Kootenai River Fisheries Investigations

Stock Status of Burbot

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KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

ANNUAL REPORT 1996

Period Covered: January 1, 1996 to December 31, 1996

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ABSTRACT

The main theme of the 1996 burbot *Lota lota* study was to test the hypothesis that winter discharge for power production/flood control inhibits burbot migration to spawning tributaries. There were to be two to three minimum discharge (113 m^3/s) periods from Libby Dam of approximately five days duration during December 1995 and January 1996. However, exceptionally heavy precipitation and an excessive amount of water stored in Lake Koocanusa created near flood conditions in the Kootenai River. These high flows prevented a controlled test. But we captured 27 burbot in the Kootenai River, Idaho and the Goat River, British Columbia, Canada. Burbot catch from November 1995 through March 1996 averaged 0.055 fish/net-day. Captured burbot ranged from 396 to 830 mm total length and weighed from 400 to 2,800 g (mean = 1,376 g). One burbot was captured at rkm 170 (the Idaho-Canada border) in mid-March after the spawning season. Nine burbot were implanted with sonic transmitters and released at the Goat River capture location. Two additional burbot had active transmitters from the previous season. Telemetry of burbot during the pre-spawn, spawning, and post-spawning periods was conducted. Burbot were located a total of 161 times from September 1, 1995 through August 31, 1996. Ripe burbot were captured at the mouth of the Goat River during February.

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INTRODUCTION

Burbot *Lota lota* once provided an important winter fishery in the Kootenai River to residents of northern Idaho (Paragamian 1994). Some anglers reported catching over 40 burbot a night during winter setline fishing (Paragamian 1994). The annual harvest of burbot from the Kootenai River by sport and commercial fishermen was estimated at approximately 22,700 kg (50,000 lbs) (Ned Horner, Idaho Department of Fish and Game, personal communication). Burbot caught during the winter fishery are thought to have been part of a spawning migration from the lower river and Kootenay Lake, British Colombia, Canada. However, after construction and operation of Libby Dam at Libby, Montana, began in 1972 (Figure 1), the fishery gradually declined until it was closed in the early 1990s. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, British Columbia (Paragamian 1993). Libby Dam has caused major changes in the hydrograph (Figure 2), temperature regime, and nutrient supply of the Kootenai River (Paragamian 1993, 1994, 1996; Snyder and Minshall 1996).

Preliminary study of burbot in the Kootenai River began in 1978 (Partridge 1983) but was secondary to a white sturgeon *Acipenser transmontanus* project. Partridge's study documented abundance, movement, harvest, and age structure of burbot. The Kootenai River Fisheries Investigations was a follow-up to Partridge's work. The Kootenai River Fisheries Investigation was initiated in 1993 and was designed to address burbot abundance, distribution, size structure, reproductive success, movement, and to identify factors limiting burbot in the Kootenai River. Few were found between rkm 244 and the Montana border (rkm 275). There has been little evidence of reproduction in Idaho. Only one juvenile burbot was captured from 1993 to 1996, and no larval fish have been collected. However, numerous age groups of fish were apparent in the net catch indicating burbot were spawning somewhere. Sampling for burbot during the winter at the mouths of Idaho tributaries was carried out in anticipation of intercepting a spawning run of fish from Kootenay Lake. Winter sampling during 1994-1995 produced no burbot. Also, a sport fishery survey in 1993 indicated they were no longer present in the anglers catch (Paragamian 1994).

Sonic telemetry of burbot during the winters of 1994-1995 and 1995-1996 indicated high velocities (>24 cm/s) produced during power production may be inhibiting spawning migration to Idaho. Ripe burbot were captured at the Goat River but few burbot were caught upstream, and no burbot have been captured or tracked upstream into Idaho waters before the end of the spawning season.

STUDY AREA

The Kootenai River is in the upper Columbia River drainage (spelled Kootenay for Canadian waters). It is the second largest tributary to the Columbia River. Originating in Kootenay National Park, British Columbia, the river flows south into Montana where Libby Dam impounds water back into Canada forming Lake Koocanusa (Figure 1). From Libby Dam the river turns west 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.

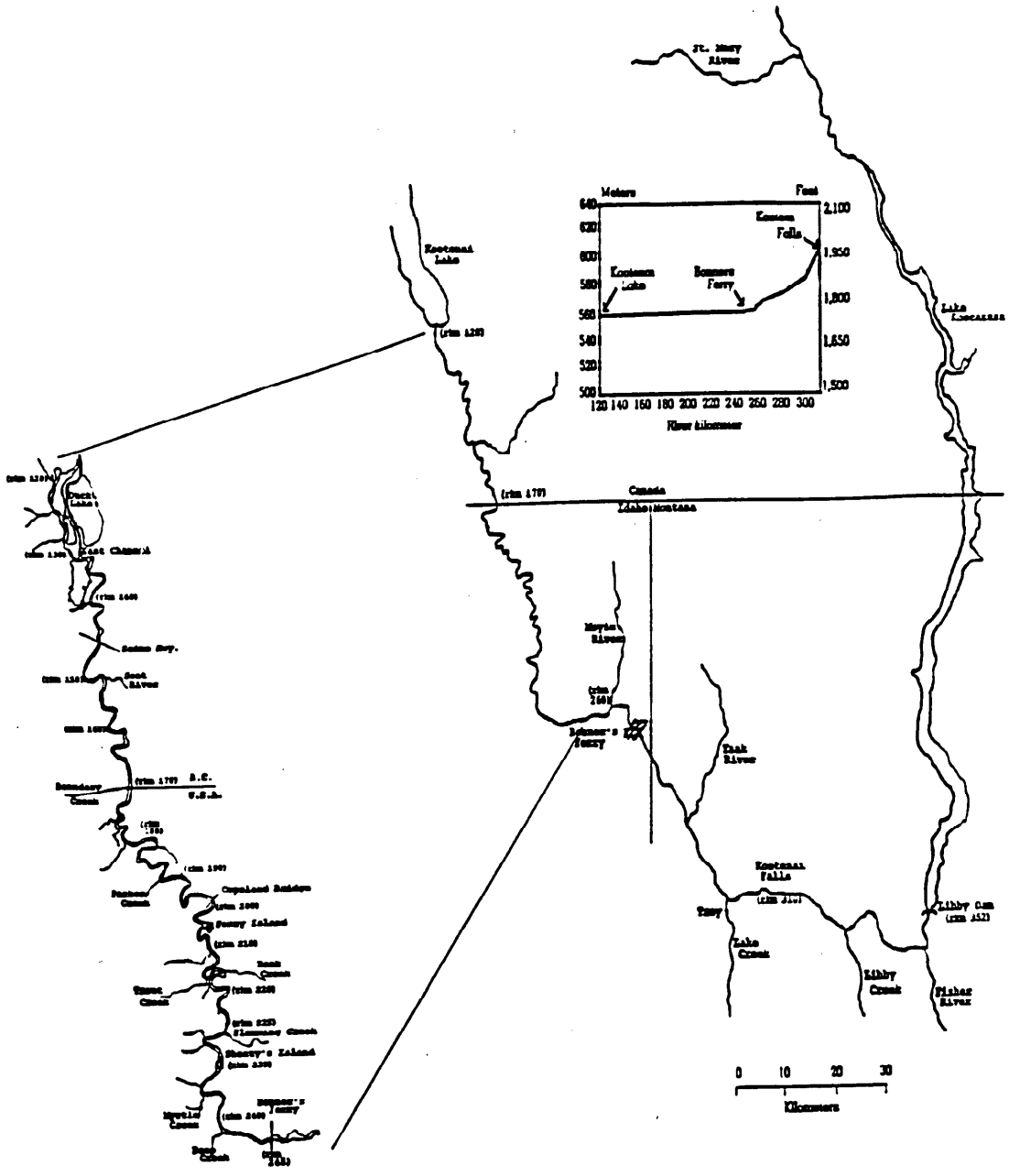

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries in Idaho. The river distances are in river kilometers (rkm) and are indicated at important access points.

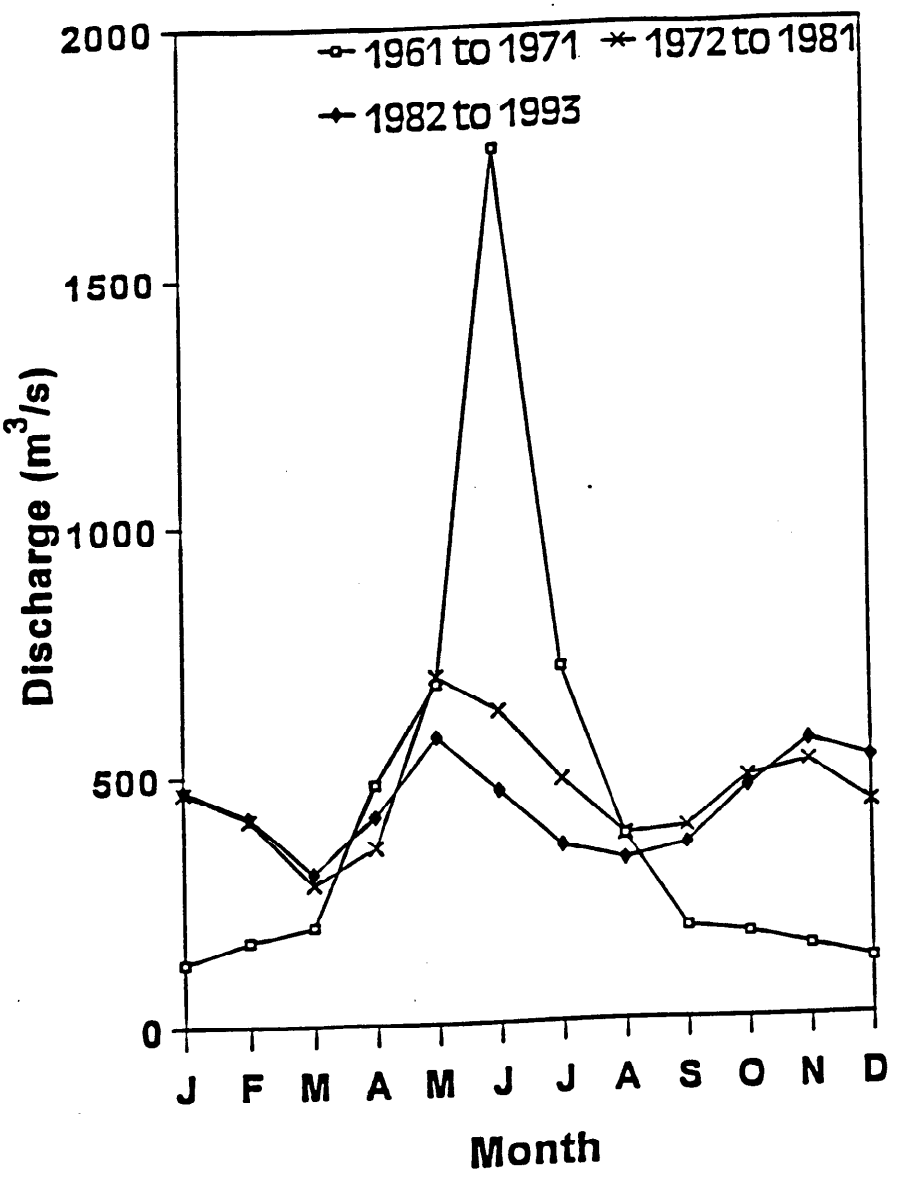

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho, from 1961 through 1971 (pre-Libby Dam), from 1972 through 1981, and 1982 through 1993 (post-Libby Dam).

The Kootenai River presents three different channel and habitat types as it passes through Idaho. As the river enters Idaho it is typified by steep canyon walls and a gradient of about 0.6 m. The river channel becomes a braided reach several km above Bonners Ferry. At Bonners Ferry, the river changes to a lower gradient of about 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. Most of these tributary streams have been channelized at their lower reach and leveed to accommodate the Kootenai River levees.

GOAL

To restore burbot populations 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 fisheries to self-sustainable levels.

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

METHODS

Sampling Adult Burbot

We sampled burbot in the Kootenai River in Idaho and British Columbia (rkm 120 to 178) in anticipation of intercepting burbot moving from Kootenay Lake and the lower river to their historic spawning areas in Idaho and British Columbia. Burbot were sampled with two to seven hoop nets of two sizes from November 6, 1995 through April 1, 1996 (for a description of the nets and method of deploying them see Paragamian 1995).

Nets were checked every 24 to 72 h. Fish captured in hoop nets were identified, enumerated, measured in total length (TL), and weighed. All burbot were Passive Integrated Transponder (PIT) tagged in the left cheek muscle and released.

Egg and Larval Sampling

We set D-ring nets (mouth area = 0.34 m^2) and drift nets (mouth area = 0.085 m^2) at the mouths of Smith and Boundary creeks and Goat River during March and April 1996. These three tributaries of the Kootenai River were sampled in an effort to capture larval burbot and eggs drifting from spawning areas. D-ring nets were set on the bottom while the smaller drift nets were deployed at the surface and various depths within the water column using anchors, ropes, and buoys to secure them in the current. An average column velocity was derived for each set location by making four, 5-min current velocity measurements using a Gurley 2030 R flow current meter. Two velocity measurements were made at 1/3 and 2/3 of the total depth, at the beginning of each set, and at the conclusion of each set. Nets were set out for 85-195 minutes, depending on the amount of debris. Effort was calculated using total set time for each net, average current velocity, and the net area to estimate the total volume of water filtered.

From March to August, four different netting methods were utilized in an attempt to capture young of the year (YOY) burbot and/or sturgeon. We towed meter nets at the surface in the Kootenai River and Kootenay Lake. We also used a shrimp trawl to sample midwater depths and D-ring nets at the bottom of the Kootenai River. Montana Department of Fish, Wildlife, and Parks (MDFWP) personnel used a beam trawl to passively sample midwater and benthic depths at several Kootenai River locations.

Burbot Telemetry

Adult burbot used for telemetry were captured with hoop nets and surgically implanted with either a 420 d or 40 d sonic transmitter (for a description of the surgical procedures see Paragamian 1995). Sonic transmitters of 420 d life expectancy were 60 mm in length, 16 mm in diameter, and weighed 8 g; while 40 d transmitters were 16 mm in diameter, 37 mm in length, and weighed 4 g. Sex of most fish was determined during the surgery, and all burbot were PIT-tagged after completion of surgery. Burbot were released at the location of capture.

Seasonal habitat use and movement of burbot were studied from September 1, 1995 through August 31, 1996. When burbot were located by telemetry, depth was measured with an echo sounder, and velocity was measured within 15 cm of the bottom using a Marsh-McBirney 201A electronic current meter.

Kootenai River Discharge, Velocity, and Temperature

Prior to the onset of burbot sampling, a conditional agreement was formulated with Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers (USACE) to provide experimental minimum flows for burbot pre-spawn migrations. Our intention was to test the hypothesis that winter discharge for power production inhibits burbot migration to spawning tributaries. There were to be two to three minimum discharge (113 m^3/s) periods from Libby Dam of approximately five days duration during December 1995 and January 1996 (Figure 3). It was hypothesized that these minimum flow periods

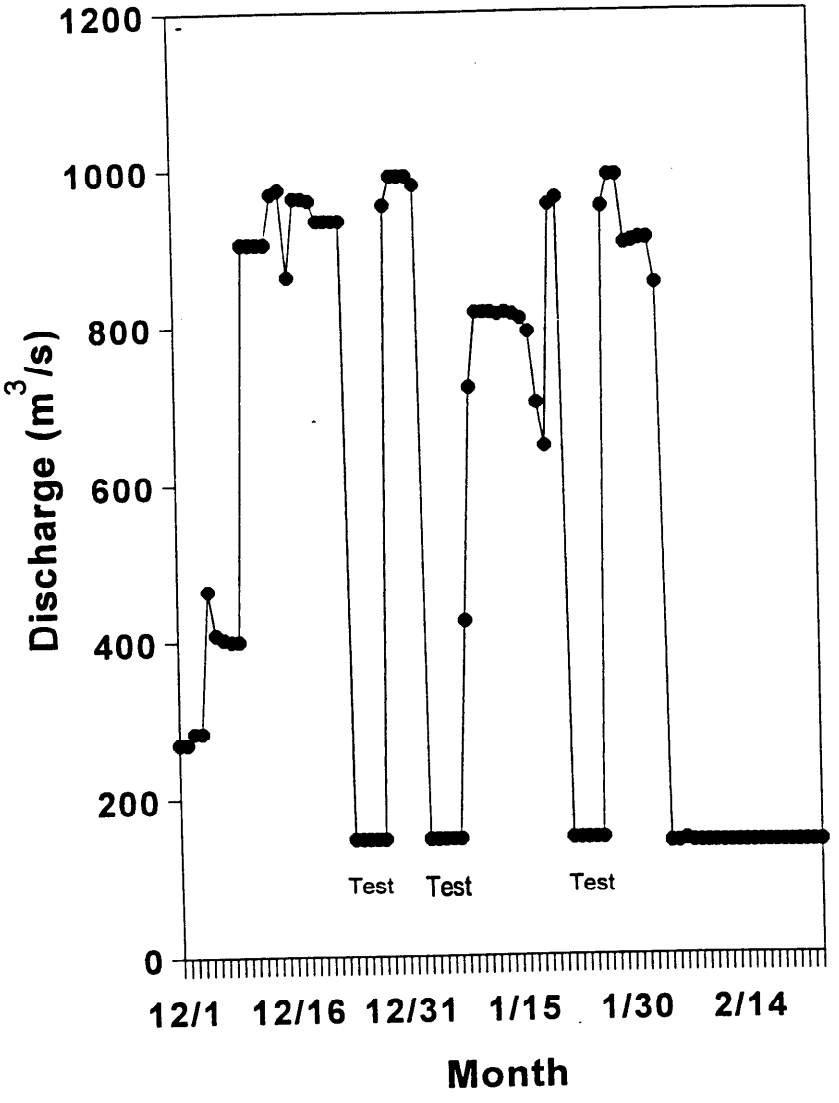

Figure 3. Proposed minimum discharges in the Kootenai River (Porthill, Idaho) to test the hypothesis that burbot migrations are inhibited during power production/flood control.

would allow burbot to move upstream by replicating pre-dam winter stream flow. In turn, it was expected that the return of power production after each minimum test flow would inhibit upstream movement or even move burbot back downstream. Daily discharge and temperature values for the Kootenai River were obtained from USACE and the U.S. Geological Survey (USGS) office in Sandpoint, Idaho. A Stowaway XI temperature logger was used to monitor daily water temperatures in Boundary Creek from December 20, 1995 to February 20, 1996, and the Goat River from March 1 until April 29, 1996.

We also studied the hypothesis that some locations in the Kootenay River may be greater velocity barriers to burbot than others. The river was segmented into three reaches based on major hydraulic controls; reach 1 - rkm 120-132 (downstream of the east channel), reach 2 - rkm 133-152 (downstream from the mouth of the Goat River), and reach 3 - rkm 153-170 (from the Goat River to the Idaho/British Columbia border at Boundary Creek). Velocities were measured during near maximum and near minimum discharge from Libby Dam. Two rkm locations within each segment were selected from a table of random numbers where velocities were measured. Velocities were measured approximately 15 cm above the river bottom using a Gurley 2030R flow meter suspended by a rope with 0.67-0.84 kg of lead weight attached. Mean bottom velocities were calculated for each randomly selected rkm based on five-minute measurements from a boat anchored at five evenly-spaced points across a transect of the river. On December 21, 1995 velocities (maximum discharge from Libby Dam) were measured at two randomly-selected Kootenay River locations in each of the three segments (for a total of six transects). Measurements of velocities at the same locations were repeated on February 16, 1996 at a much lower discharge to test for differences (ANOVA, $p=0.05$) at different discharge rates.

Archived Data

We also examined the archived burbot catch data of Partridge (1983) and discharge data from each collection year. Our objective was to determine if there was a cause/effect correlation between Kootenai River discharge and burbot catch during his study. We also contacted Paul Jeppson (former IDFG Fisheries Biologist) by phone and discussed his burbot sampling in the winters of 1957 and 1958 at Boundary Creek.

RESULTS

Hoop Net Sampling

Total Catch

We fished baited hoop nets from November 6, 1995 to April 1, 1996 for a total of 507 net days. A total of 69 fish were caught, of which 41% were burbot, 35% northern squawfish *Ptychocheilus oregonensis*, 7% were longnose *Catostomus catostomus* and largescale *C. macrocheilus* suckers, 4% were mountain whitefish *Prosopium williamsoni*, 4% were yellow perch *Perca flavescens*, and 3% were rainbow trout *Oncorhynchus mykiss,* while the remainder were comprised of one fish each of black bullhead

Ameiurus melas, pumpkinseed *Lepomis gibbosus*, cutthroat trout *O. clarki*, and bull trout *Salvelinus confluentus* (Table 1). The total catch per unit of effort (CPUE) for all fish was 0.136 fish/net-day. Burbot had the highest CPUE of 0.055 fish/net-day.

Burbot

A total of 28 burbot were captured, of which one was caught twice (Table 1, Figure 4). No burbot were captured in the British Columbia portion of the Kootenai River and only one was caught in Idaho. The remaining 27 burbot were caught at the mouth of Goat River (rkm 152) (in all likelihood these burbot came from the Kootenay River), including one which was released and recaptured. All burbot were caught over sand and/or silt substrate. The CPUE for burbot from November 1995 through March 1996 was 0.055 fish/net-day. These fish ranged from 396 to 830 mm (Figure 4) and weighed from 400 to 2,800 g (mean = 1376 g).

Burbot Spawning

No adult burbot were captured until January 29, 1996, but the capture of burbot continued sporadically through February 25, 1996. Seventeen of 27 burbot captured in the Goat River were examined and all were mature. A single mature male burbot was caught in the Kootenai River at Boundary Creek (rkm 170) on March 15, 1996.

We sampled 10,709 m^3/s of water in 72 net hours using drift nets and D-ring nets at the mouths of Smith and Boundary creeks and the Goat River in an effort to document spawning, but no eggs or larval burbot were captured. However, we did catch one non-burbot egg (possibly squawfish) and aquatic insects. Meter net tows, D-ring effort, and shrimp trawl effort reported in a companion study (Paragamian et al., in progress) failed to capture any larval or juvenile burbot.

Burbot Telemetry

Telemetry

Nine burbot captured in the Goat River were implanted with sonic transmitters; five with 40-d transmitters and the remainder with 420-d (Table 2). Two burbot that were previously implanted with sonic transmitters (Paragamian 1994) were also monitored during the 95-96 field season (Table 2). Burbot were located a total of 161 times from September 1, 1995 through August 31, 1996 (Appendices A through K).

Table 1. Hoop net catch success by number, weight (kg)[a], and catch per unit effort (CPUE)[b], Kootenai and Goat rivers, Idaho and British Columbia, November 1995 through March 1996.

Species	Number	Total weight (kg)	CPUE[b]
Pumpkinseed	1	N/A	.002
Black bullhead	1	.03	.002
Bull trout	1	N/A	.002
Cutthroat trout	1	.30	.002
Rainbow trout	2	1.20	.004
Whitefish	3	.38	.006
Yellow perch	3	.12	.006
Sucker[c]	5	3.08	.010
Squawfish	24	5.36	.047
Burbot	28[d]	38.53	.055

[a]Some totals are not complete, subfreezing weather prevented weights from being taken on some days.
[b]A unit of effort is a single 24-hour set.
[c]Species of suckers were not differentiated; longnose and largescale suckers are known to reside in the Kootenai River.
[d]One burbot was recaptured.

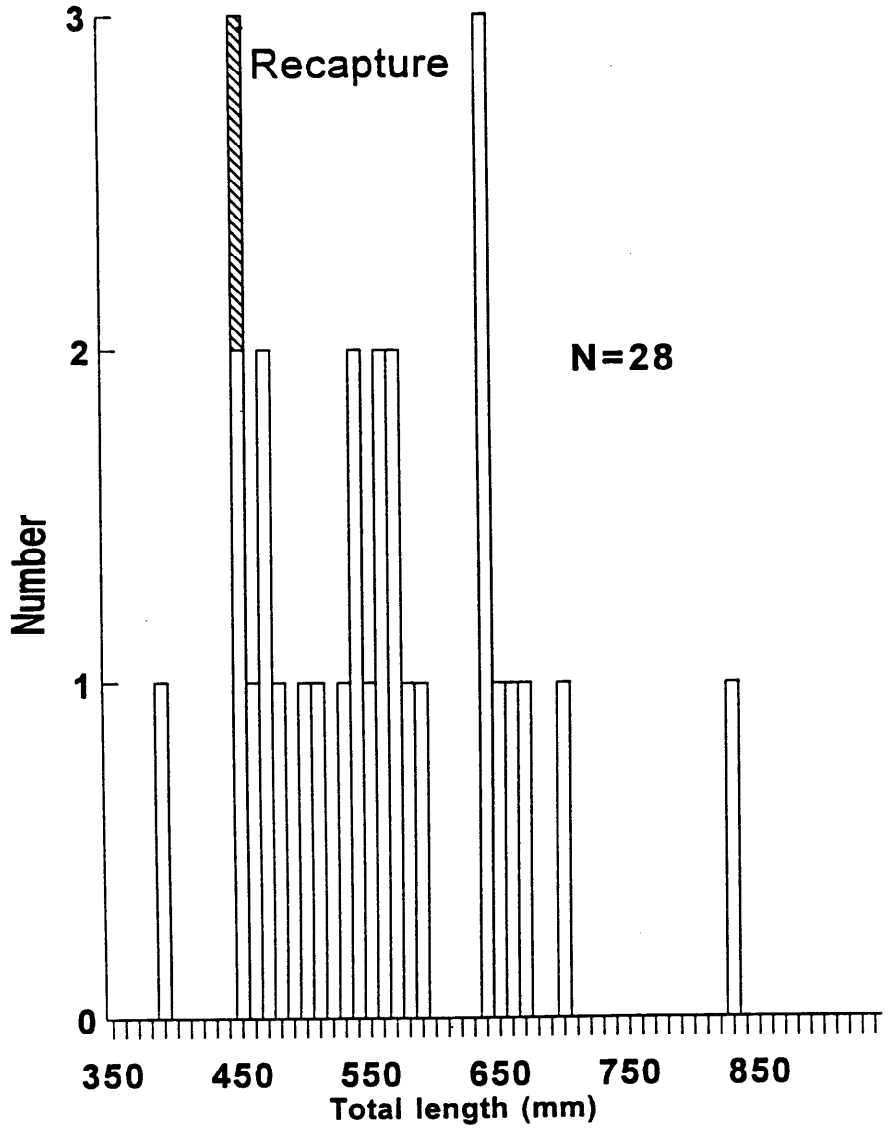

Figure 4. Length frequency distribution of burbot caught in the Goat River, British Columbia, January 1996 through March 1996.

Table 2. Summary of sonic telemetry data and physical characteristics of 11 burbot in the Kootenai River and Kootenay Lake, British Columbia, Canada, 1994 through 1996.

Sonic code	Date implanted	Total length (mm)	Weight (g)	PIT tag number	Sex	Last date located
96	06/29/94	590	1,135	7F7D0B684C	M	05/12/96
2246	02/01/95	543	1,078	34353643868	F	10/04/95
903[a]	02/13/96	830	2,800	7F7D0A373D	F	02/13/96
365	02/13/96	396	400	7F7D0D6C6C	M	09/16/96
357	02/13/96	457	650	7FD0A2409	M	09/16/96
2237[a]	02/18/96	655	2,250	7F7D0A3852	F	05/29/96
12[a]	02/20/96	560	1,000	7F7D0A407E	M	02/20/96
374	02/20/96	648	2,100	7F7D0D7748	F	09/16/96
455[a]	02/20/96	545	1,300	7F7D0D7D10	F	07/02/96
276[a]	02/20/96	703	3,100	7F7D0A3031	M	05/29/96
258[a]	02/20/96	645	2,050	7F7D0D746F	F	09/05/96

[a]Forty-day life expectancy sonic tag.

Pre-Spawn Period

Heavy precipitation during autumn 1995 through winter 1995-1996 prohibited a low flow pre-spawn migration test for burbot. Only burbot with sonic tag 96 could be monitored during the pre-spawn period (Appendix A). Burbot 96 spent the summer of 1995 in Kootenay Lake (Appendix A). In August of 1995, it reentered the river and moved upstream entering Idaho in early September and was located at Ambush Rock (rkm 244). During October 1995, it drifted 2 rkm downstream and was sedentary throughout the spawning and pre-spawning period. No other burbot could be located or captured during the pre-spawn period to monitor movement.

Temperature in the Kootenai River ranged from about 4°C to 6°C during pre-spawn (Figure 5). Discharge during the pre-spawn period at Porthill, Idaho rose from about 161.6 to 167.2 m^3/s in early October 1995 to 1,204.6 m^3/s on December 14, 1996 (Figure 6). Discharge remained high from December 1995 through January 1996.

Spawning Period

Eight burbot were monitored between February 13 and February 26, 1996 (Appendices A, D through J). All burbot implanted with transmitters during this period were ripe (Table 2). Temperature of the Kootenai River ranged from 2°C to 5°C (Figure 5). Telemetry indicated most burbot were within the confluence of the Goat River with the Kootenai River where the temperature was < 1°C to 3°C (Figure 5). None were known to move further up the Goat River during the spawning season. But telemetry upstream beyond the mouth of the Goat River was occasionally limited by ice formations.

Discharge in the Kootenai River at Porthill, Idaho, remained high during most of the spawning period (Figure 6). Discharge during the last week in January was about 765.3 m^3/s, and increased to 1,269.8 m^3/s by February 9, 1996. Discharge dropped rapidly thereafter to about 413.8 m^3/s on February 17, 1996. Reduced discharge was the result of storage of water by the USACE behind Libby Dam, in Lake Koocanusa.

Post-Spawn Period

Eight burbot were monitored during the post-spawn period which began in mid-February (Appendices A, D, through J). Burbot 96 remained in Idaho and is believed to have shed its transmitter or died in May or June 1996. Concomitant to the cessation of burbot movement was a rise in river temperature and discharge through May 8, 1996. When river temperature reached 7°C, most burbot became relatively sedentary and remained in deep pools. Discharge rapidly increased through May and June to over 1,559 m^3/s. None of the increase in river discharge was due to the Kootenai River white sturgeon test flows but to precipitation runoff (Paragamian et al., in press). All 40-d transmitters expired by July 7, 1996, but several burbot were still monitored. Burbot 2237 eventually drifted to the confluence with Kootenay Lake (rkm 121) by May 17, 1996 and remained there (Appendix F). Burbot 365 and 455 moved into the east channel of the Kootenay River about May 7, 1996. Burbot 365 remained in the east channel until September. All other burbot remained in the lower Kootenai River (rkm 130 to 136).

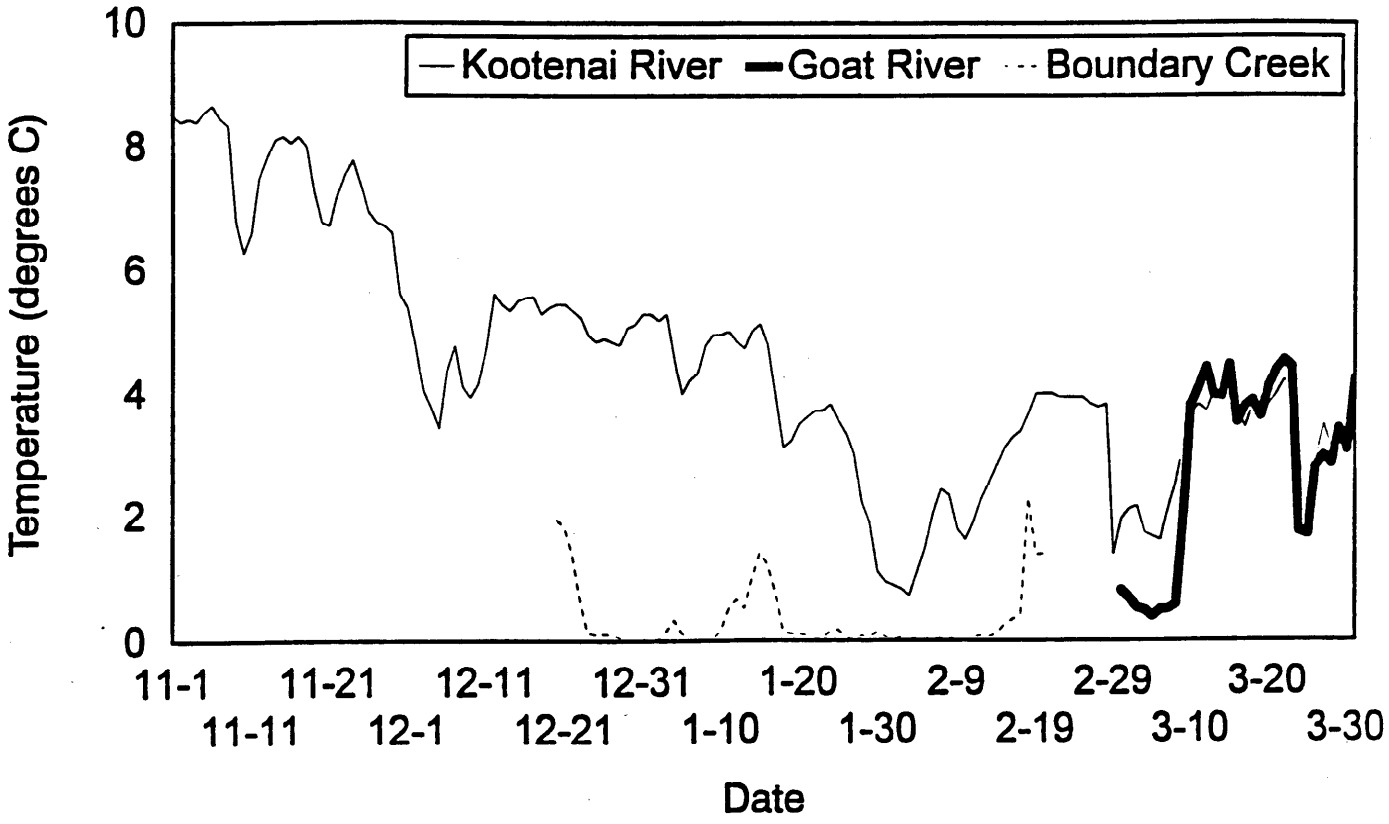

Figure 5. Temperature of the Kootenai and Goat rivers, British Columbia, and Boundary Creek, Idaho, November 1995 to April 1996.

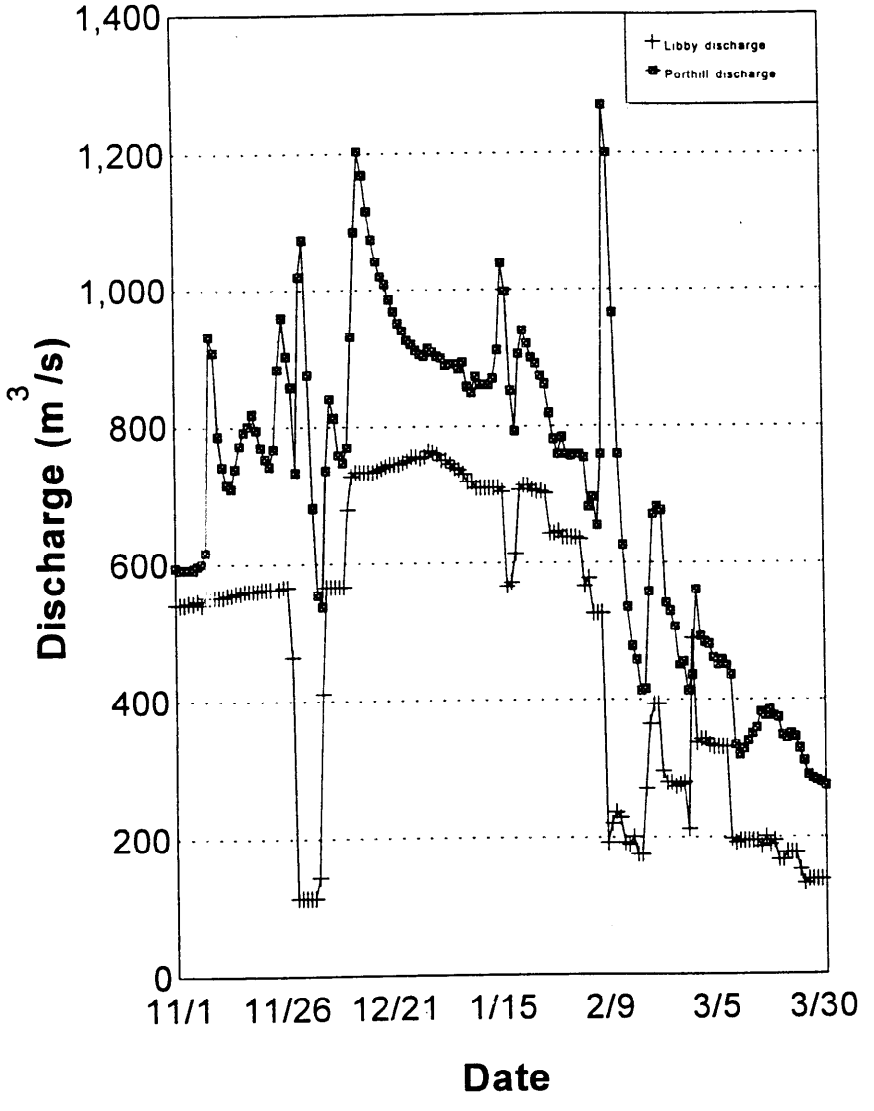

Figure 6. Discharge from Libby Dam, Libby Montana, and at Porthill, Idaho, Kootenai River, October 1995 to April 1996.

Habitat

Burbot were seldom located in depths less than 6 m, but depths ranged from 1 to 30 m. Substrate could not be identified at all locations, but most locations were comprised of silt or sand. Burbot were usually located in the thalweg during daylight, but at dusk were often found at shallower depths. The lower Goat River, where spawning is believed to have occurred, was silt and sand at depths usually less than 3 m. Approximate nose velocities were recorded. Velocities ranged from < 1 to 40 cm/s with a mean of 15 cm/s (Appendices A through K).

Kootenai River Discharge and Velocities

Discharge in the Kootenai River from Libby Dam during the pre-spawn and spawning season ranged from 113 to 510 m^3/s (Figure 6). The travel time for these releases to reach Porthill (rkm 170), Idaho, is about 24 h. Post-spawn discharges were relatively stable at 113 m^3/s, while spring and summer discharges ranged from 113 to 567 m^3/s. Velocity in the Kootenai River downstream of Bonners Ferry, Idaho, is reliant on the elevation of Kootenay Lake, British Columbia (Paragamian 1995). The lake was at it's lowest elevation during the winter months at about 531.5 m above sea level. Discharges at Porthill, Idaho were substantially higher than at Libby Dam, ranging from 155 to 1,566 m^3/s.

We found significant differences in current velocities of the Kootenai River at near maximum discharge (742.0 m^3/s), and much lower discharge (201.1 m^3/s) from Libby Dam using ANOVA testing (Figures 6 and 7, Appendix M). Discharge from Libby Dam equated to 991 and 453 m^3/s at Porthill, Idaho, respectively. At near maximum discharge, we found significant differences in velocities between sites ($P=0.0009$), but at lower discharge they were not significantly different ($P=0.088$), further testing also indicated the highest velocities during maximum discharge occurred at rkm 152 ($P=0.0015$) (Figure 7).

Archived Data

We interviewed Paul Jeppson, former IDFG fisheries research biologist. Jeppson caught burbot with 0.9 m diameter (unbaited) hoop nets in December and January. Many burbot could be caught at the mouth of Boundary Creek (rkm 170) and Deep Creek (rkm 240) (see Paragamian 1993 for a length frequency of Jeppson's catch). Burbot were captured and transported to Sandpoint for the purpose of culture, but spawning was unsuccessful. Jeppson also sampled tributaries to the Kootenai River but did not find young burbot. Jeppson prepared a narrative of his efforts (Appendix K).

We also examined Partridge's (1983) archived burbot sampling data from December 1979 through January 1982. We compared catch/effort (24 hour set) of combined hoop net and gill net catches to average discharge for the Kootenai River. Partridge's efforts were primarily at the mouth of Deep and Boundary creeks. We found Partridge's collection data was nonuniform and could not be used to compare catch success of burbot and winter power production.

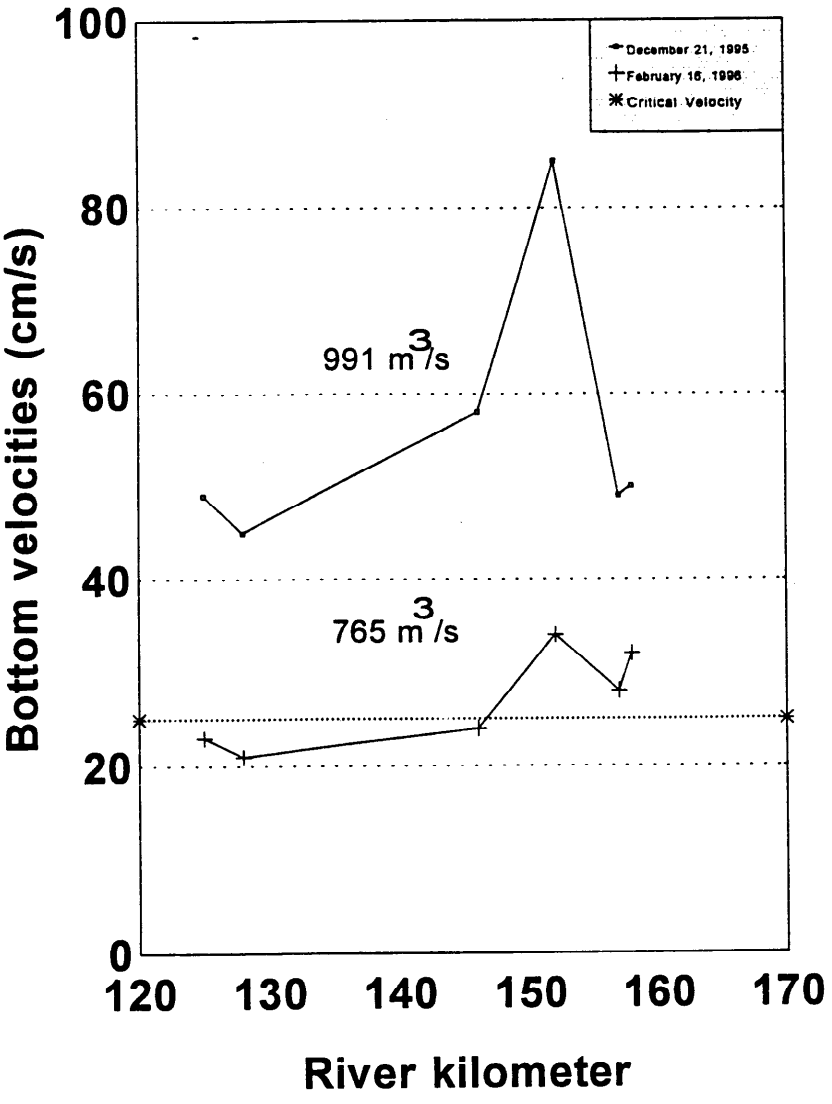

Figure 7. Bottom velocities at six randomly-chosen sites on the Kootenai River, British Columbia, downstream from Porthill, Idaho, at maximum discharge and minimum discharge from Libby Dam, maximum discharge December 21, 1995, minimum discharge February 16, 1996. The horizontal line is the critical velocity of 24 cm/s for burbot (Jones et al. 1974).

DISCUSSION

Burbot Population Status

The burbot stock in Idaho is at a very low density with little or no known reproduction (Paragamian 1993 and 1994). However, sampling of burbot in the lower Kootenai River during the winters of 1994 to 1996 indicated the presence of adult fish. Although adults were also at a low density, telemetry and netting indicated there was a spawning migration, and reproduction apparently occurred in the Goat River. These adult fish may be a vestige of the run that once provided a winter fishery in Idaho prior to Libby Dam.

The density of burbot, based on CPUE with baited hoop nets, in the Kootenai River diminishes rapidly upstream of the Goat River. We caught only one burbot from late November 1995 through April 1996 in Kootenai River, Idaho. Hoop nets fished from rkm 145 to 170 during the winter of 1994-1995 caught only two fish above rkm 153, while 31 additional burbot were caught in the Goat River and downstream during that same period. For comparison, only 17 burbot were caught in 1993 at a CPUE of 0.03 and 8 in 1994 at a CPUE of 0.009 (4 more were caught during juvenile sturgeon sampling) (Marcuson et al. 1994) in Idaho.

Burbot Flow Test

Exceptionally heavy precipitation through the winter of 1995-1996 prohibited a minimum discharge period to study burbot spawning migration. We believe a minimum discharge test is still necessary to test this hypothesis. Findings during winter 1994-1995 indicated burbot migration in the Kootenai River appeared to be seriously inhibited during high velocity periods created by discharges from Libby Dam for power and flood control (Paragamian 1995).

No burbot were caught in the Kootenai River from November 1995 through most of January 1996. Two were caught in late January and early February. Discharge was reduced on February 9, 1996 to 113.4 m^3/s, but it was not until February 13 that the remaining 25 of 27 burbot were caught at the mouth of the Goat River. At that time the temperature of the Kootenai River was 3°C and that of the Goat River was 4°C (Figure 6).

No burbot were caught in the Idaho reach of the Kootenai River until late March of 1996. The capture of a single unspawned male on March 15, 1996 was consistent with telemetry findings in 1995 when three burbot (two males and one female) on an apparent spawning migration did not reach Idaho until March, well after the traditional spawning period (Paragamian 1995). Jeppson (personal communication) and Partridge (personal communication) caught many burbot at Boundary Creek during their studies.

Velocity Barriers

Some segments of the Kootenai River during power production may be more imposing migration barriers to burbot than others. Telemetry studies of 1994-1996 indicated few burbot moved above rkm 152. Velocity measurements during winter 1995-1996 indicated this reach had higher velocities than other randomly-selected sites when discharge was 991 m^3/s at Porthill. No doubt there may be other locations in the river that may have high velocities. This fact suggests future management of the river for burbot migrations may need to take into consideration velocities at specific locations when discharge is reduced.

Burbot Behavior

A behavioral phenomenon indicates burbot have an affinity for each other not only during the spawning season but at other times. While this note is not necessarily important to the objective of this study it may be important to other researchers. Net effort early in this investigation (Paragamian 1993) indicated a high probability that multiple catches occurred frequently in a single net when two or more burbot were caught. This phenomenon has continued (Paragamian 1994, 1995). On several occasions burbot were left in unbaited nets located in the Goat River. These nets were placed in locations thought unlikely to capture more burbot. When checked, they usually contained three or more additional fish. Steve Dalbey (Montana Fish, Wildlife, and Parks, personal communication) reported a similar experience. While multiple catches of burbot in hoop nets set in the Kootenai River below Libby Dam were not uncommon, one net lifted in January 1996 contained 240 fish. Multiple catches during the spawning season may be explained by the behavioral trait of burbot to concentrate in dense schools often referred to as "balls" (Becker 1983).

RECOMMENDATIONS

1. Test the H_0 hypothesis that high winter discharge (power production) does not inhibit migration of burbot upstream to Idaho.

2. Determine the distance traveled by migrating burbot to estimate the necessary time needed for migrations to Boundary, Smith, and Parker creeks in Idaho.

3. Capture and examine post-spawn burbot in Idaho to determine whether or not they spawned.

4. Continue experimental larval burbot and sturgeon capture techniques with midwater trawls, sleds, beam trawls, D-rings, meter nets, seine nets, etc.

ACKNOWLEDGMENTS

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APPENDICES

Appendix A. Location (rkm), date, velocity, temperature (°C), and depth of burbot 96 as determined by sonic telemetry and X16 Lowrance graph recorder.

Date Released	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
06/28/94	177.2			
12/13/94	Crawford Bay 85.0			
01/01/95	116.5			
01/24/95	116.5			
02/27/95	159.8	15.85		4
03/16/95	188.3			
03/23/95	195.2	19.81	15	5
03/31/95	188.3			7
06/25/95	117.9			13.1
06/29/95	118			13.7
06/22/95	116.0	55		10.8
07/11/95	118.0			14.9
07/18/95	119.3			15.7
07/27/95	119.5	79		15.4
08/22/95	142.5	13.11	21.34	14.5
09/05/95	211.9		10.67	
09/11/95	186.8		3.05	16
09/20/95	244.6		0.30	13
10/12/95	242.2		0.30	
11/15/95	242.6			9
12/27/95	242.4			
01/22/95	242.0			4
02/20/95	242.0			4.5
03/12/96	243.5	3.62	27.5	
03/27/96	242.5	3.81	31.4	5
04/03/96	243.2			4
04/09/96	242.8	4.572	15.2	6
04/12/96	242.8			4.5
04/17/96	242.8	4.572		6
04/19/96	242.8			
04/23/96	242.0			5.5
04/25/96	242.0			6
04/30/96	242.0	5.182		6
05/02/96	242.0			7
05/06/96	242.0			7
05/08/96	242.0			7
05/10/96	242.0			7.5
05/12/96	242.0			

Appendix B. Location (rkm), date, velocity, temperature (°C), and depth of burbot 2246 as determined by sonic telemetry and X16 Lowrance graph recorder.

Date Released	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
01/31/95	152.6			
02/03/95	152.5		18.2	4
02/09/95	140.0	13.11		5
02/24/95	133.3			5
02/28/95	130.6	10.67		
04/18/95	135.3			7.5
04/27/95	135.3		.08	8.5
05/08/95	144.5			8
06/02/95	134			9.8
06/22/95	134			10.8
07/11/95	134			14.9
07/18/95	134			15.7
07/27/95	137.2		2.0	15.4
08/01/95	133.5			14.6
08/22/95	131.0			
09/14/95	129.2	12.77	15.2	17.0
10/04/95	130.5	19.76	0.4	

Appendix C. Location (rkm), date, velocity, temperature (°C), and depth of burbot 903[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/13/96[b]	152.6			

[a]This was a 40-day transmitter.
[b]Capture, implant, and release date. Transmitter is believed to have malfunctioned after release.

Appendix D. Location (rkm), date, velocity, temperature (°C), and depth of burbot 365[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/13/96	152.6			
02/16/96	152.3			2
02/21/96	152.3			5
02/26/96	152.6			3.5
03/08/96	142.0	21.4	8.5	3
03/15/96	137.3	18.3	9.6	6
03/18/96	143.0	33.6	6.8	6
03/20/96	143.8			4.5
03/28/96	135.5	15.2	16.2	4
04/01/96	125.6	24.4	10.4	5
04/05/96	142.0	24.4	10.7	7
04/11/96	140.1			7
04/18/96	140.2			7
04/29/96	141.0			6
05/07/96	126.0			7
05/15/96	126.0			8
05/22/96	126.5			8
05/29/96	126.5			10
06/11/96	126.5			
06/19/96	126.5			
07/02/96	126.0			
07/09/96	126.0			
07/27/96	126.0			18
08/05/96	128.0			
08/14/96	128.0	21.4	5.7	
09/05/96	127.0	2.4		
09/16/96	132.8			14.5

[a]Third deployment of sonic code 365.
[b]Capture, implant, and release date.

Appendix E. Location (rkm), date, velocity, temperature (°C), and depth of burbot 357[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/13/96	152.6			
02/16/96	152.0			2
02/21/96	152.0			5
02/26/96	152.0			3.5
03/04/96	149.8	16.46	3.1	3
03/08/96	144.0	16.76	15.3	3
03/15/96	144.0	15.36	12.2	6
03/18/96	143.5	12.8	29.0	6
03/20/96	143.6			4.5
03/28/96	143.5	6.09	21.4	4
04/01/96	144.4	21.36	18.3	5
04/05/96	144.4	16.76	21.4	7
04/11/96	143.8	7.62	39.7	7
04/15/96	143.8	21.34	36.4	7
04/18/96	143.9			7
04/22/96	143.9			6
04/26/96	144.0			5
04/29/96	144.7	14.63		6
05/07/96	144.0			7
05/15/96	144.5			
06/11/96	144.2			
06/19/96	144.2			
07/02/96	144.0			
07/09/96	144.2			
07/15/96	144.2			
07/27/96	144.4			18
08/05/96	144.2			
08/14/96	143.8	8.23	1.5	
08/20/96	144.0			
09/05/96	144.0		3.1	
09/16/96	144.1			

[a]Second deployment of sonic code 357.
[b]Capture, implant, and release date.

Appendix F. Location (rkm), date, velocity, temperature (°C), and depth of burbot 2237[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/18/96	152.6			
02/21/96	152.6			5
02/26/96	152.7			3.5
03/04/96	152.6	17.07	7.6	3
03/06/96	149.4	18.29	12.2	
03/08/96	144.5	4.877	18.3	3
03/15/96	144.1	22.13	15.3	6
03/18/96	143.8	22.71	18.3	6
03/28/96	143.8	29.87	3.1	4
04/01/96	144.6	27.13	12.2	5
04/05/96	144.3	29.87	12.2	7
04/11/96	143.8	7.62	39.6	7
05/15/96	120.0			
05/17/96	121.0			
05/29/96	119.5			10

[a]Second deployment of sonic code 2237.
[b]Capture, implant, and release date.

Appendix G. Location (rkm), date, velocity, temperature (°C), and depth of burbot 374[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/20/96[b]	152.6			
02/21/96	152.3			5
02/26/96	146.6			3.5
03/08/96	134.9	7.6	15.85	3
03/15/96	133.6	13.9	25.21	6
03/18/96	133.8	12.2	21.37	6
03/20/96	133.7			4.5
03/28/96	133.8	9.2	27.43	4
04/01/96	133.6	3.1	14.02	5
04/05/96	137.2	21.4	18.29	7
04/11/96	136.8			7
04/15/96	133.6			7
04/18/96	134.5			7
04/22/96	133.5			6
04/26/96	133.2			5
04/29/96	133.2		12.5	6
05/07/96	133.5			7
05/15/96	133.5			
05/29/96	133.5			10
06/11/96	133.5			
06/19/96	133.5			
06/25/96	133.6			
07/02/96	133.5			
07/09/96	134.0			
07/15/96	134.0			
07/27/96	135.2			18
08/05/96	134.0			
08/14/96	133.8		18.29	
08/20/96	134.1			
09/05/96	133.7			
09/16/96	133.8			14.5

[a]Second deployment of sonic code 374.
[b]Capture, implant, and release date.

Appendix H. Location (rkm), date, velocity, temperature (°C), and depth of burbot 455[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/20/96[b]	152.6			
02/21/96	137.8			5
03/08/96	139.6	13.72	24.4	3
03/15/96	133.6	25.21	13.9	6
03/18/96	133.8	20.88	12.2	6
03/20/96	133.8			4.5
03/28/96	133.8	19.81	9.1	4
04/01/96	133.6	15.85	6.1	5
04/05/96	137.2	22.56	18.2	7
04/11/96	133.2			7
05/07/96	127.5			7
05/15/96	141.0			8
05/22/96	139.6			8
07/02/96	152.7			

[a]Second deployment of sonic code 455.
[b]Capture, implant, and release date.

Appendix I. Location (rkm), date, velocity, temperature (°C), and depth of burbot 276 as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/20/96[a]	152.6			
02/21/96	152.6			5
03/04/96	153.5	17.98	8.5	3
03/06/96	153.3	17.98	9.2	
03/11/96	153.3		10.7	5
03/13/96	152.8	15.24	9.2	5.5
03/20/96	139.4			4.5
04/01/96	134.1	7.62	15.3	5
04/05/96	132.5	10.06	27.5	7
04/11/96	125.8			7
04/15/96	125.8			
04/18/96	127.5			7
04/22/96	132.1			6
04/26/96	133.6			5
04/29/96	131.0	21.64		6
05/07/96	131.0			7
05/29/96	131.0			10

[a]Capture, implant, and release date.

Appendix J. Location (rkm), date, velocity, temperature (°C), and depth of burbot 258[a] as determined by sonic telemetry X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/21/96[b]	152.6			
02/21/96	152.7			5
02/28/96	133.5			3
03/08/96	133.4	13.41	21.4	3
03/15/96	134.7	18.78	18.3	6
03/18/96	133.5	14.11	24.4	6
03/28/96	133.5	13.72	12.2	4
04/01/96	133.4	10.06	15.3	5
04/05/96	136.5	6.10	27.5	7
04/11/96	137.0			7
04/22/96	132.1			6
04/26/96	133.6			5
04/29/96	134.5	16.76	21.4	6
05/07/96	134.2			7
05/22/96	135.0			8
06/25/96	134.0			
07/09/96	134.3			
07/15/96	134.3			
09/05/96	133.7		3.1	

[a]Second deployment of sonic code 258.
[b]Capture, implant, and release date.

Appendix K. Location (rkm), date, velocity, temperature (°C), and depth of burbot 12[a] as determined by sonic telemetry and X16 Lowrance graph recorder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
02/20/96	152.6			

[a]This was a 40 day transmitter that malfunctioned after release.

Appendix L. Comparison of bottom velocities during high and low flow periods for randomly selected Kootenai River locations in British Columbia, Canada.

Date	Rkm	Discharge at Porthill (m^3/sec.)	Velocity (cm/s) Individual Samples					Standard Deviation	$\bar{X}$
			1	2	3	4	5		
12/21/95	125	991	22	62	70	50	48	18.2	50
02/16/96	125	453	17	21	21	38	22	8.2	24
12/21/95	128	991	58	58	60	24	29	17.7	46
02/16/96	128	453	16	11	30	24	24	7.5	21
12/21/95	146	991	60	64	62	56	44	7.9	57
02/16/96	146	453	11	23	30	30	26	7.8	24
12/21/95	152	991	69	86	92	94	83	9.9	85
02/16/96	152	453	23	40	21	46	45	12.1	35
12/21/95	157	991	17	63	64	62	46	20.1	50
02/16/96	157	453	21	32	34	30	24	5.5	28
12/21/96	158	991	41	49	56	72	35	14.4	51
02/16/96	158	453	31	37	27	33	28	4.0	31

Appendix M. Jeppson Narrative Report

Narrative report for August 1958 by Paul Jeppson, Fisheries Biologist II, Idaho Department of Fish and Game.

Kootenai River Ling (progress report)

About 10 percent of the tags placed on ling in the Kootenai drainage during the past year have been recovered. Returns are high considering that: 1) poor ice cover on the Kootenai river discouraged most fishing in the U.S. portion, 2) tagging extended beyond the "fishing season", 3) a number of the tagged ling were smaller than normally taken by sport fishermen.

Of 72 tagged at the International Boundary, 7 were recovered in Idaho and 4 in Canada. Of 49 tagged in Deep Creek near Bonners Ferry, 2 were recovered (about two months after tagging) near the point of release. All three recovered in Canada were taken in minor tributaries several miles north of the boundary some two months following release. Of the 7 taken in Idaho (tagged at Porthill), 4 were recovered at the site of tagging from 6 to 34 days. The 3 upstream migrants traveled 14 miles in 6 days, 3 miles in 3 days, and 30 miles in 33 days.

The Kootenai River ling begin eating fish, predominantly, at a length of 13 inches. Fish were found in 98 percent of the stomachs containing food, insects in 11 percent. In the order of occurrence in the stomachs, the fish consumed by ling were suckers, squawfish, redside shiner, pumpkinseed, perch, peamouth, and whitefish. The diet varied some between the two sites where samples were taken, Porthill and Deep Creek. Spiny rays possibly are the dominant food items near Porthill but are almost absent from samples taken some 40 miles upstream, at the mouth of Deep Creek.

Some tentative conclusions from the study are:

1) It appears that the harvest of ling in 1958 as determined from recovery of fish marked and released at the International Boundary was about equal in Canada and Idaho, even though the fishery in Idaho has more restrictions regarding methods of taking ling. If ice conditions had been normal, the fishery in Idaho likely would have been much greater while that in Canada would possible have been reduced.

2) The ling is highly desirable in the Kootenai River owning to its predatory food habits and high table quality. The fish population of the Kootenai River is predominantly suckers and cyprinids.

3) Ling spawning occurs during the period of heaviest fishing, in late winter. Ling mature at about 18 inches in length and 1 ½ pounds in weight. Age at maturity is 4 or 5 years.

4) Over fishing is a possibility during years of good ice cover. Commercial fishing accounts for the major take of ling in Idaho.

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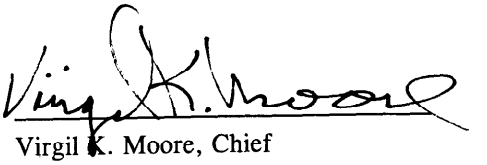
Approved by:

IDAHO DEPARTMENT OF FISH AND GAME



Virgil K. Moore, Chief
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