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

Monitoring No. 24

Date: 9th – 15th April 2019

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)

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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. 24 (9^{th} -15^{th} April 2019) on the Upper Victoria Nile is the forteenth 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 forth 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.

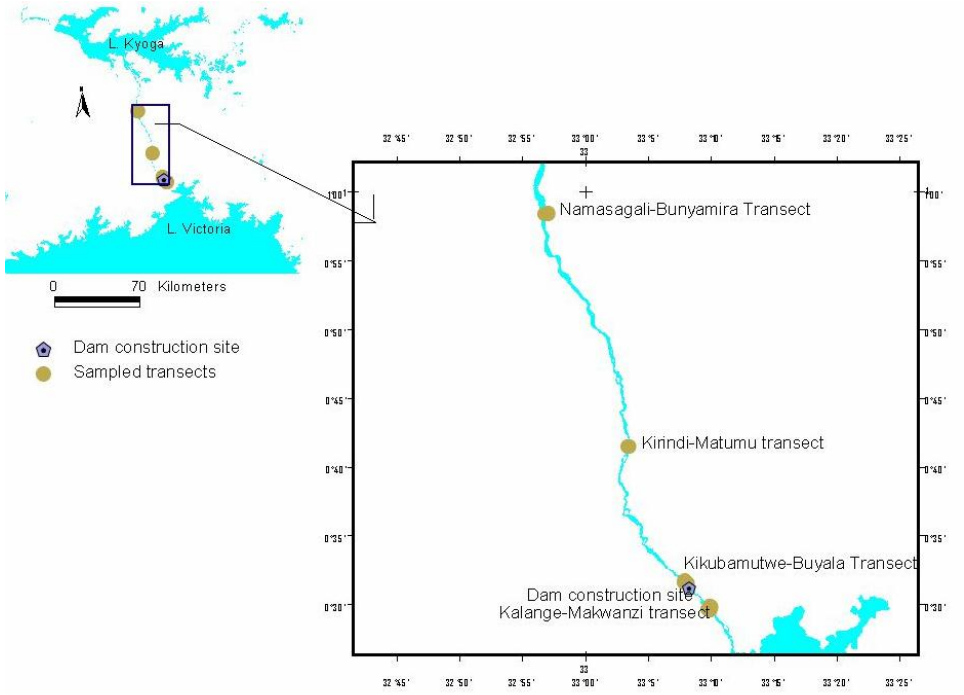


Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*

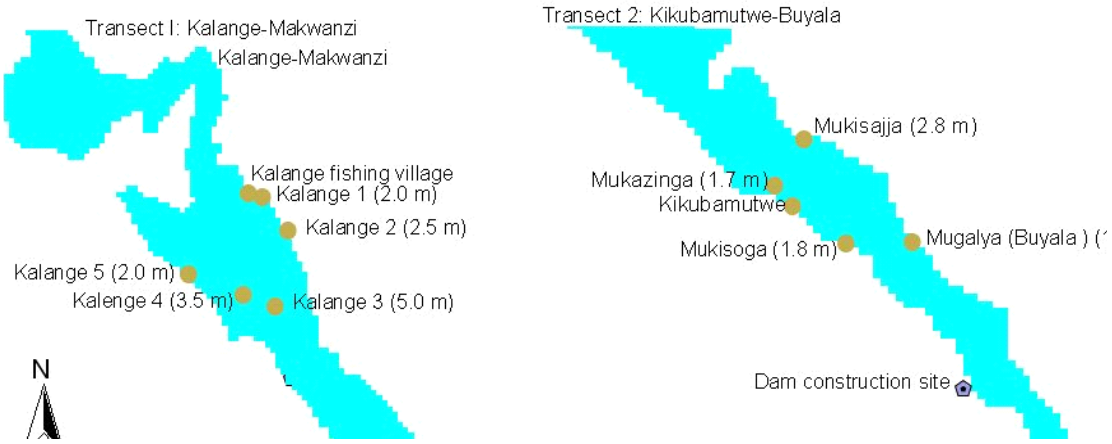


Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

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	Apr. 19
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	5.2
	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	5.1
	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	5.8
	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	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	7.4
	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	7.3
	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	7.4
	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	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	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	26.2	27.1
	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	27
	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	26.9	27.3
	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	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	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	103.1	104.4
	Mid-reservoir										97.4	95	102	110	102	98	99.3	103	104	102	96.2	103	101	104.9	104.6
	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	103.3	104.4
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	2
	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	0.6
	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	0.6
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	3.3
	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	3.6
	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	4.1
	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	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	1.8
	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	2.6
	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	0.9
	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	10

During this monitoring period-April 2019, spatial variations in dissolved oxygen concentration along the stream flow from the Kalange-Makwanzi (upstream), through the mid-reservoir to Buyala-Kikubamutwe (downstream) were minor (Table 3.1.1). Mean dissolved oxygen concentration 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). Dissolved oxygen concentration was highest at the mid-reservoir where correspondingly highest concentration (47.5±3.8 µg/l) of algal biomass

(Chlorophyll-a) was registered. At Kalange-Makwanzi and Buyala-Kikubamutwe, Chlorophyll-a of 15.8±0.4 µg/l and 16.4±3.3 µg/l, repectively was recorded.

The mean pH slightly varied amongst sites, enlisting a value of 7.4 ± 0.07 at the upstream, 7.3±0.3 at the mid-reservoir and 7.4±0.06 at the downstream transect (Table 3.1.1). The mean pH was comparable to that recorded during past monitoring periods and within the permissible NEMA range of 6 to 8.

Mean water temperatures ranged between 27.0±0.3 °C at the mid-reservoir and 27.3±0.1 °C at Buyala-Kikubamutwe. The temperatures were within the permissible NEMA range of 20 ºC to 35 ºC.

Spatial variation of average water electrical conductance was negligible, enlisting 104.0±0.1 µS/cm at the downstream transect, 104.6±0.4 µS/cm at the mid-reservoir and 104.4±0.1 µS/cm at the upstream transect (Table 3.1.1). These values befit 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 those recorded during past monitoring periods.

Water clarity at the upstream transect and the downstream was more less the same (2.0±0.6 m) and much lower at the mid-reservoir (0.6±0.01 m).

Average concentration of TSS increased along the stream flow, enlisting the lowest value (3.3±0.6 mg/l) at the upstream transect and highest (4.1±0.6 mg/l) at the downstream transect (Table 3.1.1). Despite the observed spatial variations, the concentrations of TSS were 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. 1.8 mg/L at the upstream transect, 0.9 mg/L at the mid-reservoir; and 2.6 mg/L at the downstream transect (Table 3.1.1). Compared to previous monitoring periods, status of oil and grease continues to be far below the permissible NEMA upper limit of 10 mg/L.

Vertical profiles for major water physico-chemical parameters in the mid-reservoir showed a relatively stable thermocline between 5 and 10 m in the sampled deepest part of the reservoir (30 m), with dissolved oxygen concentration being approximately 4.4 mg/l, a mean pH of 7.5, while water conductance was 104.5 µS/cm at that depth.

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

The average concentration of ammonium-nitrogen (NH_4-N) was highest (51.2±21.3 µg/l) at the upstream transect and lowest (37.6±10.5 µg/l) at the downstream transect (Table 3.1.2). NB: the concentration of NH_4-N during the current monitoring period more than doubled compared to that observed during April and September of 2018. Despite the observed variations, ammonia concentration was far below the NEMA permissible upper limit of 10,000 μg/L.

The average concentration of nitrite-nitrogen (NO_2-N) showed minimal spatial variation, ranging between 22.4±1.4 μg/L at the mid-reservoir and 30.3±2.4 μg/L at the upstream transect (Table3.1.2). During this period, nitrite-nitrogen concentration was more than double that recorded during April and September of 2018 periods. 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 average concentrations of NO_2-N were far below the NEMA permissible upper limit of 20,000 μg/L.

The average concentration of nitrate-nitrogen (NO_3-N) was highest (156.9±13.0 μg/L) at the mid-reservoir and lowest (110.2±38.7 μg/L) at the upstream transect (Table 3.1.2). Despite the observed variations, the concentration of NO_3-N remained lower than the permissible NEMA upper limit of 20,000 μg/L.

Average concentration of Total Nitrogen (TN) was highest (698.2±366.9 µg/l) at the upstream transect and lowest (169.7±14.1 µg/l) at the downstream transect (Table 3.1.2). The concentration thus reduced along the stream flow but remained below the NEMA permissible upper limit of 10,000 μg/L.

During this monitoring period, the average concentration of Soluble Reactive Phosphorus (SRP) had minimal spatial variations and ranged between 7.7±1.2 µg/l at the upstream transect and 10.6±2.3 µg/l at the downstream transect, consistently reduced along the stream flow. The average concentrations of SRP were below the permissible NEMA upper limit of 5,000 µg/L.

Total Phosphorus (TP) ranged between 35.5±8.1 μg/L at the downstream transect and 40.0±8.5 μg/l at the mid-reservoir (Table 3.1.2). The average TP concentration remained 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. It was lowest (89.4±2.5 μg/l) at the upstream transect and (91.6±1.5 μg/l) at the mid-reservoir (Table 3.1.2).

Algal biomass was highest (47.5±38.0 μg/l) at the mid-reservoir and was attributed to the relatively long residence time that allowed enhanced photosynthesis. There was however, minimal variation in algal biomass between the upstream (15.8±0.4 µg/l) and downstream (16.4±3.3 µg/l) transects (Table 3.1.2).

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

Chemical 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	Apr. 19
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	51.2
	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	42.5
	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	37.6
	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	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	30.3
	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	22.4
	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	30
	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	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	110.2
	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	156.9
	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	164.7
	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	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	698.2
	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	690
	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	169.7
	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	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	42.6
	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	35.5
	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	40
	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	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	7.7
	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	10.3
	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	10.6
	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	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	89.4
	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	91.6
	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	89.8
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	15.8
	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	47.5
	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	16.4

3.1.3 Algae and aquatic macrophytes/weeds

Table 3.1.3 *The number of species and occurrence of major algal types and at the three sites over the monitoring periods*

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

The algae community consisted of four taxonomic groups; blue-green algae, diatoms, green algae and cryptophytes (Table 3.1.3). The highest number of species was registered at the mid-reservoir, over 60% of which was attributed to blue-green algae. Like during the previous monitoring, blue-green algae were the most dominant group followed by green algae and then diatoms in the order. During April 2018 and September 2018, no dinoflagellates were recorded, however, during current monitoring period-April 2019; they were encountered but only at the upstream-Kalange-Makwanzi. During this monitoring period-April 2019, species richness was lower compared to what was recorded during September 2018. Of the 38 species recorded currently; 22 belonged to blue-green algae, 5 to diatoms, 9 to green algae and only one species from the dinoflagellates and cryptophytes (Table 3.1.3). Even though, cryptophytes were represented by just one species, they enlisted the highest bio-volume across sites; 7, 8, 6 mm^3/L at Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe respectively (Table 3.1.4). Diatoms' bio-volume then followed, dominated by *Nitzschia acicularis*, *Navicula gastrum* and *Oocystis gigas*. Despite the high species richness, blue-green algae had low bio-volume compared to other groups. However, *Planktolyngbya circumreta* and *P. Limnetica's* bio-volume

was significant and much higher than for other blue-green algae species, > 2 mm^3/L. During April 2018 and September 2017, blue-green algal bio-volume was dominated by *Dolichospermum circinale* (formerly *Anabaena circinalis*) and *Microcystis aeruginosa*.

Table 3.1.4 *Species composition of algal types at the three sites during April 2019 monitoring period (+ denotes presence).*

Major algal group	Algal species	Kalange-Makwanzi (upstream)	Mid-Reservoir	Buyala-Kikubamutwe (Downstream)
Blue-green algae (Cynophyta)	*Dolichospermum circinale*		+	+
	Aphanocapsa delicatissima	+	+	
	Aphanocapsa elachista		+	+
	Aphanocapsa holistica	+	+	+
	Aphanocapsa incerta	+	+	+
	Aphanocapsa nubilium	+	+	+
	Aphanocapsa sp.	+	+	+
	Chroococcus dispersus	+	+	
	Chroococcus limnetica	+	+	+
	Chroococcus minutus	+	+	+
	Chroococcus sp.	+		
	Chroococcus turgidus	+	+	+
	Coelomoron pusila		+	
	Coelomoron tropicale		+	+
	Coelosphaerium kuetzingianum		+	
	Merismopedia elagans		+	+
	Merismopedia tenuissima	+	+	+
	Microcystis aeruginosa		+	
	Microcystis flos-aquae	+	+	
	Planktolyngbya circumreta	+	+	+
	Planktolyngbya limnetica	+	+	+
	Planktolyngbya tallingi			+
Number of species		14	20	15
Diatoms (Baciliaphyta)	*Navicula gastrum*		+	
	Nitzschia acicularis	+	+	+
	Nitzschia fonticola	+		
	Stephanodiscus astraea			+
	Synedra cunningtonii	+	+	
Number of species		3	4	2
Green algae (Chlorophyta)	*Ankistrodesmus falcatus*	+		+
	Chodatella subsalsa	+		
	Closterium sp.			+
	Crucigenia fenestrata		+	
	Monoraphidium contortum	+	+	+
	Oocystis gigas	+	+	+
	Pediastrum simplex		+	+
	Scenedesmus acuminatus	+		+
	Scenedesmus perfolatus	+		+
Number of species		7	5	8
Dinoflagellates	*Glenodinium sp.*	+		
Number of species		1		
Cryptophyta	*Cryptomonas marssonii*	+	+	+
Number of species		1	1	1
Total number of species		26	30	26

At the three transects, bio-volume of algae compared to the previous sampling was higher during the current monitoring period (Fig. 3.1.2). The highest bio-volume was recorded at the mid-reservoir during this period but during April 2018, it soared at Buyala-Kikubamutwe. The main species succession is observed to be between diatoms and blue-green algae, a historically reported phenomenon for Lake Victoria (Haande et al., 2011; Mugidde, 1992, 1993).

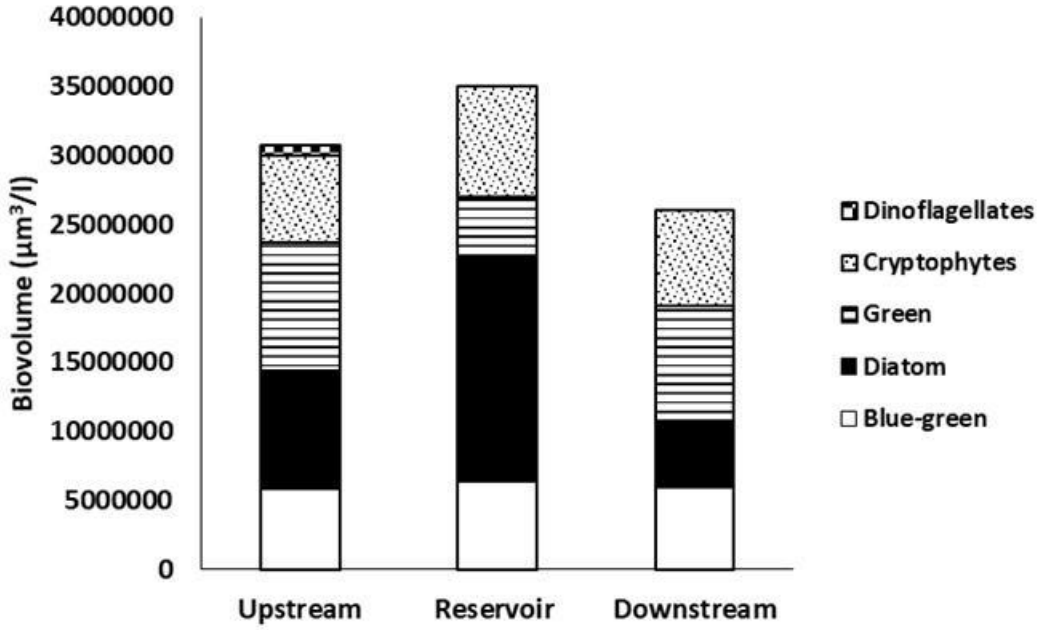


Figure 3.1.2 *Algal biovolume ($\mu m^3 L^{-1}$) by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

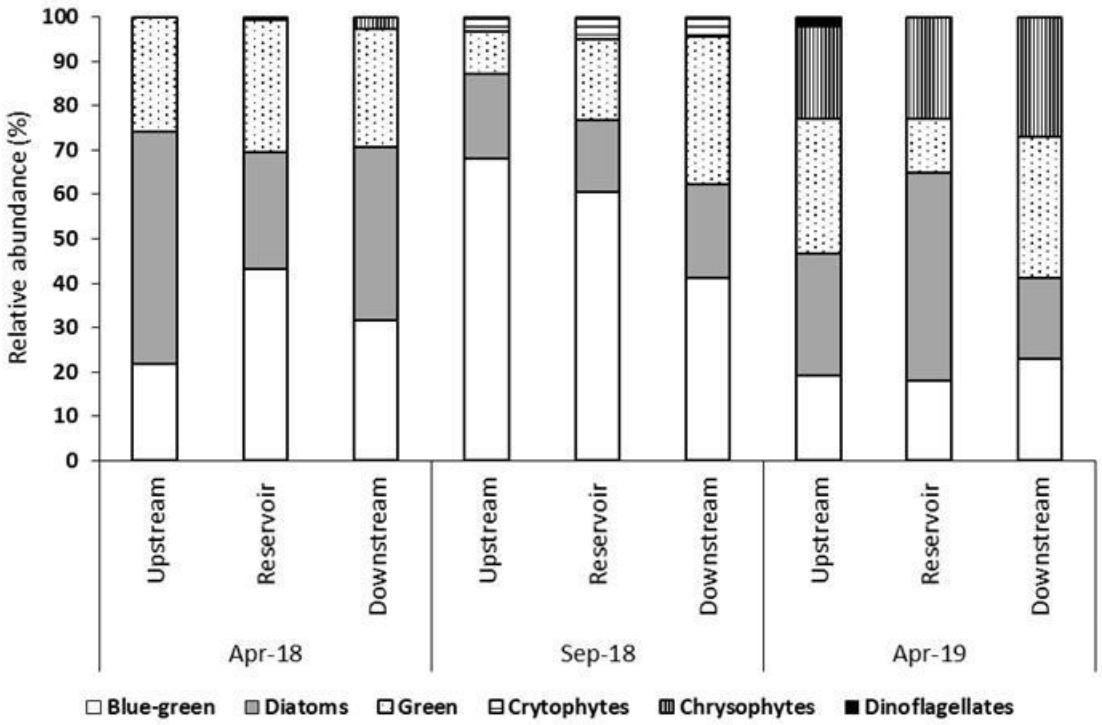


Figure 3.1.3 *Algal biovolume ($\mu m^3 ml^{-1}$) of Sep-16, Apr-17, Sep-17, Apr-18 and Sep-18 by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

The patterns in abundance of algae recorded at the three sites over the monitoring periods do not offer much explanation to algae dynamics and their driving forces. However, the increase in productivity and biomass of phytoplankton are usually influenced by nutrient availability or limitation. Dominance of non-nitrogen fixing cyanobacteria implies sufficient nitrogen for algae growth (Dokulil & Teubner, 2000). The dominant filamentous blue-green algae also signify sufficient phosphorus.

Aquatic macrophytes

The most important aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), Hippo grass (*Vossia cuspidata*), Water primrose (*Ludwigia* spp.), Cat tail (*Typha latifolia*) and Nile cabbage (*Pistia stratiotes*). During this monitoring period, cover abundance of most aquatic macrophytes at sites generally reduced compared to what was recorded during September 2017. Moreover, most macrophytes were still not un-established along the banks of the river channel.

At Kalange-Makwanzi, water hyacinth dominated the shores during this monitoring period. Cover increased from 0.80 ha during April 2018 to 3.35 ha during this monitoring period. Its percentage coverage was 56% at Kasenyanku, 25% at Hudson and 11% at Naava, with the rest of the sites having less than 10% coverage. Other aquatic macrophytes included *V. cuspidata* whose cover abundance increased from 1.12 ha during April 2018 to 2.26 ha during this reporting period. The rest of the macrophytes had reduced in their cover abundance e.g. *Ludwigia* sp and *Typha* sp each from 0.06 ha in April 2018 to insignificant levels during this monitoring period.

Water cabbage, *Pistia stratiotes* also decreased from 0.02 ha during April 2018 to insignificant levels during this monitoring period.

At Buyala-Kikubamutwe, much of the river bank (> 60%) had been cultivated down to the highest water level, and trees such as eucalyptus had been grown thus leaving little room for establishment of aquatic macrophytes. Cover abundance of most dominant macrophytes had decreased since September 2017 although that for water hyacinth increased from 0.08 ha during April 2018 to 0.14 ha during this monitoring period. Those macrophytes that decreased in cover abundance were *V. cuspidata* from 0.43 ha during April 2018 to 0.19 ha; *Ludwigia* sp from 0.01 ha during April 2018 to less than 0.01 ha during April 2019. Other macrophytes became very rare along this transect. The general reduction in cover abundance of most aquatic macrophytes compared to what was noted during April 2018 was attributed to current rains that led to a rise in water level that resulted in submerging and dislodging of rooted littoral macrophytes.

At mid-reservoir, common aquatic macrophytes were absent, however, water hyacinth dominated the shores and had increased its coverage from 1.08 ha in April 2018 to 2.09 during this monitoring period, with much of it (77%) at Buloba and (23%) at Kyekidde. Cover abundance of *V. cuspidata* increased from 0.07 ha in April 2018 to 2.53 ha, while the rest of the macrophytes reduced to insignificant levels during this period. Thus to date, aquatic macrophytes were not yet well established around the mid-reservoir bank as well as at upstream and downstream shores of the two transects.

3.2 Zooplankton (Water column micro-invertebrates)

Species diversity and distribution trends

During this monitoring period, 19 species were recorded respectively at Kalange-Makwanzi and Buyala-Kikubamutwe river channel areas and 17 at the mid-reservoir (Tables 3.2.1 a). Rotifers were the most diverse group of zooplankton, comprising of 10 species at each site, which accounted for 52.6%, 58.8%, and 52.6% of the total species at Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe transects respectively. Copepods were the second species rich group, comprising of six species (31.6% of total species) at Kalange-Makwanzi and Buyala-Kikubamutwe sites and five species (29.4% of total species) at the mid-reservoir. The cladocerans contributed <16% of the species at each site (Table 3.2.1b). During the current survey, the number of species at each site was lower than that was recorded during September 2018. Compared to earlier surveys, no major variation in diversity was observed during the current monitoring period (Tables 3.2.1a-c). However, the number of species reduced due to very few cladocera species at encountered at each site during this monitoring period. (Table 3.2.2 b).

Table 3.2.1a. *Trends in numerical abundance (ind. m^{-2}) and diversity of Copepod species at the monitored sites,* September *2016 to April 2019.*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi						Mid-reservour						Downstream-Buyala-Kikubamutwe					
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr
Copepods	*Thermocyclops incisus*	696	606	236	472		67	898				359		1,482	202	494			
	Mesocyclops sp.	1,100	808	314	269			449	404	236	943	449		1,752	180	180		449	67
	Thermocyclops emini	4,289	1,145	393	1,617	1,213	741	5,389		5,541	1,179	1,505	1,078	15,494		157		898	269
	Tropocyclops confinnis	38,197	7,410	6,130	3,503	7,399	1,011	21,108	4,244	10,807	4,884	8,713	674	55,511	1,752	3,234	674	6,175	606
	Thermodiaptomus galeboides	6,490	6,130	707	808	1,291	808	4,222	6,198	2,043	5,053	1,538	4,177	15,764	1,482	831			1,347
	Thermocyclops neglectus	25,353	7,276	3,851	10,846	3,020	1,684	2,066	14,259	4,283	8,758	4,323	4,985	19,536	472	550	606	1,763	1,684
	Tropocyclops tenellus	27733	7,747	6,602	4,244	6,411	1,145	10,060	25,465	9,038	7,444	7,983	1,954	19,267	6,086	7,388	4,379	6,591	876
	Total copepod species abundance	**103,858**	**31,124**	**18,234**	**21,759**	**19,334**	**5,456**	**44,193**	**50,570**	**31,949**	**28,261**	**24,870**	**12,868**	**128,806**	**10,172**	**12,833**	**5,659**	**15,876**	**4,849**
	Cyclopoid copepodite	94,471	56,386	70,225	28,395	52,782	22,568	90,541	67,390	88,812	59,283	99,266	28,092	254,648	21,849	49,829	10,779	56,622	16,235
	Calanoid copepodites	18,885	8,286	4,323	7,579	2,077	1,954	9,072	6,804	4,205	3,267	3,896	9,970	31,797	2,111	1,707	404	505	3,840
	Nauplius larvae	507,724	139,585	150,195	141,842	157111	73,026	315,009	171,023	196,959	295,675	188078	106,440	654,539	113,648	112,155	138,035	129,996	101,219
	Total copepod developmental stages abundance	**621,080**	**204,257**	**224,742**	**177,816**	**211,971**	**97,548**	**414,622**	**245,217**	**289,976**	**358,225**	**291,240**	**144,502**	**940,985**	**137,609**	**163,691**	**149,218**	**187,124**	**121,294**

Abundance and distribution trends

During the current survey, zooplankton abundance ranged from 121,295 ind.m^{-2} at Kalange-Makwanzi to 181,622 ind.m^{-2} at the mid-reservoir (Table 3.2.1 c). Between April 2017 and September 2018 surveys, average total zooplankton abundance fluctuated in the range: 210,455 to 258,617 ind.m^{-2} at Kalange-Makwanzi, 316,132 to 403,059 ind.m^{-2} at the mid-reservoir, and 159,166 to 220,459 indm^{-2} at Buyala-Kikubamutwe site (Table 3.2.1a-c). Copepods dominated by developmental stages (nauplius larvae and copepodites) were the most abundant zooplankton followed by rotifers and then cladocerans in that order (Tables 3.2.1 a-c). Among copepod developmental stages, the order of abundance was: nauplii > cyclopoid copepodites > calanoid copepodites (Table 3.2.1a). Comparison with previous surveys indicated that the community is still characterized by rotifer-driven species richness and copepod-dominated abundance, suggesting that these sites can still support high fish production. Like previously recorded, cladocerans were the least abundant group of zooplankton at all sites.

The copepods: *Tropocyclops confinnis, Tropocyclops tenellus, Thermocyclops neglectus, Thermodiaptomus galeboides,* and *Thermocyclops emini* were recorded at all sites (Table 3.2.1a). The most abundant copepod at all sites was *Thermocyclops neglectus* which registered a mean abundance >1,600 ind.m^{-2} at each site. The copepod species: *Thermocyclops incisus* and *Mesocyclops* sp. were recorded at Kalange-Makwanzi and Buyala-Kikubamutwe sites respectively and were absent at the mid-reservoir.

The only Cladocera species that was picked up at all sites was *Bosmina longirostris; Moina micrula* occurred at the mid-reservoir and Buyala-Kikubsmutwe sites, *Ceriodaphnia cornuta* was recorded at Kalange-Makwanzi and Buyala-Kikubamutwe sites and *Diaphanosoma excisum* was only encountered at Kalange-Makwanzi site (Table 3.2.1b).

Rotifers were the most diverse zooplankton with species such as *Polyarthra vulgaris*, *Synchaeta* sp., *Keratella tropica, Lecane bulla, Filinia opoliensis* encountered at all sites during the current survey (Table 3.2.1c). Compared to the previous surveys, the species *Lecane bulla* and *Synchaeta* sp. have been consistently encountered at all sites (Table 3.2.1c).

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 April 2019*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi						Mid-reservour						Downstream-Buyala-Kikubamutwe					
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr
Cladocerans	*Daphnia lumholtzi*		135																
	Chydorus sp.							90			472			269					
	Daphnia lumholtzi (helm)				135			90			236	101		269				56	
	Ceriodaphnia cornuta	1999	1,886	79			404	629	808	1,100	269	180		2,425		236		56	202
	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			1,617	202	1,690	2,122	359	135	5,120	337	1,033		225	135
	Bosmina longirostris	2,740	876	2,436	1,684		741	1,437	629	4,598	1,179	1,213	404	2,695	516	685		1,819	337
	Total Cladocera abundance	**8,533**	**4,850**	**4,951**	**4,244**		**1,280**	**3,952**	**3,952**	**7,742**	**4,985**	**2,257**	**539**	**14,551**	**921**	**1,954**		**2,156**	**674**

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 April 2019*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi						Mid-reservour						Downstream-Buyala-Kikubamutwe					
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr
Rotifers	*Asplanchna sp.*					146				157		112	202	674					
	Ascomorpha sp.									79								56	
	Euclanis sp.	2246	269			427		719		472		191		1,213				168	
	Brachionusfalcatus		269							79		45	269	135					
	Filinia longiseta																		67
	Polyarthra sp.	180		157										269	225				
	Filinia opoliensis	135	337	707			269	180	180	550		337	269	1,347				45	202
	Brachionus picatilis																		
	Brachionus forticula			157														56	
	Keratella cochlearis	90		2279		719	202	180		1,336	2,964	1,112		269	898	1,729	539	1,235	67
	Brachionus calyciflorus		337	314		90			606	236		56	135		135	427		292	67
	Trichocerca cylindrica	808		1415	135	1,639	876	1,976	180	1,926	2,863	3,267		1,482	404	707		2,549	269
	Brachionus angularis	180	472	236		1,415	606	898	786	2,161	404	1,067	3,368	3,234	225	427		763	
	Brachionus budapestinensis											56							
	Brachionus bidentatus										135		135						
	Hexathra sp.																		
	Lecane bulla	5,771	1,415	4480	674	5,333	1,549	10,869	3,570	4,834	674	6,288	1,617	31,932	1,482	1,134	1,617	4,480	404
	Lecane luna						67		629	275									67
	Lepadella sp.						1,179												
	Synchaeta sp.	2,852	1,617	629	3032	1,033	10,307	3,683	3,840	786	2,594	1,796	9,566	5,255	853	786	1,886	1,156	3,503
	Keratella tropica	4,222	4,783	314	2796	1,235	1,280	3,054	4,222		1,718	2,717	6,669	8,219	4,087	516		2,526	2,695
	Brachionus patulus													135					
	Cephalodella sp.					1,505			2,380		236	1,718	236		2,156	79		1,976	
	Polyarthra vulgaris					472	674						1,482				337		67
	Total Rotifer abundance	**16,483**	**9,499**	**10688**	**6637**	**14014**	**17009**	**21,557**	**16,393**	**12,890**	**11,588**	**18,762**	**23,948**	**54,163**	**10,464**	**5,805**	**4,379**	**15,302**	**7,408**
Overall zooplankton abundance		**749,954**	**249,730**	**258617**	**210455**	**246,193**	**121,295**	**484,325**	**316,132**	**342,556**	**403,059**	**337,128**	**181,622**	**1,138,505**	**159,166**	**184,283**	**159,256**	**220,459**	**134,229**

Table 3.2.2. *The Percent Similarity Index (PSI) of zooplankton community between the sites during the different survey periods*

PSI comparisons between sites	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19
Kalange-Makwanzi and mid-reservoir	76.7	73.5	66.6	77.5	37.1	88.4	88.3
mid-reservoir and Buyala-Kikubamutwe	72.7	86.4	65.6	63.8	42.0	87.6	82.5
Kalange-Makwanzi and Buyala-Kikubamutwe	61.8	74.7	58.7	70.1	68.5	81.6	82.0

During the current survey- April 2019 as well as September 2018, PSI values were >80% indicating zooplankton communities at those sites is comparable (Table 3.2.2). During the April 2018 period, low PSI values of 37.1% between Kalange-Makwanzi and mid-reservoir and 42%

between mid-reservoir and Buyala-Kikubamutwe were recorded; indicating zooplankton communities between sites were different. During the same period of April 2018, the PSI value between Kalange-Makwanzi and Buyala-Kikubamutwe (68%) indicated similar zooplankton community. Such scenario may be a result of alterations in the environmental conditions at the mid-reservoir that altered the zooplankton community that it became different from that observed at Kalange-Makwanzi and Buyala-Kikubamutwe. However, in most of the surveys, the PSI values between Kalange-Makwanzi and mid-reservoir were higher than that observed between mid-reservoir and Buyala-Kikubamutwe, and Kalange-Makwanzi and Buyala-Kikubamutwe indicating the zooplankton communities between the Kalange-Makwanzi and mid-reservoir are comparable (Table 3.2.2).

Discussion

Current zooplankton abundance was lowest at Kalange-Makwanzi and highest at the mid-reservoir. Previously, abundance has been lowest at Buyala-Kikubamutwe. These observed spatial trends could be due to changes in the flow regimes especially in the reservoir. Basu and Pick (1996), found that zooplankton abundance positively co-related to water residence time, which in this case is highest at the mid-reservoir and lowest at Buyala-Kikubamutwe. The lowest zooplankton abundance at Kalange-Makwanzi during the current survey was because the main contributors (the calanoid copepodites and nauplii) to overall abundance were very low at this site compared to that picked up at mid-reservoir and Buyala-Kikubamutwe sites. However, abundance of the rest of zooplankton (adult copepods, cladocerans and rotifers) was higher at Kalange-Makwanzi than at Buyala-Kikubamutwe.

Copepods have remained that most abundant zooplankton group, a group dominated by developmental stages (nauplii and copepodites), 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 is a result of continuous reproduction (Neves et al. 2003). This phenomenon 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). Percent Similarity Index (PSI) >80% between sites indicated similar zooplankton community at the sites during the current survey. As observed during the previous surveys, the species assemblage has not changed significantly over the years of operation of the dam and monitoring of this component of river biodiversity. Stability of the zooplankton community therefore suggested relatively corresponding stability of the environment conditions at the sites.

Conclusion

The zooplankton community and in the river channel upstream and downstream of Bujagali Dam is characterized by rotifer-driven species richness and copepod-dominated abundance. The zooplankton composition, species richness and abundance at the sites show that the hydropower plant at Bujagali has not caused major disruption of the stability of the zooplankton community.

3.3 Benthic macro-invertebrates

During this monitoring period-April 2019, benthic water snail density reduced at Kalange-Makwanzi, plunging to just 9 ind. m^{-2} from 47 ind. m^{-2} during September 2018. Only one species, *Gabbia humerosa* was encountered. At the mid-reservoir, During this recent period-April 2019, snail density remained the same as that recorded during the previous monitoring period-September 2018 at 49 ind. m^{-2} (Table 3.3.1a), comprising of three snail species, namely *Bellamya unicolor, Melanoides tuberculata and G. humerosa* encountered at densities of 21 ind. m^{-2}, 21 ind. m^{-2} and 7 ind. m^{-2} respectively. The density slightly decreased from 65 ind. m^{-2} during September 2018 to 51 ind. m^{-2} during the recent monitoring period-April 2019 at Buyala-Kikubamutwe transect (Table 3.3.1a). The snail species encountered at this site included *Anisus natalensis*, *Bellamya unicolor* and *Melanoides tuberculata* at densities of *5* ind. m^{-2}, *23* ind. m^{-2} and *23* ind. m^{-2} respectively. Since April 2018, the snail assemblage has been so poor with overall densities below 50 ind. m^{-2}.

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	Apr.19
Gastropoda (water snails)	*Bellamya unicolor*	Kalange-Makwanzi	33	173	5	33	0	0	299	0	0	0	0	35	0	0	0	0	0	0
		Mid-Reservoir				0	0	4	154	296	23	14	98	1097	61	42	21	7	21	21
		Buyala-Kikubamutwe	98	126	11	42	65	285	14	23	47	579	9	37	5	33	0	0	5	23
	Melanoides tuberculata	Kalange-Makwanzi	28	107	257	14	19	5	19	0	0	14	0	56	177	79	19	140	47	0
		Mid-Reservoir				0	0	77	5	5	9	145	35	5	107	133	28	119	28	21
		Buyala-Kikubamutwe	33	224	100	121	33	33	9	33	0	42	14	0	56	196	47	51	56	23
	Biomphalaria choanomphala	Kalange-Makwanzi	0	14	5	0	0	0	9	0	0	5	0	0	0	0	0	0	0	0
		Mid-Reservoir				2	0	4	7	25	0	0	0	61	9	0	0	0	0	0
		Buyala-Kikubamutwe	0	19	11	0	5	9	5	9	5	23	5	5	0	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	0
		Mid-Reservoir				0	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	5
	Gyraulus sp.	Kalange-Makwanzi	0	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
		Buyala-Kikubamutwe	0	0	0	0	0	47	0	5	0	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	0
		Mid-Reservoir				0	3	0	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	0
	Gabbia humerosa	Kalange-Makwanzi	0	79	5	0	0	5	23	0	0	0	0	0	0	0	5	0	0	9
		Mid-Reservoir				0	0	4	5	33	0	0	0	5	14	0	0	7	0	7
		Buyala-Kikubamutwe	0	0	121	1027	677	135	0	0	9	42	0	196	23	9	0	0	0	0
	Bulinus sp	Kalange-Makwanzi	5	9	5	0	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	0
		Buyala-Kikubamutwe	5	5	5	0	19	65	0	5	0	0	0	5	0	0	0	0	5	0
	Pila ovata	Kalange-Makwanzi	0	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	0
		Buyala-Kikubamutwe	0	0	5	0	0	5	0	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**	**9**
		Mid-Reservoir	**0**	**0**	**0**	**9**	**3**	**88**	**182**	**358**	**33**	**159**	**133**	**1181**	**191**	**175**	**49**	**133**	**49**	**49**
		Buyala-Kikubamutwe	**135**	**373**	**252**	**1242**	**808**	**602**	**28**	**75**	**61**	**686**	**28**	**247**	**84**	**238**	**51**	**51**	**65**	**51**

The density of bivalves at Kalange-Makwanzi declined from 201 ind. m^{-2} during September 2018 to 89 ind. m^{-2} during this recent survey-April 2019. Over the same monitoring interval, bivalval density at the mid-reservoir and Buyala-Kikubamutwe transects slightly increased from 231 to 336 ind. m^{-2} and 116 to 150 ind. m^{-2} respectively (Table 3.3.1 b). Overall bivalval abundance was highest at the mid-reservoir and lowest at Kalange-Makwanzi. The density of *Byssanodonta parastica* greatly increased at the mid-reservoir to 126 ind. m^{-2} during this survey period-April 2019 from 21 ind. m^{-2} during September 2018. During this period-April 2019, *B. Parastica* density increased at Kalange-Makwanzi and Buyala-Kikubamutwe transects from 19 ind. $m^{-2}$to 33 ind. m^{-2} and from 9 ind. $m^{-2}$to 37 ind. m^{-2} during September 2018 respectively. At the mid-reservoir its density rose from 21 ind. m^{-2} during September 2018 to 126 ind. m^{-2} during the recent period-April 2019. The densities Caelatura *sp*. and *Corbicular Africana* were 49 ind. m^{-2} and 147 ind. m^{-2} at the mid-reservoir during this recent period. Previously-during September 2018, the respective densities were 45 ind. m^{-2} and 154 ind. m^{-2}. The density of *C. Africana* during this survey reduced from 93 ind. m^{-2}during September 2018 to just 14 ind. m^{-2} currently at Kalange-Makwanzi and increased from 19 to 70 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	Apr.19
Bivalvia (Clams/mussels)	*Byssanondota parasitica*	Kalange-Makwanzi	79	145	252	61	75	42	121	14	0	9	0	133	5	70	9	159	19	33
		Mid-Reservoir				23	95	686	380	801	28	79	58	42	56	112	56	182	21	126
		Buyala-Kikubamutwe	0	19	63	317	9	117	733	159	205	75	149	140	61	369	79	47	9	37
	Corbicula africana	Kalange-Makwanzi	56	126	182	47	219	514	98	222	19	145	9	413	19	131	37	154	93	14
		Mid-Reservoir				5	25	196	44	581	140	481	7	406	19	427	77	448	154	147
		Buyala-Kikubamutwe	65	131	205	65	28	79	56	47	126	126	93	175	51	1116	327	0	19	70
	Caelatura spp	Kalange-Makwanzi	149	93	229	79	79	47	0	124	9	84	47	133	103	19	28	131	42	**42**
		Mid-Reservoir				9	20	28	23	44	33	5	58	135	14	7	42	105	49	49
		Buyala-Kikubamutwe	37	61	63	37	5	5	47	23	51	28	75	47	107	107	145	9	65	19
	Pisidium victoriae	Kalange-Makwanzi	0	5	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	47	0	0	7	0	0	0
		Buyala-Kikubamutwe	0	0	32	19	5	0	0	0	0	0	0	0	0	0	14	0	0	0
	Mutela sp	Kalange-Makwanzi	0	0	0	5	5	0	0	7	0	9	7	0	0	0	0	19	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	19	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	5	16	0	0	0	0	0	0	9	0	7	0	0	0	9	0	14
	Sphaerium victori	Kalange-Makwanzi	5	51	14	0	0	0	0	14	0	9	0	7	5	0	9	5	33	0
		Mid-Reservoir				2	0	0	2	14	5	14	0	9	0	0	7	0	0	14
		Buyala-Kikubamutwe	0	19	0	23	0	0	5	0	61	23	5	7	0	0	0	0	19	5
	Sphaerium stuhlm	Kalange-Makwanzi	0	0	0	9	0	0	9	0	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	0
		Buyala-Kikubamutwe	0	0	0	9	5	0	0	0	0	0	9	0	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	0
		Mid-Reservoir				0	0	0	0	0	0	5	0	19	0	0	0	7	7	0
		Buyala-Kikubamutwe	5	0	0	0	0	0	0	5	0	5	0	0	5	0	0	5	5	5
	Etheria eliptica	Kalange-Makwanzi	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	14	7	0	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	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**	**89**
		Mid-Reservoir	**0**	**0**	**0**	**44**	**286**	**928**	**453**	**1466**	**205**	**598**	**138**	**677**	**89**	**546**	**189**	**742**	**231**	**336**
		Buyala-Kikubamutwe	**112**	**233**	**383**	**476**	**51**	**201**	**840**	**233**	**444**	**266**	**331**	**385**	**247**	**1592**	**565**	**70**	**116**	**150**

During this survey-April 2019, may fly species were encountered only at Kalange-Makwanzi at very low density of 5 ind. m^{-2} . Previously-during September 2018, they were encountered at Kalange-Makwanzi and Buyala-Kikubamutwe, still at low densities of 5-28 5 ind. m^{-2} (Table 3.3.1 c). Like previously, they were not was encountered at the mid-reservoir during the recent period. In April 2018, mayflies were only recovered at Buyala-Kikubamutwe. Similarly, dragon flies were neither recovered from the sites during the recent period-April 2019 nor during the previous monitoring-September 2018. For this and the previous monitoring period, no caddis flies were recovered at the sites except at Kalange-Makwanzitwe at a low density of 14 ind. m^{-2} during this period. Compared to the previous period-September 2018, dipteran density increased from 28 to 51 ind. m^{-2} at Kalange-Makwanzi during this period and reduced from 63 to 14 ind. m^{-2} at the mid-reservoir and slightly increased from 56 to 79 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	Apr.19
Ephemeroptera (May flies)	*Povilla adusta*	Kalange-Makwanzi	19	163	9	28	0	14	0	9	0	0	0	0	0	0	14	0	0	5
		Mid-Reservoir				5	3	144	245	5	0	70	12	0	5	0	35	0	0	0
		Buyala-Kikubamutwe	5	9	63	28	5	37	9	28	0	19	5	79	5	0	5	23	0	0
	Baetis sp.	Kalange-Makwanzi	5	9	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0
		Mid-Reservoir				0	3	0	0	0	79	0	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	0
	Caenis sp.	Kalange-Makwanzi	19	75	19	5	0	0	5	0	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	0
		Buyala-Kikubamutwe	0	9	26	37	9	313	0	23	0	0	0	0	0	0	0	28	23	0
	Cloeon sp.	Kalange-Makwanzi	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
		Buyala-Kikubamutwe	37	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	5	0
	Leptophlebidae	Kalange-Makwanzi	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-Reservoir				0	0	0	5	0	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	0
	Trichorythidae	Kalange-Makwanzi	0	89	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
		Mid-Reservoir				0	0	0	19	0	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	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**	**5**
		Mid-Reservoir	**0**	**0**	**0**	**5**	**6**	**151**	**268**	**5**	**79**	**79**	**12**	**0**	**5**	**0**	**49**	**0**	**0**	**0**
		Buyala-Kikubamutwe	**65**	**23**	**89**	**70**	**28**	**383**	**19**	**51**	**19**	**19**	**5**	**79**	**5**	**0**	**5**	**56**	**28**	**0**
Odonata (Dragon flies)	*Hagenius* sp.	Kalange-Makwanzi	19	0	9	0	5	0	0	7	0	0	0	0	0	0	0	0	0	5
		Mid-Reservoir				0	3	0	0	0	0	0	7	33	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	0	0	5	5	0	0	5	0	0	5	0	5	0	5	0	0	0
	Gomphoides sp.	Kalange-Makwanzi	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-Reservoir				0	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	0
	Libellulidea	Kalange-Makwanzi	9	33	0	5	0	14	5	0	0	0	0	7	0	5	0	0	0	0
		Mid-Reservoir				2	0	18	2	2	0	0	0	84	0	14	7	0	0	0
		Buyala-Kikubamutwe	0	5	37	5	5	14	0	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	0
		Mid-Reservoir				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	0
	Coenagrion sp.	Kalange-Makwanzi	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
		Buyala-Kikubamutwe	5	0	5	0	0	0	0	0	5	0	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	0
		Mid-Reservoir				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
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**	**5**
		Mid-Reservoir	**0**	**0**	**0**	**2**	**3**	**18**	**2**	**2**	**0**	**0**	**7**	**117**	**0**	**14**	**7**	**0**	**0**	**0**
		Buyala-Kikubamutwe	**9**	**23**	**42**	**9**	**9**	**14**	**0**	**5**	**5**	**0**	**9**	**0**	**9**	**0**	**5**	**0**	**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	0
		Mid-Reservoir				0	0	0	257	0	0	0	12	0	56	0	0	0	0	0
		Buyala-Kikubamutwe	0	19	16	5	0	9	0	5	0	0	5	14	0	0	0	0	14	0
	Brachycentridae	Kalange-Makwanzi	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
		Buyala-Kikubamutwe	0	0	0	2	0	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	0
		Mid-Reservoir				0	3	4	7	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
	Polycentropodidae	Kalange-Makwanzi				0	0	0	0	0	0	0	0	0	14	0	0	0	0	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0
	Leptoceridae	Kalange-Makwanzi	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	9
		Mid-Reservoir				0	0	0	0	0	5	0	0	0	0	42	0	28	0	0
		Buyala-Kikubamutwe	0	2	3	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0
	Economidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	77	0	0	14	
		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**	**14**
		Mid-Reservoir	**0**	**0**	**0**	**0**	**3**	**4**	**264**	**0**	**5**	**0**	**12**	**0**	**61**	**42**	**77**	**28**	**0**	**14**
		Buyala-Kikubamutwe	**0**	**21**	**18**	**7**	**0**	**14**	**0**	**5**	**0**	**0**	**5**	**14**	**56**	**0**	**0**	**5**	**14**	**0**
Hemiptera (water bugs)	Nepidae	Kalange-Makwanzi	0	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	0
		Buyala-Kikubamutwe	0	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	0
		Mid-Reservoir	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	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**	**0**
		Mid-Reservoir	**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**	**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	0
		Mid-Reservoir				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
Diptera (True flies)	Chironominae	Kalange-Makwanzi	271	331	238	201	47	117	191	5	0	9	208	56	490	9	962	0	14	51
		Mid-Reservoir				201	73	98	26	27	0	0	63	51	182	21	259	0	28	14
		Buyala-Kikubamutwe	84	56	58	84	9	75	37	19	0	14	84	12	182	33	145	19	23	75
	Tanypodinae	Kalange-Makwanzi	19	33	23	5	14	33	37	19	61	5	63	21	9	56	0	5	0	0
		Mid-Reservoir				0	8	42	42	56	47	0	0	56	42	0	28	28	28	0
		Buyala-Kikubamutwe	23	42	5	26	0	14	56	0	28	42	75	7	9	14	0	28	33	5
	Chaoborus sp	Kalange-Makwanzi	9	23	9	9	42	28	70	196	0	37	96	126	7	0	84	175	14	0
		Mid-Reservoir				0	8	53	47	40	5	5	14	5	14	0	21	0	7	0
		Buyala-Kikubamutwe	5	5	0	65	0	0	23	5	23	14	14	0	28	0	0	0	0	0
	Ceratopogonidae	Kalange-Makwanzi	5	14	0	9	0	0	0	5	84	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	5	0	14	5	0	0	0	0	0
		Buyala-Kikubamutwe	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
	Psychodidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	
		Mid-Reservoir				0	0	0	5	0	0	0	0	0	0	0	7	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total trueflies abundance at each site/transect		Kalange-Makwanzi	**303**	**401**	**271**	**224**	**103**	**177**	**299**	**224**	**145**	**51**	**366**	**203**	**507**	**65**	**1050**	**180**	**28**	**51**
		Mid-Reservoir	**0**	**0**	**0**	**201**	**90**	**193**	**119**	**123**	**51**	**9**	**77**	**126**	**243**	**21**	**315**	**28**	**63**	**14**
		Buyala-Kikubamutwe	**112**	**107**	**63**	**175**	**9**	**89**	**117**	**23**	**56**	**70**	**173**	**19**	**219**	**47**	**145**	**47**	**56**	**79**

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	Apr.19
Oligochaeta (earth worms)	*Nais* sp.	Kalange-Makwanzi	0	5	5	14	5	0	28	0	9	5	14	21	23	5	5	19	0	14
		Mid-Reservoir				0	0	11	16	56	5	9	49	191	42	49	7	7	0	0
		Buyala-Kikubamutwe	0	33	11	9	5	0	19	0	9	28	42	0	19	9	0	5	0	5
Hirudinea (leeches)	Glosophomidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
		Buyala-Kikubamutwe	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
Ostracoda (seed shrimps)	Seed shrimps	Kalange-Makwanzi	0	0	0	0	5	0	9	0	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	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	5	0	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	0
		Mid-Reservoir				7	3	0	5	14	0	5	0	70	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	5	32	0	0	0	5	0	0	126	5	0	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**	**23**
		Mid-Reservoir	**0**	**0**	**0**	**236**	**14**	**11**	**28**	**72**	**5**	**14**	**49**	**261**	**42**	**49**	**7**	**7**	**0**	**28**
		Buyala-Kikubamutwe	**0**	**37**	**47**	**9**	**5**	**0**	**28**	**0**	**9**	**154**	**47**	**0**	**19**	**9**	**0**	**5**	**0**	**28**

It is now six monitoring 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 as well as during the recent period-April 2019 but were absent during September 2018. Seed shrimps have remained unseen in the benthos for the last 10 surveys. However after the previous 9 monitoring periods, not appearing in the benthos, leeches were encountered at all sites with low densities ranging from 9 ind. m^{-2}at Kalange-Makwanzi to 28 ind. m^{-2} at the mid-reservoir during the recent period-April 2019. Usually the presence of leeches in the benthos indicates deteriorating water environment conditions, especially when they occur exclusively.

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

With haplochromines taken as a single species group, a total of 9 fish species were recorded at the three transects along River Nile channel from Kalange-Mwanzi to Buyala-Kikubamutwe during April 2019 compared to 11 during September 2018 and 9 during April 2018 (Tables 3.4.1 a&b). Seven species were recorded from the upstream station (Kalange-Makwanzi), 4 from the mid-reservoir (Bujagali) and 6 from the downstream (Buyala-Kikubamutwe).

Keystone species Nile perch (*Lates niloticus*), tilapiines (*Oreochromis niloticus, O. variabilis, Oreochromis leucostictus, Coptodon zillii*), catfishes (*Bagrus docmak, Synodontis afrofischeri*), Elephant snout fish (*Mormyrus kannume*), and the haplochromines were recovered during this survey. Nile perch and haplochromines were recovered from all the three transects while *Synodontis afrofischeri* and *B. docmak* were recovered from the upstream and mid-reservoir transects respectively. For the tilapiines, *C. zillii, O. niloticus, O. variabilis* were recovered from

upstream and downstream transects while *O. leucostictus* was only caught at the downstream transect. Similar to the previous monitoring-September 2018, *M. Kannume* was recovered from the upstream and mid-reservoir transects.

The highest densities of fish by numbers was at Kalange-Makwanzi (45.7%), followed by the downstream, Buyala-Kikubamutwe transect (31.4%) and least from the mid-reservoir transect (22.9%). Haplochromines dominated by numbers at the upstream (66.2%) and downstream (56.2%) transects and by weight (69.6%) at Kalange-Makwanzi. *Lates niloticus* dominated by numbers (54.3%).

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	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	24
				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	Apr. 2019
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		P			P																	
			Mid-Reservoir										P	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	P
Characidae	*Brycinus jacksoni*	(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	P
			Mid-Reservoir												P							P					
			Buyala-Kikubamutwe	P	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																				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	P
			Mid-Reservoir										P				P										
			Buyala-Kikubamutwe	P	P		P			P	P	P	P				P		P	P						P	P
	Tilapia zillii	Red-belly tilapia (Nge	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	P											
			Buyala-Kikubamutwe	P	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 gariepinu*	Mudfish (Male)	Kalange-Makwanzi			P	P							P	P								P				
			Mid-Reservoir										P	P													
			Buyala-Kikubamutwe			P	P		P			P				P						P					

b)

Cyprinidae	*Barbus altianalis*	Barbel fish (Kisinja)	Kalange-Makwanzi	P	P	P	P		P				P																			
			Mid-Reservoir										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 victorianu	(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																							
Cyprinodontida	*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	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	P	P	P	P	P	P
			Mid-Reservoir										P	P	P	P	P	P	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 No. 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	6					
			Mid-Reservoir										10	7	8	7	6	5	7	5		6	5	6	6	7	3					
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7		6	4	3	5	4	5					

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	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	24
			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	Apr. 2019
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	P
		Mid-Reservoir										P				P						P	P	P	P	P
		Buyala-Kikubamutwe		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	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	P
		Mid-Reservoir												P	P			P								P
		Buyala-Kikubamutwe		P	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			P
	H. serranus	Kalange-Makwanzi																								
		Mid-Reservoir																								
		Buyala-Kikubamutwe	P																							

b)

Genus	Species name	Sites/Transects	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	24
			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	Apr. 2019
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		P
		Buyala-Kikubamutwe	P	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								P
		Mid-Reservoir																								
		Buyala-Kikubamutwe																								

c)

Genus	Species name	Sites/Transects	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	24
			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	Apr. 2019
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				P
		Mid-Reservoir																								
		Buyala-Kikubamutwe															P									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	P
		Mid-Reservoir																				P		P		
		Buyala-Kikubamutwe																		P			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

At least 7 species belonging to 6 genera of haplochromines were recovered during the survey (Table 3.4.2 a-c). The highest haplochromine species diversity (6 species) was recorded at Buyala-Kikkubamutwe, 5 species at Kalange-Makwanzi and 3 species at the mid- reservoir. The most dominant genera by number (85.4%), and weight (71.3%) was Astatotilapia.

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 at Kalange-Makwanzi transect (3 fish per net per night) and lowest at the mid-reservoir (1.5 fish per net per night) (Table 3.4.3). Similarly, by weight, catch rates were highest at Kalange-Makwanzi transect (151.2 g) and lowest at the mid-reservoir transect (64.8 g) (Table 3.4.4). At Kalange-Makwanzi transect, haplochromines recorded the highest catch rates by number (6.4 fish per net per night) and weight (99.0 g). Likewise haplochromines registered the highest catch rates by number and weight at the mid-reservoir (1.9 and 34.2 g fish per net per night) and at Buyala-Kikubamutwe transect (3.4 and 228.5 g fish per net per night). Overall, catch rates by number during the current monitoring period reduced from those recorded during the previous survey at the mid-reservoir transect bit increased 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	22	23	24
		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	Apr. 2019
Bagrus docmak	Kalange-Makwanzi		0.03			0.08																			
	Mid-Reservoir										0.03	0.1	0.38	0.4	0.1	0.01	0.15	0.2	0.01		0.03	0.01	0		
	Buyala-Kikubamutwe		0.07		0.04								0.08	0.1						0.01				0	0.01
Lates niloticus	Kalange-Makwanzi	0.19	3.1	3.32	2.3	9.76	0.32	0.58	1.13	0.15	2.83	0.5	1.62	0.7	0.1	0.14	0.32	0.26	0.04	0.19	0.4	0.19	0	0	0.27
	Mid-Reservoir										3.06	0.7	1.08	4.2	0.3	0.16	0.66	1	0.29	0.13	0.72	11.3	1	1	0.5
	Buyala-Kikubamutwe	1.12	1.68	1.86	2.29	2.57	0.35	0.4	0.16	0.72	0.83	0.2	0.85	1.5	0.6	0.13	0.32	0.08	0.06	0.23	0.07		0	0	0.12
Brycinus jacksonii	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe	0.04																							
B. sadleri	Kalange-Makwanzi	0.04																0.04				0.13		0	0.17
	Mid-Reservoir																								
	Buyala-Kikubamutwe																								
Oreochromis niloticus	Kalange-Makwanzi	0.04	0.33	0.1		0.2			0.01	0.01	0.02					0.01	0.01	0.03		0.01	0.37	0.15	0	0	0.05
	Mid-Reservoir												0.08							0.01					
	Buyala-Kikubamutwe	0.07	0.41	0.04	0.04	0.1		0.1			0.19	0.04	0.38	0.2	0.3								0	0	0.01
O. leucostictus	Kalange-Makwanzi	0.04	0.09																			0.02		0	0.02
	Mid-Reservoir																								
	Buyala-Kikubamutwe	0.06	0.08																						
O. variabilis	Kalange-Makwanzi	0.17	0.91	0.43	0.45	1.52	0.06	0.17	0.19		0.09	0.04	0.31	0.2			0.04	0.06		0.06	0.38	0.15	0	0	0.04
	Mid-Reservoir										0.03				0.01										
	Buyala-Kikubamutwe	0.13	0.08		0.17			0.02	0.02	0.03	0.03						0.09	0.03						0	0.02
Tilapia zillii	Kalange-Makwanzi	0.1	0.17	0.17		0.17	0.04	0.1	0.13		0.09	0.09	0.13	0.1				0.06		0.08	1.44	0.23	0	2	1.85
	Mid-Reservoir										0.05	0.05	0.25	0.5											
	Buyala-Kikubamutwe	0.88	0.46	0.04	0.43	0.1		0.04			0.16	0.16			1		0.07	0.07			0.02	0.04	0	0	0.09
Haplochromines	Kalange-Makwanzi	9	10.5	6.63	19	15.5	5.83	4.5	12.7	10.6	11.1	0.4	11.8	2.5		2.54	2.75	2.04	0.08	2.92	7.96	7.63	8	22	22.2
	Mid-Reservoir										0.25		0.5	5.8		0.13	0.15	0.1	0.13	0.08	0.29	0.42	1	0	0.33
	Buyala-Kikubamutwe	16.8	4.27	6.36	8.32	6.47	0.78	1.62	2.05	1.36	6.13	2.3	13.8	47.2		0.79	13.74	0.44	0.17	0.27	0.59	2.63	0	2	2.09
Clarias gariepinus	Kalange-Makwanzi			0.03	0.17							0.01	0.08								0.01				
	Mid-Reservoir										0.02	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				0.02														
	Mid-Reservoir										0.06	0.1	0.38												
	Buyala-Kikubamutwe	0.1	0.11	0.04	0.04		0.01	0.01		0.02	0.02		0.15		0.01					0.01					
B. paludinosus	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe	0.04																							
Labeo victorianus	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe		0.09					0.02																	
Protopterus aethiopicus	Kalange-Makwanzi						0.01																		
	Mid-Reservoir																								
	Buyala-Kikubamutwe				0.04																				
Synodontis afrofischeri	Kalange-Makwanzi	0.21	0.63	0.08	0.42	1.46	0.46	0.33	0.13	0.38	4.75	1.8	53.8	79.5	1.5	4.42	0.58	1.08	0.04	7.75	0.13	0.25	0	2	2.16
	Mid-Reservoir										0.75		1.5	1.5			0.15		0.17	0.08		0.25	0		
	Buyala-Kikubamutwe		0.27	1.09	0.37	3.58	0.28	0.1		1.07	0.06	3.7	2.5	0.5	0.1	0.04	0.87	0.5		1.73		0.04	0	0	0.17
S. victoriae	Kalange-Makwanzi			0.08		0.21	0.29		0.17			0.1	3.25	1.3	0.1	0.16		0.08							
	Mid-Reservoir										0.05	0.04		1.8		0.08	0.05	0.8		0.21	0.08	0.17	0	0	0.1
	Buyala-Kikubamutwe											0.1					0.04	0.06			0.09				
Mormyrus kannume	Kalange-Makwanzi	0.32	0.8	1.83	0.7	0.08	0.23	0.18	0.22	0.04	0.33	0.1	0.46	0.5	0.01	0.04	0.23	0.1	0.05	0.05	0.03	0.01	0	0	0.01
	Mid-Reservoir										0.82	0.9	1.46	2.7	0.3	0.23	0.48	0.6	0.21	0.21	0.14	0.08	0	0	0.05
	Buyala-Kikubamutwe	0.68	0.86	2.25	0.39	0.38	0.15	0.25	0.18	0.17	0.02	0.1	0.15				0.01	0.02							
Gnathonemus longibarbis	Kalange-Makwanzi																								
	Mid-Reservoir											0.04			0.1		0.15								
	Buyala-Kikubamutwe																								
OVERALL RATES	Kalange-Makwanzi	2.89	5.48	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	1.62	1.46	0.13	3.63	4.41	3.06	3	9	9.06
	Mid-Reservoir										4.4	1.8	4.2	10.2	0.9	2.11	1.45	1.98	0.6	0.46	1	11.6	1	1	0.88
	Buyala-Kikubamutwe	6.45	3.28	3.91	3.71	4.28	0.81	1.21	0.95	1.5	3.1	2.3	6.6	16.8	6.8	0.41	4.86	0.48	0.12	0.71	0.28	0.85	0	1	0.72

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	22	23	24
		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	Apr. 2019
Bagrus docmak	Kalange-Makwanzi		37.5			28.6																			
	Mid-Reservoir										14.1	27.7	835	136		0.51	32.5	73.6	11.4		17.1	3.88	3.31		2.56
	Buyala-Kikubamutwe		22.5		6.93								13.8	19.1	4					2.8				2.4	
Lates niloticus	Kalange-Makwanzi	15.8	271	371	114	251	49.4	35.9	11.6	8.6	156	63.3	141	77.7	9.3	25.4	13.9	53.8	30.2	21.3	25.8	8.12	48.7	31.3	28.8
	Mid-Reservoir										198	140	532	538	17.8	42.8	104.4	81.4	85.8	19.1	65	28	52.3	51.7	25.8
	Buyala-Kikubamutwe	108	108	159	111	171	28.8	39.3	16.4	44.5	30.2	18	36.8	94.8	22.7	4.29	13.4	3.2	2.14	10.4	4.9		4.51	9.01	16.7
Brycinus jacksonii	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe	3.25																							
B. sadleri	Kalange-Makwanzi	0.75																0.58				1.38		2.96	
	Mid-Reservoir																								
	Buyala-Kikubamutwe																								
Oreochromis niloticus	Kalange-Makwanzi	1.8	7.42	28.9		20.1			0.5	6.7	1.2					9.68	0.05	2.24		5.1	35.6	9.04	11.8	2.6	18.5
	Mid-Reservoir												9.2							2.9					
	Buyala-Kikubamutwe	4.53	0.18	3.93	0.93	5.05		0.83			5.8	1.7	205	7.4	29.9								0.14	0.51	4.1
O. leucostictus	Kalange-Makwanzi	3.67	6.61																			1.06		1.73	
	Mid-Reservoir																								
	Buyala-Kikubamutwe	5.75	6.75																						0.21
O. variabilis	Kalange-Makwanzi	33.5	49	63.3	44.7	82.8	14.9	19.5	26.1		18.4	8.7	122				1.02	18.1		24.8	34.5	20.6	7.9	3.18	92.3
	Mid-Reservoir										1.7				5.4										
	Buyala-Kikubamutwe	11.6	12.1		8.17			4.04	11.5	13.6	8.1				20.3		9.2	15.5						0.6	1.83
Tilapia zillii	Kalange-Makwanzi	6.92	15.7	21.7		7.92	7.71	32.2	21		10.1	2.8	18.8					3.6			69.9	11.4	19.8	60.6	25.4
	Mid-Reservoir										7.2		21.3	10.5											
	Buyala-Kikubamutwe	81.9	19.1	7.33	42.3	7.9		2.71			6.1	2.1		32	38.9		1.3	1.3			2.7	2.3		1.47	14.2
Haplochromines	Kalange-Makwanzi	304	192	168	534	383	168	113	160	246	168	8.5	219	33.8	15.5	26.2	26.6	20.4	1.21	38.6	181	97.5	168	254	99
	Mid-Reservoir										4.1		22.5	113	113	2.92	4.05	2.6	0.13	1.9	6.3	4.08	32.4	3	34.2
	Buyala-Kikubamutwe	285	51.3	206	187	168	15.8	40.4	37.7	15.3	86.9	32.3	226	697	229	9.63	143.9	5.3	1.33	2.4	10.8	44.5	3.82	27.3	229
Clarias gariepinus	Kalange-Makwanzi			6.27	69.3							8.9	100								33				
	Mid-Reservoir										9.4	48.7													
	Buyala-Kikubamutwe	9.2		52.9	89.4		33.6			3.1				139						9					
Barbus altianalis	Kalange-Makwanzi	19.3	403	501	7.27		2.31				0.6														
	Mid-Reservoir										51.3	199	266												
	Buyala-Kikubamutwe	48.9	22.9	95.6	9.36		4.03	5.73		12.8	0.3		408		8.2					4					
B. paludinosus	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe	0.5																							
Labeo victorianus	Kalange-Makwanzi																								
	Mid-Reservoir																								
	Buyala-Kikubamutwe		38.9					14.8																	
Protopterus aethiopicus	Kalange-Makwanzi						15.9																		
	Mid-Reservoir																								
	Buyala-Kikubamutwe				26.2																				
Synodontis afrofischeri	Kalange-Makwanzi	10.9	49.5	4.58	14.9	56.8	59.6	18.8	7.2	28.8	61.1	64.2	1543	2668	46.3	151	22.13	50.4	2.13	310.1	5.2	10.8	5.92	70.5	0.6
	Mid-Reservoir										15.6		62.5	61			8.75		8.25	3.3		11.2	14.6		
	Buyala-Kikubamutwe		19.1	30.6	10.4	112	12.9	2.38		17.4	1.3	87.3	45	18	3.8	1.67	34.4	15.4		67.8		1.13	0.41	5.48	
S. victoriae	Kalange-Makwanzi			12.5		17.9	39.3		28.1			7.3	278	108	5.2	18.3		5.3							
	Mid-Reservoir										6.8	3.6		236		7.63	10.1	69.5		27.4	9.2	16.2	6.15	15.3	
	Buyala-Kikubamutwe											9.6					4.39	10.3			7.8				
Mormyrus kannume	Kalange-Makwanzi	111	251	511	95.8	14.7	49	77.5	39.7	7.5	44.5	27.7	114	57.6	9.5	16.9	15.5	61.9	5.18	31.2	2.6	2.08	8.05	3.54	0.77
	Mid-Reservoir										158	156	238	643	80.1	119	108	111	81.7	68.8	29.5	25.4	37.1	12.7	25.9
	Buyala-Kikubamutwe	217	89.5	176	185	51.6	9.22	33.4	15.6	15.9	1.3	7.8	209				25.2	2.66							
Gnathonemus longibarbis	Kalange-Makwanzi																								
	Mid-Reservoir														8		9.15								
	Buyala-Kikubamutwe																								
OVERALL RATES	Kalange-Makwanzi	242	474	636	300	297	213	186	141	102	290	132	1116	1076	55.3	112	86.3	155	36.4	181.5	218	73.3	139	179	151
	Mid-Reservoir										443	573	1920	1449	115	166	254.7	288	183	100.9	117	67	111	74.3	64.8
	Buyala-Kikubamutwe	503	137	257	242	171	82.8	104	49.9	102	73	68.6	955	499	200	8.16	100.2	25.9	2.55	41.6	11.9	15.5	7.2	23	101

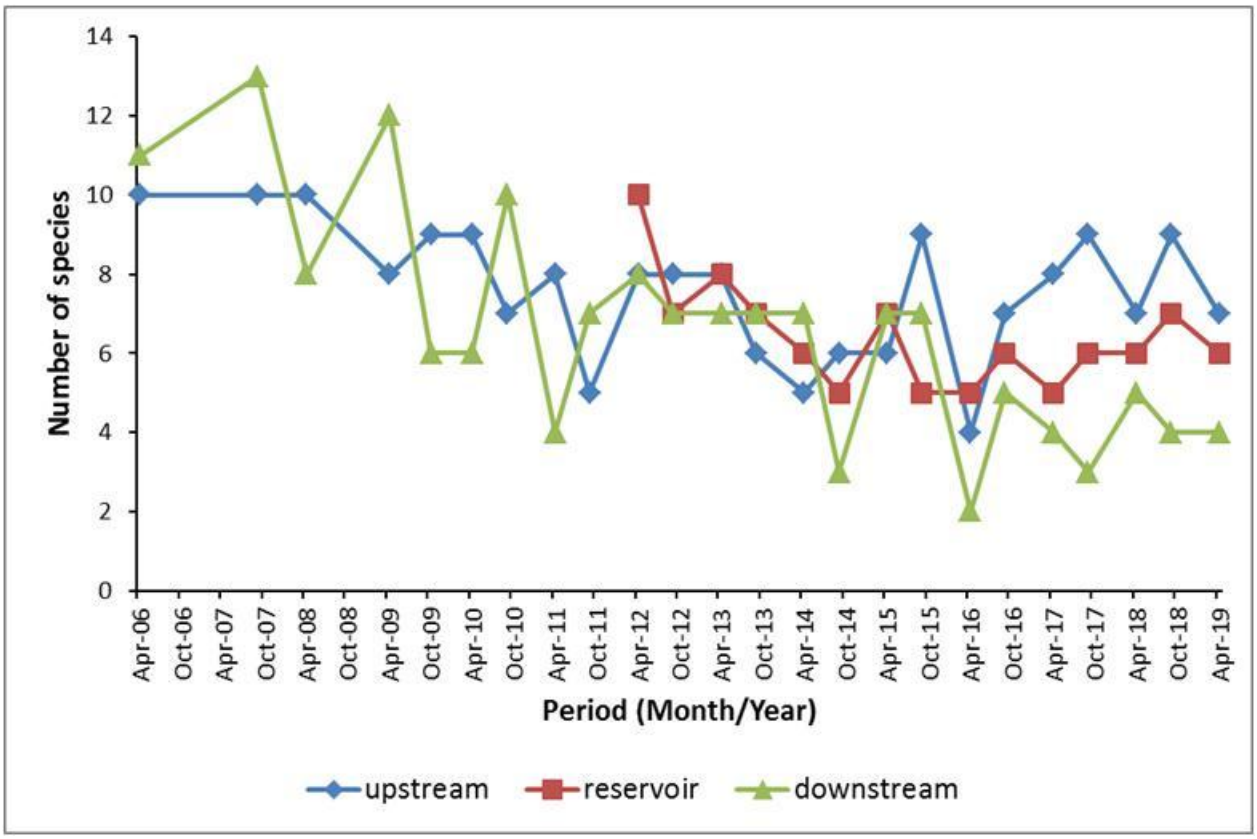


Figure 3.4.1 Cumulative *number of fish species recovered from the study transects on the Upper Victoria Nile over the sampling period.*

3.5 The Food and Trophic Ecology of the Fishes

Like it was during the previous monitoring period-September 2018, *L. niloticus* was recorded from all the three sampled transects during this survey-April 2019. At Kalange-Makwanzi, the diet of Nile perch comprised of *Caridina nilotica* by 16.2%,insects by 12.1% and fish by 71.76% (Table 3.5.1). The fish prey included haplochromine cichlids (40.4%) and unidentifiable fish remains (31.3%). The diet of *L. niloticus* was similar to observations made in the previous survey, September 2018 however, during the recent survey fish was the most dominant prey whereas in September 2018, *Caridina nilotica* dominated the diet.

In the mid-reservoir area, the diet of *L. niloticus* comprised of *Caridina nilotica* (13.8%), Odonanta nymps (5%) and fish (81.2%) during this survey of April 2019 (Table 3.5.1). The fish prey comprised of *Rastrineobola argentea* (58.8%), haplochromine cichlids (15%) and unidentifiable fish material (7.4%). during the previous surveys, April 2018 and Septermber 2018, *C. nilotica* was the most dominant prey in the diet of *L. niloticus* in the mid-reservoir but during this monitoring period-April 2019, fish was the main

prey. These differences in the diet of Nile perch are due to seasonal variations in availability of prey items.

At Buyala-Kikubamutwe transect, *L. niloticus* recorded during this survey, April 2019, had ingested fish (95.8) and chironomid larvae (4.2%). The fish prey comprised of haplochromine cichlids (50%), unidentifiable fish material (25%), *Rastrineobola argentea* (12.5%), and Tilapia (8.3%). During the previous survey, April 2018 and this survey April 2019, the diet comprised of mainly fish prey (Table 3.5.1).

Like it was during the previous survey-September 2018, *Mormyrus kannume* was recorded from Kalange-Makwanzi and mid-reservoir transects during this survey-April 2019. At Kalange-Makwanzi, *M. kannume* guts were empty whereas at the mid-reservoir, the diet of the species comprised of chironomid larvae (37.5%), ephemeroptera nymphs (45%), unidentifiable insect material (6.3%) and mollusc (5%) (Table 3.5.1). Dominance of insect prey in diet of *M. kannume has been* observed during the previous surveys, April and September 2018 too.

During the previous survey- September 2018, *Synodontis afrofischeri* was recorded at Kalange-Makwanzi and Buyala-Kikubamutwe transects. During this survey-April 2019 it was only recorded at the former. All specimens examined had empty guts (Table. 3.5.1). However, during the previous survey of September 2018, the diet of the species from Kalange-Makwanzi comprised of insects (74.7%) and *Caridina* (25.3%).

During the previous survey- September 2018, *Oreochromis variabilis* was only recorded from Kalange-Makwanzi but during this current one-April 2019, it was encountered at Kalange-Makwanzi and Buyala-Kikubamutwe transects (Table 3.5.1). The diet of the species from Kalange-Makwanzi comprised of Ephemeropera nymphs (34.9%), detritus (25.1%), blue-green algae (14.2%), high plant material (11.2%), diatoms (10.9%) green algae (2.8%) and unidentifiable insect material (0.9%). During the previous survey of September 2018, the specimens of *O.variabilis* from Kalange-Makwanzi had empty guts. At Buyala-Kikubamutwe, *O.variabilis* recorded during the survey of April 2019 had ingested high plant material (69.2%), detritus (19.6%), blue-green algae (3.5%), diatoms (4.8%), green algae (2.5%) and chironomid larvae (0.4%).

Like it was during September 2018 survey, *Oreochromis niloticus* was recorded from Kalange-Makwanzi and Buyala-Kikubamutwe transects during this survey period-April 2019. At Kalange-Makwanzi, the diet of *O.niloticus* comprised of detritus (80%), blue-green algae (10%), green algae (6%) and diatoms (4%) (Table 3.5.1). The diet of *O.niloticus* at Kalange-Makwanzi was similar to that observed in the previous survey of September 2018. 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 had ingested detritus (65%), blue-green algae (15%), diatoms (15%), and green algae (2%).

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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	24
				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	Apr. 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		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	HAP
			Mid-Reservoir	RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS
			Buyala-Kikubamutwe	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP	RAS	HAP	RAS	E	RAS	HAP	HAP
Cichlidae	*Oreochromis niloticus*	*Nile tilapia (engege kibati)*	Kalange-Makwanzi	MOL				HPM	E	E	E		HPM	DETR	DETI	BGA	DETR	DETR
			Mid-Reservoir			CHA							IR					
			Buyala-Kikubamutwe	INS	EPH	EPH	HPM	BGA								E		EPH
	O. variabilis	*Black tilapia (engege)*	Kalange-Makwanzi	BGA	BGA	INS	DETR	BGA		DETR	BGA		DETI	DETR	BGA	E	E	EPH
			Mid-Reservoir					BGA										
			Buyala-Kikubamutwe	BGA				BGA		E	DETR						E	HPM
	Tilapia zillii	*Red belly tilapia (engege)*	Kalange-Makwanzi	EPH	E	HPM		ODT			DETR		HPM	HPM	HPM	HPM		EPH
			Mid-Reservoir	E		E	E											
			Buyala-Kikubamutwe	EPH	HPM		HPM	HPM		HPM	HPM			E	HPM	HPM	CHR	EPH
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	E
			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	E
			Mid-Reservoir	EPH	EPH	CHR	EPH	CHR	CHR	MOL	CHR	EPH	EPH	CHR	MOL	CHR	CHR	EPH
			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 April 2019 survey, signs of breeding activity were only observed in four fish species namely *M.kannume, O. niloticus, O.variabilis* and *T.zillii* (Table 3.5.2). The highest breeding intensity was recorded from Kalange-Makwanzi (4 species) which included *M.kannume, O. niloticus, O.variabilis* and *T.zillii.* At Buyala-Kikubamutwe, only *T. zillii* indicated signs of breeding activity while in the mid-Reservoir only *M. kannume* was found to be in breeding condition.

Fish breeding intensity at Kalange-Makwanzi during April 2019 was higher (4 species) than that observed in the previous survey of September 2018 (2 species). At Buyala-Kikubamutwe, and the mid-reservoir, the number of fish species in breeding condition was similar to that recorded in September 2018 (1 species each).

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	24
				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	Apr. 2019
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	0
			Buyala-Kikubamutwe	0	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	33.3
			Mid-Reservoir			0	0						0					0
			Buyala-Kikubamutwe	0	0	60	0	10.5								0	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	52.4
			Mid-Reservoir					0										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	33.3
			Mid-Reservoir			0	0											
			Buyala-Kikubamutwe	0			75	6.1		0	50			50	0	0	0	5.3
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	0
			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	33.3
			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	33.3
			Buyala-Kikubamutwe	0	33.3	100				100	100							

Major observations

During the recent survey of April 2019, fish dominated by haplochromine cichlids was the major prey for *Lates niloticus* at Kalange-Makwanzi, whereas during the previous survey of September 2018, *C. nilotica* dominated the diet of the species

At the mid-reservoir, *R.argentea* was the major prey for Nile perch during April 2019 whereas as during the previous survey of September 2018, *C. nilotica* was the dominant prey.

At Buyala-Kikubamutwe, the diet of *L. niloticus* comprised of haplochromine cichlids, *R.argentea,* tilapia and chironomid larvae during the recent survey of April 2019 whereas during the previous survey of September 2018, the species had ingested haplochromine cichlids only.

During the survey of April 2019, B*agrus docmac* was only recorded from the mid-reservoir and its diet comprised of only *C. nilotica* as did during previous survey of September 2018. The diets of *S. afrofischeri* and *M. kannume* were dominated by insect prey during this survey period-April 2019 and the previous survey of September 2018.

The diets of *O.niloticus* at Kalange-Makwanzi and the mid-reservoir areas during the survey of April 2019 was dominated by detritus as was during the previous survey of September 2018. At Buyala-Kikubamutwe, the diet of *O. niloticus* was dominated by high plant material. *T. zillii* had ingested mostly insects (epheroptera and chironomids) as had during the previous survey of September 2018.

During the survey of April 2019, breeding intensity of keystone fish species from all transects was higher (4 species) than that recorded in the previous survey of September 2018 (3 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 (UVN) 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	Apr-19
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	42
	Mid-Reservoir	-	-	-	-	-	-	16	13	18	27	44	60	38	51	46	48	41	22	29	67	32
	Buyala-Kikubamutwe	26	32	23	15	12	15	34	19	28	40	20	32	25	21	18	14	21	11	13	20	79
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	2
	Mid-Reservoir	-	-	-	-	-	-	13	3	4	12	20	21	13	12	11	9	10	6	5	5	7
	Buyala-Kikubamutwe	7	6	1	2		1	4	2	7	3	1	10	1	4	7	3	-	1	1	1	26
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	9
	Mid-Reservoir	-	-	-	-	-	-	1	0	-	5	-	6	6	2	7	6	3	-	3	6	0
	Buyala-Kikubamutwe	6	6	13	6	3	7	10	7	-	-	-	-	6	-	4	3	3	-	-	-	9
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	6
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	10	-	-	7	7
	Buyala-Kikubamutwe	6	3	1	1	3	0	7	2	-	2	-	-	7	-	1	3	1	-	-	-	6
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	5
	Mid-Reservoir	-	-	-	-	-	-	1	7	3	0	16	23	9	14	9	13	13	12	11	20	12
	Buyala-Kikubamutwe	9	14	9	2	2	3	12	5	2	5	5	7	3	17	3	2	2	5	1	4	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	4
	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	19
	Mid-Reservoir	-	-	-	-	-	-	-	0	-	0	-	-	-	1	6	2	3	3	6	19	19
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	11	20	30	14	15	8		21	6	15	5	12	15	33
Number of boats using Small seine.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	1	3	2	2	4	2	2	3	3	1
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3	6
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5

During this monitoring period-April 2019, 79 fishing boats were recorded at Buyala-Kikubamutwe, making it 51.6% of the total boats at the three transects. At Kalange-Makwanzi, 42 fishing boats were recorded which is 27% of the overall boats counted at the three transect. At the mid-reservoir, 32 fishing boats were recorded; making it 20% of the total boats at the three transects (Table 3.6.1a). Compared to the previous monitoring period, overall number of fishing boats recorded at the UVN monitored transects increased by 33% during April 2019. During the current monitoring period at Kalange-Makwanzi, the number of fishing vessels increased by 44% from what was recorded during the September 2018 survey. The surge in the number of fishing vessels at Kalange-Makwanzi and Buyala-Kikubamutwe transects is due increased exploitation of juvenile *Mormyrus Kannume* by fishers, apparently a lucrative fishing venture on the UVN. At the mid-reservour though, fishing boats declined which could be attributed to migratory behaviour of fishers in search of better fish catches and fish prices at landing sites upstream and downstream. Movement of fishers to sites suspected to have better fish catches and prices as has been attested to by Lwenya *et al.*, 2009 and Binet *et al*., 2012. Njock & Westlund, 2008 postulate that fishers' migrations coincide with fish migrations. These migrations help fishers to maintain their livelihoods in form of employment, food

and nutritional security; while others opt out completely from fishing for alternative livelihood sources.

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 to alternative livelihood sources.

There were 55 fishing boats that used basket traps, 35 used gill nets, 18 used longlines, 17 used hand lines, 12 used small seines and cast nets respectively and 4 used scoop nets (Table 3.6.1b). During this monitoring period-April 2019, scoop nets were encountered at Kalange-Makwanzi and Buyala-Kikubamutwe transects. At the mid-reservoir transect, boats using small seines, seine nets, gill nets and scoop nets were encountered. From April 2009 to present-April 2019, fishing boats using gillnets have tremendously increased at Buyala-Kikubamutwe transect by 250%. There were 7 fishing boats that used gill nets at the mid-reservoir transect and 2 at Kalange-Makwanzi during the current survey. Boats using basket traps increased by 22% across the three transects during this monitoring period. This can explain the increasing fishery of *M. kannume* at the UVN. On contrary, fishing boats using hand line hooks reduced by 56% across the three transects. No boat using hand line hooks was recorded at Buyala-Kikubamutwe during the monitoring period-April 2019. It's common across different fisheries that the choice of target species is influenced by the fishing gear (s) used for fishery exploitation. The varying fishing gear at each transect, absence and presence of the other gears like small seine and scoop nets at mid-reservoir, presence of Basket traps at Buyala-Kikubamutwe transect, is due to presence or high abundance of *M. kannume* and absence of other species like *R. argentea*. Each target species is targeted by a particular fishing gear, which explains the dominance of each gear on the respective transects and season. Nevertheless, *M. kannume* is majorly exploited as live bait using basket traps which is common and dominant at Buyala-Kikubamutwe transect. *M. kannume* recorded during the current monitoring period at the mid-reservoir and Kalange-Makwanzi transects, is

highly priced and profitable fishing business making it an important venture at the UVN (Table 3.6.3).

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.

Gillnets and small seines were the most dominant gears used at the transects but during the previous monitoring-Septmber 2018, basket traps were the most dominant gear used across transects. Gillnets were encountered at all the three transects and so were the hooks, traps and lines. Cast nets, scoop nets. Basket traps were encountered at Kalange-Makwanzi and Buyala-Kikubamutwe transects (Table 3.6.1b). There were 2006 individual gear units of long lines, 1015 of basket traps, 123 of hook and line, 19 of cast nets, 8 of small seines and 2 of seine nets. However, during this monitoring period compared to September 2018 survey, individual gear units for hook and lines declined by 22%. The numbers of basket traps increased at all three transects i.e. at Kalange-Makwanzi by 45%, at Buyala-Kikubamutwe by 41% and 9% at the mid-reservoir (Table 3.4.1). Likewise, the number of small seines increased from 6 during the previous survey to 12 during the current survey period. Cast nets have remained relatively stable between September 2013 and April 2019 with migratory shifts between the three transects.

Most gillnets recorded at three transects (Table 3.6.1b) were below the legal size limit of 5 inches. They were dominated by 3 and < 2.5 inch gillnet mesh sizes. The legal gillnets encountered at monitored transects were few on UVN, an indication that large sized target species (e.g. *Lates niloticus*, *Tilapia sp.* and *Barbus sp.*) were scarce or low in abundance. This is corroborated by the low catch rates of the landed catch for these species (Tables 3.6.2) and the nature of dominant gillnets, the monofilaments being used almost exclusively at the three transects. Catch rates of the target species were very low, which could have made fishermen to resort to active fishing methods by using monofilament gillnets, usually operated actively to improve catch rates.

Since April 2017 to present, the number of boats using basket traps and the units of basket traps have been increasing at all the three transects. This increase is attributed to the increasing significance of the *Mormyrus kannume* bait fishery. The species has gained much importance as bait in the large sized fish stocks of Lakes Victoria and Kyoga, where these high valued species (*Lates niloticus*, *Protopterus aethiopicus* and *Clarias gariepinus*) are currently faced with heavy exploitation using the juveniles of *M. kannume* during fishing. *M. kannume* is experiencing growth overfishing and heavy

exploitation thus management interventions and sustainability implications of their heavily exploitations to their fisheries require urgent attention.

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 for 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	Apr-19
Gillnets - ≤2½"	Kalange-Makwanzi	-	1			4		2	0		1	11	2	8	1	6	19	5	14	10	4	4
	Mid-Reservoir	-	-	-	-	-	-	0	0		0	8	3	9		3	8	13	20	10	0	0
	Buyala-Kikubamutwe	-	10		2	-	-	0	0	12	0		38		11	-	-	-	3	3	0	53
Gillnets 3"	Kalange-Makwanzi	-	3	1	6	-	-	8	0		10	4	15	6		13	6	2	1	1	0	0
	Mid-Reservoir	-	-	-	-	-	-	0	4		16	5	39	35	9	12	19	13	3	3	2	2
	Buyala-Kikubamutwe	4	-	-	9	-	-	10	0		0			15		7	6	-	-	-	2	41
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	-	-	-	-	-	-	-	-	-	-	5
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	-	-	-	-	-	-	-	-	8
	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	5
	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	124

***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	Apr-19
Long line hooks	Kalange-Makwanzi	550	200	650	280	-	500	70	800	687	860	1360	950	230	626	250	1060	910	440	650	233	910
	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	-	-	-	1096
Cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	-	3	2	6	5	2	5	3	6	6	5	5	6
	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	-	-	-	13
Hand line hooks	Kalange-Makwanzi	105	124	26	3	18	88	35	4		26	2	10	35		30	1	10	12	15	61	20
	Mid-Reservoir	-	-	-	-	-	-	6	14			69	276	65	218	50	73	61	36	85	83	103
	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	1
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3	2
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C
Monofilament nets	Kalange-Makwanzi	-	-	-	-	-	-	0	29	15		38		16		25	24	23	18	15	7	2
	Mid-Reservoir	-	-	-	-	-	-	21	0	13	3	113	56	47	43	28	34	30	34	30	2	12
	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	407
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	10	105	22	44	36	59	207	8
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	56	151	461	460	190	97	55	39	53	127	29	62	175	601

3.6.2. Fish catch composition and catch rates

Fish catch composition

Ten fish species belonging to six families were recorded at the three transects during the April 2019 monitoring period (Table 3.4.2*)*. These fish species were: *Lates niloticus, Oreochromis niloticus, Oreochromis variabilis, Tilapia zillii, Bagrus docmak, Mormyrus kannume, Clarius gariepinus, Synodontis afrofischeri, Labeo victorianus, Rastrineobola argentea, Barbus altianalis* and haplochromine species. Similar to the previous monitoring periods, family *Cichlidae* recorded the highest number of species (four) followed by *Cyprinidae* (three) while the rest of the families were each represented by a single fish species. Ten fish species were picked at Kalange-Makwanzi, six at mid-reservoir and five at Buyala-Kikubamutwe transect. During this monitoring period, *Labeo victorianus and Barbus altianalis were picked only at* Buyala-Kikubamutwe while *Clarias gariepinus* and *Oreochromis variabilis* were only encountered at Kalange-Makwanzi. Since 2009, *Labeo victorianus* has been absent in the commercial catches, it however appeared in the catch during the current monitoring period-April 2019. Three fish species: *M. kannume, L. niloticus* and *O. niloticus* were encountered at all the three transects (Table 3.6.2). Four species: *T. zillii, Clarius gariepinus, O. niloticus*, and *B. altianalis were* previously not encountered during the September 2018 survey. During

current monitoring period, *T. zillii*, *B. altianallis* and *S. afrofischeri* were not encountered at the reservoir but were present during the previous monitoring period of September, 2018 (Table 3.6.2).

The number of commercial species encountered during the current monitoring period increased by 10 % from the number recorded during September 2018 but this was 30% reduction in the number encountered during September 2014 when the highest number of species (14) was recorded. The commercial species from the three transects have fluctuated over the monitoring periods, appearing and disappearing during some periods. Five species: *B. docmak*, *L. niloticus*, *O. niloticus*, *T. zillii* and *M. kannume* have been consistently appearing in the commercial catch at Kalange-Makwanzi transect since April 2009 (Table 3.6.2). Since September 2013, *Protopterus aethiopicus* has not featured in the commercial catches at the three transects but was recorded six times at Kalange-Makwanzi before this period. During earlier monitoring periods, *Oreochromis leucostictus* was encountered in the commercial catches at the three but during recent monitoring periods it has disappeared. Between 2015 to 2017 monitoring periods, *Synodontis victoriae* appeared in the commercial catches but has been absent in the catches recently.

Fish catch rates (kg/boat/day)

During the monitoring- April 2019, *M. kannume* registered at Kalange-Makwanzi a CPUE of 11.5 kg/boat/day, the highest recorded during this period. At the mid-reservoir, M. *kannume's* CPUE slightly increased from that recorded during the previous monitoring period but at Kalange-Makwanzi, CPUE drastically declined (Table 3.4.2). The CPUE of *Lates niloticus*, *Tilapia zillii* and *Haplochromine* species increased at the transects while that of *R. argentea*, O. *niloticus and S. afrofischeri* declined during this period (Table 3.4.2). The CPUE for *Bagrus docmak* and *Oreochromis variablis* recorded at Kalange-Makwanzi during April 2019 and the previous monitoring period did not vary much.

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	Apr-19
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	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	0.9
		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	0.6
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	3.2
		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	3
		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	4.6
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	1.2
		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	0.4
		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	-	-	-	-	-	-	0.2
	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	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	1.2
		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	-	-	-	-	-	0.3
	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	15.1
		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	0.2
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	19.7
		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	-	-	-	-	-	-	-	-	-	-	-	0.04
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	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	0.04
	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	11.5
		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	4.2
		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	1.8

3.63. Estimates of total fish catches

During April 2019 monitoring, total monthly fish catches across all transects increased to 107 t from 24 t recorded during September 2018 period. The increase was highest at Kalange-Makwanzi where 40-fold rise was registered; 2-fold increase was recorded at Buyala-Kkubamutwe and a slight increase of 10% at mid-reservoir (Table 3.6.3). At

Kalange-Makwanzi, the monthly catch estimates for *R. argentea* increased 21- fold Haplochromine species 15- fold and *M. kannume* 11- fold (Table 3.6.3). Similarly, fish catches of *T. zillii* increased by 83% and *O. niloticus* by 30% at this upstream transect. At the mid-reservoir, O. *niloticus* reduced to 77 % from what was recorded during September 2018. The increase in the total monthly catches across transects could be attributed to the general increase in the number of fishing boats, fishing gears and the CPUE for the exploited fish species especially *M. kannume* species (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	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	Apr-19
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	738.0
		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	900.0
		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	1528.6
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	4046.0
		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	2200.0
		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	7188.6
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	553.5
		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	311.3
		Buyala-Kikubamutwe	124.4	-	60.2	197.0	907.8	70.0	10.3	161.6	1069.2	120.0	-	888.3	24.0	-	-	-	-	-	-	405.2
	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	424.4
		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	1447.3
		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	-	-	-	-	-	613.2
	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	18573.0
		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	438.0
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	-	-	2671.8
	Labeo Victorianus (Ningu)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87.6
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	6463.8	2109.5	2152.8	-		1105.7		-	18371.9	15795.0	-	-	428.6	-	-	-	-	-	25830.0
		Mid-Reservoir	-		-	-	-	13128.0	1480.5	1627.6	-	27706.5	-	7057.1	23000.0	22000.0	4731.4	1500.0	-	2340.0	9600.0	10259.5
		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	430.5
		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	87.6
	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	14083.5
		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	3141.0
		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	907.63,
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	74182.7
		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	16811.7
		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	16928.1

3.6.4. Estimates of total beach value of the catch

During the current monitoring, 808 million (UGX) of monthly beach revenue was generated from 107 t of landed fish catch which represented almost a two-fold increase from that generated during September 2018 period. During this period, total monthly beach revenue of 357 m was recorded at Kalange-Makwanzi, more than 25-fold than what was registered during September 2018; 279 m at the mid-reservoir, 2.5% reduction and 171 m at Buyala-Kikubamutwe, a 1% increase. Among the encountered commercial fish catches, *Rastrineobola argentea* from the mid- reservoir contributed 32 %, the highest estimated total monthly beach value from all the species lumped together. During this period, *R.argentea* at the mid-reservoir contributed 72.3 % of total beach revenue. At Buyala-Kikubamutwe, beach value from the commercial fish catches was contributed by *M. kannume* by 44.5% and *L. niloticus by* 30.7% (Table 3.6.4).

A basin of *R. argentae* sold 25,000 UGX while large-sized *L. niloticus* commanded a price of 8,000-10,000 per kg and the small sized ones 3000 -6000 UGX. Large /adult *M. kannume* sold for human consumption was priced at 4,500 UGX per Kg and the juveniles used for bait fetched ~ 26,000 UGX per Kg. The juvenile *M. kannume* is currently sold as individual pieces, with an average juvenile of 50-100 grams costing between 2000 to 2500 Uganda shillings. The high value of catch signifies the importance of the river fishes to the riparian communities who depend on the river water, employment, income, food and nutritional security. This explains the need for proper fisheries management and strategic intervention to minimize the potential negative impacts of the dam to the fish species and their habitats. Proper intervention, sensitization and management of upper Victoria Nile fisheries will enable sustainable utilization of the resources while benefiting the riparian communities who directly or indirectly 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	Apr-19
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	1,476.0
		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	3,735.0
		Buyala-Kikubamutwe	431	110	45	586	662	1,312	450	1,489	1,443	-	983	27	7,406	494	270	-	4,928	368	19	1,555.6
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	25,011.7
		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	19,281.9
		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	52,716.3
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	6,900.4
		Mid-Reservoir	-	-	-	-	-	256	77	-	307	7,179	1,524	106	213	551	428	30,143	-	2,700	5,504	1774,1
		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	1,877.7
		Mid-Reservoir	-	-	-	-	-	402	24	-	-	787	1,544	2	-	-	-	-	26	-	-	-
		Buyala-Kikubamutwe	78	162	103	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zilli (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	6,126.9
		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	3,714.6
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	44	-	-	-	84	-	-	-	22	-	-
		Buyala-Kikubamutwe	-	-	6	20	2	-	-	-	-	47	11	60	60	-	-	143	-	-	12	2,190.0
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	-	-	18,702.6
	Labeo victorianus (Ningu)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	175
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	2,353	894	1,722	-	-	514	-	-	12,248	15,043	-	-	171	-	-	-	-	-	258,300.0
		Mid-Reservoir	-	-	-	-	-	2,864	945	814	-	18,891	-	834	21,956	22,000	1,800	4,500	-	58,500	240,000	228,639.7
		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	43.8
	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	39,049.5
		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	25,834.7
		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	76,477.0
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	357,186.1
		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	279,265.5
		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	171,655.5

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	-
2019	April	7,710	4,233	7000	8,349	4,425	7,900	2000

During this monitoring- April 2019, the unit price for most of the species (except *M. kannume*) increased at all the transects. Even though, price for *M. kannume* declined during this monitoring, its price remained the highest per kilogram, followed by that of *B. docmak* and then *L. niloticus*. Juveniles of *M. kannume* are sold per individual live specimen thus the estimated unit price was based on the number of individuals contained in a kilogram. Unlike during previous September 2018 monitoring, *C. gariepinus* was encountered at Kalange-Makwanzi during this period but was the lowest priced fish among other commercial fish species (Table 3.6.5).

The monetary value measured as mean price per kilogram weight of fish is very important in commercial catch monitoring can explain the fisheries production and dynamic nature of fisheries which depend on, habitat ecology, seasonality, demand, fish size and quantities of catch landed from each fishery. The observed increment in the prices of *L. niloticus, O. niloticus* and *B. docmak* during the current monitoring could be linked to the increased demand and market value for fish compared to during the previous survey.

Apart from increasing demand for fish, factors that determine the market value of fish include the type of species, size of fish, quantity and supply at a given time. When fish supply on market is limited, fish products corresponding increase in the costs. Surplus may cause a reduction in value of fish. However, small sized *M. kannume* commanded higher prices than the larger sizes across all the three monitored transects, which is not the case for other fish species. Due to the high demand for bait in the long-line fishery on 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 on UVN.

3.6.5 Estimated total catches and revenue of individual fishing units

During this monitoring period-April 2019, high beach values from the catch were registered at Kalange-Makwanzi and Buyala-Kikubamutwe transects probably due to high number of fish species landed, high catch rates (Kg/boat/day) and number of fishing boats. At the mid-reservoir, beach values from the catch were low and these matched up with low catch rates and few fishing boats. The high catches and beach value for *M. kannume* especially at Buyala-Kikubamutwe transect are the main incentives why fishers have invested in the illegal basket trap bait fishery. The species however showed signs of decline at Kalange-Makwanzi and mid-reservoir transects when compared to what was recorded during 2018 monitoring periods by about 63%. High fish catches and the associated economic benefits (beach revenues) from exploitation of the fishery are good for the riparian communities but its non- selective exploitation is unsustainable due to short term benefits that accrue with severe long term impacts such as loss of income, employment and livelihood sources. The current exploitation rate of M. kannume needs to be regulated by appropriate management measures aimed at sustaining fish catches. This can be achieved through use of sustainable harvesting technologies which include using the recommended gillnet mesh sizes and using alternative fish bait other than juveniles of M. kannume.

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
2019	April	74,182	357,186	16,812	279,265	16,928	171,666

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

During the monitoring period- April 2019, the domestic fish consumption was recorded at the mid-reservoir and Buyala-Kikubamutwe transects at 0.4 and 0.8 kg/boat/day respectively. The amount of fish retained for domestic consumption increased at Buyala-Kikubamutwe by 36%. Fish retained by fishers for home consumption during this monitoring period declined by 66% at the mid-reservoir from that was recorded during September 2018 monitoring period. Fish species retained for home consumption by fishers were mostly small-sized species at both transects. No fish was retained for domestic consumption at Kalange-Makwanzi probably due to the decline in fish catches

and increased fish prices that forced fishers to rather sell all their catch for money than retain some for home consumption. Still, fish retained by fishers for home consumption at the transects has remained quite small compared to the entire catch harvested. Suffice to say, fishing communities basically cater for their economic gains at the expense of nutritional needs at UVN (Kimbowa and Mourad, 2019). Around fishing communities, cases of malnutrition as well as poverty levels associated with low standards of living are high. Fish consumption targets by FAO (19.2 kg/person/year) and WHO (25 kg/person/year) even for average Uganda is far below these targets. Communities need to be sensitized on the importance of fish to their daily nutritional requirements to improve fish uptake from 10 kg/person/year.

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-		Mid-reservoir-Malindi-		Downstream-Buyala-	
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
2019	April	-	-	0.4	6.7	0.8	38.1

Fishery related jobs

During April 2019 monitoring period, 386 people were employed by the fisheries sector at the Upper Victoria Nile which represents 73 % increase in the number of people employed since September 2018 (Table 3.6.8a). Fishing remained the biggest (81%) source of employment predominantly engaging males (99%) with only one female

encountered at Kalange-Makwanzi transect. During this monitoring period, there were 153 fishers at the mid-reservoir transect, 98 at Buyala-Kikubamutwe and 61 of them at Kalange-Makwanzi. Fish trading employed 26 people, 65% of whom were females and 35% male. Majority of the fish traders were encountered at the mid-reservoir (57.7%), followed by Upstream (38%) and the least number (3%) at the Downstream transect. Dominance of women in fish trade and men in fishing is not surprising on the UVN. 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 trading, other employment opportunities included: boat builders (4%) and food vendors (2%) encountered at the three monitored transects. The landing sites cleaners were absent at the monitored transects. This can be explained by the fact that on the UVN, most of the gazetted places as the landing sites do not have people's residents, and cover a small area particularly at Kalange-Makwanzi. There are no people handling net repairing, torn fishing nets are directly repaired by the owners at their respective landing sites. Boat building and net repair activities were fully performed by men, whereas food vending was dominated by women. Few men are coming up in the food vending business at Kalange-Makwanzi and the mid-reservoir. Boat builders and net repairers were absent at Buyala-Kikubamutwe where old leaking canoes used by fishers poses a safety risk.

Management of the landing sites by BMU leadership with exclusively male chairpersons was recorded at all transects (Table 3.6.8b). At Kalange-Makwanzi, BMU committee consisted of five males and one female. At the mid-reservoir, the committee was made up of five male members and two women. At Buyala-Kikubamutwe , one BMU member was registered (Table 3.4.8). Women involvement in the fishery was mainly in post-harvest handling and marketing, a reason why women were most active in areas with high supply of traded fish commodities. At Buyala-Kikubamutwe transect, the bait fishery of *Mormyrus kan bynume* was dominated by men who transported the bait to distant markets on lakes Victoria and Kyoga since April 2012. Probably, this is the reason why omen at this transect is quite minimal. Five *M. kannume* bait transporters were encountered the mid-reservoir during the current monitoring period.

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	Apr-19
Boat builders/	Kalange-Makwanzi	M	3	1	2	3	3	2	2	3	3	3	2	2	4	3	3	5	4	3	3	2
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	1	5	-	2	2	2	2	-	-	6	10
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	2	3		1	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Food vendors	Kalange-Makwanzi	M	1	2	4	1	1	1	1		1	2	-	1	-	1	-	1	1	3	1	1
		F	2	4		3	3	3	3	2	5	2	5	4	5	5	6	3	4	1	2	3
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1		-	1	-	-	-	-	-	-	-	1
		F	-	-	-	-	-	-	2	4	3	3	1	1	-	-	-	2	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	Apr-19
Fisher(s)	Kalange-Makwanzi	M	37	30	38	25	25	25	25	25	42	39	39	54	36	52	45	42	45	37	51	60
		F	-	-	-	-	-	-	-	-	1	1	1	1	2	-	-	-	-	-	1	1
	Mid-reservoir	M	-	-	-	-	-	-	13	24	49	51	55	74	37	49	30	52	27	16	73	153
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	46	30	34	30	30	15	9	28	72	15	11	42	21	24	51	20	18	28	20	98
		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	6
		F	20	16	16	30	30	16	16	9	16	13	2	4	7	8	10	6	6	6	8	4
	Mid-reservoir	M	-	-	-	-	-	-	2	1	1	3	1	-	2	3	3	3	4	4	4	2
		F	-	-	-	-	-	-	5	1	1	12	12	16	9	16	6	7	4	-	7	13
	Buyala-Kikubamutwe	M	2	2	2			1	1		1	1	-	2	1	-	4	3	3	6	2	1
		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 cleaners	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chairpers on landing	Kalange-Makwanzi	M	1	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	1
		F	-	-	-	-	-	-	-				-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	1	1	2	2	2	1	1	2	2	1	-	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	5
		F		5	4			2	2	1	3	2	2	1	3	4	3	3	-	4	5	1
	Mid-reservoir	M	2	2	3	3	3	4	4	4	3	3	2	4	3	18	8	11	12	12	7	3
		F	1	-	-	-	-	1	1	1	1		-	1	10		3	4	4	4	-	2
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	5	4	10	4	8	2	3	3	3	3	-	4	-
		F	-	-	-	-	-	-	-	3	3	2	-	4	-	-	-	3	-	-	-	-
Landing site Guards	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Fisheries officers	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	-	-		-	-	-	-

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	Apr-19
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	10.6
		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	10.0
		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	12.7
	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	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	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	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	Apr-19
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	80.0
	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	20.0
	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	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	Apr-19
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	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	13.4
	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	39.9
	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	0.0

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	Apr-19
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	140
		Mid-Reservoir										11	30	10	7	4	55	54	20	42	20	35	75	24	52	67
		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	1
	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	2
		Mid-Reservoir										68	67	27	46	45	31	27	24	40	82	21	88	33	52	8
		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	10
	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	64
		Mid-Reservoir										13	15	63	131	100	42	58	102	104	186	52	97	45	80	52
		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	26
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	100
		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	152
		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	104
	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	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	6.5

Out of 141 stool samples collected from 568 people, 15 (10.6%) were infected with Schistosomiasis, reducing from 11% during 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 at Buyala-Kikubamutwe increased from 9.9% during the previous monitoring survey to 12.7% during this monitoring period. During this monitoring period, the disease infection rate was lowest (10 %) at the mid-reservoir (Table 3.7.1b).

People at all sites with light intensity of infection rose to 80% during this monitoring period from 76% during the previous monitoring period-September 2018 (Table 3.7.1b), those with moderate intensity reduced 20% from 24%, heavy infestation intensity remained 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. All residents found to be positive for Schistosomiasis infection were treated by the sanitation/Vector team under directly observed treatment (DOTs) using the medicines Praziquantal and Albendazole.

Fishing and Bathing/Swimming contributed 40% and 39.9% respectively as major predisposing factors to infection of Schistosomiasis (Table 3.7.1b). Fish mongers were least susceptible to the disease. 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. Even though fish mongers and water fetchers were least predisposed to the disease, we involved them in our Behaviour Change Communication (BCC) efforts.

Status of snail vectors

During this monitoring period, *Bulinus sp* vectors markedly increased at Kalange-Makwanzi transect to 142 from 26 ind. during the previous monitoring period (Table 3.7.1c). These vectors decreased from 104 to75 ind. at the mid-reservoir and slightly reduced at Buyala-Kikubamutwe (Table 3.7.1c).
The vectors of *Biomphalaria sp* reduced at the mid-reservoir transect from 52 ind during the previous monitoring period to 8 ind during the current one. .Similar cutback trends were recorded at Kalange-Makwanzi and Buyala-Kikubamutwe transects.

The numbers of non-medically important water snail species increased in numbers at Kalange-Makwanzi from 10 ind during the previous monitoring period to 64 in during the present one. A cutback was registered at the mid-reservoir transect from 80 ind. during the previous monitoring period to 52 ind. during this monitoring period.
Of the vector snails, *Bulinus sp* was the more abundant, accounting for 56.2% of the total snail abundance while *Biomphalaria sp* was contributed merely 5.4%.

Five and two specimens of *Bulinus sp* vectors encountered at Kalange-Makwanzi and mid- reservoir transects respectively shed Cercaria while those collected at Buyala-Kikubamutwe transect did not shed any. This suggests that active transmission of schistosomiasis still occurs at Kalange-Makwanzi and mid- reservoir transects.

Faecal coli forms

Generally, the level of faecal coliform contamination at shallow human-water contact points at all sites increased during this monitoring period compared to levels recorded during the previous monitoring period-September 2018. Faecal coliform contamination at shallow human-water contact points at Kalange-Makwanzi transect increased from 85 during September 2018 to 100 colonies per ml during this monitoring period (Table 3.7.1 c), at the mid-reservoir, level of contamination was 152 colonies per ml from 115 colonies per ml and at Buyala-Kikubamutwe, it was 104 from 83 colonies per ml during the previous survey period. Contamination at the mid-reservoir was significant probably due to the reduction in water flow rate.

The level of faecal contamination from the deep middle part of the river during this (April 2019) and previous (September 2018) monitoring periods remained the same - count of 6.5 colonies per 10 mls of water at Kalange-Makwanzi while at Buyala-Kikubamutwe contamination rose to 20 colonies during this monitoring period from 9

colonies per 10 mls during the previous monitoring period. The increase in contamination is suggestive of a new source of contamination in the vicinity. The micro-organisms of medical importance were predominantly *Salmonella sp* and *Shigell*a *sp.* Faecal coliform counts of 1-10 colonies per 10 ml of water are considered risk free in terms of health.

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 127 crabs.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. Trends of zooplankton composition, species richness and abundance estimates show that this assemblage is characterized by rotifer-driven species richness and copepod dominated numerical abundance and has been stable over the monitoring periods.
2. The high dominance values of copepods especially in the reservoir reaches of the dam suggests high potential for fish production, especially pelagic fishes in these areas relative to the downstream site.
3. The abundance of zooplankton at the downstream part of the study area is consistently lower compared to what is picked up in reservoir reaches. This could be a community response to prevailing water flow dynamics in this area probably created by the dam operations due to 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. The lucrative bait fishery of *M.kannume* emerged on UVN but will not be sustainable due harvesting of juveniles using basket traps.
6. Recording of *Bulinus sp* vector snail that shed cercaria at the mid-reservoir and Kalange-Makwanzi transects, bear out that the transmission loop has not been broken yet. Therefore, transmission of Schistosomiasis is still occurring among the riparian population despite drugs being administered to infected people during the survey periods. However, levels of infection have remained at light to moderate levels for the last five survey periods.

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 especially for *M. kannume* bait fishery 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. Health, hygienic and sanitation education should be intensified especially among the new settlers and cultivators at the mid-reservoir vicinity because faecal coliform counts increase that was encountered, which could be coming from a new source of contamination. Mass drug administration and health education will continue targeting fisherfolk and swimmers in order to break up transmission of Schistosomiasis from progressing.

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