# Columbia River Project Water Use Plan

## Kinbasket Fish and Wildlife Information Management Plan

## Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring

## Implementation Year 9

## Reference: CLBMON-2

**Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring – *Year 9 (2016)***

**Study Period: 2016**

**D. Sebastian[1] and T. Weir[2]**

[1] Large Lakes Biologist, BC Conservation Foundation
[2] Large Lakes Ecosystem Specialist, Fish Wildlife and Habitat Management Branch, Ministry of Forests, Lands and Resource Operations

**November 2017**

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.

Suggested Citation:

Sebastian, D. and T. Weir. 2017. Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring - Year 9 (2016). Prepared for BC Hydro under the Columbia River Water Use Plan, Water Licence Requirements Study No. CLBMON-2. 56p.

# Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring – Year 9 (2016)

Prepared by D. Sebastian and T. Weir

## INTRODUCTION

During July of 2016, the ninth year of a proposed twelve year study to monitor kokanee in the limnetic habitat of two Columbia Basin reservoirs, Revelstoke and Kinbasket, was undertaken by the Fish & Wildlife 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. The 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 2016-2019. 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 2016 field survey in relation to previous years of trend data using the same survey design, equipment and methods. 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 beginning in 2014 and the time series from 2009-2014 was adjusted to ensure consistency for the duration of this project. The same noise reduction method has been continued in 2016 on both Kinbasket and Revelstoke Reservoirs.

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 2014-15 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. Differences in spawner size and age structure led to continuation of biological sampling of both Luxor and the mainstem Upper Columbia River in 2016. Data for the Columbia River mainstem spawning population in 2016 was collected by FSRBC as part of an egg collection conducted to mitigate production shortfalls in Kootenay Lake.

## 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 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. Thirty standard transects for Kinbasket were completed in 2016 and an additional 6 short transects were undertaken to assess Bush Pool. 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.

A new method for setting the lower acoustic threshold was developed in 2013 in order to reduce the impact of low end noise (i.e. non-fish targets) encroaching on the fish distribution. The method as described in Sebastian and Weir (2015) has been applied to all SONAR5 analyses from 2009 through 2016 on both Kinbasket and Revelstoke Reservoirs. The resulting size distributions were plotted separately for noise and fish to show the suggested degree of overlap by this method for Revelstoke (Appendix 5) and Kinbasket (Appendix 6) reservoirs. The results and implications of this new approach are discussed in the *Methods Development* section of Sebastian and Weir (2016).

Standard trawl sampling was conducted at two stations on Kinbasket Reservoir (Wood Arm and Main Pool) 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 7. 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 (or average boat speed). 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.

Two pelagic gillnets were set over-night in the Lower Basin of Revelstoke Reservoir with one set at each of transects 11 and 12. Another two pelagic gillnets were set in Kinbasket Reservoir with one set in the (Mica) Forebay Reach at transect 11 and one set in Bush Pool at new Transect 32 (east of Bear Island). Gillnet sites were chosen to maximize catch by targeting locations and depths with the highest age 1-3+ kokanee densities, based on evaluation of acoustic data collected just prior to gillnetting.

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 modified RIC standard nets attached end to end for a total length of 320 or 427m respectively. RIC (1997) standard nets each consisted of 6 panels of variable sized mesh ranging from 25-89 mm stretched mesh (Appendix 8). Starting in 2015 a seventh panel of 32mm mesh was added to each RIC standard net to improve effectiveness for capturing age 1 kokanee in the 130-160mm size range (Sebastian and Weir, 2016). 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 106.7m net was submerged to pre-determined depths of 10m, 15m, or 20m (from the surface) and a second anchor was deployed at the end of the last net set. Net depths chosen for site were dependant on the depth of the majority of age 1-3+ kokanee at each location based on evaluation of acoustic data from nearby transects. A series of clip on floats with pre-measured lines of 10m, 15m, and 20m were used to suspend the net at the desired depth. 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 and zone 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 9 and biological information from gillnetted fish are shown in Appendix 10. 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.

Temperature profiles were obtained at a total of 10 locations using a Seabird water profiler. Seabird casts were made at five regular locations in Kinbasket Reservoir including Canoe Reach (transect 1), main pool (T14), Wood Arm (T19), Old Kinbasket pool (T25) and Upper Columbia (T30). With a second year of assessment of Bush Pool an additional 2 casts were made. Three casts were done in Revelstoke Reservoir at Transects 1, 11 and 16 representing the Forebay, Lower and Middle reaches, respectively.

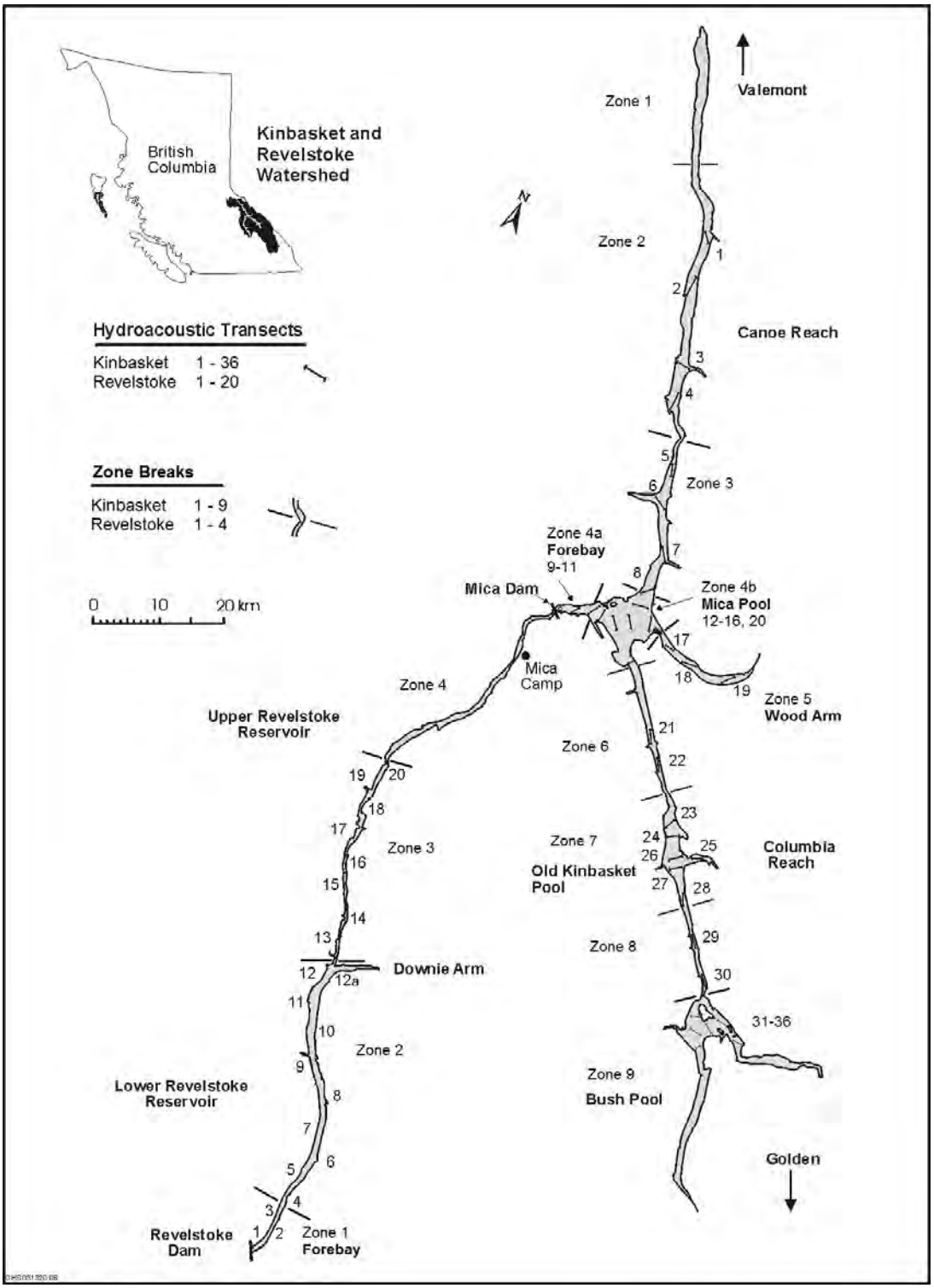



**Figure 1.** Map of Kinbasket and Revelstoke reservoirs showing location of reaches, habitat zones and acoustic transects.

Following a year with no kokanee counts in 2015 due to heavy fall rains and turbidity throughout the watershed and spawning period, counts were again resumed at three locations in 2016. Camp Creek and Bush River counts were conducted from a helicopter while total escapement for the main spawning area of the Upper Columbia River near Fairmont was estimated using a fish fence and trap by the Freshwater Fisheries Society of BC (FFSBC) as part of an egg collection program.

Kinbasket spawners were sampled for biological data by angling in Camp Creek, by dip net in Wood River, a combination of dip net and gillnet in Bush River and Luxor Creek and with a fish fence and trap in the Upper Columbia River at Fairmont. Revelstoke spawners were collected from Standard Creek, a tributary to Downie Creek, with a dip net. Sex, fork length, and age structures were collected for estimating mean length at age. In previous years, otolith ageing was conducted by Birkenhead Scale Analysis but in 2016 ageing services were provided by the BC provincial ageing lab in Abbotsford, BC. Both labs Followed ageing 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 2016 were conducted between July 29 and August 9 on Kinbasket Reservoir and on August 2$^{nd}$ and 5$^{th}$ (acoustic survey) and August 11$^{th}$ (gillnetting) on Revelstoke 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 2016 the maximum monthly discharge was 381 $m^3 \cdot sec^{-1}$ or 74% of the long-term average of 519 $m^3 \cdot sec^{-1}$ (Fig. 2). This was considered a very low freshet flow as it was beyond one standard error below the long-term mean.

A mean annual discharge of 164 $m^3 \cdot sec^{-1}$ was only 1% below the 37 year average of 166 $m^3 \cdot sec^{-1}$ (Fig. 3). For the fourth consecutive year, flow records indicate that 2016 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 752m above sea level or an average of 2m below the normal full pool level of 754m. With pool elevation one meter higher than 2015, there were moderate

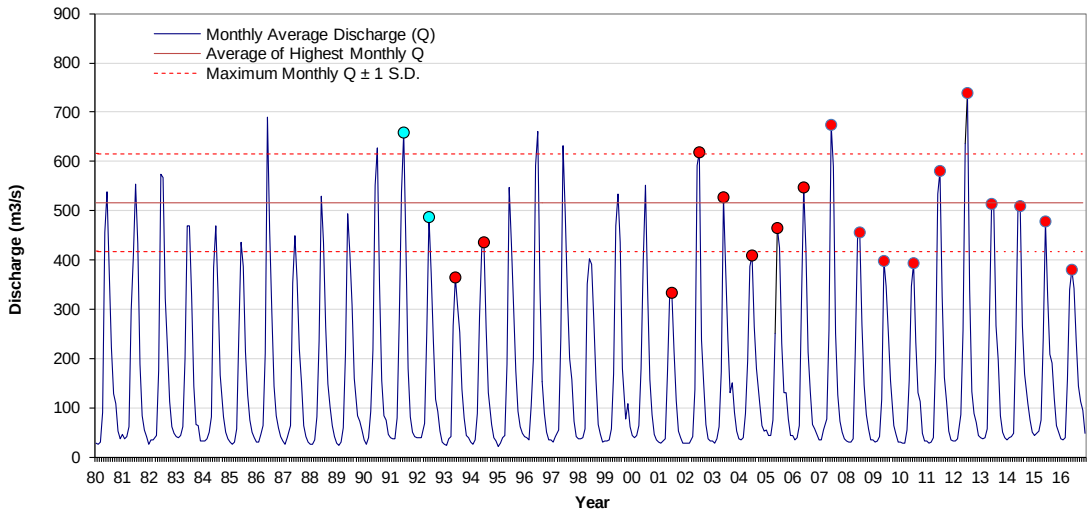



**Figure 2.** Monthly mean flows for unregulated Columbia River inflows to Kinbasket Reservoir at Donald Station (Water Survey of Canada hydrometric station 08NB005) near Golden BC. Note that red circles indicate study years with standardized ATS survey design, blue circles indicate non-standard preliminary survey years. Red line shows the 37 year (1980-2016) average of maximum monthly discharges with dotted lines at ± one standard deviation.

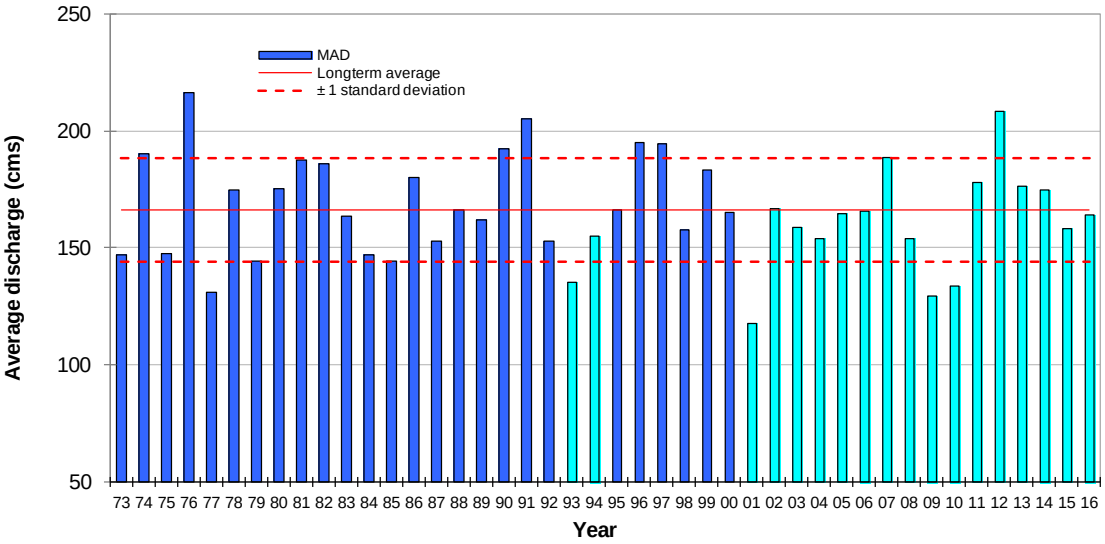



**Figure 3.** Mean Annual Discharge (MAD) of unregulated Columbia River inflows to Kinbasket Reservoir based on Water Survey of Canada station 08NB005 near Golden BC. The red line indicates the average annual flow since Mica Dam construction in 1973, with red dashed lines indicating ± 1 standard deviation.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

amounts of floating debris. At 2 meters below full pool the pelagic area was 23,401 ha for the standard reaches surveyed and 30,736 ha for the entire reservoir (Table 1). For standard areas surveyed the pelagic habitat area was only 1.4% less than at full pool and 4% below average for the entire reservoir. In 2016 an additional 6140ha of pelagic area were surveyed in Bush Pool, an addition of approximately 26% to the total pelagic habitat surveyed.

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

| Zone | Location/description | Full pool[1] surface area (ha) | Full pool[2] Pelagic area (ha) | 2016[3] Pelagic area (ha) | Pelagic[4] % reduced |
|---|---|---|---|---|---|
| | **Kinbasket Reservoir** | | | | |
| 1 | Canoe Reach - Valemont to 40m contour | 2,400 | 1,305 | 1,195 | 8% |
| 2 | Canoe Reach - 40m contour to narrows | 4,560 | 4,060 | 4,024 | 1% |
| 3 | Canoe Reach - narrows to Mica Pool | 4,900 | 4,360 | 4,320 | 1% |
| 4a,b | Mica Pool above dam[5] | 6,940 | 5,580 | 5,460 | 2% |
| 5 | Wood Arm | 2,020 | 1,560 | 1,492 | 4% |
| 6 | Mica Pool to Old Kinbasket Lake | 2,120 | 1,805 | 1,775 | 2% |
| 7 | Old Kinbasket Lake | 5,270 | 5,055 | 5,033 | 0% |
| 8 | South Columbia (Old Kin to Surprise Rapids | 1,500 | 1,315 | 1,297 | 1% |
| 9 | Bush Pool Surprise rapids to Upper Col R. | 11,350 | 6,980 | 6,140 | 12% |
| Total | | 41,060 | 32,020 | 30,736 | 4% |
| 2-8 | ***Total habitat surveyed*** | 27,310 | 23,735 | 23,401 | 1% |
| | **Revelstoke Reservoir** | | | | |
| 1 | Forebay - Revelstoke Dam to T3 | 1,525 | 1,315 | 1,315 | 0% |
| 2 | Lower Revelstoke -T4 to Downie Creek | 4,575 | 3,935 | 3,935 | 0% |
| 3 | Middle Revelstoke - Downie to Nicholls Creek | 3,100 | 2,000 | 2,000 | 0% |
| 4 | Upper Revelstoke - Nicholls Creek to Mica Dam | 2,100 | 450 | 450 | 0% |
| Total | | 11,300 | 7,700 | 7,700 | 0% |
| 1-3 | ***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. 2016 pelagic area for Kinbasket is area at 752m 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. Includes Forebay zone and the main Mica Pool zone

A summary of survey dates, pool elevation and pelagic habitat area for all previous summertime surveys is shown in Table 2. Note that habitat zones 1 and 9 were typically not included in the annual surveys due to hazards for night navigation and assumed marginal quality of pelagic habitat for kokanee with depth being the major limitation. Relatively high pool levels and only moderate amounts of debris enabled hydroacoustic and gillnet surveys to be undertaken in Bush Pool (habitat zone 9) for the second consecutive year in 2016. The rationale was to determine the extent to which kokanee utilize this basin at high summer pool levels. The “flatness” of zones 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 may have to re-colonize zones 1 and 9 following drawdown periods due to insufficient depth in winter months. However, 2015 was an exceptional year with pool level remaining well above average as a result of a warm winter, low power demands and above average inflow (BC Government website). A minimum pool elevation of 737m on May 15, 2015 (BC Hydro website, 2016) resulted in a minimum habitat area of ~4000ha with depths exceeding 10m, although by definition no "pelagic" habitat remained (i.e., 20m or more depth). In 2016, a minimum pool elevation of 729.4m was reached on April 1 (BC Hydro website, 2017). At this elevation, the maximum depth in Bush Pool was 10m. By comparison with 2015, the habitat area with depth of 10m or greater was reduced from 4,000ha in spring 2015 to 200ha during spring of 2016.

**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 |
| 2015 | July 11-19 | 751 | 3 | 23,234 |
| 2016 | July 31-Aug 5 | 752 | 2 | 23,401 |

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)

On Revelstoke Reservoir, the pool elevations remained fairly constant and the surface area and pelagic habitat area surveyed (zones 1-3) remained at approximately 9,200 and 7,250 ha, respectively. Note, zone 4 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).

### *Water temperature*

Water temperature profiles were measured at six locations on Kinbasket Reservoir in 2016 which include the Upper Canoe (T1), main pool (T14), Wood Arm (T19), Old Kinbasket Pool (T26), Upper Columbia (T30) below Bush and Bush Pool (T32).

Temperature profiles were similar between profile locations in 2016, and also generally similar to previous years, where the main feature was the steady decline in temperature from near surface to depth with weak evidence of thermal stratification (Fig. 4b). Water temperatures in 2016 were similar or cooler than the same locations in 2015 (Fig. 4a), even though the profiles were taken ~ 2 weeks later in the summer. In 2016, the preferred temperature range of 11-15°C for kokanee at night in Bush Pool extended from approximately 9m to 26m depth; nearly to the bottom.

In Revelstoke Reservoir the three temperature profiles illustrate gradually warming and stratifying epilimnetic water moving from the northernmost cast between transects 15/16, south to transect 1 near the dam, where a thermocline was evident at ~15m (Fig. 4d). Only a single cast was completed in 2015 near transect 12 (Fig. 4c), limiting the ability to compare between the 2 years.

### *Kokanee Mortality Event*

Between mid-late May and early June 2016, Ministry of Forest, Lands and Natural Resource Operations fisheries staff received reports from anglers and others working on or around Kinbasket Reservoir of dead and moribund fish floating on the surface of the reservoir. The reports indicated that the vast majority were kokanee and they were observed across a large area spanning from Bush Pool to the Forebay, over approximately 3 weeks. Most reports included the description of kokanee with fungus and open lesions or haemorrhaging around the base of fins and the caudal peduncle. Many reports noted the vast majority were of a similar size class qualitatively described as around 7 or 8 inches (15-18 cm). On May 31, 2016, local BC Hydro staff collected 18 dead or moribund kokanee from the reservoir surface where Wood Arm opens into the main Pool and from near Redrock Harbour (where the Columbia Arm opens into the main pool). The samples were frozen and sent to the Freshwater Fisheries Society of BC (FFSBC) Fish Health Laboratory in Duncan BC for pathology testing. The fish were measured and otoliths were collected for ageing (n= 16 structures suitable for ageing), which confirmed that the majority (n= 13; 81%) were age 2 with two aged as 1 yr. (13%) and a single aged as 3 yrs. (6%).

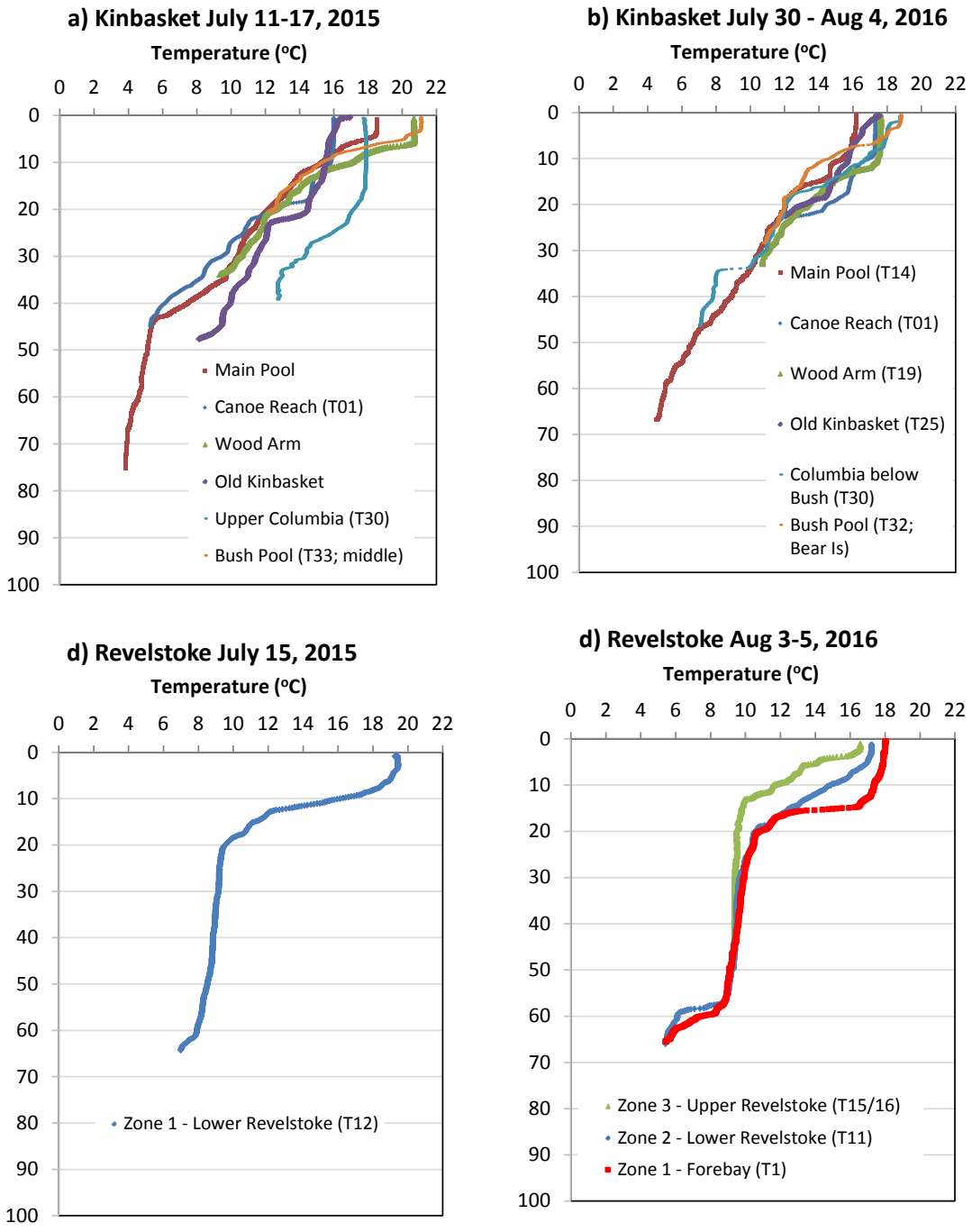



**Figure 4.** Plots comparing 2015 and 2016 water temperature profiles by location for a) and b) Kinbasket Reservoir and c) and d) Revelstoke Reservoirs respectively.

Polymerase Chain Reaction (PCR) tests confirmed the presence of infectious haematopoietic necrosis virus (IHNV) in 16/18 samples, and strain genotyping conducted at the Fisheries and Oceans Canada Fish Health lab confirmed the strain was identical to that found in kokanee in the Kootenay and Arrow systems in recent years and considered endemic to the region.

Isolation of the IHNV virus through PCR testing does not confirm it as the causal agent of the mortality event, although it is suspected to be a contributing factor at a minimum (S. Mead, Fish Health Unit, Freshwater Fisheries Society of BC; Pers. Comm., 2017). The IHNV has not been widely linked to mortality in sub-adult or adult age classes of kokanee in-lake; however one documented case involved a die-off of age 2+ Kokanee in Cowichan Lake, BC (Traxler, 1986). In that case, kokanee were found floating at the surface dead or moribund and swimming erratically and several sampled fish had skin haemorrhaging, and the event occurred in May, all of which closely mirror the circumstances in the Kinbasket event. Interestingly, a very similar set of circumstances occurred surrounding a large-scale kokanee die-off on Upper Arrow Reservoir in May 2012 as well, including dead and moribund kokanee, primarily age 2, with very similar lesions and haemorrhaging (Schindler *et al*., 2014). In that case however, samples were not sent in for pathology testing.

### *Kokanee Distribution*

Kokanee age 0 (fry) were found at 15-25m over much of Kinbasket Reservoir in 2016 and were concentrated in the Columbia Reach between the upstream end of Old Kinbasket Lake and the main pool (Fig. 5a). Fry were found in a typical night-time layer throughout Kinbasket except for the main pool, where they extended from 3-35m depth. The age 1-3+ fish were found at 15-30m over much of the reservoir, but were concentrated in the main pool and the lower Columbia Reach near the main pool. Age 1-3+ densities were quite low throughout the Canoe, Forebay, Wood Arm and Bush Pool and very low in the Upper Columbia Reach between Bush Pool and Old Kinbasket Lake (Fig. 5b).

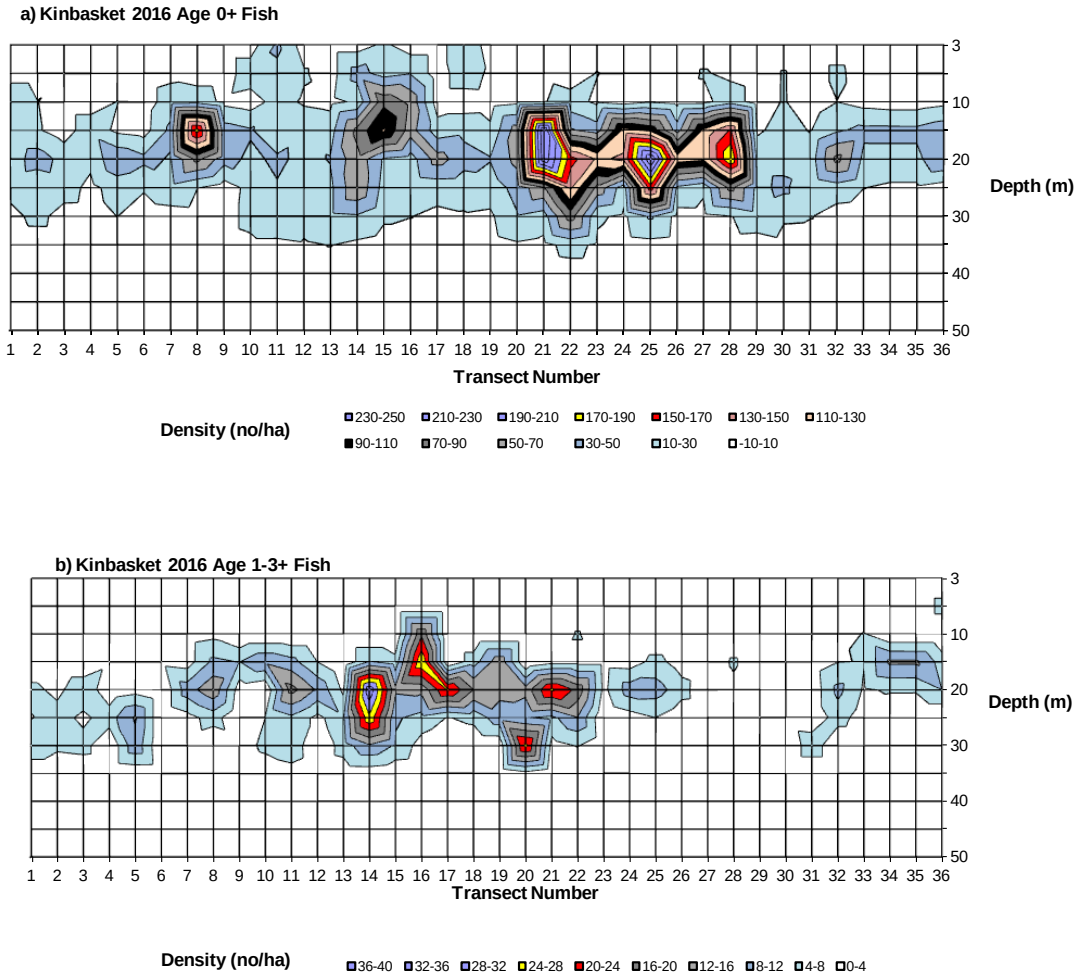



**Figure 5.** Contour plot showing kokanee distribution in Kinbasket Reservoir by depth and transect for a) age 0+ and b) age 1-3+ fish. Note: transects 31-36 show fish distribution in Bush Pool sampled in 2016.

In Revelstoke Reservoir the contour plot showed a distinct fry layer from the Forebay to the north end of Zone 2, with the main layer at 10-15m from the surface and highest densities at Transects 10-12 toward the upstream end of Zone 2 (Fig. 6a). There was no distinct layer of fry in Zone 3 (transects 13-20) as fry ranged from 3-25m depth with a patchy distribution. Age 1-3+ fish were in a night-time layer that generally increased in depth moving downstream, with the majority of fish found in the 10m layer in Zone 3 and in the 15m layer in Zones 1&2 (Fig. 6b). The age 1-3+ were patchy and at very low densities. Similar to fry, their highest concentration was found at Transect 10.

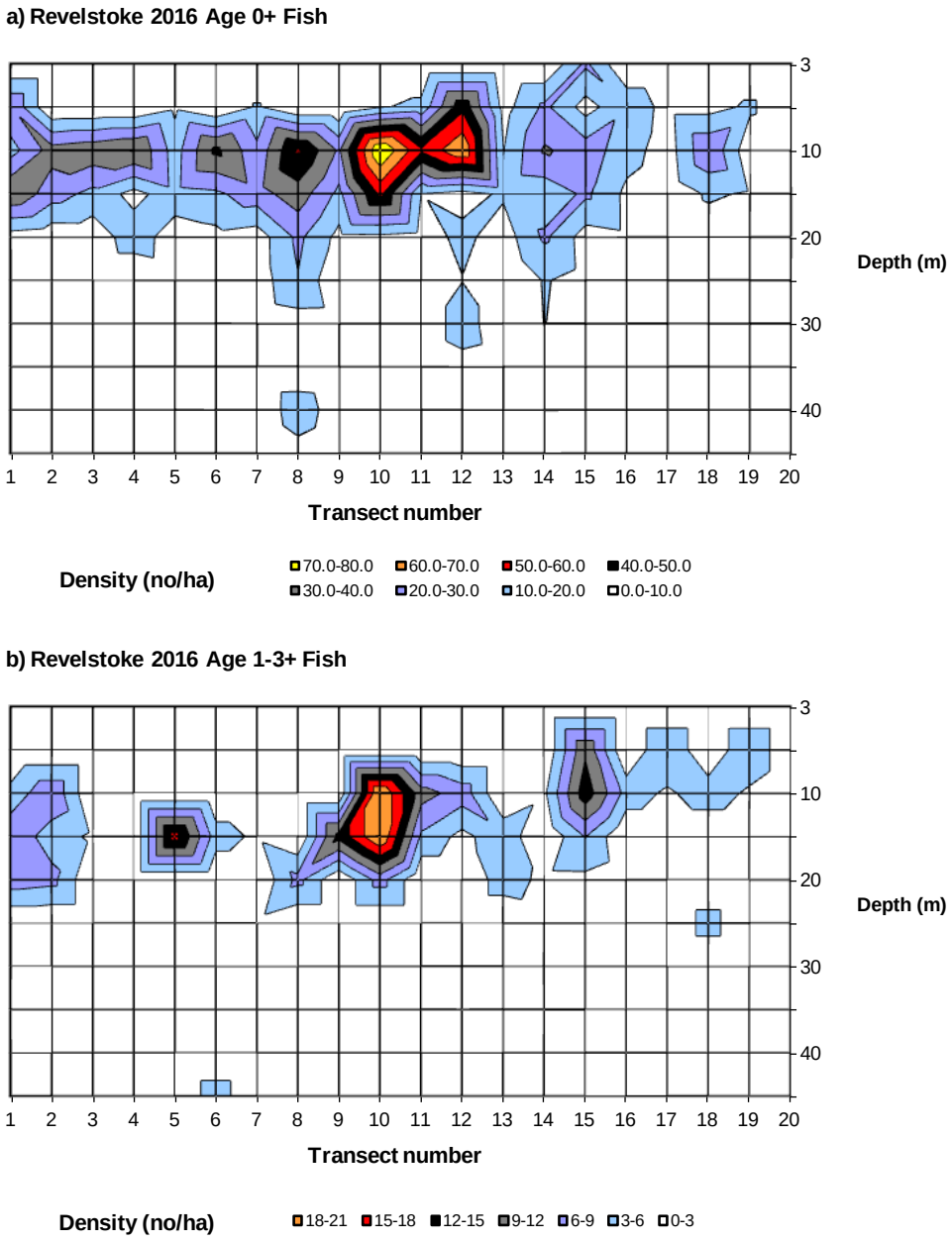



**Figure 6.** Contour plots showing kokanee distribution by depth and transect in Revelstoke Reservoir for a) age 0 and b) age 1-3+ kokanee based on 2016 acoustic surveys. Note that density (no/ha) scales are different between plots a and b as a result of major differences in fish abundance.

Fish densities at individual transects in Kinbasket Reservoir ranged from 52 fish·ha$^{-1}$ at Transect 6 in Canoe Reach to 672 fish·ha$^{-1}$ at Transect 21 in Columbia Reach, immediately upstream of the main pool (Fig. 7a). The highest and lowest densities of fish were found at similar locations in 2015.

Compared with the long-term average shown by the red line in Figure 8a, transect densities in 2016 were near or above average at most transects in the lower Columbia Reach and Old Kinbasket Pool and remained well below average at all other locations which include Canoe Reach, Forebay, the main pool, Wood Arm, Upper Columbia and Bush Pool. The longitudinal distribution in 2016 was unusual but similar to 2015. The earlier survey timing in 2015 was believed to explain the lower densities of kokanee found in the main pool and Canoe Reach compared with Wood Arm and the Columbia Reach which are closer to fry recruitment areas. However the survey time was later in 2016 so unless fry were later leaving natal streams, the timing does not really explain why concentrations of fish were further upstream than normal in 2016. Also the rationale of closer proximity to recruitment areas does not hold up in 2016 as the Upper Columbia and Bush Pool reaches had very low fry densities. Other possible factors influencing fry distribution could be lower overall fry recruitment resulting in a reduced tendency to disperse in search of lower competition for food, or a predation related mechanism resulting from either lower fry densities or a change in predator abundance/predation pressure.

Fish densities in Revelstoke Reservoir ranged from 15 fish·ha$^{-1}$ at transect 20 to 263 fish·ha$^{-1}$ at transect 10 (Fig. 7b). Compared to previous years, the 2016 transect densities remained far below average for the southernmost transects, with densities for transects 1-7 ranging between 27% and 54% of their respective long term averages. The remaining transects (8-20) were variable in comparison and ranged from 199% of average for transect 15 to only 24% of average for transect 20.

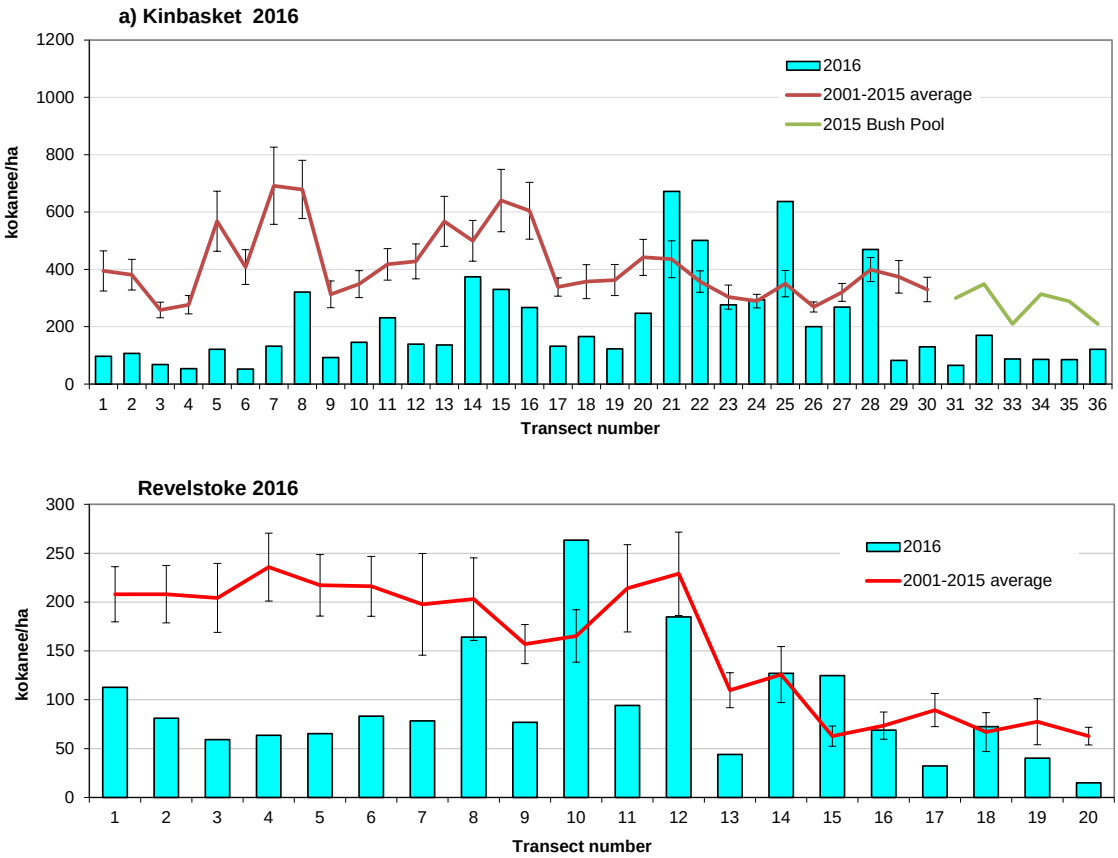



**Figure 7.** Longitudinal density distributions for kokanee in a) Kinbasket and b) Revelstoke reservoirs based on acoustic surveys. The Long-term average transect densities for 2001-2015 are shown by the red line. As only 2015 densities exist for Bush Pool they are presented separately for transects 31-36 in place of a long term average. Error bars represent the 95% confidence limits (± 2 standard errors) of the mean.

Figure 8 shows a comparison of average zone densities for age 0+ and age 1-3+ kokanee for 2015 and 2016 with statistical bounds (95% C.L.). In 2015, zone average densities of fry ranged from 118-538 fish·ha$^{-1}$ and were statistically similar in the Canoe Reach, Forebay Reach, Wood Arm, Upper Columbia and Bush Pool. Zone 6 in the Lower Columbia Reach had the highest average fry density although not significantly higher than adjacent zones of Old Kinbasket Lake, the main pool and Wood Arm. Fry densities in 2016 appeared to be much lower than in 2015 for most zones, however the difference was only statistically significant for one zone (Upper Columbia below Bush Pool) (Fig.8a). The age 1-3+ densities in 2015 were statistically similar between all zones sampled indicating how even their distribution was throughout the reservoir (Fig. 8b). In 2016 however, age 1-3+ densities were significantly lower from Old Kinbasket

Pool upstream to Bush Pool (Zones 7-9) and in upper Canoe Reach (Zone 2) compared to the remainder of the reservoir.

When Bush Pool (Zone 9) fry densities in 2015 were compared with other zones, they were statistically lower than only two of nine zones: main pool and lower Columbia Reach, while there were no significant differences in age 1-3+ density between any of the nine habitat zones including Bush Pool. A tentative conclusion based on only a single year of survey in 2015 was that habitat in Bush Pool previously thought to have only marginal use for kokanee appeared to be as productive as many other areas in the reservoir, at least at the relatively high over winter pool levels experienced in 2015 (Sebastian and Weir, 2016).

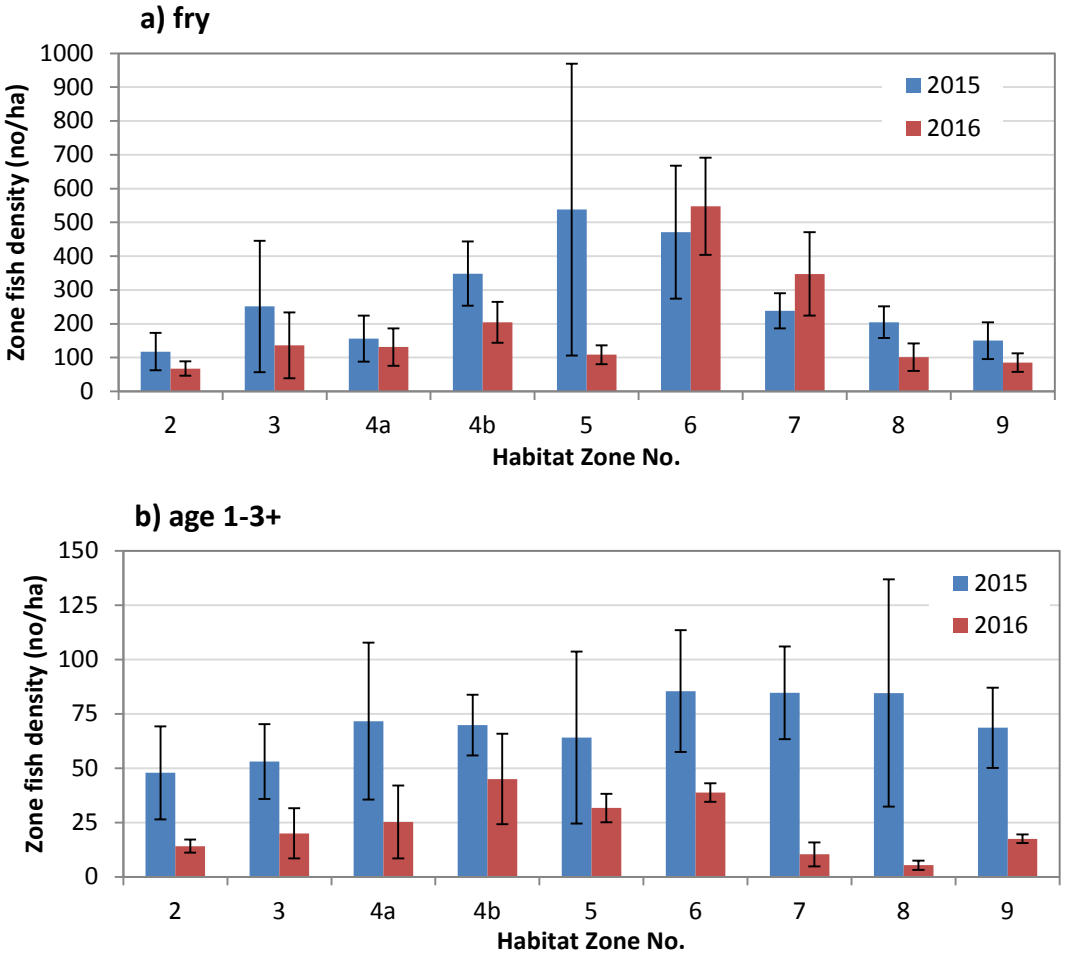



**Figure 8.** Comparison of mean transect density by habitat zone for a) fry and b)age 1-3+ kokanee in Kinbasket Reservoir in July 2015 and August 2016. Error bars denote 95% confidence limits on mean density.

A second year of data for Bush Pool showed slightly lower fry densities but much lower age 1-3+ density than in 2015. However, when compared with other zones in 2016, the densities of both fry and age 1-3+ were only slightly below the average of all zones and confirmed a second consecutive year of significant kokanee use for Bush Pool. In order to assess the effects of high winter water levels on age 1-3+ kokanee use in Bush Pool, more years of survey data and and more contrast in winter flows are needed. The die-off in June may also have impacted age 1-3+ kokanee densities and distribution in 2016.

### *Kokanee Abundance*

Total kokanee abundance (standard survey zones 2-8) in Kinbasket Reservoir for 2016 was estimated at 5.28 (4.38-6.20) million (Appendix 3a). This represented a significant decline from the 2015 estimate of 8.55 million and was only the fourth of 18 years on record that had densities significantly below the long term average of 8.72± 1.56 million. Survey years below average were 1993, 1994, 2011 and 2016 while abundance in 2007 and 2008 was above average.

The acoustic size distribution suggested a size cut-off at -44 dB between age 0+ (fry) and age 1-3+ fish in Kinbasket Reservoir. This cut-off was 4dB higher than the previous year which had the lowest fry cut-off on record presumably due to earlier sampling (i.e. mid July compared with late July or August previously). The resulting abundance estimate for fry was 4.73 (3.84-5.61) million and for age 1-3+ fish was 0.55 (0.44-0.67) million for the standard survey zones 2-8 (Fig. 9a and b). The fry abundance has been similar for the last four consecutive years up to 2015 but declined significantly in 2016 and was comparable with 2011 which was considered a poor year for fry production. Despite average levels of fry recruitment in six out of seven consecutive years (2009-2015), the resulting age 1-3+ abundance in 2010-2016 remained below average in four of the seven years (i.e., 2011, 2012, 2014 and 2016) suggesting that kokanee survival in Kinbasket Reservoir has declined starting in 2011. The age 1-3+ abundance was the lowest on record in 2016 and suggests that the prolonged die-off observed in late May to early June must have had a significant impact on the population of older kokanee.

A detailed survey of Bush Pool with nine transects in 2015 indicated that habitat in zone 9 previously considered marginal supported an estimated 1.31 million kokanee in addition to the 8.55 million reported for the standard survey of habitat zones 2-8. A fry estimate for Bush Pool of 991,000 would increase the standard fry estimate of 7.02 million by 14% to 8.01 million. An estimate of 321,000 additional age 1-3+ kokanee would increase the standard estimate of 1.53 million by nearly 21% to 1.85 million, which is significant since it is beyond the bounds of the original estimate. Further monitoring of Bush Pool in 2016 showed that including Bush Pool would increase the total kokanee population by fewer than

600,000 fish (12%) which is still within the bounds of the 2016 estimate, so would not be considered statistically significant. A separate look at the age 1-3+ population suggested that the 2016 contribution of 104,000 fish from Bush Pool would increase total abundance of age 1-3+ fish by nearly 19% to 558,000, however this is still within the bounds of the original 1-3+ abundance estimate.

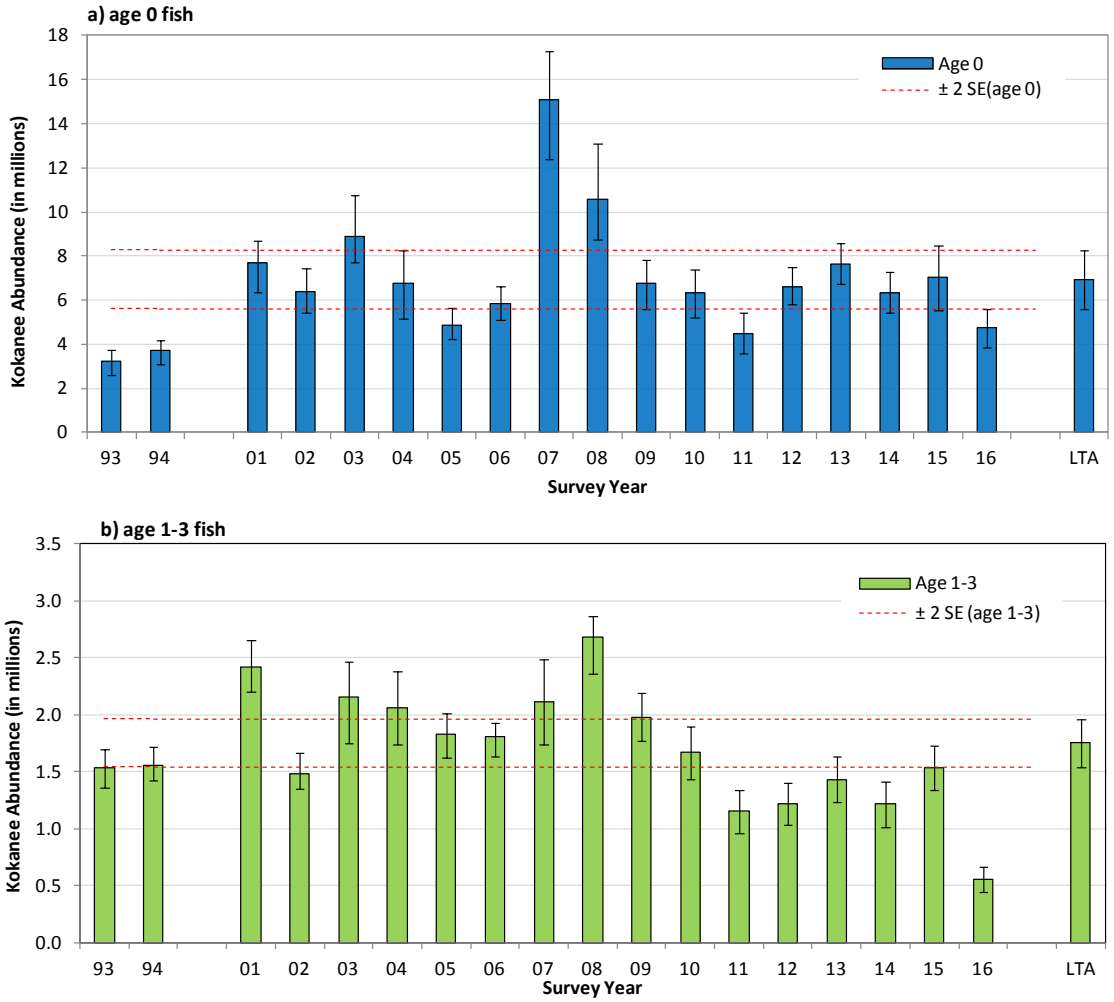



**Figure 9.** Kinbasket Reservoir kokanee abundance trends for a) age 0 and b) age 1-3 fish based on acoustic surveys. Note: LTA refers to the long-term averages and include 1993-94 and 2001-15. Error bars denote 95% confidence limits on maximum likelihood estimates. The dashed lines indicate ± 2 standard errors on the 17 year average. Estimates presented include zones 2-8 for all years.

In Revelstoke Reservoir the total abundance of kokanee (all ages) was estimated at 0.65 (0.53-0.77) million in 2016 (Appendix 4a) and was well below the long term average of 1.11 ± 0.24 million. The acoustic size distribution suggested a size cut-off of -47dB between age 0 and age 1-3 fish in Revelstoke Reservoir

marking a return to more typical cut-off values of -46dB following the two previous years where sampling time was earlier and cut-off's were smaller (eg -49dB). Fry abundance in 2016 was estimated at 0.55 (0.44 – 0.65) million and age 1-3+ abundance was estimated at 0.087 (0.058 – 0.117) million (Fig. 10a and b). The 2016 fry abundance represents a return to relatively low fry numbers similar to 2012 to 2014 and follows average fry abundance in 2015. Although slightly higher than the previous four consecutive years, the age 1-3+ abundance showed very little response to significantly higher fry abundance in 2015 than in the three years previous. This suggests relatively poor survival for kokanee between the 2015 and 2016 summer surveys.

Compared to previous years, the fish in Revelstoke in 2015 were concentrated at the downstream end of the main basin near Revelstoke Dam, and Sebastian and Weir (2016) speculated that may have been a function of higher flows through the reservoir; a result of high water releases called for by the Columbia River Treaty that were triggered by dry conditions south of the US border (Columbia River Operations Summary – spring 2016). Additional release of water from Kinbasket Reservoir was used to mitigate drawdown in Arrow Reservoir during summer and fall of 2015 resulting in increased flows through Revelstoke Reservoir. It is likely that these high flows resulted in an increase in entrainment over a normal flow year, which contributed to the poor survival between 2015 and 2016 noted above. Increased entrainment out of Revelstoke is corroborated by 2015 fall acoustic and trawl monitoring data from Arrow Reservoir, the next reservoir downstream of Revelstoke dam. Bassett *et al.* (*in prep.*) reported that a non-typical bi-modal kokanee fry fork length distribution was observed in Upper Arrow trawl samples, and proposed that the larger mode potentially represented entrained fry out of Revelstoke (assumed to be larger in size than Arrow fry). In addition, the highest proportion of large fry was found at the north (upstream) end of Upper Arrow and proportions declined moving southward by station. Bassett et al. applied the modal proportion of large fry to acoustic fry abundance data for corresponding trawl stations and produced an estimate of ~ 1 million fry of Revelstoke origin in Upper Arrow in October 2015. This number represents ~100% of the fry abundance estimate for July 2015 in Revelstoke, and it is unlikely that all fry enumerated in July were entrained out by the fall (also not supported by the presence of age 1+ kokanee in 2016). Accordingly, it is possible that significant entrainment out of Revelstoke had already occurred prior to the survey, and/or the estimate of 1 million Revelstoke origin fry in Upper Arrow was high. Another complication includes the magnitude and relevance of any Kinbasket fry entrained into Revelstoke. Regardless, multiple lines of information lead us to propose there was a high likelihood of increased and significant entrainment out of Revelstoke Reservoir in 2015. Bassett et al. (*in prep.)* recommended exploring the potential to use genetics or trace metals to determine if some portion of the trawl catch in Arrow can be tied to entrainment our of Revelstoke, which if successful would provide further insight or confirmation of the entrainment rate(s).

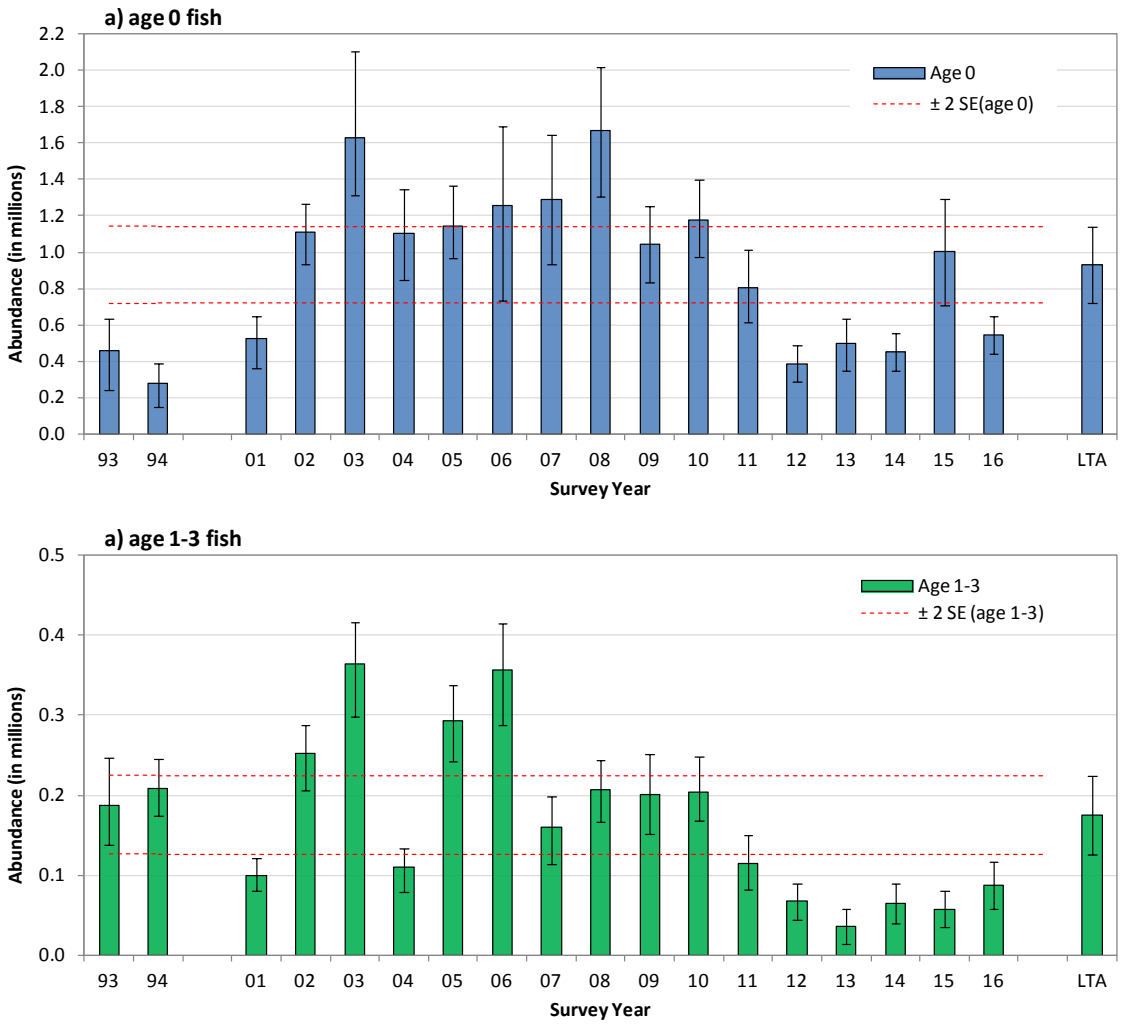



**Figure 10.** Revelstoke Reservoir kokanee abundance trends for a) age 0 and b) age 1-3 fish based on acoustic surveys. Note: LTA (reddish bars) refer to the long-term averages and include 1993-94 and 2001-15. Error bars denote 95% confidence limits on maximum likelihood estimates. The dashed lines indicate upper and lower bounds (± 2 standard errors) on the 17 year average.

### *Kokanee size at age from trawl, gillnet and spawner sampling*

Gillnet and trawl 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 94 kokanee were captured in three trawls: two on Wood Arm and one in the main pool (Appendix 7). The combined trawl catch consisted of 45 fry, 27 age 1+, 17 age 2+ and 5 age 3+ fish. Trawl catch per unit effort (CPUE) in 2016 was estimated at 1.0 and 0.59 kokanee/1000m$^3$ respectively for the Main Pool and Wood Arm compared with 2015 CPUE

estimates of 0.37 and 0.69 kokanee/1000m$^3$ for trawling in the main pool and Wood Arm.

Additional age 1-3+ kokanee were targeted with two overnight gillnet sets; one in the Main Pool near transect 11 and one in Bush Pool near transect 32 (east of Bear Island). Additional gillnetting was intended to include Wood Arm however weather conditions limited the number of sets to two. A total of 19 kokanee, 5 Bull Trout and one Pygmy Whitefish were captured at the two stations (Table 3). Gillnet catch per unit effort was 11 kokanee per ha of net area per hour in the main pool and 4.3 kokanee·ha·hr$^{-1}$ in Bush Pool (Appendix 9a). The Bush Pool set in 2016 was left soaking an additional 8 hours due to inclement weather which may have affected net efficiency. The CPUE in the main pool was 2.5 times higher than in Bush Pool and was also consistent with acoustic density of age 1-3+ kokanee which suggested densities were ~2 times higher in the main pool than in Bush Pool in 2016. Comparing years, both CPUE and acoustic density suggested abundance was lower in the main pool and much lower in Bush Pool in 2016 than in 2015.

**Table 3**. Summary of catch by species for two gillnet sets on Kinbasket Reservoir conducted during August, 2016.

| | | Number of fish captured | | | | | |
|---|---|---|---|---|---|---|---|
| Station No. | Transect | Kokanee | Bull trout | Rainbow | Chub | Pygmy whitefish | Total |
| 1 | 11 | 12 | 2 | | | | |
| 2 | 32 | 7 | 3 | | | 1 | |
| | | 19 | 5 | 0 | 0 | 1 | 25 |

A comparison of kokanee size at age between locations was continued in 2016, with further comparison of size between sampling methods. A very small sample (n=5) of angled fish from the main pool were included in the comparisons. With weather limitations in 2016, a comparison among all sampling methods was only available for the Main Pool. Similar to 2015, differences in length at age between trawling and gillnetting were not significant (although nearly significant for age 1+ fish) (Fig. 11). The angled age 1+ however were significantly larger than fish caught by trawl or gillnet, although there did not appear to be any difference in size at age for either age 2+ or 3+ fish. The comparisons in 2015 suggested that size differences between age 1+ trawl and GN caught fish were a result of selection biases of gillnets for age 1+ from the larger size mode. The rationale is that larger fish are susceptible to capture by different mesh sizes while small fish can only be captured by the small mesh panels. There is limited evidence suggesting that angling also tends to target only the largest age 1+ although a larger sample size would be required to verify this. It seems unlikely that anglers would retain the small age 1+ fish.

There was very little evidence that size at age was different for the different locations on the reservoir. It appears that age 1+ fish in Wood Arm may be smaller than age 1+ in the main pool however with only one age 1 fish caught in the main pool trawl, the sample size was too small to make comparisons. There was no gillnet set in Wood Arm during 2016 because of weather. Similarly, gillnetting provides some evidence that the age 3+ fish in Bush Pool may be slightly smaller than in other areas however the difference was not statistically significant. There were no differences in the size of fry or age 2+ either among methods or among locations.

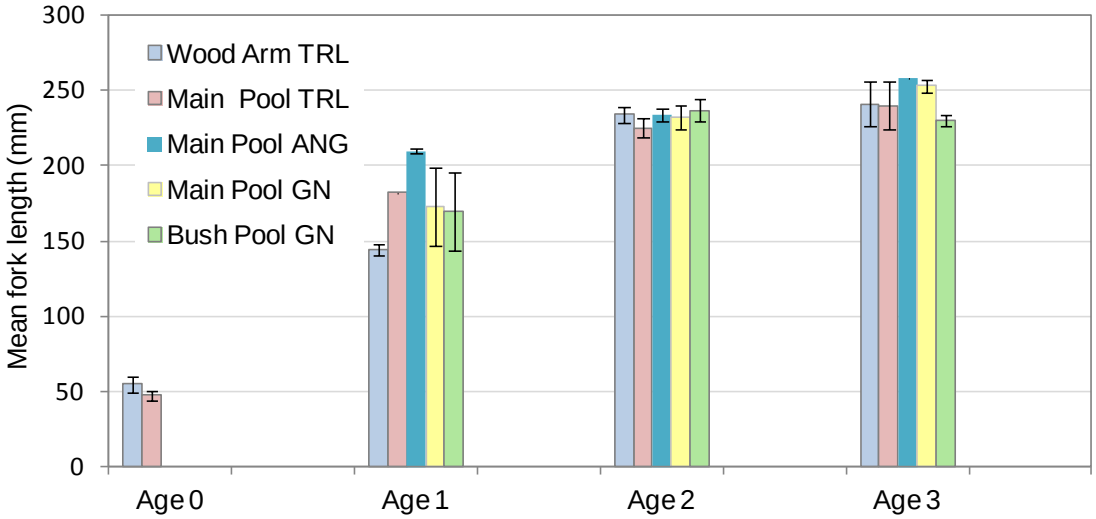



**Figure 11.** Comparison of mean length at age between sampling locations in Wood Arm, Main Pool and Bush Pool, and between different sampling methods; trawl(TRL), gillnet(GN) and angling(ANG) at the same location where available. Error bars indicate ± 2 Standard Errors of the means (95% confidence level).

Size statistics for kokanee combined for all Kinbasket Reservoir sampling in 2016 are summarized in Table 4. The mean length at age was 52 ± 4mm for age 0+, 151 ± 6mm for age 1+, 231 ± 4mm for age 2+ and 241 ± 8mm for age 3+ fish. Compared with 2015, age 0+, 2+ and 3+ fish were significantly larger in 2016. There was no significant difference in age 1+ due to their greater size variation within this age group.

Mean length at age estimates for spawners presented in Table 4 were based on combined samples from five 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 later in the report (*see pages 25-28*). The mean length at age for

spawning fish in 2016 was estimated at 252 ± 2mm for age 2+ and 270 ± 4mm for age 3+ where ranges (±) represent 95% confidence limits. There was a single age 4+ fish at 271mm. The mean spawner length at age for 2016 was significantly larger than in 2015 for both 2+ and 3+ fish and was consistent with the larger size of 2+ and 3+ fish sampled earlier in the summer using trawl, gillnets and angling. The age composition of spawners based on total numbers captured in all tributaries was 80% age 2+ and 19% age 3+ fish and was very similar to the age composition in 2015. There was again considerable overlap in the length between age 2+, age 3+ and age 4+ spawners.

**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 Wood, Bush and Upper Columbia Rivers during late September, 2016.

| Type of Sampling | Age | FL(Ave) (mm) | FL range (mm) | S.D. (FL) | No. (FL) | Weight (g) | S.D. (Wt) | No. (Wt) |
|---|---|---|---|---|---|---|---|---|
| Trawl | 0+ | 52 | 32-89 | 12.2 | 45 | 1.5 | 1.2 | 45 |
| Trawl and GN | 1+ | 151 | 130-210 | 18.6 | 35 | 40.7 | 17.3 | 35 |
| Trawl and GN | 2+ | 231 | 208-250 | 9.3 | 24 | 147 | 18.0 | 24 |
| Trawl and GN | 3+ | 241 | 224-255 | 11.5 | 9 | 163 | 29.3 | 9 |
| Spawner | 2+ | 252 | 205-293 | 14.2 | 155 | | | |
| Spawner | 3+ | 270 | 236-288 | 11.7 | 38 | | | |
| Spawner | 4+ | 271 | | | 1 | | | |

Age specific length frequencies from combined trawl and gillnet catches have recently been used to monitor annual growth of kokanee in Kinbasket and Revelstoke Reservoirs and help verify spawner ages each year. Gillnetting efforts were increased in 2014 and again in 2015 to obtain larger numbers of age 1-3+ fish and to obtain samples from more areas around Kinbasket Reservoir. However, in 2016, weather was unsettled throughout field surveys and consequently only a minimum amount of trawling and gillnetting was completed.

Figure 12 compares age specific length frequencies for fish captured in Kinbasket Reservoir (bar graphs) and spawners obtained from key tributaries (line graphs) for 2015 and 2016. Previous reporting has shown that 2013 modes for all age groups including spawners were shifted to the right indicating a very good growth year for all age classes (Sebastian and Weir, 2014). By comparison, all modes including spawners shifted to the left in 2014 and again in 2015 indicating slower growth than in 2013 and a return to more typical growth rates for this system (Sebastian and Weir, 2016). Even though some of the shift in reservoir sampled fish in 2014 and 2015 can be attributed to the earlier survey timing (i.e., July versus August), a similar shift in the spawner size at age confirms slower growth as spawner surveys are always conducted in late September at the end of the growing season.

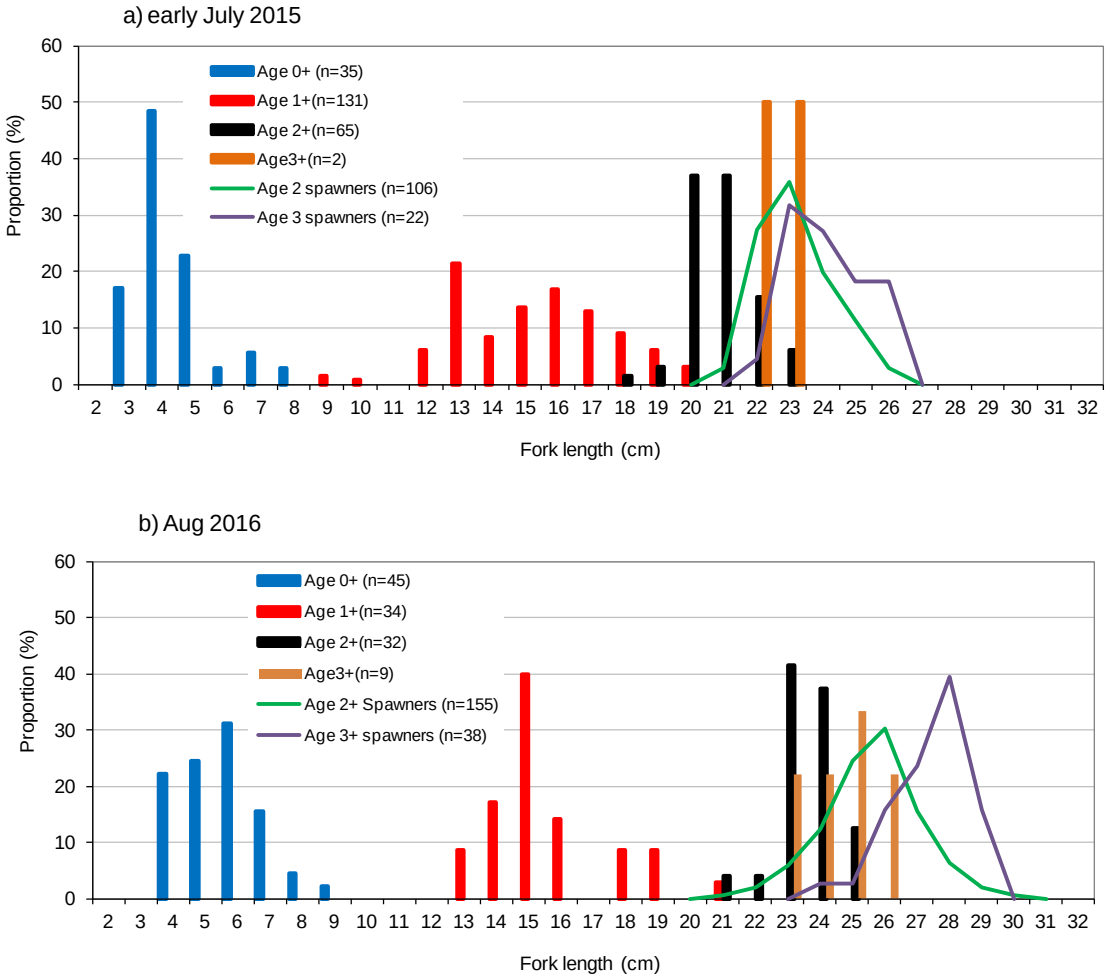



**Figure 12.** Kokanee length frequency proportion by age for a) 2015 and b) 2016 based on combined trawl and gillnet samples in Kinbasket and fall spawner sampling. Spawner data was from Camp, Bush, Luxor, and Upper Columbia River in 2015 and from Camp, Wood, Bush, Luxor and Upper Columbia 2016.

In 2016 all modes shifted back to the right indicating growth of all cohorts improved over the 2014 and 2015 size at age. In 2016, with the exception of age 1+, modes for all other in-lake and spawner age classes were all comparable to 2013, (a good growth year). The mode of 1+ in 2013 was 18 cm as it was the larger of the two modes that was dominant, while in 2016, there was only one clear mode at 15 cm and a tail of larger age 1+ fish.

A common feature of these length-frequency 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 continues to occur as fish reached maturity.

The stage of maturation in combined trawl and gillnet samples was as follows: age 0+ were 100% immature, age 1+ fish were 97% immature, age 2+ fish consisted of 12% immature and 88% maturing, and age 3+ fish were 100% maturing and expected to spawn by fall of 2016. At 210mm, the only maturing age 1+ fish was considerably greater than the average length of immature age 1+ (150±5mm). As well the average length of maturing age 2+ fish (233±3mm) was significantly greater than the average length of immature age 2+ (218±10mm). The average length of maturing age 3+ fish (241±8mm) was larger than maturing age 2+, although the difference was not statistically significant. These data support the notion of a minimum size that triggers maturity since only the largest individuals within a cohort reach maturity by the fall of age 2+. The single maturing age 1+ fish was an anomaly if ageing was accurate.

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. Gillnetting is recommended as a necessary annual monitoring activity to enable the further study and assessment of kokanee growth and maturity in Kinbasket Reservoir. In addition, methodology to estimate kokanee biomass is being developed that requires empirical size data.

### *Spawner size at age and age proportions in Kinbasket*

Spawner samples were again collected from Camp and Luxor Creeks and Bush and Columbia Rivers and size statistics summarized by stream and age in Table 5. A small sample from was also obtained opportunistically from Wood River in 2016. As in 2013 and 2014, spawners in Camp Creek during 2015 and 2016 were larger than in the southern tributaries. Previously, this size difference was attributed to the higher proportion of 3+ fish in Camp Creek while the majority of fish in southern tributaries spawned at age 2+. It was previously believed that north end kokanee grew slower and therefore matured later. However, in 2015 the average length of age 2+ spawners from Camp Creek (237±3mm) was significantly larger than in all other tributaries. In 2016, the average length of age 2+ fish in Camp Creek of 271±9mm was again larger than all other tributaries. The differences were statistically significant in Luxor Creek and Bush River but not quite for Wood River and the Upper Columbia near Fairmont (Table 5). The average length of age 3+ in Camp Creek was also greater in 2016 than in other spawning tributaries, while the differences were only significant in Bush River and Luxor Creek. It is possible that Camp Creek fish may have experienced continued growth benefits from the lower rearing densities observed in 2015 and 2016 throughout the Canoe Reach.

**Table 5.** Kokanee length statistics by age for spawners sampled in Kinbasket Reservoir tributaries during late September, 2016.

| Spawning Location | Age | Number of samples (n) | FL range (mm) | S.D. | Mean FL (mm) | 95% C.L. on mean FL |
|---|---|---|---|---|---|---|
| Camp Creek | 2+ | 10 | 246-293 | 14.3 | 271 | 262-280 |
| Wood River | 2+ | 9 | 247-269 | 6.9 | 259 | 254-262 |
| Bush River | 2+ | 51 | 218-274 | 11.5 | 248 | 245-251 |
| Luxor Creek | 2+ | 46 | 205-266 | 11.9 | 243 | 239-246 |
| Upper Columbia | 2+ | 39 | 229-282 | 10.5 | 261 | 257-264 |
| Camp Creek | 3+ | 27 | 254-288 | 8.0 | 275 | 272-278 |
| Wood River | 3+ | 3 | 258-274 | 8.5 | 264 | 255-274 |
| Bush River | 3+ | 5 | 236-270 | 13.2 | 255 | 244-267 |
| Luxor Creek | 3+ | 3 | 251-259 | 4.0 | 255 | 250-260 |
| Camp Creek | 4+ | 1 | 271 | | 271 | |
| Combined | 2+ | 155 | 205-293 | 14.2 | 252 | 250-254 |
| Combined | 3+ | 38 | 236-288 | 11.5 | 270 | 266-273 |
| Combined | 4+ | 1 | 271 | | 271 | |
| Total | | 194 | | | | |

Another change observed in 2015 and again in 2016 was that there was no statistical difference between the mean length of age 2+ and age 3+ spawners for any of the tributaries except for Luxor in 2016. This either speaks to very different rearing conditions experienced by two consecutive cohorts, or could also result from the age 1+ bimodal size distribution carrying through to maturity resulting in extensive overlap in fish length between age groups. In any case, it was not possible to estimate spawner ages based on their length frequency in 2015 or 2016, so we have relied entirely on otolith analyses for age estimates.

The length frequencies by spawner age have been shown separately for Camp, Wood, Bush, Luxor and Columbia River (Figs. 13a-e) and as a cumulative length frequency (Fig. 13f). Age specific length frequency plots show how extensive the overlap is between age 2+ and age 3+ fish for all tributaries except the Upper Columbia River where no age 3+ were captured. The best comparison of 2016 spawner length distributions between age groups in Kinbasket Reservoir is presented in the cumulative plot which shows two overlapping bell shaped curves for age 2+ and 3+ fish respectively (Fig. 13f).

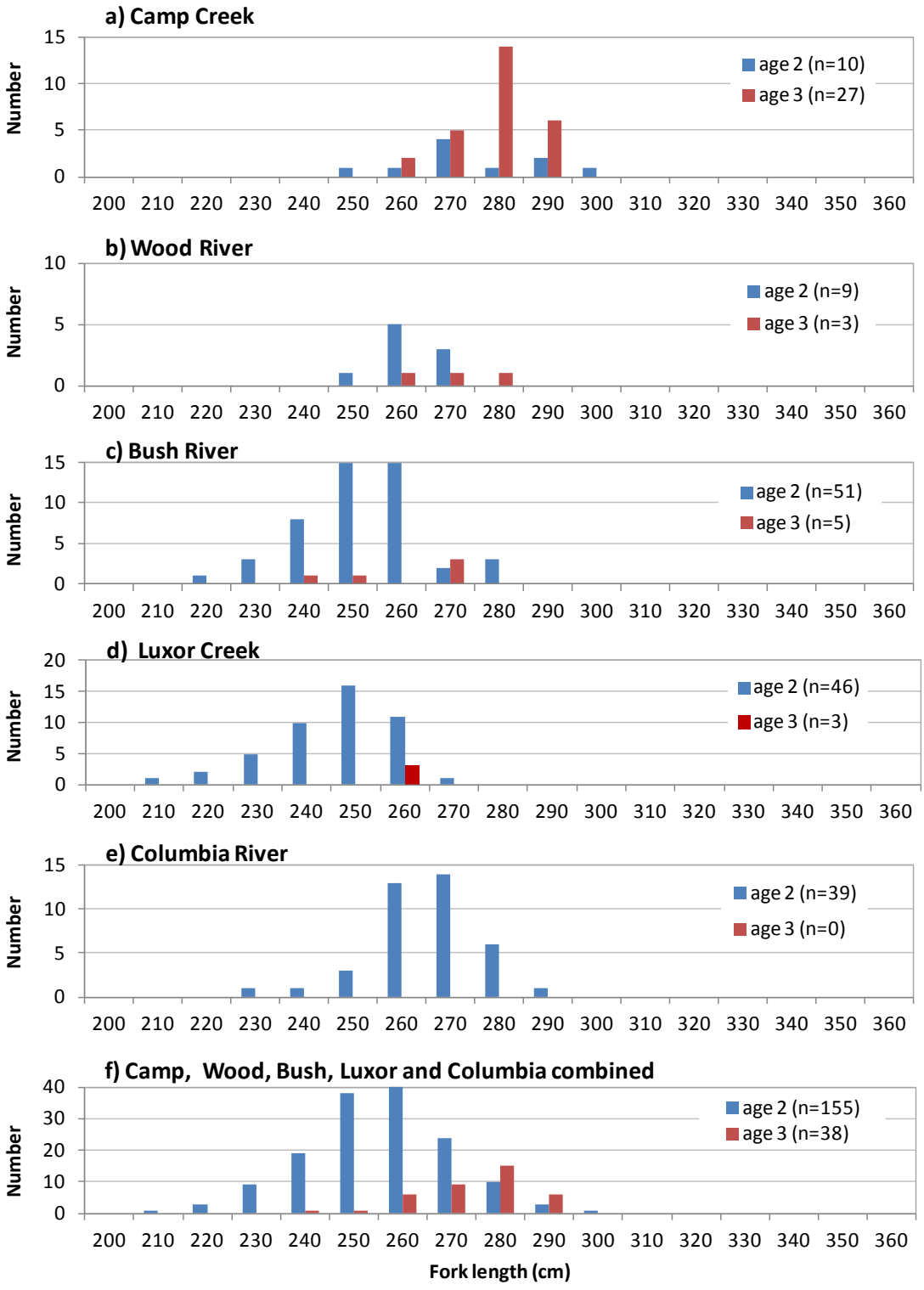



**Figure 13.** Kokanee spawner length frequency by age for a) Camp b) Bush c) Wood, d) Luxor and e) Columbia River and for f) all spawning tributaries to Kinbasket Reservoir combined.

The size 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 fish spawning at age 3+.

***Gillnet sampling on Revelstoke Reservoir***

Trawl sampling was discontinued after 2012 in Revelstoke Reservoir due to very low densities of kokanee and a lack of success with this technique for capturing age 1-3+ fish. Overnight gillnet sets have become the new standard for assessing size at age for age 1-3+ kokanee on Revelstoke Reservoir. Catch per unit effort from individual sets in Revelstoke Reservoir have previously ranged from 5.6 to 27.9 kokanee·ha·hr$^{-1}$ during 2013-2015 with a survey average of 15 (10-21) kokanee·ha·hr$^{-1}$.

In 2016, only two sets were targeted in the areas with the highest densities of age 1-3+ fish based on acoustic data. A total of 112 kokanee, 3 Mountain Whitefish and one Bull Trout were captured. CPUE for kokanee in 2016 ranged from 30.6 to 54.5 kokanee·ha·hr$^{-1}$ in the vicinity of transects 11 and 12 respectively, while the survey average CPUE for 2016 was 42.6 (18.7-66.5) kokanee·ha·hr$^{-1}$ (Table 6). The CPUE values in 2016 were 3-4 times higher than expected based on their acoustic density.

**Table 6.** Catch summary by species, age and net depth from pelagic gillnet sampling in Revelstoke Reservoir during late July, 2016.

| Net Depth | Number of Kokanee | | | | BT | MWF | Total Fish |
|---|---|---|---|---|---|---|---|
| (m) | Age 1 | Age 2 | Age 3 | Total | | | (no) |
| 10 | 6 | 21 | 5 | 32 | 1 | 2 | 35 |
| 15 | 11 | 58 | 11 | 80 | | 1 | 81 |
| All | 17 | 79 | 16 | 112 | 1 | 3 | 116 |
| *CPUE*[1] | *6.3* | *29.3* | *5.9* | *41.5* | *0.4* | *1.1* | *43.0* |

Caution must be used in interpreting gillnet CPUE as a potential index of kokanee abundance. For example a plot of gillnet CPUE against average age 1-3+ fish density at corresponding transects for three years of gillnetting in Kinbasket and Revelstoke reservoirs suggests that the relationship is different between the two reservoirs (Fig. 14a). Although data are limited, it appears that CPUE is much higher in Revelstoke Reservoir in relation to the acoustic density than in Kinbasket Reservoir. This appears to suggest that gillnets may be more efficient at catching kokanee in Revelstoke than in Kinbasket Reservoir. The larger size of fish in Revelstoke may make them susceptible to capture in a wider range of mesh sizes compared with smaller fish in Kinbasket. There could also be behavioural factors that influence capture efficiency. For example, if larger

kokanee have to feed more to sustain growth, the increased travel time in search of food would increase susceptibility to capture. Predation pressure may also play a role in making kokanee more or less susceptible to gillnet capture. Further monitoring over a wider range of densities and in more lakes will be necessary to better understand and interpret gillnet CPUE for kokanee.

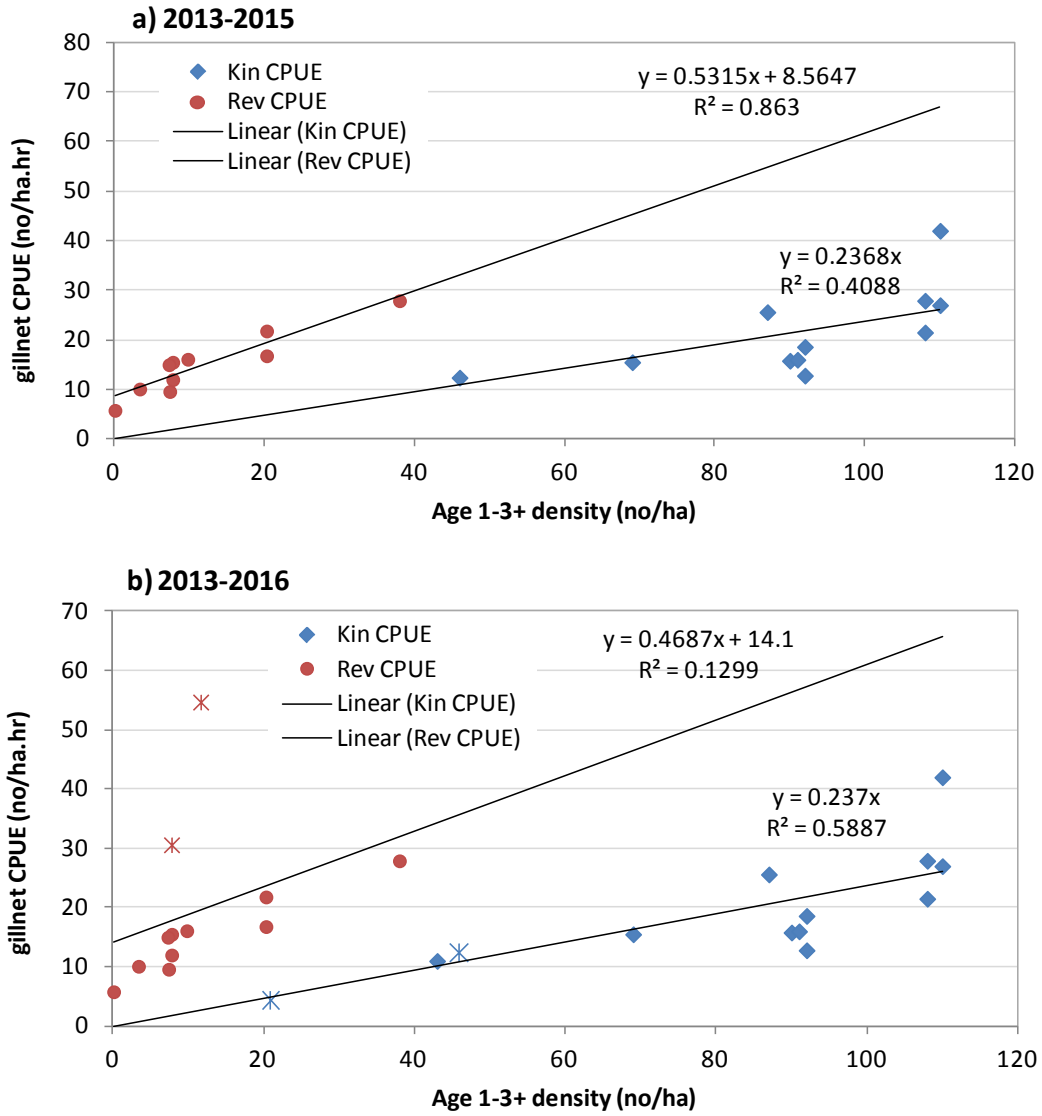



**Figure 14.** Comparison of gillnet catch per unit effort (no·ha·hr$^{-1}$) and average density of age 1-3+ kokanee (fish·ha$^{-1}$) for a) three years of gillnetting (2013-2015) and b) four years of gillnetting (2013-2016) in Kinbasket and Revelstoke reservoirs. Note: stars represent 2016 data points.

The addition of 2016 CPUE values shown in Figure 14b strengthens the fit in Kinbasket Reservoir ($R^2$ value increased from 0.41 to 0.59), however the CPUE values in Revelstoke were so high in 2016 that the regression fit previously established is no longer valid (i.e., $R^2$ value goes from 0.86 to 0.13). The 2016 data are shown in stars rather than points to illustrate how they fit with the previous data. The apparent increased efficiency of capture in Revelstoke but not Kinbasket Reservoir in 2016 cannot be explained by spawner size. Spawners in Revelstoke (Standard Creek) were smaller than in 2014 and similar in size to 2013 and 2015 while in Kinbasket Reservoir the 2016 spawners were significantly larger than in the two previous years. If size bias was the major cause, one would have expected higher CPUE in Kinbasket and the same or lower CPUE estimates for Revelstoke. Clearly other factors were at play to cause huge increases in the Revelstoke CPUE from gillnetting in 2016.

***Size at age and age at maturity in Revelstoke Reservoir***

Two gillnet sets caught a total of 112 kokanee with representation in three different age groups (1+ to 3+). All age groups were well represented with 17 age 1+, 79 age 2+ and 16 age 3+ fish. Kokanee mean length at age was estimated at 180±7 mm for age 1+, 295 ±2 mm for age 2+ and 324 ±10 mm for age 3 (Table 7). Compared with 2015, the size appeared to be slightly larger for age 1+ and were significantly larger for age 2+ fish. Compared to 2014 which had the largest reported kokanee length at age for Revelstoke Reservoir, age 1+ and 2+ in 2016 were similar and only the 3+ were significantly smaller in 2016. Growth does appear to have increased slightly over 2015.

**Table 7.** Summary of kokanee length and weight statistics by age from gillnet (GN) catches in Revelstoke Reservoirs during July/August 2016 and length statistics (no weights) for spawning kokanee caught by dipnet in Standard Creek during early October, 2016.

| Type of Sampling | Age | FL(Ave) (mm) | FL range (mm) | S.D. (FL) | No. (FL) | Weight (g) | S.D. (Wt) | No. (Wt) |
|---|---|---|---|---|---|---|---|---|
| Gillnet | 1+ | 180 | 155-200 | 13.8 | 17 | 70 | 18.0 | 17 |
| Gillnet | 2+ | 295 | 248-319 | 10.6 | 79 | 327 | 35.1 | 79 |
| Gillnet | 3+ | 324 | 270-342 | 20.3 | 16 | 430 | 70.2 | 16 |
| Spawner | 2+ | 307 | 290-322 | 8.3 | 14 | | | |
| Spawner | 3+ | 342 | | | 1 | | | |
| | | | | | 127 | | | |

Age specific length frequency distributions for gillnet caught fish are compared with spawner length frequency distributions from Standard Creek for 2014 - 2016 (Fig. 15). Following a peak year for growth and size at age in 2014, the length frequency data shows that growth rates had declined slightly in 2015 and 2016. The main decline appears to have occurred in the summer of 2015 and 2016 showing very little growth between age 2+ and 3+ sampled in July and the corresponding age 2+ and 3+ spawners sampled early October.

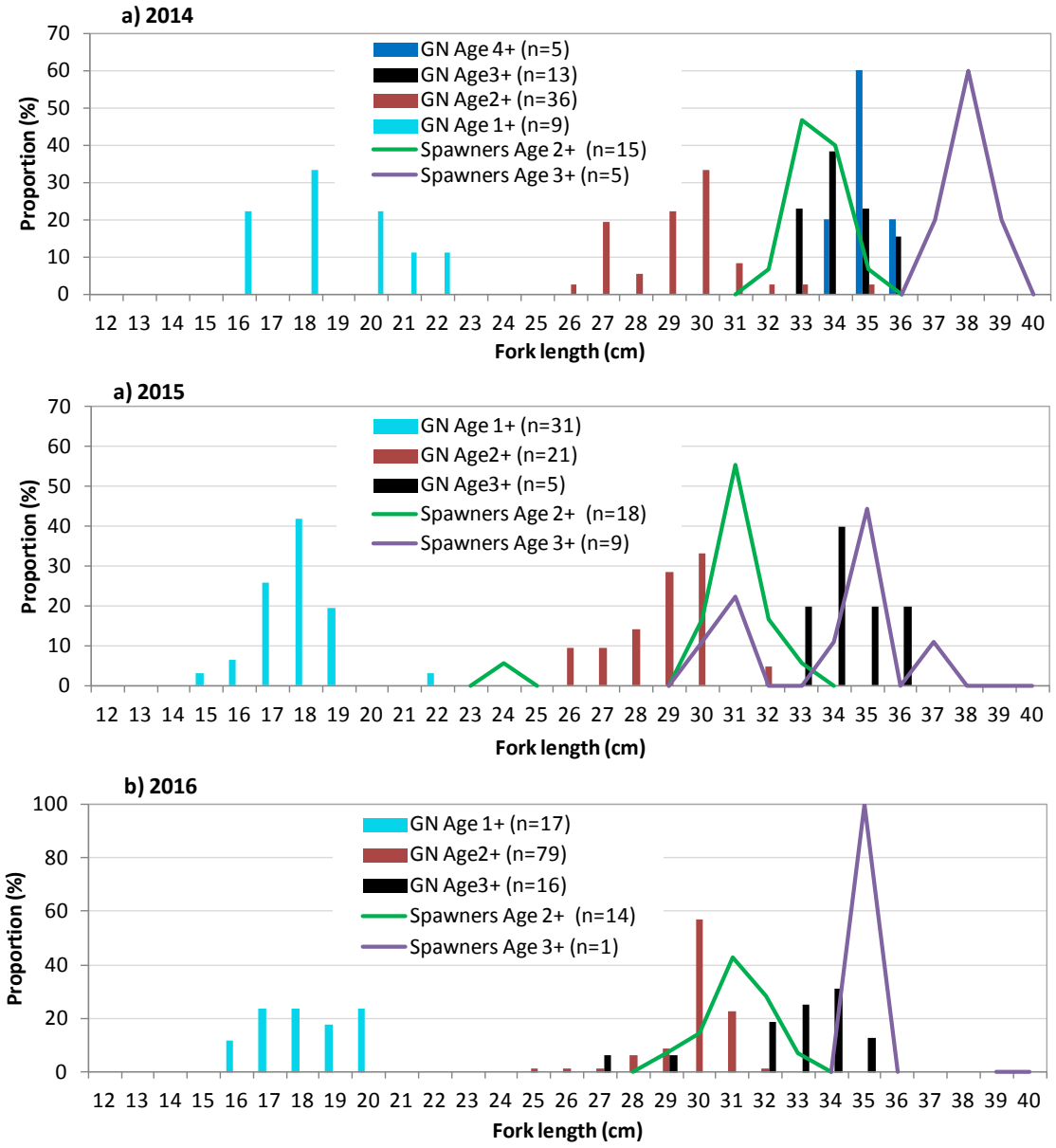



**Figure 15.** Age specific length frequency distributions for gillnet caught fish sampled in mid-summer and for spawners returning to Standard Creek during early October for a) 2014 b) 2015 and c) 2016 sampling years.

Spawners obtained from Standard Creek had a mean size of 307±4 mm for age 2+ and 342 mm for age 3+ and were similar to 2015. Trends in spawner size at age and size overall for Revelstoke show that growth rates have improved over the last four consecutive years, and appears to be a density dependent growth response as it follows consecutive years of lower than average age 1-3+ density starting in 2012 with a one year lag time (Figs. 10 & 16).

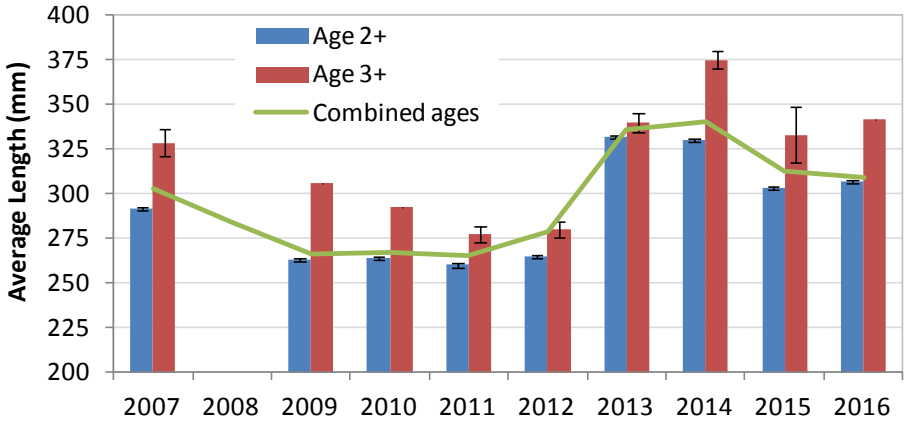



**Figure 16.** Trends in average length of age 2+ and 3+ spawning kokanee in Standard Creek, tributary to Downie Creek and Revelstoke Reservoir, October 2017.

The age at maturity for Revelstoke Reservoir kokanee is typically age 2+ with a small contingent of age 3+ most years. The exception was 2012 when the majority of spawners were age 3+.

Continued gillnetting is recommended for Revelstoke Reservoir to enable growth conditions in the reservoir to be tracked through annual estimates of length for age 2+ and 3+ fish.

### *Spawner Surveys*

Spawner counts were done in Camp Creek, Bush River and Columbia River in 2016. A return of 9,900 kokanee to Camp Creek in 2016 was about 68% of average and was within ±2 standard errors of the 17 year mean. Bush River had a return of 22,500 which was 86% of the 13 year average and well within the 95% confidence interval around the mean. The Columbia River however had a very low return of 38,200 which was only 28% of the 13 year average of 138,000 and was significantly lower than average, although no data have been collected on Fairmont spawners abundance since 2008 due to restrictions on low level helicopter use over populated areas. The count in 2016 was done with fence and trap over the spawning season so was more accurate than historical estimates which relied on a single low level helicopter flight. The Freshwater Fisheries Society of BC collected 7,300 mature kokanee from the Upper Columbia River spawning grounds near Fairmont which reduced the remaining population by an estimated 19% for a total escapement of 30,965. The collection of biological data from spawners in four major tributaries continues to be valuable in monitoring annual growth conditions in the reservoir.

### *Gillnet feasibility*

After four consecutive years of sampling, we conclude that gillnetting is a feasible method of sampling age 1-3+ kokanee for monitoring growth in large reservoirs and remains effective down to very low densities of fish. CPUE from gillnetting however does not appear to show trends in kokanee abundance. 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, but has so far been successful. 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 was required to pull gillnets in the morning and process catches during the same day. Sampling of areas far from the main pool such as Bush Pool required the relocation of crews to the east side of Rogers Pass and required additional time and resources.

## SUMMARY

***Flow and Water levels -*** Unregulated inflow from the Columbia River into Kinbasket Reservoir was average during 2016 while freshet flows were below average and occurred over a longer period of time. Pool elevation in Kinbasket Reservoir ranged from 729.4m on April 1 to 752.8m on November 16, and was 751.6m at the time of survey. With a dry summer the reservoir took longer to reach its maximum pool level in 2016.

***Kinbasket Reservoir -*** Kokanee abundance of 5.28 million fell significantly below average and was the third lowest in 18 years of survey data. A fry abundance of 4.7 million was the third lowest while age 1-3+ abundance of 0.55 million was by far the lowest on record. It appears a die-off during late May and early June of 2016 had a very significant effect on an already depressed population of age 1-3+ fish. Spawner returns were slightly below average in Camp Creek and Bush River, but were only 38% of average for the main spawning area in Columbia River. Growth for all ages was improved over 2015 and more comparable to 2013 and 2014 which were very good growth years, all of which can be attributed in part to relatively low density of age 1-3+ kokanee. Fry production for 2017 is predicted to be below average again.

***Bush Pool -*** Bush Pool added 26% to the total pelagic area surveyed in 2016 however, this area contributed only 12% (<600,000 kokanee) to the total abundance estimates for the reservoir and was within the bounds of the standard seven zone survey estimate for 2016. It appears the relatively high abundance of kokanee during July 2015 in Bush Pool may have been an anomaly, and possibly due to the high winter pool elevations during 2014-15 and maintenance of a depth suitable for winter rearing of kokanee. Normally Bush Pool dewaters

completely or to a point where depth is probably not suitable to sustain kokanee over the winter and spring periods.

***Revelstoke Reservoir*** – The total abundance of kokanee was estimated at 0.65 million and was well below the long term average of 1.11 ± 0.24 million. Except for the fry which were average in 2015, the kokanee population (both fry and age 1-3+) has remained well below average since 2012. A year following the 2012 decline in age 1-3+ kokanee abundance, there was a significant increase in the average length of spawners suggesting a density dependent growth response had occurred. The average length of spawners in 2016 was 310 ± 6mm and remained above the pre-2013 average of 276 ± 14mm. Adult returns to Downie Creek in 2016 were estimated at 2050 and were below the 14 year average of 5500 ± 3300.

## ACKNOWLEDGEMENTS

Direct funding was provided by BC Hydro and in-kind support by the Ministry of Ministry of Forests, Lands and Natural Resource Operations for this monitoring. The British Columbia Conservation Foundation (BCCF) was contracted to provide staffing and administrative support.

Field surveys and data analyses were conducted by Dave Johner and Tyler Weir of the Ministry of Forests, Lands and Natural Resource Operations with assistance from Trevor Davies (FLNRO). Karen Bray, Pierre Bourget and Beth Manson of BC Hydro provided assistance with gillnetting. Spawner data and review of this manuscript were provided by Karen Bray, BC Hydro Biologist, Revelstoke, BC. Curtis Culp with BCCF conducted spawner counts and biological data collection for Camp Creek. Spawner sampling of Bush and Upper Columbia rivers and Luxor Creek was conducted by Karen Bray. Spawner age interpretations (otoliths) and scale analyses were done by Andrew Schellenberg and reviewed by Allison Hebert of the Ministry of Environment using ministry equipment at the lab in Abbotsford, BC.

Thanks to these people!

## REFERENCES

Bassett, M., E.U. Schindler, L. Vidmanic, T. Weir and D. Sebastian. (2017). Arrow Lakes Reservoir Nutrient Restoration Program Year 17 (2015) Report. Manuscript in preparation.

BC Government Website. 2015. Columbia Basin Operations Fall 2015. http://blog.gov.bc.ca/columbiarivertreaty/files/2014/05/2015-10-27-BC-Hydro-Operations-Oct-2015-Darren-Sherbot.pdf

BC Hydro Website. 2016. Columbia River Operation Summary Spring 2016. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/community/columbia-river-operations-summary-spring-2016.pdf

BC Hydro Website. 2017. Columbia River Operation Summary Spring 2017. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/community/columbia-river-operations-summary-spring-2017.pdf

Casselman, J.M. 1990. Growth and relative size of calcified structures of fish. Transactions of the American Fisheries Society 119:673-688.

RIC. 1997. Fish Collection Methods and Standards. Prepared by the B.C. Ministry of Environment, Lands and Parks, Fish Inventory Unit for the Aquatic Ecosystems. Task Force, Resources Inventory Committee (RIC).

Schindler, E.U., T. Weir, D. Sebastian, M. Bassett and K. I. Ashley. 2014. Arrow Lakes Reservoir Nutrient Restoration Program Years 13 and 14 (2011 and 2012) Report. Fisheries Project Report No. 146, Ministry of Forests, Lands and Natural Resource Operations, Province of British Columbia. 137p.

Sebastian, Dale, George Scholten, Dean Addision, Marc Labelle and David Green. 1995. Results of the 1991-93 hydroacoustic surveys at Mica and Revelstoke Reservoirs. Stock Management Unit Report No. 1. Ministry of Environment, Lands and Parks, Victoria, 37p.

Sebastian, D., G. Scholten, H. Andrusak and P. Woodruff. 2010. Results of hydroacoustic and trawl surveys on Kinbasket and Revelstoke Reservoirs during 2001-2005. Stock Management Report No. 30, Ministry of Environment, Victoria. 124p

Sebastian, D. and T. Weir. 2015. Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring - Year 7 (2014). Prepared for BC Hydro under the Columbia River Water Use Plan, Water Licence Requirements Study No. CLBMON-2. 54p

Sebastian, D. and T. Weir. 2016. Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring - Year 8 (2015). Prepared for BC Hydro under the Columbia River Water Use Plan, Water Licence Requirements Study No. CLBMON-2. 63p

Traxler, G.S., 1986. An epizootic of infectious haematopoietic necrosis in 2-year-old kokanee, Oncorhynchus nerka (Walbaum) at Lake Cowichan, British Columbia. Journal of Fish Diseases, 9(6), pp.545-549.

# APPENDICES

**Appendix 1.** Kinbasket Reservoir fish densities by transect from hydroacoustic surveys, 2006-2016. Note densities reported here represent all depths and are not weighted by the amount of habitat at depth.

| Location | Zone | Trans No. | 2006 Aug | 2007 Aug | 2008 July | 2009 Aug | 2010 Aug | 2011 Aug | 2012 Aug | 2013 Aug | 2014 July | 2015 July | 2016 Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ptarmigan Cr | 2 | **1** | 200 | | 364 | 272 | 701 | 206 | 487 | 357 | 48 | 167 | 97 |
| | | **2** | 184 | | 427 | 224 | 268 | 183 | 761 | 479 | 308 | 261 | 107 |
| Hugh Allan Cr | | **3** | 162 | | 451 | 253 | 279 | 169 | 300 | 326 | 126 | 165 | 68 |
| Howard Bay | | **4** | 299 | 258 | 383 | 185 | 284 | 113 | 299 | 364 | 93 | 69 | 54 |
| | 3 | **5** | 1300 | 686 | 635 | 274 | 397 | 149 | 205 | 970 | 176 | 188 | 121 |
| Foster Arm | | **6** | 303 | 954 | 484 | 298 | 323 | 110 | 528 | 264 | 100 | 144 | 52 |
| | | **7** | 697 | 1910 | 1906 | 443 | 444 | 303 | 592 | 619 | 294 | 247 | 132 |
| Dainard Cr | | **8** | 558 | 1078 | 1855 | 509 | 420 | 377 | 616 | 366 | 415 | 638 | 321 |
| Mica Dam | 4a | **9** | 447 | 564 | 197 | 265 | 309 | 353 | 586 | 234 | | 126 | 92 |
| Mica Arm | | **10** | 247 | 572 | 316 | 336 | 194 | 424 | 527 | 279 | | 232 | 146 |
| Mica Arm | | **11** | 370 | 1099 | 365 | 336 | 342 | 253 | 512 | 378 | 188 | 325 | 231 |
| Sprague Bay | | **12** | 282 | 802 | 801 | 390 | 293 | 160 | 400 | 361 | 322 | 336 | 139 |
| Main pool | 4b | **13** | 222 | 1392 | 1083 | 630 | 300 | 370 | 451 | 462 | 559 | 230 | 136 |
| Main pool | | **14** | 331 | 736 | 1176 | 502 | 341 | 269 | 226 | 249 | 468 | 414 | 374 |
| Main pool | | **15** | 424 | 1133 | 543 | 819 | 365 | 332 | 338 | 247 | 385 | 502 | 330 |
| East side | | **16** | 275 | 961 | 910 | 515 | 350 | 222 | 286 | 804 | 243 | 422 | 267 |
| South side | | **2 0** | 170 | 361 | 632 | 427 | 452 | 205 | 213 | 290 | 452 | 604 | 247 |
| Wood Arm | 5 | **17** | 162 | 361 | 828 | 241 | 265 | 185 | 456 | 358 | 429 | 351 | 132 |
| Wood Arm | | **18** | 301 | 415 | 300 | 246 | 226 | 299 | 402 | 465 | 154 | 414 | 166 |
| Wood Arm | | **19** | 255 | 627 | 847 | 315 | 597 | | 160 | 290 | 183 | 1041 | 123 |
| Lower | 6 | **21** | 430 | 727 | 660 | 454 | 201 | 168 | 404 | 278 | 199 | 694 | 672 |
| Columbia | | **22** | 394 | 194 | 662 | 426 | 324 | 295 | 188 | 363 | 436 | 419 | 501 |
| Old Kinbasket | 7 | **23** | 388 | 196 | 621 | 374 | 285 | | 165 | 265 | 388 | 340 | 277 |
| Pool | | **24** | 384 | 261 | 455 | 336 | 184 | 263 | 134 | 246 | 305 | 222 | 295 |
| SullivanArm | | **25** | 208 | | 448 | 230 | 597 | 300 | 141 | 595 | 259 | 360 | 637 |
| Kyanite Cr | | **26** | 300 | 372 | 285 | 296 | 237 | 307 | 106 | 295 | 218 | 327 | 201 |
| | | **27** | 198 | 596 | 259 | 476 | 222 | 249 | 200 | 440 | 383 | 449 | 269 |
| Garrett Cr | | **28** | 350 | 674 | 496 | 423 | 553 | 317 | 190 | 748 | 370 | 239 | 470 |
| Upper | 8 | **29** | 240 | | 478 | 785 | 382 | 442 | 168 | | 447 | 229 | 83 |
| Columbia | | **30** | 331 | | | 513 | 463 | 302 | 158 | | 289 | 350 | 130 |
| Bush Pool | 9 | **31** | | | | | | | | | | 299.6 | 65 |
| | | **32** | | | | | | | | | | 348.8 | 170 |
| | | **33** | | | | | | | | | | 209.7 | 87 |
| | | **34** | | | | | | | | | | 314.3 | 86 |
| | | **35** | | | | | | | | | | 288.6 | 86 |
| | | **36** | | | | | | | | | | 209.9 | 121 |
| | | **37** | | | | | | | | | | 168.5 | |
| | | **38** | | | | | | | | | | 223.9 | |
| | | **39** | | | | | | | | | | 239.6 | |

A new Forebay Zone (4a) was added during Phase I synthesis grouping transects near the Dam while zone 4b represented the main Mica pool. In Bush Pool transect 31 from 2005 was done and 8 new transects were completed

**Appendix 2.** Revelstoke Reservoir fish densities by transect from hydroacoustic surveys, 2006-16. 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] | 2006 Aug | 2007 Aug | 2008 July | 2009 Aug | 2010 Aug | 2011 Aug | 2012 Aug | 2013 Aug | 2014 July | 2015 July | 2016 July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rev. Dam | 1 | 1 | **1** | 347 | 293 | 74 | 211 | 261 | 145 | 82 | 52 | 125 | 149 | 113 |
| Coursier Cr. | 1 | 2 | **2** | | 293 | 170 | 182 | 126 | 401 | 142 | 53 | 107 | 300 | 81 |
| | 1 | 3 | **3** | 319 | 491 | 240 | 142 | 65 | 319 | 69 | 28 | 66 | 391 | 59 |
| Martha Cr. | 2 | 4 | **4** | 207 | 368 | 360 | 235 | 213 | 221 | 48 | 57 | 97 | 435 | 64 |
| Sale Cr. | 2 | 5 | **5** | 274 | 374 | 312 | 256 | 188 | 241 | 50 | 86 | 46 | 116 | 65 |
| LaForme Cr. | 2 | 6 | **6** | 275 | 248 | 431 | 151 | 230 | 177 | 70 | 94 | 119 | 226 | 83 |
| | 2 | 7 | **7** | 253 | 234 | 384 | 112 | 131 | 49 | 24 | 44 | 123 | 71 | 78 |
| Carnes Cr. | 2 | 8 | **8** | 201 | 227 | 651 | 213 | 122 | 57 | 41 | 88 | 85 | 108 | 164 |
| Frisby Cr. | 2 | 9 | | 121 | | 705 | | 162 | | 85 | | | | |
| Mars Cr. | 2 | 10 | **9** | 174 | 239 | 192 | 123 | 205 | 65 | 29 | 65 | 96 | 101 | 77 |
| | 2 | 11 | | 126 | | | | | | | | | | |
| Park Cr. | 2 | 12 | **10** | 170 | 196 | 171 | 252 | 300 | 31 | 51 | 34 | 143 | 42 | 263 |
| Bourne Cr. | 2 | 13 | **11** | 189 | 230 | 327 | 251 | 432 | 36 | 29 | 82 | 25 | 54 | 94 |
| Keystone | 2 | 14 | **12** | | | 300 | 143 | 366 | 121 | 80 | 383 | 52 | 54 | 185 |
| Downie | 2 | 15 | **12a** | 114 | 102 | | | | | | | | | |
| Downie Arm | 2 | 16 | | | | | | | | | | | | |
| Power line | 3 | 17 | **13** | 58 | 42 | 90 | 134 | 119 | 234 | 97 | 99 | 89 | 32 | 44 |
| Fissure Cr. | 3 | 18 | **14** | 52 | 8 | 117 | 270 | 169 | 93 | 405 | 96 | 52 | 22 | 127 |
| Ferry | 3 | 19 | **15** | 52 | 11 | 65 | 76 | 158 | 23 | 69 | 13 | 61 | 25 | 125 |
| Liberty Cr. | 3 | 20 | | | | | | | | | | | | |
| Old Goldstream | 3 | 21 | **16** | 47 | 25 | 98 | 180 | 153 | 35 | 92 | 42 | 31 | 15 | 69 |
| Goldstream | 3 | 22 | | | | | | | | | | | | |
| Stump field | 3 | 23 | **17** | 144 | 39 | 72 | 68 | 87 | 65 | 157 | 51 | 39 | 6 | 32 |
| Powerline | 3 | 24 | **18** | 23 | 32 | 59 | 67 | 186 | 52 | 25 | 23 | 28 | 24 | 72 |
| Hoskins Cr. | 3 | 25 | **19** | 5 | 26 | 52 | 149 | | 69 | 2 | 20 | 18 | 1 | 40 |
| Nichols Cr. | 3 | 26 | **20** | 10 | 21 | 95 | 97 | 83 | 29 | 25 | 51 | 41 | 109 | 15 |

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 kokanee.

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 (zones 2-8) in July, 2016.

a) Fish all sizes (all ages): *( ≥ -59dB) Transects 1-30* Note: Bush Pool not included

| Zone | Depth | N | Mean | SE | Area | StratumPop | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-5 | 30 | 2.4 | 1.4 | 23902 | 58,370 | 0.3 | LB= | 4,378,761 |
| 1 | 5-10 | 30 | 8.1 | 1.9 | 23902 | 192,546 | 0.3 | MLE= | 5,284,981 |
| 1 | 10-15 | 30 | 13.4 | 3.8 | 23902 | 321,461 | 0.3 | UB= | 6,202,870 |
| 1 | 15-20 | 30 | 60.6 | 11.7 | 23902 | 1,449,637 | 0.3 | | |
| 1 | 20-25 | 30 | 81.1 | 13.4 | 23067 | 1,871,347 | 0.3 | | |
| 1 | 25-30 | 30 | 39.0 | 6.9 | 22368 | 871,774 | 0.3 | | |
| 1 | 30-35 | 30 | 18.2 | 3.3 | 21703 | 394,049 | 0.3 | | |
| 1 | 35-40 | 30 | 4.0 | 0.7 | 20758 | 82,496 | 0.3 | | |
| 1 | 40-45 | 30 | 1.3 | 0.3 | 19743 | 26,340 | 0.3 | | |
| 1 | 45-50 | 30 | 0.8 | 0.3 | 18552 | 15,743 | 0.3 | | |

*b) Age 1-3 kokanee* *( ≥ -44db) Transects 1-30*

| Zone | Depth | N | Mean | SE | Area | StratumPop | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-5 | 30 | 0 | 0 | 23735 | | | LB= | 443,956 |
| 1 | 5-10 | 30 | 0 | 0 | 23735 | | | MLE= | 554,823 |
| 1 | 10-15 | 30 | 0.9 | 0.6 | 23902 | 22,372 | 0.3 | UB= | 665,376 |
| 1 | 15-20 | 30 | 4.5 | 1.0 | 23902 | 106,875 | 0.3 | | |
| 1 | 20-25 | 30 | 9.3 | 1.6 | 23067 | 214,063 | 0.3 | | |
| 1 | 25-30 | 30 | 5.4 | 1.0 | 22368 | 120,200 | 0.3 | | |
| 1 | 30-35 | 30 | 3.7 | 0.9 | 21703 | 81,207 | 0.3 | | |
| 1 | 35-40 | 30 | 0.4 | 0.1 | 20758 | 8,948 | 0.3 | | |
| 1 | 40-45 | 30 | 0 | 0 | 19743 | 792 | 0.3 | | |
| 1 | 45-50 | 30 | 0 | 0 | 18305 | | | | |
| 1 | 50-55 | 30 | 0 | 0 | 17070 | | | | |

*c) Age 0 kokanee* *(-59dB to -44.1db) Transects 1-30*

| Zone | Depth | N | Mean | SE | Area | StratumPop | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-5 | 30 | 2.4 | 1.4 | 23902 | 58,370 | 0.2 | LB= | 3,842,299 |
| 1 | 5-10 | 30 | 8.1 | 1.9 | 23902 | 192,546 | 0.2 | MLE= | 4,730,624 |
| 1 | 10-15 | 30 | 12.5 | 3.4 | 23902 | 299,089 | 0.2 | UB= | 5,611,103 |
| 1 | 15-20 | 30 | 56.2 | 11.6 | 23902 | 1,342,763 | 0.2 | | |
| 1 | 20-25 | 30 | 71.8 | 13.0 | 23067 | 1,657,283 | 0.2 | | |
| 1 | 25-30 | 30 | 33.6 | 6.6 | 22368 | 751,575 | 0.2 | | |
| 1 | 30-35 | 30 | 14.4 | 2.8 | 21703 | 312,842 | 0.2 | | |
| 1 | 35-40 | 30 | 3.5 | 0.7 | 20758 | 73,548 | 0.2 | | |
| 1 | 40-45 | 30 | 1.3 | 0.3 | 19743 | 25,547 | 0.2 | | |
| 1 | 45-50 | 30 | 0.8 | 0.3 | 18305 | 15,743 | 0.2 | | |

**Appendix 4.** Summary of fish density statistics and Maximum Likelihood Estimates from Monte Carlo Simulations for Revelstoke Reservoir in August 2016**.**

a) Fish all sizes (all ages): *( ≥ -61dB) Transects 1-9 and 10-20*

| Zone | Depth | N | Mean | SE | Area | Stratum Population | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5-10 | 9 | 5.3 | 3.2 | 3938 | 20,740 | 0.4 | LB= | 532,250 |
| 1 | 10-15 | 9 | 33.1 | 4.1 | 3938 | 130,502 | 0.4 | MLE= | 652,043 |
| 1 | 15-20 | 9 | 27.8 | 3.8 | 3938 | 109,582 | 0.4 | UB= | 771,663 |
| 1 | 20-25 | 9 | 10.3 | 2.7 | 3938 | 40,515 | 0.4 | | |
| 1 | 25-30 | 9 | 3.2 | 2.1 | 3750 | 12,036 | 0.4 | | |
| 1 | 30-35 | 9 | 1.4 | 0.7 | 3600 | 5,161 | 0.4 | | |
| 1 | 35-40 | 9 | 1.2 | 0.4 | 3450 | 4,062 | 0.4 | | |
| 1 | 40-45 | 9 | 3.0 | 1.7 | 3263 | 9,647 | 0.4 | | |
| 1 | 45-50 | 9 | 1.9 | 0.9 | 3075 | 5,710 | 0.4 | | |
| 2 | 3-5 | 11 | 2.0 | 2.0 | 3313 | 6,494 | 0.4 | | |
| 2 | 5-10 | 11 | 15.2 | 3.7 | 3313 | 50,328 | 0.4 | | |
| 2 | 10-15 | 11 | 40.1 | 13.7 | 3313 | 132,938 | 0.4 | | |
| 2 | 15-20 | 11 | 17.5 | 6.3 | 3313 | 58,068 | 0.4 | | |
| 2 | 20-25 | 11 | 8.7 | 1.9 | 3313 | 28,830 | 0.4 | | |
| 2 | 25-30 | 11 | 4.7 | 1.3 | 3050 | 14,199 | 0.4 | | |
| 2 | 30-35 | 11 | 4.4 | 1.6 | 2800 | 12,197 | 0.4 | | |
| 2 | 35-40 | 11 | 1.8 | 0.8 | 2550 | 4,694 | 0.4 | | |
| 2 | 40-45 | 11 | 1.8 | 0.6 | 2188 | 3,898 | 0.4 | | |
| 2 | 45-50 | 11 | 0.8 | 0.3 | 1825 | 1,551 | 0.4 | | |

*b) Age 1-3 kokanee* *( ≥ -48db) Transects 1-20*

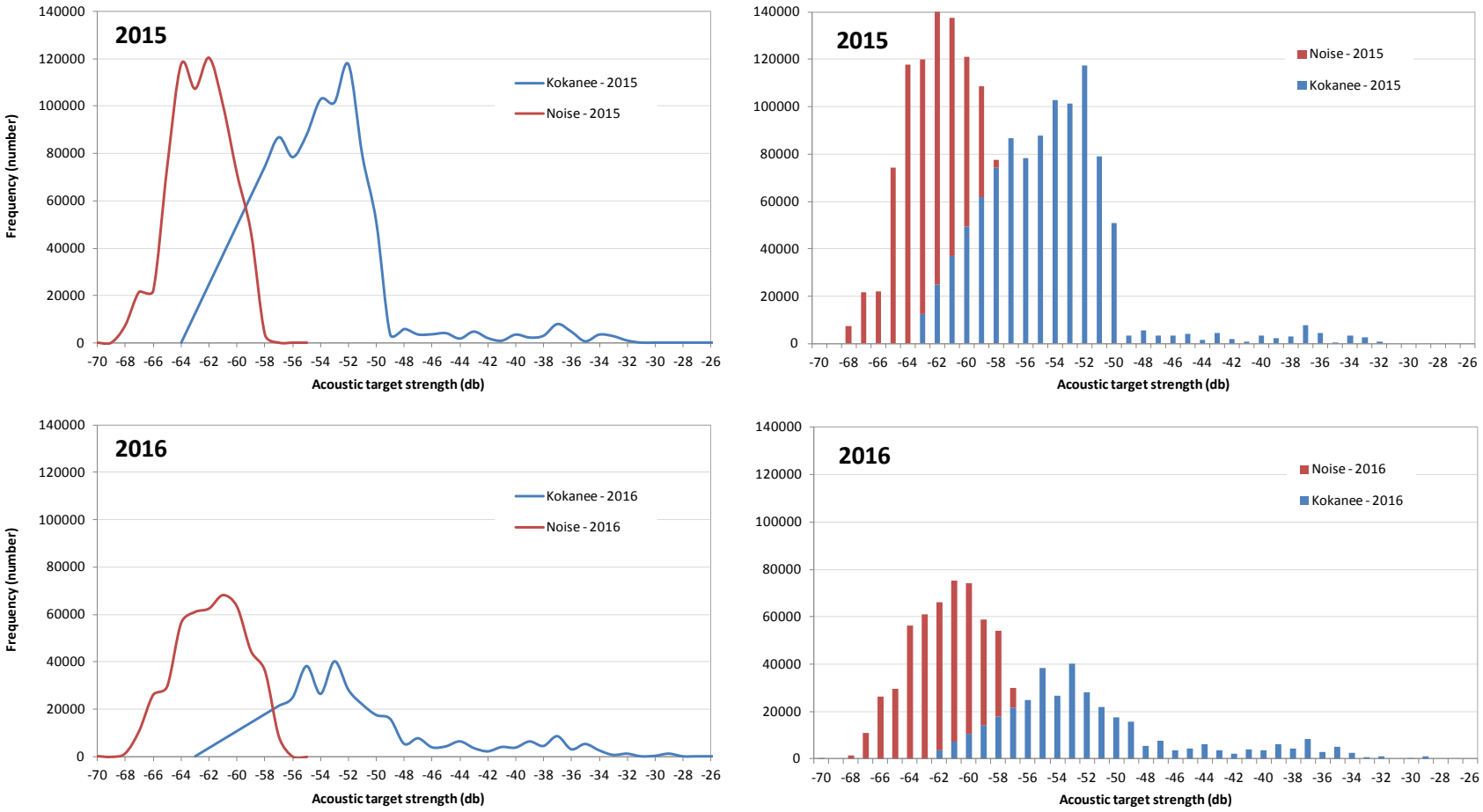
| Zone | Depth | N | Mean | SE | Area | Stratum Population | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5-10 | 20 | 1.2 | 0.7 | 6813 | 7,923 | 0.6 | LB= | 58,415 |
| 1 | 10-15 | 20 | 4.1 | 1.3 | 6813 | 28,104 | 0.6 | MLE= | 87,694 |
| 1 | 15-20 | 20 | 4.7 | 1.5 | 6813 | 32,248 | 0.6 | UB= | 116,632 |
| 1 | 20-25 | 20 | 1.9 | 0.7 | 6813 | 13,109 | 0.6 | | |
| 1 | 25-30 | 20 | 0.4 | 0.2 | 6383 | 2,322 | 0.6 | | |
| 1 | 30-35 | 20 | 0.1 | 0.1 | 6000 | 383 | 0.6 | | |
| 1 | 35-40 | 20 | 0.3 | 0.2 | 5617 | 1,763 | 0.6 | | |
| 1 | 40-45 | 20 | 0.1 | 0.1 | 5088 | 395 | 0.6 | | |
| 1 | 45-50 | 20 | 0.3 | 0.2 | 4558 | 1,322 | 0.6 | | |

## Appendix 4 continued

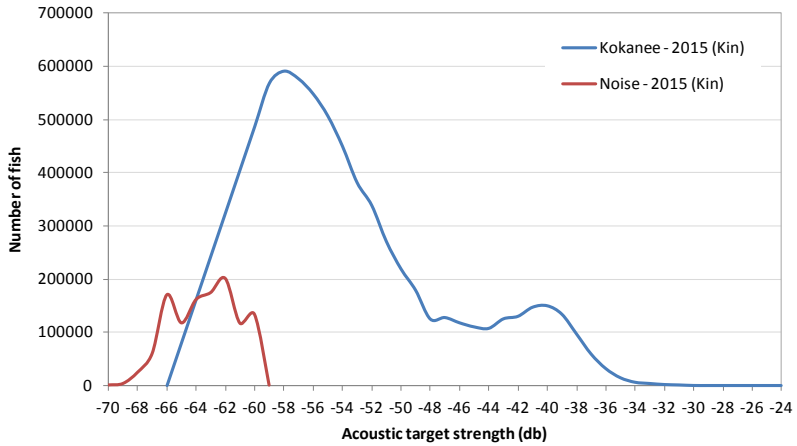
*c) Age 0 kokanee* *(-60dB to -48.1db)* *Transects 1-9 and 10-19*

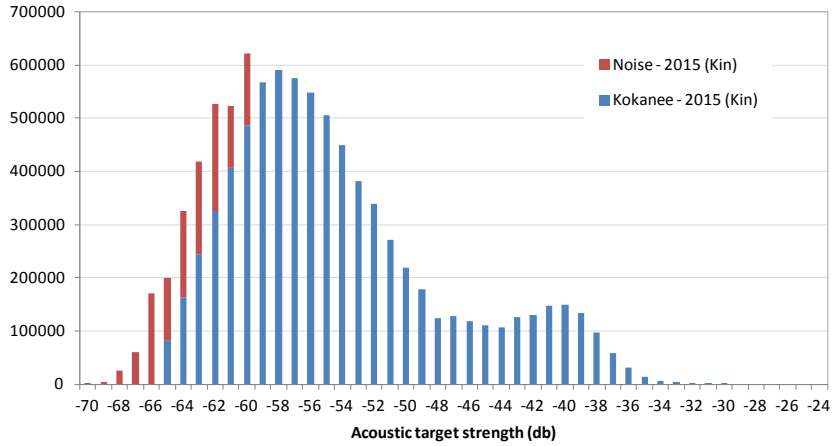
| Zone | Depth | N | Mean | SE | Area | Stratum Population | CV | Statistic | Abundance |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5-10 | 9 | 5.3 | 3.2 | 3938 | 20,740 | 0.4 | LB= | 443,093 |
| 1 | 10-15 | 9 | 31.8 | 4.2 | 3938 | 125,108 | 0.4 | MLE= | 546,404 |
| 1 | 15-20 | 9 | 22.2 | 3.4 | 3938 | 87,284 | 0.4 | UB= | 649,264 |
| 1 | 20-25 | 9 | 7.9 | 2.2 | 3938 | 31,142 | 0.4 | | |
| 1 | 25-30 | 9 | 3.0 | 2.1 | 3750 | 11,190 | 0.4 | | |
| 1 | 30-35 | 9 | 1.4 | 0.7 | 3600 | 5,161 | 0.4 | | |
| 1 | 35-40 | 9 | 0.8 | 0.3 | 3450 | 2,898 | 0.4 | | |
| 1 | 40-45 | 9 | 3.0 | 1.7 | 3263 | 9,647 | 0.4 | | |
| 1 | 45-50 | 9 | 1.3 | 0.7 | 3075 | 3,850 | 0.4 | | |
| 2 | 3-5 | 11 | 2.0 | 2.0 | 3313 | 6,494 | 0.4 | | |
| 2 | 5-10 | 11 | 13.1 | 3.9 | 3313 | 43,323 | 0.4 | | |
| 2 | 10-15 | 11 | 33.8 | 12.0 | 3313 | 111,806 | 0.4 | | |
| 2 | 15-20 | 11 | 13.6 | 4.2 | 3050 | 41,348 | 0.4 | | |
| 2 | 20-25 | 11 | 7.2 | 1.7 | 2800 | 20,027 | 0.4 | | |
| 2 | 25-30 | 11 | 4.2 | 1.1 | 2550 | 10,656 | 0.4 | | |
| 2 | 30-35 | 11 | 4.2 | 1.5 | 2188 | 9,275 | 0.4 | | |
| 2 | 35-40 | 11 | 1.5 | 0.6 | 1825 | 2,822 | 0.4 | | |
| 2 | 40-45 | 11 | 1.6 | 0.6 | 1510 | 2,478 | 0.4 | | |
| 2 | 45-50 | 11 | 0.8 | 0.3 | 1195 | 977 | 0.4 | | |

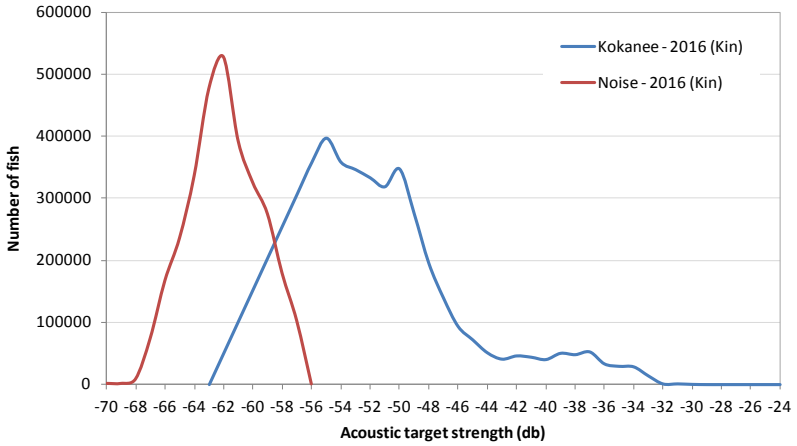
**Appendix 5**. Acoustic target strength (TS) distributions showing the result of linear noise reduction technique for separating low end noise from kokanee fry in Revelstoke Reservoir for 2015-2016 surveys. Plots to the right show cumulative frequency distribution (i.e.,fish and noise).

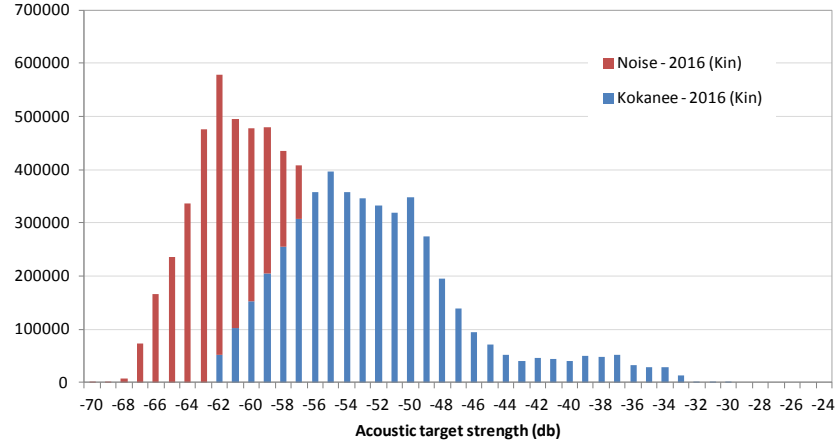


**Appendix 6**. Acoustic target strength (TS) distributions showing the result of linear noise reduction technique for separating low end noise from kokanee fry in Kinbasket Reservoir for 2015-2016 surveys. Note: the noise levels in Kinbasket tend to be much lower than in Revelstoke Reservoir (Appendix 5).



**Appendix 7.** Trawl sampling logs and catch data for Kinbasket in 2016.

**Key:** SN= Scale Number, MAT=maturing, IMM=immature, R=ripe

**Location:** Kinbasket **Trawl No:** 1 Layer # Sensor Distance & Depth (m) Target Depth
**Date:** Aug 3, 2016 **Transect No.** 17 Wood Arm 1 112 19 19-26
**UTM start:** N E **Time start:** 23:20
**UTM end:** N E **Time end:** 00:20 Net: 7x3m **Duration:** 42 min

| No. | SP | Len | Wt | Age | SN | MAT | Sex | No. | SP | Len | Wt | Age | SN | MAT | Sex |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | KO | 238 | 148.9 | 2 | 1 | Mat | F | 19 | KO | 141 | 29.9 | 1 | | Imm | F |
| 2 | KO | 231 | 156.2 | 2 | 2 | Mat | M | 20 | KO | 149 | 36.7 | 1 | 20 | Imm | |
| 3 | KO | 221 | 132.9 | 2 | 3 | Mat | M | 21 | KO | 147 | 35.2 | 1 | | Imm | |
| 4 | KO | 248 | 184.9 | 3 | 4 | Mat | M | 22 | KO | 57 | 1.8 | 0 | | Imm | |
| 5 | KO | 248 | 171 | 3 | 5 | Mat | F | 23 | KO | 38 | 0.4 | 0 | | Imm | |
| 6 | KO | 250 | 174.5 | 2 | 6 | Mat | F | 24 | KO | 63 | 2.4 | 0 | | Imm | |
| 7 | KO | 231 | 161 | 2 | 7 | Mat | M | 25 | KO | 72 | 3.8 | 0 | | Imm | |
| 8 | KO | 171 | 52.7 | 1 | 8 | Imm | F | 26 | KO | 38 | 0.4 | 0 | | Imm | |
| 9 | KO | 130 | 21.5 | 1 | | Imm | | 27 | KO | 53 | 1.4 | 0 | | Imm | |
| 10 | KO | 140 | 30.2 | 1 | 10 | Imm | | 28 | KO | 67 | 3 | 0 | | Imm | |
| 11 | KO | 150 | 37.3 | 1 | | Imm | | 29 | KO | 49 | 1.1 | 0 | | Imm | |
| 12 | KO | 143 | 33.3 | 1 | | Imm | | 30 | KO | 43 | 0.6 | 0 | | Imm | |
| 13 | KO | 143 | 31 | 1 | | Imm | | 31 | KO | 43 | 0.7 | 0 | | Imm | |
| 14 | KO | 142 | 29.8 | 1 | | Imm | | 32 | KO | 53 | 1.9 | 0 | | Imm | |
| 15 | KO | 150 | 35.6 | 1 | | Imm | | 33 | KO | 56 | 1.8 | 0 | | Imm | |
| 16 | KO | 145 | 35.1 | 1 | | Imm | | 34 | KO | 63 | 2.5 | 0 | | Imm | |
| 17 | KO | 141 | 31.5 | 1 | 17 | Imm | | 35 | KO | 32 | 0.2 | 0 | | Imm | |
| 18 | KO | 130 | 22 | 1 | | Imm | | 36 | KO | 66 | 2.7 | 0 | | Imm | |

Calculated Distance: m Average velocity: mps

**Location:** Kinbasket **Trawl No:** 2 Layer # Sensor Distance & Depth (m) Target Depth
**Date:** Aug 3, 2016 **Transect No.** 17 Wood Arm 1 112m 19 19-21
**UTM start:** N E **Time start:** 00:47
**UTM end:** N E **Time end:** 1:47 Net: 7x3m **Duration:** 40 min

| No. | SP | Len | Wt | Age | SN | MAT | Sex | No. | SP | Len | Wt | Age | SN | MAT | Sex |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | KO | 226 | 132.7 | 3 | 37 | Mat | F | 52 | KO | 148 | 34.8 | 1 | | Imm | |
| 38 | KO | 247 | 168.6 | 2 | 38 | Mat | F | 53 | KO | 136 | 27.3 | 1 | | Imm | F |
| 39 | KO | 227 | 144.6 | 2 | 39 | Mat | M | 54 | KO | 135 | 26.1 | 1 | | Imm | |
| 40 | KO | 228 | 149.6 | 2 | 40 | Mat | F | 55 | KO | 37 | 0.4 | 0 | | Imm | |
| 41 | KO | 232 | 161.5 | 2 | 41 | Mat | M | 56 | KO | 68 | 3.1 | 0 | | Imm | |
| 42 | KO | 235 | 155.9 | 2 | 42 | Mat | M | 57 | KO | 89 | 6.1 | 0 | | Imm | |
| 43 | KO | 153 | 40.5 | 1 | 43 | Imm | M | 58 | KO | 65 | 3 | 0 | | Imm | |
| 44 | KO | 130 | 23.8 | 1 | | Imm | F | 59 | KO | 55 | 1.6 | 0 | | Imm | |
| 45 | KO | 132 | 26.8 | 1 | | Imm | | 60 | KO | 72 | 3.4 | 0 | | Imm | |
| 46 | KO | 153 | 41.3 | 1 | 46 | Imm | F | 61 | KO | 58 | 1.8 | 0 | | Imm | |
| 47 | KO | 157 | 44.2 | 1 | 47 | Imm | F | 62 | KO | 41 | 0.7 | 0 | | Imm | |
| 48 | KO | 149 | 36.4 | 1 | | Imm | F | 63 | KO | 38 | 0.5 | 0 | | Imm | |
| 49 | KO | 149 | 37.5 | 1 | | Imm | | 64 | KO | 68 | 3.2 | 0 | | Imm | |
| 50 | KO | 134 | 26 | 1 | | Imm | | 65 | CC | 16 | | | | | |
| 51 | KO | 142 | 32.2 | 1 | | Imm | F | 66 | CC | 22 | | | | | |

Calculated Distance: m Average velocity: mps

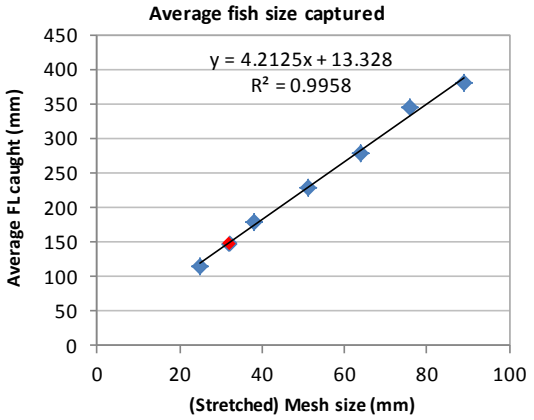
| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location:** Kinbasket | | | **Trawl No:** 3 | | | | | Layer # | Sensor Distance & Depth (m) | | | | | Target Depth | |
| **Date:** Aug 3, 2016 | | | **Transect No.** 14 Main Pool | | | | | 1 | | 111 | 19 | | | 19-26 | |
| **UTM start:** N | | E | **Time start:** 2:12 | | | | | | | | | | | | |
| **UTM end:** | | | **Time end:** 2:42 | | | | | | Net: 7x3m | | | | | | |
| **No.** | **SP** | **Len** | **Wt** | **Age** | **SN** | **MAT** | **Sex** | **No.** | **SP** | **Len** | **Wt** | **Age** | **SN** | **MAT** | **Sex** |
| 67 | KO | 230 | 146 | 2 | 67 | Mat | M | 83 | KO | 49 | 1.1 | 0 | | Imm | |
| 68 | KO | 248 | 178 | 3 | 68 | Mat | M | 84 | KO | 55 | 1.5 | 0 | | Imm | |
| 69 | KO | 182 | 65.8 | 1 | 69 | Imm | M | 85 | KO | 47 | 0.9 | 0 | | Imm | |
| 70 | KO | 229 | 139.1 | 2 | 70 | Mat | F | 86 | KO | 56 | 1.4 | 0 | | Imm | |
| 71 | KO | 232 | 148.3 | 2 | 71 | Mat | F | 87 | KO | 53 | 1.4 | 0 | | Imm | |
| 72 | KO | 230 | 142.8 | 2 | 72 | Mat | M | 88 | KO | 47 | 0.9 | 0 | | Imm | |
| 73 | KO | 222 | 118.4 | 2 | 73 | Imm | M | 89 | KO | 47 | 0.8 | 0 | | Imm | |
| 74 | KO | 208 | 99.2 | 2 | 74 | Imm | F | 90 | KO | 40 | 0.4 | 0 | | Imm | |
| 75 | KO | 232 | 153 | 3 | 75 | Mat | F | 91 | KO | 35 | 0.3 | 0 | | Imm | |
| 76 | KO | 223 | 128.1 | 2 | 76 | Imm | F | 92 | KO | 54 | 1.3 | 0 | | Imm | |
| 77 | KO | 40 | 0.5 | 0 | | Imm | | 93 | KO | 41 | 0.5 | 0 | | Imm | |
| 78 | KO | 48 | 0.8 | 0 | | Imm | | 94 | KO | 55 | 1.3 | 0 | | Imm | |
| 79 | KO | 54 | 1.2 | 0 | | Imm | | 95 | KO | 37 | 0.3 | 0 | | Imm | |
| 80 | KO | 60 | 1.7 | 0 | | Imm | | 96 | KO | 36 | 0.4 | 0 | | Imm | |
| 81 | KO | 52 | 1.1 | 0 | | Imm | | 97 | CC | 16 | | | | | |
| 82 | KO | 48 | 0.8 | 0 | | Imm | | | | | | | | | |
| Calculated Distance: | | | m | Average velocity: | | | | mps | | | | | | | |

## **Appendix 8.** Gillnet specifications showing the provincial Resource Inventory Committee (RIC) standards (1997) and the modification to include a 7th panel in 2015.

Appendix 12 Specifications for RIC Standard Gillnets mesh sizes

| Mesh size (stretched) mm | Average fish size (captured) mm |
|---|---|
| 25 | 114 |
| 32 | 148 |
| 38 | 178 |
| 51 | 228 |
| 64 | 280 |
| 76 | 345 |
| 89 | 380 |

Black font indicates RIC standards (1990)
New (7th) panel mesh size shown in red font




The RIC standard gillnet consisted of six panels measuring 50 x 8 ft using the six mesh sizes from the table above. The total length and area of a RIC six panelled net was 300 ft (91.46m) and 2400 $ft^2$ (223$m^2$)

With the addition of a seventh panel (32mm mesh) starting in 2015, the total length and area increased to 350 ft (106.7m) and 2800 $ft^2$ (853.6 $m^2$)

Typical overnight sets in Revelstoke and Kinbasket used 3 or 4 of the seven-panel RIC nets end to end for a total length and area as follows: 3 set length of 320m and area of 781 $m^2$
4 set length of 427m and area of 1041 $m^2$

**Appendix 9.** Gillnet set details and summary results for kokanee effort, catch and CPUE for a) Kinbasket and b) Revelstoke reservoirs

**a) Kinbasket GN stats**

| Attribute | GN1 | GN2 | | | |
|---|---|---|---|---|---|
| **Set date** | 8-Aug-16 | 29-Jul-16 | | | |
| **Retrieval date** | 9-Aug-16 | 30-Jul-16 | | | |
| **General location** | Sprague | Bush Pool | | | |
| **Site location (near...)** | TR11 | TR31 | | | |
| **Net depth(s) in meters** | 10,15,15,20 | 15,15,20 | | | |
| **Lake depth (m) start/end** | | | | | |
| **Start UTM East** | E 395697 | E 456380 | | | |
| **Start UTM North** | N 5773848 | N 5735760 | | | |
| **Set time** | 20:50 | 20:09 | | | |
| **Retrieval time** | 07:21 | 19:52 | | | |
| **Total time (hrs)** | 10.5 | 23.7 | | | |
| **Net area ($m^2$)** | 1040 | 780 | | | |
| **Effort ($ha \cdot hr$)** | 1.09 | 1.85 | | | |
| **Kokanee catch (no)** | 12 | 8 | | | |
| **Kokanee CPUE ($no \cdot ha \cdot hr^{-1}$)** | 11.0 | 4.3 | | | |

**b) Revelstoke GN stats**

| Attribute | GN 1 | GN 2 | | |
|---|---|---|---|---|
| **Set date** | 10-Aug-2016 | 10-Aug-2016 | | |
| **Retrieval date** | 11-Aug-2016 | 11-Aug-2016 | | |
| **Site location (near...)** | TR12 | TR11 | | |
| **Net depth(s) in meters** | 10,15,10 | 10,10,15,15 | | |
| **Lake depth (m) start/end** | | | | |
| **Start UTM East** | E 398156 | E 399917 | | |
| **Start UTM North** | N 5699335 | N 5694024 | | |
| **Set time** | 19:00 | 18:10 | | |
| **Retrieval time** | 10:50 | 08:20 | | |
| **Total time (hrs)** | 15.83 | 14.17 | | |
| **Net area ($m^2$)** | 780 | 1040 | | |
| **Effort ($ha \cdot hr$)** | 1.23 | 1.47 | | |
| **Kokanee catch (no)** | 67 | 45 | | |
| **Kokanee CPUE ($no \cdot ha \cdot hr^{-1}$)** | 54.5 | 30.6 | | |

**Appendix 10.** Gill net catch results for over night sets in a) Kinbasket Reservoir including Bush Pool and for b) Revelstoke Reservoir during summer of 2016. Note: shading highlights non-kokanee captured in Gillnets.

a) Kinbasket GN catch

**Location:** Kinbasket (Main Pool T11) **Method:** Pelagic GN **Net Type:** RIC (modified)[1]
**Net Depth:** GN#1: 10,15,15,20 **Net Area:** 1041m$^2$
**Net Description:** 7 panels of 15.24 x 2.44m 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 | 11 | 8 | 9 | 10 | 1 | KO | 152 | 42.5 | F | IMM | 1 | 1 | 1 | |
| 1 | 11 | 8 | 9 | 15 | 2 | KO | 247 | 170 | M | MAT | 2 | 2 | 2 | |
| 1 | 11 | 8 | 9 | 15 | 3 | KO | 251 | 189 | M | MAT | 3 | 3 | 3 | |
| 1 | 11 | 8 | 9 | 15 | 4 | KO | 230 | 155 | M | MAT | 2 | 4 | 4 | |
| 1 | 11 | 8 | 9 | 15 | 5 | KO | 226 | 148.5 | M | MAT | 2 | 5 | 5 | |
| 1 | 11 | 8 | 9 | 15 | 6 | KO | 236 | 162 | M | MAT | 2 | 6 | 6 | |
| 1 | 11 | 8 | 9 | 15 | 7 | KO | 220 | 116 | M | MAT | 2 | 7 | 7 | |
| 1 | 11 | 8 | 9 | 15 | 8 | KO | 210 | 106 | M | MAT | 1 | 8 | 8 | |
| 1 | 11 | 8 | 9 | 15 | 9 | KO | 172 | 54.5 | M | IMM | 1 | 9 | 9 | |
| 1 | 11 | 8 | 9 | 15 | 10 | KO | 158 | 48 | | IMM | 1 | 10 | 10 | |
| 1 | 11 | 8 | 9 | 20 | 11 | KO | 236 | 158.5 | M | MAT | 2 | 11 | 11 | |
| 1 | 11 | 8 | 9 | 20 | 12 | KO | 255 | 205.5 | M | MAT | 3 | 12 | 12 | |
| 1 | 11 | 8 | 9 | 20 | 13 | BT | 319 | 313 | | IMM | | 13 | 13 | |
| 1 | 11 | 8 | 9 | 20 | 14 | BT | 222 | 97.5 | | IMM | | 14 | 14 | |

1) see Appendix 8 for modifications to RIC nets

Note: non-kokanee species have been highlighted in grey and assigned unique fish number

**Location:** Kinbasket (Bush Pool T32) **Method:** Pelagic GN **Net Type:** RIC (modified)
**Net Depth:** GN#2: 20,15,15 **Net Area:** 781m$^2$
**Net Description:** 7 panels of 15.24 x 2.44m 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 | 32 | 7 | 29 | 15 | 1 | KO | 236 | 129.5 | F | MAT | 3 | 1 | | |
| 2 | 32 | 7 | 29 | 15 | 2 | KO | 224 | 124.7 | M | MAT | 3 | 2 | | |
| 2 | 32 | 7 | 29 | 15 | 3 | KO | 237 | 150.4 | M | MAT | 2 | 3 | | |
| 2 | 32 | 7 | 29 | 15 | 4 | KO | 190 | 73.1 | M | IMM | 1 | 4 | | |
| 2 | 32 | 7 | 29 | 15 | 5 | BT | 262 | 180.7 | M | IMM | | | | |
| 2 | 32 | 7 | 29 | 15 | 6 | PWF | 126 | 20.5 | | | | | | |
| 2 | 32 | 7 | 29 | 20 | 7 | KO | 171 | 52.9 | M | IMM | 1 | 5 | | |
| 2 | 32 | 7 | 29 | 20 | 8 | KO | 183 | 68.9 | F | IMM | 1 | 6 | | |
| 2 | 32 | 7 | 29 | 20 | 9 | KO | 135 | 55 | | | 1 | 7 | | |
| 2 | 32 | 7 | 29 | 20 | 10 | BT | 313 | 350.5 | | | | | | |
| 2 | 32 | 7 | 29 | 20 | 11 | BT | 296 | 240.2 | | | | | | |

Note: one kokanee escaped at boat - was 2+ size

b) Revelstoke GN catch

**Location:** Revelstoke (near Downie) **Method:** Pelagic GN **Net Type:** RIC (modified)

**Net Depth:** GN#1 depths 10,15,10m **Net area:** 781m$^2$

**Net Description:** 7 panels of 15.24 x 2.44m 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 | 12 | 8 | 11 | 15 | 1 | KO | 280 | 255.5 | M | G | 2 | 1 | 1 | |
| 1 | 12 | 8 | 11 | 15 | 2 | KO | 306 | 349 | M | MAT | 2 | 2 | 2 | |
| 1 | 12 | 8 | 11 | 15 | 3 | KO | 298 | 337.5 | F | MAT | 2 | 3 | 3 | |
| 1 | 12 | 8 | 11 | 15 | 4 | KO | 304 | 336.5 | M | MAT | 2 | 4 | 4 | y |
| 1 | 12 | 8 | 11 | 15 | 5 | KO | 299 | 327 | F | MAT | 2 | 5 | 5 | |
| 1 | 12 | 8 | 11 | 15 | 6 | KO | 298 | 344 | F | MAT | 2 | 6 | 6 | y |
| 1 | 12 | 8 | 11 | 15 | 7 | KO | 299 | 317.5 | F | MAT | 2 | 7 | 7 | y |
| 1 | 12 | 8 | 11 | 15 | 8 | KO | 295 | 328 | F | MAT | 2 | 8 | none | |
| 1 | 12 | 8 | 11 | 15 | 9 | KO | 340 | 452.5 | F | MAT | 3 | 9 | 9 | |
| 1 | 12 | 8 | 11 | 15 | 10 | KO | 303 | 351 | F | MAT | 2 | 10 | 10 | |
| 1 | 12 | 8 | 11 | 10 | 11 | KO | 323 | 436 | M | MAT | 3 | 11 | 11 | |
| 1 | 12 | 8 | 11 | 10 | 12 | KO | 305 | 339 | F | MAT | 2 | 12 | 12 | |
| 1 | 12 | 8 | 11 | 10 | 13 | KO | 298 | 347 | M | MAT | 2 | 13 | 13 | |
| 1 | 12 | 8 | 11 | 10 | 14 | KO | 290 | 325 | M | MAT | 2 | 14 | 14 | |
| 1 | 12 | 8 | 11 | 10 | 15 | KO | 280 | 267 | M | | 2 | 15 | 15 | |
| 1 | 12 | 8 | 11 | 10 | 16 | KO | 300 | 318 | M | MAT | 2 | 16 | 16 | |
| 1 | 12 | 8 | 11 | 10 | 17 | KO | 308 | 356.5 | F | MAT | 2 | 17 | 17 | |
| 1 | 12 | 8 | 11 | 10 | 18 | KO | 179 | 66.5 | F | IMM | 1 | 18 | 18 | |
| 1 | 12 | 8 | 11 | 10 | 19 | KO | 155 | 41.5 | F | IMM | 1 | 19 | 19 | |
| 1 | 12 | 8 | 11 | 10 | 20 | KO | 298 | 320.5 | F | MAT | 2 | 20 | 20 | |
| 1 | 12 | 8 | 11 | 10 | 21 | KO | 280 | 283 | M | MAT | 2 | 21 | 21 | |
| 1 | 12 | 8 | 11 | 10 | 22 | KO | 295 | 332 | F | MAT | 2 | 22 | 22 | |
| 1 | 12 | 8 | 11 | 10 | 23 | KO | 303 | 338.5 | F | MAT | 2 | 23 | 23 | |
| 1 | 12 | 8 | 11 | 10 | 24 | KO | 342 | 489 | F | MAT | 3 | 24 | 24 | |
| 1 | 12 | 8 | 11 | 10 | 25 | KO | 340 | 459 | F | MAT | 3 | 25 | 25 | |
| 1 | 12 | 8 | 11 | 10 | 26 | KO | 298 | 331.5 | F | MAT | 2 | 26 | 26 | |
| 1 | 12 | 8 | 11 | 10 | 27 | KO | 294 | 323 | M | MAT | 2 | 27 | 27 | |
| 1 | 12 | 8 | 11 | 10 | 28 | KO | 293 | 325.5 | M | MAT | 2 | 28 | 28 | |
| 1 | 12 | 8 | 11 | 10 | 29 | KO | 308 | 370 | F | MAT | 2 | 29 | 29 | |
| 1 | 12 | 8 | 11 | 10 | 30 | KO | 306 | 372 | M | MAT | 2 | 30 | 30 | |
| 1 | 12 | 8 | 11 | 10 | 31 | KO | 307 | 347.5 | M | MAT | 2 | 31 | 31 | |
| 1 | 12 | 8 | 11 | 10 | 32 | KO | 298 | 343 | M | MAT | 2 | 32 | 32 | |
| 1 | 12 | 8 | 11 | 10 | 33 | KO | 295 | 336.5 | M | MAT | 2 | 33 | 33 | |
| 1 | 12 | 8 | 11 | 10 | 34 | KO | 294 | 320.5 | F | MAT | 2 | 34 | 34 | |
| 1 | 12 | 8 | 11 | 10 | 35 | KO | 292 | 318 | M | MAT | 2 | 35 | 35 | |
| 1 | 12 | 8 | 11 | 10 | 36 | KO | 200 | 97.5 | unk | IMM | 1 | 36 | 36 | |
| 1 | 12 | 8 | 11 | 10 | 37 | KO | 180 | 70.5 | F | IMM | 1 | 37 | 37 | |
| 1 | 12 | 8 | 11 | 10 | 38 | MWF | 241 | 163.5 | F | IMM | | 38 | 38 | |
| 1 | 12 | 8 | 11 | 10 | 39 | MWF | 205 | 89.5 | M | IMM | | 39 | 39 | |

1) see Appendix 8 for modifications to RIC nets

Note: non-kokanee species have been highlighted in grey and assigned unique fish number

Note: ages in blue font were estimated based on length using scale ages as a guide

b) Revelstoke GN catch continued

| Gillnet No. | Trans No. | Mon | Day | Net Depth | Fish No. | Spec. | Len. | Weight | Sex | Matur. | Scale Age | Scale No. | Otol. No. | photo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 | 8 | 11 | 15 | 40 | KO | 285 | 310 | M | MAT | 2 | 40 | 40 | |
| 1 | 12 | 8 | 11 | 15 | 41 | KO | 330 | 477.5 | M | MAT | 3 | 41 | 41 | |
| 1 | 12 | 8 | 11 | 15 | 42 | KO | 290 | 302 | F | MAT | 3 | 42 | 42 | |
| 1 | 12 | 8 | 11 | 15 | 43 | KO | 313 | 392.5 | M | MAT | 3 | 43 | 43 | |
| 1 | 12 | 8 | 11 | 15 | 44 | KO | 322 | 437 | F | MAT | 3 | 44 | 44 | |
| 1 | 12 | 8 | 11 | 15 | 45 | KO | 294 | 302.5 | F | MAT | 2 | 45 | 45 | |
| 1 | 12 | 8 | 11 | 15 | 46 | KO | 303 | 346.5 | F | | 2 | 46 | 46 | |
| 1 | 12 | 8 | 11 | 15 | 47 | KO | 336 | 431 | F | MAT | 3 | 47 | 47 | |
| 1 | 12 | 8 | 11 | 15 | 48 | KO | 285 | 318.5 | M | MAT | 2 | 48 | 48 | |
| 1 | 12 | 8 | 11 | 15 | 49 | KO | 301 | 352 | F | MAT | 2 | 49 | 49 | |
| 1 | 12 | 8 | 11 | 15 | 50 | KO | 296 | 345 | F | MAT | 2 | 50 | 50 | |
| 1 | 12 | 8 | 11 | 15 | 51 | KO | 295 | 310.5 | F | MAT | 2 | 51 | 51 | y |
| 1 | 12 | 8 | 11 | 15 | 52 | KO | 303 | 372 | M | MAT | 2 | 52 | 52 | |
| 1 | 12 | 8 | 11 | 15 | 53 | KO | 300 | 339.5 | M | MAT | 2 | 53 | 53 | |
| 1 | 12 | 8 | 11 | 15 | 54 | KO | 270 | 230.5 | unk | IMM | 3 | 54 | 54 | |
| 1 | 12 | 8 | 11 | 15 | 55 | KO | 288 | 325.5 | M | MAT | 2 | 55 | 55 | |
| 1 | 12 | 8 | 11 | 15 | 56 | KO | 295 | 330.5 | M | MAT | 2 | 56 | 56 | |
| 1 | 12 | 8 | 11 | 15 | 57 | KO | 305 | 356 | M | MAT | 2 | 57 | 57 | |
| 1 | 12 | 8 | 11 | 15 | 58 | KO | 295 | 302.5 | F | MAT | 2 | 58 | 58 | |
| 1 | 12 | 8 | 11 | 15 | 59 | KO | 295 | 343 | F | MAT | 2 | 59 | 59 | |
| 1 | 12 | 8 | 11 | 15 | 60 | KO | 299 | 337.5 | F | MAT | 2 | 60 | 60 | |
| 1 | 12 | 8 | 11 | 15 | 61 | KO | 300 | 349 | F | MAT | 2 | 61 | 61 | |
| 1 | 12 | 8 | 11 | 15 | 62 | KO | 280 | 284.5 | F | IMM | 2 | 62 | 62 | y |
| 1 | 12 | 8 | 11 | 15 | 63 | KO | 289 | 319.5 | F | MAT | 2 | 63 | 63 | |
| 1 | 12 | 8 | 11 | 15 | 64 | KO | 295 | 331 | F | MAT | 2 | 64 | 64 | |
| 1 | 12 | 8 | 11 | 15 | 65 | KO | 341 | 465.5 | F | MAT | 3 | 65 | 65 | |
| 1 | 12 | 8 | 11 | 15 | 66 | KO | 306 | 369 | M | MAT | 2 | 66 | 66 | |
| 1 | 12 | 8 | 11 | 15 | 67 | KO | 200 | 96.5 | unk | IMM | 1 | 67 | 67 | |
| 1 | 12 | 8 | 11 | 15 | 68 | KO | 198 | 96 | unk | IMM | 1 | 68 | 68 | |
| 1 | 12 | 8 | 11 | 15 | 69 | KO | 160 | 45 | unk | IMM | 1 | 69 | 69 | |
| 1 | 12 | 8 | 11 | 15 | 70 | MWF | 244 | 167 | M | MAT | 5 | 70 | 70 | |

**Location:** Revelstoke (near Downie) **Method:** Pelagic GN **Net Type:** RIC (modified)

**Net Depth:** GN#2 depths 10,10,15,15m **Net area:** 1041m$^2$

**Net Description:** 7 panels of 15.24 x 2.44m 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 | 11 | 8 | 11 | 15 | 71 | KO | 299 | 350 | M | MAT | 2 | 71 | 71 | |
| 2 | 11 | 8 | 11 | 15 | 72 | KO | 298 | 334 | F | MAT | 2 | 72 | 72 | |
| 2 | 11 | 8 | 11 | 15 | 73 | KO | 300 | 333 | F | MAT | 2 | 73 | 73 | |
| 2 | 11 | 8 | 11 | 15 | 74 | KO | 311 | 422 | M | MAT | 3 | 74 | 74 | |
| 2 | 11 | 8 | 11 | 15 | 75 | KO | 303 | 348 | M | MAT | 2 | 75 | 75 | |
| 2 | 11 | 8 | 11 | 15 | 76 | KO | 297 | 343 | M | MAT | 2 | 76 | 76 | |
| 2 | 11 | 8 | 11 | 15 | 77 | KO | 301 | 343 | M | MAT | 2 | 77 | 77 | |

b) Revelstoke GN catch continued

| Gillnet No. | Trans No. | Mon | Day | Net Depth | Fish No. | Spec. | Len. | Weight | Sex | Matur. | Scale Age | Scale No. | Otol. No. | photo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 11 | 8 | 11 | 15 | 78 | KO | 295 | 316 | M | MAT | 2 | 78 | 78 | |
| 2 | 11 | 8 | 11 | 15 | 79 | KO | 299 | 345 | M | MAT | 2 | 79 | 79 | |
| 2 | 11 | 8 | 11 | 15 | 80 | KO | 248 | 187 | M | IMM | 2 | 80 | 80 | |
| 2 | 11 | 8 | 11 | 15 | 81 | KO | 290 | 324.5 | M | MAT | 2 | 81 | 81 | |
| 2 | 11 | 8 | 11 | 15 | 82 | KO | 295 | 317 | M | MAT | 2 | 82 | 82 | |
| 2 | 11 | 8 | 11 | 15 | 83 | KO | 294 | 334.5 | M | MAT | 2 | 83 | 83 | |
| 2 | 11 | 8 | 11 | 15 | 84 | KO | 292 | 319 | M | MAT | 2 | 84 | 84 | |
| 2 | 11 | 8 | 11 | 15 | 85 | KO | 193 | 89 | F | IMM | 1 | 85 | 85 | |
| 2 | 11 | 8 | 11 | 15 | 86 | KO | 173 | 63 | unk | IMM | 1 | 86 | 86 | |
| 2 | 11 | 8 | 11 | 15 | 87 | KO | 265 | 225 | F | IMM | 2 | 87 | 87 | |
| 2 | 11 | 8 | 11 | 15 | 88 | KO | 320 | 495.5 | F | MAT | 3 | 88 | 88 | |
| 2 | 11 | 8 | 11 | 15 | 89 | KO | 274 | 223 | M | IMM | 2 | 89 | 89 | |
| 2 | 11 | 8 | 11 | 15 | 90 | KO | 291 | 326.5 | F | MAT | 2 | 90 | 90 | |
| 2 | 11 | 8 | 11 | 15 | 91 | KO | 292 | 322 | F | MAT | 2 | 91 | 91 | |
| 2 | 11 | 8 | 11 | 15 | 93 | KO | 295 | 341.5 | F | MAT | 2 | 93 | 93 | |
| 2 | 11 | 8 | 11 | 15 | 94 | KO | 295 | 334.5 | M | MAT | 2 | 94 | 94 | |
| 2 | 11 | 8 | 11 | 15 | 95 | KO | 290 | 309.5 | F | MAT | 2 | 95 | 95 | |
| 2 | 11 | 8 | 11 | 15 | 96 | KO | 291 | 328.5 | M | MAT | 2 | 96 | 96 | |
| 2 | 11 | 8 | 11 | 15 | 97 | KO | 340 | 467 | M | MAT | 3 | 97 | 97 | |
| 2 | 11 | 8 | 11 | 15 | 92 | KO | 319 | 377.5 | F | MAT | 2 | 92 | 92 | |
| 2 | 11 | 8 | 11 | 15 | 98 | KO | 300 | 340 | F | MAT | 2 | 98 | 98 | |
| 2 | 11 | 8 | 11 | 15 | 99 | KO | 295 | 339.5 | M | MAT | 2 | 99 | 99 | |
| 2 | 11 | 8 | 11 | 15 | 100 | KO | 298 | 350.5 | M | MAT | 2 | 100 | 100 | |
| 2 | 11 | 8 | 11 | 15 | 101 | KO | 293 | 346 | F | MAT | 2 | 101 | 101 | |
| 2 | 11 | 8 | 11 | 15 | 102 | KO | 307 | 377.5 | M | MAT | 2 | 102 | 102 | |
| 2 | 11 | 8 | 11 | 15 | 103 | KO | 293 | 302.5 | F | MAT | 2 | 103 | 103 | |
| 2 | 11 | 8 | 11 | 15 | 104 | KO | 260 | 205 | unk | IMM | 2 | 104 | 104 | |
| 2 | 11 | 8 | 11 | 15 | 105 | KO | 188 | 82 | F | IMM | 1 | 105 | 105 | |
| 2 | 11 | 8 | 11 | 15 | 106 | KO | 185 | 78.5 | unk | IMM | 1 | 106 | 106 | |
| 2 | 11 | 8 | 11 | 15 | 107 | KO | 169 | 62 | F | IMM | 1 | 107 | 107 | |
| 2 | 11 | 8 | 11 | 15 | 108 | KO | 170 | 54.5 | F | IMM | 1 | 108 | 108 | |
| 2 | 11 | 8 | 11 | 15 | 109 | KO | 188 | 72.5 | unk | IMM | 1 | 109 | 109 | |
| 2 | 11 | 8 | 11 | 15 | 110 | KO | 170 | 50.5 | F | IMM | 1 | 110 | 110 | |
| 2 | 11 | 8 | 11 | 10 | 111 | BT | 223 | 97.5 | unk | IMM | 1 | 111 | 111 | |
| 2 | 11 | 8 | 11 | 10 | 112 | KO | 305 | 364 | M | MAT | 2 | 112 | 112 | |
| 2 | 11 | 8 | 11 | 10 | 113 | KO | 339 | 469 | M | MAT | 3 | 113 | 113 | |
| 2 | 11 | 8 | 11 | 10 | 114 | KO | 326 | 456.5 | F | MAT | 3 | 114 | 114 | |
| 2 | 11 | 8 | 11 | 10 | 115 | KO | 165 | 53 | F | IMM | 1 | 115 | 115 | |
| 2 | 11 | 8 | 11 | 10 | 116 | KO | 180 | 70 | F | IMM | 1 | 116 | 116 | |

**Note: ages in blue font were estimated based on length using scale ages as a guide**

**Appendix 11.** Kokanee spawner length and age data for a) Camp Creek, b) Bush River, c) Wood River, d) Luxor Creek, e) Upper Columbia River and f) Standard Creek, tributary to Downie Creek and Revelstoke Reservoir (Source: K. Bray, BCH Revelstoke).

a) Camp Creek

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 15-Sep | F | 288 | 2 | 1 | 15-Sep | M | 270 | 2 | 3 |
| 2016 | 15-Sep | F | 261 | 2 | 7 | 15-Sep | M | 282 | 2 | 5 |
| 2016 | 15-Sep | F | 260 | 2 | 10 | 15-Sep | M | 293 | 2 | 9 |
| 2016 | 15-Sep | F | 288 | 3 | 3 | 15-Sep | M | 278 | 2 | 10 |
| 2016 | 15-Sep | F | 280 | 3 | 4 | 15-Sep | M | 278 | 3 | 1 |
| 2016 | 15-Sep | F | 280 | 3 | 5 | 15-Sep | M | 275 | 3 | 2 |
| 2016 | 15-Sep | F | 282 | 3 | 6 | 15-Sep | M | 276 | 3 | 4 |
| 2016 | 15-Sep | F | 282 | 3 | 8 | 15-Sep | M | 276 | 3 | 6 |
| 2016 | 15-Sep | F | 272 | 3 | 9 | 15-Sep | M | 272 | 3 | 7 |
| 2016 | 15-Sep | F | 285 |  | 2 | 15-Sep | M | 274 | 3 | 8 |
| 2016 | 22-Sep | F | 280 |  | 1 | 22-Sep | M | 282 |  | 1 |
| 2016 | 22-Sep | F | 276 |  | 2 | 22-Sep | M | 264 |  | 2 |
| 2016 | 22-Sep | F | 286 |  | 3 | 22-Sep | M | 280 |  | 3 |
| 2016 | 22-Sep | F | 274 |  | 4 | 22-Sep | M | 276 |  | 4 |
| 2016 | 22-Sep | F | 275 |  | 5 | 22-Sep | M | 275 |  | 5 |
| 2016 | 22-Sep | F | 290 |  | 6 | 22-Sep | M | 289 |  | 6 |
| 2016 | 22-Sep | F | 280 |  | 7 | 22-Sep | M | 280 |  | 7 |
| 2016 | 22-Sep | F | 261 |  | 8 | 22-Sep | M | 275 |  | 8 |
| 2016 | 22-Sep | F | 250 |  | 9 | 22-Sep | M | 270 |  | 9 |
| 2016 | 22-Sep | F | 258 |  | 10 | 22-Sep | M | 265 |  | 10 |
| 2016 | 29-Sep | F | 246 | 2 | 5 | 29-Sep | M | 267 | 2 | 5 |
| 2016 | 29-Sep | F | 265 | 2 | 7 | 29-Sep | M | 265 | 3 | 1 |
| 2016 | 29-Sep | F | 272 | 3 | 1 | 29-Sep | M | 277 | 3 | 2 |
| 2016 | 29-Sep | F | 270 | 3 | 2 | 29-Sep | M | 284 | 3 | 3 |
| 2016 | 29-Sep | F | 286 | 3 | 3 | 29-Sep | M | 267 | 3 | 4 |
| 2016 | 29-Sep | F | 259 | 3 | 4 | 29-Sep | M | 276 | 3 | 6 |
| 2016 | 29-Sep | F | 269 | 3 | 6 | 29-Sep | M | 277 | 3 | 8 |
| 2016 | 29-Sep | F | 273 | 3 | 8 | 29-Sep | M | 284 | 3 | 9 |
| 2016 | 29-Sep | F | 266 | 3 | 10 | 29-Sep | M | 254 | 3 | 10 |
| 2016 | 29-Sep | F | 271 | 4 | 9 | 29-Sep | M | 276 |  | 7 |
| **Mean** |  | **F** | **273** |  |  | **Mean** | **M** | **275** |  |  |

Note: otoliths were sampled but not aged are marked in blue font

**b) Bush River**

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 15-Sep | F | 250 | 2 | 6 | 15-Sep | M | 243 | 2 | 17 |
| 2016 | 15-Sep | F | 254 | 2 | 7 | 15-Sep | M | 240 | 2 | 18 |
| 2016 | 15-Sep | F | 224 | 2 | 16 | 15-Sep | M | 253 | 2 | 21 |
| 2016 | 15-Sep | F | 253 | 2 | 23 | 15-Sep | M | 271 | 2 | 24 |
| 2016 | 21-Sep | F | 253 | | 3 | 15-Sep | M | 251 | 2 | 25 |
| 2016 | 21-Sep | F | 255 | | 4 | 15-Sep | M | 247 | 2 | 26 |
| 2016 | 21-Sep | F | 256 | | 5 | 15-Sep | M | 245 | 2 | 27 |
| 2016 | 21-Sep | F | 245 | | 7 | 15-Sep | M | 250 | 2 | 29 |
| 2016 | 21-Sep | F | 255 | | 10 | 15-Sep | M | 261 | 2 | 30 |
| 2016 | 21-Sep | F | 240 | | 12 | 15-Sep | M | 261 | 3 | 20 |
| 2016 | 21-Sep | F | 242 | | 13 | 15-Sep | M | 261 | 3 | 22 |
| 2016 | 21-Sep | F | 242 | | 16 | 15-Sep | M | 237 | | 19 |
| 2016 | 21-Sep | F | 265 | | 17 | 15-Sep | M | 265 | | 28 |
| 2016 | 21-Sep | F | 260 | | 19 | 21-Sep | M | 237 | | 1 |
| 2016 | 21-Sep | F | 240 | | 21 | 21-Sep | M | 271 | | 2 |
| 2016 | 21-Sep | F | 245 | | 22 | 21-Sep | M | 248 | | 6 |
| 2016 | 21-Sep | F | 258 | | 24 | 21-Sep | M | 255 | | 8 |
| 2016 | 21-Sep | F | 255 | | 25 | 21-Sep | M | 259 | | 9 |
| 2016 | 21-Sep | F | 253 | | 28 | 21-Sep | M | 239 | | 11 |
| 2016 | 21-Sep | F | 241 | | 29 | 21-Sep | M | 245 | | 14 |
| 2016 | 28-Sep | F | 249 | 2 | 3 | 21-Sep | M | 243 | | 15 |
| 2016 | 28-Sep | F | 238 | 2 | 6 | 21-Sep | M | 260 | | 18 |
| 2016 | 28-Sep | F | 246 | 2 | 7 | 21-Sep | M | 233 | | 20 |
| 2016 | 28-Sep | F | 242 | 2 | 9 | 21-Sep | M | 249 | | 23 |
| 2016 | 28-Sep | F | 250 | 2 | 20 | 21-Sep | M | 233 | | 26 |
| 2016 | 28-Sep | F | 253 | 2 | 23 | 21-Sep | M | 261 | | 27 |
| 2016 | 28-Sep | F | 245 | 2 | 25 | 21-Sep | M | 239 | | 30 |
| 2016 | 28-Sep | F | 241 | 2 | 27 | 28-Sep | M | 236 | 2 | 4 |
| 2016 | 28-Sep | F | 221 | 2 | 28 | 28-Sep | M | 241 | 2 | 5 |
| 2016 | 28-Sep | F | 236 | 3 | 1 | 28-Sep | M | 240 | 2 | 10 |
| 2016 | 28-Sep | F | 267 | | 2 | 28-Sep | M | 252 | 2 | 11 |
| **Mean** | | **F** | **248** | | | 28-Sep | M | 258 | 2 | 13 |
| 2016 | 15-Sep | M | 250 | 2 | 1 | 28-Sep | M | 252 | 2 | 14 |
| 2016 | 15-Sep | M | 268 | 2 | 2 | 28-Sep | M | 244 | 2 | 15 |
| 2016 | 15-Sep | M | 253 | 2 | 3 | 28-Sep | M | 257 | 2 | 16 |
| 2016 | 15-Sep | M | 253 | 2 | 4 | 28-Sep | M | 240 | 2 | 17 |
| 2016 | 15-Sep | M | 271 | 2 | 5 | 28-Sep | M | 256 | 2 | 18 |
| 2016 | 15-Sep | M | 249 | 2 | 8 | 28-Sep | M | 247 | 2 | 19 |
| 2016 | 15-Sep | M | 260 | 2 | 9 | 28-Sep | M | 274 | 2 | 21 |
| 2016 | 15-Sep | M | 255 | 2 | 10 | 28-Sep | M | 240 | 2 | 22 |
| 2016 | 15-Sep | M | 230 | 2 | 11 | 28-Sep | M | 234 | 2 | 24 |
| 2016 | 15-Sep | M | 251 | 2 | 12 | 28-Sep | M | 218 | 2 | 26 |
| 2016 | 15-Sep | M | 256 | 2 | 13 | 28-Sep | M | 250 | 2 | 29 |
| 2016 | 15-Sep | M | 238 | 2 | 14 | 28-Sep | M | 249 | 3 | 8 |
| 2016 | 15-Sep | M | 254 | 2 | 15 | 28-Sep | M | 270 | 3 | 12 |
| | | | | | | **Mean** | **M** | **250** | | |

**c) Wood River**

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 21-Sep | F | 258 | 2 | 2 | 21-Sep | M | 269 | 2 | 1 |
| 2016 | 21-Sep | F | 247 | 2 | 4 | 21-Sep | M | 266 | 2 | 6 |
| 2016 | 21-Sep | F | 260 | 2 | 8 | 21-Sep | M | 260 | 2 | 7 |
| 2016 | 21-Sep | F | 263 | 2 | 9 | 21-Sep | M | 256 | 2 | 11 |
| 2016 | 21-Sep | F | 251 | 2 | 12 | 21-Sep | M | 261 | 3 | 3 |
| | | | | | | 21-Sep | M | 258 | 3 | 5 |
| | | | | | | 21-Sep | M | 274 | 3 | 10 |
| **Mean** | | **F** | **256** | | | **Mean** | **M** | **263** | | |

**d) Luxor Creek**

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 15-Sep | F | 243 | 2 | 1 | 15-Sep | M | 253 | 2 | 11 |
| 2016 | 15-Sep | F | 243 | 2 | 12 | 15-Sep | M | 266 | 2 | 14 |
| 2016 | 15-Sep | F | 243 | 2 | 13 | 15-Sep | M | 229 | 2 | 15 |
| 2016 | 15-Sep | F | 258 | 2 | 16 | 15-Sep | M | 230 | 2 | 19 |
| 2016 | 15-Sep | F | 248 | 2 | 18 | 15-Sep | M | 259 | 2 | 20 |
| 2016 | 15-Sep | F | 255 | 3 | 7 | 15-Sep | M | 246 | 2 | 21 |
| 2016 | 21-Sep | F | 239 | 2 | 3 | 15-Sep | M | 254 | 2 | 22 |
| 2016 | 21-Sep | F | 248 | 2 | 4 | 15-Sep | M | 255 | 2 | 23 |
| 2016 | 21-Sep | F | 230 | 2 | 6 | 15-Sep | M | 230 | 2 | 24 |
| 2016 | 21-Sep | F | 255 | 2 | 8 | 15-Sep | M | 259 | 3 | 25 |
| 2016 | 21-Sep | F | 244 | 2 | 9 | 15-Sep | M | 260 | | 17 |
| 2016 | 21-Sep | F | 251 | 2 | 11 | 21-Sep | M | 238 | 2 | 1 |
| 2016 | 21-Sep | F | 248 | 2 | 17 | 21-Sep | M | 250 | 2 | 2 |
| 2016 | 21-Sep | F | 250 | 2 | 22 | 21-Sep | M | 248 | 2 | 5 |
| 2016 | 21-Sep | F | 251 | 2 | 24 | 21-Sep | M | 214 | 2 | 10 |
| 2016 | 21-Sep | F | 235 | 2 | 28 | 21-Sep | M | 238 | 2 | 12 |
| 2016 | 21-Sep | F | 251 | 3 | 16 | 21-Sep | M | 240 | 2 | 13 |
| 2016 | 21-Sep | F | 247 | | 26 | 21-Sep | M | 220 | 2 | 14 |
| **Mean** | | **F** | **247** | | | 21-Sep | M | 240 | 2 | 15 |
| | | | | | | 21-Sep | M | 242 | 2 | 18 |
| 2016 | 15-Sep | M | 240 | 2 | 2 | 21-Sep | M | 259 | 2 | 19 |
| 2016 | 15-Sep | M | 235 | 2 | 3 | 21-Sep | M | 236 | 2 | 20 |
| 2016 | 15-Sep | M | 248 | 2 | 4 | 21-Sep | M | 245 | 2 | 21 |
| 2016 | 15-Sep | M | 246 | 2 | 5 | 21-Sep | M | 246 | 2 | 27 |
| 2016 | 15-Sep | M | 229 | 2 | 6 | 21-Sep | M | 205 | 2 | 29 |
| 2016 | 15-Sep | M | 252 | 2 | 8 | 21-Sep | M | 210 | | 7 |
| 2016 | 15-Sep | M | 253 | 2 | 9 | 21-Sep | M | 238 | | 23 |
| 2016 | 15-Sep | M | 235 | 2 | 10 | 21-Sep | M | 251 | | 25 |
| | | | | | | **Mean** | **M** | **242** | | |

d) Upper Columbia River River near Radium

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 13-Sep | F | 270 | 2 | 1 | 13-Sep | M | 264 | 2 | 21 |
| 2016 | 13-Sep | F | 250 | 2 | 2 | 13-Sep | M | 256 | 2 | 22 |
| 2016 | 13-Sep | F | 273 | 2 | 3 | 13-Sep | M | 260 | 2 | 23 |
| 2016 | 13-Sep | F | 278 | 2 | 4 | 13-Sep | M | 261 | 2 | 25 |
| 2016 | 13-Sep | F | 282 | 2 | 5 | 13-Sep | M | 264 | 2 | 26 |
| 2016 | 13-Sep | F | 254 | 2 | 7 | 13-Sep | M | 257 | 2 | 27 |
| 2016 | 27-Sep | F | 270 | 2 | 41 | 13-Sep | M | 262 | 2 | 28 |
| 2016 | 27-Sep | F | 274 | 2 | 42 | 27-Sep | M | 254 | 2 | 61 |
| 2016 | 27-Sep | F | 272 | 2 | 43 | 27-Sep | M | 264 | 2 | 62 |
| 2016 | 27-Sep | F | 258 | 2 | 44 | 27-Sep | M | 258 | 2 | 63 |
| 2016 | 27-Sep | F | 257 | 2 | 45 | 27-Sep | M | 269 | 2 | 64 |
| 2016 | 27-Sep | F | 251 | 2 | 46 | 27-Sep | M | 272 | 2 | 66 |
| 2016 | 27-Sep | F | 265 | 2 | 47 | 27-Sep | M | 268 | 2 | 67 |
| 2016 | 27-Sep | F | 262 | 2 | 48 | 27-Sep | M | 255 | 2 | 68 |
| 2016 | 04-Oct | F | 258 | 2 | 82 | 04-Oct | M | 239 | 2 | 101 |
| 2016 | 04-Oct | F | 248 | 2 | 83 | 04-Oct | M | 264 | 2 | 102 |
| 2016 | 04-Oct | F | 229 | 2 | 84 | 04-Oct | M | 265 | 2 | 105 |
| 2016 | 04-Oct | F | 254 | 2 | 85 | 04-Oct | M | 263 | 2 | 106 |
| 2016 | 04-Oct | F | 245 | 2 | 87 | 04-Oct | M | 272 | 2 | 107 |
| | | | | | | 04-Oct | M | 255 | 2 | 108 |
| **Mean** | | **F** | **261** | | | **Mean** | **M** | **261** | | |

e) Standard Creek (Revelstoke Reservoir)

| Year | Date | Sex | FL (mm) | Age | Ot# | Date | Sex | FL (mm) | Age | Ot# |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 28-Sep | F | 313 | | 2 | 28-Sep | M | 314 | 2 | 1 |
| 2016 | 28-Sep | F | 302 | 2 | 3 | 28-Sep | M | 308 | 2 | 7 |
| 2016 | 28-Sep | F | 322 | 2 | 4 | 28-Sep | M | 305 | 2 | 8 |
| 2016 | 28-Sep | F | 311 | 2 | 5 | 28-Sep | M | 305 | 2 | 13 |
| 2016 | 28-Sep | F | 308 | 2 | 9 | 28-Sep | M | 317 | 2 | 14 |
| 2016 | 28-Sep | F | 300 | 2 | 10 | 28-Sep | M | 290 | 2 | 16 |
| 2016 | 28-Sep | F | 297 | 2 | 11 | | | | | |
| 2016 | 28-Sep | F | 309 | 2 | 12 | | | | | |
| 2016 | 28-Sep | F | 313 | 2 | 15 | | | | | |
| 2016 | 28-Sep | F | 342 | 3 | 6 | | | | | |
| **Mean** | | **F** | **312** | | | **Mean** | **M** | **307** | | |

**Appendix 12.** Kokanee spawner mean length by age and proportion by age for a) Kinbasket Reservoir: data from Camp Creek, Luxor Creek, Bush River and Upper Columbia River near Radium, and for b) Revelstoke Reservoir; Standard Creek.

a) Kinbasket Reservoir

| Tributary | Year | Sample Date(s) | Age 2+ spawners | | | Age 3+ spawners | | | % |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | S.D. | n | Mean | S.D. | n | age 3+ |
| 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 |
| | 2015 | Sep 15,21&28 | 237 | 9.3 | 40 | 241 | 10.8 | 17 | 30 |
| | 2016 | Sep 15,22 & 28 | 271 | 14.3 | 10 | 275 | 8.0 | 27 | 73 |
| | Mean | | 242 | | | 265 | | | 51 |
| Wood R | 2016 | Sep 21 | 259 | 6.9 | 9 | 264 | 8.5 | 3 | 25 |
| Bush R | 2013 | Sep 20 &26 | 259 | 8.3 | 34 | | | | 0 |
| | 2014 | Sep 15 & 25 | 234 | 14.1 | 16 | 244 | 18.8 | 6 | 27 |
| | 2015 | Sep 17 | 224 | 7.8 | 19 | 233 | 16.5 | 3 | 14 |
| | 2016 | Sep 15 & 28 | 248 | 11.5 | 51 | 255 | 13.2 | 5 | 9 |
| | Mean | | 241 | | | 244 | | | 12 |
| 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 |
| | 2015 | Sep 17 | 221 | 6.4 | 33 | | | | 0 |
| | 2016 | Sep 15 & 21 | 243 | 11.9 | 46 | 255 | 4 | 3 | 6 |
| | Mean | | 232 | | | 256 | | | 6 |
| Upper Columbia | 2014 | Sep 29 | 234 | 10.1 | 45 | | | 0 | 0 |
| | 2015 | Sep 29 | 226 | 6.1 | 14 | 225 | 1.2 | 2 | 13 |
| | 2016 | Sep 13, 27, Oct 4 | 261 | 10.5 | 39 | | | 0 | 0 |
| | Mean | | 240 | | | 228 | | | 6 |

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)
Note: one age 4+ spawner at 271mm in Camp Creek in 2016 not included in table (same size as 3+)

b) Revelstoke Reservoir

| Tributary | Year | Sample Date(s) | Age 2+ spawners | | | Age 3+ spawners | | | % |
|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | S.D. | n | Mean | S.D. | n | age 3+ |
| 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 | Oct 2 | 330 | 8.3 | 16 | 375 | 5.3 | 5 | 24 |
| | 2015 | Oct 2 | 303 | 18.8 | 18 | 333 | 23.6 | 9 | 33 |
| | 2016 | Sep 28 | 307 | 8.3 | 14 | 342 | | 1 | 7 |
| | Mean | | 291 | | | 319 | | | |

Note: a very small age 3+ spawner contributed to high S.D. And low mean for age 3+ spawners in Revelstoke
This fish (236mm age 3) is assumed to have dropped down from Kinbasket Reservoir.