Columbia River Project Water Use Plan

Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring

Implementation Year 5

Reference: CLBMON-2

Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring – Progress Report Year 5

Study Period: 2012

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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 5 (2012)

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 fifth year of a proposed twelve year study to monitor kokanee in the limnetic habitat of two Columbia Basin reservoirs, Revelstoke and Kinbasket, during the end of July and the beginning of August 2012. 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 2012 field survey in relation to previous years of trend data. The same survey design, methods and equipment were employed, however due to extreme debris conditions in Kinbasket during 2012, several transects were run with lights on.

In June 2012, Addendum 1 was created for the Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring (CLBMON-2) Terms of Reference. The addendum added a task to include escapement monitoring and biological sampling at established index streams in Kinbasket and Revelstoke Reservoirs each fall.

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. 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. Software settings were tested and refined over the winter of 2009-10 in order to ensure results are comparable to the existing time series dataset which was collected over a period of 10 years with a Simrad EY200P single beam echosounder operating at 70kHz as described in Sebastian et al (2010; 1995). Transect echograms were viewed and some 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. 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.

Trawl sampling on Kinbasket and Revelstoke reservoirs 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 and 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.

Pelagic gillnetting was completed at four locations on Revelstoke Reservoir with float lines set at 10, 15 and 20 meter depths (from the surface) on the first set and 10 and 15m depths on all following sets. Nets were located near the east bank at transects 5, on the east side at transect 6 north of Martha Creek, on a 60m deep shelf toward the west side at transect 12 and in the center of Downie Arm at (old) Transect 16 (Fig. 1). No attempts were made to set nets in the thalweg of the lower basin where depths were 100+m. Instead, nets were set in slightly shallower water at depths of 30-70m assumed to represent pelagic habitat.

Pelagic gillnets 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 218.8m^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 10 15 and 20m (from the surface) using a series of clip on floats with pre-measured lines of 10, 15 and 20m 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.

Temperature and dissolved oxygen profiles were obtained using a Seabird water profiler unit. Seabird casts were made at four locations in Kinbasket Reservoir; in the Forebay area at Transect 10, Lower Canoe Reach at transect 8, Wood Arm at transect 19 and Columbia Reach at the outlet of Old Kinbasket Lake between transects 22 and 23. Revelstoke Reservoir Seabird casts were conducted at two locations; Transect 6 in the Lower Basin and (new) Transect 13 near the Powerline crossing of the Middle Reach (**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). Escapement counts have been conducted 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. Based on work done by Oliver (1995) the above list of index streams was initially selected as representing ~95% of total annual escapement for Kinbasket Reservoir. On Revelstoke Reservoir kokanee counts were conducted on seven streams in the 1990s while only a single stream system, Downie Creek and its tributary Standard Creek, continue to be enumerated as an index of escapement for Revelstoke Reservoir.

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. Due to external circumstances, from 2010 onward one of the key areas with the highest annual counts (i.e. Upper Columbia River) could no longer be enumerated by helicopter so is no longer available as an index. The three Kinbasket tributaries with the most complete and consistent datasets provide the best indices of kokanee abundance annually; these include Camp Creek at the north end, Bush River at the south end of the reservoir, and Luxor Creek, tributary to the Upper Columbia River approximately halfway between Columbia Lake and Kinbasket Reservoir. The 2012 counts were compared with the average for the previous eleven years of record (2001-2011). Due to extreme year to year variability in counts and viewing conditions, a range of ± one standard deviation of the 11 year average was considered to represent "average" returns.

Biological sampling of spawners captured by dip-net or angling has been conducted at Camp Creek (1998, 00-12) and Luxor Creek (2007, 2009-12) for Kinbasket Reservoir and at Standard Creek (2007, 2009-12) for Revelstoke. Sex, fork length, and age data were collected for estimating mean length and age composition, relying on otolith analyses following protocols outlined in Casselman (1990). A small sample of angler caught fish (n=5) from May and June 2012 were available for length measurements, however were not included in average size at age calculations since they were sampled 6-7 weeks prior to trawl and gillnet sampling.

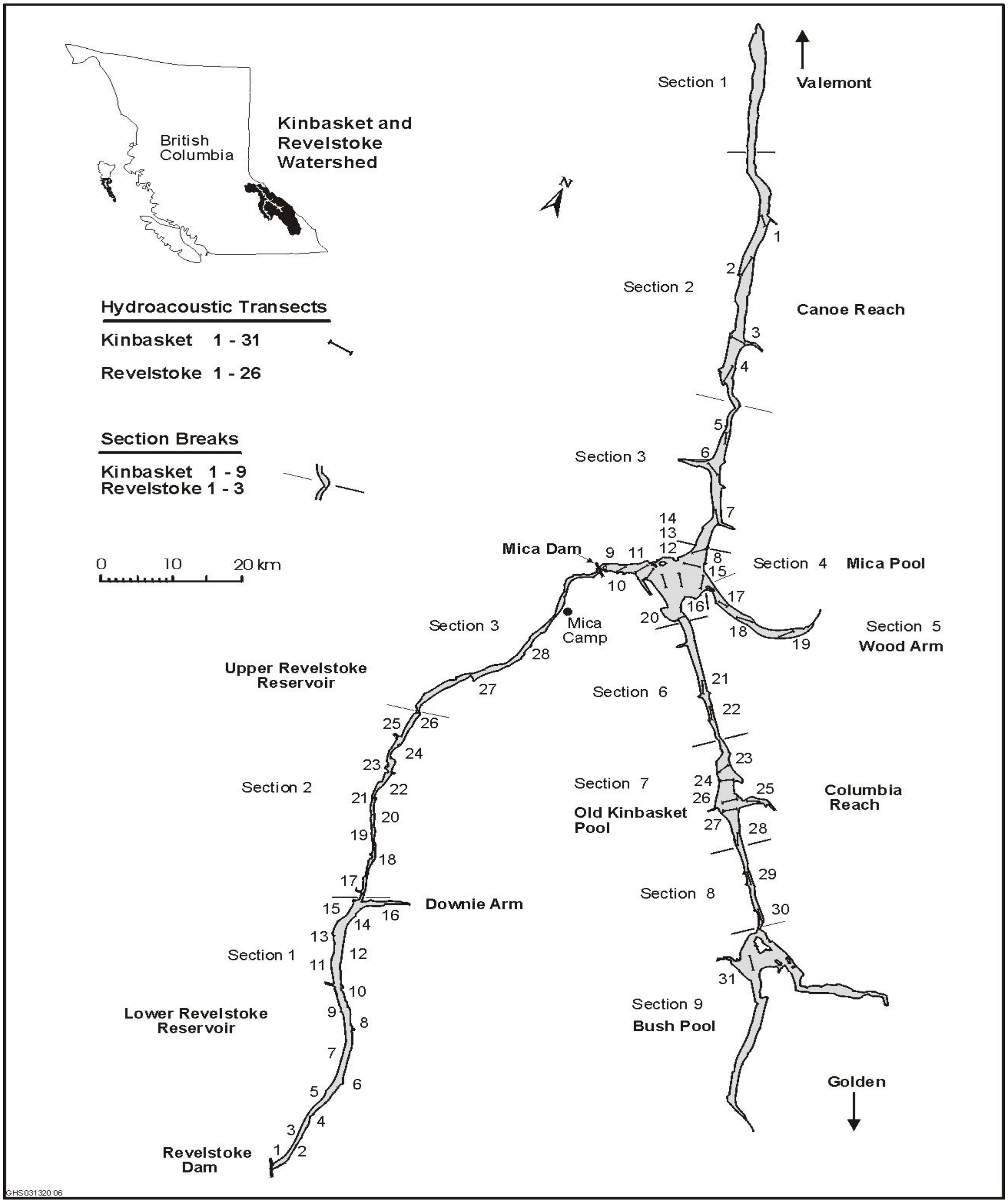


Figure 1. Map of Kinbasket and Revelstoke reservoirs showing location of reaches and acoustic transects. *Note: While transect locations for Revelstoke remain unchanged, transect numbers have been revised. See Appendix 2 for how old and new transect numbers relate.

Results and Discussion

Survey timing, general flow conditions, pool elevation and habitat

Acoustic and trawl surveys (ATS) in 2012 were conducted August 12-15 on Revelstoke Reservoir and August 16-20 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 2012 the maximum monthly discharge of 738 $m^3 \cdot sec^{-1}$ was 144% of the long-term average of 512 $m^3 \cdot sec^{-1}$ (**Fig. 2**). This was the highest monthly maximum discharge in 33 years indicating the extreme nature of the summer freshet in July 2012. The mean annual discharge of 208 $m^3 \cdot sec^{-1}$ was 127% of the average of 164 $m^3 \cdot sec^{-1}$ (n=38 yrs) (**Fig. 3**). These records indicate that 2012 was the second wettest year since Mica Dam was built exceeded only by 1976. 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.

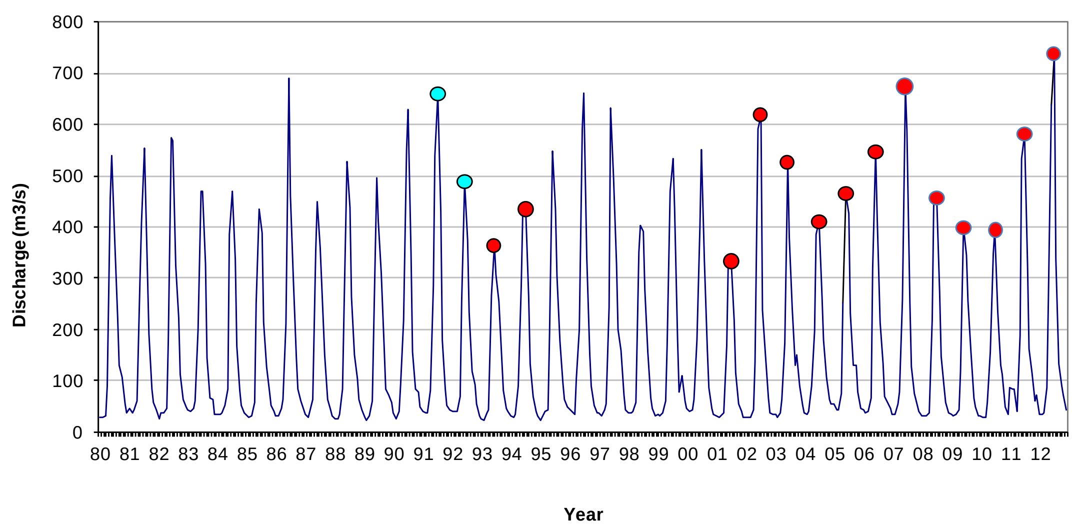


Figure 2. Monthly mean flows for unregulated Columbia River inflows to Kinbasket Reservoir at Donald Station (08NB005) near Golden BC. Note that red circles indicate study years with standardized ATS survey design, blue circles indicate non-standard preliminary survey years.

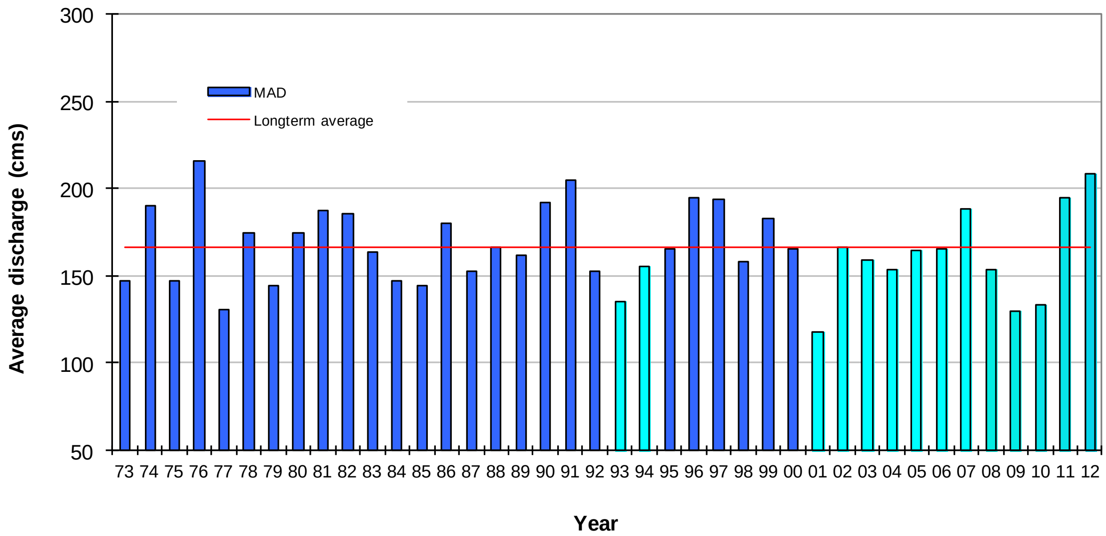


Figure 3. Mean Annual Discharge (MAD) of unregulated Columbia River inflows to Kinbasket Reservoir based on Water Survey of Canada station 08NB005 near Golden BC. The red line indicates the average annual flow of 166 cms since construction of Mica Dam in 1973.

The average pool elevation of Kinbasket Reservoir during the time of the survey was 754.43m above sea level or an average of 5cm above the normal full pool level of 754.38m. The pool elevation was 754.38m at the start of the survey on August 16th and rose 10cm over the 5 day survey period. Following the survey, the pool elevation continued to rise another 21cm to reach a maximum of 754.695 m on August 29. The surcharging (i.e. beyond normal high water) was estimated at 31.5cm in 2012. With pool elevation beyond the normal full level, woody debris of all sizes floated off from shore and was extensive throughout the reservoir (**Fig. 4**). As a result, navigation was difficult at night and many transects had to be run with the lights on. It is not known if illumination from boat running lights affect fish distributions near the boat at night. The pool elevation resulted in an estimated full pool pelagic area of 23,735 ha for the reaches surveyed and 32,020 ha for the entire reservoir (**Table 1**).

Figure 4. Photo showing extensive floating debris covering main basin and lower Canoe Reach of Kinbasket Reservoir on August 17th, 2012.

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

Section	Location/ Description	Full pool[1] Surface area (ha)	Full pool[2] Pelagic	2012[3] Pelagic area (ha)	Pelagic[4] % reduced
	Kinbasket Reservoir				
1	Canoe Reach Valemont to 40m contour	2,400	1,305	1,305	0
2	Canoe Reach 40m contour to narrows	4,560	4,060	4,060	0
3	Canoe Reach - narrows to Mica pool	4,900	4,360	4,360	0
4	Mica Pool above dam	6,940	5,580	5,580	0
5	Wood Arm	2,020	1,560	1,560	0
6	Mica Pool to Old Kinbasket Lake	2,120	1,805	1,805	0
7	Old Kinbasket Lake	5,270	5,055	5,055	0
8	South Columbia Reach	1,500	1,315	1,315	0
9	Bush Pool to Upper Columbia River	11,350	6,980	6,980	0
Total		41,060	32,020	32,020	0
2-8	***Total surveyed***	***27,310***	***23,735***	***23,735***	0
	Revelstoke Reservoir				
1	Main basin - dam to Downie Cr	6,100	5,250	5,250	0
2	Narrows - Downie to Nicholls Cr	3,100	2,000	2,000	0
3	Riverine - Nicholls Cr 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 = 754.38m
2. Full pool pelagic area = area at 20m or greater depth at full pool
3. 2012 pelagic area for Kinbasket is area at 754.43m pool elevation and 20m or greater depth
4. Percent reduction of pelagic area over full pool estimates due to lower pool elevation

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

Year	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	23,067
2006	August 19-20	751	3	23,234
2007	August 8-10	754	0	23,735
2008	July 28-Aug 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	23,735

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

Water temperature

Water temperature profiles were measured at four stations on Kinbasket Reservoir in 2012 and include the Forebay, Lower Canoe, Wood Arm and the Columbia Reach just below the outlet of Old Kinbasket Lake. All profiles were remarkably similar showing a lack of distinct stratification with a steady decline in temperature from the surface to a depth of about 60m (**Fig. 5b**). The failure to form sharp temperature stratification is likely due to the combination of high flows and possibly continuous wind mixing. A surface temperature of 19-20°C in 2012 was 2-4°C warmer than 2011 (**Fig. 5a**) and other years since 2008 and may indicate less wind mixing than most years. As in previous years the water temperature in the main basin declined to below 4°C by about 70-80m depth.

Temperature profiles in Revelstoke Reservoir in 2012 at the time of survey showed a wide variation between the Lower and Middle basins. The Lower basin had a typically warm surface temperature of nearly 17°C showing some thermal stratification with temperatures declining to about 8°C by 60m depth. By contrast, the narrower “Middle” reach was nearly isothermal at 9.7-11.0°C from the surface to a depth of 60m (**Fig 5d**). The relatively cool temperatures in the middle reach were likely the result of high outflows from Revelstoke tributaries combined with higher than average outflows of cool sub-surface water from Mica Dam.

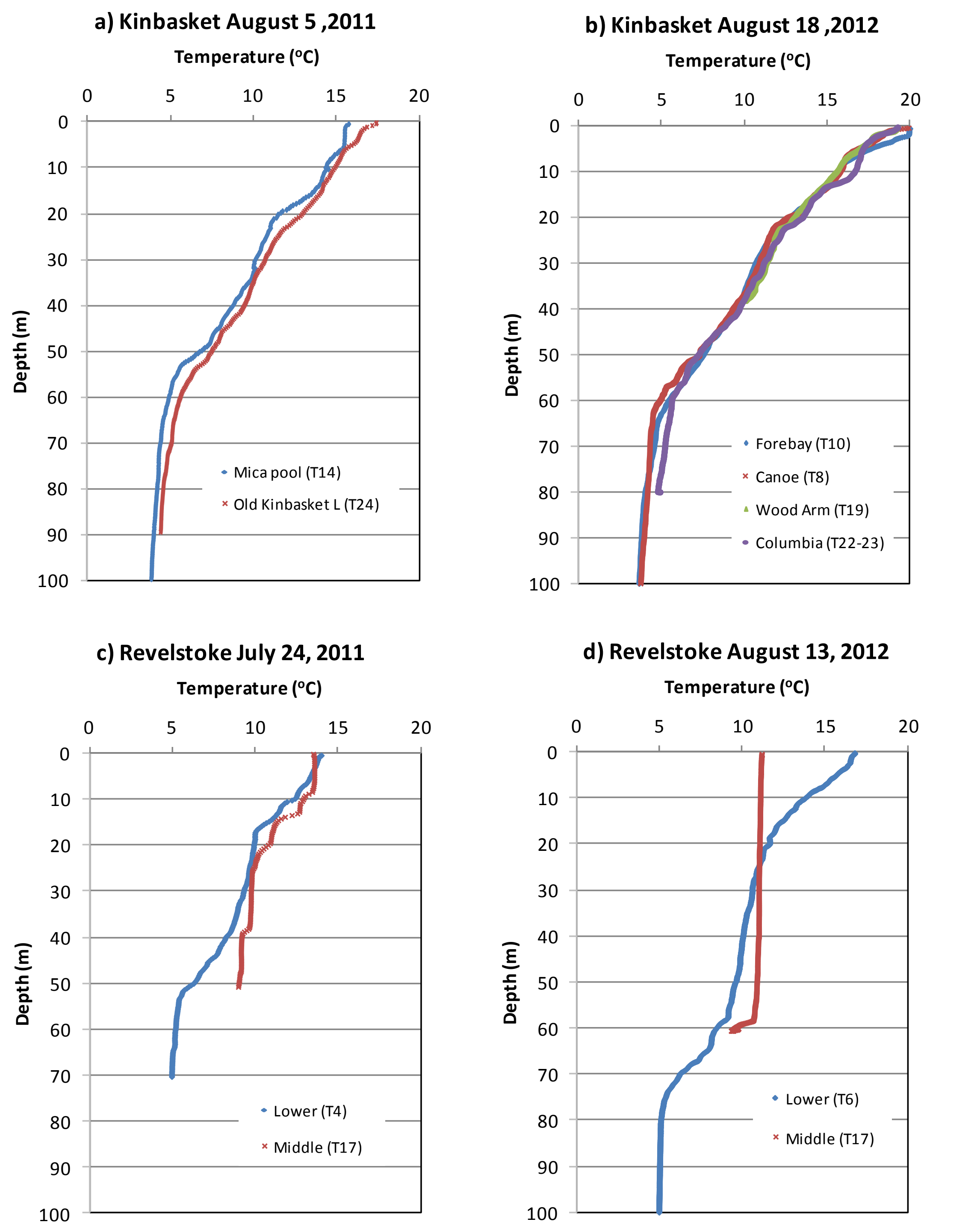


Figure 5. Plots comparing 2011 and 2012 water temperature profiles by location for Kinbasket and Revelstoke reservoirs. Note: Middle reach of Revelstoke Reservoir was nearly isothermal to 57m presumably as a result of high flows in summer of 2012.

Kokanee Distribution

The majority of kokanee in Kinbasket Reservoir were found over a depth range of 13-30m where temperatures ranged from 11-15°C (**Figs. 5b and 6a**). Even though densities varied over the length of Kinbasket, the contour plots indicate that the fish layer did not change much in depth over the length of the reservoir. This was consistent with temperature profiles which were very similar at four different locations.

In Revelstoke, the majority of fish in the Lower Basin were found slightly shallower than in Kinbasket at depths of 7-20m, coinciding with a temperature range similar to Kinbasket at 12-15°C (**Fig 5b**). Upstream in the Middle Reach, transects 13-20 (old transect #'s 17-26 see Appendix 2), the fish did not appear to be layered and were dispersed randomly from near the surface to a depth of 40+m where temperatures were isothermal at 11.0 to 11.2°C (**Figs. 5b and 6b**).

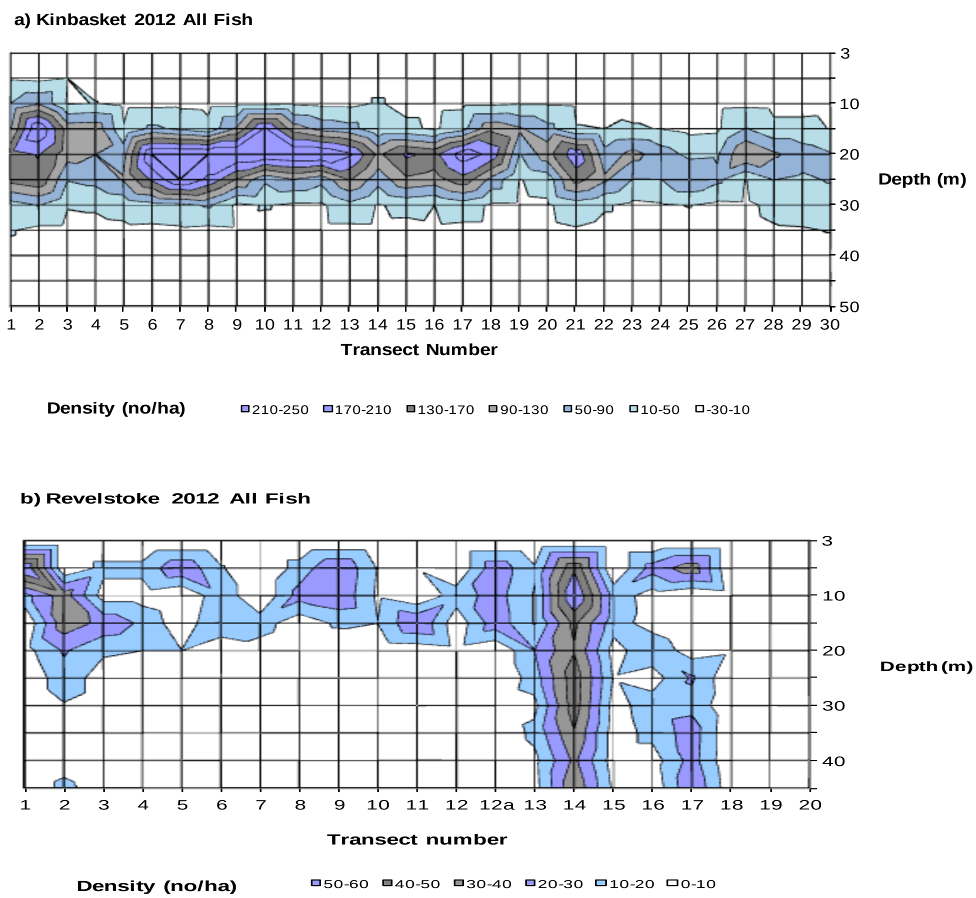


Figure 6. Contour plots showing kokanee distribution by depth and transect for a) Kinbasket and b) Revelstoke reservoirs based on 2012 acoustic surveys. Note that density (no/ha) scales are different between the two basins as a result of major differences in fish abundance.

Fish density at individual transects in Kinbasket Reservoir ranged from 106 fish·ha^{-1} at Transect 26 in old Kinbasket Lake to 761 fish·ha^{-1} at Transect 2, near the upstream end of Canoe Reach (**Fig. 7a**). The longitudinal profile shows a gradient of increasing fish density from south to north. Compared with the long-term average (shown in red) densities were lower throughout the Columbia Reach (T22-T30) and higher than average at the north end. In the main pool densities typically are lowest at the dam and increase toward the eastern shore. In 2012 however, the opposite was true with fairly low densities on the east side and center of the main pool and increasing densities toward the outlet at Mica Dam. This difference in distribution near Mica Dam may be the result of increased flows at the dam due to a combination of high water and a later than average survey time. The later survey time gives kokanee fry more time to disperse from their recruitment sites.

The longitudinal distribution in Revelstoke Reservoir was much different than average in 2012 with densities of well below 100 fish·ha^{-1} at all but 3 transects (**Fig. 7b**). Lowest densities were found in the main basin (Forebay and Lower Reaches; Transects 1-12) while highest densities were found in the narrow

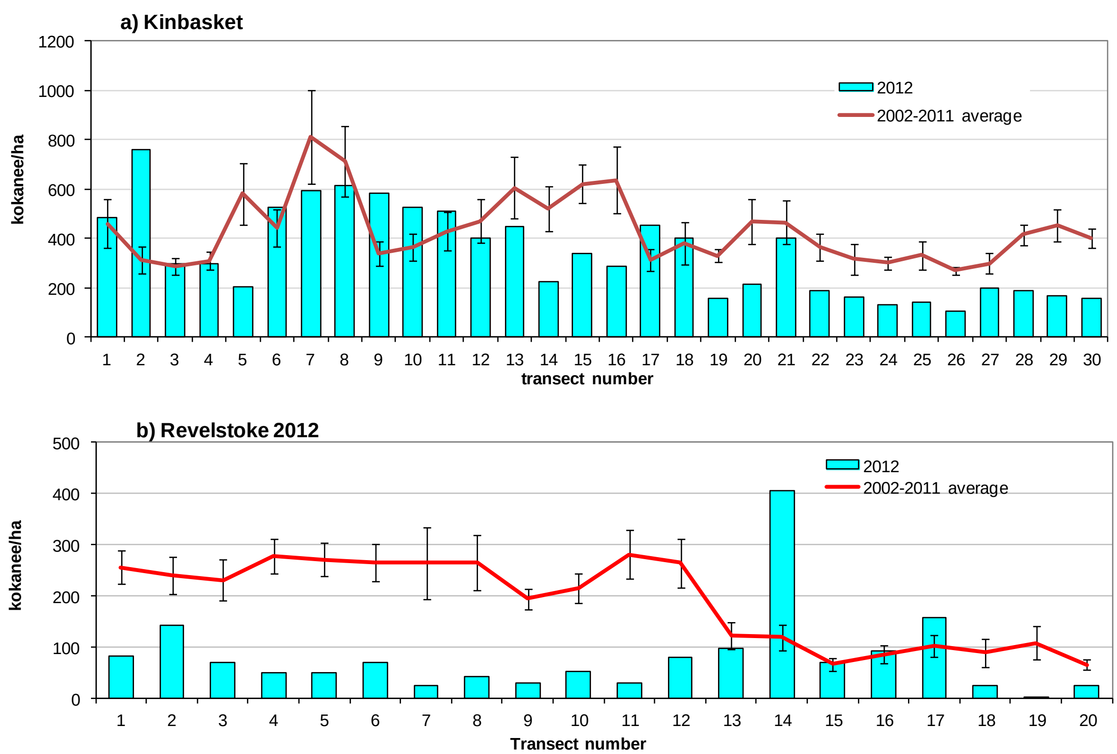


Figure 7. Longitudinal density distributions for kokanee in a) Kinbasket and b) Revelstoke reservoirs based acoustic surveys. Note the long term average transect densities for 2001-2011 are shown by the red line. Error bars represent the 95% confidence limits (± 2 standard errors) on the ten year mean.

Middle Reach (Transects 13-20). The red line on Figure 7 shows that on average fish densities have been about 3 times higher in the lower basin and forebay areas compared to the narrower middle reach. Given that densities were highest in the riverine reach, it seems likely that fry were being concentrated as the channel narrowed indicating that fish may have been moving down from upstream areas. This could possibly be an indication that entrainment at Mica may have been higher than average leading up to the time of survey in 2012. The unusually low densities in the Lower basin and Forebay Reaches suggest that fry recruitment from Downie Creek (the main recruitment area) was down considerably. Other factors possibly contributing to low fry numbers in Lower Revelstoke during 2012 may include higher than average entrainment at Revelstoke Dam due to extremely high freshet flows, and the exclusion of some of the smaller fry due to the higher threshold used to reduce noise in the data. The increased threshold reduced the number of targets by 300,000; however the majority of these echoes appeared to be too small to be kokanee fry. See the section on Methods Development for further details on separating acoustic noise from the smallest kokanee fry.

Kokanee Abundance

Total kokanee abundance in Kinbasket Reservoir for 2012 was estimated at 7.82 (6.95-8.77) million (**Fig. 8a, Appendix 3a**) and represented a statistically significant increase over 2011. The 2012 population was returning to average levels and fell within the bounds of the previous 10 year average of 9.72 ±2.03 million.

The acoustic size distribution showed a size break at -44 dB between age 0+ (fry sized fish) and age 1-3+ fish in Kinbasket Reservoir. The resulting abundance estimate for fry was 6.60 (5.80-7.48) million and for age 1-3+ fish was 1.21 (1.03-1.40) million (**Fig. 9a, Appendix 3b & 3c**). Kokanee abundance (driven largely by fry density) had previously been declining for four consecutive years from very high fry production levels in 2007. The decline is largely attributed to a shift in spawner age composition from 3+ spawners in 2006-07 to mostly age 2+ spawners during 2009-11 resulting in reductions in average size, fecundity and egg deposition. The age 1-3+ abundance in 2012 was the second lowest on record and originated from the lowest fry abundance (i.e. 2011) in the last 12 consecutive years of monitoring.

The estimated total abundance of kokanee in Revelstoke Reservoir was only 0.46 (0.36 – 0.57) million in 2012 (**Fig. 8b, Appendix 4a**). This was only about one third of the previous eleven year average of 1.37 ± 0.23 million and was the lowest abundance measured over the past 12 years. The acoustic size distribution was used to apportion the fish population into two size groups corresponding to age 0+ (fry sized fish) and 1-3+ fish with a break evident at a size of -46dB. Fry abundance was estimated at 0.38 (0.29-0.49) million and age 1-3+ fish at 0.67 (0.44-0.90) million (**Fig. 9b, Appendix 4b and c**). Due to excessive low end noise in Revelstoke Reservoir, it was necessary to elevate the lower threshold to -58dB from the typical -61dB. It is likely that fry abundance has been under estimated since some of the smallest fry may be below this threshold. Interestingly, both the age 0 and age 1-3 groups declined to about one third of the long term average in 2012. The observation that changes in abundance occur simultaneously across age groups rather than following cohorts through their life cycle makes Revelstoke different than many other kokanee producing systems. Whatever is controlling kokanee abundance appears to affect (i.e. limit) all ages of kokanee at the same time.

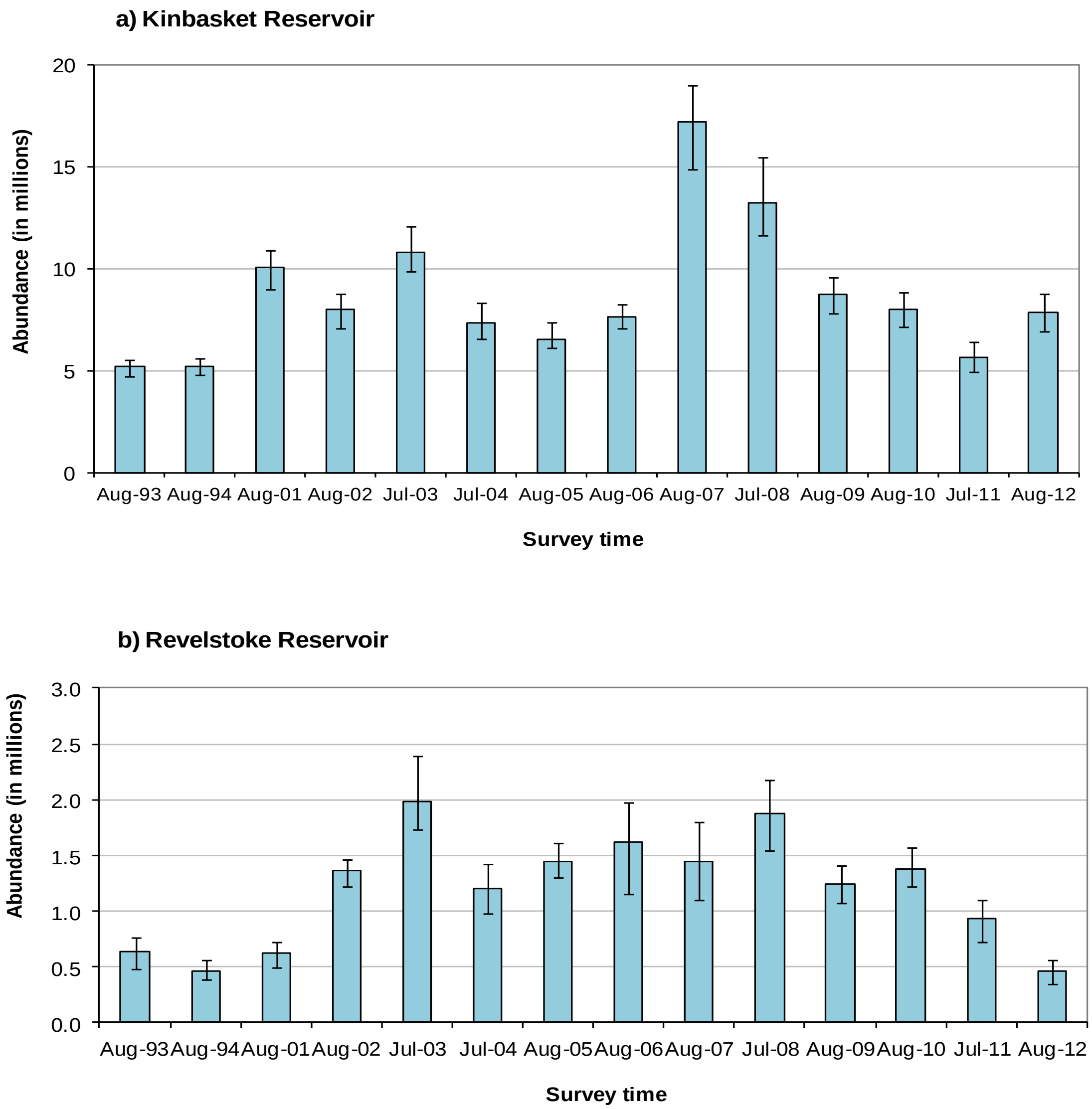
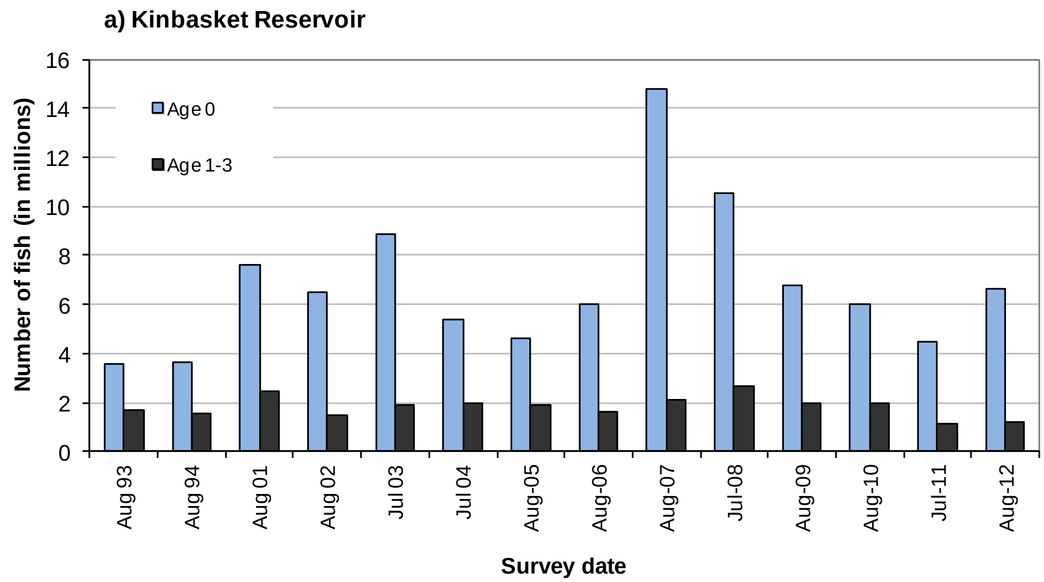


Figure 8. Kokanee trends in total abundance (all ages) in a) Kinbasket and b) Revelstoke reservoirs based on acoustic surveys, 1993-94 and 2001-2012. Note: error bars denote 95% confidence limits on maximum likelihood estimates.



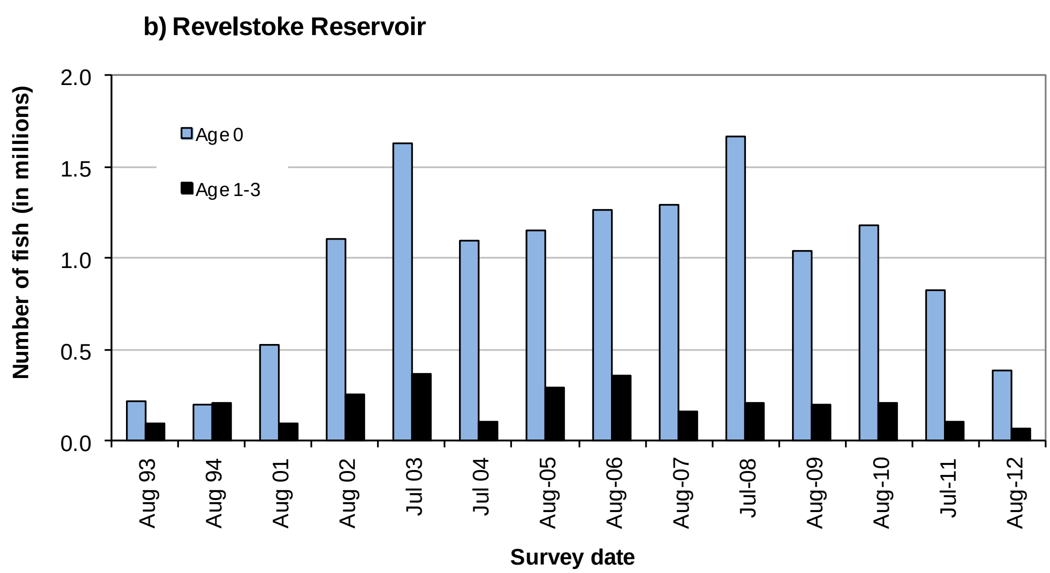


Figure 9. Abundance trends for age 0+ and age 1-3+ kokanee in a) Kinbasket and b) Revelstoke reservoirs based on mid-summer acoustic surveys, 1993-94 and 2001-2012.

In Revelstoke Reservoir, the numbers of age 1-3+ kokanee can vary considerably (e.g. from -54% to plus 63% of the mean). Although kokanee populations in other lakes can show this level of variation, the changes are typically more gradual, whereas large fluctuations in Revelstoke populations have occurred in adjacent years. This, along with the extremely low numbers of spawners, leads to the tentative conclusion that population levels must be influenced by entrainment at upper and lower ends (i.e. both immigration and emigration). It is hoped that continuous time series information will assist in better understanding the role that entrainment and dam operations play in these populations.

Kokanee size at age from trawl and spawner sampling

Trawl sampling was conducted on Kinbasket Reservoir to obtain fish samples for determining size at age and species composition to assist in interpreting acoustic data. Trawling was targeted on sampling the densest portion of the fish layer in order to maximize catch. Consequently catches were not expected to reliably represent age class proportions, especially since age classes may not have been distributed uniformly by depth at the time of survey. Two one-hour trawls were completed on Kinbasket Reservoir and a total of 206 kokanee were caught. The absence of other species indicates that the large majority of fish detected by acoustics in mid-water habitat at night were kokanee (**Appendix 5a**). The kokanee catch consisted of 202 fry, three age 1+ and only one age 2+ (**Table 3**). Fry averaged 46 ±1 mm, slightly larger than the 2010 and 2011 surveys which were completed in early August. Age 1+ fish were 166 ±11 mm and the single age 2+ fish was 201mm, both very similar to the size at age from 2010 and 2011 trawl sampling.

Table 3. Kokanee length and weight data by age from August 2012 trawl sampling in Kinbasket Reservoir and from spawner sampling in Camp and Luxor creeks during late September 2012.

Type of sampling	Age*	FL (mm)	FL range (mm)	S.D.	N (FL)	WT (g)	S.D. (WT)	N (WT)
Trawl	0+	46	26-72	8.5	202	1.7	0.7	201
Trawl	1+	166	156-174	9.2	3	52.3	8.2	3
Trawl	2+	201			1	98.6		1
Spawner[1]	2+	235	212-260	9.7	28	152.5	32.0	4
Spawner[1]	3+	262	238-290	12.2	31	213.5	55.6	26
					265			235

1. Spawner statistics based on combined samples from Camp and Luxor creeks

Figure 10 compares the length frequency distributions by age for trawl captured kokanee and returning spawners during 2010, 2011 and 2012 with cumulative catches during 2001-2005. Note that frequencies are presented as percentages within each age group to get around the problem of large variations in sample sizes (i.e. 1 to 785).

Often the frequency distribution of 2+ fish from the trawl can be used to verify spawner ages, however this approach was of limited use in Kinbasket due to

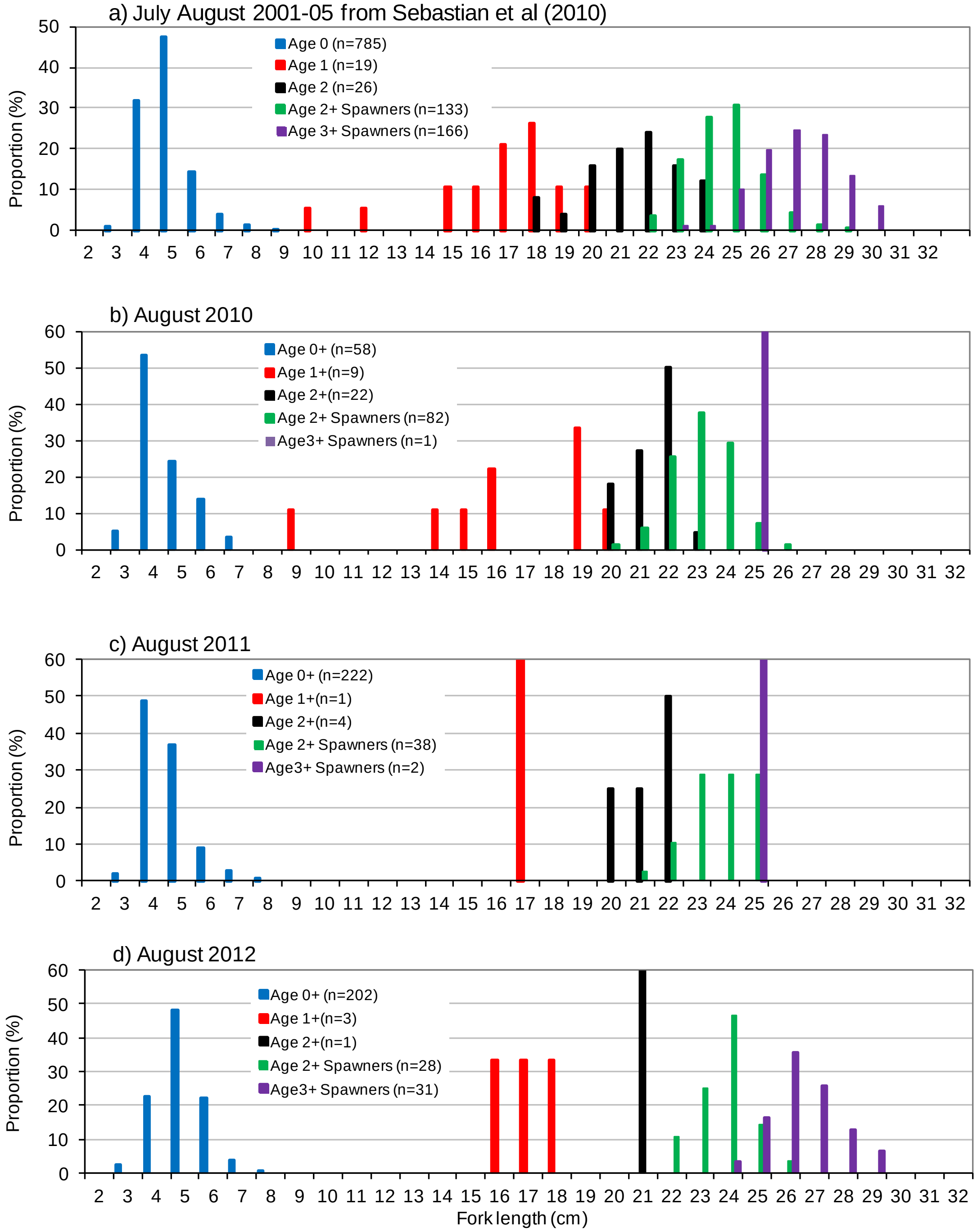


Figure 10. Kokanee length frequency proportion by age for a) 2001-05, b) 2010, c) 2011 and d) 2012 based on trawl sampling in Kinbasket pool and spawner surveys. Spawner data was from Camp Creek during 2001-05 and from Camp and Luxor creeks during 2010, 2011 and 2012. Except for Camp Creek, spawner data was provided by Karen Bray, BCH Revelstoke.

small sample sizes of age 2+ captured by limited trawling effort. Consequently, spawner ages relied on otolith interpretations and were compared with limited trawl sampling results to check for consistency. The average size of trawl fish did not vary much from year to year although the spawner size has varied considerably. **Figure 10** shows how the recent period of small spawner sizes in 2010 and 2011 can be attributed to the high proportion of age 2+ fish spawners and does not suggest large variation in growing conditions in Kinbasket Reservoir. The larger size of spawners returning in 2012 appears to be primarily due to a shift in age at maturity back to 3+ spawners.

The mean size at age for spawners based on otolith interpretation for combined samples from Camp and Luxor creeks in 2012 was 235 ± 4 mm for age 2+ and 262 ± 4 mm for age 3+ (**Table 3**). As mentioned in previous data reports, some differences in spawner size at age and age composition have been observed between Camp and Luxor creeks. Based on 95% C.L., it is apparent that the mean size of age 2+ in Camp Creek (247 ± 10mm) was significantly larger than in Luxor Creek (233 ± 3 mm). Likewise, the age 3+ fish in Camp Creek (265 ± 4 mm) were significantly larger than age 3+ in Luxor Creek (247 ± 4mm). Differences in size at age suggest they may be rearing in areas of the reservoir having different productive capacity. It is important to establish whether Luxor Creek kokanee are representative of the larger Upper Columbia spawning population by comparing them to samples from the Upper Columbia mainstem (e.g. vicinity of the golf course) and other nearby tributaries for size at age.

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 and Luxor Creek are probably more important for determining overall spawner size than differences in growth rates. The age composition has varied considerably between Luxor and Camp Creek over the past few years. For example, in 2007 the age composition between the two tributaries was very different, with only 13% of spawners aged 3+ in Luxor while 100% were age 3+ in Camp Creek. In 2011, the age composition was remarkably similar between the two streams at nearly 100% age 2+ spawners in both streams. In 2012 the majority of spawners (87%) returned as age 3+ in Camp Creek while fewer (~17%) returned at age 3+ in Luxor Creek (**Fig. 11**). This difference, assuming it is real and not a function of sampling bias or errors in otolith interpretation, is interesting and deserves further attention in the future. 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 the reservoir may help for age and growth verification on spawning populations. Gillnetting is recommended as a possible technique to increase samples of age 1-3+ fish from Kinbasket Reservoir.

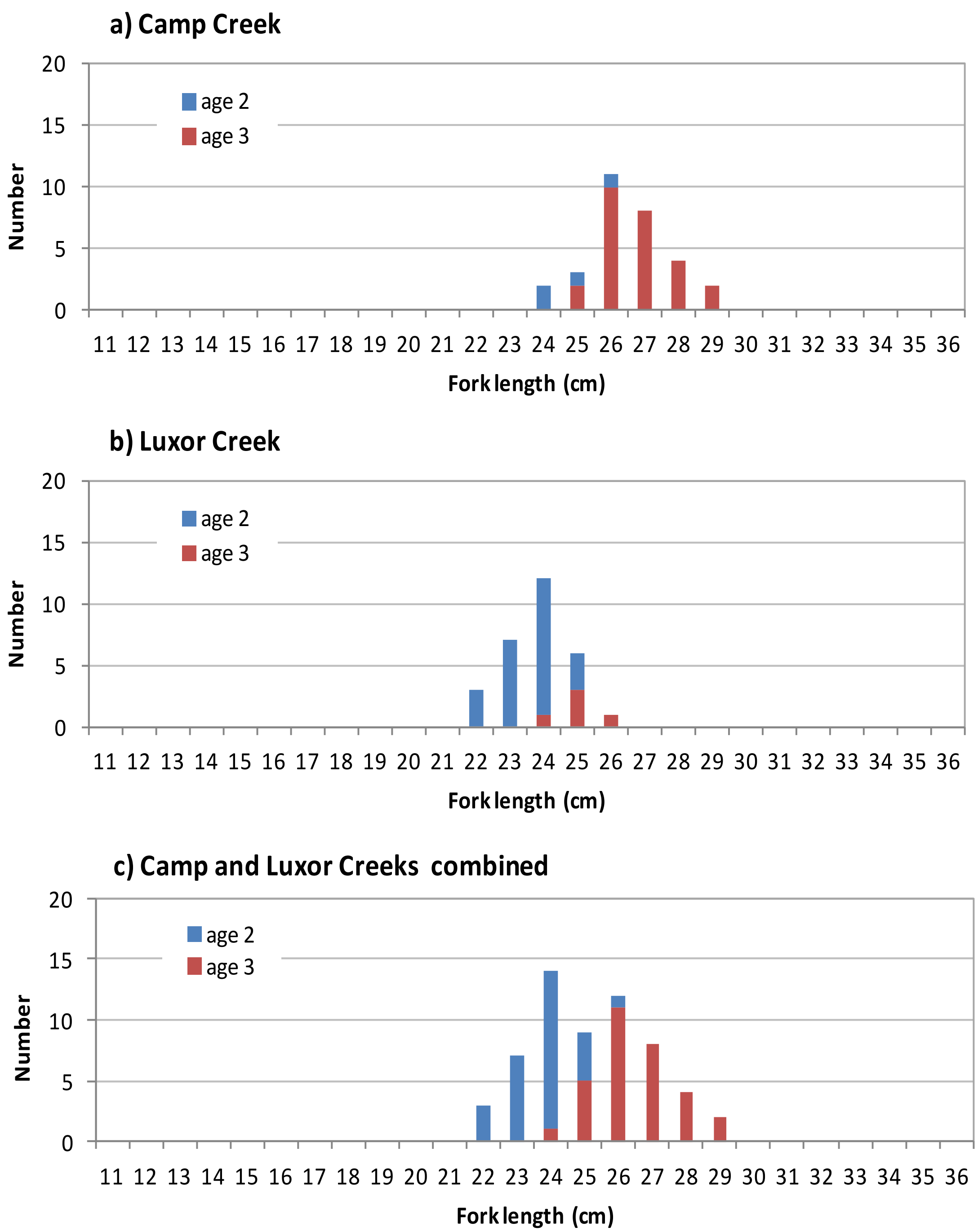


Figure 11. Kokanee spawner length frequency by age for a) Camp Creek, b) Luxor Creek and c) Combined Camp and Luxor creeks in September, 2012.

Gillnet sampling feasibility on Revelstoke Reservoir

A total of 26 fry and one age 2+ fish were captured in three one-hour trawls on Revelstoke Reservoir. Growth comparisons for kokanee between years based on size at age has not previously been done due to very low kokanee densities and failure to capture age 1-3+ fish by trawling Revelstoke Reservoir. Consequently a new sampling strategy was adopted in 2012 to test the feasibility of pelagic gillnetting as a method for capturing age 1-3+ fish for estimating size at age. A total of 20 kokanee and three bull trout were captured in overnight gillnet sets at four different locations (**Appendix 6**). Nets set at 10m and 15m depths caught 12 and 8 kokanee respectively while no kokanee (or bull trout) were caught at 20 m depth (**Table 4**). Catches of age 2+ and 3+ kokanee were similar for the two depths while age 1+ were only caught at 10m depth. In addition, three out of four age 1+ fish were caught at one location (Downie Arm) which may be an early indication of uneven distribution of 1+ fish. More netting will be required to confirm this. A total of 5.6 ha·hrs of gillnetting caught 20 fish, while catch rates for kokanee ranged from 0.5 to 7.25 kokanee per ha·hr of netting (**Appendix 6a**). The catch rate for kokanee was quite different for the first set compared to the other three sets at 0.5 kokanee per ha.hr compared with 3.2 to 7.2 kokanee per ha·hr. The first set was likely too close to shore for kokanee as indicated by bull trout catches and only 1 kokanee while the 20m net produced no fish. Based on the other three pelagic sets, an average of 5.0 kokanee per ha·hr suggests that a minimum of 6 ha·hrs of gillnetting would be required to catch a minimum sample size of 30 kokanee. If the sampling objective is to collect sufficient samples to enable statistically significant estimates of size at age for year to year comparison, then more effort would be required. Based on the three successful pelagic sets, it appears that effort would have to be increased by approximately 4 times (i.e. from 3.8 to 15 ha·hrs effort) in order to ensure catches of at least 15 kokanee from each age group. Logistically, it may be more efficient to set longer gangs (e.g. 6 RIC nets per set at six different locations) since the time locating stations and setting anchors will limit the number of stations that can be completed in a survey. Although numbers caught in these limited pelagic sets were too low to make statistical inferences, gillnetting does show promise as a future technique for monitoring size at age in Revelstoke Reservoir.

Table 4. Catch summary by species, age and net depth from preliminary pelagic gillnet sampling in Revelstoke Reservoir during August 2012.

Net Depth	Number of Kokanee				Bull	Total Fish
(m)	Age 1+	Age 2+	Age 3+	Total	trout	(no)
10	4	2	6	12	3	15
15	0	3	5	8	0	8
20	0	0	0	0	0	0
All	4	5	11	20	3	23

Size at age and age at maturity in Revelstoke Reservoir

Combining trawl and gillnet catches produced a sample size of 47 kokanee with representation in four different age groups. The 2012 size at age data, although limited, provides the first glimpse of growth between the fry and adult stages for Revelstoke. Mean length at age was estimated at 48 ±3mm for age 0+, 153 ±18 mm for age 1+, 241 ±7mm for age 2+ and 266 ±6mm for age 3+ in the reservoir (**Table 5**). Spawner mean length for Revelstoke was 265 mm for age 2+ (only one sample) and 280 ±5mm for age 3+ fish. Comparing length at age estimates between the two reservoirs, it appears that fry and age 1+ fish are similar, while age 2+ and 3+ fish grow more rapidly in Revelstoke Reservoir, where fish densities are considerably lower.

Table 5. Summary of kokanee length and weight statistics by age from combined trawl (TRL) and gillnet (GN) catches in Revelstoke Reservoirs during August 2012 and for spawning kokanee caught by dipnet (DN) in Standard Creek during late September 2012.

Gear type	Age[1]	FL (mm)	FL range (mm)	S.D.	N (FL)	WT (g)	S.D. (WT)	N (WT)
Trawl	0+	48	27-59	7.8	26	1.2	0.52	26
Gillnet	1+	153	126-166	18.1	4	44.3	15.9	4
Trawl & Gillnet	2+	241	233-253	9.1	6	171.7	20.6	6
Trawl & Gillnet	3+	266	247-280	10.2	11	223.5	22.6	11
Spawner - DN	2+	265			1			
Spawner - DN	3+	280	266-296	8.4	14			
					63			48

1. Trawl and gillnet ages derived from scales; spawner ages from otoliths

Figure 12 shows age specific length frequency for combined trawl and gillnet catches compared with age specific length frequency distributions from Standard Creek spawners. The age estimates appear to make sense, since age 2+ gillnet fish overlapped with a single age 2+ spawner and the age 3+ fish from gillnetting overlapped with the age 3+ spawners. It also makes sense that age 3+ gillnet caught fish were on average slightly smaller than age 3+ spawners since sampling of spawners occurred approximately 6 weeks later in the growing season than fish caught by gillnet sampling in mid-August.

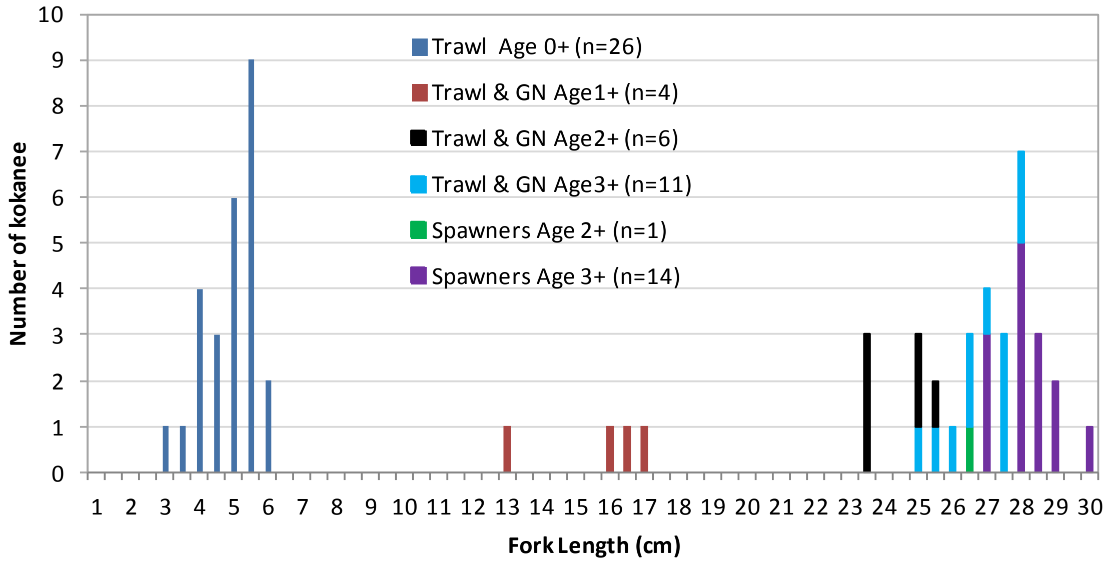


Figure 12. Age specific length frequency distributions for combined trawl and gillnet caught fish sampled in mid August, 2012 and for spawners returning to Standard Creek during September 2012.

Spawner Surveys

Spawner surveys in 2012 were conducted on the tributaries listed in **Table 6** and counts were compared with the previous eleven years. Annual counts for the 12 year period are presented in Appendix 9 for key spawning tributaries to Kinbasket Reservoir (Camp Creek, Bush River and Luxor Creek) and Revelstoke Reservoir (Downie Creek with tributary Standard Creek).To acknowledge the considerable year to year variation in counts and viewing conditions, a range of ±1 standard deviation around the mean for the eleven year period was considered to be an “average” count. Values outside this range were considered to be either below or above average. In 2012, Toby Creek was too turbid to count and Horsethief Creek received only a partial count as a result of high turbidity. Of the remaining five streams, Luxor and Camp Creeks and Kinbasket River were well below average while returns to Wood and Bush Rivers were low but within the range considered average (**Table 6**). Even though counts are fairly subjective and viewing conditions less than ideal, the cumulative counts in 2012 provide fairly convincing evidence that spawner returns in 2012 were low. The mean size at age for spawners was fairly similar to the long term average in both Camp and Luxor Creeks (**Appendix 8**). However, as mentioned previously, a very significant shift from age 2+ to age 3+ fish in both streams resulted in a fairly substantial increase in the overall mean size of spawners in 2012. The larger average size of spawners in 2012 is expected to at least partially offset the decline in egg deposition and fry recruitment that would be expected from lower than average number of spawners returning in 2012.

Table 6. Summary of 2012 kokanee spawner counts compared with long term average of previous eleven years.

Tributary	Average Count (2001-11)		2012	Survey	Comments/conditions
	Mean	(Range[1])	Count	Date	
Toby Cr.	3218	(650 - 5800)		25-Sep	not counted – too turbid
Horsethief	509	(0 - 1300)	100	25-Sep	partial count – too turbid
Luxor Cr.	36468	(14600-58300)	9100	25-Sep	Count below average – water high
Bush R.	21832	(14700-29000)	19530	25-Sep	Count average
Kinbasket R.	1490	(450-2500)	0	01-Oct	No fish observed
Wood R.	17054	(6900-27200)	8220	01-Oct	Count low; within historic range
Camp Cr.	14949	(8500-21400)	5000	29-Sep	Count below average
Total	95520	(45800-145500)	41,950		

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

Methods development

The separation of “noise” from small fish targets has been an area of ongoing development in the analysis of acoustic data using SONAR5 software. Determining threshold value of targets at the lower end of the fish size range when noise levels overlap in echo strength with fish targets is not always evident using the standard graphing techniques that are commonly utilized in less noisy data. Therefore, other 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 total threshold of all signals below -58db was applied. Consequently the fry abundance in Revelstoke has likely been under estimated which may partly explain the very low fry densities reported for 2012. As new methods of dealing with noise are developed, they will be applied at the time series scale in order to ensure the treatment of data is consistent between years.Acoustic “noise” was considerably less problematic in Kinbasket in 2012, however the effect of running many transects with lights on to avoid running over debris remains a source of some uncertainty with the Kinbasket population estimates. The estimates for Kinbasket appeared to be consistent with previous years and gave no indication that running lights affected the echo counts. Debris was also an issue for night-time work in 2007 when water levels reached full pool elevation and in 2011, again during high pool levels. Lights were used intermittently while transecting on both of these surveys. Some of the highest fish densities were observed in 2007 and were consistent with a strong escapement year in 2006. As in 2013, we found no evidence that lights had impacted acoustic results in 2007 or 2011.

It appears that gillnetting may be a viable alternative to trawling for capture of age 1-3+ fish in Revelstoke Reservoir where trawling is ineffective. It is recommended that gillnetting be continued on Revelstoke with increased effort and also be attempted on Kinbasket Reservoir as time permits in 2013. If successful on Kinbasket, gillnetting could enable sampling in many areas which cannot be safely sampled with a trawl net due to submerged hazards. This technique could be useful for sub-sampling south end kokanee where there is some evidence that growth rates and age at maturity may be different from the main pool.

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Appendix 1. Kinbasket Reservoir fish densities by transect from hydroacoustic surveys, 2002-2012. Note densities reported here represent all depths and are not weighted by the amount of habitat at depth.

Location	Zone	Trans No.	2002 Aug	2003 July	2004 July	2005 Aug	2006 Aug	2007 Aug	2008 July	2009 Aug	2010 Aug	2011 Aug	2012 Aug
Ptarmigan Cr	2	**1**	848	266	815		200		364	272	701	206	487
		2	291	304	687	231	184		427	224	268	183	761
Hugh Allan Cr		**3**	452	252	254	267	162		451	253	279	169	300
Howard Bay		**4**	474	414	311	247	299	258	383	185	284	113	299
	3	**5**	1056	320	490	398	1300	686	635	274	397	149	205
Foster Arm		**6**	460	437	295	720	303	954	484	298	323	110	528
		7	761	825	401	439	697	1910	1906	443	444	303	592
Dainard Cr		**8**	515	582	707	336	558	1078	1855	509	420	377	616
Mica Dam	4	**9**	147	376	151	428	447	564	197	265	309	353	586
Mica Arm		**10**	238	547	108	614	247	572	316	336	194	424	527
Mica Arm		**11**	352	501	373	245	370	1099	365	336	342	253	512
Sprague By		**12**	302	939	538	178	282	802	801	390	293	160	400
Main pool		**13**	229	898	530	419	222	1392	1083	630	300	370	451
Main pool		**14**	698	423	464	196	331	736	1176	502	341	269	226
Main pool		**15**	591	798	718	371	424	1133	543	819	365	332	338
East side		**16**	672	1602	543	254	275	961	910	515	350	222	286
South side		**2 0**	233	319	221	323	170	361	632	427	452	205	213
Wood Arm	5	**17**	270	910	126	438	162	361	828	241	265	185	456
		18	355	440	208	425	301	415	300	246	226	299	402
		19	329	915	283	433	255	627	847	315	597		160
Lower	6	**21**	181	955	671	215	430	727	660	454	201	168	404
Columbia		**22**	226	619	426	186	394	194	662	426	324	295	188
Old Kinbasket	7	**23**	140	496	495	177	388	196	621	374	285		165
Pool		**24**	287	348	364	169	384	261	455	336	184	263	134
SullivanArm		**25**	132	427		375	208		448	230	597	300	141
Kyanite Cr		**26**	277	242	228	203	300	372	285	296	237	307	106
		27	250	240	198	272	198	596	259	476	222	249	200
Garrett Cr		**28**	360	466	361	223	350	674	496	423	553	317	190
Upper	8	**29**	316	750	199	438	240		478	785	382	442	168
Columbia		**30**	370	274		534	331			513	463	302	158
Bush Pool	9	**31**				178							

Appendix 2. Revelstoke Reservoir fish densities by transect from hydroacoustic surveys, 2003-12. Note densities reported here represent all depths and are not weighted by the amount of habitat at depth.

Location	Zone [1]	Old Tnum	New Tnum [2]	2003 July	2004 July	2005 Aug	2006 Aug	2007 Aug	2008 July	2009 Aug	2010 Aug	2011 July	2012 Aug
Rev. Dam	1	1	**1**	371	348	172	347	293	74	211	261	145	82
Coursier Cr.	1	2	**2**	289	121	180		293	170	182	126	401	142
	1	3	**3**	226	80	144	319	491	240	142	65	319	69
Martha Cr.	2	4	**4**	470	96	287	207	368	360	235	213	221	48
Sale Cr.	2	5	**5**	481	150	243	274	374	312	256	188	241	50
LaForme Cr.	2	6	**6**	479	209	252	275	248	431	151	230	177	70
	2	7	**7**	819	127	222	253	234	384	112	131	49	24
Carnes Cr.	2	8	**8**	268	246	449	201	227	651	213	122	57	41
Frisby Cr.	2	9					121		705		162		
Mars Cr.	2	10	**9**	156	272	244	174	239	192	123	205	65	85
	2	11					126						
Park Cr.	2	12	**10**	344	214	295	170	196	171	252	300	31	29
Bourne Cr.	2	13	**11**	580	125	304	189	230	327	251	432	36	51
Keystone	2	14	**12**	629					300	143	366	121	29
Downie	2	15	**12a**		241	210	114	102					80
Downie Arm	2	16											
Power line	3	17	**13**	70	57	293	58	42	90	134	119	234	97
Fissure Cr.	3	18	**14**	78	29	193	52	8	117	270	169	93	405
Ferry	3	19	**15**	83	53	87	52	11	65	76	158	23	69
Liberty Cr.	3	20											
Old Goldstrm	3	21	**16**	52	19	129	47	25	98	180	153	35	92
Goldstream	3	22											
Stump field	3	23	**17**	196	253	46	144	39	72	68	87	65	157
Powerline	3	24	**18**	33	297	99	23	32	59	67	186	52	25
Hoskins Cr.	3	25	**19**	18	323	175	5	26	52	149		69	2
Nichols Cr.	3	26	**20**	24	121	60	10	21	95	97	83	29	25

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 not sampled (too shallow for night work).
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 2012.

Appendix 3a. Fish all ages

Kinbasket August 2012 layered analyses statistics for fish >-61 dB ; 2 zones; transects 1-21 and transects 22-30								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic[1]**	**Abundance**
1	5-10	21	1.3	0.6	16881	22508		
1	10-15	21	9.1	4.5	16881	153537		
1	15-20	21	78.9	15.2	16881	1331187		
1	20-25	21	193.7	18.5	16184	3134975	**All Fish**	**>-61 dB**
1	25-30	21	109.9	13.2	15561	1709487	**Lower**	6,948,018
1	30-35	21	20.3	3.6	15051	306037	**MLE**	7,822,283
1	35-40	21	2.2	0.6	14404	31552	**Upper**	8,769,103
1	40-45	21	0.9	0.3	13552	11616		
1	45-50	21	0.4	0.2	12662	4824		
2	10-15	9	1.0	0.6	7355	7355		
2	15-20	9	14.9	5.1	7355	109508		
2	20-25	9	74.6	10.0	7218	538105		
2	25-30	9	54.7	8.6	7073	386657		
2	30-35	9	11.2	3.0	6918	77635		
2	35-40	9	3.1	1.4	6760	21031		
2	40-45	9	0.9	0.4	6598	5864		
2	45-50	9	0.8	0.5	6384	4965		

Note: strata with density= zero have been omitted (e.g. zone 1 depth 3-5m)

[1] Key: LB=Lower bounds (95% C.L.), UB=Upper bounds, MLE=Maximum likelihood estimate

Appendix 3b. Age 0 kokanee (fry only)

Kinbasket August 2012 layered analyses statistics for fish -61 to -44 dB ; 2 zones; transects 1-21 and transects 22-30								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic**	**Abundance**
1	5-10	21	1.3	0.6	16881	22508		
1	10-15	21	9.1	4.5	16881	153537		
1	15-20	21	66.6	14.1	16881	1123792		
1	20-25	21	164.6	17.7	16184	2663342	**All Fish**	**-61 to -44 dB**
1	25-30	21	92.6	12.1	15561	1440504	**Lower**	5,799,205
1	30-35	21	16.3	2.9	15051	245116	**MLE**	6,610,114
1	35-40	21	2.1	0.6	14404	30180	**Upper**	7,480,539
1	40-45	21	0.8	0.2	13552	10325		
1	45-50	21	0.4	0.2	12662	4824		
2	10-15	9	0.8	0.6	7355	5721		
2	15-20	9	11.4	3.8	7355	84174		
2	20-25	9	60.7	8.2	7218	437862		
2	25-30	9	45.3	7.0	7073	320643		
2	30-35	9	9.3	2.9	6918	64568		
2	35-40	9	3.1	1.4	6760	21031		
2	40-45	9	0.9	0.4	6598	5864		
2	45-50	9	0.8	0.5	6384	4965		

Appendix 3c. Age 1-3 kokanee

Kinbasket August 2012 layered analyses statistics for fish >-44 dB ; 2 zones; transects 1-21 and transects 22-30								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic**	**Abundance**
1	15-20	21	12.3	2.7	16881	207395		
1	20-25	21	29.1	4.0	16184	471633		
1	25-30	21	17.3	2.7	15561	268983		
1	30-35	21	4.0	0.9	15051	60921	**All Fish**	**>-44 dB**
1	35-40	21	0.1	0.1	14404	1372	**Lower**	1,031,850
1	40-45	21	0.1	0.1	13552	1291	**MLE**	1.214,042
2	10-15	9	0.2	0.2	7355	1634	**Upper**	1,404,515
2	15-20	9	3.4	1.8	7355	25334		
2	20-25	9	13.9	2.7	7218	100243		
2	25-30	9	9.3	1.8	7073	66015		
2	30-35	9	1.9	0.8	6918	13067		

Appendix 4. Summary of fish density statistics and Maximum Likelihood Estimates from Monte Carlo Simulations for Revelstoke Reservoir in August 2012.

a) fish all ages

Revelstoke August 2012 layered analyses statistics for fish >-58 dB ; 1 zone (Transects 1-21); Note lower threshold raised to eliminate noise								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic**[2]	**Abundance**
1	5-10	21	15.9	3.7	7250	114964		
1	10-15	21	13.9	3.8	7250	100464	**All fish**	**>-58dB**
1	15-20	21	13.4	2.7	7250	97357	**Lower**	356,289
1	20-25	21	8.1	2.1	7250	59036	**MLE**	459,993
1	25-30	21	6.5	2.4	6800	44362	**Upper**	569,352
1	30-35	21	6.4	2.2	6400	40838		
1	35-40	21	5.6	2.2	6000	33714		
1	40-45	21	4.8	1.8	5450	26212		
1	45-50	21	5.0	2.2	4900	24500		

b) age 0 kokanee (fry only)

Revelstoke August 2012 layered analyses statistics for fish -58 to -46 dB ; 1 zone (Transects 1-21); Note lower threshold raised to eliminate noise								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic**	**Abundance**
1	5-10	21	14.7	3.6	7250	106333		
1	10-15	21	12.0	3.7	7250	87345	**All fish**	**-58 to -46dB**
1	15-20	21	9.1	2.2	7250	66286	**Lower**	285,247
1	20-25	21	6.9	1.9	7250	49714	**MLE**	384,244
1	25-30	21	6.2	2.3	6800	42095	**Upper**	486,842
1	30-35	21	6.2	2.1	6400	39619		
1	35-40	21	5.5	2.1	6000	32857		
1	40-45	21	4.8	1.8	5450	26212		
1	45-50	21	5.0	2.2	4900	24267		

[2] Key: LB=Lower bounds (95% C.L.), UB=Upper bounds, MLE=Maximum likelihood estimate

Appendix 4c. Age 1-3 kokanee

Revelstoke August 2012 layered analyses statistics for fish >-46 dB ; 1 zone (Transects 1-21)								
Zone	**Depth**	**N**	**Density**	**Standard Error**	**Area**	**Stratum population**	**Statistic**[3]	**Abundance**
1	5-10	21	1.2	0.7	7250	8631		
1	10-15	21	1.8	0.9	7250	13119	**All fish**	**> -46dB**
1	15-20	21	4.3	1.1	7250	31071	**Lower**	43,714
1	20-25	21	1.3	0.4	7250	9321	**MLE**	67,300
1	25-30	21	0.3	0.2	6800	2267	**Upper**	89,665
1	30-35	21	0.2	0.1	6400	1219		
1	35-40	21	0.1	0.1	6000	857		

[3] Key: LB=Lower bounds (95% C.L.), UB=Upper bounds, MLE=Maximum likelihood estimate

Appendix 5. Trawl sampling logs and catch data for 2012.

Key: No=sample number, SP=Species, KO=kokanee RB=rainbow, BT=bull trout SC= sculpin PW=pygmy whitefish, Len= length in mm, Wt=weight in g, Age was estimated by length unless SN is filled in, Mat=maturing, Imm=immature, R=ripe

a) Kinbasket Mica Pool, August 2012

Location: Kinbasket **Trawl #** 1 **Time in**: 21:32 **Time out:** 22:32 **Layer Depth**: 20-27 m
Date: Aug 18, 2012 **Cable Length:** 108 m
UTM start: N 5782141 E 400799 **Transect #:** 8 to 15
UTM end: N 5779546 E 401203 **Distance:** 2626 m **Number of layers:** 1

No.	SP	Len	Wt	Age	SN	Mat	Sex		No.	SP	Len	Wt	Age	SN	Mat	Sex
1	KO	201	98.59	2	1	MAT	M		35	KO	43	0.83	0			
2	KO	168	56.39	1	2	IMM	F		36	KO	52	1.5	0			
3	KO	58	1.92	0					37	KO	47	1.07	0			
4	KO	49	1.29	0					38	KO	55	1.8	0			
5	KO	50	1.33	0					39	KO	56	1.96	0			
6	KO	38	0.38	0					40	KO	42	0.81	0			
7	KO	40	0.57	0					41	KO	49	1.2	0			
8	KO	43	0.89	0					42	KO	42	0.79	0			
9	KO	69	3.56	0					43	KO	40	0.69	0			
10	KO	44	0.86	0					44	KO	49	1.29	0			
11	KO	34	0.32	0					45	KO	50	1.29	0			
12	KO	41	0.66	0					46	KO	48	1.18	0			
13	KO	47	1.11	0					47	KO	49	1.71	0			
14	KO	47	1.05	0					48	KO	61	2.63	0			
15	KO	46	0.97	0					49	KO	47	1.1	0			
16	KO	43	0.79	0					50	KO	35	0.35	0			
17	KO	47	1.05	0					51	KO	38	0.52	0			
18	KO	60	2.29	0					52	KO	38	0.61	0			
19	KO	42	0.76	0					53	KO	44	0.94	0			
20	KO	42	0.77	0					54	KO	46	1.06	0			
21	KO	42	0.75	0					55	KO	47	1.17	0			
22	KO	32	0.26	0					56	KO	37	0.47	0			
23	KO	55	1.67	0					57	KO	60	2.49	0			
24	KO	51	1.45	0					58	KO	54	1.66	0			
25	KO	57	2	0					59	KO	51	1.39	0			
26	KO	49	1.17	0					60	KO	43	0.73	0			
27	KO	52	1.48	0					61	KO	50	1.17	0			
28	KO	58	1.86	0					62	KO	37	0.55	0			
29	KO	58	2.3	0					63	KO	38	0.58	0			
30	KO	43	0.73	0					64	KO	56	1.88	0			
31	KO	45	0.91	0					65	KO	56	1.76	0			
32	KO	33	0.35	0					66	KO	44	0.95	0			
33	KO	47	1.11	0					67	KO	43	0.76	0			
34	KO	54	1.79	0					68	KO	26	0.16	0			

Appendix 5a - continued.

Location: Kinbasket **Trawl #** 1 **Time in**: 21:32 **Time out:** 22:32 **Layer Depth**: 20-27 m
Date: Aug 18, 2012 **Cable Length:** 108 m
UTM start: N 5782141 E 400799 **Transect #:** 8 to 15
UTM end: N 5779546 E 401203 **Distance:** 2626 m **Number of layers:** 1

No.	SP	Len	Wt	Age	SN	Mat	Sex		No.	SP	Len	Wt	Age	SN	Mat	Sex
69	KO	32	0.28	0					103	KO	40	0.68				
70	KO	32	0.33	0					104	KO	47	1.24				
71	KO	44	1.01	0					105	KO	50	1.26				
72	KO	57	2.27	0					106	KO	46	0.94				
73	KO	54	1.53	0					107	KO	42	0.8				
74	KO	37	0.62	0					108	KO	50	1.28				
75	KO	49	1.09	0					109	KO	58	2.28				
76	KO	45	0.86	0					110	KO	46	1.06				
77	KO	42	0.78	0					111	KO	46	1.15				
78	KO	47	1.16	0					112	KO	42	0.82				
79	KO	39	0.53	0					113	KO	52	1.41				
80	KO	48	1.26	0					114	KO	52	1.53				
81	KO	58	2.19	0					115	KO	39	0.6				
82	KO	47	1.23	0					116	KO	47	1.12				
83	KO	57	1.92	0					117	KO	52	1.53				
84	KO	53	2.13	0					118	KO	56	1.99				
85	KO	40	0.64	0					119	KO	47	1.11				
86	KO	65	2.96	0					120	KO	38	0.55				
87	KO	52	1.57	0					121	KO	47	1.12				
88	KO	48	1.25	0					122	KO	42	0.78				
89	KO	42	0.72	0					123	KO	41	0.76				
90	KO	52	1.52	0					124	KO	49	1.36				
91	KO	62	2.74	0					125	KO	37	0.48				
92	KO	65	3.18	0					126	KO	41	0.8				
93	KO	70	4.07	0					127	KO	55	1.85				
94	KO	39	0.87	0					128	KO	44	0.9				
95	KO	42	0.81	0					129	KO	42	0.7				
96	KO	39	0.51	0					130	KO	43	0.8				
97	KO	41	0.75	0					131	KO	45	0.94				
98	KO	44	1.01	0					132	KO	32	0.31				
99	KO	43	0.87	0					133	KO	50	1.24				
100	KO	35	0.41	0					134	KO	49	1.33				
101	KO	48	1.33	0					135	KO	39	0.62				
102	KO	45	1	0					136	KO	38	0.57				

Appendix 5a - continued.

Location: Kinbasket			**Trawl #** 2		**Time in**: 23:06				**Time out:** 00:06				**Layer Depth**: 10-27 m			
Date: Aug 18, 2012													**Cable Length:** 64,84 and 116 m			
		UTM start: N 5781052 E 401347							**Transect #:** 8 to 15							
		UTM end: N 5783400 E 400152							**Distance:** 2635 m				**Number of layers:** 3			
No.	**SP**	**Len**	**Wt**	**Age**	**SN**	**Mat**	**Sex**	**No.**	**SP**	**Len**	**Wt**	**Age**	**SN**	**Mat**	**Sex**	
137	KO	174	57.55	1	3	IMM	M	173	KO	50	1.37	0				
138	KO	156	42.84	1		IMM	F	174	KO	39	0.58	0				
139	KO	72	4.24	0				175	KO	48	1.1	0				
140	KO	54	1.63	0				176	KO	40	0.67	0				
141	KO	34	0.37	0				177	KO	54	1.65	0				
142	KO	39	0.57	0				178	KO	57	1.92	0				
143	KO	45	1.03	0				179	KO	54	1.72	0				
144	KO	38	0.54	0				180	KO	38	0.56	0				
145	KO	63	2.62	0				181	KO	32	0.32	0				
146	KO	54	1.56	0				182	KO	32	0.3	0				
147	KO	49	1.25	0				183	KO	57	1.94	0				
148	KO	49	1.26	0				184	KO	35	0.4	0				
149	KO	47	1.07	0				185	KO	37	0.44	0				
150	KO	30	0.22	0				186	KO	30	0.21	0				
151	KO	29	0.25	0				187	KO	32	0.32	0				
152	KO	65	3.1	0				188	KO	46	0.99	0				
153	KO	40	0.69	0				189	KO	37	0.49	0				
154	KO	53	1.49	0				190	KO	45	0.99	0				
155	KO	54	1.57	0				191	KO	42	0.71	0				
156	KO	59	2.21	0				192	KO	47	1.03	0				
157	KO	56	1.75	0				193	KO	56	1.84	0				
158	KO	46	0.88	0				194	KO	43	0.85	0				
159	KO	50	1.14	0				195	KO	47	1.08	0				
160	KO	43	0.9	0				196	KO	47	0.99	0				
161	KO	32	0.32	0				197	KO	48	1.09	0				
162	KO	45	0.9	0				198	KO	41	0.79	0				
163	KO	58	2.23	0				199	KO	44	0.98	0				
164	KO	60	2.47	0				200	KO	42	0.82	0				
165	KO	29	0.21	0				201	KO	44	0.93	0				
166	KO	37	0.52	0				202	KO	54	1.56	0				
167	KO	40	0.63	0				203	KO	31	0.26	0				
168	KO	49	1.21	0				204	KO	50	1.33	0				
169	KO	44	0.84	0				205	KO	40		0				
170	KO	33	0.36	0				206	KO	43	0.81	0				
171	KO	47	1.08	0												
172	KO	56	1.82	0												

Appendix 5b - Revelstoke Reservoir trawl catches, August 2012

Location: Revelstoke **Trawl #** 1 **Time in**: 21:49 **Time out:** 22:49 **Layer Depth:** 9-16 m
Date: August 14, 2012 **Cable Length:** 70 m
UTM start: N 5671277 E 415507 **Transect #:** 5 to 4
UTM end: N 5668520 E 415274 **Distance:** 2767m **Number of layers:** 1

No.	SP	Len	Wt	Age	SN	Mat	Sex		No.	SP	Len	Wt	Age	SN	Mat	Sex
24	KO	27	0.25	0												
25	KO	35	0.33	0												
26	KO	40	0.79	0												
27	KO	38	0.78	0												
28	KO	50	1.18	0												
29	KO	50	1.4	0												
30	KO	54	1.54	0												
31	KO	249	187.23	2	24	MAT	F									

Location: Revelstoke **Trawl #** 2 **Time in**: 23:10 **Time out:** 00:10 **Layer Depth:** 6-13 m
Date: August 14, 2012 **Cable Length:** 50 m
UTM start: N 5666932 E 415527 **Transect #:** 4 to 3
UTM end: N 5664623 E 416316 **Distance:** 2440 m **Number of layers:** 1

No.	SP	Len	Wt	Age	SN	Mat	Sex		No.	SP	Len	Wt	Age	SN	Mat	Sex
32	KO	55	1.71	0					40	KO	46	0.95	0			
33	KO	47	1.06	0					41	KO	39	0.63	0			
34	KO	54	1.51	0					42	KO	59	2.43	0			
35	KO	49	1.21	0					43	KO	50	1.25	0			
36	KO	52	1.5	0					44	KO	52	1.38	0			
37	KO	59	2.28	0					45	SC	17	0.06				
38	KO	55	1.61	0					46	SC	15	0.03				
39	KO	52	1.55	0												

Location: Revelstoke **Trawl #** 3 **Time in**: 00:25 **Time out:** 01:25 **Layer Depth:** 7-14 m
Date: August 14, 2012 **Cable Length:** 52 m
UTM start: N 5664000 E 416344 **Transect #:** 3 to 2
UTM end: N 5661605 E 416949 **Distance:** 2470 m **Number of layers:** 1

No.	SP	Len	Wt	Age	SN	Mat	Sex		No.	SP	Len	Wt	Age	SN	Mat	Sex
47	KO	52	1.22	0												
48	KO	38	0.55	0												
49	KO	44	0.97	0												
50	KO	42	0.7	0												
51	KO	51	1.38	0												
52	KO	45	1.06	0												

Appendix 6a. Gillnet set details and kokanee effort, catch and CPUE

Attribute	Set 1	Set 2	Set 3	Set 4
Set date	13-Aug-12	13-Aug-12	15-Aug-12	15-Aug-12
Retrieval date	14-Aug-12	14-Aug-12	16-Aug-12	16-Aug-12
Site location (near...)	TR5 east bank	TR5 east side	TR14 west of C	TR16 Downie Arm
Net depth(s) in meters	10,15,15,20	10,10,15	10.15,15	10,10,15
Lake depth (m) start/end	100/90	32/na	70/70	37/50
Start UTM East	E 415742	E 415155	E 398144	E 401363
Start UTM North	N 5671245	N 5675610	N 5699327	N 5704509
End UTM East	E 415676	E 415218	E 398228	E 401173
End UTM North	N 5670857	N 5675317	N 5699038	N 5704289
Set time	17:25	19:40	19:07	20:00
Retrieval time	11:10	12:05	10:32	11:27
Total time (hrs)	17.75	16.42	15.42	15.45
Net area (m^2)	1072	804	804	804
Effort (ha·hr)	1.9028	1.3199	1.2395	1.24218
Kokanee catch (no)	1	6	4	9
Kokanee CPUE ($no \cdot ha \cdot hr^{-1}$)	0.53	4.54	3.23	7.25

Appendix 6b. Gill net catch results (note all were overnight (ON) type sets)

Location: Revelstoke **Method:** Pelagic Gillnet **et type:** Standard RIC mesh
Net Description: 6 panels of 15 x 1.8m end to end **Mesh size:** graduated mesh from xx to yy

Day	Gillnet No.	Trans No.	Net Depth	Type	Fish No.	Spec	Len.	Weight	Sex	Maturity	Scale Age	Scale No.	Otol.	Photo
14	1	5	10	ON	1	BT	288	208.32	F		3	1	N	Y
14	1	5	10	ON	2	BT	263	164.1	M			2	N	Y
14	1	5	10	ON	3	KO	271	225.52	F	Maturing	3	3	N	Y
14	2	6	15	ON	4	KO	235	158.54	F	Maturing	2	4	N	Y
14	2	6	15	ON	5	KO	262	229.73	M	Mature	3	5	N	Y
14	2	6	15	ON	6	KO	258	212.23	F	Maturing	3	6	N	Y
14	2	6	10	ON	7	KO	271	227.24	F	Maturing	3	7	N	Y
14	2	6	10	ON	8	KO	253	200.04	M	Mature	3	8	N	Y
14	2	6	10	ON	9	KO	247	168.28	F	Maturing	3	9	N	Y
14	2	6	10	ON	10	BT	296	229.81	F	IMM		10	N	Y
16	3	16	10	ON	11	KO	156	51.35	F	Imm	1	11	Y	Y
16	3	16	10	ON	12	KO	162	52.96	F	Imm	1	12	Y	Y
16	3	16	10	ON	13	KO	233	165.13	F	Imm	2	13	Y	Y
16	3	16	10	ON	14	KO	126	20.47	M	Imm	1	14	Y	Y
16	4	14	15	ON	15	KO	274	237.79	M	Mat	3	15	Y	Y
16	4	14	15	ON	16	KO	233	139.91	F	Imm	2	16	Y	Y
16	4	14	15	ON	17	KO	264	233.42	M	Mat	3	17	Y	Y
16	4	14	15	ON	18	KO	277	237.48	M	Mat	3	18	Y	Y
16	4	14	15	ON	19	KO	248	187.49	M	Mat	2	19	Y	Y
16	4	14	10	ON	20	KO	268	241.51	M	mat	3	20	Y	Y
16	4	14	10	ON	21	KO	280	245.59	M	mat	3	21	Y	Y
16	4	14	10	ON	22	KO	253	191.91	M	Mat	2	22	Y	Y
16	4	14	10	ON	23	KO	166	52.6	M	Imm	1	23	Y	Y

Appendix 7. Kokanee spawner length, weight and age data for 2012 for a) Camp Creek, tributary to Canoe River, b) Luxor Creek, tributary to Columbia River above Kinbasket Reservoir and c) 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)	Wt (g)	Age[2]
2012	29-Sep	M	254	200	3	29-Sep	F	275	180	3
2012	29-Sep	M	285	260	3	29-Sep	F	265	180	3
2012	29-Sep	M	268	240	3	29-Sep	F	258	160	3
2012	29-Sep	M	255	210	3	29-Sep	F	270	180	3
2012	29-Sep	M	260	200	2	29-Sep	F	250	150	3
2012	29-Sep	M	257	250	3	29-Sep	F	247	140	2
2012	29-Sep	M	260	200	3	29-Sep	F	265	170	3
2012	29-Sep	M	270	210	3	29-Sep	F	240	140	2
2012	29-Sep	M	290	320	3	29-Sep	F	267	180	3
2012	29-Sep	M	280	350	3	29-Sep	F	252	160	3
2012	29-Sep	M	275	250	3	29-Sep	F	260	160	3
2012	29-Sep	M	268	250	3	29-Sep	F	260	170	3
2012	29-Sep	M	274	280	3	29-Sep	F	245	150	3
2012	29-Sep	M	270	230	3	29-Sep	F	260	160	3
2012	29-Sep	M	260	300	3	29-Sep	F	240	130	2
Mean		**M**	**268**	**250**		**Mean**	F	**257**	**161**	

b) Luxor Creek

Year	Date	Sex	FL (mm)	Wt (g)[1]	Age[2]	Date	Sex	FL (mm)	Wt (g)	Age[2]
2012	25-Sep	M	235		2	25-Sep	F	236		2
2012	25-Sep	M	245		2	25-Sep	F	236		2
2012	25-Sep	M	238		2	25-Sep	F	229		2
2012	25-Sep	M	251		3	25-Sep	F	212		2
2012	25-Sep	M	240		2	25-Sep	F	241		2
2012	25-Sep	M	227		2	25-Sep	F	249		3
2012	25-Sep	M	229		2	25-Sep	F	250		3
2012	25-Sep	M	241		2	25-Sep	F	240		2
2012	25-Sep	M	230		2	25-Sep	F	219		2
2012	25-Sep	M	240		2	25-Sep	F	225		2
2012	25-Sep	M	235		2	25-Sep	F	239		2
2012	25-Sep	M	239		2	25-Sep	F	228		2
2012	25-Sep	M	238		3	25-Sep	F	235		2
2012	25-Sep	M	245		3	25-Sep	F	228		2
2012	25-Sep	M	218		2	25-Sep	F	236		2
Mean		**M**	**237**			**Mean**	F	**233**		

1. includes spawned out fish
2. Ages by Carol Lidstone, Birkenhead Scale Analysis

*Note: Add one year to spawner age to determine brood year (e.g. an age 2+ in 2012 is from a fall 2009 spawner).

c) Standard Creek, a tributary to Downie Creek and Revelstoke Reservoir during September 2012.

Year	Date	Sex	FL(mm)	Wt (g)	Age[1]	Date	Sex	FL (mm)	Wt (g)	Age[1]
2012	27-Sep	F	284		3	27-Sep	M	279		3
2012	27-Sep	F	286		3	27-Sep	M	280		3
2012	27-Sep	F	265		2					
2012	27-Sep	F	296		3					
2012	27-Sep	F	285		3					
2012	27-Sep	F	266		3					
2012	27-Sep	F	266		3					
2012	27-Sep	F	280		3					
2012	27-Sep	F	285		3					
2012	27-Sep	F	276		3					
2012	27-Sep	F	279		3					
2012	27-Sep	F	288		3					
2012	27-Sep	F	270		3					
Mean		F	279			Mean	M	280		

1. Ages by Carol Lidstone, Birkenhead Scale Analysis
*Note: Add one year to spawner age to determine brood year (e.g. an age 2+ in 2012 is from a fall 2009 spawner).

Appendix 8. Kokanee spawner mean length by age data from Camp Creek, and Luxor Creeks (Kinbasket Reservoir) and Standard Creek (Revelstoke Reservoir) (Source: K. Bray, BCH Revelstoke).

Trib.	Sample		Age 2		Age 3		Age 4	
	Date		n	FL (mm)	n	FL (mm)	n	FL (mm)
Kinbasket								
	Camp Creek							
		1998	62	238	15	264		
		2000	47	244	13	267		
		2001	30	242	30	264		
		2002	7	265	53	278		
		2003	21	250	39	277		
25	Sep	2004	43	235	17	257		
4	Oct	2005	32	242	27	253	1	260
26	Sep	2006	1	226	59	277		
29	Sep	2007			60	273		
28	Sep	2008	11	223	19	253		
29	Sep	2009	30	223				
30	Sep	2010	60	228				
23	Sep	2011	28	237	2	244		
29	Sep	2012	4	247	26	265		
		Mean		239		264		
	Luxor Creek							
		2007	27	249	4	268		
		2009	30	209				
		2010	29	224	1	244		
29	Sep	2011	10	223				
25	Sep	2012	24	233	5	247		
		Mean		228		253		
Revelstoke								
	Standard Creek							
12	Oct	2007	22	292	10	329		
5	Oct	2009	14	263	1	306		
4	Oct	2010	9	264	1	293		
3	Oct	2011	14	260	6	277		
27	Sep	2012	1	265	14	280		
		Mean		269		297		

*Note: Add one year to spawner age to determine brood year (e.g. an age 2+ in 2011 is from a fall 2008 spawner).

Appendix 9 – 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		40450	470	
2001	18,000	15150	56225	690	
2002	11,000	16601	51925	7,735	
2003	16,900	20900	68900	7,435	Dry year, low flows (good viewing conditions)
2004	13,500		20000		Heavy fall rains, turbid conditions
2005	25,000	39250	19700	9,810	
2006	22,944	14150	46000	5,460	Dry year with low water
2007	19,125	25936	*900*	10,175	Poor weather on Luxor (Upper Columbia survey)
2008	13,500	27150	19480	14,350	
2009	8,850	19280	9510	6,320	Good viewing conditions
2010	10,825	17800	*1300*	*1,600*	Wet fall, turbid conditions, Beaver Dam on Luxor
2011	4,800	22100	20000	*950*	High pool backflooded some off channel areas
2012	5,000	19530	9100	*200*	High water and turbid conditions
Average	13,607	21,622	32,845	6,938	
Standard Dev.	6,483	7,128	20,570	4,444	
	(± 47%)	(± 33%)	(± 63%)	(± 64%)	
Range (± 1 SD)	(7124-20090)	(14494-28750)	(12275-53415)	(2494-11382)	

Note: blanks indicate no sampling

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

Partial counts have not been included in calculating average and ranges