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Abstract

Length frequency data was collected for the 6 main species from the Kainji Lake fishery for up to 16 months. Growth parameters were estimated and used for virtual population and length based cohort analysis.

The results from cohort analysis suggest that before the ban on beach seines the maximum economic yield from the fishery was overshot by 70%. Yield per recruit analysis showed that the fish are caught far below their optimum size. Fishing gears and the timing responsible for this early mortality have been identified.

After the eradication of seines from the lake a 10% increase in total catch revenue can be expected from the fishery. This is equivalent to an increase in income of Naira 18,300 per annum for each fishing entrepreneur using other methods.

A scenario for the regulation of cast net mesh size together with the ban of beach seines has been presented. A further increase of Naira 142 million (N25,500 per entrepreneur) can be anticipated if this is implemented by the Kainji Lake Fisheries Management and Conservation Unit.

It is expected that the annual increase in fishing effort presently experienced will cause future yields to decline. The rate of the decline has been reduced by the eradication of the beach seine fishery and will further fall if the minimum mesh size for cast nets is implemented.

A recommendation is made to the Kainji Lake Fisheries Management and Conservation Unit to first consolidate the beach seine ban and then to implement a ban of undersized cast nets.

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Summary

Six main species from the Kainji Lake fishery were sampled for length frequencies from Sept. 1997 to Dec. 1998. The frequencies were raised to catch data and growth parameters for each species were established. The parameters were used for virtual population and length based cohort analysis to give fish yield, biomass and catch values for varying levels of fishing effort.

Scenarios of the present ban on beach seines and the implementation of minimum cast net mesh size (less than 2.5 inch) are presented.

Results from cohort analysis indicate that the lake fishery before the ban on beach seines was being overfished by 70% of the maximum economic yield (MEY) and by 40% of the maximum sustainable yield (MSY). These findings are supported by surplus yield analysis. Yield per recruit analysis shows that fish are caught far below their optimum size (L_{opt}).

Beach seines were mainly responsible for this early mortality. The expected effect from the present ban will be a reduction of the total fishing effort and lake yield. The fall in effort is advantageous given the present level of overfishing. The reduction in yield is due to a decrease of low value clupeids that are the target species of the seine fishery. Due to the growth of by-catch species one can expect an overall increase in total catch revenue of Naira 106 m. This equates to an additional Naira 8,300 annually per fishing entrepreneur.

One inch gill nets cause an early mortality of juveniles. These nets are mainly operated by fisherwomen. The ban of this type of gear is not presently considered a practicable option for implementation because of the adverse affect on the women's livelihood.

The detrimental effect of small meshed cast nets has been highlighted in previous reports (du Feu & Abiodun 1999). The consequences of the ban of undersized cast nets (following the ban on seines) shows that the fishing effort is reduced and a further increase of Naira 142 million in catch revenue is derived.

The report shows that although the number of gears owned by fisherfolk have stabilised the actual fishing effort is increasing by 15% per annum (fisherfolk are fishing fewer gears more). Since the fishery is being overfished the increase in effort will cause yields to decline. The effect of the ban of beach seines and regulation of cast net mesh size on the fishery is to make this decline less dramatic.

In view of the present overfishing and the declines in yield expected from future increases in effort a recommendation to first consolidate efforts of the beach seine ban and then to implement a ban of undersized cast nets is made.

It is further vital that no attempt is made to increase fishing effort on Kainji Lake through the provision of fishing gears or fishing loans.

1. Introduction

Kainji Lake was created in 1968 by damming the River Niger for the generation of hydro-electricity. The lake has a surface area of 1,237 km^2 and an average depth of 11m.

In 1970 the fish yield increased to 28,639 t. due to high productivity from the initial flooding of land. Subsequently yields declined to an estimated 4,500 t. in 1978 (Ita 1993).

The decline in yield prompted the Nigerian Government in 1993 to begin a joint technical co-operation project with Germany "The Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project (NGKLFPP)".

As part of the project's activities a new catch assessment survey (CAS) for Kainji Lake began in 1994. In 1995 the estimated fish yield was 32,474 t.; an increase of over 600% since 1978. The explanation for the rise is, in part, due to the diversification of fishing methods and mesh sizes used, particularly the development of a high yielding beach seine fishery that contributed 53% to the 1995 catch (du Feu 1998).

To further explain the increase in yield and to establish whether the fish resources can sustain such a high level of exploitation the project has compared past and present primary productivity and has undertaken a swept area biomass survey of the clupeid stock.

The present study will add to this information and present more accurate estimates on the status and levels of sustainable exploitation for the lake fishery.

The anticipated effects on yield and catch value from the present ban of beach seines is quantified. This is useful to act as a guide when analysing future trends.

The use of undersized cast nets is a problem previously documented by the project (du Feu & Abiodun 1999). The consequences of the regulation of minimum mesh size of cast nets has been established in order to assist the Kainji Lake Management and Conservation Unit on future management approaches of either to continue with regulatory activities or to consolidate those already in place.

Management objectives for the lake, as well as considering the effect on fisherman's revenue, must also take into account the future stability of the fishery. An important aspect of the report is the investigation of the effect of expected future increases in fishing effort caused by the expanding rural population.

2. Methods

2.1. Survey Design

The objective when sampling length frequencies is that the distribution of lengths must mirror those within the natural population.

Length frequency data were measured for the six main commercial species which were identified from the 1995-1997 CAS. *Lates niloticus* was included due to its high commercial value.

The species included:

Citharinus citharus citharus	(Geoffroy St. Hilaire, 1808-1809)	Moon fish
Sarotherodon galilaeus galilaeus	(Linnaeus, 1758)	Mango tilapia
Oreochromis niloticus niloticus	(Linnaeus, 1758)	Nile tilapia
Synodontis membranaceus	(Geoffroy St. Hilaire, 1808-1809)	Squeakers
Chrysichthys nigrodigitatus	(Lacepede, 1803)	Bagrid catfish
Lates niloticus	(Linaeus, 1758)	Nile perch

(FishBase 1999)

Data collection took place during the middle 10 days of every month from Sept. 1997 to Dec. 1998. September coincided with the annual spawning and the start of the first year cohort of many of the lake species. Sampling stations were Anfani in the southern basin, Foge Island (central basin) and Jijima/Zamare (northern basin).

The length frequency data was separated by gear type and mesh size (annex 6). Fish lengths were divided into 5 mm length classes with records taken to the nearest unit below (e.g. 25.2 mm. was recorded in the 25 mm. length class). The length type measured varied for each species.

The monthly yield by gear type and species was estimated from the CAS.

2.2. Data Preparation

The following procedures were applied for each month, gear type and species:

(1) The total number of fish recorded in each 5 mm. length class was calculated.
(2) Length-weight relationships from old gill net trial data[1] were calculated for each species (annex 1).
(3) Total sample lengths were converted to sample weights (using (2))
(4) The sample weights were divided by the total yield (from the CAS) to establish a gear raising factor.
(5) The number of sampled fish (in (1)) was multiplied by the raising factor to give total numbers of fish in each length class caught for the whole lake.

[1] Old GN trial data: gill net trial experiments performed by the National Institute for Freshwater Fisheries Research from 1969-1982 which have been computerised by the NGKLFPP.

(6) The number of fish for each gear type was summed for each 10 mm. length class and the total entered into FiSAT[2].

(7) Where numbers exceeded 1 million fish (the maximum number allowed in FiSAT) the frequencies were re-expressed such that their sum became proportional to the square root (sqrt. transformation) of the total sample size.

(8) Where large fishing mortality of the upper length classes resulted in a skewed distribution, the data was smoothed using a three month running average.

(9) Catch value was determined by recording beach sales. The price per kilo was then converted into price per length class by using length-weight relationships (in (2)).

(10) For length based cohort analysis the F-arrays for the differing management scenarios were calculated by:

$SL_{new} = 1/(1+\exp(S_1-S_2*L)$
$Farray_{new} = Fm * S_{L\ new}$

where S_1 and S_2 are mesh size selection lengths and F_m is the maximum fishing mortality in numbers

2.3. Methods Used to Estimate Growth Parameters

(1) The length frequency data could not be used to accurately estimate asymptotic length (L_{inf}) since the larger fish in the lake migrate into deeper water where they are unable to be caught (and sampled).

The maximum length was obtained from old GN trial data and converted to L_{inf}.

Where: L_{inf}=10^(0.044+0.9841*Log10 (L_{max}) (Froese and Binohlan 1999)

The L_{inf} value was used as an initial input for the estimation of growth parameters by ELEFAN[3] and Shepard's method. For species where the length groups were well defined the estimates were checked using Bhattacharya's modal progression analysis. These were then refined using Hasselblad's NORMSEP method.

The growth rate (K), L_{inf}, and the theoretical age at which the fish has length 0 (t_0) were then established using:

- Gulland and Holt plot
- von Bertalanffy plot

In species where Bhattacharya's method could not be used the value of t_0 was obtained from FishBase 99.

(2) The indices of growth performance Phi prime (for length) was estimated using

Phi Prime=Log10 K + 2 Log10 L_{inf} (Pauly and Munro 1984)

[2] FAO-ICLARM stock assessment tools
[3] Electronic length frequency analysis, incorporated into the FiSAT program.

(3) For each species the mean value of Phi prime and L_{inf} from the ELEFAN method, Shepard's method, Gulland and Holt and von Bertalanffy plots were used to calculate the mean K (sect. 3.3).

(4) Winter points and amplitude were estimated from the biology and diet composition of the species and the flood regimes of the lake (sect. 3.2).

(4) Natural mortality was estimated using the revised Pauly's method (sect. 3.4).

$$\text{Log10}(M) = -0.065 - 0.287\,\text{log10}(L_{inf}) + 0.604\,\text{log10}(K) + 0.513\,\text{log10}(T)$$

Where: mean water temperature is 27.85 °C (Mbagwu and Adeniji 1994) and lengths are total length (in cm.).

(5) Total mortality (Z) was estimated by Jone's length-converted catch curve method (sect. 3.4).

(6) Probability at capture was calculated using Baranov/Holt model (sect. 3.5).

(7) The degree of growth overfishing was estimated (sect. 3.8)

Where: $L_{poss} = (L_m + L_{opt}) / 2$

and $W_{poss} = a * L_{poss} \wedge b * N_{<opt}$

L_m = length at maturity

L_{opt} = optimum length for harvest

a, b = length weight relationship constants

$N_{<opt}$ = number of fish at length below L_{opt}

and $L_{opt} = 10\wedge(1.0003*\text{log10}(L_{inf})-0.2161)$

and $L_m = 10\wedge(0.898*\text{log10}(L_{inf})-0.0781)$ (Froese and Binolan 1999)

(7) The fish population was reconstructed from the total catch by size using the length frequency data (representing mean annual catch at length) by length based virtual population analysis (VPA). One years data was replicated to four years (sect. 3.10).

(8) Prediction of potential yields and biomass was performed using Thompson and Bell's length converted predictive method (sect. 3.11).

(9) Surplus yield analysis was undertaken using the Shaefer model (sect. 3.12)

(10) Trophic levels of catches were assessed using CAS data and trophic level of species taken FishBase 99 (sect. 3.13).

3. RESULTS

3.1. Data Appraisal

The 6 sampled species have 49 length classes split into 10 mm. The smallest mid-length is 5 mm, the largest 49 mm.

Citharinus citharus citharus

The use of small meshed nets, beach seines and traps that target newly spawned and juvenile fish was reflected by the strong representation of the first year cohort fish and less prominence of the older fish in the sample.

The reduction of samples from March onwards was caused by juvenile fish leaving the shallow nursery areas and entering deeper water where they were unable to be caught by the majority of fishing gears.

From March onwards the larger fish in the first year cohort were caught by the small meshed cast net and gill net fisheries. This resulted in a skewed distribution of the frequency data.

The effect of a skewed distribution is a downward shift of the growth curve giving lower estimates of K and L_{inf}. To overcome this a normal distribution was approximated by smoothing the data using a 3 month running average. The application of a five month running average was not used since it disguised some of the peaks required for plotting the growth curves.

Fitting the growth curves to the first year cohort was fairly easy due to the high definition of increasing length modes for each month. Plotting growth curves through the older cohorts was more complex. The clear modes of the first year cohort facilitated the use of Bhattacharya's and NORMSEP method.

Resulting data: 16 months data with a sqrt. transformation and a 3 month running average applied. Length type: fork length.

Saratherodon galilaeus galilaeus

The length frequency data presents a confused picture due to the absence of the species set breeding patterns.

Using a 3 month running average facilitated the identification of peaks and improved the normality of the data. When using running averages care had to be taken to make sure only one cohort was represented within the normal distribution and that the smoothing process didn't obscure secondary cohorts.

There was evidence that the number of smaller fish in the sample increased from August 1998. This is also the time when spawning starts (Ita 1982) and was used as the starting point for the identification of growth curves.

Resulting data: 12 months data with a 3 month running average applied. Length type: total length

Oreochromis niloticus niloticus
There was a large disparity in the number of samples between months. Large frequencies occurred from Jan. to April 1998 after which they reduced. The main difference was in the first year cohort where the months with large frequencies represented the time when spawning occurred (Ita 1982).

To facilitate the identification of growth curves a sqrt. transformation was applied.

The frequency distributions for each month were skewed with high numbers of the smaller length classes and fewer but a wide distribution of the larger length classes. This may have been a result of large spawnings that increased the number of smaller sized fish or that the upper portions of the distributions were reduced due to fishing activity.

From the age/length keys (annex 2) it appears that the largest modes all belong to the first year cohort whilst the second year cohorts appear only as scattered points.

Smoothing the data increased normality but care had to be taken when fitting growth curves to months containing few records.

Resulting data: 12 months data with a sqrt. transformation and a 3 month running average applied. Length type: total length

Synodontis membranaceus
The data showed a good representation of first, second and third year cohorts. However, the division between the second and third years was not well defined.

The starting point for the growth curve was from Oct.-Nov. This corresponds to the peak spawning time for the species (Willoughby 1974).

The monthly distributions tended to have larger frequencies in the lower length classes. The application of a three month running average increased the normality and made fitting a growth curve easier.

Resulting data: 16 months data with a 3 month running average applied. Length type: fork length

Chrysichthys nigrodigitatus
There was a large disparity in the sample numbers between months (table 1). This is a reflection of the seasonality of traps that mainly target this species. Large samples were obtained in March when fish fencing was prominent around the lake.

The problem of unequal numbers was reduced by using a sqrt. transformation.

From the age/length keys there was evidence that both first and second year cohorts were represented. New recruits into the first year cohort seem to have occurred from Sept. to Dec. which is later than cited in the literature (July-Sept. Imevbore 1970).

The confused frequency distribution was improved by the application of a three month running average. Care had to be taken when fitting growth curves.

Resulting data: 12 months data with a sqrt. transformation and a 3 month running average applied. Length type: fork length

Lates niloticus

The lowest number of samples were collected for this species. An average of 666 fish were sampled per month (table 1) which falls below the 'excellent' category attributed to sample sizes achieved by the other species of 1,500 or more (Hoenig *et al.* 1987).

The frequency distribution showed a high dominance of the first year cohort with older cohorts represented as smaller single peaks.

A clearer picture was obtained by smoothing the data using a three month running average. The disparity in the number of samples between months was reduced using a sqrt. transformation.

For several months the normal distribution was polymodal. According to the age/length keys these cannot be equated to two separate cohorts but represented the first year cohort only.

The extended breeding period from November to April (Balogun 1988) was evident from the high number of juveniles sampled at this time.

Bhattacharya's and NORMSEP methods were applied but the subsequent linking of the means was rather cumbersome.

Resulting data: 16 months data with a sqrt. transformation and a 3 month running average applied. Length type: total length

Table 1 Number of samples collected by species, Sept. 1997- Dec. 1998

Month		Cith.	Sar.	Ore.	Syn.	Chry.	Lat.
1997	9	1,944	-	-	1,410	-	109
1997	10	3,830	-	-	1,747	-	45
1997	11	5,990	-	-	2,639	-	29
1997	12	3,553	-	-	1,606	-	139
1998	1	5,532	4,742	3,143	2,388	1,215	332
1998	2	3,501	1,355	1,710	1,675	838	477
1998	3	4,724	3,537	2,643	2,883	1,354	448
1998	4	6,602	6,113	4,002	3,701	2,133	1,041
1998	5	3,750	8,613	5,376	1,954	2,486	1,904
1998	6	3,024	7,081	5,054	2,536	11,819	927
1998	7	5,939	7,609	6,754	4,226	6,447	1,950
1998	8	2,142	2,934	1,807	338	2,119	1,061
1998	9	7,366	2,442	1,646	962	2,615	297
1998	10	12,986	1,897	1,340	3,989	5,707	1,350
1998	11	8,398	2,853	1,849	3,086	3,259	283
1998	12	8,277	2,380	1,788	3,321	1,734	160
	Total	**87,558**	**51,556**	**37,112**	**38,461**	**41,726**	**10,552**
Average per month		5,472	4,296	3,093	2,404	3,477	666

Table 2 Number of samples collected by species and gear type, Sept. 1997- Dec. 1998

Gear type	Cith.	Sar.	Ore.	Syn.	Chry.	Lat.	Total
Gill net	53,092	26,915	16,068	24,704	22,014	7,951	150,744
Drift net	10,295	7,065	7,103	6,656	6,046	140	37,305
Beach seine	15,338	3,469	1,999	6,189	1,617	563	29,175
Cast net	8,693	8,307	1,915	699	4	88	19,706
Longline	14	-	66	6	54	1,206	1,332
Trap	126	5,800	9,961	207	11,991	604	28,689
Total:	**87,558**	**51,556**	**37,112**	**38,461**	**41,726**	**10,552**	**266,951**

where: Cith: *Citharinus citharus citharus,* Sar: *Sarotherodon galilaeus galilaeus,* Ore: *Oreochromis niloticus niloticus,* Syn: *Synodontis membranaceus,* Chry: *Chrysichthys nigrodigitatus,* Lat: *Lates niloticus. Sample numbers are expressed prior to raising to the total catch.*

3.2. Winter Points and Amplitudes

The winter point (WP) expresses the fraction of a year at which the fishes' growth rate is minimal. The amplitude (C), represented by a value 0-1, describes the magnitude of the annual fluctuation of growth rate. The higher the value of C the greater the seasonal oscillation.

The values taken for each species were as follows:

Table 3 Winter points and amplitudes for the six selected species

Species	WP	C
Citharinus citharus citharus	0.75	0.2
Sarotherodon galilaeus galilaeus	0.66	0.2
Oreochromis niloticus niloticus	0.66	0.2
Synodontis membranaceus	0.25	0.2
Chrysichthys nigrodigitatus	0.25	0.2
Lates niloticus	0.17	0.2

3.3. Growth Parameters

Citharinus citharus citharus

The estimation of growth parameters was easiest for this species due to the prominent length class modes.

The initial estimate for L_{inf} using GN trial data was 43.6 cm. The value was inputted to scan the K values using ELEFAN and produced an estimate for K as 0.54, Rn=0.122[4].

Using ELEFAN 1 the two values were optimised and gave the same results for L_{inf} and a slight increase in K. Response surface analysis gave a slightly higher L_{inf} and a lower K value. Shepard's scan of K values decreased K to 0.47 (table 4).

Gulland and Holt and von Bertalanffy plots gave lower estimates of K and higher estimates for $L_{inf.}$

The computed value of K agrees the with mean of values published in FishBase 99 whilst L_{inf} is within the limits of values cited for West Africa.

[4] Rn: goodness of fit index of the EFLEFAN 1 routine ($=10^{ESP/ASP}/10$)

Table 4 Growth parameter estimation for *Citharinus citharus citharus*

Species	$L_{inf (cm)}$ 95% CI	K	Rn	Phi Prime	Method
Citharinus citharus	43.6 (FL) 42.3-45.0				Froese & Binohlan 1999)
	52	0.54	0.122	3.16	ELEFAN I, scan of K values
	52	0.58	0.123	3.20	ELEFAN I, Optimising parameter combinations
	53	0.52	0.133	3.16	ELEFAN I, Response surface analysis
	52	0.47		3.10	Shepard's, scan of K values
	52.25	0.52		3.16	Mean of Phi prime and L_{inf} to calculate K
	57.5	0.46		3.18	Gulland and Holt
	60.0	0.42		3.18	von Bertalanffy
Final Estimates	56.6	0.47		3.17	Mean of Phi prime and L_{inf} to calculate K
Conversion of lengths			P*	N	
TL=1.199FL- 2.47			0.98	269	*unsexed*
FL=0.812TL+7.08 (lengths in mm.)					

* Pearson's correlation coefficient

Saratherodon galilaeus galilaeus

Using the initial estimates as inputs for L_{inf} from the GN trial data values obtained by ELEFAN response surface analysis for the length frequency data were L_{inf}= 43.0, K=0.41.

The scan of K values gave a higher estimate of K despite varying values of L_{inf} used. ELEFAN optimising routine gave values for L_{inf} that were unrealistically high. Shepard's scan of K values also gave higher estimates for L_{inf} (table 5).

Plotting these high estimates back on to the length frequency curves missed several modes. The estimates from ELEFAN response surface analysis produced a better 'fit'. These values were used for further analysis. The estimate for L_{inf} which is at the upper end for the species agrees with cited figures in FishBase 99 for Kainji Lake whilst the growth constant K is similar to the mean for the species.

Table 5 Growth parameter estimation for *Sarotherodon galilaeus galilaeus*

Species	$L_{inf (cm)}$ 95% CI	K	Rn	Phi Prime	Method
Sarotherodon galilaeus	42.8 (TL) 42.3-43.2				Froese & Binohlan 1999
	43.0	0.41	0.11	2.88	ELEFAN. Response surface analysis
	48.5	0.55	0.14	3.11	ELEFAN, scan of K values
Final estimates	45.75	0.47		2.995	Mean of Phi prime and L_{inf} to calculate K
Conversion of lengths Insufficient data					

Oreochromis niloticus niloticus

Using estimates obtained from the old GN trial data as initial inputs gave high values of L_{inf} and K.

ELEFAN's scan of K values agreed with these estimates but displayed a second optima for Rn with a lower K value (table 6).

Shepard's scan of K values also gave a secondary lower estimate for K which is more realistic when compared to the species data from FishBase 99.

It is more accurate to opt for the lower peaks for K, where K = 0.29 and L_{inf} = 53.2.

Table 6 Growth parameter estimation for *Oreochromis niloticus niloticus*

Species	$L_{inf (cm)}$	K	Rn	Phi	Method
Oreochromis niloticus	42.8 42.4-43.3 (CI)				Froese & Binohlan 1999
	56.0	0.75	0.18	3.37	ELEFAN I,
	52.0	0.30	0.13	2.91	Optimising parameter combinations
	57.5	0.74	0.18	3.39	ELEFAN scan of K
	57.5	0.33	0.15	3.04	value
	50.0	0.26		2.81	Shepard's scan of K values
Final Estimates	53.2	0.29		2.92	Mean of Phi prime and L_{inf} to calculate K
Conversion of lengths Insufficient data					

Synodontis membranaceus

The estimates using the GN trial data were L_{inf} = 52 cm and K = 0.50.

ELEFAN scan of K values gave a strong peak of K at 0.55. The estimate of Rn was improved by inputting increasing values for L_{inf} which caused the K value to decline. The optimum was Rn= 0.16 where L_{inf}= 52 and K=0.53 (table 7).

The estimates were averaged and used as an input for Shepard's scan of K values. The resulting curve was bimodal and was not used. Response surface analysis also produced a wide spread of values making the identification of an optimum difficult.

The identification of peaks in the Bhattacharya's and NORMSEP methods was straightforward. However the subsequent linking of means was more problematic. Results from ELEFAN were therefore used.

No values in FishBase 99 are available to assist in validating results.

Table 7 Growth parameter estimation for *Synodontis membranaceus*

Species	$L_{inf\,(cm)}$ 95% CI	K	Rn	Phi Prime	Method
Synodontis membranaceus	49.9 (TL) 49.4-50.5				Froese & Binohlan 1999
	52	0.50	0.16	3.13	ELEFAN optimising routine
	52	0.53	0.16	3.14	ELEFAN scan of K value
	52	0.53		3.16	Shepard's scan of K
	52	0.28		2.88	values
Final Estimates	51	0.52		3.135	Mean of Phi prime and L_{inf} to calculate K

Conversion of lengths	P*	N	
TL=1.215FL+ 16.15	0.00	449	unsexed
FL=0.694TL+18.09 (lengths expressed in mm)	0.00	449	

* Pearson's correlation coefficient

Chrysichthys nigrodigitatus

L_{inf} derived from GN trial data inputted into ELEFAN I optimising parameter routine gave L_{inf} as 49 cm and K as 0.54.

ELEFAN scan of K values increased the estimate of K to 0.59 (Rn=0.155). Shepard's scan of K values gave unrealistic estimates of L_{inf} (table 8).

Estimates of L_{inf} and K do not compare with the figures cited in FishBase 99 (L_{inf}=85-109 cm, K 0.117-0.165). The published L_{inf} is well below the maximum recorded during gill net trials and the length frequency survey. It appears that estimates for Kainji Lake are more reliable.

Table 8 Growth parameter estimation for *Chrysichthys nigrodigitatus*

Species	$L_{inf\,(cm)}$ 95% CI	K	Rn	Phi	Method
Chrysichthys nigrodigitatus	49 (TL) 48.5-49.5				Froese & Binohlan 1999
	49	0.54	0.14	3.11	ELEFAN I, Optimising parameter combinations
	49	0.53	0.14	3.10	ELEFAN I, Scan of K values
	49	0.21		2.70	Shepard's scan of K values
Final Estimates	49	0.53		3.105	Mean of Phi prime and L_{inf} to calculate K
Conversion of lengths			P*	N	
TL=1.299FL- 0.684			0.96	264	
FL=0.715TL+14.45					

* Pearson's correlation coefficient

Lates niloticus

ELEFAN's response surface analysis estimated L_{inf} =155 cm and K = 0.27. ELEFAN's scan of K values gave the same estimates.

The values obtained from Shepard's scan of K values missed several observed peaks when plotted and were not used.

Gulland and Holt and von Bertalanffy methods gave estimates which were similar to those from ELEFAN. The results of the three estimates using a mean phi prime value were taken as being representative of the population.

The estimate of L_{inf} is higher than the figure published for Kainji Lake in FishBase 99 but is well within the limits cited for other lakes and similar to that for Lake Chad. The growth constant K was in line with those published.

Table 9 Growth parameter estimation for *Lates niloticus*

Species	$L_{inf\,(cm)}$	K	Rn	Phi	Method
Lates niloticus	74.9 (TL) 74-75.8 (CI)				Froese & Binohlan 1999
	155	0.27	0.13	3.81	ELEFAN I, Response surface analysis
	155	0.27	0.13	3.81	ELEFAN I, scan of K values
	155	0.27		3.81	Gulland and Holt
	166	0.23		3.80	von Bertalanffy
Final Estimates	158.7	0.25		3.80	Mean value, using Phi prime

Conversion of lengths
Insufficient Data

3.4. Mortality Rates

Natural mortality (M) is the mortality caused by all other factors except fishing. Common with tropical species natural mortality for all the sampled species was high (table 10). This in turn gave high M/K values which has an impact on the shape of yield per recruit curves (section 3.9).

The value of M is a mean for all the cohorts of a species. Usually one expects M to be highest during the juvenile stages when the number of predators are large. This is the case for *Lates* which has no predators at large size and has a low overall M value.

The exploitation rate (E) is the fraction of deaths caused by fishing and was lowest for *Citharinus* and *Oreochromis*. The exploitation rate for the remaining four species was high.

Apart from *Citharinus* and *Oreochromis niloticus* the remaining proportion of total mortality, fishing mortality, was high.

From the length frequency curves (sect. 3.8) it can be seen that the juveniles are mainly being fished. The high fishing mortality (and high natural mortality during juvenile stages) is therefore worrying suggesting severe growth overfishing for Sarotherodon galilaeus galilaeus, Synodontis membranaceus, Chrysichthys nigrodigitatus and Lates niloticus.

Table 10 Natural, fishing and total mortality estimates by species, Kainji Lake length frequency sample 1998

Species	M	M/K	t_0	F	Z	r (Z)	CI (Z) lower	CI (Z) upper	E
Citharinus citharus	0.90	1.91	-0.04	1.17	2.07	-0.946	1.81	2.33	0.56
Sarotherodon galilaeus galilaeus	1.00	2.14	-0.30	3.86	4.86	-0.993	4.53	5.19	0.79
Oreochromis niloticus niloticus	0.72	2.48	-0.50	0.67	1.39	-0.885	1.15	1.64	0.48
Synodontis membranaceus	0.97	1.87	-0.30	3.20	4.17	-0.947	3.32	5.01	0.76
Chrysichthys nigrodigitatus	0.98	1.85	-0.30	4.31	5.29	-0.990	4.96	5.62	0.81
Lates niloticus	0.49	1.96	0.24	3.12	3.61	-0.861	2.75	4.47	0.86

3.5. Mesh Size Selection

All fishing gears used on Kainji Lake are selective for fish of a certain size range.

Mesh sizes in nets on Kainji Lake are less selective than conventionally rigged nets since Kainji Lake fishermen use a loose hanging ratio. Because of this fish are more easily tangled than gilled. Many lake species also possess protruding spines which further assist in tangling the fish (du Feu et. al. 1997).

For management of the fishery it is useful to establish the size selection of fish for the separate mesh sizes and to investigate whether there are differences between the same mesh sizes of separate fishing methods. This can be done using length frequency data where samples per mesh size are derived from equal effort, equal standard deviation and a normal distribution (Baranov and Holt model). The ease of entanglement (and not gilling) of fish may produce curves which are not normal and in such cases more elaborate methods than this model should be applied.

Knowing the size at capture per mesh size will enable recommendations of optimal mesh sizes to be made from yield per recruit analysis (sect. 3.9).

Citharinus has the largest sample number and was used to estimate the selection curves for gill nets, cast nets and drift nets (fig. 1).

There is evidence that the size of fish captured by cast nets and drift nets is larger than those caught by equivalent mesh sizes from gill nets. This is the justification for the smaller mesh size for cast nets currently advocated in the State Fisheries Edicts.

For further analysis of the effect of banning undersized cast nets (sect. 3.11) a selection curve was derived combining all the 6 species (fig. 2). The curve is similar to that of *Citharinus* and indicates that the optimum fish length for capture by cast nets of 2.5 inch (64 mm, the legal mesh size for Kainji Lake) is 23.5 cm.

Figure 1 Selection curves for the gill net, drift net and cast net fisheries for *Citharinus citharus* and the cast net fishery for the 6 sampled species.

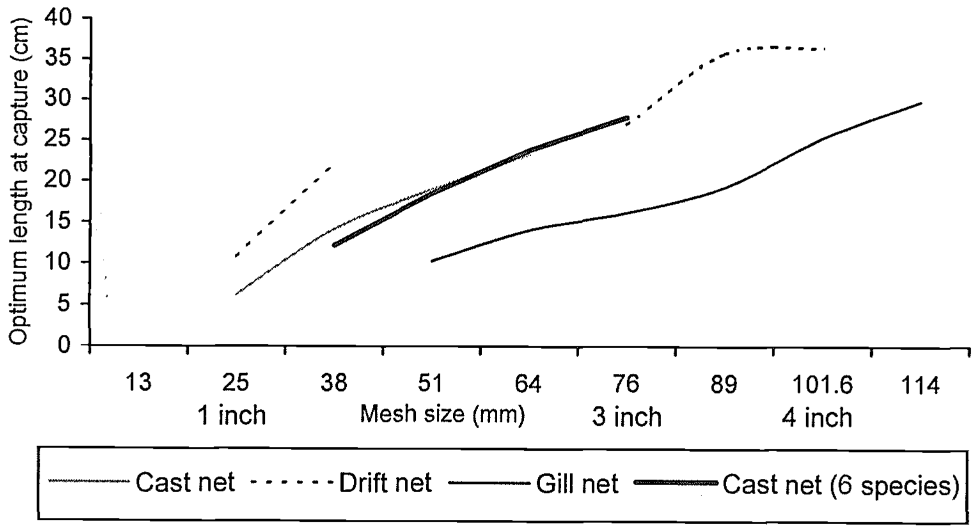
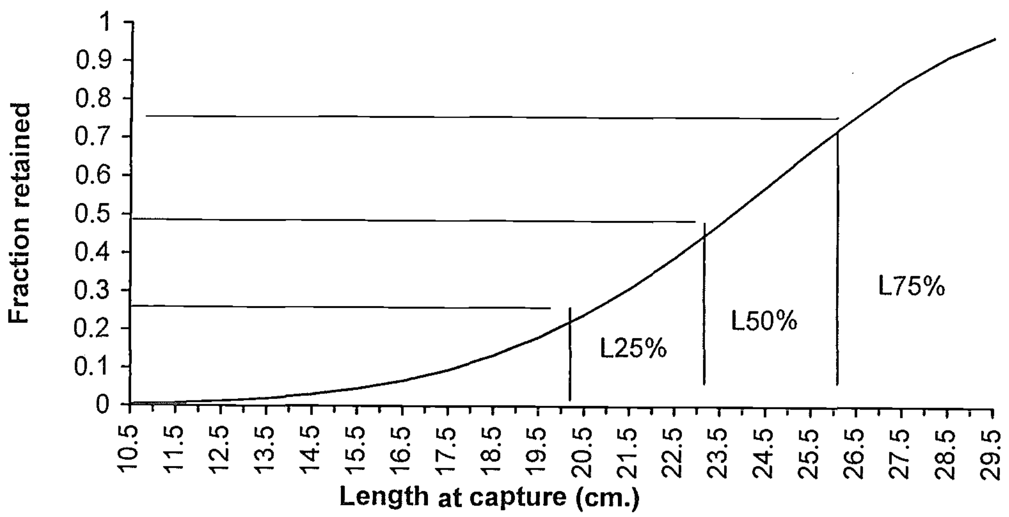


Figure 2 The selection curve for all sampled species for cast nets, mesh size 64 mm (the minimum mesh size for Kainji Lake)



where: L_{25}*= 20.4 cm.,* L_{50}*=23.5 cm and* L_{75}*=26.2 cm.*

3.6. Recruitment Patterns

Graphs of the total number of fish caught by each gear type and month will indicate the gear types and timing responsible of the fishing mortality. Consideration of the size at capture and spawning times will assist when formulating management strategies.

Citharinus citharus citharus

The estimated number of *Citharinus* caught per annum is similar to the results obtained from the CAS which is encouraging given the two different calculation routines used (43m (mean from CAS 1995-1997) *cf.* 43m (1998)).

Drift nets were mainly responsible for the high mortality in November, targeting the newly spawned juveniles as they moved into the main lake from the spawning grounds in the northern basin (fig. 3).

Fishing mortality was greatly reduced after December for beach seines and by July for cast nets. From July the juveniles migrated into deeper water from their shallow nursery grounds. Larger meshed gill nets were still able to catch them in the deeper water.

The highest fishing mortality occurred for *Citharinus* of 13 cm length, this is one third the size of L_{opt}. All *Citharinus* below 5.5 cm are caught by beach seines which are also the main contributor to fishing mortality of fish less than 10 cm. Cast nets do not catch *Citharinus* below 6 cm but have a very high contribution of mortality for fish between 10.5 and 16.5 cm. Cast nets do not catch fish above 30 cm. Sizes above 16.5 cm are mainly caught by gill nets and a lesser extent by cast nets. Apart from the odd large fish caught by beach seines, gill nets catch all of the larger sized *Citharinus* (fig. 4).

A large mortality of juveniles by drift nets occurred from October to November. Consideration must be given to controlling the use of small meshed drift nets at this time. The modal length of Citharinus caught was only 8.5 cm.(1997) and 10.5 cm. (1998).

Cast nets were responsible for catching 33% of all Citharinus below the optimum size at capture, beach seines (although targeting Citharinus at a smaller size) caught the same number of fish below the size of L_{opt} as gill nets (24%).

For the management of Citharinus the enforcement of undersized cast nets should follow the ban of beach seines.

The high mortality from Sept. to Dec. is of concern since the Citharinus caught have a length range from just 2.5-17.5 cm. Further, 95% of the fish caught at this time are from the first year cohort from the August spawning just one month previously.

From virtual population analysis 46% of all first year recruits in 1998 entering the 2 cm length class were caught before they reached a size of 15 cm. The calculation ignores natural mortality and is alarming, suggesting severe growth overfishing of this species.

Figure 3 Numbers of *Citharinus citharus citharus* caught by gear type, Kainji Lake, Jan-Dec., 1998

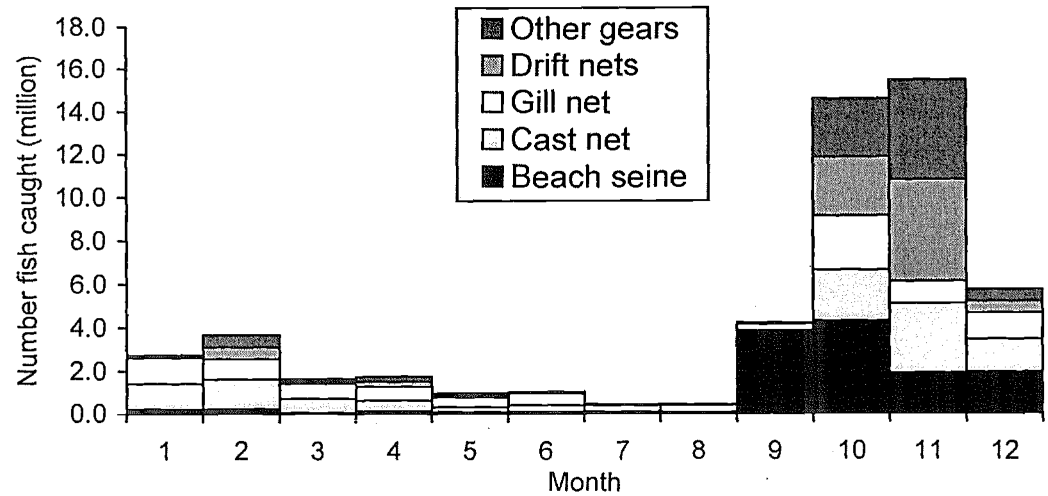
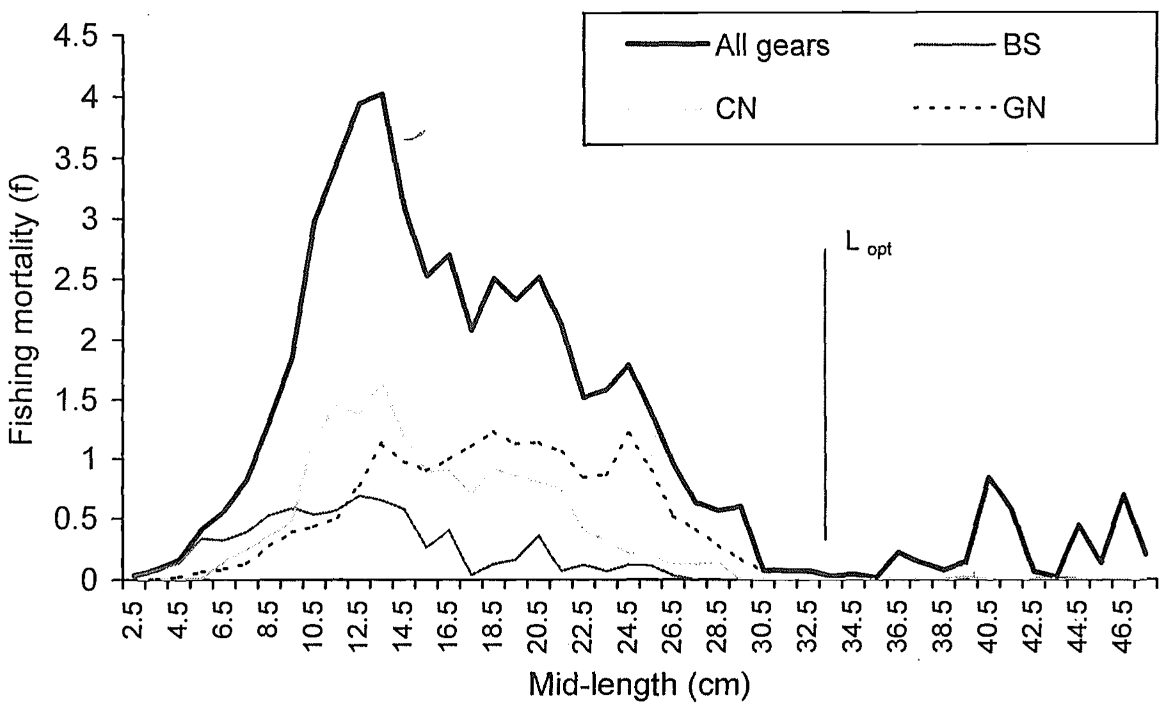


Figure 4 Contribution to the fishing mortality of *Citharinus citharus citharus* by the beach seine, cast net and gill net fisheries, Sept. 1997-Dec. 1998



Tilapiines

For the two species of Tilapiines traps followed by cast nets caught the most fish. The influence of traps was most prominent during high water when the fish were breeding within the submerged vegetation. As the water receded they were fished by cast nets (fig. 5 & 7).

Tilapiines were caught by beach seines during the low water when by-catch of other species is low. The highest mortality of *Sarotherodon galilaeus* occurred during high water.

Fishing mortality of *Oreochromis niloticus* decreased from January onwards. At this time the species spawns (Ita 1982). From the length frequency data the length range was from 6.5-22.5 cm, indicating that it is not the first year cohort being fished but rather the spawning population (fig. 6 & 8).

Tilapiines do not produce large numbers of offspring. The large numbers of juveniles caught by traps and cast nets will cause the stock to be very susceptible to recruitment overfishing. Catch per unit effort (CPUE) figure must, therefore, be closely monitored in future. Regulation of minimum cast net size will alleviate some of this early fishing pressure.

Figure 5 Number of *Sarotherodon galilaeus galilaeus* caught by gear type, Kainji Lake, Jan-Dec., 1998

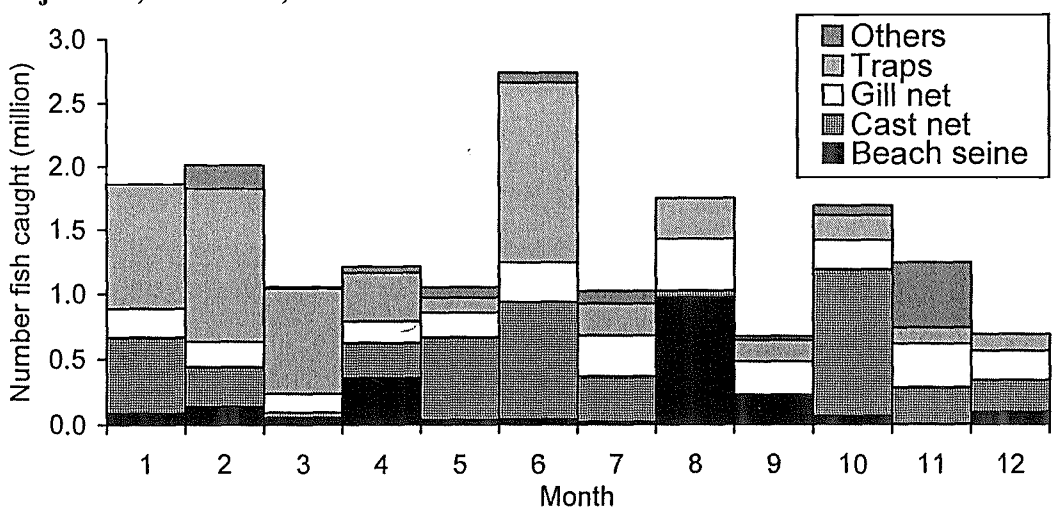
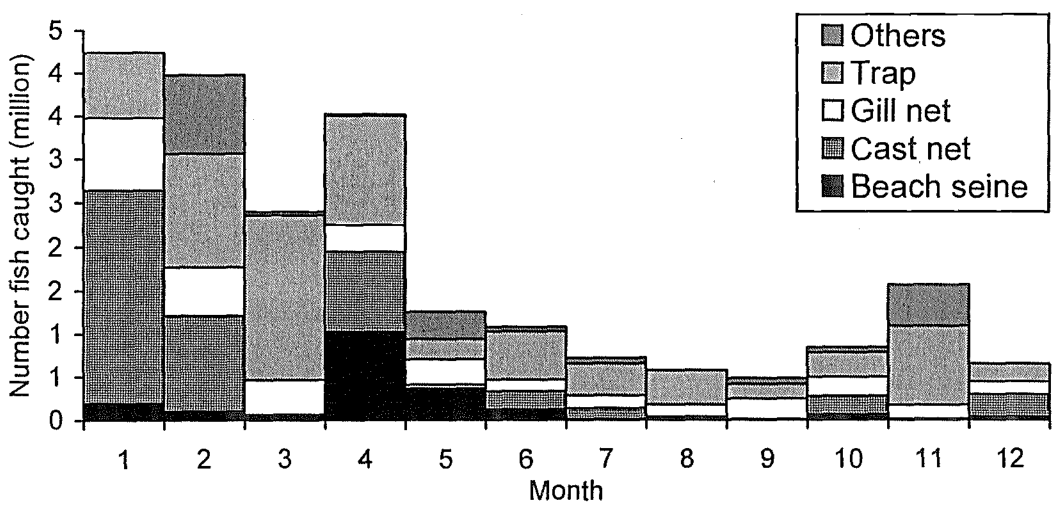


Figure 6 Number of *Oreochromis niloticus niloticus* caught by gear type, Kainji Lake, Jan-Dec., 1998



Similar to *Citharinus* the peak fishing mortality occurred at a size of 13 cm. (half the size of L_{opt}). At this size beach seines, cast nets and gill nets contributed equally to the mortality. Beach seines and cast nets were mainly responsible for catching very small fish with gill nets targeting larger fish.

Figure 7 Contribution to the fishing mortality of *Sarotherodon galilaeus galilaeus* by the beach seine, cast net, gill net and trap fisheries, Jan. 1998-Dec. 1998

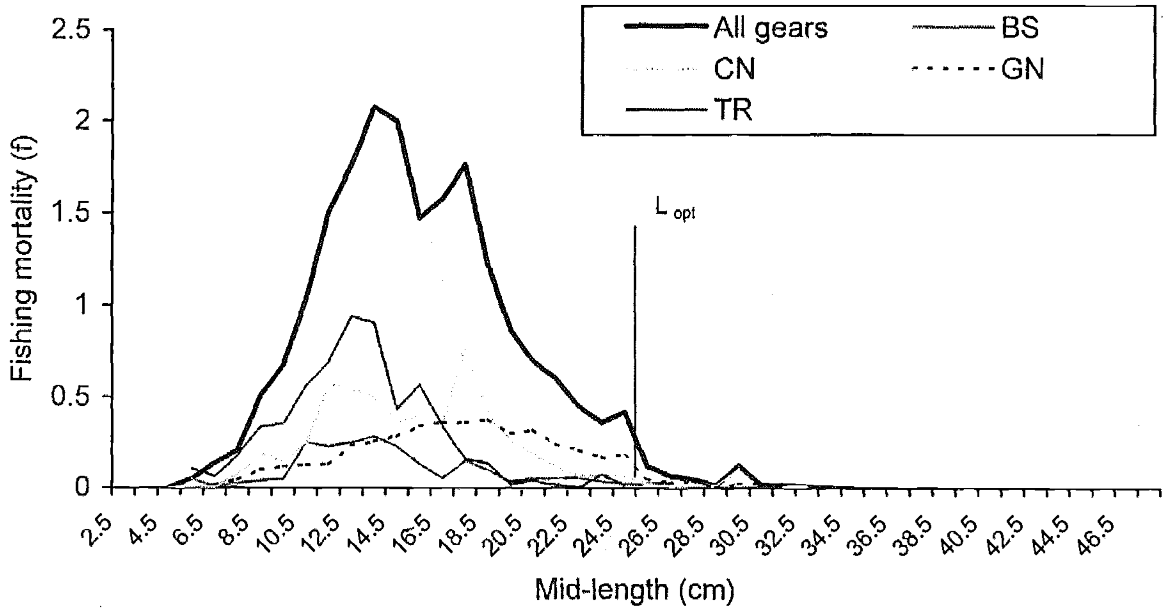
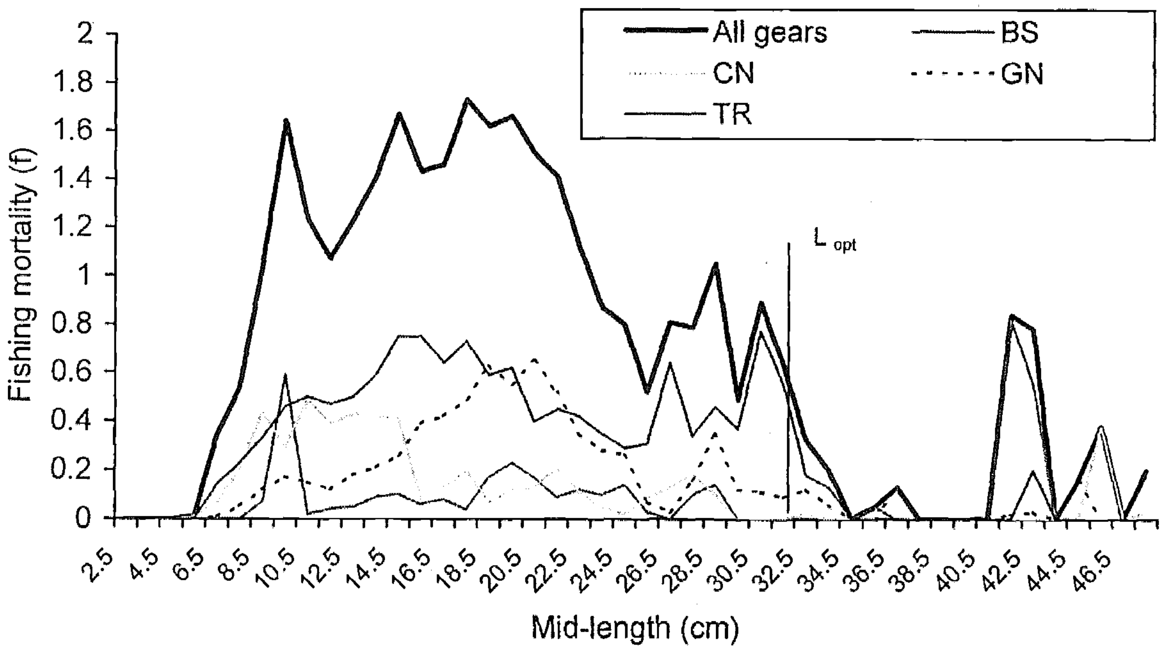


Figure 8 Contribution to the fishing mortality of *Oreochromis niloticus* by the beach seine, cast net, gill net and trap fisheries, Jan. 1998-Dec. 1998



Synodontis membranaceus
The total number of fish caught is very similar to estimates from the CAS (12.8 m *c.f.* 12.1 m).

A total of 68% of all *Synodontis* were caught by gill nets, particularly from January to June. One inch meshed nets were responsible for the highest mortality. There was a high mortality caused by beach seines and cast nets in October, the time when the species spawns (fig. 9).

The peak of fishing mortality is closer to the L_{opt} than for any other species. Large meshed gill nets were mainly responsible for catching the larger fish. Beach seines, cast nets and traps have equal contributions to those of smaller size (fig. 10).

The high fish catches by cast nets and beach seines is supported by subsequent analysis which shows that regulation of these fisheries will result in a 12% increase in yield of a species which accounted for 6.8% of total lake yield in 1998.

Figure 9 Number of *Synodontis membranaceus* caught by gear type, Kainji Lake, Jan-Dec., 1998

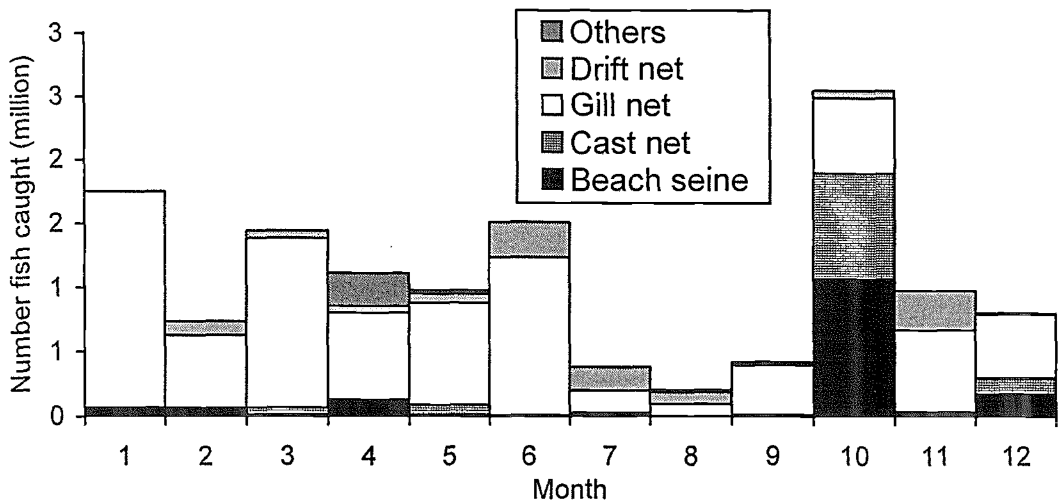
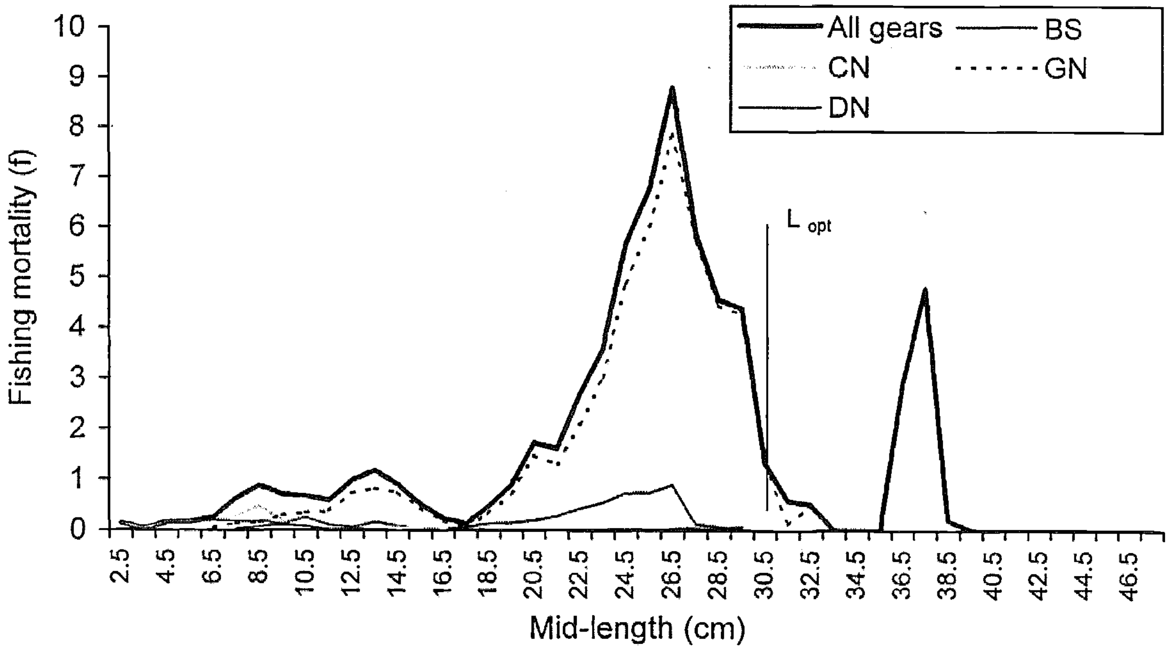


Figure 10 Contribution to the fishing mortality of *Synodontis membranaceus* by the beach seine, cast net, gill net and drift net fisheries, Jan. 1998-Dec. 1998



Chrysichthys nigrodigitatus

Traps accounted for the highest mortality of *Chrysichthys nigrodigitatus* (78%). Catches were restricted to the high water period when the fish were within the submerged aquatic vegetation, areas where fishing by traps is efficient. There was a high peak in March which may have been caused by fish fencing, a fishing method that incorporates traps. Gill nets were responsible for a small mortality during low water (fig. 11).

Traps catch a wide size range of fish and were responsible for a peak in mortality both at small and large size. Gill nets also catch a wide size range, accounting for approx. 16% of that of traps (fig. 12).

Figure 11 Number of *Chrysichthys nigrodigitatus* caught by gear type, Kainji Lake, Jan-Dec., 1998

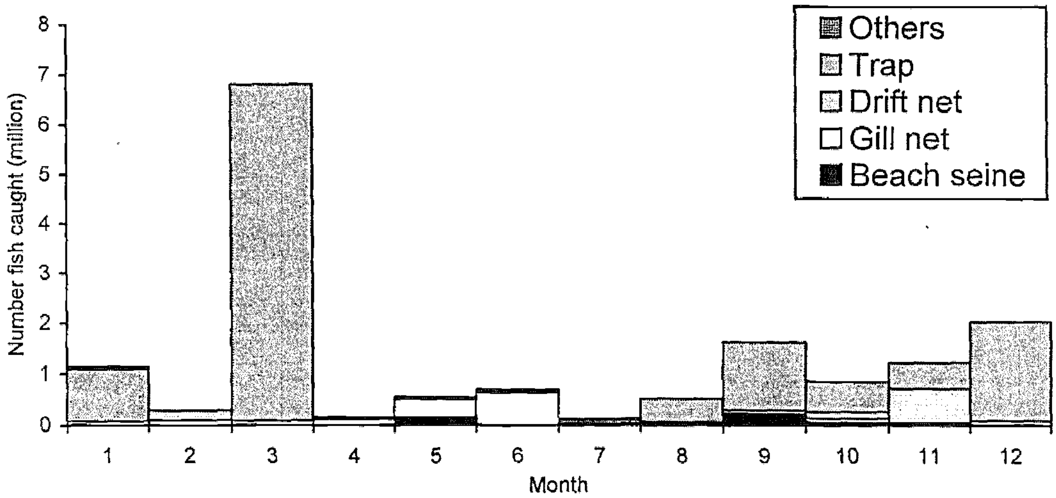
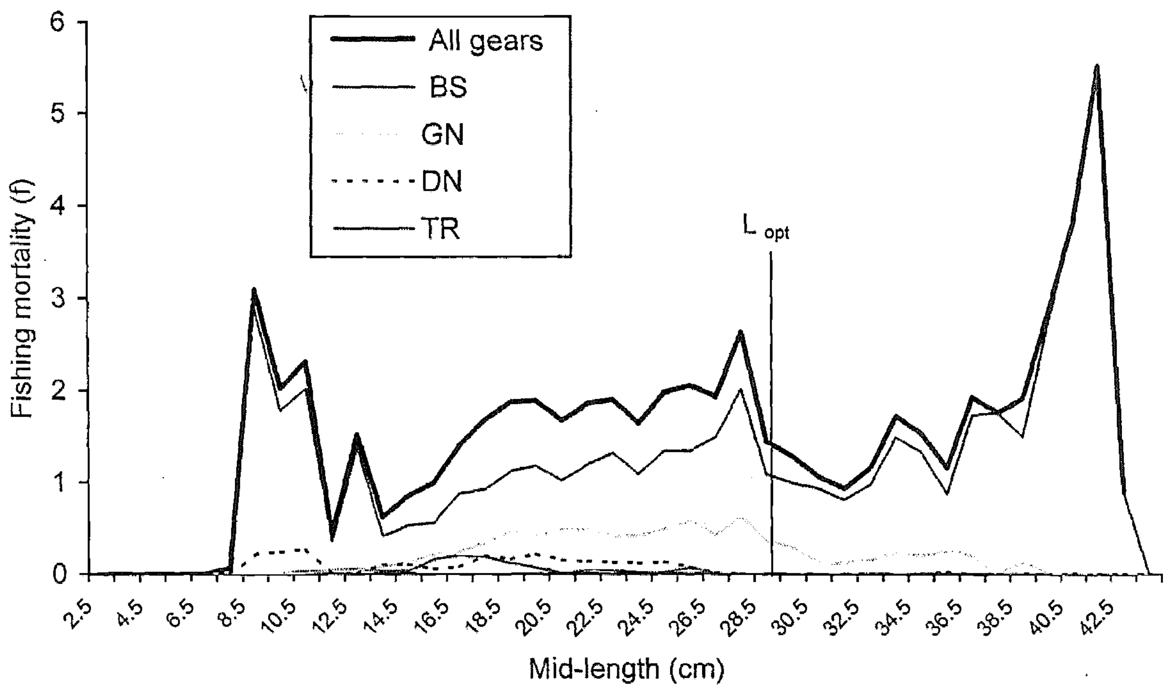


Figure 12 Contribution to the fishing mortality of *Chrysichthys nigrodigitatus* by the beach seine, gill net, drift net and trap fisheries, Jan. 1998-Dec. 1998



Lates niloticus

The recruitment pattern for *Lates* shows two peaks from January-March and August-October which are the times of the species two annual spawnings (Balogun 1988).

Gill nets accounted for the highest mortality of *Lates* with numbers decreasing from Aug. to Dec. Like *Synodontis* the species is mainly targeted by 1 inch and, to a lesser extent, 2 inch meshed nets (fig. 13).

Lates were also caught as by-catch (at a size of 8-23 cm.) by beach seines during the low water period. There was a high peak caused by longlines in October which was not characteristic of the whole year.

The high mortality of undersized Synodontis and Lates by 1 inch nets is of concern. It reduces the catch by other gears; gill nets in the case of Synodontis and longlines for Lates.
Over half of all one inch nets present on the lake are used by fisherwomen. Enforcement of this mesh size will, therefore, seriously affect their livelihood. (du Feu & Abiodun 1999)

Figure 13 Number of *Lates niloticus* caught by gear type, Kainji Lake, Jan-Dec., 1998

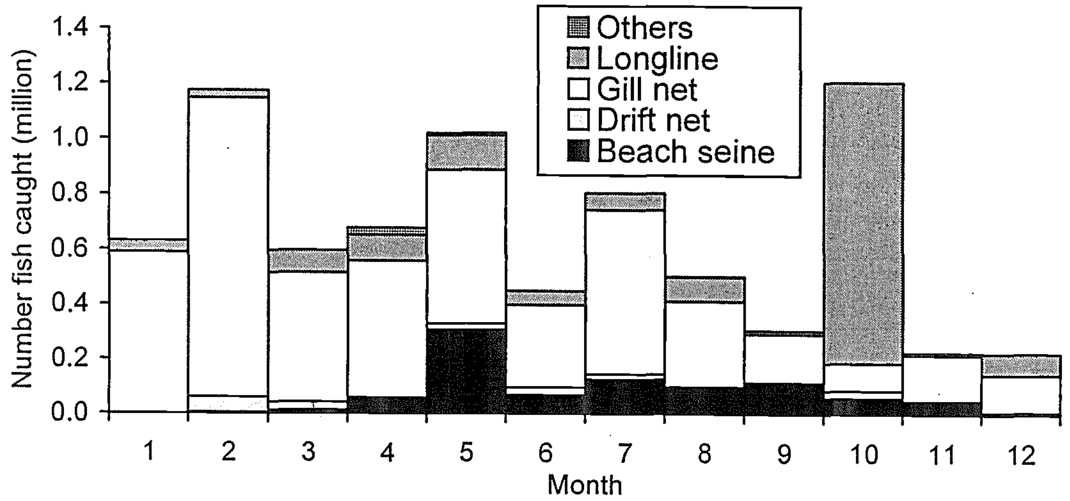
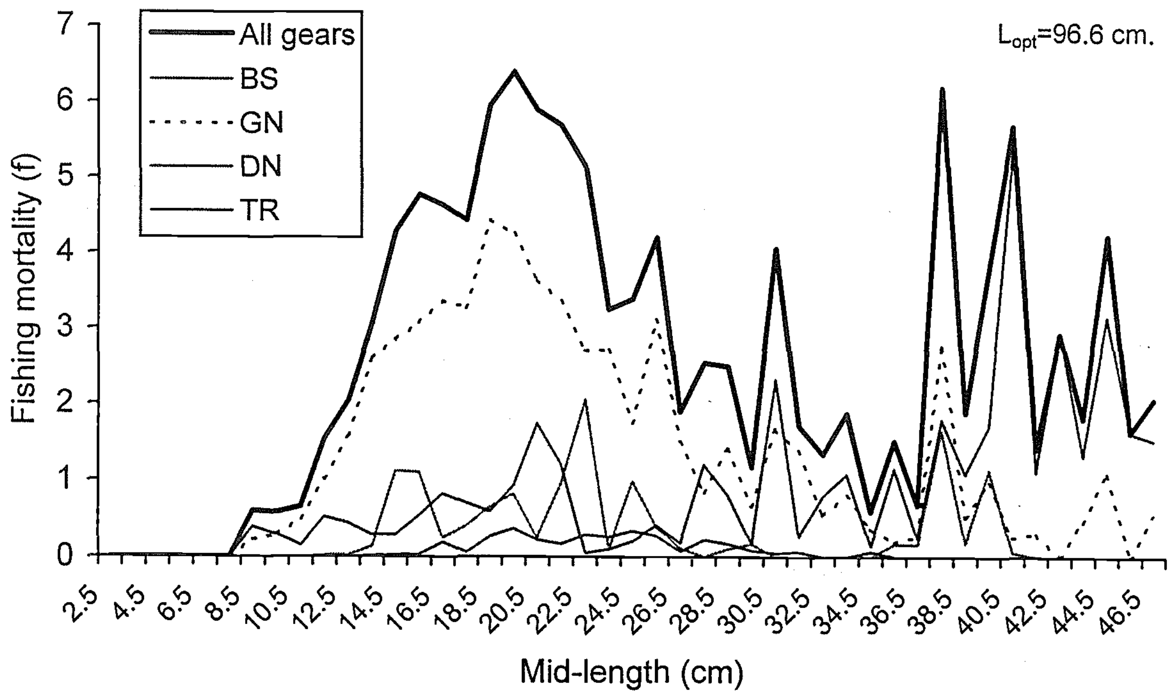


Figure 14 Contribution to the fishing mortality of *Lates niloticus* by the beach seine, gill net, drift net and longline fisheries, Jan. 1998-Dec. 1998



3.7. Fisheries Management Strategies- General Comments

Tropical fish species generally have high rates of natural mortality (M) and growth (K). By comparing M/K ratios some overall management strategies can be suggested. For the six sampled species these can be split into 3 groups (table 11):

Table 11 General fishery management strategies from natural mortality and growth rates.

Group 1	M	K	M/K	Comment
Citharinus citharus citharus	0.9	0.47	1.9	High natural mortality Moderately high growth rate
Sarotherodon galilaeus galilaeus	1.00	0.47	2.13	*as above*
Synodontis membranaceus	0.97	0.52	1.86	*as above*
Chrysichthys nigrodigitatus	0.98	0.53	1.85	*as above*
Given high natural mortality and moderate growth rate it is best to target the fish at small size. The high M/K ratio means that a high level fishing effort is required to maximise the optimal size at harvest. If high fishing mortality is exceeded it will lead to low stock biomass and low CPUE.				
Group 2				
Oreochromis niloticus niloticus	0.72	0.29	2.48	High natural mortality Average growth rate
In cases of low natural mortality and average growth rate it is best to fish the stock using large mesh sizes. i.e. to allow fish to grow without being subject to natural mortality.				
Group 3				
Lates niloticus	0.49	0.25	1.96	Low natural mortality Low growth
The effects of low natural mortality and low growth rate will cancel each other out. It will produce a flat yield per recruit curve with no distinct optimum size at capture.				

The strategies suggested for group 2 (the majority of the sampled species) are somewhat in line with those currently practised on the lake. However, the extreme early time of fishing stocks at present is far below that inferred in the text.

3.8. Levels of Growth Overfishing

Histograms of the length frequency data with asymptotic length (L_{inf}), optimum length at capture (L_{opt}) and length at maturity (L_m) plotted will give a good initial impression of the level of growth overfishing for each species.

This can be quantified by converting the total number of lengths per length class into weights to calculate the present catch. This can be compared with the possible catch if the size at capture is increased.

Care must be taken when interpreting the results since the model ignores natural mortality. An assumption of the model is that this will be counteracted by disregarding specimens larger than L_m (Froese 1999). However, there are few specimens larger than L_m being caught in the Kainji fishery. Including such species, especially those with high fecundity and high mortalities, such as *Citharinus* and *Lates* will result in unrepresentative high yields. This is particularly relevant since natural mortality increases with population biomass. *Citharinus* and *Lates* have therefore been omitted from the subsequent yield calculation.

In all species there is strong evidence of both recruitment and growth overfishing with almost all fish caught below the size at maturity and the optimal size. This is especially the case for the highest yielding species *Citharinus* and the highest valued species *Lates*.

The graphs present an alarming picture of targeting of species far below their length at maturity and their optimum length. Figures 15-20 present a clear picture and can be used to show Government and Traditional Authorities etc. "the plight of the Kainji Lake fishery".

Figure 15 Length frequency data of *Citharinus citharus citharus*, Sept. 1997-Dec. 1998

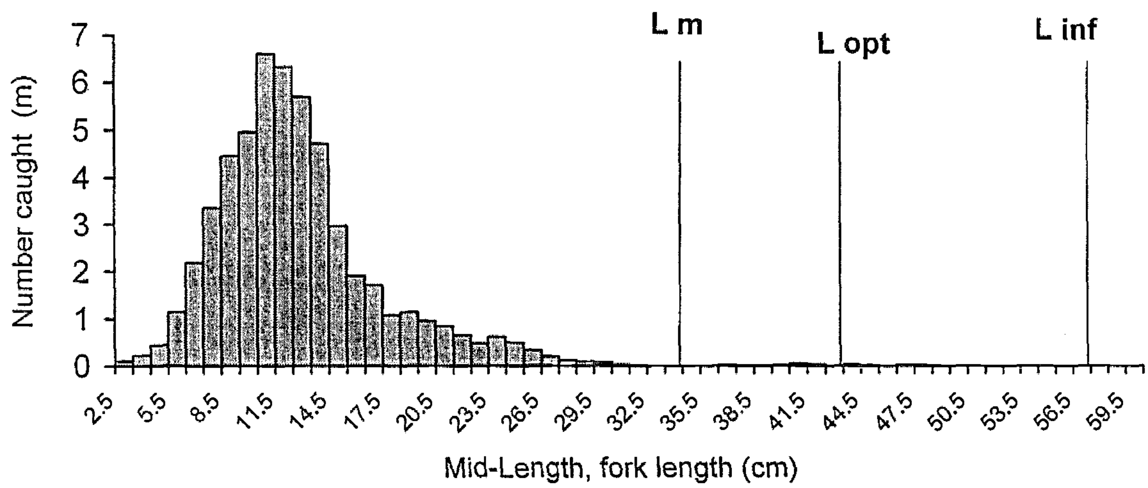


Figure 16 Length frequency data of *Sarotherodon galilaeus galilaeus*, Jan. 1997-Dec. 1998

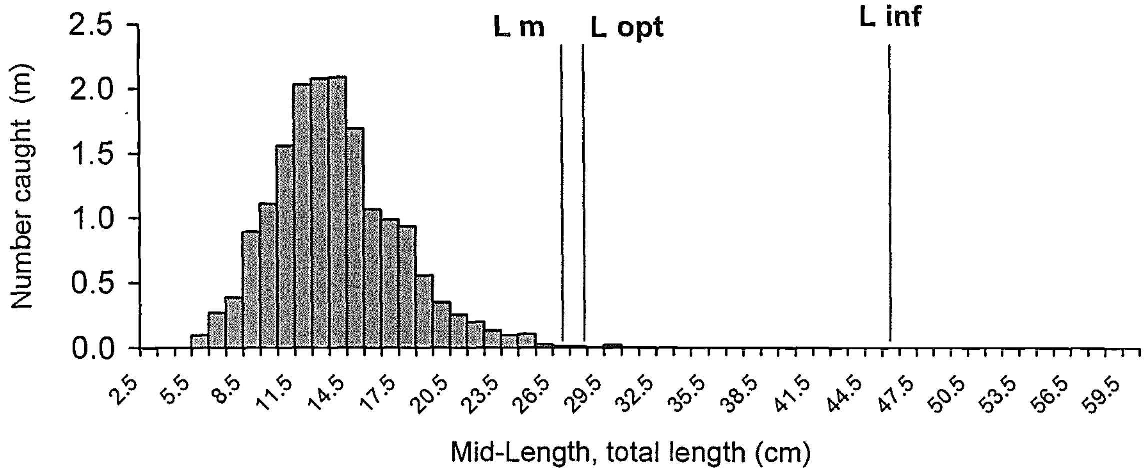


Figure 17 Length frequency data of *Oreochromis niloticus niloticus*, Jan. 1998-Dec. 1998

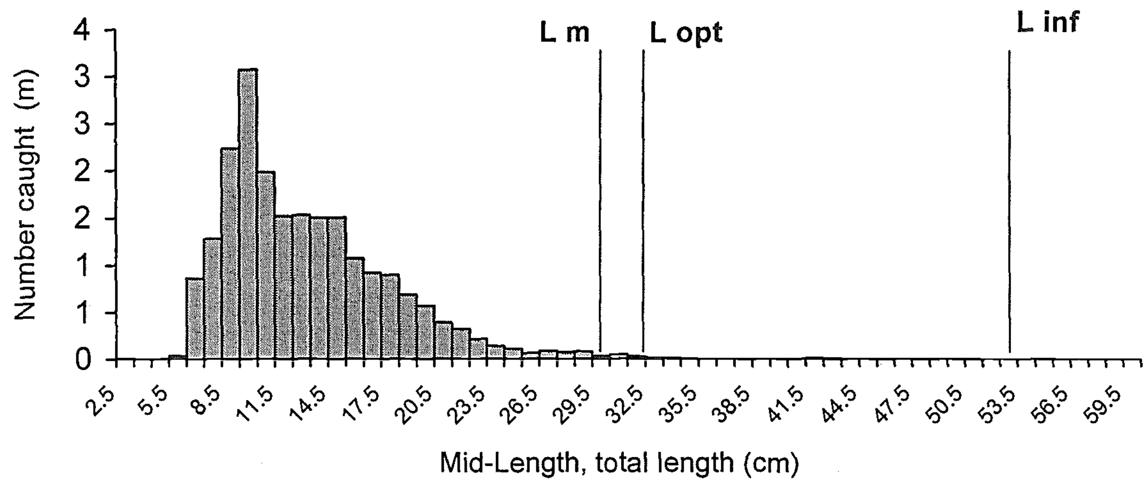


Figure 18 Length frequency data of *Synodontis membranaceus*, Jan. 1998-Dec. 1998

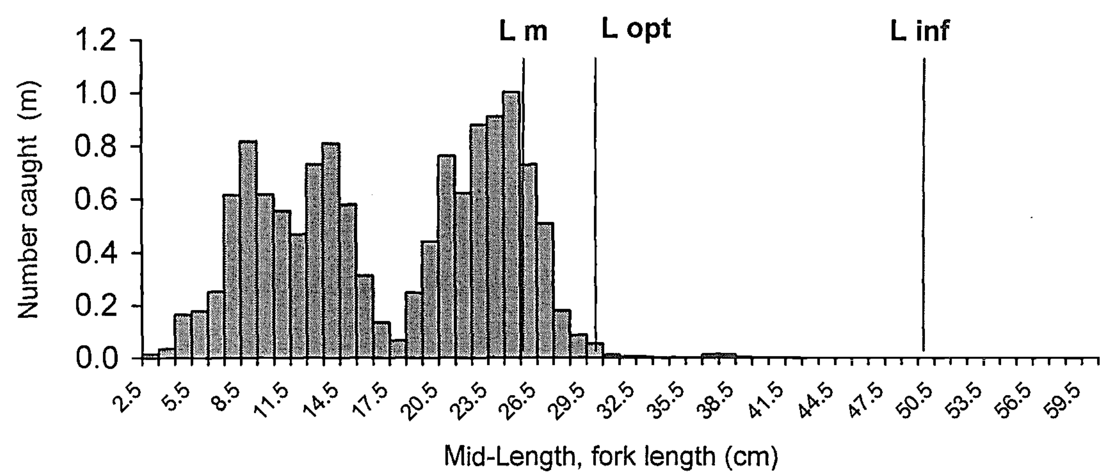


Figure 19 Length frequency data of *Chrysichthys nigrodigitatus*, Jan. 1998-Dec. 1998

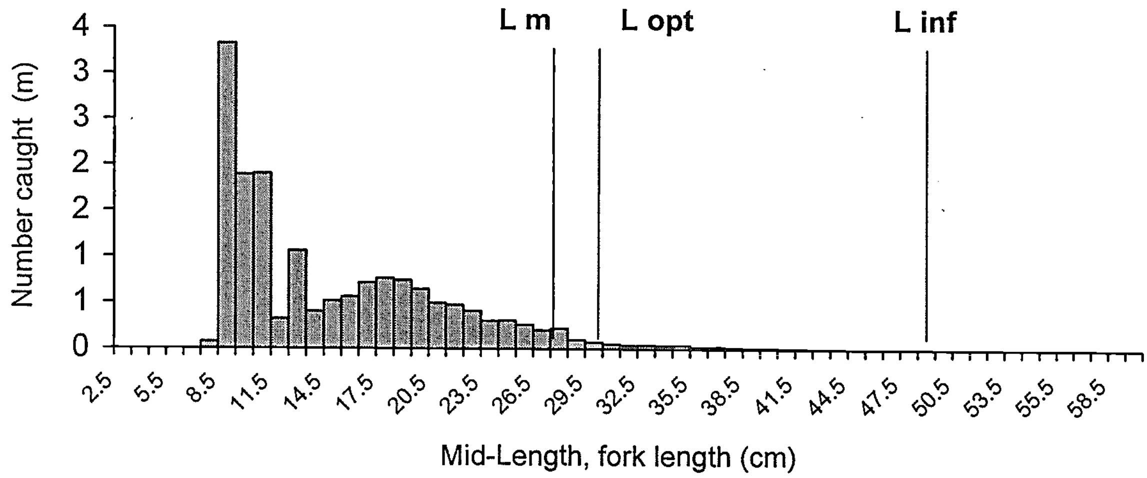
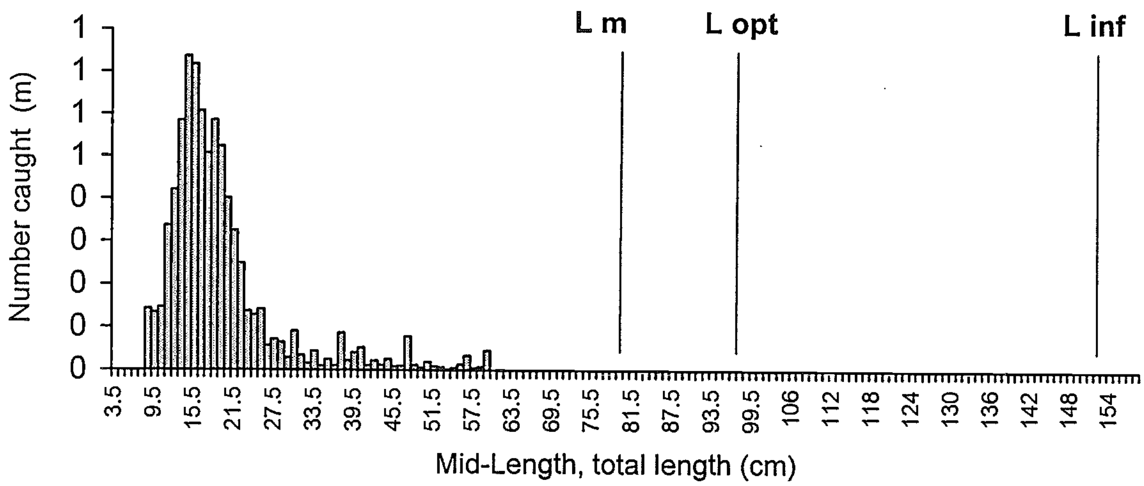


Figure 20 Length frequency data of *Lates niloticus*, Jan. 1998-Dec. 1998



all fish numbers are in millions

Table 12 The shortfall of catch due to fishing below the size at maturity, length frequency data 1998

Species	L_{inf} cm.	L_{opt} cm.	L_m cm.	L_{poss} cm.	Catch if left to grow beyond L_m (t)	Actual catch (t)
Citharinus citharus citharus	56.6	34.5	31.3	32.9		2,891
Sarotherodon galilaeus galilaeus	45.75	27.8	25.9	26.9	5,168	1,029
Oreochromis niloticus niloticus	53.2	32.4	29.6	31.0	12,169	1,637
Synodontis membranaceus	51	31	28.5	29.8	5,633	2,017
Chrysichthys nigrodigitatus	49	29.8	27.5	28.7	11,792	1,200
Lates niloticus	158.7	96.6	79.1	87.8		1,293

3.9. Optimum Size at Harvest

The yield per recruit model examines the trade-off between catching a *large* number of fish *early* in their life and capturing a *smaller* number of *larger* fish later. It is therefore dependant on the rates of fish growth and mortality (see sect. 3.7). The model is useful when assessing the impact of differing mesh size regulations on the yield from the fishery.

Citharinus citharus citharus

The yield per recruit curve has a maximum at high fishing effort (typical for species with high natural mortality and growth). The high natural mortality also causes the yield per recruit to be lower than a stock with lower natural mortality.

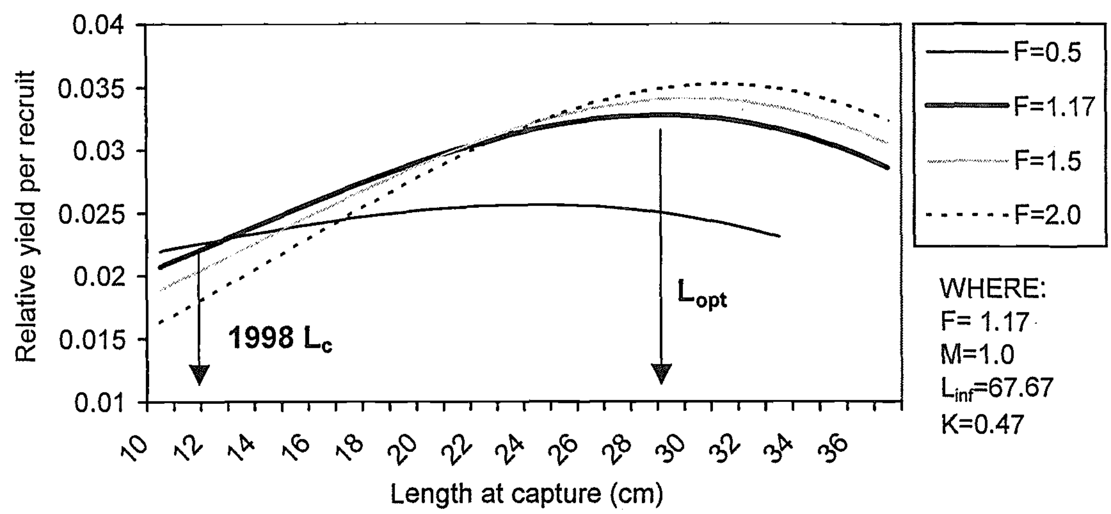
Increasing the size at first capture leads to an increase in yield which is maximised at a high fishing effort (fig. 21). There is a decrease in yield at larger size if the fishing effort is too low. There is very little change of yield by altering levels of fishing effort at the present size at capture.

At the present level of fishing effort (F=1.17) the yield from *Citharinus* can be increased by 43% if the species are caught at L_{opt}. This will allow for a small increase in fishing effort. At the present size of capture increasing effort will cause a fall in yield.

The species are targeted by almost all the gears. Controlling the early mortality by beach seines and also by implementing the minimum cast net and gill net mesh sizes will raise the size at capture and increase yields. This is important to counteract the future fall in yield expected through rising effort levels of these fisheries.

The calculated value for L_{opt} is slightly less than the range for L_{opt} defined using the equation from Froese and Binohlan 1999 (where L_{opt}=34.5, range 95% 31.4-37.8).

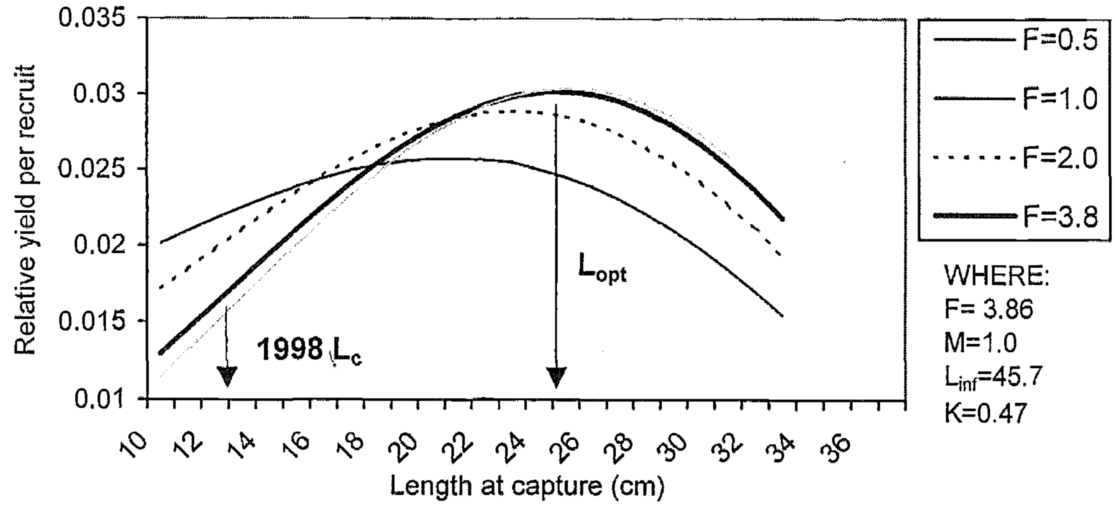
Figure 21 Yield per recruit curve for *Citharinus citharus citharus* at varying levels of fishing effort



The fishing effort for *Sarotherdon* is already at the maximum needed for optimal yield per recruit. Increasing size at capture is, therefore, the only alternative to increasing yield. One can expect sharp increases in yield if this is achieved (fig. 22).

Traps and cast nets mainly catch this species. The fishing effort of traps is increasing and this will cause lower yields of Sarotherodon. To counteract this it is important that the size at capture is increased. This is difficult to achieve in traps but can be done by implementing the minimum mesh size for the cast net fishery.

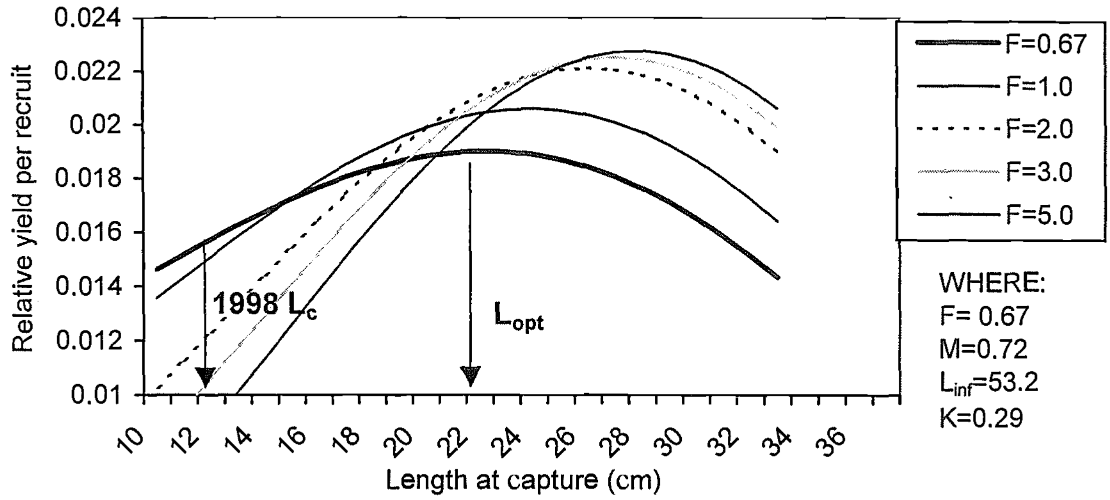
Figure 22 Yield per recruit curve for *Sarotherodon galilaeus galilaeus* at varying levels of fishing effort



Increasing the fishing effort at the present size of capture of *Oreochromis* will result in lower yields (fig. 23). However, increasing the size at capture will allow effort to be increased for optimum yield.

For Kainji the effort levels of traps are increasing and it is therefore important, in order to limit the loss in yield, to increase the species size of capture. It is however difficult to effectively control fish size in traps because of the large mesh size needed. Cast nets are the other gear targeting this species and increasing mesh size will cause an increase in yield of Oreochromis.

Figure 23 Yield per recruit curve for *Oreochromis niloticus niloticus* at varying levels of fishing effort

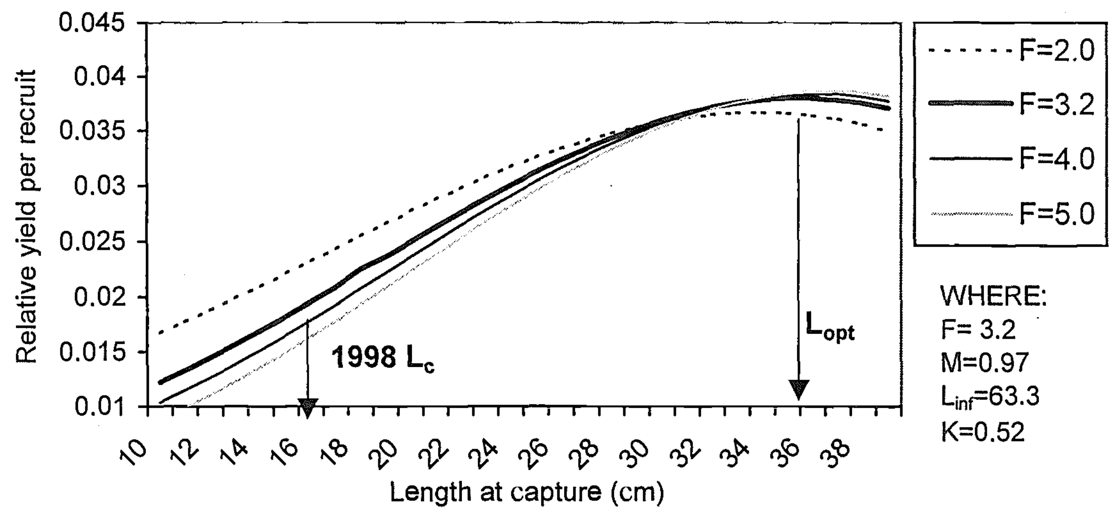


Apart from very small sizes at capture of *Synodontis membranaceus* there is little difference in the optimal size at capture for differing fishing intensities (fig. 24). There is, however, a large increase in the yield per recruit for larger sizes at capture.

Yields can be increased yield by increasing the size at capture or by decreasing fishing effort at the present capture size.

For the management of this species in Kainji decreasing effort is not practical. Limiting small meshed gill nets (the major gear for this species) to increase the size at capture should be addressed. If the size at capture is doubled yield will increase by 81%

Figure 24 Yield per recruit curve for *Synodontis membranaceus* at varying levels of fishing effort

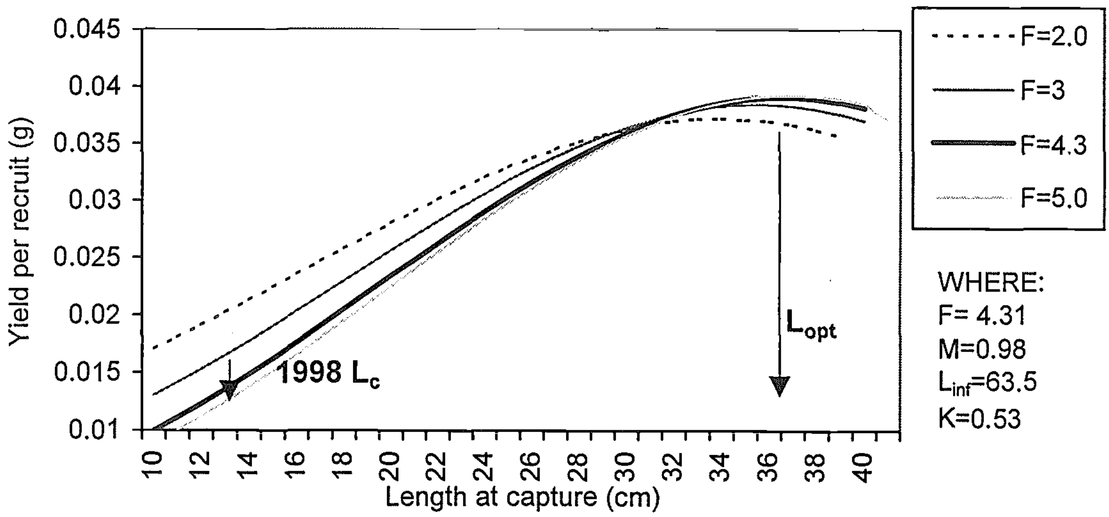


Like *Synodontis* the size at capture for *Chrysichthys* required for the optimum yield per recruit is high. The curves for the two species are similar. For large fish there is little impact on the optimal size yield per recruit for differing fishing intensities. However, for the smaller and present size at capture the yield per recruit can be increased by reducing fishing effort (fig. 25).

Traps are the major fishing method for this species. Trap effort is increasing and the graph shows that, at the present size of capture, yields will fall. The rate of decline in yield reduces as size at capture is increased.

Increasing size at capture in the trap fishery is not practical. In the case of Chrysichthys it is best to control fishing effort by limiting the number of traps fishing. A doubling of yield is possible by reducing fishing effort by a factor of 2.

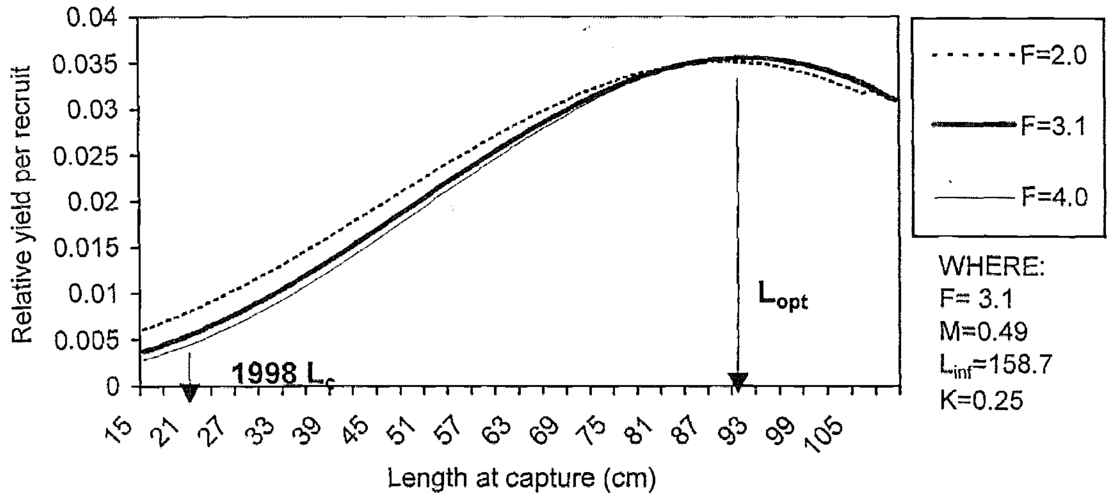
Figure 25 Yield per recruit curve for *Chrysichthys nigrodigitatus* at varying levels of fishing effort



The L_{opt} of *Lates niloticus* is very similar to that obtained by Turner, 1994 using data from Balogon 1988. It is obvious that the present size at capture is far below the L_{opt}. And that large increases in yield will result as the size at capture approaches L_{opt} (fig. 26).

Rising effort at the present length at capture will cause a fall in yield. Increasing the size at capture will have a greater effect of increasing yield than decreasing fishing effort.

Figure 26 Yield per recruit curve for *Lates niloticus* at varying levels of fishing effort



All lengths are total fish length

The mean optimum length of capture (excluding the larger Lates) weighted in terms of yield is 30.6 cm. This corresponds to 3 inch mesh size for cast nets.

Table 13 Summary table of yield per recruit analysis for six commercial species, 1998

Species	Present L_c.	L_{opt} (Yield per rec.)	L_{opt} (L_{inf}*)	Present rel. Yield/ recruit	Opt. rel.Yield per recruit	% change
Citharinus citharus citharus	12.6	29.0	34.5	0.0184	0.0264	+44
Sarotherodon galilaeus galilaeus	13.4	25.0	27.8	0.0185	0.0302	+63
Oreochromis niloticus niloticus	12.8	22.0	32.4	0.0162	0.0190	+18
Synodontis membranaceus	17.1	36.0	31.0	0.0210	0.0380	+ 81
Chrysichthys nigrodigitatus	14.6	37.0	29.8	0.0156	0.0391	+ 150
Lates niloticus	19.4	93.0	96.6	0.0051	0.0355	+ 596

* obtained from Froese and Binolan 1999

3.10. Virtual Population Analysis- Length Structured

VPA is useful to determine the mix of fishing effort (F) required to produce optimal returns.

Results of the four years data gave similar estimates to using 15 months. However, the terminal fishing mortality at larger length classes seemed better represented when using the 4 year period. For all species the 1998 data was, therefore, replicated to 4 years.

The actual catch and numbers caught (from the CAS) and calculated values (from the length frequency sampling) have been compared (table 14). *Citharinus*, Tilapiines and *Synodontis* show good agreement. The catch and numbers of *Chrysichthys* and *Lates* less so. The agreement of fish numbers is encouraging since the values are derived from two separate calculations and it is a good test for the accuracy of the CAS data sets. The difference in yield is a reflection of errors in the length-weight relationships. As expected the biomass of the top predator *Lates* is the lowest whilst that of herbivorous species is an order of 10 higher. *Lates* and *Citharinus* have the highest fishing effort; the two species are susceptible to capture by most of the gear types (table 15).

Table 14 Actual catch and numbers of fish compared with estimates from VPA for the six sampled species

Species	Actual catch (t)	Estimated catch (t)	Actual number*	Estimated number
Citharinus citharus citharus	3,038	2,894	43,509,339	43,493,388
Oreochromis niloticus niloticus	2,950	1,646	50,472,933 *combined values for all tilapiines*	21,313,374
Sarotherdon galilaeus galilaeus	2,950	1,030	50,472,933 *combined values for all tilapiines*	16,965,920
Synodontis membranaceus	2,251	2,018	12,112,749	12,843,303
Chrysichthys nigrodigitatus	2,063	1,201	59,369,672	16,052,169
Lates niloticus	1,300	1,027	2,856,965	7,707,468

** actual number estimated from total catch divided by mean weight of the species using CAS data Jan. 1995-Dec. 1997 (du Feu & Abiodun 1999). Values for tilapiines are combined for the actual number and catch from the CAS..*

Table 15 Mean effort, mean fishing effort and steady state biomass (t), length frequency 1998 using VPA

Species	Mean E	Mean F	Steady state biomass (t)
Citharinus citharus citharus	0.60	1.36	11,341
Oreochromis niloticus niloticus	0.49	0.70	6,975
Sarotherdon galilaeus galilaeus	0.38	0.61	10,456
Synodontis membranaceus	0.45	0.78	4,005
Chrysichthys nigrodigitatus	0.49	0.94	3,055
Lates niloticus	0.79	1.85	1,257

3.11. Predictions of Yields and Catch Values for the Ban on Beach Seines and Minimum Cast Net Mesh Size Regulation

Length based cohort analysis using F-array values from VPA was used.

An assumption of the analysis is that the stock remains in a steady state, with all parameters remaining constant. Recruitment patterns for species, especially *Citharinus* will vary and deviations of the estimates MSY and predicted annual catches will occur.

To pave the way for future project activities the scenario of implementing the minimum cast net mesh size for Kainji Lake was also modelled. The present ban of beach seines was also included in the model since it is already in place. The scenario assumes that all fishermen using undersized cast nets will, following the ban of undersized nets, switch to cast nets of legal mesh size[5].

The summed effort levels have been calculated for all gear types (table 17). Although gear ownership is reducing (du Feu 1999) the actual use of these gears is increasing (they are fishing more) this has resulted in a 15% increase in fishing effort per year. When assessing the varying management measures for the fishery the expansion in fishing effort should be considered.

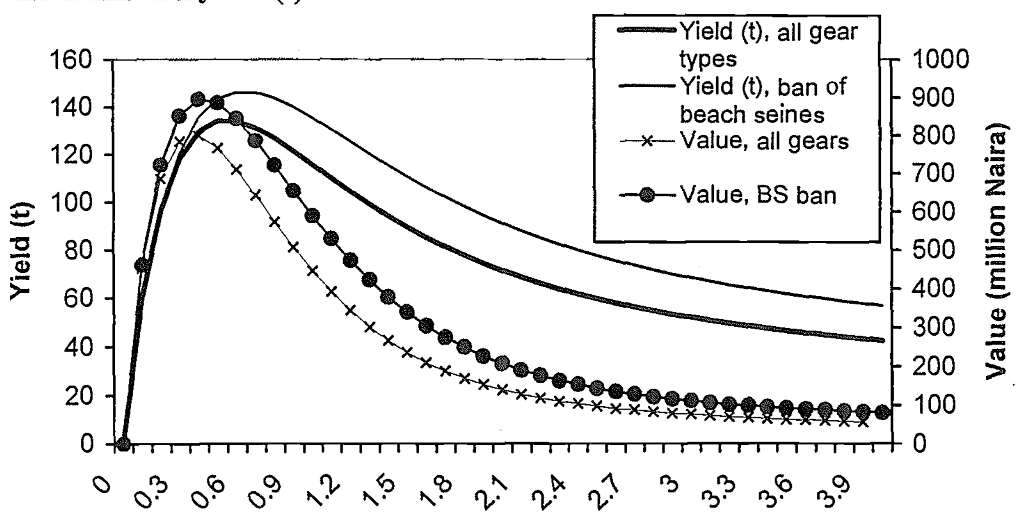
Scenarios for sampled species

In the case of the maximum sustainable yield (MSY) all the sampled species are overfished by 40 to 70% (Table 16). *Lates* is the worst example. The species is a predator and one may expect an increase in the biomass and yield of species with lower trophic levels if that of *Lates* is reduced by fishing .

As expected, the species which constitute the largest portion of by-catch of beach seines have the largest increase in yield following their ban. The annual yield of *Citharinus* is expected to increase by 17%, the MSY by 11% and the biomass by 38%. More importantly for management is the effect on the catch value which will increase by 16% (fig. 27).

If the minimum cast net size is introduced together with the ban on beach seines the yield of *Citharinus* will increase by a further 28% and catch value by 31% (equating to N 12,385 per fishing entrepreneur).

Figure 27 Thomson and Bell routine showing the scenarios for all gear types fishing (present situation), the ban of beach seines and the regulation of mesh size on the estimated yield (t) for *Citharinus citharus citharus*



[5] since many of the cast net fishermen are professional cast netters.

The effect on other species of the ban of beach seines is, apart *from Sarotherodon galailaeus*, a rise in biomass, yield and catch value. This is most pronounced for *Synodontis membranaceus* and *Lates*.

For the control of cast net mesh size Tilapiines have an increased catch value of 25% whilst *Chrysichthys* and *Lates* are largely unaffected.

Table 16 The effects of the ban of beach seines and regulation of cast net mesh size on yield and biomass of selected species

Citharinus citharus citharus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	2,895	3,389	4,335
MSY (t)	3,280	3,654	4,358
Percent change in effort to produce MSY	reduction of 40%	reduction of 40%	reduction of 10%
Present biomass (t)	2,828	3,909	7,138
Biomass at MSY (t)	5,776	7,315	8,287
Present value	N 112 m	N 147 m	N 248 m
MEY	N 192 m	N 222 m	N 291 m
Percent change in effort to produce MEY	reduction of 60%	reduction of 60%	reduction of 40%

Oreochromis niloticus niloticus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	1,647	1,689	1,940
MSY (t)	1,821	1,800	1,982
Percent change in effort to produce MSY	reduction of 40%	reduction of 30%	reduction of 20%
Present biomass (t)	1,742	2,104	2,757
Biomass at MSY (t)	3,203	3,750	3,839
Value	N 63 m	N 64 m	N 80 m
MEY	N 104 m	N 91 m	N 103 m
Percent change in effort to produce MEY	Reduction of 60%	Reduction of 60%	Reduction of 50%

Sarotherodon galilaeus galilaeus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Present yield (t)	1,032	1,016	951
MSY (t)	1,079	1,088	1,154
Percent change in effort to produce MSY	Increase of 50%	Increase of 60%	Increase of 120%
Present biomass (t)	2,617	2,889	4,012
Biomass at MSY (t)	1,454	1,375	1,567
Present value	N 26 m	N 26 m	N 28 m
MEY	N 26 m	N 26 m	N 29 m
Percent change in effort to produce MEY	Increase of 10%	Increase of 10%	Increase of 50%

Synodontis membranaceus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	2,016	2,154	2,254
MSY (t)	2,312	2,389	2,446
Percent change in effort to produce MSY	Reduction of 50%	Reduction of 50%	Reduction of 40%
Present biomass (t)	998	1,186	1,141
Biomass at MSY (t)	2,019	2,112	1,813
Present value	N 90	N 98	N 103 m
MEY	N 149	N 155	N 159 m
Percent change in effort to produce MEY	Reduction of 70%	Reduction of 70%	Reduction of 70%

Chrysichthys nigrodigitatus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	1,200	1,219	1,220
MSY (t)	1,423	1,433	1,433
Percent change in effort to produce MSY	Reduction of 50%	Reduction of 50%	Reduction of 50%
Present biomass (t)	764	796	800
Biomass at MSY (t)	1,721	1,760	1,770
Present value	N 40 m	N 42 m	N 42 m
MEY	N 79 m	N 81 m	N 85 m
Percent change in effort to produce MEY	Reduction of 70%	Reduction of 70%	Reduction of 70%

Lates niloticus

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	1,026	1,201	1,201
MSY (t)	2,209	2,476	2,624
Percent change in effort to produce MSY	Reduction of 70%	Reduction of 70%	Reduction of 70%
Present biomass (t)	311	402	402
Biomass at MSY (t)	2,353	2,706	4,208
Present value	N 133 m	N 180 m	N 180
MEY	N 646 m	N 711 m	N 723 m
Percent change in effort to produce MEY	Reduction of 70%	Reduction of 80%	Reduction of 80%

Table 17 Total effort and annual mean percentage increase by gear

	1995	1996	1997	1998	Mean annual increase (%)
GN	5,296	7,437	7,509	7,029	12
DN	2,157	2,660	2,109	3,844	28
CN	3,516	3,329	3,761	2,651	-7
LL	1,816	1,743	1,374	3,978	55
TR	1,709	3,198	3,202	4,108	39
Sum	14,494	18,366	17,955	21,610	15

where for comparison of effort levels, effort is expressed as unit of gears needed to catch 1 kg fish per 24 hrs. Mean cpue from 1995-1998 GN=3.64, DN=16.22, CN=14.4, LL=2.62, TR=0.54

Scenarios for all species
The sampling of six species accounted for 45% of the total yield of all species (omitting Clupeids). Although they are derived from different methods it is encouraging to note that the calculated total catch value for the whole lake is in agreement with the CAS (N 1,054 m *cf.* N 914 m) (table 18).

The Kainji Lake fishery, prior to the beach seine ban, was overfished (fig. 26). To attain the maximum sustainable yield required a reduction of 40% in effort, this would have increased the yield by 18% (to 33,999 t). A larger decrease in effort (70%) was required to reach the MEY, however a 169% increase in catch revenue could have been expected (from Naira 1,054m to N 2,835 m).

Under the present ban of beach seines implemented by the NGKLFPP total yield from the lake fishery will decrease by 7,394 t. Some of the loss of clupeids will be compensated for by increased production due to the growth of by-catch species.

More importantly the loss of the low value clupeids by banning the beach seine is more than compensated for by the increase in catch revenue from allowing the by-catch species to grow.

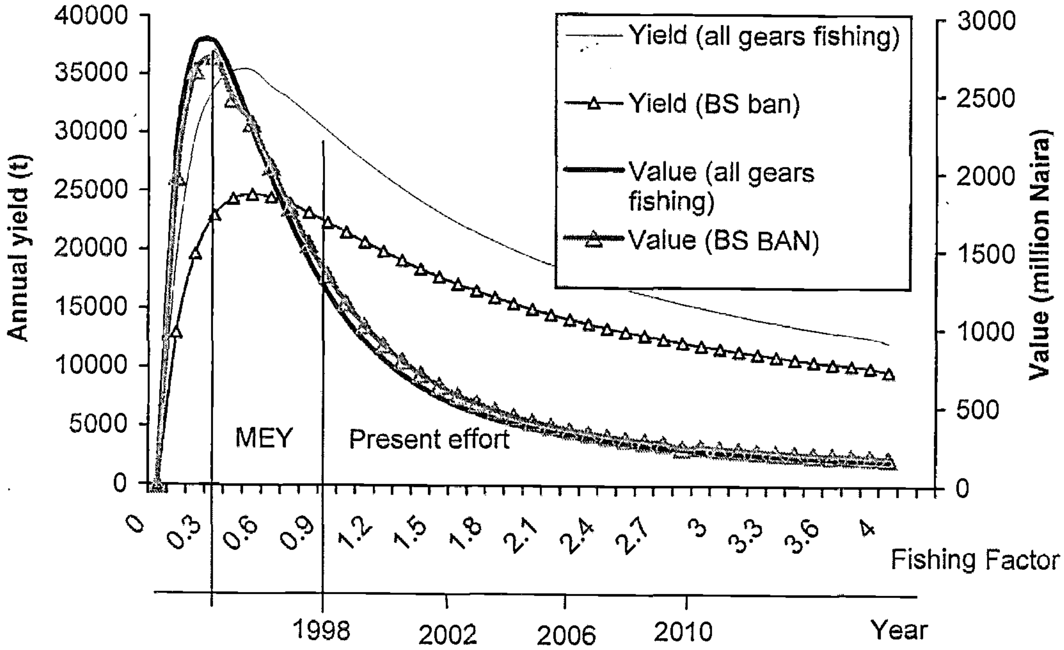
A net increase of N 102 m (10%) to the total fishery can be expected from the current ban of beach seines.

The revenue from clupeid sales was received by only 10% of the beach seining entrepreneurs. The increased revenue from the beach seine ban is available to non beach seining fishermen and is worth an extra N 18,300 per fishing entrepreneur each year.

The ban of beach seines results in a more stable fishery. When beach seines are banned the loss in yield due to increasing fishing effort is less (fig. 28). This is extremely relevant considering the future and expected increases in effort due to population growth. As discussed previously, the number of gears owned has reduced yet fishing effort continues to rise. If the fishermen are able to invest in more gears, as a result of good harvests of crops, then there may be a further increase in fishing effort precipitating the move away from the MEY and a further decline in yields.

Given the expansion in fishing effort, prior to the ban of beach seines yield will have fallen by 6.5% per annum. With the ban in place a decline of 5.5% per year can be expected (fig. 28).

Figure 28 Thomson and Bell routine showing yield and revenue curves for all gear types fishing and the ban of beach seines of all species.



If the regulation of cast net mesh size is introduced then one can expect a further increase in catch value (apart from that already experienced due to the ban of beach seine) of Naira 142 m. (table 18). This is equivalent to an extra N 25,500 per fishing entrepreneur per year. The difference in catch value resulting from the two management measures will increase as fishing effort rises (fig. 29).

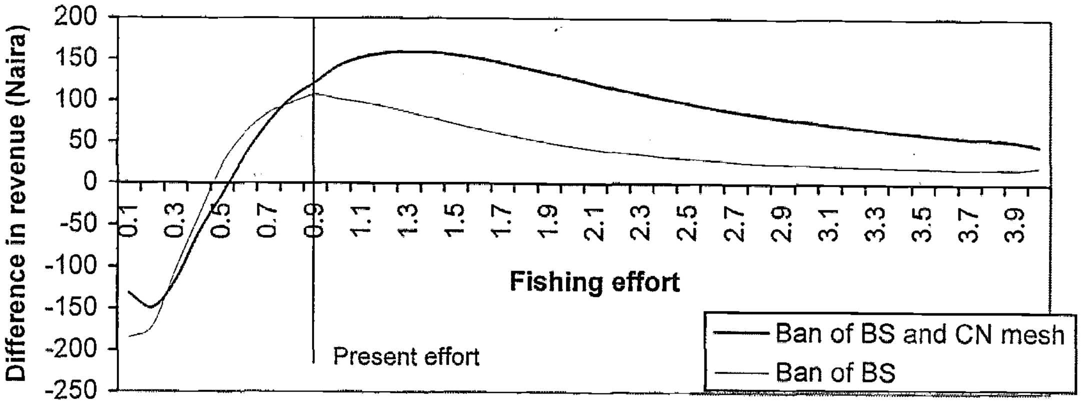
Under the present level of fishing effort yield will increase by 4% and biomass by 25% (fig. 31). Further the level of overfishing will decline by 10%.

More importantly the effect of the cast net regulation is to further increase the stability of the fishery such that the impact of an increase in fishing effort will cause yield to fall at a slower rate than during the situation where beach seines only are banned. A fall of 2% per year in yield can be expected as opposed to 5.5% for just the beach seine ban (fig. 30).

Undersized cast nets are responsible for large mortality of juvenile Citharinus and Tilapiine sp. The ban of these nets will further strengthen the results achieved through the ban of beach seines. There will be a decrease in the level of overfishing and an increase in catch revenue. More importantly the fishery will be less susceptible to declines in yield through the expansion of fishing effort. It is therefore recommended that this forms the next management measure to be introduced by the KLFMCU.
The practicalities of enforcement must be assessed by the KLCMU[6]- enforcement of mesh sizes is not as straightforward as banning complete gear types, especially for something as easily hidden and indistinguishable as a small meshed cast net.

[6] The Kainji Lake Managment and Conservation Unit mandated to managment the resources of Kainji Lake

Figure 29 The difference between the catch revenue (m Naira) from all gears fishing and the ban of beach seine and from ban of beach seine and regulation of cast net mesh size for differing levels of effort.



The figure shows that as fishing effort and total value falls the difference in revenue between the two management scenarios increases.

Figure 30 Thomson and Bell routine showing yield and revenue curves for all gear types fishing and the ban of beach seines implemented together with the minimum mesh size for cast nets, Kainji Lake

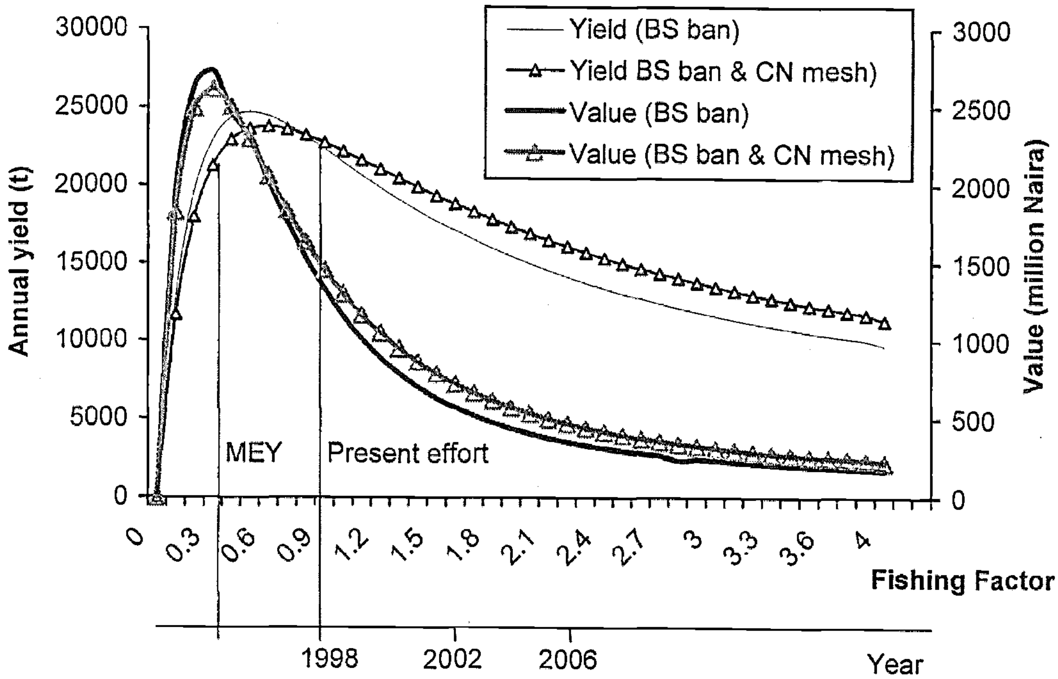
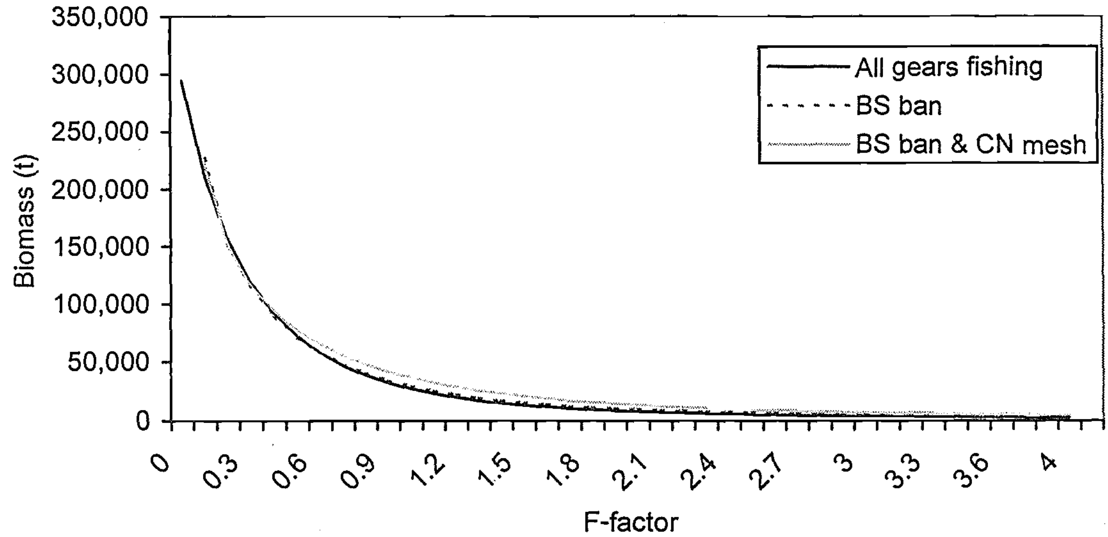


Figure 31 Estimations of biomass (t) for the two management scenarios



: for clarity the clupeid biomass has been omitted

Table 18 The effects of the ban of beach seines and regulation of cast net mesh size on yield (t) and biomass (t) of all species

	all gear types fishing (present situation)	ban of beach seines	regulation of beach seine ban and minimum cast net mesh size
Yield (t)	28,852	21,457	22,164
MSY (t)	33,999	24,686	23,738
Percent change in effort to produce MSY	Reduction of 40%	Reduction of 50%	Reduction of 40%
Present biomass (t)	26,912	29,126	36,506
Biomass at MSY (t)	57,608	71,194	65,265
Present value	N 1,054 m	N 1,156 m	N 1,298 m
MEY	N 2,835 m	N 2,732 m	N 2,616 m
Percent change in effort to produce MEY	Reduction of 70%	Reduction of 70%	Reduction of 70%

3.12. Surplus Yield Analysis

3.12.1. The Beach Seine Fishery

Surplus yield analysis normally requires more than the four years data that is available for the Kainji Lake fishery. However, if a good relationship exists between CPUE and effort then a tentative picture of the status of the fishery can be made which maybe refined later.

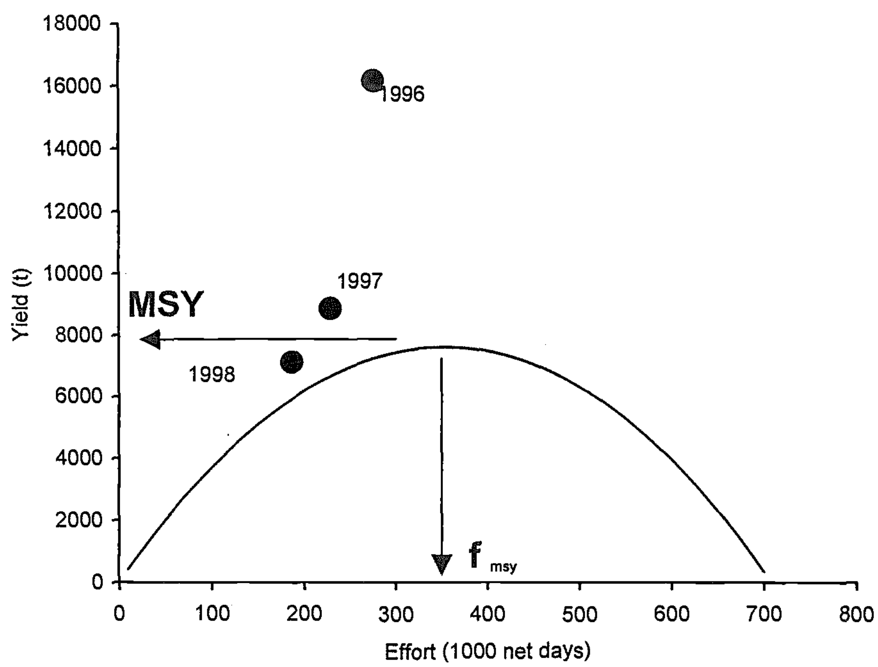
For clarity the data sets for clupeids (the beach seine fishery) and non-clupeids (all other fisheries) have been treated separately.

Using data from 1995-1998 for the beach seine fishery indicated a poor relationship between the CPUE and effort[7]. Eliminating 1995 data which was collected at the start of the survey almost gave a perfect correlation[8] and has been used in the analysis.

The surplus yield curve gives an MSY of 7,620 t. The fishery was overfished by 212% during 1996. Levels have subsequently returned to below the MSY probably as a result of the heavy pressure during 1996 which resulted in a fall in yield.

The MSY estimate is similar to the estimate from the paired trawl survey which gave an estimate of 10.590 t. (Omorinkoba et al. 1997). It remains that the clupeid stocks were being overfished and these findings support the declining CPUE experienced prior to the ban (du Feu & Abiodun 1999).

Figure 32 Surplus Yield Production Curve (Shaefer model) of the Clupeid Beach Seine Fishery, 1996-1998



7 Pearson's correlation coefficient r=-0.1, P=0.90
8 Pearson's correlation coefficient r=-1.0, P=0.05

Where MSY= $-a^2/(4b)$ = 7,620 t. per annum
where a= intercept = 43.022 and b = slope = -0.06072

3.12.2. All Fisheries Excluding Beach Seines

The estimate for MSY is almost 50% less than that calculated by Seisay (1997) when using CAS data from 1969 to 1978 collected by the Kainji Lake Research Institute. It is likely that the inclusion of the post impoundment data sets from 1969 to 1972 gave an optimistically large estimate for MSY because of the lake's initial high productivity.

Recalculation of the data excluding these years and also combining them with the present CAS data does not produce any significant negative correlation[9] between cpue and effort and has not been explored further.

Using data only from 1995-1998 (from the present CAS) revealed a strong relationship between cpue and effort[10]. The estimate was calculated by using activity from canoes excluding those using beach seines and 'not seen' during CAS sampling. Total effort was calculated using frame survey figures and the CPUE (kg/canoe/day) established using total yield figures.

The surplus yield curve shows that the fishery is operating around the apex of MSY and that the level of fishing effort is increasing each year. The results suggest that the fishery (excluding beach seines) is presently being overfished by 16% and shows the level of overfishing is likely to increase in future unless effort levels are reduced.

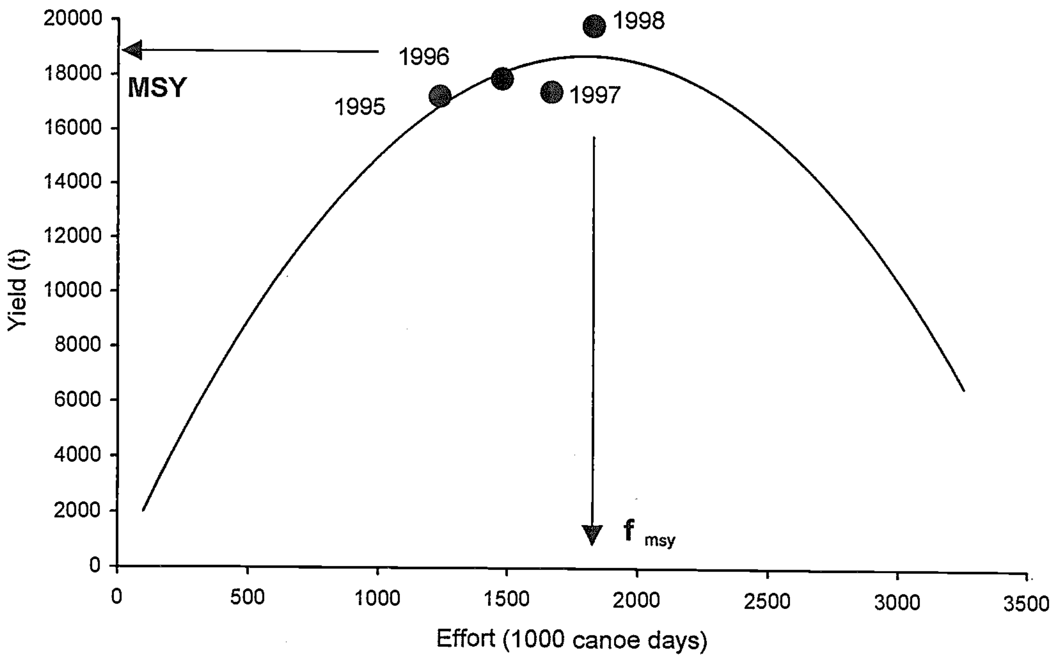
The MSY for clupeids and all other species combined is 26,370 t. which is slightly less than the MSY of 33,999 t from cohort analysis. The degree of overfishing is also less than the estimate of 50% derived from the length based cohort analysis. The differences are probably due to the short time series of data used in the surplus yield analysis. The scenario of overfishing, however, remains the same.

[9] Plotting all the data from 1972-1998 gives a positive correlation of r=0.71, P=0.02.

[10] Pearson's Correlation r= -0.93, P=0.07

Although the time series of data used for surplus yield analysis is limited the results broadly support the findings of the cohort analysis- in that the fishery in 1998 was being overfished and that future increases in fishing effort will lead to further declines in yield.

Figure 33 The Surplus Yield Production Curve for all Fisheries apart from Beach Seine, 1995-1998



Pearson's correlation r= -0.9316, P=0.068. a= 20.82378, b= - 5.7815×10^{-6}
where MSY = 18,750 t per annum.

F_{msy} = 1,801,000 canoe days per annum = 6,936 canoes assuming 72% activity (1998 level)

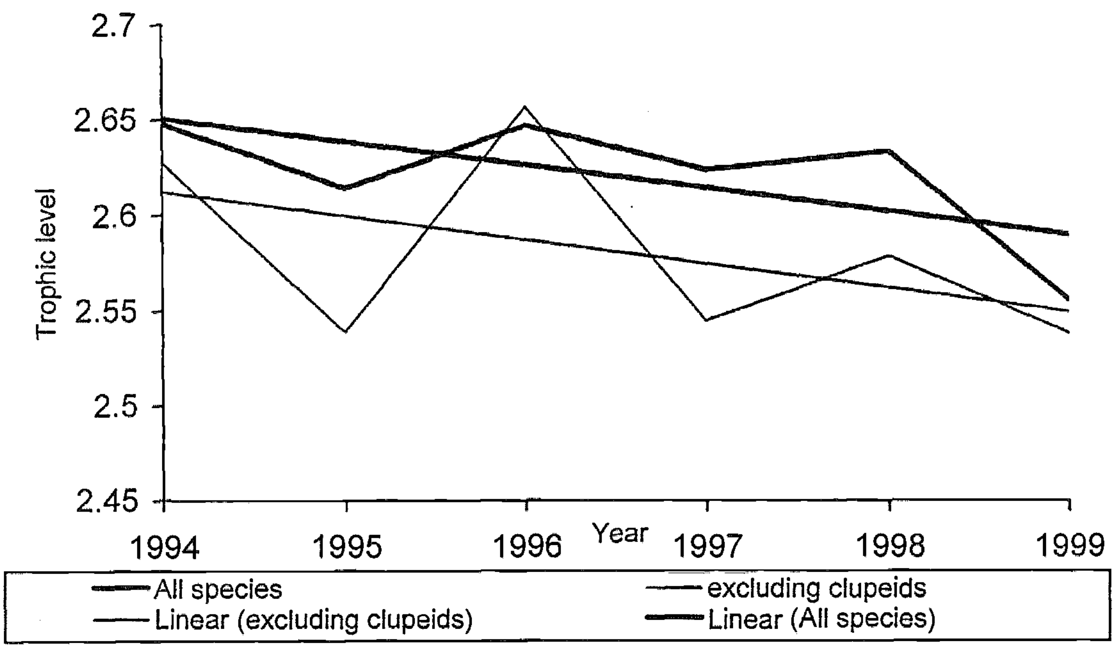
3.13. Trophic Level of Catches

As fisheries expand the concentration moves from larger and high valued species (usually species with a high trophic level) to less valuable smaller species (species with a lower trophic level). Although yield may be stable there may be a downward shift in the trophic level. One can hypothetically continue the downward shift suggesting the composition of future catches.

Given that the trophic level of herbivores is 2 the Kainji Lake fishery is operating very low down in the food chain (fig. 35). This is an indication of high effort and over fishing of species with high trophic levels and supports previous findings that the *Lates* stock is one of the most overfished species (sect 3.10).

The data available for analysis of the Kainji Lake fishery is limited and there are large fluctuations resulting from varying spawning intensities of species. There is, however, a tentative downward shift in trophic level recorded from 1994-1999.

Figure 34 Mean trophic level of all species and all species excluding clupeids for the Kainji Lake Fishery, 1994-1999



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Annex 1. Length-Weight Relationships

Table 19 Length weight parameters for the sampled species in Kainji Lake

Species	Length type*	Samp Nos	min lgth (cm)	max. Lgth (cm)	R squared	a	CV a Std, Err	b	CV b Std. Err
Citharinus citharus citharus	Fork	185	11.0	28.9	0.945	0.0197	0.1619 0.0032	3.0375	0.0519 0.0171
Lates niloticus	Total	833	13.0	52.0	0.944	0.01532	0.0022 0.0778	2.9350	0.0488 0.0249
Synodontis membranaceus	Fork	381	15.4	28.0	0.668	0.01463	0.0070 0.3318	3.1192	0.2220 0.1129
Saratherodon galilaeus	Total	59	12.4	35.7	0.983	0.01386	0.0037 0.1540	3.1358	0.1063 0.0532
Oreochromis niloticus niloticus	Total	15	8.3	19.5	0.959	0.01690	0.6017 0.0102	3.1328	0.0670 0.2099
Chrythicthys nigrodigitatus	Fork	191	16.0	30.0	0.829	0.02792	0.0118 0.2791	2.7937	0.1859 0.0918

where: Length weight function is: $W=aL^b$

and is expressed as the logarithm transformation

(W)= log 10 (a) + b * log 10 (L)

(W = weight (g), L = length (cm)

Both sexes are included

Length type used is the same as the length frequency sampling

Data extracted from gill net trial database, NGKLFPP.

Calculated using Abee ver. 1. and SPSS.

Annex 2. Mean Length at Age Data, GN Trial Data

Species	Length type	Age in years									
		1	2	3	4	5	6	7	8	9	10
Citharinus citharus	TL	242	354	451	504						
Lates niloticus	TL	349	604	812	976	1,091	1,198	1,296	1,331	1,370	1,420
Oreochromis niloticus	TL	165	295	383	428	456					
Sarotherodon galiliaeus	TL	150	277	365	408	443					
Tilapia Zillii	TL	146	209	235	236						
Synodontis filamentosus	SL	60	98	129	153	180					
Synodontis occellifer	SL	65	95	123	145						
Synodontis membranaceous	SL	72	112	155	198	228	254	275			
Synodontis schall	SL	60	100	130	160	180	210	230	240		
Bagrus bayad	SL	135	242	322	403	465	536	578	614		
Bagrus docmac	SL	137	249	340	418	485	542	591	634		
Auchenoglanis occidentalis	SL	145	250	312	356	390					
Chrysichthys nigrodigitatus	SL	137	196	237	280	308					

Annex 3. Mean Length at Age Data, Present Data

Species	Length type						
Age in years		0.254	0.298	0.527	1.003	2.009	6
Citharinus citharus	Fork	68.7	79.5	135.0	235.2	395.0	
		0.282	0.316	0.699	0.962		
Lates niloticus	Total	83.5	94.3	22.6	33.0		

Annex 4. Estimated Growth Parameters from Data Collected by GN Trial

Species	L_{inf}/mm	K	to	r	Phi prime	M (from Pauly)
Synodontis membranaceus	458.39	0.128	-0.3065	0.998	4.430	0.21
Synodontis ocellifer	290.25	0.147	-0.7180	0.999	4.093	0.26
Synodontis filamentosus	336.33	0.140	-0.4212	0.999	4.200	0.24
Citharinus citharus	668.18	0.323	-0.3875	0.997	5.159	0.35
Lates niloticus	1559.11	0.239	-0.0955	0.998	5.764	0.22
Sarotherodon galiliaeus galilaeus	497.31	0.461	0.2133	0.999	5.057	0.47
Tilapia zillii	271.80	0.675	-0.1189	0.993	4.698	0.72
Oreochromis niloticus niloticus	503.11	0.497	0.1859	0.999	5.100	0.50
Chrysichthys nigrodigitatus	433.10	0.216	-0.7550	0.999	4.608	0.30
Auchenoglanis occidentalis	446.16	0.414	0.0560	0.999	4.916	0.46
Bagrus docmac	867.60	0.162	-0.0646	0.999	5.086	0.20
Bagrus bajad	852.10	0.159	-0.0600	0.997	5.062	0.20

Source: Willoughby (1974); Arawomo (1972); Balogun (1988); Akitunde (1976); Ajayi (1976).

Annex 5. Yields, Biomass and Catch Values of Various Management Scenarios

Table 20 Estimations of Yields (t), Biomass (t) and value (million Naira) for various managment scenarios, Kainji Lake

	All gears fishing			Ban of beach seines			Ban of beach seines & CN mesh size regulation		
F-factor	Yield	Biomass	Value	Yield	Biomass	Value	Yield	Biomass	Value
		218,747.8							
0.0	-	156,980.5	-	-	201,304.4	-	-	187,155.7	-
0.1	19,311	115,862.5	2,142	12,923	148,493.6	1,958	11,673	142,916.2	1,826
0.2	29,616	87,900.1	2,813	19,639	112,611.6	2,641	17,949	112,628.3	2,492
0.3	33,833	67,995.8	2,836	22,943	89,747.0	2,732	21,259	90,981.6	2,616
0.4	35,237	53,541.6	2,600	24,347	70,639.0	2,466	22,905	74,932.8	2,500
0.5	35,375	42,849.0	2,283	24,686	56,536.5	2,305	23,598	62,667.3	2,292
0.6	33,999	34,774.5	1,966	24,431	45,907.7	2,027	23,739	53,059.9	2,060
0.7	32,857	28,589.7	1,679	23,853	37,754.6	1,764	23,556	45,384.9	1,836
0.8	31,545	23,788.7	1,432	23,111	31,406.4	1,530	23,184	39,156.5	1,633
0.9	30,187	20,017.4	1,225	22,295	26,399.9	1,332	22,704	34,037.5	1,454
1.0	28,851	17,022.9	1,054	21,460	22,407.7	1,156	22,164	29,786.7	1,298
1.1	27,571	14,621.1	913	20,637	19,197.7	1,011	21,596	26,226.3	1,164
1.2	26,366	12,676.6	797	19,843	16,581.4	890	21,019	23,222.0	1,048
1.3	25,241	11,088.3	702	19,095	14,440.7	788	20,445	20,670.8	948
1.4	24,196	9,779.7	623	18,378	12,674.8	702	19,882	18,491.9	861
1.5	23,230	8,692.7	558	17,710	11,206.9	630	19,334	16,620.9	786
1.6	22,336	7,782.7	504	17,086	9,978.3	569	18,806	15,006.9	721
1.7	21,510	7,015.1	458	16,504	8,943.4	518	18,298	13,608.1	664
1.8	20,745	6,362.9	419	15,961	8,068.6	474	17,812	12,390.6	614
1.9	20,037	5,805.0	387	15,454	7,317.7	436	17,347	11,326.6	569
2.0	19,380	5,324.4	359	14,981	6,675.7	404	16,903	10,393.0	531
2.1	18,769	4,908.0	334	14,540	6,121.8	375	16,480	9,570.8	496
2.2	18,201	4,544.9	313	14,127	5,641.3	351	16,078	8,844.0	465
2.3	17,648	4,226.5	294	13,741	5,222.2	330	15,694	8,199.3	438
2.4	17,174	3,946.0	278	13,379	4,854.8	311	15,329		413
2.5	16,681	3,697.4	264	13,039	4,531.2	294	14,981	7,112.9	391
2.6	16,274	3,476.1	251	12,740	4,244.7	279	14,650	6,653.7	372
2.7	15,865	3,279.3	239	12,419	3,990.0	266	14,334	6,241.1	354
2.8	15,479	3,100.6	229	12,135	3,762.7	234	14,033	5,869.2	337
2.9	15,115	2,941.0	219	11,867	3,558.8	243	13,746	5,533.1	322
3.0	14,771	2,791.7	210	11,614	3,375.3	234	13,472	5,228.4	309
3.1	14,446	2,663.8	202	11,375	3,209.4	225	13,211	4,951.5	296
3.2	14,138	2,543.8	195	11,148	3,059.1	217	12,961	4,699.2	285
3.3	13,845	2,434.1	188	10,932	2,922.2	209	12,722	4,468.7	275
3.4	13,567	2,333.5	182	10,727	2,797.3	202	12,493	4,257.6	265
3.5	13,302	2,241.0	176	10,531	2,683.0	196	12,277	4,064.0	256
3.6	13,050	2,155.6	170	10,345	2,577.9	190	12,064	3,885.8	248
3.7	12,810	2,076.6	165	10,168	2,481.1	184	11,863	3,721.7	240
3.8	12,581	2,003.4	160	9,998	2,391.8	179	11,670	3,570.0	233
4.0	12,152	1,935.4	152	9,681	2,309.0	173	11,307	3,429.6	220

Clupeid biomass has been omitted

Annex 6. Length Frequency Recording Form

Length Frequency Sampling

Landing site:		**Recorder:**	

Time	AM/PM	**Day**		**Month**		**Year**	

GN	DN	BS	CN	LL	TR	**Mesh**		**Number**	

Citharinus citharus citharus																		**Fork**			**Length**	
2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5
25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36
.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

Saratherodon galilaeus galilaeus — Total Length

2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5
25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36
.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

Oreochromis niloticus niloticus — Total Length

2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5
25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36

.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

Synodontis membranaceus — Fork Length

2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5
25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36
.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

Chrysichthys nigrodigitatus — Fork Length

2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5

25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36
.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

Lates niloticus — Total Length

2	.5	3	.5	4	.5	5	.5	6	.5	7	.5	8	.5	9	.5	10	.5	11	.5	12	.5	13
.5	14	.5	15	.5	16	.5	17	.5	18	.5	19	.5	20	.5	21	.5	22	.5	23	.5	24	.5
25	.5	26	.5	27	.5	28	.5	29	.5	30	.5	31	.5	32	.5	33	.5	34	.5	35	.5	36
.5	37	.5	38	.5	39	.5	40	.5	41	.5	42	.5	43	.5	44	.5	45	.5	46	.5	47	.5

48	.5	49	.5	50	.5	51	.5	52	.5	53	.5	54	.5	55	.5	56	.5	57	.5	58	.5	59
.5	60	.5	61	.5	62	.5	63	.5	64	.5	65	.5	66	.5	67	.5	68	.5	69	.5	70	.5