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Review of Demersal Monitoring Surveys in Southern Lake Malawi

Ó.K. Pálsson, M.C. Banda and A. Bulirani
Fisheries Research Unit
P.O. Box 27
Monkey Bay

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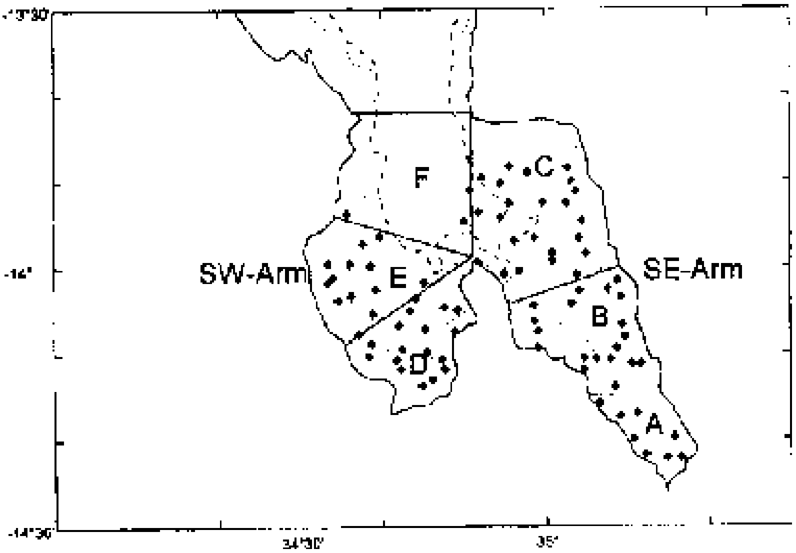
1. Introduction

Since 1994 standardized demersal surveys have been carried out in southern Lake Malawi in order to monitor the status of demersal fish stocks in the area (Fig. 1). Survey design, sampling procedures and some results are described in Banda and Tomasson (1997). The location of stations was, among other considerations, decided with respect to depth, in order to capture depth related differences in distribution. The survey was initially carried out on a quarterly basis but later reduced to one or two survyes a year. The timing of the survey has not been the same in all years due to logistic constraints, although in most years a survey was conducted in June. During 1994-96 90-97 stations were worked in a survey, whereas since 1998 83-85 station were covered (Table 1). The reduction in stations, has resulted in very limited coverage of area F (Fig. 1).

Fig. 1. Southern Lake Malawi and area division of demersal monitoring survey and 50 m and 100 m depth contours. Also shown (dots) are locations of stations worked in June-July 1999.



Since the monitoring survey has been conducted over a period of six years, it seems worth while to evaluate its potential in terms of fisheries management, which must be regarded as a main objective of a time-series survey of this type. In other words, to what extent can survey results, such as trends in species or bulk biomass or CPUE, be used as input for catch control laws or other fisheries management tools?

Table 1. Demersal monitoring surveys in southern Lake Malawi 1994-99.

Year	Month	No. of stations
1994	June	97
1994	Aug.Sept.	97
1994	Nov.-Dec.	97
1995	March	97
1995	June	97
1995	September	97
1995	December	97
1996	March-April	90
1997	June	88
1998	January	84
1998	October	85
1999	June-July	83

2. Species composition in 1995

An evaluation of species composition in Lake Malawi is, in many respects, a journey into unknown territory. The fishes of Lake Malawi have been subject to much discussion on species identity. Thus, in a number instances, a previously described species may now be considered to consist of many species. This taxonomic revision is still in progress. Also a number of species flocks are treated as one species, e.g. *Bathyclarias spp.* and *Oreochromis spp.* The term 'species composition' may therefore be misleading, and the term 'taxonomic entities' more appropriate.

The total number of taxonomic entities encountered in a survey is around 150. As a rule the same species are most abundant in all seasons in 1995. *Copadichromis virginalis* was by far the most abundant species in all seasons, contributing 12.1-17.4% to the total CPUE, 15.0% on average (Fig. 2). Other species contributed less than 8% in a survey. Five taxonomic entities contributed on average 5.1-6.5% to the total CPUE, i.e. *Bathyclarias spp., Otopharynx argyrosoma, Oreochromis spp., Lethrinops oliveri* and *L. gossei*. Other taxonomic entities contributed less than 5% on average.

Fig. 3 shows the cumulative CPUE as a percentage of the total CPUE in each season (survey) in 1995. The increase in the CPUE is rather similar in all seasons. Thus, 15 abundant taxonomic entities which occurred in all surveys in 1995 contributed 68.8, 69.8, 71,4 and 76.9% to the total CPUE in March, June, September and December respectively.

Fig. 2. Average contribution of 15 abundant taxonomic entities in 1995

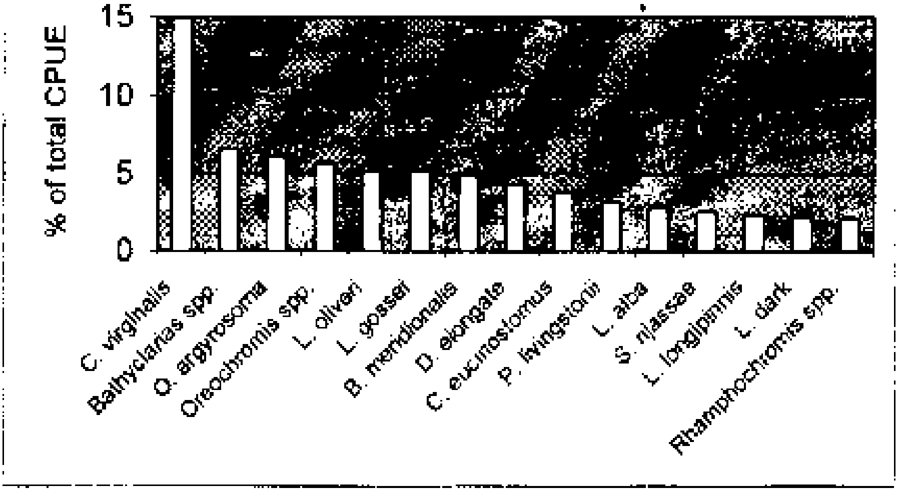
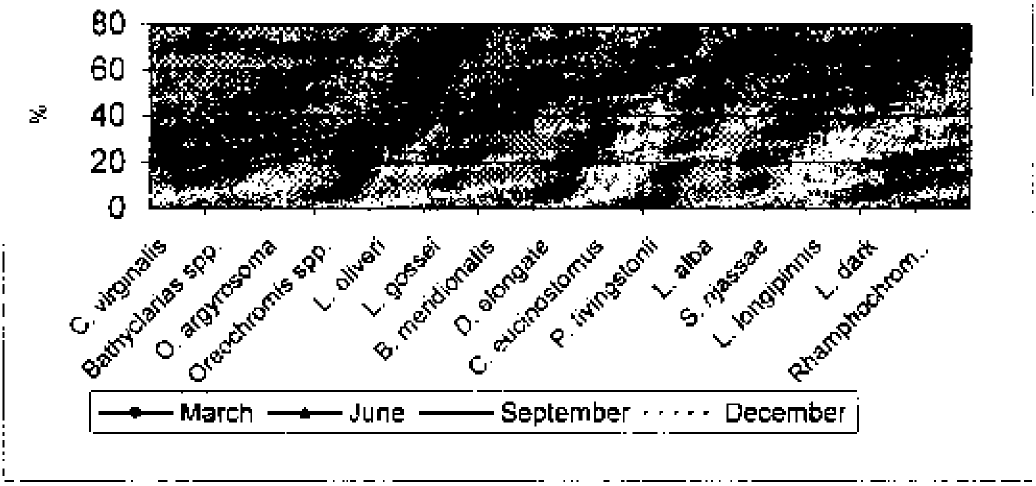


Fig. 3. Cumulative CPUE (% of total) for 15 taxonomic entities



3. Depth distributions by species

Differences in depth distributions are characteristic for Lake Malawi fish species in general (Tomasson and Banda 1996). The 16 species/taxonomic entities shown in Fig. 4 are distinctive in their depth distributions. The first four taxonomic entities (*P. livingstoni, C. eucinostomus, Oreochromis spp. and O. argyrosoma*) are mainly recorded in the uppermost 50 meters. The following three taxonomic entities, *C. virginalis, Rhamphochromis spp. and L. dark*, are mainly recorded down to a depth of 60-70 meters but are also found in deeper water. The next four taxonomic entities, *B. meridionalis, Bathyclarias spp., L. longipinnis and S. nyassae*, are rather evenly distributed whereas the last four species, *L. oliveri, D. elongate, L. gossei and L. alba*, prefer the deeper or the deepest waters. In spite of considerable seasonal variation in the depth distribution, most species show a fairly similar overall pattern in all seasons.

It should be noted that *Bathyclarias spp.* is a composite of 9 species, some of which have a characteristic depth distribution (Banda, unpubl. PhD thesis). However, two out of the nine species, *B. nyassensis* and *B. longibarbis*, are by far most abundant and, therefore, determine the overall distribution of the flock.

There is negative correlation between depth and the relative total CPUE. In the shallowest depth range the average total CPUE is close to 600 kg, whereas in the deepest range it is almost down to 300 kg. This is in agreement with the general findings for Lake Malawi that the shallowest waters are the most productive ones.

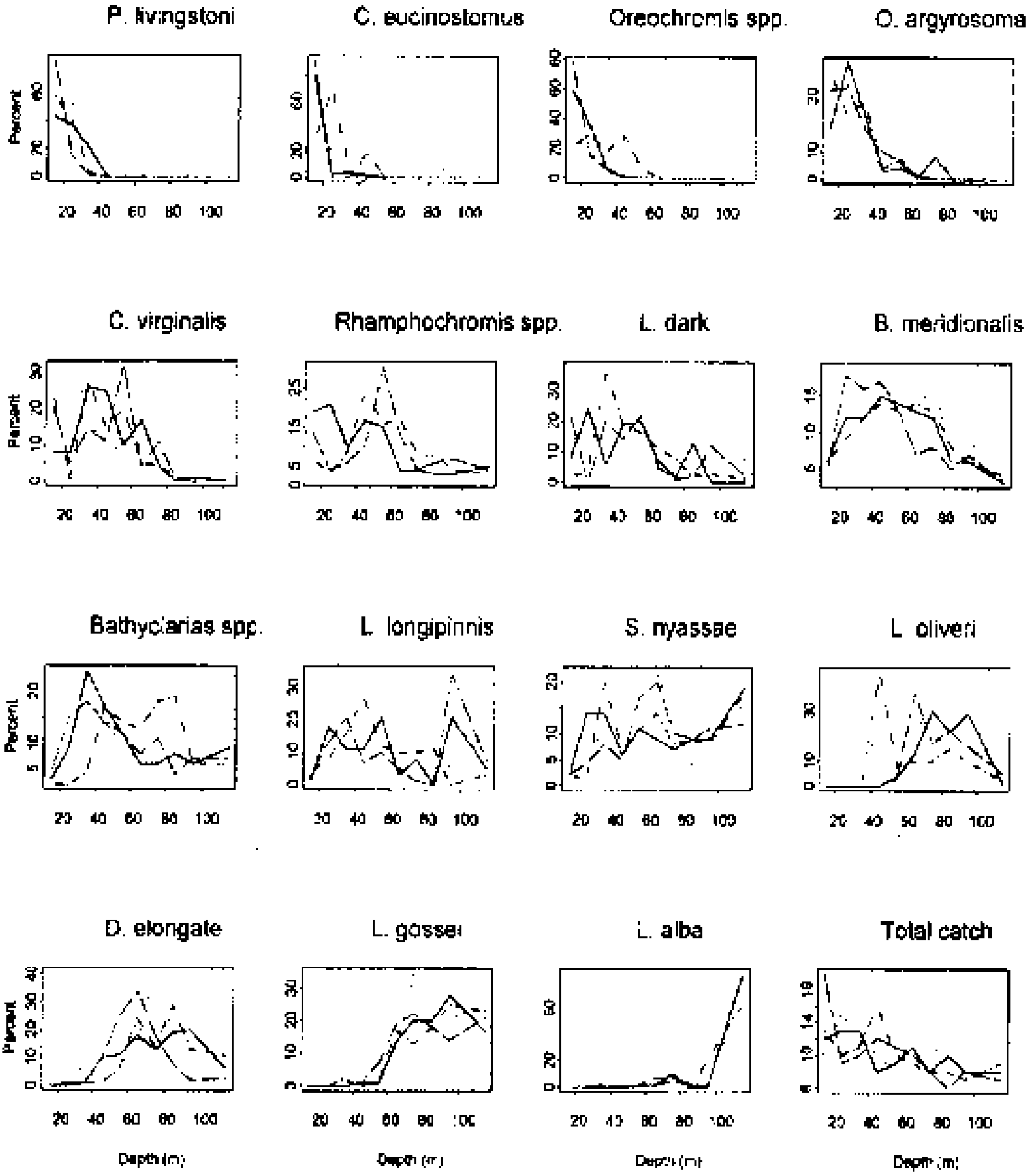


Fig 4. Relative depth distribution of some species/groups In southern Lake Malawi 1995

Legend: bold = March, dotted = June, dashed/dotted = Sept., dashed = Dec.

4. Area – depth distributions

As shown in Fig. 1, the survey area is split into sub-areas A-C in the SE-Arm and sub-areas D-F in the SW-Arm. The average total CPUE 1995 in each of these areas is shown, by season, in Figs. 5-7 for shallow waters (10-49m), deep waters (50-99m) and very deep waters (100-149m) respectively, and for all seasons combined in Fig. 8. Large, but non-significant (t-test, p>0.05), inter-seasonal differences are observed in the CPUE within area A and area C in the shallow waters (Fig. 5). The fact that the high inter-seasonal variability is non-significant, is explained by the high intra-seasonal variability and the limited number of stations in each area-depth box, or 7 in area A and 5 in area C of depth interval 10-49m. A declining trend is observed in the mean CPUE across areas (Fig. 8) and there was a statistically significant difference in mean CPUE between areas in depth interval 10-49m (t-test, p<0.05).

Fig. 5. CPUE 1995 by season and area in depth interval 10-49m

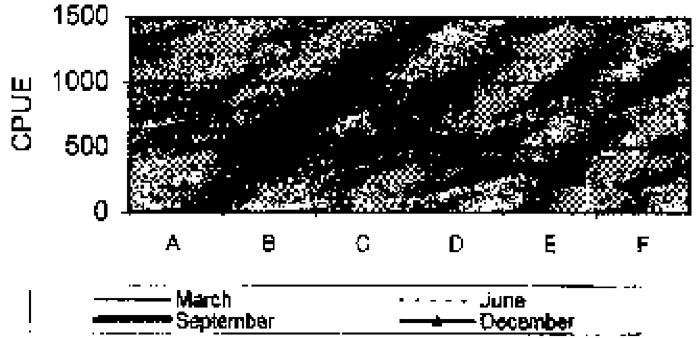


Fig. 6. CPUE 1995 by season and area in depth interval 50-99m

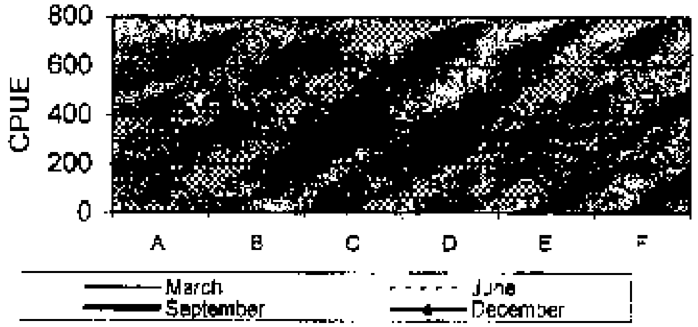


Fig. 7. CPUE 1995 by season and area in depth interval 100-149m

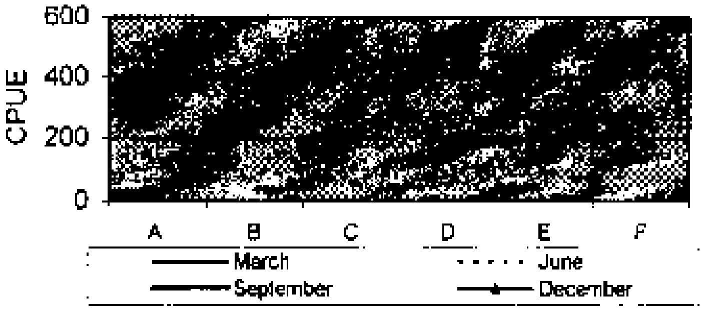
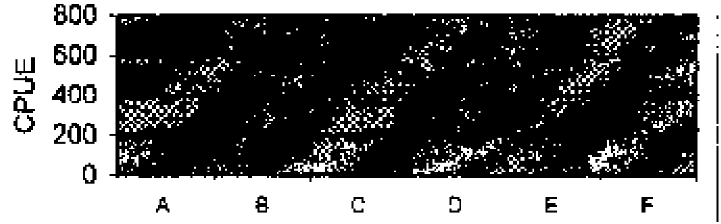


Fig. 8. Average CPUE 1995 by area and depth interval



CPUE in deep waters (50-99m) is generally lower than in shallow waters (Fig. 8). Inter-seasonal variability within areas is large and significant in areas B and D (t-test, $p<0.05$) but non-significant in other areas (Fig. 6). A significant decline in mean CPUE across areas is also observed in this depth interval, from a mean of 408 kg in area A to 254 kg in area E (Fig. 8).

In the deepest waters (100-149m) lower mean CPUE is observed in areas E and F compared to areas C and D (Figs. 7 and 8). Inter-seasonal variability within areas is large but not significant and the mean variability in CPUE across areas is not significant (Fig. 8).

As shown in Fig. 8, there is a clear difference in mean CPUE between shallow (10-49m) and deep (50-99m) waters in areas A, B and C. However, the value for area A in deep waters is only based on one station. The difference between depth intervals in area B is not significant but in area C it is significant (t-test, $p<0.05$). In areas D and E CPUE is similar, and not significantly different, in shallow and deep waters. The CPUE is virtually identical in deep (50-99m) and very deep (100-149m) waters in areas C-F.

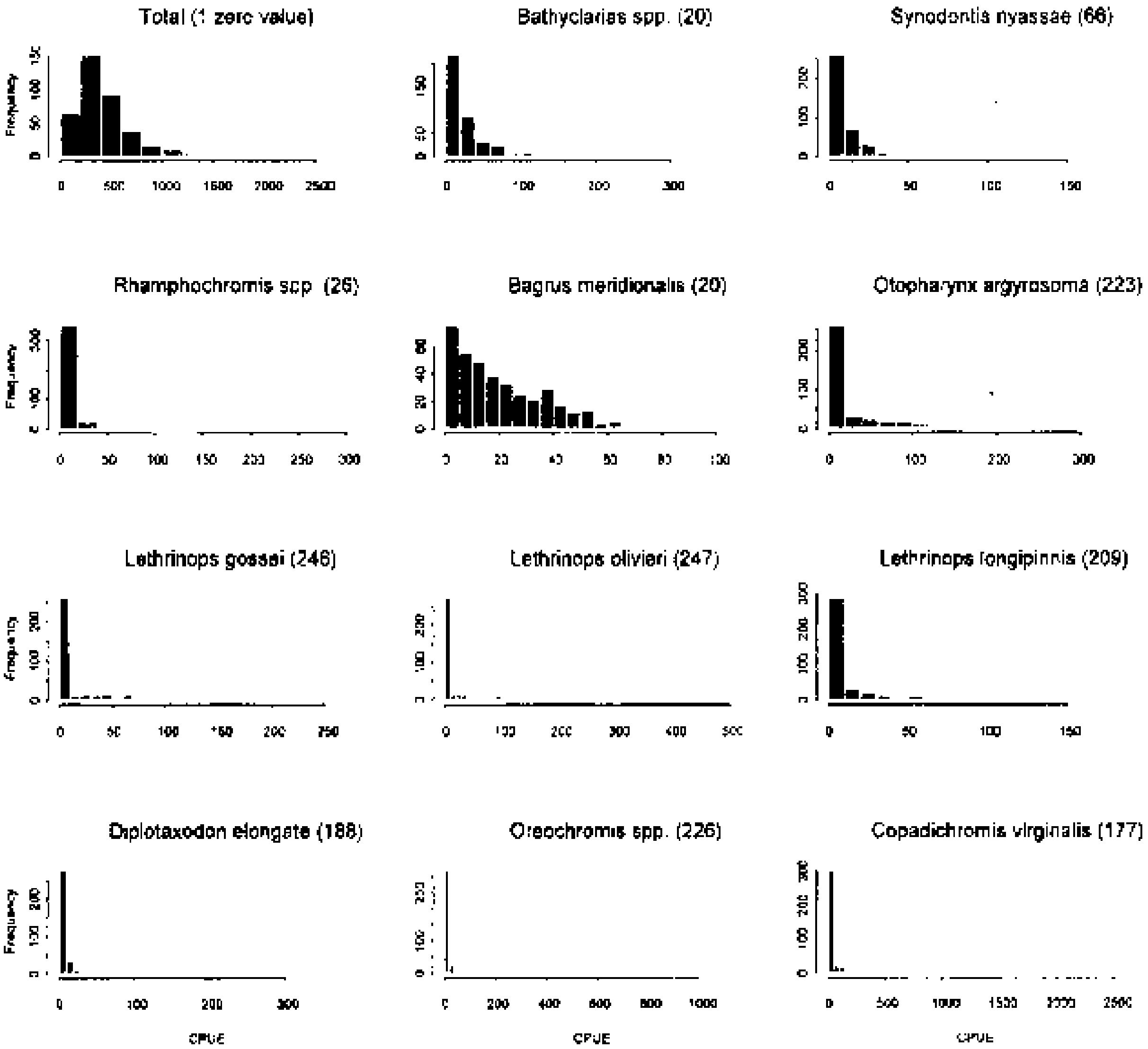
Thus, based on the depth intervals usually applied in management context in southern Lake Malawi, depth related differences in CPUE are rarely significant. However, significant differences between areas within depth intervals are found in the shallow and deep waters, as explained above. On the other hand, inter-seasonal differences within areas are not found to be significant based on data for 1995 except in areas B and D in deep waters (50-99m).

5. Frequency distribution of CPUE

The frequency distributions of the basic CPUE of some taxonomic entities for the combined (pooled) surveys 1995, are shown in Fig. 9. Some of the distributions have a large number of zero values and all appear far from a normal distribution pattern. Most of the distributions are characterized by a heavy tail, which may be difficult to see on Fig. 9, but is indicated by the right limit of the abscissa.

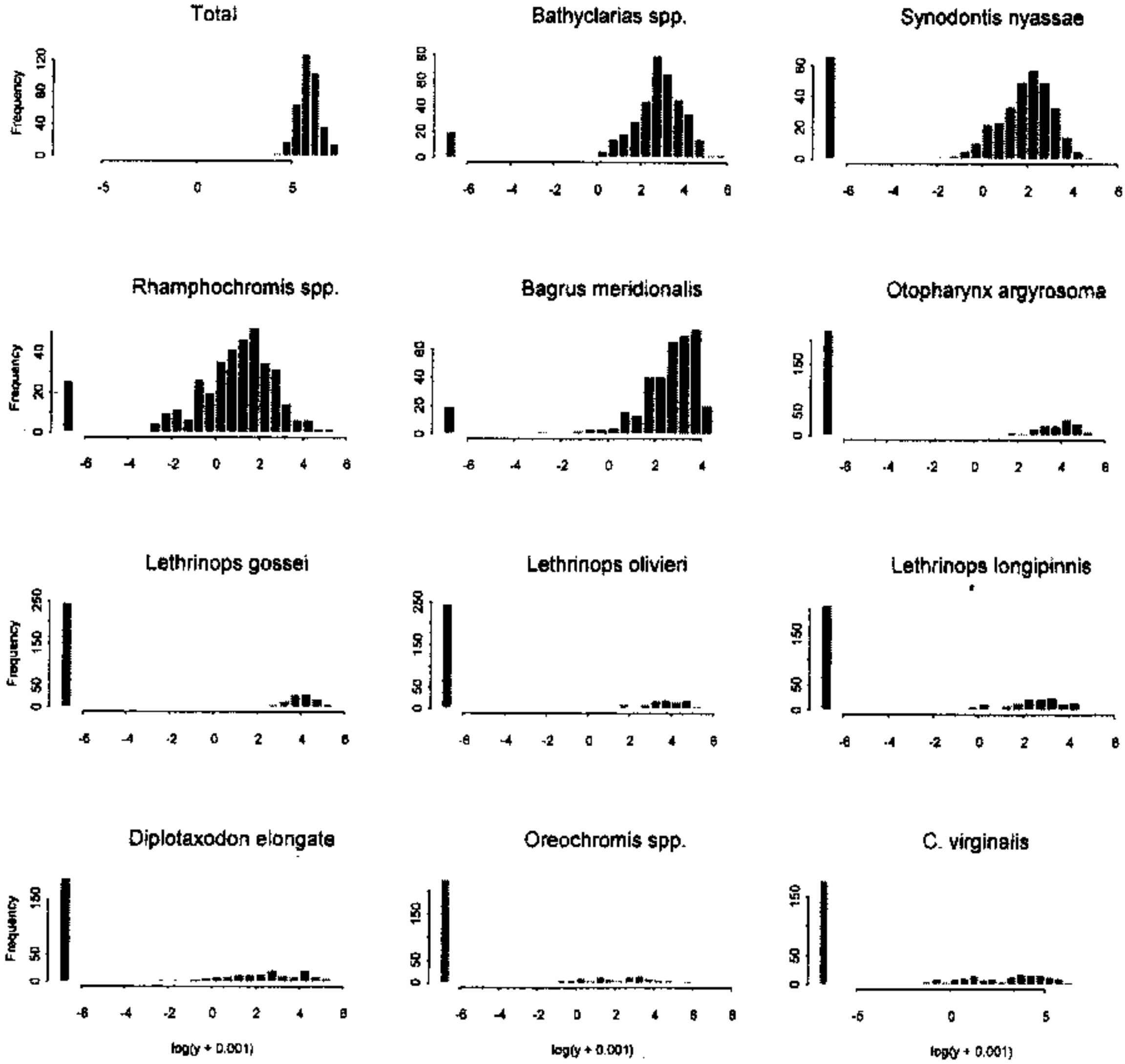
The same taxonomic entities are shown in Fig. 10 where the CPUE has been logged and shifted slightly, in order to see whether zero values and positive values form a natural

Fig. 9. Histograms of basic CPUE values for selected species
Number of zero values in parentheses



whole or two distinct entities. It is evident that zero values are not part of the distributions of non zero values. The positive values of some of the distributions are fairly close to a normal distribution mode, indicating a lognormal distribution pattern. This is the case for *Bathyclarias spp.*, *Bagrus meridionalis*, *Lethrinops gossei* , *Synodontis nyassae* and the total catch. Other taxonomic entities are rather far from a normal distribution pattern. Clearly, the number of zero values differs markedly.

Fig. 10. Histograms of logged CPUE values for selected species

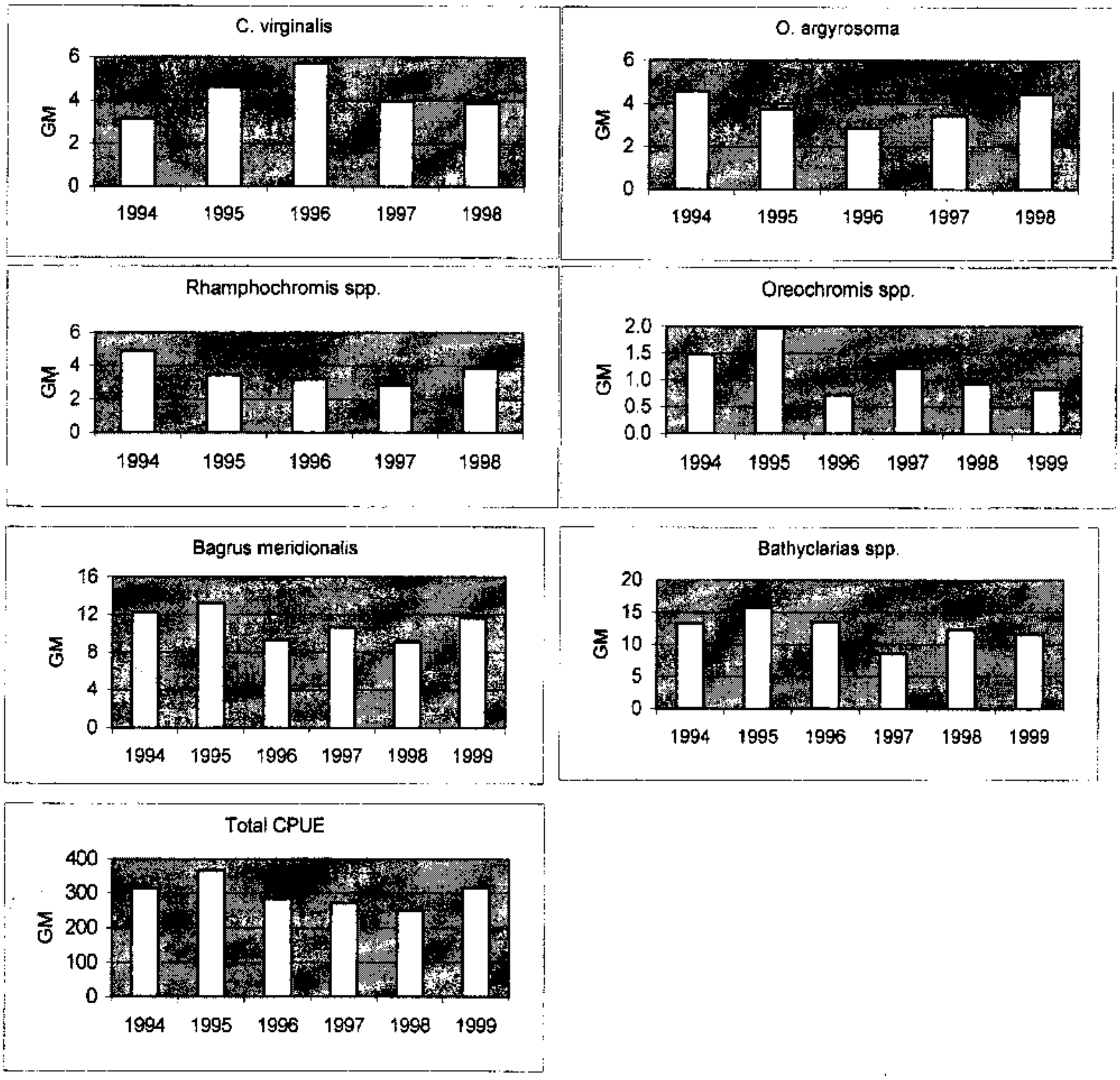


6. Stock size indices 1994-99

As explained in previous sections log-transformed CPUE values seem to behave better in statistical terms than non-transformed data. Thus, a geometric mean CPUE appears to lend itself better as an estimator of stock size than the arithmetic mean. The GM is obtained by calculating the mean across stations (s) of the log-transformed values and backtransforming that mean by taking the antilogarithm and subtracting 1, i.e.:

$$GM = 10^{\frac{1}{n}\sum_{s=1}^{n}\log(CPUE_s+1)} - 1$$

Fig. 11. Stock indices (geometric mean - GM) of selected taxonomic entities and total CPUE in monitoring surveys 1994-99



The results are shown in Fig. 11 and table 2 for selected taxonomic entities and total CPUE. All surveys (stations) in a given year are treated as one data set (pooled data). Different taxonomic entities show differing trends. *C. virginalis* and *B. meridionalis* have remained fairly stable over the period, whereas *O. argyrosoma* and *Rhamphochromis spp.* have even increased in the last one or two years. *Bathyclarias spp.* and, in particular, Oreochromis *spp.*, on the other hand, have declined. The total CPUE showed a declining trend during 1995-98 but increased again in 1999 to previous level. As shown in table 2, standard deviations are low for *B. meridionalis*, *Bathyclarias spp.* and total index but high for other taxonomic entities. It should be noted that there is a close correlation between the GM-index and the arithmetic mean CPUE. However, standard deviations are much higher for the latter index.

The stock indices of the two catfish taxonomic entities are currently similar or around 10. However, the stock index of chambo is only around 1 which seems low compared to the catfish indices and the fact that chambo catch is considerably larger than that of the catfishes. A possible explanation to this may be found in the different distribution patterns of these taxonomic entities. The catfish are relatively evenly distributed throughout their entire depth ranges whereas chambo is confined to the shallowest 50 meters (Fig. 4). There is reason to believe that a marked proportion of the chambo stocks may be above the minimum depth at which the monitoring survey can be effectively conducted, i.e. 10 m, or in the pelagic zone above the headline of the trawl, thus resulting in a lower stock index that otherwise would be anticipated. In spite of this, and the limited precision, the index may still be a useful indicator of chambo stock size. This, however, can only be verified by a longer time series in comparison to reliable stock estimate, such as age dependent stock assessment.

Table 2. Geometric mean indices of selected species/groups and total CPUE in monitoring surveys in SE- and SW-Arms 1994-99 (standard deviation in parentheses).

Year	Bathyclarias spp.	Bagrus meridionalis	Oreochromis spp.	C. virginalis	O. argyrosoma	Rhamphochromis spp.	Total CPUE
1994	16.1 (3.0)	12.2 (2.1)	1.5 (3.8)	3.2 (6.8)	4.6 (6.5)	4.9 (2.5)	314.9 (0.9)
1995	15.7 (2.2)	13.2 (2.1)	2.0 (4.5)	4.6 (7.5)	3.7 (6.1)	3.5 (2.1)	365.9 (0.8)
1996	13.5 (2.1)	9.3 (2.5)	0.7 (2.7)	5.7 (8.4)	2.9 (5.7)	3.2 (2.3)	283.5 (1.1)
1997	8.5 (2.7)	10.6 (2.1)	1.2 (3.6)	4.0 (6.9)	3.4 (5.0)	2.8 (1.9)	271.0 (0.9)
1998	12.3 (1.9)	9.1 (1.8)	0.8 (2.8)	3.9 (5.9)	4.5 (5.6)	3.9 (2.3)	249.3 (1.0)
1999	11.4 (2.0)	11.7 (2.0)	0.8 (2.1)				315.7 (0.8)

7. Management considerations

The scientific basis of fisheries management in Malawian waters must be classified as weak. Catch-effort data are available since 1976 for most waterbodies, but this data is considered as unreliable, especially for recent years, due to logistic constraints in the data collection. In addition, processing and analysis of the data is slow and results are released too late to be incorporated into current management decisions. Thus, catch and effort statistics for 1997 and 1998 are still not available in mid 1999 for the traditional fisheries in Lake Malawi. However, for Lakes Malombe, Chilwa and Chiuta results for 1997 and 1998 are available in mid 1999, although catch records were not collected in all minor-strata in Lakes Chilwa and Chiuta. Results for 1997 are available for the commercial fisheries but not the results for 1998.

In the absence of up-to-date catch and effort data, alternatives must be sought in fisheries independent data, i.e. results of standardized fish surveys. The demersal monitoring survey is the only survey of this kind which has been conducted over some period of years. The survey is limited to a relatively small area of southern Lake Malawi. However, this area has been found to be the most productive part of the lake and fishing effort is relatively high (Banda and Tomasson 1997). No time-series survey results are available for other waterbodies.

The monitoring survey is conducted with a bottom trawl and, hence, is considered to target mainly demersal, or semi-demersal, fish stocks. Thus, survey data might be used as an estimator of demersal fish abundance. Fisheries in southern Lake Malawi are regulated on a depth basis, primarily in order to maintain a physical separation of the three main fisheries. The commercial, stern trawler fishery, is confined to waters deeper than 50 m. The pair trawling semi-commercial fishery is supposed to be carried out below 18 m and down to 50 m. However, it is assumed that pair trawlers are also exploiting shallower waters. The traditional fishery is mainly confined to the shallowest part of the area, i.e. down to approximately 20 m.

As a first appoach, survey results from waters below 50 m could be taken as an estimator of the stocks exploited by the commercial demersal fishery. Results from shallower waters, on the other hand, would be used to estimate stocks exploited by the semi-commercial fishery.

7.1. The commercial demersal fishery

Since 1994 only 2 vessel have participated uninterrupted in the commercial, demersal fishery, i.e. Kandwindwi and Ndunduma. F.H. Fatch has not participated since 1995 and D. Sanudi took part in 1994 and 1996. In 1998 a new vessel, Nchenga, entered the fishery. Some figures related to this fishery are summarised in Table 3 and shown in Figs. 12 and 13.

Table 3. Catch (tons), effort (boat-days) and CPUE (tons/day) of the commercial, demersal fishery in area B and C of Lake Malawi. Monitoring survey GM-index of total CPUE in waters deeper than 50 m in areas B and C.

Year	Catch	Effort	CPUE	GM-index
1994	1101	423	2.6	326
1995	1512	420	3.6	345
1996	734	351	2.1	307
1997	1283	330	3.9	373
1998	1279 *	360 *	3.6 *	235
1999				351

* preliminary for Kandwindwi. Nchenga not included.

Catch has fluctuated considerably and effort has been lower in recent years than in 1994-95. CPUE has fluctuated in line with catch and these values are linearily correlated (Fig. 12). GM-index has been relatively stable except for 1998 when a low value was recorded. The GM-index is neither correlated to catch nor CPUE. In view of the GM-index, the status of fish stocks would be regarded as stable and no apparent need is seen for precautionary management actions.

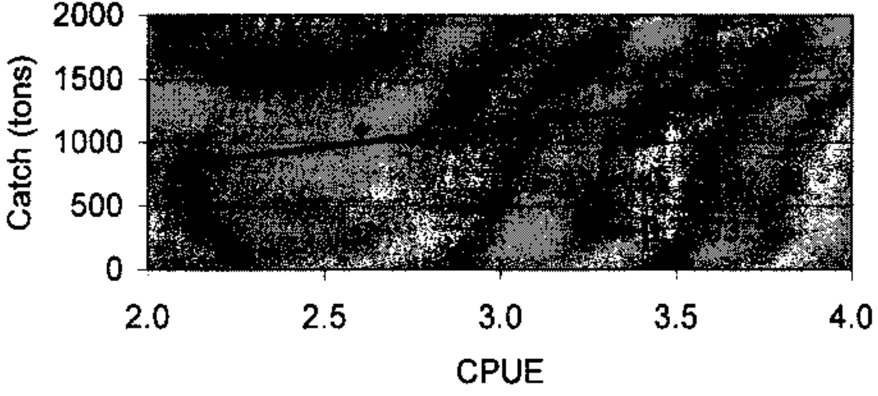


Fig. 12. Commercial demersal catch vs. CPUE in areas B+C

7.2. The semi-commercial fishery

Since 1995 the pair-trawling, semi-commercial fishery, has been conducted in areas A and D only. In area A, 4 units have participated in the fishery since 1994 and 5 units in area D. Some relevant figures are given in Tables 4 and 5 and shown in Figs. 13. and 14.

Table 4. Catch (tons), effort (boat-days) and CPUE (tons/day) of the semi-commercial fishery in area A. Monitoring survey GM-index of total CPUE in waters shallower than 50 m in area A.

Year	Catch	Effort	CPUE	GM-index
1994	792	623	1.3	408
1995	1144	661	1.7	589
1996	608	509	1.2	372
1997	736	683	1.1	364
1998	641	492	1.3	385
1999				279

Table 5. Catch (tons), effort (boat-days) and CPUE (tons/day)) of the semi-commercial fishery in area A. Monitoring survey GM-index of total CPUE in waters shallower than 50 m in area D.

Year	Catch	Effort	CPUE	GM-index
1994	1463	1145	1.3	383
1995	931	877	1.1	382
1996	500	455	1.1	403
1997	625	468	1.3	183
1998 *				304
1999				231

* Catch and effort only recorded in Jan.-April. Raising to the whole year not feasible.

In area A, catch, CPUE and GM-index have been relatively stable except in 1995 when a large increase was recorded. The GM-index declined markedly in 1999. Effort has fluctuated without a trend. Rather close correlation is observed between GM-index and catch as well as GM-index and CPUE (Figs. 13 and 14). However, this correlation depends mainly on the high 1995 values. The semi-commercial fishery in area A appeared to be stable in 1994-98, as indicated both by the CPUE of the fishery and the GM-index of the monitoring survey in the area. However, the declining GM-index in 1999 may indicate a deteriorating status of the fish stocks. Therefore, the fishery should be monitored closely through annual surveys.

Fig. 13. Semi-commercial catch vs. GM-index in area A

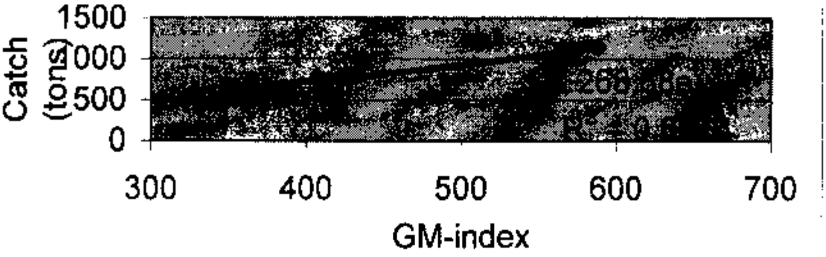
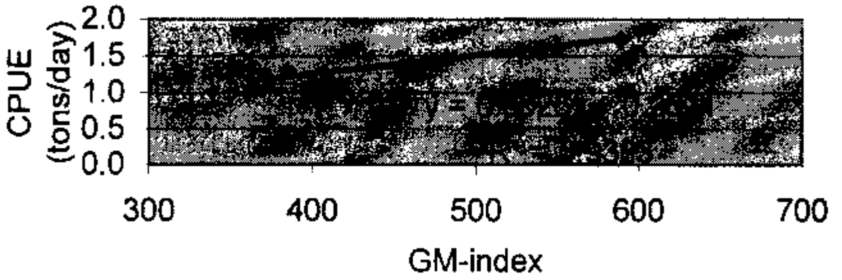


Fig. 14. Semi-commercial CPUE vs. GM-index in area A



In area D, catch and effort declined markedly in recent years but CPUE remained stable, eventually due to decreased effort. GM-index was stable in 1994-96 but markedly lower and fluctuating in recent years. Neither catch nor CPUE are correlated to GM-index. The decline in GM-index in area D since 1997 gives reason for concern and the fishery should be monitored closely.

The issue of the maximum sustainable yield (MSY) was analyzed by Tweddle and Magasa (1989) for the demersal, trawl fishery in area A, based on catch-effort data 1968-85. They arrived at a MSY of 1355 tons at an effort of 620 boat days. CPUE was markedly higher in during this period, or 1.5-4.5 tons per boat day with an average of approximately 2.5 tons per day. This is close to twice the current CPUE in area A (Table 4). Current effort, however, is close to the recommended effort or 600 boat days on average during 1994-98.

7.3. Traditional fisheries

Only 3 years of catch data (1994-96) are presently available from the traditional fishery in southern Lake Malawi for comparison with the results of the monitoring survey. This time series is too short for a meaningful comparison. The question also arises whether trawl survey results are likely to shed much light on trends in fish stocks exploited by traditional fishers.

The species composition in the traditional fishery in Lake Malawi is generally considered to be different from that of the commercial fishery and, hence, from that of a trawl monitoring survey. An attempt is made to quantify the overlap between these fisheries, based on comparison between lake wide Shallow Water Survey data collected in November 1997 and lake wide Traditional Gear Survey data collected in November 1998. The shallow water data were collected on the RV Ndunduma using a demersal trawl. The data of the traditional survey were collected from traditional gears of the artisanal fishery, along the shore of Lake Malawi. Thus, the traditional survey represents the catch composition of the traditional fishery, whereas the shallow water survey represents the catch composition of a commercial, stern trawler fishery conducted in shallow waters of less than 50 m.

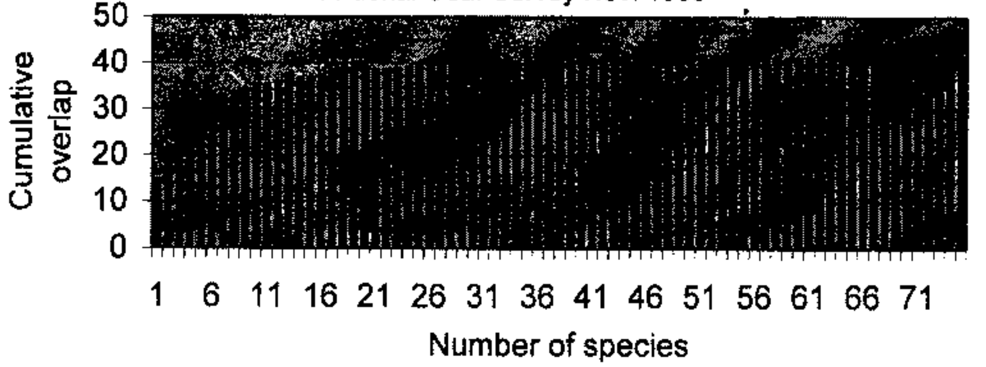
Some results of this comparison are summarised in table 6. Out of a total of 144 identified taxonomic entities, 75 (52.1%) were found in both surveys.

Table 6. Comparison of species overlap in Shallow Water Survey and Traditional Gear Survey.

Survey	No. of species	No. spp. overlapping	No. spp. not overlapping
Shallow Water	113	75	38
Traditional Gear	106	75	31
Both Surveys	144	75	69

A more useful method of quantifying the overlap between the surveys is to compare the relative catch composition (% weight) and calculate the overlap for each taxonomic entity occurring in both surveys. E.g., if species a contributes 3% to the catch of survey A and 10% to the catch of survey B, then the overlap is 3%, i.e. the lower value represents the overlap. The resulting cumulative overlap of all common taxonomic entities is 41.3% of the total catch. That is, less that half the relative catch consists of taxonomic entities found in both surveys.

Fig. 15. Cumulative overlap in relative catch composition between Shallow Water Survey Nov. 1997 and Traditional Gear Survey Nov. 1998

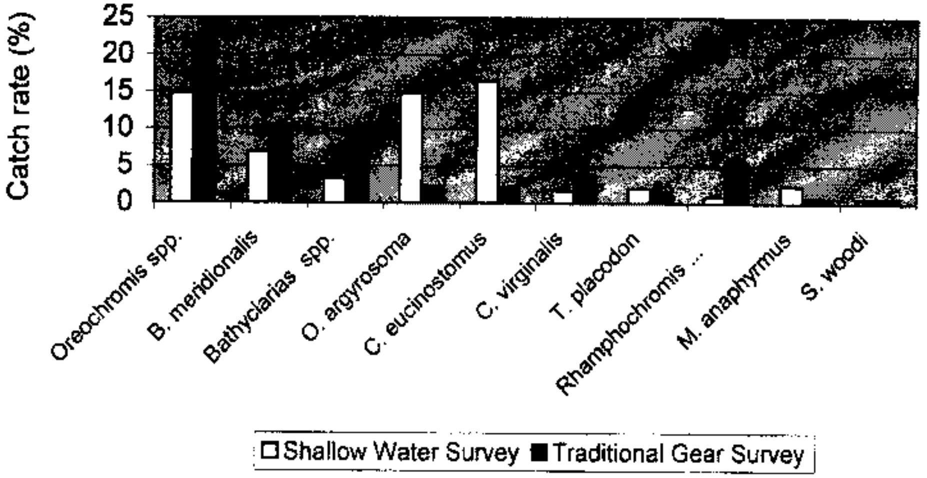


However, the overlap varies greatly between taxonomic entities, as shown in Fig. 15. Most of the overlap is generated by 5 species/groups, or 29.5% out of the total of 41.3%. Of these *Oreochromis spp.* contributes most to the overlap or approximately one third (14.8% out of 41.3%), followed by *B. meridionalis* (6.9%), *Bathyclarias spp.* (3.3%), *O. argyrosoma* (2.3%) and *Copadichromis eucinostomus* (2.2%).

The catch composition of 10 taxonomic entities contributing most to catch overlap is shown in Fig. 16. It is seen that *O. argyrosoma* and *C. eucinostomus,* although abundant in the Shallow Water Survey, contribute not correspondingly to the overlap since they are not very abundant in the Traditional Gear Survey. The outstanding contribution of chambo to the catch in both fisheries is evident. Thus, although more than 40% of the catch composition is common to both surveys, indicating a fairly high degree of overlap between traditional and commercial fisheries, relatively few species/groups generate most (2/3) of the overlap, whereas around 70 taxonomic entities yield the remaining 1/3 of the catch composition. In other words, the overall overlap seems fairly high, but relatively few taxonomic entities seem to be significantly involved in a potential struggle between traditional and commercial fisheries. Nevertheless, those few species/groups are among the highest valued fish in Malawian waters.

Overall it would appear that trawl survey data may not yield meaningful results on trends in fish stocks exploited by traditional fisheries, except perhaps for stocks of major importance to both fisheries, such as chambo and kampango and, eventually, bombe. Therefore, monitoring of most traditional fisheries must be conducted using other means than trawl surveys.

Fig. 16. Ten taxonomic entities contributing most to catch overlap



7.4. Catch control laws

In theory, the results of the monitoring survey might be be applied as input data for simple catch control law to regulate the commercial and semi-commercial fisheries. However, the time series of the survey is still very short and further data would be preferred. The following, simple form of catch control law can be applied if a time series of catch and monitoring survey index is available (Source: ICES 1997):

$$Y_t = Y_{t-1}\left[1+g\left(\frac{B_{t-1}-B_{t-2}}{B_{t-2}}\right)\right]$$

Where Y is the catch (in year t and t-1) and B the survey index (CPUE); g is a feedback gain term, defining the proportion of the biomass change (increase/decrease) which is translated into catch. Such a rule, however, might not produce very satisfactory results since it might respond too late to changes in biomass. This has to be analyzed based on further data before any such rule can by applied.

If survey index results could be converted into absolute biomass, catch statistics would not be needed, but catch would be some conventional function of biomass. Depletion fishing experiments should be conducted to establish a raising factor which could, data, and the monitoirng survey in southern Lake Malawi, no means of monitoring the traditional fisheries have been established so far. Currently work is underway aiming at improving the quality of the traditional catch and effort data collected in Malawian waters. This work should lead to improved reliability of the data in terms of fisheries management.

In 1998 a demersal, exploratory survey was conducted in central and northern Lake Malawi. This suvery was carried out in a similar fashion as the monitoring survey in the southern part of the lake. Such a survey should be carried out annually in order to monitor the status of stocks in this part of the lake. The results might yield important comparison between the different areas which are subject to different exploitation pressure. It would also give indications on the fishing potential in this part of the lake.

Monitoring survey data are not expected to yield useful information on trends in total biomass of the traditional fishery. However, the survey might be indicative of trends in important traditional stocks such as chambo, kampango and bombe as far as southern Lake Malawi is concerned. In addition, there is still need for further means of monitoring the traditional fish stocks in other areas of Lake Malawi as well as in other waterbodies. Theoretically fisheries independent surveys can be carried out using any gear. The choice of gear must depend upon the likelihood of obtaining useful results in view of target species and other relevant issues.

As seen in section 7.3 a considerable part of the traditional catch in Lake Malawi is provided by 3 species, i.e. chambo, kampango and bombe, which yield approximately 42% of the catch. These species are mainly caught in gill nets. Thus, it appears feasible to monitor the size of these fish stocks by experimental gill net fishing in selected areas of the lake. Such fishing experiments should be carried out annually during certain seasons using gill nets of different mesh sizes. A gill net survey would be expected to yield useful data for the expoitable stock, whereas others methods, e.g. beach seines, might be more suitable to assess the size of incoming year classes. Catch rates would be used as indices of stock sizes of the stock components covered by the surveys.

Similar experiments should be carried out in other waterbodies, such as Lakes Malombe, Chilwa and Chiuta, using appropriate gears. Surveys of this kind would be expected to be particularily applicable to the smaller waterbodies, which can be covered on a lake wide basis with a relatively limited effort.

In summary, monitoring surveys are recommended along the following lines:

Waterbody	**Survey gear**	**Target species**	**Number of stations/sets**
Southern Lake Malawi	Bottom trawl	Demersal stocks	95
Central and northern Lake Malawi	Bottom trawl	Demersal stocks	100
Lake Malawi (selected areas)	Gill nets	Chambo, Kampango, Bombe	
Lake Malombe	Gill nets	Chambo	
Lake Malombe	Nkacha	Kambuzi	
Lake Chilwa	Gill nets /traps?	Matemba, Makumba, Mlamba	
Lake Chiuta	Gill nets	Makumba	

8. Conclusions

Catch data collected during the monitoring survey in southern Lake Malawi 1994-99 reveal a high degree of variability in basic CPUE values of all fish stocks. The variability, and hence standard deviation, can be reduced considerably for some stocks through log-transformation of the data. This is particularity the case for the widely distributed catfish, *B. meridionalis* (kampango) and *Bathylarias spp.* (bombe), as well as for total catch. Standard deviations for other stocks remain high and stock trends for those species may be difficult to assess with reasonable precision. This is not least the case for *Oreochromis spp.* (chambo), the most important Malawian fish stock, which happens to be in a state of serious depletion in Lake Malawi and in a state of collapse in Lake Malombe.

Although the monitoring survey has been carried out over a period of 6 years, the time series is still too short to warrant a clear judgement of its applicability as a basis for fisheries management. Apparently, however, total CPUE indices are most likely to be of some value as indicators of the status of deep water commercial, stern trawler fisheries. They might also be of some use as indicators for the semi-commercial pair trawler

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