Fisheries Monitoring in the Upper Clark Fork River Basin
2017 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. 2018; NRDP 2012). 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 collection was conducted 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 and remediation actions.

Freshwater salmonids use a variety of different habitats to complete life their 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., 2018). A variety of tributary restoration projects are underway and more are planned for the coming decades (NRDP 2016). 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 mechanisms 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).

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 effects 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, 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 exposure to environmental conditions. 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 impacts 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.

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

1) Describe trout population abundances and species composition of fish communities in the Upper Clark Fork River, Silver Bow Creek, 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. 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 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. Remediation 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.

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. Meyers Dam, located 5.5 km upstream of Anaconda is a barrier to fish migrating upstream in Warm Springs Creek. 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 2017 at six established sections on the Clark Fork River. These sections are sampled annually by FWP and are referred to 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. This is an electrofishing section that was sampled from 2009-2012 and again from 2015-present.

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).

Tributary population monitoring

Population estimates were conducted in 18 tributaries in the UCFRB identified as high priority in Saffel et al. 2018 (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

In fall of 2015, water samples were collected at 16 sites throughout the UCFRB to verify that there was sufficient variation in geochemical markers to proceed with a full otolith microchemistry study (Figure 2). Mainstem sites were located near the downstream boundaries of reaches A, B, and C. An additional mainstem site was located upstream of the confluence of Racetrack Creek. Tributary water collection sites were located near tributary mouths. In Rock Creek, Flint Creek, Warm Springs Creek, and the Little Blackfoot River, additional water samples were collected approximately halfway between the mouth and the headwaters to provide additional spatial resolution of chemical markers. Water samples were extracted by pumping 50 ml of stream water through a 0.2 µm syringe filter into an acid washed vial. Water samples were preserved by adding a nitric acid solution and refrigerated until they were shipped to the Woods Hole Oceanic Institute for analyses. Water samples were analyzed for elemental ratios (i.e., Sr:Ca, Ba:Ca) using a Thermo Scientific ELEMENT 2, rapid scanning, magnetic sector, single collector inductively-coupled plasma mass spectrometer (ICPMS). Strontium isotope ratios (^{87}Sr:^{86}Sr) were determined by a Thermo Scientific NEPTUNE, large format, magnetic sector, multicollector ICPMS.

Sagital otoliths from brown trout in the Upper Clark Fork River were collected in 2106 and 2017 from the mainstem, two tributaries, and Big Springs Trout Hatchery 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 although some additional sampling was needed to reach desired sample sizes.

Between 2016 and 2017, 320 brown trout were collected from the mainstem Clark Fork River divided roughly between reaches A (n = 120), B (n = 100), and C (n = 100) (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). This sampling scheme was designed to provide roughly equal sample sizes for the different reaches of the UCFR.

In 2016, 86 juvenile brown trout otoliths were collected from 16 different sites in 11 tributaries of the Upper Clark Fork River. Tributaries sampled in 2016 included Warm Springs Creek, Lost Creek, Racetrack Creek, Cottonwood Creek, Little Blackfoot River, Warm Springs Creek at Garrison, Gold Creek, Flint Creek, and Rock Creek (Figure 2). In 2017, additional juvenile otoliths were collected again in Gold creek (n= 5) and the lower Little Blackfoot (n = 10) river to get a better baseline for the chemical signatures of those streams. The otolith collection in 2017 in Gold Creek occurred at the same site that was sampled in 2016 because several otoliths from 2016 were damaged during preparation. The otoltihs collected in the Little Blackfoot River in 2017 were from fish at previously unsampled sites in the downstream reaches. Twenty-four juvenile brown trout were also collected at four sites in the Clark Fork River to characterize chemical signature of the mainstem. These mainstem sites were located near Beavertail State Park (n=5), Jens fishing access site (n=5), Kohrs river bend fishing access site (n=8), and near Racetrack pond (n=6). Five fish were also collected from Big Springs Trout Hatchery in Lewistown, MT. Brown trout from Big Springs Trout Hatchery have been used in the caged fish studies and have been stocked in the Warm Springs ponds. By adding these hatchery fish to the list of potential natal areas, we sought to account for possible escapement may have occurred from fish cages or the Warm Springs Ponds into the mainstem Clark Fork River.

Most of the juvenile fish collected were young of year. By using such young fish, we hoped to reduce the chance that these fish had undergone large movements, and thus been exposed to various geochemical environments, over their lifetime. We could therefore be confident that juvenile fish were spawned and reared near their location of capture and the chemical signature of their otoliths would reflect the signature of these natal areas. 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. 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 $^{87}Sr{:}^{86}Sr$, Sr:Ca, and Ba:Ca within otoliths were measured using a Neptune 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). The laser was set to a scan speed of 5 µm per second, 75 µm spot size, a frequency of 20 Hz, and 100% power. A MACS3 standard was run periodically throughout each day so that instrument drift could be accounted for if necessary.

Measurements of ^{87}Sr:^{86}Sr, Sr:Ca, and Ba:Ca were each averaged from all measurements taken across juvenile brown trout otoliths. Because most of the juvenile brown trout were < 1 year of age, we assumed that they had not moved significant distances from where they were spawned and reared. Therefore, we could consider the chemical measurements from the entire otolith to be representative of both their site of capture and their natal site. We used linear discriminant function analysis (DFA) to evaluate the extent to which these different natal sites had distinct chemical signatures. We used a cross-validated, leave one out (jackknife) procedure to classify juvenile fish to their natal area (Wells et al. 2003; Gibson-Reinemer et al. 2009). ^{87}Sr:^{86}Sr and Ba:Ca ratios were log transformed to meet assumptions of normality and homogeneity of variance prior to modeling. In total, 117 juvenile otoliths from 22 different UCFRB sites and the Big Springs Fish Hatchery were used to develop the assignment model.

The DFA based on juvenile otolith signatures was then used to assign sub-adult and adult fish from the mainstem Clark Fork River to their natal areas. The signatures of previously unknown natal areas, taken from averages of chemical measurements from within the first annulus of adult and subadult brown trout (Figure 3), were entered into the model, which then assigns the otolith to natal areas defined by the juvenile fish DFA. This assignment model was used to classify the natal origin of 299 adult/subadult fish collected in the mainstem Clark Fork River.

Wild fish tissue burdens

In 2016, a subset of fish from the mainstem Clark Fork River used for otolith collection also had tissues extracted for metal burden analyses. From each of the seven electrofishing sections, two fish per length category were selected for tissue metal burden analyses. Fish in the smallest category (< 175 mm) were to small to extract large enough tissue samples for analysis, so no fish in this length category were used in the analysis. For fish > 175 mm, gills, liver, and stomachs were collected. Stomach contents were removed, and tissues were rinsed with deionized 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). Ten brown trout were collected from Rock Creek in 2017 to provide reference tissue metals concentrations. Mean tissue metals concentrations for fish collected in 2016 were compared to concentrations from brown trout collected in 1992 in the vicinity of what is now referred to as the pH Shack Section (Farag et al. 1995).

Caged fish monitoring

The objective of caged fish monitoring in 2017 was to monitor for acute and residual impacts of construction activities. Cage locations were selected to bracket potential construction efforts that on Grant-Kohrs Ranch. 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 upstream of the I-90 bridge upstream of Deer Lodge to provide a site immediately upstream of construction activities. Cages were placed upstream of the Deer Lodge waste water treatment plant to provide a site immediately downstream of construction activities. The most downstream cages were placed at the Kohrs Fishing Access Site. Three cages were placed at each site. Twenty-five brown trout were placed in each cage on May 9th, 2017. 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 12th, 2017 and all fish and cages were removed at this time.

After cages were deployed, it was decided that no construction activities would take place in 2017. The cages remained out for the normal duration of our intended study period and fish were collected as planned. In the past, fish were analyzed for copper and zinc. Since no work on the cleanup was completed in 2017, caged fish samples were not analyzed for metals.

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). Although no fish cages where intstalled at this location, an additional Hydrolab was placed near Racetrack bridge, primarily to monitor for low dissolved oxygen conditions recorded during past caged fish studies at this site (Cook et al. 2015). Water quality parameters recorded include pH, temperature and dissolved oxygen (DO).

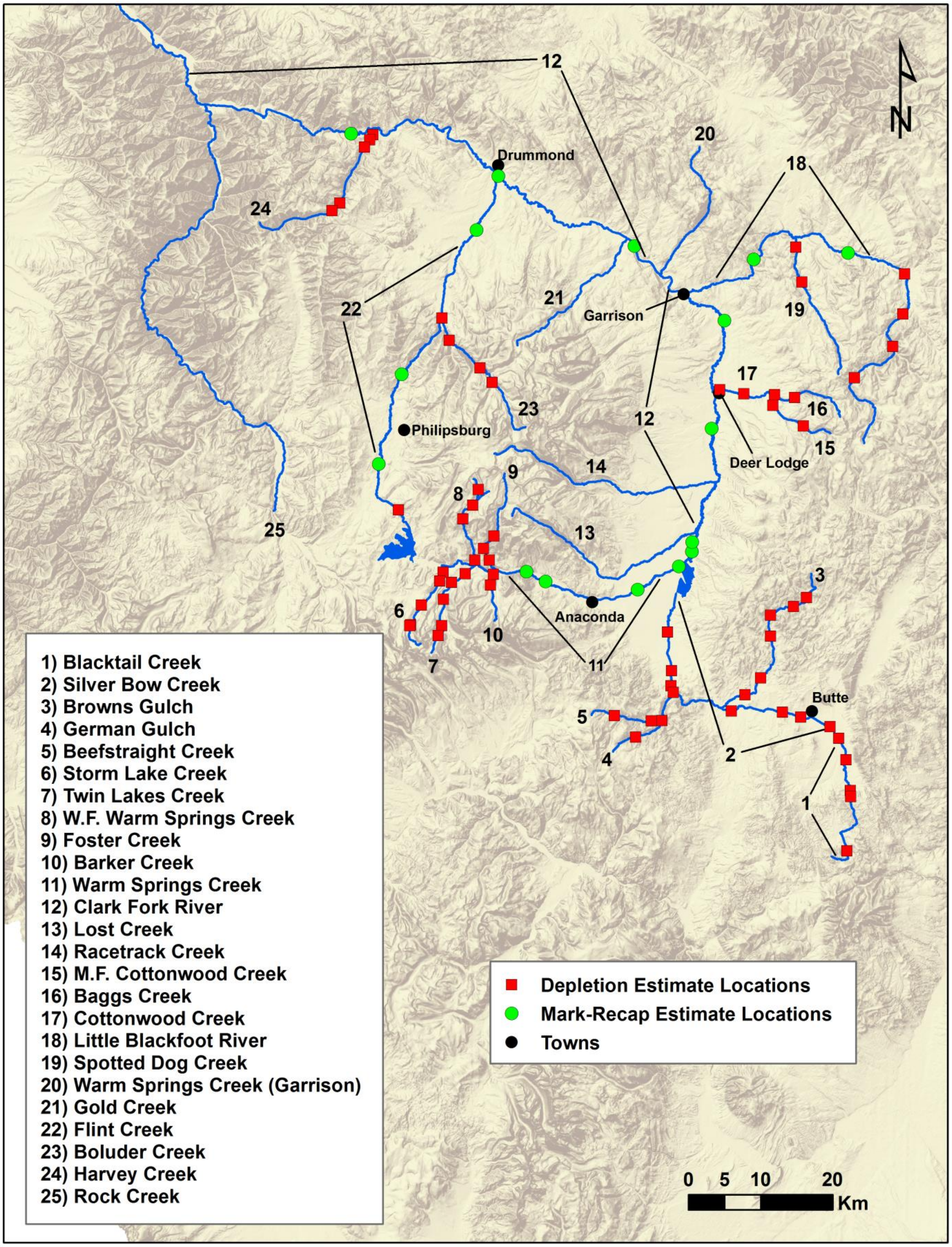

Figure 1. Map of electrofishing sections in the Upper Clark Fork River Basin. Numbers refer to specific streams.

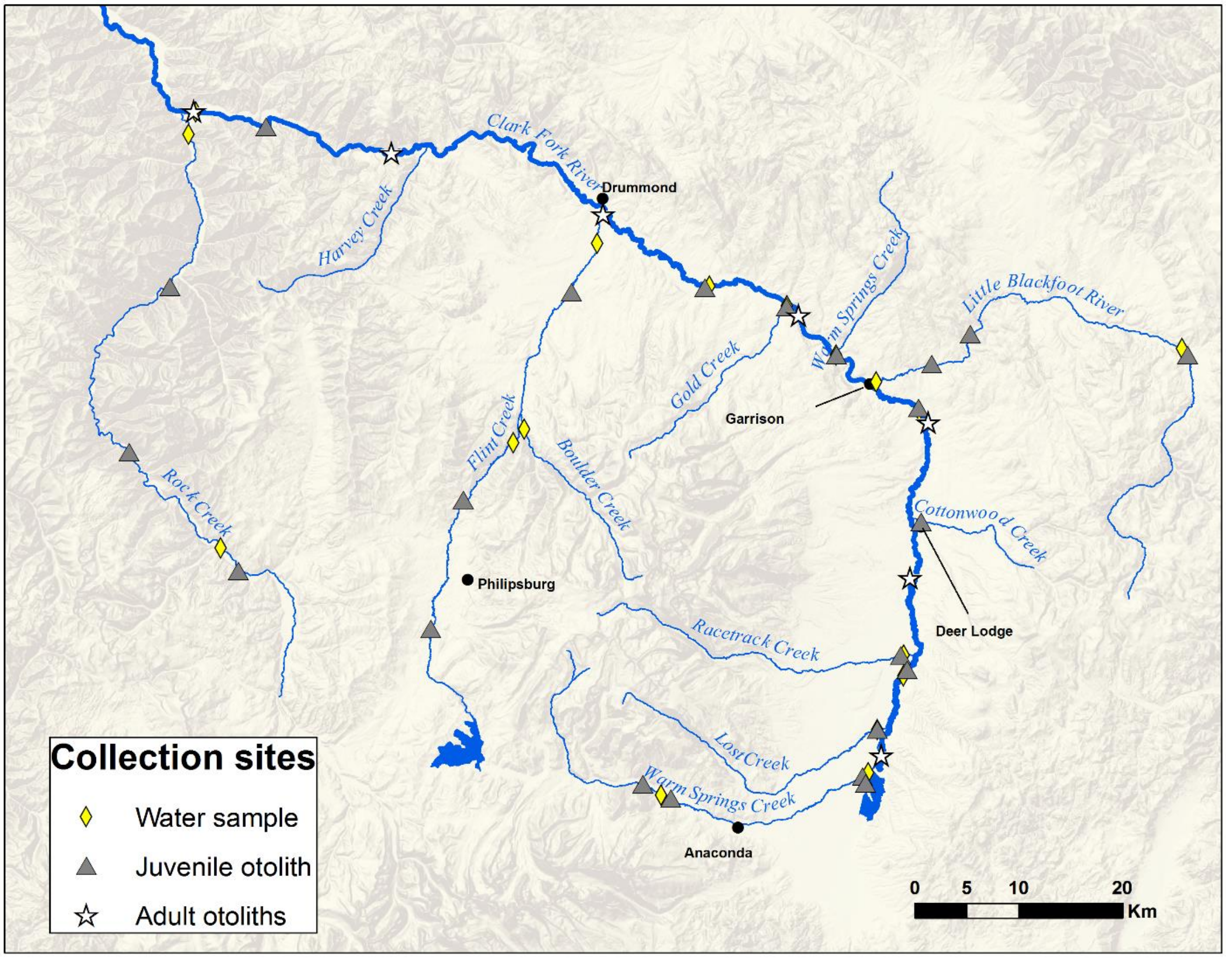

Figure 2. Map of water sampling locations and brown trout otolith collection sites for the otolith microchemistry study.

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

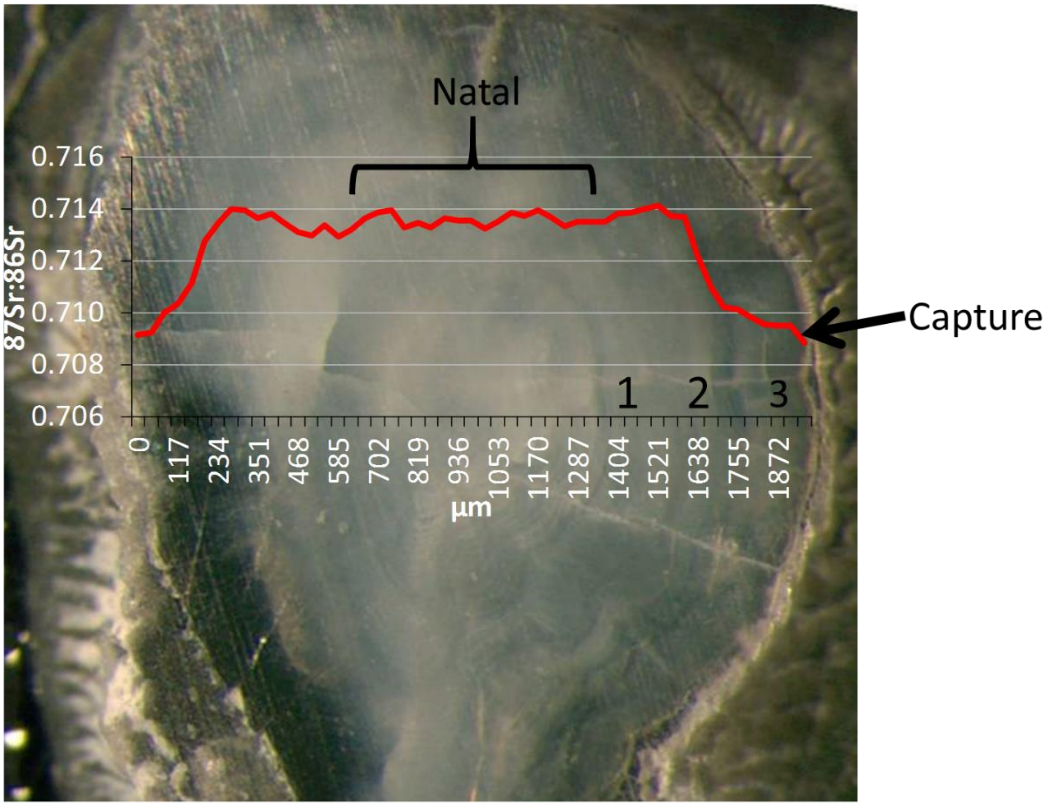

Figure 3. Example of a sanded brown trout otolith showing the approximate path of the laser transect on the x-axis for and corresponding strontium isotope (^{87}Sr:^{86}Sr) ratio on the y-axis.

Results - *Mainstem electrofishing*

Fish population estimates were conducted at seven sites on the Clark Fork River between Bearmouth and Warm Springs (Table 2). Brown trout were the most abundant trout species in all sections accounting for 62 to 99 percent of total trout present. Calculation of population estimates for rainbow trout and westslope cutthroat trout were only possible in the Bearmouth and Morse Ranch sections. Although these species were present in other sections, recapture numbers were too low to produce valid estimates. Eastern brook trout were captured in the Sager Lane section and one bull trout was captured in the Bearmouth section. Brown trout estimates ranged from 45 fish/km at Bearmouth to 331 fish/km at Phosphate. Brown trout abundance is as low as it has been since 2008 at the pH Shack section and since 2010 for the Below Sager Lane section (Figure 4). Brown trout population estimates at the other five sites were near or above average.

Table 2. Electrofishing data collected in 2017 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, 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 (%)
Bearmouth	LL	45(32-67)	185	305	100-492	62
	RB	15(11-21)	93	312	195-460	31
	WCT	3(1-6)	19	324	204-420	6
	BULL		1	295	295	1
Morse Ranch	LL	90(76-108)	535	323	95-534	95
	RB		4	302	245-362	1
	WCT	3(2-6)	24	288	214-452	4
Phosphate	LL	331(238-474)	328	323	94-474	98
	WCT		6	334	269-382	2
Williams Tavenner	LL	203(142-299)	267	336	111-500	98
	WCT		5	354	297-404	2
	RBXWCT		1	284	284	<1
Below Sager Lane	LL	92(65-133)	227	319	101-500	97
	EB		4	210	194-223	2
	WCT		2	305	304-306	1
PH Shack to Perkins Ln.	LL	140(93-220)	154	298	105-479	99
	RB		2	312	129-495	1
PH Shack	LL	140(98-210)	177	317	104-493	97
	RB		5	410	170-593	2
	WCT		1	237	237	1

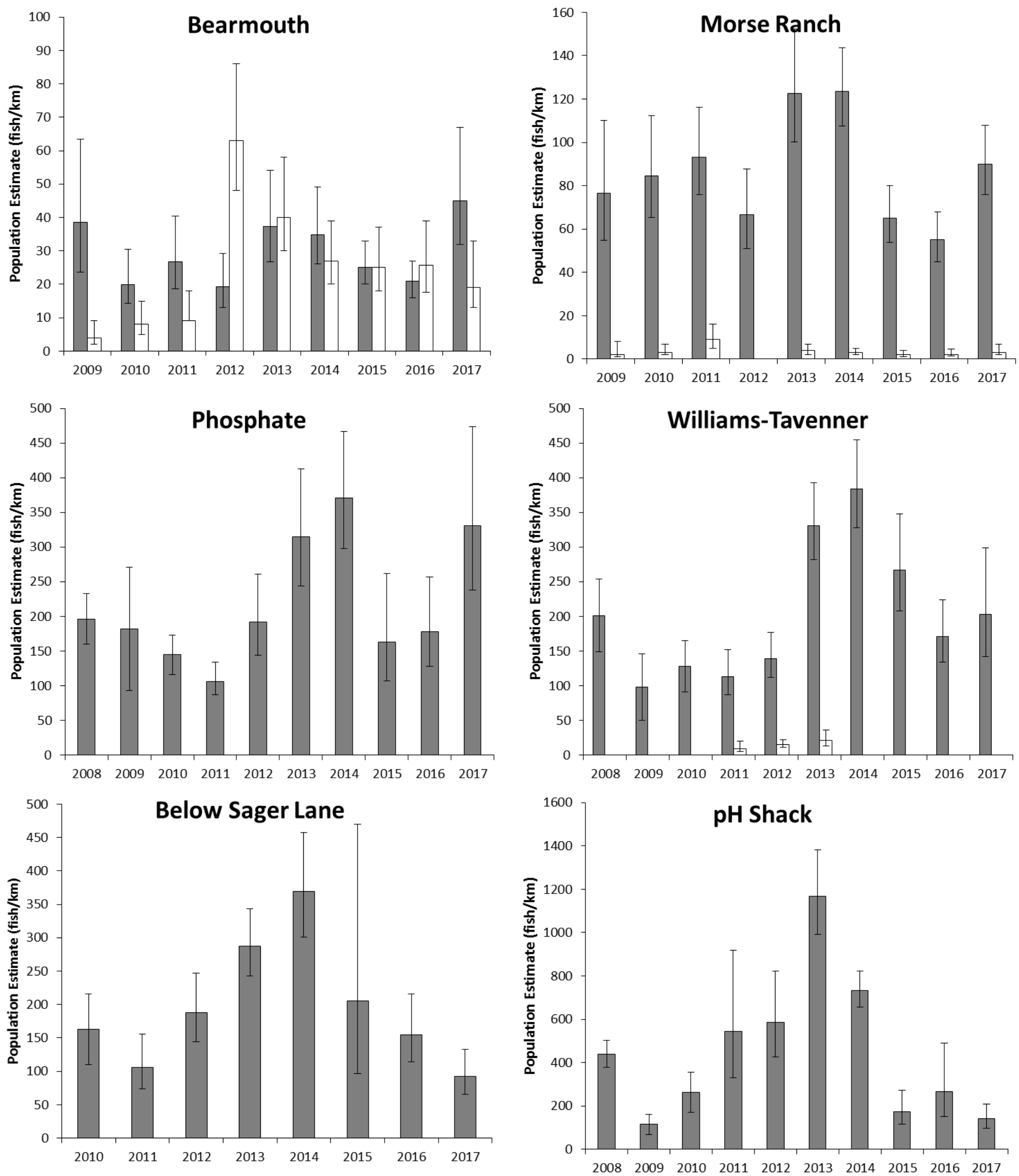

Figure 4. Clark Fork River brown trout (grey bars) and *Oncorhynchus sp.* (white bars) population estimates from 2008-2017 by sample section. Sample reaches are displayed downstream to upstream, left to right then top to bottom. Please note that axis values are not the same for every sample reach.

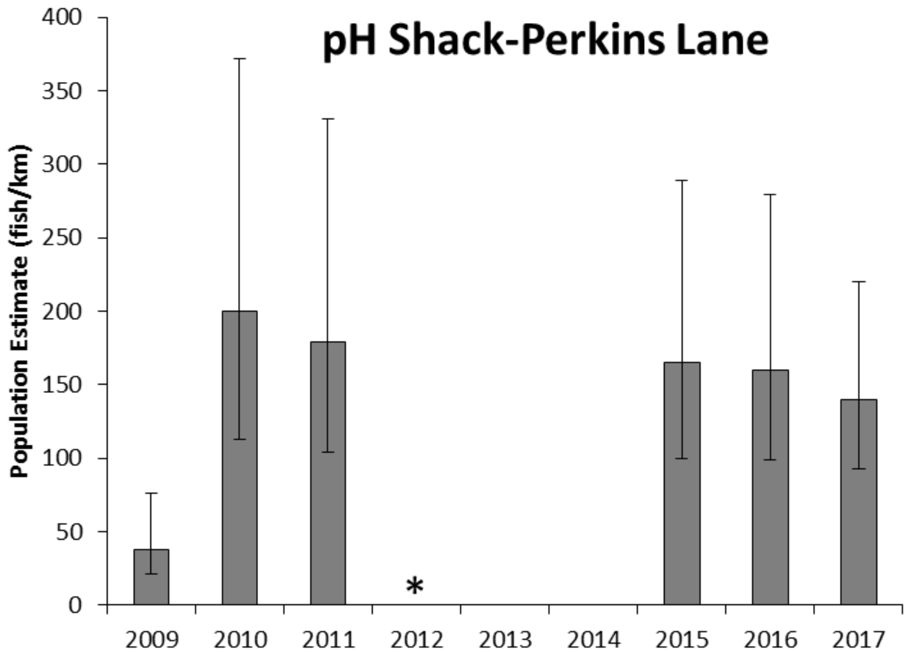

Figure 5. Clark Fork River brown trout population estimates from the pH Shack to Perkins Lane sampling section. *Only one fish was recaptured in 2012 so reliable estimate could not be calculated.

Tributary Electrofishing Surveys

Between 7/5/2017 and 10/12/17, a total of 76 sections comprising 19.8 km of stream were sampled in tributaries of the Upper Clark Fork River and Silver Bow Creek. Sixty-eight depletion estimates and eight 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 but the lowest section comprising of 40-77% of fish (Table 3). EB accounted for 50% of the trout sampled in the lowest section while WCT made up 38%. EB, bull trout (BULL), EBXBULL hybrids, RB and RBXWCT hybrids were also present in other sections. 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 in all but one section comprising 48-72% of all trout (Table 4). EB were most the most abundant (69%) trout species in the section downstream of the lower lake. BULL were present in all sections except RM 4.6 and EB were present in all but the uppermost and lowest sections. Three LL were captured in the lowest sampling section representing the first time this species has been sampled in Twin Lakes Creek. 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 most abundant in all sections and accounted for 51-84% of fish present. EB were present in all sections. BULL were only present in the lowest section. RB were present in the lower section and RBXWCT were present in the upper and lower section.

Two sections were sampled on Barker Creek (Table 6). BULL accounted for 70-71% of fish. WCT were present in both sections. No sculpins were captured.

Warms springs Creek (including the West Fork) had eight estimate sections with LL comprising 86-99% of fish in the two sections below Myers dam. WCT were most abundant in four of the five sections above Meyers dam and accounted for 59-100% of fish in those sections (Table 7). EB were present in four sections and were most abundant in the section at RM 27.4 making up 76% of trout. BULL were present in four sections. EBXBULL hybrids were found in two 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 were observed for the first time in the section above Veronica Trail Road at RM 26.0.

Table 3. Electrofishing data collected on Storm Lake Creek in 2017. 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	WCT	15(15-16)	16	156	55-232	38
RM 0.6	EB	22(21-26)	21	118	75-225	50
	BULL		1	193	193	2
	RB		4	172	143-185	10
Above First	WCT	26(26-28)	33	143	32-236	55
Crossing	EB	24(24-25)	24	128	77-223	40
RM 1.4	BULL		2	78	70-86	3
	RBXWCT		1	154	154	2
Lower	WCT	40(40-42)	46	145	58-222	65
Meadow	RB		1	313	313	1
RM 4.2	BULL	8(8-11)	13	100	23-243	18

	EBXBULL		4	190	77-234	6
	EB	7(7-8)	7	117	88-185	10
Below upper Storm Lake road crossing RM 6.3	WCT	20(20-22)	42	94	55-185	40
	EB		3	189	180-200	3
	BULL	27(26-30)	27	91	45-131	25
	EBXBULL		1	172	172	1
	RBXWCT	19(19-20)	29	96	55-164	27
	RB		4	138	59-294	4
Above upper Storm Lake road crossing RM 6.3	WCT	49(45-57)	68	108	54-267	77
	EB	4(4-6)	5	175	45-241	6
	BULL	14(14-16)	15	101	26-162	17

Table 4. Electrofishing data collected on Twin Lakes Creek in 2017. 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, RBXWCT = phenotypic hybrid between rainbow trout and westslope cutthroat trout, LL = brown trout, SL COT = Slimy Sculpin.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower RM 1.3	WCT	14(14-16)	13	159	104-230	72
	BULL		1	86	86	6
	LL		3	117	112-120	16
	RBXWCT		1	115	115	6
Meadow RM 2.8	WCT	13(13-14)	15	121	62-217	48
	EB	16(15-20)	15	133	80-194	48
	BULL		1	151	151	4
Upstream of old bridge RM 4.6	WCT	21(21-23)	22	122	69-180	69
	EB		2	86	79-93	6
	SLCOT		8	73	47-95	25
Downstream of lower lake RM 7.2	WCT		3	130	122-136	23
	EB		9	105	66-160	69
	BULL		1	183	183	8
Upstream of upper lake RM 8.5	WCT	39(32-46)	26	120	47-307	57
	BULL	14(13-15)	20	88	32-157	43

Table 5. Electrofishing data collected on Foster Creek in 2017. 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, RB = rainbow 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	45(42-51)	43	150	34-305	51
RM 1.0	BULL	5(5-6)	5	173	162-180	6
	EB		3	110	62-138	4
	RB		5	122	103-143	6
	RBxWCT	28(28-29)	28	119	86-177	33
Middle	WCT	48(47-51)	50	106	70-223	78
RM 2.3	EB	6(6-6)	14	89	45-160	22
Upper	WCT	92(89-97)	103	123	50-212	84
RM 3.8	EB	18(18-20)	18	108	80-164	15
	RBXWCT		1	134	134	1

Table 6. Electrofishing data collected on Barker Creek in 2017. 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	40(38-45)	39	146	43-184	71
RM 0.5	WCT	15(15-16)	16	177	64-251	29
RM 1.5	BULL	30(29-34)	31	151	45-578	70
	WCT	13(13-14)	13	160	107-255	30

Table 7. Electrofishing data collected on Warm Springs Creek in 2017. 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, 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	135(120-153)	749	174	64-487	99
	RB		1	282	282	<1
	WCT		2	277	224-330	<1
Below Meyers Dam	LL	99(86-115)	563	193	68-408	86
	RBxWCT	2(1-8)	11	196	123-354	2
	RB	4(3-10)	25	185	110-385	4
	EB		6	126	59-162	1
	BULL	2(1-5)	16	236	174-494	2
	WCT	7(3-15)	31	190	102-344	5
Garrity WMA (Above Meyers Dam)	WCT	49(40-62)	225	165	45-343	59
	RBxWCT	20(16-27)	46	145	89-309	12
	LL	5(4-9)	49	196	75-340	13
	BULL	10(5-25)	30	220	108-430	8
	RB	4(3-8)	28	175	102-425	7
	EBxBULL	1(1-3)	1	224	224	<1
	EB		2	146	130-162	<1

Table 7 - Continued. Electrofishing data collected on Warm Springs Creek in 2017. 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, LL = brown 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)	42	148	76-256	70
	EB		9	165	95-349	15
	BULL		2	204	116-292	3
	LL		1	180	180	2
	SL COT		6	71	40-95	10
Below Upper Bridge RM 27.4	EB	26(25-30)	25	164	82-287	76
	WCT	7(7-8)	7	193	138-322	21
	EBxBULL		1	302	302	3
Below Confluence of Upper Forks	WCT	44(40-53)	40	148	92-215	98
	BULL		1	175	175	2
West Fork	WCT	24(24-25)	29	105	48-182	100

Cottonwood Creek and Tributaries

Four depletion estimates were conducted on five sections in 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. No depletion estimate was conducted at this section. WCT and EB numbers were similar in the upper section with WCT making up 52% of fish and EB accounting for 48%. There were many young of year EB in this section that were not included in the total numbers of fish present. RM COT were captured at the lower site and SL COT were captured at the upper site. In the Middle Fork of Cottonwood Creek, WCT made up 80% of fish and EB 20%. No other fish were observed in this section.

One section was surveyed on Baggs Creek with similar numbers of WCT (80) and EB (78) being handled. No other fish species were observed in this section. The lower section on Baggs Creek was not surveyed in 2017 due to lack of time and trouble getting a hold of the landowner for access.

Table 8. Electrofishing data collected on Cottonwood Creek in 2017. 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, COT = unidentified sculpin.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
School	LL	101(94-110)	127	150	47-335	95
RM 0.8	RM COT		7	117	102-138	5
Middle	LL		10	135	52-184	72
RM 3.0	EB		3	78	50-128	21
	COT		1	113	113	7
Upper	WCT	71(67-78)	71	105	65-201	52
RM 6.9	EB	67(65-71)	65	119	85-212	48
	RM COT		93	-	46-96	-
Middle Fork	WCT	115(110-122)	136	111	52-231	80
	EB	34(33-37)	33	109	80-213	20

Table 9. Electrofishing data collected on Baggs Creek in 2017. 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 (%)
RM 2.4	WCT	70(66-76)	80	115	66-246	51
	EB	64(60-70)	78	114	46-190	49

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 four sections of the Little Blackfoot River, LL were the most abundant trout species, accounting for 42-99 % of all 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. WCT were the most abundant trout species in the upper two sections making up 41-52% 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.

Two depletion estimates were done on Spotted Dog Creek. LL were the most abundant species in both sections making up 42-90% of fish. COT were present in both sections and were not used to calculate the species composition. LN SU and LS SU were present in the lower section. EB and LN SU were present in the both sections.

Table 10. Electrofishing data collected on the Little Blackfoot River in 2017. 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	77(70-85)	660	248	101-490	99
	WCT		4	306	255-332	1
Above N. trout Creek	LL	32(28-37)	316	212	101-405	94
	EB		4	199	122-259	1
	WCT	2(1-5)	15	284	230-344	5
Above Hwy 12 Bridge near Elliston RM 26.7	MWF	11(10-12)	32	328	272-380	15
	LL	35(33-36)	115	164	55-335	54
	WCT	10(10-11)	32	234	102-336	15
	EB	5(5-6)	22	118	64-229	11
	LN SU		11	133	84-256	5
Above Sunshine Camp	WCT	9(7-11)	17	138	73-280	30
	LL	13(9-17)	24	173	38-400	42
	MWF		3	297	270-330	5
	EB	3(2-4)	8	109	55-140	14
	LN SU		5	120	93-186	9
Below Ontario Creek RM 34.9	WCT	43(33-52)	53	120	64-278	52
	LL	42(13-70)	34	128	78-230	33
	MWF		6	207	110-287	6
	EB		9	109	90-139	9
Above Kading Campground RM 40.1	WCT	25(22-28)	49	135	67-218	41
	EB	23(19-27)	42	122	67-222	35
	LL	10(6-15)	19	145	72-293	16
	MWF	5(4-6)	10	155	85-251	8

Table 11. Electrofishing data collected on Spotted Dog Creek in 2017. 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.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
RM 1.1	LL	35(30-45)	45	235	79-380	90
	WCT		1	286	286	2
	LN SU		2	170	166-173	4
	EB		1	215	215	2
	LS SU		1	162	162	2
RM 4.6	WCT	5(4-6)	16	137	52-233	32
	LL	7(6-8)	21	216	162-307	42
	EB	4(3-5)	13	108	79-187	26

Flint Creek and Tributaries

Three mark-recapture and one depletion estimate were conducted on Flint Creek and four depletion estimates were conducted on Boulder Creek (Tables 12-13). In the four Flint Creek sections, LL comprised 98-99% 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 Chor section and RB in the upper three sections. RM COT were observed in only the lowest section. One BULL was captured in each of the lowest two sections.

LL were the most abundant fish in the lower two sections of Boulder Creek accounting for 49% and 58% of fish captured. BULL were present in all four sections and relatively abundant in the upper two sections making up 56% and 53% of fish captured. WCT were present in all four sections with their numbers being similar at each. Phenotypic EBXBULL hybrids were observed in the section at RM 6.5. One RBXWCT was observed at the RM 2.0 site and one EB was captured at the RM 6.5 site.

Table 12. Electrofishing data collected on Flint Creek in 2017. 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.

Section	Species	Population Estimate (Fish/Km)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Hall	LL	493(424-582)	442	267	170-517	99
	WCT		5	294	225-363	1
	BULL		1	284	284	<1
Johnson Tuning Fork	LL	340(286-414)	285	266	166-462	99
	RB	8(5-23)	8	282	205-400	3
	WCT	3(2-10)	3	310	299-318	1
	BULL		1	240	240	<1
Chor	LL	324(287-371)	348	269	163-537	97
	EB		6	229	165-293	2
	RB		1	345	345	<1
	WCT		2	329	308-350	<1
		(Fish/100m)				
Dam (Above Campground)	LL	39(34-49)	39	258	72-417	98
	RB		1	340	340	2

Table 13. Electrofishing data collected on Boulder Creek in 2017. 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	18(18-20)	18	177	81-382	49
	WCT	17(17-19)	17	185	85-326	46
	BULL		2	229	187-270	5
RM 2.0	LL	37(32-47)	32	163	99-369	58
	WCT	19(19-21)	21	159	73-330	38
	BULL		1	56	56	2
	RBXWCT		1	331	331	2
	BULL	43(36-54)	44	154	60-339	56
	WCT	22(22-23)	26	147	78-297	33

Princeton Bridge RM 6.5	EBXBULL		5	183	121-225	6
	LL		3	240	191-298	4
	EB		1	135	135	1
Copper Lakes Trailhead	BULL	17(17-18)	17	178	91-453	53
	WCT	13(13-14)	15	170	69-261	47

Harvey Creek

Only four of six estimate sections were completed on Harvey Creek in 2017 (Table 14). Access to the upper two sections was restricted due to wildfires. WCT made up 99-100 percent of trout in the lower four sections. BULL were present in the middle two sections. Sculpin were present in the lower four sections, but were not enumerated. Young of the year WCT were abundant in most sections.

Table 14. Electrofishing data collected on Harvey Creek in 2017. 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	28(27-32)	27	159	101-270	100
RM 1.2	WCT	41(39-45)	47	149	92-308	100
RM 1.6	WCT	74(70-81)	70	156	91-299	99
	BULL		1	244	244	1
RM 2.3	WCT	59(55-66)	71	134	47-305	99
	BULL		2	206	142-270	1
Below 8 Mile		Surveys not completed due to forest fires.				
Above FS Road		Surveys not completed due to forest fires.				

Microchemistry

Values of $^{87}Sr{:}^{86}Sr$, Sr:Ca and Ba:Ca measured in juvenile fish otoliths were highly correlated to measurements of these chemical markers in water samples taken near to their location of capture (Figure 6). The relationship of $^{87}Sr{:}^{86}Sr$ in water and otoliths was nearly 1:1. Values of Sr:Ca and Ba:Ca were lower in otoliths compared to corresponding water samples. Sr:Ca values in otoliths increased linearly with increasing water values, whereas Ba:Ca values displayed more of a logarithmic relationship.

Based on otolith chemistry, the DFA correctly classified individual juvenile fish to their location on capture for 79% of the samples (Table 15). Most of the errors occurred when fish were misclassified to other sites within the same stream where they were captured. For example, only one out of five (20%) of the fish captured at the middle site on Rock Creek was correctly classified to its capture site. The other four fish from this site were classified to the other sites with Rock Creek. Individual juvenile fish from the mainstem were correctly classified to their site of capture for 60-100% of the samples, but when errors occurred, the fish were misclassified to other mainstem sites. All of the individual fish from Cottonwood, Gold, Garrison Warm Springs, Lost, and Flint creeks were correctly classified to their capture sites. All of the hatchery fish were also correctly classified. Individuals from the three sites within Warm Springs Creek were correctly classified to their capture sites in 80-100% of the cases. Little Blackfoot River were correctly classified in 60-100% of the cases. Classification of Mill Willow Bypass fish had the lowest accuracy with only 17% of the fish correctly assigned to this area. Examining the variables produced by the DFA, the multivariate chemical signature of most tributaries were distinct from one another (Figure 7). Some sites with the same tributary were also distinct, particularly sites in Flint Creek and Warm Springs Creek. There was considerable overlap in the signatures of sites within Rock Creek. Mainstem sites also tended to overlap with each other and also overlapped with sites in Mill-Willow Bypass and Racetrack Creek.

Subadult and adult brown trout captured in the mainstem were assigned to natal areas in every tributary examined as well as natal areas within the mainstem itself (Table 16). None of the fish from unknown natal origin assigned to the hatchery. Overall, the most fish were assigned to natal areas in the mainstem, particularly in Reach A. Gold Creek contributed a greater percentage (17.7%) of the fish than any other natal area. The Mill-Willow Bypass and Rock Creek contributed 12.0% and 11.7% of the fish sampled. The Little Blackfoot River, Garrison Warm Springs, and Cottonwood Creek contributed the fewest fish of the tributaries at 1.3%, 0.7%, and 0.3%, respectively. When we examine recruitment sources for reaches A, B, and C, the overall pattern is that fish tended to be assigned to recruitment sources near their location of capture (Table 17). The largest recruitment sources for fish captured in Reach A were the mainstem of Reach A (32.8%), Mill-Willow Bypass (24.1%), and Warm Springs Creek (17.2%). For Reach B fish, Gold Creek was the largest recruitment source with 46.2% of the fish assigned to this tributary. Rock Creek was the largest source of Reach C fish (37.8%) followed by Flint Creek (17.8%). Most of the fish assigned to Rock Creek assigned to the most upstream site near Gilles Bridge, but the ability of the DFA to differentiate the sites within Rock Creek was limited.

Wild fish tissue burdens

We are currently awaiting lab results of the brown trout tissue burdens from Rock Creek. These data will serve as a control to compare tissue burdens from fish from the mainstem Clark Fork River. This analysis will be included in the comprehensive Upper Clark Fork River Basin Fisheries Monitoring Report.

Caged fish monitoring

The temperature logger at the I-90 bridge site failed, so no temperature data were not available from this site. Overall, moralities tended to occur on the descending limb of the hydrograph as water temperatures increased over 19°C (Figures 8-11). This is a pattern consistent with past caged fish studies in the UCFR. Water temperatures exceeded the upper critical temperature of 19°C for 74 days at Pond 2, 76 days at the Deer Lodge Waste Water Treatment Plant, and 80 days at Kohrs Bend. Water temperatures exceeded the upper incipient lethal temperature of 24.7°C for 1 day at Pond 2, 0 days at the Deer Lodge Waste Water Treatment, and 2 days at Kohrs Bend.

There were 49 mortalities at the Pond 2 site, 43 mortalities at the I-90 Bridge, 9 at the Deer Lodge Waste Water Treatment Plant, and 28 mortalities at Kohrs Bend. Metals tissue burdens were not analyzed for cage fish in 2017 because no remediation activities took place.

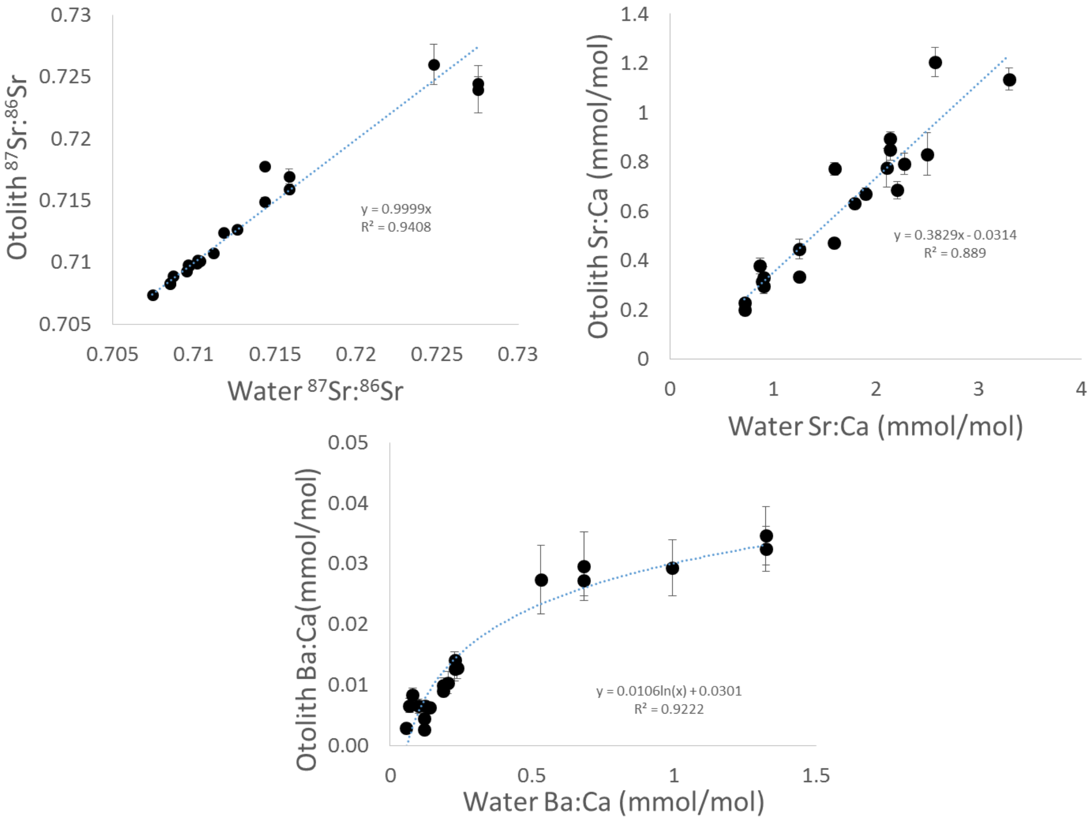

Figure 6. Average juvenile otolith $^{87}Sr:^{86}Sr$, Sr:Ca and Ba:Ca values (error bars are SD) from different sites throughout the Upper Clark Fork River basin compared to values from water samples collected at nearby locations. No water sample was collected in Cottonwood Creek, so data from in Cottonwood Creek are not included in this figure.

Table 15. Accuracy of discriminant function analysis to classify juvenile brown trout to the site from which they were captured based on otolith chemical profiles. Values in each cell are numbers of fish, except the rightmost column which is of the percent of fish captured at a site that were correctly classified to that site. Grey cells on the diagonal are fish correctly classified to their capture site. Site codes are: CF-A1, Clark Fork River Reach A #1; CF-A2, Clark Fork River Reach A #2; CF-B. Clark Fork River Reach B; CF-C, Clark Fork River Reach C; MWB, Mill-Willow Bypass; WS-U, Warm Springs Creek – Upper; WS-M, Warm Springs Creek – Middle; WS-L, Warm Springs Lower; LC, Lost Creek; RTC, Racetrack Creek; CW, Cottonwood Creek; LBF-U, Little Blackfoot River – Upper; LBF-M, Little Blackfoot River – Middle; LBF-L, Little Blackfoot River – Lower; GWS, Garrison Warm Springs; GC, Gold Creek; FC-U, Flint Creek – Upper; FC-M, Flint Creek – Middle; FC-L, Flint Creek – Lower; RC-U, Rock Creek - Upper; RC-M, Rock Creek - Middle; RC-L, Rock Creek – Lower; HAT, Big Springs Hatchery.

		Assigned																						
		CF-A1	CF-A2	CF-B	CF-C	MWB	WS-U	WS-M	WS-L	LC	RTC	CW	LBF-U	LBF-M	LBF-L	GWS	GC	FC-U	FC-M	FC-L	RC-U	RC-M	RC-L	HAT	%correct
Captured	CF-A1	4																							100
	CF-A2	1	6	1																					75
	CF-B			4	1																				80
	CF-C		1	1	3																				60
	MWB	2	2			1					1														17
	WS-U						4	1																	80
	WS-M							5																	100
	WS-L								5																100
	LC									5															100
	RTC			1		1					3														60
	CW											5													100
	LBF-U												6												100
	LBF-M													3	2										60
	LBF-L													1	4										80
	GWS															4									100
	GC																7								100
	FC-U																	5							100
	FC-M																		5						100
	FC-L																			4					100
	RC-U																				2		2		50
	RC-M																				1	1	3		20
	RC-L																					2	3		60
	HAT																							4	100
	Total	7	9	7	4	2	4	6	5	5	4	5	6	4	6	4	7	5	5	4	3	3	8	4	**79**

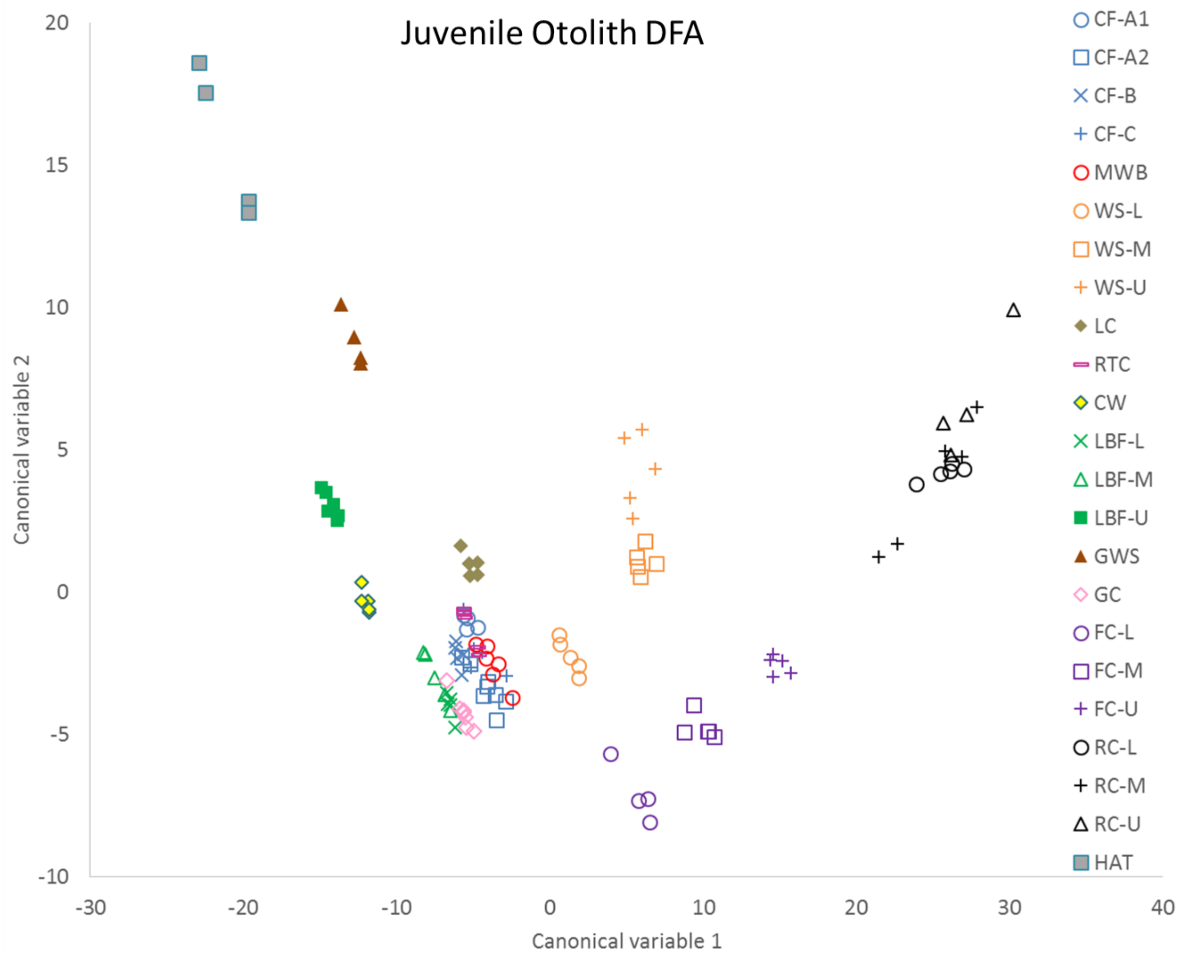

Figure 7. Results of discriminant function analysis used to characterize multivariate chemical signatures of juvenile brown trout otoliths. Data points are individual fish. Data points of the same color are from the same stream. Data points of the same color and shape are from the same site. Site codes are: CF-A1, Clark Fork River Reach A #1; CF-A2, Clark Fork River Reach A #2; CF-B. Clark Fork River Reach B; CF-C, Clark Fork River Reach C; MWB, Mill-Willow Bypass; WS-U, Warm Springs Creek – Upper; WS-M, Warm Springs Creek – Middle; WS-L, Warm Springs Lower; LC, Lost Creek; RTC, Racetrack Creek; CW, Cottonwood Creek; LBF-U, Little Blackfoot River – Upper; LBF-M, Little Blackfoot River – Middle; LBF-L, Little Blackfoot River – Lower; GWS, Garrison Warm Springs; GC, Gold Creek; FC-U, Flint Creek – Upper; FC-M, Flint Creek – Middle; FC-L, Flint Creek – Lower; RC-U, Rock Creek - Upper; RC-M, Rock Creek - Middle; RC-L, Rock Creek – Lower; HAT, Big Springs Hatchery.

Table 16. Natal area assignment results of brown trout captured in seven sections of the mainstem Upper Clark River. Numbers of fish from each mainstem capture sections assigned to different natal areas are presented as well as total numbers of fish assigned to each natal area and natal stream. The percentage of the total number of fish assigned to natal streams is also presented. Capture section codes are: PH, pH Shack; SL, Sager Lane; WT, Williams Tavenner; PE, Phosphate; MR, Morse Ranch; BM, Bearmouth; BT, Beavertail. Natal site codes are: CF-A1, Clark Fork River Reach A #1; CF-A2, Clark Fork River Reach A #2; CF-B. Clark Fork River Reach B; CF-C, Clark Fork River Reach C; MWB, Mill-Willow Bypass; WS-U, Warm Springs Creek – Upper; WS-M, Warm Springs Creek – Middle; WS-L, Warm Springs Lower; LC, Lost Creek; RTC, Racetrack Creek; CW, Cottonwood Creek; LBF-U, Little Blackfoot River – Upper; LBF-M, Little Blackfoot River – Middle; LBF-L, Little Blackfoot River – Lower; GWS, Garrison Warm Springs; GC, Gold Creek; FC-U, Flint Creek – Upper; FC-M, Flint Creek – Middle; FC-L, Flint Creek – Lower; RC-U, Rock Creek - Upper; RC-M, Rock Creek - Middle; RC-L, Rock Creek – Lower; HAT, Big Springs Hatchery.

Natal Area		**Capture section**							**Natal area total**	**Natal stream total**	**Natal Stream %**
		Reach A			**Reach B**		**Reach C**				
Stream	*Site*	**PH**	**SL**	**WT**	**PE**	**MR**	**BM**	**BT**			
Clark Fork River	CF-A1	9	13	4	1	8	8	3	46	87	29.1%
	CF-A2	3	1	8	2	3			17		
	CF-B			4	3	4	2		13		
	CF-C	1		7	2		1		11		
Mill-Willow Byp.	MWB	10	14	4	4	1	2	1	36	36	12.0%
Warm Springs Ck.	WS-L	11	6	3	2			1	23	23	7.7%
	WS-M								0		
	WS-U								0		
Lost Ck.	LC	1			3	2	1	5	12	12	4.0%
Racetrack Ck.	RTC	1	4	6	3	3	3	3	23	23	7.7%
Cottonwood Ck.	CW		1						1	1	0.3%
Little Blackfoot R.	LBF-L							1	1	4	1.3%
	LBF-M			3					3		
	LBF-U								0		
Garrison-Warm Sp.	GWS				2				2	2	0.7%
Gold Ck.	GC			1	26	17	7	2	53	53	17.7%
Flint Ck.	FC-L		1			5	8	1	15	23	7.7%
	FC-M					1	2	1	4		
	FC-U						1	3	4		
Rock Ck.	RC-L						1	5	6	35	11.7%
	RC-M						4	4	8		
	RC-U					1	7	13	21		
Hatchery	HAT								0	0	0%
Capture section total		36	40	40	48	45	47	43			

Table 17. Results of brown trout natal area assignment summarized by reach in which the fish was captured. Refer to Table 16 for natal site codes.

Natal area		**Capture reach**		
Stream	*Site*	**A**	**B**	**C**
Clark Fork R.	CF-A1	22.4%	9.7%	12.2%
	CF-A2	10.3%	5.4%	
	CF-B	3.4%	7.5%	2.2%
	CF-C	6.9%	2.2%	1.1%
Mill-Willow Byp.	MWB	24.1%	5.4%	3.3%
Warm Springs Cr.	WS-L	17.2%	2.2%	1.1%
	WS-M			
	WS-U			
Lost Cr.	LC	0.9%	5.4%	6.7%
Racetrack Cr.	RTC	9.5%	6.5%	6.7%
Cottonwood Cr.	CW	0.9%		
Little Blackfoot R.	LBF-L			1.1%
	LBF-M	2.6%		
	LBF-U			
Garrison-Warm Sp.	GWS		2.2%	
Gold Cr.	GC	0.9%	46.2%	10.0%
Flint Cr.	FC-L	0.9%	5.4%	10.0%
	FC-M		1.1%	3.3%
	FC-U			4.4%
Rock Cr.	RC-L			6.7%
	RC-M			8.9%
	RC-U		1.1%	22.2%
Hatchery	HAT			

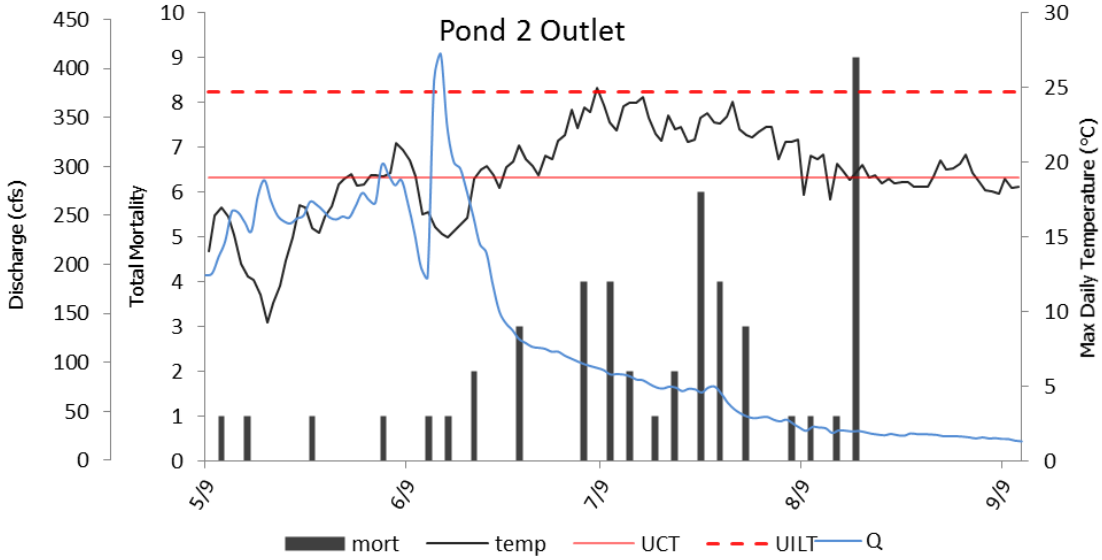

Figure 8. Total fish mortalities, maximum daily water temperature, and mean daily discharge for Silver Bow Creek at the outlet of Pond 2. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

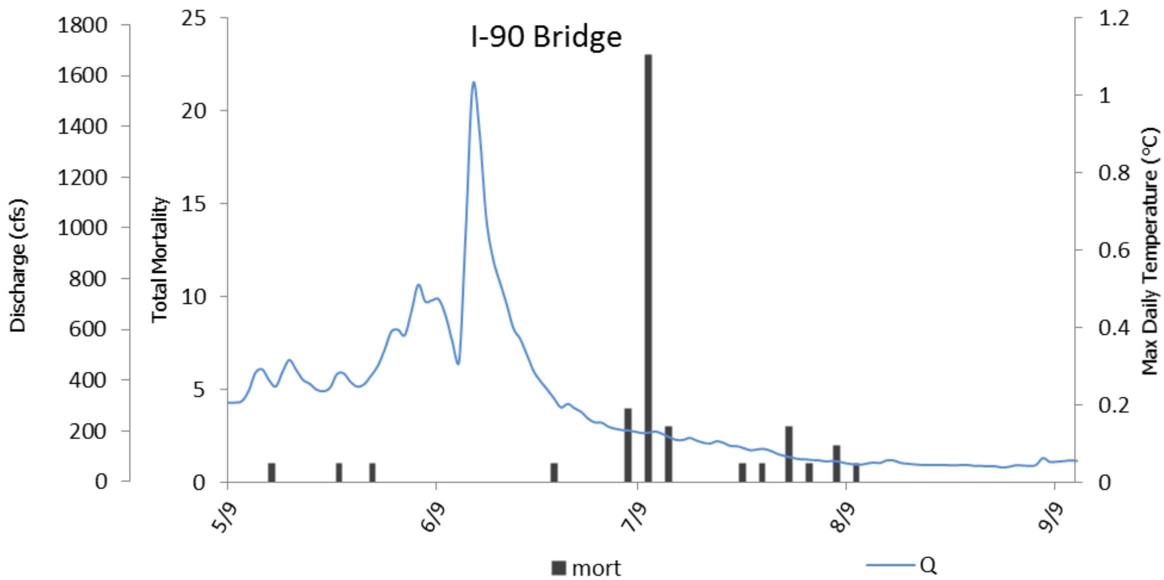

Figure 9. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the I-90 Bridge site. The temperature recorder at this site failed so no temperature data are available.
3

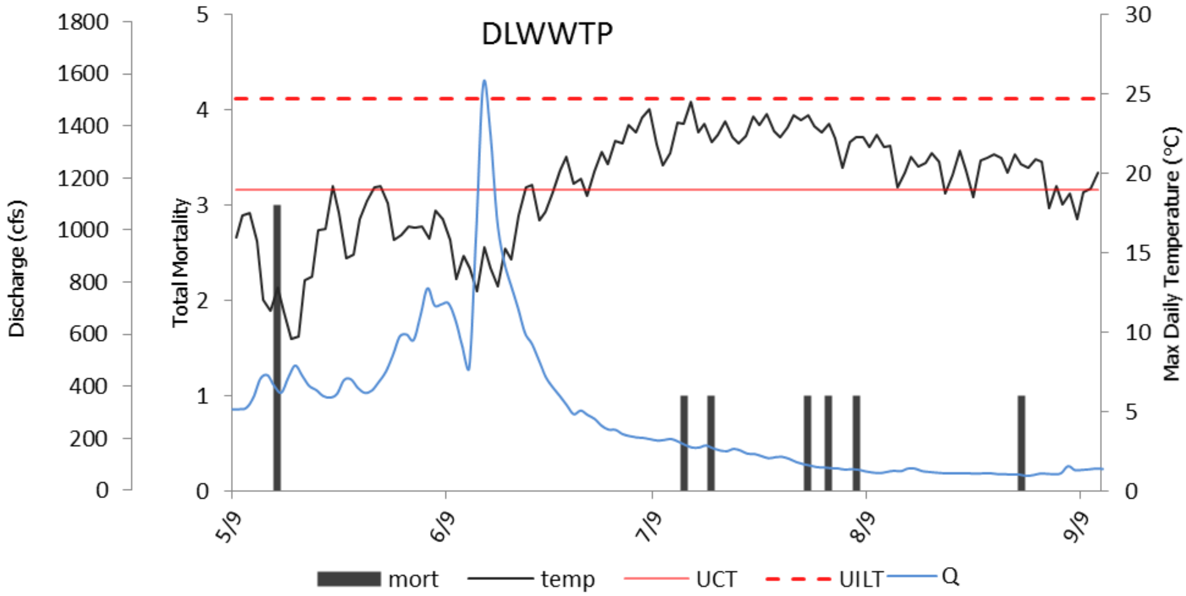

Figure 10. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the Deer Lodge Waste Water Treatment Plant site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

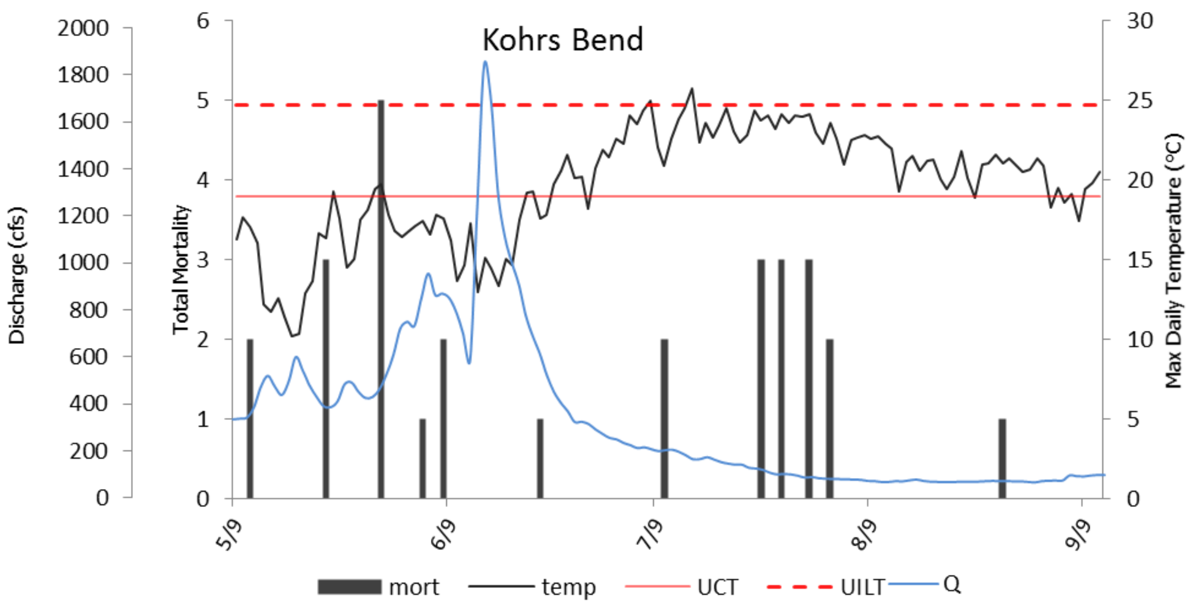

Figure 11. Total fish mortalities, maximum daily water temperature, and mean daily discharge for the Kohrs Bend site. The solid red line indicates the upper critical temperature threshold and the dashed red line represents the upper incipient lethal temperature for brown trout.

Water quality

Measurements of pH during the month of August and in early September at the Pond 2 site routinely exceeded 10 (Figure 12). The hydrolab at the Pond 2 site was temporarily moved to the Mill-Willow Bypass on 8/1 to accommodate maintenance on the dam and outlet. At the other sites studied in 2017, pH ranged from 7.4 to 9.0. Daily variations at the Pond 2 site were lower than at the other sites. As would be expected, pH at all sites increased during the day and decreased at night due to changes in photosynthetic activity. The hydrolab sensor failed at the Deerlodge Treatment plant on 8/13/18, so data after this date were not available.

Dissolved oxygen (DO) values at the six sites ranged from 4.2 to 14.7 mg/l (Figure 13). Lowest DO occurred at night and highest during the day. Daily minimum DO at the Racetrack site approached the minimum aquatic life standard of 4 mg/L , but did not dip below this value. Daily variations in DO were largest at the Racetrack site, suggesting significant biologic activity in the Clark Fork River upstream of this site.

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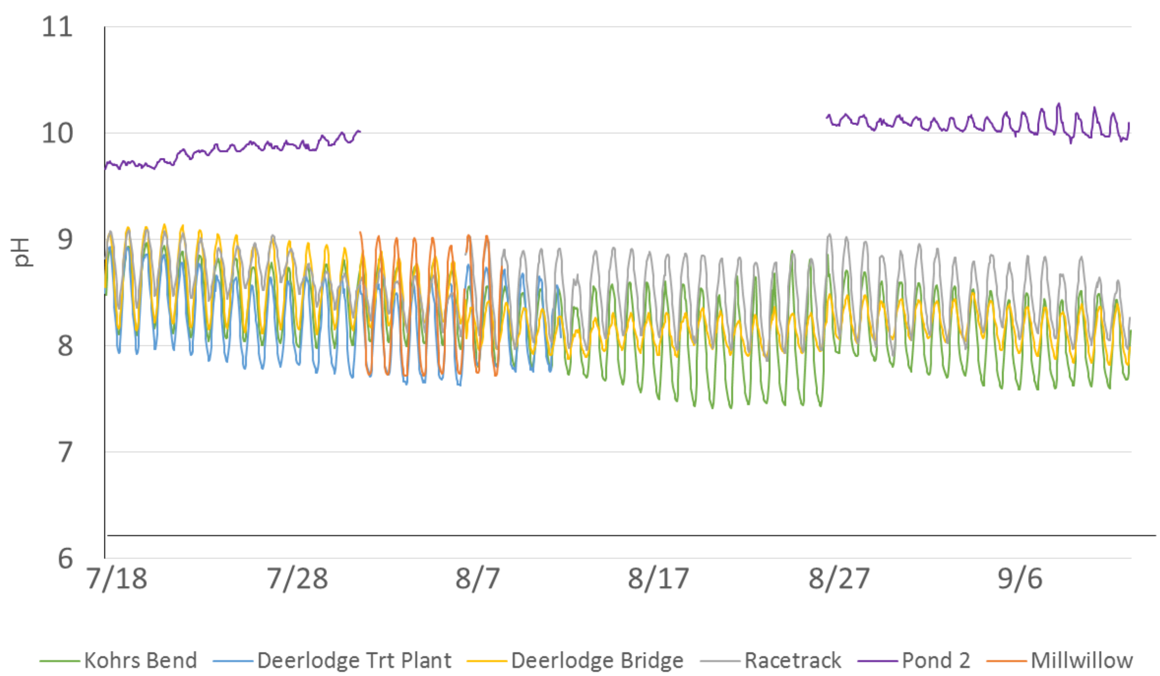

Figure 12. Hydrolab measurements of pH at six sites in the Upper Clark Fork River during 2017. The hydrolab at the Pond 2 site was temporarily moved to the Mill-Willow Bypass on 8/1 to accommodate maintenance activities on the Pond 2 outlet structure.

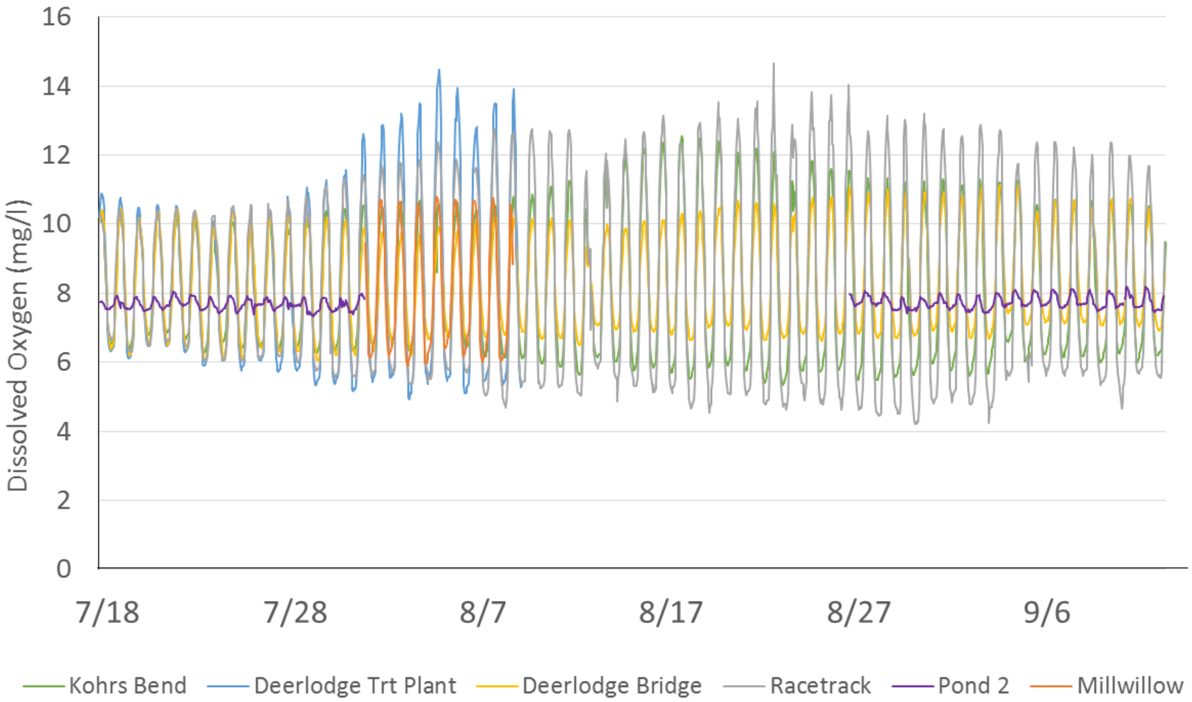

Figure 13. Minimum daily dissolved oxygen (DO) concentrations at 2016 caged fish sites. The red dashed horizontal line denotes the freshwater ALS minimum DO. Gaps in the graph indicate missing data due to instrument failures and calibration.

Discussion

Brown trout numbers at the two most upstream population estimate sections have been relatively low in recent years. Brown trout population estimates in 2017 at the pH Shack section of the Upper Clark Fork River were the lowest recorded since 2009. At the Below Sager Lange section, brown trout numbers were the lowest ever observed since annual population estimates began in 2010. Continued drought-like conditions during the summer months appear to be negatively impacting the brown trout population in the upper reaches of the Clark Fork River. 2017 was the last of a three year effort to produce annual population estimates at more than 75 sections in 18 tributaries. Fish population data from these three years will be compiled with any past data and presented in a comprehensive report (Cook et al. 2018).

Brown trout numbers in 2017 continued to be low in the two most upstream sections of the Clark Fork River that have been sampled every year. This is in contrast to brown trout numbers at the more downstream stations which were at, or even slightly above, average. Brown trout numbers in the upstream reaches of the Clark Fork River are related to flow conditions in the the years leading up to the population estimate. For instance, increases in numbers in 2013 and 2014 were due to due strong year classes from 2010 and 2011, which were good water years

(Figure 14). The higher flows during these years may have provided additional spawning and/or rearing habitats that are not are not available at lower flows. 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). 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 toxicity of heavy metals such as Cu.

Population estimates have been conducted at the 77 tributary sampling sections in this study in 2015, 2016, and 2017. However, two of the sections could not be sampled in 2017 due to wildfires and one other could not be sampled because the landowner could not be reached to gain access. Overall, these tributary sampling events will provide valuable baseline data that can be used to evaluate future restoration actions in the UCFRB. Tributary fish population data from all three years will be summarized in a comprehensive report in 2018.

Otolith microchemistry proved to be a useful tool for quantifying recruitment sources in the UCFRB. The assignment model based on measurements of otolith ^{87}Sr:^{86}Sr, Sr:Ca and Ba:Ca ratios had good power to assign fish to natal tributaries, and in some cases, to specific sites. Adult and subadult brown trout in the mainstem Clark Fork River tended to come from natal areas near their location of capture. This general lack of movement is consistent with telemetry data (Mayfield 2013) that showed that Clark Fork River do not move around very much, except during spawning season. Mainstem natal areas, including the Mill-Willow Bypass, are major sources of brown trout recruitment to the upstream reaches of the Clark Fork River. Fish from as far downstream as Beavertail were assigned to natal areas in Reach A and the Mill-Willow Bypass, indicating the importance of the recruitment of upstream natal areas to downstream reached of the Clark Fork River. Reach A has the highest concentrations of metal contamination, is the most impacted by low water during irrigation, and brown trout in this reach also have the highest mortality (Mayfield 2013, Coot et al. 2015). Despite these limiting factors, enough young brown trout this area of the Clark Fork River survive to make a significant contribution to the populations.

The main sources of brown trout recruitment to Reach A are natal areas within the mainstem. This is in contrast to the main sources for reaches B and C which are natal areas within tributaries. Gold Creek was the single largest recruitments source, contributing 18% of all the brown trout sampled in this study and 46% of the brown trout from Reach B. Gold was also a major source of fish for Reach C, as well. Rock Creek was the largest source of fish to Reach C, contributing 22% of the fish in that reach. Flint Creek was also a major contributor of fish to Reach C, again highlighting the importance of local tributary sources of trout recruitment. Similarly, the largest tributary source of recruitment to Reach A was Warm Springs. Therefore, tributaries such as Gold Creek, Rock Creek, Flint Creek, and Warm Springs should be high priority areas for restoration activities that can maintain or enhance the capacity of these streams to provide trout to the mainstem.

Only 4 of the 299 (1.3%) mainstem brown trout analyzed in the microchemistry study assigned to natal areas within the Little Blackfoot River. This number is surprisingly low considering that the Little Blackfoot River was the most common tributary spawning destination for brown trout that were radio tagged in the mainstem Clark Fork River (Mayfield 2013). Although it is common for adults to move from the Clark Fork River to the Little Blackfoot River to spawn, it is uncommon for their progeny, or the progeny of resident Little Blackfoot River spawners, to survive moving into the Clark Fork River. It is possible that there are habitat limitations that prevent fish from outmigrating from the Little Blackfoot River such as irrigation diversions.

No remediation related construction occurred in 2017, but caged fish monitoring was still conducted. Fish cages have been placed at the outlet of Pond 2 annually from 2011-2017. Fish at the Pond 2 site experienced the highest mortality of all fish cages sites in 2017. From year to year, fish in the Pond 2 fish cages consistently have high mortality rates compared to other locations in the UCFRB (Cook et al. 2014). Brown trout (both caged and free-ranging) immediately downstream of the Warm Springs Ponds tend to have relatively low metals concentrations compared to locations near Deer Lodge and upstream of the Little Blackfoot River. Therefore, toxicity of metals does not appear to be a primary driver of high fish mortality immediately below the Warm Springs Ponds. Other likely culprits include high summer water temperatures combined with high pH. A laboratory study found high mortality (> 81%) of rainbow trout exposed to water with pH above 8.4 and temperatures above 20°C (Wagner et al. 1997), conditions that are exceeded every year downstream of the Warm Springs Ponds.

Dissolved oxygen monitoring indicated that DO concentrations did not go below the minimum aquatic life standard of 4 mg/L at any of the six locations. In 2016, DO at the Racetrack site dipped below the ALS during 14 nights in 2016, reaching concentrations as low as 2.9 mg/L. In 2017, DO at the Racetrack site approached 4 mg/L on several occasions during August and September. Large daily variation in DO at the Racetrack site (Figure 13) are driven by biological activity as photosynthesis leads to an increase in DO during the day and respiration depletes DO at night. Dissolved oxygen should be continued to be monitored at Racetrack as the biological community continues to adjust to completed remediation and restoration activities in this area of the Clark Fork River.

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 2017). 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.

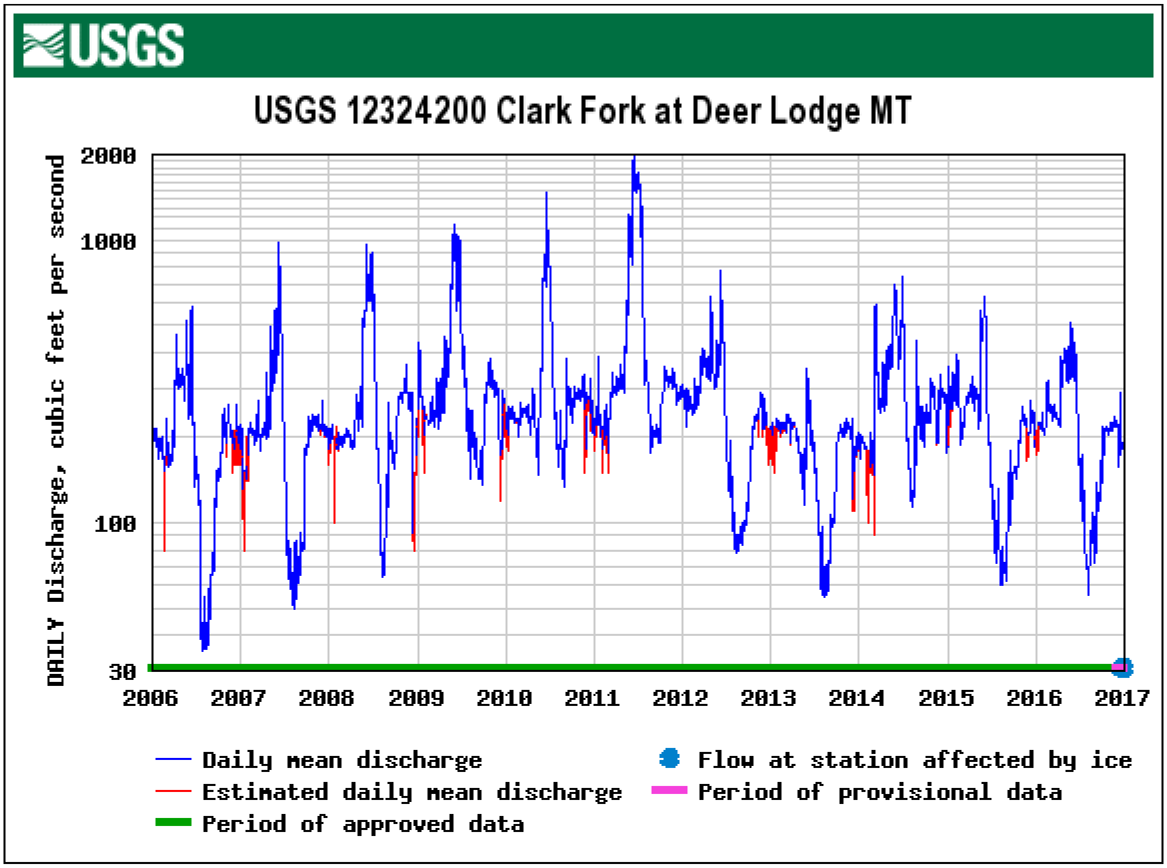

Figure 14. USGS hydrograph from the Clark Fork River gauge at Deer Lodge.

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Fisheries Monitoring in the Silver Bow Creek and Tributaries
2017 Report

Prepared by:
Nathan Cook, Tracy Elam, and Jason Lindstrom

Introduction

Contamination from Butte Area mines resulted in severe contamination of Silver Bow Creek and impacts to the residing aquatic community. Remediation activities such as groundwater treatment and streamside tailings removal have improved water quality in Silver Bow Creek, reducing concentrations of metals such as Cu and Zn (Naughton 2013). Trout have recently began to recolonize 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.

Although fish were once extirpated in portions of the mainstem Silver Bow Creek, population persisted in tributaries of the basin. These tributaries currently provide trout spawning habitat and cool water refuges during summer months. Westslope cutthroat trout avoid hypoxia in the mainstem, historically caused by nutrient releases from the Butte waste water treatment plan, by moving into the tributaries (Naughton 2013). Westslope have been observed moving from tributaries back to the mainstem in the fall and winter, after hypoxia subsides. Recent improvements to the wastewater treatment plant have reduced nutrient loading in Silver Bow Creek, which should reduce the severity and duration of hypoxic events. Tributaries of Silver Bow Creek are clearly important habitats for trout, and are also important for non-trout species such as suckers (*Catostomus* sp.) as well. FWP has recognized the importance of monitoring tributaries to understand the status, trends, and overall characteristics of the Silver Bow creek watershed fish community. To accomplish this in the past, sporadic electrofishing surveys were conducted throughout the basin. In 2014, an intensive electrofishing monitoring effort was initiated in which established sampling sections are sampled each year. This monitoring program was conducted for three years. This tributary monitoring combined with bi-annual sampling in the mainstem of Silver Bow Creek provides valuable information on the status of fish populations as the fish community continues to adjust to improvements in water quality.

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 23 (95% CI = 17-36) EB and 21 (95% CI = 20-24) WCT per 100m at the Fairmont section and 7 (95% CI = 6-8) EB and 16 (95% CI = 15-17) 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 three sections based on the October sampling (Table A2). These October estimates were 10 (95% CI = 10-11) WCT in the Fairmont section, 7 (95% CI = 6-8) WCT Below German Gulch, 3 (95% CI = 3-4) WCT per 100m at Ramsay. Total fish numbers in August were generally higher than fish numbers in October. In the three sections below German Gulch, trout numbers decreased from August to October. In the three sections above German Gulch, trout numbers increased over the same time period. It appears that trout are seeking thermal refuge below German Gulch in the summer and disperse when water temperatures above German Gulch decrease in the fall. RM COT numbers declined significantly from August to October at four of six sections. The other two sections (Ramsay and Rocker) had less significant changes in fish numbers from the summer to fall sampling events Seasonal patterns in non-trout species were less clear.

In Blacktail Creek, Eastern brook trout (EB) were the most abundant trout species in four of the seven sections and westslope cutthroat trout (WCT) were most abundant in the upper three sections (Table B). In the sections where EB were most abundant, they accounted for 72-94% of the fish captured in the section. WCT made up 54-79% percent of the catch in the sections where they were dominant. EB were present in all seven sections while WCT were present in the lowest and upper four sections. LN SU were observed in the lower four sections, RM COT in the lower two, and CM MN were observed in the lower three reaches.

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 21-84% of the species present. In the upper three sections EB accounted for 84-94% percent of fish present. WCT were present in all six sections but in small numbers compared to EB. RM COT were present in two of the lower four sections and were the abundant species in the lower section. LNSU were sampled in two of 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 77-100% 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 were the most common fish at both sampling sections in Beefstraight Creek, accounting for 70-72% of fish captured (Table E). EB were also present in both sections No non-trout species were observed in either section.

Table A1. Electrofishing data collected on Silver Bow Creek in August 2017. 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, 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		80			46
	LN SU	17(14-21)	46	156	102-230	26
	EB		6	250	223-280	3
	RB		5	69	59-75	3
	RS SH		16	90	60-120	9
	LS SU	8(6-13)	19	166	150-186	11
	WCT		2	267	238-295	1
Fairmont	RM COT		207			55
	EB	23(17-36)	56	130	58-273	15
	LN SU	4(4-6)	13	154	104-192	3
	WCT	21(20-24)	94	148	46-320	25
	RS SH		1			<1
	RB		2	319	206-432	<1
Below German Gulch	RM COT		145			55
	LN SU	4(3-10)	11	114	100-139	4
	WCT	16(15-17)	61	175	103-325	23
	EB	7(6-8)	48	77	47-251	18
	RB		1	358	358	<1
Ramsay	LN SU		90	100	36-172	71
	WCT		1	200	200	1
	RM COT		35			28
Rocker	LN SU		50	108	40-204	94
	RM COT		2	106	100-111	4
	WCT		1	279	279	2
LAO	LN SU		1	108	108	<1
	EB		1	317	317	<1
	WCT		2	243	240-245	<1
	RM COT		270			99

Table A2. Electrofishing data collected on Silver Bow Creek in October 2017. 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	RM COT		4	70	52-88	20
1 Bridge	LN SU		3	166	164-170	15
	EB		2	201	158-243	10
	RB		4	133	110-152	20
	WCT		4	245	177-303	20
	LS SU		3	224	210-237	15
Fairmont	RM COT		8	76	44-98	7
	EB		9	163	93-271	8
	LN SU	25(13-53)	46	177	53-245	39
	WCT	10(10-11)	33	231	84-455	28
	RB		9	131	82-219	8
	RS SH		11	93	70-105	9
	LS SU		2	190	183-196	2
Below	RM COT		21	71	47-115	41
German	WCT	7(6-8)	28	160	56-295	55
Gulch	EB		1	138	138	2
	LN SU		1	44	44	2
Ramsay	LN SU	6(5-7)	27	97	39-144	44
	EB		1	212	212	2
	WCT	3(3-4)	10	274	137-450	16
	RM COT		23	93	54-117	38
Rocker	LN SU		96	80	35-235	89
	RM COT		8	70	61-82	7
	EB		1	204	204	1
	WCT		3	278	240-320	3
LAO	RM COT		20	89	54-115	54
	LN SU		5	125	63-204	14
	EB		5	209	118-289	14
	WCT		3	280	262-303	8
	LN DC		4	107	58-128	10

Table B. Electrofishing data collected on Blacktail Creek in 2017. 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	75(72-78)	207	151	54-338	76
	LN SU	17(16-19)	44	129	51-264	16
	RM COT	8(8-9)	20	97	68-170	7
	CM MN		1	105	105	<1
	WCT		1	231	231	<1
Golf Course Butte C.C.	EB	171(168-176)	259	123	55-260	87
	LN SU	13(13-15)	13	165	117-227	4
	RM COT		25	84	67-132	8
	CM MN		1	92	92	<1
Above Blacktail Loop	EB	48(46-53)	74	115	55-205	94
	LN SU		3	87	60-106	4
	WCT		1	206	206	1
	CM MN		1	62	62	1
Below 9 Mile	EB	95(85-107)	86	132	59-220	72
	WCT	31(31-33)	31	159	81-263	26
	LN SU		3	198	195-202	2
Above 9 Mile	EB	22(22-24)	27	117	80-172	46
	WCT	19(19-20)	32	100	57-192	54
Upper Thompson	WCT	50(44-61)	48	115	58-250	59
	EB	34(33-37)	33	139	104-202	41
Upper Forest Service	WCT	14(14-15)	62	59	40-124	79
	EB	14(11-26)	16	94	61-140	21

Table C. Electrofishing data collected on brown's Gulch in 2017. 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.

Section	Species	Population Estimate (fish/100m)	# Fish Handled	Mean Length (mm)	Length Range (mm)	Species Composition (%)
Lower Ueland RM 2.6	EB	11(11-12)	14	189	73-306	21
	LN SU	9(9-10)	14	104	56-173	21
	WCT		2	264	258-269	3
	RM COT		37	90	75-123	55
Upper Ueland RM 5.3	EB		4	195	180-230	67
	WCT		2	247	224-270	33
Brothers Ranch RM 9.7	EB	71(66-79)	91	118	33-251	84
	LN SU	10(9-16)	9	158	126-280	8
	WCT	9(9-10)	9	167	87-212	8
Balentine RM 11.5	EB	119(116-128)	107	138	54-232	84
	WCT	12(12-13)	11	140	86-226	9
	RM COT		9	87	64-113	7
Lower Forest Service RM 13.8	EB	36(35-39)	40	123	36-185	89
	WCT		5	101	70-175	11
Upper Forest Service RM 15.3	EB	105(97-116)	101	116	42-185	94
	WCT	7(7-8)	7	127	105-171	6

Table D. Electrofishing data collected on German Gulch in 2017. 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	94(89-99)	172	111	61-316	79
	EB	16(16-18)	46	110	50-305	21
RM 3.0	WCT	108(105-113)	144	89	58-178	77
	EB	34(34-35)	43	109	41-200	23
RM 6.0	WCT	16(16-17)	24	111	58-171	100

Table E. Electrofishing data collected on Beefstraight Creek in 2017. 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	64(63-66)	148	125	60-273	70
	EB	37(36-41)	64	115	80-191	30
Below Spring Creek Trail Crossing RM 4.5	WCT	70(70-72)	72	107	54-207	72
	EB	28(28-30)	31	93	53-165	31

Discussion

In August when water temperatures were at their highest, 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 262 to 80 between August and October. Overall trout numbers for the other four sections increased from 18 to 33 from August to October. It appears that trout may have been seeking thermal refuge immediately downstream of German Gulch in August and dispersed to the rest of Silver Bow Creek after water temperatures cooled in the fall. 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 potentially water quality, strongly influence salmonid distribution in Silver Bow Creek.

No trout population estimates for Silver Bow Creek were available prior to 2015. Fish sampling had occurred in Silver Bow Creek prior to 2014, 5ut past sampling had focused on relative abundance, expressed as fish captured per unit time or length of stream (e.g., Lindstrom 2012, Naughton 2013). In the past, low fish densities made it difficult to obtain reliable population estimates. 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. Annual population estimates are now available for six sections of Silver Bow Creek from 2014-2017. Some sections have population estimates for summer and fall each year. The mainstem population estimates from all three years, and sampling data from tributaries as well, will be summarized in a comprehensive report. Remedial activities in the Silver Bow Creek have improved habitat conditions for trout and other fish taxa. As the abundance and distribution of fishes continue to change in response to improvements in habitat and water quality, comprehensive fisheries monitoring data will be critical to document and evaluate these changes.

References

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Appendix: Electrofishing section lengths, estimate types, and locations

Table I. Locations for monitoring sections on Baggs Creek in 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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 2017.

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