BONNEVILLE POWER ADMINISTRATION

Kootenai River Fisheries Investigations

Stock Status of Burbot

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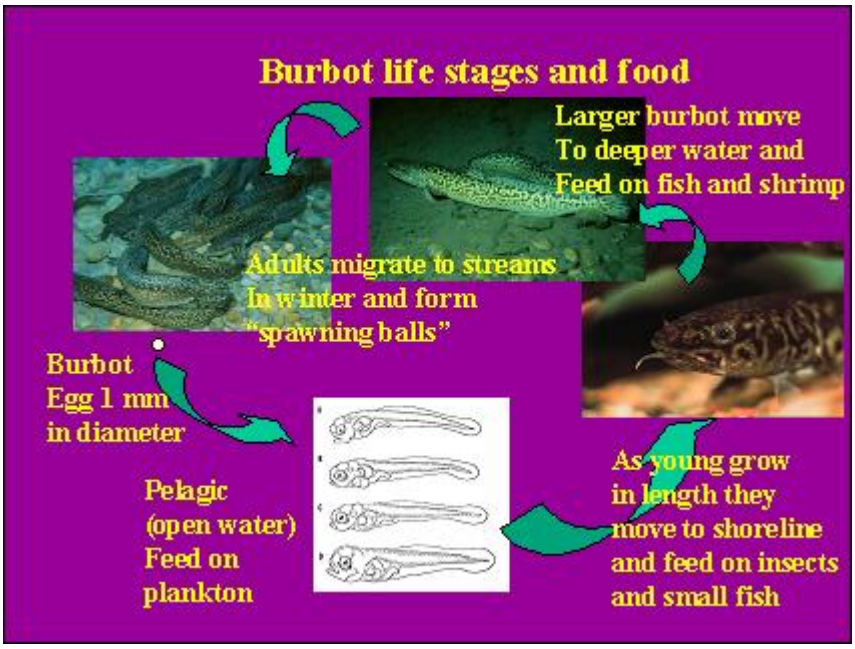
FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

ANNUAL PROGRESS REPORT
April 1, 2002—March 31, 2003



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IDFG Report Number 03-50
October 2003

KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

Project Progress Report

2003 Annual Report

By

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ABSTRACT

The Kootenai River Fisheries Investigation Project planned to monitor burbot *Lota lota* movement in the winter of 2002-2003 and test a hypothesis regarding the relationship of winter flow to upstream spawning migration success. The U.S. Army Corps of Engineers and the Bonneville Power Administration were unable to provide the consistent low winter flows needed to meet the experimental design criteria in that monitoring and evaluation plan (approximately 170 m^3/s from Libby Dam). Although conditions consistent with management for sustained minimum flows persisted throughout the winter, and stable low flows were maintained below Libby Dam from September 1 through November 24, 2002 (158 m^3/s average) and from January 1, 2003 until May 1 (144 m^3/s average), flows in the intervening 37 d period from November 25 to December 31 were increased significantly by the U.S. Army Corps of Engineers. During that important December spawning migration period for burbot, flows were well above those proposed in the monitoring and evaluation plan and peaked at 741 m^3/s on December 21, 2002. Furthermore, despite the low flow conditions for much of the winter, our capture of 10 burbot was the lowest since this investigation began in 1993, evidence that the stock is extremely depressed and the numbers of burbot are declining. We captured a single burbot in 2002-2003 that provided circumstantial evidence reproduction occurred during the winter of 2000-2001. This burbot of 352 mm TL was among the smallest captured since sampling began in 1993. Seven burbot were monitored with sonic telemetry; two of those were tagged the previous winter. The capture of a female burbot at Ambush Rock during the spawning period supports results of previous findings that low flows during winter enhances burbot migration and spawning. Sampling for larval burbot was conducted, but no larval burbot were captured.

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INTRODUCTION

In Idaho, burbot *Lota lota* are endemic only to the Kootenai River (Simpson and Wallace 1983). Burbot in the Kootenai River (Figure 1) once provided an important winter fishery to residents of northern Idaho. Some anglers reported catching up to 40 burbot per night during winter setline fishing (Paragamian 1994a), while up to 26,000 burbot were caught in one season in Kootenay Lake, British Columbia (BC) (Paragamian et al. 2000). Burbot caught during the winter fishery are thought to have been part of a spawning migration from the lower river and Kootenay Lake in BC, Canada. However, after construction and operation of Libby Dam by the U.S. Army Corps of Engineers (USACE) in 1972, the respective fisheries rapidly declined and were closed in 1992 in Idaho and in 1997 in BC. Operation of Libby Dam for hydroelectric power and flood control has created major changes in the river's seasonal flow, 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; Richards 1996; Snyder and Minshall 1996).

The Kootenai River Fisheries Investigation was initiated in 1993 by the Idaho Department of Fish and Game to address burbot abundance, distribution, size structure, reproductive success, movement, and ultimately to identify factors limiting burbot. Only one burbot was captured between rkm 246 (Bonners Ferry) and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994a). There has been little evidence of burbot reproduction in the Idaho reach. Only one larval and one fingerling burbot have been captured from 1993 to 2003 (Fredericks and Fleck 1995; Paragamian and Whitman 2000). However, numerous size-classes of burbot have been in the catch, indicating some burbot are reproducing successfully. Studies prior to Kozfkay and Paragamian (2002) had failed to document spawning burbot in the Kootenai River, Idaho, but cooperative sampling in the BC reach of the river with the British Columbia Ministry of Water, Land, and Air Protection documented spawning burbot in the Goat River, BC.

Studies completed in the winter of 1997-1998 indicated flow management at Libby Dam likely affected burbot spawning migration (Paragamian 2000). Movement of burbot with sonic transmitters was significantly higher during low flow conditions, which were designed to replicate pre-dam Kootenai River flow. Movement upstream was also significantly higher during low flow tests than the control. Winter flows are now three to four times greater than they were prior to Libby Dam when flow conditions were relatively stable. Daily differences in flow can now reach up to 652 m^3/s. 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.

Because burbot in the Kootenai River may be at risk of demographic extinction (Paragamian 2000), a Conservation Strategy (Anonymous 2002) was prepared to outline measures necessary to rehabilitate burbot. The Conservation Strategy indicated that operational flow changes at Libby Dam must be implemented during winter to provide suitable conditions for burbot migration. However, the upper limit of flow releases for adequate burbot spawning migration and flood control were unknown for inclusion in a Conservation Agreement, a legally binding document that ensures river managers would cooperate in measures to recover burbot. Experimental flows were proposed with the USACE and the Bonneville Power Administration (BPA) from 1998-2002, initially, and were set at 170 m^3/s from Libby Dam (similar to pre-dam winter flows) for burbot spawning migration (Paragamian and Whitman, 1999, 2000; and this study). The intention was to test the null hypothesis that flows below $\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 from 1998 through 2000. Since test conditions were unachievable, an alternative evaluation was necessary (Paragamian et al., in progress). 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 further determine how flow factors affect burbot travel distance and travel rate. The seasonal distribution of movements found 30 (68%) of 44 "stepwise movements" (movements of 5 km or more in 10 d or less) occurred when flows were $\leq$300 m^3/s from Libby Dam and averaged 176 m^3/s. "Stepwise movements" of burbot were examined to determine if there were statistical differences in movement when the number of days flows from Libby Dam were $\leq$300 m^3/s (N = 15 and 186 days, low flows) in comparison to the number of days flows were $\geq$301 m^3/s (N = 11 and 538 days, high flows). The Fisher exact test indicated burbot moved more frequently during lower flows. As a result of these studies, it was recommended flow for burbot prespawning migration 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). Although these recommendations appear adequate, it is important that the flow measures for burbot spawning migration be validated.

Temperature changes post-Libby Dam may be an additional factor affecting the spawning and recruitment of burbot in the Kootenai River. Partridge (1983) found temperature of the Kootenai River is now cooler in the summer and warmer in the winter by several degrees C. 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 tributaries may have potentially affected burbot spawning migration, rate of maturity, spawning synchrony, and possible larval survival.

GOAL

The management goal of this study is to restore the burbot population in the Idaho reach of the Kootenai River and improve fishing success to historic levels.

OBJECTIVES

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

2. Define temperature differences as a factor that may be limiting burbot migration and reproductive success to improve survival and recruitment of young burbot.

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

4. Determine if there is a stress relationship between flow in the Kootenai River and burbot reproductive physiology by comparing plasma steroids of burbot from the Kootenai River and a control population in Columbia Lake, BC.

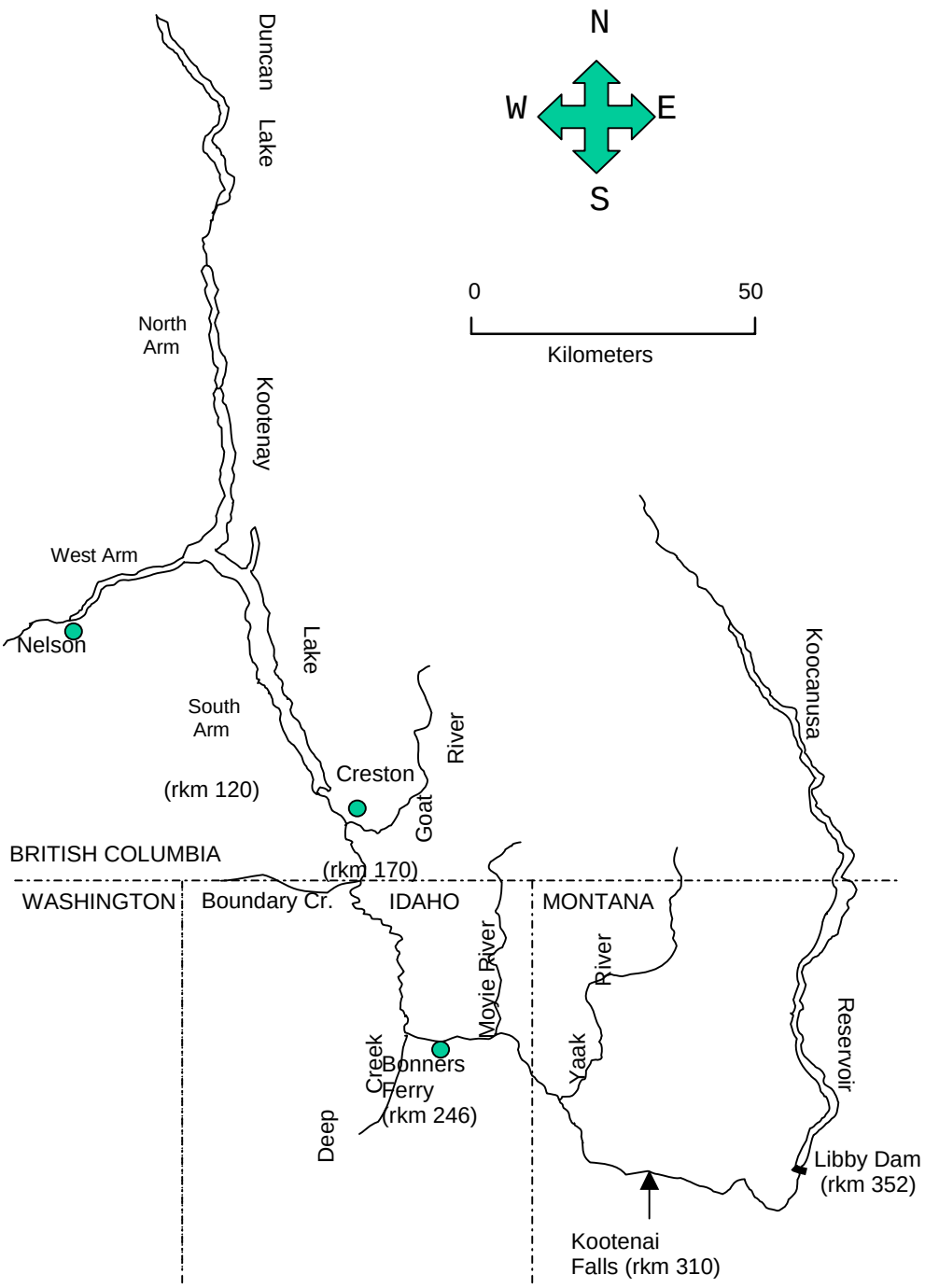

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

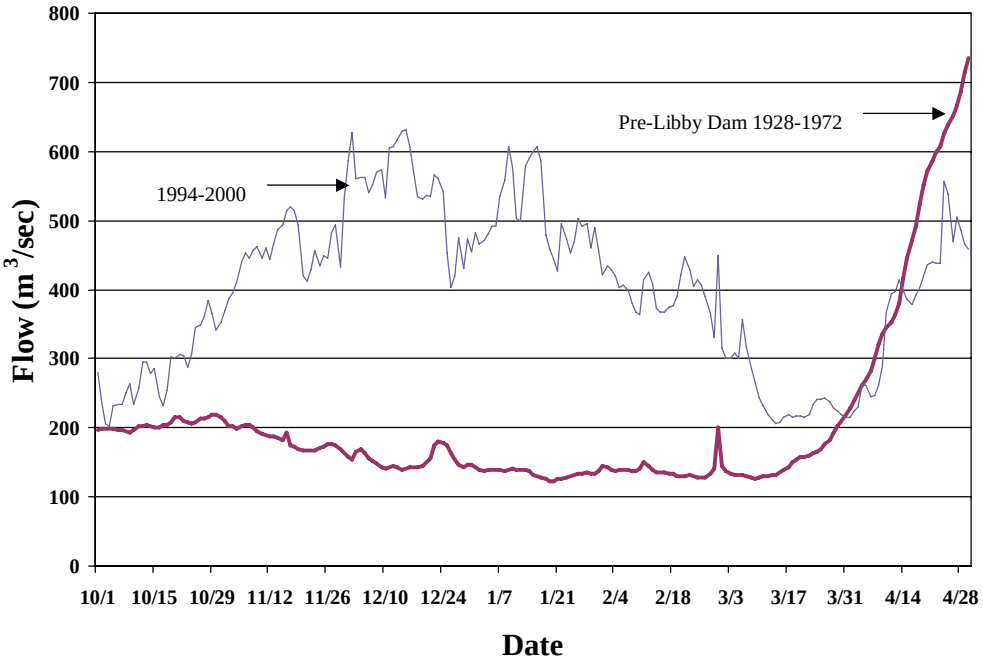

Figure 2. Mean monthly discharge (m^3/s) in the Kootenai River at Bonners Ferry, Idaho, from 1962 through 1971 (pre-Libby Dam) and from 1973 through 1982 (post-Libby Dam).

STUDY AREA

The Kootenai River (spelled Kootenay for Canadian waters) is one of the largest tributaries to the Columbia River. Originating in Kootenay National Park, BC, the river flows south into Montana where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). From Libby Dam the river flows west and then northwest into Idaho, then north into BC and Kootenay Lake. The 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, BC.

The Kootenai River presents three different channel and habitat types as it passes through Idaho. As the river enters Idaho, steep canyon walls and a gradient of about 0.6 m/km typify the corridor. The river begins a short braided reach about one km below the Moyie River, and then at Bonners Ferry the river transitions to a lower gradient of approximately 0.02 m/km and meanders through a broad flood plain. Tributary streams of the Kootenai River are typically high gradient as they pass through mountain canyons but revert to lower gradients when they reach the valley floor, where they have been diked.

METHODS

Discharge and Temperature

Daily discharge and temperature values for the Kootenai River at Libby, Montana, were obtained from the USACE and the U.S. Geological Survey (USGS) water resources website. We will identify the river temperature at the time of arrival of spawning burbot into Idaho and the temperature of spawning tributaries. This information will be compared to that of the literature. The possible effect of temperature changes in the Kootenai River (since Libby Dam) and temperatures of tributaries on burbot spawning synchrony will be examined. A StowAway® XI temperature logger was used to monitor daily water temperatures for Smith and Boundary creeks in Idaho, as well as Summit Creek, Corn Creek, and the Goat River in BC, from October 2001 through March 2002. At each location, mean temperature was calculated from five evenly spaced daily measurements. A temperature logger was deployed less than 200 meters upstream of each tributary creek confluence with the Kootenai River. In Summit and Boundary creeks, an additional thermograph was placed approximately 500 meters farther upstream to assess the infiltration of warmer water from the Kootenai River. These loggers assessed whether infiltration of Kootenai River water into these creek mouths was substantial, in which case the cold water inputs that burbot may use as migration cues would be obscured (Paragamian 2000). Although no burbot spawning has been documented recently, Summit and Boundary creeks are historical burbot spawning areas.

Sampling Adult Burbot

We sampled for adult burbot from October 17, 2001 through April 11, 2002 using up to 12 hoop nets baited with smelt *Osmerus mordax*, kokanee *Oncorhynchus nerka*, and sometimes other fish. Hoop nets had a maximum diameter of 0.61 m (see Paragamian 1995 for description of nets and method of deployment). Nets were deployed in deep (usually the thalweg) areas of the Kootenai River between Ambush Rock (rkm 244) near Bonners Ferry, Idaho and Nick's Island (rkm 144) near Creston, BC. We also sampled three tributary streams including Smith Creek near Porthill, Idaho (rkm 177), Boundary Creek, which enters the Kootenai River at Porthill, Idaho (rkm 170), and the Goat River, near Creston, BC (rkm 152).

Nets were usually lifted on Monday, Wednesday, and Friday of each week. We decompressed all burbot by lowering the net to 50% of its original depth, waiting 24 h, and then raising it halfway again before final lifting to the surface. This procedure usually took several days, depending on initial depth. Fish captured in hoop nets were identified by species, enumerated, measured for total length (TL), and weighed to the nearest gram (g). Sex of some burbot was determined by a gentle massage near the abdomen, and the vent was examined for gametes. All burbot were implanted with a passive integrated transponder (PIT) tag in the left opercular muscle. In order to minimize stress, sex was not determined via surgery on any burbot captured during the winter of 2002-2003. Relative weight (W_r; Fisher et al. 1996) was calculated for each burbot captured. Catch per unit effort (CPUE) was measured in catch per 24 h with each net day as a 24 h period.

Burbot Telemetry

Sonic and radio transmitters were used to track the movement of burbot during the winter of 2002-2003. Two 14-month 74 kHz sonic tags, which had been surgically implanted

during the 2001-2002 field season, were tracked throughout the summer and monitored daily when possible. Three burbot were fitted with externally attached 50-day, 4.7 g radio transmitters (Advanced Telemetry Systems; model #F1560; duty cycle 8h on/16h off; 40 ppm). Two burbot were fitted with 5 month, 3.7 g externally attached 80-kHz sonic tags (Sonotronics, IBT-96-5). Both sonic and radio telemetry were conducted via boat. Aerial location of radio transmitters was conducted occasionally when a burbot moved long distance.

Attachment for both radio and sonic transmitters was similar (Figures 3 and 4). The radio transmitters were first wrapped with FireLine™ fishing wire and sealed with epoxy to provide points of attachment. Sonic tags came equipped with previously drilled holes. After anesthetizing the burbot with MS-222, the FireLine™ was fed through the skin in the anterior portion of the second dorsal fin with a #12 gage 1.5 in stainless steel needle (JorVet Harvard Veterinary). Two plastic 2.5 cm diameter Peterson discs were placed on the opposite side of the tag to prevent excessive chafing, and the FireLine™ was crimped with steel ends. This procedure took between 10 and 15 minutes to complete. After the transmitters were attached, the burbot was allowed to recover in fresh river water. Before deployment, the transmitter was checked to make sure it was functioning properly.

Larval Sampling

Larval burbot sampling was conducted using paired ½ m nets (mouth area = 0.7854 m^2) with a boat 8 m in length during daylight hours in May 2003. One net was towed at the surface, while the other sampled at approximately 1.5 m of depth below the surface. Gurley 2030 R current meters were mounted in the mouth of each net, and tows were made in a downstream direction; the boat motor (150 hp) was operated at 1,000 rpm to maintain uniform towing speed. Effort was calculated using total towing time and rotation counts per second from the flow meters x mouth area (0.7854 m^2) to calculate the total volume of water filtered through each net.

Figure 3. A Kootenai River burbot with an externally attached radio transmitter. Note the size and placement of the transmitter.

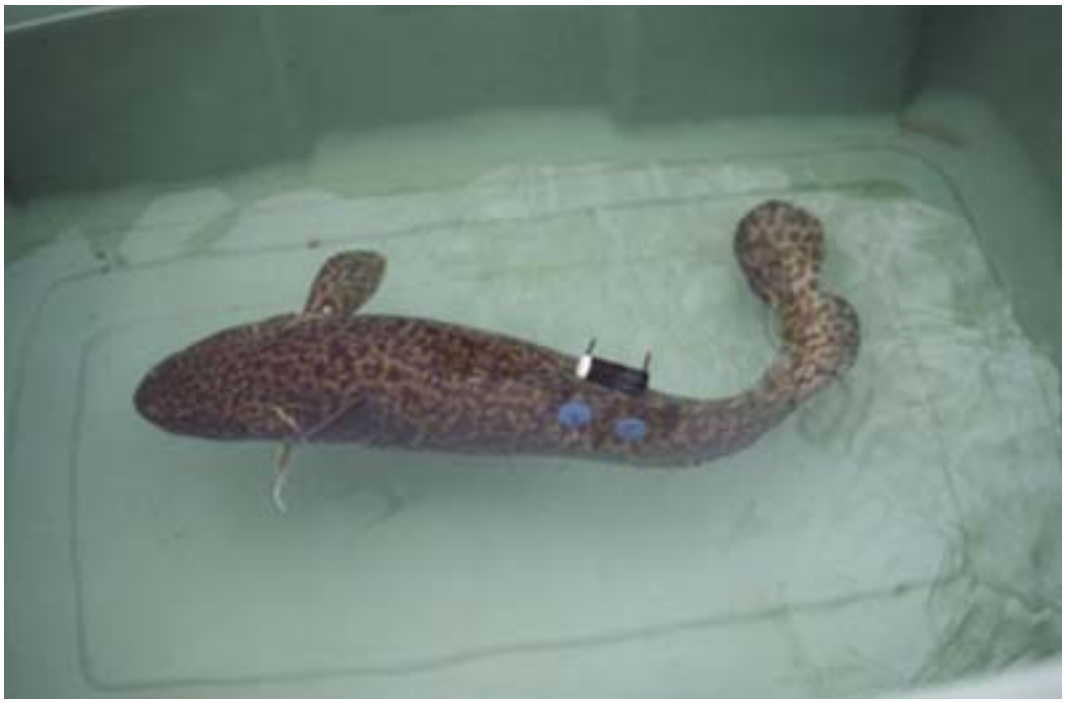

Figure 4. A Kootenai River burbot with an externally attached 80 kHz sonic tag. Note the size and placement of the transmitter.

RESULTS

Discharge and Temperature

Kootenai River Discharge

The Kootenai River discharge below Libby Dam, Montana, averaged 157.5 m^3/s from September 1 through November 24, 2002 (Figure 5). Flows increased for a period of 37 days (November 25 through December 31) and peaked at 740.5 m^3/s on December 21, 2002. The discharge remained stable from January 1, 2003 until May 1, 2003 at 144.2 m^3/s.

Kootenai River Temperature

The Kootenai River maximum temperature of 15.9°C occurred on September 5, 2002 and steadily declined over the winter. The lowest temperature of 3.3°C occurred on March 8, 2003. Mean daily Kootenai River water temperature at Ambush Rock (rkm 244.5) and Porthill (rkm 170.1) averaged 4.9°C and 4.5°C, respectively, from November 10, 2002 to April 1, 2003 (Figures 6 and 7). The lowest mean temperature of 1.9°C at Ambush Rock occurred on January 12. The lowest mean temperature of 1.9°C at Porthill occurred on January 17.

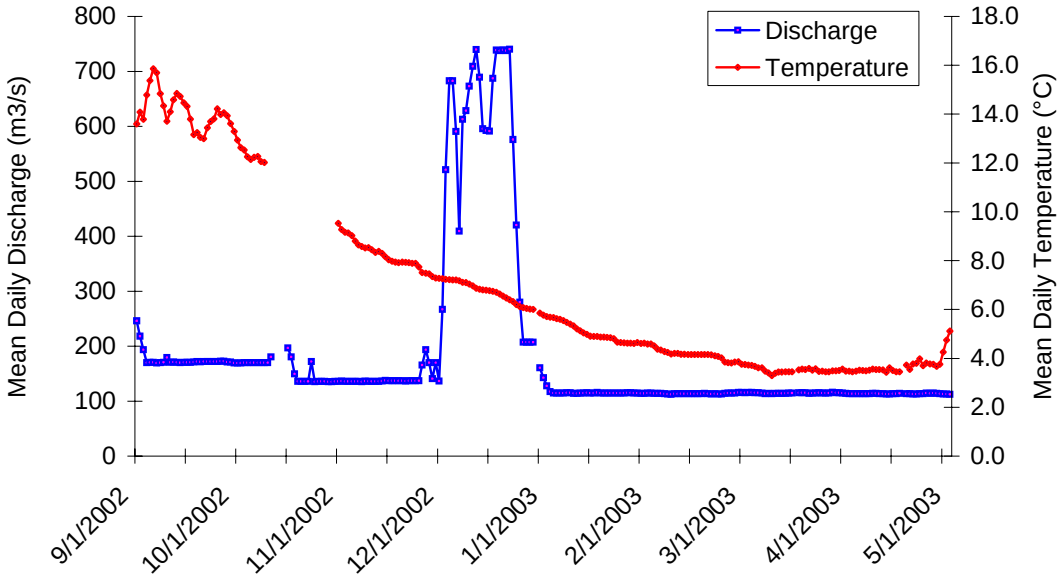

Figure 5. Mean daily discharge (m^3/s) and temperature (°C) of the Kootenai River below Libby Dam, Montana from September 1, 2002 to May 1, 2003. Data was obtained from the U.S. Army Corps of Engineers USGS site #12301933.

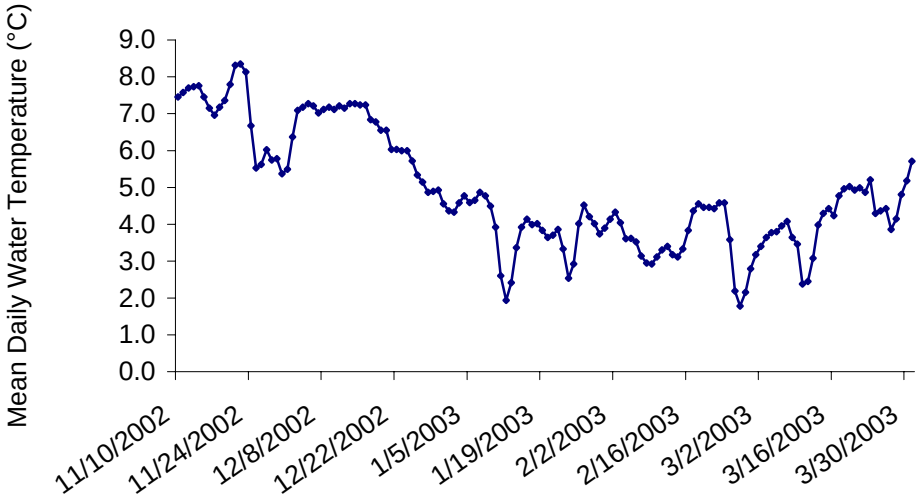

Figure 6. Mean daily water temperature of the Kootenai River at Ambush Rock in Bonners Ferry, Idaho from November 11, 2002 to March 31, 2003.

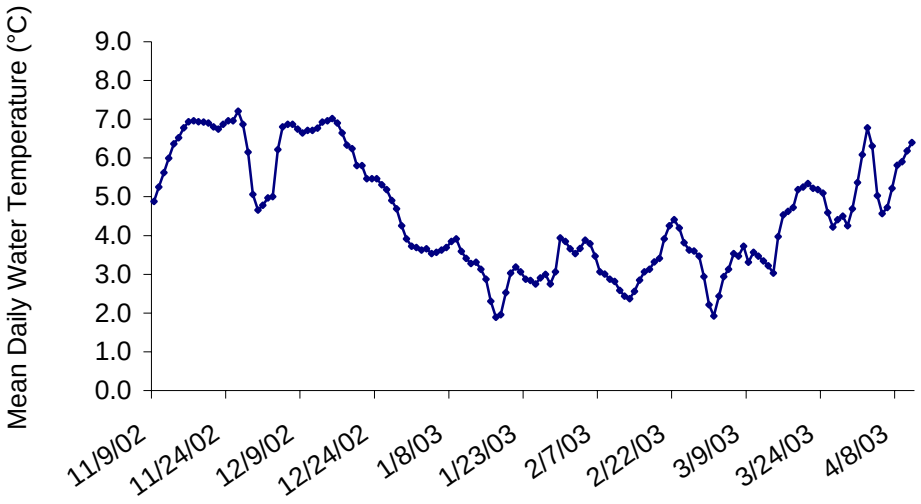

Figure 7. Mean daily water temperature of the Kootenai River at Porthill, Idaho from November 9, 2002 to April 11, 2003.

Tributary Temperatures

Temperatures of four main tributaries of the Kootenai River were monitored from November 7, 2002 through March 30, 2003. Several temperature loggers were vandalized, and as a result, we were unable to provide temperature differences between the lower and upper reaches of several tributaries. From November 7, 2002 through February 4, 2003, Corn Creek had an overall mean water temperature of 2.5°C (Figure 8). There were two spikes of warmer water temperatures on November 22 and December 12, 2002 of 5.9 and 6.0°C, respectively. The lowest recorded mean daily water temperature was 0.07°C on January 23, 2003.

Overall mean water temperature for the Goat River from November 8, 2002 to March 29, 2003 was 2.0°C (Figure 9). Again, there was a spike in temperature on November 22 to 6.1°C. The lowest recorded temperature occurred on January 12 and 13, 2003 of 0.01°C.

The overall mean water temperature for Smith Creek from November 10, 2002 to April 11, 2003 was 1.6°C, with a temperature increase to 3.9°C on November 20, 2002 (Figure 10). The warmest temperature occurred on December 10, 2003, with a mean daily water temperature 4.4°C. The lowest recorded mean daily water temperature of 0.01°C occurred on January 14 and 23, 2003.

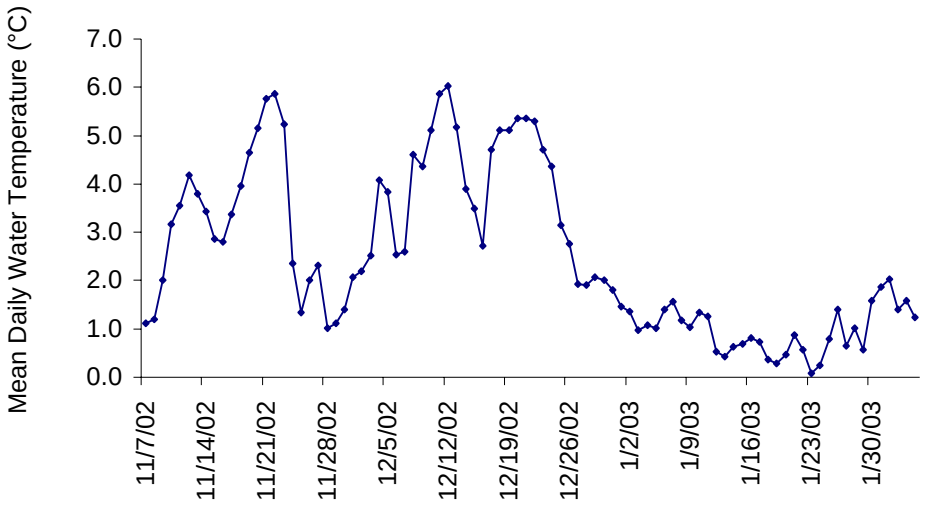

Figure 8. Mean daily water temperature (°C) of Corn Creek, BC from November 7, 2002 to February 4, 2003. Temperature data was not collected for February and March because the thermograph was vandalized.

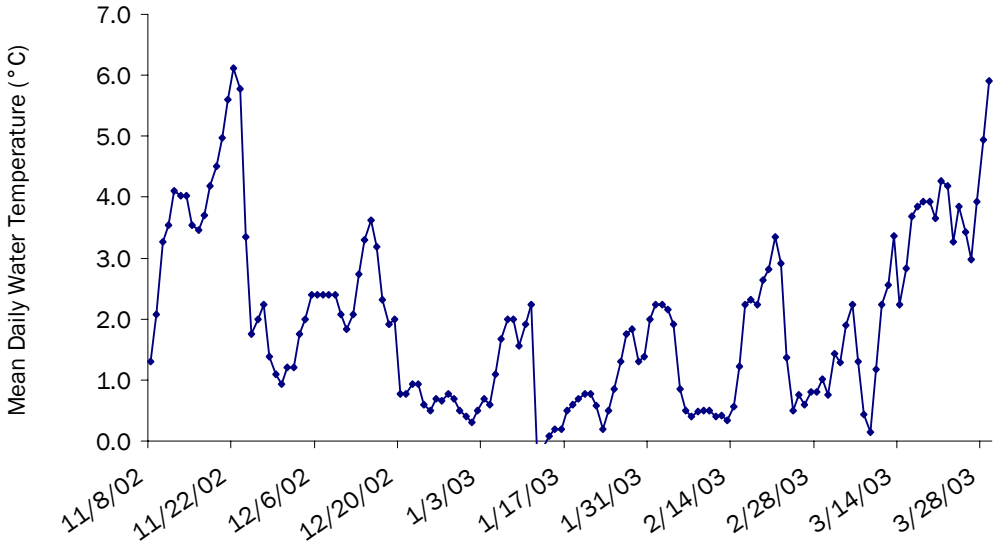

Figure 9. Mean daily water temperature (°C) of the Goat River, BC from November 8, 2002 to March 28, 2003.

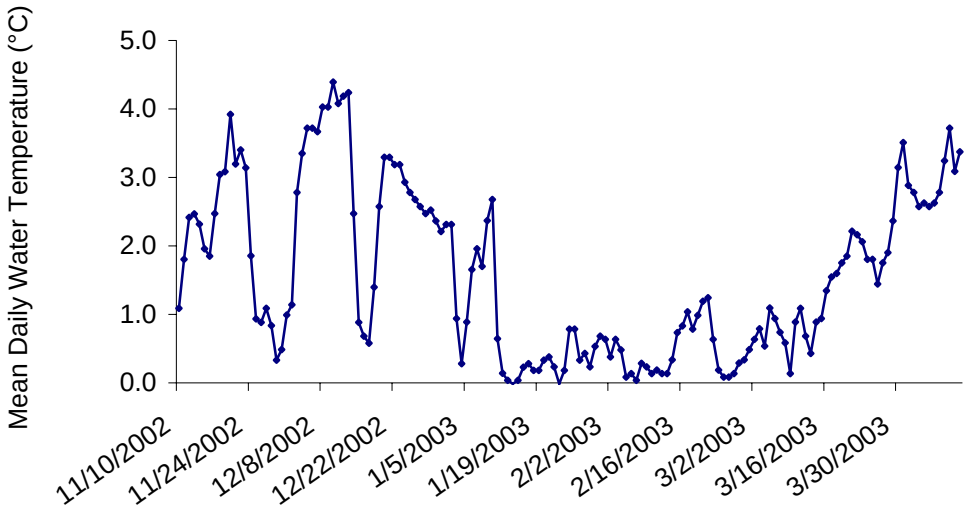

Figure 10. Mean daily water temperature (°C) of Smith Creek, Idaho from November 10, 2002 to April 11, 2003.

From November 9, 2002 through April 11, 2003, upper Summit Creek had an overall mean water temperature of 1.3°C (Figure 11). On November 22, 2002, the mean daily water temperature was 3.8°C, but the warmest recorded water temperature of 5.7°C occurred on March 31, 2003. The lowest recorded water temperatures occurred between December 30, 2002 and January 27, 2003, with the mean low being 0.05°C.

Adult Burbot Sampling

Total Catch

Hoop nets were fished from October 22, 2002 to April 1, 2003 for a total of 42,620 hours or 1,776 net days. A total of 367 other aquatic animals were caught, including nine other species of fish and one species of crustacean (Table 1). Catch per unit effort was 0.009 fish/net day for all species of fish while northern pikeminow were most abundant at 0.053 fish/net day.

Hoop Net Catch of Burbot

Overall, 11 burbot were caught in Idaho and British Columbia (Table 1 and 2); this does include a burbot released by SCUBA divers after freeing a net, snagged on a rock at Ambush Rock. Of the remaining ten burbot caught in the hoop nets, eight were caught at Ambush Rock. No more than one burbot was ever caught in a hoop net set. The CPUE for burbot was 0.0056 or about one burbot every 178 net days (Tables 1 and 2). The burbot were caught steadily over the field season. Only three burbot were caught in BC (Table 3). One capture occurred in the Goat River (rkm 152.7), and the other two occurred less than 3 km below the Goat River.

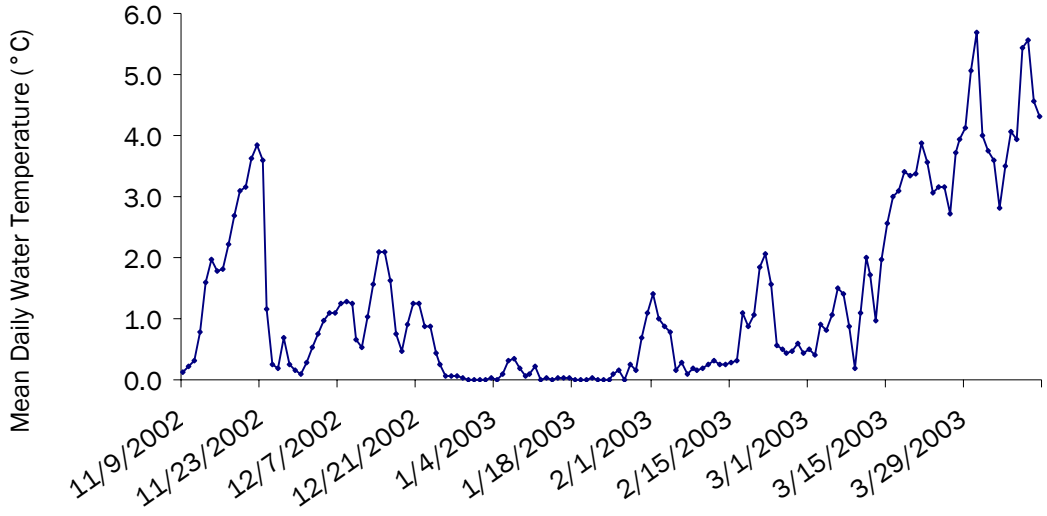

Figure 11. Mean daily water temperature (°C) of upper Summit Creek, Idaho from November 9, 2002 to April 11, 2003.

Table 1. Catch effort and total weight by species for October 2002 to April 2003 hoop net sampling in the Kootenai River (based on 1,775.8 net days of sampling effort).

Species	Total weight (g)	No. Captured	CPUE (fish/net day)
Black bullhead			
Ameiurus melas	405	5	0.003
Bull trout			
Salvelinus confluentus	1,350	1	<0.001
Burbot	15,,350[a]	11	0.006
Largescale sucker			
Catostomus macrocheilus	690	4	0.002
Longnose sucker			
C. catostomus	1,135	3	0.002
Northern pikeminnow			
Ptychocheilus oregonensis	53,360	95	0.053
Peamouth			
Mylocheilus caurinus	1,645	13	0.007
Rainbow trout			
Oncorhynchus mykiss	250	1	<0.001
White sturgeon			
Acipenser transmontanus	450	4	0.002
Yellow perch			
Perca flavescens	—	2	0.001
Crayfish			
Pacifastacus spp.	11,605	239	0.016
Total		**378**	**00.212**

[a] Includes estimated weight of burbot captured in a snagged net and released by SCUBA divers.

Table 2. Idaho Department of Fish and Game burbot captures and catch per unit effort in the Kootenai River, Idaho and British Columbia 1995-2003.

Sample Year (Fall-Spring)	No. Burbot Captures	Total Net Days	CPUE (fish/net day)
1995-1996	28	507.0	0.055
1996-1997	23	1,048.33	0.022
1997-1998	42	1,214.44	0.035
1998-1999	44	1,441.63	0.031
1999-2000	36	1,669.07	0.022
2000-2001	73	2,122.87	0.034
2001-2002	17	1,484.44	0.011
2002-2003	10	1,775.85	0.006
Total	**273**	**11,263.59**	**0.024**

[a] Does not include a burbot released by SCUBA divers after freeing a net, because the net was stuck. It was not known if the effort was hindered, thus this fish is not included.

Table 3. Idaho Department of Fish and Game Kootenai River burbot captures and catch per unit effort by river sections, 2002-2003.

Sample year	No. burbot captured	General location	River kilometer	Total days	CPUE (fish/net days)
Fall 2002–Spring 2003	3	1	120 to 152.9	646.5	0.0046
	0	2	153.0 to 169.9	64.7	0
	8	3	170+	1064.6	0.0066
Total	**11**			**1,775.8**	**0.0056**

[a] Does not include a burbot released by SCUBA divers after freeing a net.

Length and weight measurements were made on all burbot with the exception of the burbot released by SCUBA divers. Burbot total length (TL) ranged from 352 to 764 mm, and weight (g) ranged from 300 to 3,300 g (Table 4).

There were no recaptured burbot during the 2002-2003 season. One female burbot caught at Ambush Rock (rkm 244.5) on February 28 had eggs flowing.

Burbot Telemetry

Five burbot were tagged with transmitters during the 2002-2003 field season, two with sonic tags and three with radio tags. In addition, two transmittered burbot, #234 and #255, had been tagged in the 2001-2002 field season and were also monitored during the 2003-2003 season (Appendices 1, 2, and 3) for a total of seven burbot with transmitters. An eighth burbot, #232, was also tagged the previous field season, but the transmitter never moved from rkm 144.5 and was considered a shed sonic tag. The five burbot tagged in the 2002-2003 season had short-term transmitters (Table 4 and Appendices 4, 5, and 6).

During the 2002-2003 field season, burbot #234 was initially tracked at rkm 146.5 from September through December 2002. In January, the burbot began moving upstream and stopped just above the Goat River at rkm 154.8. There were weekly micromovements downstream to rkm 154.0 and 150.2 from January 9 to February 1, 2003, but this burbot remained primarily at rkm 154.8. It was last tracked at the mouth of the Goat River on February 8, 2003 and eventually was believed to have entered the Goat River.

Table 4. Hoop net capture of all burbot caught from October 22, 2002 to April 1, 2003. Eleven burbot were caught in the Kootenai River. Eight were caught at Ambush Rock in Idaho, and three were caught near the Goat River in BC, Canada.

Fish #	Recapture	Capture Date	Capture Location (rkm)	Release Date	TL (mm)	WT (g)	Notes
265	No	11/19/02	244.5	11/20/02	559	1300	50-day radio tag
266	No	11/28/02	244.5	11/29/02	628	1550	50-day radio tag
267	No	01/02/03	150.1	01/03/03	492	750	50-day radio tag
268	No	01/14/03	150.2	01/15/03	454	800	5-month sonic tag
269	No	01/19/03	244.5	01/19/03	764	3300	5-month sonic tag
270	No	02/26/03	152.7	02/26/03	744	2600	Caught in the Goat River, possibly a spent fish.
271	No	02/28/03	244.5	02/28/03	616	1750	Female with flowing eggs
272	No	03/07/03	244.5	03/07/03	592	1400	
273	No	03/11/03	244.5	03/11/03	352	300	
283	No	03/18/03	244.5	03/18/03	490	800	
N/A	N/A	03/22/03	244.5	03/22/03	N/A	N/A	Caught in hoop net retrieved by SCUBA divers; no measurements were taken; excellent shape.

Burbot #255 was initially marked in September at Krauss Hole (rkm 207.0) in Idaho, but then moved downstream and remained in British Columbia for the remainder of the field season. This burbot was very mobile and was tracked above and below the Goat River frequently. On January 23 and 25, 2003, it was believed to be in the Goat River. On January 15, 16, and 21, this burbot was in the same hole as burbot #234. From February 8-28, 2003, burbot #255 was in the mainstem Kootenai River immediately near the Goat River. In March and April, the burbot then moved two river kilometers downstream.

The three burbot fitted with externally attached radio transmitters had technical problems associated with the radio transmitters, and the burbot were extremely difficult to relocate. Two of these fish were caught and subsequently tagged at Ambush Rock (rkm 244.5). Fish #265 and #266 were tagged in November 2002. Burbot #265 was only relocated two more times after being released. Burbot #266 stayed at Ambush Rock from November 28 to January 3, 2003 but was never relocated after the latter date. The third radio-transmittered burbot, #267, was tagged on January 3, 2003 at rkm 150.1. The radio transmitter malfunctioned and was never relocated.

The two burbot that had short term sonic transmitters attached externally were also difficult to locate. Burbot #268 was initially tagged at rkm 150.2 on January 14, 2003. This burbot moved upstream as far as rkm 151.0 on January 21, then began moving slowly

downstream. It was last tracked at rkm 139.0 just below Summit Creek on February 1, 2003 and was never encountered again.

The second burbot fitted with an external sonic transmitter, #269, was initially tagged at rkm 244.5 (Ambush Rock) on January 21, 2003. It remained in the Ambush Rock area until January 28, when it began moving slowly downstream. It remained at the Shorty's Island area (rkm 230-233) from February 20 to March 8. It was last tracked at rkm 231.2 on March 8, 2003.

Larval Sampling

Three paired ½ meter net tows were made in May 2003 in the Kootenai River to capture larval burbot. Tows were made below Deep Creek (rkm 240.5) and at Ambush Rock (rkm 244.5), and the tows were approximately 30 minutes apiece and sampled about 10,710 m^3 of water. No larval burbot were captured in the larval tows.

DISCUSSION

Burbot Spawning Status

Accomplishment of our objectives during the winter of 2002-2003 was limited because of the low number of burbot captured and because flow conditions precluded a meaningful assessment of spawning migration. Only 11 burbot were caught. The low sample size prohibited plasma steroid analysis, complete monitoring of burbot by telemetry was inadequate, and mark and recapture for population estimates and demographic analysis was inadequate. We believe our low catch success during the winter of 2002-2003 reflects the diminishing numbers of burbot in the Kootenai River. In comparison to other sampling years, our CPUE of 0.006 burbot/net d is only 25% of the average of 0.024 for all years of study (Table 2).

We captured a single burbot in 2002-2003 that provided further circumstantial evidence that there was reproduction during the winter of 2000-2001 (Kozfkay and Paragamian 2002). This burbot of 352 mm TL was among the smallest captured since sampling began in 1993. In 2001-2002, two small burbot escaped through the web of a hoop net and were most likely evidence of successful spawning in winter 2000-2001 (Gunderman and Paragamian, in press). Partridge (1983) aged burbot in the Kootenai River using otoliths and found that age-1 and -2 fish were about 200 and 340 mm TL, respectively. Based on studies by Bernard et al. (1991), burbot can be caught in hoop nets at about 350 mm TL but are not fully recruited until 450 mm TL. Thus, we believe the three small burbot were most likely from the 2001 year class. Drought conditions during the winter of 2000-2001, when flows were usually below 200 m^3/s, created favorable conditions for burbot spawning (Kozfkay and Paragamian 2002). Continuation of low flows during winter will benefit burbot by providing suitable flow conditions for migration and spawning (Paragamian 2000; Kozfkay and Paragamian 2002). However, high discharges in the middle of the migration, as occurred during this study (up to 740.5 m^3/s), may disrupt spawning migrations.

We believe high fluctuating flows from Libby Dam have continuously disrupted burbot migrations (Paragamian 2000) and may be responsible for the failure of spawning. The use of plasma steroid analysis appeared to be an efficient method to address this question (DiStefano et al. 1997). Analysis during the winter of 2000-2001, when we found evidence of burbot spawning, suggested a normal trend in the temporal reduction in each of the three plasma

steroids (Kozfkay and Paragamian 2002). These results further substantiate that under the low flow conditions prevalent in 2000-2001, male and female burbot were able to mature, migrate, and spawn. Unfortunately, the 2002-2003 sample size precluded valid statistical analysis. We believe that under the circumstances, the objective of the effect of changes in river temperature and flow on burbot reproductive fitness should be carried out in a controlled laboratory environment.

Temperature Changes in the Kootenai River

Results of our 2002-2003 temperature records were similar to the warmer water experienced the previous season. As a result, the limited movement of burbot in November through early January 2003 may have been influenced by the warmer winter water temperatures of 2002-2003. Mean daily water temperature in the Kootenai River ranged from 1 to 8°C from November 2002 through mid February 2003. Temperatures in the Goat River were much cooler, ranging from about 0 to 6°C but about 0 to 2°C during December and January. The coldest temperatures did not occur until late February and March 2003 in the Kootenai River, when temperatures were about 1°C. Water temperature at the same time period during the winter of 2000-2001 was about 4°C cooler, ranging from 0 to 4°C, and burbot were thought to be more active earlier in that season. Burbot in the Kootenai and the Goat rivers are believed to spawn the last week in January and the first two weeks of February (Paragamian 2000). In 1999-2000, flows and temperatures were also high. Mean daily water temperature in the Kootenai River ranged from a maximum of 12.4°C for October 9, 1999 to a minimum of 2.4°C for February 22, 2000. There was no evidence of spawning that winter. The importance of post-Libby Dam water temperature and burbot spawning is an unresolved question regarding their decline. Our understanding could be enhanced with a well-designed laboratory study.

Burbot Population Status and Fishery

Our total capture of 11 burbot in 2002-2003 was the lowest catch of the nine years of this investigation, despite our increased sampling effort over most previous years of study and effort in locations where burbot were more abundant (Appendices 7 and 8). Since this study began in 1993, our best estimate of total population size was 540 burbot, calculated in 1998-1999 (Paragamian and Whitman 2000) when our mark and recapture effort was more evenly distributed than other years of study. Since the beginning of this investigation in March of 1993 through November of 2002, 284 burbot have been captured, of which 61 were recaptures, for a total of 277 different fish. Some burbot have been recaptured up to five times.

Because the goal of this research effort is to restore fisheries to historic pre-dam levels, target catch rates for a burbot sport fishery should be a requisite part of any proposed Conservation Agreement. Since we do not have a clear understanding of what the long-term productivity of the Kootenai River basin is with respect to burbot, even if the winter flow issue is resolved, it is difficult to establish biologically defensible catch rates at this time. However, if we examine historic catch rates from the basin or catch rate data from other basins with environments ranging from pristine to highly disturbed, we can at least get a sense of the range of possibilities.

The burbot fishery has been closed for almost a decade in the Kootenay River in Idaho and about half as long in the river and lake in BC. There were no formal creel surveys in the Kootenai River in Idaho prior to Libby Dam but there were on Kootenay Lake (Paragamian et al.

2000) and the Kootenai River, Idaho (Partridge 1983; Appendix 9). Annual harvest of burbot from Kootenay Lake by sport fisherman ranged from 2,300-26,400 burbot each year (1967-1973) with catch rates ranging from 0.28 to 1.00 burbot/h (Appendix 9). Shortly after completion of Libby Dam there was still a nominal fishery in the Kootenai River, Idaho in 1981 with Partridge (1983) estimating a combined catch of 250 burbot by sturgeon and burbot anglers, making the Kootenai Lake and river fishery one of the most robust in North America (Appendix 9).

Burbot fisheries in North America vary substantially from <0.01 fish/h and very low harvest numbers (Arrow and Moyie Lakes, BC; Hauser Lake, Montana, etc.) to excellent fisheries such as Moosehead Lake, Maine with an annual harvest of 2,200-7,100 burbot. Annual harvests of burbot in Alaskan Rivers varies, but harvests range up to almost 3,000 fish (Appendix 9). The great variability in angler harvests of burbot among watersheds exists for many bodies of water and may differ for many reasons (Quinn 2000). For example, it is common practice to set goals for one watershed based upon what we observe in another that that may or may not be ecologically similar. However, until we understand all the factors that limit burbot productivity in the Kootenay basin and have a Conservation Plan in place to address productivity issues, we have no basis for comparisons with other watersheds other than having a target. Without vital statistics of a viable Kootenai River burbot population, preliminary goals for a burbot harvest after ecosystem rehabilitation would be satisfactory if they were similar to the Tanana River, Alaska, and catch rates were at least 0.28 fish/h.

One useful measure of a system's capability of supporting a viable burbot fishery may be zooplankton abundance. Zooplankton are an important food for young burbot (McPhail and Paragamian 2000) and may be an additional limiting factor to burbot rehabilitation in the Kootenai River. It may be instructive to compare the zooplankton abundance of burbot lakes with self-sustaining and fishable populations to that of the Kootenai River and Kootenay Lake. This information would be useful in establishing target goals for improved productivity of the Kootenai River in Idaho and the South Arm of Kootenay Lake (where burbot may be rearing) when an artificial lake or river fertilization program is initiated (Hardy, in progress).

Recommended Flows for Burbot Migration and Spawning

Until a study of the relation between specific levels of flow from Libby Dam and burbot spawning migration can be successfully completed, the best available recommendation for flow will continue to rely on the studies of Paragamian et al. (in progress). As a result of these studies, it was recommended flow for burbot prespawning migration 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).

RECOMMENDATIONS

1. We recommend a burbot prespawning migration and spawning flow 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, 2003 and extending through February 15, 2004. 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 flows.

2. Under laboratory conditions, monitor physiological condition and reproductive fitness of burbot by testing the effect of high velocities (>25 cm/s) and elevated winter temperatures on blood chemistry by measuring the level of testosterone, 11 ketotestosterone, and 17β estradiol and compare these to a control.

3. Collect zooplankton samples from nearby lakes with self-sustaining burbot fisheries to develop target goals for fertilization and productivity studies; e.g., Moyie, Trout, Duncan, and Columbia lakes.

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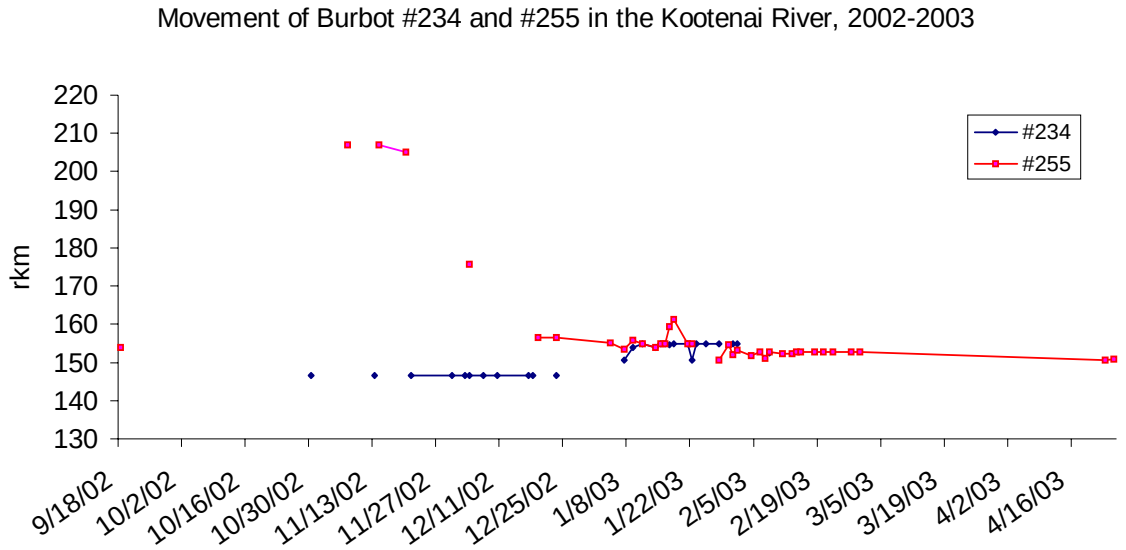
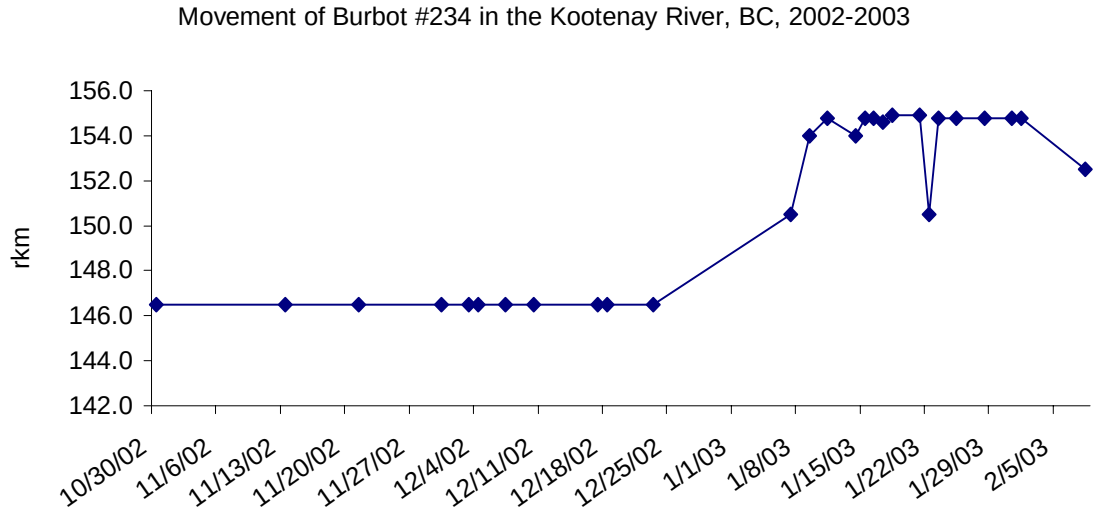
APPENDICES

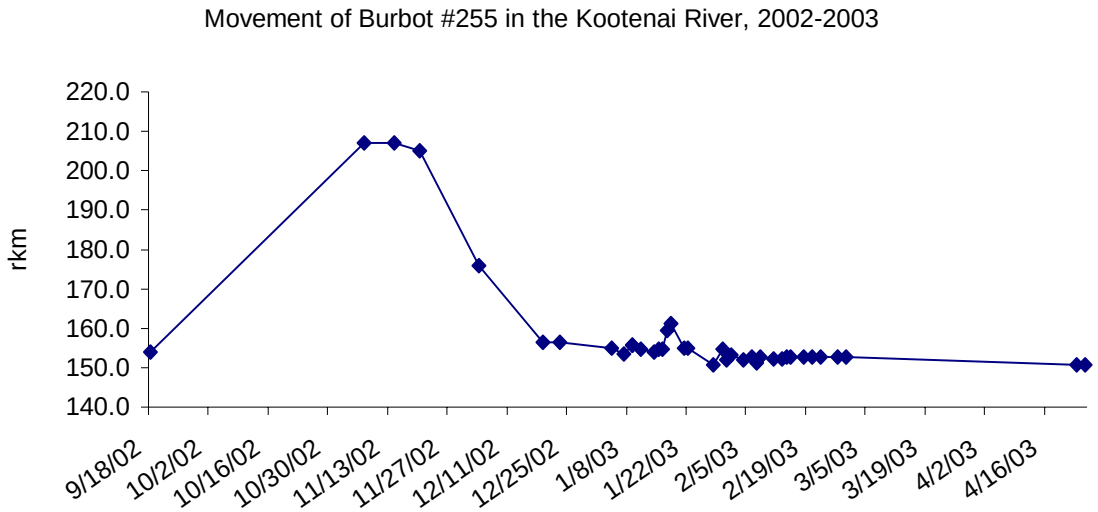
Appendix 1. Movement of burbot #234 and #255 in the Kootenai River in Idaho and BC. Note these two fish were at the same location in January. Fish #234 was last tracked in the mouth of the Goat River.



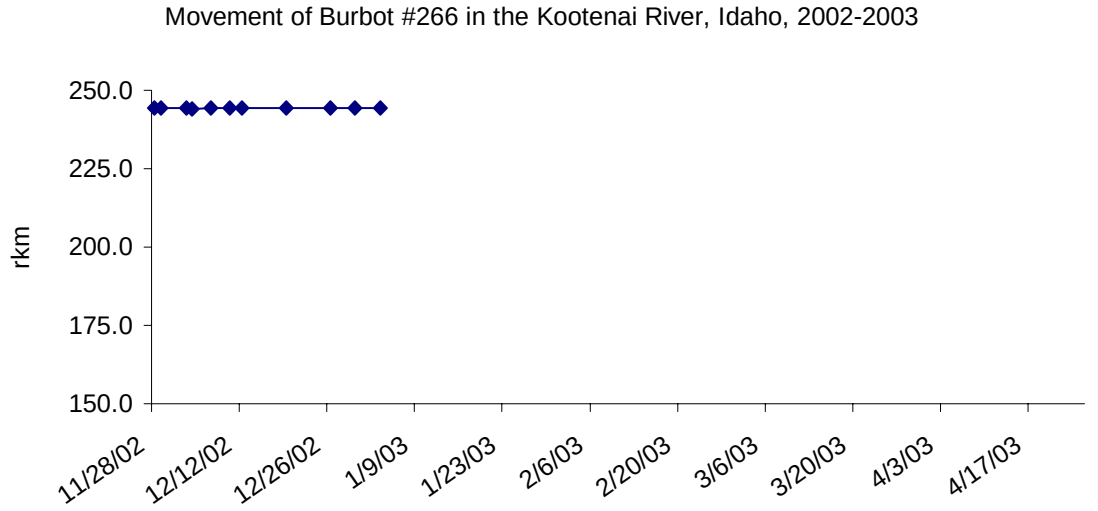
Appendix 2. Movement of burbot #234 in the Kootenay River in British Columbia from October 2002 through March 2003.



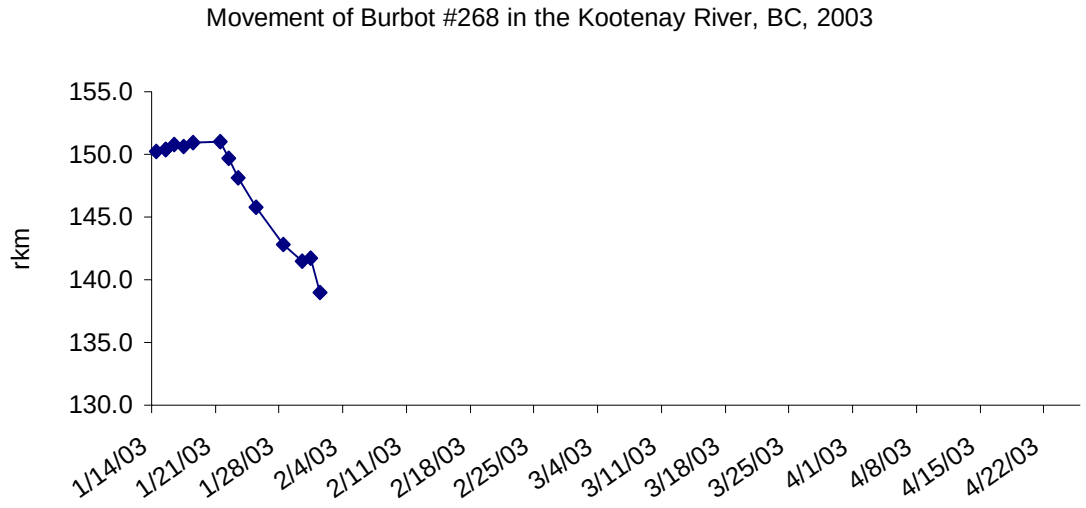
Appendix 3. Movement of burbot #255 in the Kootenai River in Idaho and British Columbia from September 2002 through April 2003.



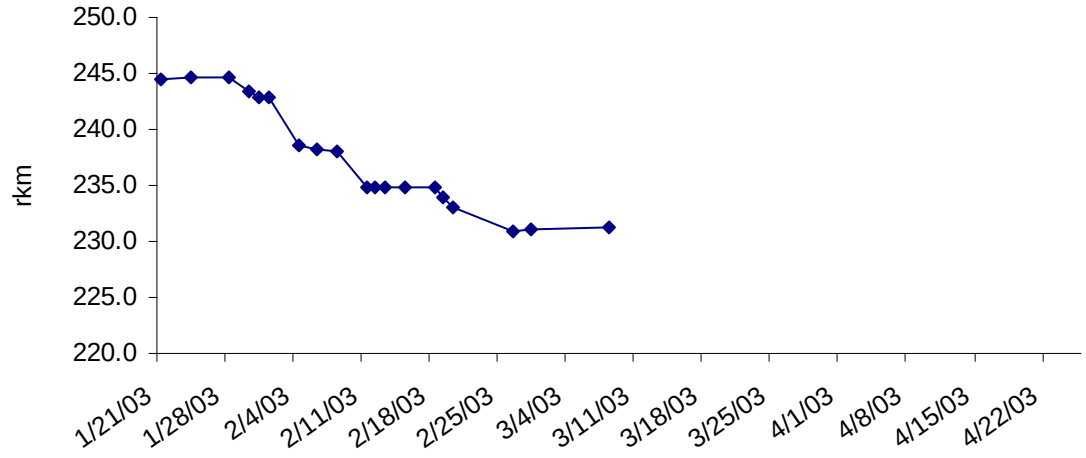
Appendix 4. Movement of burbot #266 in the Kootenai River in Idaho from November 2002 through January 2003.



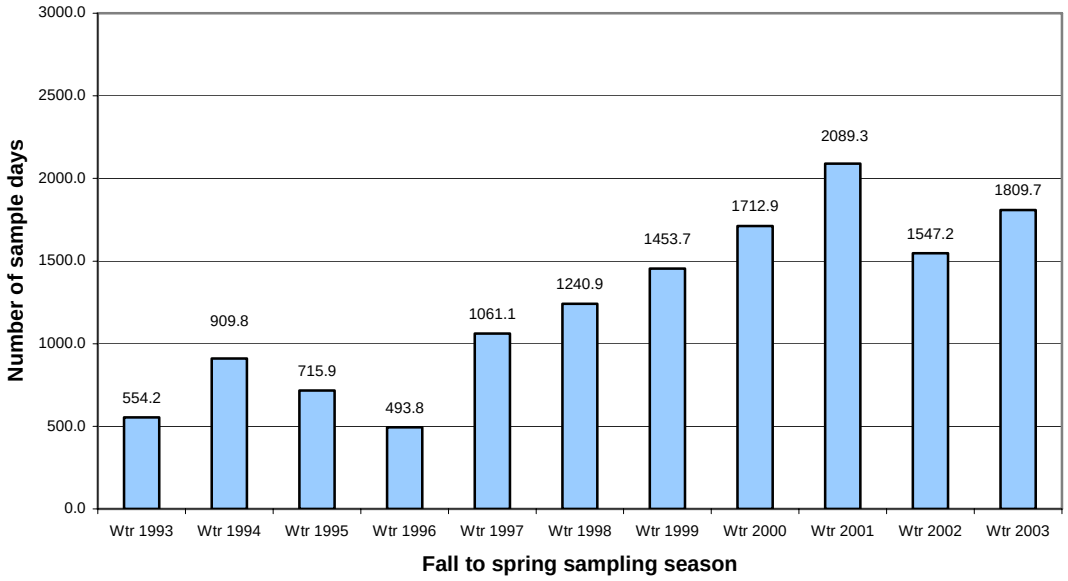
Appendix 5. Movement of burbot #268 in the Kootenay River in British Columbia from January through February 2003.



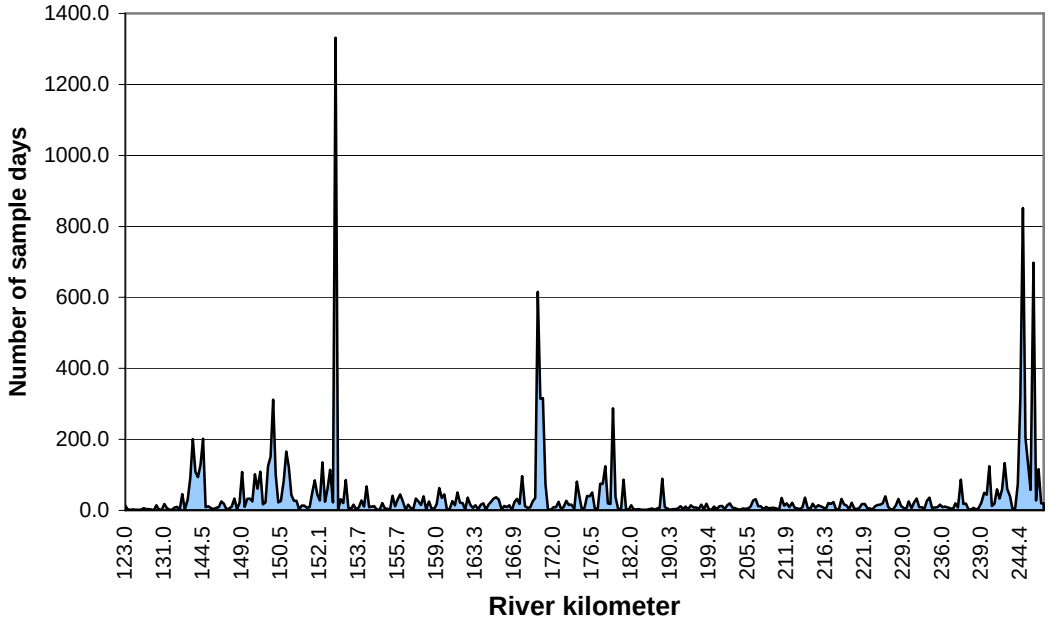
Appendix 6. Movement of burbot #269 in the Kootenai River in Idaho from January through March 2003.



Appendix 7. Total hoop net sampling effort by year (1993-2003) for the Kootenai River in Idaho and British Columbia.



Appendix 8. Days of sampling effort by river kilometer for all seasons, 1993-2003, Kootenai River in Idaho and British Columbia.



Appendix 9. Harvest numbers and rates for burbot fisheries in North America, from published and unpublished documents and personal communication. Some data was not available (NA).

Water	Size of Water (ha)	Annual Harvest Number of Burbot	Harvest Rate N/ha	Harvest Rate Kg/ha	CPUE (Number/h)	Angling Pressure (h)	Year	Source
Columbia Lake, BC	2,574	42-406	0.02-0.19	0.02-0.15	0.08-0.54 (per month)	171-989	1995-2001[a]	Arndt, S.: Summary of winter creel surveys for Columbia and Windermere lakes from 1995-2001.
Windermere Lake, BC	1,584	6-26	0.02	0.01	0.0-0.03	601-2,467	1995-1997[a]	
West Arm Kootenay Lake, BC	30,000	2,300-26,400	NA	NA	0.28-1.00	6,900-26,400	1967-1973[b]	Andrusak 1974
Arrow Lakes, BC	46,450	140 98	NA NA	0.005 0.003	0.49 1.02	NA NA	1998[c] 1999[c]	Arndt, S., Arrow Lakes Reservoir creel survey and contribution of hatchery production in 1998 and 1999.
Arrow Lakes, BC	46,450	94	NA	NA	NA	NA	1995[c]	Thorp: In Arndt 2001
Shelter, Nakusp, and Castlegar bays of Arrow Lakes	NA	146-532	NA	NA	0.5-1.0	NA	1998-2002[c]	Arndt, Steve: Personal communication
Lake of the Woods, MN[d]	384,627	82,565-400,330[e]	NA	0.10-1.04	NA	—	1930-1972[c]	K. Muth and L. Smith Jr.: The burbot fishery of Lake of the Woods:
Leech Lake, MN	45,152	957	0.02	0.05	<0.001	1,195,683	1991-1992[c]	Haukos, N. A.
		147[f]					1983-1991[c]	
		822	0.02	0.03	NA	NA	Feb. 15-17, 2002	Haukos, N. A. Leech Lake Eelpout Festival, primarily Walker Bay
		470[g]	NA	NA	NA	NA		
Hauser Lake, MT	NA	1-7	NA	NA	<0.01	NA	1996-2001	Jones, Melissa: Personal communication
Helena Valley Lake, MT	NA	1-2	NA	NA	<0.01	NA	1998-2000	Jones, Melissa: Personal communication
Mainstem Tanana River, AK	NA	0-2,948	NA	NA	NA	NA	1977-1990	M. J. Evenson and P. Hansen: Assessment of harvest characteristics of the Tanana River sport fishery in 1990 using postal questionnaire
Lower Tanana River tributaries, AK	NA	0-175	NA	NA	NA	NA	1977-1990	
Middle Tanana River tributaries, AK	NA	0-2,065	NA	NA	NA	NA	1977-1990	Same citation as above
Upper Tanana River tributaries, AK	NA	0-221	NA	NA	NA	NA	1977-1990	Same citation as above

Appendix 9. Continued.

Water	Size of Water (ha)	Annual Harvest Number of Burbot	Harvest Rate N/ha	Harvest Rate Kg/ha	CPUE (Number/h)	Angling Pressure (h)	Year	Source
Total for Tanana River, AK drainage	NS	1,311-4,854	NA	NA	NA	NA	1977-1990	
All of Alaska	NA	7,302-27,230	NA	NA	NA	NA	1977-1990	Mills, M. J.: 1979-1991 Alaska statewide sport fish harvest studies
Moosehead Lake, ME	30,308	2,200-7,100	0.7-0.23	0.3-0.17	NA	NA	1985-1999	Scott, Roy: Unpublished
Moose/Tulsona lakes, AK	260	21-684[h]	0.08-2.63	NA	NA	NA	1987-1997	Taube 2000
Susitna/Tyone lakes, AK	4,205	42-684[h]	0.01-0.18	NA	NA	NA	1987-1997	Taube 2000
Louise Lake, AK	6,529	261-998[h]	0.04-0.15	NA	NA	NA	1987-1990	Taube 2000
Harding Lake, AK	1,000	0-420[h]	0.00-0.42	NA	NA	NA	1983-1998	Taube 2000
Moyie Lake, BC		27[g] (3 others released)	NA	NA	NA	NA	Jan. 26-Feb. 23, 2002[a]	Andreashuk, Kenton: Personal Communication
Kootenay River, BC	NA	9	NA	NA	0.02	436	1962	Anonymous, 1966 (Kootenay River in BC, above Lake Koocanusa)
	Na	37	NA	NA	0.09	428	1963	
Kootenai River, Id	NA	250[h] 179[i]	NA	NA	NA	NA	1981	Partridge, 1983
Lake Superior	NA	43[j]	NA	NA	NA	NA	1980-1990	Schram, 2000

[a] Winter creel
[b] Spring creel
[c] Annual creel
[d] Commercial harvest in Minnesota waters only
[e] Kg
[f] Spear fishery
[g] Unexpanded creel
[h] Estimated
[i] Actual catch
[j] Estimated minimum exploitation of 3.9% of 1,112 tagged and at large for one to 11 years.

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