October 2001

KOOTENAI RIVER FISHERIES INVESTIGATION STOCK STATUS OF BURBOT

January 1, 1999 - March 31, 2000

Annual Progress Report

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FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

ANNUAL PROGRESS REPORT
January 1, 1999 – March 31, 2000

Prepared by:

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IDFG Report Number 01-47
October 2001

Kootenai River Fisheries Investigation: Stock Status of Burbot

Project Progress Report

1999 Annual Report

By

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ABSTRACT

In Idaho, the burbot *Lota lota* are native only to the Kootenai River and are genetically distinct from burbot in the Montana reach of the river. Burbot once provided a substantial fishery with tens of thousands of burbot harvested annually. Burbot now number fewer than 1000 in the Kootenai River and Kootenay Lake and may be nearing demographic extinction. Studies completed in the winter of 1997-1998 indicated flow management at Libby Dam likely affected burbot spawning migration during winter. The objective of our study was to monitor the movement of burbot during a period of normal winter operation and a low flow period to test the null hypothesis (H_o) that winter operation of Libby Dam does not affect burbot migration distance or travel rate.

In addition, we monitored the stock status of burbot. We captured 36 burbot in Idaho and British Columbia with baited hoop nets. Twenty-three burbot were caught in Idaho, including 12 at Ambush Rock. The remaining 13 burbot were caught in British Columbia, including eight in the Kootenai River and five in the Goat River. One burbot escaped and was not measured, and one recaptured burbot was not measured. Burbot ranged from 332 mm to 705 mm total length (TL) (mean = 541 mm, SE = 14.02) and weighed from 350 g to 2,850 g (mean = 1,059 g, SE = 90.51). Relative weight (W_r) ranged from 40.5 to 127.6 and averaged 88.6 (SE = 2.44). Population estimates for 1996, 1997, and 1998 were made for the Kootenai River from Bonners Ferry to Kootenay Lake; they were 738, 540, and 43 fish respectively. These estimates were not considered valid because we had so few recaptures, and confidence intervals could not be provided.

Four burbot were implanted with sonic transmitters and their movement was monitored. We requested a low flow test (170 m^3/s) period of five weeks from the US Army Corps of Engineers (USACE) to study burbot migration distance or travel rate. The USACE could not provide an adequate low flow test period. Mitochondrial DNA (MtDNA) analysis indicated Duncan Lake, British Columbia burbot are genetically similar to Kootenai River fish and are a potential donor stock. The capture of eight post-spawn burbot and the subsequent examination of milt and gonadal tissue indicated they were in at least four different stages of reproductive readiness. These findings further support the hypothesis that high fluctuating flows from Libby Dam, which have continuously disrupted burbot migrations, may also be responsible for the failure of some burbot to spawn.

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INTRODUCTION

Burbot *Lota lota* in the Kootenai River (Figure 1) once provided an important winter fishery to residents of northern Idaho (Paragamian et al. 2000). Anglers reported catching up to 40 burbot a night during winter setline fishing (Paragamian 1994). The annual harvest of burbot from the Kootenai River by sport and commercial fisherman in Idaho before 1972 may have been in the tens of thousands of kg (Paragamian et al. 2000). Three commercial anglers in Idaho alone harvested an estimated 2,150 kg in 1958 [Idaho Department of Fish and Game Department (IDFG) unpublished data]. Burbot caught during the winter fishery before Libby Dam are thought to have been part of a spawning migration from the lower river and Kootenay Lake in British Columbia (BC), Canada. However, after construction and operation of Libby Dam in 1972 by the US Army Corps of Engineers (USACE), the fishery rapidly declined and was closed to angling in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in the West Arm of Kootenay Lake, BC (Paragamian et al. 2000). Operation of Libby Dam for hydroelectric power and flood control created major changes in the river's seasonal flow, particularly during the winter when burbot make extensive migrations to spawn (Paragamian 2000) (Figure 2). The temperature regime and nutrient supply of the Kootenai River have also changed since operation of Libby Dam began (Partridge 1983; Snyder and Minshall 1996; Richards 1996).

The Kootenai River Fisheries Investigation was initiated in 1993 by IDFG to address burbot abundance, distribution, size structure, reproductive success, and movement and to identify factors limiting burbot recruitment. Only one burbot was captured between Bonners Ferry (rkm 246) and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994). There has been little evidence of reproduction in Idaho as only one juvenile burbot was captured from 1993 to 1998, and until 1999 no larval fish had been collected. The single burbot larva was caught in the river downstream of the confluence with the Goat River (Paragamian and Whitman 1999). However, numerous size-classes of burbot were collected in hoop nets, indicating some burbot had reproduced successfully (Paragamian 1994, 1995; Paragamian and Whitman 1996). Previous studies had failed to document a spawning run of burbot from the lower river or Kootenay Lake. However, cooperative sampling in the BC reach of the river with the Ministry of Environment Lands and Parks (MOELP) documented spawning burbot in the Goat River, BC (Paragamian 1995; Paragamian and Whitman 1996, 1997).

Studies completed in the winter of 1997-1998 indicated flow management at Libby Dam might disrupt upstream spawning migration by burbot during winter (Paragamian 2000). Movement of burbot with sonic transmitters was significantly higher ($P < 0.01$) during low flow test conditions, which were designed to replicate pre-dam Kootenai River flows. Movement upstream was also significantly higher during low flow tests than the control ($P = 0.009$), despite the fact there were low flows during the controls, i.e., periods between the high flows of power peaking or load following. Winter flows are now three to four times greater than they were pre-Libby Dam, when conditions were relatively stable. Daily differences in flow can now range up to 652 m^3/s.

The specific effect of changing flows on burbot spawning migration and spawning is unknown, but it may reduce spawning fitness or stamina and affect timing of burbot spawning. One or both of these possible factors may be sufficient to reduce spawning success and recruitment to the fishery. In addition it is unknown how temperature and nutrient losses are affecting the population.

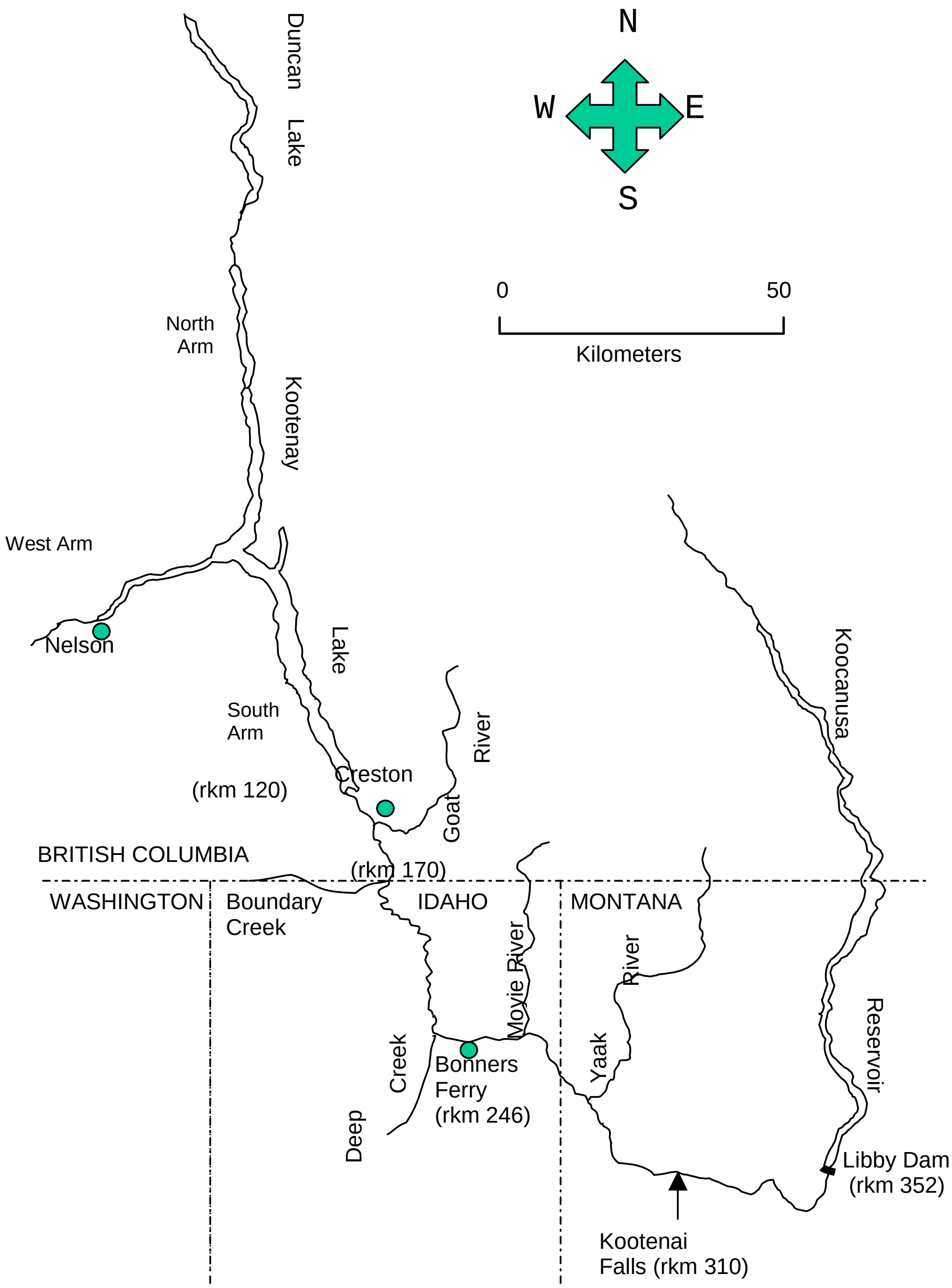

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. River distances begin at the northernmost reach of Kootenay Lake and are indicated at important points and expressed in river kilometers (rkm).

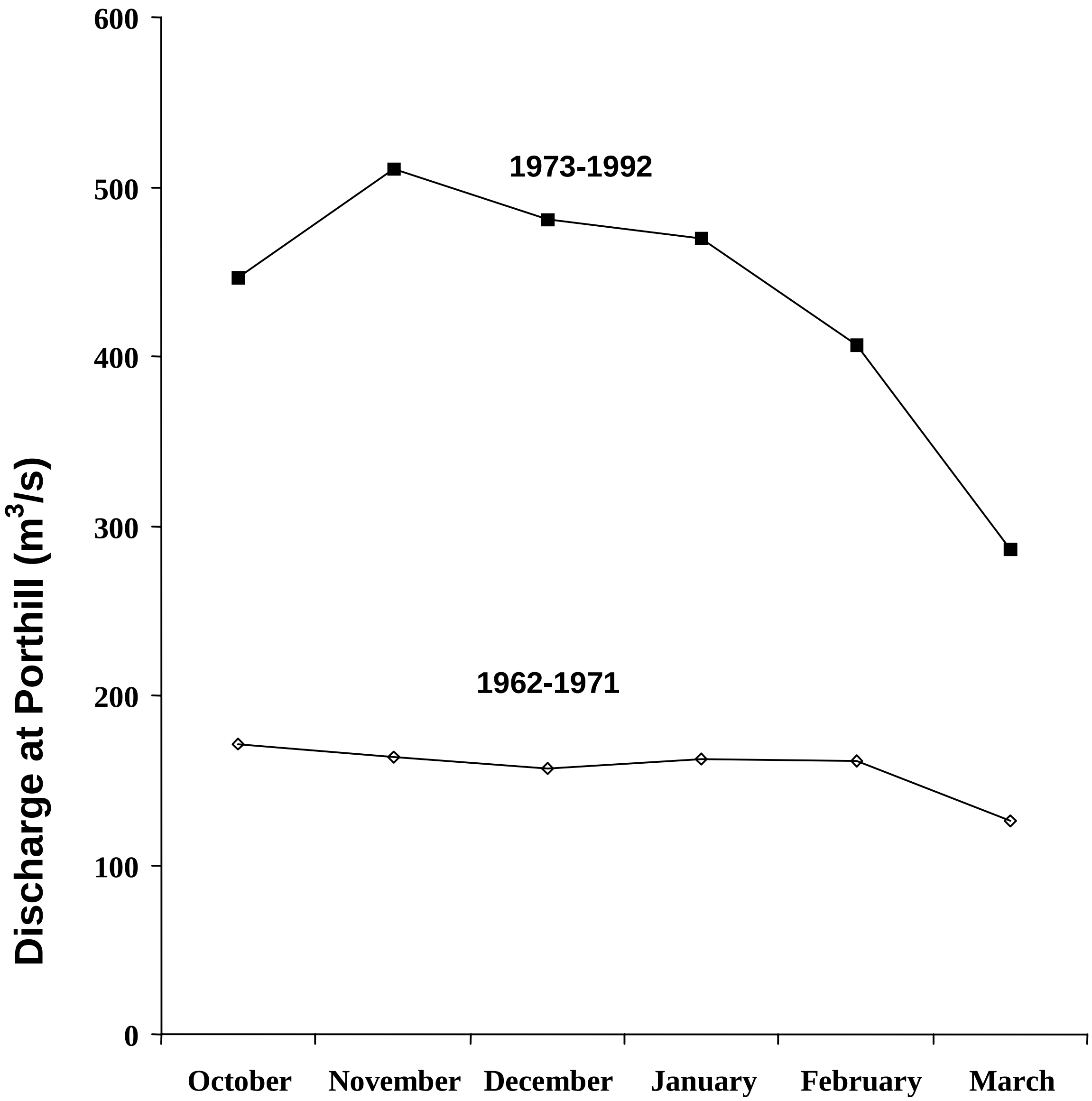

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho, during fall and winter from 1962 through 1971 (pre-Libby Dam), and from 1973 through 1992 (post-Libby Dam).

GOAL

1. Restore the burbot population in the Idaho reach of the Kootenai River and improve fishing success to sustainable harvest levels.

OBJECTIVES

1. Identify factors limiting burbot within the Idaho portion of the Kootenai River drainage and recommend management alternatives to restore the fishery to self-sustainable levels.

2. Define factors limiting burbot migration and reproductive success to improve survival and recruitment of young burbot.

3. Test the null hypothesis (H_o) that winter operation of Libby Dam does not affect burbot upstream migration distance or travel rate.

STUDY AREA

The Kootenai River (spelled Kootenay for Canadian waters) is the second largest tributary to the Columbia River. Originating in Kootenay National Park, BC, the river flows south into Montana where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). From Libby Dam the river flows west and then northwest into Idaho, then north into BC and Kootenay Lake. The river drains out the West Arm of Kootenay Lake before joining the Columbia River near Castlegar, BC. The Kootenai River at Porthill, Idaho drains about 35,490 km^2 and the reach in Idaho is 106 km long.

The Kootenai River presents three different channel and habitat types as it passes through Idaho. As the river enters Idaho, steep canyon walls and a gradient of about 0.6 m/km typify the corridor, 18 km in length. The river begins a short braided reach (13 km in length) about one km below the Moyie River, then at Bonners Ferry the river transitions to a lower gradient of approximately 0.02 m/km and meanders 75 km through a broad flood plain. Tributary streams of the Kootenai River are typically high gradient as they pass through mountain canyons but revert to lower gradients when they reach the valley floor, where most have been channelized. Many of the tributaries have manmade or natural migration barriers at the base of the mountains.

METHODS

Discharge and Temperature

A conditional agreement was formulated with the USACE and the Bonneville Power Administration (BPA) to provide an experimental low flow test of 170 m^3/s from Libby Dam (similar to pre-dam winter flows) for burbot spawning migration (Cathy Hlebechuk, USACE, personal communication). The proposed flows would occur from about January 15 through February 5, 2000, a minimum of three weeks. The intention was to test the null hypothesis that winter operation of Libby Dam does not inhibit burbot migration distance or travel rate. We hypothesized this low flow test would allow burbot to move significantly farther and faster upstream than during a control period (normal winter power and flood control operations of Libby Dam) and possibly spawn in historic tributaries and mainstem locations.

Daily discharge and temperature values for the Kootenai River were obtained from the USACE and the US Geological Survey (USGS) office in Sandpoint, Idaho. Daily temperature data were collected to relate these values to burbot spawn timing and preferred temperatures in the literature (McPhail and Paragamian 2000). A Hobo® or a Stowaway XI® temperature logger was used to monitor daily water temperatures for Smith and Boundary creeks in Idaho, Summit and Corn creeks and the Goat River in BC, and the Kootenai River at Porthill, Idaho. Water temperature was monitored from October 1999 through March 2000. At each location, four or five temperature readings were taken daily and in this report are expressed as daily means (temperature readings were spread equally through the day). Temperature loggers were deployed 20 m to 30 m upstream of tributary creek confluences with the Kootenai River. In Summit Creek, an additional thermograph was placed approximately 100 m upstream of the confluence to assess the infiltration of warmer, Kootenai River water into this tributary. If infiltration of Kootenai River water into the mouth is substantial, the cold water inputs that burbot may use as migration cues may be obscured. Although no burbot spawning has been documented in recent years, Summit Creek is a historical burbot spawning area [Les Fleck, BC Ministry of Environment Lands and Parks (BC MOELP), personal communication].

Sampling Adult Burbot

We sampled for burbot from October 5, 1999 through April 10, 2000, using up to 13 hoop nets baited with dead fish. Hoop nets had a maximum diameter of 0.61 m (see Paragamian 1995 for a description of the nets and the method of deployment). Nets were deployed in deep areas of the Kootenai River (usually the thalweg) between Ambush Rock (rkm 244) near Bonners Ferry, Idaho and Nick's Island (rkm 144) near Creston, BC. We also sampled in the mouths of Smith and Boundary creeks (Figure 1).

We attempted to sample burbot with cod traps from November 8, 1999 to November 22, 1999 to experiment with a different type of gear that had been effective in Duncan Lake (Spence 2000). The traps were placed near Nick's Island (rkm 144.0-144.3) and at rkm 173 and measured 0.98 m in diameter at the opening, 0.67 m in diameter at the base, and were 0.58 m high.

Nets were usually lifted on Monday, Wednesday, and Friday of each week. Fish captured in hoop nets were identified by species, enumerated, measured for total length (TL), and weighed to the nearest gram (g). All burbot were implanted with a passive integrated transponder (PIT) tag in the left opercular muscle, and a small piece of pelvic fin tissue was collected for genetic archiving. Relative weight (W_r; Fisher et al. 1996) was calculated for each burbot captured.

As time permitted, a sample of burbot caught during the post-spawn period had milt or gonadal tissue samples collected and preserved in alcohol. Samples were examined under an electron microscope to determine their stage of maturity.

Burbot Telemetry

Sonic transmitters were used to track adult burbot movements during the year. Sonic transmitters had a 420-day life expectancy, were cylindrical in shape, measured 18 mm by 65 mm, and weighed 8 g. Sonic transmitters were either surgically implanted (see Paragamian 1995; Hart and Summerfelt 1975 for a description of the surgical procedures), or attached externally. External attachments were done by using long hypodermic needles to run a thin stainless steel cable through the dorsal plane of the burbot and transmitter, which were then fastened with brass connector sleeves, a method similar to Malinin (1971). The preferred weight of burbot to well exceed the transmitter weight to fish weight proportion (3%) is $\geq$1,000 g. When possible, sex of each burbot was determined during surgery.

Seasonal habitat use and movement of burbot were to be studied from September 1, 1999 through August 31, 2000 to help determine the affect of flow on burbot movement. The primary period of telemetry study was from early November through February; outside of these months telemetry was weekly and coordinated with a companion study. Sonic telemetry was conducted from a boat on alternate days of net lifting and occasionally on the same day as net lifts. When burbot were located by telemetry, the location was recorded to the nearest 0.1 rkm and depth of the river was measured with a digital echo sounder.

Larval Sampling

Larval burbot sampling was conducted on March 31, 2000 using paired ½ meter nets (mouth area = 0.7854 m^2) towed at the surface. Gurley 2030 R current meters were mounted in the mouth of each net and tows were made in a downstream direction. Tows were made in the Kootenai River from rkm 150.5 to rkm 170. Effort was calculated using total towing time and rotation counts per second from the flow meters x mouth area (0.7854 m^2) to calculate the total volume of water filtered through each net.

Population Estimate of Burbot

Population estimates of adult burbot were calculated using five years of mark and recapture data and a computer generated Cormack-Jolly-Seber model (Ricker 1975). We used the mark and recapture data from autumn 1995 through spring 2000. The model can also provide an estimate of survival if sample size is adequate. The model also includes a sampling effort variable. The population estimate of adult burbot included the Kootenai River from Bonners Ferry downstream to Kootenay Lake, BC. All burbot used in the population estimate were captured in the river; however, some burbot are known to move freely between the river and the lake. The Cormack-Jolly-Seber model does not provide an estimate for the first or last year of mark and recapture.

Duncan Lake Burbot Genetic Analysis

A cooperative search for a donor stock for the recovery of burbot in the Kootenai River was continued through the 1999-2000 period of study. The BC MOELP fisheries staff collected tissue samples of burbot captured in Kootenay and Duncan lakes, BC. Tissue samples were analyzed for MtDNA haplotypes previously identified in Kootenai River burbot (Paragamian et al. 1999). Methods of analysis were similar to those presented in Paragamian et al. (1999).

RESULTS

Discharge and Temperature

Kootenai River Discharge

Mean daily flow from Libby Dam ranged from about 227 m^3/s to 340 m^3/s from October 1 to November 8, 1999, with a mean flow of 326 m^3/s (Figure 3). By November 9, 1999, flow decreased to 227 m^3/s and remained at this level through November 17, 1999. The following day, flow increased substantially and remained high until February 13, 2000, ranging from 425 m^3/s to 750 m^3/s. In addition, flow during this time period varied compared to October and November, and daily flow fluctuations of 100 m^3/s or more occurred 14 times. Low flow test conditions agreed to verbally were not met. From February 14 through March 15, 2000, flows were decreased gradually, yet variability remained high with six daily flow fluctuations of more than 60 m^3/s. By March 16, flow from Libby Dam was reduced to the minimum protected flow of 113 m^3/s and remained at this level through at least April 1, 2000.

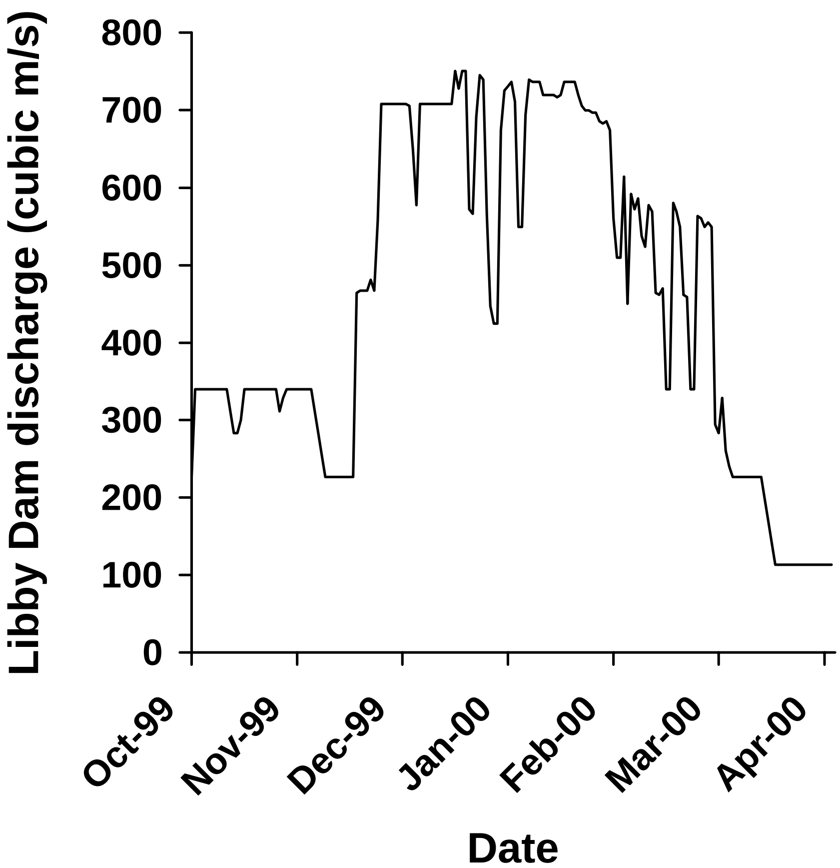

Figure 3. Mean daily Kootenai River discharge at Libby Dam October 1, 1999 through March 31, 2000.

Kootenai River Temperature

Mean daily water temperature in the Kootenai River measured at Porthill ranged from a maximum of 12.4°C for October 9, 1999 to a minimum of 2.4°C for February 22, 2000 (Figure 4).

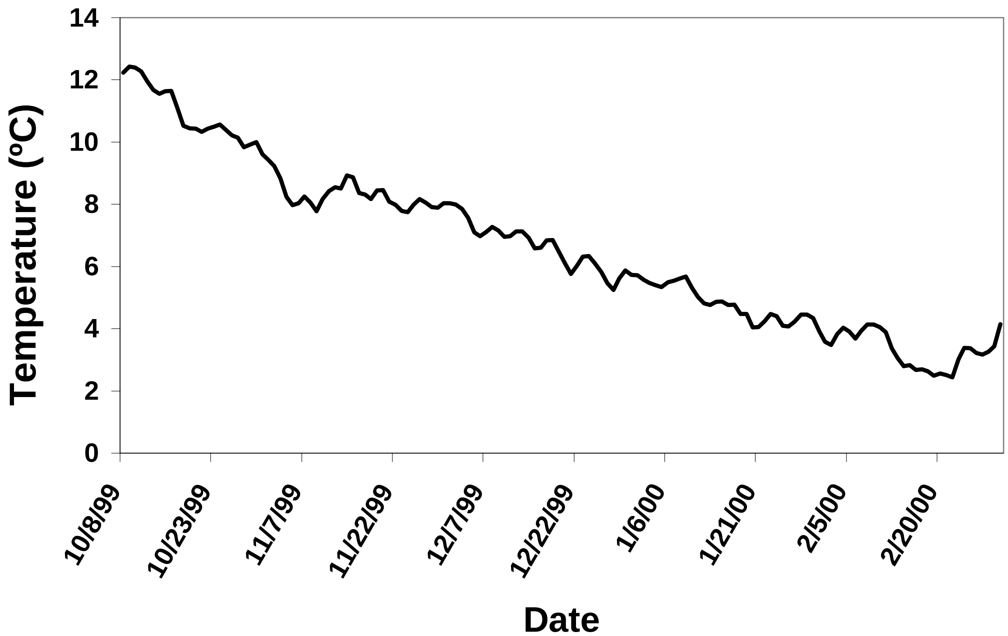

Figure 4. Mean daily temperature (°C) of the Kootenai River at Porthill, Idaho from October 8, 1999 to March 1, 2000.

Tributary Temperatures

Mean daily water temperature of Smith Creek from October 8, 1999 to March 1, 2000 was 1.5°C (Figure 5). The maximum temperature of 7.2°C occurred on October 9, 1999, whereas the minimum temperature of -0.1°C occurred on February 1, 2000. Mean water temperature of Boundary Creek over the same time period was 1.8°C (Figure 6). The maximum temperature of 8.4°C occurred on October 8, 1999, whereas the minimum temperature of -0.1°C occurred on December 30, 2000. Mean water temperature of the Goat River from October 14, 1999 to March 1, 2000, was 2.1°C (Figure 7). The maximum temperature of 7.5°C occurred on October 8, 1999, whereas the minimum temperature of -0.1°C occurred on December 30, 2000. Mean water temperature of Corn Creek from October 14, 1999 to March 1, 2000, was 3.3°C (Figure 8). The maximum temperature of 8.5°C occurred on October 15, 1999, whereas the minimum temperature of 1.1°C occurred on February 22, 2000.

The mean daily temperature of Summit Creek 100 m upstream of the confluence was 1.4°C. The maximum and minimum temperatures of 5.3°C and -0.1°C, respectively, occurred on November 14, 1999 and January 4, 2000 (Figure 9). The mean temperature near the confluence was 1.9°C (Figure 10). The maximum and minimum temperatures of 5.2°C occurred on November 11, 1999, whereas the minimum of 0.04°C occurred on February 1, 2000. Although the mean, maximum, and minimum temperatures recorded at the two locations in Summit Creek are similar, temperature was warmer at the mouths with differences being >2.5°C than the temperature recorded 100 m upstream, especially from December 29, 1999 to January 29, 2000 (Figure 11).

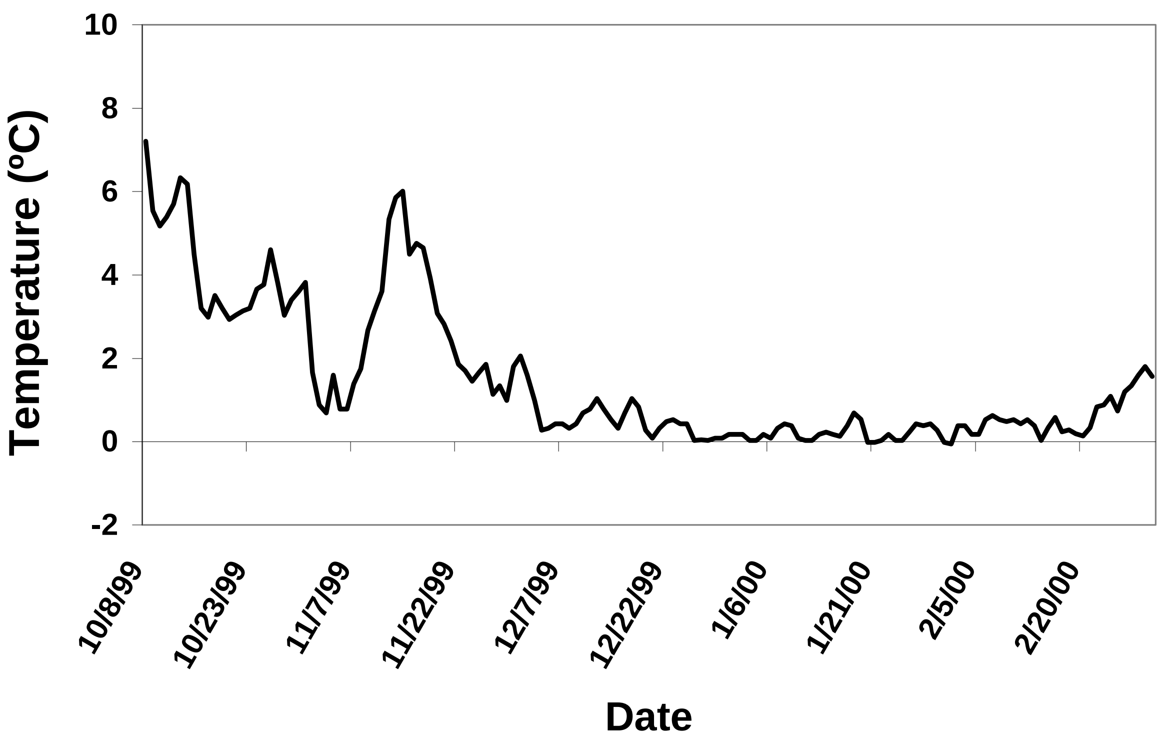

Figure 5. Mean daily temperature (°C) of Smith Creek from October 15, 1999 to February 29, 2000.

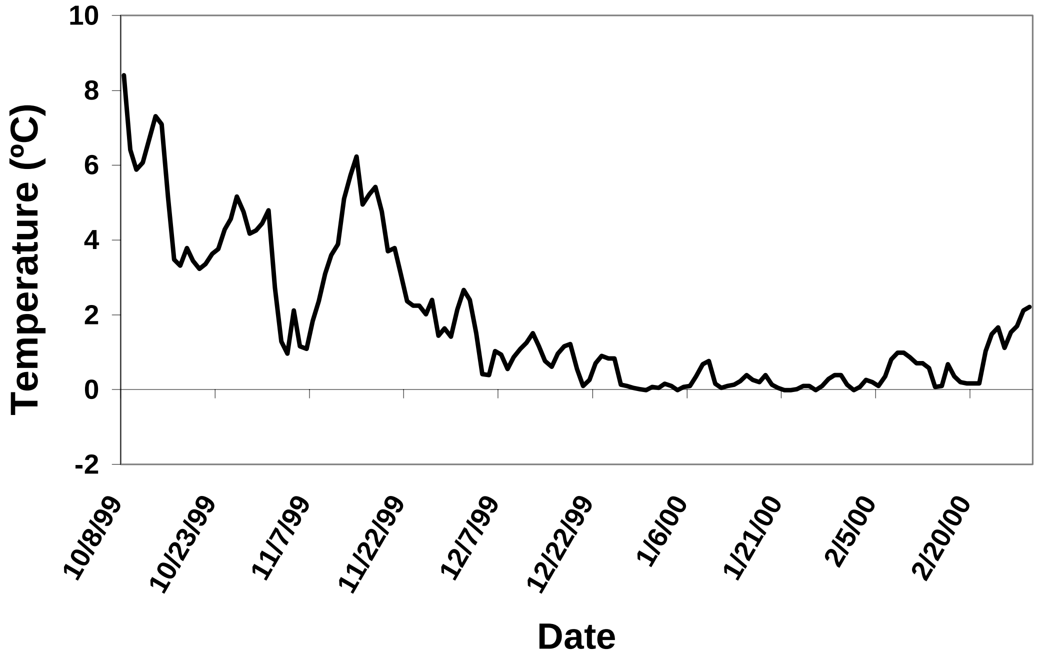

Figure 6. Mean daily temperature (°C) of Boundary Creek from October 8, 1999 to March 1, 2000.

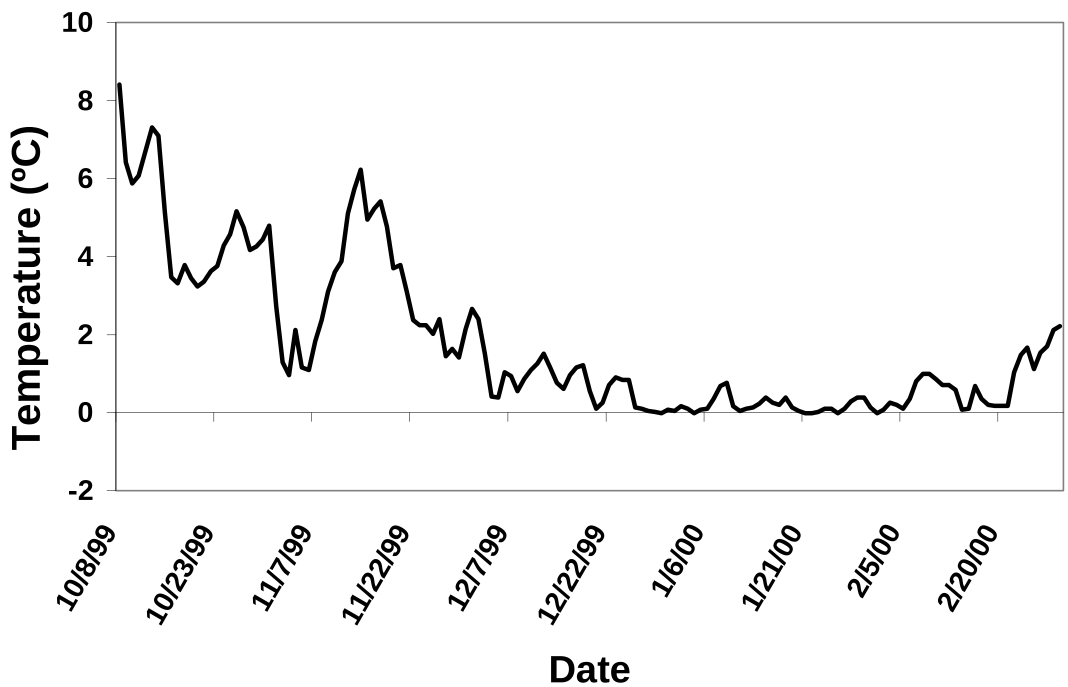

Figure 7. Mean daily temperature (°C) of the Goat River from October 14, 1999 to March 1, 2000.

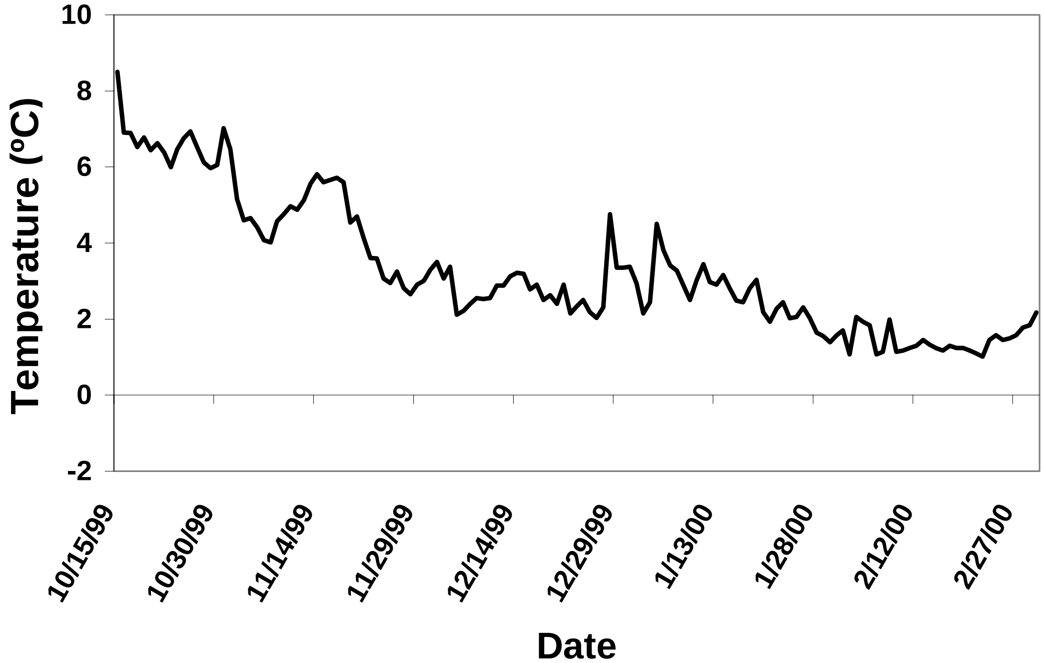

Figure 8. Mean daily temperature (°C) of Corn Creek from October 15, 1999 to March 1, 2000.

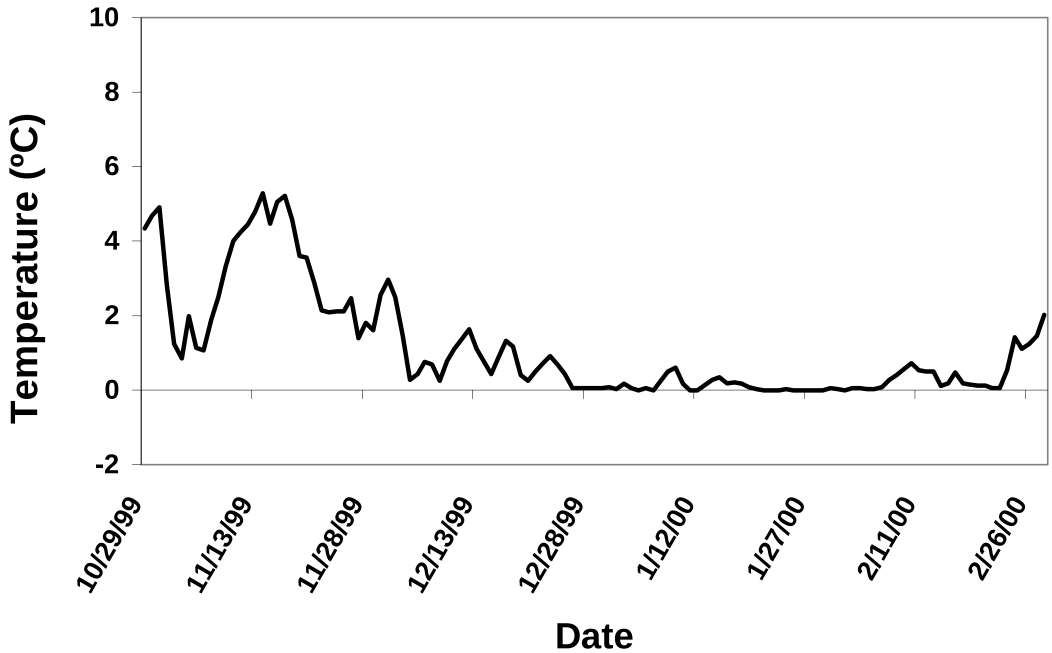

Figure 9. Mean daily temperature (°C) of Summit Creek—upstream thermograph—from October 29, 1999 to February 28, 2000.

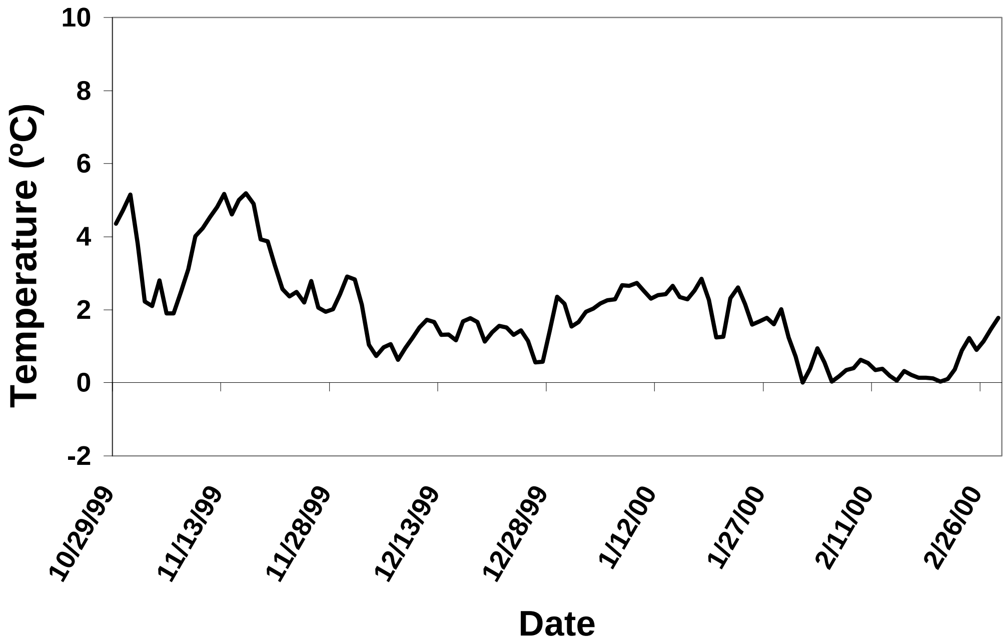

Figure 10. Mean daily temperature (°C) of Summit Creek—downstream thermograph placed near the confluence—from October 29, 1999 to February 28, 2000.

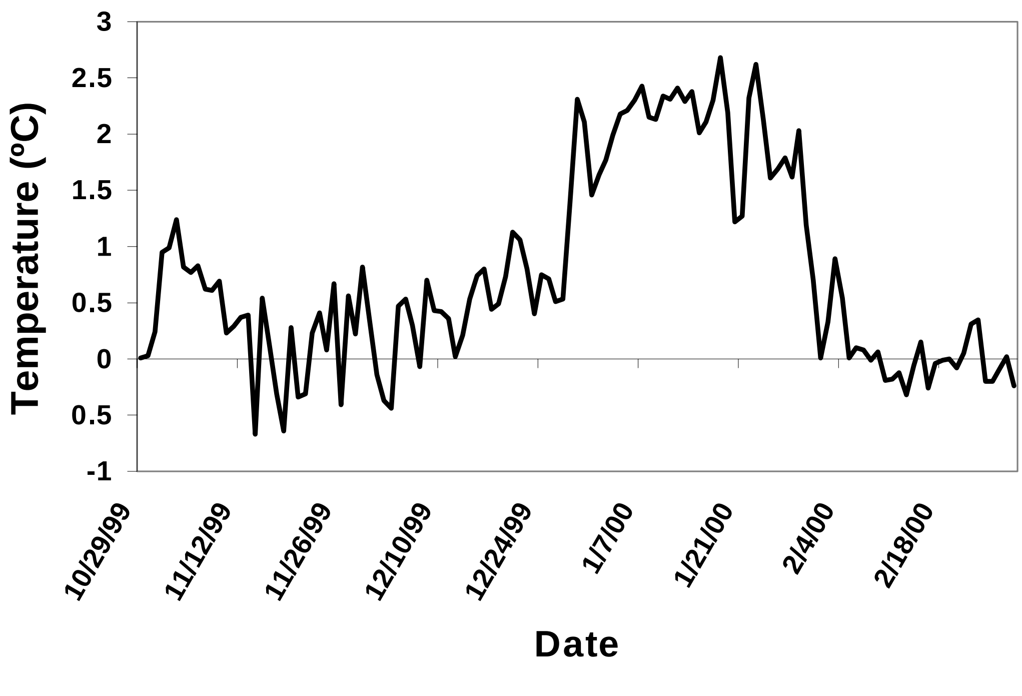

Figure 11. Mean daily temperature (°C) difference between lower Summit Creek and upper Summit Creek from October 29, 1999 to February 28, 2000 (Difference = Temperature of lower Summit Creek – upper Summit Creek).

Sampling Adult Burbot

Total Catch

We fished baited hoop nets from October 5, 1999 to April 10, 2000 for a total of 40,058 h or 1,669 net d (a net d is one 24 h set/net). A total of 231 aquatic animals were caught, including 12 different species of fish and one species of crustacean (Table 1). Catch per unit of effort (CPUE) was 0.138 fish/net d for all species of fish (crayfish excluded) and 0.022 fish/net d for burbot or one burbot captured every 46 net d (Table 1).

We fished baited cod traps from November 8 to November 22, 1999 for a total of 912 h or 38 net d. Two northern pikeminnow *Ptychocheilus oregonensis* and one peamouth *Mylocheilus caurinus* were captured.

Hoop Net Catch of Burbot

We captured 36 burbot (Table 1, Figure 12). Twenty-three burbot were caught in Idaho, including 12 at Ambush Rock. The remaining 13 burbot were caught in BC, including eight in the Kootenay River and five in the Goat River. One burbot escaped and was not measured, and one recaptured burbot was not measured. Burbot ranged from 332 mm to 705 mm TL (mean = 541 mm, SE = 14.02) (Figure 12) and weighed from 350 g to 2,850 g (mean = 1,059 g, SE = 90.51). Relative weight ranged from 40.5 to 127.6 and averaged 88.6 (SE = 2.44).

Of the 36 burbot captured, three were recaptures (9%). The first burbot, originally captured on November 22, 1999 at rkm 149.5, was recaptured on December 27, 1999 at rkm 149.5. Over these five weeks, this fish's weight decreased by 100 g. The second burbot, captured on December 18, 1998 at rkm 150.2 and recaptured on January 21, 2000 at rkm 149.0, grew 59 mm in length but gained no weight. The final burbot, initially captured on October 29, 1999 at rkm 207, was expelling milt when recaptured on March 10, 2000 at Ambush Rock (rkm 244.5) and had increased in length from 605 to 608 mm and in weight from 1,290 g to 1,325 g. It was recaptured a second time March 27, 2000 at the same location. This represents an upstream movement of 37.5 km.

Telemetry Studies

Four burbot were surgically implanted with sonic transmitters from December 12, 1999 through January 13, 2000, three with external transmitters and a fourth burbot with an internal transmitter (Table 2). One burbot was a male, while sex of the remaining three could not be determined. Burbot ranged in TL from 516 mm to 664 mm and weight from 920 g to 1,850 g (Table 2). Tagging of burbot with sonic transmitters was discontinued after January 17 because the USACE was unable to provide flows suitable for hypothesis tests. Telemetry consisted of 34.8 h of effort to search for four burbot (Appendix 1, 2, 3, and 4). Burbot were located 41 times from December 20, 1999 through February 29, 2000 (Appendices 1 through 4). A single burbot (449) of the four tagged with sonic transmitters was located on February 11 and 14 in the Goat River during the spawning period (Appendix 3). Transmitters of the three remaining fish are believed to have prematurely quit operating (Appendix 1, 2, and 4) before the spawning season, because we were unable to locate these fish despite extensive effort.

Table 1. Hoop net catch by number, weight (kg), and catch per unit effort (CPUE)[a], for the Kootenai River and its tributaries in Idaho and British Columbia, Canada, October 5, 1999 through April 10, 2000.

Species	**Number**	**Total Weight (kg)**	**CPUE[a]**
Northern pikeminnow *Ptychocheilus oregonensis*	120	46.714[b]	0.0719
Burbot *Lota lota*	36	36.015[c]	0.0216
Peamouth chub *Mylocheilus caurinus*	21	2.797	0.0126
Yellow perch *Perca flavescens*	14	NA	0.0084
Sucker[d] *Catostomus catostomus* and *C. macrocheilus*	10	3.108	0.0060
Crayfish *Pasifastacus spp.*	9	NA	0.0054
Bull trout *Salvelinus confluentus*	6	3.255	0.0036
White sturgeon *Acipenser transmontanus*	5	.870[e]	0.0030
Bullhead *Ameiurus spp.*	5	.295[e]	0.0030
Rainbow trout *Oncorhynchus mykiss*	2	.375	0.0012
Pumpkinseed *Lepomis gibbosus*	1	.045	0.0006
Mountain whitefish *Prosopium williamsoni*	1	.125	0.0006
Kokanee *Oncorhynchus nerka*	1	0.100	0.0006
Total	**231**	**93.699**	**0.1384**

[a] A unit of effort is a single net set for 24 hours.
[b] Three of 120 fish were not weighed.
[c] One burbot escaped and was not weighed, and an additional recaptured burbot was not weighed.
[d] Species of suckers were not always differentiated; however, longnose and largescale sucker species were identified in the catch.
[e] One of five fish was not weighed.

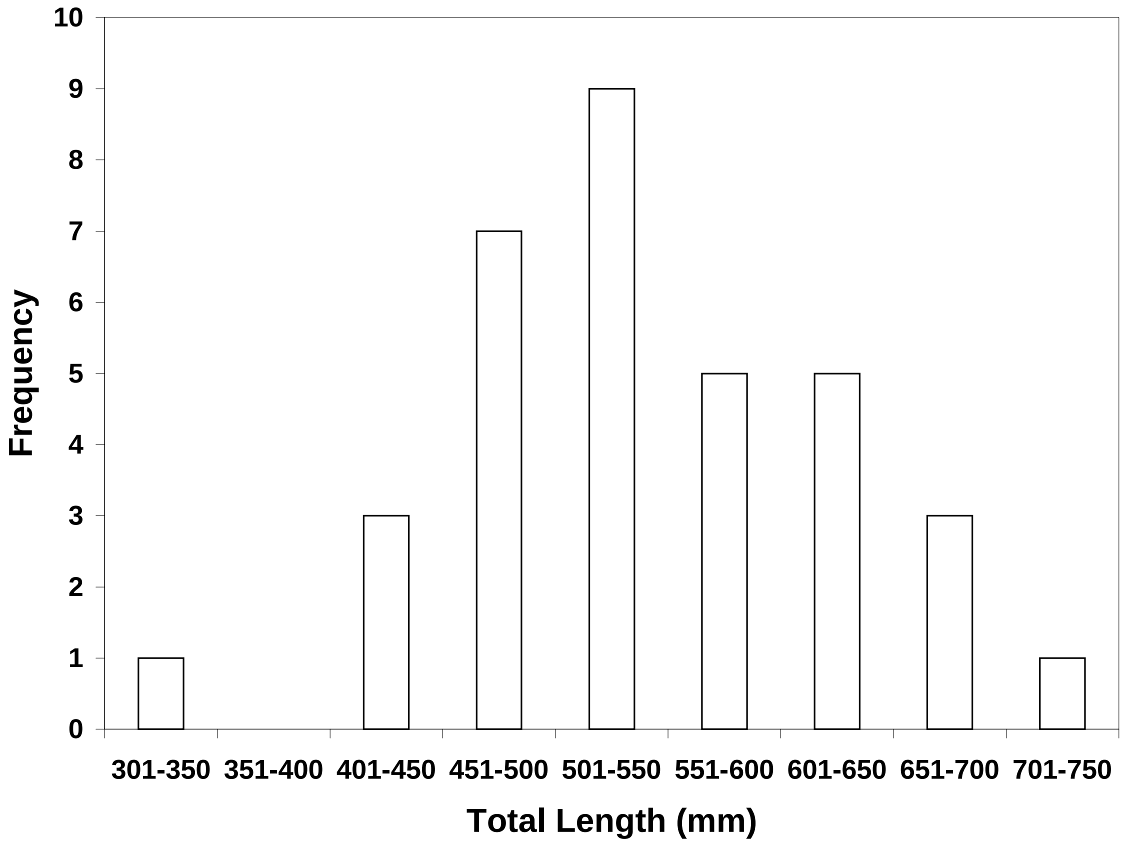

Figure 12. Length-frequency distribution of burbot caught by baited hoop nets in the Kootenai River and its tributaries in Idaho and British Columbia, Canada, October 5, 1999 through April 10, 2000.

Table 2. Summary of telemetry data and physical characteristics of four burbot in the Kootenai River, Idaho, and British Columbia, Canada, December 1999 through January 2000.

Transmitter Code	Release Date	Release Site (rkm)	Total Length (mm)	Weight (g)	PIT tag Number	Sex	Last date Located
5325	12/17/99	166.5	577	1,150	7F7D07533C	unk	1/24/2000
5622	12/20/99	159.1	582	1,040	7F7F421E43	unk	12/20/1999
449	12/23/99	152.7	664	1,850	7F7D044A67	M	2/14/2000
5262	1/13/00	144.1	516	920	7F7D296A0F	unk	1/14/2000

Spawning and Post-Spawning Studies

Spawning Period

Our first hoop net capture of a burbot migrating into the Goat River occurred about January 3, 2000 when the water temperature of the Goat River was about 0°C. A second burbot was not caught until February 18, and two more were caught on February 22, 2000. No burbot were captured in Boundary or Smith creeks.

Post-spawn Period

Hoop net sampling in Idaho through March and April, during what we believe was the post-spawn period, resulted in the capture of 11 burbot including one recapture. Eight burbot, including six males (seven total) in the same net, were captured on March 10, 2000 at Ambush Rock (rkm 244.5). All eight fish appeared to be in different stages of sexual maturity. Two were males that expressed milt when massaged. Milt was collected from these two males for microscopic examination. Four males appeared to be immature. These four fish were biopsied and a tissue section of the testes taken for examination under a microscope. We could not express milt nor determine sex from a seventh fish, and it was not biopsied because it appeared in poor condition. The eighth burbot may have been a juvenile because of its short length (<305 mm) but was of unknown sex. The examination of gonadal tissue under an electron microscope (1000X) indicated sperm of the two males that expressed milt appeared to be mature while the gonadal tissue of two others were at an earlier stage of maturity (incompletely developed sperm). Examination of tissue samples from the testes of the remaining two burbot suggested their sperm were also in a maturing process but still within the mother cells. Three additional burbot were caught March 27 at Ambush Rock; two were of unknown sex, and a third was a recaptured male previously caught on March 10 and 16, 2000 and October 29, 1999.

Larval Sampling

Ten paired ½ meter net tows were made, averaging approximately 20 minutes each. Total towing time was 3 hours, 20 minutes, and 9 seconds. The nets filtered a total water volume of 11,795 m^3. No larval burbot were captured. Additional tows were not made because of a shortage of personnel.

Population Estimate of Burbot

Cormack-Seber-Jolly population estimates for 1996, 1997, and 1998 were made for burbot in the Kootenai River from Bonners Ferry to Kootenay Lake, BC; they were 738, 540, and 43 fish, respectively. Our recaptures were so few, three for each estimate, that the model did not calculate reliable confidence intervals. Thus, these estimates are not considered valid.

Duncan Lake Burbot Genetic Analysis

Analysis of 14 burbot tissue samples from Kootenay Lake, BC, indicated 86% were of haplotype Bur-01, and 14% were Bur-06. Samples of 24 burbot from Duncan Lake, BC indicated 100% of the fish had the haplotype Bur-01.

DISCUSSION

Our objective was to test the null hypothesis that winter operation of Libby Dam does not inhibit burbot migration distance or travel rate. The hypothesis testing did not occur because the USACE did not have the flood control flexibility to provide the low flow conditions. Although only four burbot were tagged with sonic transmitters, their movement was very limited during the high winter flows. This limited movement was not unexpected (Paragamian 2000). In addition, three of the transmitters are believed to have failed before the spawning season. The continued occurrence of cancelled flow tests underscores the need to bring these studies into the laboratory and provide controlled conditions.

The low capture rate of burbot and low sample size is a continued concern for our studies. Catch per unit effort has been used to compare burbot stock densities (Parker et al. 1988) and is known to vary between river and lake environments. The CPUE in the Kootenai River for winter sampling is very low, ranging from one fish/18 net d to one fish/45 net d (Paragamian 2000). Within the 1999-2000 study period, the catch success was one burbot/46 net d. For comparison, CPUE of burbot in four Alaskan Lakes ranged from one fish/two net d to three fish/net d (Parker et al. 1988), while in the Tanana and Chena rivers, Alaska, it was >one fish/net d and one fish/two net d, respectively (Evenson 1993). Based on these comparisons, the densities of burbot in exploited Alaskan fisheries appear to be 20 times greater, at a minimum, than Kootenai River densities.

It is not known if warmer winter temperatures in the Kootenai River have affected burbot spawning synchrony, but it may have concealed the location of spawning tributaries. During January of 1995, burbot appeared to be attracted to the colder water of the Goat River (daily mean of about 1°C) compared to the Kootenai River (daily mean of about 4°C) (Paragamian 2000). However, the mouths of the tributaries are warmed by the backwater effect of the Kootenai River. Arndt and Hutchinson (2000) found that the lowest escapement of burbot spawners to a tributary of Columbia Lake, BC occurred during a season when the tributary water temperature was several degrees warmer than other years of record. We are uncertain how water temperature may have affected burbot pre-Libby Dam, but if the tributaries and the river were similar in temperature this may be an invalid point. Yet temperature may play an important role in the maturation process of burbot, and the present warmer water of the Kootenai River should be considered in a laboratory study of burbot gonadal development.

Mitochondrial DNA analysis of burbot from Duncan Lake indicated these fish could be a suitable donor stock to aid in the recovery of burbot in the Kootenai River. The haplotype Bur-01 was dominant in the Duncan Lake samples, occurring in 100% of the samples. For comparison, Paragamian et al. (1999) found the Bur-01 haplotype occurrence was 81% in the Kootenay Lake samples and 68% in Kootenai River samples from Idaho and BC. There were no natural barriers in the Duncan River prior to construction of Duncan Dam, and burbot in Kootenay Lake and Kootenai River could move freely into Duncan Lake or River. In addition to this genetics data, it will be important to understand the spawning behavioral characteristics of burbot from Duncan Lake, including spawn timing, location of spawning, date and duration of spawning, migration patterns, and temperature at spawning. Preliminary telemetry studies during the winter of 1999-2000 suggested most of the burbot in Duncan Lake were adfluvial, ascending the Duncan River and tributaries during the spawning season (Colin Spence, BC MOELP, and personal communication).

The capture of eight male burbot during March 2000 in several different stages of sexual maturity further substantiates our concern that many burbot either do not spawn or stressful conditions have disrupted their sexual maturation process (DiStefano et al. 1997). The capture of unspawned females (reabsorbing eggs) during the post-spawn season has also been common in the Idaho reach of the Kootenai River (Paragamian and Whitman 1996, 1997, 1999). We believe high fluctuating flows from Libby Dam are continuously disrupting burbot migrations (Paragamian 2000) and may be responsible for the reduced spawning success. The specific effect of this disruption to burbot spawning migration is unknown. DiStefano et al. (1997) and DiStefano and Hiebert (2000) studied blood parameters and movement in a reproductively dysfunctional walleye *Stizostedion vitreum* population downstream of a hydropower dam in Missouri. They found evidence to suggest reproductive failures and spawning movement in the walleye were due to stress, possibly related to flow and water temperature. Power peaking or the absence of requisite environmental signals necessary for spawning or both caused these changes.

RECOMMENDATIONS

1. We recommend a five week test flow of 170 m^3/s beginning January 10 through February 15 to test the null hypothesis that burbot migration distance or travel rate (distance/day) during the normal operation control treatment (hydropower production and floodwater evacuation) is not different than a low flow test treatment.

2. Monitor physiological condition of burbot during and after spawning. Document whether or not burbot spawned and monitor blood chemistry.

3. Determine, under laboratory conditions, the effect of high velocities (>25 cm/s) and elevated winter temperatures on vitellogenin synthesis and the release of gonadotropin for egg ovulation and blood chemistry.

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APPENDICES

Appendix 1. Location, date, velocity, water temperature, and depth of burbot 5325 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Depth (ft)	Water Temperature (°C)
12/14/99[a]	166.5			
12/17/99	166.5			
12/20/99	165.0			7.0
12/23/99	164.9	24.7	81	7.0
12/27/99	157.0	24.4	80	6.0
12/29/99	157.0	26.2	86	6.0
12/30/99	156.5	18.3	60	6.0
1/3/00	150.5	17.7	58	6.0
1/5/00	150.5			6.0
1/6/00	150.5	10.7	35	6.0
1/7/00	150.6			6.0
1/10/00	150.7	16.5	54	6.0
1/13/00	150.7	27.4	90	5.0
1/14/00	150.3	28.3	93	5.0
1/18/00	151.0	24.7	81	5.0
1/20/00	150.9	18.9	62	4.0
1/21/00	150.9	18.9	62	5.0
1/24/00	150.0	21.3	70	

[a] Date of capture, sonic transmitter implant, and release.

Appendix 2. Location, date, velocity, water temperature, and depth of burbot 5622 as determined by sonic telemetry depth sounder.

Date	Location (rkm)	Depth (m)	Depth (ft)	Water temperature (°C)
12/20/99[a,b]	151.9			7.0
12/20/99	151.9	27.1	89	7.0
12/20/99	151.9			7.0

[a] Date of capture
[b] Date of radio transmitter implant and release

Appendix 3. Location, date, velocity, water temperature, and depth of burbot 449 as determined by radio telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Depth (ft)	Water temperature (°C)
12/23/99[a]	152.7	16.8	55	7.0
12/29/99	152.7			6.0
12/30/99	151.5	11.0	36	6.0
1/3/00	151.0	15.2	50	6.0
1/5/00	151.0			6.0
1/6/00	152.1	10.4	34	6.0
1/7/00	152.0	25.6	84	6.0
1/10/00	151.0	12.8	42	6.0
1/13/00	152.3	10.7	35	5.0
1/14/00	152.2	25.0	82	5.0
1/18/00	152.1	24.4	80	5.0
1/20/00	152.2	9.4	31	4.0
1/21/00	152.2	9.4	31	5.0
1/24/00	152.3	7.9	26	
1/26/00	152.7	5.8	19	4.0
1/27/00	152.6			4.5
1/28/00	152.6	12.8	42	4.5
1/31/00	152.0	23.8	78	4.0
2/4/00	152.7	13.7	45	4.0
2/4/00	152.6	14.0	46	4.0
2/7/00	152.6	11.3	37	4.0
2/11/00	152.7			4.0
2/14/00	152.7	11.6	38	3.0

[a] Date of capture, radio transmitter implant, and release.

Appendix 4. Location, date, velocity, water temperature, and depth of burbot 5262 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Depth (ft)	Water Temperature (°C)
1/10/00[a]	144.1	30.5	100	5.0
1/13/00	144.3			5.0
1/14/00	144.3	15.5	51	5.0

[a] Date of capture, sonic transmitter implants, and release.

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