LAKE VICTORIA FISHERIES ORGANIZATION

OF THE EAST AFRICAN COMMUNITY

IMPLEMENTATION OF A FISHERIES MANAGEMENT PLAN (IFMP) PROJECT FOR LAKE VICTORIA

EDF PROJECT NO. 8 ACP ROR 029

REPORT OF THE LAKE-WIDE HYDRO-ACOUSTIC AND ENVIRONMENTAL SURVEY
17th March – 16th April 2010

Hydro-acoustic and Environmental Regional working group
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July 2010

Abstract

The 10th lake-wide hydro-acoustic survey under IFMP was conducted on Lake Victoria from 17th March – 16th April 2010 with the overall objective of estimating the standing stock of the major commercial fish stocks in the lake. Environmental and bottom net sampling were concurrently done using a CTD profiler and a bottom trawl net respectively. Two CTDs from NaFIRRI (Old and New) were used following the malfunctioning of the KMFRI CTD that has been used in all the previous surveys and is now due for service. Acoustic Data were analyzed using Echoview 4.90 software recently released by Myriax. Illustration of Spatial distribution of fish stocks and water environmental parameters were drawn in Arcview 3.2.

`Although the total biomass of fish in the lake recorded during this survey is lower than the corresponding survey of March 2009, the major reduction is noted in the biomass of haplochromines and others which reduced by about 300,000 t from 820,000 t0 528,000 t. The estimate of this taxon from the survey is however, similar to other corresponding years and therefore no cause of alarm. The Nile perch stock is fairly stable showing slight signs of recovery. The contribution of Nile perch in the net haul samples has remained constant over the same period while environmental parameters reveal decreased DO, with high incidences of anoxic conditions in the lake suggesting extreme stratification and consequent reduction in the habitat suitable for fish. The Dagaa stock shows a fairly stable population that is probably still underexploited. The survey recorded clustered densities of fish in shallow areas probably due to stressful conditions observed in the deep waters of the lake.

It is suggested that reduced harvest and marketing of the undersized fish and implementation of the Regional Plan of Action (RPOA) on fishing capacity may protect the Nile perch stocks and increase its recovery. It is also necessary to survey and map critical breeding and nursery areas to curb localized over fishing. In addition there should be concerted effort to redistribute effort from Nile perch to the now abundant Dagaa and Haplochromine resources. Efforts to manage nutrient input into the lake for improved water quality should be encouraged.

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1.0 Introduction

Hydro-acoustic surveys on Lake Victoria have become one of the dependable sources of informative data to guide management decisions. The surveys are conducted bi-annually (during the mixing period August –September, and the stratified period – February – March). The intervention provided by the European Union (EU) through the implementation of a Fisheries Management plan (IFMP) project for Lake Victoria coordinated by the Lake Victoria Fisheries Organization (LVFO) has successfully conducted nine (9) lake-wide hydro-acoustic surveys. The surveys followed similar efforts through the EU funded Lake Victoria Fisheries Research Project (LVFRP, 1999-2002). A total of six surveys were implemented under LVFRP. All the six surveys conducted by LVFRP and four of the eight surveys conducted by IFMP utilized a SIMRAD EY 500 120-S echo-sounder system, while the most recent surveys (August 2007 – August 2009) utilized the SIMRAD EK 60 dual frequency echo sounder system. The EY 500 comprised a 120 KHz 9° beam angle transducer while the EK 60 had 70 and 120 KHz transceiver units both with 7° beam angle transducers.

Hydro-acoustic surveys are reliable for stock monitoring activities mainly because they provide real time data. Other independent methods used to complement acoustic estimates include bottom trawl and gillnet surveys. In addition, catch and effort data obtained from fisheries dependent methods (Catch Assessment and Frame Surveys) provide realistic basis for interpretation and forecasting on the fisheries independent information.

The objectives of acoustic surveys are to estimate the biomass and determine the spatial and temporal distribution patterns of the major commercial fish species in the lake. So far, acoustic technique has been used to provide biomass estimates and distribution of the Nile perch (*Lates niloticus*) >10 cm TL and Dagaa (*Rastrineobola argentea*). The third species of commercial importance, the Nile tilapia (*Oreochromis niloticus*), is restricted to shallow inshore areas which are inadequately covered due to limitation of the current vertical beaming technique used. However, under current analytical protocols, the tilapia and haplochromines cichlids are grouped together in a group termed “other taxa”. With the help of a dual frequency echo-

sounder it has been possible to discriminate the echo traces attributed to a benthic crustacean *Caridina nilotica*. However, inadequacies related to their acoustic backscattering characteristics and experimentally evaluated target strength impair concrete estimation of their stocks. The working group has therefore continued to provide consistently and systematically generated data as indices that can guide management decisions under the current inadequacies.

Concomitant with acoustic stock estimation, bottom trawl and environmental sampling are conducted during surveys using a bottom trawl net with headline length 24.4m and a CTD and Secchi disk samplers to obtain information on species identities, size-weight evaluation and water environment parameters. Samples obtained by trawl nets are used to infer observed distribution patterns from echo traces in echograms while CTD, secchi disc and nutrient data aid in providing possible answers to the observed temporal and spatial fish distribution and abundance. Following the failure by the KMFRI CTD (which has been used in all the previous 9 surveys) profiler to operate during this survey, Two CTD profilers (New and Old) were employed to capture data and compare their results.

During this survey, the RWG was privileged to once again have the opportunity to work with the former International Short Term Technical Assistant (ISTTA) for hydro-acoustic surveys under MRAG, Dr. Inigo Everson. The team worked closely with the consultant in a bid to improve the target strength estimates of the major stocks using the recent and historical data series. The results and consequent conclusions of the analyses conducted are a subject of future publications and therefore beyond the scope of this report.

It is worthy noting that during this survey, the team experienced serious weather change in the south-western quadrant beyond what had ever been recorded. Whether the bad weather was due to surveying in a period slightly out of the usual Feb-March season or consequences associated with climate change is a subject for further exploration. Otherwise, the survey was successfully concluded and we provide the results and suggestions for management in this report.

2.0 Materials and Methods

2.1 Study area

The survey was conducted on Lake Victoria (surface area of 68,800 km^2). Just like in all the previous surveys under IFMP, the lake was divided into four ninety-degree quadrants**:** Northeast (NE), Southeast (SE), Southwest (SW) and Northwest (NW)).

2.2 Organization of the cruise

This survey was conducted from 17th March to 16th April 2010. As has been the practise in the previous surveys, there were four days of preparations during which calibration of the echo-sounders, inter-calibration of the two CTD profilers and attempt to inter-calibrate the two survey CTDs with that used by PhD students associated with the project on Segregating Drivers for Ecosystem Change (SEDEC) were done.

2.3 Cruise track design

The cruise track prepared for the March 2010 survey followed the design used in the previous IFMP surveys (August 2007 – August 2009). Just like in the previous surveys, sampling was restricted to daylight hours to avoid interference from some fish together the zooplankton biomass that show diurnal migration. Apart from days of the cross-lake transects when only CTD sampling could be accommodated due to time factor, two net hauls were taken daily.

The organization of the sampling and data collection were structured according to the type of activity taking place. The following activities were organized;

a) **Transect:** an acoustic survey track with the vessel proceeding in the same nominal direction at constant speed (normally about 9 knots). The following types of transects were designated:

Deep Transect (Code TD);

Coastal Transect (Code TC);

Inshore Transect (Code TI);

Deadhead (Code DH), the track between two transects;

b) **Net_haul**: At the beginning of the survey, a frame trawl was considered to supplement the bottom trawl and provide reliable samples of small pelagic species and juvenile Nile perch. It was however, evaluated to be underperforming and discontinued. It was therefore only the bottom trawl (NB) that was used.

c) **CTD:** Environmental sampling using the CTD, Secchi disc etc. in addition to taking water samples for nutrient analysis and grab samples for bottom classification.

d) **Drift:** the vessel is stationary and moves only by the action of wind/water currents

Groups of activities at the same nominal location were given the designation 'Stations' to indicate that they might be analyzed together. The event log for the cruise is set out in Appendix I.

2.4 Calibration of echo-sounder

Two calibrations of the echo-sounders were made. The first was done on 17th March 2010 at the beginning of the survey at Richard Island near Mwanza and the second on 12th April 2010 at Shishu Island near Ukara. Specific copper spheres for each frequency supplied by the manufacturer were used. The difference between the calibrated TS gain at the beginning and end of the survey was 0.5% for the two 120 and 70 Khz transducers. The Sv correction factors at the beginning and end of the survey were 3.5 and 4% for 120 and 70 KHz transducers respectively. The system was therefore very stable throughout the survey.

2.5 Acoustic data acquisition, processing and analysis

2.5.1 Data logging and storage

As has been the case since the introduction of the new dual frequency echo-sounder, the system was controlled from the HP laptop computer supplied by SIMRAD. At the beginning of each day, echo-sounder operation settings particularly the Data recording Range were

thoroughly checked and recording directory set. Data were logged in files of length 102 MB and then transferred to a separate laptop and backed up onto hard disks.

2.5.2 Acoustic Data Preparation

Each day's raw acoustic data files were loaded into Echoview using a standardized template to ensure consistency, specifically for selected exports and analysis telegrams and saved as EV files using the day's date as the file name.

2.5.3 Setting analysis lines and definition of regions

Four analyses lines (checked bottom, test bottom, dagaa and top line were set with specifications as detailed in the acoustic SOP. Regions were set according to the events given in the Event log. Occurrence of bottom echoes was checked and removed according to the standard detailed in the SOP.

2.5.4 Estimation of EDSU

To ensure that all cells produced for analyses from the two frequencies in and between integration and single target analyses were similar, depth layers were set at 2 m intervals with a horizontal grid of 1 km (Elementary Distance Sampling Unit – EDSU). Data collected from regions designated as 'Transect' were used for analyses for the estimation of standing stock. For single target detections, analysis from each cell were exported by transect and by cell. To ensure that cells where no target was recorded are included in the calculation of average density, the option of "Output empty cells" was selected in Echoview – EV File properties Export window prior to data export.

The GPS positions of the start and end of each cell were used to determine the distance of the cell. Through the main part of each transect, these estimated distances corresponded to the intended distance of 1 km. However, some cells produced distances well below 1 km. This occurred mainly at the beginning and end of transect. As has been the case from previous surveys, only EDSUs of length 0.9 to 1 km were accepted for analysis.

2.5.5 Single Target Analysis

Nile perch densities were estimated using single target detections in Echoview using the split beam output data of power and angle and using the algorithm 'Single Targets Split Beam Method 1' as in the previous surveys. Data were exported by transect and by cells (constituting individual EDSU). To produce results comparable to the previous surveys, only data from the 120 kHz transducer were used for standing stock estimation. Using the TS to weight relationship estimated in the August 2005 survey and used in all the previous surveys, a threshold of -50 dB was set in echo view for single target extractions. This threshold is equivalent to a Nile perch of 10 cm TL, estimated from the relationship:

$$TS = (29.9 \times Log(TL)) - 79.3$$

using the deformed cylinder Model (McClatchie *et al*., 1996). The estimate followed measurements of Nile perch in the open coastal and deep strata that revealed that only 1.06% of the fish were not Nile perch (August, 2005 Acoustic survey report).

Data were exported within two meter depth strata from Topline to Checked bottom and converted to mean numerical density using the formula:

$$Density = \left(\frac{N_{t\arg ets}}{V_{Beam}} \right)$$

Where $N_{Targets}$ and V_{Beam} are the number of targets detected and the beam volume within the cell respectively.

The mean size was estimated from the mean TS and length/weight relationship. This was multiplied by the numerical density to give the estimated standing stock within the beam volume of each respective cell. Area density was estimated from the volume density by multiplying by the layer thickness (2 m) and the EDSU Area density estimated by summing the Layer Area densities.

The values for TS/Size and Length/Weight relationships used in analysis were the same as those used for the previous surveys under IFMP. These were determined in August 2005 acoustic survey when enough samples were obtained. They are

$TL=10^{((TS+79.3)/29.9)}$ and

$Total\ weight = 0.0042 \times TL^{3.26}$ respectively.

2.5.6 Integration analysis

The standing stock of dagaa, the benthic crustacean *Caridina nilotica,* and the other species (haplochromines and others) were estimated using echo integration.

2.5.6.1 Dagaa

For dagaa analysis, integration was undertaken in the layer from 'Topline' to the 'Dagaa line' in the 120 KHz SQ1 telegram echogram and exported by regions (transects) and by cells (EDSUs) and marked "Integration Dagaa". The exported volume scatter (Sv) values were converted to Area Backscattering Coefficient (ABC) using following relationships:

$$ABC = 10^{(Sv/10)}$$

The ABC values fro dagaa were summed up for each EDSU.

The ABC values due to Nile perch in the dagaa layer were estimated from Sv values obtained by exporting the numerical density of Nile perch in the layer "Top line" to "dagaa line" in the 120 KHz split beam method 1 echogram. The Nile perch Sv values were estimated from the single target detections included in the integration range (from Top line to dagaa line) according to a model developed from the previous survey through observations of several slow speed transects.

$$Sv_{Nile\ perch} = TS_{mean} + 10 \log N_{Targets} - 10 \log Beam_{Vol} - 2.3$$

Where TS = Target strength

N = No of Targets

Beam $_{vol}$ = Beam volume

and 2.3 an observed difference between corrected and uncorrected values for single targets detected during Slow Speed transects (February 2006, acoustic survey report).

The ABC for Nile perch were estimated from Sv values determined above from the following relationship:-

$$ABC_{Nile\ perch} = 10^{((Sv\ Nile\ perch)/10)}$$

The ABC values due to dagaa alone denoted ABC_{dagaa} were obtained by subtracting ABC due to Nile perch in the dagaa range ($ABC_{Nileperchdagaarange}$) from the total ABC in the dagaa range ($ABC_{dagaarange}$) according to the following equation:

$$ABC_{dagaa} = ABC_{dagaarange} - ABC_{Nileperchdagaarange}$$

The ABC values for dagaa alone were converted into numerical densities and consequently into biomass using the TS/length relationship determined by Tumwebaze (2003). This relationship is given below

TS = 20 log TL – 72.2, and TS per kilogram of -29.4dB.

2.5.6.2 Caridina nilotica

Caridina that were noted to occupy the bottom layers of the water column were estimated by the difference in the volume scattering coefficient (Sv) between 70 and 120 kHz SQ1 telegram echograms. Integration was done between Dagaa line and checked bottom in the 70 and 120 kHz echograms and exported by Region and by cell. The exported Sv values of 120 kHz transducer were subtracted from the 70 kHz by EDSU and layer and whenever the Sv differences were between -5 and -10 dB, the Sv values from 120 kHz in those layers were accepted as Sv values due to *Caridina*. The protocol and logical equations used to estimate *Caridina* density are the same as those in the Feb 2008 acoustic survey report.

The selected Sv values due to *Caridina* were converted to density using TS per Kilo of -38.77 dB (TS for Krill – acoustically similar to *Caridina*) according to the following equation:

Caridina density = 1000 ^ ((Sv – TS)/10).

2.5.6.3 Haplochromines and others

In the case of haplochromines and other unidentified species, after taking out cells attributed to *Caridina*, the Sv values from the remaining cells were converted into ABC and summed up for each EDSU. Nile perch equivalents from the integration range (Dagaa line to checked bottom) were estimated from single targets and converted to ABC due to Nile perch in a similar way to those in the dagaa range demonstrated above. Consequently, estimation of the standing stock of haplochromines and others was made by, subtracting the area backscattering ABC of Nile perch ($ABC_{Nile\text{-}perch\text{-}other\text{-}taxa\text{-}range}$) from the total layer values (Integration other taxa - $ABC_{other\text{-}taxa\text{-}range}$) according to the following formula:-

$ABC_{Other\text{-}taxa} = ABC_{other\text{-}taxa\text{-}range} – ABC_{Nile\text{-}perch\text{-}other\text{-}taxa\text{-}range}$

The ABC values for haplochromines and other taxa were then converted to Sv and finally to numerical density using the TS per kilo of -25.17 dB according to the following equation:-

Haplochromines and other taxa density = 1000 ^ ((Sv – TS)/10).

2.5.7 Estimation of Standing Stock

The mean transect density for each taxon for each EDSU was calculated using Excel as the mean of all EDSUs within the respective transect. The mean density of all transects, within a stratum was taken as an unbiased estimator of the stratum mean. For each stratum the standard deviation (*SD*) was calculated from mean deviations and a standard error (*SE*) as:

$$SE = SD / \sqrt{n}$$

Where **n** is the number of transects surveyed in the stratum

The biomass of each taxa for each stratum was determined by multiplication of the densities and stratum area. The stratum areas are given in Table 2.1. As has been the case for all surveys

conducted under IFMP, estimates of standing stock used the 120 kHz component of the dual frequency echo sounder.

Table 2.1: Areas of Lake Surface (km^2) within each stratum

Quadrant	**Deep**	**Coastal**	**Inshore**	**Special localities**
South East	6,166	5,786	2,003	2,909 (Speke Gulf)
South West	6,251	6,601	3,181	2,022 (Emini Pasha)
North West	6,226	4,865	3,115	2,494 (Sesse Islands)
North East	4,724	3,786	5,729	1,335 (Nyanza Gulf)
TOTAL	**23,367**	**21,038**	**14,028**	**8,760**

2.5.8 Estimation of Standing Stock by country and by stratum

Following the results of the February 2008 survey, standing stock of the three major taxa (Nile perch, Dagaa, Haplochromine and others) were estimated by country and by strata. Just like in the previous survey, it was decided at the time of cruise track design to divide any transect that crosses territorial boundaries into two and mark them “a” and “b”. For estimating biomass by strata and country, each part of the transect was analyzed in the stratum of the country where they occur.

In addition, the boundary way points between Kenya and Uganda were plotted in NE quadrant and the areas occupied by the coastal and inshore strata in Kenya and Uganda re-calculated from the map grid squares (Table 2.2). The rest of the strata were analyzed by country and by quadrant.

Table 2.2: Strata areas by quadrant and by country

Quadrant	Deep	Coastal	Inshore	Gulfs/Inlets
SE	6,166 Tz	5,786 Tz	2,003 Tz	2,909 (SG) Tz
SW	6,251	6,601	3,181	2,022 (EP)

	Tz	Tz	Tz	Tz
NW	6,226 Ug	4,865 Ug	3,115 Ug	2,494 (SI) Ug
NE	4,724 Ug	2,704 (Ug) 1,082 (Ke)	3,966 (Ug) 1,763 (Ke)	1,335 (NG) Ke
TOTAL	23,367	21,038		

Tz = Tanzania, Ug = Uganda and Ke = Kenya

2.6 Biological and environmental data acquisition

2.6.1 Collection of Biological Data

A bottom trawl was used to collect biological samples and estimate catch rates from surveyed areas. The duration of each haul was generally 30 minutes although some few hours were deliberately allowed to last one hour to compare with half hour sets. Start and end times, water depths and warp length were recorded. Cod-end of the bottom trawl net was lined with nylon netting of mesh size 4 mm to ensure retention of small fish.

For each haul, the total weight of each species was measured, in the case of large samples and individual fish using a spring balance suspended from the trawl gantry, and for small samples using Salter pattern kitchen scales. In the case of numerically large catches, sub-samples were taken according to the bottom trawl SOPs for subsequent analyses of length and weight. Lengths were measured to a centimeter below for large specimens and millimeter for small fish. A complete net hauls report is appended to this report (Appendix II).

2.6.2 Environmental Sampling

Physical and chemical parameters were collected using CTD Seabird Electronics Sea Cat SBE 19 programmed to take measurements at 5 seconds intervals. Depth, temperature, dissolved oxygen, conductivity and chlorophyll-*a* were recorded. In addition water samples for nutrient

analysis were taken from a few selected stations. GPS positions of sampling stations were recorded. Detailed sampling procedure is provided in the limnological report annexed.

3.0 RESULTS

3.1a Standing stock of Nile perch by stratum

Table 3.1. Standing stock and biomass estimates of Nile perch greater than 10 cm TL, from the March - April 2010 acoustic survey by country and by stratum

		Areas (Sq. km)	Densities		**Tanzania**	
	Stratum	Tanzania	Tanzania	**Lower Limit**	**Biomass**	**Upper Limit**
SE	Deep	6,166	2.78	15,841	**17,146**	18,451
SE	Coastal	5,786	6.56	35,169	**37,958**	40,747
SE	Inshore	2,003	7.84	12,867	**15,709**	18,551
SE	SG	2,909	6.40	16,766	**18,625**	20,485
Sw	Deep	6,251	1.88	10,760	**11,767**	12,774
Sw	Coastal	6,601	7.16	44,082	**47,240**	50,397
Sw	Inshore	3,181	5.67	16,494	**18,029**	19,563
Sw	EP	2,022	0.51	879	**1,025**	1,171
				152,859	**167,499**	**182,139**
					Uganda	
NW	Deep	6,226	5.69	34,055	**35,440**	36,824
NW	Coastal	4,865	5.69	25,397	**27,692**	29,988
NW	Inshore	3,115	5.99	16,835	**18,653**	20,471
NW	SI	2,494	5.03	10,679	**12,549**	14,419
NE	Deep	4,724	5.30	23,431	**25,061**	26,690
NE	Coastal	2,704	7.89	19,177	**21,337**	23,498
NE	Inshore	3,966	9.29	31,297	**36,856**	42,414
				160,871	**177,588**	**194,306**
					Kenya	
NE	Coastal	1,082	6.43	6,002	**6,958**	7,914
NE	Inshore	1,763	8.30	13,159	**14,625**	16,091
NE	NG	1,335	0.86	568	**1,148**	1,728
				19,730	**22,731**	**25,733**
	Total	67,193		**333,460**	**367,819**	**402,178**

The standing stock of the Nile perch, *L. niloticus* in Lake Victoria estimated during March -April 2010 acoustic survey is presented in Table 3.1a. The mean total biomass was estimated as **367,494 ± 34,359** t. The lowest density was recorded in Nyanza and Emin Pasha Gulfs. Deep

water quadrants in the northern recorded densities of Nile perch higher 5 t km^{-2} compared with the southern quadrants < 3 t km^{-2}.

Table 3.1b: Comparison of biomass of Nile perch greater than 10 cm, TL recorded during surveys conducted in Feb-March 2009 and March – April 2010 from territorial waters of the three east African countries..

Country	Area (%)	Feb-Mar 2009	Mar – Apr 2010
Tanzania	51	146,489	167,499
Uganda	43	178,307	177,588
Kenya	6	25,028	22,731
Total	100	349,824	367,819

3. 2 Spatial distribution of Nile perch

The density distribution of Nile perch in Lake Victoria recorded during Mar – April 2010 acoustic survey is presented in Fig 4. Higher densities of Nile perch were recorded in shallow in shore waters of the lake. The bend on the deep transect in the SE quadrant indicate the area where the skipper had to manoeuvre through a very bad weather stretch.

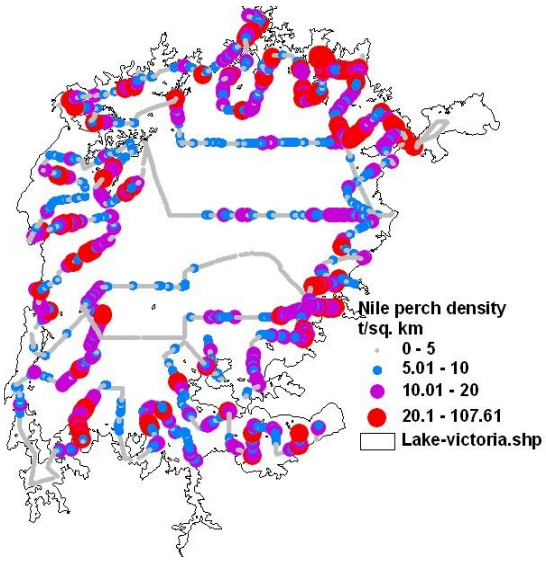

Fig.4. The density distribution of Nile perch in Lake Victoria as estimated per kilometer EDSU during March – April 2010 acoustic survey

3.3 Biomass of dagaa

Table 3.2a. Density and Biomass estimates of Dagaa from the acoustic survey conducted in March - April 2010 on Lake Victoria by country and stratum

		Areas (Sq. km)	Densities		Tanzania	
	Stratum	Tanzania	Tanzania	**Lower Limit**	**Biomass**	**Upper Limit**
SE	Deep	6,166	9.24	53,266	**57,004**	60,742
SE	Coastal	5,786	19.61	104,513	**113,479**	122,444
SE	Inshore	2,003	29.58	50,567	**59,255**	67,944
SE	SG	2,909	22.54	59,307	**65,573**	71,839
Sw	Deep	6,251	15.11	87,695	**94,478**	101,261
Sw	Coastal	6,601	23.48	147,447	**154,991**	162,535
Sw	Inshore	3,181	12.41	36,194	**39,483**	42,773
Sw	EP	2,022	12.41	22,009	**25,098**	28,186
				560,998	**609,361**	**657,724**
					Uganda	
NW	Deep	6,226	10.70	59,331	**66,626**	73,921
NW	Coastal	4,865	16.50	73,402	**80,294**	87,187
NW	Inshore	3,115	15.28	40,885	**47,603**	54,320
NW	SI	2,494	17.46	37,961	**43,557**	49,153
NE	Deep	4,724	16.19	71,868	**76,484**	81,100
NE	Coastal	2,704	11.42	27,618	**30,889**	34,159
NE	Inshore	3,966	16.74	60,825	**66,396**	71,966
				371,890	**411,848**	**451,807**
					Kenya	
NE	Coastal	1,082	13.86	12,896	**14,995**	17,094
NE	Inshore	1,763	19.71	30,033	**34,751**	39,468
NE	NG	1,335	6.31	6,106	**8,417**	10,729
				49,035	**58,163**	**67,291**
	Total	67,193		**981,924**	**1,079,372**	**1,176,821**

The estimated stock of dagaa in Lake Victoria during the March - April 2010 acoustic survey is given in Table 3.2a. The biomass estimated is ***1,079,372* ± 97,449** t. Just like in the preceding survey, the mean density was highest in the inshore Southeast (29.58 ± 4.34 t/km^2).

Table 3.2b: Comparison of biomass of dagaa recorded during surveys conducted in August 2008 and 2009 from territorial waters of the three east African countries..

Country	Area (%)	Feb-Mar 2009	Mar-Apr 2010
Tanzania	51	**673,380**	**609,361**
Uganda	43	**456,122**	**411,848**
Kenya	6	**115,242**	**58,163**
Total	100	**1,244,744**	**1,079,372**

3. 4 Spatial distribution of dagaa

The density distribution of dagaa recorded from the Mar - April 2010 acoustic survey is in indicated in Figure 5. Apart from areas south of Sese islands stretching to Bukoba and areas south of SE deep transect, significant quantities (> 10 t km^{-2}) of dagaa were recorded in the entire lake strata. The two northern quadrants together with the Southeast quadrant, Emin Pasha, Kome channel and areas around Bumbireh channel recorded dagaa densities > 40 tkm^{-2} (Fig. 5).

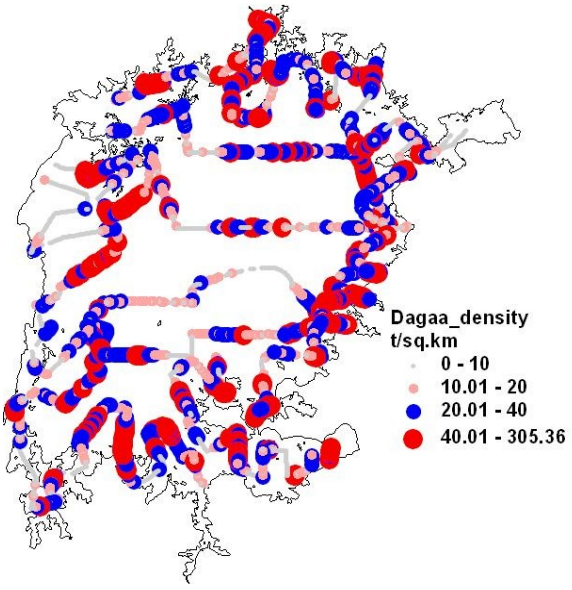

Fig 5. The density distribution of dagaa in Lake Victoria as estimated per kilometer EDSU during March - April 2010 acoustic survey

3.5. Haplochromines and others

Table 3.3a. Estimated standing stock of Haplochromines and other unidentified fish species from the March – April 2010 acoustic survey.

		Areas (Sq. km)	Densities		Tanzania	
	Stratum	Tanzania	Tanzania	**Lower Limit**	**Biomass**	**Upper Limit**
SE	Deep	6,166	2.34	13,468	**14,419**	15,371
SE	Coastal	5,786	7.01	37,810	**40,545**	43,280
SE	Inshore	2,003	18.69	31,546	**37,428**	43,310
SE	SG	2,909	28.32	71,144	**82,383**	93,622
Sw	Deep	6,251	2.12	12,434	**13,255**	14,076
Sw	Coastal	6,601	5.37	33,164	**35,416**	37,668
Sw	Inshore	3,181	11.18	33,515	**35,564**	37,612
Sw	EP	2,022	11.86	22,482	**23,987**	25,491
				255,563	**282,996**	**310,430**
					Uganda	
NW	Deep	6,226	3.54	20,369	**22,051**	23,732
NW	Coastal	4,865	7.42	33,436	**36,105**	38,773
NW	Inshore	3,115	14.63	41,043	**45,587**	50,131
NW	SI	2,494	6.38	14,670	**15,904**	17,138
NE	Deep	4,724	2.90	12,722	**13,721**	14,720
NE	Coastal	2,704	8.18	20,165	**22,119**	24,073
NE	Inshore	3,966	12.64	39,187	**50,121**	61,054
				181,594	**205,607**	**229,620**
					Kenya	
NE	Coastal	1,082	6.45	5,943	**6,974**	8,004
NE	Inshore	1,763	15.16	24,397	**26,717**	29,037
NE	NG	1,335	4.40	5,049	**5,875**	6,701
				35,389	**39,566**	**43,743**
	Total	67,193		**472,546**	**528,169**	**583,793**

The estimated biomass of haplochromines and other unidentified taxa was **528,169 ± 55,624 tkm^{-2}.** All the deep and coastal strata in the entire lake recorded densities < 10 tkm^{-2}. The highest density (28.32 **±** 3.86 tkm^{-2}) was recorded in the inshore Speke Gulf (SG).

Just like dagaa biomass, comparison of Haplochromines and other unidentified taxa over the period Feb-Mar 2009 and Mar-Apr 2010 show a reduction of close to 300,000 tonnes (Table 3.3b).

Table 3.3b: Comparison of biomass of Haplochromines and others recorded during surveys conducted in Feb - Mar 2009 and Mar-April 2010 from territorial waters of the three East African countries sharing the lake.

Country	Area (%)	Feb – Mar 2009	Mar – Apr 2010
Tanzania	**51**	**433,927**	**282,996**
Uganda	**43**	**346,192**	**205,607**
Kenya	**6**	**48,594**	**39,566**
total	**100**	**828,713**	**528,169**

3. 6 Spatial distribution of the haplochromines and other species

The distribution of haplochromines and other unidentified group of fishes is indicated in Figure 6. Apart from a few areas Southeast (around Ukerewe islands) and around Sesse islands, higher densities (>10 t km^{-2}) of this taxa were restricted to shallow inshore areas (Fig 6).

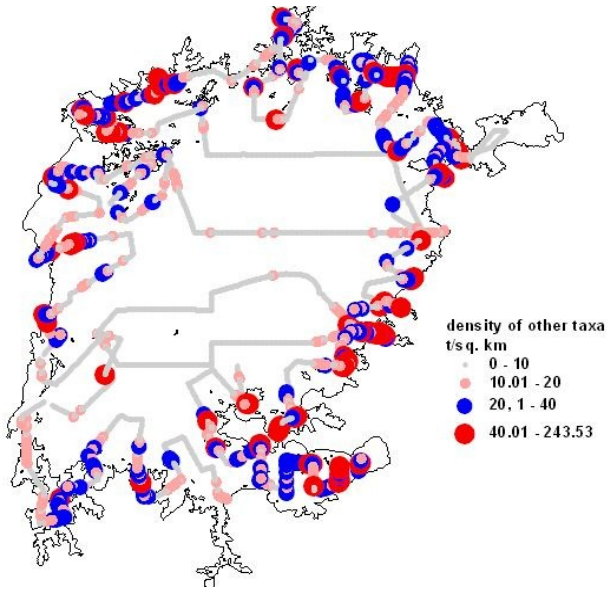

Fig 6. The density distribution of haplochromines and other species in Lake Victoria as estimated per kilometer EDSU during March - April 2010 acoustic survey

3. 7 Caridina nilotica

Tables 3.5: Estimated standing stock of *Caridina nilotica* in Lake Victoria during the Mar - April 2010 acoustic survey

		Areas (Sq. km)	Densities		Tanzania	
	Stratum	Tanzania	Tanzania	**Lower Limit**	**Biomass**	**Upper Limit**
SE	Deep	6,166	0.69	3,595	**4,232**	4,869
SE	Coastal	5,786	4.59	22,199	**26,548**	30,896
SE	Inshore	2,003	3.05	4,725	**6,107**	7,489
SE	SG	2,909	7.32	16,672	**21,304**	25,936
Sw	Deep	6,251	0.57	2,904	**3,576**	4,249
Sw	Coastal	6,601	4.29	24,806	**28,314**	31,822
Sw	Inshore	3,181	8.69	23,196	**27,638**	32,080
Sw	EP	2,022	18.32	34,037	**37,050**	40,063
				132,134	**154,770**	**177,406**
					Uganda	
NW	Deep	6,226	0.99	4,921	**6,184**	7,447
NW	Coastal	4,865	8.02	34,751	**39,018**	43,284
NW	Inshore	3,115	10.13	20,309	**31,556**	42,803
NW	SI	2,494	3.53	6,210	**8,813**	11,416
NE	Deep	4,724	3.35	11,954	**15,815**	19,676
NE	Coastal	2,704	4.67	10,359	**12,616**	14,872
NE	Inshore	3,966	11.54	30,710	**45,775**	60,841
				119,215	**159,777**	**200,339**
					Kenya	
NE	Coastal	1,082	9.96	6,934	**10,769**	14,604
NE	Inshore	1,763	8.51	12,737	**15,004**	17,272
NE	NG	1,335	3.53	3,782	**4,710**	5,637
				23,453	**30,483**	**37,513**
	Total	67,193		**274,802**	**345,030**	**415,257**

The estimated biomass of *Caridina* in the lake was **345,030 ± 70,228 tonnes**. Emin pashia Gulf recorded the highest density of *Caridina (18.32* **±** 1.49 t km^{-2}). The distribution of Caridina is similar to the distribution the major commercial fishes Nile perch and dagaa

3. 8 Net haul samples

A total of 31 net hauls were done during this survey. Since one of the hauls lasted for 1 hour and a half for some reason, then it was divided by three to bring the total number of net hauls to 33. Overall, 11 fish taxa were recorded from all the surveys. These include *Lates niloticus, Haplochromine spp, Oreochromis niloticus, Rastrineobola argentea, Barbus profoundus, Clarias gariepinus, Schilbe intermedius, Brycinus jacksonii, Brycinus sadleri, Tilapia zilli and Synodontis victoriae.* Just like the previous surveys, *Lates niloticus* dominated the catch by weight followed by Haplochromines, *Rastrineobola argentea* was third (Table 1).

Table 3.6: Catch composition

Species	%composition by weight (kg)
Lates niloticus	75.5
Haplochromines	17.3
Rastrineobola argentea	4.0
Others	3.2

3. 9 Size structure

The Length frequency distribution (by numbers) of Nile perch obtained from the March _ April 2010 acoustic survey are presented in Figure 7. Samples recorded through single target detections (blue dotted line), are plotted against those retained in net hauls (red line). Although the single target threshold is set to detect Nile perch from 10 cm upwards, while the net haul is non-selective, the two graphs are comparable overlapping close to 35 cm, TL and indicate only 1.35% and 1.59% from acoustic and nethauls respectively were above 50 cm, TL.

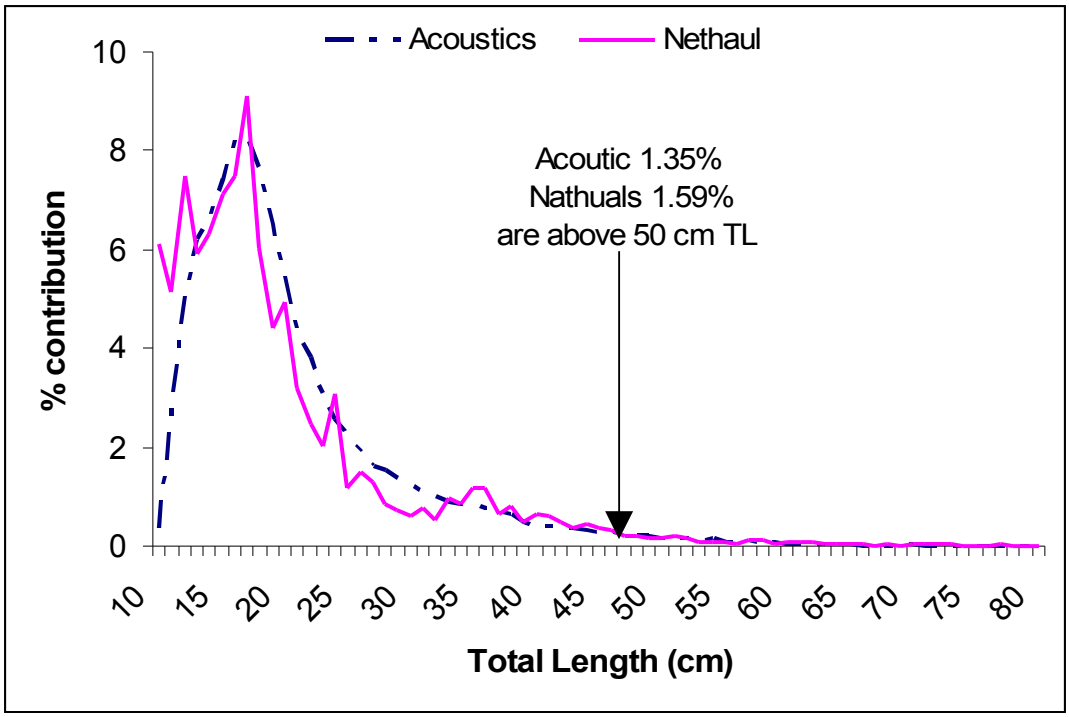

Fig. 7: Length frequency distribution of Nile perch from acoustically detected single targets and measured net haul samples

3. 10 Water quality sampling

Water sapling was done either at the beginning, middle or end of an acoustic transect in the four quadrants. The results are provided at end of this report as Appendix III. What is important to note is that this time round, serious stratification and thus anoxic conditions were observed in many areas of the lake. Dissolved Oxygen values 3ml/l (minimum value for Nile perch survival) were observed in several sampling stations (check appendix III).

4.0 Discussion

Estimated biomass of the most important commercial fish stocks in Lake Victoria, the Nile perch from the recent six surveys since August 2007 have remained fairly comparable. The lowest was recorded in August 2008, just below 250,000 t while the rest are all around 350,000 tonnes. Comparing this period to the surveys conducted from August 2005 to February 2007, there has been a 50% drop in biomass. Given the fact that the two series being compared were estimated using different echo-sounder systems, the sudden drop and stabilization after the drop casts doubt on the comparable performance of the two echo-sounder systems. Whereas the results of inter-calibration of the two echo-sounder systems conducted prior to the Feb 2009 survey detected no significant difference between integration values recorded by the two systems, results of single target diction that were not conclusive need review.

A similar snag has been to provide sufficient justification for the sudden drop from 721, 000 t to 310,000 between February and August 2007 which coincide with the period of change in the echo-sounder system. Some scientists have proposed that the drop could have been due to intense harvest of the large fish. What is not answered however is why could it have happened so suddenly and thereafter level off. It is now more than important that these issues are resolved with satisfactory explanation backed with sound scientific evidence.

Besides issues relating to equipment differences, other factors that could be contributing to the observed trends in the stocks of the major commercial fisheries range from ecological oscillations between predator (Nile perch) and prey (Haplochromines and dagaa) to efforts aimed at management of the exploitation forces.

During this survey, the team was surprised when they sampled an area around Bumbirieh channel south of Bukoba Township following a rough weather offshore and about over 2.5 tonnes, over 90% Nile perch. What could have contributed to the high concentration of fish in this small area could not easily be established. Whether it was a result of serious anoxic conditions in the open lake or violent waves it remains to be investigated in subsequent surveys.

There was a positive increase in size of fish in the population that could suggests reduced removal of the larger fishes and therefore could point to reducing pressure on the larger fishes. Observations of the fisheries marketing at the beaches across the three countries during the survey by the acoustic team witnessed continued adherence to the minimum slot size especially for the fish going onto trucks for processing factories. It was however, observed that under sized fish still found way into the market. Njiru *et al* (in press) discovered a big discrepancy between the fish landed at the beach, those loaded onto the trucks and the sizes finally processed in the factories.

Dagaa shows a stable population with consistent variation between the two periods of survey (August and February). The implication is that there is normally higher biomass of dagaa in the lake in the period of stratification compared to August mixing period. Efforts to manage the stocks of dagaa through closing the fishery during some periods of the year as had been instituted in Kenya a few years ago could look at periodic availability before selecting appropriate closed seasons. However, given that Dagaa is an annul species completing its life cycle in just one year, the estimated biomass compared to the recorded catches from CAS suggest it is underexploited. Closures like the one in Kenya will only play a role to reduce localized overexploitation although with reducing Nile perch over harvest could spread all over the lake.

Estimates of Nile perch population structure by both single target detections and measurement of specimens retained by net hauls indicate the population skewed to the juveniles. Although the single target detector is set to detect Nile perch larger than 10 cm TL, Figure 7 indicates the structure obtained from single targets and net hauls overlap about 40 cm TL. During the survey of February 2009 the overlap occurred around 30 cm, TL, this further suggests signs of increase in fish sizes in the population.

There are, however, very few fishes more that 50 cm TL (minimum legal size). The graphs reveal a population dominated with one year old fish (17 – 24 cm, TL, Taabu *et al.* 2005). Such a situation could imply a fairly adequate recruitment despite intense fishing pressure.

Management measures should therefore continue to protect the huge chunk of small fish in the population to grow to harvestable sizes. Increased exploitation simply further impairs the ability of the stock to replenish itself. Although some scientists argue that small fishes should be fished since they die naturally if not fished (LVFO conference, 2008), it is more detrimental to allow fishing using methods that target small fishes.

As far as temporal variations are concerned, there has consistently been high biomass records during surveys conducted in February (the stratification period) compared to the August when stratification breaks down. Observations of echograms during the surveys in August show fish distribution up to deeper layers of the lake while in February fish echoes only occur up to a limited depth in the water column. This situation was worse during the current survey that was conducted late in March stretching into mid April. CTD results also indicated many stations with anoxic conditions some having dissolved oxygen values to almost zero. This has made the team to suspect a possibility of extension in the severe stratification period towards April probably due to delays in onset of rains as a result of climate change.

5.0 Conclusions and recommendations

This is the 10th survey conducted under IFMP but the sixth using EK 60 software. It is important that differences recorded between the surveys conducted using EY 500 and EK 60 are resolved once and for all. There could be issues coming up after publication of most of the results these surveys relating to differences in equipment. It is recommended that the working group takes time and revisit results/experiment of inter-calibration of the two systems particularly single target component.

The current survey indicates that the Nile perch stock (biomass, size and number of mature individuals) is stabilizing with signs of imminent recovery. Reduction of the fishing efforts and self policing at community level and fish processing plants to eliminate catching of the immature fish that was instituted and continues to run across the three countries should be encouraged and supported. Intensify enforcement on illegal gears and implementation of the Regional Plan of action (RPOA) on fishing capacity to protect the stocks.

Generally fish species distribution in Lake Victoria forms aggregation in certain area as observed in areas surveyed, this makes them vulnerable to localized over exploitation by fishers. It is now necessary to survey and map critical breeding and nursery areas to curb localized over fishing. If for example the high densities recorded in Bumbeireh area were of a big spawning aggregation, could be vulnerable to over fishing if not protected.

The biomass is increasing and getting more dominated by small low value fishes. There is need to improve their handling and processing to increase their value and enhance economic gains. And further encourage some fishers to shift from Nile perch to these abundant pelagic species through efforts like species specific licensing mechanism.

Eutrophic habitats like Emin pasha, Nyanza gulf, Rosebury, and Salisbury channels had low densities of Nile perch, these areas are characterized by dense algal blooms and for the case of Nyanza gulf, presence of extensive mats of water hyacinth. Mitigations measures should be undertaken by relevant Government agencies such as NEMA/NEMC and line ministries to curb nutrient loading. Continued awareness campaigns should be encouraged and supported.

6.0 Appendices

Appendix 1: August - September 2009 Acoustic Survey Event Logsheet

Appendix 1: March - April 2010 Acoustic Survey Event Log sheet

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
19/03/10	1	DH		SW	I	0443	0506	Left Ilemera
	2	TI		SW	I	0506	0616	
	3	DH		SW	I	0616	0641	
	4	TC		SW	C	0641	0807	
	5	CTD	1	SW	C	0809	0815	
	6	DR	1	SW	C	0815	0831	
	7	DH		SW	C	0833	0920	
	8	TC		SW	C	0920	1051	
	9	TI		SW	I	1051	1200	
	10	CTD	2	SW	I	1201	1207	
	11	DR	2	SW	I	1207	1222	
	12	NB	2	SW	I	1233	1303	
	13	DH		SW	I	1315	1333	End of the day - Nyakaliro
20/03/10	14	TI		SW	I	0329	0450	
	15	TC		SW	C	0450	0657	
	16	DH		SW	C	0657	0805	
	17	CTD	3	SW	C	0808	0830	
	18	DR	3	SW	C	0830	0845	
	19	TC		SW	C	0847	1041	
	20	TI		SW	I	1041	1144	
	21	CTD	4	SW	I	1144	1158	
	22	DR	4	SW	I	1158	1213	
	23	DH		SW	I	1213	1300	
	24	NB	4	SW	I	1311	1351	
	25	DH		SW	I	1356	1416	End of the day - Dumacheri
21/03/10	26	DH		SW	I	0333	0339	
	27	TI		SW	EP	0339	0426	
	28	TI		SW	EP	0426	0507	
	29	CTD	5	SW	EP	0509	0517	
	30	DR	5	SW	EP	0517	0536	
	31	NB	5	SW	EP	0542	0612	
	32	TI		SW	EP	0623	0725	
	33	TI		SW	EP	0725	0843	
	34	TI		SW	EP	0843	1002	
	35	TI		SW	I	1002	1138	
	36	CTD	6	SW	I	1140	1149	
	37	DR	6	SW	I	1149	1205	
	38	NB	6	SW	I	1214	1246	
	39	DH		SW	I	1259	1315	End of the day Ruega Pt
22/03/2010	40	DH		SW	I	0351	0410	
	41	TI		SW	I	0410	0515	
	42	CTD	7		C	0517	0530	
	43	DR	7	SW	C	0530	0540	
	44	NP	7	SW	C	0610	0640	
	45	DH		SW	C	0649	0746	
	46	TC		SW	C	0746	0957	
	47	CTD	8	SW	C	0959	1012	
	48	DR	8	SW	C	1012	1026	
	49	NP	8	SW	C	1048	1118	
	50	DH		SW	C	1129	1138	
	51	TC		SW	C	1138	1307	
	52	DH		SW	C	1307	1404	End of day Kerebe Is.

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
23/03/10	53	DH		SW	C	0037	0211	
	54	TD		SW	D	0211	0605	
	55	CTD	9	SW	D	0608	0624	
	56	DR	9	SW	D	0624	0634	
	57	DH		SW	D	0634	0726	0648 strong mark near the lakebed
	58	TD		SE	D	0726	1115	
	59	TC		SE	C	1115	1247	
	60	TI		SE	I	1247	1400	
	61	DH		SE	I	1400	1412	End of Day Musoma
24/03/10	62	DH		SE	C	0030	0146	
	63	DH		SE	D	0146	0406	Time of event change to be checked from cruise track
	64	TD		SE	D	0406	0940	
	65	CTD	10	SE	D	0942	0958	
	66	DH		SE	D	1000	1041	
	67	TD		SW	D	1041	1428	
	68	DH		SW	C	1428	1540	End of Day Kerebe Is.
25/03/10	69	DH		SW	C	0333	0351	
	70	TC		SW	C	0351	0626	
	71	DH		SW	I	0626	0657	
	72	TI		SW	I	0657	0750	
	73	CTD	11	SW	I	0752	0802	
	74	DR	11	SW	I	0802	0813	
	75	NB	11	SW	I	0822	0854	
	76	TI		SW	I	0905	1005	
	77	DH		SW	I	1005	1030	
	78	TI		SW	I	1030	1101	
	79	CTD	12	SW	I	1103	1112	
	80	NB	12	SW	I	1120	1150	
	81	DR	12	SW		1200	1300	End of Day Bukoba
26/03/2010	Rest Day	Bukoba						
27/03/2010	82	DH		SW	I	0356	0408	
	83	TI		SW	I	0408	0507	
	84	DH		SW	C	0507	0523	
	85	TC		SW	C	0523	0815	
	86	CTD	13	NW	C	0817	0834	
	87	DR	13	NW	C	0834	0849	
	88	DH		NW	C	0850	0937	
	89	TC		NW	C	0937	1149	
	90	TI		NW	I	1149	1233	
	91	CTD	14	SW	I	1234	1244	
	92	NB	14	SW	I	1250	1321	
	93	TI	14	SW	I	1333	1407	
	94	CTD		SW	I	1409	1417	
	95	NB		SW	I	1423	1453	End of Day Rubafu
28/03/2010	96	DH		NW	I	0429	0508	
	97	TI		NW	I	0508	0629	
	98	TC		NW	C	0629	0756	
	99	CTD	15	NW	C	0758	0810	
	100	DR	15	NW	C	0810	0825	
	101	NB	15	NW	C	0835	0905	
	102	DH		NW	C	0919	0939	
	103	TC		NW	C	0939	1053	
	104	TI		NW	I	1053	1137	
	105	CTD	16	NW	I	1139	1144	
	106	DR	16	NW	I	1144	1155	
	107	NB	16	NW	I	1205	1237	
	108	DH		NW	I	1247	1320	
	109	TI		NW	I	1320	1500	End of the day Nakatiba

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
29/03/2010	110	DH		NW	SI	0300	0324	
	111	TI		NW	SI	0324	0442	
	112	DH		NW	SI	0442	0449	
	113	TI		NW	SI	0449	0541	
	114	CTD	17	NW	SI	0543	0555	
	115	DR	17	NW	SI	0555	0605	
	116	DH		NW	SI	0607	0626	
	117	TI		NW	SI	0626	0656	
	118	NB	17	NW	SI	0706	0736	BT to check strong echos at the bottom layer
	119	CTD	18		SI	0802	0818	
	120	TI		NW	SI	0819	1012	
	121	DH		NW	C	1012	1114	
	122	TC		NW	C	1114	1253	1253 reduced speed
	123	CTD	18			1312	1340	1312 stops,changing water pump's belt
	124	DR	18			1340	1420	
	125	DH				1422	1547	End of day Mpata Bay
30/03/2010	126	DH		NW	C	0037	0406	
	127	TD		NW	D	0406	0714	Separate echoes for *Barbus* and *Caridina* appear at 40 & 50 m at 0440
	128	CTD	19	NW	D	0717	0731	
	129	DR	19	NW	D	0731	0741	
	130	TD		NE	D	0741	1219	
	131	DH		NE	C	1219	1323	
	132	TI		NE	I	1323	1342	
	133	CTD	20	NE		1344	1356	
	134	DR	20	NE		1356	1406	
	135	NB	20	NE		1413	1453	
	136	DH		NE		1504	1524	End of day Karungu Bay
31/03/2010	137	DH		NE	I	0020	0110	
Kenya	138a	DH		NE	C	0110	0245	
Uganda	138b	DH		NE	C	0245	0426	
	139	CTD	21	NE	D	0428	0439	
	140	DR	21	NE	D	0439	0449	
	141	TD		NE	D	0450	0925	
	142	CTD	22	NW	D	0927	0937	
	143	DR	22	NW	D	0937	0947	
	144	TD		NW	D	0948	1226	
	145	TC		NW	C	1226	1412	
	146	DH		NW	I	1412	1425	End of day Kome Is
01/04/2010	147	DH		NW	I	0244	0252	
	148	TC		NW	C	0252	0432	
	149	DH		NW	I	0432	0454	
	150	TI		NW	SI	0454	0651	
	151	DH		NW	I	0651	0729	
	152	TI		NW	I	0729	0851	
	153	CTD	23	NW	I	0905	0913	
	154	DR	23	NW	I	0913	0925	
	155	NB	23	NW	I	0940	1010	
	156	DH		NW	I	1022	1110	
	157	TI		NW	I	1110	1237	
	158	TI		NW	I	1237	1355	
	159	CTD	24	NW	I	1356	1406	
	160	DR	24	NW	I	1406	1416	
	161	DH		NW	I	1417	1429	
	162	NB	24	NW	I	1436	1450	
	163	NB		NW	I	1516	1546	
	164	DH		NW	I	1556	1604	End of the day Entebbe
02/04/2010	165	DH		NW	I	0301	0324	

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
	166	TI		NW	I	0324	0404	
	167	DH		NW	I	0404	0420	
	168	TI		NW	I	0420	0531	
	169	CTD	25	NW	I	0533	0545	
	170	DR	25	NW	I	0545	0555	
	171	TI		NW	I	0556	0643	
	172	TI		NW	I	0643	0727	
	173	TI		NW	I	0727	0840	
	174	TI		NW	I	0840	1002	
	175	DH		NW	I	1002	1011	
	176	CTD		NE	I	1013	1019	
	177	DR	26	NE	I	1019	1029	
	178	NB	26	NE	I	1035	1105	
	179	TI		NE	I	1119	1138	End of the day Jinja
03/04/2010	Rest Day	Jinja						
04/04/2010	180	DH		NE	I	0355	0431	
	181	DH		NE	I	0431	0527	
	182	TI		NE	I	0527	0642	
	183	DH		NE	I	0642	0752	
	184	TC		NW	C	0752	0908	
	185	CTD	27	NW	C	0910	0925	
	186	DR	27	NW	C	0925	0934	
	187	DH		NW	C	0935	1045	
	188	TC		NE	C	1045	1221	
	189	CTD	28	NE	C	1223	1233	
	190	DR	28	NE	C	1233	1243	
	191	NB	28	NE	C	1258	1333	
	192	TI		NE	I	1345	1415	End of the day Kojja Bay
05/04/2010	193	DH		NE	I	0303	0334	
	194	TI		NE	I	0334	0421	
	195	DH		NE	I	0421	0508	
	196	CTD	29	NE	I	0510	0519	
	197	DR	29	NE	I	0519	0529	
	198	TI		NE	I	0530	0630	
	199	TC		NE	C	0630	0743	
	200	DH		NE	C	0743	0842	
	201	TC		NE	C	0842	0935	
	202	TI		NE	I	0935	1013	
	203	DH		NE	I	1013	1034	
	204	CTD	30	NE	I	1036	1047	
	205	DR	30	NE	I	1047	1057	
	206	NB	30	NE	I	1104	1136	
	207	TI		NE	I	1148	1223	1152-1159 and 1213-1217 power went off
	208	DH		NE	I	1223	1317	
	209	DH		NE	I	1317	1330	
	210	CTD	31	NE	I	1332	1341	
	211	DR	31	NE	I	1341	1351	
	212	NB	31	NE	I	1400	1500	End of day Port Victoria
06/04/2010	213	DH		NE	I	0328	0355	
	214	CTD	32	NE	I	0357	0406	
	215	DR	32	NE	I	0406	0421	
	216	NB	32	NE	I	0427	0457	
Ke	217	TI		NE	I	0513	0633	
Ug	218	TC		NE	C	0633	0800	
	219	DH		NE	C	0800	0917	
Ug	220a	TC		NE	C	0917	1011	
Ke	220b	TC		NE	C	1011	1120	
	221	TI		NE	I	1120	1216	
	222	DH		NE	I	1216	1223	
	223	CTD	33	NE	I	1225	1233	

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
	224	DR	33	NE	I	1233	1250	
	225	NB	33	NE	I	1259	1331	
	226	TI		NE	NG	1346	1413	End of the day Mbita
07/04/2010	227	DH		NE	NG	0258	0339	
	228	TI		NE	NG	0339	0503	
	229	DH		NE	NG	0503	0533	
	230	CTD	34	NE	NG	0535	0550	
	231	DR	34	NE	NG	0550	0600	
	232	TI		NE	NG	0601	0637	
	233	DH		NE	NG	0637	0647	
	234	CTD	35	NE	NG	0647	0655	
	235	TI		NE	NG	0657	0802	
	236	CTD	36	NE	NG	0803	0808	
	237	DR		NE	NG	0808	0828	
	238	NB		NE	NG	0835	0900	
	239	DH		NE	I	0908	0956	
	240	DH		NE	I	0956	1013	
	241	TI		NE	I	1013	1105	
	242	TI		NE	I	1105	1128	
	243	CTD	37	NE	I	1130	1141	
	244	DR	37	NE	I	1141	1156	
	245	NB	37	NE	I	1208	1308	
	246	DH		NE	I	1321	1330	End of the day Sindo
08/04/2010	247	DH		NE	I	0256	0309	
	248	TI		NE	I	0309	0400	
	249a	TC		NE	C	0400	0449	
	249b	TC		NE	C	0449	0522	
	250	DH		NE	C	0523	0551	
	251	CTD	38	NE	C	0553	0610	
	252	DR	38	NE	C	0610	0620	
	253a	TC		NE	C	0621	0655	
	253b	TC		NE	C	0655	0734	
	254	CTD	39	NE	I	0736	0748	
	255	DR	39	NE	I	0748	0758	
	256	NB	39	NE	I	0805	0905	
	257a	TC		NE	C	0918	0958	
	257b	TC		NE	C	0958	1032	
	258	DH		SE	C	1032	1101	
	259	CTD	40	SE	C	1103	1116	
	260	DR	40	SE	C	1116	1126	
	261	TC		SE	C	1127	1224	
	262	CTD	41	SE	I	1226	1235	
	263	DR	41	SE	I	1235	1245	
	264	NB	41	SE	I	1253	1323	
	265	DH		SE	I	1333	1346	End of the day Shirati
09/04/2010	266	DH		SE	I	0252	0301	
	267	TI		SE	I	0301	0336	
	268	TC		SE	C	0336	0443	
	269	DH		SE	C	0443	0512	
	270	TC		SE	C	0512	0609	
	271	TI		SE	I	0609	0652	
	272	CTD	42	SE	I	0653	0700	
	273	DR	42	SE	I	0700	0712	
	274	NB	42	SE	I	0720	0752	
	275	DH		SE	I	0802	0820	
	276	TC		SE	C	0820	0943	
	277	CTD	43	SE	C	0945	0952	
	278	DR	43	SE	C	0952	1004	
	279	DH		SE	C	1005	1040	
	280	TC		SE	C	1040	1105	
	281	DH		SE	I	1105	1115	

Date	Event No.	Activt	Stn	Quad'nt	Strat	Time Start	Time End	Remarks
	282	CTD	44	SE	I	1116	1124	
	283	DR	44	SE	I	1124	1134	
	284	NB	44	SE	I	1140	1330	
	285	DH		SE	I	1345	1400	End of the day Musoma
10/04/2010	Rest Day	Musoma						
11/04/2010	286	DH		SE	I	0340	0351	
	287	DH		SE	I	0351	0509	
	288	TI		SE	I	0509	0552	
	289	TI		SE	I	0552	0646	
	290	CTD	45	SE	I	0647	0701	
	291	DR	45	SE	I	0701	0713	
	292	TI		SE	I	0714	0756	
	293	NB	45	SE	I	0804	0835	
	294	TC		SE	C	0847	0953	
	295	DH		SE	C	0953	1025	
	296	TC		SE	C	1025	1152	
	297	DH		SE	C	1152	1200	
	298	CTD	46	SE	I	1202	1210	
	299	DR	46	SE	I	1210	1220	
	300	NB	46	SE	I	1228	1300	End of the day Burungu
12/04/2010	301	TI		SE	I	0303	0343	
	302	DH		SE	I	0343	0424	Power went off 0405:0410
	303	TI		SE	I	0424	0531	
	304	TC		SE	C	0531	0717	
	305	DH		SE	C	0717	0812	
	306	CTD	47	SE	C	0813	0839	
	307	DR	47	SE	C	0839	0849	
	308	TC		SE	C	0850	1032	Power went off 0855
	309	DH	48	SE	I	1032	1101	
	310	CTD	48	SE	I			
	311	NB	48	SE	I			
	312	DH		SE	I			End of day Ukara Is
13/04/2010	313	DH		SE	I	0321	0335	
	314	TC		SE	C	0335	0518	
	315	DH		SE	C	0518	0621	
	316	CTD	49	SE	C	0623	0637	
	317	DR	49	SE	C	0637	0652	
	318	TC		SE	C	0653	0857	
	319	DH		SE	C	0857	0915	
	320	TC		SE	C	0915	1048	
	321	CTD	50	SE	C	1050	1100	
	322	DR	50	SE	C	1100	1110	
	323	DH			I	1111	1228	
	324	NB		SE	I	1235	1407	End of day Nansio
14/04/2010	325	TI		SE	SG	0314	0439	
	326	DH		SE	SG	0439	0549	
	327	CTD	51	SE	SG	0552	0556	
	328	DR	51	SE	SG	0556	0606	
	329	TI		SE	SG	0607	0724	
	330	DH		SE	SG	0724	0826	
	331	CTD	52	SE	SG	0828	0837	
	332	DR	52	SE	SG	0837	0848	
	333	TI		SE	SG	0849	0955	
	334	DH		SE	SG	0955	1100	
	335	TI		SE	SG	1100	1140	
	336	CTD	53	SE	SG	1142	1149	
	337	DR	53	SE	SG	1149	1159	
	338	NB	53	SE	SG	1209	1240	
15/04/2010	339	TI		SE	SG	0349	0431	Nyamikoma

Appendix 2 Detailed net haul report

INTRODUCTION

Bottom trawl technique has been used concurrent with acoustics for biomass and other behavioral studies mostly to provide positive identification of recovered organisms in relation to what has been insonified by acoustics. This has enabled studies of *in-situ* measurement of target strength which compare length frequency distributions of fish retained in nethauls and acoustic single targets to be successful. Therefore, during acoustic surveys, trawling is an integral part of the acoustic surveys. Trawls are used mainly for provision of information such as species composition, distribution and size structure of insonified fish. This information is important when converting weight to length base parameters and *vice versa*.

Materials and Methods

The net hauls were done mostly in coastal and inshore waters of Lake Victoria during the March 2010 acoustic survey. The RV Lake Victoria Explorer stern trawler with propulsion power of 215 hp and length of 17 m was used. Thirty-minute net hauls were made using a bottom trawl towed at approximately 3 knots. The trawl headrope length was 24.4 m and vertical opening was 3.5 m. The cod-end was fitted with mosquito netting of 4 mm stretch mesh size to ensure retention of small fish and *caridina niloticus*. On completion of each tow the cod end was emptied into fish boxes for sorting. Catches were sorted into species and total weight of each measured using a spring balance suspended from the trawl gantry. For small samples a Salter pattern kitchen scale was used to measure the weights. Length frequency measurements based on Total Length (TL) to the nearest cm below were made for the Nile perch. In the case of small sample sizes, all fish in the haul were measured while in large samples, sub samples were drawn and lengths of fish were measured. The proportion of the sub sample weighed was used to obtain the raising factors of the frequencies of the sub sample. The data were analyzed using MS Excel and presented by quadrants (SW, NW, NE and SE).

RESULTS

Fish species composition

A total of 31 net hauls were done during this survey. Since one of the hauls lasted for 1 hour and a half for some reason, then it was divided by three to bring the total number of net hauls to 33. overall, 11 fish taxa were recorded from all the surveys. These include *Lates niloticus, Haplochromine spp, Oreochromis niloticus, Rastrineobola argentea, Barbus profoundus, Clarias gariepinus, Schilbe intermedius, Brycinus jacksonii, Brycinus sadleri, Tilapia zilli and Synodontis victoriae.* Just like the previous surveys, *Lates niloticus* dominated the catch by weight followed by Haplochromines spp., while *Rastrineobola argentea* was third (Table 1).

Table 1: Catch composition

Species	%composition by weight (kg)
Lates niloticus	75.5
Haplochromines	17.3
Rastrineobola argentea	4.0
Others	3.2

Length frequency distribution of Nile perch

The overall length distribution was multi-modal (Fig. 1) with mean length of 18.1 cm TL (s.d 10.1 cm TL). The length distribution has a broader range of lengths from 2 to 149 cm TL with some one centimeters length classes between 96 to 107 and 109 to 148 cm having no fish. Like the August 2009 survey, the overall population structure of *Lates niloticus* during the March 2010 survey shows dominance of juveniles with only 1.4% of the catch above the lower limit of slot size (50 – 85 cm).

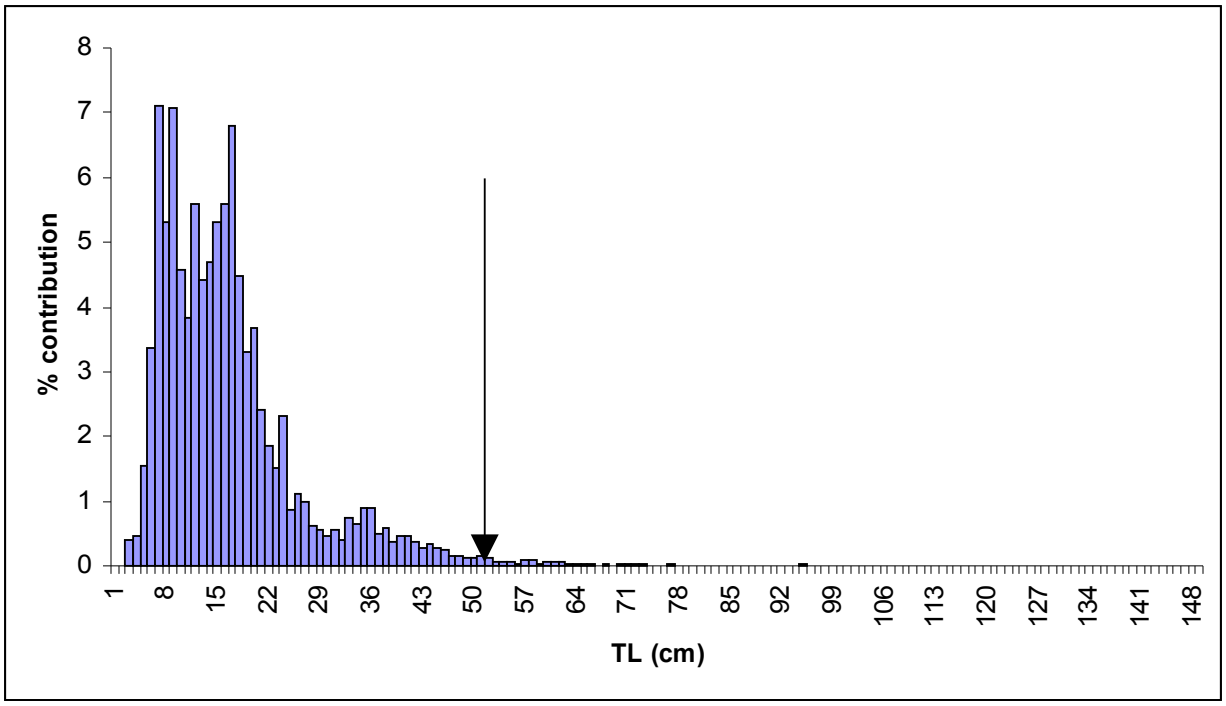

Fig 1. Size structure of *Lates niloticus* retained in nethuals during the March 2010 survey.

Length frequency distribution of *Lates niloticus* by quadrants is given in Fig 2. The four quadrants mainly constituted small sized fish similar to the overall population structure. The mean length varied from quadrant to quadrant with the highest and lowest found in SW and SE quadrants respectively. In addition, the highest and lowest percentages of fish of 50 cm TL and above were found in SW and NE quadrants respectively (Table 2).

Table.2. Size characteristics of Nile perch in the four quadrants of Lake Victoria

Quadrant	Mean Length (cm)	N	% > 50 cm
SW	34.9	552	15.6
NW	18.8	1031	0.02
NE	14.1	8414	0.01
SE	21.5	2121	0.01

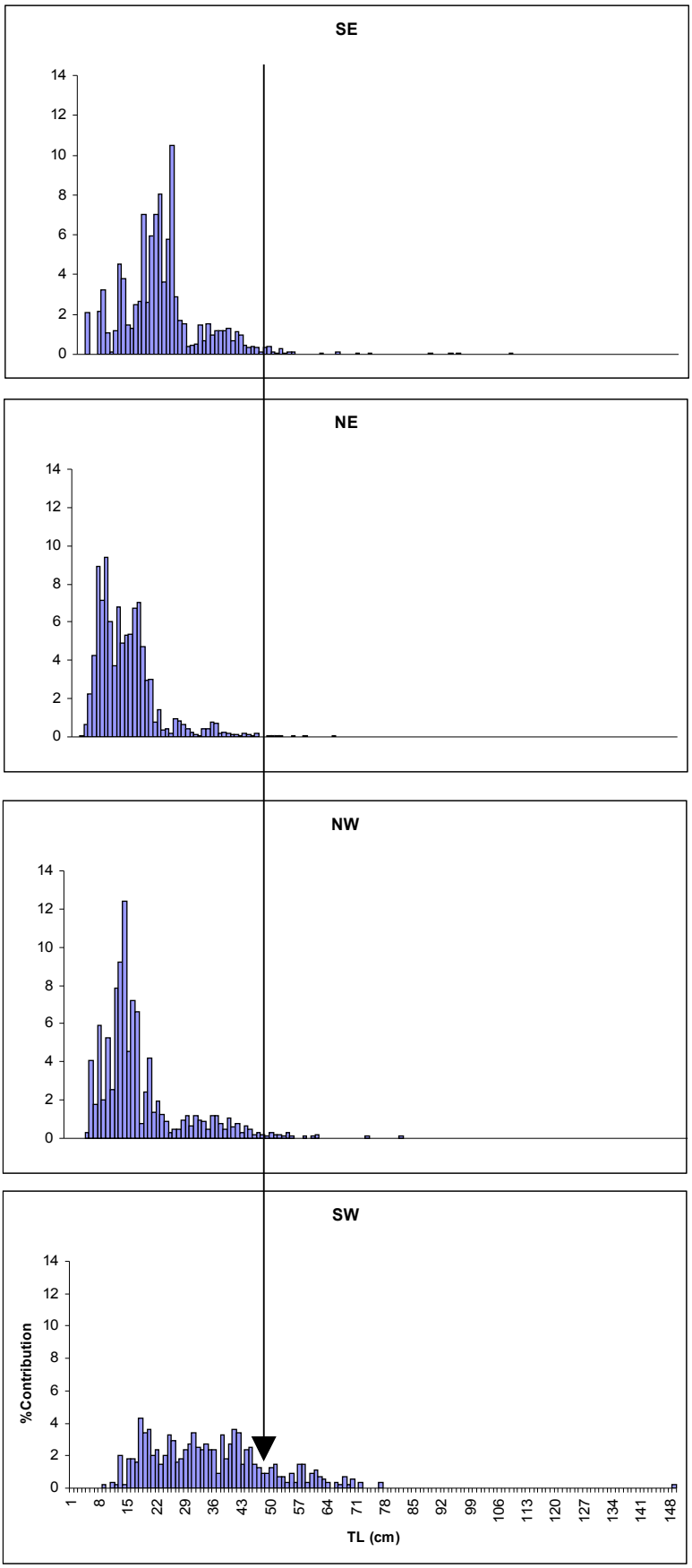
SE
NE
NW
SW
%Contribution
TL (cm)

Fig. 3: Length frequency distributions of *Lates niloticus* by quadrants

Catch rates

The overall catch rates of *Late niloticus,* Haplochromines*, Rastrineobola argentea* and others were 134.40±149.8, 30.8±11.4, 7.1±5.1 and 5.7±3.9 kilograms per 30 minutes haul respectively. The catch rates of Nile perch, *Lates niloticus* vary from quadrant to quadrant with SW and SE having the highest and lowest respectively (Table 3).

Table 3. Catch Rates (kilograms per 30 minutes haul)

	Lates niloticus	Haplochromine	*Rastrineobola argentea*	Others
SW	293.5	35.0	0.3	6.2
NW	69.3	7.7	26.2	6.9
NE	94.1	31.1	7.7	6.9
SE	57.5	38.8	5.0	3.4

DISCUSSION

We had fewer nethauls during this survey in comparison to previous survey which had a total of 40 nethauls. In addition, we encountered less species this time in comparison to the last survey. Species that were encountered during the last survey, but not encountered this time were *Protopterus aethiopicus, Synodontis afrofischeri and Afromastercembalus frenetus*. During this survey *Brycenus jacksonii* was encountered, but it was not encountered during the previous survey. The percentage composition by weight of *Lates niloticus* increased from 71.0 from previous survey to 75.5 during this survey. While that of Haplochromines decreased from 23.8 to 17.3.

The mean length has increased from 16.1 during the last survey to 18.1 cm TL during this period. Despite this increase in mean length, the percentage contribution of fish of 50 cm (lower limit of slot size) and above increased by only by 0.1% during the same periods. Like the

February 2009 and August 2009, the mean length by quadrant show similar pattern with SW quadrant having the highest with fewer numbers of individual *Lates niloticus.* The quadrant is characterized with deep waters close to the show which are highly productive. In addition, following days when the team experienced bad weather, a single 30 minute trawl in shallow inshore waters towards around Bumbireh Channel towards Bukoba recorded close to 2.5 tonnes of fish with average length 63 cm, and weight 3 kgs. This could suggest strong aggregation of stocks in the area over that period. Whether the aggregation was brought about by strong winds and rough weather characterized by virulent waves or spawning aggregations is not known.

The overall catch rates decreased from 145. 2 to 134.4 kilograms per 30 minutes haul from August 2009 to present survey. The catch rates vary from quadrant to quadrant with SW quadrant recording the highest (Table 3) during this survey. The high catch rates in the SW quadrant was due to the one haul around Bumbireh Channel mentioned above, in which at total of 2426.2 kilograms of Nile perch were recorded in 30 minutes. This has biased the total catch rates and that of SW quadrant. If this particular haul is removed from the analysis, the total catch rate of *Lates niloticus* drops by a half, while that of SW quadrant by 11 times.

Conclusion and recommendation

The strong aggregations of Nile perch stocks around Bumbireh channel observed only during this survey could not be satisfactorily explained. It is suggested that this should be further explored in subsequent surveys conducted during similar period in addition to evaluating catches from fishers around that area during the same period of the year.

Appendix 3: Detailed Environmental report