An Inventory of Irrigation Structures in the Upper Clark Fork River Drainage, Montana

2010 Annual Progress Report
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Cover photograph: Irrigation ditch (diverted from Lost Creek, Montana at RM 7.6) on private grazing land near Warm Springs, Montana.

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Introduction

Agriculture is a prevailing economic presence in the western United States. In Montana alone, the market value of agriculture is nearly $2 billion per year (Christensen 2005). Given the arid nature of Montana summers, it is often necessary to divert water from rivers and streams to support agriculture. The operation of irrigation structures such as ditches can have dramatic effects on the health of these systems by entraining resident fishes and de-watering the stream channel. In western Montana, native fishes such as westslope cutthroat trout *Oncorhynchus clarki lewisi* and the federally threatened bull trout *Salvelinus confluentus* are likely at high risk for entrainment into irrigation ditches due to their migratory life histories. These species are especially at risk as post-spawn adults and juveniles out-migrating from spawning or rearing tributaries (Bahn 2007). Also, due to the thermal sensitivity of bull trout and westslope cutthroat trout, elevated stream temperatures accompanying channel de-watering are likely to impact these species.

In 2009, Montana Fish, Wildlife & Parks (MFWP) received a grant from the U.S. Fish and Wildlife Service (USFWS) on behalf of the Fisheries Restoration and Irrigation Mitigation Act (FRIMA) to survey the Upper Clark Fork River Basin's irrigation systems. The objectives of this study were to:

1. Inventory diversions on prioritized tributaries in the Upper Clark Fork River Basin to aid in the development of fish passage/screening plans.
2. Provide recommendations for site-specific passage and entrainment solution options for prioritized streams.
3. Design, plan, and implement, as appropriate, identified fish passage and screening projects as funds become available via the accepted FRIMA proposal and ranking process and/or from other funding sources.

The area chosen for this study includes the Clark Fork River and its tributaries from the headwaters of Silver Bow Creek downstream to its confluence with Rock Creek near Clinton, MT (Figure 1). This includes major agricultural regions such as the Deer Lodge and Flint Creek valleys, as well as the Rock Creek valley, which is less impacted by agriculture and irrigation, but contains high populations of native fish species such as bull trout and westslope cutthroat trout. Irrigation structures inventoried for this study were chosen based on their presumed impact on the overall Clark Fork River fishery, as well as their suspected entrainment of native fish species.

This report incorporates data collected intensively in 2009 and 2010, as well as past sampling efforts from 2007 and 2008. This report is assembled in a similar manner to the Annual Progress Report submitted in 2009, including a prioritization list of critical diversions.

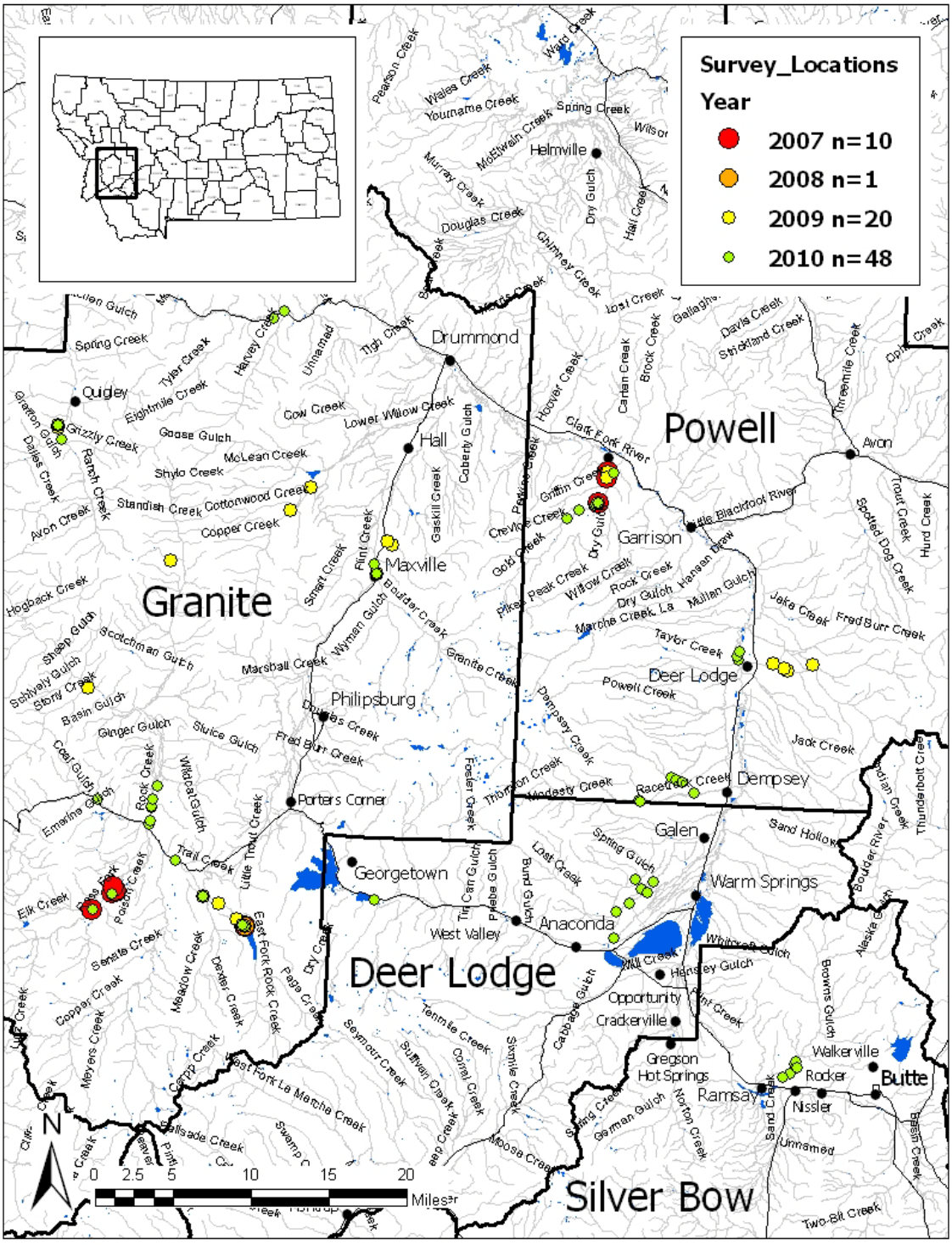

Figure 1. Survey locations within the Upper Clark Fork River Basin by year.

Methods

Irrigation Structures

Brief descriptions of the diversion and headgate styles observed at each location were recorded. This information will be useful for future planning and mitigation. During this inventory common diversion styles included gravel and boulder berms or pin and plank structures, and common headgate styles included Waterman C-10 slide gates, Waterman R-5 slide gates, and wooden gates with stopboards (See MDNRC 2001). Waterman C-10 headgates are prefabricated metal structures, adjustable with screw-down gates, and R-5 headgates are similar in construction, but are unable to seal, therefore allowing leakage past the gate when closed.

Fish Sampling

Electrofishing was used to collect fishes at the sample sites. The focus was to obtain information on the composition of fish species entrained in the ditches. In most situations, a single 100 m (unless length restricted by de-watering or access) electrofishing pass was performed. This provided information on species composition, length frequency, and catch-per-unit-effort (CPUE). Most ditches were electrofished for 100 m downstream from the headgate. At several sites, the high turbidity in the ditch resulted in poor visibility and it was more effective to sample in an upstream direction. In these instances, either a block net was placed at the upstream end of the section and a single upstream pass was made, or the headgate functioned as a barrier and no block net was installed. On certain ditches multiple electrofishing sections were selected farther downstream to further document entrainment. Additionally, in ditches expected to contain high densities of entrained fish, multiple-pass depletions were conducted to generate fish population estimates with confidence intervals. In these situations, block-nets were used, multiple passes were made through the section, and captured fish were removed and placed aside in live-cars. After all passes were completed, the fish were measured and population estimates were calculated using the maximum likelihood estimator provided by Montana Fish, Wildlife & Parks' FA+ fisheries analysis software.

Fishes were collected with a Smith-Root LR-24 Electrofisher. At each site, captured fish were identified to species, weighed, measured and released. All fish data were recorded on standard MFWP electrofishing data sheets using MFWP species abbreviations. These abbreviations are also used in the tables presented in the results section. Below are the abbreviations and the species they represent.

BULL = bull trout
EB = brook trout *Salvelinus fontinalis*
LC SU = largescale sucker *Catostomus macrocheilus*
LL = brown trout *Salmo trutta*
LNSU = longnose sucker *Catostomus catostomus*
LN DC = longnose dace *Rhinichthys cataractae*
MWF = mountain whitefish *Prosopium williamsoni*

ONC = unidentifiable *Oncorhynchus* species
RB = rainbow trout *Oncorhynchus mykiss*
RS SH = redside shiner *Richardsonius balteatu*
SL COT = slimy sculpin *Cottus cognatus*
SU = sucker species
WCT = westslope cutthroat trout

Data Summary

Fishery data was summarized by species and included the number of fish captured catch-per-unit-effort (CPUE) or depletion estimates (standardized to number of fish per 100 m), mean and range of fish lengths, and percent species composition. Tables displaying this information were assembled for each ditch sampled. Additionally, length-frequency histograms were constructed for species with ≥ 5 individuals collected per ditch to illustrate length distributions. These data are provided as an appendix (Appendix A). For the purpose of this report, ditches were named for the approximate river mile (RM) location of the diversion and headgate or the water user. Photographs were taken of most of the diversion structures and ditches (Appendix B). Fish population data for streams discussed in this report were taken from Lindstrom et al. 2008, Liermann et al. 2009, or unpublished electrofishing data collected in 2009.

In most ditches, not all slimy sculpin and other non-salmonid species (e.g., longnose sucker, largescale sucker and longnose dace) were captured or enumerated. Thus, these species were categorized as rare, common or abundant. Species with 1-10 individuals were considered rare, 11-50 individuals considered common, and ≥ 51 individuals considered abundant. The presence of an "R" in the tables of this report signifies the species was rare, a "C" signifies common and an "A" signifies abundant.

At the end of the Electrofishing Results section, all ditches sampled were summarized and given an entrainment rating (Table 24). This entrainment rating was based upon the number of fish entrained in the ditch, with native species receiving higher priority. The entrainment rating scores used in this report were low, medium, and high.

Temperature and Discharge Monitoring

Since the diversion of water for irrigation may impact downstream water temperatures, stream temperatures were monitored in several streams chosen for this study. In 2007 and 2009, one or more thermographs were deployed in the target drainages (ONSET Computer Corp, Model: HOBO Water Temp Pro V2). To most accurately determine the effects of de-watering on stream temperature, thermographs were deployed in some streams both above and below major diversions. In certain streams however, only one thermograph was deployed, generally near the mouth of the stream, below all diversions. Temperatures were measured in degrees Celsius (°C) every half hour, with temperatures above 15 °C considered harmful to bull trout and westslope cutthroat trout (Behnke 2002). Results are displayed in Appendix C.

At several locations, stream discharge was measured using a Marsh-McBirney flow meter and a top set wading rod. When feasible, discharge was measured in the ditch and the adjacent stream. Mean velocities were obtained over a 20 sec period using the fixed point average (FPA) setting and discharge was calculated as cubic feet per second (cfs). In the summer of 2010, a crew working for Montana Trout Unlimited (TU), contracted to inventory irrigation diversions within the Upper Clark Fork River drainage, collected many of the measurements in Powell and Deer Lodge counties. These discharge estimates were summarized in a report submitted to the Watershed Restoration Coalition (WRC) of the Upper Clark Fork in winter 2010, and several were included in this report (TU and WRC 2010).

Radio Telemetry

In April 2009, a radio telemetry project was initiated within the Upper Clark Fork River. This study consisted of tagging trout captured from the mainstem Clark Fork and observing their movements throughout the system (Mayfield and McMahon 2010). Fish species selected for tagging in this study were roughly proportional to overall species composition in the Clark Fork River. In 2009, 100 trout comprised of 72 brown trout, 15 westslope cutthroat trout, 6 suspected westslope cutthroat/rainbow trout hybrids, 6 rainbow trout, and 1 bull trout were implanted with radio tags. In 2010, an additional 149 trout were tagged. The 2010 fish consisted of 104 brown trout, 33 westslope cutthroat trout, 6 cutthroat/rainbow trout hybrids, 3 bull trout and 3 rainbow trout. Three of the objectives for this study are to identify 1) critical spawning and rearing habitat, 2) possible impediments to both up- and downstream fish migration, and 3) possible limiting factors and causes of mortality to trout in the Upper Clark Fork River. Any results from the telemetry study pertinent to this project's objectives are displayed in the Radio Telemetry Results section of this report. The telemetry study will continue until the winter of 2011.

Inventory Results

Ranch Creek

Ranch Creek is a tributary to Rock Creek and enters the drainage at approximately RM 11.5 (Figure 1). The entire upper portion of the creek is located on lands administered by the Lolo National Forest. Most of the lower portion runs through private land with the exception of the U.S. Forest Service (USFS) campground located near the confluence of Grizzly Creek. Land use on the lower creek is limited to a few private residences and small horse pastures. Through past electrofishing surveys, native westslope cutthroat trout and bull trout are known to inhabit Ranch Creek. Migratory bull trout from Rock Creek are also known to spawn in Ranch Creek.

Two small (<2 CFS) ditches draw water from Ranch Creek on its lower end, below the Grizzly Creek campground (Figure 1). Electrofishing surveys were completed in these ditches in August 2009 and 2010, with all sections measuring 100 m in length. The upper ditch, located at RM 1.1, is outfitted with a metal R-5 style headgate and water is diverted into this ditch by a gravel berm (Appendix B). Two sections on upper ditch (RM 1.1) were sampled, one near the headgate and one approximately one mile downstream at Norton USFS campground. In 2009, a total of 11 fish were captured below the headgate of the upper ditch (Table 1, Appendix A). Eight of these fish were westslope cutthroat trout, along with two brook trout and one brown trout. Slimy sculpin were also present but rare in this section. No fish were captured in the lower section of this ditch near the Norton campground. In 2010, a total of 26 fish were collected below the headgate of the upper ditch, comprised of fourteen westslope cutthroat trout, four brown trout, four unidentifiable *Oncorhynchus* spp, three brook trout and one rainbow trout. In 2010, slimy sculpin were abundant in this section. Again in 2010, no fish were captured at the lower section on this ditch (Norton campground). The lower of the two ditches, located at RM 0.1, has no formal headgate, but water enters this ditch from a side channel on Ranch Creek. On both occasions the lower ditch (RM 0.1) was sampled below its point of diversion near the Norton campground. In 2009, five westslope cutthroat trout were collected along with two brook trout (Table 1, Appendix A). Slimy sculpin were also abundant in the section. In 2010, ten brown trout, eight brook trout, three *Oncorhynchus* species, and one rainbow trout were collected (Table 1, Appendix A). Slimy sculpin were again abundant.

Although no bull trout were observed in these ditches in 2009 or 2010, past research found at least one has been entrained in the irrigation ditches on lower Ranch Creek. Approximately ten years ago, a radio-tagged adult bull trout was entrained in the lower ditch (RM 0.1) during a radio telemetry study and presumably died in the ditch (radio tagged fish made movements in the ditch but the radio transmitter was later recovered in the ditch- Brad Liermann, Montana Fish, Wildlife and Parks, personal communication).

Table 1. Electrofishing data collected during 2009 and 2010 in ditches on Ranch Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 1.1 (Headgate)	2009	WCT	8	8	121	78-187	73
		LL	1	1	96	96	9
		EB	2	2	83	50-115	18
	2010	WCT	14	14	95	35-161	54
		LL	4	4	86	46-135	15
		RB	1	1	77	77	4
		ONC	4	4	80	71-92	15
		EB	3	3	132	115-163	12
		SL COT	A	-	-	-	-
RM 1.1 (Norton)	2009	NO	FISH	-	-	-	-
	2010	NO	FISH	-	-	-	-
RM 0.1 (Headgate)	2009	WCT	5	5	91	78-112	71
		EB	2	2	163	133-193	29
		SL COT	R	-	-	-	-
	2010	LL	10	10	138	78-180	45
		RB	1	1	130	130	5
		ONC	3	3	58	32-109	14
		EB	8	8	157	124-235	36
		SL COT	A	-	-	-	-

Discharge was measured within both ditches and upstream of the upper ditch at RM 1.1 in mainstem Ranch Creek on August 10, 2010. The ditch at RM 1.1 was receiving 1.2 cfs, approximately 4% of the mainstem discharge at 28.6 cfs. The ditch at RM 0.1 near the mouth of Ranch Creek was receiving 0.8 cfs, approximately 3% of the remaining mainstem discharge (estimated at 27.4 cfs).

Stony Creek

Stony Creek is a tributary to Rock Creek and enters the drainage at approximately RM 38.4 (Figure 1). Roughly one mile of lower Stony Creek flows through private land, while upper Stony Creek flows through National Forest land. Forest Road 241 (FR 241) follows the lower creek for nearly five miles, while the remainder of the drainage is roadless. Fish populations in upper Stony Creek are comprised entirely of native westslope cutthroat trout and bull trout and a mix of native and non-native species are present in the lower portion of the drainage. Past electrofishing surveys found non-native brown trout and rainbow trout in lower Stony Creek, with visual evidence of hybridization between westslope cutthroat trout and rainbow trout (Liermann et al. 2008).

Fluvial bull trout from Rock Creek are also known to spawn in Stony Creek. In June 2009, a radio-tagged westslope cutthroat trout from the Clark Fork River was relocated at the mouth of Stony Creek and is believed to have spawned in the creek.

One irrigation ditch exists on Stony Creek (Figure 1). The headgate of this ditch is located in the lower portion of the drainage just above the USFS Stony Creek campground at RM 0.3. This ditch is outfitted with a Waterman C-10 style headgate and water is diverted by a gravel berm (Appendix B). In August 2009, a three-pass depletion was conducted from the headgate to a block-net 100 m downstream. A total of 53 westslope cutthroat trout and 53 brown trout were collected in this ditch (Table 2, Appendix A). The population estimate for westslope cutthroat trout was 55.0 fish per 100 m (53.0-59.3; 95% confidence interval (CI)) and for brown trout, 54.0 fish per 100 m (53.0-57.4; 95% CI).

Table 2. Electrofishing data collected during 2009 in the ditch on Stony Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (Depletion)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 0.3	2009	WCT	53	55.0	73	27-139	50
(Headgate)		LL	53	54.0	52	45-60	50

Discharge was measured within the ditch and upstream of the diversion Stony Creek on August 27, 2009. On this date, the ditch was receiving 0.8 cfs, approximately 7% of the mainstem discharge of 12.5 cfs.

Beaver Creek

Beaver Creek is a tributary to Upper Willow Creek and enters the drainage at approximately RM 12.8 (Figure 1). Beaver Creek begins on Beaverhead-Deerlodge National Forest, flows through approximately 1.5 miles of state administered land, and crosses only a small section of private land near its confluence with Upper Willow Creek. The creek is accessible by gated FR 4325, which provides vehicle access for administrative purposes, as well as walk-in traffic for recreation. Based on electrofishing surveys conducted in 2009, fish populations in Beaver Creek are comprised primarily of westslope cutthroat trout and brook trout; however, one brown trout was captured.

One irrigation ditch was observed drawing water from Beaver Creek at approximately RM 0.9 (Figure 1). This ditch is outfitted with a metal R-5 style headgate and water is diverted by a check dam spanning the channel (Appendix B). This ditch was electrofished for 100 m below the headgate in 2009 (Table 3). Both brook trout and westslope cutthroat trout were found entrained in this ditch. In total, 16 westslope cutthroat trout and 23 brook trout were collected.

Table 3. Electrofishing data collected during 2009 in the ditch on Beaver Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 0.9 (Headgate)	2009	WCT	16	16	79	58-117	41
		EB	23	23	58	46-120	59

Rock Creek

Rock Creek is a tributary to the Clark Fork River and enters the drainage at approximately RM 239.0. (Figure 1). Four forks join to form mainstem Rock Creek, including the West, Ross, Middle, and East Forks. The upper reaches of these forks are located on land administered by the Beaverhead-Deerlodge National Forest, while the lower reaches are located on private land. The upper portion of mainstem Rock Creek runs through private land, and the lower portion crosses a combination of Lolo National Forest and private land. Land use within the upper Rock Creek watershed is primarily agriculture, with historical mining present. Land use lower in the watershed is primarily recreation (National Forest) and private residences. Rock Creek provides a world renowned fishery and a valued recreational resource supported primarily by brown trout, but rainbow trout, and native westslope cutthroat trout and bull trout are also present.

In August 2010, electrofishing surveys were completed in two irrigation ditches on mainstem Rock Creek (Figure 1). The ditches were located at RM 50.6 and 50.5 just below the confluence of the West and Middle Forks at RM 51.9 on Rock Creek. These ditches are both outfitted with metal R-5 style headgates and boulder berms, and supply water to grazing land on a guest ranch (Appendix B). Two sections were sampled on the upper ditch at RM 50.6 with the first being located immediately below the headgate and the second 0.5 mi downstream. One bull trout, two westslope cutthroat, and five brown trout were collected in the first 100 m below the headgate (Table 4). Mountain whitefish were also present but rare in this section. No fish were collected in the section 0.5 mi downstream of the headgate. Three sections were sampled on the lower ditch at RM 50.5 with the first being located immediately below the headgate, the second 0.5 mi downstream and the lowest 1.6 mi downstream. In the lower ditch, three westslope cutthroat trout and 14 brown trout were collected in the first 100 m below the headgate (Table 4, Appendix A). Mountain whitefish, longnose dace and slimy sculpin were also present but rare in this section. No fish were collected 0.5 mi downstream of the headgate, likely due to very little holding water in the reach. Two species were captured in the section 1.6 mi downstream including, mountain whitefish and longnose dace (Table 4).

Table 4. Electrofishing data collected during 2010 in two ditches on Rock Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 50.6 (Headgate)	2010	BULL	1	1	197	197	13
		WCT	2	2	198	121-275	25
		LL	5	5	100	51-135	62
		MWF	R	-	-	-	-
RM 50.6 (0.5 mi)	2010	NO	FISH	-	-	-	-
RM 50.5 (Headgate)	2010	WCT	3	3	115	91-113	18
		LL	14	14	88	47-279	82
		MWF	R	-	-	-	-
		LN DC	R	-	-	-	-
		SL COT	R	-	-	-	-
RM 50.5 (0.5 mi)	2010	NO	FISH	-	-	-	-
RM 50.5 (1.6 mi)	2010	MWF	R	-	-	-	-
		LN DC	R	-	-	-	-

Discharge measurements taken on August 19, 2010 just below the headgates, established the upper ditch (RM 50.62) was receiving 5.8 cfs and the lower ditch (RM 50.55) was receiving 18.1 cfs.

West Fork Rock Creek

West Fork Rock Creek is a tributary to Rock Creek, and combines with the Middle Fork Rock Creek at approximately RM 51.3 to form mainstem Rock Creek (Figure 1). West Fork Rock Creek originates in the Sapphire Mountains on the Beaverhead-Deerlodge National Forest and the majority of the upper drainage is located within National Forest lands. Land ownership in the lower drainage is a mix of USFS, State of Montana, and private lands. Grazing occurs on private lands, as well as National Forest and State of Montana land, through grazing allotments. Historical logging is also evident in portions of the drainage. For most of its length, West Fork Rock Creek is followed by Montana Highway 38 (Skalkaho Highway). Fish populations in upper West Fork Rock Creek are comprised primarily of native bull trout, westslope cutthroat trout, and mountain whitefish, while lower in the drainage brown trout as well as native longnose sucker and longnose dace become more abundant (Liermann et al. 2009).

In August of 2010, electrofishing surveys were completed in a ditch on West Fork Rock Creek (Figure 1). This ditch was located at approximately RM 4.2, and has been used to flood irrigate a large private pasture approximately one mile downstream. The ditch is

fitted with a wooden headgate, regulated by wooden planks and a gravel berm diverts water into this ditch (Appendix B). This ditch was highly inefficient at the time of sampling with several breaks in the walls of the ditch. On August 25th the ditch held water for only 30 m. A total of 38 fishes, were collected in the section below the headgate (Table 5, Appendix A). All fish collected were sub-adult and consisted of 11 westslope cutthroat trout, one brown trout and 26 unidentifiable *Oncorhynchus* species. Slimy sculpin were present but rare in this ditch.

Table 5. Electrofishing data collected during 2010 in a ditch on the West Fork Rock Creek. (*- Indicates CPUE extrapolated from a 30 m section).

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 4.2 (Headgate)	2010	WCT	11	37*	81	73-95	29
		LL	1	3*	52	52	3
		ONC	26	87*	36	27-48	68
		SL COT	R	-	-	-	-

Although discharge was not measured in 2010, visual observations suggested the ditch was receiving less than 0.5 cfs, likely due to the low discharge of the West Fork and disrepair of the diversion/headgate.

Ross Fork Rock Creek

Ross Fork Rock Creek is a tributary to West Fork Rock Creek and enters the drainage just above the confluence of the West and Middle Forks of Rock Creek at approximately RM 0.2 (Figure 1). The Ross Fork originates on National Forest land and the upper portion of the drainage is managed as roadless. Roads are present in the middle portion of the drainage on National Forest land where historical logging is evident. Lower Ross Fork Rock Creek flows through several cattle ranches and additional grazing occurs on National Forest land through leased grazing allotments. Lower in the drainage water is diverted from the Ross Fork to flood irrigate hay pastures. In the upper and middle reaches of Ross Fork Rock Creek, fish populations are comprised almost entirely of native westslope cutthroat trout and bull trout, with migratory bull trout from Rock Creek known to spawn in the upper Ross Fork. In the lower reaches, non-native brown trout and brook trout comprise a higher proportion of the fish community, and de-watering accompanied by elevated stream temperatures is common, presumably due to irrigation withdrawals (Liermann et al. 2009).

At least seven diversions are known to withdraw water from mainstem Ross Fork Rock Creek. These diversions are primarily used to flood irrigate pastures in the lower portion of the Ross Fork valley. Several of these ditches are outfitted with metal R-5 style headgates and most draw water via gravel/boulder berms (Appendix B). The upstream most diversion was located on National Forest land at approximately RM 9.4. This ditch delivered water several miles downstream to a private ranch, but in 2007 appeared to be highly inefficient. Although this ditch received a substantial amount of water at the

diversion, it was nearly dry at its intersection with Angelico Creek, several miles upstream of the intended water users. Five more diversions were located downstream between RM 6.5 and 5.5. These diversions were located in close succession and diverted similar volumes of water. Although no measurements were collected, the mainstem appeared to be dewatered by approximately 50% of the expected average summer level below this series of diversions.

The lowest diversion on the Ross Fork, was located below RM 3.5 and when observed was diverting the majority of the water remaining in the Ross Fork. Visual estimates suggested the discharge in the mainstem below this site was less than 10% of average summer levels. This ditch was not electrofished due to a lack of landowner permission. Visual observation of the stream flows below these diversions in 2007, suggests these withdrawals greatly impacted in-stream flows.

Two thermographs were used to monitor temperatures on the Ross Fork in 2007, one above the majority of the diversions at approximately RM 6.7, and one near the mouth of a small tributary at approximately RM 0.1. At the upper site, stream temperature exceeded 20°C on four days with a maximum-recorded temperature of 20.7°C. At the lower site, temperatures exceeded 20°C on 24 days with a maximum recorded of 24.4°C. These measurements suggest water temperatures are influenced by irrigation withdrawals within this 6.5-mile stretch. These elevated temperatures likely negatively impact native bull trout and westslope cutthroat trout.

Electrofishing surveys were completed in six of the ditches on the Ross Fork in 2007. The upper ditch (RM 9.4) was sampled approximately 0.5 miles upstream of the crossing of FR 5060 over Ross Fork Rock Creek. In a 100 m section, four westslope cutthroat trout, one brown trout, and one brook trout were collected (Table 6). Longnose dace and longnose sucker were also present, but rare. Surveys of the five ditches between RM 6.5 and RM 5.5 measured 100 m in length and began within 50 meters of their headgates. Entrainment of westslope cutthroat trout was documented in all ditches and bull trout entrainment was observed in two (Table 6, Appendix A). Other salmonids collected in these ditches included brown trout, brook trout and mountain whitefish. Native longnose sucker and longnose dace were collected in the ditch located at RM 6.0, and slimy sculpin were present in the ditches located at RM's 6.5, 6.0, and 5.5.

Table 6. Electrofishing data collected during 2007 in ditches on Ross Fork Rock Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 9.4	2007	WCT	4	4	98	30-211	27
(Headgate)		LL	1	1	138	138	7
		EB	1	1	173	173	7
		LN DC	R	-	-	-	-
		LNSU	R	-	-	-	-
RM 6.5	2007	WCT	24	24	44	37-56	73
(Headgate)		LL	9	9	67	52-78	27
		SL COT	C	-	-	-	-
RM 6.2	2007	WCT	22	22	86	32-189	42
(Headgate)		LL	31	31	63	50-72	58
RM 6.1	2007	BULL	1	1	43	43	50
(Headgate)		WCT	1	1	237	237	50
RM 6.0	2007	WCT	16	16	54	41-146	49
(Headgate)		LL	17	17	64	50-150	51
		MWF	R	-	-	-	-
		LN DC	R	-	-	-	-
		LNSU	R	-	-	-	-
		SL COT	R	-	-	-	-
RM 5.5	2007	BULL	1	1	207	207	6
(Headgate)		WCT	7	7	105	41-180	41
		LL	8	8	64	55-71	47
		EB	1	1	64	64	6
		MWF	R	-	-	-	-
		SL COT	A	-	-	-	-

Middle Fork Rock Creek

Middle Fork Rock Creek and West Fork Rock Creek combine to form mainstem Rock Creek just upstream of Skalkaho Bridge at approximately RM 51.4 (Figure 1). The Middle Fork Rock Creek drainage begins in the Anaconda-Pintler Wilderness Area at the outlet of Phyllis Lake and thus fish habitat in the upper portion of the drainage is excellent. Land ownership below the wilderness boundary remains USFS; however, additional land uses are observed in this reach including cattle grazing and historical logging. In the lower portion of the drainage, land ownership is private and land use is restricted primarily to cattle ranching. In upper Middle Fork Rock Creek, fish populations are comprised of native westslope cutthroat trout and bull trout (Liermann et al. 2009). Large migratory bull trout have also been collected in the upper reaches and

are known to spawn in the mainstem Middle Fork and several of its tributaries. Lower in the drainage non-native brook and brown trout comprise more of the community, but westslope cutthroat trout and bull trout remain present. Native mountain whitefish and longnose dace are also found in the lower reaches of the Middle Fork.

In early August 2010, electrofishing surveys were completed in two 100 m sections on a ditch diverting water from Middle Fork Rock Creek at RM 0.1 (Figure 1). The headgate of this ditch is located just upstream of Skalkaho Bridge and the confluence of West and Middle Fork Rock Creek. This ditch is outfitted with a metal R-5 type headgate and a gravel berm diverts water from a side-channel (Appendix B). This ditch is routed under Montana State Highway 38 and travels through several culverts before supplying water to center pivots on a guest ranch downstream. The first section electrofished began approximately 0.2 mi below the headgate. Nine trout were collected in the 100 m section, consisting of two bull trout, two westslope cutthroat trout and five brown trout (Table 7, Appendix A). Mountain whitefish were also present in the section, but rare. The second section electrofished was located downstream of a culvert, approximately 0.5 mi below the headgate. Only three trout were collected in this section, one westslope cutthroat trout and two brown trout, but native mountain whitefish and longnose sucker were also present.

Table 7. Electrofishing data collected during 2010 in the ditch on the Middle Fork Rock Creek. Two sections were electrofished on this ditch, one 0.2 mi and one 0.5 mi downstream of the headgate.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 0.1	2010	BULL	2	2	221	187-255	22
(0.2 mi)		WCT	2	2	140	134-146	22
		LL	5	5	122	64-168	56
		MWF	R	-	-	-	-
RM 0.1	2010	WCT	1	1	125	125	33
(0.5 mi)		LL	2	2	166	154-177	67
		MWF	R	-	-	-	-
		LNSU	R	-	-	-	-

A discharge measurement collected on August 19, 2010, established the ditch at RM 0.1 was receiving 3.7 cfs. This ditch draws from a medium-sized side channel of the Middle Fork and at the time of measurement, flows in the side channel were low and debris had accumulated at the entrance to the headgate.

East Fork Rock Creek

East Fork Rock Creek is a tributary to Middle Fork Rock Creek and enters the drainage at approximately RM 2.1 (Figure 1). East Fork Rock Creek begins in the Anaconda-Pintler Wilderness Area and is fed by several tributaries before leaving the wilderness and

entering East Fork Reservoir at approximately RM 10.6. The primary purpose of East Fork Reservoir is to store spring runoff for irrigation in the Flint Creek valley via a trans-basin diversion (Flint Creek Main Canal). Releases from the East Fork dam are quite high during the irrigation season (greater than 100 cfs during May-October) and low during the remainder of the year (< 1 cfs during November through April). The major diversion into this canal is located just below the dam on the East Fork at RM 8.6. During the summer irrigation season, a majority of the East Fork Rock Creek is diverted into this canal. The diverted water travels 2.7 mi, where it is siphoned from the west side of the valley to the east side and eventually gains the necessary elevation to enter the Trout Creek drainage. This water is then delivered to the Flint Creek valley via Trout Creek.

Fish populations in East Fork Rock Creek vary above and below the dam. The reservoir and East Fork Rock Creek above the reservoir are strongholds for native bull trout. Westslope cutthroat trout are currently stocked into the reservoir by MFWP and are the most abundant species in the reservoir. Native bull trout are also relatively abundant in East Fork Reservoir while non-native brook and rainbow trout are also present limited numbers. Conversely, below the dam, fish populations are dominated by brook trout and brown trout with a limited number of bull trout and westslope cutthroat trout being present. Larger bull trout and westslope cutthroat trout are often observed in the spillway below the dam and it is likely these fish have been entrained through the dam.

Electrofishing surveys have been completed in the Flint Creek Main Canal on several occasions between 2007 and 2010 (Table 8, Appendix A). Sampling was conducted after the headgate was closed in October, due to the high volume and velocity of water in the canal during irrigation season. Each year, one 100 m section was electrofished directly below the headgate. Since large numbers of age-0 trout were often captured in this section, length data was not always collected on all fish. In 2007 and 2009, only a sub-set of the fish collected were measured, while in 2008 and 2010, all fish were measured. A single bull trout was captured in both 2007 and 2009, while three were collected in 2010 (Table 8). Numerous westslope cutthroat trout have been collected at each visit. A majority of the native bull trout and westslope cutthroat trout captured in the Flint Creek Main Canal are believed to have out-migrated from the reservoir due to their low abundance in East Fork Rock Creek below the dam. Non-native brook, brown and rainbow trout were also captured in the ditch below the headgate (Table 8). In 2009, a section of the canal was sampled approximately one mile below the headgate near the Lost Sapphire subdivision. At this site, two small westslope cutthroat trout were captured. In 2007, a pool at the siphon release valve was also electrofished. At this location fish are stranded after the siphon has been shut down for the winter. Both native bull trout and cutthroat trout were collected from this pool along with brook trout, brown trout, and rainbow trout. All years, fish collected in the Flint Creek Main Canal were released in the mainstem East Fork Rock Creek.

Table 8. Electrofishing data collected over four years in several sections of the Flint Creek Main Canal. Sections are arranged from upstream to downstream. (*- Indicates average or range based on the measurement of a sub-set of fish).

Section Name	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
Headgate	2007	BULL	1	1.6	90	90	<1
		WCT	108	177	n/a	50-70*	66
		RB	19	31	n/a	75-90*	12
		EB	35	57	n/a	75-200*	21
Headgate	2008	WCT	22	22	121	41-384	11
		LL	6	6	312	287-351	3
		RB	4	4	230	152-318	1
		EB	176	176	143	55-322	85
Headgate	2009	BULL	1	1	460	460	<1
		WCT	13	13	197	106-435	5
		LL	5	5	334*	307-375*	2
		RB	4	4	201	156-261	2
		ONC	171	171	49*	43-60*	71
		EB	46	46	136*	62-292*	19
Headgate	2010	BULL	3	3	110	91-121	1
		WCT	32	32	127	62-178	9
		LL	40	40	119	62-348	12
		RB	3	3	201	135-316	1
		ONC	49	49	50	40-61	14
		EB	213	213	119	62-279	63
		SL COT	A	-	-	-	-
Lost Sapphire	2009	WCT	2	2	55*	50-60*	100
Siphon	2007	BULL	1	n/a	90	90	4
		WCT	6	n/a	n/a	60-400*	32
		LL	3	n/a	n/a	225-325*	16
		RB	2	n/a	450*	450*	11
		EB	7	n/a	n/a	55-325*	37

In October 2007, the discharge of East Fork Rock Creek above the reservoir, just downstream of a spring-fed tributary, was 9.7 cfs. This estimate may approximate the historical discharge on the East Fork Rock Creek near the headgate of the Flint Creek Main Canal during a relatively normal snowpack year (this assumes minimal up-welling in the reservoir reach which is unknown). Recent releases from East Fork Dam however, are generally greater than 100 cfs during the irrigation season and commonly less than 1

cfs during the off-season. In August 2008 and 2009, discharges measured in Flint Creek Main Canal just below the headgate, were 104.6 cfs, and 90.0 cfs, respectively. In 2010 discharges were measured in both the canal and East Fork Rock Creek below the diversion. On August 25, 2010 an estimated 115.9 cfs was being diverted into Flint Creek Main Canal, while East Fork Rock Creek received 4.1 cfs. A minimum instream flow of 5 cfs during irrigation season was provided by the Flint Creek Water Users as mitigation for replacing the East Fork Siphon in 2008. DNRC was notified that the instream flow measurement taken on August 25 was below this agreed amount and the diversion was adjusted to meet the flow requirement.

Recent discussion between canal owners/operators (DNRC/Flint Creek Water Users) and fishery biologists may result in actions to mitigate the impacts of East Fork Reservoir on fishes in mainstem East Fork Rock Creek downstream of the canal. The absence of spring scouring flows and the lack of adequate instream flows appears to be altering fish habitat and affecting species composition, as well as abundance of salmonids. Also, the entrainment of fish into the canal represents direct losses to fish populations in the East Fork below the reservoir. To mitigate these issues, additional in-stream flows and a spring flushing flow may be provided to the mainstem and a fish screen installed at the headgate of the canal. In 2009 and 2010, additional sites were sampled on East Fork Rock Creek and in 2010, on Ross Fork Rock Creek, to obtain baseline data before these actions are potentially implemented. The sites on Ross Fork Rock Creek will serve as references or control sites to account for regional changes in fish populations. This pre-data will help in assessing the effectiveness and benefits of additional flows and fish screening, if these mitigation actions are taken. On East Fork Rock Creek, multiple-pass depletion estimates were conducted at three sites downstream of the diversion; 1) on a section near the USFS campground approximately 0.2 mi below the diversion, 2) on a private ranch approximately 3.9 mi below the diversion, and 3) on a section on state owned land approximately 7.4 mi below the diversion. On Ross Fork Rock Creek, depletion estimates were conducted on two sites, both located on U.S. Forest Service land, at approximately RM 8.9 and RM 7.0. The results from electrofishing the East Fork and the Ross Fork are summarized in Table 9 below, with sample sites arranged from upstream to downstream.

Table 9. Electrofishing results from East Fork Rock Creek and Ross Fork Rock Creek. Population estimates of fish only ≥75 mm.

Water Body	Section Name	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (Depletion)	95% CI Range	Mean Length (mm)	Length Range (mm)	Species Comp (%)
East Fork	Below dam	2009	LL	15	14.0	13.0-18.2	135	71-255	3
			EB	511	473.0	462.9-483.1	115	56-244	97
East Fork	Below dam	2010	WCT	13	13.0	13.0-14.2	118	97-136	2
			LL	30	24.0	20.0-35.4	116	65-256	3
			EB	862	710.0	659.9-760.1	95	50-223	95
East Fork	Cadieux Ranch	2009	WCT	4	4.0	4.0-4.4	249	131-318	2
			LL	127	94.0	94.0-94.7	168	61-338	68
			EB	55	47.0	46.0-50.2	122	58-268	29
			MWF	1	1 (CPUE)	N/A	317	317	<1
East Fork	Cadieux Ranch	2010	WCT	2	2.0	2.0-4.0	295	280-309	2
			LL	105	99.0	94.0-106.0	170	105-355	73
			EB	36	34.0	31.0-40.9	138	48-250	25
East Fork	State Section	2010	BULL	1	1.0	N/A	150	150	<1
			LL	130	143.0	117.1-168.9	122	68-434	90
			EB	13	12.0	12.0-13.8	134	74-206	9
Ross Fork	Above FR 70	2010	BULL	6	6.0	6.0-6.7	166	136-219	6
			WCT	30	25.0	25.0-26.0	164	86-269	29
			LL	34	20.0	20.0-20.7	147	55-316	33
			ONC	4	4 (CPUE)	N/A	51	48-53	4
			EB	28	24.0	24.0-25.5	145	73-240	28
Ross Fork	Christiansen	2010	BULL	4	4.0	N/A	216	162-290	5
			WCT	39	40.0	38.0-45.5	157	62-285	45
			LL	22	15.0	14.0-19.4	143	56-408	25
			ONC	16	16 (CPUE)	N/A	54	42-63	18
			EB	4	4.0	N/A	133	75-195	5
			MWF	2	2 (CPUE)	N/A	209	92-326	2

Harvey Creek

Harvey Creek is a tributary to the Clark Fork River and enters the drainage at approximately RM 257.3 (Figure 1). Land ownership in the upper Harvey Creek drainage is primarily National Forest, while land ownership in the lower portion of the drainage consists of National Forest, Stimson Lumber, and private lands. Primary land uses in the drainage are cattle grazing and timber harvest. At RM 0.2, just upstream from the mouth of Harvey Creek a large fish migration barrier exists and has restricted the movement of non-native fishes into the remainder of the drainage. Fish populations in Harvey Creek above the barrier are comprised exclusively of native bull trout and westslope cutthroat trout (Liermann et al. 2009). Bull trout densities are higher in the upper portions of the drainage and were absent approximately 0.5 mi upstream of the barrier.

In late August 2010, two electrofishing surveys were completed in a ditch on Harvey Creek (Figure 1). The ditch is located just upstream from the mouth (RM 0.01) and was also receiving water diverted from the Clark Fork River. This ditch was selected because in mid-June 2009, a radio-tagged bull trout was found dead approximately 0.8 mi below its headgate (see Radio Telemetry Results). This ditch is outfitted with a metal R-5 style headgate, and a wood pin and plank structure diverts water from Harvey Creek, as well as the ditch drawing water from the Clark Fork River. In a 100 m section below the headgate, 29 brown trout and eight unidentifiable *Oncorhynchus* species were collected (Table 10). Slimy sculpin were also present, but rare. The second section was located approximately 0.8 mi below the headgate. A small number of fish were collected in this section, including one unidentifiable Oncorhynchus species and a few longnose sucker. Due to the addition of water from the Clark Fork River it is difficult to know whether these fish originated from Harvey Creek or the Clark Fork River.

Table 10. Electrofishing data collected during 2010 in a ditch located on Harvey Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 0.01	2010	LL	29	29	80	66-93	78
(Headgate)		ONC	8	8	52	39-60	22
		SL COT	C	-	-	-	-
RM 0.01	2010	ONC	1	1	46	46	100
(0.8 mi)		LNSU	R	-	-	-	-

Discharge was measured within Harvey Creek upstream of the diversion and the ditch just below the headgate on August 30, 2010. The ditch was receiving 9.5 cfs, approximately 185% of the discharge of Harvey Creek at 5.1 cfs. Thus, the adjoining ditch contributed at least 4.5 cfs of Clark Fork River water to the irrigation ditch. This ditch intersects Harvey Creek before it joins with the Clark Fork River, approximately 20 m upstream from the mouth. On September 2, 2010, discharge of the adjoining ditch was measured and was receiving 9.7 cfs from the Clark Fork River.

South Fork Lower Willow Creek

South Fork Lower Willow Creek is a tributary of Lower Willow Creek and enters Lower Willow Creek Reservoir at approximate RM 9.4 (Figure 1). Land ownership above the reservoir is divided between private agricultural, USFS, and private timber land. Cattle grazing is heavy throughout the drainage on both private and USFS lands, and signs of past timber harvest and mining also exist. Fish populations above the dam are comprised primarily of westslope cutthroat trout, with some tributaries also containing native longnose sucker (Lindstrom et al. 2008). Genetic analyses conducted on several tributary populations of westslope cutthroat trout above the dam, have found these populations to be genetically pure. It is hypothesized the Lower Willow Creek dam is preserving the genetic purity of this large population of westslope cutthroat trout by inhibiting upstream migration of non-native rainbow trout. Non-native brook trout are also present above the dam however, their distribution appears limited to the North and West Fork Lower Willow Creek.

At least one irrigation ditch exists above the Lower Willow Creek Reservoir (Figure 1). The ditch draws water from the South Fork Lower Willow Creek above its confluence with Cottonwood Creek at approximately RM 2.9, and delivers it to a ranch several miles downstream near mainstem Flint Creek. Electrofishing surveys were completed in this ditch during 2007 and 2009. In 2007, a 200 m section was electrofished approximately two miles below the headgate (Table 11). At this site, two similar-sized westslope cutthroat trout were collected along with 38 longnose suckers. In 2009, a three-pass depletion was conducted on a section beginning 100 m downstream of the headgate and extending upstream to the headgate. A total of 18 westslope cutthroat trout and 53 longnose suckers were collected in the ditch (Table 11, Appendix A). There were an estimated 19.0 (18.0-22.9, 95% C.I.) westslope cutthroat trout per 100 m in this section of the ditch.

Table 11. Electrofishing data collected during 2007 and 2009 in a ditch on South Fork Lower Willow Creek. Entries are arranged chronologically.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (Depletion)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 2.9	2007	WCT	2	1 (CPUE)	142.5	142-143	5
(2.0 mi)		LNSU	38	19 (CPUE)	-	-	95
RM 2.9	2009	WCT	18	19.0	92	37-185	25
(Headgate)		LNSU	53	-	62	25-177	75

Discharge was measured in the mainstem South Fork Lower Willow Creek and the ditch on August 24, 2009. The ditch was receiving 4.0 cfs, approximately 98% of the mainstem discharge at 4.1 cfs. Below the diversion, the creek was de-watered and likely leading to increased water temperatures, stressful for westslope cutthroat trout (Appendix B). In 2007, a thermograph was positioned in South Fork Lower Willow Creek just

above its confluence with the reservoir. The maximum daily temperatures exceeded 20 °C for 23 days with a maximum recorded temperature was 25.9 °C (Appendix C).

Gird Creek

Gird Creek is a tributary to Flint Creek, and enters the drainage at approximately RM 13.7 (Figure 1). Most of upper Gird Creek is located within the Beaverhead-Deerlodge National Forest, while the lower portion runs through private lands. Cattle grazing is the primary land use on private land as well as National Forest land via grazing allotments. Recent electrofishing surveys found Gird Creek to support only westslope cutthroat trout (unpublished data).

In 2009, one irrigation ditch was observed on lower Gird Creek near RM1.1 (Figure 1). This ditch is outfitted with a metal R-5 style headgate and a check dam spanning the channel redirects water into the ditch (Appendix B). One section extending 100 m below the headgate was electrofished on this ditch in 2009 and no fish were captured. This ditch was visited again in 2010, but was not in operation at that time.

Boulder Creek

Boulder Creek is a tributary to Flint Creek, and enters the drainage near Maxville, MT at approximately RM 15.7 (Figure 1). The upper portion of Boulder Creek is primarily National Forest land, while the lower portion of the drainage (below Princeton, MT) is a mix of private land and National Forest Land. Historical land use in the drainage was mining and timber harvest, with abandoned mines visible on many tributaries and some portions of Boulder Creek. Current land use is timber harvest, small hydropower and private residences. Boulder Creek supports the only known population of bull trout in the Flint Creek drainage. In upper Boulder Creek, fish populations are comprised entirely of bull trout and westslope cutthroat trout. Brook trout first appear in the middle section near the confluence of Copper Creek. In the lower portion of the drainage, westslope cutthroat trout as well as brown trout are abundant while bull trout are found in relatively low densities (Lindstrom et al. 2008).

Three ditches draw water from the lower portion of Boulder Creek (Figure 1). Electrofishing surveys were completed in two of these ditches during 2009 and 2010, and the third during 2010. All three ditches have headgates and boulder berms as diversions. The furthest upstream ditch at approximately RM 0.9 is outfitted with a C-10 style headgate, and diverts the second-most volume of water. In 2009, one bull trout, five westslope cutthroat trout and five brown trout were collected the first 100 m below the headgate (Table 12, Appendix A). In 2010, no bull trout were observed, but six westslope cutthroat and nine brown trout were collected, along with mountain whitefish and slimy sculpin. The next ditch downstream, located at approximately RM 0.8, is outfitted with a C-10 style headgate and diverts the most volume of water. In 2009, two sections were sampled in this ditch, one near the headgate and one approximately one mile downstream near its confluence with Gird Creek. Fish were only collected near the headgate, with seven westslope cutthroat trout captured in a 100 m section (Table 12,

Appendix A). In 2010, two additional species were observed entrained in this ditch. Thirty-nine brown trout and one brook trout were collected in addition to six westslope cutthroat trout. More juvenile trout were observed but escaped capture due to their small size. The lowest ditch, located at approximately RM 0.2 is in great disrepair and highly inefficient based on visual observations. The headgate is no longer functional and water enters through a naturally cut side channel. Little water is retained in the ditch due to several breaks in the walls of the ditch. Only 40.5 m was open to electrofishing, before the ditch enters a large pipe. In this section a total of eight trout were collected, including six westslope cutthroat trout and two brown trout (Table 12, Appendix A). Slimy sculpin were also present, but rare.

Table 12. Electrofishing data collected during 2009 and 2010 in two ditches on Boulder Creek. (*- Indicates estimates were extrapolated from a 40.5 m section)

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 0.9 (Headgate)	2009	BULL	1	1	186	186	9
		WCT	5	5	141	60-269	45
		LL	5	5	201	92-292	45
RM 0.9 (Headgate)	2010	WCT	6	6	101	67-139	40
		LL	9	9	66	41-151	60
		MWF	R	-	-	-	-
		SL COT	R	-	-	-	-
RM 0.8 (Headgate)	2009	WCT	7	7	60	31-125	100
RM 0.8 (Headgate)	2010	WCT	6	6	142	33-277	13
		LL	39	39	42	30-54	85
		EB	1	1	135	135	2
RM 0.8 (Gird Ck)	2009	NO	FISH	-	-	-	-
RM 0.2 (Headgate)	2010	WCT	6	15*	114	70-180	75
		LL	2	5*	144	60-227	25
		SL COT	R	-	-	-	-

In 2010, discharge was measured in all three ditches. On August 10th, the ditches at RM 0.93 and RM 0.87 were receiving 2.4 cfs and 14.1 cfs, respectively, and the United States Geological Survey (USGS) gauging station (downstream of the ditches) recorded 33 cfs. Based on these flow measurements, the mainstem discharge upstream of the two withdrawals was estimated as 49.5 cfs (USGS gage data plus ditch discharge data). Based on these estimates, the ditch at RM 0.9 was receiving approximately 5% of the mainstem discharge and the ditch at RM 0.8 was receiving approximately 30% of the

remaining mainstem discharge. The ditch at RM 0.2 was electrofished the following week on August 18th and was receiving an estimated 0.9 cfs. The USGS station upstream recorded 25 cfs in Boulder Creek, and thus it is estimated the ditch was receiving less than 4% of the mainstem discharge.

Gold Creek

Gold Creek is a tributary to the Clark Fork River and enters the drainage at approximately RM 291.6 (Figure 1). Upper Gold Creek is located on National Forest land, but the remainder of the watershed is privately owned. Land use consists of hay production, cattle grazing, and timber harvest, but historical mining is evident. Fish populations in Gold Creek vary from the upper reaches on National Forest land to the lower reaches on heavily grazed private lands. Westslope cutthroat trout is the only species present at upper sites where the creek is best described as a high gradient mountain stream (Lindstrom et al. 2008). In the middle section, as the creek transitions from the mountains to agricultural land, westslope cutthroat trout are still dominant, but brown trout begin to appear. Conversely, in the lower section as Gold Creek nears the Clark Fork River, brown trout are the dominant species with only a few westslope cutthroat trout present.

In 2007, five irrigation ditches were observed on lower Gold Creek. Four of these diversions drew a significant amount of water from Gold Creek in close succession upstream of RM 3.6. Sediment accumulation and low in-stream flow was notable below these diversions. The stream channel was observed to be dry for a distance below the lowest of these diversions in 2007. The extent of this dewatering was not determined, but it is likely that it represents a significant seasonal migration barrier to fish in Gold Creek (Lindstrom et al. 2008). It is also likely such reductions in stream discharge result in increased water temperatures. In 2007, thermographs were placed in Gold Creek at approximate RM 0.5 and RM 5.7 (Appendix C). Above the diversions (RM 5.7), water temperatures only exceeded 15°C on ten occasions with a maximum recorded temperature of 16.1°C. At the lower site however (RM 0.5), temperatures in Gold Creek exceeded 15°C on 65 days including eight days in which they exceeded 20°C. Maximum recorded temperature at this site was 21.2°C.

Electrofishing surveys were completed in one ditch on Gold Creek at RM 3.6 during 2007 and 2009 (Table 13, Appendix A). Multiple-pass depletions were conducted at each of three locations on the ditch. Fish densities were highest near the headgate, with westslope cutthroat trout and brown trout captured both years. In 2007, depletion estimates at the headgate site were 7.3 (7.3-8.7; 95% CI) westslope cutthroat trout per 100 m and 40.7 (40.7-47.0; 95% CI) brown trout per 100 m. In 2009, fewer fish were collected and population estimates were 1.0 cutthroat trout and 22.0 brown trout per 100 m. At the lower sites, very few fish were captured in 2007 and no fish were captured in 2009 (Table 13). It is likely more fish occur at these lower sites, but high water velocities and lack of holding water force fish downstream until the ditch empties into an agricultural field.

Table 13. Electrofishing data collected during 2007 and 2009 in a ditch on Gold Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (Depletion)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 3.6 (Headgate)	2007	WCT	11	7.3	104	77-217	17
		LL	55	40.7	79	38-184	83
RM 3.6 (Headgate)	2009	WCT	1	1.0	86	86	4
		LL	21	22.0	88	45-320	96
RM 3.6 (1.8 mi)	2007	WCT	2	2.0	175	167-183	66
		LL	1	1.0	118	118	33
RM 3.6 (1.8 mi)	2009	NO	FISH	-	-	-	-
RM 3.6 (2.1 mi)	2007	LL	1	1.0	157	157	100
RM 3.6 (2.1 mi)	2009	NO	FISH	-	-	-	-

Discharge was measured as 6.4 cfs in the meadow section of the ditch at RM 3.6 on August 3, 2009.

In 2010, electrofishing surveys were completed in six additional ditches on Gold Creek. These ditches were located on private land from RM 1.1 to 6.1, with all diverting water from the mainstem using a variety of methods (Appendix B). In each ditch, one section measuring 100 m in length was sampled below the point of diversion. The furthest upstream ditch at RM 6.1 has no formal headgate or diversion (Appendix B). The ditch is closed off via a gravel push-up dam and the elevation of Gold Creek is similar to the ditch, so with the natural gradient water flows into the ditch. In the 100 m below the start of the ditch, fifteen westslope cutthroat trout and eight brown trout were collected (Table 15, Appendix A). The next ditch downstream, at RM 5.2, is fitted with a metal R-5 style headgate and a boulder berm diverts water from Gold Creek (Appendix B). Westslope cutthroat trout and brown trout were also present below the headgate in this ditch, but brown trout were more abundant. A total of eight westslope cutthroat trout and 11 brown trout were collected (Table 14, Appendix A). The ditch at RM 3.9 has no formal headgate or diversion structure (Appendix B). Similar to the ditch at RM 6.1 channel and ditch elevations are similar so water enters the ditch via the natural gradient. At the time of survey, this ditch was blocked by a combination of plywood, fenceposts, and debris, allowing minimal flow into the ditch. In the 100 m section below the opening of the ditch, 16 westslope cutthroat trout, 120 brown trout and six unidentifiable *Oncorhynchus* species were collected. Slimy sculpin were also present but rare in the section (Table 14, Appendix A). The ditch at RM 3.8 is fitted with a wooden headgate and a boulder berm reinforced with a large wooden plank serves as the diversion structure (Appendix B).

Within this ditch, 19 westslope cutthroat trout, 158 brown trout and four *Oncorhynchus* species were collected, along with several slimy sculpin (Table 14, Appendix A). The ditch at RM 3.7 has no formal headgate, but receives water diverted from Gold Creek via a boulder berm spanning the channel (Appendix B). A total of 28 westslope cutthroat trout and 41 brown trout were collected in the 100 m section. Again slimy sculpin were common (Table 14, Appendix A). The ditch at RM 3.6 is fitted with a metal R-5 style headgate and a gravel push-up dam diverts water from Gold Creek (Appendix B). At the time of the survey the headgate was closed and the push-up dam had been removed from the creek channel. The 100 m section below the headgate was still wetted and 32 westslope cutthroat trout, 145 brown trout, and eight unidentified *Oncorhynchus* species were collected from the remaining pools. Slimy sculpin were also common in this ditch (Table 14, Appendix A). The lowest of the ditches, at RM 1.1, is fitted with a metal R-5 style headgate and water is diverted by a boulder berm reinforced with wood and Visqueen. At this location, a horizontal flat-plate fish screen has been installed within the ditch approximately 70 m below the headgate (Appendix B). At the screen a secondary headgate controls releases to a nearby center pivot. A total of 161 brown trout were collected in the 70 m above the fish screen (Table 14, Appendix A). At the time of the survey, water was flowing over the screen and the structure was clear of debris.

Table 14. Electrofishing data collected during 2010 in ditches on Gold Creek. (* - Indicates average or range based on the measurement of a sub-set of fish, and [1] - indicates estimates were extrapolated from a 70 m section).

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 6.1 (Headgate)	2010	WCT	15	15	116	46-167	65
		LL	8	8	134	61-231	35
RM 5.2 (Headgate)	2010	WCT	8	8	165	102-245	42
		LL	11	11	84	47-256	58
RM 3.9 (Headgate)	2010	WCT	16	16	93	82-107	11
		LL	120	120	66*	51-125*	85
		ONC	6	6	33	31-37	4
		SL COT	R	-	-	-	-
RM 3.8 (Headgate)	2010	WCT	19	19	108	77-183	11
		LL	158	158	90*	41-216*	87
		ONC	4	4	39	34-45	2
		SL COT	C	-	-	-	-
RM 3.7 (Headgate)	2010	WCT	28	28	106	72-190	41
		LL	41	41	121*	61-159*	59
		SL COT	C	-	-	-	-
RM 3.6 (Headgate)	2010	WCT	32	32	94	81-137	17
		LL	145	145	76*	48-140	79
		ONC	8	8	37*	30-42*	4
		SL COT	C	-	-	-	-
RM 1.1 (Headgate)	2010	LL	161	230[1]	103*	55-206*	100

In August 2010, discharge was measured above, within, and below the seven ditches on Gold Creek. These measurements were collected by Montana TU technicians contracted to inventory irrigation diversions within the Upper Clark Fork River Drainage. On August 7th, the discharges of the ditches at RM's 3.9, 3.8, 3.7, and 3.6 were measured, and the discharges in ditches at RM's 6.1, 5.2 and 1.1 were measured the following day. The ditch at RM 6.1 was receiving 3.2 cfs, approximately 17% of the mainstem discharge at 18.3 cfs. The ditch at 5.2 was receiving 8.3 cfs, approximately 62% of the mainstem discharge at 13.3 cfs. The ditch at RM 3.9 was receiving less than 1 cfs, which was approximately 9% of the mainstem discharge at 9.7 cfs. The ditch at RM 3.8 was receiving 1.3 cfs, approximately 13% of the mainstem discharge at 10.4 cfs. The ditch at RM 3.7 was receiving 4.9 cfs, approximately 61% of the mainstem discharge at 8.1 cfs. The ditch at RM 3.6 was receiving less than 1 cfs, less than 27% of the mainstem

discharge at 3.3 cfs. However, the push-up dam diversion for the Lower Wall City ditch had been removed at the time measurements were collected. The ditch at RM 1.1 was receiving 5.2 cfs, approximately 32% of the mainstem discharge at 16.3 cfs.

Clark Fork River

The Clark Fork River is a major tributary of the Columbia River, flowing through Montana and Idaho. The headwaters of the Clark Fork River, beginning as Silver Bow Creek, are located near the town of Butte, MT (Figure 1). Land use within the upper Clark Fork River basin consists primarily of agriculture, but includes timber harvest and historical mining. Although crop production is limited, irrigation is extensive due to the prevalence of cattle production. Within the upper Clark Fork River, brown trout are the primarily component of the fishery, but westslope cutthroat and rainbow trout are also present in lower densities. Although rare, bull trout also occur from the town of Drummond, MT downstream.

In the August of 2010, electrofishing surveys were completed in a ditch diverting water from the Clark Fork River at RM 314.0 near the town of Deer Lodge, MT (Figure 1). This ditch, known as the Kohrs-Manning ditch, provides water to several private water users and the Grant Kohrs Ranch administered by the U.S. National Park Service . This large ditch is outfitted with two metal R-5 style headgates and water is diverted from the Clark Fork River with a boulder weir (Appendix B). The ditch intersects the extreme lower end of Cottonwood Creek approximately 0.2 mi below the headgate. At this junction a diversion near the mouth of Cottonwood Creek redirects water from the creek into the Kohrs-Manning ditch (Appendix B). At the time of the survey the headgates of the Kohrs-Manning ditch were turned down and little water was entering the ditch. Also, little to no water was advancing past the diversion at the mouth of Cottonwood Creek, and nearly all the water flowing out from Cottonwood Creek was entering the Kohrs-Manning ditch. Three 100 m sections were sampled in the ditch, one immediately below the headgate, one below the ditch's intersection with Cottonwood Creek and one approximately 1.6 mi below the headgate. No native trout were found entrained in the Kohrs-Manning ditch, but several other native fishes were observed (Table 15, Appendix A). In the section below the headgate 84 brown trout were collected, unidentified native sucker species and redside shiner were found to be abundant, and mountain whitefish, longnose dace, and slimy sculpin were also present, but rare. Below the Cottonwood Creek intersection, 20 brown trout and a few native sucker were collected. Approximately 1.6 mi below the headgate, only one adult brown trout was found in the sample reach. However, native sucker and redside shiner were found to be more common. Due to the design and location of the Cottonwood Creek diversion, it is difficult to determine where fishes captured below the ditch's intersection with the creek may have originated.

Table 15. Electrofishing data collected during 2010 in Kohrs-Manning ditch on the Clark Fork River. Longnose sucker and largescale sucker were not differentiated due to their abundance and combined as native suckers (NA SU).

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 314.0	2010	LL	84	84	107	68-207	100
(Headgate)		MWF	R	-	-	-	-
		LN DC	R	-	-	-	-
		SU	A	-	-	-	-
		RS SH	A	-	-	-	-
		SL COT	R	-	-	-	-
RM 314.0	2010	LL	20	20	100	71-134	100
(0.25 mi)		NA SU	R	-	-	-	-
RM 314.0	2010	LL	1	1	272	272	100
(1.6 mi)		SU	C	-	-	-	-
		RS SH	C	-	-	-	-

In September 2010, discharges were measured by Montana TU technicians, several days before the sections were electrofished. On September 13th, the discharge in the ditch below the headgate was approximately 1.0 cfs, and discharge of Cottonwood Creek was 6.0 cfs. The discharge in the ditch just below the intersection with Cottonwood Creek was 7.6 cfs, indicating all water from the creek was making its way into the Kohrs-Manning ditch.

Cottonwood Creek

Cottonwood Creek, a tributary to the Clark Fork River, drains for over nine miles before reaching the Clark Fork River at RM 313.8 near the town of Deer Lodge (Figure 1). Lands along Cottonwood Creek are dominated by privately owned agricultural lands, and rural and urban residences. Public ownership along the stream is limited to the lower 0.3 miles of channel that flows through the Grant Kohrs Ranch administered by the National Park Service, and the upper 0.3 miles of stream that lies within U.S. Forest Service ownership. Cottonwood Creek flows through Deer Lodge and through this reach the stream has been extensively channelized (RM 0.3 to RM 1.4). The dominant land uses in the Cottonwood Creek drainage are cattle grazing, hay production, urbanization, timber harvest, and historic mining. Fish populations in Cottonwood Creek vary from its upper reaches to the mouth. In 2007 and 2009 surveys, westslope cutthroat trout were only found in high densities in the upper reaches of Cottonwood Creek (RM 6.9; Lindstrom et al. 2008; unpublished data). On lower sections of the creek, cutthroat trout were found to be rare or absent. Brook trout were common throughout the upper and middle reaches, and brown trout numbers were highest near the mouth. Other species observed were slimy sculpin, longnose sucker and redside shiner, which were only present near the mouth of the creek.

Multiple ditches and irrigation structures are located throughout the middle to lower reaches of Cottonwood Creek. Seven of these diversions and ditches were observed between approximately RM 6.0 and RM 2.5. These structures varied in terms of size, construction, and amount of water diverted (Appendix B). The effects of these structures on Cottonwood Creek water temperatures and fish populations are likely high. In 2007, thermographs were placed in Cottonwood Creek at RM 7.0 and RM 0.5 (Appendix C). Water temperatures were found to be notably cooler at the upper site. At RM 7.0, maximum temperature recorded did not exceed 17.8°C, while at RM 0.5 it exceeded 20°C on 20 days with a maximum recorded temperature of 24.1°C. On June 30, 2009, Cottonwood Creek was found to be dry for several hundred meters below the diversion at RM 4.0 (Appendix B).

Cottonwood Creek was visited on five occasions during the summer of 2009 to assess the effects of the diversion structures on fish populations in Cottonwood Creek. A study was conducted to establish if any of the structures were fish passage barriers. At the initial visit on June 23, 2009, it was visually determined that six of the 11 diversions were not likely barriers, and mark/recapture studies were conducted on the remaining five. Fish were collected above the diversions, given a unique mark, and transported downstream of each diversion. In the subsequent weeks, extensive electrofishing was performed above the diversions to identify movement across potential barriers. Table 16 below describes characteristics of these diversions and results from this study.

Table 16. Physical characteristics of selected diversion structures on Cottonwood Creek with results from mark/recapture fish passage barrier assessment conducted during 2009.

Diversion Location (Name)	Diversion Type	Jump Pool	Jump Height	Fish Relocated Below	Fish Captured Above
RM 6.0 (Dippold/Pruyn)	Pin and Plank	<1”	1’ 5.5”	25	4
RM 5.5 (Olsen)	Concrete Dam	3’ 0”	2’ 7”	30	1
RM 5.4 (Pruyn)	Pin and blank	<1”	2’ 1”	44	1
RM 3.5 (Burt)	Concrete rip-rap	n/a	n/a	17	2
RM 3.0 (Lower Applegate)	Dirt, Sod, and rip-rap	n/a	n/a	25	6

In summary, none of the structures were found to be complete barriers to fish migration. The diversions at RM 6.0 and RM 5.4 were both pin and plank structures, and appeared to be barriers when all planks were in place. However, on July 15, 2009, at least one

plank from each of these diversions had been removed which provided easy passage for fish. The diversion at RM 5.5 was the tallest, most permanent structure and considered most likely to be a seasonal barrier (Appendix B). However, on July 15, 2009, a 153 mm EB placed below the diversion at RM 5.4 was recaptured above the diversion at RM 5.5. Multiple fish also navigated past the two lowest diversions at RM 3.5 and RM 3.0. A final barrier observed during 2009, was the several hundred meters of dry creek bed below the diversion at RM 3.5. This stretch was certainly a barrier for the seven or more days when dry, and may be dry for longer periods during low-water years. Furthermore, when surveyed on June 30, hundreds of trout fry were stranded in pools within this section of creek. Approximately 20 of these fry were positively identified as brook trout, but it is likely a small percentage were westslope cutthroat trout given their presence in this reach of Cottonwood Creek.

Also during 2009, electrofishing surveys were completed in four ditches on Cottonwood Creek to document entrainment (Figure 1). Due to fluctuating irrigation demands, certain ditches were closed off at various times throughout the field season. The ditch at RM 6.1 was only sampled for 61 m below the headgate due to private property constraints. The ditch at RM 4.0 was dry except for a small pool directly below the headgate. The two lower ditches were shocked from the headgate downstream 100 m. No other ditches were sampled either due to lack of landowner permission or water on the intended sampling date. All ditches sampled contained fish with the lower three containing non-native brook trout and the lowest also containing a brown trout (Table 17, Appendix A). The upper ditch (RM 6.1) contained one brook trout and multiple (approximately 20) smaller trout (<30 mm), one of which was identified as a westslope cutthroat trout. These fish were too small for the dip net and escaped capture; however, all were assumed to be age-0 westslope cutthroat trout due to their size. Additionally, a 135 mm westslope cutthroat trout was shocked in the ditch structure just above the headgate. The ditch at RM 3.5 also contained a single adult Columbia spotted frog *(Rana luteiventris)*.

Table 17. Electrofishing results collected during 2009 in ditches on Cottonwood Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 6.1	2009	WCT	1	n/a	27	27	50
(Headgate)		EB	1	1.6	120	120	50
RM 4.0	2009	EB	8	n/a	70	43-122	100
(Headgate)							
RM 3.5	2009	EB	11	11	111	91-187	100
(Headgate)							
RM 3.0	2009	LL	1	1	156	156	11
(Headgate)		EB	8	8	143	60-156	89

In late August and early September 2010, discharges were measured by Montana TU technicians at several of the sites electrofished in 2009. On August 30th, the headgate on the Dippold/Pruyn ditch at RM 6.0 was closed, but nearly 1 cfs continued to enter the ditch. According to measurements upstream of 4.4 cfs and downstream of 4.0 cfs, the ditch was receiving 9% or less of the mainstem discharge. The Olsen ditch at RM 5.5 was receiving 0.2 cfs on September 14th, approximately 4% of the mainstem discharge of 4.9 cfs. The headgate on the Pruyn ditch at RM 5.4 was closed on September 14th, but an estimated 1.5 cfs continued to enter the ditch (5.3 cfs upstream and 3.8 cfs downstream of the diversion). The Burt ditch at RM 3.5 was receiving <1 cfs on August 24th, approximately 6% or less of the mainstem's estimated discharge of 1.8 cfs (discharge downstream of the diversion was 1.7 cfs). The Lower Applegate ditch at RM 3.0 was receiving 2.6 cfs on August 24th, approximately 93% of the remaining mainstem discharge of 2.8 cfs.

Dempsey Creek

Dempsey Creek is a tributary to the Clark Fork River and drains for over 16 miles before reaching the Clark Fork River near RM 322.8 (Figure 1). The lower 10 miles of the stream flows through privately owned lands with the exception of property managed by the Montana State Prison (between RM 5.3 and 3.6). The upper extent of the watershed lies entirely on high elevation lands managed by the USFS. The primary land uses in the drainage are irrigated hay production (lower half of drainage), livestock grazing, and National Forest recreation (upper portion of drainage). Dempsey Creek is heavily used for irrigation, and diversions are common throughout the lower portion of the drainage. There are also a number of high elevation lakes in the headwaters of the drainage, some regulated to provide summer flows for downstream irrigators. Fish populations in Dempsey Creek vary from its upper to lower reaches. The upper reaches support mostly brook trout with a few westslope cutthroat trout also present, while the lower reaches support mainly brown trout (Liermann et al. 2009).

In early September 2010, four irrigation ditches on lower Dempsey Creek were sampled within land managed by the Montana State Prison (Figure 1). Electrofishing surveys were completed in 100 m sections on all of the ditches. The furthest upstream ditch, at approximately RM 5.1, is fitted with a wooden screw-down headgate and a check-dam which spans the creek channel (Appendix B). The headgate was opened the day before electrofishing was conducted and although no fish were captured below the headgate, one small (<80 mm) fish was observed. The next ditch downstream at approximately RM 4.8 is fitted with metal R-5 style headgate and a boulder weir, reinforced by natural vegetation, serves as the diversion structure. At the time of survey, the headgate was closed and no water was being diverted from Dempsey Creek. The remaining pools in the 100 m below the headgate however, contained 85 brown trout, four brook trout and several slimy sculpin (Table 18, Appendix A). It is likely the ditch at RM 4.8 was in operation more regularly earlier in the summer, allowing for the observed entrainment of brown trout, brook trout and slimy sculpin.

The ditch at RM 4.7 has no formal headgate, but is fitted with a concrete check-dam to divert water from Dempsey Creek. At the time of the survey, no planks were installed in the check-dam and the ditch was closed off by Visqueen. No fish were collected in the first 100 m below the opening of the ditch. The lowest ditch, at RM 4.3, was in operation. This ditch has no formal headgate, but is fitted with a wooden check-dam. No fish were collected in this ditch; however, this ditch had only been opened for a short time.

Table 18. Electrofishing data collected during 2010 in four ditches on Dempsey Creek operated by Montana State Prison.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 5.1 (Headgate)	2010	NO	FISH	-	-	-	-
RM 4.8 (Headgate)	2010	LL	85	85	173	73-356	96
		EB	4	4	153	136-171	4
		SL COT	R	-	-	-	-
RM 4.7 (Headgate)	2010	NO	FISH	-	-	-	-
RM 4.3 (Headgate)	2010	NO	FISH	-	-	-	-

In September 2010, discharge measurements were collected by Montana TU technicians on the same date ditches were electrofished. On September 10th, the ditch at RM 5.1 was receiving 0.8 cfs, approximately 8% of the mainstem discharge of 9.5 cfs. The ditches at RM's 4.8 and 4.7 were not receiving any water, and the ditch at RM 4.3 was receiving 10.5 cfs, approximately 56% of the mainstem discharge of 18.6 cfs.

Racetrack Creek

Racetrack Creek is a tributary to the upper Clark Fork River and drains for over 23 miles before the entering the Clark Fork River at RM 326.5 (Figure 1). Land ownership along the lower 12 miles of Racetrack Creek is primarily private, and land use is agriculture. The remainder of the stream flows through U.S. Forest Service administered lands that dominate the upper portion of the watershed. Numerous mountain lakes are present in the headwaters of Racetrack Creek and its tributaries. Several of the larger lakes have dams that provide storage for downstream irrigators. The primary land uses in the lower portion of the drainage are hay and crop production, cattle grazing, and rural residences. Land use in the upper portion of the watershed is dominated by motorized and non-motorized recreation on public lands. Fish populations in the upper reaches of Racetrack Creek are comprised of *Oncorhynchus* species including individuals possessing the phenotypic appearance of westslope cutthroat trout, rainbow trout, and hybrids of the two (Lindstrom et al. 2008). In middle reaches of the creek, the fish community is comprised

of brown trout, brook trout, and *Oncorhynchus* species. In the lower reaches, irrigation withdrawals and low summer flows can de-water the channel.

Electrofishing surveys were completed in three ditches on Racetrack Creek in September 2010 (Figure 1). The headgates of two ditches were accessible on State of Montana land at approximately RM 7.4 (Figure 1). The third ditch is located downstream on private property at RM 3.5. The upper ditch at RM 7.5, located just upstream of the lower ditch, is fitted with at metal R-5 style headgate and a boulder weir diversion. Two westslope cutthroat trout and 15 brown trout were collected in the first 100 m below the headgate. Slimy sculpin were also present but rare in this section (Table 19, Appendix A). The second ditch at RM 7.4 is fitted with a C-10 style headgate and a boulder weir diversion. Twenty brown trout and two unidentifiable *Oncorhynchus* species were collected in the first 100 m below the headgate. Slimy sculpin were also present, but rare (Table 19, Appendix A). At the time of these surveys, the discharge of Racetrack Creek was high due to recent rainfall, and resulted in high velocities and turbidity in the ditches. The lower ditch at RM 3.5, was also fitted with a C-10 style headgate and a boulder weir diversion, reinforced with concrete and Visqueen. A total of 40 trout were collected below the headgate, 39 brown trout and one brook trout. Slimy sculpin were also present, but rare in the section (Table 19, Appendix A).

Table 19. Electrofishing data collected during 2010 in ditches on Racetrack Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 7.5	2010	WCT	2	2	128	101-155	12
(Headgate)		LL	15	15	73	43-204	88
		SL COT	R	-	-	-	-
RM 7.4	2010	LL	20	20	97	43-321	91
(Headgate)		ONC	2	2	227	222-231	9
		SL COT	R	-	-	-	-
RM 3.5	2010	LL	39	39	127	70-197	98
(Headgate)		EB	1	1	173	173	2
		SL COT	R	-	-	-	-

In September 2010, discharges were collected by Montana TU technicians while the ditches were sampled. On September 9th, the upper ditch at RM 7.5 was receiving 8.1 cfs, approximately 8% of the mainstem discharge of 100.1 cfs, while the lower ditch was receiving 7.2 cfs, or 8% of the remaining mainstem discharge estimated at 92 cfs. The same date, the ditch at RM 3.5 was receiving 3.3 cfs, approximately 33% of the mainstem discharge of 10.2 cfs. Once again, at the time of the surveys, the discharge of Racetrack Creek was abnormally high due to recent rainfall.

Lost Creek

Lost Creek is a tributary to the Clark Fork River and drains for approximately 23 miles before reaching the Clark Fork River at RM 334.7 (Figure 1). The lower 16 miles of the stream flows primarily across private land, while the upper portion of the drainage flows on State of Montana and National Forest land. Also, Lost Creek State Park is situated along the creek from RM 16.2 to RM 18.2. Land use in the upper portion of the watershed is mostly non-motorized recreation, while cattle grazing, rural residences, and irrigated hay production are primary land uses in the lower portion of the drainage. Lost Creek is a principal source of irrigation water for adjacent hay production, and withdrawals often diminish summer flows in several reaches (e.g. upstream of the Galen Highway crossing, and near Interstate 90). A small irrigation impoundment, known as Dutchman Pond, is located on Lost Creek at RM 7.7, and the Gardiner Ditch (originating on Warm Springs Creek) bisects the stream near RM 10.3. Both locations are probable upstream fish passage barriers. Additionally, a natural waterfall located in Lost Creek State Park at RM 17.6 is a likely barrier to upstream movement. Fish populations vary from the upper reaches of Lost Creek to its mouth. Above the natural barrier the trout community is comprised of brook trout and westslope cutthroat, which show heavy hybridization with Yellowstone cutthroat trout (Liermann et al. 2009). In the middle reaches of the stream below the falls, brook trout, westslope cutthroat trout, and brown trout are all present, while in the lowest reaches of Lost Creek, brown trout dominate the trout community.

In August 2010, electrofishing surveys were completed in two ditches located on lower Lost Creek at RM 9.2 and 7.6 (Figure 1). The ditch at RM 9.2 is fitted with a metal R-5 style headgate and a pin and plank diversion spanning the channel. A Denil fish ladder has also been installed along-side the diversion. Two sections of this ditch were sampled, one 25 m below the headgate and one approximately 1.6 mi below the headgate. One adult brown trout was the only fish collected just below the headgate and no fish were collected 1.0 mi below (Table 20). The ditch at RM 7.6 is fitted with two metal R-5 style headgates and draws water from Dutchman Pond. In the first 100 m below the headgate seven brown trout and nine brook trout were collected, but in the section approximately 0.8 mi below, only one brown trout was present (Table 20, Appendix A).

Table 20. Electrofishing data collected during 2010 in two ditches on Lost Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 9.2 (Headgate)	2010	LL	1	1	191	191	100
RM 9.2 (1.6 mi)	2010	NO	FISH	-	-	-	-
RM 7.6 (Headgate)	2010	LL	7	7	214	90-418	44
		EB	9	9	197	128-283	56
RM 7.6 (0.8 mi)	2010	LL	1	1	181	181	100

Discharges were collected by Montana TU in 2010, and on September 1st, the upper ditch at RM 9.2 was receiving 5.6 cfs, approximately 89% of the estimated mainstem discharge of 6.3 cfs. No discharge measurements were collected in the ditch at RM 7.6.

Warm Springs Creek

Warm Springs Creek is a large headwater tributary to the Clark Fork River and drains for approximately 32 miles before reaching the Clark Fork River at RM 339.4 near Warm Springs, MT (Figure 1). While most of the lower reaches of Warm Springs Creek flow through private land, including the town of Anaconda, several State of Montana Wildlife Management Areas are also located along the stream. Warm Springs Creek transitions to lands managed by the USFS around RM 22.9, along with several private in-holdings. Land uses in the watershed are varied, and include rural and urban residences, cattle grazing, timber harvest, recreation, and historic mining. The trout community throughout much of upper Warm Springs Creek (above Myers Dam) is comprised largely of westslope cutthroat trout and bull trout, with brook trout, rainbow trout and the occasional brown trout also present (Lindstrom et al. 2008). In the lower reaches of Warm Springs Creek (below Myers Dam), brown trout dominate the trout community with *Oncorhynchus* species and brook trout also occurring in lower numbers.

In 2010, electrofishing surveys were completed in three sections of a ditch at RM 10.0, on Warm Springs Creek (Figure 1). This ditch, which is known as the Gardiner Ditch, is fitted with a large metal R-5 style headgate and a concrete diversion wing. In the 100 m section, beginning 175 m below the headgate, one bull trout and two brown trout were collected, along with several slimy sculpin (Table 21). Approximately 2.0 mi downstream of the headgate, 27 brown trout were collected in the survey section along with a few slimy sculpin (Table 21, Appendix A). This section was located just below an intersection with Lost Creek and the fish may have originated from either Warm Springs Creek or Lost Creek. The third 100 m section was located approximately 4.9 mi below the headgate. Five brown trout were collected in this reach (Table 21, Appendix A).

Table 21. Electrofishing data collected during 2010 in a ditch on Warm Springs Creek.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 10.0	2010	BULL	1	1	282	282	33
(175 m)		LL	2	2	107	71-143	67
		SL COT	R	-	-	-	-
RM 10.0	2010	LL	27	27	133	54-240	100
(2.0 mi)		SL COT	R	-	-	-	-
RM 10.0	2010	LL	5	5	230	159-280	100
(4.9 mi)							

Discharges related to the ditch at RM 10.0 were not measured, but visual estimates at the time of the survey suggest the ditch was receiving 15-25% of the mainstem discharge.

Storm Lake Creek

Bull trout populations in the upper Warm Springs Creek drainage are fragmented by several irrigation diversions and impassable structures. One of the more prominent migration barriers is located at the downstream terminus of Storm Lake Creek. At this location a water control and bypass structure diverts Storm Lake Creek to Silver Lake with the option of bypassing water into a canal leading directly to Warm Springs Creek. The design of this structure has produced a vertical fish barrier that blocks virtually all upstream migration (Appendix B). Barriers such as these are a concern as they inhibit individuals from returning to their natal habitats for spawning and can constrain expression of a migratory life history (DeHaan et al. 2010).

In fall of 2010, electrofishing surveys were completed below the Storm Lake Creek diversion structure to evaluate whether bull trout known to occur in Silver Lake were gathering below the structure in an attempt to move up into Storm Lake Creek to spawn. Fishes were collected with a backpack electrofisher in the 80 m canal section between the structure and Silver Lake. All bull trout collected were measured, weighed, given a unique fin clip for the date, and phenotypically identified as either a pure bull trout or a bull trout/brook trout hybrid. Fish identified as pure bull trout were then manually passed over the barrier into Storm Lake Creek. All other fish collected at the site were released below the structure. On ten occasions, over a month long period, a total of seventeen bull trout ranging from 192-570 mm were collected below the structure and moved over (Table 22, Appendix A). This work has shown that there is a definite need to provide fish passage at this structure to allow Silver Lake bull trout to return to Storm Lake Creek to spawn.

Table 22. Bull trout captured downstream of the water control structure barrier on Storm Lake Creek in the fall of 2010.

Month	Day	Length	Weight	Comment
August	5	437	698	Hook found in throat
	16	461	887	
	16	482	903	
	16	487	1075	
	16	529	1415	
	16	539	1330	
	18	447	859	
	18	473	947	
	18	495	1117	
	19	447	808	
	23	436	688	Recapture from 8/5
	23	491	1010	
	23	547	1350	
	23	570	1613	
	25	-	-	No bull trout collected
	30	539	1276	Recapture from 8/16
September	2	192	62	
	2	307	246	
	2	528	1241	
	9	424	676	
	9	530	1375	Recapture from 8/16
	14	-	-	No bull trout collected

Browns Gulch

Browns Gulch is the largest tributary to Silver Bow Creek and drains for approximately 18 miles before reaching Silver Bow Creek near Ramsay, MT (Figure 1). Connectivity between Browns Gulch and Silver Bow Creek is relatively good, but can be compromised by irrigation withdrawals in the lower reaches. Land ownership along Browns Gulch is dominated by private land, but some National Forest land is present in the upper extent of the watershed. Land uses in the drainage are primarily irrigated hay production and livestock grazing; however, timber harvest also occurs in the upper extent of the drainage. Irrigation diversions are common throughout the middle and lower reaches of the stream. Fish populations in Browns Gulch vary little throughout the drainage. The trout community is dominated by brook trout, with westslope cutthroat trout also present in low densities (unpublished data). Longnose sucker and slimy sculpin have also been observed in the lower reaches of Browns Gulch.

In late August 2010, electrofishing surveys were completed in multiple sections on two ditches carrying water from Browns Gulch (Figure1). These ditches supply water for flood irrigation and center pivots supporting hay production and grazing in the lower portion of the drainage. The upper ditch at RM 4.3, is fitted with a wooden headgate regulated by the installation of wooden planks and water is diverted from the mainstem

via a pin and plank structure spanning the channel (Appendix B). Two sections were sampled on this ditch, one 105 m below the headgate, and one 0.4 mi below the headgate. Only one species, native long nose sucker, was collected in both sections (Table 23). The lower ditch at RM 4.1 is similarly fitted with a wooden headgate and diversion structure. Three sites were sampled on this ditch below the headgate at 20 m, 0.8 mi and 1.3 mi. Similar to the upper diversion, longnose sucker were present, but rare in the first two sections and no fish were collected 1.5 mi below the headgate (Table 23).

Table 23. Electrofishing data collected during 2010 in two ditches on Browns Gulch.

Ditch Name (Section)	Year Sampled	Species	Number of Fish Captured	Fish per 100 m (CPUE)	Mean Length (mm)	Length Range (mm)	Species Comp (%)
RM 4.3 (105 m)	2010	LNSU	R	-	-	-	-
RM 4.3 (0.4 mi)	2010	LNSU	R	-	-	-	-
RM 4.1 (20 m)	2010	LNSU	R	-	-	-	-
RM 4.1 (0.8 mi)	2010	LNSU	R	-	-	-	-
RM 4.1 (1.3 mi)	2010	NO	FISH	-	-	-	-

Summary

In summary, electrofishing surveys were conducted throughout the Upper Clark Fork River Drainage (Figure 1). In total, 45 ditches have been surveyed, and valuable data has been collected at all sites including data that may be used to implement management changes in the East Fork Rock Creek, as well as in Storm Lake Creek.

Table 24 provides an overview of observed entrainment, with a rating of risk for each selected ditch. The table also includes the river mile (RM) locations and coordinates of the ditches for future reference. A “high” rating indicates a significant number (>20) of native westslope cutthroat trout or at least one bull trout were observed in the ditch. A “medium” rating indicates less than 20 westslope cutthroat or other native fish such as a slimy sculpin or longnose sucker were observed in the ditch. A “low” rating indicates no fish or only non-native species were observed in the ditch. Entrainment ratings were adjusted from medium to high if a combination of native salmonids and other native species were found in the ditch or if the potential to entrain bull trout was high, such as when bull trout were observed entrained in neighboring ditches. This adjustment was made for the five lower ditches sampled in 2007 on Ross Fork Rock Creek. All headgates are located in close proximity to one another and bull trout were found in two

of the five. Since these ditches had comparable diversion structures and drew similar volumes of water, it was theorized bull trout would have an equal likelihood of finding their way into any of the ditches. This adjustment was made for the ditch at RM 0.95 on Boulder Creek, resulting in a "high" rating since a bull trout was collected in the ditch just upstream at RM 1.0. Given their proximity and similarities in design, it was reasonable to assign a more consistent rating. Finally, the rating for the lower ditch on Ranch Creek was adjusted to "high" due to the radio-tagged adult bull trout being relocated in the ditch approximately ten years ago (Brad Liermann, Montana Fish, Wildlife and Parks, personal communication).

Table 24. Stream names, locations, and entrainment ratings for ditches sampled in the Upper Clark Fork River Basin from 2007-2010.

Water Body	Ditch Location	Latitude, Longitude	Rating
Ranch Creek	RM 1.1	46.58778, -113.66974	Medium
Ranch Creek	RM 0.1	46.58982, -113.67128	High
Stony Creek	RM 0.3	46.34804, -113.61127	High
Beaver Creek	RM 0.9	46.46953, -113.51035	Medium
Rock Creek	RM 50.6	46.24004, -113.51767	High
Rock Creek	RM 50.5	46.24091, -113.51863	High
West Fork Rock Creek	RM 4.2	46.24443, -113.59107	Medium
Ross Fork Rock Creek	RM 9.4	46.14201, -113.59182	Medium
Ross Fork Rock Creek	RM 6.5	46.15901, -113.56498	High
Ross Fork Rock Creek	RM 6.2	46.16042, -113.56088	High
Ross Fork Rock Creek	RM 6.1	46.16096, -113.56088	High
Ross Fork Rock Creek	RM 6.0	46.16124, -113.56154	High
Ross Fork Rock Creek	RM 5.5	46.16489, -113.56498	High
Middle Fork Rock Creek	RM 0.1	46.22779, -113.51920	High
East Fork Rock Creek	RM 8.6	46.13346, -113.38535	High
Harvey Creek	RM 0.01	46.70631, -113.37314	Medium
South Fork Lower Willow	RM 2.9	46.52176, -113.35271	High
Gird Creek	RM 1.5	46.49423, -113.21259	Low
Boulder Creek	RM 0.9	46.46613, -113.23254	High
Boulder Creek	RM 0.8	46.46690, -113.23292	High
Boulder Creek	RM 0.2	46.47597, -113.23605	Low
Gold Creek	RM 6.1	46.52581, -112.97921	Medium
Gold Creek	RM 5.2	46.53371, -112.96510	Medium
Gold Creek	RM 3.9	46.53926, -112.94307	Medium

Table 24 continued...

Water Body	Ditch Location	Latitude, Longitude	Rating
Gold Creek	RM 3.8	46.54041, -112.94138	Medium
Gold Creek	RM 3.7	46.54098, -112.93961	High
Gold Creek	RM 3.6	46.54156, -112.93929	High
Gold Creek	RM 1.1	46.57030, -112.91975	Low
Clark Fork	RM 314.0	46.40120, -112.74256	Medium
Cottonwood Creek	RM 6.1	46.39970, -112.64194	Medium
Cottonwood Creek	RM 4.0	46.39288, -112.67608	Low
Cottonwood Creek	RM 3.5	46.39505, -112.68085	Low
Cottonwood Creek	RM 3.0	46.39981, -112.69475	Low
Dempsey Creek	RM 5.1	46.29005, -112.82461	Low
Dempsey Creek	RM 4.8	46.28832, -112.81905	Medium
Dempsey Creek	RM 4.7	46.28791, -112.81882	Low
Dempsey Creek	RM 4.3	46.28653, -112.81057	Low
Racetrack Creek	RM 7.5	46.26722, -112.86635	Medium
Racetrack Creek	RM 7.4	46.26672, -112.86542	Medium
Racetrack Creek	RM 3.5	46.27701, -112.79395	Low
Lost Creek	RM 9.2	46.17117, -112.87405	Low
Lost Creek	RM 7.6	46.18281, -112.85074	Low
Warm Springs Creek	RM 10.0	46.13880, -112.89211	High
Browns Gulch	RM 4.3	46.03134, -112.64264	Low
Browns Gulch	RM 4.1	46.02888, -112.64421	Low

Radio Telemetry Results

Based on the 2009 and 2010 radio telemetry data, most of the fish tagged in the Upper Clark Fork River were not affected directly by irrigation structures. This does not take into account the effects irrigation may be having on the river through de-watering. Reduced flows likely increase stream temperatures, may lessen the dilution of toxic metals in the river, and may contribute to algal blooms *(Cladophora species)* which reduce dissolved oxygen concentrations.

One fish directly impacted by irrigation was a bull trout tagged in 2009. This individual was found dead in mid-June 2009 approximately 0.75 mi below the headgate of the ditch at RM 0.01 on Harvey Creek. The radio-tagged bull trout had been located utilizing the lower portion of Harvey Creek for over a month prior to its expiration. It is believed Harvey Creek was the bull trout's natal stream, and this individual was attempting to return for spawning. However, when the fish reached the impassable barrier at RM 0.2 it remained in the lower portion of the creek until water levels dropped. Falling water levels may have caused the fish to exit the creek and it likely entered the ditch on its way back to the Clark Fork River. Given the extremely low population size of bull trout in the Upper Clark Fork River, any loss of adult bull trout is considered significant.

Another fish, potentially impacted by irrigation diversions in 2009 was located in Flint Creek. In early August 2009, a radio-tagged brown trout entered Flint Creek presumably in the early stages of a spawning migration. While the final destination of this fish was Upper Flint Creek near Maxville, MT (RM 15-16) in October, it remained in lower Flint Creek (RM 3-4) for two months despite low flows and warm stream temperatures in this portion of the creek. Several irrigation diversions exist on lower Flint Creek including one adjacent to Hall, MT (RM 5.5). It is possible this fish was unable to navigate past one of these diversions until sufficient flow returned to the mainstem when the numerous ditches withdrawing water from Flint Creek were closed.

Again in 2010, few fish were directly impacted by irrigation, but one westslope cutthroat trout was located within an irrigation ditch located on Cottonwood Creek near Deer Lodge, MT. This individual was observed alive in the ditch, but the radio tag was later recovered near a heron rookery. This individual may have either been captured due to its increased vulnerability in the ditch, or scavenged upon expiration.

Future Projects

Surveys conducted in 2011 will focus on the Rock Creek, Harvey Creek, Flint Creek, Little Blackfoot River, Warm Springs Creek, Dempsey Creek, Lost Creek, Mill Creek, Willow Creek, Blacktail Creek, and Browns Gulch drainages. The study and reference sites on East Fork Rock Creek and Ross Fork Rock Creek will also be surveyed to supplement the pre-data collected in 2009 and 2010. Data collected during efforts to move bull trout past the barrier on Storm Lake Creek will be presented in the final report.

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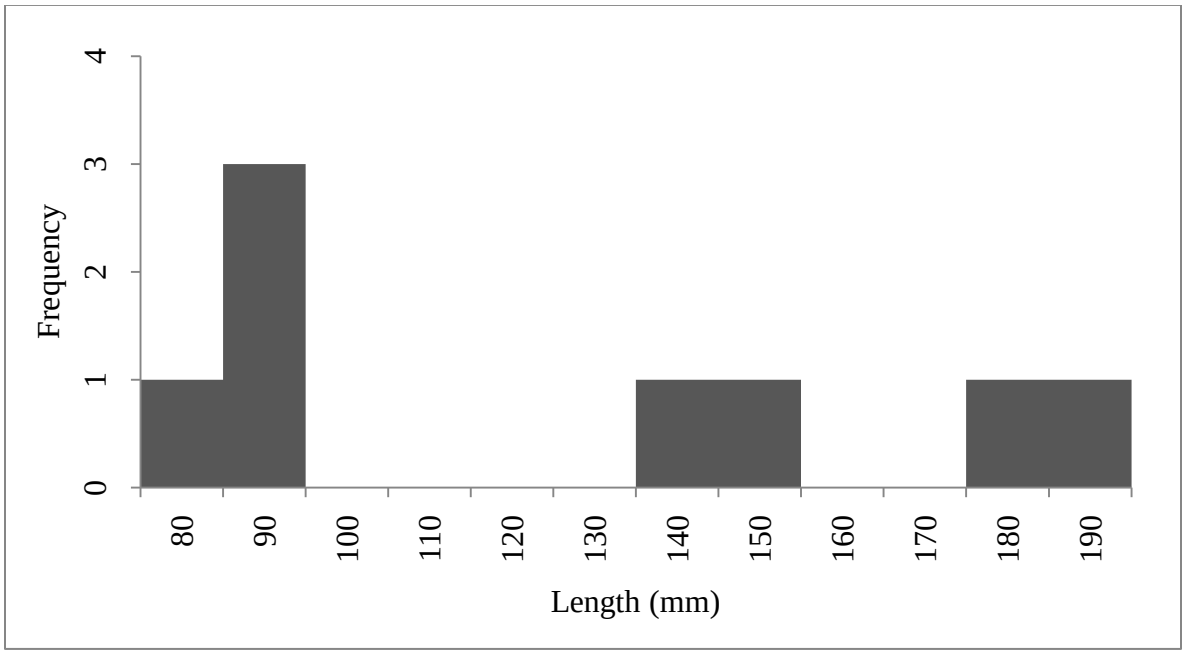
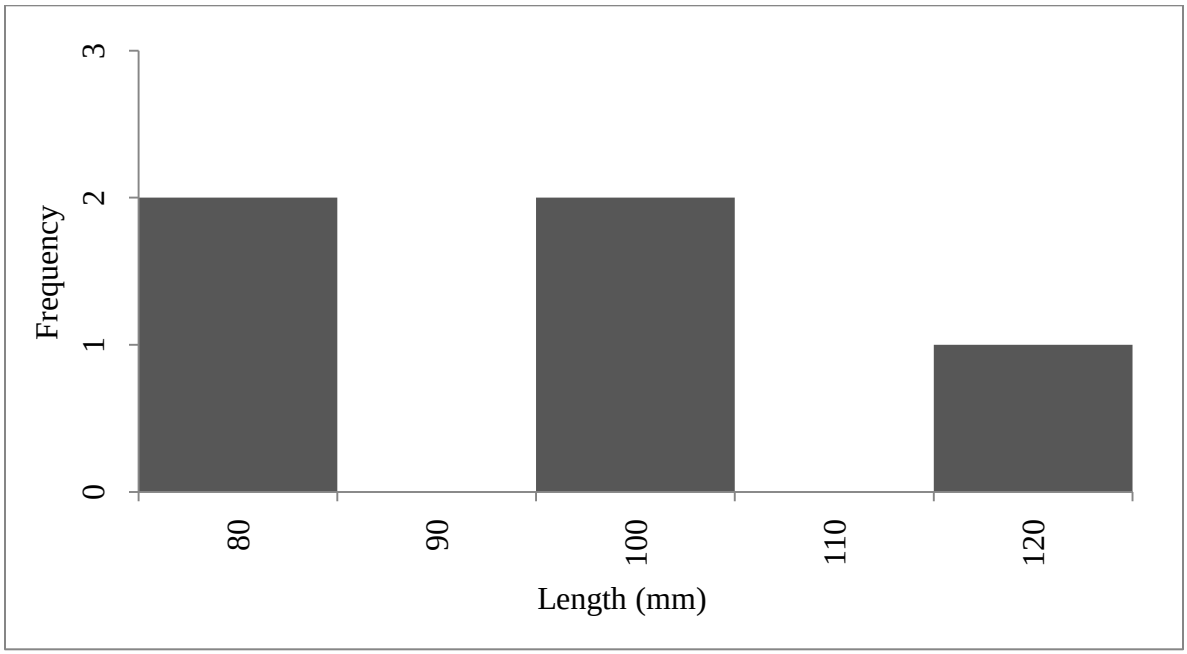
Appendix A

Ranch Creek

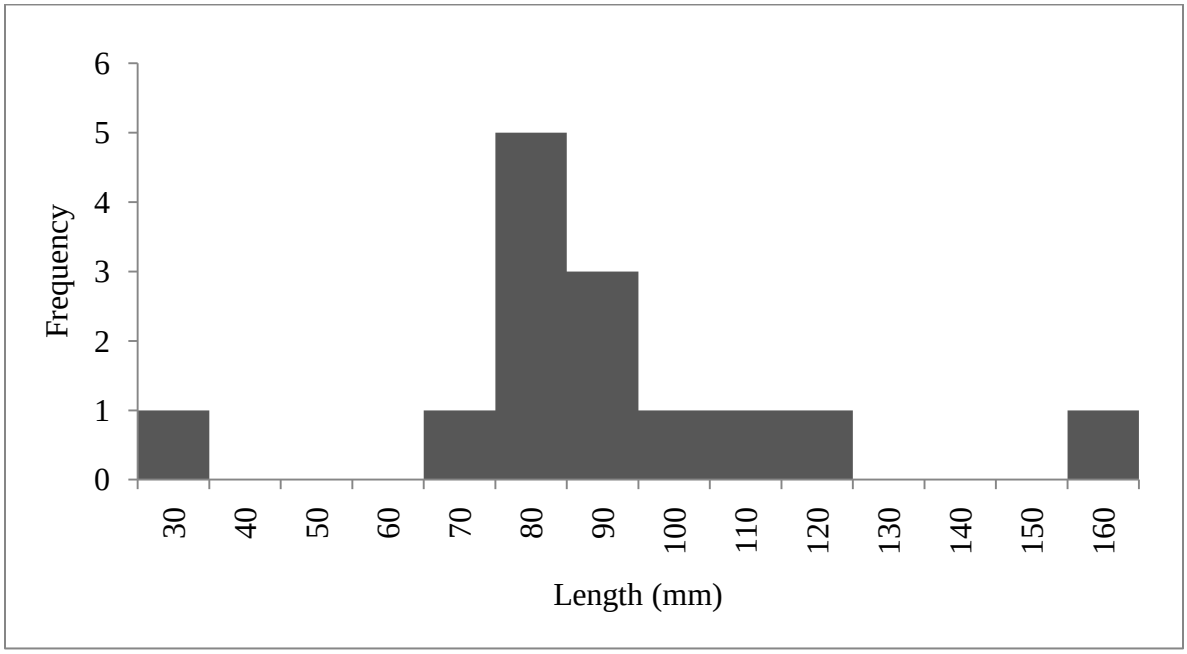


Length distribution of westslope cutthroat trout collected in the ditch at RM 1.1 on Ranch Creek below the headgate in 2009 (n=8).

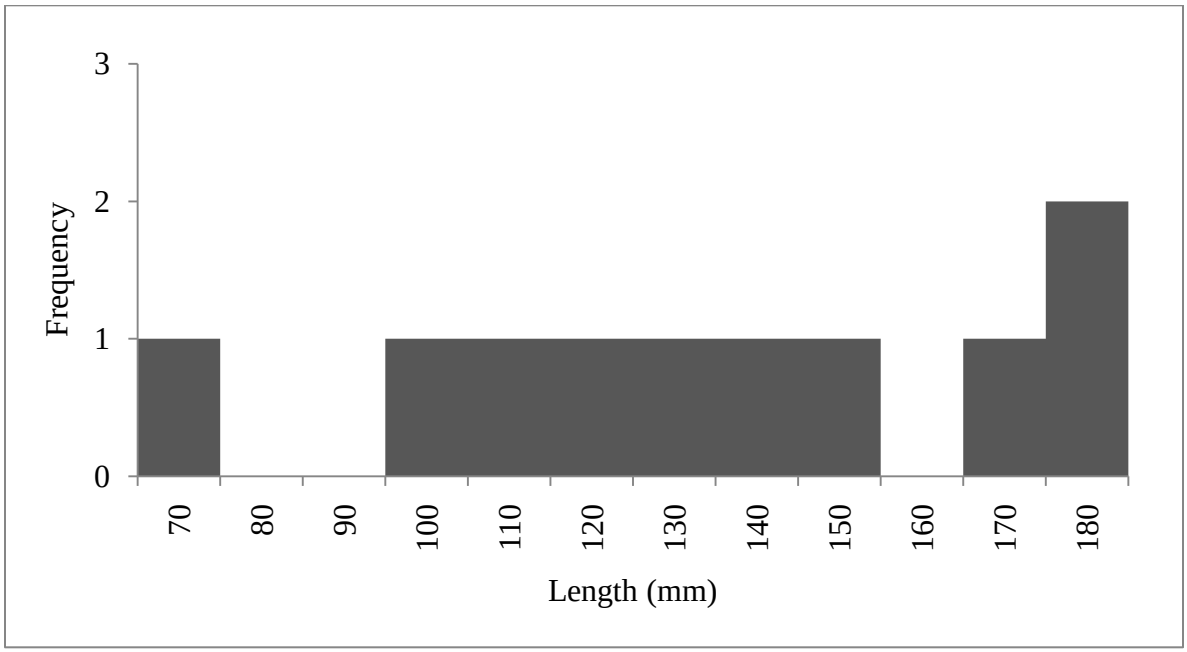


Length distribution of westslope cutthroat trout collected in the ditch at RM 0.1 on Ranch Creek below the headgate in 2009 (n=5).

Ranch Creek continued…

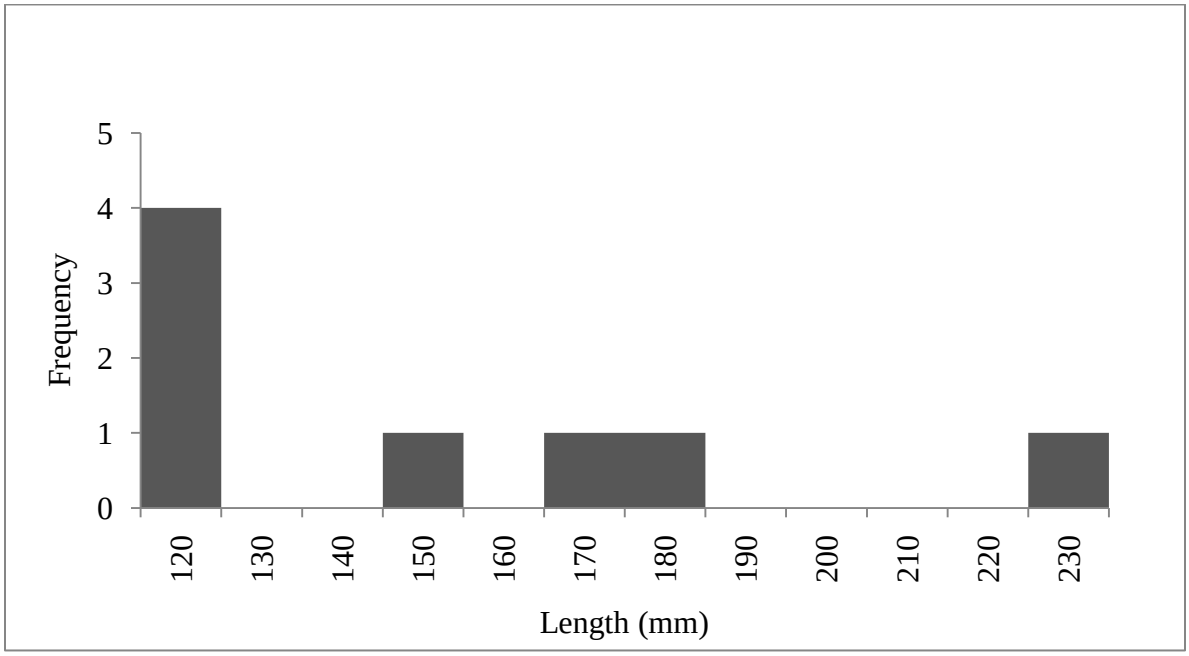


Length distribution of westslope cutthroat trout collected in the ditch at RM 1.1 on Ranch Creek below the headgate in 2010 (n=14).



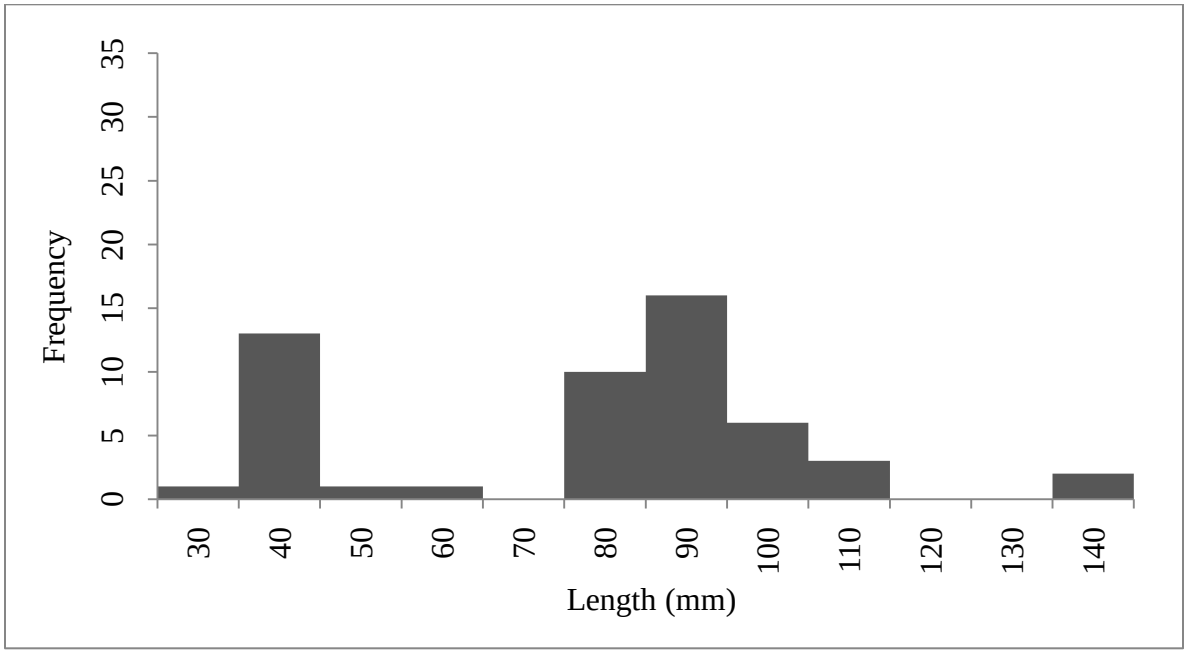
Length distribution of brown trout collected in the ditch at RM 0.1 on Ranch Creek below the headgate in 2010 (n=10).

Ranch Creek continued…



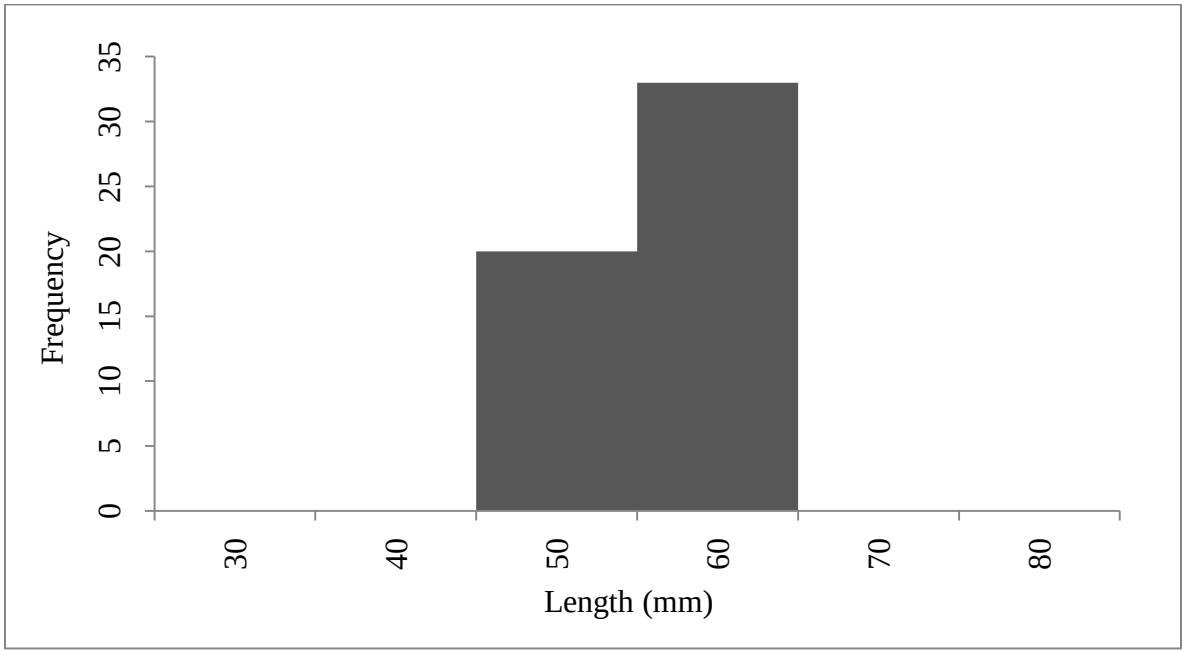
Length distribution of brook trout collected in the ditch at RM 0.1 on Ranch Creek below the headgate in 2010 (n=8).

Stony Creek



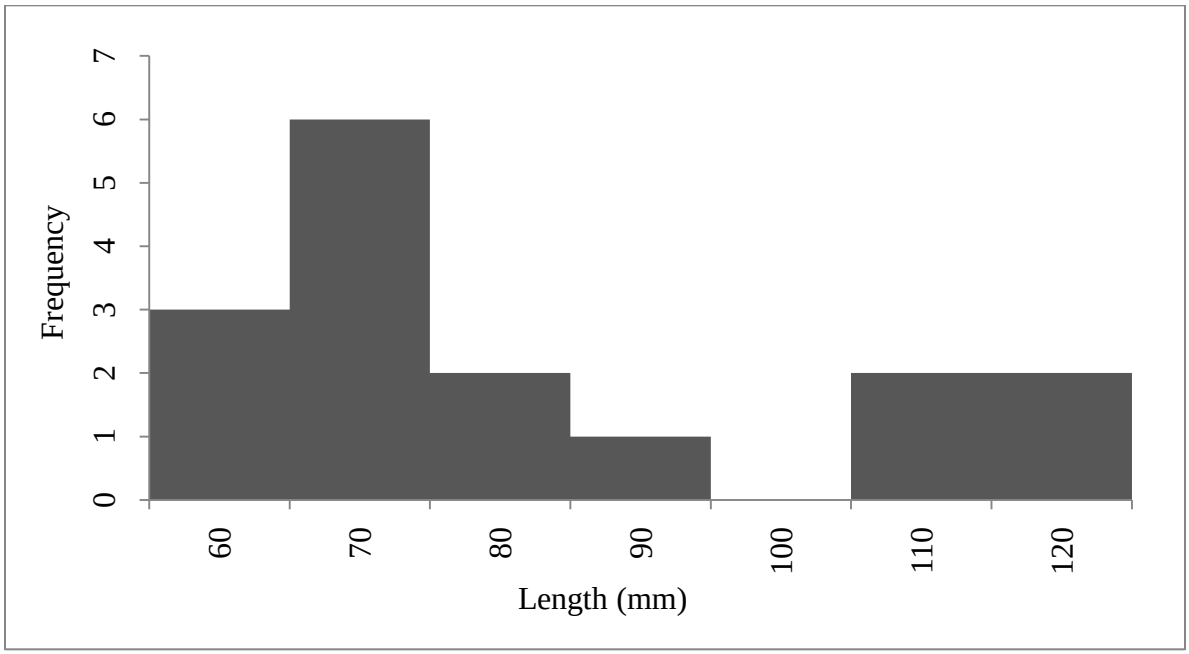
Length distribution of westslope cutthroat trout collected in the ditch at RM 0.3 on Stony Creek below the headgate in 2009 (n=53).

Stony Creek continued…



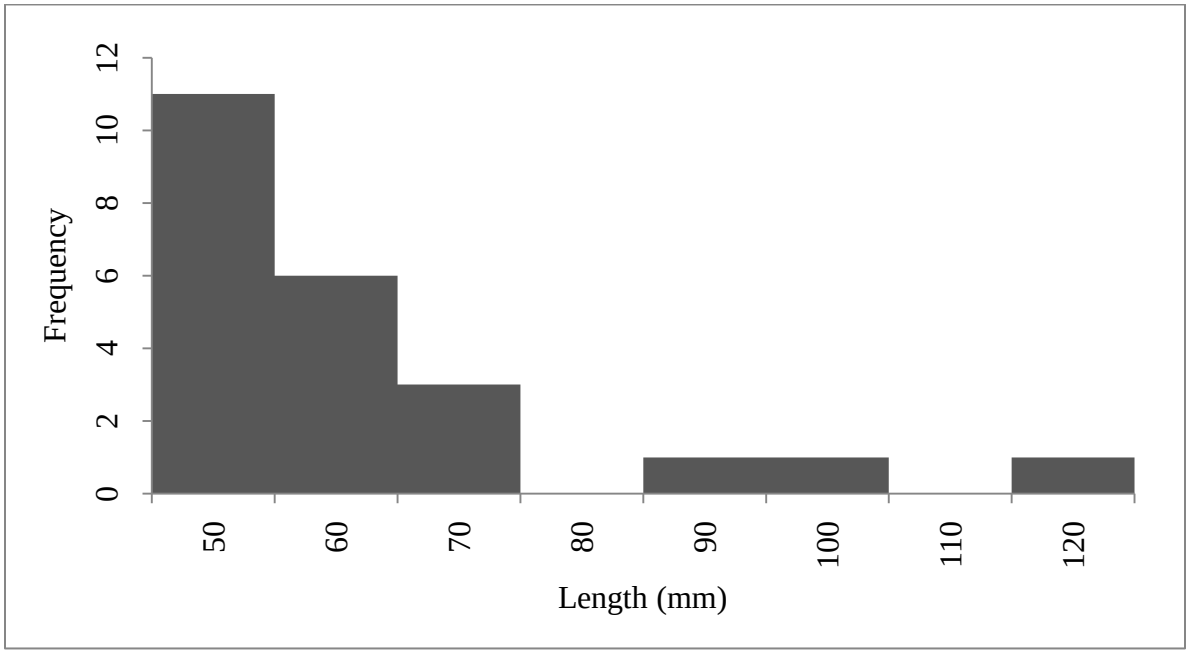
Length distribution of brown trout collected in the ditch at RM 0.3 on Stony Creek below the headgate in 2009 (n=53).

Beaver Creek



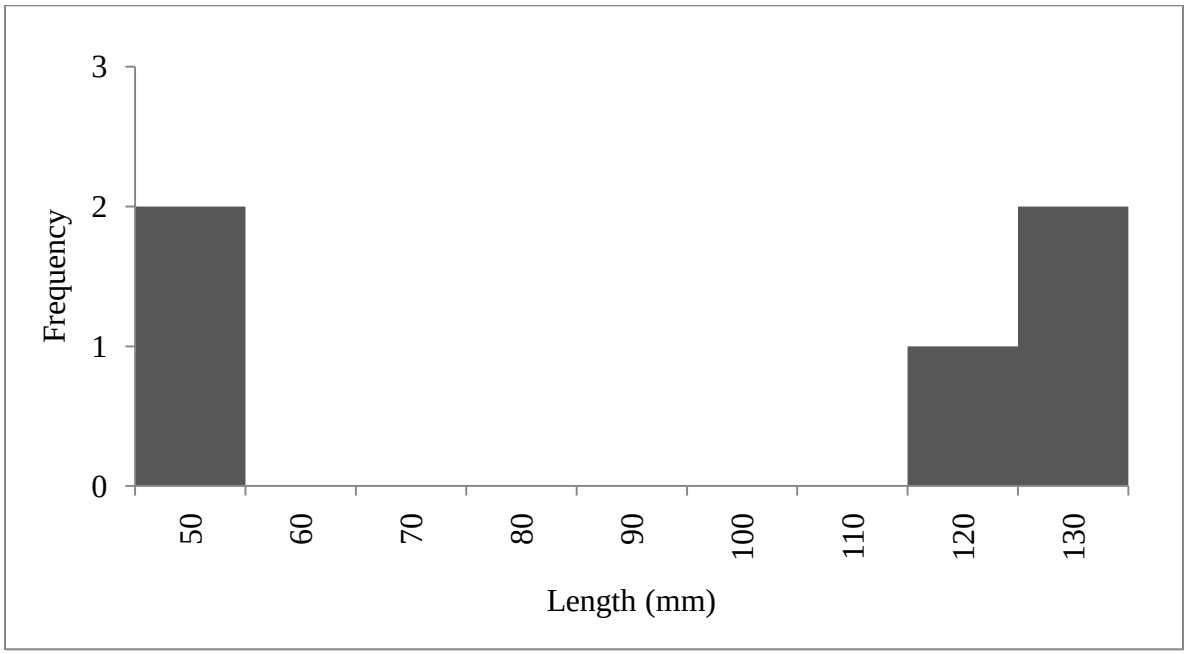
Length distribution of westslope cutthroat trout collected in the ditch at RM 0.9 on Beaver Creek below the headgate in 2009 (n=16).

Beaver Creek continued…



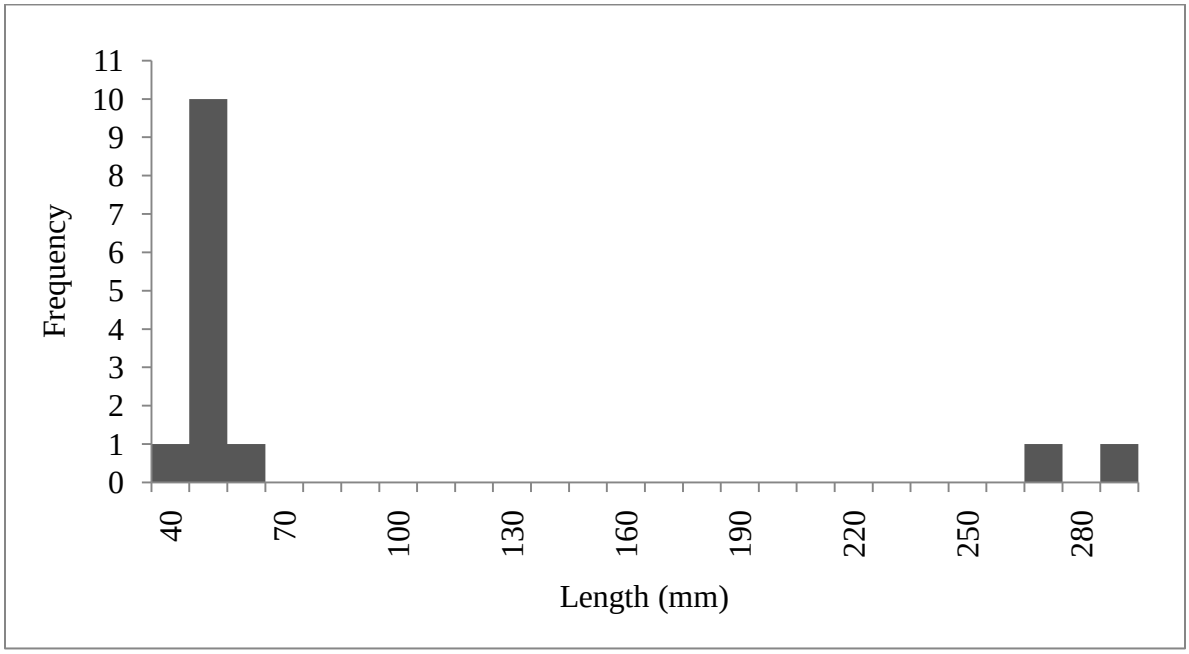
Length distribution of eastern brook trout collected in the ditch at RM 0.9 on Beaver Creek below the headgate in 2009 (n=23).

Rock Creek



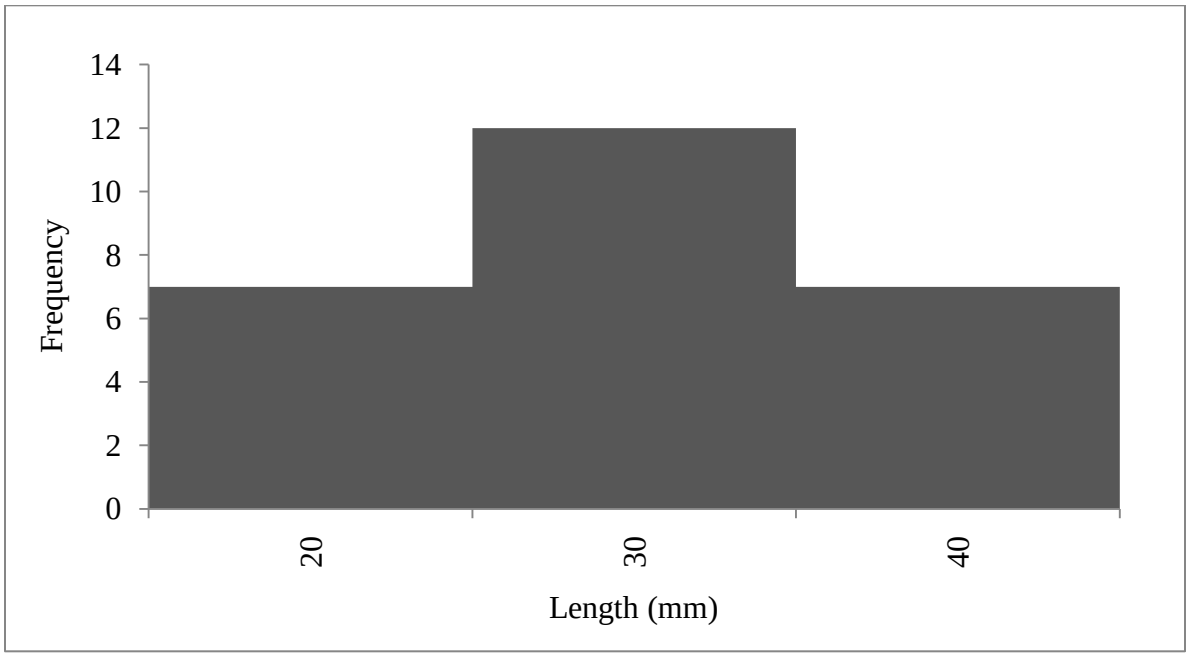
Length distribution of brown trout collected in the ditch at RM 50.6 on Rock Creek below the headgate in 2010 (n=5).

Rock Creek continued…



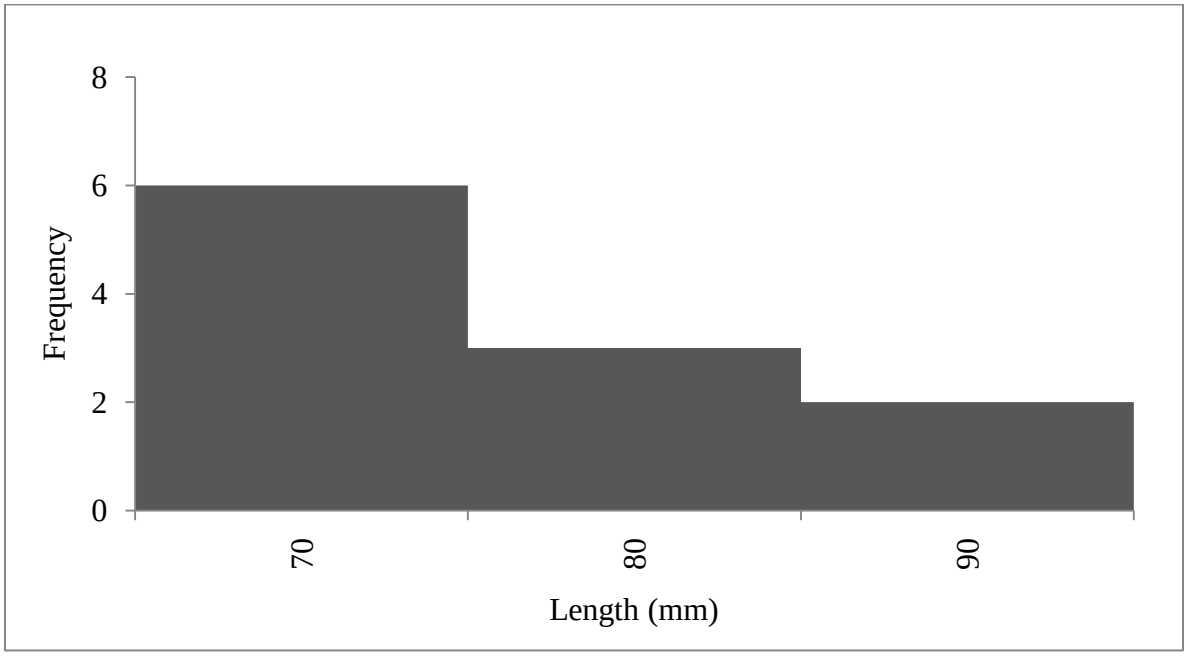
Length distribution of brown trout collected in the ditch at RM 50.5 on Rock Creek below the headgate in 2010 (n=14).

West Fork Rock Creek



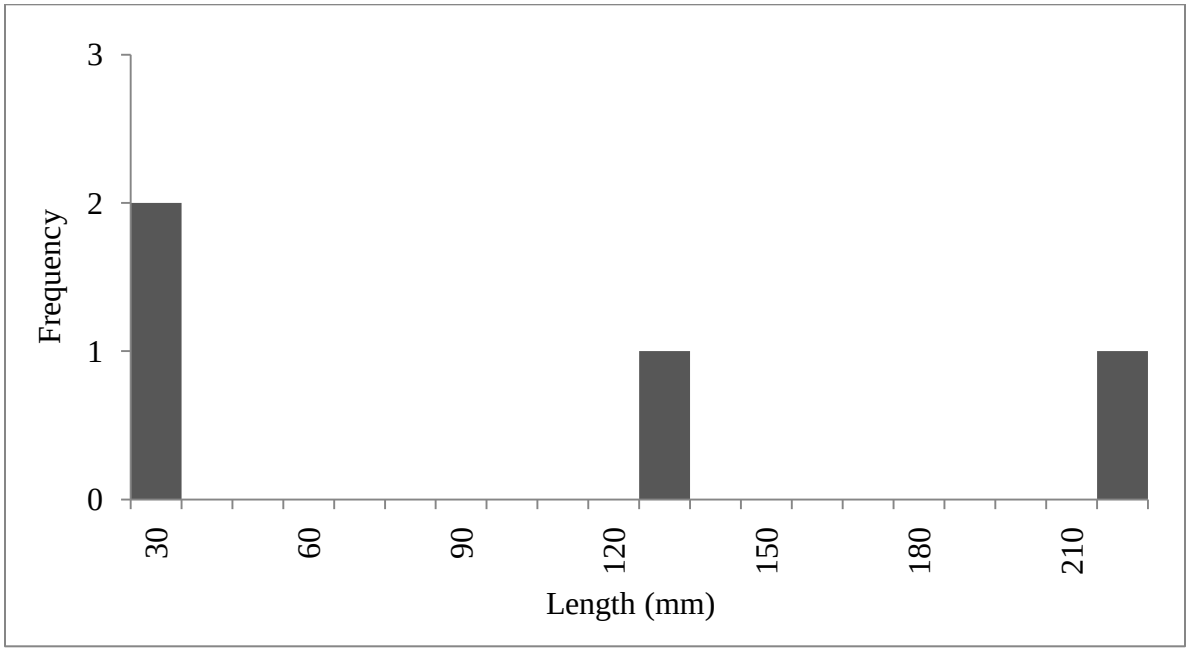
Length distribution of unidentifiable *Oncorhynchus* species collected in the ditch at RM 4.2 on West Fork Rock Creek below the headgate in 2010 (n=26).

West Fork Rock Creek continued…



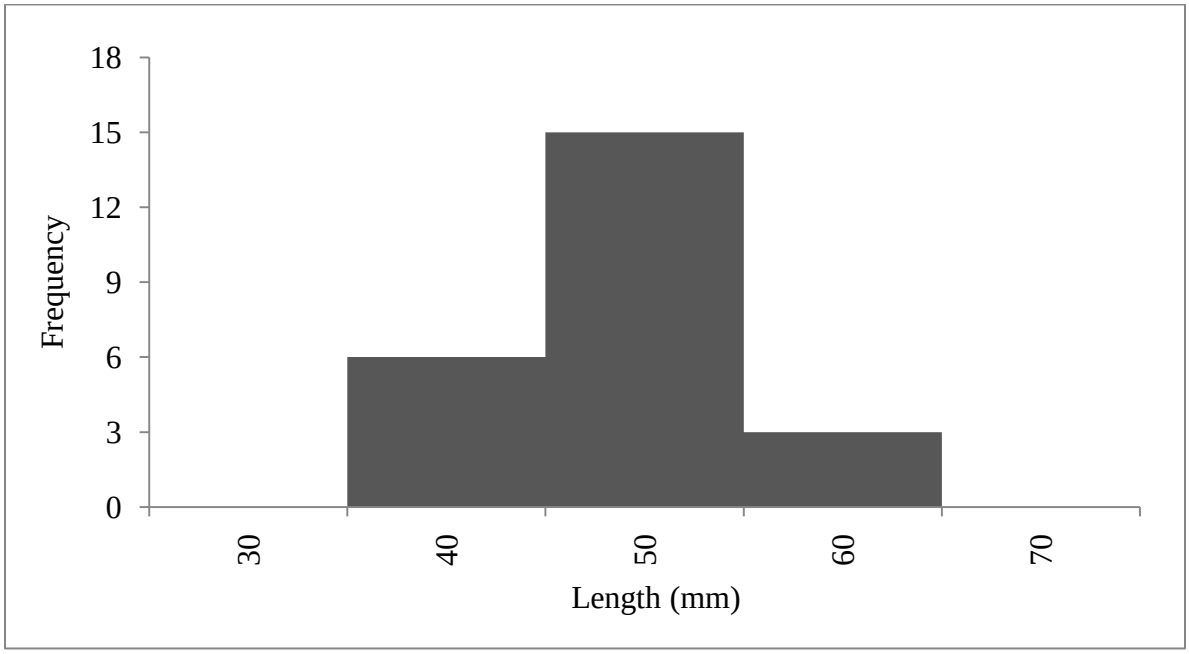
Length distribution of westslope cutthroat trout collected in the ditch at RM 4.2 on West Fork Rock Creek below the headgate in 2010 (n=11).

Ross Fork Rock Creek

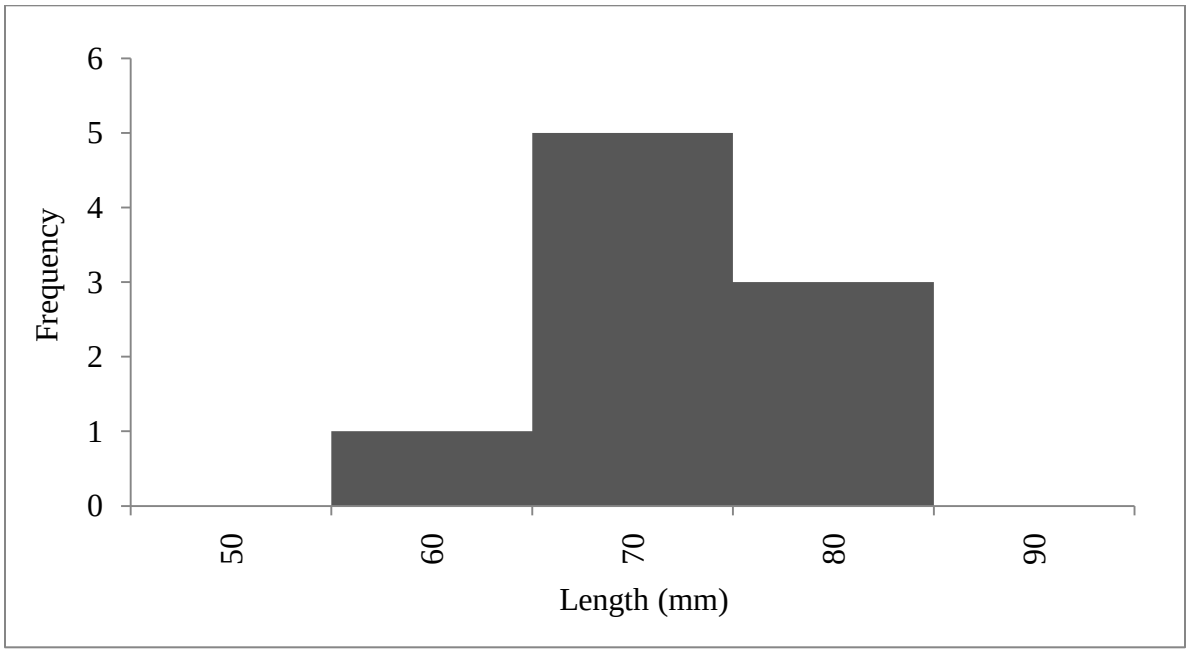


Length distribution of westslope cutthroat trout collected in the ditch at RM 9.4 on Ross Fork Rock Creek below the headgate in 2009 (n=4).

Ross Fork Rock Creek continued…

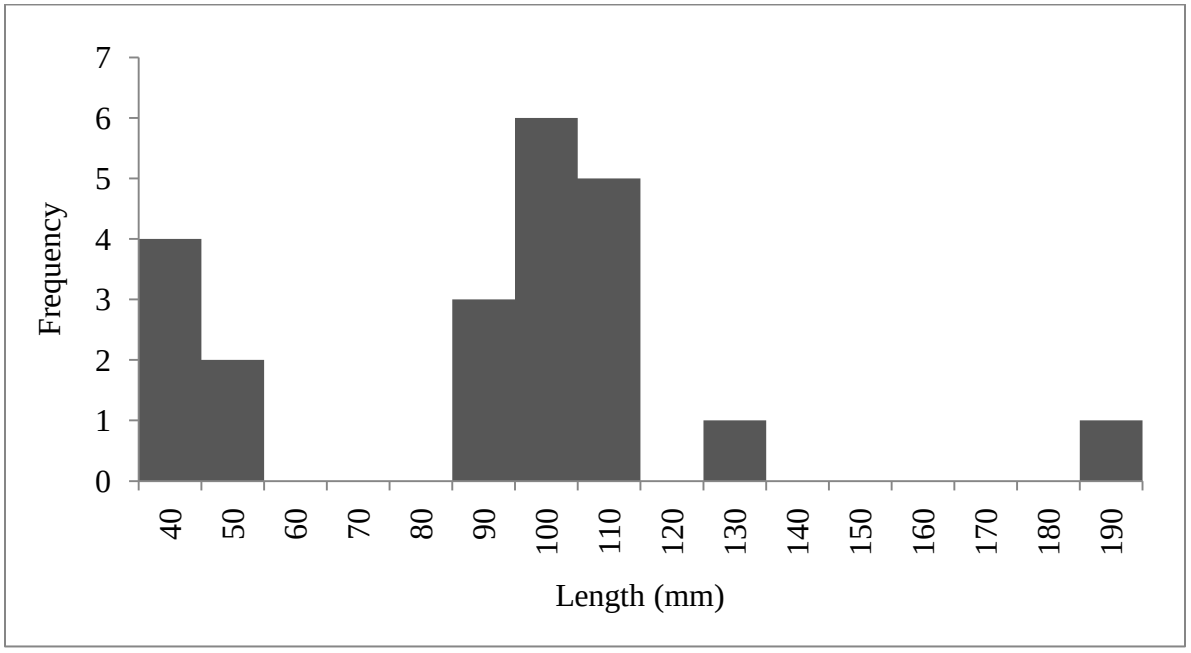


Length distribution of westslope cutthroat trout collected in the ditch at RM 6.5 on Ross Fork Rock Creek below the headgate in 2009 (n=24).

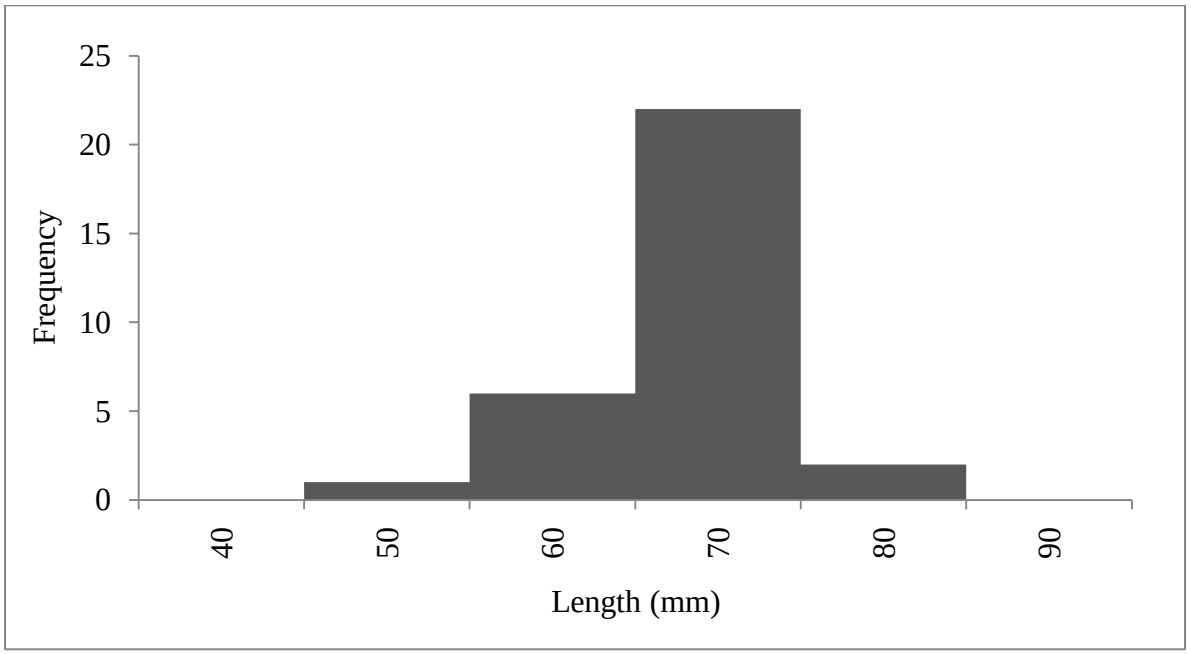


Length distribution of brown trout collected in the ditch at RM 6.5 on Ross Fork Rock Creek below the headgate in 2009 (n=9).

Ross Fork Rock Creek continued…

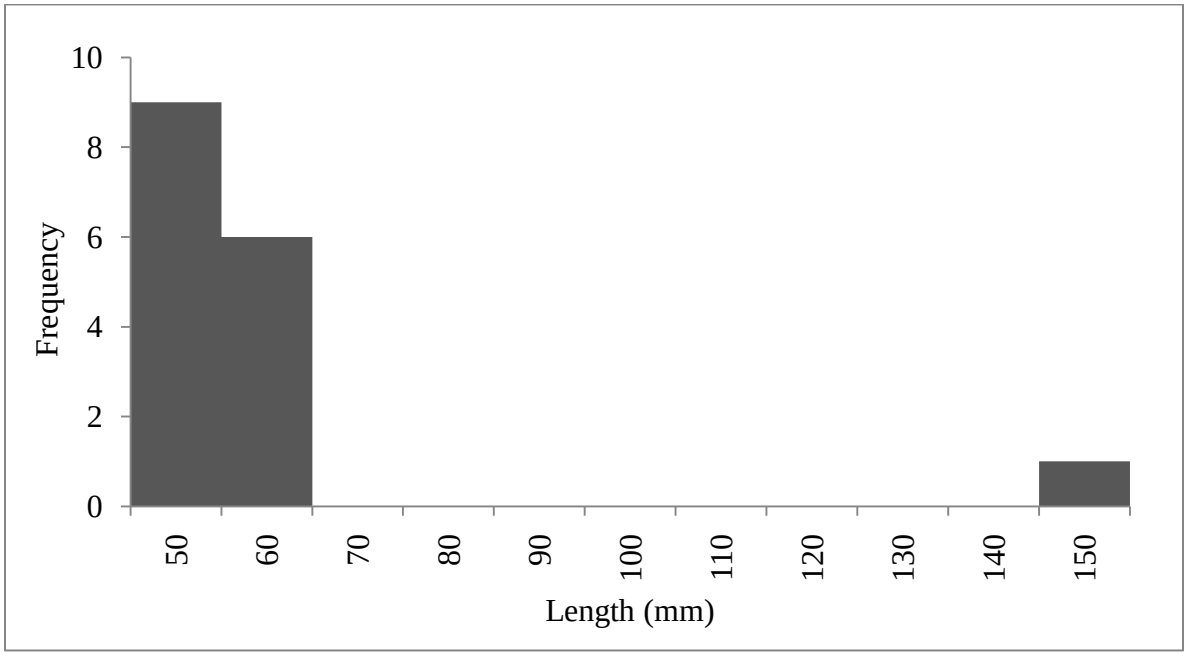


Length distribution of westslope cutthroat trout collected in the ditch at RM 6.2 on the Ross Fork Rock Creek below the headgate in 2009 (n=22).

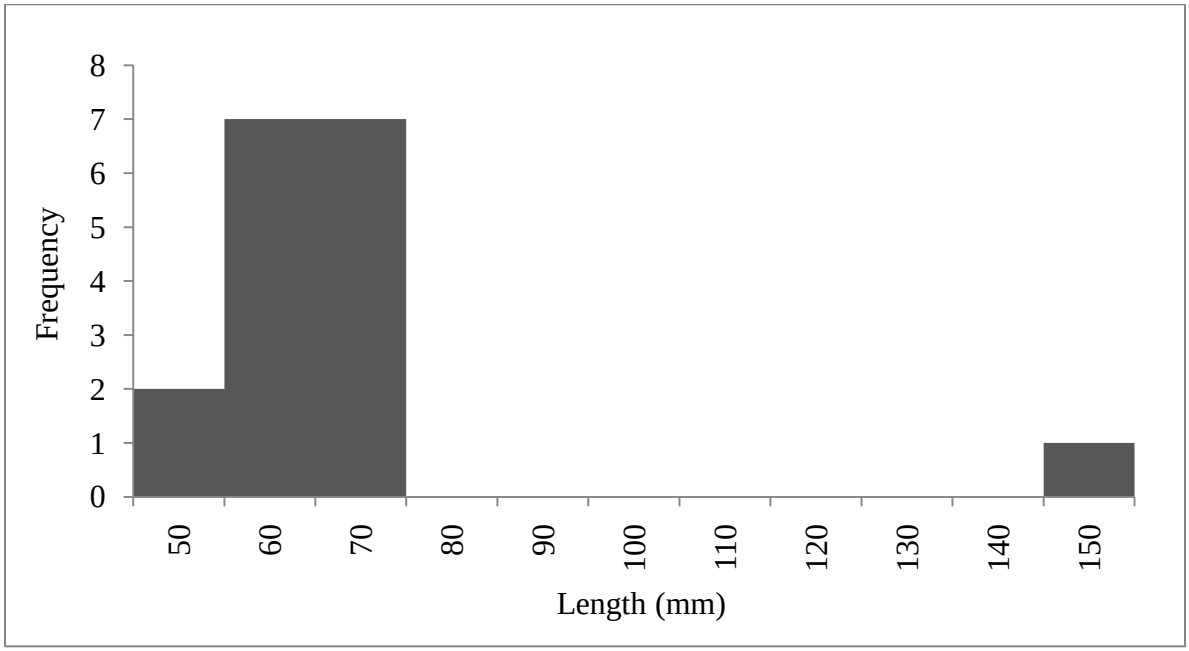


Length distribution of brown trout collected in the ditch at RM 6.2 on the Ross Fork Rock Creek below the headgate in 2009 (n=31).

Ross Fork Rock Creek continued…

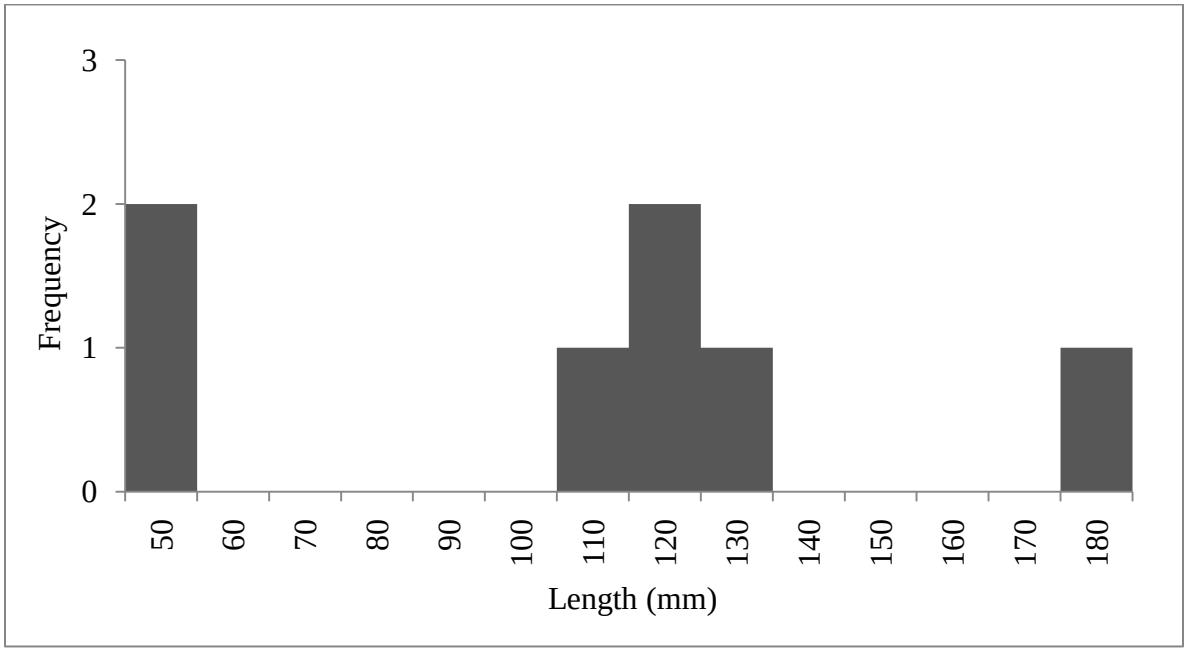


Length distribution of westslope cutthroat trout collected in the ditch at RM 6.0 on the Ross Fork Rock Creek below the headgate in 2009 (n=16).

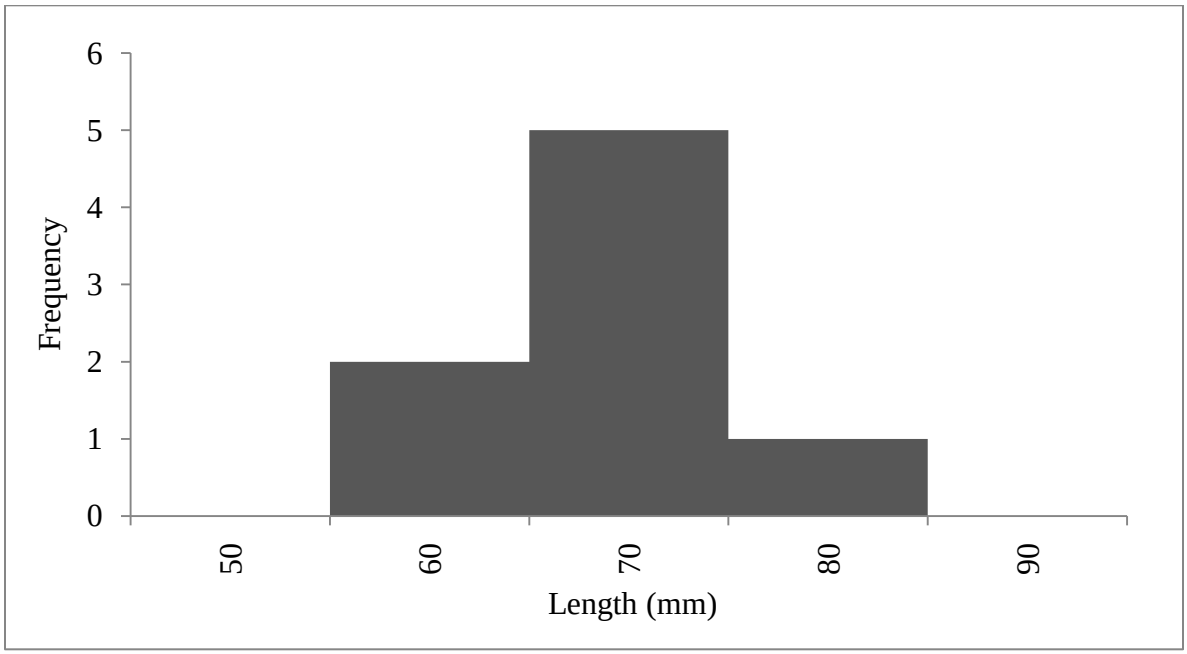


Length distribution of brown trout collected in the ditch at RM 6.0 on the Ross Fork Rock Creek below the headgate in 2009 (n=17).

Ross Fork Rock Creek continued…

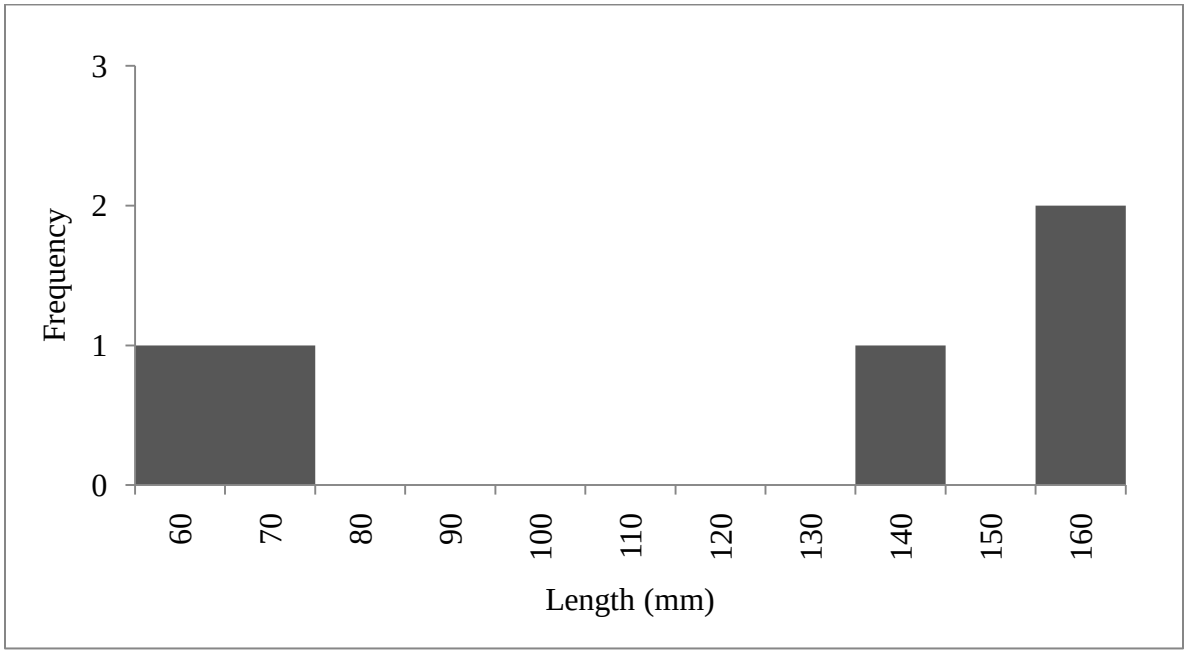


Length distribution of westslope cutthroat trout collected in the ditch at RM 5.5 on the Ross Fork Rock Creek below the headgate in 2009 (n=7).

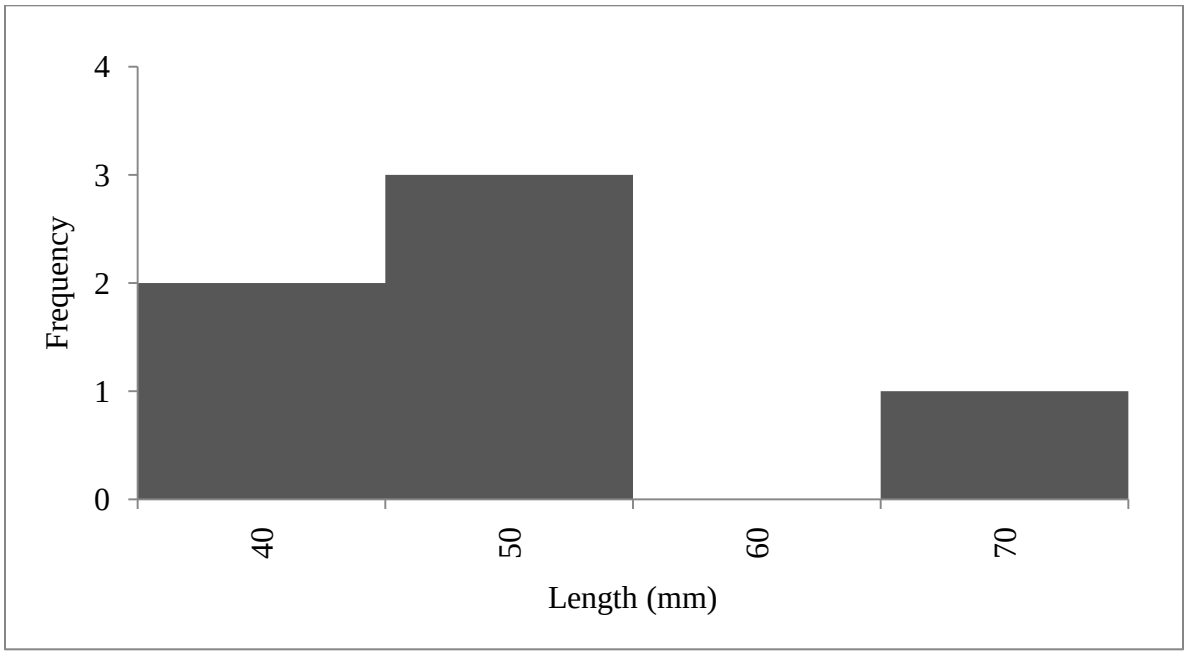


Length distribution of brown trout collected in the ditch at RM 5.5 on the Ross Fork Rock Creek below the headgate in 2009 (n=8).

Middle Fork Rock Creek

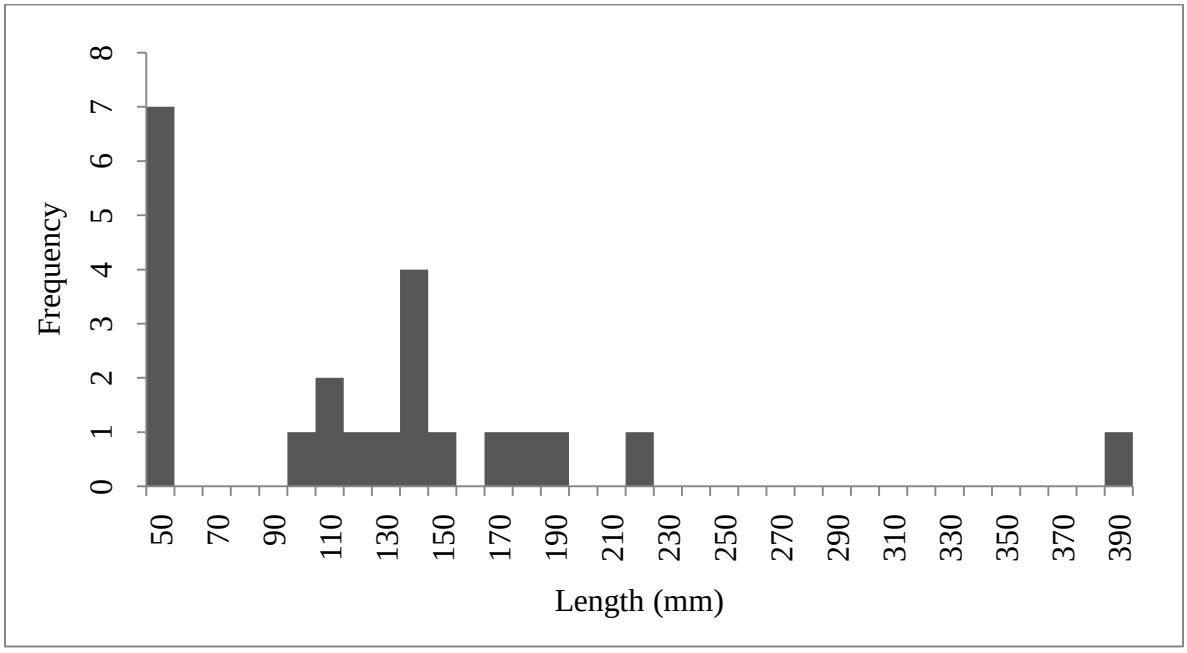


Length distribution of brown trout collected in the ditch at RM 0.1 on Middle Fork Rock Creek 0.2 mi below the headgate in 2010 (n=5).

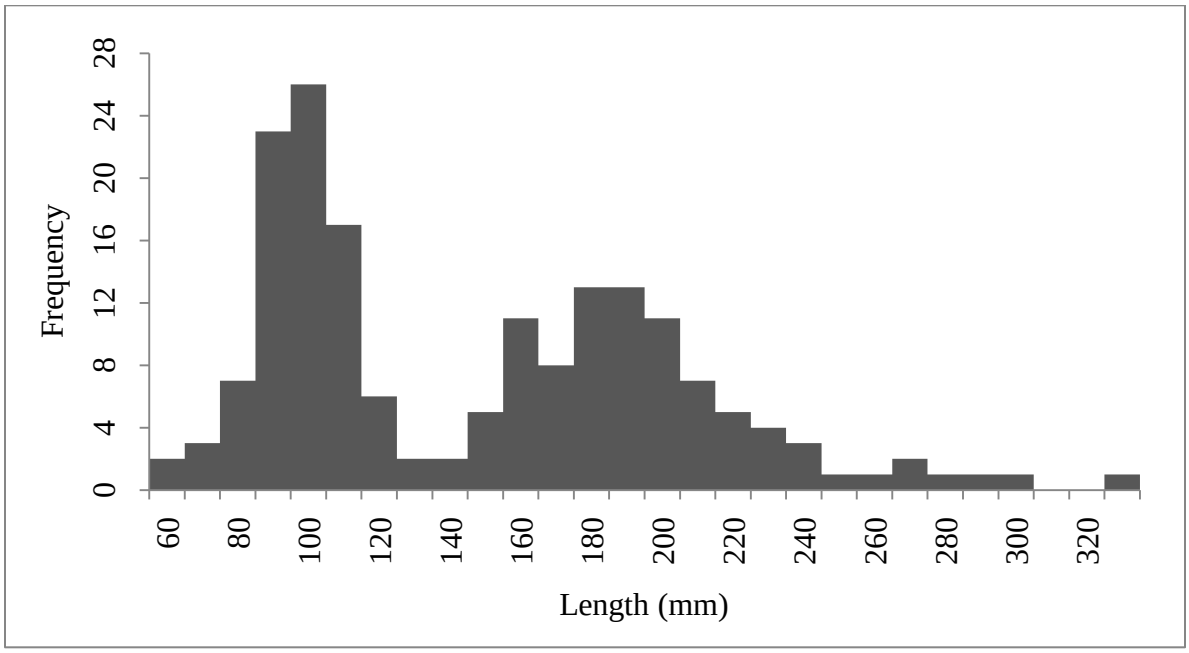


Length distribution of mountain whitefish collected in the ditch at RM 0.1 on Middle Fork Rock Creek 0.5 mi below the headgate in 2010 (n=6).

East Fork Rock Creek

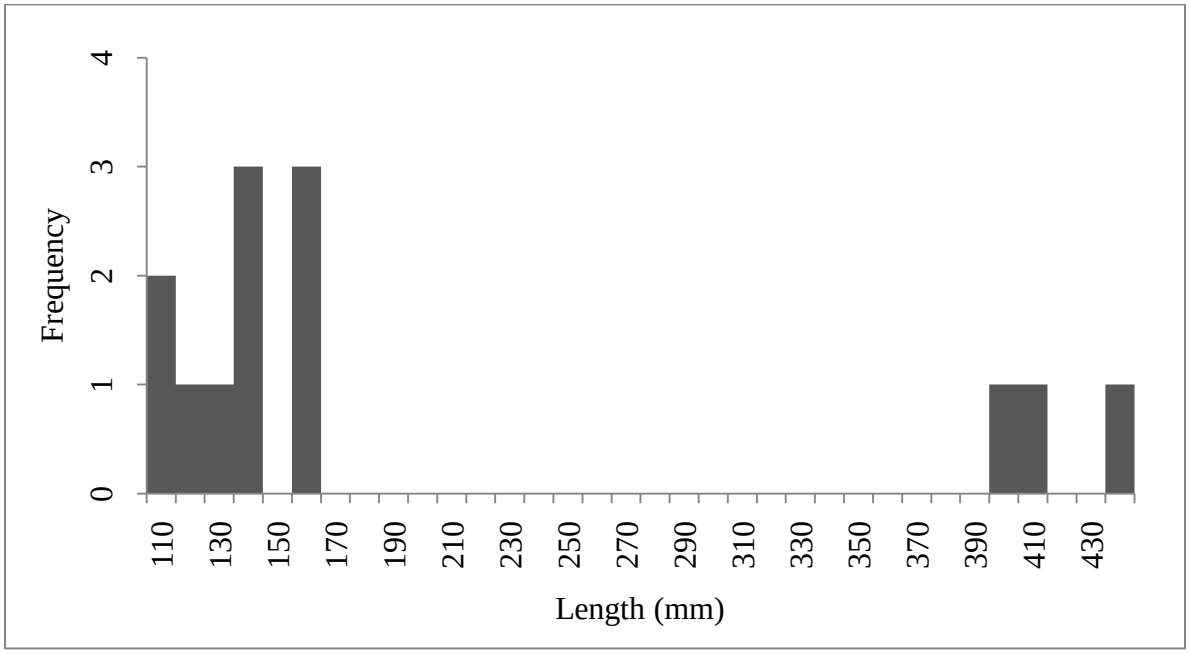


Length distribution of westslope cutthroat trout collected in Flint Creek Main Canal below the headgate in 2008 (n=22).

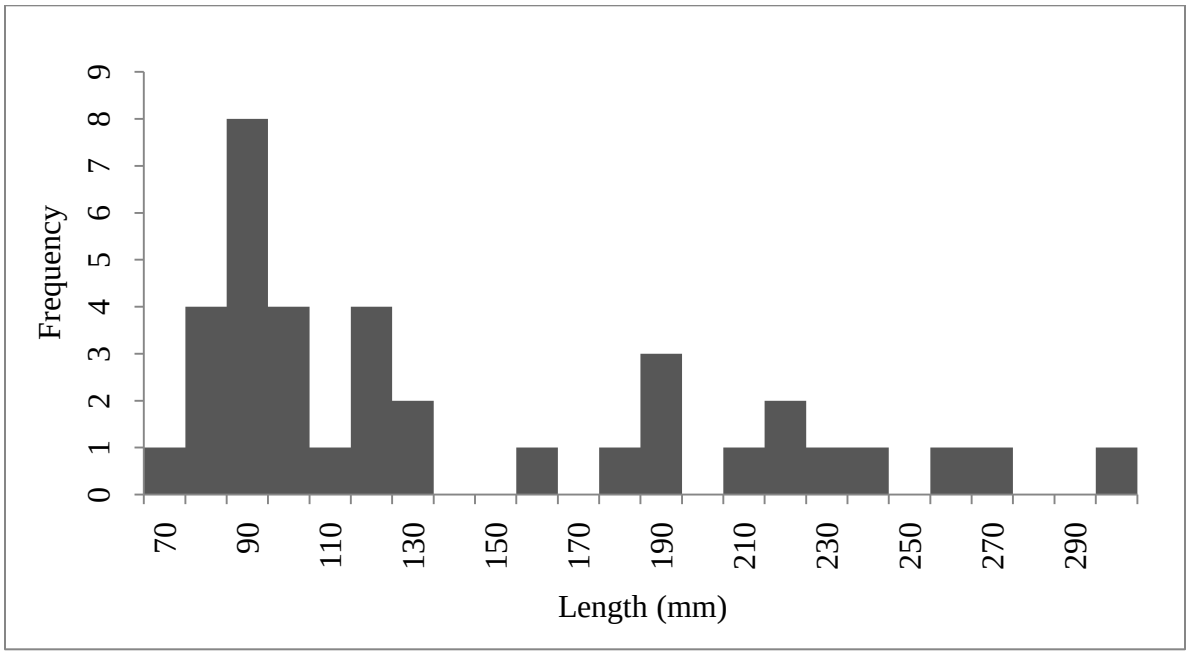


Length distribution of eastern brook trout collected in Flint Creek Main Canal below the headgate in 2008 (n=176).

East Fork Rock Creek continued…

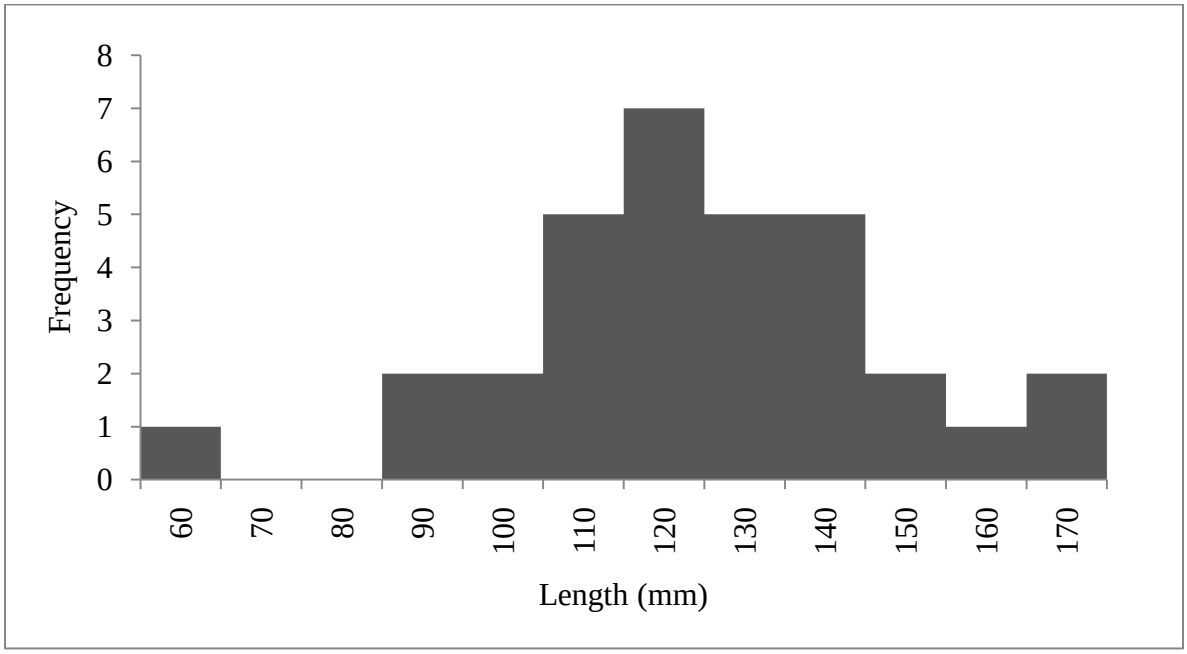


Length distribution of westslope cutthroat trout collected in Flint Creek Main Canal below the headgate in 2009 (n=13).

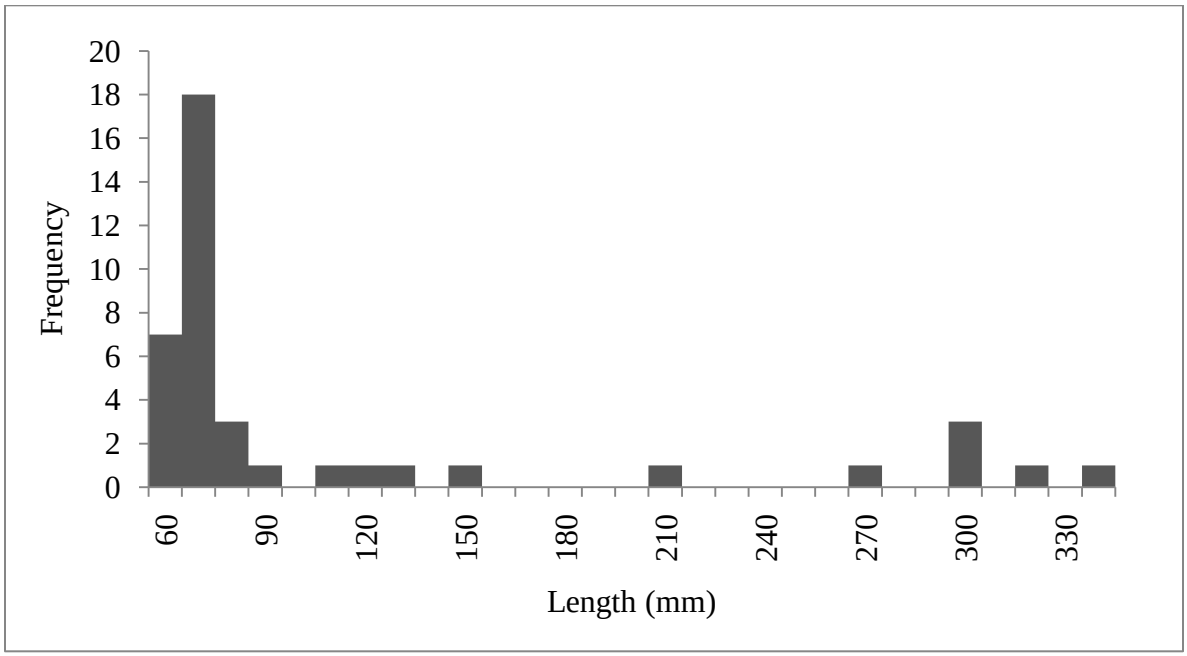


Length distribution of eastern brook trout collected in Flint Creek Main Canal below the headgate in 2009 (n=37).

East Fork Rock Creek continued…

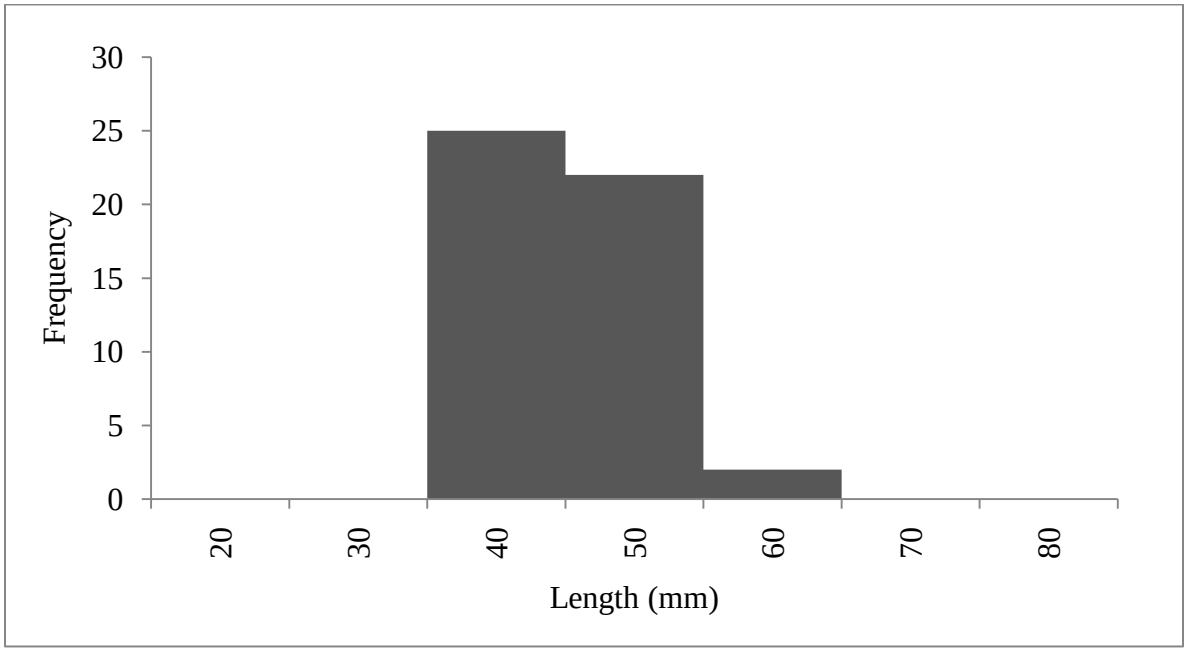


Length distribution of westslope cutthroat trout collected in Flint Creek Main Canal below the headgate in 2010 (n=32).

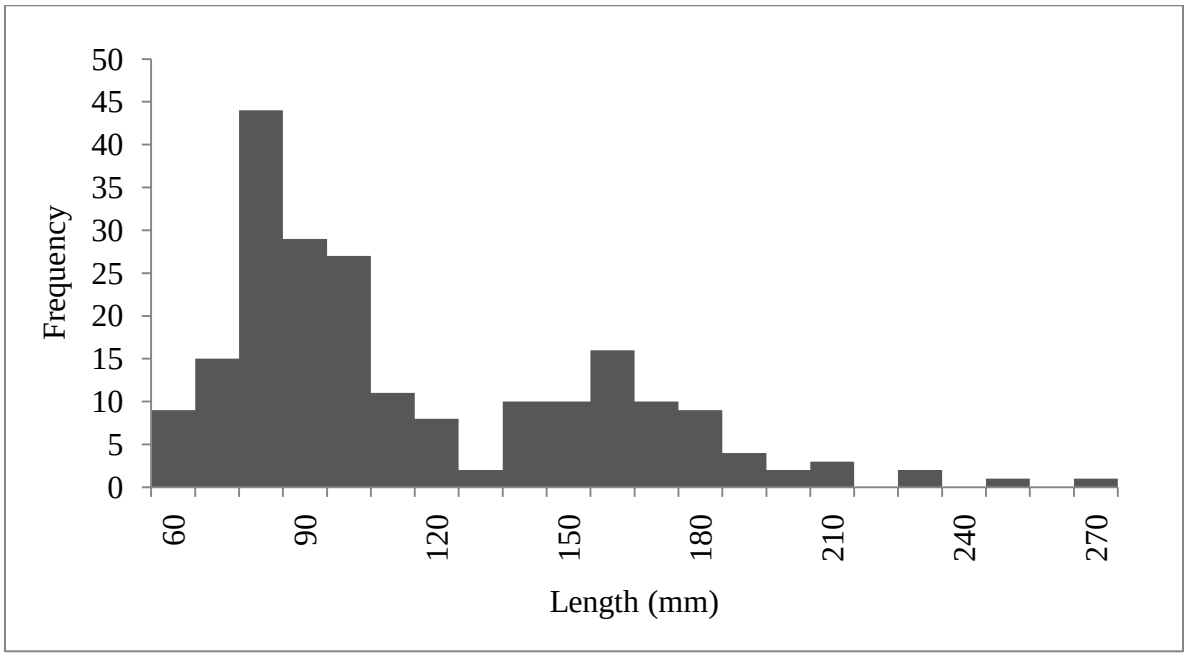


Length distribution of brown trout collected in Flint Creek Main Canal below the headgate in 2010 (n=40).

East Fork Rock Creek continued…

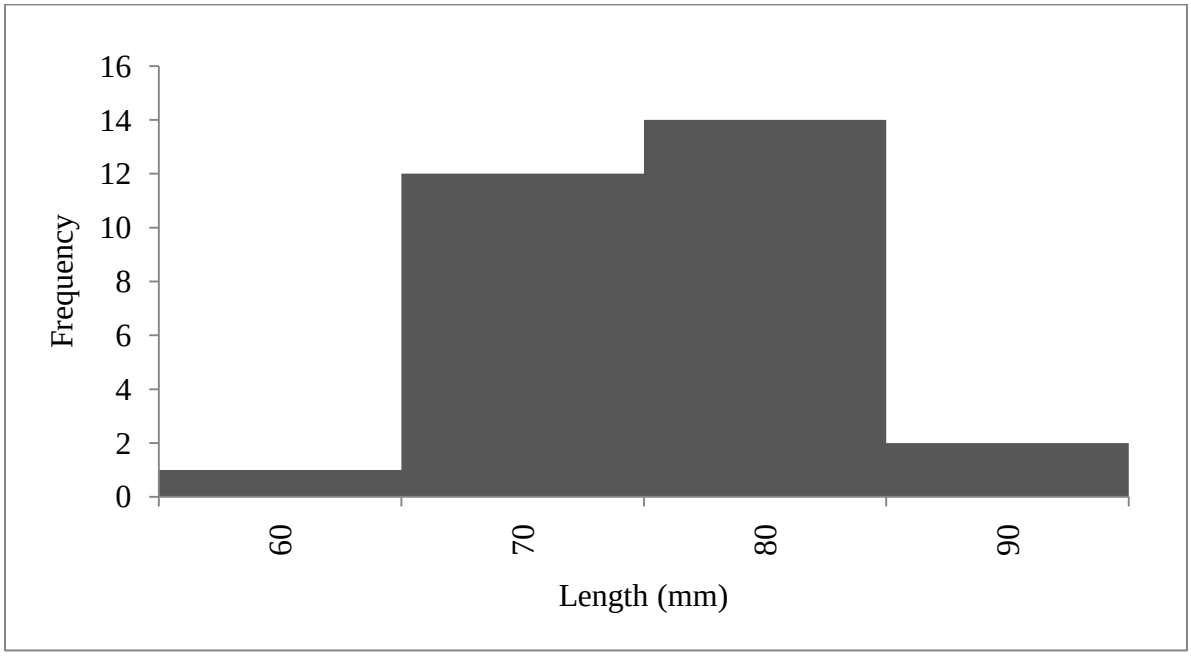


Length distribution of unidentified *Oncorhynchus* species collected in Flint Creek Main Canal below the headgate in 2010 (n=49).

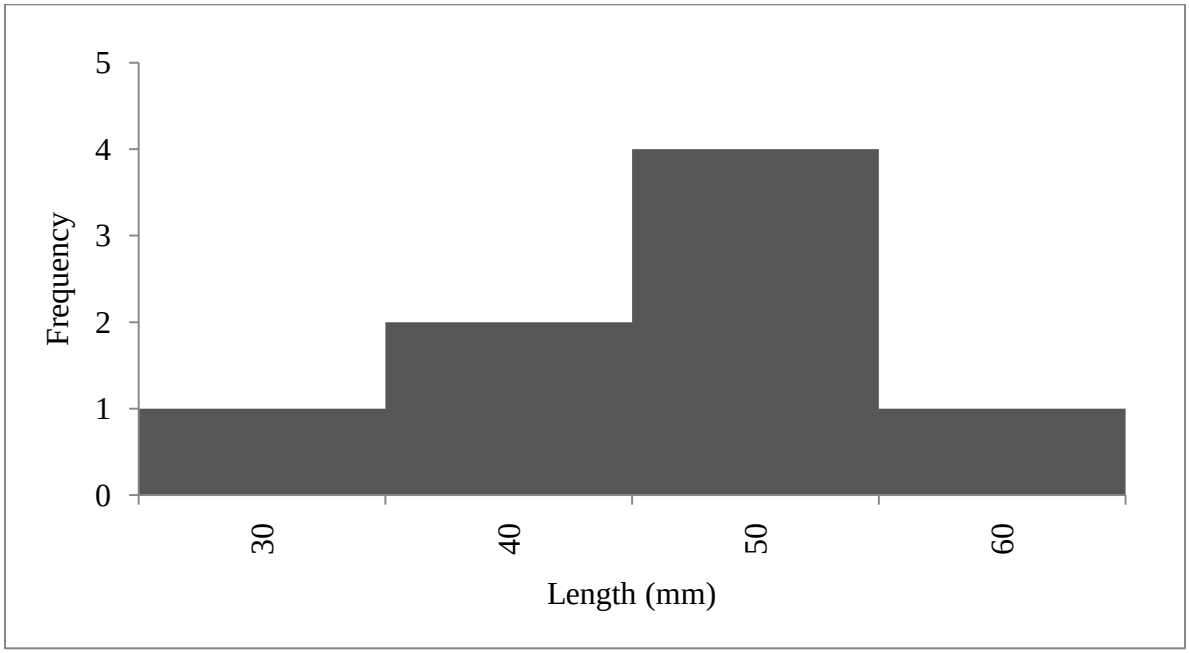


Length distribution of eastern brook trout collected in Flint Creek Main Canal below the headgate in 2010 (n=213).

Harvey Creek

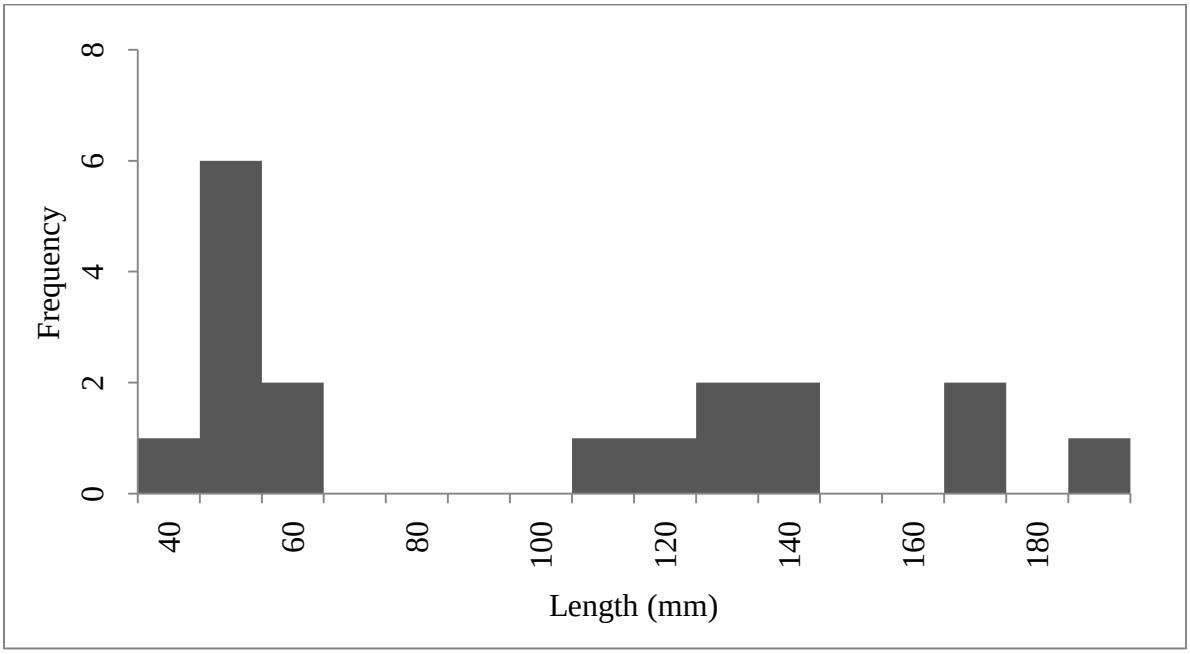


Length distribution of brown trout collected in the ditch at RM 0.01 on Harvey Creek below the headgate in 2010 (n=29).



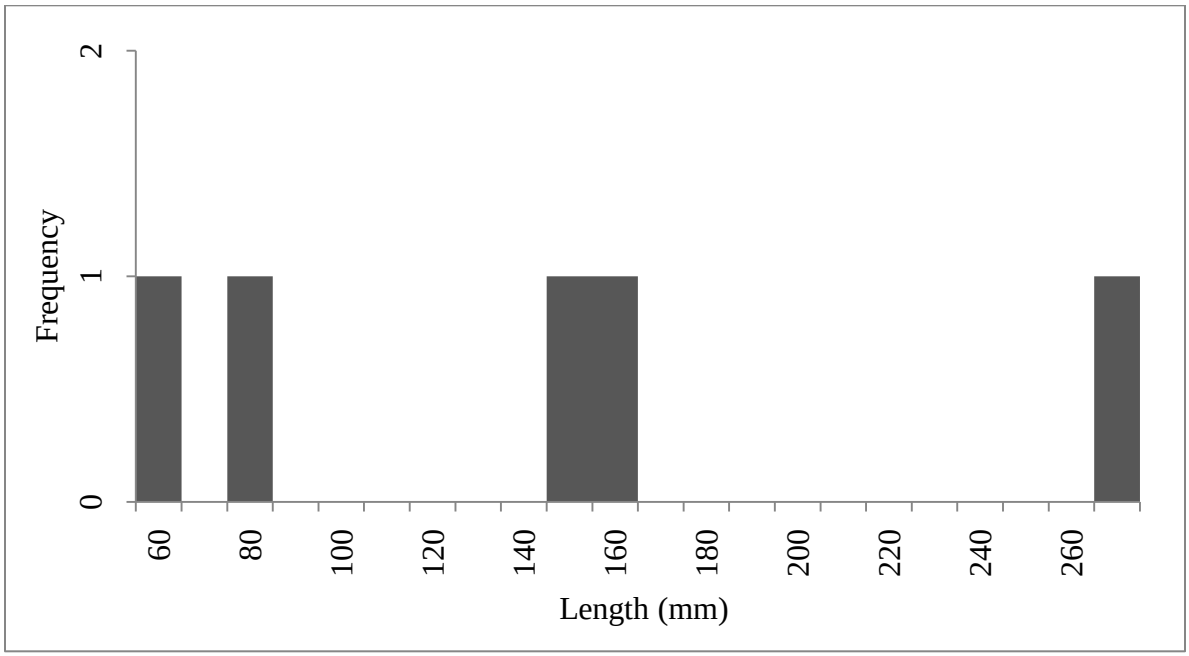
Length distribution of unidentifiable *Oncorhynchus* species collected in the ditch at RM 0.01 on Harvey Creek below the headgate in 2010 (n=29).

South Fork Lower Willow Creek



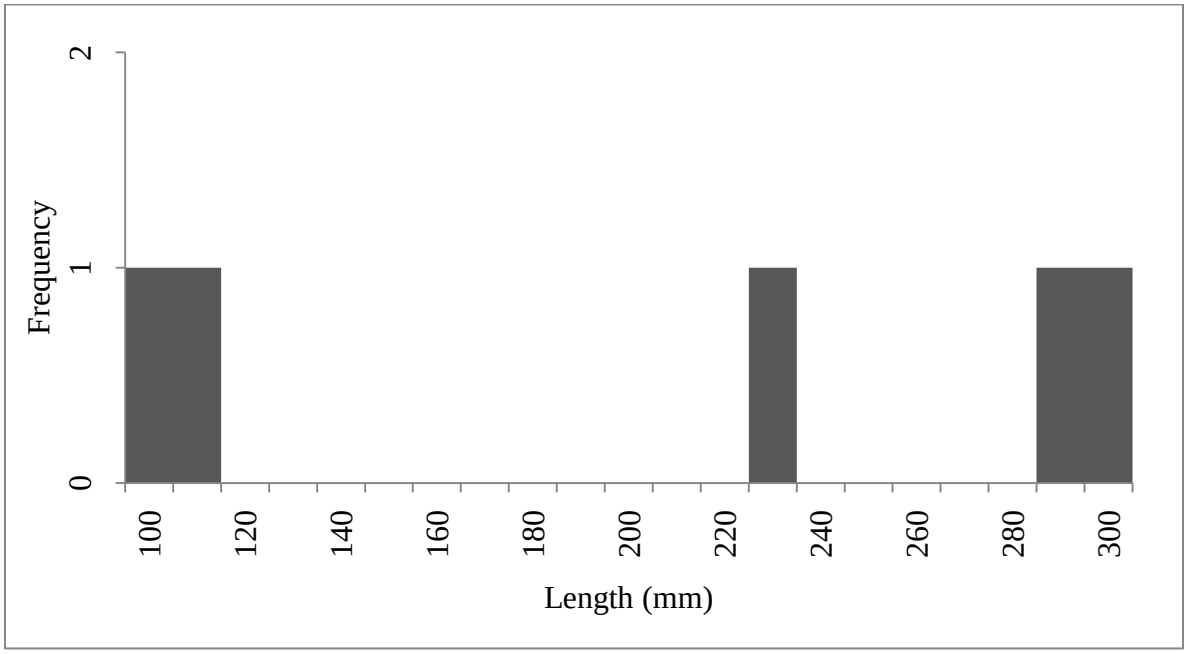
Length distribution of westslope cutthroat trout collected in the ditch at RM 2.9 on South Fork Lower Willow Creek below the headgate in 2009 (n=18).

Boulder Creek

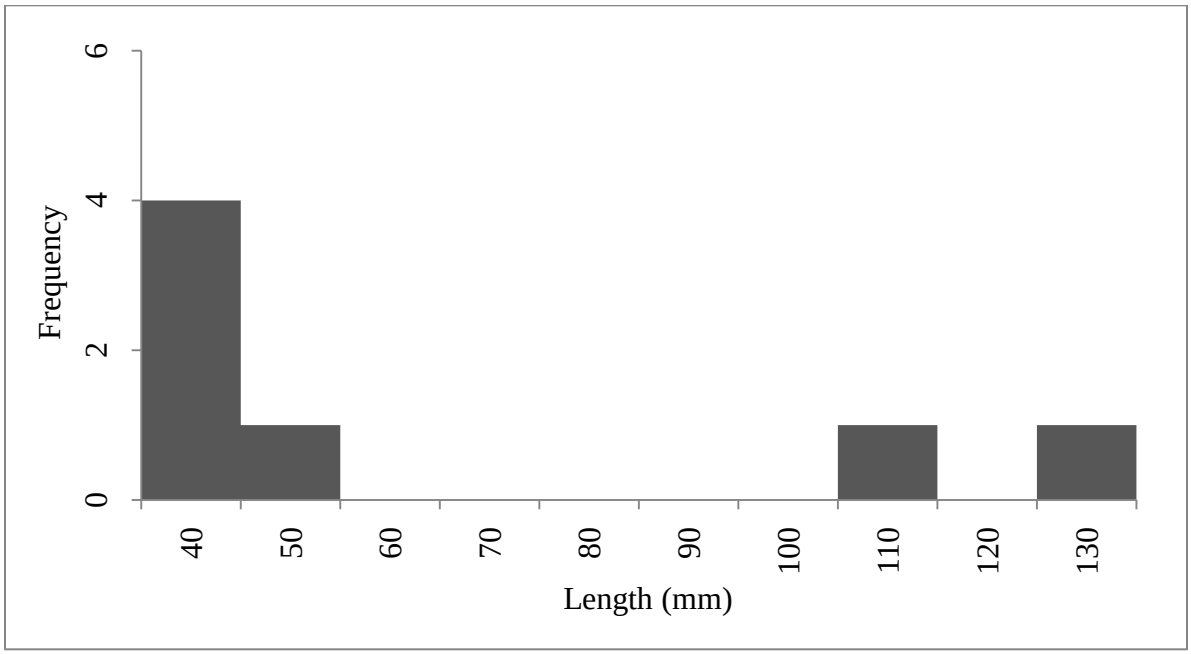


Length distribution of westslope cutthroat trout collected in the ditch at RM 0.9 on Boulder Creek below the headgate in 2009 (n=5).

Boulder Creek continued…

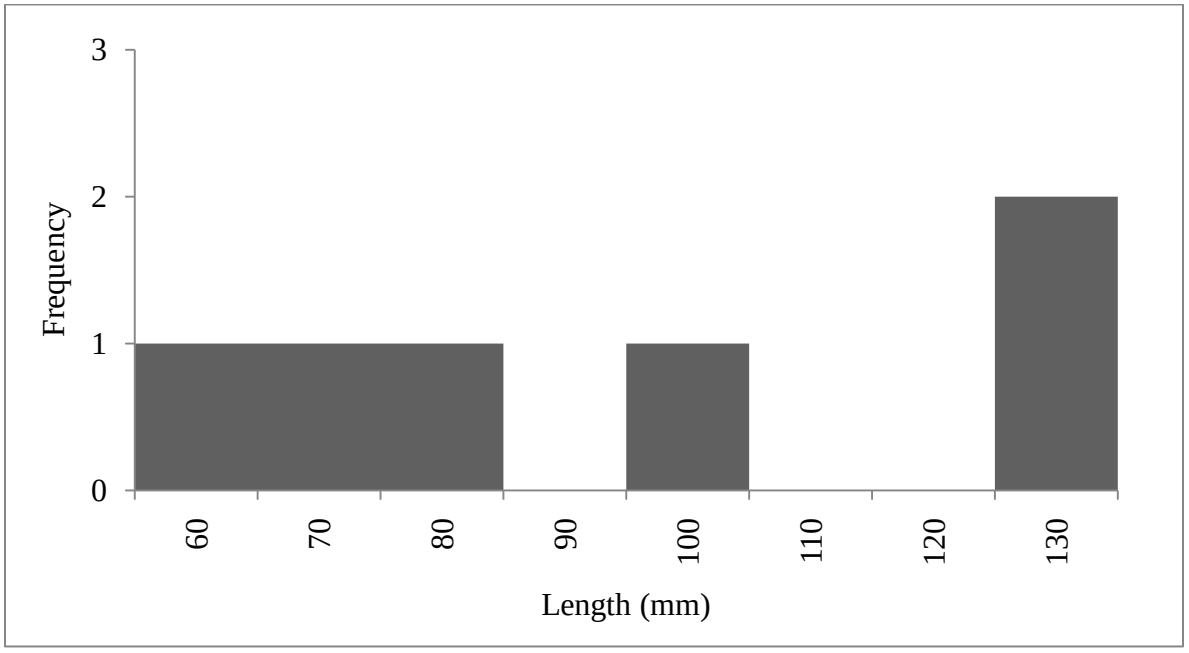


Length distribution of brown trout collected in the ditch at RM 0.9 on Boulder Creek below the headgate in 2009 (n=5).

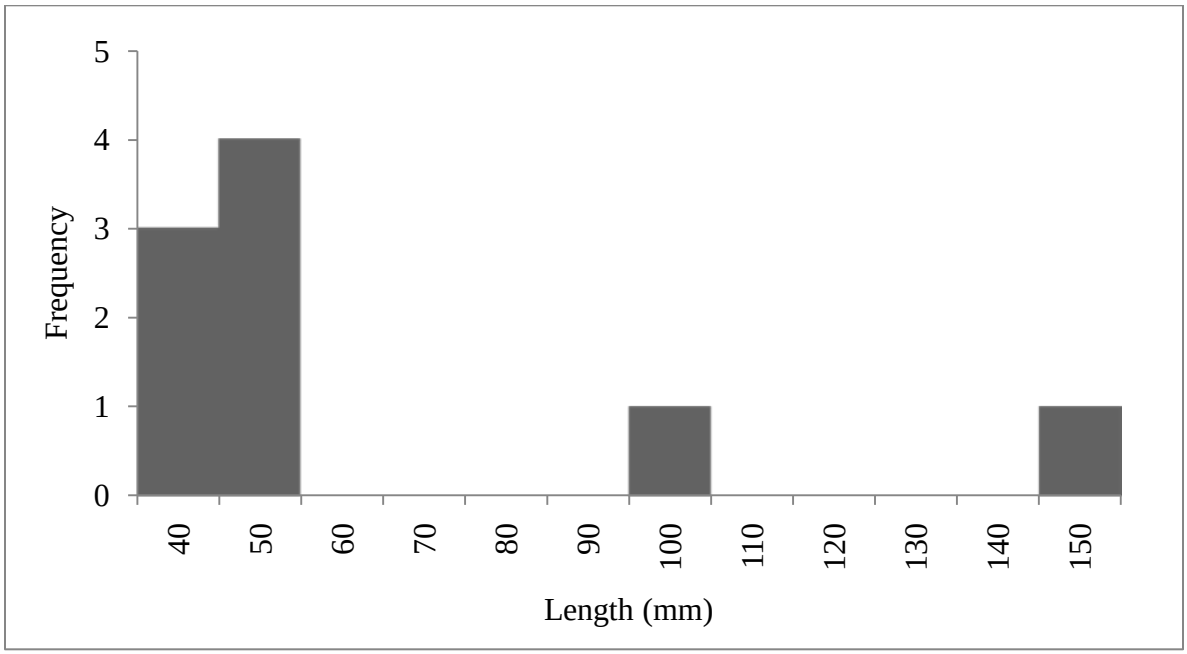


Length distribution of westslope cutthroat trout collected in the ditch at RM 0.8 on Boulder Creek below the headgate in 2009 (n=7).

Boulder Creek continued…

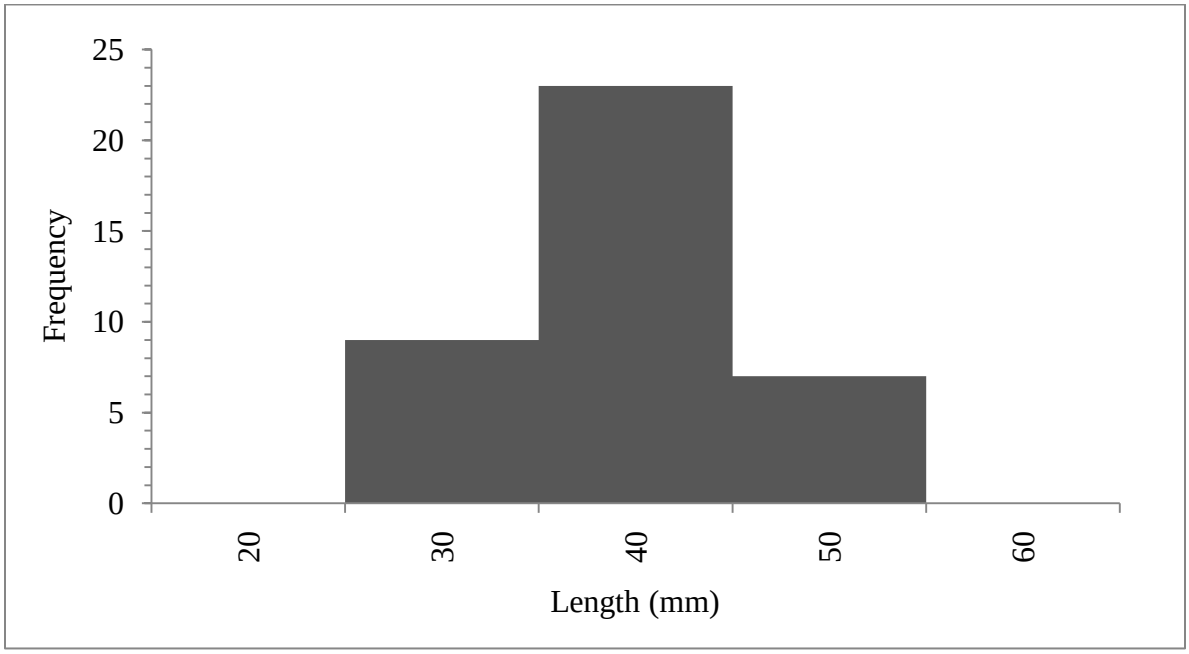


Length distribution of westslope cutthroat trout collected in the ditch at RM 0.9 on Boulder Creek below the headgate in 2010 (n=6).

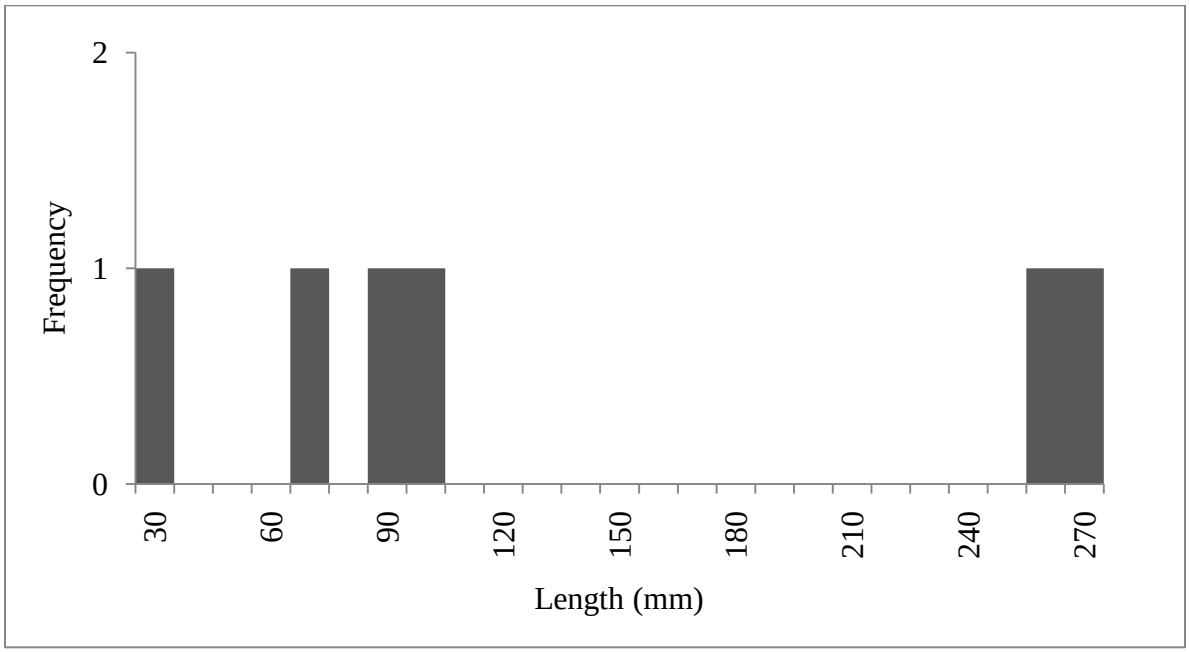


Length distribution of brown trout collected in the ditch at RM 0.9 on Boulder Creek below the headgate in 2010 (n=9).

Boulder Creek continued…

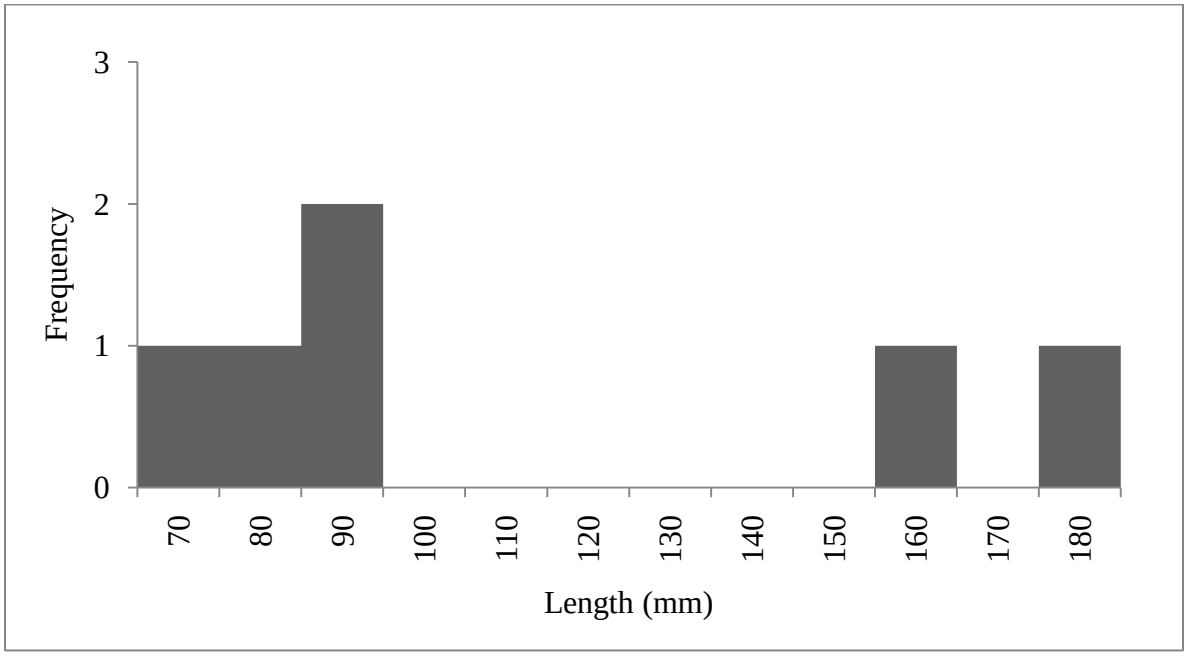


Length distribution of brown trout collected in the ditch at RM 0.8 on Boulder Creek below the headgate in 2010 (n=39).



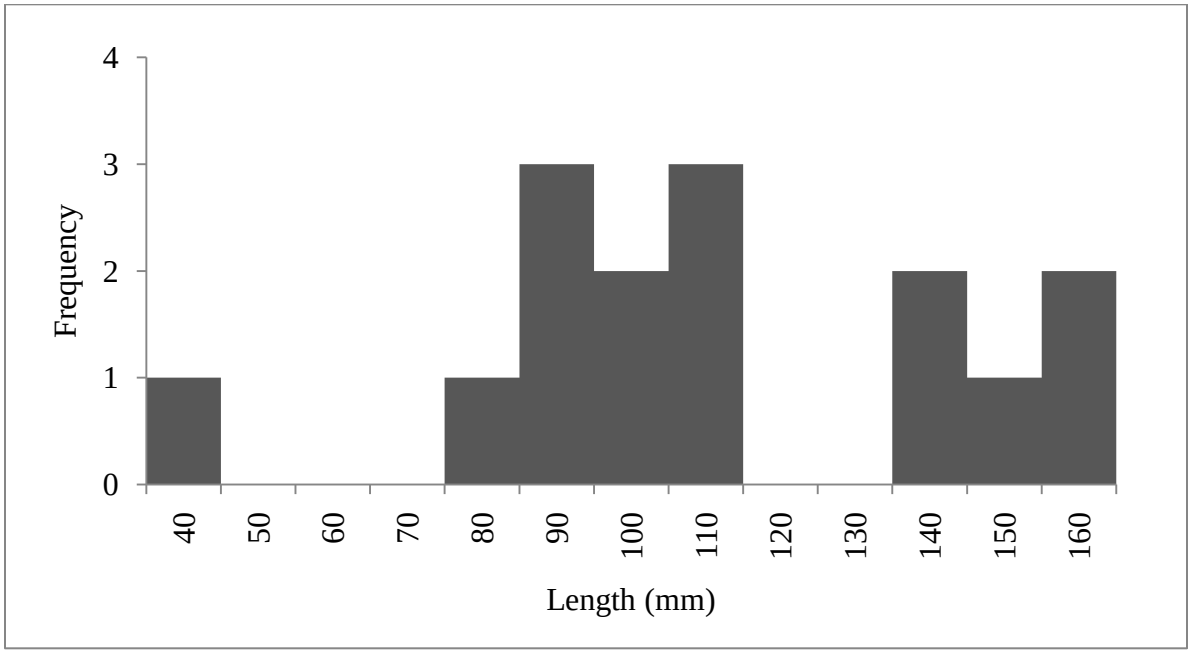
Length distribution of westslope cutthroat trout collected in the ditch at RM 0.8 on Boulder Creek below the headgate in 2010 (n=6).

Boulder Creek continued…



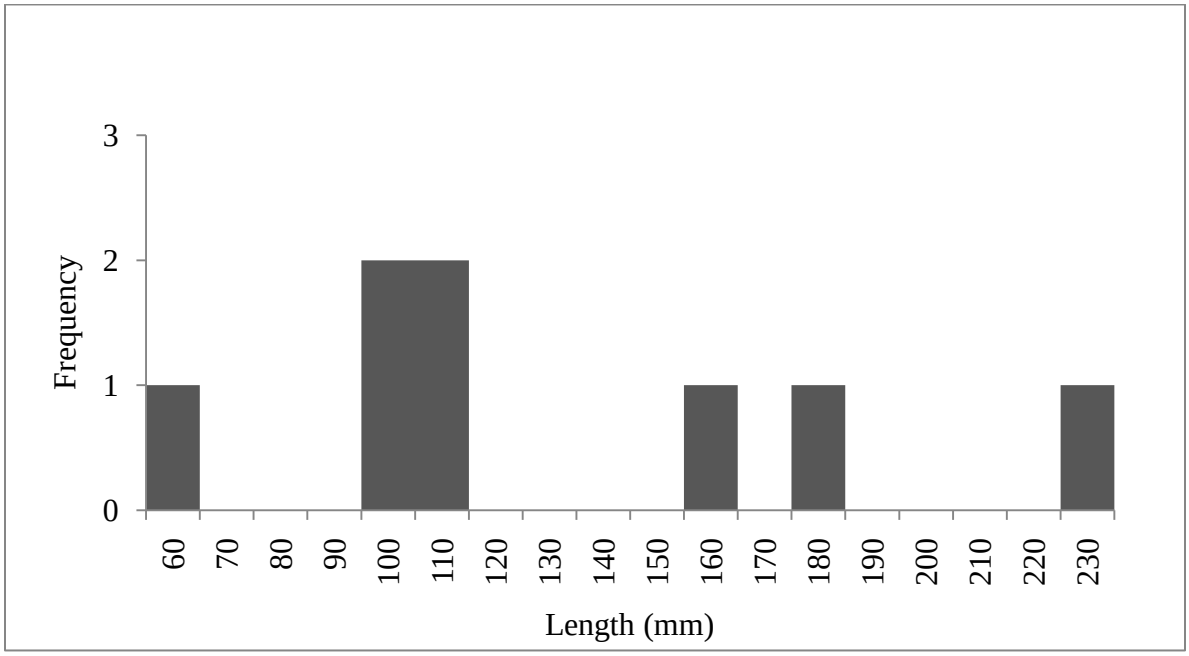
Length distribution of westslope cutthroat trout collected in the ditch at RM 0.2 on Boulder Creek below the headgate in 2010 (n=6).

Gold Creek

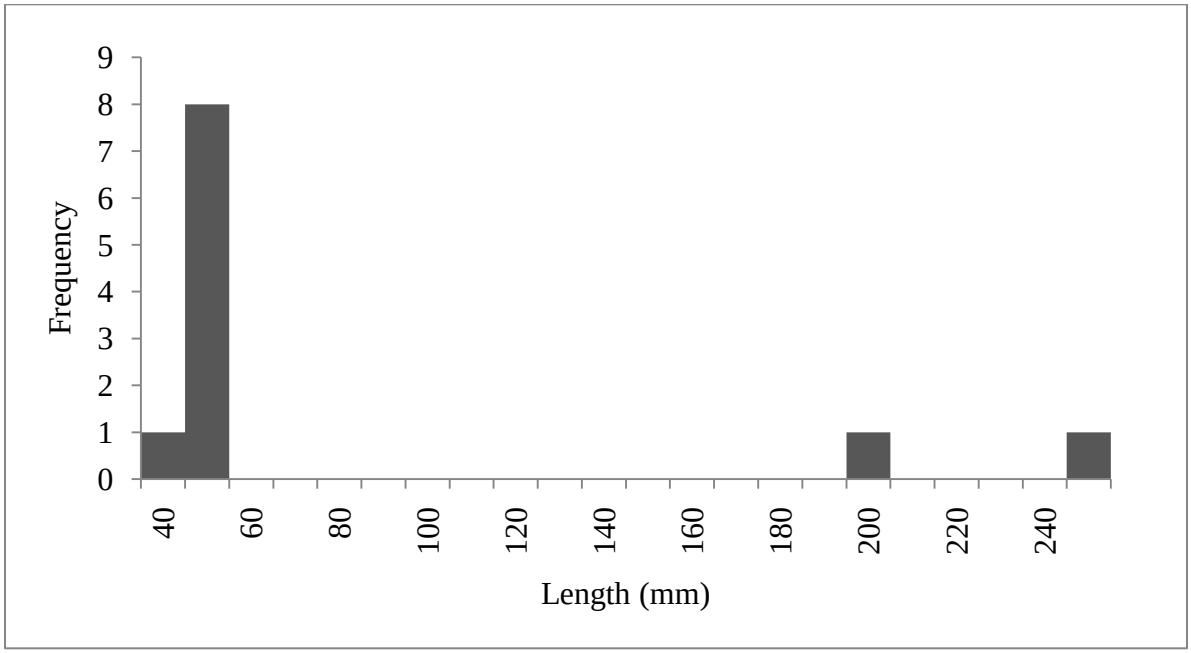


Length distribution of westslope cutthroat trout collected in the ditch at RM 6.1 on Gold Creek below the diversion in 2010 (n=15).

Gold Creek continued…

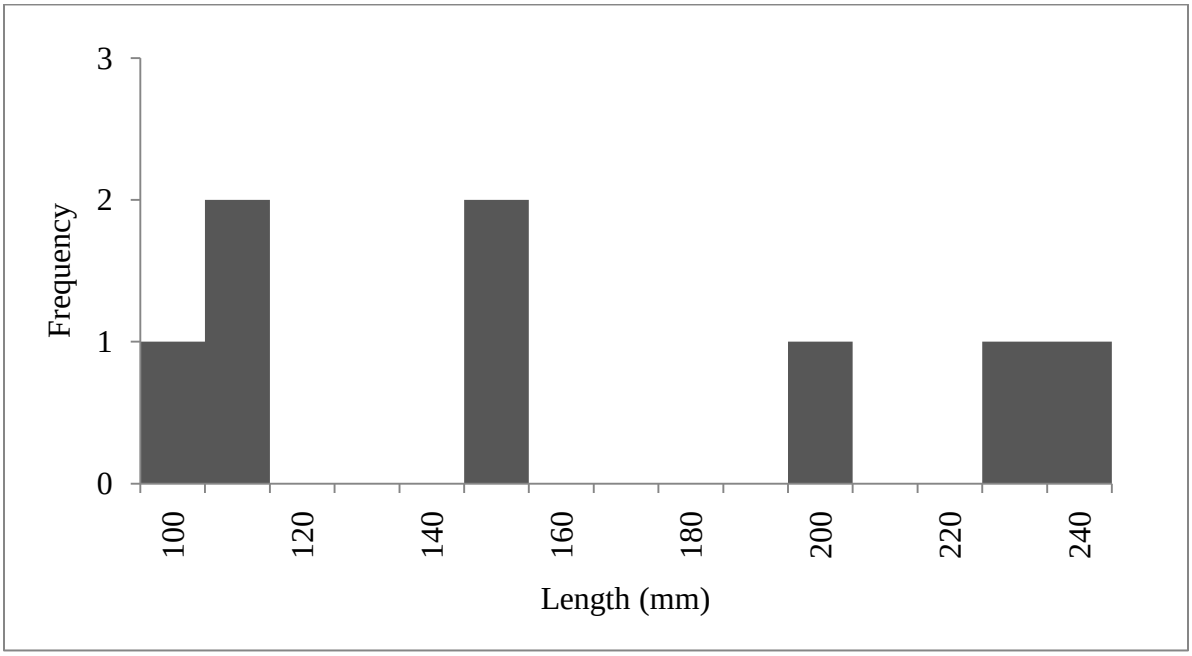


Length distribution of brown trout collected in the ditch at RM 6.1 on Gold Creek below the diversion in 2010 (n=8).

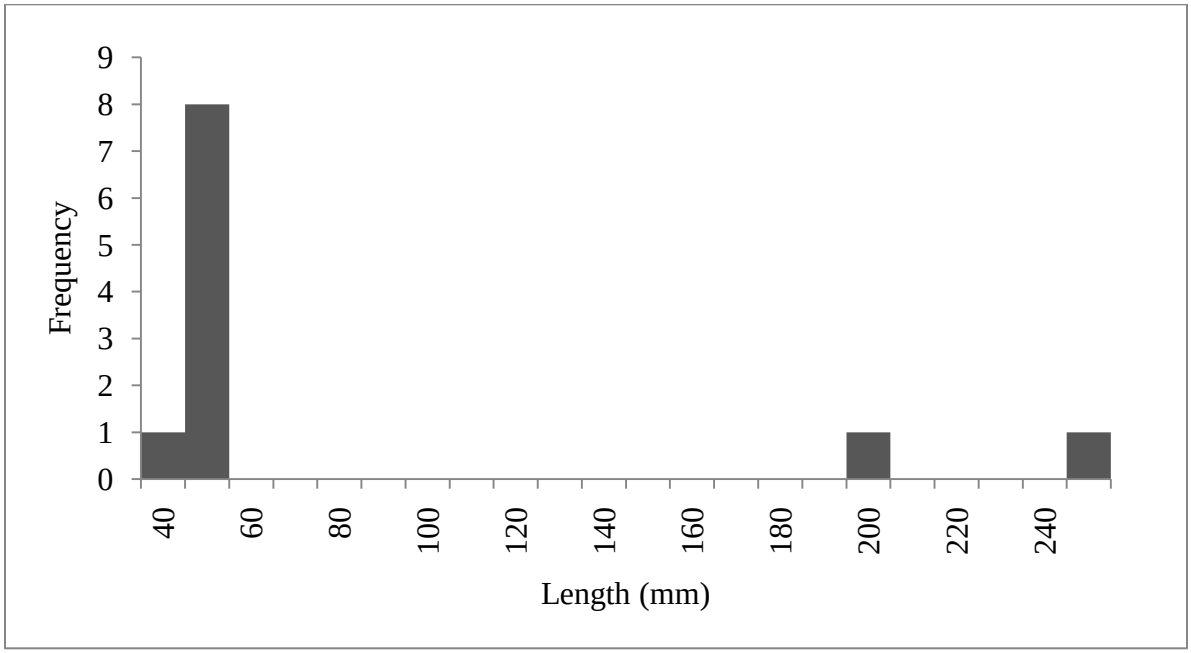


Length distribution of brown trout collected in the ditch at RM 5.2 on Gold Creek below the diversion in 2010 (n=11).

Gold Creek continued…

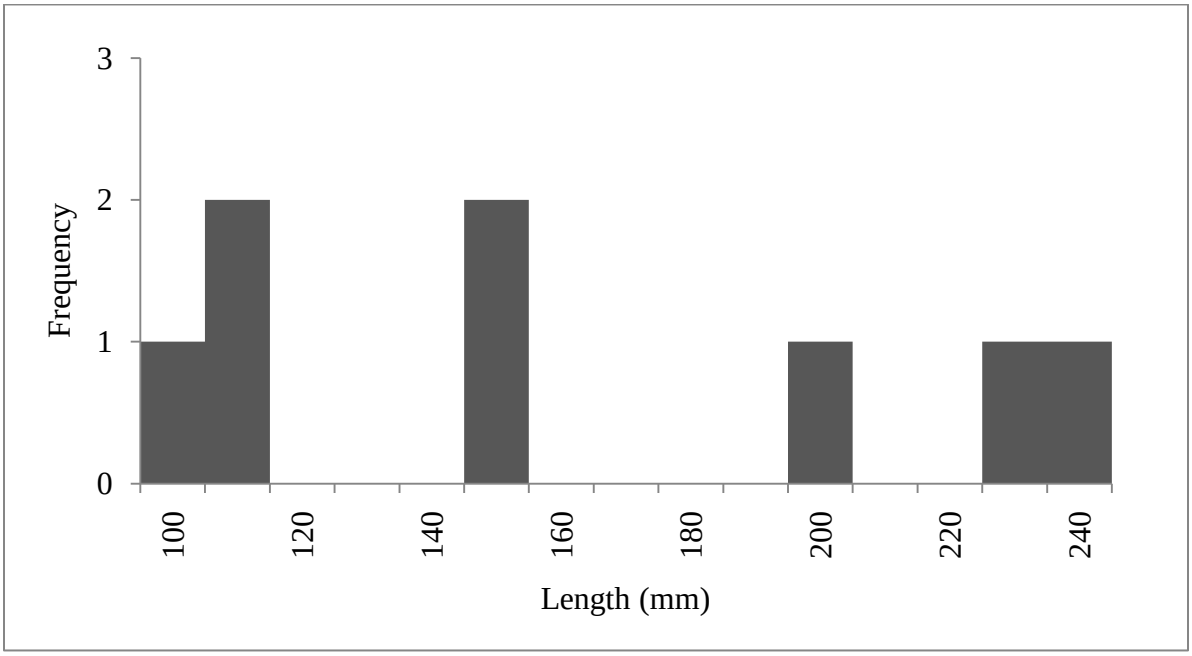


Length distribution of westslope cutthroat trout collected in the ditch at RM 5.2 on Gold Creek below the diversion in 2010 (n=8).

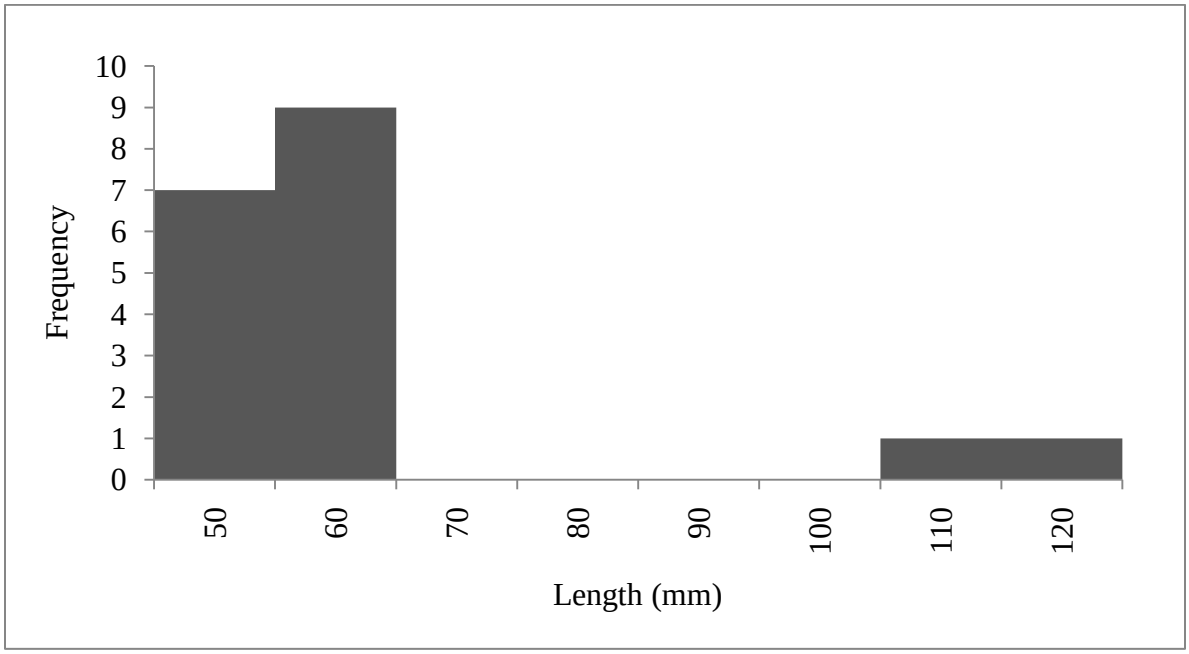


Length distribution of brown trout collected in the ditch at RM 5.2 on Gold Creek below the diversion in 2010 (n=11).

Gold Creek continued…

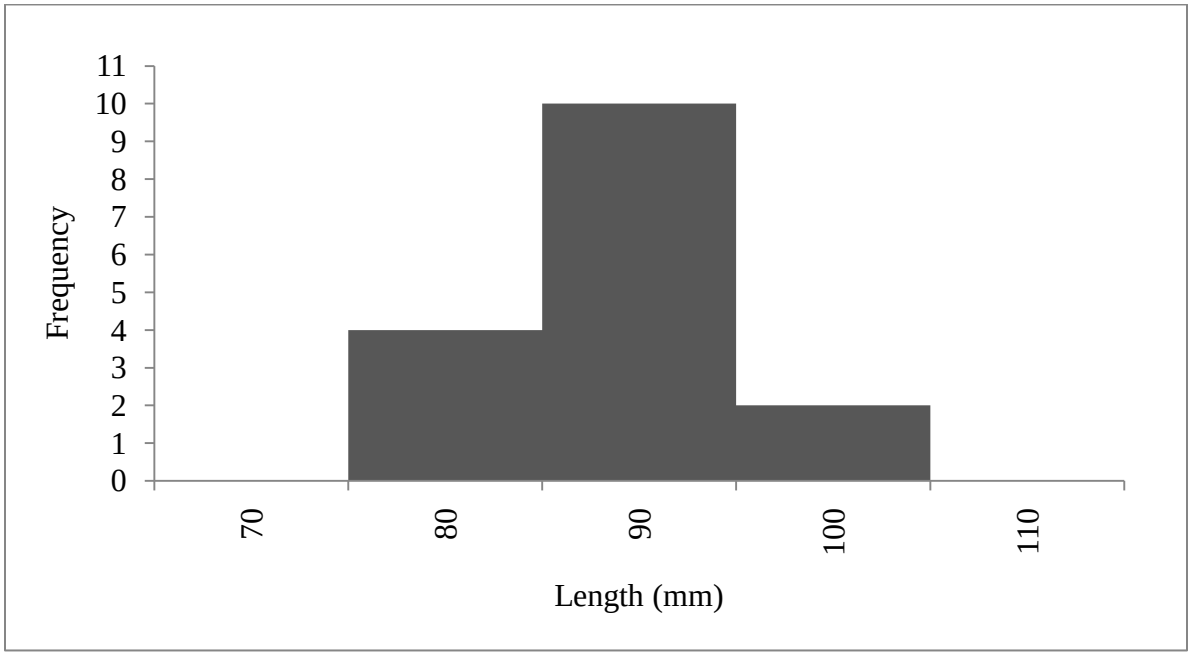


Length distribution of westslope cutthroat trout collected in the ditch at RM 5.2 on Gold Creek below the diversion in 2010 (n=8).

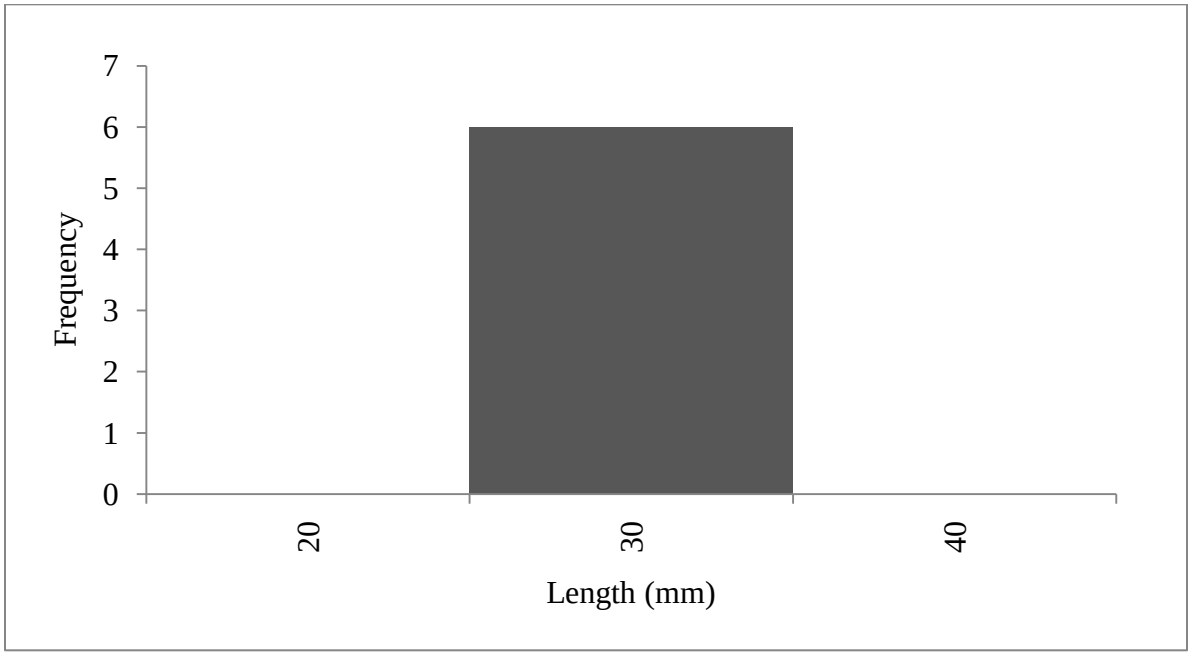


Length distribution of brown trout collected in the ditch at RM 3.9 on Gold Creek below the diversion in 2010 (n=18). An additional 102 brown trout were collected but not measured individually (ranged 50-70 mm).

Gold Creek continued…

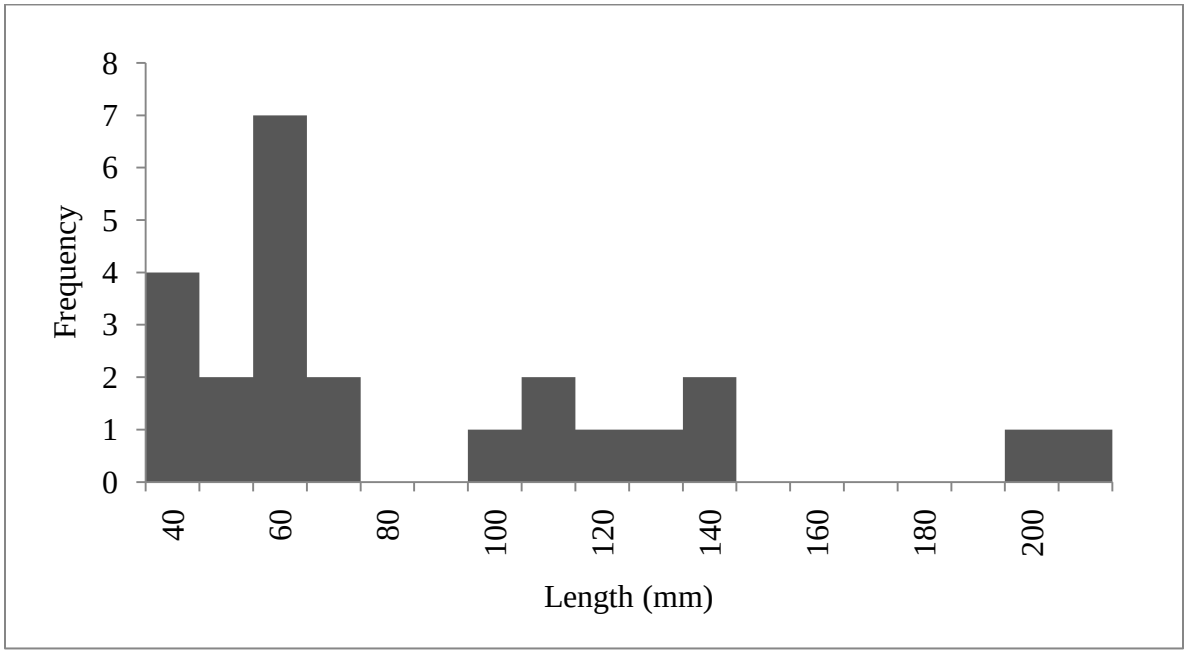


Length distribution of westslope cutthroat trout collected in the ditch at RM 3.9 on Gold Creek below the diversion in 2010 (n=16).

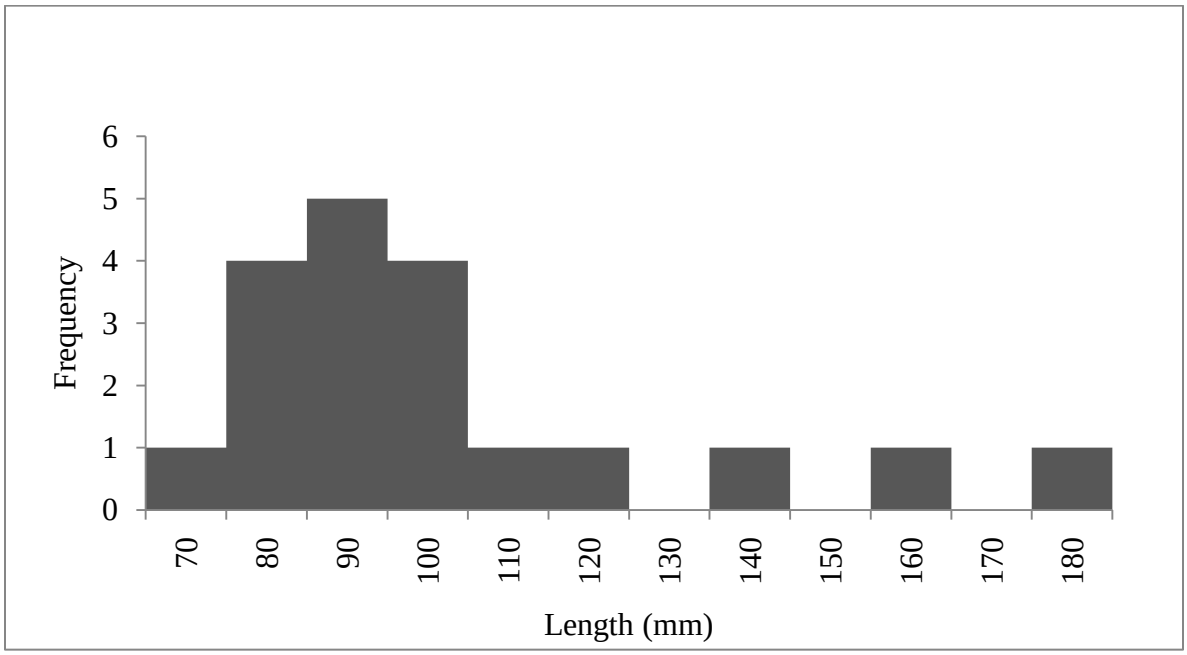


Length distribution of unidentifiable *Oncorhynchus* species collected in the ditch at RM 3.9 on Gold Creek below the diversion in 2010 (n=6).

Gold Creek continued…

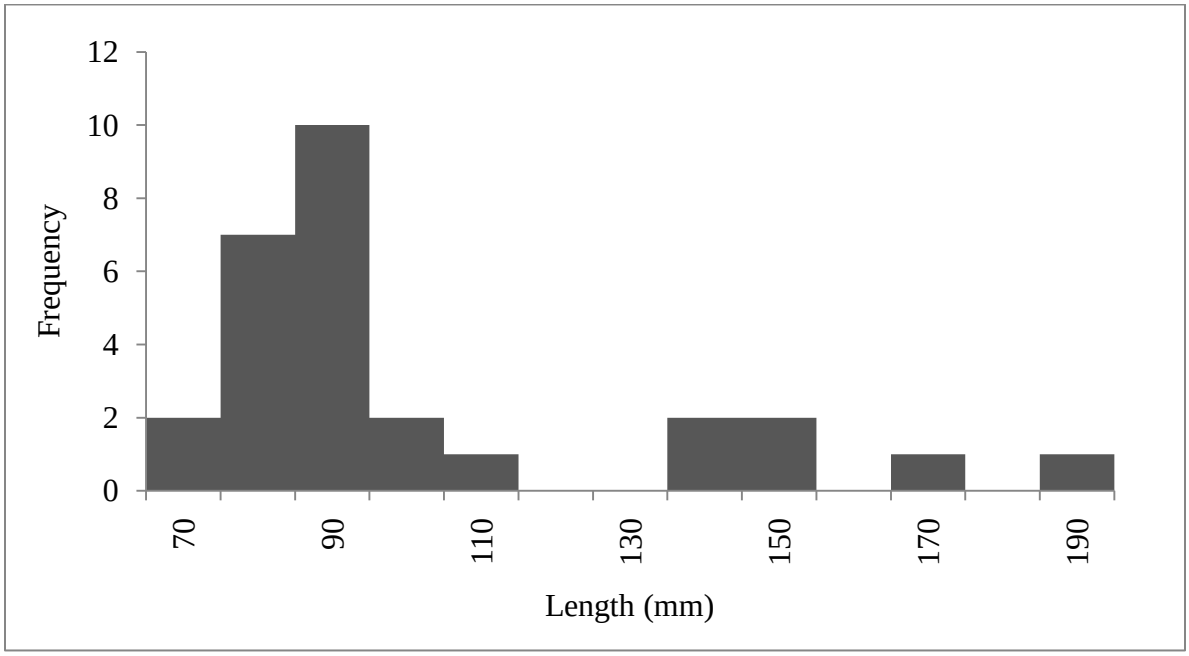


Length distribution of brown trout collected in the ditch at RM 3.8 on Gold Creek below the diversion in 2010 (n=24). An additional 134 brown trout were collected but not measured individually (ranged 50-70 mm).

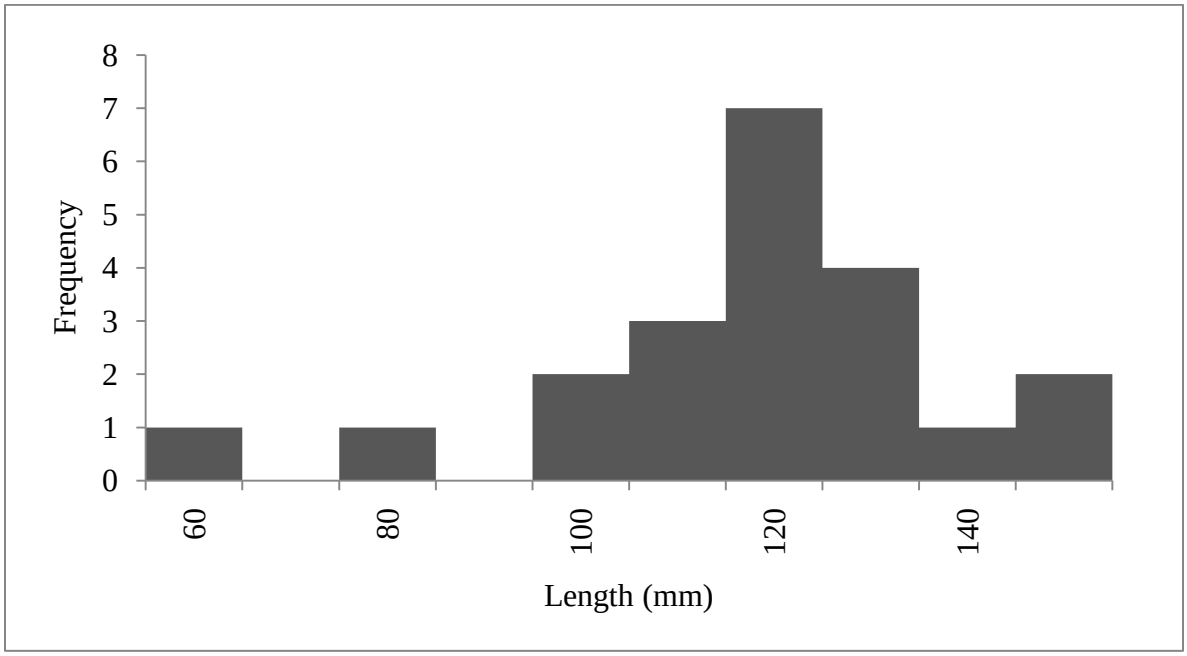


Length distribution of westslope cutthroat trout collected in the ditch at RM 3.8 on Gold Creek below the diversion in 2010 (n=19).

Gold Creek continued…

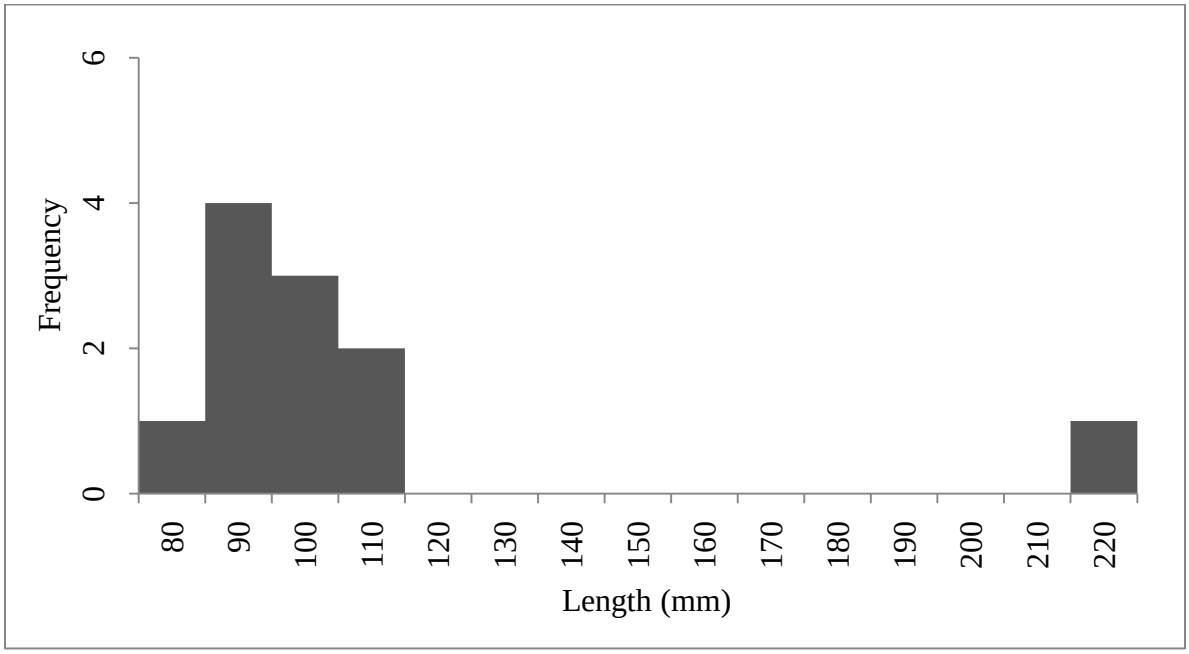


Length distribution of westslope cutthroat trout collected in the ditch at RM 3.7 on Gold Creek below the diversion in 2010 (n=28).

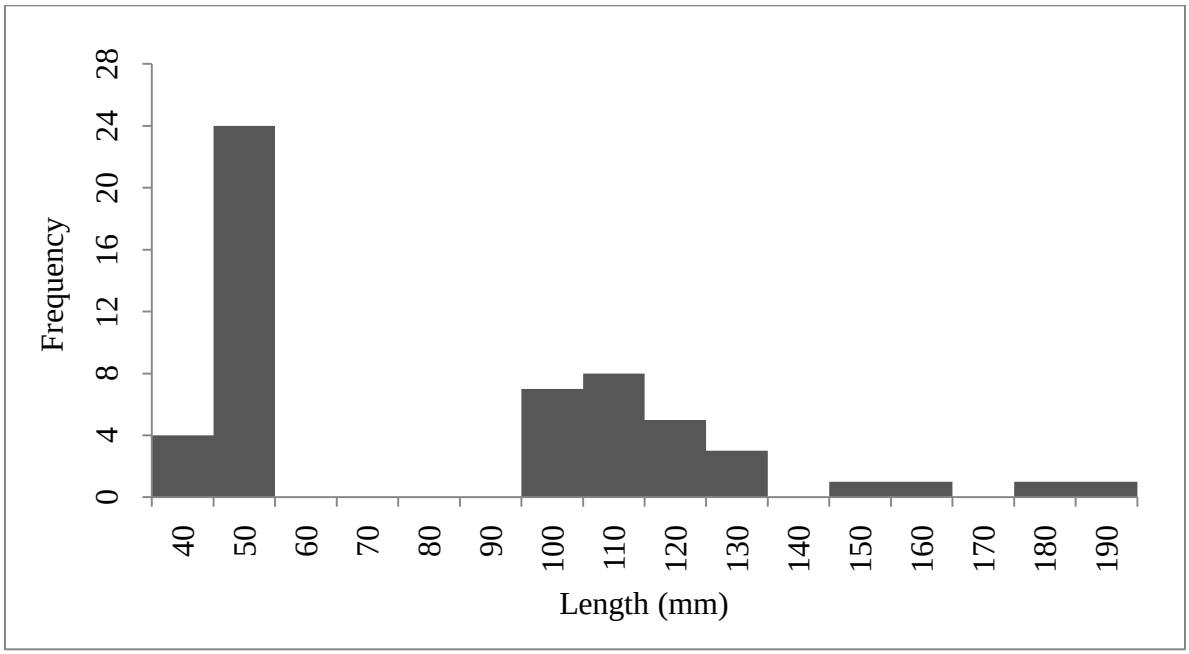


Length distribution of brown trout collected in the ditch at RM 3.7 on Gold Creek below the diversion in 2010 (n=21). An additional 20 brown trout were collected but not measured individually (ranged 50-70 mm).

Gold Creek continued…

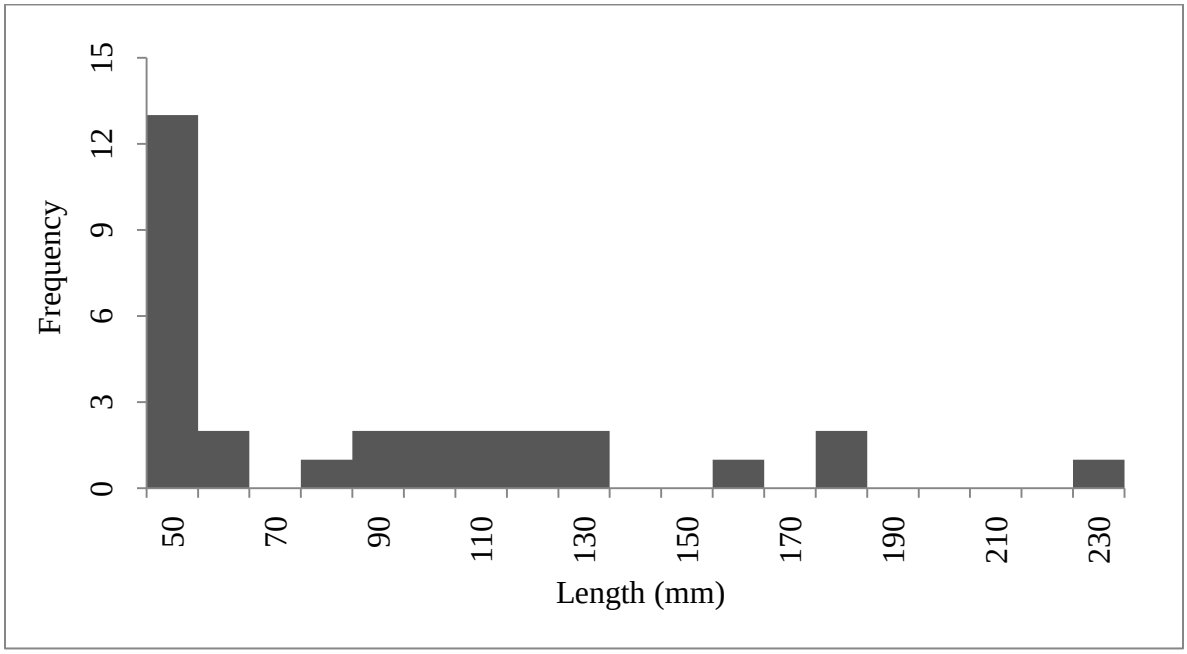


Length distribution of westslope cutthroat trout collected in the ditch at RM 3.6 on Gold Creek below the headgate in 2007 (n=11).

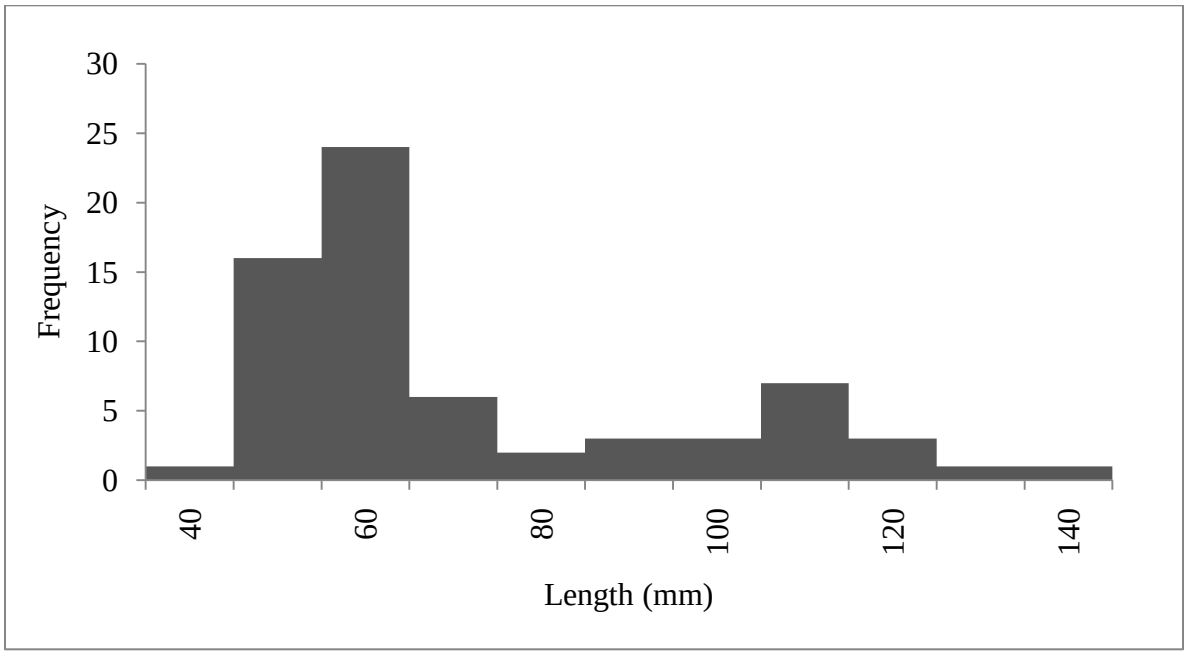


Length distribution of brown trout collected in the ditch at RM 3.6 on Gold Creek below the headgate in 2007 (n=55).

Gold Creek continued…

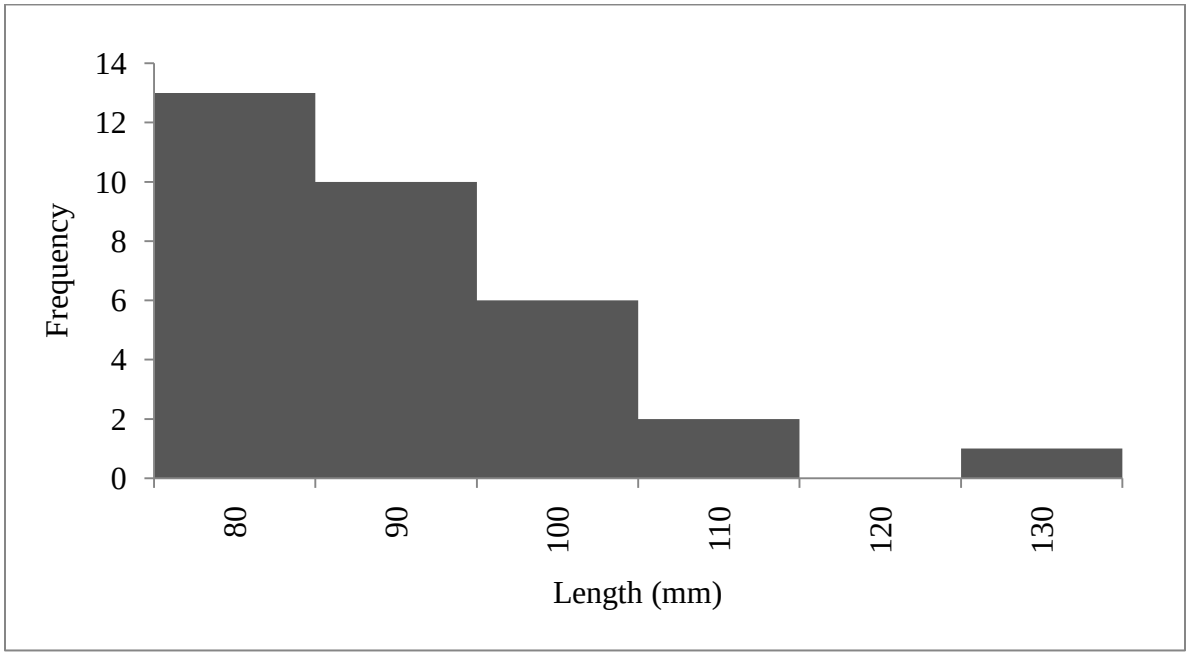


Length distribution of brown trout collected in the ditch at RM 3.6 on Gold Creek below the headgate in 2009 (n=30).

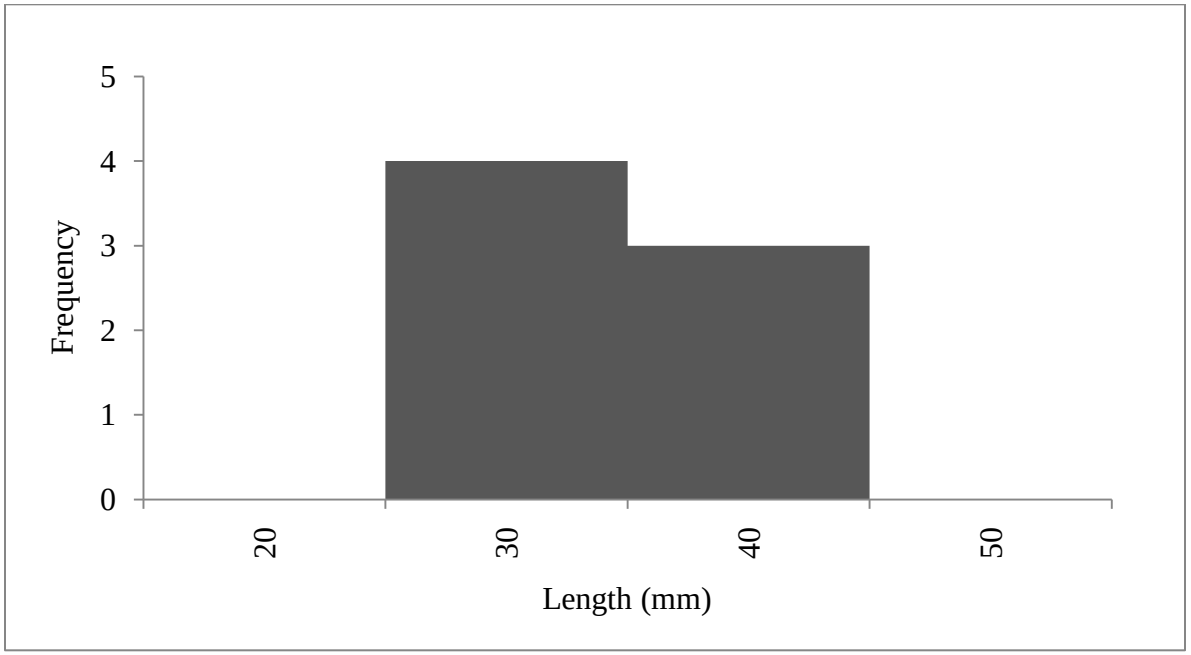


Length distribution of brown trout collected in the ditch at RM 3.6 on Gold Creek below the diversion in 2010 (n=67).

Gold Creek continued…

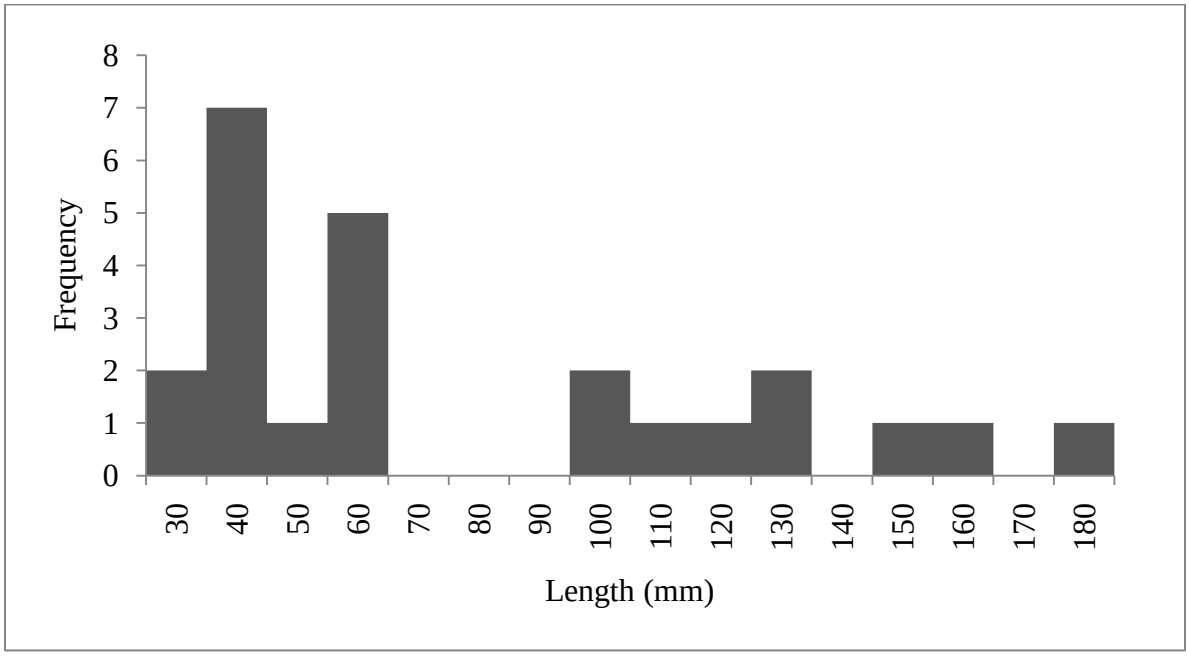


Length distribution of westslope cutthroat trout collected in the ditch at RM 3.6 on Gold Creek below the diversion in 2010 (n=32).



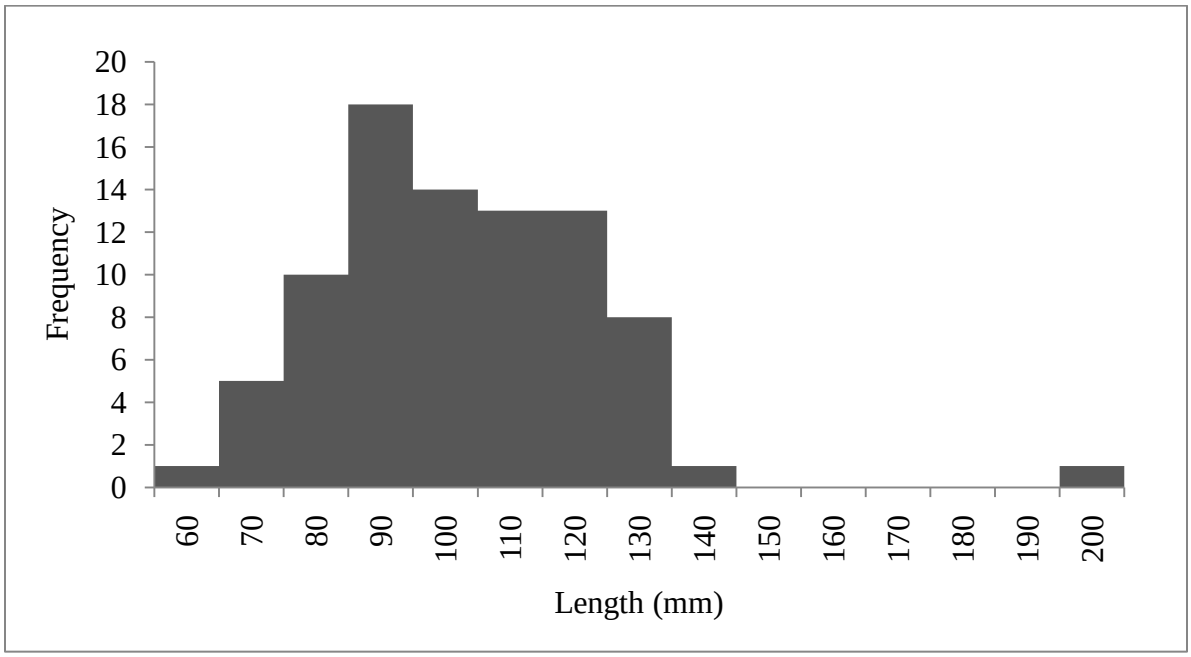
Length distribution of unidentified *Oncorhynchus* species collected in the ditch at RM 3.6 on Gold Creek below the headgate in 2010 (n=7).

Gold Creek continued…



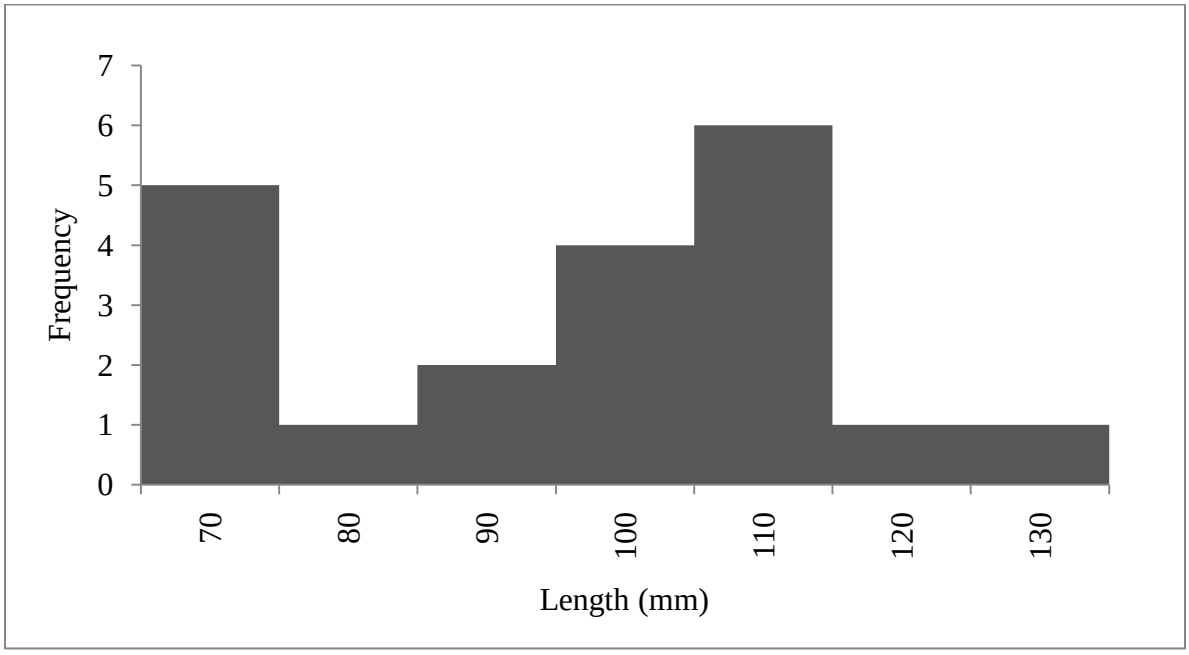
Length distribution of brown trout collected in the ditch at RM 1.1 on Gold Creek below the headgate in 2010 (n=24). An additional 137 brown trout were collected but not measured individually (ranged 40-70 mm).

Clark Fork River



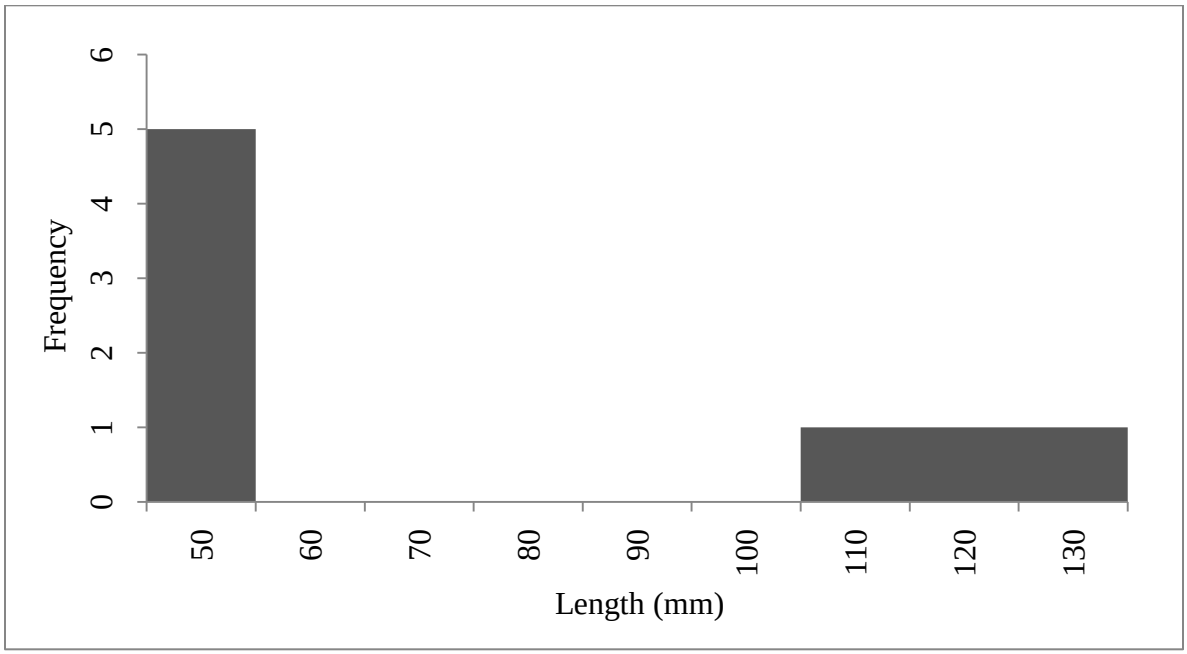
Length distribution of brown trout collected in the Kohrs-Manning ditch below the headgate in 2010 (n=84).

Clark Fork River continued…



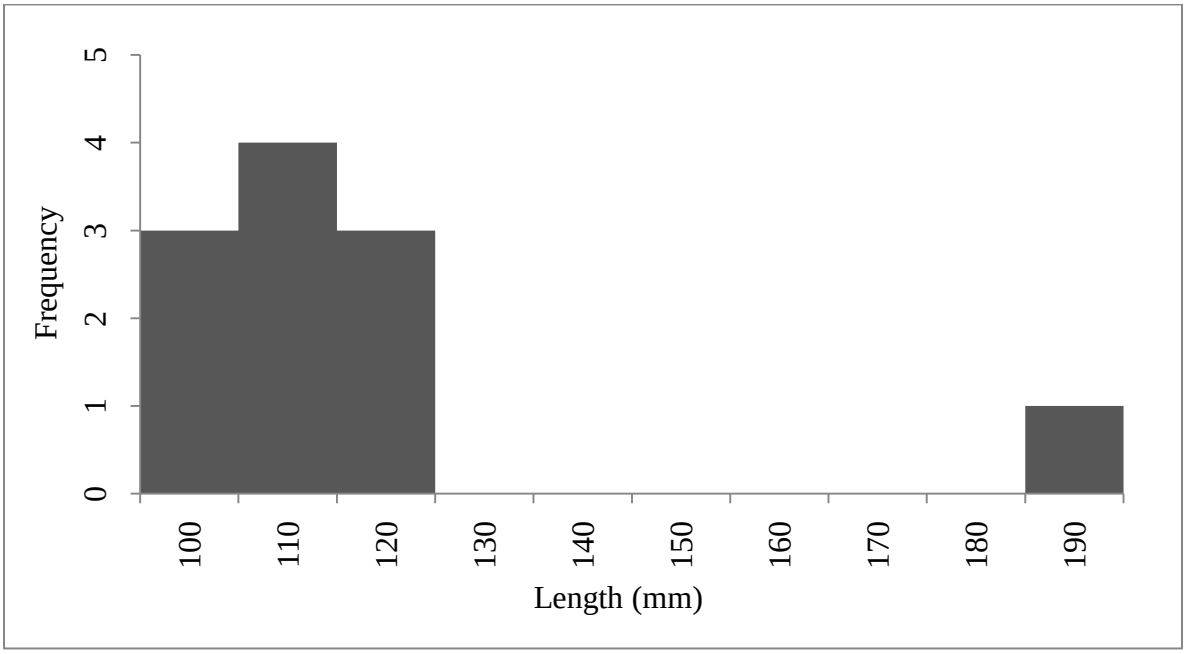
Length distribution of brown trout collected in Kohrs-Manning ditch below the intersection with Cottonwood Creek in 2010 (n=20).

Cottonwood Creek

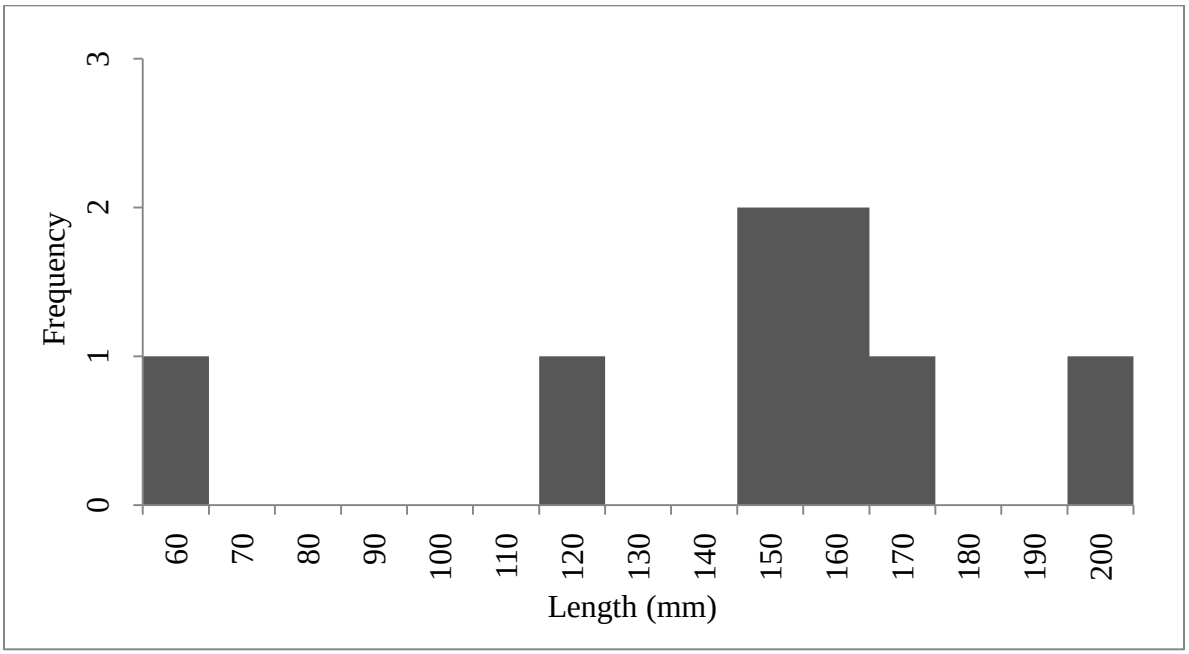


Length distribution of eastern brook trout collected in the ditch at RM 4.0 on Cottonwood Creek below the headgate in 2009 (n=8).

Cottonwood Creek continued…

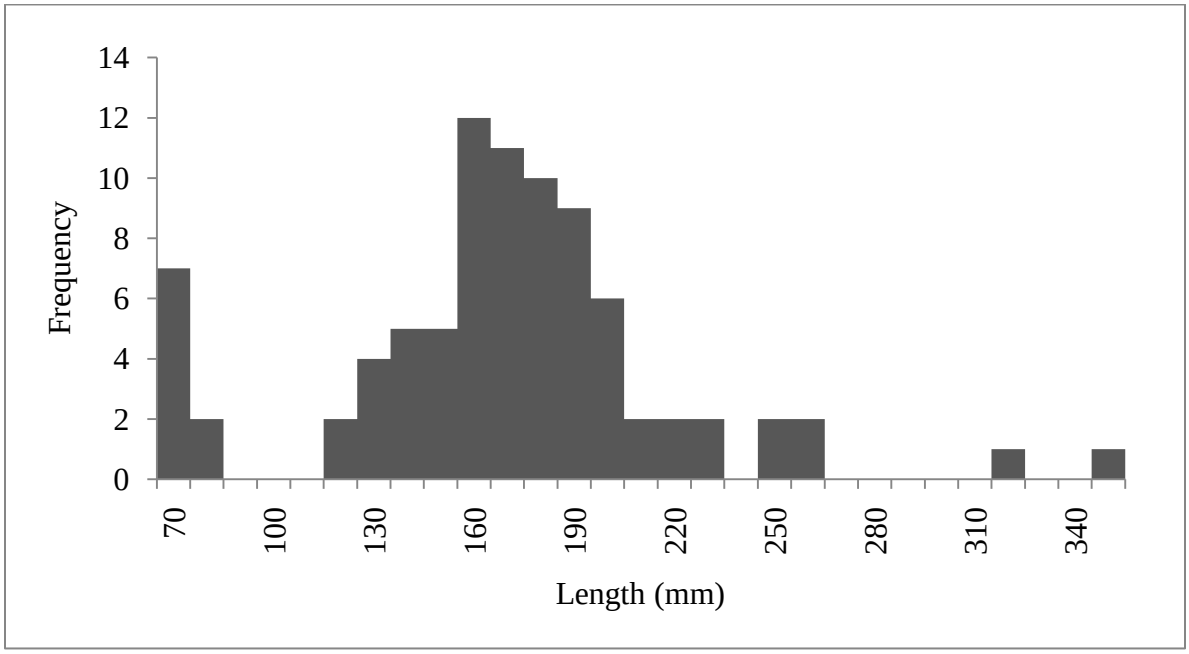


Length distribution of eastern brook trout collected in the ditch at RM 3.5 on Cottonwood Creek below the headgate in 2009 (n=11).



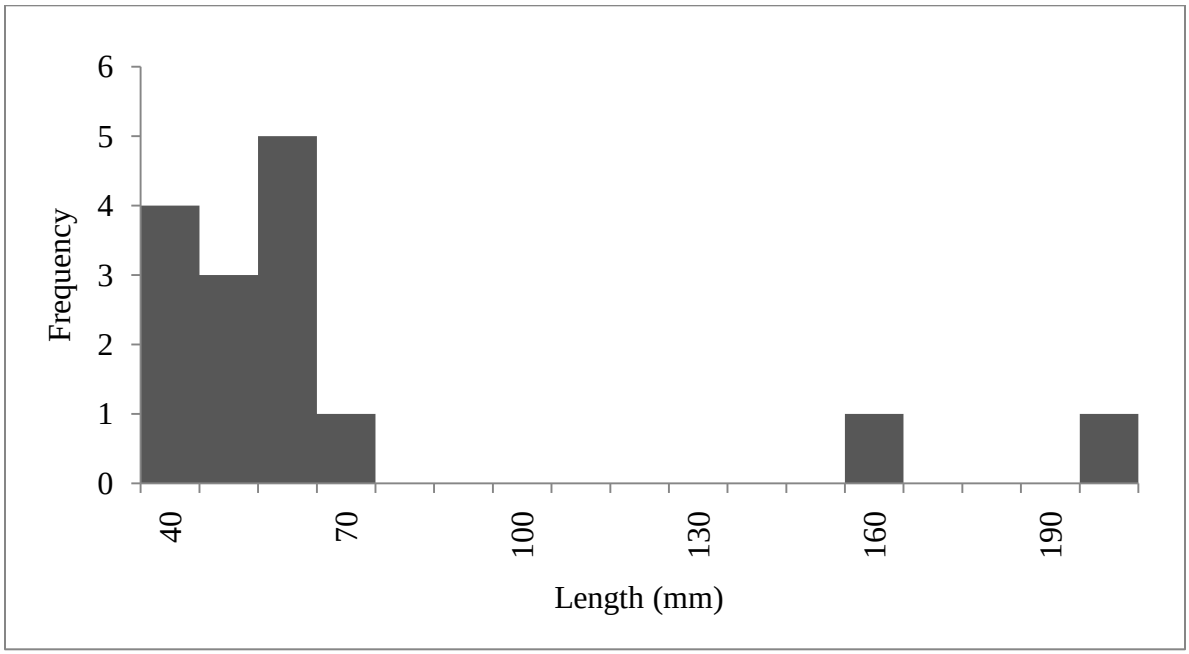
Length distribution of eastern brook trout collected in the ditch at RM 3.0 on Cottonwood Creek below the headgate in 2009 (n=8).

Dempsey Creek



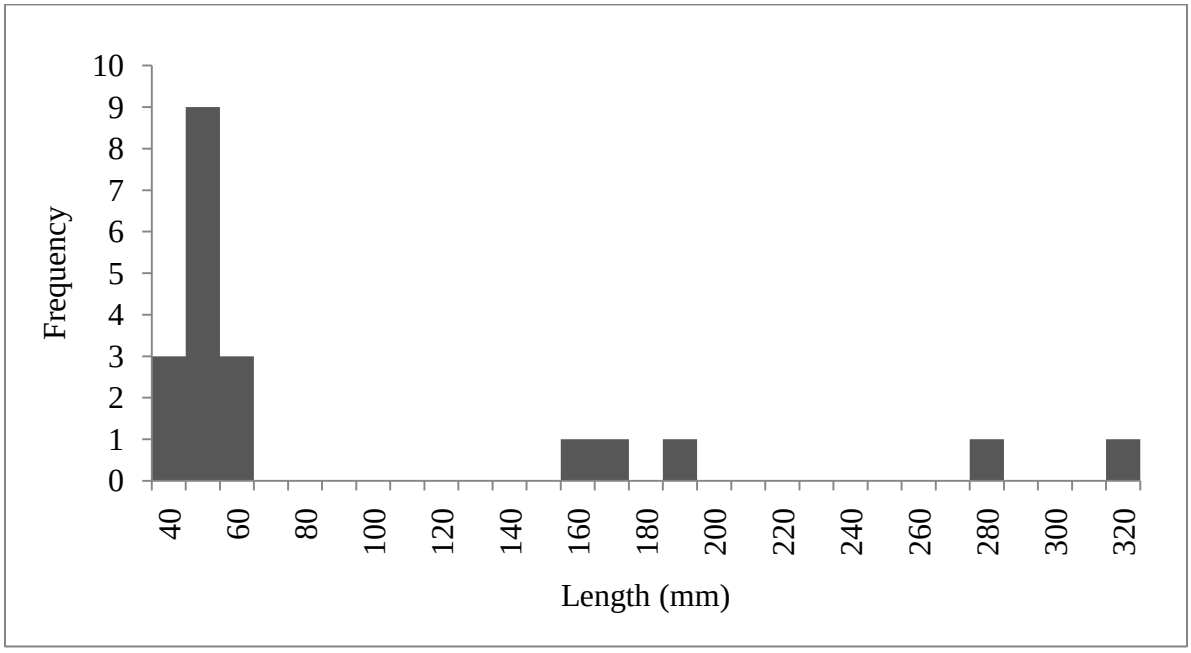
Length distribution of brown trout collected in the ditch at RM 4.8 on Dempsey Creek below the headgate in 2010 (n=85).

Racetrack Creek

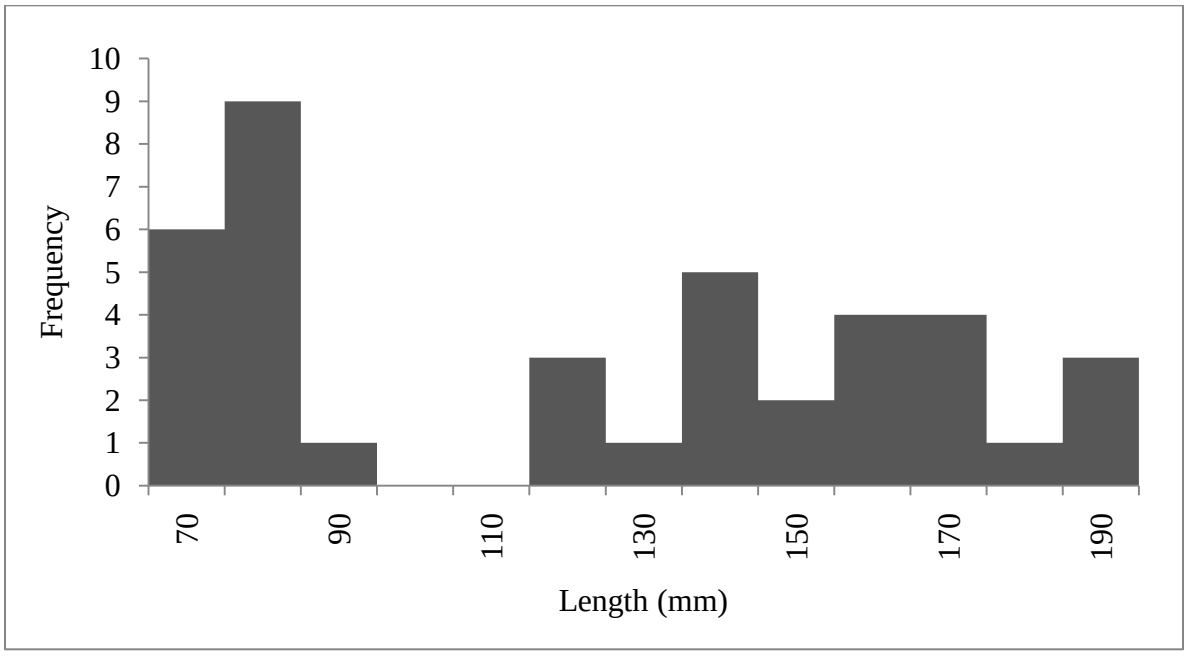


Length distribution of brown trout collected in the ditch at RM 7.5 on Racetrack Creek below the headgate in 2010 (n=15).

Racetrack Creek continued…

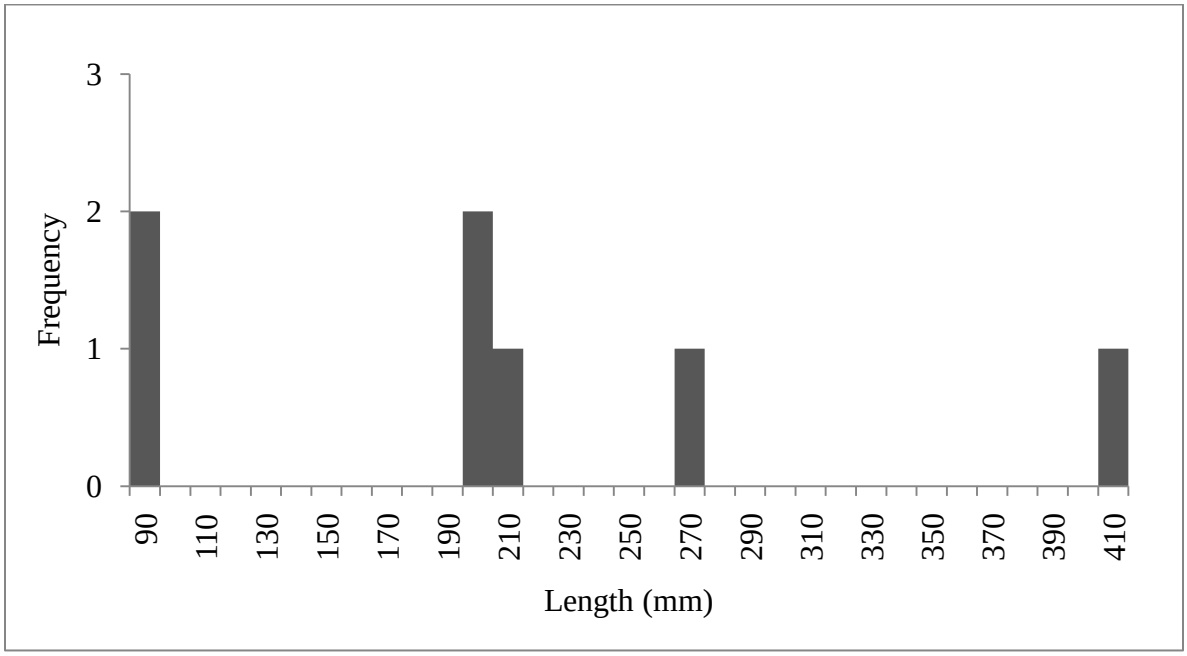


Length distribution of brown trout collected in the ditch at RM 7.4 on Racetrack Creek below the headgate in 2010 (n=20).

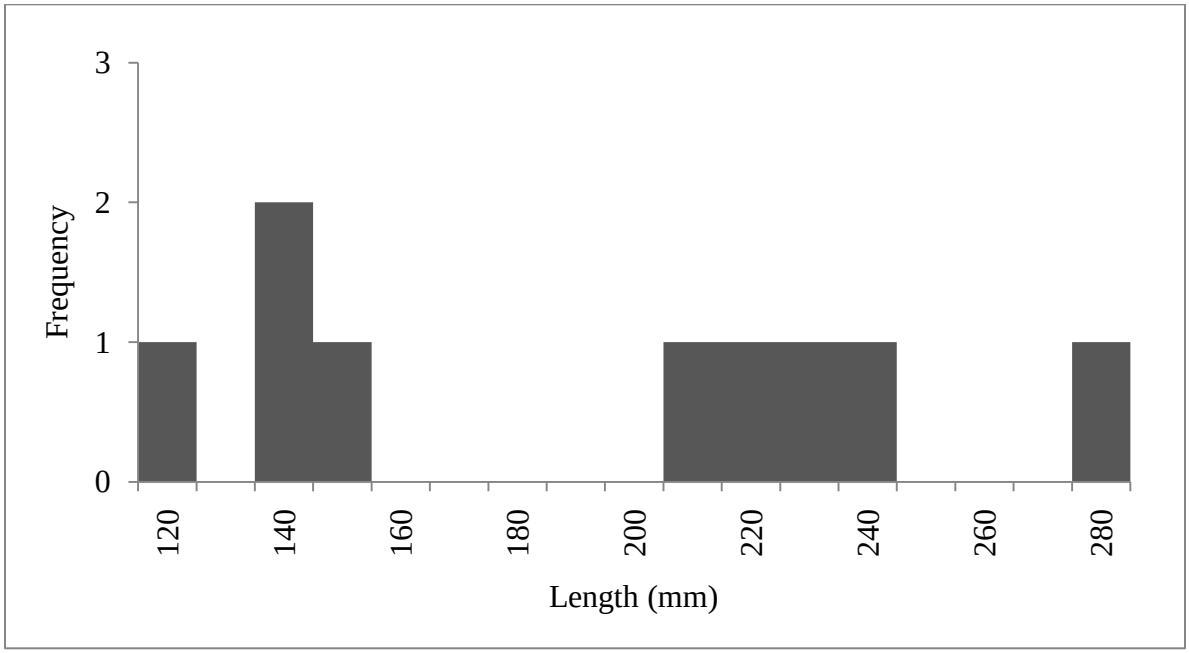


Length distribution of brown trout collected in the ditch at RM 3.5 on Racetrack Creek below the headgate in 2010 (n=39).

Lost Creek

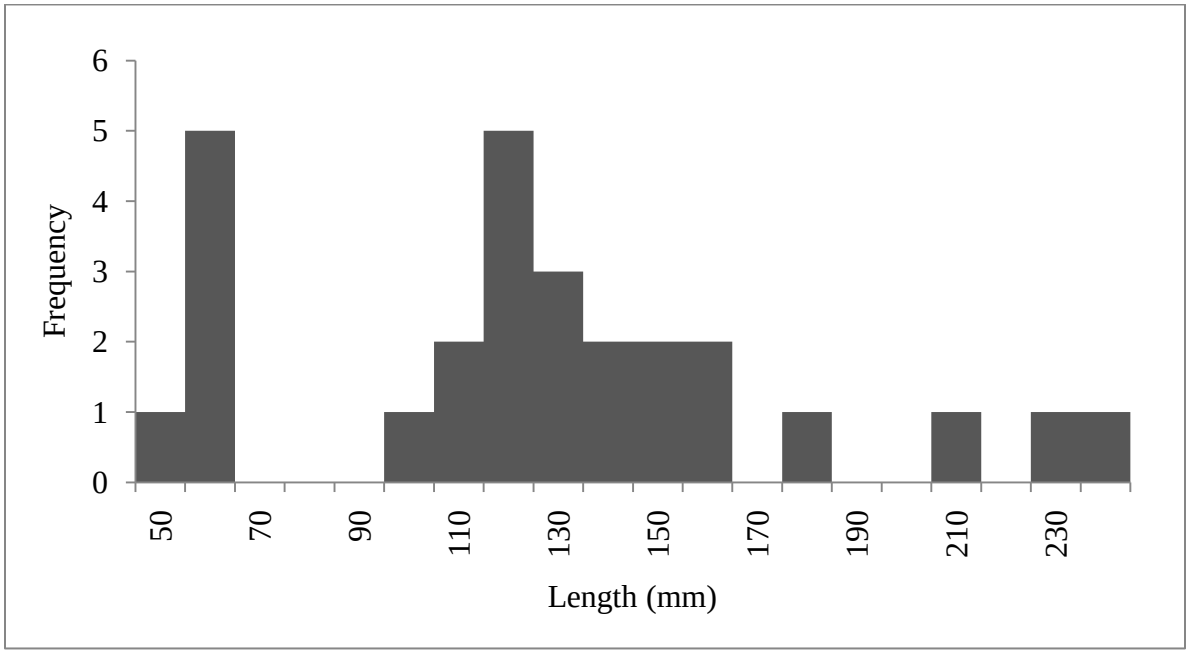


Length distribution of eastern brook trout collected in the ditch at RM 9.2 on Lost Creek below the headgate in 2010 (n=9).

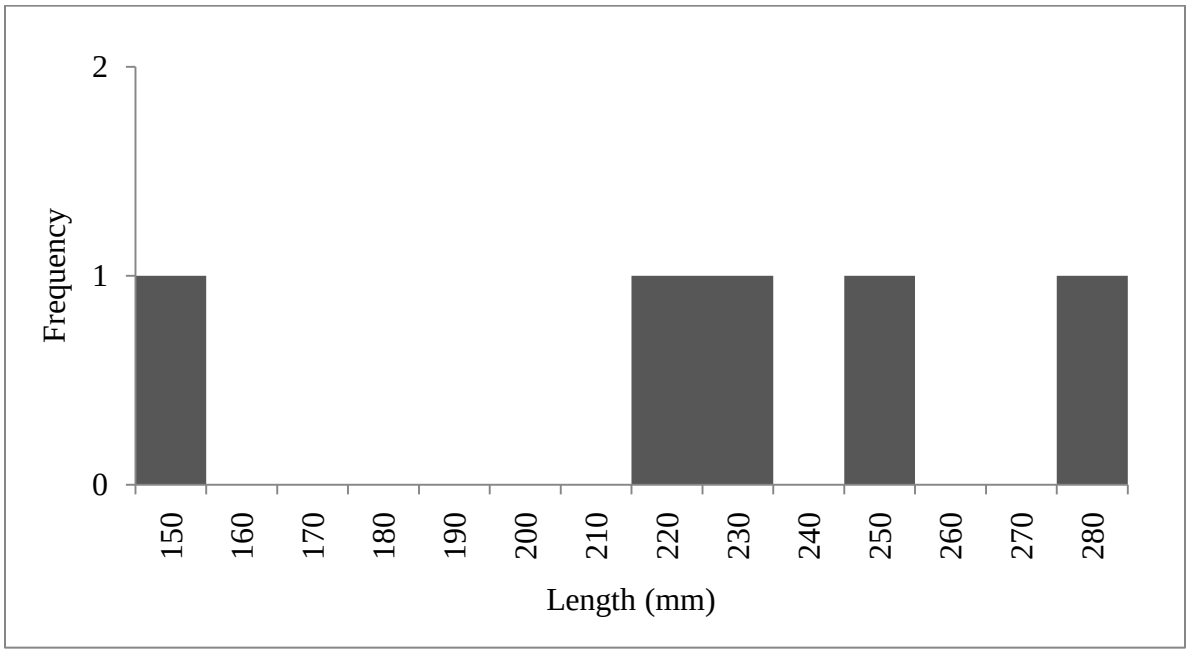


Length distribution of brown trout collected in the ditch at RM 9.2 on Lost Creek below the headgate in 2010 (n=7).

Warm Springs Creek

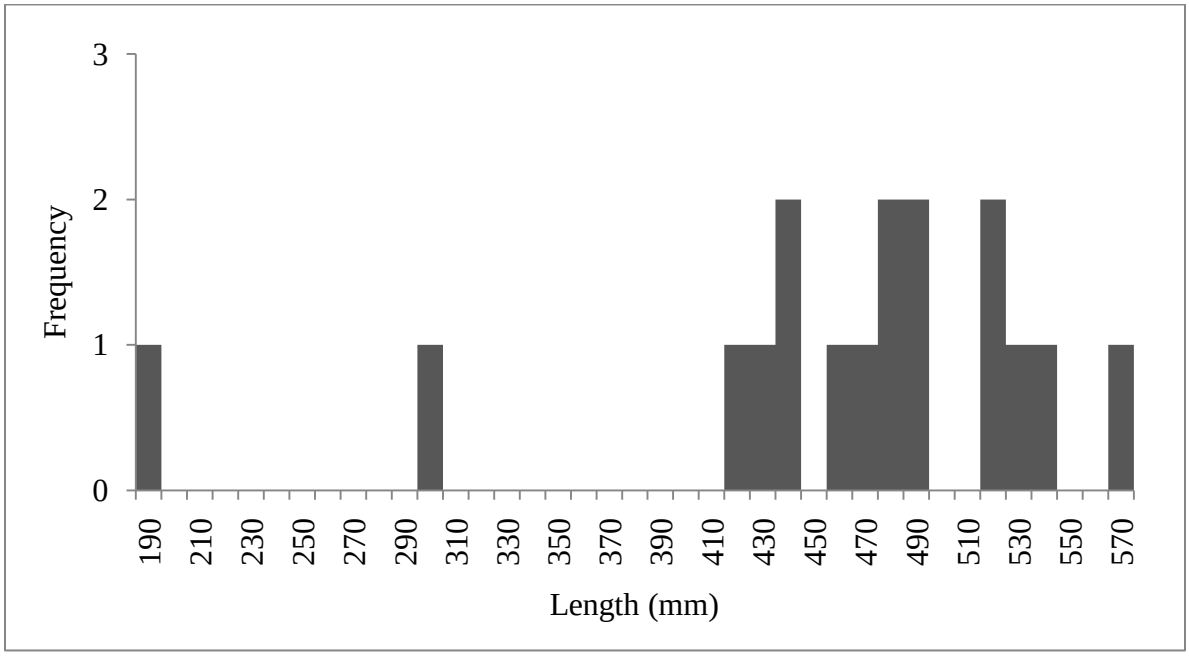


Length distribution of brown trout collected in the ditch at RM 10.0 on Warm Springs Creek 2.0 miles below the headgate in 2010 (n=27). Section located below an intersection with Lost Creek, and thus many of the fish collected may have originated from Lost Creek.



Length distribution of brown trout collected in the ditch at RM 10.0 on Warm Springs Creek 4.9 miles below the headgate in 2010 (n=5). This section was also located below the intersection with Lost Creek

Storm Lake Creek



Length distribution of bull trout collected below water control structure barrier on Storm Lake Creek in 2010 (n=17).

Appendix B

Ranch Creek

Headgate of ditch at RM 1.1 on Ranch Creek, sampled in 2009 and 2010.

View below headgate on ditch at RM 1.1 (facing upstream).

Stony Creek

Headgate and diversion for ditch at RM 0.3 on Stony Creek, sampled in 2009.

Beaver Creek

Check dam and headgate for ditch at RM 0.9 on Beaver Creek, sampled in 2009.

Rock Creek

View of ditch at RM 50.6 on Rock Creek (facing upstream), sampled in 2010.

View of ditch at RM 50.6 approximately 0.5 mi below headgate (facing upstream).

Rock Creek continued…

Diversion (left) for ditch at RM 50.5 on Rock Creek and headgate (right), sampled in 2010.

View of ditch at RM 50.5 just below headgate (facing downstream).

Rock Creek continued…

View of ditch at RM 50.5 approximately 0.5 mi below headgate (facing downstream).

West Fork Rock Creek

Headgate for ditch at RM 4.2 on West Fork Rock Creek, sampled in 2010.

West Fork Rock Creek continued…

Gravel berm diversion (left of center) and West Fork Rock Creek (far left) at RM 4.2.

Ditch at RM 4.2 approximately 0.5 mi below headgate as it enters a private pasture.

Ross Fork Rock Creek

Headgate for ditch at RM 9.4 on Ross Fork Rock Creek, sampled in 2007.

Diversion and headgate for ditch at RM 6.5 on Ross Fork Rock Creek, sampled in 2007.

Ross Fork Rock Creek continued…

Diversion for ditch at RM 6.1 on Ross Fork Rock Creek, sampled in 2009.

Diversion and headgate for ditch at RM 5.5 on Ross Fork Rock Creek, sampled in 2007.

Middle Fork Rock Creek

Headgate for ditch at RM 0.1 on Middle Fork Rock Creek, sampled in 2010.

View 0.2 mi below headgate of ditch at RM 0.1 (facing downstream).

Middle Fork Rock Creek continued…

Culvert 0.5 mi below headgate of ditch at RM 0.1 (facing upstream).

Ditch at RM 0.1 below culvert.

East Fork Rock Creek

Diversion for Flint Creek Main Canal, sampled from 2007-2010.

Headgate for Flint Creek Main Canal.

East Fork Rock Creek continued…

Flint Creek Main Canal directly below headgate (facing downstream).

Harvey Creek

Below headgate of ditch at RM 0.01 on Harvey Creek, sampled in 2010.

South Fork Lower Willow Creek

Diversion for ditch at RM 2.9 on South Fork Lower Willow Creek, sampled in 2009.

Dewatered stretch of the South Fork Lower Willow Creek directly below diversion at RM 2.9.

Gird Creek

Headgate and check-dam (right) for RM 1.1 ditch on Gird Creek.

Boulder Creek

Headgate for ditch at RM 0.9 ditch on Boulder Creek, sampled in 2009 and 2010.

Boulder Creek continued…

Headgate for ditch at RM 0.8 on Boulder Creek, sampled in 2009 and 2010.

Diversion and headgate for ditch at RM 0.2 on Boulder Creek, sampled in 2010.

Gold Creek

Ditch at RM 6.1 on Gold Creek, sampled in 2010.

View of ditch at RM 6.1 50 meters below diversion.

Gold Creek continued…

Headgate for ditch at RM 5.2 on Gold Creek, sampled in 2010.

View of ditch at RM 5.2 below headgate.

Gold Creek continued…

Ditch at RM 3.9 on Gold Creek, sampled in 2010.

View of ditch at RM 3.9 50 meters below headgate.

Gold Creek continued…

Headgate for ditch at RM 3.8 on Gold Creek, sampled in 2010.

View of ditch at RM 3.8 below headgate.

Gold Creek continued…

Headgate for ditch at RM 3.7 on Gold Creek, sampled in 2010.

View of ditch at RM 3.7 below headgate.

Gold Creek continued…

Headgate for ditch at RM 3.7 on Gold Creek, sampled in 2010.

View of ditch at RM 3.7 below headgate.

Gold Creek continued…

Headgate for ditch at RM 1.1 on Gold Creek (facing upstream), sampled in 2010.

View of the fish screen in place on ditch at RM 1.1, sampled in 2010.

Clark Fork/Cottonwood

Headgate for Kohrs-Manning ditch (RM 314.0) on the Clark Fork, sampled in 2010.

View of Kohrs-Manning ditch immediately below headgate.

Clark Fork/Cottonwood continued…

Cottonwood Creek diversion and secondary headgate (right) on Kohrs-Manning ditch (approximately 0.25 mi below headgate).

Lowest section (1.6 mi) sampled on Kohrs-Manning ditch.

Cottonwood Creek

Diversion for ditch at RM 6.0 on Cottonwood Creek, sampled in 2009.

Cottonwood Creek continued…

Concrete diversion for ditch at RM 5.5 on Cottonwood Creek, sampled 2009.

Cottonwood Creek continued…

Diversion for ditch at RM 5.4 on Cottonwood Creek, sampled in 2009.

Diversion for ditch at RM 3.5 on Cottonwood Creek, sampled 2009.

Cottonwood Creek continued…

Cottonwood Creek dewatered below the diversion at RM 3.50 on June 30, 2009.

Diversion for ditch at RM 3.0 on Cottonwood Creek, sampled 2009.

Dempsey Creek

Headgate and diversion for ditch at RM 5.1 on Dempsey Creek, sampled in 2010.

View of ditch at RM 5.1 below headgate.

Dempsey Creek continued…

Headgate for ditch at RM 4.8 on Dempsey Creek, sampled in 2010.

View of ditch at RM 4.8 below headgate.

Dempsey Creek continued…

Check-dam (left) and headgate (right) for ditch at RM 4.7 on Dempsey Creek, sampled in 2010.

View of ditch at RM 4.7 below headgate.

Racetrack Creek

Headgate (left) and diversion (right) for ditch at RM 7.5 on Racetrack Creek, sampled in 2010.

View of ditch at RM 7.5 below headgate (facing downstream).

Racetrack Creek continued…

Headgate for ditch at RM 7.4 on Racetrack Creek, sampled in 2010.

View of ditch at RM 7.4 below headgate (facing downstream).

Racetrack Creek continued…

Headgate of ditch at RM 3.5 on Racetrack Creek, sampled in 2010.

View of ditch at RM 3.5 below headgate (facing downstream).

Lost Creek

Headgate of ditch below Dutchman Pond on Lost Creek (RM 9.2), sampled in 2010.

View of ditch at RM 9.3 below headgate.

Lost Creek continued…

Ditch at RM 9.3 approximately 1.6 mi below headgate.

Ditch at RM 7.6 on Lost Creek, sampled in 2010.

Lost Creek continued…

Second view of ditch at RM 7.6 approximately 50 meters below headgate.

Ditch at RM 7.6 approximately 0.8 mi below headgate (facing upstream).

Warm Springs Creek

Headgate for ditch at RM 10.0 on Warm Springs Creek, sampled in 2010.

Ditch at RM 10.0 approximately 175 m below headgate (facing downstream).

Warm Springs Creek continued…

Ditch at RM 10.0 below intersection with Lost Creek (facing downstream).

Ditch at RM 10.0 approximately 4.9 mi below headgate (facing downstream).

Storm Lake Creek

View of the water control structure on Storm Lake Creek. Pipe in the foreground leads to Warm Springs Creek and spill on the right leads to Silver Lake.

View of the vertical barrier on the Storm Lake Creek structure.

Browns Gulch

Headgate (left) and diversion (right) for ditch at RM 4.3 on Brown's Gulch, sampled in 2010.

View of ditch at RM 4.3 approximately 0.4 mi below headgate.

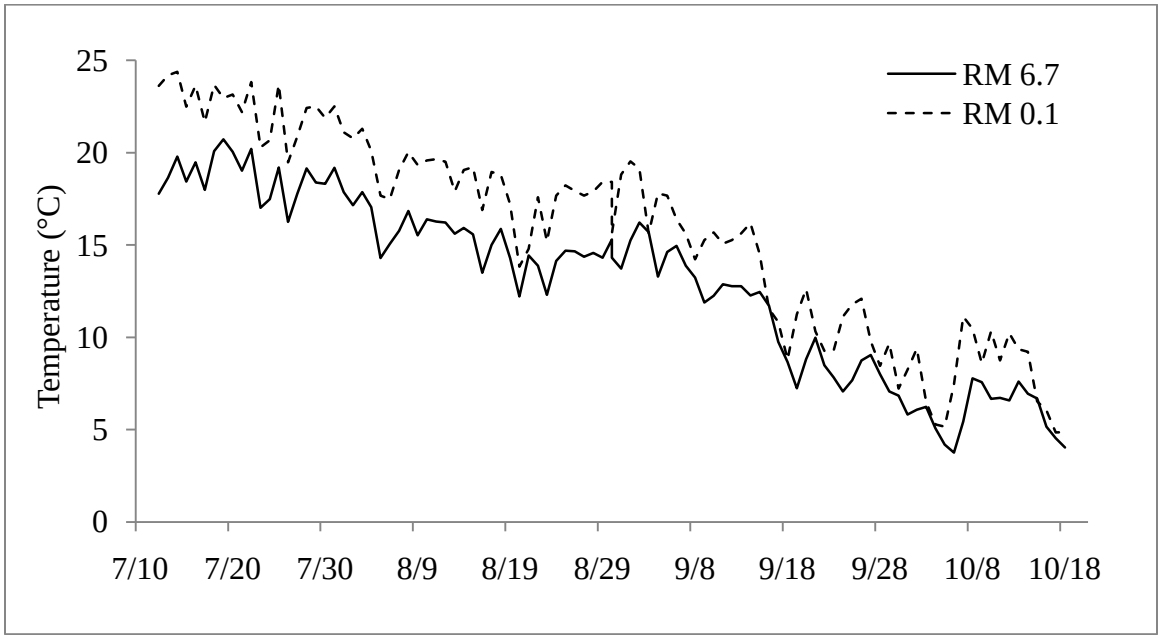
Browns Gulch continued…

View of ditch at RM 4.1 on Brown's Gulch below headgate, sampled in 2010.

View of ditch at RM 4.1 approximately 0.8 mi below headgate.

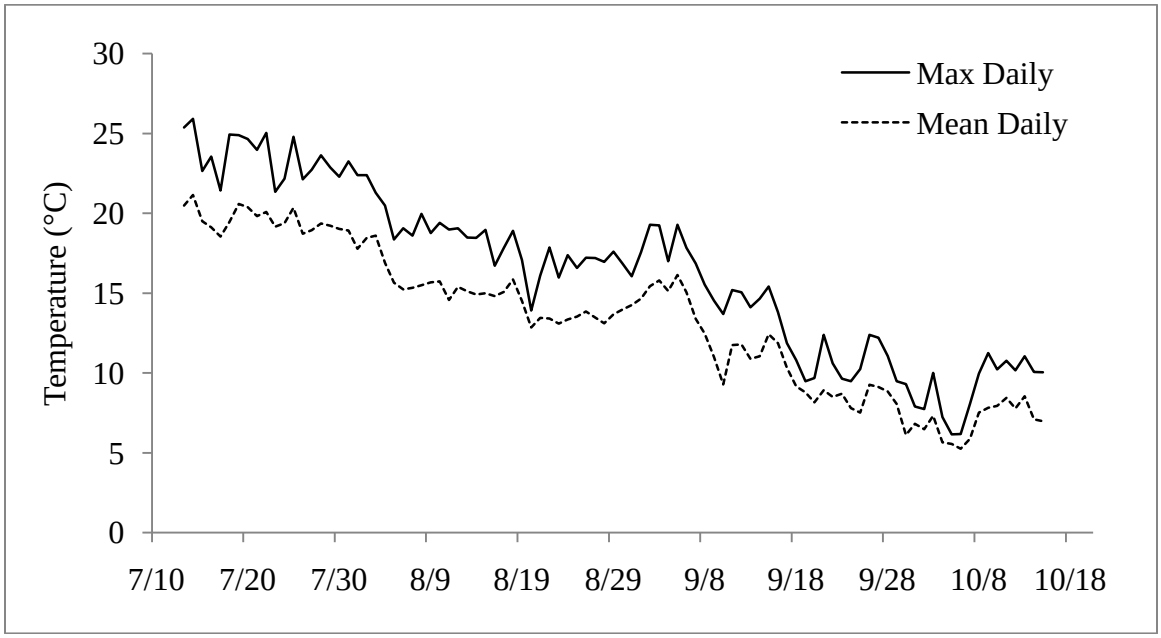
Appendix C

Ross Fork Rock Creek



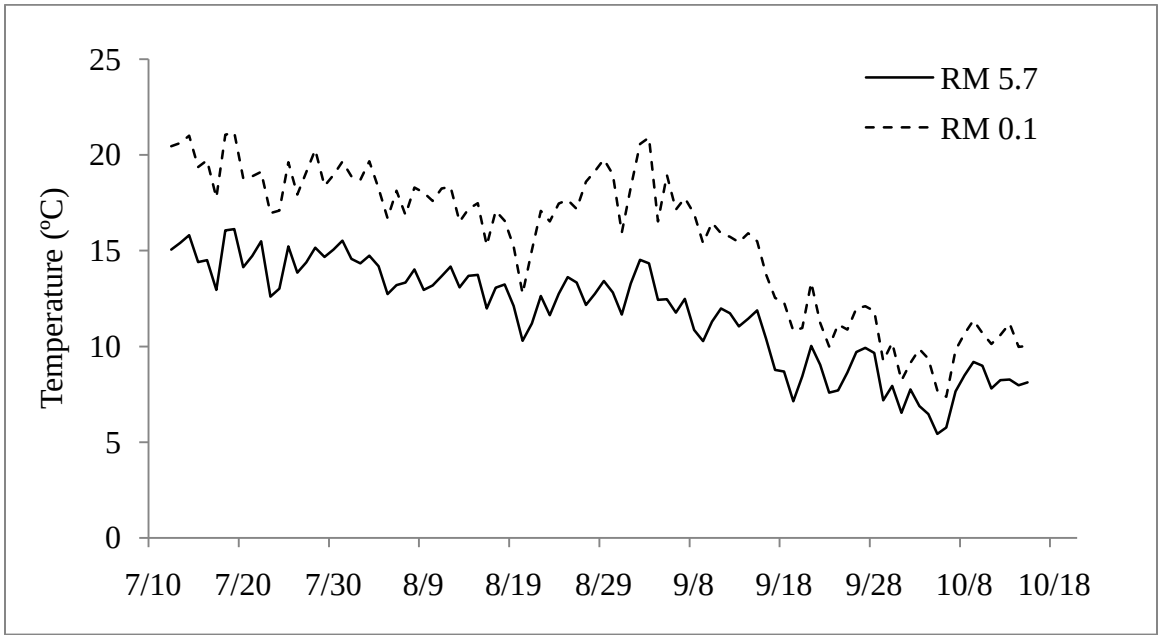
Maximum daily temperatures recorded by thermographs located at RM 6.7 and RM 0.1 on Ross Fork Rock Creek in 2007.

South Fork Lower Willow Creek



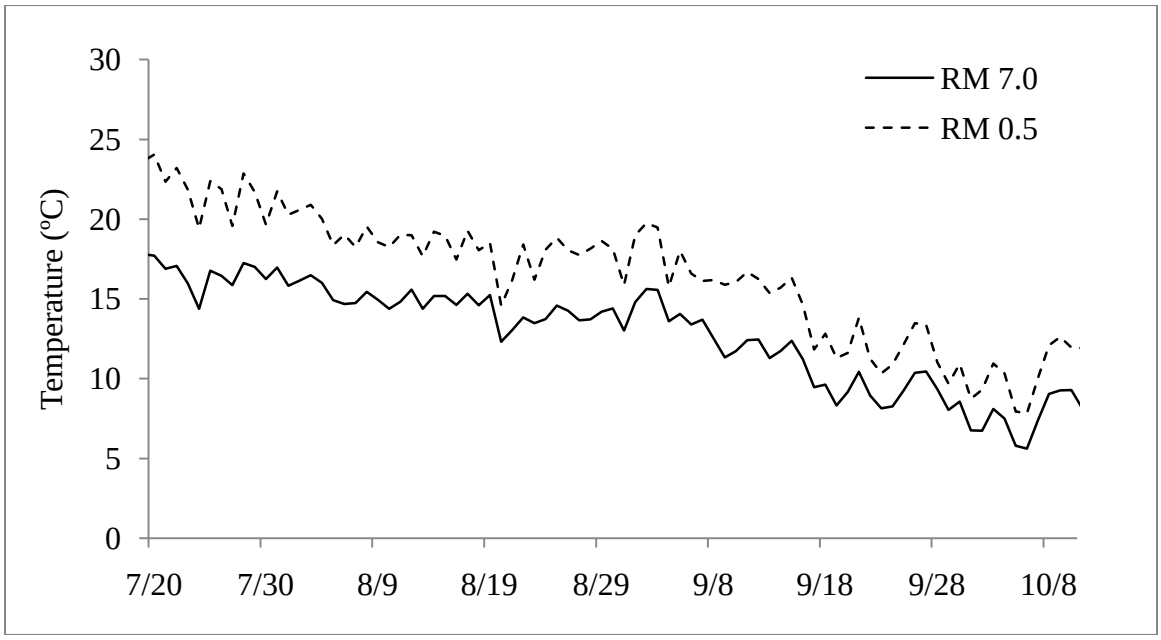
Mean and maximum daily temperatures recorded by a thermograph located in South Fork Lower Willow Creek above the Lower Willow creek reservoir in 2007.

Gold Creek



Maximum daily temperatures recorded by thermographs located at RM 5.7 and RM 0.1 on Gold Creek in 2007.

Cottonwood Creek



Maximum daily temperatures recorded by thermographs located at RM 7.0 and RM 0.5 on Cottonwood Creek in 2007.