# Kootenai River Fisheries Investigations

## Stock Status of Burbot and Rainbow Trout and Fisheries Inventory

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# KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT AND RAINBOW TROUT AND FISHERIES INVENTORY

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## ABSTRACT

I sampled 33 burbot *Lota lota* in the Kootenay River in British Columbia, Canada. Burbot catch from November 1994 to February 1995 averaged 0.047 fish/net-day. Total length ranged from 385 mm to 958 mm and weighed from 272 g to 4,086 g (mean = 982 g). Twelve burbot were implanted with sonic transmitters and released at capture sites. 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 203 times from November 1994 through August 8, 1995. Ripe burbot were captured and they appeared to have an affinity to water < 2°C. I believe burbot spawned in the Goat River, British Columbia. Burbot with sonic transmitters did not reach Idaho until after the spawning period. Statistical analysis of burbot movement and discharge from Libby Dam indicated there was a significant relation between winter power production and spawning migration of burbot. A controlled test is needed to verify this relation. Zooplankton samples from the Kootenai River were substantially lower than the delta of Kootenay Lake, British Columbia, Canada.

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# INTRODUCTION

The burbot *Lota lota* once provided an important winter fishery to the residents of northern Idaho (Paragamian 1994). Burbot caught during the winter fishery are thought to have been part of a spawning migration from the lower river and Kootenay Lake. However, after construction and operation of Libby Dam at Libby, Montana (Figure 1), the fishery gradually declined until the fishery was closed in the early 1990s. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, British Columbia, Canada (Paragamian 1993). A major change in the Kootenai River hydrograph (Figure 2) and temperature regime was thought to play an important role in impacting the ecosystem (Partridge 1983).

Preliminary study of burbot in the Kootenai River began in 1978 (Partridge 1983), but was secondary to a white sturgeon *Acipenser transmontanus* project. Partridges' study documented abundance, movement, harvest, and age structure of burbot. The Kootenai River Fisheries Investigations was a follow up to Partridges' work. It was initiated in 1993 and was designed to deal more specifically with burbot abundance, distribution, size structure, reproductive success, movement, and to identify factors limiting burbot in the Kootenai River. Burbot were found to be at a very low density with very few above river kilometer (rkm) 244. Reproduction appeared to be nonexistent in Idaho because no larval or juvenile burbot were captured from 1993 to 1994. But 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 tributaries was carried out in anticipation of intercepting a spawning run of fish from Kootenay Lake. This winter sampling produced no burbot. Also, a sport fishery survey in 1993 indicated they were no longer present in the anglers catch (Paragamian 1994).

# 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, and originates in Kootenay National Park, British Columbia (Figure 1). The river flows south into Montana where Libby Dam impounds water back into Canada forming Lake Koocanusa. 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 $km^2$, and the reach in Idaho is 106 km long. Kootenay Lake drains out the West Arm, and eventually the river joins with the Columbia River near Castlegar, British Columbia.

The Kootenai River presents two different channel and habitat types while it passes through Idaho. As the river enters Idaho it is typified by steep canyon walls and high gradient (0.6 m/km), but at about rkm 255 upstream of Bonners Ferry, the river changes to a lower gradient (0.02 m/km) and meanders through a broad flood plain. Tributary streams of the Kootenai River are typically high gradient while 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.

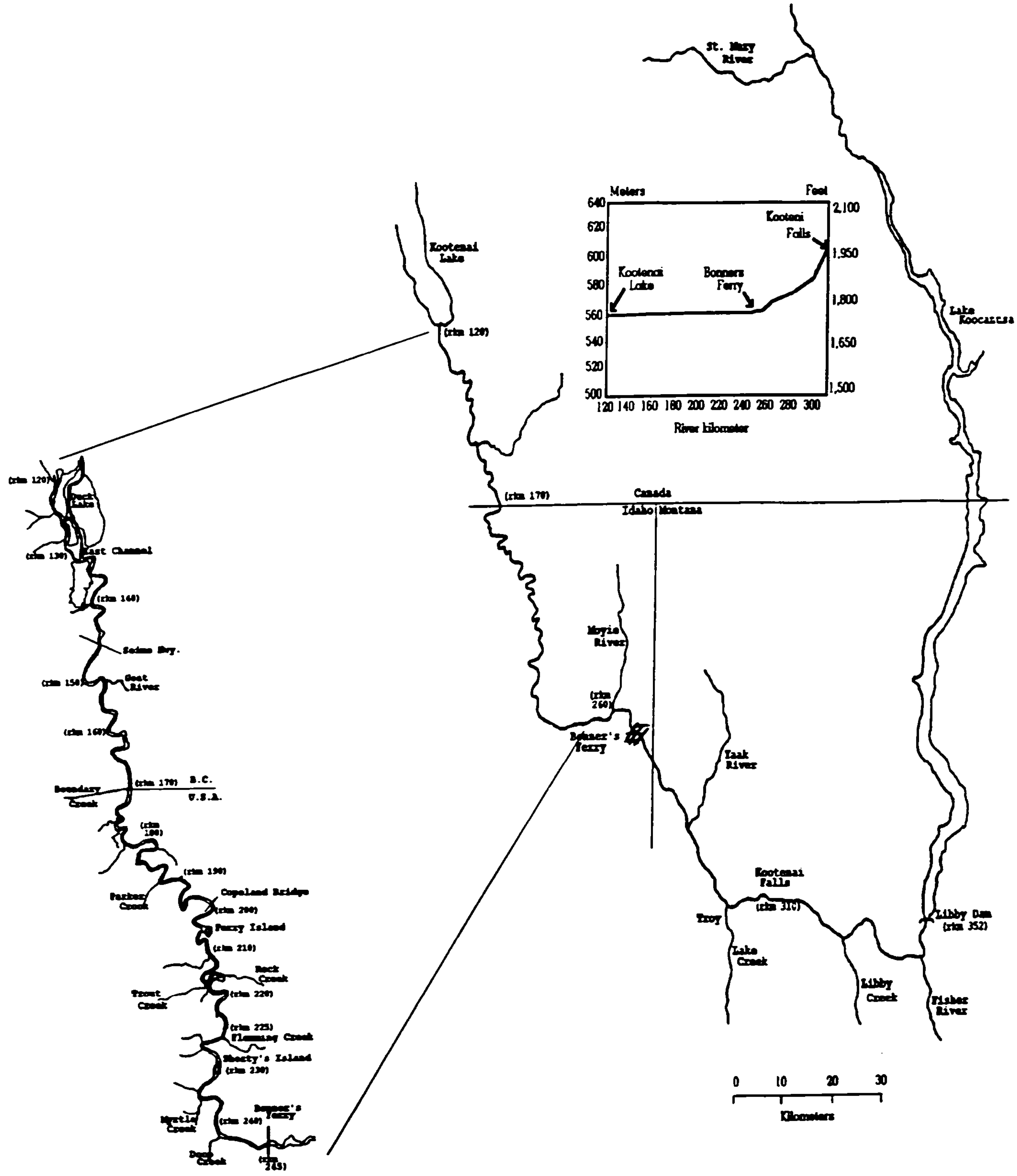


**Figure 1.** Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major Tributaries in Idaho. The river distances in Figure 1 are in kilometers (rkm) and are indicated at important access points. The Hemlock Bar is indicated by the cross hatched area at rkm 261.

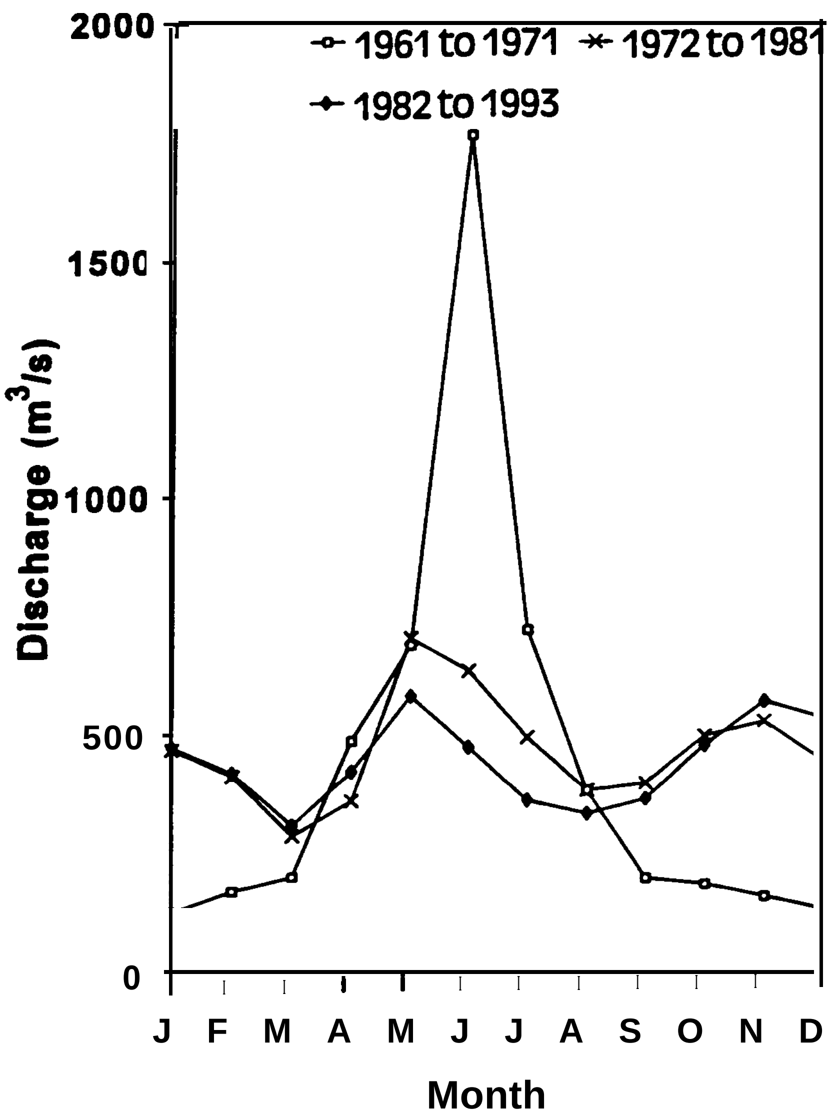


Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho, from 1961 through 1971 (pre-Libby Dam), from 1972 through 1981, and 1982 through 1993 (post-Libby Dam).

# GOAL

Restore the burbot, mountain whitefish *Prosopium williamsoni*, and rainbow trout *Oncorhynchus mykiss* populations in the Idaho reach of the Kootenai River and improve fishing success to historic levels.

# OBJECTIVES

1. To identify factors that are limiting populations of burbot, rainbow trout, and other populations 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 Burbot

I sampled burbot in the Kootenay River, British Columbia, Canada (rkm 145 to 170) in anticipation of intercepting burbot moving from Kootenay Lake to traditional spawning areas in British Columbia and Idaho. Burbot were sampled with 6 to 10 hoop nets of two sizes from November 25, 1994 through February 21, 1995. The large nets were 3.7 m long with fiberglass hoops and polyvinyl chloride spreader bars 3.1 m in length (Bernard et al. 1991). Hoops had an inside diameter of 91 cm and tapered to 69 cm toward the cod end. Each net had a double throat that narrowed to an opening of about 19 cm. Netting was nylon woven into 25 mm bar mesh and had number 15 cotton twine. The smaller hoop nets were 3.1 m long and had an entrance diameter of 61 cm tapering to 46 cm toward the cod end. Web and hardware of the smaller nets were the same as the larger nets. All nets were anchored at the cod end with a 10 kg concrete weight. An orange buoy was tied to the first hoop with a length of rope to mark the net and enable me to raise it. I placed chunks of cut fish into a woven bait bag and suspended it from the second to last hoop (from the entrance) inside each net. Pink salmon *Oncorhynchus gorbuscha,* pollock *Pollachius virens*, northern squawfish, *Ptychocheilus oregonensis,* or suckers *Catostomus* sp. were used as bait. Two nets had 3.3 m leads of the same mesh size woven into the throat and they were not fished with bait. These nets were fished perpendicular to shore, anchored at both ends with the lead at the shore margin.

Nets were set with the aid of a Lowrance Xl6 graph recorder to help ensure the opening of the net was on the river bottom. I recorded the depth, substrate type (sand, gravel, cobble, or boulder), and the location (main channel, main channel border, outside bend, or inside bend) of the individual net sets. Nets were checked every 24 to 72 h.

Fish captured in the hoop nets were identified, enumerated, measured in total length (TL), and weighed individually. Burbot were PIT (passive integrated transponder) tagged in the cheek muscle and released. Condition (K), relative weight ($W_r$), and Proportional Stock Density (PSD) (S. Fisher, South Dakota State University, personal communication) for burbot in the Kootenai River were calculated.

$W_r$ was determined from the formula using a standard weight where:

$\text{Log } W_s = -4.868 + 2.898\ (\text{Log}_{10}\ TL)$
weight is in g and TL is mm

PSD is defined as the percentage of fish greater than 380 mm in TL in a length frequency distribution of burbot that are longer than 200 mm TL.

## Burbot Telemetry

Adult burbot used for telemetry were captured with hoop nets and surgically implanted with sonic transmitters. Before surgical implantation, burbot were anesthetized in a solution of about 25 mg tricanmethanolsulfanate (MS-222)/L of water. The fish were then placed on a surgical table (Courtois 1981) and continuously bathed with water and anesthetic. Sonic transmitters were implanted according to the procedures of Hart and Summerfelt (1975) and size of transmitter was apportioned in accordance to the size of fish. Sonic transmitters of 420-day life expectancy were 60 mm in length, 16 mm in diameter, and weighed 8 g, while 40-day transmitters were 16 mm in diameter, 37 mm in length, and weighed 4 g. Sex of most fish was determined during the surgery, and most fish were tagged with a PIT tag after completion of surgery. Burbot were returned to the location of capture and released.

Seasonal habitat use and movement of burbot were studied from November 24, 1994 through August 31, 1995. When burbot were located by telemetry, depth was measured with a Lowrance Xl 6 echo sounder, and velocity within 150 mm of the bottom measured with a Gurly model 2030R flow meter. Temperature was recorded as well as substrate or cover when possible. The Fisher Exact test was used to examine the probability there was a relationship between travel of burbot and discharge (Conover 1980). Fisher Exact Test was used with a two x two contingency table; fish - up and down, and discharge - up and down.

## Population Estimates at the Hemlock Bar

Population estimates of several species of fish within the Hemlock Bar (29.4 hectare) of the Kootenai River were calculated in mid-September 1994. Four night time trials were made using an 8-m boat mounted with a 230V DC Smith Root electroshocker which was adjusted to generate 5 amps. Three technicians netted all species of fish, fish were anesthetized in MS-222, identified, weighed, measured for total length, the tip of the top caudal fin was clipped, and the fish was released. Scale samples were taken from rainbow and cutthroat trout. Population estimates were made using the Chapman modification of the Schnabel multiple census technique (Ricker 1975). Confidence intervals were determined by assuming that the number of recaptures were a Poisson-distributed variable.

## Zooplankton Sampling

The zooplankton community was sampled in the Kootenai River (rkm 244) and the delta of Kootenay Lake (rkm 120), British Columbia, Canada, to provide a general reference to the species composition and temporal abundance of macrozooplankton genera in these distinct habitats. The density of zooplankton on a temporal scale could also be contrasted with larval burbot/sturgeon catch curves or densities to determine the importance of food and respective survival. Three samples were collected once each month from January to August 1995. Zooplankton were sampled with a 0.5 m diameter 130 micron plankton net. Water volume was calculated with the aid Kahl Scientific flow meter. Vertical hauls from 15.24 m depth to the surface were made by manually raising the sampler at about 0.5 m/s. Samples were preserved in ethel alcohol. Ten subsamples from each sample were analyzed at the lab. Zooplankton were enumerated to genus and sometimes species using standard dilution and subsampling methods (Edmondson and Winberg 1971 ). Zooplankton counts were expanded to determine zooplankton densities.

## Kootenai River Discharge and Velocities

Daily discharge values were obtained from the United States Army Corps of Engineers office at Libby, Montana, U.S. Soil Conservation Service in Portland, Oregon, and some velocity measurements at various river discharges were obtained from the U.S. Geological Survey office in Sandpoint, Idaho. I also measured velocities of the Kootenay River at several locations and the Goat River with a Gurley model 2030R flow meter. Discharge, velocity, and temperature data were considered as factors contributing to burbot behavior.

# RESULTS

## Hood Net Sampling

### Total Catch

I fished hoop nets in the Kootenay River, British Columbia, Canada, (rkm 145 to 170) from October of 1994 through February of 1995 for a total of 708.9 net days. A total of 76 fish were caught of which 43% were burbot, 34% northern squawfish, 8% yellow perch *Perch flavescens,* and 7% were longnose *Catostomus catostomus* and largescale *C. macrocheilus* suckers. The remainder was comprised of mountain whitefish, peamouth *Mylocheilus caurinus*, rainbow and bull trout (Table 1 ). The total catch per unit of effort (CPUE) for all fish was 0.1 1 fish/net-day. Burbot had the highest CPUE of 0.05 fish/net-day. The total weight of my catch was 48.7 kg (Table 1). This total weight did not include six burbot that were not weighed during a subzero day.

Table 1. Hoop net catch success by number, weight (kg), and catch per unit effort” (CPUE), Kootenai River, Idaho, November, 1994 through February, 1995.

| Species | Number | Total weight (kg) | CPUE” |
|---|---|---|---|
| Cutthroat trout | 1 | 0.2 | .001 |
| Bull trout | 2 | 1.8 | .003 |
| Rainbow trout | 1 | 0.2 | .001 |
| Mountain whitefish | 1 | 0.1 | .001 |
| Longnose sucker | 1 | 0 | .001 |
| Largescale sucker | 4 | 0.8 | .006 |
| Northern squawfish | 26 | 12.6 | .037 |
| Burbot | 33 | 32.5[b] | .047 |
| Yellow perch | 6 | 0.5 | .008 |
| Peamouth | 1 | 0.1 | .001 |
| Total | 76 | 48.8 | .107 |

“A unit of effort is a single 24-hour set.

[b]Some totals are not complete, subfreezing weather prevented weights from being taken on some days.

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## Burbot

A total of 33 burbot were captured and an additional young-of-the-year (YOY) was caught during juvenile sturgeon sampling (Paragamian et al., in press). Nineteen burbot were caught at the confluence of the Goat River (rkm 152) and two were caught upstream between rkm 154 and 170. The remaining burbot were captured between rkm 147 and 150. All burbot were caught over sand and/or silt substrate. The CPUE for burbot from November 1994 through February 1995 was < 0.05 fish/net-day. These fish ranged from 385 mm to 958 mm (Figure 3) and weighed from 272 g to 4,086 g (mean = 982 g). The single YOY burbot was 50 mm TL and was captured in Idaho in a minnow trap at rkm 213.2. $W_r$ of burbot in the Kootenai River was 0.77 based on the lengths and weights of burbot captured in this study and those captured by Partridge (1983). PSD of burbot from this investigation was 97.

## Burbot Spawning

Examination of burbot captured with hoop nets through the pre- spawn and spawning season provided sequential evidence of sex and sexual maturation (Table 2). The catch of burbot was comprised of males in December, while females were not caught until January. Sexual maturity was first noted on January 13 when a ripe male was captured in the Kootenay River. Additional ripe males were captured, but the first ripe female was not caught until February 7 and the first spent female was captured on February 10 in the Goat River. After the first week in February, all burbot appeared to be ripe, while females were easily distinguished from males by a larger cloaca.

# Burbot Telemetry

## Telemetry

Fourteen burbot were monitored during the study period. They included 2 burbot that were previously implanted with sonic transmitters (Paragamian 1994) and 12 implanted and released at capture sites in the British Columbia portion of the Kootenay River during this study period (Table 3). Burbot were located a total of 203 times from November 1994 through August 1995 (Appendices A through K).

## Pre-spawn Movement, River Discharge, and Temperature

Six burbot were monitored during the pre-spawn period of November 24, 1994 through January 15, 1995. Initially, most burbot remained in deep pools in close proximity to release sites. Although, some lateral movement from the thalweg was noted. River discharges at this time from Libby Dam were usually between 383 and 510 $m^3/s$ (Figure 4). Temperature of the Kootenai River was 5°C. On two occasions discharges from Libby Dam were reduced

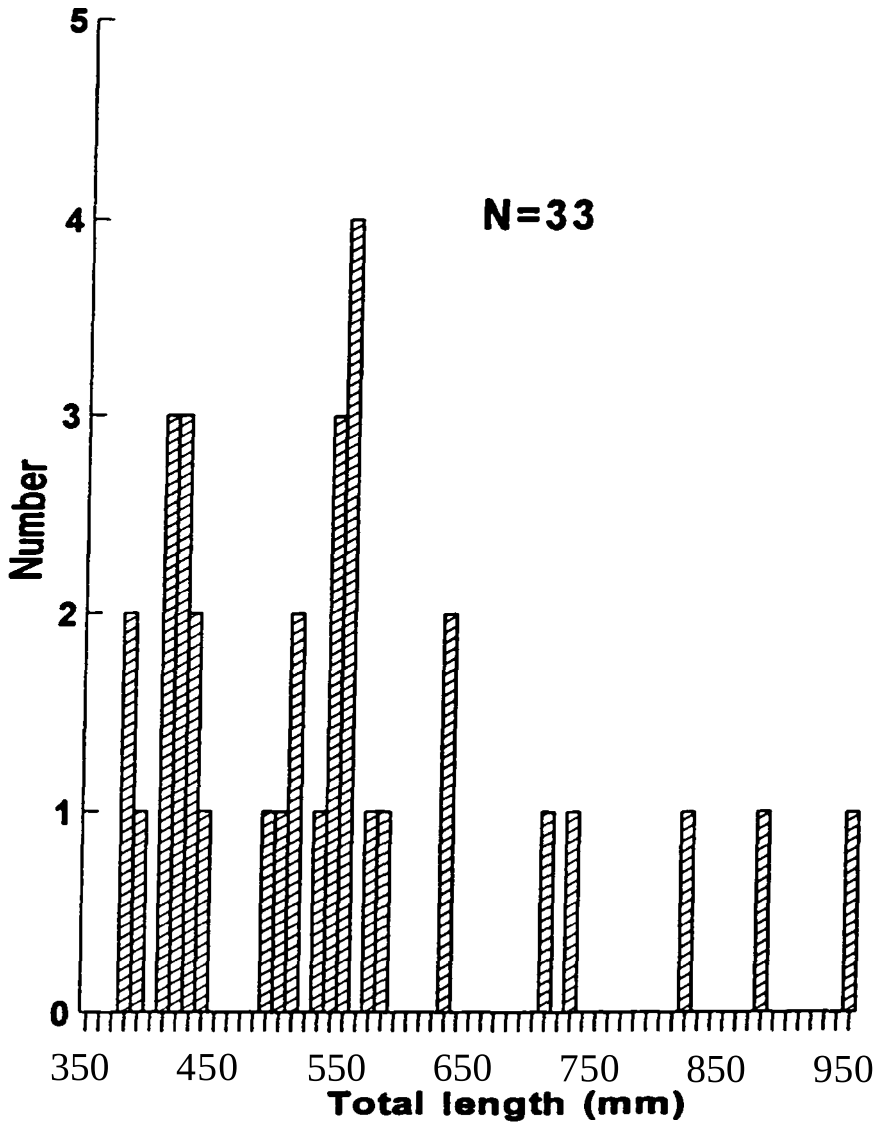


Figure 3. Length frequency distribution of burbot caught by baited hoop nets in the Kootenay River, British Columbia, Canada, December 1994 through February 1995.

**Table 2.** Burbot sexual maturation and spawning chronology and the temperature of the Kootenay and Goat Rivers, British Columbia, Canada, December 1994 through February 1995.

| | | Temperature (C°) | |
|---|---|---|---|
| Date | Note | Kootenay River | Goat River |
| 14 Dec 94 | Three males, no evidence of being gravid, caught in Kootenay River | 5 | 2 |
| 13 Jan 95 | Male burbot gravid, caught in Kootenay River. | 5 | 2 |
| 17 Jan 95 | Female burbot entered Goat River. | 6 | 2 |
| 1 Feb 95 | Male burbot gravid, caught in Goat River. | 5.5 | 2 |
| 10 Feb 95 | Captured a female burbot in Goat River. Completely spawned out. | 2.5 | 1.5 |
| 13 Feb 95 | Two male burbot caught in Goat River, gravid. | 5 | 4 |
| 21 Feb 95 | Five burbot caught in Goat River. All females and males gravid, four males and one partially spawned female. | 5 | 3.5 |

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**Table 3.** Summary of sonic telemetry data and physical characteristics of 18 burbot in the Kootenai River, Idaho, and Kootenay River and Lake, British Columbia, Canada, 1993 through 1995.

| Sonic code | Date implanted | Total length (mm) | Weight (g) | PIT tag number | Sex | Last date located |
|---|---|---|---|---|---|---|
| 446 | 17 Nov 93 | 650 | 1,600 | None | M | |
| 374 | 10 Dec 93 | 670 | 1,600 | None | F | 8 Mar 94 |
| 455 | 4 Mar 94 | 590 | 1,135 | 7F7D0132A | F | 25 Jul 95 |
| 365 | 11 Mar 94 | 574 | 945 | 7F7D0034A | Unknown | 9 Aug 94 |
| 383 | 29 Jun 94 | 527 | 1,078 | 7FD9D7C76 | F | 7 Sep 94 |
| 96 | 29 Jun 94 | 560 | 1,135 | 7FD0B684C | M | 27 July |
| 357[a] | 14 Dec 94 | 496 | 795 | 34353697187 | M | 13 Feb 95 |
| 3433[b] | 13 Dec 94 | 765 | 2,611 | 34353713629 | M | 1 Aug 95 |
| 2237[a] | 13 Dec 94 | 380 | 530 | None | M | 18 Jan 95 |
| 258[a] | 2 Jan 95 | 438 | 568 | 34353709233 | M | 6 Feb 95 |
| 356 | 2 Jan 95 | 536 | 1,121 | 34353672406 | F | 27 Feb 95 |
| 276[a] | 18 Jan 95 | 422 | 539 | None | F | 7 Feb 95 |
| 2228[a] | 18 Jan 95 | 432 | 482 | None | F | 13 Feb 95 |
| 365 | 23 Jan 95 | 630 | 1,816 | 34353682014 | F | 3 Feb 95 |
| 374 | 1 Feb 95 | 556 | 1,135 | 34353671597 | F | 17 Feb 95 |
| 446 | 1 Feb 95 | 714 | 2,043 | 34353623996 | M | 1 Aug 95 |
| 2246[a] | 1 Feb 95 | 543 | 1,078 | 34353643868 | F | 1 Aug 95 |
| 3334 | 17 Feb 95 | 881 | 3,994 | None | M | 8 Aug 95 |

[a]Forty day transmitter.
[b]Believed dead, sonic tag located in 2 m depth within debris jam.

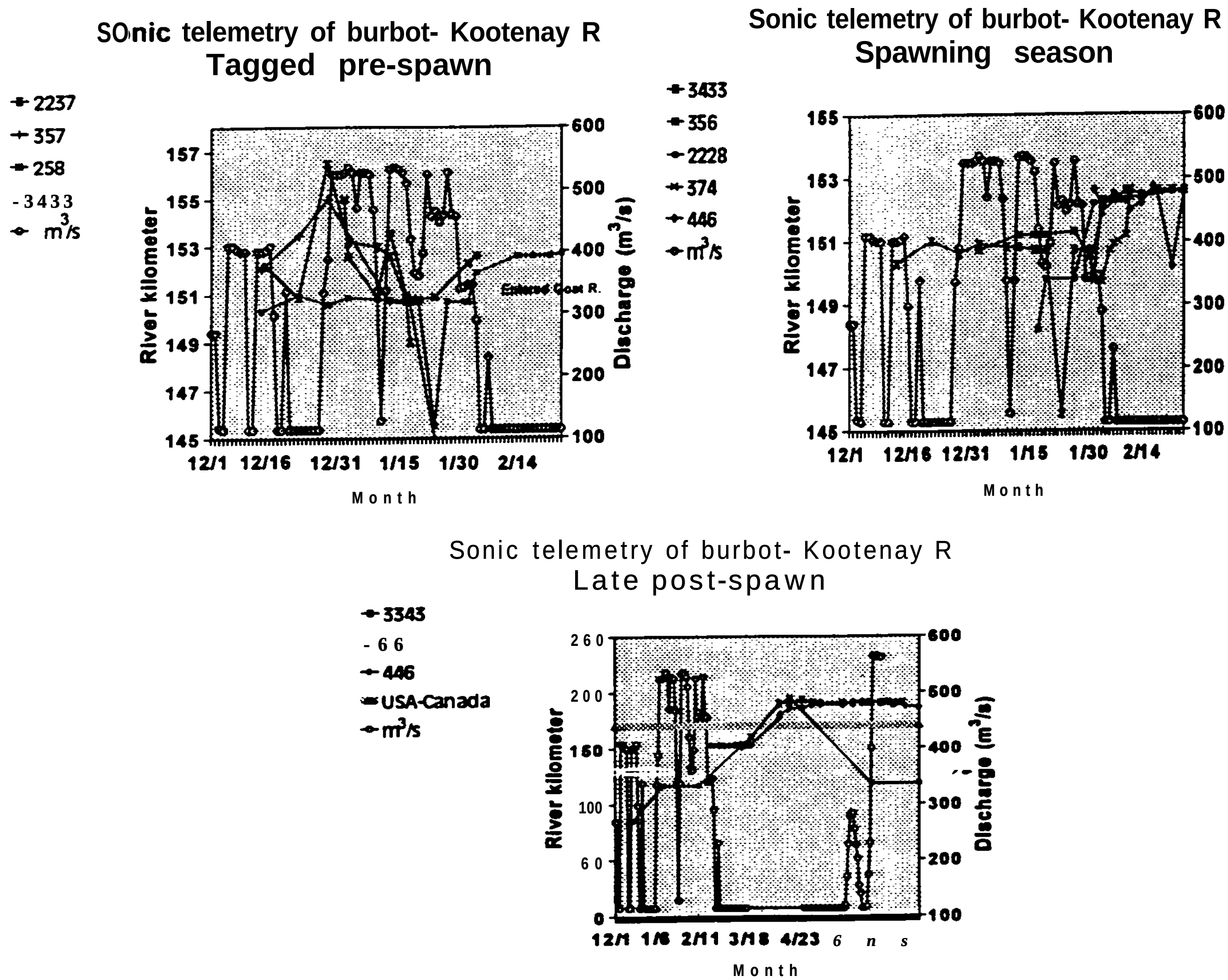


Figure 4. Sonic telemetry locations of burbot in the Kootenay River, British Columbia, Canada, and discharge from Libby Dam, Montana. Upper left figure represents movement of three burbot during the pre-spawn period, upper right movement of five burbot during the spawning season, and the lower figure movement of three burbot during post-spawn.

from about 510 to 113 $m^3$/s, on December 16, 1994 and January 11, 1995 (Figure 4). Temperature of the river remained at 5°C. On each occasion burbot moved upstream several km when discharge was decreased. But burbot drifted downstream when discharge increased to 510 $m^3$/s. Burbot returned to the vicinity of their release or were located further downstream, examples are burbot 2237, 357, 3433, and 258 (Appendix B, E, K, and M). Sexually mature burbot were noted but did not move upstream when Libby Dam was at winter hydropower operation of 510 $m^3$/s.

Burbot 96 (Appendix A) had not been located since July 7, 1994, but was relocated in Crawford Bay of Kootenay Lake (rkm 85) on December 13, 1994. It was located at rkm 1 16 on January 1, 1995. Burbot 455 remained in the delta region of Kootenay Lake for most of the year. But in December 1994 it moved into the river soon to return to the delta.

## Spawning Movement, Discharge, and Temperature

Twelve burbot were monitored between January 15 and February 27, 1995. All burbot implanted with transmitters during this period were ripe (Table 3). The most notable burbot movement occurred after January 27 when discharge was again reduced and stabilized at 1 13 $m^3$/s (Figure 4). Temperature of the Kootenay River was 4°C to 5°C. Most burbot moved upstream to the confluence with the Goat River where the temperature was 1°C to 2°C. At least three burbot ascended the Goat River (3433, 356, and 365) on several occasions during the spawning season, but returned to the confluence with the Kootenay River. I measured temperature of the Goat and Kootenay rivers and prepared a temperature profile of the confluence of the rivers (Figure 5). Most burbot staged in the cooler portion of the Kootenay River (Figure 5).

The last two burbot to be implanted during February 1995 (446 and 3334) were captured at the confluence of the two rivers. They remained in that reach for several days then bypassed the Goat River in late February when the temperature of the two rivers was the same (5°C). These two fish and burbot 96 eventually moved upstream into Idaho (Figure 4).

## Post-spawn Movement and Discharge

Seven burbot were monitored during the post-spawn period which began in mid-February. All 40-day transmitter batteries had expired by this period. Burbot 96, 3334, and 446 continued their upstream journey entering Idaho in early March. These burbot demonstrated no activity indicative of spawning behavior, although 3334 and 446 were ripe. When river temperature reached 7°C, several burbot became relatively sedentary and remained in deep pools (Appendix H, L, M, and N). Concomitant to the cessation of burbot movement was a rise in river temperature and discharge. The increase in river discharge in part was due to the Kootenai River white sturgeon test flows and local runoff (Paragamian et al., in press). Burbot 3433 eventually drifted down the Goat River to the confluence with the Kootenay River and remained there. Burbot 356 remained in the Goat River, while 2246 remained in the lower Kootenai River (rkm 130 to 136), and 455 remained in the delta (rkm 119 to 120). Burbot 446 reached rkm 191.9 in late May and drifted downstream to rkm 186, while 3334

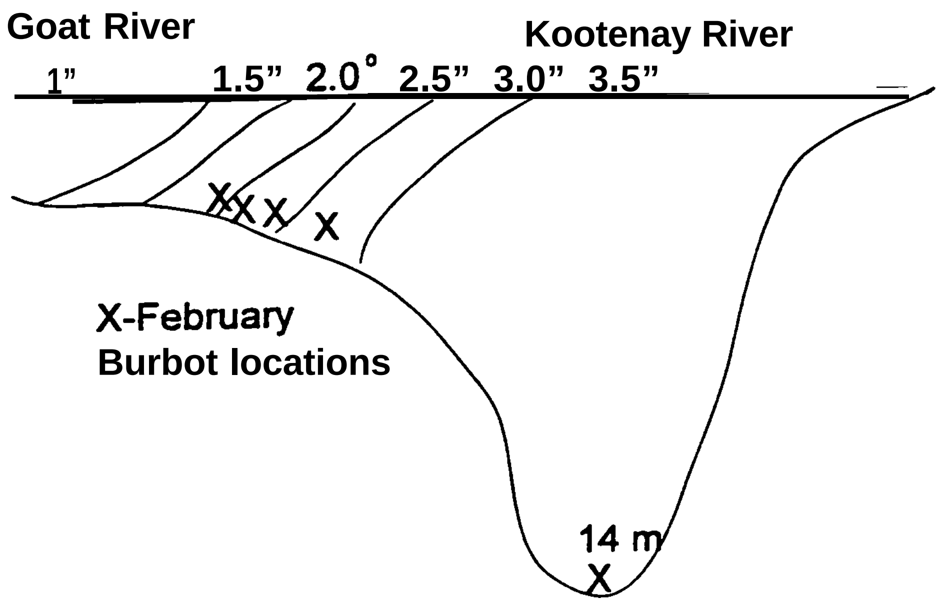


Figure 5. Temperature profile of the Kootenay River and temperature of the Goat River, British Columbia, Canada, February 16, 1995.

remained in a deep pool (25 m) at Parker Creek (rkm 1901. Burbot 96 moved downstream in late March and was relocated on the east side of Kootenay Lake (rkm 1 17.9) on June 25.

Burbot in the Kootenai River were very sedentary from spring through mid-summer. But when the temperature of the river approached 15°C in August, 446 and 3334 retreated to the lake or lower river.

### Habitat

Burbot were seldom located in less than 6 m of depth, 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 36 times. Velocities ranged from < 1 to 30 cm/s with a mean of 20 cm/s (Appendix A through K).

### Mortality

Two burbot died. The sonic transmitter of burbot 3433 was located in early May in a brush pile in the Kootenay River immediately above the confluence with the Goat River. The transmitter of 356 was located near the shoreline of the Goat River in September. These transmitters may have been shed or the burbot were eaten by predators.

## Data Analysis

There were 17 observations when a burbot moved greater than 1 km between telemetry contacts. Five burbot moved down stream when discharge went up, two fish went down when discharge went down, ten moved upstream when discharge went down, and none moved up when discharge went up. The test indicated a significant relation between burbot movement and discharge ($P = 0.0034$).

## Kootenai River Discharge and Velocities

Discharge in the Kootenai River from Libby Dam during the pre-spawn and spawning season ranged from 1 13 to 5 10 $m^3$/s. The travel time for these releases to reach Porthill (rkm 170), Idaho, is about 24 h. Post-spawn discharges were relatively stable at 1 13 $m^3$/s, while spring and summer discharges ranged from 1 13 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. The lake was at it's lowest elevation during the winter months at about 531.5

mean sea level. There are several hydropower dams on the Kootenay River downstream of Kootenay Lake at Nelson, British Columbia. The minimum and maximum elevation of the lake can be controlled by about 3 m. I obtained discharge and velocity measurements collected at Copeland, Idaho (rkm 199) to calculate a regression formula for the two variables (John Gralow personal communication, United States Geological Survey). An increase in discharge (Q) during the winter creates a direct proportional increase in velocity (V), where:

$$V = 2.82 + bQ$$
$$b = 0.078 \text{ (slope)}$$

Thus, an increase in discharge of 28.3 $m^3$/s increases velocity 5 cm/s (Figure 6). This model does not hold true after winter when the lake elevation is increased and water is stored for recreation and hydropower production.

Velocities in the Kootenay River at rkm 152.9, just above the Goat River, were collected on January 17, 1995 at a discharge of about 5 10 $m^3$/s. At two-thirds depth they ranged from 37.95 to 83.3 cm/s and averaged 64.29 cm/s ($n=5$), and at the bottom they ranged from 25.5 to 62 cm/s and averaged 44.3 cm/s. Velocities at this same location at 113 $m^3$/s were also measured on February 6, 1995. At two-thirds depth they ranged from 15 to 34 cm/s and averaged 25.2 cm/s ($n = 5$), and at the bottom they ranged from < 10 to 22 cm/s and averaged 18 cm/s. Velocities were also measured on February 6, 1995 at rkm 15 1. At two-thirds depth they ranged from 24 to 42 cm/s and averaged 35.9 cm/s ($n = 5$), and at the bottom they ranged from 12 to 24.6 cm/s and averaged 28.7 cm/s. Velocities measured at the mouth of the Goat River on February 6, 1995 at two-thirds depth ranged from 38 to 43 cm/s and averaged 40.1 cm/s ($n = 4$), and at the bottom they ranged from 22 to 38.1 cm/s and averaged 33.25 cm/s.

## Population Estimates at the Hemlock Bar

Nine species of fish were captured at the Hemlock Bar, but recaptures were only sufficient to make population estimates of five species (Table 4). Mountain whitefish were the most abundant at about 236/hectare, while largescale suckers were second at a density of 125/hectare and highest in standing stock at 1 12 kg/hectare. Standing stock of mountain whitefish was second at 32 kg/hectare. Density and standing stock of rainbow trout were 5 fish/hectare and 2 kg/hectare, respectively.

## Zooplankton Sampling

Zooplankton sampling gear captured six genera of zooplankton from the Kootenai River from September 1994 to August 1995 (Appendix L). Seven genera were captured from the Kootenay River delta of Kootenay Lake from January to August 1995 (Appendix M). In general, there was a paucity of zooplankton in the samples from the Kootenai River, Idaho, even when they were at peak density ranging from <0.04/L in September and April to 2.9/L in February 1995. Cyclops were the most abundant zooplankton genera ranging from < 0.01 /L in August to 2.4/L in February (Appendix L). All other genera were rare, and in some circumstances, only one individual was collected.

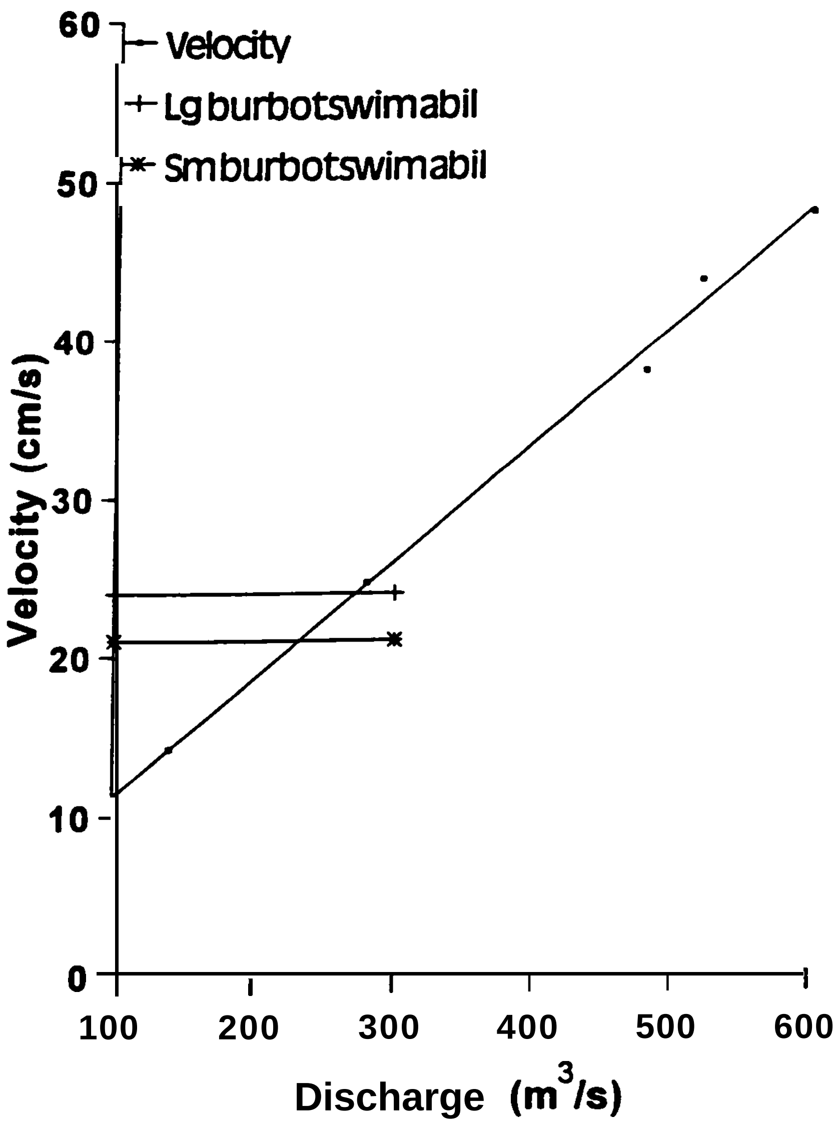


Figure 6. The discharge velocity relationship of the Kootenai River at Copeland, Idaho, represented by the ascending diagonal line. The intersection of the diagonal line with the horizontal lines represent the critical velocity for large burbot (up to 550 mm) and small burbot (<400 mm) (Jones et al. 1974).

Table 4. Catch, recapture, population estimate, density, and standing stocks of nine species of fish captured in the Hemlock Bar, Kootenai River, Idaho, September 1994.

| Species | Catch | Recapture | Population | C.I. (95%) | Density (N/ha) | Standing stock (kg/ha) |
|---|---|---|---|---|---|---|
| Mountain whitefish | 1,757 | 156 | 6,953 | 7.1 18<br>6,792 | 236 | 31.97 |
| Rainbow trout | 34 | 3 | 135 | 160<br>114 | 5 | 1.66 |
| Cutthroat trout | 5 | -- | — | -- | — | — |
| Longnose sucker | 7 | — | — | — | — | — |
| Largescale sucker | 450 | 20 | 3,682 | 3,803<br>3,623 | 125 | 112.38 |
| Chiselmouth | 4 | -- | -- | -- | -- | — |
| Northern squawfish | 43 | 3 | 194 | 223<br>169 | 7 | 2.92 |
| Kokanee | 404 | 37 | 1,561 | 1,640<br>1,485 | 53 | 6.41 |
| Peamouth | 4 | — | — | — | -- | — |

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Total zooplankton in the Kootenay River delta were higher ranging from 1 .1 /L in January to 69/L in August 1995 (Appendix M). The most abundant genera in the delta was Cyclops ranging as high as 28/L in August.

# 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). Only one juvenile burbot has been caught in Idaho since this investigation began in 1993. Yet sampling of burbot in the lower Kootenay River, British Columbia, during the winter of 1994 to 1995 indicated there were adult fish. Although they were also at a low density, telemetry and netting indicated there was a spawning migration and reproduction apparently occurred in the Goat River, British Columbia. This is important in that this stock of 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 diminished rapidly upstream of rkm 153. I caught 33 burbot from late November 1994 through February 1995 with 709 net days of effort (CPUE of 0.047 burbot/net-day) in the Kootenay River, British Columbia. Hoop nets were fished from rkm 145 to 170; two fish were caught above rkm 153, and only one of which was above rkm 169. The remainder were caught in or at the Goat River and downstream of rkm 153. 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. 19941) in Idaho.

## Burbot Telemetry

Winter hydropower production may have played a key role inhibiting migrations of burbot into Idaho. Statistical analysis of burbot movement and discharge indicated a significant relationship existed. Burbot are weak swimmers and have low endurance with a critical current velocity of 24 cm/s (Jones et al. 1974). Current velocities in the Kootenai River downstream of Bonners Ferry, Idaho, are subject to change with prevailing discharge and the stage of Kootenay Lake, British Columbia. Discharges above 255 $m^3/s$ at Copeland, Idaho, produced average current velocities higher than the critical velocity for adult burbot (Figure 6). Burbot with transmitters moved upstream when discharge was about 113 $m^3/s$, similar to pre-dam discharge, but when discharge was increased to 510 $m^3/s$ for power production, burbot drifted back downstream or did not advance. Telemetry findings were substantiated by hoop net sampling. Only two burbot were caught above rkm 153 during the period of power peaking, and only one fish was within 1 km of Idaho.

Critical velocity for burbot was determined under laboratory conditions (Jones et al. 1974). Jones et al. (1974) found critical velocity for burbot up to 550 mm to be about 24 cm/s. I found no information in the literature pertaining to critical velocities for burbot under natural conditions. My findings appeared to conform with those of Jones et al. (19741 because most of the velocity measurements I collected were similar to or less than the critical velocity determined in the lab.

While velocity may have been an inhibiting force to burbot migrating up the Kootenai River, colder temperatures may have acted as an attractant when burbot were ready to spawn. At 1 13 $m^3/s$ current velocity near the bottom of the Kootenay River, just upstream of the confluence with the Goat River, averaged about 18 cm/s (range < 10 to 22 cm/s). At 510 $m^3/s$ this same transect had an average velocity of about 44 cm/s. Several pre-spawn burbot swam upstream of the confluence with the Goat River in early January, as did several burbot in late February (late in the spawning season). On both occasions the Kootenay River was 5°C to 6°C, while the Goat River was 2°C and 5°C, respectively. But during the spawning season, burbot ascended the Goat River when it was the colder of the two. This happened despite the fact the Kootenay River just above the confluence with the Goat River averaged only 18 cm/s at 1 13 $m^3/s$. Also, a temperature profile indicated burbot appeared to prefer the colder water of the Goat River and staged in thermal transition areas of the Kootenay and Goat rivers during the spawning season (Figure 5). Late arriving, yet ripe burbot bypassed the Goat River in late February when temperatures were the same (5°C) (burbot 3334, 96, and 446). Preferred spawning temperature for burbot is usually 1°C to 3°C (Becker 1983).

Burbot move extensive distances during the winter to spawn (McCrimmon 1959, Morrow 1980, Breeser et al. 1988, and Evensen 1993), but are rather sedentary during the non-spawning season (Morrow 1980 and Carl 1995). In some systems burbot may move 125 km (Breeser et al. 1988). Burbot 96 traveled 105 km on an apparent spawning run from Kootenay Lake, but when the Kootenai River reached 7°C in March, it returned to Kootenay Lake. Burbot 446 and 3334 also arrived at the same time, soon became sedentary, and returned to the lake when the river reached 15°C.

The affect of high winter discharge may explain why no burbot were captured during the winter effort of 1993 to 1994. Sampling during the winter of 1993 to 1994 was done in anticipation of intercepting a spawning run of burbot in the lower Kootenai River (rkm 170 to 194) (Paragamian 1994). Nets were tended from December 1993 through February 1994 with over 360 net-days of effort. Telemetry of burbot during the winter of 1994 to 1995 indicated the three adult burbot that did migrate to Idaho did not enter until early March. Sampling for burbot in Idaho in 1994 was not productive until the first one was caught on March 1.

The prolonged travel time for a ripe burbot and disparity between prevailing water temperature and spawning temperature may be precluding spawning in Idaho. Examination of gonads of three burbot caught in spring of 1994 indicated all were unspawned females.

## Kootenai River System Productivity

Results of this study (Paragamian 1993 and 1994) and others (Marcuson et al. 1994; Snyder and Minshall 1994) have shown that reduced productivity of the Kootenai River has affected fish populations in numerous ways. After Libby Dam was constructed, there was a precipitous decline in the harvest of burbot from the West Arm of Kootenay Lake (British Columbia Ministry of Environment file reports; Paragamian 1993). I believe the reason the Kootenay Lake fishery mirrored the same trend in the burbot harvest in Idaho is because it is the same stock of fish. In an effort to estimate how this reduction in productivity may have changed the abundance of burbot, I examined the annual harvest of burbot from the West Arm and the concentration of Ortho-phosphate (Ortho-P) in the South Arm at spring turnover (Daley et al. 1981). Ortho-P is a very good indicator of potential primary production (Jones and Bachman 1974). Annual harvest data from 1971 through 1982 was paired to Ortho-P four years prior, 1967 through 1978, and then evaluated by regression analysis (Figure 7). A four-year lag period was used for Ortho-P because burbot recruited to the fishery at age 4. This would reflect any effect of productivity on survival of age 0 burbot, productivity of their first year of life, and productivity of the remaining stock for that year. The graphic relation indicated the higher the productivity the higher the harvest (Figure 7). The resulting analysis suggested 54% of the annual harvest may have been explained by lake productivity four years prior ($P=0.014$). Ortho-P plummeted from concentrations of 80 to 90 u/L in the late 1960s to 4 u/L by 1978 (Daley et al. 1981).

As productivity in the system was declining (Daley et al. 1981), natural Kootenai River discharge was changed to a regulated water management system. High summer flows in the Kootenai River were reduced (Figure 2) by impounding spring runoff in Lake Koocanusa. As a consequence the normally high discharge through the West Arm during spring, the prime months for fishing for burbot, was reduced. This too may have affected the harvest of burbot. The West Arm fishery for burbot was unique in that the shallow shelf at the mouth of the West Arm formed a trap for entrained Mysid shrimp, a food source for burbot (Martin and Northcote 1991). I compared the annual harvest of burbot to May discharge from the West Arm for the same years as Ortho-P, 1971 to 1982. The result indicated a significant correlation ($P = 0.013$, $r^2 = 0.557$) between discharge and harvest. Discharge data were then combined with Ortho-P in a multiple regression model ($P=0.000$, $R^2 =0.95$), 1981-l 987. Stepwise regression analysis indicated Ortho-P was the best predictor of burbot harvest. Reduced productivity of the lake could have adversely affected burbot by reducing zooplankton densities necessary for adequate larval survival. Lower abundance of mysid shrimp (Ashley et al. 1994) and other prey items could have also reduced burbot growth and productivity.

## Population Estimates at the Hemlock Bar

The low standing stocks of salmonids at the Hemlock Bar in 1995 reflected the same findings as 1994 (Paragamian 1994). Salmonids comprised only 22% of the total biomass of fish. In addition, few young rainbow or cutthroat trout were noted, with none younger than age 2 (Paragamian 1994). Many tributary streams in the Kootenai drainage are nursery streams, but it is not known in Idaho when young trout move to the Kootenai River nor what point in life is most critical to survival.

## Zooplankton

The zooplankton density of Kootenay Lake is substantially higher than that of the river. At the preparation of this report, zooplankton sampling was incomplete for the year. But the total mean density of the Kootenay Lake samples ranged from 1 to 69 zooplankton/L, while that of the river was < .1 to 3 zooplankton/L.

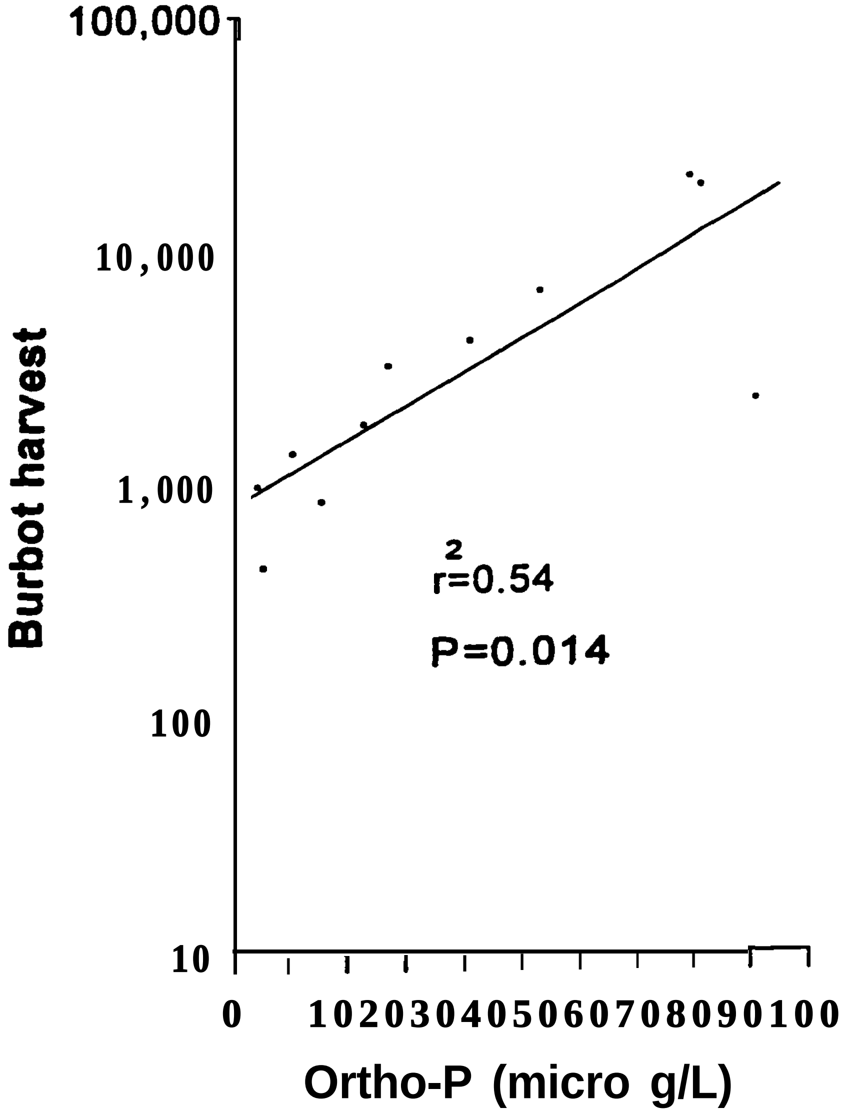


Figure 7. Relation of Ortho-P from 1967 to 1978 to the burbot harvest from the West Arm of Kootenay Lake, British Columbia four years later, 1971 to 1982.

A temporal comparison of food abundance (zooplankton) to the abundance and survival of larval burbot/sturgeon was precluded because no larval fish were caught in a companion study (J. Fredericks 1995, in preparation, Idaho Department of Fish and Game).

## RECOMMENDATIONS

1. Test the hypothesis that high winter discharge (power peaking) inhibits migration of burbot upstream to Idaho.

2. Capture and examine post-spawn burbot in Idaho to determine the presence of late vitellogenic eggs indicating they did not spawn.

3. Continue experimental larval burbot and sturgeon capture techniques with midwater trawls, sleds, beam trawls, D-rings, meter nets, seine nets, etc. This task should start immediately when burbot are known to spawn.

4. Determine the time of rainbow and cutthroat trout immigration to the Kootenai River from nursery streams and the most critical point in early life history to survival.

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# APPENDICES

Appendix A. Location (rkm), date, velocity, temperature °C, and depth of burbot 96 as determined by sonic telemetry and Xl6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 28 Jun 94 | 177.2 | | | |
| 1 Jan 95 | Crawford Bay 85.0 | | | |
| 24 Jan 95 | 116.5 | | | |
| 27 Feb 95 | 159.8 | 15.85 | | 4 |
| 16 Mar 95 | 188.3 | | | |
| 23 Mar 95 | 195.2 | 19.81 | 15 | 5 |
| 31 Mar 95 | 188.3 | | | 7 |
| 25 Jun 95 | 117.9 | | | 13.1 |
| 29 Jun 95 | 118 | | | 13.7 |
| 22 Jun 95 | 116.0 | 55 | | 10.8 |
| 11 Jul 95 | 118.0 | | | 14.9 |
| 18 Ju195 | 119.3 | | | 15.7 |
| 27 Jul 95 | 119.5 | 79 | | 15.4 |

Appendix B. Location (rkm), date, velocity, temperature “C, and depth of burbot 258 as determined by sonic telemetry and XI 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 4 Mar 94 | 244.5 | | | |
| 2 Jan 95 | 155.0 | | | |
| 3 Jan 95 | 152.6 | | | 3.5 |
| 10 Jan 95 | 150.9 | | | |
| 13 Jan 95 | 153.6 | 12.19 | | |
| 17 Jan 95 | 151.0 | | | 6 |
| 18 Jan 95 | 150.8 | 4.88 | | 6 |
| 20 Jan 95 | 150.8 | 16.76 | | 6 |
| 24 Jan 95 | 150.7 | | | |
| 1 Feb 95 | 152.3 | | 18.2 | 4 |
| 3 Feb 95 | 152.6 | | | |
| 6 Feb 95 | 152.6 | 6.71 | 22 | 5 |

Appendix C. Location (rkm), date, velocity, water temperature °C, and depth of burbot 276 as determined by sonic telemetry and XI6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 18 Jan 95 | 152.5 | | | 6 |
| 20 Jan 95 | 152.1 | 13.72 | | 6 |
| 1 Feb 95 | 151.3 | | 18.2 | 4 |
| 3 Feb 95 | 149.7 | | | 4 |
| 6 Feb 95 | 149.8 | 14.63 | 22 | 5 |
| 7 Feb 95 | 149.0 | 11.58 | 21 | 5.5 |

Appendix D. Location (rkm), date, velocity, temperature °C, and depth of burbot 356 as determined by sonic telemetry and XI 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 2 Jan 95 | 150.7 | | | |
| 13 Jan 95 | 151.2 | | | |
| 17 Jan 95 | 151.2 | | | 6 |
| 18 Jan 95 | 151.2 | 10.06 | | 6 |
| 20 Jan 95 | 151.2 | 9.45 | | 6 |
| 24 Jan 95 | 150.4 | | | |
| 27 Jan 95 | 151.3 | | | |
| 31 Jan 95 | 150.5 | 9.75 | | |
| 1 Feb 95 | 149.8 | | 18.2 | 4 |
| 3 Feb 95 | 152.3 | | 18.2 | |
| 6 Feb 95 | 152.3 | 9.14 | 22 | 5 |
| 6 Feb 95pm | 152.3 | | 22 | 5 |
| 7 Feb 95 | 152.3 | 8.84 | 21 | 5.5 |
| 9 Feb 95 | 152.3 | 12.50 | | 5 |
| 10 Feb 95 | 152.4 | | | 5 |
| 13 Feb 95 | 152.4 | | | 1.5 |
| 16 Feb 95 | 152.5 | | | |
| 17 Feb 95 | Goat R. | 2.44 | | 2 |
| 24 Feb 95 | Goat R. | | | 4 |
| 27 Feb 95 | Upper Goat R.[a] (1.5 km) | | | |

[a] Could not get boat further upstream.

Appendix E. Location (rkm), date, velocity, temperature °C, and depth of burbot 357 as determined by sonic telemetry and XI 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 13 Dec 94 | 152.1 | | | |
| 22 Dec 94 | 153.5 | 11.28 | | 5 |
| 29 Dec 94 | 155.0 | 18.90 | | |
| 3 Jan 95 | 151.9 | | | 3.5 |
| 13 Jan 95 | 150.7 | | | |
| 17 Jan 95 | 150.8 | | | 6 |
| 18 Jan 95 | 150.6 | 7.62 | | 6 |
| 24 Jan 95 | 139.0 | | | |
| 13 Feb 95 | 150.9 | | | 1.5 |

Appendix F. Location (rkm), date, velocity, temperature “C, and depth of burbot 365 as determined by sonic telemetry and Xl 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 23 Jan 95 | Goat River | | | |
| 27 Jan 95 | 152.5 | | | |
| 31 Jan 95 | 152.6 | | | |
| 1 Feb 95 | 152.6 | 11.58 | 18.2 | 4 |
| 3 Feb 95 | 153.1 | | | 4 |

Appendix G. Location (rkm), date, velocity, temperature °C, and depth of burbot 374 as determined by sonic telemetry and XI6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 1 Feb 95 | 149.7 | | | 4 |
| 3 Feb 95 | 150.9 | | | 4 |
| 6 Feb 95 | 150.7 | 18.29 | 22 | 5 |
| 6 Feb 95 pm | 150.9 | | 22 | 5 |
| 7 Feb 95 | 151.0 | 11.28 | 21 | 5.5 |
| 9 Feb 95 | 151.2 | 7.01 | | 5 |
| 10 Feb 95 | 152.4 | | | 5 |
| 13 Feb 95 | 152.4 | | | 1.5 |
| 16 Feb 95 | 152.8 | | | |
| 17 Feb 95 | 152.5 | | | 3 |

Appendix H. Location (rkm), date, velocity, temperature °C, and depth of burbot 446 as determined by sonic telemetry and Xl 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 1 Feb 95 | 152.6 | | | |
| 3 Feb 95 | 152.1 | | 18.2 | 4 |
| 6 Feb 95 | 152.4 | 6.71 | 22 | 5 |
| 6 Feb 95 pm | 152.4 | | 22 | 5 |
| 7 Feb 95 | 152.3 | 6.10 | 21 | 5.5 |
| 9 Feb 95 | 152.3 | 10.36 | | 5 |
| 10 Feb 95 | 152.0 | | | 5 |
| 13 Feb 95 | 152.2 | | | 1.5 |
| 16 Feb 95 | 152.7 | | | |
| 17 Feb 95 | 152.7 | | | 3 |
| 21 Feb 95 | 150.2 | | | 5 |
| 24 Feb 95 | 152.0 | | | 5 |
| 27 Feb 95 | 152.7 | | | |
| 16 Mar 95 | 176.7 | | | 5 |
| 17 Mar 95 | 180.2 | 8.52 | 27 | 5 |
| 23 Mar 95 | 185.3 | 6.71 | 25 | 5 |
| 31 Mar 95 | 185.8 | 7.62 | 16 | 7 |
| 6 Apr 95 | 188.8 | 12.19 | 21.3 | 6.5 |
| 7 Apr 95 | 188.9 | 12.50 | 24.4 | 6.5 |
| 12 Apr 95 | 189.0 | 9.45 | 30.0 | 4.6 |
| 26 Apr 95 | 188.5 | 17.37 | 21.3 | 8 |
| 3 May 95 | 191.1 | 4.27 | 22.9 | 6.3 |
| 9 May 95 | 191.9 | | | 8.5 |
| 13 May 95 | 190.0 | | | 6.3 |
| 14 May 95 | 191.4 | | | 8.5 |

Appendix H. Continued

| | | | | |
|---|---|---|---|---|
| 21 May 95 | 191.2 | | | 7.6 |
| 23 May 95 | 191.0 | | | 8.7 |
| 24 May 95 | 191 | 4 | | 9.0 |
| 25 May 95 | 191 | 5 | 20 | 8.7 |
| 29 May 95 | 188 | 4 | 20 | 10.1 |
| 31 May 95 | 190 | 4 | | 9.9 |
| 6 Jun 95 | 187 | 13 | | 8.8 |
| 1 Aug 95 | 126.1 | | | 14.8 |

Appendix I. Location (rkm), date, velocity, temperature °C, and depth of burbot 455 as determined by sonic telemetry and XI 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 1 Jan 95 | 119.2 | | Lake | |
| 24 Jan 95 | 119.2 | | Lake | |
| 9 Feb 95 | 120.0 | 26.52 | Lake | 5.25 |
| 28 Feb 95 | 120.0 | | Lake | |
| 18 Apr 95 | 120.0 | | Lake | |
| 27 Apr 95 | 119.5 | | Lake | 6.8 |
| 8 May 95 | 120.5 | | Lake | 8 |
| 22 May 95 | 119.5 | | Lake | 7.8 |
| 11 Jul 95 | 119.5 | 26 | Lake | 14.9 |
| 27 Jul 95 (further west) | 119.5 | 25 | Lake | 15.4 |

Appendix J. Location (rkm), date, velocity, temperature °C, and depth of burbot 2228 as determined by sonic telemetry and XI6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 18 Jan 95 | 148.2 | | | 6 |
| 20 Jan 95 | 149.8 | 16.46 | | 6 |
| 24 Jan 95 | 150.7 | 15.0 | | |
| 27 Jan 95 | 149.8 | 16.5 | | |
| 1 Feb 95 | 152.2 | 16.0 | 18.2 | 4 |
| 3 Feb 95 | 152.2 | 15.0 | 18.2 | 4 |
| 6 Feb 95 | 152.5 | 15.85 | 22 | 5 |
| 7 Feb 95 | 152.4 | 15.54 | 21 | 5.5 |
| 9 Feb 95 | 152.6 | 8.53 | | 5 |
| 10 Feb 95 | 152.6 | | | 5 |
| 13 Feb 95 | 152.5 | | | 1.5 |

Appendix K. Location (rkm), date, velocity, temperature °C, and depth of burbot 2237 as determined by sonic telemetry and XI 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 14 Dec 94 | 152.2 | | | |
| 22 Dec 94 | 150.9 | 10.97 | | 5 |
| 29 Dec 94 | 156.5 | 12.80 | | |
| 3 Jan 95 | 153.2 | | | 3.5 |
| 10 Jan 95 | 153.0 | | | |
| 13 Jan 95 | 151.6 | | | |
| 17 Jan 95 | 150.8 | | | 6 |
| 18 Jan 95 | 149.0 | 9.75 | | 6 |

Appendix L. Location (rkm), date, velocity, temperature °C, and depth of burbot 2246 as determined by sonic telemetry and Xl 6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 1 Feb 95 | 152.5 | | | |
| 3 Feb 95 | 152.2 | | 18.2 | 4 |
| 9 Feb 95 | 140.0 | 13.11 | | 5 |
| 24 Feb 95 | 133.3 | | | 5 |
| 28 Feb 95 | 130.6 | 10.67 | | |
| 18 Apr 95 | 135.3 | | | 7.5 |
| 27 Apr 95 | 135.3 | | .08 | 8.5 |
| 8 May 95 | 144.5 | | | 8 |
| 2 Jun 95 | 134 | | | 9.8 |
| 22 Jun 95 | 134 | | | 10.8 |
| 11 Jul 95 | 134 | | | 14.9 |
| 18 Ju195 | 134 | | | 15.7 |
| 27 Jul 95 | 137.2 | | 2.0 | 15.4 |
| 1 Aug 95 | 133.2 | | | 14.6 |

Appendix M. Location (rkm), date, velocity, temperature °C, and depth of burbot 3334 as determined by sonic telemetry and Xl6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 21 Feb 95 | 152.7 | | | 2 |
| 24 Feb 95 | 152.7 | | | 4 |
| 27 Feb 95 | 159.8 | 15.85 | | 4 |
| 16 Mar 95 | 190.2 | | | 5 |
| 23 Mar 95 | 190.1 | 28.35 | 21 | 5 |
| 31 Mar 95 | 193.3 | 15.85 | 23 | 7 |
| 6 Apr 95 | 190.5 | 24.51 | 12.2 | 6.5 |
| 7 Apr 95 | 190.5 | 24.38 | 12.2 | 6.5 |
| 12 Apr 95 | 190.0 | 24.08 | 12.2 | 4.6 |
| 26 Apr 95 | 190.3 | 19.20 | 27.4 | 8 |
| 3 May 95 | 190.2 | 22.25 | 19.8 | 6.3 |
| 9 May 95 | 190.3 | | | 8.5 |
| 13 May 95 | 190.3 | | | 8 |
| 14 May 95 | 190.3 | | | 8.5 |
| 21 May 95 | 190.3 | | | 7.6 |
| 23 May 95 | 190.2 | | | 8.7 |
| 24 May 95 | 190.2 | | | 9.0 |
| 25 May 95 | 191.1 | | | 8.7 |
| 29 May 95 | 190.1 | | | 10.1 |
| 30 May 95 | 190.1 | | | 10.2 |
| 31 May 95 | 190.1 | | | 9.9 |
| 4 Jun 95 | 190.5 | | | 10.7 |
| 8 Aug 95 | 118.0 | | | |

Appendix N. Location (rkm), date, velocity, temperature °C, and depth of burbot 3433 as determined by sonic telemetry and XI6 Lowrance graph recorder.

| Date | Location (rkm) | Depth (m) | Velocity (cm/s) | Water temperature °C |
|---|---|---|---|---|
| Released | | | | |
| 13 Dec 94 | 150.3 | 12.80 | | 5 |
| 22 Dec 94 | 151.0 | 12.80 | | 5 |
| 29 Dec 94 | 150.6 | 17.37 | | |
| 3 Jan 95 | 150.9 | 14.69 | | 3.5 |
| 10 Jan 95 | 150.8 | | | |
| 17 Jan 95 | 150.7 | | | 6 |
| 18 Jan 95 | 150.7 | 16.46 | | |
| 20 Jan 95 | 150.7 | 5.49 | | |
| 24 Jan 95 | 145.5 | | | |
| 27 Jan 95 | 150.7 | | | |
| 31 Jan 95 | 150.7 | | | |
| 1 Feb 95 | 150.7 | | 18.2 | 4 |
| 3 Feb 95 | 151.9 | | | 4 |
| 9 Feb 95 | 2K up Goat River (GR) | 2.44 | | 2.25 |
| 10 Feb 95 | 152.6 | | | 5 |
| 13 Feb 95 | 152.5 | | | 1.5 |
| 17 Feb 95 | GR152.6 | 2.44 | | 2 |
| 21 Feb 95 | GR152.6 | 1.83 | | 3.5 |
| 24 Feb 95 | GR152.6 | | | 4.0 |
| 27 Feb 95 | 152.7 | | | |
| 15 Mar 95 | 152.5 | | | 5 |
| 17 Mar 95 | 152.7 | 3.66 | <10 | 5 |
| 19 Mar 95 | 152.5 | | | |
| 20 Apr 95 | 152.7 | 6.10 | 3 | 8 |
| 22 May 95 | 152.5 | | | 7.8 |

Appendix N. Continued

| | | |
|---|---|---|
| 25 Jun 95 | 152.5" | 13.1 |
| 28 Jun 95 | 152.5 | 13.2 |
| 11 Jul 95 | 152.5 | 14.9 |
| 20 Jul 95 | 152.5 | 16.3 |
| 1 Aug 95 | 152.5 | 14.6 |

"Suspected mortality transmitter in 2 m of water in among brush.

Appendix 0. Monthly mean density (N/L) and range of zooplankton sampled at Ambush Rock of the Kootenai River, Idaho, during midday verticle haul, September 1994 through August 1995.

| Month | Cyclops Mean range | Nauplii Cyclops Mean range | Diaptomus Mean range | Epischura Mean range | Ergasilus Mean range | Daphnia Mean range | Diaphonosoma Mean range | Bosmina Mean range | Total |
|---|---|---|---|---|---|---|---|---|---|
| SEP | .02 .0 . .03 | -- | -- | -- | -- | -- | -- | .02 0 .03 | .04 .02 - .06 |
| OCT | .02 0 - .05 | .004 0 - .009 | -- | -- | | _ | .. | . | .024 .01 - .05 |
| NOV | .19 .14 - .23 | .02 .01 . .03 | -- | -- | -- | -- | .. | -- | .22 .17 - .26 |
| DEC | .28 .13 - .43 | .06 .02 - .11 | .01 0 .01 | .. | -- | -- | | ,003 0 - .01 | .35 .16 - .55 |
| JAN | .55 .33 . .70 | .05 .04 - .05 | .003 0 - .01 | -- | -- | .003 0 .01 | | .01 0 - .02 | .62 .38 - .76 |
| FEE | 2.42 1 .78 - 2.77 | .43 .23 - .58 | .01 0 - .02 | . | .01 0 - .02 | .. | | .02 0 - .03 | 2.89 2.04 - 3.37 |
| MAR | .70 .50 - .82 | .06 .06 . .07 | .04 .02 .11 | | | | | .02 0 - .06 | .82 .68 .93 |
| APR | .03 .01 - .06 | .01 0 - .02 | - | | | | . | .. | .04 .02 - .08 |
| MAY | .17 .11 - .23 | .21 .14 - .30 | .02 0 - .03 | | .03 0 .08 | _ | .' | .09 .03 - .20 | .52 .40 - .59 |
| JUN | .12 .02 - .24 | .04 .01 . .07 | -- | -- | | .003 0 .01 | | .01 0 - .02 | .17 .06 - .32 |
| JUL | .05 .02 .07 | .02 0 - .05 | -- | | | | | .01 0 - .04 | .08 .05 - .12 |
| AUG | .01 0 - .01 | .003 0 - .01 | .02 0 .06 | | | -- | .01 0 - .01 | .01 .01 - .01 | .05 .03 - .09 |

Appendix P. Monthly mean density (N/L) and range of zooplankton sampled at Kootenay River Delta of Kootenay Lake, B.C., during midday verticle haul, January through August 1995.

| Month | Cyclops Mean range | Nauplii Cyclops Mean range | Diaptomus Mean range | Epischura Moan range | Ergasilus Mean range | Daphnia Mean range | Diaphonosoma Mean rango | Bosmina Mean range | Total |
|---|---|---|---|---|---|---|---|---|---|
| JAN | .83 55 · 1.13 | .17 03 .31 | .04 .0 .07 | | .02 0 05 | | | .01 0 · .02 | 1.06 .65 · 1.50 |
| FEB | G4 .52 86 | .11 09 .16 | 2.04 1.46 · 2 3G | | .09 07 11 | | | | 2.88 2.16 3.43 |
| MAR | 9.08 7.10 11 78 | 2.08 1 G7 2.52 | 74 72 20.75 31.67 | | G3 .32 89 | | | | 36.51 30.70 46.86 |
| APR | 3.50 2.76 4.06 | 1 65 1 12 7.44 | 15.44 14 05 2.44 | | .82 .65 96 | | | | 21.42 18.66. 24.25 |
| MAY | 7.70 1 36 7 71 | 2 17 1 39 2.74 | 8 44 5.05 11.19 | | 26 19 33 | .01 0 · .01 | | .04 .02 .05 | 13.13 8.04 · 16.99 |
| JUN | 6.93 5 03 · 9.70 | 7.90 6.96. 6.46 | 18.68 17.14 21.11 | .01 0 · .04 | .03 0 .05 | 04 0 .12 | .01 0 · .02 | .41 .20 · .67 | 34.02 31.08 · 37.38 |
| JUL | 7.38 5 17'8 78 | 8.18 5 76 9.72 | 8.37 6.01 9.91 | | 48 25 69 | 31 06 · 55 | .26 .10 · 39 | .63 .57 · .72 | 25.60 11.90. 79.90 |
| AUG | 28.02 73.97 31 71 | 4.42 2 17 G.66 | 14.33 12.79 · 11.35 | .01 0 · .04 | 1.5% 1.41 1.65 | 6 22 5.78 G.99 | 11.38 HOI 13.31 | 3 49 2.67 · 4.67 | 69.43 57.56. 77.11 |

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