Columbia River Project Water Use Plan

Kinbasket Reservoir Fish and Wildlife Information Plan

Kinbasket Reservoir Juvenile Bull Trout Life History and Habitat Use Assessment

Implementation Year 3

Reference: CLBMON-06

WLR Monitoring Study No. CLBMON-06 (Year 3) Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment

Study Period: March - November 2017

Ktunaxa Nation Council
7825 Mission Rd, Cranbrook, BC, V1C 7E5

July 3, 2018

WLR Monitoring Study No. CLBMON-06 (Year 3)

Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment

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Cover Photo:

View of Kinbasket Reservoir from bay of Encampment Creek (May 25, 2017). Ben Meunier, VAST Resource Solutions.

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Executive Summary

Bull Trout (*Salvelinus confluentus*) were identified by the Columbia River Water Use Plan Consultative Committee (WUP CC) as a key fish species of concern in Kinbasket Reservoir because of their importance as a sport fish and the potential for links between reservoir operations and Bull Trout population productivity. This four-year study was designed to answer management questions related to i) basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir; ii) potential effects of reservoir operation on juvenile Bull Trout; iii) identification of modifications to the operation of Kinbasket Reservoir to protect or enhance juvenile Bull Trout populations.

Fyke nets were set overnight along the nearshore zone of Kinbasket reservoir at 17 sites to assess shoreline use by Bull Trout from May 25 to June 14, 2017. A total of 15 juvenile Bull Trout were captured in fyke nets set at 11 locations throughout Kinbasket Reservoir. Habitat assessments indicated that nearshore areas of Kinbasket Reservoir likely provide sub-optimal temperature and substrate conditions for juvenile Bull Trout. Cover was lacking in most areas as fine/sand substrate made up 71% of sites, while gravel and cobble substrates made up only 29% of sites

A total of 12 juvenile Bull Trout were detected by the fixed antenna reader installed near the confluence of Packsaddle Creek with Kinbasket Reservoir (Dec. 4, 2016 to June 22, 2017). Mean length at tagging of detected Bull Trout was 115.5 ± 1 mm and mean weight at tagging of detected Bull Trout was 15.1 ± 9.88 g. Inclusion of Bull Trout detection data from additional individuals in Packsaddle Creek over an extended study period in 2018 will provide useful information on the assessment of outmigration.

Management Question	**Hypotheses**	**Status**
What are the basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir (e.g., distribution, age structure)?		Basic life history and habitat use characteristics are discussed in this Year 3 report and will be further assessed in Year 4.
What are the potential effects of reservoir operation on juvenile Bull Trout, given the seasonal timing, age, and size of juveniles emigrating to the reservoir?	H_0: Operation of Kinbasket Reservoir has no effect on juvenile Bull Trout, given the seasonal timing and size/age of juveniles emigrating to the reservoir. H_1: Operation of Kinbasket Reservoir affects emigration of juvenile Bull Trout.	To be addressed in Year 4.
Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance		To be addressed in Year 4.

juvenile Bull Trout populations?		

Acknowledgements

We thank Trish Joyce at BC Hydro for management of this project and Guy Martel for review and discussion of methodology for this project.

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1 Introduction

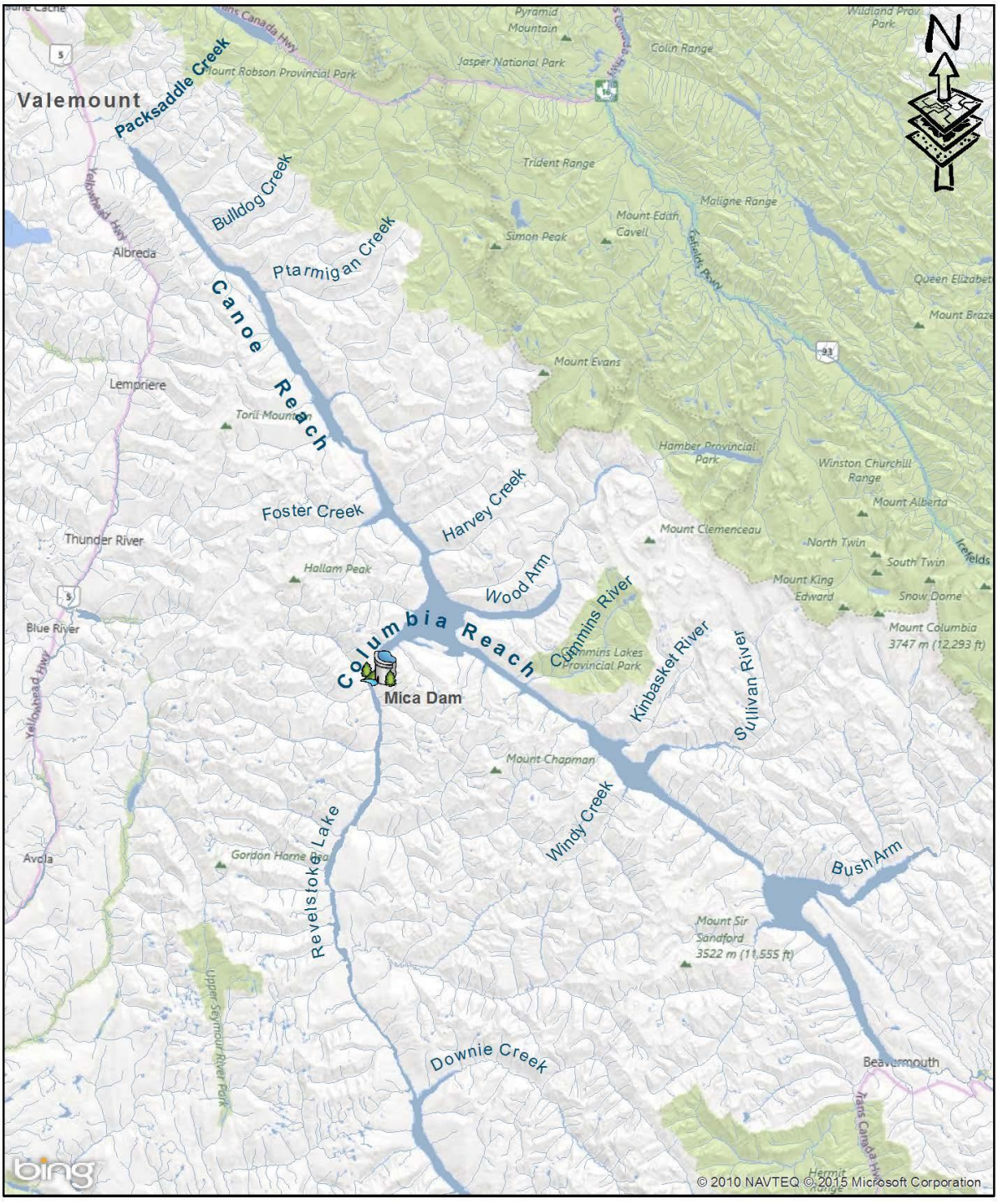
1.1 Monitoring Program Rationale

1.1.1 Background

Kinbasket Reservoir (Figure 1) was created by the construction of Mica Dam in 1973, under the terms of the Columbia River Treaty. The purposes of the creation of this earthfill, high head dam and reservoir were for optimized, coordinated power generation between Columbia River mainstem dams in the US and Canada and for downstream flood control. The reservoir inundated 216 km of the length of the Columbia River between Mica and Donald, and is among the largest reservoirs in British Columbia, with a maximum surface area of 43,200 ha and mean depth of 57 m. Prior to dam construction, the majority of this habitat was free flowing, with the exception of a lacustrine portion known as Kinbasket Lake that was 13 km long and had a surface area of 2,250 ha (Prince, 2011). The reservoir can be coarsely segregated into two main reaches, Columbia and Canoe, at the historic confluence of the Canoe and Columbia rivers, where the Columbia River turns southward approximately where Mica Dam is located. The reaches of the reservoir are typically bounded by steep valleys and are narrow, with stretches becoming riverine at low pool. Three large lacustrine portions of the reservoir occur at the confluence of the Canoe and Columbia reaches, at the historic location of Kinbasket Lake near the confluence with the Sullivan River, and at the confluence with the Bush River. Stream inputs are largely glacial, draining the high elevation northern tips of the Selkirk and Monashee mountains from the West, and the extensively glaciated West slopes of the Canadian Rockies from the East.

Operations of Mica dam result in large annual fluctuations of the reservoir levels. Kinbasket reservoir elevations may vary between a maximum of 754.38 m and a minimum 707.41 m, and may occasionally be brought up to a maximum elevation of 754.68 m if there is a high probability of spill. Normal operating level for the 2008-2012 period was between a mean maximum of 753.26 m and a mean minimum level of 718.12 m, with a normal operating range of 35.14 m. Drawdown from full pool normally begins slowly in September, and draft rate increases through the winter, with a levelling off of drafting and normal low pool occurring in mid-late April. During the spring period, discharge from Mica dam decreases, which coincides with the normal spring freshet, which rapidly refills the reservoir through the spring and early summer.

Bull Trout (*Salvelinus confluentus*) were identified by the Columbia River Water Use Plan Consultative Committee (WUP CC) as a key fish species of concern in Kinbasket Reservoir because of their importance as a sport fish and the potential for links between reservoir operations and Bull Trout population productivity. Bull Trout are also blue listed (Species of Special Concern) by the BC Conservation Data Centre due to their sensitivity to habitat loss or degradation, over-exploitation, and competition from other salmonids (CDC, 2006). However, adfluvial Bull Trout populations are considered to be doing well in Kinbasket Reservoir (RL&L, 2001), where they form a major component of the reservoir's sport fishery (Pole, 1996; RL&L, 2001).



Kinbasket Reservoir Study Area

0 10 20 40 60 Kilometers

1:750,000

Figure 1: Kinbasket Reservoir study area.

1.1.2 Bull Trout Biology

Bull Trout are native of western North America and are distributed in cool waters throughout the interior of British Columbia and in large west-flowing rivers of the Coast Mountains (McPhail, 2007). In British Columbia, Bull Trout commonly exhibit three life-history patterns: fluvial, adfluvial, and stream-resident. A fourth anadromous form is restricted to the southwestern portion of the province. Regardless of life-history type, most Bull Trout rear in streams for 2 to 4 years, with seasonal and diel shifts in microhabitats (McPhail, 2007). Juvenile Bull Trout are strongly associated with pools and deep side-channels in streams (McPhail, 2007).

Previous research suggests that an extended stream rearing period of at least 2 to 3 years is essential for Bull Trout reproductive success; sexual maturity is usually reached at age 4+ or 5+ (McPhail and Baxter, 1996; Fraley and Shepard, 1989; Mogen and Kaeding, 2005). Recent work in Arrow Lakes Reservoir has shown that some Bull Trout in the Columbia do not reach maturity until 8+ or more (Bray and Mylechreest, in preparation). For adfluvial populations, age at outmigration can vary. McPhail and Murray (1979) found that the majority of adult Bull Trout caught in Arrow Lakes emigrated at age 2. Emigrants into Lake Billy Chinook, Oregon were primarily of ages 2 and 3 (Ratliff, 1992). In Kananaskis Lake, Alberta, adult Bull Trout had emigrated from their natal tributary primarily at age 3 (Stelfox, 1997), and successful adult spawners had emigrated at ages 3 and 4 in Lake Pend D'Oreille (Downs et al., 2006). This is despite the fact that a large pulse of juvenile outmigrants occurs for fry, at age 0 (McPhail and Murray, 1979; Downs et al., 2006). Fry account for the majority of outmigrants because they are displaced by freshet flows and streams rapidly reach carrying capacity, although the lack of adult fish or spawners displaying short stream residence periods implies that fry outmigrants have poor survival and fitness (McPhail and Baxter, 1996; Downs et al., 2006).

Timing of outmigration is often associated with peak streamflow, with outmigration peaks mirroring freshet flows in spring, and in areas with more maritime or warmer climates, associated with a second peak occurring with fall rains or drops in temperature (Downs et al., 2006; McPhail and Murray, 1979; Bellerud et al., 1997; Hemmingsen et al 2001). In other areas, a single peak migration time is present and associated with spring freshet flows (Riehle et al., 1997; Moore et al., 2005; Zimmerman and Kinsel, 2010). A year-round study recently conducted in northeastern Oregon demonstrated that juvenile Bull Trout (>120mm) migrated downstream throughout the year with two migration pulses, an initial pulse in the spring, followed by a peak pulse in August (Homel and Budy, 2008). In the same area, Bowerman (2013) reported that age-1 juvenile Bull Trout (<120mm) emigrated throughout the year, with peak emigration between July and October, which is a period of low discharge in that particular river system.

Although McPhail (2007) suggests that juvenile Bull Trout rarely occupy the littoral zone of lakes and that they move into deep water when they initially enter lakes, this has not been rigorously assessed by many studies. Shoreline habitats may be important to juvenile Bull Trout if they occupy shallow habitats for foraging, holding, or for refuge, or if they are dependent on resources that are primarily derived from littoral or near-shore habitats. Meeuwig and Guy (2007) reported that juvenile Bull Trout occupy shallow, shoreline habitat and that they may have high affinity to substrate cover in lacustrine environments. Juvenile (<250 mm) Bull Trout were spatially segregated from larger Bull Trout inhabiting

shallow areas (<1 m) in a small lake in Alberta and were dependent on both pelagic and littoral food web items within these habitats (Wilhelm et al. 1999).

While rearing in nursery streams, Bull Trout have a fairly consistent growth rate and almost exclusively forage on invertebrates (Warnock, 2012). Outmigration from spawning streams at age 2-4 years is associated with rapid increases in growth in adfluvial systems, and is probably associated with a shift to piscivory soon upon lake entry (McPhail and Murray, 1979). In Kinbasket Reservoir, the dominant prey item is likely to be subyearling or yearling Kokanee (*Oncorhynchus nerka*) if Bull Trout are piscivorous and of sufficient size to overcome gape limitations. Piscivorous Bull Trout may forage on prey fish 50% of their body length (Beauchamp and Van Tassel, 2001). If Bull Trout emigrate into Kinbasket Reservoir primarily at ages >1+, Kokanee should be within their gape limit. Small size classes (75-200 mm) of Bull Trout in Lake Billy Chinook were generally not strongly piscivorous in winter, but piscivory in other seasons could not be satisfactorily assessed (Beauchamp and Van Tassel, 2001). Bull Trout were increasingly piscivorous with size in size classes above 200 mm (Beauchamp and Van Tassel, 2001). Determination of the dominant food source utilized upon outmigration is important for assessing impacts of dam operations on juvenile Bull Trout populations. Suitability of nearshore habitats for littoral macroinvertebrates and littoral production is impacted by winter drawdown operations in reservoirs in cold climates, with winter freezing and ice scour, desiccation and low water residence times (Stockner et al., 2005; Aroviita and Hamalainen, 2008). Although littoral productivity is assumed to be small in Kinbasket Reservoir (Bray et al. 2013), the diet preferences of Kinbasket Reservoir juvenile Bull Trout are unknown, as are their affinity for near shore habitats that may be impacted by reservoir operations.

The WUP CC hypothesized that the greatest potential impact of reservoir operations on the productivity of Bull Trout populations is entrainment of immature Bull Trout through Mica Dam. While juvenile Bull Trout have not been recorded or noted in fish salvage operations at Mica Dam, and entrainment will be addressed separately by BC Hydro's Fish Entrainment Strategy, there is a data gap with respect to stream emigration and reservoir habitat use by juvenile Bull Trout. To address this data gap, the WUP CC recommended that a Bull Trout life history and habitat use assessment be undertaken in Kinbasket Reservoir. The objectives of the monitoring program are to examine the early life history and habitat use of juvenile Bull Trout to infer potential effects of reservoir operations. The program is to include monitoring the size, age, and seasonal timing of juvenile emigration to the reservoir and assessment of nearshore habitat at time of outmigration to determine use of these habitats over a three year study period.

1.1.3 Management Questions

The fundamental management questions (MQs) to be addressed through the Bull Trout life history and habitat use assessment (BC Hydro, 2007) are:

1) What are the basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir (e.g., distribution, age structure)?

2) What are the potential effects of reservoir operation on juvenile Bull Trout, given the seasonal timing, age, and size of juveniles emigrating to the reservoir?

3) Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance juvenile Bull Trout populations?

1.1.4 Management Hypothesis

The primary management hypothesis to be evaluated by the monitoring program is:

H0: Operation of Kinbasket Reservoir has no effect on juvenile Bull Trout, given the seasonal timing and size/age of juveniles emigrating to the reservoir.

1.1.5 Key Water Use Decision Affected

The proposed monitoring program will provide information required to support more informed decision-making with respect to the need to balance storage in Kinbasket Reservoir with impacts on fish populations in the reservoir. Specifically, it will provide the information that is required to support future decisions around maintaining the current operating regime or modifying operations through adjusting the drawdown schedule or minimum elevation to protect juvenile Bull Trout populations.

2 Project Methodology and Management

2.1 Overview, study objectives and limitations

The approach of this study is to make observations of juvenile Bull Trout life history and habitat use through passive detection of outmigration from rearing streams and by ground surveys in nearshore areas of Kinbasket Reservoir. Capture of fish in rearing streams occurred in 2015 and 2016 and fish were tracked using passive integrated transponder (PIT) tags and a fixed antenna. Fish were tracked year-round by a fixed antenna to identify timing of outmigration from a rearing tributary to the reservoir. A complementary program of ground surveys during the spring/summer period during reservoir refilling took place in 2016 and will continue in 2017 to assess the use of shoreline habitats by juvenile and subadult Bull Trout. This ground survey program additionally consists of habitat assessments and inventory of benthic invertebrates in nearshore areas and within the drawdown zone at tributaries that may provide foraging resources for juvenile and subadult Bull Trout.

The objectives of this study are to i) understand basic life history and habitat use characteristics of juvenile Bull Trout of Kinbasket Reservoir; ii) identify the timing of juvenile Bull Trout emigration to Kinbasket Reservoir by detecting outmigration of juveniles using PIT tag antennae at the mouths of rearing tributaries; iii) confirm habitat use of juvenile and subadult Bull Trout at nearshore littoral areas of Kinbasket Reservoir through ground surveys; iv) assess the presence of barriers to outmigration from rearing tributaries and access to nearshore littoral habitats in the drawdown zone due to dam operations; and iv) identify potential modifications to Kinbasket Reservoir operations to protect or enhance juvenile Bull Trout populations based on findings from i) to iv).

Although the study is designed to discern whether current operations affect the juvenile Bull Trout population in Kinbasket Reservoir, there are some potential limitations in the study design. The study can only assess whether there may be effects on juvenile Bull Trout in the years of observation. Kinbasket operations vary from year to year, so the full range of potential impacts given different reservoir operations will not be captured. In addition, the study program identifies habitat associations based on fish presence but it cannot characterize habitat suitability based on fish absence. Fish absence does not necessarily imply that habitats are unsuitable or could be suitable if reservoir operations were modified.

2.1.1 Nearshore fish and habitat surveys

To answer MQ1, fish and habitat surveys were conducted monthly over 3 to 4 days from April to August to characterize habitat use of the nearshore area and changes with increasing reservoir elevation. Fish surveys were conducted to detect nearshore habitat use by juvenile/subadult fish, detect PIT tagged fish, and collect growth rate information (i.e., size, scale and fin samples). Surveys were conducted using fyke nets (0.9 x 1.2 m frame with 6.4 mm mesh and 9.1 m lead/wings) set overnight in a perpendicular orientation with the cod end away from shore to encounter fish moving from either direction along the shoreline. However, due to the steep gradient in many areas of the reservoir, some fyke nets were set parallel to shore. Sites were selected based on gradient for installation of fyke nets, usually in water depths of < 1 m.

Basic life history information (i.e., fork length and weight) was collected from Bull Trout, as well as other sport fish such as Rainbow Trout (*Oncorhynchus mykiss*), Burbot (*Lota lota*), Kokanee, and Mountain Whitefish (*Prosopium williamsoni*). Ages of individuals were classified based on the following thresholds: young-of-year (YOY) <70 mm, juveniles/sub-adults 70-400 mm, and adults >400 mm (McPhail and Baxter, 1996; Warnock and Rasmussen, 2013).

Habitat assessments were conducted at sampled sites to answer MQ2 that included measurement of latitudinal gradients along the shoreline of sampled sites, depth, substrate material, vegetation, and water quality parameters (temperature, pH, conductivity, total dissolved solids, and dissolved oxygen). Habitat characteristics were also documented with photographs.

Reservoir elevation information collected during the study will be used to associate reservoir operations with the accessibility of nearshore habitats of the reservoir by juvenile Bull Trout in the Year 3 report.

2.1.2 Juvenile Bull Trout detection

A total of 105 juvenile Bull Trout were implanted with passive integrated transponder (PIT) tags in Packsaddle Creek (Stream Code: 300-8326; Figure 2). Details of the methodology for the capture, tagging, and detection are provided in the Year 1 and Year 2 reports (Kang and Warnock, 2016, 2017).

This report summarizes detection information of tagged fish from the antenna installed at Packsaddle Creek from Dec. 4, 2016 to Oct. 26, 2017.

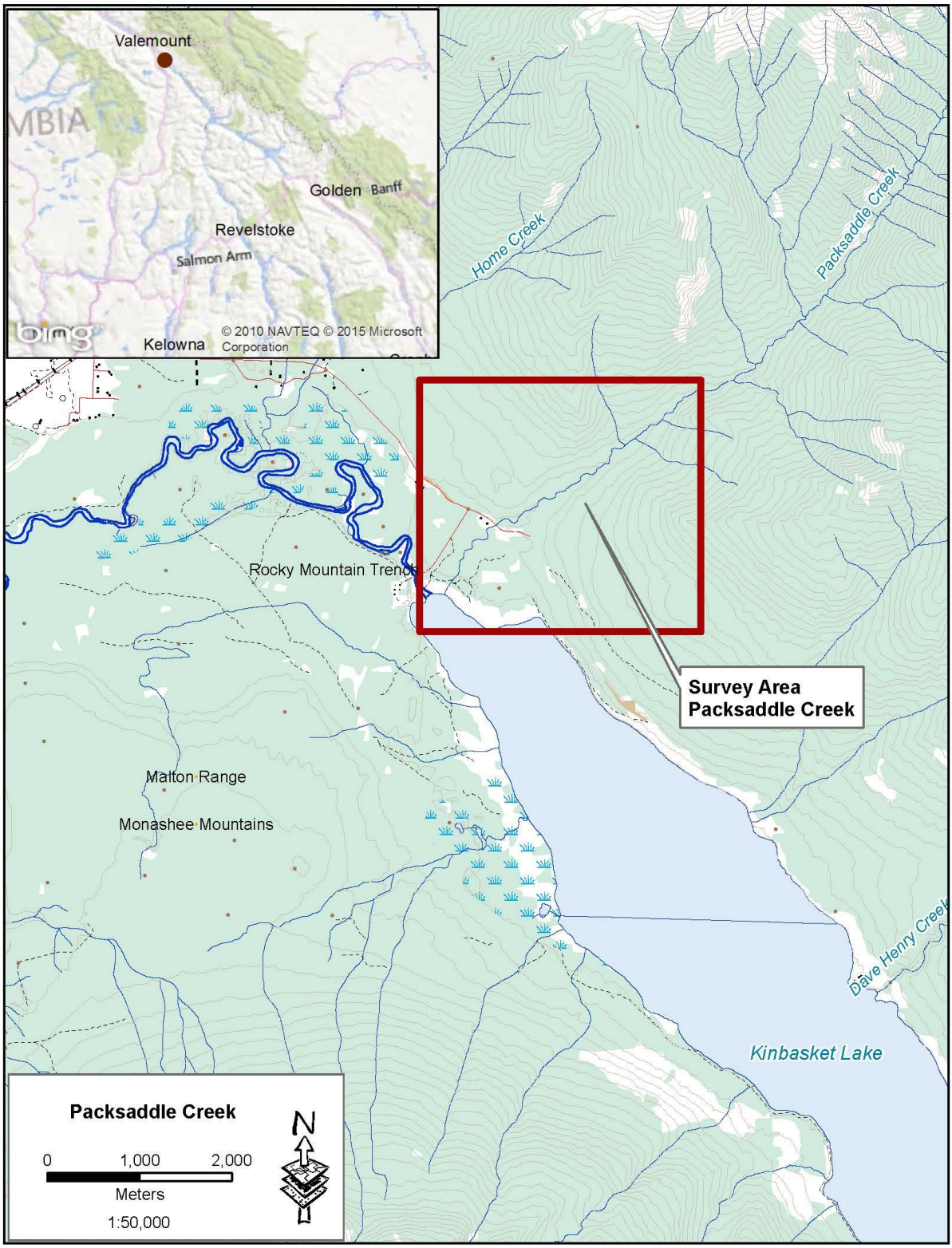


Figure 2: Map of electrofishing area on Packsaddle Creek.

3 Results

3.1 Nearshore Fish and Habitat Assessment

Fyke nets were set overnight along the nearshore zone of Kinbasket reservoir at 17 sites to assess shoreline use by Bull Trout in monthly sampling sessions from May 25 to June 14, 2017 (Figure 3). Site and water quality characteristics for all sampling sites are provided in Appendix 1.

A total of 17 Bull Trout (15 juvenile/sub-adult and 2 adult) were captured in fyke nets set at 11 locations throughout Kinbasket Reservoir (Figure 3; Table 1). Bull Trout ranged in size from 157 to 640 mm (mean length ± SD = 246.5 ± 146.78 mm; Figure 4; Table 1) and weighed 28 to 253 g (mean weight ± SD = 80.47 ± 54.35 g; Figure 5; Table 1). Other sportfish captured in fyke nets included 1 Burbot captured during the May sampling session near the entrance of the Columbia Reach and 12 Mountain Whitefish (May, June) (Table 1). Redside Shiner (*Richardsonius balteatus*), Northern Pikeminnow (*Ptychocheilus oregonensis*), and Peamouth Chub (*Mylocheilus caurinus*) were the most abundant species in order of decreasing abundance (Appendix 2). Information on all fish captured in fyke nets is listed in Appendix 2.

The maximum water temperature observed at Kinbasket Reservoir sites where Bull Trout were present was 16.0 °C (mean water temperature at fyke net sites was 11.3 ±3.7 °C; min water temperature = 1°C). In general, all Bull Trout (regardless of life stage or life history strategy) are cold water specialists and are seldom found in systems where water temperature exceeds 15°C for prolonged periods (McPhail and Baxter 1996).

Habitat assessments indicated that shoreline sites occupied by Bull Trout ranged in gradient from 0% to >30 % (mean gradient = 9.0 ± 5.39 %). Dominant and subdominant substrate of Bull Trout sites ranged from fines, gravel, and cobbles. Juvenile Bull Trout are often associated with abundant cover in the form of cobbles, large woody debris, and/or vegetation (Hammond, 2004). Of all 17 sampled sites, fines/sand was the dominant substrate at 71% of sites sampled, while substrates dominated by gravel and cobble made up only 29% and 29 % of sites, respectively. During the low pool period in early spring, substrates were predominantly fines, and Bull Trout sites had very little vegetation cover; however, during high pool, vegetation cover increased and included the presence of grasses and horsetail at sampling sites. All information collected during habitat assessments are detailed in Appendix 3. Statistics examining the associations between Bull Trout presence and various habitat features will be presented in the final report, when larger sample sizes are available.

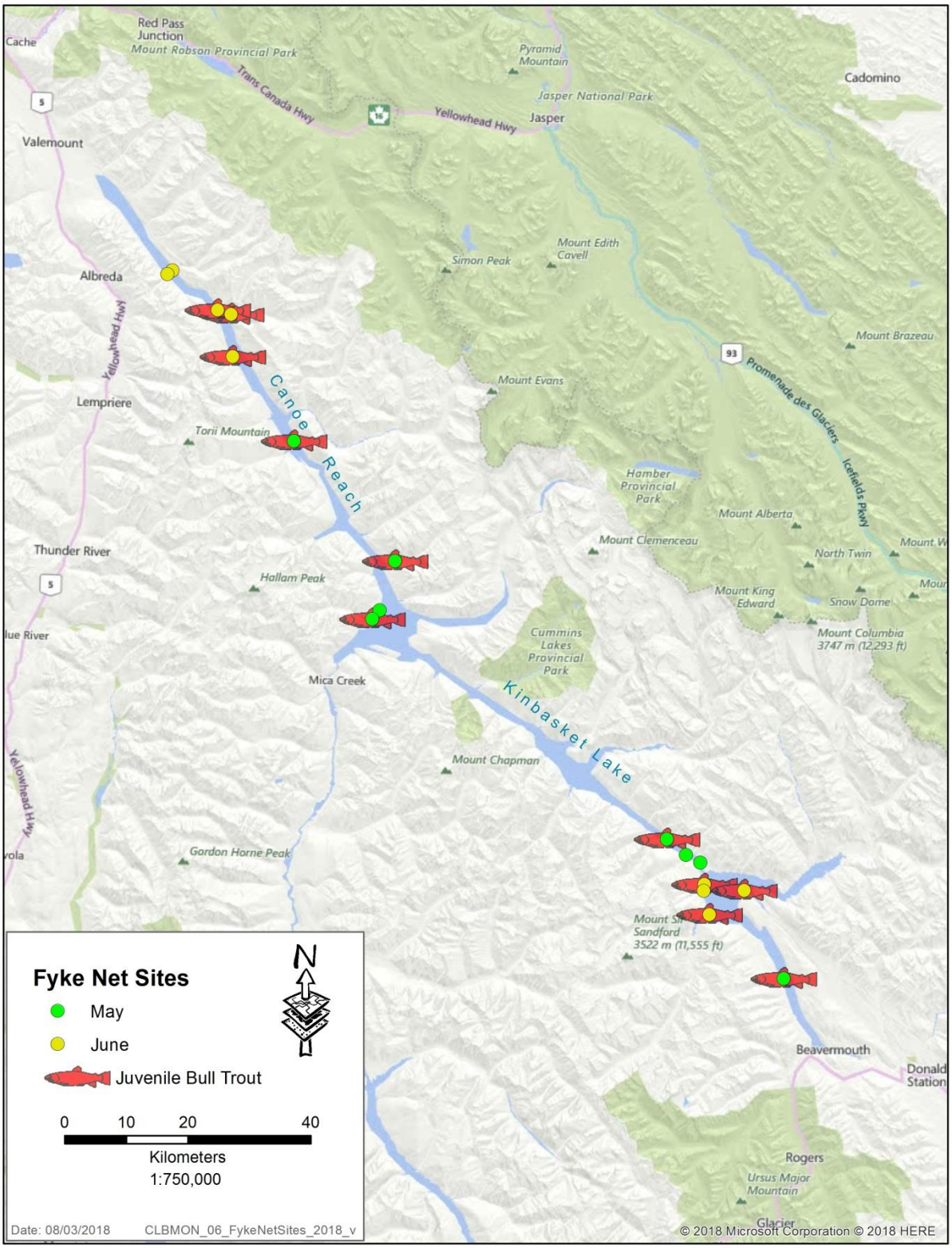


Figure 3: Locations of fyke net sampling sites and observations of Bull Trout in Kinbasket Reservoir (May 25 to June 14, 2017).

Table 1: Summary of sport fishes captured in fyke nets (n=16) set overnight along the nearshore zone of Kinbasket Reservoir from May 25 to June 14, 2017. Species abbreviations are: 'BT' - Bull Trout; 'BB' – Burbot; 'MW' - Mountain Whitefish.

Date	Location	Fyke Net #	UTM E	UTM N	Species	Count	Length (mm)	Weight (g)
25-May-17	Hugh Allan Creek	FN 1	385597	5806833	BT	1	199	83
25-May-17	Hugh Allan Creek	FN 1	385597	5806833	BT	1	164	28
25-May-17	Harvey Creek	FN 2	402040	5787358	BT	1	170	50
25-May-17	S Encampment Creek	FN 4	398372	5777917	BT	1	225	120
25-May-17	S Encampment Creek	FN 4	398372	5777917	BT	1	268	253
25-May-17	S Encampment Creek	FN 4	398372	5777917	BT	1	190	64
30-May-17	Colpitti Creek	FN 1	465224	5719534	BT	1	640	
30-May-17	Nixon Creek	FN 4	446274	5742181	BT	1	220	114
01-Jun-17	S. Surprise Rapids	FN 1	452340	5734806	BT	1	205	77
01-Jun-17	Gold Creek	FN 3	453172	5729959	BT	1	210	89
01-Jun-17	E. Succour Creek	FN 4	458844	5733846	BT	1	620	
14-Jun-17	Unknown tributary	FN 1	375632	5820546	BT	1	157	34
14-Jun-17	Unknown tributary	FN 1	375632	5820546	BT	1	169	44
14-Jun-17	Ptarmigan Creek	FN 2	375379	5827438	BT	1	193	67
14-Jun-17	N. Ptarmigan	FN 3	373214	5828140	BT	1	185	58
14-Jun-17	N. Ptarmigan	FN 3	373214	5828140	BT	1	183	57
14-Jun-17	N. Ptarmigan	FN 3	373214	5828140	BT	1	193	69
25-May-17	S Encampment Creek	FN 4	398372	5777917	BB	1	425	426
25-May-17	Harvey Creek	FN 2	402040	5787358	MW	1	900	83
25-May-17	S Encampment Creek	FN 4	398372	5777917	MW	1	342	398
25-May-17	S Encampment Creek	FN 4	398372	5777917	MW	1	317	366
30-May-17	Smith Creek	FN 3	449329	5739607	MW	7		
01-Jun-17	S. Surprise Rapids	FN 1	452340	5734806	MW	2		

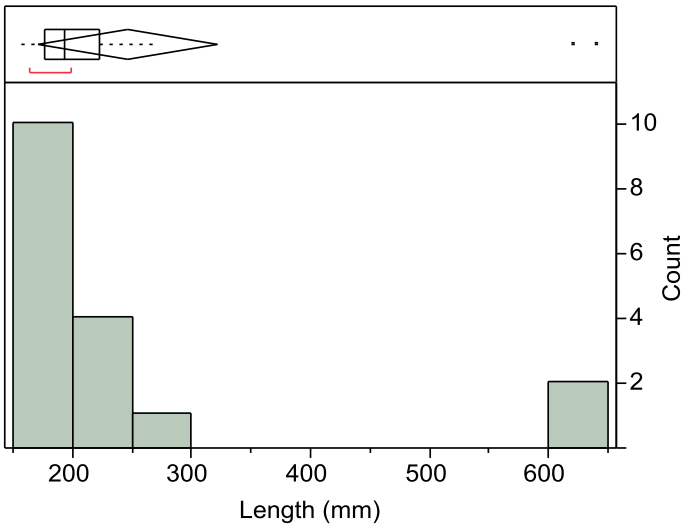


Figure 4: Distribution (histogram and box plot) of lengths (mm) of 17 Bull Trout in Kinbasket Reservoir (captured May 25 to June 14, 2017). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

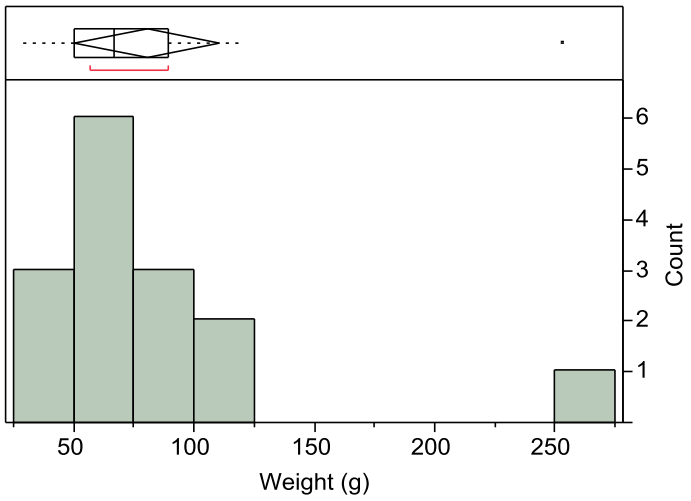


Figure 5: Distribution (histogram and box plot) of weights (g) of 17 Bull Trout in Kinbasket Reservoir (captured May 25 to June 14, 2017). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

3.2 Juvenile Bull Trout detection

Data downloaded from the antenna reader indicated that a total of 12 fish passed the Packsaddle Creek antenna between Dec. 4, 2016 to June 22, 2017 (Table 2). Of those fish that were detected, 8 were juvenile Bull Trout and 4 were Rainbow Trout (Table 2). Only single logs of the fish were recorded, which we assumed indicated unidirectional movement from the tributary to the reservoir. Details on the time and date of 11 detections were unavailable due to a malfunction with the internal clock of the antenna reader but were logged between Dec. 4, 2016 and Jun. 13, 2017. Mean length at tagging of detected Bull Trout was 115.5 ± 1 mm and mean weight at tagging of detected Bull Trout was 15.1 ± 9.88 g (Table 2).

Table 2: Summary of fish detected by antenna installed in Packsaddle Creek (Dec. 4, 2016 to Oct. 26, 2017). Species abbreviations are: 'BT' - Bull Trout; 'RB' - Rainbow Trout.

Species	Tag ID	Length (mm)	Weight (g)	Scan Period
RB	989.001006037214	85	7	Dec. 4, 2016 to Jun. 13, 2017
RB	989.001006037270	94	12	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001006037209	100	12	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001004470329	114	13	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001006037266	145	35	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001004470241	129	20	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001006037281	96	3	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001006037274	93	6	Dec. 4, 2016 to Jun. 13, 2017
RB	989.001004470332	83	8	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001004470247	132	19	Dec. 4, 2016 to Jun. 13, 2017
BT	989.001004470292	115	13	Dec. 4, 2016 to Jun. 13, 2017
RB	989.001006037196	98	9	June 22, 2017

4 Conclusions

The fyke net surveys of fish use of the nearshore habitat indicated the presence of juvenile Bull Trout at 65% of sampled sites. Suboptimal conditions related to temperatures > 15°C (McPhail, 2007) and fine substrate may limit the seasonal use of juvenile Bull Trout in these areas. Furthermore, if water levels are kept very low over vegetated shallow margins of the reservoir during summer, increasing water temperatures and suboptimal substrate further reduces the habitat available to juvenile Bull Trout. Negative effects may theoretically extend to later life stages as well, if extensive epilimnetic shallow areas created by the reservoir are impassable by adult bull trout due to thermal barriers to passage. We suggest conducting a comprehensive assessment of water temperatures in Kinbasket Reservoir using inexpensive temperature loggers to more fully evaluate the thermal suitability for various life cycle stages of Bull Trout, and determine the link of thermal regimes to reservoir operations.

Detection of juvenile Bull Trout during the antenna operation period in Fall 2015 indicated that outmigration might occur during low flow months towards the end of the growth season (Homel and Budy, 2008; Bowerman, 2013). Given that the majority of juveniles have not yet been detected, we suggest that the antenna in Packsaddle Creek operate for an additional year (spring to fall 2018) to ensure that outmigration of the maximum number of surviving tagged juvenile Bull Trout is recorded. Information from the Year 4 (2017-2018) antenna operation will provide further elucidation of movements associated with outmigration as part of their life history.

5 References

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Appendix 1: Summary of location, fyke net, and water quality details for sites along the nearshore zone of Kinbasket Reservoir sampled from May 25 to June 14, 2017.

Date	Location	UTM E	UTM N	Fyke Net #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	Secchi (cm)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Cond (µS/cm)	TDS (mg/L)	Comments
25-May-17	Hugh Allan Creek	385597	5806833	FN1	Perpendicular	12:30	48		Bottom	9:59	80cm	6.6	102.8		75.6	76.05	pH probe not working properly
25-May-17	Harvey Creek	402040	5787358	FN2	Perpendicular	13:00	60	1	Bottom	12:25	105cm	6.0	101.3	5.87	84.5	86.45	
25-May-17	N. Side of Encampment Creek	399557	5779374	FN3	Perpendicular	15:06	63	8	Bottom	14:05	98cm	9.1	102.2	4.34	97.8	91	
25-May-17	S. Side of Encampment Creek	398372	5777917	FN4	Perpendicular	15:30	54	6	Bottom	15:20		8.9		5.62	74.9	70.2	
30-May-17	Colpitti Creek	465224	5719534	FN1	Perpendicular	9:41	60	15	Bottom	8:52	121cm	16.0	100.7	7.39	171.5	134.55	
30-May-17	Little Foster Creek	451667	5738351	FN2	Perpendicular	10:58	52	13	Bottom	10:28	110cm	11.7	104.2	6.37	168	146.25	
30-May-17	Smith Creek	449329	5739607	FN3	Perpendicular	11:51	48	11	Bottom	11:28	107cm	11.7	107.2	8.36	169.6	147.55	
30-May-17	Nixon Creek	446274	5742181	FN4	Perpendicular	12:52	45	13	Bottom	12:23	104cm	12.6	108.7	8.33	179.7	153.4	
01-Jun-17	S. Surprise rapids	452340	5734806	FN1	Perpendicular	13:24	54	15	Bottom	8:38	107cm	13.6	97.1	11.73	169.5	141.7	
01-Jun-17	SW. Surprise Rapids	452236	5733788	FN2	Perpendicular	13:58	46	18	Bottom	9:32	98 cm	15.2	91	11.65	177.1	141.7	
01-Jun-17	Gold Creek	453172	5729959	FN3	Perpendicular	14:38	59	11	Bottom	10:38	95 cm	14.7	97.7	10.63	167.9	135.85	
01-Jun-17	E. Succour Creek	458844	5733846	FN4	Perpendicular	15:13	59	16	Bottom	11:34		15.3	94.7	10.97	201.3	160.55	
13-Jun-17	Unknown Creek	375632	5820546	FN 1	Perpendicular	9:41	6	9	Bottom	9:02	50cm	7.4	105.3		35.3	34.45	pH probe not working properly
13-Jun-17	Ptarmigan Creek	375379	5827438	FN 2	Perpendicular	10:41	3	9	Bottom	10:08	48.5cm	6.3	115.5		47.2	47.45	pH probe not working properly
13-Jun-17	N. Ptarmigan Creek	373214	5828140	FN 3	Perpendicular	11:06	14	12	Bottom	10:28	59cm	11.2	96.5		59.8	52.65	pH probe not working properly
13-Jun-17	Bulldog creek	365837	5834555	FN 4	Perpendicular	12:21	19	14	Bottom	11:28		11.8	101.5		50.8	44.2	Net collapsed. pH probe not working properly
14-Jun-17	Blackmore creek	365054	5833945	FN1	Perpendicular	12:06	3	12	Bottom	9:00	47cm	10.6	103.6		48.6	43.55	pH probe not working properly

Appendix 2: Summary of all fishes captured with fyke nets (n=17) set overnight along the nearshore zone of Kinbasket Reservoir from May 25 to June 14, 2017. Species abbreviations are: 'BB' – Burbot (*Lota lota*); 'BT' - Bull Trout (*Salvelinus confluentus*); 'CAS' - Prickly Sculpin (*Cottus asper*); 'CC' – Sculpin spp. (*Cottus* spp.); 'CRH' – Torrent Sculpin (*Cottus rhotheus*); 'CSU' - Largescale Sucker (*Catostomus macrocheilus*); 'KO' – Kokanee (*Oncorhynchus nerka*); 'LNC' – Longnose Dace (*Rhinichthys cataractae*); 'LSU' – Longnose Sucker (*Catostomus catostomus*); 'MW' - Mountain Whitefish (*Prosopium williamsoni*); 'NSC' – Northern Pikeminnow (*Ptychocheilus oregonensis*); 'PCC' – Peamouth Chub (*Mylocheilus caurinus*); 'PMB' – Pumpkinseed Sunfish (*Lepomis gibbosus*); 'RB' - Rainbow Trout (*Oncorhynchus mykiss*); 'RSC' – Redside Shiner (*Richardsonius balteatus*).

Date	Location	Fyke Net #	Species	Count	Length (mm)	Weight (g)	Comments
25-May-17	Hugh Allan Creek	FN 1	PCC	7			
25-May-17	Hugh Allan Creek	FN 1	RSC	8			
25-May-17	Hugh Allan Creek	FN 1	CAS	1			Dead (Partially digested)
25-May-17	Hugh Allan Creek	FN 1	BT	1	199	83	
25-May-17	Hugh Allan Creek	FN 1	BT	1	164	28	
25-May-17	Harvey Creek	FN 2	RSC	30			
25-May-17	Harvey Creek	FN 2	CAS	8			
25-May-17	Harvey Creek	FN 2	PCC	8			
25-May-17	Harvey Creek	FN 2	MW	1	900	83	
25-May-17	Harvey Creek	FN 2	BT	1	170	50	
25-May-17	N Encampment Creek	FN3	NSC	2			
25-May-17	N Encampment Creek	FN 3	RSC	27			
25-May-17	N Encampment Creek	FN 3	CAS	7			
25-May-17	S Encampment Creek	FN 4	CAS	12			
25-May-17	S Encampment Creek	FN 4	PCC	36			
25-May-17	S Encampment Creek	FN 4	RSC	124			
25-May-17	S Encampment Creek	FN 4	SSU	27			
25-May-17	S Encampment Creek	FN 4	BB	1	425	426	
25-May-17	S Encampment Creek	FN 4	MW	1	342	398	
25-May-17	S Encampment Creek	FN 4	MW	1	317	366	
25-May-17	S Encampment Creek	FN 4	BT	1	225	120	
25-May-17	S Encampment Creek	FN 4	BT	1	268	253	
25-May-17	S Encampment Creek	FN 4	BT	1	190	64	Vermiculations on the edges of caudle and dorsal fins and dorsal side of fish - looks to be the product of hybridization between Bull trout and Brook trout (see photos)
30-May-17	Colpitti Creek	FN 1	RSC	101			Two redside shiner partially digested and regurgitated by Bull trout
30-May-17	Colpitti Creek	FN 1	PCC	23			
30-May-17	Colpitti Creek	FN 1	NSC	87			White fungus found on small Pikeminnow (see photos)

30-May-17	Colpitti Creek	FN 1	CSU	5			
30-May-17	Colpitti Creek	FN 1	LSU	1			
30-May-17	Colpitti Creek	FN 1	SSU	9			
30-May-17	Colpitti Creek	FN 1	CAS	9			
30-May-17	Colpitti Creek	FN 1	BT	1	640		
30-May-17	Little Foster Creek	FN 2	NSC	23			
30-May-17	Little Foster Creek	FN 2	RSC	208			
30-May-17	Little Foster Creek	FN 2	PCC	51			
30-May-17	Little Foster Creek	FN 2	CSU	4			
30-May-17	Little Foster Creek	FN 2	LSU	1			
30-May-17	Little Foster Creek	FN 2	CAS	4			
30-May-17	Smith Creek	FN 3	RSC	398			Started to subsample half way through processing - too many fish; Started with 113 RSC then subsampled: 1 scoop = 3 NSC, 5 RSC; 57 scoops
30-May-17	Smith Creek	FN 3	PCC	22			
30-May-17	Smith Creek	FN 3	MW	7			3 MW died while processing
30-May-17	Smith Creek	FN 3	NSC	176			Started to subsample half way through processing - too many fish; Started with 5 NSC then subsampled: 1 scoop = 3 NSC, 5 RSC; 57 scoops
30-May-17	Smith Creek	FN 3	CSU	1			
30-May-17	Nixon Creek	FN 4	BT	1	220	114	Too many fish to process
01-Jun-17	S. Surprise Rapids	FN 1	NSC	18			
01-Jun-17	S. Surprise Rapids	FN 1	RSC	96			
01-Jun-17	S. Surprise Rapids	FN 1	PCC	14			
01-Jun-17	S. Surprise Rapids	FN 1	LSU	4			
01-Jun-17	S. Surprise Rapids	FN 1	CAS	7			
01-Jun-17	S. Surprise Rapids	FN 1	MW	2			
01-Jun-17	S. Surprise Rapids	FN 1	BT	1	205	77	
01-Jun-17	SW. Surprise Rapids	FN 2	See comments				Net collapsed - did not process fish; many RSC in net that died with ruptured abdomens; parasite escape wound? Rigor mortis had not yet set in
01-Jun-17	Gold Creek	FN 3	BT	1	210	89	Net collapsed due to storm the night before, middle lead buried under large amount of sediment. Did not process fish (mostly RSC and NSC), observed exploded abdomens and parasites in RSC
01-Jun-17	E. Succour Creek	FN 4	NSC	74			Net partially collapsed; out wing had no rebar
01-Jun-17	E. Succour Creek	FN 4	RSC	213			
01-Jun-17	E. Succour Creek	FN 4	PCC	25			
01-Jun-17	E. Succour Creek	FN 4	CAS	1			
01-Jun-17	E. Succour Creek	FN 4	LSU	19			
01-Jun-17	E. Succour Creek	FN 4	BT	1	620		BT too large to weight.
14-Jun-17	Unknown tributary	FN 1	BT	1	157	34	
14-Jun-17	Unknown tributary	FN 1	BT	1	169	44	
14-Jun-17	Ptarmigan Creek	FN2	BT	1	193	67	
14-Jun-17	Ptarmigan Creek	FN 2	RSC	2			
14-Jun-17	Ptarmigan Creek	FN 2	CAS	3			
14-Jun-17	N. Ptarmigan	FN 3	LSU	4			Spawning colours and tubercles on anal and caudle fin (See photos)
14-Jun-17	N. Ptarmigan	FN 3	PCC	6			
14-Jun-17	N. Ptarmigan	FN 3	CCL	10			
14-Jun-17	N. Ptarmigan	FN 3	RSC	71			
14-Jun-17	N. Ptarmigan	FN 3	BT	1	185	58	
14-Jun-17	N. Ptarmigan	FN 3	BT	1	183	57	

14-Jun-17	N. Ptarmigan	FN 3	BT	1	193	69	
14-Jun-17	Bulldog Creek	FN 4	NFC				
15-Jun-17	Blackmore Creek	FN 1	RSC	10			
15-Jun-17	Blackmore Creek	FN 1	NSC	1			

Appendix 3: Summary of habitat assessments of sites along the nearshore zone of Kinbasket Reservoir sampled from May 25 to June 14, 2017.

Date	Location	UTM E	UTM N	Fyke Net #	Transect 1						Transect 2						Vegetation cover	Upland vegetation cover	Dominant Substrate	Subdominant Substrate	Comments
					Location relative to FN	Slope T1	Slope T2	Slope T3	Slope T4	Slope T5	Location relative to FN	Slope T1	Slope T2	Slope T3	Slope T4	Slope T5					
25-May-17	N. Side of Encampment Creek	399557	5779374	FN3	SE	5	6	6	8	13	NW	6	6	11	30	30	N/A	Douglas fir (Pseudotsuga menziesii), Trembling aspen (Populus tremuloides), Alder (Alnus spp.)	Fines	Silt	
25-May-17	S. Side of Encampment Creek	398372	5777917	FN4	SE	4	5	6	5	10	NW	6	6	7	6	7	N/A	Douglas fir (Pseudotsuga menziesii), Trembling aspen (Populus tremuloides), Alder (Alnus spp.)	Fines	Gravel	
30-May-17	Colpitti Creek	465224	5719534	FN1	SE	10	10	5	7	4	NW	12	15	5	5	5	N/A	Trembling aspen (Populus tremuloides)	Fines	Clay	
30-May-17	Little Foster Creek	451667	5738351	FN2	SE	8	5	7	9	16	NW	6	6	11	+30	+30	N/A	Trembling aspen (Populus tremuloides), Engelmann spruce (Picea engelmannii)	Fines	Gravel	
30-May-17	Smith Creek	449329	5739607	FN3	W	5	12	+30	+30	+30	E	7	6	9	10	15	N/A	Douglas fir (Pseudotsuga menziesii), Engelmann spruce (Picea engelmannii)	Fines	Clay	
30-May-17	Nixon Creek	446274	5742181	FN4	W	11	10	12	11	7	E	12	9	6	9	10	N/A	Trembling aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii), Engelmann spruce (Picea engelmannii)	Fines	Gravel	
01-Jun-17	S. Surprise rapids	452340	5734806	FN1	SE	4	11	10	13	See comments							N/A	N/A	Fines	Gravel	Island long and arrow shaped - unable do complete

																				habitat survey due to the narrowness and small width; took gradient from reservoir elevation to height of island
01-Jun-17	SW. Surprise Rapids	452236	5733788	FN2	SE	4	5	4	4	5	NW	3	5	5	5	7	N/A	Trembling aspen (Populus tremuloides), Engelmann spruce (Picea engelmannii), Douglas fir (Pseudotsuga menziesii)	Fines	Sands	
01-Jun-17	Gold Creek	453172	5729959	FN3	N	27	13	8	9	8	S	+ 30	+ 30	+30	+30	+30	N/A	Trembling aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii)	Fines	Fines	
01-Jun-17	E. Succour Creek	458844	5733846	FN4	SW	17	25	19	12	7	NE	19	18	20	15	16	N/A	Trembling aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii)	Fines	Cobble	
13-Jun-17	Unknown Creek	375632	5820546	FN 1	SW	10	11	15	13	6	NE	+30	+30	+30	+30	+30	Lingonberry?	Trembling aspen (Populus tremuloides), Engelmann Spruce (Picea engelmannii), Western red cedar (Thuja plicata) - small in understorey	Cobble	Sands	
13-Jun-17	Ptarmigan Creek	375379	5827438	FN 2	E	3	3	2	1	1	W	1	2	2	3	2	N/A	Trembling aspen (Populus tremuloides), Grand fir (Abies	Cobble	Sands	

																		grandis), Alder (Alnus spp.), Lodge pole pine (Pinus contorta)			
13-Jun-17	N. Ptarmigan	373214	5828140	FN 3	SW	7	10	11	10	13	NE	7	9	6	6	5	N/A	N/A	Cobble (SW)	Sands (SW)	
13-Jun-17	Bulldog Creek	365837	5834555	FN4	SW	15	12	8	10	6	NE	7	9	7	+30	+30	N/A	Trembling aspen (Populus tremuloides), Alder (Alnus spp.), Grand fir (Abies grandis), Engelmann spruce (Picea engelmannii)	Cobble	Sand	
14-Jun-17	Blackmore Creek	365054	5833945	FN 1	S	16	11	14	15	14	N	8	11	12	12	12	N/A	Trembling aspen (Populus tremuloides), Grand fir (Abies grandis), Engelmann spruce (Picea engelmannii) Alder (Alnus spp.), Western red cedar (Thuja plicata)	Cobble	Sands	