Evaluation of Fish Population Response to Stream Channel Restoration of Silver Bow Creek, Montana

2002 - 2006

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Introduction

Historically, sampling of fish in Silver Bow Creek has been very limited because of the extremely harsh environment and the perceived absence of fish. In 2002, Montana Fish Wildlife & Parks (FWP), Montana Department of Environmental Quality (DEQ), Natural Rescource Damage Program (NRDP) and Confluence personnel believed it was important to initiate fish sampling due to the potential for improved water quality associated with restoration activities in Silver Bow Creek. Presumably, improved water quality resulting from tailing removal along Silver Bow Creek will provide conditions that will allow fish to survive and complete life-history cycles to sustain a fishery. Fish Sampling began in 2002 to monitor and document fish response to ongoing restoration activities. Sampling effort was expanded by adding new electrofishing sections during 2005 to provide better understanding of observed fishery trends during the first three years of sampling (2002, 2003, and 2004).

Methods

Two electrofishing study sections were sampled in Silver Bow Creek during 2002 to determine the presence or absence of fish in Silver Bow Creek near Butte, Montana. One section was located upstream of Rocker (see Map 2 of the Monitoring Plan for Silver Bow Creek Streamside Tailings Operable Unit, January 2004) and one section was located immediately upstream of Montana Avenue in Butte, Montana. Three electrofishing study sections were sampled during 2003 and 2004. The sections were located near Rocker, Ramsay and below the confluence with German Gulch (see Map 2 of the monitoring plan). The upper-most electrofishing section at Montana Street was not repeated in 2003 or 2004.

Due to stream channel restoration activities in the Ramsay Area during 2005, the Ramsay Section was replaced with two sections: Reach F (above Ramsay) and Miles Crossing (below Ramsay). The Rocker Section and Below German Gulch Sections were not changed from previous years. Two additional sections were added in 2005 and 2006 upstream of the sewage treatment outfall to evaluate effects of high nutrient loading to the system. One section was located in Lower Area One (LAO) and the uppermost section was added near Father Sheehan Park.

Catch-per-unit-effort (CPUE) sampling of fish was conducted using a backpack electrofishing unit (LR-24 Electrofisher manufactured by Smith Root, Inc.). A single upstream pass was conducted by a two or three-person crew. The entire channel was sampled and all observable fish were captured by one or two netters. Fish were held until the pass was completed and all fish were measured to the nearest millimeter and released. The time of electrofishing was recorded from the internal timer of the LR-24 electrofisher, and the section length was recorded to determine the sampling effort. Due to the high conductivity of the water, electrofishing appeared to be very effective at capturing fish and observations of fish escaping the electric field were rare. Future sampling of these study sections may incorporate multiple pass electrofishing runs to calculated sampling efficiencies and determine fish population estimates.

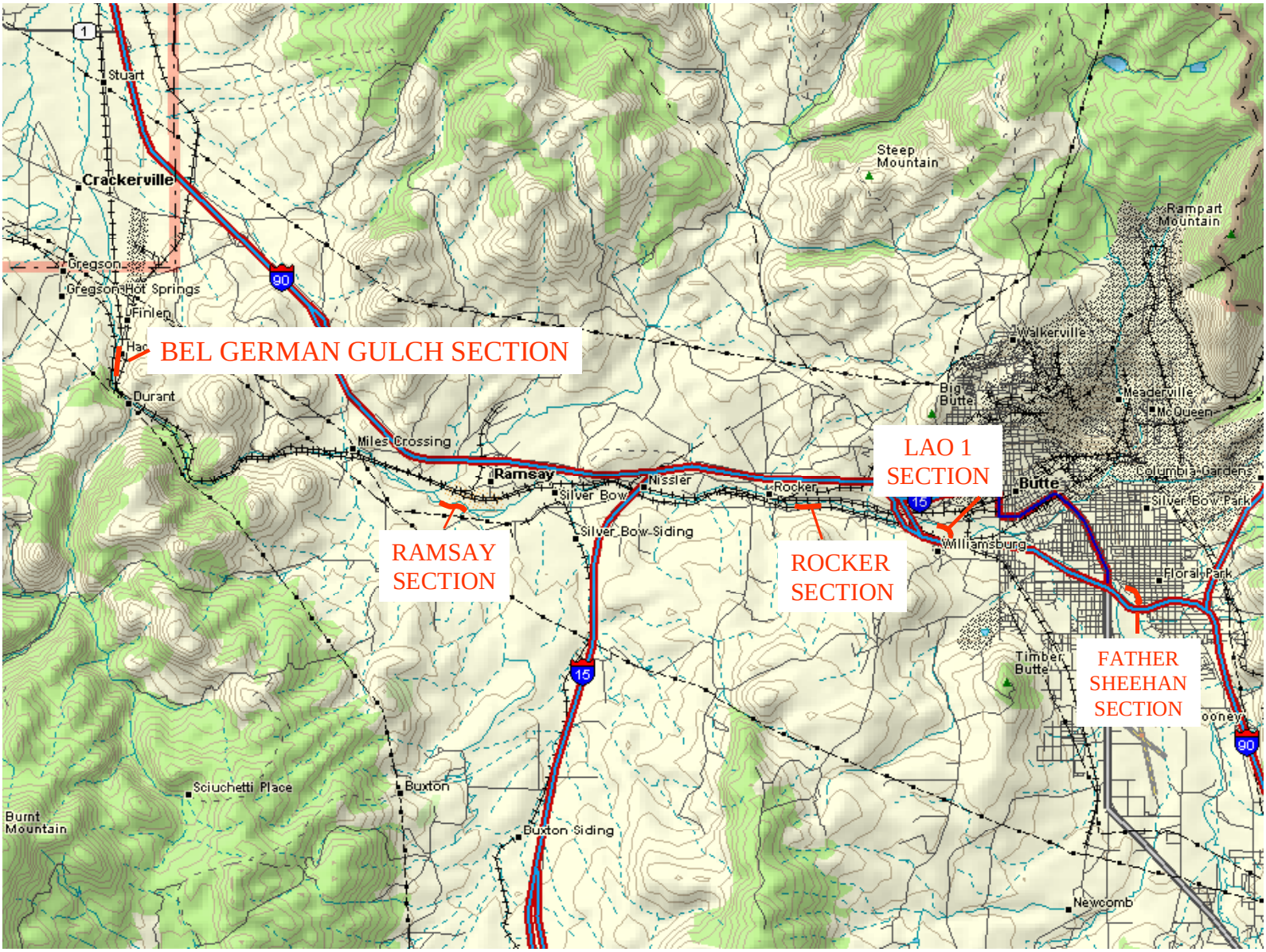

Figure 1. Map of the Study Area.

RESULTS

Fish sampling results from 2002 through 2006 primarily consisted of determining the presence or absence of a fish species, an estimate of number of fish per 100 seconds of electrofishing effort CPUE, and basic size structure of fish captured. This level of effort appears appropriate for determining fishery trends relating to water quality issues to fishery levels, and assessing fishery improvements due to ongoing mine reclamation activities. Fish sampling sections are presented in the map of study area (Figure 1).

The general trend in fish species composition indicates that trout species are limited upstream reaches of Silver Bow Creek and tributaries of Silver Bow Creek (Table 1). Based on fall sampling, trout do not appear to be tolerant of poor water quality in Silver Bow Creek from approximately Butte to Warm Springs Ponds. During spring sampling, however, brook trout and westslope cutthroat trout are commonly observed in the electrofishing section below German Gulch. Longnose sucker (Catostomus catostomus) and slimy sculpin (Cottus cognatus) are present in most electrofishing sections of Silver Bow Creek, but are much reduced or absent downstream of Ramsay. Central mudminnow (Umbra limi) are relatively rare and are dispersed throughout Silver Bow Creek from approximately Butte to above Ramsay.

Table 1. Fish species presence/absence and general rating of abundance in the upper Silver Bow Creek watershed as of 2005.

Location	Fish Species				
	WSCT	**EB**	**LNSU**	**SCULP**	**CM**
Headwaters Tributaries	C	C	R	R	NP
Silver Bow Creek - Butte Area	R	C	C	C	R
Silver Bow Creek - Restored Area Above Sewage Outfall	NP	NP	C	R	R
Silver Bow Creek - Restored Area Above Sewage Outfall (Rocker)	NP	NP	C	R	R
Silver Bow Creek - Restoration Area (Ramsay/Miles Crossing)	NP	NP	NP	NP	NP
Silver Bow Creek - Restoration Area Downstream of German Gulch (Spring Sampling)	R	R	R	R	NP
Silver Bow Creek - Restoration Area Downstream of German Gulch (Fall Sampling)	NP	R	NP	NP	NP

NP-not present, A- abundant, C- common, P- present, R - rare

Fish Sampling Results in 2002

Sampling conducted in Silver Bow Creek on 6 November 2002 found longnose suckers (Catostomus catostomus), slimy sculpin (Cottus cognatus), and a central mudminnow (Umbra limi). The fish assemblage in the Rocker Section was primarily comprised of longnose suckers.

We captured 75 longnose suckers and 2 slimy sculpin during 1529 seconds of electrofishing. The study section length was approximately 1000 ft. A brief electrofishing run was conducted upsteam of Montana Avenue to compare species composition in the area upstream of Rocker. Slimy sculpin were much more abundant near Montana Avenue, compared to the Rocker Section (Table 2).

Table 2. Comparison of fish abundance in two sections of Silver Bow Creek during CPUE sampling on 6 November 2002.

SECTION	SPECIES	#PER 100 SECONDS
ROCKER	Sucker	4.9/100 seconds
	Sculpin	0.1/100 seconds
	Mudminnow	--
MONTANA AVE.	Sucker	2.6/100 seconds
	Sculpin	3.5/100 seconds
	Mudminnow	0.002/100 seconds

Fish Sampling Results in 2003

Fish sampling on 10 October 2003 was conducted at three electrofishing sections to include a section in the previously restored reach of Silver Bow Creek near Rocker, and two sections downstream of restoration activities (near Ramsay and German Gulch). Sampling of the Rocker Section showed similar results to the sampling conducted in 2002. We captured 48 longnose suckers and one slimy sculpin during 1580 seconds of electrofishing in the Rocker Section. No fish were captured in Ramsay Section in 1622 seconds of electrofishing. No fish were captured in the Below German Gulch Section during 1412 seconds of electrofishing.

Fish Sampling Results in 2004

Fish sampling on 1 October 2004 was conducted again at the three standard electrofishing sections near Rocker, Ramsay and Below German Gulch. Once again, no fish were observed during fall sampling of the Ramsay Section and the Below German Gulch Section during 2004. As in previous years, longnose suckers and slimy sculpin were captured in the Rocker Section during fall, 2004. Sculpin continue to be rare with only two individuals captured in 2002, and one individual captured in both 2003 and 2004. Based on catch per effort sampling, abundance of longnose suckers declined between 2002 and 2004.

During spring 2004, the Below German Gulch Section was added to attempt to determine whether fish were able to persist seasonally in a section of Silver Bow Creek downstream of German Gulch where it was suspected that fish occasional migrated downstream from German

Gulch. The sampling in May 2004 was to determine the potential for Silver Bow Creek to support fish during the spring when water quality may be improved by dilution due to rainfall and snowmelt. On May 19, 2004 the standard 1000 ft section below German Gulch was sampled with three electrofishing passes. Three species of fish were observed during this sampling (Table 3).

Table 3. Results of multiple pass electrofishing in the section below German Gulch in Silver Bow Creek on May 19, 2004.

PASS #	SPECIES	TOTAL LENGTH (mm)	EFFORT
1	BROOK TROUT	290 mm	1890 seconds
	CUTTHROAT TROUT	198 mm	
	LN SUCKER	51 mm	
	LN SUCKER	48 mm	
2	CUTTHROAT TROUT	76 mm	1720 seconds
3	NO FISH		1120 seconds

During spring 2005, no westslope cutthroat trout or longnose suckers were observed during 1958 seconds of electrofishing in the 1000-foot section. Brook trout, however, were relatively common with 31 individuals captured during the sampling effort. One sculpin was also captured during the spring sampling on 27 June 2005. Streamflow was relatively high (approximately 20 to 30 cfs) during this sampling effort and capture efficiency is presumed to be very low.

Fish Sampling Results in 2005

From 2002 through 2004, three sections were sampled to determine trends in fish abundance. In 2005, the Rocker Section and German Gulch sections were conducted as usual, but the Ramsay Section was under construction and was replaced with two electrofishing sections (above Ramsay Section/Reach F) and below Ramsay Section/Miles Crossing). In addition, two new sections were added above the sewage treatment plant (LAO Section and Father Sheehan Park Section).

Fish abundance trends in 2005 indicate similar findings to previous years where sucker and sculpin abundance decline between Rocker and Ramsay. Fish were observed in the Below German Gulch Section during spring sampling, which is similar to past years, but a few fish were observed during the fall sampling at this location for the first time during this evaluation. Fish sampling of two new sections upstream of the sewage treatment outfall in 2005 provides an improved perspective of the longitudinal distribution of fish species in the upper Silver Bow drainage. See Appendix Table 1 for a list of all seven sections sampled from 2002 to 2006.

Fish species composition varies throughout the seven sections sampled from 2002 through 2006. Sensitive fish species such as westslope cutthroat trout and brook trout are located in the headwaters of some tributaries of Silver Bow Creek and occasionally during the spring time in Silver Bow Creek downstream of German Gulch (Table 1). More tolerant species such as sculpin and longnose suckers are generally not observed in most tributaries of Silver Bow Creek, and their abundance is variable in the main stem of Silver Bow Creek. Table 1 shows general species abundance in various portions of the watershed for westslope cutthroat trout (WSCT), eastern brook trout (EB), longnose sucker (LNSU), sculpin (SCULP), and central mudminnow (CM). Westslope cutthroat trout, longnose sucker and sculpin are native to the watershed and brook trout and central mudminnow are present due to introductions.

Fish Sampling Results in 2006

Four electrofishing sections were surveyed during early October 2006. Fish population surveys were conducted at the following sections: LAO Section (above sewage inflow), Rocker Section, Ramsay Section, and Below German Gulch Section. No spring sampling was conducted in 2006.

New sampling information collected during 2006 included pH and Ammonia samples collected at Rocker and Ramsay Sections and tissue samples were collected from suckers at Rocker and Ramsay.

The most notable finding during fall 2006 was the capture of a single brook trout (112 mm in TL) at the Below German Gulch Section, which represents the first trout observed at this site during fall sampling. Previously, trout were only observed during spring sampling. Fish composition at the LAO section changed between 2005 and 2006. Suckers dominated the catch in 2005 and sculpin were most abundant in 2006. It is not known whether changes in sampling efficiency or an actual change in species composition was responsible for the varying observations in 2005 and 2006. Sucker abundance appeared to increase at the Rocker Section between 2005 and 2006, and sucker abundance appeared to increase at the Ramsay Section between 2004 (no fish) and 2006 (144 suckers in 1987 seconds of sampling). Sampling of the Ramsay Section was modified in 2005 due to construction activities and results are not included in this summary.

Trends in fish abundance 2002 to 2005

In addition to presence/absence data, it is often useful to monitor trends in abundance of selected species that span most or all of the sampling sections. Longnose suckers are present in all of the sampling sections where fish have been observed from 2002 to 2005 and this species is probably the best choice for monitoring trends in abundance between various sections. In 2005, suckers appear to be most abundant at LAO, which is located above the municipal sewage outfall (Figure 2). Sucker abundance is relatively similar near Rocker and above Ramsay, and all fish (including suckers) are rare downstream of Ramsay during fall sampling despite the presence of similar physical habitat features such as streambed substrate, width depth ratio, stream flow and other factors.

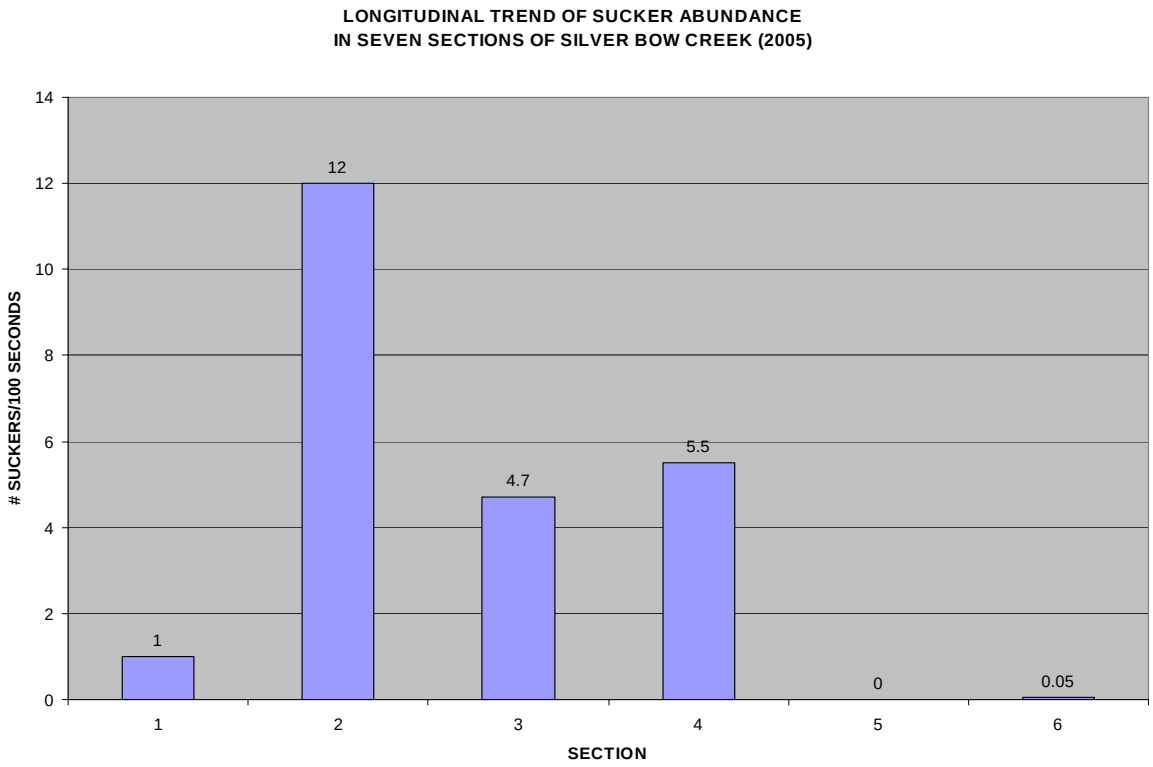

Figure 2. Longitudinal trend of longnose sucker abundance in six sections of upper Silver Bow Creek during 2005.

Section 1 (Father Sheehan Park), Section 2 (LAO), Section 3 (Rocker Section), Section 4 (Above Ramsay), Section 5 (Below Ramsay), Section 6 (Below German Gulch).

Rocker Section

Based on observed trends in abundance of longnose suckers at the Rocker Section, it appears that 2006 provided better conditions for sucker survival compared to previous years of sampling, and the highest number of suckers were captured during 2006 (Table 3). Three sculpin were also captured during sampling in 2006. In addition to fish sampling, a Hach Colorimeter was used to measure Total Ammonia at the Rocker Section on 3 October 2006. Total Ammonia was measured at 4.02 ppm, pH was 7.71 on this date.

Table 3. CPUE electrofishing trend for longnose suckers in the Rocker Section of Silver Bow Creek (2002-06).

YEAR	NO. LONGNOSE SUCKERS	EFFORT	NO. FISH/100 SEC.
2002	75	1529 seconds	4.9
2003	48	1580 seconds	3.0
2004	20	1672 seconds	1.2
2005	122	2602 seconds	4.7
2006	167	1912 seconds	8.7

A comparison of length-frequency distribution for longnose suckers in the Rocker Section during 2002 to 2005 shows similar population structure during the period of sampling with most fish being less than 200 mm in total length (Figure 3). The largest increase in sucker numbers in 2005 occurred for relatively small individuals in the size group 51-74 mm.

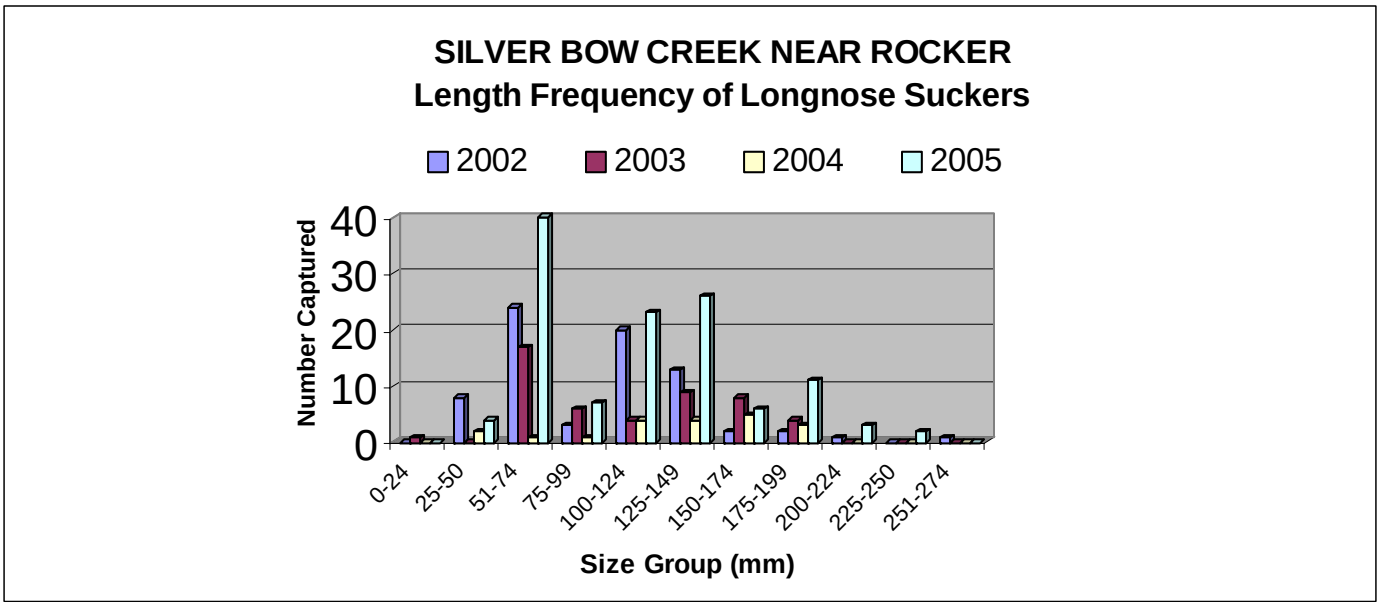

Figure 3. Comparison of length frequency of longnose suckers in the Rocker Section in 2002 through 2005.

Ramsay Section

Sampling of the Ramsay Section and the German Gulch section found no fish in 2003. The Ramsay Section was sampled for 1622 seconds and approximately 1000 feet, and the German Gulch Section was sampled for 1412 seconds and approximately 1000 feet. Sampling conditions were favorable for capturing fish if any were present in either of these study sections, and we assume this area of Silver Bow Creek to be void of fish as of October 2003. No fish were

observed during fall 2004, and construction activities in 2005 prevented sampling of the section. Due to floodplain reclamation activities, two new sections were established near Ramsay. One in the newly reconstructed reach (Reach F) and one below the Ramsay Section at Miles Crossing. Reach F contained 145 longnose suckers, 2 sculpin, and 1 central mudminow in 2648 seconds of electrofishing. The Miles Crossing section (below the Ramsay Section) contained no fish during fall 2005 based on 1473 seconds of electrofishing.

In 2006, 144 suckers and 2 sculpin were captured in the Ramsay Section during 1987 seconds of sampling. This section is similar to the location sampled during 2003, when no fish were observed prior to channel restoration. In addition, the 2006 results at the Ramsay Section were similar to findings during 2005 sampling at Reach F, when channel restoration activities prevented sampling the Ramsay Section electrofished in 2002, 2003 and 2004. In addition to fish sampling, a Hach Colorimeter was used to measure Total Ammonia on 3 October 2006. Total Ammonia was measured at 0.59 ppm, which is considerably lower than the measurement on the same day at the Rocker Section. Measured pH was 8.3 in the Ramsay Section.

Below German Gulch Section

The section below German Gulch was sampled in the fall of 2003 (no fish during 1412 seconds of sampling), and both the spring and fall of 2004. The sampling in May 2004 was to determine the potential for Silver Bow Creek to support fish during the spring when water quality may be improved by dilution due to rainfall and snowmelt. On May 19, 2004 the standard 1000 ft section below German Gulch was sampled with three electrofishing passes. Three species of fish were observed during this sampling on 19 May 2004 (one brook trout, two cutthroat trout, and two suckers during three electrofishing passes totaling 4730 seconds of sampling.

During spring 2005, no cutthroat trout or longnose sucker were observed during 1958 seconds of electrofishing in the 1000 foot section. Brook trout, however, were relatively common with 31 individuals captured during the sampling effort. One sculpin was also captured during the spring sampling on 27 June 2005. Streamflow was relatively high (approximately 20 to 30 cfs) during this sampling effort and capture efficiency is presumed to be very low.

During fall 2005, three sculpin, one longnose sucker and no trout were captured in 1956 seconds of sampling the standard section. Although it is common to capture fish in this section during spring sampling, 2005 is the first year that fish have been found during the fall sampling effort.

During 2006, sampling of the standard electrofishing section was conducted on 6 October 2006, and no sampling was done during the spring. Sampling effort was 2218 seconds in the standard 1000 ft section, and one brook trout, 3 sculpin, and 11 suckers were captured. The fall 2006 sampling observed the most fish captured since the first fall sampling was conducted in 2003. In addition, the capture of a brook trout (112 mm TL) represents the first trout observed during fall sampling of this section.

DISCUSSION

Fish sampling of Silver Bow Creek from 2002 to 2006 was conducted to provide a general perspective of fish response to ongoing restoration activities in Silver Bow Creek. Since numerous sections were sampled using relatively low effort sampling techniques, interpretation of results should be limited to observations of major trends in fish species composition. Sampling conducted in this effort will be sufficient to determine if a sampling reach was fishless for one or more years, followed by colonization by tolerant species such as suckers, and then followed by colonization by sensitive species such as trout. Relatively small fluctuations in fish abundance or species composition at specific sampling locations should not be considered significant unless a multi-year trend is observed.

The presence or absence of various fish species appears provides insight into the tolerance of each species to changes in quality. For example, brook trout are common in Silver Bow Creek at Father Sheehan Park and clearly have access to downstream areas in similar habitat types if there is no change in water quality. Brook trout were not observed in LAO in 2005 and 2006 and have not been observed at Rocker or Ramsay sections from 2002 to 2006. It can be reasonably assumed that water quality deterioration downstream of Father Sheehan Park is the primary reason for the absence of brook trout in this reach of Silver Bow Creek. The presence or absence of fish species listed in Table 2 are sometimes influence by habitat limitations that may not be related to water quality. For example, sculpin prefer streambed substrate composition of gravel and cobble and they typically do not reside in reaches of streams where the streambed is largely composed of sand and mud, regardless of water quality. Thus, it is possible for sculpin to be absent in reaches with adequate water quality due to other habitat limitations.

Based on the sampling of seven sections of Silver Bow Creek between 2002 and 2006, it is clear that sensitive species are not able to tolerate water quality problems in most of Silver Bow Creek downstream of Butte. Fish species which are more tolerant of pollution and water quality problems (such as longnose sucker and sculpin) are able to reside in more areas of Silver Bow Creek, but these species are not able to survive in Silver Bow Creek downstream of Ramsay. The fish presumably entering Silver Bow Creek from German Gulch are able to survive during relatively high flows in the spring, but it appears that most fish are unable to persist until October.

Prior to 2002 Fishery sampling in the Upper Silver Bow Creek Watershed was primarily confined to tributaries such as Blacktail Creek and German Gulch. Silver Bow Creek was generally considered to be void of fish except for occasional observations of suckers during the late 1990's when restoration of the stream channel began. Sampling described in this report represents the first formal sampling of fish presence and abundance in Silver Bow Creek. The sampling is intended to document fish response to habitat improvement activities in Silver Bow Creek and associated tributaries.

An example of how this sampling can be used to assess progress of restoration and remediation activities can be described by the longitudinal profile of fish species in the headwaters of Blacktail Creek and progressing downstream to the mouth of Silver Bow Creek (previously referenced in Table 1). The fishery of Blacktail Creek in the headwaters is composed of

westslope cutthroat trout and brook trout, both sensitive trout species. Due to high sediment loading and dewatering of Blacktail Creek near Butte, brook trout dominate the fishery and cutthroat trout become rare. In the vicinity of Butte, the increased sedimentation and reduced water quality results in the reduced abundance of brook trout and more tolerant species such as suckers and sculpin become the dominant species near Montana Street. Water quality degrades further downstream of Montana Street, resulting in the complete absence of trout in the upper segment of Silver Bow Creek and a measurable decrease in the number of relatively tolerant species such as sculpin and suckers from Montana Street to Rocker. Water quality degrades further downstream of Rocker, and no fish are observed in the Ramsay Section. Finally, even the most sensitive member of the native fish community (westslope cutthroat trout) reappear in Silver Bow Creek downstream of the mouth of German Gulch during the spring of the year, presumably due to improved water quality from spring flow conditions and inflows from a relatively clean tributary. Until 2005, it did not appear that any species of fish was able to persist throughout the year below German Gulch because no fish were observed during fall sampling. In October of 2005, three sculpin and one longnose sucker was observed in this section and this sampling confirmed the first observation of fish in this section during the fall. In 2006, one brook trout was observed in the Below German Gulch Section during October, representing the first observation of trout in this area outside of the spring time period.

The description of the longitudinal profile of fish species in Blacktail Creek and Silver Bow Creek serves to measure progress in restoring the system. At present, Silver Bow Creek can only support low to moderate numbers of relatively tolerant fish species near Rocker. Suckers and sculpin species tend to be more tolerant of a variety of pollutants such as metals, low dissolved oxygen, high sediment loading, high temperature and others. Possibly due to recent drought conditions, which exacerbate a variety of water quality problems in the watershed , even suckers and sculpin appear to decline between 2002 and 2004 in the Rocker Section. Improved stream flow during 2005 may be a possible explanation for a recovery of sucker abundance observed at this location. In 2006, sucker abundance at Rocker was higher than 2005, but no confidence intervals are available to determine the significance of this potential increase. Ongoing monitoring of the established electrofishing sections will be one of the best ways to assess restoration results and account for other issues such as drought, nutrient loading, and many others. Adding new sections, as was done in 2005, may also help understand a variety of factors associated with the recovery of this fishery.

Prior to 2005, it appeared that that Silver Bow Creek was not suitable for supporting suckers, trout, or sculpin in the two study sections located downstream of remediation activities (Ramsay or German Gulch). No fish were observed in these two sections during fall sampling in 2003 and 2004. Three species of fish, however, were found in the section below German Gulch during May 2004. One brook trout, two westslope cutthroat trout, and two longnose suckers were observed in low numbers during spring 2004, indicating that dilution water from German Gulch allows at least a temporary fishery to establish in the study section located about 0.5 miles downstream of the mouth. In addition, this observation confirms the idea that German Gulch can be an important source of fish recruitment to Silver Bow Creek. These fish did not appear to persist based on repeat sampling in October when no fish were observed in the section.

During 2005 and 2006, sampling indicated that sculpin and suckers and one brook trout were able to persist in the reach of Silver Bow Creek downstream of German Gulch. Improved stream flow during 2005 is one possible explanation for tolerant species of fish persisting through the summer, and it is possible that ongoing clean-up in upper Silver Bow Creek has contributed to improved survival. Based on data from USGS for Silver Bow Creek below Blacktail Creek (station: 12323250), the mean of monthly stream flow from 1984 through 2004 was 20 cfs during August. The mean monthly flow during August from 2000 through 2004 was relatively low and ranged from 14.0 to 17.2 cfs. Stream flow during August in 2005 ranged from 14 to 25 cfs. In 2006, August streamflow was relatively stable ranging between 14 and 15 cfs. A more detailed review of flow conditions will be helpful for interpreting current and future fishery trends.

The new fish population monitoring sections added in 2005 include Silver Bow Creek near Father Sheehan Park and a section in LAO. These two sections helped understand fish population health upstream of the sewage treatment plant. Brook trout were common near Father Sheehan Park and longnose sucker abundance at LAO was higher than sucker abundance downstream of the sewage outfall. Continued monitoring of these two new sections is recommended.

Fish sampling in the Rocker, Ramsay and German Gulch Sections should be repeated annually to monitor fish response to ongoing restoration activities in Silver Bow Creek. Multiple pass population estimates may be conducted to improve our understanding of fishery trends in Silver Bow Creek. CPUE sampling in the Rocker Section, for example, indicated that longnose sucker numbers were reduced in 2003 and 2004 and rebounded in 2005 and 2006, but the single pass index may not be sensitive enough to conclude that there was a real change in sucker abundance. In contrast, slimy sculpin were much less abundant in the Rocker Section (0.1 sculpin per 100 seconds) compared to the Montana Avenue Section (3.5 sculpin per 100 seconds) in 2002, and the CPUE method is probably sensitive enough to conclude that this difference in estimated abundance reflects a real difference in sculpin abundance.

Seasonal fish movements throughout the Silver Bow Creek watershed may result in problems interpreting trends with fish populations. Electrofishing surveys during the fall (spring and fall below German Gulch) provide a snapshot of the fishery status during a specific point in time, but fish mortality during one season may be masked by fish migration during another season. We recommend that existing electrofishing survey sections be continued in the future, and that live fish enclosures be used to determine mortality rates of sensitive and/or pollution tolerant species at various locations in the watershed.

A live fish cage study could help determine mortality rates for longnose sucker and brook trout obtained in Silver Bow Creek. If cage studies are conducted, we suggest fish be placed at the following locations:

- Above the sewage outfall:
- Below the sewage outfall;
- At the Rocker Section;
- At the Ramsay Section;

- Above German Gulch;
- Below German Gulch.

Initially, the sampling would best be done during spring flow conditions when dilution water is most abundant and during the late summer when dilution water is relatively low. Use of caged fish from other sources outside of the drainage provides the advantage of observing fish mortality of fish that have not acclimated to the conditions, but the potential for fish escape may result in disease or genetic concerns for the existing fishery. The potential use of resident fish or imported fish for "live cage studies" should weigh these potential concerns, but either method is likely to help our understanding of the system.

Appendix Table 1. Description of fish sampling sections and species occurrence in six sections of the upper Silver Bow Creek watershed prior to 2006.

Section 1. Father Sheehan Park
Section Length: 500 ft
Years Sampled: Fall 2005
GPS: N45.98524 W112.50719 (Bottom of 500 ft sections)
Species Present: Sculpin, Brook Trout, Longnose Sucker
Longnose Sucker Abundance: 1.0/100 seconds (1866 seconds; first pass); multi-pass estimate for brook trout (2005 data).

Section 2. Montana Street
Section Length: Approx. 500 ft (Montana Avenue to confluence with metro storm drain)
Years Sampled: Fall 2002
GPS: N/A
Species Present: Longnose sucker (n=15); sculpin (n=20); central mudminnow (n=1)
Longnose Sucker Abundance: 2.6/100 seconds (573 seconds of electrofishing in 2002)

Section 3. Lower Area One
Section Length: 1000 ft
Years Sampled: Fall 2005
GPS: N45.99489 W112.54819 (Bottom); N45.99550 W112.54564 (Top)
Species Present: Longnose Sucker, Sculpin, Central Mudminnow
Longnose Sucker Abundance: 12.0/100 seconds (2578 seconds in 2005)

Section 4. Rocker Section
Section Length: 1000 ft
Years Sampled: Fall 2002, 2003, 2004, 2005
GPS: N46.00070 W112.35601 (Top of section; bottom near concrete block on north bank)
Species Present: Longnose Sucker,
Longnose Sucker Abundance: 4.7/100 seconds (2602 seconds in 2005)

Section 5. Above Ramsay Section (Reach F)
Section Length: Approx. 1000 ft
Years Sampled: Fall 2005
GPS: N46.00311 W112.39756 (Bottom); N46.00388 W112.39907 (Top)
Species Present: Longnose Sucker, Sculpin, Central Mudminnow
Longnose Sucker Abundance: 5.5/100 seconds (2648 seconds in 2005)

Section 6. Ramsay Section
Section Length: Approx. 1000 ft
Years Sampled: Fall 2002, 2003, 2004 (reconstruction during 2005)
GPS:
Species Present: No Fish
Longnose Sucker Abundance: No Fish

Section 7. Below Ramsay Section (Miles Crossing)
Section Length: Approx. 1000 ft
Year Sampled: Fall 2005
GPS: N46.00756 W112.43591 (Bottom/RR crossing); N46.00678 W112.43719 (Top/road)
Species Present: No Fish
Longnose Sucker Abundance (2005): No Fish

Section 8. Below German Gulch
Section Length: 1000 ft
Years Sampled: Fall 2003, 2004, 2005 / Spring 2003, 2004, 2005
GPS: N/A Start 700 ft below bridge; End 300 ft above bridge crossing
Fall Species Present: Sculpin, Longnose Sucker
Fall Longnose Sucker Abund. (2005): 0.05/100 seconds (1 fish: 1956 seconds)

Spring Species Present (2005): Brook Trout, Sculpin
Spring Longnose Sucker Abundance (2005): No Fish