Government of Malawi
Department of Fisheries

Analysis of Catch and Effort Data for the Fisheries of the KARONGA AREA of Lake Malawi, 1980-2000

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Table of Contents

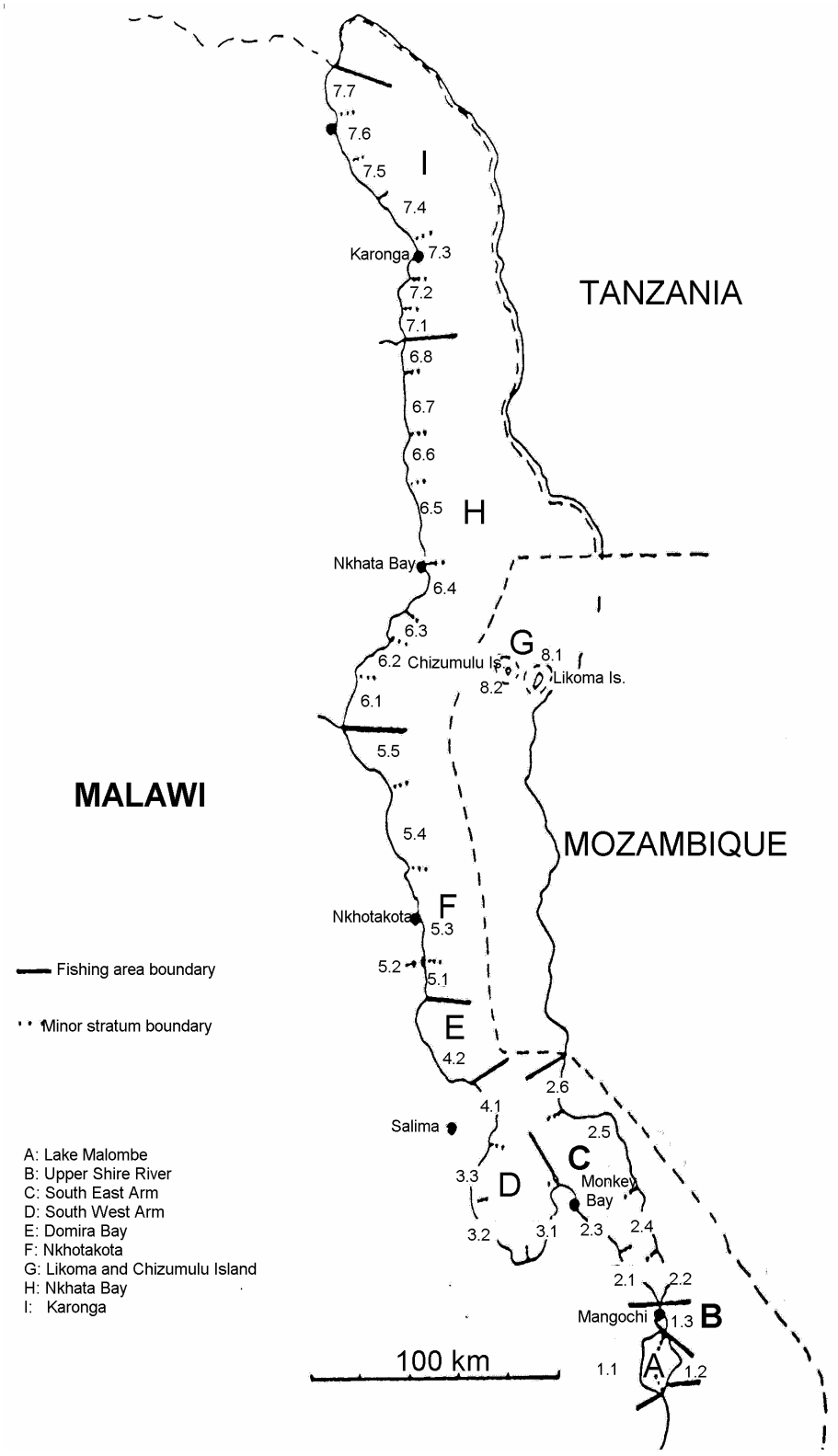

Figure 1. Map of fisheries statistical strata in Lake Malawi, the Upper Shire River and Lake Malombe.

Summary

The estimated annual total catch for all gears and species groups in the Karonga Area of Lake Malawi increased fivefold over a sixteen-year period from 700 tonnes in 1980 to about 3,500 tonnes in 1995. Thereafter, the catch fluctuated and declined by about 54% to 1,618 tonnes in 2000. Chilimira nets, gillnets, mosquito nets and kambuzi seines were the major contributing gears to the annual total catch.

Utaka (*Copadichromis* spp.) and usipa (*Engraulicypris sardella*) were by far the main contributors to the fisheries of the Karonga Area of Lake Malawi between 1980 and 2000, with annual mean percentage contributions of 37% for utaka and 22% for usipa. Altogether, more than ten different species were recorded in the catches. Catches for individual species show general declining trends over the 21-year period under review. This is occurring against a background of increasing effort and decreasing CPUEs in the majority of the fisheries. There appears to be overfishing of the chambo stock. MSY was exceeded in the early 1990s. It is, therefore, advisable to reduce gillnet effort in this fishery. The MSY for all species pooled together except usipa, and all gears pooled together save the mosquito net, seems not to have been exceeded at all.

Introduction

The Karonga Area of Lake Malawi, which is situated in the northern part of the lake, covers the following minor strata for fisheries statistical purposes: 7.1 (Chiweta), 7.2 (Chitimba), 7.3 (Chilumba), 7.4 (Nyungwe), 7.5 (Mlare), 7.6 (Karonga Boma), 7.7 (Kaporo) and, from 1998, minor stratum 6.8 (Mlowe), which was transferred from Nkhata Bay District jurisdiction because of ease of accessibility from Karonga District (Figure 1). The coastline is interspersed with sandy and rocky shores, marshes and swamps, and extensive lagoons (Tweddle *et al*. 1995). The area yields 8% of the total fish catch from Lake Malawi (Ngochera 2001). Hence, of the six Fisheries District areas bordering Lake Malawi, Karonga ranks fifth in importance after Mangochi (45%), Salima (18%), Nkhota Kota (13%) and Nkhata Bay (12%) (Ngochera 2001). Only Likoma District catches are lower than Karonga's catches.

The Fisheries Department opened an office to cover the Karonga Area of Lake Malawi in 1978. However, it was not until 1980 that the routine collection of catch and effort statistics for the fisheries of the area began in earnest (Tweddle *et al.* 1995). An analysis of catch and effort data for the period from 1980 to 1989 was reported by Tweddle *et al*. (1995). The purpose of this report is to update catch and effort data currently available for the area, and to show trends in the various fisheries of the area from 1980 up to 2000.

Methods of Data Collection

Catch and effort data on the traditional fisheries of the Karonga Area of Lake Malawi are collected and analysed according to the methods described by Bazigos (1972; 1974), Walker (1974; 1976) and Alimoso (1988). Total catch and fishing effort for each area are estimated by combining data obtained in monthly catch assessment surveys (CAS) and in annual frame surveys. The data given below are by gear and species group. To obtain estimates for maximum sustainable yield (MSY) and effort level for MSY (fMSY), methods used in Sparre and Venema (1992) were employed to fit Schaefer (Graham 1935) and Fox (Fox 1970) models to the catch and effort data.

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Data Analysis

Total catch

The estimated annual total catch for all gears and species groups in the Karonga Area of Lake Malawi from 1980 to 2000 ranged from 700 tonnes in 1980 to a peak 3,497 tonnes in 1995 (Figure 2), representing a fivefold increase. The annual catch showed a steady increase from 1980 until 1992, after which a gradual decline for the next two years occurred (Figure 2). Following the peak yield in 1995, a fluctuating but steady decrease in catches was observed. A total of 1,618 tonnes were landed in the year 2000. The overall annual mean catch from 1980 to 2000 was 1,627 tonnes. Chilimira nets (23-73%), gillnets (16-51%), mosquito nets (<1-44%) and kambuzi seines (1-30%) were the major contributing gears to the annual total catch (Figure 2). Other gears were longlines (1-4%), handlines (<1-2%) and fish traps (<1-2%).

More than ten species groups were recorded in the catches but only two of these species groups, namely the cichlid utaka (*Copadichromis* spp.) and the cyprinid usipa (*Engraulicypris sardella*), dominated the yearly catches (Figure 3). Utaka contributed between 14 and 68%, while usipa's contribution was up to 47%. Chambo (*Oreochromis* spp.) and kambuzi (various inshore small cichlids) made up between 1 and 19% each. Chisawasawa (*Lethrinops* spp.) contributed up to 19%, followed by mcheni (*Rhamphocromis* spp.), which made up to 12%. The large catfishes kampango *(Bagrus meridionalis*) and mlamba (*Clarias gariepinus*) contributed between 3 and 11% and 2 and 7 %, respectively. "Other tilapia" contributed up to 5%. The cyprinids nchila (*Labeo mesops*) and sanjika (*Opsaridium microcephalus*) each made up to 3%, whereas mpasa (*Opsaridium microlepis*) contributed up to 1%. The rest of the species grouped into "others" made up between 4 and 28% of the annual total catches over the 21-year period under review. The annual mean percentage contributions by the various species groups to the total catch from 1980 to 2000 are shown in Figure 4.

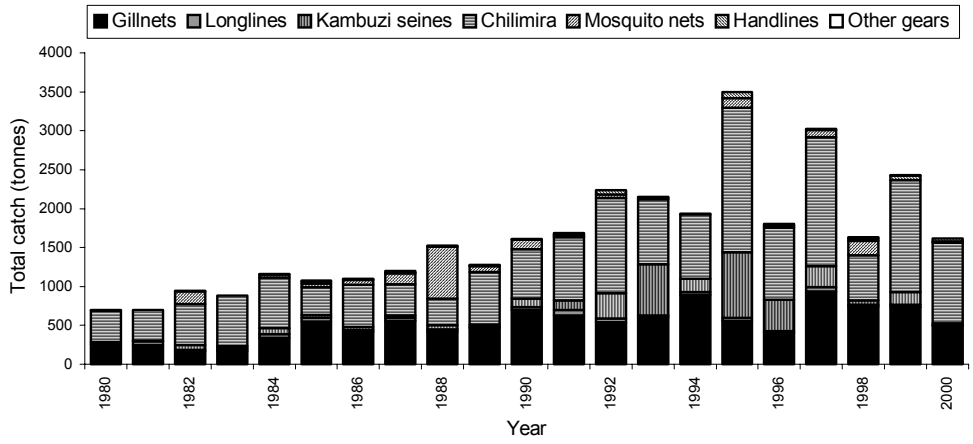

Figure 2. Annual total catch by gear for all species combined in the Karonga Area of Lake Malawi 1980-2000.

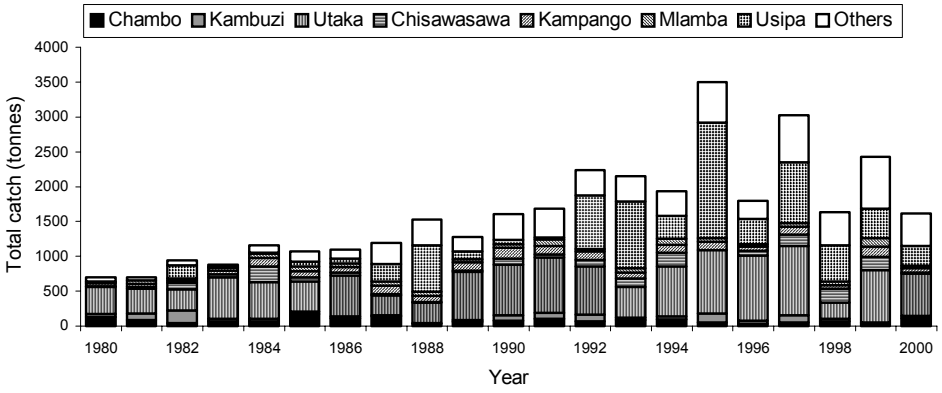

Figure 3. Annual total catch by species for all gears combined in the Karonga Area of Lake Malawi, 1980-2000.

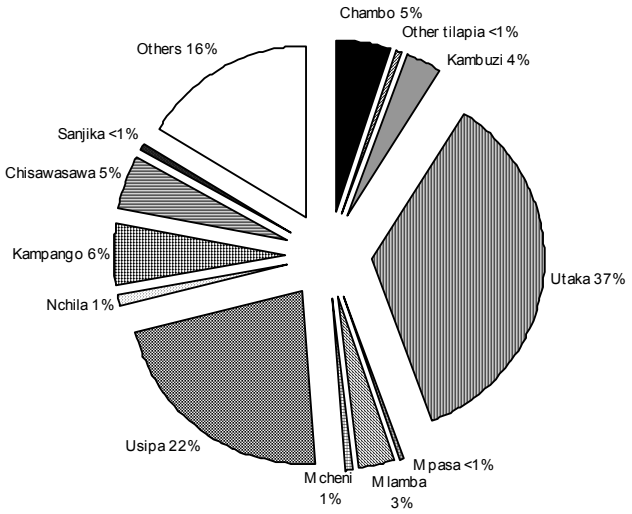

Figure 4. Annual mean percentage contribution of various fish species groups to the total catch from 1980 to 2000 in the Karonga Area of Lake Malawi.

Analysis by gear

Gear ownership

Temporal trends in the number of major fishing gears in the Karonga Area of Lake Malawi are presented in Figures 5a-5g. In the gillnet (Figure 5a) and chilimira net (Figure 5b) fisheries the number of gears increased steadily with time, with record peaks

of 5,007 gears in 1997 in the gillnet fishery and 540 gears in 1998 in the chilimira net fishery. By 1999 the number of gillnets had dropped by 11% and chilimira nets by 17% to 4,458 and 446 gears, respectively (Weyl *et al*. 2000). Similarly, the number of longlines peaked in 1997, with 295 longlines being recorded (Figure 5c). There were only 129 longlines registered during the 1999 frame survey (Weyl *et al*. 2000), which represents a 56% decline in longline ownership from the 1997 level. Kambuzi seine ownership was somewhat erratic, as were ownerships of mosquito nets, fish traps and handlines over the 20-year period from 1980 to 1999 (Figures 5d-5g). The number of kambuzi seines ranged from 1 to 202, mosquito nets from 5 to 152, fish traps from 0 to 224, and handlines from 0 to 1708. In spite of the above observations, the general trends for all gears under consideration are that gear ownerships have been increasing during the period under review.

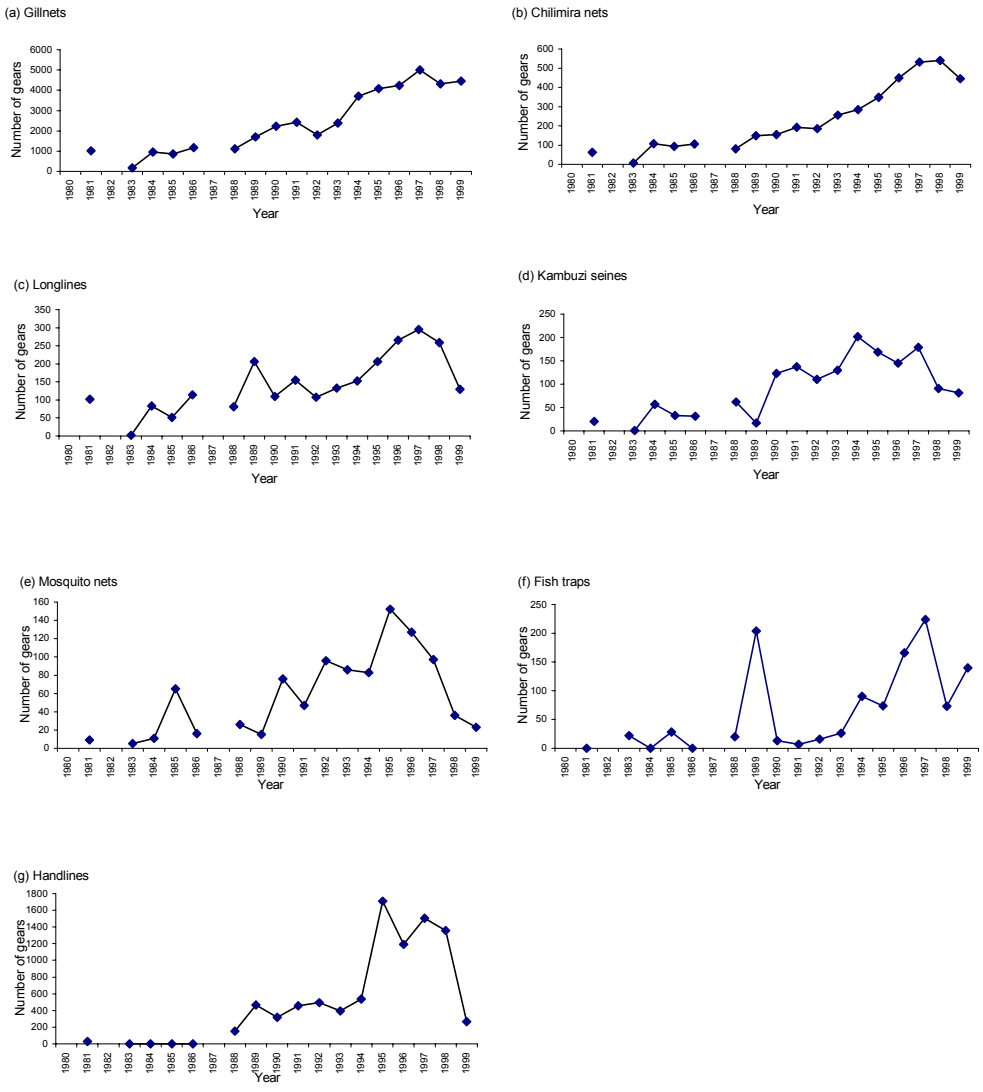

Figure 5. Temporal trends in the number of major fishing gears in the Karonga Area of Lake Malawi, 1980-1999.

Gillnets

In the gillnet fishery, annual effort estimates, CPUE estimates and catch composition are shown in Figures 6, 7 and 8, respectively. There was a general increase in effort from 1983 to 1994, but from 1994 to 1996 a substantial drop in effort occurred (Figure 6). This was followed by a large increase in effort from a low 248,044 net sets in 1996 to a peak 817,841 net sets in 1999. By 2000, effort had dropped by 48% to 421,896 net sets. However, the overall trend in gillnet effort from 1980 to 2000 is that it is increasing (Figure 6).

Estimates of gillnet CPUE rose from 1.2 kg/net set in 1980 to a peak 2.3 kg/net set in 1985 (Figure 7). Thereafter, a steady decline in CPUE was observed until 1993, when fluctuations in CPUE became apparent (Figure 7). Generally, the CPUE trend is declining (Figure 7)

The annual total catches for the gillnet fishery show a general increase from the 1980s to the 1990s, but fluctuations in catches over the 21-year period were also evident (Figure 8). A large number of species were landed by the gillnet fishery, however chambo (18%), kampango (17%), utaka (15%), chisawasawa (10%) and mlamba (6%) dominated the catch. The species grouped into "other" averaged 29% of the catch.

Chilimira nets

For the chilimira net fishery, annual effort estimates, CPUE estimates and catch composition are shown in Figures 9, 10 and 11, respectively. Annual effort rose steadily from 56,475 hauls in 1980 to a record 300,913 hauls in 1992, after which fluctuations were observed but still with an apparent overall increasing trend (Figure 9). Annual CPUE estimates in the early 1980s were high and increasing, followed by generally decreasing and fluctuating CPUEs for the rest of the period (Figure 10).

The total catch for the chilimira net fishery shows a general increase from 403 tonnes in 1980, to 633 tonnes in 1990, and 1,040 tonnes in 2000 (Figure 11). Peak yields were recorded in 1992 (1,216 tonnes), 1995 (1,854 tonnes), 1997 (1,657 tonnes) and 1999 (1,438 tonnes). The species composition of the chilimira net fishery indicates that the catch is dominated by utaka (64%) and usipa (18%); with some kambuzi (4%), chisawasawa (3%), and mcheni (1%) also being occasionally recorded in the catches (Figure 11). Catches of utaka fluctuated between 130 and 899 tonnes between 1980 and 2000, whereas that of usipa fluctuated between 0 and 822 tonnes over the same period. Both species groups show a declining trend in catches from about the mid-1990s (Figure 11).

Longlines

For the longline fishery, annual effort estimates, CPUE estimates and catch composition are shown in Figures 12, 13 and 14, respectively. The annual effort estimates indicate a gently increasing trend (Figure 12). Annual effort averaged 18,040 100-hook sets from

1980 to 2000, excluding the relatively high effort figure recorded in 1993 (37,029) and an unusually high effort in 1998 of 126,111 100-hook sets (Figure 12).

Annual estimates of longline CPUE from 1980 to 2000 display fluctuations which are associated with a general decreasing trend in CPUE (Figure 9). The CPUE ranged from a peak 4.9 kg/100-hook set in 1985 to 0.2 kg/100-hook set in 1998 and 0.6 kg/100-hook set in 2000 (Figure 13).

The annual total catch for the longline fishery shows small fluctuations over the 21-year period, however, there was a peak yield of 70 tonnes in 1991, whereas only 9 tonnes of fish were caught in the longline fishery in 2000 (Figure 14). The yield indicates an overall 26% increase from an average 31 tonnes per year in the 1980s to an average 39 tonnes per year in the 1990s. The annual catch composition of the longline fishery was dominated by mlamba (72%) and kampango (24%) (Figure 14). Mlamba catches have remained fairly stable, averaging 25 and 26 tonnes in the 1980s and 1990s, respectively. The kampango catch, however, increased from an annual average of about 6 tonnes in the 1980s to an average of about 11 tonnes in the 1990s.

Kambuzi seines

For the kambuzi seine fishery, annual effort estimates, CPUE estimates and catch composition are given in Figures 15, 16 and 17, respectively. Effort was relatively low at an annual average of 7,850 hauls between 1980 and 1989, before increasing rapidly to a high 50,983 hauls in 1990 (Figure 15). Thereafter, effort fluctuated in association with a general decreasing trend. Only 1,148 hauls of kambuzi seines were recorded in 2000. Overall, however, effort exhibits an increasing trend (Figure 15).

Annual estimates of kambuzi seine CPUE indicate a general decrease from 1981 to 1990, after which a fluctuating but increasing trend can be observed (Figure 16). In this fishery, however, CPUE shows a generally increasing trend.

The annual total catch for the kambuzi seine fishery indicates very low catches throughout the 1980s, but catches began to increase sharply during the early 1990s (Figure 17). A peak 847 tonnes were landed in 1995, in spite of poor yields in 1994. Thereafter, a marked decline in catches was observed. Only 21 tonnes of fish were caught in the kambuzi seine fishery in 2000 (Figure 17). The species composition of the kambuzi seine fishery shows that kambuzi (33%), utaka (20%), and usipa (22%) dominate the catch (Figure 17). Except for utaka yields, kambuzi and usipa catches appear to have undergone a general decline from the mid-1990s (Figure 17). Neither kambuzi nor usipa was recorded in the kambuzi seine fishery in 2000.

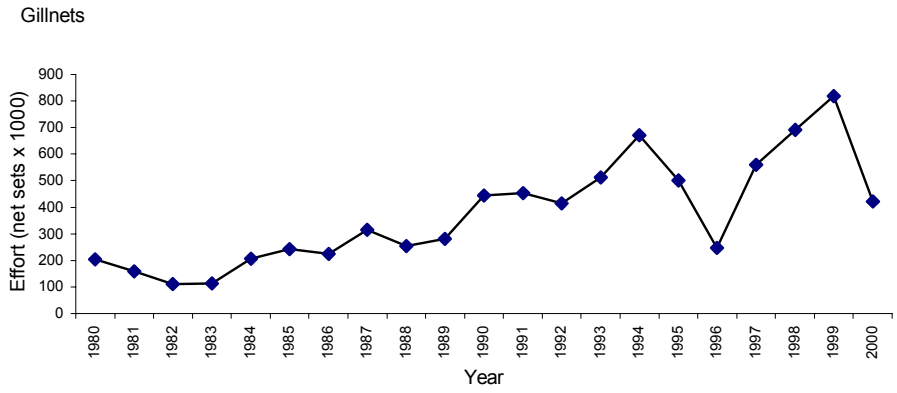

Figure 6. Effort in 91-m gill net sets for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

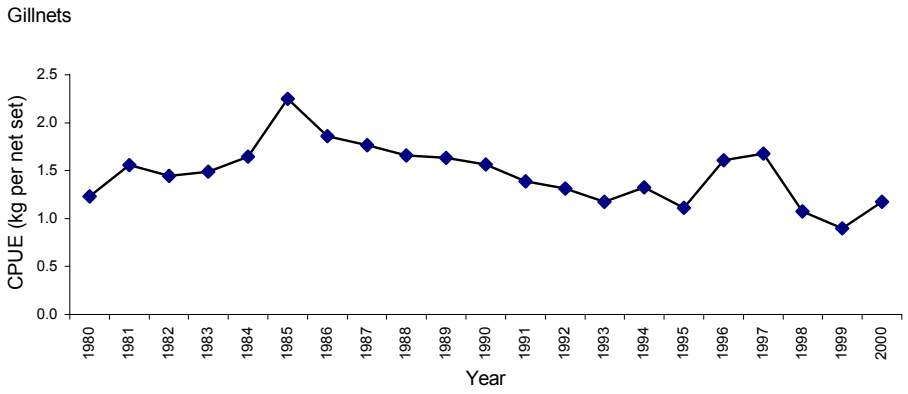

Figure 7. CPUE (kg per 91-m gill net set) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

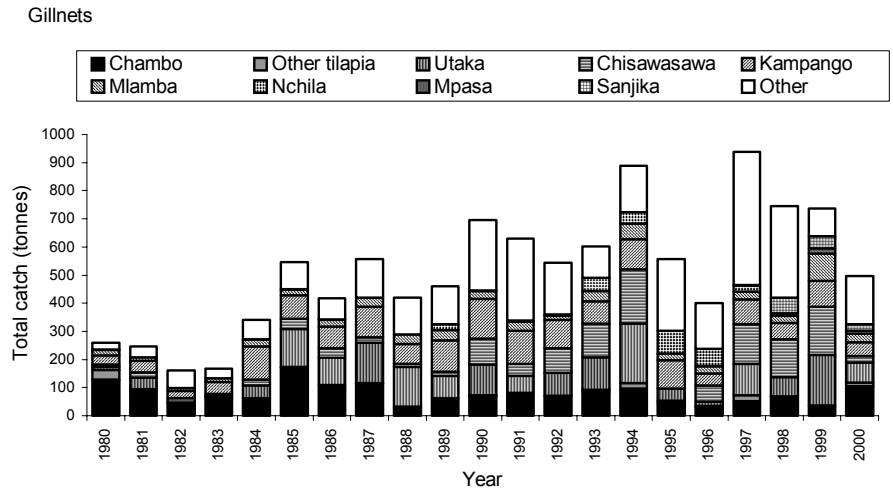

Figure 8. Annual total catch and species composition in the gillnet fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

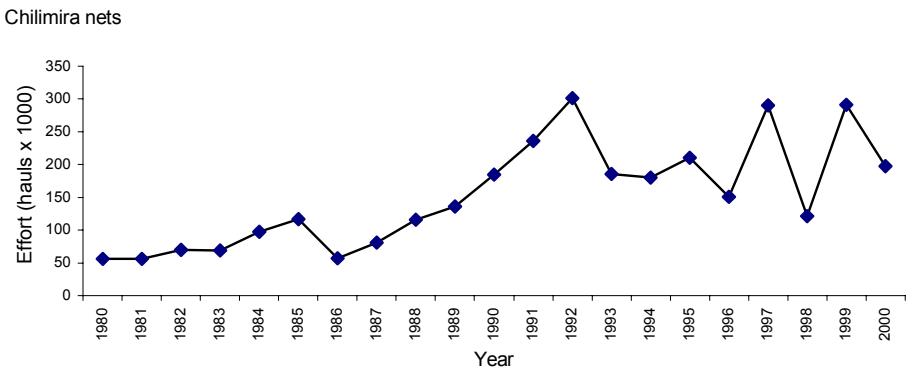

Figure 9. Chilimira net effort in hauls for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

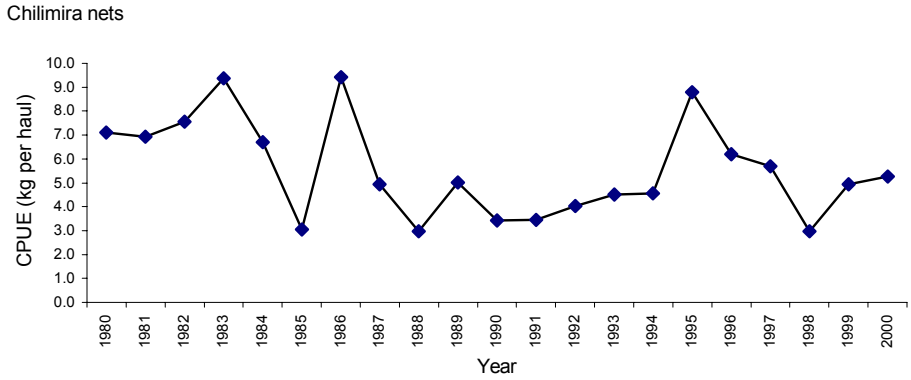

Figure 10. Chilimira net CPUE (kg per haul) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

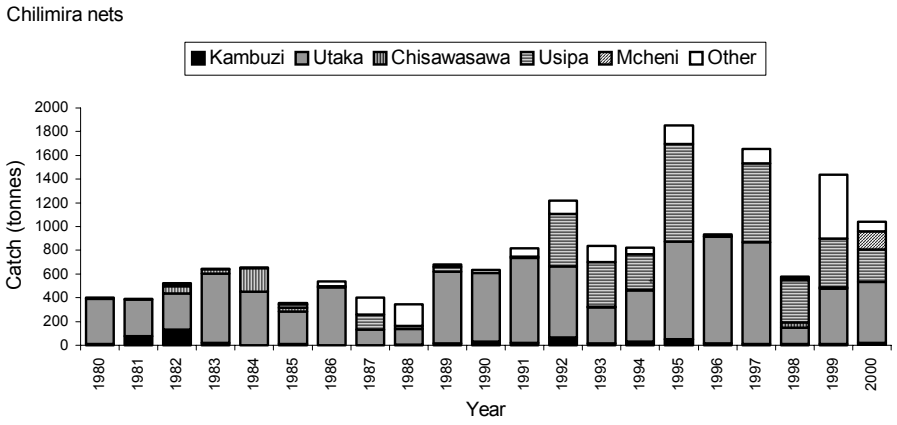

Figure 11. Annual total catch and species composition in the chilimira net fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

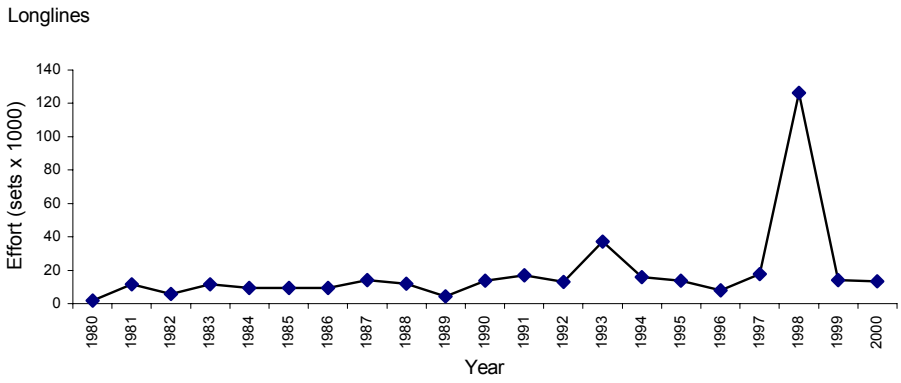

Figure 12. Longline effort in 100-hook sets for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

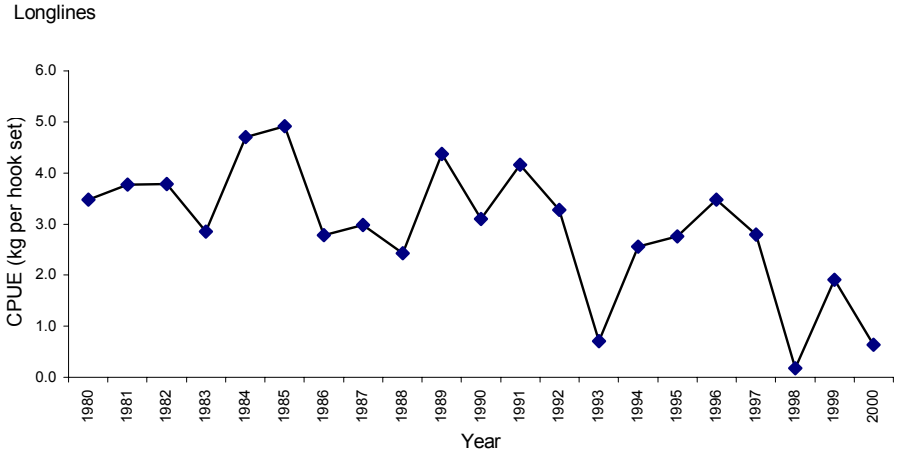

Figure 13. Longline CPUE (kg per 100-hook set) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

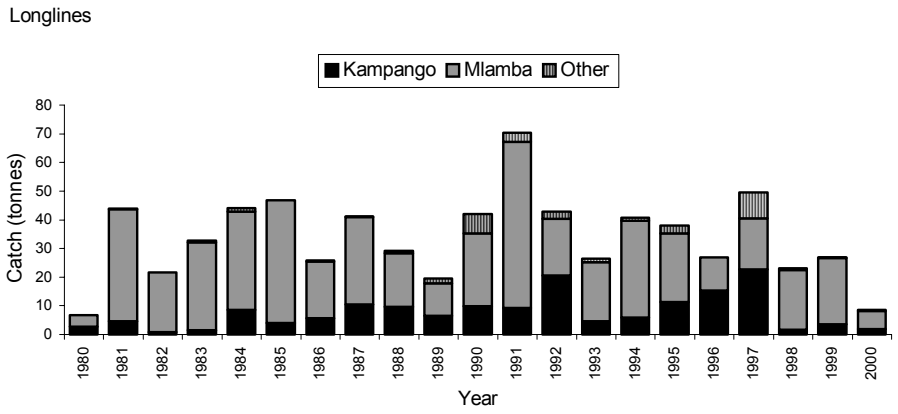

Figure 14. Annual total catch and species composition in the longline fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

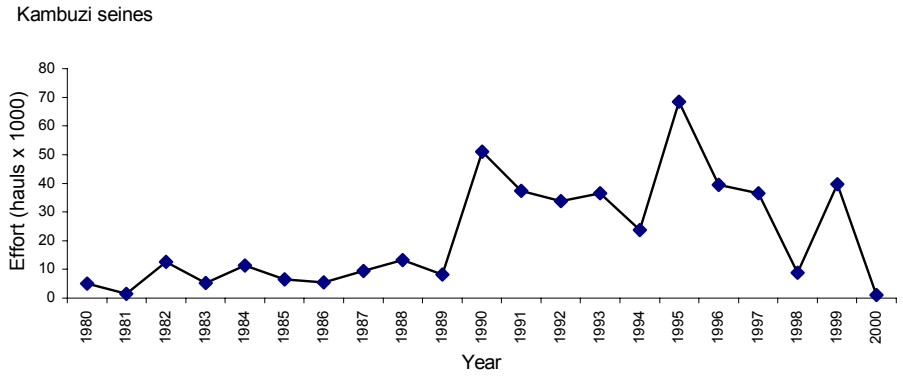

Figure 15. Kambuzi seine effort in hauls for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

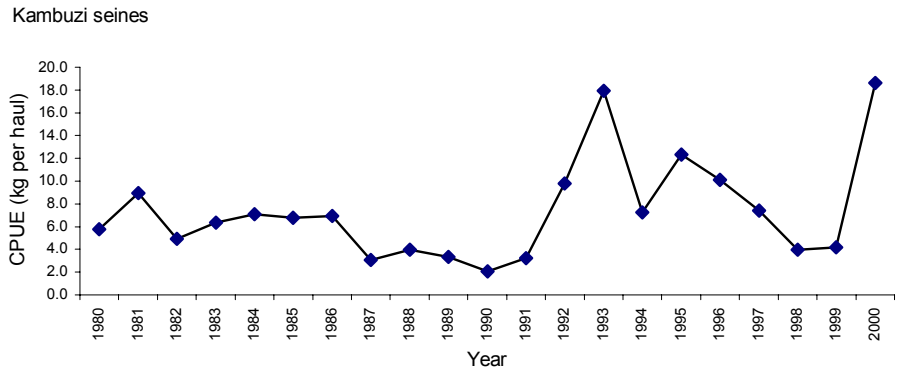

Figure 16. Kambuzi seine CPUE (kg per haul) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

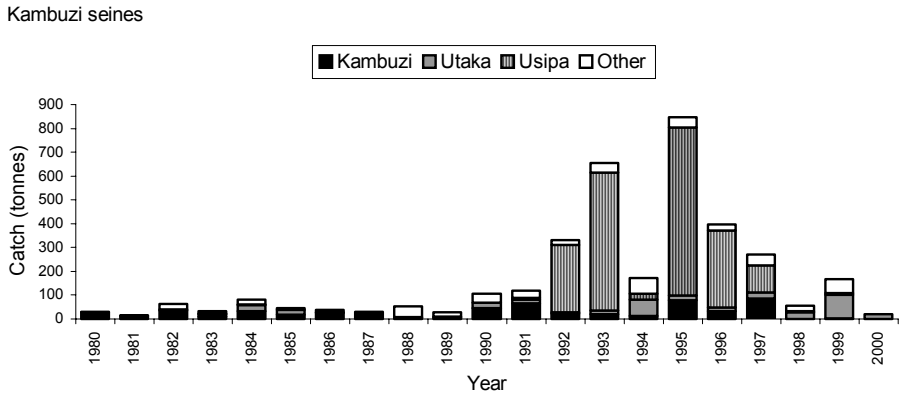

Figure 17. Annual total catch and species composition in the kambuzi seine fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

Mosquito nets

For the mosquito net fishery, annual effort estimates, CPUE estimates and catch composition are shown in Figures 18, 19 and 20, respectively. Effort estimates indicate large fluctuations in annual effort, coupled with a generally gentle decreasing trend over the 21-year period under review (Figure 18). Similarly, annual estimates of mosquito net CPUE show large fluctuations over the same period, but with no apparent trend (Figure 19).

The annual total catch for the mosquito net fishery shows peak yields in the late 1980s and late 1990s, the peaks being separated by approximately a ten-year interval (Figure 20). The average catch decreased by 39% from 119 tonnes in the 1980s to 73 tonnes in the 1990s. The landed catch in 2000 was only 14 tonnes (Figure 20).

The species composition of the mosquito net fishery shows that usipa (78%) is the most dominant species, but other species groups, e.g. utaka (4%), kambuzi (1%), chambo (<1%) and chisawasawa (<1%) may also be present in the catches (Figure 20). A total of 1,159 tonnes of usipa were landed during the 10-year period from 1981 to 1990, whereas a total of only 557 tonnes were caught from 1991 to 2000, representing an overall drop in catch of about 52% between the two succeeding decades.

Fish traps

For the fish trap fishery, annual effort estimates, CPUE estimates and catch composition are shown in Figures 21, 22 and 23, respectively. Effort estimates show large fluctuations in annual effort with no apparent trend over the 21-year period (Figure 21). Similarly, annual estimates of fish trap CPUE display fluctuations over the same period but with a gently decreasing trend (Figure 22).

The annual total catch for the fish trap fishery shows a generally increasing trend from 3 tonnes in 1980 to a peak 26 tonnes in 1991, after which yield dropped by 96% to 1 tonne in 1992 (Figure 23). Catches remained low until 1998, when 16 tonnes of fish were landed. Thereafter, catches decreased rapidly (Figure 23). Less than 1 tonne of fish was recorded in the fish trap fishery in 2000. The best years for the fish trap fishery were 1987 (20 tonnes), 1991 (26 tonnes) and, to a lesser extent, 1998 (16 tonnes) (Figure 23). The species composition of the fish trap fishery shows that chambo (49%), "other" species (43%) and mlamba (8%) dominate the catch (Figure 23). A total of 58 tonnes of chambo, 51 tonnes of "other" species and 4 tonnes of mlamba were landed from 1980 to 2000 by the fish trap fishery.

Handlines

For the handline fishery, annual effort estimates, CPUE estimates and catch composition are given in Figures 24, 25 and 26, respectively. Effort estimates show increased handline fishing activity from 1991 when 28,614 fishing trips were undertaken, followed by 178,409 trips in 1992 (Figure 24). Except for 1995, effort generally dropped after 1992 and remained low until 1999 when there were a record 899,483 fishing trips made. Only 22,262 trips were conducted in 2000. The general handline effort trend is, however, increasing slowly (Figure 24). Similarly, annual estimates of handline CPUE show

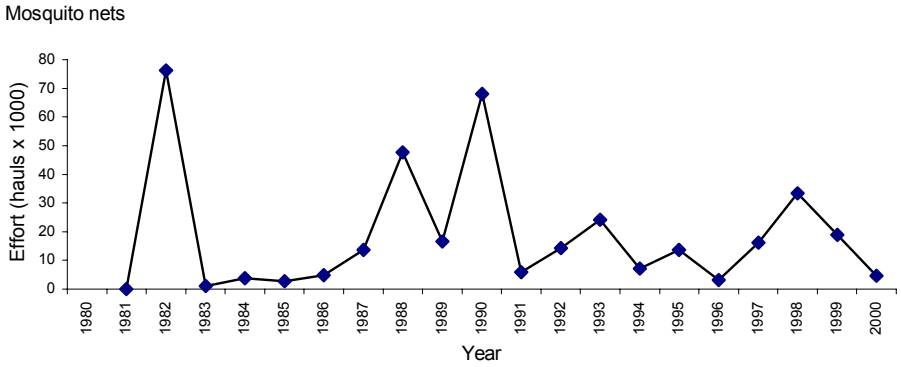

Figure 18. Mosquito net effort in hauls for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

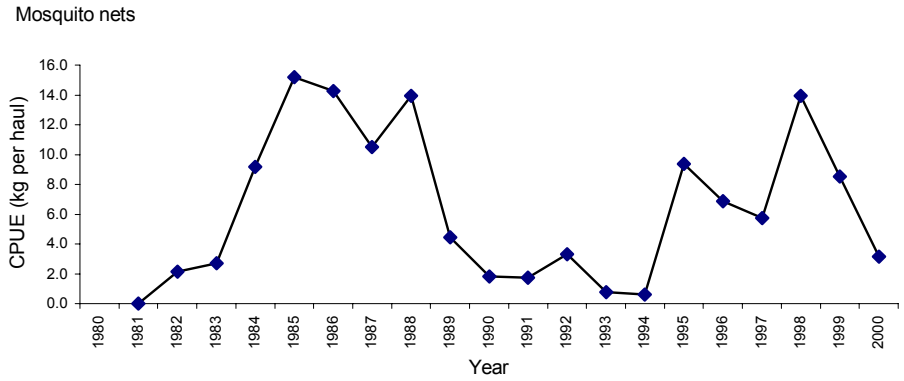

Figure 19. Mosquito net CPUE (kg per haul) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

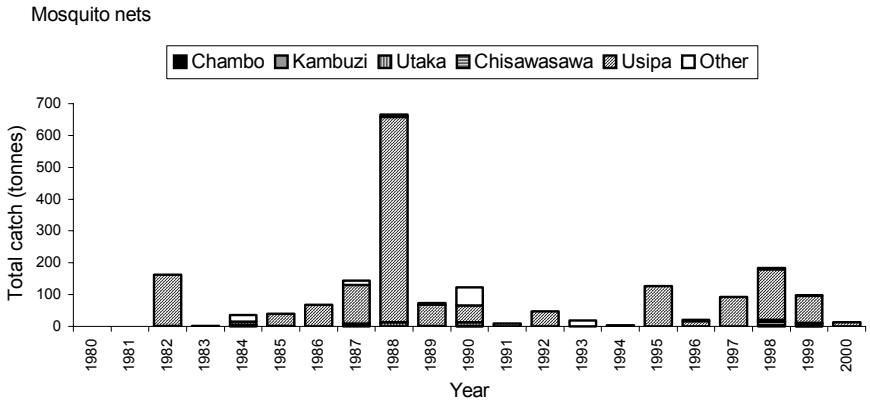

Figure 20. Annual total catch and species composition in the mosquito net fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

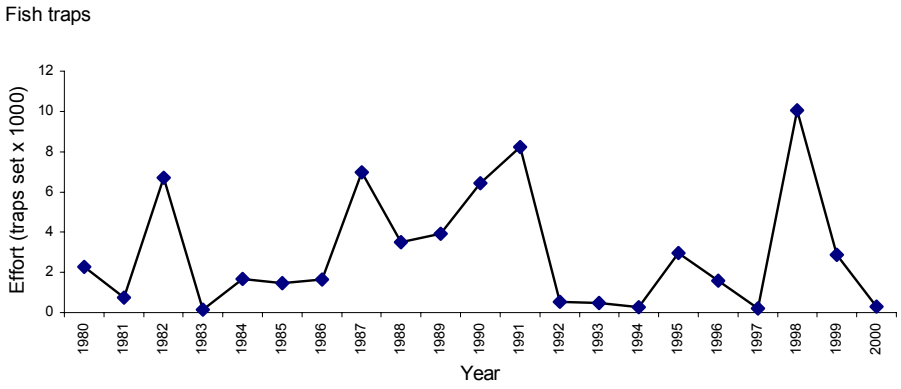

Figure 21. Fish trap effort (in trap sets) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

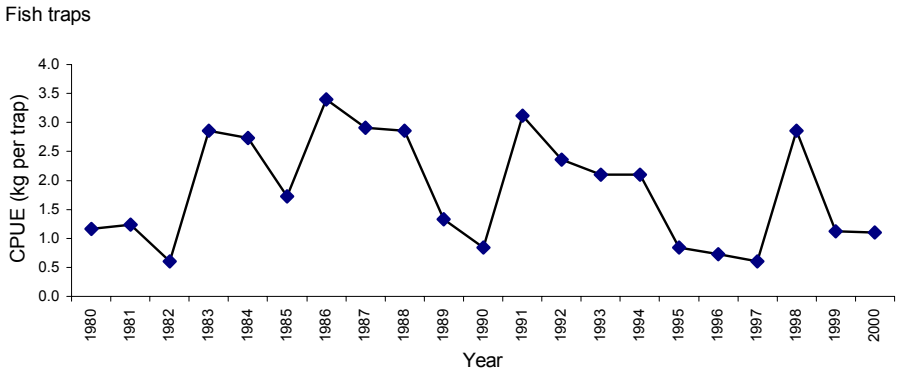

Figure 22. Fish trap CPUE (kg per trap set) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

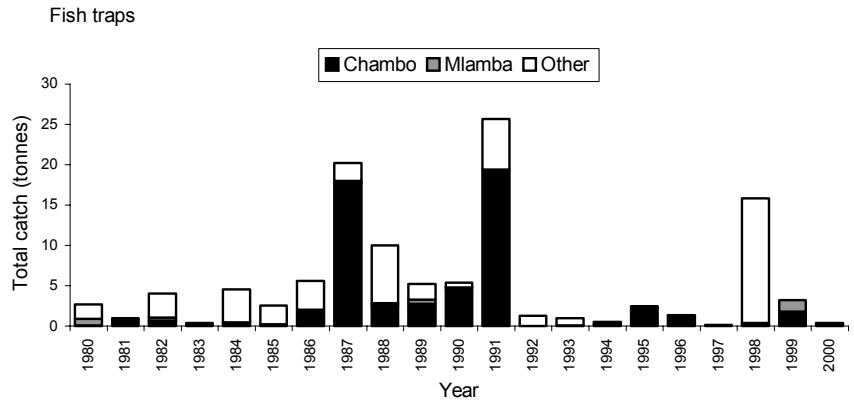

Figure 23. Annual total catch and species composition in the fish trap fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

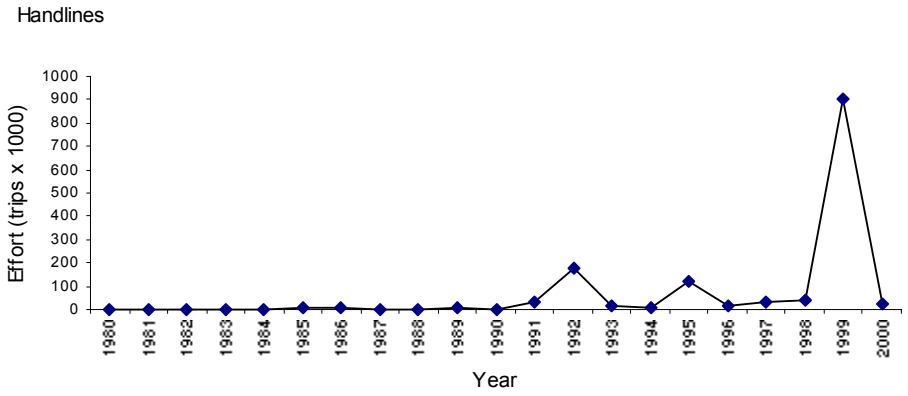

Figure 24. Handline effort (in trips) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

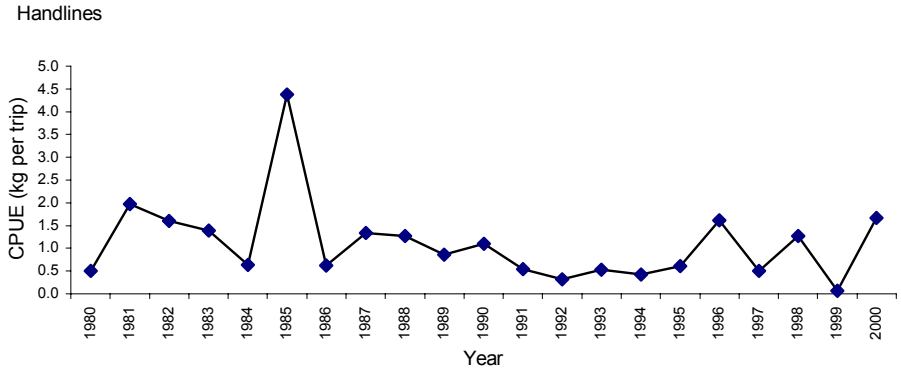

Figure 25. Handline CPUE (kg per trip) for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

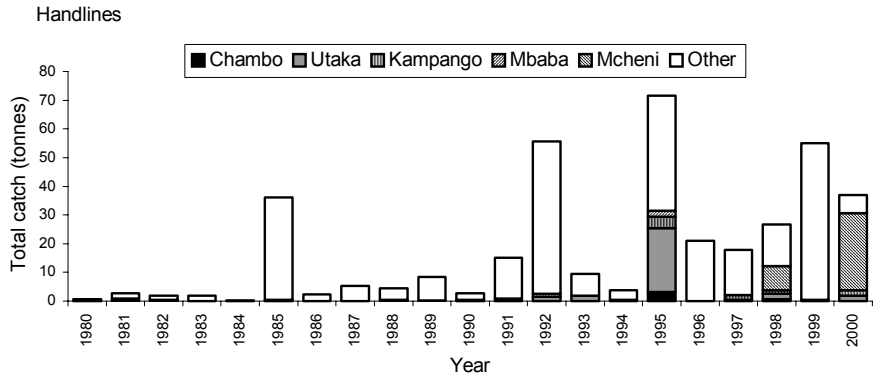

Figure 26. Annual total catch and species composition in the handline fishery of the Karonga Area of Lake Malawi from 1980 to 2000.

pronounced fluctuations, but with a general declining trend from 1980 to 2000 (Figure 25).

The annual total catch for the handline fishery shows peaks in 1985 (36 tonnes), 1992 (56 tonnes), 1995 (72 tonnes) and 1999 (55 tonnes), with the annual catches exhibiting a generally increasing trend (Figure 26). The species composition of the handline fishery has shifted from that dominated by utaka (13%) from early to mid-1990s, to that dominated by mcheni (21%) from late 1990s to 2000 (Figure 26). Most of the catch tends to be composed of species classified as "other" (81%). In addition to utaka, mcheni and "other" species, the catch was occasionally made up of kampango (4%), chambo (<1%), and mbaba (<1%) (Figure 26).

Analysis by species

Chambo

The main harvesting gear for chambo (*Oreochromis* spp.) in the Karonga Area of Lake Malawi were gillnets which contributed between 78 and 100% to the annual total catch between 1980 and 2000 (Figure 27a). Other gears worth noting were fish traps (0-19%), kambuzi seines (0-15%) and chilimira nets (0-10%). The total chambo catch shows a general decreasing trend from the mid-1980s, when 176 tonnes of chambo were landed in 1985, to the late 1990s, when 41 tonnes of chambo were caught in 1999 (Figure 27a). However, catches improved in 2000 when over 100 tonnes were recorded.

Chambo CPUEs in the gillnet fishery show substantial declines over the 21-year period (Figure 27b). Chambo CPUE declined from an average 0.4 kg/net set in the 1980s to an average 0.1 kg/net set in the 1990s. The decline in CPUE appears to follow an overall increasing trend in gillnet effort over the same period (Figures 5a & 6) and thus overfishing of the chambo stock might have occurred. Regressions of CPUE and lnCPUE against effort gave relatively good fits, r^2 = 0.51 and 0.64, respectively. Schaefer and Fox forms of the surplus production function were fitted to this stock (Figure 27c). The Schaefer and Fox forms estimated chambo MSY at 104 and 80 tonnes, respectively. MSY occurred at an annual effort level (fMSY) of 380,210 net sets, which was exceeded in the early 1990s. The 1999 effort exceeded fMSY by about 54% whereas the 2000 effort exceeded fMSY by only 10%.

Other tilapia

The main harvesting gears for "other tilapia" were gillnets and kambuzi seines, which annually contributes 27-100% and up to 73% to the total catch, respectively (Figure 28a). The total catch decreased rapidly, and then more slowly, from a peak yield of 33 tonnes in 1980 to under 5 tonnes in 1992, before recovering and peaking at 30 tonnes in 1997 (Figure 28a). Only 15 tonnes of "other tilapia" were landed in 2000.

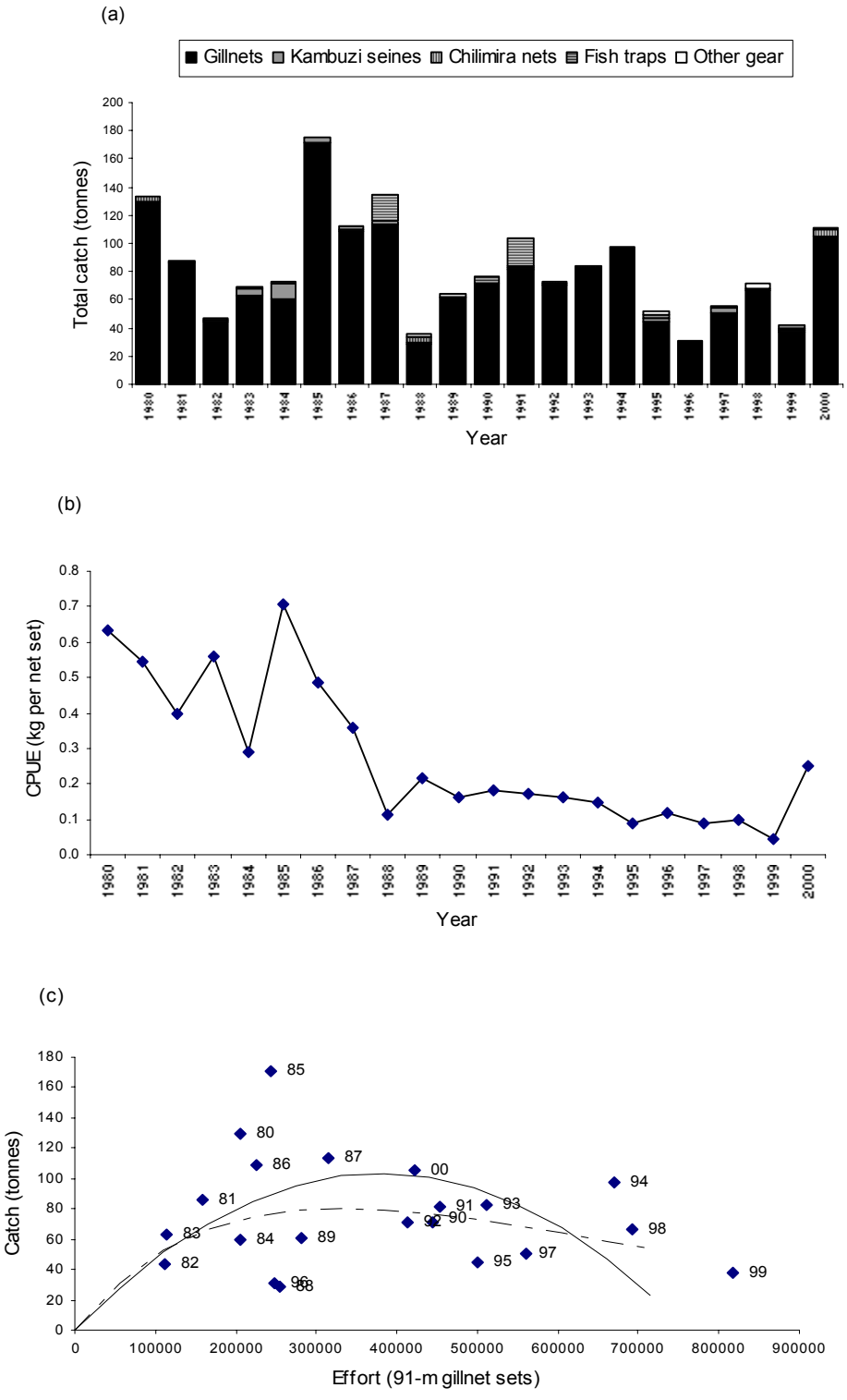

Figure 27. (a) Annual total chambo (*Oreochromis* spp.) catch by main contributing gear; (b) chambo CPUE (kg per 91-m net set) in the gillnet fishery; and (c) Schaefer (solid line) and Fox (dashed line) surplus production functions for chambo in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

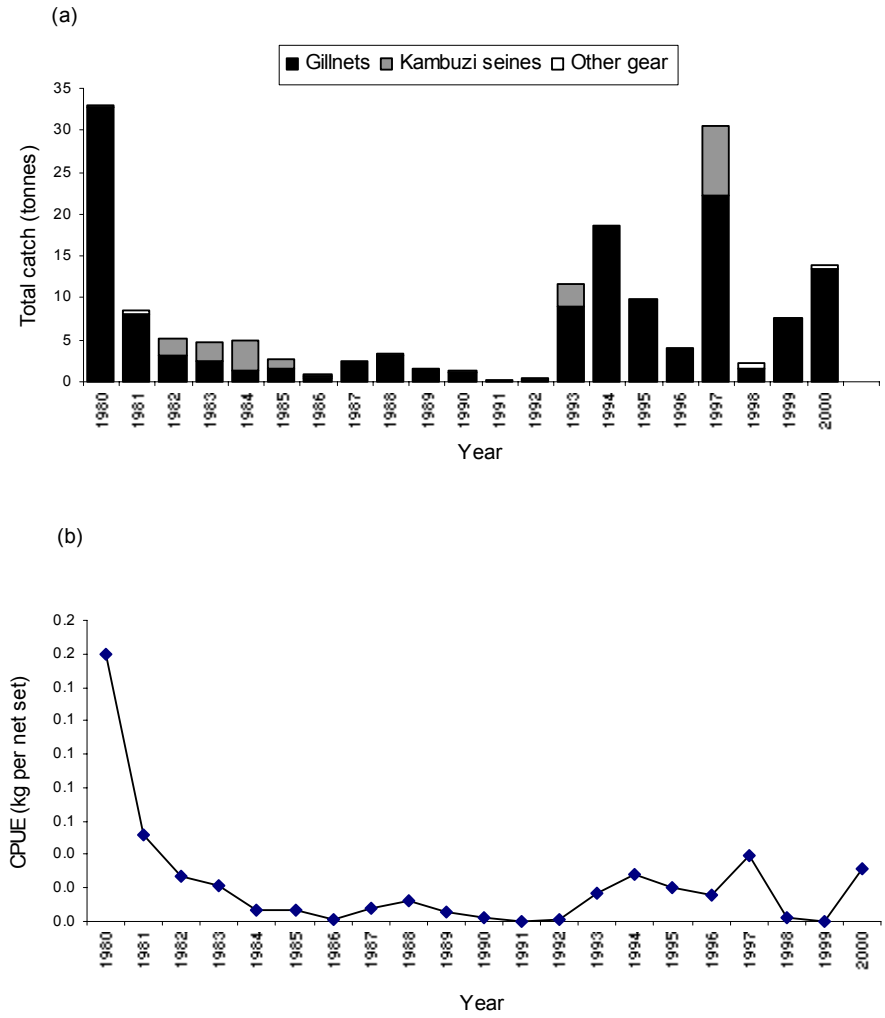

Figure 28. (a) Annual total "other tilapia" catch by main contributing gear; and (b) "other tilapia" CPUE (kg per 91-m net set) in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

The "other tilapia" CPUE declined rapidly from high levels in the early 1980s, and although the CPUE appear to fluctuate after the early 1990s, the overall CPUE trend is on the decrease (Figure 28b).

Kambuzi

The main harvesting gears for kambuzi in the Karonga Area of Lake Malawi were the kambuzi seines (1-96%), chilimira nets (0-77%) and gillnets (0-42%) (Figure 29a). The annual total kambuzi catch displays fluctuations over the 21-year period, with peak yields in 1982 (176 tonnes) and 1995 (131 tonnes) (Figure 29a). Thirty four tonnes of kambuzi were landed in 2000, a decrease of 74% from the 1995 peak level. The kambuzi catch was dominated by chilimira nets in the early 1980s, but kambuzi seines appear to have become equally important from the early 1990s (Figure 29a).

Kambuzi CPUEs in both the kambuzi seine (Figure 29b) and chilimira net (Figure 29c) fisheries show overall declining trends.

Utaka

The main harvesting gears for utaka were the chilimira nets, gillnets and kambuzi seines which, respectively, contributed between 46 and 99%, up to 51% and up to 13% to the annual total utaka catch from 1980 to 2000 (Figure 30a). The total catch shows a general increasing trend from 1980, when 391 tonnes of utaka were landed, to 1997, when a peak 995 tonnes were caught. After 1997 the yield dropped, with 603 tonnes being landed in 2000.

Utaka CPUEs in both the chilimira net and gillnet fisheries display large fluctuations, ranging from >8 kg per haul for both 1983 and 1986 to a low 1 kg per haul for both 1988 and 1998 in the chilimira net fishery; and from <0.05 kg per net set in 1982 to about 0.6 kg per net set in both 1985 and 1988 in the gillnet fishery (Figures 30b & 30c). These fluctuations are associated with generally decreasing CPUE trends over the 21-year period.

Chisawasawa

The main harvesting gears for chisawasawa (*Lethrinops* spp.) in the Karonga Area of Lake Malawi were gillnets, chilimira nets and kambuzi seines which contributed between 10 and 100%, up to 90% and up to 14%, respectively, to the total catch between 1980 and 2000 (Figure 31a). Gillnets have become increasingly important in the chisawasawa fishery, beginning with the late 1980s, replacing chilimira nets which dominated the fishery before that period. The total chisawasawa catch shows fluctuations but with a generally increasing trend (Figure 31a). Chisawasawa CPUEs in the gillnet fishery show a generally increasing trend (Figure 31b).

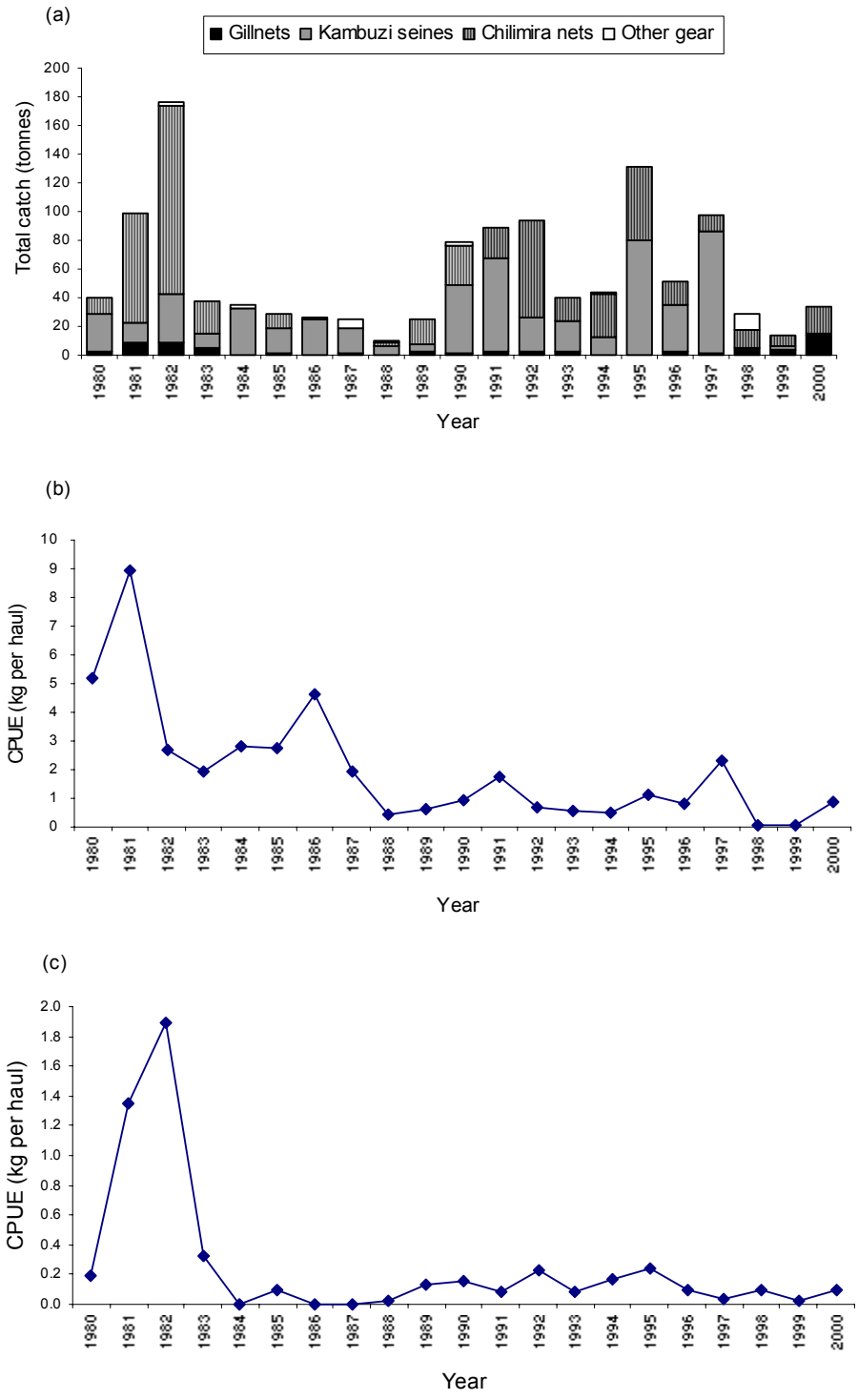

Figure 29. (a) Annual total kambuzi (small cichlids) catch by main contributing gear; (b) kambuzi CPUE (kg per haul) in the kambuzi seine fishery; and (c) kambuzi CPUE (kg per haul) in the chilimira net fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

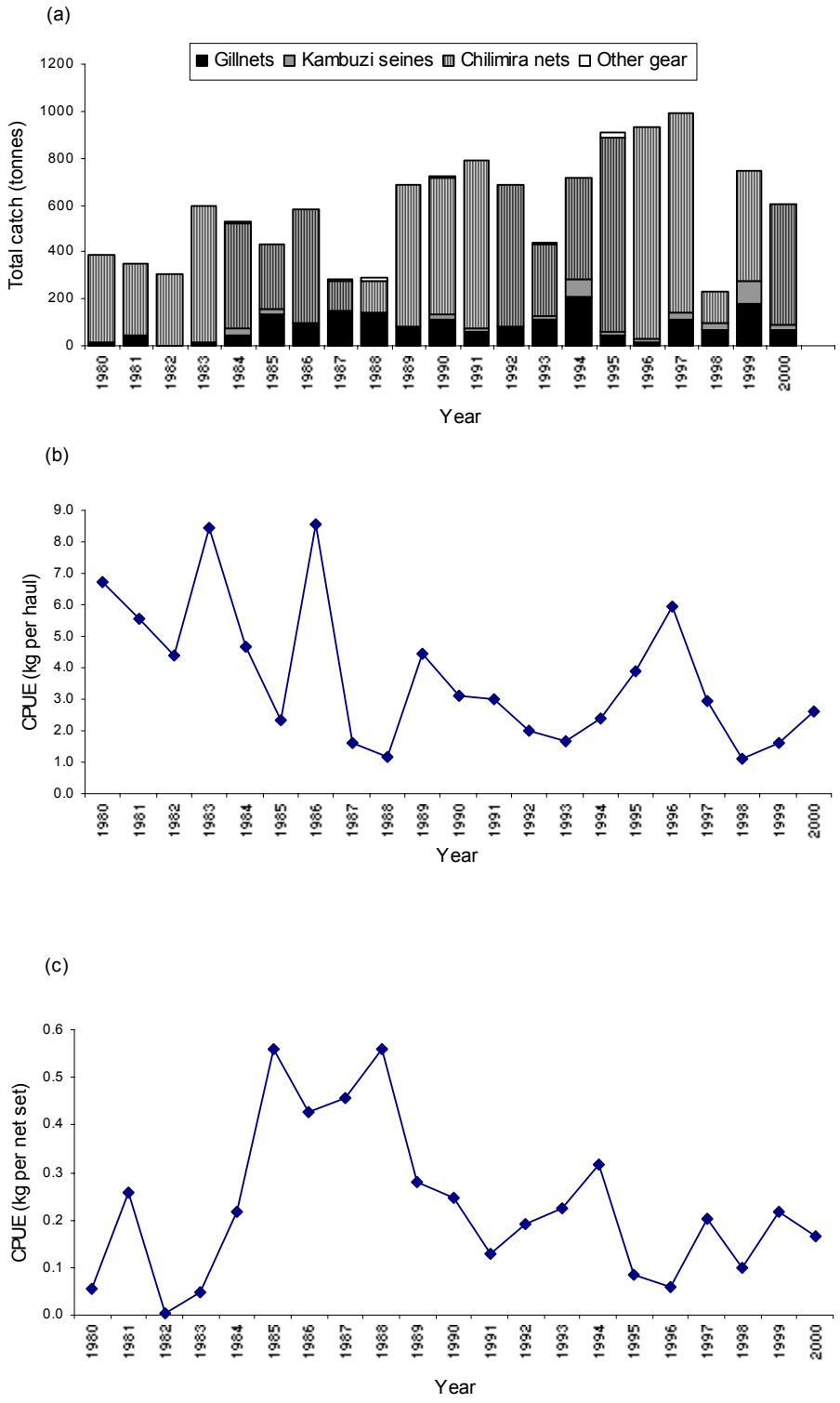

Figure 30. (a) Annual total utaka (*Copadichromis* spp.) catch by main contributing gear; (b) utaka CPUE (kg per haul) in the chilimira net fishery; and (c) utaka CPUE (kg per 91-m net set) in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

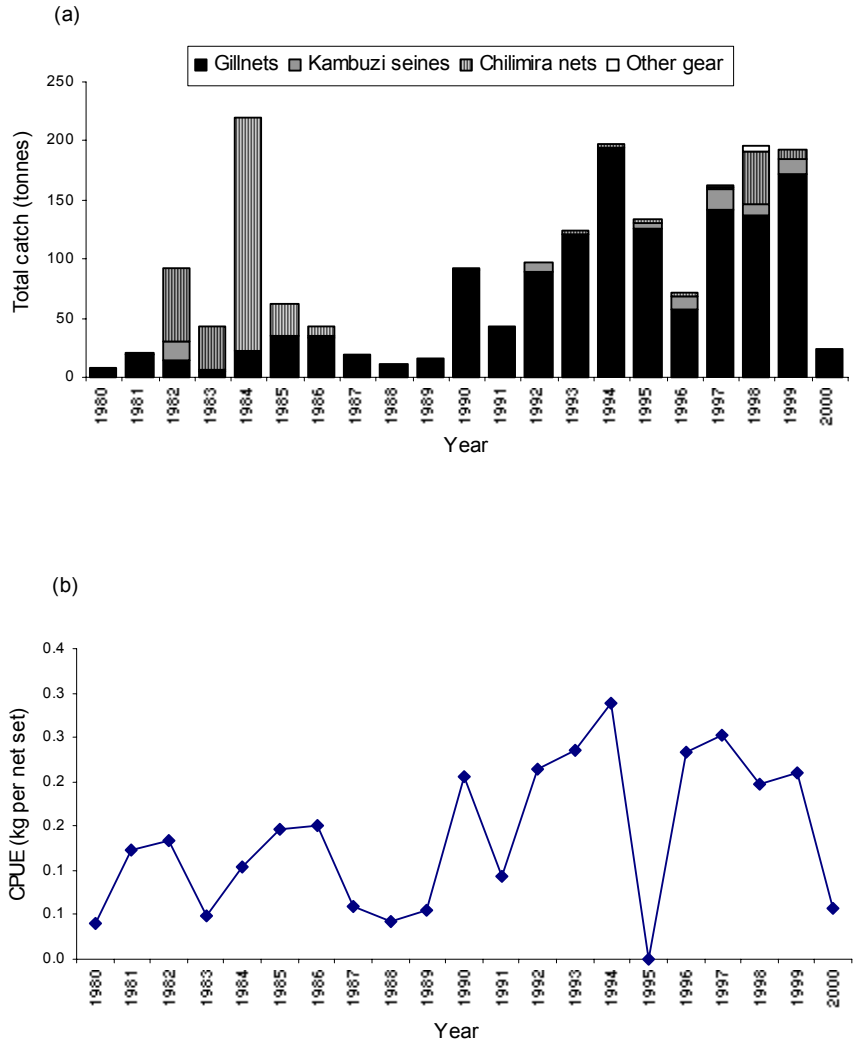

Figure 31. (a) Annual total chisawasawa (*Lethrinops* spp.) catch by main contributing gear; and (b) chisawasawa CPUE (kg per 91-m net set) in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

Kampango

The main harvesting gear for kampango in the Karonga Area of Lake Malawi were gillnets, which contributed between 62 and 96% to the annual total catch (Figure 32a). Other gears contributing to the total catch were longlines (2-26%), kambuzi seines (0-19%) and chilimira nets (0-17%). The annual total catch averaged 78 tonnes between 1980 and 1989 and 111 tonnes between 1990 and 1999. There were peak yields in 1984 (126 tonnes), 1990 (151 tonnes) and 1999 (149 tonnes) (Figure 32a). However, only 55 tonnes of kampango were landed in 2000.

Kampango CPUE in the gillnet fishery increased rapidly from 0.15 kg per net set in 1980 to a peak 0.55 kg per net set in 1984 (Figure 32b). Thereafter, CPUE has generally declined. The CPUE for 2000 was 0.12 kg per net set.

Mlamba

Gillnets and longlines were the main harvesting gears for mlamba in the Karonga Area of Lake Malawi, with gillnets contributing 23-80% and longlines 16-76% to the annual total catch (Figure 33a). The mean annual total catch increased from 48 tonnes in the 1980s to 67 tonnes in the 1990s. Peak yields were observed in 1991 (89 tonnes), 1994 (90 tonnes) and 1999 (121 tonnes). Mlamba CPUEs in both the gillnet and longline fisheries show overall decreasing trends over the 21-year period, with the gillnet CPUE showing the most decline (Figure 33b).

Usipa

The main harvesting gears for usipa in the Karonga Area of Lake Malawi were the chilimira nets, kambuzi seines and mosquito nets; with chilimira nets contributing 2-100%, kambuzi seines up to 91% and mosquito nets up to 97% to the annual total catch (Figure 34a). The total usipa catch appeared to be erratic, showing peak yields in 1982 (187 tonnes), 1988 (667 tonnes) and 1995 (1,656 tonnes) (Figure 34a). Thereafter, a marked decline in total catches was observed, with some 288 tonnes being landed in 2000. Kambuzi seines were major contributors to the total usipa catch from the early 1990s to about 1997, after which period chilimira nets, and to a lesser extent mosquito nets, became the only contributors to the usipa fishery (Figure 34a).

Usipa CPUEs in both the chilimira and mosquito net fisheries were highly erratic (Figures 34b & 34c). High usipa CPUEs were observed in 1987, 1993, 1995 and 1998 in the chilimira net fishery, while in the mosquito net fishery high CPUEs were recorded from about 1985 to 1988, and in 1995. CPUEs have generally declined in both fisheries after 1995 (Figures 34b & 34c).

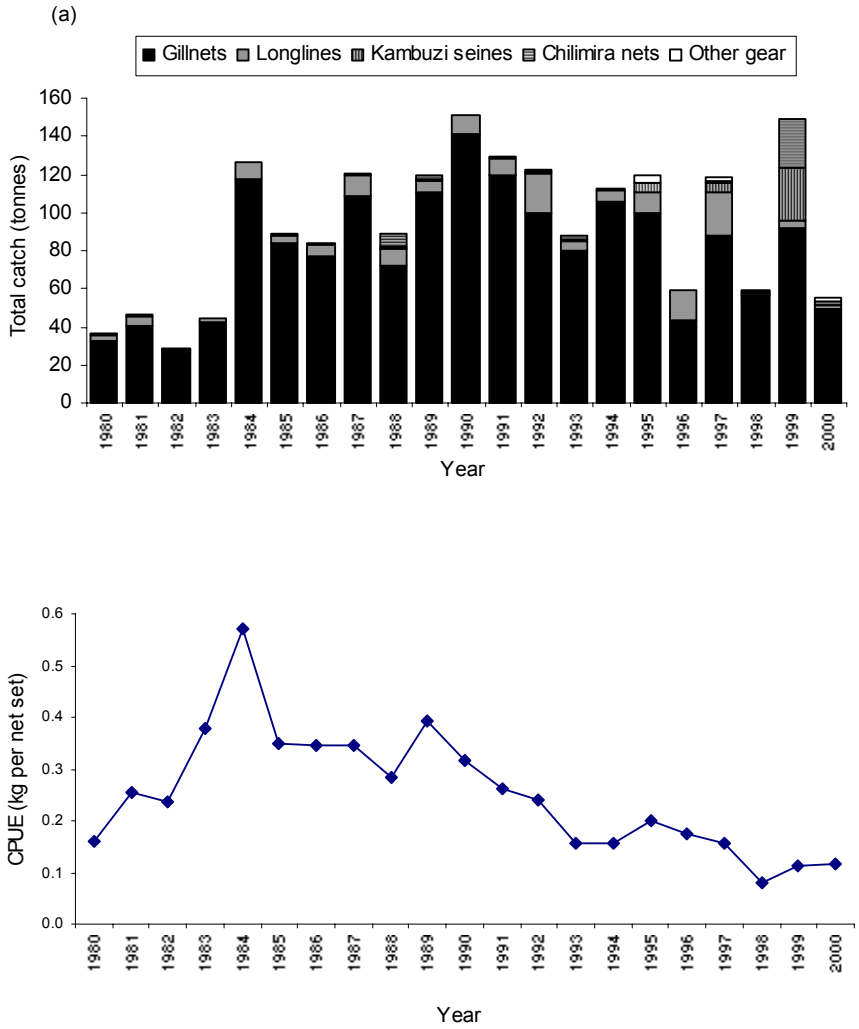

Figure 32. (a) Annual total kampango (*Bagrus meridionalis*) catch by main contributing gear; and (b) kampango CPUE (kg per 91-m net set) in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

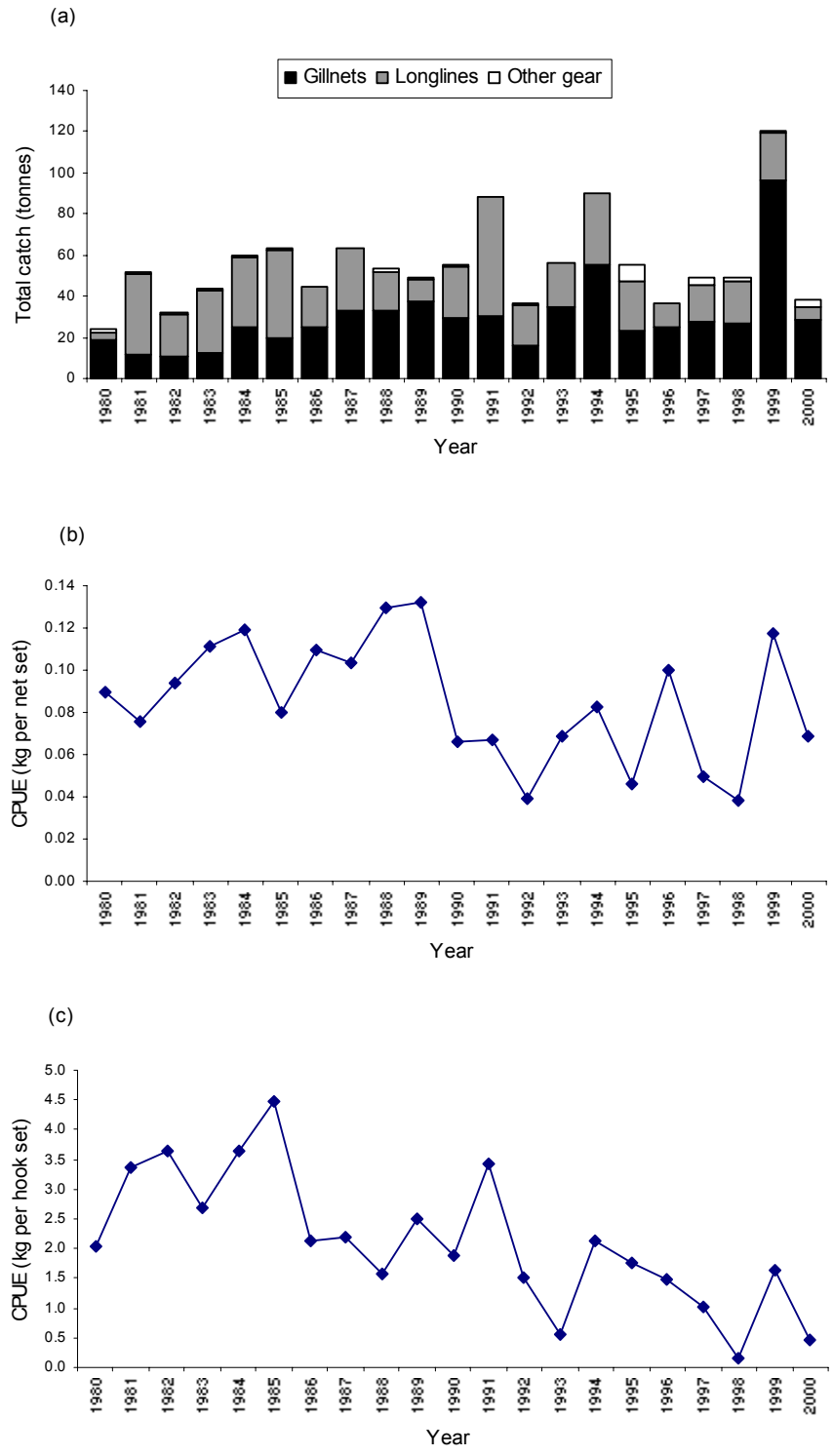

Figure 33. (a) Annual total mlamba (*Clarias gariepinus*) catch by main contributing gear; (b) mlamba CPUE (kg per 91-m net set) in the gillnet fishery; and (c) mlamba CPUE (kg per 100-hook set) in the longline fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

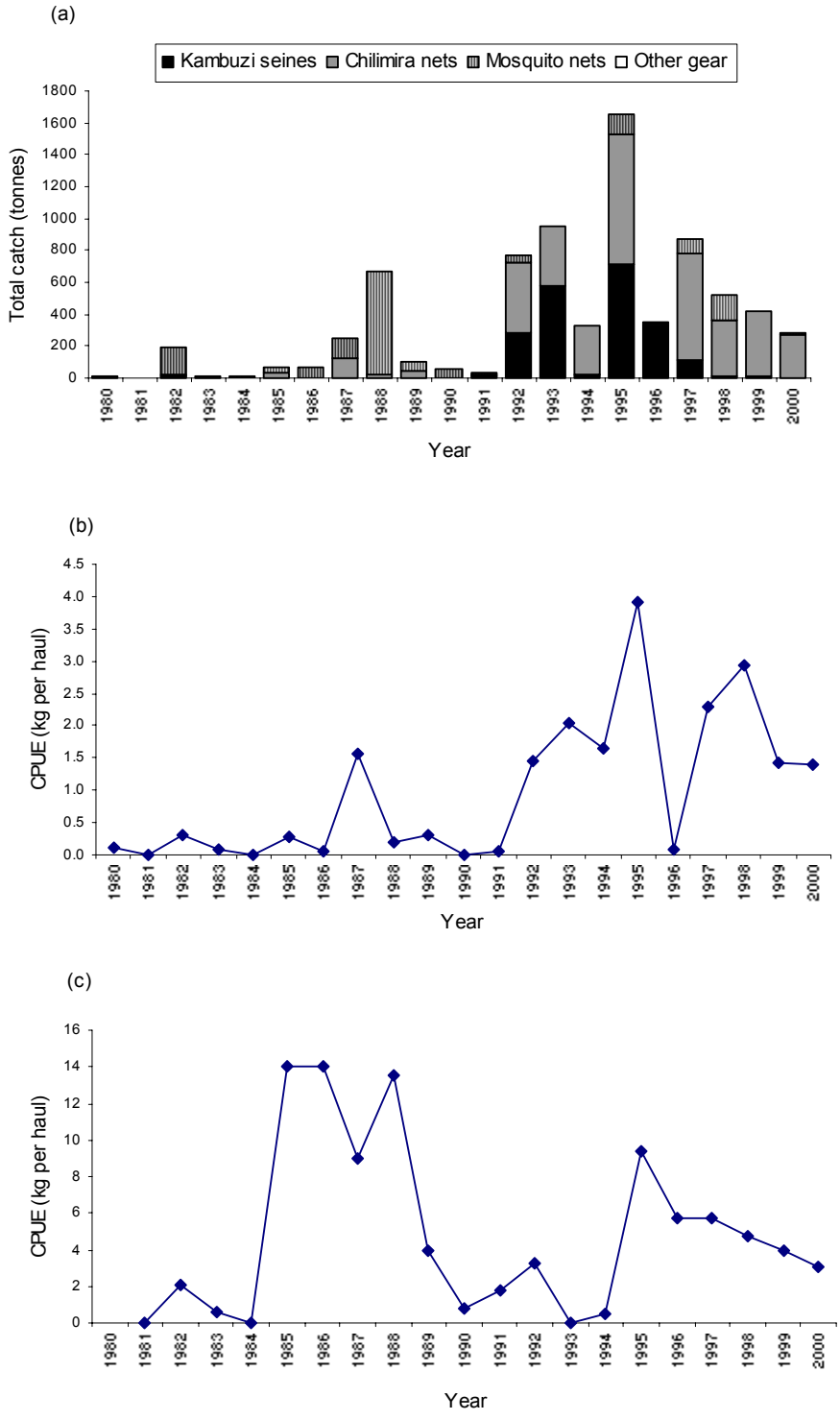

Figure 34. (a) Annual total usipa (*Engraulicypris sardella*) catch by main contributing gear; (b) usipa CPUE (kg per haul) in the chilimira net fishery; and (c) usipa CPUE (kg per haul) in the mosquito net fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

Nchila

The main harvesting gears for nchila in the Karonga Area of Lake Malawi were gillnets and chilimira nets, with gillnets and chilimira nets contributing 29-100% and up to 71%, respectively, to the annual total catch (Figure 35a). The annual total nchila catch exhibits a generally increasing trend from the 1980s to the mid-1990s (Figure 35a). While only 2 tonnes of nchila were caught in 1980, a peak 85 tonnes were landed in 1995. Catches

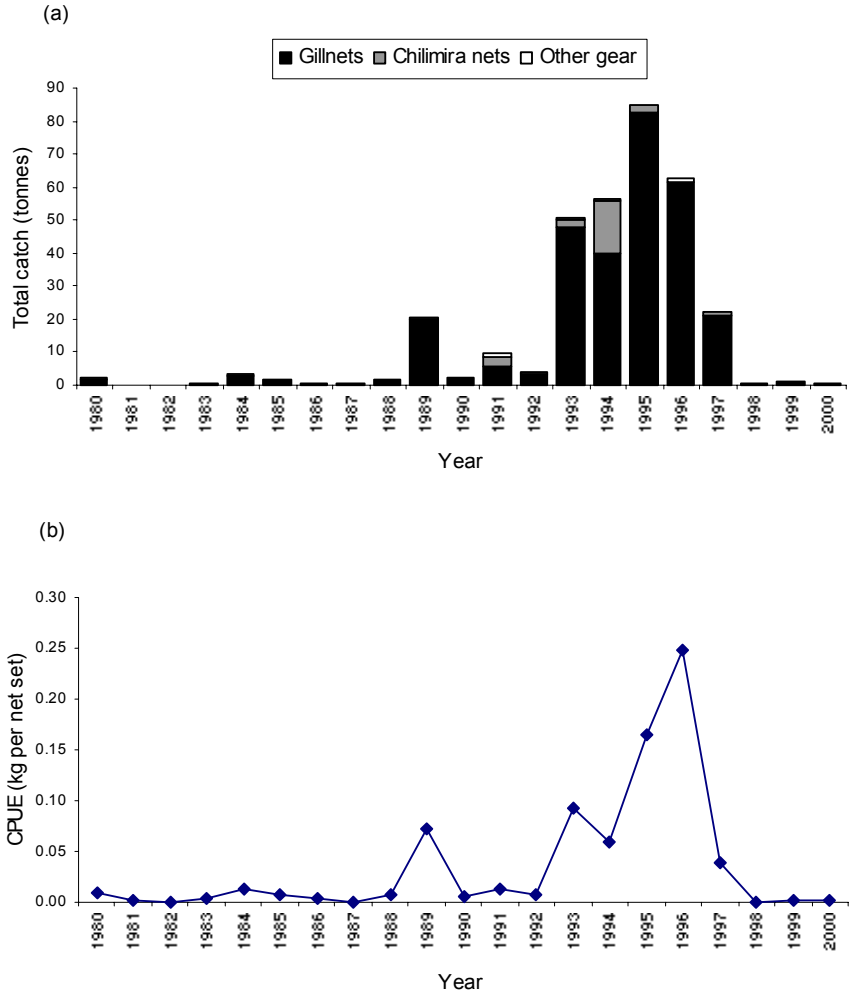

Figure 35. (a) Annual total nchila (*Labeo mesops*) catch by main contributing gear; and (b) nchila CPUE (kg per 91-m net set) in the gillnet fishery for the period 1980 to 2000 in the Karonga Area of Lake Malawi.

initially dropped slowly, and then rapidly after 1995. An annual average of only 1 tonne of nchila was landed from 1998 to 2000. Nchila CPUEs in the gillnet fishery have remained low during the periods 1980-1988, 1990-1992, and 1998-2000 (Figure 35b), averaging about 0.01, 0.01 and <0.01 kg per net set, respectively. Peak CPUEs were evident in 1989 (0.1 kg per net set), 1993 (0.1 kg per net set) and 1996 (0.25 kg per net set). The overall nchila CPUE trend, however, is increasing.

Maximum Sustainable Yield (MSY)

To obtain an estimate of maximum sustainable yield (MSY) for the Karonga Area of Lake Malawi, relative effort and relative CPUE were calculated for the 1980-2000 period using the total catch of all species except usipa. Usipa was left out because of its erratic occurrence (e.g. Tweddle 1995, Weyl *et al*. 2001). The mosquito net was also omitted from the analysis as the net caught mainly usipa. There was relatively good correlation between relative CPUE, ln(relative CPUE) and relative effort (Figures 36a & 36b). The Schaefer and Fox forms of the surplus production models were fitted to the data to yield initial MSY estimates for the Karonga Area fisheries (Figure 37). The Schaefer model estimated MSY at 2,661 tonnes (fMSY = 3,973) and the Fox form estimated MSY at 3,030 tonnes (fMSY = 6,043). Both MSY and fMSY appear not to have been exceeded in both models.

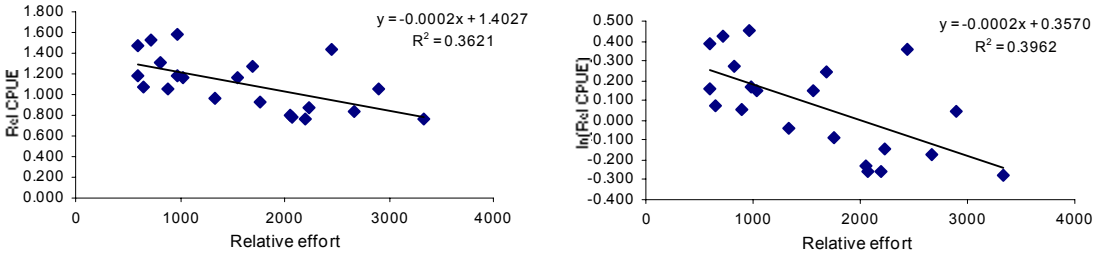

Figure 36. (a) Relative CPUE and (b) ln(Relative CPUE) as functions of relative effort in the small-scale fisheries of the Karonga Area of Lake Malawi for the period 1980 to 2000.

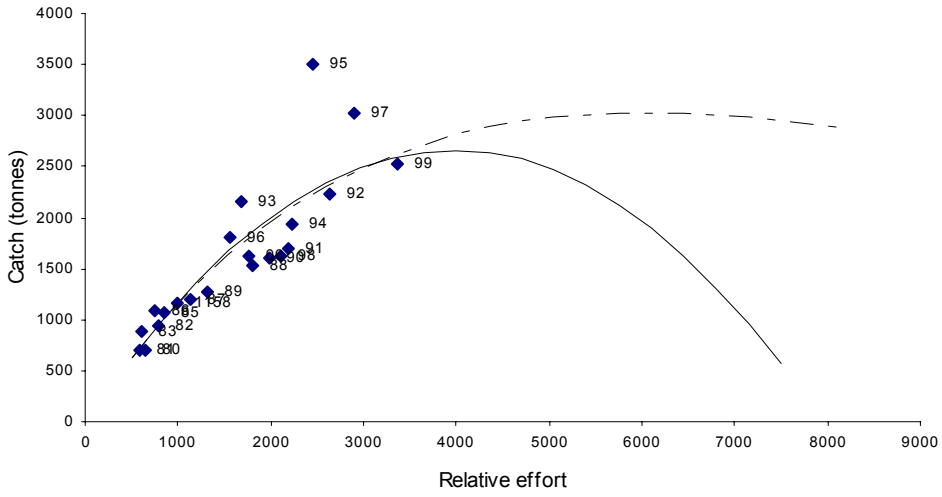

Figure 37. Schaefer (solid line) and Fox (dashed line) surplus production functions of total catch (excluding usipa) versus relative effort in the small-scale fisheries of the Karonga Area of Lake Malawi for the period 1980 to 2000.

Discussion

The number of major fishing gears, i.e. gillnets, chilimira nets, longlines, kambuzi seines, mosquito nets, fish traps and handlines, operating in the Karonga Area of Lake Malawi, as also reported by Tweddle *et al*. (1995) and Weyl *et al*. (2000), indicates that gear ownership, and thus effort, has generally increased from 1980 to 2000.

The estimated annual total catch for all gears and species groups in the Karonga Area of Lake Malawi increased fivefold over a sixteen-year period from 700 tonnes in 1980 to about 3,500 tonnes in 1995. Thereafter, the catch fluctuated coupled with a decline of about 54% to 1,618 tonnes in 2000. Chilimira nets, gillnets, mosquito nets and kambuzi seines were the major contributing gears to the annual total catch.

Utaka (*Copadichromis* spp.) and usipa (*Engraulicypris sardella*) were by far the main contributors to the fisheries of the Karonga Area of Lake Malawi between 1980 and 2000, with annual mean percentage contributions of 37% for utaka and 22% for usipa. The importance of utaka in the Karonga Area fisheries was also observed by Tweddle *et al*. (1995), who reported a figure of 42% being the contribution of utaka to the total catch between 1980 and 1989. The species grouped as "others" ranked third in importance, making up 17% of the annual mean catches. Kampango (*Bagrus meridionalis*) was fourth at 6%. The next were chambo (*Oreochromis* spp.) and chisawasawa (*Lethrinops* spp.) at 5% each. All the rest of the species contributed an annual mean percentage of <5% each to the total catches.

While total fish catches in the Karonga Area of Lake Malawi showed an increasing trend during the 1980s and early 1990s, as also reported by Ngochera (2001), there is a clear indication of decline in total fish catches following peak yields in 1995. Also, catches for most individual species show general decreasing trends over the 21-year period under review. This is happening against a general background of increasing effort in all the main gear fisheries; save for the mosquito net fishery, whose effort is decreasing slowly, and the fish trap fishery, whose effort shows no apparent trend. Utaka, for example, normally the most dominant in catches, made up 56% of the catch in 1980, 68% in 1983, but only 37% in 2000. The second in importance, usipa, contributed 1% to the total catch in 1980, 47% in 1995 and 18% in 2000. Kampango contributed 5% to the total catch in 1980, 11% in 1984 and 3% in 2000, whereas chambo catches made up 19% of the total catches in 1980, but contributed only 7% to the total catch in 2000. Chisawasawa made up 1% of the total catches in 1980, 19% in 1984, and 2% in 2000, and kambuzi contributed 6% to the total catch in 1980, 19% in 1982 and 2% in 2000, while mlamba made up 3% of the total catches in 1980, 7% in 1981 and 2% in 2000. The "others" species groups contributed 4% in 1980, 28% in 1999 and 14% in 2000.

The catch per unit effort (CPUE) showed declining trends in the following fisheries: chambo fishery associated with gillnets, "other tilapia" fishery (gillnets and kambuzi seines), kambuzi fishery (kambuzi seines and chilimira nets), utaka fishery (chilimira nets and gillnets), kampango fishery (gillnets), mlamba fishery (gillnets and longlines), usipa fishery (chilimira nets, kambuzi seines and mosquito nets). However, CPUEs generally increased in the chisawasawa fishery (gillnets) and nchila fishery (gillnets). There was no apparent CPUE trend in the usipa fishery (mosquito nets).

The decrease in chambo CPUE appear to follow a generally increasing trend in gillnet effort, hence overfishing of the chambo stock is suspected. Chambo MSY occurred at an effort of 380,210 net sets, and this figure was exceeded in the early 1990s. Therefore, it is recommended that gillnet effort be reduced to pre-1990s level if fishers were to realize any economic benefits from the fishery.

The estimated MSY and fMSY for all species pooled together except usipa, and all gears pooled together save the mosquito net, appear not to have been exceeded at all. This would seem to suggest that there is room for the fisheries to expand.

However, it is worth noting that there are problems of accuracy in catch and effort data collection in Malawian fisheries and these shortcomings have already been reviewed by Bazigos (1972), Walker (1974; 1976), Alimoso (1988), FAO (1993), Tweddle *et al*. (1995), and Weyl *et al*. (1999). Concerns raised by Tweddle *et al*. (1995) with regard to low catch estimates for mpasa and sanjika in the Karonga area riverine fisheries seem valid. It is also believed that catches in both the fish trap and handline fisheries are probably not assessed accurately and certainly very much underestimated. Margins of error in the data sets might, therefore, be expected and caution should be exercised in using the data.

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Appendix 1: Catch and effort data tables for the fisheries of the Karonga Area of Lake Malawi, 1980-2000.

Notes for tables

CPUE=	Catch per unit effort expressed as kg per unit effort
Catch and total catch =	tonnes.
GN =	Gillnet; effort in 91-m net sets.
FT =	Fish trap; effort in trap sets
CS =	Chambo seine; effort in hauls.
KS =	Kambuzi seine; effort in hauls.
CH =	Chilimira net; effort in hauls.
NK =	Nkacha net; effort in hauls.
SN =	Scoop net; effort in hauls.
CN =	Cast net; effort in hauls.
LL =	Longline; effort in 100-hook sets.
HL =	Handline; effort in trips.
MN =	Mosquito net; effort in hauls.