FISHERY RESEARCH

KOOTENAI RIVER RESIDENT FISH MITIGATION: WHITE STURGEON, BURBOT, NATIVE SALMONID MONITORING AND EVALUATION

Annual Progress Report

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CHAPTER 1: WHITE STURGEON MONITORING AND EVALUATION
AUTHORS: PETE RUST AND VIRGINIA WAKKINEN

ABSTRACT

Adult white sturgeon sampling occurred between January 19 and November 16, 2010, with IDFG and BCME crews expending 6,318 h to capture 143 adult white sturgeon with setlines and four adult white sturgeon by angling. 78% of the adults were recaptures from previous years. Catch rates were 0.023 fish/h for setlines and 0.09 fish/h for angling. In 2011, we began sampling for adult sturgeon on March 8 and continued through October 24. With 5,570 h of effort, we captured 64 adults with setlines and 5 by angling. Catch rates were 0.011 fish/h with setlines and 1.1 fish/h for angling. 75% of the sturgeon collected were recaptures from previous years. Migration, movement extent, and response to Libby Dam operations of adult sturgeon tagged with Vemco transmitters were determined after downloading 61 stationary receivers. In 2010, 24 adult white sturgeon were tagged with sonic transmitters in the spring and three were tagged in fall. In 2011, nine adults were tagged in the spring and one in the fall. Of these two years, 27 of the tagged sample (20 females) were in spawning condition and exhibited a spawning migration in 2011. All of these adults moved upstream as far as rkm 235.0. Twenty-five (93%) of the migrating adults were recorded at rkm 240.0 just below Deep Creek, and 16 (59%) of the migrating adults went upstream as far as rkm 244.5 (Ambush Rock). Additionally, four (15%, all females) of the tagged spawners went above the Hwy. 95 Bridge in Bonners Ferry into the braided reach in 2011. These data will be used in a predictive movement model to evaluate responses to different flow and/or temperature regimes. To determine the temporal and spatial extent of spawning events, we also deployed substrate mats in 2010 and 2011 in and around historical spawning locations. In 2010, we sampled 51,090 h between May 10 and July 20 and collected 87 eggs. The highest catch rate came from below the train bridge in Bonners Ferry (rkm 246.0). Eggs were first collected on May 17, and the last eggs were collected on June 30. In 2011, we sampled 39,788 h between May 6 and July 14 and collected 195 eggs. The highest catch rate came from the reach below Myrtle Creek (rkm 234.5). The first eggs were collected on May 31 and the last eggs were collected on July 7. We used short-set gill nets to evaluate natural recruitment, growth, and mortality rates of marked hatchery juveniles, as well as distribution and densities of both hatchery and wild juveniles. In 2010, we sampled 24 sites between rkm 120.0 and 257.4 and collected 871 juvenile sturgeon (866 hatchery-reared) with 549 h of combined effort. The highest percentage of the catch came from rkm 190.0 but catch was well distributed throughout the river. In 2011, we sampled 20 sites between rkm 120.0 and 244.0 and collected 1,160 juvenile sturgeon (1,144 hatchery-reared) with 448 h of combined effort. This is the highest catch to date for the juvenile monitoring program. The highest percentage of the catch came from the Kootenay Lake delta (rkm 120.0) followed by rkm 244.0, but several sites contributed to a high percentage of the catch. More recent examination of juvenile gill net captures suggests that rearing facility, age of release, and release location may also significantly affect survival. All of these factors need detailed evaluation to maximize efficiencies and maximize growth rates.

INTRODUCTION

The Kootenai River white sturgeon *Acipenser transmontanus* population is mainly comprised of old adults, and significant recruitment has not occurred since the 1970s. Although the specific causes of recruitment failure remain unclear, years of study suggest that mortality occurs between egg and larval stages. Over a decade of artificial substrate mat sampling has indicated that from nine to 20 spawning events occur annually, and many viable embryos are

produced (Paragamian and Wakkinen 2002). Most of the post-Libby Dam spawning events have been documented in areas where substrate conditions appear to be unsuitable for egg incubation and larval rearing (Paragamian et al. 2001), and only one larvae and relatively few wild juveniles have been collected despite years of intensive sampling. Research to date suggests that egg and/or larval suffocation, predation, and/or other mortality factors associated with these early life stages contribute to persistent recruitment failure (Kock et al. 2006). Hatchery-reared juveniles (as young as nine months of age at release) have average annual growth rates of 6.4 cm per year, and second year survival rates exceed 90% (Ireland et al. 2002). Growth and survival of hatchery juveniles released at a minimum of age one further suggests that mortality occurs at the egg, embryonic, or larval stage. In an effort to improve spawning conditions for Kootenai River white sturgeon (hereafter white sturgeon), Libby Dam has been operated to provide increased spring discharge (>630 m^3/s or 22,248 ft^3/s for 42 d at Bonners Ferry) since 1991 when water supplies are suitable.

GOAL

To recover the Kootenai River white sturgeon population to a level that is self-sustaining and can provide sportfishing opportunity to the public.

OBJECTIVE

To have suitable spawning, rearing, and incubation habitat for white sturgeon for successful wild recruitment. The main task of this program is to monitor the response of all life stages of white sturgeon to flow augmentation from Libby Dam provided by the U.S. Army Corps of Engineers (Corps).

STUDY SITE

The Kootenai River originates in Kootenay National Park, British Columbia (BC), Canada. The river flows south into Montana and turns northwest at Jennings, near the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1.0). Kootenai Falls, 42 rkm downstream of Libby Dam, may be an impassable barrier to white sturgeon. As the river flows through the northeast corner of Idaho, there is a gradient transition at Bonners Ferry. Upstream from Bonners Ferry, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8 m/s. Downstream from Bonners Ferry, the river slows to velocities typically less than 0.4 m/s (average gradient 0.02 m/km), and the channel deepens as the river meanders north through the Kootenai River Valley. The river returns to BC at rkm 170.0 and enters the South Arm of Kootenay Lake at rkm 120.0. The river leaves the lake through the West Arm of Kootenay Lake and flows to its confluence with the Columbia River at Castlegar, BC. A natural barrier at Bonnington Falls (now a series of four dams) has isolated the Kootenai River white sturgeon from other populations in the Columbia River basin for approximately 10,000 years (Northcote 1973). The basin drains an area of 49,987 km^2 (Bonde and Bush 1975). Regulation of the Kootenai River following the construction of Libby Dam in 1974 changed the natural hydrograph and temperatures of the river (Partridge 1983). Spring flows were reduced to about one-third of pre-dam levels, and flows during winter are now three to four times higher than under a natural flow regime. Post-dam temperatures are now cooler in summer and warmer in winter.

METHODS

Water Levels, Discharge, and River Temperature

Based on the United States Fish and Wildlife Service's (USFWS) February 2006 Biological Opinion (USFWS 2006) on operations of Libby Dam, and the volume runoff forecasts for 2010 and 2011, the USFWS in cooperation with members of the Kootenai River White Sturgeon Recovery Team (KRWSRT), submitted System Operations Requests (SOR) FWS#2010-1 and FWS#2011-1 to the Corps' regional multiagency/entity Technical Management Team (TMT) for specific shape, timing, and volume of sturgeon augmentation flow from Libby Dam during the sturgeon spawning seasons. Specific details, justifications, and biological opinion success criteria are listed at FWS#2010-1 (http://www.nwd-wc.usace.army.mil/tmt/sor/2010/FWS_2010-1Libby.pdf) for 2010 and FWS#2011-1 (http://www.nwd-wc.usace.army.mil/tmt/sor/2011/SOR_2011-FWS1.pdf) for 2011. The objective of these operation requests was to maintain higher, more stable summer discharges provided to the extent possible with the available water to meet white sturgeon and bull trout ESA responsibilities (USFWS 2006) and to attempt to mimic a more natural river hydrograph under the current water management regime. The intent was also to provide spawning and incubation flows to meet attributes for depth, velocity, and temperature in the Kootenai River as defined in the 2006 Biological Opinion RPA for white sturgeon (USFWS 2006) and improve conditions for spawning sturgeon to migrate upstream of Bonners Ferry into the braided reach (above rkm 246). We obtained Kootenai River stage, discharge, and water temperature data at Bonners Ferry from the Corps (Figure 1.1 and 1.2).

The April to July 2010 and 2011 Kootenai River (MT) stream flow forecast, which includes the white sturgeon spawning season, was 59% and 118% of average, respectively. Snow water equivalents in April 2010 and 2011 were 64% and 126% of average, respectively. For the Kootenai basin in Montana, discharges were expected to be below normal for 2010 (see http://www.mt.nrcs.usda.gov/news/releases/aprilsnow10.html) and above average for 2011 (http://www.mt.nrcs.usda.gov/news/releases/aprsnow11.html).

Adult White Sturgeon Sampling

Adult white sturgeon were collected by angling and setlines from January through November 2010 and from March to October in 2011 following the methods of Paragamian et al. (1996). From February through April, most of the sampling occurred in the staging areas at rkm 205 and 215. These areas are backwater habitats and have depths in excess of 20 m and low current velocities (<0.05 m/s). Later in the spring, areas closer to the spawning locations (near rkm 229) were sampled more frequently. Fall sampling occurred in the spring staging areas in 2010 and near the Kootenai River delta at rkm 120 in 2011. We biopsied adult sturgeon to determine sex and level of maturity (Conte et al. 1988; Van Eenennaam and Doroshov 1988). Male and female white sturgeon expected to spawn each spring were tagged with Vemco model V16 sonic transmitters and released (see telemetry section). Some gravid female white sturgeon expected to spawn during the spring of capture were transported to the Kootenai Tribe of Idaho (KTOI) Hatchery for hatchery production. Gametes from ripe male white sturgeon were collected in the field by extraction through the urogenital opening with a syringe. Gametes were placed in a Ziploc® bag, transported to the KTOI Hatchery, and stored in a refrigerator. White sturgeon sperm is viable for only 48 hours after extraction, so we did not collect male gametes until a female had been induced to ovulate.

Adult White Sturgeon Telemetry

Monitoring daily and seasonal spawning movements of white sturgeon throughout the Kootenai River/Kootenay Lake system using passive telemetry continued to be a high priority of this investigation. From 2003-2011 we maintained an array of Vemco model VR2 sonic receivers located from rkm 18.0, near the mouth of the Lardeau River in Kootenay Lake, BC, upstream to rkm 285.5, near the Yaak River in Montana (Figure 1.3). We deployed receivers in areas where fish pass through but do not usually hold for long periods to avoid redundant data collection. Most sites were below river bends or along straight reaches that allow for good signal reception but were reasonably free of drifting debris and at low risk of potential vandalism. Each receiver was tethered to a float to keep the hydrophone off the substrate, anchored to a cement block, and chained to the riverbank. Receivers were downloaded in late winter, during the spawning season, and in the fall by connecting hardware (VR2PC or Bluetooth key) through a computer serial or USB port to an external port on the receiver. Data were transferred through the serial or USB port to software (VUE) for analysis. This array allows continuous monitoring of sturgeon movements within the Kootenai River system and into Kootenay Lake.

Artificial Substrate Mat Sampling

Artificial substrate mats were used to document white sturgeon spawning in the Kootenai River (McCabe and Beckman 1990). The main purpose of this monitoring was to evaluate temporal and spatial distribution of spawning events in the Kootenai River. Mats were deployed in four general areas and were checked two or three times per week. All eggs were removed from mats each day and when eggs were found, a new mat was deployed in the same location to remove any doubts if eggs captured the next day were new or missed from the previous day. Eggs were stored in formalin and brought back to the laboratory at the field station for analysis. All eggs were staged by viewing at 120X magnification under a dissecting microscope to estimate spawn date by the methods described by Beer (1981).

Free Embryo Releases

Suitable incubation and larval rearing habitat is critical for successful recruitment, and this habitat is limited in the post-Libby Dam spawning reach (Paragamian et al. 2002). To address these recruitment issues, we released one- to four-day-old fry (free embryos) at up to seven predetermined sites in 2010 and 2011 to determine drift rates and survival. All of the release sites contained substrate and flow conditions that are similar to those used by successfully reproducing and recruiting white sturgeon populations elsewhere in the Columbia River basin (Parsley et al. 1993; USFWS 2006). Long-term survival of the free embryos will be evaluated using gillnets when potential recruits become fully vulnerable to this gear type in three years.

Juvenile White Sturgeon Sampling

We used weighted multifilament gillnets with 1.3, 1.9, 2.5, 3.8, 5.1, 6.4, and 7.6 cm stretch mesh to sample juvenile and young-of-the-year (YOY) sturgeon. The purpose of this sampling was to evaluate natural recruitment, growth, and mortality rates of marked hatchery juveniles, as well as distribution and densities of both hatchery and wild juveniles. Sampling was conducted from July 27 through September 23, 2010 and from July 18 to October 24, 2011 following the methodology of Paragamian et al. (1996). Gillnets were set during the daytime and checked every hour to reduce mortality and all sturgeon were released alive.

From 1992 to 2004, prior to release, each sturgeon received a passive integrated transponder (PIT) tag and a pattern of scutes was removed by the KTOI hatchery staff or by staff at a backup hatchery facility near Cranbrook, BC (administered by the Freshwater Fisheries Society of Canada). Most (92%) of the released juvenile white sturgeon were not PIT tagged from 2005 through 2007, although scutes were removed from each fish released. Most hatchery reared juvenile sturgeon released in the Kootenai River after 2007 were PIT tagged and all had scutes removed in a pattern unique to the brood year and rearing facility. Fork (FL) and total length (TL), weight, PIT tag numbers, fish condition, and scute removal patterns (to determine release date and location of hatchery fish) were recorded for each sampled sturgeon. Pectoral fin ray sections were removed from all wild juvenile white sturgeon for age estimation. Each wild sturgeon received a PIT tag and the second left scute was removed for future identification. BCMFLRO crews sampled 12 different sites from Kootenay Lake, BC upriver to rkm 165.0 and followed methods outlined above.

RESULTS

Water Levels, Discharge, and River Temperature

On June 1, 2010, Koocanusa Reservoir inflow peaked at 1,073 m^3/s (37,900 ft^3/s) and the reservoir filled to elevation 745 m (2,443 feet) on August 17. Full reservoir elevation is 750 m (2459 ft.). Average daily Libby Dam outflow peaked June 12 at 948 m^3/s (33,485 ft^3/s) and remained near 934 m^3/s (33,000 ft^3/s) for six days. Beginning June 16, discharge began receding into the 556 m^3/s (20,000 ft^3/s) range and slowly decreased to near 198 m^3/s (7,000 ft^3/s) by July 14.

Water temperatures measured at Bonners Ferry in 2010 remained mild throughout the winter period and began increasing slowly in mid-April to above 5°C. By mid-June, water temperatures were above 9°C, and they continued increasing through the spawning season (Figure 1.2). Water temperatures were near 15°C by the end of the spawning season in mid-July, and by August temperatures reached their maximum of 20.0°C.

On June 9, 2011, Koocanusa Reservoir inflow peaked at 1,953 m^3/s (69,000 ft^3/s) and the reservoir filled to elevation 748 m (2,453 feet) on August 5. Full reservoir elevation is 750 m (2459 ft.). Average spring daily Libby Dam outflow peaked June 17 at 730 m^3/s (25,800 ft^3/s) and remained near 708 m^3/s (25,000 ft^3/s) from June 11 to June 18. Beginning on June 19, discharge dropped to 566 m^3/s (20,000 ft^3/s) and slowly receded to 170 m^3/s (6,000 ft^3/s) by early September.

Water temperatures measured at Bonners Ferry were cooler in 2011 than in 2010. Temperatures remained below 5°C until April and temperatures during the spawning season remained cool, fluctuating around 8 or 9°C for most of the period (Figure 1.2). Water temperatures were below average for the summer, reaching their maximum of 16°C in early September.

Adult White Sturgeon Sampling

Between January 19 and November 16, 2010, IDFG and BCME crews expended more than 6,318 h to capture four adult white sturgeon by angling and 143 adult white sturgeon with setlines (Table 1.1). Additionally, one adult sturgeon was collected in gillnets while sampling for juvenile sturgeon. Catch rates were 0.09 fish per rod h for angling and 0.023 fish per setline h

(Table 1.1). One hundred sixteen (78%) of the 148 adult white sturgeon collected were recaptures from previous years (Table 1.1). Thirty-five adult white sturgeon were biopsied by IDFG and BCMFLRO. Twenty-eight (80%) of the biopsied adults were females, two were males (6%), and sex could not be determined for five individuals (14%). For some individuals, sex was determined based on previous inspection recorded in a database. Twenty-three of 28 females biopsied (82%) were stage F4 (mature eggs), three were stage F3 (developing eggs), and one was stage F2 (early developing eggs); specific stage could not be determined from the remaining one female. Two of the males were biopsied at stage M8 (mature testes) and seven of the males had non-reproductive testes at the time of capture, resulting in no stage assignment. KTOI Hatchery personnel also captured and biopsied adult white sturgeon for their propagation operations; Lewandowski (2010) provides adult capture information.

We began sampling for adult sturgeon in 2011 on March 8 and continued to October 24. We expended a total of 5,570 h of effort to capture five adult white sturgeon by angling and 64 adult white sturgeon with setlines (Table 1.1). Three adult sturgeon were sampled incidentally while gillnetting for juvenile sturgeon. Catch rates were 1.1 fish per rod h and 0.011 fish per setline h (Table 1.1). Sixty-five (90%) of the 72 adult sturgeon collected in 2011 were recaptures from previous years. For some individuals, sex was determined based on previous inspection recorded in a database. Eighteen of the 72 adults were biopsied and 13 females and five males were identified. Eleven of the females were stage F4 (85%, mature eggs), one was stage F2 (early development eggs), and one female was of unknown stage. Gonad development could not be determined from three of the males, and two were stage M8 (mature testes). KTOI Hatchery personnel also captured and biopsied adult white sturgeon for their propagation operations; Lewandowski (2011) provides adult capture information.

Adult White Sturgeon Telemetry

Migration, movement extent, and behavior during Libby Dam flow augmentation operations by adult sturgeon tagged with Vemco transmitters was determined after downloading 61 stationary Vemco VR2 sonic receivers (Figure 1.3).

Twenty-four adult white sturgeon were newly tagged with Vemco sonic transmitters in spring 2010 and three were newly tagged in fall 2010. Two previously Vemco-tagged sturgeon were also captured and a new tag was deployed to replace one of the older tags. One hundred nine adult white sturgeon had active Vemco sonic transmitters from previous years or were not expected to spawn in spring 2010 (Table 1.2).

Thirty-six sonic tagged adult white sturgeon (28 females) were in spawning condition and exhibited a spawning migration in 2010. A spawning migration was defined by fish observed in spawning condition in 2010 or expected to be in spawning condition based on previous biopsies, which moved upstream to at least the lower end of the spawning reach (rkm 228.0). All 36 of these tagged adults moved upstream as far as rkm 235.0. Thirty-two (89%) of the migrating adults were recorded at rkm 240 just downstream of Deep Creek, and twenty-three (64%) of the migrating adults went upstream as far as rkm 244.5 (Ambush Rock). Additionally, at least seven (19%, 6 females) of the tagged migrating adult sturgeon went upstream of the Hwy. 95 Bridge in Bonners Ferry into the braided reach in 2010.

Nine adult white sturgeon were newly tagged with Vemco sonic transmitters in spring 2011, and one was newly tagged in fall 2011. Four previously Vemco-tagged sturgeon were also captured and a new tag was deployed to replace one of the older tags. One hundred thirty-

eight adult white sturgeon had active Vemco sonic transmitters from previous years or were not expected to spawn in spring 2011 (Table 1.2).

Twenty-seven of the sonic tagged adult white sturgeon (20 females) were in spawning condition and exhibited a spawning migration in 2011. All 27 of these tagged adults moved upstream as far as rkm 235.0. Twenty-five (93%) of the migrating adults were recorded at rkm 240.0, sixteen (59%) of the migrating adults moved upstream as far as rkm 244.5, and four (15%, all females) adult sturgeon moved upstream of the Hwy. 95 Bridge in Bonners Ferry into the braided reach in 2011.

Appendices 1.1 and 1.2 show the movement histories of the five and four female white sturgeon that moved upstream of the Hwy. 95 Bridge in Bonners Ferry in 2010 and 2011, respectively. These data will be used in a predictive model to determine the flows, flow shape, and temperatures that initiate spawning.

Artificial Substrate Mat Sampling

We deployed substrate mats in 2010 and 2011 to evaluate the temporal and spatial extent of white sturgeon spawning events in the Kootenai River. In 2010, we sampled several sites including new areas in the lower Kootenay River (BC) near the Kootenay Lake delta (Table 1.3), and the traditional section further upstream in Idaho within the post-Libby Dam spawning reach (rkm 129.0–251.0, Table 1.3). In 2011, we sampled four different geographic river sections within the traditional post-Libby Dam spawning reach (rkm 237.0–249.3, Table 1.3).

In 2010, we sampled 51,090 mat hrs between May 10 and July 20 and collected 87 eggs (Table 1.3). The highest catch and the highest catch rate came from downstream of the train bridge in Bonners Ferry (rkm 246.0, Table 1.3). The first eggs were collected on May 17, and the last eggs were collected on June 30. Of the 81 eggs that could be staged at the time of sampling, 75% were at stage 16 and 15% had developed to stage 23. Only six eggs (7%) from the 2010 sample were dead or fungused and could not be staged.

Based on the stages of the 87 eggs collected, 93 percent of the eggs may have been viable, as such, we estimate that white sturgeon spawned during at least 14 days in 2010 (Table 1.4). Water temperature during the egg collection period ranged from 9° to 14°C (Table 1.4).

In 2011, we sampled 39,788 mat hrs between May 6 and July 14 and collected 195 eggs (Table 1.3). The highest number of eggs came from two sites near the Shorty's Island area (rkm 230.7 and 234.5), and the highest catch rate came from the reach below Myrtle Creek (rkm 234.5, Table 1.3). The first eggs were collected on May 31 and the last eggs were collected on July 7. Most of the eggs collected were at least stage 16 (84% of stageable eggs) and several eggs collected had developed to stage 23 (14%) at the time of sampling. Forty-eight eggs (25%) from the 2011 sample were dead or fungused and could not be staged.

Based on the stages of the 195 total eggs collected in 2011, 78% percent of the eggs may have been viable, and based on the stages of the viable eggs, we estimate that white sturgeon spawned during at least 19 days in 2011 (Table 1.4). Water temperature during the egg collection period ranged from 9°C to 14°C (Table 1.4).

Free Embryo Releases and Larval Sampling

In 2010, 1,076,994 free embryos (one- to four-day-old embryos) were released at six sites in Idaho and Montana and 363,978 were released at five sites in 2011 (Appendix 1.3). In 2010, the first embryos were released on June 1 and the last on July 1, and in 2011 the first releases were on May 31 and the last on June 27. Surface water temperatures during the releases ranged from 9.5° to 14.2°C in 2010 and from 10.0° to 11.0°C in 2011. Surface water velocities at the time of release were measured only once in 2010 due to equipment problems and were 0.7 m/s. In 2011, water velocities ranged from 0.3 to 2.7 m/s during the releases (Appendix 1.3). Due to the intensity and duration of the summer flows in 2010 and 2011, no larval sampling occurred either year.

Juvenile White Sturgeon Sampling

Beginning in 1990 and continuing to the present, the KTOI hatchery has released over 200,283 juvenile white sturgeon (Appendices 1.4 and 1.5).

In 2010, IDFG and BCMFLRO sampled 24 sites between rkm 120.0 and 257.4 and collected 871 juvenile sturgeon (866 hatchery-reared, 99%) with 549 h of effort (Table 1.5). The highest catch came from rkm 190.0 but catch was well distributed throughout the river. The two areas with the highest catch rates were rkm 150.0 and rkm 215.0, but several areas throughout the river had catch rates that exceeded one fish per hour. All sizes of gillnets used caught sturgeon, but the 1.75 inch mesh had the highest CPUE (Table 1.6). Over 64% of the juvenile sturgeon sampled were less than 440 mm fork length, and the length and weight frequency distribution of the 2010 catch indicates that the Kootenai River hatchery sturgeon population is dominated by small individuals. The average fork and total length of the hatchery reared juvenile white sturgeon was 41.8 cm FL and 48.6 cm TL and weight of juvenile sturgeon averaged 0.62 kg (Table 1.7).

Five wild juvenile white sturgeon were captured while gillnetting in Canada and Idaho in 2010 (Table 1.8). The TL of these five individuals ranged from 40.9 to 119.0 cm, and weights ranged from 0.3 to 7.0 kg (Table 1.8). Based on fin ray aging, two definitive year classes (1993 and 2004) were represented in the 2010 sample (Table 1.8) and a third fish was identified as being from the 1999 or 2000 year class.

In 2011, we sampled 20 sites between rkm 120.0 and 244.0 and collected 1160 juvenile sturgeon (1144 hatchery-reared) with 448 h of combined effort. The highest catch came from the Kootenay Lake delta (rkm 120.0) followed by rkm 244.0 (Table 1.5). The highest catch rates came from the Kootenay Lake delta (rkm 120.0) followed by rkm 207.5. The 2-inch mesh gillnets had the highest CPUE. Over 56% of the juvenile sturgeon sampled were less 440 mm fork length, and the length and weight frequency distribution of the 2011 catch suggests that the Kootenai River hatchery sturgeon population is dominated by small individuals. The average fork and total length of the hatchery reared juvenile white sturgeon was 43.8 cm FL and 51.0 cm TL and weight of juvenile sturgeon averaged 0.71 kg (Table 1.7).

Thirteen wild juveniles were captured while gillnetting in 2011. Eleven of the 13 had ages estimated in 2011 and six year classes were represented including 1992, 1994, 2003, 2004 (5), 2005, and 2006 (2) (Table 1.8). The TL of these individuals ranged from 34.8 to 130 cm, and the weight averaged 3.0 kg.

Appendix 1.4 lists the details on sizes and numbers and recapture rates of tagged and/or measured hatchery juvenile white sturgeon released in the Kootenai River since 1990. Appendix 1.5 provides the numbers of untagged and/or not measured juvenile hatchery releases through fall 2011. Appendix 1.6 shows the year class assignments from a sample of the wild juvenile white sturgeon collected between 1977 and 2011 that could be aged. Appendix 1.7 shows the number of wild juvenile white sturgeon collected annually from 1977 to 2011.

DISCUSSION

One of the most important aspects of this investigation is to try to determine the effects of flow and river conditions on white sturgeon movements. With 2010 and 2011 being drastically different water years, river discharge and temperature during the spawning period were different as well. Our results highlight the movement histories of the female sturgeon that made spawning migrations upstream of Bonners Ferry in 2010 and 2011. Visually, a pattern is difficult to discern with some individuals moving upstream early in the spawning season and others arriving later in the season. Some stay in the spawning reach for weeks while others move upstream quickly, presumably spawn, and return to the lower river in a matter of a week or less. There does not appear to be a group response to river conditions in either year, and this has held true since telemetry studies began in the mid-1990s. In 2008, we contracted with Simon Fraser University for statistical consulting to develop models to predict conditions under which spawning sturgeon migrate to or upstream of Bonners Ferry. The results were discouraging and no good fitting models explained movement pattern. Part of the problem with the failure to find a good fitting model may stem from a limited amount of movement data using the new passive telemetry techniques. Now that an additional four or five years of movement data are available, this exercise will be repeated to assess whether or not models could predict movements of adult sturgeon in relation to river conditions. However, based on visual examination of movement histories of gravid female sturgeon among years, it is difficult to determine any obvious movement patterns under a variety of annual flow conditions.

In 2009, we extended our egg mat sampling above Bonners Ferry into the braided reach to document possible spawning. Through 2011, no spawning has been documented despite increased effort and new approaches to hold gear in place under adverse flow conditions. Egg mat sampling is currently an important monitoring component of this program and will become more important if changes in the spatial and temporal distribution of spawning events, resulting from the habitat modification and restoration efforts identified in the KTOI habitat plan, (http://www.kootenai.org/fish_restoration.html) occur.

Locations and conditions for successful early life stage survival are still unidentified in our understanding of Kootenai River white sturgeon. The initial embryo releases in 2005 and 2006 (Rust and Wakkinen 2007; Rust et al. 2007) were an important first step in selecting release sites, determining logistics, and developing sampling techniques, and this began focusing our recovery efforts on early life history studies. However, with spawning stock limitations and hatchery production still having priority, other early life history studies were deemed a better use of a limited resource until 2008. Beginning in 2008 (scheduled to continue through 2012 in white sturgeon recovery plan), we conducted a project to release one- to four-day-old embryos (free embryos) at sites that appear suitable for early life stage survival and rearing in the Kootenai River. These embryos were hatched in the KTOI facility and released at one to four days post-hatch at sites with gravel and cobble substrates and with water velocities that exceeded 1 m/s. Unfortunately, as of 2012, we have observed no measurable increased recruitment to our gillnet catch resulting from the free embryo release program from 2008 to

2012. However, alternative approaches to evaluating recruitment failure hypothesis should be considered if evaluation of the 5-year free embryo release program fails to document any recruitment successes in the future. One alternative approach to consider includes releasing older (14-day-old) larvae on or near the Kootenai River delta and similarly evaluating recruitment to gillnets. Some researchers (Boyd Kynard, personal communication) have suggested that historically, under the higher flow conditions, Kootenai River white sturgeon embryos and larvae drifted quickly to the Kootenay River delta and initiate exogenous feeding in a more nutrient rich environment. To date, under the free embryo release program, we may have chosen adequate locations and conditions for releasing free embryos, but river hydraulics, insufficient release numbers, or other post-dam physical conditions may still be limiting larval drift and survival. Moreover, if we release suitable numbers of 14-day old larvae at or near the delta and fail to measure their recruitment in subsequent years by gillnet evaluation, we may discover yet another recruitment bottleneck. On a final note, however, the lack of a mass marking technique for sturgeon free embryos ultimately confounds any success attributed to natural recruitment. We suggest more avenues of marking be explored prior to additional releases in order to fully differentiate between successful larval releases and larvae produced from natural spawning events.

Justice et al. (2009) suggested that post-release survival of hatchery-reared juvenile sturgeon is related to stocking size and densities. More recent examination of juvenile gillnet captures suggests that rearing facility, age of release, and release location may also significantly affect survival. All of these factors need detailed evaluation to maximize efficiencies and growth rates. To become more familiar with the dynamics of the juvenile population, we plan to review our juvenile monitoring and evaluation program and initiate a detailed juvenile sturgeon survival, growth, condition, and density dependent mortality analysis.

RECOMMENDATIONS

1. As soon as water temperature at Bonners Ferry reaches 7°C after April 1, provide augmented flow from Libby Dam to achieve 425 m^3/s at Bonners Ferry. Provide stable or increasing temperature using the selective withdrawal gate system at Libby Dam as needed to initiate and maintain spawning migration of Kootenai River white sturgeon.

2. Use current movement data to re-analyze predictive modeling of sturgeon movement in relation to flow and temperature.

3. Continue to develop techniques for sampling sturgeon eggs in the braided and canyon reaches upstream to determine the upstream extent of adult spawning.

TABLES

Table 1.1. Sampling effort and number of adult and juvenile white sturgeon caught by the Idaho Department of Fish and Game alone or with Kootenai Tribe of Idaho or British Columbia Ministry of Forest Land and Resource Operations personnel, in the Kootenai River, Idaho January 19 to November 16, 2010 and March 8 to October 24, 2011.

Method and Year		Hours of effort	Number of juvenile sturgeon caught (no. of recaptures)	Number of adult sturgeon caught (no. of recaptures)	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Gillnet[a]	2010	549.5	871(555)	1(1)	1.585	0.002
	2011	448.2	1,160(716)	3(2)	1.559	0.005
Angling [b,c]	2010	42.7	0(0)	4(4)	0	0.094
	2011	4.5	2(2)	5(3)	0.442	1.106
Setline[d,e]	2010	6,275.4	6(5)	143(111)	0.001	0.023
	2011	5,565.7	3(2)	64(49)	0.001	0.011
Subtotal	2010	6,867.6	877(560)	148(116)		
by year	2011	6,018.4	1,165(720)	72(54)		
Combined Total		12,885.7	2,042(1,280)	220(170)		

[a] Includes 182.4 hours sampling by BCMFLRO for IDFG from July 19—August 24, 2010. There were 391 juveniles (256 recaptures) and 1 adult (recapture) caught during this period and included in the totals above. Includes 205.7 hours sampling by BCMFLRO for IDFG from July 18—August 25, 2011. There were 461 juveniles (256 recaptures) and 3 adults (2 recaptures) caught during this period and included in the totals above. There were an additional 50 juveniles caught and released from one gillnet set without processing.

[b] There was 1 adult (recapture, fish #894) caught by BCMFLRO during 2010 spring angling not included in the above totals and for which there was no effort recorded. Includes 0.5 hours angling by KTOI and BCMFLRO for IDFG at Creston Delta (5 adults (3 recaptures) and 2 juveniles (both recaptures) in 2011.

[c] There were an additional 146 adults (119 recaptures) and 8 juveniles (all recaptures) during KTOI spring brood stock angling efforts from January 19 – July 13, 2010 for which no effort was recorded. There were 47 additional adults (38 recaptures) and 4 juveniles (2 recaptures) during KTOI spring brood stock angling from March 8 – June 14, 2011. No effort was recorded.

[d] Based on 24 hour sets.

[e] Includes effort (67.6 hours) by BCMFLRO for IDFG from March 15–17, 2010 at Kootenay Delta. There was 1 adult (recapture) caught and included in the above totals. Includes effort (30.4 hours) by BCMFLRO for IDFG from July 18 – August 25, 2011 at Creston Delta. There were 6 adults (3 recaptures) included in the totals.

Table 1.2. Vital statistics from Kootenai River adult white sturgeon newly marked with Vemco sonic tags as part of a telemetry study, Kootenai River, Idaho, 2003-2011.

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
2003	F-2	8/26/03	119.0	2117	173.0	195.5	37.8	52[a]
2003	na	9/8/03	19.0	1471	181.0	205.0	45.0	51
2004	F-3	9/7/04	121.0	22212	204.0	229.0	78.8	259[b]
2004	M-8	9/7/04	121.0	22214	179.5	203.0	48.6	261
2004	M	9/7/04	121.0	1791	141.0	163.0	22.5	264
2004	na	9/7/04	121.0	1792	138.0	164.0	26.0	265
2004	F-3	9/8/04	121.0	22211	186.0	213.0	56.3	260
2004	M-8	9/8/04	121.0	22210	169.0	191.0	38.3	262
2004	M-8	9/8/04	121.0	22222	182.0	204.0	45.9	263
2004	M-8	9/8/04	121.0	690	168.5	190.0	38.3	266
2004	M-8	10/4/04	119.0	22213	195.5	220.0	54.9	257
2005	F-4	3/10/05	204.0	53853	170.0	197.0	41.0	275
2005	F-2	3/16/05	215.0	53855	215.0	241.0	[c]	277
2005	F-4	3/29/05	215.0	53872	165.0	191.0	48.0	274
2005	F-3	3/29/05	215.0	53871	182.0	209.0	47.0	276
2005	F-3	4/12/05	215.0	53863	182.0	200.0	59.0	273
2005	F-4	4/26/05	215.0	947	142.0	162.0	26.0	272
2005	F-4[d]	4/28/05	226.5	958	189.0	220.0	58.0	280
2005	F-1	5/18/05	230.7	348	161.0	184.0	[c]	278[e]
2005	M-8	6/08/05	229.0	906	166.0	191.0	35.0	281
2005	M-8	6/08/05	229.0	330	179.0	206.0	43.0	279
2005	M-8	6/08/05	229.0	53894	189.0	217.0	70.0	271
2005	M-7	9/26/05	215.0	406	168.0	192.0	43.0	50
2005	F-4[d]	9/26/05	215.0	345	164.0	189.0	52.0	269
2005	F-4[d]	9/26/05	215.0	535	177.0	204.0	57.0	270
2005	F-4	9/27/05	215.0	1578	178.0	200.0	40.0	267
2005	U	9/27/05	215.0	804	105.0	132.0	14.0	87[f]
2005	F-4	9/27/05	215.0	1795	185.0	208.0	54.0	268
2005	M-7	9/27/05	215.0	1794	197.0	224.0	63.0	258
2006	F-4	3/23/06	207.0	1824	166.0	189.0	36.9	9dt[g]
2006	F-1	3/28/06	190.0	202	185.0	212.0	48.6	292[h]
2006	M	3/28/06	185.0	939	147.0	171.0	21.2	294
2006	M	3/28/06	185.0	65	167.0	193.0	27.9	290[i]
2006	F-4[d]	3/30/06	215.0	1305	158.0	182.0	36.9	3dt
2006	F-4[d]	4/4/06	205.0	22218	169.0	195.0	37.2	10dt
2006	M-8	4/4/06	187.5	86	161.0	195.0	33.3	7dt
2006	M-8	4/6/06	215.0	139	175.0	202.0	43.5	1dt
2006	F-4[d]	4/10/06	205.0	1828	185.0	215.0	56.0	6dt
2006	F-4[d]	4/13/06	215.0	1833	196.0	228.0	65.0	8dt
2006	F-4[d]	4/19/06	215.0	1837	194.0	223.0	65.9	4dt
2006	F-4[d]	4/25/06	215.0	1840	186.0	217.0	53.3	288
2006	M-8	4/26/06	204.0	987	151.0	174.0	25.5	291
2006	M-8	5/4/06	229.0	2230	214.0	243.0	54.2	2dt[j]
2006	M-8	5/4/06	229.0	1842	155.0	179.0	30.5	295
2006	F-4	5/9/06	229.0	2227	170.0	190.0	37.2	287
2006	M-8	6/1/06	235.5	679	155.0	177.0	27.3	5dt
2006	M-9	6/6/06	229.0	1847	167.0	187.0	40.3	286
2006	M-9	6/7/06	229.0	7917	145.0	165.0	23.3	289

Table 1.2. Continued.

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
2006	F-3	10/5/06	215.0	57035	172.0	194.0	42.8	296
2006	F-3	9/28/06	121.0	57859	118.0	121.6	57.0	299
2006	F-3	10/5/06	215.0	57033	179.0	210.0	48.2	298
2006	F-3	10/8/06	215.0	57034	182.0	205.0	54.0	301
2006	F-4	10/24/06	215.0	1854	185.0	213.0	60.0	297
2007	F-4[k]	3/12/07	120.0	57869	207.0	235.0	82	17dt
2007	F-4[k]	3/13/07	120.0	850	207.0	230.0	95	13dt
2007	F-4[k]	3/14/07	123.0	2216	194.0	220.0	67	303
2007	F-4[k]	3/14/07	120.0	152	178.0	197.0	65	305
2007	F-4[k]	3/14/07	137.0	2198	170.0	192.0	51.3	20dt[l]
2007	U[f]	3/19/07	215.0	57873	207.0	221.0	64.1	135
2007	F-4[d]	3/28/07	215.0	891	193.0	221.0	61.8	16dt
2007	M-8	3/28/07	205.0	252	172.0	208.0	49.7	15dt
2007	F-4[d]	3/29/07	215.0	57880	185.0	214.0	65.9	14dt
2007	F-4[d]	3/29/07	215.0	57881	162.0	186.0	47.0	18dt
2007	F-4[d]	3/29/07	215.0	57882	172.0	193.0	44.8	12dt
2007	M-8	3/29/07	215.0	57883	167.0	191.0	44.8	11dt
2007	M-8	4/3/07	215.0	2268	167.0	190.0	33.2	19dt
2007	M-8	4/10/07	215.0	162	188.0	218.0	58.2	302
2007	M-8	5/23/07	232.0	1141	154.0	178.0	[c]	300
2007	F-4	5/27/07	241.0	57891	186.0	211.0	57.0	304[m]
2007	F-4[d]	9/25/07	121.0	22232	144.0	169.0	30.9	306
2007	F-4/F-3[d]	10/17/07	215.0	136	152.0	172.0	41.7	313
2007	F-4/F-3[d]	10/17/07	215.0	22401	177.0	200.0	67.2	314
2008	F-4[d]	3/12/08	215.0	605	209.0	241.0	[c]	307
2008	F-4[d]	3/25/08	215.0	62259	186.0	200.0	71.7	311
2008	F-4[d]	3/25/08	205.0	62260	182.0	206.0	49.7	309
2008	F-4[d]	4/1/08	215.0	1605	180.0	211.0	56.9	319
2008	F-4[d]	4/3/08	205.0	62261	193.0	221.0	[c]	317
2008	M-8	4/10/08	205.0	337	204.0	235.0	[c]	321
2008	F-4[d]	4/9/08	205.0	524	189.0	216.0	[c]	323
2008	M-8	4/21/08	205.0	62262	169.0	198.0	40.3	320
2008	M-8	4/21/08	205.0	364	170.0	196.0	41.7	316
2008	M-8	4/22/08	205.0	62263	177.0	202.0	[c]	325
2008	M-8	4/23/08	205.0	62264	156.0	178.0	31.4	318
2008	F-4[d]	4/22/08	205.0	62265	181.0	206.0	[c]	315
2008	F-3	9/24/08	117.0	8	186.0	210.0	[c]	310
2008	M	11/4/08	205.0	970	149.0	168.0	54.0	312[n]
2008	U[f]	11/12/08	205.0	67849	279.0	308.0	[c]	420[o]
2008	F-2	11/12/08	190.0	19	167.0	189.0	85.0	422
2009	F	2/24/09	215.0	812	185.0	213.0	[c]	417
2009	M-7	3/3/09	199.5	595	178.0	207.0	38.7	418[p]
2009	M-7	3/3/09	215.0	642	154.0	178.0	26.6	416
2009	M-7	3/4/09	207.0	57878	154.0	177.0	25.7	419
2009	M-7	3/4/09	207.0	67853	156.0	171.0	27.0	421
2009	F-2	3/4/09	195.7	202	186.0	210.0	[c]	400[h]
2009	F-2	3/18/09	190.0	229	173.0	203.0	45.0	401
2009	F-4	3/18/09	215.0	241	168.0	192.0	38.7	407
2009	F-2	3/24/09	215.0	57872	123.0	141.0	11.3	404
2009	F-4[k,q]	3/24/09	193.2	67855	157.0	183.0	36.5	403
2009	F-4[k,q]	4/7/09	190.0	373	190.0	214.0	[c]	406
2009	F-4[d]	4/21/09	222.3	213	172.0	202.0	41.0	402

Table 1.2. Continued.

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
2009	F-4[d]	4/21/09	213.0	103	181.0	198.0	51.8	405
2009	F-3	5/21/09	120.0	2288	203.0	227.0	78.0	415
2009	F-4	9/21/09	215.0	22209	162.0	188.0	35.1	408
2009	F-4	9/21/09	215.0	712	168.0	192.0	39.2	410
2009	F-3	9/30/09	213.0	1480	178.0	205.0	53.0	409
2010	F-6	3/3/2010	187.0	199	121.0	163.0	27.0	414
2010	F-4[d]	3/3/2010	193.5	651	152.0	175.0	26.0	308
2010	M-8	3/23/10	213.0	106	190.0	220.0	[c]	547
2010	F-4[d]	3/24/10	205.0	936	190.0	221.0	67.0	549
2010	U[f]	3/24/10	205.0	57872	125.0	145.0	14.0	404
2010	F-4[d]	3/24/10	207.5	81993	179.0	205.0	[c]	545
2010	F	3/25/10	213.0	812	186.0	215.0	[c]	417
2010	M-8	3/25/10	205.0	1421	165.0	190.0	40.0	543
2010	F-4	3/25/10	207.5	81999	168.0	194.0	49.0	541
2010	F	3/30/10	205.0	163	189.0	215.0	37.0	551[r]
2010	F-4	3/30/10	207.5	22234	180.0	210.0	49.0	559
2010	F-2	3/31/10	207.5	348	167.0	192.0	33.0	558[e]
2010	M	3/31/10	207.5	57878	159.0	182.0	26.0	419
2010	F-4	3/31/10	207.5	81998	179.0	209.0	[c]	557
2010	F-4[d]	4/6/10	207.5	2344	179.0	210.0	65.0	560
2010	F-4[d]	4/8/10	213.0	56981	269.0	303.0	[c]	556
2010	F-4[d]	4/8/10	213.0	82003	175.0	201.0	49.0	554
2010	M	4/13/10	215.0	145	168.0	194.0	31.0	552
2010	M	4/19/10	207.5	971	169.0	192.0	32.0	550
2010	F-4[d]	4/19/10	207.5	62253	205.0	250.0	[c]	555
2010	M	4/20/10	213.0	349	188.0	220.0	47.0	542
2010	F-4[d]	4/20/10	207.0	82004	148.0	172.0	33.0	553
2010	F-4[d]	4/27/10	213.0	715	173.0	199.0	59.0	546
2010	F-4[d]	4/27/10	207.5	931	174.0	194.0	52.0	548
2010	F-3	11/4/10	207.5	909	151.0	172.0	33.0	719[t]
2010	F-3	11/4/10	207.5	95246	186.0	216.0	63.0	544
2010	F-3	11/15/10	207.5	62245	210.0	243.0	88.0	717
2011	F	3/17/11	152.5	692	192.0	220.0	52.0	411[s]
2011	M	3/22/11	143.0	1583	168.0	193.0	[c]	715
2011	F-4	3/29/11	213.0	1482	171.0	197.0	[c]	718
2011	F-4	3/30/11	215.0	95595	190.0	215.0	65.0	716
2011	F-4	4/5/11	213.0	95596	202.0	230.0	67.0	713
2011	F-4	4/19/11	207.5	890	216.0	248.0	99.0	711
2011	F-4	4/19/11	234.4	1499	193.0	220.0	60.0	714
2011	F-4	5/2/11	207.5	95603	193.0	222.0	69.0	712
2011	M-8	5/10/11	213.0	2230	122.0	152.0	76.0	709[j]
2011	F-4	5/11/11	207.5	57886	177.0	203.0	54.0	710
2011	F-2	9/29/11	122.0	22216	198.0	216.0	70.0	703

[a] This fish (Vemco 52) recaptured 3/29/05, taken to KTOI hatchery, released 6/28/05.
[b] This fish was first tagged with Vemco 259 (2004), then 293 in May 2006.
[c] No weight taken.
[d] F-1 eggs present.
[e] Vemco 278 first tagged 5/18/05; recaptured 2006, 2007 (twice), 2008, 2009 (twice), 2010. New Vemco 558 added 3/31/10.
[f] Unknown sex/ development; Vemco #87 is 3-year tag.
[g] dt = depth sensitive tag.

Table 1.2. Continued.

[h] This fish (#202) first tagged with Vemco 292 (2006); new Vemco 400 added at 3/4/09 recapture.
[i] This fish (Vemco 290) recaptured 3/24.
[j] Vemco 2dt replaced with 709 5/10/11 (fish #2230).
[k] F-4 eggs present.
[l] This is the second deployment of tag code 20dt (was on juvenile 21890 in 2003).
[m] Vemco 304 captured 5/20/07 @ 215.6; taken to KTOI hatchery, released 5/27/07; recap 5/31/07 @ 236.0. First captured by Montana in May 1976.
[n] This fish (Vemco 312) recaptured 4/12/11.
[o] This fish (Vemco 420) recaptured 9/22/09.
[p] This fish (Vemco 418) recaptured 3/24/09.
[q] Eggs taken to hatchery
[r] This fish (Vemco 551) recaptured 4/7/10 and 5/12/11.
[s] This fish (Vemco 411) captured 3/31/10 and recaptured 3/17/11.
[t] This fish (Vemco 719) recaptured 5/4/11 by KTOI angling.

Recaptured Vemco-tagged fish (including re-tags). Re-tags are only recaptures included above too.

Tag year	Sex Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
2005	F-4	6/28/05	243.0	2117	170.0	196.0	40.0	52[a]
2006	F-4	5/4/06	229.0	22212	208.0	236.0	[c]	293[b]
2007	F-4	5/31/07	236.0	57891	189.0	212.0	[c]	304[m]
2009	F-2	3/4/09	195.7	202	186.0	210.0	[c]	400[h];re-tag
2009	M	3/24/09	213.0	65	169.0	195.0	37.4	290[i]
2009	U[f]	9/22/09	205.0	67849	279.0	320.0	[c]	420[o]
2006	F	3/30/06	215.0	348	160	180	22.0	278[e]
2007	F	2/28/07	215.0	348	158	179	28.8	278[e]
2007	F	3/19/07	215.0	348	161	179	26.0	278[e]
2008	F	4/9/08	215.0	348	158	179	31.4	278[e]
2009	F	5/19/09	229.0	348	163	185	38.3	278[e]
2009	F	6/18/09	235.5	348	162	185	41.0	278[e]
2010	F-2	3/31/10	207.5	348	167.0	192.0	33.0	558[e];re-tag
2010	F-4[d]	4/7/10	207.5	163	189.0	218.0	37.0	551[r]
2011	F	5/12/11	213.0	163	184.0	214.0	46.0	551[r]
2010	F-4	3/31/10	207.5	692	187.0	213.0	[c]	411[s]
2011	M	3/17/11	152.5	637	183.0	210.0	[c]	720
2011	M	4/12/11	225.0	970	154.0	175.0	32	312[n]
2011	M-8	5/10/11	213.0	2230	122.0	152.0	76.0	709[j];re-tag

Table 1.3. Location (river kilometer), depth (m), white sturgeon egg catch, and catch per unit effort (CPUE) by standard artificial substrate mats, IDFG and BCMFLRO, Kootenai River, Idaho 2010 and 2011.

Sample year	River location (rkm) 2010	Depth range (ft)	Total mat hours	Number white sturgeon eggs	CPUE
2010	129.0	3.6-25	1,242.6	0	[a,b]
2010	130.0	4-20.5	1,189.1	0	[a,b]
2010	231.0	5-53	9,642.6	28	0.0029
2010	237.0	17-65	8,803.3	2	0.0002
2010	246.0	4-28	15,694.5	57	0.0036
2010	246.2	3-18	1,705.3	0	[a]
2010	247.0	14-28	1,708.7	0	[a]
2010	248.0	3-16	1,707.2	0	[a]
2010	248.1	4-19	1,827.4	0	[a]
2010	248.3	4-14	3,413.2	0	[a]
2010	248.4	2-12	2,017.8	0	[a]
2010	249.4	10-11	552.9	0	[a]
2010	249.7	11-14	744.7	0	[a]
2010	251.0	3-10	841.0	0	[a]
2010	**129.0-251.0**	**2-65**	**51,090.3**	**87**	**0.0017**
2011	230.7	4-33	13,451.2	70	0.0052[a]
2011	232.0	[c]	[c]	5	[c]
2011	234.5	22-63	5,548.6	70	0.0126
2011	235.0	[c]	[c]	0	[a]
2011	235.5	25	47.5	0	[a]
2011	236.5	46	47.6	0	[a]
2011	245.8	9-30	12,324.6	50	0.0041
2011	246	12	47.1	0	0
2011	247.4	11-19	1,198.9	0	[a]
2011	248.5	6-16	1,199.6	0	[a]
2011	248.6	7-17	2,398.3	0	[a]
2011	248.7	3-13	2,326.5	0	[a]
2011	249.3	6-13	1,198.6	0	[a]
2011	**230.7-249.3**	**3-63**	**39,788.6**	**195**	**0.0049**

[a] Water velocity measurements taken only when eggs were found.
[b] Sampling done by BCMFLRO for IDFG.
[c] No depth or effort recorded.

Table 1.4. Stages of white sturgeon eggs captured by artificial substrate mats, Kootenai River, Idaho, 2010 and 2011.

				Egg Stage																	
Year	**Date Pull**	**Temp °C Pull**	**No. Egg**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**other**	**Notes**	**Hours from Fertilization (Spawn Date)**
2010	5/17	10.0	3				1												2	dead	8(5/17)
	5/17	10.0	12				1+[a]	11													11.5(5/16), 15(5/16)
	5/17	10.0	6				2	4													8(5/17),15(5/16)
	5/17	10.0	1				1+														11,5(5/16)
	5/27	9.0	1	1																	0(5/27)
	6/10	9.1	1			1															5(6/10)
	6/17	9.4	3	1	1	1															0(6/17),3(6/17),5(6/17)
	6/17	9.4	1							1											29(6/16)
	6/17	9.4	2	1				1													0(6/17), 15(6/16)
	6/17	9.4	1	1+																	0(6/17)
	6/22	11.8	3				2								1						8(6/22),73(6/19)
	6/22	11.8	1				1+														10.5(6/21)
	6/22	11.8	2							1					1						73(6/19),24(6/21)
	6/22	11.8	3												2				1	fungus	73(6/19)
	6/22	11.8	3												2				1	fungus	73(6/19)
	6/22	11.8	1				1+														10.5(6/22)
	6/24	12.1	13				1	8	3										1	dead	8(6/24),13&19(6/23)
	6/24	12.1	18				3+	11+			4										19,30(6/23)10.5(6/24)
	6/28	13.0	5												4	1					64(6/25),74(6/25)
	6/28	13.0	1										1								43(6/26)
	6/28	13.0	5						4										1	dead	17(6/27)
	6/30	14.0	1															1			94(6/26)
2010	**Total collected**		87	4	1	2	13	35	7	2	4	0	1	0	10	1	0	1	6		
	Total not staged		6																		
2011	5/31	10	32		1		1	14	4										12	dead	3,8(5/31), 15,22(5/30)
	5/31	10	16					7	1										8	7 dead, 1 broken	22(5/30), 15(5/31)
	5/31	10	5	1			4													4-15+	0,11(5/31)
	6/6	10	2										2								58(6/3)
	6/6	10	7	1					2	4										4-18+	22,28(6/5), 0(6/6)
	6/6	10	14							14											28(6/5)
	6/6	10	1							1										1-18+	32(6/5)
	6/9	9	18		3	2	1	7	4										1	broken	2,7,10,7(6/9), 25(6/8)
	6/13	10	7											1	2				4	4 dead	75(6/10), 91(6/9)
	6/16	10	2				1												1	1 dead	8(6/16)
	6/16	10	2							1		1									28(6/15), 42(6/14)
	6/16	10	27										7		14				6	6 dead, 1-23+	21(6/15), 75(6/13), 99(6/12)
	6/28		1																1	dead	
	6/28		8										3						5	dead	48(6/26), 59(6/25)
	6/30	12	29					27											2	dead	61(6/27)
	6/30	12	3	1	2																0(6/30), 50(6/28)

Table 1.4. Continued.

Year	Date Pull	Temp °C Pull	No. Egg	Egg Stage 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	other	Notes	Hours from Fertilization (Spawn Date)
	6/30	12	2			2															53(6/28)
	7/5		14											12	1				1	dead	47,49(7/3)
	7/7		5															4	1	dead	94(7/3)
2011	**Total collected**		195	3	6	4	7	55	11	20	0	1	12	13	17	0	0	4	42		
	Total not staged		42																		
All	**Total collected**		**282**	**7**	**7**	**6**	**17**	**82**	**55**	**26**	**4**	**1**	**13**	**13**	**27**	**1**	**0**	**5**	**48**		
	Total not staged		**48**																		

[a] Indicates whether egg(s) are early (-) or late (+) in particular development stage.

Table 1.5. Idaho Department of Fish and Game and British Columbia Ministry of Forest Land and Resource Operations juvenile white sturgeon gillnet sampling effort by sampling location for July 27 through September 23, 2010 and July 18 through October 24, 2011.

Year	River Kilometer	Number of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit of Effort
2010	120.0	20	25.45	0	87	3.42
2010	121.0	18	28.55	0	54	1.89
2010	123.0	8	9.13	0	30	3.28
2010	130.0	16	18.58	1	29	1.61
2010	137.4	16	17.80	0	11	0.62
2010	141.5	8	8.35	0	16	1.92
2010	144.8	16	19.62	0	72	3.67
2010	150.0	8	9.65	0	43	4.46
2010	157.3	8	8.82	0	1	0.11
2010	161.4	16	18.25	0	24	1.32
2010	165.0	16	18.17	0	24	1.32
2010	174.2	32	40.70	0	35	0.86
2010	176.5	28	38.87	0	16	0.41
2010	190.0	32	43.52	0	103	2.37
2010	192.0	16	21.10	0	26	1.23
2010	193.2	16	19.78	0	18	0.91
2010	205.0	34	42.73	0	35	0.82
2010	207.0	16	22.88	0	53	2.32
2010	207.5	16	21.55	0	24	1.11
2010	215.0	16	20.42	0	83	4.07
2010	225.0	32	42.65	0	44	1.03
2010	244.5	36	42.93	0	40	0.93
2010	253.5	5	5.47	0	0	0.00
2010	257.4	4	4.52	0	3	0.66
2010	**Total**	**433**	**549.48**	**1**	**871**	**1.59**
2011	120.0	16	17.37	2	152	8.87
2011	121.0	30	44.47	1	78	1.78
2011	123.0	12	21.17	0	70	3.31
2011	130.0	16	18.12	0	33	1.82
2011	137.0	18	20.05	0	8	0.40
2011	141.0	8	9.28	0	10	1.08
2011	145.0	18	20.50	0	53	2.59
2011	150.0	8	9.03	0	11	1.22
2011	157.0	8	9.42	0	6	0.64
2011	161.0	16	17.85	0	22	1.23
2011	165.0	16	18.47	0	18	0.97
2011	174.0	12	14.13	0	6	0.42
2011	176.5	4	6.72	0	0	0.00
2011	190.0	32	43.90	0	125	2.85
2011	193.5	16	18.45	0	10	0.54
2011	205.0	16	19.40	0	70	3.61
2011	207.5	14	21.32	0	129	6.05
2011	215.0	26	33.50	0	79	2.36

Table 1.5. Continued.

Year	River Kilometer	Number of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit of Effort
2011	225.0	32	41.22	0	78	1.89
2011	244.0	28	43.85	0	202	4.61
2011	**Total**	**346**	**448.21**	**3**	**1160**	**2.59**
2010-2011	**Combined Total**	**779**	**997.69**	**4**	**2031**	**2.04**

Table 1.6. Idaho Department of Fish and Game, and British Columbia Ministry of Forest Land and Resource Operation juvenile white sturgeon gillnet sampling catch and effort by mesh size for July 27 through September 23, 2010 and July 18 through October 24, 2011.

Year	Gillnet Mesh Size (in)	Number of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit Effort (hours)
2010	1	177	225.1	0	399	1.77
2010	1.75	9	11.4	0	22	1.94
2010	2	156	198.2	0	331	1.67
2010	2.5	5	5.7	0	6	1.05
2010	3	71	88.6	0	99	1.12
2010	3.5	15	20.5	0	14	0.68
2010	**Total**	**433**	**549.5**	**1**	**871**	**1.59**
2011	0.5	19	27.5	0	10	0.36
2011	1	156	199.7	0	284	2.65
2011	2	82	105.7	1	220	3.35
2011	3	89	115.3	0	186	2.31
2011	**Total**	**346**	**448.2**	**3**	**1160**	**2.59**
2010-2011	**Combined Total**	**779**	**997.7**	**4**	**2031**	**2.04**

Table 1.7. Summary statistics of recaptured juvenile hatchery white sturgeon from 2010 and 2011 gillnet sampling, Kootenai River, Idaho.

Year	Statistic	Fork length (cm)	Total length (cm)	Mean weight (kg)
2010	N	864	864	838
	Average	41.8	48.6	0.62
	Standard deviation	13.7	15.7	0.74
	Minimum	20.0	21.2	0.03
	Maximum	95.0	111.0	6.60
2011	N	1122	1122	1064
	Average	43.8	51.0	0.71
	Standard deviation	13.3	15.5	0.80
	Minimum	17.5	22.6	0.05
	Maximum	96.5	108.5	6.00
2010-2011	N	1986	1986	1902
	Average	42.9	50.0	0.67
	Standard deviation	13.5	15.6	0.78
	Minimum	17.5	21.2	0.03
	Maximum	96.5	111.0	6.60

Table 1.8. Wild juvenile white sturgeon captured in gillnets in 2010 and 2011, Kootenai River, Idaho (does not include wild recaptures).

Year	Date	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)	Year class
2010	8/2	205.0	35.5	40.9	0.27	2004
	8/5	255.0	46.1	53.1	0.60	1999/2000
	8/6	130.0	103.0	119.0	7.00	1993
	8/23	174.2	99.0	113.0	5.53	na
	8/30	244.5	39.2	45.0	0.36	2004
2011	7/18	165.0	63.0	96.0	4.85	1994
	7/28	123.0	57.5	67.0	1.55	2004
	7/28	123.0	44.2	51.0	0.48	2006
	8/25	120.0 (east delta)	113.0	130.0	11.75	1992
	8/25	215.0	43.0	50.3	na	2003
	8/30	193.2	30.4	34.8	0.142	2006
	9/7	225.0	36.9	43.2	0.292	2004
	9/15	205.0	37.2	43.1	0.274	2004
	9/27	215.0	36.7	42.0	0.294	2004
	10/17	190.0	43.2	50.6	0.418	2005
	10/24	225.0	41.6	48.1	0.412	2004

FIGURES

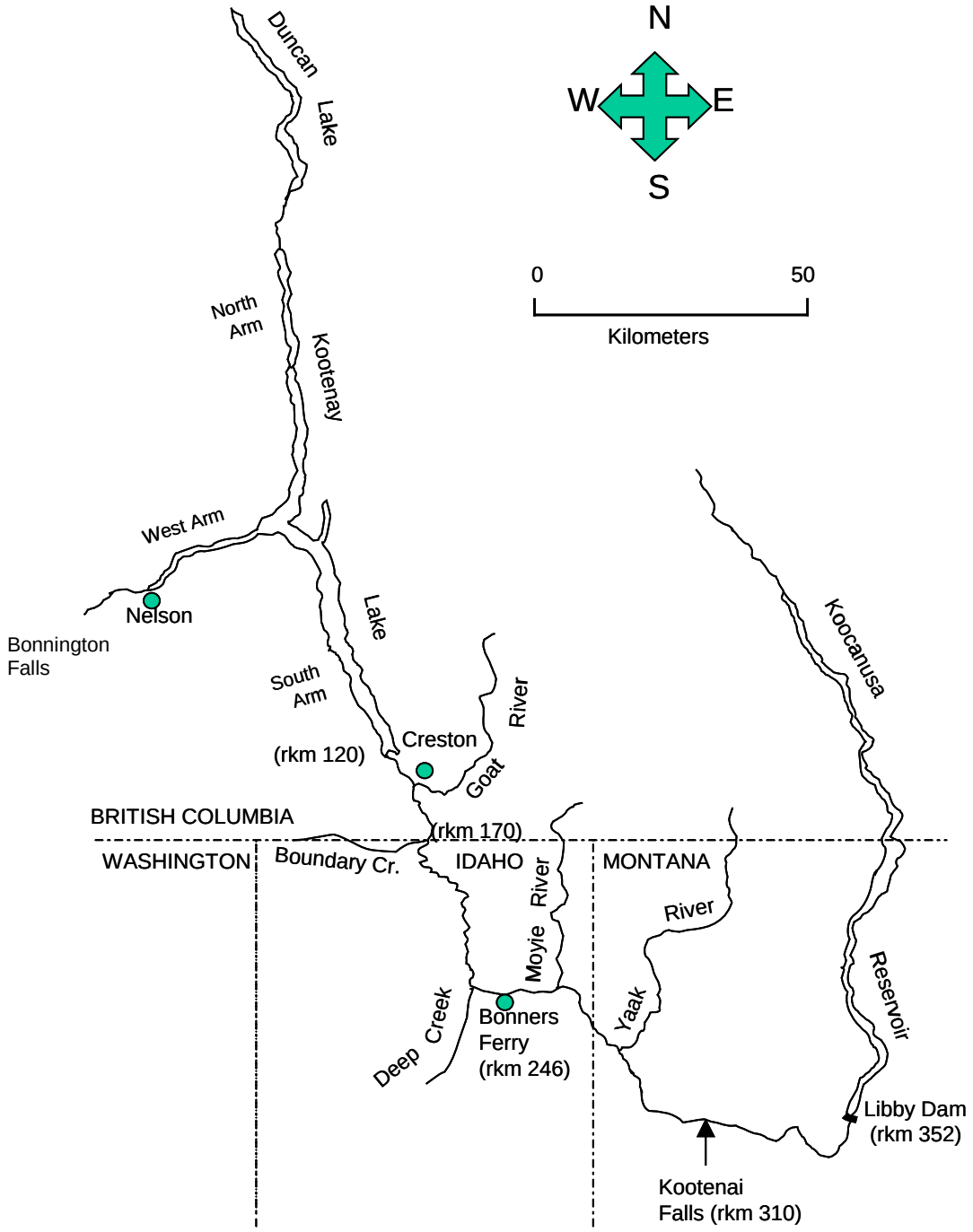


Figure 1.0 Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

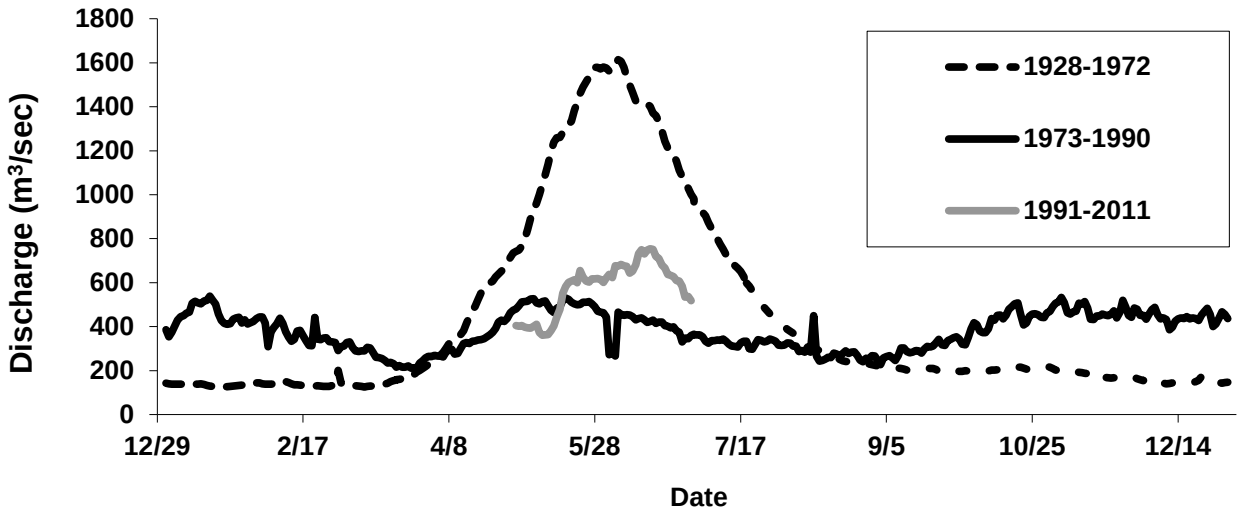


Figure 1.1. Mean daily flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928-1972 (pre-Libby Dam), 1973-1990 (post-Libby Dam), and 1991-2011 (post-Libby Dam with augmented flows, May 1 through June 30).

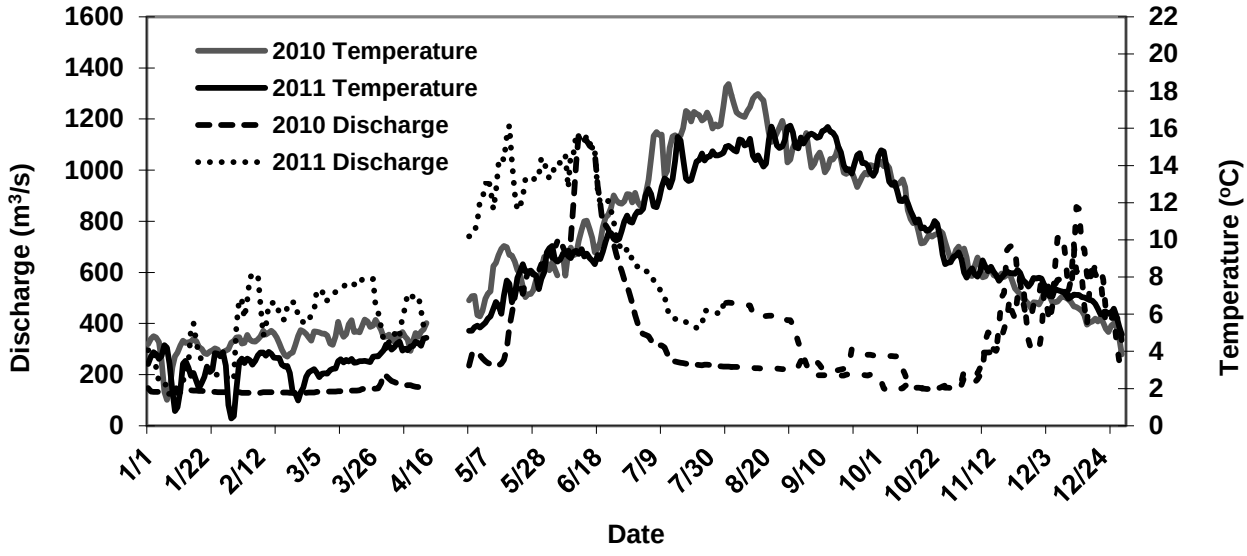


Figure 1.2. Mean daily discharge (m^3/sec) and temperature (°C) for Kootenai River at Bonners Ferry, Idaho, 2010-2011.

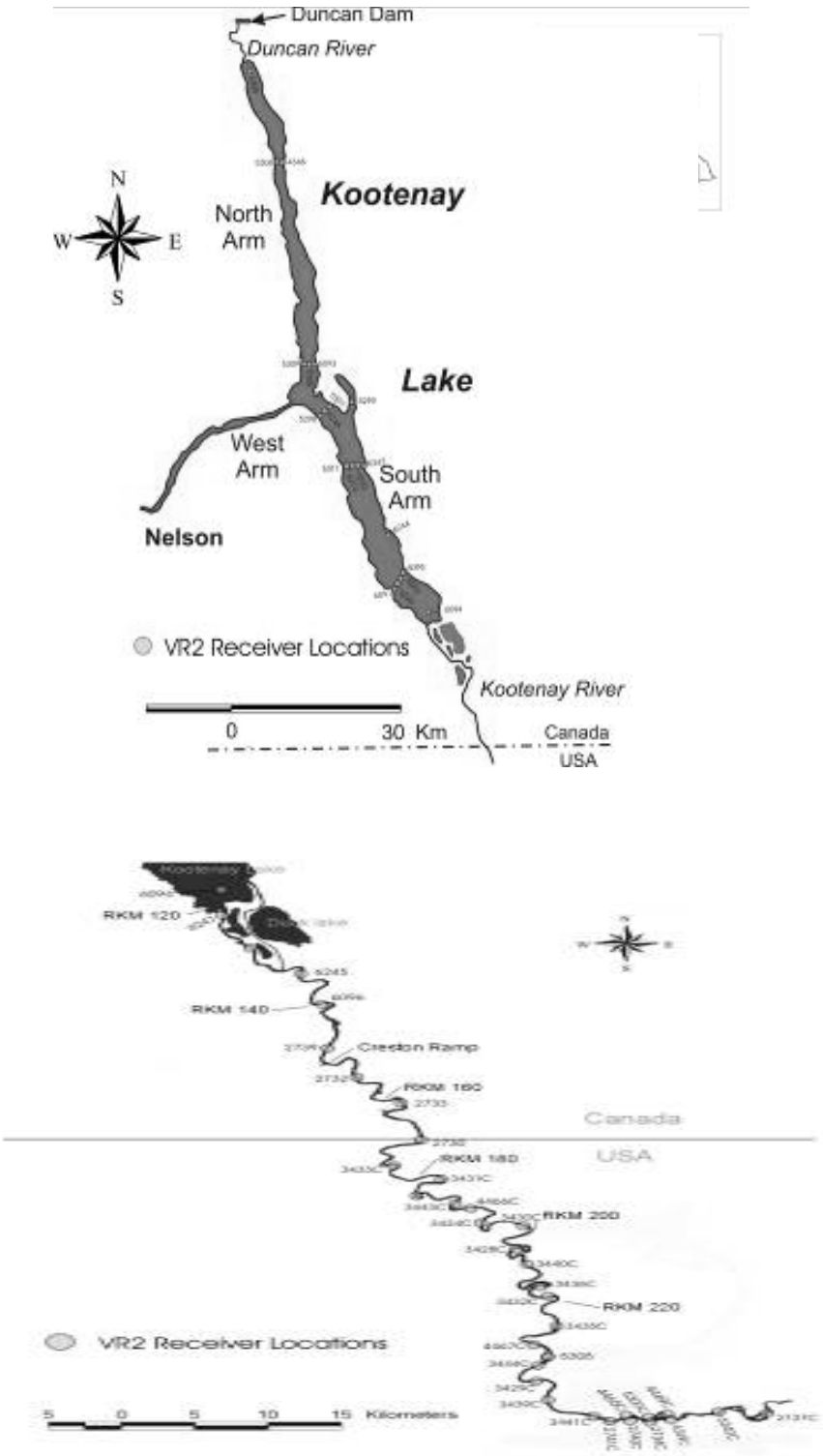
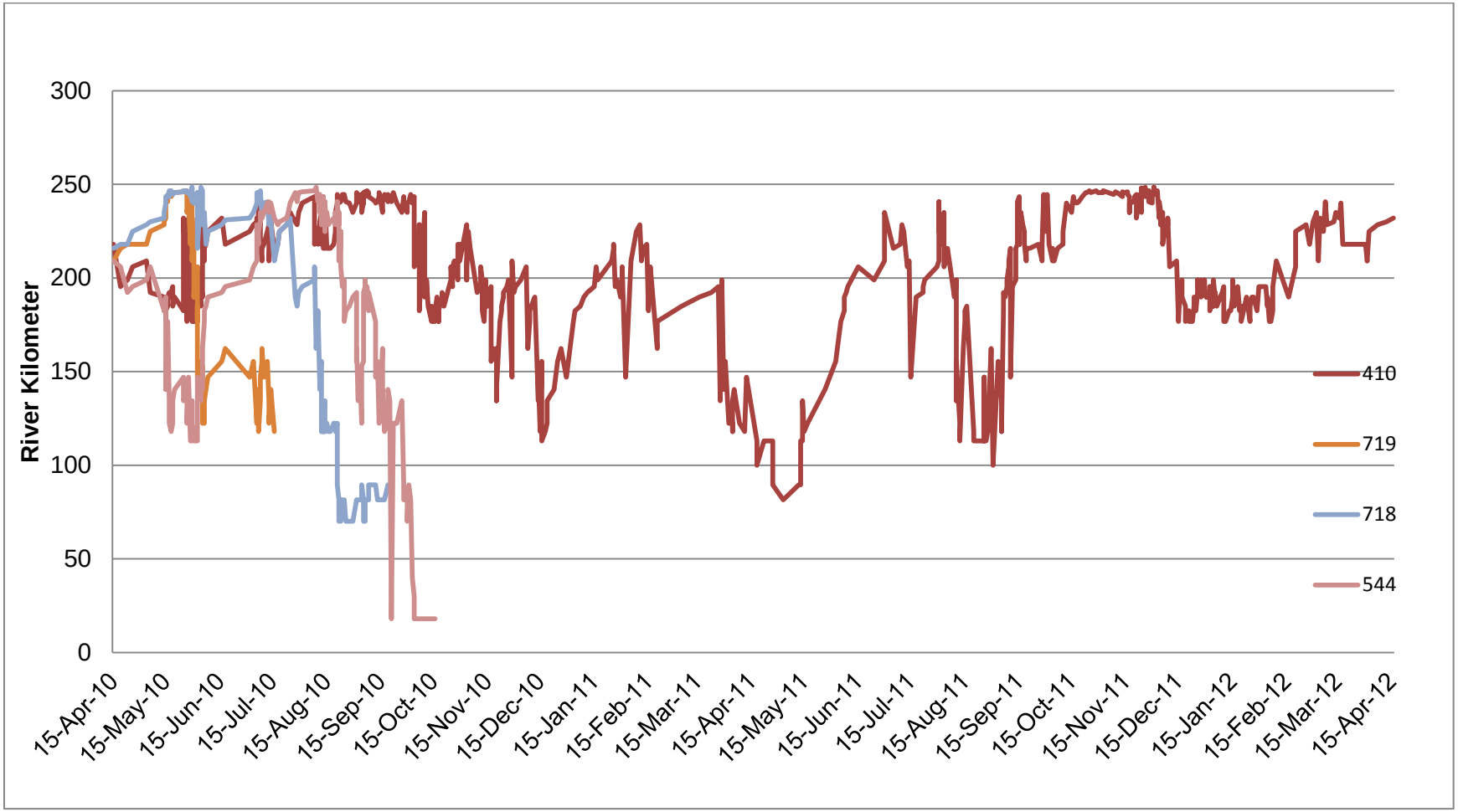


Figure 1.3. Location of Vemco VR2 receivers in Kootenai River/Lake system, Idaho and British Columbia, Canada, 2010.

APPENDICES

Appendix 1.1. Movement histories of five female white sturgeon expected to spawn in the Kootenai River in 2010.

Appendix 1.2. Movement histories of four female white sturgeon expected to spawn in the Kootenai River in 2011.



Appendix 1.3. Chronology of white sturgeon free embryo (FE) releases in 2010 and 2011, Kootenai River.

Year	1st/ Last Hatch Dates	Family #	Parents		Total # Eggs	% Neur. KT Fish	# KT FE	KT Larvae Held[a]	Cryo./ Exp'l Eggs/ Larvae[b,e,g]	# Larvae Released[c,d]	Release Date & Rkm/ Site	Release Coordinates		Water Temp C	Leonia Discharge (cfs)	Stage (ft.)	Secchi (m)	Velocity (m/s) Surf/ .2/ .8
			Female (Fish #)	Male (Fish #)								East.	North.					
2010	5/30 6/1	KT 5D40	1BF2734EDD (81994)	1BF27354D0 (2182)	80400	95	76380	4000	0	72380	6/1 251.0	555133	5394407	9.6	24100	18.1	1.9	
	5/29 6/1	KT 8749	1BF272E392 (788)	1BF2728749 (95258)	175000	83	145250	4000	0	141250	6/1 255.4	558250	5394802	9.5	24100	18.1	1.9	
	6/3 6/6	KT 0C72	1BF272DD9C (95254)	1BF2730C72 (457)	111930	86	95202	4000	1230	91202	6/7 258.6	559724	5396159	9.5	24000		2.0	
	6/13 6/15	KT 6F60	1C2D457B8F (287)	7F7D3F6F60 (2182)	162632	50	64504	4000	3600	60504	6/15 262.5	563064	5395971	10.1	38500	21.7	1.3	0.71
	6/11 6/14	KT 523F	1C2D4562DA (57885)	1BF278523F (427)	150060	20	24000	4000	0	20000								
	6/16 6/19	KT E401	1BF272AC62 (95253)	1BF272E401 (2329)	164270	75	111896	4000	0	107896	6/21 274.8	569400	5386620		27900	19.1	2.1	
	6/16 6/20	KT 3F5C	1BF2736562 (95255)	1BF2783F5C (502)	88000	96	82560	4000	2000	78560	6/21 270.5	566992	5390118		27900	19.1	2.1	
	6/18 ?	KT DAB2	1BF272E8DF (409)	1BF272DAB2 (77926)	129520	99	125483	4000	2769	121483	Koot-enai River MT							
	6/21 6/23	KT 6CD2	1BF272E300 (311)	1C2D456CD2 (998)	122680	97	119000	4000	0	115000	6/24 251.0	555136	5394405	12.1	24700	18.4	3+	
	6/28 6/30	KT 6BF7	1BF27338E5 (82000)	1C2D456B47 (204)	77700	94	71393	4000	1750	67393	6/30 251.0	555135	5394409	14.0	17700	16.1	3+	
		KT DI28		1BF272D128 (95259)	83650	90	73710	4000	1750	69710								
	6/29 7/1	KT 1193	1BF272F678 (95256)	1BF2781193 (641)	142754	95	135616	4000	0	131616	7/1 251.0	555135	5394409	14.2	16700	15.8	3+	
2010			**Totals**		**1488596**		**1124994**	**48000**	**13099**	**1076994**								
2011	5/24 5/27	RR B4DA	1BF272C6EB	1BF272B4DA	112500	83	93400	0	0	93400	5/31 270.5	567170	5390241	10	34400	20.47		1.78/1.75/2.22

Year	1st/ Last Hatch Dates	Family #	Parents: Female (Fish #)	Parents: Male (Fish #)	Total # Eggs	% Neur. KT Fish	# KT FE	KT Larvae Held[a]	Cryo./ Exp'l Eggs/ Larvae[b,e,g]	# Larvae Released[c,d]	Release Date & Rkm/ Site	Release Coordinates: East.	Release Coordinates: North.	Water Temp C	Leonia Discharge (cfs)	Stage (ft.)	Secchi (m)	Velocity (m/s) Surf/ .2/ .8
		KT B4DA			10000	80	8000	8000	0	0								
	6/10 6/14	KT 156A-1	473D135E6D[h]	473D0A156A	10600	93	9858	9858	0	0								
		RR 156A-1			18550		17250	0	0	17250	6/14 271.0	568194	5388762	10	40600	21.84	1.0	1.43/1.53/1.42
		KT 2E61-1		4738192E61	10600	10	1060	1060	0	0								
	6/10 6/14	RR 156A-2	1BF274E703[h]	473D0A156A	41925	84	33217	0	2000	33217	6/14 271.0	568194	5388762	10	40600	21.84	1.0	1.43/1.53/1.42
		KT 156A-2			11700	93	9068	9068	1950	0								
		RR-2E61-2		4738192E61	46800	0	0	0	0	0	All died							
		KT 2E61-2			12285	0	0	0	2535	0								
	6/12 6/16	RR 6870	1BF2752923	4724516870	64000	99	63360	0	0	63360	6/16 251.0	555288	5394240	10				1.7/ 2.3/ 1.92
		KT 6870-1			12000	99	11880	11880	0	0								
	6/17 6/21	RR 5A41	1BF272AC47[h]	473D5B5A41	12220	84	10265	0	0	10265	6/21	555328	5394247	11	30900	8.9	1.4	1.25/1.39/1.39
		KT 5A41			12925	91	9623	9623	2350	0								
		KT 6870-2		4724516870	11750	90	10575	10575	0	0								
	6/23 6/27	RR 2434-1	1BF272AEFC[h]	473D0A2434	48100	97	46657	0	0	46657	6/27 255.2	558422	5394635	10.5	25000	18	1.9	2.38/2.68/2.19
		KT 2434-1			12950	98.4	12740	12740	0	0								
		RR 4C2E-1		1BF2784C2E	47175	94	44345	0	0	44345	6/27 255.7	558403	5394024	10.5	25000	18	1.9	.9/ 1.28/ .81
		KT 4C2E-1			12950	90	11655	11655	0	0								
	6/24 6/27	RR 2434-2	1BF2732E93	473D0A2434	26400	97	25608	0	0	25608	6/27 255.2	558422	5394635	10.5	25000	18	1.9	2.38/2.68/2.19
		KT 2434-2			14300	95	13585	13585	0	0								

Year	1st/ Last Hatch Dates	Family #	Parents		Total # Eggs	% Neur. KT Fish	# KT FE	KT Larvae Held[a]	Cryo./ Exp'l Eggs/ Larvae[b,e,g]	# Larvae Released[c,d]	Release Date & Rkm/ Site	Release Coordinates		Water Temp C	Leonia Discharge (cfs)	Stage (ft.)	Secchi (m)	Velocity (m/s) Surf/ .2/ .8
			Female (Fish #)	Male (Fish #)								East.	North.					
		RR 4C2E-2		1BF278 4C2E	30800	97	29876	0	0	29876	6/27 255.7	558403	5394024	10.5	25000	18	1.9	.9/ 1.28/ .81
		KT 4C2E-2			15400	96	14784	14784	0	0								
2011			**Totals**		**595930**		**476806**	**112828**	**8835**	**363978**								

[a] 4,000 free embryos from each pairing (total 48,000) were held for KTOI hatchery rearing.
[b] 1,230 eggs (KT0C72) for cryopreservation study (Patton, UI).
[c] This release was done in two batches on the same day, 6/15 (KT6F60, KT523F). 30,024 eggs from female 1C2D457B8F and 30,060 from 1C2D4562DA to BC for rearing. 3,600 from 1C2D457B8F held for experimental use.
[d] 15,075 eggs from KTE401 to BC for rearing.
[e] 2,000 eggs from KT3F5C to E. Parker (U. Mass.).
[f] Release from KTDAB2 in Montana by KTOI (Siple); specifics unknown. Last hatch date also unknown.
[g] 3,500 eggs split between families for cryopreservation.

Appendix 1.4. Numbers and recapture rates of hatchery produced white sturgeon juveniles (progeny of wild broodstock) released into the Kootenai River and Kootenay Lake in Idaho, Montana, and British Columbia between 1990 and December 2011 (from Kootenai Tribe of Idaho and Idaho Department of Fish and Game Annual Reports 1990-2010). This table includes tagged and/or measured fish only.

Year class	Hatchery facility[a]	Release number	Mean total length (mm) at release (S.D.)	Mean weight (g) at release (S.D.)	Release season & year	Number re-captures	Percent of all re-captures
1990	KTOI	14	456.9 (53.0)	320.8 (112.3)	Summer 1992	11	0.14%
1991	KTOI	104	254.7 (17.3)	66.1 (13.1)	Summer 1992	117	1.47%
1992	KTOI	123	482.6 (113.0)	549.3 (482.9)	Fall 1994	121	1.52%
1995	KTOI[b]	0	--	--	?	44	0.55%
1995	KTOI	1,075	228.5 (27.0)	47.3 (16.6)	Spring1997	532	6.67%
1995	KTOI	884	343.6 (43.7)	148.0 (64.0)	Fall 1997	486	6.09%
1995	KTOI	97	410.7 (68.2)	288.5 (137.8)	Summer 1998	68	0.85%
1995	KTOI	25	581.5 (40.5)	863.3 (197.9)	Summer 1999	16	0.20%
1998	KTOI	309	260.1 (41.9)	79.0 (44.4)	Fall 1999	66	0.83%
1999	KTOI	828	256.1 (22.2)	70.6 (18.2)		186	2.33%
1999	KH	1,358	248.1 (32.9)	67.2 (27.6)	Fall 2000	464	5.82%
1999	KH	1,583	306.5 (40.4)	55.9 (39.5)		724	9.07%
1999	KTOI	491	284.3 (54.4)	107.6 (60.1)	Spring 2001	48	0.60%
1999	KH	1	520.0[h]	980.0	Spring 2010	0	0.00%
1999	KTOI[b]	0	--	--	?	3	0.04%
1999	?[b]	0	--	--	?	44	0.55%
2000	KTOI	2,286	244.0 (38.9)	64.2 (31.0)		135	1.69%
2000	KH	1,654	240.0 (23.2)	57.7 (16.4)	Fall 2001	222	2.78%
2000	KH	2,209	283.1 (28.7)	99.3 (30.2)	Spring 2002	19	0.24%
2000	KH	30	365.4 (14.0)	195.3 (19.9)	Summer 2002	0	0.00%
2000	KTOI	214	409.4 (53.5)	294.1 (109.8)	Fall 2002	34	0.43%
2000	KTOI[c]	907	333.1 (36.0)	190.8 (60.0)	Jan. 2003	162	2.03%
2000	KTOI[d]	10	557.7 (28.4)	87.6 (18.4)	Feb. 2004	0	0.00%
2000	KTOI[l]	3	662.0 (6.01)	425.0 (66.1)	Summer 2006	1	0.01%
2000	?[b]	0	--	--	?	25	0.31%
2001	KH	4,469	227.4 (24.2)	51.6 (16.6)		16	0.20%
2001	KTOI	2,672	200.1 (37.9)	33.0 (15.6)	Fall 2002	122	1.53%
2001	KH	1,715	257.1 (26.4)	71.8 (24.2)	April 2003	11	0.14%
2001	KTOI[l]	1	570.0	750.0	Summer 2006	0	0.00%
2001	KH	1	560.0	1,152.0	Spring 2009	0	0.00%
2001	?[b]	0	--	--	?	2	0.03%
2002	KH	5,864	217.3 (25.2)	41.3 (14.2)	May 2003	51	0.64%
2002	KTOI	856	214.0 (43.8)	41.9 (22.6)	Oct. 2003	0	0.00%
2002	KTOI[e]	550			Nov. 2003	0	0.00%
2002	KTOI	3,852	215.4 (37.3)	43.4 (20.0)	Late wtr. 2003	7	0.09%
2002	KTOI	3,663	214.2 (54.8)	43.1 (27.2)	Late wtr.'03-early wtr. '04	11	0.14%
2002	KTOI[l]	1	550.0	740.0	Summer 2006	0	0.00%
2002	KH	3	523.3(25.2)[h]	1,073.3(145)	Spring 2010	0	0.00%
2002	?[b]	0	--	--	?	15	0.19%
2003	KH	9,020	222.8 (25.7)	48.9 (24.4)	Spring 2004	914	11.46%
2003	KH[f]	19	229.5 (26.7)	51.9 (18.5)	Sept. 2004	0	0.00%
2003	KTOI	3,519	226.9(46.3)	55.4(31.6)	Late wtr. 2004	6	0.08%
2003	KTOI[l]	3	43.7 (2.8)	346.7 (49.3)	Summer 2006	0	0.00%
2003	?[b]	0	--	--	?	13	0.16%
2004	KH[g]	2,038	196.2(27.7)[h]	57.4(33.0)	Spring 2005	46	0.58%
2004	KTOI	1	510.0	490.0	Wtr 2007	0	0.00%
2004	KH	5	452(22.8)	563(116.5)	Spring 2009	0	0.00%
2004	?[b]	0			?	54	0.68%
2005	KH[i]	14	298.6(14.1)[h]	174.2(27.8)	Spring 2006	0	0.00%

Year class	Hatchery facility[a]	Release number	Mean total length (mm) at release (S.D.)	Mean weight (g) at release (S.D.)	Release season & year	Number re-captures	Percent of all re-captures
2005	KH[g]	1,765	197.8(24.5)[h]	54.2(22.4)		60	0.75%
2005	KTOI[j]	510	171.0(47.0)	26.8(19.9)	Fall 2006	8	0.10%
2005	KH	1	330.0	225.0	Spring 2009	0	0.00%
2005	KH	4	400(33.7)[h]	414(131.8)	Spring 2010	0	0.00%
2005	KH[b]	0			?	5	0.06%
2005	?[b]	0			?	83	1.04%
2006	KH[g,k]	600	148.8(10.8)[h]	22.9(5.4)	Fall 2006	0	0.00%
2006	KH[g]	1,877	182.2(15.0)[h]	43.8(11.7)		60	0.75%
2006	KH[g,k]	1,000	184.4(15.9)[h]	45.6(11.5)	Spring 2007	0	0.00%
2006	KTOI[g]	4,922	170.8(30.2)	21.8(10.8)	Wtr 2007	2	0.03%
2006	KH	1	390[h]	216.8	Spring 2010	0	0.00%
2006	?[b]	0	--	--	?	7	0.09%
2007	KH	2,167	241.3(23.8)[h]	91.6(26.8)	Spring 2008	134	1.68%
2007	KTOI	884	163.1(28.2)	21.5(9.8)		9	0.11%
2007	KTOI[k]	203	99.4(13.7)	6.4(5.3)	Fall 2008	0	0.00%
2008	KH	9,982	197.8(35.1)[h]	56.1(19.2)	Spring 2009	352	4.41%
2008	KTOI[g]	3,875	194.1(51.6)	32.4(18.8)	Fall 2009	5	0.06%
2008	?[b]	0	--	--	?	4	0.05%
2009	KH	7,884	207.5(42.3)[h]	66.7(22.2)	Spring 2010	93	1.17%
2009	KTOI[g]	5,343	217.7(39.6)	45.2(23.1)	Fall 2010	18	0.23%
2010	KH	5,759	197(25)[h]	58(22)	Spring 2011	110	1.38%
2010	KTOI[g]	7,785	230(40)	56(29)	Fall 2011	0	0.00%
?	KH[l]	0	--	--	?	4	0.05%
?	KTOI[l]	0	--	--	?	2	0.03%
?	?[l]	0	--	--	?	2227	27.91%
Total marked		**107,033**	--	--	--	**7979**	**7.45%**

[a] Hatchery facility refers to the rearing hatchery: Kootenai Tribal Hatchery in Idaho (KTOI) or Kootenay Hatchery in British Columbia (KH).
[b] Year class determined by scute removal; fish had shed PIT or PIT was not matched in database.
[c] Eleven fish held over for later upriver release with transmitters (only 10 released with transmitters).
[d] These fish were released upriver (rkm 306.5) with sonic and radio tags.
[e] No measurements available; exact number not known, approximate is 550; NRND (number recaptured cannot be determined).
[f] These fish were first taken to Kokanee Creek Provincial Park, then released in September 2004.
[g] Additional fish were released with no measurements taken or PITs added.
[h] Value given is mean fork length (mm).
[i] These fish were released upriver (299.0 and 258.7), 6 of them with Vemco sonic tags.
[j] There were 200 additional fish held over at KTOI hatchery for Biopar study.
[k] These fish did not have a PIT tag added and were all given fish # 999; NRND.
[l] These fish were untraceable as to brood year, rearing facility, release date, and/or family.

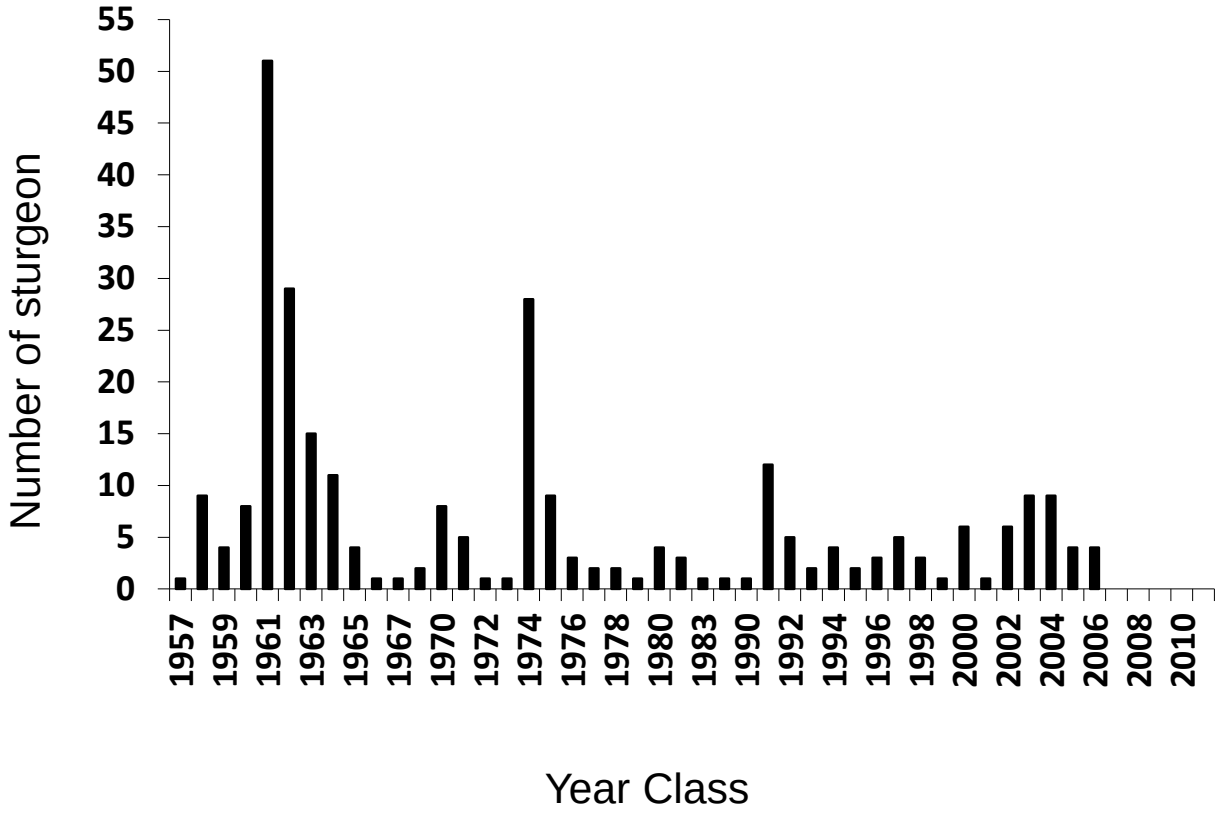
Appendix 1.5. Juvenile hatchery releases with no tag added or measurements taken through fall 2011: combined hatcheries.

Year class	Hatchery facility[a]	Release number	Release season and year
2004	KTOI	3,000	Fall 2004
2004	KTOI	1,275	Late wtr. '04-early wtr. '05
2004	KTOI	17,723	Spring 2005
2004	KH	3,440	Spring 2005
2004	KTOI	8,637	Summer 2005
2005	KTOI	6,200	Fall 2005
2005	KTOI	3,947	Spring 2006
2005	KH	13,665	Spring 2006
2006	KH	6,900	Fall 2006
2006	KTOI	6,175	Fall 2006
2006	KH	5,800	Spring 2007
2006	KTOI	12,973	Spring 2007
2007	[b]	0	
2008	KTOI	882	Fall 2009
2009	KTOI	808	Fall 2010
2010	KTOI	1,825	Fall 2011
Total		93,250	

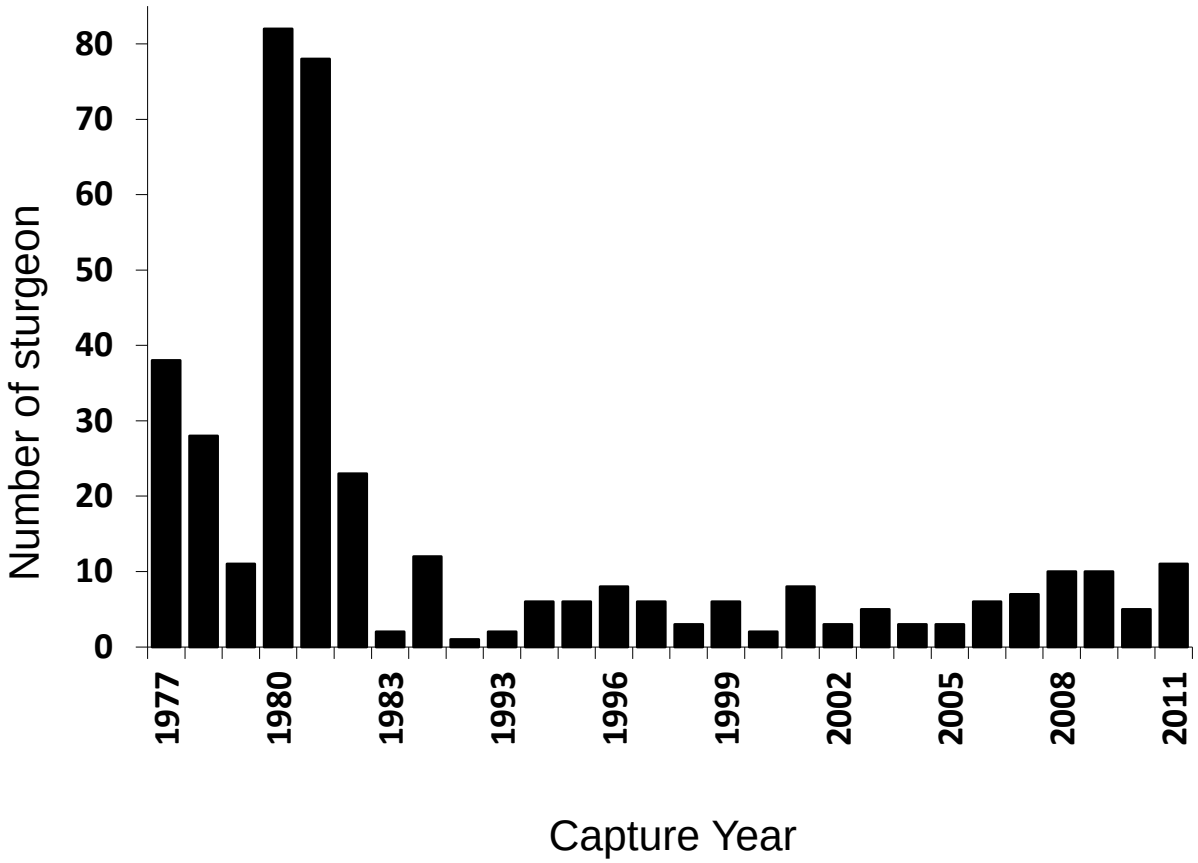
[a] Hatchery facility refers to the rearing hatchery: Kootenai Tribal Hatchery in Idaho (KTOI) or Kootenay Hatchery in British Columbia (KH).

[b] There were no 2007 year class fish that were not tagged or measured.

Appendix 1.6. Number of wild juvenile white sturgeon by age class captured in the Kootenai River, Idaho 1977-2011.



Appendix 1.7. Number of wild juvenile white sturgeon captured annually in the Kootenai River, Idaho, 1977-2011.



CHAPTER 2: BURBOT MONITORING AND EVALUATION
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ABSTRACT

Seven burbot were captured in hoop nets during the 2010-2011 winter season in 1,748 net days of effort (0.004 fish/d). Three were recaptures of hatchery releases, released in 2009 and 2010. In 2011/12 winter season, crews sampled 30 burbot in 949 net days (0.032 fish/d). This increase in CPUE is attributed to survival of burbot from stocked fish from 2007-2010. In 2010, a total of 2,155 larval and juvenile burbot hatched and reared from at the University of Idaho Aquaculture Research Institute were stocked evenly between the Kootenai, Goat, and Moyie rivers and Boundary and Deep creek. In 2011, the stocking numbers increased to 70,034 in these same locations and future increases in catch are anticipated. In 2010, 484 feeding burbot larvae were stocked in Cow Creek Pond amongst five net pens at three densities (low, moderate, and high). Mean survival for the low, moderate, and high density pens was 86, 78, and 20%, respectively. Mean TL at collection in 2010 for the low, moderate, and high densities were 37, 37, and 40 mm, respectively. Although food availability may be contributing to differences in survival, this may be confounded by the increased cannibalism presumed to occur in the net pens with higher densities.

INTRODUCTION

In Idaho, burbot *Lota lota* are endemic only to the Kootenai River (Simpson and Wallace 1982). Burbot in the Kootenai River once provided an important winter fishery. This fishery and that of Kootenay Lake, British Columbia, Canada may have been the most robust in North America (Paragamian and Hoyle 2005). However, after the construction and operation of Libby Dam by the U.S. Army Corps of Engineers (USACE) in 1972, the fishery in Idaho rapidly declined and was closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake and Kootenay River in British Columbia (Paragamian et al. 2000). Demographic studies indicated the Kootenai River burbot population might become extirpated by 2015 if no further actions are taken to restore the population (Pyper et al. 2004; Paragamian et al. 2008). Operation of Libby Dam for hydroelectric power and flood control created major changes in the river's seasonal discharge and temperature, particularly during the winter when burbot spawn. Libby Dam operations are thought to be the major factor limiting this population through a disruption of spawning caused by increased winter flows and temperatures (Paragamian 2000; Paragamian et al. 2005; Paragamian and Wakkinen 2008).

Because burbot in the Kootenai River were at risk of demographic extinction (Paragamian et al. 2008), a Conservation Strategy was prepared to outline measures necessary to restore the burbot population (Anonymous 2002; KVRI Burbot Committee 2005; Ireland and Perry 2008). The Conservation Strategy predicted that operational discharge changes at Libby Dam were required during winter to provide suitable conditions for burbot migration in temperature and discharge. Studies recommended discharge at Bonners Ferry average 176 m^3/s for a minimum of 90 days (d) (mid-November through mid-February) for burbot migration and spawning (Paragamian 2000; Paragamian et al. 2005; Paragamian and Wakkinen 2008). Results of additional movement studies indicated burbot temperatures of about 6°C were necessary for migration and cooler temperatures of 1-4°C for spawning (Paragamian and Wakkinen 2008). The Conservation Strategy identified Conservation Aquaculture as a remedial measure to help strengthen the depressed burbot stock.

Burbot stock limitations become an increasing factor to restoration with each passing year. Because the Kootenai River burbot stock is so limited, the introduction of a genetically similar donor stock was suggested to be a useful approach to enhance the population (KVRI Burbot Committee 2005). Moyie Lake is in the Kootenai River basin, and burbot from the lake had been previously provided to the University of Idaho Aquaculture Research Institute (UIARI) by the collection efforts of the Kootenai Tribe of Idaho for spawning and experimental intensive culture (Jensen et al. 2008a).

Intensive rearing techniques for burbot, although still evolving, have proven extremely successful in rearing fish to the juvenile stages and ready for stocking in the Kootenai River. Extensive rearing of larvae has also been effective at increasing growth and survival of burbot for the purposes of restoration when released as fingerlings (Dillen et al. 2008; Vught et al. 2008) and is considered important to an initial restoration strategy for Kootenai River burbot (Jensen et al. 2008a; Jensen et al. 2008b; Vught et al. 2008). Intensive culture and extensive pond rearing techniques developed by the Kootenai Tribe of Idaho, BC Ministry of Environment, the UIARI, and Idaho Department of Fish and Game (IDFG) have become an important restoration measure and show promise through increased catch rates of hatchery juveniles in the river.

GOAL

The management goal of this study is to restore the burbot population in the Idaho reach of the Kootenai River in order to provide an annual sustainable harvest of burbot.

OBJECTIVES

1. Obtain hoop net catch rates similar to populations with burbot stocks that sustain fisheries (0.9-1.2 fish/net/d).

2. Determine if return rates of intensively and extensively raised burbot differ in hoop net catches.

STUDY AREA

The Kootenai River drainage is the second largest tributary to the Columbia River and the third largest in drainage (approx. 49,987 km^2; Bonde and Bush 1975). Originating in Kootenay National Park, British Columbia, the river discharges south into Montana, where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 2.1). From Libby Dam, the river flows west and northwest into Idaho, then north into British Columbia and Kootenay Lake. Kootenay Lake drains out the West Arm, and eventually joins the Columbia River near Castlegar, British Columbia. Approximately 105 river kilometers (rkm) flow through the Idaho section of the Kootenai basin. During the study period, index hoop net sampling and monitoring of adult burbot occurred from rkm 144.5 (Nicks Island near Creston, BC) to rkm 244.5 (Ambush Rock near Bonners Ferry, Idaho) (Figure 2.2).

Cow Creek Pond (0.35 ha; 1.8 m deep) was used in 2010 for extensive rearing. Fredericks Pond was used in 2010 and 2011, and is described in Paragamian and Laude (2010). Cow Creek Pond is located approximately 13 kilometers (km) from the Kootenai Wildlife

Refuge (Figure 2.3). The pond is isolated in that the water source originates from an irrigation valve from Cow Creek and the outlet drains into a pasture. An extensive limnological survey was conducted in 2009 (Wilhelm 2010), which showed the pond to be suitable to support fish. In 2011, extensive rearing was conducted at Fredericks Pond and two ponds at Boundary Creek Wildlife Management Area (BCWMA) (Figure 2.3). Excavation of the Boundary Creek ponds occurred in July of 2010; each is rectangular, approximately 13 m x 27 m x 3 m (WxLxD), and fills naturally through runoff and seepage.

METHODS

Kootenai River Discharge and Temperature

The US Fish and Wildlife Service made a systems operation request (SOR) for winter of 2010-2011 on behalf of the Kootenai Valley Resource Initiative's (KVRI) Burbot Recovery Committee (which included the Office of Species Conservation, IDFG, Kootenai Tribe of Idaho, City of Bonners Ferry, and Boundary County) to the USACE and the Bonneville Power Administration (BPA). Like the previous year, the 2010-2011 SOR focused on cooler water temperature. As a result, the intent was an experiment to provide the coolest water possible in November (6°C and cooler water December—February) using the selective withdrawal system in place at Libby Dam with a target range from 1-4°C (Figure 2.4).

Tributary Temperatures

HOBO® or StowAway® XI temperature loggers were used to monitor daily water temperatures in Deep, Snow, and Boundary creeks in Idaho and Corn Creek in British Columbia from December 2010 through March 2011. Temperature loggers were placed in tributaries approximately 500 meters (m) upstream from the confluence to reduce the influence of the Kootenai River on daily temperature recordings.

Burbot Sampling

We sampled burbot in the Kootenai River using baited hoop nets during winter 2010/11 and 2011/12. Nets were checked three times each week. Five index sites were sampled in 2010/11 and 2011/12, and an additional 10 sites in 2011/12 (Figure 2.2). For logistical purposes, we alternated sample sites by week between Canadian sites (6) and U.S. sites (7) during 2011/12. Due to close proximity and data recording differences between years, two sites (rkm 150 and 150.5) were combined as a single index site for CPUE calculations.

We used up to 16 hoop nets with variable diameter (maximum 0.61 m) and different bar-mesh sizes (25.4 and 19.1 mm bar-mesh in 2010 and 25.4, 19.1, and 12.7 mm bar-mesh in 2011). The objective of using smaller mesh sizes was to determine if the smaller mesh would capture smaller, younger burbot (Gunderman and Paragamian 2003).

Captured fish were identified, enumerated, measured to total length (TL), weighed (g), sex determined (indicated by flowing milt or eggs), and checked for previous tags. All untagged burbot were given a unique PIT tag (9 mm FDX; RFID) implanted into their abdomen using a tagging syringe. Burbot captured in nets deeper than 9 m were reset to one-half the original depth for 24 hours (h) to allow fish decompression and reduce barotrauma related mortality. Total numbers, length, and weight were recorded for non-target species as well and the scute pattern recorded for white sturgeon *Acipenser transmontanus*. Data obtained on burbot were

used to calculate relative changes in catch rates (CPUE) from 1994-2011, size structure (PSD), and relative weight (W_r; Fisher et al. 1996).

Telemetry Monitoring

An established receiver array consisting of 73 Vemco receivers (81 kHz; VR2 and VR2Ws) extends from Idaho-Montana border downstream into and throughout Kootenay Lake, including receivers in the lower Goat River (Figure 2.5). Of these 73 receivers, 28 are located within our hoop net index study reach (Nicks Island, BC 144.5 rkm to Ambush Rock, ID 244.5 rkm). British Columbia Ministry of Forests, Lands, and Natural Resource Operations (BCMFLNRO) and IDFG personnel download receivers every spring and U.S. receivers once more in the fall. Although not analyzed for this report, in coming years these data will be used to determine dispersal, movement, survival, spawn timing, and habitat selection of tagged burbot. No new sonic tags were implanted from IDFG during these two sampling seasons. BC tagged fish with V16 three year life tags in order to determine juvenile dispersal patterns.

Extensive Rearing Ponds

Burbot brood source

Brood fish were captured in February 2010 and 2011 from Moyie Lake, British Columbia, Canada using hoop nets and angling through the ice. Moyie Lake is in the Kootenai River drainage and located approximately 20 km north of the Idaho border. Spawning crosses (fertilizations) occurred on the ice and gametes were transported to the University of Idaho Aquaculture Research Institute (UIARI), Moscow, Idaho for incubation. Approximately 40d post hatch, larvae were transported to the ponds and released for survival experiments.

Net Pens

We used two sizes of net pens for our pond-rearing study in 2010 and 2011. Smaller pens measured 1.83 m X 0.91 m X 0.91 m (volume = 1.53 m^3 [1,530 L]) with 500 µm Nitex® mesh, and large pens measured 1.83 m X 1.83 m X 0.91 m (volume = 3.66-m^3 [3,660 L]) with 500 µm Nitex®. In 2010, we used four small and one large net pen(s) in Cow Creek Pond. During 2011, we deployed two large pens (one of each mesh size) in Fredericks Pond and five smaller pens in each of the BCWMA ponds. A HOBO® temperature logger recorded daily pond temperatures.

Larval releases, stocking densities, and sampling

On May 15, 2010 Cow Creek Pond received 484 larval burbot, placed between five net pens of three different stocking densities. Two net pens were stocked at low densities (19.6 fish/m^3; 30 fish), two net pens at medium densities (39.2 fish/m^3; 60 fish), and a single large net pen was stocked at a high density (99.3 fish/m^3; 304 fish). Stocking densities were similar to previous years of extensive rearing studies conducted at Fredericks Pond (Paragamian and Laude 2008, 2010). Once a week, light traps and active dip netting were used to collect larval burbot for weekly growth data. We released burbot back into net pens after measurements were recorded.

On June 16, 2011, we stocked 4,750 feeding burbot into rearing ponds and net pens. In Fredericks Pond, 400 larval burbot were stocked into each net pen (131 fish/m^3). In BCWMA ponds, each net pen in East Pond and West Pond was stocked with 200 burbot (132 fish/m^3) for

a total of 1,000 in net pens per pond. We also stocked each BCWMA pond with additional larvae outside of the net pens (1,000 in East Pond and 950 in West Pond). To increase phytoplankton production, liquid fertilizer (10-34-0) was added to both ponds on 6/2/11 and 6/23/11, and alfalfa was added in addition to the fertilizer on 7/13/11 and 7/27/11.

In 2011, protocols similar to 2010 were used to collect to assess weekly growth rates. On August 9, we removed fish from net pens on that were not big enough to PIT tag, and marked each with a yellow Visual Implant Elastomer (VIE) mark on the right pectoral fin. This mark will be used to determine the origin of fish, following release into the Kootenai, that were not big enough to PIT tag. At-large burbot in BCWMA ponds were removed on September 20 and tagged with PIT tags. We used gas powered water pumps, with a fish screen, to drain each pond to approximately 0.5 m, then collected all fish using multiple passes with a beach seine. All burbot recovered from the ponds were released into Boundary Creek, Idaho approx. 3 km above the confluence with the Kootenai River.

Food abundance

A Wisconsin style plankton net, (0.3 m diameter, 80 µm mesh) was used to sample zooplankton in Cow Creek Pond in 2010 and BCWMA ponds in 2011. Each sample event included three spatially unique vertical hauls from bottom to surface, which were conducted weekly to estimate densities. Samples were preserved in Ethanol or 5% Lugol's solution for ease of species identification. Processing and qualitative analysis included removing samples from ethanol or Lugol's solution by washing with water through a 40 µm-mesh screen, then identifying and enumerating zooplankton from 1-2 ml subsamples (Wilhelm 2010).

Food augmentation

In 2010, we provided an additional food supply for the burbot in the Cow Pond pens by collecting zooplankton with a Turtox® style plankton net from an offsite location (63 µm mesh net was 25.4 cm in diameter and 914.4 cm long). Tows were approximately 6 m in length of filtered pond water. Samples were transferred to the Cow Pond pens and released on June 22, July 8, 15, and 22. On average, we added about 121, 92, 252, and 267 zooplankton on each day, respectively, (or 4.6, 9.3, 37.0, and 13.0 zooplankton/m^3) comprised of cladocerans, *Acroperus*, *Copepoda*, and rotifers. The most abundant zooplankton were *Daphnia*, *Alonella*, and Cyclopoids.

Statistical analysis

Differences in burbot survival for low, medium, and high densities within and between years (2008-2010) and between treatment groups were calculated with a Fischer exact test (Preacher 2001). We recognize Cow Creek Pond (2010) was used instead of Fredericks Pond (2008 and 2009) in 2010 and assumed no pond effect on burbot growth for analysis between 2008 and 2010.

RESULTS

Kootenai River Discharge and Temperature

Libby Dam Systems Operation Request

Although the SOR was delivered to the USACE for the 2010-11 water year, the request, unfortunately, could not be conducted due to unusually high forecasts in the reservoir. The USACE resumed load following during the winter of 2010-2011 with an estimated January volume forecast of 96% followed by February at 113% and 121% in March forecasts. As a result, discharge in the Kootenai River at Bonners Ferry ranged from a low of 149 m^3/s to as high as 906 m^3/s (Figure 2.6). Mean water temperature at Ambush Rock near Bonners Ferry, Idaho (rkm 244.5) was 4.47°C ranging from 0.40°C to 6.70°C. Mean water temperature at Porthill, Idaho (rkm 169.8) was 4.38°C ranging from 1.0°C to 7.28°C. Mean temperature at Nicks Island (rkm 144.5) was 4.41°C ranging from 1.33°C to 6.98°C (Figure 2.7).

Tributary Temperatures

Temperatures in Deep, Snow, Boundary, and Corn creeks ranged from 0.13–5.60°C from December 1, 2010 to April 15, 2011 (Appendix 2.1-2.4).

Burbot Sampling

For the 2010/11 sample season, we fished baited hoop nets from December 13, 2010 through April 12, 2011 capturing nine different species, including seven burbot in 1,748 net-d (41,952 net-h) of total effort (Tables 2.1, 2.2). Catch per unit effort was 0.004 burbot/net-d, lower than previous years (Figures 2.8; Appendix 2.6). Ambush Rock (rkm 244.5) had the greatest CPUE (Table 2.1; Figure 2.9). Of the seven burbot captured, four were unmarked and three had marks (PIT tags) representing three hatchery brood years (one each from 2007, 2008, and 2009). Burbot ranged from 224-796 mm TL (mean = 499.1 mm ± 69.6 mm; Figure 2.10) and weighed 86-2100 g (mean = 954.6 g ± 295.7 g). Mean W_r of burbot ≥200 mm was 86.90 and PSD was 83 (Table 2.3; Figure 2.11).

In 2011/12, baited hoop nets fished from December 5, 2011 through March 29, 2012, capturing 156 fish from 18 different species, including 30 burbot in 949 net-d of effort (Tables 2.1, 2.2; Figure 2.8). Catch per unit effort was 0.032 burbot/net d for all sites. Index sample sites had a CPUE 0.056 burbot/net d, higher than previous years. Catch per unit effort varied by bar-mesh size, with 9.1 mm bar-mesh having the greatest CPUE (Table 2.4). Ambush Rock (rkm 244.5) had the greatest amount of effort (169 net d) and burbot captured (22) (Table 2.1; Figure 2.9). Burbot ranged from 127-724 mm TL (mean = 476.43 ± 29.84 mm; Figure 2.10) and weighed 17-2,882 g (mean = 1,020.93 ± 156.08 g). Mean W_r of burbot ≥200 mm was 102.38 and a PSD of 84 (Table 2.3, Figure 2.11). Of the 30 burbot captured, eight had marks from hatchery releases representing three known brood years (2 = 2007, 5 = 2009, and 1 = 2011), and 14 were unmarked, of which three were recaptured during 2011/12. The majority (73%) of burbot captured this sample season was at index sample sites, and six of the 30 captured were identified as being hatchery reared burbot. Age-at-stocking of recaptured burbot from known brood years were age-2 (2007 brood year), age-1 (2009), and age-0 (2011). Average growth rates for recaptures from known brood years were 0.06, 0.45, and 0.29 mm/d for 2007, 2009, and 2011 brood years, respectively.

Telemetry Monitoring

A total of 121 transmitters were surgically implanted and released from September 2009 to November 2011 (Appendix 2.5), of which 77 were detected on remote receivers during 2010 and 2011 report years (April 1, 2010-March 31, 2012). Telemetry data will be analyzed in future years to examine post-stocking dispersal, survival, and identify habitat use (e.g., potential spawning locations).

Extensive Pen Rearing

Pen rearing summary 2008-Fredericks Pond--Eighty-four larvae were captured using light traps in the net pens. Daily growth for all net pens ranged from 0.00-4.28 mm/d with an average growth of 0.82 mm/d. Weekly growth of larvae ranged from 0.0-7.00 mm/wk, (mean = 6.49 mm/wk; Figure 2.12). The net pen growth experiment was concluded in August 2008. We collected 47 of the 60 burbot larva released in May for a pen survival of 78% and a mean total length of 48 mm. When viewed under a microscope, the digestive tracts of larval burbot at the end of the experiment were full of zooplankton.

Pen rearing summary 2009-Fredericks Pond—Two hundred and twenty-three larval burbot (223) were captured using light traps in the net pens. Daily growth for all net pens ranged from 0.57-1.58 mm/d with an average growth of 0.35 mm/d. Weekly growth of larvae ranged from 3.98-11.05 mm (mean = 2.45 mm/wk; Figure 2.12). By September, total length of larval burbot ranged from 39-58 mm TL (mean = 49 mm). Most fish were too small (less than 1 g) to weigh accurately. Overall growth appeared to slow for all stocking densities after the fifth week (Figure 2.12). We removed burbot from all pens on September 2, 2009.

Pen rearing 2010-Cow Creek Pond—On July 29, 2010, 206 burbot were collected from the net pens and tagged with a VIE tag prior to release. Average survival for the low, moderate, and high density pens were 86, 78, and 20%, respectively (Table 2.5). All net pens combined, TL ranged from 25-70 mm and the means for the low, moderate, and high-density pens were 37, 37, and 40 mm TL, respectively. Daily growth for all burbot in pens ranged from 0.68-1.38 mm/d with a mean growth of 0.87 mm/d. Weekly growth of larvae ranged from 4.49-9.67 mm/wk averaging 6.12 mm/wk (Figures 2.12 and 2.13).

Pen Rearing 2011-Fredericks Pond—Weekly observations indicating poor condition of burbot (emaciated) led to no weekly samples taken during weeks 4-7 to minimize handling stress. Average growth was 0.36 mm/d and 2.53 mm/wk TL. We removed 41 burbot from net pens on August 11, 2011 (5% survival) ranging from 20-68 mm TL (mean = 33.2 mm ± 1.11 mm; Table 2.6; Figure 2.14).

Pen Rearing 2011–BCWMA Pens and Ponds—Mean growth in net pens was 0.61 mm/d (4.30 mm/wk) TL in pens in the East Pond and 0.73 mm/d (5.13 mm/wk) for pens in the West Pond, peaking in week 7 (West Pond) and 8 (East Pond; Figure 2.14). At the end of the experiment, August 9-10, we removed 400 burbot from net pens in East Pond and 100 from net pens in West Pond. Survival in the net pens was higher in East Pond (30%) than West Pond (10%; Table 2.6; Figure 2.14).

We removed 100 “at-large” burbot from BCWMA ponds on September 20, 2011, about six weeks after the net-pen experiment was concluded. Of the 100 fish removed, 69 were from West Pond (7% survival) and 31 from East Pond (3% survival). Average total length and weight

was 116.16 mm (± 2.67 mm) and 12.35 g (± 0.91 g) in East Pond and 121.12 mm (± 1.24 mm) and 12.49 g (± 0.36 g) in West Pond (Table 2.5).

Food abundance

Samples taken in August 2008 of the zooplankton community in Fredericks Pond showed small species of Cladocerans. The highest density was of *Bosmina* sp. at 82,100/m^3 (± 1,300 SE), followed by *Ceriodaphnia* sp. at 56,500/m^3 (± 3,700 SE), then by *Diaphanosoma* sp. at 100/m^3 (± 100 SE). Copepod adults were relatively scarce. In contrast, copepod nauplii were dominant at 111,900/m^3 (± 8,900 SE), with calanoids at 1,610/m^3 (± 2,500 SE), and cyclopoids at 5,500/ m^3 (± 1,200 SE).

On May 7, 2010 zooplankton were sampled at Cow Creek Pond before deployment of larvae into pens. *Daphnia* were most abundant at 34,900/m^3 (± 5,800 SE), then *Ceriodaphnia* at 10,000/m^3 (± <1,000 SE), followed by *Diaphanosoma* at <1,000/m^3 (± <1,000 SE). While copepods were relatively scarce; copepod nauplii dominated at 9,832/m^3 (± 3,300 SE), cyclopoids at 34,900/m^3 (± 150 SE), and calanoids at <1,000/m^3 (± 999 SE).

A qualitative summary of zooplankton, separated by crustaceans and rotifers, was conducted for BCWMA ponds in 2011 (Figure 2.15). Weekly average of zooplankton counts (crustacean and rotifers combined) ranged from 0-364 per L in East Pond and 7-316 per L in West Pond. Relatively few to zero zooplankton were observed on June 28 and July 6.

Statistical analysis

Analysis of survival by treatment groups by year indicated there was no difference in low density pens for 2008, 2009, and 2010 ($p = 0.56$, 0.63, and 0.57, respectively). Between the years 2008 and 2009 there was no difference ($p = 0.07$), but significantly higher survival was found for 2010 vs. 2009 ($p = 0.027$), but none between 2008 and 2010 ($p = 0.786$).

Analysis of survival between medium density pens within years showed a significant difference in 2009 ($p = 0.029$), no difference between pens in 2010 ($p = 0.89$), and a significant difference in survival was found at medium densities between 2009 and 2010 ($p = 0.006$). Dropping the low survival pen in 2009 (Table 2.5) resulted in no difference between years ($p = 0.82$). A significant difference ($p < 0.001$) in survival for the high-density pens was detected in 2009 and 2010.

Feeding burbot additional zooplankton in 2010 did not improve survival in low density pens compared to previous years ($p = 0.183$), but appeared to improve survival in medium and high density pens compared to each treatment in years they were not fed ($p = 0.006$ and $p < 0.001$, respectively).

Kootenai River and Tributaries Burbot Stocking

From 2009-2010, 2,598 juvenile burbot were released into the Kootenai River and its tributaries from August through November (Appendix 2.5). Of the burbot released, only 28% (724) were uniquely marked with PIT tags to identify them as hatchery stock. In 2011, 70,535 larval and juvenile burbot were released from June through November by IDFG and KTOI in the Kootenai River and its tributaries (Appendix 2.5). Of these, 381 (5%) were VIE tagged in the right pectoral fin, 36 (0.05%) were age-2 burbot tagged with a Vemco acoustic tag, and 16,943

(24%) were PIT tagged at the UIARI facility. Release locations included the Kootenai, Goat, and Moyie rivers and Snow, Deep, and Boundary creeks (Appendix 2.5).

DISCUSSION

Burbot SOR

The burbot SOR called for mitigation of warmer winter water temperatures in the Kootenai River by releasing a large volume of cool surface water from Lake Koocanusa. The SOR request attempted to "cool" the Kootenai River during winter of 2009–2010 by using a selective withdrawal system at Libby Dam. From late December through the spawning season, the temperature varied above the SOR target maximum temperature of 4°C by less than 0.5°C, and would have been suitable for burbot spawning. In addition, the flow was low for most of the spawning season, which added to the ability of water temperatures in the river to be lower for winter 2009-2010. Managing water temperature at Libby Dam with the selective withdrawal system appears to have improved water temperatures at Bonners Ferry. In the winters of 2007/2008 and 2008/2009, prespawn and spawning water temperatures were above 6°C in early November but began to decline after November 10 through most of December. Water temperatures were usually maintained between 1°C and 4°C throughout January and February.

Maintaining cool water from Libby Dam is largely dependent on environmental factors such as microclimate, wind direction, and intense storms, which all play a role in fall turnover for Lake Koocanusa. Lake Koocanusa becomes isothermal after fall turnover, and as winter progresses, the pool continues to cool toward 4°C (Brian Marotz, Montana Fish Wildlife and Parks, personal communication). Only a thin layer of colder water exists at the surface, and surface water cannot be drawn into the turbines because of concerns for turbine cavitation. The only period that can provide cooler water is the period prior to the development of an isothermal state. The ability to attain cooler temperatures is contingent on the timing of fall turnover, which varies from year to year and can be affected by storms during fall.

The best available recommendation for discharge will continue to rely on the studies of Paragamian et al. (2005) and Paragamian and Wakkinen (2008). As a result of these studies, it is recommended that discharge for burbot prespawning migration and spawning should range from 113-300 m^3/s and average 176 m^3/s for a minimum of 90 d (mid-November through mid-February). Temperature should decline to <6°C by the first week in November and be maintained from 1 to 4°C for the duration of December through February, which includes the migration and spawning season. A study of the relation between “specific levels” of discharge and temperature from Libby Dam and burbot spawning migration and spawning cannot be successfully completed until there are sufficient numbers of burbot and that studies will not compromise burbot rehabilitation. Should burbot supplementation prove successful, these studies will be performed and a more refined recommendation provided. Recent anecdotal evidence from the UI-ARI suggests that temperatures may need to stay below 4°C during the 40-day incubation period (starting around March 1) in order for eggs to successfully hatch. It is still unclear how the current temperature regime of the Kootenai River is affecting spawning or incubation; however, further research to substantiate these observations on burbot hatching success/failure will provide us with information needed to help draft a SOR.

Index Sampling Sites and Population Status

A burbot Conservation Strategy was prepared by the Burbot Subcommittee of the Kootenai Valley Resource Initiative (KVRI Burbot Committee 2005; Ireland and Perry 2008) but a rehabilitation goal (population number) was not included. In order to address this, Paragamian and Hansen (2009) used demographic statistics (Paragamian et al. 2008) in a stochastic density-dependent population model to estimate recruitment rates in order to rehabilitate burbot. The model was developed with an adult stock of 46 burbot (equivalent to the estimate of 2006) and an annual survival of 38%. An interim Kootenai River abundance target of 5,500 individuals (45 fish/km; 3.0 fish/ha) within 25 years was determined when each adult produced 0.85 recruits per year, along with an ultimate abundance target of 17,500 individuals (143 fish/km; 9.6 fish/ha) when each adult produced 1.1 recruits per year. Recent demographic analysis, however, indicated there might only be two adults remaining by the end of 2009. Thus, any expectations that this population can recover on its own within the next decade are unreasonable even with the most suitable habitat, lower winter discharge, colder winter temperatures, and improved primary production. Further, Paragamian and Hansen (2011) developed an age-structured simulation model to estimate the number of age-0 burbot (fall juveniles) to stock to rebuild the population in the Kootenai River in 25 years. They found with the estimated survival of about 38% that 110,000–900,000 age-0 burbot will need to be stocked to rebuild the burbot population, depending on the rehabilitation goal, either 5,500 burbot as an interim goal or 17,500 burbot as an ultimate goal (longer than 250 mm and age 4 and older). If survival is higher at 61% then the stocking numbers could range from 12,000 to 35,000 age 0 juveniles. Thus, it is of crucial importance that remedial measures to improve this stock's abundance begin immediately.

Trend CPUE of burbot captured in hoop nets increased seven fold in the 2011/12 from a mean of 0.005 fish/d (fall 2006—spring 2011), suggesting that hatchery fish are surviving well after being stocked into the main stem Kootenai and its tributaries. However, since only 27% of the hatchery burbot were uniquely marked prior to release, it is difficult to determine the exact influence hatchery fish are having on catch rates. The use of genetic markers is near completion, and will likely be available for use in coming years. Originally proposed by Anderson and Garza (2006), parentage-based genetic tagging (PBT) is currently being used in other fisheries as an alternative to mechanical tagging methods (Steele et al. 2011). Burbot progeny from genotyped parents will be able to be assigned to their release group and brood year (Matt Campbell, Idaho Department of Fish and Game, personal communication). This method will also provide a way to evaluate natural production, survival by brood year, release location, or a multitude of other possible treatment combinations for producing a strong year class. Once this is fully available, all progeny back to 2011 will be included in these parent assignments. Therefore, relatively few (<1,500) burbot released will be left unmarked in the population at large.

Although growth of these recaptured hatchery burbot varied by age-at-stocking, burbot released at age-1 and recaptured during 2011/12 showed higher daily growth per day than burbot recaptures stocked at age-2 or age-0. Comparisons of these growth data are difficult because very few fish from each of the brood years were captured and stocking dates varied. Overall, burbot relative weights indicate they are in good condition and above the suggested preliminary objective of 80 ± 5 for rivers and reservoirs (Fisher et al. 1996).

The Goat River (rkm 152.5) and Ambush Rock (rkm 244.5) are the last two known spawning locations for burbot in the Kootenai River and provided a major portion of total winter catch in the early 1990s (Gunderman and Paragamian 2003). In the 2011/12 sample season,

these two sites increased in CPUE from previous years and contributed 76% of the total catch. The increase in catch rates at these locations suggests that burbot progeny from Moyie Lake broodstock are adapting to river conditions and locating these areas along with wild Kootenai River burbot. This and possibly other important staging and spawning locations should become more evident when the high number releases of burbot in 2011 become susceptible to hoop net sampling.

Extensive Burbot Pen Rearing Summary 2008-2010

Extensive rearing of larval burbot in pens provided an excellent foundation to examine if survival of burbot larvae is higher in extensive rearing pens than those reared in intensive culture. The survival rate in net pens at low densities, without supplemental feeding averaged 50% over a three-month period but with supplemental feeding averaged 81%. Survival in higher density pens averaged 13%, similar to findings of Vught et al. (2008) and Jensen et al. (2008b) using a variety of intensive culture techniques. Under intensive culture conditions, with larvae being fed *Brachionus calyciflorus* and *Artemia*, Vught et al. (2008) had 4% survival with 5,000 larvae/m^3 (Harzevili et al. 2003). Jensen et al. (2008b) experimented with incubation jars and feeding of various zooplankton and commercial food diets and had a survival range of 0 to 9.2% in year one and 0.4 to 10% survival in year two with tank densities of 2,500 and 25,000 larvae/m^3, respectively. Although our results showed better survival in extensive rearing pens, we did not test similar densities as were used in the experimental intensive rearing tanks. If additional pen rearing is used to test additional effects on growth and survival, it is recommended that similar densities is be used to provide results that are more comparable.

There were no significant differences in growth detected when comparing burbot larvae reared in varying densities. However, our larvae fed only ambient zooplankton density grew at a faster rate than larvae fed under intensive hatchery conditions in controlled experiments (Vught et al. 2008; Harzevili et al. 2003; Harzevili et al. 2004; Jensen et al. 2008b). It is, however, difficult to have an unbiased assessment of growth between this study and others because of obvious differences in experimental design and objectives. After 70 d in our net pens, larval burbot grew from a mean TL of 9-49 mm TL (0.57 mm/d) upon release into the Kootenai River. Although using different diets, Harzevili et al. (2003) found growth from about 5-9 mm TL in 35 d (0.11 mm/d).

Availability of food was likely the most limiting factor to burbot growth and survival in pens. Larval burbot that were not fed but relied on zooplankton passing through the 500 µm mesh did not exhibit better growth than those treatment groups that were supplemented with live zooplankton in addition to ambient. Zooplankton abundance in the high density larval pens was visibly lower after the fifth week as compared to those in the low density pens. This was also evident by the differences in growth rates between the two treatments. It is, however, also very important to note that cannibalism may confound these results. We did not see evidence of cannibalism in our pens; however, in intensive culture at the UIARI this was not uncommon (N. Jensen, UIARI, personal communication). Burbot culture studies have shown larvae have a high level of dependence on live food (Harzevili et al. 2003) and use of commercial diets early in life usually have low success (Jensen et al. 2008b). Additional studies would need to be set up to determine if cannibalism can be reduced by feeding larvae a high density of live prey items.

Extensive Burbot Pen Rearing Summary 2011

Boundary Creek WMA ponds provided an opportunity to conduct replicable extensive rearing experiments between ponds and net pens. We stocked net pens in BCWMA at much

higher densities than previous years at Fredericks and Cow Creek ponds (2008-2010) but similar to net pen density at Fredericks Pond in 2011. Compared to high-density net pen survival in Cow Creek Pond during 2010, BCWMA had much higher survival. Density of zooplankton was also significantly higher in the BCWMA ponds following fertilization with alfalfa.

Extensive Rearing Summary

The temperature profile of Fredericks Pond approached 20°C during the summer of 2011. Temperatures of 20°C and more are approaching the upper limit for juvenile burbot rearing (Jensen et al. 2008a). Taylor and McPhail (2000) believed fluctuations in temperatures during early life of burbot might have a large effect on recruitment. Harzevili et al. (2004) found that the best growth after 20d was in 16°C water. As such, we may need to consider that in summers with exceptionally high air temperatures, our extensive burbot rearing should be limited to a shorter period, prior to such high temperatures.

Pens worked well for providing high early survival of burbot; however, growth results suggest that after about six weeks burbot should be released in an environment with much lower competition. The practicality of pen rearing burbot could not be fully addressed by this study alone. An obvious limitation is that without supplemental feeding only low numbers of burbot could be reared in this way. Far more pens would be required to rear sufficient numbers of burbot needed for burbot rehabilitation in the Kootenai River (Paragamian and Hansen 2011).

Our at-large burbot in Cow Creek Pond survived similarly to those reared at the UIARI semi-intensive culture ponds. BCWMA ponds proved effective at increasing survival of at-large fish from 3-7%. We recommend experimenting with higher densities of at-large larvae to determine the optimum stocking density that will produce the highest survival in each pond.

There was not enough recaptured juveniles from the extensive pond releases to make an informative decision on whether larvae reared on natural live feed survive better than those reared in a hatchery setting. This future analysis will determine if extensive culture is an effective means of increasing survival.

RECOMMENDATIONS

1. Continue sampling index locations to measure changes in abundance, size structure (PSD), and condition Wr.

2. To evaluate natural production and hatchery contribution, work to reduce or eliminate the number of non-marked hatchery fish stocked.

3. We recommend that stocking of extensively reared burbot continue as defined by the Conservation Strategy (KVRI 2005).

4. Using movement data and intensive culture data that defines the bounds of thermal tolerance for eggs, refine our understanding of what is limiting natural production in order to optimize an SOR to the ACOE for Libby Dam operations.

TABLES

Table 2.1. Summary of burbot catch, hoop net effort (d), and CPUE (burbot/net-d), for hoop net sampling in the Kootenai River during sample years 2010/11 and 2011/12. Highlighted rows indicate index sites.

	2010/11			2011/12		
RKM	**Burbot**	**Effort (d)**	**CPUE**	**Burbot**	**Effort (d)**	**CPUE**
144.5	**1**	**263**	**0.004**	**0**	**77**	**0.000**
150.0	**0**	**264**	**0.000**	**0**	**36**	**0.000**
152.0				0	36	0.000
152.5	**3**	**672**	**0.004**	**1**	**72**	**0.014**
170.0	**0**	**250**	**0.000**	**1**	**72**	**0.014**
205.0	-	-	-	1	86	0.012
213.0	-	-	-	0	74	0.000
225.0	-	-	-	1	80	0.013
229.0	-	-	-	0	74	0.000
234.7	-	-	-	0	6	0.000
239.0	-	-	-	1	84	0.012
240.0	-	-	-	1	68	0.015
240.5	-	-	-	2	15	0.133
244.5	**3**	**299**	**0.010**	**22**	**169**	**0.130**
TOTAL	7	1,748	0.004	30	949	0.032

Table. 2.2. Summary of catch from hoop net sampling targeting burbot during 2010/11 and 2011/12 in the Kootenai River.

Species	**2010/11**	**2011/12**
Northern pikeminnow *Ptychocheilus oregonensis*	31	46
Largescale sucker *Catostomus macrocheilus*	12	3
Burbot *Lota lota*	7	30
Bull trout *Salvelinus confluentus*	4	5
Bullhead *Ameiurus sp*	4	1
Peamouth chub *Mylocheilus*	3	9
Mountain whitefish *Prosopium williamsoni*	2	13
White sturgeon *Acipenser transmontanus*	2	21
Yellow perch *Perca flavescens*	2	1
Rainbow trout *Oncorhynchus mykiss*		11
Redside shiner *Richardsonius balteatus*		6
Pumpkinseed *Lepomis gibbosus*		4
Brown trout *Salmo trutta trutta*		2
Longnose sucker *Catostomus catostomus*		1
Sculpin spp. *Cottus sp*		1
Unknown		2
Total	67	156

Table 2.3. Mean W_r and counts of burbot from hoop net sampling during 2010/11 and 2011/12, separated by length category. Five burbot were excluded from 2011 calculations: two due to shorter than recommended total length (<20 cm) for W_r calculation (Fisher et al. 1996) and three because missing length or weight data.

Total Length (cm)	Length Category	2010/11		2011/12	
		N	Mean Wr	N	Mean Wr
20-37	Stock	2	86.16	4	105.53
38-52	Quality	3	88.67	12	109.85
53-66	Preferred	1	115.31	5	80.26
67-81	Memorable	1	54.68	4	104.47
82+	Trophy	0	-	0	-
Totals		7	86.90	25	102.38

Table 2.4. Burbot catch and CPUE by bar-mesh (cm) size during 2011/12 hoop net sampling in the Kootenai River.

Mesh	N	Effort (d)	CPUE	Mean TL (SE)	Mean Weight (SE)
0.5	10	232	0.043	424.4 (60.7)	740.4 (244.8)
0.75	12	334	0.036	506.6 (41.4)	1156.9 (227.0)
1	8	383	0.021	502.8 (42.7)	1239.2 (325.9)
Total	30	949	0.032	476.4 (28.8)	1020.9 (148.1)

Table 2.5. Net pen number, volume, stocking numbers, density, and survival in Cow Creek Pond in 2010.

Pen	Volume (L)	Starting Count	Stocking density (fish/ m^3)	Ending Count	Ending Density (fish/ m^3)	Survival (%)
1	1.53	30	19.6	29	19.0	96.7
2	1.53	30	19.6	23	14.4	76.7
3	1.53	60	39.2	48	31.4	80.0
4	1.53	60	39.2	46	30.1	76.7
5	3.06	304	99.3	60	19.6	19.7

Table 2.6. Total number of burbot stocked, removed, survival, mean total length-TL (mm) and weight (g) with associated standard errors (SE) from BCWMA ponds and Fredericks Pond extensive rearing during summer 2011.

Location	N stocked	N removed	Survival %	Mean TL (SE)	Mean weight (SE)
BCWMA net pens - Pond 1	1,000	300	30	45.1 (0.23)	-
BCWMA net pens - Pond 2	1,000	100	10	54.7 (1.00)	-
BCWMA net pens combined	2,000	400	20	47.5 (0.37)	-
Fredericks net pens	800	41	5	33.2 (1.45)	-
BCWMA Pond 1 - "at-large"	1,000	31	3	116.2 (2.67)	12.4 (0.91)
BCWMA Pond 2 - "at-large"	950	69	7	121.1 (1.24)	12.5 (0.36)
BCWMA combined "at-large"	1,950	100	5	119.6 (1.20)	12.5 (0.37)

FIGURES

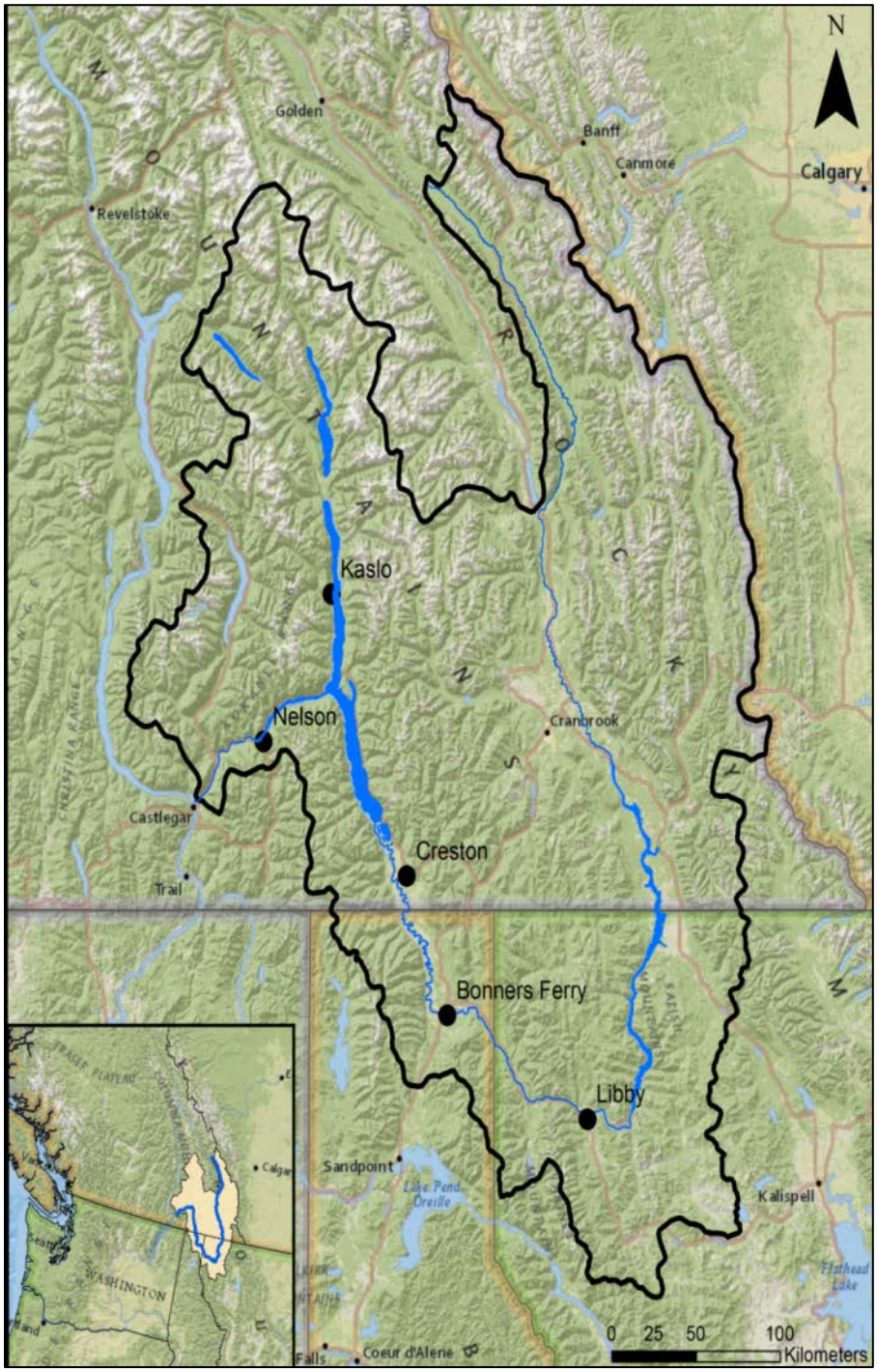


Figure 2.1. Kootenai River and its drainage basin (dark black line).

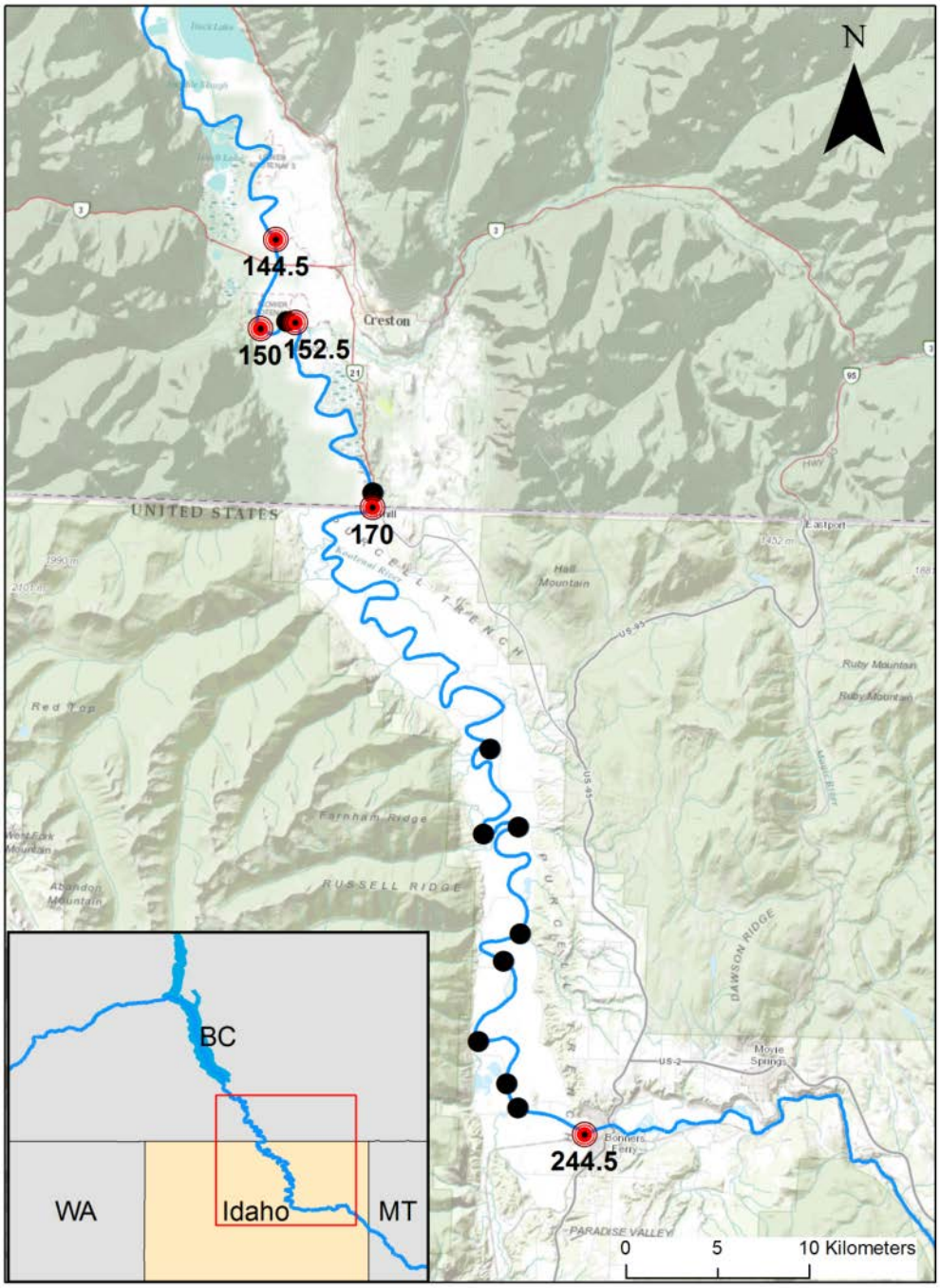


Figure 2.2. Location of hoop net index sample sites (red circles with black center), labeled with associated rkm, sampled in 2010/11 and 2011/12, and additional, non-index, sites sampled in 2011/12 (solid black dots).

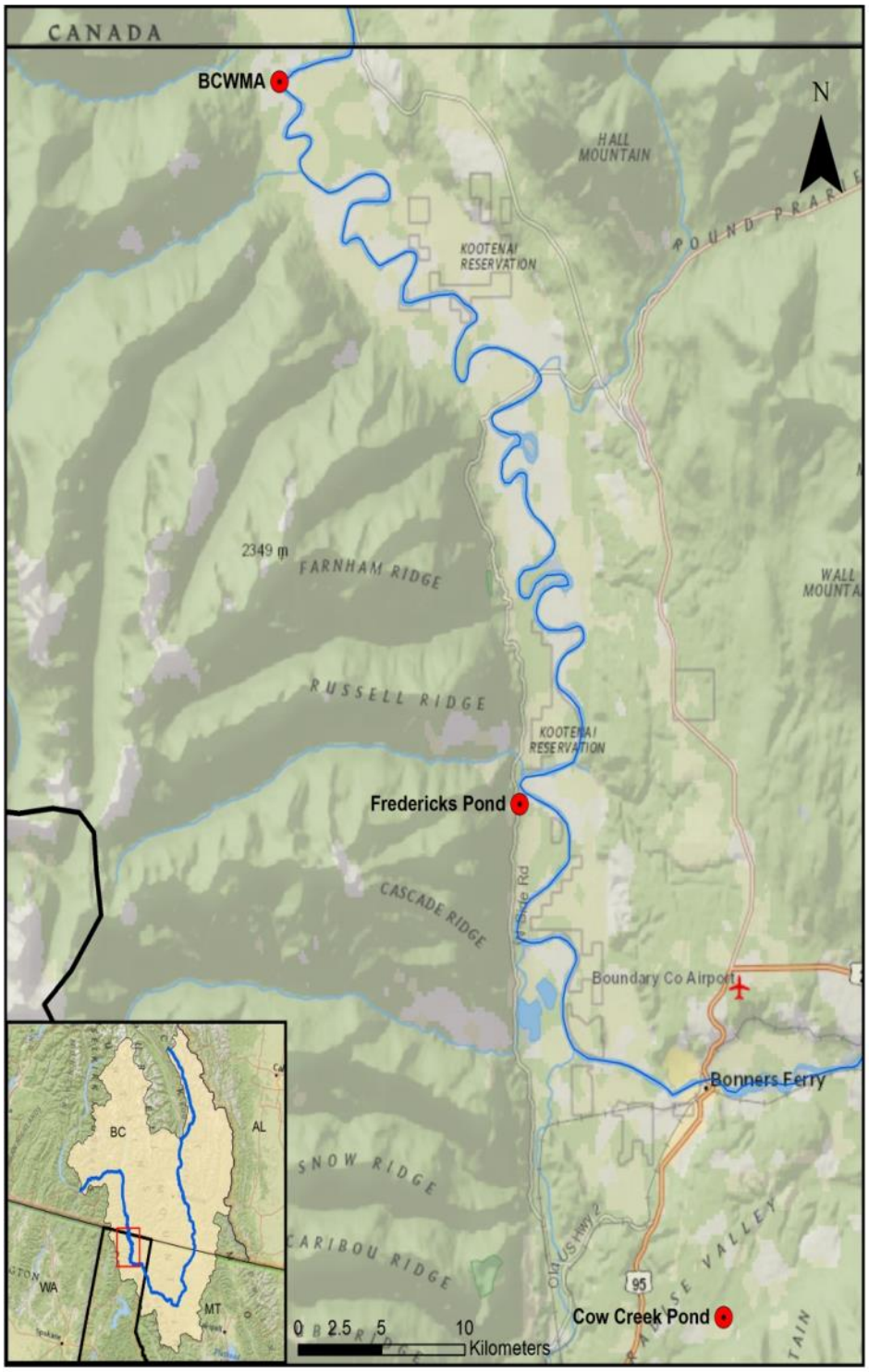


Figure 2.3. Location of ponds used for extensive burbot rearing experiments during 2010 and 2011. Fredericks Pond was used in 2011 and 2008-2009, Cow Creek Pond in 2010, and two Boundary Creek Wildlife Management Area (BCWMA) ponds in 2011.

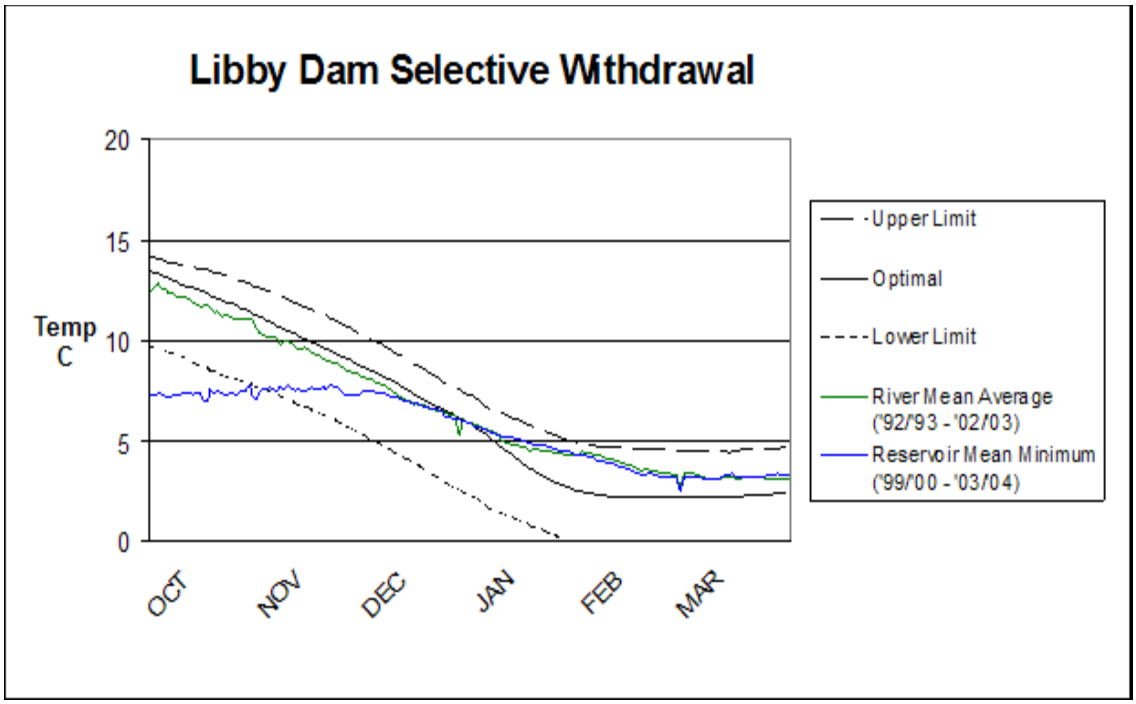


Figure 2.4. Selective withdrawal temperature guidelines for the Kootenai River below Libby Dam. Figure courtesy USACE.

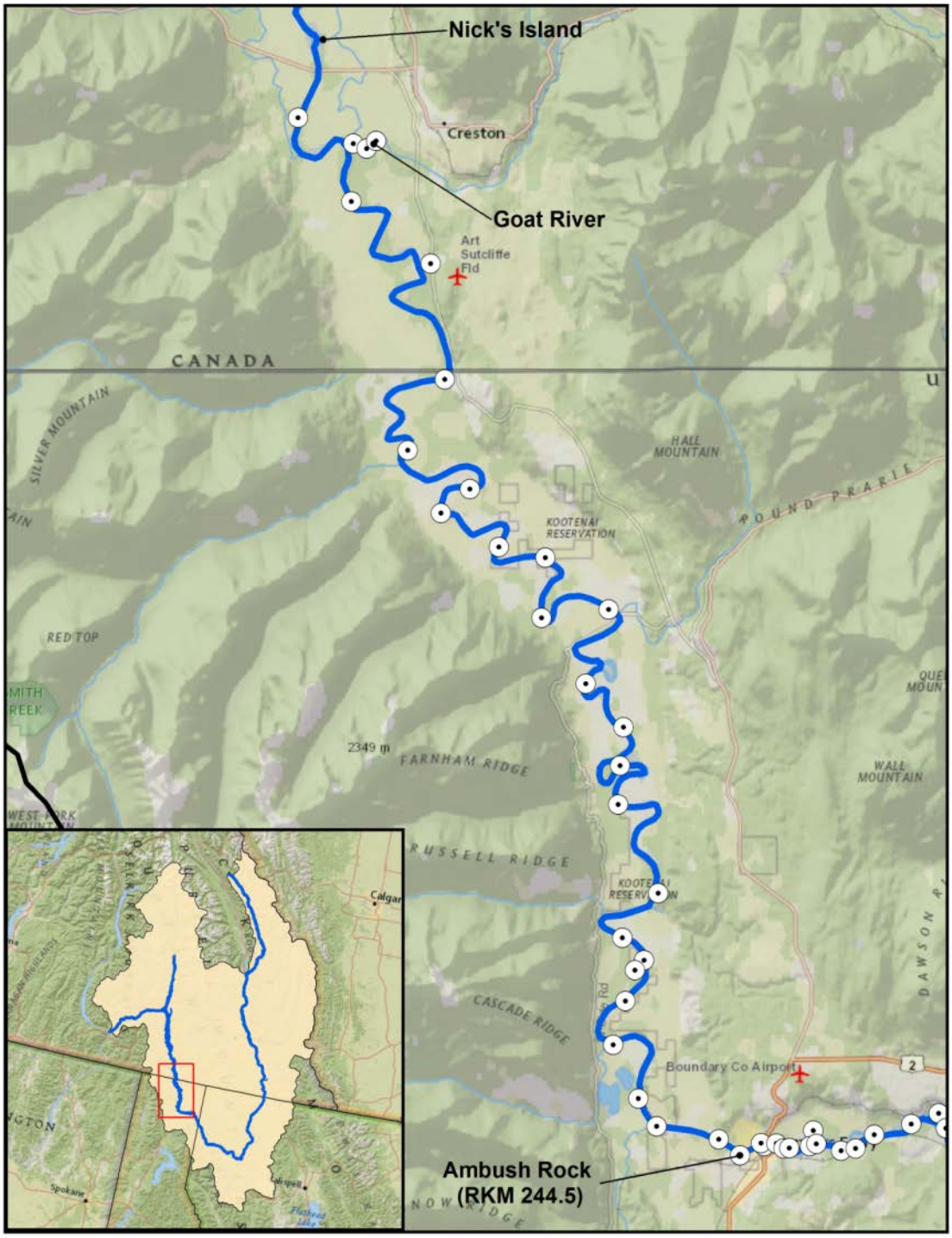


Figure 2.5. Location of remote acoustic receivers in the Kootenai River from rkm 144-255. Twenty-eight receivers, including those located just inside the Goat River, are located between Nicks Island and Ambush Rock, the extent of hoop net sampling from 2010-2012.

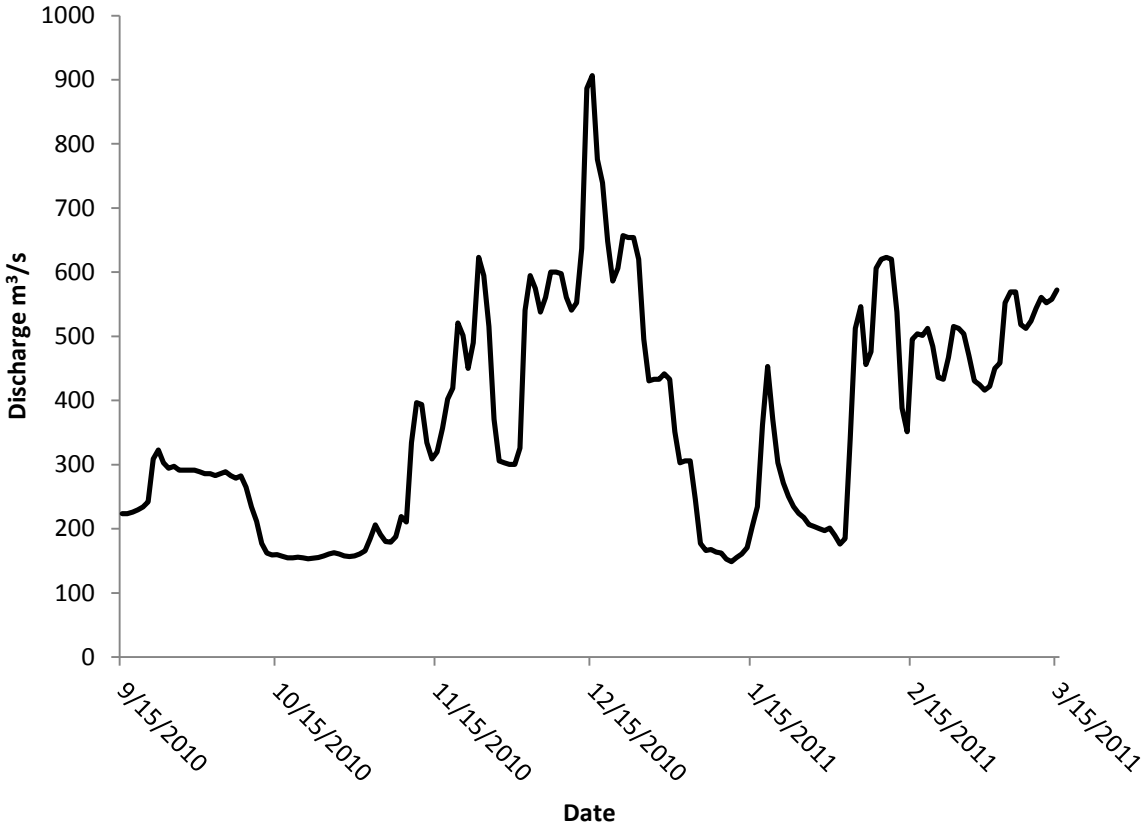


Figure 2.6. Daily mean discharge (m^3/s) near Bonners Ferry, USGS gaging station 12310100 for winter 2010-2011.

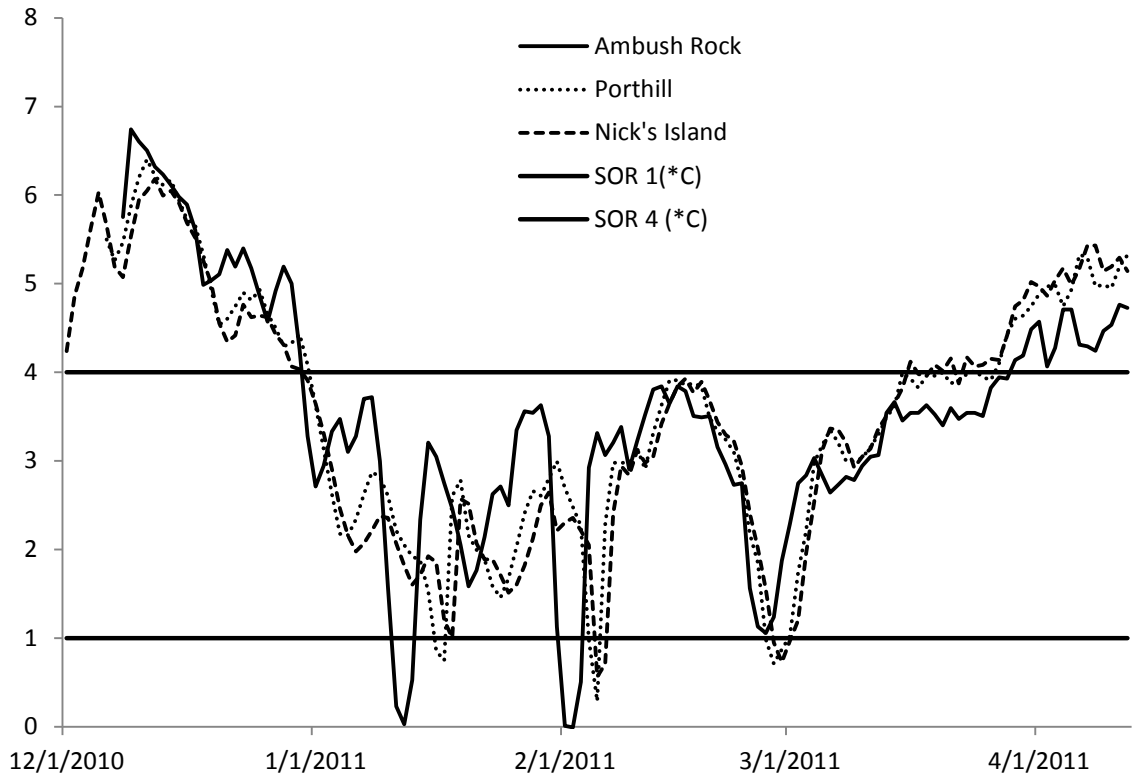


Figure 2.7. Mean daily temperature (°C) for the Kootenai River at Bonners Ferry (rkm 244.5) and Porthill, Idaho (rkm 170), and Nicks Island, BC (rkm 144.5) profile December 1, 2010 to April 12, 2011. Horizontal bars represent the target temperature values for the SOR.

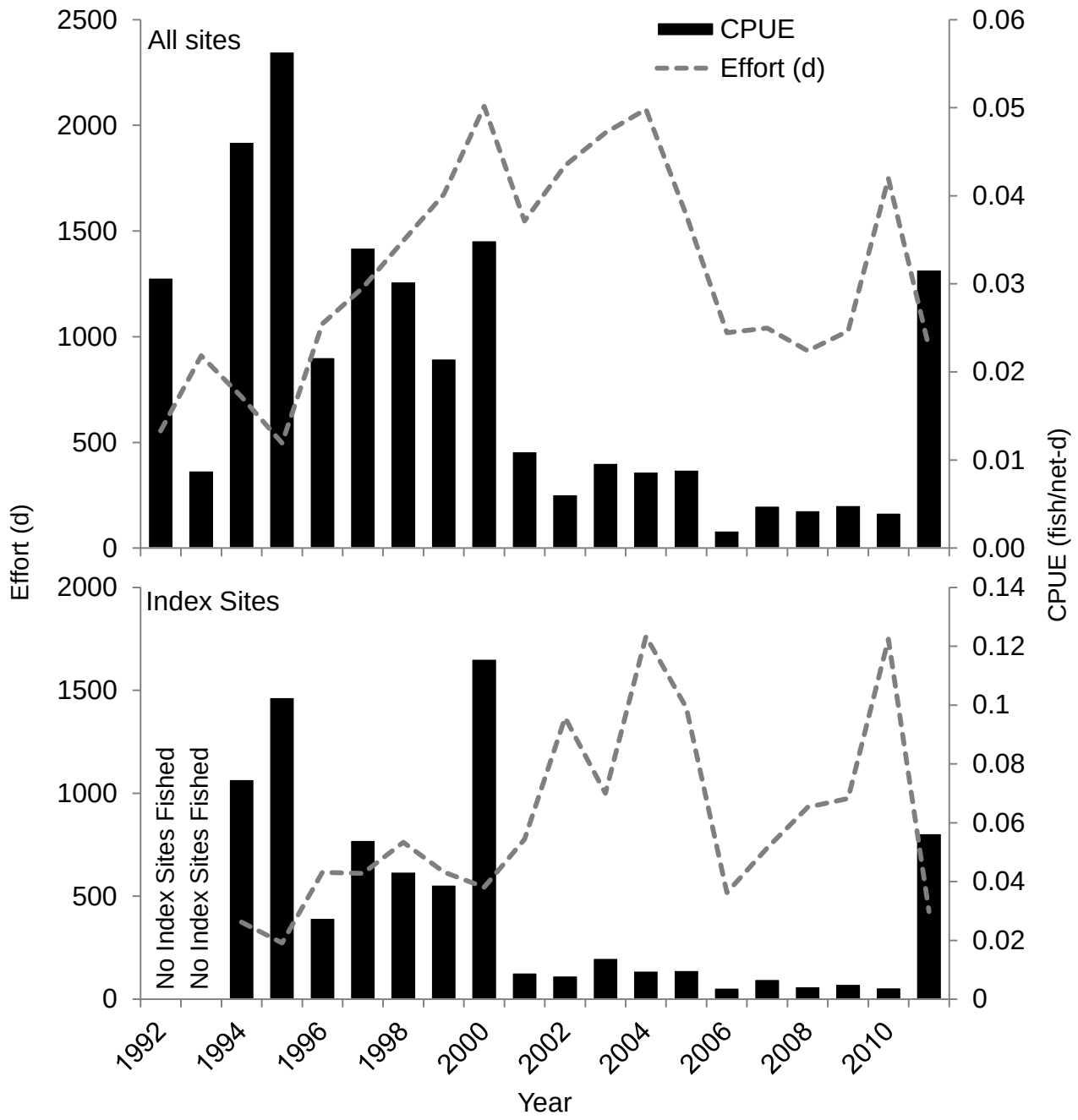


Figure 2.8. Catch per unit effort (burbot/net-d) and effort (d) of hoop net sampling for all sites (top figure) and for index sites only (bottom figure) in the Kootenai River from 1992/93-2011/12. In 1994, only rkms 150-150.5 (Corn Creek confluence) and 152.5 (Goat River) index sites were sampled; in 1995 rkm 170 was added, and all index sites (5) were sampled from 1996-2005 and 2007-2011. In 2006, rkms 144.5 (Nicks Island) and 150-150.5 (Corn Creek confluence) were not sampled.

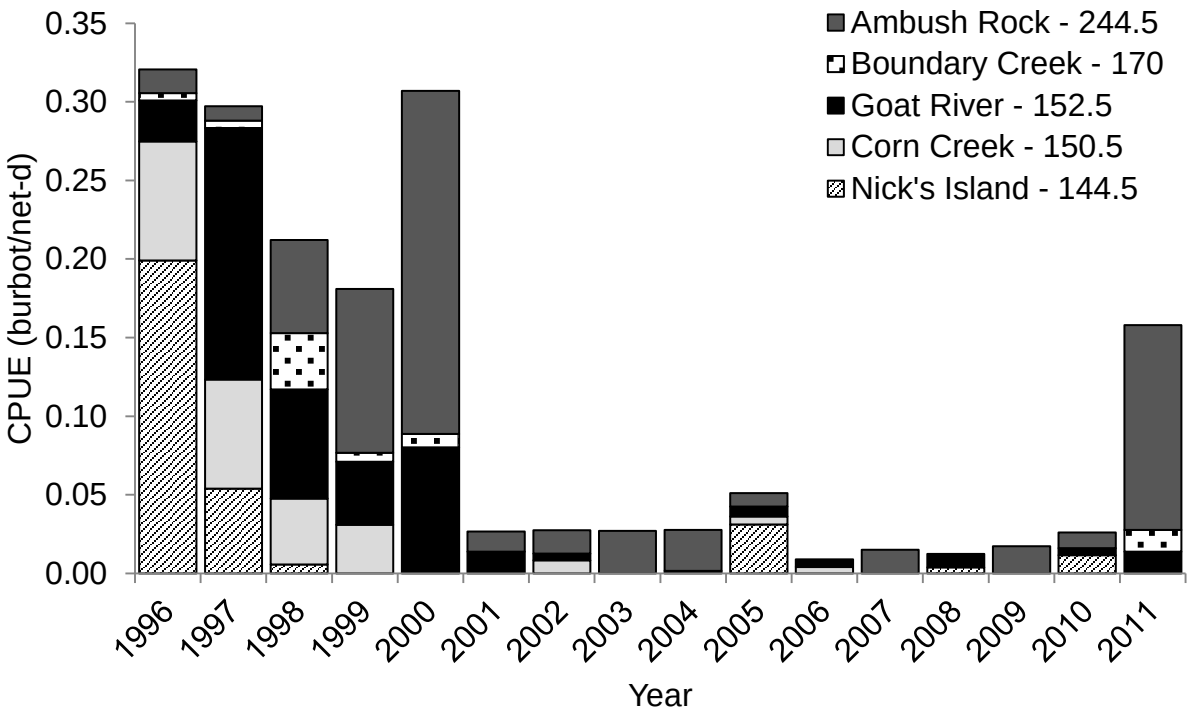


Figure 2.9. Hoop net CPUE (burbot/net-d) from 1996/97-2011/12 at index locations (name-rkm) in the Kootenai River. CPUE not averaged across sites. All five index sites were sampled every year except Corn Creek (rkm 144.5) and Nicks Island during 2006/07.

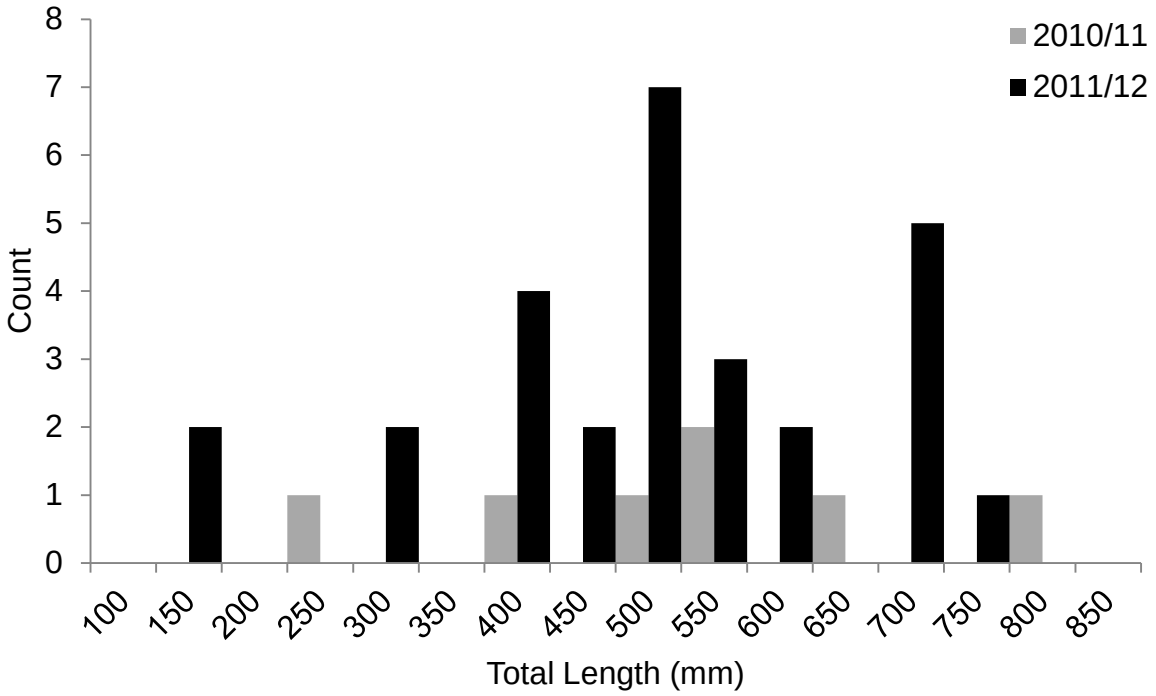


Figure 2.10. Length frequency of burbot captured in hoop nets during 2010/11 and 2011/12 sampling seasons in the Kootenai River.

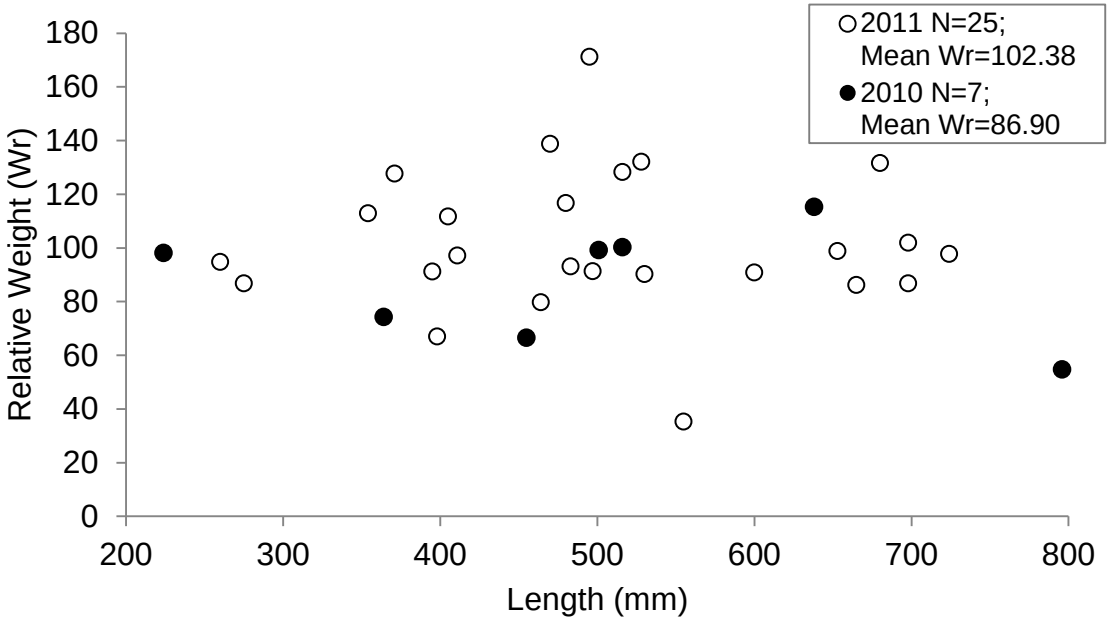


Figure 2.11. Individual relative weights (Wr) for all burbot captured in hoop nets during 2010/11 (black dots) and 2011/12 (hollow dots) in the Kootenai River.

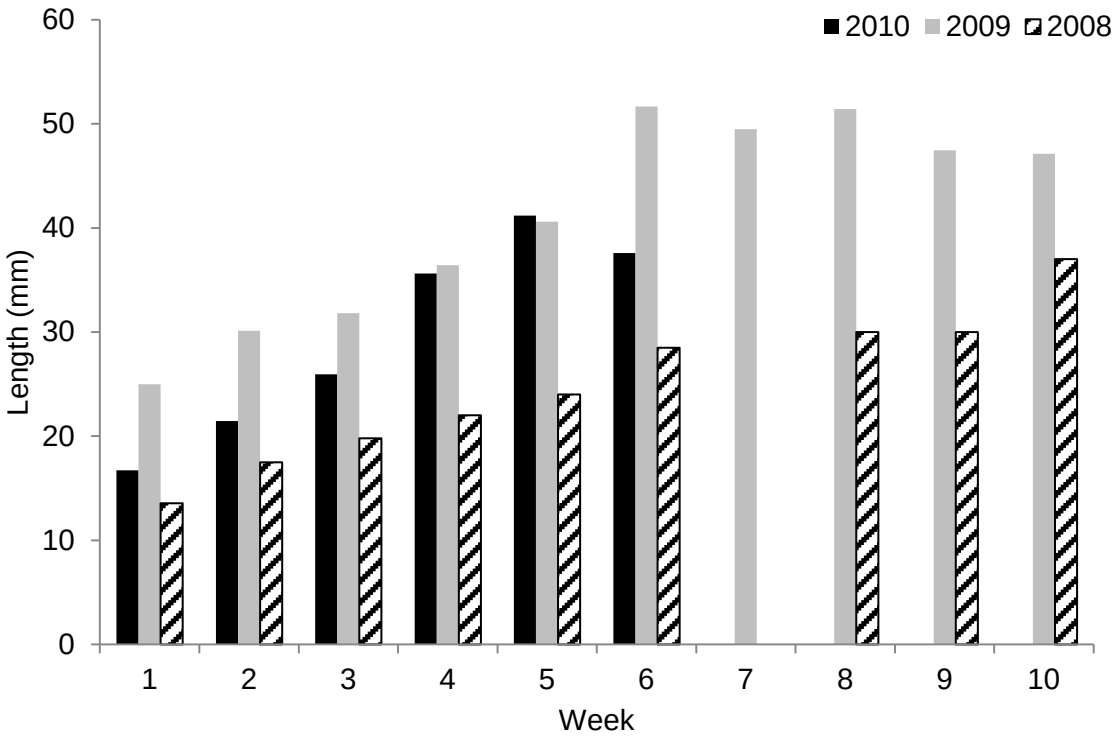


Figure 2.12. Average weekly growth of burbot in net pens 2008-2009 (Fredericks Pond) and 2010 (Cow Creek Pond), not including fish removed during week six in 2010.

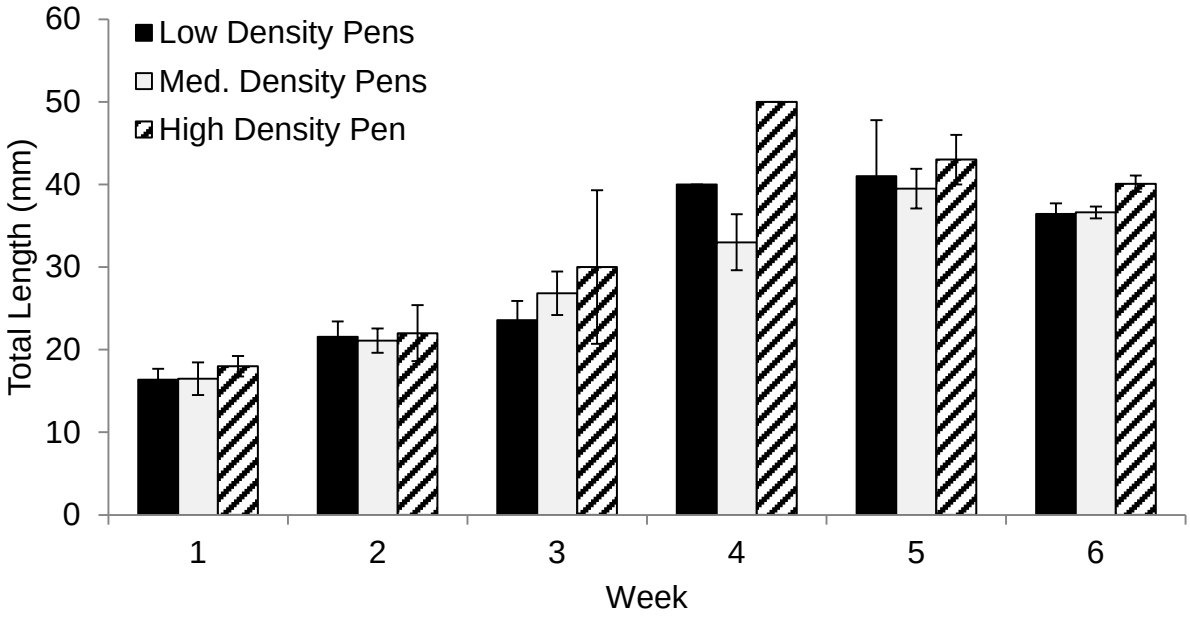


Figure 2.13. Weekly growth of burbot from three stocking densities in net pens within Cow Creek Pond during 2010 (low density = 19.6 fish/m^3; medium density = 39.2 fish/m^3; high density = 99.3 fish/m^3).

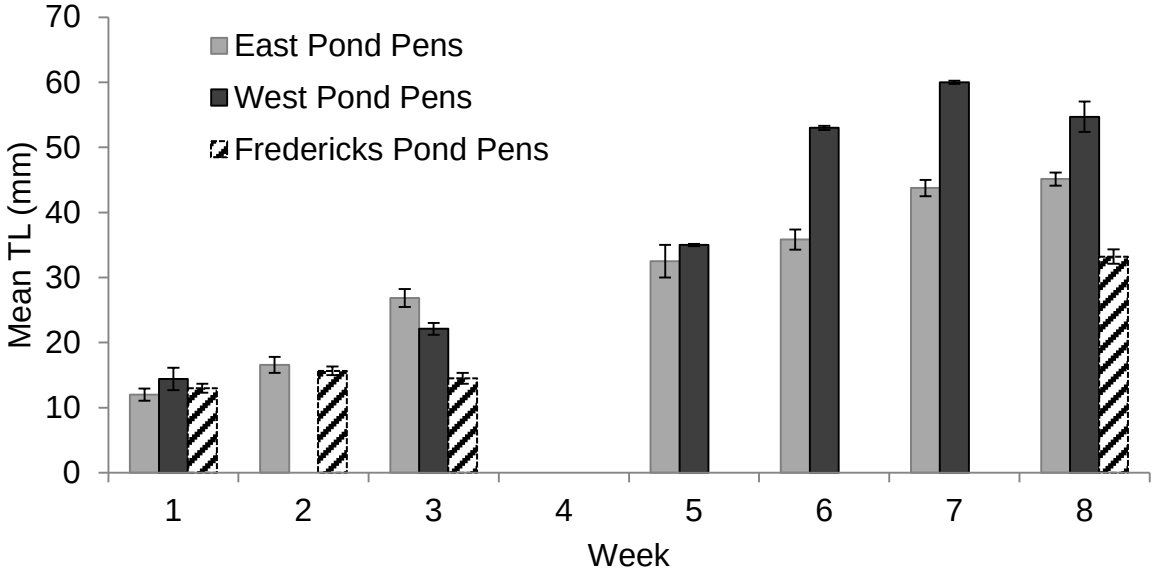


Figure 2.14. Weekly mean TL (mm) and SE (error bars) of burbot from net pens in both BCWMA ponds (east and west ponds) and Fredericks Pond during 2011.

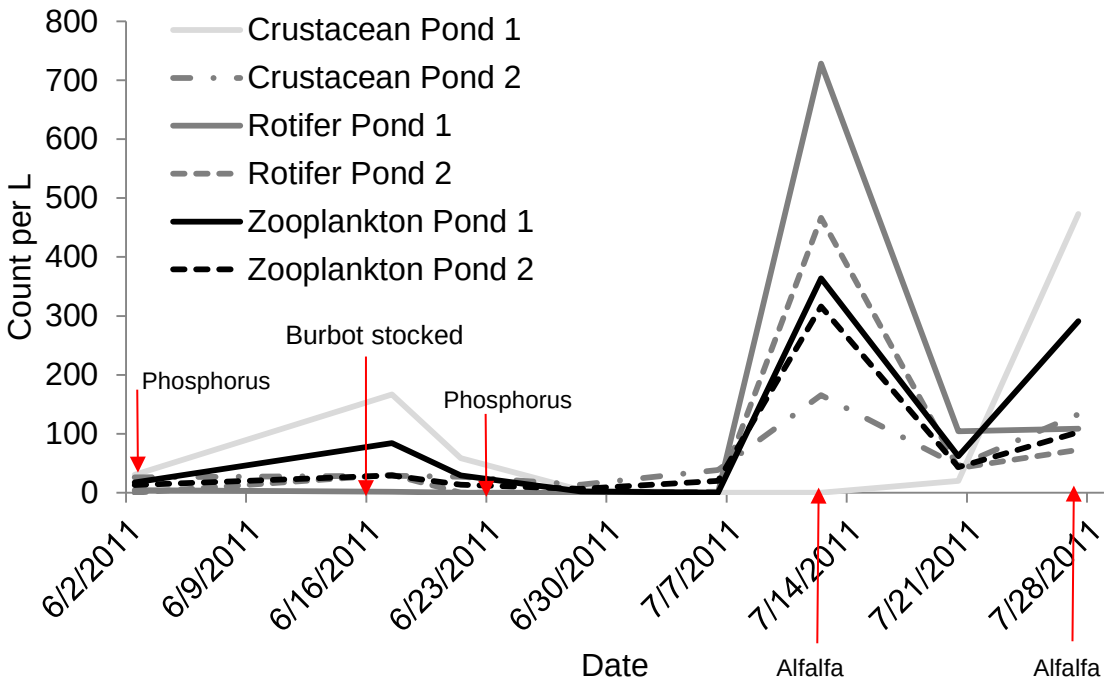
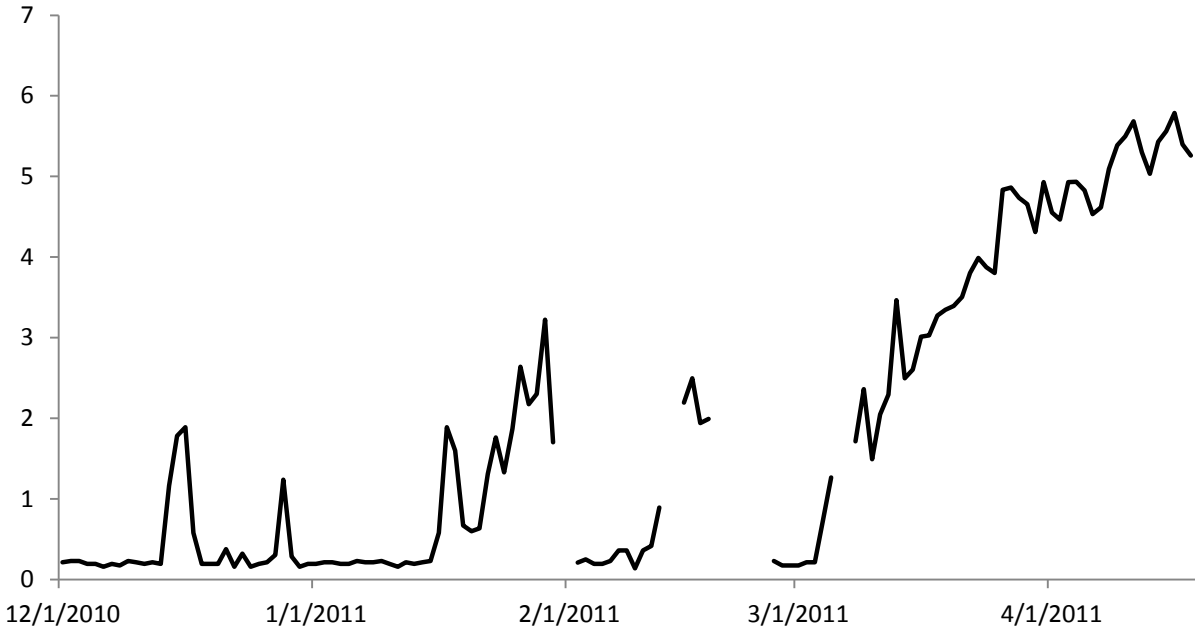


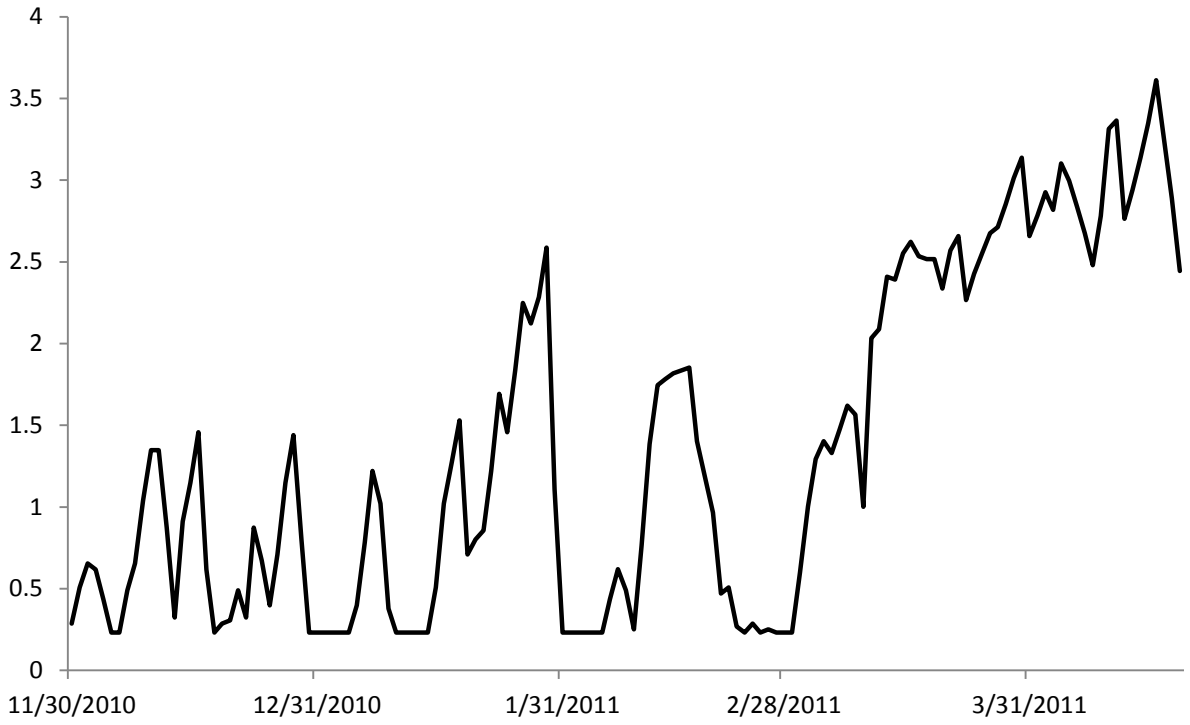
Figure 2.15. Average weekly count/L of zooplankton in Pond 1 (solid lines) and Pond 2 (dashed lines) at BCWMA pond. Zooplankton broken out by crustaceans and rotifers and combined (zooplankton). Pond 1 is the west pond and Pond 2 the east pond. Samples were taken weekly from June 2-July 27, 2011, with a 0.304 m diameter Wisconsin style plankton net and 80 µm mesh. Red arrows point to stocking and nutrient addition dates. Phosphorus (10-34-0) addition was at 250 ml per pond.

APPENDICES

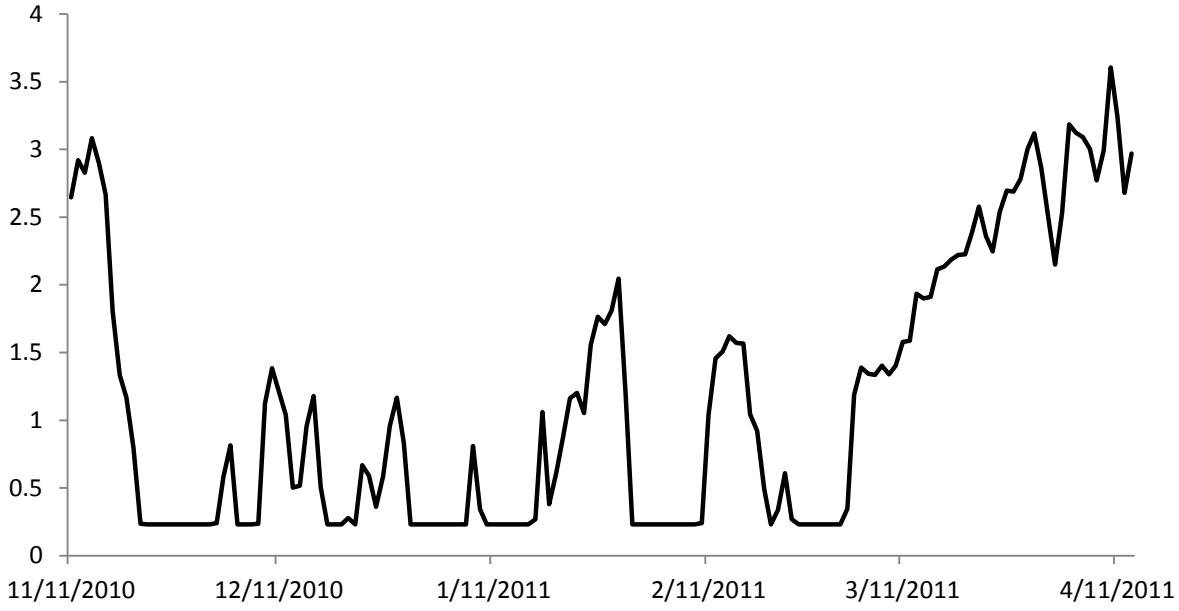
Appendix 2.1. Deep Creek mean daily temperature (°C) profile December 1, 2010 to April 19, 2011.



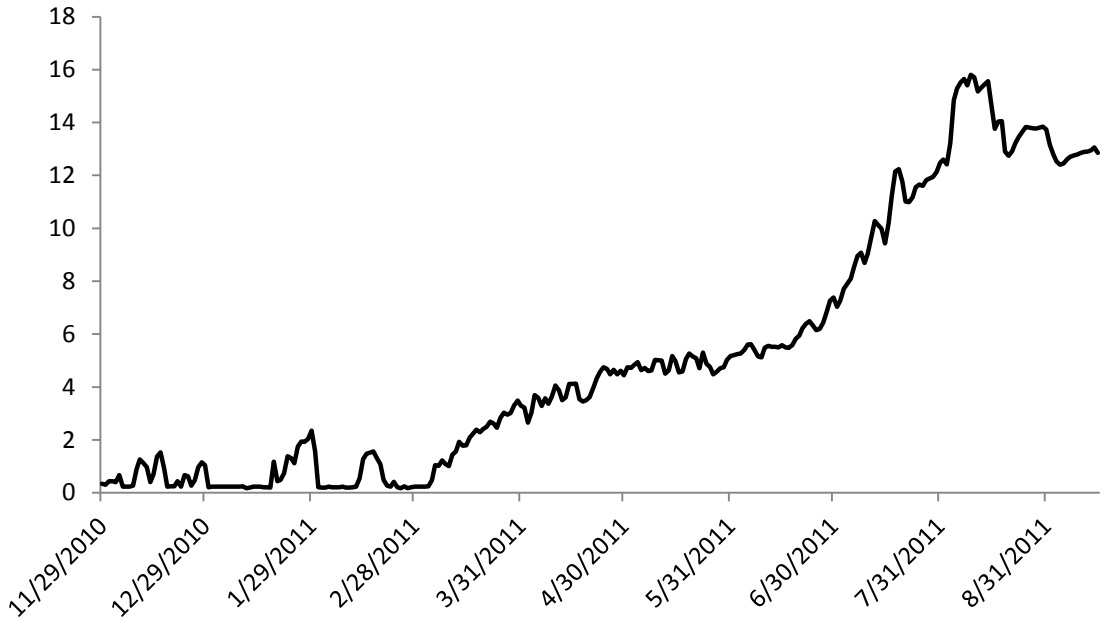
Appendix 2.2. Snow Creek mean daily temperature (°C) profile November 30, 2010 to April 19, 2011.



Appendix 2.3. Boundary Creek mean daily temperature (°C) profile November 11, 2010 to April 13, 2011.



Appendix 2.4. Corn Creek mean daily temperature (°C) profile November 29, 2010 to September 15, 2011.



Appendix 2.5. Burbot hatchery releases from all sources through fall 2011.

PIT	Vemco	Vemco codes	Year class	Stock year	No. tagged fish	No. fish without tags	Mortality	Release date	Crew	Release location	Fish numbers	Marking type & location
Yes	Yes	531-537	2006	2009	7	0		10/21/2009	NJ	Goat River, BC	354,355,357,359,379, 381,382	None
Yes	Yes	511-530, 538-540	2007	2009	23	0		10/21/2009	NJ	Goat River, BC	356,358,360-378,380,383	Left pec & dorsal notch
Yes	Yes	661-665	2007	2010	5	0		8/10/2010	NJ	Boundary Ck. & Moyie R., US	384-388	Left pec & dorsal notch
Yes	No		2008	2009	1			10/30/2009	FG	Kootenai R. @ Ambush Rk., US	349	None
No	No		2008	2009	0	178		11/3/2009	NJ	Deep Ck., US	None[a,d]	Green VIE, L pec
Yes (2)	Yes	641-644, 666-680	2008	2010	18	0	3	8/10/2010	NJ	Boundary Ck. & Moyie River, US	389-406 (2009 tagging) 99991-99999, 999910-999918 (2010 release)[b]	None
Yes	Yes	645-660, 672	2009	2010	17	0		8/10/2010	NJ	Boundary Ck. & Moyie River, US	407-423	None
Yes	No		2009	2010	519	0	6	8/10/2010	NJ	Boundary Ck. & Moyie River, US	424-942	None
Yes	Yes	681-695	2009	2010	15	0		11/3/2010	BC	Goat River, BC	943-957	Green VIE, L pec
No	No		2010	2010	0	95	5	7/27-10/1/2010	NJ	Kootenai R. @ Deep Ck., US	999[c]	Orange VIE, R pec
No	No		2010	2010	0	205	1	7/29/2010	FG	Snow & Deep Cks.; Kootenai R. @ Deep Ck., US	None[d]	Orange VIE, L pec
No	No		2010	2010	0	400		11/3/2010	FG	Deep Ck., US	None[d]	Green VIE, R pec
No	No		2010	2010	0	476		11/3/2010	UI ARI	Boundary Ck., US	None[d]	Green VIE, R pec
No	No		2010	2010	0	400		11/3/2010	BC/ KTOI	Goat River, BC	None[d]	Green VIE, R pec
No	No		2011	2011	0	15,950		6/16/2011	FG	Boundary Ck., US	None[d]	None
No	No		2011	2011	0	400		6/16/2011	FG	Fredericks Pond, US	None[d]	None
No	No		2011	2011	0	6,000		6/16/2011	FG	Mouth Deep Ck., US	None[d]	None
No	No		2011	2011	0	30,000		6/16/2011	KT	Kootenai R @ Ferry Is, US	None[d]	None
No	No		2011	2011	0	18,000		6/16/2011	KT	Cow Ck. Pond, US	None[d]	None
No	No		2011	2011	0	230		7/12/2011	FG	Snow Ck., US	None[d]	None
No	No		2011	2011	0	223		7/12/2011	FG	Mouth Deep Ck., US	None[d]	None
No	No		2011	2011	0	221		7/12/2011	KT	Kootenai R @ Ferry Is., US	None[d]	None
No	No		2011	2011	0	230		7/12/2011	KT	Moyie River, US	None[d]	None
Yes	Yes	767,769, 777,779, 780,784, 785,794, 795,798, 799	2009	2011	11	0		8/2/2011	KT	Kootenai R. @ Boundary Ck., US	963,965,967,970,971, 974,975,978,980,986, 991	None

PIT	Vemco	Vemco codes	Year class	Stock year	No. tagged fish	No. fish without tags	Mortality	Release date	Crew	Release location	Fish numbers	Marking type & location
Yes	Yes	768,770, 772,774, 775,778, 782,790, 792,797	2009	2011	10	0		8/2/2011	KT	Mouth Deep Ck., US	962,966,968,969,972,976, 979,982,983,987	None
Yes	Yes	768,771, 773,776, 781,783, 791,793, 796	2009	2011	9	0		8/2/2011	KT	Mouth Moyie River, US	964,973,977,981,984,985, 988,989,990	None
No	No		2011	2011	0	639		8/2-5, 8/10-12, 8/16-19, 8/23-24/2011	KT	Kootenai R. @ KTOI Hatchery dock or between Hwy 95 Bridge and Deep Ck., US	None[d]	Yellow VIE, L pec
No	No		2011	2011	0	71		8/16/2011	FG	Boundary Ck., US	None[d]	Yellow VIE, R pec
No	No		2011	2011	0	310		8/17/2011	FG	Boundary Ck., US	None[d]	Yellow VIE, R pec
Yes[f]	No		2011	2011	2,799	1		10/13/2011	KT	Ferry Island, US	992-998;1000-3791	None
Yes[g]	No		2011	2011	2897	0		10/20/2011	KT	Moyie River, US	3798-6694	None
Yes[h]	No		2011	2011	2898	0		10/20/2011	KT	Deep Ck., US	6695-9592	None
Yes	Yes	786,787,788,789,800,801	2009	2011	6	0		10/27/2011	KT	Goat River, US	3792-3797	None
Yes[i]	No		2011	2011	6098	0		10/27/2011	KT	Boundary Ck., US	9593-15690	None
Yes	No		2011	2011	1500	0		10/27/2011	KT	Goat River, BC	15691-17190	None
No	No		2009	2011	0	26		10/27/2011	KT	Goat River, BC	None[d]	None
No	No		2011	2011	0	500		11/1/2011	KT	Deep Ck., US	None[d]	Red VIE
No	No		2011	2011	0	3500		11/1/2011	KT	Shortys Is., US	None[d]	Red VIE
No	No		2010	2011	0	90		11/1/2011	KT	Shortys Is., US	None[d]	Red VIE
					16,833	78,145	15[e]					

[a] Fish not uniquely identified with PIT or Vemco tags.
[b] Fish must be recaptured to tie 2nd PIT added in 2010 back to first PIT added in 2009.
[c] Fish not uniquely identified with PIT or Vemco but individual length/weight measurements were taken and recorded; all fish given “999” fish number.
[d] Fish not uniquely identified with PIT or Vemco and no individual length/weight measurements were recorded; all fish given no fish number.
[e] There were 4 additional PIT tag losses (tags expelled) with the 2009 year class, Aug. 2010 release of fish from the group without Vemco tags. Mortalities are in addition to release numbers

Appendix 2.6. Idaho Department of Fish and Game burbot hoop net captures and capture effort (burbot/net-day) from all sample sites, winters/season (Wtr.) of 1993-2010, (sample year = report year).

Season	Sample Year	Burbot	Effort (h)	Effort (d)	CPUE (#/net-d)
Wtr 1993	1992	17	13,300.67	554.19	0.031
Wtr 1994	1993	8	21,834.18	909.76	0.009
Wtr 1995	1994	33	17,181.53	715.90	0.046
Wtr 1996	1995	28	11,922.08	496.75	0.056
Wtr 1997	1996	23	25,467.22	1,061.13	0.022
Wtr 1998	1997	42	29,570.28	1,232.10	0.034
Wtr 1999	1998	44	34,889.42	1,453.73	0.030
Wtr 2000	1999	36	40,174.83	1,673.95	0.022
Wtr 2001	2000	73	50,144.17	2,089.34	0.035
Wtr 2002	2001	17	37,131.75	1,547.16	0.011
Wtr 2003	2002	11	43,433.52	1,809.73	0.006
Wtr 2004	2003	19	47,160.00	1,965.00	0.010
Wtr 2005	2004	18	49,821.84	2,075.91	0.009
Wtr 2006	2005	14	37,806.48	1,575.27	0.009
Wtr 2007	2006	2	24,445.92	1,018.58	0.002
Wtr 2008	2007	5	24,980.64	1,040.86	0.005
Wtr 2009	2008	4	22,392.00	933.00	0.004
Wtr 2010	2009	5	24,629.76	1,026.24	0.005
Wtr 2011	2010	7	41,952.00	1,748.00	0.004
Wtr 2012	2011	30	22,776.00	949.00	0.032

CHAPTER 3: NATIVE SALMONID MONITORING AND EVALUATION
AUTHOR: CATHY GIDLEY

ABSTRACT

A large-scale nutrient restoration program was implemented in the Idaho portion of the Kootenai River in 2005 to restore fisheries by increasing primary production. Lake Koocanusa, the reservoir created by Libby Dam in Montana, acts as a nutrient sink. Phosphate fertilizer (10-34-0 solution) was added to the river beginning on July 13, 2005. During the first year, phosphorous was added to achieve a concentration of 1.5 µg/L of phosphate. In subsequent years, addition of phosphorous was to achieve a concentration of 3.0 µg/L of phosphate. Within three weeks of application, algal growth was present on substrates. Annual electrofishing surveys were conducted at multiple monitoring sites in order to evaluate catch per unit effort (CPUE), biomass per unit effort (BPUE), and population metrics prior to and following nutrient addition. Total CPUE and BPUE for all species combined increased post-nutrient addition, particularly in the treatment reach (sites KR6 and KR9). Sites KR2 and KR4 (located further downstream from the treatment reach) saw decreases in total abundance, post-nutrient addition. Relative weight (Wr) increased at all sites for largescale sucker *Catostomus macrocheilus* and rainbow trout *Oncorhynchus mykiss* and decreased for mountain whitefish *Prosopium williamsoni*, post-treatment. For mountain whitefish, both Wr and length-at-age at time of capture showed increases for age-1 fish. A population estimate was conducted within a three km reach of river near Hemlock Bar (within the nutrient treatment reach and near monitoring site KR9) in 2011. The estimate for mountain whitefish was 13,907 fish, similar to the 2008 estimate of 17,644 and nearly double the 2004 estimate (7,666 fish) prior to nutrient additions. Largescale sucker abundance increased to an estimated 11,346 fish from 7,609 in 2008. Rainbow trout showed a slight decline to 521 fish in 2011 as compared with 581 fish in 2008; however, rainbow trout numbers remained well above the 2004 estimate of 335 fish. These increases in fish abundance can be largely attributed to increased food availability as a result of nutrient additions. A creel survey conducted in 2010-2011 indicated an overall fishing pressure of 8,966 hours and an overall catch rate of 2.8 fish/hour. A total of 45% of anglers reported targeting trout and had a catch rate of 0.66 trout/hour.

INTRODUCTION

The Kootenai River basin has been impacted by many anthropogenic activities, including agriculture, mining, land use practices, and most notably the construction of Libby Dam, all of which have affected the ecosystem and led to declines in resident fish populations. Libby Dam has significantly altered the flow regimes and channel morphology of the Kootenai River since it was constructed in the early 1970s, and it has depleted nutrients and caused a decline in primary productivity in the Idaho portion of the river (Woods 1982; Snyder and Minshall 1996). By the 1990s, this reduction in productivity translated to a two- to four-fold decrease in the number of mountain whitefish, compared to numbers present in 1980-81 (Partridge 1983; Paragamian 1990).

Lake Koocanusa, the reservoir created by Libby Dam, acts as a nutrient sink (Snyder and Minshall 1996), retaining approximately 63% of total phosphorus (P) and 25% of total nitrogen (N) entering the reservoir (Woods 1982). Due to low current velocities in the reservoir, these nutrients bind to sediments and precipitate out of solution (Snyder and Minshall 1996), making them unavailable to organisms in the river below the dam. Consequently, the Idaho portion of the Kootenai River has been considered “nutrient poor” (ultraoligotrophic) and P-

limited (Snyder and Minshall 1996) since the completion of Libby Dam. Primary production is thought to be the foundation of bioenergetic development in higher trophic levels (Vannote et al. 1980). The loss of nutrients in the Idaho portion of the Kootenai River has reduced primary production, and this has likely contributed to poor sport fish production over the past two decades.

Evidence of community shifts in the Kootenai River has been seen at multiple trophic levels before and after the completion of Libby Dam. For example, macroinvertebrate abundance and species diversity prior to the construction of Libby Dam were significantly higher in the upper canyon sections (near the current treatment reach) of the river and are now considered low in relation to other rivers in northern Idaho (Bonde and Bush 1975; Snyder and Minshall 1996). Specialized species such as caddisflies, stoneflies, and mayflies decreased in abundance (Hauer and Stanford 1997), and generalist species, such as aquatic worms, increased (C. Holderman, personal communication, Kootenai Tribe of Idaho). This could be problematic for those fish species that rely on insect diversity for survival. Paragamian (2002) reported shifts in fish species assemblages in the Kootenai River from feeding "specialists," such as rainbow trout *Oncorhynchus mykiss* and mountain whitefish *Prosopium williamsoni*, to more habitat and feeding "generalists," such as peamouth chub *Mylocheilus caurinus* and largescale suckers *Catostomus macrocheilus.*

Increased primary production has been successfully facilitated through the addition of inorganic P and N in aquatic ecosystems (Ashley et al. 1999), which in turn has proven to be successful in recovering wild fish populations. For example, a large-scale nutrient restoration program was implemented in the north arm of Kootenay Lake, British Columbia (B.C.) in 1992 in an attempt to recover declining kokanee *Oncorhynchus nerka* populations. The results of this implementation significantly increased abundance at all levels of the food web (Ashley et al. 1999). Significant increases in zooplankton, resulting from increased algal growth, produced a higher abundance of kokanee in the lake. Within seven years, spawning kokanee in two main tributaries to the north arm increased from 300,000 (1992) to 2.1 million (1998). Similarly, a study on the Kuparuk River, Alaska found that a dramatic increase in algal biomass and productivity lead to increased growth rates of some insect species, age-0 fish, and adult fish after four years of phosphorus addition (Peterson et al. 1993). Based on results such as these, it was proposed that increases in primary production through nutrient restoration could be used to stimulate fish production in the Kootenai River, from bottom up trophic cascades (Snyder and Minshall 1996).

Liquid phosphate fertilizer [10-34-0 (N-P-K)] was first added to the Kootenai River on July 13, 2005. During the first year, phosphorous was added to achieve a phosphate concentration of 1.5 µg/L. In subsequent years, the dosing rate was increased in order to achieve a phosphate concentration of 3.0 µg/L. Target concentrations of soluble reactive phosphorus (SRP; 3-5 µg/L) in streams is generally one-third to one-half of nuisance concentrations (10 µg/L), but concentrations need to be high enough to be effective over several river kilometers (rkm) (Ashley and Stockner 2003). Nitrogen was identified to have the potential to be colimiting in the Kootenai River as the growing season progresses. Due to the potential stripping of nitrate (NO_3) from solution by increased primary production, a threshold of 60 µg/L was established, at which point nitrate fertilizer (32-0-0) would be added to the river.

The Kootenai River Ecosystem Project was designed to take a broader approach to restoring fish populations in the Kootenai River. Whereas past fisheries management programs on the Kootenai River have focused on recovering single species, this project was designed to support recovery of multiple fish populations utilizing an ecosystem-based strategy (as opposed

to simply treating the symptoms of degrading stocks). The addition of nutrients to this ultraoligotrophic system (i.e., the portion of the Kootenai River downstream from Libby Dam) should stimulate production in the nutrient-depleted food web and reverse the downward trends in populations of trout, kokanee, mountain whitefish, burbot *Lota lota*, and white sturgeon *Acipenser transmontanus*. This report summarizes results specific to fish populations. Results relative to changes in primary productivity and macroinvertebrate communities will be reported by the Kootenai Tribe of Idaho.

RESEARCH GOAL

1. Restore fish populations in the Idaho reach of the Kootenai River to densities present prior to Libby Dam, and improve angler sportfish catch.

OBJECTIVES

1. Increase rainbow trout densities (preferably a two-fold increase in age-2 and older rainbow trout densities) to 0.11 rainbow trout/100 m^2.

2. Increase rainbow trout angler catch rates, to a minimum of 0.34 fish/h, with a final target of ≥0.67 fish/h.

3. Increase the mountain whitefish population measurably by restoring the population to the 1980-81 level of 14,000-16,000 fish within the Hemlock Bar reach.

4. Increase W_r of rainbow trout and mountain whitefish, preferably between 93-101 for rainbow trout and a minimum of 90 for mountain whitefish.

STUDY AREA

The headwaters of the Kootenai River originate in Kootenay National Park in southeastern B.C., Canada (Figure 3.1). The river then flows south into northwestern Montana and enters Lake Koocanusa, the reservoir formed by Libby Dam. The river then flows west into the Idaho Panhandle, then back north into B.C. to form Kootenay Lake, and finally to the confluence with the Columbia River at Castlegar, B.C.. The Kootenai River is the second largest of the Columbia River tributaries and the third largest in drainage size (approximately 50,000 km^2; Bonde and Bush 1975). The study area consisted of approximately 106 km of the river that flowed through the Idaho Panhandle, along with two control sites in Montana and B.C.

The Montana and Idaho portions of the Kootenai River below Libby Dam can be separated into three distinct stream habitat types. Directly below the dam, the river flows through a narrow canyon reach characterized by steep canyon walls, high gradients, and boulder/cobble substrates. In this reach, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8 m/s. Downstream from the canyon reach, there is a braided transition reach that extends from the Moyie River to the town of Bonners Ferry. Downstream from the braided transition reach, velocities slow to less than 0.4 m/s, average gradient is 0.02 m/km, the channel deepens, and the river meanders through the Kootenai Valley.

Monitoring sites for the Ecosystem Project were established to gather fisheries and lower trophic level data, before and after nutrient addition (Figure 3.2). Fish populations were surveyed at six sites, two of which were control sites. The first control site (KR14) was located above Lake Koocanusa near Wardner, B.C.; this site served as an unimpounded control site. The second control site (KR10) was located in the Montana portion of the canyon reach. Three sites fall within the treatment reach of the river: sites KR9.1, KR9, and KR6. Site KR9.1, located one km downstream from the nutrient addition site, was added in 2009. This site did not have any pretreatment data so it was not included in any analyses. Site (KR9) was located in the canyon reach (near Hemlock Bar, where the population estimates were conducted) and was approximately ten km downstream from the nutrient addition site. Site (KR6) was located in the braided canyon reach above Bonners Ferry, approximately 20 km downstream from the nutrient addition site. The next two sites were located in the meander reach below Bonners Ferry, and they were considered to be in the downstream reach of the river. Site KR4 was approximately 68 km downstream from the nutrient addition site, and site KR2 was approximately 157 km downstream from the nutrient addition site.

METHODS

Fish Community Assessment

Abundance and Biomass

Electrofishing was conducted during August and September from 2002-2011 at five monitoring sites. From 2004-2011 an additional site (KR14) was added above Libby Dam near Wardner, B.C. to provide data from an unimpounded control site, and in 2009 an additional site (KR9.1) was added one km below the nutrient addition site (i.e., within the treatment reach). Sites that were surveyed included KR14, KR10, KR9.1, KR9, KR6, KR4, and KR2. Data from these sites were used to index relative species abundance and biomass, population indices, and to estimate growth of mountain whitefish and rainbow trout following methods described in Walters (2002). Specific population indices that were indexed included relative species abundance as catch per unit of effort (CPUE), abundance by weight as biomass per unit of effort (BPUE), relative weight (W_r), and length-at-age. These data documented temporal trends in the fish community and were used to evaluate the effectiveness of the addition of nutrients to the Idaho section of the Kootenai River. Sites were sampled using a jet boat (five meters long) equipped with a Coffelt VVP-15 electroshocker powered by a 5000 watt Honda generator. Electrofishing settings were typically set to generate 6-8 amps at 175-200 volts on continuous DC. The sampling crew consisted of two netters and one driver. All fish species, regardless of size, were netted to get a representative sample of the fish community structure at each site. To increase replication, each monitoring section was divided into six equal subsections of 333 m with 150 m separating each to ensure that each was independent of the next. This sampling design allowed one kilometer of electrofishing on both the left and right banks for a total of two kilometers of sampling per site. A single pass was made through each subsection, starting with lower sections first to ensure that no fish drifted into areas that had not yet been sampled. After each subsection was sampled, the elapsed sampling time was recorded and fish that had been collected were anesthetized, identified to species, measured (total length [TL], mm), and weighed (g). Scales were removed from a subsample (five fish in each ten mm length interval) of mountain whitefish and rainbow trout at each site for aging.

Relative Weight (Wr)

Relative weight was calculated, which allowed comparison of Kootenai River fish weight to that of a standard developed for each species. Relative weight was calculated using the formula:

$$W_r = (W/W_s) \times 100,$$

where:

W was the actual fish weight, and

W_s was a standard weight for fish of the same length.

Mean W_r values of 100 indicate ecological and physiological optimums (Anderson and Neumann 1996; Blackwell et al. 2000). Relative weight was calculated for rainbow trout, mountain whitefish, and largescale sucker, the only fish species we sampled with a W_s available in the literature (Anderson and Neumann 1996; Richter 2007). Minimum total lengths to calculate W_s were 120 mm for rainbow trout (Simpkins and Hubert 1996) and 140 mm for mountain whitefish (Rogers et al. 1996), with a range of 170-640 mm for largescale suckers (Richter 2007). Only fish that met these criteria were included in the W_r analysis.

Age and Growth

Scales were collected from rainbow trout and mountain whitefish during the electrofishing surveys at each site. Scales were taken posterior of the dorsal fin and above the lateral line and then placed into a coin envelope. Scales were collected from five fish for each ten mm length interval (for both species) at each site. Scales were impressed onto cellulose acetate slides and viewed on a microfiche reader at 42X magnification, similar to methods described by Devries and Frie (1996). All scales had three independent reads (each read by a different individual). If there was no agreement, a fourth read was conducted by a biologist. Length-at-age at time of capture was measured to compare annual growth and growth pre- and post-nutrient addition. Only age-1 to age-4 fish were included in the age and growth analysis; few fish older than age-4 were collected and our aging reliability was poor for older fish.

Stock Density

Proportional stock density (PSD) and quality stock density (QSD) were calculated for rainbow trout (Anderson 1976; Gabelhouse 1984). PSD and QSD standards are species-specific, defined in the aforementioned references, and calculated as:

$$PSD = \frac{Number\ of\ fish\ \geq minimum\ quality\ length}{Number\ of\ fish\ \geq minimum\ stock\ length}\ X\ 100$$

$$QSD = \frac{Number\ of\ fish\ \geq specified\ length}{Number\ of\ fish\ \geq minimum\ stock\ length}\ X\ 100$$

Proportional stock density was calculated for rainbow trout using 200 mm TL as stock length and 305 mm TL as quality length (Schill 1991). QSD was calculated using 406 mm as the specified length. This length is the minimum legal length for harvest in the Kootenai River.

Population Estimate

A mark-recapture study was conducted during August 2011 in the Hemlock Bar reach (i.e., within the treatment reach) using boat electrofishing as described by Downs (2000). In order to estimate the population size of several fish species, mountain whitefish, largescale sucker, and rainbow trout were marked with fin clips on the nights of August 15, 16, and 17. The recapture effort occurred on the nights of August 23, 24, and 25 to determine the proportion of marked to unmarked fish in the sample reach. Population estimates were calculated using Chapman's modification of the Petersen Method (Ricker 1975; Krebs 1999):

$$N = \left[(M+1) * \frac{C+1}{R+1}\right] - 1$$

where:

N = population estimate,
M = number of marked fish,
C = number of fish captured during the recapture sample, and
R = number of recapture marks in the recapture sample.

The 95% confidence limits for the population estimates were calculated based on the Poisson distribution (Ricker 1975; Seber 1982).

Sportfishing Effort and Harvest

Creel Survey—A creel survey was conducted from April 1 through October 31, 2010 and March 1 through March 31, 2011 to provide estimates of angling effort, total harvest, species composition of the catch, and catch and harvest rates. Results were compared to previous creel surveys conducted in 2001-02 (Walters 2003) and 2005-06 (Walters 2006). These creel surveys provided information regarding angling effort and catch and harvest rates pre- and post-nutrient addition. Estimates were made using Creel Application Software (Version 2.1 South Dakota State University) and hand calculations. The survey was stratified into 30-day intervals with 12 sample days randomly selected for each interval, including four weekend days, eight weekdays, and all holidays. The Kootenai River was stratified into two sections with both sections being sampled each creel day. The first section extended from the Idaho-Montana border downstream to the Highway 95 bridge at Bonners Ferry, and the second section extended from the Highway 95 bridge downstream to Deep Creek, approximately five km downstream from Bonners Ferry. A previous creel survey indicated that the majority of fishing pressure occurred within these two sections of the Kootenai River, Idaho (Paragamian 1995). Two instantaneous angler counts per section were made each creel day between sunrise and sunset, including one count prior to 1330 hours and the second count at 1330 hours or later. Instantaneous counts were conducted by boat. Counts included the number of bank anglers and the number of boats per section of river. Instantaneous count times were randomly generated.

Anglers were interviewed by boat and at access points. Angler interviews included completed and incomplete trips. Interviews were conducted on non-creel as well as creel days to increase interview sample size. Anglers were queried for their residency, amount of time spent fishing, species targeted, and the number of fish (by species) caught, harvested and/or released.

Statistical Analysis—The years from 2002-2005 were considered to be pretreatment and 2006-2011 were considered to be post-treatment for analysis. SYSTAT (SYSTAT 7.0,

1997) was used for all statistical tests, with a level of significance of α = 0.05. Catch and biomass were compared for pre- and post-treatment years using a general linear model analysis of variance for individual sites.

RESULTS

Fish Community Assessment

Abundance and Biomass

Seventeen species of fish were identified from the catch from 2002-2011, remaining consistent from year-to-year (Appendix 3.1). Six species dominated the annual catch, including mountain whitefish, largescale sucker, northern pikeminnow *Ptychocheilus oregonensis*, rainbow trout, peamouth chub, and redside shiner *Richardsonius balteatus*. The biomass was dominated by the same species as catch, with the exception of redside shiner, which contributed little to the biomass because of their size. No white sturgeon were captured, and only a few burbot, bull trout *Salvelinus confluentus*, and kokanee salmon were captured. Bull trout and kokanee were not included in the analysis of CPUE and BPUE, as they were only transitionally in the main river during certain times of the year.

Catch in the downstream reach was dominated by northern pikeminnow, peamouth chub, and redside shiner; whereas, catch at KR10 and in the treatment reach was comprised largely of mountain whitefish, largescale sucker, and rainbow trout. Catch at site KR14 was more similar to that in site KR10 and the treatment reach, but with very few rainbow trout. In terms of biomass, the downstream reach was dominated by northern pikeminnow and largescale sucker and site KR10 and the treatment reach by mountain whitefish and largescale sucker.

Abundance

Based on confidence bounds, total abundance of all species significantly increased at control site KR10 and in the treatment reach (KR6-KR9) but decreased in the downstream reach (KR2-KR4) post-nutrient addition; the decrease in abundance in the downstream reach was significant at site KR4 but not at site KR2 (Figure 3.3). Although total abundance was significantly higher post-treatment at control site KR10 and in the treatment reach, catch from 2009-2011 decreased in the treatment reach compared to previous years (Figure 3.4). Total abundance at site KR14 and KR2 remained virtually unchanged pre- versus post-nutrient addition (Figure 3.3).

The abundance of mountain whitefish, largescale sucker and rainbow trout increased in the treatment reach, pre- versus post-nutrient addition years. Mountain whitefish at site KR6 increased in abundance from 238 fish/h to 442 fish/h, and abundance at site KR9 increased from 165 fish/h to 429 fish/h (Figure 3.6). Abundance of mountain whitefish also increased at sites KR4 and KR10 (Figure 3.6). Conversely, mountain whitefish abundance at sites KR2 and KR14 decreased. Although the abundance of largescale sucker increased in the treatment reach, changes in abundance were variable among other sites. Abundance at sites KR2 and KR14 increased, site KR4 decreased, and site KR10 remained unchanged. The abundance of rainbow trout at site KR6 increased from 13 to 25 fish/h and abundance at site KR9 increased from 22 to 36 fish/h (Figure 3.7). The largest increase in rainbow trout abundance was at site

KR10, where it more than doubled. Abundance of rainbow trout in the downstream reach did not change, and site KR14 showed only a slight increase.

Biomass (BPUE)

Total biomass increased (pre- versus post-nutrient addition) at all monitoring sites except KR4 (Figure 3.7), and these increases were significant at sites KR9 and KR2. Both control sites remained relatively similar from pre- to post-nutrient addition years.

Similar to abundance, biomass of mountain whitefish, largescale sucker, and rainbow trout increased in the treatment reach from pre- to post-nutrient addition years. Biomass of mountain whitefish increased at site KR6 from 26 to 39 kg fish/h and from 27 to 58 kg fish/h at site KR9 (Figure 3.8). Biomass of mountain whitefish increased at site KR10, remained relatively unchanged at sites KR2 and KR4 and decreased at site KR14 (Figure 3.8). Biomass of largescale sucker increased in the treatment reach and remained relatively unchanged at site KR4. Rainbow trout biomass showed a similar trend of increased biomass in the treatment reach; however, the largest increase in biomass occurred at site KR10 (Figure 3.9).

Relative Weight (Wr)

Relative weights for mountain whitefish decreased at all sites, except at site KR6, where they increased slightly from 81 to 82 (Figure 3.10). Relative weights at site KR9 decreased from 89 to 86 and site KR10 had the largest decrease from 93 to 85 (Figure 3.10). Relative weights of age-1 mountain whitefish in the treatment reach increased, post-nutrient addition; whereas, beyond age-2, W_r began to decrease (Table 3.1). Relative weights at site KR10 decreased across all age classes of mountain whitefish (Table 3.1). Relative weights for largescale suckers increased at all sites; KR6 increased from 75 to 85 and KR9 increased from 75 to 86 (Figure 3.10). Relative weights for rainbow trout increased in the treatment reach and at site KR10, but increases were negligible (Figure 3.10).

Age and Growth

A total of 2,510 scales were collected from mountain whitefish to evaluate length-at-age at time of capture and growth pre- and post-nutrient addition (Table 3.5). Results include data from 2002-2010; scales from 2011 were not yet processed. Low numbers of mountain whitefish collected at sites KR2 and KR4 did not provide enough age and growth information to draw any conclusions. In addition, age-0 fish were not readily captured; hence, they were not included for analyses due to inadequate sample size. Mountain whitefish in the treatment reach increased in length-at-age at time of capture for age-1 and age-4 fish from 186 to 195 mm and 294 to 303 mm, respectively (Figure 3.11). Length-at-age at time of capture for age-2 and age-3 mountain whitefish remained the same at 235 mm and 267 mm, respectively, and age-5 fish decreased from 325 to 319 mm (Figure 3.11).

Rainbow Trout —A total of 735 rainbow trout scales were collected and aged to evaluate length-at-age at time of capture and growth pre- and post-nutrient addition (Table 3.5). Age-0 fish were not readily captured; hence, they were not included for analyses due to inadequate sample size. The number of rainbow trout collected at sites KR2, KR4, and KR14 was low and, therefore, did not provide enough age information to draw any conclusions. Length-at-age at time of capture for all age-classes of rainbow trout at site KR10 and in the treatment reach decreased, with the exception of age-1 fish in the treatment reach, which increased from 197 to 199 mm (Figure 3.12).

Population Estimate

A total of 2,441 fish were captured during the tagging and recapture efforts in the Hemlock Bar reach (near KR9) in 2011. Numbers of mountain whitefish, largescale sucker, and rainbow trout were sufficient to calculate a population estimate for each species. Mountain whitefish was the most abundant species at 13,907 fish (95% C.I. 10,756 and 17,976), followed by largescale sucker at 11,346 (95% C.I. 4,151 and 28,367), and rainbow trout at 521 (95% C.I. 271 and 1,099). Numbers for all three species increased compared with 2004 (prior to nutrient addition), with a nearly two-fold increase for mountain whitefish, a five-fold increase for largescale sucker, and an increase of 1½ times for rainbow trout (Figure 3.13).

Rainbow Trout —The 2011 population estimate for rainbow trout in the Hemlock Bar reach was 521 fish. Similar estimates were generated for this species in 1993, 1994, 1998, 1999, and 2004 (Table 3.3), and numbers have substantially increased with each estimate. In 2011, values for proportional stock density (PSD) and quality stock density (QSD) were 42 and 5, respectively. These values were consistent with the 10-year average for PSD (PSD = 43) and slightly above average for QSD (QSD = 3).

Sportfishing Effort and Harvest

Creel Survey—A total of 449 angler interviews were conducted during the 2010-2011 creel survey, 73 of which were completed trips. Estimated fishing pressure varied by section, with 6,766 ± 768 hours in section 1, and 2,200 ± 268 hours in section 2. Pressure was highest in section 1 during period 6 (August 20-September 16); whereas, pressure was highest in section 2 during period 4 (June 25-July 22). Anglers were primarily Idaho residents (78%); Montana residents made up the majority of the non-resident anglers (47%). A total of 13 states and Canada were represented.

Total catch rate (i.e., all species) was 2.8 fish/h, with section 1 having a significantly higher catch rate than section 2. Total catch also varied by section with an estimated total catch of 16,841 ± 3,212 fish in section 1 and 2,392 ± 682 in section 2. The highest catch in both sections occurred during period 4, with catch in section 1 remaining high from June through the end of September. A large portion (45%) of anglers reported targeting trout, 15% specifically targeted rainbow trout, and 37% fished for any species. Rainbow trout represented the highest catch (N = 2,782 ± 540), and mountain whitefish (N = 223 ± 146) and northern pikeminnow (N = 378 ± 279) represented the highest harvest (Table 3.4). Those anglers targeting trout had a catch rate of 0.66 fish/h and a catch rate of 1.19 fish/h in section 1. Only three trout were reported to be harvested (Table 3.4). Of the reported rainbow trout catch, 93% of fish were caught by boat and only 7% by bank anglers.

DISCUSSION

Fish Community Assessment

The fish community in the treatment reach varied among sites, but it remained largely dominated by mountain whitefish, largescale sucker, and rainbow trout. Distinct reaches of the river provided habitats that varied in their suitability for various fish species. For example, habitat conditions in the downstream reach were comprised of low flow velocities, fine substrates, and aquatic vegetation. The fish assemblage in the downstream reach was dominated by northern pikeminnow, peamouth chub, and redside shiner, all of which are

species that are better suited for these types of conditions. Flow velocities were higher and the substrate was largely comprised of cobble in the treatment reach. Mountain whitefish and rainbow trout, species preferring higher flow velocities and cobble substrate, were more predominant the treatment reach.

Species composition showed minor shifts at several sites, when compared pre- and post-nutrient addition. The proportion of mountain whitefish in the catch at site KR9 increased by 10% (73%-83%) post-treatment and by 7% (72%-79%) at site KR6. Partridge (1983) described a similar species composition at a site within the current treatment reach in the early 1980s (a time assumed similar to pre-dam conditions due to latent effects of the dam), with mountain whitefish comprising 70% of the catch and largescale sucker comprising 19%. Increased food availability, particularly macroinvertebrates, was thought to drive this increase in insectivorous mountain whitefish (Simpson and Wallace 1982). Overall insect abundance in the treatment reach increased five-fold between 2003 and 2010 (C. Holderman, personal communication). It is expected that increased productivity will continue to benefit mountain whitefish and rainbow trout.

The proportion of northern pikeminnow in the downstream reach increased in 2011. Historically, the pikeminnow population exhibited large fluctuations at these sites, generally in relation to high flow years. Site KR4 was located within the reach of the river that sturgeon are known to use for spawning. Egg predation has been identified as a factor contributing to recruitment failure of white sturgeon in the Kootenai River (Rust et al. 2007), and research has shown that northern pikeminnow readily prey upon sturgeon eggs in the Columbia basin (Miller and Beckman 1996). Hence, northern pikeminnow catch will be closely monitored at the lower river sampling sites to determine if they are heavily predating on white sturgeon eggs in the Kootenai River.

Abundance and Biomass

In general, both abundance and biomass of fish increased, post-nutrient addition. However, catch rates declined in recent years, which reduced long-term averages. Catch rates in 2009 were the highest they had been since sampling began in 2002, and declines began in 2010 and continued in 2011. This decline was likely due to a reduction in the number of mountain whitefish that were captured. Abundance of mountain whitefish decreased from 400 fish/h in 2010 to 273 fish/h in 2011 at site KR9. Similarly, catch of rainbow trout at KR9 also decreased from a rate of 82 fish/h in 2010 to 12 fish/h in 2011. Flows in the river dropped substantially the week prior to sampling in 2011 in order to allow construction to begin on the Kootenai Tribe of Idaho's habitat restoration project. This change in river flow could have caused fish to move out of near-shore areas to deeper habitats, making them difficult to effectively sample with electrofishing gear. Hence, the reduction in catch could have been a result of fish moving out of the areas being sampled, rather than a reduction in the number of fish present. The 2011 population estimate for mountain whitefish of 4,636 fish/km in the Kootenai is similar to those reported in the Snake River basin in southern Idaho, which range from 2,000-6,000 fish/km (Meyer et al. 2009) and Wydoski (2001) reported an estimated 2,375 fish/km in the Blacks Fork River in Utah.

Macroinvertebrate indices, as reported by KTOI, continued to improve fisheries. Reduced food availability, due to reduced insect densities after the construction of Libby Dam, likely reduced fish numbers and produced changes in the fish assemblage. Mountain whitefish population estimates in the Hemlock Bar reach of the Kootenai River during the mid-1990s (Paragamian 1995) were much lower than during 1980-81 (Partridge 1983). In the early 1970s

(prior to Libby Dam), insect density was approximately 3,500 insects/m^2 in the treatment reach (Bonde and Bush 1975) decreasing to 900 insects/m^2 in the mid-1990s (after Libby Dam; Snyder and Minshall 1996). The 2010 density estimate was over 5,000 insects/m^2, a substantial increase since the 1990s and higher than the pre-Libby Dam estimate. In addition to a reduction in the density of invertebrates after Libby Dam, species composition in the Kootenai River also changed, namely with a reduction in abundance of *plecoptera* and *trichoptera* (Hauer and Stanford 1997). These reduced numbers equated to reduced food abundance for insectivores like rainbow trout and mountain whitefish that often feed on drifting insects (Brown 1971; Wydoski and Whitney 1979; Simpson and Wallace 1982; Baxter and Stone 1995). Since nutrient additions began, abundance and biomass of *ephemeroptera*, *plecoptera*, and *trichoptera* (species preferred by salmonid species) have increased substantially (C. Holderman, Kootenai Tribe of Idaho, personal communication). When the relationship between insect abundance and fish abundance (from the population estimates) was examined, high correlation over time was observed. When insect densities were higher in the early 1980s, the mountain whitefish was at its highest level. When insect density dropped in the mid-1990s, the estimates for mountain whitefish were at their lowest. When macroinvertebrate densities increased as a result of nutrient addition in recent years, so, too, did mountain whitefish abundance.

Population Estimate

The mountain whitefish population in 2011 was similar to that reported in 1980-81, considered ‘pre-dam’ conditions. At the outset of the nutrient addition program, a goal of 14,000-16,000 mountain whitefish (1980-81 estimate; Partridge 1983) was proposed. The 2011 estimate of 13,907 is at the lower end of that estimate and still substantially higher than in 2004 (the year prior to the start of nutrient additions). Mountain whitefish have benefitted from nutrient additions, particularly age-0 and age-1 fish. These age classes rely heavily on larval aquatic insects, primarily chironomids (McPhail and Troffe 1998; Pontius and Parker 1973), which have increased in abundance since nutrient addition began. Similarly, largescale sucker numbers have increased more than five-fold since the 2004 estimate. This is likely a result of largescale suckers being bottom-feeders and benefitting more directly from increased primary productivity. A study on the Columbia River found that largescale suckers fed primarily on periphyton and insect larvae (Dauble 1986), further supporting this notion.

Rainbow trout numbers increased by 1.5 times since nutrient addition began. The increase in the population of rainbow trout is likely a result of both a change in fishing regulations implemented in 2002 (two fish limit, none under 16”) and the addition of nutrients prompting an increase in food availability. However, the current estimate of 174 trout/km is still well below other systems. The South Fork Boise River, managed as a quality trout fishery, contained 870 rainbow trout/km in 2009 (Butts et al. 2011). The increase in rainbow trout numbers in the Kootenai River occurred largely in fish in the 201-305 mm range, which may indicate increased recruitment or survival in response to the harvest length limit. Very few fish larger than 406 mm were captured during sampling efforts in the Kootenai River; none were captured in 2010 and 2011 during fall sampling. An increase in larger rainbow trout is expected as recruitment and food availability continue to increase.

Relative Weight

Relative weight has increased in mountain whitefish, largescale sucker, and rainbow trout since before nutrient additions. Increases have been more pronounced in largescale suckers, and this is likely a result of their foraging habits. Suckers are benthic feeders,

consuming periphyton, zooplankton, invertebrates, detritus, and plant material. Since nutrient additions began in 2005, the amount of periphyton on rocks and substrate in the river has increased, as have the levels of chlorophyll a (C. Holderman, Kootenai Tribe of Idaho, personal communication). It is likely that suckers are able to utilize the increased primary productivity more rapidly than mountain whitefish and rainbow trout. Although W_r of mountain whitefish increased post-nutrient addition, values began to decline in 2007. This decline occurred primarily in age-3+ fish; younger age classes continued to increase. Blackwell et al. (2000) identified several studies in which relative weight was correlated with fish density. Low W_r in the Kootenai River may result from increased density and competition for limited food resources. The improved W_r for rainbow trout is likely a result of increased macroinvertebrate densities, particularly in the orders *plecoptera*, *trichoptera*, and *ephemeroptera*; insect species from these orders are preferred food sources for trout.

Age and Growth

Most mountain whitefish captured during the fall sampling were alive within the timeframe of nutrient addition. The largest benefit to growth was observed for age-1 fish, with an average increase of 9 mm since nutrient addition began. Growth for age-2+ fish was not different pre- versus post-treatment; however, because the growth rates of fish are strongly influenced by size, the possible positive influence of nutrients on older size classes may appear in future years. Fish exist in the Kootenai River that have benefitted from increased nutrients throughout their entire lifespan, so increases in length-at-age may be seen as those fish age.

Sportfishing Effort and Harvest

Creel Survey—Results of the 2010-2011 creel survey supported the findings of both the population estimate and fall monitoring: fish numbers were increasing, but not many larger trout were caught. The catch rate of 0.66 fish/h was nearly double the rate reported for 2006 (0.37 fish/h). Previous catch rates ranged from 0.02 fish/h in 1993 to 0.20 fish/h in 2001 (Paragamian 1995; Walters 2003).

Increases in rainbow trout density after 2004 suggested positive responses to the change in fishing regulations initiated in 2002. These patterns were compatible with the original objectives of the regulation change, which included improving the population with a reduction in exploitation and improving the population size structure. Although rainbow trout numbers increased substantially, estimates remained well below other systems, including the Montana reach of the Kootenai. The density of rainbow trout in the Flower-Pipe reach of the Kootenai River, Montana was over 1,500 trout/km in 2007 (R. Sylvester, Montana Fish, Wildlife and Parks, personal communication), while the highest density recorded at the Hemlock Bar reach in Idaho was 194 fish/km in 2008. Fish from the Idaho portion of the Kootenai move readily into Montana. Previous telemetry work revealed that most rainbow trout tagged in Idaho moved into Montana tributaries to spawn due to a lack of suitable spawning habitat in Idaho tributaries. This lack of spawning and rearing habitat has likely contributed to reduced recruitment in the Idaho portion of the river.

RECOMMENDATIONS

1. Continue annual nutrient addition of ammonium polyphosphate (10-34-0) and ammonium nitrate (32-0-0) to the Kootenai River, following established protocols.

2. Conduct population estimates in the Hemlock Bar reach of the river every other year.

3. Continue fall electrofishing at monitoring sites.

TABLES

Table 3.1. Mean relative weight (W_r) for mountain whitefish by age-class for treatment reach sites (KR6 and KR9) and control site (KR10), pre- and post-nutrient addition.

		KR6		KR9		KR10	
	(mm)	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Age-1	120-240	79	83	84	88	87	85
Age-2	240-270	82	80	90	87	92	87
Age-3	270-310	83	79	94	83	97	84
Age-4	310-324	83	74	91	81	95	78
Age-4+	325+	77	74	85	77	93	79

Table 3.2. Number of individual fish by species (mountain whitefish [MWF] and rainbow trout [RBT]) and site aged using scales from 2002-2010. Control sites are shaded.

	Number of Samples	
Site	**MWF**	**RBT**
KR2	11	14
KR4	95	37
KR6	707	116
KR9	539	210
KR9.1	120	71
KR10	580	264
KR14	458	23
Total	2,510	735

Table 3.3. Population estimates and summary statistics for rainbow trout in the three km Hemlock Bar reach.

Year	Population estimate[a]	Lower 95% C. L.	Upper 95% C. L.	n/ha	n/km	PSD	QSD
1993	98	78	118	3	33	—	—
1994	135	114	160	5	45	—	—
1998	217	168	294	7	72	42	5
1999	217	160	332	7	72	47	3
2000	—	—	—	—	—	39	2
2001	—	—	—	—	—	24	0
2002	—	—	—	—	—	55	2
2003	—	—	—	—	—	55	6
2004	335	190	800	11	112	35	7
2005	—	—	—	—	—	29	4
2006	—	—	—	—	—	32	1
2007	—	—	—	—	—	42	4
2008	581	398	888	20	194	40	1
2011	521	271	1099	18	174	42	5

[a] Single estimate for all lengths combined.

Table 3.4. Creel survey data showing actual number of fish captured, percent of total catch, and percentage harvested by species.

Species	N	% of Catch	% Harvested
Rainbow trout	1,013	62	3
Westslope cutthroat trout	98	6	0
Mountain whitefish	212	13	37
Northern pikeminnow	116	7	34
Largescale sucker	41	3	10
Bull trout	3	0.18	0
Brook trout	5	0.31	0
Kokanee	2	0.12	0
Brown trout	4	0.25	0
Longnose sucker	1	0.06	1
Peamouth chub	58	4	15
Hybrid (rainbow x cutthroat)	74	5	0
Total	**1,627**		

FIGURES

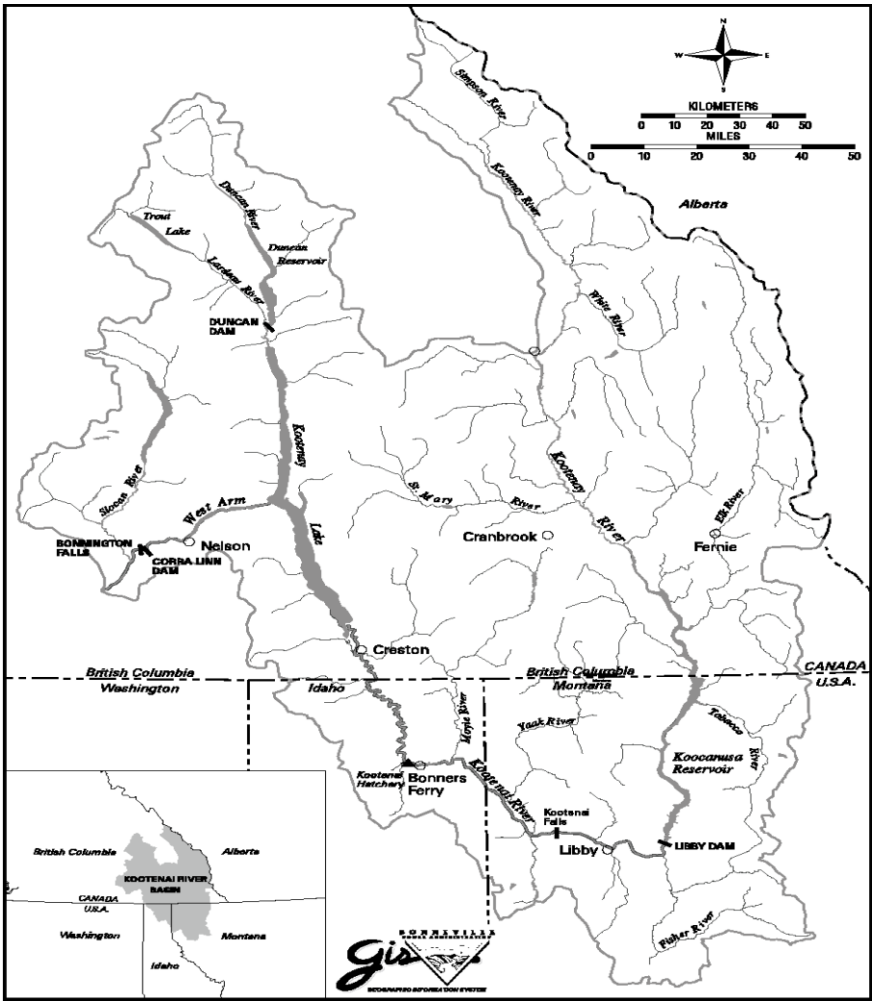


Figure 3.1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, and Bonners Ferry.

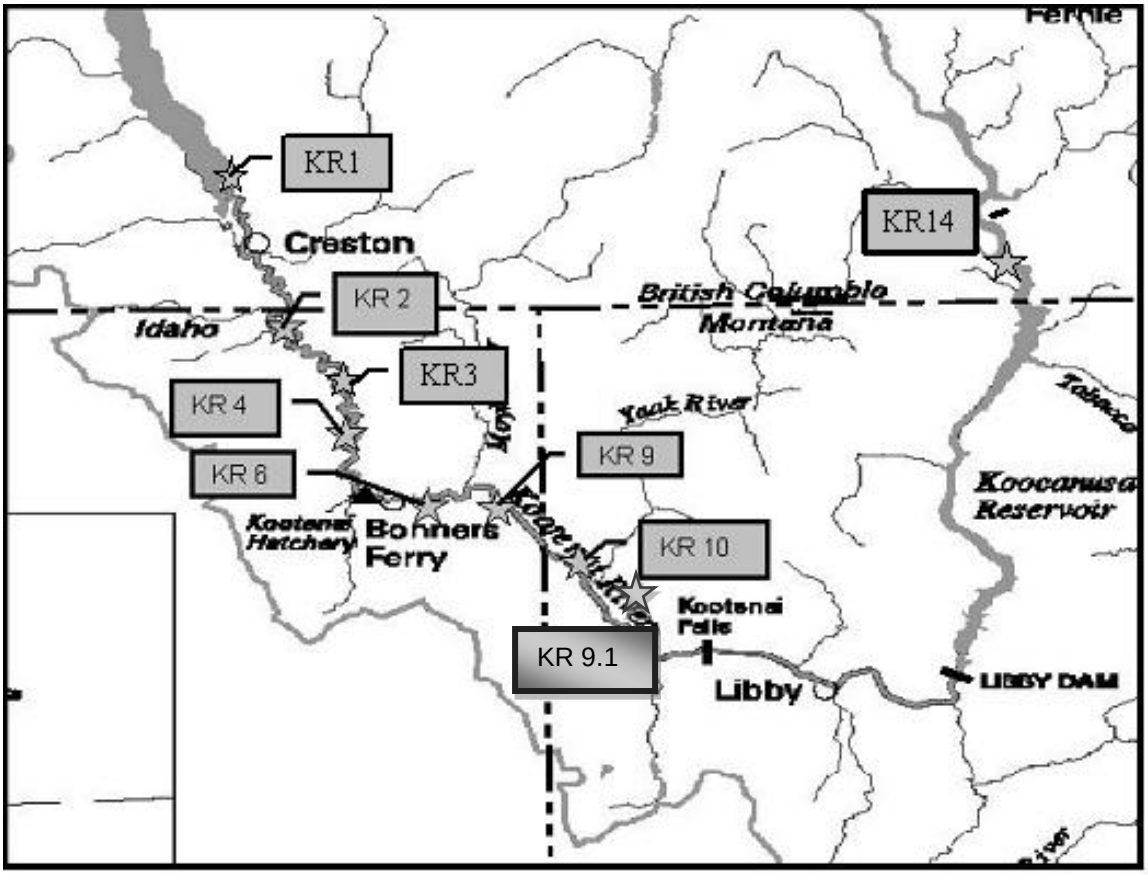


Figure 3.2. Kootenai River ecosystem study area and approximate locations of monitoring sites.

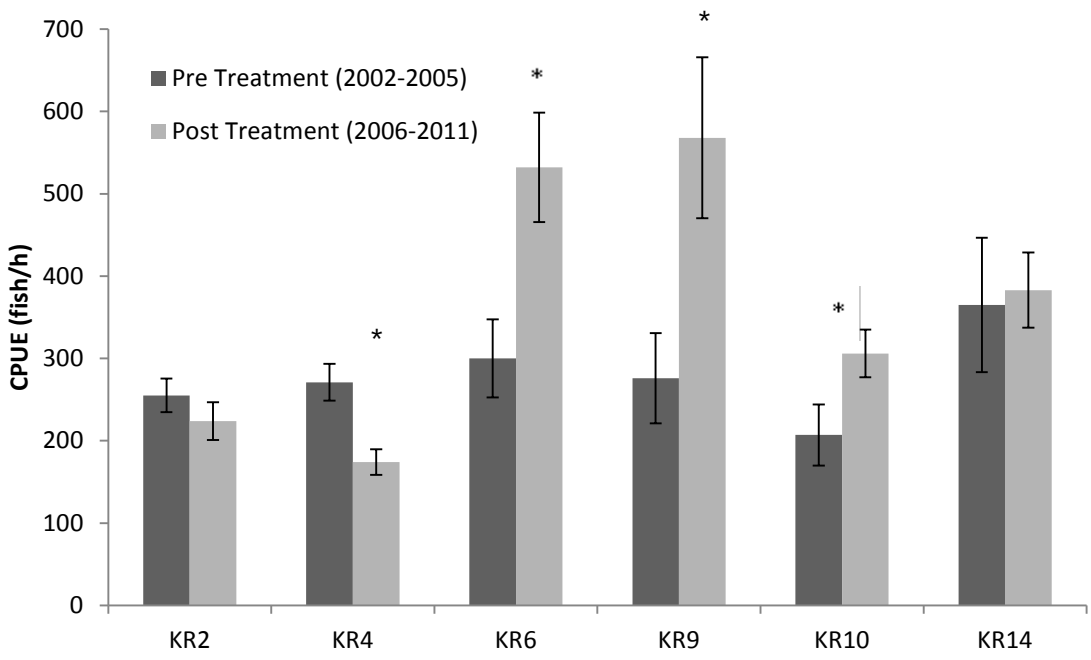


Figure 3.3. Average catch rate of all species (combined) for pre- versus post-treatment years shown by site. Error bars indicate ± one standard error (SE). Asterisks denote significant differences at α = 0.05.

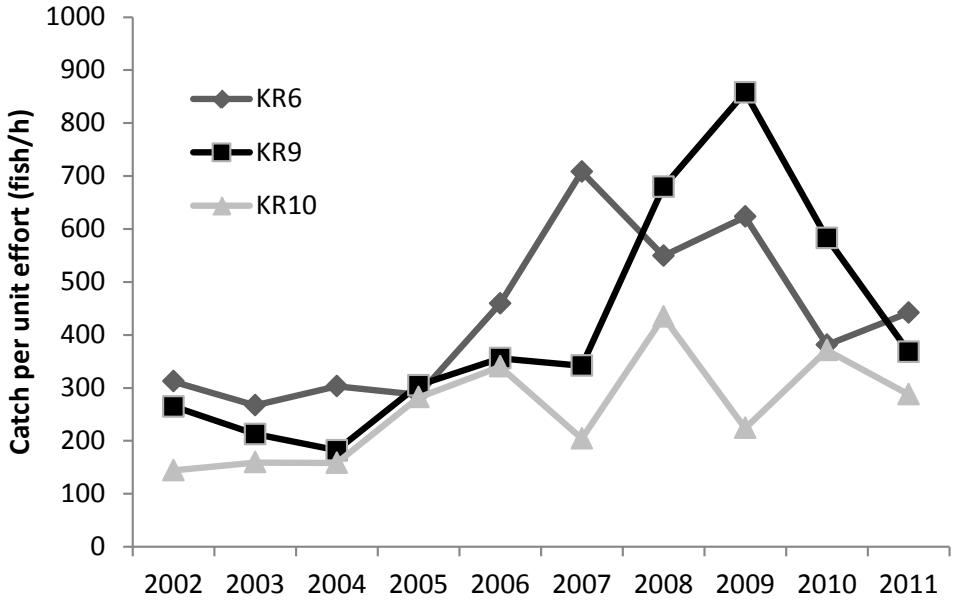


Figure 3.4. Average catch rates of all species (combined) by year for treatment reach sites (KR6 and KR9) and control site (KR10).

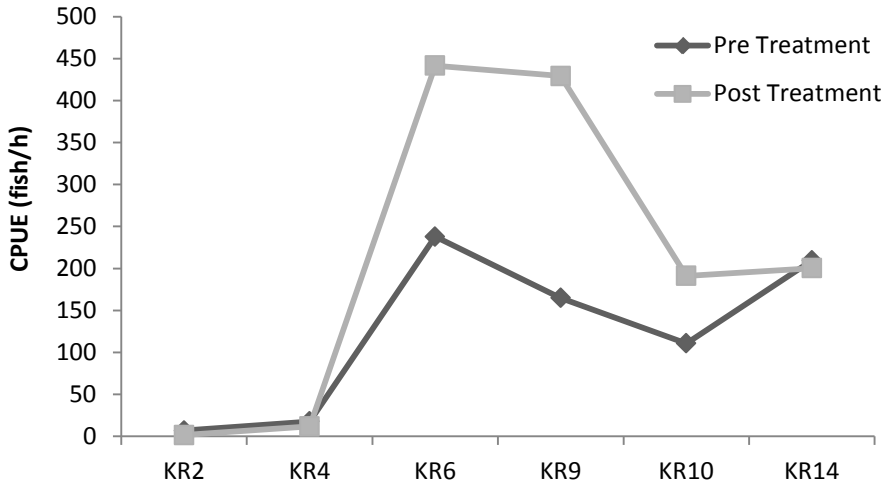


Figure 3.5. Mountain whitefish catch per unit effort (fish/h) for pre- versus post-treatment years by site.

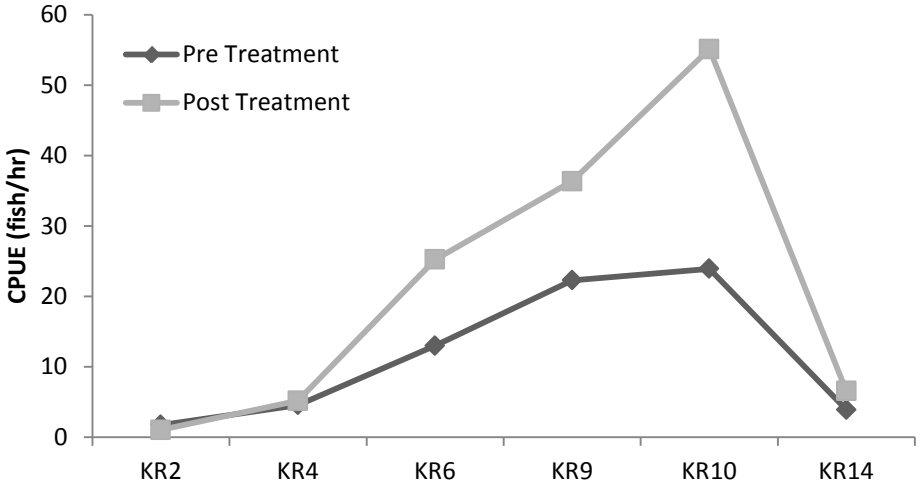


Figure 3.6. Rainbow trout catch per unit effort (fish/h) for pre- versus post-treatment years by site.

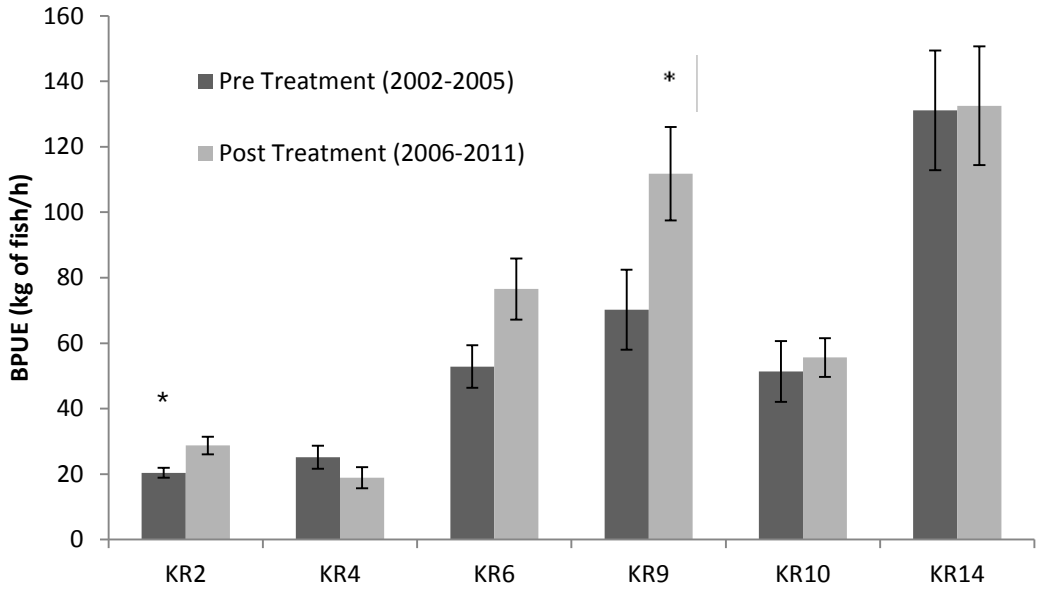


Figure 3.7. Average biomass per unit effort for pre- versus post-treatment years shown by site. Error bars indicate ± one standard error (SE). Asterisks denote significant differences at α = 0.05.

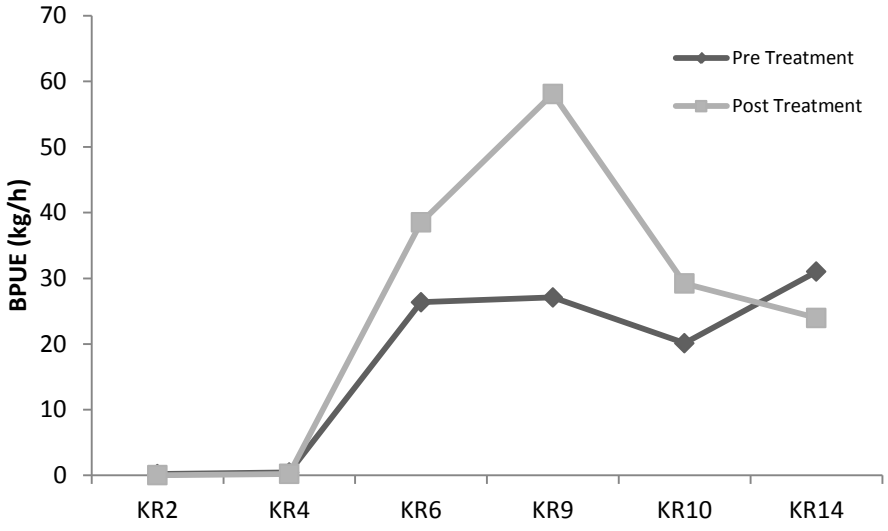


Figure 3.8. Mountain whitefish biomass per unit effort (kg/h) for pre- versus post-treatment years by site.

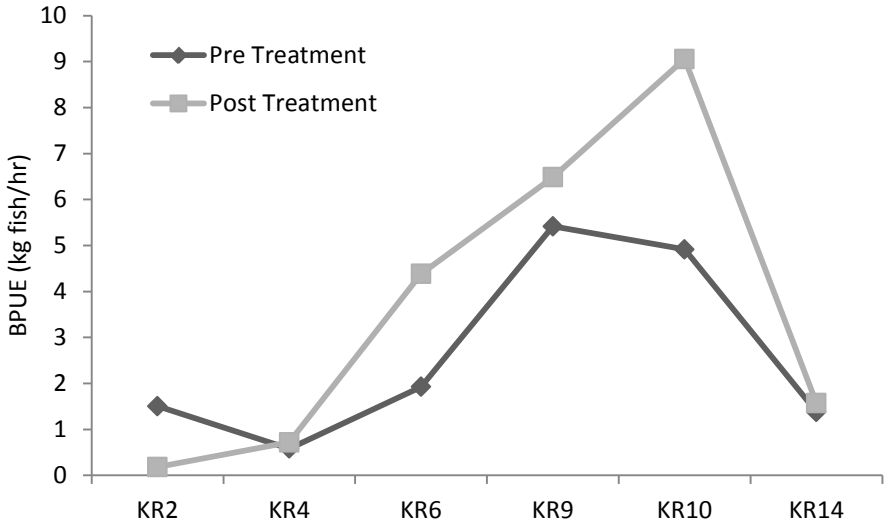


Figure 3.9. Rainbow trout biomass per unit effort (kg/h) for pre- versus post-treatment years by site.

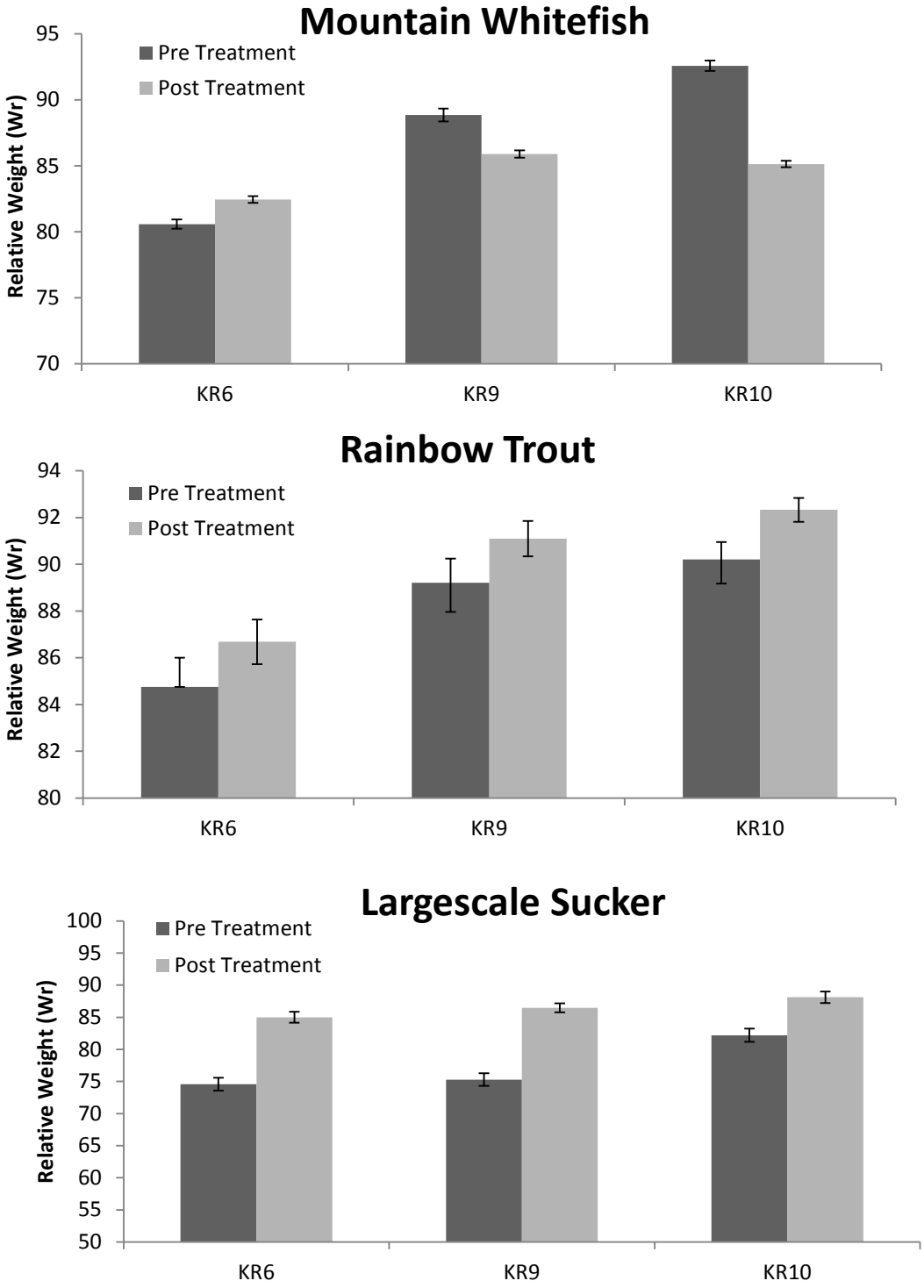
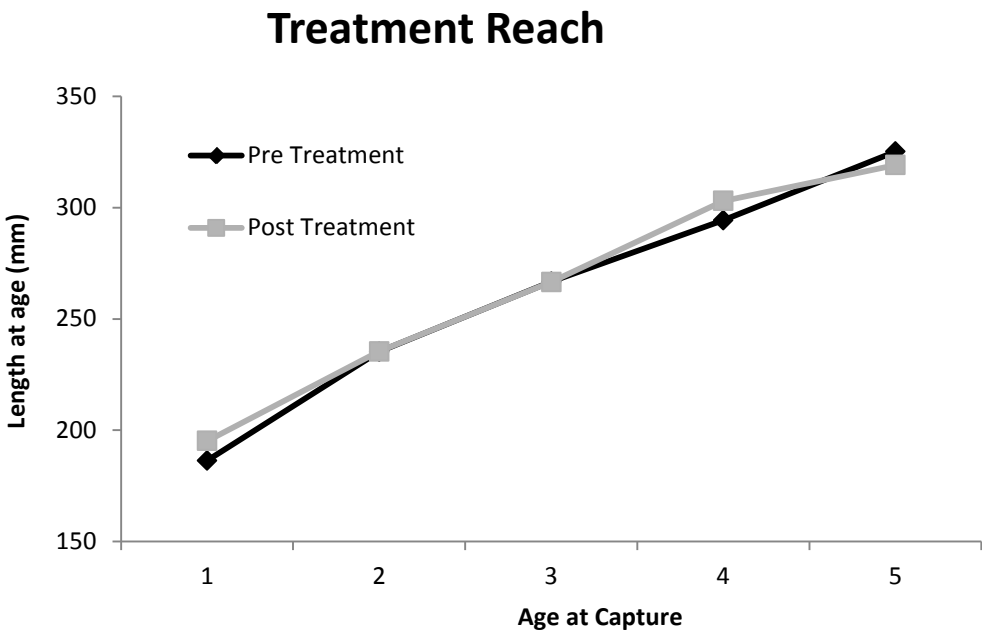


Figure 3.10. Mean relative weight (W_r) for mountain whitefish, largescale sucker, and rainbow trout shown by site, pre- versus post-treatment. Error bars indicate ± one standard error (SE).



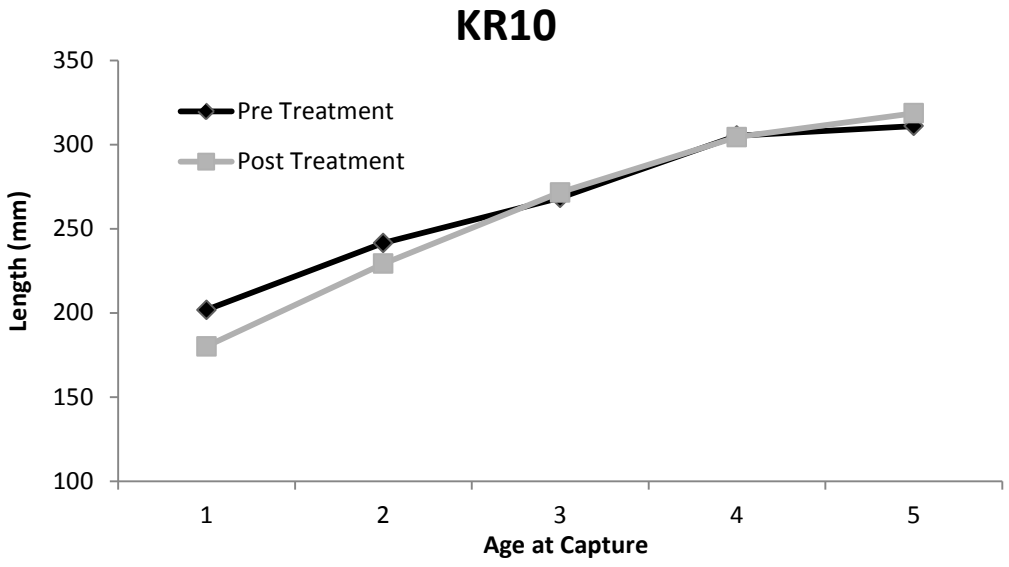


Figure 3.11. Length-at-age at time of capture for mountain whitefish in the treatment reach (KR6 and KR9) and at the control site (KR10), pre- and post-treatment years.

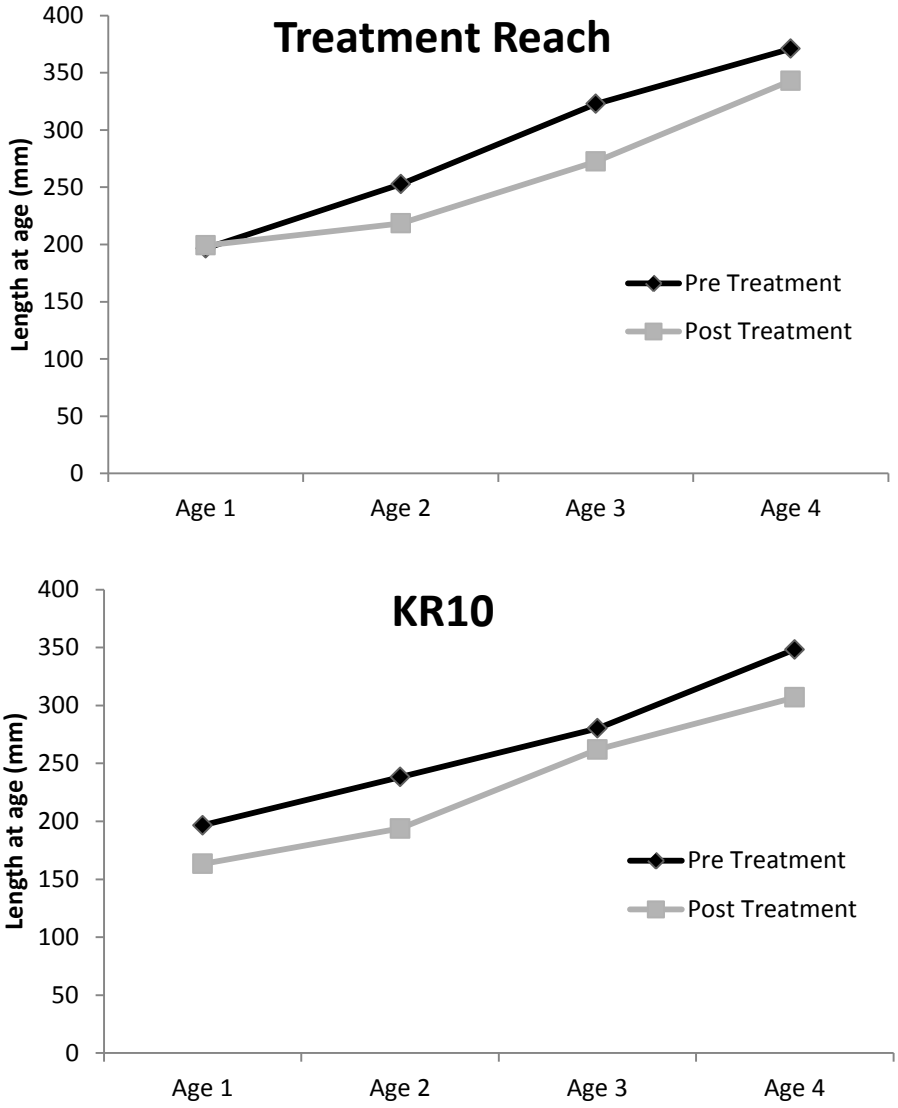


Figure 3.12. Length-at-age at time of capture for rainbow trout in the treatment reach (KR6 and KR9) and at the control site (KR10), pre- and post-treatment years.

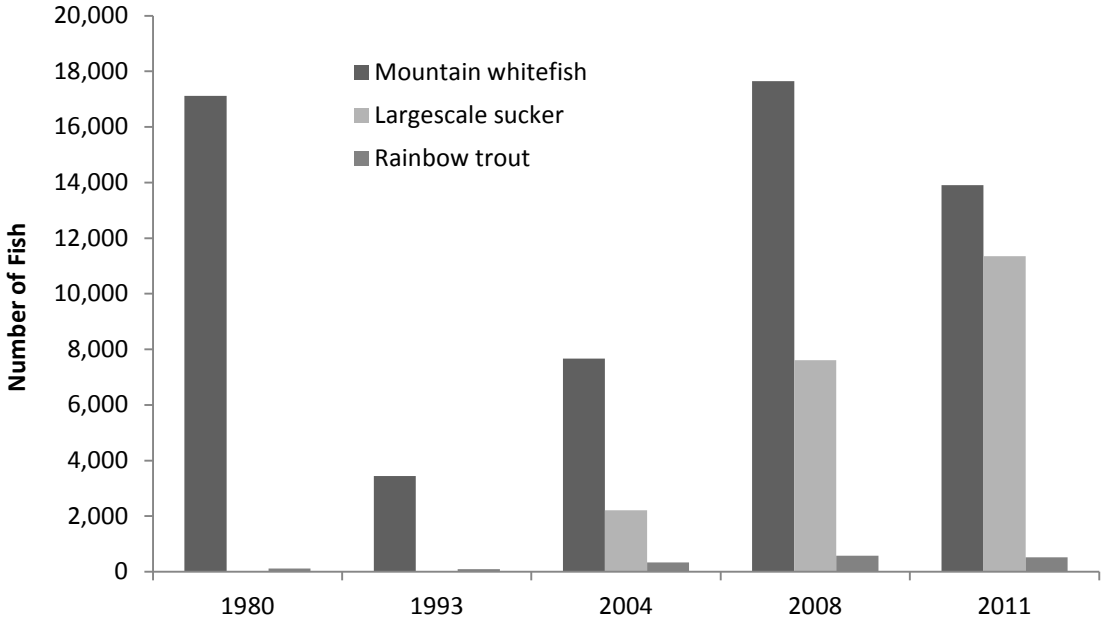


Figure 3.13. Population estimate in the three km Hemlock Bar portion of river (in the treatment reach) shown by species and year.

APPENDICES

Appendix 3.1. Electrofishing summary for monitoring sites 2002-2011 on the Kootenai River, Idaho.

2002 Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	BLT	2	1.06	1.53	5.13	11.23	3.92	1.31
	LSS	33	17.46	25.21	19.54	42.81	14.92	1.31
	MWF	93	49.21	71.04	15.18	33.26	11.60	1.31
	NPM	9	4.76	6.87	0.72	1.58	0.55	1.31
	PMC	2	1.06	1.53	0.28	0.62	0.22	1.31
	RBT	24	12.70	18.33	4.18	9.15	3.19	1.31
	RSS	25	13.23	19.10	0.37	0.81	0.28	1.31
	WCT	1	0.53	0.76	0.24	0.53	0.18	1.31
Total		**189**	**100.00**	**144.00**	**46.00**	**100.00**	**35.00**	**1.31**
KR9	LSS	28	14.66	39.00	15.42	36.96	21.35	0.72
	MWF	132	69.11	183.00	20.38	48.87	28.23	0.72
	NPM	10	5.24	14.00	4.71	11.29	6.52	0.72
	RBT	7	3.66	10.00	0.89	2.13	1.23	0.72
	RSS	12	6.28	17.00	0.12	0.29	0.17	0.72
	SCU	1	0.52	1.00	0.00	0.01	0.00	0.72
	WCT	1	0.52	1.00	0.19	0.44	0.26	0.72
Total		**191**	**100.00**	**265.00**	**42.00**	**100.00**	**58.00**	**0.72**
KR6	BRN	1	0.37	1.24	0.05	0.17	0.07	0.73
	LSS	16	5.88	18.91	8.93	27.44	12.25	0.73
	LND	1	0.37	1.15	0.00	0.00	0.00	0.73
	LNS	1	0.37	0.00	0.27	0.81	0.36	0.73
	MWF	219	80.51	251.05	18.67	57.39	25.61	0.73
	NPM	6	2.21	7.52	1.45	4.46	1.99	0.73
	PMC	4	1.47	4.55	0.78	2.41	1.08	0.73
	RBT	15	5.51	17.26	1.86	5.73	2.56	0.73
	RSS	8	2.94	9.58	0.07	0.20	0.09	0.73
	WCT	1	0.37	1.09	0.45	1.39	0.62	0.73
Total		**272**	**100.00**	**312.00**	**33.00**	**100.00**	**43.00**	**0.73**
KR4	LSS	75	23.58	44.87	37.64	74.39	22.46	1.67
	LNS	4	1.26	2.39	1.90	3.75	0.53	1.67
	MWF	3	0.94	1.79	0.12	0.24	0.07	1.67
	NPM	93	29.25	55.64	2.06	4.07	1.23	1.67
	PMC	77	24.21	46.07	7.73	15.28	5.74	1.67
	RBT	6	1.89	3.59	0.72	1.41	0.43	1.67
	RSS	59	18.55	35.30	0.35	0.70	0.18	1.67
	YP	1	0.31	0.60	0.08	0.16	0.05	1.67
Total		**318**	**100.00**	**190.00**	**51.00**	**100.00**	**31.00**	**1.67**
KR2	LSS	41	12.77	26.83	21.03	75.38	13.76	1.53
	LNS	3	0.93	1.96	0.23	0.81	0.15	1.53
	MWF	4	1.25	2.62	0.06	0.22	0.04	1.53
	NPM	146	45.48	95.53	4.13	14.80	2.70	1.53
	PMC	29	9.03	18.97	1.86	6.65	1.21	1.53
	RBT	93	28.97	60.85	0.56	2.02	0.37	1.53
	SCU	3	0.93	1.96	0.02	0.07	0.01	1.53
	WCT	2	0.62	1.31	0.01	0.05	0.01	1.53
Total		**321**	**100.00**	**210.00**	**28.00**	**100.00**	**18.00**	**1.53**

Appendix 3.1, continued.

2003

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	LNS	6	2.49	3.95	0.68	1.33	0.45	1.52
	LSS	35	14.52	23.03	16.76	32.85	11.03	1.52
	MWF	128	53.11	84.21	24.20	47.43	15.92	1.52
	NPM	14	5.81	9.21	1.54	3.01	1.01	1.52
	RBT	31	12.86	20.39	6.47	12.67	4.25	1.52
	RSS	25	10.37	16.45	0.34	0.66	0.22	1.52
	WCT	2	0.83	1.32	1.05	2.05	0.69	1.52
Total		**241**	**100.00**	**159.00**	**51.00**	**100.00**	**34.00**	**2.00**
KR2	LNS	6	1.54	3.87	0.74	1.88	0.48	1.55
	LSS	37	9.51	23.88	23.23	59.16	15.00	1.55
	NPM	202	51.93	130.39	8.37	21.32	5.40	1.55
	PEA	82	21.08	52.93	6.24	15.89	4.03	1.55
	RSS	59	15.17	38.08	0.61	1.54	0.39	1.55
	SCU	1	0.26	0.65	0.01	0.02	0.00	1.55
	YP	2	0.51	1.29	0.08	0.20	0.05	1.55
Total		**389**	**100.00**	**251.00**	**39.00**	**100.00**	**25.00**	**2.00**
KR4	LNS	13	2.55	9.36	2.37	7.21	1.71	1.39
	LSS	74	14.54	53.26	15.72	47.78	11.31	1.39
	MWF	28	5.50	20.15	0.37	1.11	0.26	1.39
	NPM	196	38.51	141.06	6.78	20.61	4.88	1.39
	PEA	97	19.06	69.81	5.45	16.56	3.92	1.39
	PMS	2	0.39	1.44	0.02	0.07	0.02	1.39
	RBT	2	0.39	1.44	0.20	0.60	0.14	1.39
	RSS	92	18.07	66.21	0.80	2.43	0.58	1.39
	SCU	1	0.20	0.72	0.00	0.01	0.00	1.39
	WCT	3	0.59	2.16	1.17	3.56	0.84	1.39
	YP	1	0.20	0.72	0.02	0.05	0.01	1.39
Total		**509**	**100.00**	**366.00**	**33.00**	**100.00**	**24.00**	**1.00**
KR6	LSS	18	10.91	29.10	14.53	44.48	23.49	0.62
	MWF	139	84.24	224.70	15.49	47.41	25.04	0.62
	NPM	6	3.64	9.70	2.59	7.93	4.19	0.62
	RBT	1	0.61	1.62	0.05	0.15	0.08	0.62
	RSS	1	0.61	1.62	0.01	0.02	0.01	0.62
Total		**165**	**100.00**	**267.00**	**33.00**	**100.00**	**53.00**	**1.00**
KR9	LSS	22	13.17	28.02	18.18	41.64	23.15	0.79
	MWF	107	64.07	136.26	16.30	37.33	20.76	0.79
	NPM	8	4.79	10.19	2.86	6.55	3.64	0.79
	PEA	2	1.20	2.55	0.22	0.51	0.29	0.79
	RBT	20	11.98	25.47	6.02	13.78	7.66	0.79
	RSS	8	4.79	10.19	0.08	0.19	0.10	0.79
Total		**167**	**100.00**	**212.66**	**43.66**	**100.00**	**55.60**	**0.79**

Appendix 3.1, continued.

2004

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR14	LND	1	0.28	1.25	0.00	0.00	0.00	0.80
	LNS	4	1.10	5.01	2.06	1.93	2.57	0.80
	LSS	83	22.93	103.86	65.82	61.67	82.36	0.80
	MWF	260	71.82	325.34	36.63	34.32	45.84	0.80
	NPM	5	1.38	6.26	0.98	0.92	1.23	0.80
	RBT	1	0.28	1.25	0.13	0.12	0.16	0.80
	RSS	3	0.83	3.75	0.03	0.03	0.04	0.80
	SCU	1	0.28	1.25	0.01	0.01	0.01	0.80
	WCT	4	1.10	5.01	1.08	1.01	1.36	0.80
Total		**362**	**100.00**	**452.97**	**106.74**	**100.00**	**133.56**	**0.80**
KR10	LSS	18	9.68	15.30	14.88	31.09	12.65	1.18
	MWF	115	61.83	97.78	22.67	47.37	19.27	1.18
	NPM	11	5.91	9.35	1.60	3.35	1.36	1.18
	PMC	10	5.38	8.50	1.23	2.58	1.05	1.18
	RBT	29	15.59	24.66	7.25	15.16	6.17	1.18
	RSS	2	1.08	1.70	0.05	0.09	0.04	1.18
	WCT	1	0.54	0.85	0.17	0.36	0.15	1.18
Total		**186**	**100.00**	**158.15**	**47.85**	**100.00**	**40.69**	**1.18**
KR9	LSS	29	22.31	40.69	23.92	59.69	33.56	0.71
	MWF	72	55.38	101.01	9.75	24.33	13.68	0.71
	NPM	4	3.08	5.61	0.74	1.85	1.04	0.71
	RBT	23	17.69	32.27	5.05	12.60	7.08	0.71
	RSS	1	0.77	1.40	0.00	0.01	0.00	0.71
	WCT	1	0.77	1.40	0.61	1.52	0.85	0.71
Total		**130**	**100.00**	**182.39**	**40.07**	**100.00**	**56.22**	**0.71**
KR6	LSS	11	5.42	16.41	8.16	23.79	12.17	0.67
	MWF	159	78.33	237.22	19.10	55.67	28.49	0.67
	NPM	6	2.96	8.95	4.23	12.33	6.31	0.67
	RBT	18	8.87	26.85	2.55	7.43	3.80	0.67
	RSS	8	3.94	11.94	0.08	0.23	0.12	0.67
	WCT	1	0.49	1.49	0.19	0.54	0.28	0.67
Total		**203**	**100.00**	**302.86**	**34.31**	**100.00**	**51.18**	**0.67**
KR4	LNS	1	0.28	0.87	0.46	1.52	0.40	1.15
	LSS	25	6.89	21.67	11.70	38.32	10.14	1.15
	MWF	39	10.74	33.80	1.10	3.59	0.95	1.15
	NPM	123	33.88	106.60	5.27	17.27	4.57	1.15
	PMC	138	38.02	119.60	9.87	32.35	8.56	1.15
	RBT	6	1.65	5.20	0.91	2.99	0.79	1.15
	RSS	28	7.71	24.27	0.26	0.86	0.23	1.15
	WCT	2	0.55	1.73	0.93	3.06	0.81	1.15
	YP	1	0.28	0.87	0.01	0.04	0.01	1.15
Total		**363**	**100.00**	**314.59**	**30.52**	**100.00**	**26.45**	**1.15**
KR2	BBH	1	0.22	0.74	0.13	0.50	0.10	1.35
	LNS	2	0.43	1.48	0.28	1.08	0.21	1.35
	LSS	19	4.11	14.03	8.23	32.10	6.08	1.35
	MWF	18	3.90	13.29	0.61	2.38	0.45	1.35
	NPM	114	24.68	84.15	4.48	17.46	3.30	1.35
	PMC	212	45.89	156.49	10.64	41.49	7.85	1.35
	RBT	1	0.22	0.74	0.36	1.41	0.27	1.35
	RSS	94	20.35	69.39	0.91	3.55	0.67	1.35
	SCU	1	0.22	0.74	0.01	0.02	0.00	1.35
Total		**462**	**100.00**	**341.03**	**25.64**	**100.00**	**18.92**	**1.35**

Appendix 3.1, continued.

2005

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR2	BBH	2	0.53	1.11	0.21	0.65	0.12	1.80
	LSS	33	8.75	18.29	21.91	66.90	12.14	1.80
	MWF	9	2.39	4.99	0.22	0.67	0.12	1.80
	NPM	110	29.18	60.98	4.01	12.25	2.22	1.80
	PMC	100	26.53	55.43	5.10	15.56	2.82	1.80
	RBT	5	1.33	2.77	0.52	1.59	0.29	1.80
	RSS	113	29.97	62.64	0.75	2.29	0.42	1.80
	SCU	5	1.33	2.77	0.03	0.09	0.02	1.80
Total		**377**	**100.00**	**208.98**	**32.75**	**100.00**	**18.15**	**1.80**
KR4	LNS	6	1.83	4.02	3.29	11.33	2.21	1.49
	LSS	30	9.17	20.12	13.77	47.41	9.24	1.49
	MWF	23	7.03	15.43	0.74	2.54	0.49	1.49
	NPM	91	27.83	61.03	3.86	13.29	2.59	1.49
	PMC	73	22.32	48.96	4.80	16.52	3.22	1.49
	PS	2	0.61	1.34	0.01	0.03	0.01	1.49
	RBT	12	3.67	8.05	1.44	4.96	0.97	1.49
	RSS	85	25.99	57.01	0.49	1.69	0.33	1.49
	SCU	1	0.31	0.67	0.01	0.02	0.00	1.49
	WCT	4	1.22	2.68	0.64	2.21	0.43	1.49
Total		**327**	**100.00**	**219.32**	**29.05**	**100.00**	**19.48**	**1.49**
KR6	LSS	24	13.11	37.62	20.42	50.64	32.01	0.64
	MWF	152	83.06	238.24	18.32	45.42	28.71	0.64
	NPM	3	1.64	4.70	0.79	1.95	1.23	0.64
	RBT	4	2.19	6.27	0.80	1.99	1.26	0.64
Total		**183**	**100.00**	**286.83**	**40.33**	**100.00**	**63.21**	**0.64**
KR9	LNS	1	0.48	1.45	0.46	0.85	0.66	0.69
	LSS	21	10.00	30.51	16.24	30.43	23.60	0.69
	MWF	165	78.57	239.71	31.45	58.92	45.69	0.69
	NPM	4	1.90	5.81	0.80	1.49	1.16	0.69
	PMC	4	1.90	5.81	0.52	0.98	0.76	0.69
	RBT	15	7.14	21.79	3.91	7.33	5.68	0.69
Total		**210**	**100.00**	**305.09**	**53.38**	**100.00**	**77.55**	**0.69**
KR14	LNS	4	2.90	5.26	2.58	3.92	3.39	0.76
	LSS	57	41.30	75.00	48.87	74.33	64.30	0.76
	MWF	71	51.45	93.42	12.31	18.73	16.20	0.76
	RBT	5	3.62	6.58	1.98	3.01	2.60	0.76
	Sculpin	1	0.72	1.32	0.01	0.01	0.01	0.76
Total		**138**	**100.00**	**181.58**	**65.75**	**100.00**	**86.51**	**0.76**
KR10	BRN	1	0.32	0.90	0.20	0.24	0.18	1.11
	LSS	51	16.24	45.88	32.81	40.89	29.51	1.11
	MWF	211	67.20	189.81	37.51	46.75	33.74	1.11
	NPM	7	2.23	6.30	1.81	2.26	1.63	1.11
	PMC	4	1.27	3.60	0.50	0.62	0.45	1.11
	RBT	36	11.46	32.38	6.72	8.38	6.04	1.11
	RSS	2	0.64	1.80	0.03	0.04	0.03	1.11
	WCT	2	0.64	1.80	0.65	0.81	0.59	1.11
Total		**314**	**100.00**	**282.46**	**80.23**	**100.00**	**72.17**	**1.11**

Appendix 3.1, continued.

2006

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR2	BBH	1	0.16	0.66	0.16	0.26	0.11	1.52
	LSS	72	11.30	47.26	49.36	80.11	32.39	1.52
	LNS	1	0.16	0.66	0.07	0.11	0.05	1.52
	MWF	2	0.31	1.31	0.02	0.03	0.01	1.52
	NPM	284	44.58	186.40	6.64	10.78	4.36	1.52
	PMC	49	7.69	32.16	3.49	5.66	2.29	1.52
	RBT	2	0.31	1.31	0.22	0.35	0.14	1.52
	RSS	215	33.75	141.11	1.47	2.38	0.96	1.52
	SCU	4	0.63	2.63	0.03	0.04	0.02	1.52
	YP	7	1.10	4.59	0.16	0.26	0.11	1.52
Total		**637**	**100.00**	**418.09**	**61.61**	**100.00**	**40.44**	**1.52**
KR4	LNS	6	1.36	3.88	1.57	6.19	1.02	1.55
	LSS	27	6.14	17.44	10.59	41.66	6.84	1.55
	MWF	61	13.86	39.40	0.66	2.59	0.42	1.55
	NPM	206	46.82	133.02	5.69	22.39	3.67	1.55
	PMC	52	11.82	33.57	4.57	18.00	2.95	1.55
	PSS	6	1.36	3.87	0.10	0.38	0.06	1.55
	RBT	9	2.05	5.81	1.62	6.38	1.05	1.55
	RSS	66	15.00	42.58	0.57	2.24	0.37	1.55
	SCU	6	1.36	3.87	0.04	0.15	0.02	1.55
	YP	1	0.23	0.65	0.01	0.02	0.00	1.55
Total		**440**	**100.00**	**283.82**	**25.41**	**100.00**	**16.39**	**1.55**
KR6	BRN	1	0.30	1.39	0.16	0.33	0.22	0.72
	LSS	34	10.33	47.39	23.00	47.48	32.06	0.72
	MWF	247	75.08	344.25	19.74	40.74	27.51	0.72
	NPM	19	5.78	26.48	2.15	4.44	3.00	0.72
	PMC	1	0.30	1.39	0.04	0.08	0.06	0.72
	RBT	22	6.69	30.66	3.27	6.76	4.56	0.72
	RSS	5	1.52	6.97	0.08	0.16	0.11	0.72
Total		**329**	**100.00**	**458.54**	**48.44**	**100.00**	**67.52**	**0.72**
KR9	LSS	25	9.73	34.66	21.81	39.22	30.23	0.72
	MWF	213	82.88	295.26	30.77	55.34	42.65	0.72
	NPM	6	2.33	8.32	0.71	1.27	0.98	0.72
	RBT	13	5.06	18.02	2.32	4.17	3.22	0.72
Total		**257**	**100.00**	**356.26**	**55.60**	**100.00**	**77.07**	**0.72**
KR14	LNS	6	3.17	9.06	4.09	4.96	6.17	0.66
	LSS	76	40.21	114.81	58.81	71.42	88.84	0.66
	MWF	96	50.79	145.03	17.35	21.07	26.21	0.66
	NPM	4	2.12	6.04	1.51	1.84	2.29	0.66
	PMC	1	0.53	1.51	0.07	0.09	0.11	0.66
	RBT	1	0.53	1.51	0.13	0.16	0.20	0.66
	RSS	4	2.12	6.04	0.07	0.08	0.10	0.66
	WCT	1	0.53	1.51	0.32	0.38	0.48	0.66
Total		**189**	**100.00**	**286.00**	**82.00**	**100.00**	**124.00**	0.66
KR10	BRN	1	0.31	1.06	0.33	0.53	0.35	0.94
	LSS	14	4.38	14.89	9.21	14.76	9.80	0.94
	MWF	234	73.13	248.86	40.74	65.27	43.33	0.94
	NPM	6	1.88	6.38	0.91	1.46	0.97	0.94
	RBT	60	18.75	63.81	10.53	16.86	11.19	0.94
	RSS	2	0.63	2.13	0.03	0.05	0.04	0.94
	WCT	3	0.94	3.19	0.66	1.06	0.71	0.94
Total		**320**	**100.00**	**340.32**	**62.42**	**100.00**	**66.38**	**0.94**

Appendix 3.1, continued.

2007 Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR2	BBH	1	0.19	0.66	0.06	0.11	0.04	1.52
	LNS	3	0.56	1.97	0.73	1.25	0.48	1.52
	LSS	56	10.47	36.82	40.12	68.80	26.38	1.52
	MWF	9	1.68	5.92	0.10	0.16	0.06	1.52
	NPM	283	52.90	186.08	7.95	13.63	5.23	1.52
	PMC	107	20.00	70.36	8.85	15.18	5.82	1.52
	RSS	73	13.64	48.00	0.49	0.84	0.32	1.52
	SCU	3	0.56	1.97	0.02	0.03	0.01	1.52
Total		**535**	**100.00**	**351.78**	**58.31**	**100.00**	**38.34**	**1.52**
KR4	LNS	3	1.25	2.10	1.44	6.11	1.01	1.43
	LSS	18	7.50	12.61	13.05	55.29	9.14	1.43
	MWF	13	5.42	9.11	0.77	3.25	0.54	1.43
	NPM	132	55.00	92.47	4.47	18.94	3.13	1.43
	PMC	39	16.25	27.32	3.21	13.60	2.25	1.43
	RBT	5	2.08	3.50	0.44	1.88	0.31	1.43
	RSS	27	11.25	18.91	0.20	0.86	0.14	1.43
	SCU	3	1.25	2.10	0.02	0.07	0.01	1.43
Total		**240**	**100.00**	**168.07**	**23.60**	**100.00**	**16.53**	**1.43**
KR6	BRN	2	0.47	3.30	0.37	0.48	0.61	0.61
	LSS	33	7.69	54.45	28.68	36.90	47.32	0.61
	MWF	382	89.04	630.25	46.61	59.96	76.90	0.61
	NPM	2	0.47	3.30	0.07	0.09	0.11	0.61
	RBT	9	2.10	14.85	2.00	2.58	3.30	0.61
	SCU	1	0.23	1.65	0.00	0.00	0.00	0.61
Total		**429**	**100.00**	**707.79**	**77.73**	**100.00**	**128.25**	**0.61**
KR9	BRN	2	0.71	2.43	0.56	0.76	0.69	0.82
	LND	1	0.36	1.22	0.01	0.01	0.01	0.82
	LSS	30	10.68	36.50	28.78	38.86	35.02	0.82
	MWF	221	78.65	268.87	37.67	50.86	45.83	0.82
	NPM	5	1.78	6.08	2.57	3.47	3.13	0.82
	PMC	1	0.36	1.22	0.11	0.15	0.14	0.82
	RBT	19	6.76	23.12	4.31	5.81	5.24	0.82
	RSS	1	0.36	1.22	0.03	0.04	0.04	0.82
	SCU	1	0.36	1.22	0.02	0.02	0.02	0.82
Total		**281**	**100.00**	**341.87**	**74.06**	**100.00**	**90.10**	**0.82**
KR14	LND	2	0.93	2.57	0.01	0.01	0.01	0.78
	LNS	1	0.47	1.28	0.67	0.94	0.86	0.78
	LSS	88	40.93	112.86	58.14	81.73	74.57	0.78
	MWF	93	43.26	119.27	9.34	13.13	11.98	0.78
	NPM	7	3.26	8.98	1.23	1.72	1.57	0.78
	PMC	8	3.72	10.26	0.88	1.23	1.12	0.78
	RBT	3	1.40	3.85	0.51	0.72	0.66	0.78
	RSS	8	3.72	10.26	0.08	0.11	0.10	0.78
	SCU	2	0.93	2.57	0.01	0.01	0.01	0.78
	WCT	3	1.40	3.85	0.27	0.39	0.35	0.78
Total		**215**	**100.00**	**275.74**	**71.14**	**100.00**	**91.23**	**0.78**
KR10	BRN	4	1.22	2.49	0.41	0.69	0.25	1.61
	LSS	19	5.81	11.83	11.40	19.44	7.10	1.61
	MWF	219	66.97	136.33	35.17	59.96	21.89	1.61
	NPM	10	3.06	6.23	1.54	2.63	0.96	1.61
	PMC	2	0.61	1.25	0.27	0.46	0.17	1.61
	RBT	54	16.51	33.62	9.21	15.71	5.74	1.61
	RSS	14	4.28	8.72	0.20	0.34	0.12	1.61
	SCU	2	0.61	1.25	0.02	0.03	0.01	1.61
	WCT	3	0.92	1.87	0.44	0.76	0.28	1.61
Total		**327**	**100.00**	**203.56**	**58.65**	**100.00**	**36.51**	**1.61**

Appendix 3.1, continued.

2008

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	BRK	1	0.21	0.92	0.09	0.11	0.08	1.09
	BRN	3	0.64	2.75	0.83	0.98	0.76	1.09
	LSS	52	11.11	47.60	25.43	29.88	23.28	1.09
	MWF	322	68.80	294.74	47.92	56.29	43.86	1.09
	NPM	15	3.21	13.73	1.37	1.61	1.26	1.09
	PMC	5	1.07	4.58	0.63	0.74	0.58	1.09
	RBT	58	12.39	53.09	7.43	8.72	6.80	1.09
	RSS	8	1.71	7.32	0.13	0.16	0.12	1.09
	WCT	4	0.85	3.66	1.29	1.52	1.18	1.09
Total		**468**	**100.00**	**428.38**	**85.13**	**100.00**	**77.92**	**1.09**
KR14	BUR	1	0.36	1.81	0.11	0.13	0.19	0.55
	LNS	2	0.72	3.62	1.18	1.44	2.13	0.55
	LSS	82	29.50	148.34	57.13	69.92	103.36	0.55
	MWF	176	63.31	318.39	19.07	23.34	34.51	0.55
	NPM	4	1.44	7.24	1.34	1.64	2.43	0.55
	RBT	7	2.52	12.66	2.05	2.51	3.70	0.55
	WCT	6	2.16	10.85	0.84	1.03	1.52	0.55
Total		**278**	**100.00**	**502.92**	**81.72**	**100.00**	**147.83**	**0.55**
KR2	LSS	28	16.18	25.63	21.34	16.19	19.53	1.09
	NPM	112	64.74	102.52	3.87	64.74	3.55	1.09
	PMC	6	3.47	5.49	0.39	3.47	0.35	1.09
	RSS	25	14.45	22.88	0.14	14.45	0.13	1.09
	SCU	1	0.58	0.92	0.01	0.58	0.01	1.09
	YP	1	0.58	0.92	0.02	0.58	0.02	1.09
Total		**173**	**100.00**	**158.35**	**25.77**	**100.00**	**23.59**	**1.09**
KR4	LSS	30	26.79	31.89	22.90	79.88	24.33	0.94
	MWF	4	3.57	4.25	0.25	0.86	0.26	0.94
	NPM	46	41.07	48.89	2.65	9.23	2.81	0.94
	PMC	20	17.86	21.26	1.90	6.64	2.02	0.94
	RBT	8	7.14	8.50	0.94	3.27	0.99	0.94
	RSS	3	2.68	3.19	0.03	0.10	0.03	0.94
	SCU	1	0.89	1.06	0.00	0.01	0.00	0.94
Total		**112**	**100.00**	**119.04**	**28.66**	**100.00**	**30.46**	**0.94**
KR6	BRN	2	0.58	3.21	0.37	0.83	0.59	0.62
	LSS	22	6.43	35.33	18.07	41.19	29.01	0.62
	MWF	277	80.99	444.78	21.25	48.44	34.12	0.62
	NPM	12	3.51	19.27	0.82	1.86	1.31	0.62
	RBT	26	7.60	41.75	3.35	7.64	5.38	0.62
	RSS	3	0.88	4.82	0.02	0.04	0.03	0.62
Total		**342**	**100.00**	**549.15**	**43.87**	**100.00**	**70.44**	**0.62**
KR9	LSS	26	5.63	38.25	22.49	26.44	33.09	0.68
	MWF	399	86.36	587.00	56.34	66.23	82.88	0.68
	NPM	7	1.52	10.30	1.80	2.12	2.65	0.68
	PMC	1	0.22	1.47	0.13	0.15	0.19	0.68
	RBT	28	6.06	41.19	3.96	4.65	5.82	0.68
	RBTxWCT	1	0.22	1.47	0.35	0.41	0.51	0.68
Total		**462**	**100.00**	**679.69**	**85.06**	**100.00**	**125.14**	**0.68**

Appendix 3.1, continued.

2009 Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR14	BLT	4	1.25	6.87	2.62	1.89	4.51	0.58
	LNS	2	0.63	3.44	0.96	0.69	1.65	0.58
	LSS	158	49.38	271.50	106.59	76.75	183.16	0.58
	MWF	138	43.13	237.14	25.11	18.08	43.14	0.58
	NPM	5	1.56	8.59	1.43	1.03	2.45	0.58
	PMC	4	1.25	6.87	0.49	0.35	0.84	0.58
	RBT	6	1.88	10.31	1.16	0.83	1.99	0.58
	WCT	3	1.53	5.16	0.52	0.38	0.90	0.58
Total		**320**	**100.59**	**549.88**	**138.87**	**100.00**	**238.64**	**0.58**
KR2	LSS	39	19.90	32.29	31.30	82.75	25.91	1.21
	MWF	1	0.51	0.83	0.01	0.04	0.01	1.21
	NPM	97	49.49	80.31	3.18	8.42	2.64	1.21
	PMC	31	15.82	25.67	3.10	8.20	2.57	1.21
	RSS	27	13.78	22.36	0.20	0.53	0.17	1.21
	YP	1	0.51	0.83	0.03	0.07	0.02	1.21
Total		**196**	**100.00**	**162.28**	**37.82**	**100.00**	**31.32**	**1.21**
KR4	LSS	16	15.24	19.14	11.53	68.39	13.79	0.84
	MWF	4	3.81	4.78	0.04	0.23	0.05	0.84
	NPM	48	45.71	57.41	3.20	18.97	3.82	0.84
	PMC	20	19.05	23.92	1.88	11.17	2.25	0.84
	RBT	1	0.95	1.20	0.07	0.42	0.08	0.84
	RSS	16	15.24	19.14	0.14	0.81	0.16	0.84
Total		**105**	**100.00**	**125.58**	**16.85**	**100.00**	**20.16**	**0.84**
KR6	LNS	3	0.74	4.64	0.15	0.34	0.23	0.65
	LSS	9	2.23	13.92	8.54	19.83	13.20	0.65
	MWF	364	90.32	562.89	29.36	68.20	45.41	0.65
	NPM	5	1.24	7.73	0.78	1.80	1.20	0.65
	RBT	19	4.71	29.38	3.80	8.82	5.87	0.65
	RSS	2	0.50	3.09	0.02	0.05	0.03	0.65
	WCT	1	0.25	1.55	0.41	0.95	0.64	0.65
Total		**403**	**100.00**	**623.20**	**43.06**	**100.00**	**66.58**	**0.65**
KR9	LND	1	0.20	1.73	0.01	0.01	0.02	0.58
	LSS	33	6.64	56.95	29.94	34.26	51.68	0.58
	MWF	435	87.53	750.72	50.80	58.13	87.67	0.58
	NPM	1	0.20	1.73	0.23	0.26	0.39	0.58
	PMC	2	0.40	3.45	0.36	0.41	0.62	0.58
	RBT	24	4.83	41.42	6.04	6.91	10.43	0.58
	RSS	1	0.20	1.73	0.01	0.01	0.02	0.58
Total		**497**	**100.00**	**857.72**	**87.39**	**100.00**	**150.82**	**0.58**
KR9.1	BRN	1	0.20	1.57	0.12	0.11	0.19	0.64
	LSS	47	9.55	73.57	38.97	34.01	60.99	0.64
	MWF	360	73.17	563.48	54.63	47.69	85.51	0.64
	NPM	18	3.66	28.17	5.68	4.96	8.89	0.64
	PMC	1	0.20	1.57	0.20	0.17	0.31	0.64
	RBT	48	9.76	75.13	14.10	12.31	22.07	0.64
	RSS	16	3.25	25.04	0.35	0.30	0.54	0.64
	WCT	1	0.20	1.57	0.52	0.45	0.81	0.64
Total		**492**	**100.00**	**770.09**	**114.56**	**100.00**	**0.16**	**0.64**
KR10	LSS	27	9.06	20.07	12.51	24.24	9.30	1.35
	MWF	141	47.32	104.81	20.19	39.14	15.01	1.35
	NPM	16	5.37	11.89	1.73	3.35	1.28	1.35
	PMC	18	6.04	13.38	2.30	4.45	1.71	1.35
	RBT	81	27.18	60.21	14.08	27.30	10.47	1.35
	RSS	13	4.36	9.66	0.31	0.60	0.23	1.35
	WCT	2	0.67	1.49	0.48	0.93	0.36	1.35
Total		**298**	**100.00**	**221.52**	**51.60**	**100.00**	**38.35**	**1.35**

Appendix 3.1, continued.

2010

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	LSS	36	7.98	29.39	23.15	28.31	18.89	1.23
	MWF	280	62.08	228.57	39.64	48.48	32.36	1.23
	NPM	11	2.44	8.98	1.83	2.24	1.50	1.23
	PMC	18	3.99	14.69	2.02	2.47	1.65	1.23
	RBT	80	17.74	65.31	14.35	17.55	11.72	1.23
	RSS	25	5.54	20.41	0.42	0.51	0.34	1.23
	WCT	1	0.22	0.82	0.36	0.44	0.29	1.23
Total		**451**	**100.00**	**368.16**	**81.77**	**100.00**	**66.75**	**1.23**
KR14	BUR	1	0.48	1.40	1.54	4.29	2.16	0.72
	LND	1	0.48	1.40	0.00	0.01	0.00	0.72
	LSS	36	17.22	50.33	23.69	65.83	33.12	0.72
	MWF	146	69.86	204.12	7.24	20.11	10.12	0.72
	NPM	7	3.35	9.79	1.81	5.02	2.53	0.72
	PMC	1	0.48	1.40	0.14	0.39	0.20	0.72
	RBT	4	1.91	5.59	0.49	1.36	0.69	0.72
	RSS	7	3.35	9.79	0.07	0.20	0.10	0.72
	WCT	6	2.87	8.39	1.00	2.78	1.40	0.72
Total		**209**	**100.00**	**292.19**	**35.99**	**100.00**	**50.31**	**0.72**
KR2	LSS	25	13.37	15.76	28.41	77.21	17.91	1.59
	NPM	77	41.18	48.54	2.99	8.13	1.89	1.59
	PMC	50	26.74	31.52	4.75	12.90	2.99	1.59
	RBT	1	0.53	0.63	0.41	1.12	0.26	1.59
	RSS	32	17.11	20.17	0.22	0.60	0.14	1.59
	SCU	2	1.07	1.26	0.01	0.04	0.01	1.59
Total		**187**	**100.00**	**117.88**	**36.79**	**100.00**	**23.19**	**1.59**
KR4	BRN	1	0.58	0.59	1.26	7.01	0.75	1.69
	LSS	20	11.56	11.80	11.41	63.36	6.73	1.69
	MWF	7	4.05	4.13	0.07	0.39	0.04	1.69
	NPM	75	43.35	44.26	2.54	14.07	1.50	1.69
	PMC	20	11.56	11.80	1.68	9.34	0.99	1.69
	RBT	6	3.47	3.54	0.76	4.21	0.45	1.69
	RSS	44	25.43	25.96	0.29	1.61	0.17	1.69
Total		**173**	**100.00**	**102.08**	**18.01**	**100.00**	**10.63**	**1.69**
KR6	LSS	16	4.28	16.22	14.92	31.58	15.13	0.99
	MWF	294	78.61	297.97	23.79	50.33	24.11	0.99
	NPM	6	1.60	6.08	2.13	4.52	2.16	0.99
	PMC	1	0.27	1.01	0.17	0.35	0.17	0.99
	RBT	21	5.61	21.28	4.65	9.84	4.71	0.99
	RSS	31	8.29	31.42	0.21	0.44	0.21	0.99
	WCT	5	1.34	5.07	1.40	2.95	1.41	0.99
Total		**374**	**100.00**	**379.05**	**47.26**	**100.00**	**47.90**	**0.99**
KR9	BRK	1	0.19	1.08	0.02	0.02	0.02	0.93
	LND	1	0.19	1.08	0.02	0.02	0.02	0.93
	LSS	30	5.60	32.38	17.23	21.15	18.60	0.93
	MWF	371	69.22	400.48	46.77	57.42	50.49	0.93
	NPM	22	4.10	23.75	4.63	5.69	5.00	0.93
	PMC	7	1.31	7.56	0.90	1.11	0.97	0.93
	RBT	76	14.18	82.04	11.05	13.56	11.93	0.93
	RSS	23	4.29	24.83	0.30	0.36	0.32	0.93
	SCU	3	0.56	3.24	0.02	0.03	0.02	0.93
	WCT	2	0.37	2.16	0.52	0.63	0.56	0.93
Total		**536**	**100.00**	**578.59**	**81.46**	**100.00**	**87.93**	**0.93**
KR9.1	BRN	1	0.13	1.39	0.16	0.10	0.23	0.72
	LSS	47	6.15	65.40	40.56	26.08	56.45	0.72
	MWF	669	87.57	930.96	106.52	68.48	148.23	0.72
	NPM	6	0.79	8.35	1.59	1.02	2.21	0.72
	PMC	4	0.52	5.57	0.60	0.39	0.84	0.72
	RBT	31	4.06	43.14	5.98	3.85	8.33	0.72
	RSS	6	0.79	8.35	0.13	0.08	0.18	0.72
Total		**764**	**100.00**	**1063.16**	**155.55**	**100.00**	**216.46**	**0.72**

Appendix 3.1, continued.

2011 Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	BRK	2	0.52	1.50	0.22	0.32	0.17	1.33
	BRN	4	1.04	3.00	0.59	0.85	0.44	1.33
	LND	1	0.26	0.75	0.02	0.03	0.01	1.33
	LNS	6	1.56	4.51	0.48	0.69	0.36	1.33
	LSS	57	14.84	42.80	27.06	39.30	20.32	1.33
	MWF	178	46.35	133.67	25.10	36.45	18.85	1.33
	NPM	18	4.69	13.52	2.21	3.21	1.66	1.33
	PMC	5	1.30	3.75	0.61	0.89	0.46	1.33
	RBT	73	19.01	54.82	11.22	16.29	8.42	1.33
	RSS	35	9.11	26.28	0.55	0.79	0.41	1.33
	SCU	2	0.52	1.50	0.01	0.02	0.01	1.33
	WCT	3	0.78	2.25	0.57	0.82	0.43	1.33
Total		**384**	**100.00**	**288.36**	**68.64**	**99.68**	**51.54**	**1.33**
KR14	LSS	67	26.07	74.10	51.82	71.92	57.31	0.90
	MWF	161	62.65	178.06	16.19	22.47	17.90	0.90
	NPM	4	1.56	4.42	0.69	0.96	0.77	0.90
	PMC	1	0.39	1.11	0.17	0.23	0.18	0.90
	RBT	5	1.95	5.53	1.98	2.74	2.19	0.90
	RSS	16	6.23	17.70	0.20	0.27	0.22	0.90
	WCT	3	1.17	3.32	1.01	1.40	1.12	0.90
Total		**257**	**100.00**	**284.24**	**72.05**	**100.00**	**79.68**	**0.90**
KR2	LNS	3	1.23	1.77	1.68	5.67	0.99	1.70
	LSS	27	11.07	15.91	21.17	71.56	12.47	1.70
	NPM	146	59.84	86.02	4.33	14.65	2.55	1.70
	PMC	25	10.25	14.73	1.89	6.40	1.12	1.70
	RBT	2	0.82	1.18	0.24	0.80	0.14	1.70
	RSS	40	16.39	23.57	0.26	0.87	0.15	1.70
	SCU	1	0.41	0.59	0.01	0.04	0.01	1.70
Total		**244**	**100.00**	**143.76**	**29.58**	**100.00**	**17.43**	**1.70**
KR4	BLG	2	0.53	1.32	0.01	0.02	0.00	1.51
	LNS	14	3.72	9.25	3.23	11.35	2.13	1.51
	LSS	20	5.32	13.22	14.20	49.92	9.38	1.51
	MWF	14	3.72	9.25	0.15	0.52	0.10	1.51
	NPM	105	27.93	69.40	3.46	12.18	2.29	1.51
	PMC	56	14.89	37.01	3.81	13.40	2.52	1.51
	RBT	13	3.46	8.59	2.14	7.52	1.41	1.51
	RSS	148	39.36	97.82	1.02	3.57	0.67	1.51
	SCU	1	0.27	0.66	0.01	0.04	0.01	1.51
	WCT	3	0.80	1.98	0.42	1.49	0.28	1.51
Total		**376**	**100.00**	**248.50**	**28.44**	**100.00**	**18.80**	**1.51**
KR6	LSS	25	6.48	28.38	26.44	50.95	30.02	0.88
	MWF	325	84.20	368.97	20.35	39.21	23.10	0.88
	NPM	4	1.04	4.54	2.76	5.32	3.13	0.88
	RBT	12	3.11	13.62	2.17	4.17	2.46	0.88
	RSS	20	5.18	22.71	0.19	0.36	0.21	0.88
Total		**386**	**100.00**	**438.22**	**51.91**	**100.00**	**58.93**	**0.88**
KR9	LND	2	0.67	2.48	0.01	0.01	0.01	0.81
	LSS	45	15.15	55.80	39.59	53.29	49.09	0.81
	MWF	220	74.07	272.82	31.43	42.32	38.98	0.81
	NPM	6	2.02	7.44	0.87	1.17	1.08	0.81
	PMC	3	1.01	3.72	0.39	0.53	0.49	0.81
	RBT	10	3.37	12.40	1.84	2.47	2.28	0.81
	RSS	11	3.70	13.64	0.16	0.21	0.19	0.81
Total		**297**	**100.00**	**368.31**	**74.28**	**100.00**	**92.11**	**0.81**
KR9.1	LND	1	0.27	0.99	0.00	0.00	0.00	1.01
	LSS	55	14.71	54.59	54.21	52.40	53.80	1.01
	MWF	282	75.40	279.90	45.42	43.91	45.08	1.01
	NPM	2	0.53	1.99	1.47	1.42	1.45	1.01
	PMC	1	0.27	0.99	0.12	0.12	0.12	1.01
	RBT	6	1.60	5.96	1.55	1.49	1.53	1.01
	RSS	25	6.68	24.81	0.24	0.23	0.23	1.01
	SCU	1	0.27	0.99	0.00	0.00	0.00	1.01
	WCT	1	0.27	0.99	0.44	0.43	0.44	1.01
Total		**374**	**100.00**	**371.22**	**103.44**	**100.00**	**102.67**	**1.01**

CHAPTER 4: TRIBUTARY HABITAT RESTORATION
AUTHOR: MELO MAIOLIE

ABSTRACT

During 2010 we worked on three habitat improvement projects in the Kootenai River drainage. First, the completed project was on Twentymile Creek, a tributary to Deep Creek, which flows into the Kootenai River. Three rock weirs were built to raise the creek bed and allow fish to more easily enter a culvert under Highway 95. Secondly, design work continues on restoring Smith Creek to its natural channel. Smith Creek flows into the Kootenai River near the Canadian border and its lower end has been rerouted into a straight channel. A consulting company, "GeoEngineers," was contracted to design a way to move the creek back to its natural channel and develop cost estimates for the project. Lastly, we worked with the Natural Resource Conservation Service who developed plans to fix a culvert on Brown Creek; a tributary to Deep Creek. These plans include rock structures to raise the creek bed and steel baffles to be placed in the culvert to aid fish passage.

INTRODUCTION

Tributaries to the Kootenai River are important spawning and rearing areas for rainbow trout, bull trout, cutthroat trout, and kokanee (Walters et al. 2005). During 2009 we surveyed streams in the Kootenai Valley to locate barriers to trout migration as part of our project funded by the Bonneville Power Administration. During the survey we identified six manmade barriers. The highest priority was given to repairing barriers on Brown Creek and its tributary, Twentymile Creek. We began the work of fixing the barrier on Twentymile Creek at the culvert under Highway 95 during 2009. During that year, construction plans were drawn, a contractor was chosen, and permits were applied for and received. During the summer of 2010, the construction took place. Fixing this barrier will give trout better access to the upper reaches of the stream for spawning or to move upstream in mid-summer when water temperatures increase.

A second project to improve fish habitat in the Kootenai River valley involved examining the reconnection of Smith Creek to its natural channel. Currently the lower end of this stream has been channelized and diked where it flows across the river's floodplain. Reconnecting the creek to its historic channel would add more than 4 km of rather complex channel to the lower reach of the stream and would create additional fish habitat. Our initial work on this project was to determine if it is feasible to reconnect the creek. Feasibility includes determining if it is physically and economically possible.

Our third activity involved beginning the work to fix a fish passage barrier on Brown Creek. This barrier is a corrugated steel culvert under the Union Pacific railroad tracks. The pipe is steeply sloped and has about a 30 cm drop at its downstream end. During 2010, we worked with the Natural Resource Conservation Service to develop a solution to problem of fish passage at this site.

METHODS

Twentymile Creek

Idaho Department of Fish and Game worked very closely with the Natural Resource Conservation Service (NRCS) on this project. The engineer for NRCS developed plans for three rock structures to be placed in the creek (Figure 4.1). They raised the stream height about 30 cm and gave fish level access into the culvert (Figure 4.2). Construction required 107 m^3 of rock and cobble.

The property owner at the site was contacted and allowed equipment access across his land. He also agreed to have his pasture fence removed during construction and it was rebuilt upon completion.

We applied for and received a permit from the Idaho Department of Transportation to allow us to work on the highway's right-of-way. The right-of-way contains buried utility lines including electric, natural gas, and water. The lines were located and are directly under the location for the stream structures. Fortunately all of the lines were at least 1.2 m deep, putting them below our structures. Extreme care was used during the placement of the large boulder structures.

We applied for, and received, permits from the Department of Water Resources, Department of Environmental Quality, and United States Army Corps of Engineers. One requirement was that no construction takes place in the stream between March 15 and July 1 to protect spawning trout and incubating eggs. Therefore, the construction phase of the project was completed on July 7, 2010 (Figure 4.2).

Smith Creek

Idaho contracted with GeoEngineers to develop plans and cost estimates for the work needed to reconnect Smith Creek to its historic channel (Figure 4.3). Specifically they were asked to develop 50% construction plans and estimated costs for:

- Redirecting Smith Creek from its current channelized section to the historic channel.
- Building dikes along the southeast and northeast sections of the wildlife management area to protect private property and state owned buildings. Soils near dike sites will need to be evaluated for the construction of dikes, and the specific diking location will need to be evaluated for suitability to minimize seepage and address groundwater issues.
- Refurbishing the natural channel so that water can flow to the Kootenai River, and upstream and downstream passage of fish is not impeded.
- Breaching the dikes along the Kootenai River to allow Smith Creek to flow to the river year round, and to allow floodwaters from the river to access and recede from the flood plain.
- The construction of a bridge so that the access road along the channelized section of Smith Creek remains fully functional.

- A water conveyance system so that Boundary Creek water can cross the historic Smith Creek channel and fill the southern wetland cell.

Brown Creek

Engineers from the Natural Resource Conservation Service provided plans for rock weirs to raise the stream bed in Brown Creek and for a series of baffles to allow fish to have easier passage through the steel culvert (Figures 4.4 and 4.5).

RESULTS

Twentymile Creek

The construction of the weirs in Twentymile Creek was completed in July 2010. All three rock weirs were built according to plan (Figure 4.1). The water level in the creek was raised to just above the concrete lip of the culvert. Fish should now have easy access to the entrance to the culvert and the fish baffles on its southern side (Figure 4.2). Even small fish that migrate upstream during summer should be able to access the baffles and make it through the culvert.

Smith Creek

GeoEngineers is currently addressing the list of tasks provided to them. No report has yet been received on their work, but they have provided updates on their progress.

DISCUSSION

Twentymile Creek

Walters (2006) found that rainbow trout densities in the Kootenai River were low and stated that this was at least partly due to limited recruitment. Removing barriers on tributary streams is one approach to increasing trout densities. Having full accessibility to Twentymile Creek, Brown Creek, and Smith Creek could help to improve adult trout densities in the Kootenai River as well as Kootenay Lake.

The Deep Creek drainage is a large tributary stream used by trout for spawning and rearing. However, mid-summer temperatures in Deep Creek may exceed 24°C at some locations (Walters et al. 2005). Improving fish passage on Twentymile and Brown creeks (tributaries to Deep Creek) would allow juvenile trout to move upstream into areas with more suitable temperatures. Ultimately this could improve trout survival and recruitment.

Smith Creek

Adding 4 km of sinuous stream channel to the lower end of Smith Creek would be a marked improvement to the rearing capacity of this stream (Figure 4.3). Benefits of the project, however, go well beyond the stream channel itself. Reconnecting the stream would require breaching the dikes along the Kootenai River. This would return a large portion of the wildlife management area into a functioning flood plain with potential benefits to wildlife species as well as fish. The cost estimates developed by the consulting companies will be a great help in evaluating whether this project will go forward.

RECOMMENDATIONS

1. Continue with the project to improve fish passage on Brown Creek.

2. Check on the rock weirs in Twentymile Creek to determine if they were damaged during spring runoff.

3. Allow GeoEngineers to complete their report on the reconnection of Smith Creek.

FIGURES

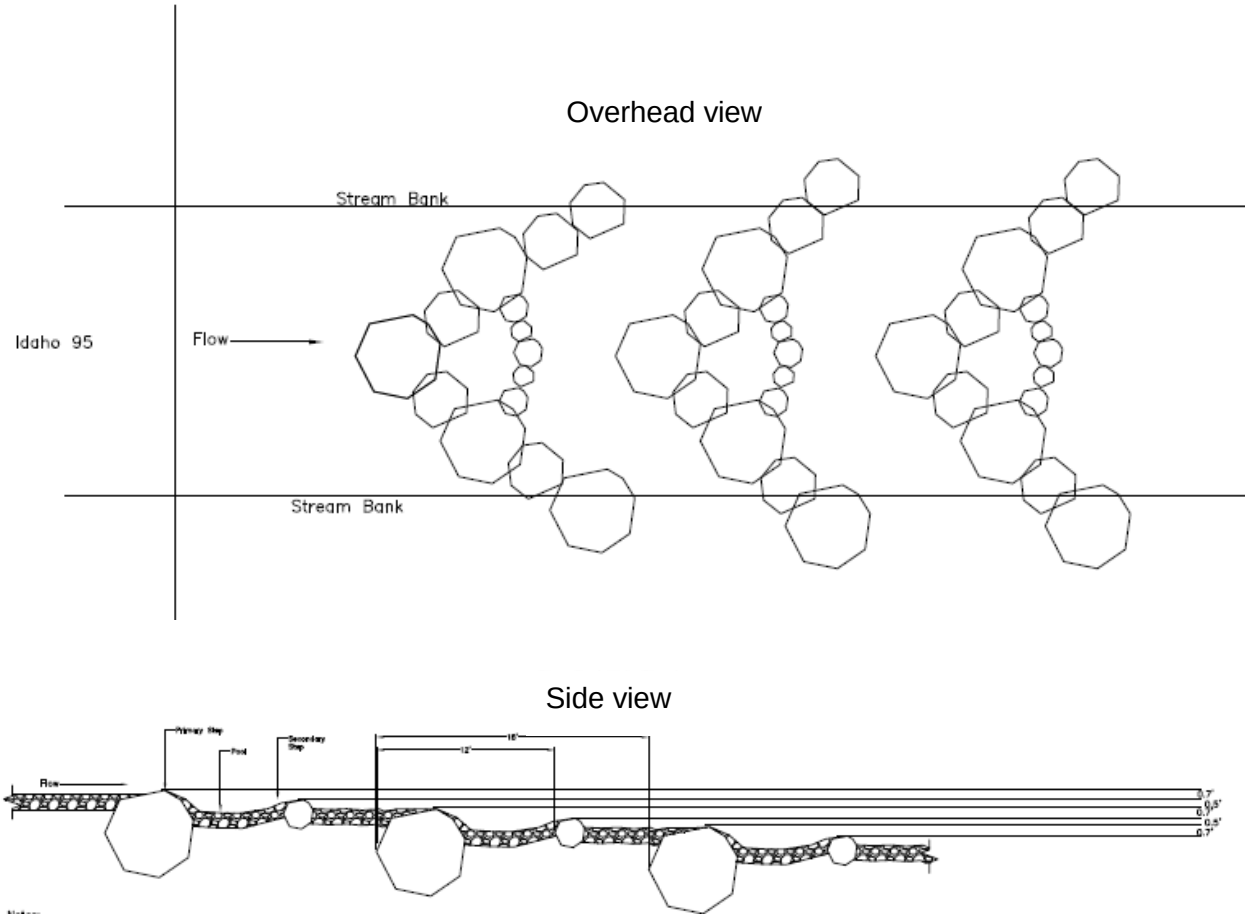


Figure 4.1. Design of the rock weirs that were built in Twentymile Creek, Idaho.

Figure 4.2. Culvert on Twentymile Creek under Highway 95. Top photograph shows the culvert prior to the construction. Lower photograph shows the culvert entrance after placement of rock weirs that were designed to raise the streambed and improve fish access at this location. Only part of the upper weir (one of three) is visible in the photograph.

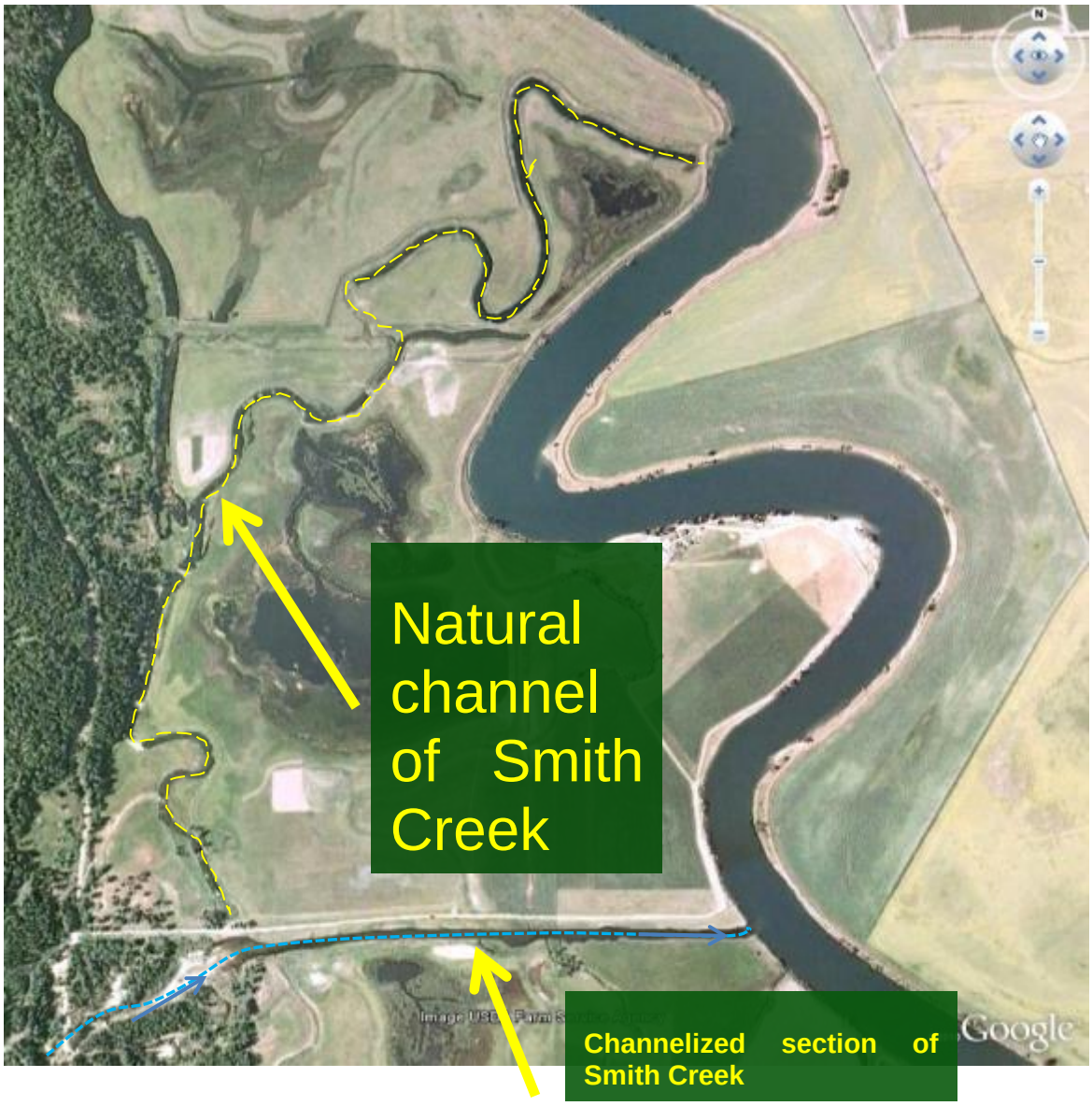


Figure 4.3. Map of the lower end of Smith Creek, a tributary to the Kootenai River, Idaho. Water currently flows out of the Selkirk Mountains, into the channelized section, and out to the Kootenai River. Studies are currently looking at reconnecting the stream to its historic natural channel.

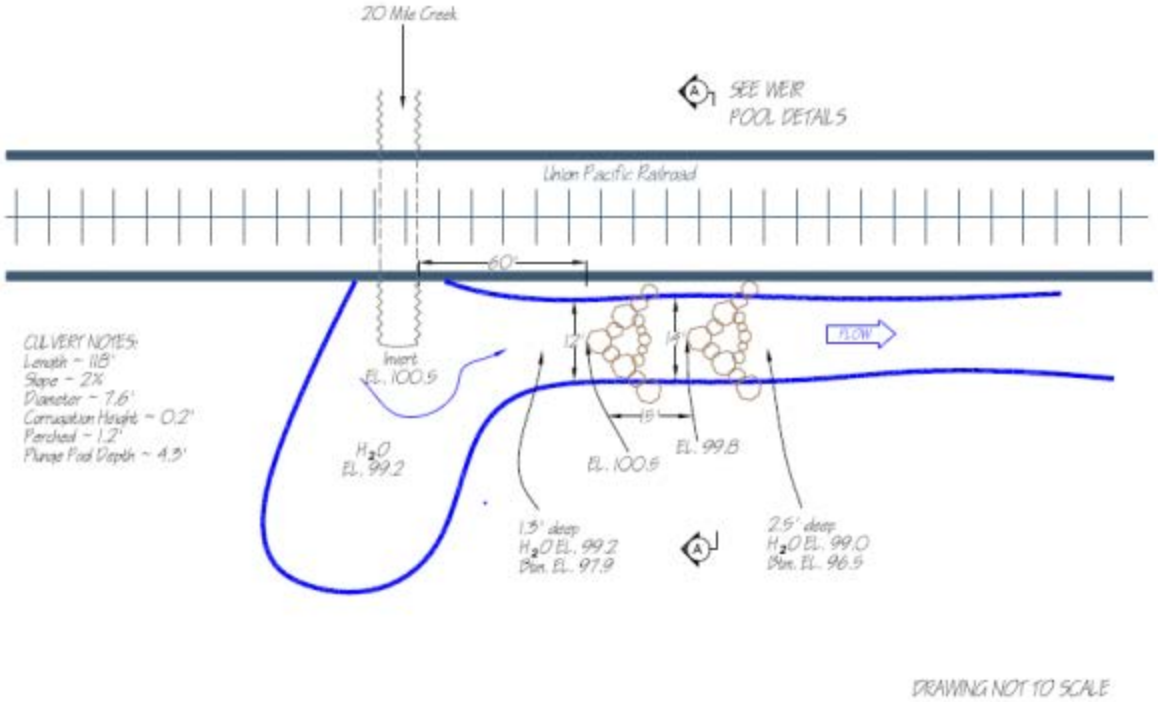


Figure 4.4. Location and design of two rock weirs planned for construction in Brown Creek, Idaho. Drawing also shows the location of the culvert that needs to have baffles installed (Figure 5).

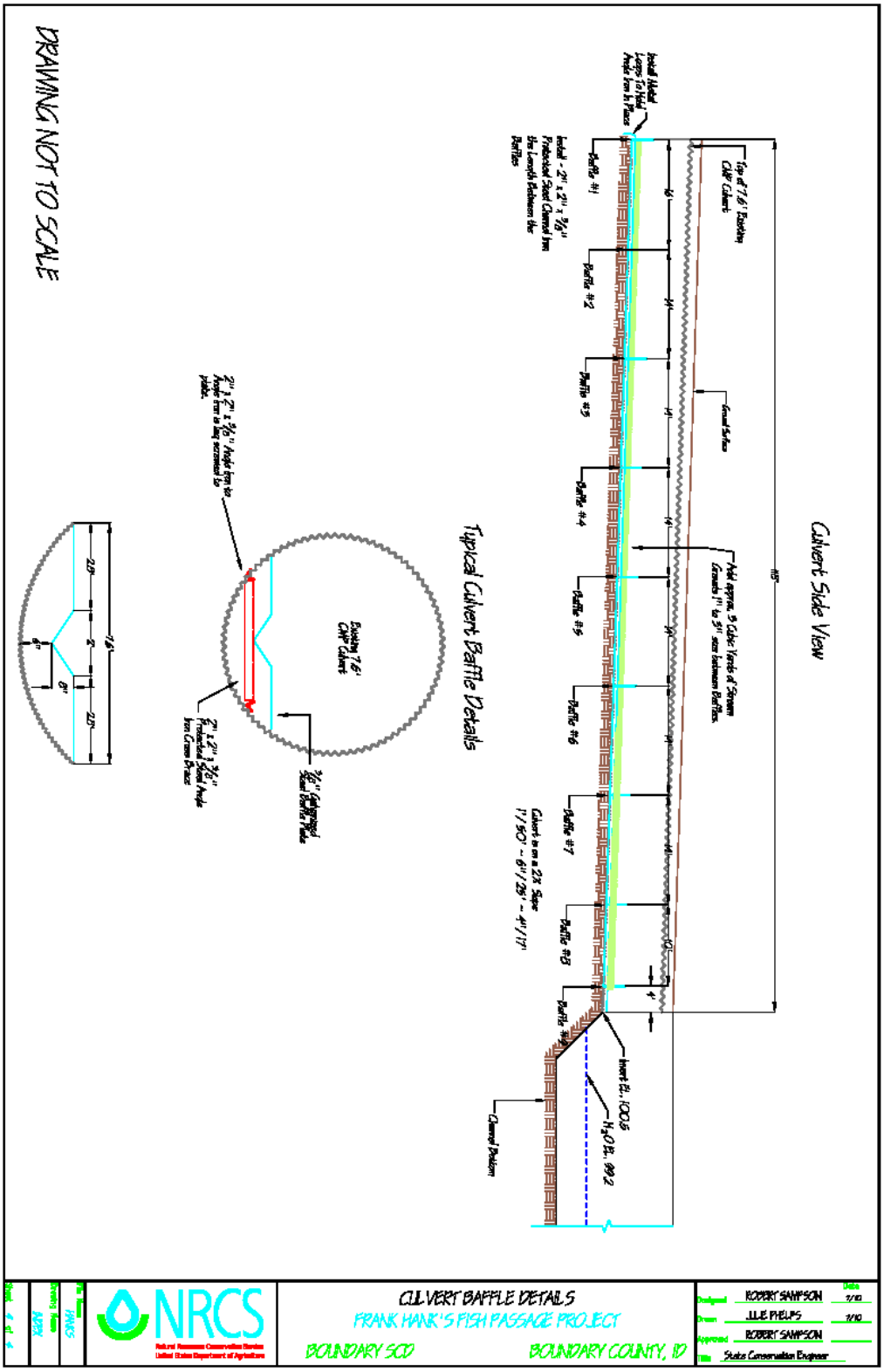


Figure 4.5. Design of baffles to be build inside of a culvert on Brown Creek, Idaho. Nine baffles are needed to allow fish to have easier passage when moving upstream on the creek.

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APPENDIX A: USE OF DATA & PROJECTS

All PIT, acoustic, radio, floy, or any other numbered tag information is housed in a central access database managed by a Sr. Fishery Technician, Diane Wakkinen, who has been on the project for 20 years. All tag orders are funneled through this database in order to have consistent numbering. In addition, capture, recapture, and movement data from all species with tags are housed in this central database in order to be consistent and allow seamless analysis on species-specific data. Fish Monitoring data (in cooperation with the KTOI) are housed under a separate database housed by SCS Incorporated, Bahman Shafii, at the University of Idaho. Limited access to the public is given to these raw data values. Additional data are entered into Excel® spreadsheets. An Access® database has been developed to incorporate our different data spreadsheets and link them where appropriate. Currently, data is shared amongst cooperators and others who request it by distributing the Excel® spreadsheets.

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