Westslope Cutthroat Trout Studies in the Upper Bull River: Preliminary Surveys Conducted in Fall 2003

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EXECUTIVE SUMMARY

This report summarizes the results of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) monitoring in the upper Bull River in 2003 by BC Hydro. Work conducted included mark-recapture population estimates in a 18 km section of the river from Sulphur Creek to Galbraith Creek, and the collection of life-history data on the population. In addition this report provides a summary of primary literature on above barrier populations of trout.

From September 15 to 18, 2003, a total of 80 westslope cutthroat trout were captured by angling, of which 69 were marked with Floy tags. Trout captured by angling ranged in size from 170 to 410 mm, with an average of 320 mm. From scale analysis, back-calculated lengths-at-annuli for the combined sample averaged 64mm, 99 mm, 166 mm, 260 mm, and 320 mm for annuli 1, 2, 3, 4, and 5, respectively. Five age classes for each sample were identified, from age 0+ through 5+. In the upper Bull River, average age class sizes at the time of capture for ages 0+, 1+, 2+, 3+, 4+, and 5+ were, respectively, 52 mm, 91 mm, 135 mm, 220 mm, 319 mm, and 350 mm.

During the diver counts conducted through September 22 to 26, 2003, a total of 1239 westslope cutthroat trout and 1264 mountain whitefish were counted in the sections where tagging occurred. The density of smaller westslope cutthroat trout was greatest in the catch-and-release section, and interestingly the density of trout greater than 300 mm was highest in the harvest section from Sulphur Creek to Galbraith Creek.

From the diver counts that were conducted, population estimates of trout > 300 mm (and 95% confidence limits) were generated for the harvest section (Sulphur Creek to Galbraith Creek; 345 fish, upper CI 423 fish, lower CI 295 fish), the catch-and-release section (Galbraith Creek to Van Creek; 506 fish, upper CI 605 fish, lower CI 439 fish) and for the entire section surveyed (Sulphur Creek to Van Creek; 860 fish, upper CI 978 fish, lower CI 771 fish). These estimates were reasonably precise, and would allow the monitoring of management or habitat enhancement projects. They would also allow the comparison between years if monitoring studies are continued.

ACKNOWLEDGEMENTS

A significant portion of the introduction of this report was adapted from reports produced through the Aberfeldie Water Use Plan, and thanks go to the committee's and authors at BC Hydro that worked on those reports. John Hagen (**John Hagen and Associates**) conducted the analysis of scales and wrote the sections pertaining to that analysis.

Field and technical support during this work was provided by a number of individuals who insured the project's success: **BC Hydro**: Gary Birch, Dean den Biesen, Bob Westcott; **BC Ministry of Water, Land and Air Protection**: John Bell, Jeff Burrows, Colin Spence; **Columbia Basin Fish and Wildlife Compensation Program**: Steve Arndt, Harald Manson, Amy Waterhouse, Tasha Kirby; **Mountain Water Research**: Jeremy Baxter, Gerry Nellestijn.

Thanks also go to Tex, Kevin, and Louise Wiebe (Trusty Creek Trout and Trail Outfitters) at Galbraith Creek for providing us with accommodation and showing us the lay of the land.

This project was funded by BC Hydro through their regional fisheries budget in attempt to better understand the biology of fish populations in the upper Bull River above Aberfeldie Dam. A secondary objective was to collect baseline data that will be of benefit upon initiation of the Water Use Plan for the Aberfeldie Facility.

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INTRODUCTION

Background

The Bull River is located within the Regional District of East Kootenay, in southeastern British Columbia, approximately 35 km east of Cranbrook. The 95 km long river flows southwesterly from the Front Ranges of the Rocky Mountains into the Rocky Mountain Trench, where it joins the Kootenay River (see Figure 1). The Aberfeldie project is part of BC Hydro's Columbia Generation Area (CGA), and is a small generating facility contributing less than one per cent to the area's total hydroelectric capacity.

The Aberfeldie project is an in-basin diversion consisting of the Aberfeldie Dam and headpond, a wood stave pipeline, surge tank and steel penstock leading to a concrete powerhouse (generating station). The dam was built on an existing natural barrier and is located approximately 10 kilometres (km) upstream of the confluence of the Bull and Kootenay rivers. The generating station is located approximately 2 km downstream of the dam and consists of two generating units with a total output capacity of 5 MW. Water from the generating station is discharged back into the Bull River, which flows into the Kootenay River system and then into Lake Koocanusa.

The current physical structures comprising the Aberfeldie project include the following:

Aberfeldie Dam**:** The Aberfeldie Dam is a concrete dam with crest length of 136 metres (m) and a maximum height of 32 m. The elevation at the top of the dam is El. 880.9 m above sea level (see Figure 2).

The dam has a free overflow spillway, which has a length of 59.7 m and a maximum discharge capacity of 923 m^3/s. The elevation of the spillway is El. 876.7 m.

The log sluice is no longer used to move woody debris past the dam. It is now used every two to three years to lower the headpond level (by removing 'stoplogs') for headpond inspection and maintenance. The length of the log sluice is 4.3 m with an elevation of El. 874.8 m.

Aberfeldie Headpond**:** The Aberfeldie headpond has an area of 20 hectares (ha) and a storage capacity of 510,000 m^3. The average drawdown of the headpond is approximately 1 m.

Wood Stave Pipe and Penstock**:** A power intake located near the centre of the dam feeds into a 1 km long wood stave pipeline which traverses the north side of the river canyon. The pipeline transitions to a 125 m-long rivetted steel plate penstock which bifurcates just above the generating station (see Figures 3 and 4).

Generating Station**:** The generating station contains two 2.5 MW Francis turbines. The combined discharge capacity of the units is 8.5 m^3/s (see Figure 4).

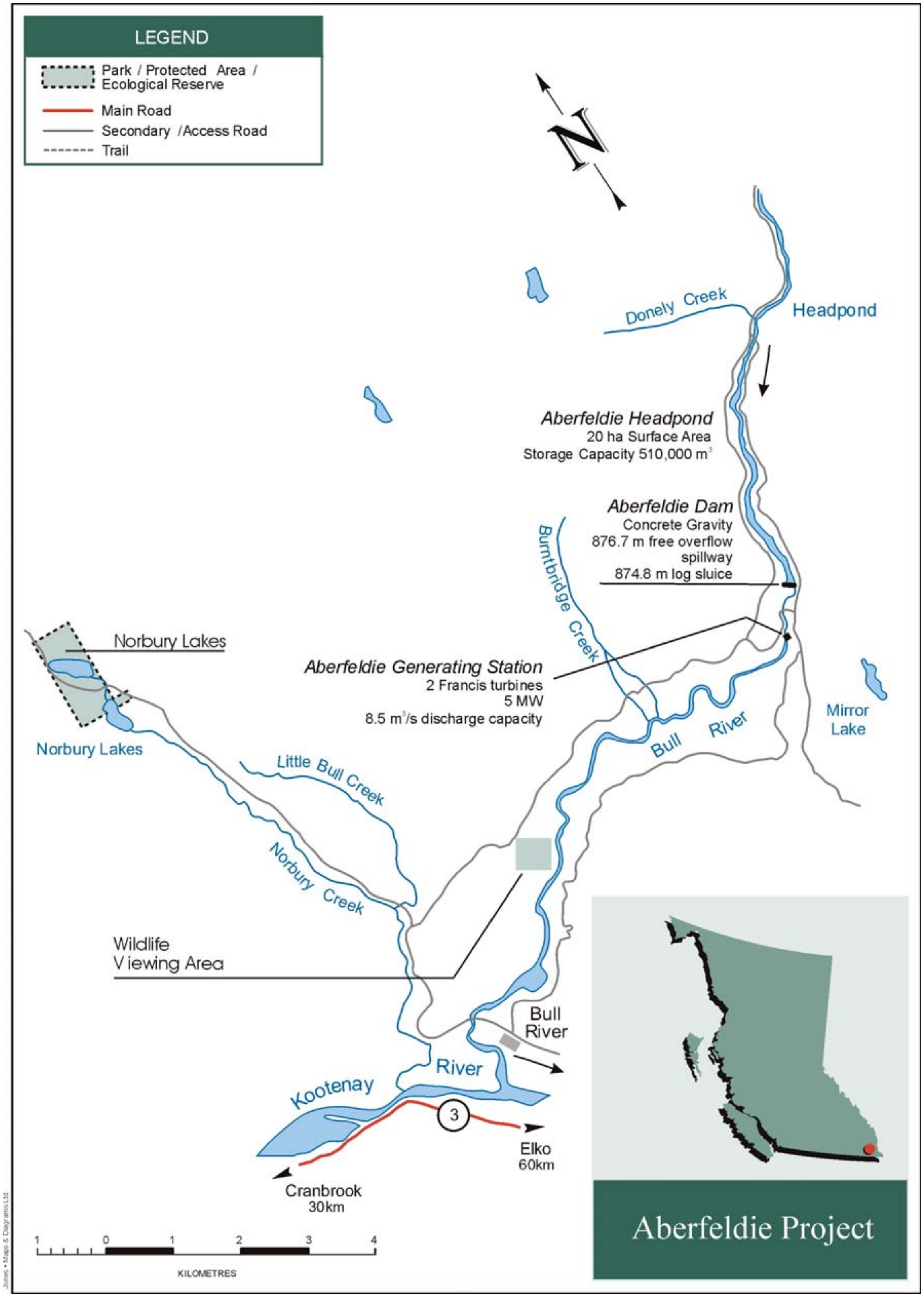

Figure 1. Aberfeldie project location.

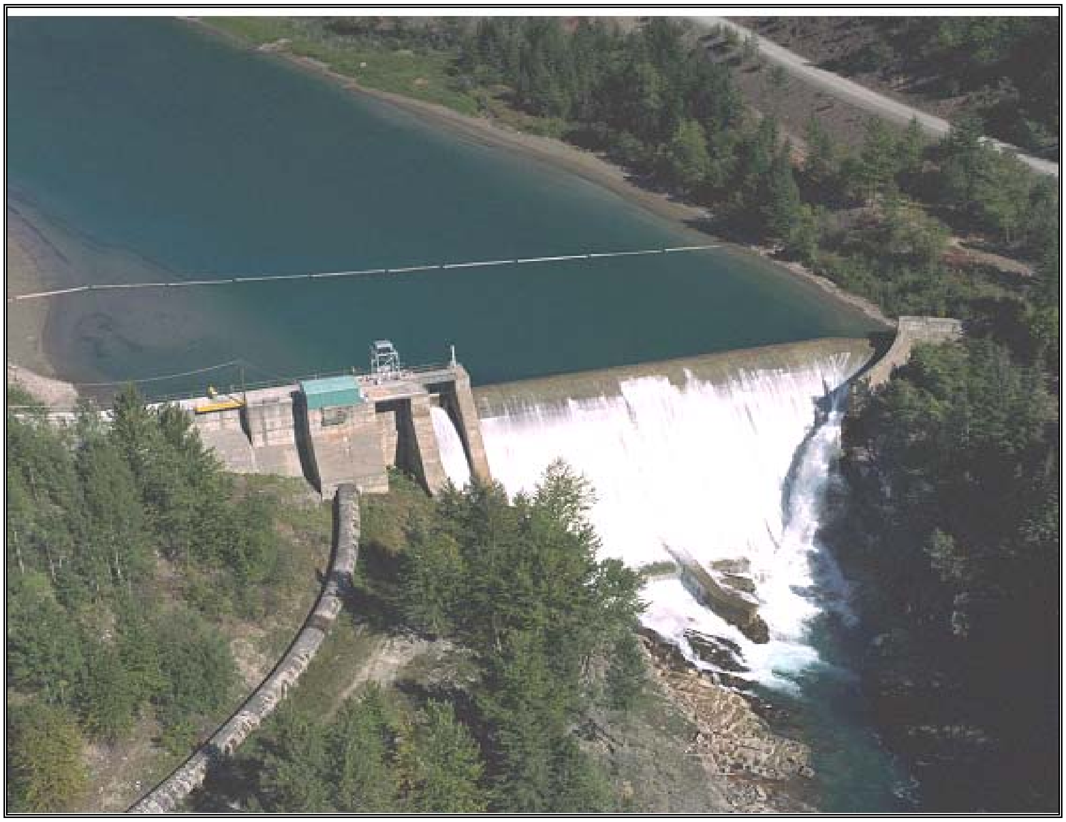

Figure 2. Aberfeldie Dam, headpond, log sluice and spillway.

Historic Project Operations

Operational Constraints: The water licence permits a maximum diversion of 9.94 m^3/s (plant capacity is 8.5 m^3/s) for power purposes. There is no storage licence at Aberfeldie; storage exists between maximum and minimum river elevations only.

Operational Considerations: There are two time periods through the year that govern how the Aberfeldie project is operated since it is a ***run-of-river*** system:

- **April to November**: Inflows are typically higher than the plant capacity of 8.5 m^3/s. The plant is operated at maximum capacity during this time. Excess water is spilled down the canyon via the dam's free overflow spillway.
- **December to March**: Inflows are typically lower than plant capacity during this time. The headpond is maintained at about 15 cm below crest level and managed by a headpond level controller, which alters power generation to match inflows. Once inflows exceed generation capacity (8.5 m^3/s), the headpond fills and water spills over the dam's spillway section and down the canyon below the dam. Low flows are evenly distributed between the two units to prevent freezing within the penstock.

Natural Inflows

The mean annual discharge (MAD), which is an average of all the daily inflows for all the data years on record for the Bull River above the dam is about 33 m^3/s. The inflow hydrograph showing the average inflows throughout the year is presented in Figure 5. This average value has considerable natural variability on any given year.

Figure 3. Aberfeldie penstock.

Figure 4. Lower Bull River showing Aberfeldie powerhouse tailrace.

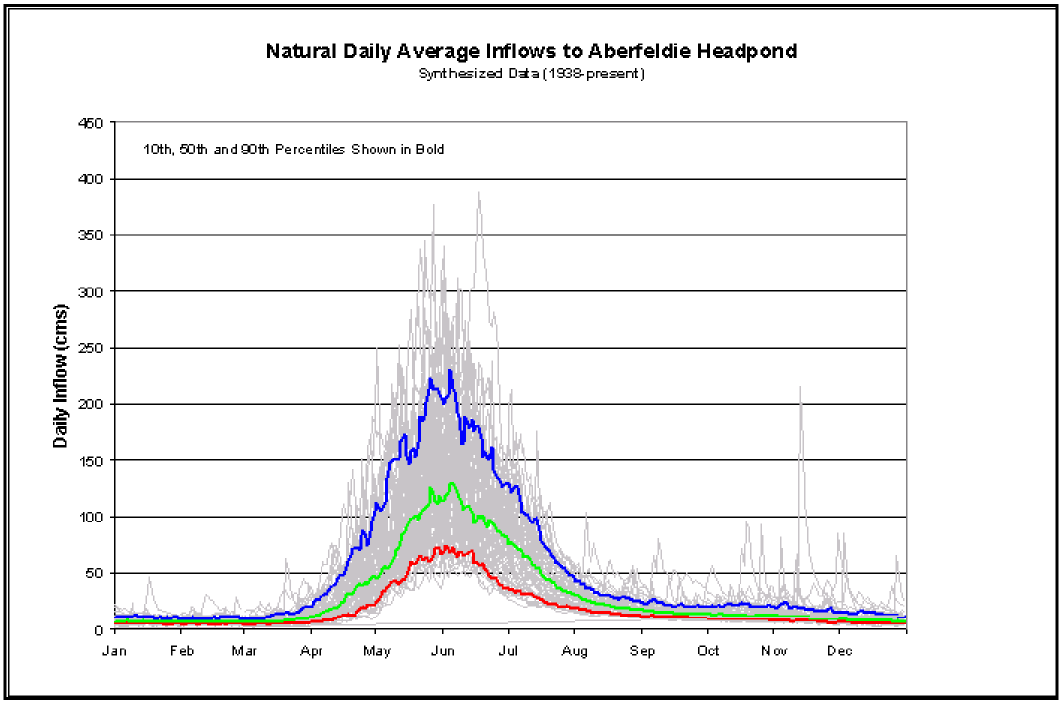

Figure 5. Natural daily average inflows to the Aberfeldie headpond.

Fish and Fish Habitat Summary and Water Use Plan Issues

Fish populations of the upper Bull River include two sportfish species: westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and mountain whitefish (*Prosopium williamsoni*) and a number of non-sport fish. The population of westslope cutthroat trout in the upper river is genetically distinct (Taylor et al. 2003), as most above barrier populations of fish can be, and is the focus of a targeted catch-and-release and harvest fishery in different sections of the river.

Through the course of the Bull River Water Use Planning process, the Fish Technical Committee (FTC) and Consultative Committee (CC) narrowed the number of issues that could be addressed through operations to two principal issues, as follows:

- **Low winter flows through the canyon** (between the dam and powerhouse) to better enable fish survival (see Figure 6).
- **Stage/discharge effects below the powerhouse** associated with planned and unplanned outages.

Figure 6. Canyon 500 m downstream of Aberfeldie Dam.

Aside from the fundamental objective of the Aberfeldie Water Use Plan to ***maximize fish (native) abundance and diversity,*** a number of sub-objectives were identified as follows:

- Minimize entrainment of fish.
- Minimize fish stranding.
- Maximize habitat suitability.
- Minimize sediment effects.
- Minimize impacts associated with maintenance and operational procedures.

Two studies were undertaken as a part of the Water Use Plan to better address the uncertainty surrounding the adequacy of winter flows on fish survival in the canyon below the dam (Cope 2003; Bisset and Cope 2003). This included an assessment of what fish species were present and their abundance, a qualitative assessment of the habitat, an assessment of leakage flows from the dam and groundwater contributions, and recommendations for a suitable flow to better ensure survival of fish.

These studies showed that the canyon area functions primarily as overwintering/rearing habitat for fish entrained over the dam (mountain whitefish, cutthroat trout) and there is limited spawning of kokanee (*O. nerka*) between the first upstream barrier and the powerhouse tailrace outlet (see Figure 4). While the presence of deep pools within the canyon provides some refuge habitat during winter, there is little safety margin given the extremely low leakage flows from the dam and it was felt that this may lead to a connectivity issue affecting fish survival (especially during long periods of cold weather). Accordingly, there was a recommendation for provision of a minimum winter flow.

As a basic summary of the results of the consultation under the Water Use Plan, it was determined that an operating alternative focusing on enhancement of the westslope cutthroat trout population above the facility was the best alternative to meet objectives through habitat enhancement in the upper river. This alternative would include a one-time gravel enhancement project to offset the risks to overwintering fish in the canyon until the cutthroat enhancement works are built. The benefits of the project were expected to be:

- Short-term – increases in invertebrate and benthic productivity and available spawning habitat as a result of gravel placement (downstream of the dam).
- Long-term – enhancement of cutthroat habitat in the upper Bull River (offsetting the risk of fish mortality associated with inadequate overwintering flows in the canyon).
- Improved information to make future water use planning management decisions for the Aberfeldie project.

2003 Fisheries Studies

Based on the results and direction evolving from the Aberfeldie Water Use Plan in terms of focusing on the westslope cutthroat trout population above the dam, environmental staff of BC Hydro in the Columbia Generation Area felt it necessary to initiate stock assessment and life-history studies on the population prior to the implementation of the WUP. As a result, in the fall of 2003 a preliminary study was conducted with several objectives that included:

- A review of the primary literature on above barrier populations of salmonids to summarize their biology and evolutionary adaptations.

- Conducting a mark-recapture study to determine westslope cutthroat trout abundance in a large portion of the watershed where potential habitat enhancement opportunities were likely to be undertaken.
- The collection of life-history data to fill in data gaps regarding the population.

This report summarizes the results of this study, and provides recommendations as to where future work in the watershed should be focused.

METHODS

Literature Review

There have been several primary publications on the biology, life-history, and population dynamics of above barrier and resident trout populations. These reviews present and summarize the unique characteristics of these populations, and discuss the local adaptations that these populations have undergone to enable persistence above barriers. The objectives of this component of the study were to provide a background review on the biology of above barrier trout populations with specific reference to:

- downstream migration (is movement over the dam/natural barrier really entrainment?);
- spawning timing;
- average size; and
- population dynamics.

To carry out this review a literature search was conducted on several library databases and several researchers that have worked on above barrier populations were contacted. The obtained papers were reviewed and roughly summarized for this report.

Mark-Recapture Study and Life-History Data Collection

Capture and Marking

For the purposes of this study, a population abundance study was undertaken on the upper Bull River between Sulphur Creek and Van Creek (see Figure 7), and encompassed two zones of harvest and channel type. These were a harvest section of a confined high gradient nature from Sulphur Creek to Galbraith Creek, and a catch-and-release section of a low gradient unconfined nature from Galbraith Creek to Van Creek (see Figure 7). This area was targeted as it is likely the primary area where habitat enhancement works could be undertaken at a reasonable cost (due to access), is the focus of the majority of angling effort, and contains a significant population of trout. The total area surveyed was 17.7 km (Sulphur Creek to Galbraith Creek, 6.2 km; and Galbraith Creek to Van Creek, 11.5 km).

From September 15 to 18, 2003, roughly an equal amount of angling effort was expended throughout this section of river in order to mark as many westslope cutthroat trout over 300 mm as possible. Captures were made by angling with artificial flies and trout were held in an angling net for processing. Biological sampling for all fish captured was standardized. First, a small section of the adipose fin was removed and stored, along with a label, in a vial of 95% ethanol for genetic analysis (see Taylor et al. 2003). Following this, a sample of at least 10 scales was removed for ageing analysis, and two pink anchor

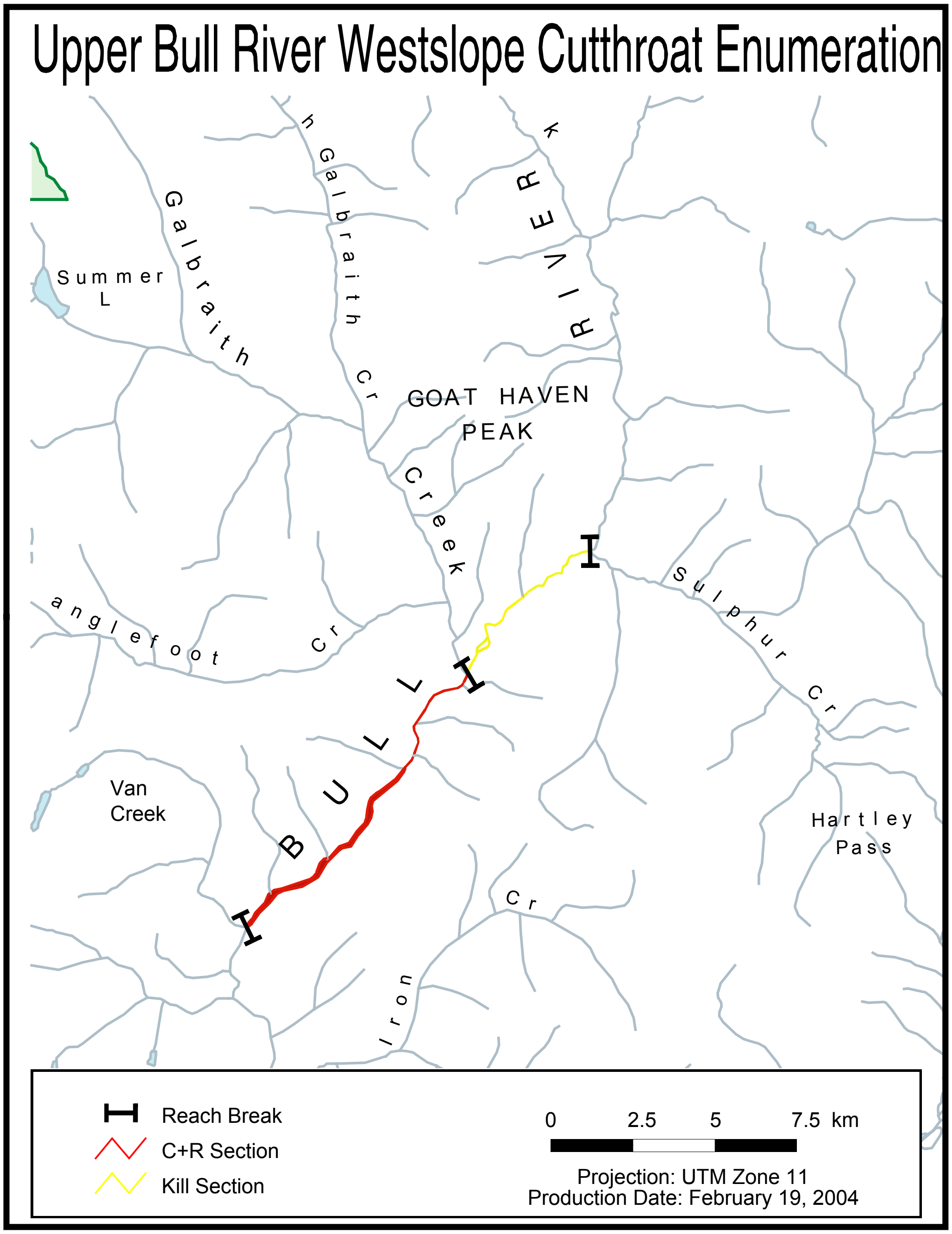

Figure 7. Sections of the upper Bull River where population estimates of westslope cutthroat trout were undertaken.

tags (Floy Tag, Seattle, WA, USA) were inserted posterior to the dorsal fin for identification during the snorkel surveys (see Figure 8). Fork length (mm), Floy tag numbers, and genetic sample number were also recorded.

Figure 8. Westslope cutthroat trout with Floy tags.

Ageing Analysis

As the first step in scale analysis, one scale suitable for analysis was identified under 49X magnification on a microfiche reader-printer, and a photograph was made. Cleaning of scales was not usually required. Regions of closely spaced circuli were identified as annuli. Each photographed scale was measured along the focus-anterior axis, with the radius of each annulus and of the outer scale margin being recorded. The relationship between the fork length of sampled fish from the watershed and their scale radius on the photographs (hereafter: relative scale radius) using simple linear regression was investigated. Lengths-at-age were then back-calculated using the Fraser-Lee equation (Duncan 1980):

$$l_k = c + (L - c)r_k/R$$

where: l_k is the length at age k
c is the constant of proportionality from the fish length/scale radius regression
L is the fish length at time of capture
r_k is the radius of the annulus at age k
R is the relative scale radius at the time of capture

Diver Counts

A week after the initial Floy tagging, diver surveys in the entire section of the upper Bull River where tags were distributed were conducted from September 22 to 26, 2003. A survey team of four divers was used. Where possible a diver's lane extended approximately 3-5 m toward shore from his swimming position, with the two offshore divers looking both ways towards the nearshore divers. Frequent stops were required to discuss whether duplication had occurred. Observed fish were described as to species, and westslope cutthroat trout were classified into one of five size categories: 0-200 mm, 200-300 mm, 300-400 mm, 400-500 mm, and 500+ mm. Tagged fish were identified by their pink Floy tags. At the beginning of each survey, visibility (horizontal secchi disk distance) was recorded for each diver and averaged. We did not extend the swimming section to account for fish that may have migrated out of the tagging section, as no fish were tagged within 750 m of the upper and lower boundary of the section (see Albanese et al. 2003), and the onset of overwintering habitat use had likely occurred. Prior to the initiation of swimming each day, sticks of known length were used for calibrating size estimates.

Population Estimates

Given suitable watershed conditions, diver counts have been proven to be a reliable and efficient means of obtaining indices of relative abundance for salmonid populations in British Columbia streams (Northcote and Wilkie 1963; Slaney and Martin 1987; Oliver 1990; Korman et al. 2002), and for cutthroat trout throughout their range in general (Schill and Griffith 1984; Slaney and Martin 1987; Zubick and Fraley 1988; Oliver 1990; Baxter and Hagen 2003). In some instances, however, it is likely that diver counts will be underestimates of true abundance because individuals are commonly missed due to imperfect visibility, fish behaviour, and stream channel complexity. Typically to address the observer efficiency issue, fish are marked within the section of stream the estimate will be conducted for, and the population estimate is generated with associated variability through a mark-recapture calculation. The results presented in this report are population estimates (±95% confidence intervals) for trout > 300 mm in the entire area that was surveyed, and in the harvest and catch-and-release sections. These estimates are based from the direct counts that were made in each section.

From the marking and snorkeling data, the population estimate for each section was calculated using the adjusted Petersen estimate (Chapman 1951; Seber 1982):

$$N = \frac{(M+1)(C+1)}{R+1} - 1$$

where N = estimate of population size at time of marking
M = number of individuals marked in the first sample
C = total number of individuals captured in second sample
R = number of individuals in the second sample that are marked

This equation is nearly unbiased if the are at least seven recaptures ($R > 7$).

To determine how reliable the estimate of population size were, the 95% confidence interval was calculated to produce confidence limits as an estimate of the precision of the estimate of population size. This was done using the Normal Approximation Confidence Interval equation. This equation was used as $R/C < 0.10$ and $R > 50$ (Ricker 1975; Seber 1982; Krebs 1999).

RESULTS AND DISCUSSION

Literature Review

Several studies on above barrier or non-migratory (resident) populations of salmonids have been undertaken, and have focused on the study of life-history traits and population dynamics of these populations (see Elliott 1987; Northcote and Hartman 1988; Northcote 1992 for reviews). The results of several of the papers on above barrier populations are summarized in Table 1 and 2, but there are several common views in the papers that should be commented on.

The first common point is that many above barrier populations having developed unique and distinct characteristics from below barrier populations in the same stream. These characteristics that are thought to have enabled stream residency to occur, and can be morphological, behavourial, and physiological and appear highly adaptive for the particular life-history strategy. Examples include limited downstream migration of above barrier populations and a later spawning period in the spring (presumably to avoid displacement during spring freshet). In combination these traits would function to ensure that these above barrier populations remain in the habitat where they reside and to ensure persistence. These general differences are summarized in Table 1.

Table 1. Summary of differences between above and below barrier populations of trout (adapted from Northcote and Hartman 1988).

Characteristic	Above falls	Below falls
Morphometry		
Gradient	higher	lower
Meanders, side channels	fewer	more
Pool & glide area	lower	higher
Flow		
Volume	lower	higher
Velocity	higher?	lower?
Variability	greater	less
Temperature	lower	higher
Conductivity	lower	higher
Invertebrate drift	lower?	higher?
Fish diversity	low	higher
Trout size (Age 1-3)	smaller	larger
Spawning time	late	early
Fecundity	low	high
Population density	lower (0 +, 1 +) higher (2 + →)	higher (0 +, 1 +) lower (2 + →)
Downstream movement	low	high
Parr mark number	high	low
Polymorphic isozymes	several differences (LDH and others); some seem adaptive	

Table 2. Summary of relevant life-history parameters on above barrier populations of salmonids (from primary literature).

Reference	Species	Above/Below Comparison?	Specific Points
Northcote 1969, 1981 Northcote et al. 1970 Northcote and Kelso 1981	RB	Yes	-Monitoring of above barrier population showed no migration over falls, but downstream population showed significant migration. -Trout from above barrier showed higher proportion of a distinctive homozygous Lactate Dehydrogenase enzyme than below barrier population. It is believed that this offers a more efficient conversion of lactic acid under acidic conditions and thus confers greater swimming ability and stamina to the above barrier population. -Above barrier population limited downstream migration (one-way barrier to gene flow; "knife-edge" selection). -Above barrier populations develop special biological traits that are conducive to stream residence. -Produced fry from above and below barrier adults, and reared under identical conditions. Above barrier fry showed lower downstream migration at night, had a slower growth rate, and matured later.
Northcote and Hartman 1988	RB, CT	Yes	-Should be strong selection for above barrier populations to evolve characteristics conducive to stream residence. -Summary of studies from five west Kootenay streams with above and below barrier populations of trout. Fish in populations above the barriers in each stream were smaller in length at each age class, spawned later in the summer (after freshet), fry emerged later, did not migrate downstream over the waterfall to a great degree, and had more parr marks than the below barrier population.

Mark-Recapture Study and Life-History Data Collection

Capture and Marking

From September 15 to 18, 2003, a total of 80 westslope cutthroat trout were captured by angling, of which 69 were marked with Floy tags (see Appendix I). Trout captured by angling ranged in size from 170 to 410 mm, with an average of 320 mm (see Figure 9). The distribution of tags in each section is summarized in Table 3.

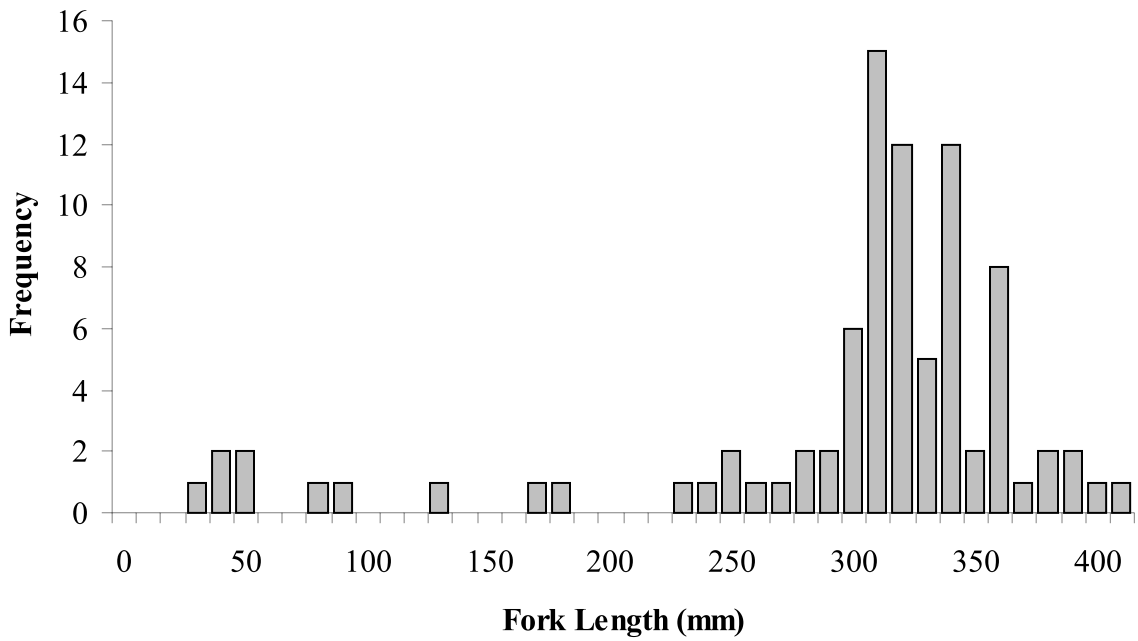

Figure 9. Length-frequency of all captured westslope cutthroat trout from the upper Bull River system (including fish not sampled for scales), September 2003 (angling captures from 170 to 410 mm).

Table 3. Distribution of Floy tags on westslope cutthroat trout > 300 mm in two sections of the upper Bull River, September 2003.

Section	Length (km)	Tags out	Tags per km
Sulphur Ck to Galbraith Creek	6.2	23	3.7
Galbraith Creek to Van Creek	11.5	46	4.0
Total	**17.7**	**69**	**3.9**

Ageing Analysis

Sampled westslope cutthroat trout (for scale analysis) from the mainstem of the upper Bull River between September 15 and September 18, 2003 ranged from 180 mm to 410 mm, and from 52 to 135 mm in Galbraith Creek on September 25 (Table 4). Smaller fish were captured in Galbraith Creek, but scales could not be recovered from them. In total 19 fish were aged from the sample, 15 from the upper Bull River of which 14 provided readable scales, and 4 from Galbraith Creek of which all provided readable scales. The relative scale radius, measured along the focus-anterior axis on the photographs, was a significant and good predictor of the fork length for the combined sample of 18 westslope cutthroat (Figure 10; $P<0.0001$, $r^2 = 0.94$). It should be noted that the radius of the scale from the largest fish captured, 410 mm in length, was considered an outlier (studentized residual = 4.12) and removed from the regression analysis. This was one of only two scales that showed a check on the scale associated with spawning. Most captured fish did not show obvious signs of sexual maturity, but the two exceptions were the two males that showed a spawning check in their scales (the other was a 365 mm fish).

Table 4. Scale measurements and back-calculated lengths-at-age of westslope cutthroat trout, upper Bull River, September 2003.

Length (mm)	Scale #	Age	Rel. Scale Radius (mm)	Radius-at-annulus 1	2	3	4	5	Back-calculated Length-at-age 1	2	3	4	5
260	3	4+	37		11	20	32			102	157	230	
250	4	3+	33	5	13	22			67	120	178		
310	5	4+	38		9	21	33			100	187	274	
340	6	4+	50		12	26	43			108	194	297	
290	7	4+	47		10	17	29			89	127	192	
370	8	5+	61		9	20	42	55		84	145	266	337
410	10	5s+	43			18	30	38			192	297	366
180	10a	3+	21		7	14				83	132		
300	14	5+	39	4	8	19	31	36	62	89	164	246	280
380	17		na										
320	18	5+	50	5	13	21	35	46	63	109	155	234	297
365	19	4s+	52		13	25	39			117	194	282	
345	22	4+	45		7	17	36			83	152	283	
320	24	4+	52	6	17	26	40		68	128	177	254	
230	25	3+	31		10	21				98	167		
52	A	0+	7										
95	B	1+	10	4					59				
86	C	1+	10										
135	D	2+	24		11					81			

	Average length-at-capture 0+	1+	2+	3+	4+	5+	Average length-at-annulus 1	2	3	4	5
	52	91	135	220	319	350	64	99	166	260	320

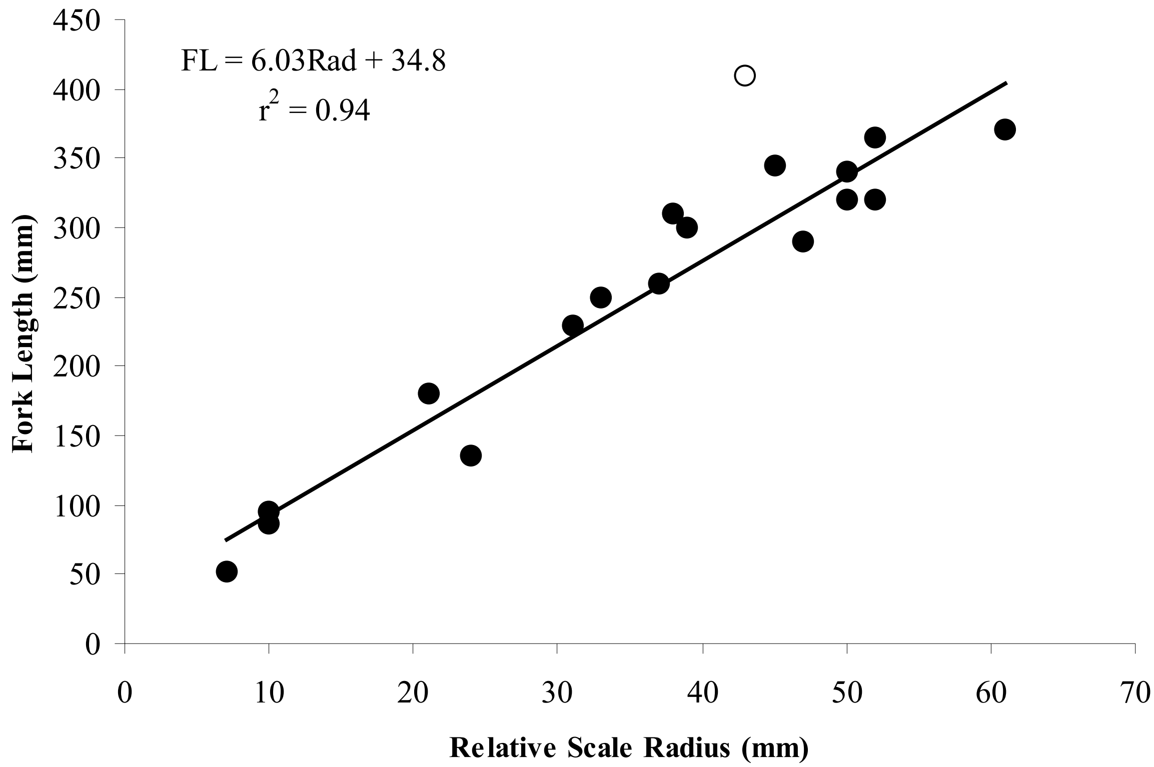

Figure 10. Relationship between fork length (mm) and scale radius (mm) measured from scale photographs for westslope cutthroat trout captured in the upper Bull River system, September 2003. One outlier (open circle) was excluded from the regression analysis.

Before lengths-at-age were back-calculated, ages to annuli present on the scales were assigned. Westslope cutthroat trout in British Columbia may commonly be missing a first year annulus, and length-frequency data (Figure 9) for smaller fish from the upper Bull River watershed suggested that the first node of higher frequency in the sample occurred for the size range 30-60 mm, presumably corresponding with the 0+ age category. Lengths for each scale sample for the first detectable annulus were back-calculated (Figure 11), and compared to 0+ sizes from the length-frequency histogram. It appears that first annuli for some scales correspond well with the 0+ sizes, but a gap exists in the histogram between this cluster and the majority of the scales, which show their first annuli at sizes of 80-120 mm. The discontinuous nature of the distribution in Figure 11 suggests that the second cluster are missing an annulus for their first winter, and thus the first annulus are considered to correspond to the second winter for these fish in all subsequent analyses. Of all upper Bull River westslope cutthroat trout scales inspected, only 29% showed a first-year annulus. In contrast, 55% of Wigwam River westslope cutthroat trout scales showed a first-year annulus (Baxter and Hagen 2003), potentially pointing to a difference in first-year growth (or emergence) in the two systems (see section on summary of above barrier populations). Back-calculated lengths-at-annuli

for the combined sample averaged 64 mm (SE = 1.7, n = 5), 99 mm (SE = 4.1 mm, n = 14), 166 mm (SE = 6.0 mm, n = 14), 260 mm (SE = 9.7 mm, n = 11), and 320 mm (SE = 20 mm, n = 4) for annuli 1, 2, 3, 4, and 5, respectively.

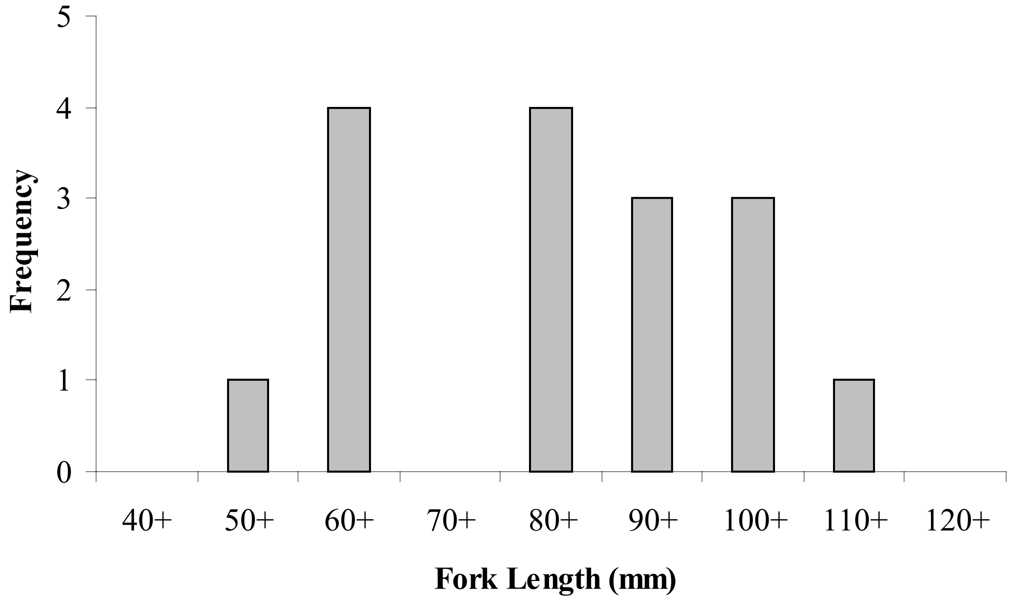

Figure 11. Length-frequency histogram for back-calculated lengths of sampled fish corresponding to the first annulus detectable on inspected scales, upper Bull River system, September 2003.

Five age classes for each sample were identified, from age 0+ through 5+ (Table 4). In the upper Bull River, average age class sizes at the time of capture for ages 0+, 1+, 2+, 3+, 4+, and 5+ were, respectively, 52 mm (n = 1), 91 mm (SE = 4.5; range = 86-95 mm; n = 2), 135 mm (n = 1), 220 mm (SE = 21; range = 180-250 mm; n = 3), 319 mm (SE = 14; range = 260-365 mm; n = 7), and 350 mm (SE = 25; range = 300-410 mm; n = 4). Length-at-age of westslope cutthroat trout in the Bull River was less than in the Wigwam River (see Baxter and Hagen 2003), where age class sizes at the time of capture for ages 4+, 5+ and 6+ were, respectively, 373 mm (SE = 7.6 mm), 405 mm (SE=5.7 mm) and 410 mm (SE = 20.8 mm).

During the concurrent mark-recapture study employing diver counts, divers correctly estimated size categories (in 100 mm increments) for tagged fish, which were mostly between 300 and 400 mm. However, in the same study, of all fish greater than 300 mm seen by divers, 8.9% were greater than 400 mm, while only one fish sampled for scales was this large. Divers noted that the largest fish were associated with cover, either in the form of instream debris or deep water, and were found in highest abundance in a stream section that receives regular angling pressure. As well, capture of fish was with floating flies, which may not have sampled deep water habitats as effectively as lures, bait, or sinking fly lines. It is possible, therefore, that larger fish were not sampled in proportion to their true abundance, and size-at-age estimates and the age structure of the sampled population have been misrepresented in the analysis. Under-sampling of larger fish could also explain the observation that most sampled fish appeared bright and without obvious signs of sexual maturity, which was consistent with the scale analysis. In the Wigwam River, 69% of fish examined for signs of maturity, either in their appearance or on their scales, appeared to have spawned in the preceding months, although it should be noted that these fish were captured two months earlier and therefore much closer to the spawning period (Baxter and Hagen 2003). Nonetheless, it appears possible that older fish than 5+ exist in the upper Bull River, and it is also possible that spawning in general occurs at larger sizes and older ages than those commonly occurring in the sample analyzed. It is recommended, therefore, for the upcoming year of the mark-recapture study that an effort be made to collect scales from a sample that is representative of the fish seen by divers, by using gear that is not selective for smaller fish. As well, an increased sample of scales from smaller fish would increase confidence that the missing first-year annulus problem has been addressed correctly.

Diver Counts

During the diver counts conducted through September 22 to 26, 2003, a total of 1239 westslope cutthroat trout and 1264 mountain whitefish were counted in the sections where tagging occurred (Table 5; a summary of data collected during diver counts (marked and unmarked fish) is provided in Appendix II). The density of smaller westslope cutthroat trout was greatest in the catch-and-release section (Table 6), and interestingly the density of trout greater than 300 mm was highest in the harvest section from Sulphur Creek to Galbraith Creek (Table 6). Qualitatively, this section did have more suitable habitat for large trout than the catch-and-release section, primarily in the form of large pool and wood. The densities of westslope cutthroat in the upper Bull River trout between 300-400 mm are higher than the Wigwam River (Baxter and Hagen 2003).

Population Estimates

From the diver counts that were conducted, population estimates of trout > 300 mm (and 95% confidence limits) were generated for the harvest section (Sulphur Creek to Galbraith Creek), the catch-and-release section (Galbraith Creek to Van Creek) and for the entire section surveyed (Table 7). These estimates were reasonably precise, and would allow the monitoring of management or habitat enhancement projects. They would also allow the comparison between years if monitoring studies are continued.

Table 5. Diver counts of westslope cutthroat trout in the upper Bull River, September 2003 (the bottom two sections comprise one of the harvest zones in the system).

Section	Date	Length (km)	Trout Observed 0-200 mm	200-300 mm	300-400 mm	400-500 mm	500+ mm	MWF
GC to 40 km FS Brdg	22-Sep-03	3.2	65	143	169	22	2	154
40 km FS Brdg to km 36	23-Sep-03	4.5	12	63	134	5	0	100
km 36 to Van Ck	23-Sep-03	3.9	18	78	64	2	0	185
		11.6	**95**	**284**	**367**	**29**	**2**	**439**
Sulphur Ck to 50 lb Hole	25-Sep-03	2.2	4	113	140	15	0	475
50 lb Hole to GC	26-Sep-03	4.0	1	42	131	16	0	350
		6.2	**5**	**155**	**271**	**31**	**0**	**825**
		17.8	**100**	**439**	**638**	**60**	**2**	**1264**

Table 6. Densities (fish per km) of westslope cutthroat trout (counted during diver counts) in different sections of the upper Bull River, September 2003 (the bottom two sections comprise one of the harvest zones in the system).

Section	Date	Length (km)	Trout Density (fish per km) 0-200 mm	200-300 mm	300-400 mm	400-500 mm	500+ mm
GC to 40 km FS Brdg	22-Sep-03	3.2	20.3	44.7	52.8	6.9	0.6
40 km FS Brdg to km 36	23-Sep-03	4.5	2.7	14	29.8	1.1	0
km 36 to Van Ck	23-Sep-03	3.9	4.6	20	16.4	0.5	0
		11.6	**8.2**	**24.5**	**31.6**	**2.5**	**0.2**
Sulphur Ck to 50 lb Hole	25-Sep-03	2.2	1.8	51.4	63.6	6.8	0
50 lb Hole to GC	26-Sep-03	4.0	0.3	10.5	32.8	4.0	0
		6.2	**0.8**	**25**	**43.7**	**5**	**0**
		17.8	**5.6**	**24.7**	**35.8**	**3.4**	**0.1**

Table 7. Population estimates of westslope cutthroat in different sections of the upper Bull River, September 2003 (the Sulphur Creek to Galbraith Creek section is a harvest section, and the Galbraith Creek to Van Creek section is a catch-and-release section).

Section	Length (km)	Recapture Rate	Population Estimate	Upper 95% CI	Lower 95% CI	Precision
Sulphur Ck to GC	6.2	0.87	345	423	295	0.19
GC to Van Creek	11.6	0.78	506	605	439	0.16
TOTAL	17.8	0.81	860	978	771	0.12

RECOMMENDATIONS

This initial year of study in the upper Bull River has identified that diver counts and associated mark-recapture estimates could be utilized as a method for monitoring the response of the westslope cutthroat trout to habitat improvement projects that would be undertaken in the watershed. The population estimates derived from this methodology are relatively precise, and the abundance of cutthroat trout in both sections is not so high that there would be a low probability of expecting a response to habitat improvements. One observation that was noted by several of the people that worked on the project was that there appeared to be a limited abundance of large woody debris in the section of river from Galbraith Creek to Van Creek. Where there was wood in this section, high densities of trout were observed during the snorkel swims. There are a number of recommendations for the second year of the study that should be considered prior to initiation of the surveys.

1. Scales should be obtained from larger cutthroat trout to refine the ageing analysis, and if possible a sample of smaller fish should occur as well.

2. Mark/Recapture studies should be repeated in 2004 using the same sections and the same methodology.

3. If habitat improvements are to be undertaken in the upper Bull River, the section from Galbraith Creek to Van Creek is likely a high priority for consideration due to its access and limited abundance of functioning woody debris. It may be worth considering conducting a preliminary Fish Habitat Assessment to determine habitat limitations within section in order to focus habitat prescriptions.

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Appendix I. Summary data of westslope cutthroat trout captured in the upper Bull River watershed, September 2003.

Date	Location	Length	Tag1	Tag2	Scales	DNA	Comments
15-Sep-03	GC to	31	2751	2752	-	-	Cabin Hole
15-Sep-03	40 km FS Brdg	34	2753	2754	-	-	Cabin Hole
15-Sep-03	↓	30	2755	2756	-	-	Cabin Hole
15-Sep-03	↓	39	2775	2774	-	-	Lone Pine
15-Sep-03	↓	32	2773	2772	-	-	Lone Pine
15-Sep-03	↓	26	-	-	3	B	Below Low Pine-GENERAL
15-Sep-03	↓	28	-	-	1	-	Below Low Pine-GENERAL
15-Sep-03	↓	31	2976	2978	-	-	Below Low Pine-GENERAL
15-Sep-03	↓	24	-	-	2	A	Below Low Pine-GENERAL
15-Sep-03	↓	25	-	-	4	C	Below Low Pine-GENERAL
16-Sep-03	U/S of	36	2978	2979	-	-	1/4 km us GC
16-Sep-03	GC	31.5	2980	2981	-	-	1/4 km us GC
16-Sep-03	↓	30.5	2982	2983	-	-	Lower Trilobite
16-Sep-03	↓	33	2984	2985	-	-	Lower Trilobite
16-Sep-03	↓	31.5	2986	2987	-	-	Lower Trilobite
16-Sep-03	↓	33	2988	2989	-	-	Upper Trilobite
16-Sep-03	↓	32.5	2990	2991	-	-	Lower Trilobite
16-Sep-03	40 km FS Brdg to	31	2770	2771	5	D	Run at Caves
16-Sep-03	km 36	34	2769	2768	6	F	Run at Caves
16-Sep-03	↓	29	-	-	7	E	Run at Caves
16-Sep-03	↓	37	2767	2766	8	G	Long Run
16-Sep-03	↓	31	2765	2764	9	H	Long Run
16-Sep-03	GC Confluence	41	2763	2762	10	I	GC Confluence
16-Sep-03	GC Confluence	18	-	-	10a	J	GC Confluence
16-Sep-03	GC Confluence	17	2761	2760	-	-	GC Confluence
17-Sep-03	U/S of	30	2992	2993	-	-	D/S McMillian Ck. Run
17-Sep-03	GC	34	2994	2995	-	-	Boulder Pocket
17-Sep-03	↓	40.5	2996	2997	-	-	Boulder Pocket
17-Sep-03	↓	32.5	2998	3000	-	-	Boulder Pocket
17-Sep-03	↓	36.5	2951	2952	-	-	Boulder Pocket
17-Sep-03	↓	32.5	2953	2954	-	-	Pinchack Hole
17-Sep-03	↓	36.5	2955	2956	-	-	Pinchack Hole
17-Sep-03	↓	32	2957	2958	-	-	Pinchack Hole
17-Sep-03	↓	36.5	2959	2960	-	-	Deadmans Corner
17-Sep-03	↓	38	2961	2962	-	-	50 lb Hole
17-Sep-03	↓	31.5	2963	2964	-	-	50 lb Hole
17-Sep-03	GC to	30	2758	2759	11	K	Lone Pine
17-Sep-03	km 36	25.5	-	-	12	L	Lone Pine
17-Sep-03	↓	31	2800	2799	13	M	Below Low Pine
17-Sep-03	↓	30	2798	2797	14	N	Below Low Pine
17-Sep-03	↓	31.5	2796	2795	15	O	Below Low Pine
17-Sep-03	↓	34	2794	2793	16	P	Below Low Pine
17-Sep-03	↓	38	2792	2791	17	Q	Below Low Pine
17-Sep-03	↓	32	2790	2789	18	R	Below Low Pine
17-Sep-03	↓	32	2788	2787	-	S	Run at Caves
17-Sep-03	↓	33.5	2786	2785	-	T	Run at Caves
17-Sep-03	↓	32	2784	2783	-	-	Run at Caves
17-Sep-03	↓	34	2782	2781	-	U	Run at Caves
17-Sep-03	↓	34	2780	2779	-	V	Run at Caves

17-Sep-03	↓	36.5	2778	2777	19	W	Run at Caves
17-Sep-03	↓	34	2726	2727	-	-	Run at Caves
17-Sep-03	↓	30.5	2728	2729	-	-	Run at Caves
17-Sep-03	↓	28	-	-	20	X	Boulder Run
17-Sep-03	↓	31	2730	2731	21	Y	Boulder Run
17-Sep-03	↓	34.5	2732	2733	22	Z	Boulder Run
17-Sep-03	↓	31.5	2734	2735	-	1	Boulder Run
17-Sep-03	↓	36	2736	2737	23	2	Cliff Run
17-Sep-03	↓	27	-	-	-	3	Cliff Run
17-Sep-03	↓	29	-	-	-	4	Cliff Run
17-Sep-03	↓	36	2738	2739	-	-	Cliff Run
17-Sep-03	↓	32	2740	2741	-	-	Cliff Run
17-Sep-03	↓	34	2742	2743	-	-	Cliff Run
17-Sep-03	↓	33	2746	2747	-	-	Cliff Run
17-Sep-03	↓	32	2748	2749	24	-	near km 36
17-Sep-03	↓	35	2701	2702	-	-	near km 36
18-Sep-03	km 36 to	35	2967	2966	-	-	sc @ km 36
18-Sep-03	Van Ck	34	2969	2968	-	-	-
18-Sep-03	↓	36	2970	2971	-	-	-
18-Sep-03	↓	32	2972	2973	-	-	-
18-Sep-03	↓	32	2974	2975	-	-	Run with culvert
18-Sep-03	↓	33	2927	2926	-	-	Run with culvert
18-Sep-03	↓	39	2928	2929	-	-	Run with culvert
18-Sep-03	↓	31	2930	2931	-	-	Run with culvert
18-Sep-03	↓	31	2932	2933	-	-	Run with culvert
18-Sep-03	U/S of	34.5	2724	2725	-	-	50 lb Hole
18-Sep-03	GC to Sulphur Ck	34	2723	2722	-	-	50 lb Hole
18-Sep-03	↓	35	2721	2720	-	-	Lower Canyon Reach Hole
18-Sep-03	↓	23	-	-	25	-	Above Canyon
18-Sep-03	↓	31	2719	2718	-	-	Above Canyon
18-Sep-03	↓	31	2704	2703	-	-	U/S of Above Canyon
25-Sep-03	Galbraith Creek	52	-	-	A	-	
25-Sep-03	Galbraith Creek	95	-	-	B	-	
25-Sep-03	Galbraith Creek	86	-	-	C	-	
25-Sep-03	Galbraith Creek	135	-	-	D	-	
25-Sep-03	Galbraith Creek	51	-	-	-	-	
25-Sep-03	Galbraith Creek	37	-	-	-	-	fry
25-Sep-03	Galbraith Creek	42	-	-	-	-	fry
25-Sep-03	Galbraith Creek	42	-	-	-	-	fry

Appendix I. Summary data from diver counts of westslope cutthroat trout observed in the upper Bull River watershed, September 2003.

Section	Date	Length (km)	0-20	20-30	30-40 untagged	30-40 tagged	30-40 total	40-50 untagged	40-50 tagged	40-50 total	50+ untagged	50+ tagged	50+ total	MWF	Vis1	Vis2	Vis3	Vis Mean	Temp
GC to 40 km FS Brdg	22-Sep-03	3.2	65	143	159	10	169	21	1	22	2	0	2	154	10.8	11.0	11.1	11.0	12.0
40 km FS Brdg to km 36	23-Sep-03	4.5	12	63	113	21	134	5	0	5	0	0	0	100	10.6	10.9	11.0	10.8	12.0
km 36 to Van Ck	23-Sep-03	3.9	18	78	60	4	64	2	0	2	0	0	0	185	10.8	11.2	10.7	10.9	12.0
Sulphur Ck to 50 lb Hole	25-Sep-03	2.2	4	113	134	6	140	15	0	15	0	0	0	475	14.2	13.8		14.0	8.0
50 lb Hole to GC	26-Sep-03	4.0	1	42	117	14	131	16	0	16	0	0	0	350	14.2	14.4	14.5	14.4	8.0
		17.7	**100**	**439**	**583**	**55**	**638**	**59**	**1**	**60**	**2**	**0**	**2**	**1264**					