ENUMERATION AND BIOLOGICAL SAMPLING OF STREAM SPAWNING KOKANEE FROM THE OKANAGAN BASIN'S MAIN LAKES, 2014

Written by:

Jason Webster
Chara Consulting
#17–1801 53 Ave, Vernon

Photo 1. Fish trap at Middle Vernon Creek – at Reimche Road, Winfield.

Prepared for:

Ministry of the Forests, Lands and Natural Resource Operations
102 Industrial Place
Penticton, BC
V2A 7C8

February, 2015

INTRODUCTION

Two critical components of long-term monitoring for the Okanagan valley's large lake fish populations are the enumeration and biological sampling of stream spawning kokanee (O*ncorhynchus nerka*). Information like this is of particular interest to fisheries managers who are constantly attempting to improve fish production in Okanagan Lake and associated tributaries in order to increase kokanee numbers. With the recent increase of the shore spawning component of kokanee in Okanagan Lake, even greater attention is now placed on stream spawners and the hope of their subsequent increase in numbers. Routine monitoring of kokanee escapements has spanned five decades with the first comprehensive enumeration conducted by Northcote et al. (1972). Northcote et al. (1972) established a critical baseline datapoint in 1971 when Mission Creek was enumerated using a fish fence (312,100 fish counted). Many of the other stream population estimates before the 1980s are less reliable because only one or a few counts were made and peak spawning numbers were probably missed. However, it is clear that there were substantially more stream spawners in Okanagan Lake in the 1970s and 1980s than in the past 30 years (Andrusak and Sebastian *in* Andrusak et al. 2000). Enumeration of kokanee is based on visual counts and the accuracy of the counts is subject to variables such as high flows, water clarity and light conditions. In spite of these limitations, the long-term data set provides fisheries management with a valuable index of population trends. This report summarizes the 2014 escapements for Okanagan, Kalamalka, Wood and Skaha Lakes and compares this information with the long-term data set.

METHODS

Enumerations and Water Temperatures

In 2014, twenty-three streams within the Okanagan Lake Drainage Area were enumerated. From the top (north) of the watershed, downstream (south), the selected streams were:

Upper Vernon	Hiram Walker flume to Duck Lake
Middle Vernon	Duck Lake to Wood Lake
Winfield	Water source to mouth
Coldstream	Coldstream Ranch to mouth
Vernon	Kalamalka Lake to Okanagan Lake
Six Mile	Accessible length for kokanee
Nashwhito	Accessible length for kokanee
Whiteman	Accessible length for kokanee
Shorts	Accessible length (falls to mouth) for kokanee
Lambly	Accessible length (falls to mouth) for kokanee
Kelowna (Mill)	City Works Yard to mouth
Mission	East Kelowna Road to mouth
Smith	Accessible length for kokanee
Powers	Glen Canyon falls to mouth
Trepanier	Accessible length for kokanee
Peachland	Hardy falls to mouth
Trout	Accessible length for kokanee
Eneas	Accessible length for kokanee
Robinson	Accessible length for kokanee
Naramata	Accessible length for kokanee
Penticton	Eckhart Road Bridge to mouth
Shingle	Accessible length for kokanee
Okanagan River Channel	Okanagan Lake to Skaha Lake

The contract specifications for the dates and number of counting days for the 2014 enumeration are consistent with enumerations in previous years (see Appendix I). The count dates covered the same peak period and were conducted every three days in most cases, the exception being Mission Creek, where counts were performed every second day. The total number of kokanee utilizing a stream was derived by multiplying the peak count by an expansion factor of 1.5 to reflect spawner residence period and subsequent spawner replacement throughout the entire spawning period (Andrusak and Sebastian, in Ashley et. al. 1999).

Enumerations of all streams, with the exception of the Okanagan River and Middle Vernon Creek, were performed by ground counts. The Okanagan River was enumerated by using a boat travelling downstream in the middle of the river channel. Middle Vernon Creek was enumerated by ground counts but also with the use of a fish fence (at Reimche Road) which intercepted all migrating kokanee in 2014 (Photo 1). Polaroid sunglasses and brimmed hats were worn on all counts to increase visibility and decrease surface glare. Fish tend to move upstream when spooked, thus counting was done while moving downstream, with the sun at the enumerator's back (when possible) - increasing the accuracy of the counts. Whenever possible, counters walked along the stream banks and observed the stream surface from a higher vantage point. Although staying out of the creek bed may have prevented the disturbance of redds, it sometimes could not be avoided. In these situations, foot placement was deliberate. Hand counters (tally whackers) were used to count live and dead kokanee, and chest waders or thigh waders were worn when needed.

Counting methodology varied according to spawner densities. On most occasions, kokanee enumerated this year were counted individually. During some of the counts performed on Mission and Coldstream Creeks, kokanee were counted ten at a time. Kokanee were counted by hundreds during the October 21 enumeration on the Okanagan River due to the high fish densities in 2014.

Water temperature was taken during each count date at or near the mouth of all streams in 2014 using an accurate, aquarium-style thermometer. Since a routine schedule was followed for each stream enumerated, the time of day when taking the temperature at each stream was consistent.

Enumeration Adjustments

For Mission Creek, the escapement estimate has been modified to include the entire accessible length of stream. As indicated in the Methods Section of this report, Mission Creek ground counts only extend upstream to the Mission Creek Spawning Channel intake due to access limitations and time requirements. In order to estimate the number of kokanee utilizing the non-enumerated section of the stream, helicopter surveys have been conducted periodically over the years (most recently in 2006). The helicopter survey indicated that approximately 0.30 (or 30%) of the total fish counted in the downstream section is representative of fish use in the upstream section of Mission Creek (Steve Matthews, per. comm.). This proportion is then used to calculate the number of fish spawning in the upstream section of creek for those years when aerial or ground surveys are not possible.

All 2014 information on Six Mile, Nashwito and Whiteman Creeks was provided by the Okanagan Indian Band. Data from Shingle Creek was collected by the Okanagan Nation Alliance. The data collected from these four creeks was not part of this contract's project specifications but will be used to calculate the total number of Okanagan Lake/Skaha Lake stream spawners in the Results and Discussion section of this report.

Poor viewing/counting conditions due to a high amount of suspended sediments occurred in Mill Creek (Sept 24, and 30) and Trout Creek (Sept 17 and 26). Poor viewing occurred during all counts on Winfield Creek due to extensive plant growth over-top of the stream. On those dates it is possible that a larger number of kokanee (up to 50% more) may have been present than were actually counted. For all other count dates on other streams, visibility was good and counting accuracy was believed to be high.

The 2014 reach by reach enumeration forms within Appendix I of this report have been modified by the contractor and may differ slightly from the historical enumeration forms designed by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). Some of the contractor-designed 2014 forms have been changed in order to give a more detailed breakdown of the enumeration data. However, most of the reach-by-reach enumeration results entered into the MFLNRO database conform to MFLNRO standards. The following points should be noted:

- Numbers entered in the Penticton MFLNRO database under Mission Creek's reach E do not include kokanee counted within the Mission Creek Spawning Channel's settling pond. The number of kokanee within the settling pond is included in reach G's total.
- Numbers entered in the Penticton MFLNRO database for Coldstream Creek reach's A to G were created by the contractor but should be considered as official reaches from this point on.
- The numbers entered in reaches B, C and D (lower, middle and upper weirs) on Powers Creek are based on the newly installed spawning platforms (summer of 2013).

Sampling

A target number of 650 kokanee carcasses were to be collected and sampled from Mission, Peachland, Powers, Penticton, Coldstream and Middle Vernon Creeks as well as the Okanagan River Channel (100 in each except 50 in Coldstream). Carcasses in as good a physical condition as possible were collected as dead pitch or near dead by a hand or dip net. Because of low numbers of kokanee in recent years, otolith collection (which requires killing the fish) from live-captured kokanee to meet target sample numbers was not considered an option (except for in-skein female collection). However, in 2014, some kokanee were live captured for length measurements in Powers and Penticton Creeks to supplement the small number of carcasses available.

All kokanee samples were placed on a portable measuring board to estimate fork length. Gender was determined by examination of external and internal features. Maturity was recorded as spent for both males and females. The only exceptions were if a significant number of eggs (in relation to the size of the female) were counted, the fish had obviously succumbed to a predator before spawning or if the fish was live captured. In all of these cases, maturity was noted as ripe. In the case of all female samples collected from Mission Creek, Powers Creek, Penticton Creek, Middle Vernon Creek, Coldstream Creek and the Okanagan River, any retained eggs were counted individually after an incision of the body wall. Any special comments on individual fish were also recorded if necessary.

A total of 200 otoliths were to be collected from Mission Creek, Peachland Creek, Powers Creek, Penticton Creek, Coldstream Creek, Middle Vernon Creek and the Okanagan River (50 from Mission and Middle Vernon and 25 from the other four streams). An incision was made through the top of the head, bisecting it as accurately as possible. An otolith was then removed from the lower portion of the brain cavity with a pair of tweezers, cleaned with water and placed in a scale sample envelope. The envelope was coded and labelled with length, gender and location and date collected. In most cases only one otolith was collected.

Data collected from carcasses was analysed in order to produce length over time and length distribution charts, fecundity estimates and length/population comparison charts.

Sampling Adjustments

Due to the problem of meeting target sample numbers in past years, carcass sampling was instigated as soon as any dead fish were noticed, not as the peak die off started (as described in the contract agreement).

As part of the 2014 Mission Creek and Channel Egg Deposition Estimate Contract, an additional 100 carcasses were collected from the spawning channel. These samples will be combined with the Mission Creek (only) samples when calculating length frequencies and averages for Mission Creek in this report. An additional 6 live-captured green female kokanee were collected from the Mission Creek spawning channel in 2014. The data from the live-captured fish will be used in calculating the mean length but retained eggs and gender ratio is disregarded.

As part of an ongoing effort to correctly estimate Wood Lake kokanee fecundity, 10 live in-skein (green) females were collected from Middle Vernon Creek in addition to the target of 100 carcasses required in the contract agreement. The green females will be used to determine average length but retained eggs and gender ratio will be disregarded. Also from Middle Vernon Creek, a total of 2214 kokanee were captured from a fish trap. The live captured fish were measured and sexed then released as part of a tagging/viewing project. These fish will be used for mean length calculations and gender ratio.

RESULTS AND DISCUSSION

Enumeration Results

By assessing the 2014 enumeration data, it is estimated that the peak of spawning activity in all creeks occurred within the enumeration dates outlined in the contract specifications.

A complete distribution breakdown, reach by reach, of enumerated kokanee of all creeks was entered into the database at the MFLNRO Office in Penticton.   For similar information refer to A*ppendix 1* of this report.

Okanagan Lake

From a total of 17 tributaries, the estimated total number of kokanee stream spawners for Okanagan Lake in 2014 is 16238 13071 **(**Table 1). The estimated number for each stream is calculated by multiplying the live peak count by a conversion factor of 1.5 (Andrusak and Sebastian, in Ashley et. al. 1999). When using only the eight primary streams to calculate the Okanagan Lake stream escapements, the 2014 escapement estimate total is more than 1500 fish higher than the previous year but still the second lowest return since 1999 Figure 1). The estimated escapement for kokanee spawners in all the streams in 2013 was 13071, in 2012 it was 19494, in 2011 it was 17250, in 2010 it was 26055 and in 2009 it was 18623. The disappointing return in 2014 is the sixth consecutive poor return and perhaps an indicator towards the need for creek spawning habitat enhancement in most streams given the recent success of the shore spawning kokanee of Okanagan Lake. Very few highlights occurred in 2014 but decent spawner numbers were estimated for Equesis, Nashwito and Vernon Creek.

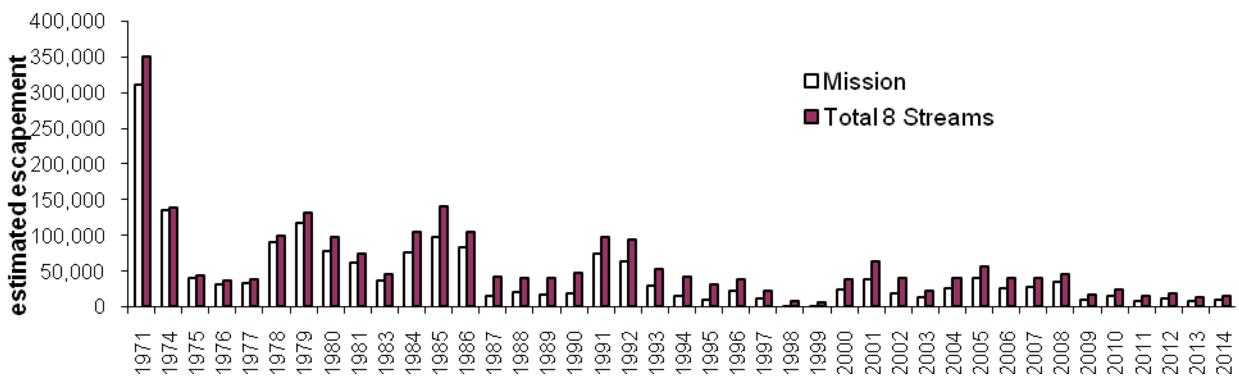

Figure 1. Escapement estimates for Mission Creek and the seven primary Okanagan Lake streams (including Lambly, Naramata, Penticton, Peachland, Trepanier, Powers and Mill (Kelowna) Creeks) where data is available.

MOE fisheries staff anticipated a better escapement of stream spawner numbers in 2014 (Hillary Ward, MLFNRO stock assessment biologist – personal communication). This prediction was based on the parental stock in 2010. It is unknown why the observed increase in shore spawner numbers has not been accompanied by a concurrent increase in creek spawning kokanee, but possible reasons are a lack of good spawning habitat and poor egg incubating conditions (and subsequent low fry production). It should also be noted that a small harvest from recreational fisheries is likely heavily biased towards stream spawners, and has removed 2-4% of the stream spawners in recent years (this would typically add 1000-2000 fish to the streamspawner total over the recent period) (Askey and Johnston 2013). No kokanee fishery data was obtained in 2014, but because kokanee were in relatively low abundance, and the proportion of streamspawners was low (~10%) there would have been very little effort and harvest targeted at kokanee (likely under 200 fish total, Askey and Johnston 2013).

Table 1. Summary of Enumeration results for Okanagan, Skaha, Wood and Kalamalka Lakes - 2013.

OKANAGAN LAKE	**TEMP(C)**	**COUNTS**	**PEAK**	**DATE**	**ADJ TOTAL**
Vernon	12	2	286	4-Oct-14	429
Mission (not inc. Sp Chan)	13	12	3351	20-Sep-14	5027
Mission Spawning Channel		33	3455	19-Sep-14	5183
Powers	13	8	297	23-Sep-14	446
Trepanier	14	8	309	23-Sep-14	464
Peachland	11	8	802	20-Sep-14	1203
Eneas	12	2	0	23-Sep-14	0
Robinson	13	2	11	17-Sep-14	17
Naramata	11	2	71	17-Sep-14	107
Penticton	14	8	770	17-Sep-14	1155
Shorts	12	2	154	18-Sep-14	231
Kelowna (Mill)	13	4	41	7-Oct-14	62
Lambly	13	2	14	18-Sep-14	21
Six Mile (Equesis)	9.5	6	573	3-Oct-14	860
Nashwito	14	6	409	19-Sep-14	614
Whiteman	11.5	6	156	19-Sep-14	234
Trout	13	2	126	17-Sep-14	189
Smith	13	1	0	17-Sep-14	0
Total					**16238**
SKAHA LAKE	**TEMP (C)**	**COUNTS**	**PEAK**	**DATE**	**ADJ TOTAL**
Okanagan River	12	5	20870	21-Oct-14	31305
Shingle Creek	7.5	12	189	28-Oct-14	284
Total					**31589**
WOOD LAKE	**TEMP(C)**	**COUNTS**	**PEAK**	**DATE**	**ADJ TOTAL**
Middle Vernon	n/a	n/a	n/a	n/a	8879
Upper Vernon	9	2	3	22-Oct-14	4
Winfield	9.5	9	126	10-Oct-14	189
Total					**9072**
KALAMALKA LAKE	**TEMP (C)**	**COUNTS**	**PEAK**	**DATE**	**ADJ TOTAL**
Coldstream	10	6	4955	10-Oct-14	7433
Total					**7433**

* Includes estimate of kokanee utilising creek upstream of the East Kelowna Bridge. (See methods section for a description of how this estimate was derived).

<u>Skaha Lake</u>

Enumerations on the Okanagan River Channel and Shingle Creek reveal that the total escapement of creek-spawners from Skaha Lake (and sockeye from Okanagan River-Osoyoos stock) in 2014 is 31589 (Table 1). Compared to returns prior to 2002, the 2013 escapement is exceptional, however, it is clear that a downward (mini) trend is occurring since the record high of 98400 kokanee in 2005 (Figure 2). It should be noted that prolonged warm Okanagan River water temperatures delayed the kokanee run in 2014. The main movement of kokanee occurred very suddenly in 2014 instead of a gradual building of kokanee numbers towards the peak (Appendix I). This run timing scenario has become a re-occurring trend over the past nine years with peak counts being recorded in late October to early November rather than mid October.

An important note for 2014 (along with 2013, 2012 and 2011) is that Sockeye Salmon were present in the OK river channel and were included (as kokanee) in the enumeration estimate. Due to the large number of fish present in the channel; the nature of the enumeration process (moving downstream in a boat); and the closeness in size between a large kokanee and small sockeye, all "red" fish were counted as kokanee in 2014. Project staff did estimate that approximately 3000 fish were (almost certainly) sockeye salmon during the peak count in 2014. This estimate would translate to approximately 4500 salmon after the 1.5 conversion is applied and an adjusted total kokanee escapement of around 27000.

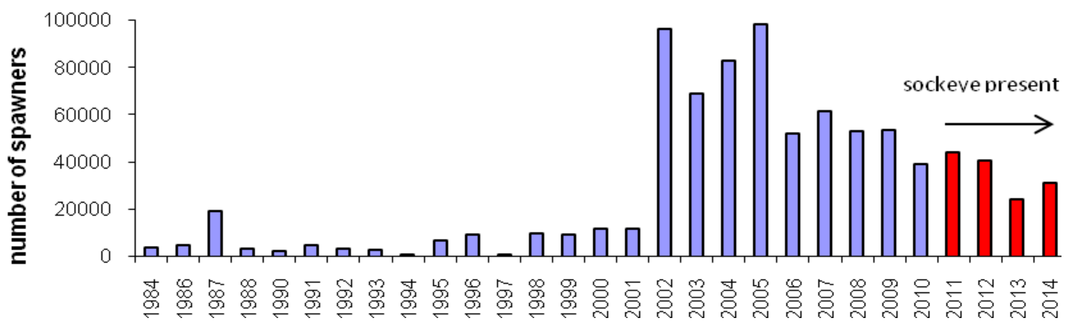

Figure 2. Okanagan River estimated kokanee escapements since 1984.

<u>Kalamalka Lake</u>

In 2014, stream spawners in Kalamalka Lake's only major tributary, Coldstream Creek, totalled 7432 (Table 1). The 2014 estimate is only half of the previous year's estimate, but a bit of an unexpected surprise given the poor parental stock (2010). High egg-to-fry and in-lake survival must have taken place for the past three seasons of returning adult kokanee because a similar high spawner return - compared to parental stock occurred in 2012 and 2013. The last two generations appear to be settling into a dominant 4-year cycle, similar to Shuswap sockeye. Although Coldstream Creek fish more than matched the abundance of their parental stock in 2014, there has clearly been an overall downward trend in Coldstream Creek kokanee escapements since reliable counts began in 1988 (Figure 3).

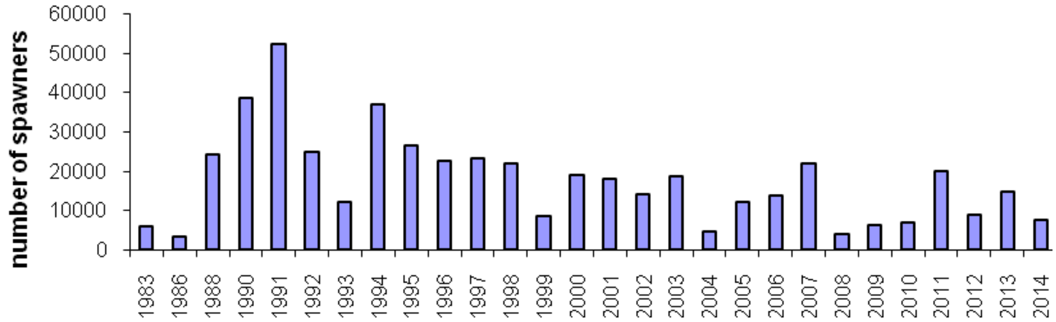

Figure 3. Coldstream Creek estimated kokanee escapements since 1983 (MOE Files).

Wood Lake

Kokanee numbers from Middle and Upper Vernon Creek along with Winfield Creek constitute total creek spawners for Wood Lake. A total estimated run of 5038 spawners was calculated for 2014 using standard survey methods (Table 1). Although the 2014 estimate is considerably higher than the 2013 estimate, it is considerably less than the strong parental stock in 2010 (MFLNRO files) (Fig. 4). Figure 4 also demonstrates the rise-and-fall trend of kokanee escapements in Middle and Upper Vernon Creek since 1995. It is worth noting that unlike other Okanagan main valley lakes Wood Lake is subject to substantial angler harvest and spawner escapement numbers do not represent the numbers of fish produced by the lake (rather just what is left over).

A second Wood Lake estimate (which is primarily composed of Middle Vernon Creek kokanee) was calculated through the use of a fish trap/fence set up in the lower portion of Middle Vernon Creek in 2014. Apart from approximately 300-500 fish that escaped the trap during the first night, the fish fence intercepted every single kokanee that passed above Reimche Road, and is a complete census of the spawning population. The complete census method showed that there were 8879 spawners above Reimche Road, which is substantially higher than the standard visual index method that uses a 1.5 conversion factor to the peak count (leads to estimate of 4845 above Reimche Road in 2014). These data are very informative as they are direct calibrations of the standard visual count index estimates and specifically the 1.5 expansion factor. Interestingly the expansion factor needed to match peak visual count to actual abundance in 2014 is 2.7. This is even greater than the 2.3 expansion factor used previous to the updated estimate from Andrusak and Sebastian (1999) in Ashley et. al. (1999). However, the Middle Vernon Creek spawner fence was also run in 2011 and 2013, and in those years the expansion factor needed to properly adjust the peak visual count was 3.3 and 2.3 respectively. Thus it is clear that annual fluctuations in flow, viewing conditions, and potentially fish abundance can impact the efficiency of visual counts. It appears obvious that the 1.5 expansion is highly conservative, and should likely be adjusted upwards.

It is also important to note that temperature and oxygen conditions within Wood Lake were extreme in 2011. There were some reports of fish mortalities (dead kokanee infrequently observed on surface) by anglers during summer creel, however, the key information came from routine temperature –oxygen profiles by Environmental

Protection. Their data showed that in September the water column was anoxic below 8-10m, and above that depth water temperature exceeded 20C. Low adult kokanee numbers were suspected prior to the 2012, 2013 and 2014 spawning season due to several reports of poor fishing and a large drop in CPUE and angler effort in 2011to 2013 (Paul Askey, former MLFNRO stock assessment biologist – personal communication). Acoustic trawl data suggests that all age classes were impacted in 2011 and that returns will be very low until 2014. A 45 day kokanee harvest fishing regulation was placed on Wood Lake in 2014 in order to prevent over harvesting of an already depleted stock. It is expected that the upcoming 2015 season will show an increase in angler catch success and should more accurately represent a normal year's spawner escapement.

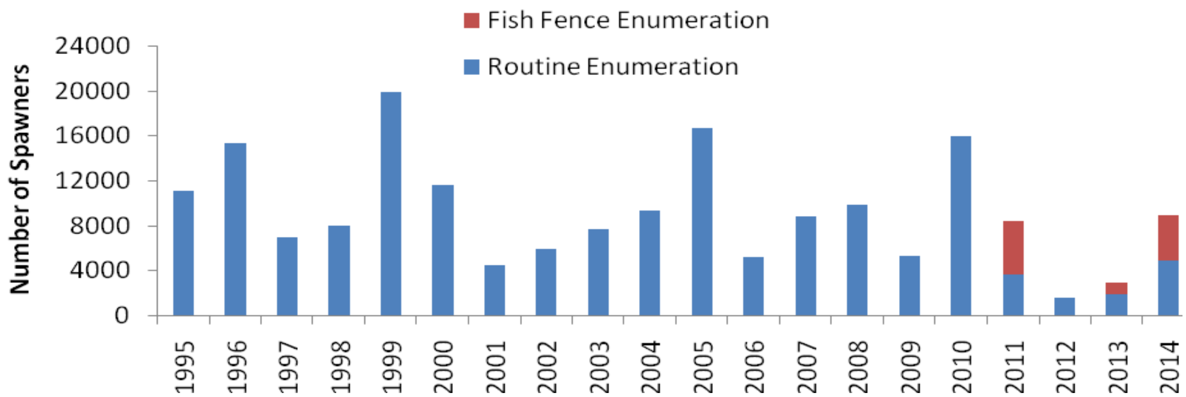

Figure 4. Middle and Upper Vernon Creek estimated kokanee escapements since 1995 (MOE Files).

Beaver dams and low water conditions were a factor in limiting upstream migration within Middle Vernon Creek in 2014 until approximately October 14. Around that time kokanee migration was possible through Duck Lake and into Upper Vernon Creek where only 2 fish were enumerated in 2014. In Winfield Creek, a kokanee escapement of only 189 was estimated. This is likely a conservative estimate, because of poor viewing conditions due to tall, overhanging grasses and other vegetation.

Biological Sampling

In 2014, the target number of carcasses was obtained from the Okanagan River Channel along with Mission, Coldstream and Middle Vernon Creeks. A total of 72, 10 and 0 carcasses were collected from Peachland Creek, Penticton Creek and Powers Creek respectively. Low carcass numbers (especially ones in decent shape for biosampling) were available to project staff in 2014 mainly due to low live kokanee numbers and high predation. In order to continue the valuable long-term data set of fish lengths, a total of 30 and 25 kokanee were live captured from Powers and Penticton Creeks respectively. Otoliths were successfully removed from all of the required carcasses in 2014.

It should be noted that all carcass sampling performed should be considered as non-random sampling, due to the fact that only carcasses deemed to be in good shape were collected. However, all of the carcasses collected from the tributary streams, with the exception of Penticton Creek, are reasonably representative of the actual size/gender distribution. Due to the fact that most of the accessible spawning portion of Penticton Creek is a concrete flume, the majority of carcasses were collected from the section of the creek close to the mouth, where flows slowed considerably. It was noted that the larger/older/male carcasses tended to get caught up in the rocks more easily than the younger/smaller/female ones at this location. In the case of this creek, the mean lengths of both male and female carcasses are certainly larger than the actual mean and the male bias is unnatural.

All data sheets were filled out and submitted at the end of the contract period. All data taken from kokanee samples can be viewed at the Ministry of Forests, Lands and Natural Resource Operation's database at Penticton or in Appendix II of this report. Otoliths were also delivered to the MFLNRO office at Penticton after the final enumeration day. Results for the otolith-aging were unavailable at the time of writing this report.

Okanagan Lake Kokanee Lengths

The mean lengths of the 2014 Okanagan Lake stream spawning kokanee show a slight increase from the previous year in Mission, Peachland and Powers Creeks and a large decrease in Penticton Creek. The decrease in size at Penticton Creek is likely a result of the live-captured kokanee lengths that supplemented the small carcass sample size (Appendix 2). These live-captured kokanee do not show the larger-than-actual fish bias that happens during the routine carcass collection process. The 2014 mean kokanee lengths seem to fit into the overall downward trend in kokanee lengths since 1998 when stream/shore populations were at an all-time low and lengths at an all-time high (Figures 5 and 6). In the majority of fish bearing systems, most scientists agree that there is a direct correlation between fish population and fish size (known as density dependence). For Okanagan Lake, it would seem reasonable to assume that the downward trend of stream spawning kokanee lengths

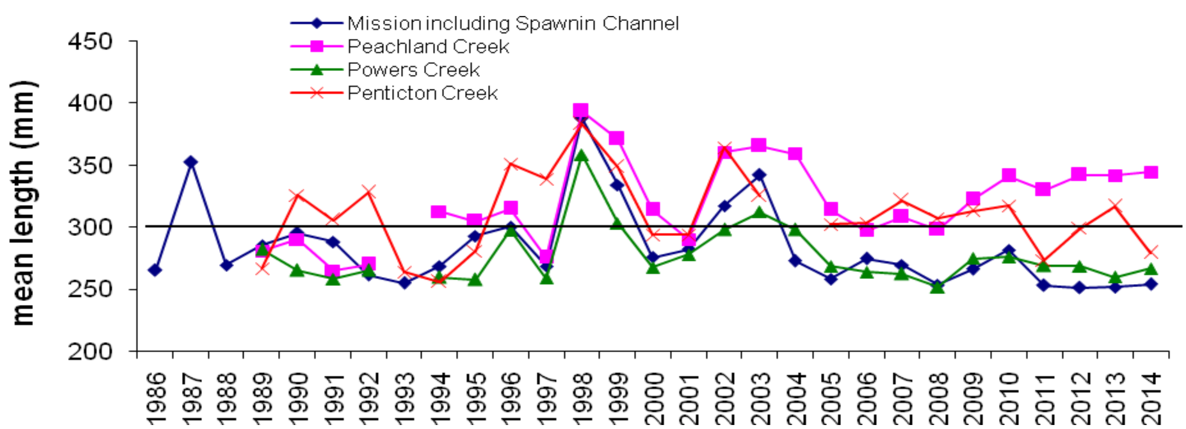

Figure 5. Mean size (mm) of kokanee spawners from Mission, Peachland, Powers and Penticton Creeks since 1986 (MFLNRO Files).

is due to the higher densities of kokanee (shore spawners in particular) in the lake. For example, over the past ten years there has been a considerable increase in overall spawner numbers and a decrease in Mission Creek spawner lengths (Figure 6). The same correlation exists for the time from 1997 to 1999, when overall kokanee numbers were the lowest they had been on record and the mean length of Mission Creek kokanee reached all-time highs. There was a drop in spawning kokanee numbers in 2014, 2013 and 2012 but a corresponding size increase may not be clearly visible until 2015 or 2016.

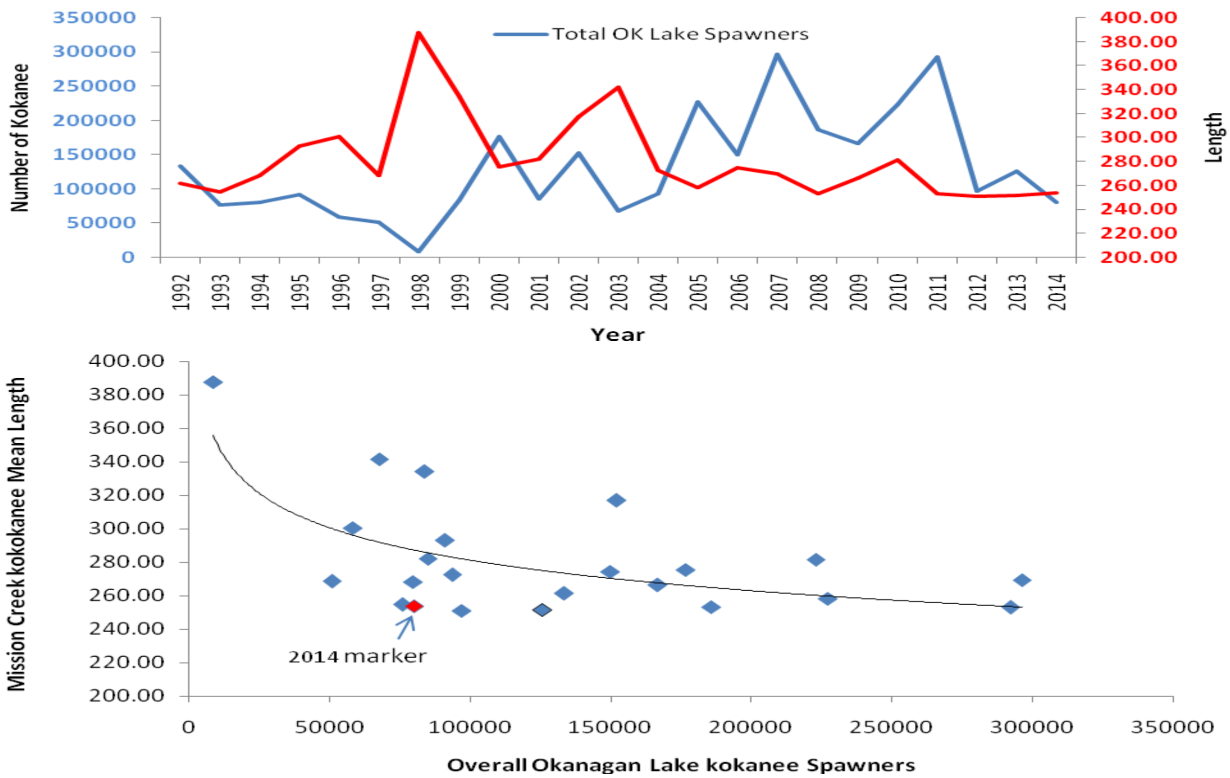

Figure 6. Mean size (mm) of Mission Creek kokanee spawners compared to overall Okanagan Lake spawner numbers (stream and shore) for years 1992 to 2014 (MFNRO Files).

There is a considerable difference between the mean lengths in both the males and females within the four Okanagan Lake streams where carcasses were collected (Table 2) (Figure 7) (Appendix II). Females in Peachland Creek averaged 330 mm, 79 mm longer than the average female length in Mission Creek (251 mm). Males in Peachland Creek (355 mm) were 98 mm longer on average than the males in Mission Creek (257 mm). The smallest and largest Okanagan Lake kokanee carcasses measured in 2014 were 204mm (Penticton Creek) and 540 mm (Peachland Creek) respectively. Figure 7 shows that the only dominant length modes in 2014 were in Powers, Penticton and Mission Creeks (and Penticton Creek to a lesser extent) at around 240 to 280 mm. A less dominant length mode is apparent around 380 to 400 mm in the Peachland Creek histogram. Because results of otolith ageing were not available at the time of writing this report, we will assume that the majority of kokanee within the 240 mm to 280 mm mode were age 3+.

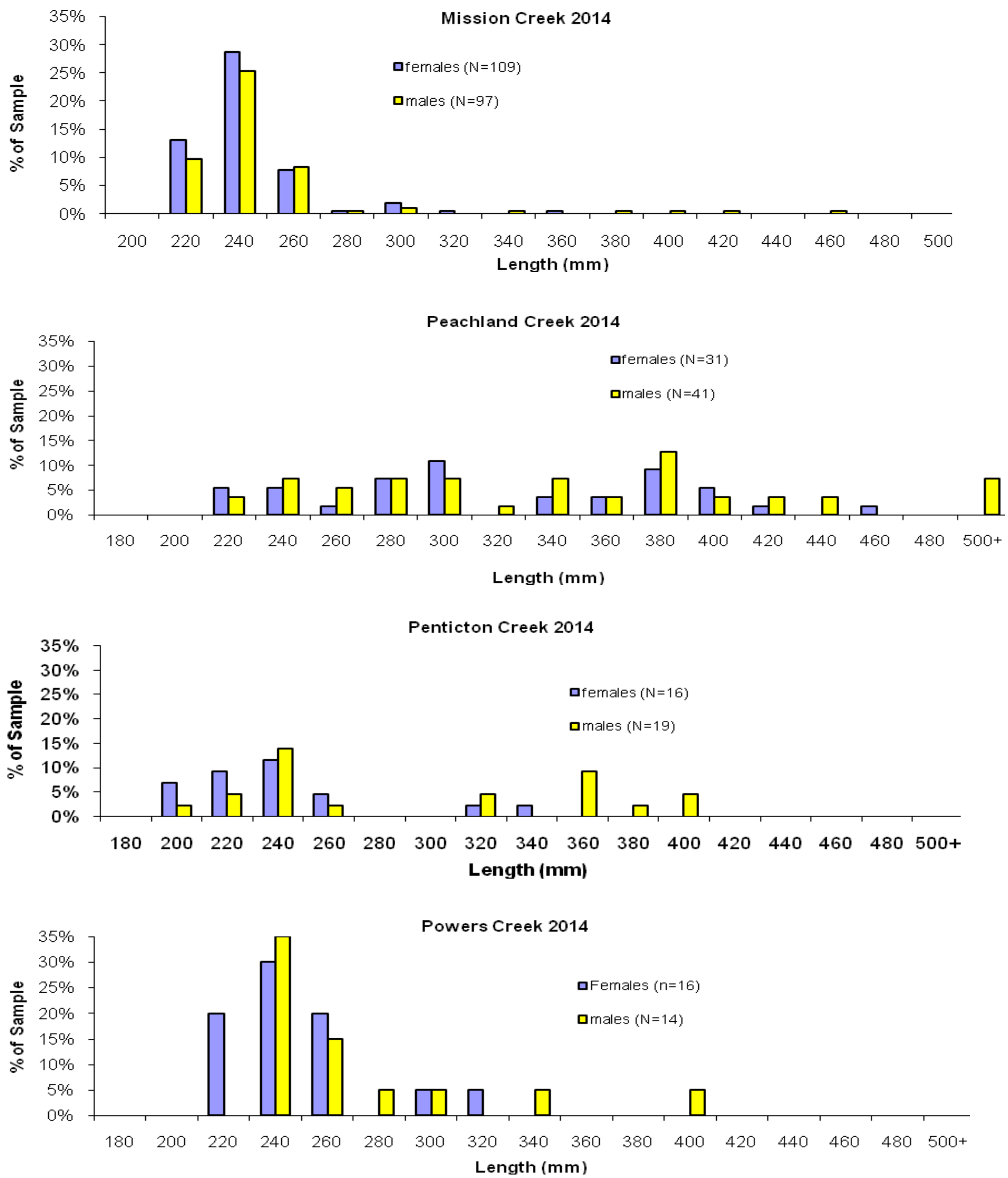

Figure 7. Length distributions of year 2014 kokanee bio-samples from Powers, Penticton, Peachland and Mission Creeks.

Kokanee greater than 300 mm are likely age 4+ fish. It is possible that the few kokanee sampled in 2014 larger than 400 mm may be age 5+ or even age 6+ fish. Although it is generally accepted that kokanee ages and length modes are correlated, otolith analysis from past years kokanee samples has been inconclusive.

Skaha Lake Kokanee Lengths

In 2014, kokanee samples collected from Skaha Lake's main tributary, the Okanagan River Channel show a much larger mean length than most of the previous years. The larger mean length is likely due to the fact that anadromous sockeye were present in the channel in 2014 and bio-sampling included several (suspected) of these sockeye. Another contributing factor to the increased size (compared to years 2002 to 2007) may be the noticeable decline in kokanee (and sockeye) numbers since 2005 (Figure 2). The year 2014 mean kokanee (and sockeye) length was 306.1 mm, around 25 mm greater than the 2013 mean (Figure 9). There were a total of 37 samples collected in 2014 that were greater than 300mm and 22 of the 37 were greater than 400 mm (probably sockeye). The kokanee samples from 2014 show a single dominant length mode for both sexes around 220-280 mm (Figure 8).

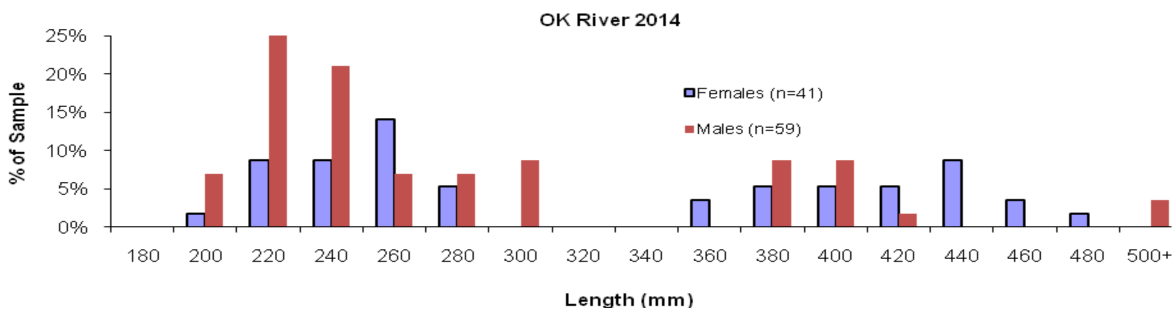

Figure 8. Length distribution of year 2014 kokanee samples – Okanagan River Channel

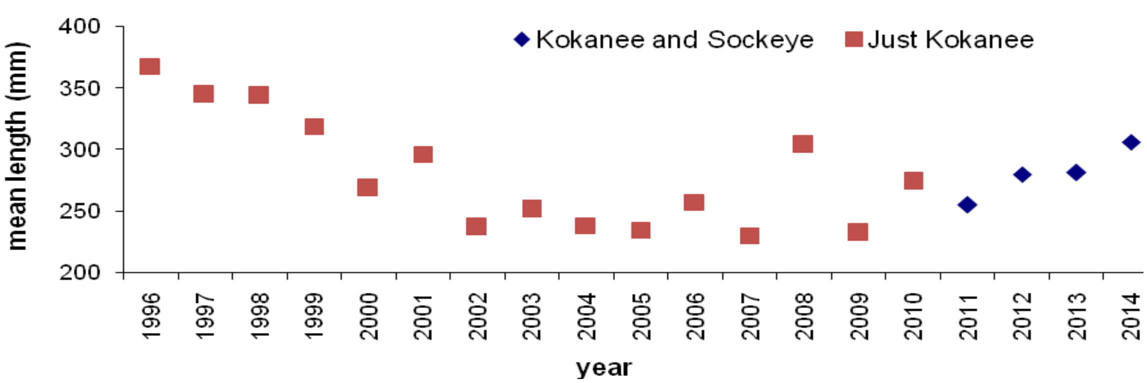

Figure 9. Mean length (mm) of kokanee spawners from the OK River Channel since 1996 (MFNRO Files). *It is important to note that the biosampling was not conducted by contractor staff in 2008 as in past and future years (since 1997). Therefore, in 2008, it is possible that some unknown bias may have been introduced into the sampling regime. Members from the Okanagan Nation Alliance also collected fish data in 2008 and came up with a mean spawner length of 250 mm. Sockeye are present in the 2011to2014 bio-sample so kokanee lengths are positively skewed.*

Kalamalka Lake Kokanee Lengths

For Kalamalka Lake's kokanee spawning tributary, Coldstream Creek, the mean length of all fish was 295.4 mm. Males averaged 288.1 mm, 7 mm longer than the female's average length of 281.5 mm. Coldstream Creek kokanee ranged from 232 mm to 520 mm with one dominant length mode around 260 to 300 mm (Figure 10). The 2014 Coldstream Creek mean kokanee length is on the low side compared to lengths since

2008 but still considerably greater than mean lengths from the 90s and early 2000s. (Figure 11). The impressive average size was no surprise considering the number of large fish reports from anglers during the summer on 2014. A higher proportion of large fish has been observed since 2008 but the possible start of a slight downward trend in quality sized fish is apparent within the 2014 biosample (Table 2).

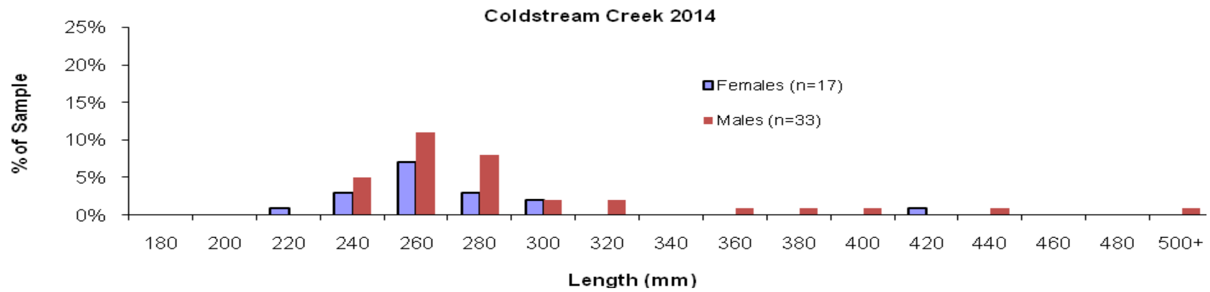

Figure 10. Length distribution of year 2014 kokanee samples – Coldstream Creek.

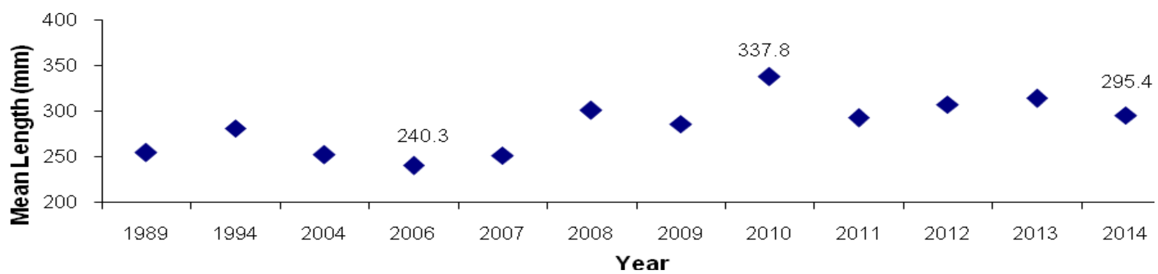

Figure 11. Mean size (mm) of kokanee spawners from Coldstream Creek for years 1989, 1994, 2004 and 2006 to 2014.

Table 2. Presence of quality and trophy sized kokanee within Coldstream Creek run (proportion of bio-sampled carcasses) for years with available data.

Category	Size (cm)	1994	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014
Typical	<30	0.74	0.79	0.92	0.86	0.47	0.63	0.32	0.76	0.70	0.56	0.76
Quality	30-40	0.16	0.20	0.08	0.12	0.49	0.33	0.56	0.14	0.22	0.31	0.16
Exceptional	40-50	0.10	0.01		0.02	0.05	0.02	0.08	0.08	0.04	0.10	0.06
Trophy	>50						0.02	0.04	0.02	0.04	0.03	0.02

<u>Wood Lake Kokanee Lengths</u>

For Wood Lake's main kokanee spawning tributary, Middle Vernon Creek, a total of 100 kokanee carcasses were sampled. In addition to the carcasses, ten in-skein females were collected and length and gender was recorded from 2215 live-trapped fish before they were released. The mean length of all fish was 341.46 mm with females and males being almost exactly the same size. The mean kokanee length in 2014 is the smallest since reliable data began in 2006 (MFLNRO Files) (Figure 13). Interestingly, the length range of Middle Vernon Creek (Wood Lake) Kokanee is usually around 100 mm, much smaller than Okanagan and Kalamalka Lake kokanee which each possessed length ranges of well over 250 mm. However, over the past three years and 2014 in particular, a few smaller fish (>300 mm) and larger fish (<500mm) were measured and a more comparable range (to Okanagan and Kalamalka Lake) was calculated (Figs. 7 and 10).

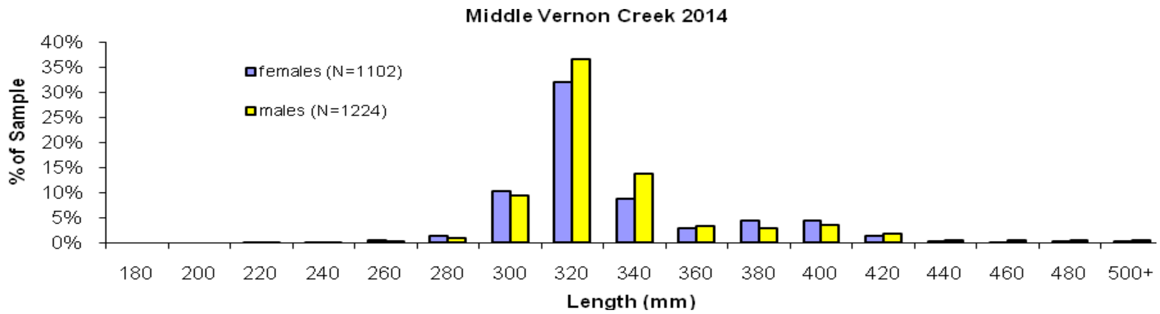

Figure 12. Length distribution of year 2014 kokanee samples – Middle Vernon Creek.

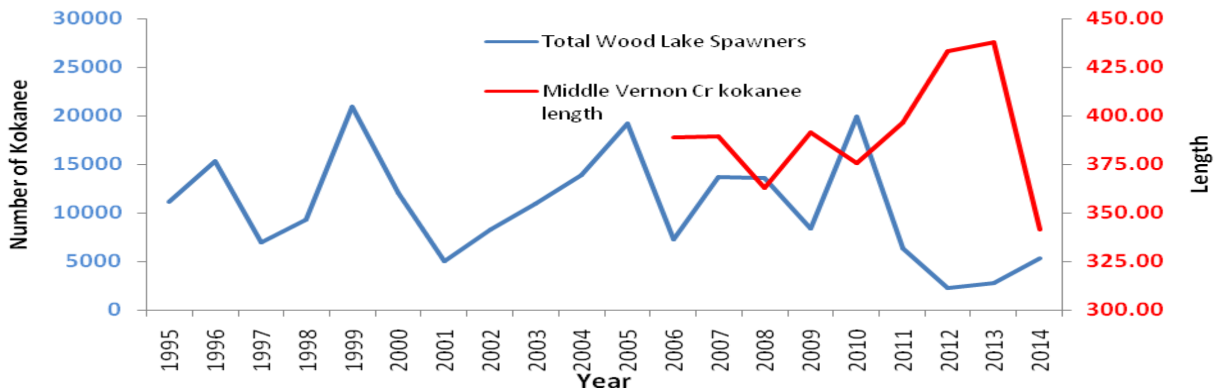

Figure 13. Mean size (mm) of Middle Vernon Creek kokanee spawners compared to overall Wood Lake spawner numbers (stream and shore) for years 1995 to 2014 – using estimates from standard counting methodology not fish trap estimates (MFNRO Files).

The 2014 Middle Vernon Creek kokanee have only one major length mode between 320 and 360 mm (Figure 12) and were the smallest on average since biological sampling has been performed. The drop in the 2014 mean length compared to previous years was predicted but such a drastic drop was a bit surprising and has left local fisheries managers suspecting a few likely hypotheses for it happening: 1) *Hillary – do you care to write a brief paragraph about the in-lake kokanee population estimates from hydro-acoustics this past year – did they show a large number of fish upcoming? and a possible explanation to the smaller sized fish we got this year ?* and or 2) the age 2+ fish matured early during the 2014 year and those fish are what brought the average size down. The high bias towards males (jacks) in 2014 may further prove this theory. Unfortunately, at the time of submitting this report the age data from otoliths taken in 2014 was not available to confirm the suspected presence of early maturing fish.

A total of 6 male and 3 female kokanee were greater than 500 mm in 2014. Even though the 500 mm plus kokanee represent a very small proportion of the total run, these impressive fish have existed only during the past three years since recent/reliable length data began in 2006. It should be noted that MFLNRO files suggest a few angler-caught specimens from 20 to 30 years ago did surpass 500 mm. The low in-lake kokanee population over the past two to three years has resulted in some increased growth rates on maturing fish. With the exception being this year (the unusual and unexpected small mean length) Figure 13 clearly shows the relation of low fish numbers and increased fish size that occurred in Wood Lake since 2011.

<u>Fecundity Estimates/Egg Retention All Lakes</u>

In 2012, in-skein female fecundity data collected from Mission Creek since 2001 was compiled and analysed in order to calculate an updated fecundity formula. The formula was not updated this year or in 2013 but will likely be updated in 2015 with the green females collected from those three years. The old (2012) formula will be used to estimate egg deposition for all Okanagan, Skaha and Kalamalka Lake streams. A power function is typically used for length-fecundity relationships, and data is log transformed to allow for simple linear regression fitting. The fecundity formula derived from the last 11 years of data is:

$$Eggs = 0.0003 * Fork\ Length^{2.569}$$

The explained variance (R^2) was 0.7995, and N = 145 (Figure 14).

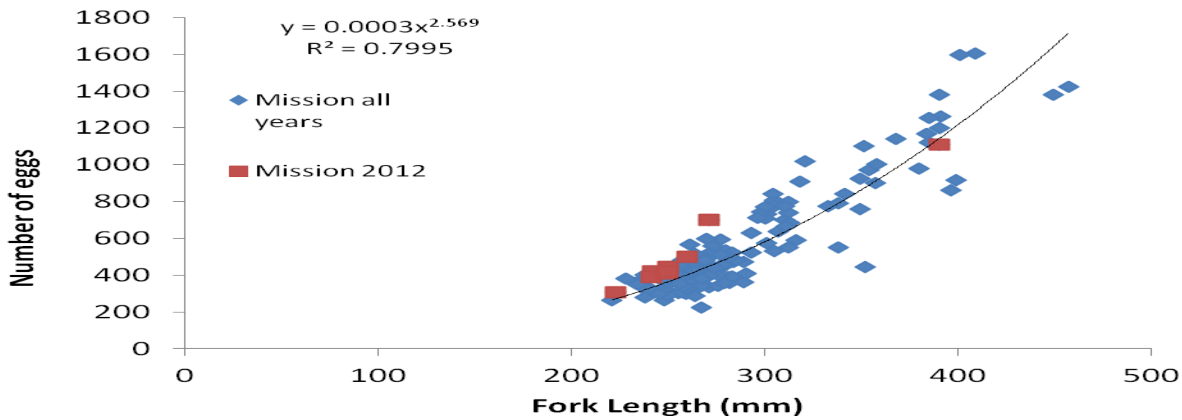

Figure 14. Year 2012 Mission Creek fecundity curve estimate based on a total of 145 green females collected from 2001 to 2012. Best fit formula: *Eggs=0.0003*FL^2.569.*

McGurk (2000) showed that there is general consistency among kokanee populations in the exponent parameter, but variation among intercepts (their formulation was ln(a)). In the case of Mission Creek, the exponent (2.569) is average compared to other kokanee populations, and ln(0.0003) = -8.52 was slightly below average compared to other populations in Table 3 of McGurk (2000).

This relationship indicates that kokanee of the Okanagan main valley are about average fecundity per size when compared the larger sample of populations in McGurk (2000) (or slightly lower than).

An updated fecundity formula was calculated for Wood Lake in 2014 due to a number of in-skein females over recent years (15%) who exhibited egg numbers that were notably below the traditional trend. In 2014 however, all egg numbers fit into the traditional trend, which hopefully will reoccur over the upcoming years. There was a small indication of the poor egg count in 2008-2010 when 3-10% of fish were observed to have low fecundity, but in recent years the prevalence seems to be more common (30-40%) although sample size is small (Table 2). The skeins of these females were fully developed but noticeably smaller than the majority. One could compare them to a mature bush with very few berries. It is possible that some unknown in-lake conditions caused these females to stress during maturation, resulting in the low egg numbers. Variance in skein size/egg count is clearly shown in Photo 2 (taken in 2012) where a 470 mm Middle Vernon Creek female has nearly 2000 fewer eggs than a smaller (450 mm) female. It should be noted that egg size may also dictate low fecundity to an extent. For example, over the past few years a handful of females have had normal sized skeins with low egg counts simply due to the large egg size.

Table 2. Total number of Middle Vernon Creek in-skein females examined compared to the number with low egg counts after skeins were boiled and counted individually.

Year	N	Number underdeveloped	Proportion underdeveloped
2008	20	0	0.00
2009	20	2	0.10
2010	36	1	0.03
2011	39	13	0.33
2012	7	2	0.29
2013	10	3	0.30
2014	10	0	0.00
Total	**142**	**21**	**0.15**

Photo 2. From the 2012 biosamples - Middle Vernon Creek Female sample #1, 490 mm long, skein egg count = 381 compared to sample #2, 450 mm long skein egg count = 2341.

The updated fecundity curve estimate for 2014 (Paul Askey, unpublished data) that takes the low egg count females into consideration is plotted in Figure 15 or can be explained with the formula:

*Eggs = (1-.prop underdeveloped)*healthy intercept*ForkLength^2.6413+ prop underdeveloped * underdeveloped intercept* Fork Length ^2.6413)*

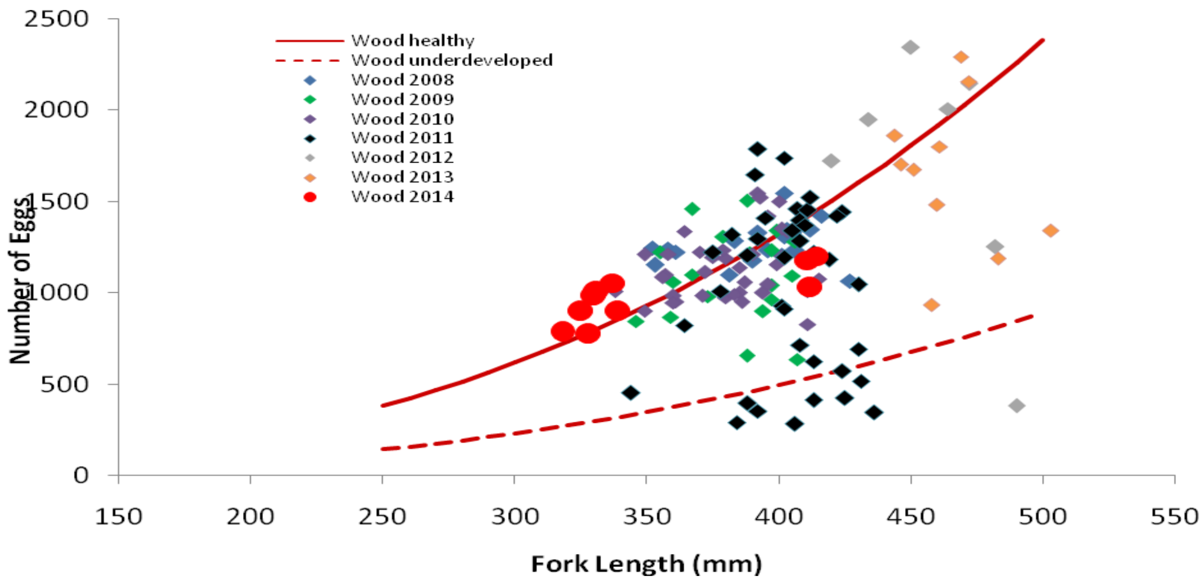

Figure 15. New Wood Lake fecundity curve estimate based on a total of 142 green females collected from 2008 to 2014. Best fit formula: *Eggs = (1-.prop underdeveloped) *healthy intercept*ForkLength^2.6413+prop underdeveloped * underdeveloped intercept* Fork Length ^2.6413).*

Using the new Wood Lake fecundity formula, the estimated average fecundity for Wood Lake females in 2014 is 732 eggs and egg retention is 1.0%. The much smaller female mean length in 2014 translates to half the number of eggs per female as was estimated in 2013 (1467 eggs). Despite the reduced eggs per female estimate, around 1675000 (how do we take into account the fish that got through the hole in the trap the first night ?) eggs were deposited in Middle Vernon Creek in 2014, a low number for Wood Lake standards (Table 3).

Fecundity and egg deposition estimates presented in Table 3 show a total stream spawner egg deposition of 3231395 from four of seventeen Okanagan Lake tributaries enumerated. By comparison, with reference to Skaha Lake and Kalamalka Lake, an estimated 13027252 and 1556632 eggs respectively (using fecundity estimates based on Mission Creek females) were deposited in the Okanagan River Channel and Coldstream Creek in 2014.

For Okanagan Lake tributaries in 2014, egg retention was lowest in Penticton Creek (1.4%) and highest in Mission Creek (3.9%) (Table 3). It should be noted that the female carcass sample was very low in Penticton Creek (N=2) and only live captured (and released) kokanee were sampled in Powers Creek so no egg retention estimate was calculated. When comparing this year's egg retention estimates to past data (MFNRO Files), egg retention was considerably below normal in 2014 – likely due to ideal water temperatures during the spawning period. A total of only one female and two male kokanee pre-spawn mortalities were collected and sampled from Okanagan Lake streams in 2014.

The egg retention estimate (using the Mission Creek fecundity formula) from females sampled from the Okanagan River Channel and Coldstream Creek was only 1.9% and 0.5% respectively (Table 3).

Table 3. Summary of 2014 Kokanee Samples Collected – Okanagan, Skaha, Wood and Kalamalka Lakes.

OKANAGAN LAKE Creek	No.	Male	Fem	Male Mean Length (mm)	Female Mean Length (mm)	Egg Retent (%)	Mean Fecund minus retention	Total Est. Females	Estimated egg depo in 2014
Penticton	35	19	16	302.47	251.56	1.4	457	528	241296
S.E.				16.48	10.13				
Powers	30	14	16	278.79	255.5	?	~460	238	109480
S.E.				12.6	6.93				
Peachland	72	41	31	354.95	330	2.5	936	518	484848
S.E.				13.1	12.29				
Mission	206	97	109 (103)	257.03	251.26	3.9	429	2589	1110681
S.E.				3.95	2.04				
Mission Chan.						2.5	435	2954	1284990
Totals									**3231295**
SKAHA LAKE				Male	Female		Mean		

Creek	No.	Male	Fem	Mean Length (mm)	Mean Length (mm)	Egg Retent (%)	Fecund minus retention	Total Estimated Females	Estimated egg depo in 2014
OK River	100	59	41	288.14	332.1	1.9	1015	12835	13027525
S.E.				10.27	14.23				
Totals	100	59	41						**13027525**
WOOD LAKE Creek	No.	Male	Fem	Male Mean Length (mm)	Female Mean Length (mm)	Egg Retent (%)	Mean Fecund minus retention	Total Estimated Females	Estimated egg depo in 2014
Mid and Upper Vernon	2325	1224	1101 (1091)	342.4	341.1	1.02	725	2313	1676925
SE				1.03	1.04				
Totals	2325	1224	1101 (1091)						**1676925**
KALAMALKA LAKE Creek	No.	Male	Fem	Male Mean Length (mm)	Female Mean Length (mm)	Egg Retent (%)	Mean Fecund minus retention	Total Estimated Females	Estimated egg depo in 2014
Coldstream	50	33	17	302.61	281.53	0.5	616	2527	1556632
SE				10.61	10.9				
Totals	50	33	17						**1556632**

*Number in parentheses represents total number of females not including live captured green females collected for fecundity estimates.

Stream Flow and Obstruction Observations

Adequate or above average stream flows occurred during the 2014 spawning period with the exception of Middle Vernon Creek. Middle Vernon Creek has a history of poor flows and beaver dam issues during the autumn spawning period and 2014 was no exception. The low flows combined with beaver dams directly downstream of Duck Lake prevented migration further than the Beaver Lake Road crossing until around October 14. At that time the beaver dams were removed and the flow control structure at Duck Lake provided enough water to allow kokanee migration into Duck Lake and Upper Vernon Creek.

Within the canyon section in Powers Creek (starts approximately 100 meters upstream of the fish ladder), a series of natural occurring events since 2006 have limited upstream migration of spawning kokanee. In 2007, it was noticed that the rock slide/slump had gotten worse since it was first observed in 2006. In 2007 it was a complete barrier to migrating kokanee. In 2009 through 2014 flows made their way through the slide and kokanee migration beyond the barrier was once again possible. There is approximately 1km of traditionally (kokanee) accessible stream above the rock slide that extends as far as the Glen canyon falls and unlike in most previous years, a good proportion of the kokanee estimate (20%) were viewed using it.

In 2014, the beaver dams immediately downstream of the Fulton Road crossing on Vernon Creek did not stop upstream kokanee migration. The beaver dams, which have been present for many years, are a barrier to migration most of the time. In 2014 however, they seemed unmaintained and migration through them was possible.

Construction and Sediment Sources

Construction was noted around some of the enumerated streams in 2014 but no damage to the streams was noted.

As per most previous years, a high sediment load was observed within the water of Trout Creek during the 2014 enumeration dates. The source of the sediment loading in Trout Creek is believed to be a perpetually eroding bank in the canyon section of the creek.

High turbidity occurred in Eneas Creek and Mill Creek in 2014. It is suspected that city waterline flushing (or something to that effect) was the cause of the turbidity rather than storm drain run-off because the days prior to the enumerations were dry.

Fish Presence in Enhanced Sections

- The gravel within the Mission Creek Spawning Channel appeared to be in excellent condition. Approximately 51% of the Mission Creek kokanee (including upstream estimate) used the spawning channel in 2014 (Table 1). Comparatively, around 14% to 51% of the Mission Creek peak count used the spawning channel from 2005 to 2013 (Webster 2014).

- Very few kokanee (approximately 1% of run) were observed using the old enhanced section in Coldstream Creek. Although the weirs and gravel within the enhanced section appear to be in good shape, the kokanee were simply using the large amount of quality spawning habitat available downstream instead. In August of 2014, eight new spawning weirs were installed immediately upstream of the Mclounie road crossing (reach C). Approximately 700 kokanee or 15% of the run during the peak count were using the new weirs in 2014.

- As the kokanee distribution in Powers Creek shows (Appendix I), about 17% of the kokanee enumerated were found using the two new and one old enhancement platform (weirs) and fish ladder pool during the peak count.

- Approximately 10% of the kokanee enumerated during the peak count in Penticton Creek were viewed in the fish ladders or large enhancement weirs.

- Although, there was no formal tally of kokanee using the enhancement weirs in Kelowna (Mill) Creek, it is estimated that nearly 20% of the fish enumerated in 2014 were viewed on or near the enhanced areas. By comparison, approximately 50% of the peak count in 2005 was viewed using the enhancement weirs (installed in 2001) – which at that time were maintained and hydraulically flushed each year since 2001 by the City of Kelowna (Webster, 2005).

- In 2014, approximately 11% of the kokanee/sockeye enumerated during the peak count in the Okanagan River Channel was viewed in the Reach I (enhancement gravel).

Photo 3. Newly installed spawning platforms directly upstream of the Mcloonie Road crossing at Coldstream Creek.

Other Notes

- Predators like mergansers, blue herons, and loons were seen in low numbers during the 2014 enumeration. However, egg-eating ducks were very apparent in 2014.

RECOMMENDATIONS

Methods

The timing of counts should be reviewed with MFNRO for Peachland Creek – potentially earlier to ensure the peak is not missed and representative biological samples are obtained from the early run of fish.

MFLNRO should continue to gather information on sightability during visual counts, so that a better (likely higher) expansion factor can be used. All spawner fence data: Peachland Creek, Middle Vernon Creek (3 years) indicate that 1.5 is a gross underestimate.

Habitat

To ensure adequate flows (or at least to increase flows) within Middle Vernon Creek, sandbags should be removed from the non-permanent weir placed at the outlet of Duck Lake at the beginning of the spawning season (as it was done in 2013 and 2014). Alternately, some type of underground pipe could be installed from Duck Lake to an area downstream of where the beavers annually back up the "natural" flows exiting Duck Lake.

The condition of the Powers Creek weirs in 2012 had reduced significantly from previous years. Two of the three weirs were completely undermined and nearly dislodged, providing little to zero enhanced spawning conditions. The weirs were replaced in 2013 (Photo 3) but should be maintained yearly. An additional weir downstream of the lowest weir should be built to optimize the excellent spawning habitat that exists at that location.

In the summer of 2013 and 2014 several of the spawning platform log weirs at Peachland Creek were upgraded and additional gravel was added to the bed of the creek. A number of other log weirs within the creek are in need of similar maintenance and upkeep. It is recommended that as many of the log weirs as possible be upgraded before the 2015 spawning season in order to improve spawning success and egg-to-fry survival.

The accessible spawning portion of Trepanier Creek is approximately 1.5 km. A series of small falls over boulders and steep grades limits upstream progress by kokanee. On a yearly basis, approximately 60-70% of the spawning run occurs within the lower 250m of the creek. During years when kokanee numbers are high, crowding is an issue in this area and it is recommended that enhancement work (weirs and spawning gravel) be implemented in order to reduce competition between kokanee for the limited areas of gravel between the rocks.

It is strongly recommended that cleaning (hydraulic flushing) of the enhancement platforms within Kelowna (Mill) Creek be performed in 2015 and in future years. Due to extremely high sedimentation of the bed material within Kelowna Creek, it is believed that the yearly cleaning of the enhancement platforms and other key spawning areas greatly reduces kokanee stress during spawning and increases egg to fry survival.

In the summer of 2011, efforts were made to prevent kokanee spawners from entering the irrigation ditch that runs parallel to Mission Creek for approximately 3.5 kilometers. The water in this irrigation ditch is diverted from Mission Creek approximately 100 meters upstream of the spawning channel intake and empties back into the main creek immediately downstream of the K.L.O. Road crossing. In 2014, there were zero kokanee viewed in this ditch which is intentionally emptied in December on a yearly basis. Considering the value of every individual kokanee, it is recommended that the barrier installed at the entrance and exit of the ditch be maintained so kokanee continue to avoid using the ditch during the spawning season.

The dismantling of the beaver dams immediately downstream of the Fulton Road crossing on Vernon Creek should be performed each year (if needed) to ensure kokanee access to upper reaches as far as Kalamalka Lake.

ACKNOWLEDGMENTS

A special thanks to Edward Schratter and Cathy Macpherson for their substantial involvement in this contract. Thanks to Keith Louis and the Okanagan Indian Band for providing escapement information on Six Mile, Nashwito and Whiteman Creeks. And a final thanks to Ryan Benson and Richard Bussanich of the Okanagan Nation Alliance for their data on Shingle Creek kokanee escapements.

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APPENDIX I – Enumeration Forms

APPENDIX II – Fish Samples