Columbia River Project Water Use Plan

BCH RESERVOIR

Reference: CLBMON-06

Kinbasket Reservoir Juvenile Bull Trout Life History and Habitat Use Assessment

Study Period: 2014 – 2019

Ktunaxa Nation Council Society

March 24, 2020

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BCH RESERVOIR

Monitoring Program No. CLBMON-06
Kinbasket Reservoir Juvenile Bull Trout Life History and Habitat Use Assessment

Final Report

Prepared for

BC Hydro

BC Hydro Generation
Water Licence Requirements
6911 Southpoint Drive
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Cover photo:

View of Kinbasket Reservoir from island north of Gold Creek, June 27, 2018 (Misun Kang, Ktunaxa Nation Council).

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 sportfish 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 operations on juvenile Bull Trout; iii) whether modifications to the operation of Kinbasket Reservoir could protect or enhance juvenile Bull Trout populations.

Basic life history. Bull Trout movements were tracked from Packsaddle Creek, a tributary of Kinbasket Reservoir using passive integrated transponder (PIT) tags and a fixed antenna installed near the confluence with Kinbasket Reservoir. Tracking occurred in 2015 (Aug. 31 - Nov. 10), 2016 (Mar. 31 - Dec. 4), 2017 (Apr. 2 - Dec. 23), and in 2018 (Mar. 11 to Oct. 27). A total of 120 Bull Trout (2015 = 97; 2016 = 23) were captured using electrofishing and 105 Bull Trout (101 juveniles/sub-adults) were implanted with PIT tags, mainly during 2015. Juvenile/sub-adult Bull Trout ranged in size from 44 to 398 mm (mean length 120 mm.) and ranged in weight from 0.5 to 652 g (mean weight 28.7g).

A total of 39 Bull Trout (3 adults and 36 juveniles) were detected by the fixed antenna reader. Detections suggest that the timing of outmigration of juvenile Bull Trout from Packsaddle Creek coincides with the peak flows of spring freshet (May-June) and fall rains (Sept-Oct; Section 4.1.1) towards the end of the growth season. The 3 adults emigrated during Sept/Oct 2015, during the spawning period. Only single logs of all fish were recorded, which we assumed indicated unidirectional movement from the tributary to the reservoir.

Habitat use. Fyke nets were set overnight along the nearshore zone of Kinbasket reservoir at 86 sites to assess shoreline use by Bull Trout from April 2016 to August 2018. A total of 38 juvenile/sub-adult Bull Trout were captured at 22 locations (26% of all surveyed sites) and were highly associated with cobbles (concentrated at higher elevations) and sand (common at all elevations) substrate (Section 8.5.2). Juvenile/sub-adult Bull Trout sizes ranged from 85 to 360 mm (mean length 193) and weights ranged from 14 to 570 g (mean weight 108.5). Based on comparison of length data collected from juveniles tagged in Packsaddle Creek and those captured in Kinbasket Reservoir, the difference in mean lengths represents a 56% increase and suggests that outmigration from Packsaddle Creek occurs at age 2+ years and corroborates estimates from the outmigration study (Sections 8.5.1 and 8.5.2).

Nearshore areas of Kinbasket Reservoir likely provide sub-optimal temperature and substrate conditions for juvenile Bull Trout. Temperatures in summer ranged near the maximum water temperature of 15°C in which Bull Trout have been observed. Cover was lacking in most areas as fine/sand substrate made up 72% of sites, while gravel and cobble substrates made up only 8% and 17% of sites, respectively.

Suboptimal conditions related to temperatures > 15°C (McPhail, 2007) and fine substrate may limit the seasonal use of juvenile Bull Trout in areas with these conditions. Furthermore, if reservoir elevations rise slowly during summer, increasing water temperatures over vegetated shallow margins and preferred substrate cover (leaving little cover) further reduce suitable habitat available to juvenile Bull Trout (Section 4.1.2).

Effect of operations. There was no evidence of an effect of reservoir elevation on Bull Trout captures in nearshore zones (Section 8.5.2).

Due to safety and logistical constraints, an assessment of juvenile Bull Trout access to and dispersal from natal streams could not be conducted. Thus, we cannot address whether modifications to enhance juvenile Bull Trout access to streams would be necessary or effective. A recommendation to potentially address these shortcomings will be developed in an internal memo to BC Hydro.

It was not possible to evaluate whether juvenile Bull Trout populations are declining due to dam operations as juvenile catches were too low to assess any trend.

Final status of CLBMON-06

Management Question	Hypothesis	Summary of Key Monitoring Results
MQ-1: What are the basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir (e.g., distribution, age structure)?		• Juvenile Bull Trout appear to be evenly distributed among spawning tributaries throughout Kinbasket Reservoir; • Juvenile Bull Trout are more highly associated with Cobble/Sand substrates than with Fines
MQ-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?	H1: Operation of Kinbasket Reservoir has no effect on juvenile Bull Trout, given the seasonal timing and size/age of juveniles emigrating to the reservoir. H2: Operation of Kinbasket Reservoir affects emigration of juvenile Bull Trout.	The management question could not be answered due to logistical constraints and safety issues. An internal memo will be prepared to BC Hydro detailing how some of these shortcoming may be addressed through potential investigations and whether habitat restoration opportunities can be developed if needed.
MQ-3: Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance juvenile Bull Trout populations?		The management question could not be addressed as the effects of reservoir operations on juvenile Bull Trout could not be fully assessed – cf. above.

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1.0 INTRODUCTION

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).

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).

Bull Trout growth is initially rapid and most populations reach a mean length of 60-70 mm by the end of their first summer; mean length typically exceeds 100 mm by the end of their second summer, and mean length approaches 200 mm by the end of their third summer (Sterling 1978; McPhail and Murray 1979; Oliver 1979; Craig and Bruce 1982; Fraley and Shepard 1989; Ratliff 1992; Ziller 1992). Above 200 mm, the rate of growth varies with habitat with many stream-resident populations reaching maturity at this stage (Robinson and McCart 1974; Craig and Bruce 1982). Individuals smaller than 200 mm are rarely found in lakes, reservoirs or larger rivers (McPhail and Murray 1979; Craig and Bruce 1982; Bruce and Starr 1985; Fraley and Shepard 1989). This suggests that recruitment from rearing streams is less successful at smaller sizes (McPhail and Murray 1979).

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 (i.e., populations that spawn in tributary streams and reside in lakes or reservoirs), age at outmigration can vary. McPhail and Murray (1979) found that emigration to Arrow Lakes from the spawning streams occurs throughout the summer, and involves fry, 1+, 2+, and 3+ juveniles, although the majority of adult Bull Trout caught in the lake emigrated at age 2. The majority of migrants to Koocanusa Reservoir are 2+ (Chisholm et al. 1989). 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 accounted for the majority of outmigrants for studies conducted in Mackenzie Creek (tributary to Arrow Lakes) and Trestle Creek (tributary to Lake Pend D'Oreille), likely due to

displacement by freshet flows and streams rapidly reach carrying capacity (McPhail and Baxter, 1996; Downs et al., 2006). However, the observations in these studies that the majority of sampled adult fish or spawners emigrated at age 2-4 implies that fry outmigrants have poor survival and fitness, contribute insignificantly to adult returns, and that at least two or three years of stream residence is critical for successful adult recruitment (McPhail and Baxter, 1996; Downs et al., 2006). Juveniles, mainly aged 2+ and 3+, remained in tributary streams until they reached about 300 mm in the Skagit system (McPhail and Keeley, in prep.).

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 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 et al. (2007) reported that juvenile Bull Trout occupy shallow, shoreline habitat and that they may have high affinity to substrate cover in lacustrine environments in 4 lakes of Glacier National Park, Montana. 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*) when juvenile Bull Trout transition to piscivory and are 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 this 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 was 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 four year study period.

This four year monitoring program provides 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 provides the information 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.

2.0 STUDY AREA

Kinbasket Reservoir 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.

3.0 METHODS

3.1 *Overview*

The approach of this study was 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. A list of candidate streams was developed to identify streams that met study criteria and due to logistical and sampling constraints, outmigration was only assessed at Packsaddle Creek (see Section 8.2.1). Capture of fish in Packsaddle Creek 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 overnight fyke-netting surveys in the spring/summer period during reservoir refilling took place from 2016 to 2018 to assess the use of shoreline habitats by juvenile and sub-adult Bull Trout. Sites were selected based on gradient for installation of fyke nets, usually in water depths of < 1 m. This survey program additionally consisted of habitat assessments within the drawdown zone to identify potential resources available to juvenile and sub-adult Bull Trout.

See Section 8.2 for further details on methodology for the study.

3.2 *Datasets*

Table 1: Summary of datasets collected for the CLBMON-06 of Kinbasket Reservoir.

Dataset	Reference	Management Question addressed
Year 1 Bull Trout capture and tracking	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr1-2016-03-14.pdf	MQ-1, MQ-2
Year 1 nearshore fish survey	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr2-2017-02-20.pdf	MQ-1, MQ-2
Year 1 nearshore habitat survey	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr2-2017-02-20.pdf	MQ-1, MQ-2
Year 2 Bull Trout capture and tagging	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr2-2017-02-20.pdf	MQ-1, MQ-2

Year 2 nearshore fish survey	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr3-2018-07-03.pdf	MQ-1, MQ-2
Year 2 nearshore habitat survey	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-6-yr3-2018-07-03.pdf	MQ-1, MQ-2
Year 3 nearshore fish survey	Current report	MQ-1, MQ-2
Year 3 nearshore habitat survey	Current report	MQ-1, MQ-2

3.3 *Data relevant to Management Questions*

The main body of this report summarizes the synthesis of data analyses conducted for the 4-year study to answer the MQs. The synthesis of data analyses are presented in Appendix 2 (Section 8.4). Table 1 provides an overview of data relevant to MQs 1 and 2. Due to logistical and safety constraints in collection of data during the low-pool period, we were not able to directly assess access during low-pool conditions for juvenile Bull Trout emigrating to the Reservoir during Winter-early Spring, but we used observational data of habitat to answer MQ3 (effect of operations). We provide recommendations in Section 5.0 to address knowledge gaps to further address MQs.

The study was designed to answer three management questions (MQs). Unfortunately, the main drawbacks of work on Kinbasket reservoir are the size of the system, and inability to conduct on-reservoir work during the low-pool period from January-March. The remoteness of the reservoir requires extensive travel with limited safe access and contact points. During the low-pool period, Kinbasket reservoir has unpredictable, dynamic ice conditions that make on-reservoir winter work unsafe.

4.0 Management Questions

4.1 MQ1: What are the basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir (e.g., distribution, age structure)?

4.1.1 Juvenile Bull Trout outmigration and age structure

Length and weight of Bull Trout captured in 2015 and 2016 in Packsaddle Creek are summarized in Table 2 (see Section 8.5.1 and A2 Table 5 for more details).

Table 2: Summary of length and weight of Bull Trout captured in Packsaddle Creek for CLBMON-6 study (2016-2016). Not all Adult Bull Trout weights were recorded so are not summarized here.

Bull Trout Age Class	Mean Length ± SD (mm), n	Length Interquartile Range (mm)	Length Min/Max (mm)	Mean Weight ± SD (kg), n	Weight Interquartile Range (mm)	Weight Min/Max (mm)
Juvenile/sub-adult	120.4 ± 46.18, 111	86 - 126	44/398	28.7 ± 78.13, 80	6 - 18	0.5/652
Adult	659.1 ± 115.40, 4	574 - 738	445/615			

Detections of juvenile Bull Trout suggest that the timing of outmigration of juvenile Bull Trout from Packsaddle Creek likely coincides with the peak flows of spring freshet (May-June) and fall rains (Sept-Oct) towards the end of the growth season (Downs et al., 2006; Homel and Budy, 2008; Bowerman, 2013). However, more information is required to confirm the exact timing of outmigration as the majority of detections could only be identified for time periods that coincided with data downloads due to antenna malfunction, and the antenna did not operate during winter.

Comparison of the length and weight of juvenile Bull Trout captured for tagging in Packsaddle Creek and those captured in the Kinbasket nearshore fish surveys suggests that outmigration occurs at age 2+ years (see Sections 8.5.1and 8.5.2). Further aging assessment is required by repeating the outmigration study to confirm at what age Bull Trout outmigrate to the reservoir.

4.1.2 Nearshore fish and habitat surveys

Bull Trout were evenly distributed among spawning tributaries throughout Kinbasket Reservoir (see Section 8.5.2 and A2 Figure 7) and appeared to have similar Catch per Unit Effort (CPUE; i.e., abundance relative to capture efficiency) relative to other lakes that have been studied in British Columbia (Hagen and Decker 2011). The fyke-net surveys of fish use of the nearshore habitat indicated the presence of juvenile Bull Trout in 38 out of 86 (26%) sampled sites. This observation is contrary to McPhail's (2007) suggestion that juvenile Bull Trout rarely occupy the littoral zone of lakes and prefer pelagic habitat (see Section 1.0). Comparing juvenile Bull Trout use of pelagic and littoral habitats was outside the scope for this study; however, our data indicated that juvenile Bull Trout do occupy the nearshore area of Kinbasket Reservoir (see Section 8.5.2). There was some evidence of a difference in the mean capture efficiency among the different substrates, but the wide confidence bounds precluded evidence of a difference except between Fine and Cobble/Sand substrates – more juvenile Bull Trout were captured on Cobble/Sand substrate than Fine substrate (Section 8.5.2).

There was no evidence of an effect of elevation on juvenile Bull Trout capture efficiency even when accounting for the effects of elevation on substrate type (Section 8.5.2; A2 Figure 14; A2 Figure 15). Cobble and boulder/gravel substrates were concentrated at higher elevations while sand was common at all elevations (A2 Figure 15). These findings suggest that although juvenile Bull Trout will utilize fines/sand substrates (the only available substrate at low elevations), they utilize cobble and boulder/gravel substrates where they become available at higher elevations, highlighting their preference for the additional cover provided by these substrate types.

Suboptimal conditions related to temperatures > 15°C (A2 Table 2; A2 Table 8; A2 Figure 18; references cited in McPhail and Baxter 1996) and fine substrate may limit the seasonal use of juvenile Bull Trout of littoral areas of the drawdown zone. Furthermore, if reservoir elevations rise slowly during summer, increasing water temperatures over vegetated shallow margins and preferred substrate cover (leaving little cover), further reduce suitable habitat available to juvenile Bull Trout. Bull Trout have been observed to move to cooler pelagic zones when temperatures exceed 15 °C in the littoral zone (Bjornn, 1961); however this study, as well as others (McPhail and Baxter 1996), recorded Bull Trout use of the littoral zone. Although Bull Trout were captured in these suboptimal areas, it's unclear to what extent Bull Trout utilize them as assessment of pelagic habitat use was outside the scope of this study and timing of Bull Trout movement to sites could not be determined with our sampling technique. Bull Trout

exhibit diel vertical migration (i.e., ascent to the water surface at dusk and descent at dawn; Neilson and Perry,1990; Gutowsky et al., 2013) so Bull Trout capture in the nearshore sites might have occurred during dusk while temperatures were <15°C. Negative effects of temperatures >15°C may theoretically extend to later life stages as well, if extensive shallow areas created by the reservoir are impassable by adult bull trout due to thermal barriers to passage. These thermal barriers may prevent Bull Trout from accessing spawning tributaries, especially if they are located near confluences with extensive low gradient margins where cooler water flowing from the tributary is quickly warmed by the reservoir.

A comprehensive assessment of water temperatures in the Kinbasket Reservoir drawdown zone using inexpensive temperature loggers may help to more fully evaluate the thermal suitability for various life cycle stages of Bull Trout, and determine the link between thermal regime and reservoir operations. An internal memo containing details of such an assessment will be developed and sent to BC Hydro.

4.1.3 Challenges and Opportunities

- Due to logistical and safety constraints in collecting data during the low-pool period (winter-early spring), we were not able to access study sites to assess juvenile Bull Trout use of nearshore zones of the Reservoir;

- Assessments of outmigration could not be made on larval fry and young-of-year <65 mm as these were not of adequate size for PIT tagging;

- High correlation between reservoir elevation and time (i.e., reservoir filling occurs throughout spring/summer) made it difficult to assess a relationship between Bull Trout capture and elevation due to confounding with time (see Section 8.5.2). Higher elevation could be associated with lower capture rates but is likely an artefact of Bull Trout seasonal development as they move away from the nearshore zones towards the end of their growth season;

- Larger sample sizes are required to detect any effect of reservoir elevation on capture efficiency. The current design leads to large variation in data values making it difficult to detect effects of elevation on Bull Trout capture.

If additional samples are taken in future years to augment this dataset, some care needs to be taken to ensure that the data are comparable. The easiest way to accomplish this would be to continue with the current design and simply repeat the protocol with some improvements to increase mean capture rate: i) longer soak time (not recommended given that survival of fish would decrease); ii) restricting sampling to substrates with higher densities of Bull Trout; or iii) selecting sites where Bull Trout presence has been confirmed, for all substrates (if possible).

If i) is pursued (i.e., the same design were to be used with a longer soak time), the data could be combined with the current data and there would be no change in the analysis. However, this approach would increase the likelihood of fish mortality. Similarly, if ii) is pursued (i.e., more samples are taken in the future only over Cobble or Sand substrates where Bull Trout capture has been higher compared to other substrates), this data could also be combined with the current data. However, establishing these sites to ensure adequate sample size for analyses will likely be difficult.

If iii) is pursued (i.e., the design were to focus on sites where Bull Trout presence has been confirmed rather than a 'random' selection of sites within a habitat), then future analyses will need to account for this with a breakpoint model (Schwarz, 2019), where data prior to 2019 is separated from data in 2019 onwards, a point where we expect a difference in the relationship between Bull Trout capture and elevation between the different datasets. All these design changes could improve power dramatically.

For example, the current average capture rate is about 2 fish/sampling event. If it were possible to increase soak time (while managing fish mortality), or select only certain substrates (cobble), or concentrate sampling on sites with an average capture rate of 8 fish/h (unrealistic as our highest capture rate was 6 Bull Trout per site), then the resulting power curve indicates that fewer sites would be required to detect a 2 % decline in capture rate with every meter of elevation (see Section 8.5.2; A2 Figure 17). These protocol changes to increase capture rates would require considerably more effort than the current protocol but would provide improved power to detect an effect of elevation on Bull Trout habitat use.

4.2 MQ2: 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?

As discussed, the majority of juvenile Bull Trout outmigration likely occurs at age 2+ years (see Section 8.5.1) and coincides with peak flows of spring freshet (May-June) and fall rains (Sept-Oct) towards the end of the growth season (Downs et al., 2006; Homel and Budy, 2008; Bowerman, 2013). Juvenile Bull Trout emigrating during spring freshet encounter low reservoir elevation conditions and potentially restricted movement at confluence areas that are eroded by reservoir operations. Alluvial fans in the lower reaches of these streams create multiple, shallow channels, which may impede migration, especially during years of low stream flows. For example, Horse, Dave Henry and Yellowjacket creeks flow into the northeastern extent of the Canoe Reach with undefined channel morphologies (Warnock and Caley, 2019). These streams flow through alluvial fans made up of multiple braided, shallow channels through long sections of the drawdown zone. Reservoir operations may create or contribute to the instability and erosion of these channels through disruption of instream flows and inundation during high reservoir elevation periods that remove substrate stabilizing features (e.g., rooted vegetation, coarse substrate). The swimming capabilities of juvenile Bull Trout are largely unknown as is their ability to disperse through these unstable and shallow channels during low-pool periods; moreover they also offer little cover from predators.

Furthermore, McPhail and Baxter (1996) identified that the effects of dams on changes in natural flows could potentially have significant impacts on Bull Trout fry. Although fry outmigration could not be assessed in this study, McPhail and Murray (1979) suggested that most young-of-the-year emigrate as fry during spring freshet in Mackenzie Creek, a tributary to Upper Arrow Lake. Young-of-the-year seek interstitial cover when disturbed and to avoid predators. This micro-habitat is especially vulnerable to changes in water levels and sudden reductions in flow may strand fry occupying these habitats. Areas that undergo these changes include confluence areas of natal streams in Kinbasket Reservoir when drawdown initiates in late summer-early fall. Our observations of juvenile Bull Trout outmigrating during spring freshet (coincides with reservoir filling) and fall rains (coincides with reservoir drawdown; see Section 8.5.1) suggests that Bull Trout

outmigrating to the Kinbasket Reservoir at these times would be especially vulnerable to lack of cover from predators during spring/fall and stranding during spring with low-pool conditions and fall as drawdown is occurring. Further investigation on the accessibility of juvenile Bull Trout to the reservoir during these spring and fall critical periods may identify habitat restoration opportunities and dam operations that supports Bull Trout outmigration.

Silt deposition, high turbidity, and high sediment transport are prevalent throughout Kinbasket Reservoir (Kang et al., 2019) and likely the result of dam operations. Reservoir filling causes decreased flows when backwatering occurs in lower reaches and extends to maximum elevation in summer/early fall. This reservoir filling saturates silt substrate, which is remobilized during drawdown in fall/winter and commencement of refilling during late winter/spring. These conditions are not suitable for juvenile Bull Trout as they cannot tolerate high turbidity, and sediment accumulation into interstitial spaces removes cover from predators. Juvenile Bull Trout outmigrating during spring freshet and fall rains are particularly vulnerable as they seek cover in the reservoir during this time. Fall outmigrants are also susceptible to stranding with Reservoir drawdown.

4.2.1 Challenges and Opportunities

- There are constraints in identifying suitable candidate tributaries for installing antennae for determining Bull Trout outmigration - these include confirmation of Bull Trout spawning, stream width <6.1 m, suitable substrate and flows;
- Assessments of outmigration could not be made on larval fry and young-of-year <65 mm as these were not of adequate size for PIT tagging;
- Outmigration during winter could not be assessed since antenna operation is not possible in temperatures below -20°C;
- Antenna battery and internal clock issues encountered in this study (see Section 8.5.1) could be mitigated with remote operation of the antenna, which could not be implemented in this study due to funding constraints;
- Due to logistical and safety constraints in data collection during the low-pool period (winter- early spring), we were not able to access confluence areas to evaluate habitat conditions for juvenile Bull Trout emigrating to the Kinbasket reservoir.

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

The current operation of Kinbasket Reservoir may create conditions for stranding spring outmigrants in low-pool conditions and fall outmigrants during drawdown, which may require further assessment. Fine sediment transport, silt deposition, and high turbidity cannot be tolerated by juvenile Bull Trout and impede their escape from predators due to loss of cover, which make spring and fall outmigrants particularly vulnerable. It is possible that juvenile Bull Trout disperse to deep water immediately after migration from natal streams, but this was not assessed as this was out of scope of the current study.

If stranding is confirmed (described above), improvements to juvenile Bull Trout access to the reservoir from their natal streams could be attained by adopting an operational regime that promotes overall stable reservoir elevations and thus minimizes stranding, sediment transport/ silt deposition / turbidity and the creation of unstable and shallow channels/alluvial fans.

5.0 Recommendations

- Conduct a comprehensive assessment of water temperatures in Kinbasket Reservoir using temperature loggers to more fully evaluate the thermal suitability of the operating regime for various life cycle stages of Bull Trout, and determine the link between thermal regimes and reservoir operations;

- Repeat outmigration study at Packsaddle Creek with remote monitoring of antenna to avoid issues with antenna operation (i.e., battery life, internal clock malfunctions) and install a gauge at Packsaddle Creek to monitor flows to confirm that outmigration occurs during spring freshet and fall rains (see Section 8.5.1).

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7.0 APPENDIX 1. Timeline of CLBMON-06

Milestone	Timeline	Reference
Year 1 Bull Trout capture and tagging	Aug 28 - Sept 2, 2015	Year 1 Report (2016)
Year 1 nearshore fish and habitat survey	Monthly from Apr 23 - Aug 18, 2016	Year 2 Report (2017)
Year 2 Bull Trout capture and tagging	Sept 20 - 23, 2016	Year 2 Report (2017)
Year 2 nearshore fish and habitat survey	Monthly from May 25 - June 14, 2017	Year 3 Report (2018)
Year 3 nearshore fish and habitat survey	Biweekly from Apr 26 - Jul 25, 2018	Year 4 Report (2019)

8.0 Appendix 2. Nearshore Fish and Habitat Assessment and Juvenile Bull Trout Outmigration

8.1 *Introduction*

The objectives of this study were to:

i. collect information on basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir;
ii. identify the timing of juvenile Bull Trout emigration to Kinbasket Reservoir by detecting outmigration of juveniles using a PIT tag antenna installed at the mouth of a rearing tributary;
iii. confirm habitat use of juvenile and sub-adult Bull Trout in 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
v. 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 was designed to discern whether current operations affect the juvenile Bull Trout population in Kinbasket Reservoir, there were limitations in the study design. The study could only assess whether there may be effects on juvenile Bull Trout for the operating regime in the study years of observation. Kinbasket operations vary from year to year, so the full range of potential impacts given different reservoir operations was not captured. In addition, the study program identified habitat associations based on fish presence but could not 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. Assessment of the use of pelagic areas by juvenile Bull Trout was out of scope of this study.

8.2 *Methods*

8.2.1 Juvenile Bull Trout Outmigration

A list of candidate streams to assess juvenile Bull Trout emigration via PIT tag antenna detection was developed based on previous sampling that detected either Bull Trout spawning (Oliver, 2001), presence of juvenile Bull Trout (Fielden et al.,1992; Golder, 2003), and physical characteristics appropriate for antenna installation (i.e., stream width < 6.1 m, substrate suitable for driving antenna anchors, flows that would not result in loss of equipment). An antenna was installed at **Packsaddle Creek**, located in the north-western side of the reservoir, in Year 1 of the study. **Carrol Creek**, located on the south-western side of the reservoir, was identified as a potential site to supplement information collected at Packsaddle Creek, but electrofishing efforts during Year 2 did not uncover any fish, likely due to a recent blow-out of the stream.

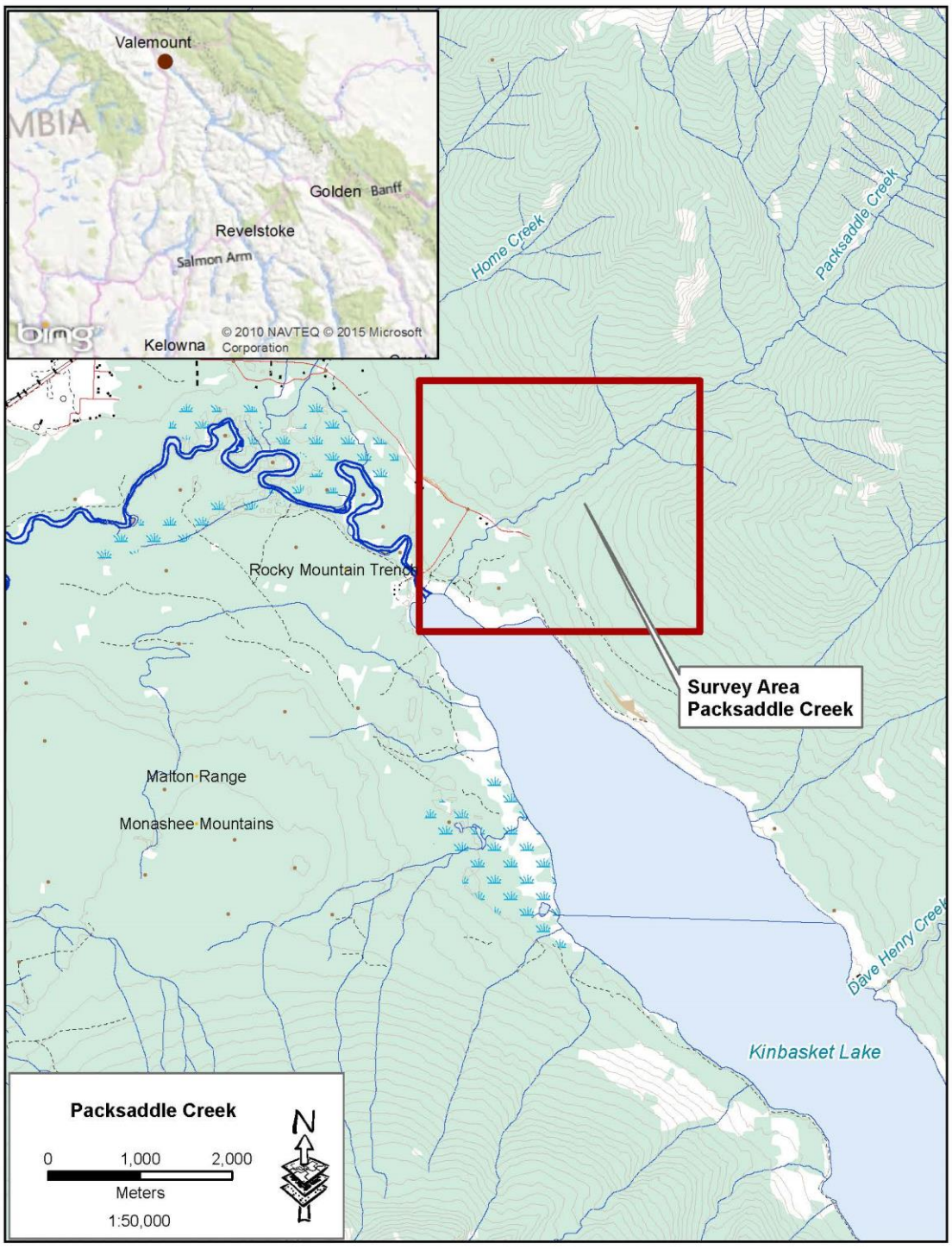
Several other tributaries were identified throughout the reservoir, but few could be accessed by road. A number of accessible tributaries on the north-eastern side of the reservoir (i.e., Dave Henry, Yellowjacket, Horse Creek) were identified as potential sites, but site visits revealed that they were inappropriate for the study due to stream width that exceeded antenna width, the presence of boulder substrate, and high energy flows. Anchoring of a PIT tag antenna into boulder substrate was not possible without heavy machinery and moreover, installation of the antenna in these streams could have resulted in loss of equipment, especially during freshet flows. Access to tributaries on the north-western side of the reservoir was not possible due to a wash-out on the Canoe River West Forest Road at km 10 during 2015.

Capture of juvenile Bull Trout occurred in Packsaddle Creek (Stream Code: 300-8326; A2 Figure 1) from August 28 to September 2, 2015 and September 20 to 23, 2016, using standard backpack electrofishing techniques. Electrofishing was conducted using a battery operated Smith-Root LR-24 backpack electrofishing unit. Settings on the unit ranged from 245 to 250 volts at 40 to 45 Hz. The electrofishing crew consisted of three certified electrofishers (one electrofisher operator and two netters). The crew scanned for fish by moving upstream from the mouth of the stream in a zig-zag pattern to span both banks. The fishes captured during each sweep were identified to species. Bull Trout, Rainbow Trout (*Oncorhynchus mykiss*), and Mountain Whitefish (*Prosopium williamsoni*) were measured for weight (g) and fork length (mm). Bull Trout of adequate size (>65 mm fork length as recommended by PIT Tag Steering Committee; CBFWA, 2014) and in good condition were anaesthetized in a 60 L bath of stream water, with a 100 mg/L concentration of clove oil. Clove oil was first dissolved in ethanol before being added to water to ensure proper mixture of anaesthetic. Once fish reached level four anaesthesia (i.e., total loss of movement and weak opercular motion; Cope, 2009), they were implanted with a full-duplex PIT tag (Biomark HPT 12) in the ventral area of the abdominal cavity posterior to the pyloric ceca using an implant gun (Biomark MK25). Fish were then placed in a recovery enclosure with mesh panels that was placed in the stream in the direction of stream flow to allow for movement of fresh stream water over the gills of the fish. Once the fish were fully recovered they were released in a backwater eddy with slow moving water in proximity to their location of capture.

Equipment to detect tagged juveniles was assembled and anchored to cobble/boulder substrate at the mouth of Packsaddle Creek. The tag detection equipment comprised of an antenna enclosed in PVC piping (Biomark Lite 20' antenna) and a control panel (to provide power to the antenna and for data storage) housed in a weather-proof enclosure

installed on the right downstream bank of the stream. The control panel comprised of a RFID transceiver (Model IS 1001) to detect the PIT tags and DC power input from 2-12 V batteries. The antenna was secured approximately 0.6 m (2 ft) into the substrate with 8 anchors positioned along the length of the antenna on both the upstream and downstream sides (4 upstream and 4 downstream). The antenna was strapped to the anchors using cam and ratchet straps. Additionally, the cable that joined the antenna to the control panel was buried in the stream bank to protect from scour.

The antenna was operated from August 31 to November 10, 2015; March 31 to December 4, 2016; April 2 to December 23, 2017; and March 11 to October 27, 2018. The antenna did not operate during the winter period because the antenna cannot be operated in temperatures below -20°C so it was disconnected from the power source when temperatures fell below -15°C.



A2 Figure 1: Map of electrofishing area on Packsaddle Creek.

8.2.2 Nearshore Fish and Habitat Assessment

To answer MQ1, fish and habitat surveys were conducted bi-weekly over 3 to 4 days from April to August (2016-2018) 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/sub-adult Bull Trout and detect PIT tagged fish. 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 Bull trout individuals were classified based on the size 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 to answer MQ2 collected the following parameters: latitudinal gradients along the shoreline of sampled sites, depth, substrate material, vegetation, and water quality (temperature, pH, conductivity, total dissolved solids, and dissolved oxygen). Habitat characteristics were also documented with photographs.

Reservoir elevation information was used to associate reservoir operations with the presence/absence of juvenile Bull Trout. The accessibility of nearshore habitats of the reservoir by juvenile Bull Trout at sites with varying reservoir elevation was also assessed.

8.3 *Dataset*

8.3.1 Juvenile Bull Trout Outmigration

This report summarizes detection information of tagged fish from the antenna installed at Packsaddle Creek from September 2015 to October 2018.

8.3.2 Nearshore Fish and Habitat Assessment

A2 Table 1: Summary of nearshore fish and habitat assessment surveys on Kinbasket Reservoir for CLBMON-06 (2016-2018, n = 86; listed according to locations from North to South).

Tributary	Number of Surveys	Survey Years		
		2016	2017	2018
Canoe	1	X		
Packsaddle	1	X		
Unnamed across from Dave Henry	2	X		X
Dave Henry	2			X
Yellowjacket	2	X		X
Horse	4	X		X
Griffin	1	X		
Bulldog	2	X	X	
Blackmore	2	X	X	
Unnamed North of Ptarmigan	1	X		
Ptarmigan, N side	2	X	X	
Ptarmigan	2	X	X	
Unnamed, Canoe reach	1		X	
Grouse	1	X		
Windfall	3	X		X

Hugh Allan	3	X	X	X
Harvey, W side	1			X
Harvey	2		X	X
Encampment, N side	2	X	X	
Encampment	1			X
Encampment, S side	1	X		
Wood, W side	1			X
Unnamed, W of Yellow	1	X		
Goosegrass	1			X
Tsar	1			X
Kinbasket	3	X		X
Sullivan	2	X		X
Windy	1	X		
Nixon	1		X	
Smith	1		X	
Surprise Rapids	2	X		
Little Foster	1		X	
Surprise Rapids, S side	2	X	X	
Bear Island, W side	1	X		
Chatter	2	X		X
Goodfellow	2	X		X
Succour, N side	2	X	X	
Succour	3	X		X
Succour, W side	1	X		
Gold, N side	1			X
Gold	2		X	X
Esplanade Bay	1	X		
Colpitti	3		X	X
Carrol	2			X
Mayvill	3	X		X
Quartz	3	X		X

Reservoir elevation data (2016 to 2018) collected by BC Hydro at Mica Dam were used to associate reservoir operations with the presence/absence of juvenile and sub-adult Bull Trout at sampled sites and their accessibility during varying reservoir operation scenarios.

A2 Table 2: Summary of location, fyke net (FN), and water quality details for sites along the nearshore zone of Kinbasket Reservoir for CLBMON-06 (2016-2018, n= 86). Records in bold and italics highlight sites where temperatures exceeded 15ºC, the temperature above which Bull Trout are seldom found for prolonged periods (references cited in McPhail and Baxter 1996).

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
26-Apr-18	Windfall	382234	5810425		Perpendicular	12:35:00	32	4	15:58:00	46	6.00	N/a	N/a	N/a		Net set with weight on offshore end, set close to shore BBC sediment very soft and unsafe
27-Apr-18	Encampment creek	398591	5777759		Perpendicular	13:16:00	68	6	09:12:00	81	5.00	78.6	7.25	134.9		Set line found during hab assessment. Refer to habitat assessment form for details.
27-Apr-18	W Harvey	398913	5787073		Perpendicular	14:51:00	96	7	10:43:00	105	3.00	81.6	6.59	161.2		Net set very deep; anchored cod end to tree trunk
28-Apr-18	Kinbasket river	430925	5757147		Perpendicular	14:13:00	66	5	09:08:00	82	3.00	87.3	6.84	219.4		Site NE of Kinbasket R. by small unnamed trib. Ice on water surface from avalanche. Need to be careful when retrieving
28-Apr-18	Narrows north of Kinbasket River	421548	5761499		Perpendicular	15:18:00	87	5	09:53:00	103	3.00	86.1	7.47	189.8		
28-Apr-18	Bay W of wood	403674	5774542		Perpendicular	16:19:00	55	5	11:45:00	71	4.00	87.2	7.69	170.6		

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
12-Jun-18	Unnamed	358082	5843759		Perpendicular	08:59:00	52	11	08:30:00	73	11.00	91.6	5.87	57.1		
12-Jun-18	Dave Henry	357955	5845548		Perpendicular	10:36:00	43	9	09:45:00	67	8.00	93.2	6.79	87		
12-Jun-18	Yellowjacket	360913	5841136		Perpendicular	11:51:00	43	12	11:39:00	64	11.50	89.1	6.97	66.3		
12-Jun-18	Horse	362595	5838848		Perpendicular	13:19:00	45	9	12:50:00	52	11.20	90.7	7.15	67.7		
13-Jun-18	Dave Henry	357955	5845548		Perpendicular	10:40:00	67	8	07:30:00	41	10.00	93.2	6.79	87		Reset
13-Jun-18	Horse	362595	5838848		Perpendicular	13:00:00	49	13.3	09:15:00	69	10.00	90.7	7.15	97.7		Reset
26-Jun-18	Quartz	471758	5707899		Perpendicular	09:43:00	26	14	09:45:00	61	12.00					
26-Jun-18	Mayvill	467629	5712982		Perpendicular	10:49:00	61	12	10:45:00	95	15.00					
26-Jun-18	***Carrol***	***466546***	***5715159***		***Perpendicular***	***11:50:00***	***47***	***16***	***11:30:00***	***81***	***16.00***					
26-Jun-18	Colpitti	465109	5719262		Perpendicular	12:30:00	49	18	12:59:00	82	16.00					
27-Jun-18	North Gold	452112	5733666		Perpendicular	15:23:00	49	18	08:22:00	69	16.00	83.2	8.24	174.1		
27-Jun-18	Island N of Gold	452842	5734868		Perpendicular	15:49:00	44	18	09:55:00	65	16.00	88.4	8.18	172.4		

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
27-Jun-18	Succour	459078	5733865		Perpendicular	16:31:00	52	20	10:45:00	75	18.00	85.6	8.27	178.6		
10-Jul-18	Hugh Allen	386845	5811911		Perpendicular	10:12:00	52	14	12:01:00	85	14.00	79.2	8.14	121.9		
10-Jul-18	Windfall	381882	5810569		Perpendicular	11:52:00	23	14	08:56:00	26	15.00	83.4	8.02	115		
10-Jul-18	Harvey	402390	5787385		Perpendicular	14:08:00	58	14	09:39:00	73	16.00	78.2	8.08	157.1		Did not use wings just middle lead
11-Jul-18	Sullivan	438525	5756800		Perpendicular	13:45:00	58	16	10:59:00	65	16.00	89.4	7.89	168.2		Photo of Sullivan river taken same day
11-Jul-18	Kinbasket river	431176	5757251		Perpendicular	14:50:00	35	18	09:42:00	39	16.20	90.6	7.99	172.9		Set very shallow due to steepness of gradient, not a very good set, small creek runs on right of net
11-Jul-18	***Unnamed adj to Cummins***	***413901***	***5764987***		***Perpendicular***	***15:55:00***	***58***	***16***	***11:02:00***	***65***	***17.00***	***93.2***	***8.14***	***162.3***		***Set with no wings, many submerged tree stumps, old grizzly bear adult and cub tracks***
11-Jul-18	Unnamed near Potlatch	413901	5764987		Perpendicular	16:37:00	51	17	12:36:00	58	17.00	90.1	8.06	157.7		No wings set and lead did not reach shore, many submerged tree stumps
23-Jul-18	Colpitti	465041	5719235		Perpendicular	11:30:00	62	18	14:08:00	66	18.00	84.7	8.2	173.5		Hab assessment to left not complete due to

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
																high gradient near trib, unsafe
23-Jul-18	Carrol	466458	5715159		Perpendicular	12:39:00	57	18	06:56:00	62	18.00	80.3	8.16	174.5		Hab assess, gradient steeper towards trib, avg of right survey accurate, survey would have crossed trib
23-Jul-18	Mayvill	467572	5712983		Perpendicular	13:32:00	53	19	07:40:00	58	17.00	83.5	8.12	175.2		Hab assess gradient homogeneous; left transect stopped at trib, right transect mean will be accurate
23-Jul-18	Quartz	472092	5707636		Perpendicular	14:12:00	48	18	08:16:00	53	18.00	77	7.45	177.1		Hab assess left survey would have crossed trib, gradient homogenous, mean gradient will be accurate; no wings just middle lead set
24-Jul-18	Goodfellow	471865	5736676		Perpendicular	11:31:00	57	19	08:50:00	56	18.00	83.2	7.73	168.6		Near campground; many submerged tree stumps, root wads; net set to right of trib; steep banks create steps along shoreline

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
																to left of net; hab assessment consists of small set of transect as gradient is homogenous and site is peninsula off bank of trib
24-Jul-18	Chatter	470342	5737796		Perpendicular	12:11:00	42	20	07:44:00	41	18.00	78.3	8.12	169.8		Lots of submerged debris, very shallow, clay substrate, west side of bridge
24-Jul-18	Succour	461186	5731990		Perpendicular	13:20:00	45	21	08:45:00	41	19.00	70.9	8.13	228		Many submerged stumps, emergent veg submerged by rising reservoir; site located on right d/s side of trib; gradient very homo so took representative gradient measurements
24-Jul-18	Gold	450932	5728041		Perpendicular	14:29:00	35	19	09:56:00		18.00	89	8.21	159.8		Set southern/ right d/s side of trib; no wings just middle lead; bear tracks, many sucker yoy in shallows; gradient very

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
																homogeneous so took representative sample; left mean 12%; right mean 5%
25-May-17	Hugh Allan Creek	385597	5806833	FN1	Perpendicular	12:30	48		9:59	80	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	12:25	105	6	101.3	5.87	84.5	86.45	
25-May-17	N. Side of Encampment Creek	399557	5779374	FN3	Perpendicular	15:06	63	8	14:05	98	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	15:20		8.9		5.62	74.9	70.2	
30-May-17	Colpitti Creek	465224	5719534	FN1	Perpendicular	9:41	60	15	8:52	121	16	100.7	7.39	171.5	134.55	
30-May-17	Little Foster Creek	451667	5738351	FN2	Perpendicular	10:58	52	13	10:28	110	11.7	104.2	6.37	168	146.25	
30-May-17	Smith Creek	449329	5739607	FN3	Perpendicular	11:51	48	11	11:28	107	11.7	107.2	8.36	169.6	147.55	
30-May-17	Nixon Creek	446274	5742181	FN4	Perpendicular	12:52	45	13	12:23	104	12.6	108.7	8.33	179.7	153.4	
1-Jun-17	S. Surprise rapids	452340	5734806	FN1	Perpendicular	13:24	54	15	8:38	107	13.6	97.1	11.73	169.5	141.7	
1-Jun-17	SW. Surprise Rapids	452236	5733788	FN2	Perpendicular	13:58	46	18	9:32	98	15.2	91	11.65	177.1	141.7	

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
1-Jun-17	Gold Creek	453172	5729959	FN3	Perpendicular	14:38	59	11	10:38	95	14.7	97.7	10.63	167.9	135.85	
1-Jun-17	***E. Succour Creek***	***458844***	***5733846***	***FN4***	***Perpendicular***	***15:13***	***59***	***16***	***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	9:02	50	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	10:08	48.5	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	10:28	59	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	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	9:00	47	10.6	103.6		48.6	43.55	pH probe not working properly
23-Apr-16	Horse Creek	363616	5837126	FN1	Parallel	19:19	72		10:43	87						Reservoir drawn down to ~Yellowjacket; good access to Horse rec site and driving on DDZ; Horse fans from rec site to reservoir; FN set SE side of Horse Cr; marina located ~1km SE of site
23-Apr-16	Horse Creek	363668	5838957	FN2	Perpendicular	19:19	78		10:43	91						Reservoir drawn down to ~Yellowjacket;

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
																good access to Horse rec site and driving on DDZ; Horse fans from rec site to reservoir; FN set SE side of Horse Cr;
24-Apr-16	Yellowjacket	361467	5840876	FN1	Perpendicular	15:00	78		10:01	86						
24-Apr-16	Griffin	362543	5838995	FN1	Perpendicular	18:30	48		11:22	59						FN set in area less affected by wind; lots of wood debris collected in nets
24-Apr-16	Yellowjacket	361467	5840874	FN2	Perpendicular	16:00	82		9:47	91						
25-Apr-16	Km 35	372439	5829459	FN1	Perpendicular	14:45	44	8	9:32	59	7					Site between Ptarmigan and Bulldog beside gravel pile
25-Apr-16	Ptarmigan	375776	5827501	FN1	Perpendicular	16:22	52		11:32	75	4					Past km 39; FN set in quasi embayment to Ptarmigan; very steep slopes to road access so had to walk ~500 m along sand dunes created by reservoir; lots of woody debris collected on shore; wildlife

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
																tracks (suspect lynx)
25-Apr-16	Bulldog	366893	5833315	FN1	Perpendicular	18:34	55		13:45	74	8					Near km 27 marker; saw ducks at site before setting up; set up SE side of Bulldog (E of bridge); evidence of upwelling along shore adjacent to FN site
26-May-16	Mica area	407305	5770914	FN1	Parallel	9:40	76	12	20:33	105	11					observed dead KO, RB, MW on water surface; observed wolf on shoreline while traveling by boat and tracks near FN
26-May-16	Sullivan	437405	5756758	FN2	Parallel	12:16	30	12	11:19	59	12					Observed wolf tracks on shore, and observed wolves on shore while travelling to next site
26-May-16	Across from Sullivan	430716	5750717	FN3	Parallel	13:15	74.5	13	9:46	109	13					Hunkered down after net check due to waves on open water.
26-May-16	Kinbasket River	431123	5757239	FN4	Parallel	14:06	65	13	12:13		12					
27-May-16	Encampment creek, NW side	398305	5778053	FN5	Parallel	15:12	67	10	8:39	86	11					

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
27-May-16	Encampment creek, SE side	397596	5777272	FN6	Parallel	15:36	33	10	9:29	49	11					
27-May-16	Embayment by encampment and boat launch	397889	5776785	FN7	Parallel	16:26	51	10	10:01	71	11					
19-Jun-16	Mayville creek	462256	5730614	FN1	Parallel	17:21	42	13	8:38	51	11.2	94.39	7.45	130.7	115.05	
19-Jun-16	Quartz creek	472100	5707650	FN2	Parallel	18:00	27	8	7:54	33	6.4	106.89	5.97	141.1	142.35	
20-Jun-16	Good Fellow creek	471899	5736880	FN1	Perpendicular	10:28	71	14	8:37	86	15.5	55.8	8.4	165.5	131.3	
20-Jun-16	Chatter creek	470311	5737782	FN2	Perpendicular	11:31	55.5	15	9:51	66	14.3	71.25	7.78	170.5	139.1	
20-Jun-16	Adj. Succour creek	456697	5735280	FN3	Perpendicular	12:24	63	16	14:42	73	17.6	63.15	7.43	164.6	124.8	dead KO with lesions on dorsal side sample collected
20-Jun-16	Succour creek	459184	5733751	FN4	Perpendicular	12:53	73	16	11:30	84.5	15.8	83.91	7.93	156.2	122.85	
21-Jun-16	West side of Succour creek	457821	5730703	FN1	Parallel	13:27	76	16	8:16	86	14	70.41	8	145.5	119.6	
21-Jun-16	Surprise Rapids reset	451802	5738430	FN1	Perpendicular	11:20	65	14.9	8:38	78	14.6	70.98	7.19	161	168.4	
21-Jun-16	Surprise Rapids	451802	5738430	FN2	Perpendicular	15:56	66	11	10:19	82	14.9	80.17	7.82	154.6	124.8	

Date	Location	UTM E	UTM N	FN #	Orientation	FN Set Time	FN Set Water Depth (cm)	FN Set Water Temp (° C)	FN Check Time	FN Check Depth (cm)	FN Check Water Temp (°C)	DO %	pH	Conductivity (µS/cm)	TDS (mg/L)	Comments
21-Jun-16	S of Surprise Rapids	452111	5735498	FN3	Parallel	16:25	24	11	9:26	83	15.6	74.76	7.96	156	123.5	
21-Jun-16	Esplanade Bay	460516	5727880	FN4	Perpendicular	17:03	70	11	13:21	84	13.9	89.27	7.77	141.9	117	
22-Jun-16	West side of Bear Island	453149	5735997	FN2	Perpendicular	12:03	27	17	9:34	41	15.7	74.41	8.14	156.8	124.12	
16-Aug-16	Hugh Allan Creek	384541	5810004	FN1	Perpendicular	10:03	65	18	9:36		17.8	90.2	8.29	113.8	85.8	net collapsed
16-Aug-16	Windfall Creek	381752	5810622	FN2	Perpendicular	10:52	42	18	10:14	43	18.1	88.7	8.33	105.4	78.65	
16-Aug-16	Grouse Creek	379190	5814764	FN3	Perpendicular	11:56	65	19	10:59	70	18.3	90.8	8.15	108.5	80.6	
16-Aug-16	North Ptarmigan Creek	373540	5827973	FN4	Perpendicular	13:34	73	19	12:38	65	18.6	87.5	7.95	103	76.05	
17-Aug-16	***Blackmore Creek***	***364934***	***5833944***	***FN1***	***Perpendicular***	***13:42***	***51***	***18.2***	***8:35***	***49***	***17.8***	***89.3***	***8.16***	***90.8***	***68.25***	
17-Aug-16	***Packsaddle Creek***	***353843***	***5849907***	***FN2***	***Perpendicular***	***14:29***	***53***	***18.2***	***12:03***	***55***	***17.5***	***85.8***	***8.07***	***95***	***72.15***	
17-Aug-16	Canoe Creek	356458	5845200	FN3	Perpendicular	15:15	64	20.5	13:09	68	19.1	74.3	7.61	88.8	65	
17-Aug-16	Unnamed tributary	357924	5843955	FN4	Perpendicular	15:41	51	11.5	10:01	49	18.2	88	8.14	89.9	66.95	

A2 Table 3:Summary of habitat assessments of sites along the nearshore zone of Kinbasket Reservoir for CLBMON-06 (2016-2018, n= 86)

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 (%)					Location relative to FN	Slope (%)									
						T1	T2	T3	T4	T5		T1	T2	T3	T4	T5					
26-Apr-18	Windfall	382234	5810425		West of net	2	15	>20	>20	>20	East	1					None	N/a	Sand	Gravel	Sediment very soft so some transects not complete
27-Apr-18	Encampment creek	398591	5777759		East of net	6	9	10	6	2	West	9	11	7	5	8	No live veg lots of dead stumps and root wads	N/a	Fines	Sand	UTM 398591 5777759 set line found on shore, looks old, all hooks have broken off. UTM of setline 398555 5777745
27-Apr-18	W Harvey	398913	5787073		West of net	9	>20	>20	>20	>20	East	9	7	7	12	8	None, tree trunks	N/a	Sand	Sand	Good BT habitat with tree trunks and across from harvey
28-Apr-18	Kinbasket river	430925	5757147		West of net	10	10	9	9	9	East	6	8	9	20	20	No live veg lots of dead stumps and root wads	N/a	Fines	Fines	Photo orientation off, see notes
28-Apr-18	Narrows north of Kinbasket River	421548	5761499		West of net	1	1	1	-2	1							No live veg dead stumps and root wads are abundant	N/a	Fines	Fines	Small island can only do one transect
28-Apr-18	Bay W of wood	403674	5774542		West of net	5	4	0	>20	>20							None	N/a	Sand	Fines	Site is a small peninsula so only one transect assessed
12-Jun-18	Unnamed	358082	5843759		West	7	7	7	7	6	East	8	8	7	7	8	None	Aspen, birch, spruce	Cobble	Sand	
12-Jun-18	Dave Henry	357955	5845548		West/left	6	4	1	3	4	Trib too swift to cross						None	Too far to influence BT habitat	Sand	Cobble	Gradient not measured on right side of fn since trib too swift to cross

12-Jun-18	Yellowjacket	360913	5841136		West/left	5						2	3	4	6	7	None	Too far	Sand	Boulder	A lot of debris on reservoir so set net without rebar on wings but weighted
12-Jun-18	Horse	362595	5838848		West/left	7	5	5	6	6	Right	8	9	7	3	4	None	Aspen, spruce, birch	Boulder	Cobble	
13-Jun-18	Dave Henry	357955	5845548		West/left	6	4	1	3	4	Trib too swift to cross						None	Too far to influence BT habitat	Sand	Cobble	
13-Jun-18	Horse	362595	5838848		West/left	5					Right	8	9	7	3	4	None	Aspen, spruce, birch	Boulder	Cobble	
26-Jun-18	Quartz	471758	5707899		N						S						Grasses (sedge?)	Horsetail, cottonwood, spruce	Fines	Cobble	Transect taken in previous years, very low varying from 2 to 3%; water very turbid
26-Jun-18	Mayvill	467629	5712982		West/left	9	11	11	9	7	East/right	8	7	8	8	9	Lwd, horsetail, grass, sedge	Sedge, horsetail, cottonwood, spruce	Sand	Cobble	
26-Jun-18	Carrol	466546	5715159														Sparse sedge, horsetail	Horsetail, sedge, cottonwood	Cobble	Fines	Use gradients from previous hab assessment
26-Jun-18	Colpitti	465109	5719262														Sparse , lwd, stumps	Horsetail, sedge, cottonwood, spruce	Sand	Cobble	
27-Jun-18	North Gold	452112	5733666		East/right	12	8	9	11	9	West/left	10	9				Patchy	Usual sispects	Sand	Cobble	Some Boulder substrate, tree stumps; stream too swift to cross for left transect
27-Jun-18	Island N of Gold	452842	5734868																		
27-Jun-18	Succour	459078	5733865																Fines	Fines	
10-Jul-18	Hugh Allen	386845	5811911		West/left	3	3	6	7	11	Bisects trib						Sedge, horsetail, smartweed?, bulrush		Sand	Boulder	
10-Jul-18	Windfall	381882	5810569		East/right	6	11	11	13	13	West/left	11	12	14	14	12			Sand	Gravel	

10-Jul-18	Harvey	402390	5787385		West/left	30	30	30	30	30	East/right bisects trib then over 30%						Horsetail,		Sand	Sand	
11-Jul-18	Sullivan	438525	5756800		East right	8	6	6	7	6	West left	4	9	10	13	16	Sedge sparse and only on left side of net		Fines	Cobble	
11-Jul-18	Kinbasket river	431176	5757251		East right	13	13	15	12	13	West left	30	30	30	30	30	Horsetail right of net, no veg left of net		Gravel	Cobble	
11-Jul-18	Unnamed adj to Cummins	413901	5764987		East right	16	21	17	19	19	West left	8	11	12	22	20	Horsetai, sedge		Sand	Cobble	
11-Jul-18	Unnamed near Potlatch	413901	5764987		Right	12	22	20	21	21	Left	12	18	9	24	8	Bulrush, sedge, smartweed - abundant; many submerged tree trunks and upland too		Fines	Boulder	
23-Jul-18	Colpitti	465041	5719235		West/left	9	5	5	7	5	East/right	11	14	30	30		Horsetail		Sand	Cobble	
23-Jul-18	Carrol	466458	5715159		West/left	7	6	6	7	6	East/right	7	12	17			Smartweed, sedge; horsetail; 10-20%		Sand	Cobble	
23-Jul-18	Mayvill	467572	5712983		West/left	8					East/right	6	7				Sedge, smartweed, horsetail; 50-75%		Gravel	Sand	
23-Jul-18	Quartz	472092	5707636		East/right	4	2										Smartweed, sedge, horsetail; 25-50%		Fines	Cobble	
24-Jul-18	Goodfellow	471865	5736676		Left	12	10	10			Right	4	3	4	3	3	Left: horsetail, smartweeed, 25%; right: same spp , <25%		Sand	Cobble	
24-Jul-18	Chatter	470342	5737796			2											Horsetail, 75%		Fines	Fines	
24-Jul-18	Succour	461186	5731990			3	4										Horsetail, sedge, clover; 100% veg cover; abundant tree trunks		Fines	Fines	
24-Jul-18	Gold	450932	5728041			5	15										Horsetail, 25-50% veg cover		Fines	Fines	

25-May-17	N. Side of Encampment Creek	398372	5777917	FN4	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	465224	5719534	FN1	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	451667	5738351	FN2	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	449329	5739607	FN3	W	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	446274	5742181	FN4	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	452340	5734806	FN1	SE	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	
1-Jun-17	S. Surprise rapids	452236	5733788	FN2	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
1-Jun-17	SW. Surprise Rapids	453172	5729959	FN3	N	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	
1-Jun-17	Gold Creek	458844	5733846	FN4	SW	27	13	8	9	8	S	30	30	30	30	30	N/A	Trembling aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii)	Fines	Fines	
1-Jun-17	E. Succour Creek	375632	5820546	FN 1	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	375379	5827438	FN 2	E	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	373214	5828140	FN 3	SW	3	3	2	1	1	W	1	2	2	3	2	N/A	Trembling aspen (Populus tremuloides), Grand fir (Abies grandis), Alder (Alnus spp.), Lodge pole pine (Pinus contorta)	Cobble	Sands	
13-Jun-17	N. Ptarmigan	365837	5834555	FN4	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	365054	5833945	FN 1	S	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	363616	5837126	FN1	SE	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	
24-Apr-16	Horse Creek	363668	5838957	FN2	SE	4	4	3	2	4	NW	7	4	4	4	5	None		Fines	Cobble	
24-Apr-16	Horse Creek	361467	5840874	FN2	SE	9	4	5	4	4	NW	6	4	4	3	3	None		Fines	Cobble	
25-Apr-16	Yellowjacket	362543	5838995	FN1	SE	2	3	5	5	4	NW	4	4	3	2	3	None		Fines		
25-Apr-16	Yellowjacket	361467	5840876	FN1	SE	2	4	4	1	8	NW						None		Fines		
25-Apr-16	Griffin	372439	5829459	FN1	SE	3	3	4	4	4	NW	8	9	9	13	15	None		Fines		
26-Apr-16	KM 35	375776	5827501	FN1	SE	12	11	10	11	9	NW	13	11	10	9	8	None	cottonwood, trembling aspen (and cottonwood x aspen), birch, spruce	Fines	large cobble; boulder/cobble/fines at higher elevation	Steep slope to truck but more gradual to FN1; slope measured in % not degrees
26-Apr-16	Ptarmigan	366893	5833315	FN1	SE	4	4	4	4	3	NW	29	64	>30	>30	>30	None		Fines		NW transects 3 to 5 >30% to treeline too dangerous to measure; SE transect

																				towards Ptarmigan; slope in %
26-Apr-16	Bulldog	407305	5770914	FN1	NW	5	12	5	10	>30	NW	9	4	2.5	3	9	None		Fines	boulder and cobble at confluence	Slope in %; areas beyond SE T5 have slope >30%
26-May-16	Mica area	437405	5756758	FN2	SE	9	12	14	17	16	SE	10	12	18	6	19	None	Fd, At, Se, Cw, Hw	Cobble	Sand	
26-May-16	Sullivan	430716	5750717	FN3	NW	33	22	20	19	29	NW	>30	>30	>30	>30	>30	None	Fd, At, Se, Cw, Hw	Sand	Gravel	No slope measurements to NW >30%
26-May-16	Across from Sullivan	431123	5757239	FN4	SE	12	25	>30	>30	>30	SE	12	16	23	>30	>30	None	Hw, Fd	Cobble	Sand	
26-May-16	Kinbasket River	398305	5778053	FN5	NE	10	12	11	12	12	NW	10	>30	>30	>30	>30	None		Sand	Gravel	
28-May-16	Encampment NW side	397596	5777272	FN6	SW	6	9	10	9	11	SW	8	9	7	9	9	None	Alnus spp.	Cobble	Sand	
28-May-16	Encampment SE side	397889	5776785	FN7	NE	0	0	11	17	16	NE	3	19	20	9	6	None		Sand	Gravel	
28-May-16	Encampment West Bay	462256	5730614	FN1	West	11	11	13	9	10	SE	11	12	12	4	7	None		Sand	Gravel	
20-Jun-16	Mayville Creek	472100	5707650	FN2	West	4	6	6	5	12	East	6	14	11	13	7	grasses (gramineae spp.), horsetail (Equisetum arvense	Trembling aspen (Populus tremuloides),Paper birch (Betula papyrifera),Western red cedar (Thuja plicata),Western white pine (Pinus monticola), Douglas fir (Pseudotsuga menziesii)	Gravel	Cobble	
20-Jun-16	Quartz Creek	471899	5736880	FN1	North	6	4	3	5	4	East	1	7	7	13	16	None	None	Fines	Gravel	
21-Jun-16	Good Fellow	470311	5737782	FN2	West	4	4	4	3	4	South	3	1	2	3	4	Grasses (gramineae	Fd,Ep,Cw,Pw,At	Gravel	Cobble	

																spp.), Horsetail (Equisetum arvense)				
21-Jun-16	Chatter Creek	456697	5735280	FN3	East	2	1	0	1	0	East	2	2	3	1	0	Horsetail	Grasses (Gramineae spp.),Trembling aspen (Populus tremuloides),Douglas fir (Pseudotsuga menziesii),Western white pine (Pinus monticola)	Fines	Sands	
21-Jun-16	Across from Succour Creek	459184	5733751	FN4	South	9	20	25	25	19	West	9	8	10	9	10	None	Grasses Gramineae spp.), Trembling aspen (Populus tremuloides), Paper birch (Betula papyrifera)	Fines	Sands	
21-Jun-16	Succour Creek	457821	5730703	FN1	North	4	10	10	12	16	North	2	6	7	9	4	Grasses, Pineapple weed	Trembling aspen (Populus tremuloides),Douglas fir (Pseudotsuga menziesii),Paper birch (Betula papyrifera),Western white pine (Pinus monticola)	Gravel	Cobble	
22-Jun-16	West side of Succour Creek	451802	5738430	FN2	South	3	5	5	4	1	South	6	7	4	2	3	Horsetail	Douglas fir (Pseudotsuga menziesii),Paper birch (Betula papyrifera),Western red cedar (Thuja plicata),Western white pine (Pinus monticola),Trembling aspen (Populus tremuloides)	Fines	Gravel	
22-Jun-16	Surprise Rapids	452111	5735498	FN3	North	7	28	25	29	30	North	11	14	10	11	13	Sedges	Trembling aspen (Populus tremuloides),Paper birch (Betula papyrifera, Western	Cobble	Gravel	

																	white pine (Pinus monticola)			
22-Jun-16	South side of Surprise Rapids	460516	5727880	FN4	East	6	5	4	6	2	South	6	4	4	6	7	Horsetail, Pineapple weed, Sedges, Clovers	Trembling aspen (Populus tremuloides),Paper birch (Betula papyrifera),Western white pine (Pinus monticola)	Fines	Sands	
22-Jun-16	Pt of Esplanade Bay	384541	5810004	FN1	East	4	12	23	25	27	West	21	30	>30	>30	>30	Grasses, Horsetail	Western red cedar (Thuja plicata), Western white pine (Pinus monticola), paper birch (Betula papyrifera),Trembling aspen (Populus tremuloides)	Sands	Gravel	
17-Aug-16	Hugh Allan Creek	381752	5810622	FN2	North	4	5	9	12	30	West	4	3	4	6	4	Common horsetail (Equisetum arvense), grasses (Gramineae spp.)	Reed canary grass (Phalaris arundinacea), bunchgrass (Gramineae spp.), foxtail (Hordeum murinum, clover (Trifolium spp), horsetail (Equisetum arvense), trembling aspen (Populus tremuloides), Lodgepole pine (Pinus Contorta)	Sands	Gravel	
17-Aug-16	Windfall Creek	379190	5814764	FN3	North	12	8	10	13	11	South	10	9	10	10	11	Horsetail (Equisetum arvense), Clover (trifolium spp.), Reed canary grass (Phalaris arundinacea)	Horsetail (Equisetum arvense), Reed canary grass (Phalaris arundinacea), Clover (Trifolium spp.), Alder (Alnus spp.), Trembling aspen (Populus tremuloides), Lodgepole pine (Pinus contorta),	Sands	Gravel	

																	Grand fir (Abies grandis)			
17-Aug-16	Grouse Creek	373540	5827973	FN4	East	12	9	8	30	30	South	11	9	8	8	10	Clover (Trifolium spp.), Bunchgrass (Gramineae spp.), Reed canary grass (Phalaris arundinacea)	Willows (Salix spp.), Yellow hawkweed (Hieracium caespitosum), Horsetail (Equisetum arvense), reed canary grass (Phalaris arundinacea), Pearly everlasting (Anaphalis margaritacea, Alder (Alnus spp.), Clover (Trifolium spp.), Trembling aspen (Populus tremuloides), lodgepole pine (Pinus contorta)	Cobbles	Sands	
17-Aug-16	North Ptarmigan Creek	364934	5833944	FN1	East	3	3	2	1	1	West	1	2	2	3	2	Bunchgrass (Gramineae spp), Clovers(Trifolium spp.), Macrophytes, Reed canary grass (Phalaris arundinacea), horsetail (Equisetum arvense)	Trembling aspen (Populus tremuloides), Lodgepole pine (Pinus contorta), Grand fir (Abies grandis), Willows (Salix spp.), Alder (Alnus spp.)	Cobbles	Sands	
18-Aug-16	Blackmore Creek	353843	5849907	FN2	North	12	8	25	13	11	West	13	12	16	13	30	Clovers (Trifolium spp.), Grasses (Gramineae spp.)	Horsetail (Equisetum arvense), Willows (Salix spp.), Yellow hawkweed (Hieracium caespitosum), Black cottonwood (Populus trichocarpa), Trembling aspen (Populus tremuloides), Pearly everlasting	Cobbles	Gravels	

																	(Anaphalis margaritacea), Engelmann spruce (Picea engelmannii), Grand fir (Abies grandis).			
18-Aug-16	Packsaddle Creek	356458	5845200	FN3	North	6	7	3	2	4	South	6	6	8	7	4	Grasses (Gramineae spp), Horsetail (Equisetum arvense), Willows (Salix spp.) Clovers (Trifolium spp.)	Grasses (Gramineae spp.), Cottonwood (Populus trichocarpa), Trembling aspen (Populus tremuloides), Lodgepole pine (Pinus contorta)	Sands	Cobbles	Mechanical site disturbance on south portion
18-Aug-16	Canoe Creek	357924	5843955	FN4	North	7	9	8	10	10	South	6	0	0	0	0	Horsetail (Equisetum arvense), Reed canary grass (Phalaris arundinacea)	Cottonwood (Populus trichocarpa), Trembling aspen (Populus tremuloides), Engelmann spruce (Picea engelmannii), Red cedar (Thuja plicata), Western hemlock (Tsuga heterophylla) Grasses (Gramineae spp.)	Gravels	Fines/Organics	
18-Aug-16	Unnamed tributary					10	7	8	9	9	South	7	11	11	8	11	Willows (Salix spp.), Grasses (Gramineae spp.)	Foxtails (Hordeum murinum), Grasses (Gramineae spp.), Horsetail (Equisetum arvense), Cottonwood (Populus trichocarpa), Alder (Alnus spp.) Willows (Salix spp.), Trembling aspen (Populus tremuloides)	Gravels	Cobbles	Stream gradient under reservoir influence, Patches of green filamentous algae on shore and trace amounts in water

A2 Table 4: Summary of sport fishes captured in fyke nets (n = 86) set overnight along the nearshore zone of Kinbasket Reservoir from April 23, 2016 to July 25, 2018. Species abbreviations are: 'BT' - Bull Trout; 'BB' – Burbot; 'KO' – Kokanee; 'MW' - Mountain Whitefish; 'RB' - Rainbow Trout; 'EB' – Brook Trout.

Date	Location	UTM E	UTM N	Species	Count	Length (mm)	Weight (g)
29-Apr-18	Tsar	421548	5761499	BT	1	400	575
13-Jun-18	Unnamed across from Dave Henry	358082	5843759	BT	1	109	483
13-Jun-18	Unnamed across from Dave Henry	358082	5843759	BT	1	180	570
13-Jun-18	Dave Henry	357955	5845548	BT	1	675	
13-Jun-18	Dave Henry	357955	5845548	BT	1	667	
13-Jun-18	Dave Henry	357955	5845548	BT	1	482	780
13-Jun-18	Dave Henry	357955	5845548	BT	1	440	695
13-Jun-18	Dave Henry	357955	5845548	BT	1	468	995
13-Jun-18	Dave Henry	357955	5845548	BT	1	138	26
13-Jun-18	Horse	362595	5838848	BT	1	140	27
14-Jun-18	Dave Henry	357955	5845548	BT	1	580	1835
27-Jun-18	Mayvill	467629	5712982	BT	1	730	323
27-Jun-18	Mayvill	467629	5712982	BT	1	164	36
27-Jun-18	Mayvill	467629	5712982	BT	1	303	271
27-Jun-18	Carrol	466546	5715159	BT	1	495	132
11-Jul-18	Hugh Allen	386845	5811911	BT	1	183	61
12-Jul-18	Goodfellow	413901	5764987	BT	1	517	876
12-Jul-18	Goodfellow	413901	5764987	BT	1	230	124
25-May-17	Hugh Allan Creek	385597	5806833	BT	1	199	83
25-May-17	Hugh Allan Creek	385597	5806833	BT	1	164	28
25-May-17	Harvey Creek	402040	5787358	BT	1	170	50
25-May-17	S Encampment Creek	398372	5777917	BT	1	225	120
25-May-17	S Encampment Creek	398372	5777917	BT	1	268	253
25-May-17	S Encampment Creek	398372	5777917	BT	1	190	64
30-May-17	Colpitti Creek	465224	5719534	BT	1	640	
30-May-17	Nixon Creek	446274	5742181	BT	1	220	114
1-Jun-17	S. Surprise Rapids	452340	5734806	BT	1	205	77
1-Jun-17	Gold Creek	453172	5729959	BT	1	210	89
1-Jun-17	E. Succour Creek	458844	5733846	BT	1	620	
14-Jun-17	Unknown tributary	375632	5820546	BT	1	157	34
14-Jun-17	Unknown tributary	375632	5820546	BT	1	169	44
14-Jun-17	Ptarmigan Creek	375379	5827438	BT	1	193	67
14-Jun-17	N. Ptarmigan	373214	5828140	BT	1	185	58
14-Jun-17	N. Ptarmigan	373214	5828140	BT	1	183	57
14-Jun-17	N. Ptarmigan	373214	5828140	BT	1	193	69
26-Apr-16	Bulldog			BT	1	161	40
26-Apr-16	Bulldog			BT	1	162	42
26-Apr-16	Bulldog			BT	1	222	105
27-May-16	Kinbasket	431123	5757239	BT	1	156	30
28-May-16	Encampment Creek NW side	398305	5778053	BT	1	176	52
28-May-16	Encampment Creek NW side	398305	5778053	BT	1	147	39
28-May-16	Encampment Creek, embayment	397889	5776785	BT	1	121	62
21-Jun-16	Good Fellow	471899	5736880	BT	1	179	52
21-Jun-16	Chatter	470311	5737782	BT	1	195	63
22-Jun-16	Surprise Rapids	451802	5738430	BT	1	214	95
22-Jun-16	Surprise Rapids	451802	5738430	BT	1	226	112
23-Jun-16	Surprise Rapids	451802	5738430	BT	1	235	104
18-Aug-16	Blackmore	364934	5833944	BT	1	85	14
18-Aug-16	Blackmore	364934	5833944	BT	1	174	47
18-Aug-16	Packsaddle	353843	5849907	BT	1	205	78
18-Aug-16	Unnamed tributary	357924	5843955	BT	1	360	421
14-Jun-18	Dave Henry	357955	5845548	BB	1	515	1056
13-Jun-18	Yellowjacket	360913	5841136	BB	3		
25-May-17	S Encampment Creek	398372	5777917	BB	1	425	426
25-Apr-16	Yellowjacket			BB	1	508	660
25-Apr-16	Yellowjacket			BB	1	541	793
25-Apr-16	Yellowjacket			BB	1	545	807
25-Apr-16	Griffin			BB	1	571	899
25-Apr-16	Yellowjacket			BB	1	599	1126

25-Apr-16	Yellowjacket			BB	1	639	1147
25-Apr-16	Yellowjacket			BB	1	662	1618
28-Apr-18	Harvey, W side	398913	5787073	MW	1		
28-Apr-18	Encampment	398591	5777759	MW	2		
29-Apr-18	Tsar	421548	5761499	MW	3		
13-Jun-18	Unnamed across from Dave Henry	358082	5843759	MW	2		
13-Jun-18	Dave Henry	357955	5845548	MW	11		
13-Jun-18	Horse	362595	5838848	MW	2		
14-Jun-18	Horse	362595	5838848	MW	4		
27-Jun-18	Carrol	466546	5715159	MW	6		
27-Jun-18	Colpitti	465109	5719262	MW	4		
14-Jun-18	Horse	362595	5838848	MW (yoy)	1		
27-Jun-18	Mayvill	467629	5712982	MW (yoy)	8	117	
11-Jul-18	Hugh Allen	386845	5811911	MW (yoy)	1		
24-Jul-18	Mayvill	467572	5712983	MW (yoy)	48		
24-Jul-18	Carrol	466458	5715159	MW (yoy)	8		
24-Jul-18	Colpitti	465041	5719235	MW (yoy)	78		
24-Jul-18	Quartz	472092	5707636	MW (yoy)	7		
24-Jul-18	Mayvill	467572	5712983	MW age 1+	1		
24-Jul-18	Carrol	466458	5715159	MW age 1+	1		
24-Jul-18	Colpitti	465041	5719235	MW age 1+	4		
24-Jul-18	Quartz	472092	5707636	MW age 1+	2		
25-May-17	Harvey Creek	402040	5787358	MW	1	900	83
25-May-17	S Encampment Creek	398372	5777917	MW	1	342	398
25-May-17	S Encampment Creek	398372	5777917	MW	1	317	366
30-May-17	Smith Creek	449329	5739607	MW	7		
24-Apr-16	Horse Creek			MW	5		
25-Apr-16	Yellowjacket			MW	19		
25-Apr-16	Yellowjacket			MW	3		
25-Apr-16	Griffin			MW	1		
26-Apr-16	Km 35			MW	1		
20-Jun-16	Mayville	462256	5730614	MW	2		
21-Jun-16	Good Fellow	471899	5736880	MW	1		
16-Aug-16	North Ptarmigan	373540	5827973	MW	9		
18-Aug-16	Blackmore	364934	5833944	MW	1		
18-Aug-16	Canoe	356458	5845200	MW	1		
18-Aug-16	Unnamed tributary	357924	5843955	MW	23		
25-Apr-16	Yellowjacket			MW (fry)	54		
13-Jun-18	Dave Henry	357955	5845548	RB	1	104	19
14-Jun-18	Dave Henry	357955	5845548	RB	1	131	19
14-Jun-18	Horse	362595	5838848	RB	1		
27-Jun-18	Mayvill	467629	5712982	RB	1	390	526
27-Jun-18	Colpitti	465109	5719262	RB	1		
27-Jun-18	Carrol	466546	5715159	RB (yoy)	4		
25-Apr-16	Yellowjacket			RB	1	135	46
20-Jun-16	Mayville	462256	5730614	RB	1		
18-Aug-16	Packsaddle	353843	5849907	RB	1	131	26
13-Jun-18	Horse	362595	5838848	KO	1		
14-Jun-18	Dave Henry	357955	5845548	KO	2		
14-Jun-18	Horse	362595	5838848	KO	1		
27-Jun-18	Carrol	466546	5715159	KO	1		
27-Jun-18	Colpitti	465109	5719262	KO	1		
28-Jun-18	Island N of Gold	452842	5734868	KO	1		
24-Jul-18	Quartz	472092	5707636	KO	1		
27-Jun-18	Mayvill	467629	5712982	KO (yoy)	1		
27-May-16	Mica Area	407305	5770914	KO	1	85	94
23-Jun-16	Surprise Rapids	451802	5738430	KO	2		
27-Jun-18	Mayvill	467629	5712982	EB	1	235	128

8.4 *Analysis*

8.4.1 Nearshore Fish and Habitat Assessment

A generalized linear model (GLM) using a Poisson distribution (i.e., Poisson ANOVA or Poisson regression) was used to assess associations between capture of juvenile/sub-adult Bull Trout, reservoir elevation, year, and substrate. Standard ANOVA and regression were not suitable given the small sample sizes of surveyed sites and the small number of sites with Bull Trout presence (see Section 8.5.1).

Due to the difference is soak times of fyke nets, the models included an offset variable being the *log(soak times)*. More formally, the Poisson ANOVA model is

$$Y_{ij} \sim Poisson(\theta_{ij})$$

$$\theta_{ij} = SoakTime_{ij} \times \mu_i$$

where Y_{ij} is the count of Bull Trout in the j^{th} replicate of group i; $SoakTime_{ij}$ is the soak time for this observation; and μ_i is the mean capture/hour of group i. Note that because $SoakTime$ operates multiplicatively on the catch/hour, the logarithm is taken on both sides to give:

$$log(\theta_{ij}) = log(SoakTime_{ij}) + \log(\mu_i)$$

and the analysis proceeds on the (hidden) logarithmic scale.

The model fit to assess how the mean capture efficiency (fish/hour) differs among the substrate is:

$$Count \sim Substrate + log(SoakTime)(offset)$$

Differences in capture-efficiency amongst substrate types were assessed using Tukey multiple comparisons.

Densities of Bull Trout naturally vary among years and this year-to-year variation adds noise to the previous analysis. A model was fit to assess if there was evidence of a year effect on the capture efficiency

$$Count \sim YearC + log(SoakTime)(offset)$$

where $YearC$ represents a categorical year effect.

A combined model was used to investigate the impact of both substrate type and elevation on the capture efficiency (fish/hour). The model is:

$$Count \sim Substrate + Elevation + log(SoakTime)(offset)$$

where $Elevation$ is the elevation of the reservoir at the mid-point of the set.

8.5 *Results*

8.5.1 Juvenile Bull Trout Outmigration

A total of 120 Bull Trout (2015 = 97; 2016 = 23) were captured using electrofishing techniques. Ages of individuals were classified based on the following thresholds to distinguish young-of-year (YOY), juveniles/sub-adults, and adults: <70 mm (YOY), 70-400 mm, and >400 mm, respectively (McPhail and Baxter, 1996; Warnock and Rasmussen, 2013). Six of the individuals were young-of-year and four were adults. A total of 105 Bull Trout (101 juveniles) were implanted with PIT tags (A2 Table 5). Tracking data from the 4 adults can provide important information on their migration during spawning and post-spawning periods. Along with Bull Trout, 33 Rainbow Trout (*Oncorhynchus mykiss*), 16 Mountain Whitefish (*Prosopium williamsoni*), 103 Sculpin (*Cottus* sp.) and 1 cyprinid were captured (A2 Table 5). Sixteen of the 25 Rainbow Trout captured were implanted with PIT tags to provide supplementary information to CLBMON-7. Voucher specimens of Sculpins were preserved in 95% ethanol for species identification.

A2 Table 5: Summary information of fish captured by electrofishing in Packsaddle Creek (Aug. 28 to Sept. 2, 2015 and Sept. 20-22, 2016). Species abbreviations are: 'BT' - Bull Trout; 'BT YOY' - Bull Trout young-of-year; 'MW' - Mountain Whitefish; 'RB' - Rainbow Trout.

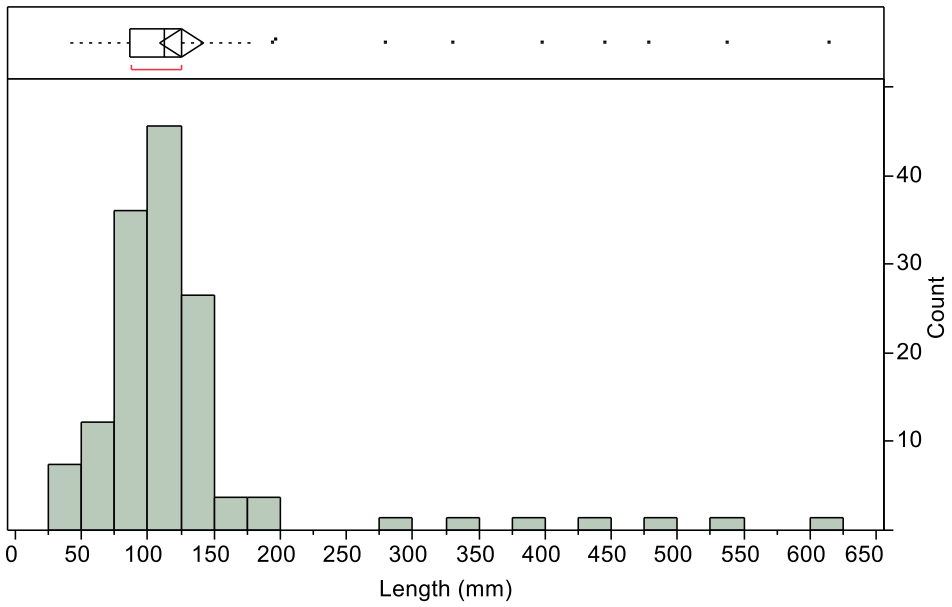
Tag Date	Species	Length (mm)	Weight (g)	Count	Tag #
21-Sep-16	BT	46	0	1	
21-Sep-16	BT	50	0	1	
21-Sep-16	BT	50	1	1	
21-Sep-16	BT	53	0	1	
20-Sep-16	BT	55	1	1	
21-Sep-16	BT	55	1	1	
21-Sep-16	BT	55	1	1	
21-Sep-16	BT	60	0	1	
21-Sep-16	BT	61	0	1	
21-Sep-16	BT	86	6	1	989001006037-226
20-Sep-16	BT	93	6	1	989001006037-274
20-Sep-16	BT	96	3	1	989001006037-281
21-Sep-16	BT	99	10	1	989001006037-233
20-Sep-16	BT	100	12	1	989001006037-209
21-Sep-16	BT	109	10	1	989001006037-234
21-Sep-16	BT	110	10	1	989001006037-225
20-Sep-16	BT	113	11	1	989001006037-241
21-Sep-16	BT	124	17	1	989001006037-290
21-Sep-16	BT	137	25	1	989001006037-248
20-Sep-16	BT	145	35	1	989001006037-266
21-Sep-16	BT	148	31	1	989001006037-244
21-Sep-16	BT	163	40	1	989001006037-292
20-Sep-16	BT	279	230	1	989001006037-215
02-Sep-15	BT	71	3	1	989001004470-319
02-Sep-15	BT	72	6	1	989001004470-374
31-Aug-15	BT	77	4	1	989001004470-277
02-Sep-15	BT	78	3	1	989001004470-297
28-Aug-15	BT	79	6	1	989001004470-312
31-Aug-15	BT	81	5	1	989001004470-281
02-Sep-15	BT	81	8	1	989001004470-268
02-Sep-15	BT	83	6	1	989001004470-244
29-Aug-15	BT	84	3	1	989001004470-303
01-Sep-15	BT	84	6	1	989001004470-251
02-Sep-15	BT	84	6	1	989001004470-243
02-Sep-15	BT	84	8	1	989001004470-323
29-Aug-15	BT	86	5	1	989001004470-248
01-Sep-15	BT	86	6	1	989001004470-275
01-Sep-15	BT	86	7	1	989001004470-265
28-Aug-15	BT	88	14	1	989001004470-325

29-Aug-15	BT	88	8	1	989001004470-330
31-Aug-15	BT	88	8	1	989001004470-252
31-Aug-15	BT	88	5	1	989001004470-257
02-Sep-15	BT	89	7	1	989001004470-310
29-Aug-15	BT	90	4	1	989001004470-285
31-Aug-15	BT	91	6	1	989001004470-289
28-Aug-15	BT	92	8	1	989001004470-318
29-Aug-15	BT	92	3	1	989001004470-276
01-Sep-15	BT	94	9	1	989001004470-295
29-Aug-15	BT	98	9	1	989001004470-290
29-Aug-15	BT	99	17	1	989001004470-331
02-Sep-15	BT	99	11	1	989001004470-242
31-Aug-15	BT	101	11	1	989001004470-334
02-Sep-15	BT	101	13	1	989001004470-308
29-Aug-15	BT	105	11	1	989001004470-278
02-Sep-15	BT	105	13	1	989001004470-237
02-Sep-15	BT	106	12	1	989001004470-315
02-Sep-15	BT	108	15	1	989001004470-307
29-Aug-15	BT	109	8	1	989001004470-282
31-Aug-15	BT	110	11	1	989001004470-273
02-Sep-15	BT	110	14	1	989001004470-288
02-Sep-15	BT	111	14	1	989001004470-333
31-Aug-15	BT	113	15	1	989001004470-269
02-Sep-15	BT	114	10	1	989001004470-305
02-Sep-15	BT	114	13	1	989001004470-329
29-Aug-15	BT	115	13	1	989001004470-292
02-Sep-15	BT	115	15	1	989001004470-287
29-Aug-15	BT	116	15	1	989001004470-316
31-Aug-15	BT	116	16	1	989001004470-238
31-Aug-15	BT	116	13	1	989001004470-311
31-Aug-15	BT	117	14	1	989001004470-335
31-Aug-15	BT	117	15	1	989001004470-270
02-Sep-15	BT	117	15	1	989001004470-324
31-Aug-15	BT	118	15	1	989001004470-249
31-Aug-15	BT	118	16	1	989001004470-271
01-Sep-15	BT	119	14	1	989001004470-246
01-Sep-15	BT	120	19	1	989001004470-239
01-Sep-15	BT	120	16	1	989001004470-245
01-Sep-15	BT	121	15	1	989001004470-264
02-Sep-15	BT	121	17	1	989001004470-309
29-Aug-15	BT	122	16	1	989001004470-301
29-Aug-15	BT	122	21	1	989001004470-255
02-Sep-15	BT	122	16	1	989001004470-298
29-Aug-15	BT	123	18	1	989001004470-313
31-Aug-15	BT	123	18	1	989001004470-262
31-Aug-15	BT	125	17	1	989001004470-284
01-Sep-15	BT	125	16	1	989001004470-260
01-Sep-15	BT	125	17	1	989001004470-236
02-Sep-15	BT	125	18	1	989001004470-328
29-Aug-15	BT	126	18	1	989001004470-321
29-Aug-15	BT	126	19	1	989001004470-317
29-Aug-15	BT	129	17	1	989001004470-256
01-Sep-15	BT	129	20	1	989001004470-241
01-Sep-15	BT	130	20	1	989001004470-300
29-Aug-15	BT	131	17	1	989001004470-326
01-Sep-15	BT	132	19	1	989001004470-247
01-Sep-15	BT	133	24	1	989001004470-254
01-Sep-15	BT	133	19	1	989001004470-302
01-Sep-15	BT	135	23	1	989001004470-259
28-Aug-15	BT	139	31	1	989001004470-327
28-Aug-15	BT	139	15	1	989001004470-258
29-Aug-15	BT	145	27	1	989001004470-293
01-Sep-15	BT	146	28	1	989001004470-240
28-Aug-15	BT	149	22	1	989001004470-299
28-Aug-15	BT	165	54	1	989001004470-286
01-Sep-15	BT	172	46	1	989001004470-266

28-Aug-15	BT	181	63	1	989001004470-314
29-Aug-15	BT	194	97	1	989001004470-272
29-Aug-15	BT	196	70	1	989001004470-306
28-Aug-15	BT	330	412	1	989001004470-320
28-Aug-15	BT	398	652	1	989001004470-304
28-Aug-15	BT	445	882	1	989001004470-283
01-Sep-15	BT	478	1086	1	989001004470-263
01-Sep-15	BT	538		1	989001004470-261
01-Sep-15	BT	615		1	989001004470-280
01-Sep-15	BT (YOY)	40		1	
01-Sep-15	BT (YOY)	42		1	
28-Aug-15	BT (YOY)	43		1	
01-Sep-15	BT (YOY)	44		1	
01-Sep-15	BT (YOY)	44	1	1	
01-Sep-15	BT (YOY)			4	
20-Sep-16	MW			1	
28-Aug-15	MW	128	19	1	
28-Aug-15	MW	155	34	1	
31-Aug-15	MW	161	39	1	
28-Aug-15	MW	175	60	1	
28-Aug-15	MW	176	49	1	
29-Aug-15	MW	180	68	1	
28-Aug-15	MW	185	53	1	
29-Aug-15	MW	195	76	1	
29-Aug-15	MW	200	65	1	
28-Aug-15	MW	218	132	1	
28-Aug-15	MW	221	68	1	
28-Aug-15	MW	226	82	1	
02-Sep-15	MW	236	147	1	
02-Sep-15	MW	237	124	1	
02-Sep-15	MW	284	300	1	
20-Sep-16	RB	63	2	1	
20-Sep-16	RB	85	7	1	989001006037-214
20-Sep-16	RB	91	7	1	989001006037-269
20-Sep-16	RB	93	9	1	989001006037-245
20-Sep-16	RB	94	12	1	989001006037-270
20-Sep-16	RB	98	9	1	989001006037-196
20-Sep-16	RB	101	11	1	989001006037-236
21-Sep-16	RB	223	124	1	989001006037-291
28-Aug-15	RB	72	4	1	
28-Aug-15	RB	72	5	1	
28-Aug-15	RB	73	5	1	
28-Aug-15	RB	74	4	1	
28-Aug-15	RB	75	4	1	
28-Aug-15	RB	77	6	1	
29-Aug-15	RB	80	6	1	989001004470-294
28-Aug-15	RB	81	6	1	
29-Aug-15	RB	82	6	1	989001004470-267
29-Aug-15	RB	83	8	1	989001004470-332
31-Aug-15	RB	83	8	1	989001004470-250
28-Aug-15	RB	85	8	1	
28-Aug-15	RB	85	9	1	
28-Aug-15	RB	87	9	1	
28-Aug-15	RB	88	8	1	
29-Aug-15	RB	88	7	1	989001004470-253
28-Aug-15	RB	89	6	1	
28-Aug-15	RB	90	8	1	
28-Aug-15	RB	95	12	1	
31-Aug-15	RB	98	9	1	989001004470-274
02-Sep-15	RB	100	14	1	989001004470-322
28-Aug-15	RB	113	16	1	
31-Aug-15	RB	128	22	1	989001004470-279
28-Aug-15	RB	138	29	1	
29-Aug-15	RB	159	47	1	989001004470-296
28-Aug-15	Cyprinid			1	
28-Aug-15	Sculpin			73	

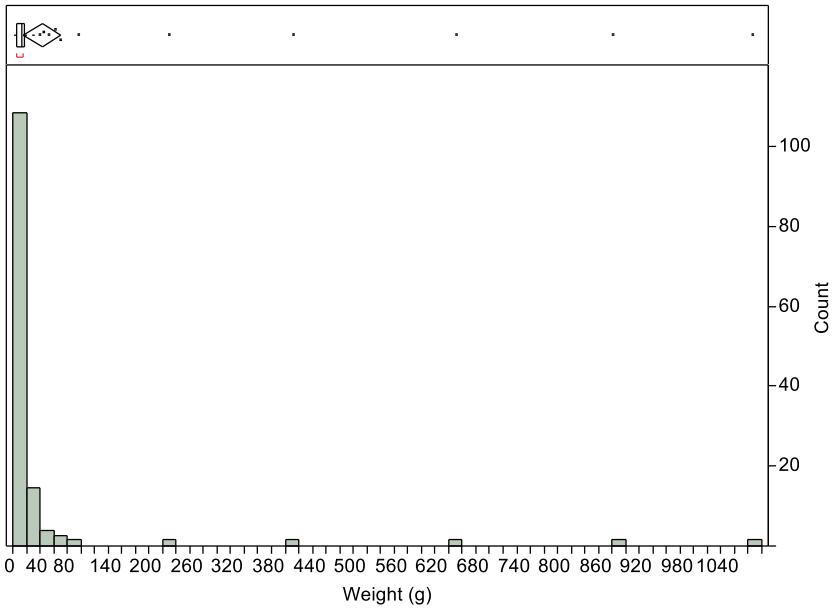
29-Aug-15	Sculpin	25
31-Aug-15	Sculpin	3
02-Sep-15	Sculpin	2

Bull Trout ranged in size from 40 to 615 mm (mean length ± SD = 125.5.0 ± 88.91 mm; A2 Table 5; A2 Figure 2). Adult Bull Trout sizes ranged from 445 and 615 mm (mean length ± SD = 519.0 ± 74.69; some weights were not recorded due to scale limitations; A2 Table 5; A2 Figure 2). Juvenile/sub-adult Bull Trout were the primary age class targeted in capture and their size ranged from 44 to 398 mm (mean length ± SD = 120.4 ± 46.18 mm), with most within 86 to 126 mm, which aligns with age 2 as reported in the literature (A2 Table 5; A2 Figure 2; Sterling 1978; McPhail and Murray 1979; Oliver 1979; Craig and Bruce 1982; Fraley and Shepard 1989; Ratliff 1992; Ziller 1992; see Section 1.0).



A2 Figure 2:Distribution (histogram and box plot) of lengths (mm) of tagged Bull Trout in Packsaddle Creek (captured Aug. 28 to Sept. 2, 2015 and Sept. 20 to 22, 2016). 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.

Bull Trout weighed from 0.5 to 1,086 g (mean weight ± SD = 43.1 ± 147.63 g; A2 Table 5; A2 Figure 3). Juvenile/sub-adult Bull Trout ranged from 0.5 to 652 g (mean weight ± SD = 28.7 ± 78.13 g), with most within 6 to 18 g (A2 Table 5; A2 Figure 3).



A2 Figure 3:Distribution (histogram and box plot) of weight (g) of tagged Bull Trout in Packsaddle Creek (Aug. 28 to Sept. 2, 2015 and Sept. 20 to 22, 2016). 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.

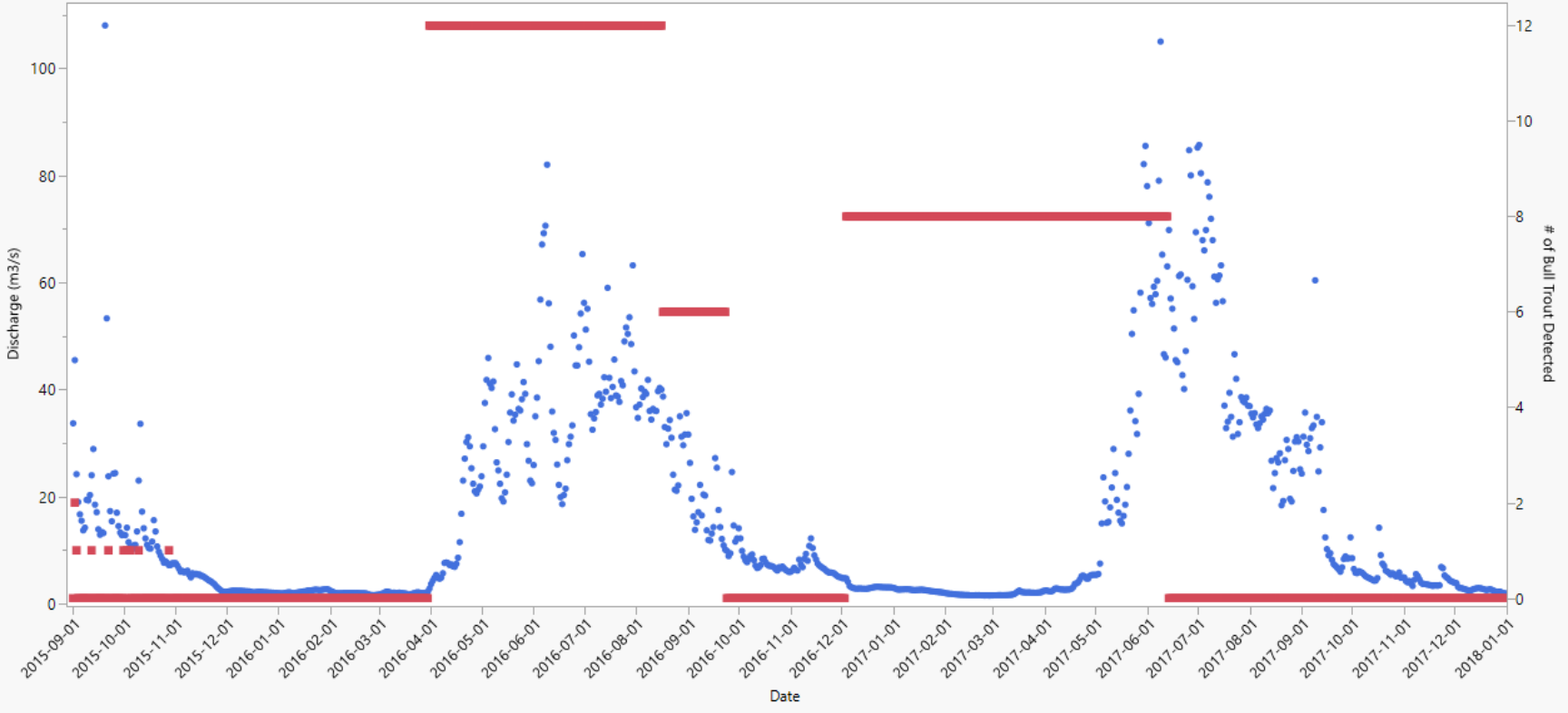
Data downloaded from the antenna reader indicated that 47 fish (2015 = 14; 2016 = 21; 2017 = 12) passed the Packsaddle Creek antenna between Aug. 31, 2015 to Oct. 27, 2018 (A2 Table 6). Of those fish, 39 were Bull Trout (3 adults and 36 juveniles) and 8 were Rainbow Trout (A2 Table 6). Specific details on the time and date of 32 detections were unavailable due to a malfunction with the internal clock of the antenna reader but these movements to the Reservoir were logged between Mar. 31, 2016 and Aug. 16, 2016 (n = 14); Aug. 16 to Sept 23, 2016 (n = 7), and Dec. 4, 2016 to Jun. 13, 2017 (n = 11; see A2 Table 6).

Of the 101 juvenile Bull Trout that were tagged, 10 (10%) passed during Sept/Oct 2015 during the night-time period; 12 (12%) passed during 31-Mar-16 to 16-Aug-16; 6 (6%) passed during 16-Aug-16 to 23-Sep-16; and 8 (8%) passed during 04-Dec-16 to 13-Jun-17. Most (86%) of these detected juvenile Bull Trout were tagged during the 2015 tagging session. These results suggest that the timing of outmigration of juvenile Bull Trout from Packsaddle Creek may coincide with the peak flows of spring freshet (May-June) and fall rains (Sept-Oct; A2 Figure 4) towards the end of the growth season and occurs at ages 2 and 3.

However, our data cannot preclude outmigration during summer and winter periods. The 3 adults passed during Sept/Oct 2015, during the spawning period in the stream. Only single logs of the fish were recorded, which we assumed indicated unidirectional movement from the tributary to the reservoir.

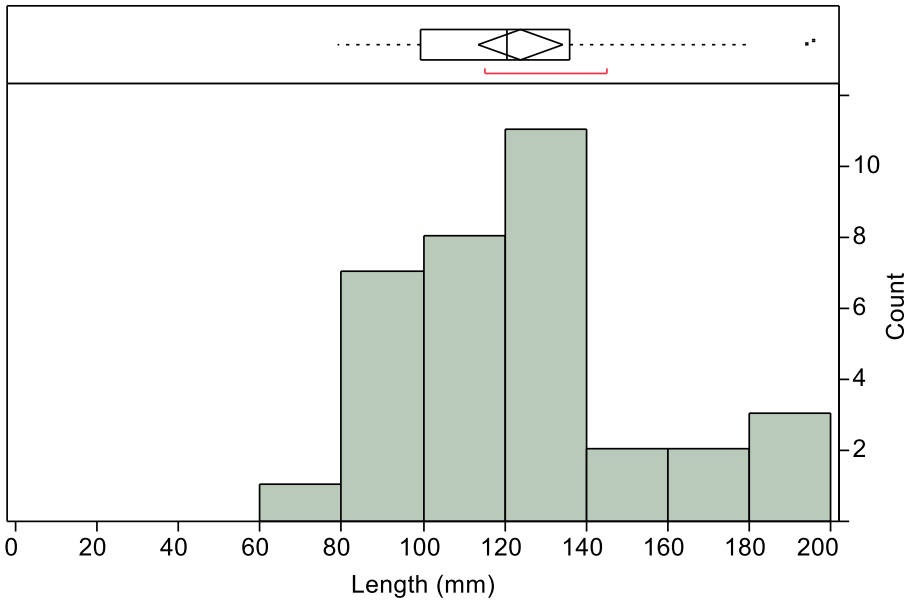
A2 Table 6: Summary of fish detected by antenna installed in Packsaddle Creek. Antenna was operated from Aug. 31 to Nov. 10, 2015; Mar. 31 to Dec. 4, 2016; Apr. 2 to Dec. 23, 2017; and Mar. 11 to Oct. 27, 2018. Species abbreviations are: 'BT' - Bull Trout; 'RB' - Rainbow Trout.

Scan Date/Time/Period	Species	Length (mm)	Weight (g)	Tag #
31-Aug-15/ 20:29	RB	80	6	989001004470-294
01-Sep-15/ 20:58	BT	538		989001004470-261
02-Sep-15/ 18:22	BT	116	15	989001004470-316
02-Sep-15/ 18:22	BT	125	17	989001004470-284
02-Sep-15/ 23:45	BT	478	1,086	989001004470-263
03-Sep-15/ 21:22	BT	181	63	989001004470-314
12-Sep-15/ 20:37	BT	145	27	989001004470-293
22-Sep-15/ 21:53	BT	126	19	989001004470-317
27-Sep-15/ 03:50	BT	615		989001004470-280
01-Oct-15/ 22:37	BT	194	97	989001004470-272
03-Oct-15/ 22:25	BT	98	9	989001004470-290
05-Oct-15/ 22:37	BT	398	652	989001004470-304
10-Oct-15/ 20:08	BT	165	54	989001004470-286
28-Oct-15/ 18:15	BT	196	70	989001004470-306
31-Mar-16 to 16-Aug-16	BT	120	19	989001004470-239
31-Mar-16 to 16-Aug-16	BT	88	8	989001004470-252
31-Mar-16 to 16-Aug-16	BT	129	17	989001004470-256
31-Mar-16 to 16-Aug-16	BT	135	23	989001004470-259
31-Mar-16 to 16-Aug-16	BT	121	15	989001004470-264
31-Mar-16 to 16-Aug-16	RB	128	22	989001004470-279
31-Mar-16 to 16-Aug-16	BT	81	5	989001004470-281
31-Mar-16 to 16-Aug-16	BT	115	15	989001004470-287
31-Mar-16 to 16-Aug-16	BT	94	9	989001004470-295
31-Mar-16 to 16-Aug-16	RB	159	47	989001004470-296
31-Mar-16 to 16-Aug-16	BT	122	16	989001004470-298
31-Mar-16 to 16-Aug-16	BT	116	13	989001004470-311
31-Mar-16 to 16-Aug-16	BT	79	6	989001004470-312
31-Mar-16 to 16-Aug-16	BT	330	412	989001004470-320
16-Aug-16 to 23-Sep-16	BT	131	17	989001004470-326
16-Aug-16 to 23-Sep-16	BT	139	31	989001004470-327
16-Aug-16 to 23-Sep-16	BT	88	8	989001004470-330
16-Aug-16 to 23-Sep-16	BT	101	11	989001004470-334
16-Aug-16 to 23-Sep-16	BT	117	14	989001004470-335
16-Aug-16 to 23-Sep-16	RB	101	11	989001006037-236
16-Aug-16 to 23-Sep-16	BT	163	40	989001006037-292
04-Dec-16 to 13-Jun-17	RB	85	7	989001006037-214
04-Dec-16 to 13-Jun-17	RB	94	12	98900100603-727
04-Dec-16 to 13-Jun-17	BT	100	12	989001006037-209
04-Dec-16 to 13-Jun-17	BT	114	13	989001004470-329
04-Dec-16 to 13-Jun-17	BT	145	35	989001006037-266
04-Dec-16 to 13-Jun-17	BT	129	20	989001004470-241
04-Dec-16 to 13-Jun-17	BT	96	3	989001006037-281
04-Dec-16 to 13-Jun-17	BT	93	6	989001006037-274
04-Dec-16 to 13-Jun-17	RB	83	8	989001004470-332
04-Dec-16 to 13-Jun-17	BT	132	19	989001004470-247
04-Dec-16 to 13-Jun-17	BT	115	13	989001004470-292
22-Jun-17/ 13:57	RB	98	9	989001006037-196

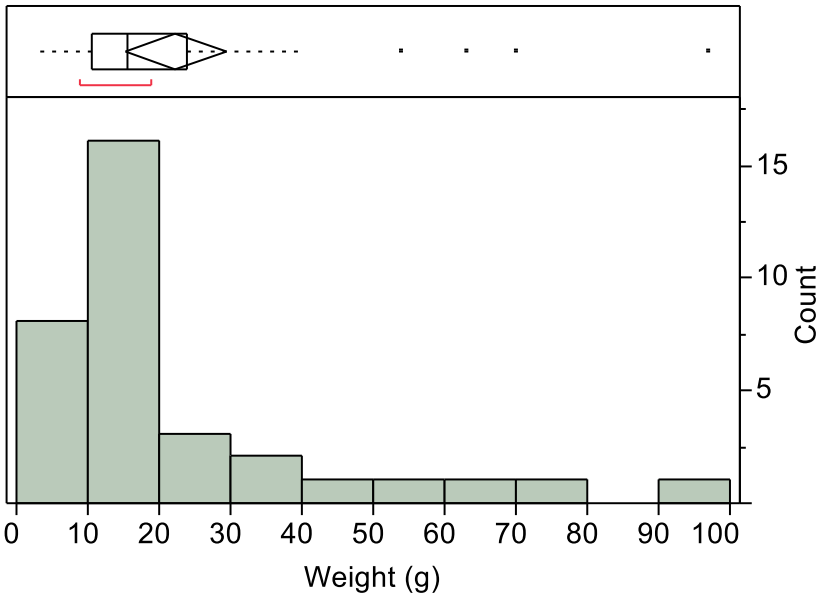


A2 Figure 4: Hydrograph of daily discharge from Gold River (Water Survey Canada Station 08NB14), tributary of Kinbasket Reservoir (Sept 2015 to Dec 2017), during 2017. Blue dots represent mean daily discharge and red squares represent number of juvenile Bull Trout detected. Note estimated time of detections of juvenile Bull Trout detected from Mar. 31, 2016 and Aug. 16, 2016 (n = 14); Aug. 16 to Sept 23, 2016 (n = 7), and Dec. 4, 2016 to Jun. 13, 2017 (n = 11; see A2 Table 6) due to antenna internal clock malfunction. Station is located 156 km South-East of Packsaddle Creek.

Mean length at time of tagging of detected juvenile/sub-adult Bull Trout was 137.1 ± 63.38 mm and mean weight at time of tagging of detected Bull Trout was 50.6 ± 123.5 g (A2 Table 6; A2 Figure 5; A2 Figure 6). However, the weight and length of 2 sub-adult individuals appeared to be outliers and when their data were removed from analyses, the mean length and weight at time of tagging were 123.8 ± 29.80 mm (A2 Figure 5) and 22.3 ± 20.55 g (A2 Figure 6), respectively, and greatly improved the variation in data. Most juvenile Bull Trout ranged from 33.5 to 136 mm and 10.5 to 24.0 g at time of tagging.



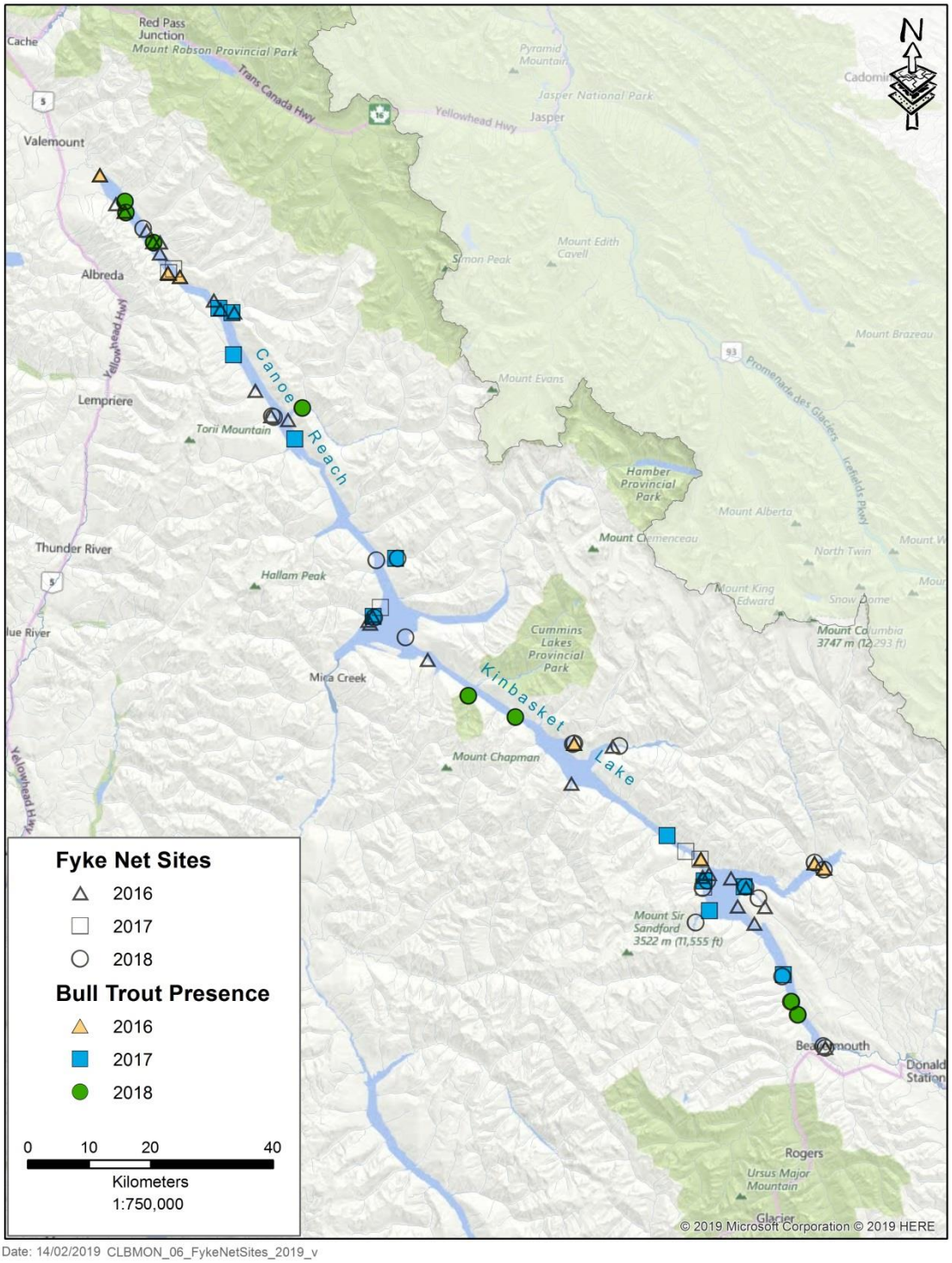
A2 Figure 5: Distribution (histogram and box plot) of lengths (mm) of tagged juvenile Bull Trout detected by antenna at Packsaddle Creek. Antenna was operated from Aug. 31 to Nov. 10, 2015; Mar. 31 to Dec. 4, 2016; Apr. 2 to Dec. 23, 2017; and Mar. 11 to Oct. 27, 2018. Boxes represent interquartile range, 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.



A2 Figure 6: Distribution (histogram and box plot) of weights (g) of tagged juvenile Bull Trout detected by antenna at Packsaddle Creek. Antenna was operated from Aug. 31 to Nov. 10, 2015; Mar. 31 to Dec. 4, 2016; Apr. 2 to Dec. 23, 2017; and Mar. 11 to Oct. 27, 2, 2018. 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.

8.5.2 Nearshore Fish and Habitat Assessment

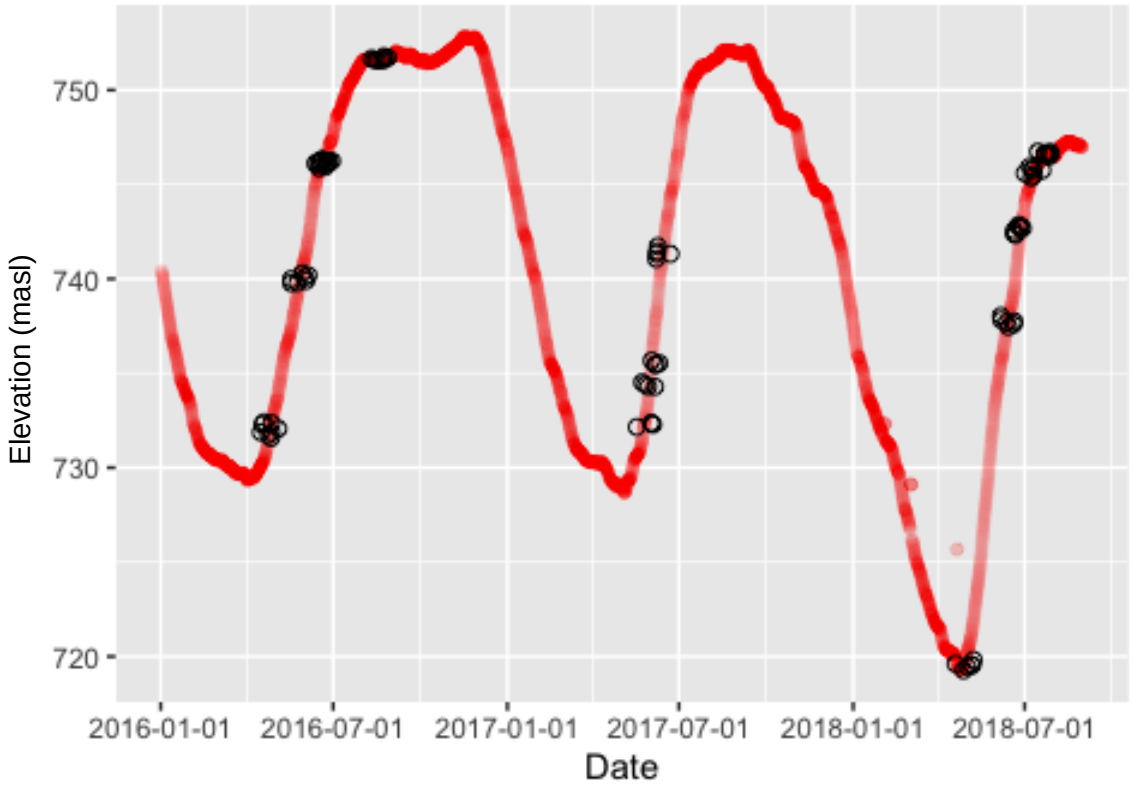
Nearshore fish and habitat assessment sites were fairly evenly distributed across Kinbasket Reservoir in all three years of sampling (2016-2018; A2 Figure 7).



A2 Figure 7: Locations of nearshore fish and habitat assessments, including observations of Bull Trout in Kinbasket Reservoir for CLBMON-06 (April 2016 to August 2018).

Sampling occurred at a range of elevation levels so there was a good contrast among elevation levels (A2 Figure 8). Unfortunately, elevation levels are highly correlated with date (i.e., the ascending limb occurs in early summer) and so any relationship between Bull Trout catch and elevation will be confounded with time. For example, higher elevation could be associated with lower counts, but this could be an artefact of Bull Trout development where Bull Trout naturally leave the sampling areas as they get older within a season. This is an unfortunate problem and impossible to disentangle with an observational study.

An experiment is also likely infeasible. It is likely not possible to manipulate reservoir levels to such a degree that lower elevations coincide with older fish. Similarly, manipulating the growth of the fish to have different ages/sizes all subject to a particular reservoir elevation is also not feasible.

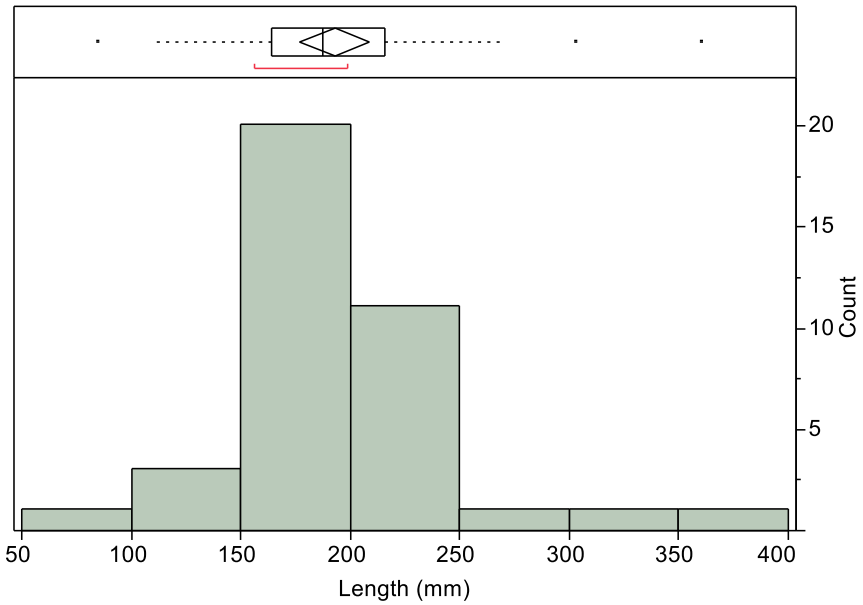


A2 Figure 8: Summary of reservoir elevations (red line) and time of surveys (black open circles) in Kinbasket Reservoir for the CLBMON-06 study (April, 2016 to August 2018). Points are jittered for better visualization of overlapping values.

A total of 51 Bull Trout (2016, n = 15; 2017, n = 14; 2018, n = 18; A2 Table 7) were captured in fyke-nets at 30 (35%) of the 86 surveyed locations (A2 Table 7). A total of 38 (75% of all Bull Trout captured) juvenile/sub-adult Bull Trout were captured at 22 sites (73% of Bull Trout sites).

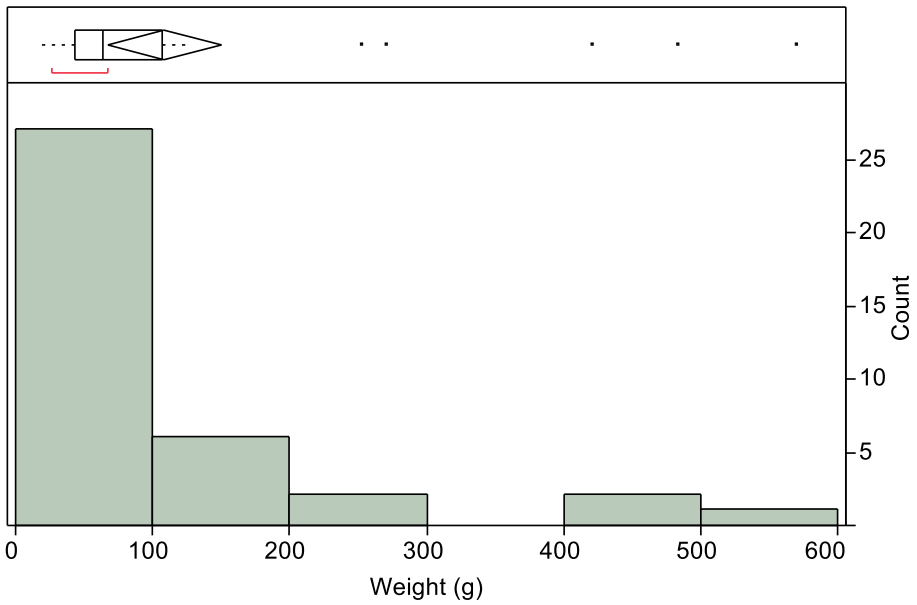
Juvenile/sub-adult Bull Trout sizes ranged from 85 to 360 mm (mean length ± SD = 193.1 ± 48.51 mm), with most within 164 to 216 mm, which aligns with age 3 as reported

in the literature (A2 Figure 9; Sterling 1978; McPhail and Murray 1979; Oliver 1979; Craig and Bruce 1982; Fraley and Shepard 1989; Ratliff 1992; Ziller 1992; see Section 1.0). This represents a 56% increase from the mean length at the time of tagging of juvenile Bull Trout detected by the antenna installed at Packsaddle Creek and suggests that outmigration from Packsaddle Creek occurs at age 2+ years. Adult Bull Trout sizes ranged from 400 and 730 mm (mean length ± SD = 552.6 ± 104.88 mm), with most within 469 to 654 mm.



A2 Figure 9: Distribution (histogram and box plot) of lengths (mm) of juvenile Bull Trout captured with fyke nets in the nearshore zones of Kinbasket Reservoir (captured April, 2016 to August 2018). 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.

Juvenile/sub-adult Bull Trout weights ranged from 14 to 570 g (mean weight ± SD = 108.5 ± 126.43 g), with most within 44 to 107 g (A2 Figure 10). This represents a 487% increase from the mean weight at the time of tagging of juvenile Bull Trout detected by the antenna installed at Packsaddle Creek. These weights are likely affected by consumption of prey fish that were caught in the fyke net at the same time. Adult Bull Trout sizes ranged from 132 and 1,835 g (mean weight ± SD = 734.4 ± 496.61 g), with most within 361 to 936 mm.



A2 Figure 10: Distribution (histogram and box plot) of weight (g) of juvenile Bull Trout captured with fyke nets in the nearshore zones of Kinbasket Reservoir (captured April, 2016 to August 2018). 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.

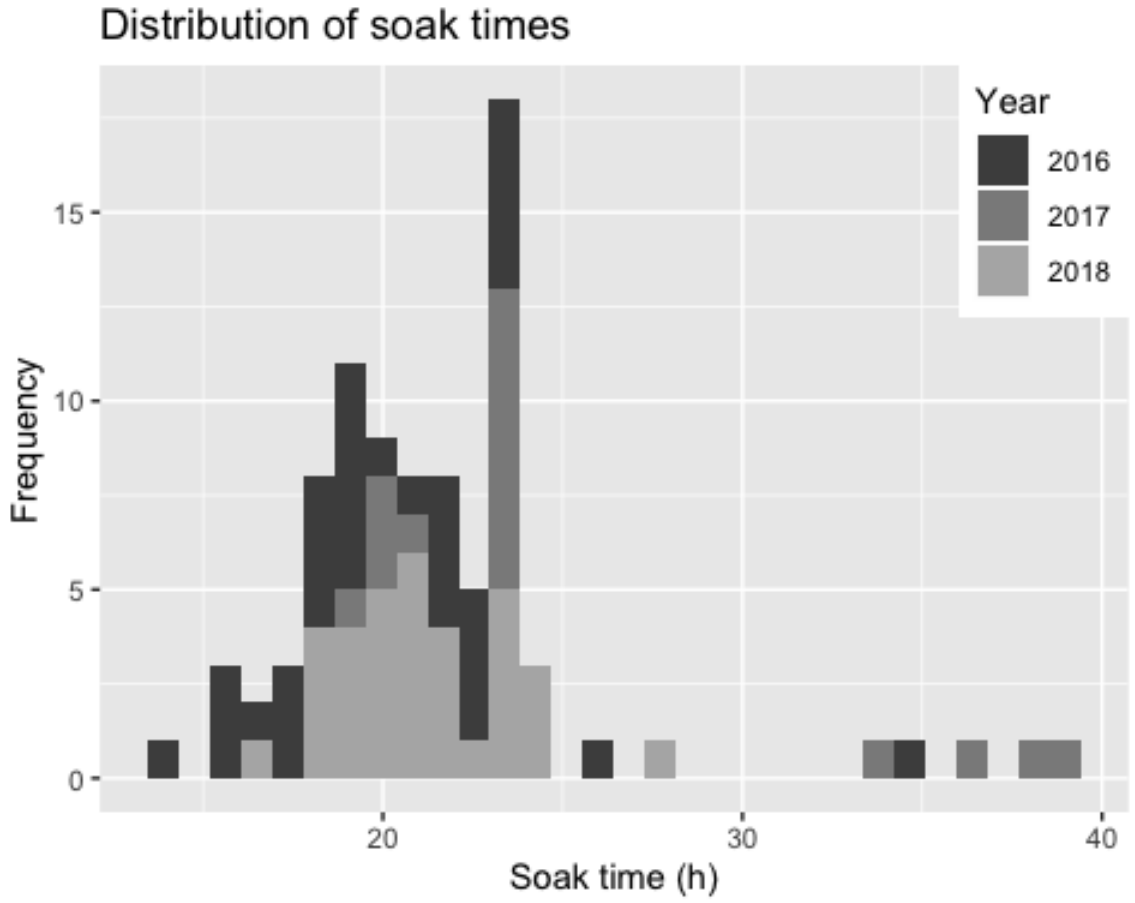
A2 Table 7: Summary of fish survey details in Kinbasket Reservoir for the CLBMON-06 study (April 2016 to August 2018).

Tributary	UTM E	UTM N	Set Date (dd/mm/yyyy)	Set Time	Check Date (dd/mm/yyyy)	Check Time	Soak Time (h)	# Bull Trout	CPUE	Dominant Substrate	Sub-dominant Substrate
Horse Creek	363616	5837126	23/04/2016	19:19	24/04/2016	10:43	15.40	0	0.00	Fines	Cobble
Horse Creek	363668	5838957	23/04/2016	19:19	24/04/2016	10:43	15.40	0	0.00	Fines	Cobble
Yellowjacket	361467	5840876	24/04/2016	15:00	25/04/2016	10:01	19.02	0	0.00	Fines	Sand
Griffin	362543	5838995	24/04/2016	18:30	25/04/2016	11:22	16.87	0	0.00	Fines	Sand
Yellowjacket	361467	5840874	24/04/2016	16:00	25/04/2016	09:47	17.78	0	0.00	Fines	Sand
Km 35	372439	5829459	25/04/2016	14:45	26/04/2016	09:32	18.78	0	0.00	Fines	Cobble
Ptarmigan	375776	5827501	25/04/2016	16:22	26/04/2016	11:32	19.17	0	0.00	Fines	Sand
Bulldog	366893	5833315	25/04/2016	18:34	26/04/2016	13:45	19.18	3	0.16	Sand	Cobble
Mica area	407305	5770914	26/05/2016	09:40	27/05/2016	20:33	34.88	0	0.00	Cobble	Sand
Sullivan	437405	5756758	26/05/2016	12:16	27/05/2016	11:19	23.05	0	0.00	Sand	Gravel
Across from Sullivan	430716	5750717	26/05/2016	13:15	27/05/2016	09:46	20.52	0	0.00	Cobble	Sand
Kinbasket River	431123	5757239	26/05/2016	14:06	27/05/2016	12:13	22.12	1	0.05	Sand	Gravel
Encampment creek, NW side	398305	5778053	27/05/2016	15:12	28/05/2016	08:39	17.45	2	0.06	Cobble	Sand
Encampment creek, SE side	397596	5777272	27/05/2016	15:36	28/05/2016	09:29	17.88	0	0.00	Sand	Gravel
Encampment, embayment	397889	5776785	27/05/2016	16:26	28/05/2016	10:01	17.58	1	0.06	Sand	Gravel
Mayville creek	462256	5730614	19/06/2016	17:21	20/06/2016	08:38	15.28	0	0.00	Gravel	Cobble
Quartz creek	472100	5707650	19/06/2016	18:00	20/06/2016	07:54	13.90	0	0.00	Fines	Gravel
Good Fellow creek	471899	5736880	20/06/2016	10:28	21/06/2016	08:37	22.15	1	0.05	Gravel	Cobble
Chatter creek	470311	5737782	20/06/2016	11:31	21/06/2016	09:51	22.33	1	0.04	Fines	Sand
Adj. Succour creek	456697	5735280	20/06/2016	12:24	21/06/2016	14:42	26.30	0	0.00	Fines	Sand
Succour creek	459184	5733751	20/06/2016	12:53	21/06/2016	11:30	22.62	0	0.00	Gravel	Cobble
West side of Succour creek	457821	5730703	21/06/2016	13:27	22/06/2016	08:16	18.82	0	0.00	Fines	Gravel
Surprise Rapids reset	451802	5738430	22/06/2016	11:20	23/06/2016	08:38	21.30	1	0.05	Cobble	Gravel
Surprise Rapids	451802	5738430	21/06/2016	15:56	22/06/2016	10:19	18.38	2	0.11	Cobble	Gravel
S of Surprise Rapids	452111	5735498	21/06/2016	16:25	22/06/2016	09:26	17.02	0	0.00	Fines	Sand
Esplanade Bay	460516	5727880	21/06/2016	17:03	22/06/2016	13:21	20.30	0	0.00	Sand	Gravel
West side of Bear Island	453149	5735997	22/06/2016	12:03	23/06/2016	09:34	21.52	0	0.00	Sand	Fines
Hugh Allan Creek	384541	5810004	16/08/2016	10:03	17/08/2016	09:36	23.55	0	0.00	Sand	Gravel
Windfall Creek	381752	5810622	16/08/2016	10:52	17/08/2016	10:14	23.37	0	0.00	Sand	Gravel
Grouse Creek	379190	5814764	16/08/2016	11:56	17/08/2016	10:59	23.05	0	0.00	Cobble	Sand
North Ptarmigan Creek	373540	5827973	16/08/2016	13:34	17/08/2016	12:38	23.07	0	0.00	Cobble	Sand
Blackmore Creek	364934	5833944	17/08/2016	13:42	18/08/2016	08:35	18.88	2	0.11	Cobble	Gravel
Packsaddle Creek	353843	5849907	17/08/2016	14:29	18/08/2016	12:03	21.57	1	0.05	Sand	Cobble
Canoe Creek	356458	5845200	17/08/2016	15:15	18/08/2016	13:09	21.90	0	0.00	Gravel	Fines
Unnamed tributary	357924	5843955	17/08/2016	15:41	18/08/2016	10:01	18.33	1	0.05	Gravel	Cobble
Harvey Creek	402040	5787358	25/05/2017	0	26/05/2017	9:59	33.98	1	0.03	Sand	Sand

Hugh Allan Creek	385597	5806833	25/05/2017	0	26/05/2017	12:25	36.42	2	0.05	Sand	Gravel
N. Side of Encampment Creek	399557	5779374	25/05/2017	0	26/05/2017	14:05	38.08	0	0.00	Fines	Fines
S. Side of Encampment Creek	398372	5777917	25/05/2017	0	26/05/2017	15:02	39.03	3	0.08	Sand	Gravel
Colpitti Creek	465224	5719534	30/05/2017	9:41	31/05/2017	8:52	23.18	1	0.04	Fines	Fines
Little Foster Creek	451667	5738351	30/05/2017	10:58	31/05/2017	10:28	23.50	0	0.00	Fines	Gravel
Nixon Creek	446274	5742181	30/05/2017	12:52	31/05/2017	12:23	23.52	1	0.04	Fines	Gravel
Smith Creek	449329	5739607	30/05/2017	11:51	31/05/2017	11:28	23.62	0	0.00	Fines	Fines
E. Succour Creek	458844	5733846	01/06/2017	15:13	02/06/2017	11:34	20.35	1	0.05	Fines	Cobble
Gold Creek	453172	5729959	01/06/2017	14:38	02/06/2017	10:38	20.00	1	0.05	Sand	Fines
S. Surprise rapids	452340	5734806	01/06/2017	13:24	02/06/2017	8:38	19.23	1	0.05	Fines	Gravel
SW. Surprise Rapids	452236	5733788	01/06/2017	13:58	02/06/2017	9:32	19.57	0	0.00	Fines	Sand
Bulldog creek	365837	5834555	13/06/2017	12:21	14/06/2017	11:28	23.12	0	0.00	Cobble	Sand
N. Ptarmigan Creek	373214	5828140	13/06/2017	11:06	14/06/2017	10:28	23.37	3	0.00	Cobble	Sand
Ptarmigan Creek	375379	5827438	13/06/2017	10:41	14/06/2017	10:08	23.45	1	0.04	Cobble	Sand
Unnamed Creek	375632	5820546	13/06/2017	9:41	14/06/2017	9:02	23.35	2	0.09	Cobble	Sand
Blackmore creek	365054	5833945	14/06/2017	12:06	15/06/2017	9:00	20.90	0	0.00	Cobble	Sand
Windfall	382234	5810425	26/04/2018	12:35	27/04/2018	15:58	27.38	0	0.00	Sand	Gravel
Encampment creek	398591	5777759	27/04/2018	13:16	28/04/2018	10:43	21.45	0	0.00	Fines	Sand
W Harvey	398913	5787073	27/04/2018	14:51	28/04/2018	09:12	18.35	0	0.00	Sand	Sand
Bay W of wood	403674	5774542	28/04/2018	16:19	29/04/2018	11:45	19.43	0	0.00	Sand	Fines
Kinbasket river	430925	5757147	28/04/2018	14:13	29/04/2018	09:08	18.92	0	0.00	Fines	Fines
Tsar	421548	5761499	28/04/2018	15:18	29/04/2018	09:53	18.58	1	0.05	Fines	Fines
Dave Henry	357955	5845548	12/06/2018	10:36	13/06/2018	09:45	23.15	6	0.26	Sand	Cobble
Horse	362595	5838848	12/06/2018	13:19	13/06/2018	12:50	23.52	1	0.04	Boulder	Cobble
Unnamed	358082	5843759	12/06/2018	08:59	13/06/2018	08:30	23.52	2	0.09	Cobble	Sand
Yellowjacket	360913	5841136	12/06/2018	11:51	13/06/2018	11:39	23.80	0	0.00	Sand	Boulder
Dave Henry	357955	5845548	13/06/2018	10:40	14/06/2018	07:30	20.83	1	0.05	Sand	Cobble
Horse	362595	5838848	13/06/2018	13:00	14/06/2018	09:15	20.25	0	0.00	Boulder	Cobble
Carrol	466546	5715159	26/06/2018	11:50	27/06/2018	11:30	23.67	1	0.04	Cobble	Fines
Colpitti	465109	5719262	26/06/2018	12:30	27/06/2018	12:59	24.48	0	0.00	Sand	Cobble
Mayvill	467629	5712982	26/06/2018	10:49	27/06/2018	10:45	23.93	3	0.13	Sand	Cobble
Quartz	471758	5707899	26/06/2018	09:43	27/06/2018	09:45	24.03	0	0.00	Fines	Cobble
Island N of Gold	452842	5734868	27/06/2018	15:49	28/06/2018	10:45	18.93	0	0.00	Fines	Sand
North Gold	452112	5733666	27/06/2018	15:23	28/06/2018	09:55	18.53	0	0.00	Sand	Cobble
Succour	459078	5733865	27/06/2018	16:31	28/06/2018	12:01	19.50	0	0.00	Fines	Fines
Harvey	402390	5787385	10/07/2018	14:08	11/07/2018	10:59	20.85	0	0.00	Sand	Sand
Hugh Allen	386845	5811911	10/07/2018	10:12	11/07/2018	08:56	22.73	1	0.04	Sand	Boulder
Windfall	381882	5810569	10/07/2018	11:52	11/07/2018	09:39	21.78	0	0.00	Sand	Gravel
Kinbasket river	431176	5757251	11/07/2018	14:50	12/07/2018	11:02	20.20	0	0.00	Gravel	Cobble

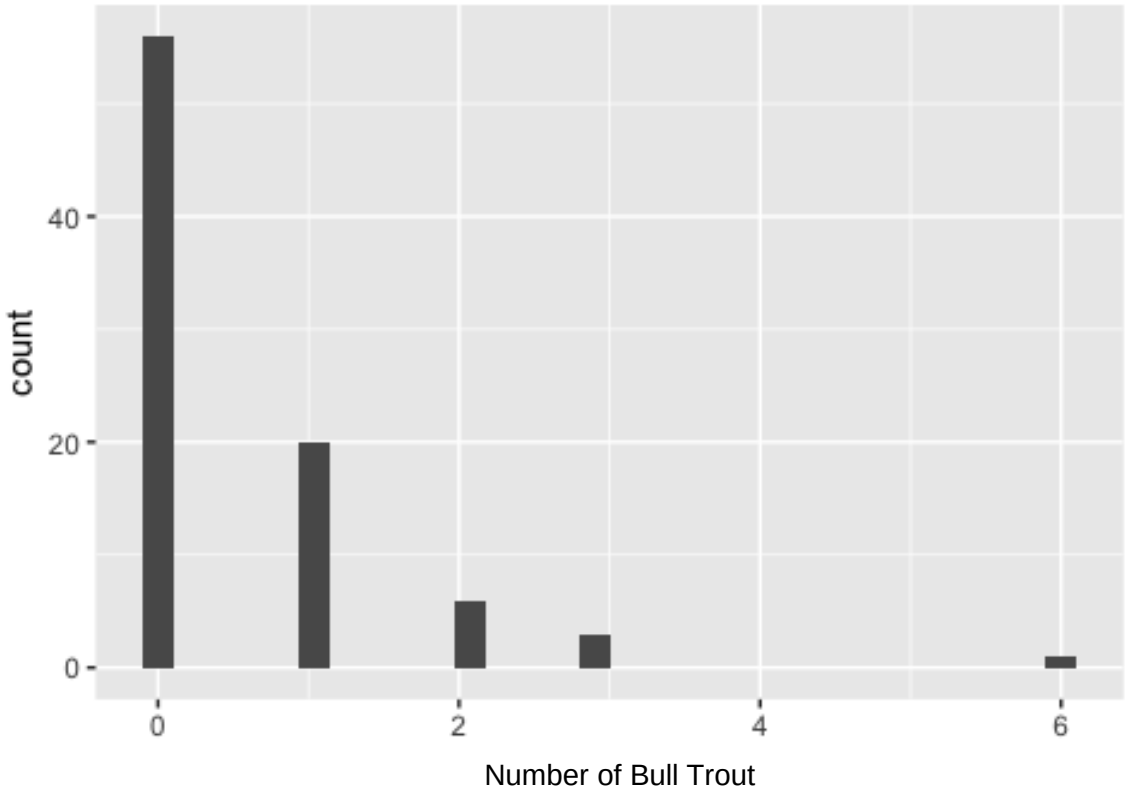
Sullivan	438525	5756800	11/07/2018	13:45	12/07/2018	09:42	19.95	0	0.00	Fines	Cobble
Unknown adj to Cummins	413901	5764987	11/07/2018	15:55	12/07/2018	12:36	20.68	2	0.10	Sand	Cobble
Unknown near Potlatch	413901	5764987	11/07/2018	16:37	12/07/2018	14:08	21.52	0	0.00	Fines	Boulder
Carrol	466458	5715159	23/07/2018	12:39	24/07/2018	08:16	19.62	0	0.00	Sand	Cobble
Colpitti	465041	5719235	23/07/2018	11:30	24/07/2018	08:50	21.33	0	0.00	Sand	Cobble
Mayvill	467572	5712983	23/07/2018	13:32	24/07/2018	07:40	18.13	0	0.00	Gravel	Sand
Quartz	472092	5707636	23/07/2018	14:12	24/07/2018	06:56	16.73	0	0.00	Fines	Cobble
Chatter	470342	5737796	24/07/2018	12:11	25/07/2018	08:45	20.57	0	0.00	Fines	Fines
Gold	450932	5728041	24/07/2018	14:29	25/07/2018	11:14	20.75	0	0.00	Fines	Fines
Goodfellow	471865	5736676	24/07/2018	11:31	25/07/2018	07:44	20.22	0	0.00	Sand	Cobble
Succour	461186	5731990	24/07/2018	13:20	25/07/2018	09:56	20.60	0	0.00	Fines	Fines

Mean soak time for fyke nets was 21.64 ± 4.509 h but some were set for > 30 h (A2 Figure 11).



A2 Figure 11: Histogram of fyke net soak times (h) for the CLBMON-06 study in Kinbasket Reservoir (April 2016 to August 2018).

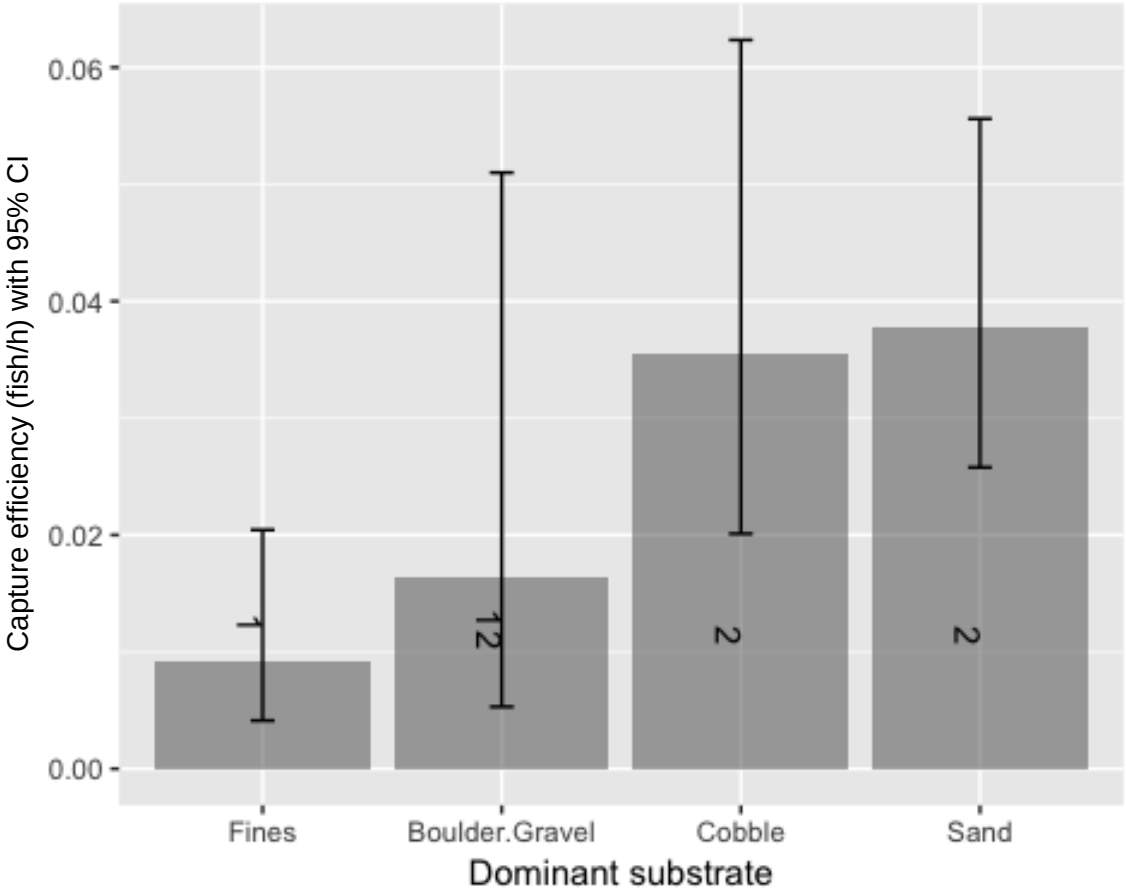
The distribution of Bull Trout counts followed a Poisson distribution with low mean (not corrected for soak time; A2 Figure 12). Most fyke nets did not capture any Bull Trout and total catch per fyke net set was very low (most capturing only a single Bull Trout) with a maximum of 6 individuals caught in a set.



A2 Figure 12: Histogram of number of juvenile Bull Trout captures in fyke nets (not corrected for soak time) for the CLBMON-06 study in Kinbasket Reservoir (April 2016 to August 2018).

Only a small number of observations of juvenile Bull Trout were made at sites with Boulder and Gravel substrates (1 Bull Trout and 2 Bull Trout, respectively), hence data for these two substrates were pooled into a single substrate type for analyses. The confidence intervals for the median number of juvenile Bull Trout captured on Cobble and the other substrate types had very little overlap (A2 Figure 13). This suggests that there were more Bull Trout captured on Cobble substrate than on the other substrate types.

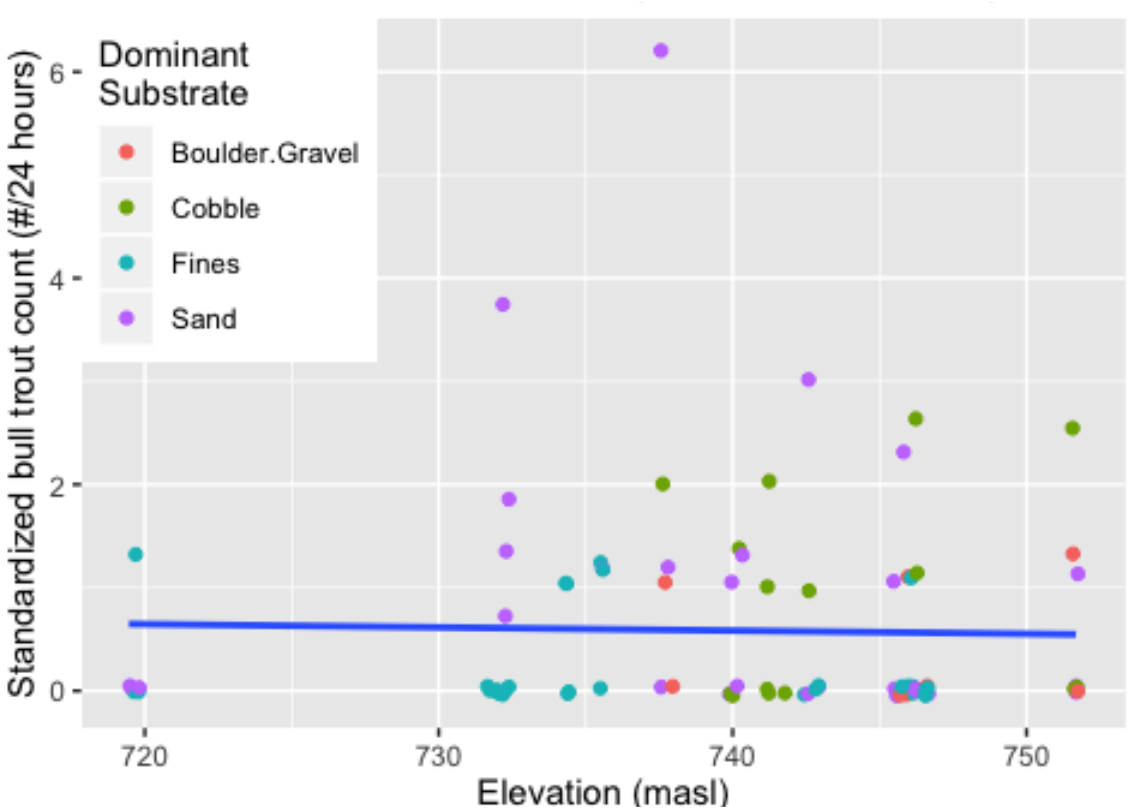
The Poisson ANOVA confirmed that there was a significant difference in the capture rate (fish/hour) among the substrate categories ($p = 0.002$). Tukey multiple comparison indicated that the capture efficiency was lowest on Fine substrate compared to Cobble and Sand substrates (A2 Figure 13). The single digits on the graph indicate substrates for which the capture rate could not be distinguished. For example, the Fines and Boulder-Gravel substrate type share the digit 1 indicating that their capture rates could not be distinguished, but Fines and Sand do not share a digit, and so it is possible to distinguish the capture rates. Also note that the confidence intervals for the capture-rate have extensive overlap for Fines and Boulder-Gravel, but there is little overlap between the confidence intervals for the capture rates for Fines and Cobble/Sand.



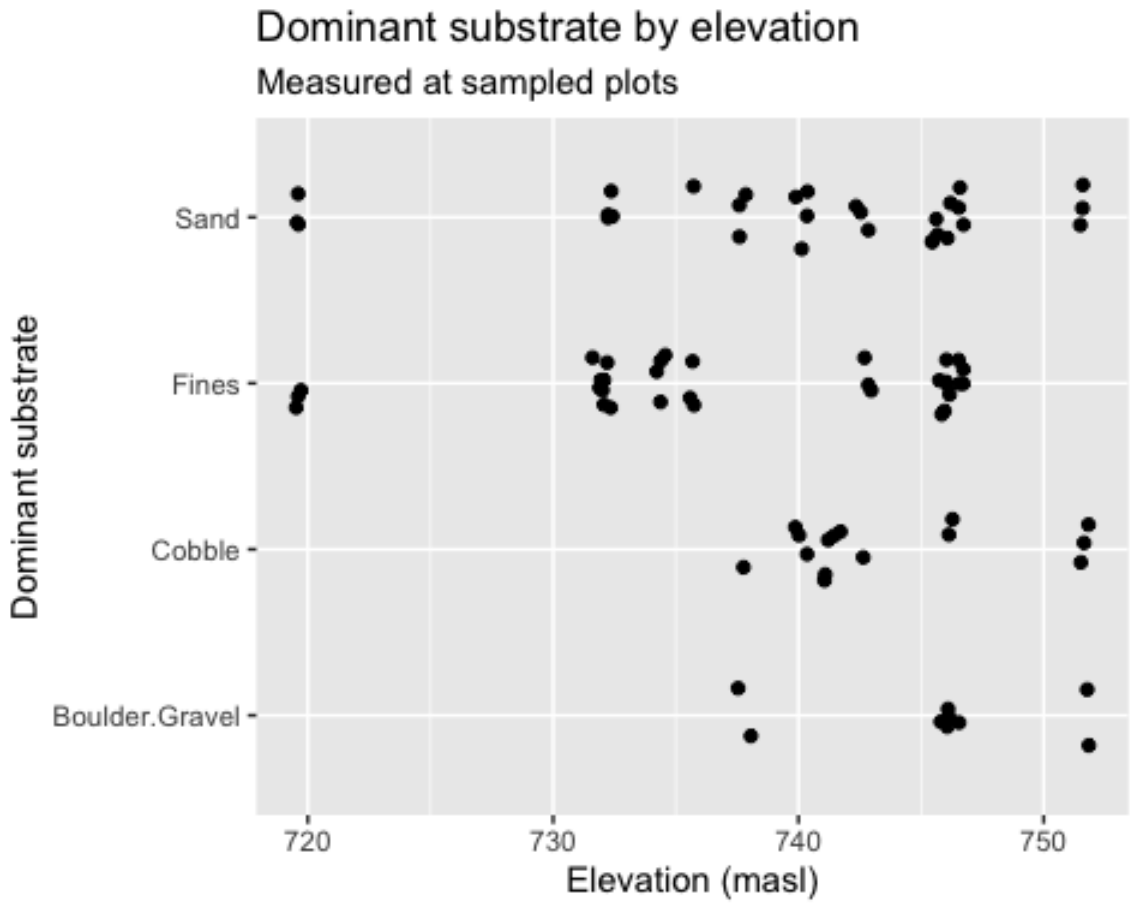
A2 Figure 13: Comparison of capture efficiency of juvenile Bull Trout among various substrate types using Tukey multiple comparison for the CLBMON-06 study in Kinbasket Reservoir (April 2015 to August 2018). The single digits on the graph indicate substrates for which the capture rate could not be distinguished. Bars indicate 95% confidence intervals.

There was no evidence of a difference in the mean capture efficiency (fish/hour) among years ($p = 0.532$).

The plot ofstandardized count of Bull Trout (per 24 h fyke net soak time) by elevation suggests no strong effect of elevation (A2 Figure 14). However, preferred cobble, boulder, and gravel substrate were concentrated at higher elevations while sand was common at all elevations (A2 Figure 15).



A2 Figure 14: Distribution of juvenile Bull Trout captures at various sampling elevations for the CLBMON-06 study in Kinbasket Reservoir (April 2015 to August 2018). Points jittered to avoid overplotting. The blue line indicates the least square line of best fit.

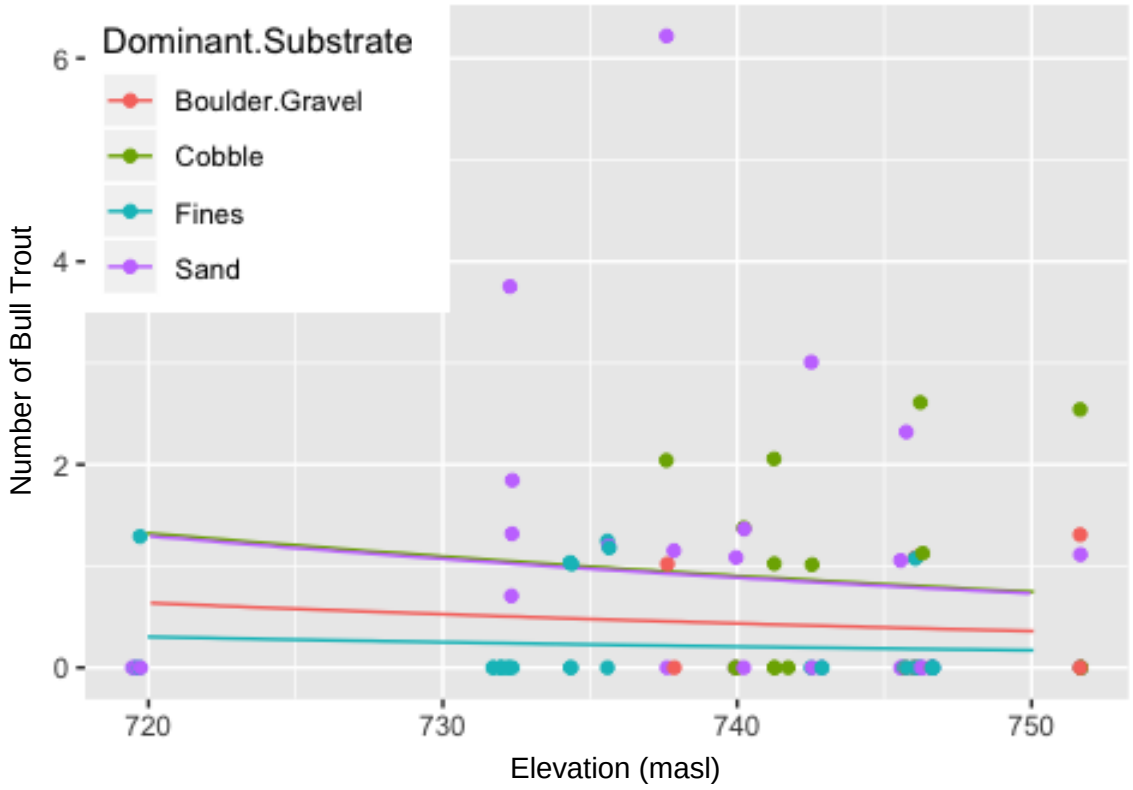


A2 Figure 15: Distribution of dominant substrate at various sampling elevations for the CLBMON-06 study in Kinbasket Reservoir (April 2015 to August 2018). Points jittered to avoid overplotting.

The combined model used to assess the influence of substrate type and elevation on capture efficiency indicated that there was no evidence of an effect of $Elevation$ on the capture-efficiency ($p = 0.31$). The estimate of the effect of elevation on capture-efficiency was -0.019 (SE = 0.018), which indicates a -1.9% drop in capture efficiency for each 1 m increase in elevation, but no effect was detected given the large SE.

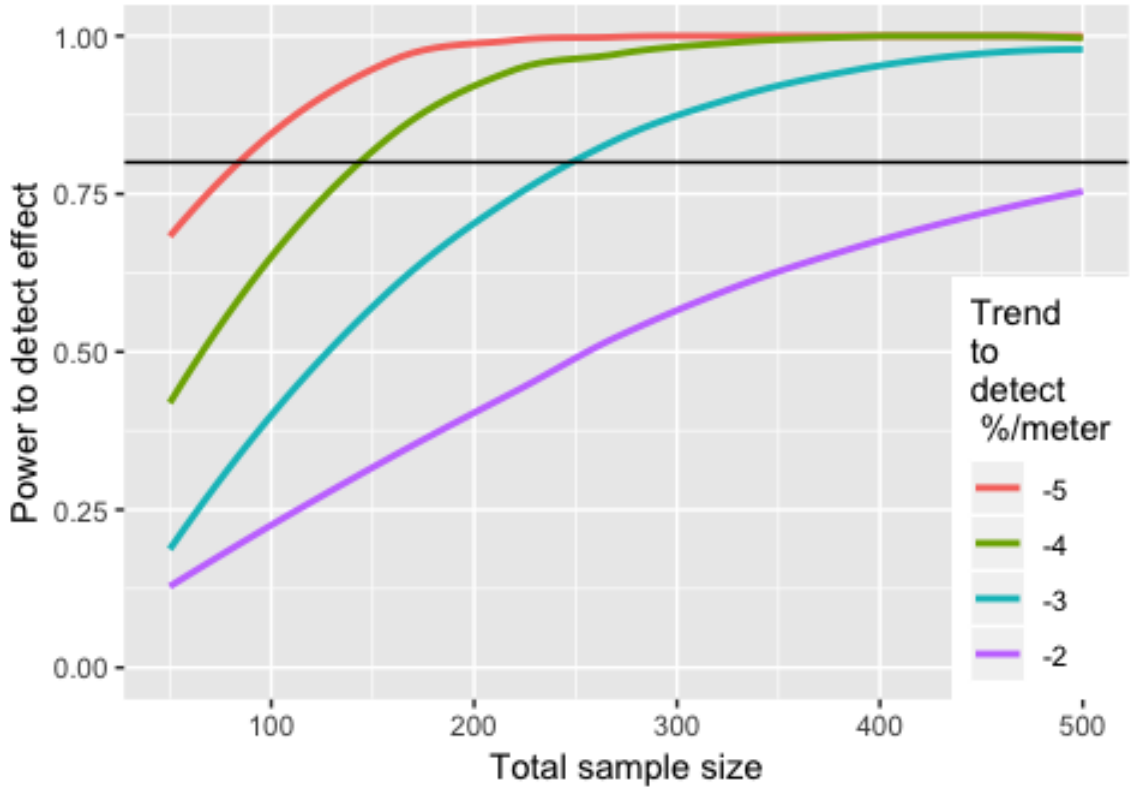
When data were adjusted for soak time by predicting the mean Bull Trout count for a 24-hour soak time and adjusting the actual data to the same 24 hour period (i.e., $adjusted\ count = count/soak\ time \times 24$), there were differences in capture efficiency among the substrate types (A2 Figure 16). However, the slope of the effect of elevation was very shallow, confirming that there was no evidence of an effect of elevation on capture efficiency.

Similar findings (not shown) were obtained when a model with only $Elevation$ but ignoring dominant substrate was also fit (i.e., no evidence of an effect of elevation).



A2 Figure 16: Distribution of juvenile Bull Trout capture, adjusted for soak time, at various sampling elevations for the CLBMON-06 study in Kinbasket Reservoir (April 2015 to August 2018). Lines indicate the least square line of best fit.

Assuming that the true effect is of comparable size and that additional samples would sample similar range of elevations, a power analysis was conducted to determine the effect size that could be detected with varying levels of effort (A2 Figure 17). Between 300 and 400 sample points (i.e., about 3-5 times the current effort) would be needed to detect a trend of $-2\%/\mathrm{m}$ with a high power (target power of 0.80 at alpha 0.05). The current design with about 80 samples, could reliably detect a trend of about $-5\%/\mathrm{m}$.

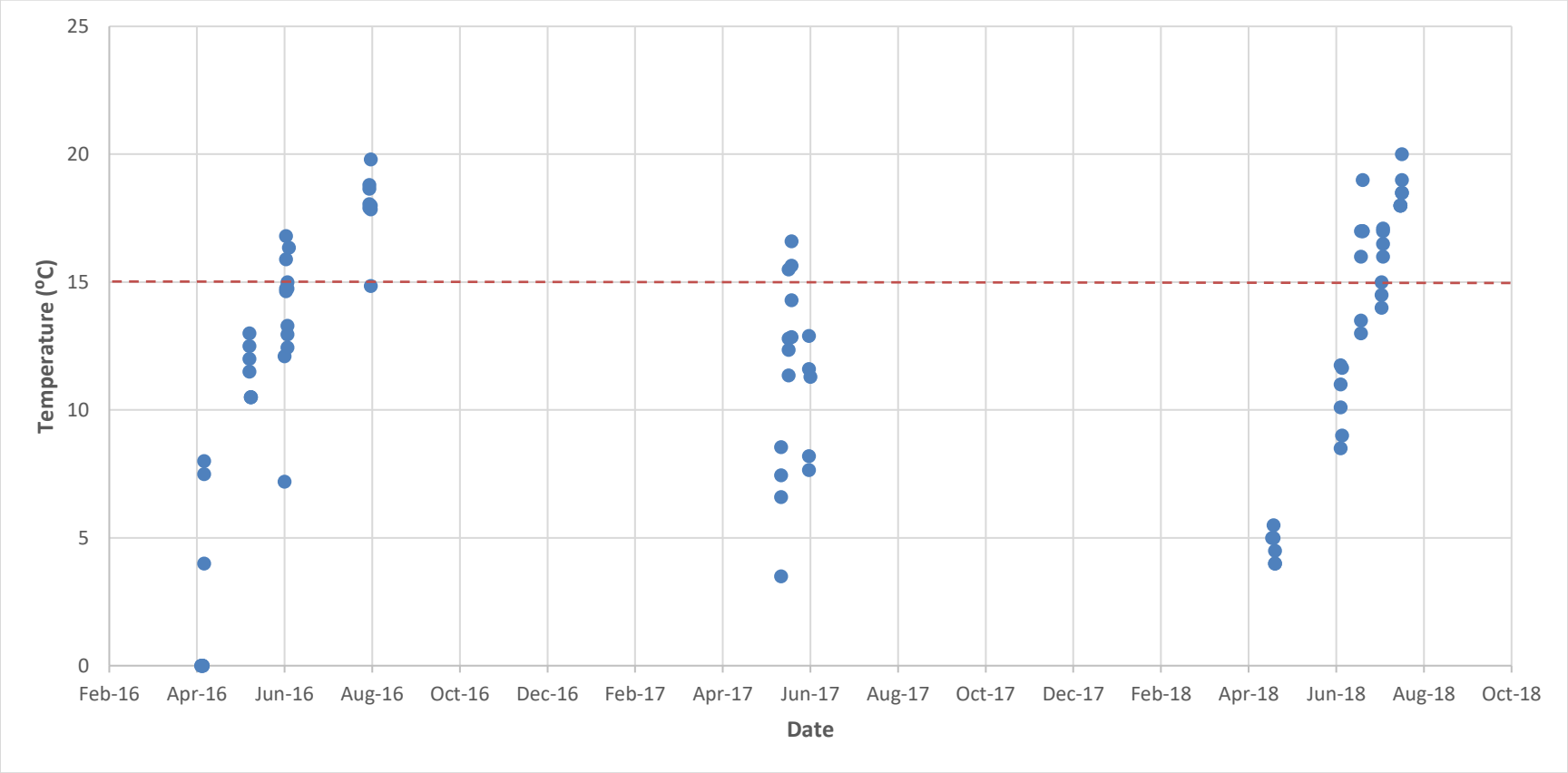


A2 Figure 17: Assessment of power to determine the effect size required to detect the effect of elevation with varying levels of sampling effort (where sample size is number of standardized fyke net samples) for the CLBMON-06 study of Kinbasket Reservoir. Target power of 0.80 at alpha 0.05 is represented by horizontal line.

Water quality data collected during fish and habitat assessments (summarized in A2 Table 8; all data presented in A2 Table 2: Summary of location, fyke net (FN), and water quality details for sites along the nearshore zone of Kinbasket Reservoir for CLBMON-06 (2016-2018, n= 86)A2 Table 2) indicated that suboptimal temperatures occurred in the nearshore zones of Kinbasket Reservoir during late May to August sampling periods (A2 Figure 18). Bull Trout are seldom found in areas >15 ºC for prolonged periods (references cited in McPhail and Baxter 1996). Bull Trout were captured at 5 sites in Kinbasket Reservoir during June and August where temperatures exceeded 15 ºC (A2 Table 2).

A2 Table 8: Summary of water quality parameters at fish and habitat assessment sites in Kinbasket Reservoir for the CLBMON-06 study (April 2015 to August 2018).

Month	Mean±SD Temperature (º C)	Mean±SD DO %	Mean±SD pH	Mean±SD Conductivity (µS/cm)	Mean±SD Total Dissolved Solids (mg/L)
April	5.2±0.66	84.2±3.88	7.2±0.45	175.2±31.65	
May	10.7±0.29	103.9±3.03	6.6±1.49	127.7±48.20	113.2±35.42
June	13.3±0.23	88.1±13.48	8.1±1.56	126.3±51.16	112.1±41.05
July	17.2±0.27	83.4±6.21	8.0±0.20	165.4±25.35	
August	18.0±0.27	86.8±5.30	8.1±0.23	99.4±9.52	74.2±7.32



A2 Figure 18: Summary of water temperatures recorded during nearshore fish and habitat assessments in Kinbasket Reservoir for the CLBMON-06 study (April 2015 to August 2018). The red dashed line marks 15 ºC, the temperature above which Bull Trout are seldom found for prolonged periods (references cited in McPhail and Baxter 1996).

8.6 *Discussion*

See Section 4.0.