Fisheries Monitoring in the Upper Clark Fork River Basin
2016 Report

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Introduction

The Upper Clark Fork River (UCFR) was subject to extensive mining and mineral processing activities during the late 19th and early 20th centuries. Metal contamination from these activities have reduced habitat quality and altered the fishery in the UCFR. Fishery changes include reduced trout numbers and changes in species composition. Because of these negative impacts, angling use of the Clark Fork River is lower than other streams in western Montana. Remediation and restoration efforts are ongoing and aim to mitigate historical mining and smelting damage to natural resources in the Upper Clark Fork River Basin (UCFRB).

The primary goal for aquatic restoration in mainstem Silver Bow Creek and the Upper Clark Fork River is to restore the fishery and angling resources to levels of similar rivers not impacted by mining contamination (Saffel et al. 2011; NRDP 2012a). Remediation and restoration in the mainstem are being completed cooperatively by the Montana Department of Environmental Quality (DEQ) and the Natural Resource Damage Program (NRDP).

Monitoring such an extensive restoration effort requires an extensive monitoring program. In the past, fisheries data (e.g., population estimates) collection was conduced sporadically in the UCFRB. In 1999, FWP biologists established long term monitoring sections that are representative of the UCFR. FWP has completed population estimates in these reaches each of the subsequent years. These mainstem population surveys provide a dataset that can be used to evaluate the mainstem Clark Fork River fishery before, during, and after restoration.

Freshwater salmonids migrate between different habitats to complete life history requirements. Therefore, enhancing the UCFR fishery requires not only improving mainstem habitats, but also insuring that fish in the mainstem have access to quality habitats in tributaries as well. Multiple tributaries have been identified as priorities for restoration in the UCFRB (Saffel et al., 2011). A variety of tributary restoration projects are underway and more are planned for the coming decades (NRDP 2012b). The goals of tributary restoration are to improve trout recruitment to the mainstem, provide additional angling opportunities to offset lost opportunity in the mainstem, and increase populations of native fishes. The effectiveness of tributary projects and the contribution of tributary restoration to the recovery of the mainstem fishery will be evaluated through fisheries monitoring. Detecting responses of tributary fish populations requires that fish surveys be comprehensive, both temporally and spatially, in order to differentiate the effects of restoration from natural variations in abundance.

Information on trout abundance is valuable, but this information does not explain the mechanism by which tributary restoration may benefit the mainstem fishery. It is also important to understand all of the critical factors limiting trout recruitment in the mainstem. Knowing the location of important spawning and rearing habitats used by a salmonid population is critical to managing and restoring these populations. Telemetry studies indicated locations of brown trout spawning activity in both the mainstem Upper Clark Fork River and tributary habitats (Mayfield 2013). However, just because a fish is in an area during spawning season does not guarantee that the fish will successfully spawn or that the resulting offspring will survive. Successful spawning and survival of juveniles (referred to as recruitment) will largely determine the abundance of adult trout in later years. Determining sources of successful recruitment requires that individual fish be assigned to these sources through genetics or other techniques such as hard part (bony tissue) microchemistry. Microchemical techniques such as laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) can determine the chemical signatures of bony structures such as fins or otoliths as those structures incorporate chemical changes in the fish's environment over a its lifetime. More specifically, this technique has been used in several studies to determine a fish's natal stream and to identify key migrations that occurred during a fish's life (Pracheil et al. 2014).

One of the primary microchemistry markers used to assess freshwater fish migrations is strontium (Sr). Otolith strontium isotope (^{87}Sr:^{86}Sr) ratios and Sr/Ca ratios have been found to discriminate between habitats of interest because these chemical markers are directly related to the chemistry of the water in which fish are living (Clarke et al. 2007,). Like Sr and Ca, barium (Ba) is also an alkaline earth metal, a chemical group that is readily incorporated into the aragonite (crystallized $CaCO_3$) matrix that make up otoliths (Campana 1999). Thus, these alkaline earth metals show the most promise for tracing life history and movements by sampling different regions of otoliths (Gibson-Reinemer et al. 2008, Wells et al. 2015). Concentrations of other elements within otoliths have been linked to waterborne exposure of contaminants such as Cu and Pb (Milton and Chenery 2001). In a laboratory study of juvenile pink snapper (*Pagrus auratus* Forster), otolith concentrations of zinc were correlated to both dietary exposure and liver Zn concentrations (Ranaldi and Gagnon 2008). Unlike Sr, uptake of Cu, Pb, and Zn within a fish and its bony structures are subject to strong physiological regulation. Thus, sampling different regions with otoliths for these contaminants may not provide a precise timeline of exposure over a fish's life, but overall otolith concentrations can still be indicative of cumulative exposure.

Caged fish studies have been used to monitor baseline survival and metals concentrations of juvenile brown trout (*Salmo trutta)* prior to restoration (Cook et al. 2015). Restoration activities are underway on the UCFR that will reduce metal contamination. By reducing metals inputs, clean-up activities will have long term benefits to the UCFR fishery. However, these activities involve removing vegetation and disturbing stream banks. These disturbances have the potential to temporarily increase inputs of metal laden sediments into the Clark Fork River. Current caged fish studies have shifted focus from providing baseline data to monitoring for potential acute affects of construction related disturbances.

Results of UCFR caged fish studies showed that fish that resided in more contaminated reaches of the UCFR accumulated more Cu and Zn compared to tributaries (Cook et al. 2014). Studies of metals concentrations in tissues of wild brown trout from contaminated reaches of the UCFR have shown elevated levels of Cu, Cd, Zn, Pb, and As compared to reference sites (Farag et al. 1995). Elevated concentrations of these metals have been linked to oxidative stress (Farag et al. 1994), reduced growth and condition, and lower reproductive success (Couture and Pyle 2012). Caged fish studies have the benefit of fixing the location in which a fish lives. Knowing a fish's location over time makes it easier to determine the environmental conditions it is exposed to. However, free-ranging wild fish must also be studied, because these are the fish that will ultimately benefit from metals cleanup efforts. In the UCFR wild fish tissues have been recently sampled for Hg recently for human health concerns (T. Selch, personal communication), but ecological evaluations of impact of Cu, Zn, Pb, Cd, and As have not been conducted on wild fish in decades. So, current data tissue burden data are needed to provide background for ongoing remediation. By coupling tissue burden data with movement and life history data obtained through otolith microchemistry, we can evaluate how these factors interact. In other words, we can investigate how a fish's movements over its lifetime affect its tissue metals burdens. Since otoliths also provide growth data and we know the length and weight of the fish at capture, we can evaluate if tissue burdens are related to growth and body condition.

To gather critical fisheries data in the UCFRB, an intensive monitoring program was initiated in 2015. This program continued in 2016 and had the following objectives:

1) Describe trout population abundances and species composition of fish communities in the Upper Clark Fork River and priority tributaries.
2) Investigate the natal origins and sources of recruitment for brown trout in the mainstem Clark Fork River using otolith microchemistry.
3) Gather additional data on age, growth, condition, and mortality from brown trout otoliths.
4) Monitor mortality and metals uptake of fish in cages upstream and downstream of reclamation sites in the Upper Clark Fork River.

Study Area

Silver Bow Creek originates from Blacktail Creek which flows from the continental divide north-east to the town of Butte (Figure 1). Silver Bow Creek flows through the town of Butte, downstream of which it is joined by two major tributaries, Browns Gulch and German Gulch. A fish barrier was constructed downstream of Durant Canyon to prevent non-native brown trout and Rainbow Trout (*Oncorhynchus mykiss)* from downstream of the barrier from negatively interacting with the genetically pure Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi)* upstream of the barrier. Silver Bow Creek flows into a series of set of settling ponds near Warm Springs. These ponds were constructed to trap sediments contaminated with mining waste and reduce the toxicity of metals such as copper and zinc. Restoration activities, including extensive tailings removal, have been completed on Silver Bow Creek between Butte and Warm Springs.

Warm Springs Creek joins Silver Bow Creek downstream of the Warm Springs Ponds to become the Clark Fork River. The Upper Clark Fork River is often divided into three reaches based on tributary confluences (Hornberger et al. 2009; Mayfield 2013). Reach A is the 63 km of the UCFR from the confluences of Warm Springs Creek to the Little Blackfoot River. Reach B is 43 km long and is bounded by the Little Blackfoot River and Flint Creek. Reach C is 84 km long and runs from Flint Creek to the Blackfoot River. Although Reach C is bounded on the downstream end by the Blackfoot River, this report focuses on monitoring activities that occur primarily upstream of Rock Creek.

Meyers Dam, located 5.5 km upstream of Anaconda is a barrier to fish migrating upstream in Warm Springs Creek. Tributaries of the upper Warm Springs Drainage originate from the south slope of the Flint Creek Range and the north slope of the Anaconda Range. Tributaries of interest in this study were the West Fork of Warm Springs, Storm Lake, Twin Lakes, Foster, and Barker creeks.

Lost and Racetrack Creeks flow east from the Flint Creek Range and join the Clark Fork River between the towns of Warm Springs and Deer Lodge. Cottonwood Creek flows out of the Boulder Mountains where it joins the Clark Fork River on the east side of Deer Lodge. The lower reaches of Lost, Racetrack, and Cottonwood creeks are impacted by dewatering during the irrigation season.

The Little Blackfoot River flows into the Clark Fork River near Garrison. The Little Blackfoot River adds significant flow to the Clark Fork River and reduces concentrations of suspended sediment and metal contaminants through dilution (Sando et al. 2014). Downstream of the Little Blackfoot River near the town of Garrison, Warm Springs Creek (different than the Warm Springs Creek near Anaconda) and Gold Creek enter the Clark Fork.

Flint Creek starts at the outflow of Georgetown Lake. It is joined by Boulder Creek near the town of Maxville. The lower reaches of Flint Creek are heavily dewatered during the irrigation season.

Harvey Creek is a small tributary that originates in the John Long Mountain Range. A barrier near the mouth of Harvey Creek isolates native Westslope Cutthroat Trout and Bull Trout (*Salvelinus confluentus)*, but also prevents nonnative species present in the Clark Fork River from moving upstream and interacting with the native species.

Rock Creek is a major tributary to the UCFR and supports a robust brown trout fishery in the lower reaches and populations of Westslope Cutthroat Trout and Bull Trout in upper reaches and tributary streams. Rainbow Trout are also present in the Rock Creek watershed as well as mountain whitefish (*Prosopium williamsoni)*, longnose sucker (*Catostomus catostomus)*, largescale sucker (*Catostomus commersonii)*, northern pikeminnow *(Ptychocheilus oregonensis)*, and sculpins (*Cottus spp.)*.

Methods

Mainstem population monitoring

Trout population estimates were conducted in spring 2016 at six established sections on the Clark Fork River. These sections are sampled annually by FWP and are referred to these stations as Bearmouth, Morse Ranch, Phosphate, Williams Tavenner, Below Sager Lane, and pH Shack. A population estimate was also conducted from the bottom of pH Shack to Perkins Lane in 2016. This is an electrofishing section that has been sampled in 2009-2012 and 2015. Fish were collected using aluminum drift boats with a mounted electrofishing unit and two front boom anodes and one netter. Estimates were made using two mark runs and two recapture runs. Recapture runs were completed roughly one week after marking runs. All captured trout were identified to species, weighed (g), measured (mm), and marked with a small fin clip. A subsample of fish was collected on the final recapture runs for otoliths and tissue metal samples (see below for specific methods). Population estimates for fish ≥ 175 mm (~7 in) were generated using the Chapman modification (Chapman 1951) of the Petersen method provided in Montana Fish, Wildlife and Park's Fisheries Information System. Estimates were calculated for trout species that had a minimum of 4 marked fish that were recaptured (B. Liermann, Montana, Fish, Wildlife, and Parks, personal communication, 2014). Estimates from 2016 were compared to the previous year and estimates with overlapping 95% confidence intervals were considered not to be statistically different.

Tributary population monitoring

Population estimates were conducted in 18 tributaries in the UCFRB identified as high priority in Saffel et al. 2011 (Figure 1). Population estimates were generated either by mark-recapture or depletion methods. Mark-recapture estimates consisting of one mark and one recapture run were conducted on larger waters (Flint Creek, lower Little Blackfoot River, and lower Warm Springs Creek). Two- to four- pass depletion estimates (Zippin 1958) were conducted at other sections. Fish were collected at most tributary sections using one or two backpack electrofishing units. In larger streams, a barge mounted electrofishing unit was used to collect fish. Descriptions of sampling methods, section lengths, and locations of sampling sections can be found in Appendix A.

Hard part microchemistry

Sagittal otoliths were collected from brown trout in the Upper Clark Fork River and 10 tributaries for microchemical analyses (Figure 2). Whole fish were collected by electrofishing and individually tagged and frozen. Fish were partially thawed at a later date and otoliths were extracted using non-metallic forceps. Most fish were collected during annual population surveys. However, population estimates were not conducted on Racetrack Creek, Lost Creek, Warm Springs Creek (Garrison), or Mill-Willow Bypass, so separate fish collections had to be conducted on those waters.

We attempted to get 150 brown trout from the mainstem Clark Fork River divided roughly between reaches A, B, and C (Table 1). There are three annual population survey sections in reach A, two in reach B, and one in reach C. Fish were collected from an additional river section between Beavertail and Rock Creek to add more otoliths to the reach C sample. When possible, we collected fish from five length categories at each mainstem sampling section. These length categories were: < 175 mm, 175-249 mm, 250-324 mm, 325-399 mm, and 400+ mm, roughly corresponding to age <2-, 3-, 4-, 5-, and 6+ year-old fish. The number of fish collected in each length category was dependent on the number of sampling sections within reaches A, B, and C (Table 1). Again, this sampling scheme was designed to provide roughly equal sample sizes for the different reaches of the UCFR.

The otolith microchemical signatures of juvenile fish from tributaries will be used as the baseline to which otoliths from mainstem fish will be assigned. Unlike the mainstem, where fish of a variety of lengths were collected, only small fish were collected for otoliths from tributaries. The selection of only juvenile fish was to reduce the chance that these fish had undergone large movements, and thus been exposed to various geochemical environments, over their lifetime. We could be more confident that juvenile fish were spawned and reared near their location of capture.

The selection of tributaries and sites from which juvenile otoliths were collected were based on locations with substantial spawning activity in a brown trout telemetry study (Mayfield 2013). These sites often overlapped with standard annual electrofishing sections. Sixteen sites in 10 different tributaries were selected for juvenile otolith collection. The target sample size was 5 fish from each site.

After extraction, otoliths were wiped clean with paper towels and nylon brushes and stored in polypropylene centrifuge tubes. One otolith per fish was mounted to a microscope slide sulcus side up using Krazy Glue. Otoliths were sanded down to an even plane just above the primordium using a variety of sand paper and diamond lapping paper (1 μm and 0.5 μm). Sanded otoliths were rinsed with Type I (ultrapure) water and transferred and mounted to a final slide. Up to 12 sanded otoliths were mounted on each final slide to facilitate rapid processing with the LA-ICPMS.

Ratios of Sr:Ca and ^{87}Sr:^{86}Sr within otoliths were measured using a Neptune multicollector inductively coupled plasma mass spectrometer (ICPMS) equipped with a Nu Wave Research laser ablation device. The laser sampled otolith material along a transect from edge to edge passing through the primordium to provide chemical profiles over the lifetime of the fish (Figure 3). A subsample of otoliths analyzed on the Neptune were also analyzed for Cu, Zn, Cd, As, and Pb using an Element 2, single collector ICPMS. The laser was also used for the elemental analyses and scanned over the same transect that was ablated during the Neptune analysis. A MACS3 standard was run periodically throughout each day so that instrument drift could be accounted for.

Mainstem wild fish tissue burdens

A subset of fish used for otolith collection were also had tissues extracted for metal burden analyses. Two fish per length category were selected for metal burden analyses. For fish in the smallest category (< 175 mm), whole fish were used for metals burdens. For fish > 175 mm, gills, liver, and stomachs were collected. Stomach contents were removed and tissues were rinsed with dionized water and frozen until analysis. Samples were dissolved using microwave digestion and analyzed for copper, zinc, arsenic, lead, and cadmium concentrations using inductively coupled plasma optical emission spectrometry (ICP-OES).

Caged fish monitoring

The objective of caged fish monitoring in 2016 was to monitor for acute and residual impacts of construction activities. Cage locations were selected to bracket construction in Phases 2, 5 and 6. Fish cages were placed below the outlet of Pond 2 to provide a site upstream of construction activities in Reach A and monitor habitability of water discharged by the Warm Springs Ponds. Cages were placed at Perkins Lane Bridge at the downstream boundry of Phase 2. Cages were placed at the Gemback Road bridge near Racetrack at the downstream boundary of phase 6. The most downstream cages were placed at the Kohrs Fishing Access Site. Three cages at each site received brown trout and three cages received westslope cutthroat trout. This was the first year that cutthroat trout were used in UCFR caged fish studies. Twenty-five fish were placed in each cage. Brown trout were placed in cages on March 9th, 2016 and westslope cutthroat trout were placed in cages on March 25th, 2016. Fish cages were checked for mortalities twice weekly. Any fish mortalities were collected and frozen. Three live fish were collected at each site the last week of every month of the study. The final cage checks were performed on September 29th, 2016 and all fish and cages were removed at this time.

A subset of fish samples collected alive was submitted to the Montana Department of Health and Human Services Environmental Laboratory in Helena for determination of whole-fish metal concentrations. Fish samples were blended to a powder to ensure homogeneity, and then the samples were weighed, dried, and reweighed to determine moisture content. The dried samples were then crushed and dissolved with nitric acid, diluted with deionized water, and analyzed for copper and zinc with ICP-OES using the U.S. Environmental Protection Agency (USEPA) Method 200.7 (USEPA 2001). All results were reported as µg/g dry weight.

Water quality

Water quality parameters were recorded in the Clark Fork River at caged fish sites with continuously recording multiparameter water quality probes (Hydrolab ® MS5). Hydrolabs water quality parameters recorded include pH and dissolved oxygen (DO). The precision with which the Hydrolab records total ammonia levels has been questionable in the past (T. Selch, Montana, Fish, Wildlife, and Parks, personal communication, 2014). As a result of the questionable reliability of the ammonia sensors, ammonia data as recorded by the Hydrolabs are not presented in this report. Daily mean values are presented for pH and minimum daily values are presented for DO.

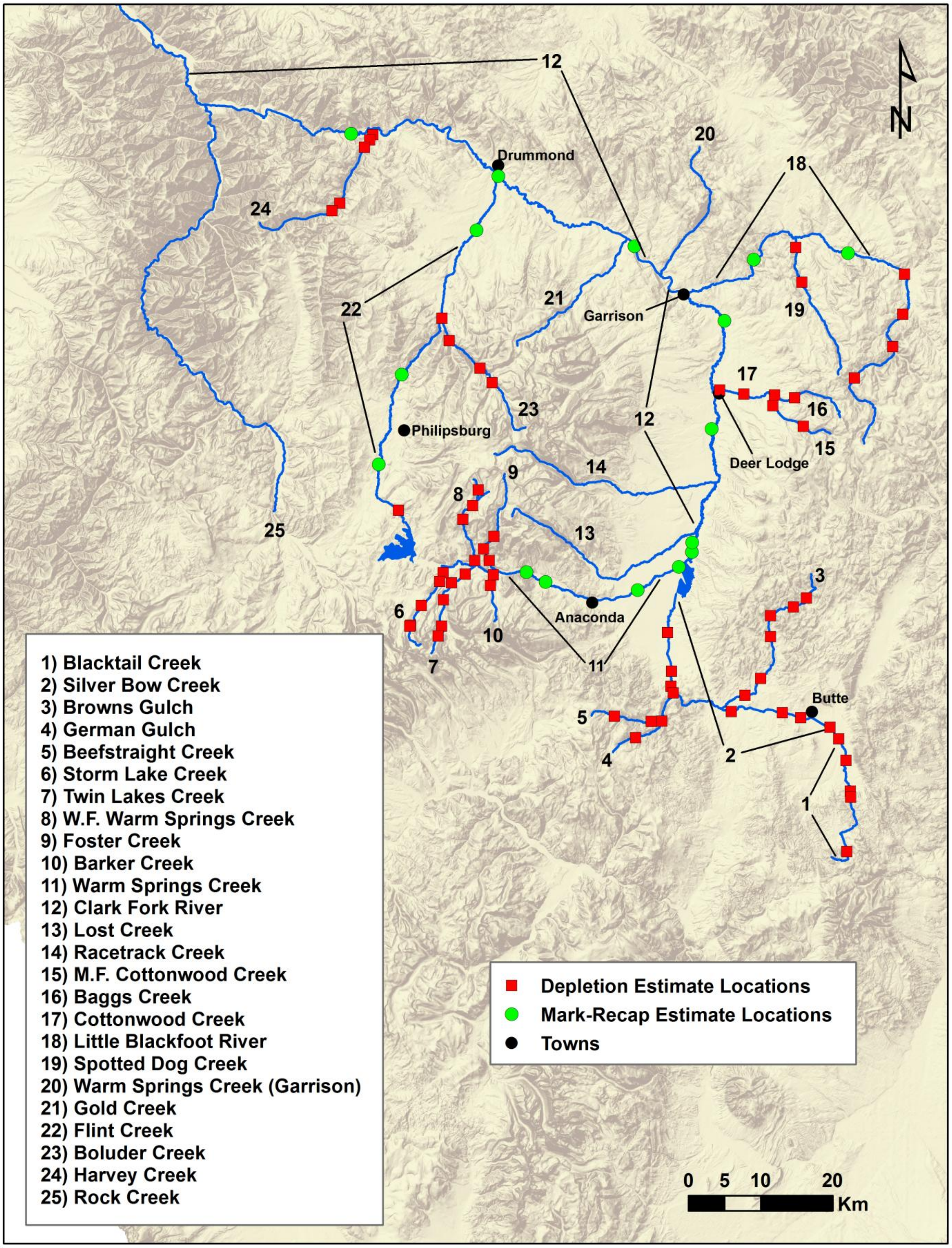

Figure 1. Map of 2016 electrofishing sections in the Upper Clark Fork River Basin. Numbers refer to specific streams.

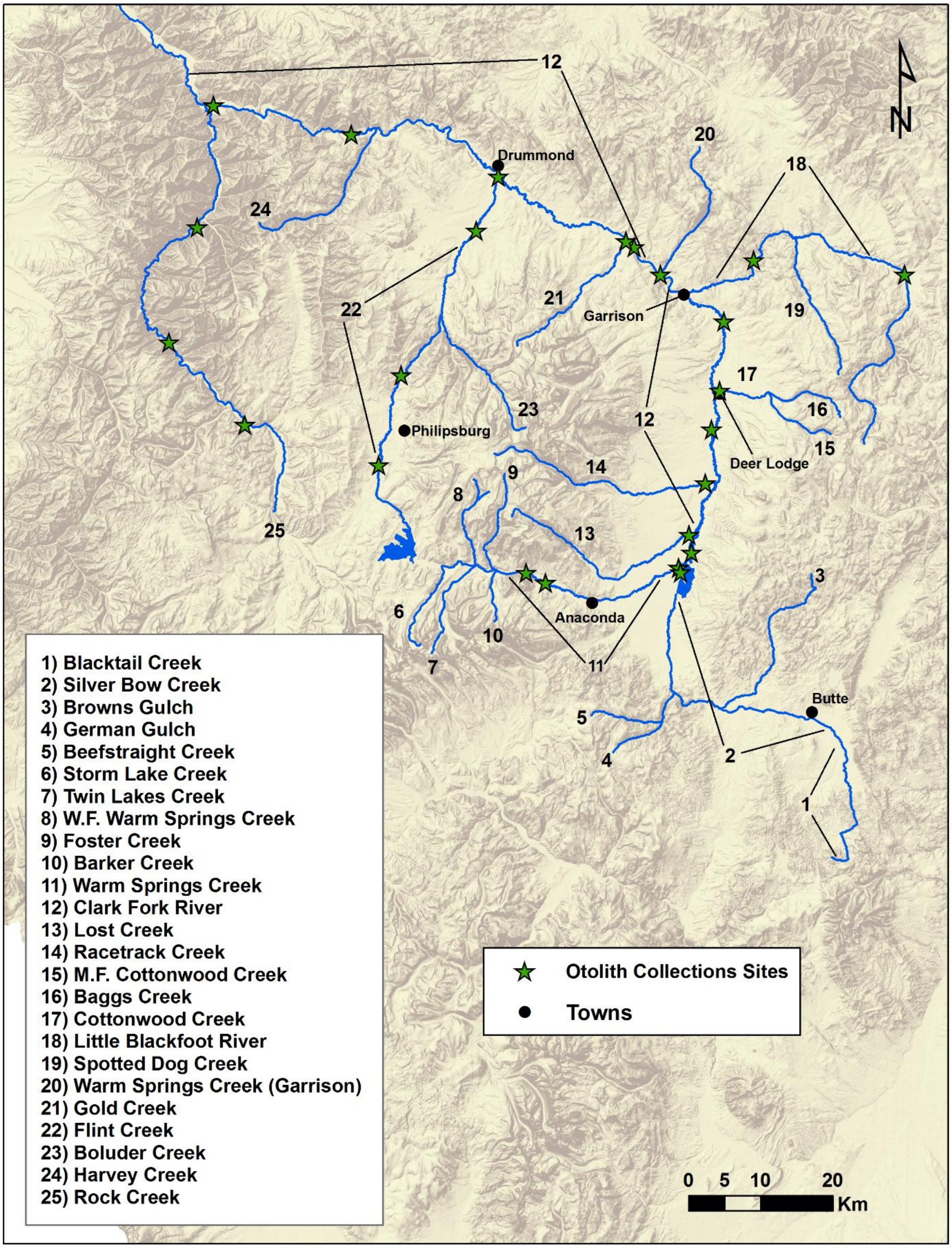

Figure 2. Map of 2016 brown trout otolith collection sites. Numbers refer to specific streams.

Table 1. Target sample allocation of fish collected for otoliths for the Upper Clark Fork River brown trout microchemistry study.

Reach	Sampling Section	# fish	Fish per length category
A	pH Shack	20	4
	Sager Lane	20	4
	Williams-Tavenner	20	4
B	Phosphate	25	5
	Morse Ranch	25	5
C	Bearmouth	25	5
	*Beavertail	25	5

*Beavertail was the only section not sampled as part of annual populations surveys

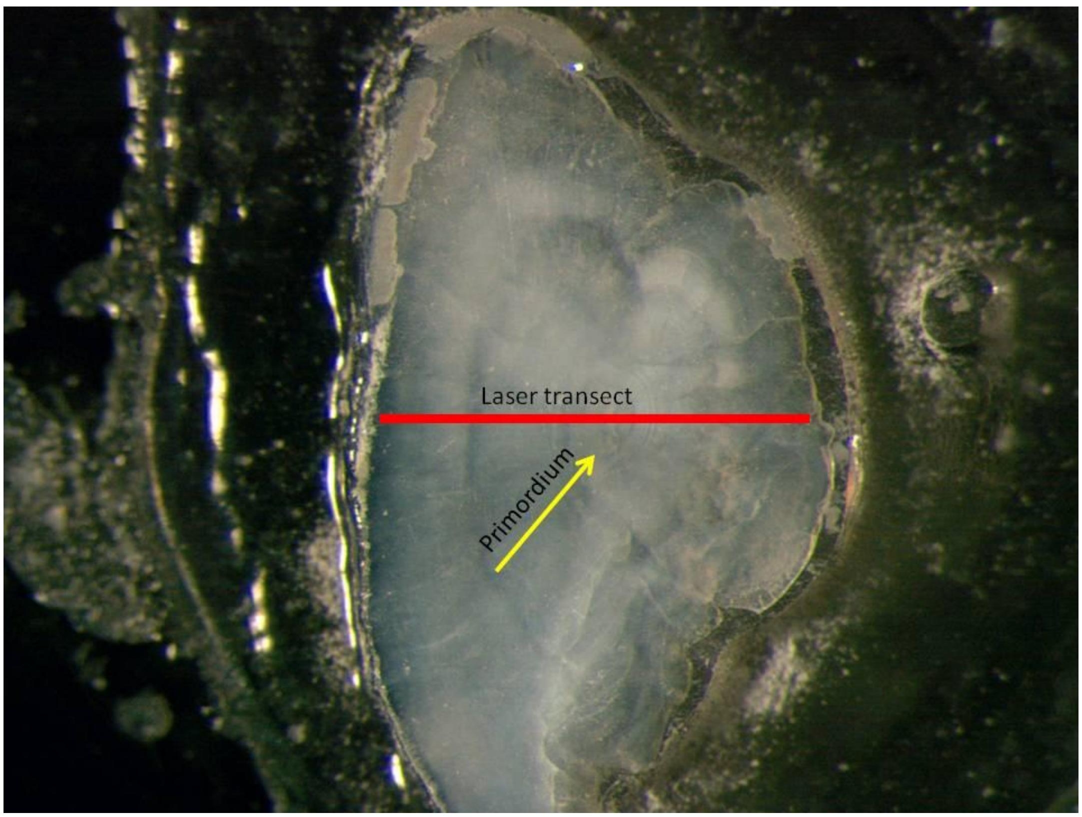

Figure 3. Example of a sanded brown trout otolith showing the location of the primordium and path of the laser ablation for ICPMS. This type of laser sampling pattern provides mirroring chemical profiles on each side of the primordium.

Results - *Mainstem electrofishing*

Brown trout population estimates at annual sampling sections ranged from 21 fish/km at Bearmouth to 265 fish/km at Ph Shack (Table 2). Brown trout were the most abundant species in all estimate sections. Rainbow trout were estimated at 22 fish/km in the Bearmouth section. Westslope cutthroat trout estimates were 4 fish/km in the Bearmouth section and 2 fish/km in the Morse Ranch section. *Oncorhynchus* estimates could not be generated for other sections because fewer than four marked fish were recaptured. Brown trout 2016 estimates were not statistically different to those from 2015 at all sections (Figure 4). Species compositions in all sections were also similar between 2015 and 2016 sampling.

Brown trout population estimates at the periodically sampled pH Shack to Perkins Lane section were similar to previous years' surveys, with the exception of 2009 which had an especially low estimate (Figure 5). Mark recapture estimates at this section tend to be imprecise (result in large CIs) due to low numbers of recaptured fish.

Table 2. Electrofishing data collected in 2016 from annual sampling sections on the Upper Clark Fork River. Population estimates (95% confidence interval) are for trout greater than 175 mm (~ 7") in total length. Species abbreviations: LL = Brown Trout, WCT = Westslope Cutthroat Trout, RB = Rainbow Trout, YP = Yellow Perch.

Section	Species	Population Estimate (fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Bearmouth	LL	21(16-27)	146	369	111-501	54
	RB	22(14-35)	99	323	196-455	37
	WCT	4(2-8)	23	342	181-413	9
Morse Ranch	LL	55(45-68)	347	370	118-545	94
	RB		5	320	242-372	1
	WCT	2(1-4)	17	305	260-387	5
	YP		1	155	155	<1
Phosphate	LL	178(128-257)	230	340	106-483	97
	WCT		6	307	243-397	3
Williams Tavenner	LL	171(134-224)	329	366	113-489	98
	WCT		6	317	189-411	2
Below Sager Lane	LL	155(114-216)	316	340	103-557	100
PH Shack to Perkins Ln.	LL	161(99-279)	134	320	112-472	97
	RB		4	311	290-331	3
PH Shack	LL	265(152-491)	163	338	100-460	96
	RB		5	377	327-496	3
	WCT		1	274	274	1

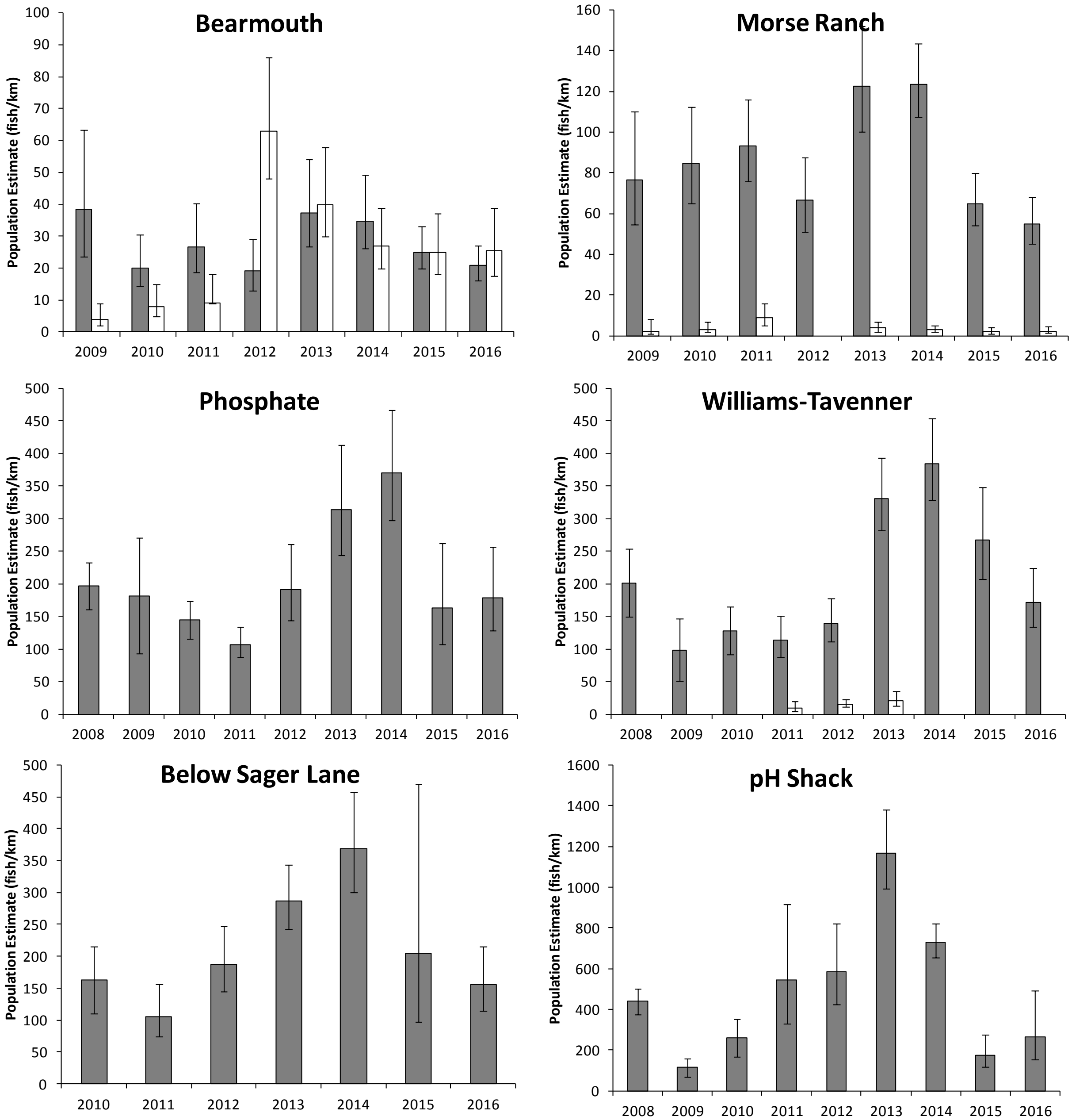

Figure 4. Clark Fork River brown trout (grey bars) and *Oncorhynchus sp.* (white bars) population estimates from 2008-2016 by sample section. Sample reaches are displayed downstream to upstream, left to right then top to bottom. Please note that axis values are not the same for every sample reach.

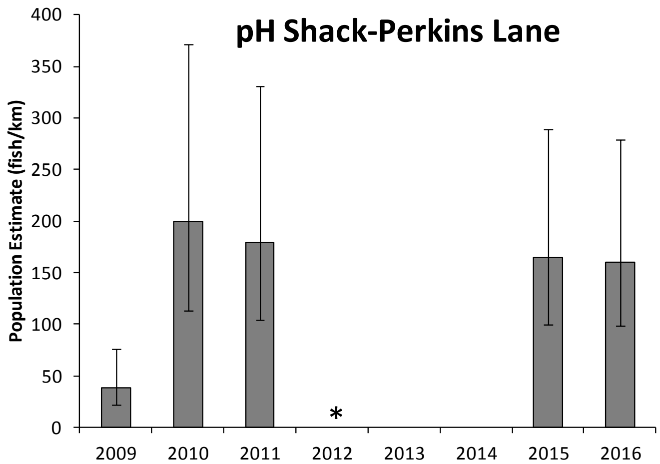

Figure 5. Clark Fork River brown trout population estimates from the pH Shack to Perkins Lane sampling section. *Only one fish was recaptured in 2012 so reliable estimate could not be calculated.

Tributary Electrofishing Surveys

Between 7/5/2016 and 10/6/16, a total of 77 sections comprising 18.8 km of stream were sampled in tributaries of the Upper Clark Fork River and Silver Bow Creek. Sixty-eight depletion and nine mark-recapture population estimates were conducted on these waters. Electrofishing data are presented for each watershed below. Data from Silver Bow Creek and its tributaries are presented in their own section of this report.

<u>Warm Springs Creek and Tributaries</u>

Nineteen depletion estimates and four mark/recapture estimates were conducted in the Warm Springs Creek watershed (Tables 3-7). Five electrofishing sections were sampled on Storm Lake Creek with WCT being the most abundant species in all sections comprising of 52-78% of fish (Table 3). EB, Bull Trout (BULL), EBXBULL hybrids, RB and RBXWCT hybrids were also present. There were no non-trout species captured in any section of Storm Lake Creek.

Five sections were sampled on Twin Lakes Creek with WCT being the most common trout species throughout and one of the most commonly captured fish among all species encountered (Table 4). BULL were present in all sections and EB were present in all but one section. Sculpin were found in all sections. RMCOT and SLCOT are in the drainage with some overlap throughout the length of the stream. With the difficulty in field identification, it is possible that some sculpins were misidentified. More rigorous sculpin identification may need to be done in the future.

Three sections were sampled on Foster Creek (Table 5). WCT were present in all sections and accounted for 35-92% of fish present. EB were present in all sections and were the most abundant trout species in the middle section. BULL were only present in the lowest section. There were EBXBULL hybrids present in the lowest section as well.

Two sections were sampled on Barker Creek (Table 6). BULL accounted for 78-81% percent of fish. WCT were present in both sections. No sculpins were captured. Estimates for BULL increased in both sections compared to 2015.

Warms springs Creek (including the West Fork) had eight estimate sections with LL comprising 73-99% of fish in the three sections below Myers dam and WCT accounting for 41-98% of fish in the five sections above Myers dam (Table 7). EB were present in five sections. BULL were present in six sections. EBXBULL hybrids were found in 3 sections. RM COT were present in the lowest two sections. SL COT were present in the middle three sections and no sculpin were observed in the upper three sections. LL numbers increased in the lowest section while other fish numbers remained similar throughout the other seven sections from 2015 to 2016

Table 3. Electrofishing data collected on Storm Lake Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, RB = Rainbow Trout, EB = Eastern Brook Trout, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout, EBXBULL = phenotypic hybrid between Eastern Brook Trout and Bull Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower RM 0.6	WCT	16(15-17)	16	193	139-258	52
	EB	9(8-10)	9	181	151-202	29
	BULL		1	144	144	3
	EBXBULL		1	234	234	3
	RB		3	150	132-168	10
	RBXWCT		1	73	73	3
Above First Crossing RM 1.4	WCT	23(22-24)	32	115	64-208	64
	EB	9(9-9)	10	164	43-219	20
	BULL		4	336	152-530	8
	RBXWCT		4	120	107-140	8
Lower Meadow RM 4.2	WCT	30(29-31)	43	116	61-205	78
	RBXWCT		5	120	76-150	9
	BULL		1	192	192	2
	EBXBULL		4	184	174-193	7
	EB		2	150	145-154	4
Above upper Storm Lake road crossing RM 6.3	WCT	16(15-17)	42	87	55-188	70
	EB		5	163	155-172	8
	BULL		2	241	233-249	4
	EBXBULL		3	160	124-228	5
	RBXWCT		8	131	121-148	13

Table 4. Electrofishing data collected on Twin Lakes Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, EB = Eastern Brook Trout, SL COT = Slimy Sculpin, RM COT = Rocky Mountain Sculpin, COT = unidentified sculpin.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower RM 1.3	WCT	9(7-11)	11	157	66-287	73
	BULL		2	187	171-203	13
	EB		1	187	187	7
	RM COT		1	91	91	7
Meadow RM 2.8	WCT	48(45-51)	48	141	65-228	41
	EB	31(29-33)	32	141	64-251	27
	SLCOT		36		33-108	31
	BULL		1	229	229	1
Upstream of old bridge RM 4.6	WCT	21(20-22)	22	141	70-345	54
	EB		2	148	140-155	5
	RMCOT		12		81-120	29
	SLCOT		4		69-92	10
	BULL		1	323	323	2
Downstream of lower lake RM 7.2	COT		37		45-95	81
	WCT		5	129	95-150	11
	EB		2	112	104-120	4
	BULL		2	334	230-437	4
Upstream of upper lake RM 8.5	WCT	39(32-46)	39	125	45-214	48
	BULL	14(13-15)	16	161	69-583	19
	COT		27		63-115	33

Table 5. Electrofishing data collected on Foster Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, EB = Eastern Brook Trout, EBxBULL = phenotypic hybrid between Eastern Brook Trout and Bull Trout, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower	WCT	94(90-98)	95	132	37-300	78
RM 1.0	EBxBULL		4	217	151-265	3
	BULL	5(3-7)	5	127	120-135	4
	EB		2	66	64-67	2
	RBxWCT	15(13-17)	15	122	90-170	12
Middle	WCT	46(43-49)	47	105	71-201	35
RM 2.3	EB	12(13-14)	85	70	45-190	63
	RBXWCT		2	92	90-93	2
Upper	WCT	93(89-97)	98	125	47-219	92
RM 3.8	EB	7(6-8)	9	101	40-127	8

Table 6. Electrofishing data collected on Barker Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower	BULL	51(38-64)	44	132	100-204	81
RM 0.5	WCT	10(9-11)	10	137	85-239	19
RM 1.5	BULL	30(18-63)	25	137	86-478	78
	WCT	4(3-6)	7	149	62-229	22

Table 7. Electrofishing data collected on Warm Springs Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, LL = Brown Trout, RB = Rainbow Trout, EB = Eastern Brook Trout, LN SU = Longnose Sucker, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout, EBxBULL= phenotypic hybrid between Eastern Brook Trout and Bull Trout.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Wildlife Management Area RM 3.3	LL	99(89-110)	666	174	61-446	73
	RBxWCT		3	250	210-306	<1
	EB		1	207	207	<1
	RM COT		53		57-100	7
	LN SU		2	216	215-217	<1
	WCT		1	290	290	<1
Below Airport Road RM 9.0	LL	93(77-115)	318	180	60-431	89
	RBxWCT		2	202	135-269	<1
	EBXBULL		1	234	234	<1
	RM COT		37		61-118	10
Below Meyers Dam	LL	94(84-107)	613	195	64-397	74
	RBxWCT	18(10-37)	62	164	54-339	8
	RB	6(3-14)	30	179	108-345	4
	EB		9	175	120-244	1
	BULL	2(1-5)	15	382	171-570	2
	WCT	6(4-13)	35	195	103-331	4
	EBxBULL		2	431	331-530	<1
	SL COT		57		54-90	6
Garrity WMA (Above Meyers Dam)	WCT	49(40-62)	271	176	84-385	47
	RBxWCT	20(16-27)	139	158	90-340	24
	LL	5(4-9)	37	226	58-396	6
	BULL	10(5-25)	36	194	108-343	6
	RB	4(3-8)	33	169	98-382	6
	EB	1(1-3)	11	161	103-215	2
	SL COT		52		45-101	9

Table 7 - Continued. Electrofishing data collected on Warm Springs Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, RB = Rainbow Trout, EB = Eastern Brook Trout, EBxBULL= phenotypic hybrid between Eastern Brook Trout and Bull Trout.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above Veronica Trail RM 26.0	WCT	27(23-31)	34	135	60-306	77
	EB		2	138	126-149	5
	BULL		2	113	48-178	5
	RB		4	171	83-237	9
	SL COT		2	79	63-95	5
Below Upper Bridge RM 27.4	EB	9(8-10)	9	183	95-238	41
	WCT	9(7-11)	9	177	80-248	41
	BULL		2	252	244-260	9
	EBxBULL		2	299	271-327	9
Below Confluence of Upper Forks	WCT	58(55-61)	60	152	56-236	98
	BULL		1	145	145	2
West Fork	WCT	39(37-41)	45	134	47-204	92
	BULL		4	80	35-113	8

Cottonwood Creek and Tributaries

Six depletion estimates were conducted on Cottonwood Creek and one of its tributaries, Baggs Creek (Tables 8-9). In Cottonwood Creek, LL were the only trout species captured in the lowest section. Several young of year LL were captured in this section. The section at river mile 3.0 was generally depauperate of fish, probably due to dewatering. EB were the dominant species in the upper section making up 46% of fish. Many of the EB in this section were less than 75mm and were not included in the estimate. RM COT were captured at the lower site and SL COT were captured at the upper site. The sculpin captured at the middle site were not identified to species. No sculpins were captured in the Middle Fork of Cottonwood Creek. From 2015 to 2016, LL numbers increased from 48 (95% CI = 46-52) to 117 (95% CI = 109-125) at the lower section. From 2015 to 2016, LL estimates in the upper two sections decreased from 52 (CI = 51-55) to 43(CI = 27-58) and 160 (CI = 155-167) to 78(CI = 71-85). EB estimates also went down at the upper sections over this time from 31 (CI = 31-32) to 28 (CI = 27-29) and 22 (CI = 21-26) to 10(CI = 9-11).

Two sections were sampled on Baggs Creek with EB being the most abundant in both sections. EB made up 93% of fish in the lower section and 51% in the upper. The lowest section had very few fish which is probably due to irrigation withdraws resulting in low stream flows. No non-trout species were captured in either section. Fish numbers in the lower section were similar to 2015. The WCT estimate was lower in 2016 than 2015 at the upper section, going from 81 (CI = 76-87) to 50(CI = 45-54). EB estimates also decreased slightly at this section, going from 40 (CI = 38-44) to 35(CI = 35-38).

Table 8. Electrofishing data collected on Cottonwood Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, LL = Brown Trout, EB = Eastern Brook Trout, RM COT = Rocky Mountain Sculpin, SL COT = Slimy Sculpin, COT = unidentified sculpin.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
School	LL	117(109-125)	124	119	55-255	90
RM 0.8	RM COT		14		103-135	10
Middle	LL		2	138	122-154	22
RM 3.0	EB		5	105	77-160	56
	COT		2	94	92-95	22
Upper	WCT	43(27-58)	35	127	76-215	23
RM 6.9	EB	28(27-29)	69	84	48-185	46
	SL COT		47		43-90	31
Middle Fork	WCT	78(71-85)	101	114	60-203	90
	EB	10(9-11)	11	121	49-180	10

Table 9. Electrofishing data collected on Baggs Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: EB = Eastern Brook Trout, WCT = Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.4	WCT		1	169	169	7
	EB		13	85	58-175	93
RM 2.4	WCT	50(45-54)	54	127	79-238	49
	EB	35(35-38)	56	111	50-203	51

Little Blackfoot River and Tributaries

Mark recapture estimates were conducted on two sections and depletion estimates were conducted on six sections in the Little Blackfoot River and one of its tributaries (Tables 10-11). In the lower two sections of the Little Blackfoot River, LL were the most abundant trout species, accounting for 93-99 % of fish captured. Many mountain whitefish (MWF) were observed in the lower two sections, but were not netted due to time constraints. RM COT were also present in the lower section. Overall, LL numbers decreased at each section further up the river. WCT were the most abundant trout species in the upper two sections making up 45-50% of fish present. EB were present in all but the lowest section. MWF were present in all sections but there were fewer present in the upper sections. From 2015 to 2016, LL numbers increased in four of the six sections with the most notable change in the lowest section where the estimate went from 57 (CI = 46-72) to 112(CI = 100-128). WCT and EB increased significantly in the upper three sections from 2015 to 2016.

Two depletion estimates were done on Spotted Dog Creek. LL were the most abundant species in the lower section making up 55% of fish. SL COT were abundant in both sections. LNSU were present in the upper and lower section. EB, LS SU and MWF were present in the upper section but not the lower. LL numbers in the lowest section increased significantly 23 (CI = 23-24) in 2015 to 63(CI = 61-66) in 2016. Trout numbers were generally low in the most upstream section.

Table 10. Electrofishing data collected on the Little Blackfoot River in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, LL = Brown Trout, EB = Eastern Brook Trout, MWF = mountain whitefish, LN SU = Longnose Sucker.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Rest Area - FWP FAS	LL	112(100-128)	800	250	77-497	99
	WCT		3	279	270-290	1
Above N. Trout Creek	LL	32(28-37)	242	233	74-389	93
	EB		5	205	162-235	2
	WCT	2(1-5)	13	280	232-335	5
Above Hwy 12 Bridge near Elliston RM 26.7	MWF	20(20-21)	61	304	108-382	33
	LL	29(25-33)	79	183	98-359	42
	WCT	12(11-14)	35	191	85-335	19
	EB	2(2-2)	8	137	70-220	4
	LN SU		3	117	95-135	2
Above Sunshine Camp	WCT	16(14-18)	31	155	76-340	33
	LL	17(17-18)	34	129	86-389	37
	MWF	10(7-14)	18	286	142-355	19
	EB	4(3-6)	8	127	110-142	9
	LN SU		2	89	81-90	2
Below Ontario Creek RM 34.9	WCT	33(18-48)	33	134	68-229	45
	LL		22	151	84-347	30
	MWF	6(4-8)	7	252	138-315	10
	EB	9(8-10)	11	122	87-185	15
Above Kading Campground RM 40.1	WCT	33(30-36)	70	140	56-287	50
	EB	22(21-23)	45	117	71-244	32
	LL	11(11-21)	15	148	75-265	11
	MWF	5(4-6)	9	180	95-267	7

Table 11. Electrofishing data collected on Spotted Dog Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, LL = Brown Trout, EB = Eastern Brook Trout, LN SU = Longnose Sucker, LS SU = Large Scale Sucker, SL COT = Slimy Sculpin, MWF = Mountain Whitefish, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 1.1	LL	63(61-66)	93	185	119-420	55
	WCT		2	205	200-210	1
	LN SU		5	124	105-157	3
	SL COT		68		64-105	41
RM 4.6	WCT	5(4-6)	10	155	40-213	5
	LL	7(6-8)	18	108	62-175	10
	EB	4(3-5)	6	104	77-166	3
	LN SU	8(6-9)	13	124	83-185	7
	SL COT		116		21-104	63
	LS SU	9(6-11)	21	89	39-145	11
	MWF		1	154	154	<1

Flint Creek and Tributaries

Three mark-recapture and one depletion estimate were conducted on Flint Creek and five depletion estimates were conducted on Boulder Creek (Tables 12-13). In the four Flint Creek sections, LL comprised 96-99% of the fish captured. Many MWF were observed in the three lowest sections, but were not netted. WCT were captured in the lower three sections, EB in the upper two sections and RB in the upper three sections. RM COT were observed in only the lowest section. One BULL was captured in the lowest section. LL numbers increased at the Hall and Dam sections compared to 2015. The Hall section saw the most significant increase from 175 (CI = 151-208) in 2015 to 461 (CI = 406-532) in 2016. LL numbers at the Dam section increased from 51 (CI = 46-56) to 96 (CI = 87-105). Numbers in 2016 at the middle two sections were similar to the previous year.

LL were the most abundant fish in the lower two sections of Boulder Creek accounting for 66% and 63% of fish captured. BULL were relatively abundant in the upper two sections making up 47% and 75% of fish captured. WCT were present in all four sections. Phenotypic EBXBULL hybrids were observed in the section at RM 6.5. One SL COT was observed in the lowest section. The LL estimate went from 15 (CI = 14-16) to 30 (CI = 26-34) from 2015 to 2016 at the lowest section. Estimates at the other sections were similar between years.

Table 12. Electrofishing data collected on Flint Creek in 2016. Population estimates (95% CI) are for trout greater than 175 mm (~ 7”) in total length for the Hall, Johnson Tuning Fork and Chor sections. Estimate is for trout greater than 75 mm (~3”) for the Dam section. Species abbreviations: WCT = Westslope Cutthroat Trout, LL = Brown Trout, EB = Eastern Brook Trout, RB = Rainbow Trout, BULL = Bull Trout, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (Fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Hall	LL	461(406-532)	531	233	77-490	99
	WCT		1	273	273	<1
	BULL		1	315	315	<1
Johnson Tuning Fork	LL	382(339-438)	394	251	93-492	99
	RB		3	310	224-395	<1
	RBXWCT		1	230	230	<1
	WCT		2	305	299-310	<1
Chor	LL	263(240-294)	369	254	72-490	98
	EB		6	237	188-310	1
	RB		2	264	214-313	<1
	WCT		1	261	261	<1
		(Fish/100m)				
Dam (Above Campground)	LL	96(87-105)	89	207	96-465	96
	RB		3	239	96-318	3
	EB		1	191	191	1

Table 13. Electrofishing data collected on Boulder Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, BULL = Bull Trout, LL = Brown Trout, SL COT = Slimy Sculpin, EBxBULL = phenotypic hybrid between Eastern Brook Trout and Bull Trout.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
USGS Gauge RM 0.4	LL	30(26-34)	29	149	75-330	66
	WCT	15(14-16)	15	183	83-353	34
	SLCOT		1	89	89	<1
RM 2.0	LL	26(12-40)	25	116	56-269	63
	WCT	14(9-19)	15	143	44-347	37
Princeton Bridge RM 6.5	BULL	26(20-32)	40	113	48-371	47
	WCT	33(25-40)	36	119	43-257	42
	EBXBULL	6(5-7)	7	185	165-250	8

	LL		2	191	186-195	2
	EB		1	66	66	1
Copper Lakes Trailhead	BULL	25(19-31)	24	123	42-279	75
	WCT	8(5-11)	8	142	75-271	25

Harvey Creek

There were six estimate sections on Harvey Creek (Table 14). WCT made up 100 percent of trout in the lower four sections. BULL were present in the upper two sections and accounted for 13% and 52% of trout captured in those sections. Sculpin were present in the lower four sections, but were not enumerated. Young of the year WCT were abundant in most sections. Compared to 2015, WCT estimates increased in 2016 from 26 (95% CI = 25-30) to 43 (95% CI = 38-48) fish/100m at the most downstream site (Figure 6). WCT numbers decreased from 121 (95% CI = 114-130) to 67 (95% CI = 60-74) fish/100m at RM 1.6. The estimate at RM 2.3 increased from 65 (95% CI = 61-72) to 112 (95% CI = 106-118) fish/100m. WCT numbers increased from 33 (95% CI = 32-36) to 40 (95% CI = 37-43) fish/100m at the most upstream site. Other WCT estimates were not significantly different between years. BULL estimates were identical in 2015 and 2016 at the Below 8 Mile section and increased from 27 (95% CI = 27-29) in 2015 to 40 (95% CI = 39-41) in 2016.

Table 14. Electrofishing data collected on Harvey Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviation: WCT = Westslope Cutthroat Trout, BULL = Bull Trout.

Section	Species	Population Estimate (Fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.6	WCT	43(38-48)	52	118	46-287	100
RM 1.2	WCT	47(45-48)	57	141	85-321	100
RM 1.6	WCT	67(60-74)	63	134	88-334	100
RM 2.3	WCT	112(106-118)	116	125	42-329	100
Below 8 Mile	WCT	77(73-82)	103	137	67-384	87
	BULL	13(3-23)	15	142	55-192	13
Above FS Road	WCT	40(37-43)	39	129	77-253	48
	BULL	40(39-41)	43	140	55-273	52

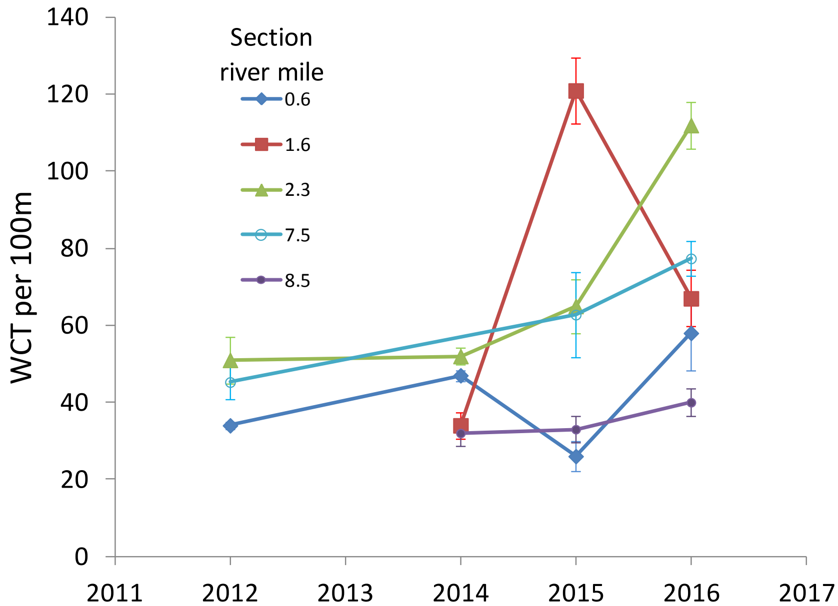

Figure 6. Westslope cutthroat trout population estimates at six Harvey Creek sampling sections.

Microchemistry

Otoliths were collected from 238 brown trout from throughout the UCFRB. Two hundred of these otoliths were analyzed for ^{87}Sr:^{86}Sr and Sr:Ca ratios. The remaining 38 samples will be analyzed in the 2017, along with additional otoliths that will be collected during mainstem population estimates in spring 2017. Twenty five otoliths and 26 fin rays were analyzed for Cu, Zn, Cd, As, and Pb. Post processing of the microchemistry data, including adjusting for minor instrument drift, is in progress at the time of writing this report. Microchemistry data from 2016 and 2017 will be combined to create a model that will assign fish captured in the mainstem to spawning and rearing areas.

Mainstem wild fish tissue burdens

Fifty-three gills, 53 stomachs, and 60 livers from brown trout were submitted to the lab for determination of Cu, Zn, Cd, As, and Pb concentrations. At the time of writing this report, we are still awaiting these results.

Caged fish monitoring

Westslope cutthroat trout mortality was highest at Racetrack and lowest at Kohrs Bend. Brown trout mortality was highest at Pond 2 and lowest at Kohrs Bend (Table 15). Overall, moralities tended to occur on the descending limb of the hydrograph as water temperatures increased over 19°C (Figure 7-10). This is a pattern consistent with past caged fish studies in the UCFR. Brown trout mortalities were temporally more spread out than westslope cutthroat trout mortalities. Most westslope cutthroat trout mortalities occurred on or around the July 4th cage check.

Water temperatures exceeded the upper critical temperature of 19°C for 64 days at Pond 2, 40 days at Perkins Lane, 49 days at Racetrack, and 72 days at Kohrs Bend. Water temperatures exceeded the upper incipient lethal temperature of 24.7°C for 0 days at Pond 2, 0 days at Perkins Lane, 3 days at Racetrack, and 5 days at Kohrs Bend.

Average whole body copper concentrations of caged brown trout at the four sites was 11.2 (SD=8.67) ug/g. Average copper concentration of westslope cutthroat trout was 9.5 (SD=17.75). A *T*-test indicated that the difference in copper concentrations between species was not statistically significant (T=0.7312, P=0.2333). Brown trout zinc concentrations averaged 161.1 (SD=60.49) ug/g and westslope cutthroat trout concentrations averaged 86.0 (SD=26.57) ug/g. Zinc concentrations in brown trout were significantly higher compared to westslope cutthroat trout (T=8.763, P<0.0001). No one site had fish with consistently higher tissue burdens compared to other sites (Figure 11-12). However, brown trout at the Pond 2 site did have significantly higher zinc burdens in July and September and fairly high zinc burdens in June as well. Copper burdens were generally highest in September. There was no apparent temporal trend in Zinc burdens over the course of the study.

Table 15. Fish added minus fish removed alive for tissue sampling and number of mortalities in 2016 fish cages in the Upper Clark Fork River. Species abbreviations: LL = Brown Trout, WCT = Westslope Cutthroat Trout.

	Fish added -fish removed		***Mortalities***	
	LL	**WCT**	**LL**	**WCT**
Pond 2	62	48	29 (46.8%)	37 (77.1%)
Perkins	61	51	15 (24.6%)	29 (56.9%)
Racetrack	56	48	6 (10.7%)	48 (100%)
Kohrs	55	50	5 (9.1%)	13 (26.0%)

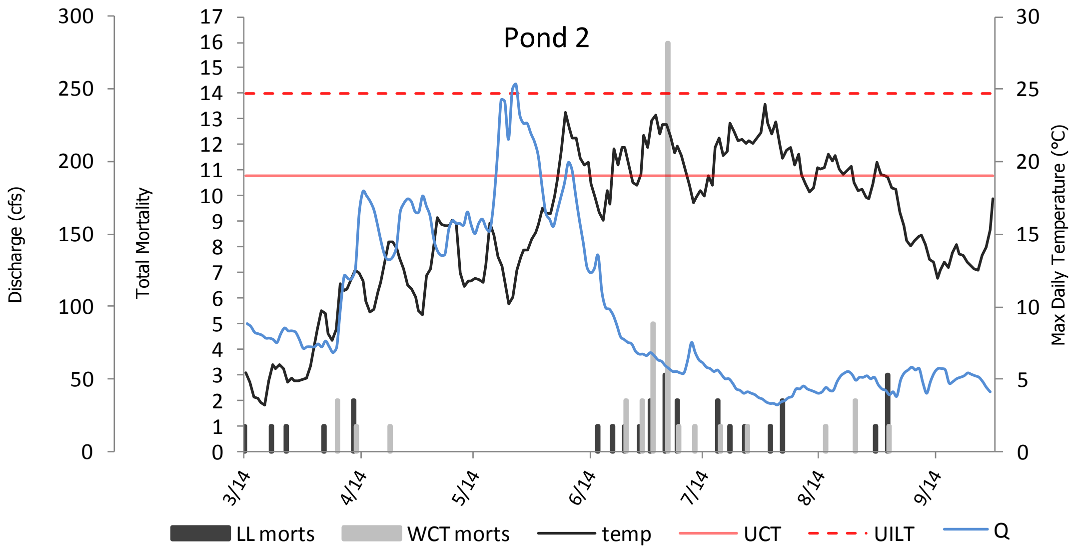

Figure 7. Total fish mortalities, maximum daily water temperature, and mean daily discharge for Silver Bow Creek at the outlet of Pond 2. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

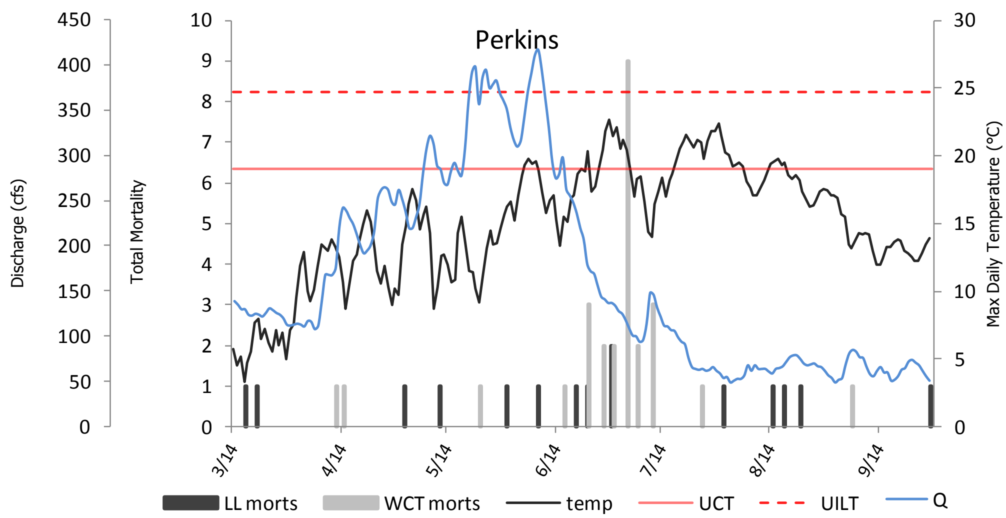

Figure 8. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the Perkins Lane site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

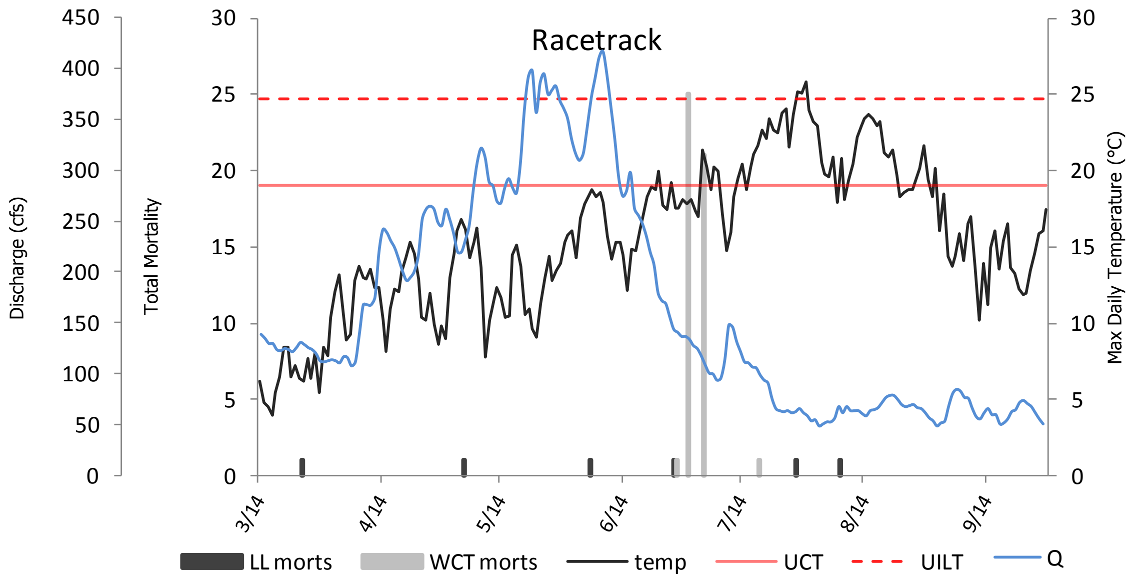

Figure 9. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the Racetrack site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

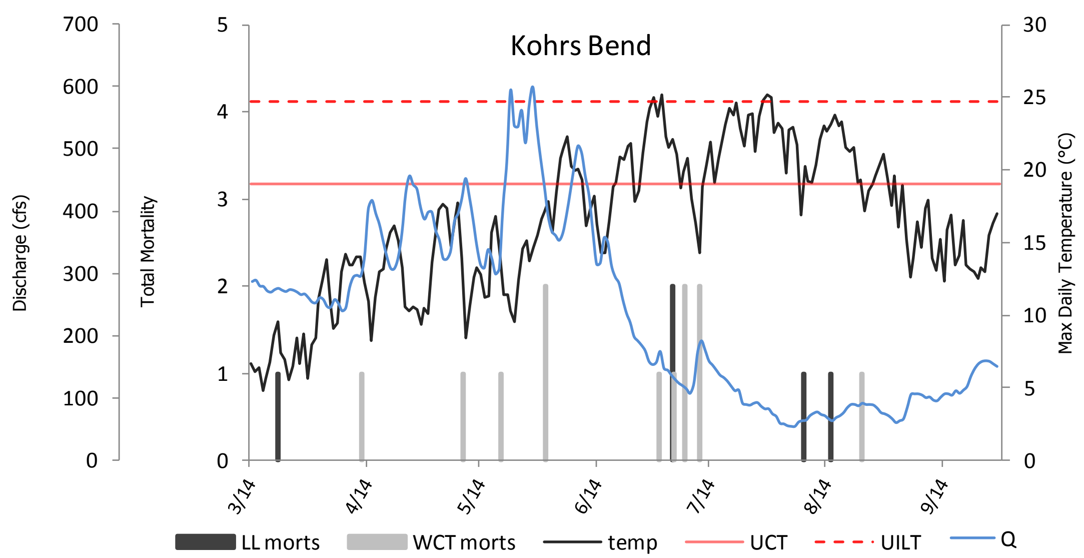

Figure 10. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the Kohrs Bend site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

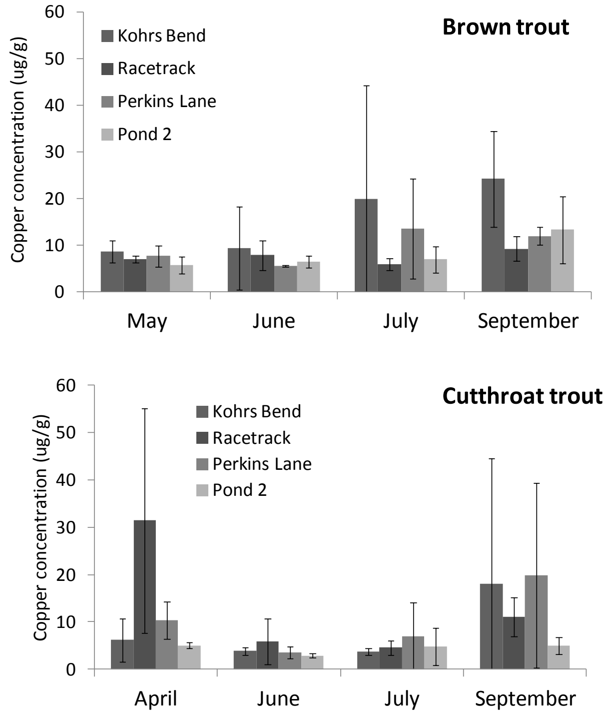

Figure11. Whole body copper concentrations of brown trout and westslope cutthroat trout from the 2016 caged fish study.

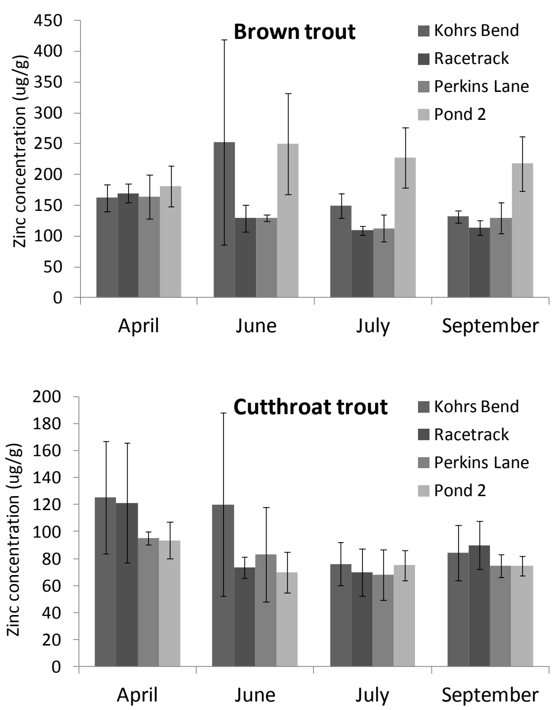

Figure 12. Whole body zinc concentrations of brown trout and westslope cutthroat trout from the 2016 caged fish study.

Water quality

From June to August, pH rapidly increased at Pond 2 and pH exceeded 10 for at least eight days (Figure 13). The number of days when pH exceeded 10 at Pond 2 was lower than in previous years. For examples, pH was over 10 for 53 days in 2015 and 64 days in 2014. The reduction in extremely high pH readings by the Hydrolab maybe a reflection in the reduction in lime additions to the Warm Spring Ponds in 2016. However, pH at the Pond 2 outlet was still higher than other caged fish sites and exceeded nine for at least 135 days.

Minimum daily dissolved oxygen ranged from 2.9 to 11.7 mg/L at the four sites, with the lowest DO occurring during the summer months (Figure 14). At the Racetrack site, DO dipped below the minimum daily ALS of 4.0 mg/L 14 times in during July, August, and September. These dips in DO at Racetrack typically lasted for 4-6 hours and occurred between 1:00 and 7:00 AM. None of the low DO readings were accompanied by major fish mortality events at Racetrack (Figure 9). Daily minimum DO was > 4.3 mg/L at the other three caged fish sites.

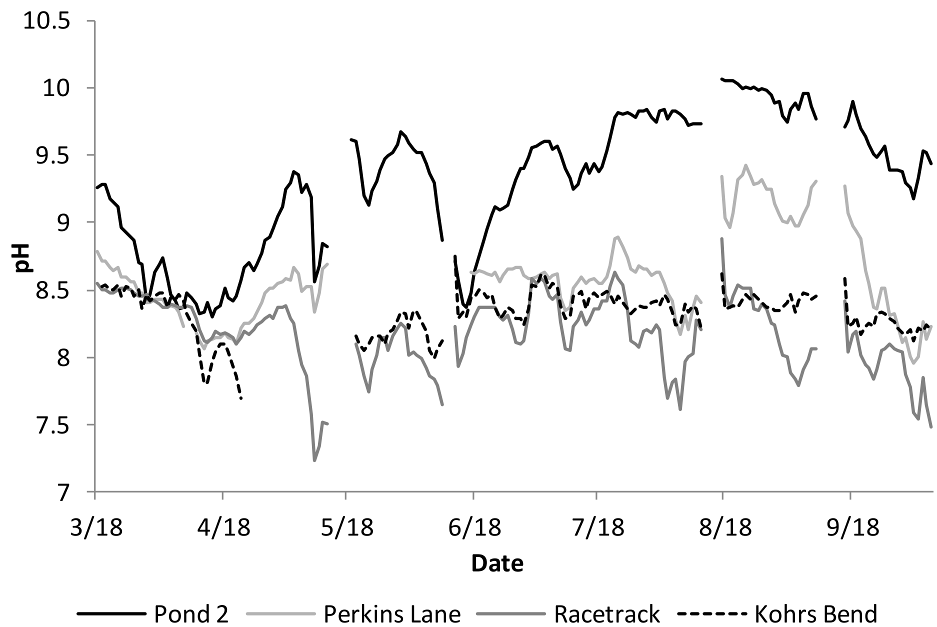

Figure 13. Mean daily water pH at 2016 caged fish sites. Gaps in the graph indicate missing data due to instrument failures and calibration.

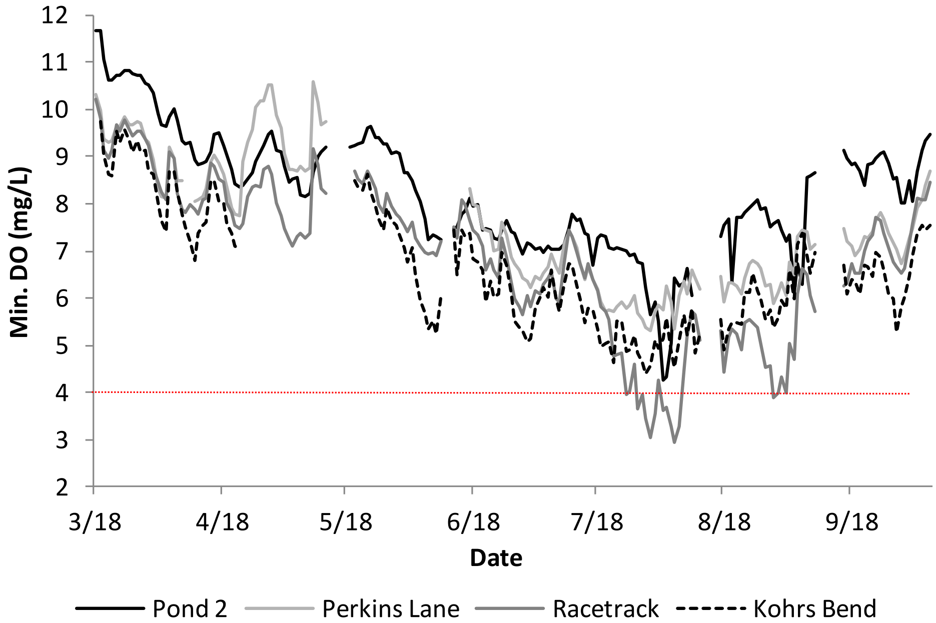

Figure 14. Minimum daily dissolved oxygen (DO) concentrations at 2016 caged fish sites. The red dashed horizontal line denotes the freshwater ALS minimum DO. Gaps in the graph indicate missing data due to instrument failures and calibration.

Discussion

Brown trout population estimates at mainstem UCFR sections were relatively low in 2016, especially when compared to estimates from 2013 and 2014. The increases in numbers in 2013 and 2014 were due to due strong year classes from 2010 and 2011, which were good water years (Figure 15). The higher flows during these years may have provided additional spawning and/or rearing habitats that are not are not available at lower flows. Flows are inversely related to water temperature in the UCFR (Nathan Cook, unpublished data), so low flow years increase the thermal stress on trout. Flows during 2012 and 2013, particularly during the summer irrigation season, were much lower than the two years before. The low flow period that follows runoff in the UCFR has been shown to be a period of high mortality for juvenile brown trout (Richards et al. 2013; Cook et al. 2014; Leon et al. 2014). The UCFR routinely exceeds 19°C during the summer, often for weeks at a time. The increase in fish mortality is presumably due to thermal stress, which may be exasperated by high tissue concentrations of toxic heavy metals such as Cu and Zn.

Population estimates have been conducted at the 77 tributary sampling sections in this study in 2015 and 2016. Most tributary sections were not sampled annually prior to 2015, but many sections were sampled semi-annually or sporadically in the past. For example, population estimates were conducted semi-annually at the FAS and Above N. Trout Creek sections on the

Little Blackfoot River from 2007-2013 (Figure 16). Combined with the 2015-2016 annual sampling, these sections have been sampled 6 times in the last 10 years. Ten is often cited as the recommended minimum number of population estimates needed to detect trends in abundance over time (Morris and Doak 2002; Lotts et al. 2004). As restoration and remediation progress in the UCFRB, detecting fishery responses will require that monitoring occur often enough and over long enough of a time period to document both natural variations in abundance and changes in abundance that are a result of improved habitat. It may not be necessary to conduct population estimates at every section annually. Some monitoring programs recommend conducting population estimates at least every 5 years (e.g., CRCT Coordination Team 2006). However, a sampling frequency of 5 years may be insufficient to detect statistically significant trends in trout abundance, even when these sampling events take place over several decades (Cook et al. 2010). Thus, conducting population estimates every 2-3 years would be preferable to less frequent sampling. After sampling is completed in 2017, a power analysis should be conducted to determine the appropriate sampling frequency for monitoring trout populations in tributaries of the UCFRB.

Patterns from caged fish monitoring did not indicate any acute negative effects from cleanup activities. Mortality patterns in 2016 caged fish monitoring were consistent with caged fish studies in previous years. Mortalities tend to peak as flows subsided and temperatures increased. Tissue metals burdens were generally similar between sites. One exception was brown trout zinc burdens at the Pond 2 site. Although water concentrations of zinc in the Pond 2 outflow are relatively low, brown trout at this site had higher zinc concentrations than 11 other caged fish sites in the UCFRB in 2014 (Cook et al. 2014). It appears that the mechanism of zinc accumulation at this site is not simply a function of exposure to dissolved zinc in the water column. Macroinvertebrates are abundant at the Pond 2 outflow, and fish at this site grow quickly. Caged fish are fed pellet food twice a week, but macroinvertebrates may provide a diet subsidy. This subsidy may provide a pathway for zinc accumulation in fish residing below the Warm Springs Ponds.

Water quality data indicated that the number of days where pH exceeded 10 at the Pond 2 outflow was lower that is has been for three years. However, the pH of this water is still high (>9) during the most of summer months, creating unfavorable and potentially toxic conditions for trout. Extended exposure to pH > 9 may be harmful to trout (Colt et al. 1979) and results in higher ammonia toxicity (MTDEQ 2012). Dissolved oxygen concentrations reached levels as low as 2.9 mg/L at the Racetrack caged fish site. The lowest DO levels occurred during warm summer nights when biological oxygen demand was high, and supply from photosynthesis was low. Although no fish mortalities appeared to be related to hypoxia at the Racetrack site, any DO concentrations less than the ALS of 4.0 mg/L are cause for concern. Water quality monitoring at Racetrack in 2015 revealed that DO concentrations dipped below 4.0 mg/L for one night in August (Cook et al 2015). In 2016 monitoring, DO reached levels below 4.0 mg/L on 14 nights at Racetrack. Given the questionable water quality observed at Pond 2 and Racetrack in recent years, it is advisable to continue water quality monitoring at these sites.

Additional fisheries monitoring data will be collected in the UCFRB in 2017. This data collection includes repeating population estimates at mainstem and tributary sampling sections, collected and analyzing additional otoliths for the microchemistry study, and caged fish monitoring of cleanup activities. These data will be integrated into a comprehensive report that will describe the current status of trout populations in the UCFRB, trout recruitment dynamics and movement, and limiting environmental factors. As restoration and remediation progress in the UCFRB, these data will serve as a baseline and guide for future evaluations of how fish respond to improved aquatic habitats.

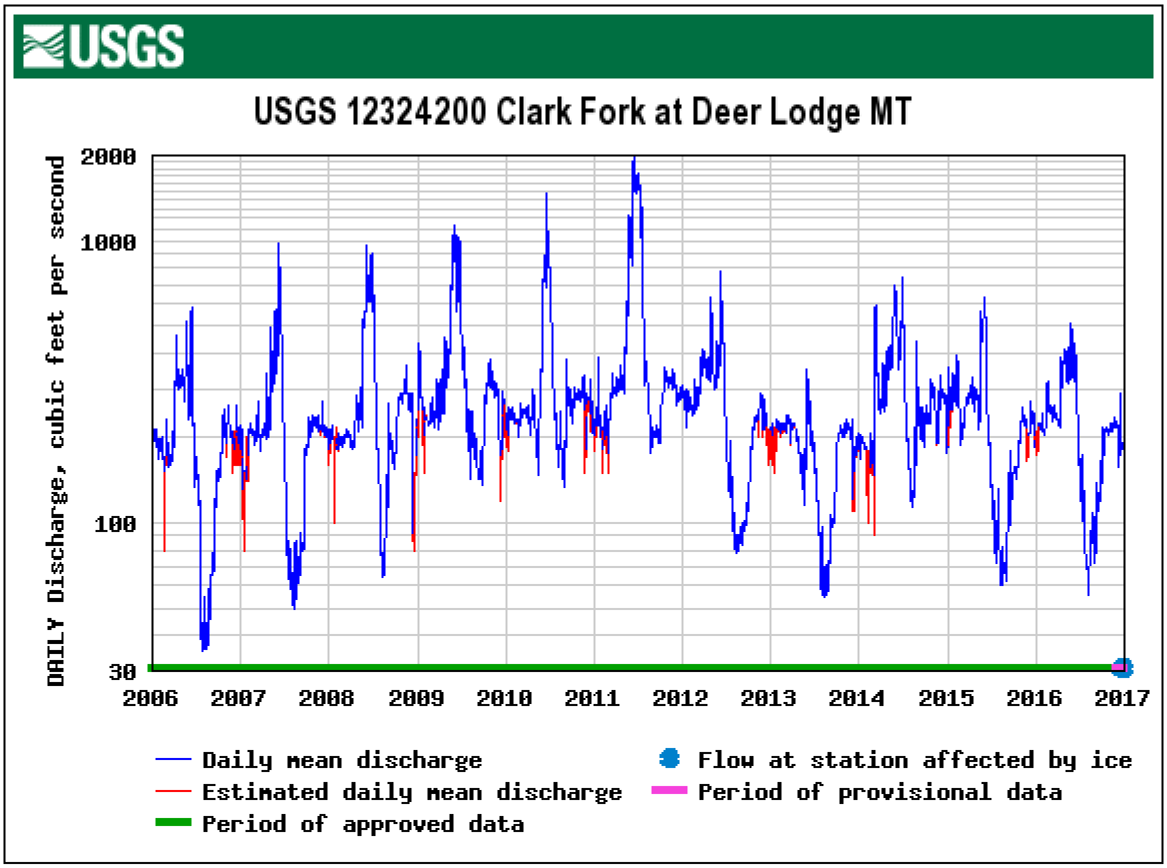

Figure 15. USGS hydrograph from the Clark Fork River gauge at Deer Lodge.

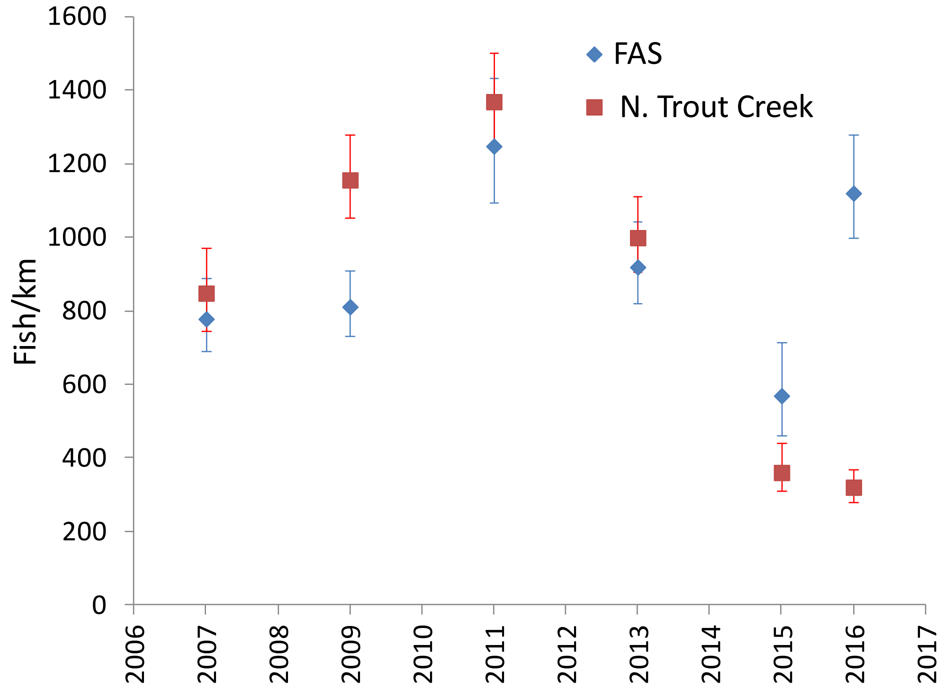

Figure 16. Population estimates from the FAS and Above N Trout Creek sampling sections on the Little Blackfoot River.

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Fisheries Monitoring in the Silver Bow Creek and Tributaries
2016 Report

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Introduction

Decades of copper mining in the Butte area led to severe contamination of Silver Bow Creek and extirpation of its fish community. Remediation activities such as groundwater treatment and streamside tailing removal have significantly reduced concentrations of contaminants such as Cu and Zn in Silver Bow Creek (Naughton 2013). These improvements in Silver Bow Creek water quality have allowed fish, including trout, to recolinize the creek. Montana Fish, Wildlife, and Parks (FWP) have been monitoring the Silver Bow Creek fish community through electrofishing surveys. FWP established six survey sections that span from Butte to 2.5 miles upstream of where the creek flows into the Warm Spring Ponds. These sections have been sampled once or twice a year since 2013.

Tributaries in the Silver Bow Creek watershed provide trout spawning habitat and cool water refuges during the heat of summer. Although concentrations of metals such as copper are far less toxic than in the past, ammonia pollution (NH_3-N) and hypoxia have recently been shown to limit the distribution of trout in the Silver Bow Creek (Naughton 2013). Recent improvements in Butte's municipal waste water treatment facilities may reduce nitrogen loading and hypoxic events in the creek. Westslope Cutthroat trout in the Silver Bow Creek watershed have been observed moving from tributaries to the mainstem in the fall and winter, after hypoxia subsides (Naughton 2013). Tributaries are clearly important habitats for trout, and are also important for non-trout species such as suckers (*Catostomus* sp.) as well. Thus, in order to thoroughly monitor fish in Silver Bow Creek, tributaries also need to be monitored. Electrofishing surveys have been conducted sporadically in the Silver Bow Creek watershed in the past, but in 2014 a sampling program was initiated in which established sections throughout the watershed are sampled each year.

Methods

Electrofishing surveys were conducted on Silver Bow Creek and four of its tributaries using backpack electrofishing units. Multiple electrofishing passes were conducted when at least six trout were captured on the first pass to allow for calculation of depletion-based abundance estimates (Zippin 1958). Descriptions of sampling methods, section lengths, and locations of sampling sections can be found in Appendix A. Six sections on Silver Bow Creek were sampled in both August and October to allow for comparison of trout numbers between warm and cool periods. Tributary sampling occurred in July.

Results

Of the 12 electrofishing surveys conducted on Silver Bow Creek, trout population estimates could be generated for six of them. Sampling during the month of August yielded estimates of 18 (95% CI = 16-20) EB and 8 (95% CI = 7-9) WCT per 100m at the Fairmont section and 4 (95% CI = 4-5) EB and 15 (95% CI = 14-16)WCT per 100m at the Below German Gulch Section (Table A1). At other sampling sections, insufficient numbers of trout were captured to calculate reliable abundance estimates. Trout population estimates could be calculated at four sections based on the October sampling (Table A2). These October estimates were 2 (95% CI = 1-2) RB and 2 (95% CI = 1-2)WCT per 100m at the Hwy 1 Bridge Section, 7 (95% CI = 6-8) EB, 6 (95% CI = 5-6) WCT, and 6 (95% CI = 4-7) RB and RBXWCT hybrids at the Fairmont section, 2 (95% CI = 1-2) EB and 4 (95% CI = 3-5) WCT per 100m at Ramsay, and 3 (95% CI = 3-3) EB per 100m at LAO. The section below German Gulch showed a general decline in fish numbers with 254 total fish captured in August and 23 total fish captured in October. Not enough trout were captured in October to generate population estimates at the German Gulch section. Non-trout species were captured in all sections with RM COT and LN SU being most abundant overall. Compared to the October 2015 data, trout estimates in October of 2016 were generally similar.

In Blacktail Creek, Eastern Brook Trout (EB) were the most abundant trout species in five of the seven sections and Westslope Cutthroat Trout (WCT) were most abundant in the upper most section (Table B). In the sections where EB were most abundant, they accounted for 52-92% of the fish captured in the section. WCT made up 85% percent of the catch in the section where they were dominant. EB were present in all six sections while WCT were only present in the upper four. LN SU, RM COT and CM MN were observed in the lower three reaches. The number of total EB handled and the population estimates increased in five of the six sections compared to 2015. WCT estimates and capture numbers were similar except for the upper section where more WCT were captured, however, most WCT captured in that section were less than 75mm and were not used in the estimate. Numbers of EB decreased from 2015 to 2016 at the Father Sheehan section from 148 (95% CI = 139-157) to 107(95% CI = 104-109) fish/100m.

Six sections were sampled in Browns Gulch with EB being the dominant trout species throughout (Table C). In the lower three sections EB accounted for 18-66% of the species present. In the upper three sections EB accounted for 83-97% percent of fish present. WCT were present in all six sections but in low numbers compared to EB. With the exception of the lowest Browns Gulch section, numbers of EB handled and EB population estimates increased significantly in 2016 compared to 2015. WCT capture numbers increased at the Brothers Ranch section from 3 in 2015 to 16 in 2016. No WCT were captured in 2015 in the Upper Ueland Section, but 3 were captured at the section in 2016. RM COT were present in the lower four sections and were the abundant species in the lower section. LNSU were sampled in the lower three sections but not in the upper three.

Three sections were sampled in German Gulch (Table D). WCT were the dominant species in all sections making up 69-100% of the species present. RM COT were the only non-trout fish captured in German Gulch and were only captured in the lowest section. EB were present in the two lower sections but absent in the upper section. WCT population estimates increased in 2016 compared to 2015 from 52 (95% CI = 51-55) to 86 (95% CI = 78-94) fish/100m at the lowest section and from 28 (95% CI = 28-29) to 77 (95% CI = 71-83) fish/100m at the middle section. The EB population estimate increased from 6 (95% CI = 6-7) to 23 (95% CI = 22-24) fish/100m from 2015 to 2016 at the middle section. EB estimates at the lower sections were similar between years.

WCT were the most common fish at both sampling sections in Beefstraight Creek, accounting for 63-76% of fish captured (Table E). Fewer EB were present in the upper section. No non-trout species were observed. WCT numbers were similar in 2016 compared to 2015 at both sections, but EB numbers increased from 22 (95% CI = 22-23) to 35 (95% CI = 31-39) fish/100m at the lowest section. A population estimate for EB could not be generated in 2015 at the upper section due to low fish numbers, but the number of EB caught at this section increased from 7 in 2015 to 18 in 2016.

Table A1. Electrofishing data collected on Silver Bow Creek in August 2016. Population estimates (95% CI) are for fish greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, RB = Rainbow Trout, LNSU = Longnose Sucker, LS SU = Large Scale Sucker, RM COT = Rocky Mountain Sculpin, CM MN = Central Mudminnow, RS SH = Redside Shiner.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above Hwy 1 Bridge	RM COT		47		28-95	37
	LN SU		48	144	83-242	38
	EB		1		91	<1
	RB		1		220	<1
	RS SH		30		55-90	24
Fairmont	RM COT		127		34-124	49
	EB	18(16-20)	60	158	67-425	23
	LN SU	12(9-15)	38	132	74-200	15
	WCT	8(7-9)	29	147	56-359	11
	RS SH		3		67-90	1
	LS SU		1		221	<1
Below German Gulch	RM COT		151		26-110	59
	LN SU	6(5-7)	25	120	66-170	10
	WCT	15(14-16)	58	200	53-415	23
	EB	4(4-5)	19	144	66-230	7
	CM MN		1		109	<1
Ramsay	LN SU		65	117	43-286	76
	WCT		2	166	165-166	3
	RM COT		18		42-123	21
Rocker	LN SU		133	151	46-212	97
	CM MN		1	128	128	1
	WCT		3	220	206-244	2
LAO	RM COT		46		31-115	78
	LN SU		6	110	95-157	10
	EB		5	262	220-285	9
	WCT		2	239	212-265	3

Table A2. Electrofishing data collected on Silver Bow Creek in October 2016. Population estimates (95% CI) are for fish greater than 75 mm (~ 3”) in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, RB = Rainbow Trout, LL = Brown Trout, LN SU = Longnose Sucker, RM COT = Rocky Mountain Sculpin, CM MN = Central Mudminnow, LS SU = Large Scale Sucker, RS SH = Redside Shiner, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above Hwy 1 Bridge	RM COT		12		51-109	30
	LN SU		11	159	51-221	28
	EB		3	119	98-129	8
	RB	2(1-2)	6	235	104-435	15
	WCT	2(1-2)	6	212	195-234	15
	LS SU		1		168	2
	RS SH		1		91	2
Fairmont	RM COT		58		42-102	32
	EB	7(6-8)	23	157	117-251	13
	LN SU		59	168	79-262	32
	WCT	6(5-6)	20	207	66-374	11
	RB*	6(4-7)*	9	127	108-161	5
	RBXWCT*		9	178	109-243	5
	LS SU		4	151	126-195	2
Below German Gulch	RM COT		16		35-118	70
	WCT		4	246	69-407	17
	EB		3	100	87-109	13
Ramsay	LN SU	8(4-13)	49	98	50-272	45
	EB	2(1-2)	6	188	125-319	6
	WCT	4(3-5)	14	272	126-414	13
	RM COT		39		56-134	36
	LL		1	260	260	1
Rocker	LN SU	74(69-78)	219	126	44-227	98
	CM MN		2	142	130-153	1
	EB		2	163	151-175	1
LAO	RM COT		56		43-112	80
	LN SU		3	109	84-131	4
	EB	3(3-3)	7	280	193-422	10
	WCT		4	260	177-420	6

*RB and RBXWCT were combined for estimate.

Table B. Electrofishing data collected on Blacktail Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, LN SU = Longnose Sucker, RM COT = Rocky Mountain sculpin, CM MN = Central Mudminnow, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Father Sheehan	EB	107(104-109)	244	169	49-440	78
	LN SU	6(5-6)	17	129	53-246	5
	RM COT		47		49-115	15
	CM MN		4		80-98	1
	WCT		1	210	210	<1
Golf Course Butte C.C.	EB	205(197-213)	296	121	51-335	92
	LN SU	14(5-22)	14	110	70-193	4
	RM COT		7		76-110	2
	CM MN		4	84	70-95	1
Above Blacktail Loop	EB	85(82-88)	187	93	42-234	91
	LN SU	15(11-19)	19	116	42-178	9
Below 9 Mile	EB	147(142-152)	144	123	60-270	77
	WCT	32(26-38)	30	167	77-251	16
	LN SU	11(11-11)	11	166	125-202	6
	CM MN		1		76	1
Above 9 Mile	EB		112	98	55-228	70
	WCT		49	105	53-174	30
Upper Thompson	WCT	48(46-50)	50	122	73-222	48
	EB	48(44-52)	55	110	44-203	52
Upper Forest Service	WCT	6(5-7)	56	62	40-142	85
	EB	9(8-10)	10	95	74-142	15

Table C. Electrofishing data collected on Brown's Gulch in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3") in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, LN SU = Longnose Sucker, RM COT = Rocky Mountain sculpin, RBxWCT = phenotypic hybrid between Rainbow Trout and Westslope Cutthroat Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower Ueland RM 2.6	EB	12(11-13)	14	204	160-282	18
	RM COT		47		68-135	61
	LN SU	9(8-10)	13	88	62-113	17
	WCT		3	178	136-199	4
Upper Ueland RM 5.3	EB	24(21-27)	26	109	54-197	43
	RM COT		26		74-109	43
	LN SU		6	111	66-155	9
	WCT		3	188	174-200	5
Brothers Ranch RM 9.7	EB	81(69-93)	87	124	45-281	66
	LN SU		14	122	92-189	11
	RM COT		15		35-126	11
	WCT	16(15-17)	16	153	100-184	12
Balentine RM 11.5	EB	153(146-161)	155	110	45-197	83
	WCT	24(18-31)	20	144	97-196	11
	RM COT		5	99	79-125	6
Lower Forest Service RM 13.8	EB	94(91-97)	105	106	50-218	91
	WCT	7(6-8)	11	97	68-143	9
Upper Forest Service RM 15.3	EB	134(131-137)	153	104	43-193	97
	WCT		5	86	68-131	3

Table D. Electrofishing data collected on German Gulch in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout, RM COT = Rocky Mountain Sculpin.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 0.2	WCT	86(78-94)	152	120	68-352	69
	EB	23(22-24)	62	113	42-353	28
	RM COT		5		70-110	3
RM 3.0	WCT	77(71-83)	83	102	59-230	69
	EB	23(22-24)	38	92	36-180	31
RM 6.0	WCT		5	167	93-215	100

Table E. Electrofishing data collected on Beefstraight Creek in 2016. Population estimates (95% CI) are for trout greater than 75 mm (~ 3”) in total length. Species abbreviations: WCT = Westslope Cutthroat Trout, EB = Eastern Brook Trout.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Above lower bridge RM 1.3	WCT	58(57-59)	146	117	54-275	63
	EB	35(31-39)	86	95	32-184	37
Below Spring Creek Trail Crossing RM 4.5	WCT	51(49-53)	58	107	52-205	76
	EB	11(10-12)	18	72	30-126	24

Discussion

In August when water temperatures were at their highest and stream flows at their lowest, trout numbers below German Gulch and the Fairmont section were significantly higher than other sections of Silver Bow Creek. Few trout were captured at the other four Silver Bow sampling sections at this time. The total number of trout captured at the Below German Gulch and Fairmont sections decreased from 166 to 68 between August and October. Overall trout numbers for the other four sections increased from 14 to 49 from August to October. It appears that trout may have been seeking thermal refuge immediately downstream of German Gulch in August and dispersed after temperatures in the rest of Silver Bow creek cooled in the fall. This pattern is similar to the findings of a trout movement study that demonstrated low abundance of salmonids in hypoxic sections of Silver Bow Creek during summer and increased abundance in these sections after hypoxic conditions subsided in the winter (Naughton 2013). Naughton 2013 found that WCT in the vicinity of German Gulch moved into sections of Silver Bow Creek as water quality improved. Thus, seasonal changes in water temperature and water quality strongly influence salmonid distribution in Silver Bow Creek.

Metals cleanup activities have improved the habitability of Silver Bow Creek for native fishes. Improvements in the Butte municipal water treatment facility should result in a reduction of ammonia discharge and potentially reduce the prevalence of hypoxic conditions. It will be critical to monitor how fish populations respond to these improvements. Past surveys on Silver Bow Creek have documented relative abundance, expressed as fish/unit time or fish per length of stream (e.g., Lindstrom 2012, Naughton 2013). This information has been valuable to document the recolinization of Silver Bow Creek by various fish species. These surveys have captured fish using a single backpack electrofishing unit and crews of two or three people. Fish surveys since 2015 have utilized two electrofishing units and four to six person crews at each section. Using two electrofishers have increased fish capture efficiency and allowed for calculation of true abundance estimates. As the abundance and distribution of fishes continue to change in response to improvements in habitat and water quality, estimates of abundance will be critical in documenting these changes.

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Appendix

Table I. Locations for monitoring sections on Baggs Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 0.4	120 m	Single Pass	46.39659	-112.63052
RM 2.4	113 m	Depletion	46.39407	-112.59422

Table II. Locations for monitoring sections on Barker Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower RM 0.5	100 m	Depletion	46.15737	-113.12189
RM 1.5	140 m	Depletion	46.14403	-113.12628

Table III. Locations for monitoring sections on Beefstraight Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower bridge RM 1.3	180 m	Depletion	45.98366	-112.82762
Spring Creek trail RM 4.5	100 m	Depletion	45.98829	-112.89375

Table IV. Locations for monitoring sections on Blacktail Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Golf Course Butte C.C	100 m	Depletion	45.97131	-112.49102
Above Blacktail Loop	100 m	Depletion	45.94505	-112.47636
Below 9 Mile	100 m	Depletion	45.90676	-112.46682
Above 9 Mile	122 m	Depletion	45.89902	-112.46577
Upper Forest Service	100 m	Depletion	45.83146	-112.46887

Table V. Locations for monitoring sections on Boulder Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
USGS Gauge RM 0.4	100 m	Depletion	46.47399	-113.23616
RM 2.0	100 m	Depletion	46.44669	-113.22075
RM 6.5 Princeton Bridge	120 m	Depletion	46.41325	-113.16090
Copper Lakes Trailhead	100 m	Depletion	46.39672	-113.14002

Table VI. Locations for monitoring sections on Brown's Gulch in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower Ueland RM 2.6	117 m	Depletion	46.02115	-112.66180
Upper Ueland RM 5.3	100 m	Depletion	46.04280	-112.63497
Brothers Ranch RM 9.7	100 m	Depletion	46.09545	-112.62047
Balentine RM 11.5	90 m	Depletion	46.12129	-112.62178
Lower USFS RM 13.8	100 m	Depletion	46.13335	-112.58119
Upper USFS RM 15.3	100 m	Depletion	46.14518	-112.55856

Table VIII. Locations for monitoring sections on Cottonwood Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
School RM 0.8	113 m	Depletion	46.40001	-112.72959
Middle RM 3.0	200 m	Single Pass	46.39602	-112.68595
Upper RM 6.9	100 m	Depletion	46.38310	-112.63288

Table IX. Location for monitoring section on Middle Fork Cottonwood Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 0.7	100 m	Depletion	46.35883	-112.57642

Table X. Locations for monitoring sections on Flint Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream lat	Downstream Long
Hall	1.54 Km	Mark/Recapture	46.58556	-113.18108
Johnson Tuning Fork	1.32 Km	Mark/Recapture	46.40133	-113.30400
Chor	1.42 Km	Mark/Recapture	46.28823	-113.33698
Dam (Campground)	100 m	Depletion	46.23226	-113.29792

Table XI. Locations for monitoring sections on Foster Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower RM 1.0	100 m	Depletion	46.17497	-113.13055
Middle RM 2.3	100 m	Depletion	46.18919	-113.14171
Upper RM 3.8	130 m	Depletion	46.20537	-113.12403

Table XII. Locations for monitoring sections on German Gulch in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 0.2	188 m	Depletion	46.02005	-112.79037
RM 3.0	100 m	Depletion	45.98455	-112.80830
RM 6.0	100 m	Depletion	45.96258	-112.85433

Table XIII. Locations for monitoring sections on Harvey Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 0.6	100 m	Depletion	46.69828	-113.37712
RM 1.2	120 m	Depletion	46.69159	-113.38245
RM 1.6	100 m	Depletion	46.6822	-113.39116
RM 2.3	100 m	Depletion	46.6768	-113.39555
Below 8 Mile	137 m	Depletion	46.61099	-113.43065
Above FS Road	100 m	Depletion	46.60113	-113.44439

Table XIV. Locations for monitoring sections on the Little Blackfoot River in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
FAS	1200 m	Mark/Recapture	46.56424	-112.67784
N. Trout Creek	1000 m	Mark/Recapture	46.57673	-112.50767
Elliston RM 26.7	300 m	Depletion	46.5535	-112.40379
Above Sunshine Camp	200 m	Depletion	46.50319	-112.40455
Ontario Creek RM 34.9	120 m	Depletion	46.46229	-112.42051
Kading Cmpgrnd RM 40.1	200 m	Depletion	46.42166	-112.48753

Table XV. Locations for monitoring sections on Silver Bow Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Hwy 1 Bridge	325 m	Depletion	46.09515	-112.80497
Fairmont	338 m	Depletion	46.04733	-112.79514
Below German Gulch	388 m	Depletion	46.02852	-112.79500
Ramsay	365 m	Depletion	46.00009	-112.68518
Rocker	250 m	Depletion	46.00108	-112.59348
LAO	237 m	Depletion	46.99606	-112.56037
Father Sheehan	204 m	Depletion	46.98526	-112.50751

Table XVI. Locations for monitoring sections on Spotted Dog Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 1.1	150 m	Depletion	46.58143	-112.60246
RM 4.6	170 m	Depletion	46.53831	-112.58932

Table XVII. Locations for monitoring sections on Storm Lake Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower RM 0.6	100 m	Depletion	46.15704	-113.21209
Above first road crossing RM 1.4	100 m	Depletion	46.14611	-113.21759
Lower end of meadow RM 4.2	100 m	Depletion	46.11486	-113.24855
Below upper road crossing RM 6.3	100 m	Depletion	46.08979	-113.26583
Above upper road crossing RM 6.3	100 m	Depletion	46.08854	-113.26732

Table XVIII. Locations for monitoring sections on Twin Lakes Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
Lower RM 1.3	96 m	Depletion	46.15655	-113.17270
Meadow RM 2.8	100 m	Depletion	46.14503	-113.19615
Upstream of old bridge RM 4.6	100 m	Depletion	46.12344	-113.20932
Downstream of lower lake RM 7.2	100 m	Depletion	46.09039	-113.21017
Upstream of upper lake RM 8.5	100 m	Depletion	46.07794	-113.21556

Table XIX. Locations for long term monitoring sections on the Upper Clark Fork River.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
PH Shack	2.57 Km	Mark/Recapture	46.19658	-112.76772
Bottom of PH Shack to Perkins Lane	2.41 Km	Mark/Recapture	46.20856	-112.76762
Below Sager Lane	5.15 Km	Mark/Recapture	46.35108	-112.74109
Williams Tavenner	4.02 Km	Mark/Recapture	46.48631	-112.72647
Phosphate	3.38 Km	Mark/Recapture	46.57443	-112.89466
Morse Ranch	12.3 Km	Mark/Recapture	46.65427	-113.14620
Bearmouth	10.6 Km	Mark/Recapture	46.69818	-113.41624

Table XX. Locations for monitoring sections on Warm Springs Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
WMA RM 3.3	900 m	Mark/Recapture	46.17756	-112.78963
Airport Road RM 3.3	609 m	Mark/Recapture	46.14632	-112.86194
Below Myers Dam	1000 m	Mark/Recapture	46.15136	-113.0276
Garrity WMA	970 m	Mark/Recapture	46.1627	-113.06291
Veronica Trail RM 26.0	100 m	Depletion	46.17413	-113.15636
Upper Bridge RM 27.4	100 m	Depletion	46.22478	-113.18143
Upper Forks Confluence	100 m	Depletion	46.24232	-113.16467

Table XXI. Location for monitoring section on West Fork Warm Springs Creek in 2016.

Section Name	Section Length	Estimate Type	Downstream Lat	Downstream Long
RM 1.0	100 m	Depletion	46.26241	-113.15594