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Demersal exploratory fishing and research survey in central and northern Lake Malawi 1998

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DEMERSAL EXPLORATORY FISHING AND RESEARCH SURVEY IN CENTRAL AND NORTHERN LAKE MALAWI, 1998

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Abstract e001006v

Data from exploratory bottom trawling were used to define demersal fish stocks of central and northern Lake Malawi in terms of abundance by genus, species, depth and area. The number of species generally declines with increasing depth however mean catch rates are not affected by changes in depth and number of species. Estimates for potential yield and number of trawlers (88 hp and 386 hp engine power) required to exploit the stocks in various areas of the lake are presented.

1.0 Introduction

Experimental trawling, which began in southern Lake Malawi in 1965, revealed the existence of large stocks of demersal fish. These experiments eventually led to the establishment of the commercial trawl fishery in 1968 which then rapidly expanded (Tweddle *et al*, 1992). As the trawl fishery intensified, large changes in species composition were observed. Large cichlid species mostly belonging to the genus *Lethrinops*, the clariid catfishes and *Bagrus meridionalis* greatly declined in abundance. This decline was followed by a corresponding increase in small cichlids most of which were *Otopharynx spp.* and *Pseudotropheus spp.* (Turner, 1976).

Since then the commercial trawl fishery has experienced unprecedented improvement through the acquisition of more powerful vessels. As of now, all the stern trawlers operate in the South East arm of Lake Malawi. The stocks in these areas, especially Area B, have already shown signs of over-exploitation as is evidenced by the steady decline of catches (Resource Report, 1999-in press). This clearly indicates that the stocks in some of these areas can not sustain the current demand and as such alternative fishing grounds must be sought so that the pressure being exerted on the stocks is reduced. Moreover, this will enable the fisheries sector to sustain the supply of the much-needed animal protein to the nation.

Objectives

Therefore the main objectives of this survey were:

i) To assess the feasibility for a commercial fishery in central and northern Lake Malawi.
ii) To map up trawlable grounds and
iii) To increase the knowledge base of the resource.

2.0 Materials and Methods

2.1 Materials

The survey was conducted in April-May 1998 using the Fisheries department's research vessel the R.V. Ndunduma, an 18 metre stern trawler which is powered by a 386 HP caterpillar engine. The trawl used through out the survey was the Gulltoper bottom trawl net with a 38 mm mesh codend, and a 100 mm mesh in the wings. The gear has a headrope of 23 metres, a horizontal openning of 14.7 m and a vertical opening of about 4 metres. Trawling speed averages about 3.5 nautical miles per hour.

2.2 Methodology

2.2.1 Sampling sites

A total of 99 stations were sampled from the Chipoka (southwest arm) to Songwe in Karonga (Table 1). These sampling sites are shown on Charts 1, 2 and 3 of Lake Malawi. The hundred-metre depth contour line is also shown on the charts. A Global Position System (GPS) model GP 1290 was used for fixing the position of shooting and hauling for each station. Of interest in this survey was the depth ranging from 50m and deeper. This is the depth range that is designated to deep-water stern trawlers.

Table 1: Showing the number of Stations sampled in each sub-area.

Area	Stations
F (SWA) Off Chipoka	6
Kambiri/Kacherenje	5
Off Sungu spit(salima)	3
Off Lifuwu	4
Mbenje south	4
Mbenje north	3
Off Nkhomo	7
Sani south/off chia	2
Off Nkhotakota	3
Off Liwalazi	6
Dwangwa	6
Bana	7
Off Kande	6
Bandawe/off Chintheche	8
Off sanga/Nkhatabay	5
Ngara	6
Chiondo/off Mlare	6
Off Karonga	6
Ngerenge/Kaporo	6
Total	**99**

Chart 1: Survey Areas for Northern Lake Malawi

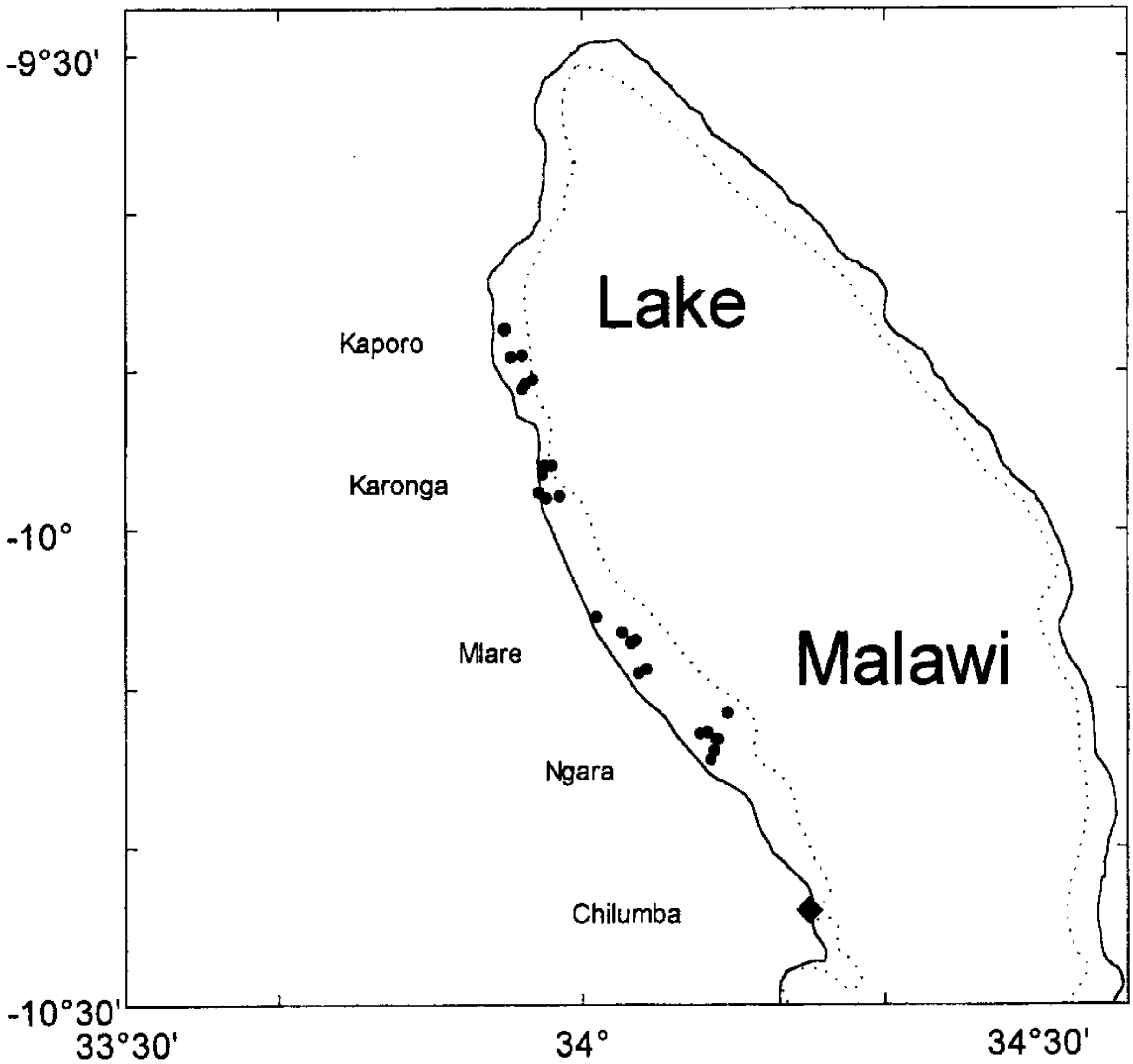


Chart 2: Survey Areas for Central Lake Malawi

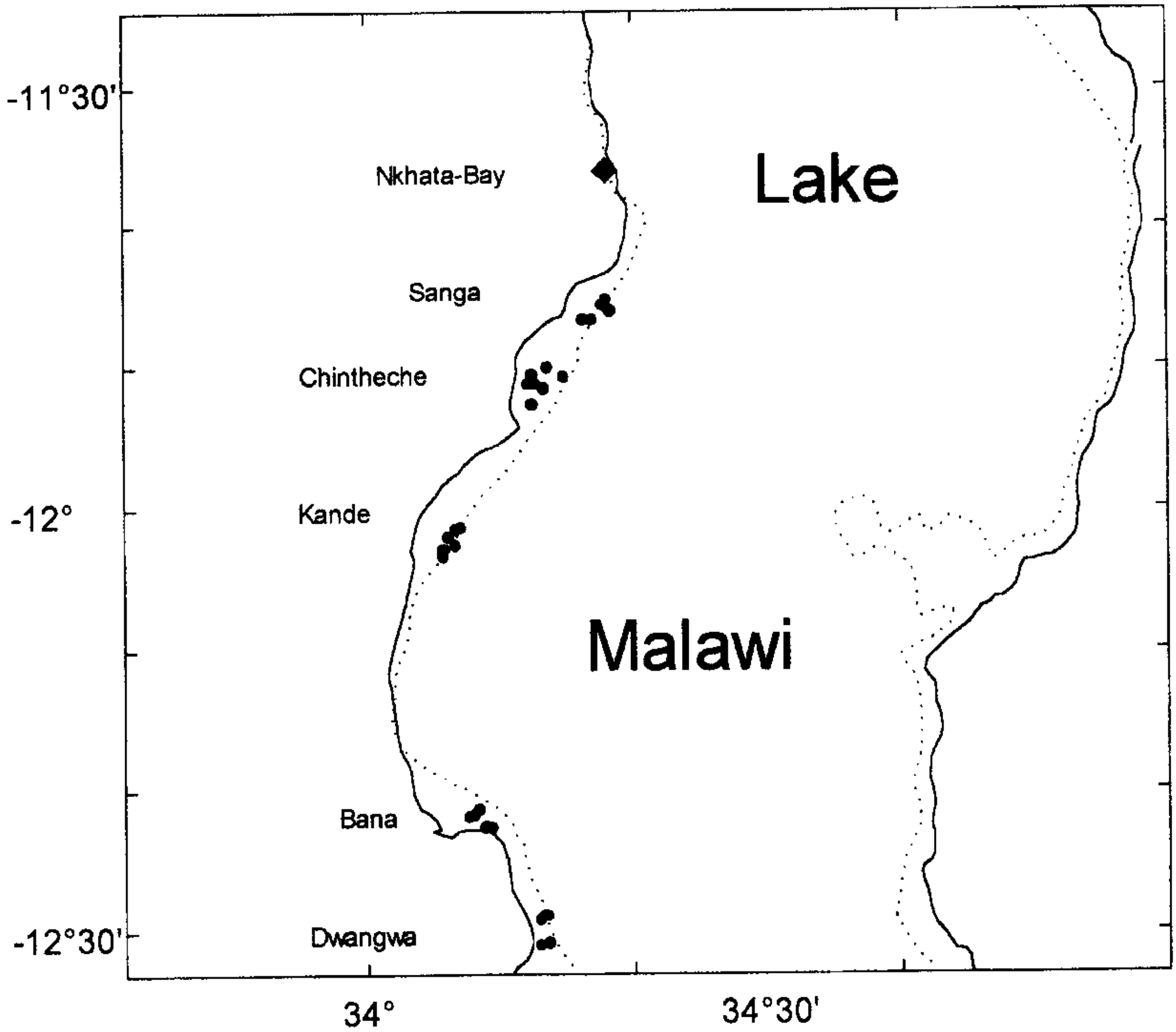
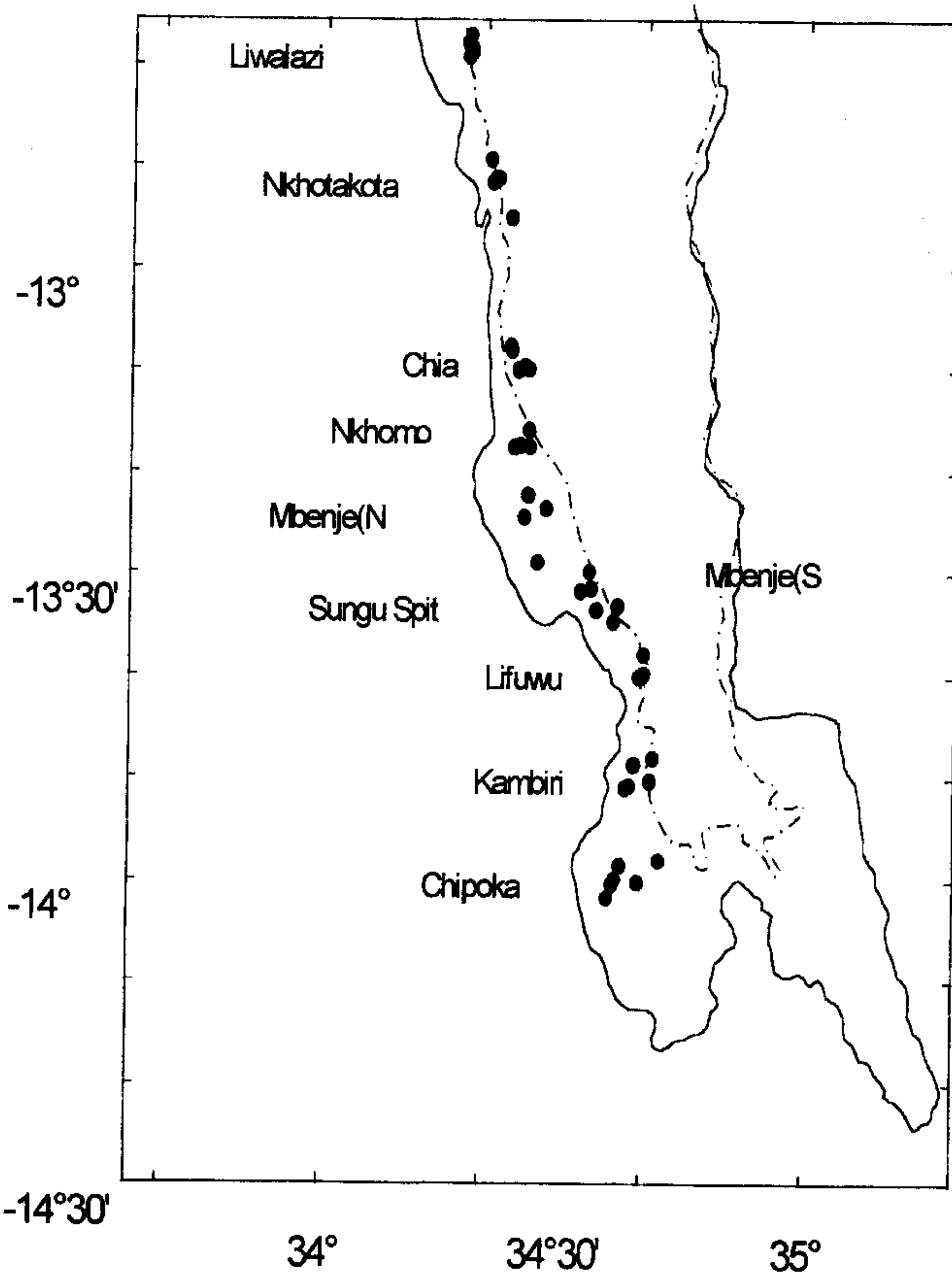


Chart 3: Survey Areas for Southern Lake Malawi



2.2.2 Catch Analysis

For all trawls, the catch was divided on deck into four categories namely; Small fish (mainly cichlids but also including *Synodontis njassae*), *Bagrus meridionalis*, Clariid catfishes and all big cichlid and non-cichlid fishes. Each category was sorted into species, length measured and weighed. From this data estimates of the percentage composition of the catch at genus down to species level were made. Depth distribution of each genus and its composite species was also analysed. Biomass for each trawling area was estimated from the mean catch of several half hour hauls in the area multiplied by the ratio of total fishing area to area covered by the trawl, using the swept area method as described below: (Sparre *et al*, 1989).

Area Swept per standard haul, a = D*h*x2, D = V*t

where V is velocity of the trawl over the ground when trawling, h is head rope length, t is trawling time, x2 is that fraction of the head-rope which is equal to the width of the path swept by the trawl, the 'wing spread', h * x2.

For the R.V. Ndunduma, the above variables become:-

V (nm) = 3.5
t (hrs) = 0.5
h (head rope, nm) = 0.01242
x2 (fraction) = 0.639
Area per haul (nm sq) = 0.0139

3.0 Results

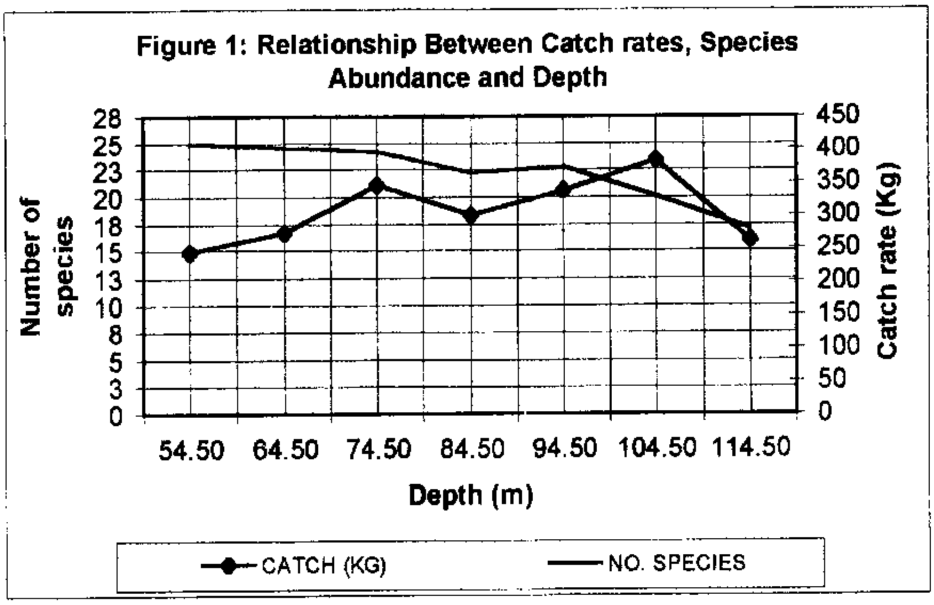
3.1 Species Distribution

Table 2 below presents a summary of the number of sampling stations, species caught and the average catch for half-hour pulls for each depth interval.

Table 2: A Summary of the number of species, catch rates and species % abundance in relation to depth.

Depth (m)	No. of Species	Catch (Kg/0.5 hr)	% Abundance	No. of Stations
50-59	25	244.64	16	20
60-69	25	272.46	16	15
70-79	24	344.99	15	18
80-89	22	299.04	14	18
90-99	23	337.79	15	12
100-109	20	383.74	13	14
110-119	17	263.06	11	2

There was generally a decline in number of species sampled with depth increase. The number of species decreased from 25 in the 50-59 m depth interval to 17 in the 110-119m depth interval (Table 2 and Figure 1 below). This negative relationship was significant at the 5% level ($P<0.05$, $r = 92\%$). However, there was no significant difference ($P >0.05$) in mean catch rates with changes in number of species and depth. This suggests that there was generally no relationship between catch rates or catches with changes in number of species.



3.2 Catch Composition by Genus

Tables 3a & 3b below present a summary of the catch composition by genus. From Table 3a and Figure 2, it is observed that the genus *Lethrinops* was the most abundant with an overall composition of 41.56%, followed by *Synodontis* 13.34%, *Bagrus* 8.18%, *Diplotaxodon* 7.98%, *Copadichromis* 7.02%, *Alticorpus* 5.19%, *Bathyclarias* 5.06%, *Aulonocara* 4.01%, *Rhamphochromis* 2.12% and *Otopharynx* 1.62%. The genera listed in Table 3a are the most important in deep and very deep waters. The less important ones (contribution of less than 1%) are shown in Table 3b below.

Table 3a: Major genera constituting more 1% of the total Catch for the whole survey.

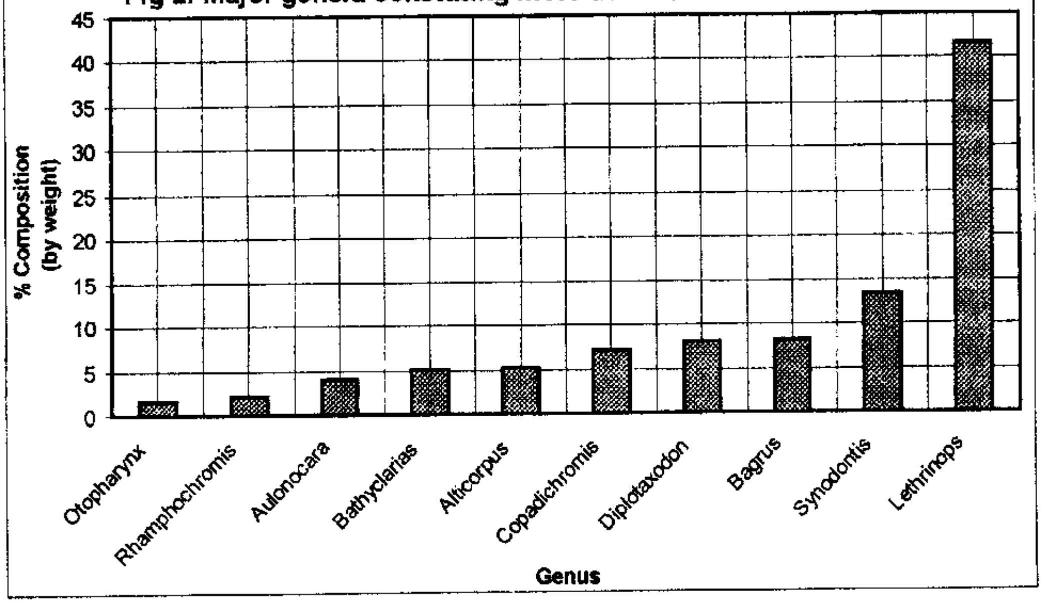
Genus	% Composition
Lethrinops	41.56
Synodontis	13.34
Bagrus	8.18
Diplotaxodon	7.98
Copadichromis	7.02
Alticorpus	5.19
Bathyclarias	5.06
Aulonocara	4.01
Rhamphochromis	2.12
Otopharynx	1.62

Most of these genera, like *Opsaridium, Mormyrus, Aristochromis, Docimodus* and *Caprichromis* are quite rare in L. Malawi, while some like *Maravichromis, Buccochromis, Ctenopharynx, Barbus, Taeniochromis* and *Taeniolethrinops* are relatively more abundant in shallow waters (<50m) than in deep waters (>50m).

Table 3b: Genera constituting less than 1% of the total Catch for the whole survey.

Genus	% Composition
Sciaenochromis	0.76
Opsaridium	0.64
Maravichromis	0.56
Buccochromis	0.51
Mormyrus	0.33
Flatjaw	0.26
Placidochromis	0.23
Haplochromis	0.14
Ctenopharynx	0.11
Stigmatochromis	0.10
Hemitaeniochromis	0.09
Barbus	0.05
Taeniolethrinops	0.04
Aristochromis	0.01
Taeniochromis	0.01
Nimbochromis	0.01
Docimodus	0.01
Caprichromis	0.01

Fig 2. Major genera constuting more than 1% of the total catch



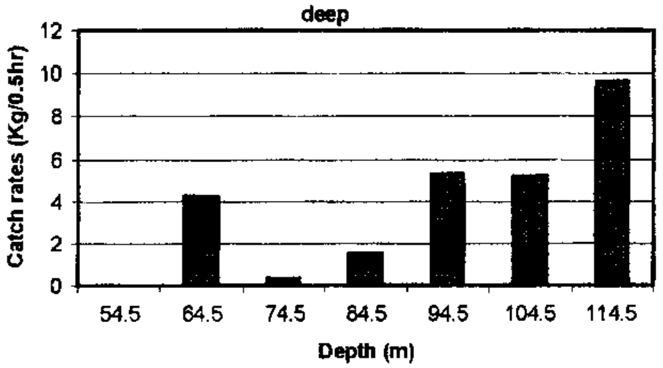
In several genera, there was great variability in species composition with changes in depth. In most cases there were marked preferences for certain depth ranges while in others no such preferences were discernible. Presented below is a summary of the composition of each genus and its constitution in the total catch. The depth distribution pattern for each genus is also presented where deemed important. The genera have been arranged alphabetically.

The genus *Alticorpus* constituted about 5.19 % of the total catch. The catch rate for the genus increased with increase in depth though not significant (P> 0.05, r = 11.31 %). Banda and Tomasson (1996) also found that the catch rates tended to increase with increase in depth. Basically these observations suggest that most members of the genus *Alticorpus* if not all, prefer deeper waters (>50m). Within the genus, *Alticorpus geoffreyi* contributed the highest about 54.5%, *A. mentale* 32.8%, *A. pectinatum* 7.9%, and *A. macrocleithrum* 4.8%. All members of this genus attain relatively large adult sizes. *A. geoffreyi* and *A. mentale* are the most abundant species.

In the genus *Aulonocara*, there was a significant increase in catch rates with increase in depth (P < 0.05, r = 61.98%). Similar findings were also reported by Banda and Tomasson (1996). The genus as a whole contributed about 4.01% to the total catch of which the highest was *A. minutus* with about 21.1%, *A. rostratum* and *A. rostratum* deep contributed 20.0% each, *A. dark* 13.8%, *A. long* and *A. guentheri* about 6.7% each. *A. pyramid, A. macrochir* and *A. brevirostris* contributed 1.09%, 1.91% and 2.34 respectively. Most members of this genus attain relatively small adult sizes.

At species level, only *A. rostratum* 'deep' showed significant preference ($P < 0.05$, $r^2 = 65.60\%$) for deeper waters as shown in Figure 3 below.

Fig 3. Trends in Catch rates for *Aulonocara rostratum* deep



The genus *Bagrus* constituted about 8.18% of the total catch. In Malawi *Bagrus meridionalis* is the only member of this genus. There was significant decrease in catch rates with increase in depth ($P < 0.05$ $r^2 = 57.45\%$). Banda and Tomasson (1996) also found that catch rates decreased with increase in depth and they found that the highest catch rate was attained in 0-50m depth range.

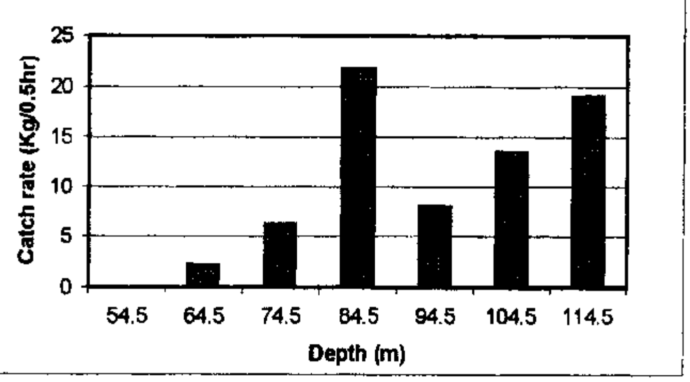
The genus *Bathyclarias* contributed about 5.06% of the total catch. Due to taxonomic problems all the species were lumped together. The catch rates generally decreased with increase in depth though not significant ($P>0.05$, r = 14.32%). Preferred depth range seems to be the 50 – 100m. Banda and Tomasson (1996) obtained much lower catch rates in the 0 – 50 m than in the 50-100 m depth range.

The genus *Copadichromis* constituted about 7.02 % of the total catch of which 90.39% was *C. virginalis*, 9.37% *C. quadrimaculatus*, 0.23% *C. pleurostigma* and 0.01% *C. trimaculatus*. There was significant relationship between decrease in catch rates and increase in depth ($P < 0.05$, r = 80.08%). Catch rates were found to diminish very quickly for depths greater than 80 m. Banda and Tomasson (1996) observed lower catch rates for C. *virginalis* in the 0 – 50 m than in the 50 – 100 m depth range. The preferred depth range is about 50 – 80 m. In this range *C. virginalis* is by far the most abundant among the *Copadichromis* group.

The overall contribution of the genus *Diplotaxodon* to the total catch was 7.98%. Of this, 54.99% was composed of *D. elongate*, 34.17% *D. 'bigeye'*, 9.78% *D. argenteus* and 1.05% *D. greenwoodi*. There was no significant increase in catch rates with increase in depth ($P > 0.05$, r = 36.68%). Banda and Tomasson (1996) also observed the same increasing trend in catch rates. Basically this suggests that the *Diplotaxodon* group has preference for waters deeper than 60 m. At the species level, as Figure 4 refers below, only *D. 'bigeye'* showed significant preference for waters deeper than 80 m ($P < 0.05$, $r^2 = 57.42\%$).

Among the *Diplotaxodon* group, only *D. greenwoodi* and *D. argenteus* attain large adult sizes. But the most abundant is *D. elongate* followed by *D. 'bigeye'*.

Fig 4. Trends In Catch rates for *Diplotaxodon* 'bigeye'



The contribution of the genus *Otopharynx* to the total catch was 1.62% of which 63.13% was *O. agyrosoma*, 35.52% *O. speciosus*, 1.27% *O. brooksi*, 0.06% *O. selenurus* and *O. auromaginatus* 0.02%. There was significant decrease in catch rates with increase in depth ($P < 0.05$, $r^2 = 68.32\%$). Generally catch rates were very low for depths deeper than

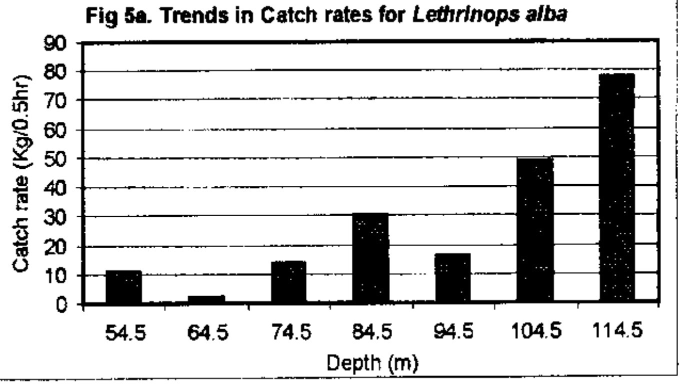
90 m. *O. agyrosoma* seems to prefer waters of less than 80 m deep while *O. speciosus* and *O. brooksi* extend their distribution up to waters of 100 m depth. Banda and Tomasson (1996) also found that *O. agyrosoma* principally inhabits shallow waters (<50m) while *O. speciosus* is mostly a habitant of deep waters (50 -100m) and attains a relatively large adult size. It is a major component of the deepwater group of big cichlids.

The genus *Rhamphochromis* contributed about 2.12% of the total catch. Due to taxonomic difficulties all the various species were lumped together. There were no significant decreases in catch rates with depth increase ($P > 0.05$, $r^2 = 6.86\%$).
The genus *Synodontis* contributed about 13.34% of the total catch. All of which was composed of *S. njassae*. The catch rates generally decreased with increase in depth although not significant ($P > 0.05$, $r^2 = 9.21\%$). The species has a wide depth distribution but is less abundant in very shallow waters and very deep waters. In this survey catch rates as high as 709.0 kg/0.5hr were quite common in Area E and Off Lifuwu. Unfortunately *S. njassae* does not do well on the market.

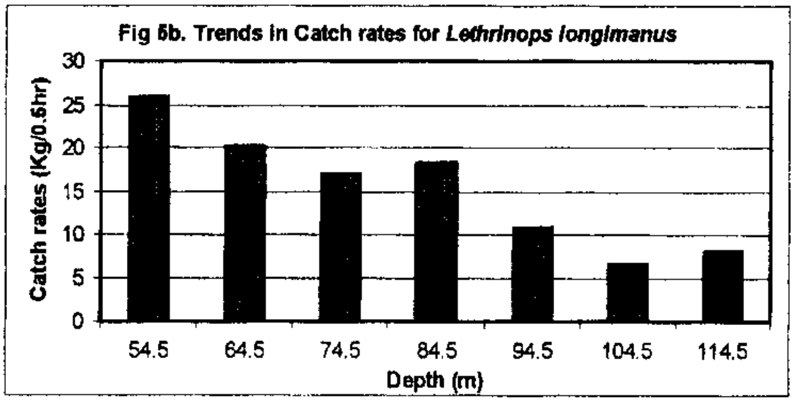
Aristochromis christyi was the only species encountered in the genus Aristochromis. The overall contribution to the total catch was 0.01%. There were significant decreases in catch rates with increase in depth ($P < 0.05$, $r^2 = 80.46\%$). At depths deeper than 80 m, catch rates declined to zero.

The species is quite rare and appears to prefer shallow waters. There is some agreement between these findings and those of Banda and Tomasson (1996) who also observed that catch rates in the 0 –50 m depth interval were much higher than those of 50 m and above.

Fig 5a. Trends in Catch rates for *Lethrinops alba*



The genus *Lethrinops* composed about 41.56% of the total catch of which *L. longipinnis* contributed 30.17%, *L. alba* 15.72%, *L. gossei* 13.05%, *L. longimanus* 12.95%, *L. parvidens* 11.84%, *L. alta* 6.01%, *L. oliveri* 2.90%, *L. dark* 2.11%, *L. minutus* 1.78%, *L. microdon* 1.13% and *L. leptodon, L. polli, L.long, L. stridei, L. mylodon, L. christyi* and *L. matumbai* contributed less than 1% each. There were no significant increases in catch rates with increase in depth ($P > 0.05$, $r = 0.9\%$). This observation probably suggests that members of this genus have a wide depth distribution. Some of which can be classified as shallow water and others as deep water species. At the species level, only *L. alba* and *L. longimanus* showed significant preference for specific depth zones. *L. alba* preferred depths of 70 m and deeper ($P < 0.05$, $r^2 = 74.53\%$) while *L. longimanus* preferred waters of less than 70 m deep ($P < 0.05$, $r^2 = 91.16\%$) as shown in Figures 5a & 5b below respectively. Banda and Tomasson (1996) also found that catch rates for *L. alba* were highest in waters of 100 m and deeper while for *L. longimanus* catch rates were highest in the 50 – 100 m depth range.

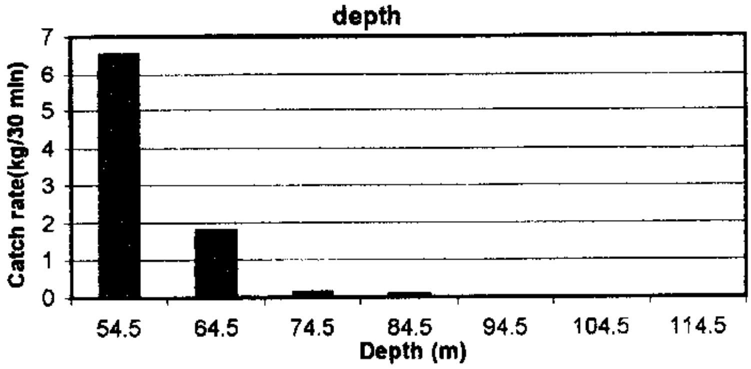


The genus *Barbus* contributed about 0.05% of the total catch of which *B. johnstoni* contributed 75.41%, *B. eurystomus* 15.08%, and *B. litamba* 9.51%. There were significant decreases in catch rates with increase in depth ($P < 0.05$, $r^2 = 77.40\%$). Generally all members of this genus are rarely found in waters of more than 90m deep. Similar findings were obtained by Banda and Tomasson (1996) who also observed higher catch rates in the 0–50 m depth range.

All the species mentioned above attain relatively large adult sizes and are in the medium to large category.

The overall contribution of the genus *Buccochromis* to the total catch was 0.51% of which 93.94% was *B. nototaenia*, 5.44% *B. lepturus* and 0.62% *B. heterotaenia*. There were no significant differences in decreases in catch rates with increase in depth ($P > 0.05$, $r^2 = 54.65$) although the decline was very strong. Neither of the species were caught at depths deeper than 90 m (Figure 6 below). The findings of Banda and Tomasson (1996) indicate that all members of this species prefer shallow waters (0-50 m).

Fig 6. *Buccochromis* spp. catch rates in relation to depth



The genus *Champsochromis* was represented by only *C. caeruleus*. The species was sampled from a single station at a depth of 52.5 m. It is quite rare. The contribution of the genus to the total catch was 0.003%.

The contribution of *Caprichromis liemi* and *Caprichromis orthognathus* to their genus was 85.18% and 14.82% respectively. Contribution of the genus to the total catch was 0.01%. There were no significant decreases in catch rates with increase in depth ($P > 0.05$, $r^2 = 3.74\%$).

The genus *Corematodus* contributed about 0.002% all of which was composed of *C. taeniatus*. There was no significant decrease in catch rates with increase in depth ($P > 0.05$, $r^2 = 8.18\%$). Its sister species *C. shiranus* prefers shallow waters. They are both scale eaters and are quite rare.

The overall contribution of the genus *Ctenopharynx* was 0.11% of which 60.25% was *C. pictus*, 9.61% was *C. nitidus* and 0.14% was *C. intermedius*. The decrease in catch rates with increase in depth was not significant ($P > 0.05$, $r^2 = 38.33\%$).

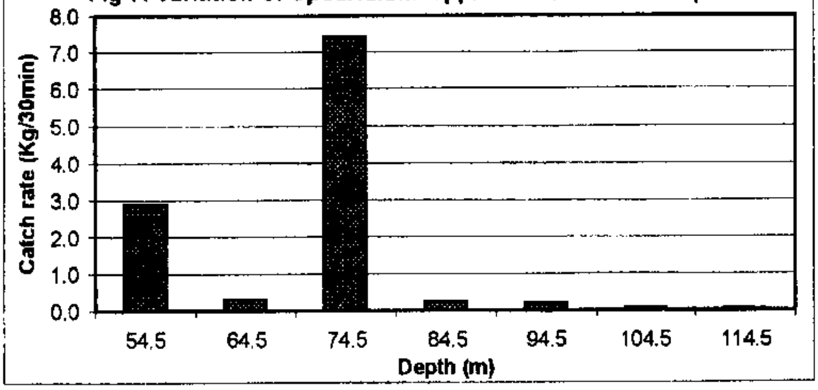
The genus *Docimodus* was represented by *D. johnstoni*. The overall contribution of the genus to the total catch was 0.01%. There were significant declines in catch rates with increase in depth ($P < 0.05$, $r^2 = 71.09\%$). The distribution of this species appears to be restricted to depths of less than 90 m.

Overall the genus *Haplochromis* contributed about 0.14% of the total catch. Of this 74.15% was *H. tokoloshi* and 25.85% was *H. platyrhynchus*. There were significant increases in catch rates with increase in depth ($P < 0.05$, $r^2 = 64.36\%$). The genus seems to prefer waters deeper than 60 m. Banda and Tomasson (1996) also found higher catch rates in waters deeper than 50 m than in the 0-50 m range.

Hemitaeniochromis urotaenia and *Hemitaeniochromis urotaenia deep* contributed 94.14% and 5.86% respectively to their genus which overall contributed 0.09% of the total catch. Generally the catch rates decreased with increase in depth though not significant ($P > 0.05$, $r^2 = 12.5\%$).

Of the 0.64% which the genus *Opsaridium* contributed to the total catch, 93.45% was composed of *O. microcephalus* and 6.55% was *O. microlepis*. Generally, the catch rates declined with increase in depth although not significant ($P > 0.05$, $r^2 = 20.47\%$).

Fig 7. Variation of *Opsaridium* spp. catch rates with depth



However at station number 37 near Namalenje island, (mean depth = 74.5m) there was an extraordinary catch of *O. microcephalus* about 123.5 kg in a single haul which has affected the pattern of the results in Figure 7.

There were significant decreases in catch rates with increase in depth ($P < 0.05$, $r^2 = 89.34\%$) for the genus *Maravichromis*. The total contribution of the genus was 0.56% to which M. anaphyrmus contributed 98.13%, *M. sphaerodon* 1.49%, *M. formossus* 0.21% and *M. semipalatus* 0.17%.

Mormyrus longirostris was the only representative of the genus *Mormyrus*. The overall contribution of the genus to the total catch was 0.33%. There were no significant changes in catch rates with increase in depth ($P > 0.05$, $r^2 = 24.13\%$).

The overall contribution of the genus *Nimbochromis* was 0.01% of which 67.54% was *N. polystigma*, 24.61% was *N. livingstoni* and 7.85% was *N. linni*. Significant decreases in catch rates with increase in depth were observed ($P < 0.05$, $r^2 = 62.17\%$).

The genus *Placidochromis* whose overall contribution to the total catch was 0.23%, was represented by *P. macrognathus* only. The decrease in catch rates as the depth increased was not significant ($P > 0.05$, $r^2 = 11.90\%$).

Although the genus *Protomelas* contributed a mere 0.004% to the total catch, there were significant decreases in catch rates with depth increase ($P < 0.05$, $r^2 = 58.73\%$). Generally this suggests that most members of the genus prefer shallow waters. Similar observations were reported by Banda and Tomasson (1996) who found that catch rates were highest in the 0-50 m range. The species sampled were *P. spilopterus, P. triaenodon* and *P. marginatus* and their respective composition in the genus were 85.29%, 11.77% and 2.94%.

Sciaenochromis gracilis and *Sciaenochromis spilostichus* contributed 23.97% and 76.03% respectively to a total contribution of 0.76% of their genus. There were no significant changes in catch rates with increase in depth ($P > 0.05$, $r^2 = 28.77\%$).
The genus *Stigmatochromis* contributed a total of 0.11% of which 96.34% *was S. woodi* and 3.66% was *S. pholidophorus*. There were also no significant changes in catch rates as the depth increased ($P > 0.05$, $r^2 = 46.76\%$).

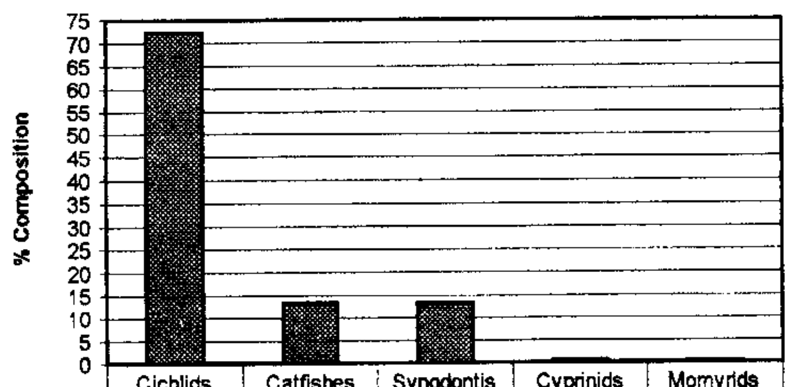
The total contribution of the genus *Taeniolethrinops* was 0.04%. To this T. laticeps, *T. praeorbitalis* and *T. furcicauda* contributed 92.96%, 6.74% and 0.30% respectively. There was significant decline in catch rates with increase in depth ($P < 0.05$, $r^2 = 78.56\%$). Catch rates declined sharply to zero at depths deeper than 70m. These findings coupled with those of Banda and Tomasson (1996) show that *Taeniolethrinops* is typically a shallow water genus.

3.3 Catch Classification, Catch Per Unit Effort (CPUE) and Biomass Estimates.

3.3.1 Catch Classification

Generally, the catch from deep water bottom trawls can be categorised as follows: Cichlids, Catfishes (*Bagrus* and the Clariid catfishes), *Synodontis njassae*, Cyprinids and Mormyrids. Using these groupings, Cichlids constituted about 72.35% of the total catch, *Synodontis njassae* 13.34%, Catfishes 13.24%, Cyprinids 0.69% and Mormyrids 0.33% (Figure 8 below).
The only species that contribute significantly to the medium to large cichlids are *Alticorpus mentale*, *Diplotaxodon greenwoodi*, *Diplotaxodon argenteus* and *Otopharynx speciosus*. Their individual composition in the total catch were: 1.70%, 0.08%, 0.78% and 0.58% respectively. A few species belonging to the genus *Rhamphochromis* attain relatively large adult sizes.

Fig 8. Composition of a Deep Water Bottom trawl catch



	Cichlids	Catfishes	Synodontis	Cyprinids	Momyrids
% comp.	72.35	13.24	13.34	0.69	0.33

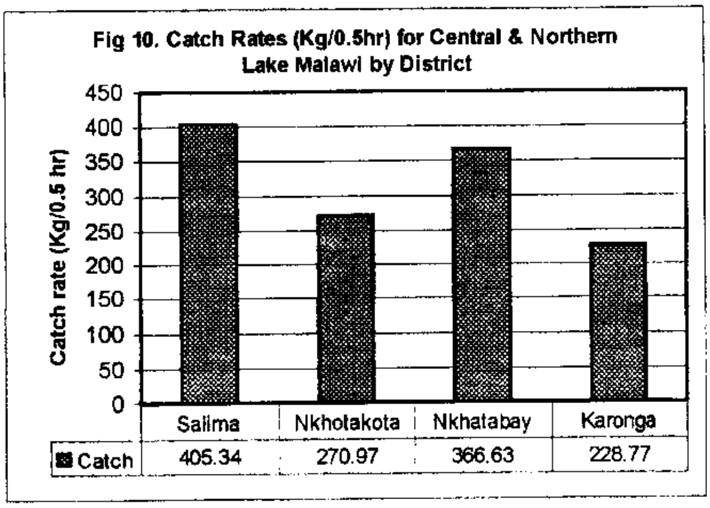
3.3.2 Catch Rates (Catch Per Unit Effort)

The catch rates from Area F (Off Chipoka) to Karonga in the north are presented in Table 4. As can be observed from the table, the catch rates varied from 41.76 kg to 693 kg per haul. The very low catch rates in Sani south may be partly due to the untrawlable nature of the bottom which impeded the performance of the fishing gear.

Table 4: Average catch rates for Central and Northern Lake Malawi.

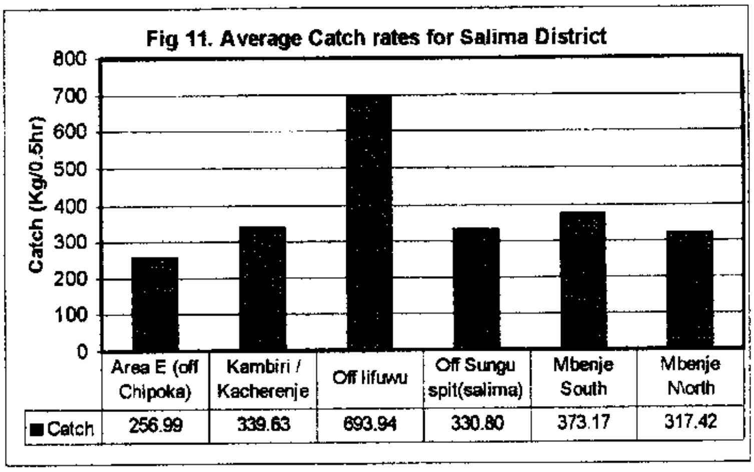
Area	No. of Stations	Average Catch/0.5hr	Depth Range
E (SWA) Off Chipoka	6	256.99	51.0 to 91.5 m
Kambiri/Kacherenje	5	339.63	53.5 to 109.5 m
Off Sungu spit(Salima)	3	330.80	56.5 to 112 m
Off Lifuwu	4	693.94	49 to 111.5 m
Mbenje south	4	373.17	50.5 to 95 m
Mbenje north	3	317.42	65 to 84 m
Off Nkhomo	7	266.82	55.5 to 106 m
Sani South/off Chia	2	41.76	95 to 105 m
Off Nkhotakota	3	234.51	58 to 75 m
Off Liwalazi	6	482.39	72.5 to 105.5 m
Dwangwa	6	303.89	53 to 94.5 m
Bana	7	296.44	52.5 to 107.5 m
Off Kande	6	750.98	57.5 to 102.5 m
Bandawe/off Chintheche	8	279.56	55 to 108 m
Off Sanga/Nkhatabay	5	69.34	55.5 to 88.5 m
Ngara	6	196.31	52.5 to 107.5 m
Chiondo/off Mlare	6	212.87	53 to 107 m
Off Karonga	6	179.51	59.5 to 103.5 m
Ngerenge/Kaporo	6	326.38	53.5 to 105.5 m

Presented in Figure 10 are the mean catch rates for the four lakeshore districts. From the figure, it is observed that the highest catch rate was attained in Salima district (405kg/0.5hr), then NkhataBay (366kg/0.5hr), followed by Nkhotakota (270kg/0.5hr) and lastly Karonga District (228kg/0.5 hr). Since the magnitude of CPUE is also a good indicator of the fish density (biomass), it therefore follows that Salima and NkhataBay districts have relatively higher densities than Nkhotakota and Karonga districts.



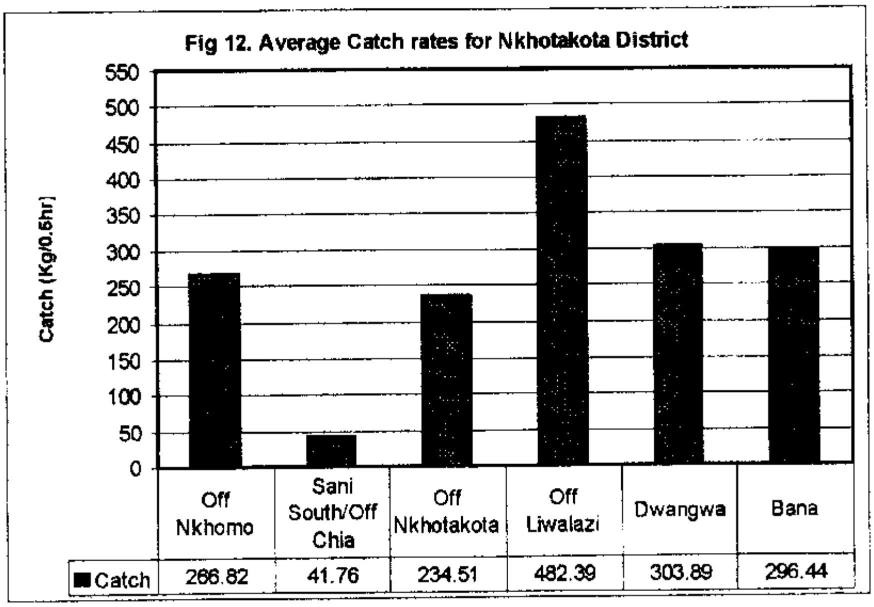
However, sustainability of the exploitation depends also on the size of the area. So although an area can have high density of fish and therefore high catch rates, if its total area is small, it is likely that the stock in question can not sustain long-term exploitation.

At sub-area level, catch rates were very variable. In Salima district (Figure 11 below), the catch rates varied from 256 to 693 Kg/0.5hr. The highest rate was obtained Off Lifuwu while the other five areas had approximately the same catch rate (about 300 kg/0.5hr).

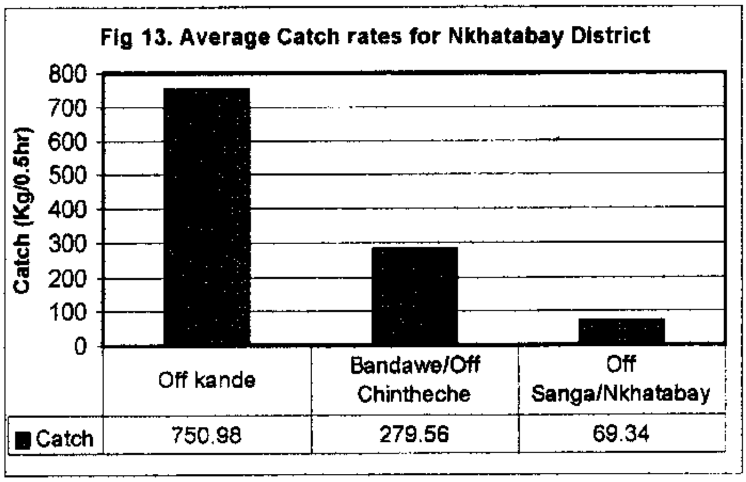


It is worth noting that the catch rate for Lifuwu was approximately twice that of the other areas.

In Nkhotakota district, the area off Liwalazi had the highest rate (690kg/0.5hr) while the area off Chia/Sani South was the lowest (41kg/0.5hr). The other four areas were around 300kg/0.5hr (Figure 12).

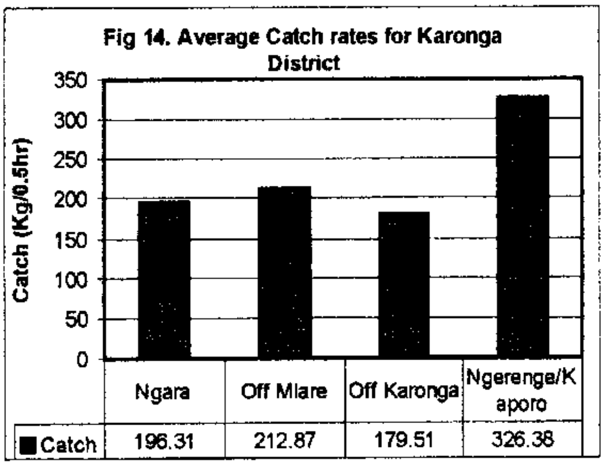


In Nkhatabay district, (Figure 13 below), the catch rates varied from 750kg to 69kg/0.5hr. The highest was the area off Kande (750.98kg), followed by Bandawe (279.56kg) and lastly Off Sanga (69.34kg). From Kande to Sanga/Off Nkhatabay, the catch rates decrease rapidly from 750 kg/0.5hr to 69kg/0.5hr. This is mainly due to rapid increase in depth further north and narrower stretches of the bottom shelf that are under 100m deep.



Consequently productivity of the lake also decreases further north. From Nkhatabay to Chilumba the lake is very deep, usually ranging from 200 m to 700 m, unproductive and too deep to be bottom-trawled.

In Karonga district, as shown in Figure 14 below, the area off Ngerenge attained the highest catch rate about 326kg/0.5hr, then off Mlare (212kg/0.5hr), off Ngara (196kg/0.5hr) and the lowest was the area off Karonga proper (179kg/0.5hr).



The lake from Chilumba to Songwe gets less and less deep and as expected productivity of the lake should also increase. This explains, to some extent, the increase in catch rates further north from Karonga boma. Of course there are other factors such as the presence of inflowing rivers like the Songwe and North Rukuru, which bring nutrient loads into the lake and hence greatly boosting productivity.

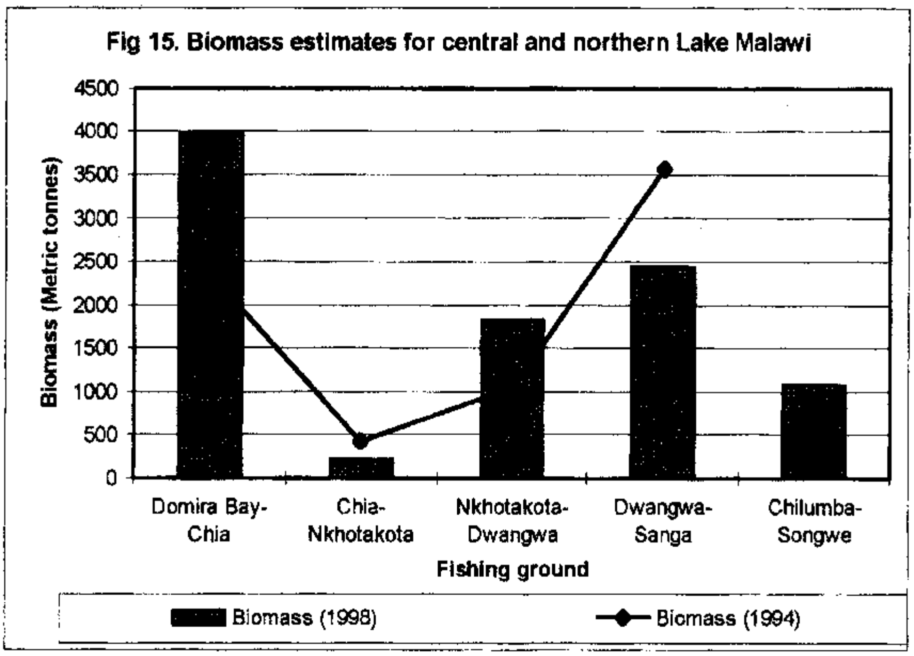
3.3.3 Biomass Estimates and Maximum Sustainable Yield (MSY)

3.3.3.1 Biomass estimates

The Swept Area method was used for estimating biomass. The total surface areas for the various locations were obtained from Banda and Tomasson (1996) and Turner (1976). Presented in Table 5 and Figure 15 below is a summary of water surface areas, catch rates, biomass estimates and number of stations sampled for each location. Also included in the Table is a summary of biomass estimates obtained earlier on by Banda and Tomasson (1996).

Table 5: Biomass estimates, area & number of stations for central & northern Lake Malawi.

Location	Area (Nm^2)	Catch/0.5 Hr	Biomass (1998)	Stations	Biomass 1996	Stations
Domira Bay-Chia	207.59	266.43	3981.85	14	2355.00	13
Chia-Nkhotakota	21.87	138.14	217.46	5	430.00	5
Nkhotakota-Dwangwa	74.64	340.26	1828.40	12	1050.00	5
Dwangwa-Sanga	97.38	349.08	2447.30	26	3570.00	15
Chilumba-Songwe	65.02	228.77	1070.83	24	N/A	N/A



The estimates obtained in the present survey vary much from those of Banda and Tomasson (1996) except for the Chia-Nkhotakota area whose estimate in 1994 was twice that of the present survey. The estimated biomass for Karonga district (1,070 metric tonnes) is not very different from that obtained by J. Turner (1,130 metric tonnes) in 1976.

As can be noticed from Table 5, the intensity of sampling was increased (as compared to that of Banda and Tomasson, (1996)) in the present survey to improve the accuracy of the results. In areas where most of the ground was untrawlable, the sampling intensity could not be increased.

3.3.3.2 Maximum Sustainable Yield (MSY)

Maximum sustainable yield was calculated using the Gulland's empirical formula shown below:

MSY = 0.5*M*Bv, where M is natural mortality (about 1.18), Bv is biomass.

However, Beddington and Cooke (1983) found that the above equation generally overestimates MSY by a factor of 2 or 3 times. They recommended replacing 0.5 by 0.2. So in this report the estimation of MSY will follow the recommendation of Beddington and Cooke (1983). Therefore substituting 0.5 with 0.2, the new equation becomes:

MSY = 0.2*M*Bv, where M is natural mortality (about 1.18), Bv is biomass.

Natural mortality (M) was estimated by using Pauly's empirical formula described below:

$$\ln M = -0.0152 - 0.279 \cdot \ln L_\infty + 0.6543 \cdot \ln K + 0.463 \cdot \ln T$$

where L_∞ is maximum length of fish observed, K is a constant and T is the average annual surface water temperature in degrees centigrade. For Lake Malawi water temperature averages 25 degrees centigrade.

The species listed in Table 6 constitute about 52% of the deep-water demersal fish community and their mean mortality has been used to estimate the overall mortality.

Table 6: Summary of species used in the estimation of natural mortality.

Estimation of Natural Mortality

Species	Proportion in catch(%)	K	L (cm)	Temp	Ln (M)	M
B. meridionalis	8	0.09	107	25	-1.40	0.25
C. virginalis	6	0.78	12.1	25	0.62	1.48
L. longipinnis	13	0.57	20.2	25	0.27	1.31
L. parvidens	5	0.49	20.8	25	0.16	1.18
D. 'big eye'	3	0.69	16.5	25	0.45	1.25
R. longiceps	-	0.55	21	25	0.23	1.01
D. elongate	4	0.84	17.5	25	0.56	1.40
S. njassae	13	0.67	17	25	0.42	1.53
Total %	52				Mean	1.18

(Data source Fishbase, 96)

In Table 7 is a summary of the biomass and MSY estimates for all the areas under study. The stocks are considered to be relatively virgin because no trawl fisheries are currently operating in these areas.

Table 7: Biomass and MSY estimates for central & northern Lake Malawi

Location	Catch/0.5 Hr	Biomass	MSY	Catch (88 hp trawler)		No. of licences
				Tonnes/ day	Tonnes/annum	
Domira Bay-Chia	266.43	3981.85	939.72	1.87	466.26	2
Chia-Nkhotakota	138.14	217.46	51.32	0.97	241.74	0
Nkhotakota-Dwangwa	340.26	1828.40	431.50	2.38	595.46	1
Dwangwa-Sanga	349.08	2447.30	577.56	2.44	610.89	1
Chilumba-Songwe	228.77	1070.83	252.72	1.60	400.35	1
Total		9545.84	2252.82			5

The estimated number of trawlers (max 88 hp) that can sustainably exploit the stocks in each area are presented in Table 7. An example is the Fisheries department's research vessel, the R.V. Ethelywn Trewavas (88 hp engine). This vessel used to land about 1,750 kg/day. On average this is about half the catch rate of the R.V. Ndunduma in the same areas as Table 8 refers. So the approximate catch/day (CPUE) of the 88 Hp trawlers, is assumed to be half that of the catch rate of the R.V. Ndunduma in each of the respective areas. It is also assumed that the vessels will be fishing for about 7 hours/day for 250 days in a year. So as Table 7 refers, the Domira Bay-Chia area can sustain two 88 hp stern trawlers, none in Chia-Nkhotakota, 1 in the Nkhotakota-Dwangwa area, 1 in Dwangwa-Sanga area and 1 in Chilumba-Songwe area.

In Table 8 is a summary of the number licenses that can be issued to boats like the department's R.V. Ndunduma in each of the respective areas. The assumption here is that the boat would be fishing for 7 hours a day for 250 days/year and the catch per day is calculated from the product of the catch/0.5 hrs multiplied by 7 hours. As noticed from the table below the catch rates are different for each area.

Table 8 MSY estimates for each area and number of licenses for 386 hp trawlers.

Location	Catch/0.5 Hr	Biomass	MSY	Catch (386 hp trawler)		No. of licences
				Tonnes/ day	Tonnes/annum	
Domira Bay-Chia	266.43	3981.85	939.72	3.73	932.52	1
Chia-Nkhotakota	138.14	217.46	51.32	1.93	483.47	0
Nkhotakota-Dwangwa	340.26	1828.40	431.50	4.76	1190.92	0
Dwangwa-Sanga	349.08	2447.30	577.56	4.89	1221.78	0
Chilumba-Songwe	228.77	1070.83	252.72	3.20	800.70	0
Total		9545.84	2252.82			1

From the table, only the Domira Bay-Chia area can support one trawler of the size of the R.V. Ndunduma. The other areas can not.

The only draw back for the development of such a fishery in the northern region is the lack of support infrastructures like ice plants and dry docks.

The MSY and biomass figures in Tables 7 and 8 are only rough estimates and they might under-estimate or over-estimate the actual values. The inaccuracy stems from the fact that these estimates depend very much on the magnitude of catchability coefficients and natural mortality. In most cases these are just estimated because they are difficult to obtain especially when there is insufficient data. For this survey, the catchability coefficient is assumed to be 1. However it is quite evident that the figure is high because not all the fish in the path of the trawl are caught. A good proportion avoids the approaching trawl net while not all those that enter the net are caught. Some squeeze themselves out through the large meshes before they reach the codend.

3.3.4 Trawling Grounds

Each sampling site was trawled according to the following depth intervals: 50 – 60 m, 60 – 70 m, 70 – 80 m, 80 – 90 m, 90 – 100 m, 100 – 110 m and 110 – 120 m. For areas where the bottom was fairly even, it was possible to cover most if not all of the above depth intervals. There were few places as indicated in Table 9 where, due to unevenness and rocky nature of the bottom, trawling was not possible.

Table 9: Status of Trawling Grounds for the whole survey area.

Area	No. of Stations	Depth Range	Remarks
E (SWA) Off Chipoka	6	51.0 to 91.5 m	Good ground
Kambiri/Kacherenje	5	53.5 to 109.5 m	Good ground
Off Sungu spit(Salima)	3	56.5 to 112 m	Good ground
Off Lifuwu	4	49 to 111.5 m	Good ground
Mbenje south	4	50.5 to 95 m	**Rocky**
Mbenje north	3	65 to 84 m	**Rocky**
Off Nkhomo	7	55.5 to 106 m	Good ground
Sani South/off Chia	2	95 to 105 m	**Rocky**
Off Nkhotakota	3	58 to 75 m	**Uneven ground**
Off Liwalazi	6	72.5 to 105.5 m	Good ground
Dwangwa	6	53 to 94.5 m	Good ground
Bana	7	52.5 to 107.5 m	Good ground
Off Kande	6	57.5 to 102.5 m	Good ground
Bandawe/off Chintheche	8	55 to 108 m	Good ground
Off Sanga/Nkhatabay	5	55.5 to 88.5 m	Good ground
Ngara	6	52.5 to 107.5 m	Good ground
Chiondo/off Mlare	6	53 to 107 m	Good ground
Off Karonga	6	59.5 to 103.5 m	Good ground
Ngerenge/Kaporo	6	53.5 to 105.5 m	Good ground

Generally the area around Mbenje Island is very rocky and the R.V. Ndunduma on more than one occasion had suffered extensive damages to its fishing gear. The area from Chia to Sani south is rocky while off Nkhotakota the ground is very uneven. From Nkhata Bay proper to Chilumba the lake is too deep to allow for the deployment of a bottom trawl gear.

These findings also agree with what Banda and Tomasson (1996) found during their survey of Trawling grounds and Demersal fish stocks in Central Lake Malawi. They found that the areas off Chia and Bua (below 50 m contour line) were untrawlable. In addition to these two areas, this survey has also identified other untrawlable areas above the 50 m contour line which have been listed above.

4.0 Conclusions

This survey has confirmed what other researchers have observed that generally the number of species declines significantly with increase in depth however this decline in species diversity does not affect the quantity of catches. The general composition of the catch was 72.35% cichlids, *Synodontis njassae* 13.34%, catfishes (*Bagrus* spp. and *Bathyclarias* spp.) 13.24%, cyprinids 0.69% and mormyrids 0.33%. In deep waters, the most important genera in the family cichlidae were *Lethrinops spp.*, *Diplotaxodon spp.*, *Copadichromis spp.*, *Alticorpus spp.*, *Aulonocara spp.*, *Rhamphochromis spp.* and *Otopharynx spp.* The highest mean catch rate attained was 349kg/0.5hrs in the Dwangwa-Sanga area, next was the Nkhotakota-Dwangwa area (340kg/0.5hrs), the Domira Bay-Chia area (266kg/0.5hrs), Chilumba-Songwe area (228kg/0.5hrs) and the lowest was the Chia-Nkhotakota area (138kg/0.5hrs). In terms of standing biomass, the highest was the Domira Bay-Chia with 3981metric tonnes, Dwangwa-Sanga with 2447 metric tonnes, Nkhotakota-Dwangwa with 1828 metric tonnes, Chilumba-Songwe with 1070 metric tonnes and the lowest was the Chia-Nkhotakota area with 217 metric tonnes. The Domira Bay-Chia can sustain one trawler of the size of the R.V. Ndunduma and none for the rest. For smaller trawlers like the R.V. Ethylywn Trewavas (88hp), the Domira Bay-Chia can support two, one in the Nkhotakota-Dwangwa area, one in the Dwangwa-Sanga area and the Chilumba-Songwe area can also support one. The only areas where bottom-trawling would be exceptionally difficult are the areas around Mbenje island, off Chia, off Nkhotakota boma and from Nkhatabay boma to Chilumba in the north.

However, before any investments are made, there is need to critically review the performance of the current bottom trawl net because of its suspected detrimental effects on the demersal stocks (Kanyerere, 1999-in press).

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References

Sparre, P., Ursin, E., and Venema, S.C. (1989). Introduction to Tropical Fish Stock Assessment. Part 1- Manual. FAO Fisheries Technical paper. No. 306.1. Rome, FAO. 337 P.

Turner, G.F., Tweddle,D. and Makwinja, R.D.(1992). Changes in Demersal Cichlid Communities as a result of Trawling in Southern Lake Malawi. Malawi Fisheries Department Project report.

Banda, M.C. and T. Tomasson, (1996). Surveys of Trawling Grounds and Demersal Fish Stocks in central Lake Malawi, from Domira Bay to Nkhata Bay in 1994 and 1995. Government of Malawi, Fisheries Department. Fisheries Bulletin No.33, 34 pp.

Turner, J. (1976). Promotion of Integrated Fishery Development-Malawi. An Analysis of the Various Fisheries of Lake Malawi. Technical report 1, Rome, FAO. 73P

Fishbase (1996). FishBase 96 CD-ROM. ICLARM, Manila.

Beddington, J.R. and Cooke, J.G. (1983). The potential yield of fish stocks. FAO Fish. Tech. Paper (2420 47p.

Kanyerere, G.Z.(1999). Trawl Selectivity and the Effect of clogging on Standard trawl surveys on Lake Malawi, Government of Malawi, Fisheries Department. Fisheries Bulletin No.39, 25 pp (in press).