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EXECUTIVE SUMMARY

This study includes an analysis of the trawl survey that was carried out by the Kainji Lake Fisheries Promotion Project in May, 1997.

The objective of the survey was to assess the biomass and the potential yield of clupeids and the carrying capacity of the beach seine fishery in the entire Kainji Lake. The biomass of the beach seine by-catch was also estimated. The Lake was stratified into eight stations in the three basins (southern, central and northern basin): Bussa, Anfani, Jetty, Duga, Papiri, Ulaira, Foge and Shagunu.

The density (Kg/Km^2) of the clupeids was higher in the Bussa and Foge than in the other stations. These stations are located in the central basin of the Lake which is wider than the southern and the northern portions and is relatively shallower in depth. The lowest density of clupeids was in the Anfani station followed by Jetty, both in the southern basin. These stations were the deepest parts of all the areas trawled, measuring between 37-120m. of depth. There was an inverse correlation between depth trawled and the catch rates of clupeids, though the correlation was poor.

The average annual biomass of the clupeids was estimated at 36,769.85 Mt in the entire Lake with an MSY of 11,705.95 Mt.

The smaller species, Sierrathrissa leonensis, made up about 97% of the total clupeid population in the Lake and occurred at a shallower depth than the larger species Pellonula afzeliusi.

From the clupeid production statistics in 1996, it is estimated that the MSY is already overshot by 34%. Therefore, about 698 beach seines instead of the present 810 would be sufficient for sustainable exploitation of the clupeid stocks.

Because of the substantial by-catch in the beach seines, this fishing method was banned from Kainji Lake in 1997. An offshore open water seine net is recommended to replace the beach seines on the Lake. The number of these nets should not exceed 500.

The current ban on beach seine is supported by this study. Nevertheless, and since the ban may not be 100% effective, effort should concentrate on maintaining that the number of beach seines must be kept at most at the present level.

Stock estimates were also derived for the by-catch species during the trawl survey. The estimates are however deemed incorrect in view of the fact that only a small fraction of the population of these species may have been retained in the trawl net.

The by-catch formed about 9% by weight of the total species caught in the survey and constituted mainly of *Alestes baremose*, *Synodontis membranaceus* and the predator *Eutropius niloticus*.

For record purposes, a simple analysis on the commercial viability of a mechanized pair trawl fishery for the clupeid was undertaken in the concluding part of this study and it was discovered that the annual operational cost is much higher that the income from fishing. It was thus concluded that the venture is not profitable.

Recommendation is made against the introduction of the pair trawling not only from an economic point of view but also for resource conservation, legal and social reasons etc.

The development of this fishery could pose a serious danger to continuity of stocks. In the first instance there has been a dramatic decline in the landings of clupeids in 1997 and the reason for this could partly be attributed to fluctuation in the abundance level of the stocks since the decline in the number of beach seines is not as dramatic. Furthermore, as stated above, clupeid fishery was operated above the maximum sustainable yield by 34% in 1996 and this must have had some negative effect on the reproductive capacity of the stock and hence depress the 1997 landings.

In the light of the above, it is proposed that priority being given to the development of an open water seine which is at the same level of exploitation as the beach seine and requires similar cost to acquire.

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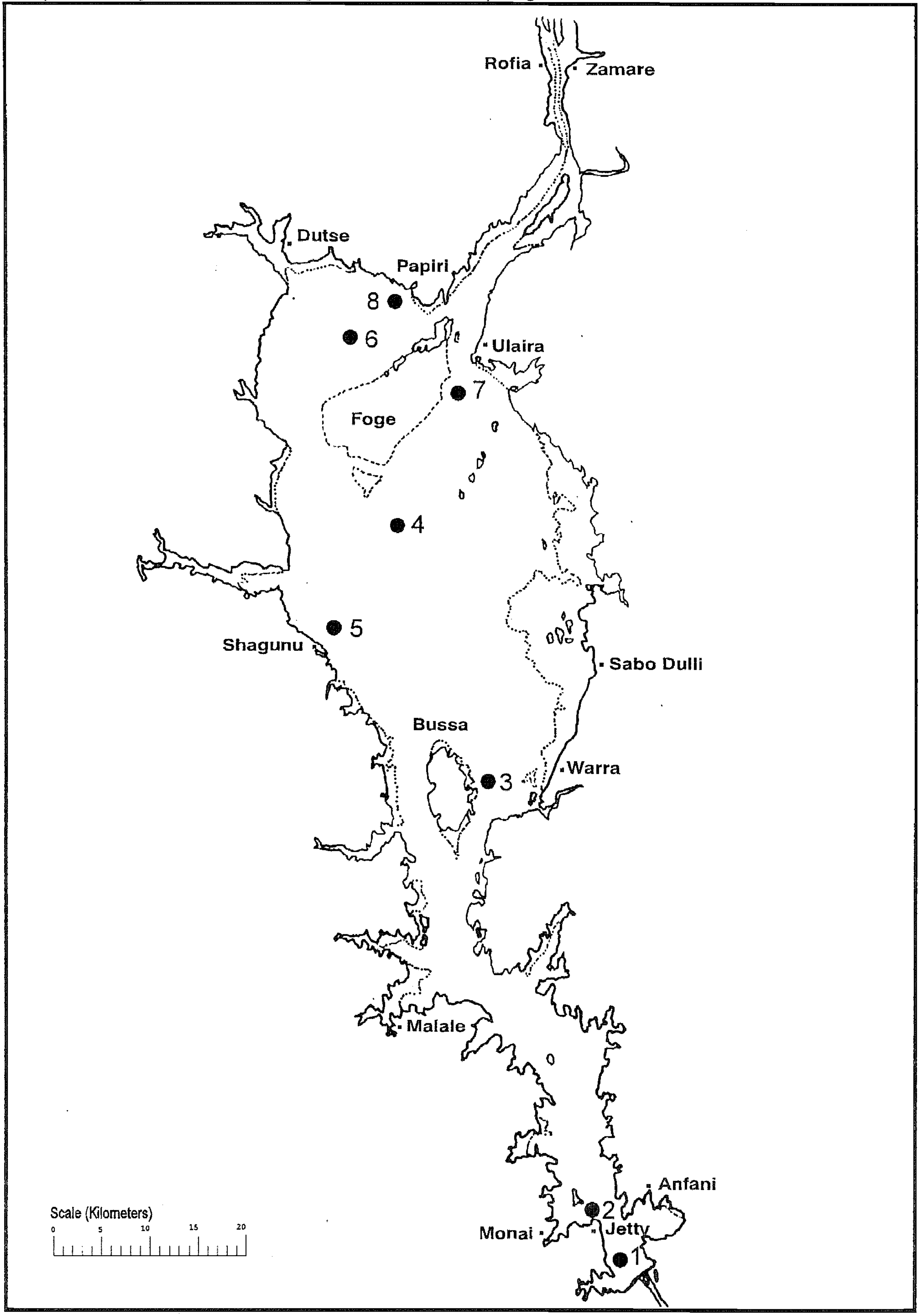

1. INTRODUCTION

Lake Kainji was created in 1968 primarily to cater for the electric power needs of Nigeria. At its highest level the Lake can measure up to 136km in length and 24km in width (Stride, 1975). The Lake has a total surface area of 1,270 km^2.

The Lake can be divided into three main sectors (basins). The northern part is narrow. The middle sector contains the main basin representing about 70% of the total surface area and includes Foge Island. At low water level large areas of Foge Island are exposed as sand banks upon which migratory fishermen build temporary fishing camps. The southern sector of the Lake is deep and narrow with the greatest depth towards the Dam site (see map).

Over 100 species of fish have been identified in the Lake of which one is clupeid. There are two clupeid fish species in the Lake: Pellonula afzeliusi and Sierrathrissa leonensis (Otobo, 1977). The observed length and weight ranges for Pellonula afzeliusi from 3.0 to 6.7cm and from 0.3 to 3.4gm respectively whilst the comparative values for Sierrathrissa leonensis are 1.7-2.8 cm and 0.175-0.3gm.

Clupeids play a vital role in the food chains linking the predatory fish species like Hydrocynus forskahlii, Lates niloticus, Eutropius niloticus and Malapterus electricus with plankton organisms.

The clupeid fishery has been in prominence south of Kainji Lake since 1970s using the lift net (Attala) fishing method (Otobo, 1977). This net is however only effective within the top 1-2m of calm water.

Migrant Malian fishermen introduced an open water seine "Dalla" mosquito net (Ita and Mdaihli, in prep). This fishing gear had comparatively low by-catch (about 4%). The Kainji Lake fishermen modified the technology into beach seining, which has become the only fishing method exploiting the clupeids.

There has been a steady increase in the number of beach seines on the Lake from 610 in 1994 to 810 nets in 1996. There are no records available for the years before 1994 but fishermen say that the introduction of the beach seines started app. 10 years ago.

The average mesh size of beach seines is 0.12 inches (du Feu, 1996), a mesh size that has a devastating effect on the juvenile/immature stages of some of the commercially important fish species.
The total estimated yield from the beach seine fishery was 21,970 tons in 1996 with clupeids contributing about 80% by weight. The remaining 20% was by-catch of juveniles and/or immature stages of species like Alestes spp, Citharinus citharus, Chrysichthys spp, Tilapia sp., Lates niloticus, Hydrocynus sp., Distichodus sp. etc.

There have been exploratory trawl survey investigations in the past to facilitate commercial exploitation of clupeids in the Lake. Stride (1975) carried out such a survey to investigate suitable methods of exploitation of the clupeid stocks while the work of Otobo (1977), and Ita and Balogun (1981, 1982) assessed the commercial viability of the clupeid fishery in Kainji Lake.

These works concluded that pair trawling was an effective fishing technology for harvesting clupeids. An investigation into the seasonal abundance of clupeids by Ita and Balogun (1982) showed that, in order to reduce the effect of diurnal migration, night fishing operation was recommended to be undertaken between April and September for these species.

All the previous works on clupeids, except Otobo (1977), failed to produce standing stock estimates for clupeids and potential sustainable yield levels, parameters that are very relevant for a successful implementation of any management measure.

In view of the biological and economic importance of the clupeids the Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project that aims at a sustainable management of fish stocks in Lake Kainji conducted a trawl survey on the lake.

The objective of the survey was to assess the biomass and the potential yield of clupeids and the carrying capacity of the beach seine fishery in the entire Kainji Lake.

2. METHOD

The trawl survey was carried out in May, 1997.

Pair trawling method with two boats propelled by 25 and 40HP outboard engines was used in the survey. The nets had a vertical and horizontal opening of 6.0m and a cod end of 0.12 inches (Annex 1).

The towing speed of the boats varied between 2.70km/h and 3.4km/h. The towing speed and the distance covered was recorded by a portable Global Positioning System (GPS). Several trawl hauls (10 -18) were made in each station in the morning (5 a.m. - 12.00 noon) and the evening hours (3 - 6 p.m.) because of the diurnal vertical migratory behaviour of the clupeids. The duration of each trawl haul was 20 minutes[1].

A total of 8 stations (see map) were sampled.

- i. Bussa -is located offshore the old Bussa village.
- ii. Anfani-is a shallow bay in the southern basin of the Lake.
- iii. Jetty- is located at the opening of the Lake immediately above the dam. The area is the deepest part of the Lake.
- iv. Duga- is on the eastern side of Foge Island
- v. Papiri-is located on the river channel at the western side of the Foge Island.
- vi. Ulaira-is situated at the eastern side of the Foge Island.
- vii. Foge- is located at the open waters of the Lake in the central basin.
- viii. Shagunu-is located at the old river channel off Shagunu camp.

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[1] The species identification code used during the survey is given in Appendix 1

3. ANALYSIS

3.1. Estimation of Standing Stock (Biomass, B) of Clupeid

Assumptions

The basic assumption in trawl survey methodology is that the mean catch per unit of trawled area is proportional to the stock abundance. A trawl net is used to estimate the mean catch at a number of stations in a fish stock; the mean catch per area swept by the trawl is multiplied by the stock area to estimate the stock size or more usually the total stock weight or biomass. A towed trawl net samples fish in an area which is equivalent to a long rectangular sampling unit. This index of stock abundance can be converted into an absolute biomass by the "Swept Area Method", (Gulland, 1975, and Sparre and Venema, 1992). It is also assumed that the density (catch rates) in the sampled area is the same as that in the survey area as a whole.

These assumptions will only be correct if the sampling is unbiased which requires careful survey planning.

The assumptions can be mathematically expressed as shown in the following derivations:

The area swept is determined from the following relationship:

$$a = d * h * 2x$$

where a = area swept
d = distance covered
h = length of trawl head rope
x2 = fraction of the head rope (assumed to be equal to 0.5)
h*x2 = width of path swept

The distance covered, d, is determined directly from GPS reading (where available) or indirectly from the boat speed and trawling time.

Estimation procedure

The actual survey data was used to produce estimates of the catch per unit area (i.e.density in Kg/Km^2) in each of the eight sampling stations.

The estimation of biomass was done using the

i) distance obtained directly from GPS - **Option 1**

ii) distance estimated indirectly from boat speed and trawling time - **Option 2.**

The estimation process took the following step by step procedure for each station:

a. Catch in weight per species per haul per unit time = C/t
b. Area swept per haul per unit time = a/t
c. Catch in weight per unit of area swept per species = (C/t)÷(a/t) = C/a
d. An average value of C/a (density) was calculated for each station as = Ave (C/a)
e. An estimate of the average biomass, b, per species per unit area was obtained from = Ave(C/a)÷0.5, where 0.5 assumes that only half of the biomass for each species in the path swept was retained by the gear
f. The total estimated average biomass for the whole Lake for each species was obtained from the relationship:

B = (Ave. (C/a) x 1270 Km^2)÷0.5, where Lake area = 1270 Km^2

3.2. Estimation of Maximum Sustainable Yield (MSY) of Clupeid

The MSY was estimated from Cadima's (in Sparre and Venema, 1992) quick approximation empirical formula for exploited fish stocks for which only limited stock assessment data are available. The formula for estimation of MSY is given as:

MSY = 0.5 x (Y+M x B)

where Y = is the total catch of clupeid in 1996
B = average biomass estimated above
M = natural mortality rate per year

3.3. Estimation of Natural Mortality Rate (M) of Clupeid

The natural mortality rate is one of the most difficult parameters to estimate accurately in fish population dynamics.

In the present study M was estimated with data on the ratio of gonadal to somatic weight for both species in Otobo's (1977) thesis applying the Gunderson and Dygert's equation (in Seisay et al, 1992) which related natural mortality to the gonado-somatic index (GSI) in the following empirical formula:

$$M = 0.03 + 1.68 \times GSI$$

The rationale is that large fish species are likely to have low natural mortality since they will suffer from less predation than the smaller fish.

Also as a result of natural control of the population, fish species with high natural mortality will invariably produce large number of eggs as a compensatory mechanism.

4. RESULTS AND DISCUSSION

Estimated density of clupeids

As stated above, analysis of the survey data was done per haul on station basis with the purpose to obtain an average density for each species per stratum and extrapolate this to the whole Lake.

The results of this estimation are shown in table 1 and table 2.

It is revealed that the average density of clupeids was much higher in Bussa and Foge stations than in the other six stations, with the lowest density in Anfani and Jetty stations.

The depth range in the Anfani and Jetty stations were relatively higher with values of 38-85m and 56-120m respectively in comparison to Bussa station (34-61m) and Foge station (24-33m) (Appendix 2).

This suggests that there is a declining trend in catch rate with increasing depth. Statistically, there is however a poor inverse correlation between depth trawled and the observed catch rates (r= -0.0853, n= 107).

The confidence limits on the average density of clupeids per stations were wide due to the variation in the catch rates between individual hauls (table 2).

The reason for the variation may, on one hand, be that the distributions of the clupeids in their natural environment is patchy. Clupeids tend to be shoaling species. Also, they make vertical diurnal movements during different times of the day.[2]

On the other hand the presence of large number of stumps on the water sea bed prevented sampling in certain depths of the Lake.

[2]The data justify the assumption that only half the biomass in the trawl path is retained by the gear.

Table 1. Estimated average density per species in Kg/Km^2 per station

Species	Sampling Stations								
	BUSSA	ANFANI	JETTY	DUGA	PAPIRI	ULAIRA	FOGE	SHAGUNU	AVERAGE
SIL	59051.28	8401.59	14692.31	29548.52	26166.67	20733.33	50618.27	16246.91	28182.36
PEA	649.59	0.00	12.82	3326.94	1518.52	0.00	0.00	654.32	770.27
HYF	0.00	71.43	0.00	0.00	0.00	0.00	0.00	0.00	8.93
SYM	0.00	0.00	0.00	1561.11	5025.46	0.00	0.00	861.11	930.96
CIC	0.00	0.00	0.00	136.57	250.00	0.00	0.00	0.00	48.32
EUN	0.00	0.00	0.00	1648.02	1009.26	0.00	0.00	1077.16	466.8
MAA	0.00	0.00	0.00	276.85	319.44	0.00	0.00	111.11	88.43
ALB	0.00	0.00	0.00	1662.04	4891.20	0.00	122.22	2672.84	1168.54
PEB	0.00	0.00	0.00	256.94	0.00	0.00	0.00	0.00	32.12
BAB	0.00	0.00	0.00	20.83	138.89	0.00	0.00	0.00	19.97
LAN	0.00	0.00	0.00	0.00	305.56	0.00	0.00	370.37	84.49
LAS	0.00	0.00	0.00	0.00	166.67	0.00	0.00	0.00	20.83
CHA	0.00	0.00	0.00	0.00	291.67	0.00	0.00	333.33	78.13
DIR	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	4.17
ORN	0.00	0.00	0.00	0.00	97.22	0.00	0.00	0.00	12.15
CLAP	0.00	0.00	0.00	0.00	1277.78	0.00	0.00	0.00	159.72
CHN	0.00	0.00	0.00	0.00	55.56	0.00	0.00	0.00	6.95
SCM	0.00	0.00	0.00	0.00	13.89	0.00	0.00	0.00	1.74
LAB	0.00	0.00	0.00	0.00	125.00	0.00	0.00	0.00	15.63
AUO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.23
TOTAL	59700.87	8473.02	14705.13	38437.82	41686.12	20733.33	50740.49	22329.00	32100.72

Table 2: Summary of estimated average density of clupeid (in Kg/Km^2)

STATION	1	2	3	4	5	6	7
BUSSA	13	59700.90	42331.40	11740.60	2.18	33572.60	84530.00
ANFANI	14	8401.50	97635.76	2040.74	2.16	3993.58	12009.59
JETTY	13	14705.13	13005.30	3607.03	2.18	6825.36	22559.30
DUGA	12	32875.46	22700.72	6553.13	2.20	18458.57	47292.36
PAPIRI	12	27685.19	20640.79	5958.48	2.20	14576.52	40793.85
ULAIRA	10	20733.34	10747.20	6556.46	2.26	5915.74	35550.92
FOGE	15	50618.27	39176.87	10115.43	2.15	28870.11	72366.44
SHAGUNU	18	16901.23	12008.58	2830.45	2.11	10928.98	22873.48
Average		**28952.64**	**21030.83**	**6175.29**		**15392.68**	**42246.99**

Note: Distance covered obtained from direct satellite reading option 1)

1: Total Number of Hauls, 2: Average Biomass per unit area, Kg/Km^2,
3: Standard Deviation, 4: Standard Error, 5: t (n-1), 6: 95 % CL Lower, 7: 95 % CL Higher

Estimated biomass

The average annual biomass of clupeids was estimated at 36,769.85Mt.. (table 3) in the whole Lake area applying option 1.
It is noted that the data have a wide range of confidence intervals at 95% which suggests that result of the survey should be validated.

Otobo (1977) estimated the annual biomass of clupeid as 3,137.66t whilst Turner (1996) gave an estimate of about 11,691t. The biomass estimates by Turner were based on data that were extracted from Otobo and Imevbore (1979).

Both under estimated the clupeid biomass; possibly because they wrongly assumed that all the clupeids in the effective path swept were retained in the trawl net. It could also be that the current fishing regime in the Lake has drastically reduced the population of predators and hence there is less predatory pressure on the clupeids. This could have given rise to a population boom of clupeids.

Attempts were also made to estimate the stock size of the by-catch species caught during the trawl surveys (table 3).

By all indications, the biomass of the by-catch was under-estimated. These species were not available in any appreciable quantity in the net since the survey was not targeting their areas of distribution (in deeper waters).

Table 3. Estimated total biomass by species per station (in tons)

Species	BUSSA	ANFANI	JETTY	DUGA	PAPIRI	ULAIRA	FOGE	SHAGUNU	AVERAGE
SIL	74995.13	10670.02	18659.23	37526.62	33231.67	26331.33	64285.20	20633.58	35791.60
PEA	824.98	0.00	16.28	4225.21	1928.52	0.00	0.00	830.99	978.25
HYF	0.00	90.72	0.00	0.00	0.00	0.00	0.00	0.00	11.34
SYM	0.00	0.00	0.00	1982.61	6382.33	0.00	0.00	1093.61	1182.32
CIC	0.00	0.00	0.00	173.44	317.50	0.00	0.00	0.00	61.37
EUN	0.00	0.00	0.00	2092.99	1281.76	0.00	0.00	1367.99	592.85
MAA	0.00	0.00	0.00	351.60	405.69	0.00	0.00	141.11	112.30
ALB	0.00	0.00	0.00	2110.79	6211.82	0.00	155.22	3394.51	1484.04
PEB	0.00	0.00	0.00	326.31	0.00	0.00	0.00	0.00	40.79
BAB	0.00	0.00	0.00	26.45	176.39	0.00	0.00	0.00	25.36
LAN	0.00	0.00	0.00	0.00	388.06	0.00	0.00	470.37	107.30
LAS	0.00	0.00	0.00	0.00	211.67	0.00	0.00	0.00	26.46
CHA	0.00	0.00	0.00	0.00	370.42	0.00	0.00	423.33	99.22
DIR	0.00	0.00	0.00	0.00	42.33	0.00	0.00	0.00	5.29
ORN	0.00	0.00	0.00	0.00	123.47	0.00	0.00	0.00	15.43
CLAP	0.00	0.00	0.00	0.00	1622.78	0.00	0.00	0.00	202.85
CHN	0.00	0.00	0.00	0.00	70.56	0.00	0.00	0.00	8.82
SCM	0.00	0.00	0.00	0.00	17.64	0.00	0.00	0.00	2.21
LAB	0.00	0.00	0.00	0.00	158.75	0.00	0.00	0.00	19.84
AUO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.35	0.29
TOTAL	75820.10	10760.74	18675.52	48816.03	52941.37	26331.33	64440.42	28357.83	40767.92

Maximum sustainable yield

The maximum yield that can be sustained from the biomass following option 1 is 11,705.95 Mt. (table 4).

Table 4: Summary of estimated biomass and MSY of clupeid - Opt.1

	95 % CL	95 % CL
Lake Area: 1,270 Km^2	Lower	Higher
Estimated Biomass: 36,769.85 Mt	19,548.71	53,653.68
Estimated MSY: 11,705.95 Mt	10,362.70	13,022.89
Estimated Yield, 1996: 17,675.8 Mt		
Natural Mortality per year: 0.156		

The figures above suggest that the MSY of clupeids was overshot by 34% in 1996. Consequently, the 1996 fishing effort of 810 beach seines would have to be reduced by 34% to 535 beach seines for optimal exploitation of clupeids alone. But since the beach seine fishery is a multi-species fishery the number of beach seines to be sustained could be as high as 698.[1]

Applying option 2 the clupeid biomass is 5,967 Mt. (table 5). This estimate is clearly unrealistic considering the current estimated yield of clupeids in the Lake. It in fact suggests that the boat towing speed must have been erroneously determined. In any case, the towing speed of the boats was higher than 2.5 Km/h which leads to severe underestimation of the biomass since a great proportion of the biomass in the effective path swept escapes (appropriate speed for resource evaluation of clupeids should be between 1.0 to 2.0 Km/h).

Table 5: Summary of estimated biomass and MSY of clupeid - Opt. 2

	95 % CL Lower	95 % CL Higher
Lake Area: 1,270km^2		
Estimated Biomass: 5,967.51Mt	3,679.52	8,231.73
Estimated MSY: 9303.37 Mt	9,124.90	9,479.98
Current Yield: 17,675.8 Mt		
Natural Mortality per year: 0.156		

Species composition

Clupeids made up 91% of the total species recorded in the survey. The smaller clupeid, Sierrathrissa leonensis, was more abundant in the Lake than the larger species, Pellonula afzeliusi, with the former making up 97.34% of the estimated total clupeid population (tables 1 and 2). This observation confirms earlier studies by Otobo (1977).

The vast disparity in abundance between the two species might be partly explained by the fact that the latter occurs at greater depth and only a very small proportion of the population may have been available to the trawl.

The by-catch was dominated by Alestes baremose, Synodontis membranaceous and the predator Eutropius niloticus. The bycatch composition of the beach seine fishery is, on the other hand, dominated by high valued species like Citharinus citharus, Tilapia, Lates niloticus. Other species of less value, for example Chrysichthys nigrodigitatus and Alestes sp., also contribute appreciably (Appendix 3).

The low bycatch of pair trawling suggests that this method could be ideal for rational exploitation of clupeids.

The observed average catch rates were much higher in the Bussa and Foge stations whilst the lowest was recorded in the Ulaira stations (Appendix 4).

5. CONCLUSION AND MANAGEMENT RECOMMENDATIONS

5.1. Non-mechanised Fishery

The main aim of this study was to determine the biomass and maximum sustainable yield of clupeids in Lake Kainji with a view of implementing a management plan for the rational exploitation of these stocks.

The results of the present study, though may be preliminary, have shown that the stock size of the clupeid populations is much higher than previously determined by Otobo (1977) and Turner (1996). It should also be pointed out that the larger species, Pellonula afzeliusi, may be the first casualty of overfishing in the face of unchecked exploitation due to its low density in the Lake. This species has a fecundity between 140-4,900 eggs and occurs at a greater depth than the smaller species Sierrathrissa leonensis. In effect, therefore, the clupeid fishery on the Lake has been sustained over the years by the latter, which is much more abundant but with a lower fecundity of 94-2,595 eggs.

The fishery is currently (1996) operating above the optimum level. A reduction of the present effort level of the beach seine fishery, from 810 nets to 698 or lower, would allow the yield from the clupeid fishery to be sustained, with reduced by-catch.

Because of the substantial by-catch in the beach seines, this fishing method was banned from Kainji Lake in 1997. There are provisions in the fisheries edicts which stipulate penalties for contravening this regulation.

The ban on the beach seines is supported by this study. Nevertheless, and since the ban may not be 100% effective, effort should concentrate on maintaining that the present number of beach seines is kept at most at the present level.

In the absence of an alternative fishing method the practical implication of the ban is, if the law is fully implemented, that a substantial amount of clupeid will remain unexploited. Therefore an open water seine net is recommended as an alternative fishing method. The number of nets should not be allowed to exceed beyond 500, and it is anticipated there would be lesser by-catches, mainly composed of matured species which must have spawned at least once.

5.2. Mechanised Fishery

Analysis of bycatch composition of the pair trawling survey above confirms that this method would be less destructive to the juvenile and immature stages of high valued species.

Theoretically, once further exploration into the biology of the bycatch species, including their reproductive biology (gonad stages, breeding seasonality etc.), size selection studies and their distribution have been completed, an **Inshore Exclusive Zone (IEZ)** has been established, closed seasons or closed areas have been introduced, the development of the pair trawl fishery for clupeids could be given go-ahead.

This idea could however be fortuitous to the unsuspecting investor for reasons listed below:

Catch expectations

There has been a drastic decline (by 51 %) in the landings of clupeids from 17,675 Mt. in 1996 to 8,648 Mt. in 1997.

It would be unwise for any potential investor to invest in such a highly variable fishery without undertaking major investigations into the cause of these variations.

Economic assessment

Otobo and Imevbore (1979) did an economic analysis of the pair trawling fishery and concluded that it is a much more viable fishing option than the gill net fishery on the Lake. Ita and Balogun (1981, 1982) also discussed the commercial viability of the trawl fishery for clupeid in Lake Kainji.

Below is shown an economic analysis of pair trawling that is based on the more recent data.

Assumptions:

i) Average number of hours trawling: 2

ii) Average number of hauls/day: 3

iii) Average number of fishing days/month: 22

iv) Average catch rate of clupeids/pair trawler: 22.13 Kg/h*

v) Average catch rate of bycatch/pair trawler: 2.08 Kg/h*

vi) Average price per kg of clupeid: N 20

vii) Average price per kg of bycatch: N 100

viii) Petrol consumption per hour trawling: 5.125 gallons

ix) Average price of petrol/gallon: N 100

x) Engine oil consumption/hour trawling: 0.81

xi) Price of gallon of engine oil: N 750

xii) Number of employees: 7 (5 fishermen; 2 boat drivers)

xiii) Pay per fishing day: N 250

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* from present survey

Annual Costs of Fishing Operation:

Fixed costs: not considered

Variable costs:

Petrol:	N	811,800
Engine oil:	N	240,570
Labour:	N	462,000
Total:	N	1,514,370

Annual Income from Fishing Operation:

Clupeids:	N	701,078.4
Bycatch:	N	329,472.0
Total:	N	1,030,550.4

Loss:	**N**	**483,819.6**

The analysis shows that about 35 Mt. of clupeids would be produced annually from one unit of pair trawl in the Lake.[3] This implies that 334 units of pair trawlers, with comparable fishing power, would produce about 11690 Mt. annually, which is almost equal to the estimated MSY. Furthermore there would be 10% (out of the total production) bycatch species of commercial value that would be an added revenue from the fishery.

The above analysis clearly indicates that the introduction of a mechanized pair trawling in the Lake is not a profitable venture, even if the fixed costs (depreciation of two boats, two 25 HP outboard engines and fishing gears) are not included.

Closing remarks:

Considering the elusive nature of fish species and the unpredictability of their environment, it seems necessary to carry out a survey that will validate the results of the current survey. The prospect of repeating the survey will depend very much on the total survey cost. An estimated 117030 Naira total cost was incurred to conduct the last survey. These were expenditures mainly for allowances, nets and fuel.

However, it should be noted that trawl survey is, although expensive, a direct and more reliable sampling method of resource evaluation than indirect stock assessment methods like length frequency.

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[3] 22.13kg/h * 2h trawling * 3 hauls of trawling/fishing day * 22 fishing days/month * 12 months

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APPENDICES

Appendix 1. List of species and their identification codes

CODE	NAME OF SPECIES
ALB	*Alestes baremose*
AUO	*Auchenoglanis occidentalis*
BAB	*Bagrus bayad*
CHA	*Chrysichthys auratus*
CHN	*Chrysichthys nigrodigitatus*
CIC	*Citharinus citharus*
CLAP	*Clarotes laticeps*
DIR	*Distichodus rostratus*
EUN	*Eutropius niloticus*
HYF	*Hydrocynus forskahlii*
LAB	*Labeo Coubie*
LAN	*Lates niloticus*
LAS	*Labeo senegalensis*
MAA	*Malapterurus electricus*
ORN	*Oreochromis niloticus*
PEA	*Pellonula afzeliusi*
PEB	*Petrocephalus bovei*
SCM	*Schilbe mystus*
SIL	*Sierrathrissa leonensis*
SYM	*Synodontis membranaceus*

Appendix 2. Estimation of clupeid biomass by Swept Area Method

Option 1 **Distance covered obtained directly from GPS (Satellite Reading)
*** Boat speed recalculated from given distance covered and time

a) Stratum 1- BUSSA

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat*** Speed Km/h	**Distance Covered Km	Trawl'Wing spread m h*X2	Area per unit time (h) Km^2/h	Avg. per unit area Kg/Km^2 divide by 'X1
1	34-57	63.00	0.33	1.21	0.40	3.0	0.0036	35000.06
2	43-57	57.00	0.33	0.61	0.20	3.0	0.0018	63333.44
3	38-47	73.50	0.33	0.91	0.30	3.0	0.0027	54444.52
4	48-61	81.00	0.33	0.30	0.10	3.0	0.0009	180000.22
5	58-60	62.40	0.33	0.91	0.30	3.0	0.0027	46222.30
6	52-55	33.00	0.33	0.30	0.10	3.0	0.0009	73333.33
7	40-51	39.00	0.33	1.21	0.40	3.0	0.0036	21666.67
8	56	50.40	0.33	0.61	0.20	3.0	0.0018	56000.11
9	62	52.20	0.33	0.61	0.20	3.0	0.0018	58000.11
10	56	24.00	0.33	0.91	0.30	3.0	0.0027	17777.78
11	53-59	54.00	0.33	0.61	0.20	3.0	0.0018	60000.11
12	51	36.00	0.33	0.30	0.10	3.0	0.0009	80000.00
13	46-54	27.30	0.33	0.61	0.20	3.0	0.0018	30333.33
							Average	59700.92

b) Stratum 2 - ANFANI

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat* Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time (h) Km^2/h	Ave. Biomass unit area Kg/Km^2 divide by 'X1
1	78-85	3.00	0.33	1.21	0.40	3.0	0.0036	1666.67
2	66-76	4.50	0.33	1.21	0.40	3.0	0.0036	2500.00
3	65-78	5.40	0.33	1.21	0.40	3.0	0.0036	3000.00
4	76-85	3.15	0.33	1.52	0.50	3.0	0.0045	1400.00
5	50-57	4.20	0.33	0.91	0.30	3.0	0.0027	3111.11
6	37-49	6.00	0.33	1.21	0.40	3.0	0.0036	3333.33
7	49-57	39.30	0.33	0.91	0.30	3.0	0.0027	29111.11
8	50-66	20.10	0.33	1.21	0.40	3.0	0.0036	11166.67
9	49-57	15.60	0.33	1.21	0.40	3.0	0.0036	8666.67
10	76-78	18.60	0.33	1.21	0.40	3.0	0.0036	10333.33
11	76-78	15.60	0.33	0.91	0.30	3.0	0.0027	11555.56
12	78-86	13.20	0.33	0.91	0.30	3.0	0.0027	9777.78
13	78-85	4.20	0.33	0.61	0.20	3.0	0.0018	4666.67
14	72-78	15.60	0.33	0.61	0.20	3.0	0.0018	17333.33
							Average	8401.59

c) Stratum 3 - JETTY

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat*** Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time (h) Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	56-87	11.40	0.33	0.61	0.20	3.0	0.0018	12666.67
2	81-87	1.20	0.33	1.21	0.40	3.0	0.0036	666.67
3	85-100	7.20	0.33	1.21	0.40	3.0	0.0036	4000.00
4	56-80	4.80	0.33	0.91	0.30	3.0	0.0027	3555.56
5	56-87	3.00	0.33	0.61	0.20	3.0	0.0018	3333.33
6	120	2.40	0.33	0.61	0.20	3.0	0.0018	2666.67
7	110-120	8.25	0.33	0.61	0.20	3.0	0.0018	9166.67
8	89-91	78.00	0.33	1.21	0.40	3.0	0.0036	43333.39
9	84-87	20.40	0.33	0.61	0.20	3.0	0.0018	22666.67
12	65-84	17.10	0.33	0.61	0.20	3.0	0.0018	19000.00
11	85-120	17.70	0.33	0.91	0.30	3.0	0.0027	13111.11
12	75-112	25.50	0.33	0.61	0.20	3.0	0.0018	28333.33
13	115-120	25.80	0.33	0.61	0.20	3.0	0.0018	28666.67
							Average	14705.13

d) Stratum 5 - DUGA

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat*** Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	37-43	30.03	0.33	1.21	0.40	3.0	0.0036	16683.33
2	34-37	10.95	0.33	0.30	0.10	3.0	0.0009	24333.36
3	37-42	19.80	0.33	0.91	0.30	3.0	0.0027	14666.67
4	27-30	29.85	0.33	1.52	0.50	3.0	0.0045	13266.68
5	30	24.00	0.33	0.91	0.30	3.0	0.0027	17777.78
6	31-37	24.00	0.33	0.91	0.30	3.0	0.0027	17777.78
7	35-45	12.00	0.33	0.30	0.10	3.0	0.0009	26666.67
8	34-44	9.00	0.33	0.30	0.10	3.0	0.0009	20000.00
9	41-43	22.50	0.33	0.30	0.10	3.0	0.0009	50000.00
10	41-43	34.50	0.33	0.30	0.10	3.0	0.0009	76666.67
11	36-41	33.00	0.33	0.30	0.10	3.0	0.0009	73333.33
12	37	19.50	0.33	0.30	0.10	3.0	0.0009	43333.33
							Average	32875.47

e) Stratum 5 - PAPIRI

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat*** Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	23-31	22.20	0.33	0.61	0.20	3.0	0.0018	24666.67
2	24-27	20.40	0.33	0.30	0.10	3.0	0.0009	45333.33
3	24-27	12.60	0.33	0.61	0.20	3.0	0.0018	14000.00
4	27-28	16.80	0.33	0.30	0.10	3.0	0.0009	37333.33
5	24-26	26.40	0.33	0.30	0.10	3.0	0.0009	58666.67
6	27	31.50	0.33	0.30	0.10	3.0	0.0009	70000.00
7	25-30	18.60	0.33	0.61	0.20	3.0	0.0018	20666.67
8	25	24.00	0.33	0.91	0.30	3.0	0.0027	17777.78
9	25-32	9.60	0.33	1.21	0.40	3.0	0.0036	5333.33
10	27-40	5.40	0.33	0.30	0.10	3.0	0.0009	12000.00
11	23-27	7.50	0.33	0.30	0.10	3.0	0.0009	16666.67
12	29-38	13.20	0.33	0.91	0.30	3.0	0.0027	9777.78
							Average	27685.19

f) Stratum 6 - ULAIRA

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat*** Speed Km/h	**Distanc Covered Km	Trawl spread m h*X2	Area swept per unit time Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	25-27	9.30	0.33	0.30	0.10	3.0	0.0009	20666.69
2	27	12.00	0.33	0.30	0.10	3.0	0.0009	26666.67
3	27	18.00	0.33	0.30	0.10	3.0	0.0009	40000.00
4	24	7.20	0.33	0.30	0.10	3.0	0.0009	16000.02
5	23-27	9.30	0.33	0.30	0.10	3.0	0.0009	20666.69
6	28	10.80	0.33	0.30	0.10	3.0	0.0009	24000.00
7	24-26	13.80	0.33	0.30	0.10	3.0	0.0009	30666.67
8	23-27	8.40	0.33	0.30	0.10	3.0	0.0009	18666.69
9	22-30	5.40	0.33	0.61	0.20	3.0	0.0018	6000.01
10	23-40	10.80	0.33	1.82	0.60	3.0	0.0054	4000.00
							Average	20733.34

g) Stratum 7 - FOGE

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat** Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time (h) Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	24	24.00	0.33	0.30	0.10	3.0	0.0009	53333.33
2	24	69.00	0.33	0.30	0.10	3.0	0.0009	153333.33
3	31	37.80	0.33	0.30	0.10	3.0	0.0009	84000.00
4	23-30	36.00	0.33	0.91	0.30	3.0	0.0027	26666.67
5	24-29	46.20	0.33	2.73	0.90	3.0	0.0081	11407.41
6	28-44	9.00	0.33	0.61	0.20	3.0	0.0018	10000.00
7	23-29	19.20	0.33	1.52	0.50	3.0	0.0045	8533.33
8	24-29	126.00	0.33	1.52	0.50	3.0	0.0045	56000.00
9	24-31	24.00	0.33	0.30	0.10	3.0	0.0009	53333.33
10	31	18.00	0.33	0.30	0.10	3.0	0.0009	40000.00
11	29-31	24.00	0.33	0.61	0.20	3.0	0.0018	26666.67
12	32	19.20	0.33	0.61	0.20	3.0	0.0018	21333.33
13	30-33	43.20	0.33	0.61	0.20	3.0	0.0018	48000.00
14	20-31	45.00	0.33	0.30	0.10	3.0	0.0009	100000.00
15	31-34	30.00	0.33	0.30	0.10	3.0	0.0009	66666.67
							Average	50618.27

h) Stratum 8 - SHAGUNU

Haul	Depth (m)	Catch per CPUE Kg/h	Trawl hour	Boat** Speed Km/h	**Distance Covered Km	Trawl spread m h*X2	Area swept per unit time (h) Km^2/h	Biomass per unit area Kg/Km^2 divide by 'X1
1	34-46	10.80	0.33	0.30	0.10	3.0	0.0009	24000.00
2	33-36	7.20	0.33	0.30	0.10	3.0	0.0009	16000.00
3	30-40	5.40	0.33	0.30	0.10	3.0	0.0009	12000.00
4	36-44	1.80	0.33	0.30	0.10	3.0	0.0009	4000.00
5	35	4.20	0.33	0.61	0.20	3.0	0.0018	4666.67
6	37-44	0.00	0.33	0.30	0.10	3.0	0.0009	0.00
7	31-44	10.20	0.33	0.30	0.10	3.0	0.0009	22666.67
8	43-58	7.80	0.33	0.61	0.20	3.0	0.0018	8666.67
9	36-47	4.80	0.33	0.30	0.10	3.0	0.0009	10666.67
10	31-44	9.30	0.33	0.30	0.10	3.0	0.0009	20666.67
11	37-50	10.20	0.33	0.30	0.10	3.0	0.0009	22666.67
12	37-44	9.60	0.33	0.61	0.20	3.0	0.0018	10666.67
13	35-44	22.80	0.33	0.30	0.10	3.0	0.0009	50666.67
14	35-48	11.40	0.33	0.30	0.10	3.0	0.0009	25333.33
15	35-45	28.20	0.33	0.91	0.30	3.0	0.0027	20888.89
16	30-51	7.80	0.33	0.30	0.10	3.0	0.0009	17333.33
17	36-44	3.60	0.33	0.61	0.20	3.0	0.0018	4000.00
18	36-44	13.20	0.33	0.30	0.10	3.0	0.0009	29333.33
							Average	16901.23

Appendix 3. Catch per hour trawling (Kg/h) per species per station

Species	BUSSA	ANFANI	JETTY	DUGA	PAPIRI	ULAIRA	FOGE	SHAGU	AVERAGE
SIL	49.85	12.03	17.12	19.28	16.50	10.50	38.04	9.01	21.54
PEA	0.37	0.00	0.01	3.15	0.85	0.00	0.00	0.34	0.59
HYF	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01
SYM	0.00	0.00	0.00	1.31	3.05	0.00	0.00	0.49	0.61
CIC	0.00	0.00	0.00	0.13	0.20	0.00	0.00	0.00	0.04
EUN	0.00	0.00	0.00	1.07	0.58	0.00	0.00	0.59	0.28
MAA	0.00	0.00	0.00	0.33	0.21	0.00	0.00	0.05	0.07
ALB	0.00	0.00	0.00	1.19	3.46	0.00	0.07	1.40	0.76
PEB	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.02
BAB	0.00	0.00	0.00	0.04	0.09	0.00	0.00	0.00	0.02
LAN	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.18	0.05
LAS	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.01
CHA	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.15	0.04
DIR	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
ORN	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.01
CLAP	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.14
CHN	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.01
SCM	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
LAB	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.01
AUO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
TOTAL	50.22	12.10	17.13	26.63	26.85	10.50	38.11	12.22	24.22

Appendix 4. Catch composition by weight per station (%)

Species	BUSSA	ANFANI	JETTY	DUGA	PAPIRI	ULAIRA	FOGE	SHAGU	AVERAGE
SIL	99.26	99.47	99.93	72.48	61.46	100.00	99.82	73.86	88.29
PEA	0.74	0.00	0.07	11.82	3.17	0.00	0.00	3.00	2.35
HYF	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.07
SYM	0.00	0.00	0.00	4.93	11.36	0.00	0.00	3.73	2.50
CIC	0.00	0.00	0.00	0.47	0.74	0.00	0.00	0.00	0.15
EUN	0.00	0.00	0.00	3.99	2.14	0.00	0.00	4.39	1.32
MAA	0.00	0.00	0.00	1.22	0.79	0.00	0.00	0.44	0.31
ALB	0.00	0.00	0.00	4.46	12.87	0.00	0.18	11.64	3.65
PEB	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.06
BAB	0.00	0.00	0.00	0.14	0.33	0.00	0.00	0.00	0.06
LAN	0.00	0.00	0.00	0.00	0.70	0.00	0.00	1.61	0.29
LAS	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.05
CHA	0.00	0.00	0.00	0.00	0.74	0.00	0.00	1.32	0.26
DIR	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01
ORN	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.03
CLAP	0.00	0.00	0.00	0.00	4.28	0.00	0.00	0.00	0.54
CHN	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.02
SCM	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.01
LAB	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.05
AUO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
TOTAL	100	100	100	100	100	100	100	100	100

Appendix 5. Further Analysis of Results

To test the robustness of the estimates of clupeid abundance changes in the coefficients were made and use of stratification included in the calculations.

The changes made were:

1) the reduction of the headrope coefficient was changed from 0.5 to 0.6, since the use of paired trawls may increase net opening.

2) the catchability coefficent was changed from 0.5 to 0.6 since the smaller clupeid may be easier caught than larger fast swimming species.

3) the total water surface area was changed from 1,270 to 1,016Km^2, since at the time of the survey the lake level was at low water.

4) horizontal and vertical stratification was included.

The effects on the biomass and MSY of the different types of stratification made are:

Type of stratification	Previous Biomass	New Biomass	Previous MSY	New MSY
Case 1: Only horizontal stratification for the whole lake	36,770	18,228	11,705	9,505
Case 2: Horizontal Stratification for the whole lake and vertical stratification for the southern lake basin only	as above	25,936	as above	10,016
Case 3: Horizontal and vertical stratification for the whole lake	as above	32,770	as above	10,590

Note: Estimates in Mt.
Horizontal stratification allows for significantly different biomass densities between white flood (north of Shagunu) and black flood estimates (P=0.1, Mann-Whitney U-test)
Vertical stratification allows for significant different biomass densities between surface (0-6m.)and lower level trawls (6-18m). (P=0.00, Mann-Whitney U-test).

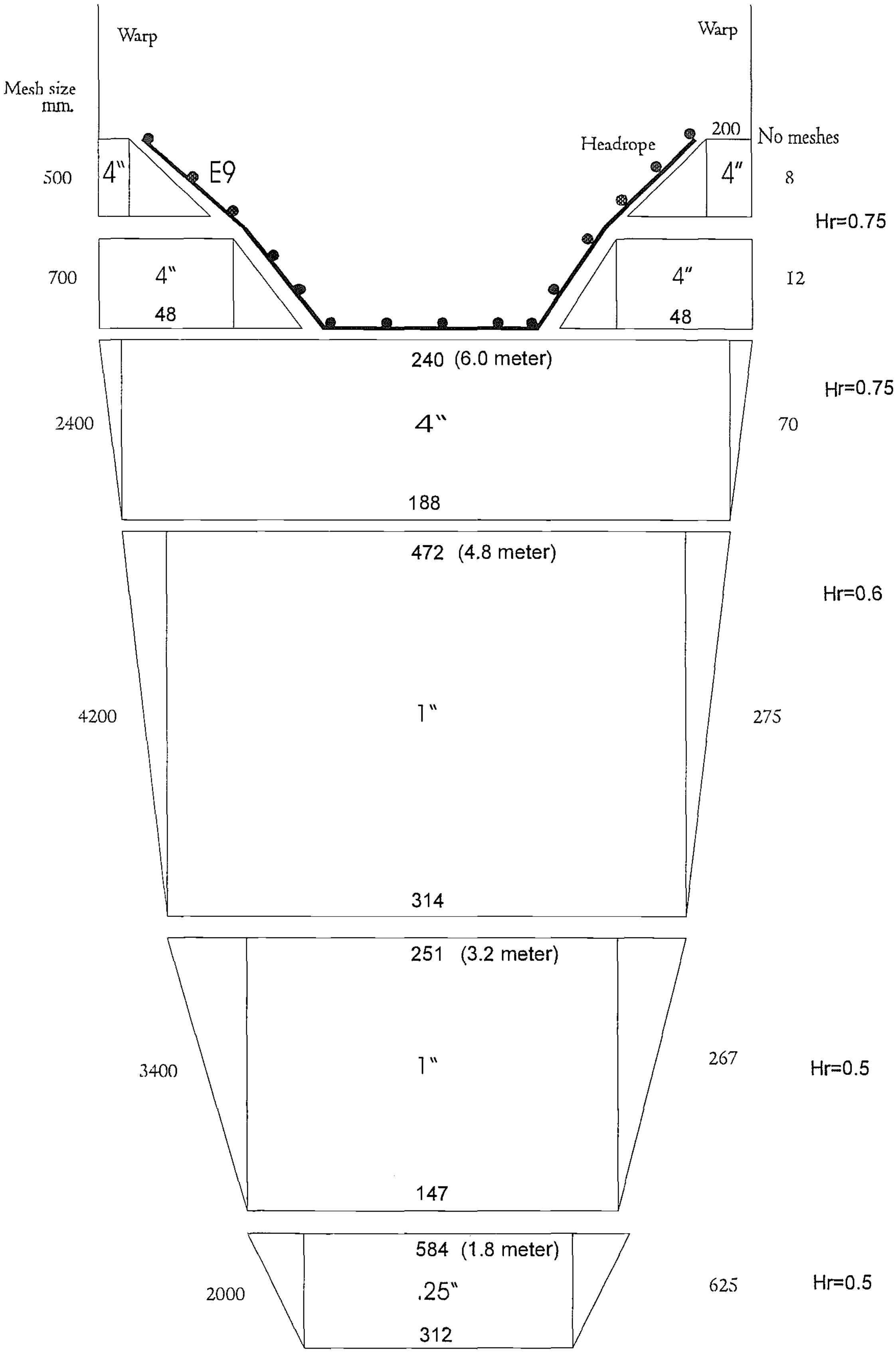
Using case 1 (only horizontal stratification) will tend to under-estimate the biomass since one assumes one is capturing the whole of the clupeid band even at lower depths. The inclusion of stations with samples only taken from the lower depths will also reduce the estimate.

Case 2 (horizontal stratification and vertical stratification in the clear water zone only) is more accurate but the use of vertical stratification will lead to error if one is sampling the main clupeid band as it migrates up and down. However there is no evidence that higher catches occurred at lower depths later in the day (when the band moves down) and trawling only took place early morning and late afternoon when the clupeids were at the surface. The high significant difference between surface and lower catches also suggests that one sampled the main clupeid band in the surface and the stragglers beneath in the lower depth trawls.

The exclusion of stratification in the north white flood area could markedly reduce the biomass figure.

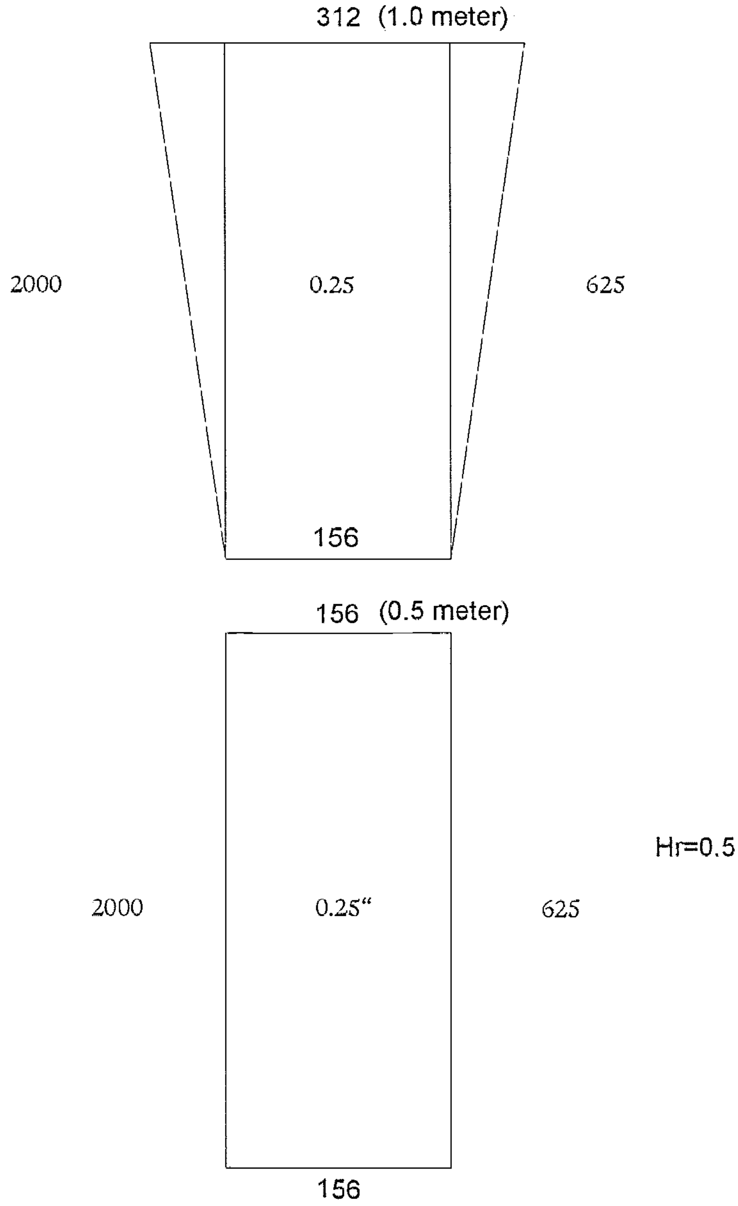
Case 3 stratifies the whole lake both horizontally and vertically and probably represents the best estimate of abundance. This is similar to results presented in the body of the report.

APPENDIX 6 Design of the mid water pair trawl net for Clupeids, Kainji Lake



Mesh size in stretched inches, number of meshes allowing for 0.5 hanging ratio, horizontal distance in mm.

Cod end



Trawl characteristics:
Type: Mid water pair trawl for Clupieds
Four pannel trawl
6m. Square mouth opening
17.2 m. overall length
Vessel: 2 x 8m. Boat 80 Hp.