Aquatic Ecology Monitoring: Water quality, fish, fish catch, sanitation and disease vectors

Monitoring No. 17

Date: 4th – 13th September 2015

Monitoring carried out by:

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On behalf of :
Bujagali Energy Limited (BEL)

Date of Report: December 2015

1.0 BACKGROUND

Ecological monitoring survey No. 17 (4th -13th September 2015) on the Upper Victoria Nile is the eighth one to be undertaken after completion of construction of Bujagali hydropower plant in February 2012. This 250 MW installation capacity plant was commissioned seven months later. During the post construction period, eight ecological monitoring surveys have so far been conducted at the original two sampling transects Kalange-Makwanzi and Buyala-Kikubamutwe and third one (mid-reservoir) established in the mid reach (30 m deep) of the new reservoir to track any developments/changes in the water environment and aquatic biota. The aforementioned surveys have followed from two pre-construction baseline surveys in (April 2000 and April 2006, and eight monitoring surveys (September 2007, April 2008, April 2009, October 2009, April 2010, September 2010, April 2011, September 2011) during construction phase.

Quarterly monitoring surveys were scaled down to biannual monitoring at an upstream and a downstream transect of the BHPP in 2009 to fast-track water quality determinants, biology and ecology of fishes and food webs, fish stock and fish catch including economic aspects of catch and sanitation/vector studies (bilharzias and river blindness). In the post-construction monitoring surveys, the assessments of algae, zooplankton and benthic macro-invertebrates which had been dropped since April 2008 were reverted to. This report presents observations made on these above-mentioned ecological aspects of the Upper Victoria Nile and draws comparisons of the present results with those made in the previous surveys at the three transects.

2.0 GENERAL METHODOLOGY AND DATA COLLECTION

2.1. Materials and Methods

For fourteen surveys including one during September 2015, Kalange-Makwanzi and Buyala-Kikubamutwe, upstream and downstream transects respectively have been sampled for water quality, fish abundance, diversity and distribution, fish biology, fish catch, sanitation conditions, bilharzia and river blindness vectors. Due to reservoir conditions created from the dam up to beyond Kalange-Makwanzi, a third transect was created in between, from which assessment of parameters as at the upstream and downstream transects was also undertaken including assessment of algae, zooplankton and benthic macro-invertebrates.

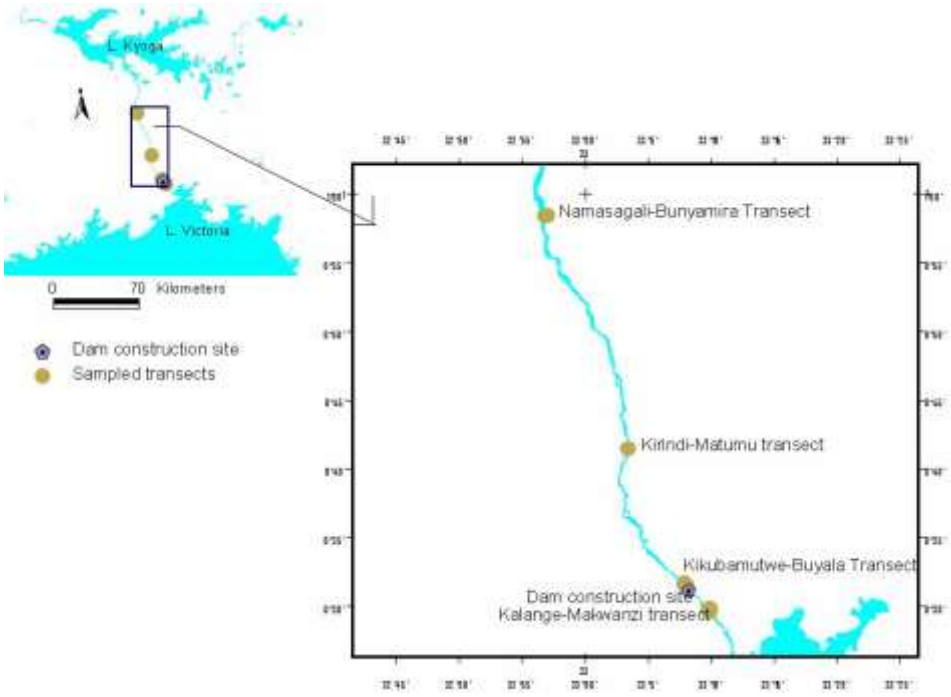

Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*



Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

Sampling, analytical procedures and techniques used in the previous surveys were followed. Sampling of zooplankton was done at designated field stations using conical plankton net of 0.25 metre mouth diameter and 60 µm mesh, towed vertically through the water column from just above the bottom sediments to the surface. Three tows taken at each sampling point were combined to make a composite sample, preserved in 4% sugar-formalin in a clean, labelled, plastic sample bottle. Species identification was done with the help of available published taxonomic keys (Boxshall & Braide, 1991; Korinek, 1999; Korovchinsky, 1992; Koste, 1978; Rutner-Kolisko, 1974) each species separately counted and recorded. Species numbers were noted and areal density estimates calculated for each station in conjunction with the diameter of the sample net and depth of sampling.

Benthic macro-invertebrates were identified and classified using keys from Merrit & Cummins 1997, Pennak 1989 and Mandahl-Barth 1954, and enumerated as mean numbers per square meter.

3.0 RESULTS

3.1 Status of Water Quality

3.1.1. Physico-chemical parameters

Table 3.1.1 *Trends in mean values of water physico-chemical parameters upstream at Kalange-Makwanzi, mid-section of the reservoir and downstream at Buyala-Kikubamutwe*

Parameter	Site	Monitoring Dates																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Apr-06	Sept. 07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Dissolved Oxygen (mg/L)	Kalange-Makwanzi	4.2	7.2	5.6	4.5	5.9	6.7	5.4	4.8	6.3	5.9	6.3	7.7	5.5	6.13	4.88	5.88	5.75
	Mid section of the Reservoir										5.2	6.4	7.02	5.3	6.27	5.47	6.06	6.78
	Buyala-Kikubamutwe	6.3	7.7	7	7.2	7.2	9.3	7.8	7.1	7.5	7.5	5.9	7.5	6.1	6.96	6.11	5.69	6.29
	NEMA Std	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
pH	Kalange-Makwanzi	7	7.3	8.2	6.7	7.6	6.8	7.1	7.4	7	8.5	7.1	7	7	7.05	7.45	7.12	7.46
	Mid section of the Reservoir										8.2	7.5	7.4	7.4	6.65	7.51	7.25	8.86
	Buyala-Kikubamutwe	7.4	7.4	7.7	6.8	7.4	7	7	7.3	7	8.2	7.4	7.17	6.9	8.59	7.71	7.24	8.01
	Upper NEMA Std	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Lower NEMA Std	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Temperature (°C)	Kalange-Makwanzi	26.7	26.1	26.2	26.4	25.7	25.6	24.8	26.4	24.9	25.3	25.9	26.85	25.2	26.56	24.64	26.24	25.91
	Mid section of the Reservoir										26.1	25.4	26.94	25.3	26.69	24.78	26.39	25.93
	Buyala-Kikubamutwe	26.4	25.7	26.9	26.8	25	25.8	25.4	26.9	26.5	26.1	25.3	27.14	25.6	27.22	24.88	26.47	26.05
	Upper NEMA Std	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Lower NEMA Std	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Conductivity (µS/cm)	Kalange-Makwanzi	103	112	81.1	95.5	96.9	87.3	100	128.6	105	92.3	90.0	101.4	110.0	100.7	98.0	99.7	101.0
	Mid section of the Reservoir										97.4	95.0	101.6	110.0	101.6	98.0	99.3	103.0
	Buyala-Kikubamutwe	88.5	114	82.8	97.6	97.7	86.1	102.4	N/D	113.7	94.8	100.0	101.5	112.0	111.9	98.6	99.4	106.7
Secchi Visibility (m)	Kalange-Makwanzi	1.9	1.6	1.9	2.2	2.2	2.3	2.2	2.2	N/D	1.5	2.1	1.72	2.03	1.71	2.37	1.26	1.83
	Mid section of the Reservoir										1.7	2.1	1.62	2.16	1.56	2.1	1.35	1.85
	Buyala-Kikubamutwe	1.7	1.8	1.8	2.5	1.9	1.9	2.1	2.5	1.3	1.4	1.5	1.63	1.77	1.59	2.34	1.25	1.9
Total Suspended Solids (mg/L)	Kalange-Makwanzi	2	2.7	4.2	7.9	3.7	3.5	2.9	3	2.4	3.1	3.3	1.92	1.78	1.2	3.33	4.13	1.22
	Mid section of the Reservoir										3.6	3.3	1.5	3.6	4.67	5.43	3.4	2.67
	Buyala-Kikubamutwe	2	4.2	3.6	5.4	3.6	3.2	2.5	4.9	4.3	3.2	2.8	1.67	3.07	2.53	4.74	2.47	1.44
	NEMA Std	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Oil & Grease (mg/L)	Kalange-Makwanzi	0.6	0.1	0.003	0.02	0.08	0.04	0.06	0.07	0.1	0.17	0.18	0.12	0.13	0.19	0.15	0.06	0.16
	Mid section of the Reservoir										0.21	0.17	0.14	0.19	0.23	0.23	0.08	0.18
	Buyala-Kikubamutwe	0.9	0.8	0.002	0.06	0.52	0.08	0.08	0.08	0.13	0.22	0.18	0.1	0.16	0.21	0.21	0.11	0.18
	NEMA Std	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

There were minimal spatial variations at all sampling sites along the transects. Mean dissolved oxygen concentrations at all sites were well above the permissible National Environment Management Authority (NEMA) lower limit of 3 mgL^{-1}, the minimum concentration required for survival of most aquatic organisms including fish.

The mean pH at all sites was in the range of 7.46 to 8.86, thus showing slight alkaline conditions especially in the mid- reservoir transenct. However, this pH range did not deviate so much when compared with those recorded in previous surveys.

At all sampled sites, average water temperatures ranged between 25.91 and 26.05 °C, and were within the permissible NEMA range of 20ºC to 35ºC.

Mean water electrical conductance was within a narrow range of 101.00 and 102.95 µS/cm whose values were within acceptable ranges recorded for unpolluted sites of Lake Victoria waters (i.e. ≤ 120 µS/cm).

During this period, water clarity was higher than what was observed in April 2015. This is attributed to inflows with less turbid waters from the surrounding landscape due to the dry spell.

Mean concentration of Total Suspended Solids (TSS) was highest (2.67 mg/L) in the mid- reservoir transect and lowest (1.22 mg/L) at the Kalange-Makwanzi transect. High concentration of TSS at the Buyala-Kikubamuttew transect compared to the Kalange-Makwanzi transect was attributed to flows from the reservoir that had the highest concentration of TSS. Despite the observed variaince, the concentration of TSS was far below the permissible NEMA standard of 100 mg/L.

The concentration of oil and grease at all sites was slightly higher (range 0.16 to 0.18 mg/L) compared to what was observed in April 2015 (range 0.06 to 0.11 mg/L) at the three sampling zone. The concentrations however,t remained far below the NEMA permissible upper limit of 10 mg/L.

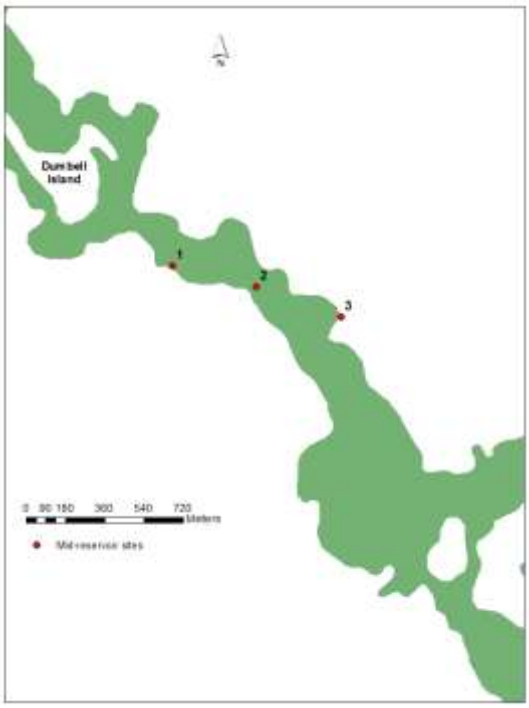

Figure 3.1.1 *Sampled points (1, 2, 3) on the section of the river where depth profiles of temperature, dissolved oxygen and conductivity were taken.* (*NB: Base map used was before dam construction*)

In the mid reservoir transect, water temperature, dissolved oxygen, pH and conductivity vertical profiles exhibited slightly reducing trends. Thus from surface to the reservoir bottom, water temperatures ranged between 25.89 and 25.96 °C, dissolved oxygen was from 6.53 to 9.21 mg/L, pH was from 8.82 to 8.89, while water conductance was in the range 99 to 110 µS/cm.

3.1.2 Nutrient (nitrogen, phosphorus and silica) concentrations in water

The concentration of ammonium-nitrogen (NH_4-N) was lowest (0.51 μg/L) in the mid-reservoir transect but highest (11.63 μg/L) in Buyala-Kikubamutwe transect Table 3.1.2). The concentrations during this survey period (September 2015) were lower than that recorded during April 2015. Despite the observed spatial variations during this survey, ammonia concentration was far below the NEMA permissible upper limit of 10,000 μg/L.

Similar trends as for NH_4-N were noted for NO_2-N and NO_3-N respectively, and with mean concentration that were far below the NEMA permissible upper limit of 20,000 μg/L. Mid-reservoir and Buyala-Kikubamutwe transects recorded the lowest and highest NO_2-N concentrations respectively.

Concentration of NO_3-N was lower at all sites during this survey period compared to what was noted during April 2015.

Mean concentration of Total Nitrogen (TN) was highest (3,651.33 μg/L) at the Kalange-Makwanzi transect and lowest (2,912.06 μg/L) in the mid reservoir transect. Concentrations remained below the NEMA permissible upper limit of 10,000 µg/L.

During this period, mean concentration of soluble reactive phosphorus (SRP) increased along the river flow i.e. lowest concentration (9.64 μg/L) at the upstream (Kalange-Makwanzi) and highest (16.05 μg/L) downstream at Buyala-Kikubamutwe transect. Concentrations at all sites were below the permissible NEMA upper limit of 5,000 µg/L.

During this period, Total Phosphorus (TP) recored was the highest since April 2006, and increased along the stream flow. Despite the observed trend, average TP concentration remained consistently below the NEMA permissible upper limit of 10,000 μg/L. The observed trend in TP concentration was likely a result of inputs from the surrounding landscape.

The concentration of Soluble Reactive Silica (SRSi) was relatively higher at the downstream transect (645.77 μg/L), while the mid-reservoir one had the lowest (588.96 μg/L). This reduction in the concentration of SRSi was attributed partly to settling of some of this nutrient in the reservoir. The outflow of bottom waters of the reservoir that were loaded with sedimented silica therefore accounted for an increase in the concentration of SRSi in the downstream transect.

The low algal biomass (Chlorophyll-a) corresponded with the relatively high water clarity during this survey compared to that of April 2015.

Table 3.1.2 *Trends in mean concentrations of nutrients and algal biomass in water at upstream, Kalange-Makwanzi, mid of the reservoir and downstream, Buyala-Kikubamutwe*

Parameter	Site	Monitoring Dates																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Apr-06	Sept. 07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Ammonium Nitrogen, NH_4-N (μg/L)	Kalange-Makwanzi	42.3	20.2	79.4	88	186	137.2	75.3	58	1.5	8.7	11.4	7.59	86.92	88.86	72.68	11.95	8.17
	Mid section of the Reservoir										10.5	4.9	7.4	81.74	45.17	36.11	13.44	0.51
	Buyala-Kikubamutwe	29.5	24	97.9	79.4	137	111.8	68.2	45.8	2	10.6	3.2	6.11	87.56	73.32	93.76	14.01	11.63
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Nitrite-Nitrogen, NO_2-N (μg/L)	Kalange-Makwanzi	8.7	9.5	4	3.1	3	4.2	7.3	4.7	2.9	5.8	2	10.6	4.53	13.35	4.94	13.55	3.01
	Mid section of the Reservoir										6.3	2.8	10.6	5.35	12.75	7.34	14.37	1.37
	Buyala-Kikubamutwe	8.7	2.8	6.1	2.6	4	5.3	4.1	4.3	4	6.6	3.8	10.46	5.08	13.35	17.52	14.98	5.83
Nitrate-Nitrogen, NO_3-N (μg/L)	Kalange-Makwanzi	12.5	36	146.3	26.4	114	120.8	47.4	36.1	46.9	55.7	20.2	44.79	79.12	74.27	63.26	46.9	9.38
	Mid section of the Reservoir										50.4	18.4	54.72	91.09	140.93	81.06	55.05	15.01
	Buyala-Kikubamutwe	12.6	94	182.5	35	76	148.6	49.2	54.7	61.2	51.5	18.6	55.38	94.65	477.8	281.05	78.55	23
	NEMA Std	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total-Nitrogen, TN (μg/L)	Kalange-Makwanzi	1174	2094	1925	306.7	2,362	1046.6	666.7	2196	1471.1	1,817.60	2,382.70	1,853.70	2,044.84	1,042.26	1,557.62	3,167.76	3,651.33
	Mid section of the Reservoir										1,606.90	4,337.30	1,335.20	394.05	1,070.04	1,266.39	3,343.18	2,912.06
	Buyala-Kikubamutwe	1193	2139	2492	216.7	2,421	2991.8	597.3	2104	2450.3	1,464.70	2,485.10	1,594.47	457.54	1,030.36	4,037.26	5,322.92	3,417.02
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Total Phosphorus, TP (μg/L)	Kalange-Makwanzi	108.6	54.5	58.5	60.3	36	186.3	84.6	30.3	32.2	65.2	106.4	48.3	50.3	46.1	29.1	50.8	113.2
	Mid section of the Reservoir										41.8	107.6	33.9	57.0	52.7	31.5	59.1	156.2
	Buyala-Kikubamutwe	100.8	48.7	76.3	47.3	45	271.9	88.8	64.1	35.6	107.7	112.0	41.1	48.5	32.7	112.7	52.7	167.5
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Soluble Reactive Phosphorus, SRP (μg/L)	Kalange-Makwanzi	19	24.2	11.7	6.9	27	15.7	21.1	31.6	9.8	6.4	20.0	12.7	11.2	12.2	14.0	10.5	9.6
	Mid section of the Reservoir										7	17.6	12.7	10.6	18.9	15.8	11.4	11.4
	Buyala-Kikubamutwe	19.2	27.7	18.9	16.6	32	24.8	25.6	20	11.7	6.6	21.4	12.7	15.6	14.0	42.0	9.5	16.1
	NEMA Std	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Soluble Reactive Silica, SRSi (μg/L)	Kalange-Makwanzi	319.9	539.7	238.4	501.2	859	521.1	265.9	149.6	23.8	176.8	146.9	309.4	406.14	408.24	783.08	410.31	629.96
	Mid section of the Reservoir										268.1	268.5	256.8	458.77	396.38	803.5	379.63	588.96
	Buyala-Kikubamutwe	309.4	530.7	282.8	496.7	847	521.7	201.5	68.8	43.8	248.1	244.6	238.8	432.46	369.38	239.73	401.65	645.77
Chlorophyll-a (µg/L)	Kalange-Makwanzi										5.1	6.3	10.2	12.51	10.01	4.32	7.26	3.55
	Mid section of the Reservoir										5.6	10.1	5.6	13.44	4.26	5.1	8.03	1.44
	Buyala-Kikubamutwe										6	9.7	6	9.27	5.37	13.9	5.87	2.67

3.1.3 Algae and aquatic macrophytes/weeds

Table 3.1.3 *Occurrence of major algal types and the number of species at the three sites, September 2012, April 2013, September 2013, September 2014, April 2015 and September 2015*

Major algal Taxonomic groups	Kalange-Makwanzi							Mid section of the Reservoir							Buyala-Kikubamutwe						
	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015
Bluegreen (Cyanopytes)	9	15	12	14	12	14	11	20	14	14	16	9	19	11	19	18	12	15	14	20	14
Green (Chlorophytes)	4	8	6	4	6	6	9	8	7	6	5	7	11	12	7	7	7	5	3	5	8
Diatoms (Bacillariophytes)	4	4	5	2	6	6	2	3	2	3	4	2	6	3	2	5	3	4	2	5	3
Euglenophytes	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0				
Dinoflagellates	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0				
Total number of species	**17**	**27**	**23**	**20**	**24**	**26**	**22**	**25**	**30**	**23**	**25**	**18**	**36**	**27**	**30**	**30**	**22**	**24**	**19**	**30**	**25**

The major taxonomic groups did not differ from what was observed in April and September 2014 (Table 3.1.3). However, species composition and their numbers varied greatly from what was noted in especially in September 2014 e.g. at all transects, the total number of species increased i.e. at the upstream, the increase

was from 24 to 26 species; in the mid- reservoir, algal species increased from 18 to 36; while at the downstream transect, species numbers increased from 19 to 30.

At all transects, blue-green algae were the dominant type and constituted 54% at the upstream, 53% in the mid reservoir, and 67% at the downstream transects (Table 3.1.3). Major taxa encountered were the blue-greens (Cyanophyta), greens (Chlorophyta) and the diatoms (Bacillariophyta).

Table 3.1.4 *Major Algal types and species composition at the three sites, September 2012 to September 2015 (P denotes presence).*

Major algal Taxonomic groups	Kalunga-Makwasi							Mid section of the Reservoir							Buyalo-Kikobamutwe						
	Sept 2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015	Sept 2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015	Sept 2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015
Bluegreens (Cyanophyta)	9	15	12	14	12	14	11	20	14	14	18	9	10	11	10	18	12	13	14	20	14
Greens (Chlorophyta)	4	8	6	4	6	6	9	8	7	6	8	7	11	12	7	7	7	8	6	5	8
Diatoms (Bacillariophyta)	4	3	7	2	6	6	2	9	3	5	2	3	6	3	3	7	3	6	2	5	5
Euglenophytes	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0				
Dinoflagellates	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0				
Total number of species	**17**	**27**	**25**	**20**	**24**	**26**	**22**	**28**	**30**	**25**	**28**	**18**	**36**	**27**	**30**	**30**	**22**	**24**	**19**	**30**	**28**

Major algal types/species	Kalunga-Makwasi							Mid section of the Reservoir							Buyalo-Kikobamutwe						
	Sept2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015	Sept2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015	Sept2012	Apr 2013	Sept 2013	Apr 2014	Sept 2014	Apr 2015	Sept 2015
Bluegreens (Cyanophyta)																					
Planktothrix limnetica		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
P. rubescens			P	P		P	P	P	P	P	P	P	P		P		P	P		P	
P. undulata								P		P					P						
P. contorta								P	P												
P. cryomerensis		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Aphanocapsa sp	P							P				P	P	P	P				P	P	P
Aphanocapsa nubilum		P		P	P	P	P		P		P	P	P	P		P		P	P	P	P
Aphanocapsa holsatica		P							P		P	P	P	P							
Aphanocapsa delicatissima			P	P	P		P			P	P		P		P	P		P	P	P	P
Aphanocapsa incerta			P	P	P	P			P	P		P	P		P		P		P	P	
Aphanocapsa holsatica	P			P											P	P		P		P	
Aphanocapsa delicatissima	P	P	P	P	P	P	P	P	P	P	P		P		P	P	P	P	P	P	P
Aphanocapsa elegans						P															
Cylindrospermopsis africana		P	P					P	P				P		P					P	
Cylindrospermopsis raciborskii								P													
Merismopedia tenuissima	P	P	P	P		P	P	P	P	P	P	P	P	P	P		P	P	P	P	P
Merismopedia glauca	P	P			P	P		P			P		P	P	P	P				P	P
Merismopedia elegans		P							P							P				P	
Microcystis flos-aquea													P								P
Microcystis aeruginosa		P		P					P		P		P			P		P	P		P
Pseudanabaena					P			P			P					P		P			
Chroococcus sp						P														P	
Chroococcus limnetica	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P		P	P	P	P
Chroococcus minutus						P	P						P							P	P
Chroococcus turgidus	P							P													
Chroococcus aphanocapsoides			P							P					P						
Chroococcus elegans				P		P	P					P	P	P	P		P				P
Cyanodictyon sp		P							P							P					
Coelosphaerium kuetzingianum				P		P	P		P	P	P			P				P	P		
Centronema sp (triquetra)	P		P		P			P			P		P	P					P	P	P
Anabaenopsis taylorii	P	P			P					P					P	P	P	P	P	P	
Anabaena constricta										P					P						
Anabaena flos-aquae		P							P												
Anabaena circinalis		P	P	P	P			P	P	P	P					P	P	P			
Nomea sp													P				P			P	
Pico filum								P													
Greens (Chlorophyta)																					
Actinastrum hantzschii									P				P					P	P		
Ankistrodesmus falcatus		P				P		P			P	P									
Ankistrodesmus falcatus	P	P	P	P	P	P	P			P	P	P	P	P	P	P	P	P		P	P
Ankistrodesmus stipitatus								P					P	P							
Monoraphidium contortum			P	P	P	P		P		P			P		P		P	P		P	P
Chodatella sp	P					P	P						P	P			P				P
Crucigenia fenestrata							P									P					
Kirchneriella obesa (subsolitaria)		P	P	P	P	P	P		P	P	P		P	P		P	P			P	P
Monoraphidium contortum		P					P		P		P			P		P					
Cosmarium sp							P	P							P						
Closterium spp (acerosum)			P	P			P		P	P						P	P		P		P
Closterium aciculare					P																
Closterium spp					P		P							P							
Staurastrum sp (cuspidatum) gracile, cingulum		P		P				P	P		P	P	W		P						
Pediastrum simplex		P	P										P			P	P				
Pediastrum duplex								P						P	P						
Scenedesmus acuminatus	P				P			P		P		P	P								P
Scenedesmus perforatus		P				P			P	P			P	P		P	P	P	P	P	
Scenedesmus serratus															P						
Scenedesmus cuitus	P														P	P					
Selenastrum gonulata			P																		
Didymocystis tuberculata														P							
Dictyosphaerium spp													P					P			
Oocystis solitaria												P									
Oocystis borgi (algae)									P					P							P
Coelastrum microporum (proboscideum)												P									P
Tetraedron trigonum							P		P			P		P							
Diatoms (Bacillariophyta)																					
Navicula gastrum, platycephala			P		P	PP			P	P			P		P	P	P		P	P	P
Nitzschia spatula (gastrum)		P				P			P		P		P					P		P	P
Navicula accularis	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P		P
Rhizosolenia eriensis	P														P						
Navicula formicula		P	P		P	P		P	P		P		P	P	P	P				P	
Synedra cunningtonii	P	P	P	P	P				P	P	P		P		P	P	P	P			
Cyclotephanodiscus spp			P		P	P	P					P		P				P		P	
Aulacoseira granulata					P								P							P	
Cyclotella sp	P							P							P						
Euglenophytes																					
Euglena acus								P													
Phacus sp															P						
Dinoflagellates																					
Gleodinium sp	P																				
Ceratium spp														P							

Algal wet biomass (Figure 3.1.1) varied according to taxa and among the three transects. Wet algal biomass was dominated by bluegreens, with the highest at the downstream transect and lowest in the reservoir. Green algal wet biomass was highest in the reservoir (151.2 µg/L) and least at the upstream transect (79.0 µg/L), hence the reservoir and downstream transects had relatively similar algal wet biomass. Wet biomass for diatoms was highest at the downstream transect (45.6 µg/L) and lowest at the upstream transect (23.7 µg/L). The relatively higher wet biomass for bluegreen algae at the downstream transect was attributed to the direct outflow from the reservoir, while the relatively similar and high wet biomass for green algae in the reservoir was attributed to the long residence time of the water in this reservoir compared to that in the riverine environment with very low residence time.

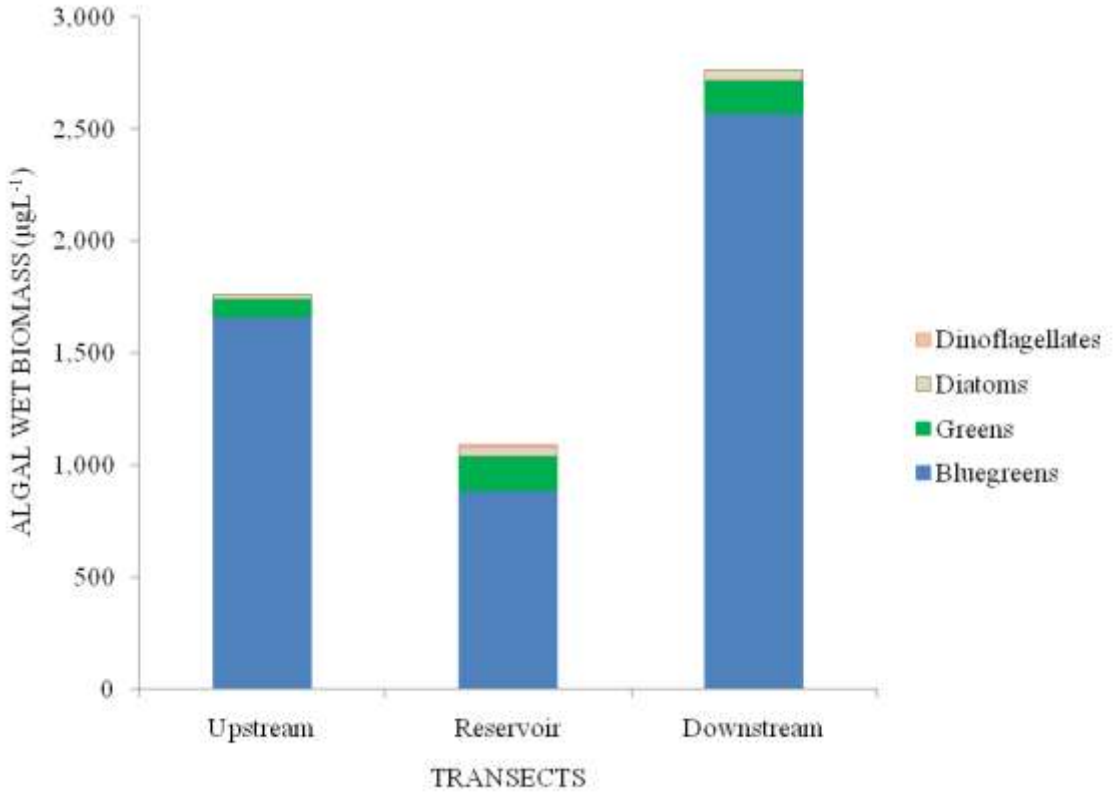

Figure 3.1.1 *Algal wet biomass by major taxa in the transects*

Aquatic macrophytes

The major aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), Hippo grass (*Vossia cuspidata*), Duckweed (*Lemna minor*), Water primrose (*Ludwigia* spp.) and Cattail (*Typha* spp.). Other than water hyacinth whose cover abundance had increased to some extent, the rest of the macrophytes were still not well established along the banks of the reservoir.

At the upstream transect (Kalange-Makwanzi), water hyacinth dominated the shores covered approximately 3.06 ha (or 59.1%). Other macrophytes associated with water hyacinth along the upstream transect were Hippo grass (*V. cuspidata*) which covered ~ 1.5 ha (or 28%), Water primrose with a cover abundance of 0.63 ha (or 12.2%), Cattail (*Typha* spp) with a cover abundance of 0.2 ha (or 0.3%) and reeds (*Phragmites* spp) with a cover abundance of 0.02 ha (or 0.4%). Other macrophytes with insignificant occurrence (i.e. < 0.01 ha) at the upstream transect were Nile Cabbage (*Pistia stratiotes*), sedges and Duck weeds (*Lemna* spp.).

At the downstream transect (Buyala-Kikubamutwe), much of the river bank (> 60%) had been cultivated down to the highest water level, and trees such as eucalyptus had been grown thus leaving little room for establishment of aquatic macrophytes. This transect was dominated by *V. cuspidata* whose cover abundance had reduced from ~ 5.5 ha in April 2015 to 0.76 ha (or 42.3%) during this survey; this significant reduction was attributed to harvesting by local people who feed it to their cattle. Water hyacinth cover abundance had also reduced from ~7 ha in April 2015 to 0.75 ha (or 41.8%) during this survey.The rest of the macrophytes were of insignificant (i.e. < 0.01 ha) occurrence and included *Typha* spp, *Ludwigia* sp. and *Phragmites* spp.

At the mid-reservoir transect, there was a void of most of the common aquatic macrophytes. The dominant macrophyte was water hyacinth and covered approximately 3.8 ha (or 87.2%) down from 8 ha in April 2015. *Vossia cuspidata* covered approximately 0.3 ha, and Ludwigia spp approximately 0.2 ha. Kyabiirwa was almost clear of any aquatic macrophytes except some water hyacinths that covered ~0.2 ha. Until this survey, aquatic macrophytes were not yet established.

3.2 Zooplankton (Water column micro-invertebrates)

Species diversity and distribution trends

The zooplankton community composition remained comparable with earlier observations made in April 2006, April 2012, September 2012, April 2013, September 2013, April 2014 and September 2014, April 2015 (Table 3.2.1). Copepod species were evenly distributed across the three study sites and this observation was comparable to the one recorded during the April 2015 survey. However, copepod species richness appeared to have decreased markedly from an average of 8 species in April 2015 to 4-5 species in September 2015. Cladoceran species were also quite comparable across the study sites but the downstream site indicated a marked increase from 1 to 4 species between April and September 2015. Rotiferan species were highest at the upstream site and decreased through the reservoir area to the downstream site; a trend similar to that of the previous survey, although species richness did not indicate much variation. Total species numbers across the study sites did not show much variation, compared to the April 2015 survey that showed much lower richness number downstream of the dam.

Table 3.2.1. *Trends in numerical abundance (ind. m^{-2}) and diversity of zooplankton species at three monitoring sites of BEL*

Taxa	Species	Kalange-Makwani									Mid section of the Reservoir								Buyala-Kikabamutwe								
		Apr-09	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-09	Sep-09	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-09	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Copepoda	*Thermocyclops incisus*		35		188		404		358		500				878	195	808	188	54	49			448	135		188	225
	Mesocyclops sp.	555	217	173	359	339	472		696		225	63	595	45	1,752	135	1,033		77	361		55	98			539	
	Thermocyclops emini	1,213	222	94	1,123	229	606	404	449			259	2,403	1,819	741		2,000		22	208			188			90	
	Tropocyclops confinis	2,458	402	582	3,448	1,702	9,791	741	2,448	2,248	1,021	660	7,087	7,223	4,448	5,256	3,270	538	177	985	356	1,600	1,412	1,038	404	472	292
	Thermodiaptomus galeboides	3,649	1,586	550	1,755	871	3,705	2,268	6,310	5,126	857	1,218	4,087	3,208	4,514	3,166	9,500	3,862	423	1,158	451	1,077	854	1,281		1,819	1,944
	Thermocyclops neglectus	6,886	3,648	1,258	7,204	5,259	9,364	2,829	7,523	9,342	2,835	1,877	6,160	8,958	15,002	4,287	3,274	1,707	197	1,218	906	343	1,392	1,324		90	1,875
	Harpacticoida						357							22										28			
	Tropocyclops tenellus	8,585	4,490	1,356	11,497	11,497	14,574	4,491	10,552	5,862	4,871	702	11,147	12,279	8,892	7,165	8,560	3,775	1,201	5,837	802	5,616	3,133	4,660	1,886	1,213	4,876
	Cyclopoid copepodite	46,138	13,684	20,749	55,645	19,959	108,719	20,233	128,110	47,696	17,788	14,194	72,754	72,754	49,111	73,183	132,471	36,819	8,449	8,482	12,214	19,679	23,348	20,567	19,671	69,478	12,710
	Calanoid copepodites	6,808	1,401	1,808	4,458	1,385	10,010	4,267	6,018	4,671	2,843	3,122	9,234	7,731	4,244	3,952	8,827	2,066	551	1,724	859	2,487	595	2,964	741	2,887	2,178
	Nauplius larvae	109,016	56,689	17,165	133,662	72,862	254,935	96,515	148,859	166,421	72,896	34,108	229,029	142,430	202,539	126,879	198,217	116,006	27,844	25,701	12,670	99,548	48,702	161,277	48,459	85,962	69,321
Total copepods		**184,509**	**82,322**	**43,715**	**195,801**	**114,023**	**513,765**	**131,748**	**311,124**	**239,558**	**103,614**	**54,463**	**342,496**	**254,341**	**290,117**	**236,236**	**365,998**	**164,152**	**38,975**	**45,829**	**28,258**	**130,423**	**80,346**	**193,194**	**71,161**	**161,840**	**91,723**
Total copepod species		**6**	**7**	**6**	**7**	**6**	**8**	**5**	**7**	**4**	**6**	**6**	**7**	**7**	**7**	**8**	**7**	**5**	**7**	**7**	**4**	**5**	**7**	**6**	**2**	**7**	**5**
Cladocera	*Daphnia lumholtzi*															67			9								
	Daphnia longispina		42																								
	Macrothrix sp.																		20								
	Chydorid sp.	29									42								7	37							
	Daphnia lumholtzi (helm.)	243	23		108			67			14		38	58		67			17					67			112
	Ceriodaphnia cornuta	58	23	65	1,118	808	2,223	448	2280	1886	147	101	584	584	1,087	1,011	1,729	90		203	89	45	79	85	427		
	Diaphanosoma excisum	287	462		1,292	382	135	112	1078	988	287	94	921	682	2,358	384	1,180	180		190	73	674	257	337			112
	Moina micrura	679	391	65	1,854	90	808	1,906	943	988	487	118	932	659	808	1,055	1,037		28	227	31	67	31				112
	Bosmina longirostris	858	254	31	444	806	180	1,548	427	1,347	330	212	584	1,329	269	1,382	1,028	448	213	219	110		528	28		516	112
Total cladocerans		**2,155**	**1,165**	**157**	**4,896**	**3,886**	**3,346**	**4,086**	**4,738**	**5,209**	**1,327**	**605**	**3,037**	**3,313**	**4,520**	**4,086**	**4,894**	**719**	**294**	**976**	**303**	**786**	**1,195**	**535**	**427**	**516**	**448**
Total cladoceran species		**6**	**6**	**3**	**5**	**4**	**4**	**4**	**4**	**4**	**6**	**4**	**5**	**5**	**4**	**6**	**4**	**3**	**6**	**5**	**4**	**3**	**4**	**4**	**1**	**1**	**4**
Rotifera	*Asplanchna sp.*							155			22	55		55													
	Accomorphus sp.							674			42	24											135				
	Euclanis sp.	19		16		108				188	28	24	225	247						14		90					
	Brachionus falcatus				45	584			90		33		90				67		11								
	Filinia longiseta	116	23		284				449	629	42	16	797	269			472					252					
	Polyarthra sp.	334						269				79		79		225	269								427	808	
	Filinia opoliensis	19	37		145		202	155	269	359	180	59	712		741						16	225		67			
	Brachionus falcatus																										124
	Brachionus forficula				135		90							168													
	Brachionus bidentatus							269					34														
	Brachionus calyciflorus	385	18	79			180			898	14	59		539		516		188	68	37		135			269	584	
	Keratella cochlearis	173	74			269			1055		184	24	258	787	202	1,437	1437		30	85	16		404		314	2223	225
	Trichocerca cylindrica	105	92	267		204			539		330	487	292	1,219	806	3,705		269	13		168	202			674	629	
	Brachionus angularis	213	48		90	494	719	898	674	898	184	51		319	404	2,368		3,527	85	97	151		79	1,078	1,280		810
	Hexarthra sp.				45			67					67				135										
	Lecane bulla	289	379	534	855	1,785	1,033	3,456	2,785	539	732	489	2,439	2,558	2,088	2,133	5,223	1,168	79	166	419	337	1,960		427	2,784	
	Lecane luna					539	449	472	90				1,880	607	404	741						269	808				108
	Synchaeta sp.	617	387	550	853	849		943	4963	359	644	487	1,758	1,072	876		6333	2915	42	291	634	748	965	915		4850	674
	Keratella tropica	581	240	546	1,506	849	5,142	988	4,758	3,595	752	330	3,734	1,278	2,156		5,915	2,425	659	647	546	1,014	698	2,457	449	4,087	898
Total rotifers		**2,485**	**1,496**	**1,792**	**3,918**	**5,053**	**7,815**	**8,219**	**15,719**	**7,565**	**3,150**	**2,068**	**12,286**	**9,156**	**7,477**	**11,025**	**19,851**	**8,084**	**997**	**1,335**	**1,730**	**3,475**	**3,989**	**4,537**	**3,840**	**18,885**	**2,707**
Total rotiferan species		**11**	**9**	**6**	**9**	**9**	**7**	**9**	**11**	**8**	**13**	**13**	**12**	**13**	**8**	**6**	**8**	**6**	**8**	**7**	**7**	**9**	**7**	**4**	**6**	**7**	**6**
Total abundance		**189,149**	**84,983**	**45,664**	**204,615**	**128,962**	**524,926**	**174,053**	**331,581**	**252,332**	**108,091**	**57,136**	**357,729**	**266,810**	**301,914**	**231,247**	**390,743**	**172,955**	**40,266**	**48,140**	**30,291**	**134,684**	**85,530**	**198,246**	**75,428**	**181,241**	**94,876**

Abundance patterns

Two copepod species: *Mesocyclops sp.* and *Thermocyclops emini* were missing during the September 2015 survey. The remaining species except *T. incisus* were recovered at all the three study sites. This trend was comparable to that of April 2015. Copepoda numerical abundance decreased from ca 20,500 upstream to ca 7,500 downstream of the dam. Copepod developmental stages (copepodites and naupliar larvae) indicated a similar trend although with much higher density estimates (i.e. 218,988 and 84,209 ind. m^{-2} respectively). Both these trends were comparable to those of April 2015.

Three cladoceran species: Chydorids, *Daphnia longispina, D. lumholtzi* and *Macrothrix* sp. were not encountered during the present survey while the remaining taxa occurred intermittently and in relatively low densities (100-1800 ind. m^{-2}). Higher cladoceran density was recorded at the mid-reservoir transect. Records of the April 2015 survey indicate similar trends.

Rotiferan species richness in the present survey was relatively low (6-8 species) compared to the previous survey (7-11). The encountered species occurred rather intermittently except *Brachionus*

angularis, Keratella tropica and *Synchaeta* sp., which were recovered in all the study sites. These widely spread rotiferan species were nearly the same as those observed in the previous survey. As a general trend, rotifer total abundances were lower (2,706-8,084 ind. m^{-2}) than levels observed in the April 2015 survey (15,719-19,851 ind. m^{-2}).

Discussion

The community composition data for April and September 2015 indicates occurrence of nearly the same zooplankton species belonging to three taxonomic categories (Copepoda, Cladocera and Rotifera). As observed in the previous survey, the species assemblage has not changed significantly for the last five years and there is close resemblance of the assemblage with that of Lake Victoria, which is the ultimate source of the River Nile water. The general similarity of the zooplankton composition over the past surveys including pre-and post-reservoir eras suggests that community composition has remained remarkably stable following and after creation of the hydropower dam and reservoir. Stability of biological communities especially those that include biological indicators of water quality, such as zooplankton, suggests corresponding stability of environment conditions over the different phases of the hydropower construction at Bujagali.
In Lake Victoria, the zooplankton assemblage has been shown to have changed since the 1960s when sizeable proportions of large-bodied members (calanoids and cladocerans) used to be the distinctive feature of the community. This status has now changed to give way to dominance of the community by medium-sized cyclopoid copepods (Mwebaza-Ndawula 1994). Such shift may be caused by a combination of environmental drivers including changes in water quality parameters and fish community probably favouring higher, size-selective planktivory. As zooplankton have been reported to provide over 70% of the diet of the pelagic *Rastrineobola argentea* in Lake Victoria (Mwebaza-Ndawula 1998), the observed occurrence of these fish food organisms in relatively high abundance (>100,000 ind. m^{-2}) at the investigated sites implies potential for the pelagic fishery in the study area, notwithstanding the generally lower density estimates during the April surveys. The latter may be due to possible seasonal variations of the community in this part of the river. The trend of lower zooplankton numerical abundance downstream of the dam (Table 3.2.1) has been consistent since 2012 through 2013 and 2014 to 2015. This observation is in contrast to the one reported by Zarfdiian *et al.* (2000) in River Aliakmon in Greece who observed much higher zooplankton abundance in a downstream site, probably due to different environmental conditions from those obtaining at BEL dam area. The consistency of this pattern of zooplankton abundance distribution over a period of four years, may suggest possible community response at the downstream site of the dam.

In contrast to the April 2015 data that showed dominance of the copepod community by two small-bodied cyclopoid species, the present data indicates co-dominance of four species: *Tropocyclops confinnis, Tropocyclops tenellus, Thermocyclops neglectus* and *Thermodiaptomus galboides* (Table 3.2.1), suggesting temporal variation in some environmental drivers of the zooplankton community. Notably, the present data confirms earlier observations of a rotifer-driven species richness and numerical superiority of copepods (Table 3.2.1). This observation explains the dominance of copepods in the diet of the pelagic and commercially important mukene (*Rastrineobola argentea*) in Lake Victoria (Mwebaza-Ndawula 1998). The higher zooplankton abundance in the upstream sand reservoir areas (Table 3.2.1) suggests higher potential of these sites for fish production relative to the downstream site.

It is clear that zooplankton community abundance is heavily dependent on copepods especially, Cyclopoid copepods. The most contributing copepod species and groups have remained the same over the survey years, namely *Tropocyclops tenellus, T. confinnis* and this time round jointly with *T. neglectus* and *T. galboides*. The juvenile stages of Copepoda i.e. copepodites and nauplius larvae have remained the most abundant entities of the zooplankton community and this consistent

pattern for the last five years defines their unsurpassed ecological importance in the upper Victoria Nile system.

3.3 Benthic macro-invertebrates

Table 3.3.1 *Trends of benthic density and number of species of macroinvertebrates at upstream-Kalange-Makwanzi, mid-section of the reservoir and downstream, Buyala-Kikubamutwe*

Taxa	Species	Kalange-Makwanzi										Mid section of the Reservoir								Buyala-Kikubamutwe									
		Apr-06	Sep-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-06	Sep-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Gastropoda (Water snails)	*Bellamya unicolor*	33	173	5	33			289	0	0	0	0			4	154	23	23	14	98	98	126	11	42	65	285	14	296	47	579	9
	Melanoides tuberculata	28	187	257	14	19	5	19	0	0	14	0			77	5	33	9	145	35	33	224	189	121	33	33	9	5	0	42	14
	Biomphalaria choanomphala		14	5				9	0	0	5	0	2			7	9	0	23	0		19	11		5			25	5	23	5
	Antrus natalensis								0	0	0	0						0	0	0				5					0	0	0
	Gyraulus sp.				5				0	0	0	0					5	0	0	0						47			0	0	0
	Segmentorbis sp.								0	0	0	0		3				0	0	0				47	9	23			0	0	0
	Gabbia humerosa		78	5			5	23	0	0	0	0			4	5		0	42	0			121	1,027	877	132		33	9	42	0
	Bulinus sp.	5	9	5					0	0	0	0				12	5	0	0	0	5	5	5		19	65			0	0	0
	Choanomphala			14					0	0	0	0	2		4			0	0	0		19	11		5	9	5		0	0	0
	Pila ovata		5	5					0	0	0	0	7					0	0	0			5			5			0	0	0
Total Gastropoda density		**66**	**387**	**286**	**52**	**19**	**10**	**550**	**0**	**0**	**19**	**0**	**11**	**3**	**89**	**183**	**75**	**52**	**224**	**133**	**136**	**393**	**264**	**1242**	**813**	**602**	**28**	**359**	**61**	**686**	**28**
Number of Gastropod species		**3**	**6**	**6**	**3**	**1**	**2**	**4**	**0**	**0**	**2**	**0**	**2**	**1**	**4**	**5**	**5**	**2**	**4**	**2**	**3**	**4**	**6**	**5**	**6**	**8**	**3**	**4**	**3**	**4**	**3**
Bivalvia (Clams/mussels)	*Byssanodonta parasitica*	79	345	252	81	75	42	121	34	0	9	0	23	93	686	380	159	28	70	58		19	63	317	8	117	733	801	203	75	149
	Corbicula africana	56	126	182	47	219	514	98	222	19	145	9	5	25	196	44	47	140	481	7	65	131	203	85	28	59	56	381	128	128	93
	Caelatura sp.	149	93	229	79	79	47		124	9	84	47	9	28	28	23	23	23	5	58	37	61	63	37	3	3	47	44	51	28	75
	Pisidium victoriae		5			9				0	0	0						0	0	0				52	19	5			0	0	0
	Muscle sp.				5	5			7	0	0	7						0	0	0	5	5	16						0	0	0
	Sphaerium victoriae	5	51	14					14	0	9	0	2			2		5	14	0		19		23			5	14	81	23	5
	Sphaerium stuhlmanni				9			9		0	0	0	5	146	18	2		0	0	7				9	5				0	0	9
	Aspatharia sp.	9	9	5	5	5	5		5	0	14	0					5	0	5	0	5								0	5	0
	Iberus elliptica									0	0	0						0	14	7			5	5					0	0	0
Total Bivalvia density		**298**	**629**	**682**	**206**	**392**	**608**	**228**	**386**	**28**	**270**	**63**	**44**	**286**	**928**	**451**	**234**	**206**	**598**	**137**	**112**	**235**	**384**	**475**	**52**	**201**	**841**	**1440**	**443**	**266**	**331**
Number of Bivalvia species		**4**	**5**	**4**	**5**	**4**	**4**	**4**	**4**	**2**	**4**	**3**	**4**	**4**	**4**	**5**	**4**	**4**	**4**	**5**	**3**	**4**	**5**	**4**	**5**	**3**	**4**	**4**	**4**	**4**	**4**
Diptera (Midge larvae)	Chironomidae	271	321	238	201	47	117	191	5	61	9	200	201	73	98	26	10	47	0	63	84	56	58	84	9	75	37	27	28	14	84
	Tanypodinae	19	33	23	5	14	33	37	19	0	5	63		8	42	42		2	0	0	23	42	5	28		14	56	56	23	42	75
	Chaoborus sp.	9	23	9	9		28	70	196	84	37	96			52	47	5	0	5	14	5	5		65			23	40	5	14	14
	Ceratopogonidae	5	14		65				5	0	0	0						0	5	0		5							0	0	0
	Psychodidae									0	0	0				5		0	0	0									0	0	0
Total dipteran density		**304**	**401**	**270**	**280**	**61**	**178**	**298**	**225**	**145**	**51**	**367**	**201**	**81**	**193**	**120**	**24**	**52**	**10**	**77**	**112**	**108**	**63**	**179**	**9**	**89**	**116**	**123**	**56**	**70**	**173**
Number of dipteran types		**4**	**4**	**3**	**4**	**2**	**3**	**3**	**4**	**2**	**3**		**1**	**2**	**3**	**4**	**2**	**2**	**2**		**3**	**4**	**2**	**3**	**1**	**2**	**3**	**3**	**3**	**3**	**3**
Oligochaeta (water worms)	*Nais sp.*		5	5	14			28		9	5	14			13	16	0	5	9	49		33	11	9			19	56	9	28	42
Ostracoda (seed shrimps)								9		0	0	0	229			7	0	0	0	0							5		0	0	0
Hirudinea (Leeches)										0	0	0					0	0	0	0				5					0	0	0
Decapoda (Fresh water shrimps)	*Caridina nilotica*		5		5			5		0	9	0	7	1		5	0	0	5	0		5	32			5	14	0	126	5
Ephemeroptera (May Flies)	*Povilla adusta*	19	183	9	28		14	0	0	5	0	0	5	3	144	245		70	70	12	5	9	63	28	5	37	9	5	19	19	5
	Baetis sp.	5	9	0	0			0	0	0	0	0		5				0	0	0	23	5			5				0	0	0
	Cloeon sp.	19	77	19	5			5	0	0	0	0			7		23	0	9	0		9	26	37	9	113			0	0	0
	Clocon sp.								0	0	0	0						0	0	0	37				9	9			0	0	0
	Leptophlebiidae		14						0	0	0	0				5		0	0	0						5	9		0	0	0
	Trichorythidae		89						0	0	0	0				19		0	0	0				5		19			0	0	0
Total Ephemeroptera density		**43**	**360**	**28**	**33**	**0**	**14**	**5**	**0**	**5**	**0**	**0**	**5**	**4**	**151**	**269**	**23**	**70**	**79**	**12**	**65**	**23**	**89**	**79**	**28**	**183**	**18**	**5**	**19**	**19**	**5**
Number of ephemeropteran types		**3**	**5**	**2**	**2**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**2**	**2**	**3**	**2**	**1**	**2**	**1**	**3**	**3**	**2**	**2**	**4**	**5**	**2**	**1**	**1**	**1**	**1**
Odonata (Dragon/damsel Flies)	*Hagenius sp.*	19		9		5			7	0	0	0		1			5	0	0	7	5			5	5				0	0	5
	Gomphoidus sp.	5		5					0	0	0	0						0	0	0		19							0	0	5
	Libellulidea	9	33	0	5		14	5	0	0	0	0	2		18	2		0	0	0		5	37	5	5	14		2	5	0	0
	Crenagrion sp.								0	0	0	0						0	0	0	5		5						0	0	0
	Protoneuridae		9	9					0	0	0	0						0	0	0									0	0	0
Total odonates density		**33**	**42**	**23**	**5**	**5**	**14**	**5**	**7**	**0**	**0**	**0**	**2**	**3**	**18**	**2**	**5**	**0**	**0**	**7**	**10**	**24**	**42**	**10**	**10**	**14**	**0**	**2**	**5**	**0**	**10**
Number of odonate types		**3**	**2**	**3**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**0**	**1**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**	**2**
Trichoptera (Caddis Flies)	Hydropsychidae								0	0	5	0				237	5	0	0	12		19	16	5		9			0	0	5
	Beschyocentridae								0	0	0	0						0	0	0				2					0	0	0
	Psychomyiidae		2				5		0	0	0	0		3	4	7		5	0	0				5			14		5	0	9
	Leptoceridae						5	9	0	0	0	0						0	0	0		2	3			5			0	0	0
Total Trichoptera density			**2**				**10**	**9**	**0**	**0**	**5**	**0**		**3**	**4**	**264**	**5**	**5**	**0**	**12**		**21**	**19**	**12**		**14**	**14**	**0**	**5**	**0**	**14**
Number of trichopteran types			**1**				**2**	**2**	**0**	**0**	**1**	**0**		**1**	**1**	**2**	**1**	**1**	**0**	**1**		**2**	**2**	**3**		**2**	**1**	**0**	**1**	**0**	**2**
Hemiptera (True bugs)	Nepidae	0	0	5	0				0	0	0	0						0	0	0									0	0	0
Coleoptera (Beetles)	Elmidae	0	3	0	0	0			0	0	0	0						0	0	0									0	0	0
Total benthic macro invertebrate density (ind.m-2)		744	1626	1309	595	677	834	937	838	187	359	644	489	385	1394	1317	366	379	925	427	435	842	904	1993	917	1303	1048	1999	598	1195	608

Water snails were absent in the benthos at Kalange-Makwanzi transect during the current survey (Table 3.3.1) and so were during the previous two surveys preceding the April 2015 survey when only 19 ind. m^{-2} of the water snails were registered. The density of *Bellamya unicolor* declined from 579 during April 2015 survey to 9 ind. m^{-2} during the present one at Buyala-Kikubamutwe transect and at the mid-reservoir transect, the density reduced from 145 during April 2015 survey to 98 ind. m^{-2} during the present one. Two other water snails (*Melanoides tuberculata and Biomphalaria choanomphala*) were encountered in the benthos at the Buyala-Kikubamutwe transect during this survey but at very low densities, 5-14 ind. m^{-2}. At the mid-reservoir transect, *M. tuberculata* was the only other water snails encountered.

The density of bivalves at Kalange-Makwanzi and mid-reservoir transects declined tremendously from 270 ind. m^{-2} during April 2015 to 63 ind. m^{-2} during the present survey period at the former and from 596 ind. m^{-2} to 137 ind. m^{-2} at the latter (Table 3.3.1). There was an increase in bivalval abundance at Buyala-Kikubamutwe transect from 266 ind. m^{-2} in the previous survey to 331 ind. m^{-2} during the current one. The most abundant bivalve at Buyala-Kikubamutwe transect was B. *parastica*, constituting 45% of the total bivalve density.

During the current survey, total dipteran density at the three transects, was 367, 77 and 173 ind. m^{-2}, increasing from during the previous survey 51, 10 and 70 ind. m^{-2}at Kalange-Mkwanzi, mid-reservoir and Buyala-Kikubamutwe transects respectively (Table3.3.1). The abundance of the insect types over the sampling periods has been continuously declining at the upstream transect in comparison to the mid-reservoir and downstream transects. These insect types are good water quality indicators where by their presence is of importance.

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

With haplochromines taken as a single species group, a total of 10 fish species were recorded at the three transects along River Nile in September 2015 compared to 10 in April 2015 and 7 in September 2014 (Table 3.4.1). A total of 9 species were recorded from the upstream station (Kalange-Makwanzi), 5 from the mid-reservoir and 7 from the downstream (Buyala-Kikubamutwe).
All keystone species Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*), Semutundu (*Bagrus docmak*), Elephant snout fish (*Mormyrus kannume*) and the haplochromines were recovered during this survey. Nile perch, haplochromines, *Mormyrus kannume* and *Synodontis victoriae* were recovered from all the three transects, while *Bagrus docmak* was recovered from the reservoir transect only. *Oreochromis variabilis, S. afrofischeri* and *Tilapia zillii* were recovered from both upstream and downstream transects, while *O. niloticus* and *Brycinus sadleri were* recorded from the upstream transect only.
The highest densities of fish by numbers was at the reservoir transect (48.3%), followed by the upstream transect (42.7%) and least from the downstream transect (9.0%). The dominance by numbers was haplochromines at the upstream transect (43%), Nile perch at the reservoir (49.6%), and S. afrofischeri at the downstream transect (33.3%). In terms of weight, *M. kannume* dominated at the upstream (39.9%) and reservoir (38.6%) transects while *O. variabilis* dominated downstream (36.0%).

3.4.2 The Haplochromines

At least 6 species belonging to 6 genera of haplochromines were recovered during the survey (Table 3.4.2). The upstream transect yielded the highest haplochromine species diversity (5 species) followed by the downstream transect with 2 haplochromine species and the reservoir which registered only one species (Neochromis sp.). The most dominant genus by number and weight was Astatotilapia (74.1%; 66.7%).

Table 3.4.1 *Fish species recorded overtime at upstream (Kalange-Makwanzi), mid of the reservoir and downstream (Buyala-Kikubamutwe) transects.*

Family names	Scientific names	English names/local names (Luganda)	Sites	Monitoring Dates															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		P			P												
			Mid section of the Reservoir										P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe		P		P								P	P				
Centropomidae	*Lates niloticus*	Nile perch/Mputa	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid section of the Reservoir										P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	p																
	B. sadleri	(Nsoga)	Kalange-Makwanzi	p																P
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe																	
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege -kibati)	Kalange-Makwanzi	P	P	P		P			P	P	P					P	P	P
			Mid section of the Reservoir												P					
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P	P	P	P			
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	P	P															
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	P	P		P													
	O. variabilis	Tilapia (Ngege)	Kalange-Makwanzi	P	P	P	P	P	P	P	P		P	P	P	P			P	P
			Mid section of the Reservoir										P				P			
			Buyala-Kikubamutwe	P	P		P			P	P	P	P				P		P	P
	Tilapia zilli	Red-belly tilapia (Ngege)	Kalange-Makwanzi	P	P	P	P	P	P	P	P		P	P	P	P				P
			Mid section of the Reservoir										P		P	P				
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P			P		P	P
	Haplochromines	(Nkeje)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid section of the Reservoir										P		P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			P	P							P	P					
			Mid section of the Reservoir										P	P						
			Buyala-Kikubamutwe			P	P		P			P				P				
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisinja)	Kalange-Makwanzi	P	P	P	P		P				P							
			Mid section of the Reservoir										P	P	P					
			Buyala-Kikubamutwe	P	P	P	P		P	P		P	P		P		P			
	B. paludinosus	Barbel fish/ (Kisinja)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	P																
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe		P					P										
	Rastrineobola argentea	Silver fish/(Mukene)	Kalange-Makwanzi							P										
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	P	P		P			P										
Cyprinodontidae	*Aplocheilichthys pumilu*	Gambusia	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe		P															
Lepidosirenidae	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						P											
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe				P													
Mochokidae	*Synodontis afrofischeri*	Tigre fish (Nkolongo)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid section of the Reservoir										P		P	P			P	
			Buyala-Kikubamutwe		P	P	P	P	P	P		P	P	P	P	P	P	P	P	P
	S. victoriae	Tigre fish (Nkolongo)	Kalange-Makwanzi			P		P	P		P			P	P	P	P	P		P
			Mid section of the Reservoir										P	P		P		P	P	P
			Buyala-Kikubamutwe											P					P	P
Mormyridae	*Brathyurus longibarbis*	Kasukubana																		
																	P		P	
	Marcusenius kannume	Elephant snout fish (Kasukubana)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid section of the Reservoir										P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P					P	P
Total No. of species			Kalange-Makwanzi	10	10	10	8	9	9	7	8	5	8	8	8	6	5	6	6	9
			Mid section of the Reservoir										10	7	8	7	6	5	7	5
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7

Table 3.4.2 *Haplochromine species recorded over time at the upstream (Kalange – Makwanzi) mid of the reservoir and downstream (Buyala – Kikubamutwe) transects.*

Genus	Species name	Sites	Monitoring Dates																
			1 (Jul)	2 (Dec)	3 (Jul)	4 (Jul)	5 (Jul)	6 (Jul)	7 (Jul)	8 (Jul)	9 (Dec)	10 (Jul)	11 (Dec)	12 (Jul)	13 (Dec)	14 (Jul)	15 (Dec)	16 (Jul)	17 (Dec)
Astatoreochromis	*A. alluaudi*	Kal-Yak	P	P	P	P	P	P	P	P	P	P	P	P	P	P			
		Res																	
		Buy-Kik	P	P	P	P	P			P						P		P	
Astatoreochromis	*A. brevimanus*	Kal-Yak	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
		Res										P				P			
		Buy-Kik		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	A. "cylindricus"	Kal-Yak			P														
		Res																	
		Buy-Kik																	
	A. "elongate"	Kal-Yak	P	P	P	P	P	P	P										
		Res										P							
		Buy-Kik			P		P			P									
	A. "purple dorsum"	Kal-Yak		P								P				P	P		
		Res																	
		Buy-Kik												P	P				
	A. "red dorsum"	Kal-Yak				P		P			P		P						
		Res																	
		Buy-Kik					P	P	P							P			
	Astatotilapia sp	Kal-Yak			P	P	P			P				P	P		P	P	
		Res												P	P			P	
		Buy-Kik		P	P	P	P				P			P	P	P		P	
	A. mdida	Kal-Yak															P		
		Res																	
		Buy-Kik																P	
Ctenochromis	*Ctenochromis sp*	Kal-Yak		P															
		Res																	
		Buy-Kik																	
Haplochromis	*H. bradus*	Kal-Yak									P								
		Res																	
		Buy-Kik																	
Harpagochromis	*H. guiarti*	Kal-Yak	P	P	P	P	P		P	P	P	P						P	P
		Res																	
		Buy-Kik	P		P	P	P		P			P	P			P		P	
	H. serranus	Kal-Yak																	
		Res																	
		Buy-Kik	P																
Labrochromis	*L. humilior*	Kal-Yak		P															
		Res																	
		Buy-Kik																	
Lithochromis	*Lithrochromis sp*	Kal-Yak		P		P	P												P
		Res																	
		Buy-Kik					P												P
Lipochromis	*L. microdon*	Kal-Yak					P												
		Res																	
		Buy-Kik																	
	L. parvidens	Kal-Yak			P			P											
		Res																	
		Buy-Kik							P			P							
Mbipia	*M. mbipi*	Kal-Yak	P	P	P	P	P	P	P	P	P	P	P				P		
		Res										P			P		P	P	
		Buy-Kik	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	
Neochromis	*N. "elongate"*	Kal-Yak										P							
		Res																	
		Buy-Kik					P												
	N. greenwoodi	Kal-Yak	P						P										
		Res																	
		Buy-Kik		P															
	N. rufocaudalis	Kal-Yak		P	P	P	P	P	P	P		P							
		Res										P			P	P			
		Buy-Kik		P															
	Neochromis sp	Kal-Yak																	
		Res																	P
		Buy-Kik																P	
Paralabidochromis	*P. "black pure"*	Kal-Yak				P			P			P							
		Res														P			
		Buy-Kik			P						P								
	P. cyaneus	Kal-Yak																	
		Res																	
		Buy-Kik	P																
	P. "sarringaabu"	Kal-Yak	P				P			P									
		Res																	
		Buy-Kik	P																
	P. flavus	Kal-Yak																	
		Res																	
		Buy-Kik					P				P								
	P. rock kribensis	Kal-Yak					P				P								
		Res																	
		Buy-Kik																	
	P. "scarlet anal"	Kal-Yak	P					P	P	P	P					P			P
		Res																	
		Buy-Kik					P										P		
	P. "yellow"	Kal-Yak																	
		Res																	
		Buy-Kik	P																
	Paralabidochromis sp	Kal-Yak	P																
		Res														P			
		Buy-Kik	P	P	P														
	P. vanicolubris	Kal-Yak																P	
		Res																	
		Buy-Kik																	
Pseudotropheus	*P. "lethrinus"*	Kal-Yak	P	P			P	P	P	P	P								
		Res																	
		Buy-Kik				P			P			P	P						
Pseudotropheus	*P. zebroides*	Kal-Yak		P					P										
		Res																	
		Buy-Kik																	
Psammochromis	*P. rigidorsalis*	Kal-Yak		P			P		P	P	P	P	P	P	P	P		P	
		Res												P					
		Buy-Kik	P		P		P		P				P	P	P	P		P	
	Psammochromis sp	Kal-Yak															P		
		Res																	
		Buy-Kik															P		
Ptyochromis	*P. xanstigmi*	Kal-Yak	P		P		P			P	P	P							
		Res																	
		Buy-Kik	P		P				P					P					
	P. xenognathus	Kal-Yak																P	
		Res																	
		Buy-Kik																	
Pundamilia	*P. "black"*	Kal-Yak		P	P	P	P	P	P	P	P								
		Res																	
		Buy-Kik					P	P											
	P. "orange anal"	Kal-Yak		P															
		Res																	
		Buy-Kik																	
	P. igneogenis	Kal-Yak										P							
		Res																	
		Buy-Kik																	
	P. macrocephala	Kal-Yak										P							
		Res																	
		Buy-Kik																	
	P. "orange tail"	Kal-Yak		P						P									
		Res																	
		Buy-Kik																	
	P. pundamilia	Kal-Yak										P							
		Res																	
		Buy-Kik																	
	P. "red tail"	Kal-Yak	P			P													
		Res																	
		Buy-Kik				P													
	Pundamilia sp	Kal-Yak		P															
		Res																	
		Buy-Kik																	
Xystichromis	*X. phytophagus*	Kal-Yak	P			P		P	P										
		Res																	
		Buy-Kik									P								
Undescribed	Haplochromines	Kal-Yak				P													
		Res																	
		Buy-Kik																	
Total number of species		Kal-Yak	14	17	12	13	16	9	14	14	11	14	5	3	3	3	4	6	7
		Res										4		2	3	3	1	2	
		Buy-Kik	10	9	10	7	12	5	9	4	6	5	8	5	5	5	5	8	

3.2.3 Catch rates / biomass estimates

As a measure of standing biomass, catch rates i.e. catch per net per night was used to indicate relative abundance of fish species from transects under survey. To analyse for catch per net, gillnets were grouped into three size categories: small (1 to 2 ½ inches stretched mesh), medium (3 to 4 ½) and large (5 to 8 inches). Overall catch rates (by numbers were highest at the reservoir (1.98 fish per net per night) and lowest at the downstream transect (0.48 fish per net per night) (Table 3.4. 3). Similarly, by weight, catch rates were highest at the reservoir (288.4g) and lowest at Buyala (25.9g) (Table 3.4.4). At Kalange, haplochromines recorded the highest catch rates by number (2.04 fish per net per night) and *M. kannume* with the highest catch rate by weight (61.9g). At Buyala-Kikubamutwe, *S. afrofischeri* and *O. variabilis* recorded the highest catch rate by number (0.5 fish per net per night) and weight (15.5g) respectively. At the reservoir, Nile perch recorded the highest rate by number (1.0 fish per net per night), while *Mormyrus kannume* had the highest catch rate (111.3g). The overall catch rates by numbers reduced from those recorded in the previous survey for the upstream and downstream transects while those of the reservoir transect increased.

3.2.4 Fish species recovery

The total number of fish species recovered from all gears at different transects has declined over time as shown in Figure 3.4.1. Since the April 2010 survey, the number of species so far recorded has remained at 63; therefore, there has been no new species added to the species list. The resurgence of the haplochromines in the mid-reservoir has been noted. All keystone fish species expected at these transects have been recovered. Further colonisation of this reservoir by new species is to be monitored.

Table 3.4.3 *Catch rates (numbers) of fish species caught over time by gillnets at the upstream (Kalange-Makwanzi), mid of the reservoir and downstream (Buyala-Kikubamutwe) transects*

Family name	Scientific Species name	English names/local names (Luganda)	Site	Monitoring dates																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Apr 2006	Sep 2007	Apr 2008	Apr 2009	Sep 2009	Apr 2010	Sep 2010	Apr 2011	Sep 2011	Apr 2012	Sep 2012	Apr 2013	Sep 2013	Apr 2014	Sep 2014	Apr 2015	Sep 2015
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		0.03			0.08												
			Mid section of the Reservoir										0.03	0.1	0.38	0.4	0.1	0.01	0.15	0.2
			Buyala-Kikubamutwe		0.07		0.04								0.08	0.1				
Centropomidae	*Lates niloticus*	Nile perch/Mputa	Kalange-Makwanzi	0.19	3.1	3.32	2.3	9.76	0.32	0.58	1.13	0.15	2.83	0.5	1.62	0.7	0.1	0.14	0.32	0.26
			Mid section of the Reservoir										3.06	0.7	1.08	4.2	0.3	0.16	0.66	1
			Buyala-Kikubamutwe	1.12	1.68	1.86	2.29	2.57	0.35	0.4	0.16	0.72	0.83	0.2	0.85	1.5	0.6	0.13	0.32	0.08
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	0.04																
	B. sadleri	(Nsoga)	Kalange-Makwanzi	0.04																0.04
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe																	
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege -lobiri)	Kalange-Makwanzi	0.04	0.33	0.1		0.2			0.01	0.01	0.02					0.01	0.01	0.03
			Mid section of the Reservoir												0.08					
			Buyala-Kikubamutwe	0.07	0.41	0.04	0.04	0.1		0.1			0.19	0.04	0.38	0.2	0.3			
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	0.04	0.09															
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	0.06	0.08															
	O. variabilis	Tilapia (Ngege)	Kalange-Makwanzi	0.17	0.91	0.43	0.45	1.52	0.06	0.17	0.19		0.09	0.04	0.31	0.2			0.04	0.06
			Mid section of the Reservoir										0.03				0.01			
			Buyala-Kikubamutwe	0.13	0.08		0.17			0.02	0.02	0.03	0.03						0.09	0.03
	Tilapia zilli	Red-belly tilapia (Ngege)	Kalange-Makwanzi	0.1	0.17	0.17		0.17	0.04	0.1	0.13		0.09	0.09	0.13	0.1				0.06
			Mid section of the Reservoir										0.05	0.05	0.25	0.3				
			Buyala-Kikubamutwe	0.88	0.46	0.04	0.43	0.1		0.04			0.16	0.16			1		0.07	0.07
	Haplochromines	(Nkanja)	Kalange-Makwanzi	9	10.46	6.63	19.04	15.5	5.83	4.5	12.7	10.6	11.1	0.4	11.8	2.5		2.54	2.75	2.04
			Mid section of the Reservoir										0.25		0.3	5.8		0.13	0.15	0.1
			Buyala-Kikubamutwe	16.83	4.27	6.36	8.32	6.47	0.78	1.62	2.05	1.36	6.13	2.3	13.8	47.2		0.79	13.7	0.44
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			0.03	0.17							0.01	0.08					
			Mid section of the Reservoir										0.02	0.03						
			Buyala-Kikubamutwe	0.01		0.25	0.07		0.03			0.02				0.1				
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisinja)	Kalange-Makwanzi	0.02	0.1	0.17	0.03		0.01				0.02							
			Mid section of the Reservoir										0.06	0.1	0.38					
			Buyala-Kikubamutwe	0.1	0.11	0.04	0.04		0.01	0.01		0.02	0.02		0.15		0.01			
	Barbus paludinosus	Barbel fish/ (Kisinja)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	0.04																
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe		0.09					0.02										
Lepidosirenidae	*Protopterus aethiopicus*	Lung fish (Lamba)	Kalange-Makwanzi						0.01											
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe				0.04													
Mochokidae	*Synodontis afrofischeri*	Tiger fish (Nkolongo)	Kalange-Makwanzi	0.21	0.63	0.08	0.42	1.48	0.46	0.33	0.13	0.38	4.75	1.8	53.8	79.5	1.5	4.42	0.58	1.08
			Mid section of the Reservoir										0.75		1.5	1.5			0.15	
			Buyala-Kikubamutwe		0.27	1.09	0.37	3.58	0.28	0.1		1.07	0.06	3.7	2.5	0.5	0.1	0.04	0.87	0.5
	S. victoriae	Tiger fish (Nkolongo)	Kalange-Makwanzi			0.08		0.21	0.29		0.17			0.1	3.25	1.3	0.1	0.16		0.08
			Mid section of the Reservoir										0.05	0.04		1.8		0.08	0.05	0.8
			Buyala-Kikubamutwe											0.1					0.04	0.06
Mormyridae	*Gnathonemus longibarbis*	Kanshibana	Kalange-Makwanzi														0.01	0.04	0.23	0.1
			Mid section of the Reservoir											0.04			0.3	0.23	0.48	0.6
			Buyala-Kikubamutwe																0.01	0.02
	Mormyrus kannume	Elephant snout fish (Kanshibana)	Kalange-Makwanzi	0.32	0.8	1.83	0.7	0.08	0.23	0.18	0.22	0.04	0.33	0.1	0.46	0.5				
			Mid section of the Reservoir										0.82	0.9	1.48	2.7	0.1		0.15	
			Buyala-Kikubamutwe	0.68	0.86	2.25	0.39	0.38	0.15	0.25	0.18	0.17	0.02	0.1	0.15					
OVERALL RATES			Kalange-Makwanzi	2.89	5.48	4.39	7.54	10.01	2.87	2.41	4.54	3.36	8.2	1.3	23.6	26.9	1.5	2.38	1.62	1.46
			Mid section of the Reservoir										4.4	1.8	4.2	10.2	0.9	2.11	1.45	1.98
			Buyala-Kikubamutwe	6.45	3.28	3.91	3.71	4.28	0.81	1.21	0.95	1.5	3.1	2.3	6.6	16.8	6.8	0.41	4.86	0.48

Table 3.4.4 *Catch rates (weight (g) of fish species caught over time by gillnets at the Upstream,Kalange – Makwanzi; mid of the reservoir and downstream, Buyala-Kikubamutwe*

Family name	Scientific Species name	English names/local names (Luganda)	Site	Monitoring dates															
				1 Aug-2006	2 Sep-2006	3 Aug-2008	4 Aug-2009	5 Sep-2009	6 Aug-2010	7 Sep-2010	8 Aug-2011	9 Sep-2011	10 Aug-2012	11 Sep-2012	12 Aug-2013	13 Sep-2013	14 Aug-2014	15 Sep-2014	16 Aug-2015	17 Sep-2015
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		37.53			28.58												
			Mid section of the Reservoir										14.1	27.7	835	136		0.51	32.5	73.6
			Buyala-Kikubamutwe		22.50		0.6.93								13.8	19.1	4			
Centropomidae	*Lates niloticus*	Nile perch/Mputa	Kalange-Makwanzi	15.75	271.27	371.00	114.13	250.84	49.44	35.86	11.6	8.6	156	63.3	141	77.7	9.3	25.4	13.9	53.8
			Mid section of the Reservoir										198	140	532	538	17.8	42.8	104.4	81.4
			Buyala-Kikubamutwe	108.21	107.79	159.07	111.00	171.43	28.81	39.28	16.4	44.5	30.2	18	36.8	94.8	22.7	4.29	13.4	3.2
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	3.25																
	B. zaalleri	(Nsoga)	Kalange-Makwanzi	0.75																0.58
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe																	
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege -kibati)	Kalange-Makwanzi	1.80	7.42	28.93		20.08			0.5	6.7	1.2					9.68	0.05	2.24
			Mid section of the Reservoir												9.2					
			Buyala-Kikubamutwe	4.33	0.18	3.93	0.93	5.05		0.83			5.8	1.7	205	7.4	29.9			
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	3.67	6.61															
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	5.75	6.75															
	O. variabilis	Tilapia (Ngege)	Kalange-Makwanzi	33.54	49.04	63.30	44.73	82.76	14.87	19.54	26.1		18.4	8.7	122				1.02	18.1
			Mid section of the Reservoir										1.7				5.4			
			Buyala-Kikubamutwe	11.58	12.08		8.17			4.04	11.5	13.6	8.1				20.3		9.2	15.5
	Tilapia zilli	Red-belly tilapia (Ngege)	Kalange-Makwanzi	6.92	15.63	21.65		7.92	7.71	32.17	21.		10.1	2.8	18.8					3.6
			Mid section of the Reservoir										7.2		21.3	10.3				
			Buyala-Kikubamutwe	81.83	19.08	7.33	42.26	7.90		2.71			6.1	2.1		32	38.9		1.3	1.3
	Haplochromines	(Nzeje)	Kalange-Makwanzi	303.92	191.92	168.08	534.33	383.24	167.67	113.11	160	246	168	8.5	219	33.8	15.5	26.2	26.6	20.4
			Mid section of the Reservoir										4.1		22.3	113	113	2.92	4.03	2.6
			Buyala-Kikubamutwe	284.88	51.27	206.00	187.05	167.90	15.78	40.38	37.7	15.3	86.9	32.3	226	697	229	9.63	143.9	5.3
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			6.27	69.33							8.9	100					
			Mid section of the Reservoir										9.4	48.7						
			Buyala-Kikubamutwe	9.20		52.93	89.36		33.58			3.1				139				
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisenja)	Kalange-Makwanzi	19.27	403.33	501.13	7.27		2.31				0.6							
			Mid section of the Reservoir										51.3	199	266					
			Buyala-Kikubamutwe	48.88	22.93	95.57	9.36		4.03	5.73		12.8	0.3		408		8.2			
	Barbus paludinosus	Barbel fish/ (Kisenja)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe	0.50																
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																	
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe		38.91					14.80										
Lepidosirenidae	*Prosopsirus anthiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						15.92											
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe				26.21													
Mochokidae	*Synodontis afrofischeri*	Tiger fish (Nkolenge)	Kalange-Makwanzi	10.92	49.50	4.58	14.92	56.79	59.63	18.75	7.2	28.8	61.1	64.2	1543	2668	46.3	151	22.13	50.4
			Mid section of the Reservoir										15.6		62.3	61			8.75	
			Buyala-Kikubamutwe		19.09	30.64	10.42	111.58	12.89	2.38		17.4	1.3	87.3	45	18	3.8	1.67	34.4	15.4
	S. victoriae	Tiger fish (Nkolenge)	Kalange-Makwanzi			12.50		17.92	39.33		28.1			7.3	278	108	5.2	18.3		5.3
			Mid section of the Reservoir										6.8	3.6		236		7.63	10.1	69.5
			Buyala-Kikubamutwe											9.6					4.39	10.3
Mormyridae	*Gnathonemus longibarbis*	Elephant snout fish (Kanzubuzu)	Kalange-Makwanzi																	
			Mid section of the Reservoir														8		9.15	
			Buyala-Kikubamutwe																	
	Mormyrus kannume	Elephant snout fish (Kanzubuzu)	Kalange-Makwanzi	110.16	250.47	511.47	95.75	14.72	49.01	77.49	39.7	7.5	44.5	27.7	114	57.6	9.5	16.9	15.3	61.9
			Mid section of the Reservoir										158	156	238	643	80.1	119.0	108.0	111.3
			Buyala-Kikubamutwe	217.37	89.54	175.64	185.00	51.62	9.22	33.36	15.6	15.9	1.3	7.8	209				25.2	2.66
OVERALL RATES			Kalange-Makwanzi	242.00	473.90	635.87	299.47	296.77	212.59	185.74	141	102	290	132	1116	1076	55.3	112.1	86.3	155.1
			Mid section of the Reservoir										443	573	1920	1449	115	165.7	254.7	288.4
			Buyala-Kikubamutwe	502.77	137.22	257.05	241.69	170.83	82.81	104.11	49.9	102	73	68.6	955	499	200	8.16	100.2	25.9

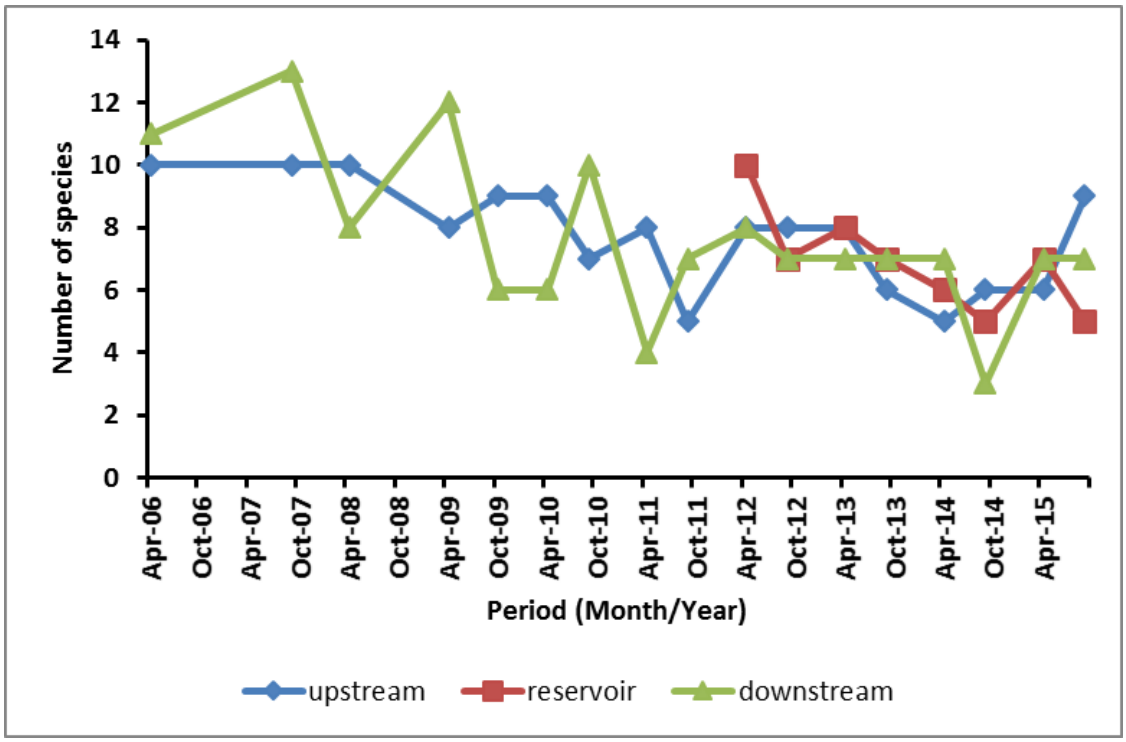

Figure 3.4.1 Cumulative *number of fish species recovered from the study transects on the Upper Victoria Nile over the sampling period.*

3.5 The Food and Trophic Ecology of the Fishes

In the survey of September 2015, *L. niloticus* from Kalange-Makwanzi transect ingested fish (34.8%) and *Caridina* (66.2%) The fish prey comprised of haplochromines (17.4%) and unidentifiable fish material (17.4%). The diet of the species is similar to the observations made in April 2015 in the same transect.

In the mid-reservoir, *Caridina* (98%) dominated the diet of *L. niloticus* during this survey of September 2015. Other prey items included *Rastrineobola argentea* (1.1%) and unidentifiable fish material (0.9%). Dominance of *Caridina* in the diet of *L. niloticus* at the mid-reservoir transect was also observed in the previous surveys of September 2014 and April 2015.

Haplochromines (80%) were the major prey ingested by *L. niloticus* from Buyala-Kikubamutwe transect during this survey of September 2015. Other prey included *Caridina* (10%) and Odonata nymphs (10%). Dominance of fish, especially haplochromines, in the diet of Nile perch at this transect was also observed in the previous survey of April 2015.

During September 2015 monitoring survey, *Oreochromis variabilis* was recorded from Kalange-Makwanzi and Buyala-Kikubamutwe transects. At Kalange-Makwanzi transect, the diet of the species comprised of blue-green algae (41.3%), diatoms (26.3%), zooplankton (15%), detritus (10%), green algae (5.7%) and insect material (1.7%). In April 2015 survey, O. variabilis from Kalange-Makwanzi transect had ingested the same food items although detritus was the most dominant. At Buyala-Kikubamutwe transect, the diet of *O. variabilis* comprised of detritus (60%), green algae (20%), blue-green algae (10%) and diatoms (10%).

The elephant snout fish**,** *Mormyrus kannume* was recorded from the three transects sampled in September 2015. At Kalange-Makwanzi transect, insects (92.2%), comprising of Ephemeroptera (82.2%), chironomids (7.8%) and odonata (2.2%), dominated the diet of *M. kannume.* Other food

items included crabs (5%), *Caridina* (2.5%) and unidentifiable fish material (0.3%). At the mid-reservoir transect, the diet of *M. kannume* during September 2015 survey comprised of insects (88.6%) and mollusc (11.4%) The insect prey included chironomids (44.3%), Ephemeroptera (34.2%) and odonata (10.1%). At Buyala-Kikubamutwe transect, the guts of *M. kannume* examined contained only chironomids. The dominance of insect prey in the diet of *M. kannume* was also observed during the previous surveys of April 2015 and September 2014.

During this survey of September 2015, *Synodontis afrofischeri* was recorded from Kalange-Makwanzi and Buyala-Kikubamutwe transects. At Kalange-Makwanzit transect, the diet of *S. afrofischeri* comprised of chironomids (62.5%), unidentifiable fish material (33.3%), molluscs (4%) and *Caridina* (0.2%) but at Buyala-Kikubamutwe rransect, the species ingested only insect prey comprising of Odonata (60%), chironomids (20%) and Ephemeroptera (20%).
The dominance of insects especially chironomids and Ephemeroptera in diet of *S. afrofischeri* at the two transects was also observed in the previous surveys of April 2015 and September 2014.

Bagrus docmac was only recorded from the main reservoir and its diet was dominated by *L. niloticus* although in previous surveys of April 2015 *Caridina* was the dominant prey, while in September 2014 the species ingested mostly fish dominated by haplochromines. The diet of the other keystone species in September 2015 was similar to the observations made in the previous survey of April 2015 and September 2014.

Table 3.5.1 *Dominant food types of common fish species caught over time at the upstream (Kalange - Makwanzi), mid of the reservoir and downstream (Buyala-Kikubamutwe) Transects*

Family name	Seclentific Species name	English/local (Luganda) name	Site	Monitoring dates															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Apr 2006	Sep 2007	Apr 2008	Apr 2009	Sep 2009	Apr 2010	Sep 2010	Apr 2011	Sep 2011	Apr 2012	Sep 2012	Apr 2013	Sep 2013	Apr 2014	Sep 2014	Apr 2015	Sep 2015
Bagridae	*Bagrus docmac*	Semutundu	Kalange-Makwanzi (upstream of the reservoir)										FR		E	E				
			Mid section of the Reservoir										SYN	CAR	SYN	CAR	FR	HAP	CAR	LN
			Buyala-Kikubamutwe (downstream)													FR				
Centropomidae	*Lates niloticus*	Nile perch/ (Mputa)	Kalange-Makwanzi (upstream of the reservoir)	FR	HAP	HAP	HAP	FR	HAP	HAP	HAP	HAP	HAP	ODT	LN	HAP	HAP	RAS	HAP	CAR
			Mid section of the Reservoir										RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR
			Buyala-Kikubamutwe (downstream)	FR	CAR	FR	CAR	ODT	RAS	RAS	CHR	HAP	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP
Cichlidae	*Oreochromis niloticus*	Nile tilapia/ (Ngege-Kibati)	Kalange-Makwanzi (upstream of the reservoir)	E	HPM	BGA	HPM	E	E	DTR	IR	DETR	MOL				HPM	E	E	E
			Mid section of the Reservoir												CHAO					
			Buyala-Kikubamutwe (downstream)	E				E	DTR	E	DETR		INS	EPH	EPH	HPM	BGA			
	O. variabilis	(Ngege)	Kalange-Makwanzi (upstream of the reservoir)	BGA	GRA	BGA	HPM	GRA	BGA	BGA	BGA	EPH	BGA	BGA	BGA	DETR	BGA		DETR	BGA
			Mid section of the Reservoir														BGA			
			Buyala-Kikubamutwe (downstream)	BGA	E		HPM				E	E	BGA				BGA		E	DETR
	Tilapia zillii	Red-belly tilapia (Ngege)	Kalange-Makwanzi (upstream of the reservoir)	MOL	HPM	E		E	IR	HPM	IR		EPH	E	HPM		ODT			DETR
			Mid section of the Reservoir										INS		E	E				
			Buyala-Kikubamutwe (downstream)	HPM	CAR	E	HPM	E	HPM	HPM			EPH	HPM		HPM	HPM		HPM	HPM
Clariidae	*Clarias gariepinus*	Mudfish (Male)	Kalange-Makwanzi (upstream of the reservoir)			FR	FR				EPH			E	MOL	MOL				
			Mid section of the Reservoir										EPH	EPH						
			Buyala-Kikubamutwe (downstream)			HAP	EPH		E			CHR				EPH				
Cyprinidae	*Barbus altianalis*	Barbelfish (Kisenja)	Kalange-Makwanzi (upstream of the reservoir)	E	INS	INS	INS		MOL	E	IR	CHR	DETR							
			Mid section of the Reservoir										INS	MOL	MOL					
			Buyala-Kikubamutwe (downstream)	E	INS	INS			E	MOL		CHR			MOL		E			
Mochokidae	*Synodontis afrofischeri*	Tigerfish (Nkolongo)	Kalange-Makwanzi (upstream of the reservoir)	CHR	EPH		CAR	CHR	EPH	CHR	EPH	INS	MOL	EPH	EPH	CHR	CHR	CHR	EPH	CHR
			Mid section of the Reservoir										INS		CHR	EPH			CHR	
			Buyala-Kikubamutwe (downstream)		CHR	CHR	INS	CHR	INS	CHR		INS		EPH	INS	EPH	CHR	E	EPH	ODT
Mormyridae	*Mormyrus kannume*	Elephant Snoutfish (Kasulubana)	Kalange-Makwanzi (upstream of the reservoir)	INS	EPH	EPH	INS	EPH	EPH	EPH		CHR	EPH	CHR		EPH	CHR	EPH	CHR	EPH
			Mid section of the Reservoir										EPH	EPH		EPH	CHR	CHR	MOL	CHR
			Buyala-Kikubamutwe (downstream)	INS	EPH	INS	EPH	CHR	CHR	INS	EPH	INS	E	ODT					E	E

Food types: *HAP = Haplochromines, FR = Unidentifiable fish remains, CAR = Caridina nilotica, MOL = Mollusk, BGA = Blue-green algae, GRA = Green algae, EPH = Ephemeroptera, INS = Unidentifiable insect material, HPM = High plant material (water weeds), E = Empty stomachs, ODT = Odonata*

3.3.1 Maturity and Breeding

Six out of the seven fish species examined during the survey of September 2015 showed signs of breeding and they were: *Bagrus docmac*, S. *afrofischeri, M. kannume, O.variabilis, T. zillii and L. niloticus* (Table 3.5.2*).* The highest breeding intensity was observed at Buyala-Kikubamutwe transect (5 species) followed by Kalange-Makwanzi transect (4 species) and at the mid-reservoir transect (2 species).

At Kalange-Makwanzi transect, breeding activity was recorded in *L. niloticus, M. kannume, S. afrofischeri and O. variabilis* while at Buyala-Kikubamutwe transect breeding was observed in *M.*

kannume, S. afrofischeri, O. variabilis and *T. zillii.* Only *M. kannume* and *B. docmac* showed signs of breeding at the mid-reservoir transect. Fish breeding intensity was higher in September 2015 than that observed in the previous survey of April 2015.

Table 3.5.2 *Proportion (%) of breeding fishes over time among commonly encountered fish species at the upstream (Kalange-Makwanzi), mid of the reservoir and downstream (Buyala-Kikubamutwe) Transects*

Family name	Scientific Species name	English/local (Luganda) name	Site	Monitoring dates															
				1 Apr 2006	2 Sep 2007	3 Apr 2008	4 Apr 2009	5 Sep 2009	6 Apr 2010	7 Sep 2010	8 Apr 2011	9 Sep 2012	10 Apr 2012	11 Sept. 2012	12 Apr 2013	13 Sep 2013	14 Apr 2014	15 Sep 2014	16 Apr 2015	17 Sep 2015
Bagridae	*Bagrus docmak*	Semutundu	Kalange-Makwanzi (upstream of the reservoir)												0					
			Mid section of the Reservoir										50	25	40	14.3			20	30
			Buyala-Kikubamutwe (downstream)												0					
Centropomidae	*Lates niloticus*	Nile perch/ (Mputa)	Kalange-Makwanzi (upstream of the reservoir)												0				4.3	5.6
			Mid section of the Reservoir										1		7.1			8.3	2.4	0
			Buyala-Kikubamutwe (downstream)												0					0
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege-Kibati)	Kalange-Makwanzi (upstream of the reservoir)			71.4			50	54.5	38.3	70					6.7	100		0
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe (downstream)												60		10.5			
	O. variabilis	(Ngege)	Kalange-Makwanzi (upstream of the reservoir)	12.5		22.2	55.2		50	38.1	48.3	50			14.3	45.5	46.2		0	33.3
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe (downstream)									100					11.1			100
	Tilapia zillii	Red-belly tilapia (Ngege)	Kalange-Makwanzi (upstream of the reservoir)							83.3	42.9		33.3	33.3	0		57.1			0
			Mid section of the Reservoir												0					
			Buyala-Kikubamutwe (downstream)	7.1	25	100										75	6.1			50
Clariidae	*Clarias gariepinus*	Mudfish (Male)	Kalange-Makwanzi (upstream of the reservoir)								100					50				
			Mid section of the Reservoir																	
			Buyala-Kikubamutwe (downstream)																	
Cyprinidae	*Barbus altianalis*	Barbelfish (Kisinja)	Kalange-Makwanzi (upstream of the reservoir)	100	100	80	100		64.7		64.3	100								
			Mid section of the Reservoir										50	50						
			Buyala-Kikubamutwe (downstream)	12.5	100	100				100		100			50					
Mochokidae	*Synodontis afrofischeri*	Tigerfish (Nkolongo)	Kalange-Makwanzi (upstream of the reservoir)	20	100		70	91.7	90	88.9	100	87.5	7.9	35.3	34	68	54.8	98.8	100	96.4
			Mid section of the Reservoir										6.7	12.5	16.7	25			33.3	
			Buyala-Kikubamutwe (downstream)		75	36.4	50	100	100	100		100			70	100	16.7	100	100	87.5
Mormyridae	*Mormyrus kannume*	Elephant Snoutfish (Kasulubana)	Kalange-Makwanzi (upstream of the reservoir)	44.1	58.3	43.5	23.8	50	56.7	72.2	59.3	30	17.6	33.3	45.5	28.6	25		38.5	25
			Mid section of the Reservoir										25	44.2	42.1	44.4	61.9	88.9	25.8	18.9
			Buyala-Kikubamutwe (downstream)	37.5	41.7	27.1	54.5	33.3		33.3	18.8	20		33.3	100				100	100

3.6. THE COMMERCIAL FISHERY

3.6.1 Fishing effort in the fishery

Variations in fishing effort and catchability coefficients (a measure of fishing mortality) are used to assess trends in stocks of natural fish populations (Arreguín-Sánchez, 1996). Fishing effort and fish catch trends have been assessed to estimate fish yield from the Upper Victoria Nile with respect to Bujagali Hydro-power dam construction Project because fishing is an important socio-economic activity for the riparian communities.

Therefore, monitoring of fish effort and catches can help to detect environmental concerns that might require mitigation measures to ameliorate negative impacts of river ecosystem functioning and loss of aquatic biota, particularly fish.

During the current survey- September 2015, the number of fishing boats increased by 25.5% at the mid-reservoir transect and slightly declined by 16% at the Upstream (Kalange-Makwanzi) and 22% Downstream (Buyala-Kikubamutwe) transects (Table 3.6.1). At the downstream station, 21 boats were recorded which is still higher than the least number of 12 boats ever recorded in April 2011. The surveys from April 2015 to the current one, continued to indicate fluctuations in the number of boats among the three sites, probably attributed to the periodic migration of fishers to sites suspected to have more fish at those times. The high number of fishing boats at the mid-reservoir could therefore be attributed to high fish catches compared to the other two sites. The decrease in numbers of fishing boats at the Downstream and Upstream stations could be attributed to some fishers engaging alternative livelihoods sources (e.g. farming) during fish scarcity The September 2015 survey was conducted during the onset of the rainy season, thus coinciding with the planting season. It has previously been a common practice for fishers to shift to farming as alternative livelihood during rainy seasons and periods of low fish catches, with fishing a subsistence activity. The surveys conducted between April 2009 and April 2012 similarly experienced fluctuations in the number of fishing boats across the three sites, the lowest being 30 boats and the highest 65 boats but there have been a progressive increase in numbers of fishing boats since September 2012, save for the 50% drop at the Downstream station in April 2014.

During the current survey, higher effort was registered at the mid-reservoir transect than at either at the upstream or downstream transects. However, earlier studies on Table Rock and Taneycomo dams on the White River, USA and Clearwater Dam on the Black River, USA (Fry 1965) showed that downstream sites (tail waters) to had more fishing effort per unit area than the head waters (Upstream). The dams enhanced riverine fisheries especially in the tail waters (downstream) because fish tend to concentrate as a result of the attractive foraging opportunities there, as well as seasonal congregations of migratory fishes (Jackson, 1985).

Like in the previous survey, the mid-reservoir transect registered the highest number of gillnets (52), followed by the Upstream transect (29) and then the Downstream (18). Overall, number of gillnets at the mid-reservoir decreased by 37% from 51 in April, 2015 survey to 32 in September 2015 (Table 3.6.1). The mesh sizes of gillnets used ranged between two inches (50.8 mm) and six inches (152.4 mm). Overall, numbers of gillnets at the three transects between April and September 2015 reduced. As observed with boats, the mid-reservoir transect recorded the highest number of gillnets. Monofilament gillnets were recorded only at the reservoir. In this and the previous surveys, small seine nets were only recorded at the upstream transect while scoop nets were only recorded at the mid-reservoir transect. Similarly, boats using small seine nets to harvest *R. argentea* (Mukene) were only recorded at the upstream station. The multifilament gillnets, long lines and traps were the most frequent fishing gears at all the three transects. Long lines and traps were most

dominant at the Upstream and mid reservoir transects respectively. (Table 3.6.1). The downstream transect registered the highest number of cast nets in April 2015 recorded but none during the September 2015 survey. The mid-reservoir transect recorded only two cast nets in April 2015 and seven cast nets during the current survey. It is most likely that the cast net fishers at the Downstream transect migrated to the mid-reservoir reach during the current survey in search for high catches. In April 2015 survey, scoop nets were present at Upstream and mid-reservoir transects but during the current survey, no scoop net was recorded.

Basket traps were used to target particularly young *Mormyrus kannume* which were marketed live to fishers for use as bait for the Nile perch, a highly prized commercial fish in Uganda and other commercially important species e.g. *Clarias gariepinus* and *Protopterus aethiopicus* on Lakes Victoria and Kyoga. Overall, the number of boats using traps in the three study sites reduced from 145 in April 2015 to 66 in September 2015, representing a 120% decline. The mid-reservoir transect has never recorded any basket traps but during the September 2015 survey, 10 basket traps were recorded. This observation could be an indication of a shift in demand and species composition of commercial fisheries at this site. Fishers tend target those fish species with high demand and of high market value.

The number of boats at the Upstream and Downstream transects decreased which could have resulted from the declining catches at these sites, forcing some fishers to migrate to the mid-reservoir area suspected to have high fish catches or engage in other alternative livelihood activities. The choice of gears at the three sites during the September 2015 survey could therefore be a reflection of the target fish species available at those sites. The type of fishing gear used by fishermen at a particular fishing ground is said to be influenced by the target fish species, the cost of fishing unit, the catch per unit of effort (CPUE), the habitat and the suitability of the gear with respect to that particular site (Hovgard and Lassen, 2000). Fishermen have also been found to shift between fishing gears in response to seasonal variations in catches of the target species thus fishers can use a particular fishing gear when catches of the target species are high and can abandon it when catches go down. The continued use of basket traps at the Downstream transect is attributed to the high catch per unit of effort for those gears targeting the species and the improved prices for the species. The high demand for bait to support exploitation of other fisheries (*L. niloticus*, *P. aethiopicus* and *C. gariepinus*) on Lakes Victoria and Kyoga is probably the major factor contributing to this. The sustainability of *M. kannume* as bait fishery against an increasing fishing effort to target the juveniles of this species remains an unanswered question. The juveniles of *M. kannume* have a high demand and fetch more market prices compared to the big sizes of the same species which is sold for direct human consumption. On the other hand, the introduction of long line hooks at the mid-reservoir area which was not the case in the earlier surveys and the increase in the number of gillnets could be probably due to general improved catches of *L. niloticus* and *O. niloticus* in the study area.

Table 3.6.1. *The trend in numbers of fishing boats and fishing gears, upstream at Kalange-Makwanzi, mid-section of the reservoir and downstream at Buyala-Kikubamutwe*

Number of common gears in use	Transect	Monitoring dates																
		Apr-06	Sep-07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Number of fishing boats	Kalange-Makwanzi	9	10	7	22	18	23	23	18	32	15	20	19	24	27	27	32	25
	Mid section of the Reservoir										16	13	18	27	44	60	38	51
	Buyala-Kikubamutwe	13	17	23	26	32	23	15	12	15	34	19	28	40	20	32	25	21
Number of boats using gillnets	Kalange-Makwanzi		9	7	10	6	7	13	6	8	9	9	7	12	15	9	6	10
	Mid section of the Reservoir										13	3	4	12	20	21	13	12
	Buyala-Kikubamutwe		7	18	7	6	1	2		1	4	2	7	3	1	10	1	4
Number of boats using long line hooks	Kalange-Makwanzi		1	2	3	1	2	2	0	2	1	4	6	5	8	5	3	4
	Mid section of the Reservoir										1	0	0	5		6	6	2
	Buyala-Kikubamutwe		10	8	6	6	13	6	3	7	10	7	0	5			6	
Number of boats using cast nets	Kalange-Makwanzi					5	4	1	1	5	1	0	3	3	2	6	5	2
	Mid section of the Reservoir										0	0	0	2			2	7
	Buyala-Kikubamutwe			1	6	3	1	1	3	0	7	2	0	2			7	
Number of boats using Hand line hooks	Kalange-Makwanzi			7	9	5	4	2	6	8	3	3	1	3	1	1	4	
	Mid section of the Reservoir										1	7	3	0	16	23	9	14
	Buyala-Kikubamutwe			15	9	14	9	2	2	3	12	5	2	5	5	7	3	17
Number of boats using traps	Kalange-Makwanzi															5	7	7
	Mid section of the Reservoir																	1
	Buyala-Kikubamutwe														14	15	8	
Number of boats using small seines	Kalange-Makwanzi															1	3	2
	Mid section of the Reservoir															2		
	Buyala-Kikubamutwe																	
Number of boats using scoop nets	Kalange-Makwanzi					1	6	4	4	4	1	2	3	2			4	
	Mid section of the Reservoir										6	3	12	8	8	8	8	
	Buyala-Kikubamutwe			2	1	1		1	2	1	1	0	0					
Number of fishing gears by mesh size																		
Gillnets - ≤2½"	Kalange-Makwanzi		3			1			4		2	0	0	1	11	2	8	1
	Mid section of the Reservoir										0	0	0		8	3	9	
	Buyala-Kikubamutwe			1		10		2			0	0	12			38		11
Gillnets 3"	Kalange-Makwanzi					3	1	6			8	0	0	10	4	15	6	
	Mid section of the Reservoir										0	4	0	16	5	39	35	9
	Buyala-Kikubamutwe			1	4			9			10	0	0	0	0	0	15	
Gillnets 3½"	Kalange-Makwanzi		3			1	1	4		5	16	0	0	0	1	3	1	8
	Mid section of the Reservoir										0	3	0	12	7	16	5	
	Buyala-Kikubamutwe			25							3	11	3	0	0	0		
Gillnets 4"	Kalange-Makwanzi		30		21	8	2	26	20	20	10	0	0	18	35	17	1	
	Mid section of the Reservoir										0	0	0	5	98	16	1	
	Buyala-Kikubamutwe		20	4			1			13	0	0	0	0	10			
Gillnets 4½"	Kalange-Makwanzi			21	5			2	2	12	4	0	0	0	3			
	Mid section of the Reservoir										0	0	0	0	0	8	1	
	Buyala-Kikubamutwe		3	12		6	1				0	0	0	12				
Gillnets 5"	Kalange-Makwanzi		2	25	12	1					1	0	0	0	3			
	Mid section of the Reservoir										14	0	0	0	0	1		
	Buyala-Kikubamutwe		5	47						5	0	0	0	0	0	0		
Gillnets 5½"	Kalange-Makwanzi											0	0	0	0	0		
	Mid section of the Reservoir											0	0	0	0	0		
	Buyala-Kikubamutwe											0	0	0	0	0		
Gillnets 6"	Kalange-Makwanzi							4		8		2	2	8	0	0		
	Mid section of the Reservoir										22	0	0	0	0	0		32
	Buyala-Kikubamutwe			5	18	15						0	9	0	0	0		
Total gillnets	Kalange-Makwanzi		38	46	38	20	24	42	28	43	41	2	8	37	57	37	16	18
	Mid section of the Reservoir										36	7	0	33	118	87	51	32
	Buyala-Kikubamutwe		28	99	22	37	4	11		18	13	11	24	12	10	38	15	11
Long line hooks	Kalange-Makwanzi		300	330	550	200	650	280		500	70	800	687	860	1360	950	230	626
	Mid section of the Reservoir										50	0	0	70		580	378	200
	Buyala-Kikubamutwe		510	445	277	180	380	142	110	482	525	420	0				1100	420
Beach seines	Kalange-Makwanzi																	
	Mid section of the Reservoir																	
	Buyala-Kikubamutwe			1														
Cast nets	Kalange-Makwanzi					5	4	1	1	5	1	0		3	2	6	5	2
	Mid section of the Reservoir										0	0		2			2	7
	Buyala-Kikubamutwe			1	6	3	1	1	3		7	2		2			7	
Hand line hooks	Kalange-Makwanzi			91	105	124	26	3	18	88	35	4		26	2	10	35	
	Mid section of the Reservoir										6	14			69	276	65	218
	Buyala-Kikubamutwe			394	97	152	32	16	8	5	51	24	2					
Scoop nets	Kalange-Makwanzi					1	6	4	4	4	1	2	3	5	5	39	4	
	Mid section of the Reservoir										6	3	12	8	8	8	8	15
	Buyala-Kikubamutwe			2	1	1		1	2	1	1	0	0	2				
Small seines	Kalange-Makwanzi															3	3	2
	Mid section of the Reservoir															2		
	Buyala-Kikubamutwe																	
Monofilament nets	Kalange-Makwanzi										0	29	15		38		16	
	Mid section of the Reservoir										21	0	13	3	113	56	47	43
	Buyala-Kikubamutwe										0	0	0		4			
Traps	Kalange-Makwanzi											0	0			43	48	1
	Mid section of the Reservoir											0	0					10
	Buyala-Kikubamutwe											56	151	461	460	190	97	55

3.6.2. Fish catch composition and catch rates

Overall, 13 fish species belonging to seven families were recorded along the three transects (Table 3.6.2). As in the last survey, family Cichlidae registered the highest number of species (five), while majority of the families were represented by only a single species. The Upstream transect registered 9 species among which were *O. variabilis, O. leocostictus, and B. altianalis* being recorded only at this station. Eight fish species (*L. niloticus, B. docmak, M. kannume, S. afrofischeri, T. zilli, O. leucostictus, haplochromines* and *O. niloticus*) were recorded at all transects. *S. victoriae was* recovered *only* at the mid-reservoir transect. The lung fish, *Protopterus aethiopicus has not appearead* in the commercial catch since 2013 at the three study sites. The continued absence of *P. aethiopicus,* previously present in the other surveys especially at the upstream transect should be a concern from the conservation point of view in the study area.

During the current survey, *R. argentiea* was only recorded at the mid-reservoir station where it registered 51 kg/boat/day (Table 3.6.2) and 23 tonnes in monthly catch landings (Table 3.6.3). The species has been absent at the downstream station since September 2011 and has been recorded only three times at this station from the start of fisheries monitoring surveys in the study area. At the time of the September 2015survey, fishers targeting it at the upstream station were not fishing due to the bright moon given that the species is mainly fished during the dark phase of the moon. The absence of the species at the upstream site should therefore be attributed to seasonal and lunar variations since fishing gears for the species were also recorded at the other sites under frame survey (Table 3.6.1). The current survey emphasizes the ecological importance of the Upstream transect (Kalange-Makwanzi) in supporting a high diversity of fish species besides the presence of the three rare species that are always significantly absent at the other two transects in the study area. Any post effects of the Bujagali hydropower dam construction in the upstream area would therefore not only impact on the diversity of fisheries resources but also, fisher communities along the river whose livelihoods are either directly or indirectly derived from the prevalent diverse fish species.

Both *L. niloticus* and *T. zillii* registered an increase in catch rates at all the three transects compared to the previous surveys (Table 3.6.2) but *O. niloticus,* increase was registered at the Upstream and mid-reservoir transects. It declined at the downstream transect.

Although there was a general drop in the total number of traps recorded during the Frame survey (Table 3.6.1) in the study area, their rapid expansion to target live *M. kannume* for bait in the long line hook fisheries of *L. niloticus* on Lakes Victoria and Kyoga and the associated returns from these fisheries partly explain the relatively high CPUE for *M. kannume* at all the transects. It was further observed that catches for *L. niloticus* significantly increased at all the three transects of the study area (Table 3.6.2). It was further observed that catches for *L. niloticus* drastically reduced at the Upstream transect by 93.1% from 5.9 kg/boat/day to 0.4 kg/boat/day and the Reservoir by 40.1% from 2.6 kg/boat/day to 1.6 kg/boat/day.

Table 3.6.2 *Trend of fish catch rates (kg/boat/day) with all gears pooled, of the main fish taxa the upstream at Kalange-Makwanzi, mid of the reservoir and downstream at Buyala-Kikubamutwe.*

Family	Species/taxa	Transect	Monitoring Period														
			Sep. 2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	0.05	0.21	0.4	0.27	0.08	0.15	0.09	0.5	0.53	0.9	0.46	0.8	1	0.7	0.2	1
		Mid section of the Reservoir									0.18	6	0.2	1.1	0.9	1.2	0.3	1.6
		Buyala-Kikubamutwe	0.39	0.1	0.03	0.21	0.17	0.06	0.83	0.16	0.94	1	0.5	1.4		8	0.2	2
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	1.11	1.56	0.78	2.12	0.64	0.76	0.52	0.11	1.79	1.8	1.56	2.9	2.5	5.9	0.4	2.7
		Mid section of the Reservoir									0.43	3.5	0.81	1.9	2.5	2.6	1.6	2.5
		Buyala-Kikubamutwe	0.52	0.15	1.01	0.79	1.3	0.38	1.97	3.38	1.41	1.5	0.56	4.9	2		0.2	1.8
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Brycinus sadleri	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	1.5	1.05	0.86	2.81	1.16	0.1	0.48	1.27	0.06		0.6	0.6	1.2	1.2	0.4	1.5
		Mid section of the Reservoir									0.3	0.3	0	0.6	1.9	0.3	0.2	1.5
		Buyala-Kikubamutwe	0.18	0.64	0.95	0.14		0.14	0.84	0.02	0.16	0.6	0.2	4.1	0.2		1.4	0.3
	Oreochromis leucostictus	Kalange-Makwanzi			0.01	0.13	0.01								0.2	0.1	0.01	0.2
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Oreochromis variabilis	Kalange-Makwanzi	1.25	1.43	1.44	0.88	1.03	0.68	0.23	0.61	0.65	0.4	0.66	1.7	2	1.7	0.2	1.6
		Mid section of the Reservoir									0.48	0.1	0		0.5	0.5		0.5
		Buyala-Kikubamutwe				0.06	0.25	0.1	1.67									
	Tilapia zillii	Kalange-Makwanzi	0.88	0.9	0.25	1.04	0.21	0.22		0.12	0.59	0.1	0.11	0.9	1.1	0.3	0.02	1
		Mid section of the Reservoir									1.13	0.1		0.8	0.5	0.2	0.02	0.5
		Buyala-Kikubamutwe	0.06	0.38		0.01	0.15	0.04					0.02	0.5				0.6
	Haplochromines	Kalange-Makwanzi	0.22		0.02	0.04	0.01	0.01	0.01	0.15	0.03			0.1		0.02	0.01	0.1
		Mid section of the Reservoir									0.01				0.1			0.01
		Buyala-Kikubamutwe		0.1		0.01		0.02	0.1	0.01				0.6	0.2	0.04	0.2	0.8
Clanidae	*Clarias gariepinus*	Kalange-Makwanzi	0.08	1.22	0.18	0.07		0.04		0.22	1.77	0.5	0.18	3.5	3.8	1.5	0.1	2.8
		Mid section of the Reservoir									1.35							5.1
		Buyala-Kikubamutwe		0.83	0.18								0.05			0.3	0.1	
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	2.88	6.72	5.98	5.11	2.27	2.87	1.66	0.28	6.05	0.1	0.24	1.2	9.8			9.8
		Mid section of the Reservoir									0.95			0.5		0.7		
		Buyala-Kikubamutwe	2.72	0.35	1.17	0.54	2.1	1.58	1.13	2.98	1.4	1.5				9.4		
	Barbus paludinosus	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Labeo victorianus	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Rastrineobola argentea	Kalange-Makwanzi					11.4	2.96	34.5			43	43		24	21		
		Mid section of the Reservoir									115	25.3	4.29		22		7.2	31
		Buyala-Kikubamutwe		1.92	5.3			3.05	50									
Cyprinodontidae	*Aplocheilichthys pumilus*	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
Lepidosirenidae	*Protopterus aethiopicus*	Kalange-Makwanzi		0.19	0.06		0.05	0.48			0.05		0.05			12		
		Mid section of the Reservoir																
		Buyala-Kikubamutwe											0.04					
Mochochidae	*Synodontis victoriae*	Kalange-Makwanzi														0.3		
		Mid section of the Reservoir														0.4		0.5
		Buyala-Kikubamutwe												0.1			0.2	
	Synodontis afrofischeri	Kalange-Makwanzi	0.04		0		0.02	0.01		0.01	0.2				0.3	0.4	0.4	0.7
		Mid section of the Reservoir									0.06			0.5	0.1	0.2		0.5
		Buyala-Kikubamutwe	0				0.01							0.1		1		0.4
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	2.21	6.77	2.93	0.43	1.84	2.03	0.25	0.7	5.47	1.5	1.35	1.4	0.7	2.5	2.2	1.1
		Mid section of the Reservoir									1	4.7	0.96	3.4	3.3	4.8	0.4	2.7
		Buyala-Kikubamutwe	0.28	0.31	0.23	0.19	0.39	0.06	1.04	0.61		2.3	4.07	4.3	3.2	3.9	2.5	2.3

3.63. Estimates of total fish catches

The total monthly catch estimates between April and September 2015 increased by 46% at the upstream and by 215.6% at the mid-reservoir transect (Table 3.6.3) but at the downstream transect, estimates reduced by 18.8%. Varied increases and declines in total monthly catches of individual fish species were also observed across transects in the study area. For instance, *O. niloticus* increased at the upstream transect from 0.38 t to 1.3 t but decreased at the mid-reservoir (0.18 t to

0.07 t) and the downstream stations (0.9 t to 0.02 t). *B. docmak, L. niloticus* and *C. gariepinus* registered significant increased across all transects. The declining catch trend was also observed in the *M. kannume* at all except the mid-reservoir station where a 48.1% decrease (1.6 t to 0.83 t) was registered.

Fishery yields have been found to increase with increases in fishing inputs up to a point of maximum sustainable yield (MSY) beyond which further increase in fishing inputs results into diminishing returns. Similar studies on effects of fishing effort on fish stock biomass (Jennings & Polinin, 1996) have shown that biomass decreases with increase in fishing intensity. The interactions between fishing effort and catch per unit effort show that high fishing effort leads to a slight increase in CPUE, while high CPUE attracts additional fishing effort, which in the long term leads to reductions in CPUE. In an unexploited fishery, introduction of small amount of fishing effort will result into high catch rates (catch-per-unit-effort) but further increase beyond the maximum sustainable yield (MSY) will result into a decrease in CPUE thus a decrease in stock biomass since CPUE is at times used as a measure of biomass index (stock size of the species).

The numbers of traps targeting *M. kannume* for bait remained relatively high which could partly account for their high total catches across the study area. The long term sustainability of this fishery however should be a concern for the fisheries conservationists, managers and researchers as traps target and harvest mainly the live juvenile mormyrids for bait which have tended to fetch high market prices due to the increased demand. Although live fish fetch high prices in a short term, harvesting juveniles leads to heavy ecological losses as fish are not allowed to attain mature stages to reproduce which in the long term affects recruitment and may lead to reductions in fish stocks. Similarly, harvesting juvenile species for bait away (Lakes Victoria and Kyoga) from the study area deprives the riparian communities of the rich fish protein hence may lead to prevalence of malnutrition among the fisher communities.

Table 3.6.3 *Trends of total fish catch estimates (kg), upstream at Kalange-Makwanzi, mid-section of the reservoir and downstream at Buyala-Kikubamutwe*

Family	Species/Taxa	Transect	Monitoring dates															
			Sep.2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr 2010	Sept. 2010	Apr. 2011	Sept. 2011	Apr. 2012	Sept. 2012	Apr. 2013	Sept. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	11.3	38.1	182.7	68.4	52.8	59.8	33.9	355.1	139.8	381.7	267.7	130.9	376.8	491.4	228.0	303.0
		Mid section of the Reservoir									88.4	481.8	74.5	187.1	1,193.4	2,068.4	284.0	1,724.0
		Buyala-Kikubamutwe	198.3	87.6	24.4	191.6	109.0	25.8	195.3	73.5	396.7	128.6	367.0	360.8		7,200.0	117.0	741.0
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	252.8	212.4	381.5	592.2	422.1	369.1	193.3	78.3	475.6	870.7	948.7	5,940.2	1,950.1	4,418.1	576.0	1,252.0
		Mid section of the Reservoir									185.1	248.7	365.7	347.1	3,185.2	4,680.0	1,356.0	2,470.0
		Buyala-Kikubamutwe	263.3	89.2	741.2	707.8	840.6	163.5	465.5	1612.5	592.7	117.1	449.6	452.3	1,200.0		132.0	1,874.0
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi					-	-										
		Mid section of the Reservoir																
		Buyala-Kikubamutwe					-	-										
	Brycinus sadleri	Kalange-Makwanzi					-	-										
		Mid section of the Reservoir																
		Buyala-Kikubamutwe					-	-										
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	313	162.1	395.6	705.7	765.1	39.9	179	7.5	14.6			96.6	930.0	842.4	576.0	1,318.0
		Mid section of the Reservoir									112.8	25.5	0.0	102.3	2,392.8	453.6	177.0	70.9
		Buyala-Kikubamutwe	95.5	378.5	696.7	124.4	-	60.2	187	907.8	70	10.3	161.6	1,069.2	120.0		888.0	24.0
	Oreochromis leucostictus	Kalange-Makwanzi			3.5	52.4	6.6	-							153.0	90.3	8.5	
		Mid section of the Reservoir																
		Buyala-Kikubamutwe			-		-	-										
	Oreochromis variabilis	Kalange-Makwanzi	261.7	226.1	665.3	221.8	678.4	271.2	625.6	434.9	172.6	552.0	380.4	273.2	1,515.7	1,278.6	228.0	592.0
		Mid section of the Reservoir									184.2	8.0			514.8	468.0	12.3	
		Buyala-Kikubamutwe			-	52.3	161.7	43	53.9									
	Tilapia zilli	Kalange-Makwanzi	285.8	140.6	187.4	261.5	138.5	87.7	88.9	87.7	105.3	98.2	82.4	146.9	803.8	240.7	15.7	174.0
		Mid section of the Reservoir									429.5	8.4	0.0	15.8	650.7	288.0	22.7	
		Buyala-Kikubamutwe	28.5	227.1	-	9	97	17.2	52.9	2.1			16.8	13.9				159.0
	Haplochromines	Kalange-Makwanzi	46.8		7.9	9.8	6.6	4	4.88	108.3	6.7		0.2	7.9		15.0	4.6	92.0
		Mid section of the Reservoir									5.3				88.2			
		Buyala-Kikubamutwe		62.2	-	7.5	-	8.6	24.5	9				166.5	95.0	27.0	132.0	120.0
Claridae	*Clarias gariepinus*	Kalange-Makwanzi	17.8	191.5	80.9	17	-	16			467	109.2	102.8	554.4	2,870.6	1,147.0	80.1	210.0
		Mid section of the Reservoir									515.5							1,098.0
		Buyala-Kikubamutwe		338.1	335.5		-	-		159	-	-	25.9			270.0	52.8	
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	605.8	1,055.10	1,857.80	1,282.50	1,497.20	1,144.50	436.4	200.8	1,397.80	30.0	141.7					
		Mid section of the Reservoir									362.7			180.1	7,301.8			
		Buyala-Kikubamutwe	1388.3	210.9	863.2	482.8	1,357.90	679.7	268.6	1341	515.5	209.4		89.1		1,200.0		
	Barbus paludinosus	Kalange-Makwanzi					-	-								8,460.0		
		Mid section of the Reservoir																
		Buyala-Kikubamutwe					-	-										
	Labeo victorianus	Kalange-Makwanzi					-	-										
		Mid section of the Reservoir																
		Buyala-Kikubamutwe					-	-										
	Rastrineobola argentea	Kalange-Makwanzi		1,243.80	-		6,463.80	2,109.30	2,152.80			1,105.7			18,371.9	13,793.0		
		Mid section of the Reservoir									13,128	1,490.3	1,427.6		27,708.5		7,357.0	23,000.0
		Buyala-Kikubamutwe			2,873.70		-	980.4	1,960.00									
Cyprinodontidae	*Aplocheilichthys pumilus*	Kalange-Makwanzi					-	-										
		Mid section of the Reservoir																
		Buyala-Kikubamutwe					-	-										
Lepidosirenidae	*Protopterus aethiopicus*	Kalange-Makwanzi		80.5	25.4		38	191.4			32		26.4			9,023.7		
		Mid section of the Reservoir																
		Buyala-Kikubamutwe			-		-	-										
Mochochidae	*Synodontis victoriae*	Kalange-Makwanzi																
		Mid section of the Reservoir													251.9	729	7.9	398.9
		Buyala-Kikubamutwe												26.4			126.0	
Mochochidae	*Synodontis afrofischeri*	Kalange-Makwanzi	8.1		1.8		13.2	4		10.4	32.8		31.9		229.6	905.9	409.0	426.1
		Mid section of the Reservoir									22.9			89.1	125.9	524.0		124.9
		Buyala-Kikubamutwe	0.6		-		6.5	-						13.2	300.0	900.0		158.3
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	463.8	2,060.10	1,552.50	106.9	1,213.60	829.5	389.6	500.1	1,444.10	517.6	783.2	214.1	562.6	1,753.3	1,956.0	831.7
		Mid section of the Reservoir									981.8	874.7	365.3	603.2	4,156.0	8,568.0	348.0	388.1
		Buyala-Kikubamutwe	141.7	185.9	178.5	169.2	252.2	25.8	57.8	276		842.1	3,248.0	1,135.2	1,900.0	3,465.0	1,607.0	834.8
TOTAL		Kalange-Makwanzi	2148.5	5,107.40	5,021.80	5,258.30	11,291.90	5,040.40	4,097.50	2842	4,484.50	5,508.1	5,141.0	2,066.0	36,626.2	55,651.7	5,384.0	4,940.9
		Mid section of the Reservoir									15,417.20	2,625.2	2,480.4	1,539.0	49,633.1	21,245.0	9,508.9	30,008.9
		Buyala-Kikubamutwe	2114.2	3,001.30	5,505.00	1,740.70	2,825.80	2,004.20	3,247.00	3513.6	1,847.30	1,389.3	4,468.7	6,850.0	5,613.0	20,322.0	5,890.0	5,110.9

3.6.4. Estimates of total beach value of the catch

The September 2015 survey showed a substantial increase in the beach revenue generated from the commercial catch landed at all the study sites compared to that of April 2015 (Table 3.6.4), with the highest increase (727.5%) registered at the mid-reservoir. A total beach revenue of 83.3 million Uganda shillings (Table 3.6.4) representing a 241.4% increment was obtained from the 38.1 t of fish landed in the commercial fishery at the three study sites (Table 3.6.4). The fishes that contributed most to the total beach revenue were: *L. niloticus, R. argentea* and *B. docmak.* The high revenue recorded at the mid-

reservoir transect could be attributed to high catches of Mukene and the booming bait fishery of *M. kannume*, beside the presence of high value fish species like *L. niloticus, B. docmak,* and *C. gariepinus*. The high values of beach revenue from the commercial fish species in the study area emphasizes their significant contribution to the livelihoods of the riparian communities particularly the women who are involved in the downstream fishing activities like processing and marketing. Deliberate efforts therefore need to be put in place to minimize the potential negative impacts of the dam to the fisheries, their environment and the riparian communities who directly derive their livelihood from fishing activities

Table 3.6.4. *Trend of monthly gross value of fish catches (shs) upstream at Kalange-Makwanzi; mid of the reservoir and downstream at Buyala-Kikubamutwe*

Family	Species/Taxa	Transect	Monitoring dates															
			Sep. 2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr. 2010	Sep.2010	Apr.2011	Sep.2011	Apr.2012	Sep.2012	Apr.2013	Sep.2013	Apr.2014	Sep.2014	Apr.2015	Sep.2015
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	10,313	74,417	912,400	136,800	138,400	104,678	181,790	1,065,257	482,400	1,245,321	802,998	349,184	2,548,860	37,600,000	280,302	1,054,792
		Mid section of the Reservoir									226,200	1,344,781	250,418	966,733	2,455,898	8,029,612	248,289	3,28,794.7
		Buyala-Kikubamutwe	180,880	162,093	87,541	451,200	108,900	46,173	185,342	661,500	1,312,000	450,000	1,488,858	1,448,200		982,800	26,564	7,405,714
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	96,602	338,182	944,702	987,782	729,780	549,555	868,725	274,040	1,299,000	3,294,528	2,188,276	1,771,868	9,165,457	14,568,489	368,900	4,053,465
		Mid section of the Reservoir									847,400	746,328	1,088,138	1,239,440	12,396,184	23,573,230	3,928,051	10,887,951
		Buyala-Kikubamutwe	415,276	141,247	2,225,704	1,887,578	1,821,328	296,650	2,100,908	12,255,000	1,825,400	585,714	2,248,482	15,760,800	8,400,000		68,067	9,558,600
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Brycinus sadleri	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	574,535	240,815	553,823	776,226	1,336,200	83,741	179,810	2,289,48	33,200			117,344	3,606,458	3,790,800	167,974	5,534,460
		Mid section of the Reservoir									256,300	76,526		167,397	7,178,330	1,526,064	106,301	212,573
		Buyala-Kikubamutwe	111,172	160,620	1,047,083	186,667		126,485	198,980	18,750	159,000	90,857	329,208	2,138,400	960,000		837,858	36,000
	Oreochromis leucostictus	Kalange-Makwanzi			5,198	52,378	19,200								533,846	182,314	911	
		Mid section of the Reservoir																
		Buyala-Kikubamutwe			-													
	Oreochromz variabilis	Kalange-Makwanzi	245,206	378,091	964,656	277,301	1,358,800	650,788	625,810	1,158,784	376,400	1,048,822	1,024,216	724,088	6,585,852	4,560,483	162,898	1,754,840
		Mid section of the Reservoir									402,000	23,918			787,117	1,344,600	1,871	
		Buyala-Kikubamutwe		-	-	78,400	163,700	103,253	55,900									
	Tilapia zillii	Kalange-Makwanzi	170,908	161,568	161,123	167370	277,800	175,457	88,908	179,314	241,000	285,356	249,851	365,310	2,712,721	408,168	3,826	357,714
		Mid section of the Reservoir									1,800,000	19,131		277,892	1,626,709	910,400	6,340	
		Buyala-Kikubamutwe	26,067	280,740	-	7,467	87,000	34,428	52,920	4,200				278,080				876,113
	Haplochromines	Kalange-Makwanzi	46,848	-	2,558	4,902	3,300	2,991	5,748	34,154				5,860			41	
		Mid section of the Reservoir													44,579			
		Buyala-Kikubamutwe		62,139	-			6,453	19,600	1,500					46,500	100,800	39,770	60,000
Clariidae	*Clarias gariepinus*	Kalange-Makwanzi	17,769	284,350	88,240	17,100		31,901		655,888	1,151,500	527,800	256,865	2,772,000	8,611,815	4,588,071	15,191	360,000
		Mid section of the Reservoir									1,248,900							3,844,000
		Buyala-Kikubamutwe		799,854	270,947			-								1,350,000	16,736	
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	674,221	1,660,815	3,215,809	1,921,750	2,245,800	1,823,982	872,820	501,428	4,411,000	75,016	481,904	855,360	22,505,558			
		Mid section of the Reservoir									1,001,000	633,600		267,300		5,600,000		
		Buyala-Kikubamutwe	1,549,215	332,592	1,366,671	881,522	2,580,000	1,085,347	799,680	6,705,000	1,625,500					38,070,000		
	Barbus paludinosus	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Labeo victorianus	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
	Rastrineobola argentea	Kalange-Makwanzi		-	-		2,932,823	894,417	1,722,240			534,286			12,247,912	13,642,857		
		Mid section of the Reservoir									2,883,600	945,000	813,813		18,890,818		894,028	21,958,404
		Buyala-Kikubamutwe		226,418	1,456,842			415,672	1,568,000									
Cyprinodontida	*Aplocheilichthys pumilus*	Kalange-Makwanzi																
		Mid section of the Reservoir																
		Buyala-Kikubamutwe																
Lepidosireniidae	*Protopterus aethiopicus*	Kalange-Makwanzi		13,231	38,115		23,100	310,914			36,000		12,880			27,077,143		
		Mid section of the Reservoir																
		Buyala-Kikubamutwe		-	-			-					43,844					
	Synodontis victoriae															384,721		
															442,788	1,749,600	1,179	217,800
																	11,423	
	Synodontis afrofischeri	Kalange-Makwanzi	1,813	-	554		9,900	1,894		10,400	32,000	4,992			344,473	316,459	191,050	480,828
		Mid section of the Reservoir									22,900				251,878	567,000		218,500
		Buyala-Kikubamutwe	113	-	-		-	-							800,000	80,000		206,069
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	528,240	977,422	1,527,914	89,110	1,745,943	1,160,277	389,610	450,682	1,959,800	572,883	1,391,462	415,900	1,133,409	7,813,514	11,206,742	1,291,329
		Mid section of the Reservoir									318,000	374,457	749,504	1,249,000	5,669,628	17,892,800	374,423	1,201,202
		Buyala-Kikubamutwe	190,500	169,322	170,310	338,488	201,780	38,999	14.4	891,288		2,105,357	24,360,527	11,312,000	9,658,355	15,582,740	5,259,740	4,201,587
TOTAL		Kalange-Makwanzi	2,356,254	4,127,892	7,912,939	4,422,724	10,478,246	5,850,683	4,850,660	6,395,785	10,089,000	7,467,968	7,162,475	7,434,812	89,797,498	80,934,829	12,648,861	17,267,307
		Mid section of the Reservoir									7,987,000	3,799,146	2,852,725	4,208,884	48,064,513	59,152,558	5,300,098	43,838,480
		Buyala-Kikubamutwe	2,379,023	2,894,454	8,611,098	5,731,317	9,971,698	2,148,248	4,377,844	19,877,138	4,720,000	3,694,829	28,484,724	46,733,280	19,864,853	113,713,300	6,250,856	22,184,084

Table 3.6.5. *Trends of the mean unit prices (shs/kg) of the most common fish species at the beach level along the upper Victoria Nile between April 2006 and September 2015.*

Species/Taxa	Monitring Dates																
	Apr-06	Sep-07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Lates niloticus	900	1576	1583	2188	2423	2000	1813	3286	6429	2750	2785	3063	3830	4363	4571	5198	4945
Oreochromis niloticus	750	1189	1481	1409	1189	2000	2100	1000	2500	2300	3000	2250	2278	3429	3686	3286	3526
Barbus altianalis	800	1113	1577	1666	2250	1722	1594	2250	4000	2760	3370	3400	3750	3000	3375	3000	
Mormyrus kannume	786	708	922	983	1416	1310	1433	667	986	1400	1825	3886	4600	2635	3444	2709	2877
Oreochromis variabilis	550	937	1687	1450	1357	1929	2400	1000	2667	2200	2860	2692	2650	4045	3500	3350	4300
Bagras docmak													3950	3028	3780	2813	3542
Clarias gariepinus													5000	3000	4333	3000	2875

3.6.5 Estimated total catches and revenue of individual fishing units

There have been fluctuations in mean price per kilogram weight of fish landed in the commercial catches since April 2009 for those species whose mean prices were calculated (Table 3.6.5). Four species (*O. niloticus, M. kanume, O. variabilis* and *B. docmak*) whose mean prices per kilogram were calculated showed increased mean prices compared with the April 2015 survey. The declines in mean prices were observed as follows: *L. niloticus* (4.9%), and *C. gariepinus* (4.2%).

During this round of sampling, *L. niloticus* (Shs. 4945/kg) and *O. variabilis* (Shs. 4300/kg) and were the most highly priced fish species per unit weight of catch. The mean prices are very important in commercial catch monitoring since they reflect the dynamic nature of fisheries and are dependent on seasonality, demand and quantities of catch landed. The observed increases and reductions in mean prices during the current survey could reflect the quantity and sizes of individual fish landed which in turn is associated to the type and size of fishing gears used to harvest fish. Generally, the larger the size of fish harvested, the higher the price and vice versa. Similarly, when fish supply is scarce, the demand for fish irrespective of their individual sizes is high thus forcing the prices to rise.

Table 3.6.6 *Trend of monthly total catches and revenue of individual fishing units upstream at Kalange-Makwanzi, the mid-section of the reservoir and downstream at Buyala-Kikubamutwe*

Parameter rate	Site	Monitoring Dates															
		Sep-07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Total catch (Kg/boat/month)	Kalange-Makwanzi	215	444	228	180	418	219	467	89	47	144	158	103	1,356	1,320	3,383	4,941
	Mid section of the Reservoir									307	389	150	79	924	354	9,508	30,009
	Buyala-Kikubamutwe	124	130	212	55	123	134	329	221	275	66	154	343	181	677	3,830	3,111
Total revenue (Shs/boat/month)	Kalange-Makwanzi	223,625	589,698	359,679	245,707	388,009	253,508	298,445	206,118	188,500	418,986	7,162,475	7,434,812	2,585,093	2,997,586	12,648,861	17,267,307
	Mid section of the Reservoir									1,227,000	883,296	2,882,725	4,208,684	1,131,216	992,209	5,300,098	43,858,498
	Buyala-Kikubamutwe	139,943	117,150	254,273	116,604	216,161	143,217	410,225	1,331,810	1,098,000	187,657	28,484,724	46,733,280	953,242	3,757,110	6,250,856	22,164,084

Compared to the April 2015 survey, there was an increase in both the total monthly catch and beach revenue from catch in September 2015. The mid- reservoir area registered the

highest mean monthly catches and beach revenue from catch. The upstream and downstream transects also registered sharp increases in the mean monthly catches and beach revenue from catch (Table 3.6.6). Trends revealed at the study area show a positive correlation between mean monthly catches and total revenue of catch, thus, an increase in one, results into a corresponding increase in the other. High fish catch was good for the riparian communities due to the associated economic benefits (beach revenues). There is therefore a need to sustain the fish catches in the study area through sustainable harvesting technologies and minimization of environmental negative impacts of the dam that affect fish production in their natural habitats.

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

The fish consumption culture by fishers improved slightly at the upstream (1.3. t) and mid-reservoir transects (0.5 t) during the current survey (Table 3.6.7). The quantity of fish retained at the two stations can be attributed to the improved catch landings (monthly catch) during the September 2015 survey (Table 3.6.3). There was no fish retained at the downstream station which also recorded the least total monthly catch (Table 3.6.3). The retention of relatively small proportions of catch for domestic consumption at the downstream station however is linked to large quantities of juvenile *M. kannume* sold live as bait for exploitation of other fisheries on other water bodies like Lake Victoria but not for human consumption. There were also large quantities of Mukene landed at the mid-reservoir. Mukene is less preferred for human consumption and is difficult to quantify how much is retained for human consumption when it is still fresh. Absence of fish for domestic consumption at the downstream transect exposes the riparian communities, especially the children to risks of malnutrition given that fish is the major available source of animal protein to these vulnerable groups of people. In addition to nutrition, fish also contributes significantly to local livelihoods in terms of food security.

Table 3.6.7 *Trends of the average weight of fish (kg/boat/day) retained by fishers for domestic use between September 2007 and September 2014. In brackets the weight of fish retained is expressed as a percentage of the overall average weight of fish caught per boat.*

Sites	Monitoring dates															
	Sep-07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-10	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15
Kalange-Makwanzi	0.3 (2.9%)	1.1 (5.5%)	0.4 (3.7%)	3.5 (27.1%)	2.2 (11.8%)	1.5 (16.8%)	1.4 (30.7%)	2.1 (60.0%)	1.2 (12.8%)	1.2 (20.4%)	0.1 (2.58%)		1.3 (2.72%)		0.5 (92%)	1.3 (1.8%)
Mid section of the Reservoir									1.5 (50 %)		0.1 (1.1%)	5.4 (3.3 %)	0.5 (1.55 %)	1.4 (6 %)	0.1 (0.6 %)	0.5 (0.8 %)
Buyala-Kikubamutwe	0.7 (16.9%)	0.1 (2.1%)	0 (0%)	1.4 (71.8%)	1.3 (29.7%)	0.8 (16.5%)	1.2 (23.8 %)	3.0 (45.8%)	0.8 (14.4%)		0.2 (3.2%)				0.1 (3%)	

Fishery related jobs

The current survey recorded 165 people employed by the fisheries sector (i.e. fishing and other fishing related activities) in the study area compared to the 172 and 248 people recorded in September 2014 and April 2015 respectively (Table 3.6.8). Fishing remained the most prominent job engaging a total of 75 people (45.5%) but was dominated by

males with only two women at the upstream transect involved directly as fishers, a similar scenario observed in the previous three surveys of April & September in 2014 and April 2015.

During this survey, the highest number of fishers (38) was recorded at the upstream transect followed by the mid-reservoir transect (37) and least (21) at the downstream. The number of fishers at all sites in the study area decreased (Table 3.6.8). Besides fishing, fish trade employed a high number of people in the study area (i.e. 20 people, 80 % of whom were women). The mid-reservoir had the highest number of fish traders (11) while the upstream and the downstream transects recorded eight and one trader(s) respectively. The dominance of women in fish trade business in the study area shows the significance of the river fisheries in empowering women financially. Overall, food vending employed only five people (all women) down from the 11 people previously employed by this activity in the April 2015 survey (Table 3.6.8). This could be an indication of a reduction in fish supply. The general decrease in the number of fishers at all the three transects could be attributed to the reduction in catches of the target species and low economic returns from the fishing activities. This should be a point of concern given that fishing has traditionally been the key livelihood option for the riparian communities. The number of people involved in boat building and repairs increased from two in April 2015 to six in the current survey but only at the upstream and mid-reservoir stations. There is still no single boat repairer at the downstream transect and relatively old canoes were still in use. Absence of boat builders/repairers and the continued use of old leaking canoes by fishers at the downstream transect puts their safety on water at a risk and this could also be an indication of low returns from fishing. In terms of BMU membership, there were a fair proportion of women representation on the executive committees and considering that it is of recent when women started engaging directly in fishing activities, it is hoped that their numbers shall increase in the future.

Table 3.6.8 *The numbers of people by gender (Male/ Female) engaged in different jobs at landing sites upstream at Kalange-Makwanzi, mid of the reservoir and downstream and downstream at Buyala-Kikubamutwe*

Job description	Transect	Sex	Monitoring Dates																
			Apr-06	Sep-07	Apr-08	Apr-09	Oct. 09	Apr. 10	Sep. 10	Apr. 11	Sep. 11	Apr. 12	Sep. 12	Apr. 13	Sep. 13	Apr. 14	Sep. 14	Apr. 15	Sep. 15
Boat builders/repairers	Kalange-Makwanzi	M	2	1	3	3	3	1	2	3	3	2	2	3	3	3	2	2	4
		F																	
	Mid section of the Reservoir	M														1	5		2
		F																	
	Buyala-Kikubamutwe	M	5	2	4	2	2	3		1	1	3	3						
		F																	
Food vendors	Kalange-Makwanzi	M				1	1	2	4	1	1	1	1		1	2		1	
		F	4	3	5	4	2	4		3	3	3	3	2	5	2	5	4	5
	Mid section of the Reservoir	M												1	1			1	
		F											2	4	3	3	1	1	
	Buyala-Kikubamutwe	M										3	3		2				
		F		2														4	
Net repair(s)	Kalange-Makwanzi	M			5	4	4		3	5	5	3	3	7	5	6	4	6	4
		F																	
	Mid section of the Reservoir	M																	
		F																	
	Buyala-Kikubamutwe	M		2		1			3			6	6		3		11		
		F																	3
Cleaner fish landing	Kalange-Makwanzi	M																	
		F																	
	Mid section of the Reservoir	M																	
		F																	
	Buyala-Kikubamutwe	M																	
		F																	
Fisher(s)	Kalange-Makwanzi	M	57	20	32	43	37	30	38	25	25	25	25	25	42	39	39	54	36
		F													1	1	1	1	2
	Mid section of the Reservoir	M											13	24	49	51	55	74	37
		F																	
	Buyala-Kikubamutwe	M	26	30	42	47	46	30	34	30	30	15	9	28	72	15	11	42	21
		F																	
Fish trader(s)	Kalange-Makwanzi	M	11	3	2	3	6	4	4	6	6		2	1	1	2	6	1	1
		F	12	9	13	10	20	16	16	30	30		16	9	16	13	2	4	7
	Mid section of the Reservoir	M											2	1	1	3	1		2
		F											6	1	1	12	12	16	9
	Buyala-Kikubamutwe	M	5	2		2	2	2	2				1		1	1		2	1
		F	8	2		4	3	5	5	5	5		3	6	5		1	3	
Fish processor(s)	Kalange-Makwanzi	M																	
		F													3	3			
	Mid section of the Reservoir	M																	
		F														2		2	
	Buyala-Kikubamutwe	M			3							1	1						
		F			5							6	6						
Fish cleaner	Kalange-Makwanzi	M																	
		F																	
	Mid section of the Reservoir	M																	
		F												1	1				
	Buyala-Kikubamutwe	M																	
		F																	
Chairperson landing	Kalange-Makwanzi	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		F																	
	Mid section of the Reservoir	M												1	1	1	1	1	1
		F																	
	Buyala-Kikubamutwe	M		1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1
		F																	
BMU committee member(s)	Kalange-Makwanzi	M				6		4	5			7	7	5	5	7	4	5	6
		F				3		5	4			2	2	1	3	2	2	1	3
	Mid section of the Reservoir	M												5	3	3	2	4	3
		F												3	1			1	10
	Buyala-Kikubamutwe	M				4	2	2	3	3	3	4	4	4	4	10	4	8	2
		F				2	1					1	1	1	3	2		4	
Landing site askali	Kalange-Makwanzi	M	1										1	1	1				
		F																	
	Mid section of the Reservoir	M																	
		F																	
	Buyala-Kikubamutwe	M											1	1	1				
		F																	

3.7 SCHISTOSOMIASIS, RIVERBLINDNESS AND SANITATION STUDIES

3.7.1 Parasitological analysis of bilharzias in humans

Sampling for parasitological prevalence and intensity of Bilharziasis infection were maintained at Kalange-Makwanzi (an upstream transect), mid-reservoir and downstream (Buyala-Kikubamutwe).

Table 3.7.1 *Trend of Schistomiasis infection prevalence and intensity, schistosomiasis vector numbers, coliform counts among sample of people at Kalange-Makwanzi, mid of the reservoir and Kikubamutwe-Buyala*

Parameter	Variety	Site	Monitoring dates															
			Apr.06	Sept.07	Apr.08	Apr.09	Sept.09	Apr.10	Sept.10	Apr.11	Sept.11	Apr.12	Sept.12	Apr.13	Sept.13	Apr.14	Sept.14	Apr.15	Sept.15
Schistosomiasis Prevalence	*Mansoni*	Kalange-Makwanzi	53	46	56	28	49	21	21.8	16	18	18.6	17	25	20	19.6	20	22	16
		Mid section of the Reservoir										20.3	16.7	18.5	20	15	14.2	20	10
		Buyala-Kikubamutwe	48	43	40	22	33	19	16.7	18.6	21.8	19.6	20	17.5	18.6	16.4	20	15	20
	Haematobium	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid section of the Reservoir										0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Schistosomiasis Intensity	*Mansoni*	Light	32	60.8	59	35	77	83	86	87	86.3	75	67	79.2	83.3	90.5	70	81.2	76
		Moderate	50	27.5	32	12	4	17	13.6	13	13.7	18.1	33	16.7	16.6	9.5	20.5	12.8	23.5
		Heavy	18	11.8	10	3	4	0	0	0	0	6.2	0	4.1	0	0	8.5	6.1	0
Prevalence by water contact	*Mansoni*	Fishing	71.4	94.4	60	68	79	62	31.4	21.9	24	28	27.8	25.8	32	38.9	37.2	32.7	20
		Fetching water	18.1	38.4	36.6	30.9	48	0	6.5	14.3	20	20.5	18	17.6	16.6	9.1	13.3	15.3	16.6
		Bathing/swimming	70	93.4	54.5	54.8	63	15	18.6	20	46	20.4	23	34	20	42	20	20.5	30.1
		Fish mongers	60	42.8	16.6	15	33	8	14.3	5	14	13.3	11	18	14.2	10	18.1	16.6	0
Snail Species abundance	*Bulinus sp.*	Kalange-Makwanzi	10	21	14	8	23		19	37	85	17	251	20	8	6	20	44	118
		Mid section of the Reservoir										11	50	10	7	4	35	34	20
		Buyala-Kikubamutwe	13	11	50	8	83		9	51	18	3	5	7	21	8	37	7	74
	Biomphalaria sp.	Kalange-Makwanzi	22	31	26	25	20		63	182	33	26	26	47	16	20	16	16	32
		Mid section of the Reservoir										68	67	67	46	45	31	27	24
		Buyala-Kikubamutwe	11	9	65	74	122		62	80	60	200	167	22	51	44	47	18	28
	Others	Kalange-Makwanzi	127	39	51	135	67		101	455	81	8	72	59	68	222	28	4	59
		Mid section of the Reservoir										13	15	63	131	100	42	58	102
		Buyala-Kikubamutwe	50	37	52	188	91		118	96	57	71	105	87	84	42	37	70	36
Coliforms in water	Shallow	Kalange-Makwanzi	200	73	63	105	15	50	50	48	70	57	60	60	96	92	105	99	104
		Mid section of the Reservoir										79	80	94	80	80	135	130	131
		Buyala-Kikubamutwe	50	87	73	100	10	87	80	82	81	82	76	80	94	90	91	89	90
	Deep	Kalange-Makwanzi	40	10	43	15	1	1	1	1	2	79	80	80	80	80	135	130	131
		Mid section of the Reservoir										1	1	5	5	3.1	5	3.1	2
		Buyala-Kikubamutwe	10	21	70	22	1	1	1	1	1	6	1	1	1	4	10	7	7

Out of 105 stool samples collected from 485 people, 17 people (16 %) were infected with Schistosomiasis. During the previous survey-April 2015, the nfection rate was 18.8%. Like in all the previous sampling occasions, infection was still of the intestinal type of

Schistosomiasis (*Schistosoma mansoni*); the urinary type, *Schistosoma haematobium*, has never been detected at all. Infection with Schistosomiasis was highest (20%) at Buyala-Kikubamutwe, the downstream site (20%) and lowest (10 %) at the reservoir transect. A reverse trend was observed during the previous survey of April 2015 (Table. 3.7.1)

During the current survey, light intensity infection was 76% of all infection examined, decreasing from 81.2 % during the previous survey-April 2015 (Table 3.7.1). Both mid-reservoir and upstream transects (Kalange-Makwanzi) registered a slight decrease in schisitosomiasis infection but there was a small increase in infectvity at the downstream transect (Buyala-Kikubamutwe). While moderate infection intensity rose from 12.8 % during the previous survey-April 2015 to 23.5% during the current one-September 2015, heavy infection intensity dropped from 6.1% to nil. The results indicate a decline in rate of transmission of the disease and perhaps praziquatal treatment given to those infected was effectively working.

Bathing and swimming remained the main predisposing factors to Schistosomiasis infection contributing to 30.1% (Table 3.7.1). Fishing contributed 20% and fetching of water 16 %. All fish mongers did not have bilharzia infection. This indicates that the fish mongers could be the group that is taking their medication and contributing to the marked reduction in heavy infestation. This result will help focus current behaviour change communication (BCC) efforts towards the swimmers and fishermen to help bring down prevalence and intensity of infection even further. All residents found to be positive for schistosomiasis infection were treated under directly observed treatment (DOTs) by the sanitation team.

Status of snail vectors

Schistosomiasis vector, *Bulinus sp.* markedly increased at the upstream transect (Nkalange-Makwanzi) with the vector load numbers stepping up from 44 during April 2015 period to 118 during this survey-September 2015 (Table 3.7.1). Similarly, at the downstream transect (Buyala-Kikubamutwe), Bulinus *sp* numbers rose from were 7 in the previous survey period to 74 during the current survey but they dropped at the mid-reservoir transect from 54 during the previous survey to 20 during the current one. Like for *Bulinus sp* snail vectors, the *Biomphalaria sp* vector snail also remarkbly increased at thee upstream transect from 16 during the previous survey to 32 during the current one.

For the non-medically important snail species, their numbers dropped at the mid-reservoir and at downstream transects but increased at the upstream transect (i.e. from 4 to 39).

Four of the *Biomphalaria sp* collected at the mid-reservoir transect and two *Bulinus sp* snails at the upstream transect shed Cercaria. At the downstream transect, only one snail shed Cerceria.

Faecal coli forms

Colonies of faecal coliforms at shallow human-water contact points upstream were 104 colonies per ml during this survey up from 99 colonies per ml from the previous one (Table 3.7.1). At the downstream transect, similar counts of faecal coliform colonies have been registered during the previous and current surveys respectively (i.e. .90 Colonies per ml). At the mid-reservoir transect, 131 colonies per ml were recorded during this survey, just about the same during the last one. This heavy contamination portends high risk level for water borne diseases like cholera and diarrhoea.
Water from the deep middle part of the river recorded coliform counts of 7 colonies per 10 mls at the downstream transect and 2 colonies at the upstream transect. The micro-organisms of medical importance were predominantly *Salmonella sp* and *Shigell*a *sp.*
Water with ten colonies per ml and above is considered unsafe for human consumption.

Blackfly/*Mbwa Fly* Sampling
Medically important species of *Simulium* flies mostly live in sheltered areas of the river/stream in fast moving waters where they breed on crabs and Twigs depending on their species and sub species. During this sampling, none were detected either by human landing catches, foot patrol or of 103 crabs examined.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. Data trends of zooplankton composition, species richness and abundance estimates show that the construction of the hydropower dam and creation of the reservoir have not disrupted the stability of the zooplankton community (characterized by rotifer-driven species richness and copepod dominated numerical abundance), which still confers potential for fishery production in the reservoir and associated dam areas relative to the downstream site.
2. The occurrence of lower species richness and lower abundance of zooplankton in the downstream part of the study area observed during the present and September 2014 survey will require further inquiry to establish consistency of this pattern over time and whether this can be regarded as an impact of the constructed dam.
3. No new species recoveries on the list were recorded. The list of fish species expected from this section of the river (Upper Victoria Nile) seems to have been exhausted.
4. In the mid-reservoir, the biomass of keystone species (*L. niloticus, B. docmak* and *M. kannume*) has reduced when compared to previous surveys of April and September 2013. This is attributed to increase in fishing activities' in the main reservoir by the local fishers

5. In the September 2015 survey, *Caridina* was the dominant prey for *L. niloticus* at the mid-reservoir and Kalange-Makwanzi transets whereas at Buyala-Kikubamutwe transect, haplochromines were the major prey for the species. The diet of *L. niloticus* in September 2015 at the mid-reservoir and Buyala-Kikubamutwe transects was similar to observation made in the previous survey of

April 2015. The change in the diet of L, niloticus from dominance of haplochromines in April 2015 to *Caridina* in September 2015 at Kalange-Makwanzi is attributed to seasonal variation in availability of the prey species.

6. Breeding intensity of keystone fish species in all transects was higher in September 2015 (6 species) when compared to the previous survey of April 2015 (4 species). This is attributed to the higher fish species diversity recorded in the recent surveys.

7. There was an increase in shistosomiasis prevalence at the downstream transect. Though this scenario may not currently be attributable to the construction of the dam, it merits closer monitoring during subsequent sampling.

3.8.2 Recommendations

1. Given the observed stability and ecological roles of the zooplankton community, protective management needs to be maintained to preserve the community for continued ecological benefits with respect to the water environment quality, fish production as well as biodiversity concerns.

2. Fishing and other activities of the communities need to be properly monitored and regulated for a sustainable future fishery based on the created reservoir and other sections of the river. Entry in the reservoir fishery should still be restricted until more information on fish stocks in this water body is available.

3. Regular environment monitoring of the dam/reservoir areas is useful for early detection of water quality and biotic changes for timely institution of necessary remedial measures.

4. Mass drug administration and health education should be intensified in order to interrupt transmission of Schistosomiasis especially at the downstream transect where infection increased. Health education should be intensified especially among the new settlers and cultivators at the reservoir.

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