FISHERY RESEARCH

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

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TABLE OF CONTENTS

Page

Table of Contents, continued.

Page

CHAPTER 1: WHITE STURGEON MONITORING AND EVALUATION

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ABSTRACT

The objective of this research was to determine the environmental requirements for successful spawning and recruitment of the Kootenai River White Sturgeon *Acipenser transmontanus* population. Annual tasks include monitoring and evaluating the response of various life stages of Kootenai River White Sturgeon to flow augmentation supplied by the U.S. Army Corps of Engineers. On June 8, 2012, Koocanusa Reservoir inflow peaked at 2,155 m^3/s (76,100 ft^3/s) and the reservoir filled to elevation 750 m (2,459.9 feet) by mid-July. Average daily Libby Dam outflow peaked July 5 at 1,359 m^3/s (48,000 ft^3/s). Between March 3 and October 18, IDFG and BCMFLNRO crews expended more than 5,764 h to capture 20 adult White Sturgeon by angling and 62 adult White Sturgeon by setlining. Catch rates were 0.72 fish per rod h for angling and 0.012 fish per setline h. Forty-two (67%) of the 63 adult White Sturgeon collected were recaptures from previous years. Ten adult White Sturgeon were newly tagged with Vemco sonic transmitters in spring and two were tagged in fall. Thirty-two sonic tagged adult White Sturgeon (21 females) were in spawning condition and exhibited a spawning migration in 2012. Thirty-one (97%) of these tagged adults moved upstream as far as rkm 235.0. Twenty-three (72%) of the migrating adults were recorded at rkm 240.7 just downstream of Deep Creek, and 19 (59%) of the migrating adults went upstream as far as rkm 244.5 (Ambush Rock). Additionally, at least nine (28%, 6 females) of the tagged migrating adult sturgeon went upstream of the Hwy. 95 Bridge in Bonners Ferry into the braided reach. We deployed substrate mats to evaluate the temporal and spatial extent of White Sturgeon spawning events in the Kootenai River. We sampled 51,910 mat hrs between May 14 and July 17 and collected 71 eggs. The highest catch and the highest catch rate came from the Myrtle Creek area (rkm 234.0) although most of the effort was in the straight reach downstream of the train bridge in Bonners Ferry. Based on 44 viable eggs, we estimate that White Sturgeon spawned at least 11 days in 2012 between May 30 and June 25. In 2012, 450,379 free embryos (one- to four-day-old embryos) were released at three sites in Idaho. There were four releases, with the first embryos released on June 11 and the last on July 2. Surface water temperatures during the releases ranged from 9.6° to 11.6°C. IDFG and BCMFLNRO sampled 24 sites between rkm 18.0 and 244.5 and collected 810 juvenile sturgeon (800 hatchery-reared, 99%) with 456 h of effort. The highest catch came from the Kootenay Lake delta (rkm 120.0) but catch was well distributed throughout the river. The Rock Creek area (rkm 215.5) had the highest catch rate for the river sites, but several areas throughout the river had catch rates that exceeded one fish per hour. Eight wild juvenile White Sturgeon were captured while gill netting in Canada and Idaho in 2012. The TL of these five individuals ranged from 40.0 to 89.1 cm, and weights ranged from 0.3 to 3.2 kg. Six-year classes (2001 – 2007) were represented in the 2012 sample.

INTRODUCTION

The Kootenai River White Sturgeon *Acipenser transmontanus* population is comprised mainly 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. More than 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) embryos and larvae, 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 1.1). 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 the natural flow regime (Figure 1.2). Post-dam water 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 2012, the USFWS in cooperation with members of the Kootenai River White Sturgeon Recovery Team (KRWSRT), submitted System Operations Requests (SOR) FWS#2012 to the Corps' regional multi-agency/entity Technical Management Team (TMT). The team determined the 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#2012-1 (http://www.nwd-wc.usace.army.mil/tmt/sor/2012/SOR_2012-FWS1.pdf).

The intent 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 VarQ regime). The intent was also to provide spawning and incubation flows to meet attributes for water depth, water velocity, and water temperature in the Kootenai River as defined in the 2006 Biological Opinion RPA for Kootenai River 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 1.3).

The 2012 April to July Kootenai River (MT) stream flow forecast, which includes the White Sturgeon spawning season, was 109% of average. Snow water equivalents in April 2012 were 127% of average. For the Kootenai Basin in Montana, discharges were expected to be above normal for 2012. (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/newsroom/?cid=nrcs144p2_057960).

White Sturgeon Sampling

Adult White Sturgeon were collected by angling and setlines from March through November 2012 following the methods of Paragamian et al. (1996). From March through April, most of the sampling occurred in the staging areas between rkm 200 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 near the Kootenai River delta at rkm 120 in 2012. We biopsied adult sturgeon to determine sex and level of maturity following the methods of Conte et al. (1988) and 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). Working in cooperating with the Kootenai Tribe of Idaho (KTOI), some gravid female White Sturgeon expected to spawn during spring 2012 were transported to the 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 male gametes were only collected when a female was in the hatchery and 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. Beginning in 2003 and continuing to the present, we maintain an array of Vemco model VR2 and VR2W 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 1.4). Receivers were located 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. Data from receivers were stored in the .vrl files in VUE (Vemco) and imported into a Microsoft Access™ database 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 based on previous years of known spawning locations 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 2012 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 gill nets when potential recruits become fully vulnerable to this gear type in three years.

Juvenile White Sturgeon Sampling

We used weighted multifilament gill net 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 24 through October 25, 2012 following the methodology of Paragamian et al. (1996). Gill nets 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 hatchery reared sturgeon received a passive integrated transponder (PIT) tag and a pattern of scutes were removed at the KTOI hatchery or at the Kootenay Trout and Sturgeon Hatchery located in Ft. Steele, BC, and operated by the Freshwater Fishery Society of BC as the backup facility for the KTOI. Most (92%) of the released juvenile White Sturgeon were not PIT tagged from 2005 through 2007, although scutes were removed from each fish prior to release. Most hatchery reared juvenile sturgeon released in the Kootenai River after 2007 were PIT tagged and all had scutes removed. PIT tagging fish prior to release provide a unique identifier for each fish and allows tracking of the size at release, rearing facility, release location, and time of release. Scute removal patterns only identify brood year and rearing location, and there can be subjective errors with applying and recording scute patterns. 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. BC Ministry of Forests, Lands and Natural Resource Operations (BCMFLNRO) 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 8, 2012, Koocanusa Reservoir inflow peaked at 2,155 m^3/s (76,100 ft^3/s) and the reservoir filled to elevation 750 m (2,459.9 feet) by mid-July. Average daily Libby Dam outflow peaked July 5 at 1,359 m^3/s (48,000 ft^3/s). Due to the high volume of water in the reservoir, flows remained high throughout the summer. Summer flows of less than 227 m^3/s (8,000 ft^3/s) were not realized until early September.

Water temperatures measured at Bonners Ferry in 2012 were cooler than normal due to the high volume of water released from Koocanusa reservoir, and from the cool wet spring and early summer air temperatures. Water temperatures remained below 6°C until early May and remained cool through the spawning period. Mid-summer water temperatures also were cool, and temperatures did not exceed 12°C until late July (Figure 1.3). The maximum river water temperature in 2012 of 15.5°C did not occur until September 9 and water temperatures remained near 13°C through early fall, before rapid cooling late in October.

Adult White Sturgeon Sampling

Between March 3 and October 18, 2012, IDFG and BCMFLNRO crews expended more than 5,764 h to capture 20 adult White Sturgeon by angling and 62 adult White Sturgeon by setlining (Table 1.1). Additionally, one adult sturgeon was collected in gill nets while sampling for juvenile sturgeon and one was captured in a hoop net while sampling for burbot.

Catch rates were 0.72 fish per rod h for angling and 0.012 fish per setline h (Table 1.1). Forty-two (67%) of the sixty-three adult White Sturgeon collected were recaptures from previous years (Table 1.1). Fourteen adult White Sturgeon were biopsied by IDFG and BCMFLNRO. Eleven (78%) of the biopsied adults were females, two were males (14%), and sex could not be determined for one individual. For some individuals, sex was determined based on previous inspection recorded in a database. Nine of 11 females biopsied (82%) were stage F4 (mature eggs), one was stage F2 (early developing eggs), and specific stage could not be determined for the remaining female. One of the males was biopsied at stage M8 (mature testes) and the other male had non-reproductive testes at the time of capture, resulting in no stage assignment. For one additional sturgeon, sex could not be determined at the time of sampling. KTOI Hatchery personnel also captured and biopsied adult White Sturgeon for their propagation operations; Lewandowski (2012) 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 83 stationary Vemco VR2/W sonic receivers (Figure 1.4).

Ten adult White Sturgeon were newly tagged with Vemco sonic transmitters in spring 2012 and two were tagged in fall 2012. Including the 10 tagged in 2012, 113 adult White Sturgeon had active Vemco sonic transmitters during the 2012 spawning season from previous years or were not expected to spawn in spring 2012 (Table 1.2).

Based on capture and telemetry data, 32 sonic tagged adult White Sturgeon (21 females) were in spawning condition and exhibited a spawning migration in 2012. A spawning migration was defined by fish observed in spawning condition in 2012 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). Thirty-one (97%) of these tagged adults moved upstream as far as rkm 235.0. Twenty-three (72%) of the migrating adults were recorded at rkm 240.7 just downstream of Deep Creek, and nineteen (59%) of the migrating adults went upstream as far as rkm 244.5 (Ambush Rock). Additionally, at least nine (28%, 6 females) of the tagged migrating adult sturgeon went upstream of the Hwy. 95 Bridge in Bonners Ferry into the braided reach in 2012.

Appendix 1.1 shows the movement histories of the six female White Sturgeon that moved upstream of the Hwy. 95 Bridge in Bonners Ferry in 2012.

Artificial Substrate Mat Sampling

We deployed substrate mats in 2012 to evaluate the temporal and spatial extent of White Sturgeon spawning events in the Kootenai River. In 2012, we sampled 51,910 mat hrs between May 14 and July 17 and collected 71 eggs (Table 1.3). The highest catch and the highest catch rate came from the Myrtle Creek area (rkm 234.0) although most of the effort was in the straight reach downstream of the train bridge in Bonners Ferry (rkm 246.0, Table 1.3). The first eggs were collected on May 29, and the last eggs were collected on June 28.

Forty-four of the 71 (62%) eggs could be staged and were viable, and egg stages ranged from 14 to 28, with 14 of those 44 eggs having developed to stage 21 (Beer 1981). Based on the 44 viable eggs, we estimate that White Sturgeon spawned at least 11 days in 2012 between May 30 and June 25 (Table 1.3). Water temperature during the egg collection period ranged from 8.5° to 12°C (Table 1.3), surface water velocity ranged from 0.6 to 0.8 m/s (Table 1.4), and Secchi disk depth ranged from 1.1 to 1.8 m.

Free Embryo Releases and Larval Sampling

In 2012, 450,379 free embryos (one- to four-day-old embryos) were released at three sites in Idaho (Appendix 1.2). There were four releases, with the first embryos released on June 11 and the last on July 2. Surface water temperatures during the releases ranged from 9.6° to 11.6°C (Appendix 1.2). Due to the intensity and duration of the summer flows in 2012, no larval sampling occurred.

Juvenile White Sturgeon Sampling

Beginning in 1990 and continuing to the present, the KTOI and BC hatcheries have released over 222,722 juvenile White Sturgeon (Appendix 1.3). 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 juvenile White Sturgeon.

IDFG and BCMFLNRO sampled for juvenile White Sturgeon with gill nets between July 25 and October 24, 2012 in Idaho and Canadian sections of the Kootenai River and Kootenay Lake. Since this population is transboundary, data collected in Idaho and Canada were included.

In 2012, IDFG and BCMFLNRO sampled 24 sites between rkm 18.0 and 244.5 and collected 810 juvenile sturgeon (800 hatchery-reared, 99%) with 456 h of effort (Table 1.5). The highest catch came from the Kootenay Lake delta (rkm 120.0) but catch was well distributed throughout the river. The Rock Creek area (rkm 215.5) had the highest catch rate in the river, but several areas throughout the river had catch rates that exceeded one fish per hour. All sizes of gill nets used caught sturgeon, but the 2-inch mesh caught the most, accounting for over 30% of the catch (Table 1.6). The 2-inch mesh was fished the most, representing 36% of the sets. The highest CPUE was from the 4-inch mesh (0.81 sturgeon/net hour). The average fork and total length of the hatchery reared juvenile White Sturgeon was 48.0 cm and 54.5 cm, respectively, and weight of juvenile sturgeon averaged 0.87 kg (Table 1.7). Gillnet catch parameters pertaining to hatchery brood year assignments are in Appendix 1.4.

Ten wild juvenile White Sturgeon were captured while gill netting in Canada and Idaho in 2012 (Table 1.8). The TL of these 10 individuals ranged from 40.0 to 89.1 cm, and weights ranged from 0.3 to 3.2 kg (Table 1.8). Six year classes (2001 – 2007) were represented in the 2012 sample (Table 1.8). Figure 5.1 shows the year class assignments from a sample of the wild juvenile White Sturgeon collected between 1977 and 2012 that could be aged. Figure 1.6 shows the number of wild juvenile White Sturgeon collected annually from 1977 to 2012.

DISCUSSION

This year marked the third and final year of a spill test intended to improve migration conditions and spawning for sturgeon in the Kootenai River. Libby Dam released water at powerhouse capacity of 708 m^3/s (25,000 ft^3/s) plus an additional 283 m^3/s (10,000 ft^3/s) through the spillway gates. The operation was intended to test whether the spill increase changes White Sturgeon spawning behavior and increases upstream movement and potential spawning in the Kootenai River above Bonners Ferry, Idaho. Habitat conditions (substrates and water velocities) above Bonners Ferry appear to be better for spawning and larval rearing compared to conditions where most of the spawning currently occurs. Preliminary results suggest that spill did not dramatically increase upstream movements but a more detailed analysis and modeling exercise may be warranted to better explain fish movement responses to flow conditions.

In 2012, we worked in conjunction with USGS to refine sturgeon spawning site selection at Shortys Island. This project provides guidance to the KTOI who is planning a habitat enhancement pilot project in this reach to improve substrate conditions for spawning sturgeon. This involved collecting GPS data at all sites where egg mats were deployed throughout the egg mat sampling period. USGS collected bathymetric and bed slope data throughout the reach as well as ADCP velocity and backscatter measurements at 30 transects throughout this reach. Combining these data provided a clear picture of the substrate and flow conditions of where most of the spawning occurs and provided contractors valuable guidance for specific locations to add gravel and cobble for habitat enhancement projects aimed at improving egg to fry survival. This project will be continued in 2013 at Myrtle Creek and similar data will be collected to provide continued guidance to KTOI and their contractors for future habitat enhancement projects.

Juvenile sturgeon catch statistics and population dynamics is a major component of IDFG’s monitoring and evaluation program. Gill net catch and catch per effort continues to increase over time, and determining a balance between stocking rates, growth, and survival of juvenile sturgeon is an important long-term issue. Previously, contractors were hired to perform most of this analysis, but we intend to initiate an intensive effort to evaluate juvenile sturgeon sampling study design, and intensively evaluate juvenile sturgeon growth and survival.

RECOMMENDATIONS

1. **For ACOE:** As water temperature at Bonners Ferry reaches 7°C after April 1, provide augmented flow from Libby Dam to achieve 425 m^3/s. 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. **For ACOE:** Provide minimum flows of 630 m^3/s for 42 d (as prescribed for spawning and rearing in the Kootenai River White Sturgeon Recovery Plan, USFWS 2006) at Bonners Ferry once water temperatures of 8-10°C are reached to stimulate spawning and optimize egg/larval survival of Kootenai River White Sturgeon.

3. Continue fine-scale sturgeon spawning habitat studies at Myrtle Creek to provide guidance to KTOI for proposed habitat enhancement projects.

4. Evaluate juvenile sturgeon sampling study design and initiate detailed juvenile survival, growth, and density dependent mortality analysis.

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 Forests, Lands and Natural Resource Operations personnel, in the Kootenai River, Idaho, and Kootenay Lake, Canada, February 27 to October 25, 2012.

	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)**
Gill net[a]	455.9	798(516)	6(5)	1.7504	0.0132
Angling [b,c]	27.8	0(0)	20(12)	0	0.7194
Setline[b],[d]	5,281.2	3(2)	63(42)	0.0006	0.0119
Total	5,764.9	801(518)	89(59)		

[a] Includes 196.9 hours sampling by BCMFLNRO for IDFG from July 24 – September 25, 2012. There were 604 juveniles (373 recaptures, 224 untraceable recaptures) and 5 adults (4 recaptures; 1 untraceable recapture) caught during this period and included in the totals above. There were 14 more juveniles captured during this effort that were not worked up.

[b] Does not include angling effort by BCMFLNRO for IDFG in April and October 2012 at Kootenay Delta which resulted in 6(6) juveniles and 19(13) adults. It does include 465.5 hours setline effort with 1(1) juvenile and 9(5) adults captured.

[c] There were an additional 87 adults (71 recaptures) and 19 juveniles (11 recaptures) during KTOI broodstock angling efforts from February 27 – October 9, 2012 for which no effort was recorded.

[d] Based on 24 hour sets

Table 1.2 Vital statistics from Kootenai River adult White Sturgeon marked with Vemco sonic tags as part of a telemetry study, Kootenai River, Idaho, 2003-2012.

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[w]
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
2006	F-3	9/28/06	121.0	57859	118.0	121.6	57.0	299

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	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[u]
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
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

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
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[v]
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
2012	F-4	3/13/2012	207.7	101848	175.0	191.0	45.0	696
2012	F-4	4/5/2012	207.7	101861	183.0	210.0		697
2012	M-8	4/5/2012	207.0	1791	161.0	184.0	39.0	698
2012	F-4	4/5/2012	207.0	1580	191.0	216.0	64.0	699
2012	M-8	4/16/2012	207.0	860	169.0	193.0	44.0	700
2012	F-4	4/3/2012	207.0	22210	172.0	201.0		701
2012	F-2	9/6/2012	120	1836	233.0	204.0	89.0	702
2012	F-4	4/4/2012	207.0	101860	189.0	214.0		704
2012	F-4	4/26/2012	120.0	101885	197.0	220.0	71.0	705
2012	F	4/17/2012	207.0	101866	185.0	211.0	70.0	707
2012	F-4	4/11/2012	207.0	101864	190.0	212.0	65.0	708
2012	F-3	9/27/2012	122.0	131525	224.0	251.0	110	810

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code

[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 1st 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.
[h] This fish (#202) 1st 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. 1st 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) captured 11/4/2010 and recaptured 5/4/11 by KTOI angling.
[u] This fish (Vemco 401) captured 3/18/2009 and recaptured 3/28/2012.
[v] This fish (Vemco 560) captured 4/6/2010 and recaptured 9/18/12 by BC.
[w] This fish (Vemco 266) captured 9/8/04 and recaptured 9/20/12 by BC.

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

Tag year	Sex/Devel-opment 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]

Tag year	Sex/Development Stage	Release Date	Release RKM	Fish #	Fork Length (cm)	Total Length (cm)	Weight (kg)	Vemco Code
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
2012	F-1	3/28/2012	208.0	229		212.0	47.0	401[u]
2004	M-8	9/8/04	121.0	690	168.5	190.0	38.3	266[w]
2010	F-4[d]	4/6/10	207.5	2344	179.0	210.0	65.0	560[v]

Table 1.3. Stages of White Sturgeon eggs captured by artificial substrate mats, Kootenai River, Idaho, 2012.

			Egg Stage																		
Date Pull	**Temp °C Pull**	**No. Egg**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**other**	**Notes**	**Hours from Fertilization (Spawn Date)**
5/31/2012	10	1					1															27(5/30)
6/12/2012	9.5	1																		1	dead	
6/12/2012	9.5	7								1	1	5										49,45(6/10;67(6/9)
6/12/2012	9.5	13								1	1	7								4	3 hatched cases;1 dead	49,45(6/10);67(6/9)
6/19/2012	8.5	3						2												1	1-busted	28(6/18)
6/19/2012	8.5	14			2	1	3			1										7	7-dead	16(6/18);5,8(6/19); 41(6/17)
6/19/2012	8.5	1			1																	5(6/19)
6/19/2012	8.5	8																		8	non-readable	
6/19/2012	8.5	1																	1		hatching	355+ hrs
6/19/2012	9.5	7					2													5	5 dead	20(6/18)
6/21/2012	9.5	4						3												1	1-dead	21((6/20)
6/25/2012	11.0	1												1							+1 hatched casing	81(6/22)
6/25/2012	11.0	1						1					1									67(6/22);20(6/24)
6/25/2012	11.0	2															1					118(6/20)
6/25/2012	11.0	6										2	4									67(6/22);53(6/23)
6/28/2012	12.0	1												1								81(6/25)
Total collected		71	0	0	3	1	6	6	0	3	2	14	5	2	0	0	1	0	1	27		
Total not staged		27																				

Table 1.4. Location (river kilometer), depth (m), White Sturgeon egg catch, and catch per unit effort (CPUE) by standard artificial substrate mats, IDFG, Kootenai River, Idaho 2012.

Sample year	**River location (rkm)**	**Depth range (m)**	**Total mat hours**	**Number White Sturgeon eggs**	**Mean water velocity (m/s)**	**CPUE**
2012	230.5	3.6-19.1	5,302.6	12	0.6[a]	0.0023
	230.6	3.0-11.9	4,664.6	8	0.8	0.0017
	234.5	2.9-18.2	5,887.2	27	0.7	0.0046
	234.6	3.6-20.1	6,402.6	1	0.6	0.0002
	245.5	4.3-10.3	12,344.6	23	0.8	0.0019
	245.7	3.0-7.6	4,766.2	0		0
	246.2	2.9-7.7	6,513.5	0		0
	246.5	2.5-6.1	6,029.2	0		0
2012	**230.5-246.5**	**2.5-20.1**	**51,910.6**	**71**		**0.0014**

[a] Water velocity measurements taken only when eggs were found.

Table 1.5. Idaho Department of Fish and Game and British Columbia Ministry of Forests, Lands and Natural Resources juvenile White Sturgeon gill net sampling effort by sampling location for August 20 through October 25, 2012 and August 21 through September 20, 2012, respectively.

Year	River Kilometer	Number of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit of Effort
2012	18.0	11	16.68	4	12	0.96
	120.0	20	20.73	0	187	9.02
	121.0	18	29.48	0	126	4.27
	123.0	8	11.20	1	29	2.68
	130.0	12	23.53	0	117	4.97
	137.0	8	10.63	0	1	0.09
	141.0	6	10.58	0	7	0.66
	145.0	13	17.48	0	62	3.55
	150.0	8	8.55	0	4	0.47
	157.0	8	10.42	0	15	1.44
	161.0	16	18.38	0	31	1.69
	165.0	18	19.25	0	13	0.68
	174.0	16	189.63	0	2	0.01
	176.0	16	193.92	0	5	0.03
	177.5	16	191.92	0	0	0.00
	185.0	16	206.72	0	10	0.05
	190.5	16	192.60	0	26	0.13
	193.0	16	199.78	0	4	0.02
	205.0	20	79.37	0	22	0.28
	207.0	14	174.92	0	26	0.15
	215.5	6	69.52	0	51	0.73
	225.0	32	208.45	0	7	0.03
	235.0	16	192.53	1	0	0.01
	244.0	20	244.53	0	19	0.08
	245.0	18	222.92	0	22	0.10
	Total	**368**	**2,563.73**	**6**	**798**	**0.31**

Table 1.6. Idaho Department of Fish and Game and British Columbia Ministry Forests, Lands and Natural Resource Operations juvenile White Sturgeon gill net sampling effort by mesh size for August 20 through October 25, 2012 and August 21 through September 21, 2012, respectively.

Year	Gill Net Mesh Size (cm)	Number of Sets	Hours of Effort	Number of Adults Captured	Number of Juveniles Captured	Sturgeon Catch Per Unit Effort
2012	1.3	1	14.83	0	4	0.27
	2.5	34	327.12	0	22	0.07
	5.1	133	826.40	2	276	0.34
	8.5	1	14.75	0	0	0.00
	11.4	82	410.15	3	331	0.81
	14.2	17	212.60	0	35	0.16
	17.1	85	571.95	1	129	0.23
	22.8	15	185.93	0	1	0.01
	Total	**368**	**2563.73**	**6**	**798**	**0.31**

Table 1.7. Summary statistics of recaptured juvenile hatchery White Sturgeon from 2012 net sampling, Kootenai River, Idaho and Kootenay Lake, B.C.

Year	Statistic	Fork length (cm)	Total length (cm)	Mean weight (kg)
2012	N	786	706	632
	Average	48.0	54.5	0.87
	Standard deviation	15.7	18.2	1.00
	Minimum	16.2	13.2	0.04
	Maximum	100.5	120.4	7.60

Table 1.8. Wild juvenile White Sturgeon captured in gill nets in 2012, Kootenai River, Idaho and Kootenay Lake, B.C. (does not include wild recaptures).

Year	Date	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)	Year class
2012	8/14	130.0	38.2	45.0	0.32	2007
	8/15	121.0	35.0	40.0	0.30	2007
	8/15	121.0	57.8	66.0	1.35	2001
	8/21	215.5	42.1	48.6	0.42	2006
	8/22	130.0	41.6	47.1	0.40	2005
	8/22	130.0	47.2	55.1	0.70	2006
	8/22	130.0	38.7	44.0	0.35	2005
	9/13	120.0	48.2	54.6	0.65	2004
	9/13	120.0	77.2	89.1	3.20	2004
	9/25	121.0	47.7	56.0	.68	2003

FIGURES

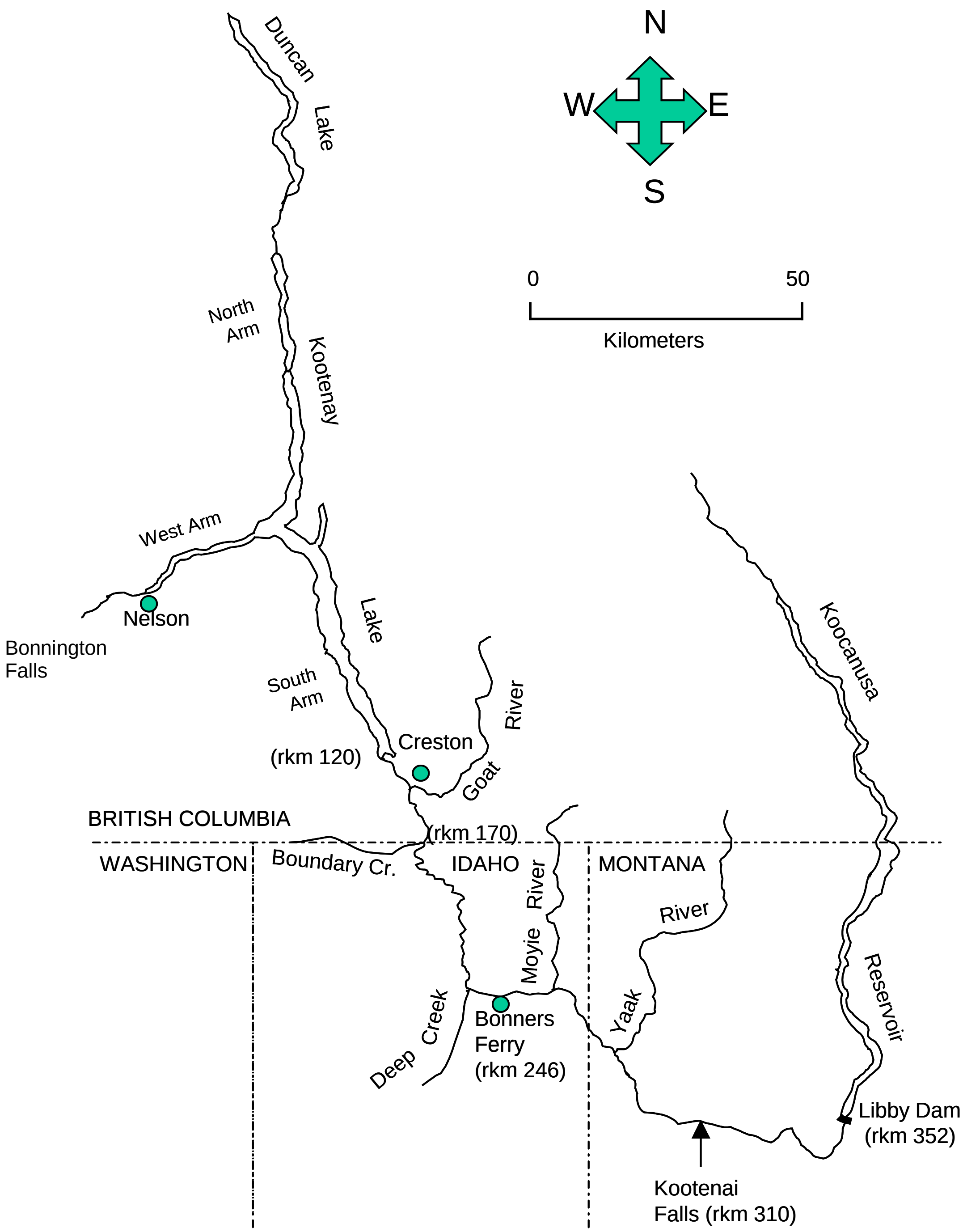


Figure 1.1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

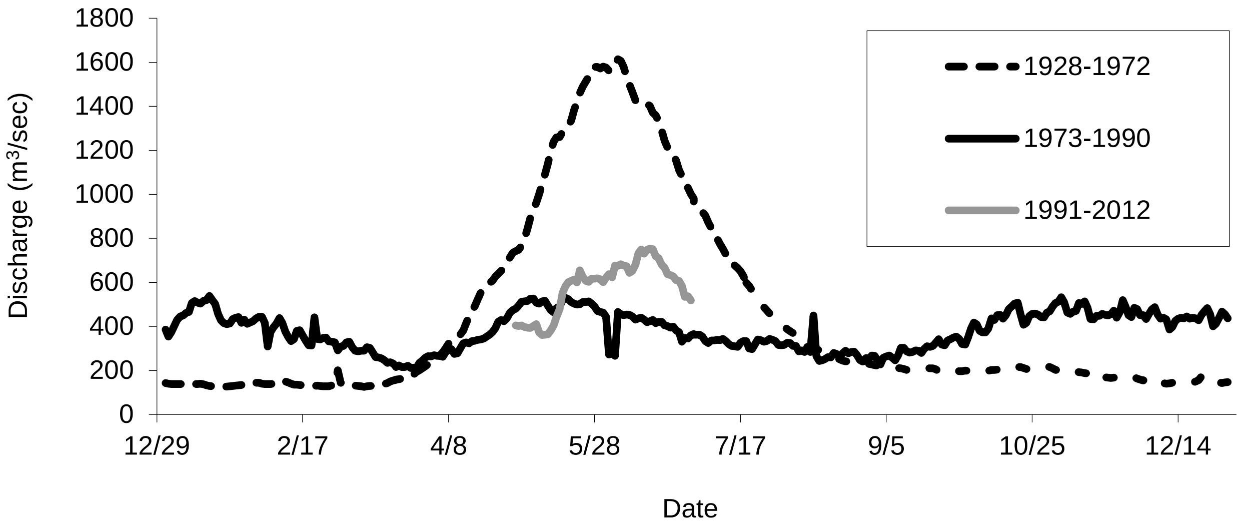


Figure 1.2. Mean daily flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928-1972 (pre-Libby Dam), 1973-1990 (post-Libby Dam), and 1991-2012 (post-Libby Dam with augmented flows, May 1 through June 30).

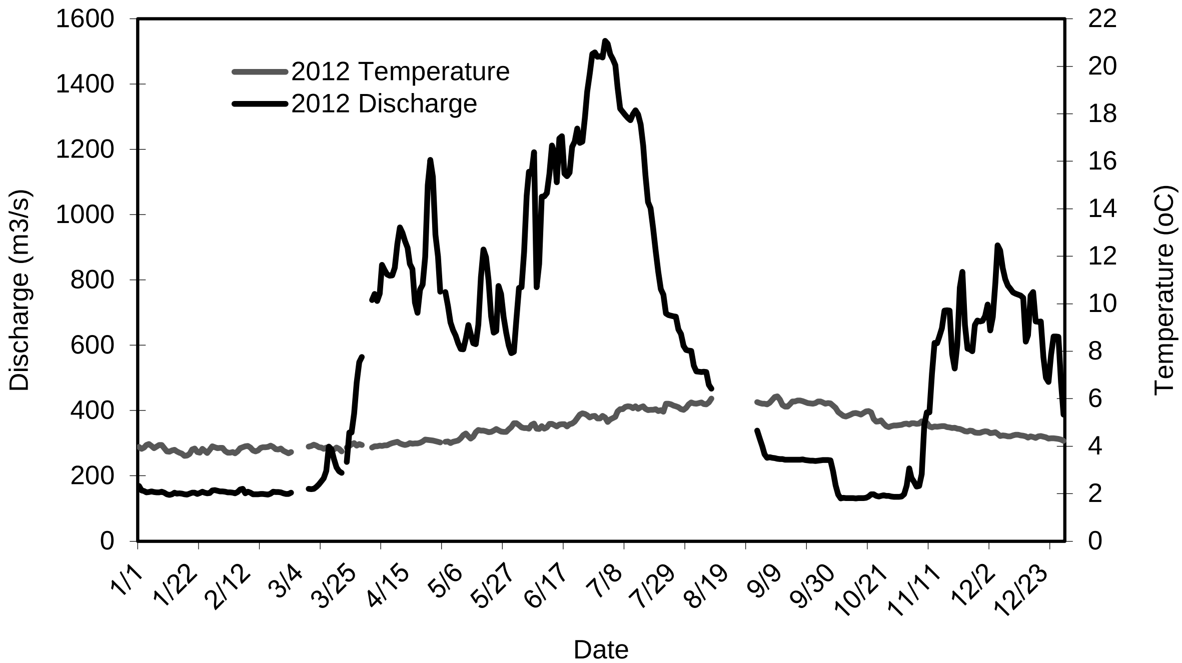
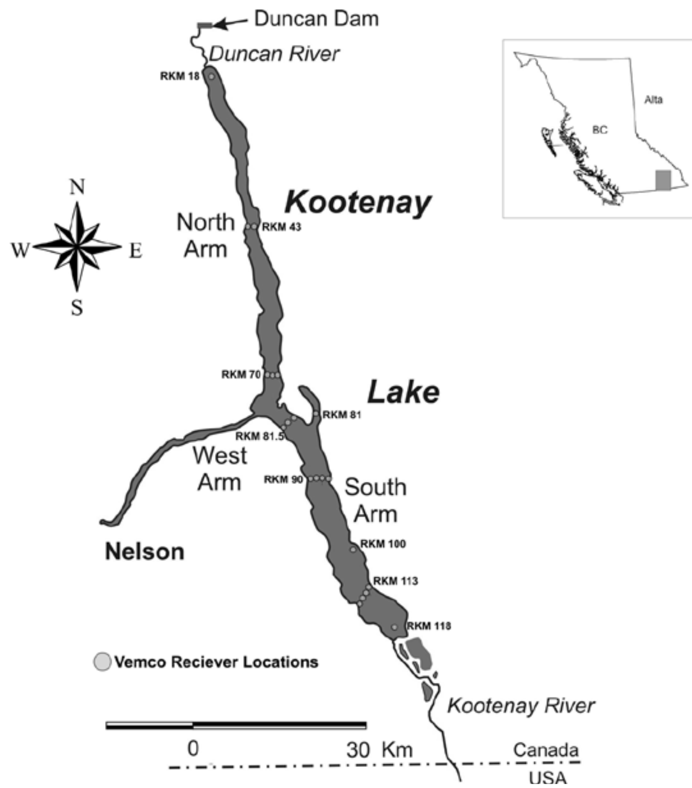


Figure 1.3. Mean daily discharge (m^3/sec) and temperature (°C) for Kootenai River at Bonners Ferry, Idaho, 2012.



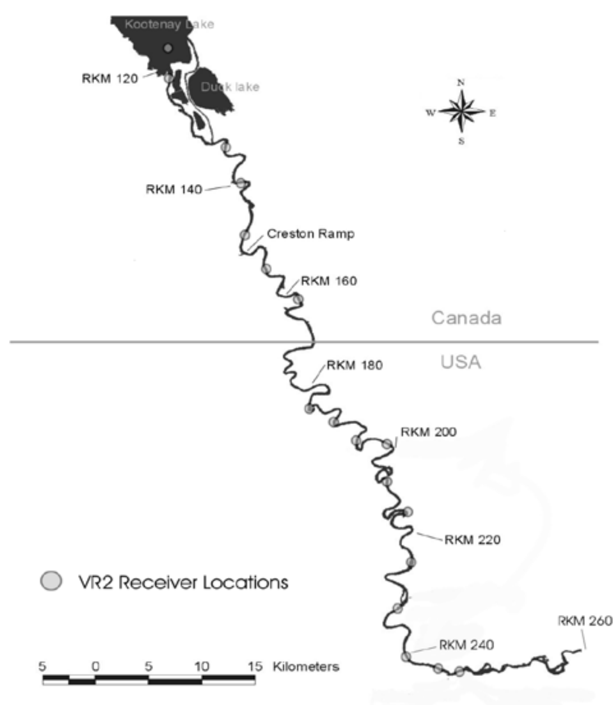


Figure 1.4. Location of Vemco VR2 receivers in Kootenai River/Lake system, Idaho and British Columbia, Canada, 2012 (receivers locations are depicted by circles).

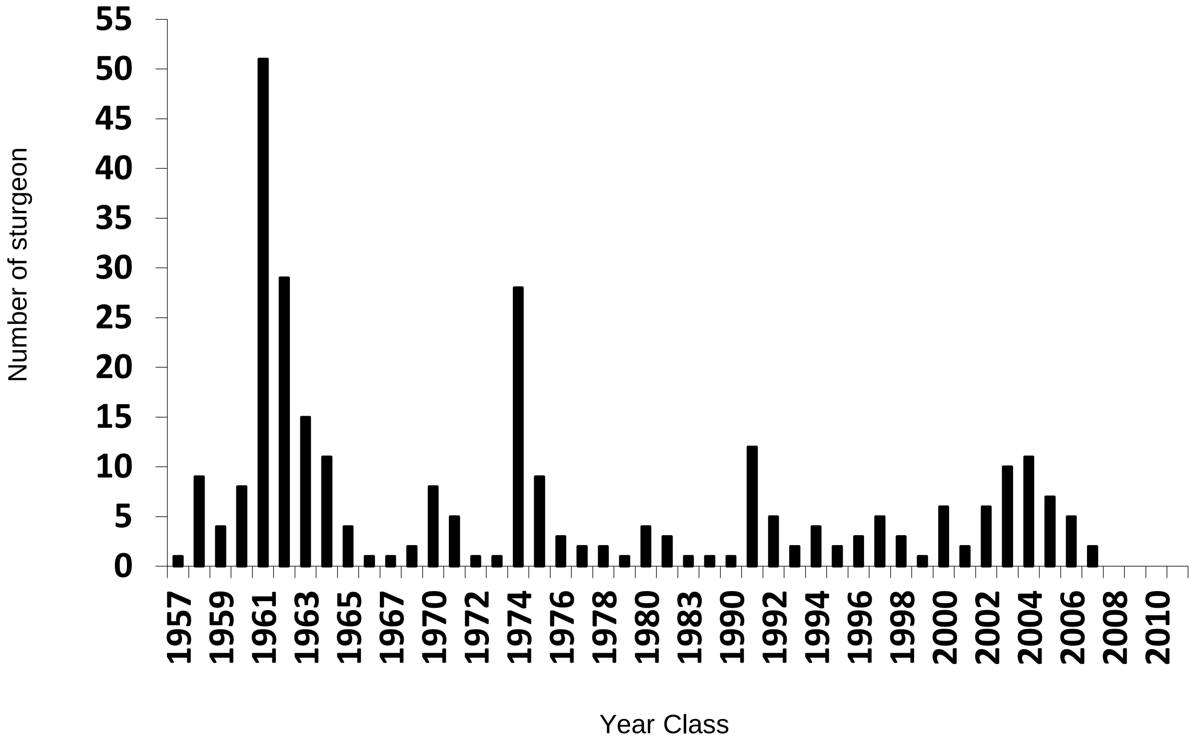


Figure 1.5. Number of wild juvenile White Sturgeon by age class captured in the Kootenai River, Idaho 1977-2012.

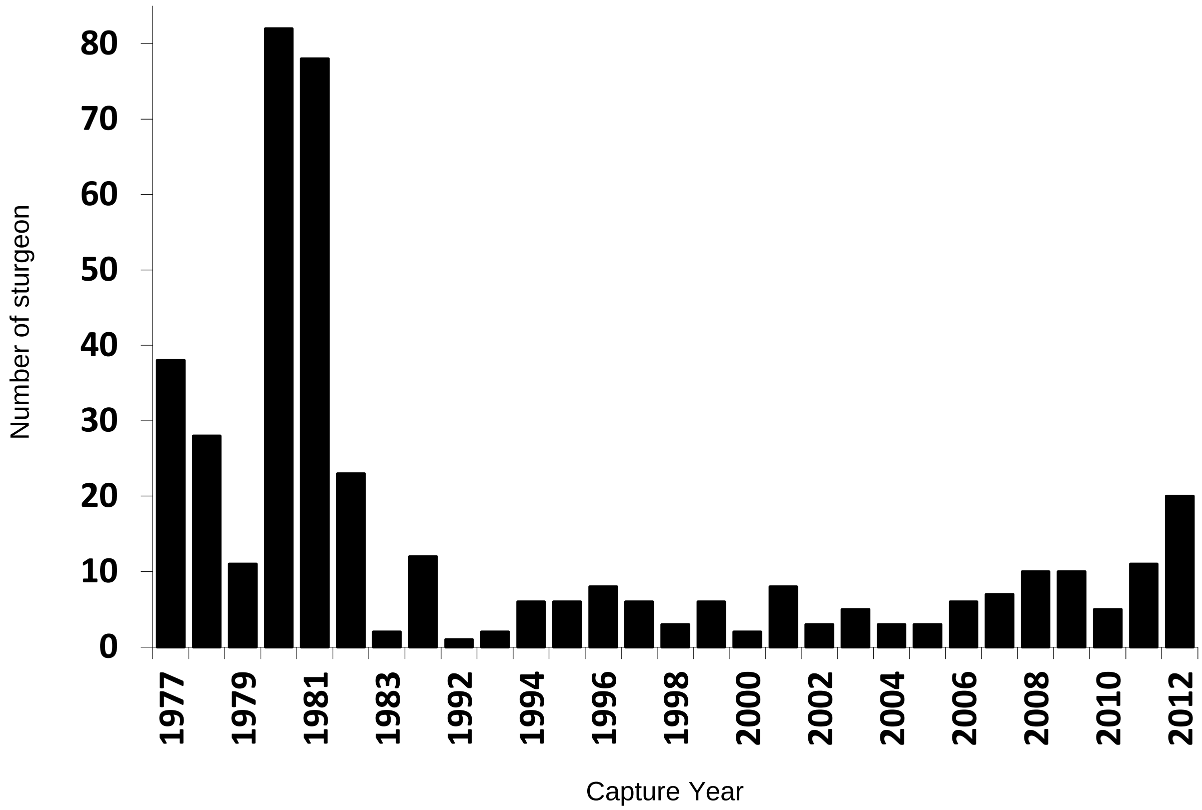
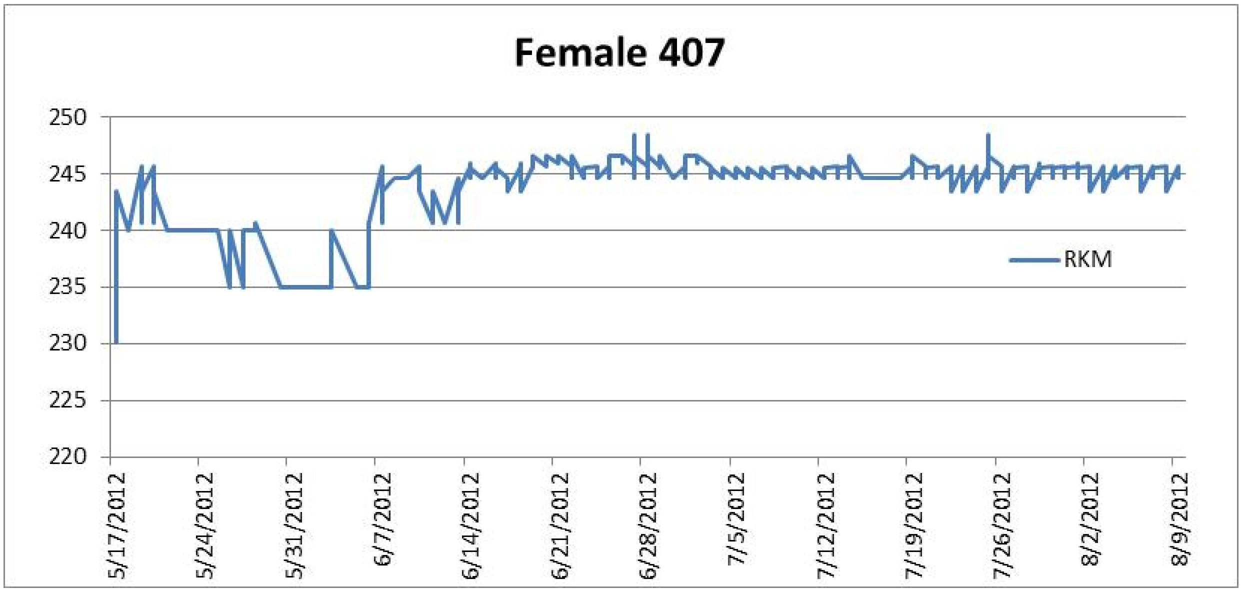
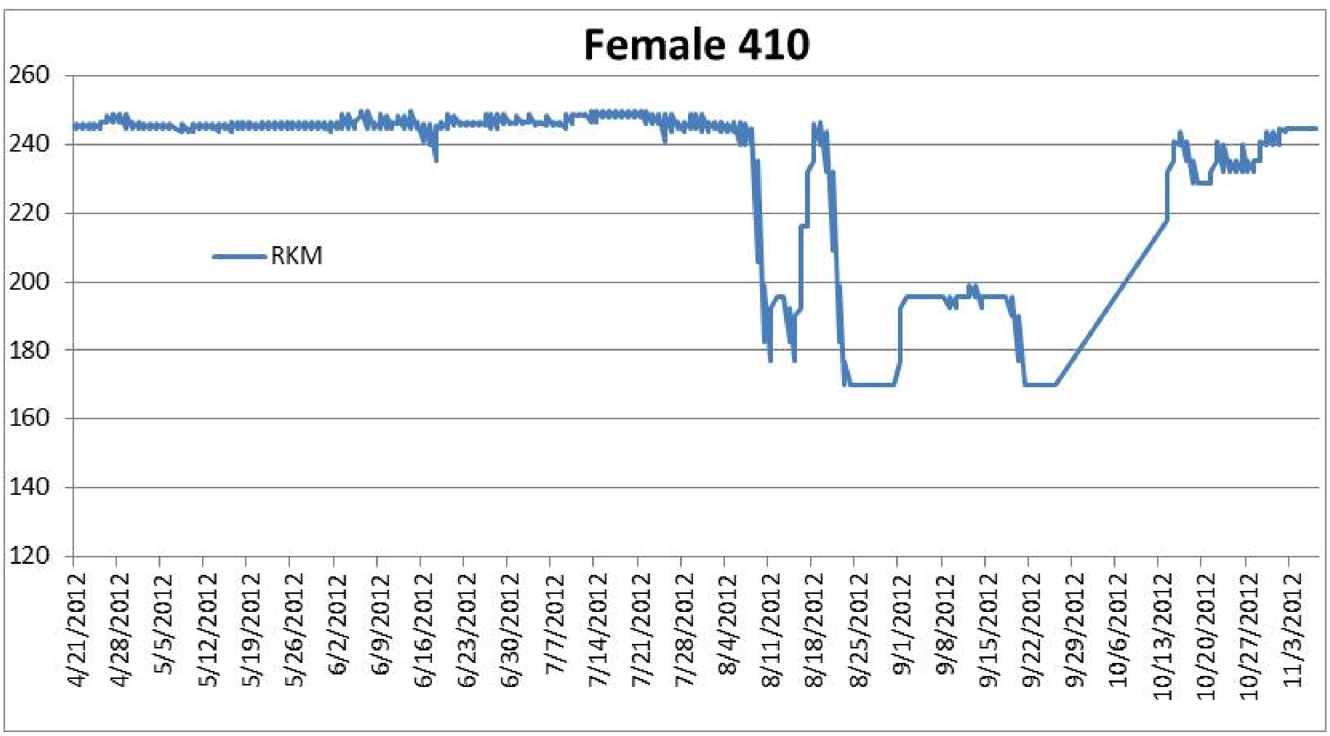


Figure 1.6. Number of wild juvenile White Sturgeon captured annually in the Kootenai River, Idaho, 1977-2012.

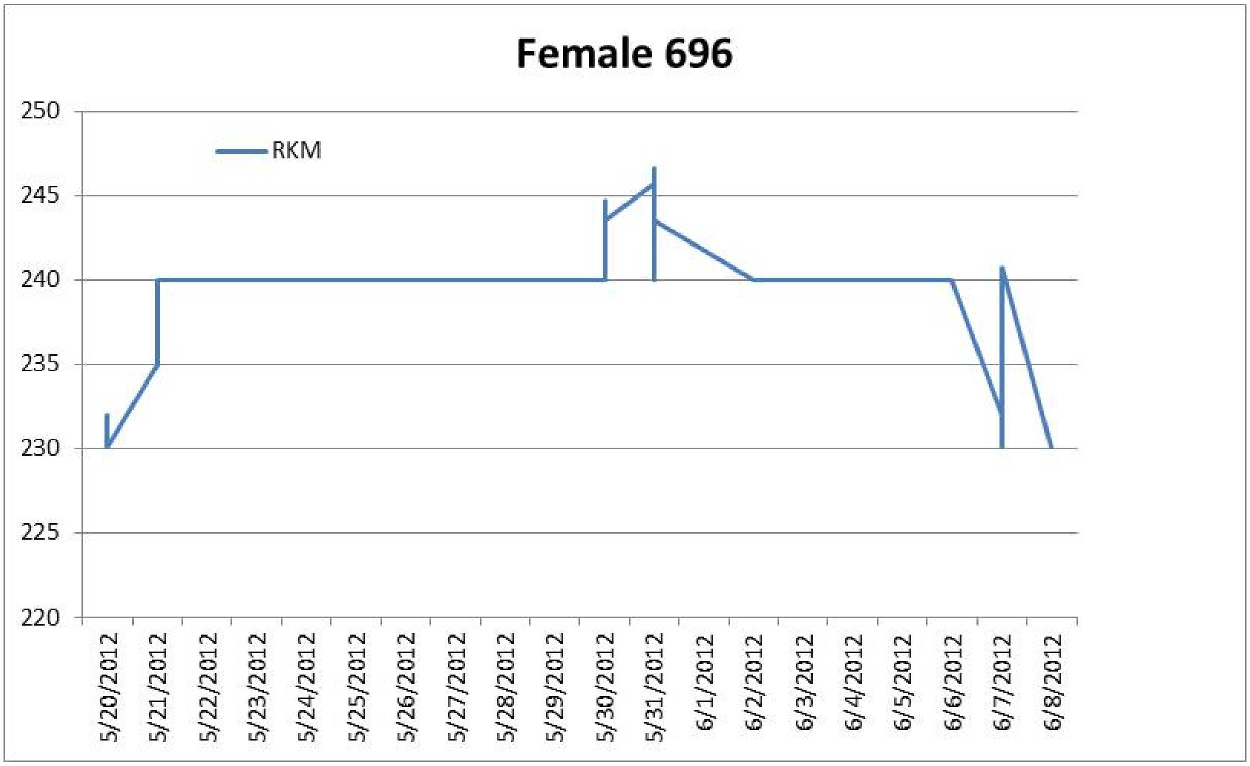
APPENDICES

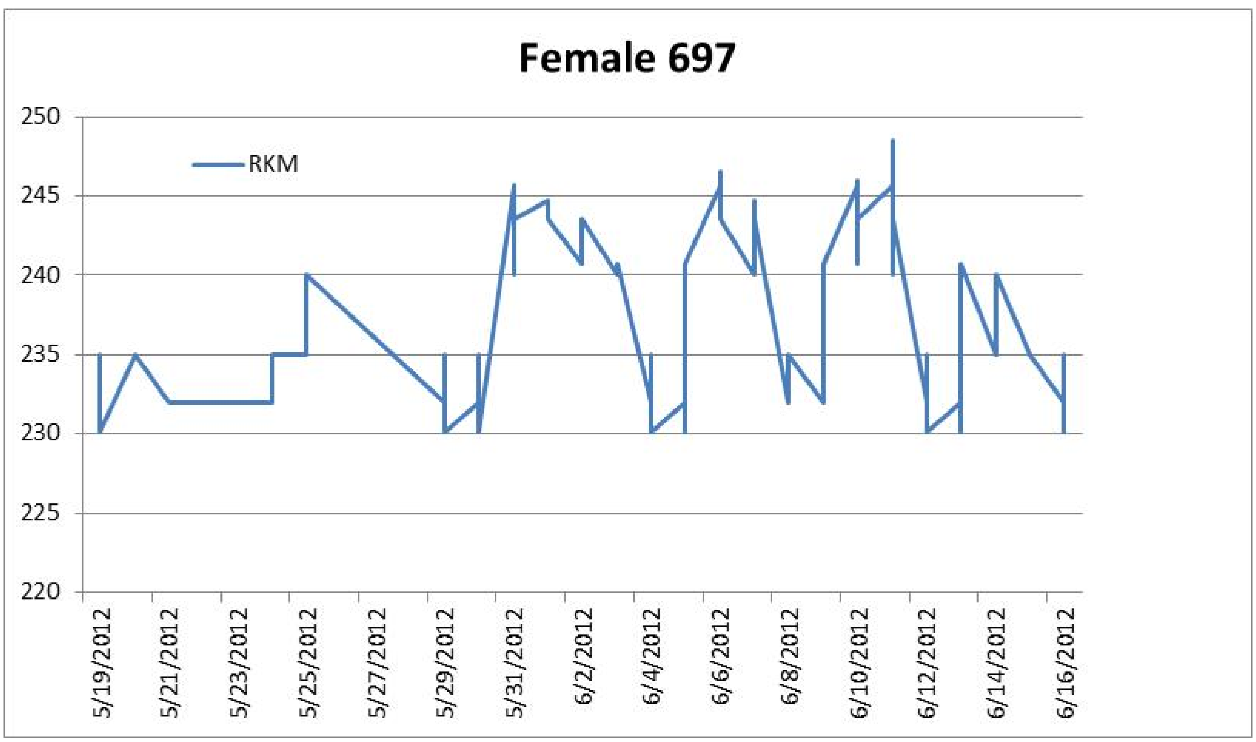
Appendix 1.1. Movement histories of six female White Sturgeon that migrated above Bonners Ferry and were expected to spawn in the Kootenai River in 2012.



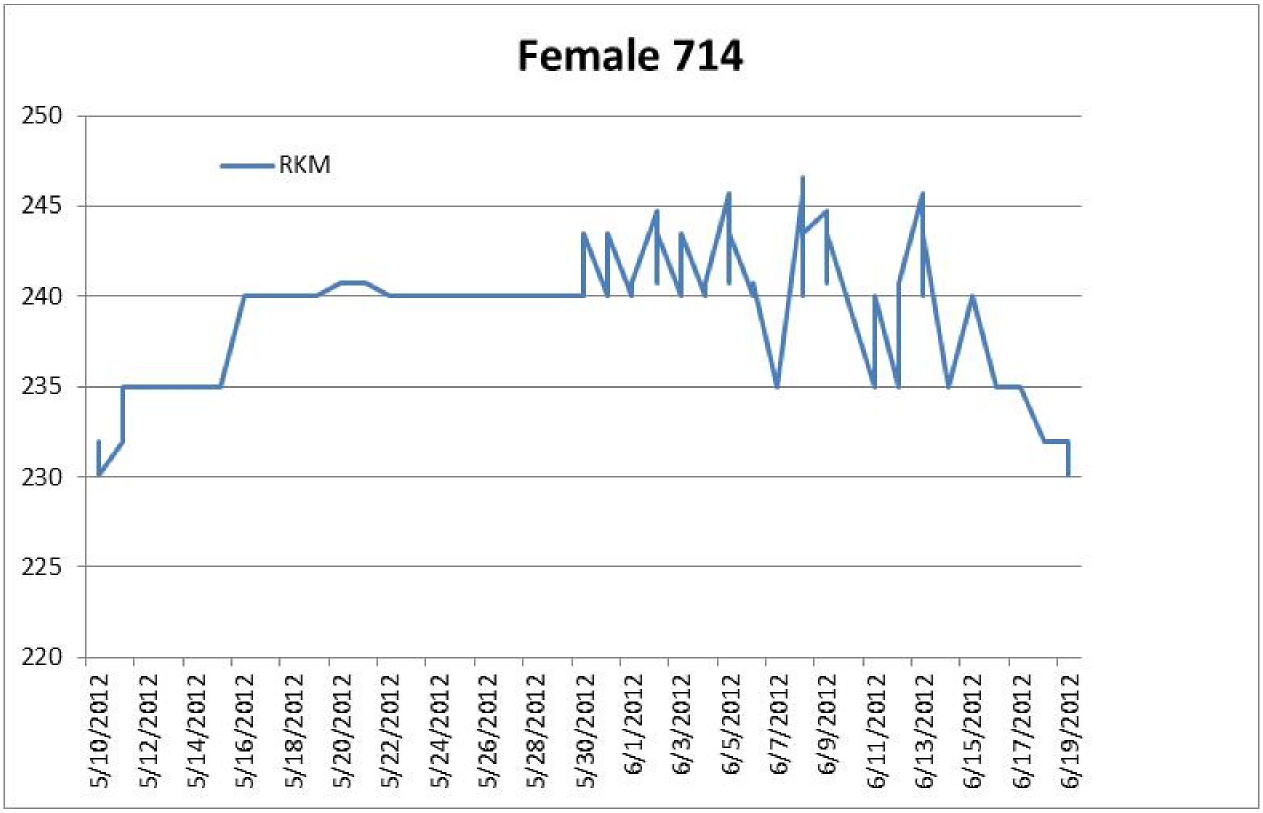


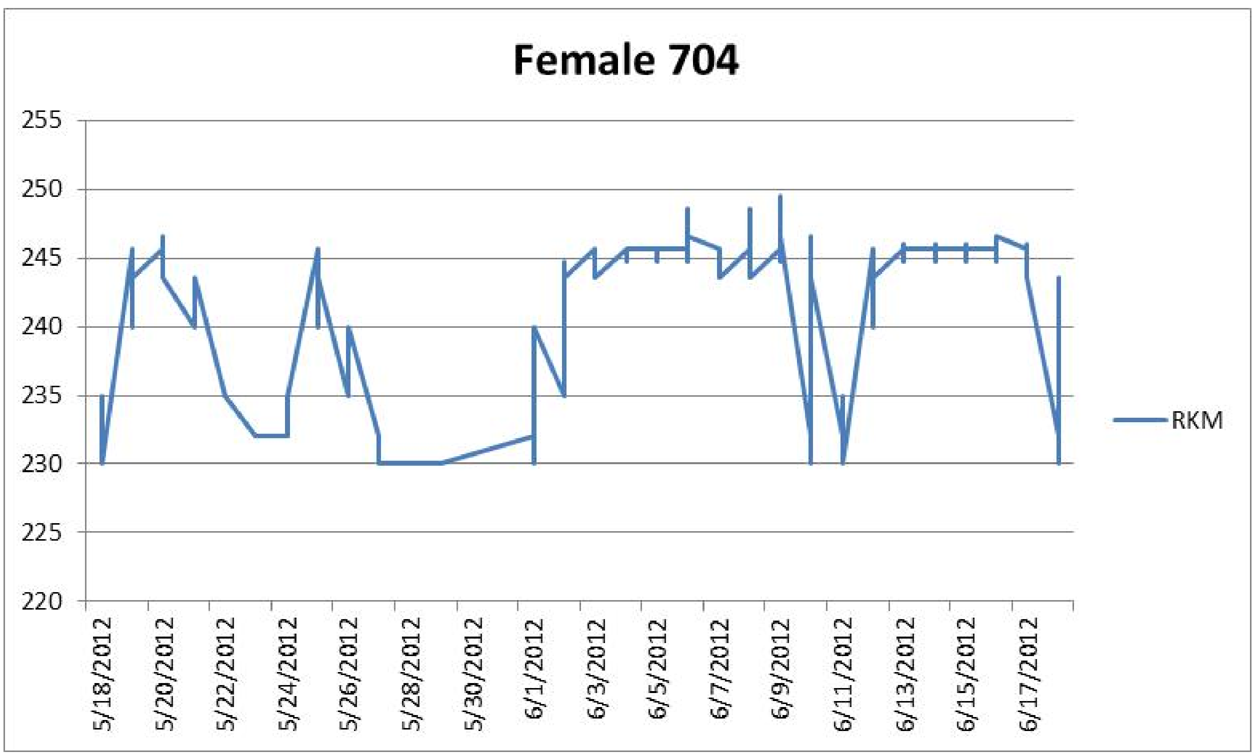
Appendix 1.1. Continued.





Appendix 1.1. Continued.





Appendix 1.2. Chronology of released and hatchery-bound White Sturgeon free embryo in 2012, Kootenai River.

1st Hatch Date	Family #	Parents		# Fert. Eggs Inc. at Hatchery	% Neur.	# KT FE	KT Larvae Held to Rear at Hatchery	# Eggs for Cryopreserva-tion or Larval Behavior Exp. (# not incl. in "# Eggs" column)	# Larvae Released	Release Date & Rkm/ Site	Release Coords.		Water Temp C	Leonia Disch. (cfs)	Stage (ft.)	Sec-chi (m)	Velocity (m/s)		
		Female (Fish #)	Male (Fish #)								Lat.	Long.					Surf	.2	.8
6/6	KT2B00-1	1BF273 1043	1BF2782B00	10,500	90	9,450	9,450	0	0										
	RRF04B-1		1BF26FF04B	63.,000	96	60,438	0		60,438	6/11 251.0	48.42 .017	116.15 .057	8	39,000	21.59	1.8	1.7	1.6	1.9
	KTF04B-1			10,500	94	9,870	9,870		0										
	KTFO4B-2	1BF272 FBF1		10,750	96	10,320	10,320		0										
	RRF04B-2			50,525	93	46,988	0		46,988	6/11 251.0	48.42 .017	116.15 .057	8	39,000	21.59	1.8	1.7	1.6	1.9
6/7	KT90D2	1BF2724 86C1	1BF27490D2	11,025	15	1,650	1,650	0	0										
	RR90D2			82,050	10	7,305	7,305												
	KT2B00-2		1BF2782B00	11,025	96	10,584	10,584												
	KTC0B0		1BF272C0B0	11,025	89	9,813	9,813												
6/8	KT C523	1BF273 0A06[a]	1BF274C523	11,000	90	9,900	9,900	0	0										
	RR C523-1			49,500	95	47,025	0		47,025	6/11 251.0	48.42 .017	116.15 .057	8	39,000	21.59	1.8	1.7	1.6	1.9
6/14	RR7235	1BF274 6CF3[b]	1BF2737235	37,800	98	37,044	0	0	37,044	6/18 255.0	48.42 .241	116.12 .460	9	40,500	21.90	1.0	0.11	0.15	0.25
	KT7235			10,500	91	9,555			9,555										
	RR2C27-1		1BF2782C27	36,750	89-99	34,493			34,493										
6/15	RRFD8A	1BF272 F4FA	1BF277FD8A	39,900	0	0	0	0	0										

1st Hatch Date	Family #	Parents		# Fert. Eggs Inc. at Hatchery	% Neur.	# KT FE	KT Larvae Held to Rear at Hatchery	# Eggs for Cryopreserva-tion or Larval Behavior Exp. (# not incl. in "# Eggs" column)	# Larvae Released	Release Date & Rkm/ Site	Release Coords.		Water Temp C	Leonia Disch. (cfs)	Stage (ft.)	Sec-chi (m)	Velocity (m/s)		
		Female (Fish #)	Male (Fish #)								Lat.	Long.					Surf	.2	.8
	KT2C27-1		1BF2782C27	10,500	92	9,660	9,660		0										
	RR2C27-2			50,400	92-96	47,964	0		47,964	6/18 255.0	48.42 .241	116.12 .460	9	40,500	21.90	1.0	0.11	0.15	0.25
6/22	KT13DB	1BF26F F621	1BF27813DB	11,250	89	10,012	10,012	2,500	0	6/26 270.0			11.9	48,100	23.46				
	RR 13DB			75,000	92-96	70,400	0		70,400										
	KT5021-1	1BF274 E47A	1BF2785021	10,105	89	8,993	8,993	3,055	0										
	RR 5021			44,415	83-95	38,764	0		38,764										
6/28	RRC523	1BF273 629B	1BF274C523	71,400	93-96	67,263	0	3,150	67,263	7/2 255.0	48.42 .241	116.12 .460	11			.9	.95	.79	.06
	KTC523			12,600	94	11,844	11,844		0										
	KT5021-2		1BF2785021	11,500	65	7,508	7,508		0										
Total				743,070		576,843	116,909	8,705	459,934										

[a] There were an additional 20,625 eggs from the pairing of female 1BF2730A06 with 1BF274F6B7 (family BCF6B7) and 20,625 eggs from the pairing of this female with 1BF272E7C2 (family BCE7C2) that were taken to the Kootenay Trout Hatchery for rearing. BC families survived.

[b] There were an additional 19,950 eggs from the pairing of female 1BF2746CF3 with 1BF2780D78 (family BC0D78) and 19,950 eggs from the pairing of this female with 1BF2782C27 (BC2C27) that were taken to the Kootenay Trout Hatchery for rearing. BC families survived.

[c] There were an additional 15,120 eggs from the pairing of female 1BF272F4FA with 1BF277FD8A (family BCFD8A) that were taken to the Kootenay Trout Hatchery for rearing. There was 0% survival.

Appendix 1.3. Number of hatchery produced White Sturgeon juveniles released into the Kootenai River and Kootenay Lake in Idaho, Montana, and British Columbia, 1992 through Oct. 25, 2012 hatchery releases.

Year class	***Rearing facility*** [a]	***Release number***		***Mean total length (mm) (SD[b])***	***Mean weight (g) (SD[b])***	***Release season & year***
		Tagged	***Untagged***			
1990	KT	14	0	457 (53)	321 (112)	Summer 1992
1991	KT	104	0	255 (17)	66 (13)	Summer 1992
1992	KT	123	0	483 (113)	549 (483)	Fall 1994
1995	KT	1,075	0	228 (27)	47 (17)	Spring 1997
1995	KT	884	0	344 (44)	148 (64)	Fall 1997
1995	KT	96	0	411 (68)	288 (138)	Summer 1998
1995	KT	25	0	582 (40)	863 (198)	Summer 1999
1998	KT	309	0	260 (42)	79 (44)	Fall 1999
1999	KT	828	0	256 (22)	71 (18)	Fall 2000
1999	KH	1,358	0	248 (33)	67 (28)	Fall 2000
1999	KT	491	0	284 (54)	108 (60)	Spring 2001
1999	KH	1,583	0	306 (40)	56 (39)	Spring 2001
1999	KH	1	0	520[j]	980	Spring 2010
2000	KT	2,286	0	244 (39)	64 (31)	Fall 2001
2000	KH	1,654	0	240 (23)	58 (16)	Fall 2001
2000	KH	2,209	0	283 (29)	99 (30)	Spring 2002
2000	KH	30	0	365 (14)	195 (20)	Summer 2002
2000	KT	214	0	409 (54)	294 (110)	Fall 2002
2000	KT[c]	907	0	333 (36)	193 (63)	Jan. 2003
2000	KT[d]	10	0	558 (28)	88 (18)	Feb. 2004
2000	KT[e]	3	0	662 (61)	425 (66)	Summer 2006
2001	KT	2,672	0	200 (38)	33 (16)	Fall 2002
2001	KH	4,469	0	227 (24)	52 (17)	Fall 2002
2001	KH	1,715	0	257 (26)	72 (24)	April 2003
2001	KT[e]	1	0	570	750	Summer 2006
2001	KH[e]	1	0	560[j]	1152	Spring 2009
2002	KH	5,864	0	217 (25)	41 (14)	May 2003
2002	KT	856	0	214 (44)	42 (23)	Oct. 2003
2002	KT[f]	550	0			Nov. 2003
2002	KT	3,852	0	215 (37)	43 (20)	Winter 2003
2002	KT	3,663	0	214 (55)	43 (27)	Winter 2003-2004
2002	KT[e]	1	0	550	740	Summer 2006
2002	KH	3	0	523(25)[j]	1073(145)	Spring 2010
2002	KH	1	0	530	1020	Spring 2012
2003	KH	9,020	0	223 (26)	49 (24)	Spring 2004
2003	KH[g]	19	0	230 (27)	52 (19)	Sept. 2004
2003	KT	3,519	0	227(47)	55 (32)	Late winter 2004

Year class	Rearing facility [a]	Release number		Mean total length (mm) (SD[b])	Mean weight (g) (SD[b])	Release season & year
		Tagged	Untagged			
2003	KT[e]	3	0	437 (27)	347 (49)	Summer 2006
2003	KT	1	0	690	[f]	Winter 2011
2004	KT[h]	0	3,000			Fall 2004
2004	KT[h]	0	1,275			Late wtr '04-early wtr '05
2004	KT[h]	0	17,723			Spring 2005
2004	KH[i]	1,238	800	196 (28)[j]	57 (33)	Spring 2005
2004	KH[h]	0	3,440			Spring 2005
2004	KT[h]	0	8,637			Summer 2005
2004	KT	1	0	510	490	Winter 2007
2004	KH[e]	5	0	452(23)[j]	563(116.5)	Spring 2009
2005	KT[h]	0	6,200			Fall 2005
2005	KH[k]	14	0	299 (14)[j]	174 (28)	Spring 2006
2005	KH	1,762	0	198 (25)[j]	54 (22)	Spring 2006
2005	KH[h]	0	13,665			Spring 2006
2005	KT[h]	0	3,947			Spring 2006
2005	KT[l]	510	0	171(47)	27 (20)	Fall 2006
2005	KH[e]	1	0	330[j]	225	Spring 2009
2005	KH	2	0	400(34)[j]	414(132)	Spring 2010
2005	KH	2	0	500(42.4)	860(197)	Spring 2012
2006	KH[h]	0	6,900			Fall 2006
2006	KH[i]	0	600	149 (11)[j]	23 (5)	Fall 2006
2006	KT[h]	0	6,175			Fall 2006
2006	KH[h]	0	5,800			Spring 2007
2006	KH[i]	1,877	1,000	182 (15)[j]	44 (12)	Spring 2007
2006	KT[h]	0	12,973			Spring 2007
2006	KT	4,922	0	171 (30)	22 (11)	Winter 2007
2006	KH	1	0	390[j]	220	Spring 2010
2007	KH	2,167	0	241(24)[j]	92(27)	Spring 2008
2007	KT[i]	884	203	151(36)	20(10)	Fall 2008
2007	KT	7	0	455(46)	426(12)	Winter 2011
2008	KH	9,982	0	198(35)[j]	56(19)	Spring 2009
2008	KT[m]	3,875	882	194(52)	32(19)	Fall 2009
2008	KT	3	0	412(29)	276(74)	Winter 2011
2008	KH	1	0	430	555	Spring 2012
2009	KH	7,884	0	207(42)[j]	67(22)	Spring 2010
2009	KT[h]	5,343	808	218(39)	45(23)	Fall 2010
2010	KH	5,759	0	197(25)[j]	58(22)	Spring 2011
2010	KT	7,785	1,825	230(40)	56(29)	Winter 2011
2011	KH	11,243	0	202(20)[j]	56(22)	Spring 2012
2011	KT	10,280	907	244(34)	62(27)	Fall 2012

Year class	*Rearing facility [a]*	*Release number*		*Mean total length (mm) (SD[b])*	*Mean weight (g) (SD[b])*	*Release season & year*
		Tagged	*Untagged*			
Subtotal		125,962	96,760			
Total		**222,722**				

[a] Kootenai Tribal Hatchery in Idaho (KT) or Kootenay Hatchery in British Columbia (KH).
[b] Standard deviation.
[c] Ten fish from this group held-over for later upriver release with transmitters.
[d] These 10 fish were released upriver (rkm 306.5) with sonic and radio tags.
[e] These fish were held over for later release (2006-released with Vemco tags).
[f] No measurements available for these fish; exact number not known.
[g] These fish were first taken to Kokanee Creek Provincial Park, then released in Sept.'04.
[h] The untagged fish were not given a PIT tag or measured.
[i] The untagged fish did not have a PIT tag added and were all given fish #999.
[j] Value given is for mean fork length (mm).
[k] These fish were released upriver (299.0 and 258.7), 6 of them with Vemco sonic tags.
[l] There were 200 fish held over at KT hatchery for Biopar study.
[m] Includes KT "Childrens' Release" 11/2009.

Appendix 1.4. Year class, number captured, capture locations, fork length (cm), total length (cm), and weight (kg) of hatchery released juvenile sturgeon captured with gill net from Kootenai River, Idaho, through 2012.

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
1990	1	120.0	76.5	88.0	3.00
	4	205.0	61.0-81.4	74.0-95.0	1.75-2.70
	1	208.0	87.0	104.0	7.0
	2	215.4	55.4-66.2	66.2-78.1	1.86
	1	215.6	65.2	76.0	2.00
	1	215.7	69.0	82.0	2.25
	1	225.1	65.8	77.0	1.95
	1	306.5	85.6	100.7	4.1
	1	Unknown	66.5	76.1	1.95
1991	1	118.0	95.0	110.5	5.65
	3	119.0	73.0-85.0	85.5-98.0	1.10-4.50
	1	119.5	75.0	88.5	--
	5	120.0	63.0-107.0	73.5-126.0	1.60-8.0
	6	121.0	67.0-95.0	77.2-92.0	2.10-4.65
	1	134.0	82.0	94.5	4.1
	1	140.0	70.4	83.2	--
	1	190.0	70.0	83.0	2.20
	1	192.0	35.1	40.8	0.16
	1	203.4	56.0	64.0	1.05
	4	203.5	52.0-72.0	61.0-83.0	0.95-2.70
	1	204.5	64.0	76.0	--
	1	204.7	60.0	68.8	1.36
	22	205.0	26.5-84.0	30.5-100.0	0.11-3.60
	1	205.4	51.0	60.0	1.10
	4	205.5	47.0-76.0	56.0-89.1	0.69-3.10
	1	207.0	81.0	96.5	3.70
	5	215.0	40.0-53.0	47.0-62.0	0.14-0.70
	1	215.3	47.0	56.0	0.70
	1	215.4	64.2	75.4	2.15
	18	215.5	46.0-74.0	54.0-85.1	0.21-2.85
	8	215.6	41.0-57.0	48.0-66.2	0.43-1.80
	4	215.7	39.0-61.0	46.0-72.0	1.05-1.60
	3	216.0	44.0-53.0	51.0-61.0	0.50-0.88
	1	217.1	33.0	42.0	0.49
	1	224.6	48.0	58.0	0.65
	1	224.7	46.0	55.0	0.70
	2	224.9	42.0-73.5	50.0-84.8	0.45-2.80
	10	225.0	38.0-60.5	45.0-70.0	0.40-1.65
	3	225.1	39.0-49.6	46.0-58.0	0.40-0.78
	2	225.5	50.0-52.0	55.0-61.0	1.90-1.95
	1	227.0	36.0	43.0	0.52
	2	227.5	63.0-73.0	74.0-88.0	2.0-3.0
	1	244.5	--	35.0	0.07

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
1992	1	18.0	120.0	137.0	28.0
	3	118.0	80.0-97.5	95.0-110.0	3.4-5.95
	4	119.0	61.0-102.0	69.0-118.0	1.20-5.5
	5	120.0	45.0-104.0	52.0-123.0	2.20-8.0
	3	121.0	77.0	92.0	3.19
	1	122.5	130.0	151.0	20.0
	3	123.0	78.0-101.0	90.5-124.0	3.3-6.95
	1	134.0	77.1	90.5	2.95
	2	161.0	67.3-87.5	77.5-110.0	2.10-4.2
	1	174.3	56.0	62.0	1.06
	1	182.5	51.5	59.0	0.78
	1	190.3	61.2	71.0	1.53
	1	190.4	73.0	86.0	4.25
	1	203.4	74.0	85.0	5.20
	4	203.5	52.0-66.0	62.0-75.0	1.55-1.90
	1	204.0	59.0	69.5	1.50
	1	204.3	64.5	75.0	1.77
	1	204.7	65.8	75.6	1.60
	17	205.0	49.0-68.6	58.0-79.2	2.00
	1	205.3	50.0	90.0	1.80
	2	205.4	62.0-65.3	75.0-75.2	1.83
	6	205.5	49.0-69.0	57.0-79.1	0.20-3.50
	1	205.6	54.0	64.0	--
	1	208.0	70.4	79.4	1.90
	1	210.5	66.3	75.6	1.80
	1	215.0	50.0	59.0	0.70
	2	215.1	59.0-67.90	67.5-81.0	1.11-2.10
	1	215.3	58.0	66.5	1.20
	14	215.5	50.2-74.3	57.9-87.4	0.11-2.44
	8	215.6	45.0-62.0	52.0-75.0	0.48-2.40
	6	215.7	42.0-66.0	49.0-77.0	1.05-2.30
	1	215.8	57.0	65.0	1.08
	1	215.9	63.0	75.0	1.35
	2	216.0	49.0-67.5	56.0-78.6	0.70-1.78
	1	216.9	64.0	75.0	2.3
	2	217.1	30.0-36.0	35.0-44.0	0.35-0.51
	1	224.5	56.5	66.5	1.16
	2	224.9	50.0-69.5	61.0-80.5	1.30-1.68
	9	225.0	31.0-78.0	37.0-94.0	0.35-2.94
	5	225.1	47.0-62.0	56.0-73.0	0.60-1.30
	1	227.0	66.0	80.0	1.70
	1	227.4	59.1	62.0	1.00
	1	227.8	42.0	49.0	0.90
	2	229.0	46.0	55.0	0.55
	1	231.0	66.0	77.0	2.0
	1	231.1	71.0	85.0	2.3
	1	306.0	72.2	82.5	2.45

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
1995	1	17.0	125.0	146.0	14.5
	3	18.0	99.5-122.5	121.0-141.5	7.5-11.7
	5	118.0	63.1-74.0	72.6-84.6	1.8-3.05
	3	119.0	49.0-58.0	56.5-67.1	0.70-1.27
	30	120.0	56.5-96.0	65.5-107.0	0.82-5.40
	32	121.0	43.9-108.0	50.0-126.0	0.53-7.2
	1	122.5	131.0	147.5	18.5
	8	123.0	65.2-88.5	70.1-100.2	1.30-5.35
	8	130.0	38.0-95.0	43.9-105.0	0.46-5.45
	3	134.0	49.0-70.5	57.0-81.3	0.73-2.4
	1	137.0	50.9	59.2	0.76
	1	141.0	53.8	60.4	0.83
	1	144.3	39.8	45.3	0.38
	2	144.5	29.0-45.5	33.5-52.0	0.14-0.56
	5	145.0	42.5-85.1	50.0-99.7	0.50-4.6
	1	150.0	88.5	100.0	4.25
	1	157.0	54.1	62.6	0.99
	1	157.5	33.2	37.3	0.18
	3	161.0	45.6-51.0	51.8-59.5	0.44-.70
	2	163.0	35.2-49.1	41.7-56.9	0.24-0.73
	1	165.0	92.0	103.0	5.0
	1	174.2	58.8	67.9	1.04
	1	174.5	52.4	60.7	0.77
	1	176.0	33.9	40.0	0.20
	4	176.3	24.7-49.3	40.0-58.1	0.15-0.68
	4	176.4	42.5-51.0	50.0-59.0	0.42-0.71
	2	176.5	39.3-44.1	46.2-53.0	0.33-0.48
	2	177.3	37.9-45.0	43.7-52.0	0.28-0.49
	1	184.9	44.2	51.0	0.31
	2	185.0	39.1-58.3	43.3-68.5	0.33-1.25
	1	189.9	51.5	59.5	0.74
	23	190.0	31.0-72.0	36.0-83.9	0.15-2.21
	4	190.1	36.8-54.0	43.9-63.5	0.28-0.87
	2	190.3	27.2-48.5	31.7-56.0	0.15-0.63
	1	190.4	43.0	50.5	0.47
	3	190.5	53.3-62.4	62.4-73.1	0.90-1.53
	1	191.9	35.7	41.3	0.20
	2	192.0	34.7-61.4	38.2-71.8	0.18-1.49
	1	192.1	36.1	42.0	0.25
	1	193.0	65.0	75.5	1.61
	3	193.2	57.8-69.9	67.7-79.5	1.14-2.31
	3	195.7	35.5-50.0	42.0-57.0	0.24-0.65
	2	195.8	47.5-49.0	55.5-57.0	0.64-1.34
	1	195.9	43.0	50.5	0.42
	1	203.3	39.3	45.5	0.34
	2	203.4	33.2-37.0	38.5-42.9	0.25-0.36
	7	203.5	36.5-49.8	42.5-57.5	0.28-0.60
	6	204.0	37.9-61.0	43.5-70.0	0.27-1.39

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	204.1	39.0	45.0	0.35
	1	204.3	44.0	51.0	0.35
	3	204.7	43.0-54.3	49.8-63.6	0.43-1.00
	5	204.8	35.4-50.3	41.2-58.4	0.26-0.67
	7	204.9	35.2-48.0	41.2-55.2	0.20-0.62
	178	205.0	30.8-99.0	35.0-114.0	0.13-8.0
	3	205.3	38.0-50.0	44.0-51.0	0.30-0.76
	10	205.4	36.0-50.5	42.2-58.5	0.28-0.78
	33	205.5	26.0-62.1	31.0-71.8	0.08-1.50
	26	207.0	45.8-96.0	52.5-111.0	0.54-7.0
	17	207.5	44.6-72.0	51.3-84.0	0.46-1.99
	2	207.8	28.4-39.5	33.0-45.9	0.15-0.3
	1	208.0	70.0	82.0	--
	3	213.2	37.0-58.1	43.0-67.0	0.30-1.17
	1	213.5	58.6	67.6	1.13
	56	215.0	33.1-70.0	37.8-81.1	0.10-3.0
	9	215.1	36.1-49.5	41.1-58.2	0.25-0.69
	6	215.2	25.0-47.0	30.0-55.5	0.05-0.55
	23	215.4	31.2-49.0	36.5-56.4	0.20-0.75
	150	215.5	25.5-64.8	29.1-74.0	0.06-1.32
	41	215.6	30.0-48.9	34.2-56.8	0.13-0.60
	61	215.7	25.0-54.8	29.0-63.8	0.05-0.93
	9	215.8	25.0-50.2	30.0-58.4	0.08-0.68
	2	216.0	40.5-45.6	47.3-52.5	0.39-0.53
	4	219.0	22.0-58.4	25.3-67.4	0.10-1.18
	2	219.8	28.7-33.5	33.5-39.0	0.13-0.25
	1	220.0	32.5	38.0	0.24
	5	222.0	25.9-30.5	30.0-35.0	0.20-0.30
	1	222.7	33.0	38.2	0.20
	1	224.0	61.2	70.9	1.32
	1	224.5	39.0	45.4	0.34
	4	224.6	29.4-37.4	33.0-42.0	0.15-0.35
	13	224.7	29.8-50.9	34.4-58.7	0.16-0.95
	16	224.8	31.9-50.1	36.2-59.3	0.18-0.76
	24	224.9	30.4-64.0	34.2-74.0	0.15-1.70
	112	225.0	21.0-66.6	24.0-78.0	0.05-4.0
	34	225.1	28.0-55.4	32.0-64.2	0.09-1.20
	2	225.2	24.0-27.0	28.0-32.0	0.05
	1	225.4	37.1	43.0	0.20
	1	226.1	45.3	52.3	0.53
	5	227.0	29.5-51.0	33.5-61.0	0.10-1.00
	3	227.2	33.0-35.0	38.0-40.5	0.20
	6	227.3	30.0-34.5	34.5-39.0	0.10-0.20
	11	227.4	22.7-41.4	33.0-48.6	0.10-0.45
	2	227.8	48.3-51.5	54.8-60.2	0.65-0.78
	1	229.0	59.0	69.0	5.0
	1	229.7	46.3	53.5	0.55
	2	229.8	39.9-42.3	46.6-50.1	0.35-0.38

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	230.0	64.0	75.0	--
	1	230.5	51.5	60.3	0.75
	2	230.8	29.0-36.3	35.0-41.3	0.13-0.25
	3	230.9	27.9-47.5	32.3-55.0	0.13-0.68
	1	234.1	38.0	44.4	0.30
	1	234.2	66.0	77.0	1.0
	3	234.3	33.2-35.0	37.0-39.0	0.16-0.19
	2	234.4	25.0-37.0	29.0-42.0	0.09-0.20
	5	234.5	224.0-52.0	27.0-60.2	0.06-0.83
	1	235.5	34.2	39.0	0.21
	1	236.0	33.2	38.8	0.20
	1	237.0	48.9	55.7	0.60
	1	241.5	31.0	36.0	0.14
	3	244.0	56.8-66.0	66.2-76.3	0.98-1.67
	10	244.4	24.9-44.0	28.8-50.5	0.06-0.55
	19	244.5	24.8-66.0	33.3-78.5	0.10-1.50
	2	244.6	31.5-33.0	36.6-38.8	0.13-0.20
	1	244.7	--	61.4	0.85
	1	244.8	45.1	52.6	0.60
	3	245.0	46.4-63.7	67.0-73.6	1.02-1.08
	1	257.4	67.3	77.1	1.93
	2	278.8	61.3-75.5	71.4-88.0	1.49-2.81
	1	285.0	65.3	75.1	1.54
	1	301.3	87.3	99.6	6.15
	5	305.0	87.0-95.8	98.5-109.0	5.12-6.98
	2	305.5	68.7-78.0	79.2-87.8	2.12-3.04
	1	306.0	68.0	78.0	1.87
	8	306.5	64.0-104.0	73.5-117.0	1.65-10.02
	11	Unknown	21.5-83.3	25.5-96.3	0.06-4.19
1998	2	120.0	71.0	83.0	2.5
	1	121.0	88.0	102.0	4.75
	1	145.0	28.5	31.1	0.13
	1	150.0	56.6	66.5	1.10
	1	193.5	50.0	57.6	0.71
	1	204.0	38.4	44.4	0.28
	11	205.0	30.0-59.1	35.0-69.4	0.13-1.28
	2	207.0	45.2-58.4	53.1-69.1	0.53-1.34
	1	207.5	69.0	81.0	1.58
	1	213.2	35.5	41.5	0.24
	1	213.5	37.7	43.2	0.28
	7	215.0	36.1-61.1	52.0-71.5	0.51-1.51
	6	215.5	22.6-46.6	26.7-52.5	0.08-0.34
	1	215.7	33.2	38.7	0.20
	1	224.0	32.5	38.7	0.20
	1	224.8	36.0	41.7	0.30
	6	224.9	30.0-51.0	35.1-60.2	0.12-0.83
	8	225.0	27.0-56.9	31.6-66.0	0.06-1.25
	2	225.1	27.7-27.8	32.0-32.4	0.10-0.14

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	226.1	36.1	41.8	0.28
	1	227.4	25.7	30.5	0.07
	1	227.8	28.4	33.1	0.13
	2	229.8	22.5-25.6	26.4-30.2	0.06-0.10
	1	230.0	54.0	63.7	1.10
	2	230.9	23.5-25.0	28.0-29.5	0.07-0.08
	6	244.5	40.7-76.0	47.4-90.0	0.35-4.12
	1	278.8	102.0	116.0	9.43
	1	300.3	70.3	81.5	2.37
	1	305.5	73.4	85.8	2.83
	1	306.0	72.2	82.5	2.45
	2	306.5	84.7-84.8	99.8	4.56-4.63
1999	1	18.0	110.0	130.0	9.6
	55	118.0	42.3-74.0	49.5-86.6	0.47-3.25
	2	119.0	--	39.0-45.2	0.24-0.38
	118	120.0	29.1-90.0	33.9-103.0	0.15-4.80
	137	121.0	29.5-92.0	34.0-110.0	0.16-6.10
	1	122.5	84.0	98.0	3.20
	30	123.0	32.1-81.5	37.5-95.0	0.18-3.80
	23	130.0	27.6-78.5	31.8-90.5	0.12-3.00
	9	134.0	31.3-40.5	36.5-47.0	0.17-0.38
	7	137.0	28.3-71.4	33.4-83.0	0.14-2.70
	3	141.0	48.8-83.5	57.1-97.2	0.60-3.85
	1	144.1	--	37.0	0.20
	1	144.8	53.9	62.4	0.90
	18	145.0	26.5-81.0	31.1-92.5	0.11-3.75
	1	147.0	22.4	25.9	0.10
	7	150.0	32.0-83.0	40.5-95.5	0.22-4.20
	4	152.7	37.8	39.5	0.24
	1	154.3	22.2	26.7	0.10
	2	154.5	26.4	31.2	0.10-0.12
	6	157.0	31.2-50.0	36.9-58.7	0.19-0.80
	23	161.0	27.4-86.0	31.9-101.0	0.12-3.90
	2	161.4	61.7-86.4	71.1-99.4	1.45-4.65
	2	163.0	29.0	33.7	0.15
	8	165.0	27.2-51.2	31.0-59.8	0.14-0.90
	2	167.0	32.1-32.7	37.1-38.1	0.16-0.20
	1	169.0	26.0	30.2	0.15
	4	169.6	20.8-22.7	24.5-26.5	0.05-0.10
	1	170.2	37.2	44.4	0.20
	1	173.2	--	41.5	0.30
	1	174.0	46.0	53.7	0.55
	2	174.2	45.2-51.9	52.2-59.8	0.54-0.83
	31	174.5	24.1-33.4	28.3-38.9	0.04-0.20
	1	175.2	--	31.0	0.13
	1	176.1	35.7	42.4	0.25
	1	176.4	26.5	30.5	0.10
	4	176.5	24.5-54.4	28.5-63.7	0.07-1.07

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	176.9	31.3	36.3	0.17
	5	182.0	30.1-38.5	35.6-44.5	0.15-0.29
	5	185.0	44.1-53.9	50.7-62.9	0.5-0.95
	1	189.9	29.0	34.0	0.13
	62	190.0	23.0-59.0	26.5-70.0	0.06-1.14
	2	190.1	27.0-29.0	31.0-33.0	0.10-0.14
	2	190.2	23.5-31.0	28.0-36.0	0.07-0.15
	8	190.3	27.0-41.5	31.1-49.1	0.10-0.36
	5	190.4	27.0-36.0	31.0-41.5	0.10-0.20
	3	190.5	47.1-49.5	54.6-57.4	0.57-0.69
	6	192.0	28.5-43.0	33.0-49.9	0.15-0.35
	3	193.0	46.5-49.2	54.3-57.3	0.61-0.76
	1	193.2	52.2	60.9	0.78
	2	193.5	48.3-48.7	55.4-56.5	0.48-0.62
	4	195.7	22.3-32.0	25.9-37.0	0.08-0.20
	12	195.8	24.5-36.0	28.6-42.0	0.07-0.31
	14	195.9	22.5-33.5	26.5-39.2	0.04-0.68
	6	196.0	25.5-33.5	30.0-38.5	0.05-0.23
	8	203.5	27.5-52.5	32.1-60.7	0.12-0.73
	11	204.0	30.5-51.5	35.6-59.7	0.15-86
	3	204.7	26.3-31.7	29.8-38.0	0.11-0.21
	1	204.8	29.0	34.0	0.12
	4	204.9	27.6-32.4	32.0-37.9	0.11-0.19
	294	205.0	19.5-64.9	28.5-75.7	0.05-2.0
	1	205.3	28.0	32.0	0.10
	1	205.4	24.0	29.3	0.05
	49	205.5	25.6-51.5	29.1-60.0	0.11-0.88
	53	207.0	34.4-62.9	40.1-74.0	0.45-1.39
	14	207.5	43.5-57.4	50.8-71.0	0.53-1.14
	7	208.0	27.1-35.1	31.4-41.5	0.12-0.23
	4	213.2	29.6-40.6	33.6-47.3	0.15-0.35
	1	213.5	31.0	36.1	0.18
	141	215.0	34.5-61.3	39.6-72.1	0.23-1.27
	1	215.4	--	35.5	0.10
	89	215.5	20.9-83.6	31.5-98.0	0.14-4.06
	2	215.6	61.0-66.0	73.0-77.0	1.6-2.0
	1	216.0	28.9	33.6	0.11
	1	219.0	51.4	59.0	0.70
	1	219.5	36.0	41.2	0.30
	6	224.7	22.6-30.0	24.9-34.9	0.05-0.15
	8	224.8	25.0-27.4	28.5-32.2	0.08-0.12
	14	224.9	26.9-43.5	30.9-50.7	0.10-0.67
	45	225.0	23.2-57.4	26.1-65.6	0.07-1.24
	1	225.1	26.5	30.7	0.12
	4	230.0	27.0-44.0	26.6-51.2	0.08-0.47
	4	230.9	25.0-27.5	29.0-32.0	0.10-0.14
	2	231.0	25.5-285	30.0-33.5	0.10-0.14
	7	244.0	42.3-62.3	49.3-72.4	0.47-1.43

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	15	244.5	27.5-57.5	27.3-66.8	0.10-1.17
	1	244.6	--	44.0	0.28
	2	245.0	47.1-58.7	54.0-68.2	0.58-1.07
	2	300.3	58.5-67.3	67.0-77.0	1.09-2.06
	91	Unknown	19.0-39.0	22.0-44.2	0.05-0.90
2000	3	18.0	70.4-100.5	80.6-120.4	1.75-7.60
	1	76.0	25.6	31.0	0.11
	19	118.0	36.9-67.0	42.1-77.7	0.29-1.65
	77	120.0	26.3-77.2	30.9-89.6	0.12-3.10
	73	121.0	26.4-81.6	30.4-92.9	0.12-3.20
	16	123.0	29.5-67.0	34.3-77.9	0.14-2.30
	23	130.0	25.1-70.6	29.3-84.5	0.09-2.55
	2	134.0	36.5-42.5	42.5-49.2	0.25-0.48
	2	137.0	28.2-42.0	32.6-48.3	0.11-0.51
	3	141.0	30.8-39.0	34.8-46.0	0.14-0.31
	5	145.0	31.1-39.5	33.2-44.7	0.15-0.48
	3	150.0	29.3-33.5	34.0-44.3	0.19-0.26
	4	157.0	23.5-27.8	27.0-31.9	0.09-0.11
	10	161.0	21.8-49.5	24.5-56.2	0.07-0.80
	3	163.0	25.5-29.0	29.6-33.5	0.13-0.14
	10	165.0	26.0-41.0	29.7-48.0	0.09-0.45
	4	167.0	27.2-35.5	31.4-41.5	0.10-0.26
	1	170.2	27.9	32.2	0.50
	4	174.0	38.9-53.0	44.8-61.0	0.34-0.86
	1	174.2	38.0	43.9	0.32
	1	176.0	50.8	58.3	.090
	2	182.0	29.2-29.4	33.5-34.7	0.13-0.15
	3	185.0	40.0-42.7	46.3-50.1	0.36-0.47
	13	190.0	26.1-49.4	30.6-53.8	0.08-0.74
	2	190.3	25.5-29.0	30.9-33.6	0.09-0.14
	2	190.5	39.5-40.9	45.6-47.9	0.43-0.45
	4	192.0	30.0-41.9	35.0-48.4	0.14-0.47
	4	193.0	38.6-70.5	44.4-80.5	0.32-2.08
	3	193.2	36.1-49.8	41.7-57.9	0.30-0.78
	6	193.5	37.4-45.8	42.2-52.6	0.14-0.51
	5	195.8	26.5-34.2	32.3-40.2	0.11-0.27
	2	204.0	37.0-46.1	43.1-53.3	0.03-0.43
	106	205.0	21.0-57.6	26.2-66.0	0.05-0.77
	26	205.5	24.1-42.7	28.0-49.2	0.08-0.42
	24	207.0	33.6-53.2	38.5-62.2	0.30-0.89
	13	207.5	41.1-57.4	47.9-69.0	0.44-1.16
	2	208.0	25.6-32.0	30.0-37.5	0.10-0.19
	1	210.0	34.2	40.4	0.25
	10	213.2	26.0-35.3	30.2-41.1	0.10-0.29
	4	213.5	28.0-32.5	32.0-38.6	0.12-0.19
	45	215.0	30.2-54.5	33.8-64.2	0.13-0.78
	1	215.2	--	33.0	0.10
	25	215.5	25.1-37.7	27.3-44.0	0.09-0.30

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	219.0	38.7	45.4	0.37
	6	224.0	29.6-38.0	34.3-44.0	0.15-0.31
	9	224.9	32.2-39.0	37.7-45.5	0.23-0.44
	35	225.0	26.1-53.7	30.5-63.0	0.09-1.04
	1	227.8	24.3	27.8	0.09
	1	230.5	32.9	37.5	0.21
	5	244.0	38.7-47.9	45.6-55.8	0.37-0.82
	8	244.5	33.6-59.9	49.5-68.8	0.54-1.42
	3	245.0	45.3-48.5	52.3-56.2	0.56-0.80
	4	306.5	54.0-85.1	65.0-100.0	0.94-5.79
	3	Unknown	28.0-32.2	32.4-38.0	0.12-0.18
2001	2	18.0	78.3-90.5	89.2-107.5	3.6-5.90
	4	118.0	36.6-64.1	43.0-73.4	0.27-1.95
	18	120.0	42.8-79.0	49.6-90.5	0.51-3.40
	23	121.0	41.5-82.6	48.6-96.1	0.40-3.95
	7	123.0	26.2-65.5	31.3-76.0	0.09-2.08
	1	137.0	64.0	73.0	1.80
	1	144.8	56.0	65.0	1.05
	1	145.0	70.0	81.0	2.20
	1	161.0	18.9	21.9	0.04
	2	185.0	39.5-48.3	46.1-56.1	0.46-0.65
	3	190.0	31.5-40.8	36.6-47.9	0.19-0.36
	1	192.0	34.9	39.4	0.22
	1	193.0	54.4	64.0	0.98
	2	195.8	21.9	25.2	0.06
	2	203.5	40.9-42.0	47.6-49.1	0.18-0.34
	3	204.0	35.5-38.0	41.8-44.2	0.25-0.30
	19	205.0	25.0-49.4	28.2-57.0	0.08-0.64
	3	205.5	23.6-29.1	27.2-33.7	0.08-0.13
	8	207.0	35.3-47.4	41.3-54.5	0.33-0.57
	6	207.5	44.6-48.7	25.6-56.3	0.05-0.64
	1	213.2	23.0	26.5	0.07
	1	213.5	24.5	28.9	0.09
	27	215.0	28.9-53.5	30.9-62.1	0.14-0.67
	7	215.5	21.2-29.3	24.4-33.8	0.05-0.15
	2	224.0	22.9-26.1	26.6-30.4	0.07-0.09
	3	224.9	22.3-29.0	25.8-33.2	0.06-0.20
	12	225.0	18.2-47.4	20.6-55.2	0.04-0.58
	1	228.5	22.7	26.6	0.06
	4	244.0	44.1-52.9	51.6-60.6	0.51-0.81
	1	244.5	40.0	47.1	0.34
2002	1	18.0	47.5	54.7	0.60
	2	118.0	51.5-53.0	61.0-62.8	0.89-1.10
	16	120.0	26.0-72.8	30.1-84.8	0.10-2.60
	31	121.0	24.5-80.0	27.5-94.0	0.08-3.80
	9	123.0	26.0-77.0	30.1-89.2	0.08-2.85
	5	130.0	22.0-67.0	25.7-78.2	0.07-2.30
	1	134.0	24.0	27.9	0.09

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	2	137.0	26.4-54.2	30.6-63.2	0.10-1.20
	4	145.0	20.8-23.4	24.1-27.1	0.05-0.08
	4	161.0	24.1-57.2	27.8-67.0	0.07-1.14
	2	163.0	19.0-21.9	22.2-25.2	0.030.06
	3	165.0	22.2-23.6	26.1-27.3	0.05-0.07
	2	167.0	15.0-21.0	17.6-24.0	0.03-0.05
	1	176.5	34.4	40.2	0.24
	1	177.5	36.6	41.9	0.31
	3	190.0	29.3-43.7	33.5-51.3	0.14-0.52
	2	205.0	27.5-33.1	31.6-38.9	0.11-0.28
	2	205.5	27.7	31.4	0.10-0.13
	1	207.0	35.0	40.2	0.24
	1	225.0	40.0	46.0	0.44
	2	306.5	70.9-72.0	83.5-85.2	2.76-2.93
2003	2	18.0	78.-80.0	89.0-93.0	3.4-3.75
	4	118.0	33.8-36.0	39.0-42.0	0.21-0.27
	65	120.0	30.0-87.5	35.0-99.0	0.13-4.20
	100	121.0	21.0-72.5	24.8-84.0	0.08-3.10
	1	122.5	67.0	80.0	1.80
	44	123.0	22.5-70.0	26.14-82.0	0.06-2.80
	69	130.0	20.2-74.0	23.4-84.6	0.04-2.10
	25	134.0	19.5-41.5	23.0-48.3	0.05-0.38
	14	137.0	21.3-40.5	24.6-47.3	0.04-0.44
	20	141.0	20.0-40.6	23.1-48.3	0.06-0.42
	1	141.5	61.5	83.4	1.75
	1	144.5	--	43.1	0.26
	3	144.8	42.4-70.7	48.5-83.4	0.50-2.40
	79	145.0	19.0-64.5	22.1-74.8	0.04-1.70
	38	150.0	17.8-41.5	20.8-48.2	0.03-0.47
	6	157.0	20.6-39.0	24.1-45.5	0.07-0.34
	1	157.3	44.5	51.1	0.55
	55	161.0	19.5-43.0	22.8-50.0	0.03-0.51
	1	161.4	51.1	59.4	0.65
	14	163.0	20.9-36.6	23.8-42.5	0.04-0.33
	21	165.0	20.7-42.5	24.0-49.3	0.05-0.46
	8	167.0	14.9-35.5	17.1-41.6	0.02-0.29
	2	170.0	35.4-36.9	40.7-43.4	0.15-0.19
	4	174.0	37.1-41.1	43.5-48.2	0.31-0.41
	2	174.2	41.7-42.2	48.8-49.3	0.33-0.48
	2	176.5	29.3-35.5	40.9-46.1	0.27-0.42
	14	185.0	23.9-41.8	29.6-49.1	0.13-0.43
	1	188.0	32.5	37.7	0.21
	55	190.0	28.0-48.3	32.7-55.6	0.13-0.69
	7	190.5	33.5-51.8	39.2-60.4	0.23-0.85
	5	192.0	20.4-43.6	29.6-51.0	0.09-0.53
	5	193.0	27.4-42.9	38.1-50.0	0.20-0.52
	3	193.2	38.4-42.5	44.7-49.6	0.35-0.50
	5	193.5	31.9-41.0	37.4-47.4	0.11-0.41

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	3	203.5	33.5-44.1	39.3-50.9	0.24-0.43
	4	204.0	31.0-35.7	36.1-41.5	0.02-0.22
	75	205.0	23.5-64.2	27.2-63.3	0.08-0.93
	52	207.0	29.9-54.3	36.8-63.0	0.22-0.67
	28	207.5	33.2-55.1	39.0-64.0	0.22-1.03
	1	208.0	62.0	73.0	1.20
	109	215.0	22.5-55.1	26.5-65.5	0.07-1.10
	17	215.5	41.1-53.7	47.6-63.0	0.44-1.01
	31	225.0	25.8-53.1	29.7-62.7	0.11-0.97
	1	230.0	31.2	36.8	0.18
	9	244.0	38.0-54.4	43.4-62.9	0.31-0.95
	6	244.5	41.1-51.7	49.1-60.7	0.18-0.82
	5	245.0	32.4-56.2	37.9-65.1	0.17-0.89
	1	257.4	50.3	59.0	0.81
2004	1	118.0	27.9	32.1	0.11
	4	120.0	56.0-63.9	65.5-67.0	1.05-1.30
	3	121.0	42.0-50.0	49.3-58.0	0.55-0.80
	2	123.0	28.0-57.4	32.1-66.5	0.12-1.30
	8	130.0	23.6-42.0	27.5-48.8	0.08-0.42
	1	134.0	23.8	28.4	0.07
	5	141.0	20.5-21.5	23.1-25.3	0.04-0.06
	12	145.0	19.0-40.8	22.0-47.9	0.02-0.43
	4	150.0	17.8-31.0	21.0-35.1	0.04-0.15
	2	157.0	25.5-28.0	29.6-30.5	0.08-0.12
	5	161.0	24.0-29.2	27.9-34.2	0.07-0.14
	2	165.0	28.0-30.0	32.6-35.2	0.11-0.15
	2	167.0	29.0-29.4	33.4-34.3	0.12-0.16
	1	174.0	35.4	40.5	0.28
	1	185.0	36.2	42.0	0.30
	1	190.0	32.1	37.3	0.13
	3	193.0	31.2-33.6	35.5-39.3	0.18-0.23
	2	193.5	32.3-32.5	38.1	0.19-.20
	2	204.0	25.9-30.0	30.0-33.5	0.09-0.12
	7	205.0	23.0-47.3	25.0-54.4	0.07-0.50
	3	207.0	28.0-33.0	32.7-38.5	0.13-0.20
	1	207.5	40.5	48.4	0.39
	2	215.0	32.9-39.8	37.9-46.1	0.22
	1	215.5	35.5	41.9	0.25
	7	225.0	25.6-38.6	26.0-46.8	0.06-0.23
	10	244.0	21.5-53.6	25.3-61.7	0.06-0.95
	8	244.5	25.4-50.0	29.9-58.0	0.09-0.81
	6	245.0	34.2-44.0	40.3-51.6	0.21-0.48
	1	245.5	46.9	55.1	0.68
2005	15	120.0	23.1-57.0	27.3-66.5	0.06-1.20
	8	121.0	40.5-58.0	47.0-68.0	0.37-1.40
	2	123.0	42.4-54.0	50.1-64.2	0.65-1.10
	8	130.0	23.3-51.5	26.8-60.1	0.06-0.90
	1	134.0	22.6	26.5	0.06

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	7	137.0	25.0-36.5	30.0-43.4	0.07-0.26
	13	141.0	20.5-37.6	24.0-43.5	0.04-0.27
	1	141.5	35.9	42.0	0.28
	18	145.0	19.5-33.0	23.2-37.5	0.04-0.19
	2	150.0	27.7-30.0	32.7-35.2	0.12-0.16
	1	157.0	25.5	30.7	0.09
	10	161.0	21.3-32.2	22.9-38.2	0.05-0.19
	2	163.0	20.9-24.1	24.5-28.8	0.04-0.09
	6	165.0	23.0-31.3	27.0-36.3	0.06-0.17
	1	167.0	31.0	36.0	0.16
	1	177.5	31.4	37.1	0.17
	1	185.0	35.1	41.8	0.26
	5	190.0	20.8-36.4	23.2-42.8	0.04-0.27
	2	190.5	30.6-39.1	36.1-45.8	0.16-0.33
	3	192.0	22.6-24.3	26.9-27.6	0.06-0.08
	4	193.0	30.4-32.7	35.8-38.3	0.15-0.19
	3	193.5	14.9-36.5	17.4-42.0	0.01-0.18
	9	204.0	19.5-25.5	22.6-29.2	0.03-0.08
	3	205.0	20.5-36.0	23.7-42.7	0.05-0.26
	2	207.0	25.0-36.3	28.9-43.2	0.06-0.28
	4	215.0	28.6-35.0	33.2-40.5	0.12-0.24
	5	225.0	20.0-40.1	24.3-47.4	0.06-0.40
	3	229.0	25.1-28.6	29.5-33.0	0.08-0.13
	1	235.0	29.9	35.0	0.13
	9	244.0	32.6-49.7	39.5-59.7	0.21-0.77
	26	244.5	18.5-49.3	21.1-58.1	0.03-0.82
	4	245.0	21.6-33.5	25.2-39.3	0.06-0.18
	2	--	36.0-41.0		0.24-0.48
2006	9	120.0	35.5-62.3	41.3-71.6	0.25-1.40
	7	121.0	36.0-56.0	42.0-66.5	0.33-1.40
	2	123.0	24.5-51.5	28.5-60.0	0.09-0.85
	6	130.0	32.9-41.4	38.5-47.1	0.17-0.43
	2	141.0	22.5-24.0	26.0-28.2	0.07-0.08
	1	141.5	36.5	41.7	0.50
	1	144.8	40.5	47.5	0.45
	5	145.0	26.9-36.3	31.1-42.3	0.09-0.26
	2	150.0	22.4-23.0	26.4-26.6	0.07-0.08
	4	165.0	27.5-34.4	32.2-39.4	0.10-0.14
	5	190.0	30.7-36.4	35.4-42.2	0.15-0.22
	2	192.0	25.5-33.7	39.8-41.5	.26-.42
	6	193.5	23.4-30.3	26.3-35.1	0.03-0.09
	3	205.0	26.3-38.2	28.5-42.7	0.22-0.96
	1	225.0	37.0	43.3	--
	1	240.5	24.0	27.0	0.08
	9	244.0	29.1-48.5	33.1-57.0	0.13-0.70
	3	244.5	19.6-27.4	23.6-32.3	0.05-0.12
	7	245.0	23.8-27.6	27.9-39.6	0.04-0.11
	1	257.4	43.9	50.8	0.55

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
2007	9	120.0	33.6-58.3	38.5-68.0	0.19-1.25
	5	121.0	31.7-54.8	37.0-63.0	0.15-0.90
	7	123.0	34.0-63.9	40.3-74.0	0.24-1.60
	9	130.0	29.8-55.0	34.5-63.5	0.13-1.05
	4	137.0	27.5-32.0	32.6-38.0	0.12-0.21
	2	141.0	30.5-32.0	35.7-37.5	0.12-0.19
	13	145.0	26.0-44.1	30.5-48.5	0.07-0.50
	1	150.0	30.0	36.0	0.18
	2	157.0	27.7-32.8	31.0-38.4	0.11-0.21
	1	163.0	28.0	32.8	0.12
	3	165.0	29.0-33.5	33.8-38.7	0.12-0.17
	2	174.0	30.1-34.6	34.6-40.5	0.14-0.24
	3	174.2	20.9-32.2	24.0-37.2	0.07-0.17
	7	176.5	20.2-33.0	23.7-38.1	0.14-0.94
	2	185.0	29.4-34.6	34.3-40.4	0.13-0.25
	6	190.0	22.8-31.8	26.5-37.4	0.06-0.16
	1	190.5	33.1	38.6	0.21
	1	192.0	32.9	38.3	0.20
	3	193.0	27.4-31.7	31.9-36.9	0.12-0.16
	1	193.2	30.7	35.7	0.17
	1	199.5	30.1	35.6	0.15
	7	205.0	27.8-30.1	33.0-35.4	0.13-0.15
	6	207.0	21.6-33.2	26.4-38.2	0.07-0.23
	3	207.5	30.8-38.3	35.3-45.0	0.15-0.29
	6	215.0	31.1-36.3	36.3-43.0	0.17-.27
	1	215.5	35.2	40.7	0.25
	3	225.0	29.0-37.5	34.2-43.1	0.12-0.27
	44	244.0	23.9-50.7	28.3-59.4	0.07-0.70
	21	244.5	20.8-38.5	25.3-45.0	0.05-0.35
	3	245.0	45.8-46.5	53.1-55.1	0.56-0.58
	1	306.5	56.3	65.2	1.11
2008	7	120.0	30.5-47.8	35.4-55.8	0.14-0.65
	6	1212.0	34.9-47.0	39.5-55.5	0.60
	3	123.0	29.5-45.1	35.0-53.0	0.15-0.60
	13	130.0	28.5-38.0	33.0-44.3	0.09-0.33
	1	137.0	31.4	36.4	0.16
	7	141.0	24.9-32.1	29.1-37.5	0.05-0.16
	5	144.8	28.6-34.3	33.5-40.1	0.14-0.22
	58	145.0	18.0-33.5	21.1-39.4	0.02-0.21
	47	150.0	20.1-33.6	22.3-39.6	0.05-0.20
	9	157.0	21.5-.6	24.2-36.0	0.04-0.17
	1	157.3	34.5	40.5	0.24
	11	161.0	24.0-30.5	27.9-36.0	0.06-0.16
	2	161.4	33.0-35.2	38.7-41.1	0.20-0.25
	22	165.0	20.0-31.5	23.0-36.6	0.04-0.21
	8	174.2	22.2-31.1	26.0-36.5	0.06-0.14
	1	176.0	33.2	39.3	0.20
	5	176.5	23.1-29.7	27.0-35.0	0.06-0.15

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	1	185.0	36.3	42.5	0.26
	17	190.0	23.5-31.6	28.2-36.4	0.07-0.16
	2	190.5	31.5-35.0	35.5-40.4	0.15-0.23
	10	192.0	24.2-30.6	28.3-35.8	0.07-0.15
	8	193.2	22.9-29.7	27.2-34.6	0.08-0.92
	2	193.5	27.1-28.2	31.6-33.3	0.10-0.11
	5	199.5	23.5-26.8	28.0-31.1	0.07-0.10
	41	205.0	23.2-36.3	27.3-42.1	0.07-0.94
	16	207.0	24.7-32.8	28.8-38.5	0.07-0.92
	13	207.5	27.4-32.2	32.6-37.8	0.09-0.18
	5	215.0	23.952.0	25.2-59.6	0.07-0.19
	2	215.5	34.0-37.0	40.0-43.5	0.21-0.28
	10	225.0	25.1-36.0	28.0-42.6	0.08-0.24
	1	228.7	29.0	33.0	--
	27	244.0	33.8-42.1	39.5-49.1	0.21-0.41
	31	244.5	20.3-44.0	23.5-52.0	0.05-0.80
	3	245.0	37.0-41.9	43.6-49.0	0.29-0.43
2009	8	120.0	27.5-68.0	32.5-78.5	0.13-1.90
	7	121.0	24.7-39.1	27.9-46.7	0.11-0.22
	3	123.0	30.5-39.1	35.2-43.8	0.16-0.33
	10	130.0	25.0-31.8	29.4-37.1	0.10-0.19
	2	137.0	23.0-26.3	27.7-29.7	0.05-0.09
	6	141.0	25.1-26.3	29.2-30.2	0.07-0.09
	1	141.5	32.5	37.9	0.21
	7	144.8	26.9-31.7	30.4-36.0	0.12-0.17
	19	145.0	23.0-28.4	24.9-32.5	0.05-0.13
	29	150.0	21.0-27.7	24.8-32.0	0.03-0.09
	6	161.0	24.1-27.1	27.9-31.5	0.06-0.10
	1	161.4	30.0	34.1	0.15
	5	165.0	23.0-38.7	26.5-34.5	0.05-0.15
	2	174.0	23.8-28.5	27.4-32.5	0.08-0.10
	2	174.2	25.1-26.2	29.7-30.3	0.08-0.09
	1	176.5	25.2	28.9	0.08
	9	190.0	25.1-28.4	29.2-32.3	0.06-0.12
	2	190.5	27.1-30.1	32.2-36.1	0.11-0.17
	1	192.0	21.0	27.2	0.10
	2	193.2	27.0-28.2	30.1-33.0	0.10-0.13
	1	193.5	24.5	28.1	0.08
	1	205.0	27.1	31.0	0.12
	1	207.5	27.0	31.6	0.11
	1	215.5	29.3	34.4	0.16
	9	244.0	23.3-32.6	27.3-38.3	0.08-0.19
	1	244.5	23.8	27.5	0.07
	1	245.0	27.2	31.5	0.11
2010	2	121.0	26.0-31.5	30.4-37.8	0.11-0.21
	1	123.0	30.6	35.0	0.16
	3	130.0	25.2-26.7	29.5-30.5	0.09-0.11
	1	141.0	20.5	24.2	0.06

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	14	144.8	24.0-31.0	28.0-36.1	0.09-0.16
	6	145.0	21.5-24.0	23.0-28.0	0.06-0.08
	5	150.0	21.0-24.0	24.5-27.5	0.05-0.07
	1	157.3	26.6	31.1	0.11
	4	161.0	24.0-28.0	28.0-32.5	0.08-0.13
	3	161.4	27.8-29.6	32.5-34.3	0.12-0.15
	4	165.0	26.0-28.1	30.1-32.3	0.09-0.13
	1	185.0	26.4	31.3	0.12
	3	190.0	22.4-26.2	26.5-29.9	0.08-0.09
	1	190.5	28.7	33.6	0.14
	1	193.0	27.9	32.2	0.11
	13	205.0	24.2-29.5	28.5-34.9	0.06-0.13
	2	207.5	27.6-27.7	30.1-31.2	0.10
	2	215.5	29.1-30.5	33.6-35.5	0.14-0.16
	2	225.0	23.5-29.2	27.8-33.5	0.07-0.14
	79	244.0	17.5-33.3	22.6-37.7	0.05-0.90
	4	245.0	26.6-30.4	31.3-36.1	0.10-0.15
	2	--	25.0	28.5	0.15
2011	1	130.0	21.5	25.1	0.06
	2	141.5	22.5-23.6	26.6-28.5	0.07-0.08
	13	144.8	16.2-28.7	13.2-32.9	0.06-0.12
	2	150.0	23.0-26.7	26.1-31.0	0.06-0.10
	10	157.3	22.5-27.0	26.1-31.5	0.06-0.11
	17	161.4	21.8-27.2	25.6-31.6	0.05-0.10
	6	165.0	21.8-25.0	25.2-29.5	0.06-0.09
	1	174.0	24.2	28.1	0.08
	1	176.0	24.5	28.0	0.07
	3	190.5	25.5-29.0	29.5-33.9	0.09-0.12
	1	193.0	23.9	27.5	0.06
	1	199.5	22.3		0.60
	1	205.0	23.0	26.6	0.04
	2	207.0	27.7-28.4	32.6-33.0	0.10-0.11
	2	215.5	23.8-27.0	27.6-31.1	0.06-0.10
	1	244.0	26.0	30.0	0.09
Unknown year class	6	18.0	56.0-83.2	63.0-97.1	1.10-4.40
	4	118.0	44.5-60.0	51.5-69.2	0.52-1.80
	285	120.0	33.5-95.0	39.3-111.0	0.21-6.60
	223	121.0	24.5-94.0	28.5-108.0	0.08-4.80
	90	123.0	27.2-85.4	31.8-98.6	0.11-4.25
	131	130.0	18.0-96.5	21.8-108.5	0.03-6.00
	10	134.0	21.4-109.0	25.1-125.0	0.05-13.00
	26	137.0	22.5-94.2	26.0-114.5	0.06-6.90
	1	137.4	37.3	44.4	0.31
	46	141.0	18.0-77.5	21.5-90.0	0.03-3.20
	1	141.5	38.5	45.0	0.30
	17	144.8	25.3-55.2	29.5-63.0	0.10-1.25
	111	145.0	19.5-84.0	22.8-96.5	0.04-4.10
	38	150.0	20.3-56.5	23.4-66.0	0.05-1.00

Year class	Number captured	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)
	15	157.0	21.6-35.3	24.1-41.3	0.06-0.27
	2	157.3	36.5-40.4	42.3-46.6	0.29-0.46
	38	161.0	22.1-65.0	25.9-75.0	0.06-1.80
	5	161.4	32.1-40.1	36.4-47.2	0.17-0.38
	7	163.0	18.5-34.7	21.0-40.7	0.03-0.22
	57	165.0	16.8-49.5	19.0-57.1	0.03-0.76
	7	167.0	15.4-40.0	17.8-46.0	0.02-0.35
	4	170.0	24.8-32.0	29.2-37.7	0.05-0.11
	9	174.0	27.0-37.9	31.4-43.3	0.12-0.27
	40	174.2	23.6-85.6	29.0-45.0	0.12-0.30
	2	176.0	37.6-40.4	44.2-47.3	0.31-0.38
	29	176.5	28.3-52.2	32.6-60.3	0.13-0.95
	3	177.5	31.2-36.8	35.8-43.4	0.16-0.28
	5	182.0	26.2-33.5	30.5-38.8	0.10-0.21
	46	185.0	25.9-67.3	30.1-78.0	0.04-2.01
	4	188.0	26.3-34.0	30.2-39.3	0.06-0.19
	167	190.0	20.5-72.2	24.7-83.0	0.06-2.34
	35	190.5	26.9-69.1	31.5-81.0	0.10-2.06
	18	192.0	21.4-37.5	24.6-44.6	0.03-0.35
	56	193.0	20.3-73.1	26.2-83.5	0.07-2.35
	23	193.2	25.5-37.2	30.1-44.2	0.10-0.30
	44	193.5	13.6-45.7	16.0-52.9	0.01-0.42
	1	195.8	34.2	38.0	0.20
	7	203.5	25.0-65.9	30.0-75.7	0.07-1.42
	4	204.0	21.2-72.5	25.0-84.8	0.05-0.56
	176	205.0	15.4-90.0	17.2-105.0	0.01-4.48
	6	205.5	33.4-35.0	38.1-40.7	0.16-0.33
	134	207.0	22.9-90.0	26.2-105.0	0.05-3.50
	72	207.5	25.6-59.1	30.0-70.0	0.05-1.27
	4	208.0	53.0-86.0	65.0-97.0	3.00-4.00
	168	215.0	24.0-84.0	28.5-100.0	0.06-2.79
	1	215.4	61.0	72.0	1.10
	27	215.5	21.8-51.0	24.7-60.1	0.07-0.90
	1	215.6	55.0	66.0	1.20
	2	219.5	30.9-33.0	35.5-36.7	0.20-0.23
	3	224.9	30.0-36.1	34.6-40.7	0.13-0.26
	150	225.0	21.3-67.0	26.7-77.8	0.06-1.88
	1	227.0	106.0	126.0	--
	1	230.0	30.0	35.0	0.13
	1	235.0	27.5	33.1	0.12
	1	241.0	24.7	29.0	0.05
	68	244.0	22.4-68.0	25.4-80.8	0.06-1.87
	62	244.5	19.1-106.0	22.0-126.0	0.04-19.00
	43	245.0	20.8-62.4	22.3-72.5	0.03-1.40
	2	306.5	85.3-89.8	97.8-103.5	4.82-5.03
	1	Unknown	24.0	27.2	0.07
Total	**8834**				

CHAPTER 2: BURBOT MONITORING AND EVALUATION
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ABSTRACT

We sampled 18 sites totaling 3,721 net days and captured 258 burbot from November 29, 2012 to March 29, 2013. Trend CPUE of burbot captured in hoop nets increased 17-fold in the 2012/13 sampling season from a mean of 0.004 fish/d (fall 2006 to spring 2011) to 0.095 fish/d. Initial estimates based on PIT tag returns indicate that hatchery-reared burbot are surviving well following release events. Growth rates of hatchery-reared burbot were similar to those of wild fish that were captured in the early 1980s and higher than those captured in the late 1950s. There was anecdotal evidence that hatchery-reared burbot spawned at Ambush Rock in March of 2013. Adults of an untraceable origin made distinct movements into and out of Deep Creek during this period, as well. The 2013 spawning activity peaked later in the year and mean temperatures were warmer than what was reported for wild burbot in 2001, which may have implications on egg hatching success. We installed and operated a PIT tag array approximately seven rkm above the mouth of Deep Creek in October 2012. During November 2012, 3,000 PIT tagged burbot were stocked 10 and 20 rkm above the PIT tag array to evaluate timing of outmigration (i.e., movement past the array, post-stocking). From October to April 2013, relatively few juvenile burbot passed by the PIT tag array in Deep Creek, with the majority of detections occurring within 30 days after stocking. Twelve additional burbot, some of which were originally stocked as far as 70 rkm downstream of Deep Creek, were also detected crossing the array during this period. In addition to juvenile detections, the PIT tag array also detected several adult burbot of wild/unknown-origin during mid-March as temperatures warmed from 1 to 4°C, corresponding with spawn timing in the Kootenai River. In our extensive burbot rearing ponds on the Boundary Creek Wildlife Management area, we performed an experiment with stocked larvae in pens to determine if the addition of substrate reduces cannibalism. Our results provided little evidence to support the hypothesis that adding substrates would reduce mortality. In addition, during the 2012/13 season, no fish reared in the BCWMA ponds and released into the Kootenai were sampled using the standardized hoop netting techniques.

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 ultimately closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake and Kootenay River, British Columbia (Paragamian et al. 2000). Demographic studies suggested that the burbot population in the Kootenai River might become extirpated by 2015 (Pyper et al. 2004; Paragamian et al. 2008). Operation of Libby Dam for hydroelectric power and flood control created major changes in the river's seasonal discharge 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 (Strategy) was prepared to outline measures necessary to restore the burbot population (Anonymous 2002; KVRI Burbot Committee 2005; Ireland and Perry 2008). The Strategy predicted that operational discharge changes at Libby Dam were required during winter to provide suitable conditions (i.e., temperature and discharge) for burbot migration. 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 that temperatures of about 6°C were needed to trigger migration and cooler temperatures of 1-4°C were needed for spawning (Paragamian and Wakkinen 2008). The Strategy identified conservation aquaculture as a remedial measure to help strengthen the depressed burbot stock.

Because the Kootenai River burbot stock was so limited, the introduction of a genetically similar donor stock was proposed as a potentially viable option to enhance the population (KVRI Burbot Committee 2005; Powell et al. 2008). One such similar stock was identified in Moyie Lake, which is in the Kootenai River basin. Starting in 2008, burbot from Moyie Lake were provided to the University of Idaho Aquaculture Research Institute (UIARI) by the collection efforts of the Kootenai Tribe of Idaho, BC Ministry of Environment (BCMOE), and Idaho Fish and Game (IDFG) for spawning and experimental intensive culture (Jensen et al. 2008a).

Over the past few years, the intensive and extensive culture techniques developed by the Kootenai Tribe of Idaho, BCMOE, the UIARI, and IDFG have become an important restoration measure for burbot on the Kootenai River. Stockings of these hatchery-reared burbot into tributaries and the mainstem Kootenai River have survived well and significantly increased catch rates in hoop net monitoring by IDFG. Extensive rearing of larval burbot in ponds has also been effective at increasing growth and survival 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). These ponds may also provide valuable information on factors that affect burbot survival in the main Kootenai River following stocking. For example, they may aid in determining if larvae raised on a natural diet have a competitive advantage over intensively reared larvae, resulting in higher survival in the main Kootenai River. These ponds may also provide useful information on additional factors that can increase survival at release locations.

Burbot monitoring and evaluation studies conducted by IDFG are designed to evaluate whether or not recovery strategies being implemented in the basin are enhancing natural recruitment. Population viability modeling done by Paragamian and Hansen (2009) identified an interim abundance target of 5,500 adult (age-4 and older) burbot within 25 years and an ultimate abundance target of 17,500 individuals. Analysis of current population-level data will aid IDFG management biologists in determining whether or not these targets are being approached and a harvest fishery for burbot could be opened. Evaluating factors such as timing of outmigration from stocked tributaries, spawning and habitat use/selection in tributaries, and sampling gear selectivity will effectively refine current and future population estimates for burbot.

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 a sustainable harvest of burbot.

OBJECTIVES

1. Conduct monitoring and evaluation studies of sufficient rigor to enable development of a viable burbot fishery by 2017.

2. Evaluate timing of downstream outmigration of burbot in Deep Creek.

3. Evaluate survival of larval burbot reared in different substrate types in Boundary Creek ponds.

STUDY AREA

The Kootenai River is the second largest tributary to the Columbia River and its drainage is the third largest (approx. 49,987 km^2; Bonde and Bush 1975). The river originates in Kootenay National Park, British Columbia, discharges south into Montana, where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). The river flows west from Libby Dam, northwest into Idaho, then north into British Columbia and Kootenay Lake. The river then drains out of the West Arm of Kootenay Lake, and it 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 for adult burbot occurred at 18 sites between river kilometer (rkm) 144.5 (Nick's Island near Creston, BC) and rkm 244.5 (Ambush Rock near Bonners Ferry, Idaho) (Figure 2.1). Extensive rearing of burbot was conducted at two similar sized ponds at Boundary Creek Wildlife Management Area (BCWMA; Figure 1). Excavated in 2010, each BCWMA pond is approximately 13 x 27 x 3 m, and fills naturally through runoff and seepage. A pass-over PIT tag array was installed in Deep Creek, approximately seven km upstream from its confluence with the Kootenai River (Figure 2.2).

METHODS

Burbot Hoop Net Sampling

Adult burbot were sampled at 18 locations using 32 baited hoop nets during winter 2012/13 (seven Canadian and 11 U.S. sites; Figure 2.1) to measure relative changes in the population through catch-per-unit-of-effort (CPUE). We sampled six index sites (historically sampled since 1994) throughout the entire netting season, and an additional 12 sites were sampled in order to increase opportunities to capture and tag fish (with ultrasonic tags). Burbot captured in nets deeper than nine meters were re-set to one-half the original depth for 24-hours to allow for fish decompression and to reduce barotrauma-related mortality. These fish were included in the original lift date for CPUE calculations.

We used up to 32 hoop nets with variable diameter (maximum 0.61 m) and different bar-mesh sizes (25.4, 19.1, and 12.7 mm) throughout the season. During the final weeks of the netting season, two crews lifted nets (one crew in Canada and one crew in the US) on the same days, two to three times per week. Nets were baited with frozen kokanee *Oncorhynchus nerka* and paired with a large (25.4 mm) and small (12.7-19.1 mm) mesh size at each location to evaluate potential gear selectivity. All captured fish were identified, enumerated, measured for total length (TL; mm), weighed (g), sex determined (i.e., if flowing milt or eggs), and examined for previous tags and marks. All untagged burbot were given a unique PIT tag (FDX,RFID; 9 mm) into their anterior dorsal muscle. Genetic samples were collected from the anterior portion of the dorsal fin of all untagged burbot to determine brood year and stocking strategy using Parental Based Tagging (PBT) analysis (methods described by Anderson and Garza 2005). Evidence of spawning was determined by methods described by Kozfkay and Paragamian (2002), where the number of flowing males, gravid females, and spent adults were recorded. Fish that were recaptured within a 14-day period and exhibited weight loss were also used to identify approximate spawn timing.

In order to get information on spawning movements in relation to environmental conditions, 15 burbot ≥400 mm were implanted with ultrasonic transmitters during the 2012/13 sample season. Analysis of these movements will be described in a future report. The V9 Vemco tags were surgically implanted within the peritoneum by methods similar to those described by Neufeld and Rust (2009). The ultrasonic telemetry system utilized VEMCO VR@W stationary sonic receivers deployed from Kootenay Lake upstream into Idaho near the Montana border.

PIT Antenna Monitoring – Deep Creek

On October 11, 2012, we installed three Biolite BioMark Passover PIT antennas (FDX) (in sequence) to construct a single antenna spanning a 9.14 meter channel width in Deep Creek (7.3 rkm from mouth). The array was on private land and powered by a thermoelectric generator fueled with four 100-pound propane tanks. To evaluate timing of downstream outmigration, we stocked 3,000 juvenile burbot (age-0; 180 dph) upstream of the antenna on November 6, 2012. Prior to release, we PIT tagged burbot abdominally (RFID; PT300; 9 mm tag) on October 1, 2012 and held them for one month to eliminate tagging-induced mortality. Two sites upstream from the mouth of Deep Creek (Naples at 21 rkm and McArthur Lake at 34 rkm) were chosen as release points and each was subsequently stocked with 1,500 burbot on November 6, 2012. All recordings of PIT-tagged fish from this stocking, as well as those that entered the stream from prior capture events, were recorded on the array data recorder. The PIT tag array could not determine direction of fish movements; therefore, time of outmigration was defined as the first time of detection by the array (i.e., when fish were first detected, they were considered out-migrating).

Extensive Burbot Rearing

We evaluated burbot growth, survival, food preference, and the effect of different substrates on cannibalism of larval burbot reared in two manmade ponds at BCWMA. Each pond measured approximately 25 x 15 x 3.5 meters. On May 1, 2012, we stocked 10,500 feeding larval burbot into each BCWMA pond (0.01 fish/L). Burbot larvae for this study were provided by UIARI, Moscow, Idaho. Hatch dates ranged from March 20-26, 2012. For analysis, the median day (March 23) was used as the hatch date for all larval burbot.

Growth and food preferences were evaluated by weekly collections of larval burbot from the ponds using vertical hauls of a D-Ring net (750 µm) through the pond; fish ($n \approx 5$) were preserved in 90% ethanol for later analysis. Preserved larvae were then sent to the University of Idaho for analysis, where fish were weighed (g), measured for total length (TL; mm), and gut contents identified to the nearest species to determine food preference and size relationships. Food availability in the water column was quantified by obtaining three vertical tow samples weekly in each pond using a Wisconsin-style plankton net (0.3 m diameter, 80 µm mesh). Additionally, three replicate samples (each 18.93 L) were taken every week from Boundary Creek and the Kootenai River to compare the zooplankton availability in the pond to that of Boundary Creek and the Kootenai River. Zooplankton samples were preserved with 10% Lugol's solution and sent to the University of Idaho for analysis.

Floating net pens within each pond were used to determine whether or not different substrate types would reduce cannibalism of burbot reared in the ponds. The study was comprised of control groups and two different substrate types. The first substrate type consisted of PVC elbows to simulate cobble-holding habitat and the second substrate type was made of plastic vegetation to simulate natural vegetation at release locations. Net pens measured 1.80 m X 0.97 m X 0.91 m (volume = 1.59 m^3 [1,590 L]) constructed of PVC pipe frame (1.9 cm and 10.2 cm diameter pipe) and a 3.18 mm knotless mesh net. Each pond had three net pens with a substrate type (West Pond: PVC, East Pond: plastic vegetation) and three control net pens (no substrate), randomly positioned within each pond. PVC substrate consisted of 1.3 cm diameter 90° PVC elbows encased in a plastic mesh case. On June 14, 2012, 200 burbot were stocked into each net pen (approximately 8 fish/L). The experiment ran for 41 days, and we removed net pens on July 24, 2012 to collect remaining. Each burbot was measured for TL and weighed (if possible). The majority of burbot were too small for the scale and, thus, were weighed in groups of 10 to obtain an average weight. Survival was estimated by the total remaining divided by the total originally stocked into each replicate. Statistical significance was tested using two-sample t-Tests assuming unequal variances.

We drained the ponds from July 25-31, 2012 to <0.5 m using gas powered water pumps and conducted multiple passes with a 1,000 µm mesh beach seine to capture all burbot remaining from the original stocking event. All fish were anesthetized with MS-222, weighed (g), measured (TL; mm), and PIT tagged in the abdominal cavity if they were >65 mm. After tagging, all burbot were transported and stocked into Boundary Creek, 2 rkm above the confluence.

RESULTS

Burbot Hoop Net Sampling

We sampled 18 sites from November 29, 2012 to March 29, 2013, totaling 3,721 net days and captured 258 burbot. Overall CPUE was 0.07 burbot/net day, higher than any previous year (1992-2012; Table 2.1; Figure 2.3). Daily CPUE ranged from 0.00-1.49 burbot/net day for U.S. sites and 0.0-0.11 burbot/net day for Canadian sites (Table 2.1). CPUE for index sites was 0.095 burbot/net day (Figure 2.4) and ranged from 0.00-0.32 burbot/net day (Table 2.1; Figure 2.4). The site at rkm 244.5 (Ambush Rock) had the highest CPUE of all U.S. sites (0.32 burbot/net day; Table 2.1; Figure 2.4). This index site has had the highest increase in CPUE for the second consecutive year. The site at rkm 169 (non-index) had the highest CPUE of all of the Canadian sites (0.068 burbot/net day; Table 2.1). Catch rates across all sites remained relatively similar throughout the sampling period, with a significant increase at U.S. sites from mid-February to mid-March. During this peak, 30 flowing males (289-760 mm) and three gravid females (459-751 mm) were captured, primarily at the Ambush Rock. Thirteen of the 33 spawners were conclusively identified as hatchery-reared fish based on PIT tag records. The 2012/13 peak in CPUE coincided with a significant amount of weight loss from burbot recaptured within 14 days of initial handling (Figure 2.5). Comparison of the 2012/13 catch rates with the only significant historical sampling season recorded for wild burbot (2001) indicated that spawn timing peaked later and mean temperatures were warmer this season than those in 2001 (Figures 2.6 and 2.7).

Of the 258 total captures, 179 (69%) were unique individuals consisting of 105 burbot that did not have a PIT tags and 74 that had a PIT tag at first capture during 2012. Of the PIT tags that returned to the hoop nets this season, year class assignments showed that the majority came from 2009 and 2011 brood years (Table 2.2; Figure 2.8). However, 2007 and 2008 had the highest proportion of returns, based on the total number stocked with PIT tags by brood year (Table 2.2). Sixty-six recaptured burbot were identifiable to a hatchery, release location, and age-at-release by PIT tags (Table 2.3). Of these traceable recaptures, the majority (27) were age-1 at release burbot stocked into Boundary Creek/Moyie River in 2010 followed by ten that were age-0 at release and stocked into Boundary Creek in 2011 (Table 2.3). Hoop net CPUE and average burbot length and weight were highest in hoop nets with 12.7 mm (1/2-inch) mesh (Table 2.4).

Length-at-age-at-time-of-capture indicated that burbot were annually increasing in growth, ranging from 60-114 mm / yr. (Figure 2.9). Growth rates appear to be similar to those from burbot that were captured and aged using otoliths in the early 1980s, and higher than those obtained in the late 1950s (Figure 2.9).

Sonic transmitters were surgically implanted in 15 mature burbot (<400 mm) from May 1, 2012 to April 30, 2013 (Appendix 2.1). Analysis of these movements in relation to river conditions will be reported on in the next cycle.

PIT Antenna Monitoring – Deep Creek

Eighty-seven burbot were detected by the PIT tag antenna between October 1, 2012 and April 25, 2013. Sixty-three of the detections were from the 3,000 burbot released in Deep Creek on November 6, 2012, 12 from other stocking events, and 12 burbot of wild/unknown-origin that were tagged during hoop net index sampling in previous years (Table 2.5; Figure 2.10). The 12 burbot of unknown origin were detected during the peak of spawning, as identified at Ambush Rock in the Kootenai River (Table 2.6; Figure 2.10). Vemco transmitters were present in three of the unknown origin burbot (Table 2.6). Of these tagged fish, one male was captured in January at Ambush Rock in the Kootenai River. He was then picked up by the PIT tag array in Deep Creek on February 22, stayed above the array for 18 hrs, and returned to the Kootenai where he was then recaptured at Ambush Rock on March 4, weighing approximately 450 g less.

Extensive Burbot Rearing

After three months, burbot outside of the net pens (i.e., at-large) experienced higher survival in the East Pond (9%) than the West Pond (3%; Table 7). Conversely, the mean total length of juveniles in the East Pond (56.6 mm) was significantly smaller than the West Pond (83.7 mm; Table 2.7; Figure 2.11). Only 7% of burbot in the East Pond were large enough to PIT tag, compared to 90% that were large enough to PIT tag in the West Pond. We released 1,305 burbot from the at-large groups into Boundary Creek (947 from East Pond and 358 from West Pond) at the end of the growing period. We also captured three holdover burbot (from the 2011 pond-rearing experiment) in the East Pond, with an average length of 297.3 mm (range 281-312 mm) and weight of 175.7 g (range 148-216). Two of the holdover burbot were surgically implanted with Vemco sonic tags and released into Boundary Creek for future movement analysis.

Survival of the net pen treatment groups varied between ponds. Within ponds, survival there was no difference between the vegetation substrate and the control group ($df = 2$; $p = 0.40$) in the East Pond; whereas, the control substrate had higher survival than the PVC substrate ($df = 2$; $p = 0.022$) in the West Pond (Table 2.8; Figure 2.12). Juvenile burbot in the control pens of the West Pond had higher survival ($df = 3$; $p<0.015$; 51%) than those in control pens in the East Pond 36%. Similar to the at-large population, final total length of burbot in net pens within the West Pond were significantly greater ($df = 862$; $p < 0.0001$) than burbot growth in East Pond net pens (Table 2.8; Figure 2.13). Average total lengths of burbot between all net pen groups ranged from 32.9-37.3 mm (Appendix 2.2). No burbot from the net pens were large enough to PIT tag by the end of the experiment.

Burbot Stocking

The total number of burbot released into the Kootenai River and its tributaries in 2012 was around 273,197 fish, of which, 3,392 were PIT-tagged juveniles released into tributaries and the mainstem. To date, KTOI and IDFG personnel have stocked approximately 346,000 larval and juvenile burbot into the Kootenai River and its tributaries since 2009 (Table 2.9).

DISCUSSION

Burbot Hoop Net Sampling

Initial estimation based on PIT tag returns showed that a lake-origin hatchery fish survived, grew, and matured following release events into the Kootenai River and tributaries. Trend CPUE of burbot captured in hoop nets increased seventeen-fold in the 2012/13 sampling season from a mean of 0.004 fish/d (fall 2006 to spring 2011) to 0.095 fish/d. Initial estimation based on PIT tag returns showed that hatchery fish were surviving well following release events. In addition, evidence that burbot progeny from lake-origin brood stock will successfully adapt to a river environment is important to current and future restoration programs across the northwest. Although there have been substantial increases in burbot CPUE since initial stocking, the Kootenai River population still remains low relative to other burbot populations. As a comparison, CPUE in the Chena and Tanana rivers of Alaska was 0.9 and 1.2 fish/d, respectively (Evenson 1993), and burbot in four Alaskan Lakes ranged from 0.5-3 fish/d (Parker et al. 1988). The catch rates of burbot reported in these studies of unexploited Alaskan water bodies are much greater than those currently seen in the Kootenai River. Since the abundance of burbot in the Kootenai River was unknown prior to Libby Dam, Paragamian and Hansen (2009) used the population data in the aforementioned Alaskan rivers as surrogate restoration targets to guide Kootenai River recovery. Targets included an interim abundance of 5,500 individuals (45 fish/km; 3.0 fish/ha) within 25 years, with each adult producing 0.85 recruits per year. The ultimate target abundance was 17,500 individuals (143 fish/km; 9.6 fish/ha) with each adult producing 1.1 recruits per year. Although the current catch rates are much lower than those used to develop these objectives, catch rates continue to annually increase.

Although hatchery supplementation is bolstering the burbot population in the Kootenai River, only 6% of the hatchery burbot have been uniquely marked with PIT tags prior to release. Therefore, it is difficult to determine the degree to which this effect is occurring until parentage-based tagging analysis (PBT) is complete. PBT will allow all burbot progeny from genotyped parents to be assigned to a release group and brood year; therefore, all burbot reared in the hatchery will be tagged. Originally proposed by Anderson and Garza (2005), PBT is currently being used in other fisheries as an alternative to mechanical tagging methods (Steele and Campbell 2011). Parentage-based tagging will also provide a way to evaluate: (1) whether or not natural production reproduction is occurring, (2) survival by brood year, (3) survival by release location, as well as many other possible treatment combinations for producing strong(er) year classes. Approximately 99% of the 359,000 burbot released into the Kootenai River and its tributaries (to-date) are genetically tagged; therefore, a clearer picture of brood year assignments and influence of the conservation aquaculture program on natural production should be available by 2014.

Hatchery burbot growth rates were similar to those of wild fish captured and aged using otoliths in the early 1980s (Partridge 1983) and higher than those of burbot captured in the late 1950s (IDFG, unpublished data). Burbot grow rapidly in their first year and, depending on food resources and length of growing season, can reach 110-120 mm in TL by late fall (Chen 1969; Sandlund et al. 1985). We only captured one age-0 burbot in December of 2012 that measured 183 mm. Since very few age-0 fish were captured in hoop nets (presumably due to gear selectivity), a comparison of growth rates young-of-year burbot is unclear at this time. With regards to older burbot recaptures, although we know the year class of many recaptured hatchery fish from PIT tags, a more accurate estimation of length-at-age should be performed using otoliths or other calcified structures to compare growth rates to other water bodies.

Multiple lines of evidence suggested that lake-origin hatchery reared burbot adapted to spawn in the Kootenai River near Ambush Rock in late February to mid-March of 2013 and 2014. Additionally, adults of an untraceable origin made distinct movements into and from Deep Creek during this same period, suggesting that Deep Creek may also be a possible spawning location. And although these are known historical spawning locations for burbot in the River (Paragamian et al. 2000), these recent spawning events peaked later and at warmer temperatures than reported for wild Kootenai River burbot (Kozfkay and Paragamian 2002). The observed peak in spawn-timing in 2013 and 2014 was also later than the mid-late February spawn-timing in Moyie Lake, where the original broodstock were collected (Matt Neufeld, MFLNRO, personal communication). This outcome was not expected and it is possible that the shift in spawn-timing may directly affect hatching success of burbot in the Kootenai River. Taylor and McPhail (2000) suggested that maximum egg survival occurred at 3°C, with 0% survival above 6°C. In addition, these authors reported the mean time to hatching increased from 41 to 46-d if the incubation temperature was reduced from 5 to 3°C. Temperatures in the Kootenai River following the 2013 spawning event exceeded the lethal temperature (6°C) during the critical 40-45 day incubation period. The spawn-timing of this newly stocked population may be later than the historical and donor population, therefore subjecting eggs to greater peaks above lethal temperatures. Identification of hatchery reared burbot first surviving and then spawning in known historical riverine locations was a significant step in the success of this conservation aquaculture program. Going forward, the final step is to identify recruitment in the wild, and will likely include determining temperature influence on spawn timing and how temperature affects egg hatching success. Not only will this information help drive identification of tributaries to focus on for release efforts, it may also provide useful recommendations to the United States Army Corps of Engineers (USACOE) on how to manage the selective temperature withdrawal system at Libby Dam in a way that will promote successful burbot recruitment through increased egg survival.

PIT Antenna Monitoring – Deep Creek

Relatively few juvenile burbot passed over the PIT tag array in Deep Creek during the 15-month monitoring period, and the majority was detected within 30 days after stocking. Further evaluation with hoop nets set at the stocking locations upstream of the array showed that at least a portion of those that were not detected leaving survived and increased in length and weight during this time period. Previous telemetry study results also suggested similar results with wide-ranging dispersal rates by age-2 and 3 burbot, while age-1 burbot remained relatively close to stocking locations (Stephenson et al. 2013). These findings suggest that stocking burbot at younger ages may increase residence time in targeted tributaries that have suitable habitat. On the contrary, detections of 16 additional hatchery-reared burbot revealed interesting and unexpected movement patterns, as they were originally stocked in the mainstem of the Kootenai River as far as 70 rkms downstream of Deep Creek. This also suggests the ability of younger hatchery burbot to pioneer new habitats and choose suitable habitat if it exists. In the near future, estimates of relative survival and movement of fish stocked into Deep Creek and other tributaries should aid in determining optimal release strategies that will promote survival and ultimately wild burbot recruitment in the Kootenai River system.

In addition to juvenile detections, the PIT tag array also detected several adult burbot of wild/unknown-origin during mid-March as temperatures warmed from 1 to 4°C. This corresponded with peak spawn timing in the Kootenai River at Ambush Rock. Although use of the main stem of Deep Creek by burbot for spawning was an encouraging and unexpected finding, egg hatching success may still be limited. Temperature loggers in Deep Creek indicated that temperatures near the array exceeded lethal incubation temperatures within the 40-45 day post-spawn period. Future efforts to track adults in order to determine the location and occurrence of spawning will aid in determining if natural production is possible in this, and potentially other, tributary streams.

Extensive Burbot Rearing

During the 2012/13 season, no fish reared in the ponds and released into the Kootenai River were captured using the standardized hoop-netting techniques. Burbot do not fully recruit to the hoop-netting gear until they reach 450 mm (Lafferty et al. 1991), so it was still early for determining the extent to which burbot reared in the ponds survived after being released into the Kootenai River drainage.

Our net pen experiment provided little evidence to support the hypothesis that adding substrates would reduce mortality. Cannibalism has been identified as a major contributor to early life mortality in intensive burbot culture (Trebelsi et al. 2011), as well as in the natural environment (Kahilainen and Lehtonen 2003). Kahilainen and Lehtonen (2003) reported cannibalism in burbot that were 21.1 mm long, which was within the size range where metamorphosis occurred. In our experiment, it is unclear what mortality occurred from cannibalism or other natural effects. Burbot exhibited similar increases in growth and declines in survival across treatment groups, suggesting that the substrates tested did not affect the rate of cannibalism.

RECOMMENDATIONS

1. Provide comprehensive analyses and recommendations to management by 2015 that provide clear criteria for opening up a burbot fishery on the Kootenai River.

2. Fully evaluate natural production and hatchery contribution through the use of PIT tags and PBT genetic marking.

3. Use available data to refine our understanding of what is limiting natural production in order to optimize a Systems operation request to the ACOE for Libby Dam.

4. Continue sampling index locations to measure changes in abundance, survival, size structure, and hatchery vs. natural production.

ACKNOWLEDGMENTS

We thank Shaun Lacy, Cathy Gidley, Wes Ewing, and Brian Simmons for helping in the rigorous fieldwork. We would also like to thank Diane Wakkinen and other temporary employees of IDFG for assistance with summarizing the data. Thanks to Dan Schill with IDFG for the editorial comments and Bonneville Power Administration for provided funding for this research.

TABLES

Table 2.1. Sample sites by river kilometer (RKM) and associated country, general name (if applicable), total burbot catch, and CPUE (burbot/net d). One net d is equivalent to 24 h. Rows shaded in grey are index sites. Listed separately, rkm 149.5 and 150.0 are a single index site at the mouth of Corn Creek.

RKM	Country	Effort (d)	Catch	CPUE
144.5	Canada	244.11	0	0.00
149.5	Canada	244.08	5	0.02
150	Canada	114.88	3	0.03
151.5	Canada	55.99	1	0.02
152.5	Canada	488.27	8	0.02
169	Canada	425.13	33	0.08
169.5	Canada	6.99	0	0.00
170	USA	236.86	3	0.01
199.5	USA	137.83	1	0.01
204.5	USA	239.64	7	0.03
213	USA	57.70	0	0.00
215.5	USA	43.79	0	0.00
225	USA	159.72	8	0.05
234.5	USA	241.33	11	0.05
239	USA	241.52	10	0.04
240.5	USA	227.77	14	0.06
241.5	USA	13.91	1	0.07
244.5	USA	482.33	153	0.32
TOTALS		3661.85	258.00	0.07

Table 2.2. Total number of burbot stocked from 2006-2012, PIT tagged, and recaptured in hoop nets during the 2012/13 winter season.

Year Class	Total Number Released	Total Number PIT Tagged	Number Recaptured	% Recapture	Not tagged
2006	0	7	0	0.000	
2007	28	28	2	0.071	0
2008	198	20	3	0.150	178
2009	587	557	28	0.050	30
2010	1,778	112	4	0.036	1,666
2011	70,535	16,943	26	0.002	
2012	285,830	3,397	3	0.001	
Totals	358,956	21,064	66	0.003	1,874

Table 2.3. Origin of PIT-tagged burbot that were recaptured in hoop nets during the 2012/13 season. Proportion is based on the number recaptured and not the total available for recapture. Stocking locations denoted with * indicate that release groups were mixed in transport prior to release and therefore cannot be differentiated between release origin.

Stocking Location	Year Class	Year Stocked 2009	2010	2011	2012	Total	% Return
Boundary Creek	2007		1			1	1.5
Goat River	2007	1				1	1.5
*Boundary Creek and Moyie River	2008		3			3	4.5
*Boundary Creek and Moyie River	2009		27			27	40.9
Goat River	2009		1			1	1.5
Boundary Creek	2010				2	2	3.0
Deep Creek Mouth	2010			1		1	1.5
Goat River	2010				1	1	1.5
Boundary Creek	2011			10	3	13	19.7
Deep Creek Mouth	2011			2	3	5	7.6
Ferry Island	2011			6		6	9.1
Goat River	2011			1	1	2	3.0
Boundary Creek	2012				1	1	1.5
Deep Creek @ Naples	2012				2	2	3.0

Table 2.4. Burbot catch, effort, CPUE (burbot/net-d), mean length (mm), and mean weight (g) with standard error in parentheses (SE), separated by mesh size for 2012 season. Recaptures were included in the calculations.

Mesh size (mm)	Count	Effort	CPUE	Mean length (SE)	Mean weight (SE)
6.4	8	93	0.09	363.9 (34.3)	385.5 (85.1)
12.7	129	372	0.35	441.3 (11.1)	719.1 (53.9)
19.1	121	470	0.26	426.5 (10.2)	652.8 (53.1)
Total	258	935	0.28	431.9 (7.4)	677.5 (36.9)

Table 2.5. Number, release location, release year, and brood year of burbot detected at the Deep Creek PIT tag array from 10/1/2012–4/25/2013.

Stocking Location	Stock Year	Year Class	Number Recorded
Deep Creek at Naples	2012	2012	58
Wild/Unknown	-	-	12
Deep Creek at McArthur outlet	2012	2012	5
Boundary Creek	2011	2011	4
Deep Creek Mouth	2012	2011	4
Deep Creek	2011	2011	2
Ferry Island	2011	2011	2
Total			87

Table 2.6. PIT antenna detection (first and last detections) and hoop net (HN) capture dates of "wild" or unknown-origin burbot. Fish No. corresponds to fish identification number in the database.

Fish No.	Vemco ID	First Detection Date	Last Detection Date	HN Capture 1	HN Capture 2	HN Capture 3	HN Capture 4
18341		2/13/13	3/8/13	1/7/2013	1/14/2013	3/11/2013	
17493	908	2/21/13	2/22/13	12/14/2011	2/17/2012	1/11/2013	3/4/2013
21488		2/26/13	2/26/13	1/22/2013			
18335	910	3/1/13	3/1/13	12/20/2012	1/29/2013	2/21/2013	3/4/2013
21532		3/3/13	3/10/13	3/14/2013			
21479		3/3/13	3/4/13	2/21/2013			
18333		3/4/13	3/9/13	12/17/2012	2/27/2013		
18344		3/4/13	3/4/13	2/21/2013	3/4/2013	3/11/2013	
18349	912	3/5/13	3/5/13	2/8/2013			
17502		3/6/13	3/7/13	2/17/2012	2/21/2013		
18351		3/16/2013	3/19/2013	2/21/2013			
21501		4/19/2013	4/19/2013	3/4/2013	3/14/2013	3/26/2013	

Table 2.7. Burbot mean total length (mm) and standard error (SE), number captured, number PIT-tagged, and survival rates for both BCWMA rearing ponds.

Pond	Mean Length (SE)	# Recovered	# PIT Tagged	% Survival
East	56.6 (0.19)	948	67	8.6
West	83.7 (0.50)	362	326	3.5
Combined	64.1 (0.39)	1,310	392	6.0

Table 2.8. Average length (mm) with standard error in parentheses (SE), number stocked on June 14, 2012, number removed on July 24, 2012, and survival with standard error, of burbot in BCWMA net pen rearing for all substrate treatment groups.

Treatment Groups	# Net pens	Avg. length (SE)	# Stocked	# Removed	% Survival (SE)
East Pond Control	2	34.1 (0.2)	400	142	35.5 (0.05)
East Pond Vegetation	3	33.7 (0.2)	600	251	41.8 (0.04)
West Pond Control	3	35.7 (0.2)	600	305	50.8 (0.06)
West Pond PVC	3	36.0 (0.2)	600	203	33.8 (0.04)

Table 2.9. Total number of burbot released from 2009-2012 into the Kootenai River and its tributaries. Tags indicate tagging with FDX PIT tags. Burbot without tags from 2011 – present will be able to have brood year assigned by PBT (genetic tagging).

Stock year	Brood year	Fish released with tags	Fish released without tags	Total fish released
2009	2006	7	-	7
	2007	23	-	23
	2008	1	178	179
2010	2007	5	-	5
	2008	18	-	18
	2009	555	-	555
	2010	-	1,576	1,576
2011	2009	-	26	26
	2010	36	90	126
	2011	16,297	53,966	70,263
2012	2010	82	-	82
	2011	656	-	656
	2012	3,392	269,805	273,197
Total		**21,072**	**325,641**	**346,713**

FIGURES

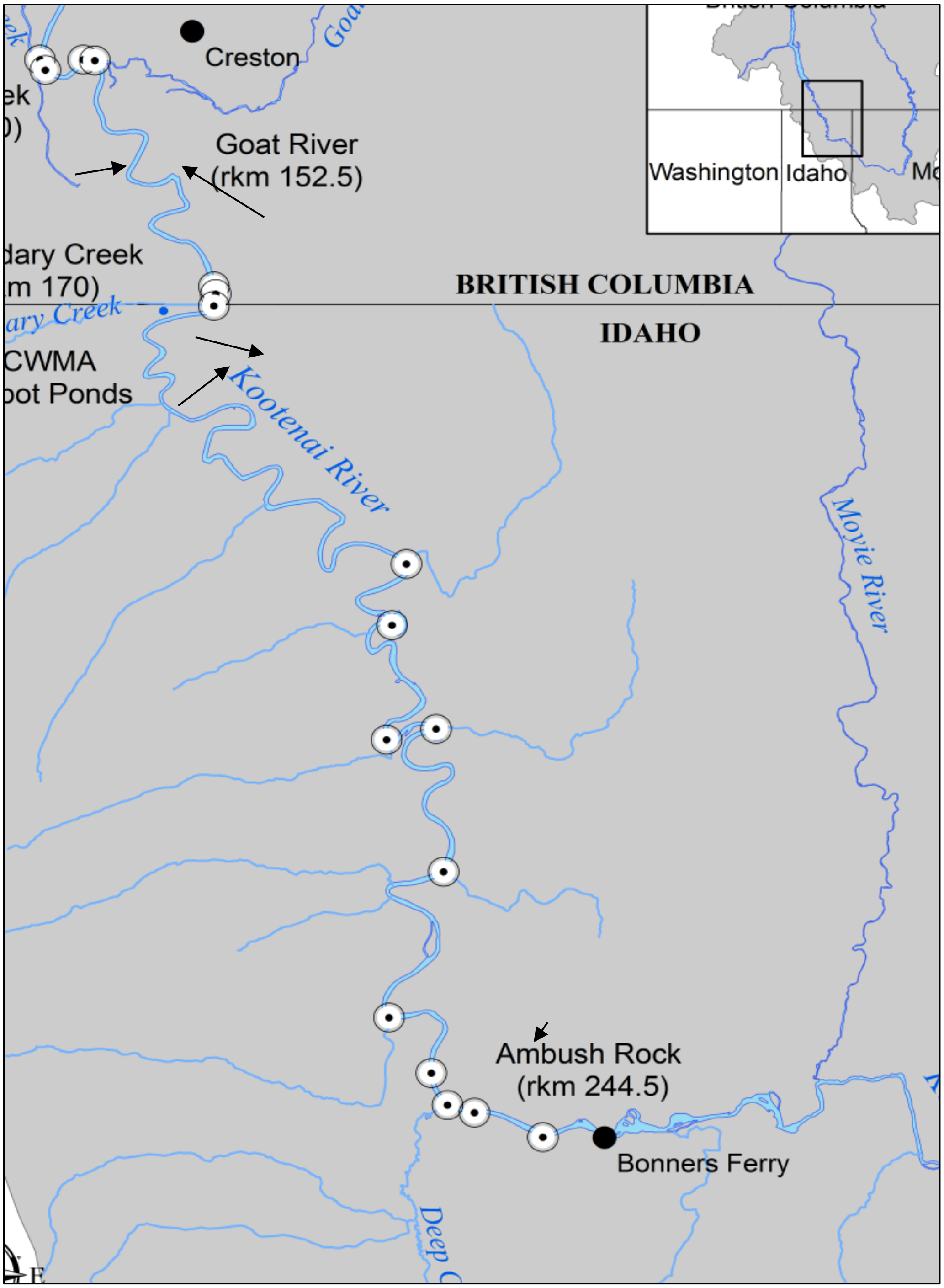

Figure 2.1. Locations of hoop net sample sites (black dot inside white circle) during 2012/13 sample season. Index sites are labeled with location name and associated rkm in parentheses.

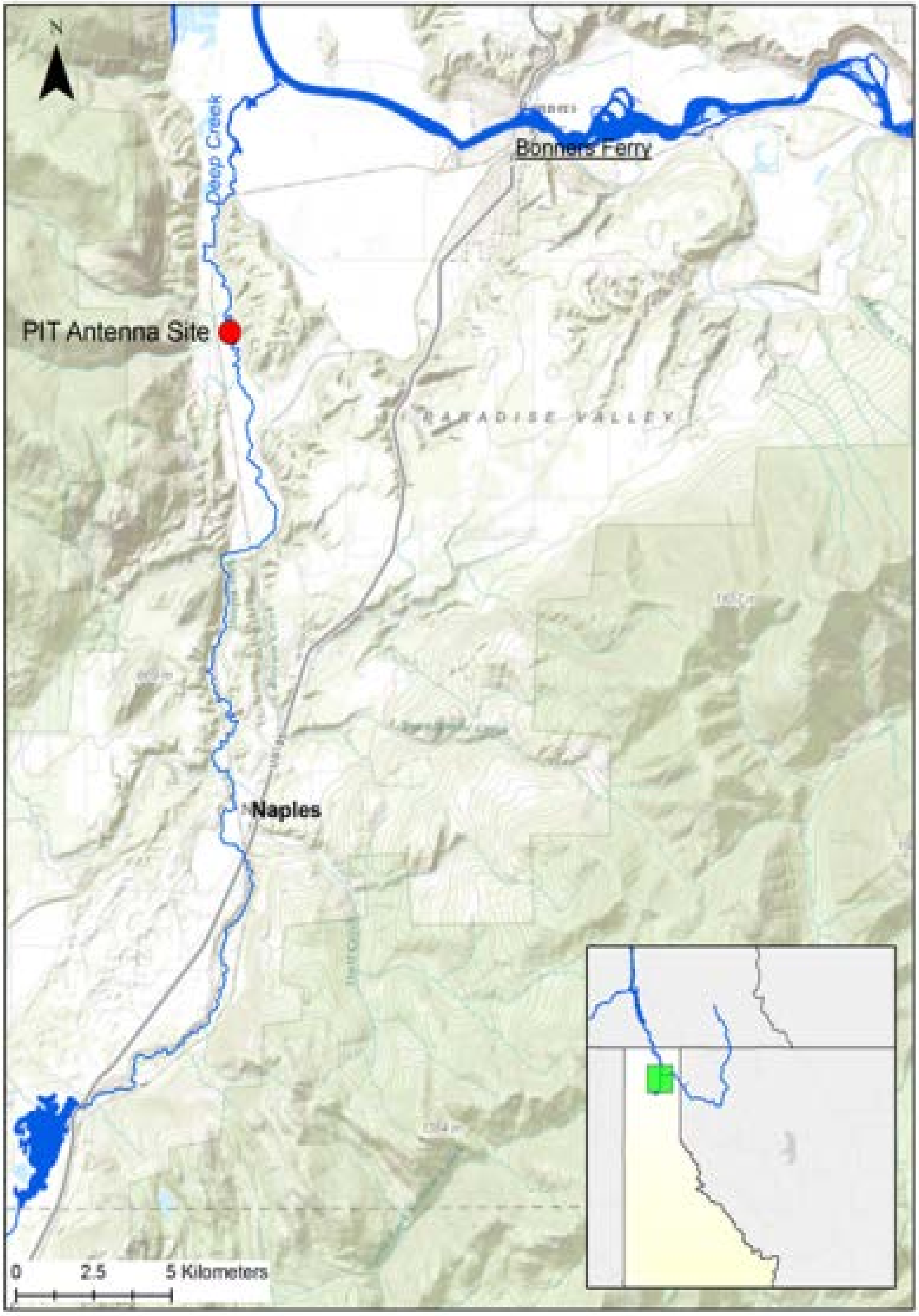

Figure 2.2. Location of Bio Mark PIT tag array installed October 2013. Location denoted by solid red dot 7 rkm upstream from confluence.

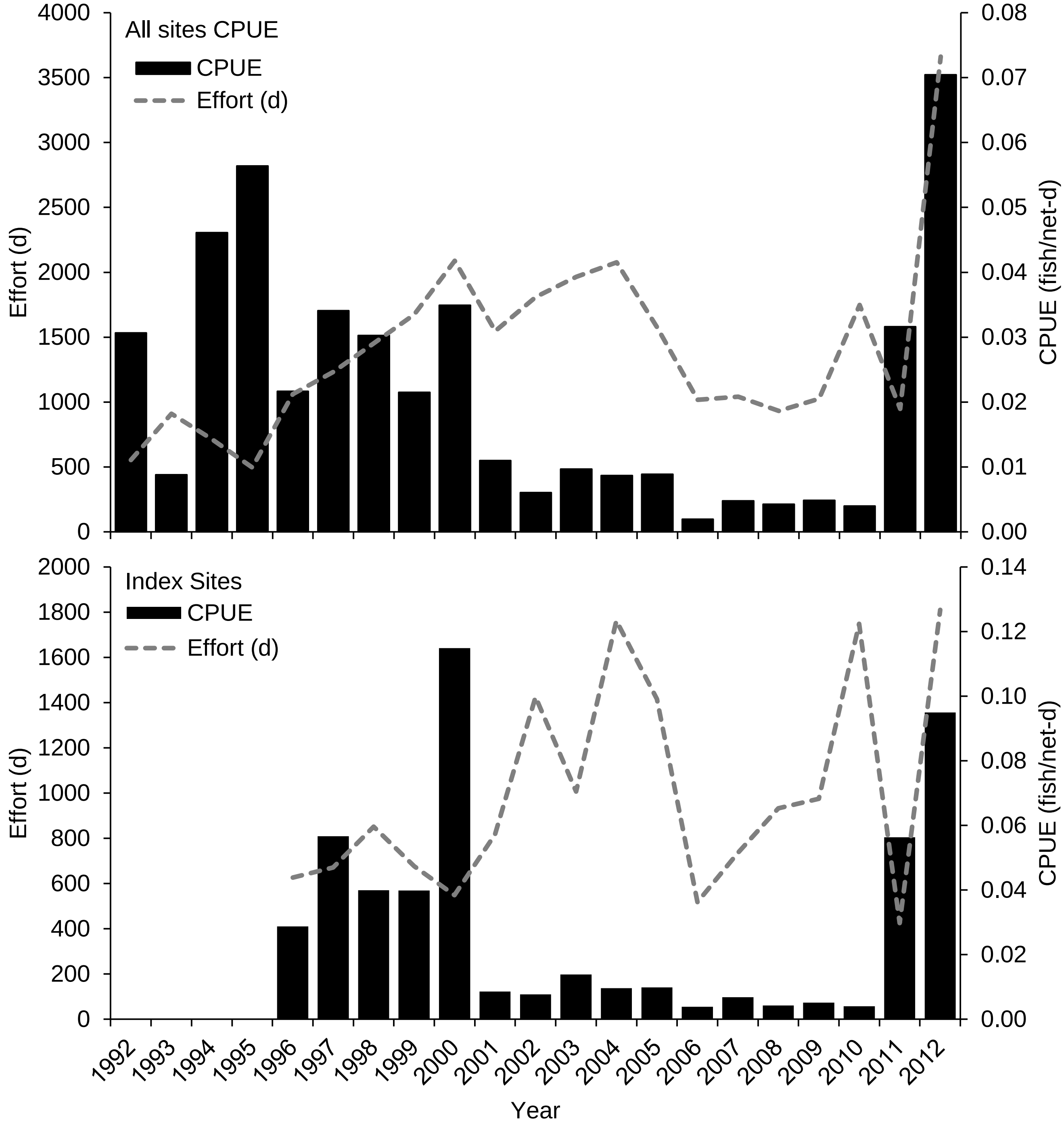

Figure 2.3. Catch-per-unit-of-effort (burbot/net-d) and effort (d) of hoop net sampling for all sites (top panel) and index sites (bottom panel) from 1992-2012. All five index sites were fished every year except 2000, 2006, and 2007, when Nick's Island (rkm 144.5, 2000 and 2006) and Corn Creek (rkm 150.0, 2007) were not sampled.

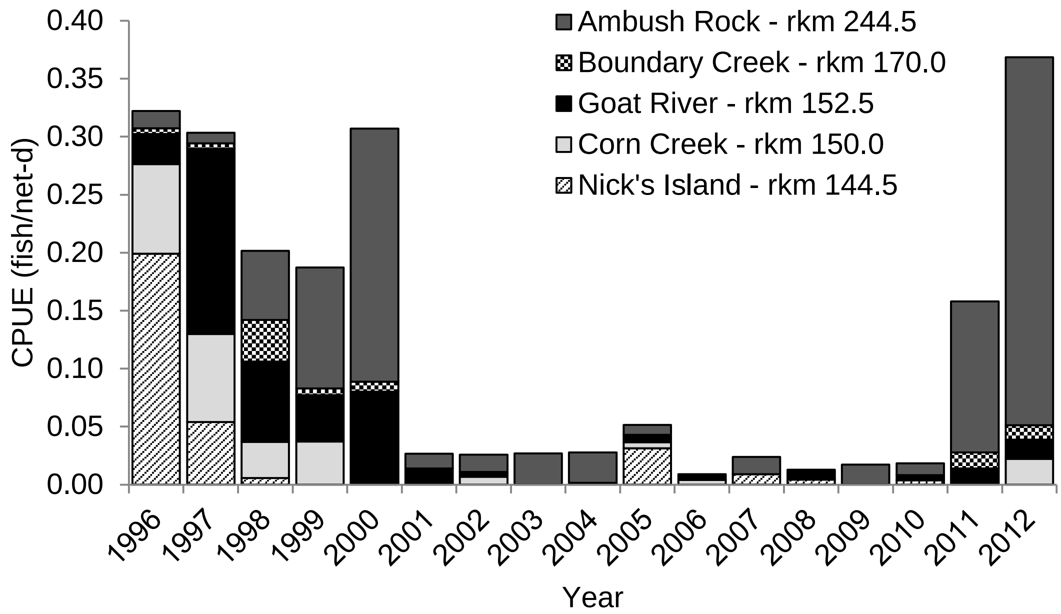

Figure 2.4. Composition of burbot hoop net CPUE (burbot/net-d) by index locations from 1996 to 2012.

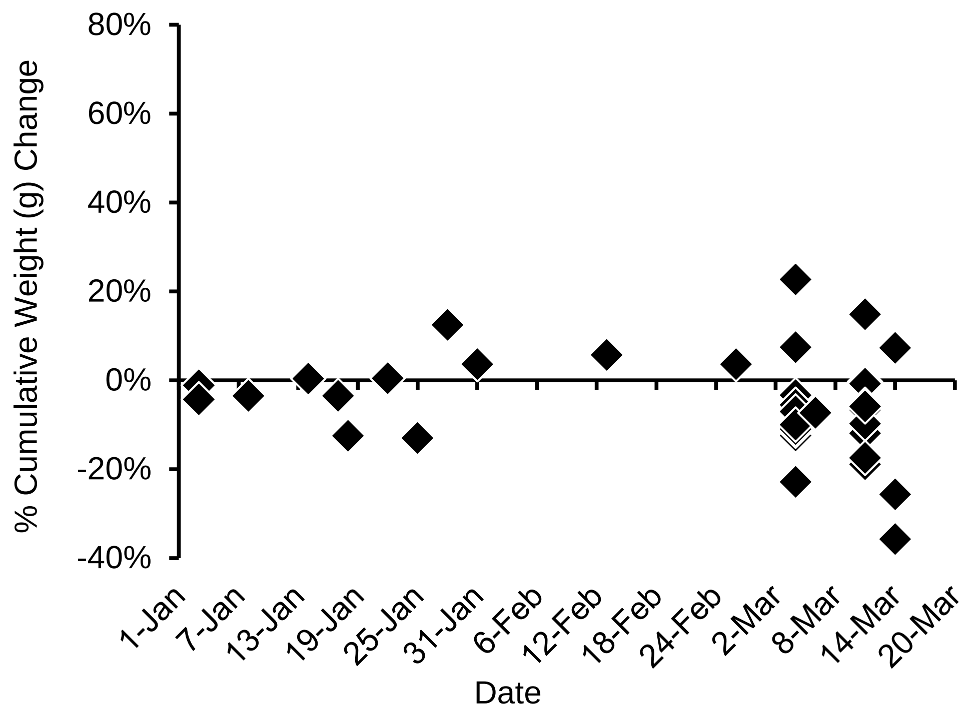

Figure 2.5. Timing of percent weight change in burbot recaptured within 14 days or less of initial handling.

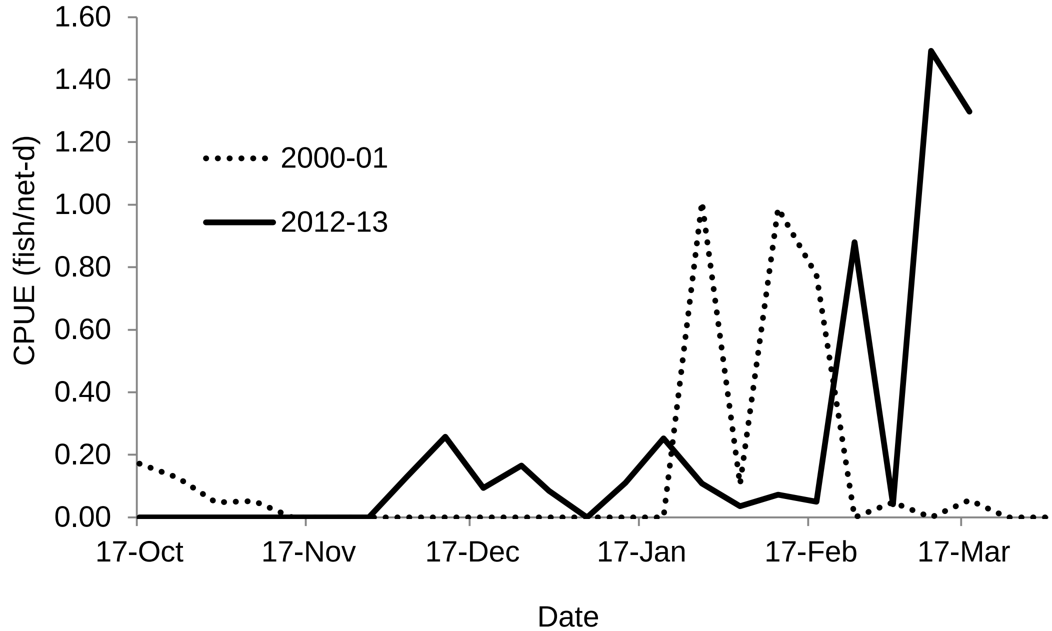

Figure 2.6. Catch-per-unit-of-effort of burbot over the winter sampling period in hoop nets fished at Ambush Rock during 2000/01 and 2012/13. These seasons were the two highest CPUE years and, thus, were used for comparison.

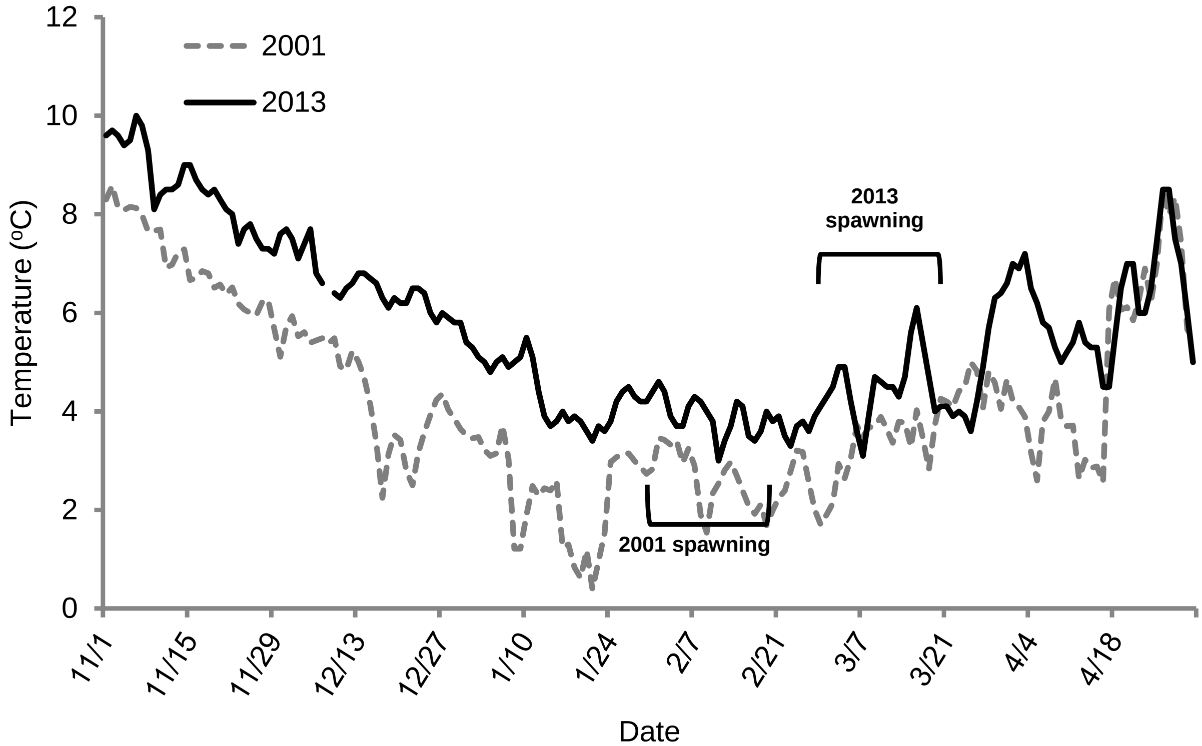

Figure 2.7. Temperatures in the Kootenai River at Ambush Rock during identified burbot spawning events in 2001 and 2013.

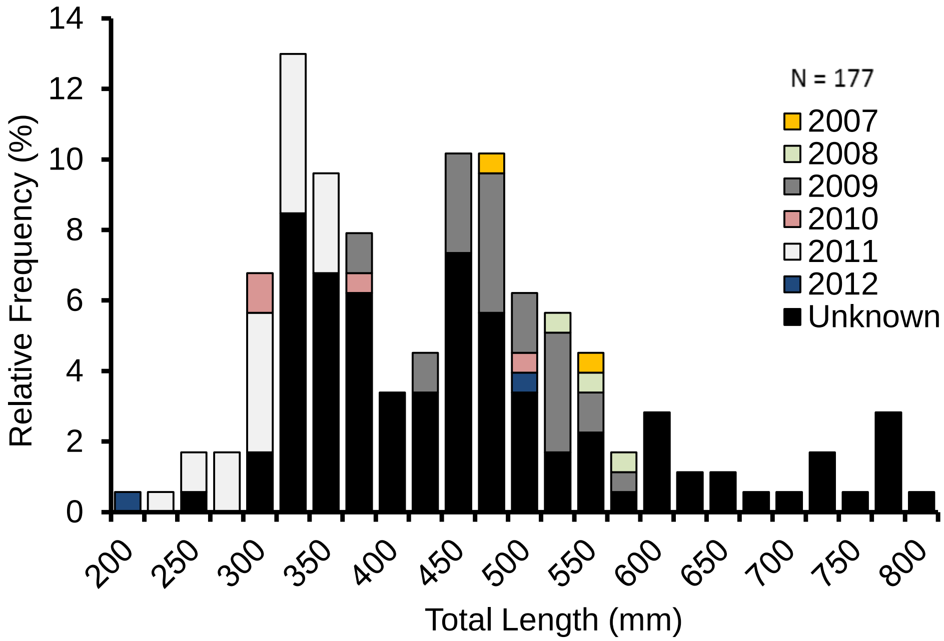

Figure 2.8. Length frequency and brood year assignments (through PIT tag returns) of burbot captured during hoop net index sampling from November 29, 2012-March 29, 2013.

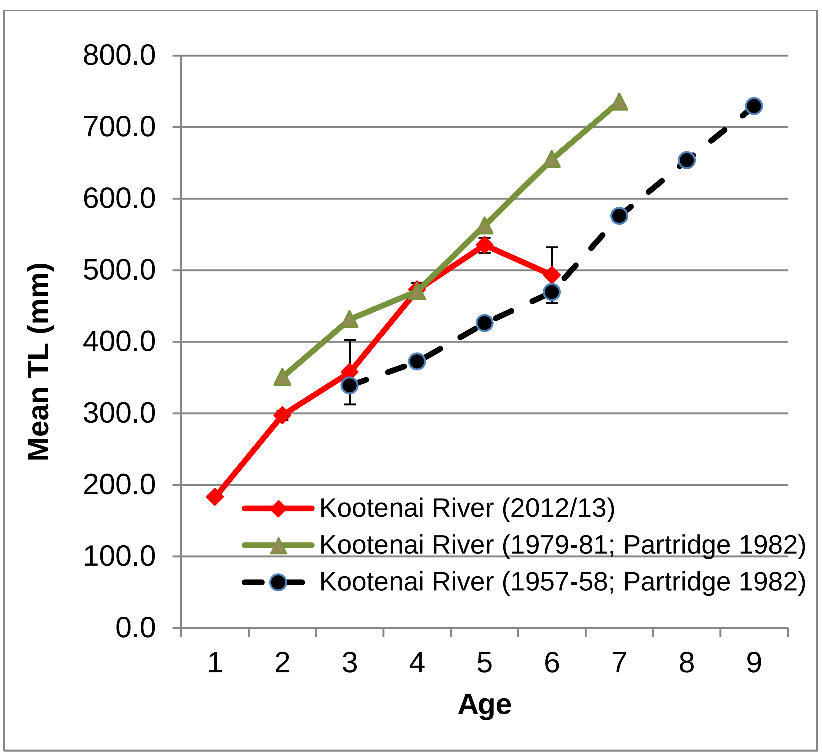

Figure 2.9. Length-at-age-at-time-of-capture for burbot captured in hoop nets in 2012/13 compared to that of fish captured in 1979-81 and 1957/58). Error bars (± 1 standard error) could not be calculated for data prior to 2012.

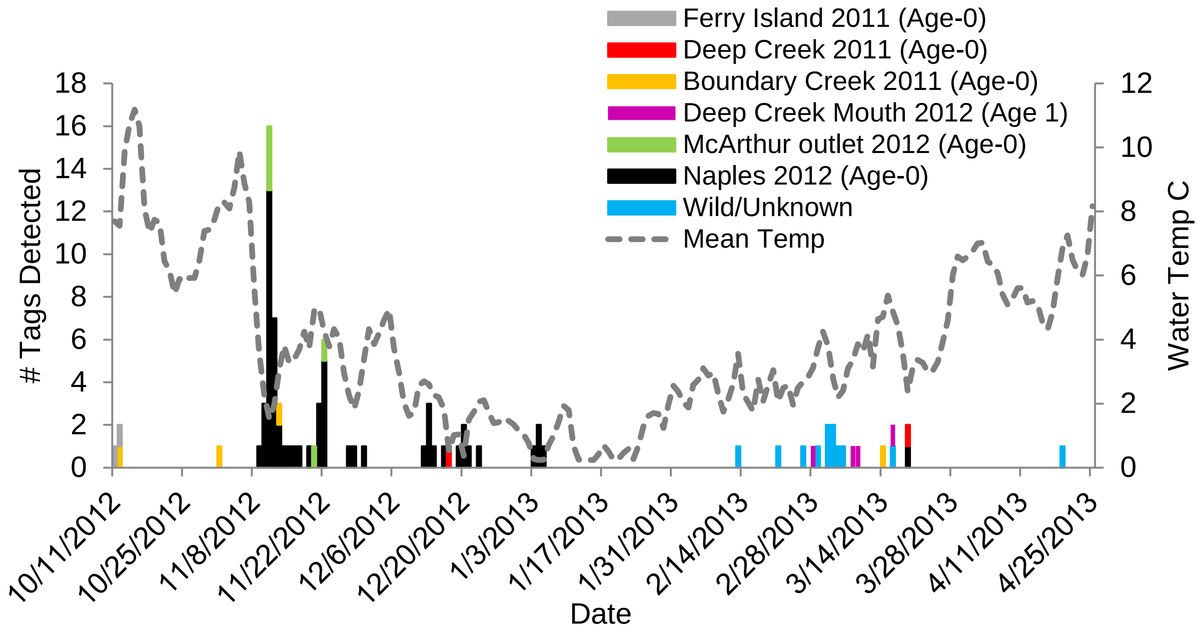

Figure 2.10. Number of PIT tag detections of individual burbot and corresponding and stream temperatures in Deep Creek. Detections are color-coded by release location, release year, and age at release. Only the first tag detection for each fish is represented.

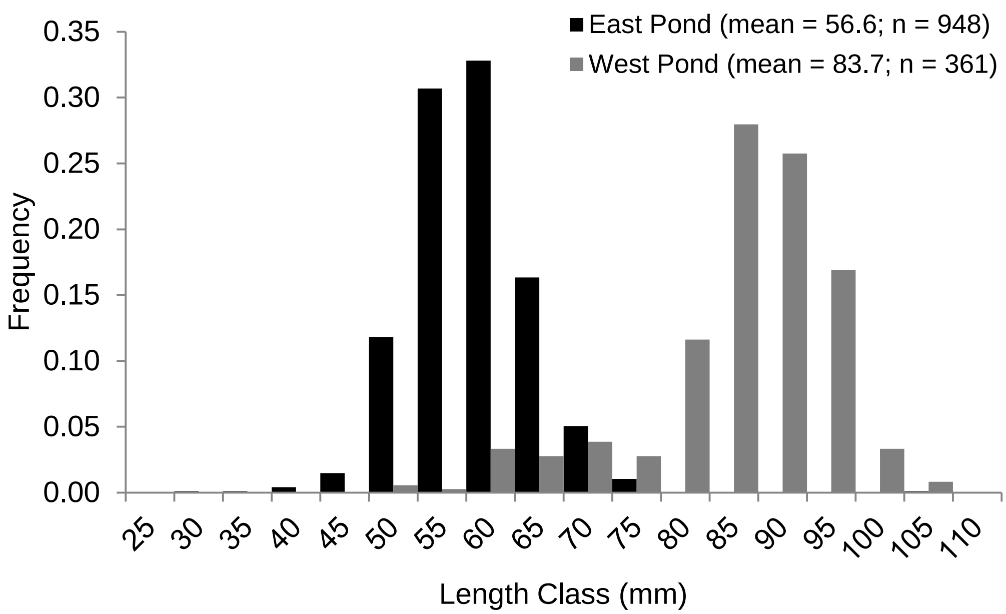

Figure 2.11. Length frequency of 2012 brood year of at-large burbot reared in BCWMA ponds during summer 2012.

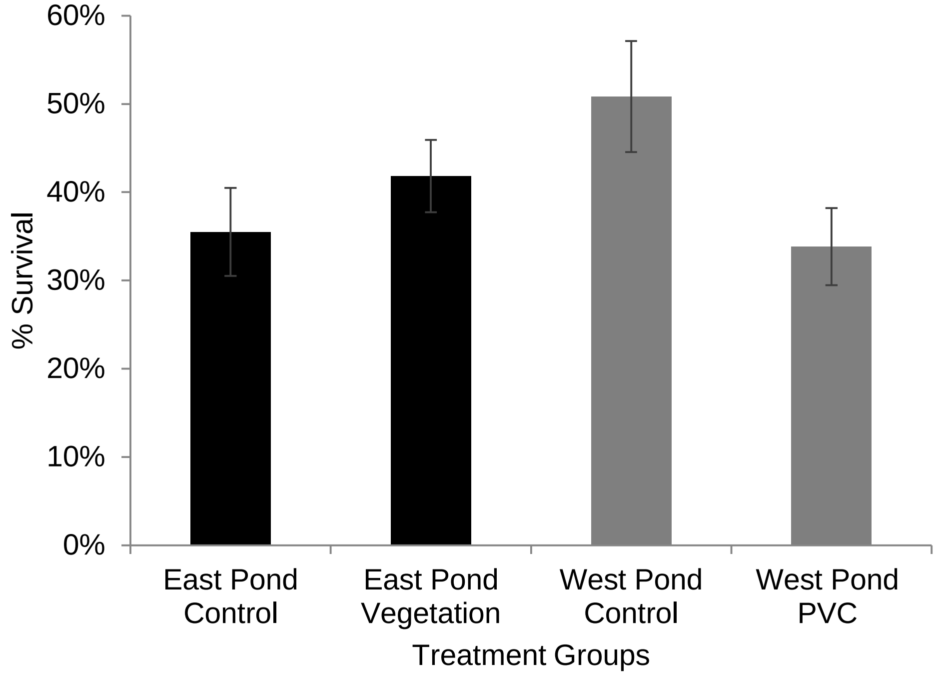

Figure 2.12. Percent survival of burbot reared in net pens of different substrate types in BCWMA East Pond and West Pond from June 14-July 24, 2012. Error bars = ± 1 standard error.

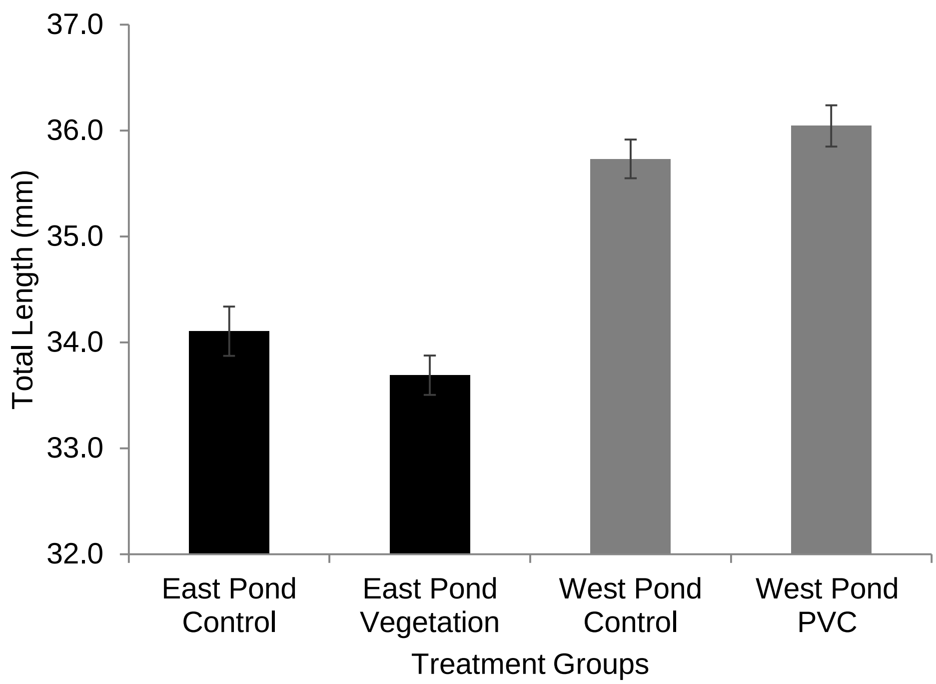

Figure 2.13. Mean total length (mm) for burbot raised in each net pen treatment group at BCWMA ponds from June 14 to July 24, 2012. Error bars = ± 1 standard error.

APPENDICES

Appendix 2.1. Capture information for each burbot surgically implanted with a Vemco sonic tag during 2012/13 hoop net sample season in the Kootenai River.

Date	Length (mm)	Weight (g)	Capture RKM	PIT Tag	Vemco Tag #	Prior PIT tag (Y/N)	Year Class	Stock Year	Sex
11/29/2012	751	2392	150.2	3D9.239F84582D	900	N			F
11/30/2012	579	1191	234.5	3D9.1BF2746DD5	901	Y			UNK
12/4/2012	416	387	244.5	3D9.239F844E70	902	N			UNK
12/5/2012	411	609	169.0	3D9.1C2D4CDAD4	903	Y	2009	2010	UNK
12/6/2012	522	820	225.0	3D9.1C2D456DE2	904	Y	2009	2010	UNK
12/7/2012	390	464	152.5	3D9.239F8446B5	905	N			UNK
12/11/2012	434	700	152.5	3D9.239F845BF1	906	N			M
12/21/2012	520	834	169.0	3D9.1C2D4D1DC1	907	Y	2009	2010	UNK
1/11/2013	565	1628	244.5	3D9.1C2D44D1CB	909	Y	2009	2010	UNK
1/11/2013	609	2106	244.5	3D9.1BF274790D	908	Y			M
1/29/2013	492	968	244.5	3D9.239F846044	910	Y			M
2/1/2013	487	838	199.5	3D9.1C2D458C5A	911	Y	2009	2010	UNK
2/8/2013	698	1840	244.5	3D9.239F844842	912	N			UNK
2/21/2013	526	1074	244.5	3D9.239F84479B	913	N			F
3/26/2013	765	2664	239.0	3D9.239F844B4C	914	N			F

Appendix 2.2. Burbot mean length (mm) with standard error (SE) and survival from net pen rearing experiment in BCWMA ponds during summer 2012. A hole in net pen # 4 mesh (East Pond; control) allowed burbot to escape into the at-large population.

Net pen Type	Net pen #	Mean length (SE)	# Stocked	# Removed	Survival Rate
East Pond Control	1	34.2 (0.3)	200	81	0.41
East Pond Control	5	34.1 (0.3)	200	61	0.31
East Pond Control	4	-	200	1	-
East Pond Vegetation	2	33.8 (0.3)	200	100	0.50
East Pond Vegetation	3	32.9 (0.3)	200	77	0.39
East Pond Vegetation	6	34.3 (0.3)	200	74	0.37
West Pond Control	8	35.5 (0.3)	200	106	0.53
West Pond Control	10	37.3 (0.3)	200	78	0.39
West Pond Control	12	34.9(0.3	200	121	0.61
West Pond PVC	7	36.9 (0.3	200	65	0.33
West Pond PVC	9	36.3 (0.3	200	54	0.27
West Pond PVC	11	35.2 (0.3	200	84	0.42

CHAPTER 3: NATIVE SALMONID MONITORING AND EVALUATION

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ABSTRACT

A large-scale nutrient rehabilitation 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, retaining approximately 63% of total phosphorus and 25% of total nitrogen entering the system. Declines in fish stocks have long been attributed to this loss of nutrients via bottom-up trophic cascades. Phosphate fertilizer has been added to the river during the growing season since 2005 in an attempt to increase primary production below Libby Dam, with the long-term intent of bolstering both sport and non-sport fish populations. Annual electrofishing surveys were conducted at multiple biomonitoring sites before and after nutrient addition in order to evaluate fish catch-per-unit-effort (CPUE), biomass-per-unit-effort, and various population metrics. Catch-per-unit-effort for rainbow trout and mountain whitefish exhibited similar (increasing) trends in the Nutrient Addition Zone for pretreatment years compared to post-treatment years; however, these trends were generally marginal, and similar trends were observed in the Control Zone. Relative weight increased at all sites for largescale sucker *Catostomus macrocheilus* and rainbow trout *Oncorhynchus mykiss* and decreased for mountain whitefish *Prosopium williamsoni*, post-treatment relative to pretreatment. Growth models for mountain whitefish indicated that growth was higher post-treatment for fish located at sites within the Nutrient Addition Zone; this trend was not observed in the Control site. These results indicate that this program has largely been successful; however, additional research and analyses are needed to better understand different effect levels.

INTRODUCTION

The Kootenai River basin has been impacted by many anthropogenic activities (e.g., agriculture, mining, land use practices, and the construction and operation 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); this was one noticeable effect, among many.

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. The loss of nutrients in the Idaho portion of the Kootenai River has reduced primary production, and this has likely contributed to poor sport and non-sport fish production over the past two decades.

Primary production is thought to be the foundation of bioenergetic development in higher trophic levels (Vannote et al. 1980). 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 Nutrient Addition Zone) 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*.

Increases in primary production have been successfully facilitated through the addition of inorganic P and N in other aquatic ecosystems (Ashley et al. 1999), which in turn has been 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 effort 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, kokanee spawners 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; nitrogen-phosphorus-potassium)] 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 (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 (Ashley and Stockner 2003). Nitrogen was identified to be potentially co-limiting in the Kootenai River as the growing season progressed. Due to the potential stripping of nitrate from solution by increased primary production, a threshold of 60 µg/L (of nitrate) was established, at which point nitrate fertilizer (32-0-0) would be added to the river.

The Kootenai River Ecosystem Project was designed to support recovery of fish populations utilizing an ecosystem-based strategy, as opposed to simply treating the symptoms of degrading stocks and individually declining species. The addition of nutrients to this ultraoligotrophic system was hypothesized to stimulate production in the nutrient-depleted food web and reverse the downward trends in populations of trout, kokanee, mountain whitefish, burbot *Lota lota*, White Sturgeon *Acipenser transmontanus*, as well as others species. 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.

OBJECTIVES

1. Attain a measurable increase in 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. Attain a measurable increase in the mountain whitefish population, preferably restoring the population back to the 1980-81 estimate of 14,000 -16,000 fish within the three km Hemlock Bar reach (Partridge 1983).

3. Attain a measurable increase in 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 north back 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 was comprised of approximately 106 km of the river that flowed through the Idaho Panhandle, along with two control sites (one in in Montana, and one in B.C.).

The Montana and Idaho portions of the Kootenai River below Libby Dam can be separated into three distinct river habitat types. Directly below the dam, the river flows through a narrow canyon segment characterized by steep canyon walls, high gradients, and boulder/cobble substrates. In this segment of the river, 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 segment there is a braided transition segment that extends from the Moyie River to the town of Bonners Ferry (Figure 3.1). Downstream from the braided transition segment, 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 (termed the meander segment).

Biomonitoring sites for this study were established to gather fisheries and lower trophic level data, before and after nutrient addition (Figure 3.2). Fish populations were surveyed at six biomonitoring 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. Site KR14 markedly differs (in habitat and fish community) from all sites below Libby Dam; therefore, it was not used in any analyses. The second control site (KR10) was located in the Montana portion of the canyon reach, termed the Control Zone of the river. Three sites were located within the Nutrient Addition Zone 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 segment and was approximately 10 km downstream from the nutrient addition site. Site KR6 was located in the braided segment above Bonners Ferry, approximately 20 km downstream from the nutrient addition site. The next two sites were located in the meander segment below Bonners Ferry, and they were considered to be in the Downstream Zone 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

Boat electrofishing was conducted during August and September from 2002-2012 at five biomonitoring sites. Site KR14 was added as a biomonitoring site from 2004-2012, and in 2009 site KR9.1 was added one km below the nutrient addition site. Collectively, sites that were surveyed in 2012 included KR14, KR10, KR9.1, KR9, KR6, KR4, and KR2. Data from these sites were used to assess relative species abundance and biomass and to compare various population metrics. 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-at-time-of-capture. These data were used to document temporal trends in the fish community and 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. The sampling crew consisted of two netters and one driver. All fish, regardless of species and size, were netted in order to get a representative sample of the fish community at each site. In order to increase replication, each biomonitoring site was divided into six equal subsections of 333 m with 150 m separating each to ensure that each subsection was independent of the next. This sampling design resulted in one kilometer of electrofishing occurring 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 taken to a workup station where they were 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 (W_r)

Relative weight was calculated, which allowed comparison of Kootenai River fish weight to that of a standard developed for each species. Mean W_r values of 100 indicate ecological and physiological optimums (Anderson and Neumann 1996; Blackwell et al. 2000). Relative weight was calculated using the formula:

$$Wr = \left(\frac{W}{Ws}\right) x\ 100,$$

where:

W was the actual fish weight, and
W_s was a standard weight for fish of the same length.

Relative weight was calculated for rainbow trout, mountain whitefish, and largescale sucker, the only fish species 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), and 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 (i.e., each read by a different individual). If there was no agreement, a fourth read was conducted by a biologist to make a final age-determination. Length-at-age-at-time-of-capture was used to compare growth before and after nutrient addition.

Age and growth data for mountain whitefish from pre- and post-treatment periods were compared using the FSA (Ogle 2013a), FSAdata (Ogle 2013b) and nlstools (Baty and Delignette-Muller 2013) packages in R. Data from KR10, KR9, and KR6 were first fit to the Von Bertalanffy growth equation, as described by Cailliet et al. (2006), and shown, below:

$$L_t = L\infty * [1 - e^{-K(Age - t_0)}],$$

where:

L_t= total length (mm) at time t,

$L\infty$= asymptotic or theoretical maximum total length,

K= growth coefficient, and

t_0= theoretical age when length equals zero.

Growth curves of pre- and post-treatment periods were compared by site using indicator variables and Akaike's information criterion (AIC), as described by Ogle (2013a). Fish scales from 2011-2012 were not read during this period; therefore, those data will be incorporated into future analysis. To ensure that fish alive during both periods were not included in the analysis (i.e. independence between periods), fish that were only alive during the pretreatment years were included in the pretreatment dataset, and fish that were only alive during the post-treatment years were included in the post-treatment dataset. This criterion resulted in only fish ages 0-4 being included in the post-treatment dataset. Likewise, to ensure that equal pre- and post-treatment comparisons were being made, the pretreatment dataset was filtered to only include fish ages 0-4, as well. This resulted in a total of 602 mountain whitefish comprising the pretreatment dataset and 548 mountain whitefish comprising the post-treatment dataset (i.e., summing across all sites). Eighty-seven mountain whitefish either (1) overlapped the two periods or (2) were older than age-4, and, hence, were removed from the dataset for analysis. Similar analyses were attempted for rainbow trout, but inadequate sample size and large variability in age estimates prevented proper fitting of the data to the growth model(s).

Statistical Analysis

The years from 2002-2005 were considered to be pretreatment and 2006-2012 were considered to be post-treatment, for all analyses. Site KR10 comprised the "Control Zone" of the river, sites KR9 and KR6 comprised the "Nutrient Addition Zone," and sites KR4 and KR2 comprised the "Downstream Zone". This delineation remained consistent across all analyses. R statistical software (R Core Team 2012) and SAS 9.3 (SAS Institute, Cary NC) were used for all statistical tests.

Abundance, Biomass, and Relative Weight (W_r)

Catch-per-unit-of-effort and BPUE data from pre- and post-treatment periods were compared using a repeated measures analysis of variance (ANOVA) model. The form of the model was:

$$Y_{ijk} = \mu + \alpha_i + T_k(i) + \beta_j + \alpha\beta_{jj} + \varepsilon_{ijk},$$

where:

Y_{ijk} = the catch metric (i.e., CPUE, BPUE or W_r),

μ = the intercept (i.e., overall mean),

α_i = the main effect "Period" (i.e., pre- or post-treatment),

$T_k(i)$ = the effect of year within period,

β_j = the main effect “Zone”,

$\alpha\beta_{jj}$ = the interaction effect “Period*Zone”, and

ε_{ijk} = the model error.

If model effects were found to be significant, post-hoc comparisons were made using differences of least square means. A similar model was used for the W_r data; however, there was no repeated measures statement in the model. Future analyses of W_r will utilize the same model used for the CPUE and BPUE data.

RESULTS

Fish Community Assessment

Abundance and Biomass

Seventeen species of fish were identified from the catch from 2002-2012, remaining relatively 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 due to 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.

Consistent with data from previous years, catch in the Downstream Zone in 2012 was dominated by northern pikeminnow, peamouth chub, and redside shiner; whereas, catch in the Control and Nutrient Addition Zones was comprised largely of mountain whitefish, largescale sucker, and rainbow trout. Catch at site KR14 was more similar to that in the Control and Nutrient Addition Zones, but with fewer rainbow trout. In terms of biomass in 2012, the Downstream Zone was dominated by northern pikeminnow and largescale sucker and the Control and Nutrient Addition Zones by mountain whitefish and largescale sucker.

Abundance (CPUE)—Total CPUE (i.e., all species combined) was higher in both the Control and Nutrient Additions Zones from pre- to post-treatment periods; however, the inverse trend was observed in the Downstream Zone (Figure 3.3). The repeated measures ANOVA model for CPUE of rainbow trout indicated that the main effects of Zone (df = 4, F = 36.45, p<0.002) and Period (df = 4, F = 11.79, 0.002) were both significant; however, the Zone*Period interaction term was not significant. Post-hoc tests on the interaction term indicated that abundance of rainbow trout in the Control Zone was significantly higher post-treatment compared to pretreatment (p = 0.03; Table 3.1). Catch-per-unit-of-effort of rainbow trout in the remaining river zones was not significantly different pre- and post-treatment; however, CPUE increased in the Nutrient-Addition Zone, post-treatment (Table 3.1; Figure 3.4). The model for CPUE of mountain whitefish indicated that Zone (df = 4, F = 289.40, p <0.0001), Period (df = 4, F = 17.93, p <0.01), and the interaction term (df=4, F=9.87, p = 0.03) were all significant. Post-hoc comparisons on the interaction term indicated that the Nutrient Addition Zone had higher CPUE of mountain whitefish post-treatment compared to pretreatment ($p = 0.004$; Table 3.2; Figure 3.5); CPUE in other river zones did not differ during pre- and post-treatment periods (Table 3.2).

Biomass (BPUE) —Total BPUE (i.e., all species combined) showed a trend similar to that of total CPUE. Biomass-per-unit-of-effort was higher in both the Control and Nutrient Additions Zones from pre- to post-treatment period, and this trend was most pronounced in the Nutrient Addition Zone (Figure 3.6). Also consistent with total CPUE, the inverse trend was observed in the Downstream Zone (Figure 3.6), although the decline in BPUE from pre- to post-treatment periods was small. The ANOVA model for BPUE of rainbow trout indicated that the effect of Zone ($df = 4$, $F = 11.61$, $p = 0.02$) was significant, but the main effect of Period and the interaction term were not (Figure 3.7). Similarly, the ANOVA model for BPUE of mountain whitefish indicated that the effect of Zone ($df = 4$, $F = 119.16$, $p <0.001$) was significant, but the main effect of Period and the interaction term were not (Figure 3.8).

Relative Weight (W_r)

Few mountain whitefish were captured at sites KR4 and KR2; hence, data from these sites were not included in the analysis of W_r. The ANOVA model for W_r of mountain whitefish indicated that the main effects of Site ($df = 3$, $F = 189.47$, $p <0.0001$) and Period ($df = 1$, $F = 253.18$, $p <0.0001$) were significant, as well as the interaction term, Site*Period ($df = 3$, $F = 69.91$, $p <0.0001$). Post-hoc Tukey HSD tests on the interaction term revealed that W_r of mountain whitefish from KR14 ($p <0.0001$), KR10 ($p <0.0001$), and KR9 ($p <0.0001$) were significantly lower post-treatment compared to pretreatment (Table 3.3); W_r of mountain whitefish from KR6 did not differ between the two periods (Figure 3.9).

The ANOVA model for W_r of largescale suckers indicated that the main effects of Site ($df = 5$, $F = 21.10$, $p <0.0001$) and Period ($df = 1$, $F = 183.88$, $p <0.0001$) were significant, as well as the interaction term, Site*Period ($df = 5$, $F = 15.68$, $p <0.001$). Post-hoc tests on the interaction term revealed that W_r of largescale suckers from sites KR10 ($p <0.0001$), KR2 ($p <0.0001$), KR4 ($p <0.0001$), KR6 ($p <0.0001$), and KR9 ($p <0.001$) were significantly higher post-treatment compared to pretreatment (Table 3.3); this effect was greatest at sites KR6 and KR9 (Figure 3.10). Relative weights of largescale suckers at site KR14 were similar between pre- and post-treatment periods.

Few rainbow trout were captured at sites KR14 and KR2; hence, data from these sites were not included in the analysis of W_r. The ANOVA model for W_r of rainbow trout indicated that the main effects of Site ($df = 3$, $F = 30.86$, $p <0.0001$) and Period ($df = 1$, $F = 10.19$, $p = 0.001$) were significant; however, the interaction term, Site*Period, was not (Figure 3.11). Although not significant, W_r of rainbow trout at sites KR10, KR9, KR6, and KR4 were all (generally) higher post-treatment compared to pretreatment (Table 3.3).

Age and Growth

Von Bertalanffy growth models that were developed for pre- and post-treatment periods for mountain whitefish were compared to one another, by site, using AIC procedures. Results from the model comparison for KR10 (Table 3.4) indicated that pre- and post-treatment growth of mountain whitefish was similar in all regards, with the exception of t_0, the theoretical age at which length was equal to zero. Generally, t_0 is not considered a readily informative parameter to the model or for biologically comparative purpose (Quist et al. 2012); hence, these results suggest that growth of mountain whitefish at site KR10 was similar during pre- and post-treatment periods (Figure 3.12). Results from the model comparisons for KR9 (Table 3.4) indicated that growth of mountain whitefish during pre- and post-treatment periods was significantly different. More specifically, growth (based on length-at-age-at-time-of-capture) appeared to be higher during the post-treatment period compared to the pretreatment period; this was most apparent for age-1, age-2, and age-3 fish (Figure 3.13). The model also indicated that length-at-age-at-time-of-capture of age-0 and age-4 fish appeared to be lower during the post-treatment period than during the pretreatment period. Bootstrapped estimates of mean length-at-age-at-time-of-capture and 95% confidence intervals corroborated the model output (Table 3.5). Data collected during future years will allow for additional model fitting, and, thus, better inform the extent of these apparent trends. Results from the model comparisons for KR6 (Table 3.4) indicated that growth of mountain whitefish during pre- and post-treatment periods was significantly different in all regards except for t_0. Furthermore, the model revealed that growth during the post-treatment period was higher than growth during the pretreatment period. This was apparent for age-0, age-1 and age-2 fish; length-at-age-at-time-of-capture of age-3 fish appeared to be similar during pre- and post-treatment periods, and length-at-age-at-time-of-capture of age-4 fish appeared to be lower during the post-treatment period compared to the pretreatment period (Figure 3.14). These findings were evident in bootstrapped estimates of mean length-at-age-at-time-of-capture and 95% confidence intervals, as well (Table 3.5).

DISCUSSION

<u>Fish Community Assessment</u>

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 habitat conditions. Flow velocities were higher and the substrate was largely comprised of cobble in the treatment reach. Mountain whitefish and rainbow trout, species preferring cobble substrate and higher flow velocities, were more predominant in the treatment reach. Future analyses will incorporate ordination techniques in an attempt to explain the variability observed in fish assemblages among sites. Generalizations can then be drawn from these analyses with regard to habitat differences among sites.

Species composition (based on proportion of catch) showed only minor shifts at a few sites, when compared between pre and post-treatment periods. Species composition at sites KR6 and KR9 remained very similar from pre- and post-treatment periods. The most notable shifts in species composition occurred at sites KR4 and KR2. The proportion of northern pikeminnow at these sites increased from 35-50% at site KR4 and from 33-38% at site KR2. Historically, the pikeminnow population exhibited large fluctuations at these sites, generally in relation to high flow years. Site KR4 is 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

Total CPUE in the Nutrient Addition Zone showed an increasing trend from the pretreatment period to the post-treatment period; however, the inverse relationship was observed in the Downstream Zone (i.e., CPUE showed a decreasing trend). Stream and river ecosystems generally follow a predictable, longitudinal continuum in terms of stream characteristics (e.g., discharge, temperature, and fish/macroinvertebrate feeding guilds; Vannote et al. 1980). According to this continuum concept, the macroinvertebrate communities in the lower reaches of streams and rivers, such as those found in the Downstream Zone of the Kootenai River in Idaho, are generally comprised of collectors that consume any available fine particulate organic matter (FPOM) and detritus that are transported from reaches located higher in the system. Artificially increased production in a river ecosystem (such as that created by the nutrient enhancement project on the Kootenai River) can alter the breakdown efficiency and transport of FPOM, which can ultimately create unexpected, bottom-up trophic cascades in river reaches where the macroinvertebrate base relies on FPOM resources (Benstead et al. 2009). This type of increase in FPOM export could potentially decrease the density and relative abundance of macroinvertebrates in a given system (due to a reduction in basal food sources as a function of increased export), which could then translate to decreases in higher trophic levels (e.g., fish) that prey on these macroinvertebrates. Macroinvertebrate data collected by the KTOI in the Downstream Zone show slightly decreasing trends in density that are consistent with the decreases in total CPUE and BPUE of fish (C. Holderman, personal communication, Kootenai Tribe of Idaho). Although further analysis is required, it is possible that increased FPOM export in response to nutrient enhancement may be one (of many) mechanisms explaining the trends in CPUE observed in the Downstream Zone.

It is often difficult to predict the outcome(s) of large-scale, manipulation-type experiments at all trophic levels, and it is not uncommon for unexpected or unforeseen outcomes to arise (Cross et al. 2011). A primary target for the nutrient project that was identified by the Idaho Department of Fish and Game was to increase the abundance of rainbow trout. Marked increases in CPUE have been achieved for mountain whitefish; however, CPUE of rainbow trout has not shown the same magnitude of increase (as mountain whitefish), and recent population estimates for rainbow trout at the sole long-term index site suggest the same. This result was not expected. Davis et al. (2010) suggested that unexpected predator-prey responses and effects on food web efficiencies can occur with long-term nutrient enrichment projects, such as the one on the Kootenai River. It is unknown whether or not the aforementioned types of responses are occurring in the Kootenai River; however, it is possible that the addition of nutrients to the Kootenai River has affected the food web in unforeseen ways that have allowed mountain whitefish to capitalize on specific prey items more readily than rainbow trout. This, in turn, could potentially explain the higher increase in catch of mountain whitefish, relative to rainbow trout. Alternatively, the response of rainbow trout compared to mountain whitefish (as gauged by CPUE), may not be related to forage and growth, but rather, it may be an artifact of spawning and recruitment. Mountain whitefish are known to be spawning generalists that utilize both tributary and mainstem systems for spawning (Wallace and Zaroban 2013); whereas, rainbow trout are known to have more specific requirements for spawning habitat (Wallace and Zaroban 2013). Lack of spawning habitat for rainbow trout in the Kootenai River has long been proposed to be a factor limiting recruitment (in addition to food limitation; Partridge 1983). In contrast, forage limitation has been identified to be a primary limiting factor for mountain whitefish and other fish species in the Kootenai River (Snyder and Minshall 1996). Therefore, it is logical that mountain whitefish have shown more drastic increases in catch than rainbow trout. This information may provide evidence to eliminate forage availability from the list of potential factors limiting the recruitment of rainbow trout to the Kootenai River. Additional research is needed (and currently underway) to determine the extent to which spawning habitat may be limiting recruitment of rainbow trout.

Relative Weight

Changes in W_r from pre- and post-treatment years were most notable in largescale suckers in the Nutrient Addition Zone. Largescale suckers are benthic feeders consuming periphyton, zooplankton, invertebrates, detritus, and plant material. Since nutrient addition 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, personal communication, Kootenai Tribe of Idaho). It is likely that suckers have been able to utilize the increased primary production more rapidly and directly than mountain whitefish and rainbow trout, which likely explains the increases in W_r.

Unlike largescale suckers and rainbow trout that exhibited increases in W_r during the post-treatment period (especially in the Nutrient Addition Zone), mountain whitefish had lower W_r at all sites during the post-treatment period. Blackwell et al. (2000) identified several studies in which relative weight was strongly correlated with fish density (i.e., indicating density-dependent effects). It is possible that the decrease in W_r of mountain whitefish during the post-treatment period could be in response to the increased abundance of mountain whitefish during this same period. However, if this were the case, growth would also reflect density-dependent effects, which it currently does not. It is more probable that specific age-classes of mountain whitefish may be suffering from density dependent effects; the growth models anecdotally support this, but it is not known if the W_r data support this, as well. Further and more specific (i.e., by age-class) analysis of the W_r data for mountain whitefish is needed to determine if (1) density-dependence is affecting mountain whitefish, (2) all age-classes are affected by density-dependent effects, or (3) if only specific age-classes are being affected.

Age and Growth

Length-at-age-at-time-of-capture was greater for younger mountain whitefish in the treatment reach during the post-treatment period (compared to the pretreatment period); however, this increase was not present in older age-classes, and ultimately resulted in what appeared to be a net-loss in terms of growth. Other studies involving nutrient enrichment of stream and river systems have reported similar growth results. For instance, all age classes of arctic grayling in the Kuparuk River, Alaska were found to have greater growth following the addition of nutrients when compared with fish from a control reach; however, younger age-classes of fish experienced greater increases in growth than older age-classes (Deegan and Peterson 1992). The authors attributed this response to increased abundance of smaller prey items in the fertilized reach of the river, which the younger grayling were able to exploit. In general, growth of young salmonids is known to be food-limited in many river systems (Johnston et al. 1990); whereas the ability to store energy (i.e., in the form of lipids) as well as growth is often food-limited in adult salmonids (Deegan and Peterson 1992). Therefore, it is possible that both younger and older age-classes of mountain whitefish in the Kootenai River are benefitting from the increased productivity created by nutrient additions. Although further analysis is required, young fish may manifest this benefit via growth; whereas, older fish may manifest this benefit via body condition and energy stores (rather than growth). Alternatively, the variability observed in growth may be attributed to density dependent effects on the older age-classes of mountain whitefish. Additional and more specific analyses of growth, W_r and population data need to be conducted to determine whether this mechanism is affecting the status of mountain whitefish in the Kootenai River.

RECOMMENDATIONS

1. Continue annual 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 biomonitoring sites.

ACKNOWLEDGEMENTS

Numerous people helped with field sampling and preparation of this report. Charlie Holderman (KTOI) is the co-manager of the nutrient addition program and provided information on lower trophic level results. For assistance with field work, thanks to: Jim Dunnigan and crew (MTFWP), Gen Hoyle (KTOI), Wes Ewing, Shaun Lacy, Cathy Gidley, and Jake Hughes. For preparation of this report, thanks to Ryan Hardy, Mike Petersen, Jim Dunnigan, and Cathy Gidley for edits and Cheryl Zink for preparing the report for printing.

TABLES

Table 3.1. Average CPUE and BPUE of rainbow trout from all river zones during pre- and post-treatment periods. Values shown denote mean ± standard deviation. * indicates significant difference between pre- and post-treatment periods (compared by river zone).

	RBT CPUE (fish/min)		**RBT BPUE (kg of fish/min)**	
	Pretreatment	**Post-treatment**	**Pretreatment**	**Post-treatment**
Control	0.37±0.10*	0.83±0.21*	1.29±0.38	2.19±0.78
Nutrient-Addition	0.29±0.18	0.49±0.29	0.95±0.73	1.44±0.75
Downstream	0.05±0.05	0.05±0.05	0.11±0.11	0.11±0.13

Table 3.2. Average CPUE and BPUE of mountain whitefish from all river zones during pre- and post-treatment periods. Values shown denote mean ± standard deviation. * indicates significant difference between pre- and post-treatment periods (compared by river zone).

	MWF CPUE (fish/min)		**MWF BPUE (kg of fish/min)**	
	Pretreatment	**Post-treatment**	**Pretreatment**	**Post-treatment**
Control	2.25±0.99	3.33±0.89	6.92±2.96	8.29±2.83
Nutrient-Addition	3.68± 1.00*	7.60±2.66*	8.17±3.42	14.05±6.17
Downstream	0.18±0.18	0.14±0.21	0.08±0.09	0.04±0.05

Table 3.3. Average W_r of mountain whitefish, largescale sucker, and rainbow trout from sites KR14, KR10, KR9, KR6, KR4, and KR2 for pre- and post-treatment periods. Values shown denote mean ± standard deviation (N). * indicates significant difference between pre- and post-treatment periods (compared by biomonitoring site).

	MWF		**LSS**		**RBT**	
	Pretreatment	**Post-treatment**	**Pretreatment**	**Post-treatment**	**Pretreatment**	**Post-treatment**
KR14	84.72±11.41 (314)	80.31±9.27 (870)	81.17±11.50 (140)	82.14± 8.26 (623)	----------	----------
KR10	92.59± 9.26 (533)	84.29±8.13 (1592)	82.19±11.52 (125)	88.12±10.73 (173)	89.83±8.22 (119)	91.99±9.40 (453)
KR9	88.85±10.32 (456)	85.24±9.44 (2166)	75.28± 7.59 (97)	87.71± 8.92 (277)	88.81±8.29 (65)	90.77±9.46 (178)
KR6	80.58± 8.40 (580)	81.32±8.58 (1873)	74.56± 8.31 (69)	83.95± 8.45 (184)	84.36±7.66 (36)	85.88±8.67 (118)
KR4	----------	----------	82.47±11.05 (165)	87.64±11.47 (131)	80.91±9.03 (23)	84.44±9.24 (48)
KR2	----------	----------	83.49± 7.15 (119)	88.28± 6.81 (262)	----------	----------

Table 3.4. Akaike's information criterion results for comparison of pre- and post-treatment growth models for sites KR10, KR9, and KR6. The most parsimonious model for each site is shaded in grey.

		AIC Scores		
Model equation	**Model description**	**KR10**	**KR9**	**KR6**
$L_t = L\infty\,[Period] * [1 - e^{-K[Period](Age - t_0[Period])}]$	No parameters in common	2697.59	2997.28	4644.45
$L_t = L\infty * [1 - e^{-K[Period](Age - t_0[Period])}]$	L∞ in common	2695.63	2998.76	4646.60
$L_t = L\infty[Period] * [1 - e^{-K(Age - t_0[Period])}]$	K in common	2695.74	3000.47	4647.84
$L_t = L\infty[Period] * [1 - e^{-K[Period](Age - t_0)}]$	t_0 in common	2696.97	3001.70	4644.26
$L_t = L\infty * [1 - e^{-K(Age - t_0[Period])}]$	L∞ and K in common	2694.34	3001.87	4646.20
$L_t = L\infty * [1 - e^{-K[Period](Age - t_0)}]$	L∞ and t_0 in common	2696.64	3000.00	4644.64
$L_t = L\infty[Period] * [1 - e^{-K(Age - t_0)}]$	K and t_0 in common	2698.05	2999.74	4647.93
$L_t = L\infty * [1 - e^{-K(Age - t_0)}]$	All parameters in common	2699.50	3000.35	4652.71

Table 3.5. Bootstrapped estimates (1,000 replicates) of mean length-at-age-at-time-of-capture and 95% confidence intervals for mountain whitefish during pre-and post-treatment periods at sites KR10, KR9 and KR6. All lengths are in millimeters.

	KR10		**KR9**		**KR6**	
	Pretreatment	**Post-treatment**	**Pretreatment**	**Post-treatment**	**Pretreatment**	**Post-treatment**
Age-0	131.07 (119.34-142.47)	113.58 (103.05-123.67)	135.54 (121.67-147.23)	120.18 (113.51-126.78)	109.64 (101.35-117.95)	113.17 (109.23-117.23)
Age-1	197.27 (193.68-201.24)	189.34 (182.74-195.66)	189.18 (183.82-194.28)	195.56 (190.06-201.10)	186.76 (182.89-190.62)	197.302 (193.45-200.93)
Age-2	243.30 (239.74-246.68)	239.98 (233.94-245.41)	231.91 (226.38-237.23)	242.26 (237.29-246.75)	236.29 (232.76-239.62)	242.67 (239.01-246.22)
Age-3	275.31 (272.05-278.43)	273.82 (265.41-281.89)	265.95 (260.73-270.58)	271.21 (264.50-278.09)	268.09 (264.50-271.64)	267.13 (261.23-273.86)
Age-4	297.55 (292.24-302.64)	296.45 (281.29-313.07)	293.07 (284.97-300.85)	289.15 (278.17-301.29)	288.51 (282.79-294.48)	280.32 (271.29-291.10)

FIGURES

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

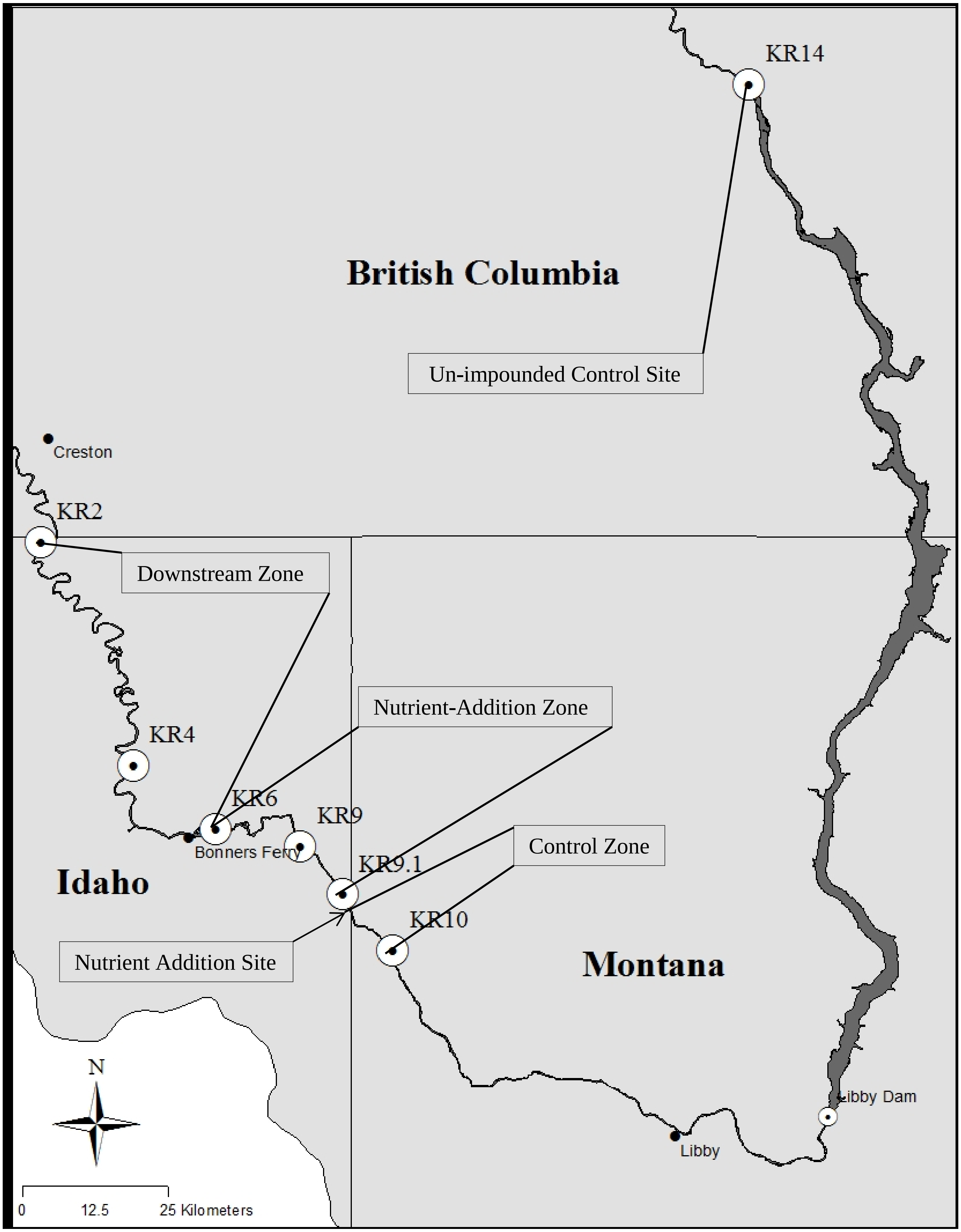


Figure 3.2. Kootenai River ecosystem study area and approximate locations of biomonitoring sites.

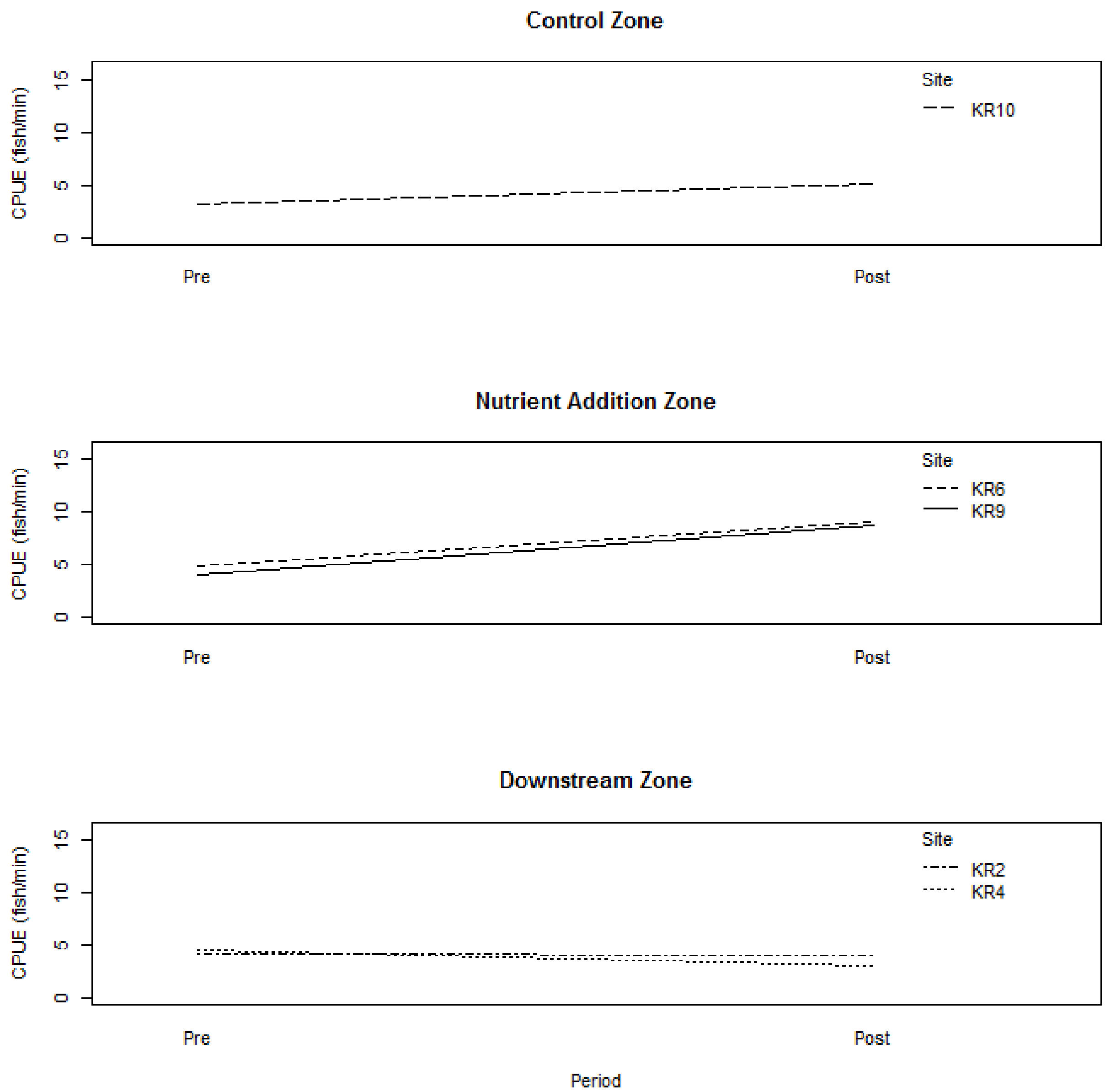


Figure 3.3. Average total CPUE (i.e., all species, combined) by river zone during pre- and post-treatment periods. The Control Zone includes site KR10, the Nutrient Addition Zone includes sites KR9 and KR6, and the Downstream Zone includes sites KR4 and KR2.

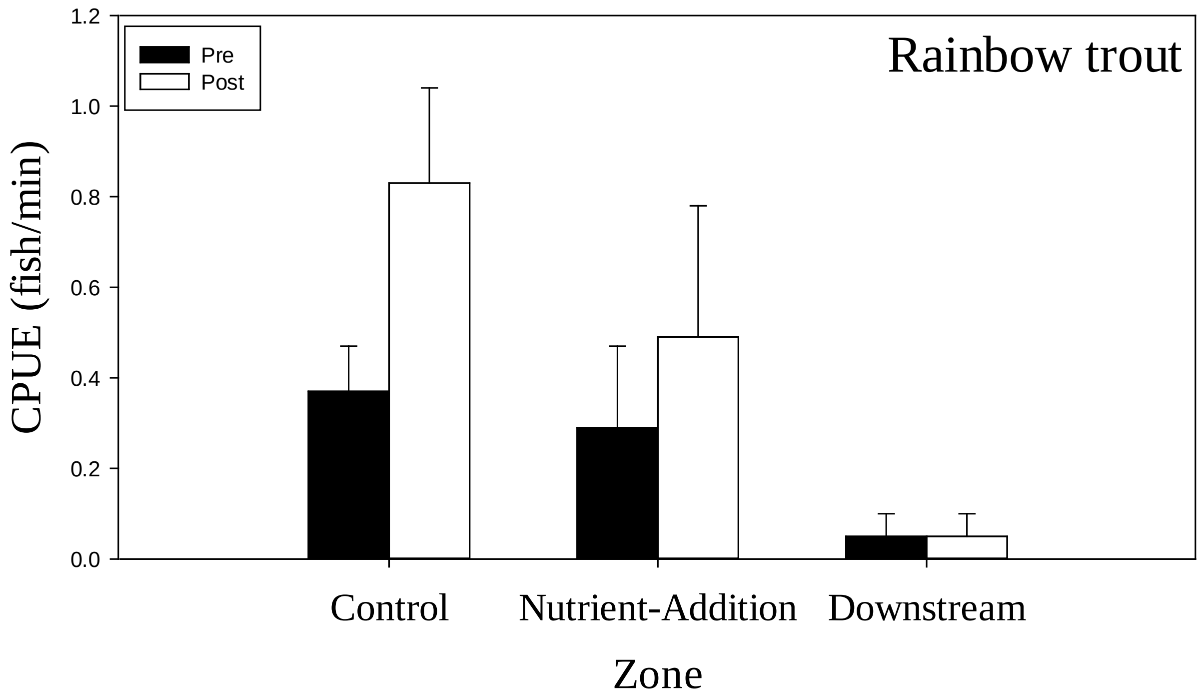


Figure 3.4. Average CPUE of rainbow trout by Zone*Period. Plot represents the Zone*Period interaction term from the repeated measures ANOVA model. Error bars are ± one standard error.

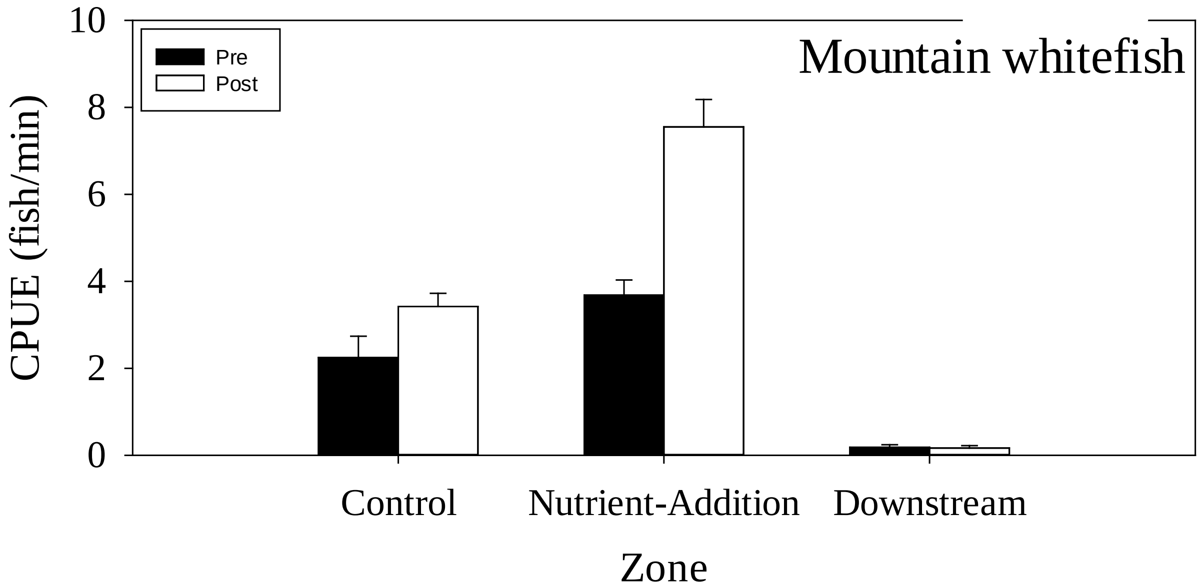


Figure 3.5. Average CPUE of mountain whitefish by Zone*Period. Plot represents the Zone*Period interaction term from the repeated measures ANOVA model. Error bars are ± one standard error.

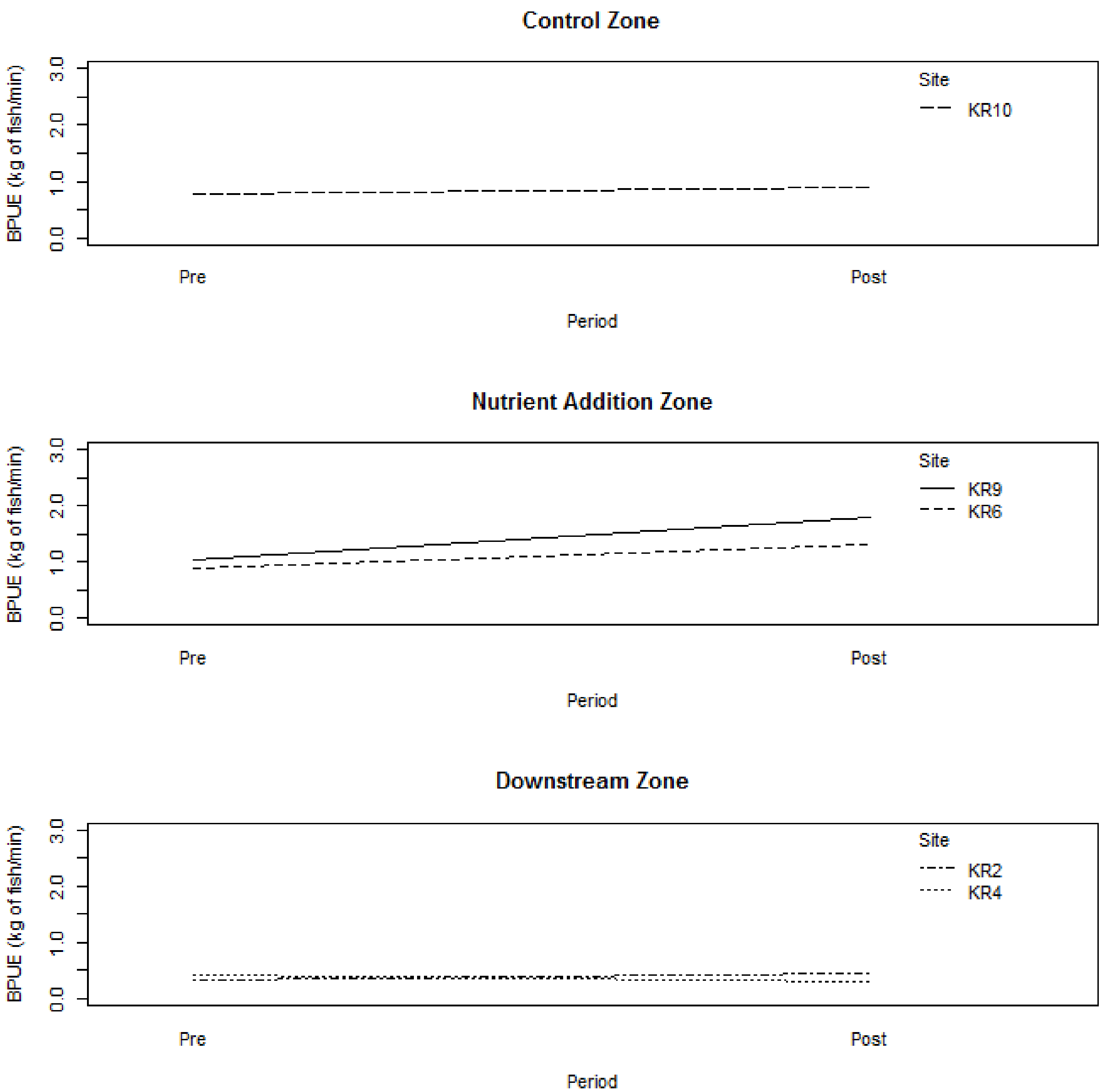


Figure 3.6. Average total BPUE (i.e., all species, combined) by river zone during pre- and post-treatment periods. The Control Zone includes site KR10, the Nutrient Addition Zone includes sites KR9 and KR6, and the Downstream Zone includes sites KR4 and KR2.

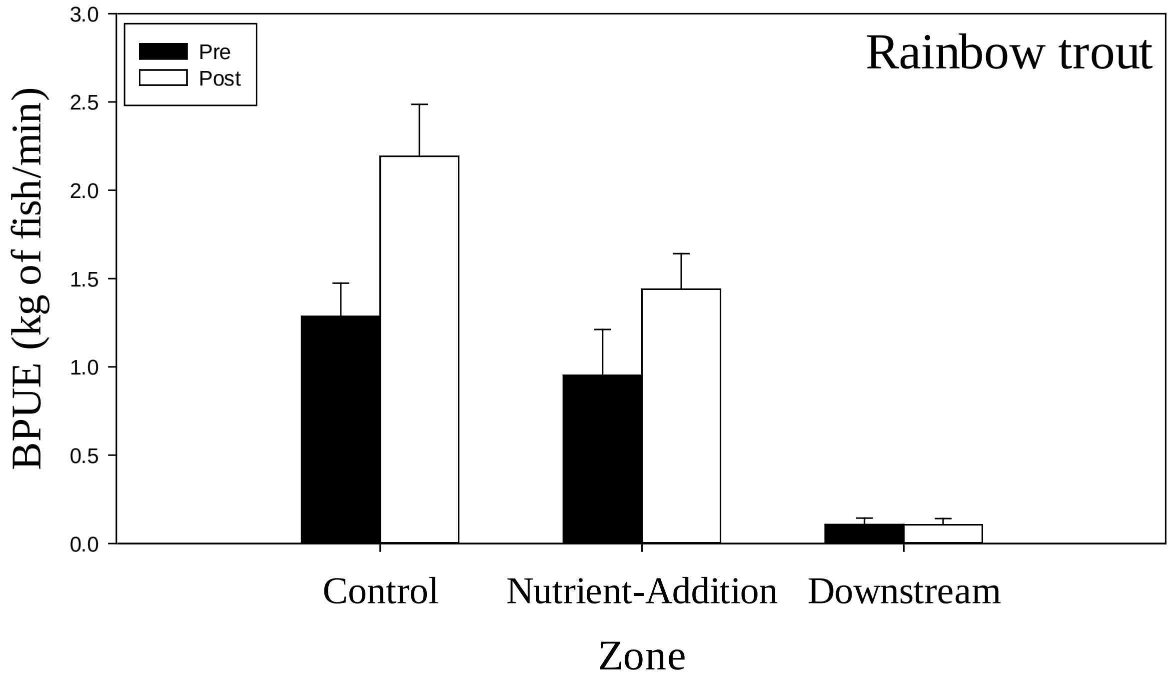


Figure 3.7. Average BPUE of rainbow trout by Zone*Period. Plot represents the Zone*Period interaction term from the repeated measures ANOVA model. Error bars are ± one standard error.

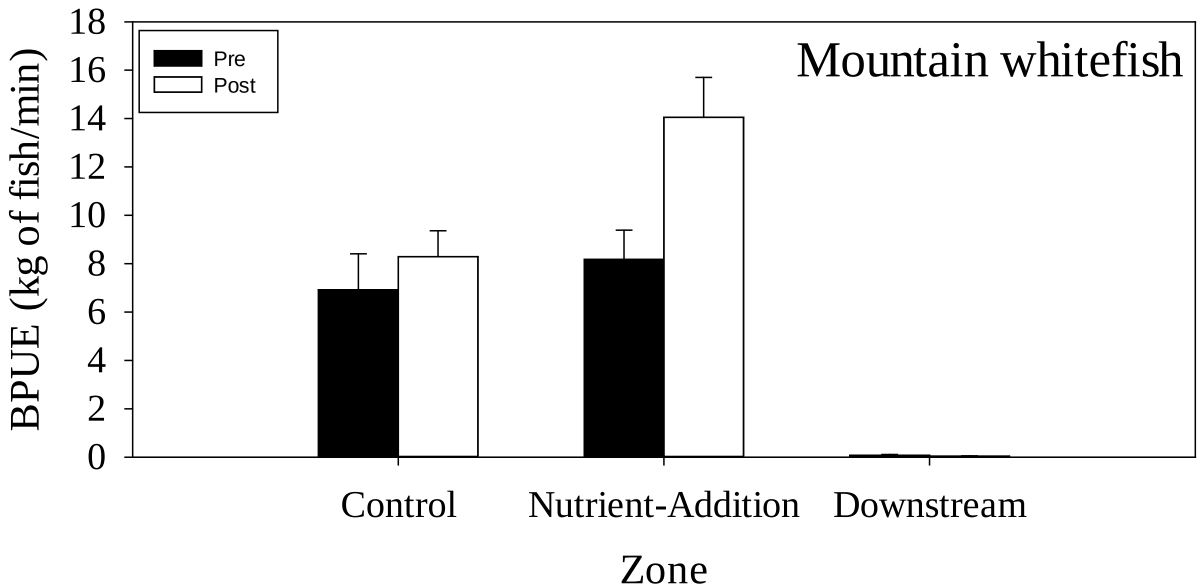
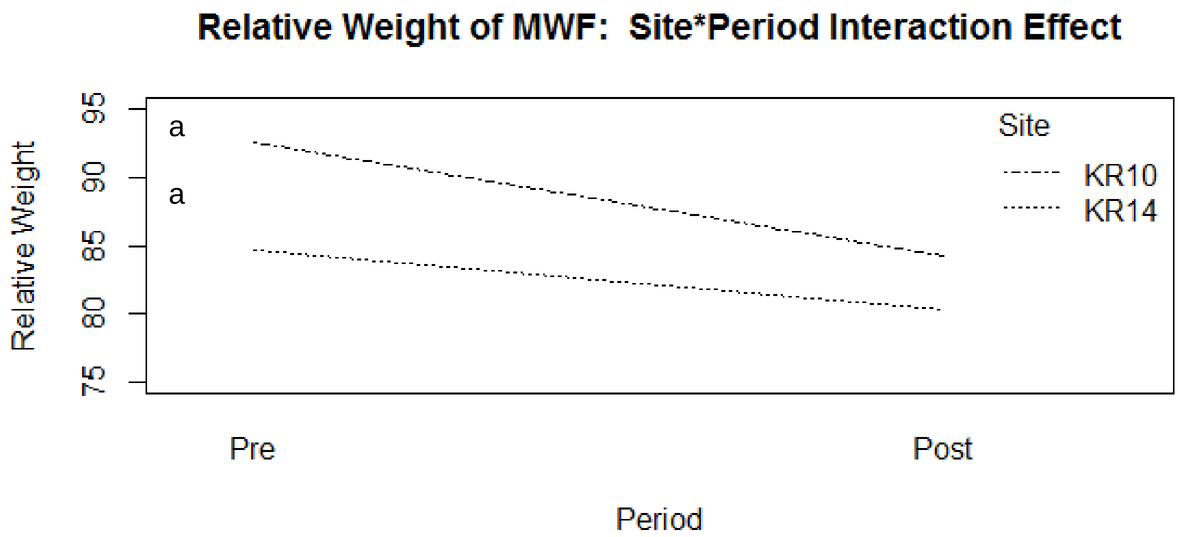


Figure 3.8. Average BPUE of mountain whitefish by Zone*Period. Plot represents the Zone*Period interaction term from the repeated measures ANOVA model. Error bars are ± one standard error.



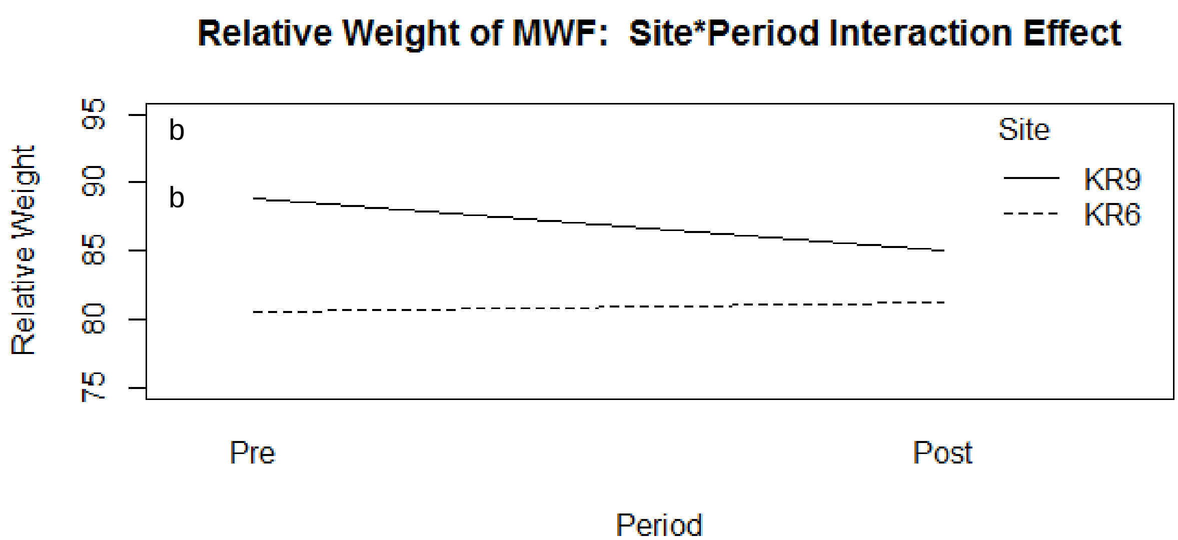


Figure 3.9. Average W_r of mountain whitefish by Site*Period. Plot "a" depicts the control sites (KR14 and KR10) and plot "b" depicts sites within the treatment reach (KR9 and KR6).

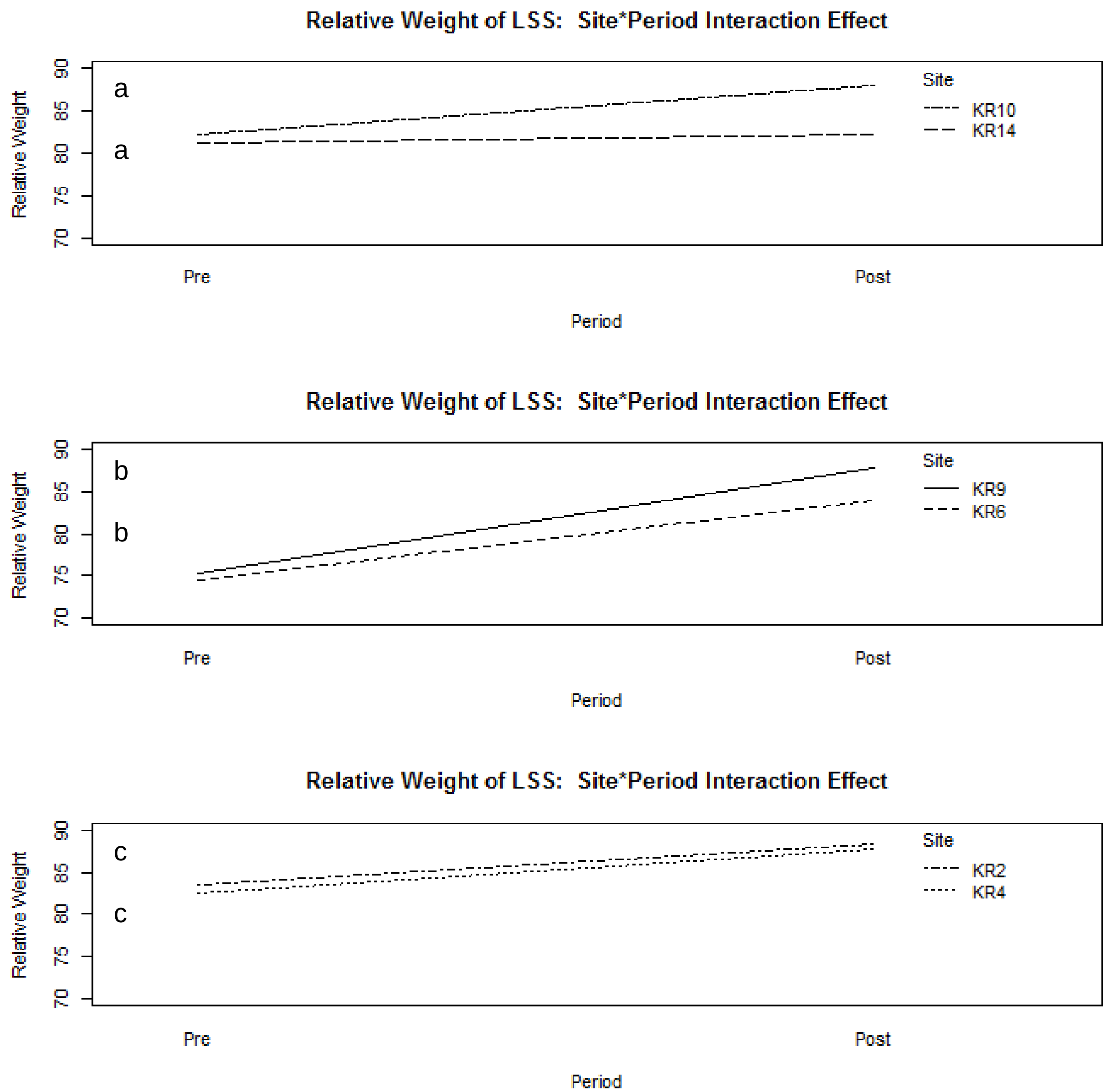


Figure 3.10. Average W_r of largescale sucker by Site*Period. Plot "a" depicts the control sites (KR14 and KR10), plot "b" depicts sites within the treatment reach (KR9 and KR6), and plot "c" depicts sites within the downstream reach (KR4 and KR2).

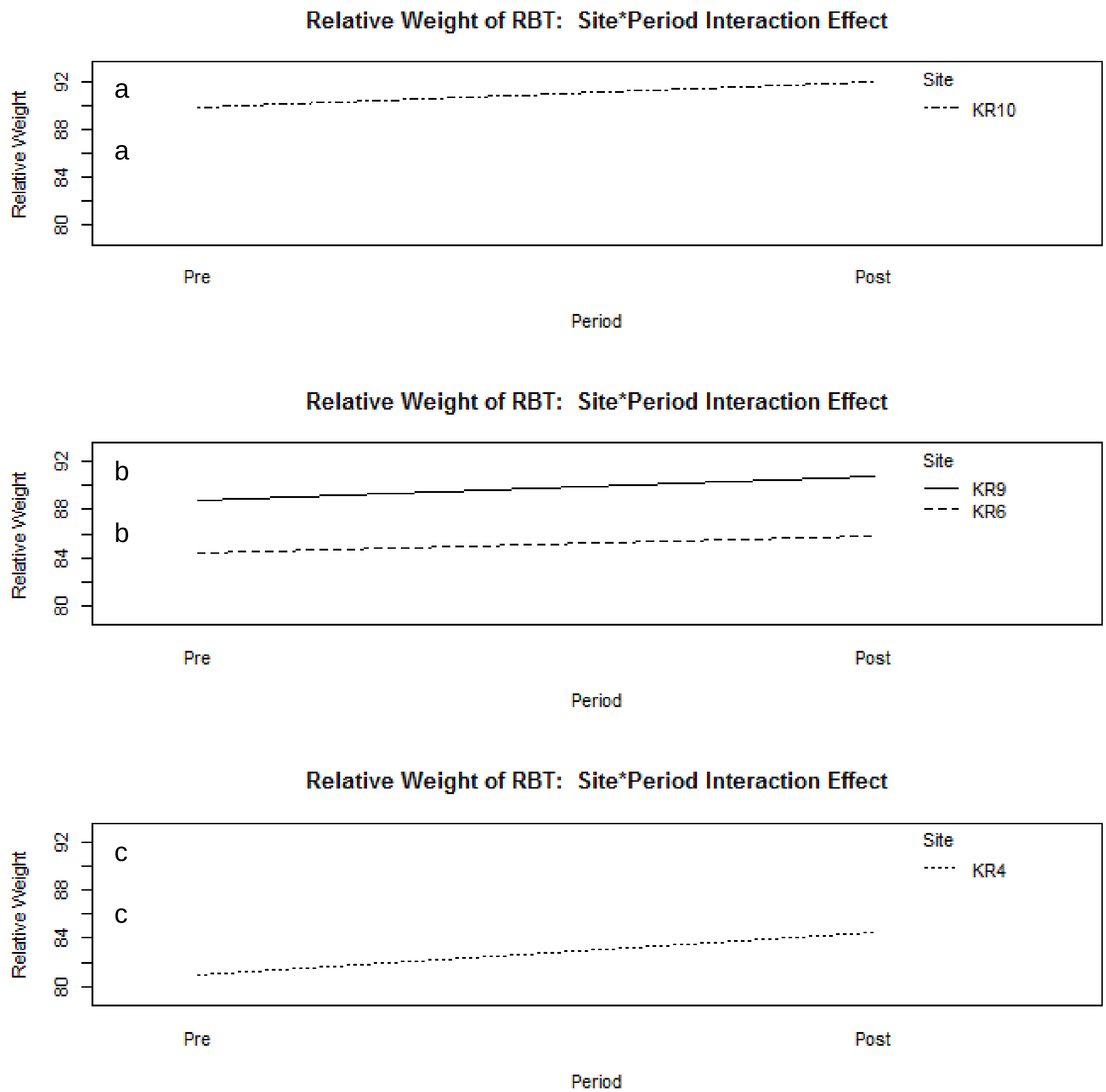


Figure 3.11. Average W_r of rainbow trout by Site*Period. Plot “a” depicts the control site (KR10), plot “b” depicts sites within the treatment reach (KR9 and KR6), and plot “c” depicts a sites within the downstream reach (KR4).

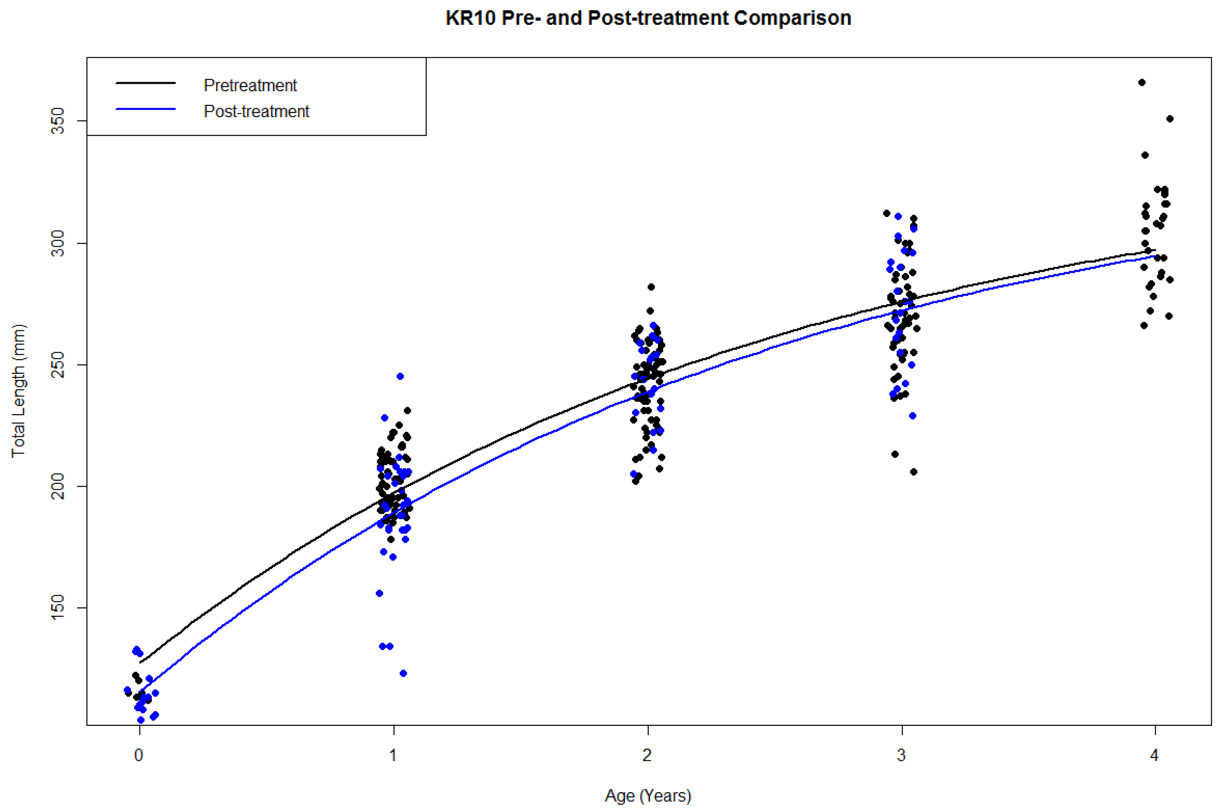


Figure 3.12. Fitted Von Bertalanffy growth curves for KR10, pre- and post-treatment. Models depicted are most parsimonious based on comparison with candidate models; they share common L∞ and K parameters, but t_o differs between the two models. Black points and lines represent pretreatment data, and blue points and lines represent post-treatment data.

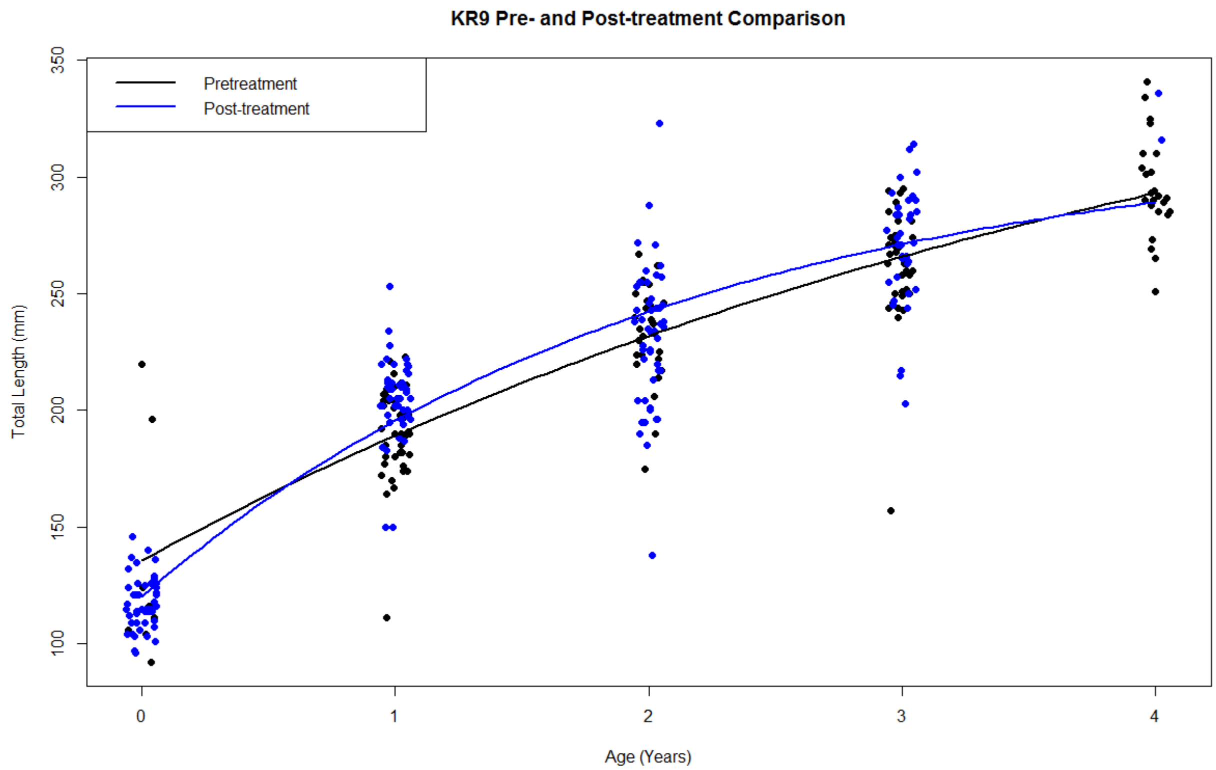


Figure 3.13. Fitted Von Bertalanffy growth curves for KR9, pre- and post-treatment. Models depicted are most parsimonious based on comparison with candidate models; L_∞, K and t_o differ between the two models. Black points and lines represent pretreatment data, and blue points and lines represent post-treatment data.

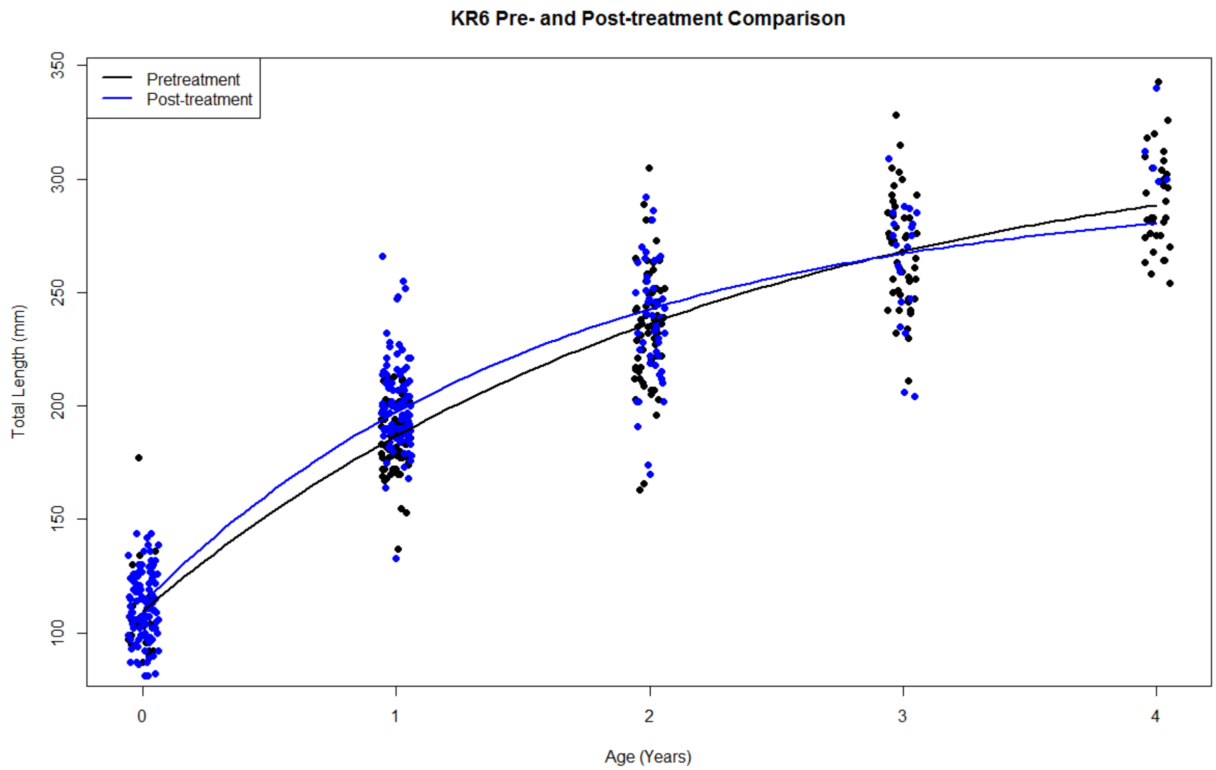


Figure 3.14. Fitted Von Bertalanffy growth curves for KR6, pre- and post-treatment. Models depicted are most parsimonious based on comparison with candidate models; L_∞, K and t_o differ between the two models. Black points and lines represent pretreatment data, and blue points and lines represent post-treatment data.

APPENDICES

Appendix 3.1. Electrofishing summary for biomonitoring sites 2002-2012 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

Appendix 3.1, 2007, continued.

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
	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

Appendix 3.1, 2009, continued.

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
	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

Appendix 3, 2010, continued.

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
	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

Appendix 3.1, 2011, continued.

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
	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**

Appendix 3.1, continued.

2012

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
KR10	BRN	3	0.86	2.41	0.74	1.53	0.60	1.24
	LNS	2	0.57	1.61	0.76	1.56	0.61	1.24
	LSS	23	6.59	18.49	10.34	21.28	8.31	1.24
	MWF	209	59.89	167.98	26.34	54.22	21.17	1.24
	NPM	13	3.72	10.45	1.95	4.02	1.57	1.24
	PMC	3	0.86	2.41	0.52	1.07	0.42	1.24
	RBT	60	17.19	48.23	7.56	15.56	6.08	1.24
	RSS	36	10.32	28.94	0.37	0.76	0.30	1.24
Total		**349**	**100.00**	**280.51**	**48.58**	**100.00**	**39.05**	**1.24**
KR14	LNS	6	1.35	6.11	1.16	0.84	1.18	0.98
	LSS	135	30.27	137.56	98.90	71.54	100.77	0.98
	MWF	250	56.05	254.74	35.50	25.68	36.17	0.98
	NPM	4	0.90	4.08	0.89	0.64	0.91	0.98
	RBT	4	0.90	4.08	0.39	0.28	0.40	0.98
	RSS	44	9.87	44.83	0.43	0.31	0.43	0.98
	WCT	3	0.67	3.06	0.98	0.71	1.00	0.98
Total		**446**	**100.00**	**454.46**	**138.23**	**100.00**	**140.85**	**0.98**
KR2	LSS	40	8.44	26.52	8.63	37.96	5.72	1.51
	MWF	13	2.74	8.62	0.25	1.09	0.16	1.51
	NPM	221	46.62	146.55	10.77	47.38	7.14	1.51
	PMC	52	10.97	34.48	1.86	8.17	1.23	1.51
	PMK	7	1.48	4.64	0.13	0.55	0.08	1.51
	RSS	106	22.36	70.29	0.84	3.69	0.56	1.51
	YP	35	7.38	23.21	0.27	1.17	0.18	1.51
Total		**474**	**100.00**	**314.31**	**22.73**	**100.00**	**15.07**	**1.51**
KR4	LNS	1	0.29	0.66	0.42	1.84	0.28	1.51
	LSS	36	10.32	23.84	13.50	59.76	8.94	1.51
	MWF	27	7.74	17.88	0.31	1.39	0.21	1.51
	NPM	79	22.64	52.31	3.35	14.82	2.22	1.51
	PMC	44	12.61	29.13	2.90	12.83	1.92	1.51
	PMK	2	0.57	1.32	0.02	0.07	0.01	1.51
	RBT	6	1.72	3.97	0.51	2.28	0.34	1.51
	RSS	152	43.55	100.64	1.44	6.37	0.95	1.51
	WCT	2	0.57	1.32	0.15	0.65	0.10	1.51
Total		**349**	**100.00**	**231.08**	**22.58**	**100.00**	**14.95**	**1.51**
KR6	LNS	6	1.01	6.87	2.76	2.77	3.16	0.87
	LSS	51	8.57	58.40	50.69	50.89	58.05	0.87
	MWF	490	82.35	561.07	40.27	40.43	46.11	0.87
	NPM	10	1.68	11.45	2.71	2.72	3.11	0.87
	PMK	1	0.17	1.15	0.11	0.11	0.12	0.87
	RBT	13	2.18	14.89	2.60	2.61	2.98	0.87
	RSS	23	3.87	26.34	0.26	0.26	0.29	0.87
	WCT	1	0.17	1.15	0.22	0.22	0.25	0.87
Total		**595**	**100.00**	**681.30**	**99.62**	**100.00**	**114.07**	**0.87**
KR9	LND	7	1.43	6.77	0.04	0.03	0.04	1.03
	LNS	1	0.20	0.97	0.67	0.50	0.65	1.03
	LSS	95	19.43	91.91	82.16	61.52	79.49	1.03
	MWF	352	71.98	340.55	45.11	33.77	43.64	1.03
	NPM	9	1.84	8.71	2.46	1.84	2.38	1.03
	RBT	14	2.86	13.54	2.66	1.99	2.57	1.03

Appendix 3.1, 2013, continued.

Site	Species	Count	% of Total	CPUE (fish/h)	kg	% of Total	BPUE (kg of fish/h)	Effort (h)
	RSS	9	1.84	8.71	0.14	0.10	0.13	1.03
	WCT	2	0.41	1.93	0.33	0.24	0.32	1.03
Total		**489**	**100.00**	**473.10**	**133.55**	**100.00**	**129.21**	**1.03**
KR9.1	BRK	1	0.13	1.04	0.26	0.13	0.27	0.97
	LND	1	0.13	1.04	0.00	0.00	0.00	0.97
	LNS	6	0.79	6.22	2.49	1.24	2.58	0.97
	LSS	122	16.07	126.42	109.21	54.50	113.17	0.97
	MWF	564	74.31	584.46	83.11	41.48	86.12	0.97
	NPM	6	0.79	6.22	0.68	0.34	0.70	0.97
	PMC	5	0.66	5.18	0.76	0.38	0.78	0.97
	RBT	19	2.50	19.69	3.36	1.68	3.48	0.97
	RSS	34	4.48	35.23	0.31	0.16	0.32	0.97
	WCT	1	0.13	1.04	0.20	0.10	0.21	0.97
Total		**759**	**100.00**	**786.53**	**200.38**	**100.00**	**207.64**	**0.97**

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