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STANDARDIZATION OF FISHING GEARS USED FOR STOCK ASSESSMENT IN LAKE VICTORIA

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ABSTRACT

Designs and theoretical performance of bottom and pelagic trawls for fish stock assessment in Lake Victoria (East Africa) were studied in order to evaluate their present standardization. Three nations cooperate in assessing the fish stocks in Lake Victoria and standardization of gears and methods is of importance for reliable and consistent sampling. The trawl plans from the net manufacturers, together with the ones provided in the standard operating procedures (SOPs), were investigated by direct measurements and calculations. The trawl plans were re-drawn to scale, compared and their resistances in relation to the towing powers of the used research vessels evaluated. Comparison of the plan and rigging of two bottom trawl nets (the old one supplied in 1997 and the new one obtained in 2010), and two pelagic nets (old and new) were done. The two bottom trawls differed in the fore openings, twine area, belly size and sweep line lengths. Calculations showed that changes in these parameters resulted in changes in trawl resistance and the area swept. The old and new pelagic nets showed minimal difference in total resistance and can be towed at approximately 2 knots using the power of the current vessels. The lack of standardization reduces reliability in stock assessment surveys. In this project, I propose a guide to standardize the sampling gears for stock assessment in Lake Victoria.

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1 INTRODUCTION

1.1 Background

Accurate assessment of the size and state of the stocks exploited by fisheries is one of the pillars of modern fisheries management. Stock assessment involves evaluation and characterization of the magnitude of fishery dependent (catch and exploitation) and fishery independent (fish population) studies. One of the important technical aspects of fishery independent data collection for fish stock assessment is the sampling gear and the sampling method used. In many parts of the world, fisheries scientists and gear technologists pay little or no attention to standardization of the sampling gears in relation to target fish species' behaviour/reaction (Bonar and Hubert 2002). Fish reactions towards sampling gears vary by species, age and physical conditions (Ona and Godø 1990). In order to collect comparable data from a given stock, there is need to standardize the sampling gear.

1.2 Lake Victoria fishery

Before the introduction of Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*), Tilapia zillii, and *Oreochromis leocostictus*, the Lake Victoria fishery was dominated by the endemic fish species like *Haplochromine cichlids*, and two native tilapia species *Oreochromis esculentus* and *Oreochromis variabilis* (Graham 1929). These indigenous fish stocks were exploited at subsistence level using simple locally made crafts like dugout canoes that operated in the inshore shallow waters of the lake with seine nets of papyrus and reeds, basket traps, hooks and harpoons (Jackson 1971). These fishing methods had little impact on the fish stocks. At the beginning of the 20th century commercial exploitation started with the introduction of cotton flux gill nets in 1905 (Ogari 1988, Ogari and Asila 1990). Use of these gill nets was quickly adapted and adopted by the fishers throughout the whole lake and the native fishing methods died out (Jackson 1971). The commercial fishery was then boosted by the introduction of synthetic gill nets and fishing boats propelled by outboard engines. These developments coupled with the introduction of Nile perch, Nile tilapia and other tilapia species in the early 1960s led to many changes in Lake Victoria fish composition. Currently the commercially exploited fishes include introduced species (Nile tilapia 8%, Nile perch 40%) and indigenous Dagaa (*Rastrineobola argentea*) 41%, and are exploited by mainly gill nets and lampara nets respectively. In addition, the *Haplochromine sp.* hitherto diminished in the catches are now resurging and are targeted in an important lampara fishery in the southern part of the Lake (LVFO 2008).

1.3 Main target fish species

The main target fish species whose standing stocks are assessed using bottom or pelagic trawl nets are Nile perch, Nile tilapia and Haplochromine species. Nile perch (Figure 1) is a silver coloured fish belonging to family Centropomidea. Its length at 50% first maturity is 50 cm and 75 cm for male and female respectively (LVFO 2002). However, it has been reported to grow to over 190 cm in total length (TL) with over 200 kg body weight. Nile perch juveniles aggregate in the shallow areas of the lake (Asila and Ogari 1988, Ogutu-Ohwayo 1988), and spread to the open water as they grow. Ogari (1988) observed that Nile perch fish size tends to increase with increasing depth.

Figure 1: Adult Nile perch (*Lates niloticus*) (Source: National fisheries resources research institute).

Nile tilapia (Figure 2) belongs to the family cichlidae. It grows to maximum total length of 60 cm and maximum weight of 4 - 5 kg. Length at first maturity is reported to be on average 18.6 cm, ranging from 8-28 cm (Greenwood 1960). Field trawl survey data of the National Fisheries Resources Research Institute (NaFIRRI) show maximum TL of 60 cm and maximum weight of 5.0 kg for the period 1990 to 2009. Nile tilapia is a bentho-pelagic fish and mostly inhabits shallow inshore areas of 5-10 m depth.

Figure 2: Adult Nile tilapia (*Oreochromis niloticus*) (Source: Fishbase).

The haplochromines in Lake Victoria are of several species (close to 200) and are locally known as nkejje. They belong to the family of cichlids. They are endemic to eastern and southern Africa. In Lake Victoria, they are found inhabiting both shallow and deeper waters. The maximum total length for most of the species range from 6-12 cm (Greenwood 1960). They are typically brightly coloured with distinct egg spots on the anal fin (Figure 3)

Figure 3: One of the Haplochromine species found in Lake Victoria (Source: Fishbase).

1.4 Fish stock assessment in Lake Victoria.

In Lake Victoria, gillnets were the first gears to be used for experimental studies like selectivity and stock size estimation, when there were signs that the commercially important fish of the lake were being overfished (Graham 1929, Ogutu-Ohwayo 1988). The outcome of the gill net studies resulted in recommendation to use gill nets of stretched mesh size above 5 inches. However, the tilapia fishery collapsed when the mesh size restriction was removed and fishers resorted to using gill nets of less than 5 inches that cropped immature fish (LVFO 2005). The haplochromines became the dominant fish species after the collapse of the indigenous tilapia fishery. Following the domination of the lake by haplochromines, bottom trawl surveys were conducted covering the whole of Lake Victoria starting in 1968. These surveys were coordinated by the United Nations Development Program (UNDP), in co-operation with the East African Community (EAC), through the East African Fresh Water Fisheries Research Organisation (EAFFRO). A stern trawler (RV. Ibis) mounted with a trawl net of cod-end mesh sizes of 2.5”- 3.25” and towing speed of 2.5 knots was used. The otter boards used were of the V-type (Kudhongania and Cordone 1974). The bottom trawl surveys were a means to ascertain the relative abundance and distribution of the major fish stocks and evaluate the appropriate technique for commercial exploitation of the then dominant haplochromines. It was observed that 18% of the fish stocks were haplochromines, which could be exploited using trawl nets (Kudhongania and Cordone 1974). In the early 1970s bottom trawling was initiated to explore haplochromines in the Tanzanian part of Lake Victoria, but before it was adopted on the entire lake, the Nile perch that had been introduced in the lake in the late 1950s and early 1960s had already spread around the lake and therefore swatted the efforts (Kudhongania and Cordone 1974, Okaronon *et al*. 1985, Witte and van Oijen 1985).

The 3rd subsequent lake-wide stock assessment, based on bottom trawl surveys, under the first phase of the Lake Victoria Fisheries Research Project (LVFRP 1992 – 1997) used cod-end meshes of 1” and V-shaped otter boards. Towing speed was 3 knots. Later, between 1997 to 2000, under the Lake Victoria Fisheries Research Project (LVFRP II), acoustic equipment was introduced to re-enforce the trawl surveys in the three East African states Uganda, Kenya and Tanzania. In 2010, Kenya and Uganda each received a new 250 hp trawler equipped with bottom and pelagic trawl for stock assessment. The new trawls were manufactured using old trawls as prototypes. Tanzania on the other hand continued to use the old ones.

In East Africa, not much is written on the technical aspects of fishing gear standardization for fish stock assessment. For Lake Victoria, there is a section guide included in the standard operating procedure (SOP) of Lake Victoria Fisheries Organization (LVFO 2005). The fishing gears that are currently used for stock assessment in Lake Victoria are gill nets, bottom trawl nets, and the recently introduced pelagic trawl nets. Gillnets are among the passive gears that are recommended for stock assessment surveys, especially in freshwater, shallow or rocky areas that cannot be accessed by trawlers. They are also technically simple, easy to mend and require little in the way of equipment on board the vessels used (Hovgard and Lassen 2000). Gillnets are passive gears and their energy consumption is generally low, implying an environmental advantage compared to the more energy consuming fisheries using towed gears (Gabriel *et al.* 2005). However, significant environmental problems are found in some fisheries due to ghost fishing especially in monofilament gill nets. Trawls are recommended for stock assessment, as they can catch large quantities of fish, which are good sample representatives of the fish stock (Gabriel *et al.* 2005). In fish sampling, the following should be standardized: gear type, design, size, colour, material, duration of fishing and handling of the gear. Net colour seems important in fish getting caught; previous studies reported that fish are able to distinguish colours and lights at various intensities (Brown 1937, Hurst 1953). Jester (1973) reported that catostomids and carps were caught in higher numbers in brown nets while game fish catches were higher in white nets.

1.5 General description of bottom and pelagic trawls

Bottom trawls are active gears operated in the fisheries for bottom fish or at least near-bottom fish (Gabriel *et al.* 2005). A typical bottom trawl (Figure 4) is made of net panels joined to make wings, squares, cone shaped bellies and a pocket called cod-end that are funnel shaped with the head rope being shorter than the fishing line.

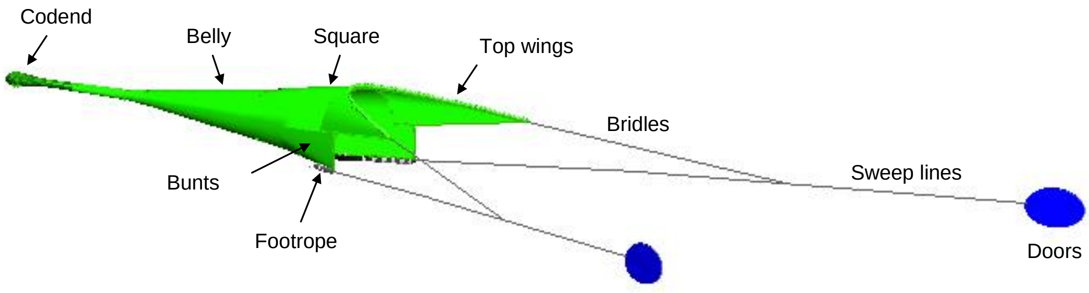


Figure 4: General structure of a bottom trawl.

A typical mid-water trawl (Figure 5) is designed to be towed mid-water for catching pelagic species. The mid-water trawls were developed in the early 1950s as a result of invention of fish detecting devices such as echo sounders. It was later improved by the invention of the net recorder (Gabriel *et al.* 2005). The vertical opening and position of the gear could be shown at the bridge and therefore any disarrangements of the net could be immediately detected (Scharfe 1960)

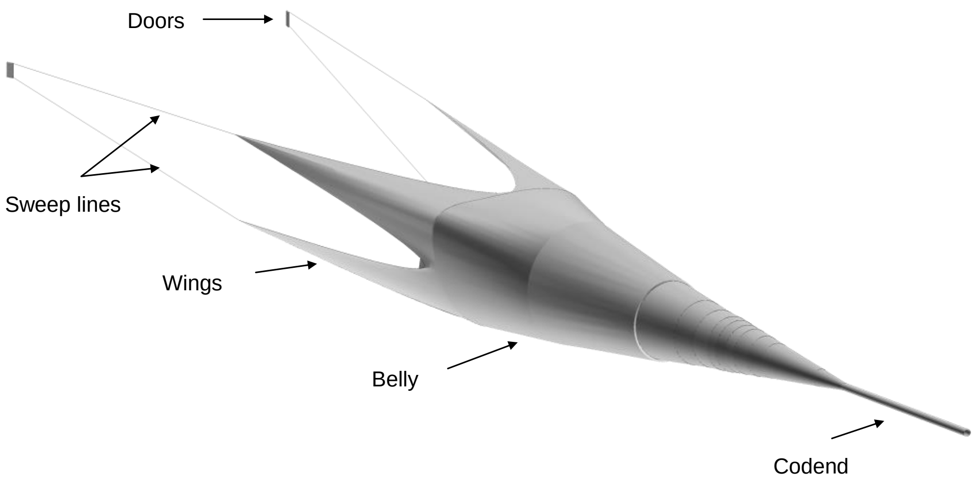


Figure 5: General structure of a pelagic trawl.

1.6 Statement of the problem

According to Lake Victoria Fisheries Organization (LVFO) stock assessment SOPs, surveys in Lake Victoria are conducted at the same time, but separately by the three member states. Each country uses a standardized bottom trawl net and rigging. However, there is a likelihood that gear standardization could have derailed gradually due to separate repairs carried out from time to time. Different net makers supply additional trawl nets, yet there are no regular joint inspections, let alone manual/hand book to guide the fisheries scientists and fishing gear technologist, to ensure sampling gear standardization. Tanzania uses the old set of bottom and pelagic trawls, while Kenya and Uganda are now using new sets supplied along with new vessels.

At present the three East African member states have two stock assessment working groups, the bottom trawl and acoustic survey groups each. The two groups have separately cited a gap in mid-water column sampling (LVFO 2007). There is therefore a need to use gillnets or pelagic trawls for mid-water sampling. Large adult Nile perch are underrepresented in stock assessment samples compared to the commercial catches, suggesting that they either avoid gears or swim faster than the towing speed of the trawl (LVFO 2005).

1.7 Scope of the study

The study was designed to investigate the current status of the fishing gears used for stock assessment in Lake Victoria. The study evaluated the fishing gear drawings available in the current guide and the SOPs, and looked into possible effects of subsequent repairs and changes made on the gears. Deficiencies were pointed out and possible improvements suggested.

1.8 Overall objectives

The purpose of this study was to come up with detailed, but simple manual on standardization of fishing gears used in Lake Victoria for fish stock assessment. To achieve the objectives, the following tasks were carried out:

- Take measurements of the current and previous trawl gears, analyse the data in relation to vessel characteristics and their towing powers.
- Re-draw diagrams/plans of the current bottom and mid water sampling trawls used in Lake Victoria.
- Study the gear standards used by other nations for stock size assessment.
- Prepare a manual for standardised sampling gear.

2 MATERIALS AND METHODS

2.1 Study area

Lake Victoria (Figure 6) is the largest fresh water lake in the tropics with surface area of 68,680 km^2, mean depth of 40 m, maximum depth of 80 m, and located 1,134 m above sea level (World Atlas 2010). The lakebed is mostly covered by mud and sand, (hard and soft ground), it is characterised by numerous islands mostly at the north-eastern part (Uganda side). Many fishing villages are found on these islands and along the periphery of the lake. The fishers mostly use gillnets, hooks and beach seines. There are over 25 fish export processing factories around the lake that have increased the demand for fish.

Figure 6: Map of Lake Victoria (Source: World Atlas 2010).

2.2 Methods

The information involving the technical aspects of the current fishing gears was mainly based on reviewing documents and specific measurements from the trawl nets and research vessels, guided by a predesigned data collection form. Calculations and formulae by Fridman (1986) were used to verify, cutting ratios, cutting combinations, net area, net resistance and vessel´s towing power.

Design CAD V21 computer-drawing software from IMSI design was used for drawing bottom and pelagic trawls. The following calculations were done to describe the trawl nets:
Sinking force of trawl components (P) was calculated using:

$$P = A \times \{1\text{-}DW/DM\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(i) (Fridman 1986)}$$

where:

P = Weight (Kg) of the object in water.
A = Weight (Kg) of the object in air.
DW = density (Kg/cc) of fresh water.
DM = density (Kg/cc) of the material in question.

The mesh sizes for each panel were determined by measuring 10 stretched meshes from knot to knot and average mesh size computed for each panel. The cutting ratios and cutting combinations used for tapering the different panels of both bottom and pelagic were determined in two ways; by physical observation and using:

$$R = MT/MN \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(ii)}$$

where:

R = cutting ratio (taper ratio).
MT = total number of twine wise meshes (Ts) lost/gained.
MN = total number of nominal meshes (Ns) in the section.

Cutting combination is a regular, repeated cycle of B-cuts and N-cuts or B-cuts and T-cuts (Figure 7), made in the netting to produce the required shape of net web piece. The formula below was used:

$$Y = M\text{-}m/2m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(iii)}$$

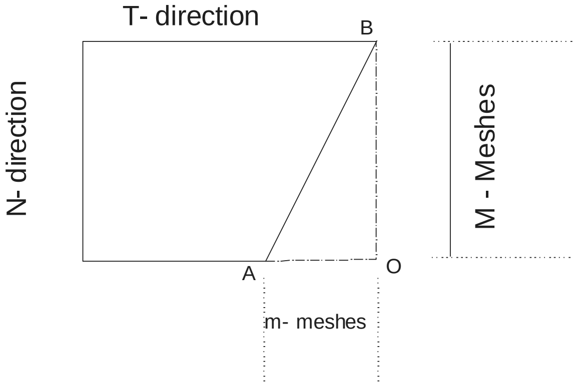
where:

Y = the cutting combination.
M = the higher number of meshes (Ns or Ts) to be cut.
m = the lower number of meshes to be cut.

Example: If a triangle has 50 Ns (O – B on Figure 7) and 10 Ts (A – O) then the cutting combination will be:

$$Y = 50 - 10 / 2 \times 10 = 40 / 20 = 4/2 = 2/1, \text{ that is 2N-1B}$$

Illustration



$$\text{Cutting combination along AB} = \frac{\text{OB - AO (meshes)}}{\text{2AO (meshes)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(iv)}$$

Figure 7: Illustration on how cutting combinations were obtained.

Hanging ratio is the length of mounting rope divided by stretched length of the netting mounted on that rope:

$$U = L/LO \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(iv)}$$

where:

U = hanging ratio.
L = line length that the net is to be mounted.
LO = stretched net length (number of meshes × mesh size).

The hanging ratio on the wings depends on the cutting combinations used when tailoring it. However, most of them were B-cuts, which determined the LO.

Netting twine diameters were measured using vernier calipers and to ensure consistency figures given in denier system by the manufacturer were converted to millimetres.

The diameters of twines were also determined by Prado (1990) method by first winding the twine 20 times on a pencil then dividing its length in millimetres by number of turns (Figure 8).

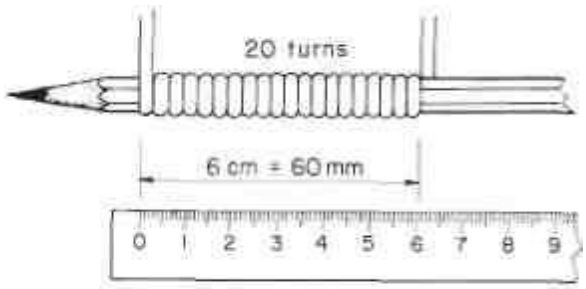


Figure 8: Determining twine diameter (Source: Prado 1990).

The twine surface area has influence on the drag of the trawl. The calculations of twine surface area was done for both the bottom and pelagic trawls using the formula given in equation (v).

$$A = (N + M)/2 \times H \times 4 \times a \times d \times 10\text{-}6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(v)}$$

Where:

A = the surface area of the twine in square metres.
N = the number of meshes across the top part of the panel (number of transverse meshes).
M = the number of meshes across the bottom part of the panel.
H = the panel length in number of meshes.
a = the bar length in millimetres.
d = the twine diameter in millimetres.

The diameter of the trawl mouth (d) is approximated by assuming the foremost part of the belly, towards the square and bunt, to be circular i.e. dividing the estimated circumference by □.

d = (total number of meshes making the top belly × mesh size × hanging ratio of 0.5) / □ ……………………………………………………………… (vi)

Netting resistance was determined using:

$RN = Cx \times q \times A$……………………………………………………..(vii) (Fridman 1986)

where:

A = twine area.
RN = netting restistancer.
Cx = hydrodynamic drag force coefficient (depending on angle of incidence, Figure 9).
q = hydrodynamic stagnation pressure =ɩv2/2.
ɩ = 100 (mass density of fresh water)
v = velocity of gear relative to the water

Angle of incidence (angle of attack) of trawl netting is the angle at which the trawl net is oriented to the water flow. This angle affects the lift and drag coefficients (Figure 9). It was approximated by considering the cone shape of the belly, right from the bigger upper most part downward to the last smallest part attached to the cod-end, as illustrated in Figure 10.

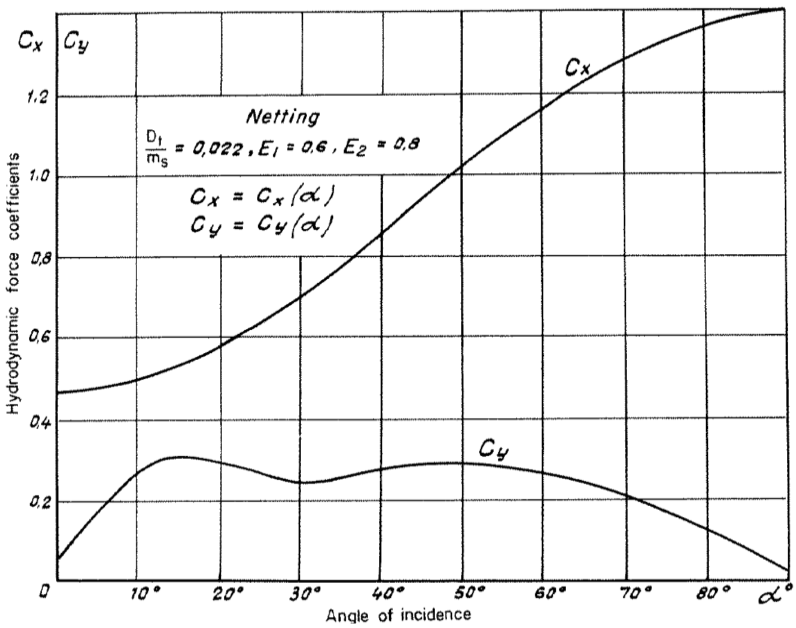


Figure 9: Hydrodynamic drag force (Cx) as a function of angle of incidence (Fridman 1986: p.55).

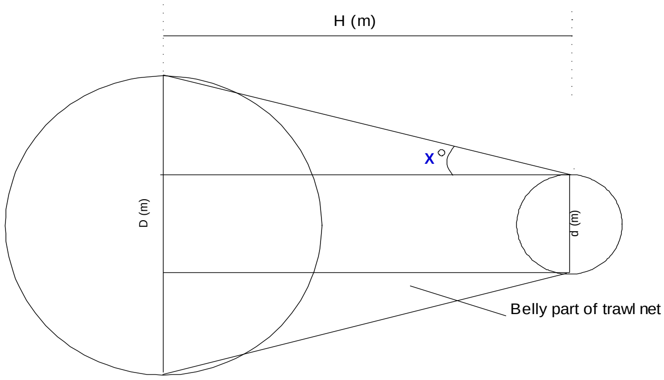


Figure 10: Estimation of the angle of incidence for twine netting.

By using the diameters D and d (Figure 9) and applying trigonometric ratios:

$$\tan(x) = (D - d) / (2 \times H) \quad \text{(viii)}$$

where:

x = angle of attack of the trawl net
D = the diameter of the wider part of the belly
d = the diameter of the narrower part of the belly
H = the length of the cone between basis

the hydrodynamic drag force coefficient of the net was obtained as a function of angle of incidence (Figure 9).

Hydrodynamic drag force on fishing lines, ropes and trawl auxiliaries (floats, otter boards) were obtained using the following:

$$Rx = Cx \times L \times D \times q \quad \text{...} \quad \text{(ix)}$$

where:

Rx = resistance of the rope.
Cx = drag coefficient (obtained from angle of attack)
L = length of the rope/fishing line
D = diameter of the fishing line
q = hydrodynamic stagnation pressure

The resistances of individual floats were obtained using formula (vii) above, and taking Cx = 0.5 (Fridman 1986 p. 66).

The sweep line angle of incidence is important for determining individual warp drag coefficient. It was assumed that: (a) the distance between the trawl doors is approximately the same as sweep line length, (b) the distance between the wing ends is half the length of the headline. The sweep line and headline were then drawn to scale (Figure 11) using CAD v 21-design program, and the angle of incidence ʎ (RST) was determined.

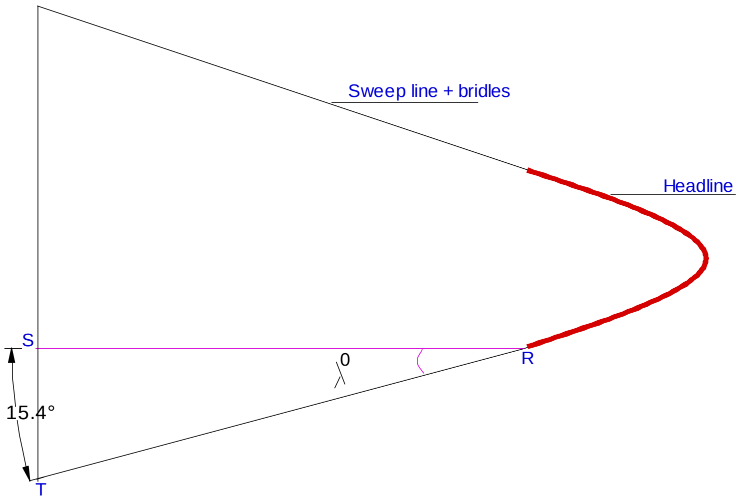


Figure 11: Shows angle of incidence (ʎ) of trawl warp.

Optimal angle of incidence for a V shaped otter board was considered in determining the drag coefficient (Fridman 1986 p. 67).

The vessel´s towing power was calculated using the formula.

$$P \times (kf - 0.7 \times V) \quad \text{...} \quad \text{(x) (Fridman 1986)}$$

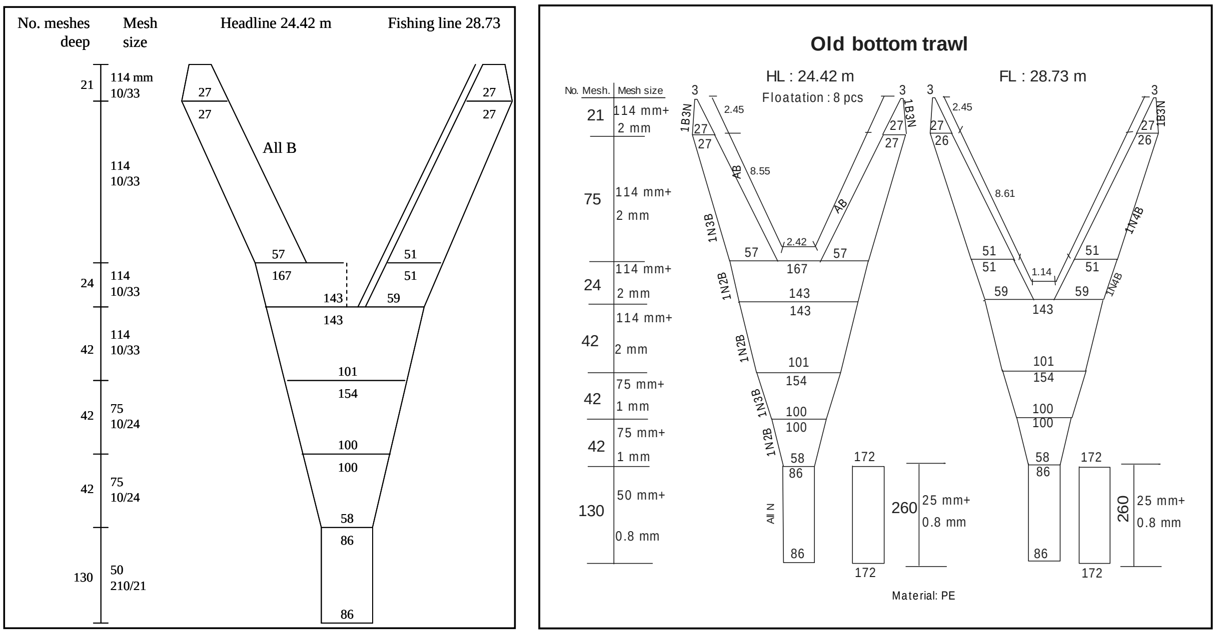
where:

Ft = towing force
P = horse power of the vessel engine
Kf = coefficient = 10 (for fixed propeller design)
V = towing speed of the vessel.

3 RESULTS

3.1 Old bottom trawl

The old bottom trawl as given in the LVFO SOP and the one re-drawn to scale in this study, are shown in Figure 12a and b. The redrawn plan indicates both the upper and lower panels drawn side by side. It gives details of the parts making up the panels (cutting combinations, mesh number and sizes, and material the trawl is made of). In addition, it gives the details of the headline and fishing line. The number and size of floats are also given. These details were not clear in the old plan.

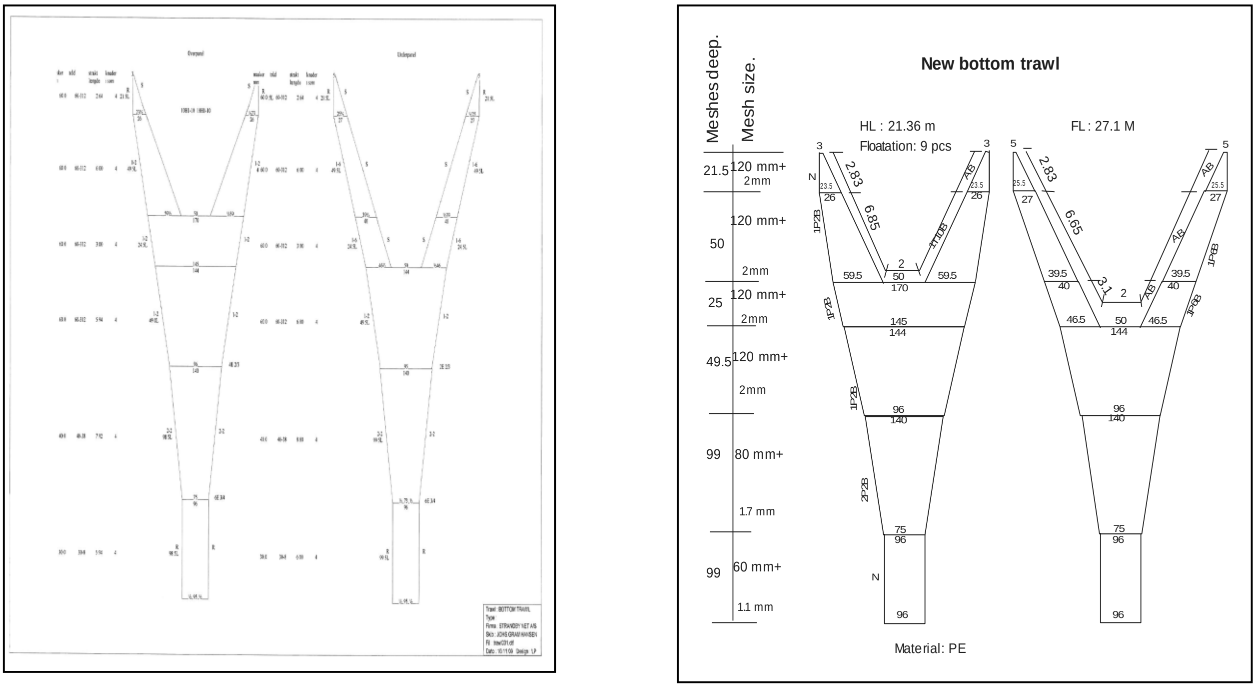


(a) (b)

Figure 12: Old bottom trawl plan (a) and its re-drawn plan (b). Enlarged drawings are provided in Appendix 1 and 2.

3.2 New bottom trawl

Figure 13 shows the new bottom trawl as provided by the Danish manufacturer (Strandby net loft) (Figure 13a) and the one re-drawn to scale in the present study (Figure 13b). Whereas both plans show both the upper and lower panels drawn side by side, the one supplied by the manufacturer was faint and generally not drawn to scale. In addition, it lacked information on the headline and fishing line. The number and size of floats were also not given, as is the case in the redrawn plan. The manufacturer's plan lacks information on the type of net material used. All these details were made clearer in the re-drawn plan (Appendix 3 and 4).



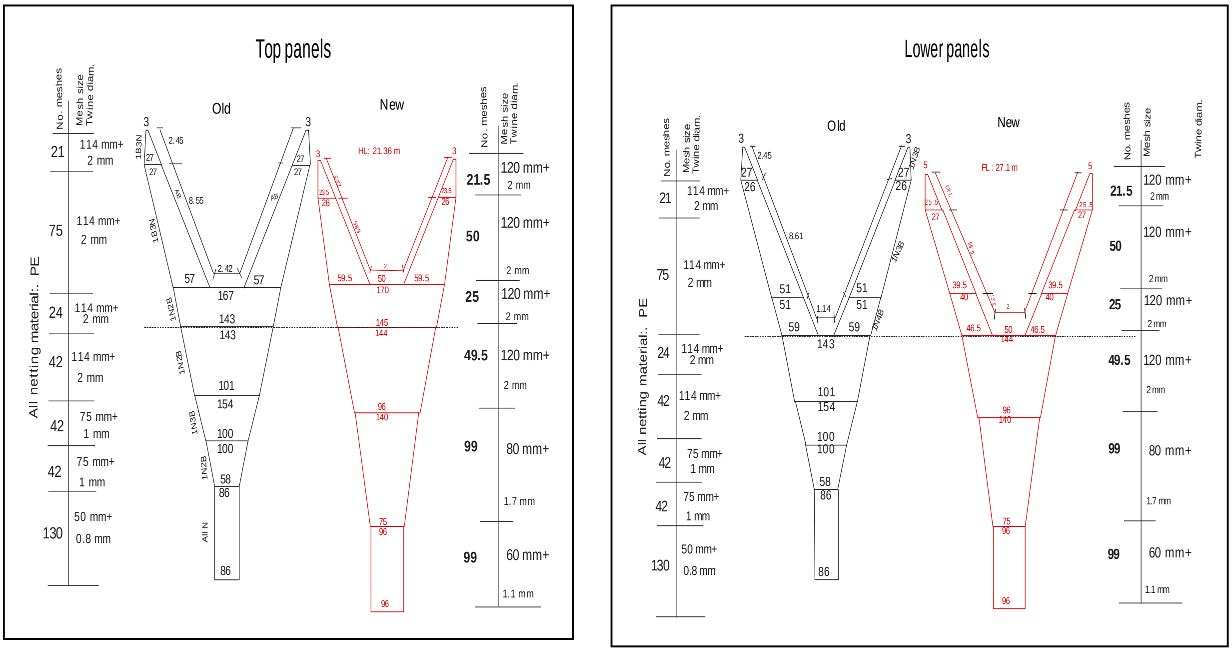
(a) (b)

Figure 13: New bottom trawl plan from the manufacturer (a) and its re-drawn plan (b), enlarged drawings are given in Appendix 3 and 4 respectively.

3.3 Comparison of the re-drawn old bottom trawl and the new one

Aligning the top panels through the top most part of the belly revealed that the belly of the new net was longer than that of the old one by 2.77 m (Figure 14). The belly was also wider by 1.36 m at the top and 1.65 m at the bottom, the wings were shorter by 2.37 m, and the meshes bigger compared to the older. In addition, the new net had more meshes at the square (170 meshes of 120 mm external stretched mesh size compared to 167 meshes of 114 mm). The new net had a shorter headline, 21.36 m as compared with 24.42 m in the old net.

The new net was generally larger than the old net, but the proportion between the lower and upper panels were similar for both nets. However, the fishing line and the headline of the new net were smaller than the old net. The fishing line for the new net was 27.1 m, while that of the old net was 28.73 m.



(a) (b)

Figure 14: Comparison of the re-drawn top panels (a) and lower panels (b) of the new and old bottom trawls.

3.4 Comparison of both old and new bottom trawl riggings

The rigging plan of the two bottom trawl nets (old and new) is provided in Figure 15. The bridles of the old net were 20 m while those of the new net were 15 m long. The sweep line of the old net was 15 m and that of the new was 60 m, giving a difference of 45 m.

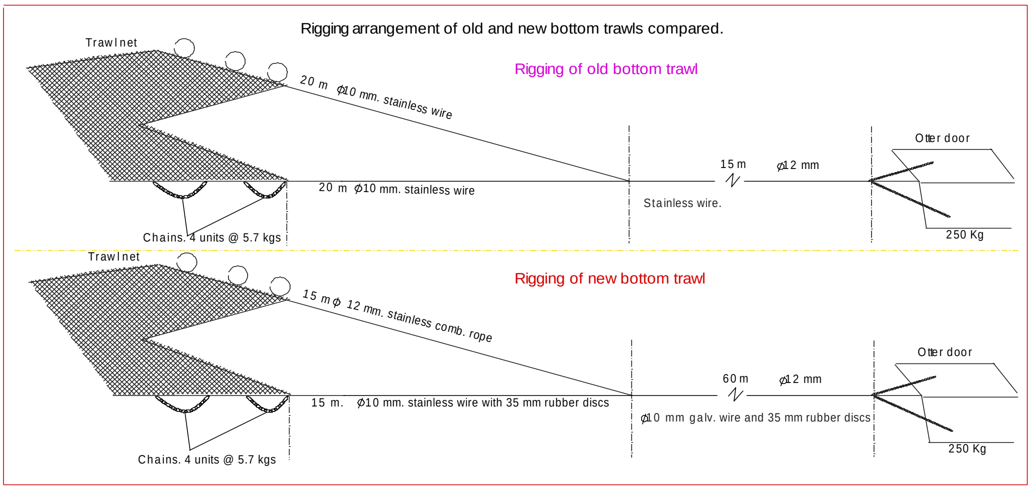


Figure 15: Comparison of the rigging of the old and new bottom trawls.

3.5 Towing power and gear resistance

A plot of towing power (kg-force) of the two research vessels, RV Ibis (Appendix 5) and MV Hammerkop (Appendix 6) against towing speed (knots) illustrates the trend in net resistance with trawling speed (Figure 16). From the graph the estimated resistance indicate that the maximum towing speed of the RV Ibis pulling the old and new net was 3.6 and 3.4 knots respectively. While the maximum towing speed of MV Hammerkop pulling old and new net was 3.8 and 3.6 knots respectively. The graph (Figure 16) is based on calculation provided in Appendix 7.

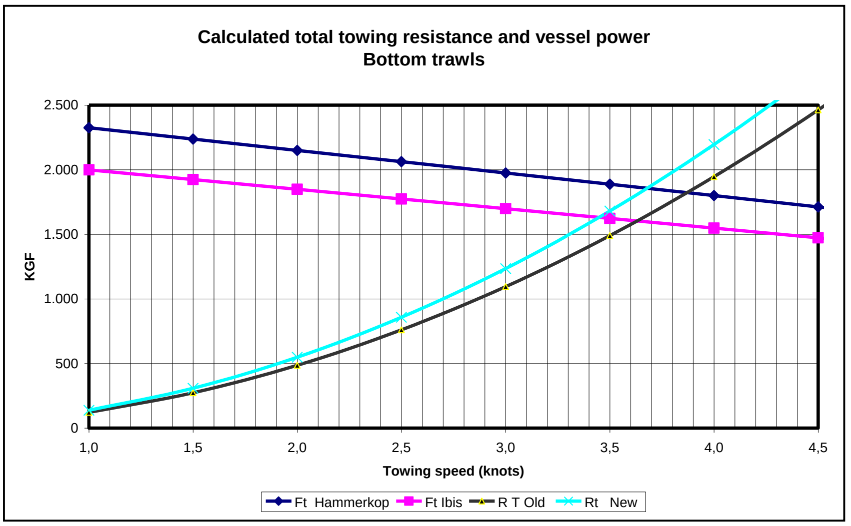
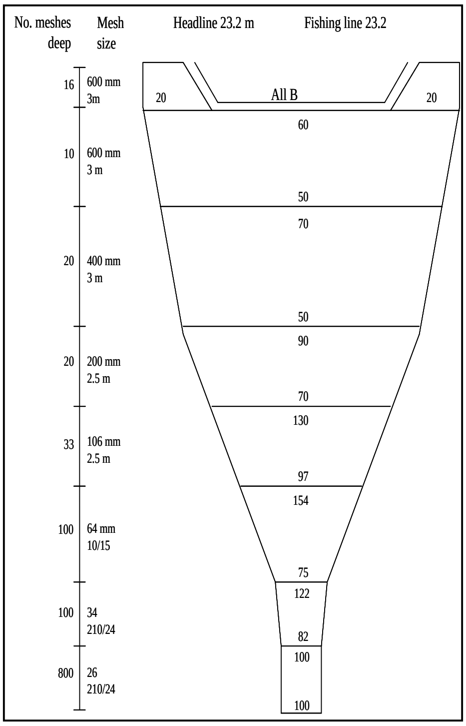


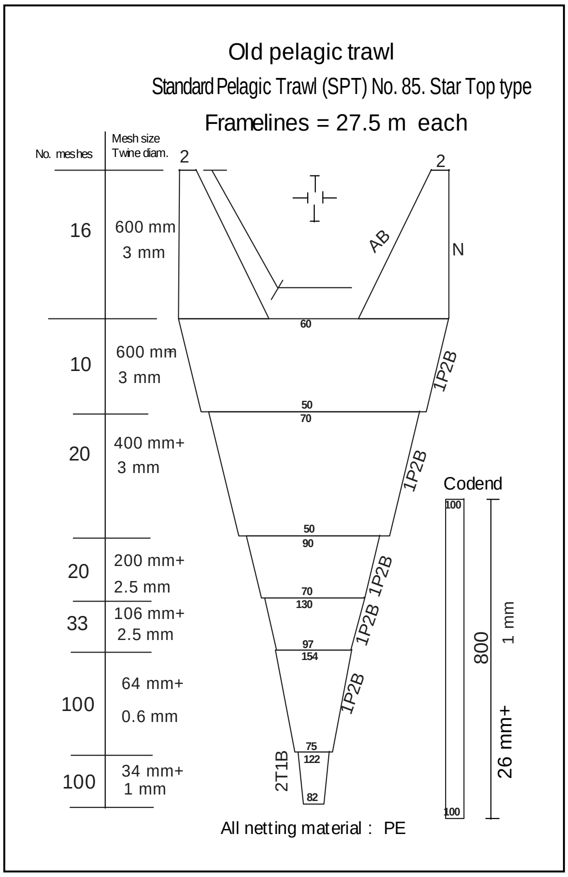
Figure 16: Towing force of the two research vessels (RV Ibis and MV Hammerkop) kg force (vertical) and towing speed (knots) horizontal.

3.6 The old pelagic trawl from the SOP

The drawings of the old pelagic trawl plan from the SOP and a re-drawn plan are given in Figure 17. The old plan (Figure17a) lacked cutting combinations for parts making the panels and were not drawn to scale. In addition the number of panels is not reflected in the drawing. The re-drawn plan (Figure 17b) shows all these details. The enlarged drawings are given as Appendix 8 and 9.



(a)

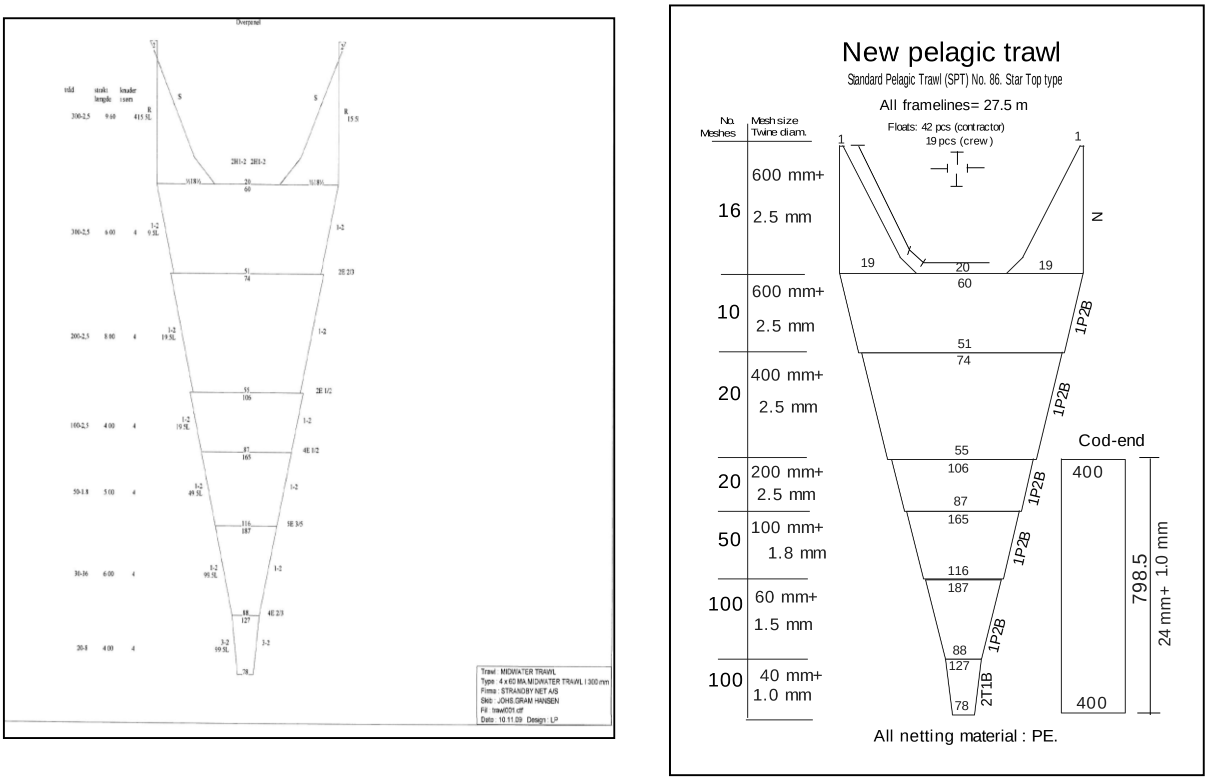


(b)

Figure 17: The drawing of the old pelagic net provided in the SOP (a) and the plan of the old pelagic trawl re-drawn in the course of this study (b).

3.7 The new pelagic trawl drawing from the Manufacturer

The drawings of the new pelagic trawl as provided by the manufacturer (Strandby net loft) and the re-drawn plan in the current study, are provided in Figure 18. The plan provided by the manufacturer (Figure 18a) was not drawn to scale, lacked the cod-end, the material used was not indicated, details of the frame lines were lacking, and above all it did not reflect the number of panels. All these lacking specifications on the manufacturers drawing have been indicated in the re-drawn plan on the left (Figure 18b). Enlarged drawings are provided as Appendix 10 and 11.



(a) (b)

Figure 18: The drawing of the new pelagic trawl net supplied by the manufacture (a) and the new pelagic trawl as re-drawn in the course of this study (b).

3.8 The re-drawn old and new pelagic trawls compared

A comparison of the re-drawn plans of the old and the new pelagic trawl nets is provided in Figure 19. New pelagic net was slightly longer due to a slight difference in the number of meshes in 3rd segment of the belly and the different mesh size in the 5th segment. In the new net there was re-enforcement reflected at corners where the wings connect to the bosom.

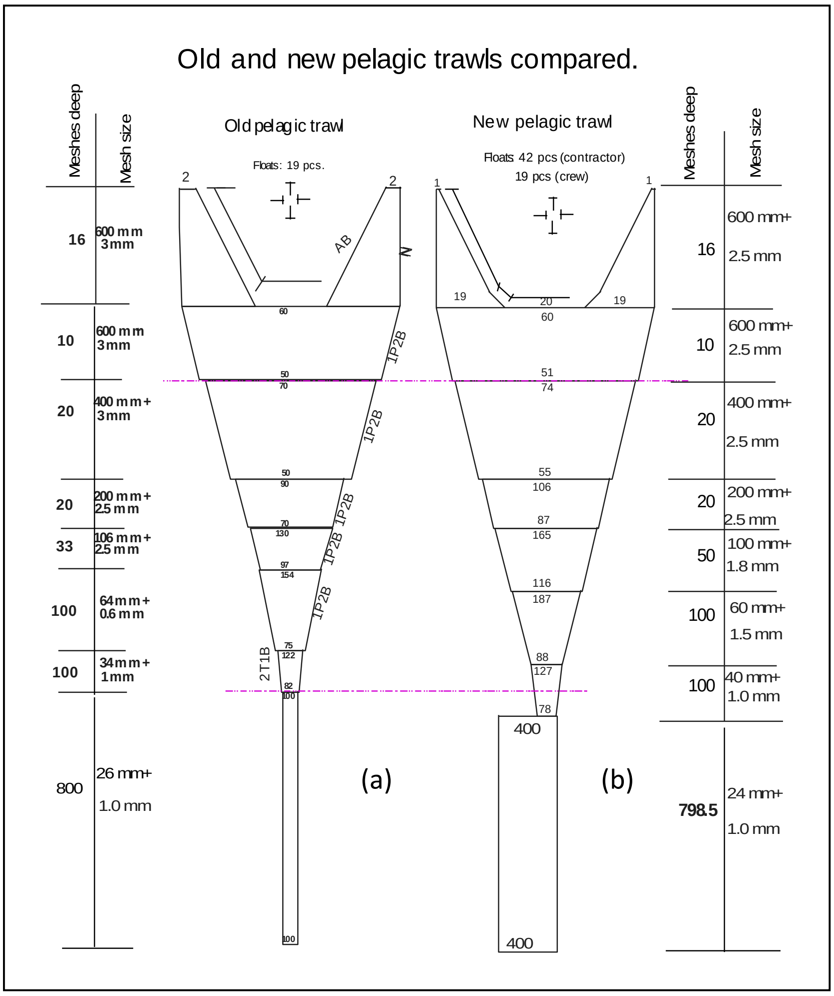


Figure 19: Comparison of the re-drawn plans of the old (a) and new (b) pelagic trawl nets. The cod end drawing plans have been illustrated to show 100 meshes for one of the 4 panels (a) and 400 meshes for all the four panels (b). The two cod ends have exactly the same number of meshes in all the four panels.

3.9 The rigging of the old and new pelagic nets

The rigging of the new and old pelagic net is provided in Figure 20. The rigging of the two nets was exactly the same.

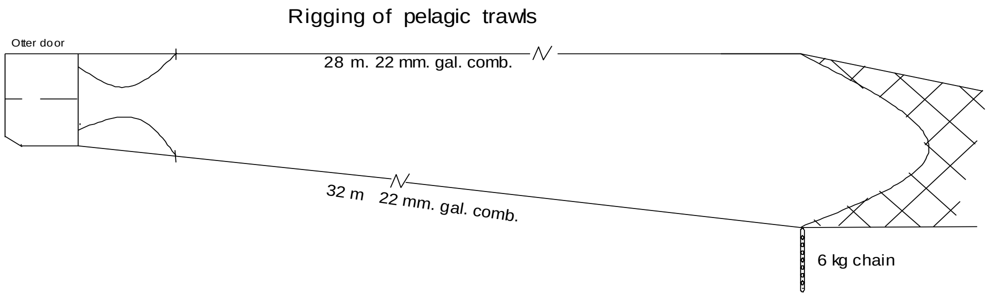


Figure 20: Comparison of the rigging of the old and new pelagic trawls nets.

3.10 Towing force of research vessels and the total resistances of the pelagic trawl nets

The total resistances of each net and towing power of each vessel were obtained using equations: (v), (vi), (vii), (ix) and (x), and by modelling in Excel (see Appendix 7ii). The calculated resistance of the new pelagic trawls was similar at lower towing speeds, but the resistances of the new nets increase more as the speed increases (Figure 21). The calculated towing force of the Hammerkop was greater than for the Ibis. The maximum towing speed of the Hammerkop was 2.2 knots for the old net and slightly lower for the new one (Figure 21).

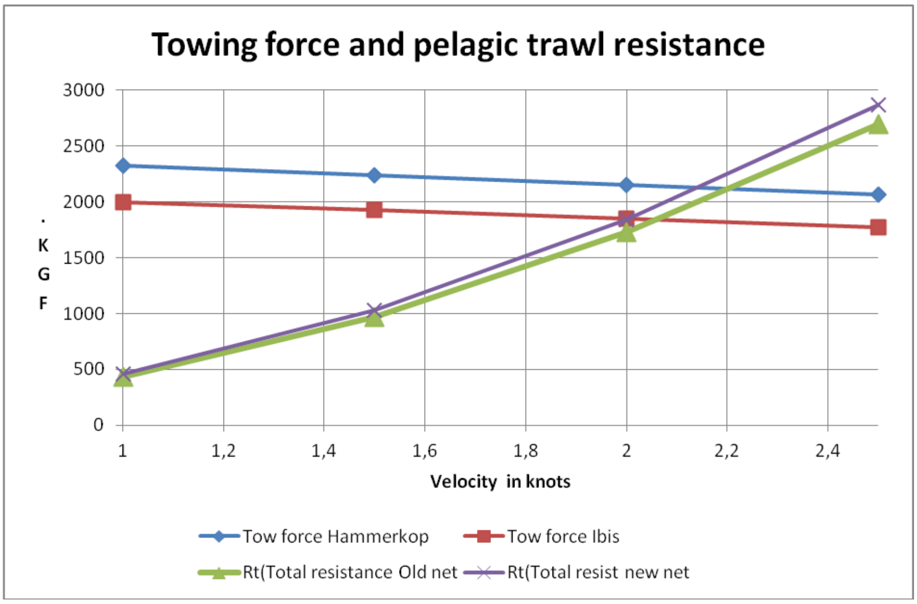


Figure 21: Relation between towing power and pelagic trawl resistances.

4 DISCUSSION

The findings from this study have shown that despite the attempts by regional scientists to conduct inter-calibration experiments on the bottom trawl gears in 1999 (LVFRP II), the current gears used are no longer standardized. There is a difference in the net drawings as provided in the SOP and the actual measurements of the nets used. This could be because of repairs on the nets done during surveys. The drawings provided were made at the start of a funding intervention (LVFRP II project, 1997 - 2002) during which the nets were standardized and appropriate towing speed adopted. Later on various modifications were made as and when necessary resulting in changes in the materials added and riggings. It was not until the inauguration of Implementation of Fisheries Management Plan (IFMP) that a documented manual plan was made and put into the SOP. However, reference to these documents and standards remains at the discretion of the responsible scientists and gear technologists/skippers. There has not been any effort to conduct joint checks on the status and performance of the sampling gears, which further leads to uncertainty.

The results given in this report further show a difference between the old and new trawl nets. Despite the fact that the manufacturer was given the initial drawings provided in the SOP (Figure 12a), the new net (Figure 13a) is different in many aspects. There was increase in the number and size of meshes used resulting in increased mouth opening from the initial 5 m diameter in the old net to 5.5 meters in the new one. Increasing mesh size would mean decrease in resistance, but in this case the number of the meshes was also increased, and this led to a general increase in net area and therefore resistance of the new trawl net. The implication is that the sampling efficiency of the two nets will differ. This in turn translates in the differences in standing stock estimates based on the two sampling gears. Interestingly, one of the reasons biologists have resisted modification of fishing gears is loss of historical trends (Bonar and Hubert 2002), which may unfortunately be lost in the case of lake Victoria trawl trends unless the two nets are standardized and if need be a correction factor developed.

A further difference between the new and old nets that warrants mention is in relation to sizes of specific parts. The short headlines and fishing lines of the new bottom trawl implies smaller wingspread. Sweep line length of the old and new bottom trawls differed by 45 m (Figure 15). In standardizing fishing gears, the net areas, resistance, fishing lines, headlines, sweep lines, mesh size and twine diameters, among others, of respective gears should be the same. The rigging details of the nets were missing both in the SOPs guide and that of the net manufacturer. This gives high chances of derailing from set standards as concerned gear technologist from each respective country (Tanzania, Kenya and Uganda) have nothing common to refer to. It was also observed that the drawing/plans of the bottom nets (Figure12a and 13a) were misleading as the bases of the wings make sharp corners at the bosom (Figure 22).

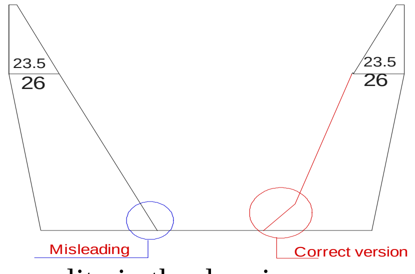


Figure 22: Illustration of the abnormality in the drawings

Little difference was observed between the old and new pelagic nets (Figure 19) indicating that the manufacturer used the provided drawing with minimal modifications. However, the two pelagic nets seem to be too big for the research vessels used (Figure 21). The estimated maximum towing speed of 2.2 knots from the relationship of the net resistance and vessel power implies that the current proposed towing speed of 3.5 knots and above (SPO LVFO 2005) for bottom trawl nets cannot be achieved with the pelagic nets. In addition, if the vessels are forced to achieve that speed it could result in change in the shape of the gear during trawling. This in turn would impair their fishing efficiency and consequent estimation of standing stock. Unfortunately, there is no information from acoustic or any reported studies on Lake Victoria regarding shape of the pelagic net during trawling. It could be of interest to investigate the impact of the current pelagic net sizes on their opening with the current vessels before their use for meaningful assessment can be instituted.

The other important aspect of gear standardization that could influence its efficiency is the reaction of the target species to the gear. However, the reactions of target fish species to the fishing gears used for stock assessment in Lake Victoria have not been studied (LVFO 2005). Fish species react differently to different mobile or immobile gears ranging from diving to fast swimming away from the gear. The maximum swimming speed of fish is said to be generally in the range of 10 times its body length per second and can be maintained only for short periods (Fernö and Olsen 1994). Fish, especially pelagic ones, may hear sounds of approaching fishing vessel and exhibit avoidance reactions by both horizontal and vertical movements (Ona and Godø 1990). Therefore, innovations on any standardized gears aimed at increasing their consistency are normally acceptable if they take into account behaviour of the target species.

5 CONCLUSIONS AND RECOMMENDATIONS

This study has shown that there are two different bottom trawl nets in use for stock assessment on Lake Victoria, the old and new, whose consistency has not been verified. It is recommended that inter-calibration experiments be conducted and if a significant difference in their performance is noted, a correction factor be developed to scale the trend analysis data.
It has also been noted that the individual repairs on the nets and separate modifications based on innovations by scientists and gear technologist could cause shifts in gear performance. It is therefore recommended that periodic checks such as inter-calibration done in 1999, be adopted and occasionally implemented.

Standardization of any fishing gear requires sufficient knowledge of target species behaviour. The behaviour/reaction of the target fish species to the sampling gears should be carried out with the help of gear experts using a combination of acoustic and photographic equipment. Evidence has been provided that the size of the provided pelagic nets could be beyond the suggested towing speed of the vessels and their use in the current form could lead to changes in their shape and size. It is therefore recommended that field trials using acoustic equipment be conducted with pelagic trawls to ascertain their behaviour (shape, and vertical mouth opening), during trawling and adjust their resistances by increasing mesh sizes and decreasing twine size or by reducing number of meshes making their respective parts, in order to match the towing capacities of the available research vessels.
This study was unable to verify the effect of changing the sweep line of bottom trawls from 15 to 60 m as provided in the new bottom nets rigging. It is therefore recommended that the effect of this change be evaluated and accounted for.

The discrepancy in the drawings of the gears in the SOPs with the actual gears in use indicates the SOP has not been strictly adhered to. A review of the present standardization provided in the SOPs needs to be carried out and appropriate action taken. In the meantime standardizing and constant checks on the current available trawls should be done using the proposed guide (Appendix 12) developed from this study.

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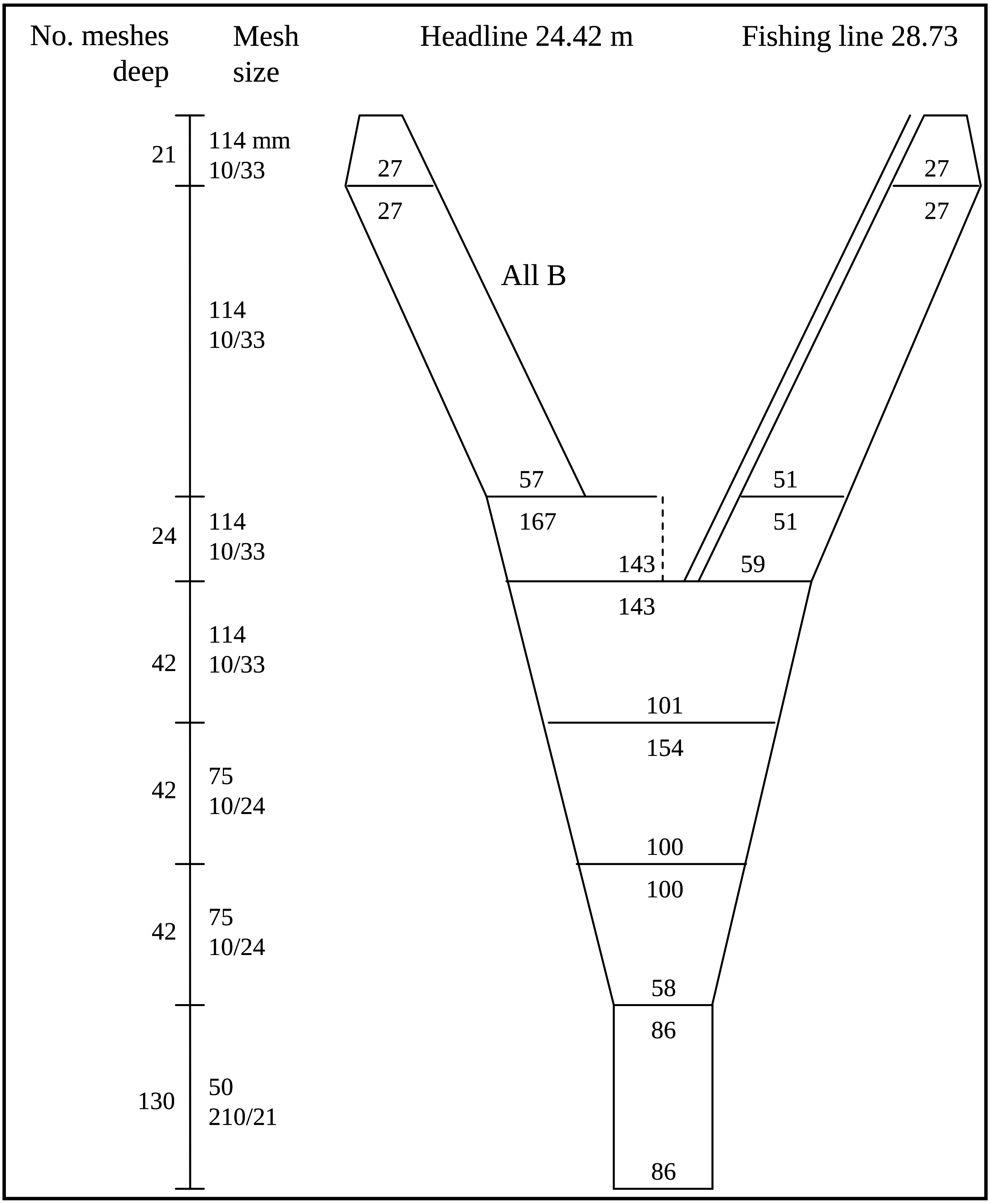
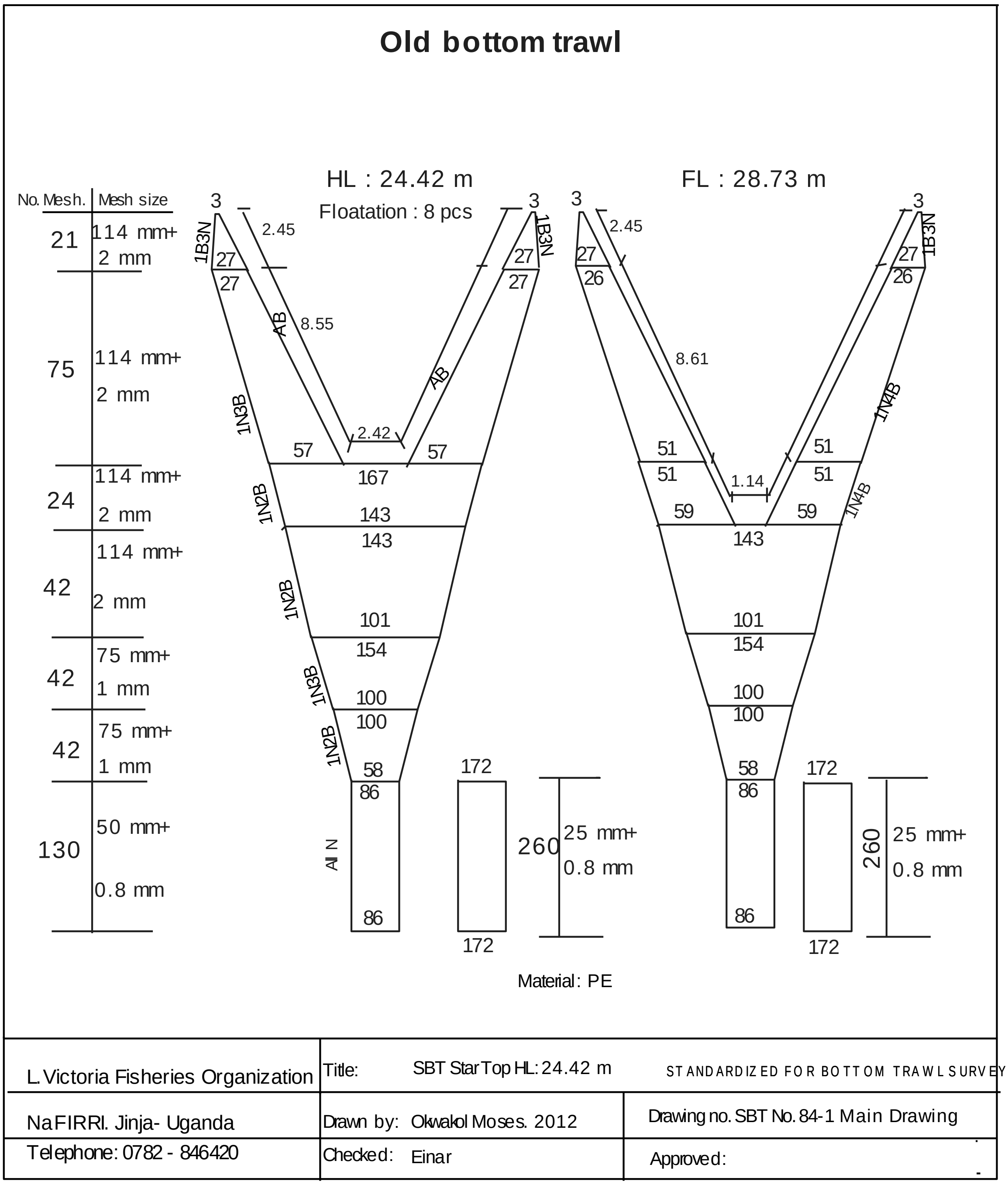
I'm indebted to Mr. Taabu Munyaho for his tireless efforts in sourcing for information from the trawl net and Research Vessel Manufactures and his positive criticisms that improved the quality of this report. Last but not least I wish to express my heartfelt gratitude to my family for enduring my absence during the 6 month course of this study in Iceland.

APPENDIX

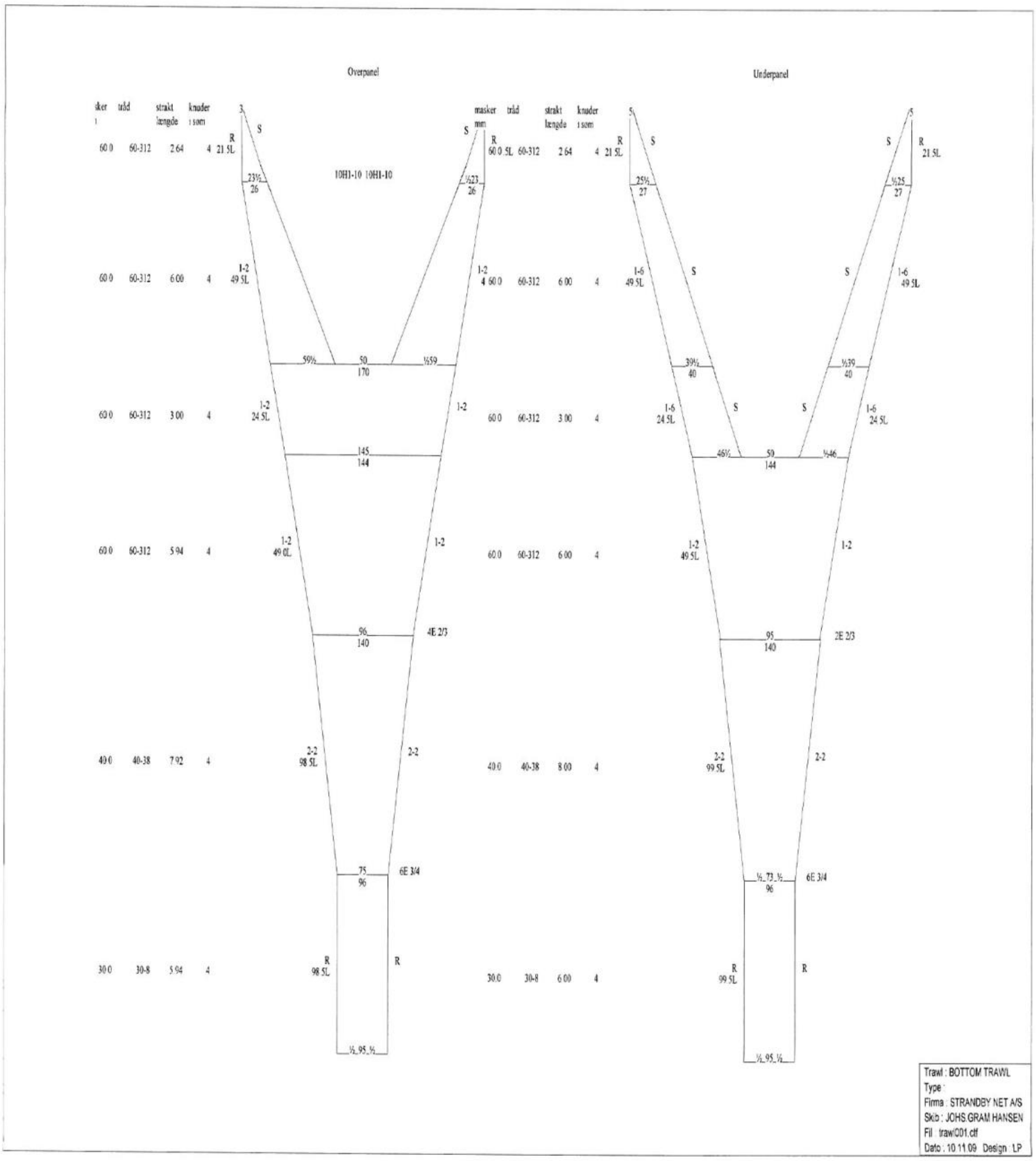
Appendix 1: Enlarged old bottom trawl drawing



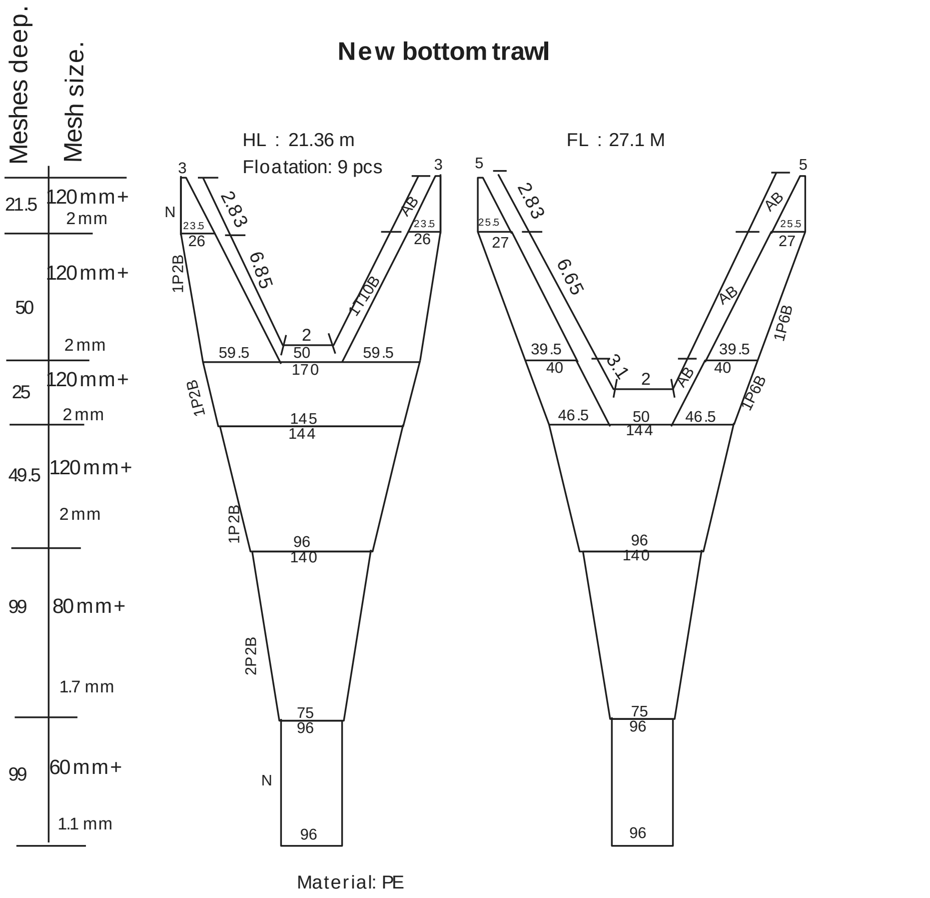
Appendix 2: Enlarged re-drawn old bottom trawl



Appendix 3: New bottom trawl drawing as provided by the manufacturer (Source: Strandby net loft)



Appendix 4: Re-drawn new bottom trawl



L. Victoria Fisheries Organization	Title: SBT Star Top HL: 21.36 m	STANDARDIZED FOR BOTTOM TRAWL SURVEY
NaFIRRI. Jinja- Uganda	Drawn by: Okwakol Moses. 2012	Drawing no. SBT No. 84- 1 Main Drawing
Telephone: 0782 - 846420	Checked: Einar	Approved:

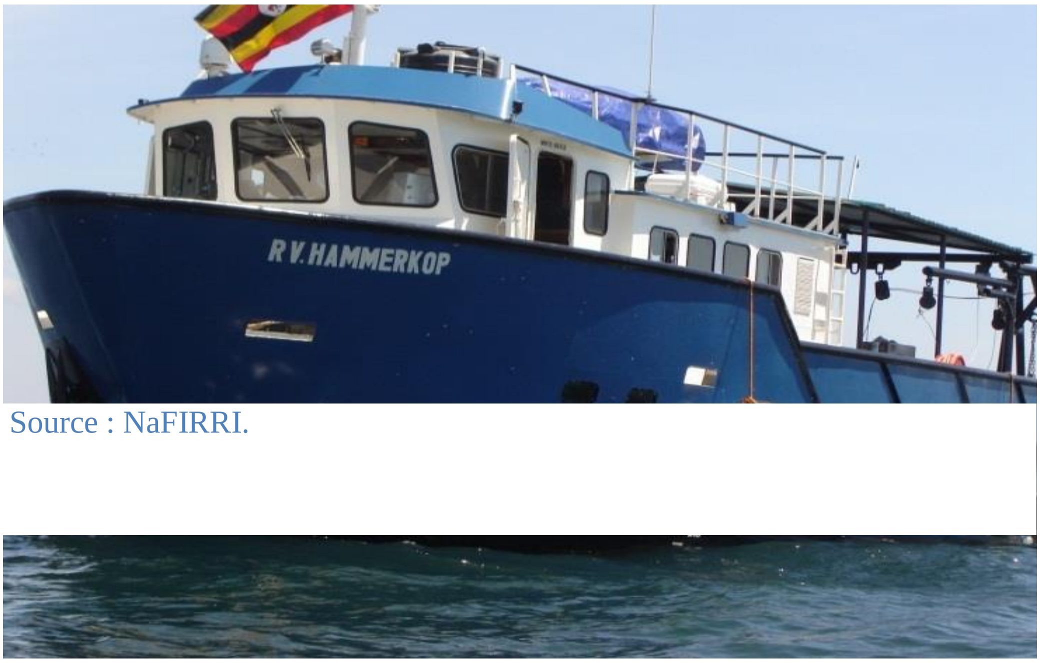
Appendix 5: rv. ibis

Year of build:	1967
Port of registration:	Jinja
Registration number:	MU157
Length overall (L.O.A):	17.86 m
Width:	4.88 m
Draft:	2.70 m
Engine power:	215 hp
Trawling winch:	Hydraulic type Marco W- 1100

Source : NaFIRRI.

Appendix 6: Mv. Hammerkop

Year of build:	2009
Port of registration:	To be registered at Jinja
Length overall:	18 m
Width:	4.4 m
Draft:	1.8 m
Engine power:	250 hp
Trawling Winch:	To be ascertained



Source : NaFIRRI.

Appendix 7: Resistance table.

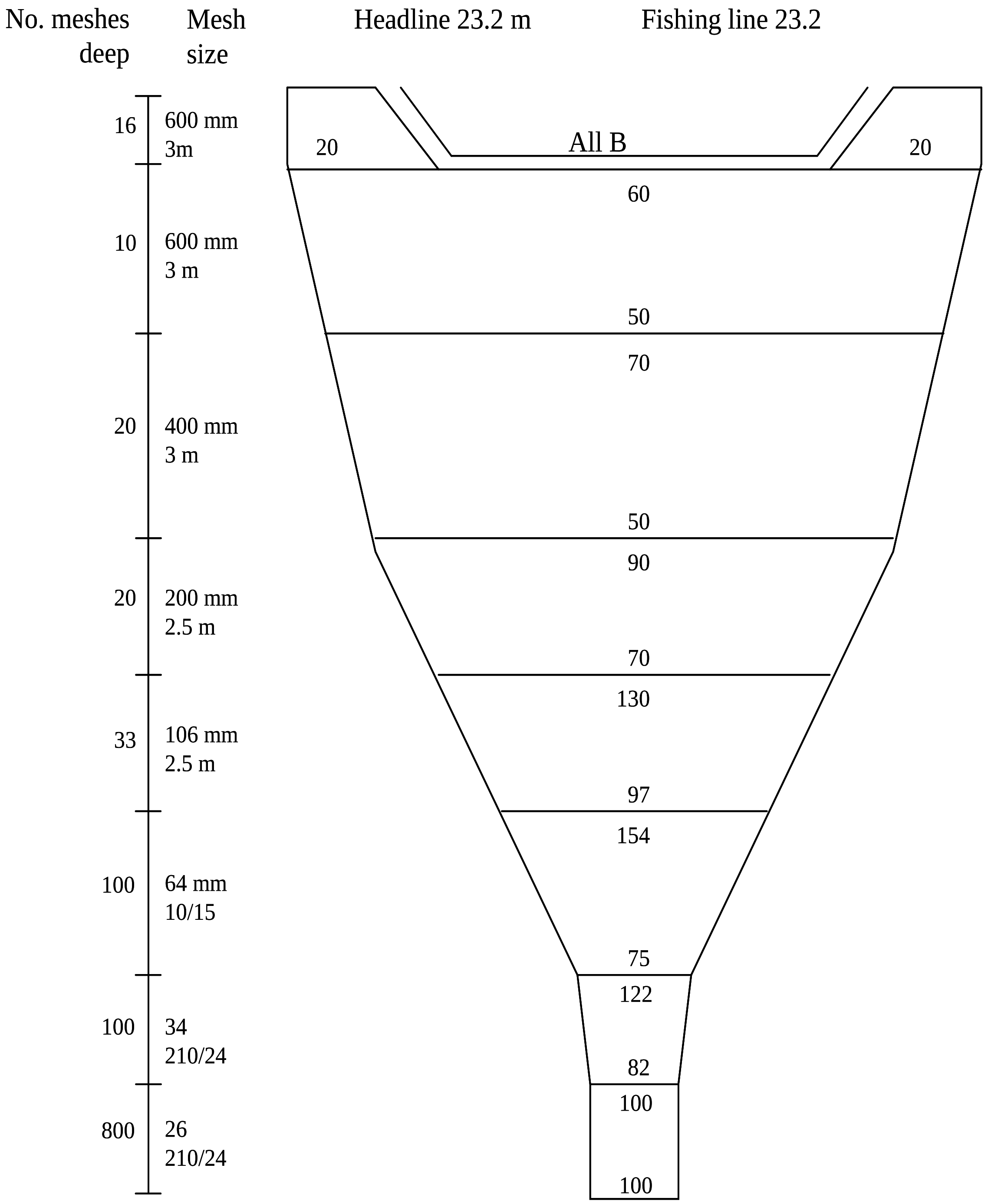
Bottom Trawls Resistance

				Vessels					Sweep lines				Headline				Floats			Doors			Old bottom trawl			New bottom trawl		
V Knots	p	Cx net	q	Hammer-kop HP	Ibis HP	Kf	F_t Hammerkop	$F_{t\ Ibis}$	$C_{x\ Sweep\ line}$	Swp length (m)	Swp diam. (mm)	R_s Sweep lines	Cx Head line	HL (m)	HL daim. (mm)	R_{HL}	Float daim. (mm)	A_{floats}	R_t floats	Cx Doors	A_{Door}	R_t Doors	A_n old	R_N old	R_T Old	A_n New	R_n New	R_t New
1,0	100	0,5	13,2	250	215	10	2.325	2.000	0,3	94,4	0,012	4,50	0,7	24,48	0,012	2,72	0,19	0,0361	1,69	0,25	1,58	5,23	16,251	108	122	19	123	137
1,5	100	0,5	29,8	250	215	10	2.238	1.924	0,3	94,4	0,012	10,12	0,7	24,48	0,012	6,12	0,19	0,0361	3,80	0,25	1,58	11,76	16,251	242	274	19	277	309
2,0	100	0,5	52,9	250	215	10	2.150	1.849	0,3	94,4	0,012	17,98	0,7	24,48	0,012	10,88	0,19	0,0361	6,75	0,25	1,58	20,90	16,251	430	487	19	492	549
2,5	100	0,5	82,7	250	215	10	2.063	1.774	0,3	94,4	0,012	28,10	0,7	24,48	0,012	17,00	0,19	0,0361	10,54	0,25	1,58	32,66	16,251	672	760	19	769	857
3,0	100	0,5	119,1	250	215	10	1.975	1.699	0,3	94,4	0,012	40,47	0,7	24,48	0,012	24,49	0,19	0,0361	15,18	0,25	1,58	47,03	16,251	968	1.095	19	1.107	1.235
3,5	100	0,5	162,1	250	215	10	1.888	1.623	0,3	94,4	0,012	55,08	0,7	24,48	0,012	33,33	0,19	0,0361	20,67	0,25	1,58	64,02	16,251	1.317	1.490	19	1.507	1.680
4,0	100	0,5	211,7	250	215	10	1.800	1.548	0,3	94,4	0,012	71,94	0,7	24,48	0,012	43,53	0,19	0,0361	26,99	0,25	1,58	83,62	16,251	1.720	1.946	19	1.969	2.195
4,5	100	0,5	267,9	250	215	10	1.713	1.473	0,3	94,4	0,012	91,05	0,7	24,48	0,012	55,09	0,19	0,0361	34,17	0,25	1,58	105,83	16,251	2.177	2.463	19	2.492	2.778
5,0	100	0,5	330,8	250	215	10	1.625	1.398	0,3	94,4	0,012	112,41	0,7	24,48	0,012	68,01	0,19	0,0361	42,18	0,25	1,58	130,65	16,251	2.688	3.041	19	3.076	3.429

Pelagic Trawls Resistance

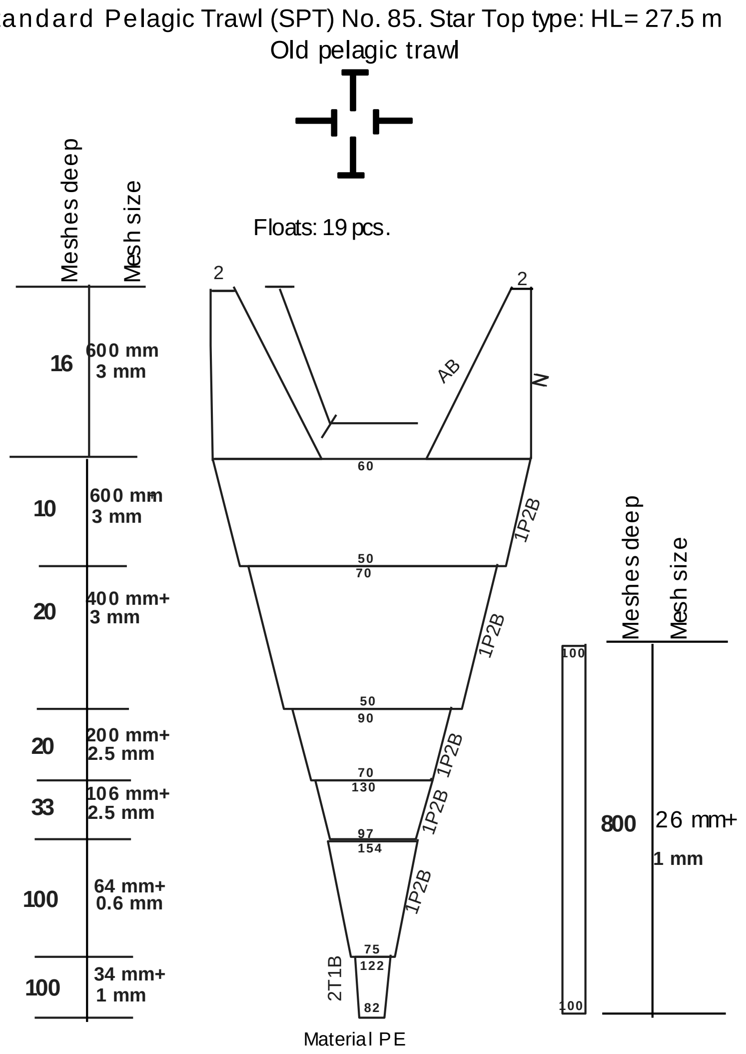
				Vessels					Sweep lines				Headline				Floats			Doors			Old Pelagic trawl			New Pelagic Trawl		
V Knots	p	Cx net	q	Hammer-kop HP	Ibis HP	Kf	F_t Hammerkop	$F_{t\ Ibis}$	$C_{x\ Sweep\ line}$	Swp length (m)	Swp diam. (mm)	R_s Sweep lines	Cx Head line	HL (m)	HL daim. (mm)	R_{HL}	Float daim. (mm)	A_{floats}	R_t floats	Cx Doors	A_{Door}	R_t Doors	A_n old	R_N old	R_T Old	A_n New	R_n New	R_t New
1,0	100	0,5	13,2	250	215	10	2.325	2.000	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	6,75	0,25	1,77	44,25	62,95	416	431	67	444	890
1,5	100	0,5	29,8	250	215	10	2.238	1.924	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	15,18	0,25	1,77	44,25	62,95	937	971	67	1.000	1.966
2,0	100	0,5	52,9	250	215	10	2.150	1.849	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	26,99	0,25	1,77	44,25	62,95	1.666	1.726	67	1.777	3.472
2,5	100	0,5	82,7	250	215	10	2.063	1.774	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	42,18	0,25	1,77	44,25	62,95	2.603	2.696	67	2.777	5.409
3,0	100	0,5	119,1	250	215	10	1.975	1.699	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	60,74	0,25	1,77	44,25	62,95	3.748	3.882	67	3.999	7.776
3,5	100	0,5	162,1	250	215	10	1.888	1.623	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	82,67	0,25	1,77	44,25	62,95	5.101	5.284	67	5.443	10.574
4,0	100	0,5	211,7	250	215	10	1.800	1.548	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	107,98	0,25	1,77	44,25	62,95	6.663	6.902	67	7.109	13.802
4,5	100	0,5	267,9	250	215	10	1.713	1.473	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	136,66	0,25	1,77	44,25	62,95	8.433	8.735	67	8.998	17.460
5,0	100	0,5	330,8	250	215	10	1.625	1.398	0,3	91,5	0,012	32,94	0,7	27,5	0,01	23,10	0,19	0,04	168,72	0,25	1,77	44,25	62,95	10.411	10.785	67	11.109	21.548

Appendix 8: Old pelagic trawl



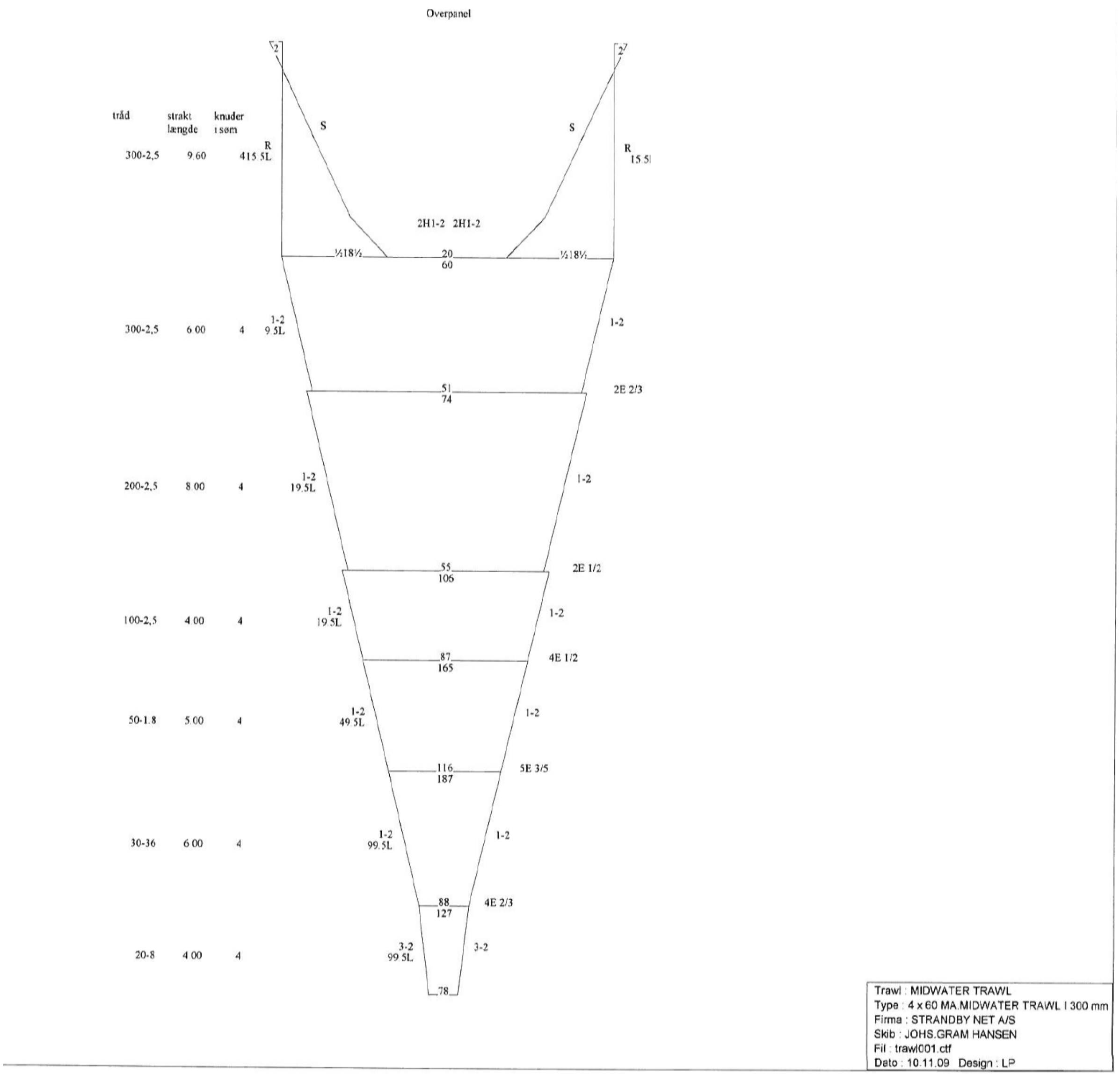
Source: LVFO: Standing Operating Procedures manual (2005)

Appendix 9: Re-drawn old pelagic trawl

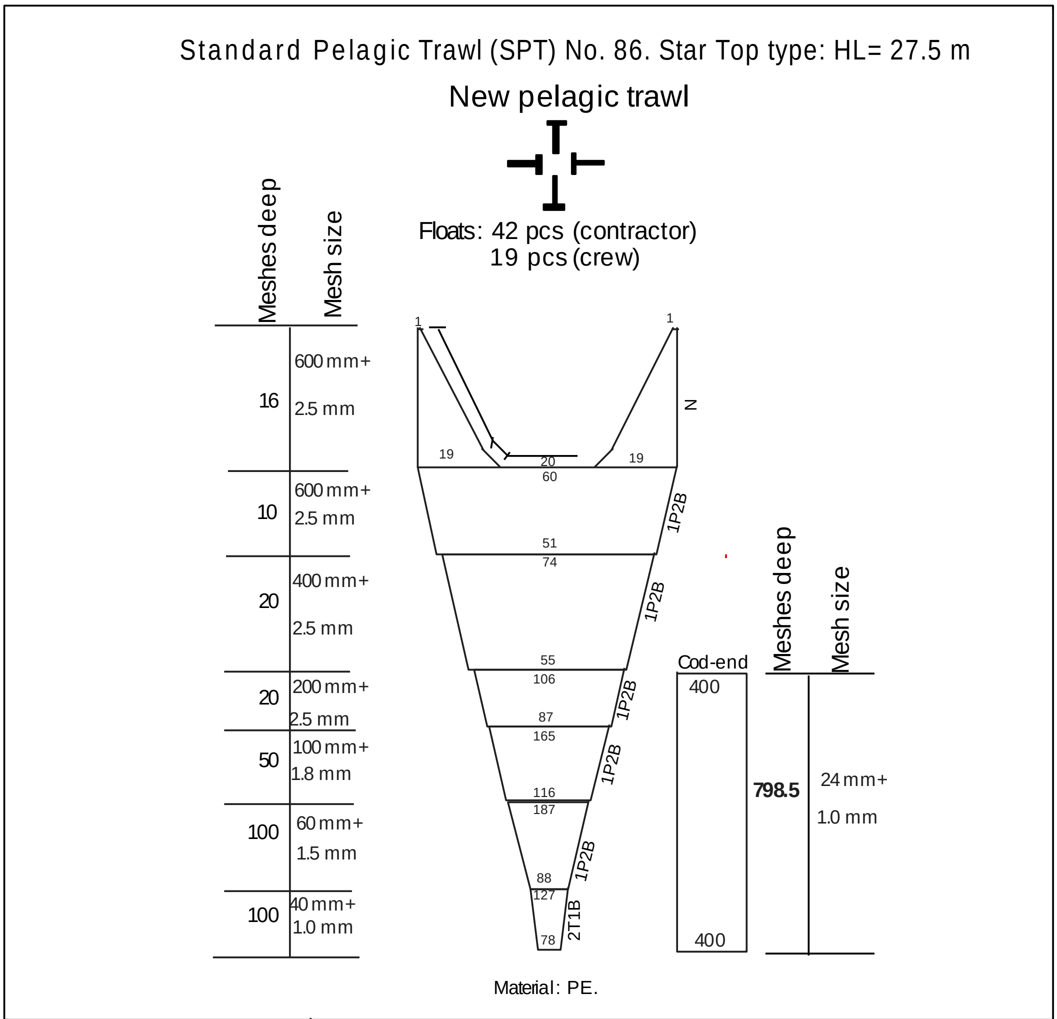


L. Victoria Fisheries Organisation	Title : **SPT Star Top HL: 27.5 m**	**STANDARD FOR PELAGIC TRAWL SURVEY**	
NaFIRRI. Jinja - Uganda	Drawn by: Okwakol Moses. 2012	Drawing no. SPT No. 84 - 1	Main Drawing
Telephone: 0782 - 846420	Checked: Einar	Approved:	

Appendix 10: New pelagic net



Appendix 11: Re-drawn new pelagic trawl (Source: Strandby net loft)



L. Victoria Fisheries Organisation	Title : SPT Star Top HL: 27.5 m	STANDARD FOR PELAGIC TRAWL SURVEY	
NaFIRRI. Jinja - Uganda	Drawn by: Okwakol Moses. 2012	Drawing no. SPT No. 86 - 1	Main Drawing.
Telephone: 0782 - 846420	Checked: Einar	Approved:	

Appendix 12: Proposed guide

The new bottom trawl was considered for making the proposed guide.

(A) Inspection guide

It is critically important that the sampling gear is set up according to the approved standardized gear diagram. It is therefore necessary to check if all measurements of all gears are in accordance to the diagram.

This check is to be done by:

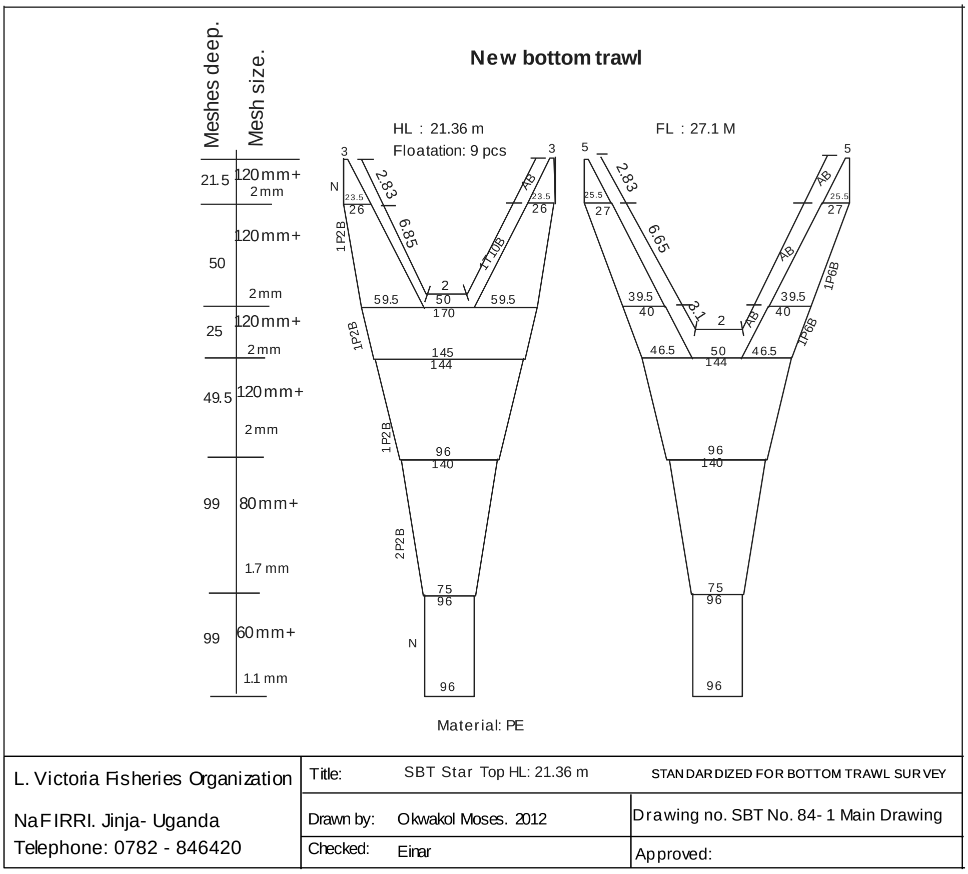
- Gear technologists, before they are shipped on board the survey vessels.
- Cruise leaders before the vessels leave harbour.
- The following specifications (length and weights) in Table A below are checked.

Table A: Specifications to be checked

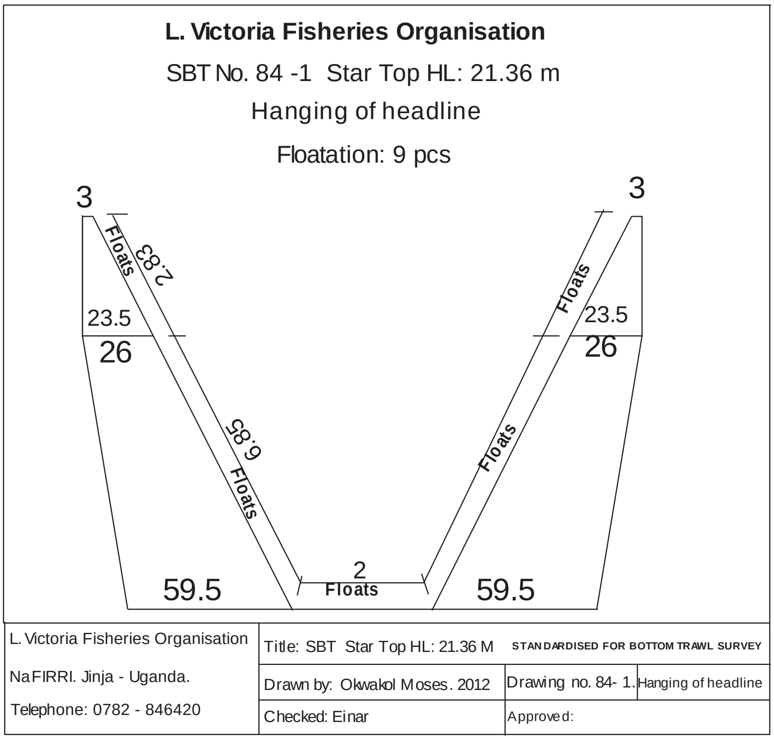
Trawl part	Standard	1st check (technologists)	2nd check (cruise leaders)
Headline Length. Diameter.	 21.36 m 12 mm		
Floats (kgf/each)	9 floats. (@ 3.3Kgf)		
Top bridles wire Length Diameter	 15 m 12 mm		
Bottom bridles Length: Diameter: Extension	 15 m 12 mm 0.5 m		
Fishing line Length: Diameter:	 27.1 m 12 mm. Stainless combination rope		
Sweep line Length: diameter	 60 m (mm)		
Foot rope Length: diameter	 29.1m 11mm. Stainless with12 mm danline turned around		
Otter boards Weight: Length: Width:	 250 Kg 1.66 m 1.0 m		

(B) Construction/ Maintenance guide.

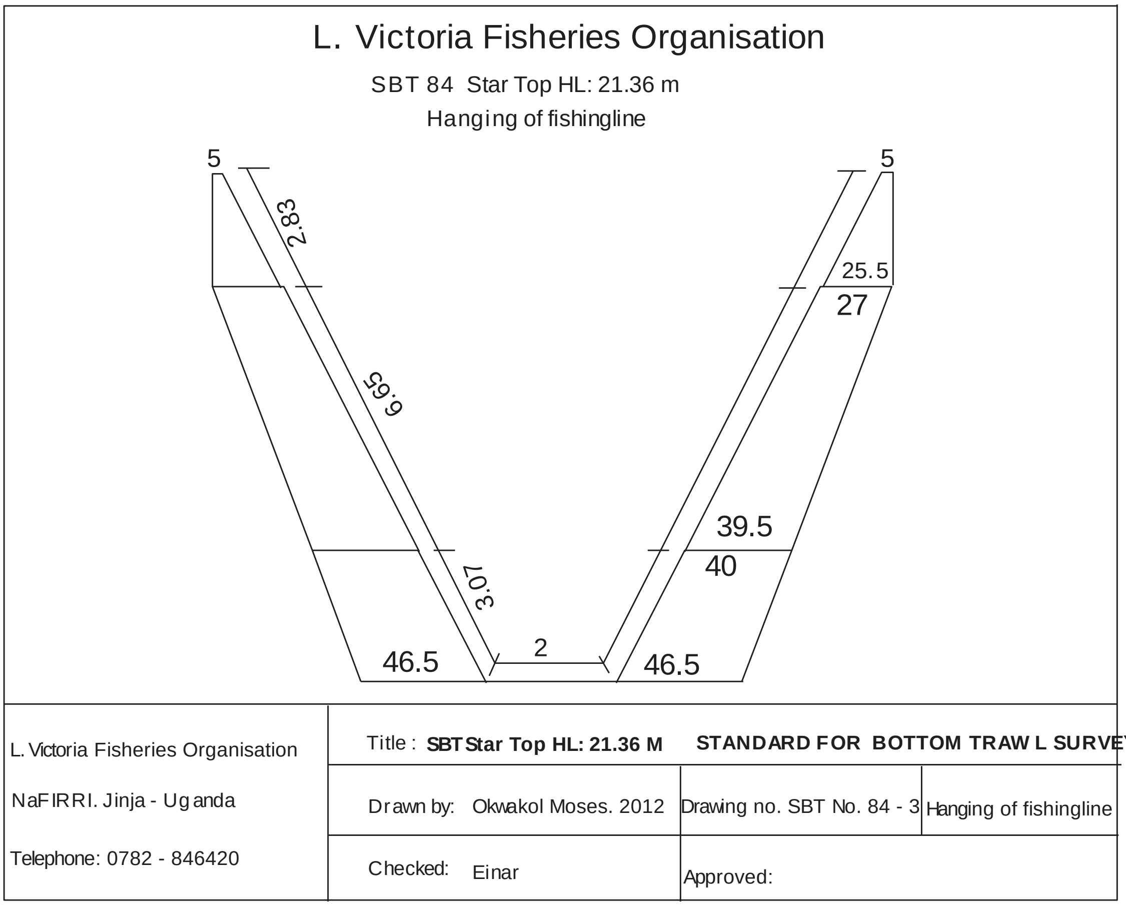
B (i): Main drawing plan of the trawl



B (ii): Hanging of Headline



B (iii) Hanging of fishing line



B (iv): Rigging arrangement