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Job Title: (3140 LAKE KOOCANUSA AND KOOTENAI RIVER BASIN BULL TROUT MONITORING REPORT)

Abstract:

We collected population and habitat features for bull trout streams in the Kootenai River drainage. Surveys included juvenile population estimates, streambed coring, substrate scoring, redd counts and gillnetting.

We conducted juvenile bull trout population estimates within reference reaches on index creeks. Juvenile estimates for all of the streams below Libby Dam including O'Brien Creek, Bear Creek and Callahan Creek have decreased dramatically from survey peaks. Substrate scores and substrate coring data are presented.

Bull trout redd counts in Grave Creek and the Wigwam River significantly increased between 1995 and 2005, exhibited decreases until 2010-2011 and recovered to levels below peak numbers. This was due, in great part, to re-opened bull trout harvest fishery in 2004 that through time went from two bull trout per year harvest to one to no harvest to the current one bull trout per year harvest. Bull trout redd counts in tributaries downstream of Libby Dam including Quartz, Pipe, Bear, and O'Brien creeks, and the West Fisher River have been variable over the survey period, but with the exception of O'Brien Creek have decreased dramatically. More than 50 percent of bull trout residing below Libby Dam were entrained so much of the impacts to downstream tributaries are likely related to bull trout from Lake Koocanusa remaining to spawn. Prior to redd counts in 2007 and 2008, bull trout redd counts in Keeler Creek exhibited a positive trend since monitoring began. Since 2005, there appears to be a negative trend that is substantially different from a stable population. Growing northern pike population in Bull Lake is a concern.

We continued monitoring bull trout populations within Lake Koocanusa using spring gill netting. Spring gill net catch of bull trout during the period 1975-2017 and Wigwam River/Grave Creek redd counts have significantly similar trends. This also coincides with the opening of bull trout harvest initiated in 2004 for Koocanusa. Both indices are useful and were used to determine management direction for the harvest of bull trout from Lake Koocanusa.

LAKE KOOCANUSA AND KOOTENAI RIVER BASIN BULL TROUT MONITORING REPORT

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EXECUTIVE SUMMARY

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INTRODUCTION

The bull trout that inhabit Lake Koocanusa and Kootenai River represent geographically distinct and important populations within their range. Montana Fish, Wildlife & Parks listed bull trout as a species of special concern and in 1996 the United States Fish and Wildlife Service (USFWS), through the Endangered Species Act, listed bull trout as threatened throughout their range

Forestry practices are the dominant land use in all bull trout core areas and represent the highest risk to bull trout in the middle Kootenai (Libby Dam to Kootenai Falls). This risk to the bull trout population in the middle Kootenai is elevated due to the low number of spawning streams (Quartz, Pipe, O'Brien, Callahan and Libby Creek drainages) available; a direct result of habitat fragmentation caused by Libby Dam. The Kootenai River is a nodal habitat containing critical over-wintering areas, migratory corridors, and habitat required for reproduction and early rearing.

Dam operations are considered a very high risk to the continued existence of the Kootenai drainage population of bull trout (Montana Bull Trout Scientific Group 1996a). Dam operations represent a direct threat to bull trout in the middle Kootenai because of the biological affects associated with unnatural flow fluctuations and real potential gas supersaturation problems arising from spilling water. The dam is a fish barrier, generally restricting a portion of this migratory population to 29 miles of river between Libby Dam and Kootenai Falls.

In the upper Kootenai (above Libby Dam), the threats to bull trout habitat include illegal fish introduction, introduced fish species, rural residential development, and forestry. Additional risks come from mining, agriculture, water diversions, and illegal harvest (Montana Bull Trout Scientific Group 1996b). Critical spawning streams include the Grave Creek drainage in the U.S. and the Wigwam drainage in British Columbia. Transboundary research is ongoing in B.C. tributaries: Elk River, St. Mary River, Skookumchuck Creek, White River, Palliser River, and the Kootenay River upstream (Baxter and Oliver 1997). Nodal habitats for this population are provided in Lake Koocanusa, Tobacco River, and the Kootenay River in Canada.

Bull trout are found below Kootenai Falls in O'Brien Creek, Callahan Creek and in Bull Lake. The latter is a disjunct population that migrates out of Bull Lake, downstream to Lake Creek then upstream in Keeler Creek. These fish inhabit areas in the lower Kootenai River and Kootenay Lake during most of the year.

It is the intention of MFWP to manage bull trout populations as sport fisheries. For this to occur, relevant population information must be compiled. This report will help to provide MFWP and other decision makers with the best available information for bull trout populations in the Kootenai River system. In an effort to maintain consistent survey and analysis throughout the region, we reproduced an effort initiated in the Flathead drainage. Much of the survey background information for this report is excerpted, with thanks, from Deleray et al. (1999).

DESCRIPTION OF STUDY AREA

Kootenai River Drainage

The Kootenai River basin is an international watershed that encompasses parts of British Columbia (B.C.), Montana, and Idaho (Figure 1). The headwaters of the Kootenai River originate in Kootenay National Park, B.C. The river flows south within the Rocky Mountain Trench to the reservoir created by Libby Dam, which is located near Libby, Montana. From the reservoir, the river turns west, passes through a gap between the Purcell and Cabinet Mountains, enters Idaho, and then loops north where it flows into Kootenay Lake, B.C. The waters leave the lake's West Arm and flows south to join the Columbia River at Castlegar, B.C. In terms of runoff volume, the Kootenai is the second largest Columbia River tributary. In terms of watershed area (36,000 km^2 or 8.96 million acres), it ranks third (Knudson 1994).

Nearly two-thirds of the 485-mile-long channel, and almost three-fourths of the Kootenai watershed is located within the province of British Columbia. Roughly twenty-one percent of the watershed lies within Montana (Figure 1), and six percent is in Idaho (Knudson 1994). The Continental Divide forms much of the eastern boundary, the Selkirk Mountains the western boundary, and the Cabinet Range the southern. The Purcell Mountains fill the center of the river's J-shaped course to Kootenay Lake. Throughout, the basin is mountainous and heavily forested.

Libby Reservoir (Lake Koocanusa) and its tributaries receive runoff from 47 percent of the Kootenai River drainage basin. The reservoir has an annual average inflow of 10,615 cubic feet per second (cfs). Three Canadian rivers, the Kootenay, Elk, and Bull, supply 87 percent of the inflow (Chisholm et al. 1989). The Tobacco River and numerous small tributaries flow into the reservoir south of the International Border.

Major tributaries to the Kootenai River below Libby Dam include the Fisher River (838 sq. mi.; 485 average cfs), Yaak River (766 sq. mi. and 888 average cfs) and Moyie River (755 sq. mi.; 698 average cfs). Kootenai River tributaries are characteristically high-gradient mountain streams with bed material consisting of various mixtures of sand, gravel, rubble, boulders, and drifting clay and silt, predominantly of glacial/lacustrine origin. Fine materials, due to their instability during periods of high stream discharge, are continually eroded and re-deposited as gravel bars, forming braided channels with alternating riffles and pools.

Streamflow in unregulated tributaries generally peaks in May and June after the onset of snow melt, then declines to low flows from November through March. Flows also peak with rain-on-snow events. Kootenai Falls, a 20-foot-high waterfall and a natural fish-migration barrier, is located eleven miles downstream of Libby, Montana.

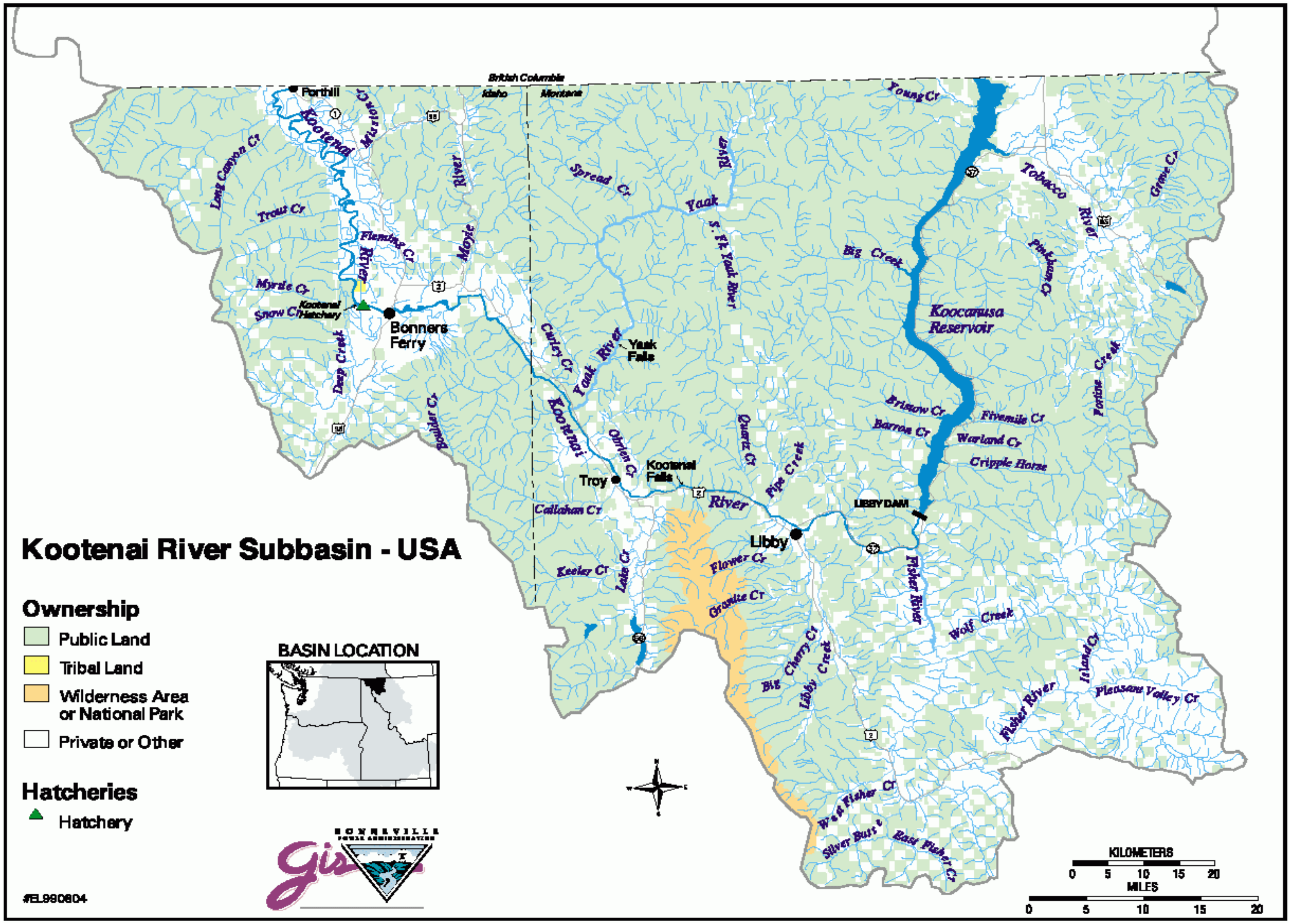

Figure 1. Kootenai River Basin (Montana, Idaho and British Columbia, Canada).

Libby Dam and Lake Koocanusa

Lake Koocanusa was created under an International Columbia River Treaty between the United States and Canada for cooperative water development of the Columbia River Basin (Columbia River Treaty 1964). Lake Koocanusa inundated 109 stream miles of the mainstem Kootenai River in the United States and Canada, and 40 miles of tributary streams in the U.S. that provided habitat for spawning, juvenile rearing, and migratory passage for salmonids.

Libby Dam is a 113-m (370-ft) high concrete gravity structure with three types of outlets: sluiceways (3), operational penstock intakes (5 operational, 8 possible), and a gated spillway. The dam crest is 931 m long (3,055 ft), and the widths at the crest and base are 16 m (54 ft) and 94 m (310 ft), respectively. A selective withdrawal system was installed at Libby Dam to allow for temperature-controlled release of water from the reservoir.

Completion of Libby Dam in 1972 created the 109-mile Lake Koocanusa. Specific morphometric data for Lake Koocanusa are presented in Table 1. Filling Lake Koocanusa inundated and eliminated 109 miles of the mainstem Kootenai River and 40 miles of critical, low-gradient tributary habitat. This conversion of a large segment of the Kootenai River from a lotic to lentic environment changed the aquatic community (Paragamian 1994). Replacement of the inundated habitat and the community of life it supported are not possible. However, mitigation efforts are underway to protect, reopen, or reconstruct the remaining tributary habitat to offset the loss. Fortunately, in the highlands of the Kootenai Basin, tributary habitat quality is high. The headwaters are relatively undeveloped and retain a high percentage of their original wild attributes and native species complexes. Protection of these remaining pristine areas and reconnection of fragmented habitats are high priorities for bull trout and other native species.

Table 1. Morphometric data presented for Lake Koocanusa Morphometric data.

Surface elevation	
maximum pool	749.5 m (2,459 ft)
minimum operational pool	697.1 m (2,287 ft)
minimum pool (dead storage)	671.2 m (2,222 ft)
Area	
maximum pool	188 sq. km (46,500 acres)
minimum operational pool	58.6 sq. km (14,487 acres)
Volume	
maximum pool	7.24 km^3 (5,869,400 acre-ft)
minimum operational pool	1.10 km^3 (890,000 acre-ft)
Maximum length	145 km (90 mi)
Maximum depth	107 m (350 ft)
Mean depth	38 m (126 ft)
Shoreline length	360 km (224 mi)
Shoreline development	7.4 km (4.6 mi)
Drainage area	23,271 sq. km (8,985 sq. mi)

Fish Species

Twenty species of fish are present or have been found in Koocanusa Reservoir and/or the Kootenai River drainage (Table 2). The reservoir currently supports an important fishery for kokanee *Oncorhynchus nerka* and rainbow trout *Oncorhynchus mykiss* (Gerrard strain), and a bull trout fishery that was re-opened in 2004 (Hensler and Benson, 2007) which is currently one bull trout per year harvest. The annual fishing pressure has ranged from 30,000 to over 100,000 angler days. The Kootenai River below Libby Dam is a "blue ribbon" rainbow trout fishery, and the state record fish was harvested there in 1997 (over 33 pounds). Bull trout *Salvelinus confluentus* are captured "incidentally".

Table 2. Current relative abundance (A=abundant, C=common, R=rare, N = Not Found) and abundance trend from1975 to 2018 (I=increasing, S = stable, D = decreasing, U = unknown) of fish species present in Lake Koocanusa and the Kootenai River drainage.

Common Name	Scientific name	Relative Abundance/Trend Reservoir		Relative Abundance drainage	Trend	Native (Y/N)
Game fish species						
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	R	D	C	S	Y
Rainbow trout	*Oncorhynchus mykiss*	R	D	C	S	Y
Bull trout	*Salvelinus confluentus*	C	S	C	I	Y
Brook trout	*Salvelinus fontinalis*	R	U	A	S	N
Lake trout	*Salvelinus namaycush*	N	U	R	U	N
Brown trout	*Salmon trutta*	N	U	R	I	N
Kokanee salmon	*Oncorhynchus nerka*	A	U	R	U	N
Mountain whitefish	*Prosopium williamsoni*	R	D	A	S	Y
Burbot	*Lota lota*	R	D	R	D	Y
Largemouth bass	*Micropterus salmoides*	R	U	R	U	N
Smallmouth bass	*Micropterus dolomieu*	N	U	C	I	N
White sturgeon	*Acipenser transmontanus*	R	D[a]	R	D	Y[b]
Northern pike	*Esox lucius*	R	U	R	U	N
Black Crappie	*Pomoxis Nigromaculatus*	N	U	R	I	N
Yellow perch	*Perca flavescens*	C	I	R	U	N
Northern Pike	*Esox Lucius*	R	U	C	I	N
Non-game fish species						
Pumpkinseed	*Lepomis gibbosus*	R	U	R	U	N
Redside shiner	*Richardsonius balteatus*	R	D	C	U	Y
Peamouth chub	*Mylocheilus caurinus*	A	I	C	U	Y
Northern pikeminnow	*Ptychocheilus oregonensis*	A	S	C	U	Y
Largescale sucker	*Catostomus macrocheilus*	A	S	C	U	Y
Longnose sucker	*Catostomus catostomus*	C	D	R	U	Y

[a] Five white sturgeon were relocated from below Libby Dam to the reservoir. At least one of these fish moved upriver out of the reservoir while two have been accounted for from angler reports; one verified mortality.

[b] Several anecdotal reports exist of white sturgeon above Kootenai Falls although surveys to date have failed to validate any reports.

JUVENILE BULL TROUT ABUNDANCE ESTIMATES

Estimation of fish population abundance is necessary for understanding basic changes in numbers, species composition and year class strength. Direct enumeration is the most accurate technique, but in most situations indirect methods must be employed. We generally use a combination of techniques to minimize errors. Fish populations are dynamic and may fluctuate considerably, even over relatively short periods of time, regardless of human influence. Consequently, managers seeking to assess the effects of various activities on fish populations must understand the nature and causes of such fluctuations as fully as possible.
We used the protocols similar to those developed to assess fish abundance in the Flathead Basin using electrofishing techniques (Shepard and Graham 1983). Monitoring focuses on quantifying yearly variation of fish abundance in stream sections sampled consistently year after year. We recommend using electrofishing techniques to assess fish abundance in accessible streams because:

1. The precision of electrofishing can be estimated and reported, providing a measure of reliability;

2. There is less bias associated with changes in field personnel; and

3. Estimates derived using electrofishing techniques are presently more accepted by fisheries professionals.

Two-pass Assumptions (Seber and LeCren 1967):

1. Probability of capture (p) is large enough to have a significant effect upon population total (N).

We can test this assumption by computing (p) after two passes are complete. If p is less than 0.5, assumption 1 probably has been violated (Junge and Libovarsky 1965) and more effort is required. We recommend (p) should be 0.6 or larger.

2. Probability of capture is constant. Fishing effort is the same for both catches and fish remaining after the first pass are as vulnerable to capture as were those that were caught in the first pass.

Assumption 2 has frequently been found to be faulty when electrofishing (Lelek 1965, Gooch 1967, Cross and Stott 1975, Mahon 1980). White et al. (1982) found if p was 0.8 or larger, two-catch estimates were reliable because failure of constant probability of capture (assumption 2) did not matter. We found that as long as p was 0. 6 or larger and stream discharge was less than 20 cfs, estimates computed using two-catch estimators were similar to mark-recapture estimates. Zippin (1958) determined that if the probability of capture (p) decreases with subsequent collections, the estimate was an underestimate of the true population size. These estimates may still be reported, but should be used cautiously. They can be used to compare trends in population abundance, provided the same techniques are used throughout the monitoring program.

3. There is no recruitment, mortality, immigration or emigration between the times of the two collections.

Assumption 3 was met, since both electrofishing collections take place within a single day and the section is isolated using block nets.

4. The first catch is removed from the population or, if returned alive, the individuals are marked so they can be ignored when counting the second catch.

This assumption was met by removing the first catch from the population.

Bull trout fry are exceedingly difficult to capture by electrofishing. There are several reasons for this:

1: Their small surface area makes effective, efficient, repeatable shocking difficult
2: Their small size (usually 35 to 50 mm at time of estimates) makes seeing them difficult
3: Because of their small size there is a high likelihood they will slip through nets during the estimate
4: Because of their small size there is a high likelihood that they will slip through the block nets.

We felt that these reasons led to too much probability to violate our capture assumptions, especially 1, 2 and 3. We therefore chose not to include fry in the yearly estimates. We captured a representative sample of bull trout fry and included measurements on the field sheets.

Methods

We incorporated the following fish abundance monitoring guidelines for Kootenai drainage estimates:

1. In streams less than 10 cfs, we used two-pass electrofishing technique. In these small streams adequate numbers of fish were captured using a backpack mounted generator-Variable Voltage Pulsator combination. Probability of capture (p) should be higher than 0.6 to obtain reliable results.

2. In streams 10 to 20 cfs, we used two-pass electrofishing estimation. We used two backpack mounted shocking units. If the p-value falls below 0.6 for a sample site, more effort (third pass) should be made instead of simply reporting the two-catch estimate.

3. In streams larger than 20 cfs, two-pass electrofishing technique was used. We used as many as 3 backpack mounted shocking units simultaneously for these sample sections.

Two-pass Procedure:

We placed a braided nylon block net (6.35 mm mesh) at the lower boundary of the shocking section. When using a block net, we placed the net in the stream with the bottom edge facing upstream and place rocks on the weighted (bottom) edge of the net to hold it in position. We tied the ropes along the top edge of the net to a tree (or any available stable item) on each bank to stretch the net tight and hold it perpendicular to the flow. Rocks placed along the entire bottom edge of the net ensure no fish move under the net. Rebar cut to approximately 1.0 m lengths supported the net upright.

We chose sample sections based on accessibility and proximity to redds that were found in previous years. Though we kept sample sites consistent, section length was not consistent between sites or between years due to considerable shifting of streambeds during some years. Section lengths typically were based on riffle breaks at the top of sections and pools at the bottom.

We sampled each section from the upstream boundary to the lower block net. We found that downstream electrofishing was more efficient than upstream electrofishing, and if two passes were needed for each catch (to provide a reliable estimate), both passes should be downstream. It was important to extend equal efforts during each pass, so that if two passes were used for the first catch; two passes must also be completed for the second catch. Mahon (1980) believed longer time periods between catches improved the accuracy of catch per unit effort estimators. For this reason, we recommend some time between collections. During this time, we worked all fish captured on the first pass.

Two-Pass Estimators:

We used the following formula to estimate population number (Seber and LeCren 1967):

$$N = \frac{C_1^{\,2}}{C_1 - C_2}$$

Where N = population size at the time of first pass

C_1 = number of fish > 1+ captured during first pass (by species)
C_2 = number of fish > 1+ captured during second pass (by species)

Variance of the estimate:

$$V(N) = \frac{C_1^{\,2} C_2^{\,2} (C_1 + C_2)}{(C_1 - C_2)^4}$$

Probability of capture (p):

$$p = \frac{C_1 - C_2}{C_1}$$

As stated previously, p should be $\geq$0.6 for a reliable, two-pass estimate. Though there were instances when time constraints made a third pass problematic, if p $\leq$0.6, the estimate was reported, but must be viewed with caution. If p $\geq$0.6 we completed the estimate; otherwise, generally more fishing effort was expended. This effort can be expended for computing a multiple estimate (by completing additional electrofishing and computing a multi-catch estimate using formulas presented in Zippin 1958). Population estimates and associated 95% confidence intervals were estimated using *Microfish 2.2* (Van Deventer and Platts 1983) and MFWP's Fisheries Analysis +.

When reporting the estimates of fish numbers computed by electrofishing, we reported the estimate, the 95 percent confidence interval, the area of the section surveyed, the date, and the density and number of mortalities. When reporting two-pass estimates, we reported the probability of capture (p) with the estimate.

Findings

Grave Creek

The Grave Creek fish abundance section is the only section in the U.S. portion of Lake Koocanusa. It is located just upstream of Clarence Creek and has varied from 190m to 220m in length. It is a relatively stable section but has been affected periodically by high flows and beaver activity. We have electrofished this section annually since 1997 (Table 3). Redd counts increased dramatically in this tributary since 1997 (Table 16), but densities of juveniles have not shown similar results. The 2012 population estimate and density of juvenile bull trout in this section was lowest on record, although density recovered in 2013.

Table 3. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of Grave Creek, 1997 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
Grave Creek	1997	158	+/- 12	0.72	9.7
	1998	186	+/- 9	0.77	11.4
	1999	139	+/- 27	0.57	8.5
	2000	160	+/- 17	0.51	9.8
	2001	165	+/- 18	0.67	11.6
	2002	116	+/- 15	0.66	8.5
	2003	156	+/- 19	0.75	15.6
	2004	153	+/- 10	0.83	13.3
	2005	153	+/- 17	0.76	14.5
	2006	117	+/- 12	0.69	8.8
	2007	145	+/- 10	0.76	12.7
	2008	127	+/- 8	0.77	11.4
	2009	123	+/- 43	0.59	11.8
	2010	104	+/- 19	0.72	7.9
	2011	No estimates due to high flows			
	2012	71	+/- 4	0.82	5.8
	2013	96	+/-7	0.76	10.5
	2014	107	+/-13	0.69	10.0
	2015	140	+/-18	0.65	14.3
	2016	105	+/-15	0.66	8.7
	2017	No estimate due to fire closure			

In 1998 MFWP initiated a survey to determine entrainment of bull trout through the Glen Lake Irrigation ditch (unpublished). The irrigation ditch is located approximately 7 miles upstream from the confluence with Fortine Creek. The diversion is located downstream from the juvenile estimate section. We installed a screw trap approximately 100 m. down the ditch from the control gate for the diversion. In 1998, 100 percent of the bull trout captured (32) in the screw trap were 1+ and older. In 2001 Montana Fish, Wildlife & Parks and Glen Lake Irrigation District installed a passive screen at the entrance to the ditch and installed an additional headgate upstream (Figures 2 and 3). We began operating the screen on May 12, 2001.

The screen is composed of wedge wire panels with 3/8 inch spacing (Figures 2 and 3). Though the number of entrained bull trout age 1+ and older decreased, during this same time we also saw an increase in Young-of-year bull trout caught. In 2001, we captured 204 bull trout in the trap of which ten were 1+ and older; and in 2002, only one of 178 trapped was 1+. The trend continued through 2008 when 9 of 744 bull trout captured were age 1+ none were older. There are many possible variables associated with outmigration, although it appears that spring flows positively affect outmigration. So far, out migration of young of year bull trout does not appear to have a negative effect on the population of 1+ and older juveniles. Our assessment of the operation of the diversion structure is an ongoing process that we will evaluate more fully and is beyond the scope of this report but contained in Dunnigan et al. (2011) and as unpublished data.

Figure 2. Photographs of Glen Lake Irrigation District diversion on Grave Creek, Montana.

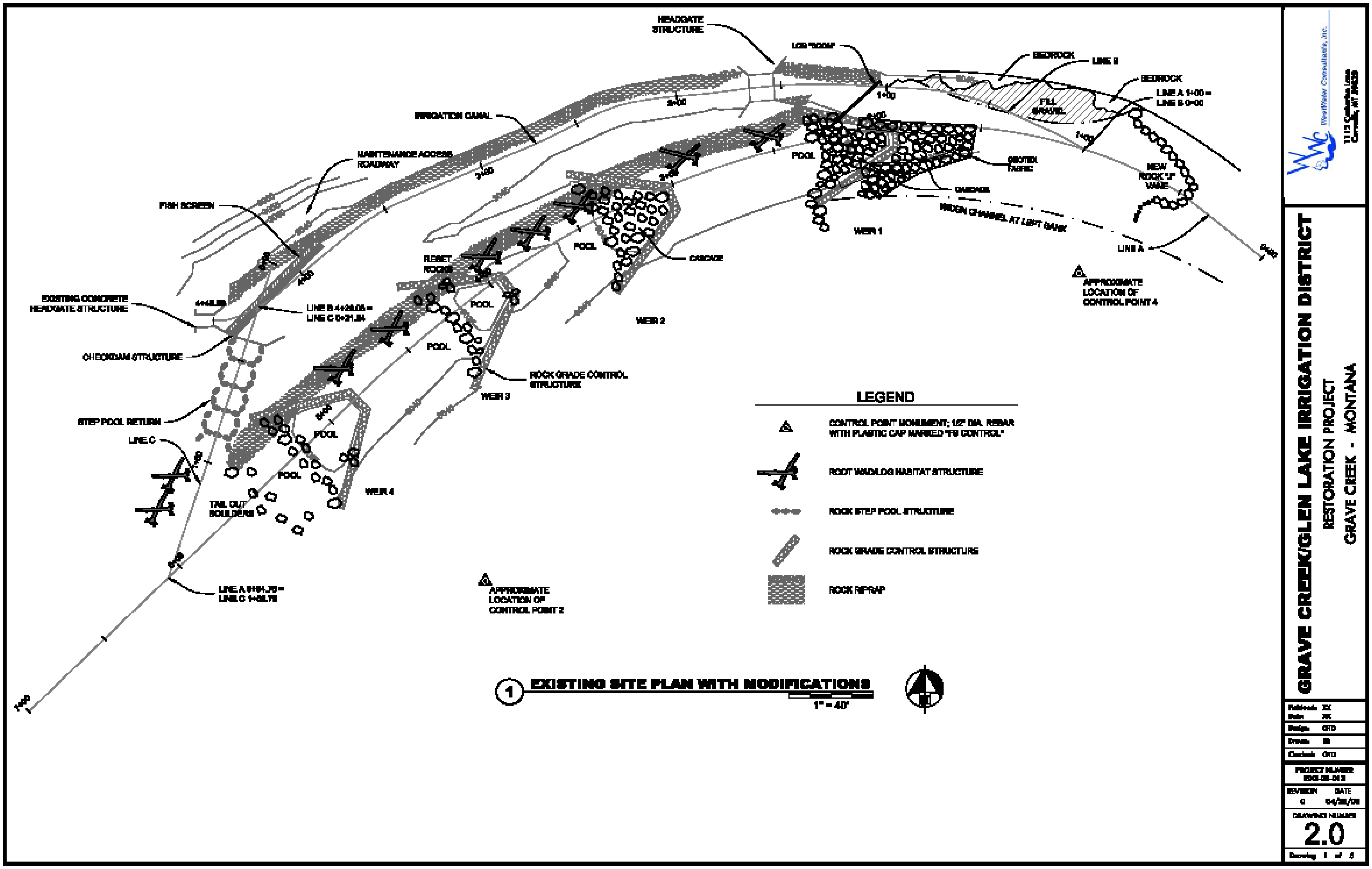

Figure 3. Footprint of Glen Lake Irrigation diversion, Grave Creek, Montana.

West Fork Quartz Creek

The West Fork Quartz Creek fish abundance section is located at the FS 399 bridge. The section has varied in length from 165 m to 248 meters due to spring flows and downfall from wind events. We chose West Fork Quartz rather than mainstem Quartz Creek because we found the majority of redds from year to year are in that tributary. Densities of juvenile bull trout generally increased between 1997 and 2002 then decreased to a relatively stable level until 2008 and since then have decreased (Table 4).

Table 4. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of West Fork Quartz Creek, 1997 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
West Fork Quartz Creek	1997	76	+/- 1	0.94	5.4
	1998	82	+/- 5	0.74	6.6
	1999	Not Sampled			
	2000	87	+/- 14	0.60	9.2
	2001	89	+/- 9	0.67	7.4
	2002	89	+/- 4	0.77	10.6
	2003	70	+/- 6	0.67	7.6
	2004	72	+/- 6	0.81	7.9
	2005	64	+/- 10	0.76	7.3
	2006	61	+/- 7	0.73	6.7
	2007	63	+/- 3	0.86	6.7
	2008	98	+/- 7	0.76	10.2
	2009	41	+/- 1	0.95	4.5
	2010	52	+/- 4	0.84	5.7
	2011	41	+/- 2	0.89	4.7
	2012	16	+/- 1	0.89	1.7
	2013	49	+/-3	0.81	4.9
	2014	42	+/-12	0.61	4.5
	2015	22	+/-23	0.96	2.4
	2016	23	+/-2	0.85	2.5
	2017	21	+/-2	0.84	2.2

The juvenile estimate trends for West Fork Quartz Creek are similar to redd counts (Figure 4) and could be due to a number of factors that include considerably lower water years since 1997 and flow operations from Libby Dam that resulted in major spill events in 2002, 2006 and 2010. In addition, there has been a steady buildup of log jams that are at least partial barriers and could be sequestering quality sized spawning gravels.

Pipe Creek

The Pipe Creek fish abundance section is located approximately 3 miles below the confluence with East Fork Pipe Creek. We have found redds above and below the section. The section has varied in length from 147 to 206 meters due to changes caused by spring flows and downfall from wind events. Densities of juvenile bull trout remained relatively stable to slightly decreasing between 1999 and 2005 (Table 5). This occurred as redd counts decreased substantially in 1999 and 2005 likely from low water conditions, and periodic manmade/natural dams below the spawning sites. We caught no or one juvenile bull trout in Pipe Creek between 2007 and 2009. The increase in juvenile estimates are similar to trends in redd counts during the same time frame.

Table 5. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of Pipe Creek, 1999 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
Pipe Creek	1999	31	+/- 1	0.76	2.2
	2000	54	+/- 9	0.68	3.8
	2001	23	+/- 4	0.76	2.1
	2002	18	+/- 1	0.71	1.8
	2003	24	+/- 4	0.77	2.2
	2004	22	+/- 2	0.85	1.6
	2005	12	No Recaptures		1.0
	2006	7	+/- 2	0.78	0.6
	2007	0	-	-	-
	2008	One bull trout caught			0.1
	2009	No bull trout caught			-
	2010	3	+/- 0	1.00	0.2
	2011	4	+/- 1	0.80	0.4
	2012	15	+/- 4	0.70	1.12
	2013	16	+/-1	0.89	1.48
	2014	6	+/-1	0.86	0.57
	2015	6	No Recaptures		0.57
	2016	2	No Recaptures		0.19
	2017	No Bull Trout Captured			

West Fisher Creek

West Fisher Creek was sampled for the first time in 2002. The section is centered on the FS 231 road bridge and was 207 meters long and averaged 7.6 meters in width. Though densities were low, the 2002 estimate of 37 juvenile bull trout was unexpected because of extremely low redd counts and low water during 2001 and 2002 (Table 6). About one-half of the juveniles counted were from the adults that spawned in 2000. The trend continued downward through 2005 and increased again in 2006 and 2007. Much of the decreases were likely due to drought over the last several years that caused low flows and elevated temperatures in the downstream tributaries. Additionally, some larger spring flow events have altered habitat in the estimate site. The relatively stable spawning since 2006 (Table 16) generally appears to have a positive influence on juvenile densities.

Table 6. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of West Fisher Creek, 2002 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
West Fisher Creek	2002	37	+/- 2	0.75	2.0
	2003	9	+/- 2	0.81	0.6
	2004	5	+/- 1	0.83	0.3
	2005	2	No Recaptures		0.1
	2006	8	+/- 3	0.73	0.4
	2007	31	+/- 5	0.77	1.6
	2008	3	+/- 1	0.75	0.1
	2009	31	+/- 1	0.91	1.6
	2010	9	+/- 1	0.90	0.4
	2011	17	+/- 1	0.90	0.7
	2012	54	+/- 12	0.71	2.3
	2013	13	+/- 2	0.81	0.6
	2014	18	+/- 2	0.82	0.8
	2015	18	+/- 1	0.86	0.8
	2016	21	+/- 2	0.66	1.0
	2017	1	No Recaptures		0.05

Bear Creek

The Bear Creek fish abundance section is centered on the FS 278 bridge. The section has varied in length from 132 to 213 meters due to changes caused by spring flows and downfall from wind events. This is a relatively stable stretch of stream although there have been some pool changes. Densities of juvenile bull trout increased substantially between 1999 and 2002 (Table 7). We believe the dramatic decrease in 2002, 2004, 2005 through 2008 were caused by low water. The low juvenile estimate in 2016 was likely a result of a 20+ year rain on snow event in December 2015. Several sections of Libby Creek, to which Bear Creek is a tributary, dried by late July in 2001. Water years and juvenile estimates have generally improved since 2008. Montana Fish, Wildlife & Parks special projects is working with private, corporate and public landholders to reconstruct portions of Libby Creek in hopes that the complete loss of stream flow during low water years can be minimized. Stream rehabilitation is a slow and laborious process that can take 10's of years. Another issue that has surfaced in recent years is the dramatic increased densities of the algae *Didymosphenia geminata* in the spawning/rearing reaches of Bear Creek. Survey of the algae and its potential impacts should be a priority.

Table 7. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of Bear Creek, 1999 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
Bear Creek	1999	101	+/- 9	0.73	8.5
	2000	103	+/- 3	0.87	12.1
	2001	80	+/- 9	0.72	14.0
	2002	67	+/- 3	0.85	6.2
	2003	108	+/- 10	0.79	8.4
	2004	46	+/- 7	0.77	2.6
	2005	79	+/- 18	0.69	3.8
	2006	73	+/- 7	0.75	3.5
	2007	17	+/- 1	0.94	1.3
	2008	8	+/- 1	0.89	0.4
	2009	39	+/- 13	0.66	2.4
	2010	128	+/- 24	0.70	7.4
	2011	119	+/- 15	0.68	5.6
	2012	108	+/- 13	0.69	5.4
	2013	82	+/-7	0.77	5.2
	2014	114	+/- 17	0.65	6.0
	2015	130	+/- 18	0.78	10.4
	2016	46	+/- 5	0.77	2.7
	2017	84	+/- 9	0.72	5.2

O’Brien Creek

O’Brien Creek is one of two tributaries below Kootenai Falls in Montana that support bull trout spawning and rearing from the Kootenai River. The O’Brien Creek fish abundance section was initially centered on the FS 331 bridge above Rabbit Creek. The section remained stable at 140 meters from1998 through 2005. This was a relatively stable stretch of stream with little change in pools from year to year. Densities of juvenile bull trout decreased dramatically between 1998 and 2002 and remained extremely low through 2005 (Table 8). We could not do estimate in 2002 or 2005 because we got no recaptures. In 2006 we moved the section downstream to be centered on the 4445 road near Lynx Creek.

Table 8. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of O’Brien Creek, 1998 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
O’Brien Creek	1998	91	+/- 4	0.84	13.2
	1999	29	+/- 1	0.88	4.2
	2000	21	+/- 7	0.66	3.0
	2001	11	+/- 2	0.61	1.6
	2002	2	No Recaptures		0.3
	2003	5	+/- 1	0.83	0.5
	2004	16	+/- 1	0.89	2.1
	2005	2	No Recaptures		0.3
	2006*	31	+/- 1	0.97	3.3
	2007	5	0	1.0	0.5
	2008	11	+/- 1	0.92	1.1
	2009	5	+/- 0	1.00	0.5
	2010	8	+/- 2	0.80	0.7
	2011	7	+/- 1	0.88	0.6
	2012	2	No Recaptures		0.2
	2013	9	+/-2	0.82	0.8
	2014	3	No Recaptures		0.3
	2015	1	No Recaptures		0.1
	2016	1	No Recaptures		0.1
	2017	No bull trout captured			

*Juvenile bull trout estimate section was moved downstream due to beaver encroachment.

We believe that the decrease in juvenile densities was caused by a combination of an encroaching beaver population high fines sediments and low water. Redd counts remained relatively stable over this time but the distribution of redds shifted downstream because beaver dams have caused very high sedimentation in traditional spawning areas. Additionally, estimates of resident brook trout have decreased substantially since 2005 while westslope cutthroat trout and rainbow trout were similar throughout the survey years (unpublished data). The juvenile estimates continue to remain low regardless of redd counts.

Keeler Creek

Bull trout that spawn in Keeler Creek (including the North, South and West Forks) are adfluvial fish that migrate downstream out of Bull Lake into Lake Creek, then upstream into Keeler Creek. This downstream spawning migration is unique when compared to other bull trout populations (Montana Bull Trout Restoration Team 1996a). A micro-hydropower dam constructed in 1916 and a series of high gradient waterfalls on Lake Creek are barriers to all upstream fish passage. Keeler Creek likely supplies some recruitment to the Kootenai River through one-way downstream migration.

The Keeler Creek fish abundance section located approximately 1 mile below North Fork Keeler Creek. The section lengths remained relatively constant between 192 and 214 meters. This was a relatively stable stretch of stream with little change in pools from year to year. The top of the section is controlled by a rock out crop and the bottom is a stable pool. In December 2015 a rain on snow event altered the channel shape filling in the two prominent pools. Densities of juvenile bull trout remained very stable between 1999 and 2002 (Table 9). The estimates in 1998 and 2010 were exceptions. We captured considerably more bull trout than other years. One explanation might be that the flows were very high that year and more juveniles passed into this stable section that includes two large pools. Low estimates since 2010 likely reflect low water and beaver activity and a slow deterioration of quality spawning habits. Recent illegal introductions of northern pike and smallmouth bass into Bull Lake are expected to have negative effects to the bull trout population.

Table 9. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of Keeler Creek, 1998 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
Keeler Creek	1998*	159	+/- 50	0.33	7.7
	1999	65	+/- 16	0.69	3.3
	2000	61	+/- 41	0.42	3.1
	2001*	66	+/- 12	0.50	3.0
	2002	74	+/- 13	0.73	3.9
	2003	63	+/- 11	0.74	3.4
	2004	27	+/- 2	0.84	1.4
	2005	18	+/- 1	0.95	1.1
	2006	32	+/- 2	0.87	1.6
	2007	38	+/- 1	0.93	2.4
	2008	27	+/- 2	0.97	1.4
	2009	85	+/- 13	0.75	4.7
	2010	109	+/- 10.2	0.80	6.1
	2011	No estimate due to high flows late into year.			
	2012	29	+/-4	0.78	1.7
	2013	57	+/-9	0.69	3.1
	2014	28	+/-2	0.85	1.5
	2015	22	+/-1	0.88	1.4
	2016	21	+/-1	0.88	1.3
	2017	25	+/-2	0.84	1.5

*Three pass estimates.

Callahan Creek

The Callahan Creek fish abundance section is located on North Callahan Creek just above the confluence with South Callahan Creek and is located above the FS 414 Bridge. The section has varied in length from 154 m to 183 meters due to spring flows and downfall from wind events. We chose North Callahan Creek rather than mainstem Callahan Creek because we found the majority of redds from year to year are above that tributary and logistics of access to mainstem was difficult at best. Densities of juvenile bull trout are quite variable in this section (Table 10). There was a 20+ year flood event during November of 2006 and high flows in 2011and 2015 that may have affected population densities in succeeding years. Idaho Fish and Game has monitored redds for this stream and MFWP will continue to track juvenile estimates.

Table 10. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of North Callahan Creek, 2003 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#/100m^2)
Callahan Creek	2003	10	+/- 1	0.83	0.7
	2004	43	+/- 4	0.82	2.4
	2005	35	+/- 4	0.79	2.2
	2006	11	+/- 3	0.85	0.6
	2007	4	+/- 1	0.80	0.2
	2008	Caught 11 bull trout all less than 70 mm (young-of-year)			
	2009	11	+/- 1	0.92	0.5
	2010	40	+/- 2	0.87	1.7
	2011	No estimate due to high flows late into year.			
	2012	12	+/- 1	0.86	0.5
	2013	25	+/-2	0.83	1.0
	2014	18	+/-1	0.90	0.7
	2015	41	+/-3	0.82	2.1
	2016	1	0	1.0	0.1
	2017	No Bull Trout Captured			

Libby Creek Upstream of Libby Falls

The Libby Creek fish abundance section is located above Libby Falls below the Montenore mine site. We have monitored bull trout abundance at this site since 2003 and the section has remained at 152 - 183 meters. This population is an isolated resident population separated from upstream movement by Libby Falls (approximately 60 ft). The estimate has included resident adults (near 350 mm). Densities of bull trout have remained relatively stable from 2003 to 2015 (Table 11). It is possible that the population decrease since 2015 is related to a 20-year rain-on-snow event in December 2015. We will continue to monitor this unique population as it is downstream of a proposed adit mine and the United States Fish and Wildlife Service through their Biological Opinion has proposed to move portions of this population to repopulate other streams as part of mitigation for the proposed mine and apply stream reconstruction to a portion of Libby Creek upstream of the juvenile estimate site.

Table 11. Population estimates (N), 95 percent confidence intervals (95% C.I.), probability of first pass capture (p) and densities for Age 1 and older bull trout calculated from electrofishing in the permanent section of Libby Creek, 2003 - 2017.

Stream	Year	N	95 % C.I.	p	Density (#100/m^2)
Libby Creek Above Libby Falls	2003	27	+/- 2	0.90	3.0
	2004	No estimate			
	2005	55	+/- 8	0.72	5.2
	2006	24	+/- 5	0.77	2.3
	2007	25	+/- 8	0.63	2.1
	2008	33	+/- 3	0.89	2.4
	2009	90	+/- 28	0.63	6.0
	2010	77	+/- 7	0.82	5.8
	2011	41	+/- 7	0.75	2.8
	2012	48	+/- 5	0.77	3.3
	2013	63	+/-9	0.71	4.5
	2014	36	+/- 2	0.86	2.3
	2015	64	+/- 9	0.77	4.3
	2016	33	+/- 6	0.72	2.6
	2017	23	+/- 2	0.89	2.0

STREAMBED CORING

Successful egg incubation and fry emergence are dependent on gravel composition, gravel permeability, water temperature, and surface flow conditions. The female trout begins redd construction by digging an initial pit or depression in the streambed gravel with her tail. After the spawning pair deposits eggs and sperm into this area, the female moves upstream a short distance and continues the excavation, covering the deposited eggs. The process is then repeated several more times, resulting in a series of egg pockets formed by the upstream progression of excavations. The displaced gravel mounds up, covering egg pockets already in place. After egg deposition is complete the female creates a large depression at the upstream edge of the redd. This enhances intra-gravel flow and displaces more gravel back over the entire spawning area. Excavation of the redd causes fine sediments and organic particles to be washed downstream, leaving the redd environment with less fine material than the surrounding substrate. Weather, streamflow, and transport of fine sediment and organic material in the stream can change conditions in redds during the incubation period. Redds can be disturbed by other spawning fish, animals, human activities, or by high flows which displace streambed materials (Chapman 1988).

Redd construction by migratory bull trout in the Flathead drainage disturbs the streambed to a depth of at least 18.0 to 25.0 cm (Weaver and Fraley 1991). Egg pockets of smaller fish (brook trout) tend to be shallower. The maximum depth of gravel displacement is indicative of egg deposition depth (Everest et al. 1987). Freeze coring documented larger substrate particles (up to 15.2 cm) at the base of egg pockets than in overlying substrates (Weaver and Fraley 1991). These particles are likely too large for the female to dislodge during redd construction. Eggs are deposited and settle around these larger particles (Chapman 1988). Continued displacement of streambed materials by the female then covers the eggs.

Redds become less suitable for incubating embryos if fine sediments and organic materials are deposited in interstitial spaces of the gravel during the incubation period. Fine particles impede movement of water through the gravel, thereby reducing delivery of dissolved oxygen to, and flushing of metabolic wastes away from incubating embryos. This results in lower survival (Wickett 1958; McNeil and Ahnell 1964; Reiser and Wesche 1979). For successful emergence to occur fry need to be able to move within the redd, but high levels of fine sediment can restrict their movements (Koski 1966; Bjornn 1969; Phillips et al. 1975). In some instances, embryos that incubate and develop successfully can become entombed (trapped by fine sediments). Sediment levels can alter timing of emergence (Alderdice et al. 1958; Shumway et al. 1964) and affect fry condition at emergence (Silver et al. 1963; Koski 1975).

Measurements of the size range of materials in the streambed are indicative of spawning and incubation habitat quality. In general, research has shown negative relationships between fine sediment and incubation success for salmonids that construct redds (Chapman 1988). A significant inverse relationship exists between the percentage of fine sediment in substrates and survival to emergence of westslope cutthroat trout and bull trout embryos in incubation tests (Weaver and White 1985; Weaver and Fraley 1991, 1993). Mean adjusted emergence success ranged from about 80 percent when no fine material was present, to less than 5 percent when half of the incubation gravel was smaller than 6.35 mm; about 30 percent survival occurs at 35 percent fines. Entombment was the major mortality factor.

Median percentages of streambed materials smaller than 6.35 mm at fry emergence ranged from 24.8 to 50.3 percent in 29 separate bull trout spawning areas sampled during the Flathead Basin Forest Practice Water Quality and Fisheries Study (Weaver and Fraley 1991). Linear regression of results against output from models assessing ground disturbing activity and water yield increases in these 29 Flathead Basin tributary drainages showed significant positive relationships (Weaver and Fraley 1991). These results demonstrate a linkage between on-the-ground activity and spawning habitat quality. This testing allowed development of models that predict embryo survival to emergence, given the percentage of material smaller than 6.35 mm in the incubation environment. We monitor bull trout spawning and incubation habitat quality by determining the percent fines in each spawning area through hollow core sampling across years.

Methods

Field crews used a standard 15.2 cm hollow core sampler (McNeil and Ahnell 1964) to collect four samples at each of three sites at each study area. We located actual coring sites at the transects using a stratified random selection process. The total width of stream having suitable depth, velocity, and substrate for spawning was visually divided into four equal cells. We randomly took one core sample in each cell. In some study areas we deviated from this procedure due to limited or discontinuous areas of suitable spawning habitat. We selected study areas based on observations of spawning. We only sampled in spawning areas used by adfluvial and fluvial bull trout. During this study, bull trout spawned in the same general areas, so sampling locations remained similar.

Sampling involved working the corer into the streambed to a depth of 15.2 cm. We removed all material inside the sampler and placed it in heavy duty plastic bags. We labeled the bags and transported them to the Kootenai National Forest Soils Laboratory in Libby, Montana, for gravimetric analysis. We sampled the material suspended in water inside the corer using an Imhoff settling cone (Shepard and Graham 1982). We allowed the cone to settle for 20 minutes before recording the amount of sediment per liter of water. After taking the Imhoff cone sample, we determined total volume of the turbid water inside the corer by measuring the depth and referring to a depth to volume conversion table (Shepard and Graham 1982).

The product of the cone reading (ml of sediment per liter) and the total volume of turbid water inside the corer (liters) yields an approximation of the amount of fine sediment suspended inside the corer after sample removal. We than applied a wet to dry conversion factor developed for Flathead tributaries by Shepard and Graham (1982), yielding an estimated dry weight (g) for the suspended material.

We oven dried the bagged samples and sieve separated them into 13 size classes ranging from >76.1 mm to <0.063 mm in diameter (Table 12). We weighed the material retained on each sieve and calculated the percent dry weight in each size class. The estimated dry weight of the suspended fine material (Imhoff cone results) was added to the weight observed in the pan, to determine the percentage of material <0.063 mm.

Table 12. Mesh size of sieves used to gravimetrically analyze hollow core streambed substrate samples collected from Kootenai River basin tributaries.

76.1 mm	(3.00 inch)
50.8 mm	(2.00 inch)
25.4 mm	(1.00 inch)
18.8 mm	(0.74 inch)
12.7 mm	(0.50 inch)
9.52 mm	(0.38 inch)
6.35 mm	(0.25 inch)
4.76 mm	(0.19 inch)
2.00 mm	(0.08 inch)
0.85 mm	(0.03 inch)
0.42 mm	(0.016 inch)
0.063 mm	(0.002 inch)
Pan	(<0.002 inch)

We refer to each set of samples by using the median percentage <6.35 mm in diameter. This size class is commonly used to describe spawning gravel quality, and it includes the size range typically generated during land management activities. We examined the range of median values for this size class observed throughout the survey area.

Findings

Core sampling in indicator streams generally has been consistent since 2002 although there have been sites and years where stream conditions prevented sampling (Table 13). The current standard for assessing impairment of streams due to increase in sediments continues to be based on fine sediment (<6.35 mm). Weaver and Fraley (1991) found that survival is reduced to one-third when fine sediments reach 35 percent and at 40 percent the survival drops to one-quarter.

Median fines from most of the index streams showed quite variable but relatively stable fine sediment levels that remain less than 35 percent. Two exceptions are O'Brien Creek and Pipe Creek. Both have been impacted by extra activities in the past several years. O'Brien has increased redd counts but decreased juvenile abundances. This is not surprising when viewed in context of the percentage of fine sediments and substrate scores (Tables 13 and 15, respectively). As was mentioned previously, beavers have become well established in the upper end of O'Brien Creek and are migrating downstream. Relative to other streams in the drainage, O'Brien Creek appears to be a high fine sediment system at the upper end with a large amount of low gradient tortuous stream immediately above the historic spawning areas. Fine sediments may be held back from flushing during high water events and the additional daily activity of the beavers throughout the lower water may release more fine sediments into the stream. Pipe Creek also has low survival of bull trout from egg to juvenile and has similar conditions as O'Brien Creek.

The sediment characteristic in the Wigwam River drainage like most of the bull trout drainages in the Kootenai River basin is a product of natural and anthropogenic disturbances through history. Heavy logging activities in both Montana and British Columbia drainages and 100-year and 200-year flood events have shaped the system in the last 50 years. Oliver and Cope (1999) suggested that "…Frequent lateral channel migrations over time have resulted in erosion of adjacent terraces, coarse sediment delivery to the mainstem river, and have created numerous section of braided channel comprised of sorted gravels and cobbles that provide prime spawning habitat for bull trout". Tepper (2002) found that between 1998 and 2002 the average median of fine sediments (<6.35 mm) increased from 26.5 to 31.7 from the upstream (Montana portion) to downstream (Bighorn Creek) survey sites. It would be advisable to continue monitoring this important tributary as land management activities continue.

Table 13. Median percentage of streambed material smaller than 6.35 mm in McNeil core samples collected from bull trout spawning areas in tributary streams to the Kootenai River basin, 2002 – 2017.

Stream	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Grave Creek	29.8	28.2	27.4	23.5	23.6	*	31.5	28.0	29.5	24.5	25.6	26.1	29.1	22.3	25.9	*
West Fork Quartz Creek	27.0	26.4	30.6	24.3	26.3	*	29.5	21.3	24.7	28.9	23.1	25.7	*	24.4	23.7	*
Pipe Creek	32.1	35.3	29.7	34.6	28.8	*	23.9	29.8	35.3	30.3	28.5	32.7	32.3	27.7	31.6	*
Bear Creek	27.5	22.0	34.3	34.7	31.3	*	17.1	26.7	25.0	25.2	32.6	29.2	25.0	28.0	14.6	*
O'Brien Creek	31.5	35.3	34.8	39.8	32.5	30.5	23.4	29.5	27.9	34.5	31.1	30.8	28.7	*	30.1	*
North Fork Keeler Creek	26.9	33.1	29.8	27.3	19.9	23.1	19.0	28.0	29.5	24.5	25.6	26.1	22.5	18.1	11.5	*
Wigwam River U.S.			29.6	24.8	26.8	25.9	21.1	27.7	28.1	*	24.9	*	27.8	*	30.0	*
West Fisher Creek					27.1	*	11.4	31.1	26.8	31.5	29.5	31.4	31.5	17.5	*	*

* Coring not accomplished on these years

SUBSTRATE SCORING

Environmental factors influence distribution and abundance of juvenile bull trout within drainages throughout the range of the species, as well as within specific stream segments (Oliver 1979, Allan 1980, Leathe and Enk 1985, Pratt 1985, Fraley and Shepard 1989, Ziller 1992). Temperature, cover, and water quality regulate general distributions and abundances of juvenile salmonids within drainages. Depth, velocity, substrate, cover, predators, and competitors affect juvenile presence at specific locations in a stream. Although spawning occurs in limited portions of the drainage, juvenile salmonids disperse to occupy most of the areas within the drainage that are suitable and accessible (Everest 1973; Leider et al. 1986).

Juvenile bull trout rear for up to four years in Kootenai Basin tributaries. Snorkel and electrofishing observations during past studies indicate juvenile bull trout are extremely substrate-oriented and can be territorial (Fraley and Shepard 1989). This combination of traits results in partitioning of suitable rearing habitat and a carrying capacity for each stream. We monitor substrate-related habitat potential by calculating substrate scores (Leathe and Enk 1985).

Substrate composition influences distribution of juvenile bull trout and rearing capacities of nursery streams. Sediment accumulations reduce pool depth, cause channel braiding or dewatering, and reduce interstitial spaces among larger streambed particles (Megahan et al. 1980, Shepard et al. 1984, Everest et al. 1987). Juvenile bull trout are almost always found in close association with the substrate (McPhail and Murray 1979, Shepard et al. 1984, Weaver and Fraley 1991). A significant positive relationship existed between substrate score and juvenile bull trout densities in Swan River tributaries (Leathe and Enk 1985) and Flathead River tributaries (Weaver and Fraley 1991), where a high substrate score was indicative of large particle sizes and low score of embeddedness (Crouse et al. 1981). This relationship is thought to reflect substrate types favoring over winter survival (Pratt 1984, Weaver and Fraley 1991).

A substrate score is an overall assessment of streambed particle size and embeddedness. Large particles that are not embedded in finer materials provide more interstitial space that juvenile bull trout favor. This situation generates a higher substrate score. Low substrate scores occur when smaller streambed particles and greater embeddedness limit the interstices within the streambed.

Linear regression of substrate scores against output from a model assessing ground disturbing activity in 28 Flathead Basin tributary drainages showed a significant negative relationship. Researchers also obtained a significant negative relationship between substrate scores and output from a model predicting increases in water yields (Weaver and Fraley 1991). These results demonstrate a linkage between ground disturbance and increased water yield and streambed conditions. Linear regression of juvenile bull trout density against substrate scores in 15 Flathead Basin streams showed a significant positive relationship (Weaver and Fraley 1991). This showed a strong linkage between streambed condition as measured by substrate scoring and actual juvenile bull trout abundance.

Methods

Substrate scoring involves visually assessing the dominant and subdominant streambed substrate particles, along with embeddedness across transects. Surveyors assign a rank to both the dominant and subdominant particle size classes in each cell (Table 14). They also rank the degree to which the dominant particle size is embedded (Table 14). The three ranks are summed, obtaining a single variable for each cell. A mean of all transects in a section results in the substrate score.

Table 14. Characteristics and ranks for computing substrate scores (modified by Leathe and Enk 1985 from Crouse et al. 1981).

Rank	Characteristic
	Particle Size Class[1]
1	Silt and/or detritus
2	Sand (<2.0 mm)
3	Small gravel (2.0-6.4 mm)
4	Large gravel (6.5-64.0 mm)
5	Cobble (64.1-256.0 mm)
6	Boulder and/or bedrock (>256.0 mm)
	Embeddedness
1	Completely embedded or nearly so (75% - 100%)
2	50% - 75% embedded
3	25% – 50% embedded
4	5% – 25% embedded
5	Unembedded

[1]Used for both dominant and subdominant particle ranking

We obtained the substrate scores using ten equally spaced transects in the juvenile bull trout abundance sections. Again, lower scores indicate poorer quality rearing habitat; higher values indicate good conditions.

Findings

We began collecting substrate scores in 1998 and collected them only sporadically until 2002 (Table 15). In general, embedded substrate is not an overriding factor in Kootenai drainage index streams. We did combine all Kootenai drainage bull trout streams to compare juvenile bull trout population estimates to substrate scores. We found a positive correlation but it was not significant ($P>>0.1$). In the case individual streams, because of limited sampling (only in juvenile estimate sections), a whole stream quality assessment was not possible.

For the most part, the scores from most of the streams continue to compare favorably with Flathead River basin streams where Flathead Basin Cooperative Forest Practice Study determined that scores of 10.0 or less threatened juvenile bull trout rearing capacity and scores 9.0 or less impaired rearing capacities (Deleray et al. 1999).

Though O'Brien Creek improved since 1998 it continues to lag behind most core streams in juvenile bull trout abundance, especially considering the relatively high number of redds that are produced each year (Table 16). We changed our population estimate site in 2006 to determine if location reflected the population structure in O'Brien Creek or some other factor (environmental or biological) was responsible for this apparent lack of recruitment; capture was still poor. Fine sediments appear to negatively impact bull trout survival from egg to juvenile in O'Brien Creek. Substrate scores in Keeler Creek dropped substantially in 2016 and 2017 quite probably due to the December 2015 rain-on-snow event.

Table 15. Summary of Kootenai Drainage substrate scores the stream sections monitored at juvenile population estimate sites in Kootenai River basin stream, 1998 - 2017.

Stream	1998	1999	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Grave Creek	13.4		13.2	14.3	13.8	12.8	13.9	13.2	13.1	13.8	12.7	*	12.4	13.2	14.9	15.8	14.8	*
West Fork Quartz Creek	13.2		13.2	13.3	14.5	14.1	14.1	13.4	13.9	14.5	15.5	14.4	14.6	12.6	14.7	14.6	15.8	13.5
Pipe Creek	13.0	14.0	13.7	12.3	12.1	12.9	12.8	14.1	12.4	12.7	12.8	12.4	14.1	12.4	13.2	*	14.1	14.6
Bear Creek		13.0	13.6	14.6	13.8	13.7	13.5	15.5	13.9	13.9	13.0	12.4	12.6	12.2	14.4	15.1	13.4	14.6
West Fisher Creek			13.1	13.8	12.9	14.1	13.3	15.1	13.3	13.8	14.0	12.0	14.6	13.7	14.7	14.6	12.0	14.5
O'Brien Creek	11.5	12.2	10.6	11.9	10.9	11.8	12.3	12.8	12.7	13.1	12.4	13.3	12.8	13.3	13.8	13.8	10.5	9.5
Keeler Creek	12.8	14.4	12.4	13.2	15.5	13.4	14.1	15.5	15.0	15.2	14.3	*	13.4	13.5	15.6	15.2	13.8	12.3
Callahan Creek				14.5	15.5	13.9	14.1	14.0	14.8	14.9	15.1	*	14.9	14.2	14.9	15.6	13.7	12.6
Libby Creek above falls				14.3		13.6	13.4	15.2	12.8	13.7	13.1	13.1	12.9	14.8	14.0	11.3	15.4	14.4

BULL TROUT REDD COUNTS

A reliable survey of annual spawner escapement is a valuable element of any fisheries monitoring program. These data are frequently used as measures of anticipated production in succeeding generations. They also provide an index of success in regulating the fishery. Observations during past studies indicate that migratory fish populations in the Kootenai System consistently use the same stream sections for spawning. Similar findings resulted from spawning site surveys in the Flathead and Clark Fork River drainages (Montana Fish, Wildlife & Parks, Kalispell, unpublished file data; MBTSG 1996b, 1996c). As a result of specific spawning habitat requirements, the majority of bull trout spawning is clustered in a small portion of the available habitat, making these areas critical to bull trout production.

Field crews annually monitor the number of spawning sites (redds). These counts provided information on trends in escapement into upper basin tributaries and allowed us to choose sampling locations for other monitoring activities. Timing of salmonid spawning has likely evolved in response to seasonal changes in water temperature (Bjornn and Reiser 1991). Initiation of spawning by bull trout appears to be strongly related to water temperature, although photoperiod and streamflow may also be factors (Shepard et al. 1984). Most bull trout spawn between late August and early November (McPhail and Murray 1979; Oliver 1979; Shepard et al. 1984; Pratt 1985; Brown 1992; Ratliff 1992). Spawning in the Flathead drainage (Fraley and Shepard 1989) and in Mackenzie Creek, British Columbia (McPhail and Murray 1979), began when daily maximum water temperatures declined to 9-10^{o} C. Spawning takes place primarily at night (Heimer 1965; Weaver and White 1985), but has been observed during daylight hours (Needham and Vaughan 1952; personal observations).

Bull trout spawning typically occurs in areas influenced by groundwater (Allan 1980; Shepard et al. 1984; Ratliff 1992; Fraley and Shepard 1989). Such areas tend to remain open in the Kootenai drainage during harsh winter conditions, while adjacent stream sections ice over or contain extensive accumulations of anchor ice. Recent investigations in the Swan River drainage found that bull trout spawning site selection occurred primarily in stream reaches that were gaining water from the subsurface, or in reaches immediately downstream of upwelling reaches (Baxter 1997).

Reaches used by spawning adults typically have gradients less than 2 percent (Fraley and Shepard 1989). Water depths at the upstream edges of 80 redds of migratory bull trout in the Flathead drainage ranged from 0.1 to 0.6 m and averaged 0.3 m; water velocities (at 0.6 of the depth below the surface) ranged from 0.09 to 0.61 m/s and averaged 0.29 m/s (Fraley et al. 1981). Similar mean depths (0.3 m) and water velocities (0.31 m/s) at migratory bull trout redds were documented in the Swan River drainage (Kitano et al. 1994).

Migratory bull trout redds ranged from 1.0 to 3.1 m in length (mean 2.1 m) in tributaries of the North and Middle forks of the Flathead River (n=465); width of these redds ranged from 0.8 to 1.5 m and averaged 1.1 m (Fraley et al. 1981). These dimensions are comparable to redds created by fluvial and adfluvial bull trout in the Kootenai drainage.

Areas in which redds are counted on a routine basis are called “index” areas. In some cases these index surveys continue to an upstream barrier. It is important to establish upper and lower limits of index areas. Through repeated annual index surveys we obtain valuable trend information to use in monitoring bull trout populations. Detection of trends will often require at least 10 years of monitoring index areas (Rieman and Meyers 1997).

Methods

We conducted preliminary surveys to determine appropriate timing for final counts. During a basin-wide count we surveyed all habitat that appeared suitable for bull trout spawning (as described above). From this basin-wide survey, index areas were identified for annual surveys. We began final inventories after we observed completed redds, few adult fish, and little evidence of active spawning during the preliminary surveys. Timing of final counts is critical, because as redds age, they lose the characteristic cleaned or bright appearance becoming more difficult to identify. Also, as winter approaches, fall freshets are common in the Kootenai drainage and can wipe out traces of redds if flows get high enough.

We surveyed the Wigwam River (US portion), West Fisher, Grave, Quartz, Bear (tributary to Libby Creek), Keeler, Pipe, Callahan and O’Brien Creeks. MFWP, Idaho Fish and Game and U.S. Forest Service (USFS) personnel walked streams in the United States and personnel from the British Columbia Ministry of Water, Land, and Air Protection walked the Wigwam River and associated tributaries. We visually identified redds by the presence of a pit or depression and associated tail area of disturbed gravel. If timing was correct, identification of redds presented little problem. We classified redds differently than in the Flathead. We counted redds only if they were positively identified. We did not include “probable redds” in our counts. We felt that our crews were well trained and confident enough to assess redds as existing or not. We used linear regression to assess population trends.

Findings
Grave Creek

MFWP counted redds in the Grave Creek Basin (including Blue Sky, Clarence, Williams and Lewis Creeks) for the first time in 1983, as well as in 1984, 1985, and 1993 through 2004. Grave Creek was surveyed from its confluence with the Tobacco River upstream to near the mouth of Lewis Creek (approximately13 miles), where it becomes intermittent. Most redds in Grave Creek were located upstream from the mouth of Clarence Creek to the confluence with Lewis Creek. MFWP found 10 redds between the confluence with the Tobacco River and one mile below Clarence Creek in 1983. However, we did not find redds in this reach during surveys conducted in 1993 and 2000. The distributions of bull trout redds in Blue Sky Creek, and Clarence Creek were similar to observations in previous years (Hoffman et al. 2002).

We observed the largest number (245) of bull trout redds in Grave Creek in 2003. Between 2003 and 2014 counts exhibited significant negative trend (Figure 4). These trends are similar to Wigwam redd counts (Figure 5) and similar mean bull trout per net caught during spring sets (Table 16 and Figure 13). There is indication that the bull trout harvest regulation may have influenced redd count trends for Grave Creek.

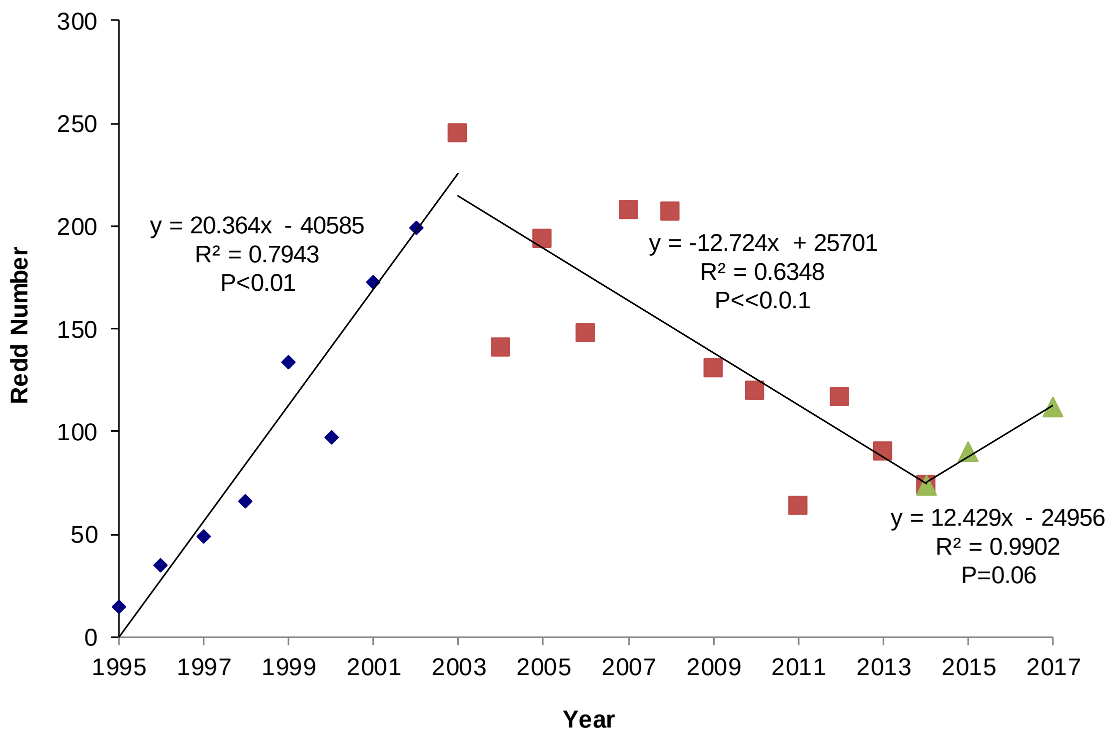

Figure 4. Bull trout redd counts and trend analysis for Grave Creek (including Clarence and Blue Sky Creek) 1995-2017.

Table 16. Summary of Kootenai Drainage bull trout spawning site inventories from 1993 - 2013 in the stream sections monitored Annually (note many redd counts in 2016 were not conducted due to high fall flows).

Stream	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
O'Brien Creek	22	12	36	47	37	34	47	45	46	51	86	65	77	79	40	27	32	18	35	34	22	35	35
Pipe Creek	5	17	26	34	36	30	6	11	10	8	2	6	0	4	9	16	2	12	8	8	0	0	2
Bear Creek	6	10	13	22	36	23	4	17	14	6	3	14	9	14	6	8	3	4	8	11	7	4	1
West Fisher Creek	3	4	0	8	18	23	1	1	1	13	27	4	18	6	8	12	3	5	4	14	4		8
Grave Creek		24	42	52	85	87	131	156	173	102	153	118	166	170	55	102	51	82	55	56	84		85
Clarence Creek		5	6	13	39	9	29	38	52	29	32	22	42	27	24	9	10	23	20	13	6		17
Blue Sky Creek		6	1	1	10	1	13	5	20	10	9	8	0	10	8	9	3	12	15	5	0		10
Grave Drainage Total		35	49	66	134	97	173	199	245	141	194	148	208	207	87	120	64	117	90	74	90		112
Quartz Creek	41	9	30	33	14	52	45	52	29	8	25	23	20	14	18	12	7	14	4	5	17	10	9
West Fork Quartz Creek	26	42	39	72	88	39	109	10	26	41	46	28	15	32	13	27	30	4	10	19	5	6	18
Quartz Drainage Total	67	47	69	105	102	91	154	62	55	49	71	51	35	46	31	39	37	18	14	24	22	16	27
Keeler Creek		74	25	39	42	3	11	27	61	53	85	52	50	32	24	45	29	23	3	13	14		12
North Fork Keeler Creek			18	43	52	82	4	75	26	30	45	59	30	22	0	19	29	32	21	14	4		6
South Fork Keeler Creek			16	10	5	5	0	0	0	43	40	31	4	8	0	11	10	16	9	7	0		0
Keeler Drainage Total		74	59	92	99	90	15	102	87	126	170	142	84	62	24	75	68	71	33	34	18		18
North Callahan Creek									32	17	12	29	0	14	10	9	1	6	9	7	1		6
South Callahan Creek									10	8	8	4	3	1	0	1	2	0	2	0	0		0
Callahan Drainage Total									40	25	20	33	3	15	18	10	3	6	11	7	1	0	6
Wigwam River (B.C.)	247	500	581	673	838	1186	1477	1881	2043	2106	635	2285	1850	1827	1567	1114	1198	1367	1441	1420	1601	1561	1607
Wigwam River (U.S.)		12	17	6	21	9	19	11	10	27	7	13	33	6	8	4	8	3	6	7	1		5
Wigwam Drainage Total	247	512	598	679	849	1195	1496	1892	2053	2133	642	2298	1883	1833	1575	1118	1206	1370	1447	1427	1602	1561	1612
Skookumchuk River (B.C.)			66	105	161	189	132	143	134	140	111	163	144	137	64	112	86	100	78	121	182	101	200
White River (B.C.)							166	153	143	93	137	167	193	137	112	122	206	182	124	335	340	449	368
Blackfoot Creek (B.C.)								108	96	91	106	144	73	73	0	7		65		92	58		116
Kootenai Total	350	711	916	1158	1472	1772	2194	2733	2924	2876	1569	3235	2727	2613	1974	1666	1710	1968	1852	2181	2346	2166	2505

Wigwam Drainage

Bull trout redd counts for the Wigwam River includes the tributary streams of Bighorn, Desolation, and Lodgepole creeks, and the portion of the Wigwam River within Montana. A large flood event caused a landslide to partially block the Wigwam downstream of the traditional redds count area in 2005. It was obviously a partial barrier for that year and has been passable since. A total of 1916 and 1839 bull trout redds were observed in the Wigwam Drainage in 2007 and 2008, respectively. This was the first time since 1995 in which counts were not higher than the previous year (Figure 5). Anglers have been allowed to harvest bull trout from Koocanusa since 2004. Redds counts continued to decline and in 2010 MFWP reduced harvest to one bull trout annually. Then in 2012 harvest was eliminated and the bull trout fishery remained catch-and-release until 2016 when 1 one bull trout harvest per year was re-instituted. Regardless of other natural or anthropogenic factors, bull trout angling, both in Montana and British Columbia appears to have a pronounced effect on redd counts in the Wigwam drainage.

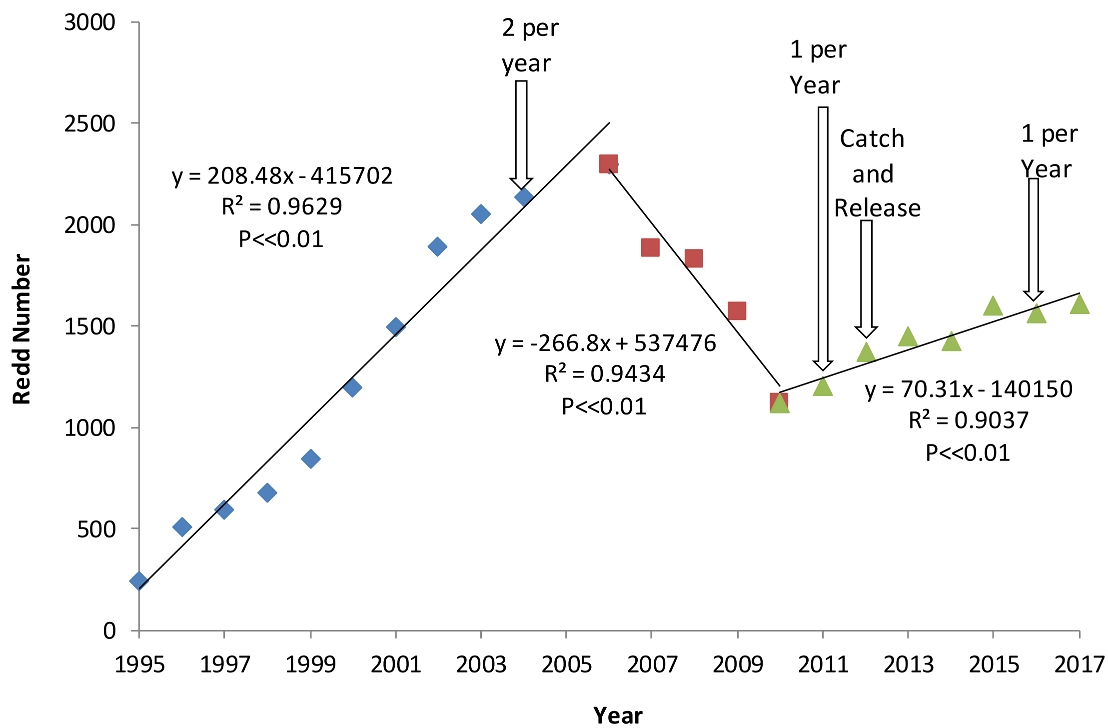

Figure 5. Bull trout redd counts and trend analysis for the Wigwam River (including Bighorn, Desolation, and Lodgepole creeks) 1995-2017.

Quartz Creek

Bull trout redd counts in Quartz Creek between 1989 and 2001 were variable but the trend was positive and significant (Figure 6). Between 2001 and 2013 the trend was negative and significant. We observed a total of 14 redds in Quartz and West Fork Quartz creeks in 2013 (Table 1). The average number of redds of the period of record was 60 redds. The 2013 observation of 14 redds was 23.3% of the average over the period of record and redd counts stabilized at much lower numbers since. Several log jams located upstream of the confluence of West Fork Quartz Creek may have limited bull trout spawner escapement during these years. One log jam was removed prior to adult bull trout upstream migration in 2004. Additionally, using genetic analysis, Dehaan and Adams (2011) found that greater than 50 percent of bull trout downstream of Libby Dam originated upstream of the dam. It is likely that as the bull trout population decreased as shown by redd counts, that lessened the entrainment and had a direct negative effect on redd counts in Quartz Creek.

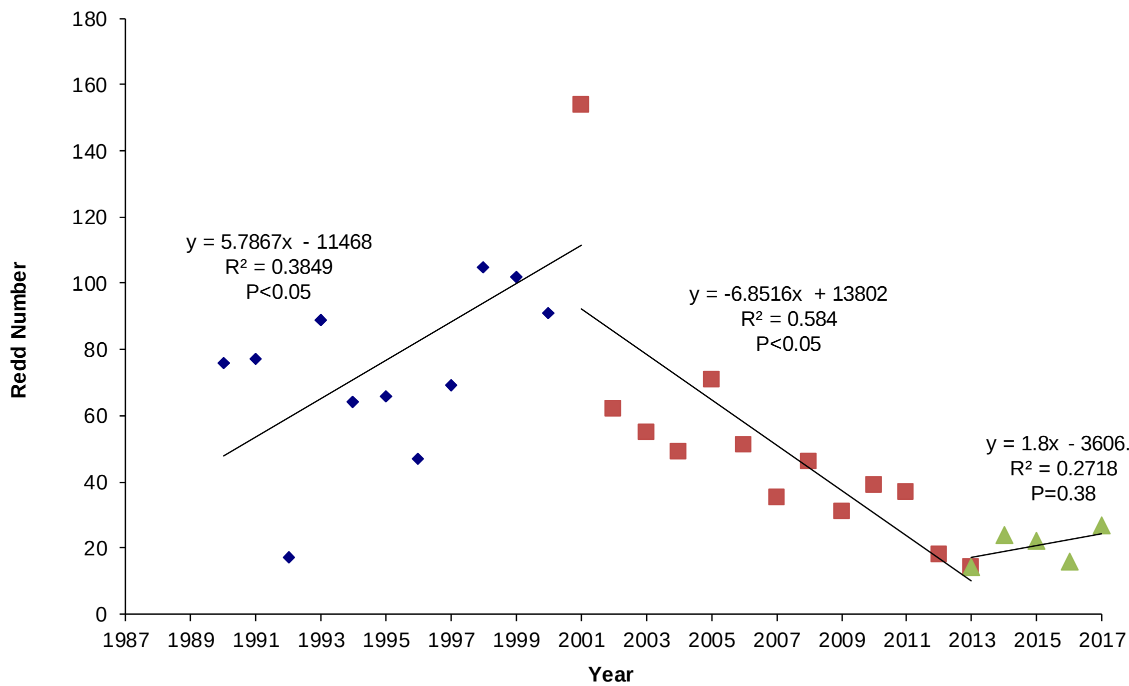

Figure 6. Bull trout redd counts and trend analysis for Quartz Creek (including West Fork Quartz) 1990-2017.

Pipe Creek

Bull trout redd counts in Pipe Creek peaked in 1999 with 36 redds, and have decreased since that peak. Despite the decreasing trend of bull trout redds during the last five years, the overall general trend during the 1995-2017 was quite variable, with a negative slope that was not significantly different than a stable population (Figure 7). The mean number of bull trout redds was 12 since 1990. Low water conditions during the fall spawning season during the last several years may partially explain the low spawner escapement into Pipe Creek. We found no redds in 2007, 2015 and 2016 but did find any indication of barriers downstream of the typical spawning habitat. During spring 2008 a logjam downstream of the traditional spawning area blew out. This was a possible reason for we found redds again in the fall. Since then the trend has been not significantly different than stable but lower than long term average.

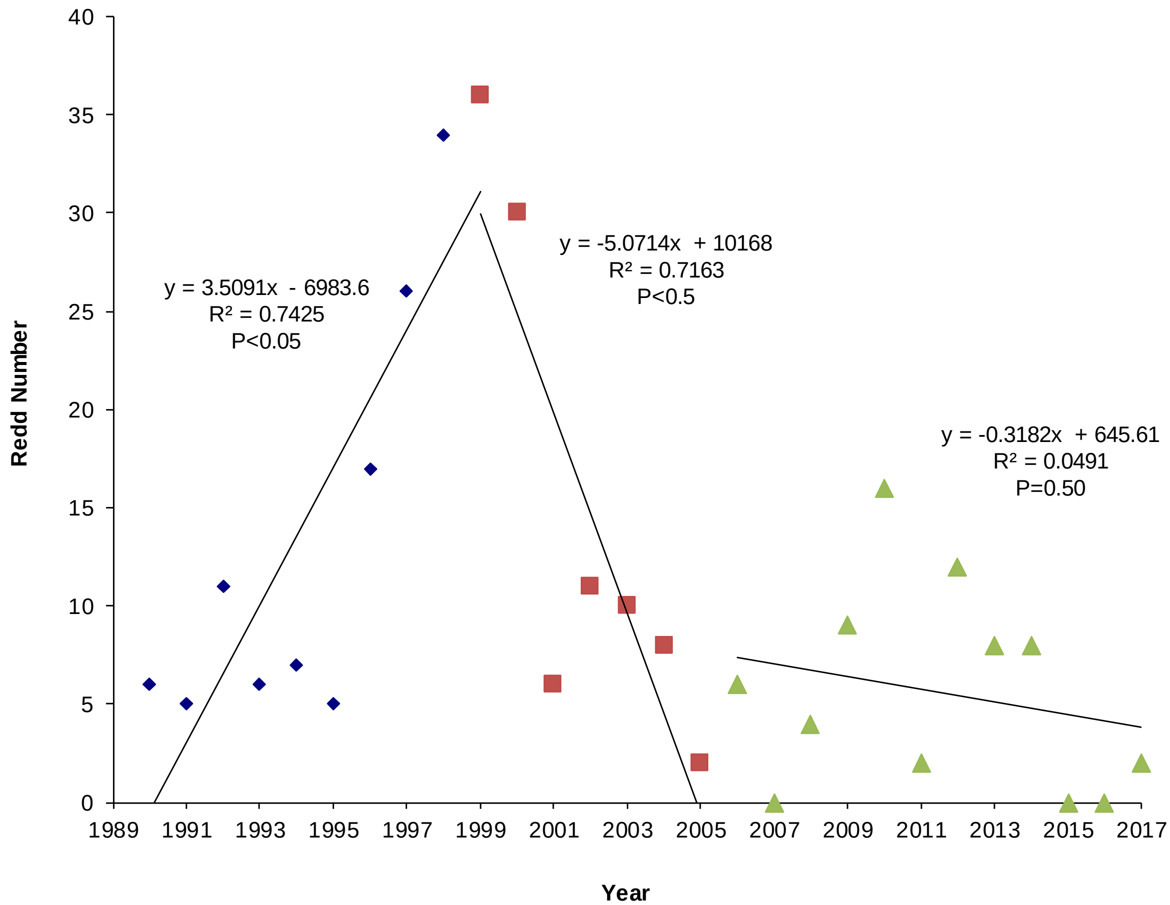

Figure 7. Bull trout redd counts and trend analysis for Pipe Creek 1990-2017.

Bear Creek

Bear Creek bull trout redd counts showed three trends during the period 1995-2013 (Figure 8). Low water conditions in Libby and Bear Creeks and reservoir populations that support the spawning population between 2000 and 2005 partially explain the decreased spawner escapement. The average number of bull trout redds since 2008 in Bear Creek was seven redds (65% of the long-term mean). We are not positive of the effects of entrainment through Libby dam during spill events like 2006 or deep drawdowns like 2011 and what bull trout populations in Lake Koocanusa have on bull trout escapement to the tributaries downstream of the dam although it may be an explanation for trends in Bear Creek.

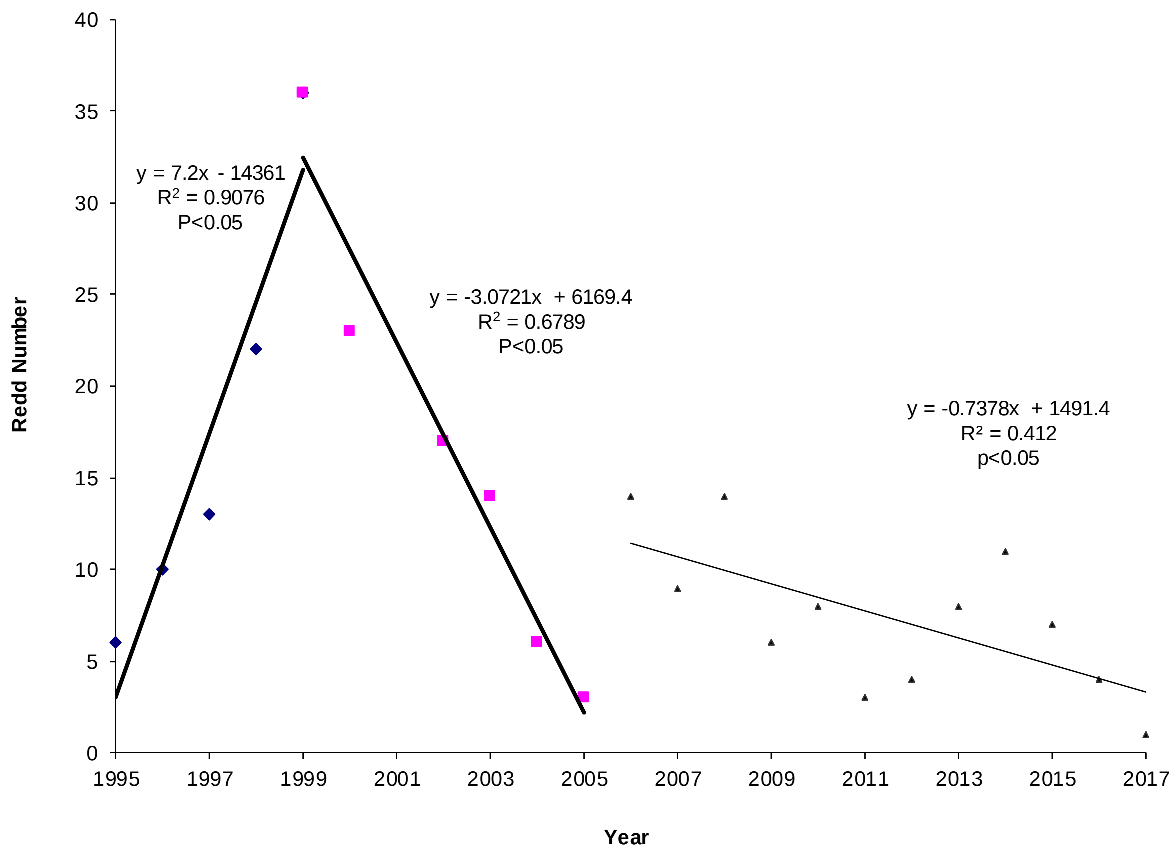

Figure 8. Bull trout redd counts and trend analysis for Bear Creek, a tributary to Libby Creek, 1995-2017.

O'Brien Creek

The trend of bull trout redds in O'Brien Creek generally increased from 1990 to 2005 (Figure 9). We observed a total of 86 bull trout redds in O'Brien Creek in 2005 (Table 14). This was surprising considering the low juvenile survival downstream of the redds. Like Quartz Creek, Dehaan and Adams (2011) found that most of bull trout downstream of Libby Dam originated upstream of the dam. It is quite possible that the adult escapement is affected by Lake Koocanusa bull trout numbers and is more a function of adults moving downstream from Libby Dam over Kootenai Falls (a substantial partial barrier). They likely drop back to the nearest acceptable stream to spawn.

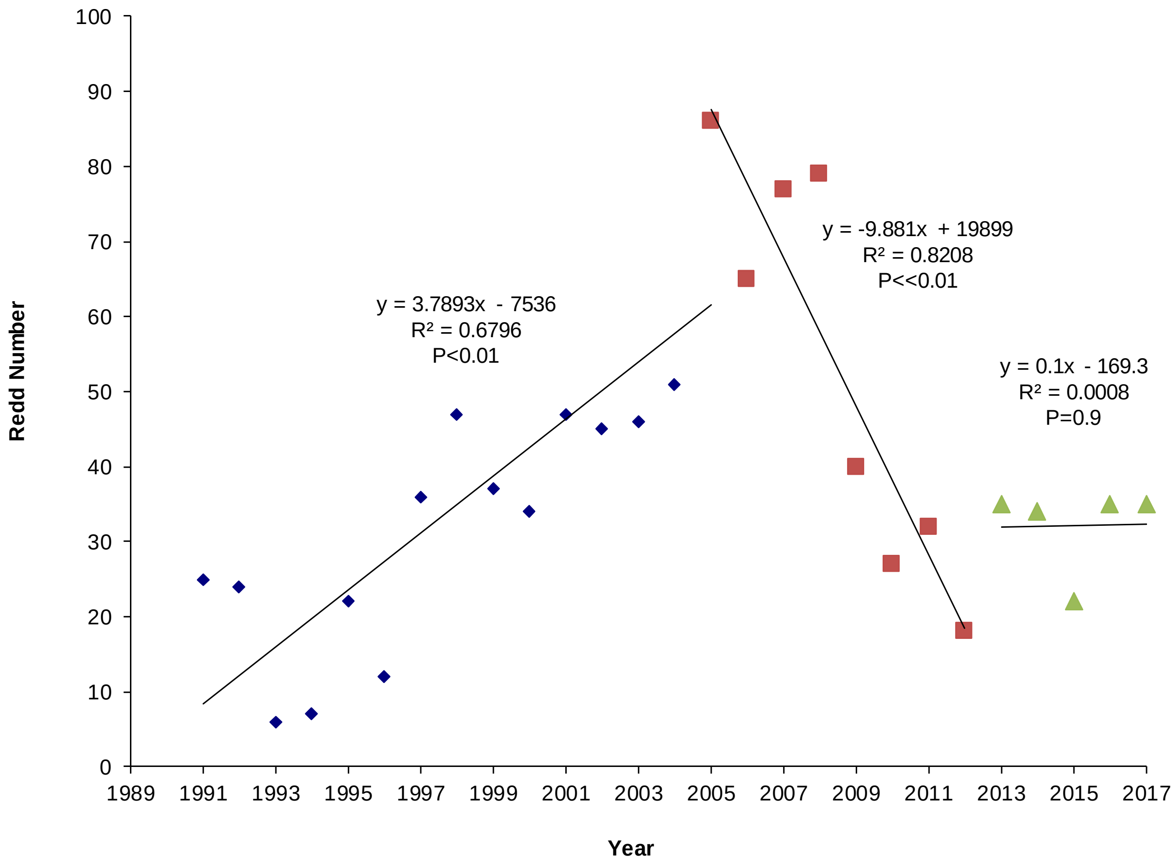

Figure 9. Bull trout redd counts and trend analysis for O'Brien Creek 1991-2017.

West Fisher Creek

We were unable to determine any trend in bull trout redd counts in West Fisher Creek over the period of record for this stream (1993-2017). Although, there appears to be several episodes of redd building. From the period 1993-2000, the general trend was one of increasing abundance. However, during the period of 2001-2003, we observed only 1 bull trout redd each year (Figure 10). A second episode of redd building began after 2003 and a third appears to have begun in 2006. These trends are somewhat similar to other spawning tributaries between Libby Dam and Kootenai Falls and are similar to bull trout trends in Lake Koocanusa.

Extreme low water since 1998 and extreme spill events from Libby (2002, 2006, 2011, 2012 and 2013) may have periodically influenced redd building. The low water events dramatically increase water temperatures to as high as 76 degrees F in July and August (MFWP unpublished data) in mainstem Fisher River that is the corridor to reach West Fisher Creek. The effect could be to discourage or delay migration to the traditional spawning grounds during those years. Additionally, high spill events from Libby dam may have move adults downstream in the Kootenai and reduced the number of adults available to spawn in this tributary.

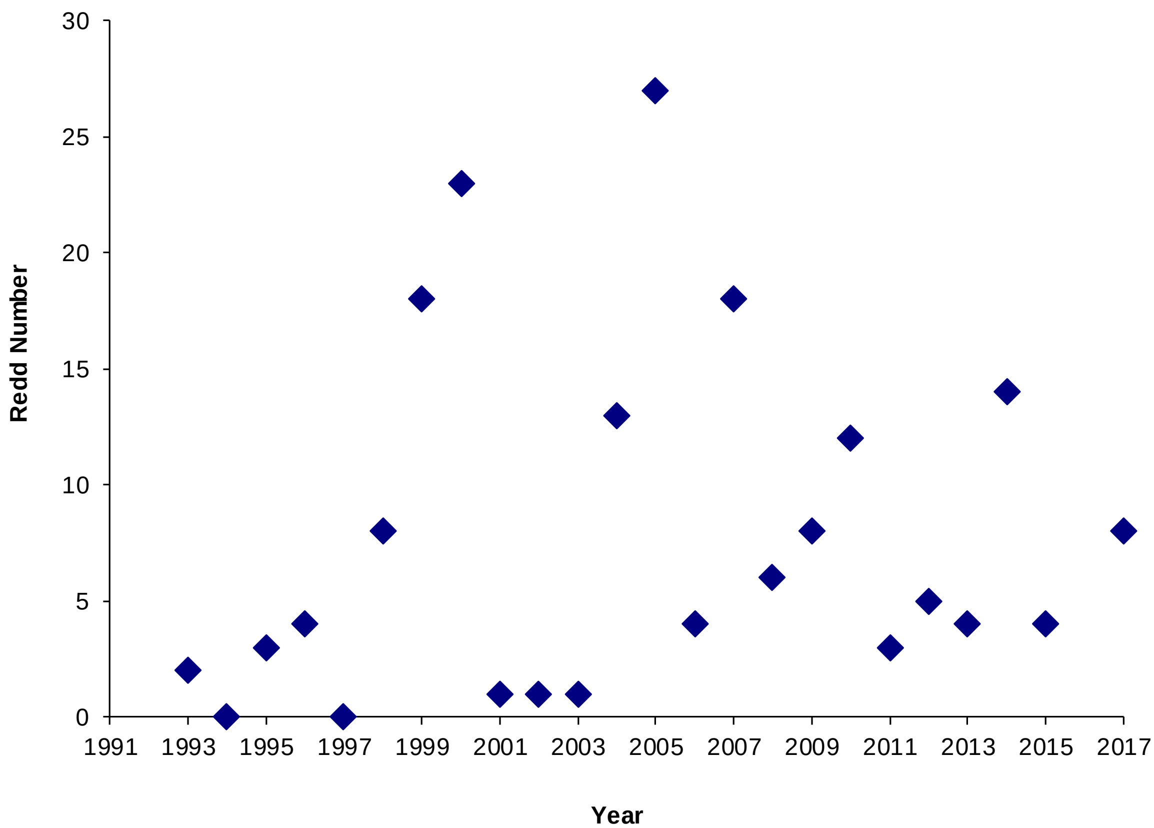

Figure 10. Bull trout redd counts for the West Fisher Creek, 1993-2017.

Keeler Creek

Bull trout that spawn in Keeler Creek (including the North, South and West Forks) migrate downstream out of Bull Lake into Lake Creek, then up Keeler Creek. The population is isolated from the rest of the Kootenai drainage. This downstream spawning migration is somewhat unique when compared to other bull trout populations (Montana Bull Trout Scientific Group 1996).

We observed a total of 13 and 102 bull trout redds in Keeler Creek and associated tributaries in 2001 and 2002, respectively (Table 16). A beaver dam built in lower Keeler Creek during late summer/early fall 2001 impeded upstream bull trout migration. The dam was removed, but a fall freshet increased stream flow substantially and prevented accurate counts. Therefore, the 13 redds observed in 2001 is undoubtedly an underestimate of the true number of redds in Keeler Creek in 2001.

We observed a total of 84 and 62 bull trout redds in Keeler Creek and associated tributaries in 2007 and 2008, respectively. Prior to those counts, bull trout redd counts in Keeler Creek exhibited a positive trend since monitoring began. Since 2005 redd counts have exhibited a significant negative trend (Figure 11). The 2013 observation represents 38 % of the 10-year average. A growing northern pike population in Bull Lake May be contributing to the downward trend.

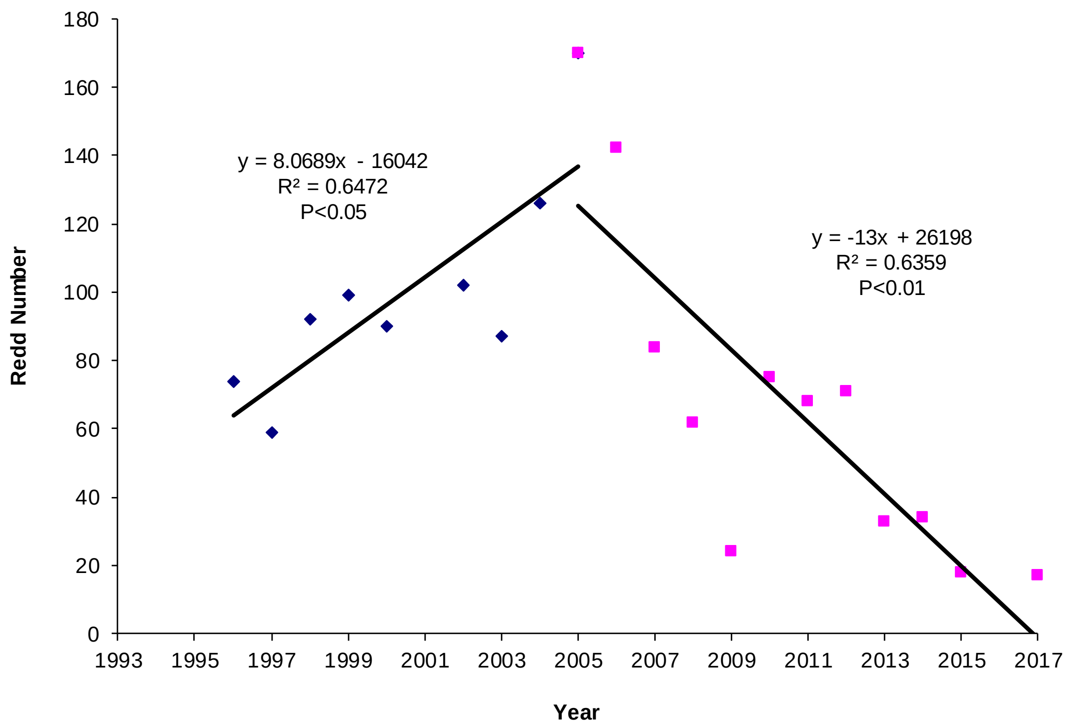

Figure 11. Bull trout redd counts and trend analysis for Keeler Creek, a tributary to Lake Creek, 1996-2017.

Callahan Creek

The Callahan Creek redd counts were completed on North Callahan Creek from just above the confluence with South Callahan Creek upstream to water fall in Idaho and in South Callahan Creek from the confluence with North Callahan upstream approximately 3 miles. Redd counts for bull trout have quite variable in this drainage but show a significant downward trend (Figure 12). There was a 20+ flood event during November of 2006 that may have affected population densities in 2007. Idaho Fish and Game monitored redds for this stream from 2003-2007 and will in the future; MFWP did redd counts for this stream in 2008-2011.

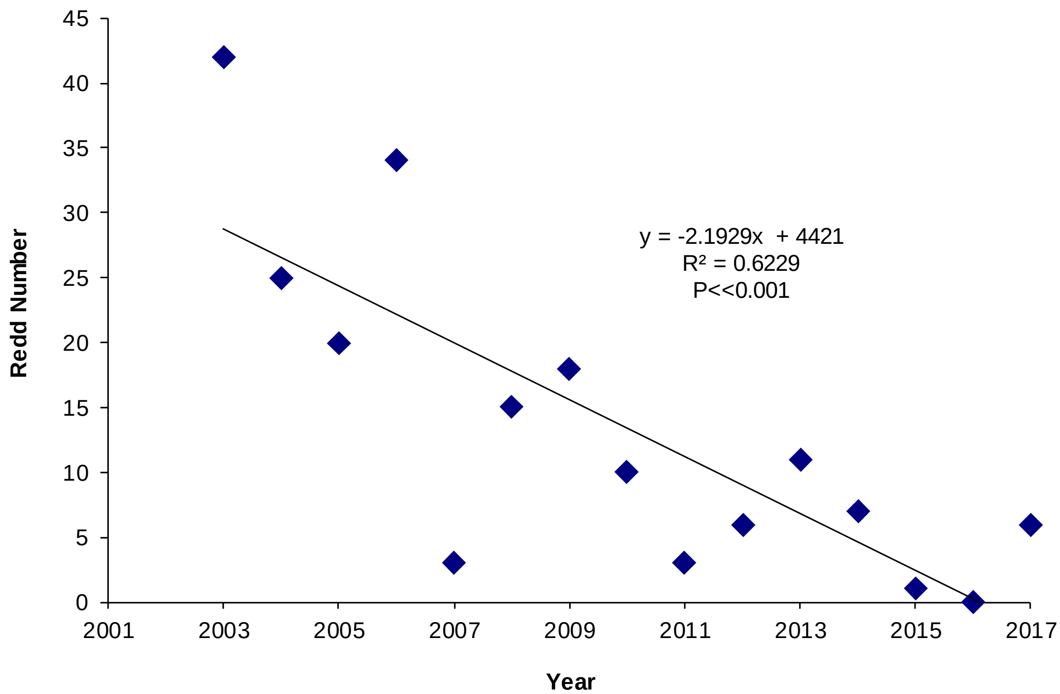

Figure 12. Bull trout redd counts for Callahan Creek, 2003 - 2017.

LAKE KOOCANUSA GILLNET MONITORING

Methods

Gillnets have been used by MFWP since 1975 to assess annual trends in fish populations and species composition. These yearly sampling series were accomplished using criteria established by Huston et al. (1984).

Netting methods remained like those reported in Chisholm et al. (1989) and adjusted by Dunnigan et al. (2017). Netting effort was reduced from 128 ganged (coupled) nets in 1975, to 56 in 1988, and 14 ganged floating and 28 single sinking nets in 1991. Netting effort occurred in the spring and fall, rather than the year-round effort prior to 1988. Because of their importance to bull trout either as prey or competitors, kokanee salmon (*Oncorhynchus nerka*) and Kamloops rainbow trout (*Oncorhynchus mykiss gairdneri*) were included in this assessment. Kamloops rainbow trout were distinguished from wild rainbow trout by eroded fins (pectoral, dorsal and caudal); these fish are held in the hatchery until release into the reservoir at age 1+.

The year was stratified into two gillnetting seasons based on reservoir operation and surface water temperature criteria:

1) Spring (April - June): The reservoir was being refilled, surface water temperatures increased to 9 - 13^{o}C.

2) Fall (September - October): Drafting of the reservoir began, surface water temperature decreased to 13 - 17^{o}C.

Seasonal and annual changes in fish abundance within the near-shore zone were assessed using floating and sinking horizontal gillnets. These nets were 38.1 m long and 1.8 m deep and consisted of five equal panels of 19-, 25-, 32-, 38-, and 51-mm mesh.

Fourteen to twenty-eight floating (ganged) and one or two single, sinking nets were set in the fall in the Tenmile, Rexford and Canada portions of the reservoir. Spring netting series consisted of 20 to 111 (standardized to 28 in 1991) sinking nets and an occasional floating net set only in the Rexford area. Spring floating and fall sinking net data are not included in this report due to a lack of standardization in net placement. Nets were set perpendicular from the shoreline in the afternoon and were retrieved before noon the following day. All fish were removed from the nets and identified, followed by collection of length, weight, sex and maturity data. When large gamefish (rainbow, cutthroat, bull trout or burbot) were captured alive, only a length was recorded and the fish were released.

Findings

Initially, we netted areas that included the entire reservoir through all seasons. Over time, seasonal netting was reduced to spring and fall series (Chisholm, et al 1989, Dalbey et al 1997). However, our fall gill netting series typically capture few bull trout. The primary reasons are that sampling dates purposely coincided with the period in which adults were in spawning tributaries, and that bull trout are not traditionally captured in floating gillnets. We netted one area (Koocanusa Bridge to Montana/B.C. border) from 1988 through 2017. Table 17 summarizes long-term bull trout mean catch per net in Koocanusa from spring sinking nets.

Table 17. Spring sinking gill net summary of bull trout catch per net in Lake Koocanusa 1975 - 2017.

Year	Date	Reservoir Elevation	Mean Catch Per Net
1975	6/9		1.4
1976	5/1	2373	1.9
1978	5/15	2367	2.2
1980	5/5	2389	0.8
1981	5/5	2378	1.3
1982	5/25	2363	1.5
1984	6/12	2412	1.8
1985	6/6	2415	1.3
1986	5/8	2379	1.9
1987	5/5	2390	1.2
1988	5/12	2344	2.0
1989	5/1	2355	1.2
1990	5/10	2358	1.2
1991	5/16	2330	0.5
1992	5/5	2333	2.3
1993	5/17	2352	1.2
1994	5/16	2405	3.0
1995	5/8	2386	2.3
1996	5/12	2365	3.5
1997	5/12	2350	3.1
1998	5/11	2418	2.5
1999	5/17	2352	3.6
2000	5/14	2371	6.7
2001	5/15	2393	5.4
2002	5/13	2384	4.9
2003	5/13	2417	5.4
2004	5/11	2419	6.4
2005	5/10	2425	6.1
2006	5/10	2423	4.4
2007	5/21	2408	4.5
2008	5/13	2397	5.4
2009	5/18	2406	3.1
2010	5/17	2411	4.4
2011	5/16	2341	1.9
2012	5/14	2399	4.1
2013	5/13	2409	4.3
2014	5/19	2391	3.5
2015	5/11	2442	5.4
2016	5/16	2416	5.6
2017	5/16	2378	2.7

Spring gill net catch of bull trout during the period 1975-1989 appeared to exist at an equilibrium that was not significantly different than zero (Figure 13). Bull trout catch per net in Libby Reservoir significantly increased between 1990 and 2004. The trend was negative between 2005 and 2011. This coincides with the opening of bull trout harvest initiated in 2004 for Koocanusa (Hensler and Benson 2013). As regulations changed from two bull trout harvest (2004-2009) to one (2010-2011) to catch-and-release angler harvest and by-catch decreased and bull trout captured in gill nets generally trended upward again. Since 2016 the bull trout regulation has been one per year.

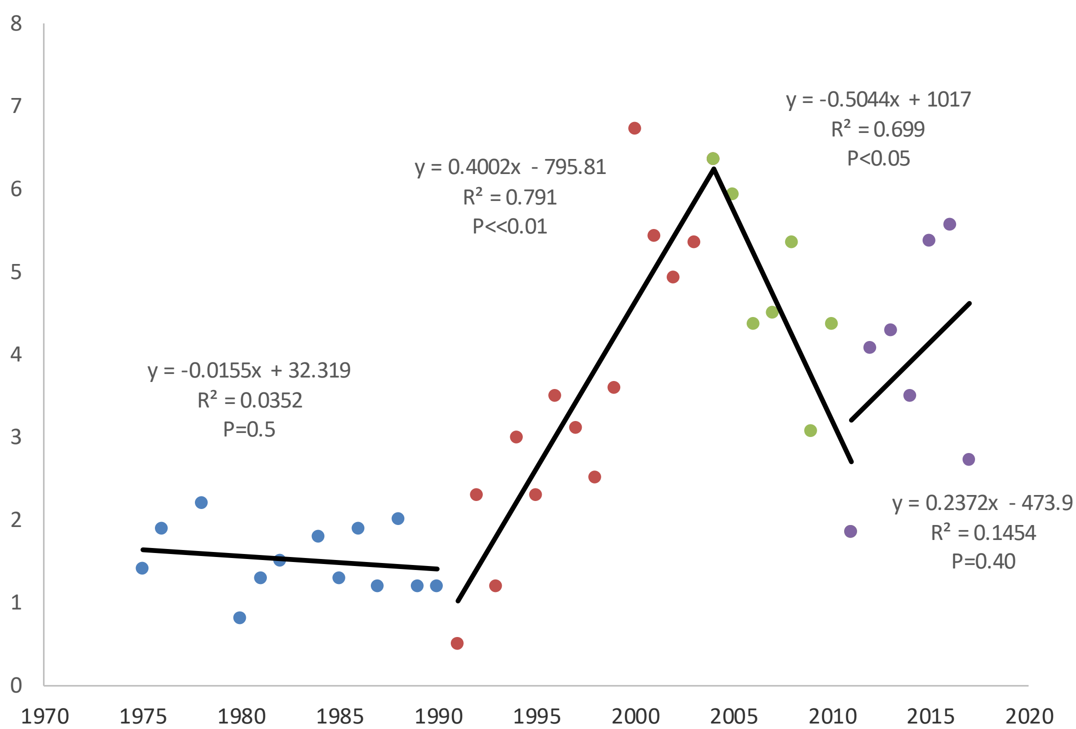

Figure 13. Average catch per net of bull trout in spring gill nets at the Rexford site on Lake Koocanusa 1975-2017.

Dunnigan (2017) also found that Grave Creek redd counts and bull trout catch per net in Koocanusa have similar trends and that those trends are significant ($P<0.001$). Both indices are useful for determining management direction for the harvest of bull trout from Koocanusa.

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