LAKE KOOCANUSA AND KOOTENAI RIVER BASIN BULL TROUT MONITORING REPORT

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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 list 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 in the future. For this to happen, 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 effort initiated in the Flathead drainage. Much of the background information for this report is excerpted with thanks from Deleray et al (1999).

DESCRIPTION OF STUDY AREA

Kootenai River Drainage

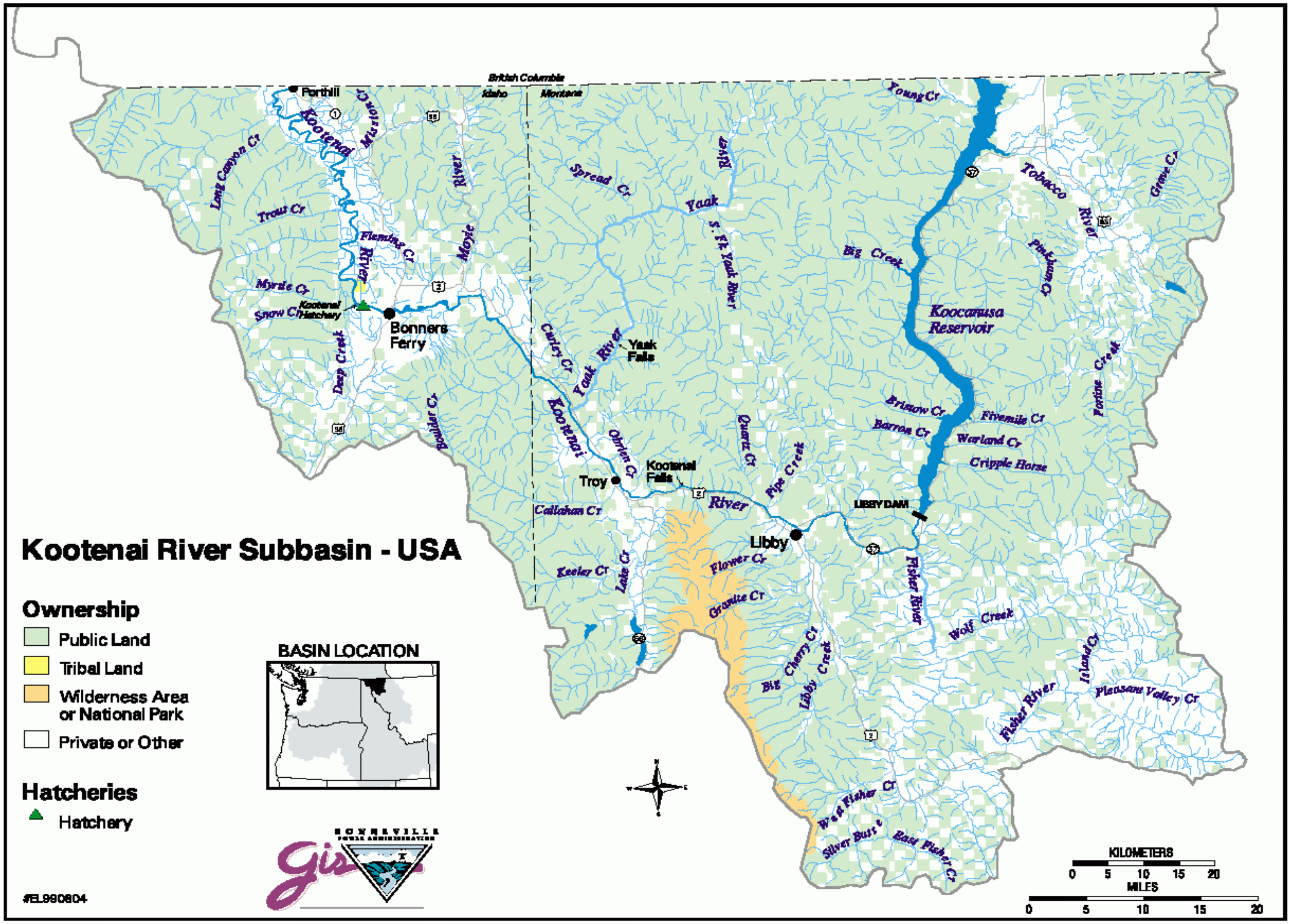
The Kootenai River basin is an international watershed that encompasses parts of British Columbia (B.C.), Montana, and Idaho (Figure 1). The headwaters of the Kootenai River originate in Kootenay National Park, B.C. The river flows south within the Rocky Mountain Trench to the reservoir created by Libby 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 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.


Kootenai River Subbasin - USA
Ownership
Public Land
Tribal Land
Wilderness Area or National Park
Private or Other
Hatcheries
Hatchery
BASIN LOCATION
British Columbia
Idaho
Montana
Porthill
Kootenai River
Bonners Ferry
Kootenai Hatchery
Moyie River
Yaak River
Yaak Falls
Troy
Kootenai Falls
Libby
LIBBY DAM
Koocanusa Reservoir
Tobacco River
Fisher River
KILOMETERS
MILES
#EL990604

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

Eighteen species of fish are present in Koocanusa Reservoir and the Kootenai River drainage (Table 2). The reservoir currently supports an important fishery for kokanee *Oncorhynchus nerka* and rainbow trout *Oncorhynchus mykiss* (Kamloops strain), with annual fishing pressure 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 2002 (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 Reservoir	Trend	Relative Abundance drainage	Trend	Native
<u>Game fish species</u>						
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	I	C	I	Y
Brook trout	*Salvelinus fontinalis*	R	U	A	S	N
Lake trout	*Salvelinus namaycush*	N	U	R	D	N
Kokanee salmon	*Oncorhynchus nerka*	A	U	R	U	N
Mountain whitefish	*Prosopium williamsoni*	R	D	A	S	Y
Burbot	*Lota lota*	C	D	R	D	Y
Largemouth bass	*Micropterus salmoides*	R	U	R	U	N
White sturgeon	*Acipenser transmontanus*	R	D[∈]	R	D	Y[∉]
Northern pike	*Esox lucius*	R	U	R	U	N
Yellow perch	*Perca flavescens*	C	I	R	U	N
<u>Non-game fish species</u>						
Pumpkinseed	*Lepomis gibbosus*	R	U	R	U	N
Redside shiner	*Richardsonius balteatus*	R	D	R	U	Y
Peamouth	*Mylocheilus caurinus*	A	I	R	U	Y
Northern pikeminnow	*Ptychocheilus oregonensis*	A	I	R	U	Y
Largescale sucker	*Catostomus macrocheilus*	A	S	C	U	Y
Longnose sucker	*Catostomus catostomus*	C	D	R	U	Y

[∈] 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 and one verified mortality.

[∉] An abundance of anecdotal reports exist of white sturgeon above Kootenai Falls although research to date has failed to validate any reports.

STREAM ELECTROFISHING/
JUVENILE BULL TROUT ABUNDANCE ESTIMATES

Introduction

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 in order 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 can be easily 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 can be 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; however p value must be higher than 0.6. We used both boat mounted shocking equipment and backpack mounted equipment simultaneously for these sample sections.

Two-pass Procedure:

We placed a braided nylon block net (1/4 inch 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 into 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 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 is 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 ≥ 0.6 for a reliable, two-pass estimate to be made. Though there were times when time constraints made a third pass problematic, if p ≤ 0.6, the estimate was reported, but must be viewed with caution. If p ≥ 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).

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 190 m to 220 m 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 results are presented in Table 3. Redd counts have increased dramatically in this tributary since 1997, but densities of juveniles are not showing similar results. At the same time we saw an increase in Young-of-year bull trout caught in a screw trap (located approximately 7 miles upstream from the mouth) that was installed to assess migration into an irrigation ditch. In 1998, we trapped 32 bull trout, all of which were 1+ and older; in 2001, we found 204 bull trout in the trap of which ten were 1+ and older; and in 2002, only one of 178 trapped was 1+. These results lead us to believe that under current habitat conditions, Grave Creek may be near or at carrying capacity for juvenile bull trout.

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 - 2002.

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

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 have generally increased since 1997 (Table 4). This is likely due to a number of factors that include reduced land management in the drainage and increased numbers of spawning adults from the Kootenai River.

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 - 2002.

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

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. This is a relatively stable stretch but, there have been some pool changes. Densities of juvenile bull trout remained relatively stable to slightly decreasing between 1999 and 2002 (Table 5). This occurred as redd counts decreased substantially in 2000 and 2001 likely from low water conditions.

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 - 2002.

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

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 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. We intend to continue monitoring this stream in the future.

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.

Stream	Year	N	95 % C.I.	p	Density (#100m^2)
West Fisher Creek	2002	37	+/- 2	0.75	2.0

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 from 2001 to 2002 was caused by low water. Several sections of Libby Creek, to which Bear Creek is a tributary, were dry by late July in 2001. The same occurred in 2002 so we expect similar, if not lower densities. 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. This is a slow and laborious process that will likely take 10's of years.

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 - 2002.

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

O'Brien Creek

O'Brien Creek is the only tributary below Kootenai Falls confirmed to support bull trout spawning from the Kootenai River (there are bull trout in Callahan Creek, although we have not been successful in trapping upstream migrating adults). The O'Brien Creek fish abundance section currently is centered on the FS 331 bridge above Rabbit Creek. The section has remained stable at 140 meters since the initial survey in 1998. This is 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 (Table 8). We could not do an estimate in 2002 because only two juvenile bull trout were captured.

We believe that the decrease in juvenile densities was caused by an encroaching beaver population. Redd counts remained relatively stable over this time but the distribution of redds shifted downstream because beaver dams have caused very high sedimentation in some traditional spawning areas. Additionally, estimates of resident brook trout and westslope cutthroat trout and rainbow trout were similar throughout the survey years. We intend to include another section downstream of the current section for several years to help track juvenile densities more accurately. If the beaver situation persists we will abandon the current section until conditions improve.

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 - 2002.

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			0.3

Keeler Creek

Bull trout that spawn in Keeler Creek (including the North, South and West Forks) are adfluvial and migrate downstream out of Bull Lake into Lake Creek, then up Keeler Creek. This downstream spawning migration is somewhat unique when compared to other bull trout populations (Montana Bull Trout Restoration Team 1996a). Lake Creek, a tributary of the Kootenai River, has an upstream waterfall barrier isolating this population from the mainstem Kootenai River population. A micro-hydropower dam constructed in 1916 covered the upper portion of the waterfall. A series of high gradient waterfalls are still present below the dam, and are barriers to all upstream fish passage. Keeler Creek may supply some recruitment to the Kootenai River through downstream migration.

The Keeler Creek fish abundance section located approximately 1 mile below North Fork Keeler Creek. The section lengths remained fairly constant between 203 and 214 meters since the initial survey in 1998. This is 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 very stable pool. Densities of juvenile bull trout remained very stable between 1999 and 2002 (Table 9). The estimate in 1998 was an exception. We captured more than twice as many bull trout that year as others. One explanation might be that the flows were very high that year and more juveniles passed into this stable section that includes two fairly large pools. The preceding two years of redd counts (Table 14) don't appear to account for the increase.

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 - 2002.

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

* Three pass estimates.

STREAMBED CORING

Introduction

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 a given 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 across each of three transects 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 natural spawning. We only sampled in spawning areas used by adfluvial and fluvial bull trout. During the period of study, these fish 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 10). 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 10. 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 has been sporadic since 1994 (Table 11). The current standard for assessing impairment of streams due to increase in sediments is 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.

Though there is not enough long-term data presented to fully assess trends in the monitored streams, most appear show stable if not decreasing fine sediment levels. Two exceptions are O'Brien Creek and the British Columbia portion of the Wigwam River. Both have been impacted by extra activities in the past several years.

As was mentioned previously, beavers have become well established in the upper end of O'Brien creek and are migrating downstream. O'Brien Creek appears to be a fairly high 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.

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 25.2 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 including considerable new road building occur in the next 10 years.

Table 11. 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, 1994 – 2002.

Stream	1994	1995	1996	1997	1998	1999	2000	2001	2002*
Grave Creek					22.0		25.3	20.4	
West Fork Quartz Creek	27.0	30.7			27.5			29.3	
Pipe Creek					38.5	31.5	31.4	29.1	
Bear Creek							19.0		
O'Brien Creek					36.5			35.5	
North Fork Keeler Creek					29.0		18.7	22.4	
Wigwam River (Ram Cr)					24.0	30.0	37.0	34.0	35.0
Wigwam River U.S.					26.5	21.0	24.9		

*

2002 samples collected, not yet analyzed.

SUBSTRATE SCORING

Introduction

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 12). They also rank the degree to which the dominant particle size is embedded (Table 12). 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 12. 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 13). Because of limited sampling a quality assessment is not possible. For the most part, the scores from most of the streams 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). The exception in this assessment is O'Brien Creek. As was mentioned previously, the section used for juvenile estimates has likely been impacted by beaver activity. We intend to continue gathering substrate scores yearly to assess trends.

Table 13. Summary of Kootenai Drainage substrate scores the stream sections monitored at juvenile population estimate sites in Kootenai River basin stream, 1998 - 2002.

Stream	1998	1999	2000	2001	2002
Grave Creek	13.4				13.2
West Fork Quartz Creek	13.2				13.2
Pipe Creek	13.0	14.0			13.7
Bear Creek		13.0			13.6
West Fisher Creek					13.1
O'Brien Creek	11.5	12.2			10.6
Keeler Creek	12.8	14.4			12.4

BULL TROUT REDD COUNTS

Introduction

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 fairly common in the Kootenai drainage and can wipe out traces of redds if flows get high enough.

We surveyed the Wigwam River and West Fisher, Grave, Quartz, Bear (tributary to Libby Creek), Keeler, Pipe, and O'Brien Creeks. MFWP 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. They visually identified redds by the presence of a pit or depression and associated tail area of disturbed gravel. If timing is correct, identification of redds presents 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 personnel 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 2002 (Table 14). We surveyed Grave Creek 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. Surveyors 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 distribution of bull trout redds in Blue Sky, Clarence, Williams and Lewis Creeks was similar to observations in previous years (Hoffman et al. 2002).

We observed a total of 173 and 199 bull trout redds in Grave Creek in 2001 and 2002, respectively (Table 14). Bull trout have exhibited a positive trend in spawning abundance in Grave Creek since 1993 (Figure 2; $r^2 = 0.733$; $p = 0.0016$).

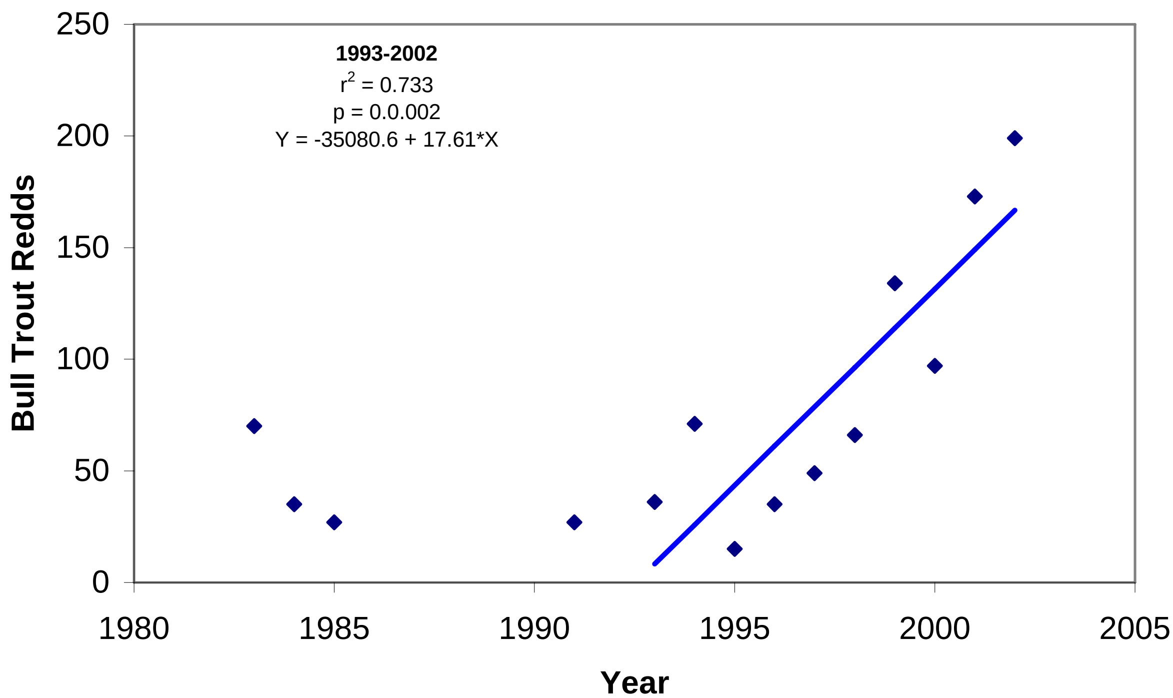


Figure 2. Bull trout redd counts, and trend analysis in Grave Creek, 1993 through 2002.

Table 14. Summary of Kootenai Drainage bull trout spawning site inventories from 1983 - 2002 in the stream sections monitored annually.

Stream	1983	1984	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Grave Creek [a]	70	35	27		27		36	71	15	35	49	66	134	97	173	199
Quartz Creek [c]				76	77	17	89	64	66	47	69	105	102	91	154	62
Pipe Creek				6	5	11	6	7	5	17	26	34	36	30	6	11
Bear Creek									6	10	13	22	36	23	4	17
West Fisher Creek							2	0	3	4	0	8	18	23	1	1
O'Brien Creek					25	24	6	7	22	12	36	47	37	34	47	45
Keeler Creek [d]										74	59	92	99	90	13	102
Wigwam River (U.S. &B.C.) [b]								104	247	512	598	679	868	1204	1496	1916
Skookumchuk River (B.C.)											66	105	161	189	132	143
White River (B.C.)															166	153
Total										711	916	1158	1491	1781	2192	2649

[a] Includes mainstem Grave Creek, Clarence Creek, Blue Sky Creek
[b] Includes mainstem Wigwam River, Ram Creek, Lodgepole Creek, Desolation Creek.
[c] Includes mainstem Quartz Creek and West Fork Quartz Creek
[d] Includes mainstem Keeler Creek, North Fork Keeler Creek, South Fork Keeler Creek.

Wigwam Drainage

Bull trout redd counts for the Wigwam River includes the tributary streams of Bighorn, Desolation, and Lodgepole creeks. We observed a total of 1496 and 1916 redds in the Wigwam Drainage in 2001 and 2002, respectively (Table 14). Bull trout redds in the Wigwam River have consistently increased each year since 1995 (Figure 3; $r^2 = 0.946$; $p = 4.9*10^{-5}$).

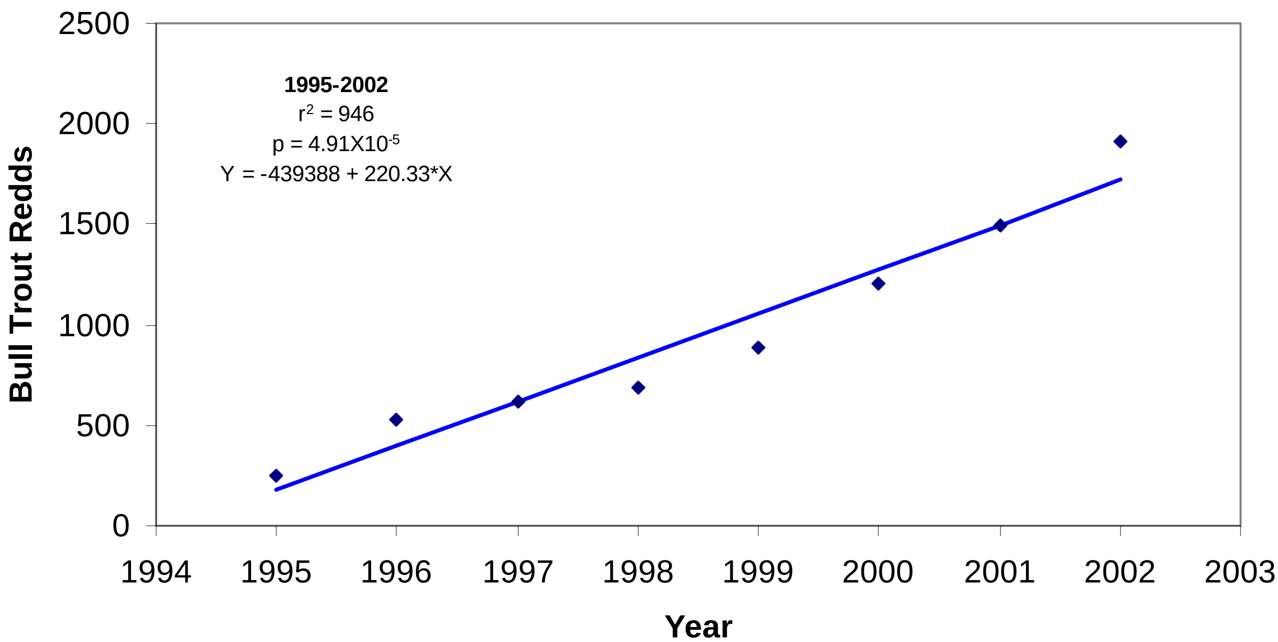


Figure 3. Bull trout redd counts and trend analysis for the Wigwam River (including Bighorn, Desolation, and Lodgepole Creeks) 1995-2002.

Quartz Creek

Bull trout redd counts in Quartz Creek since 1995 have been quite variable (Figure 4; r^2 = 0.224). Although overall trend is positive, annual variation limits our ability to statistically distinguish this relationship from a stable (zero slope) population (Figure 4; p = 0.102). We observed a total of 154 and 62 redds in Quartz and West Fork Quartz creeks in 2001 and 2002, respectively (Table 14). The average number of redds of the period of record was 78.4 redds. The 2001 observation represented a record number of bull trout redds in Quartz Creek, and a 96.5% increase over the average. However, the 2002 observation of 62 redds was 20.9% lower than the average over the period of record. A log jam located approximately 0.25 miles upstream of the confluence of West Fork Quartz Creek in 2002 likely limited adult bull trout escapement in 2002. If we remove the 2002 bull trout redd counts from the dataset, and repeat the regression analysis, the variation between years decreases slightly (r^2 = 0.385), and the positive trend is significant (p = 0.031).

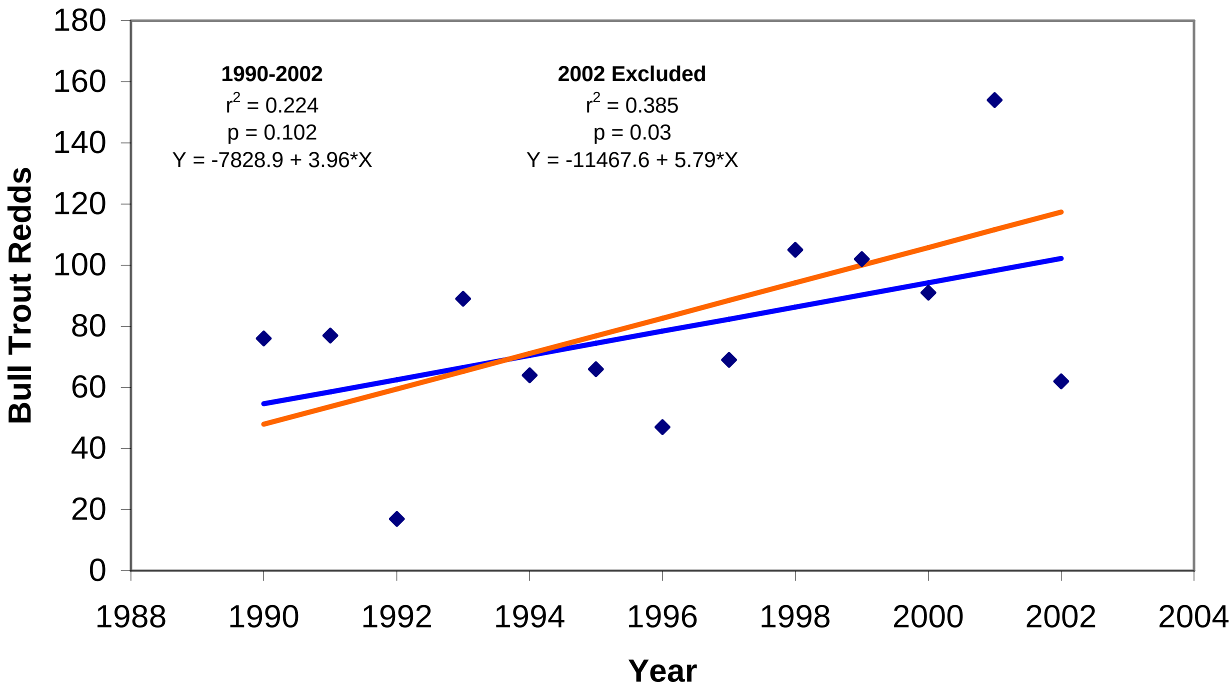


Figure 4. Bull trout redd counts and trend analysis (blue line) for Quartz Creek (including West Fork Quartz) 1990-2002. The 2002 observation was removed and the regression analysis repeated due to the presence of a logjam in the West Fork Quartz Creek in 2002 (orange line).

Pipe Creek

Bull trout redd counts in Pipe Creek peaked in 1999 at 36, with redd numbers decreasing since that peak (Table 14). Despite the decreasing trend of bull trout redds during the last three years, the overall general trend during the time period 1995-2002 has been variable, but a slightly increasing trend (Figure 5; $r^2 = 0.2478$; $p = 0.0834$). We observed a recent low of 6 and 11 redds observed in 2001 and 2002, respectively. This decrease may be partially explained by the presence of a man made obstruction (swimming hole) during two extreme low water years on lower Pipe Creek. If we remove the 2001 bull trout redd counts from the dataset, and repeat the regression analysis, the variation between years decreases slightly ($r^2 = 0.433$), and the positive trend is significant ($p = 0.0201$).

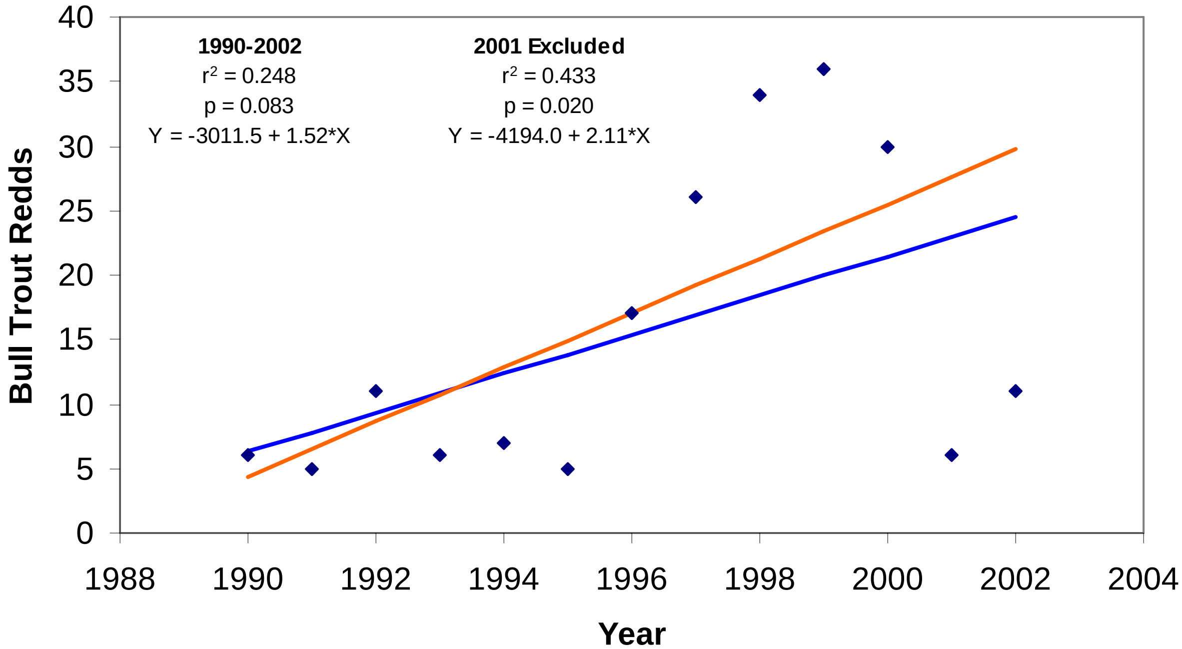


Figure 5. Bull trout redd counts and trend analysis (blue line) for Pipe Creek 1990-2002. A manmade dam was present in lower Pipe Creek in the fall of 2001 that likely impeded bull trout migration. Therefore the 2001 observation was removed and the regression analysis was repeated (orange line).

Bear Creek

Bear Creek bull trout redd counts have been variable during the period 1995-2002 (Figure 6; $r^2 = 0.06$). Although the overall general trend has increased since 1995, the relationship is not statistically different than a stable population (Figure 6; $p = 0.5465$). A logjam was also located on lower Bear Creek in the fall of 2001. Libby Creek, the major tributary to which Bear Creek flows was intermittently dry during critical migration times in both 2001 and to a lesser extent in 2002. These conditions may have limited adult bull trout escapement during those year.

If we remove the 2001 bull trout redd counts from the dataset, and repeat the regression analysis, the variation between years decreases slightly ($r^2 = 0.313$), but the overall trend remains non-significant ($p = 0.191$), suggesting that the population is stable. The average number of bull trout redds since 1995 in Bear Creek has been 16.4. The number of redds observed in 2001 was 75.6% lower than the annual average since 1995. In 2002, we observed 3.8% more bull trout redds than average in Bear Creek.

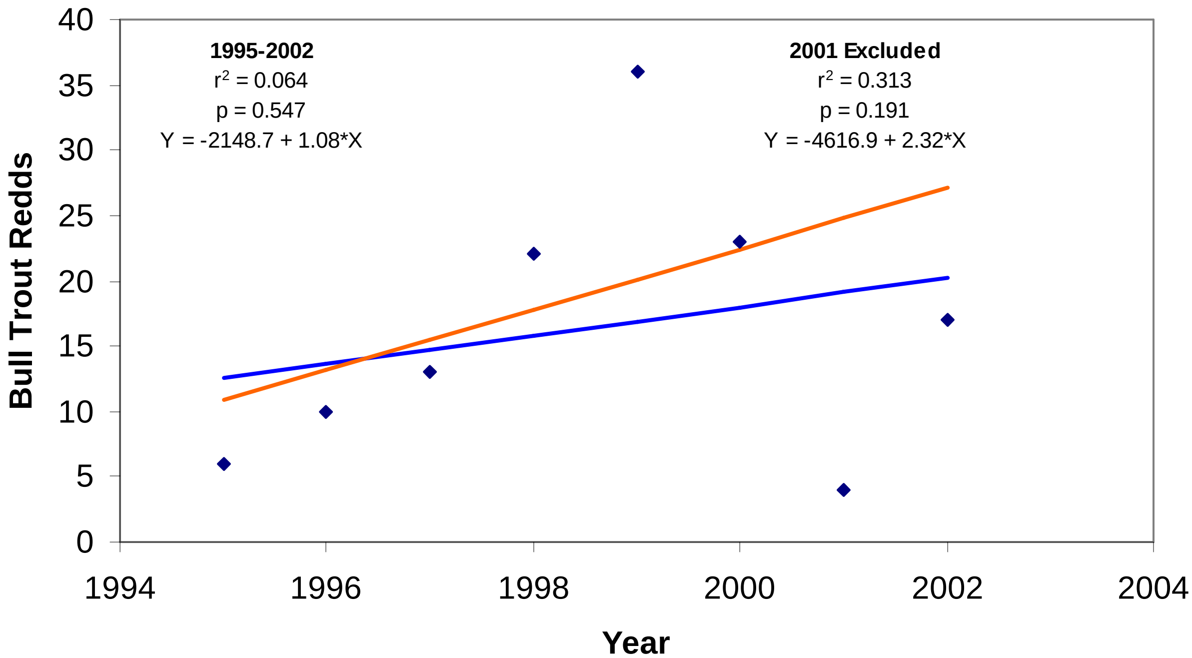


Figure 6. Bull trout redd counts and trend analysis (blue line) in Bear Creek, a tributary to Libby Creek, 1995-2002. A log and debris jam was present in lower Bear Creek in the fall of 2001 that likely impeded bull trout migration. Therefore the 2001 observation was removed and the regression analysis was repeated (orange line).

O'Brien Creek

The general trend of bull trout redds in O'Brien Creek is increasing since 1995 (Figure 7; $r^2 = 0.547$; $p = 0.006$). We observed a total of 47 and 45 bull trout redds in O'Brien Creek in 2001 and 2002, respectively (Table 14). This does not compare well with the juvenile estimate trend for the same years likely because we survey redds throughout the drainage and the juvenile estimates are near the current upper end of spawning.

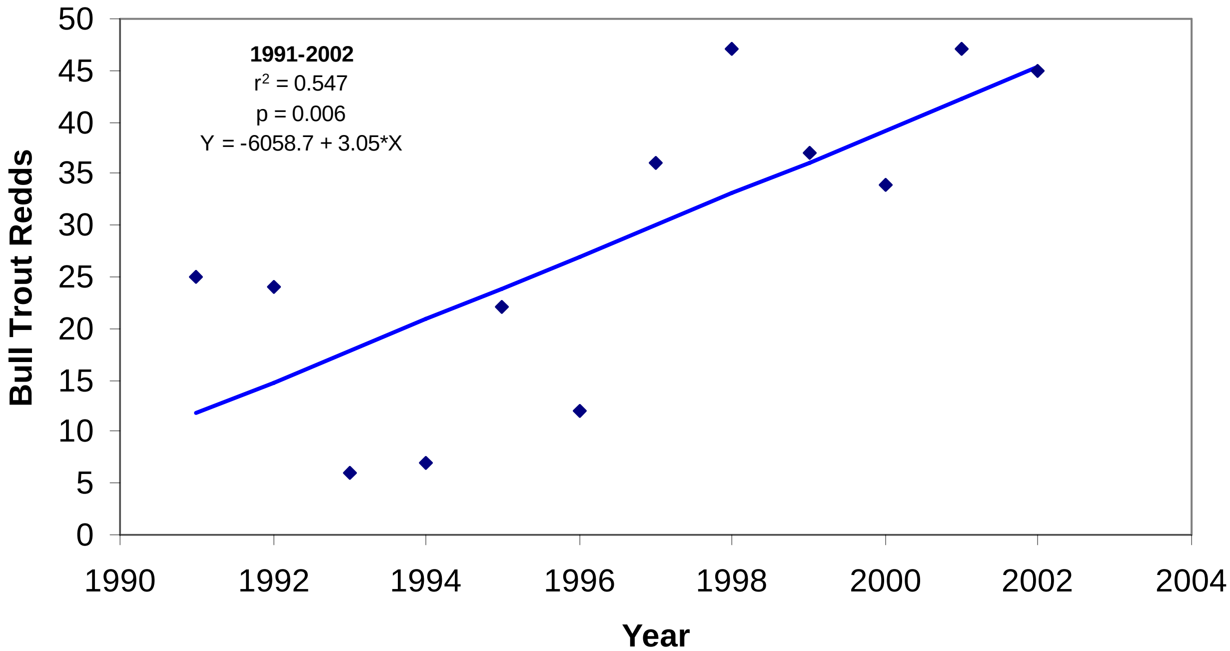


Figure 7. Bull trout redd counts and trend line (blue line) in O'Brien Creek 1991-2002.

West Fisher Creek

We were unable to determine a significant trend in bull trout redds in the West Fisher Creek over the period of record for this stream (1993-2002). From the period 1993-2000, the general trend was one of increasing abundance. However, we observed only 1 bull trout redd in each 2001 and 2002 (Table 14). These two years were extreme low water years in the Kootenai drainage; the major migration corridor for West Fisher is Fisher River and during those two years water temperatures approached intolerable levels during traditional migration timing. In 2001 daily maximum temperatures in the Fisher River immediately below West Fisher Creek reached 70 degrees F by July 1 and remained above 60 degrees Fahrenheit until October 1. Though we did not monitor temperatures in 2002, we expect that similar conditions existed.

The overall trend was not significantly different than a stable (zero slope) population (Figure 8. r2 = 0.113; p = 0.343). Given the amount of variation present within this dataset, the overall mean number of redds in the West Fisher (mean = 6.0 redds) does an equally well job at predicting redd numbers.

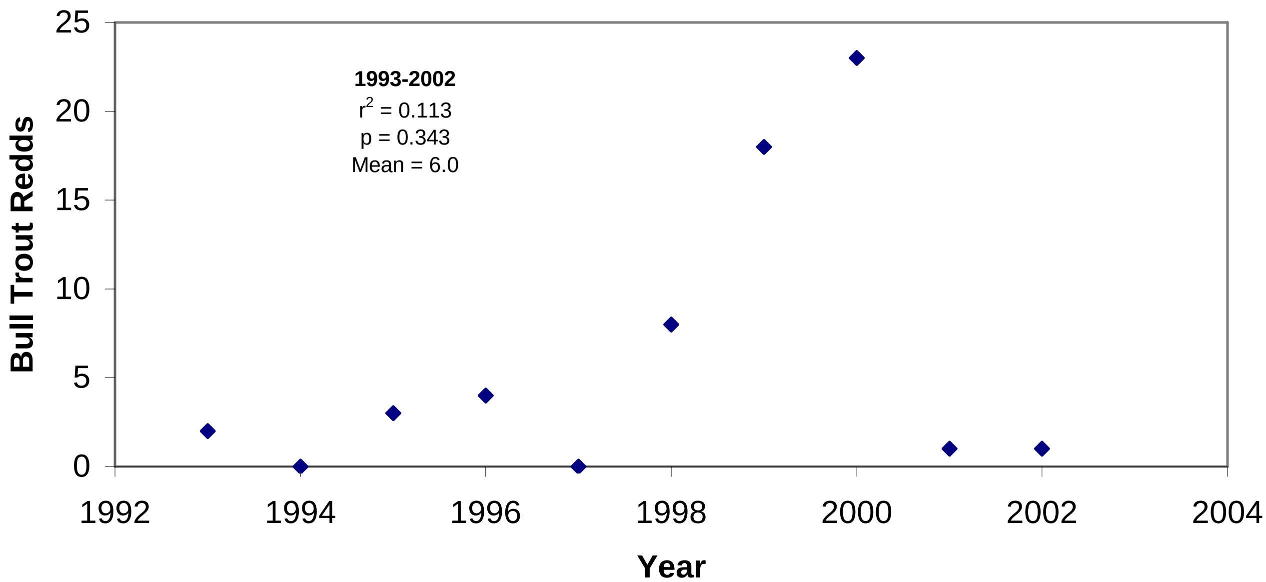


Figure 8. Bull trout redd counts in West Fisher Creek, 1993-2002.

Keeler Creek

As was presented earlier, Keeler Creek bull trout are adfluvial and migrate downstream out of Bull Lake into Lake Creek, then up Keeler Creek to spawn. This downstream spawning migration is somewhat unique when compared to other bull trout populations (Montana Bull Trout Restoration Team 1996a). Lake Creek, a tributary of the Kootenai River, has an upstream waterfall barrier isolating this population from the mainstem Kootenai River population. A micro-hydropower dam constructed in 1916 covered the upper portion of the waterfall. A series of high gradient waterfalls are still present below the dam, and are barriers to all upstream fish passage.

We observed a total of 13 and 102 bull trout redds in Keeler Creek and associated tributaries in 2001 and 2002, respectively (Table 14). 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.

With the 2001 observation included, annual variation is high ($r^2 = 0.001$; Figure 9), and the trend is a decreasing population, although the relationship is not significantly different from a stable population (Figure 9; $p = 0.958$). Given this relationship, the annual mean (75.6 redds) does an equally well job of prediction. The 2002 observation represents a 35% increase over the annual mean, and the 2001 observation represents an 82.8% reduction from the annual mean. However, if we remove the 2001 observation from the dataset and repeat the regression trend analysis, bull trout redds in Keeler Creek show a significant increasing trend since 1996 (Figure 9; $r^2 = 0.587$; $p = 0.076$).

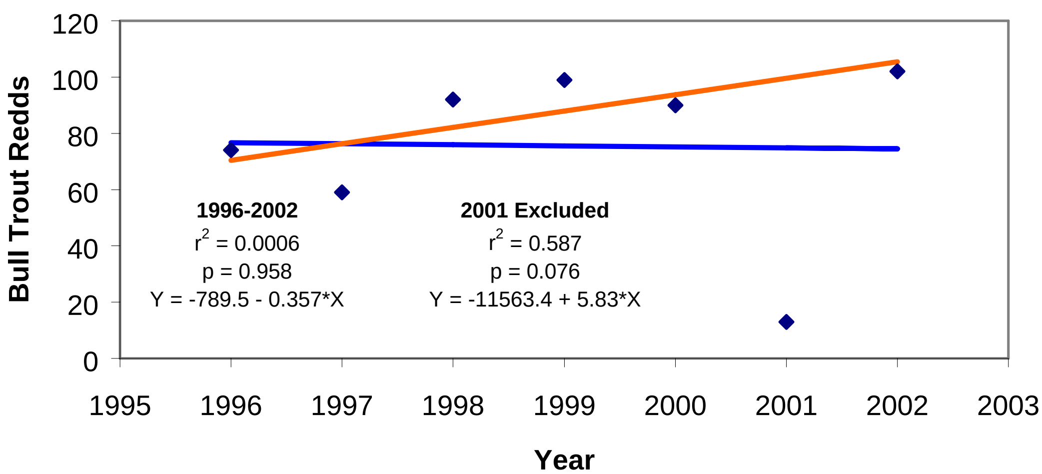


Figure 9. Bull trout redd counts and trend line (blue line) in Keeler Creek, 1996-2002. The 2001 observation was removed because beaver activity impeded bull trout migration and the regression analysis was repeated (orange line).

RADIO TELEMETRY MONITORING

Methods

To monitor movements of bull trout in the Kootenai River and Koocanusa system, we surgically implanted radio tags into a sample of fish. Lotek Engineering Inc., New Market, Ontario manufactured the tags. We used two sizes of radio tags for this study, in an attempt to balance battery life versus tag size. We reserved our 12 smaller tags for smaller bull trout. These tags weighed 9.5 g, had a minimum life span of 180 days, a burst rate of 56 pulses per minute, a 25 cm flexible external whip antenna attached to one end, and transmitted on frequencies ranging from 48.021 to 48.251 MHz. The remaining 53 (larger) radio tags weighed 25.6 g had a minimum life span of 750 days, a burst rate of 55 pulses per minute, a 35.6 cm flexible external whip antenna, and transmitted on frequencies ranging from 49.014 to 49.800 MHz.

All tags transmitted on a unique frequency that allowed individual fish identification and were powered by a single 3.6 V lithium battery. We used telemetry receivers manufactured by Lotek Engineering (Model SRX-400) for mobile monitoring activities. When practicable, we implanted radio tags in bull trout greater than 500 mm TL to ensure the weight of the radio tag did not exceed two percent of the weight of the bull trout.

We anesthetized each bull trout with tricane methane sulfonate (MS222) and placed it on its back in a v-shaped trough so that the gills remained irrigated but the incision site was dry. We made an incision in the abdominal cavity just long enough to receive the transmitter (approximately 2.5 cm), just anterior to the pelvic girdle and approximately 2 cm off the mid-ventral line.

We inserted a stainless steel spinal tap needle through the body cavity posterior to the incision near the pelvic girdle. We then threaded the antennae through the incision and needle, removed the needle and closed the incision with three or four interrupted sutures. After surgery we kept the bull trout in a live car until the effects of the anesthesia sufficiently wore off (generally overnight) and released them in a backwater eddy near the capture site.

We surgically implanted radio tags into 65 bull trout from late January 1998 to early December 2000. Most (51; 78.5%) of the tagged fish were captured in the Kootenai River below Libby Dam (between Libby Dam and Alexander Creek; river mile [RM] 220.5 - 221.7). Fish captured at this location were tagged over the same general time period, and were captured via nighttime jetsled electrofishing using a Coffelt model Mark 22 electrofishing unit, operating with an electrical output ranging from 200-350 volts at 5-8 amps. Nine out of the 65 radio tagged bull trout (13.8%) were captured in a downstream weir in lower Quartz Creek (above Kootenai Falls; RM 199.1) between 9/28/99 and 10/7/99, after the fish had likely spawned in Quartz Creek. We also captured one bull trout (1.5%) in a downstream weir in lower Callahan Creek (below Kootenai Falls; RM 186.4) in October 1998. Three additional bull trout (4.6%) were also captured from Koocanusa Reservoir and radio tagged. All but 4 of the radio tagged bull trout were released in the general vicinity of capture. Release locations and study objectives of these four bull trout are described below.

Skaar et al. (1996) documented bull trout entrainment at Libby Dam. However, the proportion of bull trout in the Kootenai River downstream of Libby Dam and the ultimate fate bull of trout that survive entrainment are unknown. To assess if bull trout that survive entrainment would spawn in tributaries downstream of Libby Dam, we captured 4 bull trout in Koocanusa Reservoir and released these fish below Libby Dam. These fish were to serve as surrogates for bull trout that survived entrainment. Likewise, one of the bull trout captured below Libby Dam was released in the reservoir, and was intended to serve as a surrogate for an entrained bull trout. This bull trout was captured below Libby Dam in March 1999 and released in Koocanusa Reservoir approximately 1 mile above Libby Dam. The objective of releasing this fish in the reservoir was to assess whether or not this fish would spawn in a tributary above the dam.

We determined the location of tagged fish using mobile tracking that consisted of a combined effort of fixed wing aircraft and jetboat observations. Each mobile monitoring unit consisted of a radio receiver, data processor, internal clock, and either a single (jetboat) or double (fixed wing aircraft) tuned loop antenna. We used fixed wing aircraft with antennae attached to both struts and mobile antennae in vehicles and boats. When a bull trout was located we entered the locations by 0.1 river mile. Fish movement and visual observations were used as the primary as indicators of live fish. The fish were generally tracked weekly through the spring and summer months and monthly during the winter due to decreased movement patterns during the colder months.

We also implanted radio tags into 15 out-migrating adults “Kelts” from Wigwam River to assess migration patterns and timing in Koocanusa and the Kootenai River above. We accomplished this part of the project between September 1996 and July 1998. The techniques for implantation and location of the bull trout were identical to those for the river fish.

Findings

Kootenai River Telemetry

Montana FWP personnel radio tagged a total of 65 bull trout ranging from 362-823 mm total length (Figure 10). The length frequency distribution of radio tagged bull trout tagged throughout the duration of this study shows a bimodal distribution (Figure 10). We attribute this bimodal distribution to our intentional selection smaller fish in 1998 and 1999. This was especially true in 1998, where the 12 bull trout tagged with the 48 MHz (smaller) radio tags were significantly smaller sized fish (mean total length = 459 mm; $p = 5.02*10^{-6}$) when compared to all bull trout tagged with the 49 MHz (larger) tags. The overall mean total length of all bull trout radio tagged in 1998 was 552.9 mm (Table 15), and was significantly smaller than those fish tagged in 1999 and 2000 ($p < 0.05$; Table 15). However, when the fish tagged with the 48 MHz (smaller) tags were removed from this analysis, and the analysis was repeated with only those fish tagged with the 49 MHz (larger) tags, the mean total length of fish tagged each year (Table 15) was not significantly different between years ($p = 0.499$).

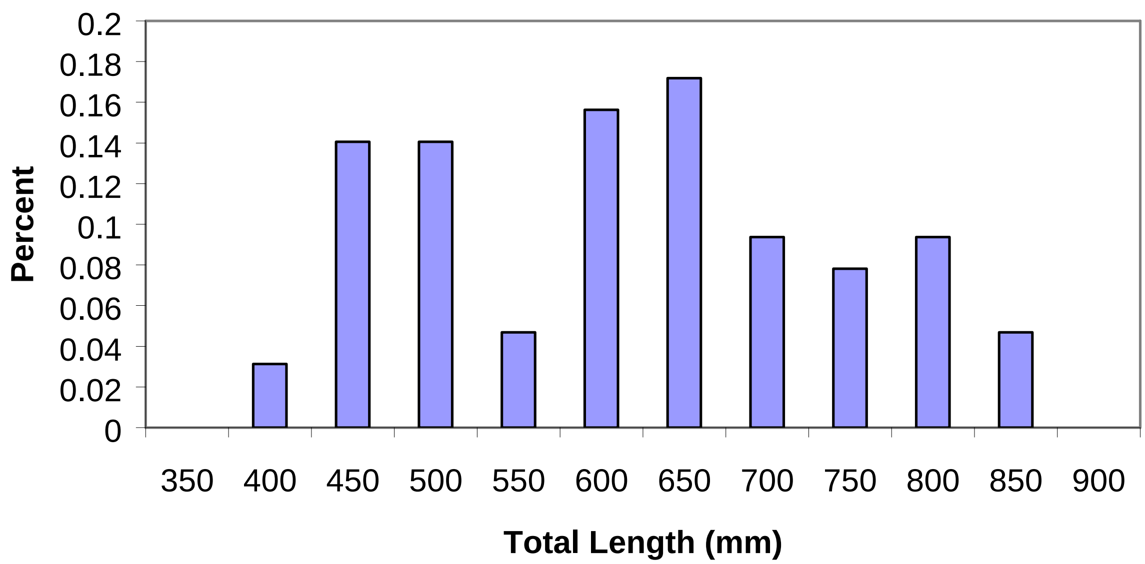


Figure 10. Length frequency distribution of the total length (mm) of all bull trout radio-tagged in the Kootenai River from 1998-2000.

Table 15. Total number, frequency and mean total length of bull trout tagged in the Kootenai River from 1998 - 2000

	1998 All Tags	1998 48 MHz Only	1998 49 MHz Only	1999	2000
Number Tags	32	12	20	22	10
Mean Total Length (mm)	552.9	458.8	609.4	632.8	660
Range Total Length (mm)	362-818	362-666	482-818	430-823	565-800

We had relatively good success tracking radio tagged bull trout after release. We tracked the radio tagged bull trout throughout the battery's lifespan for each particular tag. The smaller (48 MHz) tags were all placed in bull trout in 1998 and were tracked through 1998 and most of 1999. The remaining larger (49 MHz) radio tags were placed in fish from 1998 to 2000 and tracked from 1998 to 2002.

A total of eight (12.3%) tagged fish were never located after the first month of the survey. These included the single bull trout captured and tagged as an outmigrant from Callahan Creek, one of the three captured in Koocanusa Reservoir and placed below Libby Dam, one of the nine bull trout captured in the Quartz Creek weir, and five bull trout captured in the Kootenai River below Libby Dam. In particular, the bull trout that was captured in the Kootenai River below Libby Dam and placed in the reservoir was entrained through the dam a few days after tagging and a fisherman recovered the tag. The fate of the other 7 bull trout not located is unknown.

The three bull trout that were captured in Koocanusa Reservoir and placed in the Kootenai River directly below Libby Dam collectively provided little information as to the behavior or movement patterns due to a limited number of observations on these fish. One of these fish was never observed after release in the Kootenai River.

A second bull trout (tag number 49.055) was tagged on May 7, 1999, and subsequently observed twice 3.6 miles downstream of the release point within two weeks of release. The only other observations of this bull trout included 21 observations near the top of Jennings Rapids (RM 217.5) between June 22, 1999 and January 2, 2001, when the tag was ultimately recovered. Given the extended period of time this fish was observed at the same location and the recovery of the tag, it is likely this fish died or shed the tag within weeks of tagging and within 3.8 miles of the release location.

The third bull trout captured in Koocanusa Reservoir and released below Libby Dam migrated below Kootenai Falls. This bull trout was tagged and released on May 18, 1998 and first detected after release approximately 1 mile upstream of the Leonia gauging station (RM 167.9) 203 days after release. This fish was detected an additional 15 times within 2.3 miles of this location. The tag was last detected on September 24, 2001 at RM 165.6.

The remaining 58 radio tagged bull trout (89.2%) observed after tagging were released above Kootenai Falls, and observed an average of 30.7 observations per fish. The average number of days between observations was 22.6 and the average date of encounter was 8/14/99. We estimated that 36 of the 58 radio tagged bull trout (62%) remained above Kootenai Falls for the duration of our mobile tracking efforts.

The remaining 22 of the 58 radio tagged bull trout (38%) migrated downstream of Kootenai Falls. All the radio tagged bull trout that migrated below Kootenai Falls were either originally captured in the downstream weir in Quartz Creek or captured in the Kootenai River immediately below Libby Dam. The total proportion of the fish that migrated below Kootenai Falls was similar for Quartz Creek fish (n=4; 44.4%) and the Kootenai River below Libby Dam (n = 18; 36.0%).

The maximum distance a radio tagged bull trout traveled from the original release location was 84 miles. The mean distance traveled between observations for all radio tagged bull trout was 1.2 miles (standard deviation =6.2 miles). The mean total length (at time of tagging) of those bull trout that migrated downstream of Kootenai Falls was 622 mm, and was not significantly different (p = 0.189) than those bull trout that remained above Kootenai Falls (mean total length = 576). We were not able to assess if there were differences in either the sex or age of bull trout that migrated below Kootenai Falls because we didn't collect age or sex information at the time of tagging.

In order to assess if our handling at time of tagging influenced the migration of tagged fish below Kootenai Falls, we bracketed the true number of days after tagging that it took for each fish to migrate over Kootenai Falls. For each fish that migrated over Kootenai Falls, we calculated the minimum number of days by subtracting the last observation date prior to being detected below Kootenai Falls from the tagging date. Likewise, we calculated the maximum number of days by subtracting the first date each fish was detected below Kootenai Falls from the tag date.

The mean number of days between the minimum number of days before migration over Kootenai Falls was 158.3 days (Figure 11; standard deviation = 187.9 days and median = 68.5 days), and the mean number of days between the maximum number of days before migration below Kootenai Falls was 231 days (standard deviation = 223.7; median = 180.5 days). However, the distribution of both the minimum and maximum are skewed (Figure 11). For example, the minimum number of days before migration over Kootenai Falls was 25 days or less for 27.3% of the fish, and 25 to 50 days for 22.7% of the fish. In comparison, the maximum number of days before migration over Kootenai Falls was 25 days or less for none of the tagged bull trout and 25 to 50 days for 9.1% of the fish.

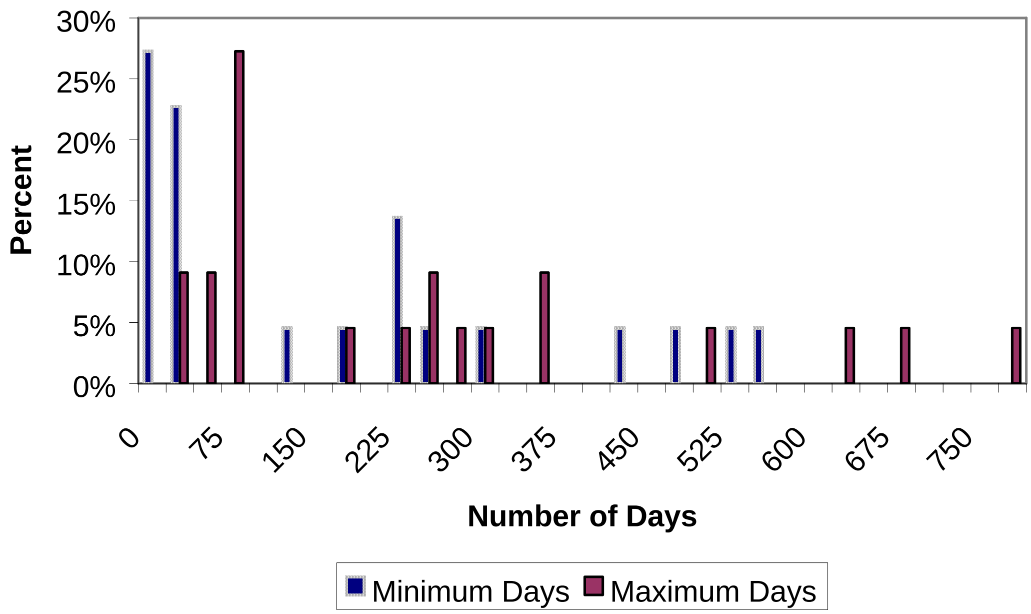


Figure 11. Histogram of the minimum (last observation date prior to being detected below Kootenai Falls minus tagging date) and maximum number of days (first date each fish was detected below Kootenai Falls minus the tag date) for all radio tagged bull trout that migrated below Kootenai Falls from 1998-2001.

Of the 22 radio-tagged bull trout that migrated over Kootenai Falls, we only documented one fish (tag number 49.221) that migrated upstream over the falls. This female bull trout was originally radio-tagged as an outmigrant from Quartz Creek on 10/7/99, and observed below Kootenai Falls on 11/4/99. The fish ascended Kootenai Falls between 7/18/00 and 9/18/00. The Kootenai River mean discharge including flows from Libby Dam and the Fisher River during this period was 8090 cfs (standard deviation = 47.4; range 7956 – 8275 cfs). The fish was observed on a probable spawning migration in Quartz Creek on 9/18/00 through 9/27/00. This female bull trout remained above the falls for the remainder of 2000 and throughout 2001 and entered Quartz Creek again in 2001 for a third year of probable spawning.

Although this is the first documented instance of fish migrating downstream to upstream over Kootenai falls, in 2001 a second bull trout (tag number 49.650) was observed near Kootenai Falls on 7/18/01, but this was our last observation for this fish. We believe the transmitter battery failed shortly after this observation. We suspected but could not confirm that this fish might have also migrated over the falls. The Kootenai River discharge during the period July 18, 2001 to September 30, 2001 was 6278 cfs (standard deviation = 476.6; range 5826 – 9170 cfs). The upstream migration pattern we observed for these two bull trout shortly before spawning season was not a common movement pattern for all bull trout that migrated below Kootenai Falls. Although some of the fish below the falls did exhibit similar movements in the fall, others moved only slightly or not at all.

We were only able to document four out of the 65 (6.2%) radio tagged bull trout in tributaries to the Kootenai River during spawning season. These four bull trout included two fish entering Quartz Creek (including tag number 49.221 described above), one entered the Fisher River and one entered O'Brien Creek. We averaged 8 observation days per year during the spawning seasons (August to mid November) 1998 through 2001. Our strongest effort occurred during the 1998 spawning season where we searched on 14 separate occasions (days). However, our effort in 1999 and 2000 was approximately half of what it was during the 1998 spawning season where the number of observation days dropped to 7 days each year. Due to the higher occurrence of battery failure we observed during 2001 and 2002, we reduced our effort even further, with the number of observation days during the spawning season dropping to four and one day, respectively. Of the bull trout that were observed in tributaries, two returned to Quartz Creek.

One female bull trout spawned in Quartz Creek in 2000 and 2001 (described above), but the other fish (tag number 49.210) was observed in Quartz Creek only in 2000. In 2000 both fish entered Quartz Creek between 7/20/00 and 9/15/00, one traveled a minimum of five miles and the other traveled over eight miles. Both fish migrated out of Quartz Creek between 9/27/00 and 11/6/00. The fish that returned to spawn in Quartz Creek in 2001 began staging near the mouth of Quartz Creek around 7/18/01 and then entered the creek between 8/28/01 and 9/24/01. We were unable to document an out migration time for this fish.

We do not know if the other fish that spawned in Quartz Creek the previous year migrated up Quartz Creek in 2001. The radio signal from this fish was detected on 11 different occasions between 11/6/00 and 9/24/01 at the same location approximately 1.7 miles downstream from the confluence of Quartz Creek. The last two observations of this fish were on 8/28/01 and 9/24/01, at which time the battery had been active for 727 days, approaching the life span for the tag. We made no attempts to locate this radio tag between 8/28/01 and 9/24/01. In 2000, this bull trout entered Quartz Creek before 9/15, and exited between 9/27 and 11/6/00. We are therefore unable to determine the location of this fish between 8/28/01 and 9/24/01.

We also observed a bull trout that was originally tagged in the Kootenai River directly below Libby Dam on 2/22/98. This particular bull trout migrated into the Fisher River on a probable spawning run in 1998 and 1999. In 1998 the fish migrated into the Fisher River between 9/24/98 and 10/19/98, traveling over 30 miles upstream. The fish then started its out migration between 10/19/98 and 10/26/98 and didn't reach the Kootenai River until 1/3/99. The following year this fish migrated in to the Fisher River sometime after 8/25/99. We located the shed tag on a gravel bar approximately 26 miles up the Fisher River on 7/24/00, directly downstream of the confluence of the West Fisher River. It is likely that this fish spawned in the West Fisher River.

The only other bull trout that may have entered a tributary was at O'Brien Creek in 1999. This fish was originally captured and subsequently tagged and released in the Kootenai River directly below Libby Dam, and migrated below Kootenai Falls less than a month after being tagged. We estimated the fish was approximately 200 meters upstream from the O'Brien Creek confluence during an aerial survey using a fixed wing aircraft on 8/25/99. However, we did not confirm the observation with an independent field reconnaissance. Our next attempt to locate this fish on 10/22/99 within the same general vicinity was unsuccessful. This fish was next detected in the Kootenai River between 12/10/99 and 1/10/00 approximately 2 miles upstream of the O'Brien Creek confluence.

Twelve other bull trout were detected near the confluence of the Fisher and Yaak rivers, O'Brien, Lake, and Quartz creeks during the late summer/fall of this study. However, we never observed these fish entering the tributaries during any of our aerial surveys. We observed five radio tagged bull trout in the vicinity of the Fisher River confluence. Our search patterns could not confirm that these fish entered the Fisher River.

Four of the five fish that were located near the vicinity of the Fisher River confluence were unaccounted for when searches of the mainstem Kootenai River were conducted over a period ranging from 12 to 26 or more days during the spawning season. We did not search for these four bull trout in the Fisher River drainage. The fifth bull trout that was located near the Fisher River confluence during the spawning season was unaccounted for from October 13 to December 4, 1998. We failed to locate that fish during an aerial search of the mainstem Kootenai Rive and Fisher River Basin.

Two bull trout were observed around the mouth of the Yaak River on September 24, 2001 and one bull trout was observed at this location on October 19, 1998. However, no searches were conducted for the two tagged bull trout located in 2001 until June 2002. The bull trout observed near the Yaak River confluence in 1998 was located 7 days later directly below Kootenai Falls, and remained there the rest of the year. We have surveyed the Yaak River drainage below Yaak Falls for spawning activity in the past and it is unlikely bull trout use this tributary for anything other than feeding forays.

We located two bull trout near the O'Brien Creek confluence during the bull trout spawning period. We located one radio tagged bull trout near Kootenai Falls on 6/1/99 and could not account for it until 10/22/99 when it was detected near the O'Brien Creek Confluence. We could not account for it again until 12/10/99 when it was located back at the mouth of O'Brien Creek. We conducted aerial searches within the O'Brien Creek watershed on 7/8 and 8/25/99, but did not locate this fish.

The other radio tagged bull trout that was located near the O'Brien Creek confluence was observed at this location in 1998 and 1999. We found the fish on 10/19/98 near the confluence, then again on 10/26/98 near Kootenai Falls, leaving 6 days unaccounted for. We found the same fish approximately 2 miles downstream of Kootenai Falls in June 1999 and then could not account for it the entire 1999-spawning season. We did not search for this fish in the O'Brien Creek drainage in 1998; however, we conducted aerial searches in the O'Brien Creek drainage twice in 1999 and once in the O'Brien, Lake, and Callahan creek drainages in 2000. We did not locate either of these fish during these aerial searches.

The same bull trout that was present near the O'Brien Creek confluence in 1998 and 1999 was observed around the mouth of Lake Creek in 2000. This fish was also unaccounted for a portion of the 2000 spawning season for a period of 60 days (9/27-11/6). We conducted no surveys during this period. The final bull trout observed near a tributary confluence was observed near Quartz Creek in 2000. This fish was present near the Quartz Creek confluence on 7/20/00 and then unaccounted for until 9/22/00 (64 days), when we located it approximately 3 miles downstream of the Quartz Creek confluence. We conducted 2 aerial searches within the Quartz Creek drainage during this period but failed to locate this fish.

We identified several common locations that adult radio tagged bull trout frequented in the Kootenai River above Kootenai Falls. Common locations for above the falls vary slightly from season to season with some of the more popular year round areas being the Libby Dam tailrace area that extends from Libby Dam to approximately 2 miles downstream to confluence of Alexander Creek.

We defined seasons of the years as follows; spring (April – June), summer (July – August), fall (September – November), and winter (December – March). During the spring and winter seasons radio tagged bull trout were frequently located in the tailrace area to the Dunn Creek confluence (RM 219.8), downstream to the Fisher River (RM 219.2) and the Jennings Rapids area (RM 217.3). Common year round holding areas in the lower Kootenai River below the falls included the area from Flemming Creek, Idaho (RM 137.6) to approximately five miles down river. However, during fall and winter seasons, tagged bull trout were frequently located between Throops Lake (RM 190.4) and the Sturgeon Hole (RM 191.4).

We stratified our radio tag observations based on season and location above or below Kootenai Falls and used an analysis of variance (ANOVA) to assess seasonal movement. We compared the mean number of days between detections, mean miles traveled between detections, and mean number of miles traveled between detections (miles traveled between detections divided by number of days between detections) between seasons for radio tagged bull trout above and below Kootenai Falls using ANOVA and subsequent multiple comparisons. Significant differences existed between the mean numbers of days between detections ($p = 4.91*10^{-13}$; Table 16).

The subsequent multiple comparisons revealed that 19 out of 26 possible comparisons were significantly different ($p = 0.05$; Table 16). However, we found no significant difference between the mean number of miles or the mean number of miles traveled per day each radio tagged bull trout traveled between detections when stratifying by season or location (above and below Kootenai Falls) ($p = 0.242$ and 0.144, respectively; Table 16).

Since neither of these analyses suggested that seasonal bull trout movement differed by the location of the fish above or below Kootenai Falls, we pooled the observations from above and below the falls within a season and repeated the ANOVA (Table 17). In each instance, ANOVA suggested that at least one pair wise comparison differed significantly ($p = 0.10$). Subsequent multiple comparisons indicated that both the mean miles traveled and the number of miles traveled per day between detections differed during the fall season from all other seasons. During the fall season bull trout moved and average of 1.35 miles between detections, and an average of 0.10 miles per day (Table 17). We also pooled the seasonal movement information in an attempt to determine if movement differed between fish locations above or below Kootenai Falls. Although the mean distance traveled and the mean distance traveled per day between detections was higher for radio tagged bull trout below

Kootenai Falls (seasons pooled), these differences were not significantly different than fish located above Kootenai Falls (p = 0.727 and 0.663, respectively; Table 17).

Table 16. The sample size, mean days between detection, mean distance traveled between detections, and mean distance traveled per day between detections for radio tagged bull trout in the Kootenai River. The analyses were stratified based on season and fish above and below Kootenai Falls. The p-value from the ANOVA testing for differences between seasons and above/below Kootenai Fall, and those pair wise comparisons that were significantly different are also given.

Season	**Above or Below Kootenai Falls**	**Sample Size**	**Mean Days Between Detection**	**Mean Distance (miles) Traveled Between Detections**	**Mean Distance (miles) Traveled Per Day**
Spring	Above	47	16.9	0.58	0.049
Spring	Below	17	33.2	1.00	0.036
Winter	Above	53	16.5	0.50	0.038
Winter	Below	17	23.8	0.34	0.013
Fall	Above	36	13.7	1.35	0.073
Fall	Below	16	25.2	1.37	0.172
Summer	Above	45	12.8	0.28	0.037
Summer	Below	13	23.9	0.16	0.008
Overall Mean			18.1	0.66	0.051
ANOVA p-value			$4.91*10^{-13}$	0.242	0.144
<u>Non-</u>Significant (p > 0.05) Pair-wise comparisons				Spring Above/Winter Above Spring Above/Fall Above Winter Above/Fall Above Winter Above/Summer Above Winter Below/Fall Below Winter Below/Summer Below Fall Above/Summer Above	

Table 17. The sample size, mean distance traveled between detections, and mean distance traveled per day between detections for radio tagged bull trout in the Kootenai River. The analyses were stratified based on season and above and below Kootenai Falls. Fish from above and below Kootenai Falls were pooled from these analyses due to a lack of significant differences (above and below the falls), and by season (see Table 3). The p-value from the ANOVA testing for differences between seasons and by location above or below the falls is stated. Significantly different pair wise comparisons are also given.

Season	**Above/Below Kootenai Falls**	**Sample Size**	**Mean Distance (miles) Traveled Between Detections**	**Mean Distance (miles) Traveled Per Day**
Spring	Pooled	63	0.69	0.046
Winter	Pooled	70	0.46	0.032
Fall	Pooled	52	1.35	0.103
Summer	Pooled	58	0.25	0.031
Overall Mean			0.66	0.051
ANOVA p-value			0.035	0.087
Significant pair-wise (p =0.10) Comparisons			Spring/Fall Winter/Fall Fall/Summer	Spring/Fall Winter/Fall Fall/Summer
Pooled	Above	181	0.63	0.048
Pooled	Below	62	0.74	0.059
ANOVA p-value			0.727	0.663

Discussion

Kootenai River Telemetry

We believe that our bull trout radio telemetry study provided us with an accurate assessment of seasonal movement patterns, overall spatial distribution, and areas of congregation for bull trout in the Kootenai River below Libby Dam. We based this assessment on relatively high proportion of tagged fish that maintained locations (89%), the relatively high number of mean observations per tagged fish (30.7 observations per fish) and the relatively short mean period between observations for tagged fish (22.6 days) throughout the duration of the 3-year study.

We acknowledge that the estimates of the proportion of radio tagged fish that migrated over Kootenai Falls and the proportion of radio tagged bull trout that ascended tributaries during the spawning season may not be accurately represent the behaviors of all non-tagged bull trout in the Kootenai River below Libby Dam. For example, up to 50% of the radio tagged bull trout that migrated below Kootenai Falls did so within 50 days after being tagged, suggesting the possibility that our handling and tagging the fish may have influenced their behavior, and contributed to the fallback of 11 of the radio tagged bull trout. The remaining 50% of the radio tagged bull trout that migrated over Kootenai Falls did so much longer after being handled and tagged. We are not certain whether these observations are an accurate indicator of the prevalence of bull trout migration over the falls. If we assume that the effects of tagging and handling did not contribute to this latter group of fish that migrated over Kootenai Falls, then approximately 19% of the bull trout in the Kootenai River may be migrating over the falls.

Although we did document a single bull trout ascend Kootenai Falls proving that the falls are not a complete fish barrier, Kootenai Falls is likely a substantial obstacle to upstream migration, especially during period of extremely high and low flows. Given the low proportion of bull trout that migrated upstream of the falls and the relatively high proportion of bull trout that may be migrating below Kootenai Falls, this situation may be constitute a source/sink population which may influence the probability of the long-term persistence of this population (Harrison 1991; Gilpin 1987).

Another explanation for inconsistent migration behaviors that deserves consideration is that a large, if not significant, number of bull trout are entrained through Libby dam and we radio-tagged at least some of them during the study. We have captured several adult bull trout that were floy-tagged during the Wigwam River studies. It is possible that those fish exhibited less fidelity to the Kootenai River between Libby Dam and Kootenai Falls and were more likely to migrate downstream. It is important that we determine the proportion of reservoir resident to river resident bull trout in the Kootenai River below Libby Dam in the near future.

We observed 4 (6.2%) of the radio tagged bull trout throughout the duration of the three-year study that ascended tributaries during the fall. Although we did not observe any of these fish spawning, the timing and behavior suggested that these fish did likely spawn. Two of these four bull trout entered (and presumably spawned) in consecutive years in Quartz Creek and the Fisher River, respectively. Two other radio tagged bull trout may have also spawned in consecutive years. However, mobile tracking information was insufficient to confirm this assumption. Given the broad geographical distanced required to effectively cover all spawning tributaries in the lower Kootenai River with mobile tracking gear, it is likely that we may have not observed an additional 12 bull trout that ascended the Fisher and Yaak Rivers, O'Brien, Lake and Quartz Creeks. Once again, it is important to include the possibility that at least some of the bull trout that were tagged may have originated in tributaries to Lake Koocanusa. If that was the case we expect it is possible that some bull trout may not have chosen to spawn in typical tributaries below Libby Dam during the duration of the study.

Our radio telemetry study confirmed that bull trout seasonally congregate in several locations below Libby Dam. Angling is very common in many of these areas, and has created a public impression that bull trout may be much more abundant than they actually are within the Kootenai River below Libby Dam. The congregation of bull trout at common locations in the Kootenai River also has the potential to create a mixed stock (population) fishery that could potentially impact the weakest stock either through non-compliance, hooking mortality, or the establishment of an angling season for bull trout. Potential for this situation would be highest during the spring and winter when fish movement was lowest. The bull trout we tagged during this study moved nearly twice as much during the fall season. We assumed that at least some of the increase in distance moved during the fall season was due to spawning movements.

Lake Koocanusa Telemetry

In cooperation with then British Columbia Ministry of Environment (BCMOE), MFWP surgically implanted low frequency radio transmitters in 15 bull trout captured in downstream traps in the Wigwam River. We implanted 10 transmitters in bull trout in 1996 and 5 in 1997. We followed the migrations of these fish through July of 1999. Radio tags were located from a Cessna 206 airplane equipped with external antennas. When a fish was located, and the strongest signal received, a GPS position was noted.

In general, we located bull trout weekly or biweekly during spawning migrations and monthly during the rest of the year. Locations of bull trout in the Lake Koocanusa were uncommon because once fish swam below about 40 feet of water signals were lost. Nevertheless, we found enough locations throughout the reservoir to accurately determine major migration patterns for bull trout spawning in the Wigwam River.

Of the 15 radio-tagged bull trout, we were able to effectively track 13 through most of the tags' battery lives (Approximately 2.0 years). Two were captured and kept by anglers in B.C. and tags were returned. General locations for bull trout during the three-year study showed that bull trout tended to be somewhat randomly dispersed throughout the entire Montana portion of the reservoir between October and end of February. By March, bull trout appeared to be more closely associated with the shorelines and moving northward.

By April, most bull trout had migrated to between Koocanusa Bridge and the Montana/B.C. border. By May, the bull trout generally reached the mouth of the Elk River, although two tagged bull trout were still in the U.S. portion of Koocanusa through May and into June. The radio tagged bull trout spent July-September from the mouth of Wigwam River to Nearly the Montana/B.C. border and generally ascended the tributaries and spawned from mid September through early October. The radio tagged bull trout generally migrated back to Lake Koocanusa by the end of October and dispersed throughout the reservoir.

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 similar to those reported in Chisholm et al. (1989). 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 (Kamloops rainbow, cutthroat, bull trout or burbot) were captured alive, only a length was recorded and the fish were released.

Findings

Bull trout

From 1988 until present, one monitoring area (Koocanusa bridge to Montana/B.C. border) was netted. 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 captures 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. Table 18 summarizes long-term bull trout mean catch per net in Koocanusa from spring sinking nets.

Table 18. Spring sinking gill net summary of bull trout catch per net in Lake Koocanusa 1975 - 2002.

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

The long-term trend indicates stable numbers of bull trout per sinking net between 1975 and 1993 (Figure 12). From 1993 through 2002 trends are increasing. Furthermore, the bull trout catch in the sinking gillnets is correlated to redd counts from the Wigwam River and Grave Creek.

Bull trout redd counts in both the Wigwam River and Grave Creek are significantly and positively correlated (r^2 = 0.562; p = 0.03 and r^2 = 0.485; p = 0.02, respectively) to spring gill net catch rates for bull trout (Figure 13). A log transformation of redd counts within these two tributaries slightly increased the overall fit of the relationship between redd counts and the gillnet catch of bull trout (Figure 14). Koocanusa Reservoir pool elevations during the annual gill netting activities ranged from 39.9 – 124.0 feet below full pool elevation.

We attempted to correct bull trout gill net catch rates for annual reservoir pool elevation by developing an index of abundance that was calculated by multiplying the annual bull trout catch per net by the estimated reservoir volume (thousand acre feet; Figure 15). Although we feel this correction also indicates an increasing bull trout population, especially from 1993 to present, we believe that the uncorrected gill net catch data provides a better fit than the data corrected for reservoir pool elevation. We base this on the higher r^2 values obtained for the gillnet catch data and the relationship between gillnet catch and redd counts from the uncorrected datasets.

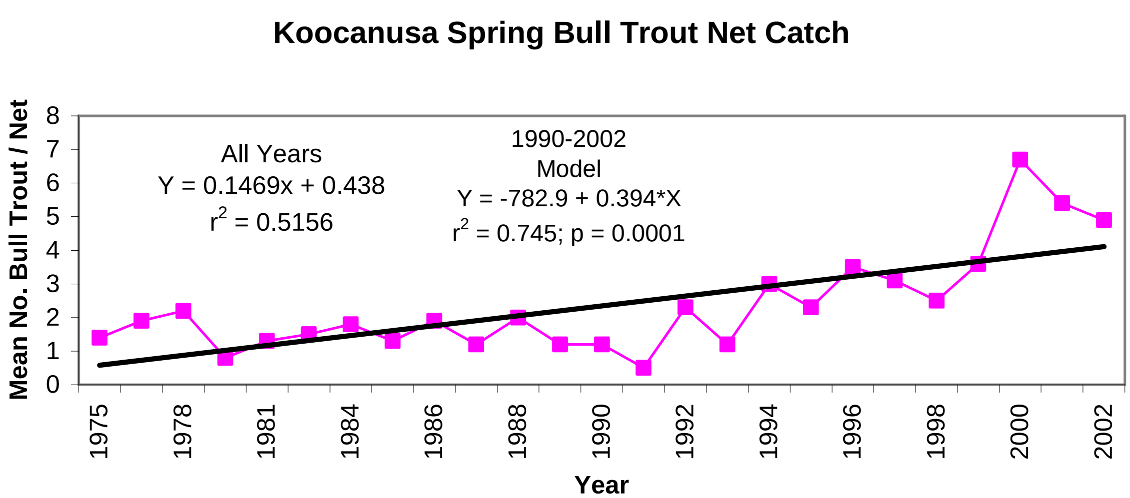


Figure 12. Spring sinking gill net summary of bull trout catch in Lake Koocanusa and linear regression (1975-2002).

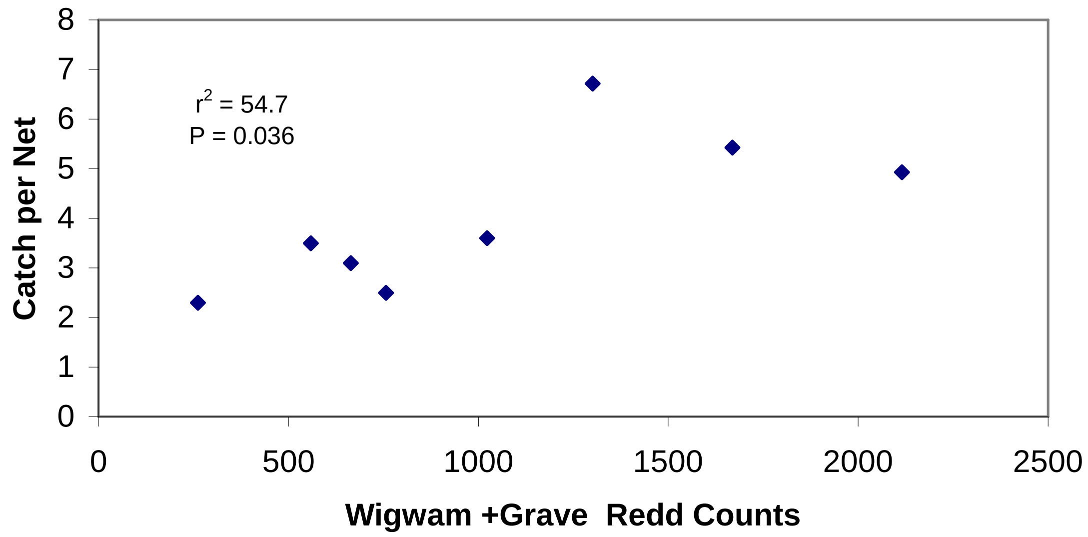


Figure 13. The relationship between redd counts in the Wigwam River and Grave Creek and bull trout catch per net in spring sinking gill nets in Koocanusa Reservoir from 1994 – 2002.

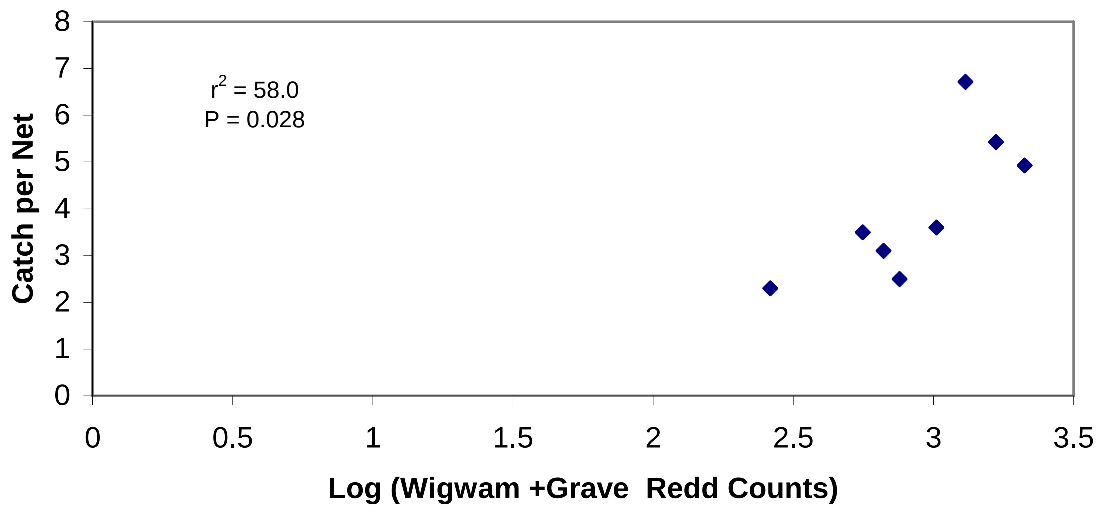


Figure 14. The relationship between log (redd counts in the Wigwam River and Grave Creek) and bull trout catch per net in spring sinking gill nets in Koocanusa Reservoir from 1994 – 2002.

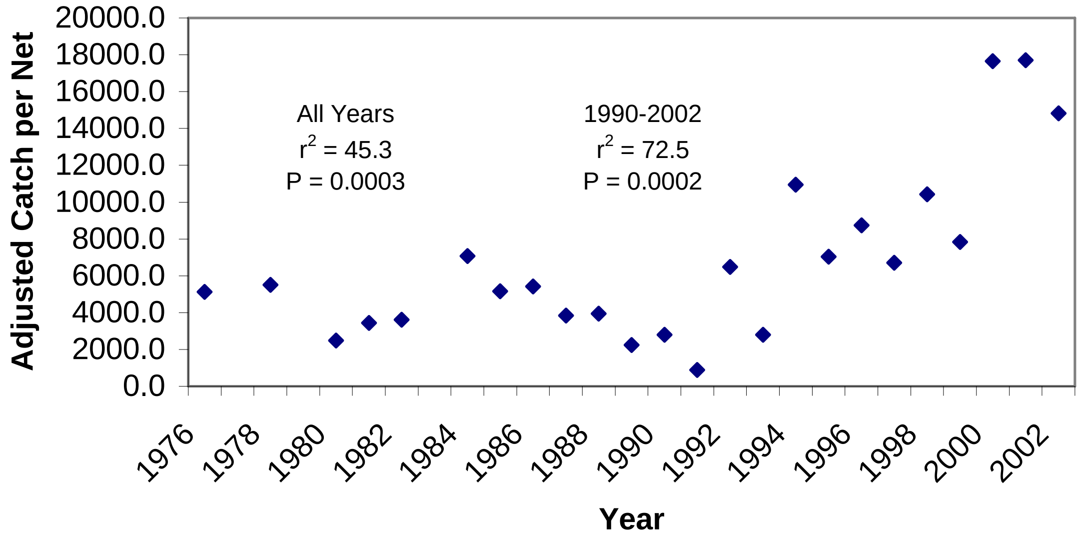


Figure 15. Time series trend of adjusted bull trout catch data for sinking gill nets in Koocanusa Reservoir from 1976-2002. Bull trout catch rates (fish per net) were adjusted for varying reservoir pool elevations between years by multiplying catch per net by reservoir volume (thousand acre feet). Trend analyses for all years and 1990-2002 are presented.

Kokanee

Chisholm et al. (1989) found that kokanee were the most important prey species in stomachs of bull trout between October and April. Trout were next but as the number of trout has decreased in the reservoir, the importance of kokanee has certainly increased. For that reason, the gill netting surveys for kokanee are included in this report.

Since the accidental introduction of at least 250,000 fry from the Kootenay Trout Hatchery in British Columbia into Lake Koocanusa in 1980 and quite likely other inadvertent introductions of presumed moribund fish, kokanee have become the second most abundant fish captured during fall gillnetting (Peamouth chub [*Mylocheilus caurinus*]). Fluctuations in catch have corresponded to the strength of various year classes and have varied by year, with no apparent trend in abundance (Figure 16).

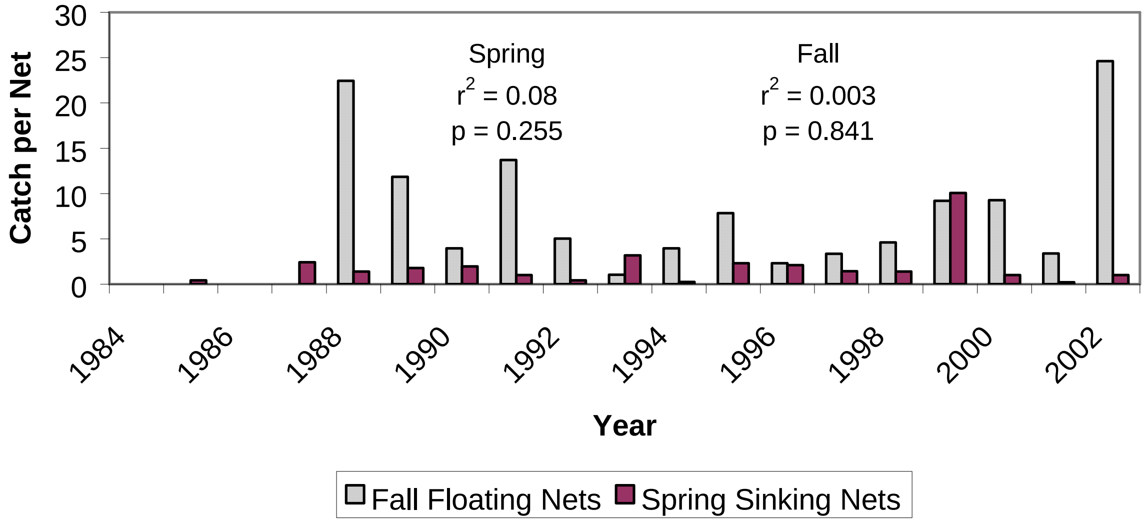


Figure 16. Average catch per net of kokanee for fall floating (1988-2002) and spring sinking (1984-2002) gill nets in Koocanusa Reservoir.

Average length of kokanee varied among years. Average length and weight between 1988 and 2002 was 292.0 mm and 239.2 g respectively (Table 19), while maximum average size occurred in 1992 (350 mm, 411 g). However, the minimum mean length was observed in 2002 (Table 19). Adult escapement to surveyed tributaries has increased substantially since 1997. It appears as though increasing bull trout; Kamloops trout and other predators have not negatively impacted kokanee populations during this time.

Table 19. Average length and weight of kokanee salmon captured in fall floating gillnets (Tenmile and Rexford) in Lake Koocanusa, 1988 through 2002.

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	AVG.
Sample size (n)	2150	1259	517	624	250	111	291	380	132	88	76	200	342	120	357	
Length (mm)	315.5	275	257.3	315.8	350	262.7	270.2	300.2	293.7	329.6	333.9	291.6	271.3	261.6	251.3	292.0
Weight (gm)	289.1	137.2	158.4	327.3	411.3	162.3	191.7	261.6	234.5	363.2	322.0	229.6	185.6	161.6	152.2	239.2
Adult Escapement*									397,697	116,317	147,026	258,817	328,747	351,653	452,740	

*Escapement count from Westover (2002)

Kamloops Trout (Duncan Strain)

Kamloops trout were first introduced to Koocanusa Reservoir in 1985 by The British Columbia Ministry of Environment (Now Ministry of Water, Land and Air Protection). The BCMOE continued to annually stock approximately 5,000 fingerling Kamloops (gerrard strain) into Kikomun Creek, a tributary to Lake Koocanusa, between 1988-1998 (L. Siemens, MWLAP, personal communication). Montana FWP stocked between 11,000 and 73,000 Duncan strain Kamloops trout since 1988 to 1998 (Table 20). We stocked no Kamloops during 1999 and 2000. Since 2001 FWP has stocked only sterile (Triploid) Kamloops trout in the reservoir. Some believe that the introduction and continued stocking of kamloops trout in Koocanusa will have a negative impact on bull trout populations due to competition and possible predation. For that reason, gillnetting information for Kamloops trout is included in this report.

The catch of Kamloops rainbow trout in fall floating gillnets (fish per net) was significantly and positively correlated with the number of hatchery Kamloops rainbow trout stocked in the reservoir the previous year (P=0.002; r^2 = 0.63; Table 20) for 1988 through 1999.

Table 20. Kamloops rainbow trout captured in fall floating gillnets in the Rexford and Tenmile areas of Lake Koocanusa, 1988 through 2002. The Tenmile site was not sampled in 2001 or 2002.

	1988	1989	1990	1991	1992	1993	1994	1995
No. Caught	3	0	18	6	3	4	0	12
Avg. Length mm)	289	n/a	301	383	313	460	N/A	313
Avg. Weight (gm)	216	n/a	243	589	289	373	N/A	311
No. Stocked	20,546	73,386	36,983	15,004	12,918	10,831	16,364	15,844
Length (mm)	208-327	175-198	175-215	180-190	198-208	165-183	168-185	165-178

	1996	1997	1998	1999	2000	2001	2002
No. Caught	2	1	2	3	3	0	0
Avg. Length (mm)	460	395	376	378	395	N/A	N/A
Avg. Weight (gm)	1192	518	450	504	555	N/A	N/A
No. Stocked	12,561	22,610	16,368	13,123	none	none	29,546
Length (mm)	170.5	152-178	127-152	255-280	N/A	N/A	80.3

However, the catch rate of Kamloops rainbow trout in fall floating gillnets shows no significant trend (Figure 17; r^2 = 0.136; p = 0.177). Catch rates for Kamloops rainbow trout in fall gillnets has been low since 1996.

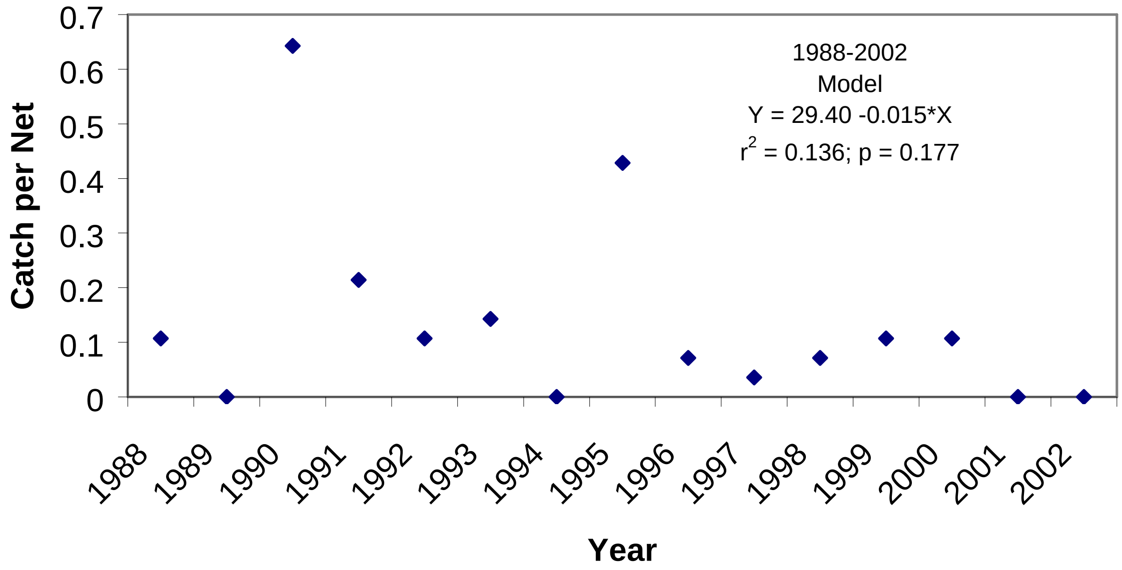


Figure 17. Average catch (fish per net) of Kamloops rainbow trout (Duncan strain) in fall floating gill nets in Koocanusa Reservoir at the Rexford and Tenmile sites 1988-2002. The Tenmile site was not sampled in 2001 or 2002.

There is no indication from these data that the stocking of Kamloops trout in Lake Koocanusa has had a negative impact on bull trout populations. In fact, bull trout appear to be thriving at the same time. We feel that the addition of Kamloops presents no danger to the continued existence of bull trout and provides a trophy fishery while angling for bull trout remains closed.

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