Population Abundance and Stock Assessment of Westslope Cutthroat Trout in the Upper Oldman River Watershed

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EXECUTIVE SUMMARY

Westslope cutthroat trout currently occupies no more than 20% of its historical distribution in Alberta. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has designated the species as 'Threatened'. In the Upper Oldman River drainage, cutthroat trout still occupies most of its historical range; however, detailed information on the current status of the population is insufficient for fisheries management. We conducted a basin-wide stock assessment to facilitate collection of a rigorous database and to evaluate the need for a catch-and-release fishery. We divided the drainage into four strata based on stream size and electrofished a total of 126 stream sections between 2006 and 2007. We calculated fish density and abundance per sample site and then projected values to the entire drainage area using capture-mark-recapture and bootstrapping methods.

We captured 9,266 cutthroat trout, the majority of which (95%) were larger than 70 mm FL. Of the total catch, 52% were of spawning size (> 149 mm fork length), with less than 3% of legal harvest size (> 300 mm total length). We estimated the drainage population of trout (> 70 mm) to be 296,981 individuals, consisting of 125,479 and 2,996 individuals of spawning and legal harvest-sized fish, respectively. A comparison of fish density, abundance and population structure between the Livingstone River (catch-and-release fishery) versus the Oldman River (allowable harvest fishery) indicated that the mainstem Oldman River had more than three times as many fish as the Livingstone River. However, the Livingstone River had more than four times as many legal harvest-sized fish than the Oldman River. In addition, the catch from the Livingstone River had proportionately more legal harvest-sized fish than that from the Oldman River. Angling harvests may have altered fish population structure and size in the Oldman River, despite hooking damage in the Livingstone River mainstem being more than double that of the Oldman River mainstem (52% vs. 23%). In addition, data from a 2004 creel survey suggested there were more than twice as many anglers in the Upper Oldman River drainage, at 7,185 ± 13.9%, than legal-size cutthroat trout, leading to potentially high incidences of hooking damage in the stock.

Key words: cutthroat trout, Oldman River, Livingstone River, bootstrapping, electrofishing, hooking damage, catch-and-release, Alberta, density, abundance.

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The statistical expertise of Dr. Carl Schwartz (Professor of Statistics, Simon Fraser University) was a crucial component in study design. The watershed-level, stratified random monitoring approach, the conceptual foundation of this study, was presented to us by Craig Johnson and by Mike Blackburn, who also provided ongoing project consultation and feedback. Thanks also to Mike Rodtka (ACA) for initiating and hosting the ACA Bull Trout Monitoring Working Session where discussions and critique greatly benefitted this project. Gratitude is extended to Ken Thompson (ASRD) for acting as the field check-in person, and the Livingstone Gap Fire Base for providing meals and accommodation. Work conducted within Alberta protected areas could not have been completed without the assistance and support of Calvin McLeod (Alberta Tourism, Parks, Recreation, and Culture). Editorial review by Cam Stevens (ACA) was greatly appreciated. Final thanks goes to Trevor Council (ACA) without whom this project could not have been completed, from initial project planning, partner liaisons and project management, to support in field sampling, logistics, team building and editorial review.

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1.0 INTRODUCTION

Westslope cutthroat trout (*Oncorhynchus clarkii lewisi)* currently occupies no more than 20% of its historical distribution in Alberta (Costello 2006). In 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated westslope cutthroat trout as 'Threatened' because genetically pure populations have become severely isolated (COSEWIC 2006). Increasing pressures on populations include competition with introduced species, hybridization with non-native rainbow trout (*Oncorhynchus mykiss*), habitat degradation from recreational and industrial activities, and increased angling pressure.

In the Oldman River drainage, westslope cutthroat trout still occupies most of its historical range in the upper part of the basin (Mayhood 2000), but the current status of the population is unknown. A systematic assessment of the regional stock using a stratified random design would provide a rigorous reference or benchmark for future assessments to help identify declining trends. Unfortunately, past study designs and sampling protocols to monitor fish populations have typically been at the sample site level, and biased toward locations of high fish density and productivity where sample sizes of fish were sufficient to calculate site level estimates. The sites that traditionally produced adequate samples of fish were often used as index locations for monitoring. However, the bias associated with such sampling can result in unreliable and hyper-stable indices of abundance, and potentially inadequate warning systems regarding fish population trends (Sullivan 2004; Ripley et al. 2005). Therefore, the Alberta Conservation Association (ACA) and Alberta Sustainable Resource Development (ASRD) proposed watershed-scale fish stock assessments to describe the status of fish populations throughout the province. A study design of random sampling within defined strata was deemed a more reliable and accurate means to measure fish abundance and detect change in population sizes and structure.

Fish and habitat inventories have been conducted in the upper Oldman Drainage for several decades. As early as the 1960s, and throughout the 1970s (Radford 1975, 1977), population inventories and depletion removal estimates have been periodically conducted. Recently, under the Cooperative Fisheries Inventory Program (CFIP, Fisher 2000; Dahl 2002; Jokinen 2002; Faulter 2003), more comprehensive fisheries and habitat data have become available. However, no cutthroat trout population assessment has ever been conducted at the watershed level and taken a random sampling approach. This study is the first watershed-scale cutthroat trout population stock assessment to occur in the drainage and provides the first temporal snapshot of the population as a whole. The stratified-random sampling approach was first introduced in Alberta for bull trout monitoring. The design for this study was an adaptation of previously completed projects in the Clearwater River (Rodtka 2005) and McLeod River (K. Fitzsimmons, in press) watersheds. Our objectives for this study were to:

i. Provide managers with accurate, watershed-scale information on the abundance and density of cutthroat trout in the Upper Oldman River drainage;

ii. Compare abundance and population structure of cutthroat trout between a catch-and-release population (Livingstone River) versus an allowable harvest population (Oldman River) to help determine whether angling regulation changes could contribute to cutthroat trout recovery;

iii. Evaluate abundance calculations for cutthroat trout with those from past creel survey data in the study area; and

iv. Describe and compare population abundance and structure by stream size.

2.0 STUDY AREA

The Oldman River is formed by three main watersheds that originate in the southern Rockies of Alberta, the Castle River, Crowsnest River, and the Upper Oldman River watersheds. The watersheds converge in the Oldman Reservoir, and form the Oldman River downstream of the dam. The Upper Oldman River is the northernmost watershed in the drainage, bordered to the south by the Crowsnest River watershed and to the north by the Highwood River watershed of the Bow River drainage. The study area encompasses the entire Upper Oldman River basin to the west of the Livingstone Mountain range. The downstream boundary of the study area is the Oldman Gap falls, a significant barrier to upstream fish migration located at the eastern edge of the mountain front. There are four main tributaries to the mainstem Oldman River in the upper part of the basin: Racehorse Creek, Dutch Creek, the Upper Oldman River (northwest branch) and the Livingstone River (Figure 1).

Recreational activity is extensive throughout the upper basin with high levels of ATV use and widespread random camping. The study area is also renowned for exceptional fly-fishing and is subject to high angling pressure (Speigl and Hurkett 2005). Since 1995, the Livingstone River watershed has been designated as a catch-and-release only fishery, and is extensively guided by fly-fishing outfitters both local and from afar. The primary industrial activity in the area is timber harvest. The Upper Oldman watershed lies within the C5 forest management unit where Spray Lakes Sawmills is the primary operator and holder of timber quotas and permits. Additional land use activities include oil and gas exploration and production, as well as cattle grazing inside the forest reserve boundary. Protected areas within the study area include the Beehive Natural Area and portions of the Bob Creek and Don Getty Wildlands.

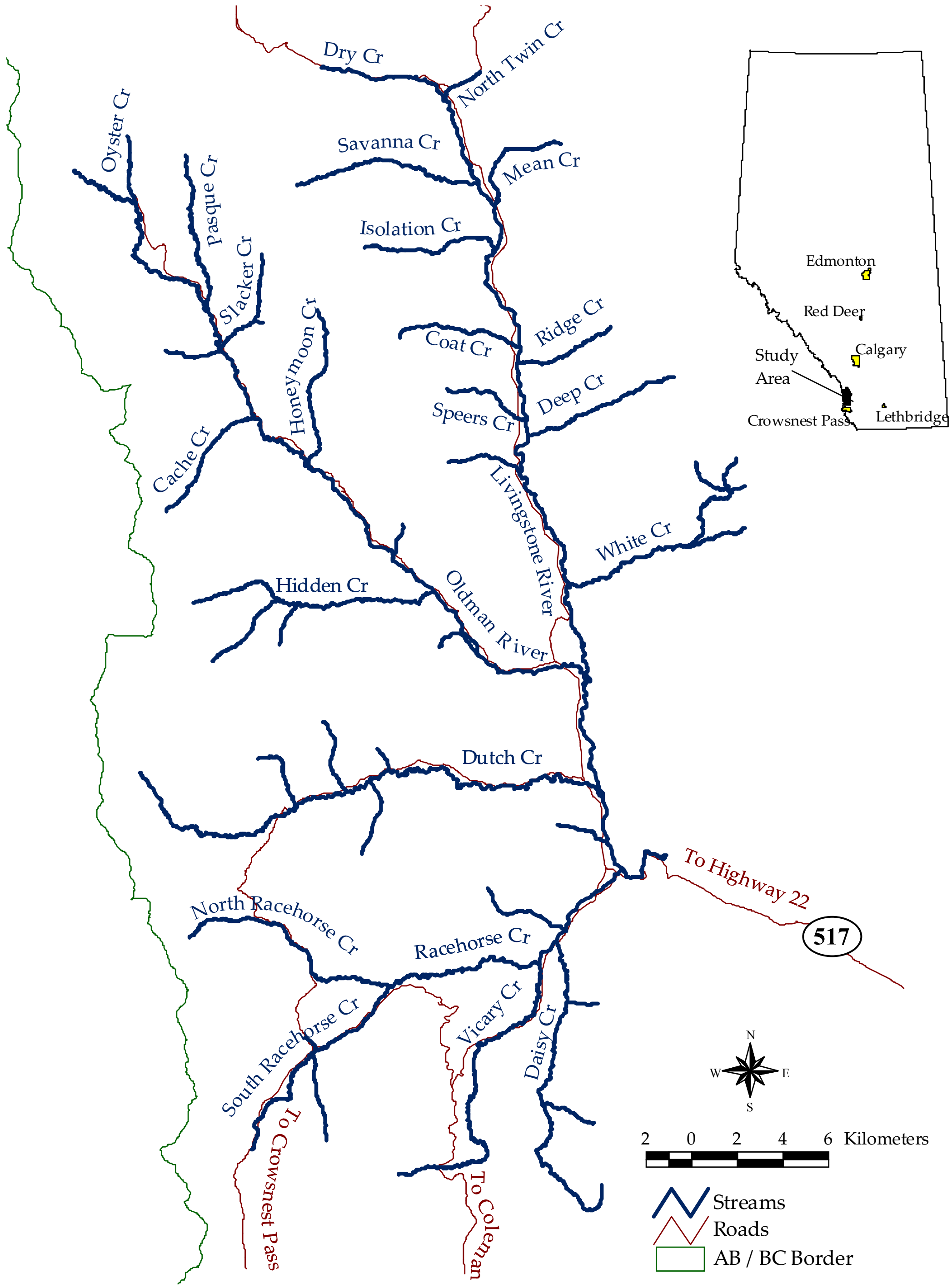


Figure 1. Upper Oldman River cutthroat trout population assessment study area. Inset is a map of Alberta indicating the location of the study area within the province.

3.0 MATERIALS AND METHODS

The Upper Oldman River study was divided into two working phases. The first phase was conducted in 2006 on the Oldman River and Livingstone River watersheds upstream from their confluence. The second phase was conducted in 2007 and included Dutch Creek and Racehorse Creek watersheds and a portion of the Oldman River downstream from the mouth of the Livingstone River. Study design and sampling effort were determined, in part, using power analysis methods and data archived in the CFIP.

3.1 Study area stratification

To determine the scope of the project and generate the total potential number of sample sites, we initially stratified the 2006 study area by Strahler stream order using ArcView 3.2 GIS software. In the absence of quantitative habitat measurements such as riffles and pools, which directly relate to species abundance patterns (Taylor 2000), we used stream size as a surrogate measure of habitat. Similarly, the Strahler stream-order system was used as a measure of stream size. We excluded order 1 streams from the sample pool because they are typically ephemeral or dry and fishless. We also excluded watershed areas upstream of suspected fish barriers (waterfalls) where past data collections resulted in zero fish. Consequently, the study area was initially divided into stream-orders 2 through 6.

We further refined our stratification of the study area using mean wetted-widths from CFIP sample sites compiled by their respective stream-orders (Appendix 1) and bootstrapped (Efron and Tibshirani 1993) 10,000 times. Data were limited for orders 5 and 6 streams on the Oldman River and Livingstone River mainstems, so additional wetted-width datasets were collected at random locations along both streams during pre-season field reconnaissance. Final corrected strata were derived from a combination of stream-order and stream width. Bootstrapping revealed stream orders that were distinct from one another in terms of mean wetted-width distribution, by means of non-overlapping confidence intervals, as well as those that had substantial overlap between them. Stream-orders that were distinct were used as separate strata, whereas those that overlapped were combined as a single stratum or reclassified based on known widths of individual streams. A final total of four strata were identified for allocation of sampling based on non-overlapping confidence intervals (Table 1 and Figure 2).

Each stratum was then divided into segment lengths at approximately 85-times stream wetted-width, derived by Hughes et al. (2002), as a means to attain 95% species richness in raftable streams (Appendix 2). This division also served as a logical and conservative sample unit for our study to encompass the habitat requirements of resident cutthroat trout life history needs. The minimum sample unit length was set at 150 m (Reynolds et al. 2003); the length that we used for all stratum 1 streams (Table 1). Stratum 2 streams were divided into 300-m units and stratum 3 and 4 streams into 500-m units (Table 1). We then calculated the sum total of the combined sample units as the total number of potential sample sites in the study area.

Table 1. Final strata delineation from pre-season bootstrapping of stream-order wetted-width data.

Stratum	**Stream Order**	**Mean wetted-width (m)**	**95% CI (m)**	**Watershed unit length (m)**
1	2	1.0	0.8 - 1.1	150
2	3 and 4	2.9	2.1 - 3.8	300
3	5	5.4	4.6 - 6.2	500
4	5 and 6	14.6	13.3 - 15.8	500

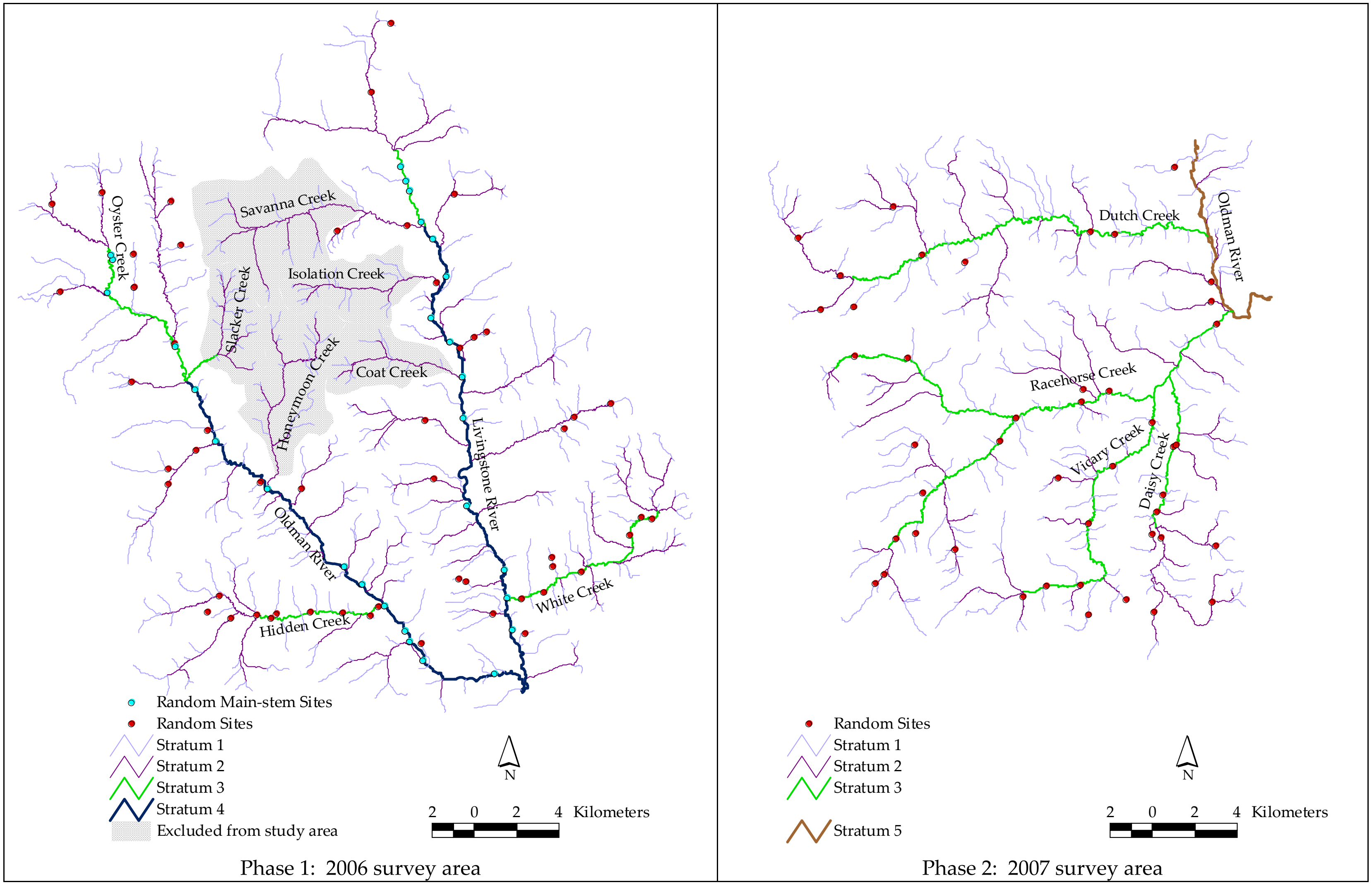


Figure 2. Delineation of final strata and arrangement of random sample sites in the Upper Oldman River watershed study area.

3.2 Sample size determination

Prior to field work, and to aid with determining necessary sample sizes for estimating abundance, we collected archival information (from CFIP) for calculation of total population size, mean number of individuals per sample unit and standard deviation (SD) of individuals per sample unit. Since fish-capture totals (C) do not equal the number of fish present (N) at a given location, we applied a coarse capture probability (*Q)*; i.e., the ratio of fish captured to the total number of fish present in a given area, derived from past depletion removal population estimates (Lockwood and Schneider 2000) in southwestern Alberta mountain streams (Appendix 3). After *Q* was incorporated, a coarse population size was calculated by multiplying the mean number of fish per CFIP site by the total number of potential sites within a stratum, and then summing the four strata totals. The calculated population size, as well as the mean and SD of individuals per sample unit, were then entered (Microsoft Excel) into a statistical formula designed by Carl Schwartz, Professor of Statistics (Simon Fraser University), for delivering project cost and resource allocation scenarios (Schwartz 2005).

It was determined that a minimum functional degree of precision for the cutthroat trout abundance measurement was one within 50% of the population mean, or a "sample survey" level of precision (Schwartz 2005). Additional precision levels considered were within 25% and 10% of the population mean representing management and research levels of precision, respectively. Final determination of our sampling intensity was a balance between acceptable precision levels and time and cost restraints. A total of 58 sites were required to achieve a precision level of 50% of the population mean in the 2006 season (Table 2); however, 80 sites were selected for sampling to maintain a large enough sample size for comparisons between the Livingstone and Oldman watersheds. The resulting predicted level of precision for the 2006 season was therefore ± 42% of the estimated population. In 2007, a total of 46 sites was determined as the sample size for that year with a predicted survey precision level of ± 38% of the estimated population.

Table 2. Sampling intensity required at various precision levels based on calculated Cooperative Fisheries Inventory Program (CFIP) mean and standard deviation (SD) values. N = number of fish; RSE = relative standard error.

Study area watersheds	Approximate population size	SD of N fish/site	Mean N fish/site	Research RSE 10%	Management RSE 25%	Survey RSE 50%
				# sites	# sites	# sites
2006						
Livingstone	91,087	161.13	79.55	1,500	260	65
Oldman	44,184	81.08	60.79	700	110	29
Total	135,271			2,200	370	94
Combined	173,125	138.73	73.14	1,300	230	58
2007						
Dutch & Racehorse	87,214	52.11	79.55	500	87	21

3.3 Allocation of sample sites

Equal allocation of 80 sample sites divided among the four strata resulted in ten sample sites per stratum in 2006 at random locations in the Livingstone River and Oldman River watersheds (Figure 2 and Appendix 4). Proportional allocation of sites in 2007 resulted in a total of 46 sample sites, 12 sites in stratum 1, 16 sites in stratum 2, and 18 sites in stratum 3, using total stream surface area as a guide (Table 3). No stratum 4 sites were present in the 2007 study area. A fifth stratum was present downstream from the confluence of the Livingstone and Oldman rivers; however, conditions did not permit sampling of this stratum and it was subsequently omitted from the study area.

Table 3. Proportional allocation of 46 sample sites over the 2007 study area based on proportion of stream surface area per stratum.

Stratum	Surface area (m^2)	Percent of watershed area	Number of sites	Percent of sample sites
1	413,140	25	12	26
2	531,528	33	16	35
3	689,579	42	18	39
Total	1,634,246	100	46	100

3.4 Data collection

Sample site lists were ordered in random sequence using a Microsoft Excel random number generator to ensure temporal randomness of the four strata throughout the sampling season. Sampling of sites occurred within one sample site length of the random point on the map. In order to maintain independence, a minimum of one sample site length also separated sample sites located on the same stream. Only flowing waterbodies were sampled. Sites that were impounded by beaver dams or were dry (non-response sites), or inaccessible within a 1-km one-way hike, were omitted from sampling and a different random site from the same stratum was selected from the backup random site list. Ground-truthing of the random sample sites was conducted during pre-season reconnaissance of the study area to eliminate the non-response sites from the master sampling list.

We sampled fish via electrofishing using Smith-Root backpack types 15 and 12B electrofishers, as well as a Smith-Root LR-6 tote-barge electrofisher with 5.0 GPP control box. Two crews made up of two individuals each simultaneously backpack-electrofished stratum 1, 2 and 3 sites in the Oldman and Livingstone watersheds, in an upstream progression. Tote-barge electrofishing was conducted using a combined four-member crew on stratum 4 streams in a downstream progression. One crew-member operated the tote-barge and controlled power output. A second crew-member operated an anode pole, while the remaining two crew members captured fish with dipnets and transferred them to a live-well in the tote-barge. Fish and site data collection were the same for backpack electrofishing as for tote-barge electrofishing, except transects occurred at 100-m intervals for tote-barge electrofishing and 50-m intervals for backpack methods. Captured fish were measured and then returned to the stream a short distance downstream of the processing area. Data collected included species, fork length (FL, mm), total length (TL, mm), weight (g), and whether the fish appeared to have any angling related damage. Periodically, DNA samples of adipose tissue were collected as part of a separate provincial genetic study. Site data collected along transects were wetted-width, rooted-width, maximum depth and electrofishing effort (s).

3.5 Calculating population density and abundance

Density and abundance were calculated for three size classes of cutthroat trout. The first size class included all cutthroat throat and cutthroat-rainbow hybrids combined, representing only fish that were enumerated in past population estimates (> 70 mm FL) from which our original *Q* values were calculated. The second class included all mature-size cutthroat trout (> 149 mm FL; Downs and White 1997) and cutthroat-rainbow hybrids combined to facilitate an adult population abundance calculation. The third size class included only harvest-sized fish (> 300 mm TL), those that could be legally harvested in portions of the study area, to help evaluate angling regulations (ASRD 2006). Density and abundance were calculated for the entire study area in fish per m², as well as fish per km, using the following generalized model:

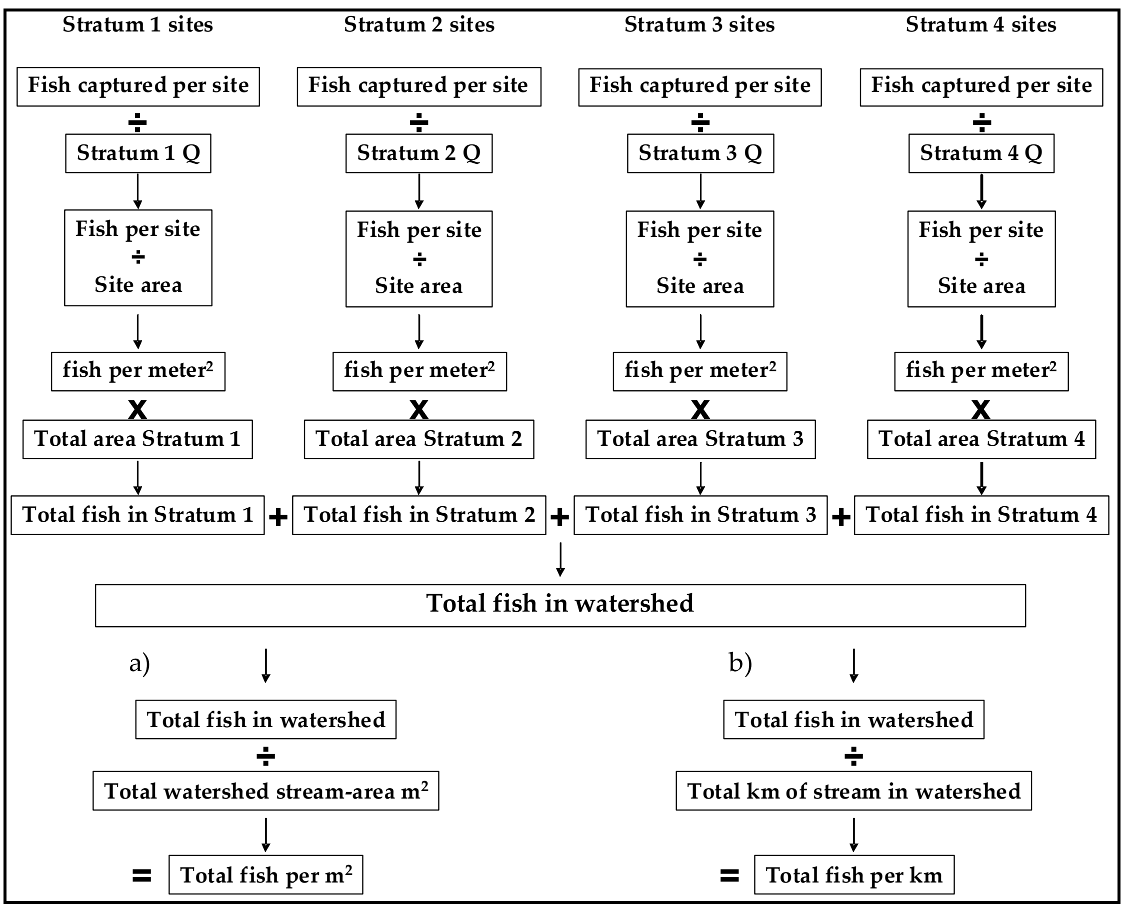


Figure 3. Model used to calculate density and abundance in the Upper Oldman River drainage.

3.6 Calculating *Q*

Integral to density calculations are valid capture probabilities (*Q*). To determine *Q*, a total of 12 Peterson capture-mark-recapture (CMR) estimates were conducted across the four strata. Mean catchability values were then averaged per stratum to be used in density and abundance calculations. CMR estimate results from waterbodies within each stratum indicated mean catchability values of 0.743, 0.403, 0.430, and 0.471 for strata 1 through 4, respectively (Table 4).

Estimates derived using backpack electrofishing were conducted over two consecutive days with a mark run on the initial day and a recapture run the following day. Stream sections sampled using backpack electrofishers were blocked off using blocking nets for the duration of the population estimate (~ 24 h). However, sites sampled using tote-barge electrofishers were not sectioned off with blocking nets when estimating *Q*. At these sites, mark and recapture runs ranged from one to seven days apart. Population estimate reaches were generally the same length as the corresponding stratum in which they were conducted, unless predicted recapture numbers were deemed too low for a valid estimate, in which case reaches were extended in length.

Table 4. Peterson capture-mark-recapture estimate summaries and *Q* values. M = fish marked and released on first pass, C = total fish captured on second pass, R = recaptured fish on second pass, E = Peterson population estimate, *Q* = catchability factor (M/E).

Stratum	**Waterbody**	**M**	**C**	**R**	**E**	**Lower 95% CI**	**Upper 95% CI**	***Q***	**Mean *Q***
1	Tributary to South Racehorse 2007	17	8	6	22	17.6	48.7	0.776	0.734
	Straight 2007	18	12	8	26	20.0	51.6	0.692	
2	Daisy 2007	145	96	27	502	379.3	746.6	0.289	0.403
	Station 2007	135	102	38	357	284.9	484.2	0.379	
	Tributary to Racehorse 2007	56	60	32	104	84.4	140.0	0.541	
3	Daisy 2007	60	61	26	138	107.2	199.7	0.435	0.430
	Racehorse 2007	41	40	17	93	69.4	151.4	0.439	
	Dutch 2007	49	47	19	118	87.9	185.8	0.417	
4	Oldman 2007	25	20	14	35	28.4	54.7	0.714	0.471
	Livingstone 2007	91	63	19	291	211.5	473.2	0.313	
	Oldman 2006	89	37	18	178	135.7	278.8	0.500	
	Livingstone 2006	56	38	13	156	109.0	285.2	0.360	

3.7 Data analyses

Sample site fish density values (fish per m^2) were bootstrapped 10,000 times by stratum. Total fish per stratum was calculated by multiplying the densities by the total stratum stream surface-area. Results were presented per stratum as well as per drainage, and included lower and upper 95% confidence intervals (CI). Data were compared between Oldman and Livingstone watersheds for the three size ranges of cutthroat trout. To help evaluate the need for changes in the harvest regulation on the Oldman watershed, a statistical comparison between the Livingstone River (catch-and-release fishery) and the Oldman River (allowable harvest fishery) was conducted from the mainstems of the two rivers upstream of their confluence, where harvest-sized fish are almost exclusively found and the best angling potential and highest angling pressure exists (Speigl and Hurkett 2005). Specifically, the river reaches included the Livingstone River mainstem upstream from the confluence of the Oldman to the mouths of South Twin, North Twin, and Dry Creeks, where the river becomes an order 5 stream. On the Oldman River, the reaches included the mainstem upstream from the confluence of the Livingstone River up to and including the portion of Oyster Creek that is an order 5 stream (Figure 2). Density and abundance were calculated in the same manner as for the watershed-scale analysis, including all three size classes.

One-way ANOVA with post-hoc Tukey tests (alpha level 0.05) were performed on (1) fish density per sample site to examine the differences in densities between strata by size range; and (2) mean fork-length per sample site to determine the relationship between the four strata and average fish size. One-way ANOVA (alpha level 0.05) was performed on (1) the proportions of spawning and harvest-sized fish per sample site to examine the effects of catch-and-release fishing on size ranges; and (2) the proportions of harvest-sized fish that were hook-damaged to examine the effects of catch-and-release fishing on hooking-damage incidence.

Bootstrapping was used to compare extrapolated population densities (fish per m^2) between the Oldman and Livingstone watersheds, as well as extrapolated population densities between the mainstem stream surface areas. We combined datasets for both watersheds, as well as the mainstems, and bootstrapped the combined dataset 10,000 times, calculating the difference in means (delta mean) between a randomly drawn subset of samples from the combined pool of sampled sites. To make comparisons between watersheds, 40 samples were randomly drawn of the combined 80 sample sites. To make comparisons between the mainstems, 14 samples were randomly drawn of the combined 28 mainstem sample sites. Densities were considered statistically different if the observed difference in the two actual sample means occurred less than 95% of the time within the 10,000 bootstrapped sample means. P-values were calculated as the cumulative percent of events with a difference greater than the observed mean difference between the two original datasets.

All ANOVA analyses were performed using JMP IN version 8 statistical software. Bootstrapping, density and abundance calculations, and all other forms of data manipulation were performed using Microsoft Excel.

4.0 RESULTS

4.1 Fish capture summary

Across a total of 126 sample sites, 9,266 cutthroat trout were captured between 2006 and 2007. Of these, 8,809 cutthroat trout were > 70 mm FL (Table 5), including 65 that were visible cutthroat-rainbow trout hybrids. A total of 4,859 sexually mature cutthroat trout (> 149 mm FL) were captured, of which 45 were visible hybrids. A total of 216 harvest-sized cutthroat trout (> 300 mm TL) were captured, of which five were visible hybrids. The majority of fish, as well as mature fish, were captured in stratum 3 streams (comprising 62% of the total catch in both instances) and averaged 144 and 79 fish per sample site, respectively (Table 5). Harvest-sized fish were primarily captured in stratum 4 streams (69%), averaging eight fish per site.

4.2 Watershed population density and abundance

Using bootstrapped sample-site fish densities derived from capture and abundance totals (Appendix 5) and stream surface area data (Appendix 6), we estimated the Upper Oldman River drainage (Table 6), excluding the Oldman River downstream of the Livingstone River mouth, contains 296,981 (95% CI = 171,249 – 450,332) cutthroat-trout (> 70 mm FL; hybrids included). An estimated 125,476 (95% CI = 77,099 – 183,322) spawning-sized individuals (> 149 mm FL) inhabit the Upper Oldman River drainage, and an estimated 2,996 (95% CI = 1,522 – 4,475) harvest-sized cutthroat trout occur in the drainage. In the fish-bearing portion of the watershed (1,118.7 stream km), abundance was estimated at 265.5 fish/km, 112.2 sexually-mature fish/km, and 2.8 harvest-sized fish/km (Table 7). Abundance of fish in the entire Upper Oldman River watershed (1,737.0 stream km), which includes watershed areas upstream of barriers, was estimated to be 171.0 fish/km, 72.2 mature fish/km and 1.8 harvest-sized fish/km.

Table 5. Cutthroat trout capture summary by size for the Upper Oldman River drainage study area in 2006 and 2007.

Stratum	Sites	Stream length sampled (m)	Stream area sampled (m^2)	Number of fish captured			Mean number of fish per site ± SE		
				> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
1	32	4,800	5,901	142	37	0	4.4 ± 1.7	1.2 ± 0.5	0.0 ± 0.0
2	36	10,800	29,392	1,530	536	2	42.5 ± 9.2	14.9 ± 4.1	0.1 ± 0.0
3	38	19,000	120,853	5,480	3,032	71	144.2 ± 22.5	79.8 ± 10.8	1.9 ± 0.5
4	20	10,000	134,190	1,657	1,254	164	82.9 ± 23.1	62.7 ± 15.0	8.2 ± 1.7
All strata	126	44,600	290,336	8,809	4,859	237	69.9 ± 9.4[a]	38.6 ± 5.1[a]	1.9 ± 0.4[a]

[a]Value presented is the mean number of fish per site with data from all strata combined.

Table 6. Total fish abundance and density by stratum and size range for the entire Upper Oldman River study area.

Size Class	Stratum	Mean estimated population (95% CI)	Mean density fish/km (95% CI)	CV
> 70 mm	1	18,868 (5,546 - 35,800)	33.2 (9.8 - 62.9)	42%
	2	138,010 (80,598 - 201,814)	374.8 (218.9 - 548.1)	22%
	3	116,551 (73,619 - 170,474)	922.8 (582.9 – 1,350.0)	22%
	4	23,551 (11,487 - 42,244)	425.4 (207.5 - 763.1)	24%
	All strata	296,981 (171,249 - 450,332)	265.5 (153.1 - 402.6)	24%
> 149 mm	1	4,089 (1,375 - 7,500)	7.2 (2.4 - 13.2)	39%
	2	44,035 (24,127 - 68,405)	119.6 (65.5 - 185.8)	26%
	3	59,863 (42,375 - 78,236)	473.9 (335.5 - 619.4)	15%
	4	17,492 (9,222 - 29,181)	316.0 (166.6 - 527.1)	30%
	All strata	125,479 (77,099 - 183,322)	112.2 (68.9 - 163.9)	22%
> 300 mm	1	0 (0)	0(0)	0%
	2	131 (0 – 335)	0.4 (0 - 0.9)	69%
	3	826 (340 - 1,135)	7.8 (4.4 – 12.0)	25%
	4	2,039 (1,182 - 3,006)	36.8 (21.4 - 54.3)	23%
	All strata	2,996 (1,522 - 4,475)	2.8 (1.6 - 4.3)	26%

Table 7. Mean population densities of cutthroat trout by area for fish-bearing areas of the Upper Oldman River (UOM) drainage and for the total watershed area of the drainage.

	Total stream length (km)	Stream surface Area (m²)	Size range	Fish/km (95% CI)	Fish/100 m² (95% CI)	CV
Fish bearing	1,118.71	3,153,273	> 70 mm	265.5 (153.1 - 402.5)	9.4 (5.4 - 14.3)	24%
			> 149 mm	112.2 (68.9 - 163.9)	4.0 (2.5 - 5.8)	22%
			> 300 mm	2.8 (1.5 – 4.3)	0.10 (0.1 - 0.2)	26%
Total UOM	1,736.99	3,439,796	> 70 mm	171.0 (98.6 – 259.3)	8.6 (5.0 - 13.1)	24%
			> 149 mm	72.2 (44.4 - 105.5)	3.7 (2.2 - 5.3)	22%
			> 300 mm	1.8 (0.1 - 2.8)	0.1 (0.0 - 0.1)	26%

4.3 Spatial trends in density

One-way ANOVA results indicated that fish densities across the four strata differed significantly for total fish ($F_{3,122} = 5.6$, $P < 0.0012$), mature-sized fish ($F_{3,122} = 9.2$, $P < 0.0001$), and harvest-sized fish ($F_{3,122} = 17.2$, $P < 0.0001$). Post-hoc Tukey test results revealed that stratum 3 streams had the highest densities of fish (i.e., total fish) and mature-sized fish (Figure 4a, b). Stratum 4 streams had the highest densities of harvest-sized fish (Figure 4c). Total densities of fish in strata 2 and 3 streams (14.5 and 14.6 fish/100 m²) were five times greater than densities in strata 1 and 4 streams (2.8 and 3.2 fish/100m²; Figure 4a). Densities of mature fish increased with stratum size from stratum 1 to stratum 3, where fish density (7.5 fish/100 m²) was 12 times greater than in stratum 1 (0.6 fish/100 m²), nearly two times greater than stratum 2 (4.6 fish/100 m²), and more than three times greater than stratum 4 (2.4 fish/100 m²) streams (Figure 4b). Density of harvest-sized fish showed an increasing trend with stratum size, from 0 fish in stratum 1 to a maximum of 0.28 fish/100 m² in stratum 4, where mean density was twice that of stratum 3 streams and 28 times that of stratum 2 streams (Figure 4c).

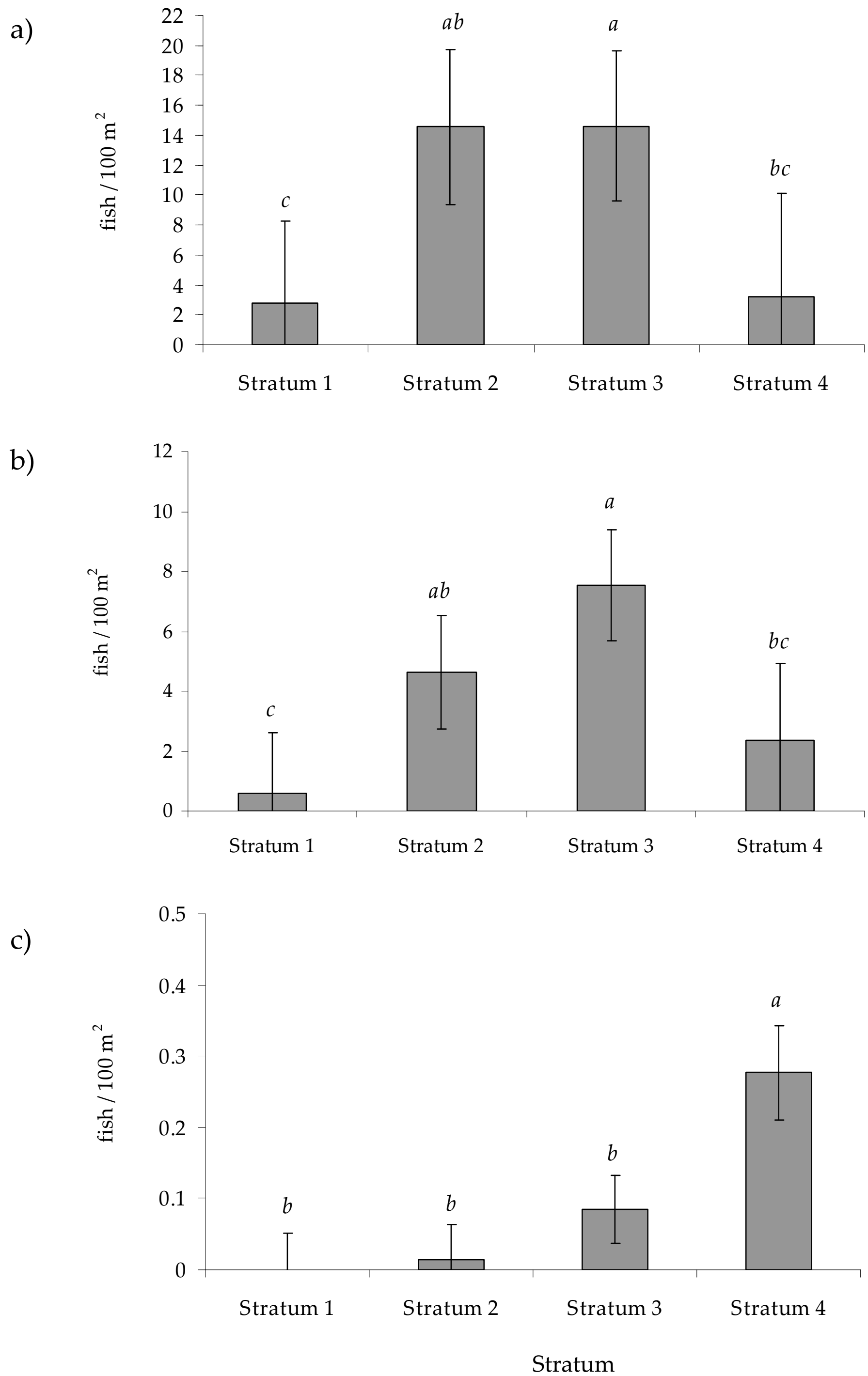


Figure 4. Mean cutthroat trout density by stratum for a) fish > 70 mm FL, b) fish > 149 mm FL, and c) fish > 300 mm TL. Letters denote significant differences in mean density; means with the same letters are not significantly different (P > 0.05). Error bars denote 95% confidence intervals.

4.4 Spatial trends in density comparison between watersheds

We estimated watershed level abundance and density of harvest-sized fish in the Livingstone watershed to be nearly four times that of the Oldman watershed (Table 8). Bootstrapping analysis determined the difference in harvest-sized fish abundance to be highly significant ($P = 0.008$). Total abundance and abundance of mature-sized fish were similar between watersheds (Table 8) and not statistically different based on comparative bootstrapping results ($P = 0.304$ and 0.364).

Observed densities by stratum suggest that the highest fish densities occurred in stratum 3 streams in the Oldman watershed and stratum 2 streams in the Livingstone watershed (Figure 5a). By comparison, densities in stratum 2 streams of the Oldman watershed were three times greater than stratum 2 streams of the Livingstone watershed, whereas the reverse was true for stratum 3 streams which were three times greater in density in the Livingstone watershed than in the Oldman watershed. Density of spawning-sized individuals was nearly three times greater in stratum 1 streams of the Oldman watershed than in the Livingstone watershed; however, density of spawning-sized fish in stratum 3 streams was nearly three times greater in the Livingstone watershed than in the Oldman watershed (Figure 5b). Overall density of harvest-sized fish was higher in the Livingstone watershed than the Oldman watershed, with density more than two times greater in stratum 3 streams and nearly five times greater in stratum 4 streams (Figure 5c).

Table 8. Cutthroat trout abundance and density by size range in the fish-bearing areas of the Oldman River and Livingstone River watersheds derived from bootstrapping. Values in parentheses denote 95% confidence intervals.

	Total fish			Mean fish/100 m^2		
Watershed	**> 70 mm**	**> 149 mm**	**> 300 mm**	**> 70 mm**	**> 149 mm**	**> 300 mm**
Livingstone	97,519 (42,322 - 166,738)	37,821 (20,099 - 58,882)	1,406 (655 - 2,282)	10.00 (4.30 - 17.10)	3.88 (2.06 - 6.04)	0.14 (0.07 - 0.23)
Oldman	84,450 (49,626 - 126,860)	38,812 (22,159 - 59,719)	383 (181 - 625)	8.88 (5.23 - 13.34)	4.08 (2.33 - 6.29)	0.04 (0.02 - 0.07)

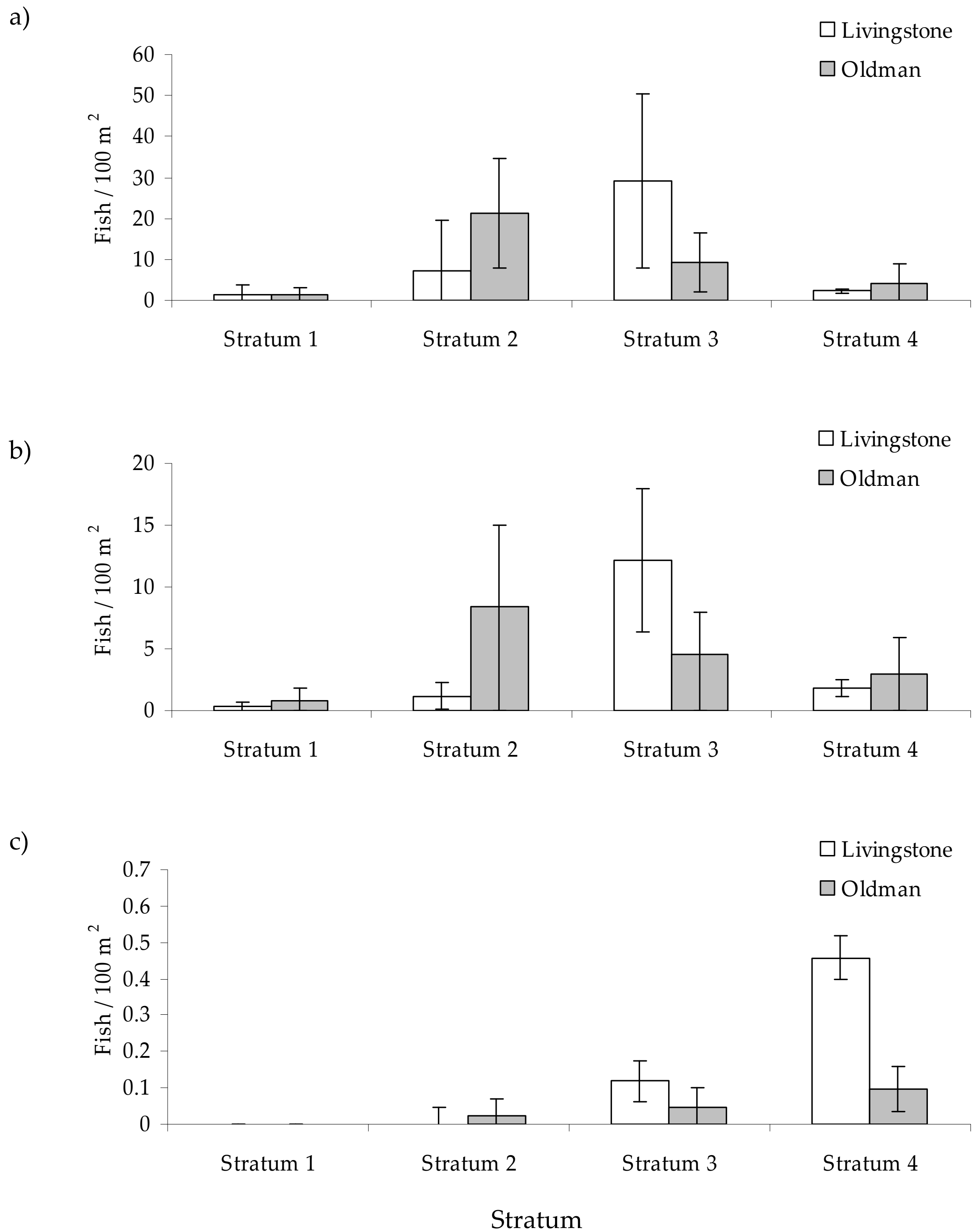


Figure 5. Watershed level comparison of fish density by stratum between the Livingstone River and Oldman River watersheds. Error bars denote 95% confidence intervals.

4.5 Mainstem population density and abundance comparison

We estimated total extrapolated abundance and density of cutthroat trout in the Oldman River mainstem to be three times greater than in the Livingstone River mainstem (Table 9). Similarly, total abundance and density of mature-sized individuals in the Oldman mainstem were more than twice that of the Livingtone mainstem. Conversely, abundance and density of harvest-sized fish were nearly five times greater in the Livingstone mainstem than the Oldman mainstem. All bootstrapped comparisons of the two mainstems showed significant to highly significant differences in density; for all fish ($P = < 0.001$), mature-sized fish ($P = < 0.001$), and harvest-sized fish ($P = 0.002$).

At the site level, on average, total fish density was three times higher and total number of fish two times higher at Oldman River sample sites (n = 14) than the Livingstone River sample sites (n = 14; Table 9). Similarly, density of mature-sized fish was more than two times greater for the Oldman River, and mature-sized fish were nearly two times more abundant (i.e., total fish) than the Livingstone River. However, harvest-sized fish were, on average, nearly six times more abundant in the Livingstone River sample sites in terms of density and five times more abundant in terms of total fish.

Table 9. Mainstem abundance and density totals by size range. Values in parentheses denote 95% confidence intervals.

	Livingstone River			Oldman River		
	> 70 mm	**> 149 mm**	**> 300 mm**	**> 70 mm**	**> 149 mm**	**> 300 mm**
Extrapolated total fish	9,229 (6,908 – 11,738)	7,352 (5,048 – 9,964)	1,688 (1,005 - 2,443)	29,567 (11,742 - 52,224)	17,729 (6,573 - 32,480)	372 (190 – 598)
Extrapolated density (fish/100 m^2)	2.44 (1.83 - 3.10)	1.94 (1.33 - 2.63)	0.45 (0.27 - 0.65)	6.47 (2.57 - 11.43)	3.88 (1.44 - 7.11)	0.08 (0.04 - 0.13)
Mean fish per sample site	140 (23 - 257)	109 (38 - 179)	23 (15 - 30)	296 (179 - 412)	178 (107 - 248)	5 (2 - 12)
Mean density per sample site (fish/100 m^2)	2.9 (1.2 - 7.0)	2.2 (0.02 - 4.4)	0.4 (0.3 - 0.5)	8.6 (4.5 - 12.7)	4.8 (2.6 - 6.9)	0.07 (0.06 - 0.2)

4.6 Population structure and size distribution

A total of 9,266 cutthroat trout were measured in 2006 and 2007, ranging from 25 - 461 mm (Table 10). Weight ranged from 1 – 1,674 g across a total of 5,203 measured weights. The fork length frequency distribution of all measured fish shows a normalized distribution pattern with an average FL of 160 mm (Appendix 7a).

Table 10. Cutthroat trout measurement summary by stratum for the Upper Oldman River study area.

Stratum	Fork Length (mm)					Weight (g)				
	Min	**Mean**	**Max**	**SD**	**n**	**Min**	**Mean**	**Max**	**SD**	**n**
1	43	112.4	240	52.5	244	1	35.0	248	49.4	162
2	25	127.6	340	48.3	1,742	1	36.6	444	45.6	1,803
3	39	159.2	363	51.5	5,571	1	63.1	597	68.3	1,782
4	41	204.2	461	68.9	1,709	1	171.1	1,674	185.5	1,456
All strata	25	160.3	461	60.0	9,266	1	75.8	1,674	106.8	5,203

The cutthroat trout population displayed a trend toward greater mean and maximum FL with increasing stratum size (Figure 6 and Appendix 7). Mean FL in stratum 4 streams was 50% greater than mean FL in stratum 1 and stratum 2 streams, and 27% greater than mean FL in stratum 3 streams, and mean FL of fish in stratum 3 streams was 18% greater than stratum 2 streams. One-way ANOVA ($F_{3,88} = 13.9$, $P < 0.0001$) with post-hoc Tukey test demonstrated a significant increase in mean FL with stratum size from stratum 2 to stratum 4 (Figure 6).

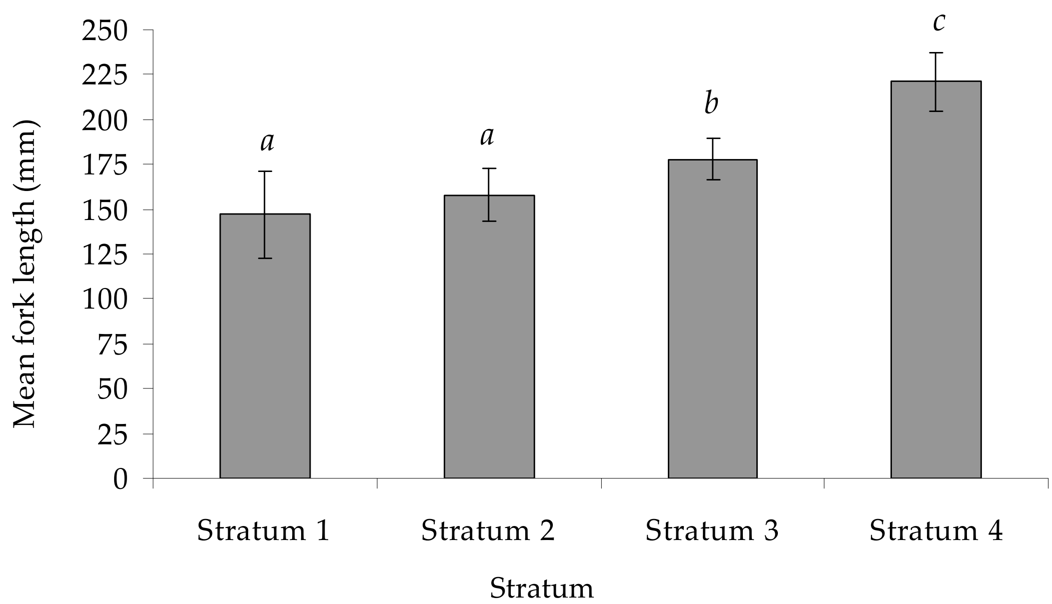


Figure 6. Mean cutthroat trout fork length by stratum. Letters indicate significant differences in fork length among strata; strata with the same letters do not differ significantly in fork length (P > 0.05). Error bars denote 95% confidence intervals.

4.7 Comparison of population structures between mainstems

A comparison of total length distribution between the Oldman River (allowable harvest) and the Livingstone River (catch-and-release) suggested that legal harvest of cutthroat trout (> 300 mm TL) likely impacted population structure in the Oldman River. The bulk of the Oldman River distribution terminates at or near 300 mm TL, whereas the Livingstone River distribution continues well beyond 300 mm TL (Figure 7). There was no significant difference in mean FL between the mainstems ($F_{1,26} = 2.2$, $P = 0.149$), with mean FL values of 217 mm and 196 mm for the Livingstone and Oldman Rivers, respectively. The proportion of spawning-sized individuals captured did not differ significantly between the rivers ($F_{1,26} = 0.4$, $P = 0.501$; Figure 8a). However, the proportion of harvest-sized individuals captured was significantly greater ($F_{1,26} = 6.4$, $P = 0.018$) in the Livingstone River (Figure 8b). Total capture of harvest-sized fish in the Livingstone River mainstem was more than double that of the Oldman mainstem, making up nearly a fifth of the population (19.2%) compared to less than a tenth of the population in the Oldman mainstem (7.7%; Figure 8b).

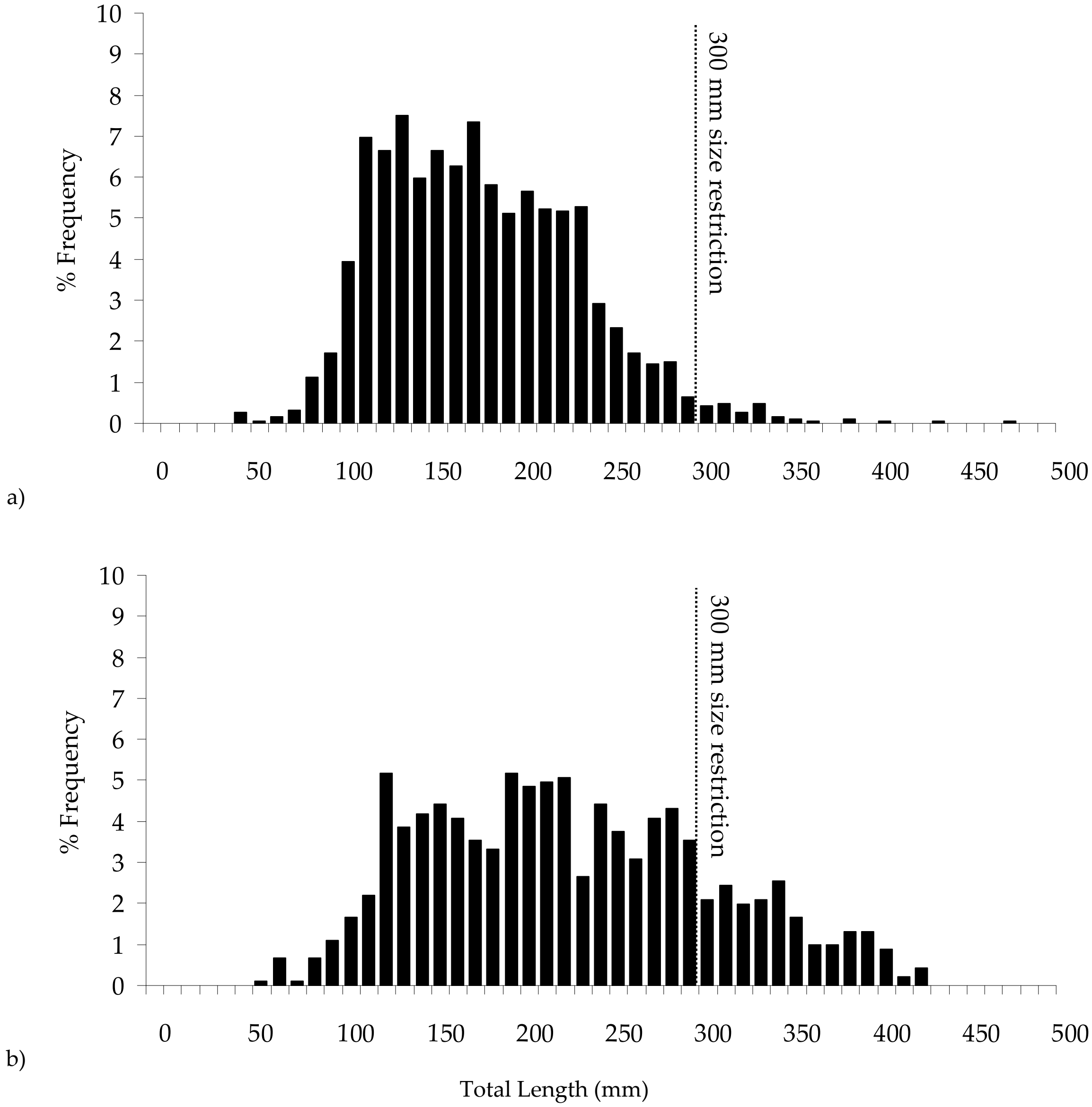


Figure 7. Comparison of total length frequency distributions between a) the Oldman River (allowable harvest fishery) and b) Livingstone River (catch-and-release fishery).

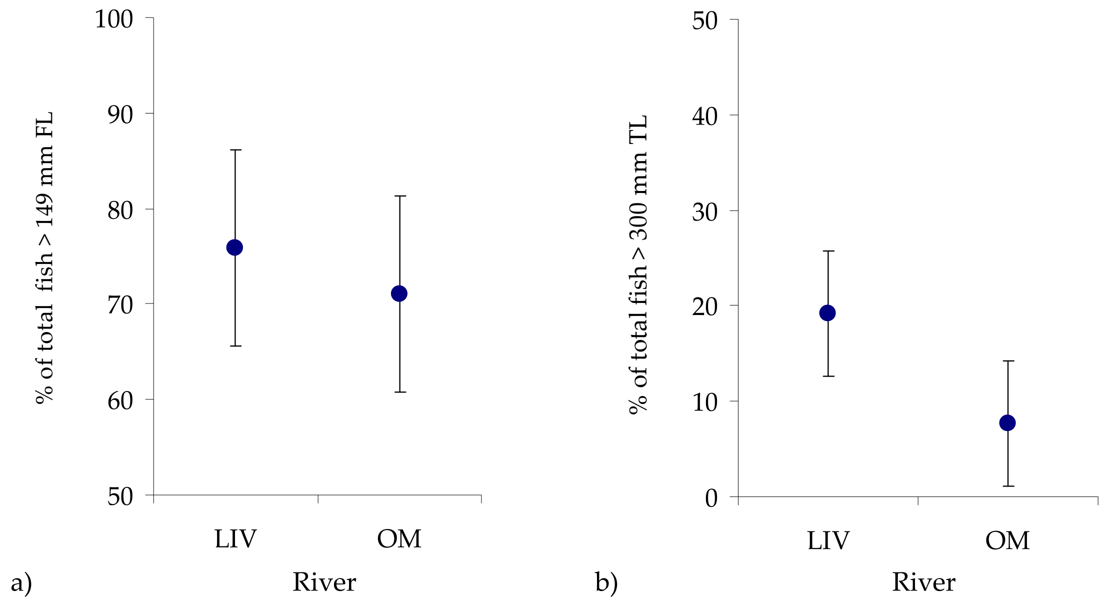


Figure 8. Comparison of the proportions of total captured cutthroat trout between the Livingstone (LIV) and Oldman (OM) rivers that were a) > 149 mm FL and b) > 300 mm TL. Error bars denote 95% confidence intervals.

4.8 Hooking damage comparisons

A comparison of hook-damaged fish between the Livingstone and Oldman rivers suggested higher angling pressure on the Livingstone River (consistent with 2004 creel data, Speigl and Hurkett 2005), and supported the observed effects of legal harvest on the population structure in the Oldman River where recaptured fish of legal size were less prevalent, possibly due to higher harvest rates. Hooking damage was observed on fish as small as 137 mm TL; however, most fish were greater than 180 mm (Figure 9). A greater proportion of fish from the Livingstone River was hook-damaged compared to the Oldman River (Figure 9). Similarly, the proportion of hook-damaged harvest-sized fish captured in the Livingstone River was significantly greater ($F_{1,20}$ = 4.4, P = 0.05) at 52% (95% CI = 30 - 74%) compared to 23% (95% CI = 7 - 38%) for the Oldman River (Figure 10). The Livingstone River also had more than twice the proportion of hook-damaged fish than Racehorse and Dutch creeks, the other major allowable harvest tributaries in the drainage, which had significantly less ($F_{1,25}$ = 4.1, P = 0.05) combined hooking damage at 23% (95% CI = 3 - 44%; Figure 10). The Oldman River had nearly identical proportions of hook-damaged fish as Racehorse and Dutch creeks, suggesting similar angling pressure and harvests throughout those systems.

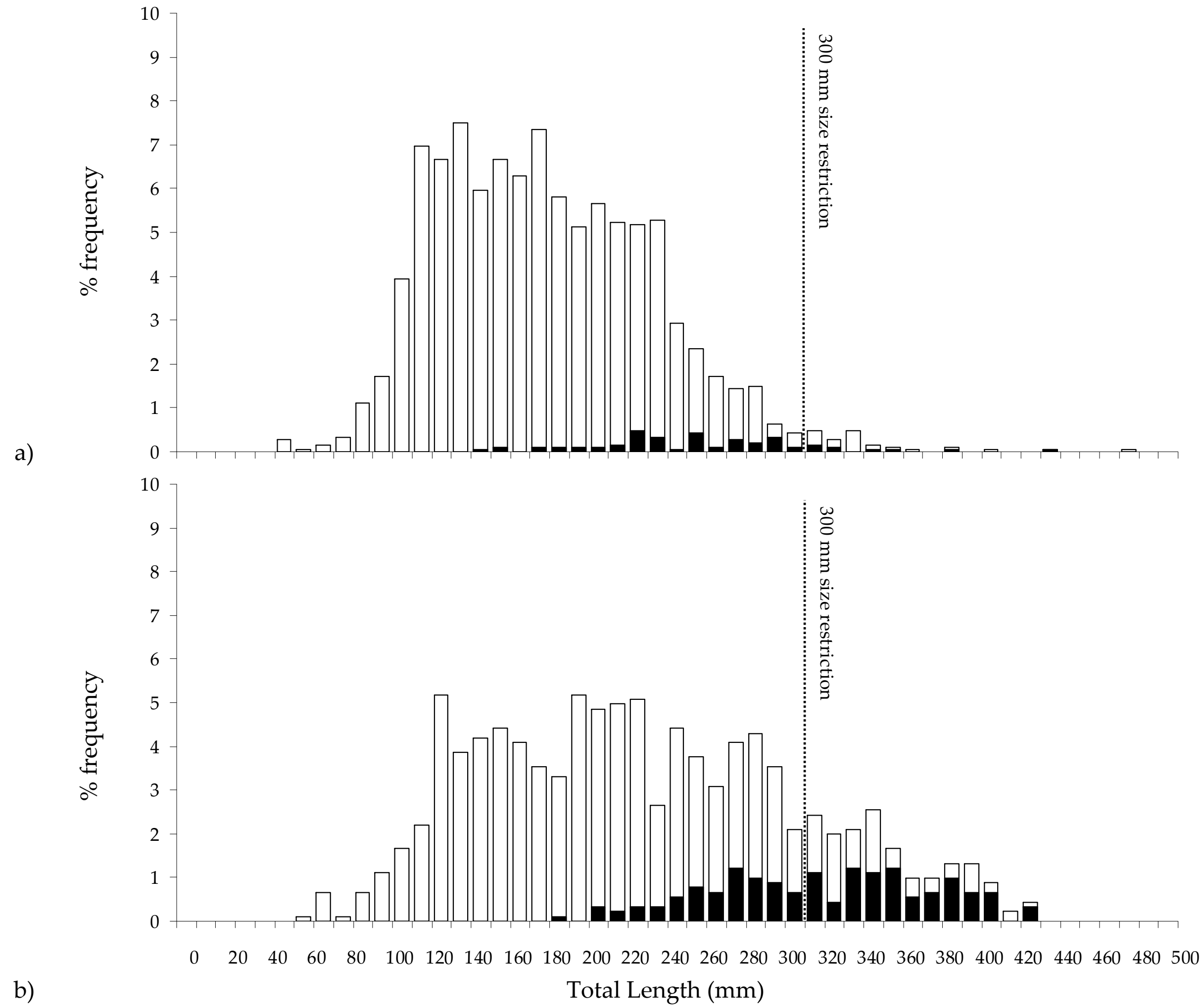


Figure 9. Frequency distributions showing the proportions of hook-damaged fish (shaded area) in the a) Oldman River (allowable harvest fishery) and b) Livingstone River (catch-and-release fishery).

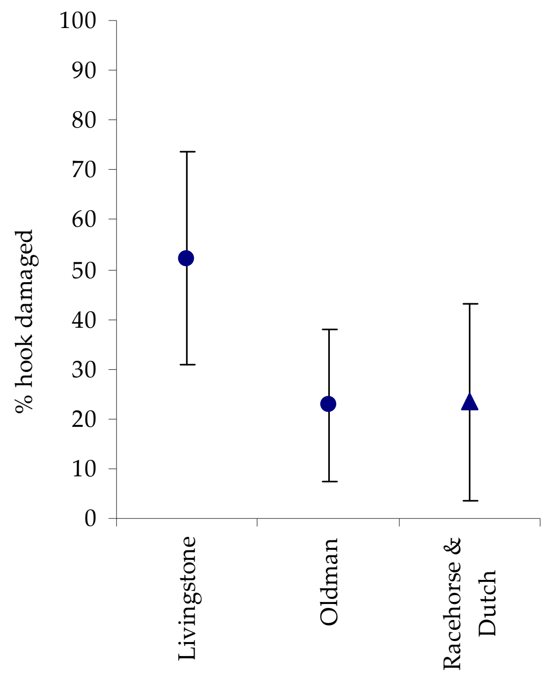


Figure 10. Comparison of percent hook-damaged harvest-sized fish per site between the Livingstone River (catch-and-release) and the Oldman River (allowable harvest) and Dutch and Racehorse creeks combined (also allowable harvest). Error bars denote 95% confidence intervals.

4.9 Comparison of cutthroat trout abundance data with 2004 creel data

A roving creel survey in 2004 in the same study area interviewed a total of 2,941 anglers who captured a total of 2,539 harvest-sized cutthroat trout (Speigl and Hurkett 2005). The estimated total number of anglers that fished between 16 June to 6 September 2004 was 7,185 (95% CI = 6,186 – 8,184). Captures of harvest-sized fish represented 26.6% of the estimated total of 22,797 cutthroat trout (95% CI = 19,452 – 26,142), which equates to approximately 6,064 (95% CI = 5,174 – 6,954) harvest-sized fish. By comparison, we estimated total abundance of harvest-sized cutthroat trout at 2,996 fish (95% CI = 1,522 – 4,475) in the same sample area, suggesting twice as many capture events than total harvest-sized fish. This result suggested a high degree of repeat captures of individual fish. Assuming population abundance in 2004 and 2006 was similar, approximately one harvest-sized fish was available per interviewed angler. However, the total number of anglers in 2004 was more than double the 2006 harvest-sized fish population at 2.4 anglers per fish.

Of 768 interviewed anglers who fished the Oldman River in 2004, 290 harvest-sized fish were reported captured. The estimated total number of anglers that fished the Oldman River in 2004 was 1,998 (95% CI = 1,679 – 2,318), representing an approximate total capture of 755 (95% CI = 634 – 875) harvest-sized fish. By comparison, we estimated total number of harvest-sized cutthroat trout to be 372 (95% CI = 190 - 598), suggesting the number of anglers interviewed was more than double the number of harvest-sized fish available, and the total number of anglers that fished in the 2004 season was more than five times the total harvest-sized fish population in the river (Table 11). Similarly in the Livingstone River, of 1,088 anglers interviewed, 1,607 harvest-sized fish were captured. The estimated total of 2,697 anglers (95% CI = 2,376 – 3,018) who fished the Livingstone in 2004 captured approximately 3,983 (95% CI = 3,059 – 4,458) harvest-sized fish. We estimated abundance of harvest-sized fish in the Livingstone River to be 1,688 (95% CI = 1,005 - 2,443), which equates to approximately one angler interviewed per harvest-sized fish in the drainage, and approximately 1.6 times as many anglers as harvest-sized fish (Table 11). In both rivers, the number of harvest-sized fish reported captured was nearly equal to the total abundance of all fish available based on 2006 calculations. Also, the estimated total angler capture of harvest-sized fish in 2004 far exceeded the estimated total available in 2006, further suggesting a high degree of repeat captures of individual fish.

4.10 Comparison of 2004 harvest rates and 2006 abundance estimates

Of the 9,560 cutthroat trout reported captured in the 2004 creel survey, 67 were reported harvested (0.7% harvest rate). The total estimated catch in 2004 was 22,797 cutthroat trout (95% CI = 19,452 – 26,142). This estimate equates to a total of 160 fish harvested throughout the season; or approximately 5% (95% CI = 4 - 11%) of our total estimated harvest-sized population of 2,996 (95% CI = 1,522 – 4,475); 11% (95% CI = 7 - 24%) of our estimated harvest-sized population in the Livingstone River watershed; or 42% (95% CI = 26 - 88%) of our total estimated Oldman River watershed harvest-sized population of 383 (95% CI = 181 - 625) upstream of the Livingstone confluence. Similarly, of the 2,996 (95% CI = 1,522 – 4,475) cutthroat trout that inhabit the entire

Upper Oldman study area, 1,406 (95% CI = 655 – 2,282) inhabit the catch-and-release Livingstone watershed, resulting in approximately 1,590 (95% CI = 867 – 2,193) individuals available to be legally harvested. Based on 2004 harvest totals, 10% of the legal harvest-sized cutthroat trout population is removed annually.

Table 11. Comparison of estimated total anglers from 2004 creel survey with estimated total abundance in 2006 of harvest-sized cutthroat trout in the Oldman and Livingstone River mainstems. 95% confidence interval around estimates are shown in parentheses.

Watershed	Anglers interviewed in 2004	Reported fish > 300 mm in 2004	Estimated total captures > 300 mm in 2004	Estimated total anglers in 2004	Estimated abundance of fish > 300 mm in 2006
Oldman	768	290	754 (634 - 875)	1,998 (1,679 - 2,318)	372 (190 - 598)
Livingstone	1,088	1,607	3,983 (3,059 - 4,458)	2,697 (2,376 - 3,018)	1,688 (1,005 - 2,443)

5.0 LITERATURE CITED

Alberta Sustainable Resource Development. 2006. 2006 Alberta guide to sport fishing regulations. Queens Printer Bookstore, Edmonton, Alberta, Canada. 92 pp.

Angermeier, P.L., and R.A. Smogor. 1995. Estimating number of species and relative abundances in stream-fish communities: effects of sampling effort and discontinuous spatial distributions. Canadian Journal of Fisheries and Aquatic Sciences 52: 936-949.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. COSEWIC assessment and update status report on the westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) (British Columbia population and Alberta population) in Canada. vii + 67 pp. Available online at: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=861#ot18.

Costello, A. 2006. The status of westslope cutthroat trout (*Onchorhynchus clarkii lewisii*) in Alberta. Prepared for Alberta Sustainable Resource Development and Alberta Conservation Association, Alberta Sustainable Resource Development Wildlife Status Report No. 61, Edmonton, Alberta. 34 pp.

Dahl, M. 2002. Cooperative fisheries inventory program, Atlas Lumber timber quota: 1999 catalogue of sample sites. Alberta Conservation Association, Blairmore, Alberta. 103 pp. + App.

Downs, C., and R. White. 1997. Age at sexual maturity, sex ratio, fecundity, and longevity of isolated headwater populations of westslope cutthroat trout. North American Journal of Fisheries Management 17: 85-92.

Efron, B., and J. Tibshirani. 1993. An introduction to the bootstrap: monographs on statistics and applied probability. Volume 57. Chapman and Hall / CRC press, Boca Raton, Florida. 436 pp.

Faulter, R. 2003. Cooperative fisheries inventory program: 2003 survey site reference catalogue, Blairmore area. Alberta Conservation Association, Blairmore, Alberta. 82 pp + App.

Fisher, J. 2000. Cooperative fisheries inventory program, Atlas Lumber timber quota: 2000 catalogue of sample sites. Atlas Lumber Ltd., Blairmore, Alberta. 99 pp. + App.

Hughes, R.M., P.R. Kaufmann, A.T. Herlihy, S.S. Intelmann, S.C. Corbett, M.C. Arbogast, and R.C. Hjort. 2002. Electrofishing distance needed to estimate fish species richness in raftable Oregon rivers. North American Journal of Fisheries Management 22: 1229-1240.

Jokinen, M. 2002. Cooperative fisheries inventory program: 2002 survey site reference catalogue, Blairmore. Alberta Conservation Association, Blairmore, Alberta. 97 pp. + App.

Lockwood, R., and J Schneider. 2000. Stream fish population estimates by mark-and-recapture and depletion methods. Chapter 7. *In:* J.C. Schneider, editor. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor, Michigan.

Lyons, J. 1992. The length of stream to sample with a towed electrofishing unit when fish species richness is estimated. North American Journal of Fisheries Management 12: 198-203.

Maret, T., and D. Ott. 2002. Assessment of fish assemblages and minimum sampling effort required to determine biotic integrity of large rivers in southern Idaho. US geological survey, Water Resources Investigations Report 03-4274, prepared in cooperation with Idaho Department of Environmental Quality and US department of the interior, Denver, Colorado. 16 pp.

Mayhood, D. 2000. Provisional evaluation of the status of westslope cutthroat trout in Canada. Pages 579-585. *In:* L. M. Darling, editor. Proceedings of the biology and management of species and habitats at risk, Kamloops, British Columbia, 15 - 19 February 1999. British Columbia Ministry of Environment, Lands and Parks, Victoria, BC, and University College of the Cariboo, Kamloops, British Columbia. 974 pp.

Paller, M.H. 1995. Relationships among number of fish species sampled, reach length surveyed, and sampling effort in South Carolina Coastal Plain streams. North American Journal of Fisheries Management 15: 110-120.

Radford, D.S. 1975. Livingstone drainage district inventory: Coat Creek, Dutch Creek, Honeymoon Creek, Isolation Creek, Pasque Creek, Savanna Creek, Slacker Creek, Ridge Creek, Livingstone River, Oldman River, Hidden Creek, Oyster Creek, Deep Creek, White Creek, Daisy Creek, Racehorse Creek and Vicary Creek. Fish and Wildlife Division, Department of Recreation, Parks and Wildlife, Lethbridge, Alberta. 217 pp.

Radford, D.S. 1977. A report of biological inventories of 17 streams in the Livingstone drainage district of Alberta. Fish and Wildlife Division, Department of Recreation, Parks and Wildlife, Lethbridge, Alberta. 77 pp + App.

Reynolds, L., A.T. Herlihy, P.R. Kaufmann, S.V. Gregory, and R.M. Hughes. 2003. Electrofishing effort requirements for assessing species richness and biotic integrity in western Oregon streams. North American Journal of Fisheries Management 23: 450-461.

Ripley, T., G. Scrimgeour, and M. Boyce. 2005. Bull trout (*Salvelinus confluentus*) occurrence and abundance influenced by cumulative industrial developments in a Canadian boreal forest watershed. Canadian Journal of Fisheries and Aquatic Sciences 62: 2431-2442.

Rodtka, M. 2005. Status of bull trout in the Upper Clearwater River - 2004. Technical Report, T-2005-003, produced by Alberta Conservation Association, Rocky Mountain House, Alberta, Canada. 42 pp. + App.

Schwartz ,C. 2005. Statistics for resource managers: subset from STAT 403/650. Simon Fraser University, Department of Statistics and Actuarial Science, Burnaby, British Columbia. 834 pp.

Speigl C., and B.J. Hurkett. 2005. Upper Oldman River drainage angler survey, 2004. Data report, D-2005-036, produced by Alberta Conservation Association, Blairmore and Lethbridge, Alberta. 23 pp. + App.

Sullivan M. 2004. Monitoring fish populations: theory and practice. Computer simulation of population monitoring. Alberta Fish and Wildlife Division, unpublished memorandum, Edmonton, Alberta. 29 pp.

Taylor, C. 2000. A large-scale comparative analysis of riffle and pool fish communities in an upland stream system. Environmental Biology of Fishes 58: 89–95.

6.0 APPENDICES

Appendix 1. Summary of Cooperative Fisheries Inventory Program data used in the Upper Oldman River drainage cutthroat trout (CTTR) density and abundance study design. Universal Transverse Mercator coordinates are NAD 83, Zone 11.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted Width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Livingstone	Unnamed Creek	2	1999	681435	5554984	2.16	200	487	0
Livingstone	Unnamed Creek	2	1999	688541	5551599	1.52	200	619	12
Livingstone	Unnamed Creek	2	1999	684156	5545194	1.92	200	574	20
Livingstone	Unnamed Creek	2	2002	675669	5557777	0.97	300	329	0
Livingstone	Beaver Creek	2	2003	684386	5554096	2.31	300	436	54
Livingstone	Beaver Creek	3	1999	683188	5553119	2.18	200	878	45
Livingstone	Deep Creek	3	1999	685872	5546672	5.32	210	738	38
Livingstone	Deep Creek	3	1999	688227	5547701	2.88	175	638	63
Livingstone	Speers Creek	3	1999	681030	5548432	1.78	200	385	0
Livingstone	Unnamed Creek	3	1999	680172	5562063	3.34	200	489	1
Livingstone	Savanna Creek	3	2002	674502	5557296	2.18	300	438	0
Livingstone	Unnamed Creek	3	2002	674076	5557328	2.61	300	489	0
Livingstone	Unnamed Creek	3	2002	674514	5557287	2.31	300	435	0
Livingstone	Deep Creek	3	2003	684918	5546378	5.63	300	1,074	32
Livingstone	Deep Creek	3	2003	687676	5547528	4.87	300	542	62
Livingstone	Unnamed Creek	3	2003	684170	5544430	0.75	300	850	0
Livingstone	Coat Creek	4	1999	680946	5551080	2.1	200	549	0
Livingstone	Coat Creek	4	1999	683865	5550390	3.16	205	620	23

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Livingstone	Dry Creek	4	1999	679681	5562024	3.44	200	419	0
Livingstone	Livingstone River	4	1999	680653	5561512	6.04	200	437	0
Livingstone	Mean Creek	4	1999	683226	5556484	6.74	200	609	2
Livingstone	Mean Creek	4	1999	683185	5558097	4.14	200	649	2
Livingstone	Mean Creek	4	1999	683548	5558670	8.28	200	578	1
Livingstone	North Twin Creek	4	1999	681027	5561117	2.2	200	260	5
Livingstone	North Twin Creek	4	1999	681631	5561704	1.32	200	263	0
Livingstone	Ridge Creek	4	1999	686813	5550223	1.68	200	498	4
Livingstone	Ridge Creek	4	1999	684311	5549510	2.36	200	734	58
Livingstone	Savanna Creek	4	1999	680343	5557740	9.1	200	593	0
Livingstone	Savanna Creek	4	1999	682350	5557408	8.22	200	604	11
Livingstone	Speers Creek	4	1999	683013	5548240	2.96	200	767	23
Livingstone	Unnamed Creek	4	1999	678700	5554466	2.26	200	469	0
Livingstone	Unnamed Creek	4	1999	683133	5554625	4.54	200	641	7
Livingstone	Savanna Creek	4	2002	678655	5558393	5.45	300	636	0
Livingstone	Savanna Creek	4	2002	680162	5557855	4.96	300	415	2
Livingstone	Savanna Creek	4	2002	679547	5558109	4.88	300	569	3
Livingstone	Unnamed Creek	4	2002	681485	5554867	3.72	300	450	0
Livingstone	Unnamed Creek	4	2002	680308	5554386	3.32	300	452	0
Livingstone	Unnamed Creek	4	2002	678124	5554609	2.28	300	390	0
Livingstone	Coat Creek	4	2003	683808	5550391	2.56	300	485	0
Livingstone	Coat Creek	4	2003	682853	5550882	3.07	300	383	0

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Livingstone	Ridge Creek	4	2003	685158	5549512	1.85	300	312	0
Livingstone	Ridge Creek	4	2003	684275	5549577	2.18	300	576	20
Livingstone	Speers Creek	4	2003	684148	5547126	2.83	300	533	27
Livingstone	Speers Creek	4	2003	681708	5548270	2.96	300	612	1
Livingstone	Unnamed Creek	4	2003	684139	5544963	2.17	300	683	0
Livingstone	Livingstone River	5	1999	683388	5554777	14.34	200	719	6
Livingstone	Livingstone River	5	1999	683378	5552254	12.14	200	421	7
Livingstone	Livingstone River	5	1999	684705	5543871	10.68	200	623	9
Livingstone	Livingstone River	5	1999	682185	5557878	7.88	200	639	12
Livingstone	White Creek	5	1999	688003	5540120	7.5	200	821	51
Livingstone	White Creek	5	1999	690707	5541431	5.9	200	953	49
Livingstone	White Creek	5	1999	688711	5540575	5.82	250	932	65
Oldman	Straight Creek	2	2000	668735	5554653	2.36	200	549	0
Oldman	Beehive Creek	2	2002	672102	5547834	2.13	300	456	48
Oldman	Straight Creek	2	2002	668791	5556132	2.27	300	518	1
Oldman	Straight Creek	2	2002	668670	5553435	1.8	300	350	9
Oldman	Hidden Creek	3	2002	673493	5539331	3.48	300	625	10
Oldman	Lyall Creek	3	2002	669361	5552995	2.92	300	469	28
Oldman	Cache Creek	4	2000	672591	5547111	4.34	200	599	8
Oldman	Cache Creek	4	2000	671021	5546208	4	300	616	32
Oldman	Honeymoon Creek	4	2000	675036	5545133	3.4	200	1,017	11
Oldman	Pasque Creek	4	2000	670643	5551850	4.34	200	851	39

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Oldman	Cache Creek	4	2002	671021	5546208	4	300	616	32
Oldman	Honeymoon Creek	4	2002	675766	5550594	3.26	300	504	0
Oldman	Honeymoon Creek	4	2002	675042	5545154	4.06	300	456	1
Oldman	Oyster Creek	4	2002	667195	5558636	2.61	300	365	45
Oldman	Pasque Creek	4	2002	669865	5556180	3.36	300	279	40
Oldman	Pasque Creek	4	2002	670545	5552202	5.14	300	449	27
Oldman	Soda Creek	4	2002	670981	5549990	2.06	300	414	26
Oldman	South Hidden Creek	4	2002	672803	5538459	3.58	300	453	4
Oldman	Hidden Creek	5	2000	680514	5539518	5.46	200	1,136	8
Oldman	Oldman River	5	2000	669208	5553223	7.44	200	690	77
Oldman	Slacker Creek	5	2000	671267	5550262	3.46	200	948	48
Oldman	Hidden Creek	5	2002	679029	5539126	5.68	300	521	2
Oldman	Hidden Creek	5	2002	677479	5539163	8.79	300	596	4
Oldman	Hidden Creek	5	2002	675442	5538852	5.7	300	520	17
Oldman	Oyster Creek	5	2002	667688	5555804	4.04	300	508	45
Oldman	Slacker Creek	5	2002	672464	5551190	4.12	300	411	0
Oldman	Slacker Creek	5	2002	671311	5550399	4.16	300	557	26
Dutch & Racehorse	South Racehorse Creek	1	1999	671704	5515502	1.36	200	517	0
Dutch & Racehorse	Unnamed Creek	1	1999	684155	5545194	1.92	200	574	20
Dutch & Racehorse	Unnamed Creek	1	1999	673789	5526117	1.66	200	554	11
Dutch & Racehorse	Unnamed Creek	1	1999	673721	5525098	1.05	200	553	23
Dutch & Racehorse	Unnamed Creek	1	1999	675856	5514601	1.6	200	547	0

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Dutch & Racehorse	Unnamed Creek	1	1999	674296	5521309	1.76	200	637	0
Dutch & Racehorse	Unnamed Creek	1	1999	680709	5524886	1.74	200	448	0
Dutch & Racehorse	Unnamed Creek	1	1999	681507	5514630	1.98	150	228	0
Dutch & Racehorse	Daisy Creek	2	1999	685052	5514885	4.34	175	648	120
Dutch & Racehorse	Dutch Creek	2	1999	669843	5529163	4.78	200	447	8
Dutch & Racehorse	Dutch Creek	2	1999	670910	5528565	5.2	250	681	19
Dutch & Racehorse	Fly Creek	2	1999	688397	5527530	2.3	200	568	44
Dutch & Racehorse	Pocket Creek	2	1999	686898	5521469	2.16	200	378	0
Dutch & Racehorse	Salt Creek	2	1999	682594	5523466	2.84	250	805	40
Dutch & Racehorse	Station Creek	2	1999	687827	5528623	2.58	200	558	32
Dutch & Racehorse	Unnamed Creek	2	1999	685122	5512655	2.06	200	735	75
Dutch & Racehorse	Unnamed Creek	2	1999	669917	5524399	2.96	250	584	4
Dutch & Racehorse	Unnamed Creek	2	1999	672662	5514725	2.48	250	716	33
Dutch & Racehorse	Unnamed Creek	2	1999	672852	5515774	4.86	200	723	18
Dutch & Racehorse	Unnamed Creek	2	1999	672337	5523774	2.42	200	693	6
Dutch & Racehorse	Unnamed Creek	2	1999	672432	5523369	2.4	200	579	11
Dutch & Racehorse	Unnamed Creek	2	1999	673533	5532246	4.74	200	351	0
Dutch & Racehorse	Unnamed Creek	2	1999	674429	5530126	2.5	200	671	30
Dutch & Racehorse	Unnamed Creek	2	1999	675353	5519477	3.9	200	672	2
Dutch & Racehorse	Unnamed Creek	2	1999	674794	5519932	2.2	200	883	0
Dutch & Racehorse	Unnamed Creek	2	1999	673928	5519773	4.84	200	523	0
Dutch & Racehorse	Unnamed Creek	2	1999	673228	5522818	4.94	250	758	4

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Dutch & Racehorse	Unnamed Creek	2	1999	675222	5519145	2.8	200	622	52
Dutch & Racehorse	Unnamed Creek	2	1999	674519	5520984	3.18	200	596	0
Dutch & Racehorse	Unnamed Creek	2	1999	678544	5514204	3.98	200	396	0
Dutch & Racehorse	Unnamed Creek	2	1999	680709	5524886	1.74	200	448	0
Dutch & Racehorse	Vicary Creek	2	1999	678892	5513920	4.72	200	413	0
Dutch & Racehorse	Wintering Creek	2	1999	680537	5524526	2.36	200	700	25
Dutch & Racehorse	Wintering Creek	2	1999	682372	5523208	6.02	225	72	28
Dutch & Racehorse	Daisy Creek	2	2006	685466	5515414	NA	35	NA	30
Dutch & Racehorse	Daisy Creek	2	2006	685207	5514561	NA	35	NA	34
Dutch & Racehorse	Wintering Creek	2	2006	680318	5524569	NA	84	NA	12
Dutch & Racehorse	Vicary Creek	2	1999	679724	5514091	5.22	200	441	0
Dutch & Racehorse	Daisy Creek	3	1999	685961	5523979	6.94	200	695	21
Dutch & Racehorse	Daisy Creek	3	1999	686279	5521882	6.38	200	979	98
Dutch & Racehorse	Daisy Creek	3	1999	685648	5518623	5.06	200	883	94
Dutch & Racehorse	Dutch Creek	3	1999	677257	5530888	8.18	200	521	28
Dutch & Racehorse	North Racehorse Creek	3	1999	675156	5522866	6.1	200	713	16
Dutch & Racehorse	North Racehorse Creek	3	1999	670497	5525020	8.34	270	859	7
Dutch & Racehorse	North Racehorse Creek	3	1999	674995	5523670	5.42	228	713	12
Dutch & Racehorse	North Racehorse Creek	3	1999	672486	5525183	4.52	270	1,101	3
Dutch & Racehorse	Racehorse Creek	3	1999	682037	5522972	8.6	200	724	35
Dutch & Racehorse	Racehorse Creek	3	1999	679209	5522527	7.24	200	897	23
Dutch & Racehorse	Racehorse Creek	3	1999	680510	5522700	10.4	215	673	14

Appendix 1. Continued.

Watershed	Waterbody	Stream Order	Year	UTM Easting	UTM Northing	Mean wetted width (m)	Sample distance (m)	Effort (s)	Captured CTTR
Dutch & Racehorse	Racehorse Creek	3	1999	687152	5526017	13.92	250	921	29
Dutch & Racehorse	South Racehorse Creek	3	1999	673580	5517221	9.22	200	621	4
Dutch & Racehorse	Vicary Creek	3	1999	683632	5520186	6.94	200	711	16
Dutch & Racehorse	Vicary Creek	3	1999	680722	5514256	6.04	250	588	15
Dutch & Racehorse	Dutch Creek	3	2006	685809	5531397	NA	836	NA	30
Dutch & Racehorse	Dutch Creek	3	2006	678884	5531605	NA	500	NA	30
Dutch & Racehorse	Dutch Creek	3	2006	674513	5530038	NA	1260	NA	32
Dutch & Racehorse	Dutch Creek	3	2006	670989	5528872	NA	850	NA	30
Dutch & Racehorse	Dutch Creek	3	2006	678754	5531641	NA	300	NA	115
Dutch & Racehorse	Dutch Creek	3	2006	671007	5528865	NA	250	NA	15
Dutch & Racehorse	North Racehorse Creek	3	2006	675113	5523323	NA	90	NA	30
Dutch & Racehorse	South Racehorse Creek	3	2006	672863	5516395	NA	125	NA	30
Dutch & Racehorse	Vicary Creek	3	2006	680711	5514247	NA	200	NA	20
Dutch & Racehorse	Vicary Creek	3	2006	682501	5514502	NA	100	NA	13
Dutch & Racehorse	Vicary Creek	3	2006	681737	5514411	NA	400	NA	65
Dutch & Racehorse	Vicary Creek	3	2006	683504	5520122	NA	150	NA	28

Appendix 2. Respective site-length literature sources used to derive Upper Oldman River drainage sampling intensities.

Strata	Length	Literature derived from	Target	Source
1	150 m	-Minimum 150 m or 40 times wetted-width -Wadeable streams 1.6 - 12.4 m wide -Backpack electrofisher	90% species richness	Reynolds et al. 2003
2	300 m	-Wadeable streams -22 - 67 times wetted-width -Backpack electrofisher	90% species richness	Angermeier and Smogor 1995
		-raftable rivers 10 - 150 m wide -85 times wetted-width -Raft electrofisher	95% species richness	Hughes et al. 2002
3	500 m	-Wadeable streams -22 - 67 times wetted-width -Backpack electrofisher	90% species richness	Angermeier and Smogor 1995
		-raftable rivers 10 - 150 m wide -85 times wetted-width -Raft electrofisher	95% species richness	Hughes et al. 2002
4	500 m	-Wadeable streams 4.9 - 17.2 m wide -40 times wetted-width -Tote-barge, backpack, raft and boat	95% species richness	Maret and Ott 2002
		-Wadeable streams 4.9 - 17.2 m wide -35 times wetted-width -Tote-barge electrofisher	cumulative species asymptote	Lyons 1992
		-Wadeable streams 1.7 - 10.8 m wide -35-158 times wetted-width -Tote-barge and backpack electrofishers	100% species richness	Paller 1995

Appendix 3. Approximate cutthroat trout capture probabilities (*Q*) from past depletion removal population estimates conducted in southwestern Alberta mountain streams (ACA/ASRD file data). C = fish captured on the first pass, E = Peterson estimate.

Waterbody	**C**	**E**	***Q***
Lynx Creek 2003	233	462	0.5043
Lynx Creek 2004	155	259	0.5985
Lynx Creek 2005	112	230	0.4869
Lost Creek 2004	56	122	0.4590
Lost Creek 2005	154	271	0.5682
Carbondale River 2003	470	983	0.4781
Carbondale River 2004	248	384	0.6458
Carbondale River 2005	199	337	0.5905
Dutch Creek 2004	115	264	0.4356
Oldman River upstream of the Upper Falls 2004	215	521	0.4126
Mean			0.5180

Appendix 4. Upper Oldman River drainage sample site locations in 2006 and 2007. Abbreviation: Loc ID = location identification.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Oldman	1	2	Unnamed	Pasque Creek	670460	5558597	670520	5558725	18-Jul-06
Oldman	1	14	Unnamed	Oldman mainstem	674668	5545285	674584	5545176	7-Jul-06
Oldman	1	24	Soda Creek	Soda Creek	668730	5554507	668727	5554625	17-Aug-06
Oldman	1	27	Unnamed	Hidden Creek	675424	5539054	675402	5539105	29-Jul-06
Oldman	1	44	Unnamed	Oldman mainstem	682303	5537663	682237	5539674	8-Aug-06
Oldman	1	50	Unnamed	Pasque Creek	670894	5556513	671039	5556482	18-Jul-06
Oldman	1	51	Straight Creek	Straight Creek	668667	5556073	668700	5556662	18-Jul-06
Oldman	1	52	Straight Creek	Straight Creek	668730	5554507	668727	5554625	23-Aug-06
Oldman	1	56	Unnamed	Soda Creek	668605	5550008	668515	5549951	17-Aug-06
Oldman	1	58	Beehive Creek	Beehive Creek	672188	5547745	671895	5547964	17-Aug-06
Oldman	1	59	Unnamed	Cache Creek	670320	5545934	670174	5545942	17-Aug-06
Oldman	2	1	Cache Creek	Cache Creek	671631	5546818	671412	5546597	17-Aug-06
Oldman	2	8	Oyster Creek	Oyster Creek	667206	5558990	667166	5559248	26-Jul-06
Oldman	2	9	Cache Creek	Cache Creek	670325	5545190	670267	5544269	17-Aug-06
Oldman	2	12	Unnamed	Oyster Creek	664828	5558456	664728	5558688	23-Aug-06
Oldman	2	13	Unnamed	Hidden Creek	674500	5539027	674334	5539217	25-Jul-06
Oldman	2	21	Unnamed	Oldman mainstem	676627	5544982	676654	5545357	8-Aug-06
Oldman	2	22	Hidden Creek	Hidden Creek	672752	5539929	672530	5539861	27-Jul-06
Oldman	2	33	South Hidden Creek	Hidden Creek	673264	5538849	673174	5538768	23-Aug-06
Oldman	2	34	Pasque Creek	Pasque Creek	670627	5551843	670620	5552102	3-Aug-06
Oldman	2	38	Oldman River	Oldman mainstem	665199	5554316	665085	5554253	3-Aug-06
Oldman	3	3	Oldman River	Oldman mainstem	670671	5551702	670508	5552053	19-Jul-06

Appendix 4. Continued.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Oldman	3	4	Oyster Creek	Oyster Creek	667601	5556054	667460	5556391	26-Jul-06
Oldman	3	6	Hidden Creek	Hidden Creek	672176	5539133	677701	5539261	25-Jul-06
Oldman	3	17	Oyster Creek	Oyster Creek	667681	5555814	667560	5556102	7-Jul-06
Oldman	3	20	Hidden Creek	Hidden Creek	678589	5539085	678151	5539128	31-Jul-06
Oldman	3	28	Hidden Creek	Hidden Creek	680287	5539413	680000	5539288	15-Aug-06
Oldman	3	29	Hidden Creek	Hidden Creek	677065	5539129	676646	5539016	27-Jul-06
Oldman	3	30	Hidden Creek	Hidden Creek	679898	5538974	679256	5539051	15-Aug-06
Oldman	3	32	Hidden Creek	Hidden Creek	675193	5538834	674845	5538900	24-Jul-06
Oldman	3	37	Oyster Creek	Oyster Creek	667431	5554241	667510	5554579	21-Jul-06
Oldman	4	5	Oldman River	Oldman mainstem	671588	5549708	671231	5550021	12-Sep-06
Oldman	4	7	Oldman River	Oldman mainstem	681757	5537746	681639	5538171	2-Aug-06
Oldman	4	11	Oldman River	Oldman mainstem	679500	5540451	679771	5540030	29-Aug-06
Oldman	4	15	Oldman River	Oldman mainstem	685779	5536215	685383	5536088	10-Aug-06
Oldman	4	16	Oldman River	Oldman mainstem	682378	5536879	682275	5537298	2-Aug-06
Oldman	4	18	Oldman River	Oldman mainstem	680562	5539457	680184	5539804	30-Aug-06
Oldman	4	19	Oldman River	Oldman mainstem	681532	5538270	681293	5538650	30-Aug-06
Oldman	4	23	Oldman River	Oldman mainstem	672581	5547222	672472	5547675	12-Sep-06
Oldman	4	31	Oldman River	Oldman mainstem	675039	5544976	674862	5545351	10-Aug-06
Oldman	4	36	Oldman River	Oldman mainstem	678677	5541289	678183	5541443	29-Aug-06
Livingstone	1	15	Unnamed	Livingstone mainstem	684084	5540718	683958	5540733	17-Jul-06
Livingstone	1	19	Unnamed	White Creek	688489	5541750	688374	5541892	24-Aug-06
Livingstone	1	21	Unnamed	Livingstone mainstem	684432	5540604	684318	5540663	17-Jul-06

Appendix 4. Continued.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Livingstone	1	26	Unnamed	Livingstone mainstem	680881	5567003	681001	5566909	10-Jul-06
Livingstone	1	30	Deep Creek	Deep Creek	691264	5549005	691363	5549064	25-Jul-06
Livingstone	1	32	Unnamed	Livingstone mainstem	687214	5538147	687313	5538157	5-Jul-06
Livingstone	1	46	Unnamed	White Creek	688532	5541321	688530	5541448	16-Aug-06
Livingstone	1	49	Unnamed	Livingstone mainstem	685685	5539073	685521	5539090	24-Aug-06
Livingstone	1	59	Unnamed	Livingstone mainstem	685411	5552415	685533	5552391	17-Jul-06
Livingstone	1	60	Unnamed	Deep Creek	689084	5547807	689132	5547684	18-Aug-06
Livingstone	2	1	Speers Creek	Speers Creek	682481	5548227	682302	5548373	24-Aug-06
Livingstone	2	6	Deep Creek	Deep Creek	689536	5548389	689730	5548552	25-Jul-06
Livingstone	2	7	Isolation Creek	Isolation Creek	683039	5554739	682907	5554924	12-Sep-06
Livingstone	2	24	Mean Creek	Mean Creek	683862	5558902	684099	5558886	10-Jul-06
Livingstone	2	27	Savanna Creek	Savanna Creek	681612	5557441	681350	5557444	11-Jul-06
Livingstone	2	29	Unnamed	Livingstone mainstem	684125	5551622	683879	5551836	20-Jul-06
Livingstone	2	36	Livingstone River	Livingstone mainstem	679917	5563757	678972	5564051	5-Jul-06
Livingstone	2	37	Unnamed	Savanna Creek	678326	5557170	678195	5556942	19-Jul-06
Livingstone	2	38	Unnamed	Livingstone mainstem	682874	5545465	682601	5545477	24-Aug-06
Livingstone	2	66	Unnamed	Livingstone mainstem	684804	5552150	685075	5552327	19-Jul-06
Livingstone	3	2	Livingstone River	Livingstone mainstem	681565	5559536	681396	5560061	31-Jul-06
Livingstone	3	8	Livingstone River	Livingstone mainstem	681734	5559102	681575	3559540	11-Aug-06
Livingstone	3	9	Livingstone River	Livingstone mainstem	682318	5557590	682093	5557945	14-Aug-06
Livingstone	3	13	White Creek	White Creek	688090	5540098	688291	5540432	24-Aug-06
Livingstone	3	17	White Creek	White Creek	692733	5543625	693089	5543594	26-Jul-06

Appendix 4. Continued.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Livingstone	3	20	White Creek	White Creek	689870	5541073	690197	5541326	16-Aug-06
Livingstone	3	25	White Creek	White Creek	687035	5539796	687453	5539915	16-Aug-06
Livingstone	3	28	White Creek	White Creek	693217	5543537	693493	5543872	22-Aug-06
Livingstone	3	31	White Creek	White Creek	692149	5542794	692297	5543172	8-Aug-06
Livingstone	3	39	Livingstone River	Livingstone mainstem	681311	5560217	681222	5560599	20-Jul-06
Livingstone	4	3	Livingstone River	Livingstone mainstem	682773	5553068	682822	5553492	9-Aug-06
Livingstone	4	4	Livingstone River	Livingstone mainstem	684234	5550280	684218	5549822	21-Aug-06
Livingstone	4	5	Livingstone River	Livingstone mainstem	682861	5556796	682523	5557122	11-Aug-06
Livingstone	4	11	Livingstone River	Livingstone mainstem	686635	5538306	686656	5537855	28-Aug-06
Livingstone	4	12	Livingstone River	Livingstone mainstem	684464	5544201	684403	5544487	1-Aug-06
Livingstone	4	14	Livingstone River	Livingstone mainstem	686355	5539818	686369	5539308	28-Aug-06
Livingstone	4	16	Livingstone River	Livingstone mainstem	686249	5541148	686110	5540845	1-Aug-06
Livingstone	4	18	Livingstone River	Livingstone mainstem	683652	5551921	683409	5552212	9-Aug-06
Livingstone	4	35	Livingstone River	Livingstone mainstem	684297	5548341	684204	5548803	31-Aug-06
Livingstone	4	40	Livingstone River	Livingstone mainstem	683484	5555024	683471	5555417	31-Aug-06
Dutch & Racehorse	1	8	Unnamed	Daisy Creek	688075	5516153	688175	5516212	17-Jul-07
Dutch & Racehorse	1	10	South Racehorse Creek	Racehorse Creek	671977	5514384	671916	5514231	12-Jul-07
Dutch & Racehorse	1	16	Unnamed	Vicary Creek	682090	5512926	681988	5512854	17-Jul-07
Dutch & Racehorse	1	26	Unnamed	Racehorse Creek	673887	5516754	673866	5516619	16-Jul-07
Dutch & Racehorse	1	29	Regal Creek	Oldman mainstem	686121	5534073	686029	5534002	1-Aug-07
Dutch & Racehorse	1	30	Unnamed	Dutch Creek	670973	5527464	670853	5527451	24-Jul-07
Dutch & Racehorse	1	40	Unnamed	Racehorse Creek	673855	5520932	673793	5520899	26-Jul-07

Appendix 4. Continued.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Dutch & Racehorse	1	50	Unnamed	Racehorse Creek	676229	5529580	676233	5529458	18-Jul-07
Dutch & Racehorse	1	51	Unnamed	Daisy Creek	685583	5518590	685491	5518610	30-Aug-07
Dutch & Racehorse	1	67	Unnamed	Vicary Creek	683831	5513621	683881	5513520	8-Jul-07
Dutch & Racehorse	1	99	Unnamed	Racehorse	674248	5518650	674235	5518617	25-Jul-07
Dutch & Racehorse	2	5	Unnamed	Vicary Creek	680636	5519398	680362	5519293	16-Jul-07
Dutch & Racehorse	2	13	Fly Creek	Oldman mainstem	687869	5527709	687605	5527620	11-Jul-07
Dutch & Racehorse	2	19	Unnamed	Dutch Creek	672825	5532216	672654	5532395	20-Jul-07
Dutch & Racehorse	2	20	Daisy Creek	Daisy Creek	685512	5516533	685660	5516250	23-Jul-07
Dutch & Racehorse	2	21	Unnamed	Dutch Creek	670335	5528950	670162	5528994	20-Jul-07
Dutch & Racehorse	2	23	Unnamed	Dutch Creek	669420	5527358	669159	5527304	24-Jul-07
Dutch & Racehorse	2	24	Unnamed	Racehorse Creek	681824	5523583	681603	5523749	24-Jul-07
Dutch & Racehorse	2	28	Unnamed	Vicary Creek	678992	5513743	678967	5513488	26-Jul-07
Dutch & Racehorse	2	31	Station Creek	Oldman mainstem	687855	5528663	687848	5528611	31-Jul-07
Dutch & Racehorse	2	33	Daisy Creek	Daisy Creek	685179	5513016	685166	5512705	9-Aug-07
Dutch & Racehorse	2	38	Unnamed	Daisy Creek	685059	5516712	685122	5516437	11-Sep-07
Dutch & Racehorse	2	41	Unnamed	Racehorse Creek	675769	5515997	675797	5515679	16-Jul-07
Dutch & Racehorse	2	43	Unnamed	Dutch Creek	668349	5530731	668502	5530795	6-Sep-07
Dutch & Racehorse	2	45	Daisy Creek	Daisy Creek	687895	5513483	688112	5513541	5-Sep-07
Dutch & Racehorse	2	69	South Racehorse Creek	Racehorse Creek	672406	5514832	672203	5514517	26-Jul-07
Dutch & Racehorse	2	98	Unnamed	Daisy Creek	686227	5520938	686366	5520721	11-Sep-07
Dutch & Racehorse	3	1	Vicary Creek	Vicary Creek	683209	5519936	682797	5519779	10-Jul-07

Appendix 4. Continued.

Watershed	Stratum	Loc ID	Waterbody	Subshed	Start Easting	Start Northing	End Easting	End Northing	Sample date
Dutch & Racehorse	3	2	South Racehorse Creek	Racehorse	672988	5516499	672750	5516270	12-Jul-07
Dutch & Racehorse	3	3	Dutch Creek	Dutch Creek	683304	5530917	682951	5531006	12-Jul-07
Dutch & Racehorse	3	6	Racehorse Creek	Racehorse	688120	5526652	687741	5526411	13-Aug-07
Dutch & Racehorse	3	7	Vicary Creek	Vicary Creek	682086	5517215	682087	5517211	17-Jul-07
Dutch & Racehorse	3	9	Daisy Creek	Daisy Creek	686103	5520854	685931	5520398	17-Jul-07
Dutch & Racehorse	3	11	Vicary Creek	Vicary Creek	685081	5522009	685056	5521715	18-Jul-07
Dutch & Racehorse	3	15	South Racehorse Creek	Racehorse	677875	5521118	677776	5520975	19-Jul-07
Dutch & Racehorse	3	18	Dutch Creek	Dutch Creek	682151	5531033	681855	5531048	12-Jul-07
Dutch & Racehorse	3	22	Racehorse Creek	Racehorse	681734	5522979	681373	5522756	19-Jul-07
Dutch & Racehorse	3	25	North Racehorse Creek	Racehorse	678641	5522202	678233	5522248	25-Jul-07
Dutch & Racehorse	3	27	North Racehorse Creek	Racehorse	671022	5525146	670691	5525110	25-Jul-07
Dutch & Racehorse	3	32	Vicary Creek	Vicary Creek	681675	5514310	681258	5514275	1-Aug-07
Dutch & Racehorse	3	34	Dutch Creek	Dutch Creek	674211	5529915	673951	5529658	14-Aug-07
Dutch & Racehorse	3	35	Racehorse Creek	Racehorse	683055	5523504	682646	5523369	23-Aug-07
Dutch & Racehorse	3	36	Daisy Creek	Daisy Creek	686512	5525047	686267	5521892	30-Aug-07
Dutch & Racehorse	3	37	Daisy Creek	Daisy Creek	685295	5517763	685208	5517439	31-Jul-07
Dutch & Racehorse	3	42	Vicary Creek	Vicary Creek	680086	5514254	679674	5514032	13-Sep-07

Appendix 5. Cutthroat trout (CTTR) capture totals, fish abundance totals, and resulting densities per sample site that were used in bootstrapping to calculate drainage fish abundance, density, and 95% confidence intervals. Abbreviations: Loc ID = location identification.

Stratum	Loc ID	Sample date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
1	8	17-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	10	12-Jul-2007	15	5	0	20	7	0	3.82	1.27	0.00
1	16	18-Jul-2007	4	0	0	5	0	0	4.45	0.00	0.00
1	26	16-Jul-2007	28	5	0	38	7	0	30.51	5.45	0.00
1	29	1-Aug-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	30	24-Jul-2007	37	1	0	50	1	0	22.40	0.61	0.00
1	40	26-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	50	18-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	51	30-Aug-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	67	8-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	99	25-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
1	15	17-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	19	24-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	21	17-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	26	10-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	30	25-Jul-2006	16	2	0	22	3	0	11.01	1.38	0.00
1	32	5-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	46	16-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
1	49	24-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	59	17-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	60	18-Aug-2006	3	2	0	4	3	0	2.33	1.56	0.00
1	2	18-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	14	7-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	24	17-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	27	29-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	44	8-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	50	18-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	51	18-Jul-2006	3	3	0	4	4	0	2.19	2.19	0.00
1	52	23-Aug-2006	14	5	0	19	7	0	5.78	2.06	0.00
1	56	17-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
1	58	17-Aug-2006	22	14	0	30	19	0	7.81	4.97	0.00
1	59	17-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
2	5	16-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
2	13	11-Jul-2007	68	22	0	169	55	0	26.38	8.53	0.00
2	19	20-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
2	20	23-Jul-2007	180	122	0	447	303	0	33.22	22.52	0.00
2	21	20-Jul-2007	5	4	0	12	10	0	0.91	0.72	0.00
2	23	24-Jul-2007	2	2	1	5	5	2	0.54	0.54	0.27

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
2	24	24-Jul-2007	56	21	0	139	52	0	19.04	7.14	0.00
2	28	26-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
2	31	31-Jul-2007	121	27	0	300	67	0	57.77	12.89	0.00
2	33	9-Aug-2007	126	31	0	313	77	0	55.86	13.74	0.00
2	38	11-Sep-2007	3	1	0	7	2	0	2.81	0.94	0.00
2	41	16-Jul-2007	0	0	0	0	0	0	0.00	0.00	0.00
2	43	6-Sep-2007	0	0	0	0	0	0	0.00	0.00	0.00
2	45	5-Sep-2007	101	8	0	251	20	0	27.25	2.16	0.00
2	69	26-Jul-2007	40	5	0	99	12	0	12.81	1.60	0.00
2	98	11-Sep-2007	2	1	0	5	2	0	1.10	0.55	0.00
2	1	24-Aug-2006	10	8	0	25	20	0	3.03	2.42	0.00
2	6	25-Jul-2006	132	9	0	328	22	0	58.78	4.01	0.00
2	7	12-Sep-2006	46	17	0	114	42	0	9.36	3.46	0.00
2	24	10-Jul-2006	0	7	0	0	17	0	0.00	2.03	0.00
2	27	11-Jul-2006	10	0	0	25	0	0	1.30	0.00	0.00
2	29	20-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
2	36	5-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
2	37	19-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00
2	38	24-Aug-2006	0	0	0	0	0	0	0.00	0.00	0.00
2	66	19-Jul-2006	0	0	0	0	0	0	0.00	0.00	0.00

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
2	1	17-Aug-2006	34	34	1	84	84	2	7.78	7.78	0.23
2	8	26-Jul-2006	184	58	0	457	144	0	68.69	21.65	0.00
2	9	17-Aug-2006	13	13	0	32	32	0	2.96	2.96	0.00
2	12	23-Aug-2006	32	8	0	79	20	0	16.72	4.18	0.00
2	13	25-Jul-2006	47	2	0	117	5	0	21.81	0.93	0.00
2	21	8-Aug-2006	65	6	0	161	15	0	25.12	2.32	0.00
2	22	27-Jul-2006	10	9	0	25	22	0	2.02	1.82	0.00
2	33	23-Aug-2006	24	15	0	60	37	0	5.81	3.63	0.00
2	34	3-Aug-2006	149	36	0	370	89	0	31.55	7.62	0.00
2	38	3-Aug-2006	70	70	0	174	174	0	31.03	31.03	0.00
3	1	10-Jul-2007	125	80	1	290	186	2	6.74	4.31	0.05
3	2	12-Jul-2007	63	42	0	146	98	0	7.21	4.81	0.00
3	3	12-Jul-2007	24	11	5	56	26	12	1.02	0.47	0.21
3	6	13-Aug-2007	54 (9)	21 (4)	5 (2)	125	49	7	1.78	0.69	0.10
3	7	17-Jul-2007	161 (2)	114 (2)	0	374	265	0	16.20	11.47	0.00
3	9	17-Jul-2007	213 (6)	128 (5)	0	495	297	0	19.84	11.92	0.00
3	11	18-Jul-2007	97 (26)	31 (14)	1 (1)	225	72	2	5.95	1.90	0.06
3	15	19-Jul-2007	69	61	10	160	142	2	4.39	3.88	0.06
3	18	12-Jul-2007	20	13	5	46	30	9	1.03	0.67	0.21
3	22	19-Jul-2007	21	13	2	49	30	2	0.91	0.56	0.04

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
3	25	25-Jul-2007	21	12	2	49	28	2	1.18	0.68	0.06
3	27	25-Jul-2007	156	112	1	362	260	0	20.08	14.42	0.00
3	32	1-Aug-2007	164 (2)	133 (2)	0	381	309	0	17.13	13.89	0.00
3	34	14-Aug-2007	57	37	2	132	86	2	4.53	2.94	0.08
3	35	23-Aug-2007	35 (1)	20 (1)	5 (1)	81	46	9	1.88	1.07	0.21
3	36	30-Aug-2007	210	166	6	488	386	9	20.04	15.84	0.38
3	37	31-Jul-2007	268	174	0	623	404	0	24.14	15.67	0.00
3	42	13-Sep-2007	138 (19)	127 (17)	3 (1)	321	295	2	15.13	13.92	0.11
3	2	31-Jul-2006	96	80	13	223	186	30	6.60	5.50	0.89
3	8	11-Aug-2006	33	23	1	77	53	2	2.08	1.45	0.06
3	9	14-Aug-2006	58	37	1	135	86	2	4.56	2.91	0.08
3	13	24-Aug-2006	294	234	0	683	544	0	22.22	17.68	0.00
3	17	26-Jul-2006	388	103	0	902	239	0	50.42	13.39	0.00
3	20	16-Aug-2006	367	237	0	853	551	0	31.58	20.40	0.00
3	25	16-Aug-2006	186	159	0	432	369	0	15.06	12.87	0.00
3	28	22-Aug-2006	577	144	0	1341	335	0	103.14	25.74	0.00
3	31	8-Aug-2006	487	183	0	1132	425	0	52.51	19.73	0.00
3	39	20-Jul-2006	61	31	2	142	72	5	4.48	2.28	0.15
3	3	19-Jul-2006	171	84	0	397	195	0	9.27	4.55	0.00
3	4	26-Jul-2006	260	131	0	604	304	0	26.67	13.44	0.00

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
3	6	25-Jul-2006	10	6	0	23	14	0	0.77	0.46	0.00
3	17	7-Jul-2006	161	63	0	374	146	0	14.68	5.74	0.00
3	20	31-Jul-2006	20	16	3	46	37	7	1.60	1.28	0.24
3	28	15-Aug-2006	8	5	2	19	12	5	0.55	0.35	0.14
3	29	27-Jul-2006	22	19	0	51	44	0	1.34	1.16	0.00
3	30	15-Aug-2006	12	11	0	28	26	0	0.90	0.82	0.00
3	32	24-Jul-2006	106	41	1	246	95	2	8.78	3.40	0.08
3	37	21-Jul-2006	267	130	0	620	302	0	28.92	14.08	0.00
4	3	9-Aug-2006	61	47	1	129	100	2	1.92	1.48	0.03
4	4	21-Aug-2006	107	99	10	227	210	21	4.05	3.75	0.38
4	5	11-Aug-2006	45	14	0	95	30	0	1.67	0.52	0.00
4	11	28-Aug-2006	59	47	15	125	100	32	1.67	1.33	0.42
4	12	1-Aug-2006	55	52	21	117	110	45	2.54	2.40	0.97
4	14	28-Aug-2006	61	50	16	129	106	34	1.50	1.23	0.39
4	16	1-Aug-2006	36	35	15	76	74	32	1.04	1.01	0.43
4	18	9-Aug-2006	89	81	20	189	172	42	3.11	2.83	0.70
4	35	31-Aug-2006	80	67	22	170	142	47	3.03	2.54	0.83
4	40	31-Aug-2006	56	37	11	119	78	23	2.12	1.40	0.42
4	5	12-Sep-2006	476	307	1	1010	651	2	22.29	14.38	0.05
4	7	2-Aug-2006	33	30	4	70	64	8	0.72	0.66	0.09

Appendix 5. Continued.

Stratum	Loc ID	Sample Date	Captured CTTR per site*			Number of CTTR per site			Density of CTTR/100 m²		
			> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm	> 70 mm	> 149 mm	> 300 mm
4	11	29-Aug-2006	32	29	2	68	62	4	1.08	0.98	0.07
4	15	10-Aug-2006	16	15	2	34	32	4	0.45	0.42	0.06
4	16	2-Aug-2006	23	20	3	49	42	6	0.54	0.47	0.07
4	18	30-Aug-2006	61	57	9	129	121	19	2.05	1.92	0.30
4	19	30-Aug-2006	63	50	8	134	106	17	1.67	1.33	0.21
4	23	12-Sep-2006	229	163	0	486	346	0	10.27	7.31	0.00
4	31	10-Aug-2006	59	44	3	125	93	6	1.70	1.27	0.09
4	36	29-Aug-2006	16	10	1	34	21	2	0.47	0.30	0.03
		Total	8,809	4,859	237	To derive densities			Densities to be bootstrapped		
		SD	105.85	57.52	4.42	244.13	130.94	9.51	0.1650	0.0625	0.0019
		Mean	69.91	38.32	1.91	160.64	87.99	4.11	0.0979	0.0410	0.0009

*Brackets indicate how many of the number shown were cutthroat-rainbow trout hybrids.

Appendix 6. Stream measurement data including average stream surface area used in density calculations.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
1	Racehorse	8	1.7	3.1	0.25	2007	122	250
1	Racehorse	10	3.6	4.8	0.34	2007	567	535
1	Racehorse	16	1.1	1.8	0.15	2007	527	123
1	Racehorse	16	0.8	1.7	0.08	2007	443	125
1	Racehorse	26	0.8	0.9	0.15	2007	478	95
1	Oldman mainstem	29	0.6	1.8	0.50	2007	334	225
1	Dutch	30	1.5	2.6	1.10	2007	994	205
1	Racehorse	40	1.4	2.5	0.20	2007	516	230
1	Racehorse	50	1.5	2.3	0.25	2007	250	105
1	Racehorse	51	0.7	1.4	0.50	2007	235	78
1	Racehorse	67	0.5	0.7	0.10	2007	119	315
1	Racehorse	99	2.1	2.6	0.25	2007	523	184
1	Livingstone	15	1.2	1.4	0.11	2006	312	79
1	Livingstone	19	0.5	2.3	0.21	2006	136	101
1	Livingstone	21	0.7	1.3	0.10	2006	423	195
1	Livingstone	26	1.3	1.4	0.11	2006	445	198
1	Livingstone	30	1.3	1.5	0.18	2006	668	166

Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
1	Livingstone	32	1.1	1.3	0.04	2006	233	156
1	Livingstone	46	1.0	3.1	0.07	2006	116	115
1	Livingstone	49	0.8	0.9	0.07	2006	448	107
1	Livingstone	59	0.7	0.8	0.19	2006	440	175
1	Livingstone	60	1.2	4.7	0.12	2006	254	86
1	Oldman	2	0.6	1.3	0.06	2006	315	119
1	Oldman	14	0.8	0.8	0.03	2006	313	173
1	Oldman	24	1.2	2.3	0.10	2006	173	108
1	Oldman	27	0.7	1.6	0.11	2006	468	60
1	Oldman	44	0.4	0.9	0.03	2006	334	166
1	Oldman	50	1.1	4.2	0.18	2006	514	187
1	Oldman	51	1.2	1.1	0.12	2006	746	330
1	Oldman	52	2.2	6.3	0.17	2006	507	133
1	Oldman	56	0.9	1.9	0.14	2006	163	384
1	Oldman	59	2.7	4.0	0.29	2006	403	398
2	Racehorse	5	1.3	2.3	0.22	2007	481	400
2	Oldman mainstem	13	2.1	3.2	0.33	2007	1,183	640

Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
2	Dutch	19	3.5	3.9	0.27	2007	918	1,055
2	Racehorse	20	4.5	8.1	0.42	2007	2,796	1,345
2	Dutch	21	4.6	6.5	0.41	2007	1,344	1,370
2	Dutch	23	3.1	3.7	0.25	2007	1,279	920
2	Racehorse	24	2.4	4.7	0.30	2007	1,405	730
2	Racehorse	28	1.6	4.1	0.27	2007	382	490
2	Oldman mainstem	31	1.7	2.9	0.39	2007	2,800	520
2	Racehorse	33	1.9	3.3	0.46	2007	1,895	560
2	Racehorse	38	0.9	1.5	0.16	2007	912	265
2	Racehorse	41	2.3	3.5	0.18	2007	673	680
2	Dutch	43	1.4	2.6	0.17	2007	481	430
2	Racehorse	45	3.1	2.9	0.22	2007	1,523	920
2	Racehorse	69	2.6	4.7	0.19	2007	1,389	775
2	Racehorse	98	1.5	4.1	0.18	2007	875	450
2	Livingstone	1	2.7	8.4	0.18	2006	945	820
2	Livingstone	6	1.9	3.6	0.25	2006	1,716	558
2	Livingstone	7	4.1	6.7	0.25	2006	880	1,220

Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m²)
2	Livingstone	24	2.9	3.6	0.13	2006	1,014	858
2	Livingstone	27	6.4	7.9	0.36	2006	2,061	1,914
2	Livingstone	29	2.8	3.9	0.16	2006	623	830
2	Livingstone	36	2.6	3.0	0.19	2006	786	792
2	Livingstone	37	1.0	1.7	0.13	2006	366	313
2	Livingstone	38	2.6	5.4	0.16	2006	691	770
2	Livingstone	66	1.7	3.1	0.41	2006	565	523
2	Oldman	1	3.6	3.5	0.37	2006	1,319	1,085
2	Oldman	8	2.2	3.2	0.20	2006	1,732	665
2	Oldman	9	3.6	4.0	0.32	2006	760	1,090
2	Oldman	12	1.6	3.5	0.11	2006	902	475
2	Oldman	13	1.8	3.8	0.18	2006	1,152	535
2	Oldman	21	2.1	3.6	0.15	2006	1,592	643
2	Oldman	22	4.1	4.3	0.25	2006	1,819	1,229
2	Oldman	33	3.4	4.4	0.20	2006	1,136	1,025
2	Oldman	34	3.9	6.5	0.21	2006	1,240	1,173
2	Oldman	38	1.9	2.5	0.26	2006	1,285	560

Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
2	Oldman	58	2.6	4.0	0.22	2006	926	
3	Racehorse	1	8.6	0.3	0.34	2007	2,753	4,310
3	Racehorse	2	4.1	5.6	0.33	2007	1,664	2,030
3	Dutch	3	10.9	16.4	1.12	2007	2,010	5,444
3	Racehorse	6	14.1	25.1	0.87	2007	3,244	7,063
3	Racehorse	7	4.6	6.4	0.36	2007	1,908	2,310
3	Racehorse	9	5.0	7.1	0.72	2007	3,184	2,495
3	Racehorse	11	7.6	10.4	0.50	2007	2,392	3,790
3	Racehorse	15	7.3	10.1	0.46	2007	2,530	3,650
3	Dutch	18	9.0	13.4	1.29	2007	2,643	4,500
3	Racehorse	22	10.7	14.1	0.90	2007	2,784	5,365
3	Racehorse	25	8.3	11.4	0.84	2007	2,225	4,125
3	Racehorse	27	3.6	5.6	0.75	2007	2,210	1,805
3	Racehorse	32	4.5	7.5	0.39	2007	2,072	2,225
3	Dutch	34	5.8	8.0	0.71	2007	4,001	2,922
3	Racehorse	35	8.7	13.9	0.63	2007	3,669	4,335
3	Racehorse	36	4.9	9.0	0.55	2007	3,116	2,435

Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
3	Racehorse	37	5.2	9.6	0.59	2007	3,112	2,580
3	Racehorse	42	4.2	7.9	0.80	2007	2,119	2,120
3	Livingstone	2	6.8	9.6	0.4	2006	3,143	3,380
3	Livingstone	8	7.4	8.1	0.31	2006	2,245	3,690
3	Livingstone	9	5.9	6.9	0.28	2006	2,153	2,955
3	Livingstone	13	6.2	11.5	0.32	2006	3,294	3,075
3	Livingstone	17	3.6	6.8	0.29	2006	3,421	1,788
3	Livingstone	20	5.4	11.8	0.19	2006	3,767	2,700
3	Livingstone	25	5.7	9.5	0.34	2006	2,932	2,870
3	Livingstone	28	2.6	8.0	0.23	2006	3,466	1,300
3	Livingstone	31	4.3	6.9	0.35	2006	3,137	2,155
3	Livingstone	39	6.3	8.0	0.50	2006	2,851	3,165
3	Oldman	3	8.6	10.4	0.40	2006	4,400	4,289
3	Oldman	4	4.5	5.5	0.34	2006	2,937	2,265
3	Oldman	6	6.1	8.7	0.46	2006	3,686	3,030
3	Oldman	17	5.1	6.0	0.31	2006	2,792	2,549
3	Oldman	20	5.8	8.4	0.43	2006	3,536	2,904

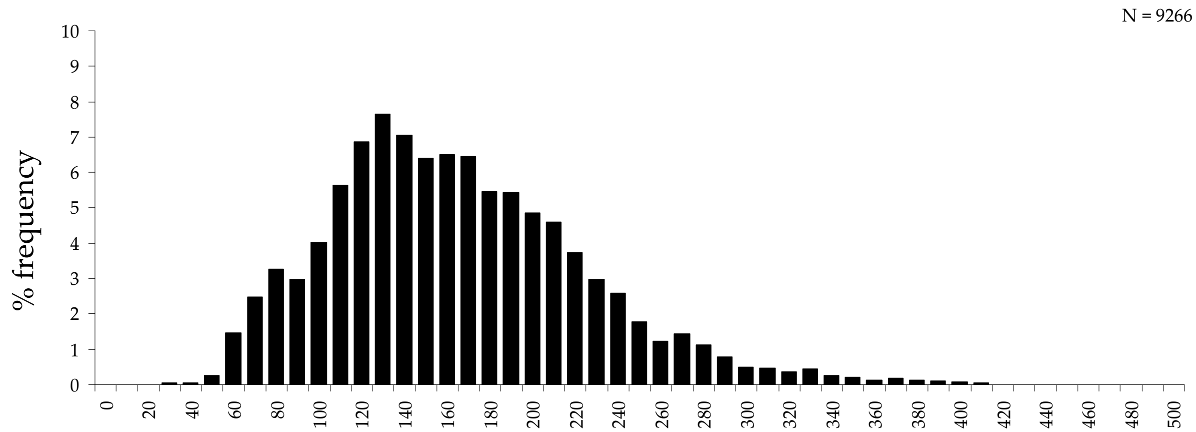
Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
3	Oldman	28	6.7	9.4	0.33	2006	1,579	3,365
3	Oldman	29	7.6	8.9	0.39	2006	2,873	3,810
3	Oldman	30	6.2	7.5	0.33	2006	2,073	3,110
3	Oldman	32	5.6	8.0	0.46	2006	3,415	2,805
3	Oldman	37	4.3	6.8	0.34	2006	2,926	2,145
4	Livingstone	3	13.5	17.6	0.63	2006	1,920	6,740
4	Livingstone	4	11.2	16.0	0.57	2006	2,929	5,600
4	Livingstone	5	11.4	21.3	0.32	2006	2,909	5,705
4	Livingstone	11	15.0	25.7	0.66	2006	2,290	7,510
4	Livingstone	12	9.2	39.3	0.73	2006	1,250	4,600
4	Livingstone	14	17.2	27.4	0.69	2006	2,683	8,600
4	Livingstone	16	14.8	21.9	0.50	2006	2,016	7,375
4	Livingstone	18	12.1	20.3	0.65	2006	2,661	6,070
4	Livingstone	35	11.2	26.4	0.53	2006	2,313	5,600
4	Livingstone	40	11.2	14.6	0.48	2006	2,485	5,590
4	Oldman	5	9.1	13.3	0.34	2006	3,646	4,530
4	Oldman	7	19.4	23.0	0.45	2006	1,090	9,700

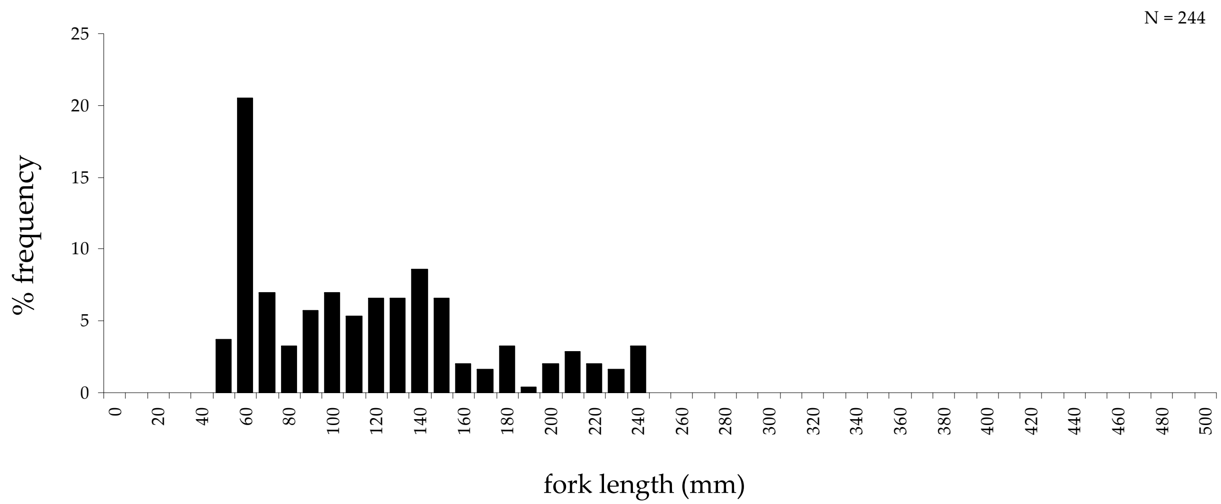
Appendix 6. Continued.

Strata	Watershed	Location ID	Mean wetted-width (m)	Mean rooted width (m)	Mean depth (m)	Sample year	Effort (s)	Mean area/site (m^2)
4	Oldman	11	12.6	19.6	0.50	2006	1,792	6,300
4	Oldman	15	15.2	28.0	0.93	2006	1,952	7,600
4	Oldman	16	18.2	34.6	0.37	2006	1,529	9,100
4	Oldman	18	12.6	21.0	0.48	2006	1,858	6,300
4	Oldman	19	16.0	30.4	0.54	2006	2,476	8,000
4	Oldman	23	9.5	13.7	0.35	2006	2,646	4,730
4	Oldman	31	14.7	17.0	0.42	2006	2,608	7,350
4	Oldman	36	14.4	45.5	0.41	2006	2,541	7,190

Appendix 7. Cutthroat trout fork length percent frequency distributions for: a) all captured fish, b) Stratum 1 fish, c) Stratum 2 fish, d) Stratum 3 fish, and e) Stratum 4 fish.

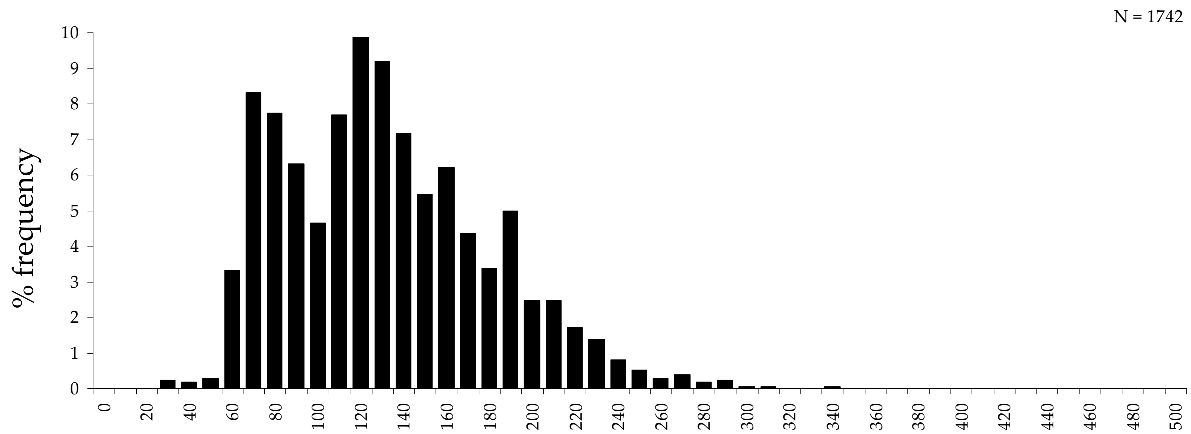


a)

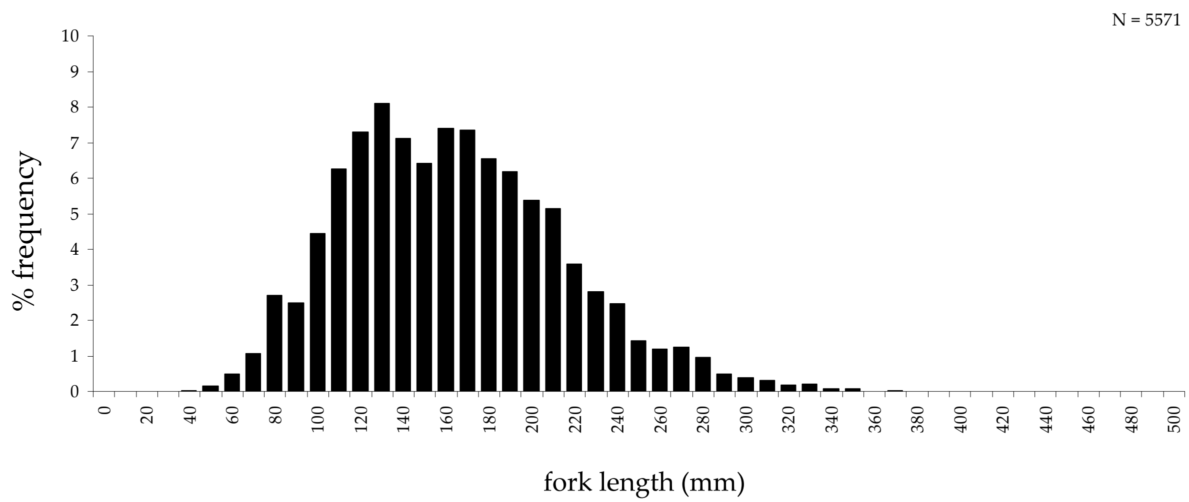


b)

Appendix 7. Continued.

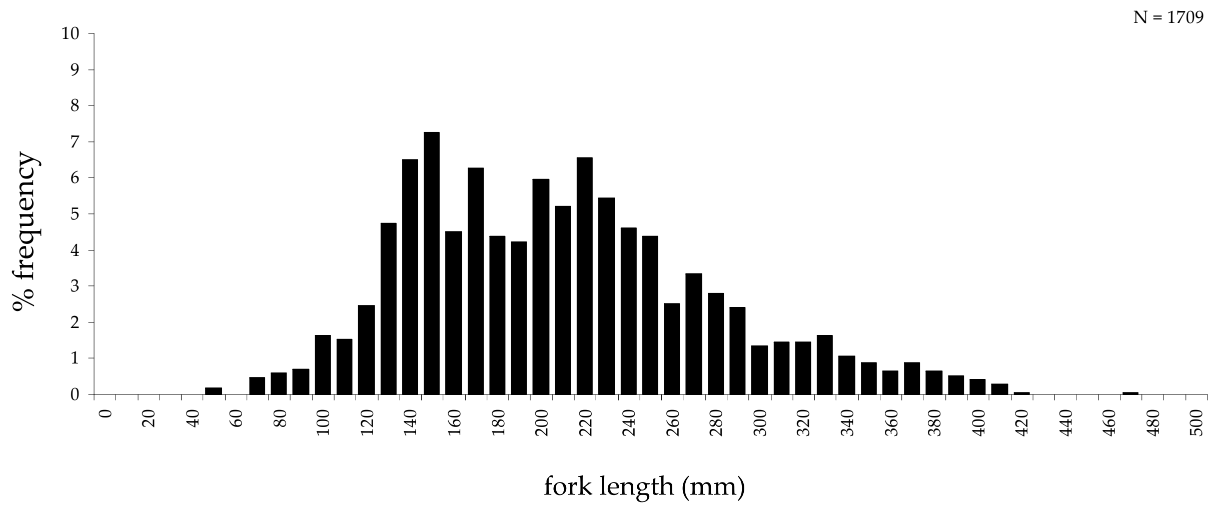


c)



d)

Appendix 7. Continued.



e)

The Alberta Conservation Association acknowledges the following partner for their generous support of this project

Alberta

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