Columbia River Project Water Use Plan

Kinbasket Reservoir Fish and Wildlife Information Plan

Implementation Year 1

Reference: CLBMON-06

Kinbasket Reservoir Juvenile Bull Trout Life History and Habitat Use Assessment

Study Period: June - December 2015

Canadian Columbia River Inter-Tribal Fisheries Commission.
7468 Mission Rd, Cranbrook, BC, V1C 7E5

March 14, 2016

WLR Monitoring Study No. CLBMON-06 (Year 1)

Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment

Prepared for:
BC Hydro
Water License Requirements Implementer
6911 Southpoint Drive, 11th Floor
Burnaby, BC
Attention: Phil Bradshaw and Guy Martel

Submitted by:
M. Kang, PhD, R.P.Bio
W.G. Warnock, PhD, P. Biol.
Canadian Columbia River Inter-Tribal Fisheries Commission
7468 Mission Road
Cranbrook, BC V1C 7E5
Email: mkang@ccrifc.org

Original Copy

Executive Summary

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

This report provides preliminary results from the Bull Trout capture and outmigration assessment for Year 1 of a 3 year study (2015 to 2017). Bull Trout capture was conducted in Packsaddle Creek, a tributary of Kinbasket Reservoir, using electrofishing (August 28 to September 2, 2015). Bull Trout (87 juveniles, 4 adults) movements were tracked using passive integrated transponder (PIT) tags and a fixed antenna installed near the confluence with Kinbasket Reservoir (operated from August 31 to November 10, 2015). Juvenile/sub-adult Bull Trout ranged in size from 71 to 398 mm (mean length ± SD = 119.0 ± 45.85 mm) and ranged in weight from 3 to 652 g (mean weight ± SD = 28.1 ± 81.14 g). During antenna operation, 13 Bull Trout (10 juvenile, 3 adult) were detected. Inclusion of Bull Trout movement data from Packsaddle Creek over 2 years (2015 to 2017), as well as information collected from a tributary from the Columbia Reach will provide useful information on the assessment of outmigration.

Management Question	**Hypotheses**	**Status**
What are the basic life history and habitat use characteristics of juvenile Bull Trout in Kinbasket Reservoir (e.g., distribution, age structure)?		To be addressed in years 2 and 3.
What are the potential effects of reservoir operation on juvenile Bull Trout, given the seasonal timing, age, and size of juveniles emigrating to the reservoir?	H_0: Operation of Kinbasket Reservoir has no effect on juvenile Bull Trout, given the seasonal timing and size/age of juveniles emigrating to the reservoir. H_1: Operation of Kinbasket Reservoir affects emigration of juvenile Bull Trout.	To be addressed in years 2 and 3.
Can modifications be made to the operation of Kinbasket Reservoir to protect or enhance juvenile Bull Trout populations?		To be addressed in years 2 and 3.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Monitoring Program Rationale

1.1.1 Background

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

Operations of Mica dam result in largeannual 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 on application to the Comptroller of Water Rights if there is a high probability of spill. Normal operating level for the 2008-2012 period was between a mean maximum of 753.26 m and a mean minimum level of 718.12 m, with a normal operating range of 35.14 m. Drawdown from full pool normally begins slowly in September, and draft rate increases through the winter, with a levelling off of drafting and normal low pool occurring in mid-late April. During the spring period, discharge from Mica dam decreases, which coincides with the normal spring freshet, which rapidly refills the reservoir through the spring and early summer.

Bull Trout (*Salvelinus confluentus*) were identified by the Columbia River Water Use Plan Consultative Committee (WUP CC) as a key fish species of concern in Kinbasket Reservoir because of their importance as a sport fish and the potential for links between reservoir operations and Bull Trout population productivity. Bull Trout are also blue listed (Species of Special Concern) by the BC Conservation Data Centre due to their sensitivity to habitat loss or degradation, over-exploitation, and competition from other salmonids (CDC, 2006). However, adfluvial Bull Trout populations are presently 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).

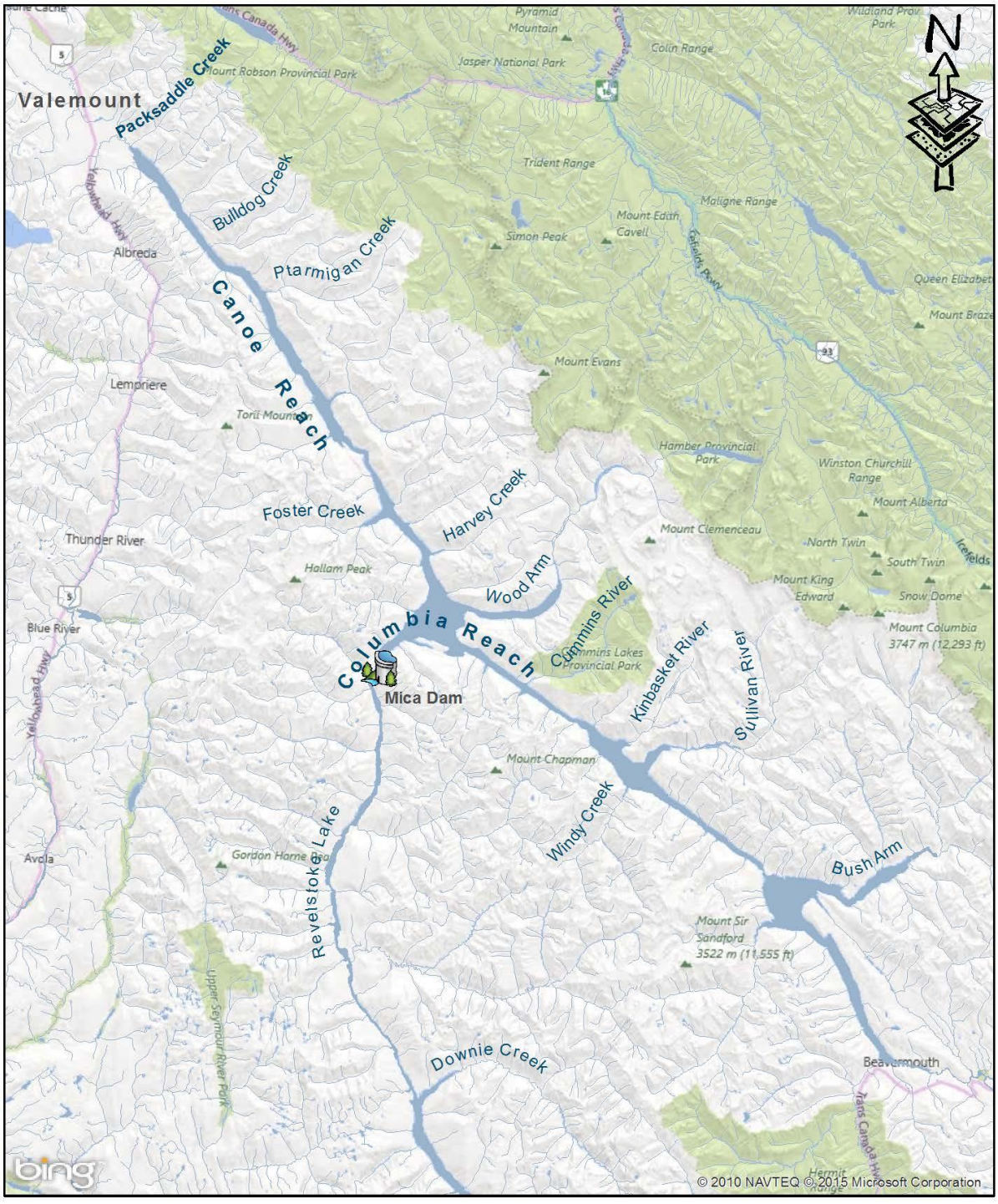

Figure 1: Kinbasket Reservoir study area.

1.1.2 Bull Trout Biology

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

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

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

Although McPhail (2007) suggests that juvenile Bull Trout rarely occupy the littoral zone of lakes and that they move into deep water when they initially enter lakes, this has not been rigorously assessed by a large body of studies. Shoreline habitats may be important to juvenile Bull Trout if they occupy shallow habitats for foraging, holding, or for refuge, or if they are dependent on resources that are primarily derived from littoral or near-shore habitats. Meeuwig and Guy (2007) reported that juvenile Bull Trout occupy shallow, shoreline habitat and that they may have high affinity to substrate cover in lacustrine environments. Juvenile (<250 mm) Bull Trout were spatially segregated from larger Bull Trout inhabiting shallow areas (<1 m) in a small lake in Alberta and were dependent on both pelagic and littoral food web items within these habitats (Wilhelm et al. 1999).

While rearing in nursery streams, Bull Trout have a fairly consistent growth rate and almost exclusively forage on invertebrates (Warnock, 2012). Outmigration from spawning streams at age 2-4 years is associated with rapid increases in growth in adfluvial systems, and is probably associated with a shift to piscivory soon upon lake entry (McPhail and Murray, 1979). In Kinbasket Reservoir, the dominant prey

item is likely to be subyearling or yearling Kokanee if Bull Trout are piscivorous and of sufficient size to overcome gape limitations. Piscivorous Bull Trout may forage on prey fish 50% of their body length (Beauchamp and Van Tassel, 2001). If Bull Trout emigrate into Kinbasket Reservoir primarily at ages >1+, Kokanee should be within their gape limit. Small size classes (75-200 mm) of Bull Trout in Lake Billy Chinook were generally not strongly piscivorous in winter, but piscivory in other seasons could not be satisfactorily assessed (Beauchamp and Van Tassel, 2001). Bull Trout were increasingly piscivorous with size in size classes above 200 mm (Beauchamp and Van Tassel, 2001). Determination of the dominant food source utilized upon outmigration is important for assessing impacts of dam operations on juvenile Bull Trout populations . Suitability of nearshore habitats for littoral macroinvertebrates and littoral production is impacted by winter drawdown operations in reservoirs in cold climates, with winter freezing and ice scour, desiccation and low water residence times (Stockner et al., 2005; Aroviita and Hamalainen, 2008). Altough, littoral productivity is assumed to be small in Kinbasket Reservoir (Bray et al. 2013), the diet preferences of Kinbakset Reservoir juvenile Bull Trout are unknown, as are their affinity for near shore habitats that may be impacted by reservoir operations.

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

1.1.3 Management Questions

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

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

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

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

1.1.4 Management Hypothesis

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

H_0: Operation of Kinbasket Reservoir has no effect on juvenile Bull Trout, given the seasonal timing and size/age of juveniles emigrating to the reservoir.

1.1.5 Key Water Use Decision Affected

The proposed monitoring program will provide information required to support more informed decision-making with respect to the need to balance storage in Kinbasket Reservoir with impacts on fish populations in the reservoir. Specifically, it will provide the information that is required to support

future decisions around maintaining the current operating regime or modifying operations through adjusting the drawdown schedule or minimum elevation to protect juvenile Bull Trout populations.

2 Project Methodology and Management

2.1 Overview, study objectives and limitations

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

The objectives of this study are to i) understand basic life history and habitat use characteristics of juvenile Bull Trout of Kinbasket Reservoir; ii) identify the timing of juvenile Bull Trout emigration to Kinbasket Reservoir by detecting outmigration of juveniles using PIT tag antennae at the mouths of rearing tributaries; iii) confirm habitat use of juvenile and subadult Bull Trout at nearshore littoral areas of Kinbasket Reservoir through ground surveys; iv) assess the presence of barriers to outmigration from rearing tributaries and access to nearshore littoral habitats in the drawdown zone due to dam operations; and iv) identify potential modifications to Kinbasket Reservoir operations to protect or enhance juvenile Bull Trout populations based on findings from i) to iv). This Year 1 report provides an overview of the methods used for detecting outmigration of juvenile Bull Trout and preliminary results (ii).

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

2.1.1 Capture, tagging and detection methodology

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) or presence of juvenile fish (Fieldenet al.,1992; Golder, 2003). Several 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 might result in loss of equipment, especially during freshet.

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.

Capture of juvenile Bull Trout occurred in Packsaddle Creek (Stream Code: 300-8326; Figure 2) from August 28 to September 2, 2015, 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 and measured for weight (g) and fork length (mm). Scale and fin samples were collected from each fish, and scale samples will be used to determine age of tagged fish. Bull Troutof 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.

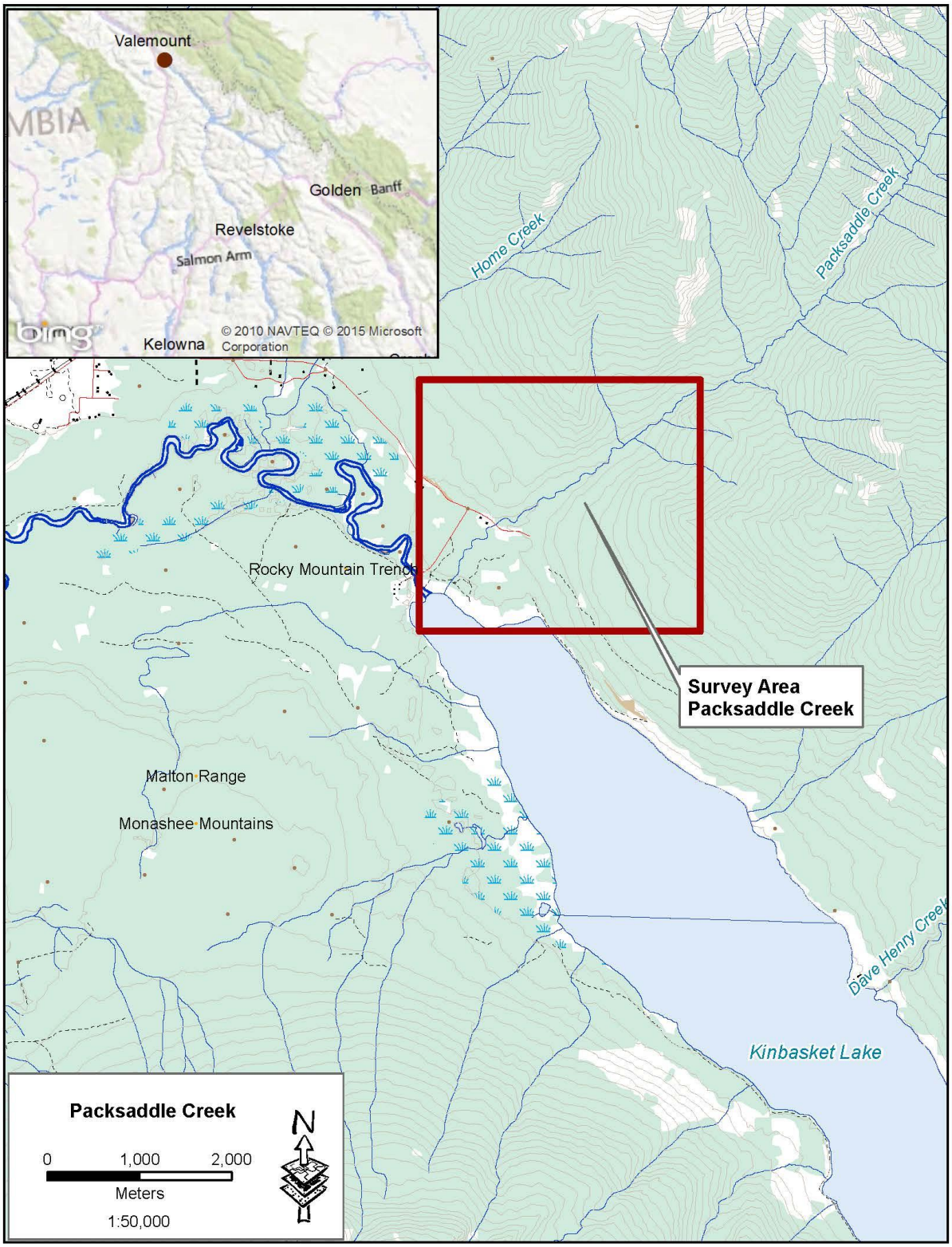

Figure 2: Map of study area on Packsaddle Creek for Year 1 (2015).

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 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 Aug. 31 to Nov. 10, 2015 and then disconnected from the power source because the antenna cannot be operated in temperatures below -20°C.

3 Results

3.1 Juvenile Bull Trout capture, tagging and detection

A total of 97 Bull Trout were captured using electrofishing. 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,>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 91 Bull Trout (89 juveniles) were implanted with PIT tags (Table 1). Tracking data from the 4 adults will provide important information on their migration during spawning and post-spawning periods. Along with Bull Trout, 25 Rainbow Trout (*Oncorhynchus mykiss*), 15 Mountain Whitefish (*Prosopium williamsoni*), 103 Sculpin (*Cottus* sp.) and 1 cyprinid were captured (Table 1). Nine of the 25 Rainbow Trout captured were implanted with PIT tags to provide supplementary information to CLBMON-7. Voucher specimens of Sculpins were preserved for species identification.

Table 1: Summary information of fish captured by electrofishing in Packsaddle Creek (Aug. 28 to Sept. 2, 2015). Species abbreviations are: 'BT' - Bull Trout; 'BT YOY' - Bull Trout young-of-year; 'MW' - Mountain Whitefish; 'RB' - Rainbow Trout.

Date	Species	Length (mm)	Weight (g)	Count	Tag #
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

Date	Species	Length (mm)	Weight (g)	Count	Tag #
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

Date	Species	Length (mm)	Weight (g)	Count	Tag #
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	

Date	Species	Length (mm)	Weight (g)	Count	Tag #
28-Aug-15	Cyprinid			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	
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

Date	Species	Length (mm)	Weight (g)	Count	Tag #
28-Aug-15	Sculpin			73	
29-Aug-15	Sculpin			25	
31-Aug-15	Sculpin			3	
02-Sep-15	Sculpin			2	

Juvenile/sub-adult Bull Trout ranged in size from 71 to 398 mm (mean length ± SD = 119.0 ± 45.85 mm; Table 1; Figure 3). Adult Bull Trout sizes were 445 and 615 mm (weights were not recorded; Table 1; Figure 3). Juvenile Bull Trout were the primary age class targeted in capture and their size ranged from 50 to 200 mm, with most within 100 to 115 mm (Table 1; Figure 3).

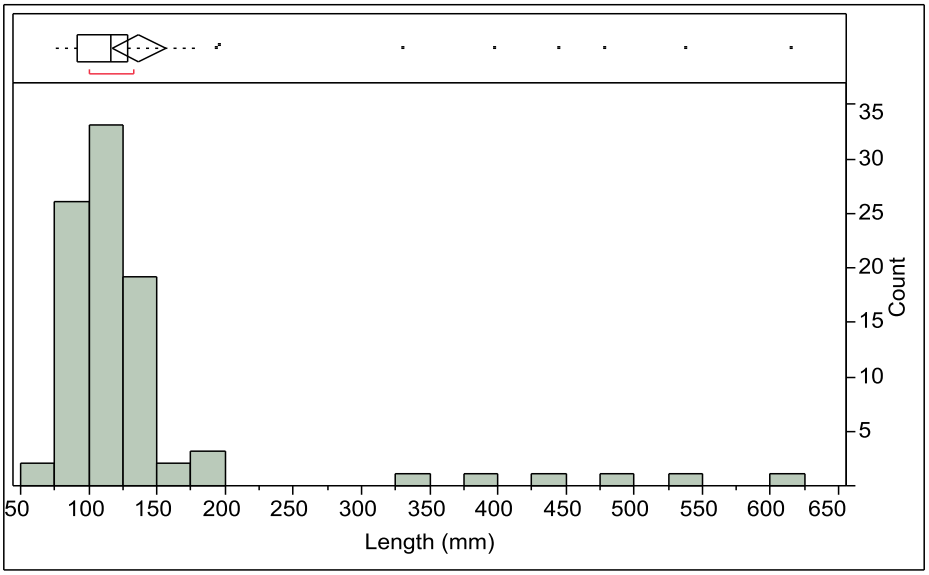

Figure 3: Distribution (histogram and box plot) of lengths (mm) of tagged Bull Trout in Packsaddle Creek (captured Aug. 28 to Sept. 2, 2015). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

Juvenile Bull Trout weighed 3 to 652 g (mean weight ± SD = 28.1 ± 81.14 g; Table 1; Figure 4). Juvenile Bull Trout rangedfrom 0 to 100 g, with most within 12 to 20 g (Table 1; Figure 4).

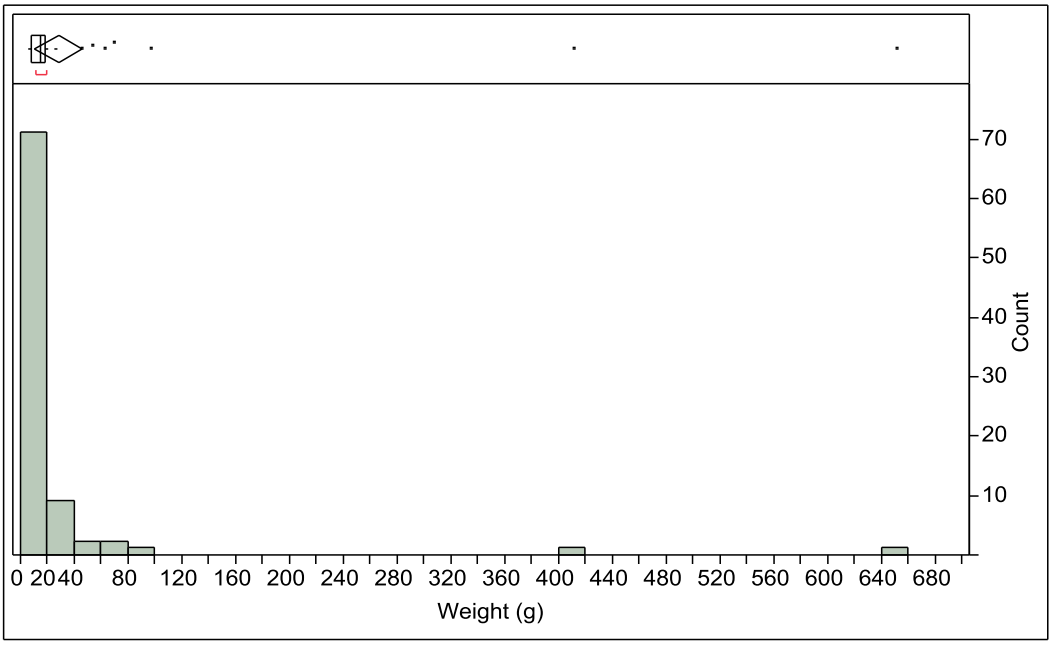

Figure 4: Distribution (histogram and box plot) of weight (g) of tagged Bull Trout in Packsaddle Creek (Aug. 28 to Sept. 2, 2015). Boxes represent interquartile range, diamonds represent the sample mean and 95% confidence interval, while the middle line in the box is the median sample value. Whiskers represent observations outside of the interquartile range, with outlier data points. The red line indicates the densest 50% of the observations.

Data download from the antenna reader indicated that 14 fish passed the antenna between Aug. 31 and Oct. 28 (Table 2). Of the 14 fish that were detected, 10 were juvenile Bull Trout and 3 were adult Bull Trout (Table 2). Only single logs of the fish were recorded indicating unidirectional movement from the tributary to the reservoir. Fish movement primarily occurred during night-time between the hours of 18:00 and 04:00.

Table 2: Summary of fish detected by antenna installed in Packsaddle Creek. Antenna was operated from Aug. 31 to Nov. 10, 2015. Species abbreviations are: 'BT' - Bull Trout; 'RB' - Rainbow Trout.

Scan Date/Time	Species	Length (mm)	Weight (g)	Tag #
31-08-15/ 20:29	RB	80	6	989001004470-294
01-09-15/ 20:58	BT	538		989001004470-261
02-09-15/ 18:22	BT	116	15	989001004470-316
02-09-15/ 18:22	BT	125	17	989001004470-284
02-09-15/ 23:45	BT	478	1,086	989001004470-263
03-09-15/ 21:22	BT	181	63	989001004470-314
12-09-15/ 20:37	BT	145	27	989001004470-293
22-09-15/ 21:53	BT	126	19	989001004470-317
27-09-15/ 03:50	BT	615		989001004470-280
01-10-15/ 22:37	BT	194	97	989001004470-272
03-10-15/ 22:25	BT	98	9	989001004470-290
05-10-15/ 22:37	BT	398	652	989001004470-304

10-10-15/ 20:08	BT	165	54	989001004470-286
28-10-15/ 18:15	BT	196	70	989001004470-306

4 Discussion and Recommendations

Detection of juvenile Bull Trout during the antenna operation period in the fall indicated that outmigration may occur during low flow months towards the end of the growth season (Homel and Budy, 2008; Bowerman, 2013). More information is required to discern whether movements were associated with outmigration as part of their life history or observation of escape behaviour in response to handling. Conversely, the observation of outmigration by the three adult Bull Trout suggests either the end of the spawning period or escape behaviour from handling. The inclusion of data that will be collected during 2016 will provide useful information on the timing of outmigration. If the majority of juveniles are not detected during Spring/Summer 2016 (including freshet), we suggest that the antenna in Packsaddle Creek operate for an additional year (2016-2017) to ensure that outmigration of all juvenile Bull Trout is recorded.

5 References

Aroviita, J., and H. Hämäläinen. 2008. The impact of water-level regulation on littoral macroinvertebrate assemblages in boreal lakes. In *Ecological Effects of Water-Level Fluctuations in Lakes* (pp. 45-56). Springer Netherlands.

BC Conservation Data Centre (CDC). 2016. Species Summary: *Salvelinusconfluentus*. BC Conservation Data Centre, Ministry of the Environment, Victoria, BC. Available: http://a100.gov.bc.ca/pub/eswp/speciesSummary.do?id=28551 (accessed Jan. 5, 2016).

BC Hydro. 2007. Columbia River Project Water Use Plan Monitoring Program Terms of Reference. Kinbasket Reservoir Fish and Wildlife Information Plan - CLBMON-6 Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment. BC Hydro, Castlegar, BC, pp. 9.

Beauchamp, D.J. and J.J. Van Tassel. 2001. Modeling seasonal trophic interactions of adfluvial Bull Trout in Lake Billy Chinook, Oregon. Transactions of the American Fisheries Society, 130:204-216.

Bellerud, B.L., S. Gunckel, A.R. Hemmingsen, D.V. Buchanan and P.J. Howell. 1997. Bull trout life history, genetics, habitat needs and limiting factors in central and northeast Oregon, 1996 annual report. Bonneville Power Administration, Portland, Oregon.

Bowerman, T. 2013. A multi-scale investigation of factors limiting bull trout viability [online].Ph.D. thesis, Utah State University, Logan, Utah. Available from http://digitalcommons.usu.edu/etd/1524/

Bray, K. and P. Mylechreest. In prep.Spawning and migratory movements of bull trout (*Salvelinusconfluentus*) in Arrow Lakes Reservoir.Columbia Basin Fish and Wildlife Compensation Program, Revelstoke, BC.

Bray, K., D. Sebastian, T. Weir, R. Pieters, S. Harris, D. Brandt and L. Vidmanic. 2013. Kinbasket and Revelstoke Reservoirs Ecological Productivity and Kokanee Population Monitoring. CLBMON-2 and CLBMON-3. 2008-2011 synthesis report.

Cope, R.S. 2009. Duncan Reservoir burbot monitoring annual report: 2008-2009. prepared for BC Hydro. Westslope Fisheries Ltd. Cranbrook, B.C., pp. 35

Downs, C.C., D. Horan, E. Morgan-Harris and R. Jakubowski. 2006. Spawning demographics and juvenile dispersal of an adfluvial Bull Trout population in Trestle Creek, Idaho. North American Journal of Fisheries Management 26:190-200.

Fielden, R.J., T.L. Slaney and A.W. Wood. 1992. Survey of tributaries to Kinbasket Reservoir. Report prepared by Aquatic Resources Ltd., Vancouver, BC, for the Mica Compensation Program, Nelson, BC.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinusconfluentus*) in the Flathead Lake and river system, Montana. Northwest Science 63: 133-143.

Golder. 2003. Kinbasket Reservoir tributary fish passage improvement 2002-2003 – Phase 1. Report prepared by Golder Associates Ltd. for the Columbia Basin Fish and Wildlife Compensation Program, Revelstoke, BC.

Hemmingsen, A.R., S.M. Gunckel, P.M. Sankovich and P.J. Howell. 2001. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. Annual Report, Bonneville Power Administration, Project No. 199405400, Portland Oregon.

Homel, K. and P. Budy. 2008. Temporal and spatial variability in the migration patterns of juvenile and subadult bull trout in northeastern Oregon. Transactions of the American Fisheries Society 137:869–880.

McPhail, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press, Edmonton, AB.

McPhail, J.D. and C.B. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Submitted to BC Hydro and Power Authority and Kootenay Region Fish and Wildlife.113 p.

McPhail, J.D. and J.S. Baxter. 1996. A review of bull trout (*Salvelinusconfluentus*) life history and habitat use in relation to compensation and improvement opportunities. Fisheries management report No. 104. Department of Zoology, University of British Columbia. Vancouver, BC.

Meeuwig, M.H. and C.S. Guy. 2007. Evaluation and action plan for protection of 15 threatened adfluvial populations of bull trout in Glacier National Park, Montana. Final scientific report of US Geological Survey to US Fish and Wildlife Service, Kalispell, Montana.

Mogen, J.T. and L.R. Kaeding. 2005. Identification and characterization of migratory and non-migratory bull trout populations in the St. Mary River drainage, Montana. Transactions of the American Fisheries Society 134: 841-852.

Moore, T.L., S.J. Starcevich, S. Jacobs and P.J. Howell. 2005. Migratory patterns, structure, abundance, and status of bull trout populations from subbasins in the Columbia Plateau. 2004 Annual Report.Project 199405400. Bonneville Power Administration, Portland, OR

Muhlfeld, C.C. and B. Marotz. 2005. Seasonal movement and habitat use of subadult bull trout in the upper Flathead River system, Montana. North American Journal of Fisheries Management 25: 797-810.

Oliver, G.G. 2001. Kinbasket Reservoir bull trout radio telemetry study; 2000 tributary use summary. Report prepared by G.G. Oliver and Associates Environmental Science, Cranbrook, BC, for BC Hydro, Castlegar, BC.

Columbia Basin Fish and Wildlife Authority. 2014. PIT Tag Marking Procedures Manual, Version 3.0. Prepared by: PIT Tag Steering Committee.http://www.ptagis.org/resources/document-library

Pole, M. 1996. Kinbasket Reservoir creel surveys, 1995. Report prepared for Columbia Basin Fish and Wildlife Compensation Program, BC Hydro and BC Environment, Nelson, BC.

Prince, A. 2011.Kinbasket Reservoir white sturgeon inventory and habitat use assessment (final report). prepared for BC Hydro. Canadian Columbia River Inter-tribal Fisheries Commission. Cranbrook, B.C., pp. 20

Ratliff, D.E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. In: Howell, P. J.; Buchanan, D. V., eds. Proceedings of the Gearhart Mountain bull trout workshop; 1992 August; Gearhart Mountain, OR. Corvallis, OR: Oregon Chapter of the American Fisheries Society: 37-44.

Riehle, M., W. Weber, A.M. Stuart, S.L. Thiesfeld and D.E. Ratliff. 1997. Progress report of the multi-agency study of bull trout in the Metolius River system, Oregon. Pages 137- 144 in W.C. Mackay, M.K. Brewin, and M. Monita, editors.Friends of the bull trout conference proceedings.Trout Unlimited Canada, Bull Trout Task Force (Alberta), Calgary.

RL&L. 2001. Environmental information review and data gap analysis volume 1: Upper Columbia, Mica and Revelstoke projects. Report prepared by RL&L Environmental Services Ltd., Castlegar, BC, for BC Hydro, Burnaby, BC.

Stockner, J., A. Langston, D. Sebastian and G. Wilson. 2005. The limnology of Williston Reservoir: British Columbia's largest lacustrine ecosystem. Water quality research journal of Canada 40: 28-50.

Stelfox, J.D. 1997. Seasonal movements, growth, survival and population status of the adfluvial bull trout population in lower Kananaskis Lake, Alberta. Pp. 309-316 *In*Friends of the Bull Trout Conference Proceedings (Mackay. W.C., M.K. Brewin, and M. Monita, eds.). Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary, AB.

Warnock, W. 2012.Examining brook trout invasion into bull trout streams of the Canadian Rockies.Ph.D. Thesis, University of Lethbridge, Alberta, Canada.184 pp.

Warnock, W.G. and J.B. Rasmussen. 2013. Abiotic and biotic factors associated with brook trout invasiveness into bull trout streams of the Canadian Rockies. Can. J. Fish.Aquat. Sci. 70: 905-914

Wilhelm, F.M., B.R. Parker, D.W. Schindler and D.B. Donald. 1999. Seasonal food habits of bull trout from a small alpine lake in the Canadian Rocky Mountains. Transactions of the American Fisheries Society 128:1176-1192.

Zimmerman, M.S. and C. Kinsel. 2010. Migration of anadromous juvenile bull trout in the Skagit River, 1990-2009, FPT 11-02. Washington Department of Fish and Wildlife, Olympia, Washington.