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KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

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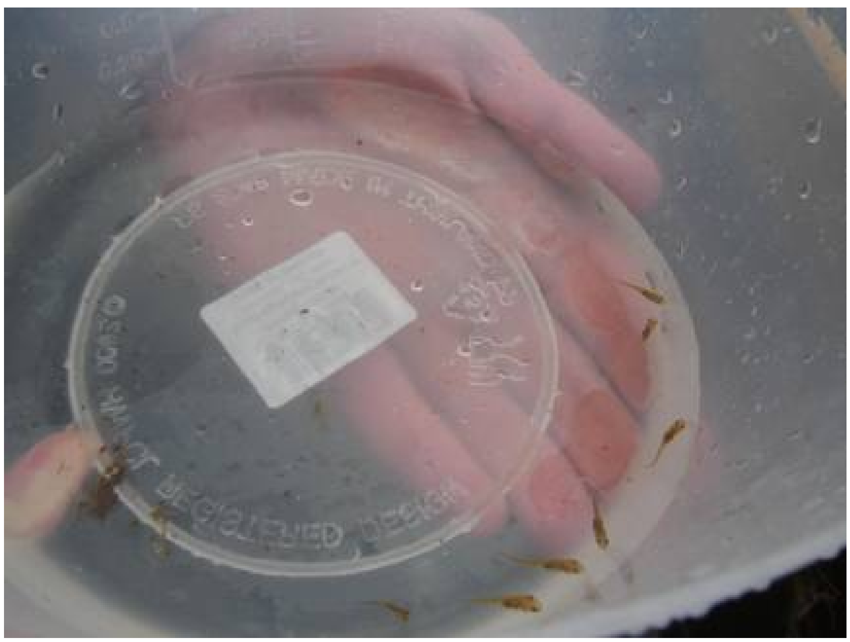

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IDFG Report Number 08-13
December 2008

Kootenai River Fisheries Investigation: Stock Status of Burbot

Project Progress Report

2008 Annual Report

By

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TABLE OF CONTENTS

Page

ABSTRACT 1
INTRODUCTION 2
GOAL 7
OBJECTIVES 7
STUDY AREA 7
METHODS 8
Kootenai River Discharge and Temperature 8
Tributary Temperatures 9
Burbot Sampling 10
Adult Burbot 10
Extensive Burbot Rearing 10
Larval Release 10
Fredericks Pond Temperature 11
RESULTS 11
Kootenai River Discharge 11
Kootenai River Temperature 11
Tributary Temperatures 12
Idaho 12
Canada 12
Sampling Adult Burbot 13
Total Catch 13
Hoop Net Catch of Burbot 13
Fredericks Pond Extensive Rearing and Pond Temperature 13
DISCUSSION 16
Index Sampling Sites and Population Status 16
Burbot SOR 17
Extensive Burbot Rearing and Fredericks Pond 18
Recommended Discharge and Temperature for Burbot Migration and Spawning 18
RECOMMENDATIONS 19
ACKNOWLEDGMENTS 20
LITERATURE CITED 21
APPENDICES 25

LIST OF TABLES

Page

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 2007 through March 2008 with 1040.79 d of effort (24978.95 h of effort). ... 15

Table 2. Burbot identification number, location of capture, date of capture, total length, weight, and tag number for captures from November 2005 through January 2008. ... 15

Table 3. Burbot hoop net captures and capture effort in three primary locations, October 2003-April 2004, November 2004-April 2005, October 2005-March 2006, November 2006-March 2007, and November 2007-February 2008. ... 16

LIST OF FIGURES

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. ... 4

Figure 2. Mean daily discharge of the Kootenai River at Porthill, Idaho from 1962 through 1971 (pre-Libby Dam), and from 1994 through 2000 (post-Libby Dam). ... 5

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. ... 6

Figure 4. Robert Fredericks pond located 7 km from the Kootenai River Field Station; Burton Creek is just beyond the dyke. ... 8

Figure 5. Selective withdrawal temperature guidelines for the Kootenai River below Libby Dam. Figure courtesy USACE. ... 9

Figure 6. Daily mean discharge (m^3/s) near Bonners Ferry, USGS gauging station 12310100. ... 11

Figure 7. Mean daily temperature (°C) for the Kootenai River at Bonners Ferry and Porthill, Idaho (rkm 245.7), profile November 1, 2007 to February 29, 2008. Horizontal bars represent the target temperature values for the USFWS Systems Operations Request (SOR). ... 12

Figure 8. Hoop net catch for the Kootenai River, Idaho and British Columbia from November 2007 through March 2008. ... 14

LIST OF APPENDICES

Page

Appendix 1. Lower Boundary Creek (°C) mean daily temperature profile November 1, 2007 to February 29, 2008. 26

Appendix 2. Upper Goat River (°C) mean daily temperature profile November 2, 2007 to February 24, 2008. 27

Appendix 3. Lower Goat River (°C) mean daily temperature profile November 6, 2007 to February 25, 2008. 28

Appendix 4. Idaho Department of Fish and Game burbot hoop net captures and capture effort (burbot/hoop net day), winters (Wtr.) of 1993-2008. 29

ABSTRACT

Objectives of this investigation were to 1) monitor the population status and recruitment of burbot *Lota lota* in the Kootenai River, Idaho and British Columbia, Canada during the winter of 2006-2007; 2) evaluate the selective withdrawal system in place at Libby Dam to maintain the river temperature near Bonners Ferry between 1-4°C (November-December) to improve burbot migration and spawning activity; and 3) determine if a hatching success of 10% of eyed burbot embryos could be achieved through extensive rearing and produce fingerlings averaging 9.8 cm in six months. Water temperature did not fall below the upper limit (4°C) until mid-January but was usually maintained between 1-4°C January through February and was acceptable. Snowpack was characterized by a 101% of normal January runoff forecast. Adult burbot were sampled with hoop nets and slat traps. Only three burbot were captured in hoop nets, all at Ambush Rock (rkm 244.5). No burbot were caught in either slat traps or juvenile sampling gear, indicating the population is nearly extirpated. Burbot catch per unit effort in hoop nets was 0.003 fish/net d. Extensive rearing was moved to a smaller private pond and will be reported in the 2008-2009 annual report.

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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 and nonresidents. This fishery and that of Kootenay Lake, British Columbia (BC), Canada (Paragamian et al. 2000a) may have been the most robust in North America (Paragamian and Hoyle 2005). 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 and Kootenay River, British Columbia (Paragamian et al. 2000a). Demographic studies indicate that the Kootenai River burbot population may likely become extinct by 2015 (Pyper et al. 2004; Paragamian et al. 2008). Operation of Libby Dam for hydroelectric power and flood control 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 Idaho Department of Fish and Game (IDFG) to document burbot abundance, distribution, size structure, reproductive success, movement, and to identify factors limiting burbot. There has been little evidence of burbot reproduction in the Idaho reach. However, sampling indicated numerous length-classes of burbot were in the catch, indicating some burbot were reproducing successfully albeit insufficiently to sustain the population while genetic analysis suggests some emigration has come from above Kootenai Falls (Paragamian et al. 1999; Powell et al. 2008). 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, British Columbia (Paragamian 2000), and during the winter of 2000-2001 a "spawning ball" of burbot was documented at Ambush Rock (Paragamian et al. 2000b; Kozfkay and Paragamian 2002). Since then other potential spawners were captured in the same location, but the numbers have been low.

Studies completed during the winter of 1997-1998 indicated 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 that 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). The specific effect of this disruption to burbot spawning migration and spawning is unknown, but it may have reduced spawning fitness or stamina or negatively affected timing of burbot spawning, which could, in turn, compromise 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 are at risk of demographic extinction (Paragamian 2000), a Conservation Strategy (Anonymous 2002; Kootenai Valley Resource Initiative [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 are required during winter to provide suitable conditions for burbot migration. Paragamian et al. (2005) found the majority of seasonal burbot movements of 5 km or more in 10 d or less occurred when discharges were $\leq$300 m^3/s from Libby Dam and averaged 176 m^3/s

(Paragamian et al 2005). Results of additional movement studies indicated burbot moved more frequently during lower discharges. Consequently, it was 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) (Paragamian et al 2005).

Post-Libby Dam temperature changes are an additional factor affecting the spawning and recruitment of burbot in the Kootenai River (Paragamian and Wakkinen 2008). 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 cause mortality in larval burbot (Taylor and McPhail 2000). Paragamian and Wakkinen (2008) modeled burbot migrations based on temperature and discharge and found that burbot migration was predictable under pre-Libby Dam conditions but erratic post Libby Dam. This partially explained why burbot migrations post Libby Dam are late and occur at temperatures warmer than expected for spawning. Thus, it will be important to mimic historic flows and temperatures as close as possible to improve burbot migrations, spawning, rearing, and survival to adult spawners.

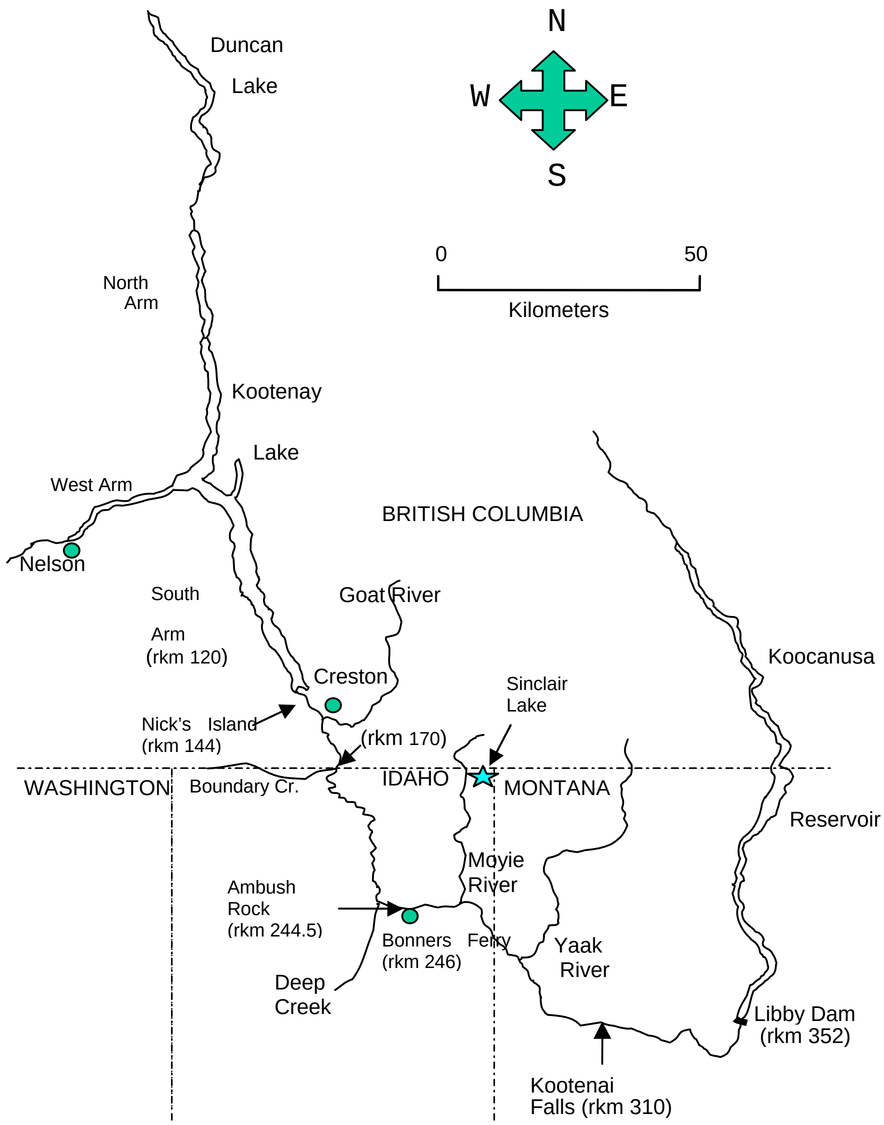

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

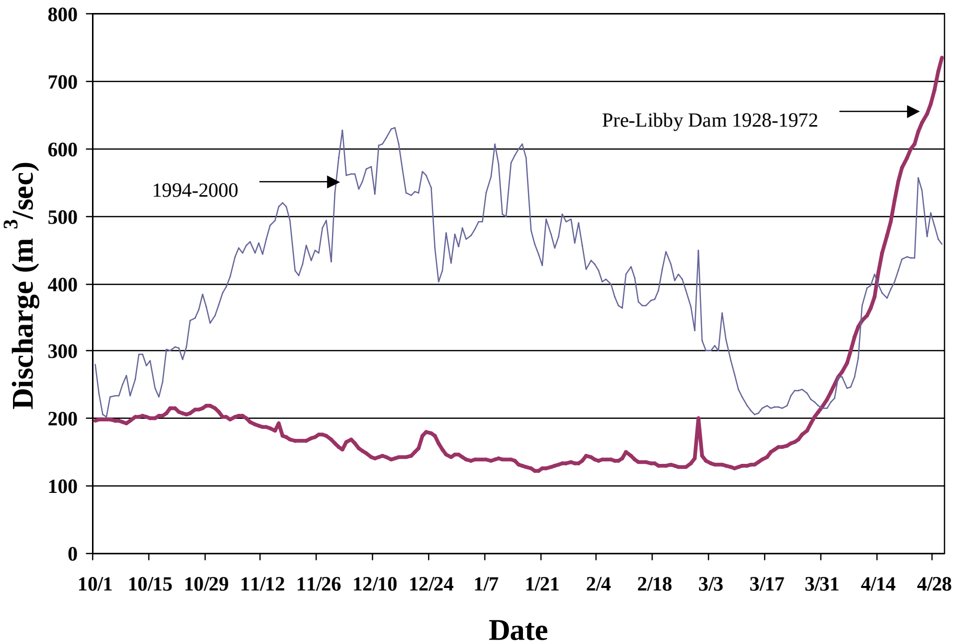

Figure 2. Mean daily discharge of the Kootenai River at Porthill, Idaho from 1962 through 1971 (pre-Libby Dam), and from 1994 through 2000 (post-Libby Dam).

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). Currently there are perhaps fewer than 50 burbot in the population. 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 the Kootenai River burbot population may be through the introduction of progeny of a similar genetic and behavioral stock. Intensive rearing techniques for burbot, although progressing, are not standardized sufficiently to consistently provide large numbers of young for stocking (Jensen et al. 2008; Vught et al. 2008). But extensive rearing of eyed burbot embryos or larvae has been shown effective in burbot restoration (Dillen et al. 2008; Vught et al. 2008) and in the interim may be a more valuable tool in burbot rehabilitation than stocking eyed embryos.

We selected Sinclair Lake for extensive burbot rearing and released 100,000 eyed burbot embryos in March 2007. We sampled with light traps, ½ m nets, and minnow traps but were unable to show any hatching survival. The results of hatching in four incubators suggested hatching may have been about 0.05%, but the collection of eggshells in the incubators indicated it might have been as high as 2.8%. Dissolved oxygen (4.3 ppm) for a two-week period may have been too low to ensure survival. While the results of extensive rearing in 2007 are inconclusive, the methodology deems further research.

Recent analysis of the cytochrome B region of mtDNA indicated Columbia and Moyie lakes, British Columbia burbot were of a similar phylogenetic group as Kootenai River burbot (Powell et al. 2008) and may be suitable stock. Moyie Lake is in the Kootenai River basin. Coordination of this study with Matt Neufeld (BCME) and the University of Idaho Aquaculture Research Institute (UIARI) (Dr. Ken Cain and Nathan Jensen) indicated Moyie Lake burbot could be captured from Moyie Lake, spawned at UIARI, and eyed eggs transported to Sinclair Lake for extensive rearing.

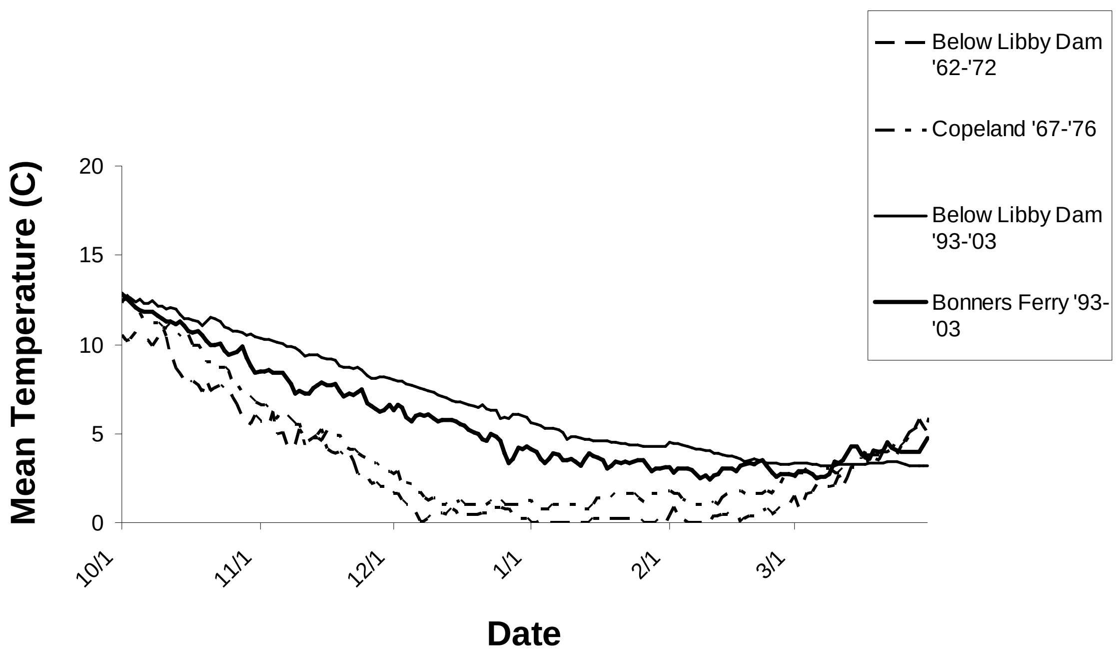

Figure 3. Pre-Libby Dam Kootenai River temperatures at the dam site 1962-1972, at Copeland, Idaho 1967-1972 and post Libby Dam below the dam from 1993-2003, and at Bonners Ferry, Idaho from 1993-2003.

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. Determine the population trajectory and vital statistics of burbot through mark and recapture studies (survival, population numbers, recruitment, size structure).

2. Determine if the selective withdrawal system in place at Libby Dam can maintain the river temperature near Bonners Ferry between 1-4°C (November-February) to improve burbot migration and spawning activity.

3. Determine if releasing burbot larvae for extensive rearing can produce a survival rate of 10% or more and fingerlings from 70 to 98 mm in length within 6 months of stocking.

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. Kootenay Lake drains out the West Arm, and eventually the river joins the Columbia River near Castlegar, British Columbia. The Kootenai River at Porthill, Idaho, drains about 35,490 km^2. The reach in Idaho is 106 km long.

An alternative pond was examined for the 2007-2008 experimental release of larval burbot for extensive rearing (Figure 4). The pond is on private property approximately 8 km (5 miles) from the Kootenai Wildlife Refuge and has easy access. It is in the Kootenai River drainage in Boundary Co., Idaho and located off the West Side Road with higher security and is smaller in size for manageability. The pond is rectangular in shape, is about 79 x 37 m (260 x 120 ft), and is about 2.4 m (8 ft) deep. It is about 46 m (150 ft) from Burton Creek and has easy access. The pond is isolated in that the water source is seepage from under a dyke that separates it from Burton Creek, surface runoff, and the outlet drains into a pasture. It is fenced from livestock. Typically, it is reported to be ice covered each winter.

Figure 4. Robert Fredericks pond located 7 km from the Kootenai River Field Station; Burton Creek is just beyond the dyke.

METHODS

Kootenai River Discharge and Temperature

The USACE and the US Geological Survey (USGS) office in Sandpoint, Idaho provided the daily discharge and temperature values for the Kootenai River. The US Fish and Wildlife Service made a Systems Operation Request (SOR) for winter of 2007-2008 on behalf of the Kootenai Valley Resource Initiative's (KVRI) Burbot Recovery Committee (which included the IDFG, Office of Species Conservation, Kootenai Tribe of Idaho, City of Bonners Ferry, and Boundary County) to the USACE and the Bonneville Power Administration (BPA). Like the previous year, the 2007-2008 SOR focused on cooler water temperature. Expecting a measurable biological response to a temperature SOR was not reasonable because the burbot population is stock limited. As a result, the intent was an experiment to provide the coolest water possible in November and December using the selective withdrawal system in place at Libby Dam with a target range from 1-4°C (Figure 5). These months are important to burbot migration (Paragamian and Wakkinen 2008). However, once Lake Koocanusa becomes isothermal, usually late December or early January, it is not possible to provide water cooler than the reservoir.

Tributary Temperatures

HOBO® or StowAway® XI temperature loggers were used to monitor daily water temperatures for Smith, Deep, Myrtle, and Boundary creeks in Idaho; Corn and Summit creeks and the Goat River in British Columbia; and the Kootenai River at Porthill, Idaho and Nicks Island, British Columbia from October 2007 through March 2008. 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. Data from these loggers would be used to assess whether infiltration of Kootenai River surface water into creek mouths was substantial. Infiltration of river water may obscure coldwater cues used by migrating burbot (Paragamian 2000). Although no burbot spawning has been documented in tributaries recently, anecdotal data indicates that Summit and Boundary creeks were historical burbot spawning areas.

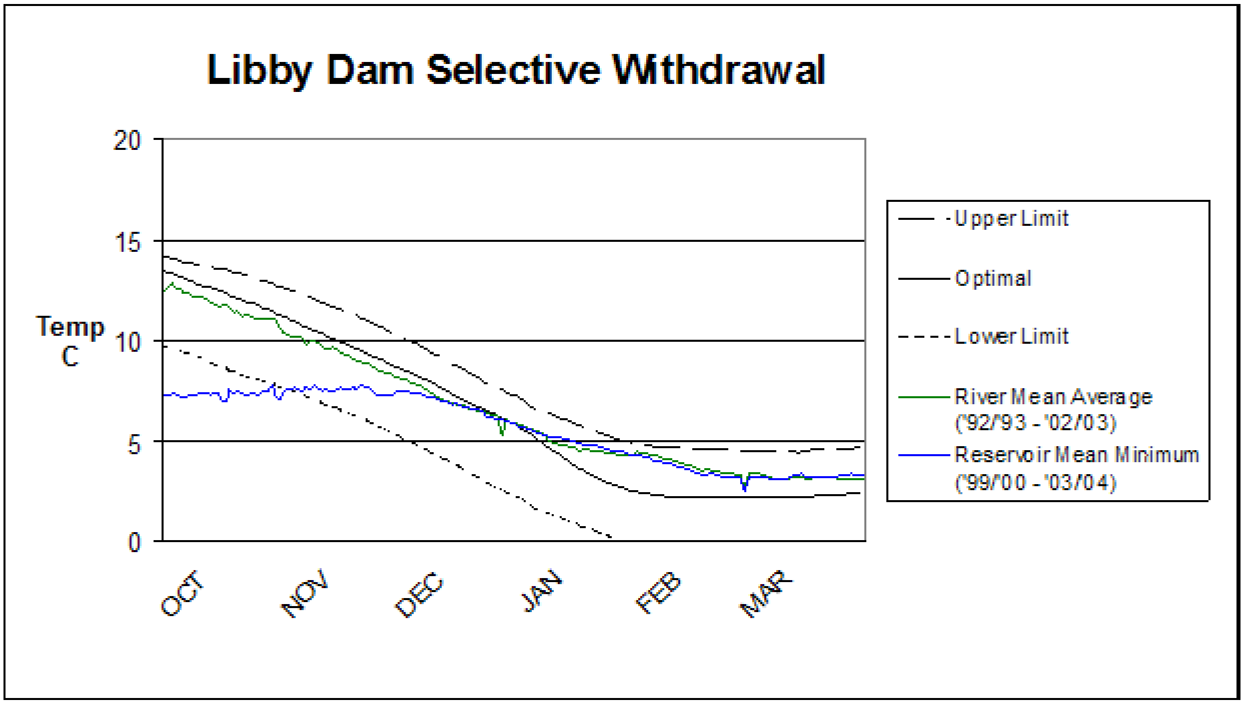

Figure 5. Selective withdrawal temperature guidelines for the Kootenai River below Libby Dam. Figure courtesy USACE.

Burbot Sampling

Adult Burbot

Technicians sampled adult burbot from early November 2007 through March 2008 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). Bernard et al. (1991) found that burbot can be caught in 0.6 m diameter hoop nets with 25.4 mm bar web at about 350 mm 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 TL and evaluate recovery measures earlier, we had three hoop nets of 19 mm bar web constructed to compare to the catch to the standard web of 25.4 mm. We used 12 nets with 25.4 cm bar mesh, pairing three of them with nets having 19 cm bar mesh for a total of 15 nets. The objective was to determine if the smaller mesh would capture smaller, younger burbot (Gunderman and Paragamian 2003).

We sampled at established index locations to measure changes in population numbers (Jolly-Seber population estimate, chapter 2), size structure (PSD), body condition (W_r), and abundance (CPUE) (see Paragamian and Laude 2008 for a description of index locations). We deployed nets 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 (Figure 1). We sampled river reaches where 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).

We usually lifted nets on Monday, Wednesday, and Friday of each week. Fish captured in hoop nets were identified, enumerated, measured for total length (TL), and weighed (g). We implanted all burbot with a passive integrated transponder (PIT) tag in the left opercular muscle. Biopsies were not performed in an effort to reduce stress; therefore, sex of burbot could not be determined. We calculated relative weight (W_r; Fisher et al. 1996) for each burbot captured.

Extensive Burbot Rearing

Larval Release

An experiment devised to measure the success of extensive rearing was implemented by releasing burbot larvae into Fredericks Pond, Idaho. Extensive rearing is the process of raising fish in an outside environment where there is less environmental control as opposed to intensive culture in a building. Burbot larvae were provided by the UIARI, Moscow, Idaho and were part of an intensive research sponsored jointly by the KTOI and UIARI. The Moyie Lake stock was provided to the UIARI by the BCME. Adult brood fish were captured in November 2006 from Moyie Lake, BC, Canada using baited cod traps (Spence 2000; Neufeld and Spence 2005). Moyie Lake is in the Kootenai River drainage and located about 20 km north of Sinclair Lake. Although logistic work was completed at the preparation of this annual report contract period, burbot larvae were still in the embryo stage at UIARI, extensive rearing of larvae will be reported in the 2008-2009 annual report.

Fredericks Pond Temperature

We deployed a single HOBO® temperature logger in to monitor Fredericks Pond daily temperature fluctuations.

RESULTS

Kootenai River Discharge

The USACE resumed load following during the winter of 2007-2008 with an estimated December 31, 2007 volume forecast of 101% (Figure 6). As a result, discharge in the Kootenai River at Bonners Ferry ranged from a low of about 150 m^3/s on November 11, 2007 to as high as 650 m^3/s on December 20, 2007. Discharge was stable from January 1, 2008 through February 11, 2008 ranging from 155 to 176 m^3/s.

Kootenai River Temperature

Mean water temperature at the USGS gage 12309500 near Bonners Ferry, Idaho (rkm 245.7) was 4.5°C ranging from 0°C to 7.9°C (Figure 7). Mean water temperature at Porthill, Idaho (rkm 169.8) was 3.93°C ranging from 0.12°C to 7.4°C (Figure 7). The Nicks Island (rkm 144.5) thermograph was lost due to ice cover and river conditions.

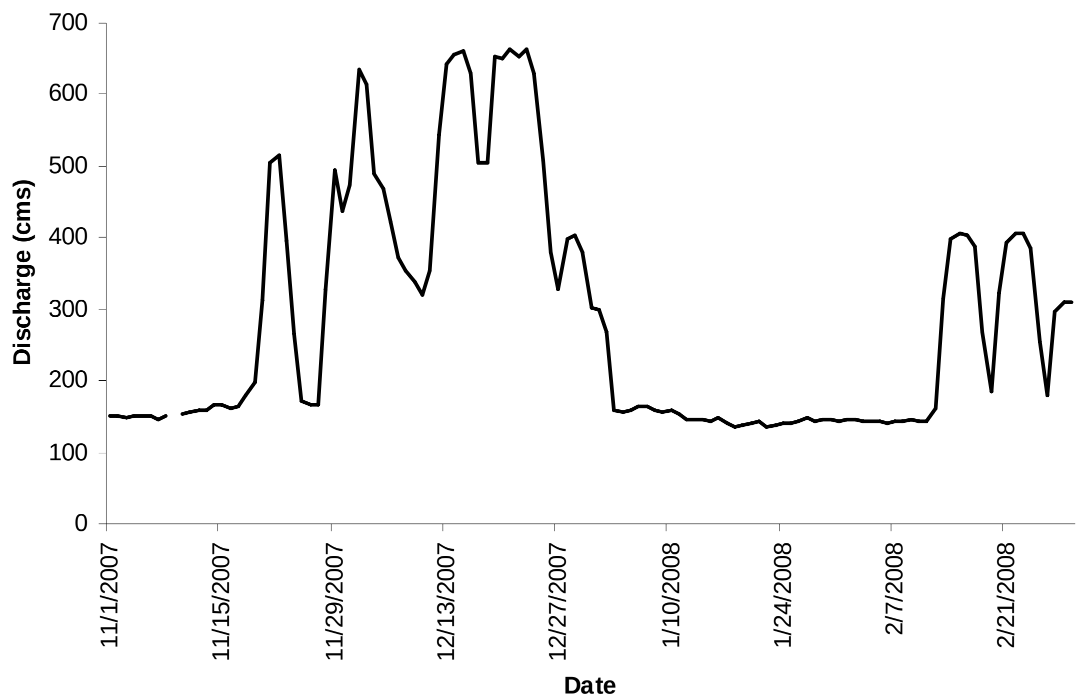

Figure 6. Daily mean discharge (m^3/s) near Bonners Ferry, USGS gauging station 12310100.

Tributary Temperatures

Thermographs were deployed from November 2007 to March 2008. Due to ice cover and stream conditions, the Deep, upper Boundary, Myrtle, Summit, and upper Corn creeks thermographs were lost. The Smith Creek thermograph was lost due to vandalism.

Idaho

Mean water temperature of lower Boundary Creek was 1.3°C ranging from <0.1°C to 5.1°C (Appendix 1).

Canada

Mean water temperature in the upper Goat River was 1.20°C, with temperatures ranging from 0.23°C to 6.3°C (Appendix 2). Mean water temperature in the lower Goat River was 2.3°C, with temperatures ranging from 0.8°C to 6.47°C (Appendix 3).

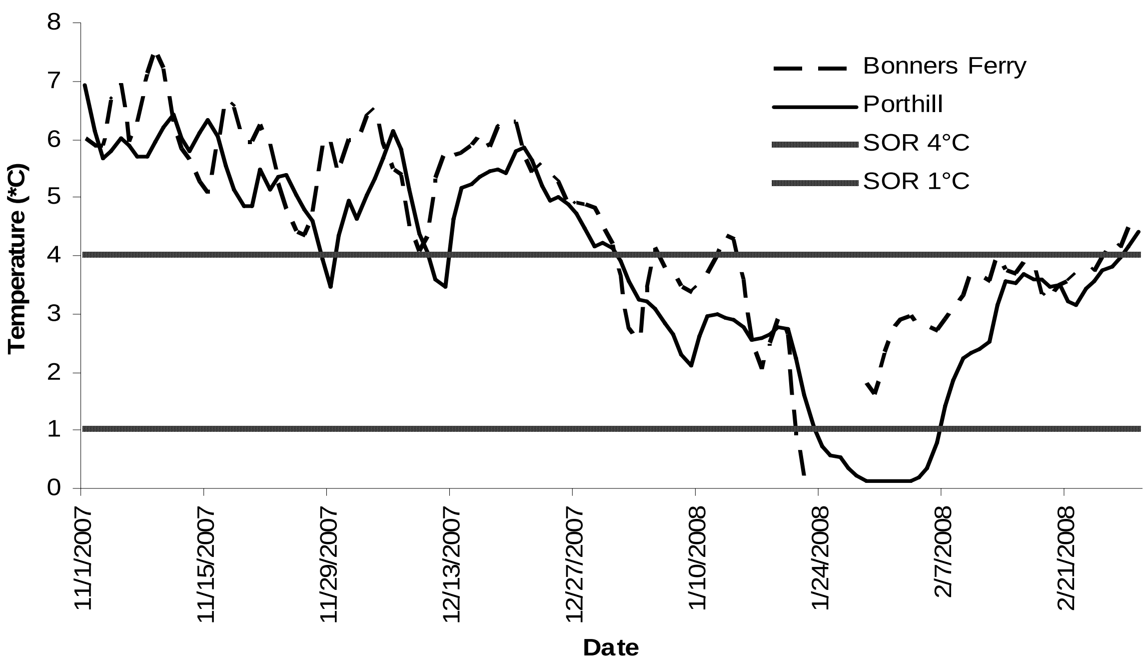

Figure 7. Mean daily temperature (°C) for the Kootenai River at Bonners Ferry and Porthill, Idaho (rkm 245.7), profile November 1, 2007 to February 29, 2008. Horizontal bars represent the target temperature values for the USFWS Systems Operations Request (SOR).

Sampling Adult Burbot

Total Catch

Baited hoop nets were fished from November 1, 2007 through February 28, 2008 for a total of 24,978.95 h or 1,040.79 net d. Thirty-one fish were caught encompassing nine different species of fish, and the crayfish *Pacifastacus spp.* were also caught (Table 1). Northern pikeminnow *Ptychocheilus oregonensis* was the most abundant species caught totaling 11 fish in the hoop net bycatch (Figure 8 and Table 1). Catch per unit effort was 0.0298 fish/net d for all species of fish (excluding crayfish).

Wooden slat traps were fished in shallow water at Ambush Rock (rkm 244.5). They were deployed from November 5, 2007 through February 28, 2008 for a total of 3656.18 h or 152.34 trap d. There were no fish caught in the slat traps.

Hoop Net Catch of Burbot

Throughout the winter of 2007-2008, three burbot were captured in baited hoop nets (Tables 1 and 2, Figure 8, and Appendix 4). All burbot were captured at Ambush Rock (rkm 244.5). Hoop net catch per unit effort for burbot was 0.0029 fish/net d or 346.93 net d/fish with effort in Idaho and BC (Tables 1 and 3 and Appendix 4).

Fredericks Pond Extensive Rearing and Pond Temperature

Because extensive rearing in Fredericks pond took place in the FY08 BPA contract period data will be included in the 2008-2009 Kootenai River Fisheries Investigations: Stock Status of Burbot Annual Report.

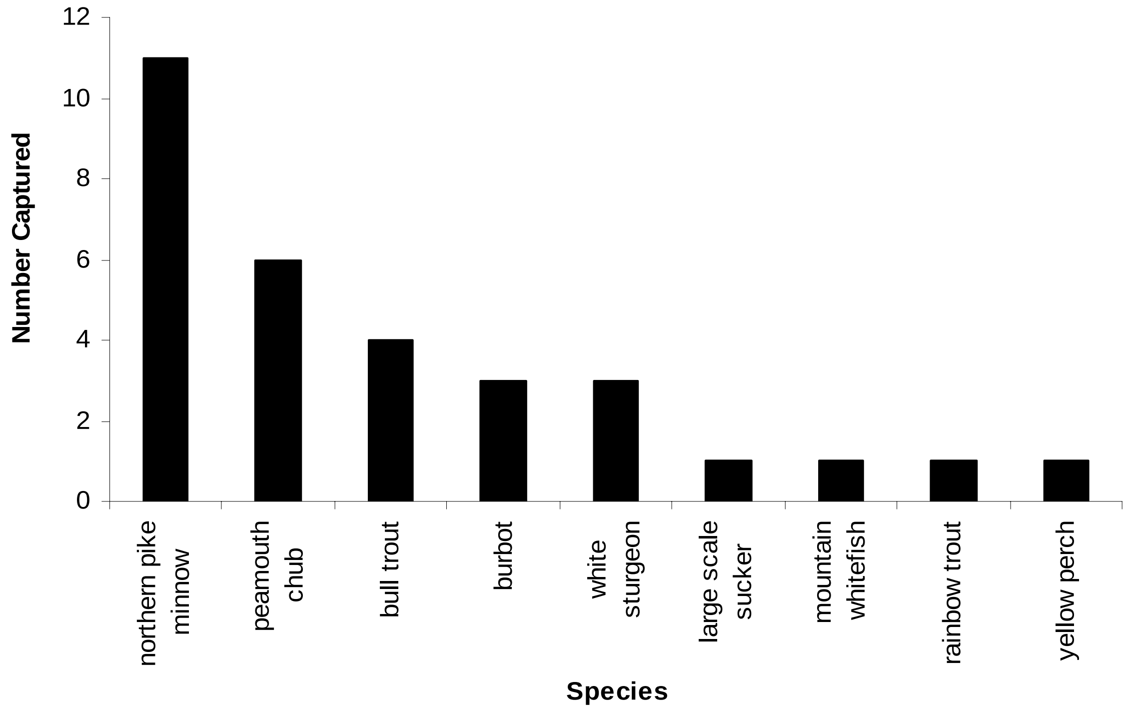

Figure 8. Hoop net catch for the Kootenai River, Idaho and British Columbia from November 2007 through March 2008.

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 2007 through March 2008 with 1040.79 d of effort (24978.95 h of effort).

Species	**Number**	**Total Weight (g)**	**CPUE[a]**
Northern Pikeminnow	11	4,175	0.0106
Burbot	3	5,053	0.0029
Largescale Sucker *Catostomus macrocheilus*	1	57	0.0010
White sturgeon *Acipenser transmontanus*	3	214	0.0029
Yellow perch *Perca flavescens*	1	79	0.0010
Mountain whitefish *Prosopium williamsoni*	1	159	0.0010
Bull trout *Salvelinus confluentus*	4	3,847	0.0038
Peamouth chub *Mylocheilus spp*	6	449	0.0058
Rainbow trout *Oncorhynchus mykiss*	1	335	0.0010
Total[b]	62	14,368	0.0298
Crayfish *Pacifastacus* spp	31	1,215	0.0298

[a] A unit of effort is a single hoop net set for 24 h.
[b] Does not include crayfish.

Table 2. Burbot identification number, location of capture, date of capture, total length, weight, and tag number for captures from November 2005 through January 2008.

Fish ID number	**Location of Capture (rkm)**	**Date of Capture**	**Total length (mm)**	**Weight (g)**	**Tag Type**	**Tag Code**
333	144.5	11/1/05	383	322	na	na
279	144.5	11/14/05	732	2793	na	na
329	244.5	11/18/05	645	1596	na	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	na
337	144.5	1/9/06	515	781	na	na
338	244.5	1/12/06	714	2662	Vemco	283
339	152.7	2/6/06	624	1673	Vemco	082
340	152.7	2/6/06	588	1235	Vemco	284
341	244.5	2/23/06	713	1860	Vemco	111
342	150	2/26/07	766	2199	na	na
214	244.5	1/10/08	720	2330	na	na
344	244.5	1/30/08	505	1061	na	na
345	244.5	1/30/08	620	1662	na	na

Table 3. Burbot hoop net captures and capture effort in three primary locations, October 2003-April 2004, November 2004-April 2005, October 2005-March 2006, November 2006-March 2007, and November 2007-February 2008.

Sample year	River kilometer	Number of burbot captured	Total net days	CPUE (fish/net day)
	120-152.9	0	377.8	0
2003-2004	153-169.9	0	47	0
	170 +	19	1,540.3	0.12
	120-152.9	2	806.9	0.002
	153-169.9	0	0	0
2004-2005	170 +	16	587.2	0.03
	120-152.9	11	896.6	0.01
	153-169.9	0	0	0
2005-2006	170 +	3	501.3	0.006
2006-2007	120-152.9	2	1,223.0	0.00007
	153-169.9	0	174.9	0
	170 +	0	99.5	0
	120-152.9	0	725.9	0
	153-169.9	0	0	0
2007-2008	170 +	3	314.9	0.003

DISCUSSION

Index Sampling Sites and Population Status

We used index sampling sites for the fourth season during the winter of 2007-2008 in an effort to maximize our catch and evaluate stock status. We captured only three burbot the winter of 2007-2008, which yielded a CPUE of 0.003 as compared to the capture of 14 burbot and CPUE of 0.007 fish/net d the winter of 2005-2006, which was slightly less than the previous winter (2004-2005) capture of 18 fish and CPUE of 0.009 fish/net d.

No burbot were captured in the Goat River, which is an additional indicator of the depressed status of burbot in the Kootenai River. This tributary was one of the last two known spawning locations for burbot and provided a major portion of the total winter catch in previous years. One burbot each was captured in the Goat River during winter 2006-2007, 2000-2001, and winter of 2001-2002 (Kozfkay and Paragamian 2002; Gunderman and Paragamian 2003).

As expressed in Chapter 2 of Paragamian et al. (2008), the Kootenai River burbot will likely be extinct within the decade. There will always be a remnant stock but this will only be due to emigration of a few burbot from above Kootenai Falls (Powell et al. 2008). These fish will not have an admix of Pacific and Mississippi clade genetics but will be exclusively Mississippi clade. Thus the next generation of burbot may not be of the original unique genetic stock.

A burbot Conservation Strategy was prepared by the Burbot Subcommittee of the Kootenai Valley Resource Initiative (KVRI Burbot Committee 2005) but a rehabilitation goal (population number) was not included. The reason a goal was not set was that the pre-Libby Dam Kootenai River burbot population density, prior to their decline, is unknown. It is important that a rehabilitation goal be set in order to establish benchmarks of success for rehabilitation measures regardless if it is through wild/natural recruitment or the release of artificially propagated burbot. One possible means of establishing a goal for rehabilitation could be to base it, initially, on the burbot population densities in Alaskan Rivers. A model could be produced with Kootenai River burbot population estimates, CPUE (Paragamian et al. 2008; Paragamian and Laude 2008), and an adjustment for river scale. Published CPUE values of several Alaskan rivers could be used to project a range of recovery goals. CPUE has been used to compare burbot stock densities (Parker et al. 1988). For example, CPUE values for burbot in Alaskan rivers ranged from a CPUE in the Chena and Tanana rivers from about 0.5 and 1.0, respectively (Evenson 1993). Values for Alaskan lakes were higher, CPUE of up to 3.0 burbot/ net d (Parker et al. 1988). This method would assume that CPUE was directly proportional to population number or density of adult burbot. Any bias of using a least squares method can be calculated, thus explaining statistical precautions.

Burbot SOR

The burbot SOR mitigated for warmer winter water temperatures in the Kootenai River caused by the release of a large volume of warm surface water in Lake Koocanusa. The SOR request attempted to "cool" the Kootenai River during winter of 2007–2008 by using a selective withdrawal system at Libby Dam. Prespawn water temperature was above 6°C in early November 2007 but fell below after November 10 through most of December. Water temperature was usually maintained between 1 and 4°C throughout January and February 2008 and was acceptable. However, the attempt was not acceptable for the winter of 2006-2007 because the water was too warm. For most of November and December of 2006 water temperature at Bonners Ferry was held between 4°C and 6°C. The coldest period was during late November when temperature fell to about 3.8°C. Water temperature remained below 5.5°C during late December and through most of January. River water less than 6°C is important to stimulate prespawn migration and water temperatures <4°C are preferred for spawning (Paragamian and Wakkinen 2008). The results during the winter of 2004–2005 were also less than satisfactory because river water temperature was too warm (Paragamian and Laude 2006) while temperatures of 2005-2006 were cooler (Paragamian and Laude 2008). The committee did not address discharge from Libby Dam because the burbot stock is so low a response is immeasurable.

Maintaining cool water from Libby Dam is very dependent on uncontrollable factors such as microclimate, wind direction, and intense storms. These all play a role in 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 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 and can be affected by storms during fall. 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 as water becomes isothermal (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. There is a chance for atmospheric cooling between Libby Dam and the lower Kootenai River, so the artificially warmer discharge from the reservoir can chill as it moves downstream. This effect is dependent on discharge volume because air temperature has more effect on water temperature at lower discharge volumes. Prior to Libby Dam, the Kootenai River often super-cooled, caused ice jams and associated ice scour (Figure 3).

Extensive Burbot Rearing and Fredericks Pond

Experimental extensive rearing of burbot at Sinclair Lake was our first attempt to rear burbot outside of the intensive forum of a hatchery facility. To our knowledge, this was the first attempt in North America but it has been implemented in Europe with good success showing positive results for burbot recovery in Belgium (Dillen et al. 2008; Vught et al. 2008). To compare intensive and extensive rearing, Belgian researchers stocked intensively reared burbot as recently hatched larvae in a Belgian river. Research efforts failed to document any survival. A contingent representing the same families was held for an additional period to rear extensively to fingerling length. The fingerling burbot were stocked (70 to 98 mm in length) into the same river and were recaptured several months later had grown in length and weight.

Our attempt at extensive rearing in 2007 met with only modest success. Of approximately 4,000 eyed embryos placed in incubation jars and set in Sinclair Lake, we found 20 larvae in the jars, a hatching success average of about 0.05% and 2.75% based on eggshells. We also found 110 eggshells suggesting many other larvae hatched but perished under confined conditions. All of the larvae we collected from incubation jars were dead. Of the eggs released into Sinclair Lake, approximately 65% were eyed, range 53-75%, while hatching success of a contingent of the same family held in the laboratory was observed to be >50% survival (Nathan Jensen, University of Idaho, personal communication). Had we calculated our estimate of hatching success based on the percent of eyed eggs, survival would have been higher. We did not use the eyed percentage because of the wide range and the point was moot, survival would still be less than satisfactory. Although no age 0 burbot were captured through our sampling efforts some larvae could have hatched but their numbers were so low they remain undetected. Further sampling for burbot survival will be done in 2008. Taylor and McPhail (2000) found that about 75% of the burbot larvae they hatched under laboratory conditions died within the first four weeks of life. In our study the cause of mortality is unknown, but DO at the surface and at 1.6 m at Sinclair Lake were 4.3 and 1.7 ppm, respectively, while that of laboratory experiments of Jensen et al. (2008) were 10.0 ppm. Lake DO was not suitable for larval survival at hatching. Further experiments with extensive rearing should follow with multiple trials with an array of controls using larvae (Dillen et al. 2008). However, if this is not possible, the extensive rearing study should continue to apply known methods determined through previous studies and literature research. Using the smaller Fredericks pond for extensive rearing may show more promise as a rearing facility because it is smaller for manageability and has higher security.

Recommended Discharge and Temperature for Burbot Migration and Spawning

The best available recommendation for discharge will continue to rely on the studies of Paragamian et al. (2005) and Paragamian and Wakkinen (2008). 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 decline to <6°C by the first week in November and maintained from 1 to 4°C for the duration of December through February, which includes the migration and spawning season. A study of the relation between “specific levels” of discharge and temperature from Libby Dam and burbot spawning migration and spawning cannot be successfully completed until there are sufficient numbers of adult burbot.

RECOMMENDATIONS

1. While the population of burbot is critically low, continue sampling index locations to measure changes in population numbers (Jolly-Seber population estimate), size structure (PSD), condition W_r, and abundance (CPUE). Effort shall continue at Nicks Island, the Creston Boat Ramp, Boundary Creek, the international border, Goat River, Ambush Rock, and near Deep Creek.

2. We recommend Moyie Lake burbot stock be used to evaluate extensive rearing of cultured larvae. The primary objectives would be to determine whether burbot larvae could be reared to a minimum length of 25 mm or larger, released, and recaptured. Successful rearing would lead to further development of extensive rearing methods and release as fingerlings for burbot rehabilitation.

3. We recommend that a rehabilitation goal in terms of burbot numbers in the Kootenai River population be established. This could be accomplished with density analysis of CPUE, corresponding population estimates, a target CPUE based on Alaskan burbot stocks, and Population Viability Analysis.

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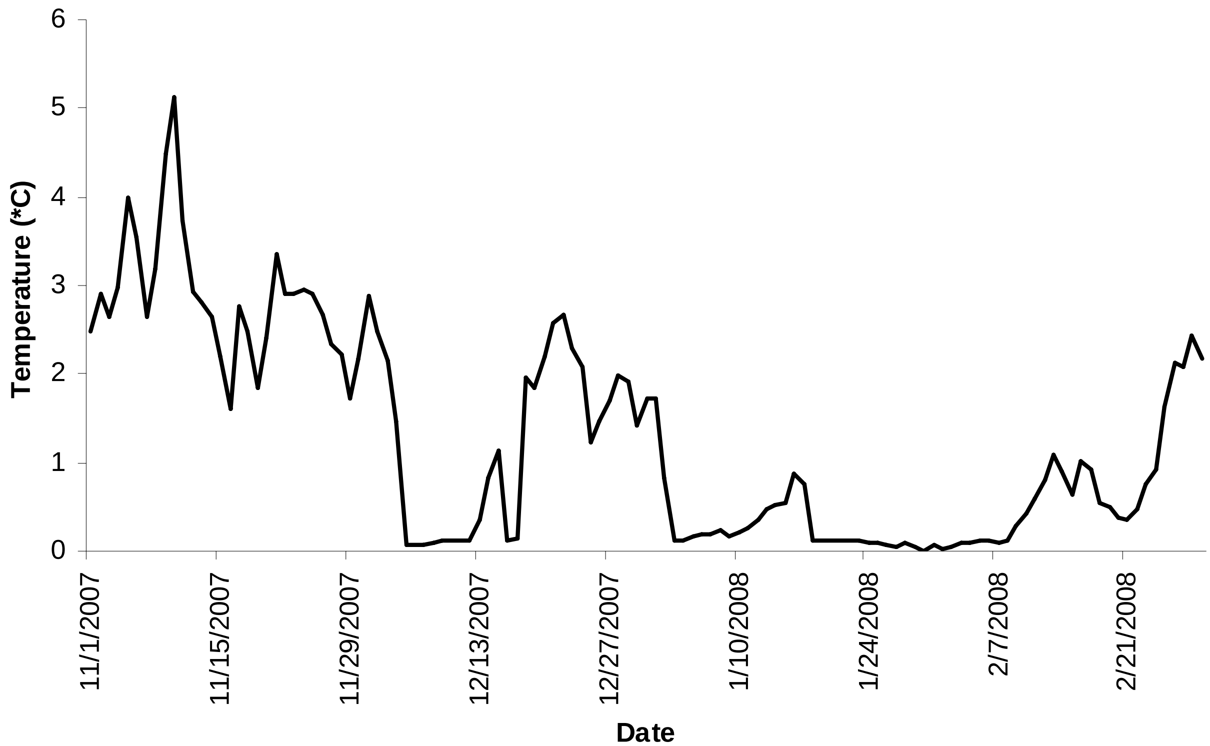
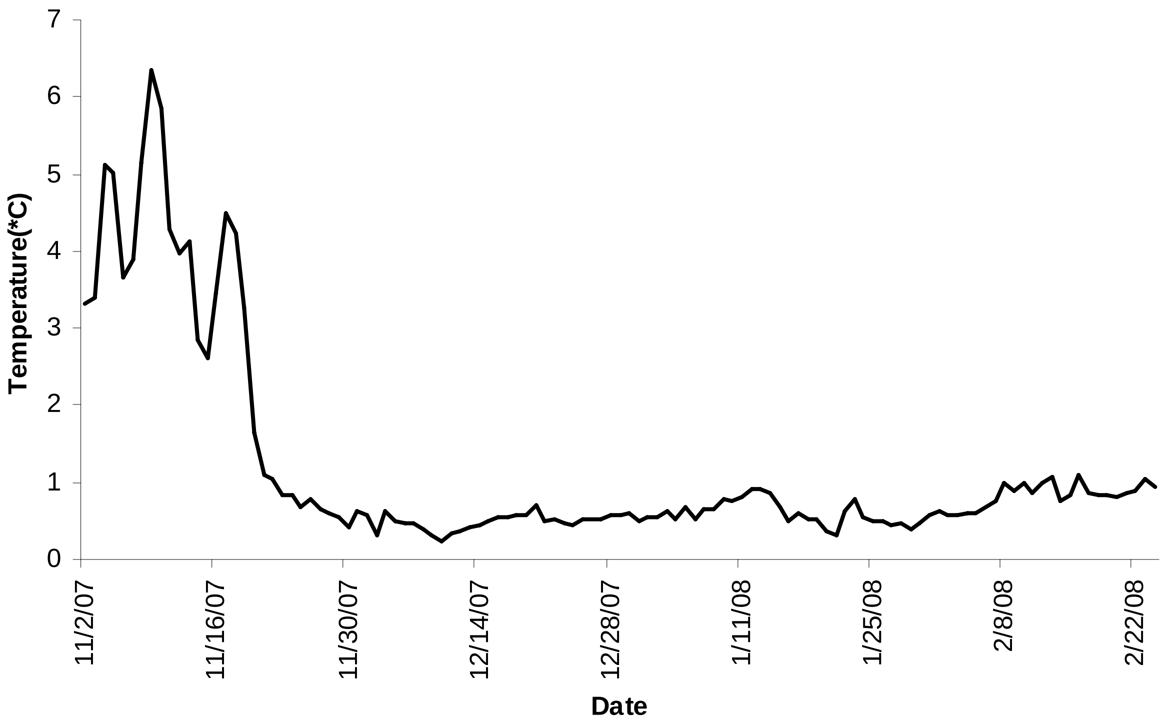
APPENDICES

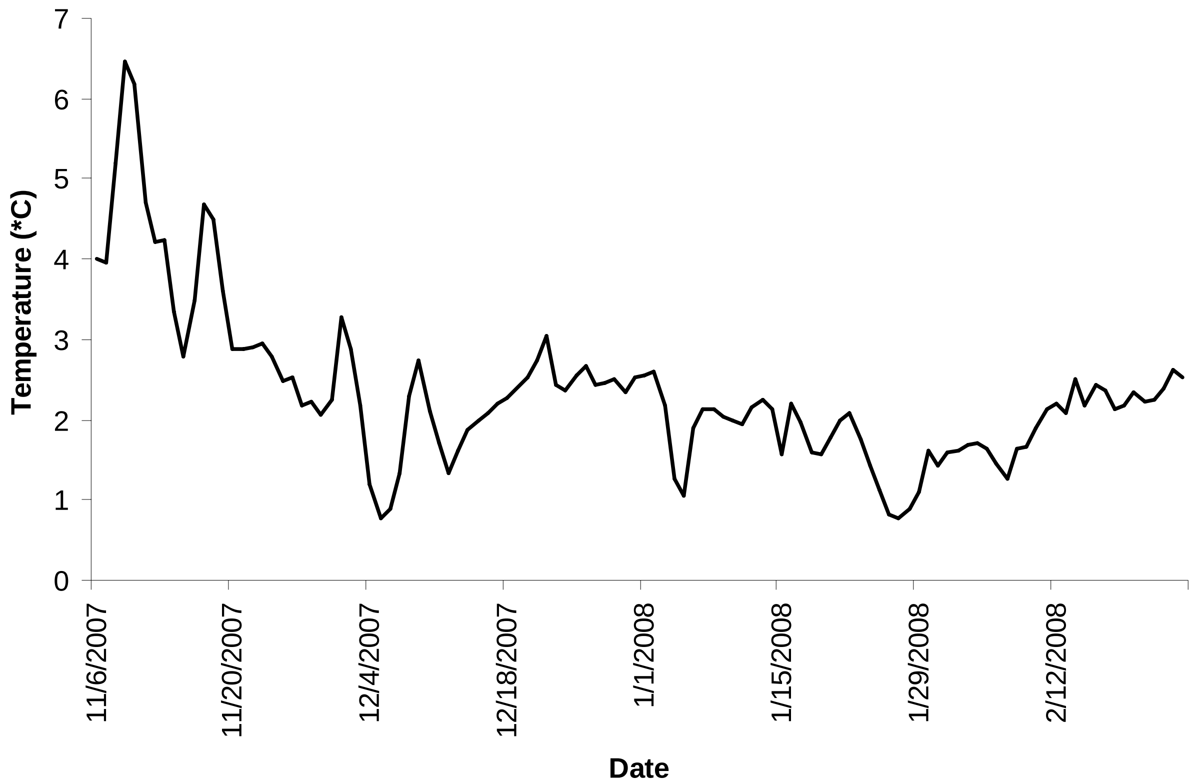
Appendix 1. Lower Boundary Creek (°C) mean daily temperature profile November 1, 2007 to February 29, 2008.



Appendix 2. Upper Goat River (°C) mean daily temperature profile November 2, 2007 to February 24, 2008.



Appendix 3. Lower Goat River (°C) mean daily temperature profile November 6, 2007 to February 25, 2008.



Appendix 4. Idaho Department of Fish and Game burbot hoop net captures and capture effort (burbot/hoop net day), winters (Wtr.) of 1993-2008.

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	2,045.7	0.009
Wtr. 2006: Oct. 2005–Mar. 2006	14	1,999.9	0.007
Wtr. 2007: Nov. 2006-Mar. 2007	2	1,497.4	0.001
Wtr. 2008: Nov. 2007-Mar. 2008	3	1,040.8	0.003
Totals	388	22,090.9	0.015
Mean			0.021

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