Slocan River Bull Trout Spawning Assessment – 2018

FWCP Study No. COL-F19-F-2733

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EXECUTIVE SUMMARY

This report summarizes the results of the pilot project to assess and identify key Bull Trout spawning sites in the Slocan River tributaries which have not been surveyed historically. The Slocan River associated systems of Little Slocan and its tributaries and Lemon Creek and its tributaries were surveyed during Bull Trout spawning season in Fall of 2018 to assess the habitat, confirm the barriers to fish movement and enumerate redds and spawners. The spawning streams of Wilson and Silverton, that were identified as providing the majority of the spawning habitat for the Slocan Lake system from previous research, were also surveyed in 2018 to provide an index of spawning for the Lake tributaries. The assumption is that Bull Trout move freely between the tributaries of the Slocan River and Slocan Lake. This project occurs within the Columbia Sub-region and aligns with Fish and Wildlife Compensation Program's the Streams Action Plan as the primary action plan and with the priorities of Assessment of Bull Trout and Inventory.

The estimated escapement from the 2018 surveys was 481 for all potential Bull Trout spawning habitat in the Slocan Watershed. The total escapement values were derived from the redd and unspawned female counts and low-density and high-density expansion factors to apply to the lineal habitat available from the unsurveyed streams. The Slocan Lake tributaries provided the majority of the redds recorded with escapement from those creeks estimated at 442 fish. The escapement from the Slocan River tributaries was estimated at 39 fish. During the surveys, 25 female spawners and 43 male spawners were observed for a total of 68 spawners.

Previous estimates of the risk category and total watershed escapement made assumptions about the relative contribution of the Slocan River tributaries. This pilot project allows the actual contributions of the river's tributaries to be evaluated with the Slocan Lake tributaries' contribution through carrying out surveys on the key spawning creeks of Wilson and Silverton that flow into Slocan Lake for the 2018 spawning season.

The Slocan Lake Bull Trout population continues to be 'At Risk' as designated in the provincial species status summary report. This rating is due to: 1) the spawning escapement values estimated being consistently less than 500 fish; 2) the habitat available to the fish has either remained stable or has decreased in quality through time; 3) the overall population trend remains unknown since it needs to be assessed over 2 generations (14 years), and; 4) the severity, scope and immediacy of threats to the population have increased or remained stable. Planned development in the Silverton Creek watershed is of significant concern for increasing the threat rating given the highly crucial nature of this creek in providing the majority of the Bull Trout spawning habitat for the Slocan population. If creek temperatures increase as predicted from climate change models, that would also have high potential impacts on the cold-water char species. Development plans in the Dennis/Wilson watershed may also be of concern since Wilson Creek is also a stronghold of Bull Trout Spawning in the watershed and may be of considerable importance in low water years. The addition of the Slocan River tributaries added 39 spawners to the overall calculations of Bull Trout abundance in the watershed despite providing ~63km of lineal habitat. Restoration options could be explored across the watershed.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The Bull Trout (*Salvelinus confluentus*) population in the Slocan watershed is a recreationally important population. In addition to its status as an important sport fish, Bull Trout are a keystone predator and important ecosystem component of the watershed. Historically, this population was not well studied, and this has been partially addressed by the 2013 pilot project and the 2014-2016 FWCP project assessing spawning habitat, escapement estimates, and potential restoration options for the Slocan Lake tributary component of the watershed's Bull Trout population (Baxter and Irvine, 2014, 2017). A gap in knowledge about the watershed's population as a whole was identified after the completion of the 3-year Slocan Lake tributary monitoring project. This project addresses that gap by surveying all potential Bull Trout spawning habitat in the tributaries of the Slocan River as well as the high value Slocan Lake tributaries in order to estimate the escapement for the entire Slocan watershed population of Bull Trout.

Slocan Lake Bull Trout were historically connected to the Kootenay and Columbia River systems and the overall Columbia basin through the Slocan River. The movement patterns and potential for interchange of gene flow for this population is now truncated by hydro-electric development on the Kootenay and Columbia Rivers. High water temperatures in the Slocan River may also potentially limit the mobility of the Slocan Lake Bull Trout in the present day. It is considered likely that significant declines in abundance and diversity occurred in the Slocan population following the loss of connectivity with adult rearing habitats in the lower Kootenay and Columbia systems following hydroelectric development in the early 1990s (Hagen and Decker, 2011; Hirst, 1991).

In an assessment of the impacts of dam construction and flow regulation on Bull Trout populations throughout the Canadian portion of the Columbia River watershed, Slocan River Bull Trout were identified as a population of high conservation concern, and it was recommended that these fish be given priority in future management (Hagen, 2008; Hagen and Decker, 2011). Hagen and Decker (2011) considered that the Slocan population as a whole met major criteria with respect to known threats to population perseverance for this species in their native range, including: isolation from other populations and from productive rearing habitats, small population size, possible evidence of negative population growth, unfavourable thermal regimes in remaining habitats, and encroachment and competition by native and non-native species. Threats to this population additionally include angling harvest, harvest pressure through poaching, sediment loading and habitat degradation in spawning and rearing streams, increasing water temperature from climate change and linear development and population sizes of spawners that may limit genetic adaptability and variation.

The Provincial Conservation Status of Bull Trout in the Slocan Valley was classified as C2 or "At Risk" in 2011. This was based on an estimate of between 200 and 500 spawning adults and on estimated habitat, exploitation and competition in the system (Hagen and Decker 2011). The monitoring efforts since 2013 and the gathering of additional information on distribution and available habitat and habitat degradation have demonstrated that this population remains within the 'At Risk' category with escapement estimates consistently below 500 fish and increased pressure to develop within the watershed. The risk level designation based on abundance, trends

in population size, available habitat for distribution as well as the threats affecting the population. The next and highest level of risk is 'High Risk' which is defined as 'extremely limited and/or rapidly declining numbers, range, and/or habitat, making the bull trout in this core area highly vulnerable to extirpation' (Hagen and Decker 2011). Factors to consider when assessing the threat rating to this population include the reality that although there is theoretically over 92 km of spawning habitat, the habitat that is actually used is significantly less than that and the redundancy associated with a widely dispersed spawning population is not afforded to this watershed's Bull Trout since they rely heavily on very few creeks. In addition, water temperature is a significant driver of Bull Trout's ability to compete with Rainbow Trout and is likely to increase across the watershed with climate change.

Bull Trout are provincially blue-listed and their conservation is a priority to the province of British Columbia and to the Fish and Wildlife Compensation Program. In the Streams Action plan the priority one action taken by this project is Bull Trout Assessment and the second priority is Bull Trout and stream habitat inventory. The Bull Trout in the Slocan system have a typical adfluvial life history characterized by spawning and rearing in major tributaries to Slocan Lake for the first 1-4 years of life, and adult rearing in the lake. Multiple and varied options for compensation efforts and management to maintain and increase this population exist. Recent changes to the BC Fishing Regulations in 2017 allow a harvest of one Bull Trout a day per person over 60 cm (previously 30 cm) in Slocan Lake. Poaching within the population's spatial extent is suspected to be moderate to high based on limited resources for Conservation Officers to patrol and commonly observed poaching incidents in areas with aggregations of pre-spawning Bull Trout (P. Corbett, Pers. Comm.).

Previous estimates of the risk category and total watershed escapement made assumptions about the relative contribution of the Slocan River tributaries. This pilot project allows the actual contributions of the Slocan River's tributaries (Little Slocan and Lemon) to be evaluated with the Slocan Lake tributaries' contribution for the 2018 spawning season.

The primary benefits of this project are to improve the understanding of the population size and trends for the entire Slocan Watershed Bull Trout population, to identify opportunities for restoration and enhancement and to provide the best available scientific information for establishing management tactics to meet conservation goals.

2.0 STUDY AREA

The primary focus of this study was the Slocan River tributaries that provide potential Bull Trout spawning habitat. The Slocan River is the outflow of Slocan Lake and flows from its head at the lake in a southerly direction for approximately 58 km to the confluence with the Kootenay River. The secondary focus of this study was the key Bull Trout spawning tributaries that drain into Slocan Lake: Wilson and Silverton Creeks. Slocan Lake is situated between the Valhalla and the Selkirk Mountain Ranges in the West Kootenay Region of British Columbia and is approximately 39 km long and has an area of 69 km² (Figure 1). The goal of the expanded survey area was to get a complete index for the Slocan watershed for Bull Trout spawning in 2018.

Elevation in the basin ranges from 480 meters at the Slocan River mouth to 2,800 meters at the height of land in the Selkirk Mountains. Within this elevation range, the system is comprised of two bio-geoclimatic zones. At lower elevations, the valley lies within the Interior Cedar-Hemlock zone, while areas in the higher elevations are found within the Engelmann Spruce-Subalpine Fir zone. Historically, the river was connected to the lower Columbia and Kootenay rivers, but hydroelectric developments in the 1940s fragmented the system from these major rivers. The Slocan used to contain now extirpated populations of Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead Trout (*Oncorhynchus mykiss)*.

Redd surveys were conducted in the two largest potential Bull Trout spawning creeks of the Slocan River system (Lemon Creek, Little Slocan River) and their associated tributaries as well as in Silverton and Wilson creeks to provide an index of Bull Trout spawning for the Slocan Lake tributaries as well (Table 1). The entire length of each Slocan River tributary was surveyed from the upstream migration barrier (Figure 1) and extended to the stream mouth. Index sections in Silverton Creek, Wilson Creek and Dennis Creek were surveyed from the barriers to the low-use habitat sections identified during previous studies (Baxter and Irvine, 2017).

Table 1. Geographic information on the surveyed tributaries in the study area. All streams reside within Region 4

Gazetted Name	Watershed Code	Total Stream Length (km)	Order	Area (km²)
Airy Creek	340-047200-233001	11.7	4th	59.2
Bannock Creek	340-047200-233007	12.9	4th	63.5
Crusader Creek	340-047200-518005	7.4	3rd	26.7
Dennis Creek	340-047200-91700	9.7	3rd	20.4
Hoder Creek	340-047200-233005	22.8	5th	101.2
Holmson Creek	340-047200-518003	7.6	3rd	73.7
Koch Creek	340-047200-233002	39.6	6th	425.3
Lemon Creek	340-047200-518000	25.6	5th	202.1
Little Slocan	340-047200-233009	39.5	7th	821.6
Monument Creek	340-047200-518004	6.5	3rd	17.2
Silverton Creek	340-047200-82200	20.8	5th	121.7
Wilson Creek	340-047200-91700	35.3	6th	583.7

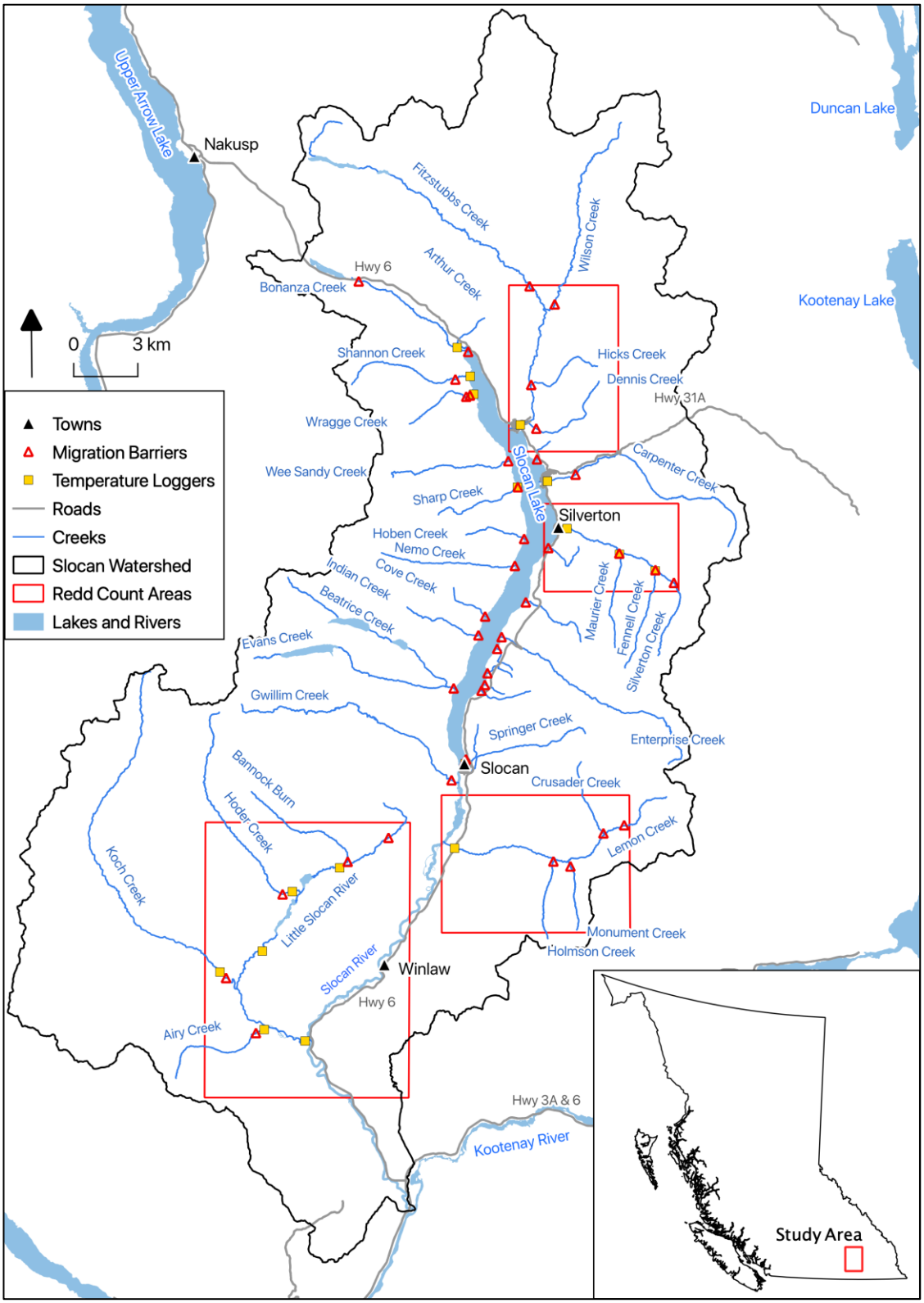

Figure 1. **The Slocan Lake study area showing redd count areas surveyed in 2018, migration barriers to spawning Bull Trout in all tributaries and locations of temperature loggers.**

3.0 METHODS

3.1 Redd Surveys

As an index of adult Bull Trout escapement the method of visual counts of redds in the substrate that indicate spawning activity and egg deposition was used (Dunham et al., 2001; Rieman and Myers, 1997). Redd counts are one of the least expensive and least invasive adult population assessment methods and under appropriate conditions, can be precise indicators of abundance (Johnston et al., 2007).

Redd surveys began in late September based on timing determined from surveys done in the watershed since 2013. Redd surveys were conducted by a crew of two people, each equipped with waders and polarized glasses, who walked downstream from the barriers parallel to one another on either side of the stream. All observed redds and spawners were enumerated, recorded and marked with a handheld GPS device for each survey area. Where possible, the sex and approximate fork length (visual estimate) of individual fish was also recorded. We assumed that females not associated with redds were unspawned females and would construct redds after the survey was completed. We counted each unspawned female as one redd when estimating the number of redds for each stream. If an index area could not be completed in one day (typically, five kilometers can be surveyed in a day) the survey was resumed the following day.

There are three potential classifications for an excavation found by a survey crew: 1) natural stream scour 2) viable redd, 3) test dig. There are several characteristics that may be present to allow redds to be differentiated from natural scour:

- Circular, dish-shaped excavations in the creek bed material, accompanied by a gravel deposit beginning in the excavated pit and spilling out of it in a downstream direction
- The overall pit is broader than the area where gravel is deposited over the eggs
- A steep pit wall, with perched substrate that can be easily dislodged into the pit
- Bright and clean substrate, and sand deposited in the area of quiet water created by the upstream edge of the pit
- Tail stroke marks or excavation marks around the redd or alongside the front portion of the gravel deposit

Test digs are very similar to redds but are usually smaller in size, with a shorter and narrower mound of gravels around the downstream edge, and have no gravel deposit swept into the pit, which would indicate at least one egg deposition event.

Redd survey dates ranged from September 21st to 27th (Table 2). Complete surveys were conducted from the barriers to the mouth for the Slocan River tributaries and in all the high-use index sections for the Slocan Lake tributaries (Table 2).

Table 2. Redd survey dates for each stream in the study area 2018.

Stream	Date Surveyed	Barrier UTM	Distance (km) (Barrier to Mouth)	Distance Surveyed (km)
Airy Creek	Sept 23	11 U 448148 5489543	1.36	1.36
Bannock Creek	Sept 21	11 U 456117 5504431	0.74	0.74
Crusader Creek	Sept 24	11 U 478323 5506903	0.15	0.15
Dennis Creek	Sept 27	11 U 472493 5542080	1.01	1.01
Hoder Creek	Sept 22	11U 450459 5501602	1.89	1.89
Holmson Creek	Sept 25	11U 473979 5504458	0.21	0.21
Koch Creek	Sept 22	11 U 445551 5494328	2.33	2.33
Lemon Creek	Sept 24, 25	11 U 480127 5507606	20.25	20.25
Little Slocan	Sept 21, 22	11 U 459658 5506512	35.24	35.24
Monument	Sept 24	11 U 475462 5504025	0.54	0.54
Silverton Creek	Sept 26	11 U 483409 5529352	13.51	7.50
Wilson Creek	Sept 27	11 U 474092 5552886	15.26	2.70

3.2 Escapement Estimate

In other studies where counted redds were compared with complete kelt counts the number of adults (kelts) per redd ranged from 1.0 to 4.3 and are summarized in previous reports on this project (e.g., (Irvine and Baxter, 2016)). The 2.4 adults per redd expansion factor used herein was averaged from those studies.

For the escapement estimate we assumed that all unspawned females not associated with a redd were going to construct one. The escapement estimate equation uses total number of redds and unspawned females multiplied by the expansion factor (2.4) (Decker and Hagen, 2007; Hagen and Baxter, 2010) to calculate the total Bull Trout escapement (N) for an individual stream. For creeks that were not surveyed in the 2018 field season, we categorized them as either high density or low-density Bull Trout habitat based on historical surveys and used an expansion factor for each density in order to estimate escapement for all known Bull Trout spawning habitat in the Slocan watershed where a section of creek was considered accessible to Bull Trout if it was below the primary barrier. High density creeks have a consistent spawning population of Bull Trout that is greater than 0.5 fish per km; low density creeks had intermittent or non-existent spawning populations at lineal densities less than 0.5 fish per km. The high-density creeks were Dennis, Silverton and Wilson Creeks and their tributaries. All other creeks and sections were classified as low density creeks or zero density sections based on previous surveys. The below equation was calculated once for high density creeks and again for low density creeks and the two values for escapement at each density level were summed for the total.

The escapement estimate equation is:

$$N = 2.4 \cdot (\text{Redds} + \text{Unspawned Females}) \cdot \frac{\text{Accessible Creek Length}}{\text{Accessible Length Surveyed}}$$

3.3 Temperature Measurements

Seven Onset TidbiT v2 temperature loggers were deployed in the study area in August and only one temperature logger (Wilson Creek) was recoverable from the previous study in 2016 (Table 3). The loggers recorded the water temperature every 15 minutes and were downloaded in September 2018. Temperature data were imported into R, inspected for any errors and plotted.

Table 3. Temperature logger location, deployment and retrieval dates.

Stream	Temperature Logger UTM	Deployment Date	Retrieval Date
Airy Creek	11 U 448863 5489841	August 3, 2018	Sept 25, 2018
Hoder Creek	11 U 451307 5501836	August 3, 2018	Sept 25, 2018
Koch Creek	11 U 445027 5494838	August 3, 2018	Sept 25, 2018
Lemon Creek	11 U 465398 5505602	August 3, 2018	Sept 25, 2018
Little Slocan Creek (DS of Lakes)	11 U 448701 5496661	August 3, 2018	Sept 25, 2018
Little Slocan Creek (US of Lakes)	11 U 455419 5503896	August 3, 2018	Sept 25, 2018
Little Slocan Creek (Mouth)	11 U 452414 5488849	August 3, 2018	Sept 25, 2018
Wilson Creek	11 U 471109 5542398	2016	Sept 27, 2018

3.4 Data Preparation and Plotting

The Bull Trout fish and redd count data for the surveyed tributaries were collected by Mountain Water Research and databased in a customized relational SQLite database by Poisson Consulting Ltd. Poisson Consulting Ltd. carried out plotting, mapping and data QA/QC before analyses using R version 3.5.1 (R Core Team, 2018).

4.0 RESULTS

4.1 Redd Count Surveys

In 2018, redd surveys were conducted from September 21 until September 27 (Table 2). Water clarity conditions were excellent, and there was no evidence of redd scour prior to the surveys. In total, 73.9 km of stream were surveyed, and 193 redds, 68 spawners (43 males and 25 females), and 2 unspawned females were observed for all streams combined (Table 4, Table 5).

Table 4. Bull Trout redd and unspawned female counts in surveyed Slocan tributaries, 2018

Tributary	Surveyed Length (km)	Unspawned Females	Redd Count
Airy Creek	1.36	0	0
Bannock Creek	0.74	0	0
Crusader Creek	0.15	0	0
Dennis Creek	1.01	0	20
Hoder Creek	1.89	0	0
Holmson Creek	0.21	0	2
Koch Creek	2.33	0	0
Lemon Creek	20.25	0	14
Little Slocan	35.24	0	0
Monument	0.54	0	0
Silverton Creek	7.50	2	137
Wilson Creek	2.70	0	20
Totals	73.92	2	193

Table 5. Slocan Lake and River tributary spawner counts and estimated size ranges for the streams surveyed streams in 2018.

Tributary	Female Count	Female Min Length (cm)	Female Max Length (cm)	Male Count	Male Min Length (cm)	Male Max Length (cm)
Airy Creek	0	-	-	0	-	-
Bannock Burn	0	-	-	0	-	-
Crusader Creek	0	-	-	0	-	-
Dennis Creek	6	40	75	5	40	80
Fennel Creek	0	-	-	0	-	-
Hicks Creek	0	-	-	0	-	-
Hoder Creek	0	-	-	0	-	-
Holmson Creek	1	50	50	1	30	30
Koch Creek	0	-	-	0	-	-
Lemon Creek	0	-	-	1	-	60
Little Slocan River	0	-	-	0	-	-
Maurier Creek	0	-	-	0	-	-
Monument Creek	0	-	-	0	-	-
Silverton Creek	17	45	70	34	70	90
Wilson Creek	1	65	65	2	65	95
Totals	25			43		

4.1.1 Silverton Creek and Tributaries

In 2018, 137 redds, 34 male spawners and 15 female spawners, and 2 unspawned females were observed in Silverton Creek (Figure 2, Table 5). Both Fennell and Maurier creeks have gradient barriers within the first 100 m from their creek mouths and neither contained unspawned females nor redds in 2018. Surveys extended from the barriers to the low-use spawning sections identified during previous studies and where 100% of the redds have occurred in the survey coverage area historically (Baxter and Irvine, 2017).

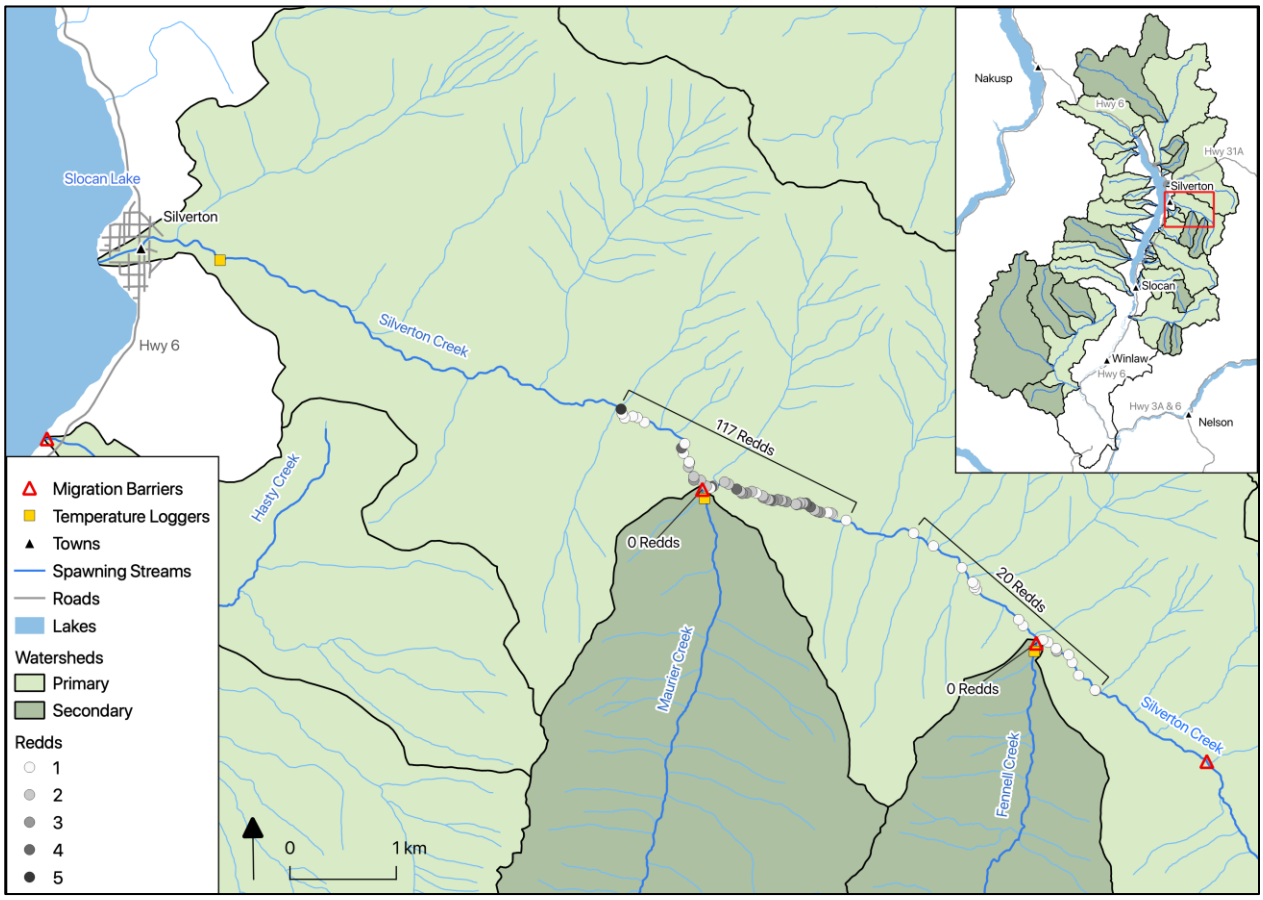

Figure 2. **Bull Trout barriers and redd assessment results for Silverton Creek and tributaries, 2018.**

4.1.2 Wilson Creek and Tributaries

In 2018, 20 redds and 0 unspawned female were observed in Wilson Creek and 20 redds and 0 unspawned females were seen in Dennis Creek which together account for 20.5% of the total escapement (Figure 3). In addition, 7 female and 7 male spawners were observed in the surveyed systems (Table 5). Surveys extended from the barriers to the low-use spawning sections identified during previous studies and where 100% of the redds have occurred in the survey coverage area historically (Baxter and Irvine, 2017).

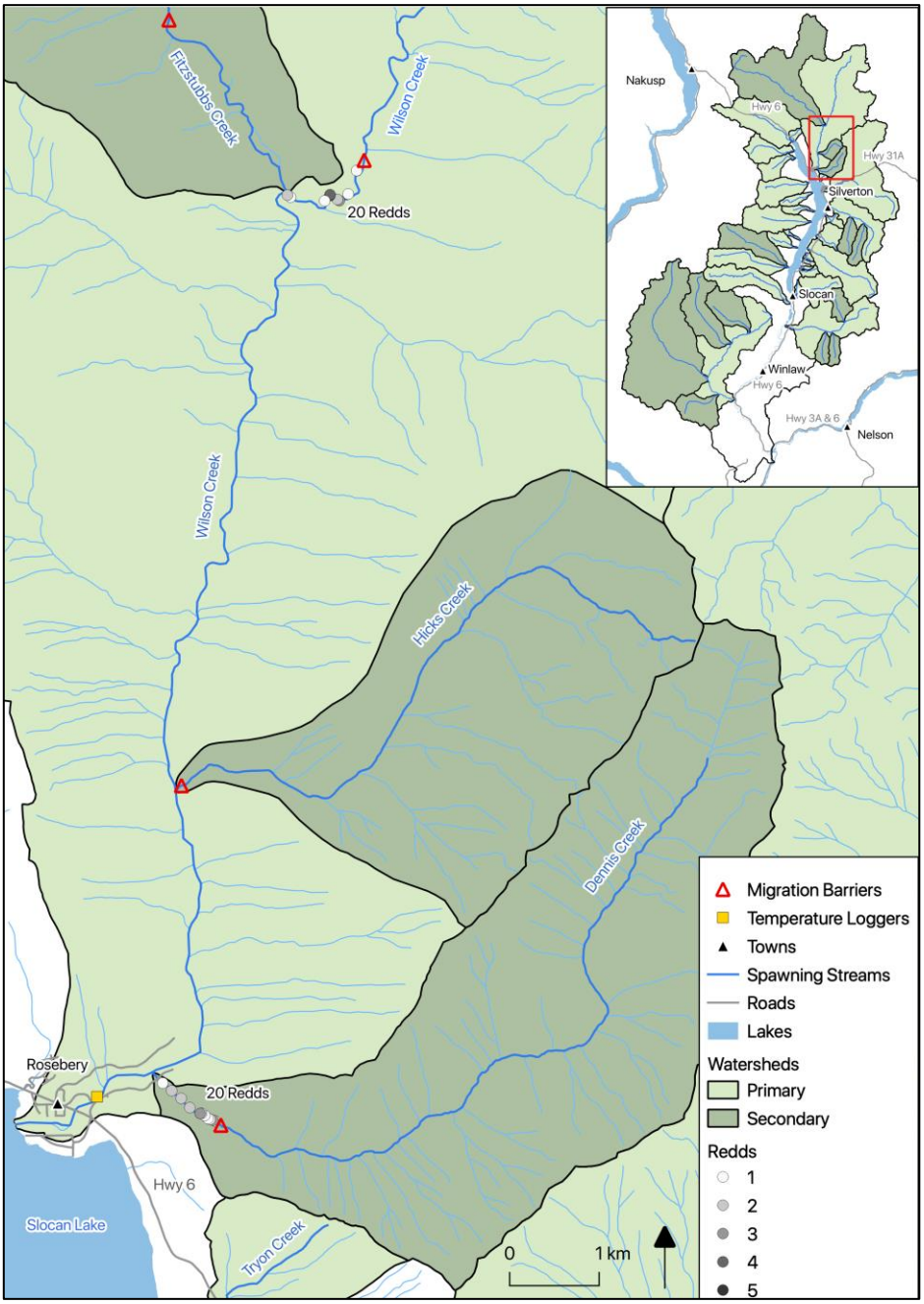

Figure 3. Bull Trout barriers and redd assessment results for Wilson Creek and tributaries, 2018.

4.1.3 Lemon Creek and Tributaries

In 2018, 14 redds and 0 unspawned females were observed in Lemon Creek (Figure 4). Two redds were observed in Holmson Creek and no redds nor females were observed in Crusader and Monument Creeks. One male spawner was observed in Lemon Creek and 1 female and 1 male spawner were observed in Holmson Creek (Table 5). Surveys extended from the barriers to the mouth for all systems.

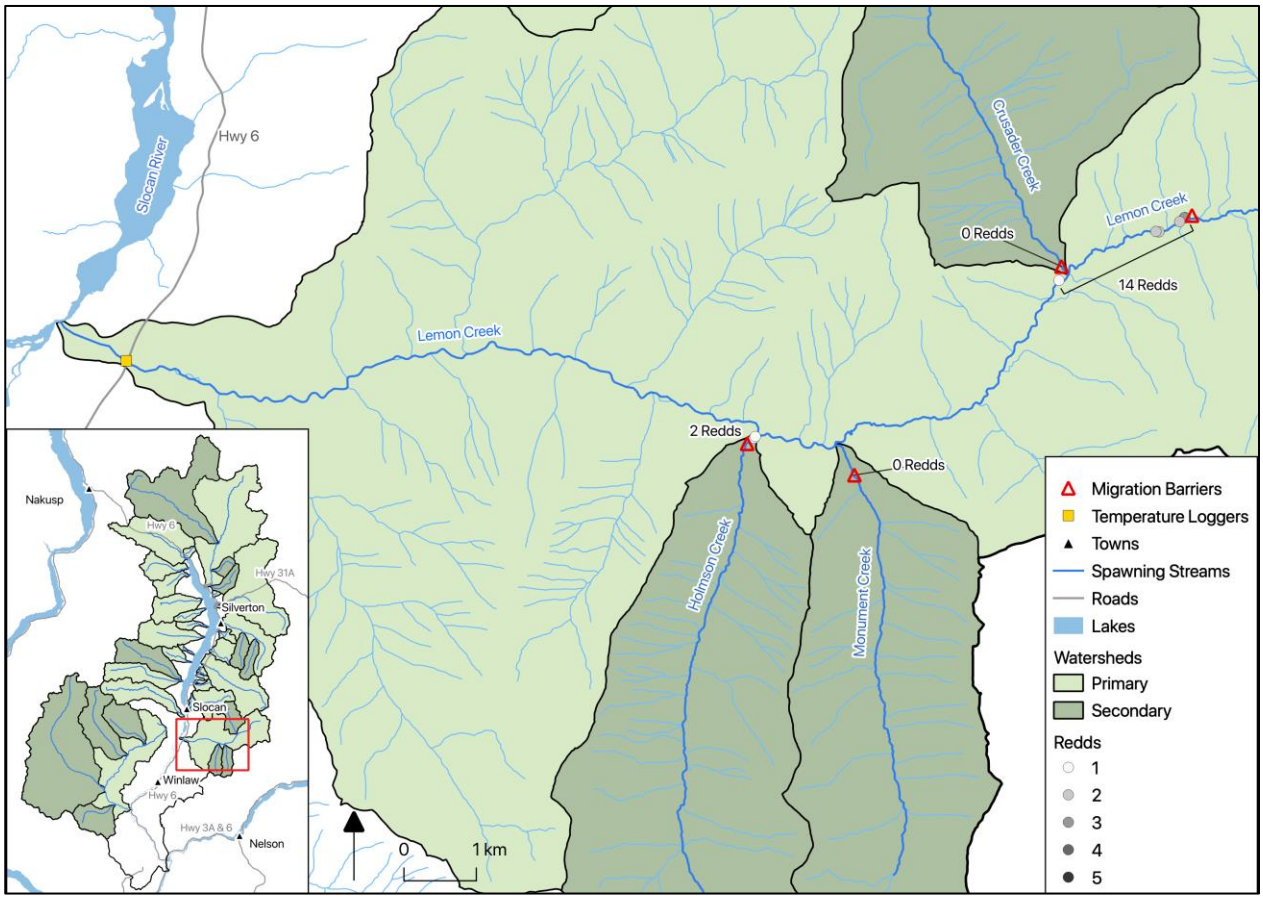

Figure 4. Bull Trout barriers and redd assessment results for Lemon Creek and tributaries, 2018.

4.1.4 Little Slocan Creek and Tributaries

In 2018, 0 redds, 0 spawners and 0 unspawned females were observed in Little Slocan Creek or its tributaries (Figure 5, Table 5). Surveys extended from the barriers to the mouth for all systems.

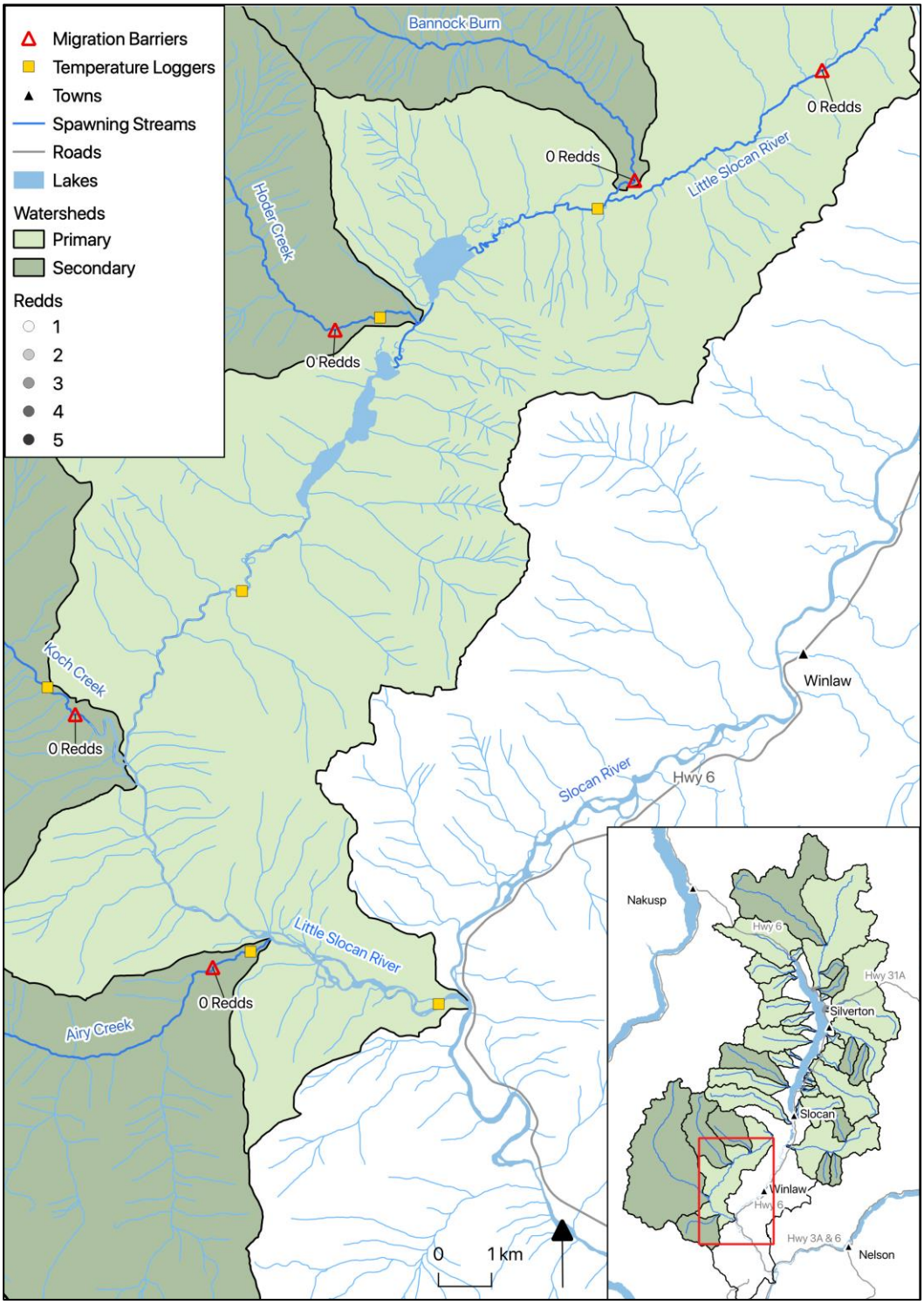

Figure 5. Bull Trout barriers and redd assessment results for Little Slocan Creek and tributaries, 2018.

4.2 Escapement Estimate

Bull Trout escapement (assuming 2.4 adults per redd and utilizing the low- and high-density expansion factors as described in the methods for creeks that were not surveyed in 2018) of all accessible Slocan Lake tributaries in 2018 was 442 adults, which was 92% of the watershed-wide escapement estimate. Escapement of Bull Trout from the Slocan River tributaries was estimated to be 39 fish, accounting for 8% of the escapement across the watershed.

The average total escapement across the five years is 321 fish. Silverton Creek contributes the largest proportion (71%) of the total redds (Table 6).

Table 6. Slocan Lake and River tributary redd and unspawned female counts for the surveyed streams and percent totals.

Tributary	Redd Count Plus Unspawned Females	Percentage of Redds (%)
Airy Creek	0	0
Bannock Burn	0	0
Crusader Creek	0	0
Dennis Creek	20	10.3
Fennel Creek	0	0
Hicks Creek	0	0
Hoder Creek	0	0
Holmson Creek	2	1.0
Koch Creek	0	0
Lemon Creek	14	7.2
Little Slocan River	0	0
Maurier Creek	0	0
Monument Creek	0	0
Silverton Creek	139	71.3
Wilson Creek	20	10.3
Totals	195	~100%

The escapement numbers for the Slocan Lake portion of the population through the five years of monitoring have ranged from a low of 194 fish to this year's high of 442 fish (Table 7).

Table 7. Slocan Watershed escapement estimates through time assuming 2.4 adults per redd and using the expansion factor in years when all available habitat was not surveyed (2013 and 2018).

Spawn Year	Slocan Lake Tributary Escapement	Slocan River Tributary Escapement
2013	194	-
2014	389	-
2015	314	-
2016	264	-
2017	-	-
2018	442	39
Average	321	39

During the surveys any spawners still in the tributaries were enumerated and their size range noted. Across all surveyed systems, 25 female Bull Trout were observed and 43 males with the largest female observed in Dennis and the largest male observed in Wilson Creek (Table 5).

4.3 Water Temperature

Data loggers were installed in early August and downloaded at the end of September to capture the temperature regimes in potential spawning habitat surveyed in the Slocan River tributaries as well as in Wilson Creek. Wilson and Little Slocan below the lakes and at the mouth were the warmest with temperatures in excess of 15°C, and the coolest creeks were Lemon and Hoder (Figure 6). In previous reports on the Slocan Lake tributaries, the accumulated thermal units (ATUs) until emergence were calculated for Bull Trout in Silverton Creek (Baxter and Irvine, 2017). It was not calculated for any of the creeks this year given the lack of year-round data, but the emergence date range calculated from 2013-2016 Silverton data was from April 25 - June 2.

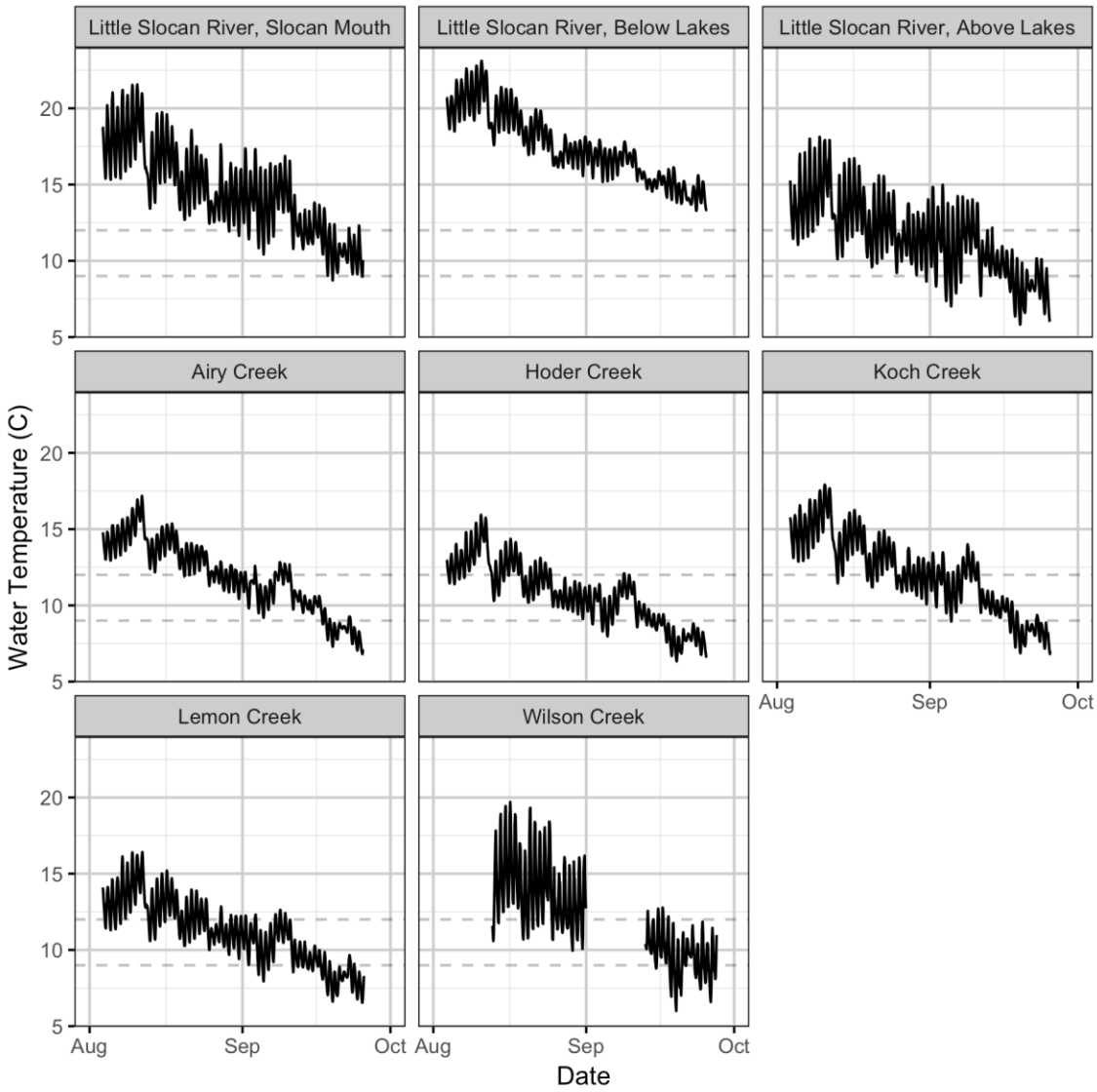

Figure 6. Water temperature (°C) by date for a subset of the creeks in the Slocan watershed surveyed for Bull Trout spawning, 2018. Temperature thresholds for migration (12°C) and spawning (9°C) are marked with horizontal dashed lines.

5.0 DISCUSSION

The main question posed in this year's project was the relative contribution of the Slocan River tributaries. The surveys covered 98% of the available habitat in the Slocan River tributaries and observed 16 redds. The physical surveys in combination with the application of the expansion factor to the remaining 2% of the habitat generated an escapement estimate of 39 fish. This comprises 8% of the total estimated escapement for the entire Slocan watershed.

The importance of Silverton Creek as the primary spawning creek for the Slocan population of Bull Trout is emphasized with this whole system assessment where it accounted for 71% of the escapement. It is crucial that the key habitats and the cold waters of the critical spawning habitat of this species be maintained through careful management of development and conservation in the area and through thoughtful restoration projects. Potential restoration options for the Slocan Lake tributaries were explored in Irvine and Baxter, 2016. Bull Trout restoration options for the tributaries to the Slocan River are limited based on the observations of the 2018 survey crews. The primary restoration option identified in 2018 includes a large bank stabilization in Little Slocan River that is contributing a substantial amount of turbidity into the system and may be deterring Bull Trout from migrating, although stream temperature is likely the major reason for the lack of Bull Trout use. It is unknown whether Lemon Creek was a more significant contributor to the spawning population prior to the fuel spill that occurred in 2013 and whether its gradual recovery will eventually improve its habitat.

For the Slocan Lake tributaries portion of the population, the escapement estimates over the five years of this study have ranged from 194 to 442 Bull Trout with 2018 having the highest abundance estimates to date. The removal of the old barrier in Dennis Creek in 2017 during an upgrade of a micro-hydro site has provided approximately 400 meters of new spawning habitat. Dennis Creek was a heavily used spawning site in 2018 supporting 10.3% of the escapement. Some of the increase in abundance may be driven by the improvement in Dennis Creek's available spawning habitat and some may be attributable to the April 1, 2017 changes in fishing regulations for adult Bull Trout on Slocan Lake from a harvest of one a day at 30 cm to one a day at 60 cm which allows adult Bull Trout to spawn at least once prior to harvest. Although redd surveys can be biased due to missing redds or false positive identifications of redds that are not present, the usage by this project of experienced observers and most of the same observers from year to year minimizes these sources of observer bias (Dunham et al., 2001). The estimates are considered to be a good index of abundance through time.

The risk category for this population was re-calculated with all contributing spawning tributaries. The Slocan watershed Bull Trout population remains in the 'At Risk' category. This is the same rating as that accorded this population in 2011 (Hagen and Decker, 2011). The water temperature in the Slocan River system was identified in the 2011 risk rating as a significant issue for Bull Trout utilising the habitat in that system (Hagen and Decker, 2011) and this remains the case. Many aspects of this risk categorization calculation are subjective and/or unknown (e.g., how much will Wilson creek increase in water temperature and how quickly). Given the lack of redundancy in highly used spawning streams, the immediacy of the threat of development and water

temperature changes and the relatively low numbers of spawners, it is recommended that a small workshop with the regulatory agencies and subject matter experts be held to determine how to assess the upcoming risks to Bull Trout in the Slocan watershed and to plan for mitigation of those likely risks.

The spawning habitat for these ecologically and recreationally important fish species is mainly provided by Silverton Creek and Wilson Creek and their tributaries with a small amount of spawning in Lemon Creek and several small tributaries around the lake. Silverton Creek is the most important creek by a large margin in most years, though one hypothesis is that Wilson may have greater spawning importance in years of low flow based on the percentage usage in 2015, but this only has one year of data to support the idea at this point. Wilson Creek tends to be warmer than Silverton and temperature thresholds are related to land use practices as well as climate change (Parkinson et al., 2016) and may limit the utility of Wilson in the future without remediation of open sections of the river from road clearing and forestry. With a slight shift in temperature, creeks can move from a Bull Trout dominated system to a Rainbow Trout dominated system and there is a current push towards protecting and identifying temperature sensitive streams across BC in order to ensure that cold water species such as Bull Trout still have sufficient habitat in perpetuity (Parkinson et al., 2016).

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