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

Monitoring No. 23

Date: 5th – 11th September 2018

Monitoring carried out by:

National Fisheries Resources Research Institute (NaFIRRI)
P.O. Box 343, Jinja, Uganda
Tel: 256-43-120384
Fax: 256-43-120192
Email: **firi@firi.go.ug**, **director@firi.go.ug**

On behalf of :
Bujagali Energy Limited (BEL)

Date of Report: December 2018

1.0 BACKGROUND

Pre-construction ecological baseline surveys, April 2000 and April 2006 were conducted on the Upper Victoria Nile at one upstream site (Kalange-Makwanzi transect) and three downstream sites (Buyala-kikubamutwe, Kirindi-Matamu and Namasagali-Bunyamira) to establish the prevailing water quality determinants, biology and ecology of fishes and food webs, fish stock and fish catch including economic aspects of catch and sanitation/vector situation (bilharzias and river blindness). These baseline assessments were preceded by eight ecological monitoring surveys: September 2007, April 2008, April 2009, October 2009, April 2010, September 2010, April 2011 and September 2011 during construction period.

This ecological monitoring survey No. 23 (5th -11th September 2018) on the Upper Victoria Nile is the thirteenth one to be undertaken after completion of construction of 250 MW Bujagali hydropower plant commissioned in September 2012. During the post construction period, ecological monitoring surveys have 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.

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 the 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

This is the twenty third monitoring survey at Kalange-Makwanzi and Buyala-Kikubamutwe, upstream and downstream transects respectively where water quality, fish abundance, diversity and distribution, fish biology, fish catch, sanitation conditions, bilharzia and river blindness vectors have been assessed. A third transect, the mid-reservoir was established when a reservoir spanning beyond Kalange-Makwanzi was created by the Bujagali Dam for assessment of parameters as at the upstream and downstream transects, including assessment of algae, zooplankton and benthic macro-invertebrates.

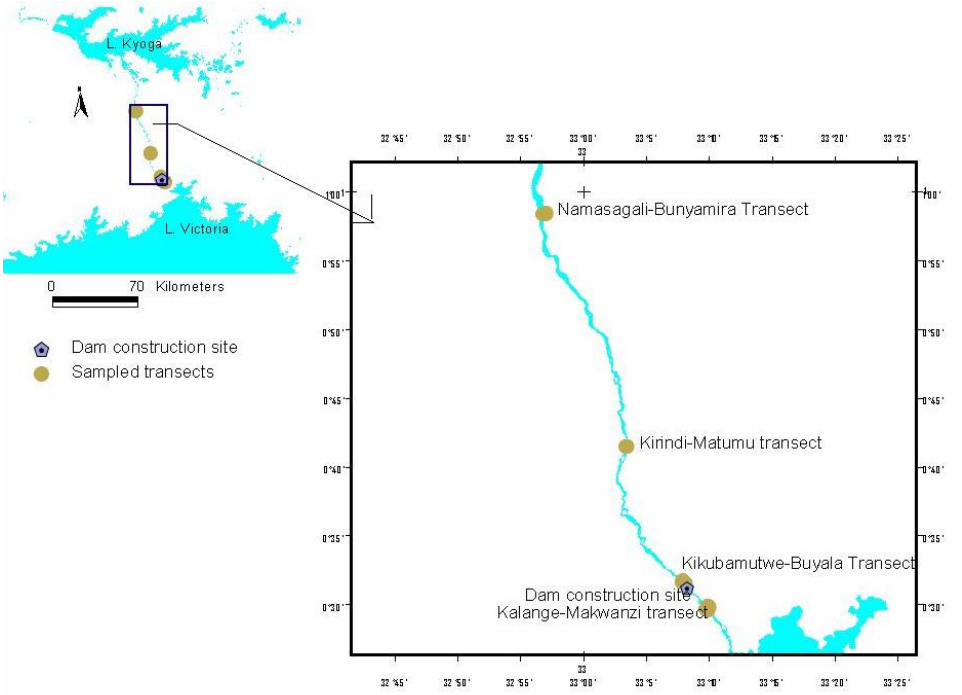

Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*

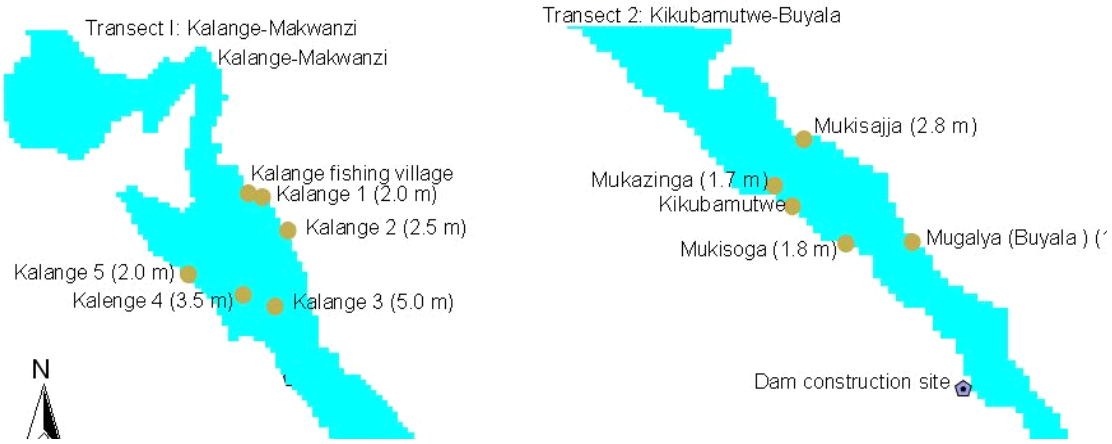

Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

Sampling, analytical procedures and techniques used in the previous surveys were followed.
At Sampling, analytical procedures and techniques used right from the baseline surveys are followed.

Assessment of algae

At each sampling site, 20 ml of water for assessment of phytoplankton is drawn at 0.5m depth, fixed with Lugol´s solution (Utermöhl, 1958), and stored away from light

(Wetzel and Likens, 2000). The sedimentation method of Utermöhl (1958) is used to count the phytoplankton under an inverted microscope (Leica DM IL). Taxonomic identification is made with the help of standard literature (John et al. 2002; Komarek and Anagnostidis, 1999). Species counts are made at a 400X magnification. For each sample, two transects in the sedimentation chamber are counted and the average recorded. *Nitzschia* and *Planktolyngbya* are counted as filaments, and their total length and width measured using the micrometer scale inserted into the eyepiece (1 unit in the scale equal to 2.5 µm). Other species such as *Anabaena*, *Chroococcus*, *Merismopedia* and *Oocystis* are counted as single cells. Cell lengths and widths are determined for bio-volume calculation (Hillebrand et al. 1999; Wetzel and Likens 2000). The bio-volume is calculated by multiplying the mean cell volume with cell density.

Assessment of zooplankton

Sampling of zooplankton is 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 are combined to make a composite sample, preserved in 4% sugar-formalin in a clean, labelled, plastic sample bottle. Species identification is 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 are noted and areal density estimates calculated for each station in conjunction with the diameter of the sample net and depth of sampling.

Assessment of benthic macro-invertebrates

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

Catch rates / biomass estimates

Catch rates i.e. catch per net per night are indicative of relative abundance of fish species from the transects under survey. Catch rates are used to estimate standing biomass. To analyse for catch per net, gillnets are grouped into three size categories: small (1 to 2 ½ inches stretched mesh), medium (3 to 4 ½) and large (5 to 8 inches).

Estimation of fishing effort

Fishing effort and catchability coefficients are used to measure fishing mortality whose variations can be used to assess trends in stocks of natural fish populations (Arreguín-Sánchez, 1996). Since 2006, Fish Catchment assessment Surveys (CAS) have been conducted on the Upper Victoria Nile at the Bujagali Hydro-power dam construction

Project area by assessing fishing effort and fish catch trends to estimate periodic fish yield due to fishing. Besides estimation of fishery yields, information that guides formulation of sustainable management advice alongside development projects such as dam construction is provided. Thus, 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.

Malacological assessments of Schistosomiasis (Bilharzia) Vector snails

Snails are collected at the designated transects and placed on white plastic trays to pick out vector snails (*Bulinus sp.* and *Biomphalalia sp*) from the rest. The vector snail samples are placed in labelled containers and transferred to the NAFFIRI laboratory for further identification using the standard field key guide from the Danish Bilharziasis Laboratory-DBL (Kristensen, 1987). In the laboratory, the vector snails are placed in 5 ml of clean water in petri dishes and exposed to light for at least two hours to induce cercarial emergence. Every 20 min, the snails are checked for cercaria shedding using a dissecting microscope. Snails found shedding cercaria are transferred into individual tubes to completely identify the shedding snails. The number of snails shedding cercariae is recorded. The shed cercariae are identified as described by (Frandsen and Christensen, 1984).

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 at the monitored sites*

Parameter	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	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18
Dissolved Oxygen (mg/L)	Kalanga-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	4.9	5.88	5.75	6.18	5.83	5.2	5.2	4.9	4.4
	Mid-reservoir										5.2	6.4	7.02	5.3	6.27	5.5	6.06	6.78	6.3	5.67	4.9	5.4	5.3	4.8
	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	6.1	5.69	6.29	7.03	5.9	5	5.3	4.1	5.1
	NEMA Std	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
pH	Kalanga-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	7.5	7.12	7.46	6.87	8.03	8	8	8.1	7.9
	Mid-reservoir										8.2	7.5	7.4	7.4	6.65	7.5	7.25	8.86	6.95	7.93	8.1	7.6	8.4	8.2
	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	7.7	7.24	8.01	7.23	7.97	8	7.4	8.2	7.7
	Upper NEMA Std	8	8	8. 0	8	8	8	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	6	6	6	6	6	6
Temperature (°C)	Kalanga-Makwanzi	26.7	26.1	26.2	26.4	25.7	25.6	24.8	26.4	24.9	25.9	25.3	26.9	25.2	26.6	25	26.2	25.9	24.4	26.1	27.5	25	26	26
	Mid-reservoir										26.1	25.4	26.9	25.3	26.7	25	26.4	25.9	25.1	26.1	27.3	25	26	26
	Buyala-kikubamutwe	26.4	25.7	26.9	26.8	25	25.8	25.4	26.9	26.5	26.1	25.3	27.1	25.6	27.2	25	26.5	26.1	26	26.2	27.5	26	26	27
	Upper NEMA Std	35	35	35	35	35	35	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	20	20	20	20	20	20
Conductivity (µS/cm)	Kalanga-Makwanzi	103	112	81.1	95.5	96.9	87.3	100	129	105	92.3	90	101	110	101	98	99.7	101	100	102	96.1	103	101	103
	Mid-reservoir										97.4	95	102	110	102	98	99.3	103	104	102	96.2	103	101	105
	Buyala-kikubamutwe	88.5	114	82.8	97.6	97.7	86.1	102		114	94.8	100	102	112	112	99	99.4	102	108	103	96.1	102	101	103
Secchi Visibility (m)	Kalanga-Makwanzi	1.9	1.6	1.9	2.2	2.2	2.3	2.2	2.2		1.5	2.1	1.72	2.03	1.71	2.4	1.26	1.83	0.83	1.93	1.6	2	1.6	1.8
	Mid-reservoir										1.7	2.1	1.62	2.16	1.59	2.3	1.35	1.85	0.72	1.97	1.6	2.3	2.1	2.1
	Buyala-kikubamutwe	1.7	1.8	1.8	2.3	1.9	1.9	2.1	2.5	1.3	1.4	1.5	1.63	1.77	1.56	2.1	1.25	1.9	1.14	2.05	1.4	1.6	2.1	1,7
Total Suspended Solids (mg/L)	Kalanga-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	3.3	4.13	1.22	7.8	5.21	4	2.6	1.6	4
	Mid-reservoir										3.6	3.3	1.5	3.6	4.67	5.4	3.4	2.67	5.8	7.45	3	5.7	4.1	2,4
	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	4.7	2.47	1.44	5.73	3.89	4	4.3	0.8	2.2
	NEMA Std	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Oil & Grease (mg/L)	Kalanga-Makwanzi	0.6	0.1	0	0.02	0.08	0.04	0.06	0.07	0	0.17	0.18	0.12	0.13	0.19	0.2	0.06	0.16	0.01	41.3	0.48	0.1	0.3	1.5
	Mid-reservoir										0.21	0.17	0.14	0.19	0.23	0.2	0.08	0.18	0.02	49.6	0.54	0.7	0.6	0.6
	Buyala-kikubamutwe	0.9	0.8	0	0.06	0.5	0.08	0.08	0.08	0.13	0.22	0.18	0.1	0.16	0.21	0.2	0.11	0.18	0.02	106	0.54	1.1	0.2	2.4
	NEMA Std	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Mean dissolved oxygen concentration along the stream flow from Kalange-Makwanzi transect, through the mid- reservoir to Buyala-Kikubamutwe transect has continued to be well above the permissible National Environment Management Authority (NEMA) lower limit of 3 mg/L, which is essential for survival of most aquatic organisms including fish (Table 3.1.1).

The mean pH varied within a narrow alkaline range from 7.7 at Buyala-Kikubamutwe transect to 8.2 at the mid-reservoir transect (Table 3.1.1). This slightly alkaline pH range was within the permissible NEMA range of 6 to 8.

Mean water temperatures ranged between 26.0°C at the mid-reservoir and 26.9 ºC at Buyala-Kikubamutwe transect. The temperatures were within the permissible NEMA range of 20 ºC to 35 ºC.

Average water electrical conductivity ranged between 103.1 µS/cm at Kalange-Makwanzi transect and 104.0 µS/cm at the mid-reservoir area. This range befits acceptable ranges recorded at unpolluted sites of Lake Victoria waters that show values of ≤ 120 µS/cm. Moreover, the range recorded during this monitoring period was comparable to that of September 2017.

Water clarity was lowest (1.7 m) at Buyala-Kikubamutwe transect and highest (2.1 m) at the mid-reservoir area. This trend in water clarity was probably due to the relatively clean water from the upstream coupled with settling of sediments and algae in the reservoir, while the outflow was influenced by release of sediments and algae from the reservoir.

Average concentration of TSS was highest (4.0 mg/l) at Kalange-Makwanzi transect and lowest (2.2 mg/l) at Buyala-Kikubamutwe transect. Despite the observed spatial variations, the concentration of TSS was far below the permissible NEMA upper limit of 100 mg/L.

During this monitoring period, the concentration of oil and grease at all sites was 2 to 6 times lower than the NEMA permissible upper limit of 10 mg/L i.e. 1.5 mg/L at Kalange-Makwanzi transect, 0.6 mg/L in the mid-reservoir; and 2.4 mg/L at Buyala-Kikubamutwe transect. Though the observed situation was not better than that of September 2017, the status remained far below the permissible NEMA upper limit of 10 mg/L.

NB: The vertical profiles for major physico-chemical parameters usually recorded at the mid-reservoir transect were not taken during this monitoring period due to failure of the CTD Profiler.

3.1.2 Nutrient (nitrogen, phosphorus and silica) concentrations and algal biomass

The concentration of ammonium-nitrogen (NH_4-N) was hig hest (19.6 μg/L) at Kalange-Makwanzi transect and lowest (4.5 μg/L) at Buyala-Kikubamutwe transect. Despite the observed variations, ammonia concentration was far below the NEMA permissible upper limit of 10,000 μg/L.

The concentration of nitrite-nitrogen (NO_2-N) showed minimal spatial variation and ranged between 3.6 μg/L in the mid-reservoir and 6.0 μg/L at Buyala-Kikubamutwe transect. Despite these observations, the low levels of both NH_4-N and NO_2-N indicated a healthy system since conversion of the former into the latter, a process known as nitrification or oxidation of ammonia was at its best. It was also noted, like in previous assessments that the mean concentrations of NO_2-N were far below the NEMA permissible upper limit of 20,000 μg/L.

The mean concentration of nitrate-nitrogen (NO_3-N) was highest (56.0 μg/L) at Kalange-Makwanzi transect and lowest (31.0 μg/L) at Buyala-Kikubamutwe transect. Despite the observed variations, the concentration of NO_3-N remained lower than the permissible NEMA upper limit of 20,000 μg/L.

Mean concentration of Total Nitrogen (TN) reduced along the stream flow though this remained below the NEMA permissible upper limit of 10,000 μg/L.

During this monitoring period, the average concentration of soluble reactive phosphorus (SRP) was lowest (16.0 μg/L) at Kalange-Makwanzi transect and highest (18.7 μg/L) at Buyala-Kikubamutwe transect. Despite this observation, average concentrations of SRP were below the permissible NEMA upper limit of 5,000 µg/L.

The concentration of Total Phosphorus (TP) ranged between 87.9 μg/L at Buyala-Kikubamutwe transects and 370.4 μg/L at the mid-reservoir transect. Despite the observed trend, average TP concentration remained consistently below the NEMA permissible upper limit of 10,000 μg/L.

The concentration of Soluble Reactive Silica (SRSi) did not show any consistent trend along the stream flow since it was highest (266.2 μg/L) at Buyala-Kikubamutwe transect and lowest (152.5 μg/L) at the mid-reservoir transect probably due to uptake by diatoms and sedimentation in the reservoir.

Algal biomass was highest (29.0 μg/L) at Kalange-Makwanzi transect and was attributed to the direct inflow from the lake in addition to the ample nutrient base, but its concentration reduced along the stream flow.

Table 3.1.2 *Trends in mean concentrations of nutrients and algal biomass (chlorophyll-a) in surface waters (0-2m) at monitored sites*

Parameter	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	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18
Ammonium Nitrogen, NH_4-N (μg/L)	Kalanga-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	7.78	3.81	30.6	23.3	7.6	19.6
	Mid-reservoir										10.5	4.9	7.4	81.74	45.17	36.11	13.44	0.51	18.4	4.83	30	24.6	9.2	8.9
	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	9.76	5.46	23.1	53.7	8.5	4.5
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10000	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)	Kalanga-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	4.41	3.81	10	5.4	6.1	4.8
	Mid-reservoir										6.3	2.8	10.6	5.36	12.75	7.34	14.37	1.37	6.64	4.83	11.5	6.6	6.1	3.6
	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	5.42	5.46	10.6	6.6	6.4	6
	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	20,000	20,000	20,000	20,000	20,000	20,000
Nitrate-Nitrogen, NO_3-N (μg/L)	Kalanga-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	196.07	84.42	46.7	32.8	48.8	56
	Mid-reservoir										50.4	18.4	54.72	91.09	140.93	81.06	55.05	15.01	214.3	48.71	56.2	21.4	55.3	40.8
	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	197.51	49.39	47.9	20.1	25.8	31
	NEMA Std	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20000	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)	Kalanga-Makwanzi	1174	2093.5	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	782.94	1,132.10	214.8	2,514	382.6	382.6
	Mid-reservoir										1,606.90	4,337.30	1,335.20	394.05	1,070.04	1,266.39	3,343.18	2912.06	806.75	1,663.87	548.1	1,422	349.4	349.4
	Buyala-kikubamutwe	1192.5	2138.8	2492.3	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	814.68	1,822.62	881.4	2,234	349.4	349.4
	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	10,000	10,000	10,000	10,000	10,000	10,000
Total Phosphorus, TP (μg/L)	Kalanga-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	46.06	29.09	50.77	113.15	63.03	79.52	50.5	117	62.3	193.8
	Mid-reservoir										41.8	107.6	33.9	56.97	52.73	31.52	59.08	156.16	58.79	95.76	86	108.2	63.1	370.4
	Buyala-kikubamutwe	100.8	48.7	76.3	47.3	45	271.9	88.8	64.1	35.6	107.7	112	41.1	48.48	32.73	112.73	52.68	167'52	57.58	124.85	61.9	124.9	59.6	87.9
	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	10,000	10,000	10,000	10,000	10,000	10,000
Soluble Reactive Phosphorus, SRP (μg/L)	Kalanga-Makwanzi	19	24.2	11.7	6.9	27	15.7	21.1	31.6	9.8	6.4	20	12.7	11.17	12.18	14	10.45	9.64	16.92	18.69	17.8	61.5	33	16
	Mid-reservoir										7	17.6	12.7	10.61	18.85	15.82	11.38	11.39	21.08	25.36	19.6	46.1	31.7	18.3
	Buyala-kikubamutwe	19.2	27.7	18.9	16.6	32	24.8	25.6	20	11.7	6.6	21.4	12.7	15.61	14	42	9.53	16.05	17.85	20.51	21.9	47.5	33.9	18.7
	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	5,000	5,000	5,000	5,000	5,000	5,000
Soluble Reactive Silica, SRSi (μg/L)	Kalanga-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	1,236.78	336.16	102.6	162.3	379.8	158.8
	Mid-reservoir										268.1	268.5	256.8	458.77	396.38	803.5	379.63	588.96	1,573.23	321.73	103.2	104.3	285.1	152.5
	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	369.37	239.73	401.65	645.77	1,268.92	288.88	110.9	96.1	165.2	266.2
Chlorophyll-a (μg/L)	Kalanga-Makwanzi										5.1	6.3	10.2	12.51	10.01	4.32	7.26	3.55	1.48	5.56	3.7	14.7	10.3	29
	Mid-reservoir										5.6	10.1	5.6	13.44	4.26	5.1	8.03	1.44	1.76	3.24	3.9	12.3	6.6	10.2
	Buyala-kikubamutwe										6	9.7	6	9.27	5.37	13.9	5.87	2.67	0.93	3.71	2.8	11.7	8.3	8.3

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 over survey monitoring periods*

Broad taxa	English name	Transects/sites	Monitoring dates												
			Sept. 12	Apr. 13	Sept. 13	Apr. 14	Sept. 14	Apr. 15	Sept. 15	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18
Cyanophtes	Blue-greens	Kalange-Makwanzi	9	15	12	14	12	14	11	6	25	16	14	16	15
		Mid-Reservoir	20	14	14	16	9	19	11	11	28	17	11	18	14
		Buyala-Kikubamutwe	19	18	12	15	14	20	14	11	27	16	16	15	13
Chlorophytes	Greens	Kalange-Makwanzi	4	8	6	4	6	6	9	4	23	7	7	14	5
		Mid-Reservoir	8	7	6	5	7	11	12	5	17	12	12	10	6
		Buyala-Kikubamutwe	7	7	7	5	3	5	8	7	14	7	7	9	9
Bacillariophytes	Diatoms	Kalange-Makwanzi	4	4	5	2	6	6	2	5	10	4	4	8	5
		Mid-Reservoir	3	2	3	4	2	6	3	2	9	4	4	5	4
		Buyala-Kikubamutwe	2	5	3	4	2	5	3	5	12	5	5	6	5
Euglenophytes	Uni-cellular flagellated algae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir	0	1	0	0	0	0	1	0	1	0	0	0	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	0	0
Dinoflagellates		Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	1	0	0	0
		Mid-Reservoir	0	1	0	0	0	0	0	0	0	0	0	1	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	1	0
Cryptophytes		Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	1
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	1
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	1
Total number of species		Kalange-Makwanzi	**17**	**27**	**23**	**20**	**24**	**26**	**22**	**15**	**58**	**28**	**28**	**38**	**26**
		Mid-Reservoir	**25**	**30**	**23**	**25**	**18**	**36**	**18**	**27**	**55**	**33**	**33**	**34**	**25**
		Buyala-Kikubamutwe	**30**	**30**	**22**	**24**	**19**	**30**	**25**	**25**	**54**	**28**	**38**	**31**	**28**

The algae community consisted of four taxonomic groups; blue-green algae, diatoms, green algae and cryptophytes (Table 3.1.3). Like in the previous survey, blue-green algae species were highest at Kalange-Makwanzi. Blue-green algae were the most prevalent and dominant group, followed by green algae and then diatoms in that order. This species occurrence trend was similar to what was observed during the previous monitoring period. Similar to April 2018 and September 2017 monitoring periods though, no dinoflagellates and euglenophytes were recorded. Generally, species richness was much lower in the current survey compared to previous one (April 2018) but similar to what was recorded during September 2017 (45 species). Of the 44 species recorded currently; 22 belonged to blue-green algae, 11 to diatoms, 12 to green algae and only one species from the cryptophytes group (Table 3.1.4a-c). For September 2017 results, *Dolichospermum circinale* (formerly *Anabaena circinalis*) dominated the blue-greens but during April 2018, *Microcystis aeroginosa* was the most important. As in the previous investigations, *Nitzschia acicularis* dominated among diatoms. Among the green algae, *Coelastrum* dominated

at Kalange-Makwanzi area, *Ankistrodesmus falcatus* in the mid-reservoir and *Oocystis gigas* at Buyala-kikubamutwe.

Table 3.1.4a *Species composition of the blue-greens and cryptophytes at the three sites during September 2018 monitoring period (P denotes presence).*

Broad Taxonomic group	Algal species	Kalange-Makwanzi-upstream	Mid-reservoir	Buyala-Kikubamutwe-downstream
Blue-greens	*Aphanocapsa delicatissima*		*	*
	Aphanocapsa elachista	*		*
	Aphanocapsa holistica			*
	Aphanocapsa incerta		*	
	Aphanocapsa nubilium	*	*	*
	Aphanocapsa sp.	*		
	Chroococcus dispersus	*	*	*
	Chroococcus limnetica	*	*	*
	Chroococcus minutus		*	*
	Chroococcus turgidus	*	*	
	Coelastrumm icroporum	*		
	Coelomoron pusila		*	
	Coelomoron tropicale	*		*
	Coelosphaerium kuetzingnium	*	*	*
	Dolichospermum circinale	*	*	*
	Merismopedia tenussima	*	*	
	Planktolyngbya circumcreta	*	*	*
	Planktolyngbya limnetica	*	*	*
	Planktolyngbya tallingii	*	*	*
	Psuedonabaena limnetica	*		
Number of species		**15**	**14**	**13**
Cryptophytes	*Cryptomonas marssonii*	*	*	*
No. of species		**1**	**1**	**1**

Table 3.1.4b *Species composition of the green algae at the three sites during September 2018 monitoring period (P denotes presence).*

Broad Taxonomic group	Algal species	Kalange-Makwanzi-upstream	Mid-reservoir	Buyala-Kikubamutwe-downstream
Green algae	*Ankistrodesmus falactus*	*	*	*
	Chodatellas ubsalsa		*	
	Coelastrum microporum	*		*
	Cosmarium sp.			*
	Crucigenia fenestrata			*
	Kirchneriella sp.			*
	Monoraphidium contortum	*	*	*
	Oocystis gigas		*	*
	Scenedesmus acuminatus	*		*
	Scenedesmus perfolatus		*	*
	Staurastrum gracile		*	
	Tetraedron trigonum	*		
No. of species		**5**	**6**	**9**

Table 3.1.4c *Species composition of the diatoms at the three sites during September2018 monitoring period (P denotes presence).*

Broad Taxonomic group	Algal species	Kalange-Makwanzi-upstream	Mid-reservoir	Buyala-Kikubamutwe-downstream
Diatoms	*Aulacoseira granulata*	*		
	Centric diatom	*	*	
	Cyclostephanodiscus sp.			*
	Cymbella sp.	*		
	Epithemia argus	*		
	Navicula gastrum			*
	Navicula radiosa		*	
	Nitzschia acicularis	*	*	*
	Nitzschia fonticola			*
	Pediastrum tetras		*	
	Synedra cunningtonii			*
No. of species		**5**	**4**	**5**

Bio-volume of algae across the three transects was higher during this monitoring period compared to the previous ones (Figure 3.1.3). Bio-volume values increased by 79.8, 80.3 and 137.6 mm^3L^{-1} at upstream, mid-reservoir and downstream transects respectively during this monitoring period (Figure 3.1.3) which could be attributed to high nutrient availability.

Cryptophytes were not encountered in the previous three but one monitoring periods. They were seen during the current one in which they too contributed to increment in bio-volume of the algae. However, species composition in the current survey dropped by twelve, nine and three species at the upstream, in the mid-reservoir and downstream respectively.

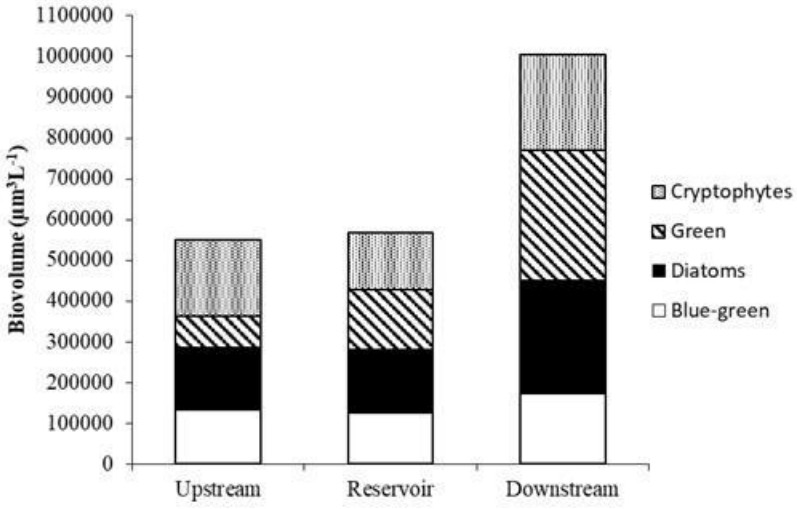

Figure 3.1.2 *Algal biovolume ($\mu m^3 L^{-1}$) by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

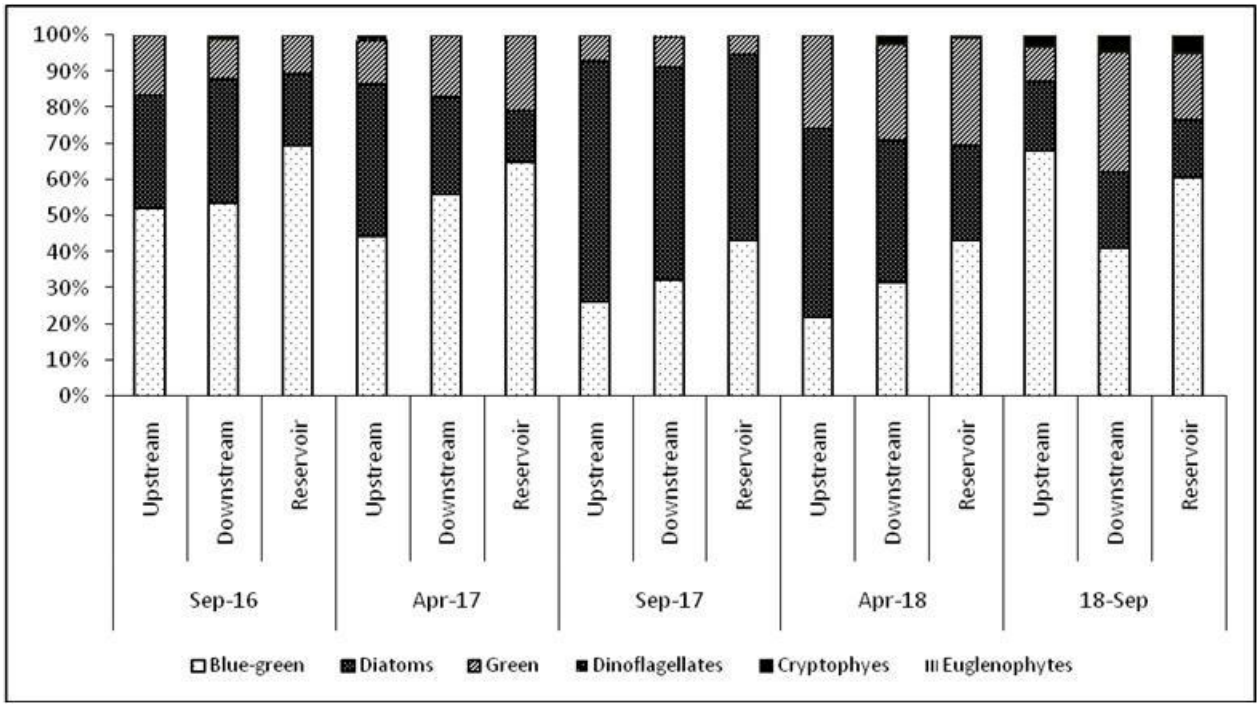

Figure 3.1.3 *Algal biovolume ($\mu m^3 ml^{-1}$) of Sep-16, Apr-17, Sep-17, Apr-18 and Sep-18 by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

Between April and September 2018, relative abundance of diatoms declined while that of blue-green algae increased (Figure 3.1.3). Green algae also decreased at the upstream and at the mid-reservoir zones but increased at the downstream transect. The dynamics in abundance of the groups of algae could be related to nutrient ratios. This variation in dominance between blue-greens and diatoms could in addition to the TP:Si ratio, be related to the non-turbulent conditions during the September 2018 monitoring period. However, the environment downstream was turbulent implying imperfect conditions that could sustain high algal populations. Such conditions promote suspension of diatoms. These results are however not peculiar compared to the previous findings, and therefore no noticeable impact from the dam on phytoplankton species could be deduced.

Aquatic macrophytes

The major aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), Hippo grass (*Vossia cuspidata*), Water primrose (*Ludwigia* spp.), Cat tail (*Typha latifolia*) and Nile cabbage (*Pistia stratiotes*). Cover abundance of most aquatic macrophytes had reduced at most sites compared to what was recorded in September 2017, and most were still not well established along the banks of the reservoir and the river.

Although water hyacinth dominated the shores, its cover abundance reduced from 1.02 in September 2017 to 0.88 ha at Kalange-Makwanzi during this reporting period. Cover abundance of the Water Primrose (*Ludwigia* sp.) also reduced from 0.26 ha in September 2017 to 0.01 ha during this period; while Hippo grass (*V. cuspidata*) reduced from 1.12 ha in September 2017 to 0.54 ha during this period. Other aquatic macrophytes, though still rare, had their cover abundance decreased, each covering less than 0.01 ha. These included *Phragmites* sp, *Pistia stratiotes* and *Typha* sp. Of the total water hyacinth cover abundance of 0.88 ha, 0.50 ha was recorded at Kasenyanku, and 0.12 ha at Kalange and Naavau respectively. Additionally, *V. cuspidata* was of relatively lower occurrence at Muluwanvu (0.23 ha) compared to 1.12 ha in September 2017, while the rest of the macrophytes were of minor occurrence (< 0.01 ha).

At Buyala-Kikubamutwe transect, much of the river bank (> 60%) was cultivated down to the highest water level, and trees such as eucalyptus were grown, thus leaving little room for establishment of aquatic macrophytes. Cover abundance of most dominant macrophytes had decreased in cover abundance since September 2017 although that for water hyacinth increased from 0.06 ha in September 2017 to 0.10 ha during this period. Those macrophytes that decreased in cover abundance were *Vossia cuspidata* from 0.75 ha to 0.47 ha; *Ludwigia* sp from 0.04 ha in September 2017 to 0.01 ha in September 2018; and *Pistia stratiotes* from 0.22 ha in September 2017 to < 0.001 ha in September 2018. The general reduction in cover abundance of most aquatic macrophytes compared to what was noted in September 2017 was attributed to current rains that led to a rise in water level that resulted in submerging and dislodging of rooted littoral macrophytes.

At the mid-reservoir bank was devoid of most of the common aquatic macrophytes, although water hyacinth dominated the shores but with a similar decrease in cover abundance from 3.45 ha in September 2017 to 1.55 ha during this period. Kyekidde and Buloba had water hyacinth cover abundance of approximately 0.91 ha (58%) and 0.60 ha (38%), respectively, while other sites had less than 3% of this waterweed. Aquatic macrophytes, *Ludwigia* sp and *T. latifolia*t

were very rare (< 0.01 ha). Thus to date, aquatic macrophytes were not yet well established around the reservoir and at much of the shores of the two transects.

3.2 Zooplankton (Water column micro-invertebrates)

Species diversity and distribution trends

The zooplankton community composition was comparable with earlier observations with the three key groups represented by different species numbers in the three study sites (Tables 3.2.1a, b,c). Species richness was highest (25 species) at the mid-reservoir and lowest (20 species) at the upstream transect. At Buyala-Kikubamutwe, 21 species were recorded. Similar to previous records, the abundance of copepods, cladocerans and rotifers were highest at the mid- reservoir and lowest at Buyala-Kikubamutwe. Rotifers were the most speciose, followed by copepods and then cladocera.

Table 3.2.1a. *Trends in numerical abundance (ind. m^{-2}) and diversity of Copepod species at the monitored sites,* September *2016 to September 2018.*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi					Mid-reservour					Downstream-Buyala-Kikubamutwe				
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep
Copepods	*Thermocyclops incisus*	696	606	236	472		898				359	1,482	202	494		
	Mesocyclops sp.	1,100	808	314	269		449	404	236	943	449	1,752	180	180		449
	Thermocyclops emini	4,289	1,145	393	1,617	1,213	5,389		5,541	1,179	1,505	15,494		157		898
	Tropocyclops confinnis	38,197	7,410	6,130	3,503	7,399	21,108	4,244	10,807	4,884	8,713	55,511	1,752	3,234	674	6,175
	Thermodiaptomus galeboides	6,490	6,130	707	808	1,291	4,222	6,198	2,043	5,053	1,538	15,764	1,482	831		
	Thermocyclops neglectus	25,353	7,276	3,851	10,846	3,020	2,066	14,259	4,283	8,758	4,323	19,536	472	550	606	1,763
	Tropocyclops tenellus	27733	7,747	6,602	4,244	6,411	10,060	25,465	9,038	7,444	7,983	19,267	6,086	7,388	4,379	6,591
	Total copepod species abundance	**103,858**	**31,124**	**18,234**	**21,759**	**19,334**	**44,193**	**50,570**	**31,949**	**28,261**	**24,870**	**128,806**	**10,172**	**12,833**	**5,659**	**15,876**
	Cyclopoid copepodite	94,471	56,386	70,225	28,395	52,782	90,541	67,390	88,812	59,283	99,266	254,648	21,849	49,829	10,779	56,622
	Calanoid copepodites	18,885	8,286	4,323	7,579	2,077	9,072	6,804	4,205	3,267	3,896	31,797	2,111	1,707	404	505
	Nauplius larvae	507,724	139,585	150,195	141,842	157111	315,009	171,023	196,959	295,675	188078	654,539	113,648	112,155	138,035	129,996
	Total copepod developmental stages	**621,080**	**204,257**	**224,742**	**177,816**	**211,971**	**414,622**	**245,217**	**289,976**	**358,225**	**291,240**	**940,985**	**137,609**	**163,691**	**149,218**	**187,124**

Abundance and distribution trends

The abundance of copepods, cladocerans and rotifers was highest at the mid-reservoir and lowest at the downstream site, a trend similar to previous surveys (Table3.2.1a-c). Since April 2017, average total zooplankton abundance has fluctuated in the range: 210,455 to 258,617 ind.m^{-2} at the Upstream, 316,132 to 403,059 ind.m^{-2} at the md-reservoir, and 159,166 to 220,459 indm^{-2} at the downstream site (Table 3.2.1a-c).Copepods were the most abundant zooplankton followed by rotifers during current monitoring-September 2018. This trend is similar to previous surveys. The high abundance of copepods was attributed to the juveniles (copepodites and nauplius larvae) which contributed >88% of the total abundance of copepods at the sites. Among copepod developmental stages, the order of numerical abundance at all sites was nauplii > cyclopoid

copepodites > calanoid copepodites. Like previously recorded, cladocerans were the least abundant group of zooplankton at all sites.

The copepods: *Tropocyclops confinnis*, *Tropocyclops tenellus*, copepodites and nauplius larvae occurred at all sites. Moreover, more copepod species (*Thermocyclopsemini, Thermocyclops neglectus, Thermodiaptomus galeboides, Tropocyclops confinnis,* and*Tropocyclops tenellus*) occurred with 100% frequency at Upstream and reservoir than recorded at downstream site where only *Tropocyclops confinnis* and *Tropocyclops tenellus* had 100% frequency of occurrence. *Thermocyclops incisus*which was only encountered at the upstream site during the April 2018 survey was only recorded at the reservoir in the current survey (Table 3.2.1a).

Among the Cladocera,only *Bosmina longirostris* was encountered at all stations of all sites (Upstream, Reservoir and Downstream), with the highest abundance recorded downstream (Table 3.2.1b). Other species encountered in all sites although in a few stations of these sites were: *Daphnia lumholtzi* (helm) and *Moina micrura* each with frequency ranging from 33.3-66.7% at the sites.

The rotifers: *Keratella tropica*, *Lecane bulla* and *Trichocerca cylindrica* were the most frequently occurring (100% frequency), recorded all sites. Other species encountered at all the sites although not in all stations were: *Brachionus calyciflorus* (33.3 – 66.7% frequency), *Euclanis* sp.(66.7% frequency at all sites), *Brachionus angularis*(33.3-100%frequency),*Cephlodella* sp.(66.7-100% frequency), *Keratella cochlearis*(66.7-100%frequency), and*Synchaeta* sp.(33.3-100% frequency). In April 2018 sampling period, none of the rotifer and cladocera species were recorded at every station of all the sites, like exhibited in the current period (September 2018).

Table 3.2.1b. *Trends in numerical abundance (ind. m^{-2}) and diversity of Cladocera (water fleas) species at the monitored sites, September 2016 to September 2018*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi					Mid-reservour					Downstream-Buyala-Kikubamutwe				
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep
Cladocerans	*Daphnia lumholtzi*		135													
	Chydorus sp.						90			472		269				
	Daphnia lumholtzi (helm)				135	101	90			236	101	269				56
	Ceriodaphnia cornuta	1999	1,886	79			629	808	1,100	269	180	2,425		236		56
	Diaphanosoma excisum	1347	606	1,022		135	90	2,313	354	707	404	3,773	67			
	Moina micrura	2448	1,347	1,415	2,425	258	1,617	202	1,690	2,122	359	5,120	337	1,033		225
	Bosmina longirostris	2,740	876	2,436	1,684	382	1,437	629	4,598	1,179	1,213	2,695	516	685		1,819
	Total Cladocera abundance	**8,533**	**4,850**	**4,951**	**4,244**	**876**	**3,952**	**3,952**	**7,742**	**4,985**	**2,257**	**14,551**	**921**	**1,954**		**2,156**

Table 3.2.1c. *Trends in numerical abundance (ind. m^{-2}) and diversity of Rotifer (wheel animalcules) species and overall zooplankton density at the monitored sites, September 2016 to September 2018*

		Upstream-Kalange-Mawkanzi					Mid-reservour					Downstream-Buyala-Kikubamutwe				
Broad taxa	Species name	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep
	Asplanchnasp.					146			157		112	674				
	Ascomorphasp.								79							56
	Euclanis sp.	2246	269			427	719		472		191	1,213				168
	Brachionusfalcatus		269						79		45	135				
	Filinia longiseta															
	Polyarthrasp.	180		157								269	225			
	Filinia opoliensis	135	337	707			180	180	550		337	1,347				45
	Brachionus picatilis															
	Brachionus forticula			157												56
	Keratella cochlearis	90		2,279		719	180		1,336	2,964	1,112	269	898	1,729	539	1,235
	Brachionus calyciflorus		337	314		90		606	236		56		135	427		292
	Trichocerca cylindrica	808		1,415	135	1,639	1,976	180	1,926	2,863	3,267	1,482	404	707		2,549
	Brachionus angularis	180	472	236		1,415	898	786	2,161	404	1,067	3,234	225	427		763
	Brachionus budapestinensis										56					
	Brachionus bidentatus									135						
	Hexathra sp.															
	Lecane bulla	5,771	1,415	4,480	674	5,333	10,869	3,570	4,834	674	6,288	31,932	1,482	1,134	1,617	4,480
	Lecane luna							629	275							
	Synchaeta sp.	2,852	1,617	629	3,032	1,033	3,683	3,840	786	2,594	1,796	5,255	853	786	1,886	1,156
	Keratella tropica	4,222	4,783	314	2,796	1,235	3,054	4,222		1,718	2,717	8,219	4,087	516		2,526
	Brachionus patulus											135				
	Cephalodella sp.					1,505		2,380		236	1,718		2,156	79		1,976
	Polyarthra vulgaris					472									337	
Rotifers	**Total Rotifer abundance**	**16,483**	**9,499**	**10,689**	**6,637**	**14,012**	**21,557**	**16,393**	**12,890**	**11,588**	**18,762**	**54,163**	**10,464**	**5,805**	**4,379**	**15,302**
Overall zooplankton abundance		**749,954**	**249,730**	**258,617**	**210,455**	**246,193**	**484,325**	**316,132**	**342,556**	**403,059**	**337,128**	**1,138,505**	**159,166**	**184,283**	**159,256**	**220,459**

Discussion

The abundance of zooplankton has consistently remained highest at the mid-reservoir, followed by Kalange-Makwanzi and least at Buyala-kikubamutwe. The trend of least zooplankton abundance downstream of the dam has been consistent since 2012. According to Basu and Pick (1996), the abundance of zooplankton is positively related to water residence time, this premise is observed to hold true to these sites where highest zooplankton has been recorded at the mid-reservoir and lowest at the downstream of the dam. Moreover, the different zooplankton groups (copepods, cladocerans and rotifers) respond differently to water residence time. For instance, when water residence time is short, rotifers dominate the zooplankton and when the residence time is long the community is dominated by crustaceans (Baranyi*et al.*, 2002; Shiel and McEvoy, 2015).In the current period of September 2018, the zooplankton community at all sites was dominated by rotifers in terms of species richness.

Among zooplankton groups, copepods were still the most abundant, dominated by developmental stages notably nauplii, a common pattern observed in Lake Victoria and other freshwater habitats (Vasquez and Rey 1992, Sampaio and Lopea 2000). The high density of immature copepods which is a result of continuous reproduction (Neves et al. 2003) is important

for zooplankton population dynamics and trophic aspects. The immature forms of copepods occupy trophic niches different from those of the adult forms e.g. the nauplii and first copepodite instars of the cyclopoids have a filtration feeding habit and are predominantly herbivorous, while the later copepodite stages and the adults have raptorial feeding habits and are predominantly carnivorous (An et al. 2012).

Rotifer genera: *Brachionus*, *Filinia* and *Lecane* have been used as indicators of eutrophy (Pejler 1957). In the current sampling period, species of the genera *Brachionus* and *Filinia* were very rare at all sites while the genus *Lecane* represented by one species *Lecane bulla* occurred prevalently at all sites. Therefore, their observed abundance and distribution could not clearly point to any impacts associated with dam operation. As observed in the previous surveys, the species assemblage has not changed significantly over the years of operation of the dam. Stability of zooplankton communities suggests relatively corresponding stability of the environment conditions at the sites.

3.3 Benthic macro-invertebrates

During this survey period, benthic water snail density reduced at two sites, slumping from 140 ind. m^{-2} during April 2018 to 47 ind. m^{-2} at Kalange-Makwanzi, from 133 to 49 ind. m^{-2}at mid-reservoir (Table 3.3.1a) The density slightly increased from 51 to 65 ind. m^{-2}at Buyala-Kikubamutwe transect (Table 3.3.1a). Like in the previous surveys April 2017-April 2018, *Melanoides tuberculata* was the highest contributor to overall water snail density, registering 47 at Kalange-Makwanzi, 28 at the mid-reservoir transect and 56 ind. m^{-2} at Buyala-Kikubamutwe transect. At the mid reservoir, *Bellamya unicolor* was important but not at Kalange-Makwanzi and Buyala-Kikubamutwe transects. At Buyala-Kikubamutwe, very low density (5 ind. m^{-2}) of *Bulinus sp.* was encountered and was absent at the other two sites.

Table 3.3.1a *Trends of benthic density and number of species of water snails at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time															
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18
Gastropoda (water snails)	*Bellamya unicolor*	Kalange-Makwanzi	33	173	5	33	0	0	299	0	0	0	0	35	0	0	0	0	0
		Mid-Reservoir				0	0	4	154	296	23	14	98	1097	61	42	21	7	21
		Buyala-Kikubamutwe	98	126	11	42	65	285	14	23	47	579	9	37	5	33	0	0	5
	Melanoides tuberculata	Kalange-Makwanzi	28	107	257	14	19	5	19	0	0	14	0	56	177	79	19	140	47
		Mid-Reservoir				0	0	77	5	5	9	145	35	5	107	133	28	119	28
		Buyala-Kikubamutwe	33	224	100	121	33	33	9	33	0	42	14	0	56	196	47	51	56
	Biomphalaria choanomphala	Kalange-Makwanzi	0	14	5	0	0	0	9	0	0	5	0	0	0	0	0	0	0
		Mid-Reservoir				2	0	4	7	25	0	0	0	61	9	0	0	0	0
		Buyala-Kikubamutwe	0	19	11	0	5	9	5	9	5	23	5	5	0	0	0	0	0
	Anisus natalensis	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	5	0	0	0	0	0	0	0	5	0	0	5	0	0
	Gyraulus sp.	Kalange-Makwanzi	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	47	0	5	0	0	0	0	0	0	0	0	0
	Segmentorbis sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	3	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	47	9	23	0	0	0	0	0	0	0	0	0	0	0
	Gabbia humerosa	Kalange-Makwanzi	0	79	5	0	0	5	23	0	0	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	0	4	5	33	0	0	0	5	14	0	0	7	0
		Buyala-Kikubamutwe	0	0	121	1027	677	135	0	0	9	42	0	196	23	9	0	0	0
	Bulinus sp	Kalange-Makwanzi	5	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	12	0	0	0	0	14	0	0	0	0	0
		Buyala-Kikubamutwe	5	5	5	0	19	65	0	5	0	0	0	5	0	0	0	0	5
	Pila ovata	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				7	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Total snail abundance at each site/transect		Kalange-Makwanzi	**65**	**383**	**275**	**51**	**19**	**9**	**350**	**0**	**0**	**19**	**0**	**91**	**177**	**79**	**23**	**140**	**47**
		Mid-Reservoir	**0**	**0**	**0**	**9**	**3**	**88**	**182**	**358**	**33**	**159**	**133**	**1181**	**191**	**175**	**49**	**133**	**49**
		Buyala-Kikubamutwe	**135**	**373**	**252**	**1242**	**808**	**602**	**28**	**75**	**61**	**686**	**28**	**247**	**84**	**238**	**51**	**51**	**65**

Like for benthic water snails, the density of bivalves too decreased at two sites from the previous survey to the current one i.e. from 467 to 201 ind. m^{-2}at Kalange-Makwanzi, from 742 to 231 ind. m^{-2}at the mid-reservoir transect (Table 3.3.1 b). Density slightly increased from 70 to 116 ind. m^{-2}at Buyala-Kikubamutwe. Overall bivalval abundance was highest at the mid-reservoir and lowest at Buyala-Kikubamutwe. The most prevalent bivalves at the transects included *Caelatura sp*. and *Corbicular Africana*. The density of *C. Africana* during this survey reduced from 454 ind. m^{-2}during April 2018 to 93 ind. m^{-2} currently at Kalange-Makwanzi and from 448 to 154 ind. m^{-2} at the mid-reservoir. At Buyala-Kikubamutwe, a paltry density of 19 ind. $m^{-2}$was recorded during this period. The density of *Byssanodonta parastica* greatly reduced at the transects ie from 159 ind. m^{-2}during april 2018 to 19 ind. m^{-2} during this period at Kalange-Makwanzi, from 182 ind. $m^{-2}$to 21 ind. m^{-2}at the mid-reservoir and from 47 ind. $m^{-2}$to 9 ind. m^{-2} at Buyala-Kikubamutwe.

Table 3.3.1 b *Trends of benthic density and number of species of bivalves at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18
Bivalvia (Clams/mussels)	*Byssanondota parasitica*	Kalange-Makwanzi	79	145	252	61	75	42	121	14	0	9	0	133	5	70	9	159	19
		Mid-Reservoir				23	95	686	380	801	28	79	58	42	56	112	56	182	21
		Buyala-Kikubamutwe	0	19	63	317	9	117	733	159	205	75	149	140	61	369	79	47	9
	Corbicula africana	Kalange-Makwanzi	56	126	182	47	219	514	98	222	19	145	9	413	19	131	37	154	93
		Mid-Reservoir				5	25	196	44	581	140	481	7	406	19	427	77	448	154
		Buyala-Kikubamutwe	65	131	205	65	28	79	56	47	126	126	93	175	51	1116	327	0	19
	Caelatura spp	Kalange-Makwanzi	149	93	229	79	79	47	0	124	9	84	47	133	103	19	28	131	42
		Mid-Reservoir				9	20	28	23	44	33	5	58	135	14	7	42	105	49
		Buyala-Kikubamutwe	37	61	63	37	5	5	47	23	51	28	75	47	107	107	145	9	65
	Pisidium victoriae	Kalange-Makwanzi	0	5	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9
		Mid-Reservoir				0	0	0	0	0	0	0	0	47	0	0	7	0	0
		Buyala-Kikubamutwe	0	0	32	19	5	0	0	0	0	0	0	0	0	0	14	0	0
	Mutela sp	Kalange-Makwanzi	0	0	0	5	5	0	0	7	0	9	7	0	0	0	0	19	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	19	0	0	0	0	0
		Buyala-Kikubamutwe	5	5	16	0	0	0	0	0	0	9	0	7	0	0	0	9	0
	Sphaerium victoriae	Kalange-Makwanzi	5	51	14	0	0	0	0	14	0	9	0	7	5	0	9	5	33
		Mid-Reservoir				2	0	0	2	14	5	14	0	9	0	0	7	0	0
		Buyala-Kikubamutwe	0	19	0	23	0	0	5	0	61	23	5	7	0	0	0	0	19
	Sphaerium stuhlman	Kalange-Makwanzi	0	0	0	9	0	0	9	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				5	146	18	2	26	0	0	7	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	9	5	0	0	0	0	0	9	0	0	0	0	0	0
	Aspantharia sp	Kalange-Makwanzi	9	9	5	5	5	5	0	5	0	14	0	0	0	0	0	0	5
		Mid-Reservoir				0	0	0	0	0	0	5	0	19	0	0	0	7	7
		Buyala-Kikubamutwe	5	0	0	0	0	0	0	5	0	5	0	0	5	0	0	5	5
	Etheria eliptica	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	14	7	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	5	0	0	0	0	0	0	0	9	23	0	0	0	0
Total bivalve abundance at each site/transect		Kalange-Makwanzi	**299**	**430**	**682**	**205**	**392**	**607**	**229**	**385**	**28**	**271**	**63**	**686**	**131**	**219**	**84**	**467**	**201**
		Mid-Reservoir	**0**	**0**	**0**	**44**	**286**	**928**	**453**	**1466**	**205**	**598**	**138**	**677**	**89**	**546**	**189**	**742**	**231**
		Buyala-Kikubamutwe	**112**	**233**	**383**	**476**	**51**	**201**	**840**	**233**	**444**	**266**	**331**	**385**	**247**	**1592**	**565**	**70**	**116**

During this September 2018 survey, may fly species were encountered at a very low density of 5 ind. m^{-2} at Kalange-Makwanzi and 28 ind. m^{-2}at Buyala-Kikubamutwe (Table 3.3.1 c). None was encountered at the mid-reservoir. In April 2018, may flies were only recovered at Buyala-Kikubamutwe. Even though no dragon flies were recovered from the sites during the previous monitoring-April 2018, only 5 ind. m^{-2} were recorded at Kalange-Makwanzi during this period. Still Buyala-Kikubamutwe and mid-reservoir transects recorded no dragon flies during this period. For this and the previous monitoring period, no caddis flies were recovered at Kalange-Makwanzi. They were encountered at Buyala-Kikubamutwe at a low density of 14 ind. m^{-2} during this period. Compared to the previous survey period of April 2018, dipteran density decreased from 180 to 28 ind. m^{-2} at Kalange-Makwanzi during this period and slightly increased from 28 to 63 ind. m^{-2} at the mid-reservoir and from 47 to 56 ind. m^{-2} at Buyala-Kikubamutwe.

Table 3.3.1 c *Trends of benthic density and number of species of insect types at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18
Ephemeroptera (May flies)	*Povilla adusta*	Kalange-Makwanzi	19	163	9	28	0	14	0	9	0	0	0	0	0	0	14	0	0
		Mid-Reservoir				5	3	144	245	5	0	70	12	0	5	0	35	0	0
		Buyala-Kikubamutwe	5	9	63	28	5	37	9	28	0	19	5	79	5	0	5	23	0
	Baetis sp.	Kalange-Makwanzi	5	9	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	3	0	0	0	79	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	23	5	0	0	5	0	0	0	19	0	0	0	0	0	0	5	0
	Caenis sp.	Kalange-Makwanzi	19	75	19	5	0	0	5	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	7	0	0	0	9	0	0	0	0	14	0	0
		Buyala-Kikubamutwe	0	9	26	37	9	313	0	23	0	0	0	0	0	0	0	28	23
	Cloeon sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	37	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	5
	Leptophlebidae	Kalange-Makwanzi	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		Mid-Reservoir				0	0	0	5	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	5	9	0	0	0	0	0	0	0	0	0	0
	Trichorythidae	Kalange-Makwanzi	0	89	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	0	0	19	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	5	0	19	0	0	0	0	0	0	0	0	0	0	0
Total Mayflies abundance at each site/transect		Kalange-Makwanzi	**42**	**350**	**28**	**33**	**0**	**14**	**5**	**9**	**5**	**0**	**0**	**0**	**0**	**0**	**23**	**0**	**5**
		Mid-Reservoir	**0**	**0**	**0**	**5**	**6**	**151**	**268**	**5**	**79**	**79**	**12**	**0**	**5**	**0**	**49**	**0**	**0**
		Buyala-Kikubamutwe	**65**	**23**	**89**	**70**	**28**	**383**	**19**	**51**	**19**	**19**	**5**	**79**	**5**	**0**	**5**	**56**	**28**
Odonata (Dragon flies)	*Hagenius* sp.	Kalange-Makwanzi	19	0	9	0	5	0	0	7	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	3	0	0	0	0	0	7	33	0	0	0	0	0
		Buyala-Kikubamutwe	5	0	0	5	5	0	0	5	0	0	5	0	5	0	5	0	0
	Gomphoides sp.	Kalange-Makwanzi	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	19	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
	Libellulidea	Kalange-Makwanzi	9	33	0	5	0	14	5	0	0	0	0	7	0	5	0	0	0
		Mid-Reservoir				2	0	18	2	2	0	0	0	84	0	14	7	0	0
		Buyala-Kikubamutwe	0	5	37	5	5	14	0	0	0	0	0	0	0	0	0	0	0
	Cordulidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
	Coenagrion sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0
	Protoneuridae	Kalange-Makwanzi	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	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
Total dragonflies abundance at each site/transect		Kalange-Makwanzi	**33**	**42**	**23**	**5**	**5**	**14**	**5**	**7**	**0**	**0**	**0**	**7**	**0**	**5**	**5**	**0**	**5**
		Mid-Reservoir	**0**	**0**	**0**	**2**	**3**	**18**	**2**	**2**	**0**	**0**	**7**	**117**	**0**	**14**	**7**	**0**	**0**
		Buyala-Kikubamutwe	**9**	**23**	**42**	**9**	**9**	**14**	**0**	**5**	**5**	**0**	**9**	**0**	**9**	**0**	**5**	**0**	**0**

Trichoptera (Caddis flies)	Hydropsychidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0
		Mid-Reservoir				0	0	0	257	0	0	0	12	0	56	0	0	0	0
		Buyala-Kikubamutwe	0	19	16	5	0	9	0	5	0	0	5	14	0	0	0	0	14
	Brachycentridae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiid	Kalange-Makwanzi	0	2	0	0	0	5	9	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	3	4	7	0	0	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
	Polycentropodidae	Kalange-Makwanzi				0	0	0	0	0	0	0	0	0	14	0	0	0	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0
	Leptoceridae	Kalange-Makwanzi	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	5	0	0	0	0	42	0	28	0
		Buyala-Kikubamutwe	0	2	3	0	0	5	0	0	0	0	0	0	0	0	0	5	0
	Economidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	77	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Caddisflies abundance at each site/transect		Kalange-Makwanzi	**0**	**2**	**0**	**0**	**0**	**9**	**9**	**0**	**5**	**5**	**0**	**0**	**14**	**0**	**9**	**0**	**0**
		Mid-Reservoir	**0**	**0**	**0**	**0**	**3**	**4**	**264**	**0**	**5**	**0**	**12**	**0**	**61**	**42**	**77**	**28**	**0**
		Buyala-Kikubamutwe	**0**	**21**	**18**	**7**	**0**	**14**	**0**	**5**	**0**	**0**	**5**	**14**	**56**	**0**	**0**	**5**	**14**
Hemiptera (water bugs)	Nepidae	Kalange-Makwanzi	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	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
	Aphelocheiridae (*Aphelocheirus* sp.)	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Total waterbugs abundance at each site/transect		Kalange-Makwanzi	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Mid-Reservoir	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Buyala-Kikubamutwe	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**
Coleoptera (beetles)	Elmidae	Kalange-Makwanzi	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	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

Table 3.3.1 d *Trends of benthic density of other benthic macro-invertebrates at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18
Oligochaeta (earth worms)	*Nais* sp.	Kalange-Makwanzi	0	5	5	14	5	0	28	0	9	5	14	21	23	5	5	19	0
		Mid-Reservoir				0	0	11	16	56	5	9	49	191	42	49	7	7	0
		Buyala-Kikubamutwe	0	33	11	9	5	0	19	0	9	28	42	0	19	9	0	5	0
Hirudinea (leeches)	Glosophomidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda (seed shrimps)	Seed shrimps	Kalange-Makwanzi	0	0	0	0	5	0	9	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				229	11	0	7	2	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Decapoda (Shrimps)	*Caridina nilotica*	Kalange-Makwanzi	0	5	0	5	0	0	5	0	0	9	0	0	0	0	0	0	0
		Mid-Reservoir				7	3	0	5	14	0	5	0	70	0	0	0	0	0
		Buyala-Kikubamutwe	0	5	32	0	0	0	5	0	0	126	5	0	0	0	0	0	0
Total other benthic macroinvertebratess abundance at each site/transect		Kalange-Makwanzi	**0**	**9**	**5**	**19**	**9**	**0**	**42**	**0**	**9**	**14**	**14**	**21**	**23**	**5**	**5**	**19**	**0**
		Mid-Reservoir	**0**	**0**	**0**	**236**	**14**	**11**	**28**	**72**	**5**	**14**	**49**	**261**	**42**	**49**	**7**	**7**	**0**
		Buyala-Kikubamutwe	**0**	**37**	**47**	**9**	**5**	**0**	**28**	**0**	**9**	**154**	**47**	**0**	**19**	**9**	**0**	**5**	**0**

It is now five sampling consecutive periods, when no nile shrimps (*Caridina nilotica*) have been recorded at all sites (Table 3.3.1 d). The waterworms (Oligocheata) were recovered during April 2018 but not during the current monitoring period. The seed shrimps and leeches have remained unseen in the benthos for the last 9 previous surveys.

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

With haplochromines taken as a single species group, a total of 11 fish species were recorded at the three transects along River Nile in September 2018 compared to 9 in April 2018 and 11 in September 2017 (Tables 3.4.1a&b). Nine species were recorded at Kalange-Makwanzi, 7 at mid-reservoir and 4 at Buyala-Kikubamutwe.

Keystone species Nile perch (*Lates niloticus*), tilapiines (*Oreochromis niloticus, O. variabilis, Tilapia zillii*), catfishes (*Bagrus docmak, Synodontis afrofischeri, S. victoriae*), Elephant snout fish (*Mormyrus kannume*), Sadler's robber (*Brycinus sadleri*) and the haplochromines were recovered during this survey. Nile perch and haplochromines were recovered from all the three transects. *Oreochromis leucostictus* and *B. Sadleri* were recovered from Kalange-Makwanzi transect only, *B. Docmak* from Buyala-Kikubamutwe transect, *M. Kannume* from Kalange-Makwanzi and mid-reservoir transects, *O. niloticus, C. zillii*, *O. variabilis*, *S. Afrofischeri* from Kalange-Makwanzi and Buyala-Kikubamutwe transects, while *S.victoriae* was recovered from the mid-reservoir only.

The highest densities of fish by numbers was at Kalange-Makwanzi (85.1%), followed by the downstream, Buyala-Kikubamutwe transect (8.2%) and least from the mid-reservoir transect (6.7%). Haplochromines dominated by numbers at the upstream (75.4%) and downstream (70.6%) transects and by weight (43.7%) at Kalange-Makwanzi. *Lates niloticus* dominated by

numbers (69.6%) and weight (69.2%) at the mid-reservoir transect, and by weight (39.2%) at Buyala-Kikubamutwe.

Tables 3.4.1 *a & b Fish species recorded overtime at the monitored sites.*

a)

Family names	Scientific names	English names (local names-Luganda)	Sites/Transects	Sampling Numbers and Monitoring Dates																				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
				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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		P			P																		
			Mid-Reservoir										P	P	P	P	P	P	P	P		P	P	P		
			Buyala-Kikubamutwe		P		P								P	P						P				P
Latidae	*Lates niloticus*	Nile perch (Mputa)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid-Reservoir										P	P	P	P	P	P	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	P	P	P		P	P
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																							
			Mid-Reservoir																							
			Buyala-Kikubamutwe	P																						
	B. sadleri	(Nsoga)	Kalange-Makwanzi	P																P				P		P
			Mid-Reservoir																							
			Buyala-Kikubamutwe																							
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege-kibati)	Kalange-Makwanzi	P	P	P		P			P	P	P					P	P	P		P	P	P	P	P
			Mid-Reservoir												P							P				
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P	P	P	P								P	P
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	P	P																			P		P
			Mid-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		P	P	P	P	P
			Mid-Reservoir										P				P									
			Buyala-Kikubamutwe	P	P		P			P	P	P	P				P		P	P						P
	Tilapia zillii	Red-belly tilapia (Ngege)	Kalange-Makwanzi	P	P	P	P	P	P	P	P		P	P	P	P				P		P	P	P	P	P
			Mid-Reservoir										P		P	P										
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P			P		P	P			P	P	P	P
	Haplochromines	(Nkejje)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid-Reservoir										P		P	P	P	P	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	P	P	P	P	P	P
Clariidae	*Clarias gariepinus*	Mudfish (Male)	Kalange-Makwanzi			P	P							P	P								P			
			Mid-Reservoir										P	P												
			Buyala-Kikubamutwe			P	P		P			P				P						P				

b)

Family names	Scientific names	English names (local names-Luganda)	Sites/Transects	Sampling Numbers and Monitoring Dates																						
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
				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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Cyprinidae	*Barbus altianalis*	Barbel fish (Kisinja)	Kalange-Makwanzi	P	P	P	P		P				P													
													P	P	P											
			Buyala-Kikubamutwe	P	P	P	P		P	P		P	P		P		P					P				
	B. paludinosus	Barbel fish (Kisinja)	Kalange-Makwanzi																							
			Mid-Reservoir																							
			Buyala-Kikubamutwe	P																						
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																							
			Mid-Reservoir																							
			Buyala-Kikubamutwe		P					P																
	Rastrineobola argentea	Silver fish (Mukene)	Kalange-Makwanzi							P																
			Mid-Reservoir																							
			Buyala-Kikubamutwe	P	P		P		P																	
Cyprinodontidae	*Aplocheilichthys pumilus*	Gambusia	Kalange-Makwanzi																							
			Mid-Reservoir																							
			Buyala-Kikubamutwe		P																					
Protopteridae	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						P																	
			Mid-Reservoir																							
			Buyala-Kikubamutwe				P																			
Mochokidae	*Synodontis afrofischeri*	Tiger fish (Nkolongo)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid-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	P	P
	S. victoriae	Tiger fish (Nkolongo)	Kalange-Makwanzi			P		P	P		P			P	P	P	P	P		P						
			Mid-Reservoir										P	P		P		P	P	P		P	P	P	P	P
			Buyala-Kikubamutwe											P					P	P			P				
Mormyridae	*Mormyrus kannume*	Elephant snout fish (Kasulubana)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid-Reservoir										P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P				P	P							
	Gnathonemus longibarbis		Kalange-Makwanzi																							
			Mid-Reservoir														P		P							
			Buyala-Kikubamutwe																							
Total number of species			Kalange-Makwanzi	10	10	10	8	9	9	7	8	5	8	8	8	6	5	6	6	9		7	8	9	7	9
			Mid-Reservoir										10	7	8	7	6	5	7	5		6	5	6	6	7
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7		6	4	3	5	4

3.4.2 The Haplochromines

Ten 10 species belonging to 6 genera of haplochromines were recovered during the survey (Tables 3.4.2 a, b and c). Nine haplochromine species were recoreded at Kalange-Makwanzi transect, 5 at Buyala-Kikubamutwe and 1 species at mid-reservoir transect. The most dominant genera by number (64.3%), and weight (53.0%) was Astatotilapia.

Tables 3.4.2 a, b and c *Haplochromine species recorded over time at the monitored sites*

a)

Genus	Species name	Sites/Transects	Sampling Numbers and Monitoring Dates																						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Astatoreochromis	*A. alluaudi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P								P	P
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P	P	P	P	P			P						P		P							
Astatotilapia	*A. brownae*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
		Mid-Reservoir										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	P	P	P		P
	A. "cylindrical"	Kalange-Makwanzi			P																				
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	A. "elongate"	Kalange-Makwanzi	P	P	P	P	P	P	P																
		Mid-Reservoir										P													
		Buyala-Kikubamutwe			P		P			P															
	A. "purple dorsum"	Kalange-Makwanzi		P								P				P	P								
		Mid-Reservoir																							
		Buyala-Kikubamutwe												P	P										
	A. "red dorsum"	Kalange-Makwanzi				P	P		P		P		P											P	P
		Mid-Reservoir																							
		Buyala-Kikubamutwe					P	P	P							P									
	Astatotilapia sp	Kalange-Makwanzi			P	P	P			P				P	P		P	P						P	P
		Mid-Reservoir												P	P			P							
		Buyala-Kikubamutwe		P	P	P	P			P				P	P	P		P						P	P
	A. nubila	Kalange-Makwanzi															P								
		Mid-Reservoir																						P	
		Buyala-Kikubamutwe																P							
Gaurochromis	*Gaurochromis sp*	Kalange-Makwanzi		P																					
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
Haplochromis	*H. lividus*	Kalange-Makwanzi									P													P	
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
Harpagochromis	*H. guiarti*	Kalange-Makwanzi	P	P	P	P	P		P	P	P	P						P	P		P	P	P	P	
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P		P	P	P		P			P	P			P		P					P		
	H. serranus	Kalange-Makwanzi																							
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P																						

b)

Genus	Species name	Sites	Sampling Numbers and Monitoring Dates																						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Labrochromis	*L. humilior*	Kalange-Makwanzi		P																					
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
Lithochromis	*Lithrochromis sp*	Kalange-Makwanzi		P		P	P												P						
		Mid-Reservoir																							
		Buyala-Kikubamutwe					P												P						
Lipochromis	*L. microdon*	Kalange-Makwanzi					P																		
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	L. parvidens	Kalange-Makwanzi			P			P																	
		Mid-Reservoir																							
		Buyala-Kikubamutwe							P			P													
Mbipia	*M. mbipi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P				P				P	P	P	P	P
		Mid-Reservoir										P			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
Neochromis	*N. "elongate"*	Kalange-Makwanzi										P													
		Mid-Reservoir																							
		Buyala-Kikubamutwe						P																	
	N. greenwoodi	Kalange-Makwanzi	P							P															
		Mid-Reservoir																							
		Buyala-Kikubamutwe		P																					
	N. rufocaudalis	Kalange-Makwanzi		P	P	P	P	P	P	P		P													
		Mid-Reservoir										P			P	P									
		Buyala-Kikubamutwe		P																					
	Neochromis sp	Kalange-Makwanzi																						P	
		Mid-Reservoir																	P						
		Buyala-Kikubamutwe																P							
Paralabidochromis	*P. "black para"*	Kalange-Makwanzi				P			P			P													
		Mid-Reservoir														P									
		Buyala-Kikubamutwe			P						P														
	P. cyaneus	Kalange-Makwanzi																							
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P																						
	P. "earthquake"	Kalange-Makwanzi	P				P			P															
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P																						
	P. flavus	Kalange-Makwanzi																							
		Mid-Reservoir																							
		Buyala-Kikubamutwe					P				P														
	P. rock kribensis	Kalange-Makwanzi					P				P												P		
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. "scarlet anal"	Kalange-Makwanzi	P						P	P	P	P				P			P						
		Mid-Reservoir																							
		Buyala-Kikubamutwe					P										P								
	P. "yellow"	Kalange-Makwanzi																							
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P																						
	Paralabidochromis sp	Kalange-Makwanzi	P																					P	
		Mid-Reservoir														P									
		Buyala-Kikubamutwe	P	P	P																				
	P. crassilabris	Kalange-Makwanzi																P							
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							

c)

Genus	Species name	Sites	Sampling Numbers and Monitoring Dates																						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
			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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Prognathochromis	*P. "shovel mouth"*	Kalange-Makwanzi	P	P			P	P	P	P	P														
		Mid-Reservoir																							
		Buyala-Kikubamutwe				P			P			P	P												
Psammochromis	*P. aelecephalus*	Kalange-Makwanzi		P					P																
		Mid-Reservoir																							
		Buyala-Kikubamutwe		P					P																
	P. riponianus	Kalange-Makwanzi	P	P	P	P	P		P	P		P	P					P				P		P	P
		Mid-Reservoir												P		P				P			P	P	
		Buyala-Kikubamutwe	P		P		P		P				P	P	P	P		p					P		P
	Psammochromis sp	Kalange-Makwanzi															P				P	P			
		Mid-Reservoir																							
		Buyala-Kikubamutwe															P								
Ptyochromis	*P. sauvagei*	Kalange-Makwanzi	P		P		P			P	P	P										P	P		P
		Mid-Reservoir																							
		Buyala-Kikubamutwe	P		P				P					P									P		
	P. xenognathus	Kalange-Makwanzi																P							
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
Pundamilia	*P. "black"*	Kalange-Makwanzi		P	P	P	P	P	P	P	P														
		Mid-Reservoir																							
		Buyala-Kikubamutwe					P	P																	
	P. "orange anal"	Kalange-Makwanzi		P																					
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. igneopinnis	Kalange-Makwanzi										P													
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. macrocephala	Kalange-Makwanzi										P													
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. "orange tail"	Kalange-Makwanzi		P						P															
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. pundamilia	Kalange-Makwanzi										P													
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
	P. "red tail"	Kalange-Makwanzi	P			P																			
		Mid-Reservoir																							
		Buyala-Kikubamutwe				P																			
	Pundamilia sp	Kalange-Makwanzi		P																P	P	P	P	P	P
		Mid-Reservoir																				P		P	
		Buyala-Kikubamutwe																		P			P	P	
Xystichromis	*X. phytophagus*	Kalange-Makwanzi	P			P		P	P												P				
		Mid-Reservoir																		P					
		Buyala-Kikubamutwe									P														
Unidentified	Haplochromines	Kalange-Makwanzi				P																			
		Mid-Reservoir																							
		Buyala-Kikubamutwe																							
Total number of species		Kalange-Makwanzi	14	17	12	15	16	9	14	14	11	14	5	3	3	4	6	7	9	4	7	7	8	11	9
		Mid-Reservoir										4		2	3	5	1	2	5	5	1	3	3	6	1
		Buyala-Kikubamutwe	10	8	10	7	12	5	9	4	6	5	8	5	5	7	3	8	7	2	1	2	7	2	5

3.2.3 Catch rates / biomass estimates

Catch rate as a measure of standing biomass, i.e. catch per net per night was used to indicate relative abundance of fish species from the transects. 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 (9.06 fish per net per night) at Kalange-Makwanzi transect and lowest (0.72 fish per net per night) at the mid-reservoir (Table 3.4.4). Similarly, by weight, catch rates were highest (178.5g) at Kalange-Makwanzi and lowest (23.0g) at Buyala-Kikubamutwe transect (Table 3.3.5). At Kalange, haplochromines recorded the highest catch rates by number (22.2 fish per net per night) and weight (253.8g). Likewise at the Buyala-Kikubamutwe transect, haplochromines recorded the highest catch rates by number and weight (2.1 and 27.3g fish per net per night respectively). At the mid-reservoir, *L.niloticus* dominated the catch by number (0.5 fish per net per night) and weight (51.7 g fish per net per night). While the overall catch rates by numbers reduced from those recorded in the previous survey at the reservoir transects, an increase in overall catch rates by number and weight was realised at Kalange-Makwanzi and Buyala-Kikubamutwe transects.

3.2.4 Fish species recovery

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 (Figure 3.4.1). 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 by gillnets over time at the monitored sites*

Species	Sites	Monitoring Dates																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Apr. 2006	Apr. 2008	Sep. 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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017
Bagrus docmak	Kalange-Makwanzi		0			0.1																
	Mid-reservoir										0	0.1	0.38	0.4	0.1	0.01	0.2	0.2	0.01		0	0
	Buyala-Kikubamutwe		0.1		0.04								0.08	0.1						0.01		
Lates niloticus	Kalange-Makwanzi	0.19	3.1	3.32	2.3	9.8	0.32	0.58	1.13	0.15	2.8	0.5	1.62	0.7	0.1	0.14	0.3	0.3	0.04	0.19	0.4	0.2
	Mid-reservoir										3.1	0.7	1.08	4.2	0.3	0.16	0.7	1	0.29	0.13	0.7	11
	Buyala-Kikubamutwe	1.12	1.7	1.86	2.29	2.6	0.35	0.4	0.16	0.72	0.8	0.2	0.85	1.5	0.6	0.13	0.3	0.1	0.06	0.23	0.1	
Brycinus jacksonii	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe	0.04																				
B. sadleri	Kalange-Makwanzi	0.04																0				0.1
	Mid-reservoir																					
	Buyala-Kikubamutwe																					
Oreochromis niloticus	Kalange-Makwanzi	0.04	0.3	0.1		0.2			0.01	0.01	0					0.01	0	0		0.01	0.4	0.2
	Mid-reservoir												0.08							0.01		
	Buyala-Kikubamutwe	0.07	0.4	0.04	0.04	0.1		0.1			0.2	0.04	0.38	0.2	0.3							
O. leucostictus	Kalange-Makwanzi	0.04	0.1																			0
	Mid-reservoir																					
	Buyala-Kikubamutwe	0.06	0.1																			
O. variabilis	Kalange-Makwanzi	0.17	0.9	0.43	0.45	1.5	0.06	0.17	0.19		0.1	0.04	0.31	0.2			0	0.1		0.06	0.4	0.2
	Mid-reservoir										0				0.01							
	Buyala-Kikubamutwe	0.13	0.1		0.17			0.02	0.02	0.03	0						0.1	0				
Tilapia zillii	Kalange-Makwanzi	0.1	0.2	0.17		0.2	0.04	0.1	0.13		0.1	0.09	0.13	0.1				0.1		0.08	1.4	0.2
	Mid-reservoir										0.1	0.05	0.25	0.5								
	Buyala-Kikubamutwe	0.88	0.5	0.04	0.43	0.1		0.04			0.2	0.16			1		0.1	0.1			0	0
Haplochromines	Kalange-Makwanzi	9	10	6.63	19	16	5.83	4.5	12.7	10.6	11	0.4	11.8	2.5		2.54	2.8	2	0.08	2.92	8	7.6
	Mid-reservoir										0.3		0.5	5.8		0.13	0.2	0.1	0.13	0.08	0.3	0.4
	Buyala-Kikubamutwe	16.8	4.3	6.36	8.32	6.5	0.78	1.62	2.05	1.36	6.1	2.3	13.8	47.2		0.79	14	0.4	0.17	0.27	0.6	2.6
Clarias gariepinus	Kalange-Makwanzi			0.03	0.17							0.01	0.08								0	
	Mid-reservoir										0	0.03										
	Buyala-Kikubamutwe	0.01		0.25	0.07		0.03			0.02				0.1						0.01		
Barbus altianalis	Kalange-Makwanzi	0.02	0.1	0.17	0.03		0.01				0											
	Mid-reservoir										0.1	0.1	0.38									
	Buyala-Kikubamutwe	0.1	0.1	0.04	0.04		0.01	0.01		0.02	0		0.15		0.01					0.01		
B. paludinosus	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe	0.04																				
Labeo victorianus	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe		0.1					0.02														
Protopterus aethiopicus	Kalange-Makwanzi						0.01															
	Mid-reservoir																					
	Buyala-Kikubamutwe				0.04																	
Synodontis afrofischeri	Kalange-Makwanzi	0.21	0.6	0.08	0.42	1.5	0.46	0.33	0.13	0.38	4.8	1.8	53.8	79.5	1.5	4.42	0.6	1.1	0.04	7.75	0.1	0.3
	Mid-reservoir										0.8		1.5	1.5			0.2		0.17	0.08		0.3
	Buyala-Kikubamutwe		0.3	1.09	0.37	3.6	0.28	0.1		1.07	0.1	3.7	2.5	0.5	0.1	0.04	0.9	0.5		1.73		0
S. victoriae	Kalange-Makwanzi			0.08		0.2	0.29		0.17			0.1	3.25	1.3	0.1	0.16		0.1				
	Mid-reservoir										0.1	0.04		1.8		0.08	0.1	0.8		0.21	0.1	0.2
	Buyala-Kikubamutwe											0.1					0	0.1			0.1	
Mormyrus kannume	Kalange-Makwanzi	0.32	0.8	1.83	0.7	0.1	0.23	0.18	0.22	0.04	0.3	0.1	0.46	0.5	0.01	0.04	0.2	0.1	0.05	0.05	0	0
	Mid-reservoir										0.8	0.9	1.46	2.7	0.3	0.23	0.5	0.6	0.21	0.21	0.1	0.1
	Buyala-Kikubamutwe	0.68	0.9	2.25	0.39	0.4	0.15	0.25	0.18	0.17	0	0.1	0.15				0	0				
Gnathonemus longibarbis	Kalange-Makwanzi																					
	Mid-reservoir											0.04			0.1		0.2					
	Buyala-Kikubamutwe																					
Overall rates	Kalange-Makwanzi	2.89	5.5	4.39	7.54	10	2.87	2.41	4.54	3.36	8.2	1.3	23.6	26.9	1.5	2.38	1.6	1.5	0.13	3.63	4.4	3.1
	Mid-reservoir										4.4	1.8	4.2	10.2	0.9	2.11	1.5	2	0.6	0.46	1	12
	Buyala-Kikubamutwe	6.45	3.3	3.91	3.71	4.3	0.81	1.21	0.95	1.5	3.1	2.3	6.6	16.8	6.8	0.41	4.9	0.5	0.12	0.71	0.3	0.9

Table 3.4.4 *Catch rates (weight (g) of fish species caught by gillnets over time at the monitored sites*

Species	Sites	Monitoring Dates																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Apr. 2006	Apr. 2008	Sep. 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	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017
Bagrus docmak	Kalange-Makwanzi		38			28.6																
	Mid-reservoir										14	28	835	136		0.5	33	73.6	11.4		17	3.88
	Buyala-Kikubamutwe		23		6.93								13.8	19.1	4					2.8		
Lates niloticus	Kalange-Makwanzi	16	271	371	114	251	49	36	12	8.6	156	63	141	77.7	9.3	25	14	53.8	30.2	21	26	8.12
	Mid-reservoir										198	140	532	538	17.8	43	104	81.4	85.8	19	65	28
	Buyala-Kikubamutwe	108	108	159	111	171	29	39	16	45	30	18	36.8	94.8	22.7	4.3	13	3.2	2.14	10	4.9	
Brycinus jacksonii	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe	3.3																				
B. sadleri	Kalange-Makwanzi	0.8																0.58				1.38
	Mid-reservoir																					
	Buyala-Kikubamutwe																					
Oreochromis niloticus	Kalange-Makwanzi	1.8	7.4	29		20.1			0.5	6.7	1.2					9.7	0.1	2.24		5.1	36	9.04
	Mid-reservoir												9.2							2.9		
	Buyala-Kikubamutwe	4.5	0.2	3.9	0.93	5.05		0.8			5.8	1.7	205	7.4	29.9							
O. leucostictus	Kalange-Makwanzi	3.7	6.6																			1.06
	Mid-reservoir																					
	Buyala-Kikubamutwe	5.8	6.8																			
O. variabilis	Kalange-Makwanzi	34	49	63	44.7	82.8	15	20	26		18	8.7	122				1	18.1		25	35	20.6
	Mid-reservoir										1.7				5.4							
	Buyala-Kikubamutwe	12	12		8.17			4	12	14	8.1				20.3		9.2	15.5				
Tilapia zillii	Kalange-Makwanzi	6.9	16	22		7.92	7.7	32	21		10	2.8	18.8					3.6			70	11.4
	Mid-reservoir										7.2		21.3	10.5								
	Buyala-Kikubamutwe	82	19	7.3	42.3	7.9		2.7			6.1	2.1		32	38.9		1.3	1.3			2.7	2.3
Haplochromines	Kalange-Makwanzi	304	192	168	534	383	168	113	160	246	168	8.5	219	33.8	15.5	26	27	20.4	1.21	39	181	97.5
	Mid-reservoir										4.1		22.5	113	113	2.9	4.1	2.6	0.13	1.9	6.3	4.08
	Buyala-Kikubamutwe	285	51	206	187	168	16	40	38	15	87	32	226	697	229	9.6	144	5.3	1.33	2.4	11	44.5
Clarias gariepinus	Kalange-Makwanzi			6.3	69.3							8.9	100								33	
	Mid-reservoir										9.4	49										
	Buyala-Kikubamutwe	9.2		53	89.4		34			3.1				139						9		
Barbus altianalis	Kalange-Makwanzi	19	403	501	7.27		2.3				0.6											
	Mid-reservoir										51	199	266									
	Buyala-Kikubamutwe	49	23	96	9.36		4	5.7		13	0.3		408		8.2					4		
B. paludinosus	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe	0.5																				
Labeo victorianus	Kalange-Makwanzi																					
	Mid-reservoir																					
	Buyala-Kikubamutwe		39					15														
Protopterus aethiopicus	Kalange-Makwanzi						16															
	Mid-reservoir																					
	Buyala-Kikubamutwe				26.2																	
Synodontis afroflscheri	Kalange-Makwanzi	11	50	4.6	14.9	56.8	60	19	7.2	29	61	64	1543	2668	46.3	151	22	50.4	2.13	310	5.2	10.8
	Mid-reservoir										16		62.5	61			8.8		8.25	3.3		11.2
	Buyala-Kikubamutwe		19	31	10.4	112	13	2.4		17	1.3	87	45	18	3.8	1.7	34	15.4		68		1.13
S. victoriae	Kalange-Makwanzi			13		17.9	39		28			7.3	278	108	5.2	18		5.3				
	Mid-reservoir										6.8	3.6		236		7.6	10	69.5		27	9.2	16.2
	Buyala-Kikubamutwe											9.6					4.4	10.3			7.8	
Mormyrus kannume	Kalange-Makwanzi	111	251	511	95.8	14.7	49	78	40	7.5	45	28	114	57.6	9.5	17	16	61.9	5.18	31	2.6	2.08
	Mid-reservoir										158	156	238	643	80.1	119	108	111	81.7	69	30	25.4
	Buyala-Kikubamutwe	217	90	176	185	51.6	9.2	33	16	16	1.3	7.8	209				25	2.66				
Gnathonemus longibarbis	Kalange-Makwanzi																					
	Mid-reservoir														8		9.2					
	Buyala-Kikubamutwe																					
Overall rates	Kalange-Makwanzi	242	474	636	300	297	213	186	141	102	290	132	1116	1076	55.3	112	86	155	36.4	182	218	73.3
	Mid-reservoir										443	573	1920	1449	115	166	255	288	183	101	117	67
	Buyala-Kikubamutwe	503	137	257	242	171	83	104	50	102	73	69	955	499	200	8.2	100	25.9	2.55	42	12	15.5

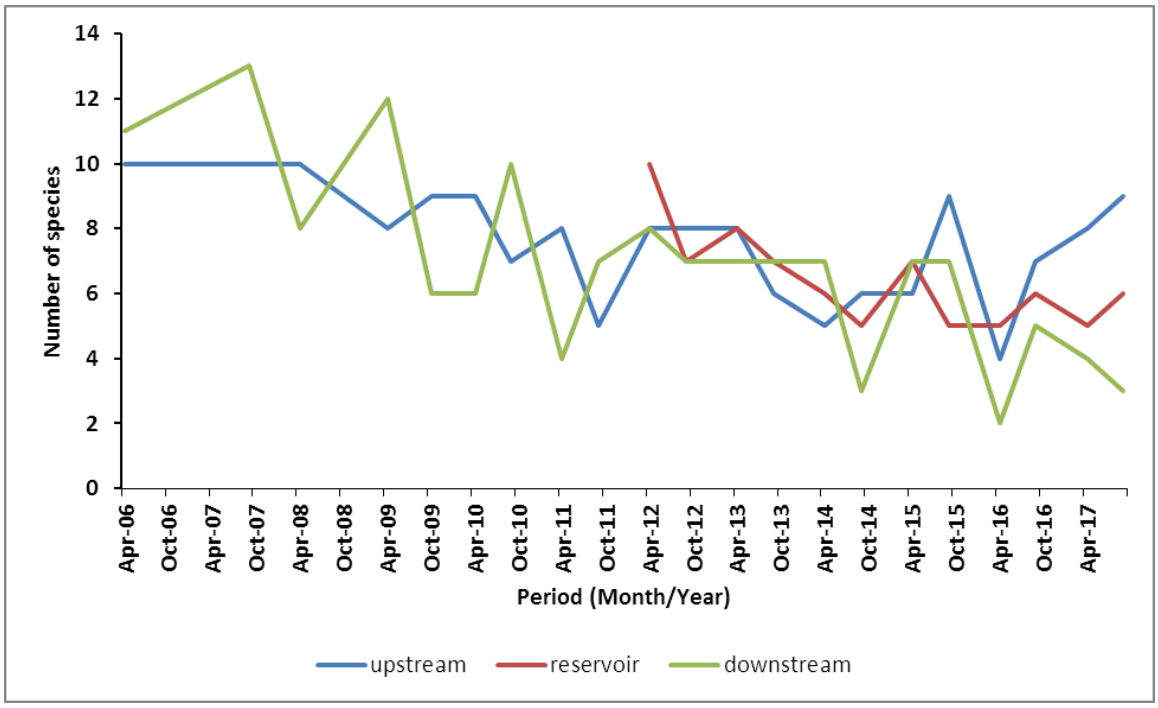

Figure 3.4.1 Cumulative *number of fish species recovered from the study transects on the Upper Victoria Nile over the sampling period.*

3.5 The Food and Trophic Ecology of the Fishes

During this survey, September 2018, *L. niloticus* was recorded from all the three sampled transects. At Kalange-Makwanzi, the diet of Nile perch comprised of *Caridina nilotica* by 51.4% and fish by 48.6% (Table 3.5.1). The fish prey included haplochromine cichlids (25.7%) and unidentifiable fish remains (22.9%). The diet of *L. niloticus* was similar to observations made in the previous survey, April 2018 however, during the recent survey *Caridina* was the most dominant prey whereas in April 2018, fish dominated the diet.

In the mid-reservoir area, the diet of *L. niloticus* comprised of *Caridina nilotica* (52.5%) and fish (47.5%) during this survey of September 2018 (Table 3.5.1). The fish prey comprised of *Rastrineobola argentea* (20.5%), haplochromine cichlids (18.2%) and unidentifiable fish material (9.1%). Dominance of *C. nilotica* in the diet of *L. niloticus* in the mid-reservoir was also observed during the previous survey, April 2018.

At Buyala-Kikubamutwe transect, *L. niloticus* recorded during this survey, September 2018, had ingested only haplochromine cichlids. During the previous survey, April 2018, the diet comprised of *R.argentea* and haplochromine cichlids (Table 3.5.1).

During this survey-September 2018, *Mormyrus kannume* was recorded from Kalange-Makwanzi and mid-reservoir transects. At Kalange-Makwanzi, *M. kannume* guts were empty whereas at the mid-reservoir, the diet of the species comprised of chironomid larvae (Table 3.5.1). Dominance of insect prey in diet of *M. kannume* was also observed during the previous survey, April 2018.

During this survey- September 2018, *Synodontis afrofischeri* was recorded from at Kalange-Makwanzi and Buyala-Kikubamutwe transects. The diet of *S. afrofischeri* from Kalange-Makwanzi comprised of insects by74.7% and Caridina by 25.3% (Table. 3.5.1). The insect prey included chironomid larvae (63.3%), Ephemeroptera nymphs (1.3%) and chaoborids. At Buyala-Kikubamutwe, the diet of the species comprised of only chironomid larvae. Dominance of insect prey in the diet of *S. afrofischeri* in the same transects was also observed during the previous survey- April 2018.

During this survey- September 2018, *Oreochromis variabilis* was only recorded from Kalange-Makwanzi however; its gut was empty as was during the previous survey- April 2018 (Table 3.5.1). During the survey- September 2017, the diet of the species from Kalange-Makwanzi comprised of blue-green algae (32%), diatoms (28%), detritus (26%), water plants (10%) and green algae (9%).

During September 2018 survey, *Oreochromis niloticus* was recorded from Kalange-Makwanzi and Buyala-Kikubamutwe transects. At Kalange-Makwanzi, the diet of *O.niloticus* comprised of detritus (45.0%), blue-green algae (27%), green algae (12%) rotifer (10%) and diatoms (6%). However, during the previous survey- April 2018, the diet of the species from the same transect was dominated by blue-green algae (Table 3.5.1). Variation in the diet of *O.niloticus* is attributed to seasonal changes in availability of food items of the species in the environment. The specimen from Buyala-Kikubamutwe had an empty gut (Table 3.5.1).

.

Table 3.5.1 *Dominant food types of common fish species caught over time at monitored sites*

Family name	Species scientific name	English (local) name	Sites/transects	Monitoring dates													
				10	11	12	13	14	15	16	17	18	19	20	21	22	23
				Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Bagridae	*Bagrus docmak*	*Cat fish (semutundu)*	Kalange-Makwanzi			E	E						CRB		CG		
			Mid-Reservoir	SYN	CAR	SYN	CAR	FR	Hap	CAR	LN	RAS	E	ODT	CG	CAR	
			Buyala-Kikubamutwe				FR						FR				CHR
Centropomidae	*Lates niloticus*	*Nile perch (Mputa)*	Kalange-Makwanzi	HAP	ODT	LN	HAP	HAP	RAS	HAP	CAR	LN	HAP	CAR	HAP	HAP	CAR
			Mid-Reservoir	RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS	CAR	CAR	CAR	CAR	CAR
			Buyala-Kikubamutwe	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP	RAS	HAP	RAS	E	RAS	HAP
Cichlidae	*Oreochromis niloticus*	*Nile tilapia (engege kibati)*	Kalange-Makwanzi	MOL				HPM	E	E	E		HPM	DETR	DETR	BGA	DETR
			Mid-Reservoir			CHA							IR				
			Buyala-Kikubamutwe	INS	EPH	EPH	HPM	BGA								E	
	O. variabilis	*Black tilapia (engege)*	Kalange-Makwanzi	BGA	BGA	INS	DETR	BGA		DETR	BGA		DETR	DETR	BGA	E	E
			Mid-Reservoir					BGA									
			Buyala-Kikubamutwe	BGA				BGA		E	DETR						E
	Tilapia zillii	*Red belly tilapia (engege)*	Kalange-Makwanzi	EPH	E	HPM		ODT			DETR		HPM	HPM	HPM	HPM	
			Mid-Reservoir	E		E	E										
			Buyala-Kikubamutwe	EPH	HPM		HPM	HPM		HPM	HPM			E	HPM	HPM	CHR
Claridae	*Clarias gariepinus*	*mud fish (Male)*	Kalange-Makwanzi		E	MOL	MOL							CRAB			
			Mid-Reservoir	EPH	EPH								E				
			Buyala-Kikubamutwe				EPH						E				
Cyprinidae	*Barbus altianalis*	*Barbel fish (Kisinja)*	Kalange-Makwanzi	DETR													
			Mid-Reservoir	MOL	MOL	MOL											
			Buyala-Kikubamutwe			MOL		E					E				
Mochokidae	*Synodontis afrofischeri*	*Tiger fish (Nkolongo)*	Kalange-Makwanzi	MOL	EPH	EPH	CHR	CHR	CHR	EPH	CHR	CHR	EPH	CHR	CHR	EPH	CHR
			Mid-Reservoir	CHR		EPH	EPH			CHR		EPH	EPH		EPH		
			Buyala-Kikubamutwe		EPH	EPH	EPH	CHR	E	EPH	ODT		EPH		E	EPH	CHR
Momyridae	*Mormyrus kannume*	*Elephant snout fish (kasulubana*	Kalange-Makwanzi	EPH	CHR	EPH	EPH	CHR	EPH	CHR	EPH	CHR	CHR	CHR	E	EPH	E
			Mid-Reservoir	EPH	EPH	CHR	EPH	CHR	CHR	MOL	CHR	EPH	EPH	CHR	MOL	CHR	CHR
			Buyala-Kikubamutwe	E	ODT	INS				E	CHR					INS	

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

During the recent September 2018 survey, signs of breeding activity were only observed in three fish species namely *M.kannume*, *S. afrofischeri* and *S.victoriae* (Table 3.5.2). The highest breeding intensity was recorded from the mid-reservoir (2 species) followed by Kalange-Makwanzi and Buyala-Kikubamutwe (1 species each). At Kalange-Makwanzi, the species that indicated signs of breeding activity was *S. afrofischeri*. The species that showed signs of breeding in the mid-reservoir included *M. kannume*, and *S. victoriae.* At Buyala-Kikubamutwe, only *S.afrofischeri* showed signs of breeding activity.

Fish breeding intensity at Kalange-Makwanzi during September 2018 was lower (2 species) than that observed during the previous survey of April 2018 (5 species). In the mid-reservoir, the number of fish species in breeding condition was lower during September 2018 (1 species) than during April 2018 (3 species). The observations on the breeding status of fish species recorded from Buyala-Kikubamutwe during the recent survey of September 2018 was better (1 species) than during the previous survey of April 2018 in which all the specimens examined from the transect were found to be immature.

Table 3.5.2 *Proportion (%) of breeding fishes over time among commonly encountered fish species at monitored sites*

Family name	Species scientific name	English (local) name	Sites/transects	Monitoring date													
				10	11	12	13	14	15	16	17	18	19	20	21	22	23
				Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018
Bagridae	*Bagrus docmak*	*Cat fish (semutundu)*	Kalange-Makwanzi		0	0	0						0		100		
			Mid-Reservoir	50	25	40	14.3	0	0	20	30	0	0	0	100	100	
			Buyala-Kikubamutwe		0	0	0						0				
Centropomidae	*Lates niloticus*	*Nile perch (Mputa)*	Kalange-Makwanzi	0	0	0	0	0	0	4.3	5.6	0	0	0	0	15	0
			Mid-Reservoir	1	0	7.1	0	0	8.3	2.4	0	8	8	0	4	0	0
			Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cichlidae	*Oreochromis niloticus*	*Nile tilapia (engege kibati)*	Kalange-Makwanzi	0				6.7	100	0	0		100	40	0	48.5	0
			Mid-Reservoir			0	0						0				
			Buyala-Kikubamutwe	0	0	60	0	10.5								0	0
	O. variabilis	*Black tilapia (engege)*	Kalange-Makwanzi	0	0	14.3	45.5	46.2		0	33.3		75	30	25	50	0
			Mid-Reservoir					0									
			Buyala-Kikubamutwe	0				11.1		0	100						
	Tilapia zillii	*Red belly tilapia (engege)*	Kalange-Makwanzi	33.3		0	0	57.1			0		0	37	25	29	0
			Mid-Reservoir			0	0										
			Buyala-Kikubamutwe	0			75	6.1		0	50			50	0	0	0
Claridae	*Clarias gariepinus*	*mud fish (Male)*	Kalange-Makwanzi		0	0	50							50			
			Mid-Reservoir	0	0								50				
			Buyala-Kikubamutwe				0						0				
Cyprinidae	*Barbus altianalis*	*Barbel fish (Kisinja)*	Kalange-Makwanzi	0													
			Mid-Reservoir	50	50	0											
			Buyala-Kikubamutwe			50		0					50				
Mochokidae	*Synodontis afrofischeri*	*Tiger fish (Nkolongo)*	Kalange-Makwanzi	7.9	35.3	34	68	54.8	98.8	100	96.4	100	92.6	40.2	83.3	100	68.3
			Mid-Reservoir	6.7	12.5	16.7	25			33.3		25	0	0	60	75	
			Buyala-Kikubamutwe	0		70	100	16.7	100	100	87.5		100	0	0	0	50
Momyridae	*Mormyrus kannume*	*Elephant snout fish (kasulubana*	Kalange-Makwanzi	17.6	33.3	45.5	28.6	25	0	38.9	25	25	100	50	100	30	0
			Mid-Reservoir	25	44.2	42.1	44.4	61.9	88.9	25.8	18.9	56.3	24.6	64	83.3	48	50
			Buyala-Kikubamutwe	0	33.3	100				100	100						

Major observations

During September 2018 survey, *Caridina nilotica* was the major prey for *Lates niloticus* from Kalange-Makwanzi, however, Haplochromine cichlids also contributed significantly to the diet of the species as they during the previous survey-April 2018.

For the two consecutive surveys- April 2018 and September 2018, *Caridina* was the major prey for Nile perch at mid-reservoir. At Kalange-Makwanzi, Nile perch had ingested only haplochromine cichlids during September 2018 survey whereas during the previous survey- April 2018, the species had ingested haplochromine cichlids and *R. argentea.*

During the survey of September 2018, B*agrus docmac* was only recorded from Kalange-Makwanzi and its diet comprised of only Chironomid larvae. During the previous survey of April 2018, however, the species had ingested *Caridina*. The diets of *S. afrofischeri* and *M. kannume* were dominated by insect prey during April 2018 and September 2018 surveys.

The diet of O.niloticus during the survey of September 2018 was dominated by detritus whereas during April 2018, the diet of the species was dominated by blue-green algae. During the September 2018 survey, *T. zillii* had ingested mostly chironomid larvae but during the previous survey- April 2018, the species had fed on water plants.

During the survey of September 2018, breeding intensity of keystone fish species from all the Transects was lower (3) than that recorded in the previous survey- April 2018 (5 species)

3.6. THE COMMERCIAL FISHERY

3.6.1 Fishing effort in the fishery

Fishing effort and catchability coefficients measure fishing mortality whose variations can be used to assess trends in stocks of natural fish populations (Arreguín-Sánchez, 1996). Since 2006, Fish Catchment assessment Surveys (CAS) have been conducted on the Upper Victoria Nile at the Bujagali Hydro-power dam construction Project area by assessing fishing effort and fish catch trends to estimate periodic fish yield because fishing is an important socio-economic activity for the riparian communities. Besides estimation of fishery yields, information that guides formulation of sustainable management advice alongside development projects such as dam construction is provided. For example, Tolmazin (1979) attributed reduced fish yields in the Black Sea and the Sea of Azov to impoundments on the Danube, Dnieper and Dniester rivers in Europe. Thus, 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.

Table 3.6.1a*. Trends in numbers of fishing boats using particular fishing gears at monitored sites.*

Number of fishing gears in use	Sites	Monitoring periods																			
		Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Number fishing boats	Kalange-Makwanzi	22	18	23	23	18	32	15	20	19	24	27	27	32	25	40	31	37	45	25	29
	Mid-Reservoir	-	-	-	-	-	-	16	13	18	27	44	60	38	51	46	48	41	22	29	67
	Buyala-Kikubamutwe	26	32	23	15	12	15	34	19	28	40	20	32	25	21	18	14	21	11	13	20
Number of boats using gillnets	Kalange-Makwanzi	10	6	7	13	6	8	9	9	7	12	15	9	6	10	3	11	7	9	7	4
	Mid-Reservoir	-	-	-	-	-	-	13	3	4	12	20	21	13	12	11	9	10	6	5	5
	Buyala-Kikubamutwe	7	6	1	2		1	4	2	7	3	1	10	1	4	7	3	-	1	1	1
Number of boats using long line hooks	Kalange-Makwanzi	3	1	2	2	0	2	1	4	6	5	8	5	3	4	3	6	-	5	4	2
	Mid-Reservoir	-	-	-	-	-	-	1	0	-	5	-	6	6	2	7	6	3	-	3	6
	Buyala-Kikubamutwe	6	6	13	6	3	7	10	7	-	-	-	-	6	-	4	3	3	-	-	-
Number of boats using cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	3	3	2	6	5	2	5	4	6	6	5	5
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	10	-	-	7
	Buyala-Kikubamutwe	6	3	1	1	3	0	7	2	-	2	-	-	7	-	1	3	1	-	-	-
Number of boats using Hand line hooks	Kalange-Makwanzi	9	5	4	2	6	8	3	3	1	3	1	1	4	-	6	3	10	2	3	6
	Mid-Reservoir	-	-	-	-	-	-	1	7	3	0	16	23	9	14	9	13	13	12	11	20
	Buyala-Kikubamutwe	9	14	9	2	2	3	12	5	2	5	5	7	3	17	3	2	2	5	1	4
Number of boats using scoop nets	Kalange-Makwanzi	-	1	6	4	4	4	1	2	3	2	-	-	4	-	-	-	2	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	6	3	12	8	8	8	8	-	10	16	9	-	-	7
	Buyala-Kikubamutwe	1	1	-	1	2	1	1	0	-	0	-	-	-	-	-	-	-	-	-	-
Number of boats using Traps	Kalange-Makwanzi	-	-	-	-	-	-	-	0	-	0	-	5	7	7	7	3	12	21	14	9
	Mid-Reservoir	-	-	-	-	-	-	-	0	-	0	-	-	-	1	6	2	3	3	6	19
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	11	20	30	14	15	8		21	6	15	5	12	15
Number of boats using Small seine.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	1	3	2	2	4	2	2	3	3
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The total number of fishing boats recorded across the three transects during this monitoring period-September 2018 increased by 73% compared to the number recorded during the previous survey- April 2018 (Table 3.6.1a) The highest number of fishing boats ever recorded, happened during September 2014 (Table 3.6.1a). During this period- September 2018, the highest increment in fishing boats occurred at the mid-reservoir transect by 67.6%, then at Kalange-Makwanzi by 29.3% and least 20.2% at Buyala-Kikubamutwe. The number of fishing boats at the mid-reservoir transect more than doubled since April 2018. This number of fishing boat is the highest so far at this transect since April 2009. The upsurge in the number of fishing vessels at all transects is explained by the increasing exploitation of juvenile *Mormyrus Kannume* by fishers, an apparent lucrative fishing venture.

Both monitoring surveys i.e. April and September surveys often coincide with the rainy spells, when fish catches are generally expected to be high due to associated seasonal variations in the physical and biotic environments ranging from food availability and better conditions for fish to spawn. Mansor et al (2012) found the primary and secondary wet seasons in March–June and August–November to influence both the water chemistry and fish assemblage in Merbok Estuary. During periods of low returns such as the dry months of the year, fishers tend to respond by withdrawing their fishing inputs (boats and gears) from the fishery for more productive alternative livelihood sources. Therefore the growing increase in fishing boats between September 2016 and the current survey in the study area could be attributed to improvements in fishing conditions, which has attracted fishers to search for fish where even catch prices may be better than at other fishing jurisdications. As a fishing strategy, fishers occasionally migrate to sites suspected to have better fish catches and prices (Lwenya et al., 2009; Binet et al., 2012). The patterns of fisher migrations also tend to coincide with fish migrations (Njock & Westlund, 2008). Such migrations help fishers to maintain their livelihoods in forms of employment, food and nutritional security; while others opt out completely from fishing for alternative livelihood sources.

Fishing boats using basket traps 43, 30 used hook and line, 12 used cast nets, 10 used gillnets, 8 used long line hooks, 7 used scoop nets and 6 used small seines (Table 3.6.1a). Fishing boats using all the fore- mentioned gears except scoop nets were encountered at the mid-reservoir and Kalange-Makwanzi transecst during the September 2018 survey. At Buyala-Kikubamutwe, boats using only basket traps and hooks were encountered. Fishing boats using gillnets continued to reduce-this reduction is 75% for the past eight monitoring periods since September 2014. There were 5 fishing boats using gillnets at the mid-reservoir transect and just 1 boat at Buyala-Kikubamutwe during the current survey. On the contrary, since April 2017, boats using basket traps have drastically increased across the three transect making them the most dominant gears used by fishers. In addition, the number of boats using Hook and line doubled from 15 boats during April 2018 survey to 30 boats during September 2018.

Hovgêrd & Lassen (2008) have shown that the choice of fishing gear at a particular fishing ground is influenced by the target fish species, the cost of fishing gear, the catch per unit of effort (CPUE), the habitat and the suitability of the gear with respect to that particular site. The fishing gears encountered at the three study sites during the current survey could therefore give an insight of the possible target fish species at those sites. It should be noted that the choice of target species determines the choice of fishing gear(s) to use in exploitation. The very few boats encountered using gillnets and absence of other gears like small seine and scoop nets at Buyala-Kikubamutwe is due to absence of species (*R. argentae*) that require these gears for harvesting. Nevertheless, the *M.*

kannume live bait majorly exploited by basket traps is the most dominant fishery at the this transect (Table 3.6.3) and even at mid-reservoir and Kalange-Makwanzi transects during current monitoring period.

Basket traps remained the most dominant gear and were encountered at all the three transects. The hook and lines and gillnets too were encountered at the three transects. At mid-reservoir and Kalange-Makwanzi transects, longline hooks, cast nets and small seine nets were recorded. Scoop nets were recorded only at the mid-reservoir (Table 3.6.1c). They were 574 Basket traps, 321 longline hooks, 158 Hook and line and 6 small seine nets recorded (Table 3.6.1c). The number of basket traps across the transects was moreless similar i.e. 33% at Kalange-Makwanzi, 36% at the mid-reservoir and 30% at Buyala-kikubamutwe. Gillnets and cast nets were more prevalent at the mid-reservoir transect compared to the other two transects. The longline hooks were most prevalent at Kalange-Makwanzi (Table 3.6.1c). The total number of cast-nets increased during the current survey to 12 from 5 recorded during the previous survey. Cast nets have remained relatively stable between September 2013 and September 2018. The majority of gillnets recorded at all the transects (Table 3.6.1b) were below the legal size limit of 127 mm (five inches) and were dominated by 101.6 mm and 63.5 mm mesh sizes. The fewer number of legal gillnets in the study area is an indication of scarcity or low abundance of the target species (e.g. *Lates niloticus*, *Tilapia spp* and *Barbus spp*) known to mature at large sizes. This is further reflected in the low catch rates of the landed catch for these species (Table 3.6.2) and nature of gillnets used, only monofilaments especially at Kalange-Makwanzi and Buyala-kikubamutwe transects. Therefore, it is likely that fishermen tend to resort to active fishing methods whenever catch rates of the target species go down. Monofilament gillnets are usually operated actively in order to improve catch rates.

The composition and distribution of fishing effort (boats, gears and size) at the three study sites during the September 2018 survey provides an insight of the possible target fish species at those sites. Fishermen often shift between fishing gears in response to seasonal variations in catches of the target species thus they can use a particular fishing gear when catches of the target species are high and can abandon it when catches go down (Lwenya et al., 2009; Binet et al., 2012; Njock & Westlund, 2008). It is worth noting that both the number of boats using basket traps and basket trap units increased for all the three transects since April 2017. This increase is attributed to the increasing significance of the *Mormyrus kannume* bait fishery. The species has gained importance as bait in the large size high valued species such as *Lates niloticus*, *Protopterus aethiopicus* and *Clarias gariepinus* on lakes Victoria and Kyoga and is currently faced with heavy exploitation. The species appears to be experiencing growth overfishing thus the sustainability implications of their heavy exploitations to their fisheries require urgent investigation.

***Table 3.6.1 b**. The trend in numbers of gillnets per mesh and total number per boat at monitored sites*

Average number of gillnets per mesh per boat	Sites	Monitoring periods																			
		Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Gillnets - ≤2½"	Kalange-Makwanzi	-	1			4		2	0		1	11	2	8	1	6	19	5	14	10	4
	Mid-Reservoir	-	-	-	-	-	-	0	0		0	8	3	9		3	8	13	20	10	0
	Buyala-Kikubamutwe	-	10		2	-	-	0	0	12	0		38		11	-	-	-	3	3	0
Gillnets 3"	Kalange-Makwanzi	-	3	1	6	-	-	8	0		10	4	15	6		13	6	2	1	1	0
	Mid-Reservoir	-	-	-	-	-	-	0	4		16	5	39	35	9	12	19	13	3	3	2
	Buyala-Kikubamutwe	4	-	-	9	-	-	10	0		0			15		7	6	-	-	-	-
Gillnets 3½"	Kalange-Makwanzi	-	1	1	4	-	5	16	0		0	1	3	1	8	-	1	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	0	3		12	7	16	5		16	8	7	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	3	11	3	0	-	-	-	-	-	-	-	-	-	3
Gillnets 4"	Kalange-Makwanzi	21	8	2	26	20	20	10	0	-	18	35	17	1	-	6	3	-	3	-	11
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	5	98	16	1	-	-	-	15	11	-	-
	Buyala-Kikubamutwe	-	-	1			13	0	0	-	0	10	-	-	-	-	-	-	-	-	-
Gillnets 4½"	Kalange-Makwanzi	5	-	-	2	2	12	4	0	-	0	3	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	0	-	8	1	-	-	3	5	-	-	-
	Buyala-Kikubamutwe		6	1	-	-	-	0	0	-	12	-	-	-	-	-	-	-	-	-	-
Gillnets 5"	Kalange-Makwanzi	12	1		-	-	-	1	0	-	0	3	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	14	0	-	0	-	1	-	-	-	2	10	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	5	0	0	-	0	-	-	-	-	-	3	-	-	-	-
Gillnets 6"	Kalange-Makwanzi	-	-	-	4	-	8	-	2	-	8	-	-	-	-	-	-	-	-	6	-
	Mid-Reservoir	-	-	-	-	-	-	22	0	-	0	-	-	-	32	-	-	-	-	-	6
	Buyala-Kikubamutwe	18	15	-	-	-	-	-	0	9	0	-	-	-	-	-	-	-	-	-	-
Gillnets 6½"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 7"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 8"	Kalange-Makwanzi	-	-	-	-	-	-	-	0	8	0	-	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-
Total gillnets	Kalange-Makwanzi	38	20	24	42	28	43	41	2	8	37	57	37	16	18	25	29	7	18	29	7
	Mid-Reservoir	-	-	-	-	-	-	36	7	0	33	118	87	51	32	31	40	63	34	13	19
	Buyala-Kikubamutwe	22	37	4	11	-	18	13	11	24	12	10	38	15	11	7	6	-	3	3	2

***Table 3.6.1c**. The trend in numbers of fishing gear types per boat at monitored sites.*

Average number of fishing gear types per boat	Sites	Monitoring periods																			
		Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Apr-18
Long line hooks	Kalange-Makwanzi	550	200	650	280	-	500	70	800	687	860	1360	950	230	626	250	1060	910	440	650	233
	Mid-Reservoir	-	-	-	-	-	-	50	-	-	70	-	580	378	200	140	154	112	-	55	88
	Buyala-Kikubamutwe	277	180	380	142	110	482	525	420	-	-	-	-	1100	420	56	420	300	-	-	-
Cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	-	3	2	6	5	2	5	3	6	6	5	5
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	-	-	-	7
	Buyala-Kikubamutwe	6	3	1	1	3		7	2	2	2	-	-	7		1	3	1	-	-	-
Hand line hooks	Kalange-Makwanzi	105	124	26	3	18	88	35	4		26	2	10	35		30	1	10	12	15	61
	Mid-Reservoir	-	-	-	-	-	-	6	14			69	276	65	218	50	73	61	36	85	83
	Buyala-Kikubamutwe	97	152	32	16	8	5	51	24	2	5	5	39	18	63	18	-	4	15	10	14
Scoop nets	Kalange-Makwanzi	-	1	6	4	4	4	1	2	3	2	-	-	4		-	-	2	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	6	3	12	8	8	8	8	15	10	16	9	-	-	-
	Buyala-Kikubamutwe	1	1		1	2	1	1	0	-	-	-	-	-	-	-	-	-	-	-	-
Small seine nets	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	3	3	2	2	4	2	2	3	3
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monofilament nets	Kalange-Makwanzi	-	-	-	-	-	-	0	29	15		38		16		25	24	23	18	15	7
	Mid-Reservoir	-	-	-	-	-	-	21	0	13	3	113	56	47	43	28	34	30	34	30	2
	Buyala-Kikubamutwe	-	-	-	-	-	-	0	0	-	-	4				7	10	12	3	2	2
Number of Traps	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	43	48	1	124	41	189	110	164	192
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	10	105	22	44	36	59	207
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	56	151	461	460	190	97	55	39	53	127	29	62	175

3.6.2. Fish catch composition and catch rates

Fish catch composition

Ten fish species (*Lates niloticus, Oreochromis niloticus, Oreochromis variabilis, Tilapia zillii, Bagrus docmak, Mormyrus kannume, Synodontis afrofischeri, Rastrineobola argentae,* Barbus altianalis and haplochromine species), belonging to six families were recorded at the three transects during the September 2018 survey (Table 3.6.2*).* Similar to the previous surveys, Family *Cichlidae* recorded the highest number of species (four) followed by *Cyprinidae* which registerd two while the other families were each represented by a single fish species. They were nine fish specie recorded at Kalange-Makwanzi transect, eight at mid-reservoir and five at Buyala-Kikubamutwe. *Rastrineobola argentae* was encountered only at the mid-reservoir and *Oreochromis variabilis* at Kalange-Makwanzi only. The following fish species: *M. kannume, S. afrofischeri, L. niloticus* and *B. docmak* were encountered at all the three transects (Table 3.6.2). The two species, *O. variabilis* and *B. altianalis* previously not encountered during the April 2018 survey were encountered during the current survey, making the number of

species encountered in this survey similar to those encountered in September 2017 (Table 3.6.2).

The number of commercial species encountered during the current period have increased by 25 % since the April 2018 survey and reduced by 40% since September 2014 when 14 fish species (14) were recorded. The commercial species at the three transects have fluctuated since April 2009, with some species absent in some surveys only to reappear in the subsequent ones. Only six species (*B. docmak, L. niloticus, O. niloticus, T. zillii* and *M. kannume*) have up to date consistently appeared in the commercial fisheries at Kalange-Makwanzi since April 2009 (Table 3.6.2). The lung fish, *Protopterus aethiopicus* has been recorded six times at this transect over the same period and has not been recorded at any of the three transects since September 2013. Since April 2014, *Oreochromis leucostictus* has also not been encountered at the monitored transect despite being present during the earlier surveys.

Fish catch rates (kg/boat/day)

During this September 2018 survey, Catch per Unit of Effort (CPUE) of *M. kannume* at Buyala-Kikubamutwe was 10.6 kg/boat/day. It declined at the mi d-reservoir transect and slightly increased at Kalange-Makwanzi transect between April and September 2018 (Table 3.6.2). The CPUE of *Synodontis afrofischeri* over the same period interval increased at all the three transects. The CPUE of following fish species: *B. altianalis, R. argentae, T. zillii, O. variabilis and O. niloticus* increased at the transects they have been encountered before (Table 3.6.2). CPUE for *L. niloticus* declined at Kalange-Makwanzi and mid-reservoir transects while that of M. *kannume* and *B. docmak* reduced respectively at the mid-reservoir and Buyala-Kikubamutwe transects.

The most common effects associated with hydro-power dam projects of concern to fisheries biologists, conservationists and managers include changes in fish species composition, catch rates, relative abundance and diversity. According to Agostinho, et al. (2008), some fish populations may increase in numbers, others may reduce or even go extinct. This is so because dams create barriers that obstruct the migratory patterns of aquatic organisms including fish between the upstream and downstream sites (Hafiz, et al., 2014; Hall, Jordan, & Frisk, 2011; and Roberts, 2001). When fish are hindered to search for suitable breeding and feeding habitats, their recruitment and growth get negatively affected. Thus, fish species that can adapt the new habitat conditions will servive.

Since 2012 to-date, the number of fish species encountered at the mid-reservoir transect has increased while the number at Buyala-Kikubamutwe transect has greatly dwindled. This change could be attributed to the ecological habitat alterations that have created lentic-like environment at the mid-reservoir transect which support lacustrine-adapted fish species and community assemblages. Such post-dam construction effects affect fish

species diversities and distribution and impact on the riparian fisher communities whose livelihoods are either directly or indirectly derived from the diverse fish species. Previously common species like *Protopterus aethiopicus and Oreochromis leucostictus* have become rare in the commercial fisheries, especially during the recent survey April 2014 to present. If such a trend continues in the subsequent monitoring surveys, corrective measures will be made to avert the situation. Since the creation of the reservoir, the number of fish species have declined from 11 in April 2012 to 8 at Kalange-Makwanzi and the total number of fish species at all the three transects has reduced from 14 to 10 species. This observation is in agreement with studies of Agostinho et al., 2007 where species composition increased during the initial stages of the reservoir formation due to the mixture of local assemblages that distributed over a range of fluvial environments which had become flooded and homogenized. After the complete filling of the reservoir, environmental quality may deteriorate and fish begin to search for adequate environments nearby including the free flowing stretches to upstream, or shoreline areas. The decline in number of species recorded downstream could also be attributed to the barrier created by the dam, which hinders fish migration from uptream and the reservoir to downstream. This hinderance could be mitigated by providing for fish migration ladders.

Table 3.6.2 *Trend of fish catch rates (kg/boat/day) of the main fish species from all gears at the monitored sites*

Family name	Species name (Luganda	Sites/Transects	Monitoring periods																			
			Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	0.4	0.27	0.08	0.15	0.09	0.5	0.53	0.09	0.5	0.8	1	0.7	0.2	1	0.9	1	1.7	2	0.3	0.6
		Mid-Reservoir	-	-	-	-	-	-	0.18	6	0.2	1.1	0.9	1.2	0.3	1.6	1.1	2	1.2	4.2	1.8	2
		Buyala-Kikubamutwe	0.03	0.21	0.17	0.06	0.83	0.16	0.94	1	0.5	1.4	-	8	0.2	2	1.6	2.3	-	4	0.4	0.04
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	0.78	2.12	0.64	0.76	0.52	0.11	1.79	1.8	1.6	2.9	2.5	5.9	0.4	2.7	2.8	1.9	2.6	2	3.3	1.6
		Mid-Reservoir	-	-	-	-	-	-	0.43	3.5	0.8	1.9	2.5	2.6	1.6	2.5	1.6	2.8	2.3	3.3	3.9	2.9
		Buyala-Kikubamutwe	1.01	0.79	1.3	0.38	1.97	3.58	1.41	1.5	0.6	4.9	2	-	0.2	1.8	0.1	8	-	1.4	-	0.7
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	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	0.6	1	1.4	0.5	-	0.3
		Mid-Reservoir	-	-	-	-	-	-	0.3	0.3	-	0.6	1.9	0.3	0.2	1.5	0.3	2.3	2.8	0.1	1.8	1.8
		Buyala-Kikubamutwe	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 (Ngege-Nabutono)	Kalange-Makwanzi	0.01	0.13	0.01	-	-	-	-	-	-	-	0.2	0.1	0.01	0.2	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	1.44	0.88	1.03	0.68	0.23	0.61	0.65	0.4	0.7	1.7	2	1.7	0.2	1.6	1	1.2	0.4	0.4	-	0.3
		Mid-Reservoir	-	-	-	-	-	-	0.48	0.1	-	-	0.3	0.3	-	0.3	-	-	-	0.1	-	-
		Buyala-Kikubamutwe	-	0.06	0.25	0.1	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	0.23	1.04	0.21	0.22	-	0.12	0.39	0.1	0.1	0.9	1.1	0.3	0.02	1	0.2	0.8	1	0.7	0.1	0.2
		Mid-Reservoir	-	-	-	-	-	-	1.13	0.1		0.8	0.5	0.2	0.02	0.5	0.2	-	-	-	-	0.7
		Buyala-Kikubamutwe	-	0.01	0.15	0.04	-	-	-	-	0	0.5	-	-	-	0.6	0.2	-	-	-	-	-
	Haplochromines (Nkejje)	Kalange-Makwanzi	0.02	0.04	0.01	0.01	0.01	0.15	0.03	-	-	0.1	-	0.02	0.01	0.1	0.1	0.2	0.2	0.3	-	0.1
		Mid-Reservoir	-	-	-	-	-	-	0.01	-	-	-	0.1	-	-	0.1	0.1	-	-	0.1	0.3	-
		Buyala-Kikubamutwe	-	0.01	-	0.02	0.1	0.01		-	-	0.6	0.2	0.04	0.2	0.8	-	-	0.3	-	-	0.1
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	0.18	0.07	-	0.04		0.22	1.77	0.5	0.2	3.5	3.8	1.5	0.1	2.8	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	1.35	-	-	-	-	-	-	3.1	-	4.5	8	4.8	-	-
		Buyala-Kikubamutwe	0.18	-	-	-	-	-		-	0	-	-	0.3	0.1	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	3.98	5.11	2.27	2.87	1.66	0.28	6.05	0.1	0.2	1.2	9.8	-	-	9.8	-	-	-	2.1	-	1.9
		Mid-Reservoir	-	-	-	-	-	-	0.95	-	-	0.5	-	0.7	-	-	-	-	-	-	-	4
		Buyala-Kikubamutwe	1.17	0.54	2.1	1.58	1.13	2.98	1.4	1.5	-	-	-	9.4	-	-	-	3	-	15	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	-	11.4	2.96	34.5	-		43	-	-	24	21	-	-	5	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	115	23.5	4.3	-	22	-	7.2	51	73.3	23	25	-	26	32
		Buyala-Kikubamutwe	5.3	-	-	3.05	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	0.06	-	0.05	0.48	-	-	0.05	-	0.1	-	-	12	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	-	0.02	0.01	-	0.01	0.2	-	-	-	0.3	0.4	0.4	0.7	0.3	1.9	-	0.2	0.5	0.6
		Mid-Reservoir	-	-	-	-	-		0.06		-	0.5	0.1	0.2	-	0.5	0.2	0	-	0.5	0.3	0.4
		Buyala-Kikubamutwe	-	-	0.01	-	-	-	-	-	-	0.5	0.5	1	-	0.4	0.4	-	-	1.7	-	0.3
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	0.2	-	0.9	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	0.4	-	0.3	0.5	-	0.1	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	0.1	-	-	0.2	-	-	-	-	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	2.93	0.43	1.84	2.03	0.25	0.7	5.47	1.5	1.4	1.4	0.7	2.3	2.2	1.1	2.1	0.3	0.3	2.2	0.5	0.6
		Mid-Reservoir	-	-	-	-	-	-	1	4.7	1	3.4	3.3	4.8	0.4	2.7	2.7	0.8	0.6	5.8	1.1	0.5
		Buyala-Kikubamutwe	0.23	0.19	0.39	0.06	1.04	0.61		2.3	4.1	4.3	3.2	3.9	2.5	2.3	9.7	2.3	1.6	7.5	1	10.6

3.63. Estimates of total fish catches

The total monthly fish catch across all transects during September 2018 monitoring survey increased to 24 t from 7 t during the previous period- April 2018. The increase

was 13-fold at Buyala-Kikubamutwe transect, two times at the mid reservoir transect and 10 % at Kalange-Makwanzi between April and September 2018 (Table 3.6.3). The monthly catch estimates for *M. Kannume* was 10-fold at Buyala-Kikubamutwe, 5-fold and 3 fold for *B. docmak* and *R. Argentae* respectively at the transect (Table 3.6.3). On the other hand, fish catch for *T.zillii* declined by 89% at Kalange-Makwanzi transect and for *B. docmak* by 54% at Buyala-Kikubamutwe transect. The increase in the total monthly catches across transects could be attributed to the increase in the number of fishing boats, fishing gears especially at mid-reservoir transect and the CPUE for the exploited species especially *M. kannume* species recorded at Buyala-Kikubamutwe (Table 3.6.4).

Studies on effects of fishing effort on fish stock biomass (Jennings & Polinin, 1996) have shown that biomass decreases with increase in fishing intensity. Fishery yields can increase with rise in fishing inputs up to a point of maximum sustainable yield (MSY) beyond which further increase in fishing inputs results into diminishing returns. 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 number of fishing boats and gears targeting the different exploitable fish species across all the transects has fluctuated since the onset of the monitoring surveys (Table 3.6.1 a). The fluctuations in effort (fishing crafts and gears) have also been reflected by the fluctuations in daily mean catch rates, monthly catches and revenue of total catch at beach level (Tables 3.6.2 and 3.6.3). Reductions in catch rates and biomass could suggest over-exploitation and unsustainable selective fishing for species. These have to be regulated to avoid collapse of the fisheries. These observations are apparent due to failure or laxity in management and regulation of fishing effort to sustainable levels. Decline in the catch rates and total monthly catch of the species at the transects is a concern to the resources users, fisheries conservationists, managers and researchers. For instance, the effort levels of the *M. kannume* bait fishery have not been regulated since its emergency. *M. kannume* has dominated the commercial fisheries across all transects since April 2013, but drastically reduced especially at Kalange-Makwanzi during the September 2018 survey. The basket traps used to harvest *M. kannume*, target mainly the live juvenile individuals for bait in the Nile perch fishery on lakes Victoria and Kyoga. The price for bait has always fetched high market prices than the mature individuals and this has been the main incentive for harvesting in large quantities the juveniles of the target species. 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. There is need for concerted efforts from

particularly the fisheries managers to protect *M. kannume* by prohibiting the use of basket traps. Basket traps are already declared illegal fishing gears under the Uganda fishing regulations. The development of M. kannume bait fishery evolved in response to decline in catches of the large sized species *L. niloticus*, *Tilapia sp*, *C. gariepinus*, *Bagras sp* and *Barbus sp*.

Table 3.6.3 *Trends of total fish catch estimates (kg) at monitored sites*

Family name	Species name (Luganda name)	Sites/Transects	Monitoring periods																		
			Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	68.4	52.8	59.8	33.9	355.1	139.8	381.7	267.7	130.9	376.8	491.4	228.4	305.0	1448.3	481.7	1362.0	2498.0	52.5	318.0
		Mid-Reservoir						68.4	481.5	74.3	187.1	1133.4	2068.4	283.8	1724.1	1014.8	697.8	1940.6	2579.0	265.0	1606.5
		Buyala-Kikubamutwe	191.6	109.9	25.8	195.3	73.5	396.7	128.6	397.0	360.8	-	7200.0	116.9	740.6	164.6	398.6	-	1232.0	10.5	4.8
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	532.2	422.1	303.1	193.1	78.3	473.6	870.7	948.7	3940.2	1950.1	4418.1	375.6	1252.4	6865.8	1,052,8	4452.2	2305.0	1048.4	864.1
		Mid-Reservoir	-	-	-	-	-	163.1	248.7	305.7	347.1	3183.1	4689.0	1536.3	2469.8	3502.1	1748.5	3836.3	1876.0	1024.2	2753.9
		Buyala-Kikubamutwe	707.8	840.6	163.5	463.5	1612.5	592.7	117.1	449.7	452.3	1200.0	-	151.9	1074.0	63.0	617.1	168.0	400.0	-	21.0
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	705.7	765.1	39.9	179.0	7.5	14.6		384.6	96.6	950.0	842.4	376.3	1317.7	875.6	468.6	1081.9	592.0	-	37.8
		Mid-Reservoir	-	-	-	-	-	112.8	25.5	-	102.3	2392.8	453.6	177.2	70.9	220.5	1007.3	4057.7	6.0	270.0	1080.0
		Buyala-Kikubamutwe	124.4	-	60.2	197.0	907.8	70.0	10.3	161.6	1069.2	120.0	-	888.3	24.0	-	-	-	-	-	-
	Oreochromis leucostictus (Ngege-Nabutono)	Kalange-Makwanzi	32.4	6.6	-	-	-	-	-	-	-	153.0	90.3	8.5	-	-	-	-		-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-		-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-		-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	221.8	679.4	271.2	623.6	434.9	172.6	352.0	380.4	273.2	1515.7	1278.6	227.7	391.7	912.0	379.6	120.0	417.0	-	30.0
		Mid-Reservoir	-	-	-	-	-	184.2	8.0	-	-	314.8	468.0	12.3	-	-	-	-	52.0	-	-
		Buyala-Kikubamutwe	52.3	161.7	43.0	53.9	-	-	-	-	-		-	0.0	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	261.5	138.5	87.7	88.9	87.7	103.5	96.2	62.4	146.1	803.8	240.7	15.7	174.3	298.7	265.3	553.5	796.0	210.0	22.8
		Mid-Reservoir	-	-	-	-	-	429.5	6.4		13.9	650.7	288.0	22.7	-	140.0	-	-	-	-	105.0
		Buyala-Kikubamutwe	5.0	97.0	17.2	52.9	2.1	-	-	16.8	13.9	-	-	0.0	159.1	85.5	-	-	-	-	-
	Haplochromines (Nkejje)	Kalange-Makwanzi	9.8	6.6	4.0	4.7	108.3	6.7	-	0.2	7.9	-	15.0	4.6	32.0	215.1	63.8	186.3	385.0	-	7.2
		Mid-Reservoir	-	-	-	-	-	3.5	-	-	-	88.2	-	0.0	-	84.0	-	-	6.0	41.0	-
		Buyala-Kikubamutwe	7.5	-	8.6	24.5	3.0		-		166.3	93.0	27.0	131.5	120.0	-	-	71.1	-	-	12.0
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	17.0	-	16.0		-	467.0	109.2	102.8	554.4	2870.6	1147.0	85.1	210.0	-	-	4320.0	-	-	-
		Mid-Reservoir	-	-	-	-	-	515.5	-	-	-	-	-	0.0	1098.3	-	969.1	-	2957.0	-	-
		Buyala-Kikubamutwe	-	-	-	-	159.0	-	-	23.9	-	-	270.0	52.6	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	1282.5	1497.2	1144.5	436.4	200.6	1597.8	30.0	141.7	190.1	7501.8	-	-	-	-	-	-	2583.0	-	228.8
		Mid-Reservoir	-	-	-	-	-	362.7	-	-	89.1	-	1200.0	-	-	-	-	-	-	-	600.0
		Buyala-Kikubamutwe	482.8	1357.9	679.7	266.6	1341.0	515.5	209.4	-	-	-	8460.0	-	-	-	90.0	-	4620.0	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	6463.8	2109.5	2152.8	-		1105.7		-	18371.9	15795.0	-	-	428.6	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	13128.0	1480.5	1627.6	-	27706.5	-	7057.1	23000.0	22000.0	4731.4	1500.0	-	2340.0	9600.0
		Buyala-Kikubamutwe	-	-	980.4	1960.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	-	33.0	191.4	-	-	12.0	-	26.4	-	-	9025.7	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	13.2	4.0	-	10.4	52.8	-	31.9		229.6	305.9	409.0	426.1	245.4	864.1	-	293.0	148.5	85.2
		Mid-Reservoir	-	-	-	-	-	22.9	-		89.1	125.9	324.0		124.9	154.0	8.6	-	308.0	67.5	240.0
		Buyala-Kikubamutwe	-	6.5	-	-	-		-		13.2	300.0	900.0		158.5	292.5	-	-	524.0	-	36.0
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-		248.2		-	144.0	-	1083.6	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	251.9	729.0	7.9	108.9	441.0	-	57.6	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	26.4	-	-	125.6	-	-	-	132.0	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	106.9	1213.6	809.5	389.6	500.1	1444.1	357.6	783.2	214.1	562.6	1753.3	1986.0	831.7	2733.3	95.7	208.8	2807.0	374.6	254.4
		Mid-Reservoir	-	-	-	-	-	381.8	374.7	365.5	605.2	4156.0	8568.0	348.9	508.1	3283.0	172.3	1296.1	3581.0	397.5	273.6
		Buyala-Kikubamutwe	169.2	252.2	25.8	57.8	276.0	-	842.1	3248.0	1135.2	1900.0	3465.0	1607.1	834.8	8821.9	417.4	520.7	2310.0	350.4	5629.7
TOTAL		Kalange-Makwanzi	3238.3	11291.9	5040.4	4097.3	2842.0	4484.5	3308.1	3141.0	2066.0	36626.2	35651.7	3383.8	4940.9	14166.8	3671.7	10368.2	12675.0	1687.0	1847.4
		Mid-Reservoir	-	-	-	-	-	15417.2	2625.2	2400.4	1559.0	40633.1	21245.0	9507.9	30008.9	30839.4	9335.1	12688.3	11365.0	4800.0	16259.0
		Buyala-Kikubamutwe	1740.7	2825.8	2004.2	3247.0	3315.6	1647.3	1309.3	4468.7	6850.0	3613.0	20322.0	3830.0	3110.9	9427.5	1523.2	892.4	9086.0	403.0	5703.5

3.6.4. Estimates of total beach value of the catch

The estimated monthly beach revenue during the current survey was 416 million (UGX) which was generated from total fish catch of 24 t. Compared to what accrued during the April 2018 survey, this monthly beach revenue increased two-fold. The highest total monthly beach revenue occurred at the mid-reservoir area which generated 287 m. At Buyala-Kikubamutwe and Kalange-Makwanzi, monthly beach revenue of 115 m and 14 m respectively was generated. When compared with the previous survey (April 2018), the total monthly beach value increased at the downstream transect more than 30-fold and 2-fold at mid-reservoir transect during this period. At Kalange-Makwanzi transect on the other hand, registered a decline of 37% in the estimated total monthly revenue. The *R. argentae* was encountered only at the mid-reservoir whose estimated total monthly beach value contributed 57.7% of all species lumped together. *M. kannume* contributed 31.1%, *L. niloticus* 6.5% and *B. docmak* 2% to beach revenue (Table 3.6.4).

Fish species also fetched high ex-vessel and/ or market prices e.g. a basinful of *R. argentae* sold 25,000 UGX. The market prices for large sized *L. niloticus* commanded a price per kg of 8,000-10,000 UGX and the small sized ones fetched 3500-5000 UGX. Adult *M. kannume* sold for direct human consumption fetched lower price per kilogram of 4,500 UGX but a Kg of juveniles used for bait fetched ~ 26,000 UGX. The juvenile *M. kannume* is currently sold as individual pieces, with an average juvenile of 50-100 grams costing between 1500 to 2500 Uganda shillings. The high value of catch signifies the importance of the river fishers to the riparian communities who depend on the river water, employment, income, food and nutritional security. There is therefore need for strategic intervention to minimize the potential negative impacts of the dam to the fisheries and their habitats and improve fisheries management in order to sustain their benefits to the riparian communities who directly derive their livelihood from fishing activities.

Table 3.6.4. *Trend of monthly gross value of fish catches (UGX) at monitored sites*

Family name	Species name (Luganda name)	Sites/Transects	Monitoring periods																		
			Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	137	158	105	102	1,065	462	1,365	803	349	2,548	57,600	193	1,055	5,122	534	4,086	10,743	578	1399
		Mid-Reservoir	-	-	-	-	-	226	1,565	230	967	2,456	8,029	248	5,251	3,653	360	10,565	10,108	3,705	6,827
		Buyala-Kikubamutwe	431	110	45	586	662	1,312	450	1,489	1,443	-	983	27	7,406	494	270	-	4,928	368	19
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	998	760	550	869	274	1,299	3,295	2,189	1,772	9,165	16,568	369	6,053	34,166	366	10,957	10,132	9,762	5,063
		Mid-Reservoir	-	-	-	-	-	447	746	1,089	1,239	12,398	23,575	3,929	10,957	14,592	589	29,960	14,156	7,298	21,936
		Buyala-Kikubamutwe	1,888	1,821	296	1,101	12,255	1,625	386	2,248	15,761	8,400	-	69	9,559	410	900	1,680	4,004	-	168
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	776	1,530	84	179	2	33	-	813	117	3,606	3,791	168	5,534	2,773	446	7,573	1,777	-	104
		Mid-Reservoir	-	-	-	-	-	256	77	-	307	7,179	1,524	106	213	551	428	30,143	-	2,700	5,504
		Buyala-Kikubamutwe	187	-	126	197	19	159	31	323	2,138	360	-	808	56	-	-	-	-	-	-
	Oreochromis leucostictus (Ngege-Nabutono)	Kalange-Makwanzi	32	13	-	-	-	-	-	-	-	536	181	1	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	277	1,359	651	624	1,160	376	1,049	1,024	724	6,366	4,560	153	1,735	1,824	273	720	1,000	-	236
		Mid-Reservoir	-	-	-	-	-	402	24	-	-	787	1,544	2	-	-	-	-	26	-	-
		Buyala-Kikubamutwe	78	162	103	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	167	277	175	89	175	241	266	150	365	2,713	409	4	558	597	300	3,321	2,387	17	45
		Mid-Reservoir	-	-	-	-	-	1,000	19	-	278	1,627	950	5	-	233	-	-	-	-	105
		Buyala-Kikubamutwe	7	97	34	53	4	-	-	-	278	-	-	-	676,11.3	171	-	-	-	-	-
	Haplochromines (Nkejje)	Kalange-Makwanzi	5	3	3	4	54	-	-	-	4	-	-	0	-	215	122	233	557	-	7
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	44	-	-	-	84	-	-	-	22	-
		Buyala-Kikubamutwe	-	-	6	20	2	-	-	-	-	47	11	60	60	-	-	143	-	-	12
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	17	-	32	-	636	1,132	328	257	2,772	8,612	4,588	15	560,00.0	-	-	21,600	-	-	-
		Mid-Reservoir	-	-	-	-	-	1,249	-	-	-	-	-	-	3,844	-	360	-	35,482	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	1,350	17	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	1,924	2,246	1,824	873	501	4,411	75	482	855	22,506	-	-	-	-	-	-	9,041	-	1368
		Mid-Reservoir	-	-	-	-	-	1,001	633	-	267	-	3,600	-	-	-	-	-	-	-	3600
		Buyala-Kikubamutwe	802	2,580	1,083	800	6,705	1,623	-	-	-	-	38,070	-	-	-	450	-	32,340	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	2,353	894	1,722	-	-	514	-	-	12,248	15,043	-	-	171	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	2,864	945	814	-	18,891	-	834	21,956	22,000	1,800	4,500	-	58,500	240,000
		Buyala-Kikubamutwe	-	-	416	1,568	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	-	23	351	-	-	36	-	53	-	-	27,077	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	64	-	-	-	-	-	-	-	-	-	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	10	2	-	10	52	5	-	-	344	336	191	481	245	90	-	256	163	112
		Mid-Reservoir	-	-	-	-	-	23	-	-	-	252	567	-	219	159	45	-	154	2,109	240
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	600	90	-	206	146	-	-	524	-	36
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	385	-	-	144	-	264	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	441	1,750	2	218	441	-	1,625	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	115	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	89	1,744	1,160	390	450	1,960	572	1,391	416	1,153	7,013	11,207	1,291	21,121	180	418	14,574	11,531	5,774
		Mid-Reservoir	-	-	-	-	-	518	375	749	1,149	5,700	17,993	174	1,201	9,723	180	5,647	14,921	11,717	8,550
		Buyala-Kikubamutwe	338	202	37	0	331	-	2,105	24,360	11,352	9,658	15,593	5,260	4,202	48,288	546	2,950	6,930	3,212	115
TOTAL		Kalange-Makwanzi	4,423	10,476	5,831	4,850	6,596	10,003	7,468	7,162	7,435	69,797	80,935	12,649	17,267	66,378	2,310	50,533	50,487	22,050	13,979
		Mid-Reservoir	-	-	-	-	-	7,987	3,750	2,883	4,209	49,774	59,533	5,300	43,858	51,437	3,761	80,931	74,847	86,050	286,659
		Buyala-Kikubamutwe	3,731	4,972	2,148	4,378	19,977	4,720	3,605	28,485	46,733	19,065	112,713	6,251	22,164	49,509	2,166	5,038	48,726	3,579	115,440

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.*

Year	Month	*Lates niloticus*	*Oreochromis niloticus*	*Barbus altianalis*	*Mormyrus kannume*	*Oreochromis variabilis*	*Bagras docmak*	*Clarias gariepinus*
2009	April	2,188	1,409	1,666	983	1,450	-	-
	October	2,423	1,189	2,250	1,416	1,357	-	-
2010	April	2,000	2,000	1,722	1,310	1,929	-	-
	September	1,813	2,100	1,594	1,433	2,400	-	-
2011	April	3,286	1,000	2,250	667	1,000	-	-
	September	6,429	2,500	4,000	986	2,667	-	-
2012	April	2,750	2,300	2,760	1,400	2,200	-	-
	September	2,785	3,000	3,370	1,825	2,860	-	-
2013	April	3,063	2,250	3,400	3,886	2,692	-	-
	September	3,830	2,278	3,750	4,600	2,650	3,950	5,000
2014	April	4,363	3,429	3,000	2,635	4,045	3,028	3,000
	September	4,571	3,686	3,375	3,444	3,500	3,780	4,333
2015	April	5,198	3,286	3,000	2,709	3,350	2813	3,000
	September	4,945	3,526	-	2,877	4,300	3,542	2,875
2016	April	4,689	2,900	-	5,787	2,000	3,540	-
	September	5,700	4,850	5,000	5,353	3,033	4,885	4,000
2017	April	8,500	7,300	-	4,000	6,000	4,200	5,000
	September	6,250	3,000	5,600	4,800	2,100	4,150	12,000
2018	April	8,600	5,500	-	27,300	-	7,600	-
	September	7,215	3,500	6000	23,000	3,500	4,200	-

During the September 2018 survey, the unit price for most of the species (except B. altinalis) dropped from what had been recorded during April 2018 (Table 3.6.5). Fish species *M. kannume*, remained as the most highly priced fish species per kilogram during the two 2018 surveys, followed by *L. niloticus*. Juvenile *M. kannume* was sold per individual live specimen thus the estimated unit price was based on the number of individuals contained in a kilogram. The species *C. gariepinus*, one of the monitored species has consecutively missed in the commercial catch in the 2018 surveys, *B. altianalis* and *O. variabilis* on the other hand reappeared in the September 2018 survey after missing out in the previous survey (Table 3.6.5). The increment in the price of *B. altianalis* in the current survey could thus be linked to its absence during the previous survey becaus scarcity of the species led to high market prices. On the other hand, the drop in unit prices of the other species such as *L. niloticus* and *M. kannume* could probably be related to the increased supply given the increased fishing effort and catches for the two species.

In general, given the ever increasing demand for fish, factors that determine the market value of fish include, the type of species, size of fish and supply at a given time as well as

the relationships between demand and supply, where by scarcity of a fish commodity results into a corresponding increase in its cost while surplus may cause a reduction in its value. Interestingly for the size aspect, small sized *M. kannume*, command higher prices than the larger sizes at the UVN which is not the case for other fish species. During scarcity, the demand for fish irrespective of the individual sizes is high thus forcing the prices to rise. Due to the high demand for bait in the long-line fishery on large lakes Victoria and Kyoga, the live juvenile *M. kannume* has progressively gained economic value than the large sized, becoming the most highly valued fish species in the study area.

3.6.5 Estimated total catches and revenue of individual fishing units

During this September 2018 monitoring survey, total monthly catch landings and beach revenue especially for the reservoir and downstream transects significantly increased from the values recorded during April 2018 (Tables 3.6.3 & 3.6.4). Monthly beach revenue at the mid-reservoir and Buyala-Kikubamutwe has been relatively high compared to that generated at Kalange-Makwanzi since 2009. At Kalange-Makwanzi, monthly revenue has been declining since April 2016 but monthly catches slightly increased between April 2018 and September 2018 (Table 3.6.6).

The high beach values of catch at the mid-reservoir and Buyala-Kikubamutwe transects could be explained by the high number of fish species landed, high catch rates (Kg/boat/day) and number of fishing boats while the lower beach values at Kalange-Makwanzi transect corresponded to the low catch rates, number of landed species and fishing boats. It is likely that the high catches and beach value for *M. kannume* especially at Buyala-Kikubamutwe is the main incentive for investment in the illegal basket trap bait fishery. The species has however has started to show signs of decline at Kalange-Makwanzi and mid-reservoir transects where a drop of 63% was recorded during 2018 surveys. Although high fish catches are good for the riparian communities due to the associated economic benefits (beach revenues), unattainable selective exploitation of a species may yield only short term benefits with severe long term impact that may range from loss of income, employment and livelihood sources. Alongside the formulation of mitigation measures for the likely negative impacts resulting from the current exploitation rate, there should be management measures aimed at sustaining fish catches in the study area. This can be achieved through use of sustainable harvesting technologies, introducing of fish bait alternatives to close the supply gap and mitigation of negative environmental impacts associated with dam construction.

Table 3.6.6 *Trend of monthly total catches and revenue of individual fishing units at the monitored sites*

Monitoring period		Upstream-Kalange-Makwanzi		Mid-reservoir		Downstream-Buyala-Kikubamutwe	
Year	Month	Catch (Kgs)	Beach revenue (UGX)	Catch (Kgs)	Beach revenue (UGX)	Catch (Kgs)	Beach revenue (UGX)
2009	April	228	360	-	-	212	254
	September	180	246	-	-	55	117
2010	April	418	388	-	-	123	216
	September	219	254	-	-	134	143
2011	April	467	298	-	-	329	410
	September	89	206	-	-	221	1,332
2012	April	47	189	307	1,227	275	1,098
	September	144	419	389	883	66	188
2013	April	158	7,162	150	2,883	154	28,485
	September	103	7,435	79	4,209	343	46,733
2014	April	1,356.50	2,585	923.5	1,131	180.7	953
	September	1,320.40	2,998	354.1	992	677.4	3,757
2015	April	3,383.80	12,649	9,507.90	5,300	3,830.00	6,251
	September	4,940.90	17,267	30,008.90	43,858	3,110.90	22,164
2016	April	14,166.80	66,378	30,839.40	51,437	9,427.50	49,509
	September	3,671.70	2,309.60	9,335.10	3,761.30	1,523.20	2,166.40
2017	April	10,368.20	50,533	12,688.30	80,931	892.4	5,038
	September	12,675	50,487	11,365	74,847	9,086	48,726
2018	April	1,687	22,050	4,800	86,050	403	3,579
	September	1,847	13,979	16,259	286,659	5,704	115,440

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

During the September 2018 survey, domestic fish consumption was only recorded at the mid-reservoir transect (Table 3.6.7) where fishers retained 1.2 kg/boat/day for domestic consumption. During the previous period-April 2018, fishers retained 0.7 kg/boat/day for domestic comsumption. The increase in fish retained at this transect could be due to the general increase in catch. Besides, the transect registered a variety of species that included the large sized species suitable for home consumption unlike at Buyala-Kikubamutwe where catches were majorly composed of juvenile M. kannume targeted for commercial purposes (bait). The absence of fish retained for home consumption at Klange-Makwanzi could be due to the decline in the catches of large sized fishes such

that fishers would rather sell all their catch than retain some for home consumption. Generally, the observed amount of fish retained by fishers for home consumption is quite small given the harvested quantities (consumption as a percentage of average catch). This should be taken with caution because it is likely that fishing communities are basically catering for their economic needs at the expense of nutritional needs. In the need to fulfill the fish consumption targets by FAO (17 kg/person/year) and WHO (25 kg/person/year), it is pertinent that communities are sensitized on the importance of fish to their daily nutritional fulfillment.

Table 3.6.7 *Trends of the average weight of fish (kg/boat/day) retained by fishers for domestic use and weight of fish retained as a percentage of the overall average weight of fish caught per boat.*

Monitoring period		Sites					
		Upstream-Kalange-Makwanzi		Mid-reservoir-Malindi-Namizi		Downstream-Buyala-Kikubamutwe	
Year	Month	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch
2009	April	0.4	3.7	-	0	0	0
	October	3.5	27.1	-	0	1.4	71.8
2010	April	2.2	11.8	-	0	1.3	29.7
	September	1.5	16.8	-	0	0.8	16.5
2011	April	1.4	30.7	-	0	1.2	23.8
	September	2.1	60	-	0	3	45.8
2012	April	1.2	12.8	1.5	50	0.8	14.4
	September	1.2	20.4	-	0	-	0
2013	April	0.1	2.6	0.1	1.1	0.2	3.2
	September	-	0	5.4	3.3	-	0
2014	April	1.3	2.7	0.5	1.6	-	0
	September	-	0	1.4	6	-	0
2015	April	0.5	9.2	0.1	0.6	0.1	3
	September	1.3	1.8	0.5	0.8	-	0
2016	April	-	0	0.9	0.3	0.3	0.2
	September	0.6	43	-	-	-	0
2017	April	0.9	59	-	0	0.3	18
	September	0.3	26	0.1	0	0.3	5
2018	April	0.8	50	0.7	17.2	0.3	5.5
	September	-	0	1.2	17.1	-	0

Fishery related jobs

During the current survey, 222 people were employed by the fisheries sector from Kalange-Makwanzi to Buyala-Kikubamutwe, a 48% increase in the number of people employed since the April 2018 survey (Table 3.6.8). Fishing remained the biggest (65%) source of employment predominantly engaging males (99%) with only one female encountered at Kalange-Makwanzi. The mid-reservoir transect registered 73 fishers,

Upstream transect 52 and Downstream transect registered 20 during the present monitoring period. In addition to fishing another prominent activity was fish trading which employed 27 people, 55% were female traders and 44% male. Majority of the fish traders were encountered at the Upstream (52%) and Reservoir transects (41%) and only a few (7%) at the Downstream transect. Dominance of women in fish trade and men in fishing is not quite surprising as this trend has widely been documented in the fisheries (Medard *et al*, 2002; FAO, 2014) indicating division of labour tendencies in the fisheries sector. Besides fishing and fish trade, other employment opportunities included net repairers (4%), boat builders (4%) and food vendors (2%), encountered at the Upstream and mid-reservoir transects. Boat building and net repair activities were fully performed by men whereas food vending by women. Absence of boat builders/repairers and net repairers at Buyala-Kikubamutwe indicates the continued use of old leaking canoes by fishers posing is a safety risk to them, besides it could also be an indication of low returns from fishing especially from the large fishes.

Management of the landing sites was represented by the presence of the BMU leadership at all transects who were exclusively male (Table 3.6.8). BMU at Kalange-Makwanzi had 45% of members with almost equal proportions between females and males, 35% at the mid-reservoir, all male members and the least number at the Buyala-Kikubamutwe transect, also all male committee members (Table 3.6.8). The small number of the BMU leadership at the Downstream transect could be due to the continued low fish supply; especially the large sized commercial species e.g. *L. niloticus* and *O. niloticus* to keep people involved in the fisheries sector. Women are involved mainly in post-harvest handling and marketing hence are most likely to be active in areas with high supply of the traded fish commodities. Since April 2012, the Downstream transect has been dominated by bait fishery of *Mormyrus kannume* transported by men to the distant markets on lakes Victoria and Kyoga thus engagement of women at the transect is quite minimal. Additionally, five *M. kannume* bait transporters were also encountered and recorded at the mid-reservoir transect in the current survey, thus increasing the number of employment opportunities and people in depending on the river fisheries

The relatively high number of people employed in the fisheries sector (222), with the majority (55%) being fishers underpins the significance of fisheries and fishing in sustaining the livelihoods of the river-dependent communities. This increased number of people in the fishery indicates a high dependence of communities on the fisheries but also a lack of genuine alternative livelihood options in these communities. Subsequently, any negative effects from the dam that may alter the ecological functioning of the monitored aquatic habitats and cause shifts in fish species composition, distribution and abundance may severely impact on the livelihoods of these communities. Therefore, there is a need for a clear strategic mitigation plan for such impacts. Any economic activity with high returns attracts more investment, fishers respond in a similar manner by investing substantially in gears and species with better economic returns.

Table 3.6.8a *The numbers of people by gender engaged in different jobs at monitored landing sites*

Job type	Sites	Sex	Monitoring periods																		
			Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Boat builders/	Kalange-Makwanzi	M	3	1	2	3	3	2	2	3	3	3	2	2	4	3	3	5	4	3	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	1	5	-	2	2	2	2	-	-	6
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	2	3		1	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Food vendors	Kalange-Makwanzi	M	1	2	4	1	1	1	1		1	2	-	1	-	1	-	1	1	3	1
		F	2	4		3	3	3	3	2	5	2	5	4	5	5	6	3	4	1	2
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1		-	1	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	2	4	3	3	1	1	-	-	-	2	2	-	2
	Buyala-Kikubamutwe	M	-	-	-	-	-	3	3	-	2	-	-		-	-	-	-	-	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Net repair(s)	Kalange-Makwanzi	M	4		3	5	5	3	3	7	5	6	4	6	4	5	5	-	6	5	4
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	11	-	-	-	3	15	-	-	5
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	3	-	-	6	6	-	3		-	-	3	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleaner fish landing	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.6.8b *Number of people by gender engaged in different jobs at monitored landing sites*

Job type	Sites	Sex	Monitoring periods																		
			Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Fisher(s)	Kalange-Makwanzi	M	37	30	38	25	25	25	25	25	42	39	39	54	36	52	45	42	45	37	51
		F	-	-	-	-	-	-	-	-	1	1	1	1	2	-	-	-	-	-	1
	Mid-reservoir	M	-	-	-	-	-	-	13	24	49	51	55	74	37	49	30	52	27	16	73
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	46	30	34	30	30	15	9	28	72	15	11	42	21	24	51	20	18	28	20
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Fish trader(s)	Kalange-Makwanzi	M	6	4	4	6	6	2	2	1	1	2	6	1	1	3	14	3	4	4	6
		F	20	16	16	30	30	16	16	9	16	13	2	4	7	8	10	6	6	6	8
	Mid-reservoir	M	-	-	-	-	-	-	2	1	1	3	1	-	2	3	3	3	4	4	4
		F	-	-	-	-	-	-	5	1	1	12	12	16	9	16	6	7	4	-	7
	Buyala-Kikubamutwe	M	2	2	2			1	1		1	1	-	2	1	-	4	3	3	6	2
		F	3	5	5	5	5	5	3	6	5	-	1	3	-	3	1	1	-	5	-
Fish processor(s)	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	3	3		-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-		2		2	-	6	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fish cleaner	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
	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	1	1
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
		F	-	-	-	-	-	-	-				-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	1	1	2	2	2	1	1	2	2	1	-	1
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMU committee member (s)	Kalange-Makwanzi	M		4	5			7	7	5	5	7	4	5	6	5	5	5	2	5	4
		F		5	4			2	2	1	3	2	2	1	3	4	3	3	-	4	5
	Mid-reservoir	M	2	2	3	3	3	4	4	4	3	3	2	4	3	18	8	11	12	12	7
		F	1	-	-	-	-	1	1	1	1		-	1	10		3	4	4	4	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	5	4	10	4	8	2	3	3	3	3	-	4
		F	-	-	-	-	-	-	-	3	3	2	-	4	-	-	-	3	-	-	-
Landing site Guard	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Fisheries officer	Kalange-Makwanzi	M	-	-	-	-	-	-	1	1	1	-	-		-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-
	Mid-reservoir	M	-	-	-	-	-		1	1	1				-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1	1
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-		-	-	-

Based on observations obtained through the monitoring period and the key monitored indicators in the study area (fishing effort, fish composition, beach revenue and fishery related jobs); besides being dominated by juvenile *M. kannume* catches, the Downstream river-dependent communities seem to experience more the negative impacts of Dam construction than the Upstream and Reservoir transects. There has been a substantial decline in composition of exploitable species, landed catch, beach revenue of catch, CPUE of the regular commercial species, and fishery related jobs. Although the downstream river-dependent communities may benefit from some degree of flood protection and enhanced irrigation opportunities provided by dams (Richter , et al., 2010), studies by Richter, et al., 2010 and Adams, 1985 have demonstrated the adverse effects of dams to the downstream areas as decline in fish populations (fish species, abundance and composition) thus decline in fishing opportunities and income. The negative impacts outweigh the benefits thus result in reduction of their incomes and livelihoods. There is need to quantify and account for these impacts thus recommending mitigation measures to allow for the co-existence of the river-dependent communities and the dam.

3.7 SCHISTOSOMIASIS, RIVERBLINDNESS AND SANITATION STUDIES

3.7.1 Parasitological analysis of bilharzias in humans

Table 3.7.1 *Trend of Schistomiasis infection prevalence, intensity and vector numbers; coliform counts among sampled people at monitored sites*

a

Type of Schistosomiasis		Transect/sites	Monitoring periods																							
			Apr-06	Sep-07	Apr-08	Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Prevalence rate	Schistosomiasis mansonii	Kalange-Makwanzi	53.0	46.0	56.0	28.0	49.0	21.0	21.8	16.0	18.0	18.6	17.0	25.0	20.0	19.6	20.0	22.0	16.0	17.0	15.3	17.5	9.1	17.0	12.5
		Mid-Reservoir										20.5	16.7	18.7	20.0	13.0	14.2	20.0	10.0	12.0	3.3	5.2	5.0	12.0	11.0
		Buyala-Kikubamutwe	48.0	43.0	40.0	22.0	33.0	19.0	16.7	18.6	21.8	19.6	20.0	17.5	18.6	16.4	20.0	15.0	20.0	14.0	18.4	15.0	11.6	13.0	9.9
	S. Haematobium	Kalange-Makwanzi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Mid-Reservoir										0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

b)

Schistosomiasis Intensity of *S. mansonii*		Monitoring periods																							
		Apr-06	Sep-07	Apr-08	Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Intensity levels	Light	32.0	60.8	59.0	35.0	77.0	83.0	86.0	87.0	86.3	75.0	67.0	79.2	83.3	90.5	70.0	81.2	76.0	57.8	80.0	85.7	75.0	73.6	76.0
	Moderate	50.0	27.5	32.0	12.0	4.0	17.0	13.6	15.0	13.7	18.1	33.0	16.7	16.6	9.5	20.5	12.8	23.5	21.0	20.0	14.3	25.0	21.2	24.0
	Heavy	18.0	11.8	10.0	3.0	4.0	0.0	0.0	0.0	0.0	6.2	0.0	4.1	0.0	0.0	8.3	6.1	0.0	10.5	0.0	0.0	0.0	5.2	0.0

Prevalence of Schistosomiasis by water contact		Monitoring periods																							
		Apr-06	Sep-07	Apr-08	Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Prevalence rates	Fishing	71.4	94.4	60.0	68.0	79.0	62.0	31.4	21.9	24.0	28.0	27.8	25.8	32.0	38.9	37.2	32.7	20.0	28.5	46.8	42.8	41.6	31.6	40.0
	Fetching water	18.1	38.4	36.6	30.9	48.0	0.0	6.5	14.3	20.0	20.5	18.0	17.6	16.6	9.1	13.3	15.3	16.6	16.0	13.3	21.6	8,3	10.5	10.0
	Bathing/Swimming	70.0	93.4	54.5	54.8	63.0	15.0	18.6	20.0	46.0	20.4	23.0	34.0	20.0	42.0	20.0	20.5	30.1	17.0	33.3	28.5	41.6	52.6	37.0
	Fish mongers	60.0	42.8	16.6	15.0	33.0	8.0	14.3	5.0	14.0	13.3	11.0	18.0	14.2	10.0	18.1	16.6	0.0	9.0	6.6	7.1	8.5	5.3	13.0

c)

Parameter		Transect/sites	Monitoring periods																					
			Apr-06	Sep-07	Apr-08	Apr-09	Sep-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	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18
Snail Species abundance	*Bulinus sp.*	Kalange-Makwanzi	10	21	14	8	23	20	19	37	85	17	251	20	8	6	20	44	118	64	111	66	119	111	26
		Mid-Reservoir										11	30	10	7	4	55	54	20	42	20	35	75	24	52
		Buyala-Kikubamutwe	13	11	50	8	83	81	9	51	18	3	5	7	21	8	37	7	74	10	12	58	93	12	18
	Biomphalaria sp.	Kalange-Makwanzi	22	31	26	25	20	28	63	182	33	26	26	47	16	20	16	16	32	79	32	15	17	26	24
		Mid-Reservoir										68	67	27	46	45	31	27	24	40	82	21	88	33	52
		Buyala-Kikubamutwe	11	9	65	74	122	60	62	80	60	200	167	22	51	44	47	18	28	40	54	18	68	24	18
	Others	Kalange-Makwanzi	127	39	51	135	67	100	101	455	81	8	72	39	68	222	28	4	39	185	15	36	94	147	10
		Mid-Reservoir										13	15	63	131	100	42	58	102	104	186	52	97	45	80
		Buyala-Kikubamutwe	50	37	52	188	91	98	118	96	57	71	105	87	84	42	37	70	36	39	74	78	125	61	138
Coliforms in water	Shallow	Kalange-Makwanzi	200	73	63	105	15	50	50	48	70	57	60	72	96	92	105	99	104	97	99	163	163	174	85
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	79	80	94	80	80	133	130	131	152	144	213	212	231	115
		Buyala-Kikubamutwe	50	87	73	100	10	87	80	82	81	82	76	80	94	90	91	89	90	104	109	104	109	115	83
	Deep	Kalange-Makwanzi	40	10	43	15	1	1	1	1	2	6	1	3.5	3.5	3.1	5	3	2	6.5	5	6.5	6.4	7	6.5
		Buyala-Kikubamutwe	10	21	70	22	1	1	1	1	1	1	1	5	5	4	10	7	7	2	3	4	20	19	9

Out of 153 stool samples collected from 565 people, 17 (11%) were infected with Schistosomiasis, reducing from 14.8% from the previous period (Table 3.7.1a). The infection rate has been reducing since April 2016. The intestinal type of Schistosomiasis (*Schistosoma mansonii*) has continued to be prevalent while the urinary type, *Schistosoma haematobium*, has remained undetected (Table 3.7.1 a). Infection rates of the disease registerd were highest at Kalange-Makwanzi by 12.5% and lowest at Buyala-Kikubamutwe by 9.9% (Table 3.7.1b).

The percentage of people at all sites with light intensity of infection rose to 76% from 73.6% during the previous monitoring period-April 2018 (Table 3.7.1b), those with moderate intensity went up to 24% from 21% , heavy infestation intensity decreased from 5.2% to nil. This decline in heavy intensity infection is indicative of recovery from the disease due to medication that has been administered to patients during the previous

monitoring periods. However, the increase in moderate intensity may indicate reduced uptake of medication as prescribed or re-infection is occurring somehow.

Fishing and Bathing/Swimming contributed 40% and 37% respectively as major predisposing factors to infection of Schistosomiasis (Table 3.7.1b). Those who fetch water from the river were predisposed to this disease infection by 10%. A decline in the predisposing factors of Fishing and bathing and swimming probably indicate that people have improved their sanitation practices, which should be sustained. We have been focusing our Behaviour Change Communication (BCC) efforts towards people involved in fishing and bathing/swimming at the river bank, leaving out fish mongers and water fetchers. In subsequent BCC interventions, we will include them. All residents that were positive with Schistosomiasis infection were treated under Directly Observed Ttreatment (DOT) using the medicines Praziquantal and Albendazole administered by the sanitation team.

Status of snail vectors

During this monitoring period, *Bulinus sp* vectors markedly decreased at Kalange-Makwanzi transect to 26 from 111 ind. during the previous monitoring period (Table 3.7.1c). These vectors increased from 24 to 52 ind. at the mid-reservoir and slightly rose up from 12 to 18 ind. at Buyala-Kikubamutwe (Table 3.7.1c). The vectors of *Biomphalaria sp* also increased at the mid-reservoir transect from 33 during the previous monitoring period to 52 ind during the current one. The abundance of this vector at Kalange-Makwanzi and Buyala-Kikubamutwe transects remained unchanged. Due to an increase of both vector snail species at the mid reservoir transect during this period, close follow up will be made during the subsequent monitoring to establish why this is. Other non-medically important snail species increased in numbers at Buyala-Kikubamutwe from 61 during April 2018 to 138 ind. during the current period and from 45 to 80 ind at the mid-reservoir transect.

Ten *Bulinus sp* collected from the mid-reservoir transect shed Cercaria, while those collected at both the upstream and the downstream transect did not shed any. This is indicative of increased transmission at the reservoir during this sampling period and this will have to be double checked with other methods in the issuing monitoring periods.

Faecal coli forms

Level of faecal coliform contamination at shallow human-water contact points at Kalange-Makwanzi transect dropped from 167 during April 2018 to 85 colonies per ml during this monitoring period (Table 3.7.1 c), at the mid-reservoir, level of contamination was 115 colonies per ml down from 215 colonies per ml and at Buyala-Kikubamutwe, it was 83 down from 102 colonies per ml during the previous survey period. This time round, faecal contamination significantly reduced at all three transects from the previous

sampling period. Water from the deep middle part of the river had a lower coli form count of 6.5 colonies per 10 mls at Kalange-Makwanzi while at Buyala-Kikubamutwe count recordings dropped to 9 colonies per 10 mls from 20 colonies during the previous survey period. Faecal coliform counts of 1-10 colonies per 10 ml of water are considered risk free in terms of health. The coliforms of medical importance were predominantly *Salmonella sp* and *Shigell*a *sp.*

Blackfly/*Mbwa Fly* Sampling

During this sampling period, no medically important species of *Simulium* flies were detected either by human landing catches, foot patrol or by physical examination of 177 crabs.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. 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).
2. The high dominance values of copepods especially in the reservoir and upstream reaches of the dam suggests high potential for fish production, especially pelagic fishes in these areas relative to the downstream site.
3. The consistent occurrence of lower abundance of zooplankton in the downstream part of the study area is likely a reflection of community response to prevailing water flow dynamics in this area probably created by the dam operations for instance periodic opening and shutting of the sluice gates
4. 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.
5. Transmission of Schistosomiasis is still occurring among the riparian population despite drugs being administered to infected people during the survey periods but levels of infection have remained at light to moderate levels for the last four survey periods. Recording of *Bulinus sp* vector snail that shed cercaria at the mid-reservoir and Kalange-Makwanzi transects, confirmed that the transmission loop has not been broken yet.

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 around the dam-reservoir areas need to be properly monitored and regulated for a sustainable future fishery in this structurally changed section of the river.

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 at the mid-reservoir targeting fisherfolk and swimmers in order to interrupt transmission of Schistosomiasis because here infection increased. Health education should be intensified especially among the new settlers and cultivators at the mid-reservoir.

3.9 References

Adams, W. M. (1985). "The downstream impacts of dam construction: a case study from Nigeria." Transactions of the Institute of British Geographers: 292-302.

Allan J. D. (1995) Stream ecology, structure and function of running waters. Kluwer Academic Publishers, 388pp.

Arreguín-Sánchez, F. (1996). "Catchability: a key parameter for fish stock assessment." Reviews in fish biology and fisheries **6**(2): 221-242.

Baxter, R. (1977). "Environmental effects of dams and impoundments." Annual Review of Ecology and Systematics **8**: 255-283.

Boxshall, G.A., and E. L. Braide. (1991). The freshwater Cyclopoid Copepods of Nigeria, with illustrated key to all species. *Bull. Br. Mus. Nat. Hist*. (zool) 57, 185–212.

Grabowska, M., Ejsmont-Karabin, J., & Karpowicz, M. (2013). Reservoir-river relationships in lowland, shallow, eutrophic systems: an impact of zooplankton from hypertrophic. *Pol. J. Ecol*, 759–768. Retrieved from http://www.pje.miiz.waw.pl/article/ar61_4_13.pdf

Hillebrand, H., Durselen, C.D., Kirschtel, D., Pollingher, U., Zohary, T., 1999. Biovolume calculation for pelagic and benthic microalgae. *J. Phycol*. **35**, 403–424.

Hovgard, H.; and Lassen, H. (2000). Manual on estimation of selectivity of gillnets and longline gears in abundance surveys. *FAO Fisheries Technical Paper*. No. 397. Rome, FAO. 2000. 84p.

John, M.D., Whitton, A.B. & Brook, J.A. eds., 2002. The freshwater algal flora of the British Isles. An identification guide to freshwater and terrestrial algae., London: Cambrige University Press

Kiggundu, V., L. Mwebaza-Ndawula, B. Makanga, & S. Nachuha (2012). Variation in zooplankton community structure and water quality conditions in three habitat types in northern Lake Victoria. *Lakes and Reservoirs: Research and Management*. xx xx.

Kilham, P., 1971. A hypothesis concerning Silica and the freshwater planktonic diatoms. *Limnology and Oceanography*, **16**(January), pp.10–18.

Korinek V. (1999). A guide to limnetic species of Cladocera of Africa Inland Waters. (Cladocera Branchiopoda). Occasional publication No. 1. The International publication of theoretical and Applied limnology. SIL.

Komarek, J. and Anagnostidis,K., 1999: Süâwasserflora von Mitteleuropa. Band 19/1. Cyanobacteria 1. Teil: Chroococcales. Gustav Fischer. Jena/Stuttgart.

Korovchinsky N. M. (1992). Guides to the identification of the Micro-invertebrates of continental waters of the world. Dididae and Holopedidae (Crustacea, Daphniiformes). SPB Academic Publishing. The Hague. The Netherlands

Koste W. (1978). Rotetria Die Radertiere Mitteleuropas Ein Bestmmungwerk, begrandet vo Max Volg. Uberrordnung Monogmonta. Geburuder Borntraeger, Berlin, Stuttgart.

Mwebaza-Ndawula, L. (1998) Distribution and abundance of zooplankton and *Rastrineobola argentea* (Pisces: Cyprinidae) and their trophic interactions in northern Lake Victoria. *Ph.D. Thesis, University of Vienna, Austria. 162pp.*

Mwebaza-Ndawula L, V. Kiggundu and W. Pabire Gandhi 2003. Diversity and abundance if invertebrates in the Victoria basin lakes and their role in fishery production. Uganda Journal of Agricultural Sciences 8: 209-220

Mwebaza-Ndawula L, S.B.K. Sekiranda and V. Kiggundu 2005. Variability of zooplankton community along a section of the upper Victoria Nile, Uganda. *African Journal of Ecology 43:251-257*

NEMA (1999) State of the environment report for Uganda. Standards for

discharge of effluent into water or on land, Statutory instruments No. 5 of Government of Uganda, 1999.

NaFIRRI, 2008. Environmental and Social Impact Monitoring of the Bujagali Hydropower Project (BHPP), Uganda Fisheries Component. A Report prepared for Bujagali Energy Limited (BEL) April 2008. 119p.

FIRRI-National Agricultural research Organization (NARO).2000 Aquatic and Fisheries Survey of the Upper Victoria Nile. A report prepared for AES Nile Power, Bujagali Hydropower Project. Second Quarter Survey 5-14 April 2000

NaFIRRI (2006). Environmental and Social Impact Assessment (ASIA) of the Bujagali Hydropower Project (BHPP), Uganda. A report prepared for R.J. Burnside International Limited. The First Quarter Survey 6th -13th April 2006

NaFIRRI (2007). Environmental and Social Impact Assessment (ASIA) of the Bujagali Hydropower Project (BHPP), Uganda. A report prepared for Bujagali Energy Limited (BEL). 27th September to 3rd October 2007.

World Health Organisation, January 2000, Human health and dams, The World Health Organization's submission to the World Commission on Dams Geneva, January 1999

Journal of environmental management **ISSN** 0301-4797 **CODEN** JEVMAW 2004, vol. 72, n°3, pp. 189-194 [6 page(s) (article)] (26 ref.)

Padisak, J., Reynolds, C.S. & Sommer, U., 1993. Intermediate disturbance in the ecology of phytoplankton and the maintenance of species diversity : a synthesis. *Hydrobiologia*, 249, pp.183–188.

Rutner-Kolisko, A., 1974. Plankton rotifers: Biology and taxonomy. E. Schweizerbart'sche Veriagsbuchhandlung. Nagelen Obermiller.

Shiel, R. J., & Mcevoy, P. (2015). Conceptual Understanding of CLLMM Zooplankton Structure and Function.

Stainton M. P., Capel M. J. and Armstrong F. A. J. (1977) The Chemical Analysis of Fresh Waters, 2nd Edition. Misc. Spec. Publ. Environnent Canada 25,166pp.

Tallling, G. F., 1963. 1963. Origin of stratification in an African rift lake. *Limnology and Oceanography*. 8: 68-78.

Utermöhl, H., 1958. Vervollkommnung der quantitativen Phytoplankton-Methodik. Verhandlungen des Internationalen Verein Limnologie, 9, pp.1–38.

Wetzel, G.R., 2001. Limnology. Lake and River Ecosystems. Third Edition. Academic Press. San Diego.

Wetzel, R. G. and Likens G. E. 2000. Limnological Analyses, 3rd edn. Springer, New York: p. 429.

Zarfdiian, M., E. Michaloudi, D.C. Bobori and S. Mourelatos (2000). Zooplankton abundance in the Alkaiamon river, Greece. Belg. J. Zool. 130 (1): 29-33.

Zhou, S., Tang, T., Wu, N., Fu, X., & Cai, Q. (2008). Impacts of a small dam on riverine zooplankton. *International Review of Hydrobiology*, *93*(3), 297–311. http://doi.org/10.1002/iroh.200711038

.