FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

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Kootenai River Fisheries Investigation: Stock Status of Burbot

Project Progress Report

2005 Annual Report

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ABSTRACT

The main objective of this investigation was to monitor movement, spawning activity, and evidence of successful spawning of burbot *Lota lota* in the Kootenai River, Idaho and British Columbia, Canada during the winter of 2004-2005. As a secondary objective, we examined the literature to obtain inferential information on how changes in historic water temperatures may have affected burbot movement and spawning. A Systems Operation Request was made to the US Army Corps of Engineers to facilitate burbot migration and spawning. Discharge did not meet the systems operation request as a burbot rehabilitation measure. Baited hoop nets were fished from November 5, 2004 through April 4, 2005 for 2,046 net d (one net day is a single 24 h set). One hundred twenty-two fish were caught encompassing ten different species of fish. Eighteen burbot (14 different fish) were captured. Hoop net catch per unit effort for burbot was 0.009 fish/net d or 111.1 net d/fish. Burbot total length ranged from 489 mm to 764 mm TL (mean = 615.7 mm, SD = 74.6 mm, n = 13). Burbot weight ranged from 867 g to 2,798 g (mean = 1695.8 g, SD = 555.5 g, n = 13). Our literature review indicated even subtle changes in temperature can cause a variety of changes in fish life history patterns and in some cases seriously alter the outcome of spawning and recruitment. Furthermore, results from a summary of our previous investigations and this study indicated burbot behavior might be modified by the combination of changes in river discharge and temperature.

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INTRODUCTION

In Idaho, burbot *Lota lota* are endemic only to the Kootenai River (spelled Kootenay for Canadian waters) (Simpson and Wallace 1982) (Figure 1) but this population is now in serious decline (Paragamian et al. 2000). Burbot once provided an important winter fishery to residents of northern Idaho and that of Kootenay Lake, British Columbia, Canada (Paragamian et al. 2000) and may have been the most robust in North America (Paragamian and Hoyle 2005). Some anglers reported catching up to 40 burbot per night during winter setline fishing (Paragamian 1994a). The annual harvest of burbot from the Kootenai River by sport and commercial fisherman in Idaho prior to 1972 may have been in the tens of thousands of kg. Three commercial anglers alone harvested an estimated 2,150 kg in 1958 (Idaho Department of Fish and Game [IDFG] Regional Archives, unpublished). Burbot caught during the winter fishery were thought to have been part of a spawning migration from the lower river and Kootenay Lake in British Columbia, Canada. However, after construction and operation of Libby Dam by the U.S. Army Corps of Engineers (USACE) in 1972, the fishery rapidly declined and closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, British Columbia (Paragamian et al. 2000). Operation of Libby Dam for hydroelectric power and flood control has created major changes in the river's seasonal discharge, particularly during the winter when burbot spawn (Figure 2). The temperature regime and nutrient supply of the Kootenai River are also thought to be important factors for burbot spawning and recruitment; they too have changed since construction of Libby Dam (Partridge 1983; Snyder and Minshall 1996; Richards 1996).

The Kootenai River Fisheries Investigation was initiated in 1993 by the IDFG to document burbot abundance, distribution, size structure, reproductive success, and movement, and to identify factors limiting burbot in the Kootenai River. Few burbot were captured between river kilometer (rkm) 246 (Bonners Ferry) and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994a). There had been little evidence of burbot reproduction in the Idaho reach. Only one juvenile burbot was captured from 1993 through 1998, and only one larval fish was collected. However, numerous size-classes of burbot were in the catch, indicating some burbot were reproducing successfully, albeit insufficiently to sustain the population (Pyper et al. 2004). Previous studies had failed to document a spawning run of burbot from the lower river or Kootenay Lake. But cooperative sampling in the British Columbia reach of the river with the British Columbia Ministry of Environment (BCME) documented spawning burbot in the Goat River (Paragamian 2000), and during the winter of 2000-2001 a "spawning ball" of burbot was documented at Ambush Rock (Kozfkay and Paragamian 2002). Since then other potential spawners were captured in the same location, but their numbers have been low.

Studies completed during the winter of 1997-1998 indicated discharge management at Libby Dam likely affected burbot spawning migration during winter (Paragamian 2000). Movement of burbot with sonic transmitters was significantly higher during low discharge test conditions designed to mimic pre-dam Kootenai River discharge. Movement upstream was also significantly higher during low discharge tests (170 m^3/s) than the control (170–736 m^3/s); despite the fact, there were low discharges during the controls. Post-dam winter discharges are now three to four times greater than they were historically when conditions were relatively stable (Figure 2). Daily differences in discharge now range from 113 m^3/s up to 652 m^3/s, a six-fold change. Fluctuating discharges from Libby Dam caused by hydropower production and floodwater evacuation appear to have continuously disrupted upstream migrations of burbot. Female burbot have been captured post spawn resorbing eggs and males caught in the same net have been found to be in different stages of maturity (Paragamian et al. 2001). The specific effect of increased winter flows and warmer winter temperatures to burbot spawning migration and spawning is unknown, but it may have reduced spawning fitness or stamina or affected timing of burbot spawning. One or all of these possible factors could have been sufficient to contribute to reduced spawning success and recruitment.

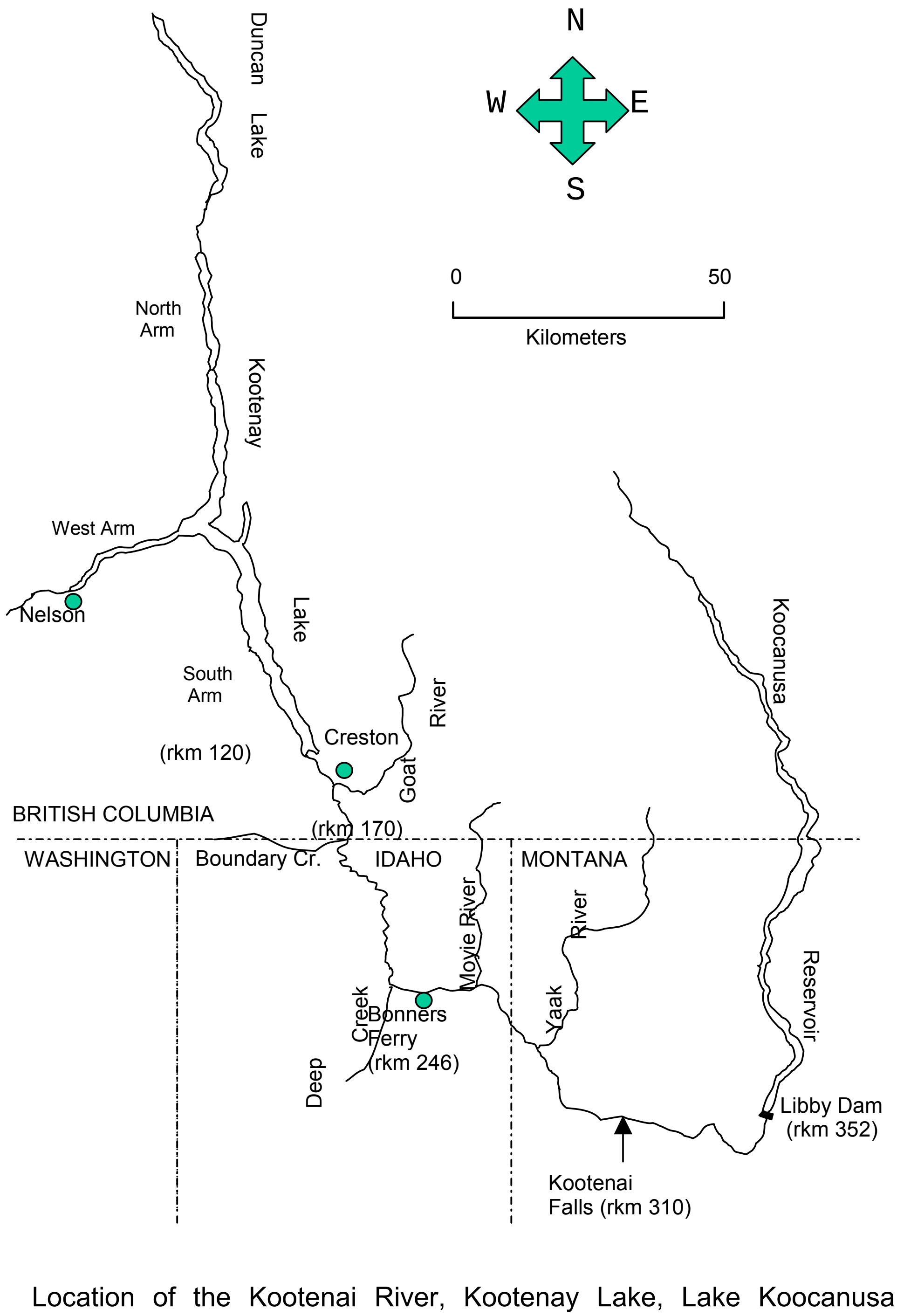

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

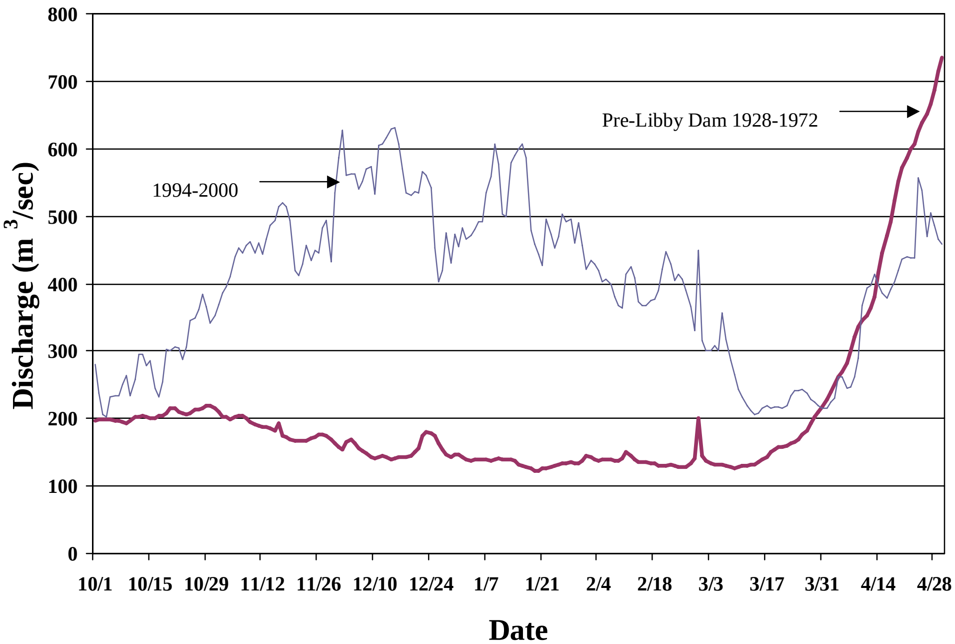

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho from 1962 through 1971 (pre-Libby Dam), and from 1994 through 2000 (post-Libby Dam).

The present population status of burbot is seriously imperiled and the number of adults may be as few as 50 (Pyper et al. 2004). Because the numbers of burbot are so low, we changed our sampling design in 2004-2005 to make better use of time and the capture of burbot. As a result, our sampling for burbot was restricted to Nicks Island (rkm 144.5), the vicinity of the Creston boat ramp (rkm 150), Boundary Creek and vicinity (rkm 170), the Goat River and vicinity (rkm 155.7), and Ambush Rock reach (rkm 244). In addition, because in recent years several small burbot have escaped hoop nets while they were being retrieved, we initiated a sampling experiment with smaller web. Bernard et al. (1991) found that burbot could be caught in 0.6 m diameter hoop nets with 25.4 mm bar web at about 350 mm total length (TL) but are not fully recruited until 450 mm TL. In an effort to predict burbot year class strength sooner than fish of 450 mm and evaluate recovery measures earlier, we had three hoop nets of 19 mm bar web constructed. The objective was to compare the catch of this smaller web to the standard web of 25.4 mm.

Given that burbot in the Kootenai River may be at risk of demographic extinction (Paragamian 2000), a Burbot Conservation Strategy (Anonymous 2002) was prepared to outline measures necessary to rehabilitate the burbot population. The Conservation Strategy indicated that operational discharge changes at Libby Dam must be implemented during winter to provide suitable conditions for burbot migration. However, the upper limit of discharge releases for adequate burbot spawning, migration, and flood control were unknown for inclusion in a more recent Conservation Agreement (KVRI Burbot Committee), a document that suggests river managers would cooperate in measures to recover burbot. From 1998 through 2002, experimental discharges were proposed to the USACE and the Bonneville Power Administration (BPA). The discharges were set at 170 m^3/s from Libby Dam (similar to pre-dam winter discharges) for burbot spawning migration (Paragamian and Whitman 1999, 2000, and this study). The intent was to test the null hypothesis that discharges ≤300 m^3/s from the dam do not inhibit burbot migration distance or travel rate. However, studies were largely ineffective because of hydropower and flood management priorities of the BPA and the USACE from 1998 through 2000.

Because test conditions were unachievable, an alternative evaluation was necessary (Paragamian et al. 2005). Telemetry records of burbot collected from 1994 through 2000 (Paragamian 1994b, 1995; Paragamian and Whitman 1996, 1997, 1998, 1999, 2000) were examined to determine how discharge factors affect burbot travel distance and travel rate. The seasonal distribution of movements found 30 (68%) of 44 "stepwise movements" (movements of 5 km or more in 10 d or less) occurred when discharges were ≤300 m^3/s from Libby Dam and averaged 176 m^3/s. "Stepwise movements" of burbot were examined to assess possible statistically significant differences in movement when the number of days discharges from Libby Dam were ≤300 m^3/s (N = 15 and 186 days, low discharges) in comparison to the number of days discharges were ≥301 m^3/s (N = 11 and 538 days, high discharges). Burbot moved more frequently during the lower discharges (Paragamian et al. 2005). Consequently, it recommended that discharge for burbot prespawning migration should range from 113 to 300 m^3/s and average 176 m^3/s for a minimum of 90 d (mid-November through mid-February). Although these recommendations appear adequate, it is important that the discharge measures for burbot spawning migration be evaluated.

Post-Libby Dam temperature changes may be an additional factor affecting the spawning and recruitment of burbot in the Kootenai River. Partridge (1983) found temperature of the Kootenai River is now cooler in the summer and warmer in the winter by several degrees C (Figure 3). Burbot spawn at temperatures of 1-4°C (McPhail and Paragamian 2000), and even subtle temperature changes in the Kootenai River, could have affected the timing and maturation rate of burbot. In addition, temperatures above 6°C have been found to cause mortality in larval burbot (Taylor and McPhail 2000). Thus, it is important to determine how these changes in the Kootenai River and its tributaries may have potentially affected burbot spawning migration, rate of maturity (annual gonadal development), spawning synchrony, and possible larval survival.

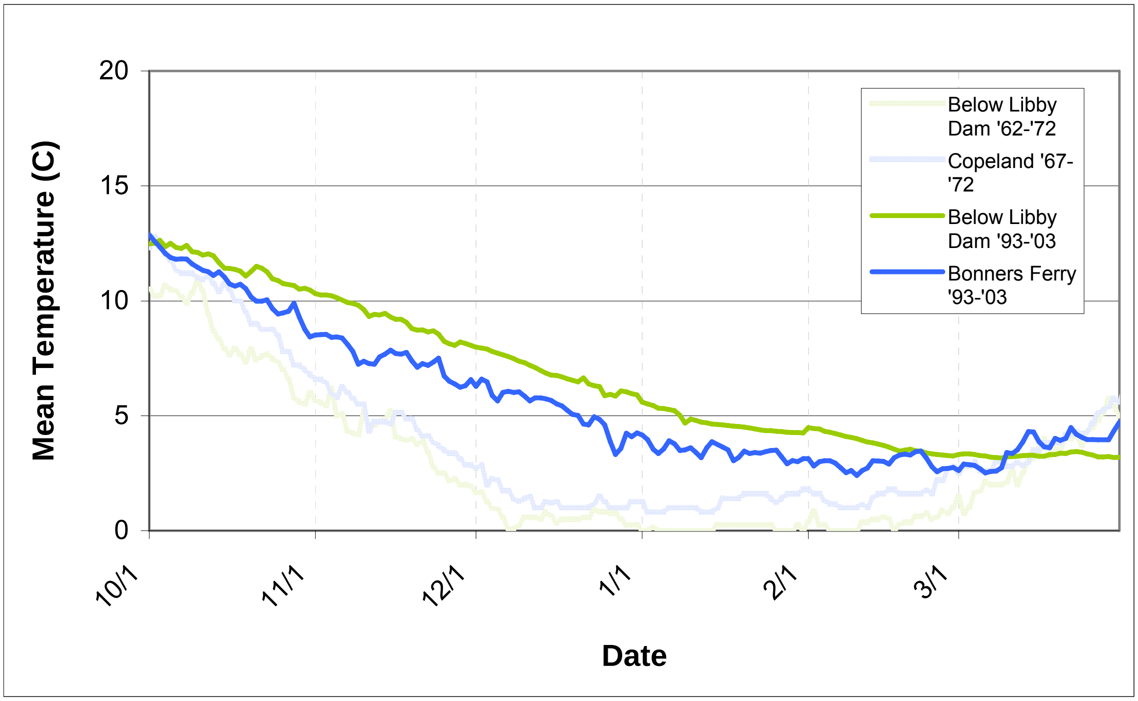

Figure 3. Pre-Libby Dam Kootenai River temperatures at the dam site 1962-1972; at Copeland, Idaho 1967-1972; and post Libby Dam below the dam from 1993-2003; and at Bonners Ferry, Idaho from 1993-2003.

GOAL

The fishery management goal of this study is to restore the burbot population in the Idaho reach of the Kootenai River to provide an annual sustainable harvest of burbot.

OBJECTIVES

1. Define discharge and temperature factors limiting burbot migration and reproductive success to improve survival and recruitment of young burbot.

2. Through a literature search and analysis of existing data, help define how temperature changes from pre- to post-Libby Dam could have affected burbot migration and spawning success.

STUDY AREA

The Kootenai River is one of the largest tributaries to the Columbia River. Originating in Kootenay National Park, British Columbia, the river discharges south into Montana, where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). From Libby Dam, the river discharges west and then northwest into Idaho, then north into British Columbia and Kootenay Lake. The Kootenai River at Porthill, Idaho, drains about 35,490 km^2. The reach in Idaho is 106 km long. Kootenay Lake drains out the West Arm, and eventually the river joins the Columbia River near Castlegar, British Columbia.

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. The river begins a short braided reach about 1 km below the Moyie River, and then downstream at Bonners Ferry the river transitions to a lower gradient of approximately 0.02 m/km and meanders 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 they have been altered (e.g., diked, channelized, and meet the river at right angles) to improve agriculture lands.

METHODS

Discharge and Temperature

Daily discharge and temperature values for the Kootenai River were obtained from the USACE and the U.S. Geological Survey (USGS) office in Sandpoint, Idaho. A systems operation request (SOR) for winter of 2004-2005, by the Kootenai Valley Resource Initiative's (KVRI) Burbot Recovery Committee, called for a maximum discharge from Libby Dam of 425 m^3/s from December 1 through 22, 2004 and a maximum discharge of 283 m^3/s from December 23 through January 31, with a preference during the latter portion of the request for an average of 207 m^3/s.

It was also requested by the KVRI that Libby Dam release the coolest water possible for the winter of 2004-2005. Temperatures of water released from Libby Dam was to be at or near the coolest available in the range of the selective withdrawal system for the duration of the SOR. In October and November (pre-SOR), cooler water is available for release, and the USACE could target them to at least the lower limit of the Selective Withdrawal Agreement. It is hypothesized these lower temperatures could be beneficial to burbot because lower temperatures would more closely approximate natural pre-dam conditions (Partridge 1983). Temperature for the Kootenai River was recorded at five locations: Bonners Ferry, Ambush Rock, Copeland, and Porthill, Idaho, and Libby Dam, Montana (Figures 4, 5, 6, and 7).

A HOBO® or StowAway® XI temperature logger was used to monitor daily water temperatures for Smith and Boundary creeks in Idaho, Corn and Summit creeks and the Goat River in British Columbia, and the Kootenai River at Porthill, Idaho from October 2004 through March 2005. At each location, mean temperature was calculated from five evenly spaced daily measurements. A temperature logger was deployed less than 50 meters upstream from each tributary creek confluence with the Kootenai River. In Summit and Boundary creeks, an additional thermograph was placed approximately 500 meters upstream to assess the infiltration of warmer water from the Kootenai River. These loggers assessed whether infiltration of Kootenai River water into these creek mouths was substantial, in which case the coldwater inputs that burbot may use as migration cues would be obscured (Paragamian 2000).

Sampling Burbot

Adult Burbot

Technicians sampled adult burbot from early November 2004 through March 2005 with up to 15 baited hoop nets. Hoop nets had a maximum diameter of 0.61 m (see Paragamian 1995 for a description of the nets, detail, and the method of deployment). We usually lifted nets on Monday, Wednesday, and Friday of each week. Fish captured in hoop nets were identified by species, enumerated, measured for total length (TL), weighed (g), and all were scanned for passive integrated transponder (PIT) tags. All burbot were implanted with a PIT tag in the left opercular muscle. Sex of most burbot could not be determined, because biopsies were not performed in an effort to reduce stress. Relative weight (W_r; Fisher et al. [1996]) was calculated for each burbot captured. We used 12 nets with 25.4 cm bar mesh, three of which were paired with hoop nets with 19 cm bar mesh. The objective was to determine if the smaller mesh would capture smaller and younger burbot (Gunderman and Paragamian 2003) and provide an earlier insight into year class abundance and recovery measure success. A *t*-test would be used to determine any statistical differences in length of burbot ($p < 0.01$) between the two gear sizes.

Because the burbot population is low, we established a monitoring scheme to measure changes in population numbers (population estimate and an index of abundance, catch per unit effort [CPUE]). The key locations were based on three to four site-specific sampling reaches where burbot were frequently captured. Nets were deployed in deep (usually the thalweg) areas of the Kootenai River between Ambush Rock (rkm 244.5) near Bonners Ferry, Idaho, and Nicks Island (rkm 144) near Creston, BC. We sampled river reaches in which burbot were more likely to be captured, e.g., Nicks Island, Boundary Creek and the international boundary, Goat River, and Ambush Rock because burbot numbers are low and we wanted to maximize our opportunity to capture them. We also sampled three tributary streams including Deep Creek near Bonners Ferry, Idaho (rkm 240); Boundary Creek, which enters the Kootenai River at Porthill, Idaho (rkm 170); and the Goat River near Creston, BC (rkm 152).

½ meter Net Tows

Larval burbot were sampled in the Kootenai River towing paired ½ m nets (mouth area = 0.79 m^2) with a boat 8 m in length. One net was towed at the surface and a second at approximately 1.5 m of depth below the surface. In water less than 2 m, nets were towed near the bottom. Gurley 2030R current meters were mounted in the mouth of each net, and tows were made in a downstream direction; the boat motor (150 hp) was operated at 1,000 rpm to maintain uniform towing speed relative to current velocity. Tows were made at mid channel near Ambush Rock (rkm 244.5) because of shallow water and debris near the river margins. Tows downstream to the mouth of the Kootenai River (rkm 124.7) were conducted near the shoreline. Effort was calculated using total towing time and rotation counts per second from the discharge meters x mouth area (0.79 m^2) to calculate the total volume of water filtered through each net.

Light Traps

Technicians also sampled for larval burbot with light traps described by Fisher (2000). Light traps were made from four plastic cylinders joined laterally, described as a quatrefoil measuring approximately 25 cm high by 30 cm wide. Traps were suspended near the water surface and powered by a 12 h photochemical stick. Up to six traps were deployed at dusk and checked the next morning.

Temperature Literature Review

Temperature and its effect on burbot reproduction and recruitment in the Kootenai River has been an ongoing issue. Repeated attempts to initiate a study of how variations in prespawn temperatures may have effected a physiological change in burbot reproductive fitness and readiness had failed for one reason or another through three different study periods. For this reason, we believed the next best effort was to search the fisheries and ecology literature for clues on how temperature variations could possibly influence burbot as well as other fish species.

RESULTS

Discharge and Temperature

Kootenai River Discharge

Discharge for Libby Dam was held relatively steady for October 2004 ranging from 133 to 272 m^3/s but was ramped up to 532 m^3/s on November 3, 2004 (Figure 4). Discharge was eventually brought down to about 283 m^3/s through the last 10 days of the month. In early December 2004, discharge was brought up to full powerhouse of nearly 900 m^3/s several times but remained above 436 m^3/s for most of the month. However, with the prospect of a below normal snowpack and a mild winter, discharge was brought down to 113 m^3/s, minimum flow, for the remainder of January through March 2005. Estimated discharge at Bonners Ferry followed the same hydrologic pattern as Libby Dam discharge but with a 19 h lag, which was evident for weekly peaks (Figure 4).

Kootenai River Temperature

Mean water temperature of the Kootenai River at Libby Dam from November 1, 2004 through April 5, 2005 was 5.3°C, ranging from 10.45°C on November 1, 2004 to 3.2°C on March 2, 2005 (Figure 5). Mean water temperature of the Kootenai River at Bonners Ferry was 3.6°C, ranging from 8.9°C on November 3, 2004 to -1.6°C on January 15, 2005 (Figure 6). Mean water temperature of the Kootenai River at Porthill, Idaho was 4.5°C, ranging from 9°C on November 10, 2004 to -0.1°C from January 17 through January 21, 2005 (Figure 7). The Porthill temperature recorder was out of the water from February 21, 2005 until March 2, 2005 and again between March 21 and March 22, 2005.

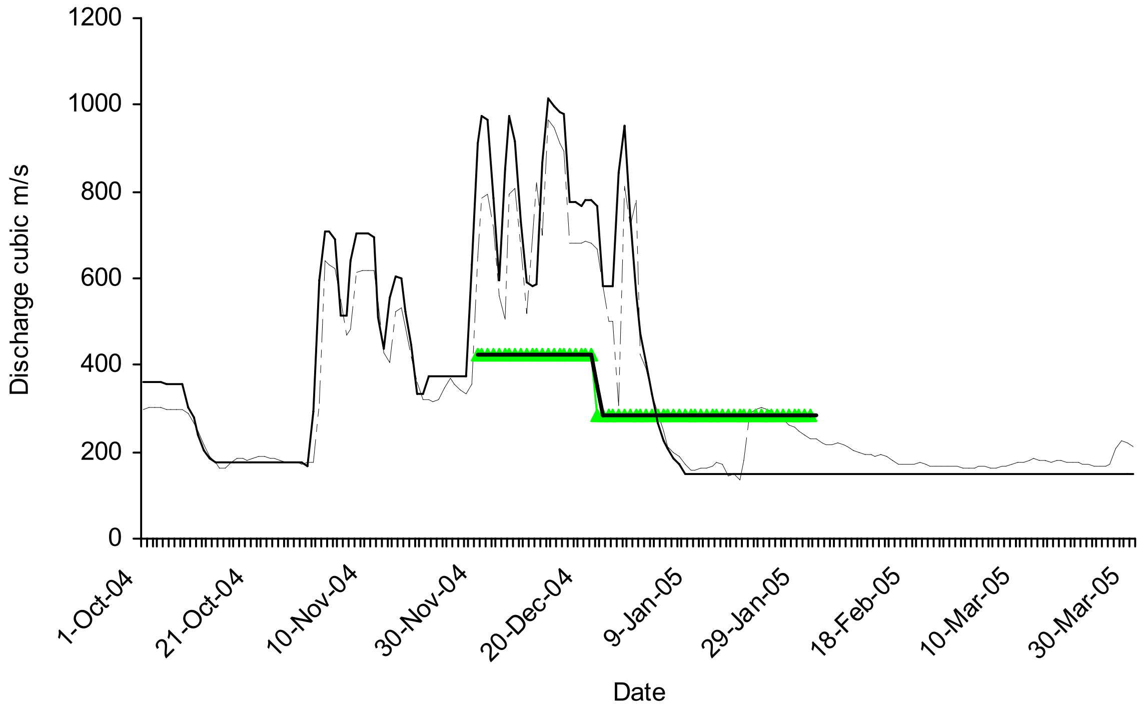

Figure 4. Discharge (m^3/s) in the Kootenai River at Libby Dam (dashed line) and near Bonners Ferry (solid line), Idaho from October 1, 2004 to March 30, 2005. The single line from December through January represents the maximum discharge for the Systems Operation Request. The difference in Libby and Bonners Ferry flows when peak discharges occur is due to the 19-hour lag of water travel to Bonners Ferry and calculation error for estimated discharge at Bonners Ferry.

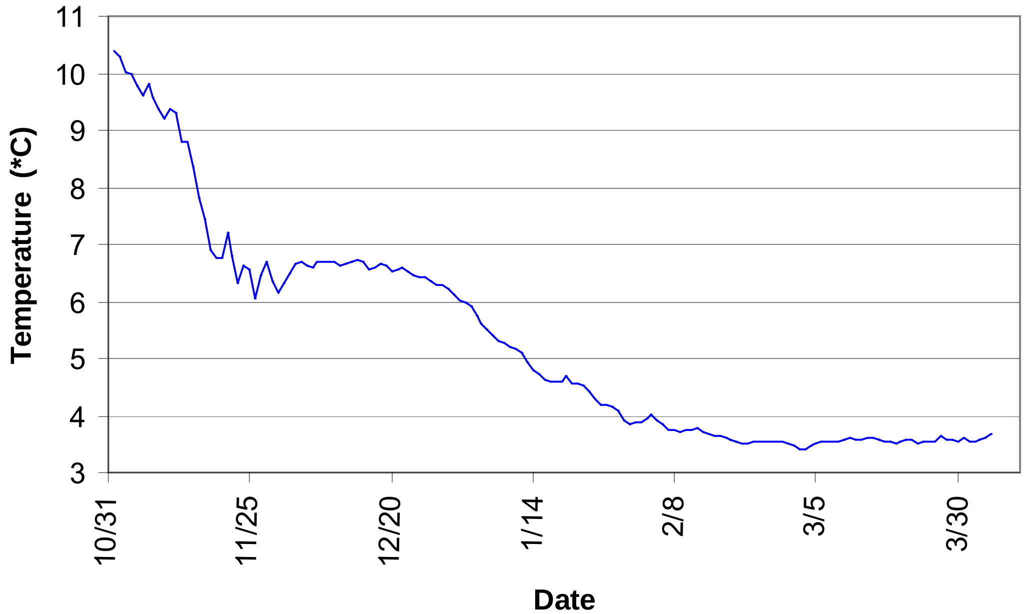

Figure 5. Kootenai River at Libby Dam, Montana mean daily temperature (°C) profile November 1, 2004 to April 5, 2005.

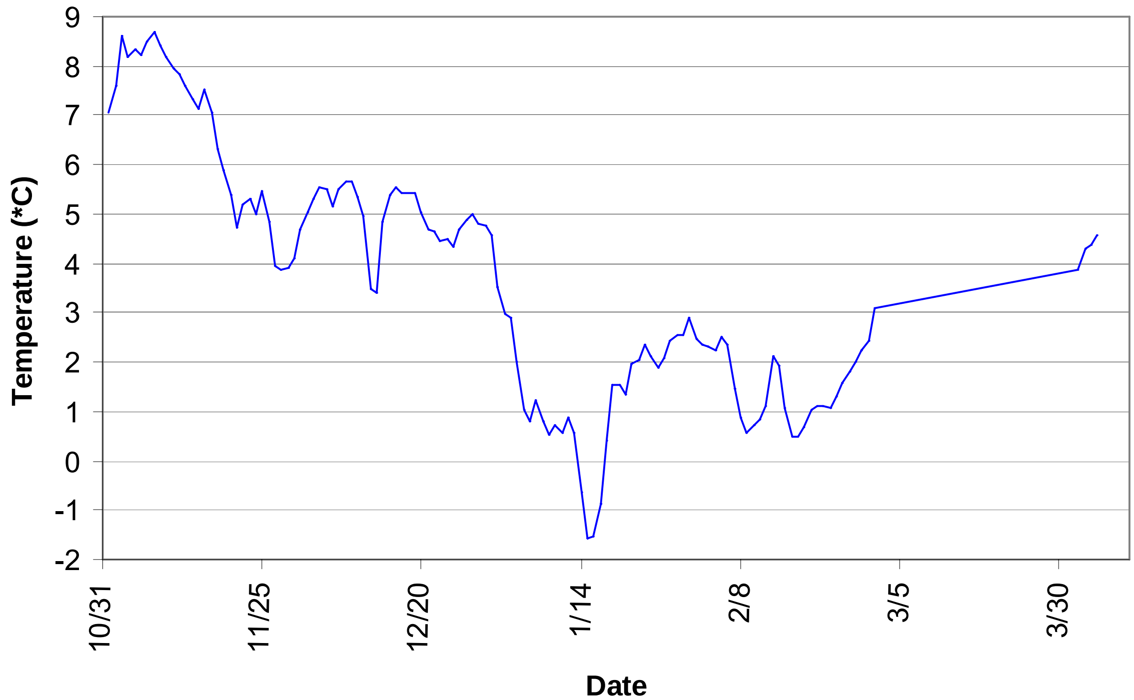

Figure 6. Kootenai River temperature (°C) at Bonners Ferry, Idaho (rkm 244.5), mean daily temperature profile November 1, 2004 to April 5, 2005.

Tributary Temperatures

Tributary water temperature was monitored in Deep Creek, Smith Creek, and Boundary Creek in Idaho and in the Goat River, Corn Creek, and Summit Creek, British Columbia, Canada from November 1, 2004 to about April 18, 2005.

Idaho—Mean water temperature of Deep Creek was 2.4°C, with temperatures ranging from -0.1°C on several days in December, January, and February to 8.2°C on April 14, 2005 (Figure 8). The temperature recorder was pulled from the water by an elk or deer on the morning of February 28, 2005; it was found and replaced that afternoon. Smith Creek mean temperature was 0.56°C, with temperatures ranging from –0.1°C on several days in November, December, most of January and February and also on March 19 and 29, 2005 to 4.5°C on several days in mid-April (Figure 9). Mean water temperature of lower Boundary Creek was 1.2°C, ranging from –1.0°C on March 17 and April 10, 2005 to 11.3°C on April 9, 2005 (Figure 10). Mean water temperature of upper Boundary Creek was 1.0°C, with temperatures ranging from –0.6 on several days in December, January, and February to 5.8°C on April 13 through 15, 2005 (Figure 11).

Canada—Mean water temperature in the lower Goat River was 2.1°C, with temperatures ranging from –0.1°C on several days in December, January, and February to 7.4°C on April 8, 2005 (Figure 12). Mean water temperature in the upper Goat River was 1.9°C with temperatures ranging from –0.1°C on several days in December, January, and February to 13.7°C on April 7, 2005 (Figure 13). The temperature recorder was out of the water from March 5, 2005 until replacement on March 10, 2005, due to dropping water levels. Mean temperature in lower Corn Creek was 2.6°C, ranging from –1.9°C on March 17, 2005 to 8.6°C on April 10, 2005 (Figure 14). Due to receding water level, the lower Corn Creek temperature recorder was out of the water from March 5, 2005 until March 15, 2005 and from March 21 until March 22, 2005. Mean temperature in upper Corn Creek was 2.7°C, ranging from –2.4°C on March 3, 2005 to 10.2°C on April 9 through 11, 2005 (Figure 15). The upper Corn Creek temperature recorder was out of the water from March 5, 2005 until March 22, 2005. Mean water temperature in Summit Creek was 0.92°C, ranging from –1.4°C on March 22, 2005 to 6.2°C on March 30, 2005 (Figure 16). The Summit Creek temperature recorder was out of the water from March 13, 2005 until March 21, 2005.

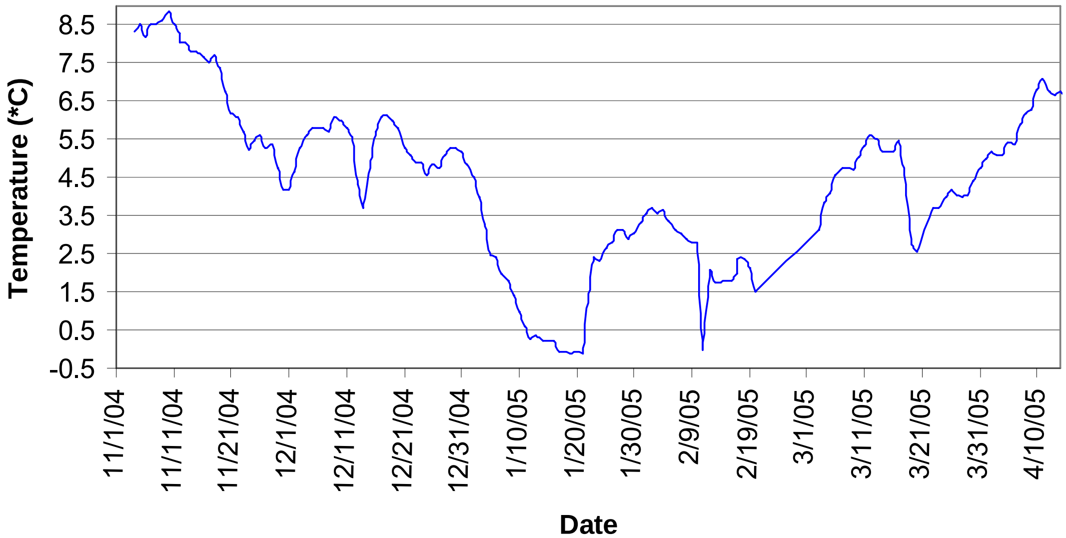

Figure 7. Kootenai River at Porthill, Idaho (rkm 170), mean daily temperature (°C) profile November 4, 2004 to April 17, 2005.

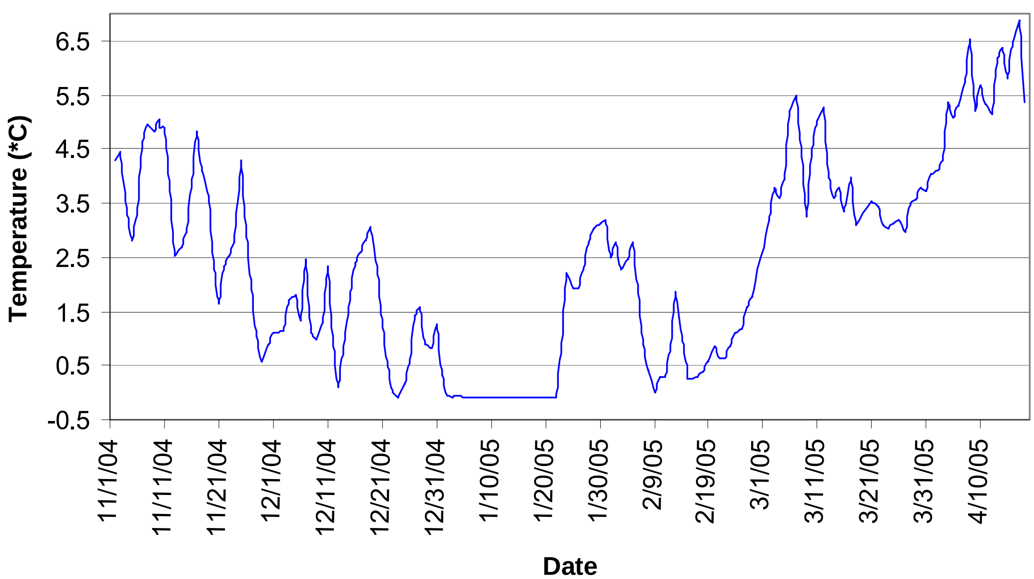

Figure 8. Deep Creek mean daily temperature (°C) profile November 2, 2004 through April 18, 2005.

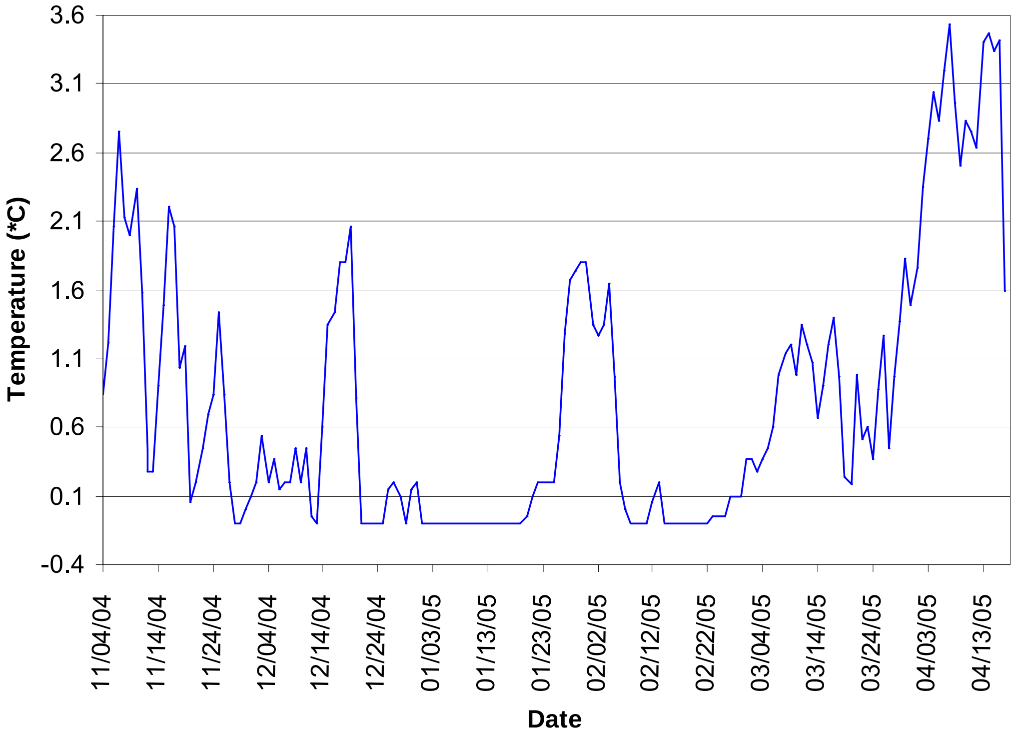

Figure 9. Smith Creek mean daily temperature (°C) profile November 4, 2004 through April 17, 2005.

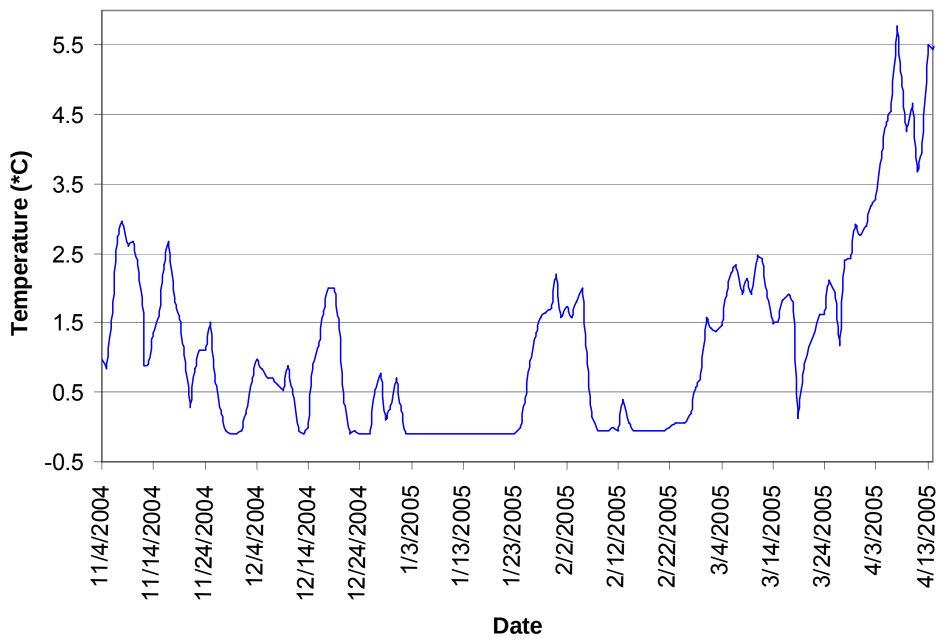

Figure 10. Lower Boundary Creek mean daily temperature (°C) profile November 4, 2004 through April 17, 2005.

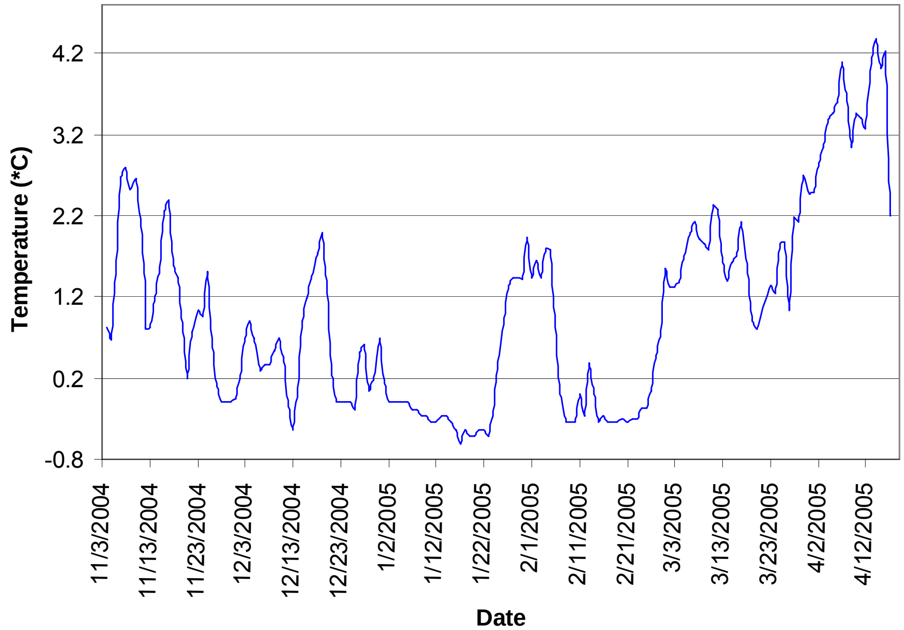

Figure 11. Upper Boundary Creek mean daily temperature (°C) profile November 4, 2004 through April 17, 2005.

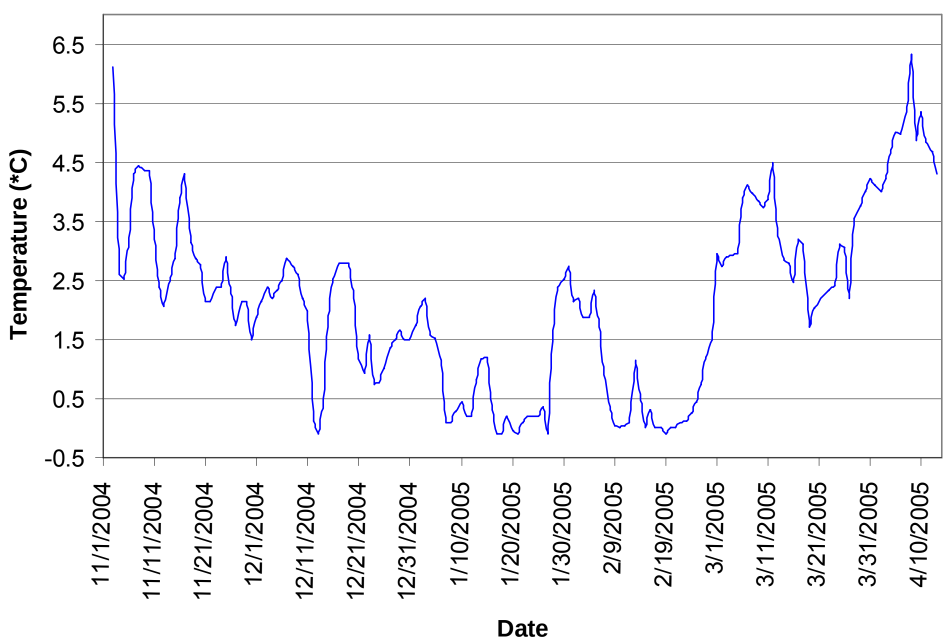

Figure 12. Lower Goat River mean daily temperature (°C) profile November 3, 2004 through April 13, 2005.

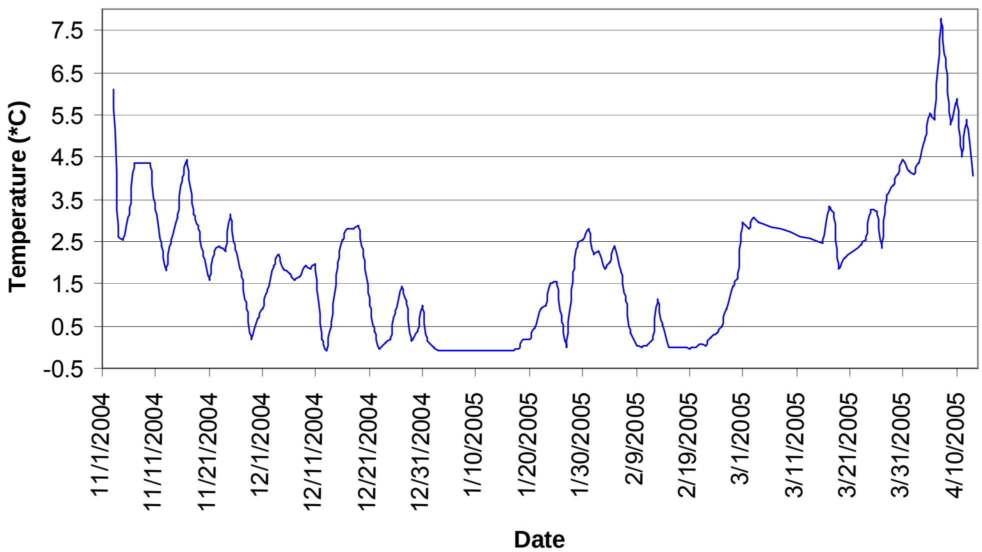

Figure 13. Upper Goat River mean daily temperature (°C) profile November 3, 2004 through April 13, 2005.

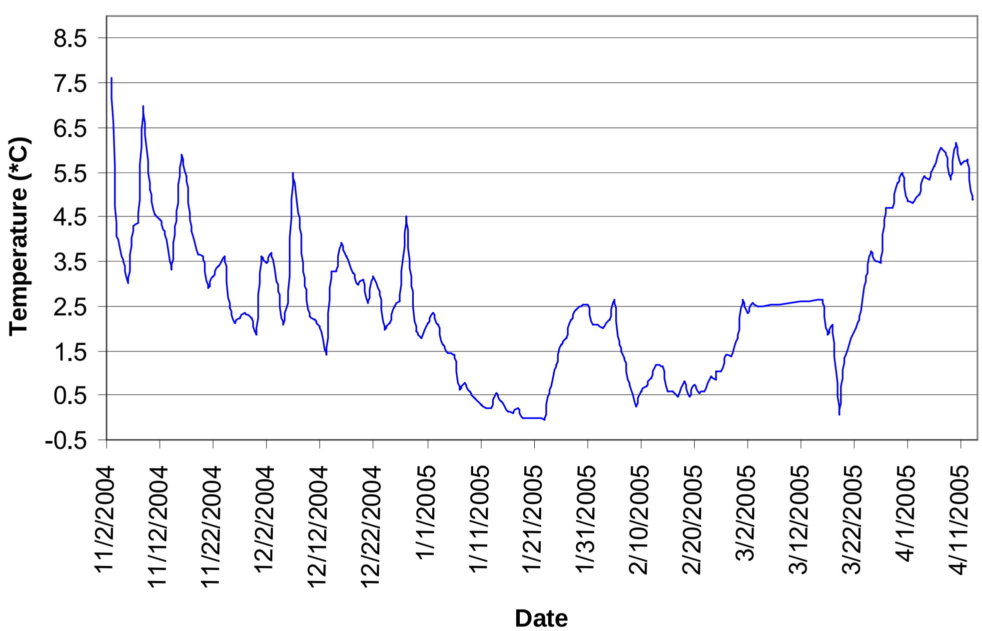

Figure 14. Lower Corn Creek mean daily temperature (°C) profile November 3, 2004 through April 13, 2005.

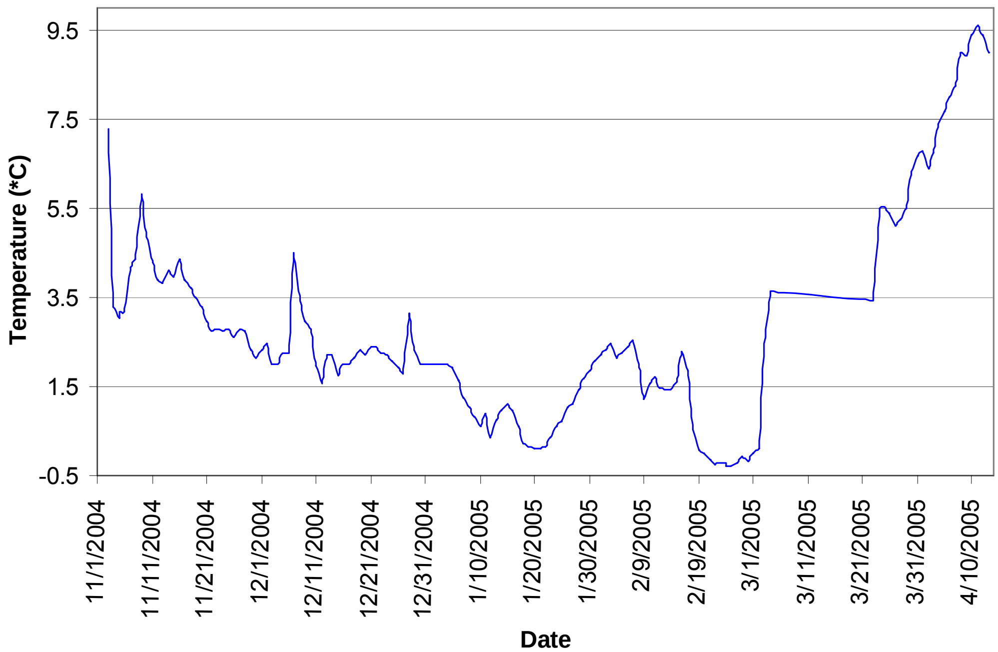

Figure 15. Upper Corn Creek mean daily temperature (°C) profile November 3, 2004 through April 13, 2005.

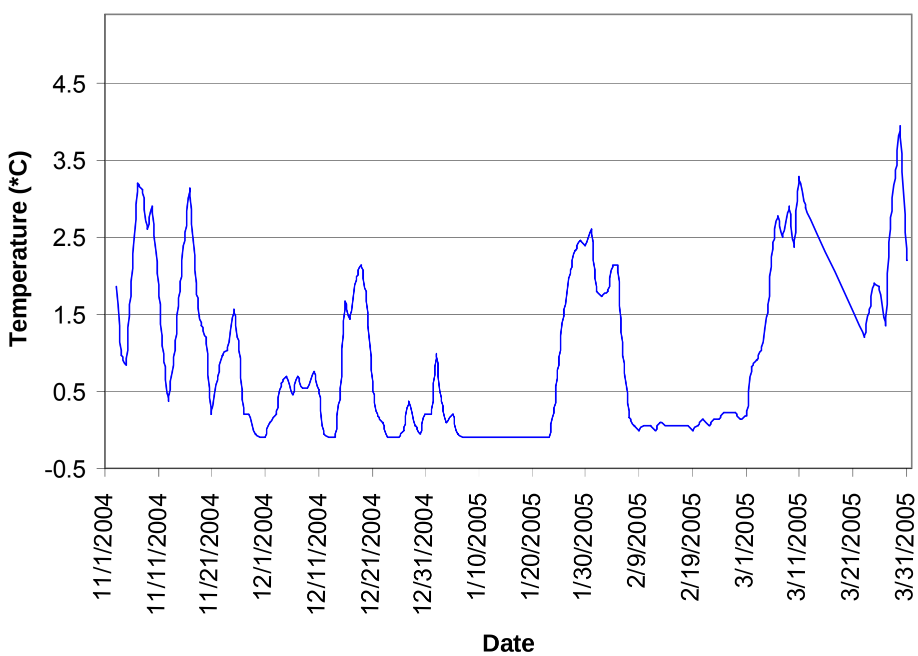

Figure 16. Summit Creek mean daily temperature (°C) profile November 3, 2004 through March 31, 2005.

Sampling Burbot

Total Catch

Baited hoop nets were fished from November 5, 2004 through April 4, 2005 for 49,097.3 h or 2,045.7 net d. One hundred twenty fish were caught encompassing ten different species of fish and 220 crayfish *Pacifastacus spp.* (Table 1). Catch per unit of effort was 0.059 fish/net d for all species of fish (excluding crayfish). Northern pikeminnow *Ptychocheilus oregonensis* was the most abundant species caught totaling 48% of the hoop net by catch, 49 fish (Figure 17 and Table 1).

Hoop Net Catch of Burbot

Throughout the 2005 winter season, 18 burbot (14 different fish) were captured in baited hoop nets (Tables 2, 3; Figure 18). Sixteen of the captures were at Ambush Rock (rkm 244.5), one was near Nicks Island (rkm 144.5), British Columbia, and the other was downstream of the Goat River (rkm 152.7), British Columbia. Of the 18 burbot captured in this study, one fish escaped from the net overnight, four were recaptures from this year's study, six were recaptures from previous years, and seven were new fish (the 18^{th} fish remained unknown). Burbot 234 was a recapture from February 2001 and was previously tagged with an internal sonic transmitter. Hoop net CPUE for burbot was 0.009 fish/net d or 111.1 net d/fish (Appendix 1).

We obtained length and weight measurements from 13 burbot (fish repeatedly captured over a short time were excluded). Burbot total length ranged from 489 mm to 764 mm TL (mean = 615.7 mm, SD = 74.6 mm, n = 13) (Figure 18). Burbot weight ranged from 867 g to 2,798 g (mean = 1,695.8 g, SD = 555.5, n = 13).

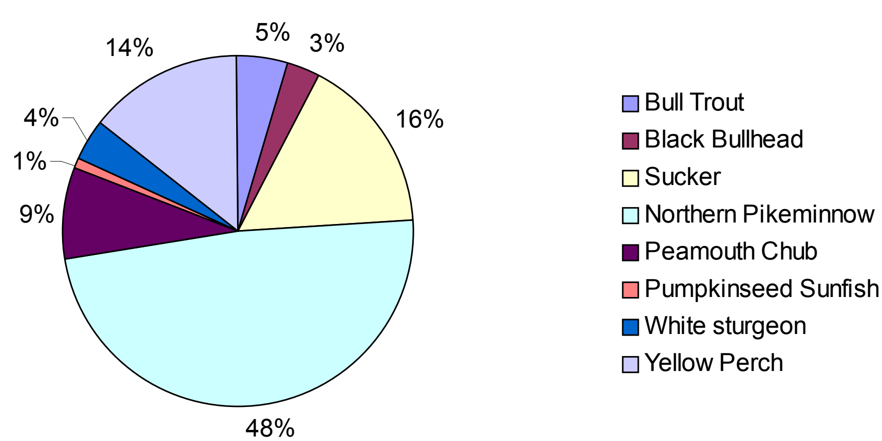

Figure 17. Hoop net by catch for the Kootenai River, Idaho and British Columbia from November 5, 2004 through April 4, 2005.

Comparison of Paired Hoop Nets

Paired hoop nets were set at Nicks Island (rkm 144.5), Goat River, and Ambush Rock (rkm 244.5) Sampling resulted in eight burbot captured in the 19 mm bar web hoop nets and eight in the 25.4 cm bar web. CPUE was 0.061 (SD = 0.451) for the 19 mm bar web hoop nets and 0.018 (SD = 0.120) for the 25.4 cm bar web. We found no statistical difference between the lengths of burbot captured in 19 or 25.4 cm bar web of hoop nets ($p > 0.01$). The mean length of burbot caught by the 19 cm bar web was 589 mm TL, while that of the 25.4 cm bar web was 656 mm TL.

Table 1. Hoop net catch by number, weight (g), and catch per unit effort (CPUE) for the Kootenai River and its tributaries in Idaho and British Columbia, November 2004 through March 2005 with 2045.72 d of effort (49,097.3 h of effort).

Species	**Number**	**Total Weight (g)**	**CPUE**[a]
Northern *Pikeminnow Ptychocheilus oregonensis*	49	21,165	0.0240
Burbot *Lota lota*	18	22,045	0.0088
Sucker[b] *Catostomus catostomus* and *C. macrocheilus*	16	3,023	0.0078
Peamouth Chub *Mylocheilus caurinus*	9	811	0.0044
White Sturgeon *Acipenser transmontanus*	4	456	0.0020
Bull Trout *Salvelinus confluentus*	5	9,246	0.0024
Yellow Perch *Perca flavescens*	15	1,168	0.0073
Black Bullhead *Ameiurus melas*	3	179	0.0015
Pumpkinseed Sunfish *Lepomis gibbosus*	1	20	0.0005
Crayfish *Pacifastacus* spp.	220	8,216	
Total[c]	**120**	**58,113**	**0.0587**

[a] A unit of effort is a single hoop net set for 24 hours.
[b] Includes longnose and largescale sucker.
[c] Crayfish excluded from data.

Larval Sampling Tows

Sampling for larval burbot in the Kootenai River was conducted two days per week from March 9, 2005 until April 18, 2005 from rkm 149 through 244.5. Thirty-two paired ½ meter net tows were made (16 surface and 16 mid-depth), averaging 17 minutes and 52 seconds (SD = 3 minutes 23 seconds) each. Total towing time was 18 hours 27 minutes and 30 seconds. The nets filtered a total water volume of 69,323.20 m^3. No larval burbot were captured.

Light Traps

Four to six light traps were deployed two to three evenings per week from March 2, 2005 through April 18, 2005 at nine different locations (rkm 169.5, 170, 205, 205.5, 239, 240, 240.5, 244.5 and in the Goat River). Seventy light trap sets were operating during this period for a total time of 1,784.02 h. Six juvenile and larval fish were caught but none were burbot.

Table 2. Burbot identification number, location of capture, date of capture, and total length and weight for 17 burbot. An additional fish escaped overnight while going through the decompression process.

Fish ID Number	Location of capture (rkm)	Date of capture	Total length (mm)	Weight (g)
214	244.5	2/23/05	657	1834
214	244.5	3/2/05	659	1730
234	151.1	2/17/05	709	2250
316	244.5	1/26/05	654	2104
318	244.5	2/23/05	764	2798
318	244.5	3/2/05	769	2740
320	244.5	1/26/05	586	1628
321	244.5	1/26/05	661	2140
326	244.5	11/9/04	608	1278
327	152.3	11/24/04	530	910
328	244.5	11/26/04	592	1260
329	244.5	1/20/05	629	1744
330	244.5	1/26/05	489	867
330	244.5	2/23/05	484	926
330	244.5	3/2/05	494	692
331	244.5	2/23/05	554	1382
332	244.5	3/2/05	571	1850

Table 3. Idaho Department of Fish and Game burbot hoop net captures and capture effort in three primary locations, October 2003-April 2004 and November 2004-April 2005.

Sample year	River kilometer	Number of burbot captured	Total days	CPUE (fish/net days)
2003-2004	120-152.9	0	377.8	0
	153-169.9	0	47	0
	170 +	19	1540.3	0.01234
2004-2005	120-159.9	2	806.9	0.002479
	153-169.9	0	0	0
	170 +	16	587.15	0.02725

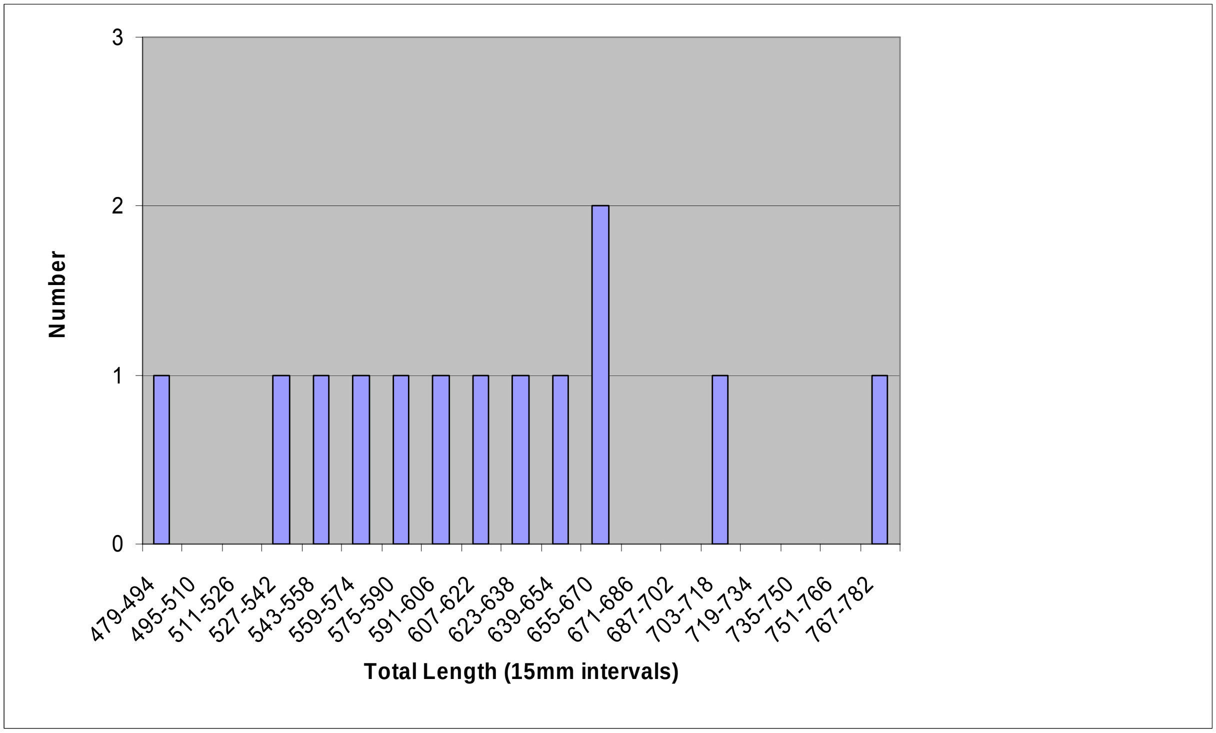

Figure 18. Length frequency distribution of burbot (n = 13) caught by baited hoop nets, excluding recaptures, Kootenai River, Idaho and British Columbia from November 2004 through March 2005.

Temperature Literature Review

Physiological Changes in Fish

Temperate zone fish are dependent on specific environmental cues to begin gametogenesis and to complete gamete maturation (DiStefano et al. 1997); any variation of these cues can delay or even eliminate successful spawning. DiStefano et al. (1997) found that in walleyes *Sander vitreum*, fluctuations in spring water temperature could cause females to resorb their eggs, eliminating spawning for the current year and delaying spawning for the next year. Steroid analysis showed preliminary evidence of irregularities in the reproductive physiology of both male and female walleyes resulting in reproductive failure (DiStefano et al. 1997). Changes in chloride levels were also observed, suggesting that female walleyes were undergoing physiological stress, possibly caused by fluctuating water temperature. Pankhurst et al. (1996) found that elevated temperatures could have a negative effect on rainbow trout *Oncorhynchus mykiss* ovulation, egg production, and fertility; however, vitellogenesis does not seem to be negatively effected. In a study by Davies and Bromage (2002), they indicate that elevated water temperature can increase the rate of over-ripening in ovulated eggs in rainbow trout *O. mykiss*. This leads to developmental problems during embryogenesis and lower fry survival. Elevated temperatures can also cause a decrease in the diameter of the eggs produced resulting in smaller, less desirable fry (Atse et al. 2002).

Migration Timing

Richkus (1974) found that temperature could control when alewives *Alosa pseudoharengus* hold at the entrance of a stream or estuary and when they will enter to spawn, acting as a gating factor. Paragamian (2000) reported at least three burbot entering the Goat River in late January when the temperature reached 1-2°C from the Kootenai River with a temperature of 4-5°C. In regulated rivers, or rivers that have little change in flows during the migration period, upstream movement is controlled by water temperature (Jonsson 1991). In systems where there are extreme variations from the historic thermal regime, upstream migrations can slow or even completely stop with changes of only a few °C (Jonsson 1991). While studying alewife migration, Richkus (1974) determined that fluctuations in water temperature accounted for most of the variability in fish movement, and where light cycles control the timing of activity, stream temperature determines if this activity will result in stream entrance.

Spawn Timing

Spawning is triggered by exact environmental conditions, with water temperature being one of the most critical cues. Baras (1995) showed that *Barbus barbus*, the common barbel, exhibited temperature preference in the River Ourthe by beginning active spawning on the first morning where the water temperature was greater than 13.5°C and continuing until the temperature dropped below 13.5°C. Temperatures outside the species preferendum can delay or expedite spawning from days to possibly weeks. In Arctic charr *Salvelinus alpinus* (L.), adults held in water warmer than 12°C during final gamete maturation showed a delay in ovulation of three to four weeks when compared to broodstock held at 4°C (Atse et al. 2002). If Arctic charr broodstock are held at a constant 11°C, ovulation will not occur. McPhail (1997) showed that burbot would delay spawning up to 14 days with a temperature increase from 0°C to 2.5°C. Some species have shown even more extreme modification of spawn timing due to temperature change. As an example, the orange throated darter *Etheostoma spectabile*, normally a winter and spring spawner, now reproduces during all parts of the year in the Guadalupe River below Canyon Reservoir, Comal County, Texas (Edwards 1978). The modified thermal regime in this river is thought to be a result of hypolimnic water releases from the Canyon Reservoir Dam. Female Kootenai River white sturgeon are known to begin spawning migration from staging areas when the temperature approaches 8.0°C and will abandon spawning with a temperature decrease of as little as 0.8°C (Paragamian and Kruse 2001; Paragamian and Wakkinen 2002).

DISCUSSION

Key Sites and Population Status

We selected sampling sites during the winter of 2004-2005 to maximize our catch, because only a few burbot remain in this population, estimated to be less than 50 fish (Pyper et al. 2004). However, despite sampling at key locations with a hoop net effort of 2,046 net d, exceeded only by 2,085 net d during the winter of 2000-2001, our total catch was only 18 burbot (Appendix 1). We believe this catch, which was similar to that of two of the last three years, would have even been lower had effort been distributed more evenly as in past years. Furthermore, the CPUE was the second lowest (0.009 fish/net d) on record, and of the 18 burbot captured in this study, four were recaptures from this year's study, six were recaptures from previous years, and only seven were new fish.

It is unlikely that any recruitment occurred in the 2004-2005 spawning season for burbot. Results of ½ m net tows and light traps failed to demonstrate measurable recruitment of burbot, although in past seasons these same sampling techniques have proven useful and valid in other systems (Fisher et al. 1996; Fisher 2000).

Analysis of a hoop net web experiment indicated we were unable to detect a statistical difference in the total length of burbot caught by 19 vs. 25.4 mm bar web. However, the sample size was small and may have limited our ability to statistically detect a difference in the observed effect size (6.4 mm), even if it was real. Additional years of pairing the larger and smaller web may make a difference in improving our total sample size and validating the comparison.

For the third consecutive winter, no burbot were captured in the Goat River. This is of major concern because this tributary was once thought to be one of the last known spawning locations for burbot and provided a major portion of the total catch. February of 2001 and winter of 2001-2002 (Kozfkay and Paragamian 2002; Gunderman and Paragamian 2003) were the last winters that burbot were caught in the Goat River. Bisset and Cope (2002) also sampled the Goat River during late January and all of February 2002. They captured 15 burbot, four of which were previously marked by IDFG with a weir and trap. Paragamian and Wakkinen (in progress) hypothesized the Goat River stock of burbot may have been the least impacted by ecological changes to the Kootenai River. They found telemetered burbot returning to this tributary were usually sedentary during post-spawn, had established home pools in the Kootenai River to pass an inactive summer, had home pools within 10 km of the Goat River, and thus had a relatively short distance to migrate.

Kootenai River and Tributary Temperatures and Burbot Spawning and Migration

The effect of post-Libby Dam water temperature changes on burbot migration and spawning success is likely a key factor in their decline. Discharge and temperature conditions in 2004-2005 were similar to 2003-2004 and might have provided sufficiently cold conditions for burbot to spawn, but discharge was too high. Temperatures most of November 2004, ranging from 3.5 to 5.5°C, were relatively low and were similar to pre-dam conditions. Temperature at Bonners Ferry cooled below 3.0°C in early January and ranged from 0.5 to 2.9°C for the remainder of the month and through February. Contrary to this, temperature records of winters of 2001-2002 (Gunderman and Paragamian 2003) and 2002-2003 (Paragamian and Hoyle 2005) were warmer despite low discharges. As a result, the limited movement of burbot in November through early January of those years may have been influenced by the warmer winter water temperatures. Mean daily water temperature in the Kootenai River during the winter of 2002-2003 ranged from 1-8°C from November through mid February. In 1999-2000 (Paragamian et al. 2001), discharges and temperatures were also high. Mean daily water temperature in the Kootenai River ranged from a maximum of 12.4°C on October 9, 1999 to a minimum of 2.4°C on February 22, 2000. There was no evidence of spawning that winter. For comparison, temperatures in the Goat River where burbot were once known to spawn each year were much cooler, ranging from about 0-2°C during December and January. Water temperature at the same time during the winter of 2000-2001 when burbot were known to have spawned was also cooler, ranging from 0-4°C, and burbot were thought to be more active earlier in that season (Kozfkay and Paragamian 2002).

Burbot usually spawn at temperature at or below 4°C, even under the ice (Becker 1983). Although spawning temperatures for burbot, 0.5-4°C in the Kootenai and Goat rivers, were consistent with the range of temperatures found for other burbot populations (Becker 1983; McPhail and Paragamian 2000), they may not be adequate to initiate spawning migration to the Goat River. Because burbot normally move long distances to spawn (Breeser et al. 1988; Schram 2000) and are slow in migration rate (Paragamian et al. 2005), they need adequate time to travel distances of 120 km or more to reach some spawning locations in the Kootenai River (Paragamian et al. 2005). Thus, the actual temperature at spawning may not be as important as the cooling of the river during October and November to initiate spawning migration. Furthermore, winter discharges are known to impede migration; thus, this may explain why burbot are captured at Ambush Rock during some years well after the spawning season and in various stages of reproductive readiness (Paragamian and Whitman 2000, Paragamian et al. 2001; Paragamian 2000). Slavík & Bartoš (2002) found movements of burbot in the regulated Ohře River were most common after high discharges of winter management had ended (post-spawn). In the Kootenai River, high discharge may have imposed a serious physiological barrier in the potential spawning of burbot, because all burbot captured and biopsied post-spawn had failed to spawn (Paragamian and Whitman 2000, Paragamian et al. 2001; Paragamian 2000).

Temperature is an important environmental variable in the life history of all poikilothermic animals. Subtle changes in temperature can cause a variety of changes in life history patterns and in some cases seriously alter the outcome of spawning and recruitment (DiStefano et al. 1997). Temperature change in the Kootenai River post-Libby Dam is one aspect of the environment that has been monitored, yet we do not fully understand how it may have affected burbot migration and spawning. Paragamian and Wakkinen (in progress) investigated the possible effects of temperature and discharge to help formulate rehabilitation recommendations for burbot (KVRI Burbot Committee 2005). They had the unique opportunity to study the movements of 11 individual burbot through two or more spawning seasons. They found burbot spawning locations in the Kootenai River were spatially different (Goat River and Ambush Rock); burbot exhibited different movement or life history patterns ranging from active lotic/lentic migrations to sedentary, while several fish had predictable seasonal movement patterns. Prespawn migration temperature for six burbot between the years 1995 and 2002 ranged from 3.0-4.9°C. Migration timing for the remaining burbot was not determined because of their sedentary behavior, or because they may have already been in a prospective spawning location. If the temperature range of 3.0-4.9°C was representative of an activity range for the remaining burbot population, then migration movements prior to Libby Dam may have started a month earlier in November rather than late December or January when these same temperatures are reached during post-Libby Dam (Figure 3). This observation of colder water in January may explain why Paragamian (2000) found significantly more movement of burbot during January than November and December in his post-Libby Dam studies.

Paragamian and Wakkinen (in progress) examined the relationship of pre- and post-Libby Dam river temperatures and burbot migration (three burbot and seven migration events) to the probability of spawning migration with a logistic model. Prior to Libby Dam, the model predicted burbot spawners to the Goat River would have followed a very consistent pattern of migrating in November to spawn (Appendix 2). Post-Libby Dam, observed discharge and temperatures, produced a very unpredictable pattern of migration in the modeling effort.

The significance of a delay in burbot spawning migration may be in arrival timing. Burbot are highly synchronized in spawning (Evenson 2000; Arndt and Hutchinson 2000) and travel slowly. Their maximum travel rate in a recent study was 8 to 11 km/d (Paragamian et al. 2005).

Burbot also have low swimming endurance (Jones et al. 1974). Therefore, the combination in temperature and discharge change and delayed migration may have resulted in the failure of burbot to spawn in most years of study (Paragamian 2000). Spawning is triggered by exact environmental conditions, with water temperature being one of the most critical cues. Pääkkönen et al. (2000) found that burbot were most active at temperatures less than 5°C but correlated negatively with day length. McPhail (1997) showed that burbot would delay spawning up to 14 days with a temperature increase from 0°C to 2.5°C, and Taylor and McPhail (2000) found temperatures approaching 7°C were lethal to developing embryos.

Recommended Discharge and Temperature for Burbot Migration and Spawning

We conclude that water temperature and discharge changes to the Kootenai River during fall and winter post-Libby Dam have had a serious impact on burbot spawning migration. Until adequate discharge and temperature targets are provided for a direct study of burbot spawning success, the best available recommendation for these variables will continue to rely on the studies of Paragamian et al. (2005) and Paragamian and Wakkinen (in progress). As a result of these studies, it is recommended that discharge for burbot prespawning migration and spawning should range from 113-300 m^3/s and average 176 m^3/s for a minimum of 90 d (mid-November through mid-February). Temperature should approach <5°C by the first week in November and be maintained via selector gates as low as possible thereafter for the duration of December through February.

RECOMMENDATIONS

1. We recommend a burbot prespawning migration and spawning discharge from Libby Dam ranging from 113-300 m^3/s and averaging 176 m^3/s for a minimum of 90 d, beginning November 15, 2005 and extending through February 15, 2006.

2. We recommend a burbot prespawning migration temperature from Libby Dam of <5.0°C should commence November 1 with the coldest available water provided from December through February. This combined with low discharge will encourage earlier migration of burbot and achieve a longer migration potential to spawning locations.

3. Burbot spawning migration (arrival time) and evidence of spawning (spent burbot, eggs, and larvae) should be monitored at Ambush Rock to test the null hypothesis that burbot migration is not different from previous years (1996, 1997, 1998, and 1999) of high discharges.

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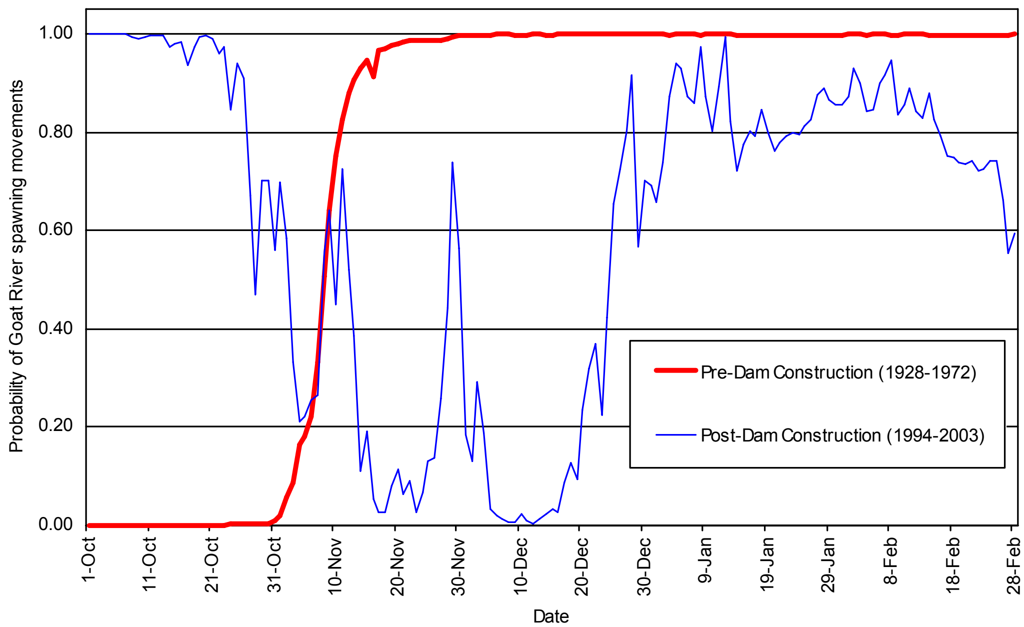
APPENDICES

Appendix 1. Idaho Department of Fish and Game burbot hoop net captures and capture effort (burbot/hoop net day), winters (Wtr.) of 1993-2005.

Sampling season	**Number of burbot captures**	**Total net days**	**CPUE (fish/net day)**
Wtr. 1993: Mar. 1993-May 1993	17	554.2	0.031
Wtr. 1994: Oct. 1993-April 1994	8	909.8	0.009
Wtr. 1995: Nov. 1994-Feb. 1995	33	688.8	0.048
Wtr. 1996: Nov. 1995-Mar. 1996	28	495.8	0.056
Wtr. 1997: Oct. 1996-Mar. 1997	23	1,061.1	0.022
Wtr. 1998: Oct. 1997-May 1998	42	1,240.9	0.034
Wtr. 1999: Oct. 1998-April 1999	44	1,453.7	0.030
Wtr. 2000: Oct. 1999-April 2000	36	1,712.9	0.021
Wtr. 2001: Oct. 2000-Mar. 2001	73	2,085.2	0.035
Wtr. 2002: Oct. 2001-April 2002	17	1,529.9	0.011
Wtr. 2003: Oct. 2002-Mar. 2003	11	1,809.7	0.006
Wtr. 2004: Nov. 2003-Mar. 2004	19	1,965.1	0.010
Wtr. 2005: Nov. 2004-April 2005	18	2,045.72	0.009
Totals	**369**	**17,552.88**	
Mean			**0.024**

Appendix 2. Predicted probability of Goat River burbot spawning movements based on a logistic regression model using historical discharge and temperature data, pre- and post-Libby Dam construction (Paragamian and Wakkinen, in progress).



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