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

2006 Annual Report

By

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ABSTRACT

The main objectives of this investigation were: 1) to establish a positive population trend of burbot *Lota lota* in the Kootenai River, Idaho and British Columbia, Canada with rehabilitation measures, 2) To restore the Kootenai River winter temperatures and discharge to levels that are suitable for burbot prespawning migration and spawning, and 3) To have at least 500 mature burbot in the Kootenai River for natural reproduction by stocking fingerling burbot—this appears to be the best short-term prospect to improving the stock numbers. The winter of 2005-2006 was characterized by an 88% of normal January runoff forecast. Discharge from Libby Dam and at Bonners Ferry gradually decreased at the beginning of September 2005 from about 340 m^3/s to about 133 m^3/s through much of October but was then increased in November to about 550 m^3/s. Peak discharge at Bonners Ferry nearly reached 800 m^3/s in December but usually maintained between 500 and 600 m^3/s through the first week in January 2006, then ramped down to a steady 113 m^3/s through February. Water temperature at Bonners Ferry in November ranged from 4.5 to 7.5°C but fell within the upper and lower limits of 1-4°C for the months of December through February as prescribed by a Systems Operation Request. Fourteen burbot were captured; seven of the captures were at Nicks Island (river kilometer [rkm] 144.5), four from Ambush Rock (rkm 244.5), two near the mouth of the Goat River (rkm 152.7), and one downstream of Corn Creek (rkm 150.3). One burbot escaped from a net, one was caught in a snagged net and released prior to marking, four were recaptures from previous years, and eight were new fish. Burbot catch per unit effort in hoop nets was 0.0065 fish/net d or 153.84 net d/fish. Total length of burbot ranged from 368 to 732 mm TL (mean = 591 mm, SD = 30.04 mm, n = 12). Burbot weight ranged from 368 to 2,793 g (mean = 1,473 g, SD = 238 g, n = 12). Vemco VR2 single channel monitoring receivers were used for the first time of our studies. Seven burbot were implanted with Vemco coded transmitter tags between October 2005 and March 2006. Two burbot (327 and 339) were observed ascending the Goat River during the spawning season eventually moved back into the Kootenai River and entered Summit Creek, behavior not previously documented. Temperature and flow from Libby Dam at prescribed levels are necessary to facilitate migration and spawning of burbot in the Kootenai River. Evaluation of the physical attributes of four prospective lakes suggested Sinclair Lake was the best for extensive burbot rearing.

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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). Burbot in the Kootenai River (Figure 1) once provided an important winter fishery to residents of northern Idaho. This fishery and that of Kootenay Lake, British Columbia, Canada (Paragamian et al. 2000a) 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 as recently as the early 1970s (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 (Idaho Department of Fish and Game [IDFG] Regional Archives, unpublished data). Three commercial anglers alone harvested an estimated 2,150 kg in 1958. 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 US Army Corps of Engineers (USACE) in 1972, the fishery rapidly declined and eventually closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, British Columbia (Paragamian et al. 2000a). 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 also changed (Partridge 1983; Snyder and Minshall 1996; Richards 1996) and are thought to be important factors for burbot spawning and recruitment.

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. It was believed burbot had been extirpated from the Kootenai River, Idaho since the construction of Libby Dam. Undocumented results of Montana Fish Wildlife and Parks efforts to capture burbot in the Kootenai River, Idaho suggested there were no burbot. Results of IDFG sampling from 1993-1994 the population was likely low with few burbot between rkm 246 (Bonners Ferry) and the Montana border (rkm 275) (Paragamian 1994a). There was little evidence of burbot reproduction in the Idaho reach with one juvenile and one larval burbot captured from 1993 through 1998 (Paragamian et al. 2000). However, numerous size-classes of burbot were in the catch, indicating some burbot were reproducing successfully, albeit insufficiently to sustain the population. Previous studies had failed to document a spawning run of burbot from the river in British Columbia or Kootenay Lake, but sampling with the British Columbia Ministry of Environment (BCME) in the British Columbia reach documented burbot spawning in the Goat River (Paragamian 2000). Spawning was also documented during the winter of 2000-2001 when a "spawning ball" of burbot was captured at Ambush Rock (Kozfkay and Paragamian 2002); although other potential spawners were captured in the same location, their numbers were low in comparison to other populations (Arndt and Hutchinson 2000).

Studies completed during the winter of 1997-1998 indicated discharge management at Libby Dam likely affected burbot spawning migration (Paragamian 2000). Movement of burbot 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. Winter discharges are now three to four times greater than they were prior to the dam (Figure 2). Daily differences in discharge now range up to 652 m^3/s. Fluctuating discharges from Libby Dam due to hydropower production and floodwater evacuation appear to have continuously disrupted upstream migrations of burbot. The specific

effect of this disruption 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.

Because burbot in the Kootenai River may be at risk of demographic extinction (Paragamian 2000), a Conservation Strategy (Anonymous 2002; KVRI Burbot Committee 2005) was prepared to outline measures necessary to rehabilitate the burbot population. The Conservation Strategy indicated that operational discharge changes at Libby Dam were to 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.

Experimental discharges from Libby Dam from 1998-2002 were set at 170 m^3/s, similar to pre-dam winter discharges during burbot spawning migration (Paragamian and Whitman 1999, 2000). The intention was to test whether discharges $\leq$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. Since test conditions were unachievable, an alternative evaluation was necessary (Paragamian et al. 2005). The objective was to examine existing telemetry records of burbot collected from 1994 through 2000 (Paragamian 1994b, 1995; Paragamian and Whitman 1996, 1997, 1998, 1999, 2000) to determine how discharge factors affected burbot travel distances and travel rate.

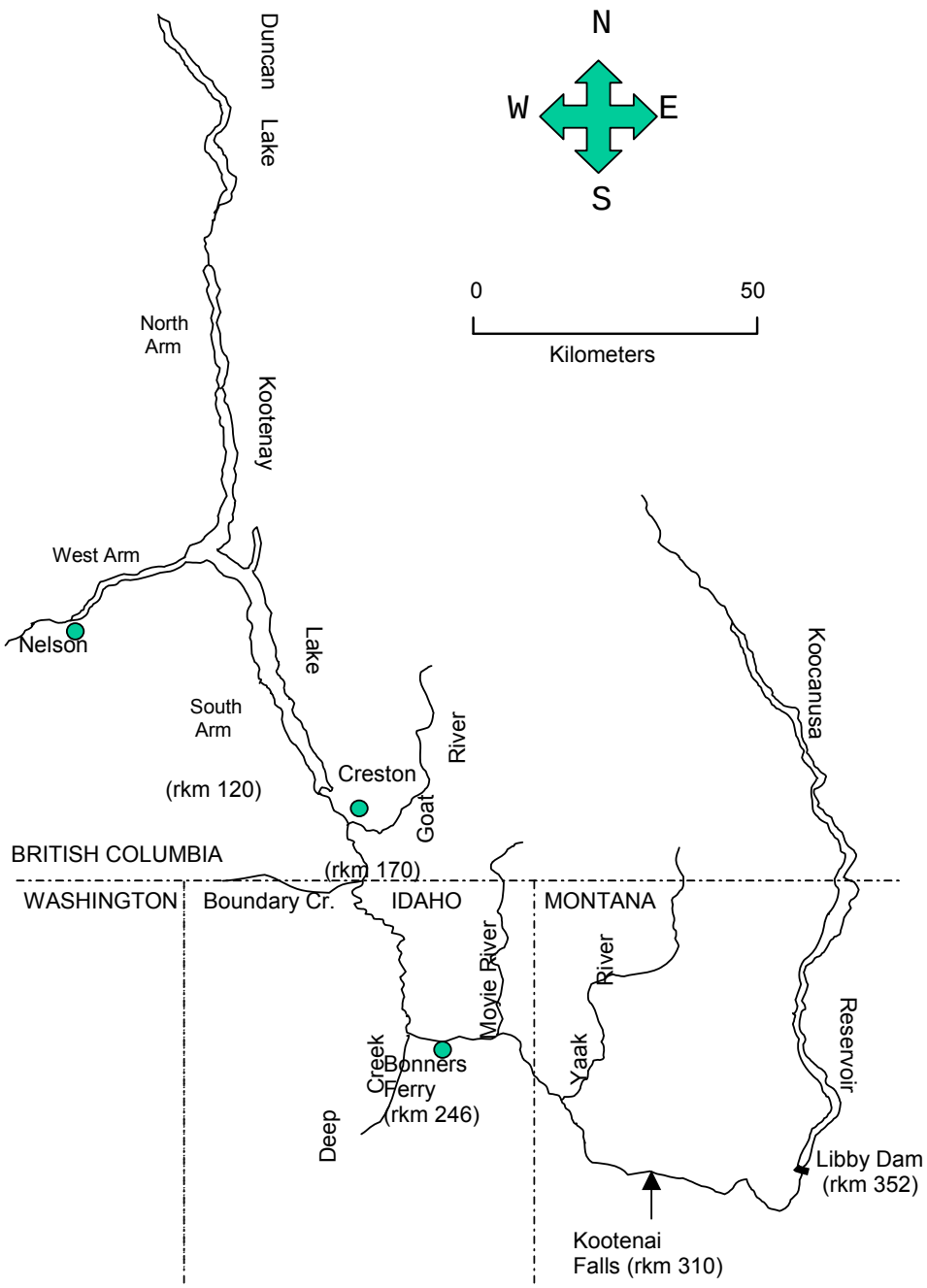

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

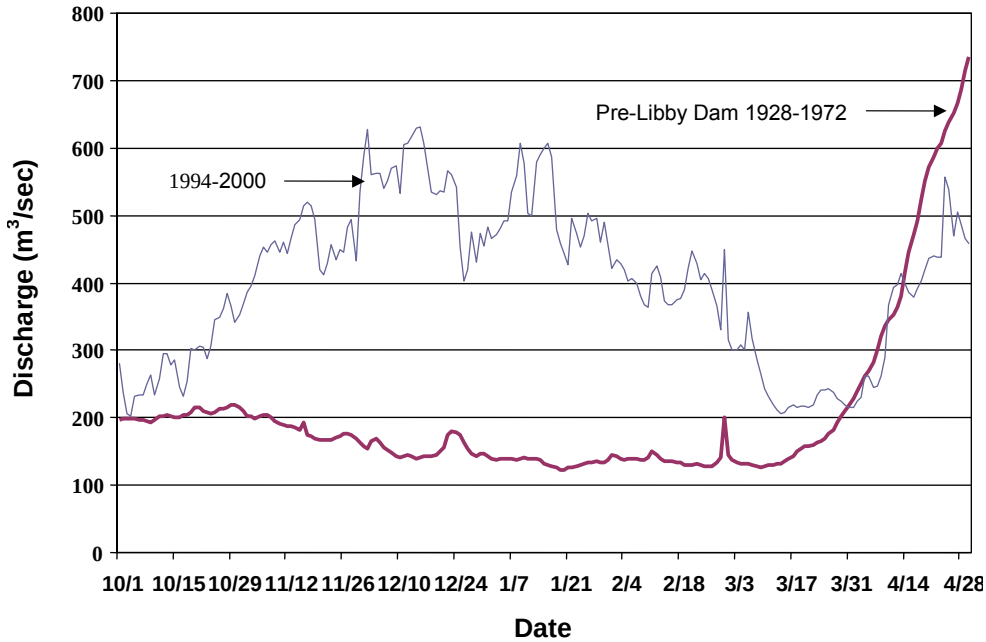

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho from 1962 through 1971 (pre-Libby Dam), and from 1994 through 2000 (post-Libby Dam).

Examination of seasonal 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 (average 176 m^3/s). "Stepwise movements" of burbot were further examined to assess possible statistically significant differences in movement when the number of days that discharge from Libby Dam were ≤300 m^3/s (N = 15 and 186 days, low discharges) in comparison to the number of days that discharge was ≥301 m^3/s (N = 11 and 538 days, high discharges). Results indicated burbot moved more frequently during lower discharges. Consequently, we 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 also affect 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.

Concerned stakeholders formed the Kootenai Valley Resource Initiative (KVRI) Burbot Committee to formulate a Conservation Strategy to: "1) prevent further burbot losses, 2) identify actions needed to rehabilitate the burbot population, and 3) avoid extinction of additional local burbot stocks." "This Conservation Strategy represents the collective contribution of the Burbot

Committee to conserve and restore burbot in the Kootenai/y Basin (KVRI 2005)." Because the population is at a critically low number it is likely successful rehabilitation will depend on reintroductions of burbot of similar genetic and behavioral patterns. Thus, research into intensive culture was recommended as well as experiments with extensive culture. While the Kootenai Tribe of Idaho (KTOI) and the University of Idaho (UOI) experiment with intensive culture of burbot, an IDFG task is to find a suitable lake for extensive rearing of burbot derived from the culture of burbot brought into the hatchery. The chosen body of water would then be the study site for IDFG experiments with extensive rearing with the cooperation of KTOI and UOI.

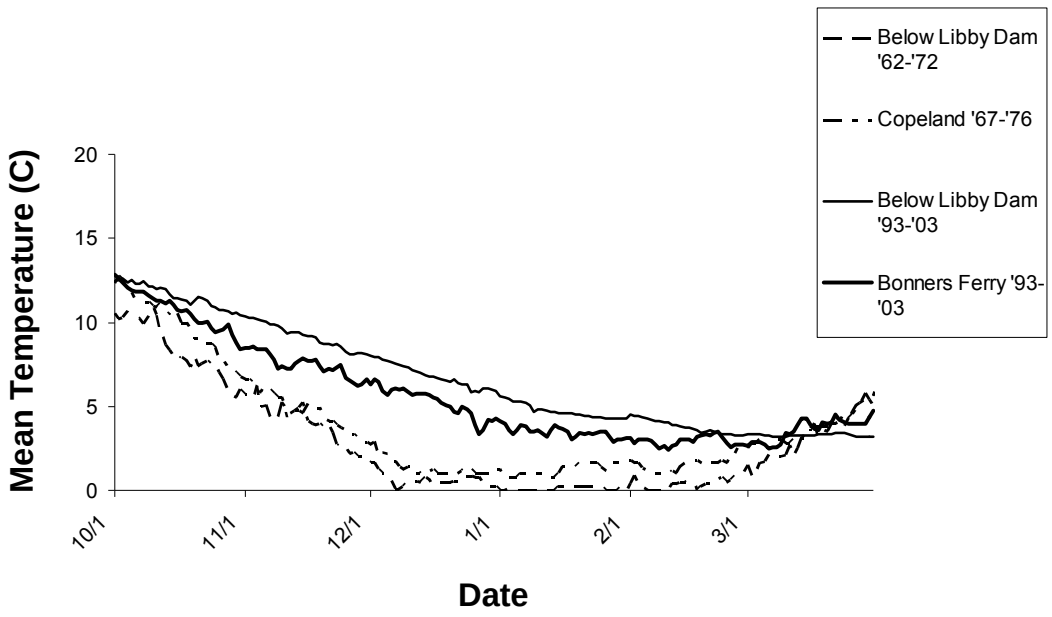

Figure 3. Pre-Libby Dam Kootenai River temperatures at the dam site 1962-1972, at Copeland, Idaho 1967-1972 and post Libby Dam below the dam from 1993-2003, and at Bonners Ferry, Idaho from 1993-2003.

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. Establish a positive burbot population increase with affective rehabilitation measures (population trajectory can be determined with mark and recapture studies - survival, population numbers, recruitment, size structure).

2. To have at least 500 mature burbot in the Kootenai River for natural reproduction by stocking fingerling burbot – this appears to be the best short-term prospect to improving the stock numbers.

3. To restore Kootenai River habitat with winter temperatures and discharge levels suitable for burbot prespawning migration and spawning.

STUDY AREA

The Kootenai River is one of the largest tributaries to the Columbia River. Originating in Kootenay National Park, British Columbia, 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 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.

METHODS

Discharge and Temperature

Daily discharge and temperature measurements for the Kootenai River were obtained from the USACE and the United States Geological Survey (USGS) office in Sandpoint, Idaho. A systems operation request (SOR) to the USACE and the BPA for winter of 2005-2006 was requested by the United States Fish and Wildlife Service (USFWS) on behalf of the Kootenai Valley Resource Initiative's Burbot Recovery Committee (which included the IDFG, Office of Species Conservation, Kootenai Tribe of Idaho, City of Bonners Ferry, and Boundary County). The intention was to provide water cooler than previous dam operations to facilitate burbot migration and spawning. Because the burbot population is stock limited, expecting a measurable biological response to a temperature SOR was unreasonable. As a result, the SOR was to determine if river temperature could be maintained between 1-4°C (Paragamian and Wakkinen, in press) in Bonners Ferry by using the selective withdrawal system in place at Libby Dam. These temperatures were to occur during the burbot migration (November–December) and spawning period (late January and February). The committee did not address discharge from Libby Dam during this same period.

HOBO® or StowAway® XI temperature loggers were 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. Mean temperature was calculated from five evenly spaced daily measurements. A temperature logger was deployed less than 50 meters upstream from each tributary creeks 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. Using temperature data, we assessed whether infiltration of Kootenai River water into these creek mouths was substantial, obscuring the coldwater inputs that burbot may use as migration cues would be obscured (Paragamian 2000). Although no burbot spawning has been documented in tributaries recently, Summit and Boundary creeks were anecdotal historical burbot spawning areas.

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 and the method of deployment). We used 12 nets with 25.4 cm bar mesh, three of which were paired with hoop nets with 19 cm bar mesh. The intention 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. ANOVA could be used in a one factor model to determine any statistical differences in length of burbot between the two gear sizes.

Because the burbot population was low, we established a monitoring scheme that used previous sites where their captures were highest to measure changes in population numbers (Seber-Jolly population estimate), size structure (PSD), condition W_r, and abundance (CPUE). These "key" locations are based on three to four site-specific sampling reaches. 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. "Key" sites were: Nicks Island (rkm 144.5), and the international boundary (rkm 170), outside the confluence with the Goat River (152.7), and Ambush Rock (244.5). 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 152.7).

Nets 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 (g). All burbot were tagged with a passive integrated transponder (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.

Burbot Telemetry

Vemco V13-1L-R04K coded acoustic pinger transmitters were surgically implanted in burbot during winter season of 2005-2006. Each transmitter was 13 mm in diameter and 36 mm long, had an approximate battery life of three years, and weighed 6 grams in water. An array of passive Vemco VR2 sonic single channel fixed telemetry receivers were previously deployed from Kootenay Lake, British Columbia upstream into Idaho near the Montana border (Rust and Wakkinen 2004). Receiver arrays allow for efficient, cost-effective monitoring of white sturgeon *Acipenser transmontanus* and burbot movements throughout the Kootenai system and will aid in our understanding of seasonal movement patterns and seasonal behavior. Vemco VR2 location receivers were also placed in Deep, Smith and Boundary creeks in Idaho, and in the Goat River and Summit Creek in British Columbia.

Larval Burbot Sampling

Burbot recruitment was assessed in the Kootenai River using paired half m nets (mouth area = 0.79 m^2) pulled with a boat (Almar) 8 m in length. One net was towed at the surface and a second at approximately 1.5 m below the surface. In water less than 2 m, both nets were

towed near the bottom. Gurley 2030R current meters were mounted in the mouth of each net two thirds of the way from the center to the outside, and tows were made in a downstream direction; the boat motor (150 horsepower) 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 et al. (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 as the light source. Up to six traps were deployed at dusk and checked the next morning.

Pond Inspection for Extensive Rearing of a Donor Stock

On July 6, 2006, project personnel inspected four prospective rearing ponds for extensive burbot rearing and eventual release as a donor stock for burbot rehabilitation. All ponds were in Boundary County, Idaho. Eight main features were examined: location, water source, water depth, boat access, shoreline access, absence of a fish community, temperature, and perceived risk of summer or winter kill.

RESULTS

Discharge and Temperatures

Kootenai River Discharge

The winter of 2005-2006 was characterized by an 88% of normal January 2006 runoff forecast in the Canadian Rockies of the Kootenai basin. Discharge at Libby Dam comprised the major portion of discharge at Bonners Ferry from September 2005 through early January 2006 (Figure 4). Discharge in early October was about 150 m^3/s but was increased in late October and November to about 580 m^3/s. On two occasions, peak discharge in December from Libby Dam nearly reached 800 m^3/s but was usually between 500 and 600 m^3/s through the first week in January 2006. After the first week in January, discharge from Libby Dam was decreased to a steady 113 m^3/s through February but during that same time, local discharge increased it to over 300 m^3/s.

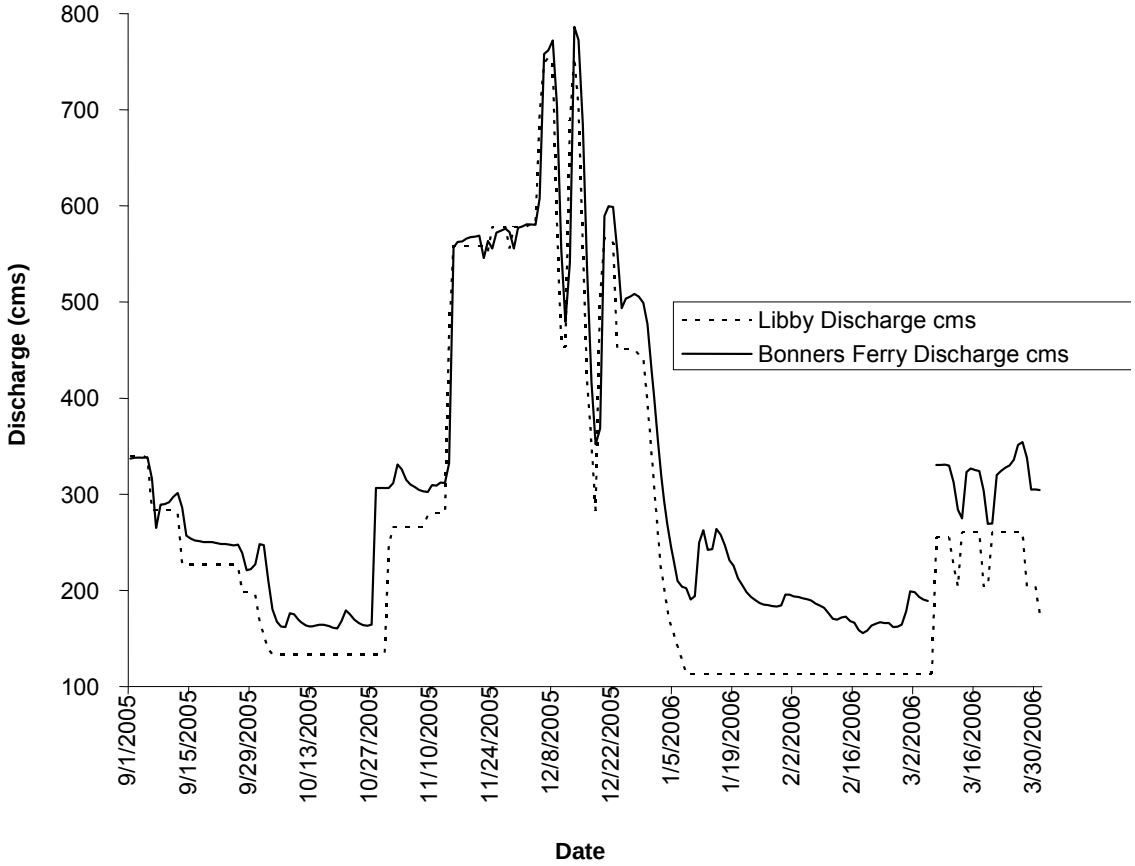

Figure 4. Mean daily discharge (m^3/s) and temperature (°C) of the Kootenai River below Libby Dam, Montana and Bonners Ferry, Idaho from September 1, 2005 to March 31, 2006. Data was obtained from the U.S. Army Corps of Engineers.

Kootenai River Temperatures

From September through October 2005 mean daily water temperature at Libby Dam and Bonners Ferry rapidly decreased (Figure 5). In general, water temperature was warmer at Libby Dam, usually cooling several degrees before reaching Bonners Ferry. Mean water temperature at Bonners Ferry (rkm 244.5) for the winter was 3.4°C ranging from -1.35°C on February 19, 2006 to 6.5°C on October 31, 2005 (Figure 5). Water temperature at Bonners Ferry for the months of December through February fell within the upper and lower limits of 1–4ºC as prescribed by the 2005-2006 SOR (Figure 5).

Mean water temperature at Porthill, Idaho (rkm 169.8) was 4.12°C with a low of 0.2°C on February 21, 2006 and February 26, 2006 to a high of 11.7°C on April 13, 2006 (Figure 6). Mean water temperature at Nicks Island (rkm 144.5) from October 28, 2005 through March 6, 2006 was 3.6ºC ranging from 1°C to 9.5°C (Figure 7).

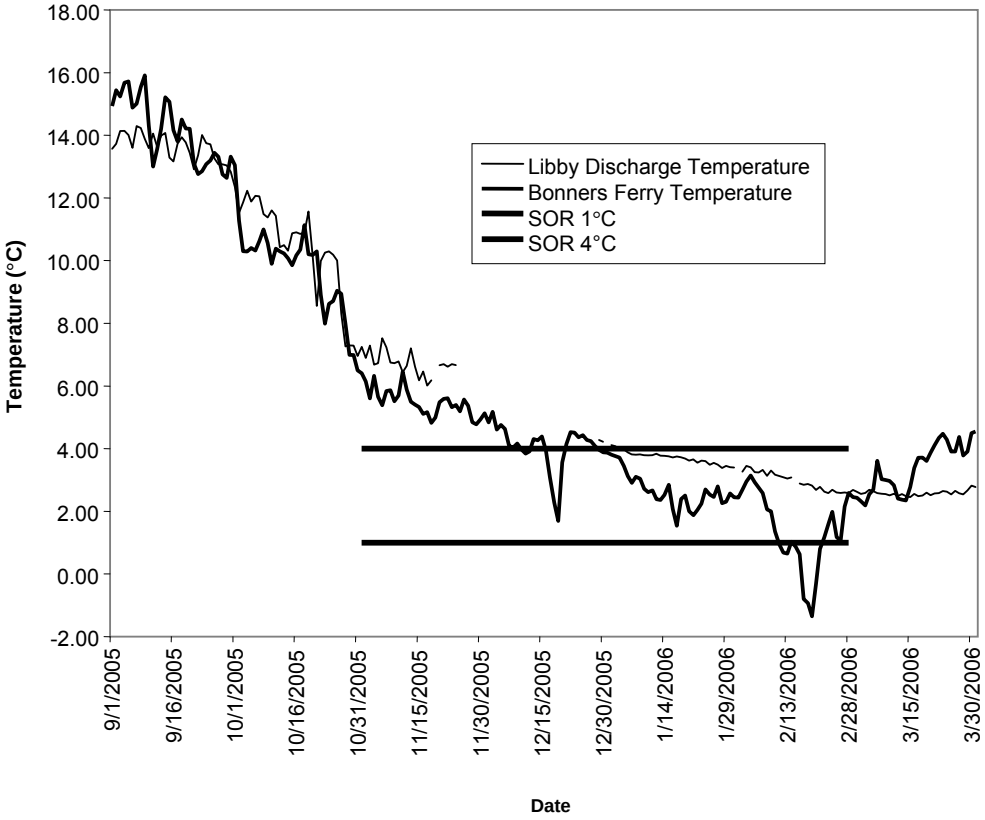

Figure 5. Mean daily temperature (°C) of the Kootenai River below Libby Dam, Montana and Bonners Ferry, Idaho from September 1, 2005 to March 31, 2006 obtained from the USACE. The flat horizontal lines are the upper and lower bounds for 1 and 4°C for the systems operation request for water temperature.

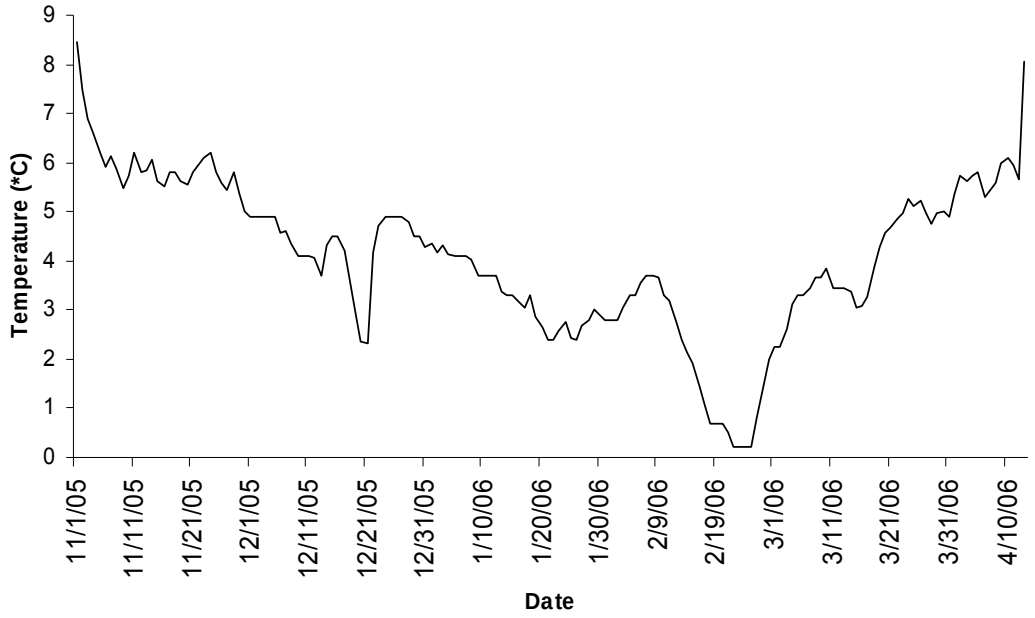

Figure 6. Kootenai River at Porthill, Idaho (rkm 170) (°C) mean daily temperature profile November 1, 2005 to April 14, 2006.

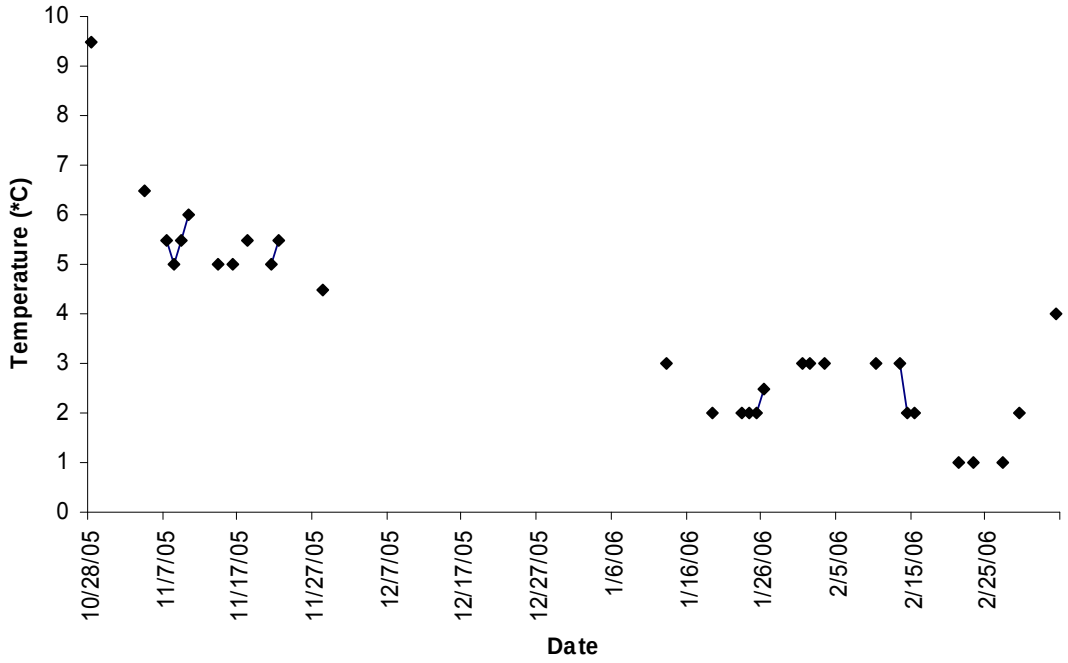

Figure 7. Kootenai River at Nicks Island (rkm 144.5) (°C) mean daily temperature profile October 28, 2005 to March 6, 2006. Missing data points were due to recorder malfunction.

Tributary Temperatures

Water temperatures were monitored from October 2005 to April 2006 in Deep, Smith, Myrtle, and Boundary Creeks in Idaho and in the Goat River, Corn, and Summit creeks, BC, Canada (Appendices 1 through 7).

Idaho Tributaries—Mean water temperature of Smith Creek was 0.55°C, with temperatures ranging from -0.6°C to 4.1°C (Appendix 1). Mean water temperature of upper Boundary Creek was 0.63°C, with temperatures ranging from -0.6°C to 5.3°C (Appendix 2). The battery in the upper Boundary Creek recorder malfunctioned, stopping data collection on February 9, 2006. Mean water temperature of lower Boundary Creek was 1.13°C ranging from -0.6°C to 6.6°C (Appendix 3). Mean water temperature in Myrtle Creek was 0.96°C, with temperatures ranging from -1° to a maximum of 4.9°C (Appendix 4). Water temperature was not measured in Deep Creek because the temperature recorder malfunctioned.

Canadian Tributaries—Mean water temperature in the lower Goat River was 1.68°C, with temperatures ranging from -0.1°C to 6.6°C on October 28, 2005 (Appendix 5). The temperature recorder deployed in the upper Goat River malfunctioned and did not record data. Mean water temperature in upper Corn Creek was 1.26°C ranging from -0.1°C to 5.3°C (Appendix 6). Mean temperature in lower Corn Creek was 2.89°C ranging from –0.1°C to 8.2°C (Appendix 7). The temperature recorder in Summit Creek was damaged during the season and did not record data.

Adult Burbot Sampling

Total Catch

Baited hoop nets fished from October 28, 2005 through March 6, 2006 for a total of 47,999 h or 2,000 net d. A total of 110 fish of 15 different species were caught along with 404 crayfish *Pacifastacus spp.* (Table 1). Catch per unit effort was 0.055 fish/net d for all species of fish (excluding crayfish). Northern pikeminnow *Ptychocheilus oregonensis* was the most abundant species caught totaling 40 fish or 35% of the hoop net by catch (Table 1).

Hoop Net Catch of Burbot

Fourteen burbot were captured during the winter of 2005-2006 (Tables 1 and 2 and Figure 8). Seven of the captures were at Nicks Island (rkm 144.5), BC, four from Ambush Rock (rkm 244.5), two near the mouth of the Goat River (rkm 152.7), BC, and one was caught immediately downstream of Corn Creek, BC (rkm 150.3). Of the 14 burbot captured, eight were new fish, one fish escaped overnight, one was in a snagged net and released by a diver (without a PIT tag reading) to avoid further stress, and four were recaptures from previous years. Hoop net catch per unit effort for burbot was 0.0065 fish/net d or 154 net d/fish (Table 3; Appendix 8).

We obtained length and weight measurements from 12 burbot. Burbot total length ranged from 368 mm to 732 mm TL (mean = 591.3 mm, SD = 30.04 mm, n = 12) (Figure 8). Burbot weight ranged from 368 g to 2,793 g (mean = 1472.75 g, SD = 238.35 g, n = 12).

Table 1. Hoop net catch by number, weight (g), and catch per unit effort (CPUE) for the number of fish or crayfish, for the Kootenai River and its tributaries in Idaho and BC, October 2005 through March 2006 with 1999.94 d of effort (47,998.57 h of effort).

Species	Number	Total Weight (g)	CPUE[a]
Northern Pikeminnow *Ptychocheilus oregonensis*	40	13,329	0.020
Burbot *Lota lota*	14	14,765	0.007
Sucker[b] *Catostomus catostomus* and *C. macrocheilus*	15	3,263	0.008
Peamouth Chub *Mylocheilus caurinus*	9	921	0.005
White Sturgeon *Acipenser transmontanus*	4	952	0.002
Bull Trout *Salvelinus confluentus*	1	1,136	<0.001
Yellow Perch *Perca flavescens*	2	233	0.001
Black Bullhead *Ameiurus melas*	9	569	0.005
Bullhead *Ameiurus spp.*	9	633	0.005
Pumpkinseed Sunfish *Lepomis gibbosus*	1	70	<0.001
Rainbow Trout *Oncorhynchus mykiss*	4	2,081	0.002
Redside Shiner *Richardsonius balteatus*	1	14	<0.001
Brook Trout *Salvelinus fontinalis*	2	438	0.001
Mountain Whitefish *Prosopium williamsoni*	1	171	<0.001
Crayfish *Pacifastacus* spp.	404		0.202
Total[c]	112	38,575	0.056

[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.

Table 2. Burbot identification number, location of capture, date of capture, total length, weight, and tag number.

Fish ID Number	Capture location (rkm)	Capture date	Total length (mm)	Weight (g)	Tag type	Tag code
333	144.5	11/1/05	383	322	na	
279	144.5	11/14/05	732	2793	na	
329	244.5	11/18/05	645	1596	na	
334	144.5	11/28/05	714	2294	Vemco	282
335	144.5	12/9/05	539	965	Vemco	285
327	144.5	12/16/05	561	1126	Vemco	106
336	144.5	1/3/06	368	366	na	
337	144.5	1/9/06	515	781	na	
338	244.5	1/12/06	714	2662	Vemco	283
339	152.7	2/6/06	624	1673	Vemco	82
340	152.7	2/6/06	588	1235	Vemco	284
341	244.5	2/23/06	713	1860	Vemco	111
999[a]	244.5	3/7/06	460	na	na	
999[a]	150.3	3/21/06	na	na	na	

[a] Data insufficient to assign fish number: one fish escaped during the decompression process and a second was released by a diver.

Table 3. Idaho Department of Fish and Game burbot hoop net captures and capture effort in three primary locations, October 2003-April 2004, November 2004-April 2005, and October 2005-March 2006.

Sample year	River kilometer	Number of burbot captured	Total days of effort	CPUE (fish/net days)
2003-2004	120-152.9	0	377.8	0
	153-169.9	0	47	0
	170 +	19	1,540.3	0.012
2004-2005	120-159.9	2	806.9	0.003
	153-169.9	0	0	0
	170 +	16	587.15	0.027
2005-2006	120-152.9	11	896.57	0.012
	153-169.9	0	0	0
	170+	3	501.32	0.006

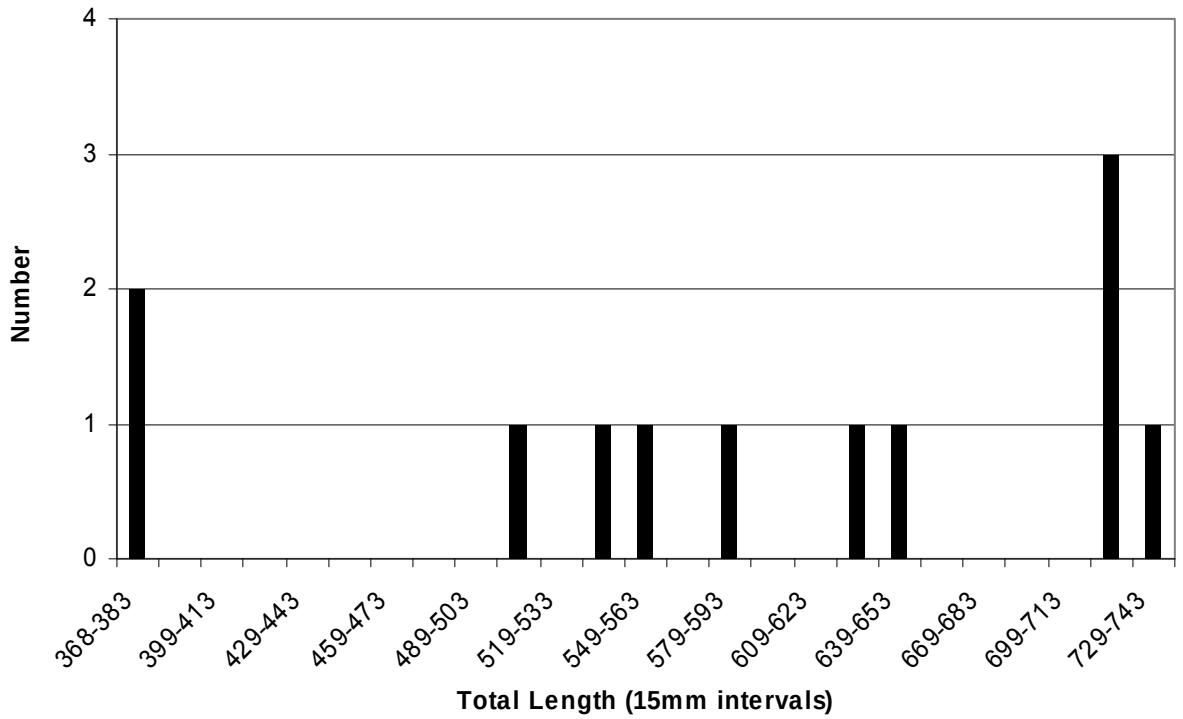

Figure 8. Length frequency distribution of burbot (n = 12) caught by baited hoop nets, excluding recaptures, Kootenai River, Idaho and BC from October 2005 through March 2006.

Burbot Telemetry

Seven burbot were implanted with Vemco transmitters between October 2005 and March 2006 (Table 4). Three burbot were tagged near Nicks Island (rkm 144.5), two near the mouth of the Goat River (rkm 152.7), and two were tagged at Ambush Rock (rkm 244.5). Burbot 338 tagged on January 13, 2006 at rkm 244.5 had very limited movement remaining within one km of the tagging site; the last contact was on March 18, 2006. Burbot 341 tagged on March 2, 2006 at rkm 244.5 moved up and downstream remaining within three km of the tagging site until last contact on May 15, 2006 (Figure 9; Appendix 9). Burbot 339 tagged on February 8, 2006 at rkm 152.7 moved into the Goat River on February 15, 2006, then moved back into the Kootenai River on February 21, 2006. Burbot 339 then moved downstream and briefly entered Summit Creek, then re-entered the Kootenai River, and continued downstream to the point of last contact February 22, 2006 at rkm 122.5 near Kootenay Lake on (Figure 10; Appendix 10). Burbot 327, tagged on December 21, 2005 at rkm 144.5, was detected at rkm 140.5 on December 28, 2005. Burbot 327 was later detected by the Summit Creek Vemco receiver on February 26, 2006 and contacted on March 5, 2006 (Figure 11; Appendix 11). Burbot 335 tagged on December 12, 2005 at rkm 144.5 moved steadily downstream moving between the tagging site and the last contact on December 28, 2005 at rkm 122.5 (Figure 12; Appendix 12). Burbot 340 tagged on February 8, 2006 at rkm 152.7 was recorded on the Goat River Vemco

receiver on February 24, 25, and 28, 2006 and contacted there on March 23, 2006. Burbot 340 was not detected in the Kootenai River. Burbot 334, tagged on November 30, 2005 at rkm 144.5, was detected at rkm 140.5 on December 20, 2006 where contact was lost on December 24, 2006. Burbot 334 was not recorded on any other Vemco receivers. Additional records will be included in the next annual report.

Table 4. Data for burbot tagged with Vemco sonic transmitters. Fish were tagged in the Kootenai River, Idaho and British Columbia, winter 2005-2006.

Fish #	Tag Code	Serial #	Tag Date	RKM Released	Length (mm)	Weight (g)	PIT #
334	282	5185G	11/30/05	144.5	714	2294	7F7D043C32
335	285	5188G	12/12/05	144.5	539	965	7F7D07437B
327	106	4726F	12/21/05	144.5	561	1126	134714173A
338	283	5186G	1/13/06	244.5	714	2662	7F7D0E5021
340	284	5187G	2/8/06	152.7	588	1235	7F7D400A51
339	082	4298F	2/8/06	152.7	624	1673	7F7D042D4B
341	111	7773F	3/2/06	244.5	713	1860	7F7D0F7466

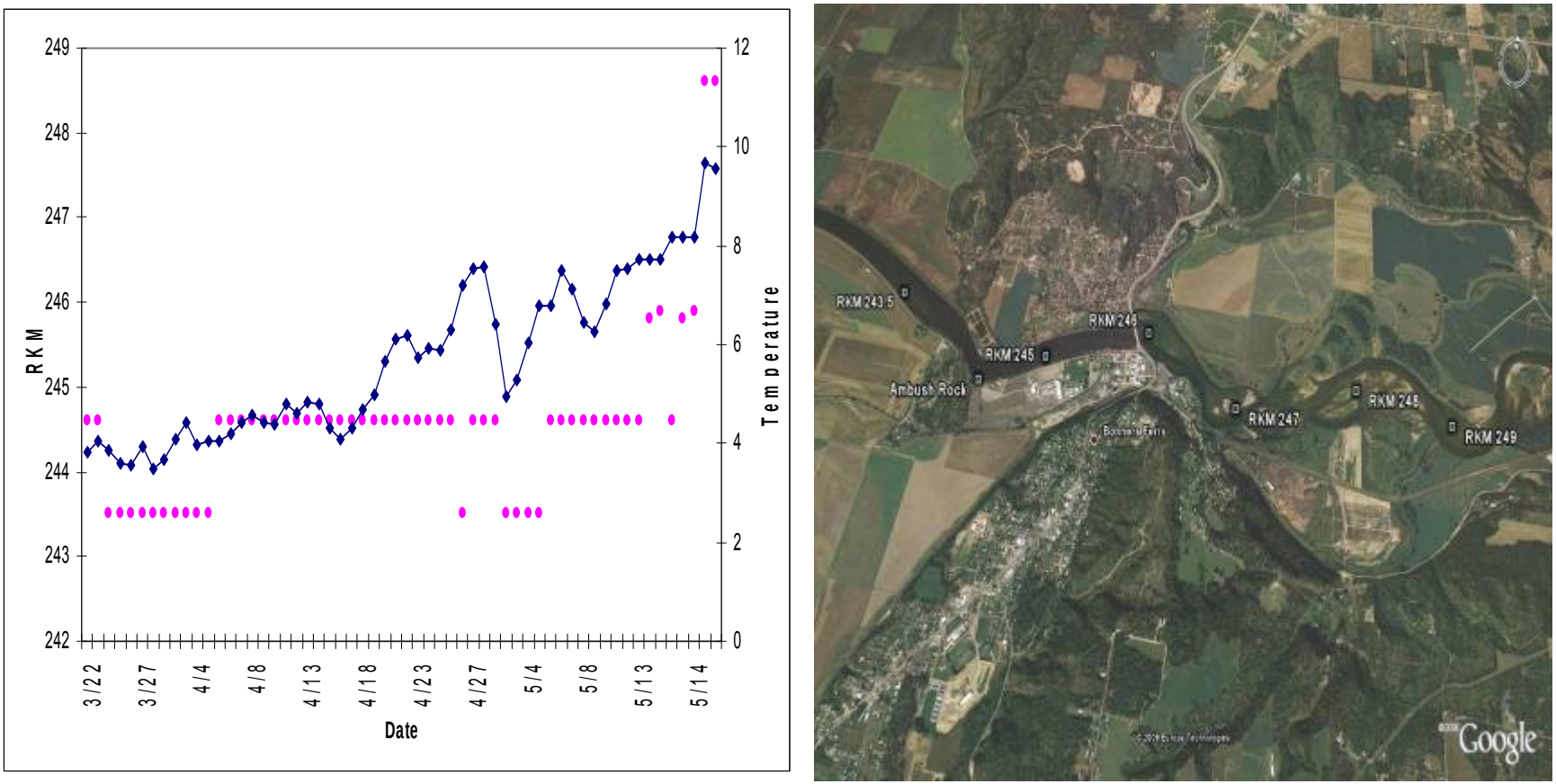

Figure 9. Recorded locations of burbot 341 movement; red are burbot rkm locations and blue is temperature between March 2, 2006 and May 15, 2006 in the Kootenai River.

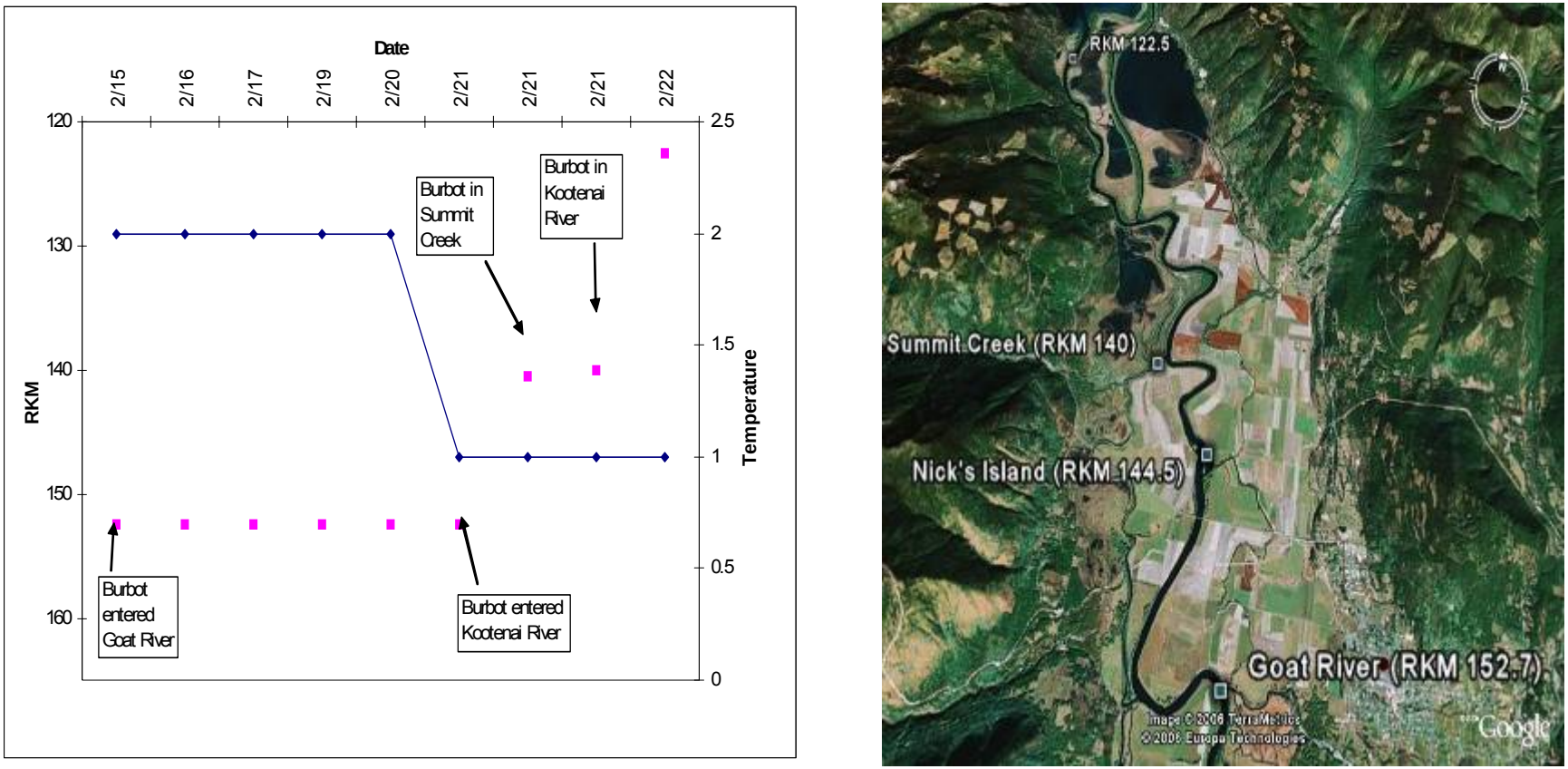

Figure 10. Recorded locations of burbot 339 movement; red are burbot rkm locations and blue is temperature between February 8, 2006 and February 22, 2006 in the Kootenai River.

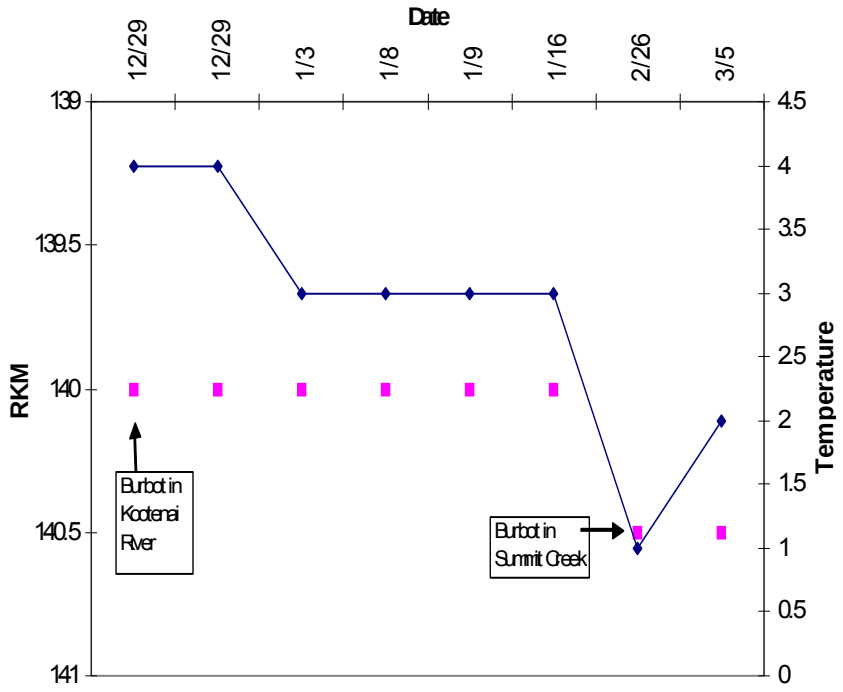

Figure 11. Recorded locations of burbot 327 movement; red are burbot rkm locations and blue is temperature between December 29, 2005 and March 5, 2006 in the Kootenai River.

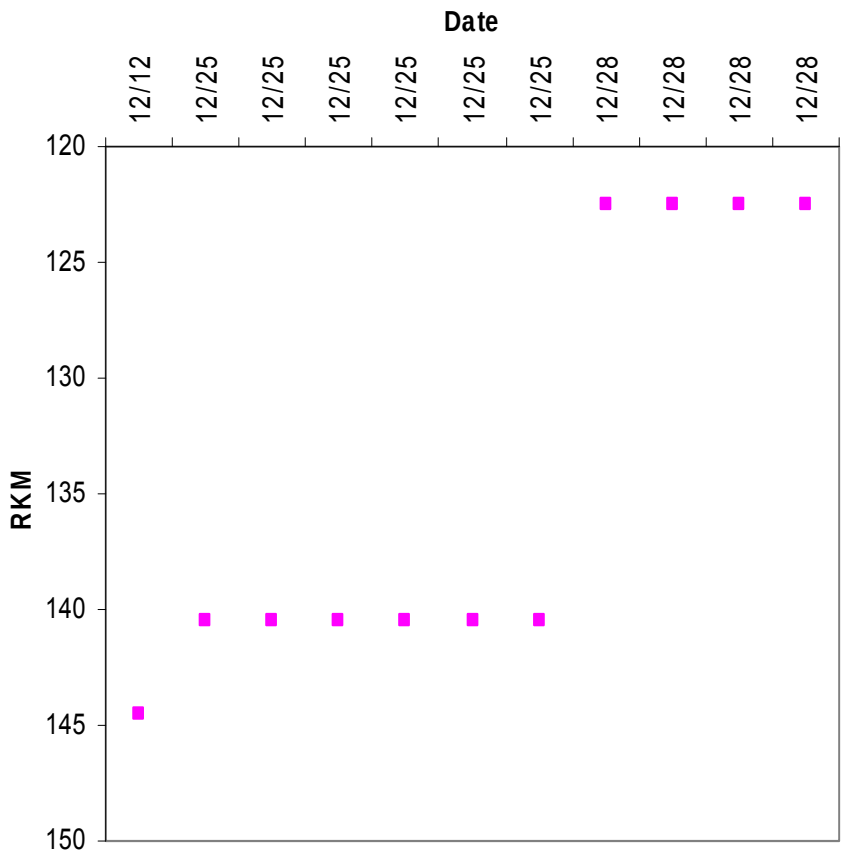

Figure 12. Recorded locations of burbot 335 movement; red are burbot rkm locations and blue is temperature between December 12, 2005 and December 28, 2005 in the Kootenai River.

Larval Sampling

Larval Sampling Tows

Sampling for larval burbot was conducted on March 23, 2006 at rkm 244.5 and March 29, 2006 at rkm 204 in the Kootenai River. Six paired half m net tows were made (three surface and three mid-depth), averaging 20 minutes and 26 seconds (SD = 7 minutes 39 seconds) each. Total towing time was 2 hours 2 minutes and 33 seconds. The nets filtered a total water volume of 7,216 m^3. No larval burbot were captured.

Light Traps

Four to six light traps were deployed on March 19, 27, 28, 29, 2006 at Ambush Rock (rkm 244.5). Twenty-one light trap sets were operated during this period for a total of 430.3 h. No larval fish were captured.

Pond Inspection for Extensive Rearing of a Donor Burbot Stock

Sinclair Lake best met the criteria for a pond for rearing trials for a donor stock of burbot. Sinclair Lake has the best access for sampling, has a permanent dock and developed boat launch. Weed development along shorelines, although present, did not completely obscure the bottom in any location, did not extend far from shore, and was not dense enough to inhibit recapture of juvenile burbot. Based on weed development (or lack thereof) the depth appears to be greater than any of the other ponds visited. Although there is a possibility that perch and pumpkinseed are present in the lake as well as stocked rainbow trout, the presence of perch and pumpkinseed was also possible in all the other ponds visited. The water temperature recorded (24°C), although relatively high compared to what is typically observed in burbot rearing sites, was in the range often observed in juvenile burbot habitat on Columbia Lake where wild juvenile burbot can be captured (Taylor 2002; Juvenile Burbot Sampling in Columbia and Windermere Lakes 2002). The lake appears to be “closed” with no developed outlet. Because this lake has no outlet and is on State owned land, it is possible that if environmental concerns were met and the need arose, burbot progeny could be removed from the lake using Rotenone or other fish eradication techniques. As well, from a management level perspective, the lake is in the Moyie drainage, and rearing larvae from the same drainage (i.e. Moyie Lake) may present fewer disease transfer and escapement concerns for cooperating agencies than two of the other ponds that could be connected to the Kootenai River in high water years.

DISCUSSION

Key Sites and Population Status

We used “key” sampling sites for the second season during the winter of 2005-2006 to maximize our catch to evaluate burbot stock status. Our capture of 14 burbot with a CPUE of 0.007 fish/net d this season was slightly less than the previous winter with a capture of 18 fish and CPUE of 0.009 fish/ net d. However, despite sampling at “key” locations with an effort of 2,000-2,046 net d, exceeded only by that of the winter of 2000-2001 of 2,085 net d, our total catch each year was still low (Appendix H). We believe these captures and CPUE, which was

similar to that of two of the last three years, would have been even lower had effort been distributed more evenly as in past years. Furthermore, the CPUE during 2005-2006 was the second lowest (0.007 fish/net d) on record, and of the 14 burbot captured in this study, four were recaptures. Attempts to assess recruitment of burbot to the population using half m net tows and light traps failed to demonstrate measurable recruitment of burbot, although these same sampling techniques, while successful in other systems (Fisher 2000), also failed to capture burbot recruits.

For the fourth consecutive winter, no burbot were captured in the Goat River. This continues to be a major concern since this tributary was once thought to be one of the last known spawning locations for burbot providing a major portion of the total catch each winter. February of 2001 and winter of 2001-2002 were the last winters that burbot were caught in the Goat River (Kozfkay and Paragamian 2002; Gunderman and Paragamian 2003). Bisset and Cope (2002) also sampled the Goat River during late January and all of February 2002. However, one telemetered burbot was recorded entering the Goat River in January of 2006. It stayed for several days before returning to the Kootenai River and eventually Summit Creek (see Telemetry of Burbot). The Goat River may be a good stream to reintroduce burbot because of its historical significance.

Telemetry of Burbot

Fixed-location Vemco single channel receivers were used for the first season and proved beneficial. They required less time to download in comparison to daily boat telemetry for burbot and saved operational money. However, they did not provide the precise locations that were possible with our previous use of ATS radio transmitters and Sonotronics acoustic transmitters.

We have devoted a great deal of time and effort to monitor the behavior and activity of burbot (Paragamian 2000; Paragamian et al. 2005; Paragamian and Wakkinen, In press). Distinct behavior and migration patterns were found for burbot, and in particular, individual fish that spawned in the Goat River. Burbot monitored in the Goat River during the spawning season were thought to be committed to spawning in that tributary. However, telemetry of two burbot during the season of 2005-2006 contradicted previous findings. At least one burbot (fish 339) ascended the Goat River during the spawning season, eventually moved out and reentered the Kootenai River, moved downstream, and entered Summit Creek. Burbot 339 was soon joined by burbot 327 in Summit Creek. We documented for the first time a burbot entering one tributary, moving out, and entering a second. This is also the first time we have recorded burbot in Summit Creek. Our only explanation is that burbot are group spawners (McPhail and Paragamian 2000) and that since burbot were recorded in the Goat River, burbot 339 sought other conspecifics and entered Summit Creek. Another unusual circumstance we encountered was burbot 341 moved from Ambush Rock (244.5) on May 14, 2006 to RKM 248.5 during a discharge of about 990 m^3/s, three times the discharge that normally restricts burbot movement (Paragamian et al. 2005).

Burbot SOR

The burbot SOR was an attempt to "cool" the Kootenai River during winter of 2005–2006 through the use of a selective withdrawal system at Libby Dam. The results of this effort allowed the river at Bonners Ferry to cool to about 5°C for most of November but ranged up to 7.5°C. The river was at or below 4°C for all of December through February. River water less than 6°C is important to stimulate prespawn migration and water temperatures less than 4°C are

preferred for spawning (Paragamian and Wakkinen, In press). The results during the winter of 2004–2005 did not meet temperature goals (Paragamian and Laude, in progress).

Maintaining cool water in the Kootenai River from Libby Dam is dependent on other uncontrollable factors such as microclimate, wind direction, and storms; all play a role in determining fall turnover for Lake Koocanusa (18,819 ha and 113 m deep). Lake Koocanusa becomes isothermal after fall turnover and as winter progresses the pool continues to cool toward 4°C (Brian Marotz, Montana Fish, Wildlife and Parks, personal communication). Only a thin layer of colder water exists at the surface, and surface water cannot be drawn into the turbines because of concerns for turbine cavitation. The only period that can provide cooler water is the period prior to the development of an isothermal state. During 2004–2005 a similar effort showed that cooler water could be achieved in early November, during a time in which burbot may be migrating in response to thermal conditions. After about mid-November there is little opportunity to make a difference because the reservoir temperature is isothermal, allowing only a limited opportunity to mechanically change temperature. Thus, the ability to attain cooler temperatures is contingent on the timing of fall turnover, which varies from year to year. Each fall as the surface cools and the density gradient erodes, all it takes is a wind event to cause turnover. As soon as turnover occurs, the ability to influence temperature in the discharge ends (Brian Marotz, Montana Fish, Wildlife and Parks, personal communication). Water is most dense at 4°C so unless there is a chemocline (sometimes observed in Lake Koocanusa) the water at the bottom will be no colder than 4°C. Atmospheric cooling between Libby Dam and the downstream Kootenai River can also occur so the discharge from the reservoir can chill as it moves downstream. Discharge volume is a factor in downstream cooling because lower volumes allow faster cooling. Prior to Libby Dam, the Kootenai River often super-cooled, caused ice jams and associated ice scour (Figure 3).

Stock Enhancement, Extensive Burbot Rearing and Lake Inspections

The Kootenai River burbot population likely consists of fewer than 40 adults (Pyper et al. 2004; Paragamian et al. In press). Demographic studies indicate that the Kootenai River burbot population may likely become extinct by 2015 (Pyper et al. 2004; Paragamian et al. In press). Theoretical conservation biologists and geneticists estimate that a minimum effective breeding population (N_e) of at least 50 to 500 individuals is necessary to sustain a viable population (Soule 1980; Lande and Barrowclough 1987). Genetic and demographic risks and uncertainties with fewer individuals are high (Allendorf and Ryman 2002; McElhany et al. 2000; Musick 1999). Genetic risks include the potential loss of rare alleles, drift in gene frequencies, increased genetic load from inbreeding, and a small population founder effect in the next generation. Demographic risks include too few spawners to take advantage of suitable habitat conditions. Any expectations that this population can recover within the next decade are unreasonable even with the most suitable habitat changes in winter discharge, winter temperatures, and improved primary production. Thus, it is of crucial importance that remedial measures to improve this stock's abundance begin immediately.

One way to enhance and rehabilitate the Kootenai River burbot stock may be through the introduction of progeny of a donor stock. Although intensive culture techniques for burbot are progressing (Jensen et al. In press; Vught et al. In press), they are still unsuccessful in providing large numbers for stocking. However, extensive rearing of burbot may become a more valuable tool in burbot rehabilitation and has already shown positive results for burbot recovery in Belgium (Alain Dillon, personal communication, Agency for Nature and Forest, Belgium; Vught et al. In press). Intensively reared burbot were stocked as recently hatched larva in a

Belgian river. Research efforts failed to document any survival. A contingent of the same families was held for an additional period to rear extensively to fingerling length. The fingerling burbot were stocked into the same river and were recaptured several months later.

Recent analysis of the cytochrome B region of mtDNA indicated Columbia and Moyie lakes, British Columbia burbot were of similar phylogenetic group as Kootenai River burbot (Powell et al. In press) and may be suitable as a donor stock. Furthermore, burbot broodstock from Moyie Lake are available (Matt Neufeld, BCME, personal communication) and they are in the Kootenai River drainage. Moyie Lake burbot could be spawned at the University of Idaho Aquaculture Research Institute and eggs transported to a nursery lake for extensive culture.

Evaluation of the physical attributes of four prospective lakes indicated Sinclair Lake was the best for extensive burbot culture. Selection of a lake for extensive burbot rearing was based on eight important features: location, water source, water depth, boat access, shoreline access, absence of a fish community, temperature, and perceived risk of summer or winter kill. This lake has easy access with a boat ramp, is over 7 m deep, has no outlet (a seepage lake), is in the Moyie River drainage, was previously Rotenoned to eliminate the fish community, and has sufficiently cool surface temperature (~20C^{o}).

Crayfish Abundance

Although monitoring and evaluation of crayfish abundance was not an objective of this investigation, it was apparent that their abundance at Ambush Rock has increased substantially through the last decade (Appendix P). The IDFG burbot investigation began in January of 1993 and included sampling with baited hoop nets at Ambush Rock (rkm 245.5). Crayfish were not documented in the by-catch of the baited hoop nets until the winter of 1998–1999 when three crayfish were captured. The following year nine crayfish were caught with one individual weighing 340 g. Since the winter of 2001–2002, crayfish by catch has increased to a high of 404 individuals during this past winter. The increase in abundance of crayfish may likely be due to the collapse of large predators like white sturgeon and burbot.

Recommended Discharge and Temperature for Burbot Migration and Spawning

Until a study of the relation between “specific levels” of discharge and temperature from Libby Dam and burbot spawning migration and spawning can be successfully completed, the best available recommendation for discharge 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 between 1 and 4°C in December through February, which includes the migration and spawning season.

RECOMMENDATIONS

1. Continue with a monitoring scheme to measure changes in population numbers at index sites, size structure (PSD), condition W_r, and a key of abundance (CPUE) that is based on three to four site specific sampling reaches while the population is low.

2. 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. 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 than previous years (1996, 1997, 1998, and 1999) of high discharges.

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

4. It is unlikely even with the most suitable habitat changes that burbot will recover in the Kootenai River during the next decade. We recommend Moyie Lake burbot donor stock be used to evaluate extensive rearing in Sinclair Lake. The primary objectives would be to determine if burbot eggs can hatch, and larvae reared to a minimum length of 25 mm, and recaptured. Successful rearing would lead to further extensive rearing development and release as fingerlings for burbot rehabilitation. In addition standard water quality measurements and zooplankton samples should be taken biweekly from Sinclair Lake.

ACKNOWLEDGMENTS

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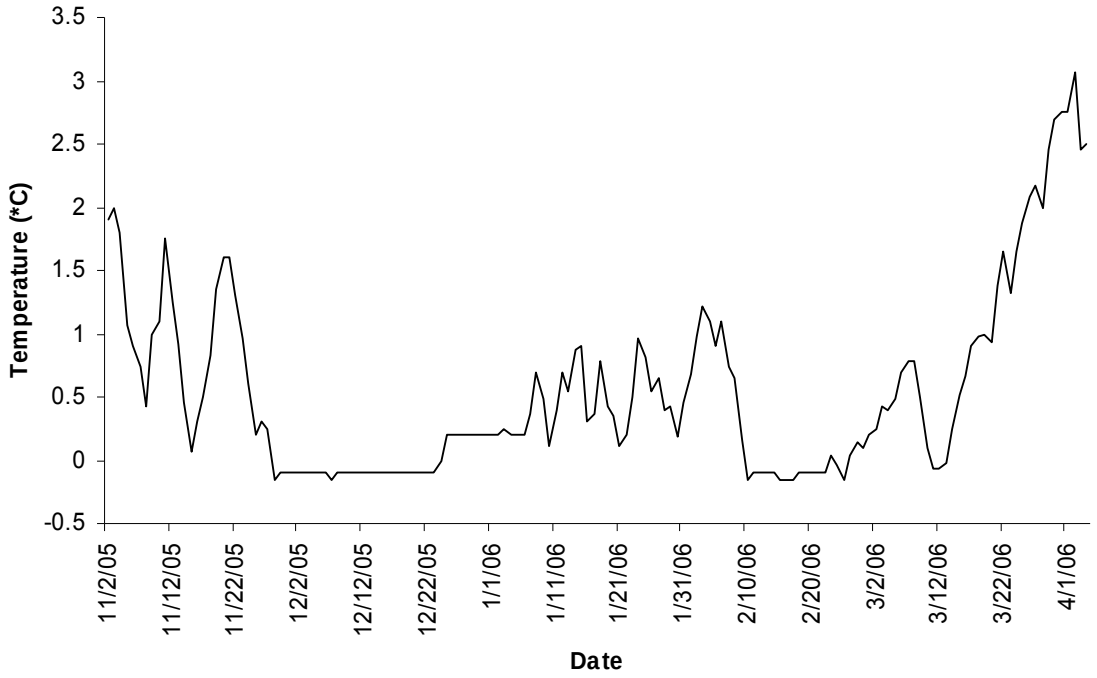
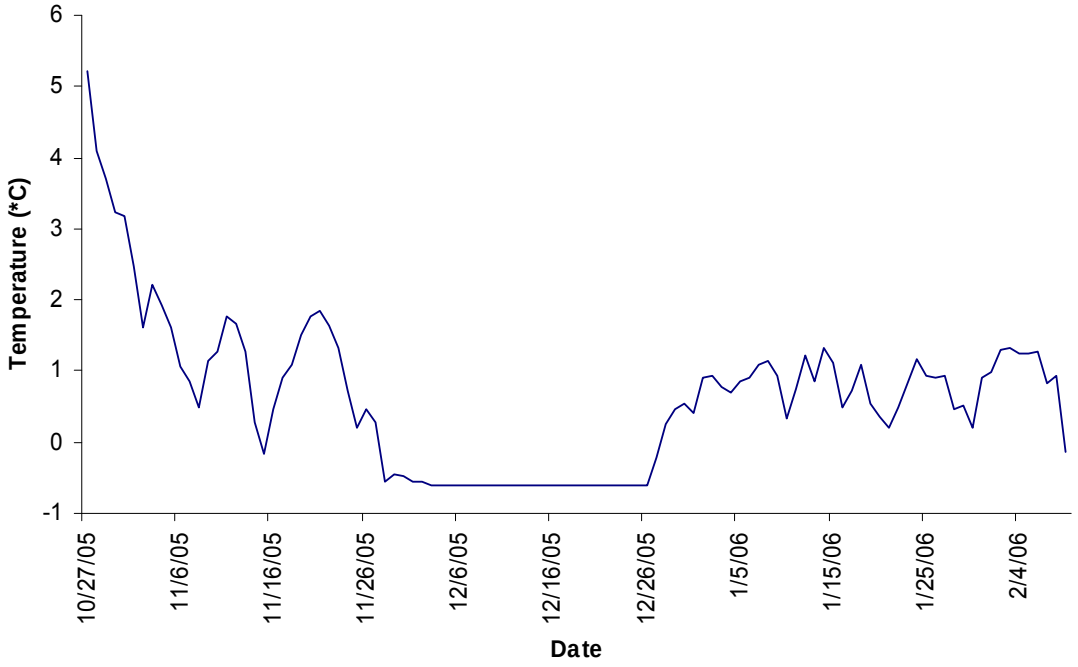
APPENDICES

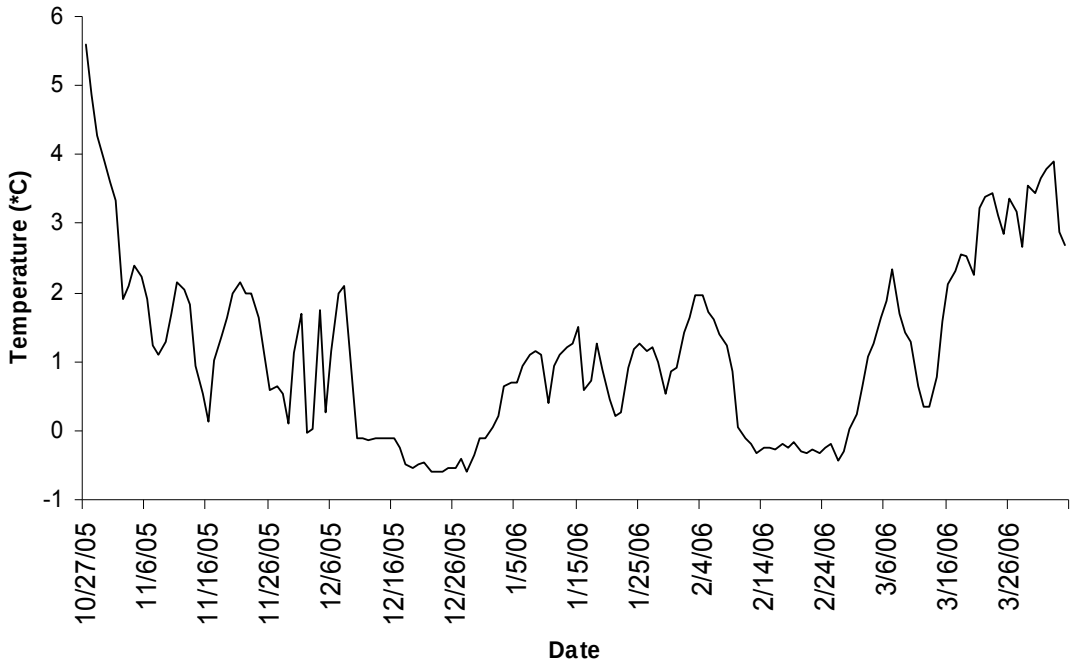
Appendix A. Smith Creek mean daily temperature (°C) profile November 2, 2005 through April 4, 2006.



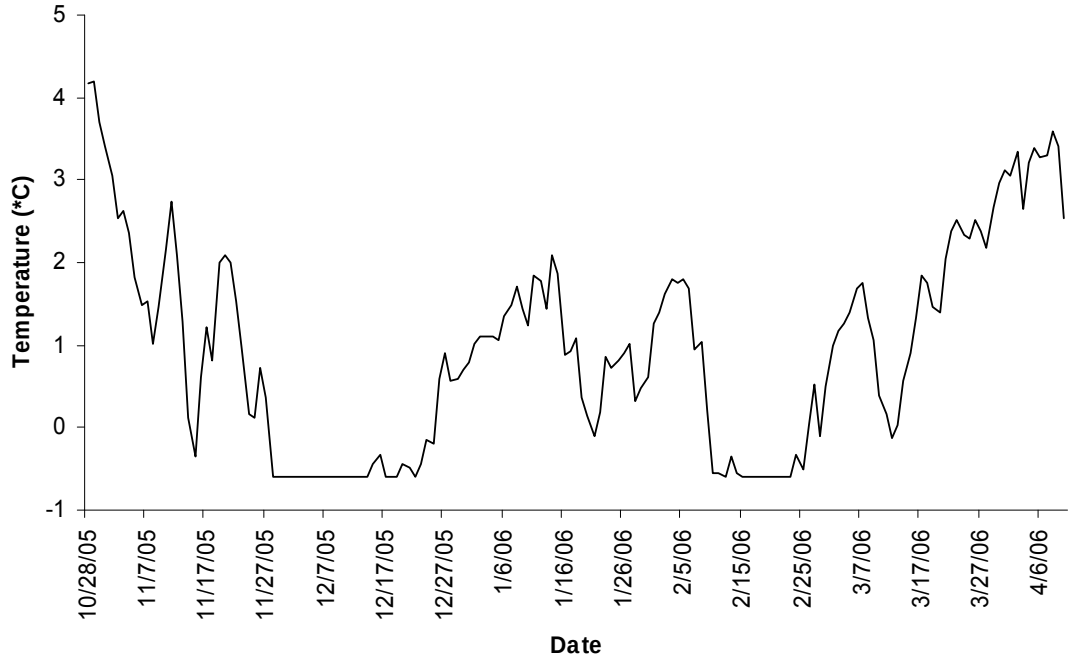
Appendix B. Upper Boundary Creek mean daily temperature (°C) profile October 27, 2005 through February 9, 2006.



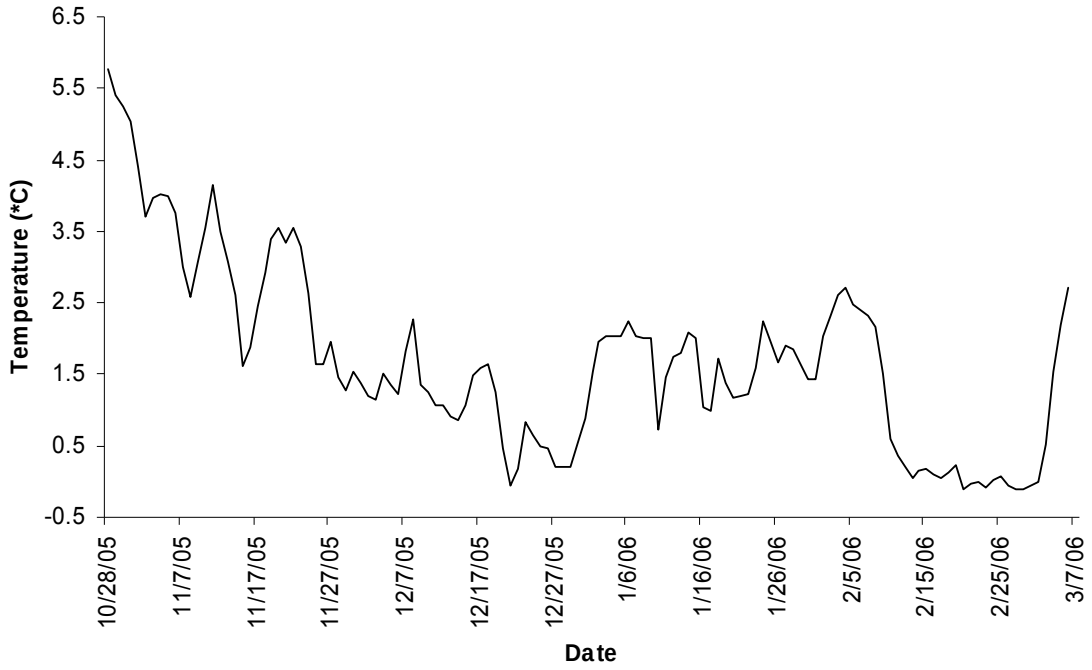
Appendix C. Lower Boundary Creek mean daily temperature (°C) profile October 27, 2005 through April 4, 2006.



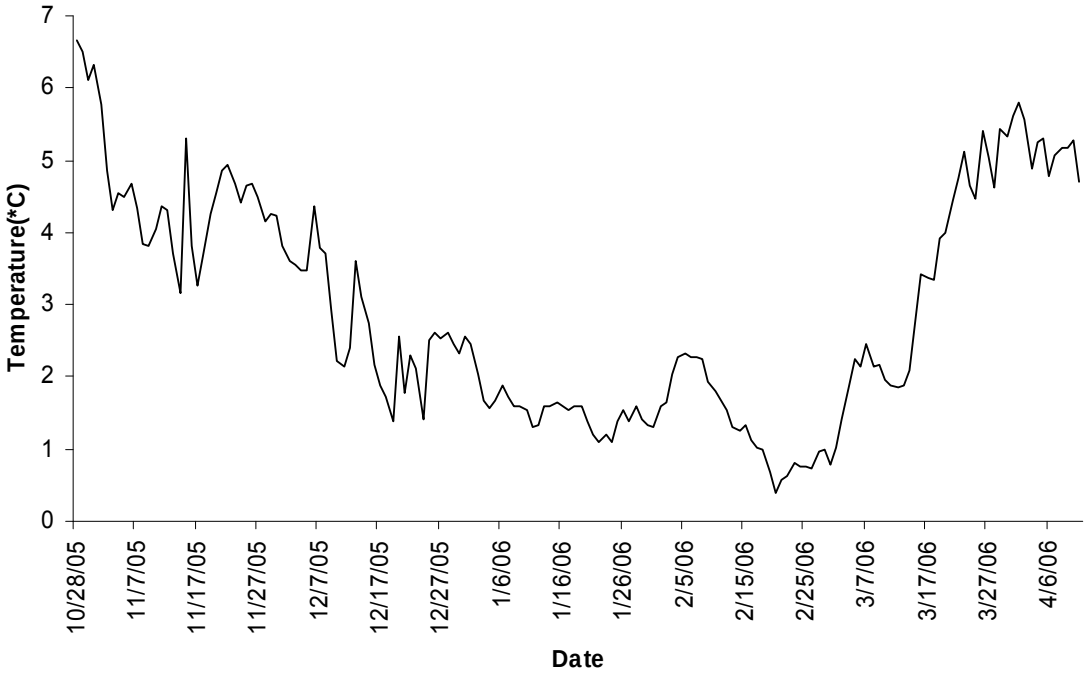
Appendix D. Myrtle Creek mean daily temperature (°C) profile October 28, 2005 through April 10, 2006.



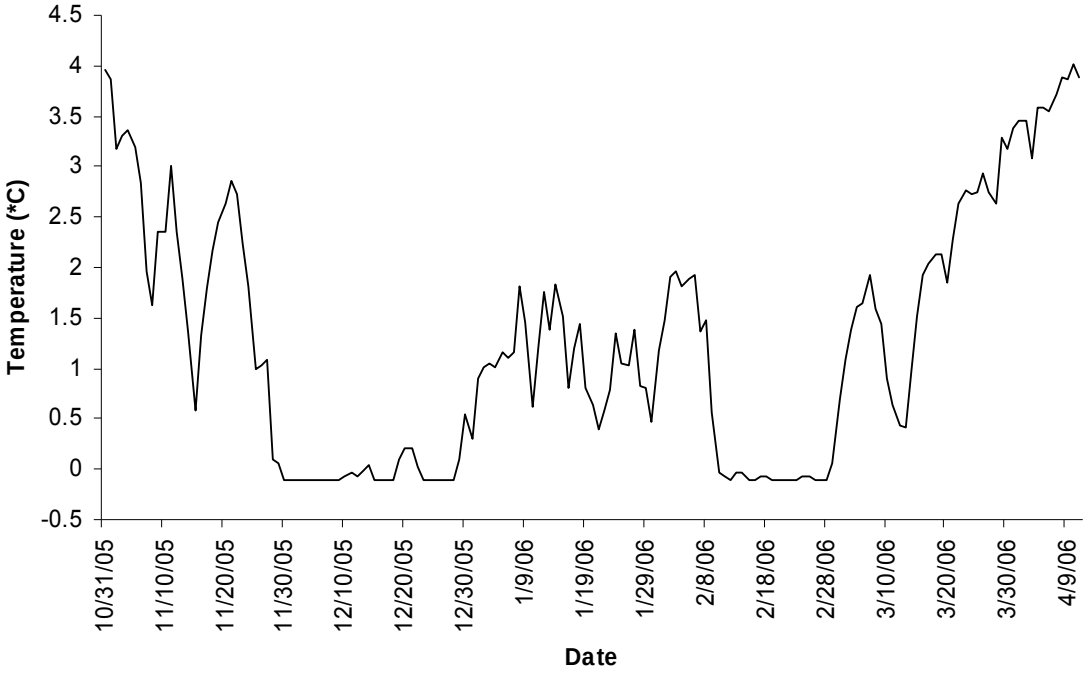
Appendix E. Lower Goat River mean daily temperature (°C) profile October 28, 2005 through March 6, 2006.



Appendix F. Lower Corn Creek mean daily temperature (°C) profile October 28, 2005 through April 11, 2006.



Appendix G. Upper Corn Creek mean daily temperature (°C) profile October 31, 2005 through April 11, 2006.



Appendix H. Captures and catch per unit effort of burbot caught in hoop nets in the Kootenai River, winters of 1993-2006.

Sampling season	Number of burbot captures	Total net days	CPUE (fish/net day)
1993: Mar. 1993-May 1993	17	554.2	0.031
1994: Oct. 1993-April 1994	8	909.8	0.009
1995: Nov. 1994-Feb. 1995	33	688.8	0.048
1996: Nov. 1995-Mar. 1996	28	495.8	0.056
1997: Oct. 1996-Mar. 1997	23	1,061.1	0.022
1998: Oct. 1997-May 1998	42	1,240.9	0.034
1999: Oct. 1998-April 1999	44	1,453.7	0.030
2000: Oct. 1999-April 2000	36	1,712.9	0.021
2001: Oct. 2000-Mar. 2001	73	2,085.2	0.035
2002: Oct. 2001-April 2002	17	1,529.9	0.011
2003: Oct. 2002-Mar. 2003	11	1,809.7	0.006
2004: Nov. 2003-Mar. 2004	19	1,965.1	0.010
2005: Nov. 2004-April 2005	18	2,045.72	0.009
2006: Oct. 2005 – Mar. 2006	14	1,999.94	0.007
Totals	383	19,552.82	
Mean			0.0235

Appendix I. Location and date of burbot 338 as determined by fixed Vemco receiver.

Date	Location (rkm)
1/20/2006	243.5
1/22/2006	243.5
1/23/2006	243.5
1/24/2006	243.5
1/25/2006	243.5
1/26/2006	243.5
1/27/2006	243.5
1/28/2006	243.5
1/29/2006	243.5
1/30/2006	243.5
1/31/2006	243.5
2/1/2006	243.5
2/2/2006	243.5
2/3/2006	243.5
2/4/2006	243.5
2/5/2006	243.5
2/6/2006	243.5
2/7/2006	243.5
2/8/2006	243.5
2/9/2006	243.5
2/10/2006	243.5
2/11/2006	243.5
2/12/2006	243.5
2/13/2006	243.5
2/14/2006	243.5
2/15/2006	243.5
2/16/2006	243.5
2/17/2006	243.5
2/18/2006	243.5
2/20/2006	243.5
2/21/2006	243.5
2/22/2006	243.5
2/23/2006	243.5
2/24/2006	243.5
2/25/2006	243.5
2/26/2006	243.5
2/28/2006	243.5
3/1/2006	243.5
3/2/2006	243.5
3/3/2006	243.5
3/4/2006	243.5
3/5/2006	243.5
3/6/2006	243.5
3/10/2006	243.5
3/12/2006	243.5
3/13/2006	243.5
3/18/2006	243.5

Appendix J. Location and date of burbot 341 as determined by fixed Vemco receiver.

Date	Location (rkm)
3/22/2006	244.6
3/23/2006	244.6
3/24/2006	243.5
3/25/2006	243.5
3/26/2006	243.5
3/27/2006	243.5
3/28/2006	243.5
3/29/2006	243.5
3/30/2006	243.5
4/1/2006	243.5
4/4/2006	243.5
4/5/2006	243.5
4/5/2006	244.6
4/6/2006	244.6
4/7/2006	244.6
4/8/2006	244.6
4/9/2006	244.6
4/10/2006	244.6
4/11/2006	244.6
4/12/2006	244.6
4/13/2006	244.6
4/14/2006	244.6
4/15/2006	244.6
4/16/2006	244.6
4/17/2006	244.6
4/18/2006	244.6
4/19/2006	244.6
4/20/2006	244.6
4/21/2006	244.6
4/22/2006	244.6
4/23/2006	244.6
4/24/2006	244.6
4/25/2006	244.6
4/26/2006	244.6
4/27/2006	243.5
4/27/2006	244.6
4/28/2006	244.6
4/29/2006	244.6
5/2/2006	243.5
5/3/2006	243.5
5/4/2006	243.5
5/5/2006	243.5
5/5/2006	244.6
5/6/2006	244.6
5/7/2006	244.6
5/8/2006	244.6
5/9/2006	244.6
5/10/2006	244.6
5/11/2006	244.6
5/12/2006	244.6
5/13/2006	244.6
5/13/2006	245.8
5/13/2006	245.9
5/14/2006	244.6
5/14/2006	245.8
5/14/2006	245.9
6/2/2006	248.6
6/3/2006	248.6

Appendix K. Location and date of burbot 339 as determined by fixed Vemco receiver.

Date	Location (rkm)
2/15/2006	152.5
2/16/2006	152.5
2/17/2006	152.5
2/19/2006	152.5
2/20/2006	152.5
2/21/2006	152.5
2/21/2006	140.5
2/21/2006	140
2/21/2006	140.5
2/21/2006	140.5
2/22/2006	122.5

Appendix L. Location of burbot 327 as determined by fixed Vemco receiver.

Date	Location (rkm)
12/29/2005	140
12/29/2005	140
1/3/2006	140
1/8/2006	140
1/9/2006	140
1/16/2006	140
2/26/2006	140.5
3/5/2006	140.5

Appendix M. Location of burbot 335 as determined by fixed Vemco receiver.

Date	Location (rkm)
12/12/2005	144.5
12/25/2005	140.5
12/25/2005	140.5
12/25/2005	140.5
12/25/2005	140.5
12/25/2005	140.5
12/25/2005	140.5
12/28/2005	122.5
12/28/2005	122.5
12/28/2005	122.5
12/28/2005	122.5

Appendix N. Location of burbot 340 as determined by fixed Vemco receiver.

Date	Location (rkm)
11/15/2005	Goat River
11/15/2005	Goat River
11/15/2005	Goat River
11/15/2005	Goat River
11/15/2005	Goat River
2/24/2006	Goat River
2/24/2006	Goat River
2/24/2006	Goat River
2/25/2006	Goat River
2/25/2006	Goat River
2/25/2006	Goat River
2/25/2006	Goat River
2/28/2006	Goat River
2/28/2006	Goat River
2/28/2006	Goat River
2/28/2006	Goat River
3/23/2006	Goat River
3/23/2006	Goat River

Appendix O. Location of burbot 334 as determined by fixed Vemco receiver.

Date	Location (rkm)
12/20/2005	140.5
12/21/2005	140.5
12/22/2005	140.5
12/23/2005	140.5
12/24/2005	140.5

Appendix P. Crayfish total catch by baited hoop net, by season (November through March), weight, mean weight, and catch per unit of effort.

Season	Crayfish catch	Weight (g)	Mean weight (g)	Catch per unit of effort
1993-1994	0	0		0
1994–1995	0	0		0
1995-1996	0	0		0
1996–1997	0	0		0
1997–1998	0	0		0
1998–1999	3	0.30	0.10	0.002
1999–2000	9	—	—	0.005
2000–2001	28	—	—	0.013
2001–2002	78	3,400	43.58	0.053
2002–2003	239	11,605	48.56	0.016
2003-2004	327	19,944	60.99	0.222
2004–2005	220	8,216	37.35	0.108
2005-2006	404	15,098	37.37	0.202

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