Fish Distribution and Abundance Studies

Fisheries Survey of Big Creek, Mill Creek, and Upper Shields River Drainages 2012 Report

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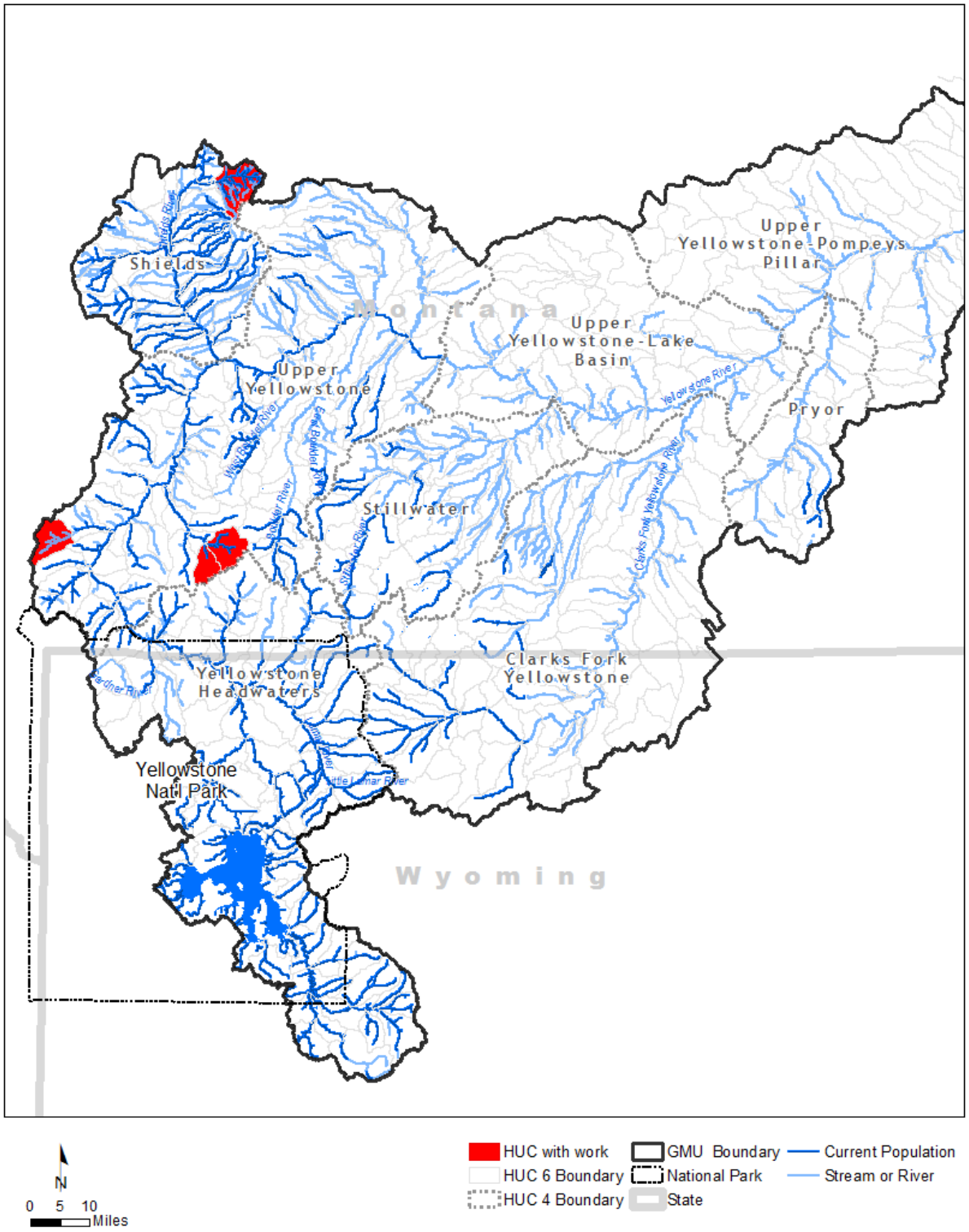
Introduction and Background

The Yellowstone Cutthroat Conservation Strategy for Montana (YCT Strategy) indicates that "continued survey and assessment is a considerable need that will identify secure populations, and areas where intervention is needed to meet conservation goals." (Endicott et. al. 2013). To meet this need, Fish, Wildlife & Parks and the Gallatin National Forest are cooperating on annual basin-wide survey efforts. Basin-wide surveys are designed to systematically sample at a large-spatial scale within drainages. This systematic approach is valuable in that it clearly defines fish species distribution throughout target drainages and provides an in-depth "snapshot" of fish species abundance longitudinally. Because basin-wide sampling occurs over a large spatial scale, typically only two or three drainages can be sampled in a given field season even with multiple crews. The primary objective of basin-wide sampling is to provide baseline fish species distribution and demographic information for drainages where data are limited or are dated. Because the approach is standardized, it does allow long-term monitoring of reaches of interest and comparison of fish densities within and among drainage basins. The YCT Strategy is utilized to help prioritize watersheds for basin-wide sampling because it summarizes the available fish distribution information for the Upper Yellowstone Geographic Management Unit (GMU) and identifies watersheds with limited or out of date data.

Study Area

The Upper Yellowstone GMU lies in the upper Yellowstone River Basin. Watersheds selected for sampling in 2012 included Big Creek, Mill Creek, and the upper Shields (Figure 1). The following watershed descriptions are modified from the YCT Strategy. More detailed descriptions can be found in the strategy (Endicott et al. 2012 and Endicott et al. 2013).



• Figure 1: Map of the Upper Yellowstone GMU with HUCs where sampling occurred in 2012 highlighted in red.

Big Creek Basin

The Big Creek watershed is the second largest in the Paradise Valley (70 square miles). Big Creek proper is 17 miles in length and its 12 tributaries total 56 miles in length (73 total stream miles). Much of this stream and many of its tributaries, flow through the Gallatin National Forest. Its lowermost five miles flow through private lands. Named primary tributaries include Little Bear Creek, Bear Creek, Mist Creek, Smokey Creek, Bark Cabin Creek, Cottonwood Creek, Cliff Creek, Lewis Creek, and Hyalite Creek.

Prior to 2012 sampling, there were limited data on the resident fishery of Big Creek and its tributaries. Genetic investigations conducted in the 1980's suggested the presence of genetically pure Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri* (YCT) higher in the watershed, with an area of genetic mixing downstream of the Forest Boundary. This investigation focused on Big Creek and its tributaries upstream from Cottonwood Creek to confirm genetic purity and identify any barriers that could be serving to maintain genetic purity.

Mill Creek Basin

Mill Creek is the largest sub-watershed in the upper Yellowstone HUC and encompasses over 160 square miles. Mill Creek proper is 22 miles in length. The upper watershed (including the upper Mill Creek and Passage Creek 6th code HUCs), which is the focus of this investigation, encompasses 55 square miles (not including the East Dam Creek which is part of the Lower Mill Creek HUC). There are 47 tributary stream miles in the upper watershed including East Dam Creek.

Fish population sampling has occurred in several tributaries in the upper watershed. However, determining the presence of YCT x rainbow trout hybrids in the drainage upstream from a man-made barrier requires current genetic data which is not currently available. Streams sampled in 2012 to meet this need included Mill Creek, East Dam Creek, Anderson Creek, Lambert Creek, Colley Creek, and Passage Creek.

Upper Shields River Drainage

The upper Shields River Drainage is 50 square miles in size with over 61 tributary stream miles. Extensive fish population surveys have been conducted in the upper drainage. These surveys indicate that brook trout *Salvelinus fontinalis* have been rapidly expanding their distribution and that management action is warranted to secure YCT streams that have not yet been invaded. One such action includes modifying existing road crossings into temporary fish barriers to prevent the upstream invasion of brook trout. Sampling in 2012 was focused on the upper Shields River, Turkey Creek, an unnamed tributary to the Shields River near Turkey Creek and Scofield Creek to confirm the absence of brook trout.

Objectives

Objectives of the native fish distribution and abundance studies are to:

- Determine the distribution and abundance of native and nonnative fish species in the Upper Yellowstone GMU.
    - For long-term monitoring reaches with existing data, evaluate trends in abundance.

- Determine the current genetic status of native YCT.
- Evaluate habitat conditions (migration barriers, habitat quality, etc) and their influence on native and nonnative fish distribution and relative abundance.
- Fulfill annual Gallatin National Forest Plan inventory and monitoring requirements.

Methods

Basin-Wide Electrofishing Protocol

Electrofishing crews consisted of 2 to 3 people equipped with a Smith-Root LR-24™ or Smith-Root Model 12-B™ backpack electrofishing unit. Maps of the basin were created through the use of ArcMap™ with sampling points plotted every 0.5 miles (beginning at the stream mouth and proceeding upstream) on all waters in the basin. Sampling points were uploaded into GPS units allowing crews to quickly and accurately locate them in the field. Sampling of a specific water began at the mouth or the lowest accessible predetermined sampling point and proceeded upstream every 0.5 miles until two successive fishless points were sampled. This was done to approximate, with confidence, the uppermost limit of fish distribution to within 0.5 mile. Streams with intermittent middle reaches and perennial upper reaches could potentially require sampling above two successively sampled fishless reaches.

Once crews reached a 0.5-mile sampling point, a 100 meter sampling section was measured upstream from that point with the use of a hip chain or GPS unit. To allow future location of the sampling section, start and end points were flagged, their GPS coordinates were recorded, and site notes and photos were taken. Stream width was measured to the nearest 0.1 meter at a representative location with a tape or a net handle having metric demarcations to allow fish densities (number of fish per area) to be calculated.

At a minimum, a one pass electrofishing sample was completed beginning at each 0.5-mile sampling point. In an alternating pattern, every other 0.5-mile sampling point was designated for a multiple pass depletion population estimate in order to obtain fish density information (estimated number of fish per 100 meters). To obtain a quantitative estimate of the population size and confidence limits, a minimum of two electrofishing passes must be performed. If efficiency between the first and second pass was less than 50%, a third pass was conducted. Efficiency was calculated in the field as (a – b / a) where a = the number of fish captured on the first run and b = the number of fish captured on the second pass. If less than ten fish of a given species were captured on the first pass of a population estimate section, no further passes were conducted. This is because at low fish densities the population estimates are typically close or equal to the number of fish captured (FWP data files). The sampling time was also recorded for each site to provide a measure of electrofishing effort.

Fish Handling Protocol

All captured fish were anesthetized, identified to species, measured to the nearest mm and weighed to the nearest .01 gram. Fin clips were taken from YCT and stored in sample vials filled with 95% ethanol for later genetic analysis. A label with a unique sample number was placed in each vial. The genetic

sample number of each individual fish was also recorded on the data sheet to allow for tracking of individual fish.

Habitat Characterization

For each sampling section a qualitative assessment of fish habitat was recorded in the "comments" area of the data sheet. The assessments included information relevant to the site such as: stream gradient; dominant substrate type; Rosgen channel type; channel and stream bank stability; streamside vegetation (dominant types, condition, and extent); spawning habitat quality; pools (frequency, depth, and types); location relative to any fish barriers; and any natural or anthropogenic disturbance such as debris flows, channel erosion, channel intermittency/dewatering, cattle grazing, riparian timber harvest or mining impacts. Water temperature, conductivity and time of collection were also recorded. Digital photos were also taken at sampling sections to help document characteristic habitat features and any impacts.

Any natural or manmade features perceived to be significant barriers to upstream fish passage were also recorded irrespective of whether they were within or outside of a sampling section. For each perceived barrier the following attributes were recorded: GPS coordinates, barrier type, height, material and persistence. Photos of each barrier were also taken with people or objects in the frame for scale reference.

Data Analysis

For each sampling reach with multiple pass data, population estimates were generated for each species. Fish population estimates were calculated using the Zippin K-pass removal method (Zippin 1956 and 1958).

Length-frequency histograms were plotted for captured fish using 10-mm size intervals. Within a given stream, data from multiple sample sections were combined because histograms of individual sections were less complete due to lower numbers of fish. The use of 10-mm size intervals provided the resolution necessary to infer age structure.

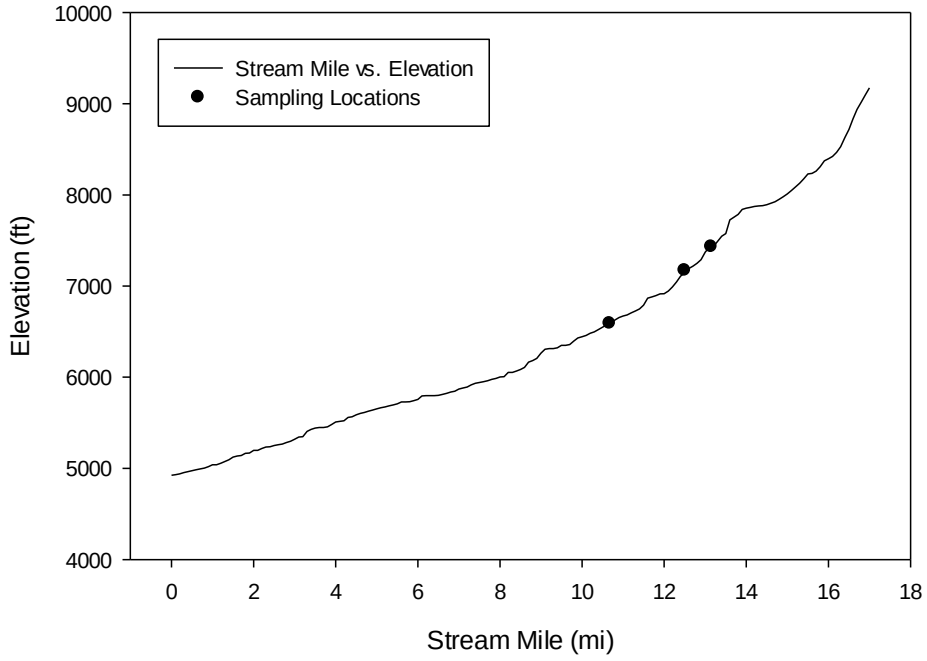
Results Big Creek Basin

Big Creek

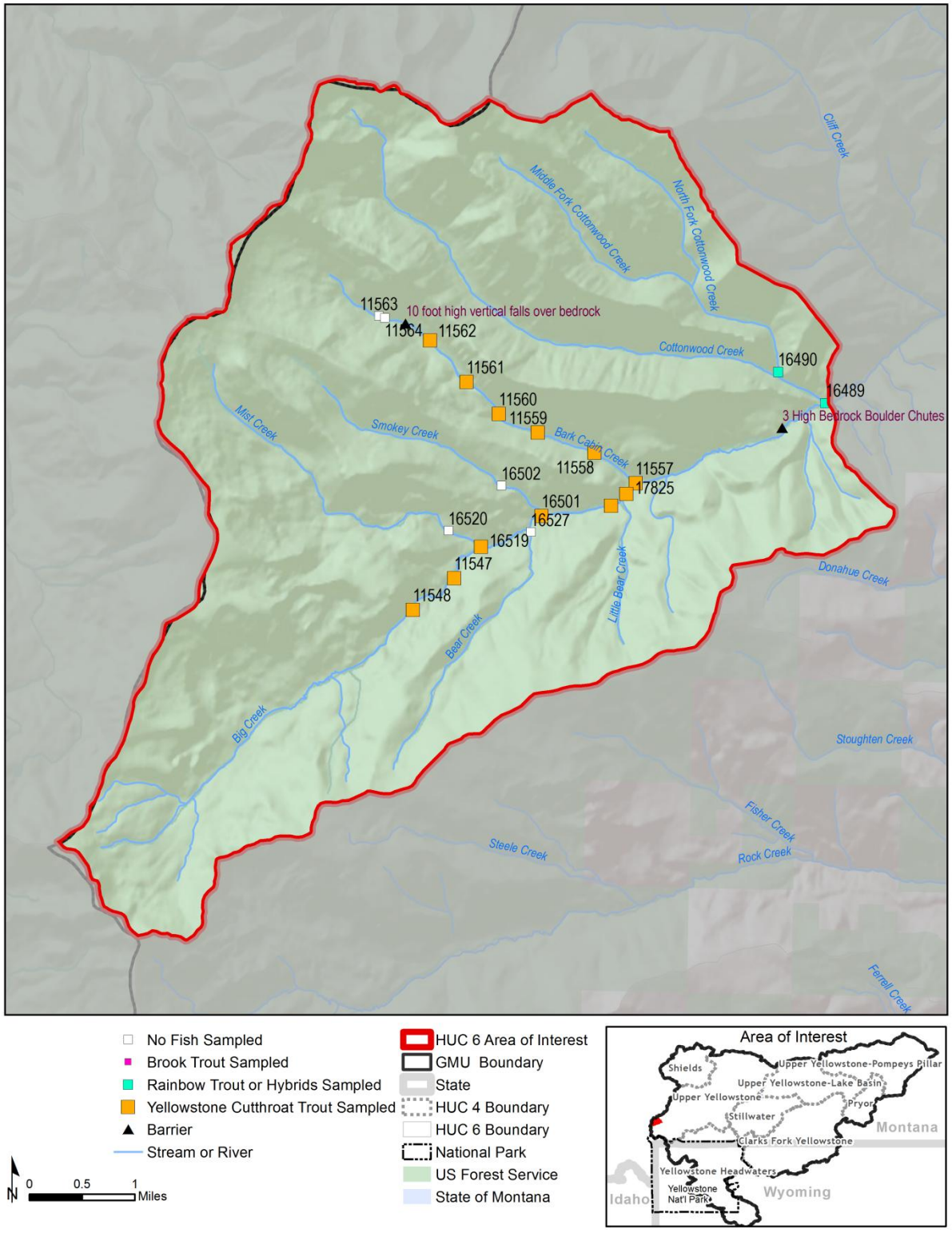
Big Creek is a large tributary of the Yellowstone River that flows from the southwest to the east. Big Creek is 17.1 miles in length, has numerous tributaries, and flows through both private and public lands. Three sections located on Forest Service land were sampled on Big Creek in 2012 (Table 1, Figure 2 and Figure 3).

• Table 1: Big Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
2	100	7.5	56	8
11547	100	5	51	7
11548	100	-	48	1



• Figure 2: Location of sampling locations on Big Creek in relation to stream elevation.



• Figure 3: Big Creek sample locations, species presence and barrier locations in 2012.

Two backpack electrofishing units were used at the same time on Section 2 and Section 11547 because of the wide stream width (Table 1). The wide stream width in Section 2 resulted in poor capture efficiency with backpack electrofishing units and it was not feasible to conduct population estimates. Because of low efficiency, the small number of fish captured in section 2 (n = 8) is likely not representative of actual abundance (Appendix 1). The Rosgen channel type for Section 2 was B3 with moderate gradient and cobble dominated substrate and banks. The habitat sampled was primarily riffles with pocket pools and some lateral scour pools along undercut banks (Figure 4).

• Figure 4: Big Creek Section 2 on left and YCT from Section 2 on right.

Section 11547, located approximately 0.5 mile upstream from the Mist Creek confluence is a Rosgen A2 or B2 channel type with a high gradient, numerous small boulder cascades, and boulder-formed plunge pools (Figure 5). Large woody debris (LWD) is abundant in the section and contributes to the formation of large pools, overhead cover, and complex habitat. Much of the reach is shaded by a dense alder canopy.

Only seven YCT were captured in the reach, though high discharge, surface turbulence, and habitat complexity likely resulted in low capture efficiency (Appendix 1).

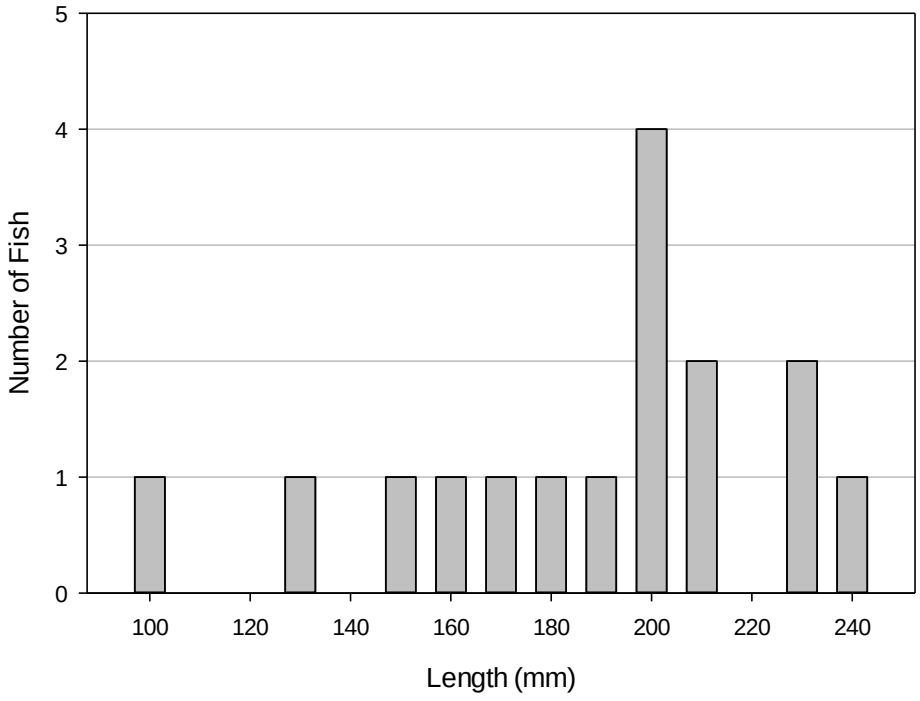

• Figure 5: Big Creek Reach 11547 located upstream from the Mist Creek confluence.

The Rosgen channel type for Section 11548 was C4 or B4 (low gradient gravel bottom channel) with abundant LWD, well vegetated undercut banks, and scour pools with depths up to three feet (Figure 6). The section also had an abundant Spruce tree over story. Given the depth of pools and abundance of gravel this reach should provide excellent spawning,rearing and overwintering habitat.

Despite the high quality habitat, only one YCT was captured in the 100 meter reach (Appendix 2). An additional ~7-inch fish avoided capture. Based on the fish response to electrofishing, water conductivity appeared to be low which reduced capture efficiency.


• Figure 6: Reach 11548 has complex habitat with abundant LWD and spawning gravel.

YCT were the only fish captured in all three Big Creek sections and ranged in size from 100 to 247 mm in total length (Figure 7). Due to the small number of fish captured, age classes could not be determined from the length-frequency histogram. Figure 7 does illustrate a higher frequency of fish 200 mm and larger.



• Figure 7: Length-frequency distribution of YCT in all sampled sections of Big Creek.

Due to time constraints and logistical considerations, no reaches were sampled upstream of section 11548 in 2012 and the upper distribution of YCT in Big Creek was not identified.

A narrow bedrock canyon is located approximately 0.3 mile upstream from the Cottonwood Creek confluence and 1.5 mile downstream from the Bark Cabin Creek Confluence (Figure 3). Investigation of the canyon revealed a series of three, boulder/bedrock falls ranging in height from about 4 to 7 feet (Figure 8). The presence of rainbow trout in Cottonwood and Big Creek below the canyon, but not above the canyon, suggests that one or more of these falls provides a functional fish barrier.

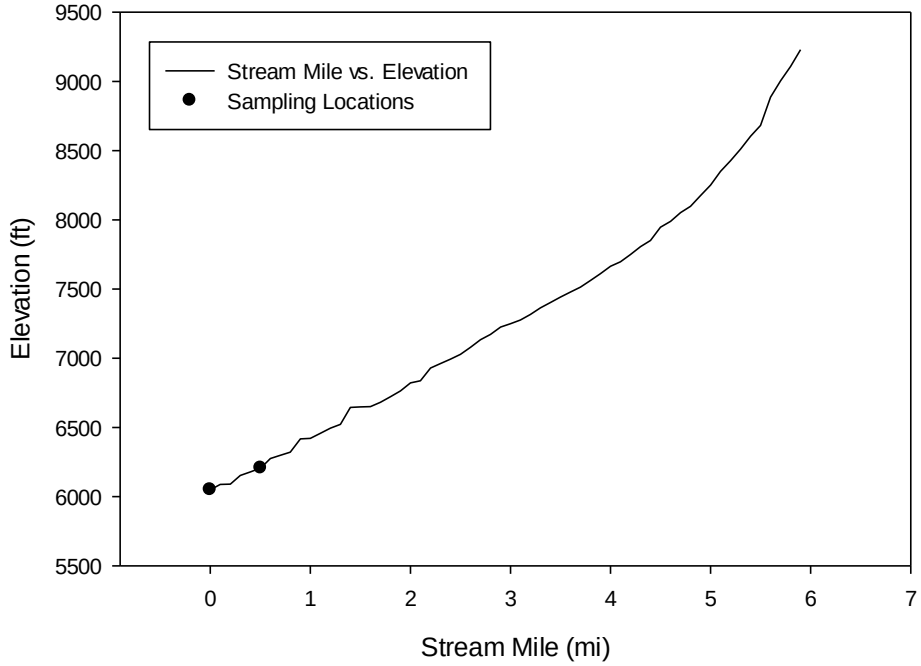
- Figure 8: A series of three boulder/bedrock cascades on Big Creek that appear to exclude nonnative fish from the upper watershed. Upper falls (top left and right). Middle Falls (bottom left). Lower falls (bottom right).

Cottonwood Creek

Cottonwood Creek is a tributary to Big Creek that enters from the northwest between Cliff and Bark Cabin Creeks and lies completely within Forest Service lands (Figure 3). Cottonwood Creek is six miles long and has two tributaries, North Fork and Middle Fork, which enter from the northwest. Two sections were sampled in Cottonwood Creek and no sampling was done in North or Middle Fork Cottonwood Creek (Table 2 and Figure 9).

• Table 2: Cottonwood Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
16489	100	100	53	0
16490	100	-	49.5	0



• Figure 9: Location of sampling locations on Cottonwood Creek in relation to stream elevation.

Section 16489 is relatively high in gradient with boulder/cobble substrate and some gravel. Riffle and run habitat is predominant with pools being less frequent. Two rainbow trout *Oncorhynchus mykiss* and two rainbow x Yellowstone cutthroat hybrid trout were captured (Appendix 3). Two additional fish were observed, but not captured in this section.

The Rosgen channel type for Section 16490 was a B3 with numerous LWD scour pools. B3 channels are moderate in gradient and have cobble substrate. The section had a dense spruce and alder canopy (Figure 10). A total of four rainbow trout were captured in this section (Appendix 4). Faint slashes were noted on the throat of some of the fish.

Due to time constraints, no electrofishing occurred upstream from Section 16490 and the upstream extent of fish distribution was not determined.

• Figure 10: Cottonwood Creek Section 16490 showing typical habitat conditions (left) and rainbow trout (right).

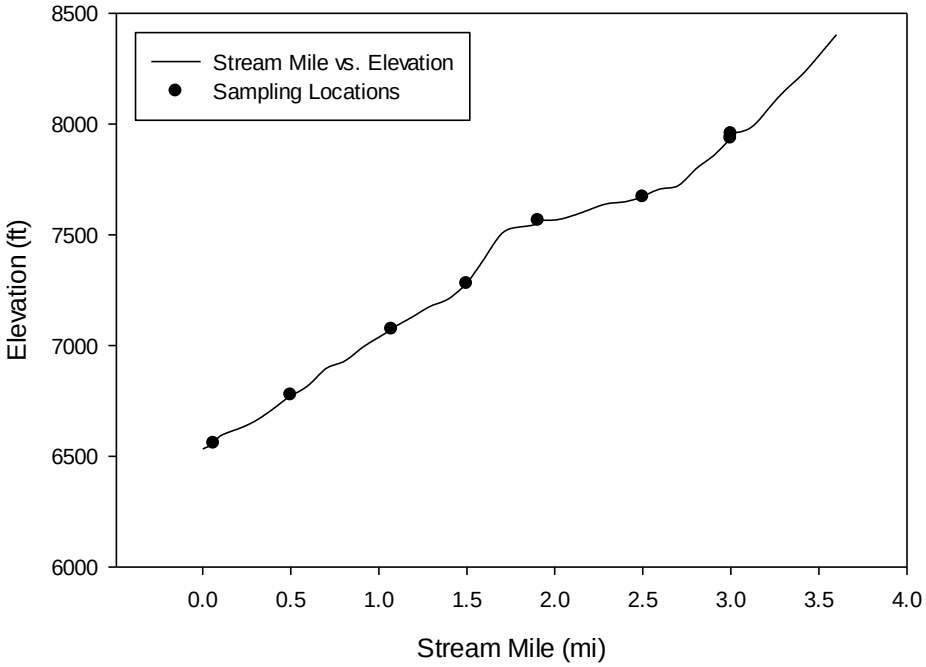
Bark Cabin Creek

Bark Cabin Creek is a 3.7 mile long tributary that enters Big Creek from the northwest, upstream of Cottonwood Creek. The entire stream lies within Forest Service lands (Figure 3).

On Bark Cabin Creek, a total of eight sections were sampled (Table 3 and Figure 11). In Section 11557 6 YCT and 3 potential rainbow x YCT hybrids were captured (Appendix 5). Section 11558 had good habitat and step pools. Nine YCT were captured in Section 11558 (Appendix 6). In section 11559, 4 YCT were captured and 17 YCT were captured in Section 11560 (Appendix 7 and Appendix 8). A potential barrier was noted at the upstream end of Section 11560 that consisted of cascades and small falls. YCT were present in sampled sections upstream from this point.

• Table 3: Bark Cabin Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
11557	100	3	54	6
11558	100	2	54	9
11559	100	1.5	51	4
11560	100	-	56	17
11561	100	2	51	21
11562	100	2	50	8
11563	100	2	54	0
11564	100	1	56	0



• Figure 11: Location of sampling locations on Bark Cabin Creek in relation to stream elevation.

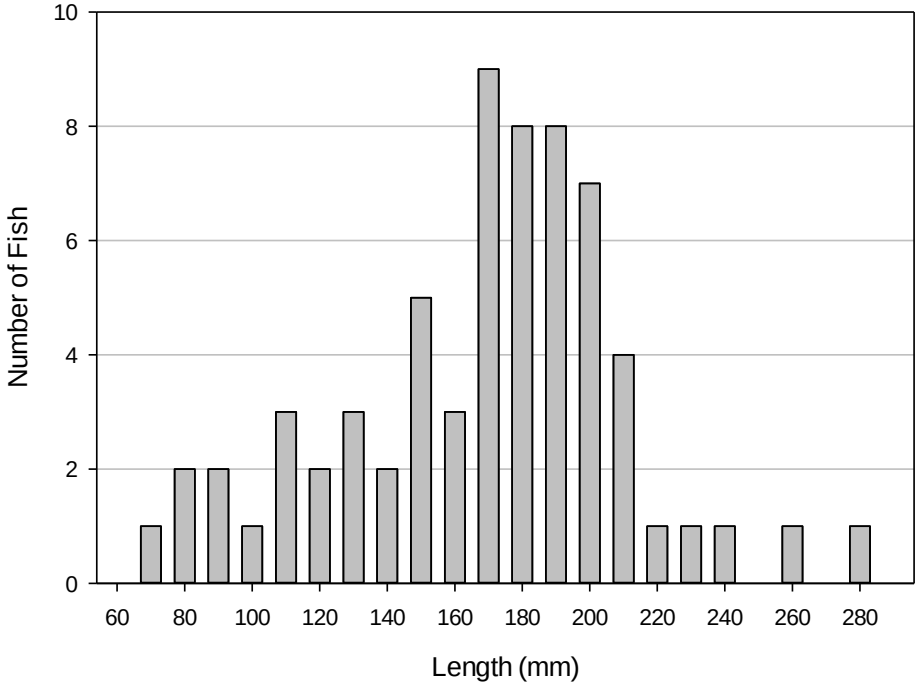
Section 11561 was located in a large alpine meadow with a meandering, low-gradient, gravel bottom channel characteristic of the Rosgen C4 channel type (Figure 12). Banks were stable and well vegetated with grasses, sedges, and willow and were undercut along much of the reach. The section was dominated by long pools separated by short, shallow riffles. There was little LWD in the section as would be expected in a montane meadow stream section. This section had the highest number of fish captured (n = 21) of all stream sections sampled in the Big Creek drainage in 2012 (Appendix 9). It was noteworthy that YCT captured here had very large spots (Figure 12).


- Figure 12: Bark Cabin Creek Section 11561 is located in a large alpine meadow. YCT captured in this section had very large spots.

Eight YCT were captured in Section 11562 (Appendix 10). A 10-foot vertical water fall barrier was located downstream of Section 11563 and appears to be the upstream limit of fish distribution in Bark Cabin Creek (Figure 13). Sections 11563 and 11564 both had steep, rocky Rosgen A2 channels and Section 11564 was located in an alpine meadow. Per the basin-wide survey protocol, no further sampling was completed on this stream do to the lack of fish in two consecutive sections (11563 and 11564).


- Figure 13: Distant and close up views of the Bark Cabin Creek barrier falls.

The length-frequency histogram for Yellowstone cutthroat trout captured in all sections of Bark Cabin Creek indicates that the highest frequency of fish was between 170 and 200 mm in total length (Figure 14). No obvious age classes for YCT were evident from the histogram.



• Figure 14: Length frequency distribution of YCT in all sections sampled in Bark Cabin Creek.

Genetic samples from sample sections 11557, 11558, 11559, 11560, and 11561were analyzed for hybridization. Initial analysis indicated genetic divergence between the samples and the lower three samples and the upper two samples were combined into two separate groups.

Results from the lower group indicated no detection of rainbow or westslope cutthroat trout alleles. All of the Yellowstone cutthroat trout alleles that were examined were characteristic of Yellowstone cutthroat trout with one exception. This could indicate a small amount of rainbow or westslope cutthroat trout hybridization or it could be a Yellowstone cutthroat trout polymorphism. Currently there is not enough data to distinguish between these possibilities. It was recommended that the lower portion of Bark Cabin Creek be managed as non-hybridized Yellowstone cutthroat trout (Leary 2013).

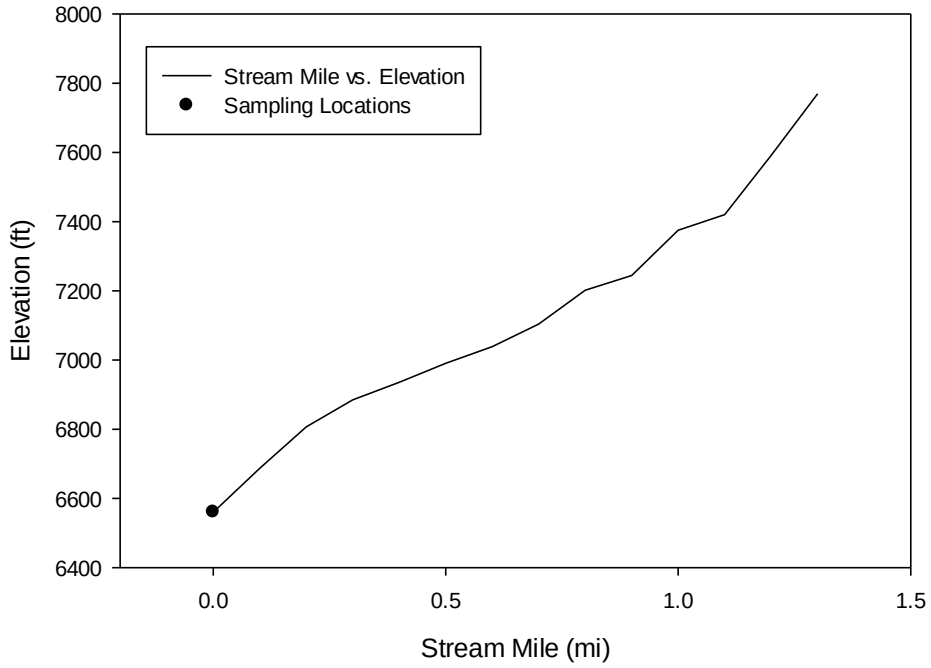
Genetic results for the upper group showed no presence of alleles for rainbow or westslope cutthroat trout and all of the markers for Yellowstone cutthroat trout were characteristic of Yellowstone cutthroat trout. These fish are non-hybridized Yellowstone cutthroat trout. With the sample size of 13 individuals there was a greater than 99% chance of detecting as little as 0.5% rainbow or westslope cutthroat trout genetic contribution (Leary 2013).

Little Bear Creek

In Little Bear Creek, only one section was sampled, Section 17825 (Table 4, Figure 3 and Figure 15). The section had very little flow and limited habitat suitable for fish. Only one YCT was captured in the section (Appendix 11).

• Table 4: Little Bear Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
17825	100	-	52	1



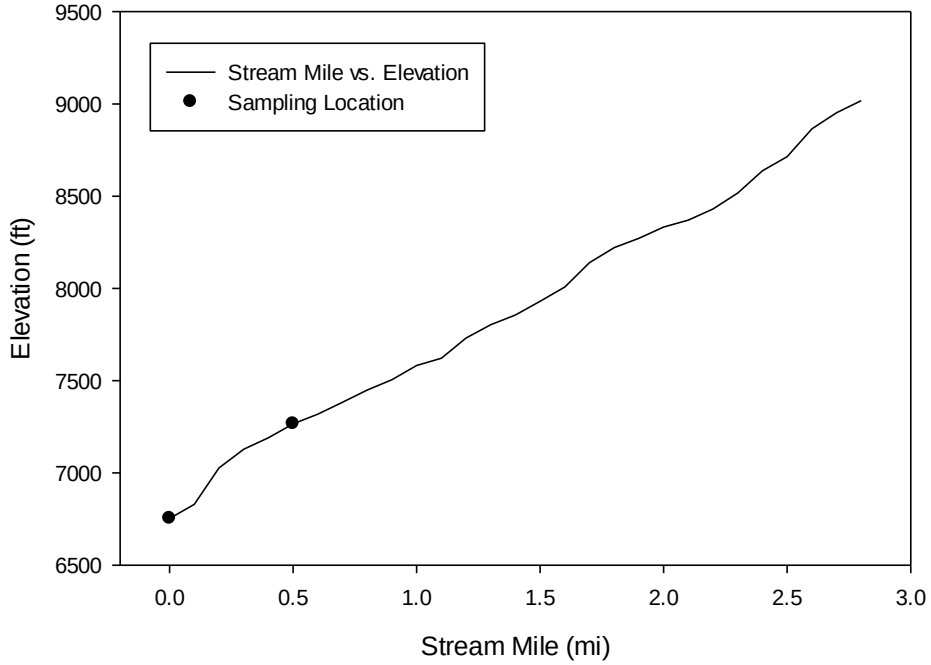
• Figure 15: Location of sampling locations on Little Bear Creek in relation to stream elevation.

Smokey Creek

Two sections were sampled in Smokey Creek (Table 5, Figure 3 and Figure 16). Two YCT were sampled in Section 16501 and no fish were found in Section 16502 (Appendix 12). There is a cascade in a canyon between these two sections and it likely precludes fish passage.

• Table 5: Smokey Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
16501	100	1.5	51	2
16502	100	2	49	0



• Figure 16: Location of sampling locations on Smokey Creek in relation to stream elevation.

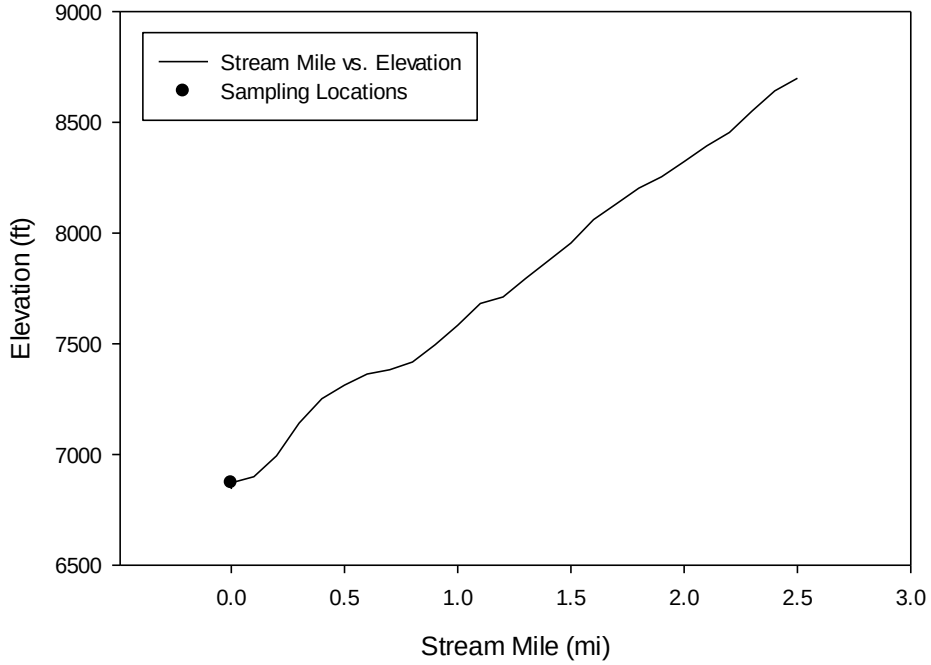
Bear Creek

Only one section, 16527, was sampled in Bear Creek (

Table 6, Figure 3 and Figure 17). This was a small stream with a high gradient cascade that likely precludes fish passage (Figure 18). No fish were captured in this section of Bear Creek.

• Table 6: Bear Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
16527	100	1.1	51	0



• Figure 17: Location of sampling locations on Bear Creek in relation to stream elevation.

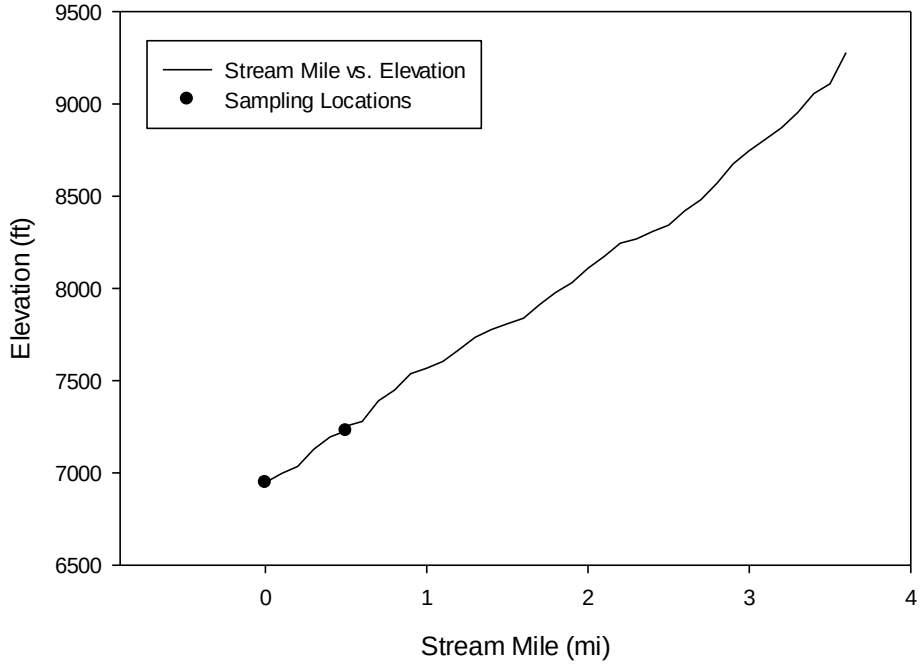
- Figure 18: A high gradient reach near the mouth (left) likely precludes fish passage into Bear Creek. Section16527 in Bear Creek (right).

4.7 Mist Creek

Two sections were sampled on Mist Creek (Table 7, Figure 3 and Figure 19). Section 16519 was 100 m long and had a Rosgen channel type of B3 (moderate gradient/cobble bottom). Section 16520 was 244 m long with Rosgen channel-type varying from A1 (steep bedrock), to B3 (moderate gradient/cobble bed), to D3 (moderate gradient of coarse depositional material) at the upper end of the reach where a landslide had occurred (Figure 20 and Figure 21). A total of two Yellowstone cutthroat trout were captured and two more were seen but not captured in Section 16519 (Appendix 13). No fish were captured in Section 16520 and no further sampling upstream, in Mist Creek occurred due to time and logistical constraints.

- Table 7: Mist Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
16519	100	-	48	2
16520	244	3.5	49	0



• Figure 19: Location of sampling locations on Mist Creek in relation to stream elevation.

- Figure 20: Example of Rosgen A2 (left) and Rosgen B3 (right) channels in Mist Creek Section 16520.

- Figure 21: The upper end of Mist Creek Section 15520 was impacted by a debris flow event that filled the channel with large cobble.

Results Mill Creek

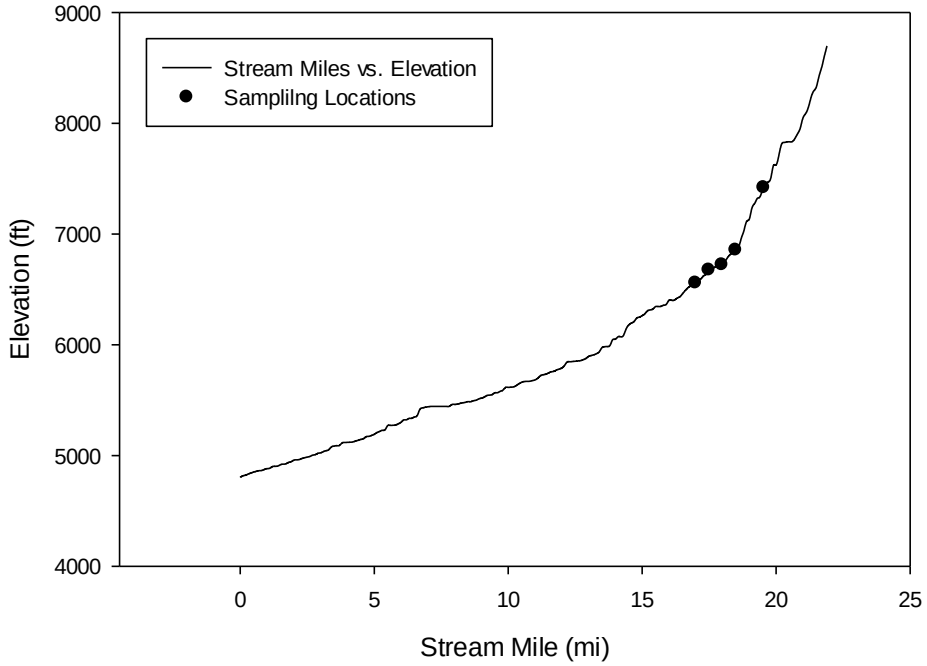
Mill Creek

In Mill Creek, five sections were sampled (Table 8, Figure 22, Figure 23, Appendix 14 and

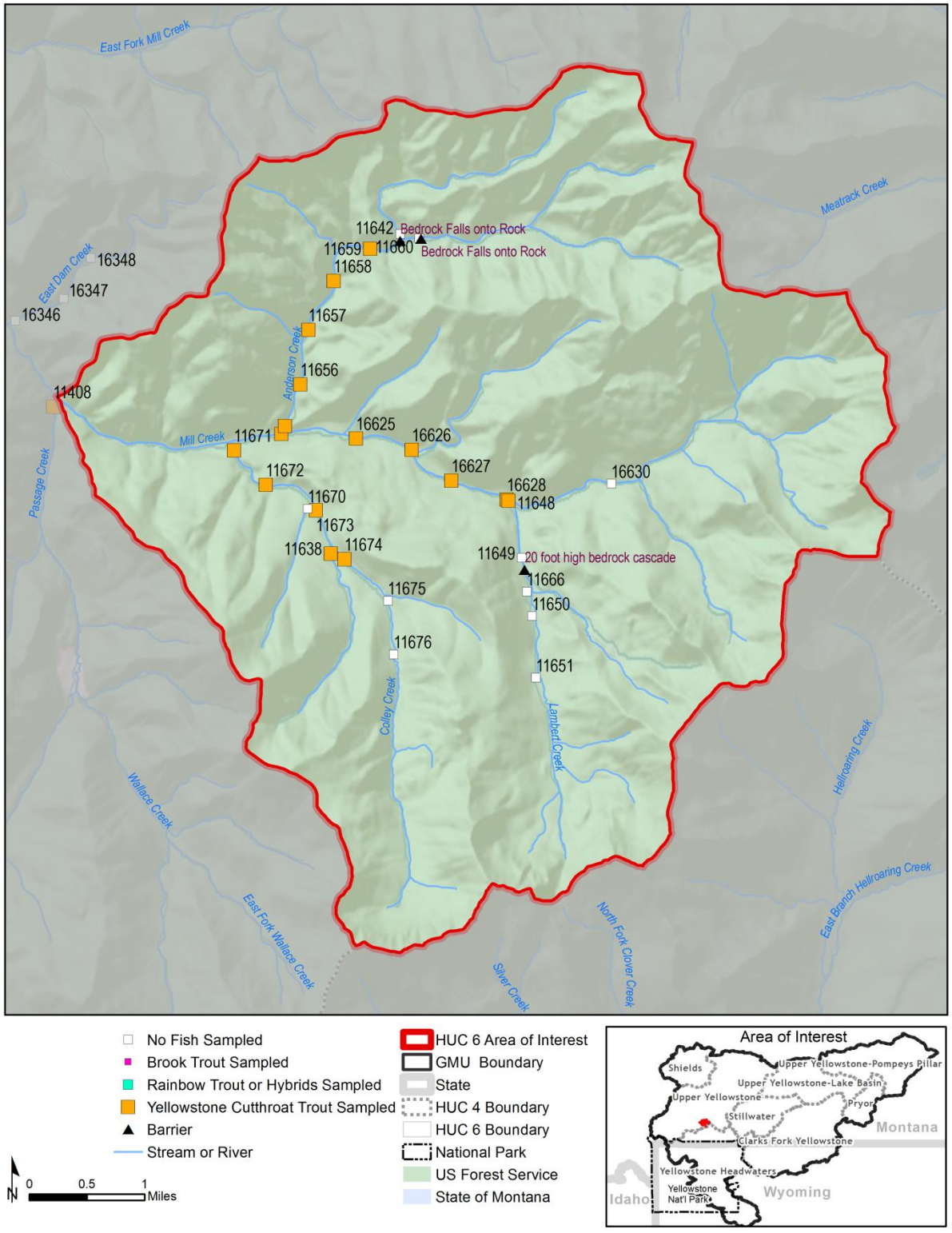
Appendix 15). Two backpack units were used simultaneously to sample all of the reaches in Mill Creek in order to increase capture efficiency. High stream gradient and step pool habitats were noted in the reaches that were sampled.

• Table 8: Mill Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
16625	100	-	47	11
16626	100	-	49	4
16627	100	5	50	3
16628	100	4	51	3
16630	100	-	55	0

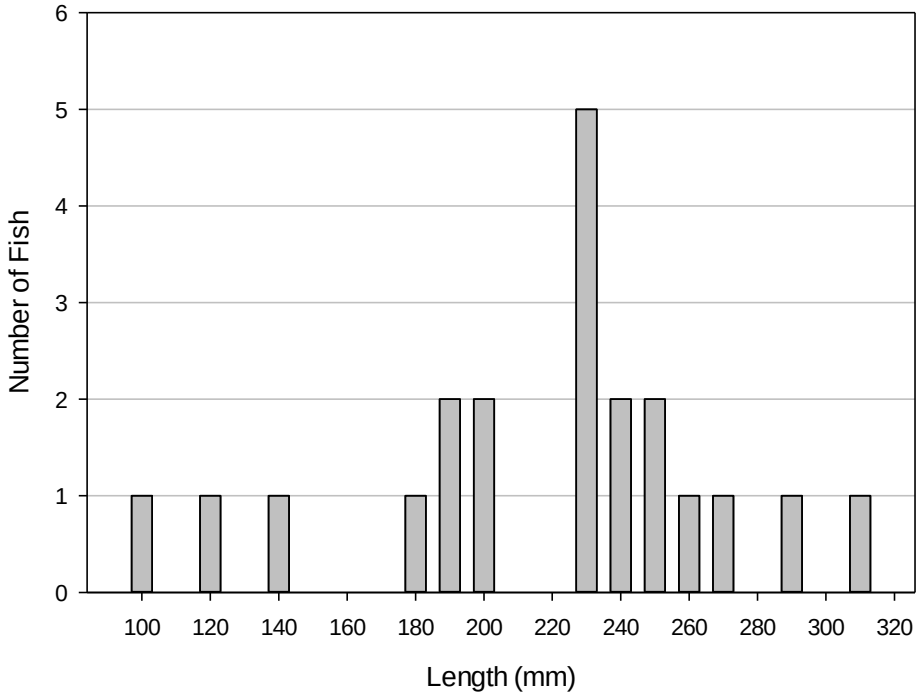


• Figure 22: Location of sampling locations on Mill Creek in relation to stream elevation.



• Figure 23: Mill Creek Basin sampling sections, species distribution, and barrier locations in 2012.

The length-frequency histogram for all YCT captured in all sampled sections of Mill Creek indicates a wide range of length groups varying from 100 to 310 mm (Figure 24). The peak frequency was in the 230 mm length group and no obvious age classes were noted.



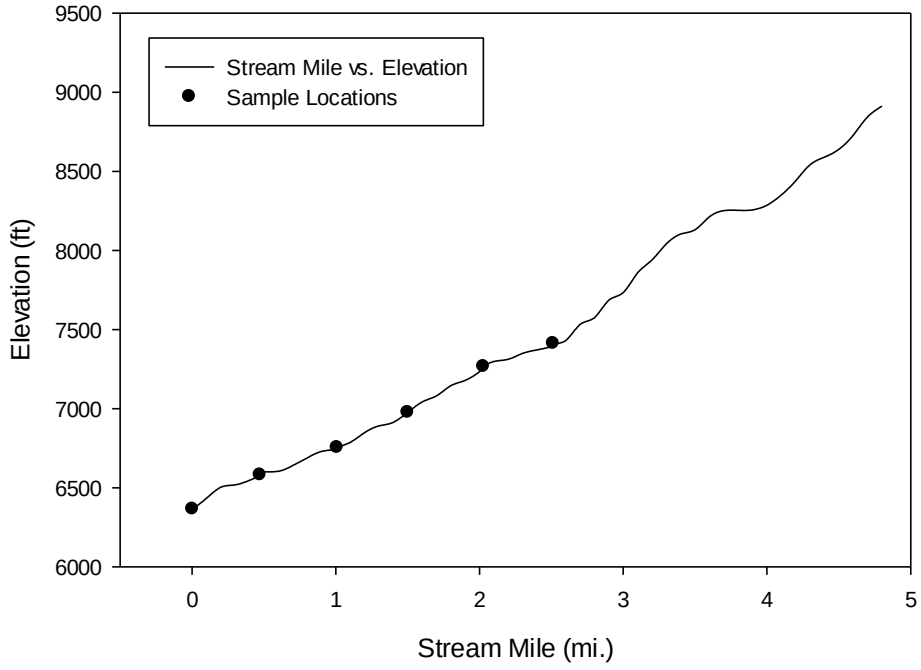
• Figure 24: Length frequency distribution of YCT in all sampled sections of Mill Creek.

Colley Creek

In Colley Creek, six sections were sampled in 2012 (Table 9, Figure 23 and Figure 25). Section 11671 was a high gradient reach with a Rosgen B2 channel type with large amounts of boulder and cobble. Section 11672 had a Rosgen channel type of B3 with some good pool habitat. Section 11673 had a high gradient and transitioned between a B2 and B3 channel type. This reach also had a large amount of woody debris and fallen trees. Section 11674 was a Rosgen B3 channel type that had good pool habitat and a lot of woody debris. Section 11675 was also a B3 channel type with a steep gradient. Section 11676 was a B4 channel type with a potential barrier located within the reach.

• Table 9: Colley Creek sample section details.

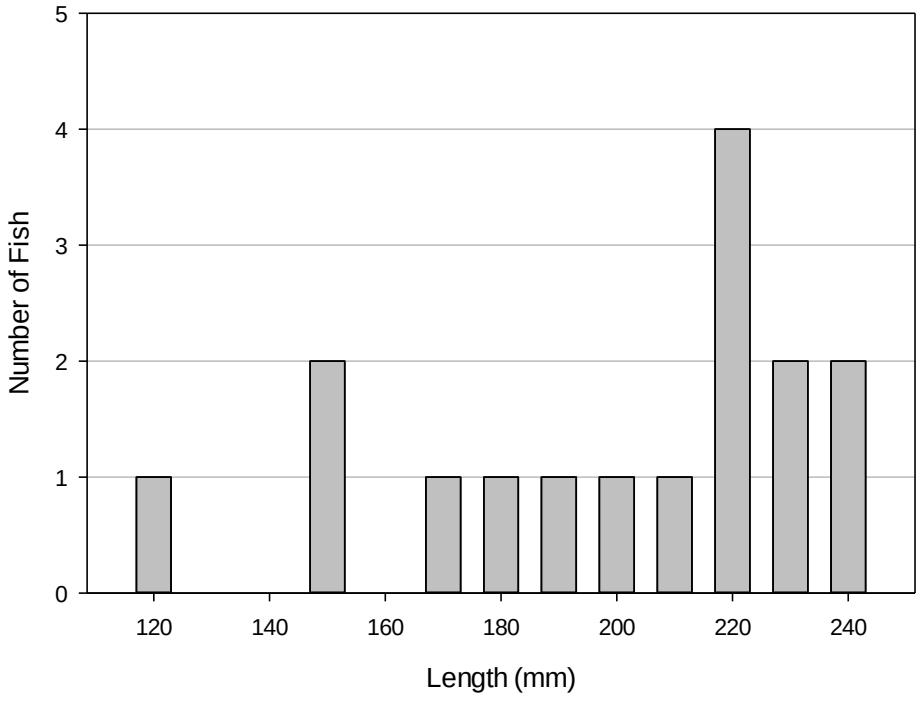
Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
11671	100	3.5	49	1
11672	100	2.5	50	6
11673	100	2.25	49	2
11674	100	2.1	50	8
11675	100	2	48	0
11676	100	1.7	50	0



• Figure 25: Location of sampling locations on Colley Creek in relation to stream elevation.

In Section 11671, one YCT was captured and one was observed but not captured (Appendix 16). A total of six YCT were captured in Section 11672. Two YCT were captured and two more were observed but not captured in Section 11673. In Section 11674, eight YCT were captured (Appendix 17).

The length-frequency histogram for Yellowstone cutthroat trout captured in all sections of Colley Creek indicates that the highest frequency of fish was between 220 and 240 mm in total length (Figure 26). No obvious age classes for YCT could be derived from the histogram.



• Figure 26: Length frequency distribution for YCT in all sampled sections of Colley Creek.

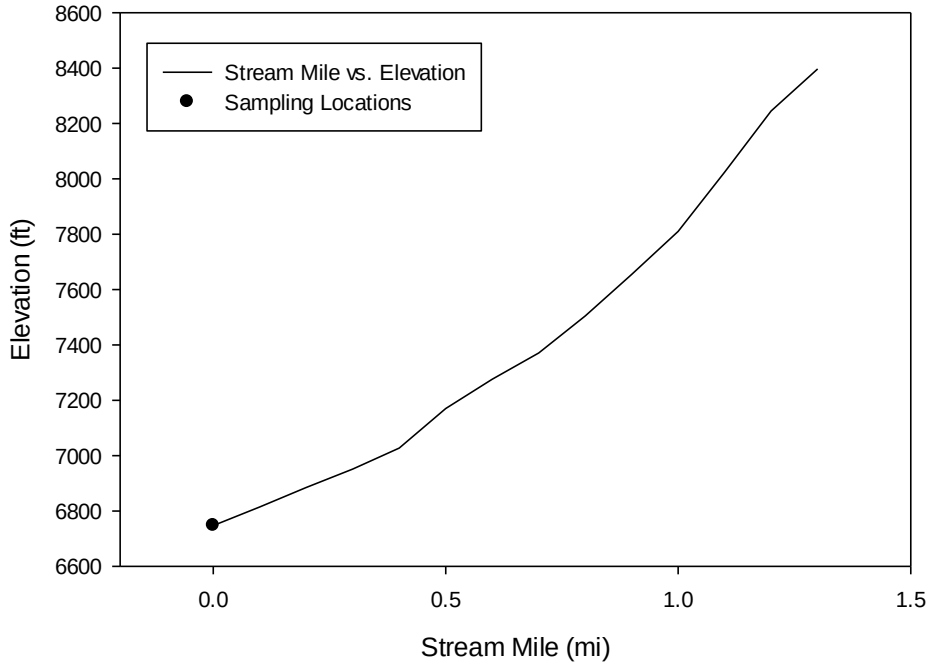
Lower Unnamed Tributary of Colley Creek

One section was sampled on an unnamed tributary of Colley Creek (Table 10, Figure 23 and Figure 27). Section 11638 was a Rosgen B3 channel type with dense riparian vegetation that made sampling difficult. Only one YCT was captured in this section (

Appendix 18).

• Table 10: Lower unnamed trib to Colley Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
11638	100	1.7	50	1



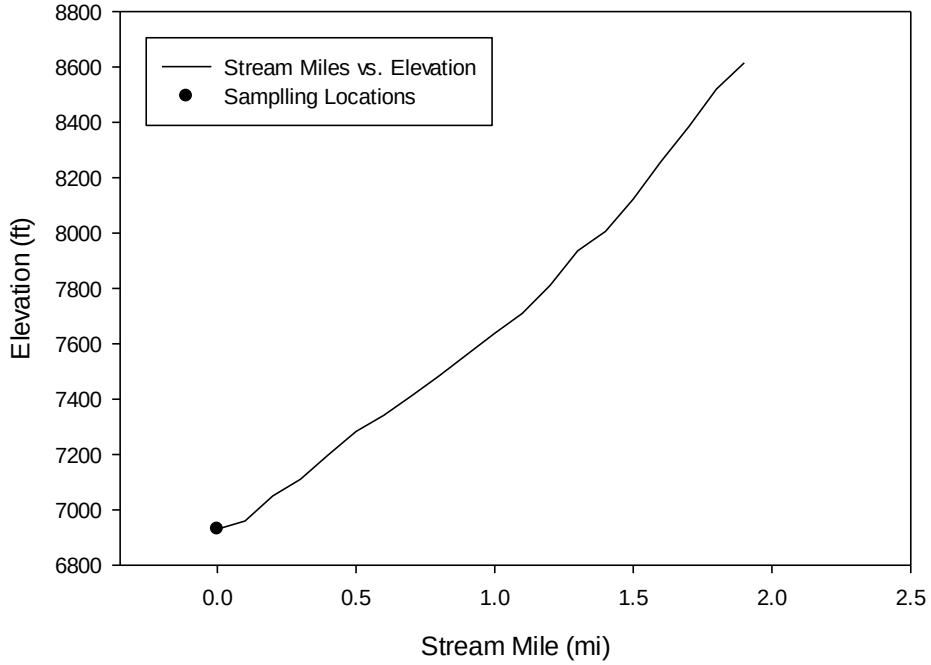
• Figure 27: Location of sampling location on lower unnamed tributary of Colley Creek in relation to stream elevation.

Upper Unnamed Tributary of Colley Creek

Section 11670 was the only section sampled in this Unnamed Tributary of Colley Creek and dense riparian vegetation limited sampling ability (Table 11, Figure 23 and Figure 28). This section had little water and limited habitat. No fish were sampled in Section 11670.

• Table 11: Upper unnamed tributary to Colley Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
11670	100	0.6	78	0



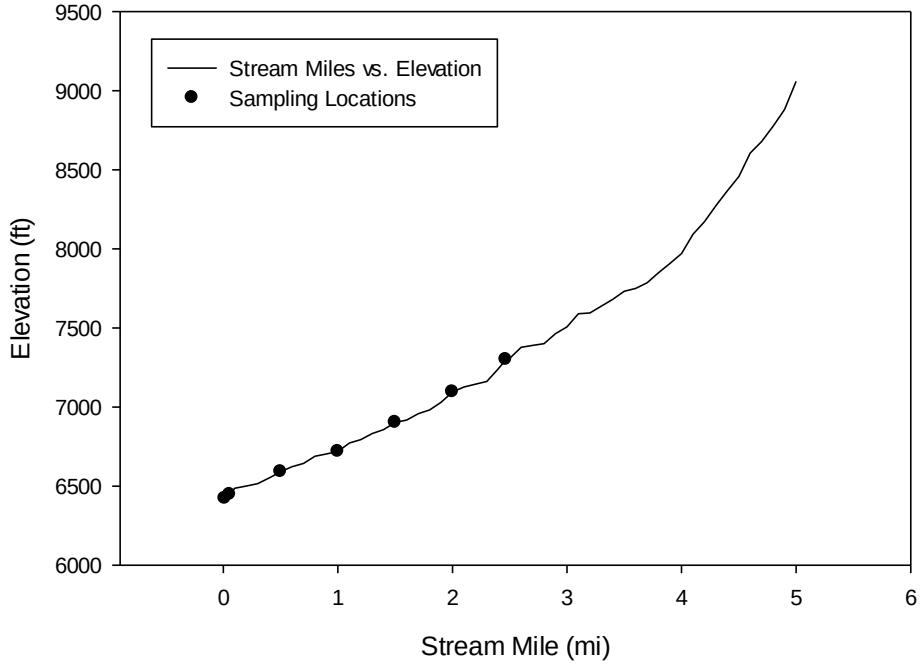
• Figure 28: Location of sampling location on upper unnamed tributary of Colley Creek in relation to stream elevation.

Anderson Creek

A total of seven sections were sampled in Anderson Creek (Table 12, Figure 23 and Figure 29). The two lowest sections, from the mouth to the bridge and above the bridge are long-term monitoring sections that were initiated by the Forest Service in 2003 to evaluate recovery of the YCT population from the 2006 Passage Fire and 2007 Wicked Fire which burned most of the drainage (USFS 2013).

• Table 12: Anderson Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
Mouth-bridge	50	3.5	57	19
Above bridge	95	4	52	32
11656	100	3	63	38
11657	100	3	65	26
11658	100	-	66	12
11659	100	4	-	21
11660	104	3	-	0



• Figure 29: Location of sampling locations on Anderson Creek in relation to stream elevation.

YCT were captured in all sections up through 11659 despite the presence of two post-fire debris flows (Figure 30, Appendix 19, Appendix 20,Appendix 21, Appendix 22,

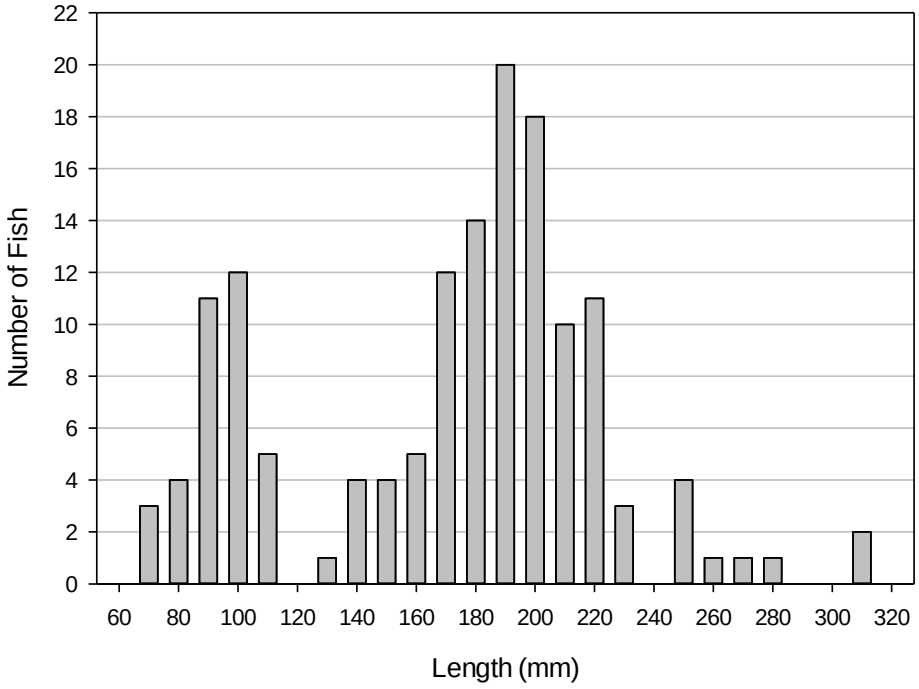
Appendix 23 and Appendix 24). A bedrock barrier cascade (Figure 31) located upstream from section 11659 precludes fish passage. As a result, no fish were captured upstream in section 11660. An attempt was made to reach section 11661 in adherence to the basin-wide protocol of sampling two successive fishless reaches. However, a 15-foot high waterfall was encountered in a steep narrow canyon and the crew was unable to proceed safely. Given the presence of both barriers, upstream fish presence was highly unlikely.

- Figure 30: Two post-fire landslides/debris flows looking downstream (left) and upstream (right) filled the Anderson Creek Channel with sand, cobble and large woody debris.

- Figure 31: A four-foot high waterfall at the base of a long cascade marks the uppermost distribution of fish in Anderson Creek.

Of all streams sampled in the Mill Creek drainage, Anderson Creek had the highest densities of fish (number captured per 100 meters). A total of 38 fish were captured in reach 11656. These relatively high densities likely reflect a post-fire increase in productivity from canopy removal and habitat complexity from accelerated LWD recruitment. The geology of the basin is also dominated by limestone which tends to promote productivity.

The length-frequency histogram of all YCT captured in all sections of Anderson Creek indicates a wide range of length groups with a peak frequency in the 190 mm length group (Figure 32). Distinct age-1(lengths 70-110 mm), age-2 (lengths 130-230 mm), and age-3+ (lengths 250-310 mm) year-classes are noted as well.



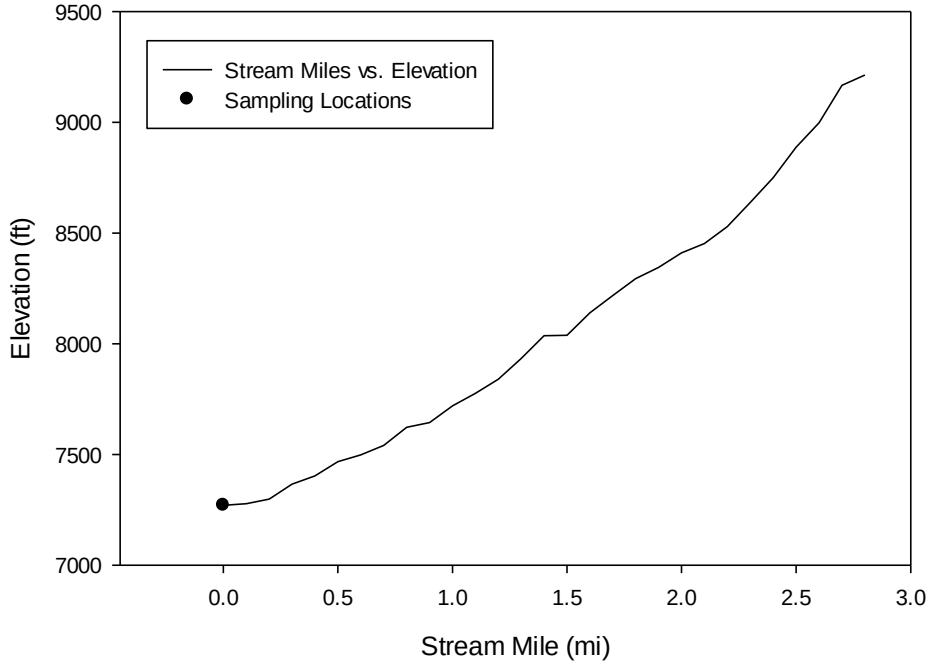
• Figure 32: Length frequency distribution of YCT in all sampled sections of Anderson Creek.

Unnamed Tributary of Anderson Creek

One section was sampled in the unnamed tributary of Anderson Creek and no fish were captured or observed (Table 13, Figure 23 and Figure 33). Water temperature (70ºF) may have limited ability to capture fish as well as habitat suitability for fish in this section.

• Table 13: Unnamed tributary of Anderson Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (ºF)	Yellowstone cutthroat captured
11642	100	1	70	0



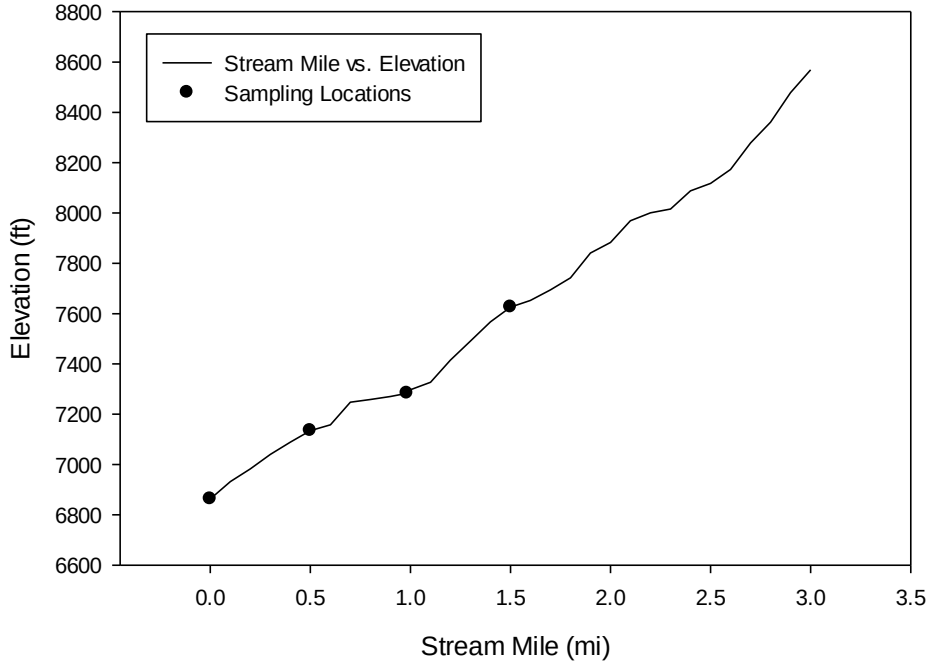
• Figure 33: Location of sampling location on unnamed tributary of Anderson Creek in relation to stream elevation.

Lambert Creek

Four sections were sampled in Lambert Creek (Table 14, Figure 23 and Figure 34). Two backpack units were used simultaneously in Section 11648 in order to increase sampling efficiency.

• Table 14: Lambert Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
11648	100	-	48	2
11649	100	4	55	0
11650	100	3	42	0
11651	100	2.7	-	0



• Figure 34: Location of sampling locations on Lambert Creek in relation to stream elevation.

Only two YCT were sampled in Section 11648 (Appendix 25). No fish were captured or observed in any of the other sections.

Section 11650 was a B4 Rosgen channel type with LWD pools. Section 11651 also had LWD pools and spawning gravel was noted as well (Figure 35). This section was deemed fishless as the result of a barrier (Figure 36Figure 36).

- Figure 35: Fish habitat in Lambert Creek upstream of the barrier is excellent due to its low gradient and abundant large woody debris pools.

- Figure 36: Lambert Creek barrier.

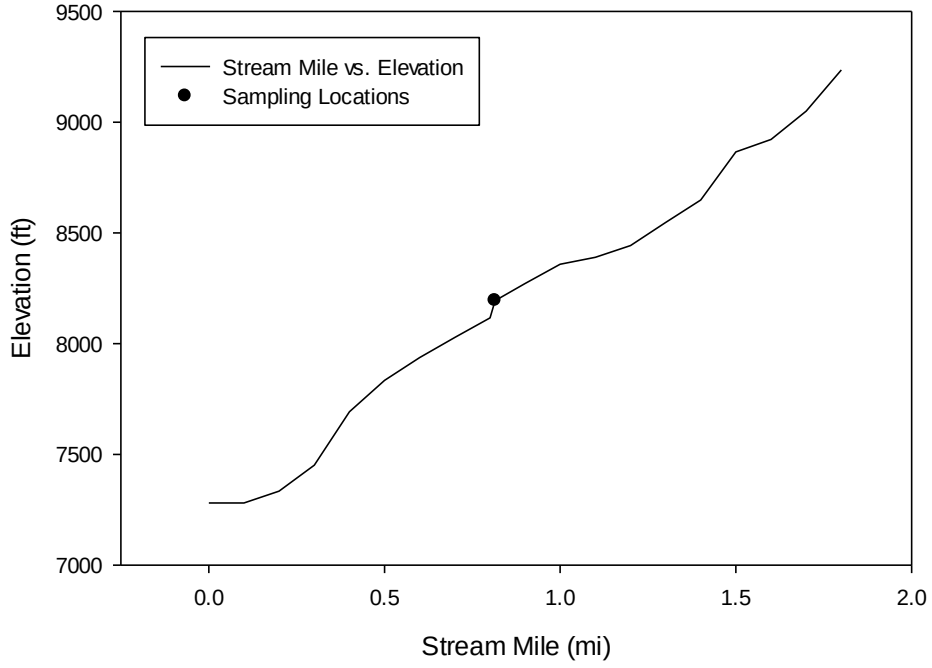
Additional work should be conducted to evaluate the extent of habitat suitability in Lambert Creek for introducing YCT upstream of the barrier falls. This would include collecting macroinvertebrate samples and temperature data and determining the uppermost extent of suitable habitat (perennial flow, deep pools, spawning gravel etc.).

Unnamed Tributary of Lambert Creek

One section was sampled in Unnamed Tributary of Lambert Creek (Table 15, Figure 23 and Figure 37). This tributary is located upstream of the barrier on Lambert Creek and no fish were captured or observed (Figure 36).

• Table 15: Unnamed Tributary of Lambert Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
11666	100	1.2	45	0



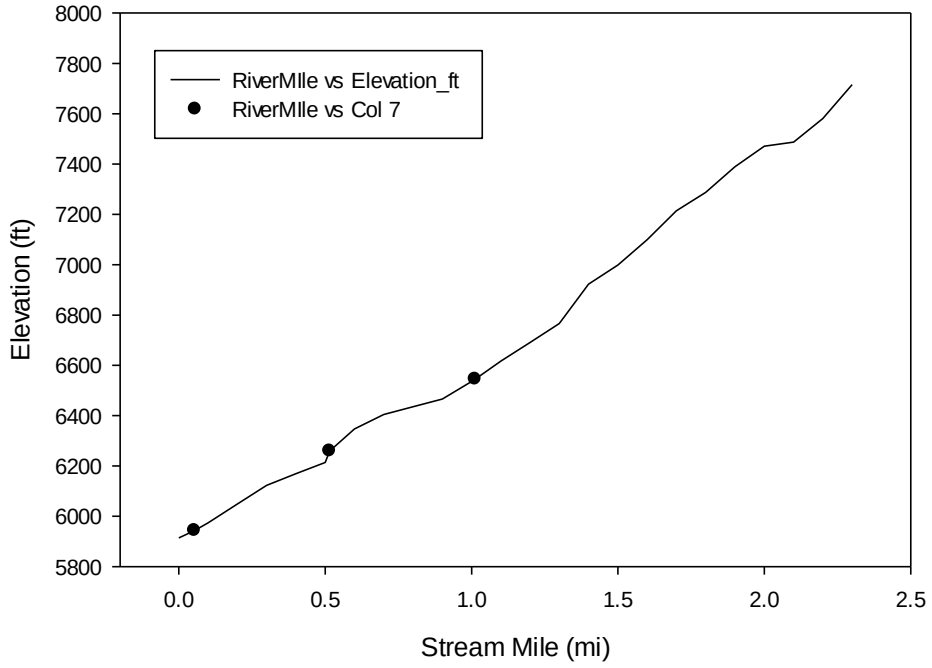
• Figure 37: Location of sampling locations on unnamed tributary to Lambert Creek in relation to stream elevation.

East Dam Creek

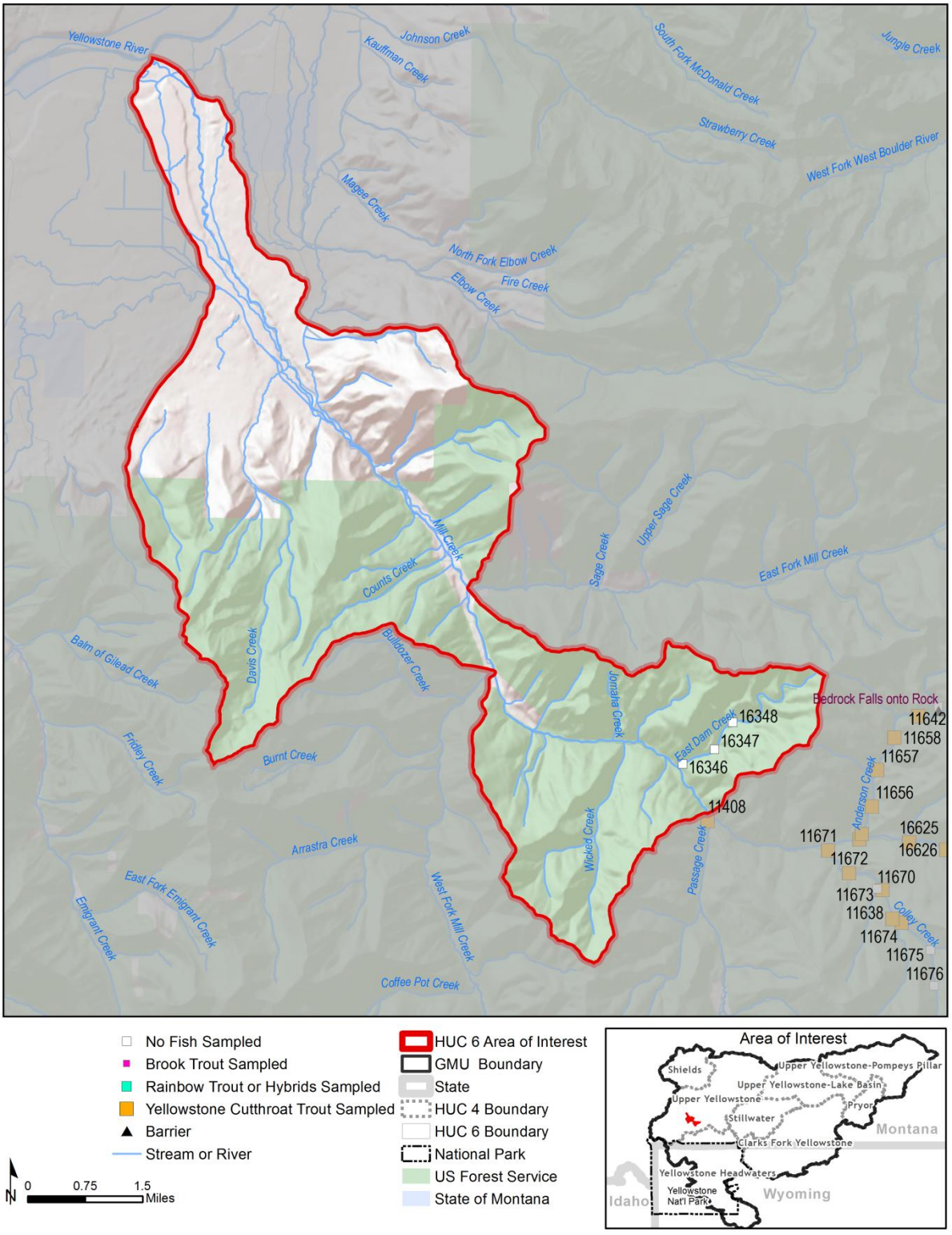
Three sections were sampled in East Dam Creek (Table 16, Figure 33 and Figure 38). Sections 16346 and 16347 were both 100 m in length. Section 16348 was 50 m in length as a result of the creek going sub surface upstream of this point (Figure 40). No fish were found in this stream. The lowest section, 16346 started upstream of the culvert that passes under Forest Service Road 486. The approximately 25 ft long culvert out flows to Mill Creek directly and is perched approximately 3 ft (Figure 40). As such, the culvert appears to serve as a barrier to fish passage from Mill Creek. An abandoned road with a perched culvert also crosses East Dam Creek between Section 16347 and 16348.

• Table 16: East Dam Creek sample section details.

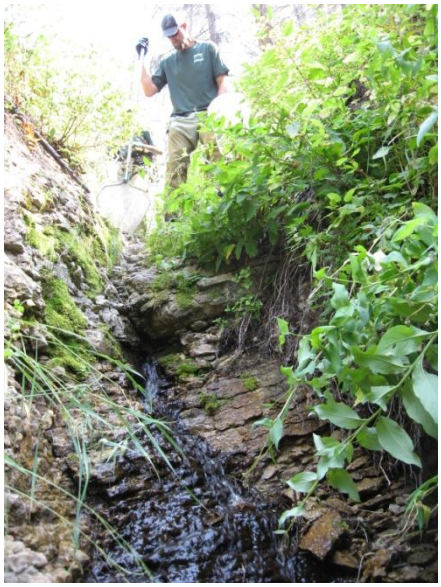
Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
16346	100	1	54	0
16347	100	1.1	51	0
16348	50	1	46	0

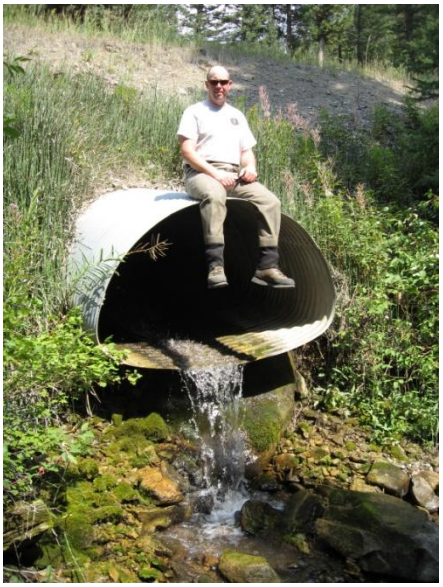


• Figure 38: Location of sampling locations on East Dam Creek in relation to stream elevation.



• Figure 39: East Dam Creek sampling locations.





- Figure 40: The point that East Dam Creek converts from subsurface to surface flow (left). East Dam Creek culvert under Forest Service Road 486 (right).

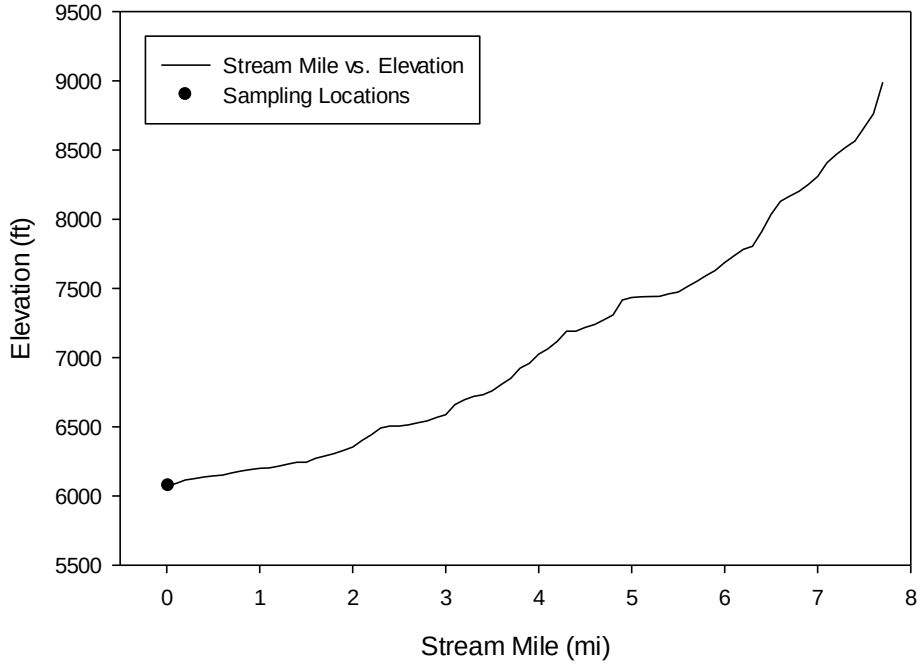
Passage Creek

Only one section was sampled in Passage Creek in 2012 (Table 17, Figure 41 and Figure 42). This section was located at the mouth of Passage Creek and was too wide for one backpack unit to be effective. As a result capture efficiency was very low. Three Yellowstone cutthroat trout were captured, and five more were observed but not captured (Appendix 26). More survey work will be completed on this stream in the future.

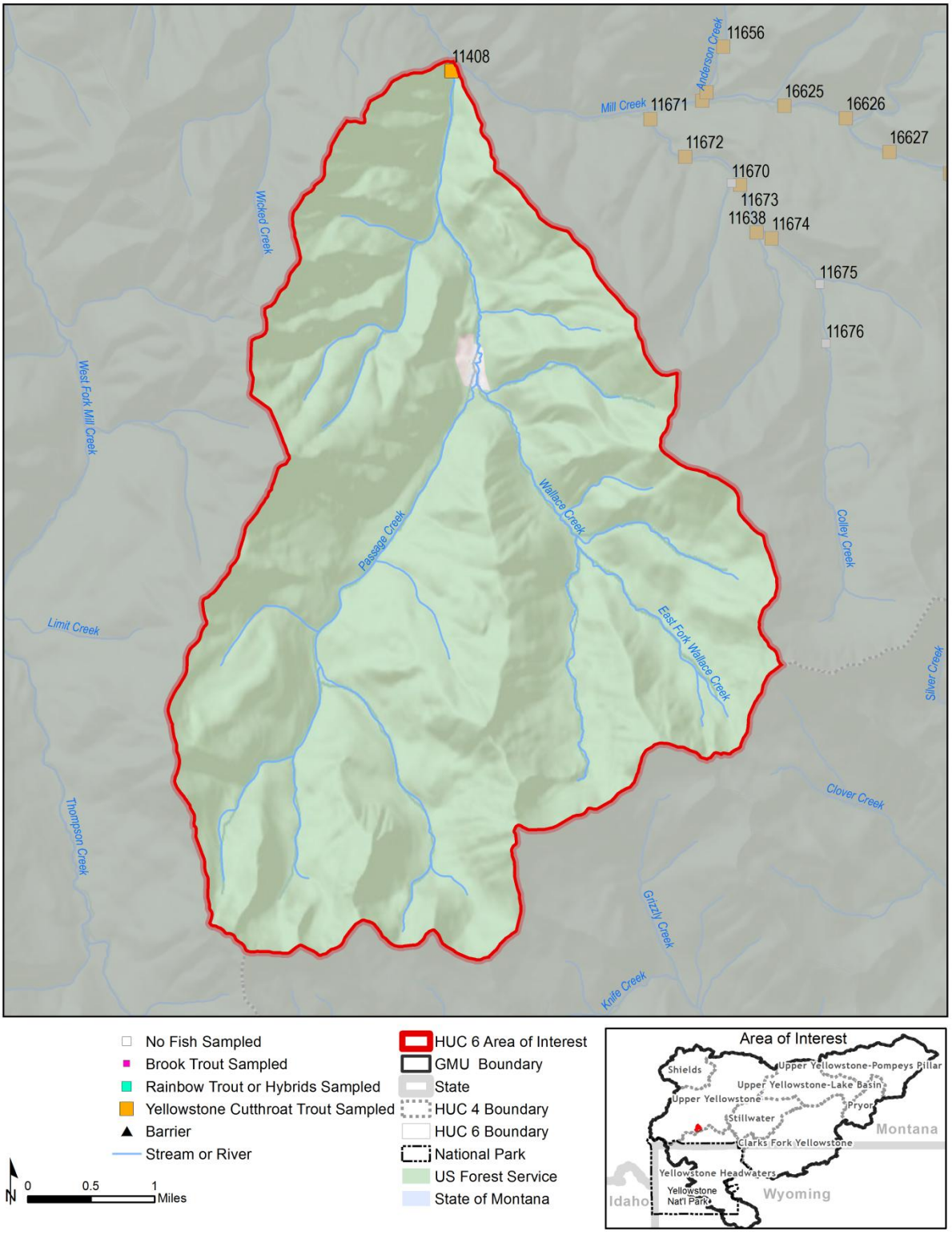
Passage Falls is a large multi-story waterfall that is a definite barrier to fish passage and is located approximately 2.5 miles upstream of the mouth (Figure 43).

- Table 17: Passage Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
11408	100	4.5	62	3



• Figure 41: Location of sampling locations on Passage Creek in relation to stream elevation.



• Figure 42: Passage Creek Sampling location and species in 2012.

• Figure 43: Passage Falls

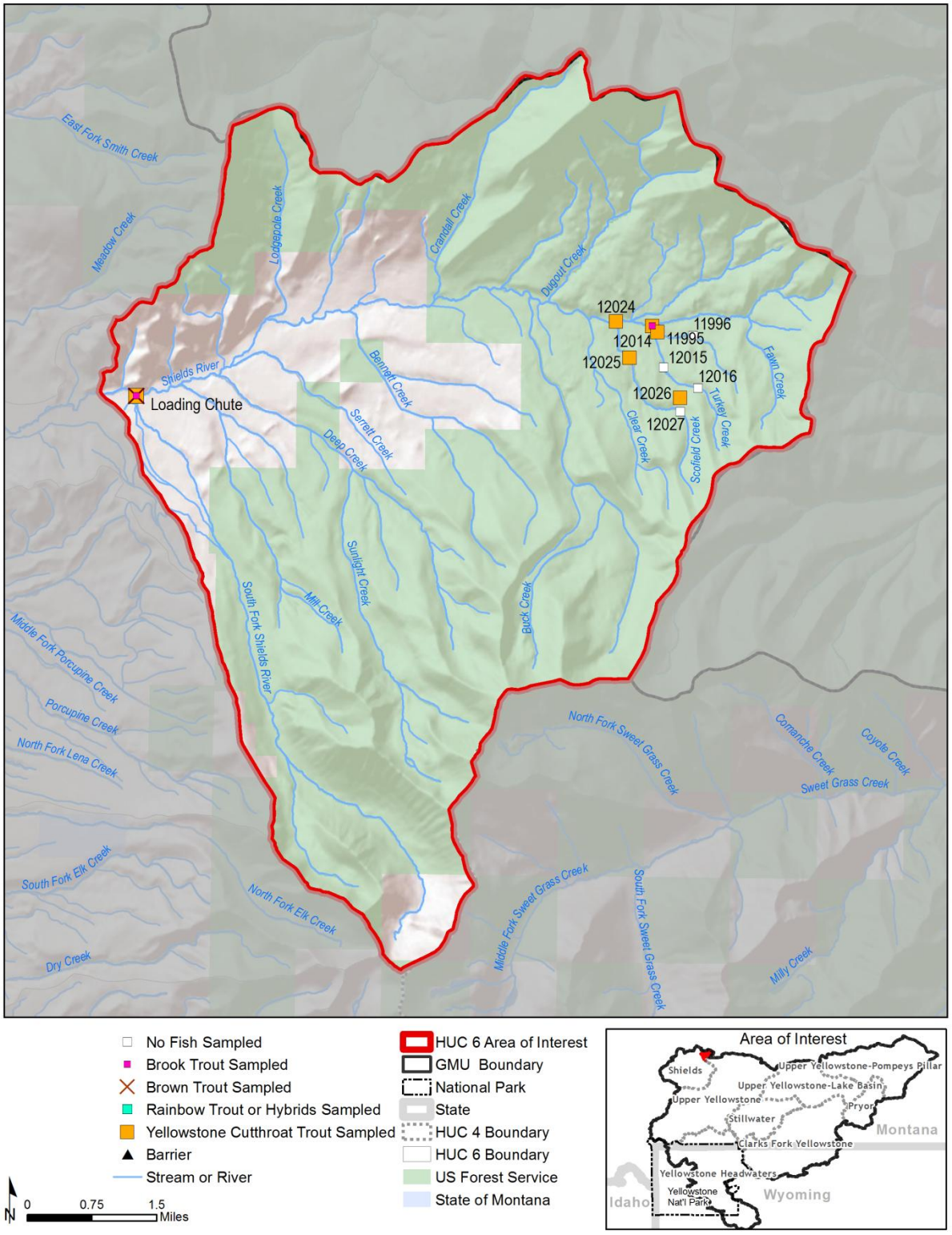
Results Upper Shields River Tributaries

Shields River

One section, Loading Chute, was sampled in the Shields River in 2012 (Table 18 and Figure 44).

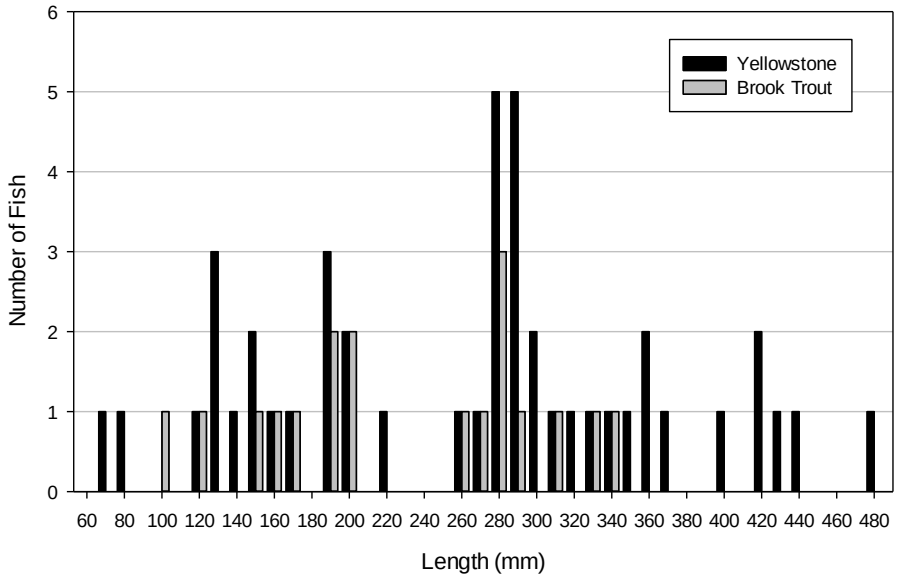
• Table 18: Loading Chute Section of the Shields River sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
Loading Chute	956.6	-	54-60	47



• Figure 44: Shields River Basin sampling sections and species distribution in 2012.

When plotted on a length-frequency histogram, YCT had a wider range of lengths sampled than brook trout (Figure 45, Appendix 27, and Appendix 28). YCT had an equal or higher frequency than brook trout for each length group with the exception of the 100 mm length group.



- Figure 45: Length-frequency distribution for Yellowstone cutthroat and brook trout sampled in the Loading Chute Section of the Shields River.

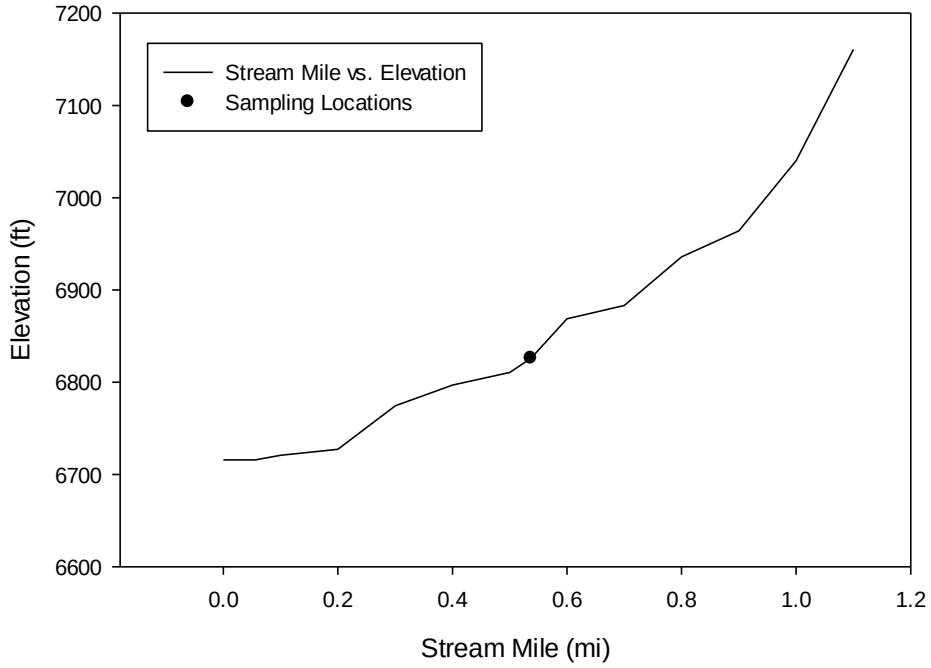
Unnamed Tributary of Shields River

Two sections were sampled in the Unnamed Tributary of Shields River (Table 19, Figure 44 and Figure 46). A total of eight YCT were captured in Section 11995 and no fish were observed in Section 11996 which contained a large amount of silt (

Appendix 29).

• Table 19: Unnamed tributary of the Shields River sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
11995	100	-	58	8
11996	100	-	54	0



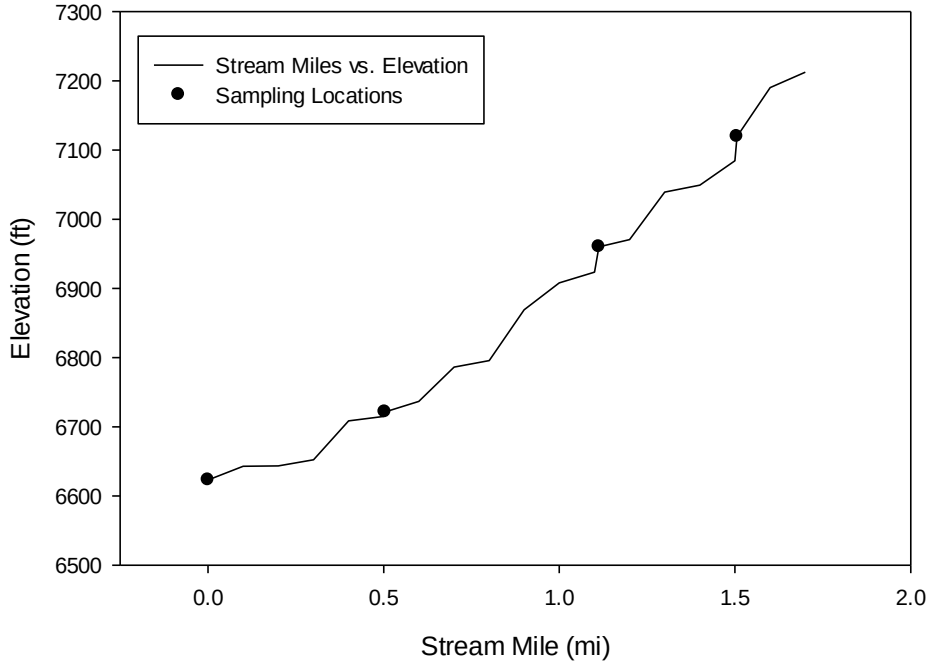
• Figure 46: Location of sampling location on unnamed tributary of Shields River in relation to stream elevation.

Scofield Creek

In 2012, four sections were sampled in Scofield Creek (Table 20, Figure 44 and Figure 47). Sections 12025, 12026, and 12027 were the same as sections that had been sampled in 2009.

• Table 20: Scofield Creek sample section details.

Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (°F)	Yellowstone cutthroat captured
12024	100	-	58	10
12025	100	1.4	58	21
12026	100	1.4	51	1
12027	100	0.5	48	0

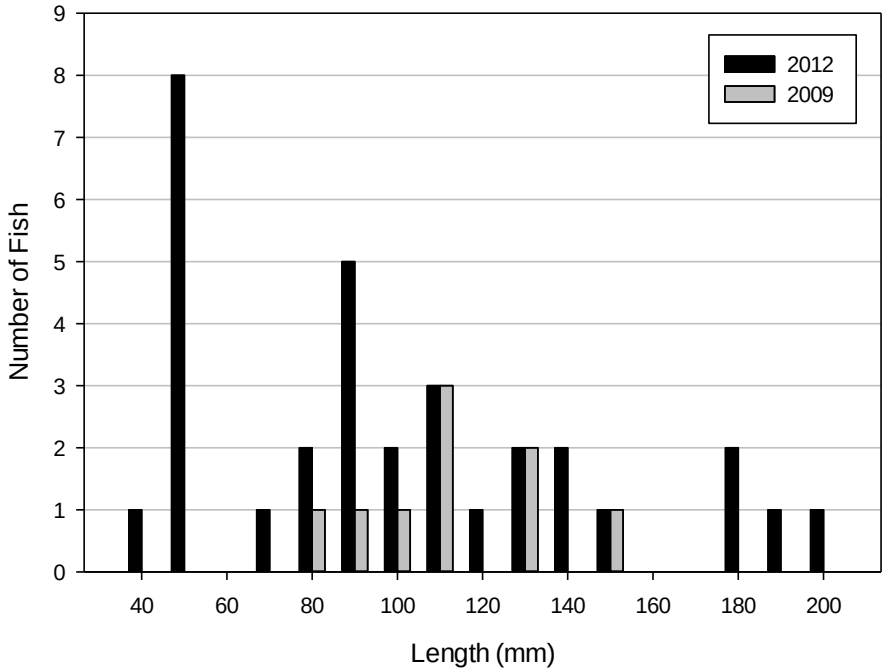


• Figure 47: Location of sampling locations on Scofield Creek in relation to stream elevation.

In 2012, a total of 10 YCT were sampled in Section 12024 (Appendix 30). This section had not been sampled previously. In 2009, seven YCT and one brook trout were captured in Section 12025. The number of YCT captured in this section increased to 21, in 2012, and no brook trout were captured (Appendix 31). No fish were captured or observed in Section 12026 in 2009 and one YCT was captured in 2012 (

Appendix 32). No fish were seen or observed in Section 12027 in 2009 or 2012.

The length-frequency histogram of YCT from all sampled sections in Scofield Creek in 2009 and 2012 indicates a wider range of length groups in 2012 (Figure 48). Length groups that YCT appeared in, for both 2009 and 2012, had similar frequencies. YCT in the 50 mm range had the highest frequency in 2012 and comprise most of the age-1 year class.



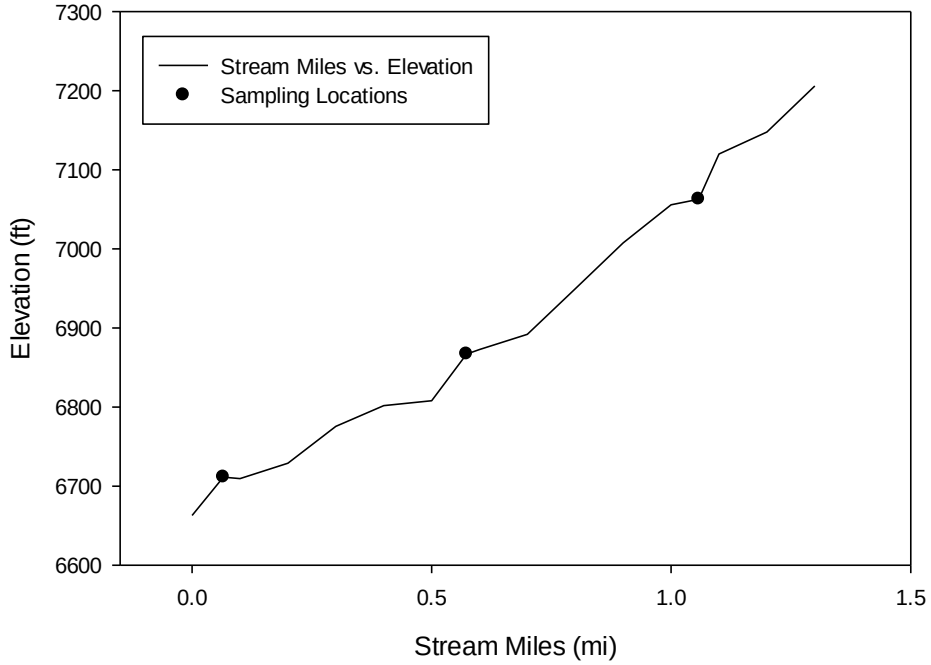
• Figure 48: Length-frequency distribution of YCT in all sampled sections of Scofield Creek in 2009 and 2012.

Turkey Creek

In 2012, three sections were sampled in Turkey Creek (Table 21, Figure 44 and Figure 49). Sections 12015 and 12016 were sampled in 2009 as well as 2012. An additional section, immediately below Section 12015 and the Forest Service road culvert, was sampled only in 2009.

• Table 21: Turkey Creek sample section details.

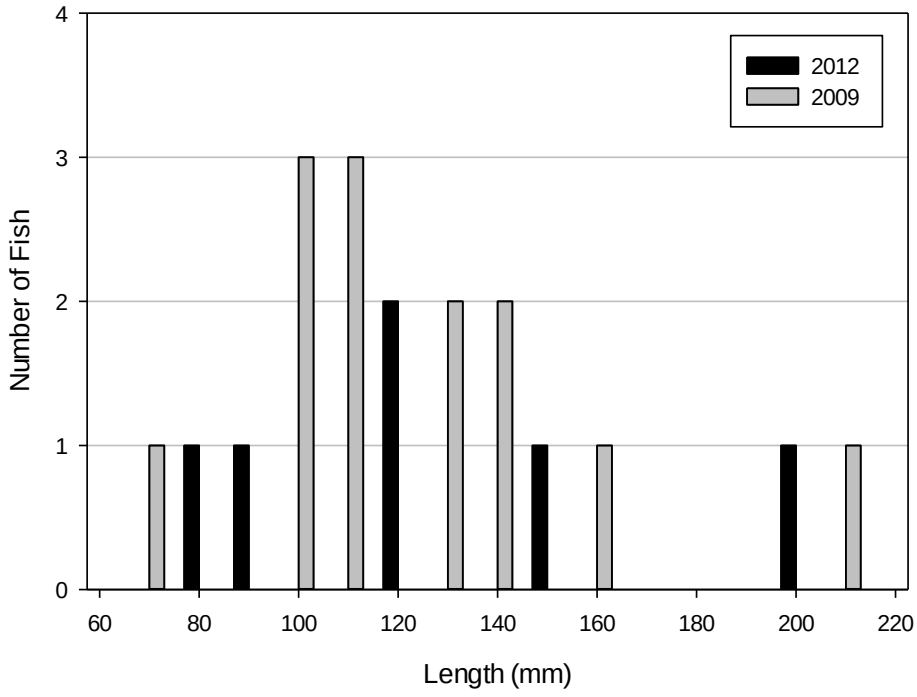
Section #	Section Length (m)	Average Stream Width (m)	Water Temperature (^{o}F)	Yellowstone cutthroat captured
12014	100	-	58	6
12015	100	-	52	0
12016	100	-	49	0



• Figure 49: Location of sampling locations on Turkey Creek in relation to stream elevation.

In 2012, six YCT and one brook trout were sampled in Section 12014 (Appendix 33). A total of seven YCT were sampled below the forest service road culvert and Section 12015 in 2009. In Section 12015, six YCT were captured in 2009 and no fish were observed in 2012. No fish were sampled in Section 12016 in either 2009 or 2012.

The length-frequency distribution for YCT captured in all sections of Turkey Creek is presented below (Figure 50). The limited amount of data did not allow for identification of age classes.



• Figure 50: Length-frequency distribution of YCT in all sampled sections of Turkey Creek in 2009 and 2012.

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Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

Appendix

- Appendix 1: Yellowstone cutthroat trout lengths and weights for Sections 2 and 11547 in Big Creek.

Section 2		Section 11547	
Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)
136	27	153	34
200	88	168	46
203	77	174	55
204	90	187	61
219	111	198	72
219	107	204	94
233	150	231	120
247	171		

- Appendix 2: Yellowstone cutthroat trout lengths and weights for Section 11548 in Big Creek.

Section 11548	
Yellowstone cutthroat	
Length (mm)	Weight (g)
100	4

- Appendix 3: Rainbow and hybrid lengths and weights for Section 16489 in Cottonwood Creek.

Section 16489			
Rainbow Trout		Hybrid	
Length (mm)	Weight (g)	Length (mm)	Weight (g)
191	88	131	21
232	140	215	127

- Appendix 4: Rainbow trout lengths and weights for Section 16490 in Cottonwood Creek.

Section 16490	
Rainbow Trout	
Length (mm)	**Weight (g)**
133	20
172	68
183	62
197	130

- Appendix 5: Yellowstone cutthroat and hybrid lengths and weights for Section 11557 in Bark Cabin Creek.

Section 11557			
Yellowstone cutthroat		**Hybrid**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
102	5	159	35
115	10	206	80
181	56	211	70
200	80		
205	90		
264	190		

- Appendix 6: Yellowstone cutthroat lengths and weights for Section 11558 in Bark Cabin Creek.

Section 11558			
Yellowstone cutthroat			
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
112	13	188	61
114	13	189	59
147	29	191	67
170	55	245	136
174	50		

- Appendix 7: Yellowstone cutthroat lengths and weights for Section 11559 in Bark Cabin Creek.

Section 11559	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
70	7
124	12
174	66
200	93

- Appendix 8: Yellowstone cutthroat lengths and weights for Section 11560 in Bark Cabin Creek.

Section 11560			
Yellowstone cutthroat			
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
129	20	177	42
132	18	180	41
135	23	184	53
145	26	196	70
150	31	197	61
154	32	202	75
164	37	206	93
168	44	220	92
175	48		

- Appendix 9: Yellowstone cutthroat lengths and weights for Section 11561 in Bark Cabin Creek.

Section 11561			
Yellowstone cutthroat			
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
85	2	181	55
86	2	182	50
95	3	186	49
98	4	192	51
135	12	195	59
150	25	198	71
152	28	199	71
157	18	205	75
175	48	210	82
176	48	215	90
178	52		

- Appendix 10: Yellowstone cutthroat lengths and weights for Section 11562 in Bark Cabin Creek.

Section 11562			
Yellowstone cutthroat			
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
167	40	224	96
175	43	225	97
191	59	230	93
203	70	280	196

- Appendix 11: Yellowstone cutthroat length and weight for Section 17825 in Little Bear Creek.

Section 17825	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
80	8

- Appendix 12: Yellowstone cutthroat lengths and weights for Section 16501 in Smokey Creek.

Section 16501	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
190	75
195	76

- Appendix 13: Yellowstone cutthroat trout lengths and weights for Section 16519 in Mist Creek.

Section 16519	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
190	70
224	100

- Appendix 14: Yellowstone cutthroat trout lengths and weights for Section 16625 in Mill Creek.

Section 16625			
Yellowstone cutthroat		**Yellowstone cutthroat**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
107	14	237	168
122	20	240	154
140	35	271	2560
199	90	292	287
201	91	315	360
236	151		

- Appendix 15: Yellowstone cutthroat trout lengths and weights for Sections 16626, 16627, and 16628 in Mill Creek.

Section 16626		Section 16627		Section 16628	
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
204	103	185	76	196	91
234	139	233	145	230	142
253	209	256	192	244	174
266	232				

- Appendix 16: Yellowstone cutthroat trout lengths and weights for Sections 11671, 11672, and 11673 in Colley Creek.

Section 11671		Section 11672		Section 11673	
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
209	92	118	18	157	40
		150	30	234	143
		189	72		
		228	128		
		241	151		
		248	165		

- Appendix 17: Yellowstone cutthroat trout lengths and weights for Section 11674 in Colley Creek.

Section 11674	
Yellowstone cutthroat	
Length (mm)	Weight (g)
171	57
194	81
201	86
220	121
221	128
222	130
229	128
238	157

- Appendix 18: Yellowstone cutthroat trout length and weight for Section 11683 in Unnamed Trib of Colley Creek.

Section 11638	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
211	110

- Appendix 19: Yellowstone cutthroat trout lengths and weights for the Mouth-Bridge Section in Anderson Creek.

Mouth-Bridge			
Yellowstone cutthroat		**Yellowstone cutthroat**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
83	6	110	15
87	7	113	17
90	10	145	33
92	7	160	43
101	11	180	63
101	11	198	83
102	12	205	97
103	16	208	93
103	11	226	130
107	13		

- Appendix 20: Yellowstone cutthroat trout lengths and weights for Above Bridge Section in Anderson Creek.

Above Bridge					
Yellowstone cutthroat		**Yellowstone cutthroat**		**Yellowstone cutthroat**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**	**Length (mm)**	**Weight (g)**
88	2	107	6	192	86
88	2	112	12	193	75
93	3	113	12	195	95
95	3	115	10	198	79
95	5	154	39	207	100
98	4	160	36	221	125
99	4	170	45	235	147
100	4	177	55	236	154
103	6	178	56		
104	5	178	60		
105	6	180	60		
105	7	190	75		

• Appendix 21: Yellowstone cutthroat trout lengths and weights for Section 11656 in Anderson Creek.

Section 11656					
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
95	8	191	80	214	114
97	10	196	87	215	113
97	11	196	82	221	122
174	54	197	88	223	122
174	65	201	93	223	137
175	64	201	94	225	103
179	63	204	96	225	108
181	71	206	96	226	135
182	73	206	95	229	157
183	69	207	101	261	186
185	70	210	112	277	237
186	70	211	120	283	258
189	75	212	133		

• Appendix 22: Yellowstone cutthroat trout lengths and weights for Section 11657 in Anderson Creek.

Section 11657					
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
149	41	190	76	209	105
158	44	191	79	212	115
166	49	192	77	213	106
172	54	194	91	217	117
174	61	199	95	227	144
187	89	200	104	230	152
187	82	200	96	252	150
188	76	201	97	315	312
190	87	202	106		

• Appendix 23: Yellowstone cutthroat trout lengths and weights for Section 11658 in Anderson Creek.

Section 11658			
Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)
91	8	185	78
152	37	193	91
154	41	199	90
163	52	207	113
171	62	213	111
183	75	314	352

• Appendix 24: Yellowstone cutthroat trout lengths and weights for Section 11658 in Anderson Creek.

Section 11659					
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
71	-	155	-	202	-
71	-	163	-	204	-
72	-	170	-	212	-
131	-	184	-	228	-
142	-	198	-	250	-
143	-	198	-	250	-
146	-	200	-	250	-

• Appendix 25: Yellowstone cutthroat trout lengths and weights for Section 11648 in Lambert Creek.

Section 11648	
Yellowstone cutthroat	
Length (mm)	Weight (g)
210	101
233	154

• Appendix 26: Yellowstone cutthroat trout lengths and weights for the Section in Passage Creek.

Section 11408	
Yellowstone cutthroat	
Length (mm)	Weight (g)
127	22
144	33
214	121

• Appendix 27: Yellowstone cutthroat trout lengths and weights for the Loading Chute Section on the Shields River.

Loading Chute Section					
Yellowstone cutthroat		Yellowstone cutthroat		Yellowstone cutthroat	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
77	4	207	105	309	338
80	4	227	150	310	386
101	11	267	218	324	415
123	21	269	228	339	464
135	24	273	212	344	416
137	24	286	310	358	527
137	28	286	248	364	549
142	28	287	-	367	465
153	37	288	247	371	504
155	41	288	208	408	-
168	50	291	308	423	875
172	58	291	321	427	-
195	86	293	322	439	910
197	85	293	-	443	1028
197	79	295	301	482	967
203	89	302	310		

• Appendix 28: Brook trout lengths weights for the Loading Chute Section on the Shields River.

Loading Chute Section					
Brook Trout		Brook trout		Brook Trout	
Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
101	11	197	79	288	247
123	21	203	89	288	208
155	41	207	105	295	301
168	50	267	218	310	386
172	58	273	212	339	464
197	85	286	248	344	416

- Appendix 29: Yellowstone cutthroat trout lengths and weights for Section 11995 in Unnamed Tributary of Shields River.

Section 11995	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
34	20
54	-
56	1
57	-
57	-
58	-
61	-
63	-

- Appendix 30: Yellowstone cutthroat trout lengths and weights for Section 12024 in Scofield Creek.

Section 12024			
Yellowstone cutthroat		**Yellowstone cutthroat**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
81	5	92	8
83	8	105	13
90	7	117	15
90	7	129	21
92	7	150	33

- Appendix 31: Yellowstone cutthroat trout lengths and weights for Section 12025 in Scofield Creek.

Section 12025					
Yellowstone cutthroat		**Yellowstone cutthroat**		**Yellowstone cutthroat**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**	**Length (mm)**	**Weight (g)**
48	1	55	1	136	25
50	1	57	2	139	26
50	1	78	5	142	28
51	1	94	8	145	31
51	1	104	10	184	60
53	1	110	13	195	75
53	1	113	15	204	83

- Appendix 32: Yellowstone cutthroat trout lengths and weights for Section 12026 in Scofield Creek.

Section 12026	
Yellowstone cutthroat	
Length (mm)	**Weight (g)**
186	79

- Appendix 33: Yellowstone cutthroat trout lengths and weights for Section 12014 in Turkey Creek.

Section 12014			
Yellowstone cutthroat		**Brook trout**	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
80	2	100	4
98	4		
122	14		
127	16		
158	25		
204	75		