The design of multimesh, multidepth gillnet fleets for use in the Lake Victoria Fisheries Research Project

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Abstract

Multimesh, multidepth gillnet fleets are useful in assessing fish stock abundance, size distribution and depth distribution. Using data collected on net mesh selectivity for Nile perch, *Lates niloticus* (L.), in the Kenyan waters of Lake Victoria, suitable mesh sizes for gillnet fleets for use in the Lake Victoria Fisheries Research Project were determined. The modal selection length for Nile perch in the mesh sizes used in the earlier experiment were determined, as was the size range vulnerable to capture. Mesh sizes were selected so that their catch selectivity curves overlapped at 50% efficiency of capture. Monofilament nylon gillnet fleets with ten mesh sizes from 30 to 252 mm were obtained. Four identical fleets are set, one at the surface, one at the bottom and two at intermediate depths. Extra netting of different material is added at each end of each fleet to eliminate poor efficiency of the ends of the experimental fleets caused by poor setting, twisting or bunching of the net ends. Such problems affect only the extra netting, the catches from which are discarded. Initial trials suggest 60% of the Nile perch swim within 5 m of the bottom. Setting and hauling of the nets is simple and quick, allowing the nets to be used at the same time as other sampling programmes.

Introduction

Experimental fishing programmes are essential to obtain indices of biomass in fisheries. In the case of a fishery for demersal species, bottom trawling is an effective method for assessing the size of a stock, particularly if the target species are slow-moving and unlikely to escape the trawl. For species which are distributed throughout the water column, and for species which swim fast enough to avoid moving nets, bottom trawling is less suitable and other methods of assessing biomass are needed.

In Lake Victoria in the 1970s before the Nile perch, *Lates niloticus* (L.), population explosion, there was a substantial stock of small, demersal, haplochromine cichlid species, and bottom trawling was an effective method for obtaining biomass indices (Bergstrand & Cordone 1971; Kudhongania & Cordone 1974). Similar cichlid species flocks in Lake Malawi were also assessed by bottom trawling (FAO/UNDP 1976; Banda *et al.* 1994; Tweddle *et al.* 1995), but, as Banda *et al.* (1994) demonstrated, cichlids were able to avoid slow-moving trawl nets even at sizes as small as 12 cm TL.

In Lake Victoria, the small haplochromines were replaced in the 1980s by Nile perch, a large (>100 kg) predator which can be found throughout the water column. If cichlids above 12 cm TL can avoid trawls, Nile perch, with their very similar morphology, may also exhibit avoidance behaviour. Bottom trawling in isolation, therefore, may not give true estimates of Nile perch biomass, though it will demonstrate fluctuations in abundance.

A further complication in Lake Victoria is the regular occurrence of an oxycline at depths ranging from 20 to 45 m (sometimes as shallow as 5 m in sheltered bays). Trawling below the oxycline results in zero catches and it is evident that fish that are present in such areas are up in the water column above the oxycline.

Indices of biomass derived from bottom trawling surveys in Lake Victoria therefore require verification and correction to account for the vertical distribution and the almost certain bias in favour of small specimens arising from trawl avoidance. Two methods are employed in the Lake Victoria Fisheries Research Project (LVFRP), hydroacoustic surveys and multimesh, multidepth gillnet surveys.

In this paper, we report on the choice of mesh sizes and the design of the net fleets for the gillnet survey. We also present results of initial trials with the selected nets.

Graded fleets of gillnets are a recognised method for assessing the size distribution of fish stocks. Most early authors used fleets with equal increments in mesh size, e.g. 12 mm (½"), 25 mm (1"), 37 mm (1½"), 51 mm (2"), etc. Tweddle (1995) used 12 mm (½") increments for smaller meshes and 25 mm (1") for larger meshes in Lake Malawi for a mixed species fishery. For some species, regular increments result in an accurate picture of the stock size distribution, e.g. tilapias (Kolding 1998) where 12 mm (½") increments were used.

For most species, however, the length range over which the species is vulnerable to capture for a particular mesh size increases as mesh size increases. If mesh size increments do not increase, therefore, the size ranges of fish captured in larger meshes show greater overlap. Larger fishes of a given length become vulnerable to capture by more than one mesh size in a graded fleet, which increases their overall likelihood of capture compared to smaller fishes. The fleet of nets therefore results in catches biased in favour of larger fishes. Kolding (1998) found that the same fleet of nets which was suitable for tilapias in Lake Kariba gave a distorted picture of the true size distribution of tigerfish, *Hydrocynus vittatus* Castelnau.

To overcome this problem, a geometric progression in mesh sizes has been recommended (Regier & Robson 1966). Unfortunately, this is far from ideal for many species, e.g. the southern African cyprinids. Nets used in research on Lake Le Roux (now Lake Vanderkloof) on the Orange River were suitable for the smaller specimens but the mesh increments for the larger fish were too widely spaced, resulting in missed data for certain size ranges (Tomasson 1983). Tweddle (1996) conducted studies on the same two large cyprinids as Tomasson (1983), *Barbus aeneus* (Burchell) and *Labeo capensis* (A. Smith) in Katse Reservoir, Lesotho, and recommended a simpler incremental system for further studies, i.e. increments widening by 2 mm at each mesh.

Nile perch in Lake Victoria has also been found to have a size structure for which 12 mm (½") increments are not suitable in the larger meshes (A. Asila unpublished). To use simple equal increments would result in large corrections having to be made for net selectivity.

Ideally, to minimise the need for selectivity correction, and assuming a normal distribution for length of fish caught in a particular mesh size, meshes should be selected so that catches of adjacent mesh sizes overlap at the point at which each mesh is 50% efficient. Catches for one mesh size should drop to zero at the fish length where the efficiency of the next mesh size is maximum. In practice, normally distributed catches are rare as fish can be caught in several ways, e.g. snagged by teeth or fin spines, gilled, wedged by the body, or generally entangled. Catch distribution may therefore be skewed or even bimodal and selectivity must always be taken into account in determining the true population structure from which the catches are made.

Following corrections for selectivity, gillnet data can be used to apply correction factors to indices of biomass obtained by bottom trawling during the LVFRP. Vertical distribution of the Nile perch will be assessed by using gillnets spanning the full depth range of the lake at each position. Bias in length distribution in the trawl will be assessed by catching the full size range of perch in the multimesh nets.

Gillnetting experiments have been conducted on Nile perch in Lake Victoria by one of us (A.A.). The data collected so far are used here to determine optimum mesh sizes for the graded fleet of nets to be used in the LVFRP.

Allison *et al.* (1994) described gillnet sampling in Lake Malawi using graded fleets of identical nets at different depths to obtain a picture of vertical distribution of the fish species. A modification of this system has been developed for use on Lake Victoria and this is described below.

Methods

Mesh size selection

Nylon multifilament gillnets with a wide range of mesh sizes (those available locally at the time of purchase) were set in the Winam Gulf, Kenya. Several mounting ratios were also tested in the trials. All available catch data were pooled for each mesh size, irrespective of mounting ratios and number of sets. The length frequency distribution for Nile perch was plotted for each mesh size. The modal length of capture was noted for each mesh and the relationship between modal length and mesh size calculated by linear regression.

The lengths above and below the mode at which each net had 50% of the maximum efficiency were noted by eye. Secondary modes and skewed distributions were ignored for the purpose of mesh selection. Biases caused by such distributions will be assessed when sufficient catch data are available from the new nets. The length range from lower 50% efficiency to upper 50% efficiency for each mesh was plotted against mesh size. The length range increased exponentially with increasing mesh size (see Results). Length ranges obtained were noted in order of mesh size and those which had 50% efficiencies at or near the same length (upper 50% range of one mesh against lower 50% range of next larger mesh) were initially selected as possible mesh sizes for the new fleet. Adjustments were made by interpolation for missing mesh sizes based on the linear relationship between modal length and mesh size and the exponential increase in length range observed with increasing mesh size. The meshes provisionally chosen were plotted using the Microsoft Excel exponential trend line to obtain exact mesh sizes to be used in the fleets.

Gillnet fleet design

The net design described by Allison *et al.* (1994) for floating gillnets in Lake Malawi was modified for use in the shallower waters of Lake Victoria. Modifications include an anchoring system, while the slightly negatively buoyant nets were maintained at the selected depths by the use of additional floats attached to the headlines by ropes of the exact depth required. Full details are given below.

Gillnet trials

Following the arrival of the nets from the manufacturer (Collins Nets, Bridport, UK) preliminary trials were conducted in the Napoleon Gulf and Buvuma Channel near Jinja, Uganda, using the research vessels RV Ibis and RV Victoria Explorer.

The first two trials used one net only to determine the feasibility of using the large trawlers for shooting and hauling. Successful results were followed by three settings with four fleets and one with three (the fourth needed minor repairs). The four fleets were arranged with one at the surface, one at the bottom and two at intermediate depths, in water depths of 20-25 m. The nets were set from plastic fish boxes, with the nets attached to the anchor/buoy ropes by snap links on the bridles connected to plastic codend rings looped and tied on the ropes at the relevant depth. Hauling was carried out into the wind over the stern of the vessel, with judicious use of the engine going astern to relieve the strain of hauling without risk of over-running the nets. Catches were sorted after the nets had been hauled, and the nets were relaid into the plastic boxes at the same time.

Results

Selection of mesh sizes

The length frequency distributions for Nile perch catches from the previous gillnetting experiments in the Nyanza Gulf in half-inch incremental mesh sizes are shown in Fig. 1.

The relationship between modal length of capture and mesh size is linear (Figure 2) and significant ($r = 0.998$). The relationship between the range of vulnerability to capture (lower 50% efficiency to upper 50% efficiency) and mesh size is exponential ($r = 0.90$)(Figure 3).

Mesh sizes chosen by eye based on these relationships are shown in Figure 4, together with the fitted exponential curve to obtain the final choice of meshes to be used. Mesh sizes selected (in mm) were: 30, 38, 48, 60, 77, 97, 124, 157, 199, 252.

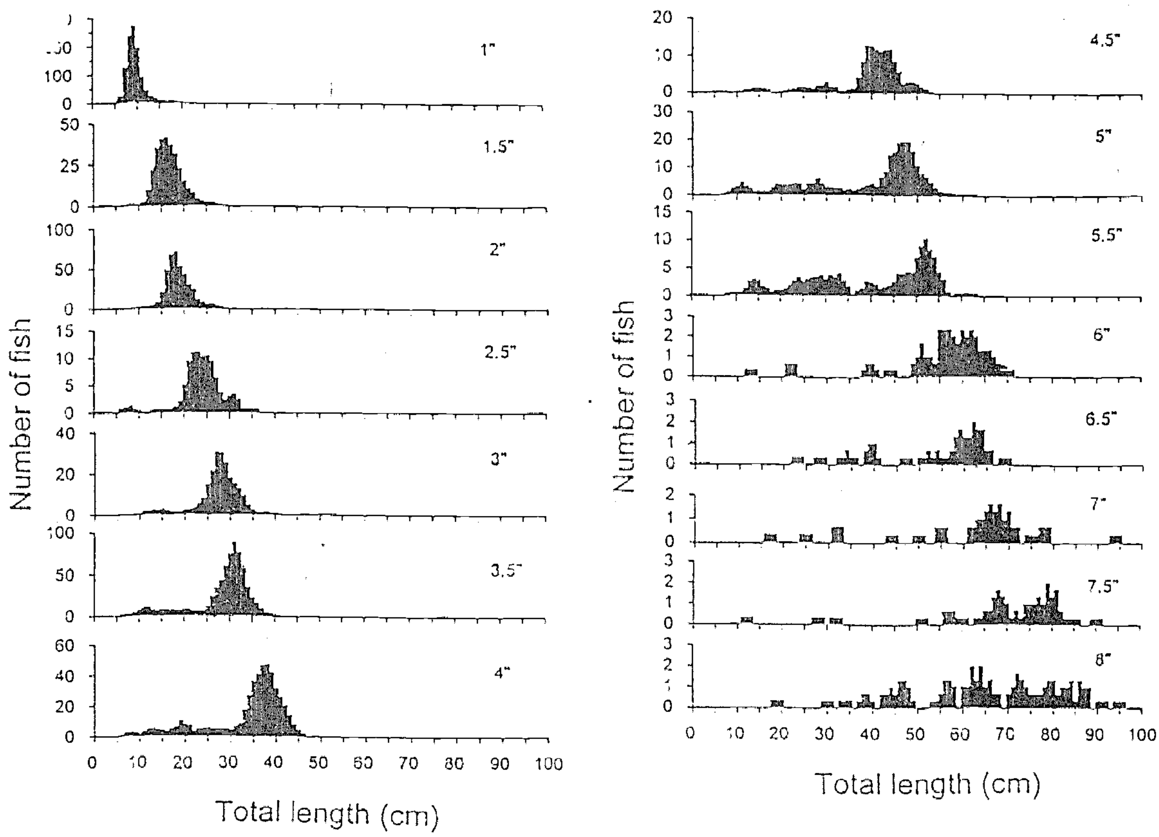

Figure 1. The length frequency distributions for Nile perch catches in Nyanza Gulf in experimental gillnets with 0.5" mesh increments.

Fleet design

The design of the fleets of nets was based on the fleets used in midwater in Lake Malawi by Allison *et al.* (1994). The fleets used in Lake Malawi were of monofilament, with six mesh sizes. They were not anchored because of the great depth of the lake. As Lake Victoria is shallower and depths to be fished do not exceed 60 m, it was possible to modify the fleets to set the nets at the required depths more accurately. This was achieved by anchoring the nets between fleets and by having intermediate floats to support net headropes at the chosen depths (Figure 5).

As recommended by Allison *et al.* (1994), the headrope is of eight-strand braided rope rather than three-stranded twisted rope, thus reducing twisting of the net. The footrope is lead-cored, of a total weight such that each net has slight negative buoyancy, which is countered by the intermediate floats to make each net fish at the required depth.

Each fleet has 10 panels, one of each selected mesh size, each 15 m long by 5 m deep. Collins Nets were able to match the specifications very closely, with only two minor differences, i.e. 64 mm instead of 60 mm and 144 mm instead of 157 mm mesh.

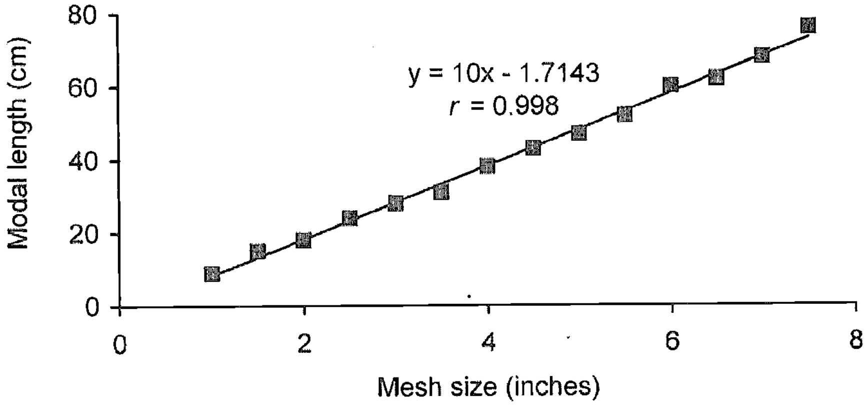

Figure 2. The relationship between the modal lengths for the length frequencies mesh size from Figure 1.

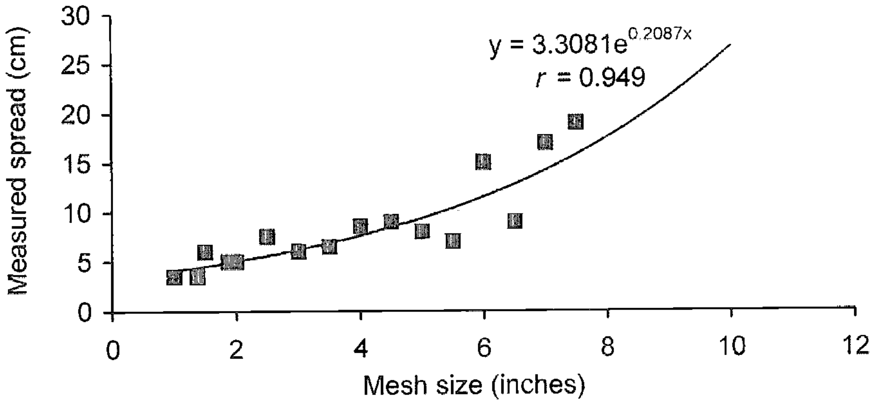

Figure 3. The relationship between the width of the main length frequency distribution (from lower 50% efficiency to upper 50% efficiency) and each mesh size used in the Nyanza Gulf experimental fleet.

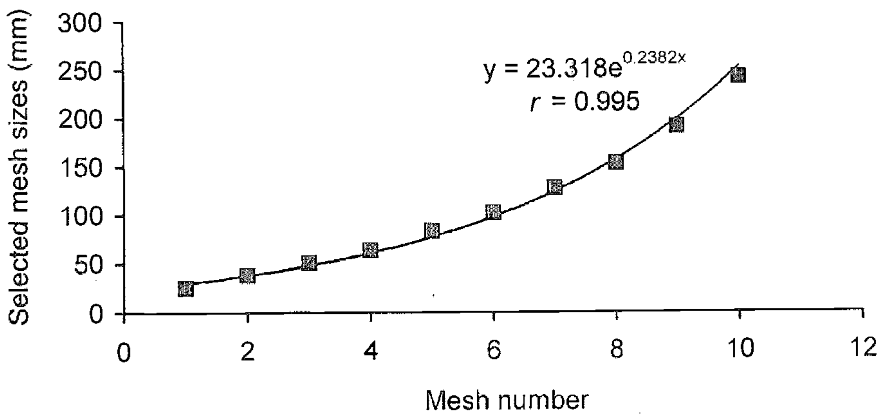

Figure 4. The mesh sizes chosen by eye based on the relationships in Figures 2 and 3, and the exponential relationship fitted to the data. The ten mesh sizes chosen were calculated using the equation shown on the graph.

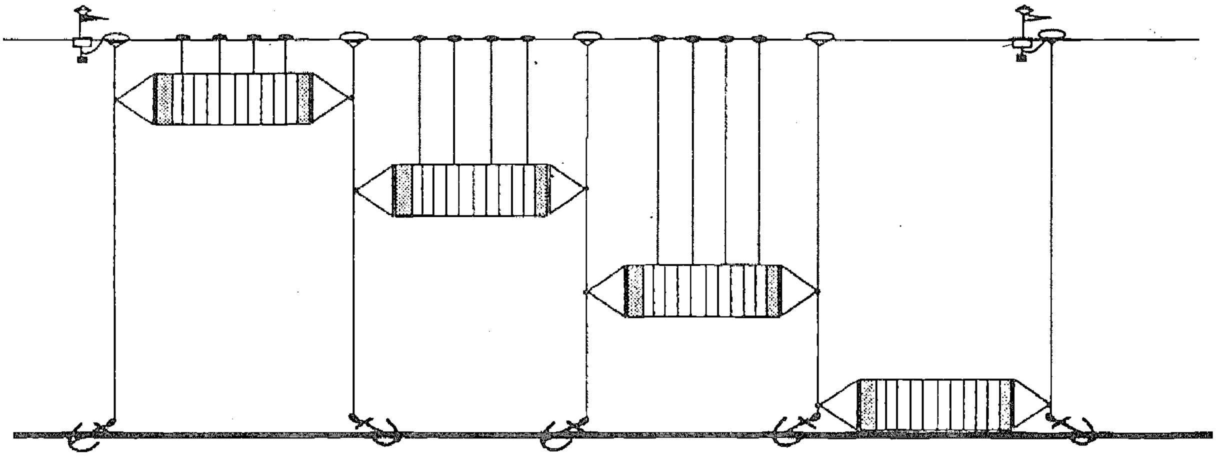

Figure 5. The system for setting the four fleets of nets at different depths in the lake.

While random positioning of mesh sizes in a fleet was used by Allison *et al.* (1994), setting the nets in order of mesh size greatly simplifies accurate recording of catches per net panel. The reduced risk of error in assigning catch to mesh size in experiments where 40 different samples may have to be recorded outweighs the benefits of random selection of mesh sizes. If, however, nets were to be set in areas where different biotopes occur in the sampling area, there would be a risk of bias, e.g. if the nets were set from the shoreline out to deeper water. In the trawl areas to be sampled in the project, relatively uniform conditions are anticipated for each set. To further reduce the risk of misrecording, nets were numbered from 1 (smallest mesh) to 10 (largest), with mesh size being added later at the data entry and analysis stage.

A further modification was the addition of 7.5 m of netting made of a different material at each end of each fleet. This eliminates the tendency of the ends of experimental nets to catch less well than the centre because of twisting or bunching caused by imperfect setting. Imperfections due to poor setting occur in the surplus netting added to the ends, the catches of which are discarded; this ensures that all the experimental nets have similar efficiencies. In the nets used in Lake Victoria, the surplus netting is of 75 mm stretched mesh, white multifilament nylon, cut and mounted to have the same fishing depth as the other net panels.

Gillnet trials

After two trials with single fleets in May, four fleets were set on three occasions and three fleets on one occasion in June 1999 (Table 1).

Table 1. Gillnetting trial research results.

A. The results of the three trials using four fleets

Fleet	Percentage of total catch by weight
Surface fleet	22.3
Upper midwater fleet	6.4
Lower midwater fleet	12.3
Bottom fleet	58.9

B. The results of the single trial using three fleets

Fleet	Percentage of total catch by weight
Surface fleet	12.6
Midwater fleet	7.7
Bottom fleet	79.7

Catches were consistently highest in the bottom-set fleet and lowest at intermediate levels. In the three four-fleet sets, almost the entire water column was fished as each fleet has a fishing depth of 5 m and the lake depth at each position ranged from 20 to 25 m. It follows that approximately 60% of the perch occupied the bottom 5 m, fish were relatively scarce in midwater but slightly more abundant near the surface.

The catches were dominated by Nile perch (Table 2), with the exception of the second trial set. The second trial was made with a single surface-set fleet close to shore in a bay and the catch was dominated by tilapiines. During the six trials, Nile perch made up 47.6 kg of the catch overall, *Oreochromis niloticus* (L.) 10.7 kg, *Oreochromis leucostictus* (Trewavas) 0.4 kg and *Synodontis afrofischeri* Hilgendorf and haplochromines 0.1 kg each.

Table 2. Catch rates for *L. niloticus* for each fleet in each set.

	Mesh size (mm	30	38	48	64	77	97	124	144	199	252
L. niloticus	kg per 100 m	1.0	1.9	4.3	2.2	4.8	2.6	1.0	0	0	0

Although data are limited, the length frequencies observed so far for the Nile perch catches in the six sets combining all meshes and depths suggest that the nets are effectively sampling the full size range of fish with the possible exception of larger specimens. Further sampling outside the area fished is needed to ascertain whether large fish are less vulnerable or simply absent from the area. Meshes 38 mm to 77 mm have so far recorded the largest catches by number and meshes 48 mm to 97 mm by weight.

Discussion

Preliminary trials with the gillnet fleets described here suggest that they will be useful in quantifying the distribution of Nile perch in the lake. Trials with the nets will address a number of problems in assessing perch distribution.

Vertical distribution

Nile perch are distributed throughout the water column. In the four sets so far which have covered surface, midwater and bottom, consistent results have been obtained suggesting 60% of the perch swim within 5 m of the lake bottom. A limited area of the lake adjacent to Jinja has been fished. With fleets now being set throughout the lake, a more comprehensive picture of depth distribution will be obtained.

Biomass estimation

Biomass cannot be assessed directly by gillnetting. Gillnets are passive gears and thus depend on fish swimming into them. They do not, therefore, sample a known area of the lake. Used in conjunction with other sampling methods, however, gillnet catches can be used to correct results from other sampling gears for bias. Trawling samples a known area of lake bottom and trawl catches are used to calculate biomass indices. By correlating trawl and gillnet cpues in the same areas, biomass estimates can be indirectly obtained from gillnet cpue data. If good correlation is obtained, gillnets can then be used to obtain biomass indices for areas which cannot be trawled, such as rocky areas.

Initial gillnetting targets trawl areas to obtain a correlation in results of the two sampling methods. Thereafter, gillnetting will be extended to untrawlable areas.

Biomass indices from trawling can also be corrected to allow for fish higher in the water column and thus missed by the trawl. The gillnets are 5 m deep while the trawl is estimated to have a 3 m headline height. This will be checked using a netsounder. Results from bottom set gillnets will be adjusted to compensate for the different fishing height.

Size distribution of catch

The nets have mesh sizes up to 252 mm to catch large Nile perch. The trials in the Jinja area did not, however, catch large perch. The area is very heavily fished commercially and few large perch are seen in the area. Trials in other areas where large perch still occur are necessary to assess whether the nets will achieve the aim of sampling the full size range of perch with similar efficiency.

The data used for the initial determination of mesh sizes were excellent for the smaller mesh sizes. In larger meshes, however, very few fish were caught and thus the estimates of size range caught were somewhat subjective. Pooling of catch data from the research programmes in each country later in the experimental programme will be necessary to determine how accurate the initial mesh selection was and to apply correction factors to the catch data.

Distribution of fish in relation to limnological parameters

Bottom trawling below 40 m in depth in Lake Victoria rarely yields fish, due to the oxycline which persists for most of the year (Bugenyi date) at 30 to 40 m depth. This oxycline can clearly be seen on the echosounder as a continuous scattering layer. Frame trawl sampling (Tweddle *et al.* 1999) and underwater video (L. Kaufman, pers. comm.) show this to be caused by concentrations of *Caridina nilotica* (Roux) and fine, flocculent sediment at the oxycline.

Setting the gillnets in such areas will indicate the concentrations of fish above the thermocline and allow for more accurate biomass indices for the lake as a whole.

Ease of use

The multimesh, multidepth gillnets are easy to set and to haul. During the initial trials, preparation of the nets on deck took 30 minutes and will become much less with practice. It is important to decide in advance the depths to be fished as the amount of anchor/buoy rope has to be fixed. The depth of the fleet ends is determined by the position of the plastic rings on the rope. Too much slack rope results in inaccurate depth setting. In practice, adjusting rope length to recorded depth plus 4 m of slack (the remainder is tied in a coil beside the anchor) has been found to allow good setting. The net between the anchor ropes is set at an accurate depth by using intermediate floats tied to the headline with ropes adjusted to the required headline depth.

Setting the nets with satisfactory tension needed some practice. With insufficient tension the nets sagged between the supporting buoys. Too much tension resulted in the main buoys being dragged underwater as two adjoining nets set at different depths pull sideways at different points on the common buoy/anchor rope, resulting in incorrect depth of the net ends. These problems were identified very quickly and adjustments were made to speed of setting and the amount of tension applied to the nets to obtain accurate sets.

Setting the four fleets took 20 minutes. Hauling took 45 minutes in normal weather conditions. Adverse weather such as strong winds can be handled because the speed of wind can be counteracted by use of the engine in reverse gear. With strong winds there is less risk of nets fouling the propeller. Sorting the catch and relaying the nets into the setting boxes took a variable amount of time depending on catch rates but was usually less than one hour.

With this time frame, gillnetting can be included in the bottom trawling research programme without compromising the trawl timetable. Preparation of the fleets in the evening before setting allows the nets to be set early in the morning, to be retrieved in the early evening after a full day's trawling.

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Figure captions

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Figure 2. The relationship between the modal lengths for the length frequencies for each size from Figure 1.

Figure 3. The relationship between the width of the main length frequency distribution (from lower 50% efficiency to upper 50% efficiency) and each mesh size used in the Nyanza Gulf experimental fleet.

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