Columbia River Project Water Use Plan

Kinbasket Fish and Wildlife Information Management Plan

Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring

Implementation Year 7

Reference: CLBMON-2

Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring – *Year 7 (2014)*

Study Period: 2014

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This is a progress report for a long term monitoring program and, as such, contains preliminary data. Conclusions are subject to change and any use or citation of this report or the information herein should note this status.

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Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring – Year 7 (2014)

Prepared by D. Sebastian and T. Weir

INTRODUCTION

The Fish, Wildlife and Habitat Management Branch of the Ministry of Forests, Lands and Natural Resource Operations (FLNRO) and BC Hydro (BCH) under its Columbia River Water License Requirements (WLR) program undertook the seventh year of a proposed twelve year study to monitor kokanee in the limnetic habitat of two Columbia Basin reservoirs, Revelstoke and Kinbasket, during late July of 2014. This project is part of a long term monitoring program to determine if there is a correlation between reservoir operations and the abundance and growth of kokanee.

This report documents progress to date on the study as part of the terms outlined in the CLBMON 2 Contribution Agreement 2012-2015. The agreement outlines roles and responsibilities in this mutually beneficial partnership between BC Hydro and the Province of BC.

This report presents summary data and results of the 2014 field survey in relation to previous years of trend data. The same survey design, equipment and methods were employed. A new approach for setting acoustic thresholds applied on Revelstoke data in 2013 in order to reduce the influence of noise on fry estimates was also applied to Kinbasket Reservoir in 2014 and the time series from 2008-2014 was adjusted to ensure consistency for the duration of this project.

In June 2012, Addendum 1 was created for the Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring (CLBMON-2) Terms of Reference. The addendum added escapement monitoring and biological sampling for selected tributaries to Kinbasket and Revelstoke in 2013 and for continued escapement and biological monitoring in Camp Creek beyond 2013. In 2014 the feasibility of biological sampling in the mainstem Upper Columbia River was investigated in order to determine if annual sampling in Luxor Creek was representative of the larger mainstem spawning population in terms of spawner size and age structure.

METHODS AND EQUIPMENT

Hydroacoustic data collection and trawl sampling were done at night from a closed cabin 7.3m Ministry research boat fully equipped for night work and navigation. From 2009 onward, acoustic data were collected continuously along 30 established transects using a Simrad EK60 split beam scientific sounder operating at a frequency of 120 KHz. Digital raw data were stored on a Panasonic Toughbook laptop computer and backed up on external hard drive. The files were compressed and analysed using SONAR-5 version 6.0.0 software operating on a Windows XP platform. Prior to 2009 an additional eight years of comparable data (2001-2008) were collected using a Simrad EY200P single beam echosounder operating at 70kHz as described in Sebastian *et al*. (2010; 1995). Transect echograms were viewed and preliminary analyses performed on site to ensure data quality. Radar and a Global Positioning System (GPS) were used for efficiency of night-time navigation and to locate and verify sampling locations. Transect fish densities for Kinbasket and Revelstoke reservoirs are summarized in Appendices 1 and 2, respectively. Twenty-eight of the 30 standard transects for Kinbasket were completed in 2014. Two transects (T9 and T10) were missed due to poor weather. Time constraints and scheduling conflicts with other surveys prohibited returning, however these missed transects are not expected to compromise the reservoir abundance estimate. Statistics used to calculate Maximum Likelihood population estimates (MLE) and bounds using Monte Carlo simulations are shown in Appendices 3 and 4 for Kinbasket and Revelstoke reservoirs respectively. Other statistical bounds represent 95% confidence limits on mean values using ± 2 times standard error.

In order to reduce the impact of low end noise (i.e. non-fish targets) encroaching on the fish distribution, a new method for setting the lower acoustic threshold was developed in 2013 and has been applied to all SONAR5 analyses (2009-2014) on both Kinbasket and Revelstoke Reservoir. Based on the acoustic size distribution for a number of surveys it was assumed that the echoes in Revelstoke Reservoir were most likely to consist of 100% kokanee down to -55dB. Below this point there was an apparent overlap of noise and fish. We applied a linear reduction to estimate the potential number of fish by 1 decibel size interval assuming they decrease in numbers over the next 6dB to a point where there would be no fish targets below -61dB. The numbers of kokanee were then summed by one decibel size interval for the entire kokanee fry distribution to estimate their total abundance. A new threshold was then redefined as the point that achieved a best fit with the linear (i.e. modelled) fry estimate. For each 1 decibel step within the range where fish and noise overlap (i.e. from -55 to -61dB) the difference between the total echoes and kokanee echoes represent the noise component. The resulting size distributions were plotted separately for noise and fish to show the suggested degree of overlap by

this method (Appendix 11). In Kinbasket where kokanee fry size data were available for all years, we used the acoustic size equivalent of the smallest kokanee fry captured in the trawl to define the size below which all fry abundance estimates were determined by the linear model. The results and implications of this new approach are discussed in the *Methods Development* section later in this report.

Trawl sampling on Kinbasket Reservoir was conducted using a 3 x 7m opening/closing trawl net deployed by a hydraulic dual drum winch and boom. The net was lowered (in the open position) to the top of the visible fish layer and fished for 20-60 minutes per layer covering one to three consecutive seven meter layers at a speed of 0.7-0.9 $m \cdot s^{-1}$. At the end of the trawl, the net was closed for retrieval. Trawl depths, duration fished and a summary of biological data are presented in Appendix 5. Note that trawl sampling was directed at the most dense parts of the fish layer to optimize numbers of fish in hand. The net depth, water temperature and distance from the boat were measured using a Notus trawl depth sensor system. Total length of habitat trawled was determined by GPS. The purpose of trawling was to verify the assumption that kokanee was the main species observed at night with the echosounder, and to collect biological samples for determining length, weight, age and growth.

Four pelagic gillnets were set over-night in the Lower Basin of Revelstoke Reservoir with one set at each of transect 5 and 6 and two sets at transect 14. Another four pelagic gillnets were set in Kinbasket Reservoir with two sets in Wood Arm at transect 17 and one set at each of transects 23 and 24 on opposite sides of Old Kinbasket Lake. Gillnetting was done instead of trawling on Revelstoke Reservoir and to complement trawl catches on Kinbasket Reservoir. Each gillnet set consisted of three or four RIC standard nets attached end to end for a total length of 274 or 365m respectively. RIC (1997) standard nets each consisted of 6 panels of variable sized mesh ranging from 25-76 mm stretched mesh. Each panel was 15.2m long and 2.4m deep giving a combined length of 91.2m, depth of 2.4m and area of 218.9m^2. With one end anchored to the bottom using up to 100m of line, the nets were stretched out parallel to the prevailing wind and each 91.2 m section was submerged to pre-determined depths of 10m and 15m (from the surface) using a series of clip on floats with pre-measured lines of 10 and 15m respectively. Nets were typically set in late afternoon or evening and left to fish overnight until morning; a duration of 15-18 hrs. When retrieved, the catches from each specific depth section were bagged separately to determine the most effective depth for catching kokanee at each location. Gillnetting details including GPS coordinates, net area, soak time, kokanee catch and CPUE are presented in Appendix 6 and biological information from gillnetted fish are shown in Appendix 7. Ages for trawl and gillnet caught fish were determined through scale analyses by specialists under contract to the Ministry of Environment using Ministry equipment at the lab in Abbotsford, BC.

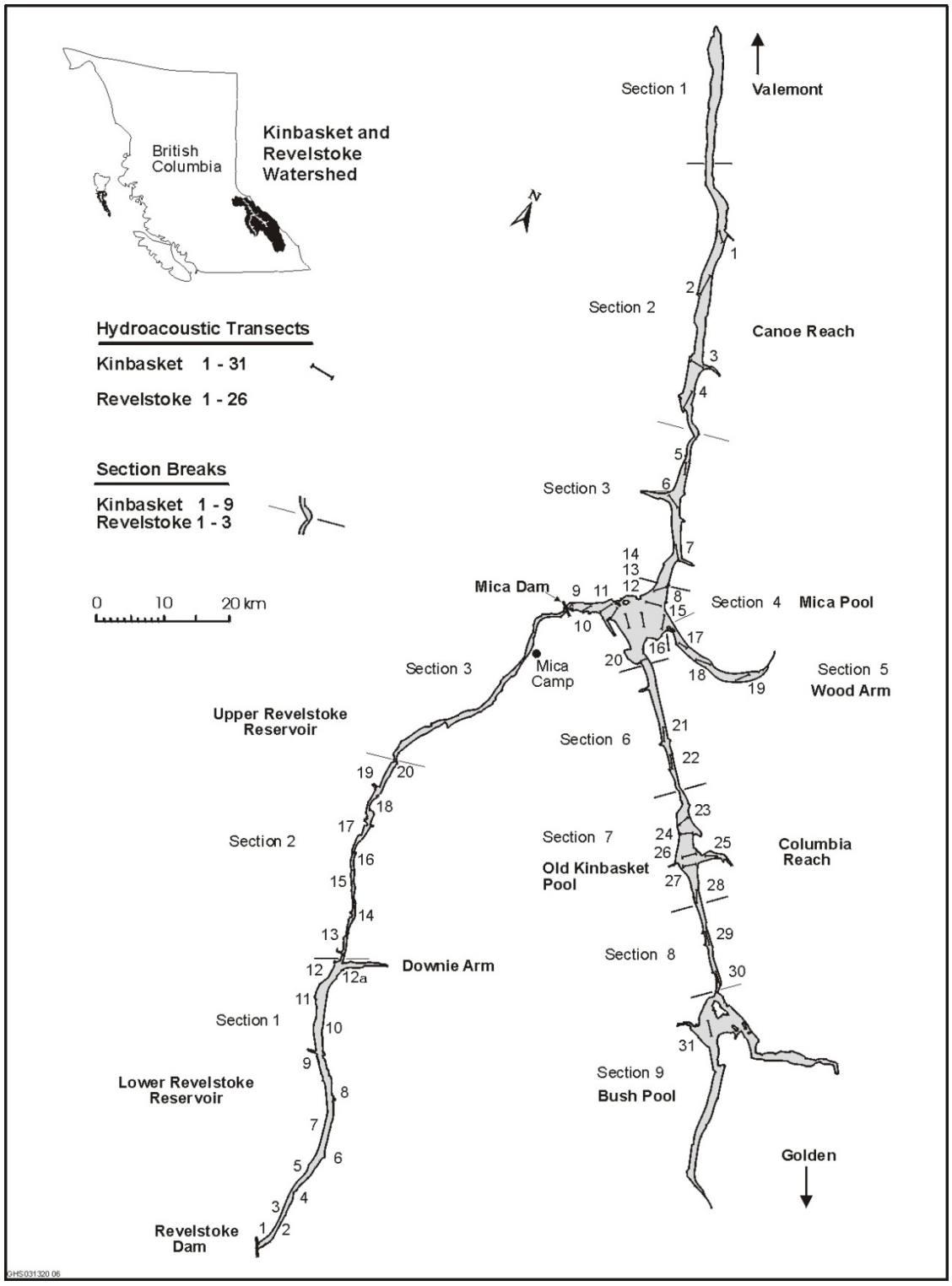

Figure 1. Map of Kinbasket and Revelstoke reservoirs showing location of reaches, habitat sections and acoustic transects.

Temperature profiles were obtained using a Seabird water profiler. Seabird casts were made at three locations in Kinbasket Reservoir as follows: Canoe Reach (Transect 1), the main pool (T08), and Wood Arm (T19). In Revelstoke Reservoir Seabird casts were conducted at two locations; Lower Reach (T12) and the Middle Reach (T20) (Fig. 1).

Kokanee have been enumerated annually by spawner surveys in up to 11 index streams for Kinbasket Reservoir including the Columbia River mainstem since the mid 1990's based on Oliver (1995). Until 2008, escapement counts have been conducted when feasible by aerial survey on Dutch Creek, Columbia River (upper), Toby Creek, Horsethief Creek, Forster Creek, Luxor Creek, Bush River, Succour Creek, Kinbasket River, Wood River and Camp Creek. In 2013 and 2014, escapement counts were reduced to only three streams for Kinbasket Reservoir and more effort was spent capturing and obtaining length and age structures (otoliths) from the spawners.

Spawner surveys consisted of one flight by helicopter at approximately 16-30 kph at a height of at least 50 meters. Either one or two observers grouped the fish into schools of 50, 100, 500 individuals etc and summed to provide a total count. Flights were conducted during the approximate peak of spawning activity during the last week of September or first week of October. In 2014 counts were conducted on Camp and Luxor Creeks and Bush River; the three Kinbasket tributaries with the most complete and consistent datasets. The 2014 counts were compared with the average for the previous thirteen years of record (2001-2013). Due to extreme year to year variability in counts and viewing conditions, a range of ± one standard deviation of the 13 year average was considered to represent "average" returns. Spawners were captured by angling in Camp Creek (1998, 00-14), by dip net from Luxor Creek (2007, 2009-14) and Bush River (2013-14) and using a combination of angling and dip-netting from the Upper Columbia River near Fairmont. Revelstoke spawners were collected from Standard Creek (2007, 2009-14), a tributary to Downie Creek, with a dip net. Sex, fork length, and age structures were collected for estimating mean length at age, relying on otolith analyses following protocols outlined in Casselman (1990).

RESULTS AND DISCUSSION

Survey timing, general flow conditions, pool elevation and habitat

Acoustic and trawl surveys (ATS) and gillnet sampling in 2014 were conducted July 28-30 on Revelstoke Reservoir and July 25-29 on Kinbasket Reservoir.

The maximum monthly discharge of the largest tributary, the Columbia River near Golden BC provides an index of the magnitude of annual spring freshet. In 2014 the maximum monthly discharge of 510 $m^3 \cdot sec^{-1}$ was 98% of the long-term

average of 522 $m^3 \cdot sec^{-1}$ (Fig. 2). A mean annual discharge of 175 $m^3 \cdot sec^{-1}$ was 5% above the 34 year average of 167 $m^3 \cdot sec^{-1}$ (Fig. 3). These records indicate

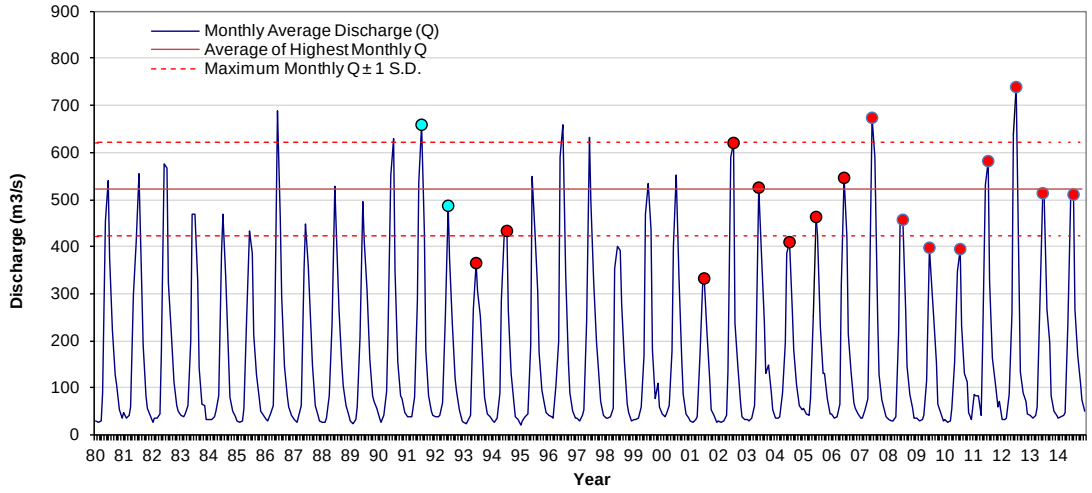

Figure 2. Monthly mean flows for unregulated Columbia River inflows to Kinbasket Reservoir at Donald Station (08NB005) near Golden BC. Note that red circles indicate study years with standardized ATS survey design, blue circles indicate non-standard preliminary survey years. Red line shows the average of maximum monthly discharges with dotted lines at ± one standard deviation.

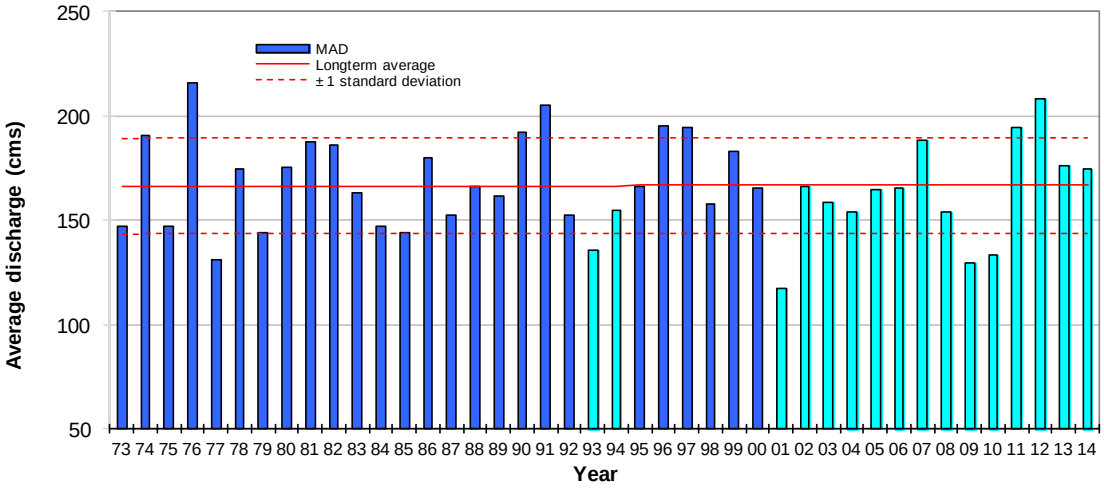

Figure 3. Mean Annual Discharge (MAD) of unregulated Columbia River inflows to Kinbasket Reservoir based on Water Survey of Canada station 08NB005 near Golden BC. The red line indicates the average annual flow of 167 cms since construction of Mica Dam in 1973, with red dashed lines indicating ± 1 standard deviation.

that 2014 was very near the average since Mica Dam was built. Although flows in the Columbia River upstream of Kinbasket Reservoir only provide a coarse index of annual climatic conditions in the drainage, any significant changes in the natural run-off patterns that might affect kokanee distribution and abundance should be detectable at this scale.

The average pool elevation of Kinbasket Reservoir during the time of the survey was 751m above sea level or an average of 3m below the normal full pool level of 754.38m. With pool elevation a meter lower than 2013, there was again considerable floating debris. Night navigation was slightly improved over 2013 and much improved over the high water year of 2012. Navigation at night was slow in some locations and lights were used intermittently on many transects. At 3 meters below full pool the pelagic area was 23,234 ha for the reaches surveyed and 30,094 ha for the entire reservoir (Table 1). For areas surveyed the pelagic habitat area was only 2% less than at full pool and 6% below average for the entire reservoir.

Table 1. Summary of surface area and pelagic habitat area (>20m depth) by section based on full pool elevations for Kinbasket and Revelstoke.

Section	Location/description	Full pool[1] surface area (ha)	Full pool[2] Pelagic area (ha)	2014[3] Pelagic area (ha)	Pelagic[4] % reduced
	Kinbasket Reservoir				
1	Canoe Reach - Valemont to 40m contour	2,400	1,305	1,140	13%
2	Canoe Reach - 40m contour to narrows	4,560	4,060	4,006	1%
3	Canoe Reach - narrows to Mica Pool	4,900	4,360	4,300	1%
4	Mica Pool above dam[5]	6,940	5,580	5,400	3%
5	Wood Arm	2,020	1,560	1,458	7%
6	Mica Pool to Old Kinbasket Lake	2,120	1,805	1,760	2%
7	Old Kinbasket Lake	5,270	5,055	5,022	1%
8	South Columbia (Old Kin to Surprise Rapids	1,500	1,315	1,288	2%
9	Bush Pool Surprise rapids to Upper Col R.	11,350	6,980	5,720	18%
Total		41,060	32,020	30,094	6%
2-8	***Total habitat surveyed***	27,310	23,735	23,234	2%
	Revelstoke Reservoir				
1	Main Basin - dam to Downie Creek[6]	6,100	5,250	5,250	0%
2	Middle Basin - Downie to Nicholls Creek	3,100	2,000	2,000	0%
3	Upper Basin - Nicholls Creek to Mica Dam	2,100	450	450	0%
Total		11,300	7,700	7,700	0%
1-2	***Total habitat surveyed***	9,200	7,250	7,250	0%

1. Full pool elevation for Kinbasket Reservoir = 754.38m
2. Full pool pelagic area = area at 20m or greater depth at full pool (area at elevation 734.38m)
3. 2014 pelagic area for Kinbasket is area at 751m elevation that is 20m depth or greater
4. % reduction in pelagic area over full pool estimates due to the lower pool elevation at survey
5. Mica Pool includes Forebay near Mica Dam and the main Mica Pool
6. Main Basin includes Forebay and Lower Basin reaches.

A summary of survey dates, pool elevation and pelagic habitat area for all previous summertime surveys is shown in Table 2. Note that habitat sections 1 and 9 were not included in the annual surveys due to hazards for night navigation and marginal quality of pelagic habitat for kokanee with depth being the major limitation. The "flatness" of sections 1 and 9 make habitat area particularly sensitive to changes in pool elevation (Table 1). It is also worth noting that age 1-3+ kokanee have to re-colonize zones 1 and 9 following each winter drawdown period since there is insufficient depth in winter months to support kokanee in these areas.

On Revelstoke Reservoir, the pool elevations remained fairly constant and the surface area and pelagic habitat area surveyed (sections 1 and 2) remained at approximately 9,200 and 7,250 ha, respectively. Note, Section 3 of Revelstoke has never been included in annual abundance surveys since it is shallow, riverine and has very little pelagic habitat suitable for kokanee rearing (Table 1).

Table 2. Survey dates, pool elevation and pelagic habitat area at the time of survey for Kinbasket Reservoir.

Year	Survey Dates	Pool elevation[1] (m)	Drawdown (m)	Pelagic habitat area[2] (ha)
1993	August 11-13	741	13	21,836
1994	August 8-10	743	11	22,102
2001	August 24-29	742	12	21,969
2002	August 9-14	750	4	23,067
2003	July 23-28	742	12	21,969
2004	July 14-20	740	14	21,703
2005	August 6-12	750	4	23067
2006	August 19-20	751	3	23,234
2007	August 8-10	754	0	23,735
2008	July 28 - August 1	747	7	22,634
2009	August 21-25	750	4	23,067
2010	August 7-10	749	5	22,900
2011	August 2-5	753	1	23,568
2012	August 16-20	754.5[3]	-0.3	23,735
2013	August 2-7	752	2	23,401
2014	July 25-29	751	3	23,234

1. pool elevation at time of survey rounded to nearest meter
2. refers to area surveyed in sections 2-8 at the time of survey
3. pool elevation in 2012 exceeded maximum through surcharging (~30cm)

Water temperature

Water temperature profiles were measured at three stations on Kinbasket Reservoir in 2014 and include the Upper Canoe (T1), main pool (T8) and Wood Arm (T19), Temperature profiles were fairly similar between stations and also similar to previous years. The main feature was the steady decline in temperature from 15°C at 10-15m depth to ~6°C at ~50m depth (Fig.5 b). Wood Arm was 17-18°C over the upper 10m and then declined steadily to 50m depth. The main pool had the warmest surface temperatures (22°C) however the warm (17-22°C) layer only extended to a depth of 3-4m. The Upper Canoe Reach showed the deepest mixing with temperatures of 14°C or higher extending down to a depth of 20m. As in previous years the water temperature in the main basin declined to below 4°C by 70m depth.

In Revelstoke Reservoir, the temperature differences including thermal stratification observed between the Lower and Middle basins were less defined than in the previous year (Figs. 5c and d). The main basin had a surface temperature of 19.3°C and a relatively thin layer of warm water (15.5-19°C) to a depth of only 3.6m. By contrast, the warm surface layer extended to a depth of 11 meters in 2013. In 2014 the Middle Basin showed a similar temperature profile to the Lower Basin with a very thin warm layer from 0- 4m depth and then a steady decline in temperature with depth (Fig. 5d).

Kokanee Distribution

In Kinbasket Reservoir the majority of kokanee in the main pool, lower Canoe Reach, Wood Arm and Columbia Reach were found at a depth range of 10-25m where temperatures ranged from 11-15°C (Figs. 5b and 6a). The kokanee layer has typically been found deeper in Kinbasket Reservoir (eg. 20-35m in 2013) however their preferred temperature range was very similar between years (eg. 11-14°C in 2013). In the upper Canoe Reach, kokanee were slightly deeper in 2014 at 20-30m while the temperature range remained similar at 10-15°C.

In Revelstoke Reservoir the contour plot showed slightly different fish distributions by depth that roughly aligned with habitat zones referred to as the Forebay, Lower Basin and Middle Basin (Appendix 2). The night time fish layer was found deeper at the Forebay (10-25m) compared with the Lower Basin (5-20m) and the Middle Basin (3-15m) (Fig. 6b). Temperature profiles suggest the kokanee preferred a temperature range similar to Kinbasket at 11-15°C in the Lower Basin and 12-15°C in the Middle Basin (Fig. 5d).

The vertical distribution of kokanee appears to be closely tied to water temperature which can vary from place to place and between surveys as a result of local inflow and weather patterns. The 2014 survey was slightly earlier in the

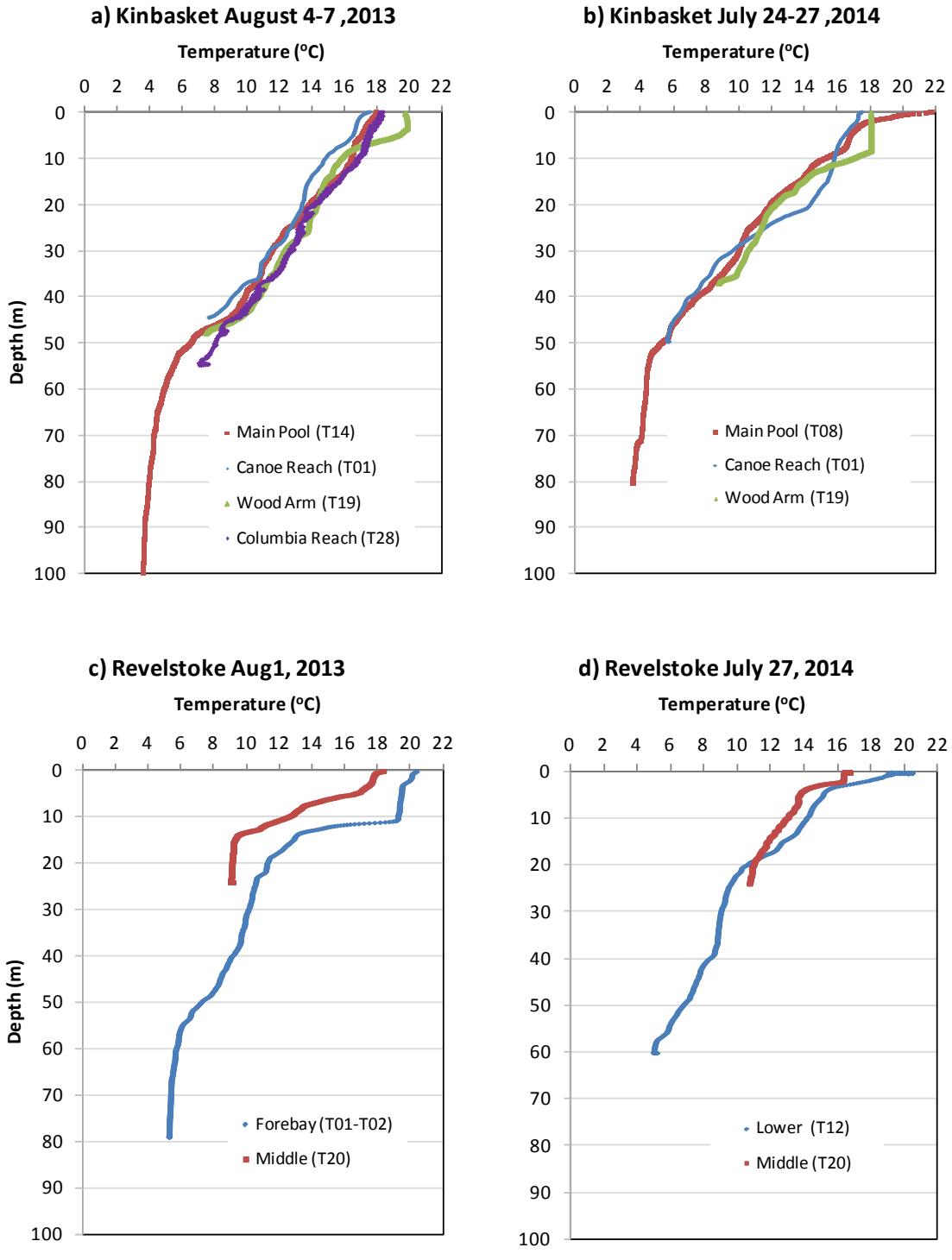

Figure 5. Plots comparing 2013 and 2014 water temperature profiles by location for a) and b) Kinbasket Reservoir and c) and d) Revelstoke Reservoirs respectively.

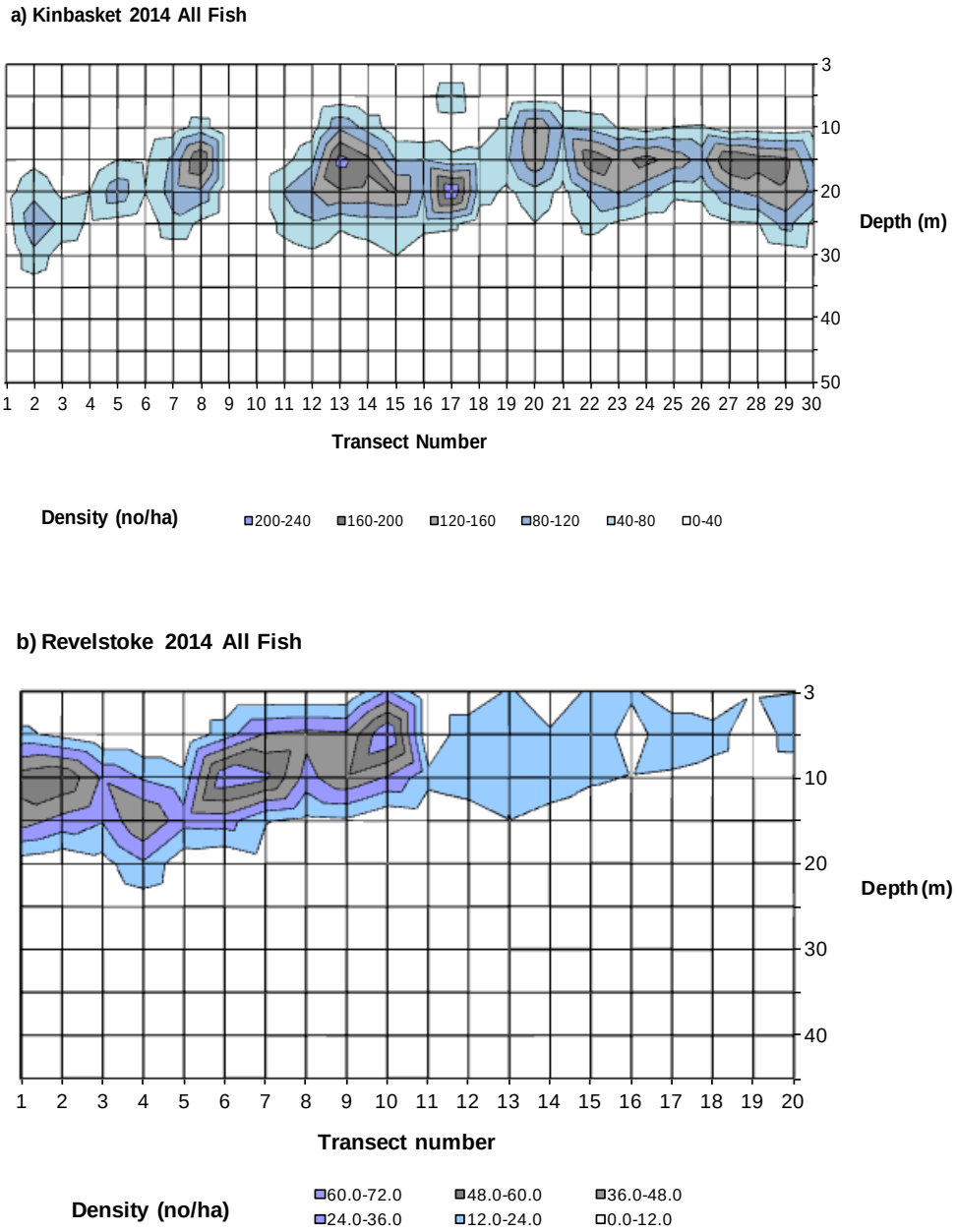

Figure 6. Contour plots showing kokanee distribution by depth and transect for a) Kinbasket and b) Revelstoke reservoirs based on 2014 acoustic surveys. Note that density (no/ha) scales are different between the two basins as a result of major differences in fish abundance.

summer than other recent (eg 2009-2013) surveys which may help to explain why the night time fish layer was nearer to the surface than other years.

Fish density at individual transects in Kinbasket Reservoir ranged from a low of 48 fish·ha^{-1} at Transect 1 in Canoe Reach to 559 fish·ha^{-1} at Transect 13 at the centre of the main pool (Fig. 7). The longitudinal profile shows relatively consistent densities of 250-400 fish·ha^{-1} throughout the Columbia Reach and into the central part of the main pool with densities similar to the long-term average. Exceptions were the east side of the main pool (T15-16), the upper two transects in Wood Arm (T18-19) and the entire Canoe Reach (T1-8) where densities remained well below average at all transects (Fig. 7). Although the two transects nearest the dam were not done, it would appear from nearby transects 11 and 12 that kokanee densities were most likely below average in the Forebay area as well. With the large majority of fry recruitment originating in tributaries to Columbia Reach, it is believed that fry moving down into the main pool from Columbia Reach continue to disperse over the summer period to the upper extremities of Canoe Reach and Wood Arm. The earlier survey timing might help to explain the lower densities of kokanee in Canoe Reach, Upper Wood Arm and the Forebay area of Kinbasket Reservoir in 2014. The longitudinal distribution could also be a result of lower than average fry recruitment levels from the southern tributaries.

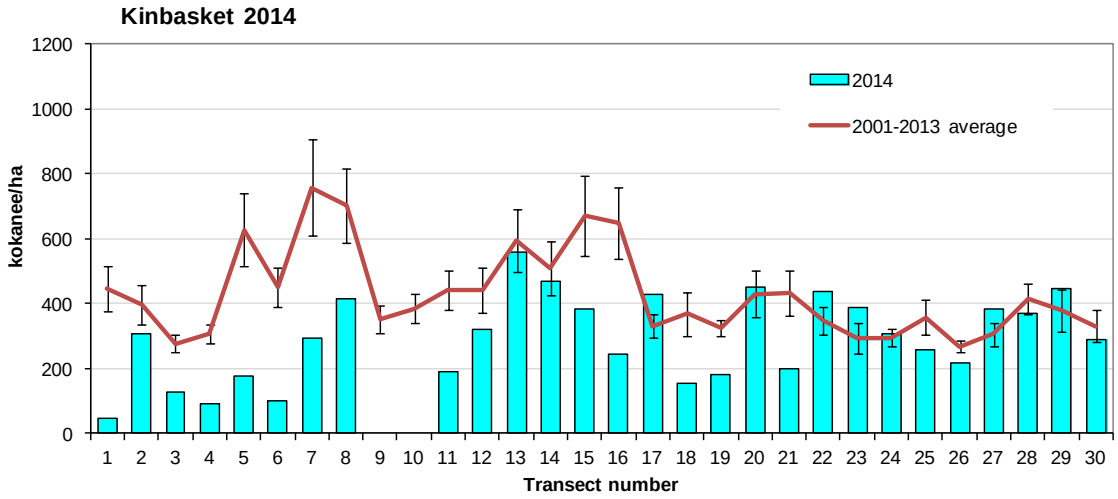

Figure 7. Longitudinal density distributions for kokanee in Kinbasket Reservoir based on acoustic surveys. Note the long term average transect densities for 2001-2013 are shown by the red line. Error bars represent the 95% confidence limits (± 2 standard errors) of the mean.

Fish density at individual transects in Revelstoke Reservoir ranged from 25-143 fish·ha^{-1} in 2014. The longitudinal distribution in Revelstoke Reservoir represented a return to more typical conditions where the Forebay and Lower Basins had at least two times higher densities than the Middle Basin. Even

though the distribution was more typical, the overall density remained very low at about 40% of average for the Forebay and Lower Basins and 48% of average for the Middle Basin (Fig. 8).

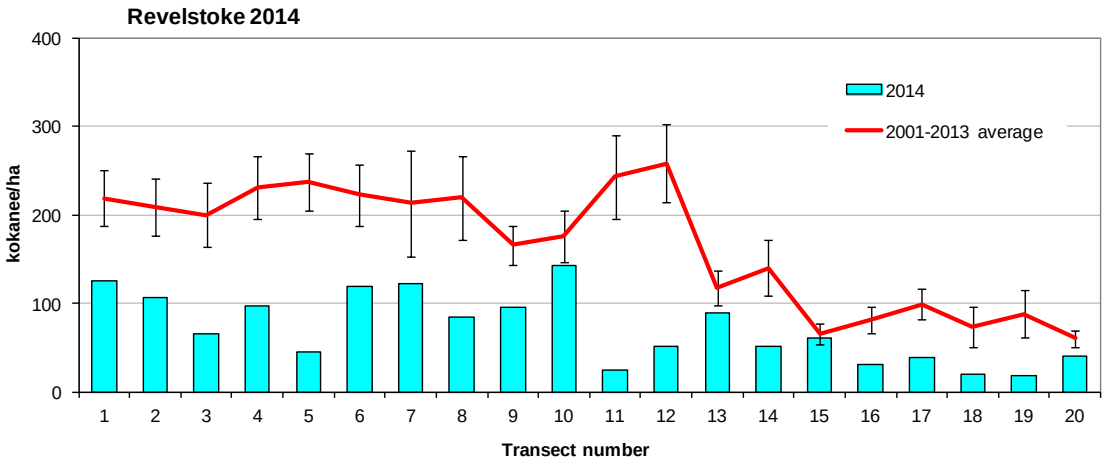

Figure 8. Longitudinal density distributions for kokanee in Revelstoke Reservoir based acoustic surveys. Note the long term average transect densities for 2001-2013 are shown by the red line. Error bars represent the 95% confidence limits (± 2 standard errors) on the thirteen year mean.

Kokanee Abundance

Total kokanee abundance in Kinbasket Reservoir for 2014 was estimated at 7.57 (6.54-8.62) million (Appendix 3a). Although 16% lower than the 2013 estimate of 9.05 million, the difference was not statistically significant. In fact, the kokanee population has been remarkably stable in Kinbasket with 11 of 16 years on record showing no statistically significant difference from the long-term average of 8.80± 1.65 million. Survey years below average were 1993, 94 and 2011 while abundance in 2007 and 2008 was above average.

The acoustic size distribution suggested a size cut-off at -46 dB between age 0+ fish (i.e. fry) and age 1-3+ fish in Kinbasket Reservoir. The resulting abundance estimate for fry was 6.36 (5.44-7.27) million and for age 1-3+ fish was 1.22 (1.02-1.42) million (Fig. 9a and b). The fry abundance has been similar for the last three consecutive years and was again well within the bounds of the long term average. By contrast the age 1-3 fish were well below average in 2011, 2012 and 2014 while only 2012 originated from a lower than average fry recruitment year. Fry recruitment has been relatively stable in Kinbasket Reservoir with 11 of the last 14 consecutive years being within 2 Standard Errors of the mean. Years below average were 1993-94 and 2011 and years above average were 2007-08.

Age 1-3 populations have also been stable in Kinbasket Reservoir with only three years below average (2011, 12 and 14) and two years above average (2001 and 2008). Of interest is that in the 1990's, below average fry numbers led to average numbers of age 1-3 fish. By contrast, average numbers of fry in three of the last four years has resulted in lower below average numbers of age 1-3+ fish.

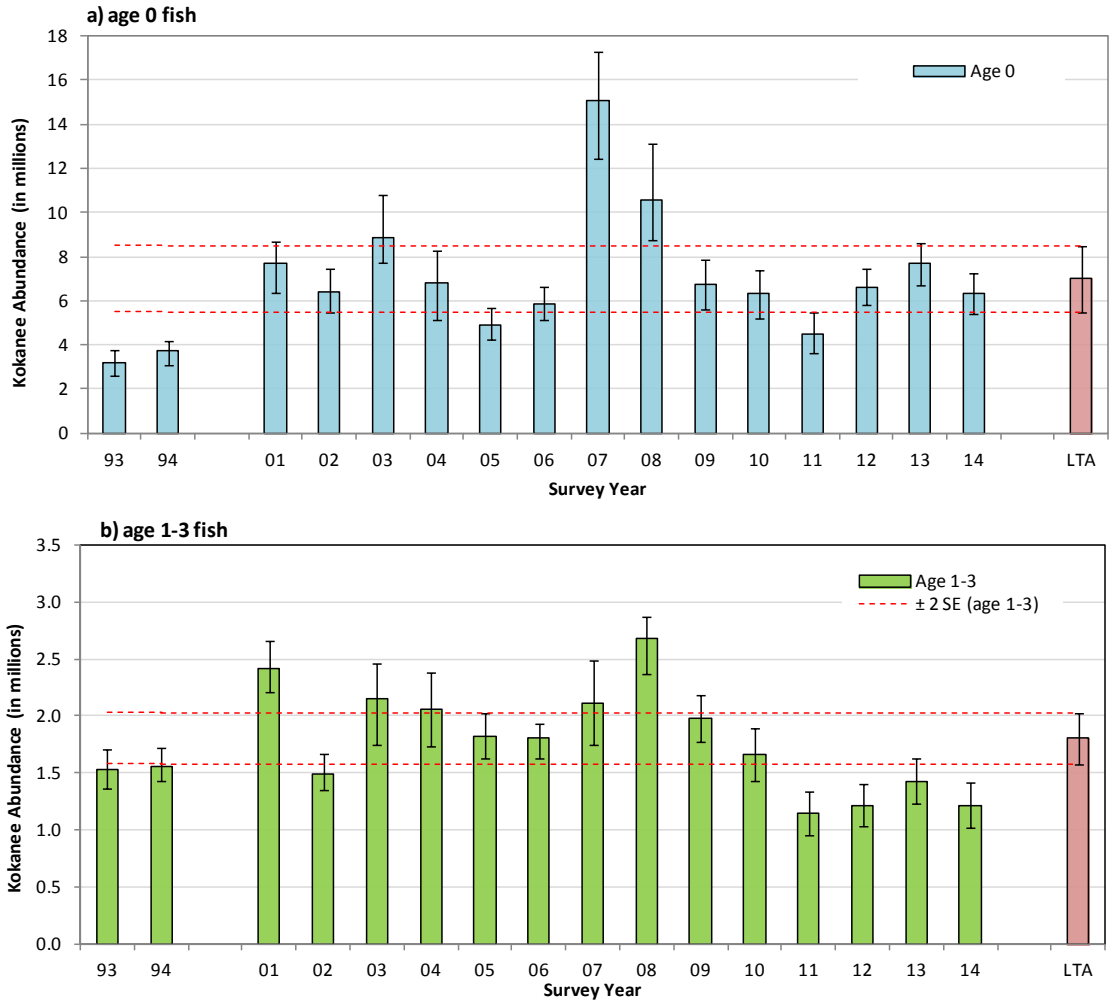

Figure 9. Kinbasket Reservoir kokanee abundance trends for a) age 0 and b) age 1-3 fish based on acoustic surveys. Note: LTA (reddish bars) refer to the long-term averages and include 1993-94 and 2001-13. Error bars denote 95% confidence limits on maximum likelihood estimates. The dashed lines indicate upper and lower bounds (95% C.L.) on the 15 year average.

In Revelstoke Reservoir the total abundance of kokanee (all ages) was estimated at 0.52 (0.41 – 0.62) million in 2014 (Appendix 4a). Similar to 2013, the 2014 abundance was only 45% of the long term average of 1.15 ± 0.26 million and was the fourth lowest abundance measured in fifteen years of survey, with 2012 being

the lowest. The acoustic size distribution suggested a size cut-off of -49db between age 0 and age 1-3 fish in Revelstoke Reservoir. The smaller size of the fry cut-off may be partly due to the smaller size of fry expected with the earlier survey timing of late July in 2014. Fry abundance was estimated at 0.45 (0.35 – 0.56) million and age 1-3+ abundance was estimated at 0.065 (0.040 – 0.089) million (Fig. 10a and b). The fry abundance was the third lowest on record at 47% of the 1993-2013 mean of 0.96 ± 0.23 million. The age 1-3+ abundance in

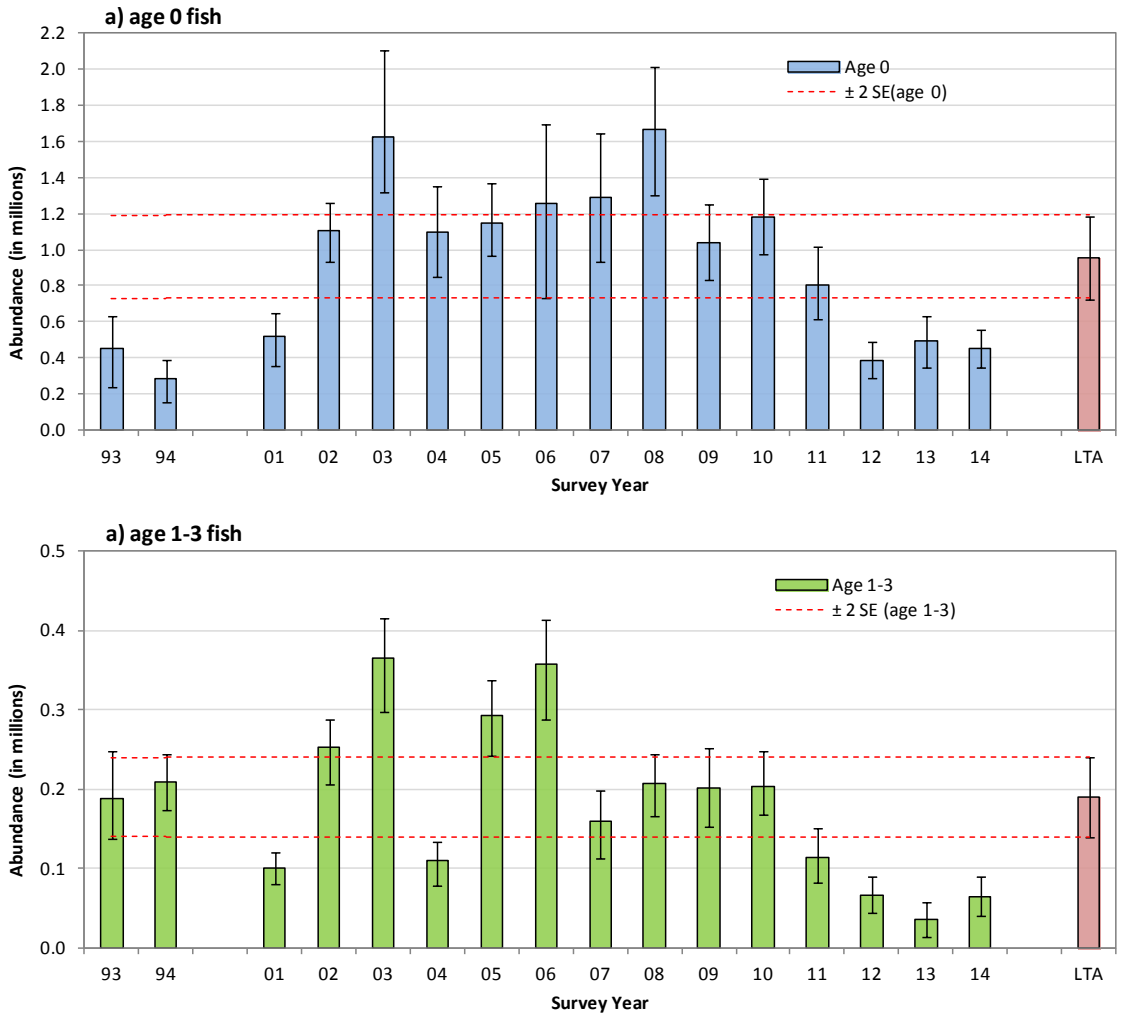

Figure 10. Revelstoke Reservoir kokanee abundance trends for a) age 0 and b) age 1-3 fish based on acoustic surveys. Note: LTA (reddish bars) refer to the long-term averages and include 1993-94 and 2001-13. Error bars denote 95% confidence limits on maximum likelihood estimates. The dashed lines indicate upper and lower bounds (95% C.L.) on the 15 year average.

2014 was the second lowest on record at only 33% of the 1993-2012 average of 0.19 ± 0.05 million fish and followed the lowest age 1-3 abundance on record in 2013. It appears that the age 1-3+ population in 2014 was limited by very poor fry recruitment in 2012 and possible higher than average entrainment rates on all ages throughout the high flow year of 2012.

It appears that the survival from fry to older age groups in Revelstoke Reservoir has been far lower than average during the past four consecutive years (eg. 2010- 2013 fry years), and in Kinbasket in 2 of the past 4 years (2010, 2013 fry years). Interestingly this coincides with very significant declines in survival of age 0+ to 1+ kokanee observed in Kootenay Lake and Arrow Reservoir recently, however increased predation is thought to be causing the decline in Kootenay Lake (FLNRO, unpublished data).

Kokanee size at age from trawl, gillnet and spawner sampling

Trawl and gillnet sampling were conducted on Kinbasket Reservoir to obtain fish samples for determining size at age and to confirm species composition to assist in interpreting acoustic data. A total of 110 kokanee were captured in three trawls on Wood Arm (Appendix 5). The trawl catch consisted of 84 fry, 18 age 1+ and 8 age 2+ fish. Age 1-3+ kokanee were also targeted with four overnight gillnet sets; two in Wood Arm and two in Columbia Reach in the vicinity of old Kinbasket Lake. A total of 88 kokanee, 9 Bull Trout, two whitefish, one sucker and one chub were captured at four stations (Table 3.) The gillnet catch per unit effort was 26-27 kokanee per ha of net area per hour in Wood Arm and was lower at 14-21 fish·ha·hr^{-1} in Columbia Reach (Appendix 6a). Kokanee catch rates were similar to 2013 gillnet sampling where CPUE ranged from 16-26 fish·ha·hr^{-1}. Kokanee were the dominant species captured at all sites.

Table 3. Summary of catch by species for four gillnet sets on Kinbasket Reservoir conducted during July, 2014.

		Number of fish captured					
Station No.	Transect	Kokanee	Bull trout	Whitefish	Chub	Sucker	Total
1	17N	26					26
2	17S	27	2			1	30
3	23W	21	3	1			25
4	24E	14	4	1	1		20
		88	9	2	1	1	101

A comparison of mean length at age between trawl and gillnet samples was done to determine if results were likely to be biased by the capture method. A further comparison was done between mean length at age from gillnet samples at two different locations on the reservoir. There was no significant difference in mean length for either age 1+ or age 2+ fish captured by trawl and gillnet in Wood Arm (Fig. 11). Age 1+ fish were, however, significantly larger in Columbia Reach than Wood Arm while other age groups showed no significant differences between sampling methods or sampling location. Even though trawling was more effective at catching smaller fish (i.e. age 0+ and age 1+) and gillnetting was more efficient at capturing larger kokanee (i.e. age 2+ to 4+) the comparison of size at age between methods provided no evidence to suggest that sampling results should not be combined. Trawl and gillnet catches were therefore combined to increase sample size of individual age groups and increase the reliability of size at age estimates in 2014, particularly for the older age groups. The mean size at age for combined gillnet and trawl caught kokanee was 37 ± 2 mm for age 0+, 139 ± 5 mm for age 1+, 215 ± 6 mm for age 2+ and 242 ± 3 mm for age 3+ fish (Table 4). A single age 4+ fish was 251mm.

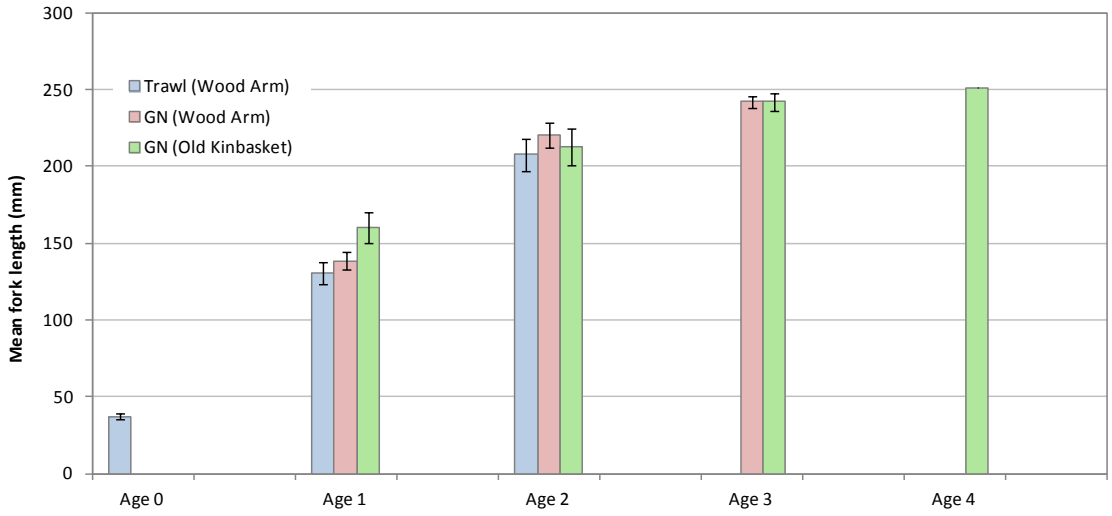

Figure 11. Comparison of mean length at age between capture methods (gillnet and trawl) in Wood Arm and between locations Wood Arm and Columbia Reach using the same method (gillnetting). Error bars indicate ± 2 Standard Errors of the means.

Table 4. Kokanee length and weight statistics by age for combined trawl and gillnet samples from Kinbasket Reservoir during July and from spawner samples obtained from Camp and Luxor Creeks and Upper Columbia and Bush Rivers during late September, 2014.

Type of Sampling	Age	FL(Ave) (mm)	FL range (mm)	S.D. (FL)	No. (FL)	Weight (g)	S.D. (Wt)	No. (Wt)
Trawl	0+	37	25-65	9.3	84	0.6	0.6	83
Trawl and GN	1+	139	100-188	18.3	54	29	13.3	54
Trawl and GN	2+	215	152-268	20.7	45	105	27.4	45
Trawl and GN	3+	242	229-251	6.3	14	142	10.9	14
Trawl and GN	4+	251			1	149		1
Spawner	1+	203	200-205	3.5	2			
Spawner	2+	234	213-265	11.2	116	141	27.2	19
Spawner	3+	263	231-350	19.0	47	220	44.9	41

Note that spawner mean length at age estimates presented in Table 4 were the result of combined samples from four different spawning areas with no attempt to weight samples based on the number of spawners returning to each system. Further details on spawner size and age composition for individual tributaries are presented and discussed later in the report (pages 23-25). Average length at age for spawners was estimated at 203 mm (198-208) for age 1+, 234 mm (232-236) for age 2+ and 263 mm (257-269) for age 3+. Values in brackets indicate 95% confidence limits. The combined samples suggested an age composition of 1% age 1+, 70% age 2+ and 29% age 3+ spawners. There was no overlap in size between the two age 1+ fish and the main group of age 2+ fish (n=116), while there was considerable overlap in the length of age 2+ and age 3+ spawners.

Age specific length frequencies from trawling have typically been used in other large lakes to monitor annual growth of kokanee and help verify spawner ages each year. Trawling provided an indication of kokanee size, however sample sizes for age 1-3+ fish were too small to be statistically valid. The addition of two experimental gillnet sets in 2013 doubled the sample size of age 1-3+ kokanee from 45 to 86 and provided the majority of age 2+ and 3+ fish. A further increase in gillnetting effort from 2 to 4 sets in 2014 roughly doubled the gillnet contribution from 41 in 2013 to 86 in 2014 for a total age 1-3+ sample size of 114 fish when combined with trawl data.

Figure 12 compares age specific length frequencies for fish captured in Kinbasket Reservoir (bar graphs) and spawners obtained from key tributaries (line graphs) for 2013 and 2014. A previous report showed that 2013 modes for all age groups including spawners were shifted to the right indicating a very good growth year for all age class (Sebastian and Weir, 2014). By comparison, all modes including spawners in 2014 have shifted to the left suggesting slower

growth than in 2013 and a return to more typical growth rates for this system. Even though some of the shift in reservoir sampled fish can be attributed to the earlier survey timing, a similar shift in the spawner size at age confirms slower growth since spawner surveys are always conducted in late September.

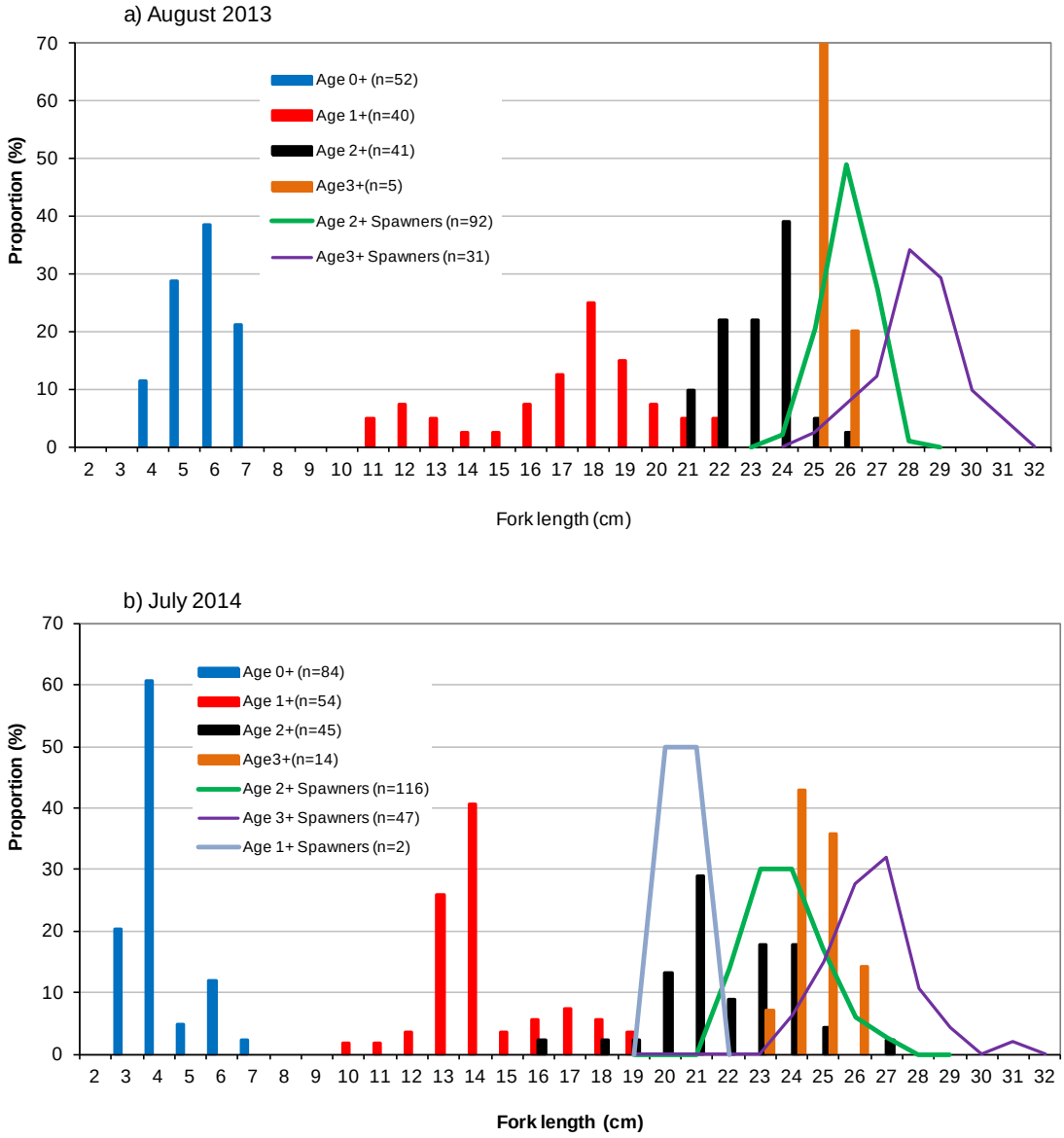

Figure 12. Kokanee length frequency proportion by age for a) 2013 and b) 2014 based on combined trawl and gillnet samples in Kinbasket and spawner surveys. Spawner data was from Camp, Luxor and Bush River in 2013 and Camp, Luxor, Bush and Upper Columbia in 2014. Except for Camp Creek, spawner data were provided by Karen Bray, BCH Revelstoke.

The appearance of two age 1+ spawners in 2014 was very unusual and may be due to errors in age interpretation (eg missed annulus). Based on size of 1+, it seems that if some were to achieve maturity, it should have occurred in 2013 when there were many more large 1+ fish present. The modes for age 1+, 2+ and 3+ spawners in 2014 make sense in terms of relative positioning and expected overlap between cohorts that were sampled in late July.

Both years showed bimodal size distributions for age 1+ fish which are commonly seen in other large lakes and may be a result of different feeding strategies within the same cohort. In 2014, the smaller mode of 1+ fish was dominant, while the larger mode was dominant in 2013. The result was a considerable reduction in mean length for age 1+ fish in 2014 compared with 2013. A common feature of these plots is that modes for spawners were all shifted to the right of their corresponding cohorts which were sampled in the reservoir 6-8 weeks earlier. From this it appears that growth continued to occur as fish reached maturity.

The stage of maturation in trawl and gillnet samples was as follows: age 0+ and 1+ fish were all immature, age 2+ consisted of 20% immature and 80% maturing, while all age 3+ and 4+ fish were maturing and expected to spawn by fall of 2014. The mean length of immature 2+ (199±16mm) was smaller than maturing age 2+ (219±5mm) however the difference in mean lengths was not statistically significant.

The addition of gillnet sampling to the Kinbasket program has proven successful at capturing larger numbers of age 1-3+ fish which enable tracking their growth within the reservoir from year to year. The added benefit of gillnetting is that sampling can be done at many more locations than trawling, which is limited to the main pool and Wood Arm due to the presence of submerged trees at many other locations. The additional two gillnet sets conducted in the Columbia Arm in 2014 indicated that age 1+ were significantly larger in the vicinity of old Kinbasket Lake than in Wood Arm and may help to explain observed differences in age at maturity and age structure of spawning fish in different tributaries around the reservoir. A further expansion of gillnetting is recommended for 2015 to compare kokanee growth at the south end of the reservoir (e.g. Bush pool) with other locations in Kinbasket Reservoir.

Spawner size at age and age proportions in Kinbasket

Spawner samples were again collected from Camp and Luxor Creeks and Bush River as in 2013. In addition, an attempt was made to capture spawners from the Upper Columbia River near Fairmont. The objective was to determine if Luxor Creek samples were representative of the larger spawning population in the Upper Columbia River. A secondary objective was to test the feasibility of

capturing spawners from a medium sized river using a dip net and angling. With laminar flows and swift velocity, it was slightly more efficient to catch kokanee with angling than using a dip net. Comparison of length frequencies showed no difference in size range or average size between the two methods (Fig. 13).

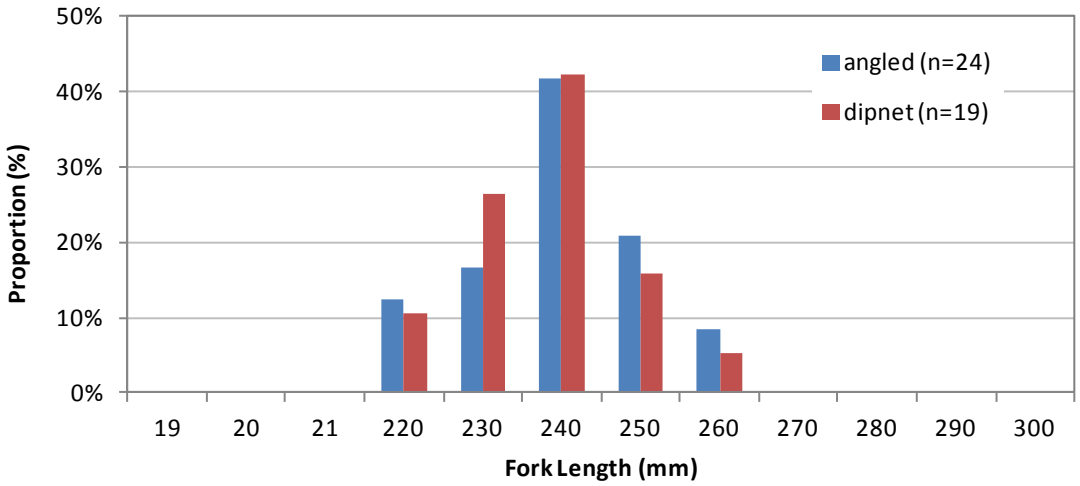

Figure 13. Comparison of length frequency for angled and dipnet caught kokanee from main spawning area in Upper Columbia River during September, 2014.

Angling appeared to be equally selective for capture of sexes with 46% males, while dip netting appeared to be more successful for males over females (e.g. 85% males). This could be due to small sample sizes or there may be some behavioural differences that make males more susceptible to capture by dip net.

Comparison of Luxor Creek spawner size and age structure with the mainstem Columbia River showed more similarities than differences. Both samples consisted mostly of age 2+ spawners (92% in Luxor and 100% in Columbia R.) and age 2+ in both systems ranged in length from approximately 220-260mm (Fig. 14). Columbia River fish appeared to be slightly larger at 235±3 mm compared with 231±3 mm in Luxor Creek although size differences were not statistically significant (Table 5). In fact, statistics in Table 5 suggest no significant differences in mean length of age 2+ fish between any of the four tributaries sampled, while the age 3+ fish in Camp Creek were marginally larger at 266±6 mm than age 3+ found in Bush River at 244±15mm). Again, limited sample size for age 3+ fish in southern tributaries may be a contributing factor to apparent size differences.

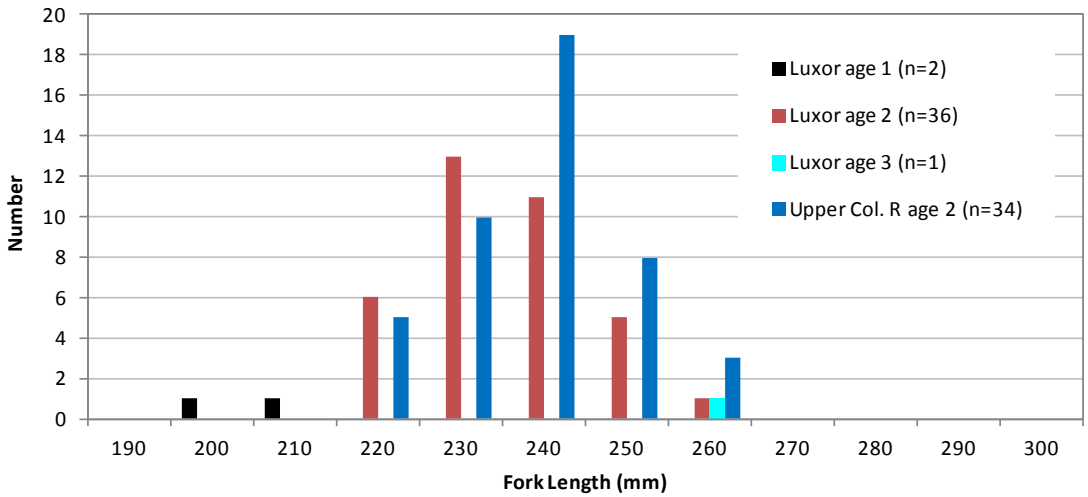

Figure 14. Comparison of kokanee spawner length frequency by age for Upper Columbia River near Fairmont and nearby tributary Luxor Creek during September, 2014.

The length frequencies are compared between Camp Creek, Bush River and Upper Columbia (combined Luxor and Columbia R) in Figure 15. The sample size was too small in Bush River to produce age modes (Fig. 15b). Combining all spawner samples produced two fairly smooth distributions with peaks at 230-240mm and 270mm for age 2+ and age 3+ spawners, respectively (Fig. 15d). Age 2+ and 3+ overlapped in the length range of 240 to 270mm.

Table 5. Size statistics by age for spawners sampled in Kinbasket Reservoir tributaries during late September, 2014.

Spawning Location	Age	Number of samples (n)	FL range (mm)	S.D.	Mean FL (mm)	95% C.L. on mean FL
Luxor Creek	1+	2	200-205	3.5	203	198-208
Camp Creek	2+	19	222-265	13.0	238	232-244
Luxor Creek	2+	36	213-253	10.0	231	228-234
Bush River	2+	16	215-261	14.1	234	227-241
Upper Columbia	2+	45	216-260	10.0	235	232-238
Camp Creek	3+	41	245-350	18.0	266	260-272
Luxor Creek	3+	1	256		256	
Bush River	3+	6	231-277	18.8	244	229-259
Upper Columbia	3+	0				
Combined	1+	2	200-205	3.5	203	198-208
Combined	2+	116	213-265	11.2	234	233-237
Combined	3+	48	231-350	19.0	263	258-268
Total		166				

Age composition is clearly a key factor determining overall average size of spawners which affects fecundity and fry recruitment levels the following year. Differences observed in age composition between Camp Creek and all southern spawning areas could be more important for determining overall spawner size than differences in growth rates between years. The age composition of spawners has varied considerably but in general the southern-most populations are smaller in size and consist almost entirely of age 2+ fish, while the North end (Camp Creek) spawners are typically larger in size and have a higher proportion of age 3+ than age 2+ spawners.. This difference is interesting and deserves continued attention. It could indicate that the factors determining the age at maturity may vary between spawning populations even though they rear in the same reservoir. Acquiring a larger sample of age 1-3+ fish from around the reservoir for the first time in 2014 suggested that age 1+ fish may be growing more rapidly in Columbia Reach than in Wood Arm. Following initial success in 2013 the expanded gillnetting program is recommended to increase samples of age 1-3+ fish from more locations in Kinbasket Reservoir in order to determine if growth is better in the southern reaches of the reservoir. Slightly better growth between age 0+ and 1+ suggested for the Columbia Reach appears to result in a large proportion of the age 1+ fish achieving a critical size of ~180-190mm which triggers the onset of maturation the following year as suggested by Patterson *et al.* (2008). Likewise, the slower growth of the Camp Creek fish (presumed to rear in Canoe Reach) enable a smaller proportion of the total age 1+ to achieve the size necessary to trigger maturation the following year producing only a few age 2+ spawners.

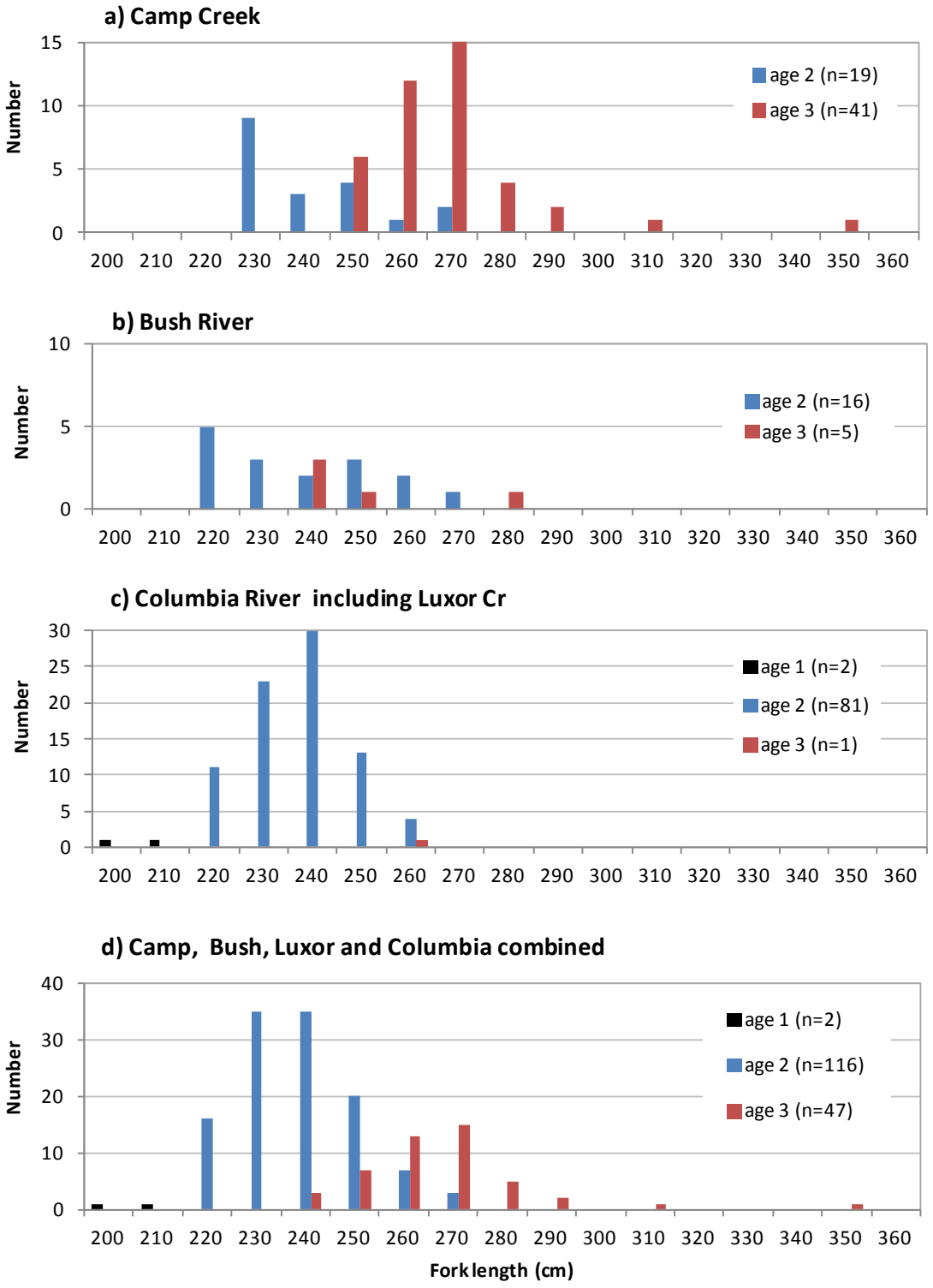

Figure 15. Kokanee spawner length frequency by age for a) Camp b) Luxor c) Bush, d) Columbia R and e) combined Kinbasket tributaries (Camp, Luxor, Columbia and Bush R.) in September, 2014.

Gillnet sampling on Revelstoke Reservoir

Trawl sampling has been discontinued in Revelstoke Reservoir since 2012 due to very low densities of kokanee and a lack of success with this technique for capturing age 1-3+ fish. The feasibility of using overnight gillnet sets to catch kokanee in pelagic habitat was tested in 2012 with promising results. A total of 20 age 1-3+ kokanee and 3 bull trout were captured in four overnight sets at 10, 15 and 20m depths for an average CPUE of 3.6 kokanee·ha·hr^{-1}. With some refinements including elimination of the 20m deep sets, a total of 75 age 1-3+ kokanee were captured with four overnight sets in 2013 for an average CPUE of 14.8 kokanee·ha·hr^{-1}. A similar level of effort was repeated in 2014 in which four overnight sets caught a total of 63 kokanee and 3 bull trout for an average CPUE of 14.7 kokanee·ha·hr^{-1} (Table 6). The CPUE from individual sets ranged from 9.6 at transect 5 to 21.8 kokanee·ha·hr^{-1} in the vicinity of transect 14 (Appendix 6b). There did not appear to be a clear correlation between average density of age 1-3+ fish from echosounder surveys and average CPUE from gillnetting. For example, the average density of age 1-3+ fish nearly doubled from 4.9 fish·ha^{-1} in 2013 to 8.9 fish·ha^{-1} in 2014 while the average gillnet CPUE remained the same at 14.8 kokanee·ha·hr^{-1}. Acoustic surveys indicating age 1-3+ densities were 6-10 times higher at 51-60 fish·ha^{-1} in Kinbasket Reservoir while the average gillnet CPUE of 18-20 kokanee·ha·hr^{-1} was only 20-30% higher than Revelstoke. With similar effort, but focused on different net depths, it is likely that CPUE can vary considerably with how well the net depths correspond with kokanee concentrations at specific locations. For example, in 2013 when the thermocline in Revelstoke was reported to be relatively deep and well defined, 64% of the catch was reported in the 15m deep sets. In 2014 the thermocline was shallower and less defined and kokanee captures were about even between the 10 and 15m nets. Another factor that may be acting to improve efficiency of gillnet captures in Revelstoke compared with Kinbasket could be the larger size of kokanee in Revelstoke Reservoir. Regardless, these results confirm the effectiveness of gillnets for capturing kokanee at very low densities in pelagic habitat, and make this technique valuable in targeting age 1-3+ fish for monitoring growth and comparing size at age between surveys.

Table 6. Catch summary by species, age and net depth from pelagic gillnet sampling in Revelstoke Reservoir during late July, 2014.

Net Depth	Number of Kokanee					BT	Total Fish
(m)	Age 1	Age 2	Age 3	Age 4	Total		(no)
10	8	13	7	3	31	2	33
15	1	23	6	2	32	1	33
All	9	36	13	5	63	3	66
CPUE[1]	*2.1*	*8.4*	*3.0*	*1.2*	*14.7*	*0.7*	

1. *CPUE* in no·ha·hr^{-1}

Size at age and age at maturity in Revelstoke Reservoir

Four gillnet sets caught a total of 63 kokanee with representation in four different age groups (1+ to 4+). The age 2+ and 3+ fish were reasonably well represented with sample sizes of 36 and 13 fish, respectively. Although much improved over 2013, the age 1+ and age 4+ fish were considered minimally represented with capture numbers of 9 and 4, respectively. Kokanee mean length at age was estimated at 183±13 mm for age 1+, 290 ±6 mm for age 2+, 340 ±5 mm for age 3+ and 347±5 mm for age 4+ (Table 7). Spawners obtained from Standard Creek had a mean size of 331±4 mm for age 2+ and 375±5 mm for age 3+ in 2014. The 2013 spawners and by association all younger age groups were reported to have been the largest on (recent) record for Revelstoke Reservoir (Sebastian and Weir, 2014). In 2014 mean size at age for all age groups except for age 2+ spawners were larger than in 2013, which makes 2014 the new record year for exceptional growth in Revelstoke Reservoir. Age 2+ spawners appeared to be the same size in 2013 and 2014 while the age 3+ spawners were considerably larger in 2014 (Appendix 9). The large size of spawners in 2013 and again in 2014 is presumably in response to the lowest age 1-3+ densities on record in 2013 and second lowest in 2014. This exceptional growth is consistent with density dependent growth responses for kokanee described in the literature.

Table 7. Summary of kokanee length and weight statistics by age from gillnet (GN) catches in Revelstoke Reservoirs during July/August 2014 and for spawning kokanee caught by dipnet (DN) in Standard Creek during early October, 2014.

Type of Sampling	Age	FL(Ave) (mm)	FL range (mm)	S.D. (FL)	No. (FL)	Weight (g)	S.D. (Wt)	No. (Wt)
Gillnet	1+	183	158-216	20.2	9	75	24.8	9
Gillnet	2+	290	260-345	18.8	36	304	58.1	36
Gillnet	3+	340	326-357	9.7	13	481	40.6	13
Gillnet	4+	347	340-355	5.5	5	512	22.7	5
Spawner	2+	331	315-348	8.0	15			
Spawner	3+	375	368-381	5.3	5			
					83			

Age specific length frequency distributions for gillnet caught fish are compared with spawner length frequency distributions from Standard Creek for years with gillnet data; 2012, 2013 and 2014 (Fig. 16). The 2012 year has previously been described as having average size at age for Revelstoke Reservoir, while the shift to the right of all age 2+ and older fish including spawners in 2013 was characterised as an exceptional growth year (Sebastian and Weir, 2014). Figure 16c shows a further shift to the right of all age groups except for age 2+

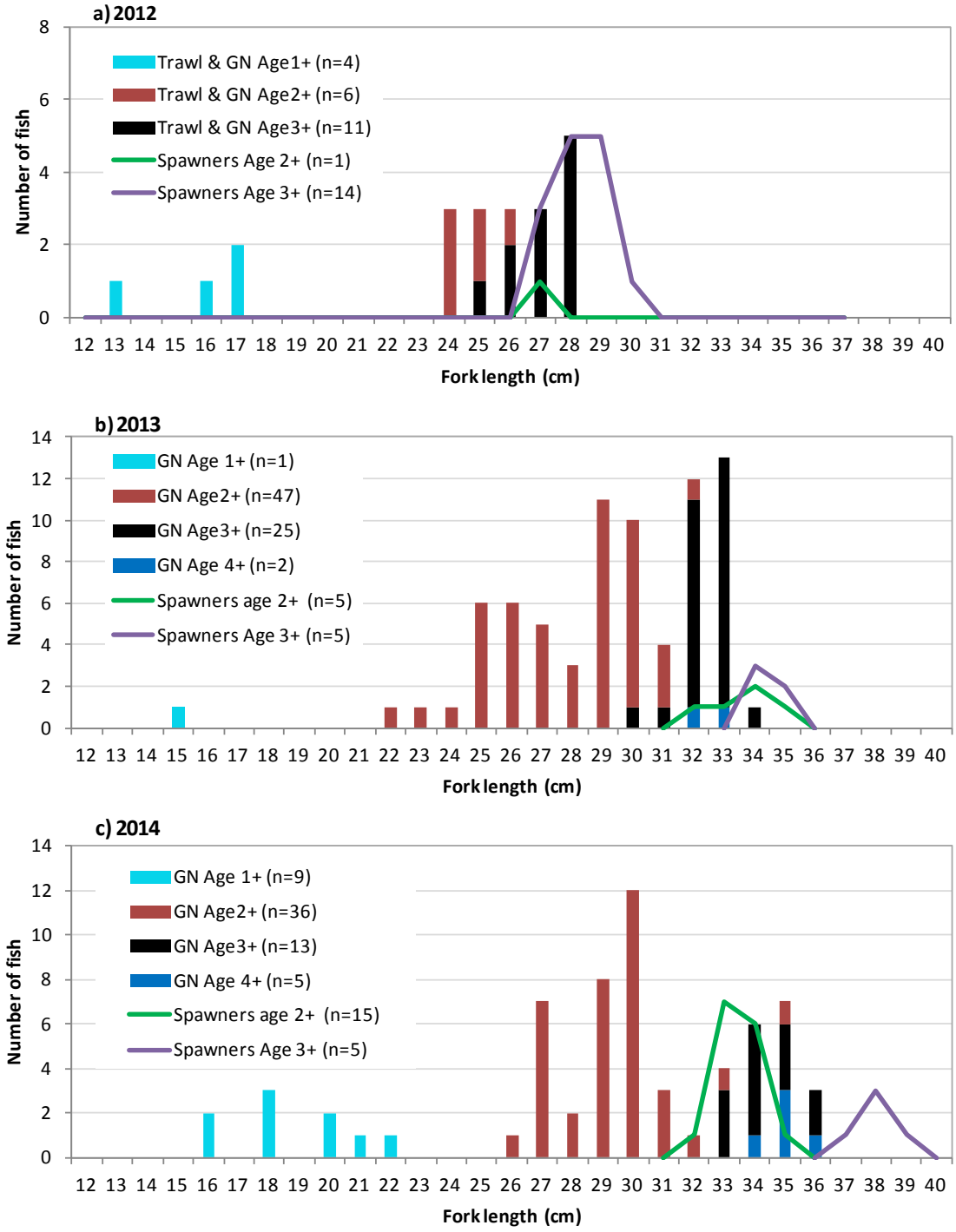

Figure 16. Age specific length frequency distributions for gillnet caught fish sampled in mid-summer and for spawners returning to Standard Creek during early October for a) 2012, b) 2013 and c) 2014 sampling years.

spawners indicating growth was even better in 2014 for most kokanee. With smaller age 1+ and 2+ fish in 2012, the dominant spawning age was 3+. Following exceptional growth in 2013 the dominant age shifted to even proportions of age 2+ and 3+ fish, with the size of age 2+ nearly catching up to 3+ fish. With a second year of exceptional growth in 2014, all ages shifted further to the right and age 2+ spawners became the dominant group (75%). At very low densities, the age 3+ spawners continued to grow resulting in the largest age 3+ spawners of the seven years on record (Appendix 9).

Continued gillnetting is recommended for Revelstoke Reservoir to enable growth conditions in the reservoir to be tracked through annual estimates of age 2+ and 3+ size. Time permitting an additional set in Downie Arm could be useful to follow up on a notion in 2012 that age 1+ fish may be patchy and prefer certain areas of the reservoir. This could be the reason age 1+ catches have appeared sporadically in the main basin.

Spawner Surveys

Spawner counts in 2014 were again conducted on Camp and Luxor Creeks and Bush River, index tributaries for Kinbasket Reservoir and for Downie Creek, the main spawning tributary for Revelstoke Reservoir. Annual counts for 15 consecutive years of record (including 2014) for Camp and Luxor Creeks and for 13 years of record for Bush River are presented in Appendix 10 and summarized below in Table 8. To acknowledge the considerable year to year variation in counts and viewing conditions, a range of ±1 standard deviation around the mean for the fourteen year period (2000-2013) was considered to be an "average" count. Values outside this range were considered to be either below or above average. In 2014, Downie Creek represented only a partial count due to heavy siltation (e.g. only Standard Creek could be counted). With average fall flows, the conditions for viewing in Kinbasket Reservoir tributaries were fairly good in 2014. Counts were about average in Luxor Creek, slightly above average in Camp Creek and well above average in Bush River (Table 8).

Table 8. Summary of 2014 kokanee spawner counts compared with long term average of previous fourteen years.

Tributary	Average Count (2001-13)		2013	Survey	Comments/conditions
	Mean	(Range[1])	Count	Dates	
Luxor Cr.	31,667	(11634-51700)	18,710	Sep 15,25	Count average
Bush R.	26,525	(12744-40306)	48,380	Sep 15,25	Count well above average
Camp Cr.	14,200	(7923-20476)	20,600	Sep 22,29 & Oct 2	Count slightly above average
Downie Cr.	6,823	(2617-11029)	*300*	04-Oct	*Partial count (poor visibility)*
Total	79,215	(34918-121794)	112,903		

1. Range is shown here as ± 1 standard deviation of the mean (considered as average returns)

With spawner size (and fecundity) about average and 2014 returns at average or better, fry recruitment levels in 2015 are expected to be above average from Camp Creek and Bush River and about average from Luxor Creek in Kinbasket Reservoir. Note that even though size at age has returned to average, the proportion of age 3+ spawners remained above average in Camp Creek (n=14 years) and possibly in Bush River (n=2yrs) (Appendix 9).

In Revelstoke Reservoir, with no direct count of spawner numbers in 2014, predictions for 2015 fry recruitment are speculative. Based on very low densities of age 1-3+ fish for the last three consecutive years, it is most likely that spawner returns were very low. However with the large size of age 2+ spawners and the largest age 3+ spawners on record, the average fecundity is expected to be very high. Applying a length to fecundity relation suggested by McGurk (2000) to the large sized females in 2014 suggests average fecundity of 1060 eggs for Revelstoke spawners. Even though the large size and fecundity will help mitigate for low numbers of spawners, fry recruitment in 2015 is expected to be lower than average, however it is uncertain how much lower.

Methods development

Acoustic analyses

The separation of “noise” from small fish targets has been an area of ongoing development in the analysis of acoustic data using SONAR5 software. With the 70 kHz single beam echosounder used up until 2008, the low end noise was typically not a problem since fish echoes declined to near zero by -62dB as would be expected without significant low end noise. However, with the use of the higher resolution 120 kHz split beam echosounder starting in 2009, the number of small echo targets was often high and increasing at -62dB and was clearly made up of low end noise. In addition to target strength, attributes of target echoes such as echo length, track association in relation to mean size, and phase deviation have been investigated as a means of helping to “clean” the acoustic data and refine the results. In 2012, however, the noise levels in Revelstoke Reservoir were so high that none of the typical “cleaning” techniques were successful in eliminating low end noise, so a threshold of -58db was applied as a “best guess” of where the cut-off between fish and noise would minimize the potential to over-estimate kokanee fry abundance by including noise.

Further investigation in 2013 led to developing a more objective way to “set” the lower threshold in order to minimize impacts from surveys with higher noise levels. This new approach is considered preliminary and is being further evaluated with each new survey. A review of the 2009-2014 acoustic size distributions for the fish population in Revelstoke Reservoir showed a fairly consistent pattern with a peak for the noise distribution occurring at -61dB (-59 to -63db) and a peak for the kokanee fry distribution at -53dB (-52 to -56dB). A

valley between the two distributions at -55.6dB (-57 to -55dB) likely indicates approximately where the cut-off point occurs between the two distributions. Since the mean target strength of the smallest fry (i.e. -55dB) was slightly to the left of the visible cut-off point, we have assumed that the -55dB size class contains entirely kokanee fry. The left leg of the fry distribution was then modelled using a simple linear reduction between -55dB and -61dB to acknowledge there would be diminishing numbers of echoes associated with fish extending downward about 6dB to -61dB. For the area of overlap (i.e. -55 to -61dB), the difference between the modelled fry estimate and the total (echo) estimate for each decibel size interval was considered to be noise as shown by the frequency distributions for noise and fish (Appendix 11). The sum of estimates for fry over their entire acoustic size range of -61 to -45dB represented a best estimate for kokanee fry abundance. The lower threshold was then defined as the location on the cumulative target size distribution which produced the closest fry estimate to the modelled value. This newly defined threshold was then used for all kokanee abundance estimates for that survey.

A summary of initial and revised fry abundance estimates is shown for the new 120kHz echosounder (Table 9). The new lower thresholds reduced the fry abundance estimates by 26-40% by reducing the over-estimation of kokanee fry numbers by including noise echoes. It appears that a fixed threshold of -61dB when applied to 120kHz acoustic data will over estimate fry abundance and a

Table 9. Summary of equipment and thresholds used for data processing and resulting fry abundance estimates showing revised thresholds and fry estimates using a linear reduction model to determine lower thresholds

Year	Echosounder Mode - Frequency	Threshold (dB) (dB)	Fry estimate (number)	Revised lower threshold (dB)	Revised fry estimate (no.)	Difference (no)	% reduction
2001	EY200P[1]	-62	782,700				
2002	EY200P[1]	-62	1,366,800				
2003	EY200P[1]	-62	2,003,000				
2004	EY200P[1]	-62	1,137,000				
2005	EY200P[1]	-62	1,335,000				
2006	EY200P[1]	-62	1,563,600				
2007	EY200P[1]	-62	1,212,800				
2008	EY200P[1]	-62	1,707,500				
2009	EK60[2]	-61	1,063,000	-57	635,200	427,800	40%
2010	EK60[2]	-61	1,187,800	-58	877,200	310,600	26%
2011	EK60[2]	-61	848,100	-57	587,500	260,600	31%
2012	EK60[2]	-58	427,200	-56	262,300	164,900	39%
2013	EK60[2]	-59	525,500	-59	525,500	-	0%
2014	EK60[2]	-59	493,600	-59	493,600	-	0%

1 The Simrad EY200P single beam echosounder operated at 70kHz and used HADAS processing software

2 The Simrad EK60 split beam echosounder operated at 120kHz and used SONAR5 processing software

threshold of -59dB is more appropriate for separating fry and noise during average years. During years with higher than average noise the linear method suggests raising the threshold to -56 or -57dB in order to prevent noise echoes from inflating fry estimates. With this approach the thresholds for estimating fish abundance will move according to the ratio of noise to fish in order to prevent the fish numbers from increasing as a result of added noise levels. This approach provides more conservative estimates for fry abundance than fixed thresholds, particularly when fish densities are low and/or when noise levels are high.

Other investigators have used more elaborate statistical routines to separate kokanee fry from noise. Biosonics (2013) also found that noise levels interfered with kokanee fry abundance estimates during a study using hydroacoustics to measure entrainment rates at Revelstoke Dam. They identified three overlapping size classes representing non-fish or particulate, kokanee fry and age 1+ kokanee. Gaussian functions (bell-shaped curves) were fitted to the target strength distribution and a least squares fit procedure was used to determine best cut-off points or thresholds for minimizing bias of counts between the size classes. The method was used to develop a table of seasonal values for lower thresholds which were used to separate fry from non-fish (noise). The cut-off points suggested for mid-July and mid-August 2010 were -58.6dB and -56.8dB respectively, and compare well with our linear approach which suggested a threshold of -58dB for our early August survey of Revelstoke Reservoir in 2010.

The overall impact on results is that the linear model suggests higher thresholds which produce lower fry estimates for most years and the amount of the reduction will vary depending on the amount of low end noise detected during each survey. It will be necessary to apply this method to all surveys conducted with the 120kHz split beam echosounder (i.e. from 2009 onward) and revise the fry estimates accordingly over the time series. Note these changes will only affect fry population estimates and not change estimates of age 1-3+ fish. It is recommended that the time series be updated and included in the upcoming Year 8 synthesis report.

The approach should also be applied to Kinbasket Reservoir fry estimates since low end noise has also been observed at a number of locations on the echosounder. During the 2013 survey on Kinbasket, a mysis sampling net was hauled vertically through “noise plumes” capturing four specimens which appeared to be sculpin larvae ~10-15mm in length. Similar larvae were found in the stomach of a 263mm bull trout captured from Revelstoke Reservoir in 2012 (see photos in Appendices 12 & 13 of the 2013 report by Sebastian and Weir, 2014). While these larval sculpin are not conclusively the only source of low end ‘noise’ in Kinbasket and Revelstoke, there is convincing evidence they are relatively common and likely to contribute to the acoustic noise. It is speculated that other potential causes of low end noise may include small gas bubbles (e.g. methane) from decomposing vegetation and accumulations of settling debris or

detritus that becomes suspended mid-water at density interfaces which coincide with depths where kokanee typically reside at night.

Gillnet feasibility

Following a third year of success, we conclude that gillnetting is the best way to obtain kokanee samples for determining size at age for age 2+ and 3+ kokanee in Revelstoke Reservoir for growth analyses. The capture efficiency on age 1+ fish is questionable in view of low catches to date on this age group. More gillnet trials are required to assess the reliability of gillnets for assessing the mean size of age 1+ kokanee in Revelstoke Reservoir. In Kinbasket Reservoir, initial success of gillnetting based on only two sets in 2013 was promising for capture of age 1-3+ fish. An additional two sets in old Kinbasket pool provided a first glimpse suggesting that growth of age 1+ may be better in southern areas of the reservoir. This technique may be very useful in assessing differential growth rates of kokanee at different locations in the reservoir and may help to explain differences in spawner size at age around the reservoir. Gillnetting increases the potential for sampling areas that cannot be trawled safely. With more log debris and higher winds in Kinbasket Reservoir, this technique may prove to be more challenging than in Revelstoke Reservoir. The size of Kinbasket Reservoir continues to present significant logistical challenges for gillnet sampling concurrent with night-time acoustic and trawl surveys. A second field crew is required to pull gillnets in the morning and process catches during the same day. Sampling of areas far from the main pool may require relocation of crews and will require additional time and resources.

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APPENDICES

Appendix 1. Kinbasket Reservoir fish densities by transect from hydroacoustic surveys, 2004-2014. Note densities reported here represent all depths and are not weighted by the amount of habitat at depth.

Location	Zone	Trans No.	2004 July	2005 Aug	2006 Aug	2007 Aug	2008 July	2009 Aug	2010 Aug	2011 Aug	2012 Aug	2013 Aug	2014 July
Ptarmigan Cr	2	**1**	815		200		364	272	701	206	487	357	48
		2	687	231	184		427	224	268	183	761	479	308
Hugh Allan Cr		**3**	254	267	162		451	253	279	169	300	326	126
Howard Bay		**4**	311	247	299	258	383	185	284	113	299	364	93
	3	**5**	490	398	1300	686	635	274	397	149	205	970	176
Foster Arm		**6**	295	720	303	954	484	298	323	110	528	264	100
		7	401	439	697	1910	1906	443	444	303	592	619	294
Dainard Cr		**8**	707	336	558	1078	1855	509	420	377	616	366	415
Mica Dam	4a	**9**	151	428	447	564	197	265	309	353	586	234	
Mica Arm		**10**	108	614	247	572	316	336	194	424	527	279	
Mica Arm		**11**	373	245	370	1099	365	336	342	253	512	378	188
Sprague Bay		**12**	538	178	282	802	801	390	293	160	400	361	322
Main pool	4b	**13**	530	419	222	1392	1083	630	300	370	451	462	559
Main pool		**14**	464	196	331	736	1176	502	341	269	226	249	468
Main pool		**15**	718	371	424	1133	543	819	365	332	338	247	385
East side		**16**	543	254	275	961	910	515	350	222	286	804	243
South side		**2 0**	221	323	170	361	632	427	452	205	213	290	452
Wood Arm	5	**17**	126	438	162	361	828	241	265	185	456	358	429
Wood Arm		**18**	208	425	301	415	300	246	226	299	402	465	154
Wood Arm		**19**	283	433	255	627	847	315	597		160	290	183
Lower	6	**21**	671	215	430	727	660	454	201	168	404	278	199
Columbia		**22**	426	186	394	194	662	426	324	295	188	363	436
Old Kinbasket	7	**23**	495	177	388	196	621	374	285		165	265	388
Pool		**24**	364	169	384	261	455	336	184	263	134	246	305
SullivanArm		**25**		375	208		448	230	597	300	141	595	259
Kyanite Cr		**26**	228	203	300	372	285	296	237	307	106	295	218
		27	198	272	198	596	259	476	222	249	200	440	383
Garrett Cr		**28**	361	223	350	674	496	423	553	317	190	748	370
Upper	8	**29**	199	438	240		478	785	382	442	168		447
Columbia		**30**		534	331			513	463	302	158		289
Bush Pool	9	**31**		178									

Note: a new Forebay Zone (4a) was added during Phase I synthesis grouping transects near the Dam while zone 4b represents the main Mica pool.

Appendix 2. Revelstoke Reservoir fish densities by transect from hydroacoustic surveys, 2004-14. Note densities reported here represent all depths and are not weighted by the amount of habitat at depth.

	Zone[1]	Old Trans No.	New Trans No.[2]	2004 July	2005 Aug	2006 Aug	2007 Aug	2008 July	2009 Aug	2010 Aug	2011 Aug	2012 Aug	2013 Aug	2014 July
Rev. Dam	1	1	**1**	348	172	347	293	74	211	261	145	82	52	125
Coursier Cr.	1	2	**2**	121	180		293	170	182	126	401	142	53	107
	1	3	**3**	80	144	319	491	240	142	65	319	69	28	66
Martha Cr.	2	4	**4**	96	287	207	368	360	235	213	221	48	57	97
Sale Cr.	2	5	**5**	150	243	274	374	312	256	188	241	50	86	46
LaForme Cr.	2	6	**6**	209	252	275	248	431	151	230	177	70	94	119
	2	7	**7**	127	222	253	234	384	112	131	49	24	44	123
Carnes Cr.	2	8	**8**	246	449	201	227	651	213	122	57	41	88	85
Frisby Cr.	2	9				121		705		162		85		
Mars Cr.	2	10	**9**	272	244	174	239	192	123	205	65	29	65	96
	2	11				126								
Park Cr.	2	12	**10**	214	295	170	196	171	252	300	31	51	34	143
Bourne Cr.	2	13	**11**	125	304	189	230	327	251	432	36	29	82	25
Keystone	2	14	**12**					300	143	366	121	80	383	52
Downie	2	15	**12a**	241	210	114	102							
Downie Arm	2	16												
Power line	3	17	**13**	57	293	58	42	90	134	119	234	97	99	89
Fissure Cr.	3	18	**14**	29	193	52	8	117	270	169	93	405	96	52
Ferry	3	19	**15**	53	87	52	11	65	76	158	23	69	13	61
Liberty Cr.	3	20												
Old Goldstream	3	21	**16**	19	129	47	25	98	180	153	35	92	42	31
Goldstream	3	22												
Stump field	3	23	**17**	253	46	144	39	72	68	87	65	157	51	39
Powerline	3	24	**18**	297	99	23	32	59	67	186	52	25	23	28
Hoskins Cr.	3	25	**19**	323	175	5	26	52	149		69	2	20	18
Nichols Cr.	3	26	**20**	121	60	10	21	95	97	83	29	25	51	41

1. Note a new Forebay zone was added during the Phase 1 synthesis. Sampled zones are as follows: Zone 1 (Forebay), Zone2 (Lower Revelstoke), Zone 3 (Middle Revelstoke) and Zone 4 (Upper Revelstoke). Zone 4 is too shallow for kokane

2. Note new transect numbers in bold font reflect all regular sampling (6 transects discontinued)

Blank values indicate no data.

Appendix 3. Summary of fish density statistics and Maximum Likelihood Estimates from Monte Carlo Simulations for Kinbasket Reservoir in August 2014.

a) Fish all sizes (all ages): *(? -60dB) Transects 1-8, 11-30*

Zone	Depth	N	Mean	SE	Area	StratumPop	CV	Statistic	Abundance
1	3-5	28	3.2	1.6	23735	77022	0.3	LB=	6,537,017
1	5-10	28	5.5	2.6	23735	130161	0.3	MLE=	7,574,544
1	10-15	28	38.4	8.7	23735	911914	0.3	UB=	8,621,075
1	15-20	28	113.4	15.8	23735	2692520	0.3		
1	20-25	28	102.5	11.8	22900	2346878	0.3		
1	25-30	28	44.7	5.9	22235	994338	0.3		
1	30-35	28	14.6	2.9	21570	315415	0.3		
1	35-40	28	3.4	0.8	20555	70624	0.3		
1	40-45	28	1.2	0.3	19540	23051	0.3		
1	45-50	28	0.9	0.3	18305	16470	0.3		

b) Age 1-3 kokanee *(? -46db) Transects 1-8, 11-30*

Zone	Depth	N	Mean	SE	Area	StratumPop	CV	Statistic	Abundance
1	5-10	28	0.7	0.4	23735	16561	0.3	LB=	1,018,047
1	10-15	28	2.5	0.9	23735	58169	0.3	MLE=	1,218,106
1	15-20	28	14.7	2.4	23735	348950	0.3	UB=	1,417,040
1	20-25	28	19.8	3	22900	454156	0.3		
1	25-30	28	10.8	1.6	22235	239534	0.3		
1	30-35	28	3.7	1.1	21570	80070	0.3		
1	35-40	28	0.7	0.3	20555	13476	0.3		
1	40-45	28	0.2	0.1	19540	3311	0.3		
1	45-50	28	0.2	0.1	18305	2890	0.3		

c) Age 0 kokanee *(-60dB to -47db) Transects 1-8, 11-30*

Zone	Depth	N	Mean	SE	Area	StratumPop	CV	Statistic	Abundance
1	3-5	28	3.2	1.6	23735	77022	0.3	LB=	5,438,152
1	5-10	28	4.8	2.6	23735	113601	0.3	MLE=	6,361,297
1	10-15	28	36	8.6	23735	853745	0.3	UB=	7,273,229
1	15-20	28	98.7	14.4	23735	2343569	0.3		
1	20-25	28	82.7	9.4	22900	1892722	0.3		
1	25-30	28	33.9	4.5	22235	754804	0.3		
1	30-35	28	10.9	1.9	21570	235345	0.3		
1	35-40	28	2.8	0.6	20555	57148	0.3		
1	40-45	28	1	0.2	19540	19740	0.3		
1	45-50	28	0.7	0.2	18305	13580	0.3		

Appendix 4. Summary of fish density statistics and Maximum Likelihood Estimates from Monte Carlo Simulations for Revelstoke Reservoir in August 2014**.**

a) Fish all sizes (all ages): *(≥ -59dB) Transects 1-20*

Zone	Depth	N	Mean	SE	Area	Stratum Population	CV	Statistic	Abundance
1	3-5	20	4.6	1.7	7250	33135	0.3	LB=	413,181
1	5-10	20	18.9	4.2	7250	137100	0.3	MLE=	518,910
1	10-15	20	27.1	4.7	7250	196538	0.3	UB=	623,922
1	15-20	20	13.3	3.4	7250	96296	0.3		
1	20-25	20	3.8	1.1	7250	27343	0.3		
1	25-30	20	1.7	0.4	6800	11309	0.3		
1	30-35	20	1.0	0.4	6400	6537	0.3		
1	35-40	20	0.6	0.2	6000	3754	0.3		
1	40-45	20	0.8	0.3	5450	4190	0.3		
1	45-50	20	0.5	0.2	4900	2489	0.3		
1	50-55	20	0	0	4435	0	0.3		
1	55-60	20	0	0	3970	0	0.3		

b) Age 1-3 kokanee (≥ -49db) Transects 1-20

Zone	Depth	N	Mean	SE	Area	Stratum Population	CV	Statistic	Abundance
1	3-5	20	0	0	7250	0	0.6	LB=	40,403
1	5-10	20	1.6	0.8	7250	11533	0.6	MLE=	64,610
1	10-15	20	4.4	1.3	7250	31996	0.6	UB=	89,259
1	15-20	20	1.5	0.6	7250	10934	0.6		
1	20-25	20	1.0	0.5	7250	7449	0.6		
1	25-30	20	0.3	0.2	6800	1768	0.6		
1	30-35	20	0	0	6400	75	0.6		
1	35-40	20	0	0	6000	100	0.6		
1	40-45	20	0.1	0	5450	374	0.6		
1	45-50	20	0.1	0	4900	322	0.6		
1	50-55	20	0	0	4435	0	0.6		
1	55-60	20	0	0	3970	0	0.6		

c) Age 0 kokanee (-59dB to -50db) Transects 1-20

Zone	Depth	N	Mean	SE	Area	Stratum Population	CV	Statistic	Abundance
1	3-5	20	4.6	1.7	7250	33135	0.3	LB=	350,966
1	5-10	20	17.3	4.2	7250	125567	0.3	MLE=	453,842
1	10-15	20	22.7	4.5	7250	164542	0.3	UB=	555,788
1	15-20	20	11.8	3.2	7250	85362	0.3		
1	20-25	20	2.7	0.7	7250	19894	0.3		
1	25-30	20	1.4	0.4	6800	9541	0.3		
1	30-35	20	1.0	0.4	6400	6463	0.3		
1	35-40	20	0.6	0.2	6000	3654	0.3		
1	40-45	20	0.7	0.3	5450	3816	0.3		
1	45-50	20	0.4	0.2	4900	2167	0.3		
1	50-55	20	0	0	4435	0	0.3		
1	55-60	20	0	0	3970	0	0.3		

Appendix 5. Trawl sampling logs and catch data for Kinbasket in 2014.

Key: No=sample number, SP=Species, KO=kokanee Len= length in mm, Wt=weight in g, Age was estimated by length unless SN is filled in, MAT=maturing, IMM=immature, R=ripe

Location: Kinbasket **Trawl No:** 1 Layer # Sensor Distance & Depth (m) Target Depth
Date: July 26, 2014 **Transect No.** 17 1 116 23 15-30
UTM start: N 5777402 E 409033 **Time start:** 22:32 2 100 19 15-30
UTM end: N 5777352 E 411257 **Time end:** 23:17 3 81 14 15-30

No.	SP	Len	Wt	Age	SN	MAT	Sex	No.	SP	Len	Wt	Age	SN	MAT	Sex
1	KO	230	125.91	2	SC1	MAT	F	12	KO	36	0.52	0		IMM	
2	KO	203	96.06	2	SC2	MAT	F	13	KO	56	1.65	0		IMM	
3	KO	176	55.42	1	SC3	IMM	F	14	KO	33	0.26	0		IMM	
4	KO	146	30.95	1		IMM	F	15	KO	55	1.61	0		IMM	
5	KO	128	21.94	1		IMM		16	KO	44	0.8	0		IMM	
6	KO	117	15.49	1		IMM		17	KO	34	0.31	0		IMM	
7	KO	136	25.97	1		IMM		18	KO	39	0.51	0		IMM	
8	KO	135	23.67	1	SC8	IMM	F	19	KO	61	2.11	0		IMM	
9	KO	129	21.85	1		IMM		20	KO	39	0.45	0		IMM	
10	KO	140	29.48	1	SC10	IMM		21	KO	32	0.27	0		IMM	
11	KO	33	0.28	0		IMM									

Calculated Distance: 2225 m
Average velocity: 0.82 mps

Location: Kinbasket **Trawl No:** 2 Layer # Sensor Distance & Depth (m) Target Depth
Date: July 26, 2014 **Transect No.** 17 1 113 22 15-30
UTM start: N 5777407 E 411735 **Time start:** 23:46 2 100 19 15-30
UTM end: N 5777387 E 408895 **Time end:** 00:46 3 81 14 15-30

No.	SP	Len	Wt	Age	SN	MAT	Sex	No.	SP	Len	Wt	Age	SN	MAT	Sex
22	KO	30	0.2	0		IMM		42	KO	36	0.44	0		IMM	
23	KO	35	0.34	0		IMM		43	KO	38	0.47	0		IMM	
24	KO	30		0		IMM		44	KO	59	2.18	0		IMM	
25	KO	32	0.26	0		IMM		45	KO	57	1.75	0		IMM	
26	KO	201	84.79	2	SC26	MAT	F	46	KO	54	1.47	0		IMM	
27	KO	195	77.64	2	SC27	MAT	F	47	KO	38	0.52	0		IMM	
28	KO	122	19	1		IMM		48	KO	32	0.24	0		IMM	
29	KO	138	27.25	1		IMM		49	KO	32	0.32	0		IMM	
30	KO	130	21.8	1		IMM		50	KO	37	0.5	0		IMM	
31	KO	125	20.43	1		IMM		51	KO	37	0.37	0		IMM	
32	KO	100	10.18	1		IMM		52	KO	31	0.25	0		IMM	
33	KO	49	1.28	0		IMM		53	KO	38	0.49	0		IMM	
34	KO	27	0.1	0		IMM		54	KO	34	0.29	0		IMM	
35	KO	33	0.34	0		IMM		55	KO	32	0.22	0		IMM	
36	KO	65	2.56	0		IMM		56	KO	35	0.37	0		IMM	
37	KO	33	0.29	0		IMM		57	KO	30	0.14	0		IMM	
38	KO	57	2.02	0		IMM		58	KO	30	0.18	0		IMM	
39	KO	55	1.79	0		IMM		59	KO	29	0.19	0		IMM	
40	KO	35	0.47	0		IMM		60	KO	40	0.54	0		IMM	
41	KO	32	0.2	0		IMM		61	KO	28	0.1	0		IMM	

Calculated Distance: 2840 m
Average velocity: 0.79 mps

Location: Kinbasket **Trawl No:** 3 Layer # Sensor Distance & Depth (m) Target Depth

Date: July 26, 2014 **Transect No.** 18 1 86 15 15-22

UTM start: N 5777196 E 408914 **Time start:** 01:20 2

UTM end: N 5776984 E 410246 **Time end:** 01:50 3

No.	SP	Len	Wt	Age	SN	MAT	Sex	No.	SP	Len	Wt	Age	SN	MAT	Sex
62	KO	208	98.1	2	SC62	MAT	M	87	KO	37	0.4	0		IMM	
63	KO	199	83.16	2	SC63	MAT	F	88	KO	33	0.34	0		IMM	
64	KO	232	137.45	2	SC64	MAT	M	89	KO	60	2.03	0		IMM	
65	KO	193	86.53	2	SC65	MAT	F	90	KO	36	0.42	0		IMM	
66	KO	124	20.45	1		IMM		91	KO	40	0.64	0		IMM	
67	KO	135	25.25	1		IMM		92	KO	32	0.2	0		IMM	
68	KO	130	22.38	1		IMM		93	KO	25	0.09	0		IMM	
69	KO	127	20.9	1		IMM		94	KO	34	0.32	0		IMM	
70	KO	109	11.33	1		IMM		95	KO	35	0.38	0		IMM	
71	KO	28	0.16	0		IMM		96	KO	36	0.39	0		IMM	
72	KO	26	0.1	0		IMM		97	KO	38	0.31	0		IMM	
73	KO	31	0.21	0		IMM		98	KO	39	0.47	0		IMM	
74	KO	34	0.32	0		IMM		99	KO	30	0.19	0		IMM	
75	KO	33	0.26	0		IMM		100	KO	33	0.25	0		IMM	
76	KO	30	0.25	0		IMM		101	KO	39	0.55	0		IMM	
77	KO	45	0.79	0		IMM		102	KO	32	0.24	0		IMM	
78	KO	33	0.28	0		IMM		103	KO	31	0.24	0		IMM	
79	KO	52	1.53	0		IMM		104	KO	33	0.33	0		IMM	
80	KO	47	1.17	0		IMM		105	KO	32	0.24	0		IMM	
81	KO	40	0.61	0		IMM		106	KO	36	0.42	0		IMM	
82	KO	37	0.33	0		IMM		107	KO	32	0.38	0		IMM	
83	KO	30	0.21	0		IMM		108	KO	34	0.33	0		IMM	
84	KO	52	1.43	0		IMM		109	KO	27	0.11	0		IMM	
85	KO	29	0.17	0		IMM		110	KO	28	0.12	0		IMM	
86	KO	29	0.36	0		IMM									

Calculated Distance: 1349 m

Average velocity: 0.75 mps

Appendix 6. Gillnet set details and summary results for kokanee effort, catch and CPUE for a) Kinbasket and b) Revelstoke reservoirs

a) Kinbasket GN stats

Attribute	Set 1	Set 2	Set 3	Set 4
Set date	25-Jul-14	25-Jul-14	26-Jul-14	26-Jul-14
Retrieval date	26-Jul-14	26-Jul-14	27-Jul-14	27-Jul-14
Site location (near...)	TR17 South	TR17 North	TR23 West	TR24 East
Net depth(s) in meters	20,20,15,15	10,15,15	20,20,15,15	10,15,15
Lake depth (m) start/end	65/65	70/70	90/85	82/85
Start UTM East	E 408755	E 409106	E 425565	E 430209
Start UTM North	N 5777075	N 5777480	N 5757089	N 5755418
End UTM East	E 408256	E 408730	E 425378	E 429856
End UTM North	N 5777192	N 5777513	N 5757465	N 5755621
Set time	19:30	20:00	17:58	18:20
Retrieval time	9:20	10:45	9:30	11:30
Total time (hrs)	13.83	14.75	15.50	17.17
Net area (m^2)	876	657	876	657
Effort ($ha \cdot hr$)	1.21	0.97	1.36	1.13
Kokanee catch (no)	26	27	21	14
Kokanee CPUE ($no \cdot ha \cdot hr^{-1}$)	21.5	27.9	15.5	12.4

NR= not recorded

b) Revelstoke GN stats

Attribute	Set 1	Set 2	Set 3	Set 4
Set date	29-Jul-14	29-Jul-14	27-Jul-14	27-Jul-14
Retrieval date	30-Jul-14	30-Jul-14	28-Jul-14	28-Jul-14
Site location (near...)	TR5	TR6	TR14 North	TR14 South
Net depth(s) in meters	10,10,15,15	10.15.15	10,10,15,15	15,15,10
Lake depth (m) start/end	65/93	30/30	71/85	75/72
Start UTM East	E 415744	E 415155	E 398080	E 397807
Start UTM North	N 5671244	N 5675610	N 5699452	N 5698487
End UTM East	E 415672	E 415229	E 398092	E 397974
End UTM North	N 5670787	N 5675251	N 5699829	N 5698772
Set time	20:30	20:00	19:00	19:30
Retrieval time	10:00	8:40	10:05	8:45
Total time (hrs)	14.33	12.67	14.92	13.25
Net area (m^2)	876	657	876	657
Effort ($ha \cdot hr$)	1.26	0.83	1.31	0.87
Kokanee catch (no)	12	10	22	19
Kokanee CPUE ($no \cdot ha \cdot hr^{-1}$)	9.6	12.0	16.8	21.8

Appendix 7. Gill net catch results for a) Kinbasket and b) Revelstoke reservoirs in Summer of 2014 (note all were overnight (ON) type sets) Note: shading highlights non-kokanee captured in Gillnets.

a) Kinbasket GN catch

Location: Kinbasket **Method:** Pelagic GN **Net Type:** RIC Standard
Net Depth: GN#1 20,20,15,15
Net Description: 6 panels of 15x1.8m end to end **Mesh size:** graduated mesh 25-75mm (stretched)

Gillnet No.	Trans No.	Mon	Day	Net Depth	Fish No.	Spec.	Len.	Weight	Sex	Matur.	Scale Age	Scale No.	Otol. No.	photo
1	17S	7	26	15	1	KO	220	112.1	M	mat	2	SC 1	Oto 1	
1	17S	7	26	15	2	KO	136	26.74		Imm	1	SC 2	Oto 2	
1	17S	7	26	15	3	KO	129	22.28		Imm	1	SC 3	Oto 3	
1	17S	7	26	15	4	KO	205	87.05	F	mat	2	SC 4	Oto 4	TW
1	17S	7	26	15	5	KO	151	35.56		Imm	1	SC 5	Oto 5	
1	17S	7	26	15	6	KO	131	19.6	F	Imm	1	SC 6	Oto 6	
1	17S	7	26	15	7	KO	137	27.69	F	Imm	1	SC 7	Oto 7	
1	17S	7	26	15	8	KO	131	22.23	F	Imm	1	SC 8	Oto 8	
1	17S	7	26	15	9	KO	223	112.52	F	mat	2	SC 9	Oto 9	TW
1	17S	7	26	15	10	KO	240	156.09	F	mat	3	SC 10	Oto 10	TW
1	17S	7	26	15	11	KO	242	142.41	M	mat	3	SC 11	Oto 11	
1	17S	7	26	15	12	KO	245	152.67	M	mat	3	SC 12	Oto 12	
1	17S	7	26	15	13	KO	223	116.33	M	mat	2	SC 13	Oto 13	
1	17S	7	26	15	14	KO	246	139.92	F	mat	2	SC 14	Oto 14	
1	17S	7	26	15	15	KO	135	25.82	F	Imm	1	SC 15		
1	17S	7	26	15	16	KO	135	27.14		Imm	1	SC 16	Oto 16	
1	17S	7	26	15	17	KO	237	134.24	M	mat	3	SC 17	Oto 17	
1	17S	7	26	15	18	KO	208	94.1	M	mat	2	SC 18	Oto 18	
1	17S	7	26	15	19	WF	144	32.83						TW
1	17S	7	26	20	20	KO	191	70.09	F	Imm	2	SC 20	Oto 20	
1	17S	7	26	20	21	KO	171	56.11	F	Imm	1	SC 21	Oto 21	
1	17S	7	26	20	22	KO	184	72.85	F	Imm	1	SC 22		
1	17S	7	26	20	23	KO	132	25.46	F	Imm	1	SC 23	Oto 23	
1	17S	7	26	20	24	KO	239	142.89	F	mat	3	SC 24	Oto 24	
1	17S	7	26	20	25	KO	221	114.63	F	mat	2	SC 25	Oto 25	
1	17S	7	26	20	26	KO	251	149.11	M	mat	3	SC 26	Oto 26	
1	17S	7	26	20	27	KO	231	127.98	M	mat	2	SC 27	Oto 27	
1	17S	7	26	20	28	KO	131	21.42	F	Imm	1	SC 28	Oto 28	
1	17S	7	26	20	29	BT	308	272.77						
1	17S	7	26	20	30	BT	430							
1	17S	7	26	20	31	SU								

Note: non-kokanee species have been highlighted in grey

a) Kinbasket GN catch (continued)

Location: Kinbasket **Method:** Pelagic GN **Net Type:** RIC Standard
Net Depth: GN#2 10,15,15 GN#3 20,20,15,15
Net Description: 6 panels of 15x1.8m end to end **Mesh size:** graduated mesh 25-75mm (stretched)

Gillnet No.	Trans No.	Mon	Day	Net Depth	Fish No.	Spec.	Len.	Weight	Sex	Matur.	Scale Age	Scale No.	Otol. No.	photo
2	17N	7	26	10	32	KO	205	89.04	F	mat	2	SC 32	Oto 32	
2	17N	7	26	10	33	KO	218	106.79	M	mat	2	SC 33	Oto 33	
2	17N	7	26	10	34	KO	203	84.49	F	Imm	2	SC 34	Oto 34	
2	17N	7	26	10	35	KO	225	121.03	F	mat	2	SC 35	Oto 35	
2	17N	7	26	10	36	KO	140	25.41	F	Imm	1	SC 36	Oto 36	
2	17N	7	26	10	37	KO	226	115.89	M	mat	2	SC 37	Oto 37	
2	17N	7	26	10	38	KO	126	19.35		Imm	1		Oto 38	
2	17N	7	26	15	39	KO	240	132.47	F	mat	3	SC 39	Oto 39	
2	17N	7	26	15	40	KO	268	188.92	M	mat	2	SC 40	Oto 40	
2	17N	7	26	15	41	KO	213	104.65	M	mat	2	SC 41	Oto 41	
2	17N	7	26	15	42	KO	236	130.15	F	mat	2	SC 42	Oto 42	
2	17N	7	26	15	43	KO	139	28.92		Imm	1	SC 43	Oto 43	
2	17N	7	26	15	44	KO	176	56.82	M	Imm	1	SC 44	Oto 44	
2	17N	7	26	15	45	KO	130	24.39	F	Imm	1	SC 45	Oto 45	
2	17N	7	26	15	46	KO	140	28.13	F	Imm	1	SC 46	Oto 46	
2	17N	7	26	15	47	KO	230	120.48	F	mat	2	SC 47	Oto 47	
2	17N	7	26	15	48	KO	138	27.49		Imm	1	SC 48	Oto 48	
2	17N	7	26	15	49	KO	130	23.92		Imm	1	SC 49	Oto 49	
2	17N	7	26	15	50	KO	140	26.4	F	Imm	1	SC 50	Oto 50	
2	17N	7	26	15	51	KO	195	75.16	F	Imm	2	SC 51	Oto 51	
2	17N	7	26	15	52	KO	137	25.13		Imm	1		Oto 52	
2	17N	7	26	15	53	KO	122	20.71	M	Imm	1		Oto 53	
2	17N	7	26	15	54	KO	137	24.53		Imm	1	SC 54	Oto 54	
2	17N	7	26	15	55	KO	135	24.1		Imm	1	SC 55	Oto 55	
2	17N	7	26	15	56	KO	130	22.21		Imm	1			
2	17N	7	26	15	57	KO	117	15.82		Imm	1			
3	23W	7	27	15	77	KO	209	92.82	F	mat	2	SC 77	Oto 77	
3	23W	7	27	15	78	KO	250	150.97	M	mat	2	SC 78	Oto 78	
3	23W	7	27	15	79	BT	440							
3	23W	7	27	15	80	BT	441							
3	23W	7	27	15	81	BT	479							
3	23W	7	27	15	82	KO	236	134.78	M	mat	2	SC 82	Oto 82	
3	23W	7	27	15	83	KO	238	135.88	F	mat	3	SC 83	Oto 83	
3	23W	7	27	15	84	KO	210	92.28	F	mat	2	SC 84	Oto 84	
3	23W	7	27	15	85	KO	239	135.01	M	Imm	2	SC 85	Oto 85	
3	23W	7	27	15	86	KO	138	23.61	F	Imm	1	SC 86	Oto 86	
3	23W	7	27	15	87	KO	237	133.27	F	mat	2	SC 87	Oto 87	
3	23W	7	27	15	88	KO	163	44.75	M	Imm	1	SC 88	Oto 88	
3	23W	7	27	15	89	KO	225	117.34	F	Imm	2	SC 89	Oto 89	
3	23W	7	27	15	90	KO	142	30.54	F	Imm	1	SC 90	Oto 90	

a) Kinbasket GN catch (continued)

Location: Kinbasket **Method:** Pelagic GN **Net Type:** RIC Standard
Net Depth: GN#3 20,20,15,15 GN#4 10,15,15
Net Description: 6 panels of 15x1.8m end to end **Mesh size:** graduated mesh 25-75mm (stretched)

Gillnet No.	Trans No.	Mon	Day	Net Depth	Fish No.	Spec.	Len.	Weight	Sex	Matur.	Scale Age	Scale No.	Otol. No.	photo
3	23W	7	27	15	91	KO	251	142.02	M	mat	3	SC 91	Oto 91	
3	23W	7	27	15	92	KO	209	102.87	M	mat	2	SC 92	Oto 92	
3	23W	7	27	15	93	KO	197	76.39	F	Imm	2	SC 93	Oto 93	
3	23W	7	27	15	94	KO	169	48.99	F	Imm	1	SC 94	Oto 94	
3	23W	7	27	15	95	KO	202	89.49	M	mat	2	SC95	Oto 95	
3	23W	7	27	15	97	KO	209	107.57	M	mat	2	SC97	Oto 97	
3	23W	7	27	15	98	KO	177	55.83	M	mat	2	SC98	Oto 98	TW
3	23W	7	27	15	99	KO	187	64.33	M	Imm	2	SC99		
3	23W	7	27	15	100	KO	160	44.21	M	Imm	1	SC100	Oto 100	
3	23W	7	27	15	101	MWF	329	382.47						
4	24E	7	27	15	58	BT	450	600						
4	24E	7	27	15	59	KO	235	115.66	F	mat	2	SC 59	Oto 59	
4	24E	7	27	15	60	KO	236	128.46	M	mat	3	SC 60	Oto 60	
4	24E	7	27	15	61	KO	229	123.18	F	mat	3	SC 61	Oto 61	
4	24E	7	27	15	62	KO	251	149.35	M	mat	4	SC 62	Oto 62	
4	24E	7	27	15	63	KO	232	123.73	F	mat	2	SC 63	Oto 63	
4	24E	7	27	15	64	KO	244	149.01	F	mat	3	SC 64	Oto 64	
4	24E	7	27	15	65	KO	250	161.85	M	mat	3	SC 65	Oto 65	
4	24E	7	27	15	66	KO	209	97.15	M	mat	2	SC 66	Oto 66	
4	24E	7	27	15	67	KO	214	106.63	F	mat	2	SC 67		
4	24E	7	27	15	68	Chub	145	30.95			1			DJ (3)
4	24E	7	27	15	69	KO	151	34.42		Imm	1	SC 69	Oto 69	
4	24E	7	27	15	70	KO	152	34.42		Imm	2	SC 70	Oto 70	
4	24E	7	27	15	71	KO	188	68.53	M	Imm	1	SC 71	Oto 71	
4	24E	7	27	15	72	KO	169	48.2		Imm	1	SC 72	Oto 72	
4	24E	7	27	15	73	KO	163	43.07	M	Imm	1		Oto 73	
4	24E	7	27	15	74	BT	299	256.07						
4	24E	7	27	15	75	BT	365							
4	24E	7	27	15	76	BT	379		F	Imm				

b) Revelstoke GN catch

Location: Revelstoke **Method:** Pelagic GN **Net Type:** RIC Standard
Net Depth: GN#1 10,10,15,15 GN#2 10,15,15 GN#3 10,10,15,15
Net Description: 6 panels of 15x1.8m end to end **Mesh size:** graduated mesh 25-75mm (stretched)

Gillnet No.	Trans No.	Mon	Day	Net Depth	Fish No.	Spec.	Len.	Weight	Sex	Matur.	Scale Age	Scale No.	Otol. No.	photo
1	5	7	30	10	44	KO	199	91.5	M	IMM	1	SC44	Oto 44	
1	5	7	30	10	45	KO	339	455.0	M	MAT	3	SC45	Oto 45	
1	5	7	30	10	46	KO	202	98.0	F	IMM	1	SC46	Oto 46	
1	5	7	30	10	47	KO	293	283.0	F	MAT	2	SC47	Oto 47	
1	5	7	30	10	48	KO	300	311.5	F	MAT	2	SC48	Oto 48	
1	5	7	30	10	49	KO	289	292.0	F	MAT	2	SC49	Oto 49	
1	5	7	30	15	50	KO	346	525.0	M	MAT	4	SC50	Oto 50	
1	5	7	30	15	51	KO	286	283.0	M	MAT	2	SC51	Oto 51	
1	5	7	30	15	52	KO	295	321.0	M	MAT	2	SC52	Oto 52	
1	5	7	30	15	53	KO	319	419.0	M	MAT	2	SC53	Oto 53	
1	5	7	30	15	54	KO	282	285.5	F	MAT	2	SC54	Oto 54	
1	5	7	30	15	55	KO	345	480.0	M	MAT	3	SC55	Oto 55	
1	5	7	30	15	56	BT	276	180.0	F	IMM	2	SC56	Oto 56	
2	6	7	30	10	57	KO	287	289.0	M	MAT	2	SC57	Oto 57	
2	6	7	30	10	58	KO	173	65.0	F	IMM	1	SC58	Oto 58	
2	6	7	30	10	59	KO	216	119.5	F	IMM	1	SC59	Oto 59	
2	6	7	30	10	60	KO	330	408.5	M	IMM	3	SC60	Oto 60	DJ
2	6	7	30	10	61	KO	345	479.5	M	MAT	2	SC61	Oto 61	
2	6	7	30	15	62	KO	287	311.0	M	MAT	2	SC62	Oto 62	
2	6	7	30	15	63	KO	328	397.0	F	MAT	2	SC63	Oto 63	
2	6	7	30	15	64	KO	303	337.0	F	MAT	2	SC64	Oto 64	
2	6	7	30	15	65	KO	261	214.0	F	IMM	2	SC65	Oto 65	
2	6	7	30	15	66	KO	300	332.0	-	-	2	SC66	Oto 66	
3	14S	7	28	10	37	KO	345	499.5	F	MAT	4	SC37	Oto 37	
3	14S	7	28	10	38	KO	357	555.1	F	MAT	3	SC38	Oto 38	
3	14S	7	28	10	39	KO	338	496.6	M	MAT	3	SC39	Oto 39	
3	14S	7	28	10	40	KO	172	58.9	F	IMM	1	SC40	Oto 40	
3	14S	7	28	10	41	KO	263	221.4	F	IMM	2	SC41	Oto 41	
3	14S	7	28	10	42	KO	348	489.1	F	MAT	3	SC42		
3	14S	7	28	10	43	KO	350	512.4	M	MAT	3	SC43	Oto 43	
3	14S	7	28	15	1	KO	328	431.6	M	MAT	3	SC1	Oto 1	
3	14S	7	28	15	2	KO	295	319.7	M	MAT	2	SC2	Oto 2	
3	14S	7	28	15	3	KO	338	504.7	M	MAT	3	SC3	Oto 3	
3	14S	7	28	15	4	KO	262	224.8	M	IMM	2	SC4	Oto 4	
3	14S	7	28	15	5	KO	353	503.5	F	MAT	3	SC5	Oto 5	
3	14S	7	28	15	6	KO	295	332.2	M	MAT	2	SC6	Oto 6	

b) Revelstoke GN catch continued

Location: Revelstoke **Method:** Pelagic GN **Net Type:** RIC Standard
Net Depth: GN#3 10,10,15,15 GN#4 15,15,10
Net Description: 6 panels of 15x1.8m end to end **Mesh size:** graduated mesh 25-75mm (stretched)

Gillnet No.	Trans No.	Mon	Day	Net Depth	Fish No.	Spec.	Len.	Weight	Sex	Matur.	Scale Age	Scale No.	Otol. No.	photo
3	14S	7	28	15	7	KO	293	287.2	M	MAT	2	SC7	Oto 7	
3	14S	7	28	15	8	KO	295	323.7	M	MAT	2	SC8	Oto 8	
3	14S	7	28	15	9	KO	284	304.3	M	IMM	2	SC9		
3	14S	7	28	15	10	KO	285	305.4	M	MAT	2	SC10	Oto 10	
3	14S	7	28	15	11	KO	297	325.8	M	MAT	2	SC11	Oto 11	
3	14S	7	28	15	12	KO	270	232.0	unk	IMM	2	SC12	Oto 12	
4	14N	7	28	10	22	KO	280	289.5	F	MAT	2	SC22	Oto 22	
4	14N	7	28	10	23	BT	350	359.6	M	IMM			Oto 23	
4	14N	7	28	10	24	BT	423	667.2	F	MAT			Oto 24	
4	14N	7	28	10	25	KO	191	84.2	unk	IMM	1	SC25	Oto 25	
4	14N	7	28	10	26	KO	175	66.3	F	IMM	1	SC26	Oto 26	
4	14N	7	28	10	27	KO	268	232.0	M	IMM	2	SC27	Oto 27	
4	14N	7	28	10	28	KO	300	347.4	M	MAT	2	SC28	Oto 28	
4	14N	7	28	10	29	KO	159	50.0	F	IMM	1	SC29	Oto 29	
4	14N	7	28	10	30	KO	269	240.5	F	IMM	2	SC30	Oto 30	
4	14N	7	28	10	31	KO	355	538.8	M	MAT	4	SC31	Oto 31	
4	14N	7	28	10	32	KO	340	480.4	M	MAT	4	SC32	Oto 32	
4	14N	7	28	10	33	KO	339	516.9	F	MAT	3	SC33	Oto 33	
4	14N	7	28	10	34	KO	272	248.8	M	IMM	2	SC34	Oto 34	
4	14N	7	28	10	35	KO	310	353.4	M	MAT	2	SC35	Oto 35	
4	14N	7	28	10	36	KO	290	322.3	M	MAT	2	SC36	Oto 36	
4	14N	7	28	15	13	KO	300	334.9	M	MAT	2	SC13	Oto 13	
4	14N	7	28	15	14	KO	297	351.7	M	MAT	2	SC14	Oto 14	
4	14N	7	28	15	15	KO	266	243.4	F	IMM	2	SC15	Oto 15	
4	14N	7	28	15	16	KO	334	435.3	M	MAT	3	SC16	Oto 16	
4	14N	7	28	15	17	KO	326	468.9	M	MAT	3	SC17	Oto 17	
4	14N	7	28	15	18	KO	349	517.4	M	IMM	4	SC18	Oto 18	
4	14N	7	28	15	19	KO	301	323.0	M	MAT	2	SC19	Oto 19	
4	14N	7	28	15	20	KO	260	211.0	F	IMM	2	SC20	Oto 20	
4	14N	7	28	15	21	KO	158	43.6	unk	IMM	1	SC21		

Appendix 8. Kokanee spawner length, weight and age data for 2014 for a) Camp Creek, tributary to Canoe River, b) Luxor Creek, tributary to Columbia River above Kinbasket Reservoir c) Bush River, tributary to Kinbasket Reservoir d) Upper Columbia near Radium and d) Standard Cr, tributary to Downie Creek and Revelstoke Reservoir (Source: K. Bray, BCH Revelstoke).

a) Camp Creek

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	W (g)	Age[2]
2014	22-Sep	F	225	100	2	22-Sep	M	242	180	2
2014	22-Sep	F	230	120	2	29-Sep	M	265	200	2
2014	22-Sep	F	235	150	2	06-Oct	M	230	160	2
2014	22-Sep	F	235	140	2	06-Oct	M	240	170	2
2014	22-Sep	F	245	150	2	22-Sep	M	252	170	3
2014	29-Sep	F	222	120	2	22-Sep	M	256	250	3
2014	29-Sep	F	223	120	2	22-Sep	M	260	230	3
2014	29-Sep	F	230	110	2	22-Sep	M	265	220	3
2014	29-Sep	F	230	110	2	22-Sep	M	268	220	3
2014	29-Sep	F	247	150	2	22-Sep	M	270	250	3
2014	29-Sep	F	258	120	2	22-Sep	M	270	260	3
2014	06-Oct	F	225	120	2	22-Sep	M	277	252	3
2014	06-Oct	F	230	130	2	22-Sep	M	350	353	3
2014	06-Oct	F	242	150	2	29-Sep	M	250	190	3
2014	06-Oct	F	262	170	2	29-Sep	M	263	250	3
2014	22-Sep	F	250	200	3	29-Sep	M	265	230	3
2014	22-Sep	F	264	220	3	29-Sep	M	270	240	3
2014	22-Sep	F	265	190	3	29-Sep	M	270	260	3
2014	22-Sep	F	270	200	3	29-Sep	M	274	240	3
2014	22-Sep	F	284	200	3	29-Sep	M	280	240	3
2014	29-Sep	F	245	150	3	29-Sep	M	280	250	3
2014	29-Sep	F	254	150	3	29-Sep	M	288	340	3
2014	29-Sep	F	260	180	3	06-Oct	M	254	220	3
2014	29-Sep	F	302	270	3	06-Oct	M	255	180	3
2014	06-Oct	F	245	160	3	06-Oct	M	255	180	3
2014	06-Oct	F	246	150	3	06-Oct	M	260	200	3
2014	06-Oct	F	248	170	3	06-Oct	M	260	210	3
2014	06-Oct	F	260	180	3	06-Oct	M	262	260	3
2014	06-Oct	F	260	200	3	06-Oct	M	263	260	3
2014	06-Oct	F	268	210	3	06-Oct	M	268	230	3
Mean		**F**	**249**	**160**		**Mean**	**M**	**265**	**230**	

b) Luxor Creek

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	W (g)	Age[2]
2014	15-Sep	F	222		2	15-Sep	M	205		1
2014	15-Sep	F	225		2	25-Sep	M	200		1
2014	15-Sep	F	229		2	15-Sep	M	227		2
2014	15-Sep	F	243		2	15-Sep	M	233		2
2014	25-Sep	F	213		2	15-Sep	M	235		2
2014	25-Sep	F	218		2	15-Sep	M	236		2
2014	25-Sep	F	220		2	15-Sep	M	239		2
2014	25-Sep	F	220		2	15-Sep	M	240		2
2014	25-Sep	F	220		2	15-Sep	M	240		2
2014	25-Sep	F	223		2	15-Sep	M	241		2
2014	25-Sep	F	225		2	15-Sep	M	244		2
2014	25-Sep	F	226		2	15-Sep	M	248		2
2014	25-Sep	F	229		2	15-Sep	M	253		2
2014	25-Sep	F	235		2	25-Sep	M	215		2
2014	25-Sep	F	236		2	25-Sep	M	221		2
						25-Sep	M	222		2
						25-Sep	M	227		2
						25-Sep	M	227		2
						25-Sep	M	228		2
						25-Sep	M	232		2
						25-Sep	M	232		2
						25-Sep	M	234		2
						25-Sep	M	250		2
						15-Sep	M	256		3
Mean		**F**	**226**			**Mean**	**M**	**233**		

c) Bush River

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	W (g)	Age[2]
2014	15-Sep	F	215		2	15-Sep	M	220		2
2014	25-Sep	F	219		2	15-Sep	M	241		2
2014	25-Sep	F	220		2	15-Sep	M	241		2
2014	25-Sep	F	220		2	15-Sep	M	242		2
2014	25-Sep	F	228		2	25-Sep	M	228		2
2014	25-Sep	F	232		2	25-Sep	M	230		2
2014	25-Sep	F	237		2	25-Sep	M	255		2
2014	25-Sep	F	253		2	25-Sep	M	261		2
2014	25-Sep	F	231		3	25-Sep	M	237		3
2014	25-Sep	F	234		3	25-Sep	M	241		3
2014	25-Sep	F?			3	25-Sep	M	277		3
Mean		**F**	**229**			**Mean**	**M**	**243**		

d) Upper Columbia River near Radium

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	W (g)	Age[2]
2014	29-Sep	F	219		2	29-Sep	M	216		2
2014	29-Sep	F	224		2	29-Sep	M	219		2
2014	29-Sep	F	230		2	29-Sep	M	220		2
2014	29-Sep	F	231		2	29-Sep	M	220		2
2014	29-Sep	F	232		2	29-Sep	M	224		2
2014	29-Sep	F	233		2	29-Sep	M	225		2
2014	29-Sep	F	233		2	29-Sep	M	225		2
2014	29-Sep	F	234		2	29-Sep	M	226		2
2014	29-Sep	F	235		2	29-Sep	M	227		2
2014	29-Sep	F	237		2	29-Sep	M	227		2
2014	29-Sep	F	238		2	29-Sep	M	229		2
2014	29-Sep	F	241		2	29-Sep	M	230		2
2014	29-Sep	F	245		2	29-Sep	M	231		2
2014	29-Sep	F	248		2	29-Sep	M	232		2
2014	29-Sep	F	253		2	29-Sep	M	234		2
2014	29-Sep	F	256		2	29-Sep	M	234		2
						29-Sep	M	235		2
						29-Sep	M	236		2
						29-Sep	M	236		2
						29-Sep	M	237		2
						29-Sep	M	237		2
						29-Sep	M	239		2
						29-Sep	M	239		2
						29-Sep	M	241		2
						29-Sep	M	242		2
						29-Sep	M	244		2
						29-Sep	M	247		2
						29-Sep	M	250		2
						29-Sep	M	260		2
Mean		**F**	**237**			**Mean**	**M**	**233**		

e) Standard Creek (Revelstoke Reservoir)

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	W (g)	Age[2]
2014	02-Oct	F	320		2	02-Oct	M	315		2
2014	02-Oct	F	327		2	02-Oct	M	325		2
2014	02-Oct	F	327		2	02-Oct	M	325		2
2014	02-Oct	F	328		2	02-Oct	M	327		2
2014	02-Oct	F	348		2	02-Oct	M	329		2
2014	02-Oct	F	368		3	02-Oct	M	331		2
2014	02-Oct	F	373		3	02-Oct	M	334		2
2014	02-Oct	F	380		3	02-Oct	M	334		2
2014	02-Oct	F	381		3	02-Oct	M	338		2
						02-Oct	M	339		2
						02-Oct	M	340		2
						02-Oct	M	375		3
Mean		**F**	**350**			**Mean**	**M**	**334**		

Appendix 9. Kokanee spawner mean length by age data from Camp Creek, Luxor Creek, Upper Columbia near Radium and Bush River (Kinbasket Reservoir) and Standard Creek (Revelstoke Reservoir) (Source: K. Bray, BCH Revelstoke).

System/ Tributary	Year	Sample Date(s)	Age 2+ spawners			Age 3+ spawners			%
			Mean	S.D.	n	Mean	S.D.	n	age 3+
Kinbasket									
Camp Cr	1998	Sep 28-Oct 17	238	9.0	62	264	7.9	15	19
	2000	Sep 24-28	244	9.5	47	267	9.7	13	22
	2001	Sep 23-25	242	8.4	30	264	10.9	30	50
	2002	Sep 28-Oct 17	265	12.3	7	278	11.2	53	88
	2003	Sep 28-Oct 17	250	6.0	21	277	9.0	39	65
	2004	Sep 25	235	14.5	43	257	15.9	17	28
	2005	Oct 4	242	6.6	32	253	8.2	27	46
	2006	Sep 25	226		1	277	10.7	59	98
	2007	Sep 29				273	13.6	60	100
	2008	Sep 28, Oct 4	223	15.6	11	253	8.7	19	63
	2009	Sep 29	223	10.3	30				0
	2010	Sep 30	228	10.6	60				0
	2011	Sep 23	237	7.8	28	244	1.4	2	7
	2012	Sep 29	247	9.4	4	265	10.7	26	87
	2013	Sep 13,19 &26	264	6.3	15	283	10.3	34	69
	2014	Sep 22,29, Oct 6	238	13.0	19	266	18.0	41	68
	Mean		240			266			51
Luxor Cr	2007		249	8.4	27	268	3.2	4	13
	2009		209	11.0	30				0
	2010		224	9.2	29	244		1	3
	2011		223	10.3	10				0
	2012	Sep 25	233	8.3	24	247	5.3	5	17
	2013	Sep 13,20 &26	252	6.7	41	264	10.3	6	13
	2014	Sep 15 & 25	231	10.0	36	256		1	3
	Mean		232			256			7
Bush R	2013	Sep 20 &26	259	8.3	34				0
	2014	Sep 15 & 25	234	14.1	16	244	18.8	6	27
Upper Columbia	2014	29-Sep	234	10.1	45			0	0
Revelstoke									
Standard Cr	2007		292	10.6	22	329	11.9	10	31
	2009		263	10.7	14	306		1	7
	2010		264	11.8	9	293		1	10
	2011		260	7.5	14	277	5.5	6	30
	2012	Sep 27	265		1	280	8.4	14	93
	2013	Oct 4	332	11.9	5	340	5.7	5	50
	2014	02-Oct	330	8.3	16	375	5.3	5	24
	Mean		287			314			

Note: only one age 4+ spawner at 260mm in 2005 and rating very low so excluded from this table
Note: two very small males in Luxor in 2014 were thought to be age 1+ (very unusual)

Appendix 10. Spawner counts for three key index tributaries on Kinbasket Reservoir and main spawning area for Revelstoke Reservoir

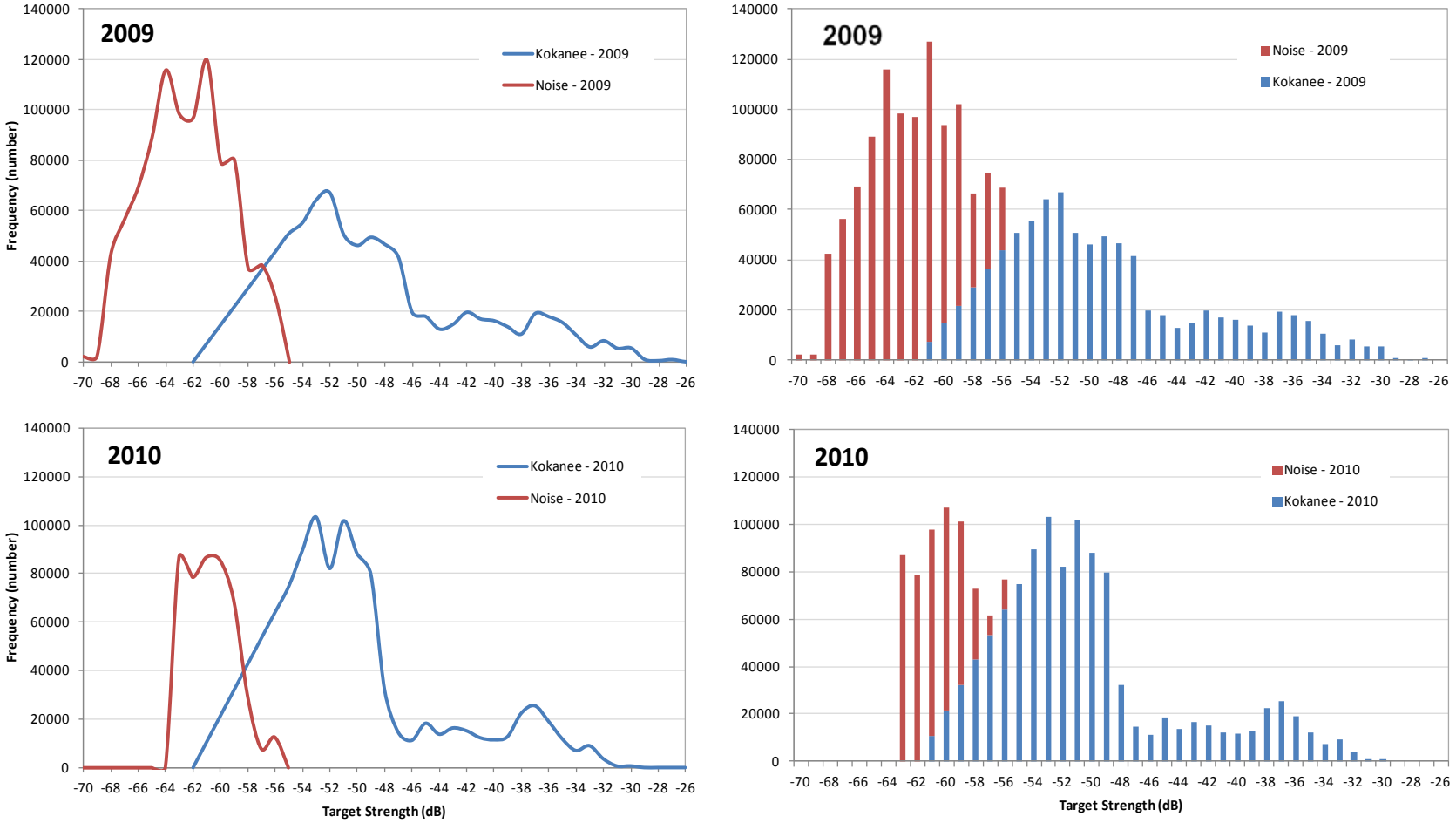
Year	Kinbasket			Revelstoke	Comments/conditions
	Camp Creek	Bush River	Luxor Creek	Downie/Standard	
2000	7,450		40,450	470	
2001	18,000	15,150	56,225	690	
2002	11,000	16,601	51,925	7,735	
2003	16,900	20,900	68,900	7,435	Dry year, low flows (good viewing conditions)
2004	13,500		20,000		Heavy fall rains, turbid conditions
2005	25,000	39,250	19,700	9,810	
2006	22,944	14,150	46,000	5,460	Dry year with low water
2007	19,125	25,936	*900*	10,175	Poor weather on Luxor (Upper Columbia survey)
2008	13,500	27,150	19,480	14,350	
2009	8,850	19,280	9,510	6,320	Good viewing conditions
2010	10,825	17,800	*1,300*	*1,600*	Wet fall, turbid conditions, Beaver Dam on Luxor
2011	4,800	22,100	20,000	*950*	High pool backflooded some off channel areas
2012	5,000	19,530	9,100	*200*	High water and turbid conditions
2013	15,500	58,600	*4,200*	*5,780*	Luxor did not include section above highway
2014	20,600	48,380	18,710	*300*	Standard Cr only (Downie Cr turbid)
Average	14,200	26,525	31,667	6,823	
Standard Dev.	6,277	13,781	20,033	4,206	
	(± 44%)	(± 52%)	(± 63%)	(± 62%)	
Range (± 1 SD)	(7923-20476)	(12744-40306)	(11634-51700)	(2617-11029)	

Note: blanks indicate no sampling

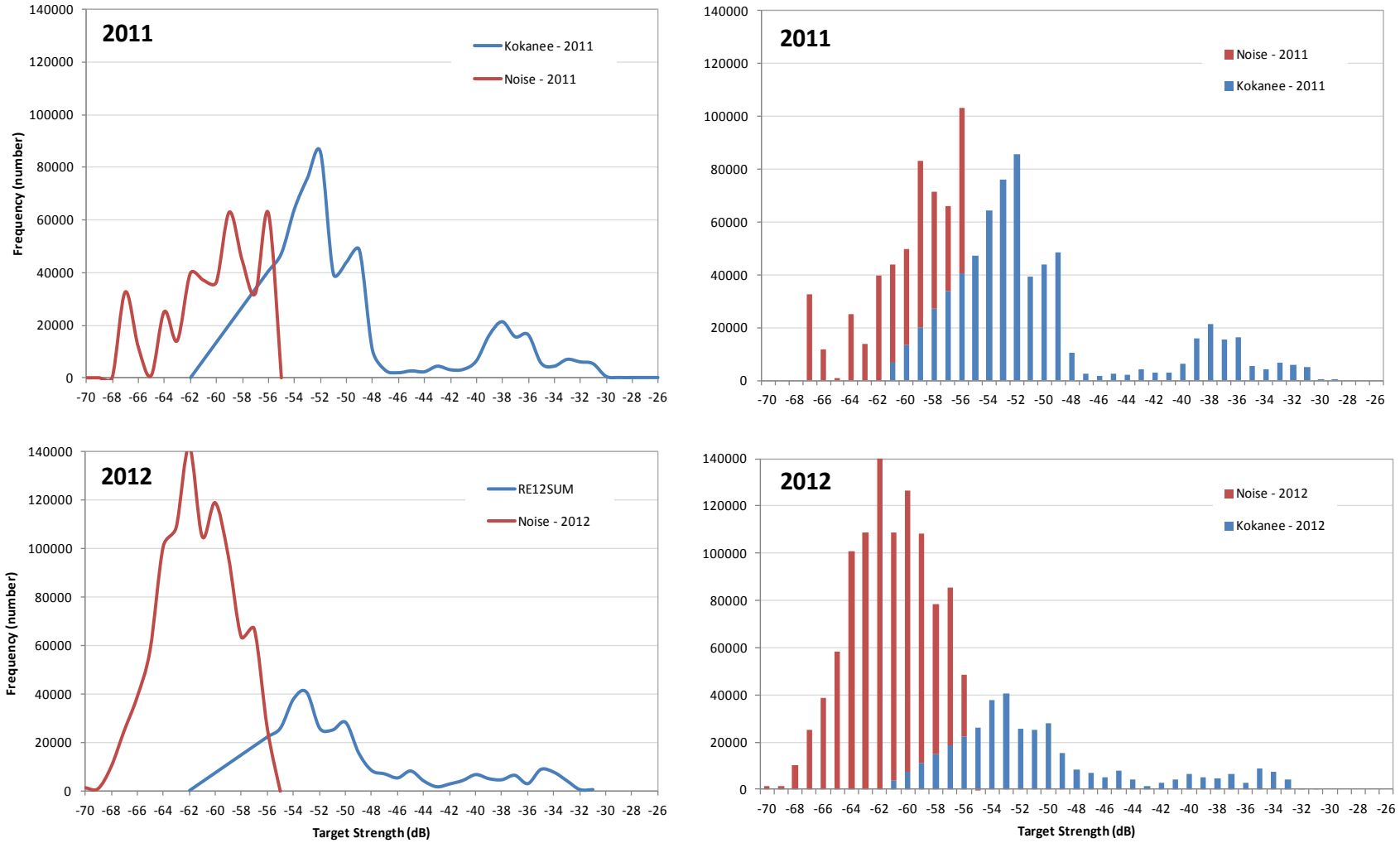
Note: red font indicates partial counts (eg 2010-12 and 2014 only Standard Creek counted as Downie was too turbid)

Partial counts have not been included in calculating average and ranges

Appendix 11. Acoustic target strength (TS) distributions showing the result of linear noise reduction technique for separating low end noise from kokanee fry in Revelstoke Reservoir for 2009-2014 surveys. Note: the noise level was much higher relative to fish abundance in 2009 and 2012 than other years.



Appendix 11 – continued



Appendix 11 – continued