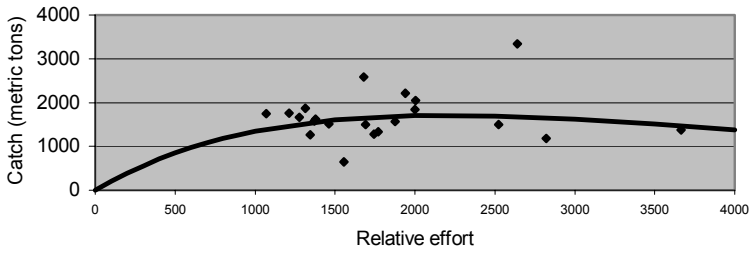


3.2.4. Surplus production in Lake Malawi

A plot of CPUE against effort indicates a significant relationship using the Fox model of surplus production ($p<0.05$, $r^2=0.50$). Fig. 40 shows the relationship between catch and effort. The calculated maximum sustainable yield (MSY) is 1713 tons which is reached at an effort of 2190 units. However, slightly lower MSY (1500 tons) can be reached already at around 1600 effort units which is the effort level observed during the period of relatively stable catches and effort, i.e. during 1979-1990. Effort fluctuates

considerably from year to year, but it seems that effort in some of recent years has been higher than the effort corresponding to MSY. Concurrently CPUE has been at a lower level than observed before (Fig. 38). However, since current biomass ($B_{cur)}$ is close to $B_{pa,}$ specific management recommendation are not made.

Fig. 40. Kampango stock production in Lake Malawi

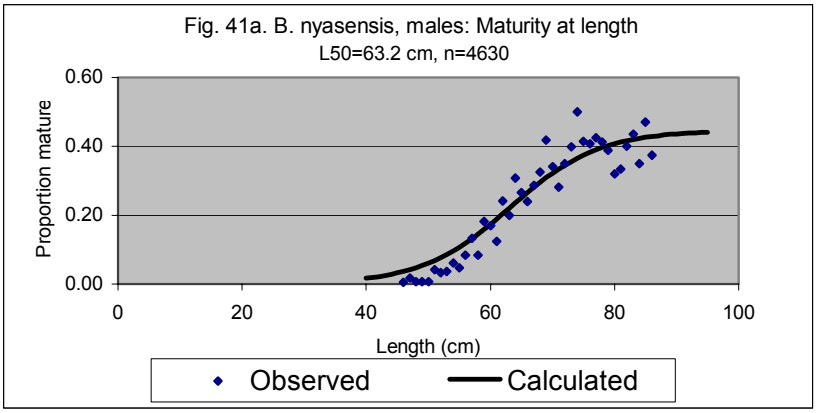


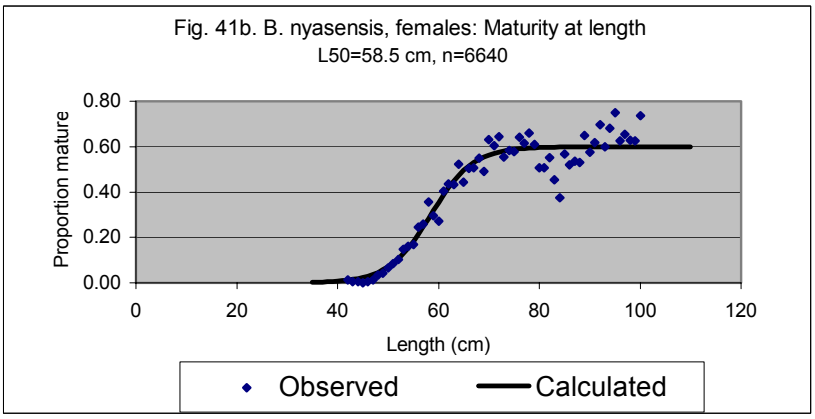
3.3. Bombe

3.3.1. Length at maturity

Extensive material is available on the biology of bombe (*Bathyclarias spp*.) collected during the 1990s (Banda, PhD-thesis, unpublished manuscript). Of 9 *Bathyclarias* species *B. nyasensis* is by far the most abundant one and, therefore, accounting for most of the fishing potential. *B. longibarbis* is also found in some numbers, but other species are relatively rare. As a rule bombe reaches maturity around 50 cm total length, and most of the fish are sexually mature around 70 cm. The length at 50% maturity is reached midway between these limits, i.e. around 60 cm and may differ for males and females (Fig. 41 a-b).

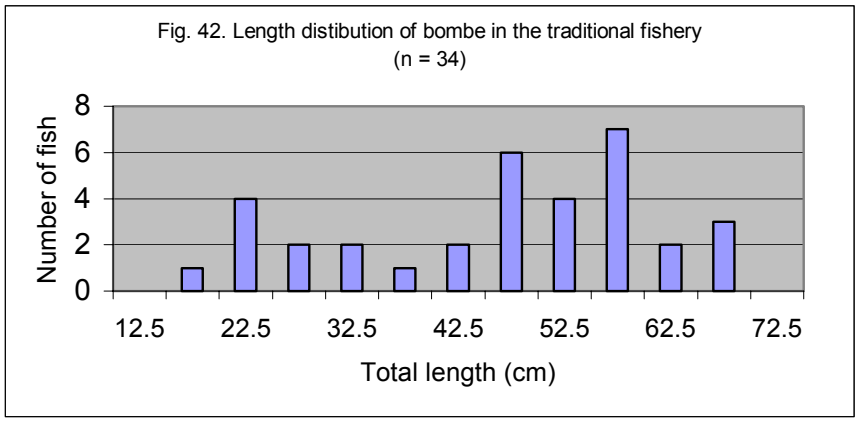
Fig. 41a. B. nyasensis, males: Maturity at length
L50=63.2 cm, n=4630





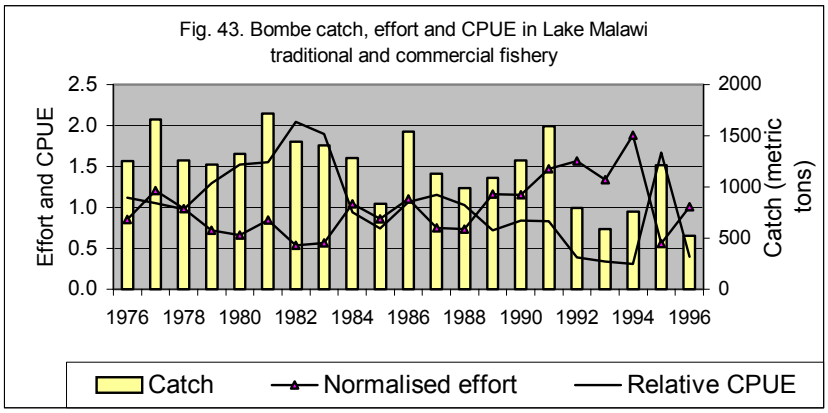
3.3.2. Length distributions of catches

Limited length measurements of bombe are available from an ongoing survey of the traditional fishery in Lake Malawi and only 34 fish were measured in 1997-98. Most of the fish measured were caught in gillnet and longline and half of the fish (50%) were in the range 45-59 cm (Fig. 42). Immature fish (<50 cm) was 53% of the number measured.



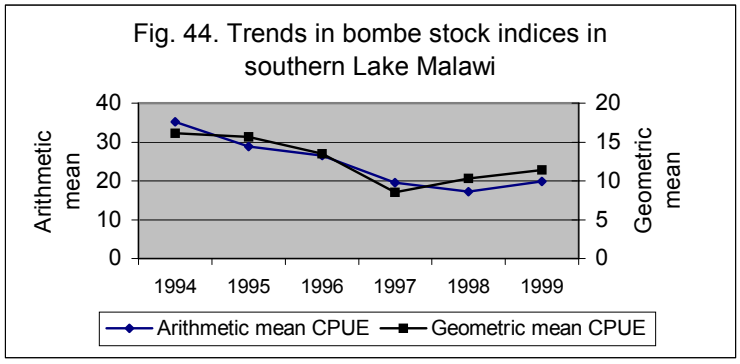
3.3.3. Catch and effort in Lake Malawi

Bombe is mainly caught in gillnets in the traditional fishery (66.3% of the recorded traditional catches 1976-96) and on longline (27.8%). The average annual catch over the period 1976-96 was 675 tons in SE- and SW-arms and 324 tons in Domira and Nkhotakota. The average catch in Lake Malawi as a whole was 1184 tons.



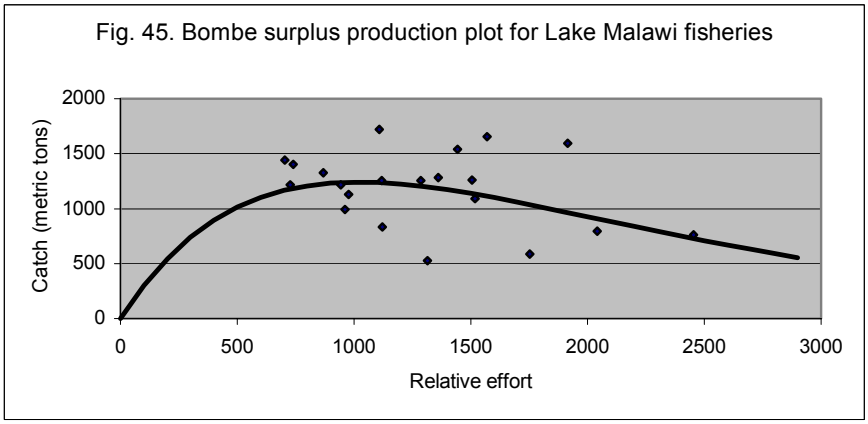
Catches in Lake Malawi traditional and commercial fisheries were relatively stable in the late 1970s and early 1980s in the range of 1200-1400 tons, with peaks around 1700 tons in 1977 and 1981 (Fig. 43, Table 20). A general decline was observed in later year to 524 tons in 1996. Effort was relatively stable until in the early 1990s when it increased to a peak in 1994. A sudden drop in effort was observed in 1995. CPUE increased to a peak in 1982 and declined in later years, reaching a low in the 1990s except for 1995 when high catch was associated with high CPUE. B_{cur} (1994-96) is 58% of B_{max} (1976-84), but if the high CPUE of 1995 is omitted B_{cur} (1994 and 1996) is only 25%.

Results from the monitoring surveys in southern Lake Malawi in 1994-99 are shown in Fig. 44., indicating a declining trend for bombe in southern Lake Malawi since 1994. The average stock index in 1997-99 was 62% and 67% of the average 1994-96 for arithmetic and geometric mean respectively.



3.3.4. Surplus production in Lake Malawi

A plot of bombe CPUE against effort in Lake Malawi indicates a significant relationship using the Fox model of surplus production ($p<0.05$, $r^2 = 0.68$, Fig. 45). The

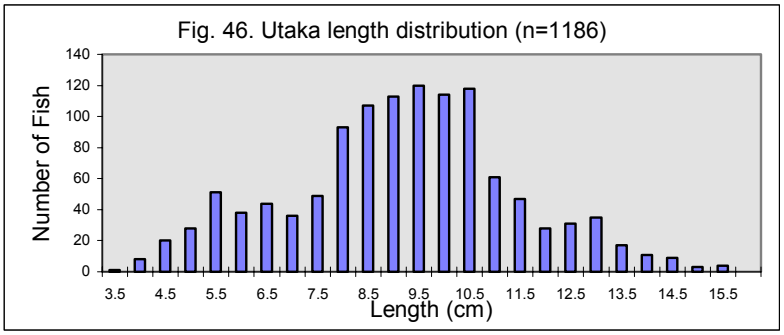


calculated maximum sustainable yield (MSY) is 1240 tons which is reached at an effort of 1017 units (FMSY). However, slightly lower catch (1100 tons) can be reached already at around 600 effort units. Effort was in excess of fmsy during 1989-94 when a rather sudden drop occurred in 1995, followed by a very low catch in 1996. The effort observed in recent years has been far beyond FMSY except in 1995 when effort was in fact very close to an optimum level. In view of the uncertain level of $B_{cur,}$ specific management recommndations are not made, pending further data for most recent years.

3.4. Utaka in Lake Malawi

3.4.1 Length distribution of catches

Utaka (*Copadichromis spp*.), collected from most fishing gears of the artisanal fishery of Lake Malawi in October and December 1998, was measured for length (Fig. 46). Total length was in the range 4-16 cm, with most of the counts registering between 8 and 11 cm..



3.4.2. Catch and effort in Lake Malawi

Utaka is mainly taken in chilimira in the traditional fishery in Lake Malawi (69.9% of recorded catches 1976-96). A smaller amount is taken in kambuzi seine (13.7%). The commercial fisheries caught 14.6% of the total catch over the same period. Thus, utaka is primarily caught in the traditional fishery in Lake Malawi.

Catches have fluctuated heavily over the period and an increasing, although non-significant, trend is observed (Fig. 47, Table 21). The average annual catch was 7300 tons. Effort was relatively low during the first 10 years but increased markedly in the late 1980s and has remained at a relatively high level in the 1990s. CPUE has fluctuated heavily and remained relatively high into the early 1980s but declined in later years. B_{cur} is 37% of B_{max} (1976-84). Thus, increased effort has not resulted in a significant increase in catches. However, CPUE, and hence, the profitability of the fishery has been brought to a lower level. It can be concluded that a reduction in effort should lead to improved CPUE without substantially affecting total catches. However, in view of the fluctuating, multi-species nature of this fishery, a recommendation to that effect cannot be made at present.

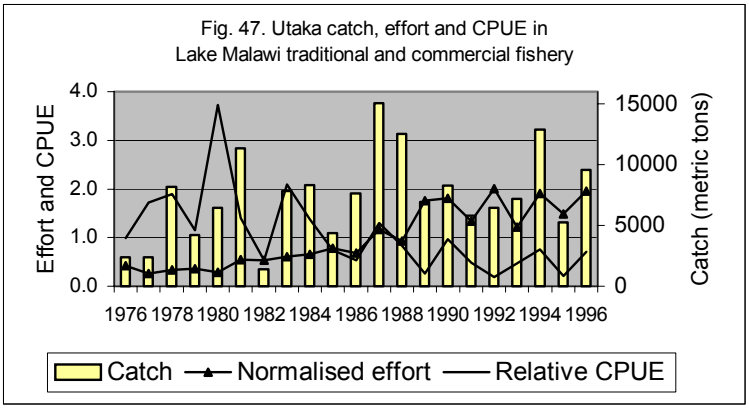
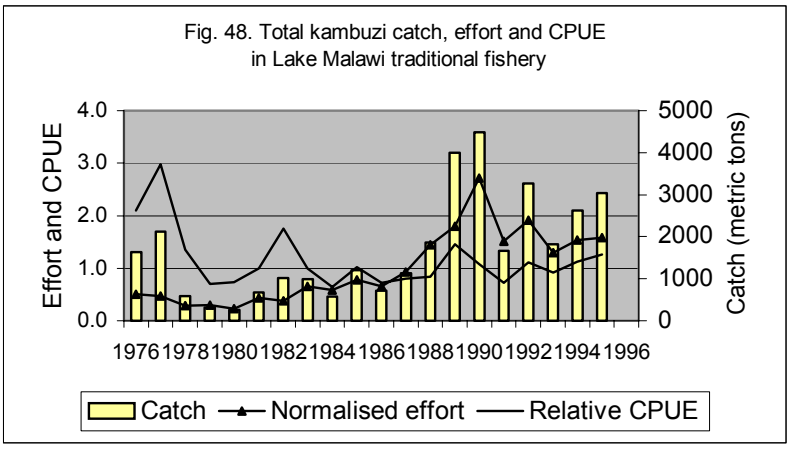


Fig. 47. Utaka catch, effort and CPUE in Lake Malawi traditional and commercial fishery

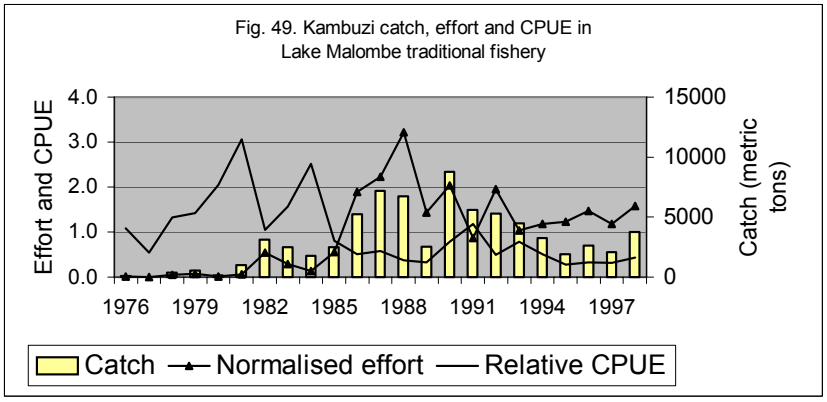
3.5. Kambuzi

3.5.4. Catch and effort in Lakes Malawi and Malombe

Trends in catch, effort and CPUE of the kambuzi fishery in Lake Malawi show major changes in recent years (Fig. 48, Table 22). Catches remained low until the late 1980s when an increase to considerably higher level was recorded. Effort has followed the trend in catches rather closely, i.e. increased catches are the result of increased effort. CPUE, therefore, has remained relatively stable throughout the period and B_{cur} is 88% of B_{max} (1976-84). These findings indicate a stable status of kambuzi stocks in Lake Malawi.



Trends in total catch, effort and CPUE in the kambuzi fishery of Lake Malombe are shown in Fig. 49. In the mid 1980s kambuzi species became the dominating catch in Lake Malombe and attained a level of more than 6000 tons in the early 1990s. These high catches were a result of high effort levels, particularly in the kambuzi seine fishery during this period. By 1994 the kambuzi seine fishery declined to 9% of its former effort levels and was replaced by the nkacha net fishery. From 1994 and 1998 the kambuzi catch has fluctuated between 2000 and 4000 tons. Relative CPUE was highest from 1976 to 1984, when effort was low, dropping markedly with increasing effort levels. Although, B_{cur} is 33% of B_{max} (1982-1986), CPUE for kambuzi has been relatively stable since 1985 (Fig. 49). However, the fishery needs to be monitored closely to assess changes resulting from gear changes in the fishery.

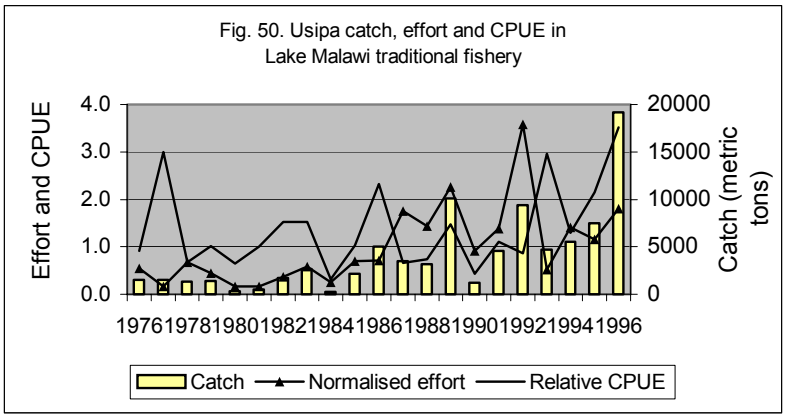


3.6. Usipa

3.6.1. Catch and effort in Lake Malawi

Usipa (*Engraulicypris sardella*) is mainly taken in chilimira in the traditional fishery (58.8% of recorded traditional catches 1976-96), mosquito net (28.5%) and kambuzi seine (12.3%).

Annual catch was less than 3000 tons during the late 1970s and the early 1980s, when increased effort resulted in increased catches (Fig. 50, Table 24). However, both effort and catches have fluctuated greatly. The largest catch (19 thousand tons) was recorded in 1996. CPUE has fluctuated heavily without a trend and high CPUE values were observed in recent years. B_{cur} is 197% of B_{max} (1976-84). Thus, the available results indicate a satisfactory status of the usipa stock in Lake Malawi.

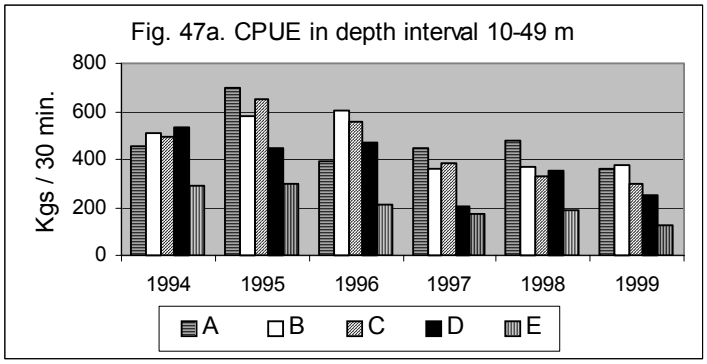


3.7. Demersal monitoring surveys 1994-99

The current series of demersal monitoring surveys were initiated in the SE- and the SW-Arms in 1994 and have been conducted at least once a year since that time. These surveys provide fisheries independent information on the status of the fish stocks in the sense that results are not based on data collected from fishing vessels, but data collected during research surveys of RV Ndunduma. The first survey was conducted in June 1994 and two other surveys were conducted in that year. Four surveys were conducted in 1995, one in 1996 and in 1997, two in 1998 and, finally, one in 1999. In each survey 85-97 hauls were worked on the same stations each year. The duration of a haul is 30 minutes.

Average catch per haul (CPUE) in a given year is used as an estimator of fish abundance. In years when more than one survey has been conducted the mean (pooled) CPUE across the surveys is calculated. Although the data is characterised by large variability, especially on a species level, CPUEs of total biomass yield relatively well behaved results in terms of statistical properties and precision. Nevertheless, the coefficient of variation (CV) of the mean total CPUE is 71-85% (of the mean).

Therefore, CPUE of the total catch is used here to describe the trend in fish stocks during the 5 years under consideration, by depth interval and area and in the whole survey area (Fig. 51a-d).



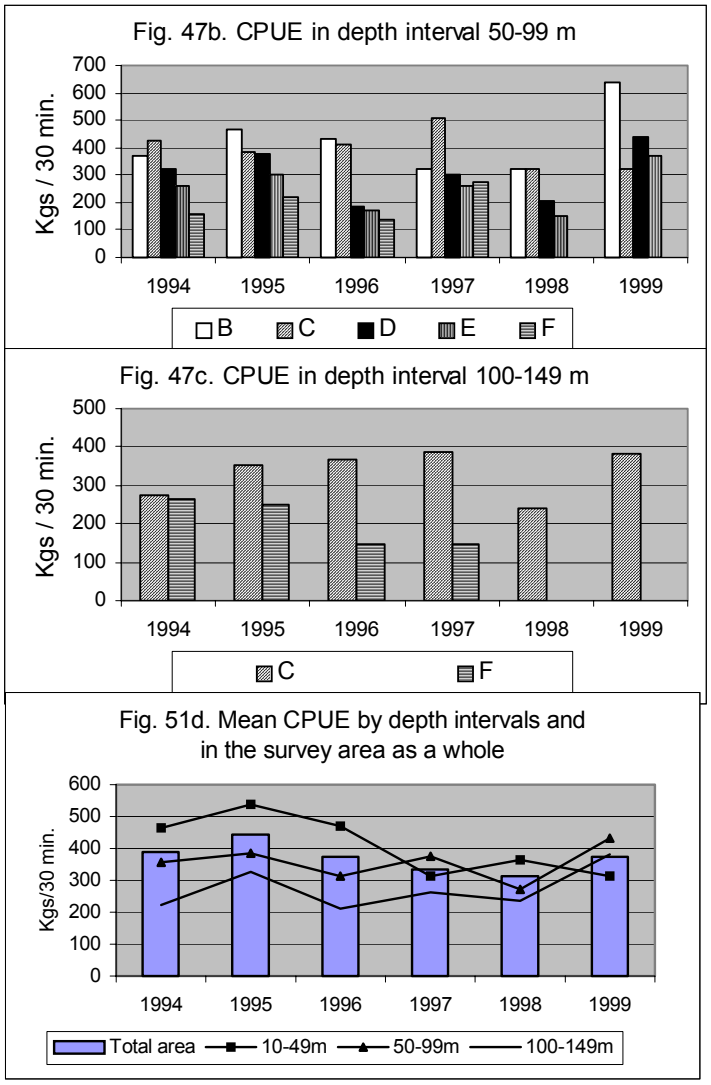


Fig. 51. Catch Per Unit Effort (CPUE) by area within each depth interval (a-c), as a mean of each depth interval and in the surveyed area as a whole (d), in monitoring surveys 1994-99.

In depth interval 10-49 m the CPUE in area A was exceptionally high in 1995, but otherwise relatively stable (Fig. 51a). In other areas CPUEs declined during 1995-97 but have been relatively stable in recent years. The mean CPUE in depth interval 10-49 m (Fig. 51d) shows the stable CPUEs 1997-99 clearly.

In depth interval 50-99 m no trend was observed in the different areas (Fig. 51b). The mean CPUE in the depth interval (Fig. 51d) has fluctuated considerably in recent years, but is higher in 1999 than observed before.

In depth interval 100-149 m a drastic decline was observed in area C in 1998 which was reversed in 1999 (Fig. 51c). The CPUE in the surveyed area as a whole (Fig. 51d) shows considerable fluctuations, but overall the situation must be regarded as stable.

The above results indicate reduced demersal fish density in recent years in the shallow waters of the SE- and SW- Arms, except perhaps in area A. In other depth ranges fish density appears to be stable.

4. Current management measures

Fisheries management regulations in Malawian waters are currently based on technical restriction of fishing gears, i.e. gear mesh size or size of gear (e.g. head line length) and restrictions of fishing areas or fishing times. The extent of these regulations is summarised in Table 25 (appendix). The commercial fisheries in Lake Malawi are subject to a variety of technical and other restrictions. For the traditional fishery the restrictions are primarily confined to mesh size and gear size limitations as well as closed seasons for beach seines. A number of gears are without any restrictions, i.e. longlines (except closed hours in L. Malawi), handlines, traps, scoop nets and cast nets. Some gear types are generally or locally prohibited, i.e. kauni for chambo, nkacha (except in L. Malombe) and beach seines (in L. Chiuta, Upper Shire (kambuzi) and in rivers and dams).

Some species are subject to minimum landing size, i.e. all species of chambo (genus *Oreochromis* subgenus *Nyasalapia*) 150 mm fork length, other tilapia (e.g. *O. shiranus shiranus*) 100 mm fork length and mpasa (*Opsaridium microlepis*) 300 mm fork length.

The traditional fisheries are "open-entry", although a licence is formally needed to operate in that fishery. An annual basic fee must be paid depending on type of gear.

The commercial fisheries, on the other hand, are strictly entry limited. The total number of licences issued for each area is based on biomass estimates of the monitoring surveys. A number of fees must be paid for operating a commercial vessel.

Thus, Malawian fisheries are subject to a rather extensive arsenal of management measures. In view of the current status of fisheries and fish stocks in Malawian waters, however, the effectivity of these measures appears to be limited.

5. Short-term management recommendations

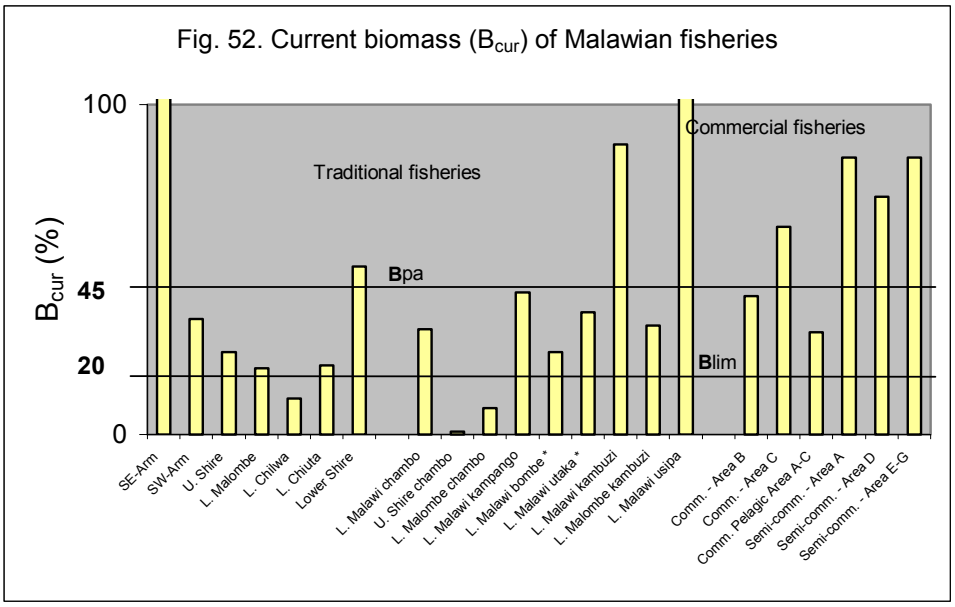
Past trends and current status (B_{cur}) of fisheries and fish stocks in Malawian waters are summarised in Table 26 and Fig. 52 based on findings presented in previous sections of this report. In general the status of the traditional fisheries seems to be markedly worse than that of the commercial fisheries. Only 2 traditional fisheries out of 7 are above B_{pa} and 4 are close to or below $B_{lim.}$ Two out of 9 traditional stocks analysed are above B_{pa} and 4 are close to or below $B_{lim,}$ including all the chambo stocks. In the commercial sector, on the other hand, 4 out of 6 fisheries are well above B_{pa} and only the commercial pelagic fishery for chambo is close to $B_{lim.}$ The main reason for this difference is probably related to different trends in effort. In most traditional fisheries effort has increased in recent years. In the commercial fisheries, on the other hand, effort has been variable or declining.

Table 26. A summary of status of fisheries and fish stocks in Malawian waters 1999

Fish				Long term trends (1976-96)			
Stock(s)	**Fishery/Survey**	**Waterbody**	**Area(s)**	**Catch**	**Effort**	**CPUE**	**B_{cur} (%)**
All	Traditional	South East Arm	All	Increasing	Increasing	Stable	111
All	Traditional	South West Arm	All	Variable	Increasing	Decreasing	35
All	Traditional	Upper Shire	All	Decreasing	Variable	Decreasing	25
All	Traditional	Lake Malombe	All	Decreasing	Increasing	Decreasing	20
All	Traditional	Lake Chilwa	All	Decreasing	Increasing	Decreasing	11
All	Traditional	Lake Chiuta	All	Decreasing	Increasing	Decreasing	21
All	Traditional	Lower Shire	All	Decreasing	Decreasing	Variable	51
All	Commercial dem.	South East Arm	B	Decreasing	Decreasing	Decreasing	42/65 *
All	Commercial dem.	South East Arm	C	Increasing	Increasing	Stable	63/88 *
All	Comm. pelagic	South East Arm	A-C	Decreasing	Stable	Decreasing	31
All	Semi-commercial	South East Arm	A	Variable	Variable	Stable	84
All	Semi-commercial	South West Arm	D	Variable	Variable	Stable	72
All	Semi-commercial	SWA-Salima	E-G	Decreasing	Decreasing	Stable	84
Chambo	Trad./Commer.	Lake Malawi	All	Decreasing	Increasing	Decreasing	32
Chambo	Traditional	Upper Shire	All	Decreasing	Variable	Decreasing	1 **
Chambo	Traditional	Lake Malombe	All	Decreasing	Decreasing	Decreasing	10
Kampango	Traditional	Lake Malawi		Decreasing	Increasing	Decreasing	43
Bombe	Trad./Commer.	Lake Malawi	All	Decreasing	Increasing	Decreasing	58/25 ***
Utaka	Trad./Commer.	Lake Malawi	All	Increasing	Increasing	Decreasing	37
Kambuzi	Traditional	Lake Malawi	All	Increasing	Increasing	Stable	88
Kambuzi	Traditional	Lake Malombe	All	Decreasing	Stable	Stable	33
Usipa	Traditional	Lake Malawi	All	Increasing	Increasing	Variable	197
Demersal	Monitoring Surveys	SE & SW Arms	A-F		Constant	Stable	93 ****

* Means for 1991-93 and 1995-97 respectively. ** Current CATCH (%)
*** Means for 1994-96 and 1994 & 1996 respectively. **** CPUE 1999/mean CPUE 1994-96

Most fisheries (traditional and commercial) in the south east and south west arms of Lake Malawi appear to be stable when analysed as a bulk biomass of all species. Thus B_{cur} is, in all cases except for traditional fisheries in the SW-Arm, well abowe B_{pa}, indicating that precautionary actions are not needed. The fisheries in the smaller waterbodies, on the other hand, show declining trends in catch and CPUE and many appear currently to be at a low level in terms of resource status. This is particularity the case for Lakes Chilwa, Malombe and Chiuta and the Upper Shire River. B_{cur} is extreme low for fish stocks in these lakes and close to or even below B_{lim}, which indicates a state of serious depletion and danger of subsequent collapse. The prospects for fisheries in these lakes seem to be extremely discouraging. However, in view of severe limitations of the available data for Lakes Chilwa and Chiuta, precise recommendations are not given at this stage. For the Upper Shire, however, a total ban of fishing with seines and gillnets is recommended. The Lower Shire River, on the other hand, seems to be more stable and B_{cur} was still slightly above B_{lim} in 1994-96.



When fish stocks are analysed at a species or genus level some of the most important stocks seems to be at a low or very low level. The most apparent cases are that of chambo in Lake Malombe and in the Upper Shire River. B_{cur} is far below B_{lim} in both cases and these stocks are classified as collapsed or virtually collapsed. Furthermore, Lake Malawi chambo and bombe seem to be at a low level, with B_{cur} below B_{lim}, and precautionaly management actions are recommended for chambo. Usipa and kambuzi in Lake Malawi, on the other hand, seem to be at a stable, although fluctuating, level, and kampango is only slightly below $B_{pa.}$ Specific recommendations are not made for utaka in Lake Malawi and kambuzi in Lake Malombe although both groups are markedly below $B_{pa.,}$ since they have remained more or less stable in recent years. However, both fisheries might benefit from reduced effort.

In summary, recommended precautionary management actions are as follows:

- Lake Malawi traditional fishery: In order to restore the chambo stocks, a total ban on chambo seines and a ban on chilimira/kauni in area A is recommended.
- Lake Malombe fishery: To restore chambo stocks a total ban on gill nets and chambo seines will be necessary. To maintain the kambuzi stocks effort limitations in the nkacha net and kambuzi seine fisheries need to be undertaken, by denying new entries.
- Lake Chiuta fishery: To restore stocks a reduction in effort is recommended.
- Upper Shire fishery: To restore stocks a total ban on seines and gillnets is recommended.

6. Medium and long-term management considerations

The scientific basis of fisheries management in Malawian waters is basically limited to catch-effort data as well as some fish ecology data such as spawning seasonality or maturity ogives. Furthermore, some information has been gathered on gear selectivity. The catch-effort data are considered to be rather unreliable due to limited funds and, hence, inefficient data collection and analysis. Efforts are currently undertaken to re-evaluate and restructure the catch-effort data collection system. Fish ecology and gear

selectivity data are limited in terms of coverage of species and need to be extended and refined to meet growing demand for increased precision of the scientific basis.

Monitoring surveys have been conducted annually in southern Lake Malawi since 1989. A demersal trawl survey was conducted in other areas of the lake in 1998. In the context of medium-term (3-5 years) management considerations these surveys constitute the most promising basis for improvements in fisheries management. Stock indices from these surveys might be used as input to simple catch control laws, whereby recent change in a given stock index would generate a feed back change in allowable catch of that stock(s). However, the statistical properties of the data must be carefully analysed before any firm conclusion can be drawn as to the actual applicability of the survey data for such a task. In addition, there is an urgent need for monitoring surveys of fish stocks in the smaller waterbodies (Lakes Chilwa, Chiuta and Malombe), using traditional gears such as gill nets or seines.

Single species age based stock assessments constitute the fundamental methodology on which most of the more advanced fisheries management regimes are based in many countries. This methodology has only rarely been considered for Malawian waters. However, the available results indicate that age based methods may be a feasable approach in fish stock assessments in tropical freshwaters. Such an approach is urgently needed in order to get a firmer grip on the status of some of the most important Malawian fish stocks, such as chambo, bombe and kampango. For other, short lived fish species, this approach may be less suitable, but still might yield relevant information on population parameters such as growth and mortality. This kind of research may require a long-term (5-10 years) commitment in terms of data collection and analysis before firm results on stock status and dynamics are produced.

In recent years bulk biomass models, e.g. Ecopath, have been applied in some African lakes to describe the transfer of biomass along trophical paths of the ecosystems. Such a model is presently under development within the EU Demersal Fish Ecology Project in Lake Malawi. This is a long term commitment which is expected to be finalised within the next 5 years. The results from this model, and similar static models, may yield some important, basic insights into the productivity of the demersal community and its performance in terms of fish production. Thus, it would produce results which would be expected to enhance our understanding of the system and, eventually, provide guidance as to the direction of future research. However, in terms of direct fisheries management issues models of this type can not be expected to yield concrete inputs.

7. Names of fish species

Local name	Scientific name
Chambo	*Oreochromis spp.*
Kambuzi	*Lethrinops spp.*
Kasawala	Juvenile *Oreochromis spp*.
Kampango	*Bagrus meridionalis*
Mlamba	*Clarias spp.*
Bombe	*Bathyclarias spp.*
Mlamba/Bombe	*Bathyclarias/Clarias*
Catfish	*Bagrus/Clarias/Bathyclarias*
Mbaba	*Buccochromis spp.*
Ncheni	*Rhamphochromis spp.*
Nchila	*Labeo mesops*
Sanjika	*Opsaridium microcephalus*
Usipa	*Engraulicypris sardella*
Utaka	*Copadichromis spp.*
Chisawasawa	*Lethrinops spp.*
Makumba	*O. shiranus chilwae*
Matemba	*Barbus spp.*
Mphende	*O. placidus, O. mossambicus*
Chikano	*Clarias ngamensis*
Ndunduma	*Diplotaxodon spp.*
Other tilapia	*T. rendalli, O. shiranus*
Others	All other species

Appendix: Tables 1, 3-12 and 14-23

Table 1. Total Malawian catch (metric tons) by waterbodies and type of fishery 1976-96/98.

	Traditional fisheries						
Year	Lake Malawi	Lake Malombe	Lake Chilwa	Lake Chiuta	Upper Shire	Lower Shire	Total
1976	16921	4776	15115	700 *	823	9657	47992
1977	24710	4937	21200 *	1800 *	1153	5438	59238
1978	21149	6841	20800 *	1500 *	637	5600	56527
1979	14031	2917	24310	1589	418	3349	46614
1980	16268	4969	16839	777	1716	3778	44347
1981	22043	7559	9797	937	1624	4278	46238
1982	16957	12936	15567	1229	551	5225	52465
1983	23900	9677	14447	1053	444	5787	55308
1984	21263	10375	13026	1838	862	4922	52286
1985	20233	8313	13040	1307	223	7351	50467
1986	25457	12618	13720	698	739	9041	62272
1987	31087	12330	7990	3223	651	7156	62437
1988	26138	10535	6708	1659	582	8178	53800
1989	33231	6607	7023	1109	358	11056	61384
1990	24803	12084	23558	2381	504	6997	70327
1991	23551	9625	7389	1773	283	9050	51671
1992	29479	7600	10459	2687	440	2958	53623
1993	23842	5811	10810	3532	439	2893	47327
1994	29461	4134	10186	3350	265	1746	49142
1995	21470	2653	1328	1159	174	1900	27356
1996	36716	3573	0	4035	326	1847	46497
1997		2790	4510	2733			
1998		4789	4973	3250			

* Source: J.-P. Vanden Bossche and G.M. Bernacsek, 1990. Source book for the inland fishery resources of Africa. Vol. 1, CIFA technical paper 18/1. FAO, Rome.

Table 1 (continued)

	Commercial fisheries				
Year	Comm. demersal	Comm. pelagic	Semi-comm.	Total	Grand total
1976	1052	3322	2280	6654	54646
1977	1302	2931	2371	6604	65842
1978	1214	2808	2436	6458	62985
1979	1622	2558	2937	7117	53731
1980	1510	2747	2344	6601	50948
1981	1565	2888	2339	6792	53030
1982	2130	3009	1873	7012	59477
1983	1665	3346	2286	7297	62605
1984	1655	3316	2551	7522	59808
1985	1262	3809	2877	7948	58415
1986	1447	3198	2657	7302	69574
1987	1162	2814	3680	7656	70093
1988	788	2725	3568	7081	60881
1989	658	1766	2811	5235	66619
1990	705	2303	3197	6205	76532
1991	856	2241	2863	5960	57631
1992	423	2275	2850	5548	59171
1993	451	948	2150	3549	50876
1994	1456	892	2430	4778	53920
1995	1921	918	2076	4915	32271
1996	776	990	1130	2896	49393

Table 3. Number of vessels, fishers and gears in Frame Surveys of Malawian waters 1990-97

Malawi	1990	1991	1992	1993	1994	1995	1996	1997
Boats + Engine	360	372	397	449	393	441	461	502
Boats - Engine	2167	2367	2425	2164	2551	1361	2273	2787
Dugout canoes	9671	9716	9858	9111	10068	10487	11158	11821
Fishermen	10601	10193	11181	9517	10602	10982	11310	13546
Assistants	25495	26866	30090	28152	32625	30001	30961	37310
Gillnets	19699	16624	20410	17443	19996	23213	30906	37987
Longline	2627	2698	2752	2112	2806	3177	4169	2176
Kambuzi seine	654	609	732	1124	1277	880	538	718
Chilimira	1479	1229	1627	1632	1893	2001	2226	2416
Fish traps	24716	21488	35890	26779	19407	28571	25428	32350
Handline	5463	1323	2383	2899	4642	6193	4104	4245
Mosquito nets	237	260	270	183	439	502	571	637
Scoop nets	127	159	110	79	208	181	85	118
Cast nets	605	352	314	263	339	261	347	472
Chambo seine	141	113	134	90	121	135	116	102
Nkacha	217	237	281	263	311	348	282	278
Psyailo	0	7	14	5	10	6	6	9
Seine nets	0	0	0	0	31	24	35	32
Matemba seine	281	327	340	0	549	191	93	396
Chomanga	0	0	0	0	0	0	0	0
Others	143	5	2	0	56	3	7	491

Table 4. Total catch (metric tons), effort and CPUE in South East Arm traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	3993	0.90	4032	4530	0.61	-0.117
1977	7451	1.27	7453	5891	0.79	0.235
1978	6219	0.91	6222	6862	0.92	-0.098
1979	3737	1.14	3761	3330	0.45	0.122
1980	4378	1.60	4394	2754	0.37	0.467
1981	5417	0.95	5417	5678	0.76	-0.047
1982	4928	1.47	4928	3346	0.45	0.387
1983	9280	1.68	9281	5512	0.74	0.521
1984	7454	1.05	7454	7093	0.95	0.050
1985	7084	0.89	7085	7922	1.06	-0.112
1986	7484	1.03	7493	7256	0.97	0.032
1987	8323	0.94	8323	8848	1.18	-0.061
1988	5430	0.99	5430	5490	0.73	-0.011
1989	12838	1.13	12863	11445	1.53	0.117
1990	7486	0.71	7493	10625	1.42	-0.349
1991	7987	0.69	7988	11600	1.55	-0.373
1992	11181	0.92	11182	12178	1.63	-0.085
1993	7729	1.21	7732	6415	0.86	0.187
1994	8470	0.69	8471	12362	1.65	-0.378
1995	8265	0.84	8321	9924	1.33	-0.176
1996	19208	2.41	19208	7963	1.06	0.880

Table 5. Total catch (metric tons), effort and CPUE in South West Arm traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	5788	1.09	5788	5310	0.74	0.086
1977	8309	1.61	8309	5175	0.73	0.473
1978	7741	1.80	7741	4312	0.60	0.585
1979	3778	1.13	3778	3357	0.47	0.118
1980	3482	1.00	3482	3466	0.49	0.004
1981	8110	2.83	8110	2864	0.40	1.041
1982	4750	1.79	4750	2651	0.37	0.583
1983	6486	1.90	6486	3411	0.48	0.643
1984	2918	0.70	2918	4185	0.59	-0.361
1985	4015	0.97	4015	4134	0.58	-0.029
1986	5996	1.04	5996	5761	0.81	0.040
1987	6237	0.91	6237	6878	0.96	-0.098
1988	8147	0.82	8147	9991	1.40	-0.204
1989	6977	0.60	6977	11554	1.62	-0.504
1990	4552	0.55	4552	8235	1.16	-0.593
1991	8202	0.81	8202	10184	1.43	-0.216
1992	9657	0.49	9657	19793	2.78	-0.718
1993	4151	0.58	4151	7157	1.00	-0.545
1994	3763	0.43	3763	8808	1.24	-0.850
1995	5152	0.61	5152	8480	1.19	-0.498
1996	7513	0.54	7513	13984	1.96	-0.621

Table 6. Total catch (metric tons), effort and CPUE in the commercial demersal fishery in area B.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1972	138	0.67	138	206	0.21	-0.402
1973	2159	1.28	2159	1681	1.69	0.251
1974	3327	1.39	3327	2393	2.40	0.330
1975	3757	1.41	3757	2668	2.68	0.342
1976	1011	1.34	1011	757	0.76	0.290
1977	1212	1.50	1212	808	0.81	0.406
1978	1086	1.60	1086	679	0.68	0.470
1979	1508	1.58	1508	957	0.96	0.455
1980	1444	1.32	1444	1091	1.09	0.281
1981	1508	1.25	1508	1206	1.21	0.224
1982	2093	1.33	2093	1572	1.58	0.286
1983	1203	1.12	1203	1077	1.08	0.111
1984	992	0.79	992	1248	1.25	-0.230
1985	729	0.70	729	1036	1.04	-0.351
1986	931	1.02	931	909	0.91	0.024
1987	763	1.00	763	764	0.77	-0.002
1988	458	0.54	458	853	0.86	-0.621
1989	348	0.50	348	699	0.70	-0.697
1990	484	0.57	484	850	0.85	-0.563
1991	487	0.71	487	690	0.69	-0.348
1992	271	0.56	271	488	0.49	-0.588
1993	324	0.49	324	667	0.67	-0.722
1994	155	0.45	155	348	0.35	-0.808
1995	257	1.30	257	198	0.20	0.260
1996	425	0.69	425	618	0.62	-0.375
1997	478	0.72	478	659	0.66	-0.322

Table 7. Total catch (metric tons), effort and CPUE in the commercial demersal fishery in area C.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	41	1.10	41	37	0.11	0.093
1977	90	1.00	90	90	0.27	-0.005
1978	118	1.13	118	105	0.31	0.121
1979	60	1.05	60	57	0.17	0.051
1980	63	1.08	63	58	0.17	0.077
1981	57	0.94	57	60	0.18	-0.059
1982	21	0.82	21	26	0.08	-0.197
1983	461	1.78	461	259	0.78	0.576
1984	663	1.36	663	488	1.46	0.306
1985	533	1.07	533	499	1.49	0.066
1986	516	1.22	516	423	1.27	0.199
1987	399	0.96	399	418	1.25	-0.046
1988	330	0.86	330	384	1.15	-0.152
1989	310	0.90	310	344	1.03	-0.103
1990	216	0.79	216	273	0.82	-0.235
1991	356	0.88	356	404	1.21	-0.125
1992	119	0.64	119	185	0.55	-0.442
1993	51	0.74	51	69	0.21	-0.297
1994	946	1.04	946	913	2.74	0.035
1995	1255	1.06	1255	1189	3.56	0.054
1996	309	1.12	309	275	0.82	0.117
1997	805	1.02	805	787	2.36	0.022

Table 8. Total catch (metric tons), effort (days) and CPUE (tons/day) in the commercial pelagic fishery in areas A-C.

Year	Total yield	Normalised Effort	effort	CPUE
1976	3322	5979	2.35	5.40
1977	2931	4803	1.96	5.18
1978	3069	7032	2.36	5.02
1979	2558	6152	2.20	4.20
1980	2747	5729	2.06	5.19
1981	2888	9924	2.72	4.63
1982	3009	8697	2.46	5.18
1983	3346	8105	2.32	5.88
1984	3316	8720	2.54	5.30
1985	3809	7022	2.27	6.73
1986	3198	7433	2.25	5.78
1987	2814	5545	2.10	5.52
1988	2725	4689	1.80	4.61
1989	1766	3579	1.58	3.80
1990	2303	4489	1.86	4.70
1991	2241	2590	1.50	5.92
1992	2275	3919	1.77	5.56
1993	948	3292	1.56	2.38
1994	892	2040	1.37	1.99
1995	918	2062	1.40	1.58
1996	990	2790	1.56	1.63

Table 9. Total catch (metric tons), effort and CPUE in the semi-commercial fishery in area A.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	1508	0.94	1508	1611	1.58	-0.066
1977	343	0.25	476	1892	1.86	-1.380
1978	958	0.92	965	1053	1.03	-0.087
1979	1530	0.95	1530	1606	1.58	-0.048
1980	1213	0.94	1213	1296	1.27	-0.066
1981	1035	1.21	1059	877	0.86	0.188
1982	518	0.92	575	628	0.62	-0.088
1983	760	0.94	966	1033	1.01	-0.067
1984	694	0.89	861	962	0.94	-0.112
1985	808	0.81	878	1087	1.07	-0.213
1986	1057	1.16	1057	910	0.89	0.150
1987	1476	1.13	1476	1301	1.28	0.126
1988	1022	1.22	1022	839	0.82	0.198
1989	899	1.42	899	633	0.62	0.351
1990	1152	1.10	1323	1203	1.18	0.095
1991	1107	1.04	1107	1066	1.05	0.038
1992	1084	1.00	1084	1081	1.06	0.002
1993	71	1.12	71	64	0.06	0.109
1994	792	1.01	792	781	0.77	0.014
1995	1144	1.47	1144	781	0.77	0.382
1996	458	0.90	630	699	0.69	-0.104
1997	327	0.66	736	1112	1.09	-0.413

Table 10. Total catch (metric tons), effort and CPUE in the semi-commercial fishery in area D.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1978	802	1.18	802	678	0.69	0.168
1979	166	0.65	166	255	0.26	-0.430
1980	97	0.96	97	101	0.10	-0.040
1981	590	1.22	590	485	0.50	0.196
1982	874	0.87	874	1007	1.03	-0.141
1983	864	1.05	893	849	0.87	0.051
1984	907	1.06	907	856	0.87	0.058
1985	1510	1.03	1516	1474	1.51	0.028
1986	1308	1.13	1312	1165	1.19	0.119
1987	1428	1.34	1428	1067	1.09	0.292
1988	1917	1.70	1930	1134	1.16	0.532
1989	1395	1.36	1395	1025	1.05	0.309
1990	957	0.90	1105	1233	1.26	-0.110
1991	1250	0.87	1336	1542	1.58	-0.143
1992	1462	1.18	1527	1289	1.32	0.169
1993	1543	1.06	1687	1587	1.62	0.061
1994	1463	1.16	1463	1260	1.29	0.149
1995	931	0.90	931	1033	1.06	-0.104
1996	500	0.90	500	554	0.57	-0.103
1997	625	0.97	625	644	0.66	-0.030

Table 11. Total catch (metric tons), effort and CPUE in the Upper Shire River traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort
1976	796	1.61	823	511	0.78
1977	1119	1.60	1153	720	1.10
1978	634	1.65	637	387	0.59
1979	321	0.76	418	547	0.83
1980	1692	2.00	1716	858	1.31
1981	1624	2.47	1624	657	1.00
1982	525	1.60	551	346	0.53
1983	438	1.64	444	270	0.41
1984	839	1.28	862	673	1.03
1985	165	0.82	223	270	0.41
1986	606	1.18	739	624	0.95
1987	643	0.87	651	744	1.14
1988	499	0.63	582	922	1.41
1989	314	0.53	358	677	1.03
1990	313	0.94	504	534	0.81
1991	87	0.37	283	774	1.18
1992	155	0.73	440	600	0.92
1993	40	0.26	439	1692	2.58
1994	33	0.37	265	719	1.10
1995	17	0.24	174	717	1.09
1996	51	0.64	326	511	0.78

Table 12. Total catch (metric tons), effort and CPUE in the traditional fishery in Lake Malombe.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	4769	0.78	4776	6097	0.59	-0.244
1977	4867	0.68	4937	7241	0.70	-0.383
1978	6834	0.98	6841	6997	0.68	-0.023
1979	2911	0.92	2917	3186	0.31	-0.088
1980	4969	1.14	4969	4342	0.42	0.135
1981	7559	1.46	7559	5161	0.50	0.382
1982	12765	1.32	12936	9818	0.95	0.276
1983	9653	1.38	9676	6992	0.68	0.325
1984	10374	1.92	10375	5395	0.52	0.654
1985	8305	1.42	8313	5849	0.57	0.352
1986	12097	0.83	12617	15173	1.47	-0.184
1987	12330	0.46	12330	26654	2.58	-0.771
1988	10534	0.47	10535	22240	2.15	-0.747
1989	5156	0.53	6607	12554	1.21	-0.642
1990	11839	0.70	12084	17164	1.66	-0.351
1991	9448	1.30	9625	7397	0.72	0.263
1992	7374	0.44	7600	17157	1.66	-0.814
1993	5811	0.72	5811	8046	0.78	-0.325
1994	4134	0.47	4134	8840	0.85	-0.760
1995	2652	0.27	2653	9709	0.94	-1.297
1996	3573	0.30	3573	11725	1.13	-1.188
1997	2790	0.28	2789	9811	0.95	-1.258
1998	4789	0.39	4792	12184	1.20	-0.933

Table 14. Total catch (metric tons), effort and CPUE in Lake Chilwa traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	
1976	14979	0.72	15115	20946	0.94	
1979	22883	1.32	22883	17281	0.77	
1980	16752	1.83	16752	9173	0.41	
1981	8429	1.74	8429	4836	0.22	
1982	15558	1.51	15576	10344	0.46	
1983	14612	1.75	15079	8603	0.38	
1984	12752	1.09	13020	11902	0.53	
1985	13111	0.80	13196	16506	0.74	
1986	13731	2.11	13733	6499	0.29	
1987	7985	0.88	7990	9076	0.41	
1988	6723	0.48	6723	14068	0.63	
1989	6997	0.48	7023	14624	0.65	
1990	23485	3.38	23562	6976	0.31	
1991	7278	0.26	7389	28235	1.26	
1992	10360	0.22	10454	48561	2.17	
1993	10792	0.18	10810	59392	2.66	
1994	10092	0.11	10156	92919	4.16	
1995	1328	0.07	1328	20224	0.99	The lake dryed up during the year
1996	0		0			No fishing
1997	4510	0.25	4658	18575	0.84	Recorded catch Oct.-Dec.: 1069 tons
1998	4973	0.14	5163	36441	1.66	Recorded catch Jan.-Sept.: 3031 tons

Table 15. Total catch (metric tons), effort and CPUE in the Lake Chiuta traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	
1979	1586	1.50	1586	1060	0.37	
1980	776	0.98	776	792	0.28	
1981	937	0.99	937	947	0.33	
1982	1230	1.24	1230	993	0.35	
1983	1053	2.39	1053	440	0.15	
1984	1838	2.15	1838	855	0.30	
1985	1306	1.04	1306	1259	0.44	
1986	698	0.62	698	1120	0.39	
1987	3213	1.90	3213	1697	0.59	
1988	1656	1.19	1656	1394	0.49	
1989	1107	0.99	1107	1122	0.39	
1990	2377	1.97	2377	1207	0.42	
1991	1768	0.52	1768	3381	1.19	
1992	2617	0.29	2617	9323	3.27	
1993	3516	0.41	3516	8618	3.02	
1994	3289	0.28	3289	12153	4.26	
1995	1671	0.20	1681	8222	0.24	Recorded catch Jan.-May: 521 tons
1996			4035			Effort records not available
1997	2733	0.29	2823	9809	1.24	Recorded catch Oct.-Dec.: 844 tons
1998	3250	0.38	3332	8881	2.24	Recorded catch Jan.-Sept.: 2244 tons

Table 16. Total catch (metric tons), effort and CPUE in the Lower Shire River traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort
1976	9617	1.00	9659	9650	1.77
1977	5402	0.66	5438	8272	1.52
1978	5382	0.93	5600	5998	1.10
1979	3208	0.74	3349	4539	0.83
1980	3566	0.90	3778	4186	0.77
1981	4155	0.82	4278	5195	0.95
1982	5188	1.13	5225	4613	0.85
1983	5699	1.00	5787	5789	1.06
1984	4497	1.26	4922	3906	0.72
1985	7167	1.64	7351	4493	0.82
1986	8849	1.57	9041	5745	1.05
1987	6895	1.29	7156	5562	1.02
1988	7705	1.78	8178	4591	0.84
1989	10469	1.21	11056	9174	1.68
1990	6597	1.08	6997	6465	1.19
1991	8663	0.71	9050	12672	2.33
1992	2691	0.83	2958	3561	0.65
1993	2721	1.09	2893	2653	0.49
1994	1619	0.65	1747	2687	0.49
1995	1792	0.84	1900	2252	0.41
1996	1674	0.75	1848	2452	0.45

Table 17. Chambo catch (metric tons), effort and CPUE in Lake Malawi traditional and commercial fisheries.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	4380	0.81	4747	5890	1.05	-0.216
1977	8614	1.76	9019	5136	0.92	0.563
1978	7552	1.34	7842	5868	1.05	0.290
1979	4474	1.09	4795	4391	0.78	0.088
1980	5187	1.09	5696	5213	0.93	0.089
1981	5315	1.01	5748	5685	1.01	0.011
1982	7434	1.76	8036	4569	0.81	0.565
1983	8210	2.13	8679	4082	0.73	0.754
1984	6904	1.19	7330	6166	1.10	0.173
1985	8673	1.52	9109	5993	1.07	0.419
1986	6720	1.24	7081	5715	1.02	0.214
1987	5137	1.19	5486	4622	0.82	0.171
1988	5164	1.16	5411	4681	0.83	0.145
1989	5401	1.03	5778	5616	1.00	0.028
1990	4969	0.91	5192	5706	1.02	-0.094
1991	5799	0.93	6015	6475	1.15	-0.074
1992	4792	0.68	5030	7375	1.32	-0.383
1993	3770	0.71	3985	5641	1.01	-0.348
1994	2394	0.31	2598	8412	1.50	-1.175
1995	1644	0.27	1825	6649	1.19	-1.293
1996	2581	0.73	2815	3882	0.69	-0.321

Table 18. Chambo catch (metric tons), effort and CPUE in Lake Malombe traditional fisheries.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	4118	0.98224	4118	4192.45	1.7082236	-0.01792
1977	4160	0.83345	4160	4991.33	2.0337261	-0.18219
1978	5221	0.9996	5221	5223.1	2.1281616	-0.0004
1979	1957	0.99444	1957	1967.95	0.8018444	-0.00558
1980	4344.4	1.37131	4344.4	3168.08	1.2908385	0.315763
1981	6018	1.75829	6018	3422.65	1.394566	0.564339
1982	8484	1.68671	8484	5029.9	2.0494409	0.522783
1983	5982	1.5516	5982	3855.37	1.5708773	0.439288
1984	6678	2.32626	6678	2870.71	1.1696754	0.84426
1985	5159	2.11147	5159	2443.32	0.995536	0.747384
1986	4968	1.5246	4968	3258.55	1.3277024	0.421735
1987	2023	1.12277	2023	1801.79	0.7341442	0.115799
1988	1901	0.89744	1901	2118.25	0.8630835	-0.10821
1989	1274	0.56911	1274	2238.57	0.9121104	-0.56368
1990	493	0.46178	502	1087.1	0.4429417	-0.77267
1991	408	0.94541	416	440.023	0.179288	-0.05614
1992	542	0.47676	545	1143.13	0.4657723	-0.74074
1993	36	0.13895	40	287.875	0.1172953	-1.97365
1994	42	0.16241	43	264.77	0.107881	-1.81766
1995	105	0.17897	193	1078.39	0.4393924	-1.72054
1996	120	0.18583	122	656.517	0.2674989	-1.68293
1997	102.67	0.13	104	811	0.33	-2.05842
1998	96.21	0.09242	97.86	1058.9	0.4314507	-2.38145

Table 19. Kampango catch (metric tons), effort and CPUE in Lake Malawi artisanal fisheries.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	1223	1.14	2216	1939	1.07	0.133
1977	2322	1.27	3342	2640	1.45	0.236
1978	1500	1.02	2046	2003	1.10	0.021
1979	1136	1.15	1576	1372	0.75	0.138
1980	1404	1.31	1669	1275	0.70	0.269
1981	1160	1.03	1505	1461	0.80	0.030
1982	1352	1.42	1868	1315	0.72	0.030
1983	1364	1.63	1746	1071	0.59	0.351
1984	1373	0.92	1842	1998	1.10	0.489
1985	826	0.73	1274	1744	0.96	-0.081
1986	1081	0.89	1502	1692	0.93	-0.314
1987	1177	1.45	1756	1211	0.67	-0.120
1988	799	0.93	1258	1346	0.74	0.371
1989	1021	0.84	1570	1874	1.03	-0.067
1990	1177	1.18	1625	1378	0.76	-0.177
1991	2210	1.54	2579	1679	0.92	0.165
1992	853	0.42	1182	2823	1.55	0.429
1993	1024	0.59	1494	2524	1.39	-0.871
1994	944	0.38	1378	3663	2.01	-0.524
1995	1162	0.75	1327	1771	0.97	-0.978
1996	549	0.42	650	1555	0.85	-0.289

Table 20. Bombe catch (metric tons), effort and CPUE in Lake Malawi traditional and commercial fisheries.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	1110	1.12	1254	1118	0.86	0.114
1977	1332	1.05	1656	1571	1.20	0.053
1978	975	0.98	1257	1286	0.98	-0.023
1979	961	1.29	1218	943	0.72	0.256
1980	1183	1.52	1324	868	0.66	0.422
1981	1465	1.55	1720	1108	0.85	0.440
1982	1183	2.04	1440	705	0.54	0.714
1983	1182	1.90	1404	740	0.57	0.641
1984	1029	0.94	1280	1361	1.04	-0.062
1985	608	0.75	835	1120	0.86	-0.294
1986	969	1.07	1539	1442	1.10	0.065
1987	943	1.16	1128	976	0.75	0.145
1988	775	1.03	991	960	0.74	0.031
1989	840	0.72	1090	1518	1.16	-0.331
1990	894	0.84	1260	1505	1.15	-0.178
1991	1347	0.83	1594	1916	1.47	-0.184
1992	546	0.39	792	2041	1.56	-0.947
1993	518	0.34	587	1752	1.34	-1.094
1994	529	0.31	761	2454	1.88	-1.171
1995	994	1.67	1214	727	0.56	0.512
1996	347	0.40	524	1315	1.01	-0.920

Table 21. Utaka catch (metric tons), effort and CPUE in Lake Malawi traditional and commercial fisheries.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort
1976	1741	0.64	2397	3750	0.42
1977	2054	1.03	2384	2310	0.26
1978	6926	2.77	8176	2955	0.33
1979	3203	1.33	4228	3176	0.36
1980	5595	2.59	6438	2489	0.28
1981	10364	2.37	11347	4796	0.54
1982	743	0.30	1401	4686	0.53
1983	6508	1.48	7847	5320	0.60
1984	6718	1.43	8308	5825	0.66
1985	3025	0.63	4365	6927	0.78
1986	6550	1.27	7642	6011	0.68
1987	13118	1.47	15065	10272	1.16
1988	9329	1.53	12534	8173	0.92
1989	5377	0.45	6952	15576	1.76
1990	6539	0.52	8268	15952	1.80
1991	4482	0.49	5794	11830	1.34
1992	5765	0.37	6459	17691	2.00
1993	6588	0.67	7189	10774	1.22
1994	11881	0.77	12902	16816	1.90
1995	4166	0.40	5247	13090	1.48
1996	8520	0.55	9544	17272	1.95

Table 22. Total kambuzi catch (metric tons), effort and CPUE in Lake Malawi traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort
1976	1633	2.10	1633	777	0.51
1977	2117	2.98	2117	710	0.46
1978	591	1.35	593	440	0.29
1979	311	0.69	312	449	0.29
1980	260	0.73	260	356	0.23
1981	670	1.00	670	671	0.44
1982	1022	1.75	1022	583	0.38
1983	993	1.00	993	993	0.65
1984	574	0.65	574	889	0.58
1985	1208	1.02	1208	1189	0.78
1986	713	0.72	713	991	0.65
1987	1138	0.80	1138	1415	0.93
1988	1856	0.84	1856	2214	1.45
1989	3989	1.45	4001	2751	1.80
1990	4435	1.08	4486	4150	2.72
1991	1660	0.72	1662	2304	1.51
1992	3214	1.11	3260	2928	1.92
1993	1554	0.91	1813	1985	1.30
1994	2309	1.12	2626	2340	1.53
1995	2716	1.26	3043	2412	1.58
1996					

Table 23. Total kambuzi catch (metric tons), effort and CPUE in Lake Malombe traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort
1976	90	1.08	90	83	0.01
1977	7	0.55	7	13	0.00
1978	375	1.33	375	283	0.05
1979	546	1.42	546	386	0.07
1980	155	2.04	155	76	0.01
1981	1005	3.06	1005	329	0.06
1982	3130	1.04	3130	3001	0.54
1983	2495	1.57	2495	1594	0.29
1984	1775	2.52	1775	706	0.13
1985	2475	0.81	2475	3059	0.55
1986	5232	0.50	5232	10447	1.89
1987	7165	0.58	7165	12358	2.23
1988	6732	0.38	6732	17774	3.21
1989	2534	0.32	2534	7907	1.43
1990	8743	0.78	8743	11243	2.03
1991	5613	1.18	5613	4774	0.86
1992	5302	0.49	5302	10784	1.95
1993	4467	0.78	4467	5726	1.04
1994	3256	0.50	3256	6504	1.18
1995	1900	0.28	1900	6769	1.22
1996	2642	0.33	2642	8112	1.47
1997	2062	0.31	2062	6557	1.19
1998	3752	0.43	3752	8753	1.58

Table 24. Total usipa catch (metric tons), effort and CPUE in Lake Malawi traditional fishery.

Year	Yield sampled	Rel. wgted CPUE	Total yield	Rel. Effort	Normalised effort	ln(CPUE)
1976	1494	0.92	1494	1632	0.54	-0.088
1977	1533	2.99	1534	513	0.17	1.096
1978	1354	0.67	1357	2023	0.67	-0.399
1979	1378	1.02	1386	1360	0.45	0.019
1980	313	0.65	311	481	0.16	-0.436
1981	506	1.01	506	503	0.17	0.005
1982	1707	1.52	1706	1122	0.37	0.419
1983	2683	1.53	2683	1758	0.58	0.423
1984	242	0.32	242	757	0.25	-1.141
1985	2145	1.02	2144	2094	0.69	0.023
1986	4999	2.33	5009	2151	0.71	0.845
1987	3365	0.66	3485	5302	1.76	-0.420
1988	3134	0.74	3186	4316	1.43	-0.304
1989	9962	1.47	10064	6839	2.27	0.386
1990	1188	0.43	1195	2773	0.92	-0.842
1991	4451	1.10	4591	4170	1.38	0.096
1992	9358	0.87	9386	10820	3.59	-0.142
1993	4632	2.96	4685	1584	0.52	1.084
1994	5416	1.30	5505	4245	1.41	0.260
1995	7303	2.14	7470	3483	1.15	0.763
1996	19028	3.52	19183	5454	1.81	1.258

Table 25. Technical, spatial and temporal management restrictions in Malawian waters.

Waterbody Gear type	Technical restrictions			Spatial or temporal restrictions					Remarks
	Minimum mesh size	Maximum gear size	Maximum engine	Closed areas	Minimum shore dist.	Minimum depth	Closed season	Closed hours	
Lake Malawi - commercial									
Mid-water trawl (chambo)	100 mm	110 m, nmw *		Area A	1 nm	50 m	Nov-Dec		* net mouth width
Mid-water trawl	50 mm	110 m, nmw		Areas A, B	1 nm	50 m		6pm - 6am	
(utaka/ndunduma)									
Shallow water pair-trawl	25 mm	37 m, nmw	30Hp	cf. licence	1 nm	18 m	Nov-Dec in A & B	6pm - 6am	
Deep water trawl	25 mm *	37 m, nmw		cf. licence	1 nm	50 m, Area A		6pm - 6am	* if eng. < 90Hp
	38 mm *	37 m, nmw							* if eng. > 90Hp
Purse seine/Ring net	100 mm	650 m, nmw			1 nm	18 m	Nov-Dec		
Usipa lift net				Area A					
Lake Malawi - traditional									
Chirimila (Utaka,	25 mm						Nov-Dec in area A		
ndunduma, usipa)	(not for usipa)								
Gillnets SE Arm	95 mm							6am - 6pm	
Gillnets SW Arm	90 mm							6am - 5pm	
(South of 12 15 S)									
Gillnets								6am - 5pm	
(North of 12 15 S)									
Chambo beach seines	100 mm	1000 m,hll *					Nov-Dec		* head line length
		18 m, net depth							
Kambuzi beach seines	25 mm	150 m, hll		A, B, D & E			Nov-Dec		
		10 m, net depth							
Usipa beach seine		100 m, hll							
		6 m, net depth							
Long lines								6am - 5pm	
Hand lines									No restrictions
Traps									No restrictions
Scoop nets									No restrictions
Cast nets									No restrictions
Kauni for chambo									Prohibited gear
Nkacha									Prohibited gear
Lake Malombe									
Nkacha net	25 mm	250 m, hll					Oct.-Dec		
Chambo beach seine	100 mm	1000 m, hll					Nov.-Dec.		
Gillnets	95 mm	4.5 m, net depth							
Longlines									No restrictions
Handlines									No restrictions
Traps									No restrictions
Cast nets									No restrictions
Kambuzi beach seine									??
Upper Shire									
Chambo beach seine	100 mm						Oct.-Dec		
Gillnets	95 mm	3 m net depth							
Longlines									No restrictions
Handlines									No restrictions
Traps									No restrictions
Cast nets									No restrictions
Nkacha									Prohibited gear
Kambuzi beach seine									Prohibited gear

Table 25 (continued).

Waterbody / Gear type	Technical restrictions: Minimum mesh size	Technical restrictions: Maximum gear size	Technical restrictions: Maximum engine	Spatial or temporal restrictions: Closed areas	Spatial or temporal restrictions: Minimum shore dist.	Spatial or temporal restrictions: Minimum depth	Spatial or temporal restrictions: Closed season	Spatial or temporal restrictions: Closed hours	Remarks
Lake Chilwa									
Matemba beach seine	12 mm	300m, hll							
		5m, net depth					Dec.-March		
Gillnets	70 mm	3 m, net depth						6am - 6pm	
Traps									No restrictions
Long lines									No restrictions
Hand lines									No restrictions
Cast nets									No restrictions
Nkacha									Prohibited gear
Lake Chiuta									
Gillnets	64 mm								
Traps									No restrictions
Cast nets									No restrictions
Beach seines									Prohibited gear
Nkacha nets									Prohibited gear
Lower Shire									
Beach seines		200 m, hll							
		15 m, net depth							
Gillnets	51 mm	3 m, net depth							
Traps and fences									No restrictions
Scoop nets									No restrictions
Long lines									No restrictions
Hand lines									No restrictions
Cast nets									No restrictions
Rivers and dams									
Poison/Katupe									Prohibited gear
Traps									No restrictions
Hand lines									No restrictions
Long lines									No restrictions
Beach seines									Prohibited gear
Rivers to L. Chilwa							May-Dec.		
River mouths									
Gillnets	110 mm						2 months after		
							first rains		
Weirs	1m gap/10m weir								
Seine nets									Prohibited gear