FISHERY RESEARCH

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

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CHAPTER 1: WHITE STURGEON MONITORING AND EVALUATION

ABSTRACT

Kootenai River White Sturgeon were listed as endangered in 1994 due primarily to recruitment failure. This population had been declining for at least forty years and natural reproduction has been insignificant since 1974. Libby Dam, completed in 1972, drastically changed the Kootenai River ecosystem by disrupting the natural flow regime and altering seasonal and daily water temperatures. Idaho Department of Fish and Game is funded through Bonneville Power Administration to monitor and evaluate the effects of mitigative flows from Libby Dam on all life stages on Kootenai Sturgeon and to provide recommendations for recovery to action agencies. The objective of these studies is to determine how current Dam operations influence recruitment, survival, and behavior. The sturgeon flow augmentation in 2014 included a double peak, which was intended to maximize the use of a limited water supply to improve sturgeon spawning and migration conditions. Adult sturgeon were Vemco tagged in fall 2013 and spring 2014 provide movement data aimed at testing flow augmentation operations and to collect pretreatment movement data on proposed habitat enhancement projects near Shorty's Island and Myrtle Creek. Based solely on movement extent, 30 percent of the spawning group of sturgeon moved above Bonners Ferry in 2014, which is near the highest percentage of upstream migration by the annual spawning group in recent years. In the future, we plan to incorporate new ways to more closely classify the annual spawning group. Juvenile sturgeon were Vemco tagged to evaluate movements among the Kootenay Lake delta, main basin Kootenay Lake, and the Kootenai River. Early results from this study suggest most young juvenile movements were from the delta into the main lake basin, and older juveniles were moving more than younger juveniles. In the future, this movement data will be used to refine abundance and survival models by validating closure assumptions. To improve spawning substrate, two substrate enhancement pilot projects are scheduled for construction in winter 2014. This year, we incorporated new sampling techniques to our monitoring program while collecting pretreatment data on habitat selection of spawning female sturgeon, spawning occurrence using egg mats, and hatching success of drifting larvae. Habitat selection will be evaluated using a Vemco VPS system, and the pre-treatment test yielded favorable results with high tag and receiver reception. Egg mat sampling documented 22 spawning events in 2014, and three larvae sturgeon were collected with new drift netting methods. In future investigations, pre- and post-treatment datasets will be compared to determine the effectiveness of the substrate enhancement pilot projects on increasing habitat use by female sturgeon, improving spawning rates, and improving hatching success.

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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. Over a decade of artificial substrate mat sampling has indicated that from nine to 20 spawning events occur annually, and many viable embryos are produced (Paragamian et al. 2002). Most 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). Only three 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 suggest that mortality occurs at the egg, embryonic, or larval stage. To improve spawning conditions for Kootenai River 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 provide 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 exits through the West Arm of Kootenay Lake and joins 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 three to four times higher than under the natural flow regime (Figure 1.2). Post-dam water temperatures are 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 2014, the USFWS in cooperation with members of the Kootenai River White Sturgeon Recovery Team (KRWSRT) submitted a System Operations Request (SOR) FWS#2014-1 to the Corps' regional multiagency/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 season. Specific details, justifications, and biological opinion success criteria are listed at http://www.nwd-wc.usace.army.mil/tmt/sor/2014/SOR_2014-FWS1.pdf.

The intent of these SORs was to maintain higher, more stable summer discharges to the extent possible with the available water to meet White Sturgeon and Bull Trout *Salvelinus confluentus* ESA responsibilities (USFWS 2006) and to attempt to mimic a more natural river hydrograph (under VarQ regime). Another objective of the SOR's is 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). An additional objective of this SOR is to 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 2014 April to July Kootenai River (in Montana) stream flow forecast, which includes the White Sturgeon spawning season, was 107% of average. Snow water equivalents in April 2014 were near normal and 84% of 2013 levels. For the Kootenai Basin in Montana, discharges were expected to be near normal for 2014. For details see: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mt/newsroom/releases/?cid=STELPRDB1250836.

Adult White Sturgeon Sampling

Adult White Sturgeon were collected by angling and setlining from March through October 2014 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 documented spawning locations (near and above rkm 229) were sampled more frequently. Fall sampling in 2014 occurred near the Kootenay River delta in BC at rkm 120 and in Idaho above rkm 200. To determine sex and level of maturity, adult sturgeon were biopsied 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 cooperation with the Kootenai Tribe of Idaho (KTOI), some gravid female White Sturgeon expected to spawn during spring 2014 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 89 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 306, near the "Sturgeon hole" in Montana, below Kootenai Falls (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 (Neufeld and Rust 2009). Receivers were downloaded in late winter, prior to the spawning season, and again in the fall. Data from receivers were stored in .vrl file format 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.

Juvenile White Sturgeon Telemetry

In 2014, we initiated a study of Vemco tag hatchery reared juvenile White Sturgeon in Kootenay Lake to gather data on mixing rates between the lake and river. This project intends to fill a gap which was identified during a recent Kootenai White Sturgeon hatchery survival and abundance estimate. That analysis recognized the large area available within Kootenay Lake that is currently underrepresented in the sampling efforts, relative to river monitoring. Additionally, this telemetry project intends to answer questions regarding whether "closure" was met during our Kootenay delta sampling efforts (Dinsmore et al. 2015).

Two age groups of juveniles were targeted: (1) ≥10 years old (≤2004 brood year) and (2) ≤6 years old (≥2008 brood year). The data from the younger juveniles will expand on the findings from telemetry work completed in 2005-2008 (Neufeld and Rust 2009). The results from those studies concluded that juveniles (≤9 years old) largely stayed within 40 km of their tagging site, and yet small age-1 hatchery released juveniles were capable of substantial movements. The older juveniles will provide additional data on movements of hatchery-reared juvenile sturgeon in Kootenay Lake.

Juvenile White Sturgeon were targeted on the Creston Delta (rkm 119-121) or at the north end of Kootenay Lake at the Lardeau Delta (Rkm 18, Figure 1.4). Two Vemco 81 kHz tag types were used, all set with a 120 second nominal delay, 11 V16-6xs (3410 day battery life, 20g in air), and 17 V13-1xs (1120 day battery life, 11g in air). All juveniles were captured during the regular sturgeon sampling program, with angling, set lines, and gill nets. Prior to selecting a juvenile for sonic tagging, they were scanned for an existing passive integrated transponder (PIT) tag. Only those juveniles with a traceable release record and known brood year were used for tagging. All incisions were made on the ventral surface, 1-3 cm to the right of the ventral midline. The length of the incision ranged between 2 to 4 cm, depending on the size of the tag; all incisions were sutured with Ethicon PDS II (size 3-0) dissolvable sutures. Tracking of the tagged juveniles was completed by the existing passive array of 89 VR2Ws that extends from Montana downstream through Idaho and BC portions of Kootenai River to Kootenay Lake (Figure 1.4).

Substrate Enhancement Pilot Projects (SEPPs)

Kootenai River White Sturgeon spawn primarily between rkms 228 and 240.5 (Paragamian et al. 2002). This reach is dominated by sand, silt, and clay substrate (Fosness 2013), conditions that, at least recently, are unsuitable for successful early life stage recruitment. Other White Sturgeon populations in the Columbia basin spawn specifically over some combination of rock and gravel (Parsley et al. 1993). Because of the lack of suitable spawning and early life-stage supporting substrate in this meander reach, one recommendation from the Kootenai River White Sturgeon Recovery Implementation Plan proposed "adding rock substrate in the current spawning areas and evaluating its role in providing suitable spawning and incubation conditions."

In April 2010, under the authority provided by the Continuing Authorities Program, Section 1135, the Corps, in cooperation with the KTOI, initiated a feasibility study to "identify and implement cost-effective, self-sustaining ecosystem restoration actions to improve ecosystem function and habitat attributes for the early life stage survival of the ESA-listed Kootenai River White Sturgeon" (USACE 2012). The Corps' feasibility study recommended a substrate enhancement pilot project (SEPP) at two locations, Shorty's Island South and Myrtle Creek (Figure 1.5). In 2013, KTOI continued the implementation of the SEPP at two sites in the meander reach. The objective of the SEPP is to test "the sustainability and effectiveness of placing rock substrate over existing clay surfaces in two sub-reaches of the river where wild White Sturgeon currently spawn" (KTOI 2013). Construction of the SEPPS will begin in winter 2014.

As part of the Kootenai River Resident Fish Mitigation Project, IDFG is funded by Bonneville Power Administration to monitor and evaluate the effects of Libby Dam operations as well as potential habitat enhancement projects intended to benefit sturgeon and other focal species in the Kootenai River. With 2014 being a pretreatment year, the focus of this section is to provide methods for evaluating the SEPPs and to collect pretreatment data. Specifically related to the SEPPs, IDFG will monitor biological responses of three White Sturgeon life stages to these spawning habitat enhancement projects. Our long-term objectives are to determine if the SEPPs quantitatively changed: 1) habitat selection by spawning females, 2) occurrence of spawning on the projects, and 3) hatching success of eggs deposited on the site. Details of each monitoring component are listed below.

Habitat Selection

To determine pretreatment habitat usage by adult spawning sturgeon on the proposed SEPP sites in 2014, we incorporated a Vemco VR2W Positioning System (VPS) system. VPS is a low-cost, non-real-time underwater acoustic fine-scale positioning system, using the same off-the-shelf equipment used in our passive telemetry array. Initial set up of the VPS system involved placing six VR2W receivers in a grid of equidistant triangles and squares (Figure 1.6). This ensured that every tag transmission is detected by at least three receivers (more is better). Ideally, the area of interest is covered with enough receivers to ensure that tagged sturgeon are always inside of a triangle of receivers, and in this study receivers were placed close enough together to maximize the overlap in detections among receivers. Synchronization tags, (Synctags) were moored along with each receiver (co-located) to correct for clock drift between submerged receivers. Additional reference tags were placed within the receiver grid in known locations to measure system performance. Final positioning data will be provided from VEMCO and more information is available at http://vemco.com/products/vps/. On a periodic basis, receiver data were sent to VEMCO for position resolution and to determine if the system was functioning properly. At the end of the study, once all receiver data has been collected, VEMCO will provide a final report and calculated positions. For most studies, VEMCO expects position accuracy similar to that provided by the GPS standard positioning service: 95% of positions within a 15-metre error circle. VEMCO considers this a conservative estimate, based on results from field studies conducted to date. We used a Trimble Juno 3D and differentially correct positions which will allow accuracies in receiver deployments of up to 15 cm and may improve post-processed sturgeon position accuracies to less than 5 meters.

The first phase of the monitoring plan included tagging 12 adult female sturgeon (stage F4) with specialized Vemco V16 transmitters (V16TP-6X) that included a depth sensor for increased position accuracy and a temperature sensor to account for speed of sound in water variability. Tagging sturgeon with these V16TP tags began in the fall of 2013, and sampling effort intensified in early spring 2014. Prior to the study, we also had at least 82 sturgeon with active telemetry transmitters (V16 transmitters without the depth component) which will also be compatible with the VPS system, although less accurate. Because of budgetary and time constraints, the VPS system was only set up at the Shorty's Island site.

Summary evaluation of system performance and pre-treatment positioning will be provided by Vemco in winter 2015. Detailed analysis of sturgeon habitat selection and treatment effect evaluation will commence after the SEPPs are in place and post-treatment habitat selections are compared and evaluated in 2016.

Spawning Occurrence

Artificial substrate mats (McCabe and Beckman 1990) were used to document White Sturgeon spawning on and off the proposed SEPP sites to determine if adult spawning females are using the substrate additions in a higher proportion than in previous years. We sampled Shorty's Island and Myrtle Creek in a systematic design (Figure 1.6) using 21 mats at each site. Seven mats will be deployed in three independent treatment locations including one on each habitat enhancement site (Strata 1) and two control locations. Location of the first control site (Strata 2) was approximately 500 m downstream of the substrate enhancement site in an area that has traditionally yielded eggs and has similar physical conditions to the treatment site. An additional control site (Strata 3) was on river left, 150 m downstream of the treatment site in an area where few eggs have been collected in the past. Total area sampled within the treatment reach and at the two control sites were identical. Designs are similar for both the Shorty's Island and Myrtle Creek SEPP sites (Figure 1.6). Crews sample mats twice per week and all eggs were stored in formalin and brought back to the laboratory 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). More details of the substrate sampling methods are available in Rust and Wakkinen (2010).

Hatching Success

Hatching success was determined through extensive larval sampling around the Shorty's Island and Myrtle Creek SEPP sites and occurred concurrently with egg mat sampling. This year, we incorporated a new larval sampling design for the duration of this study (see Crossman and Hildebrand 2012). Two nets were paired on a metal frame with each net being 80 cm wide X 60 cm high with 1.6 mm net mesh. Each frame was anchored independently to the substrate and retrieved from a boat without moving the anchor. The collection bucket carrying the debris was replaced with a clean bucket, and the bucket with the debris was sorted on the riverbank. In 2014, there will be no treatment to evaluate, and we sampled two pairs of frames (four nets per site) on the downstream end of each proposed SEPP site and one pair of nets in the lower end of the straight reach near Bonners Ferry (near rkm 245.5). Sampling started 10 days after the first eggs were collected. Sampling efficiency and duration was a function of river conditions (debris and flow) and sampling effort and duration increased as the hydrograph receded and debris load reduced. Full 24 h sets began once drifting debris is at a low enough level to allow nets to fish the entire night period without debris fully saturating the net holding capacity.

Juvenile White Sturgeon Sampling

We used weighted multifilament gill net with 2.5, 5.1, 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, as well as distribution, densities, growth, and mortality rates of both hatchery and wild juveniles. Sampling was conducted from July 23 through September 30, 2014 following the methodology of Ross et al. (2015). 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 either at the KTOI hatchery or at the Kootenay Trout and Sturgeon Hatchery located in Ft. Steele, BC,(operated by the Freshwater Fishery Society of BC as the backup facility for the KTOI). Most of the released juvenile White Sturgeon (92%) 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 again PIT tagged and all had scutes removed. PIT tagging fish prior to release provides a unique identifier for each fish and allows tracking of the size at release, rearing facility, release location, and time of release as well as subsequent individual performance (annual growth etc.). 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.

RESULTS

Water Levels, Discharge, and River Temperature

Libby Dam outflow operations for 2014 included a hydrograph with a double peak. This operation was intended to most efficiently use the limited water supply to benefit sturgeon spawning by extending the highest available discharges throughout the spawning period.

On May 26, 2014, Koocanusa Reservoir inflow peaked at 1,906 m^3/s (67,300 ft^3/s) and the reservoir filled to elevation 748 m (2,453.7 feet) by August 12. Spring outflow initially increased from 113 m^3/s (4,000 ft^3/s) to 739 m^3/s (26,100 ft^3/s) on April 3 before dropping back to 453 m^3/s (16,000 ft^3/s) on May 9. The double peak operations began May 15 when outflow discharge increased from 453 m^3/s (16,000 ft^3/s) to 693 m^3/s (24,500 ft^3/s) on May 18. The double peak was achieved when outflow discharge dropped down to 510 m^3/s (18,000 ft^3/s) on May 25. Discharge was held at 510 m^3/s (18,000 ft^3/s) until June 1, when outflow discharge again increased to 733 m^3/s (25,900 ft^3/s), where it was held for one week (Figure 1.3).

Water temperatures measured at Bonners Ferry in 2014 were below 6°C until May, and warmed steadily to 10°C by early June. With the comparatively low water volume and warm air temperatures, mid-summer water temperatures warmed quickly and surpassed 15°C by early June (Figure 1.3). The maximum river water temperature in 2014 of 16.3°C occurred on July 16. The mild fall weather allowed water temperatures to remain above 9°C through October and early November, before rapidly cooling in December.

Adult White Sturgeon Sampling

Between March 13 and November 4, 2014, IDFG, BCMFLRO, and KTOI crews expended more than 6,977 h to capture 86 adult White Sturgeon by angling and 87 adult White Sturgeon by setlining (Table 1.1). Additionally, one adult sturgeon was collected in gill nets while sampling for juvenile sturgeon.

Catch rates were 0.12 fish per rod h for angling and 0.017 fish per setline h (Table 1.1). One hundred thirty-three (78%) of the 174 adult White Sturgeon collected were recaptures from previous years (Table 1.1). Eleven adult White Sturgeon were biopsied by IDFG and BCMFLNRO to determine sex and reproductive stage. Ten (91%) of the biopsied adults were females, and sex could not be determined for one individual. Of these 10 females sturgeon biopsied, 90% were stage F4 (mature eggs), while the specific stage could not be determined from the remaining female. KTOI Hatchery personnel also captured and biopsied adult White Sturgeon for their propagation operations; Lewandowski (2014) 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 89 stationary Vemco VR2W sonic receivers (Figure 1.4).

Ten adult White Sturgeon were tagged with Vemco sonic transmitters in fall 2013 and five were tagged in spring 2014. Twelve of these individuals were tagged with Vemco V-16TP-6X transmitters to coincide with the 2014 VPS studies (see next section). The remaining three were tagged with general V16 tags. In addition to providing detailed information within the VPS arrays, these VPS tags were also compatible with the existing VR2W array and individuals containing these transmitters were included in large-scale movement analysis. In preparation for 2015 VPS studies, seven adult White Sturgeon were tagged with Vemco VPS tags in fall 2014.

Prior to sampling in 2014 there were 82 adult females with active sonic tags. An evaluation of previous spawn and capture records for those individuals revealed that 35 had some likelihood of spawning in 2014. The likelihood was broken down into “High” or “Low” probability to spawn. The likelihood assignments were assigned based on these criteria:

“High” probability:

- 2014 lined up with previously documented spawn periodicity, or;

- A recent capture provided an egg maturity suggesting spawn in 2014, or;
- Only one previous spawn movement was documented and 2014 fell on the five-year spawn period.

"Low" probability:

- Females with only one previous spawn record, or capture record with a surgery confirming spawn condition, three or four years prior.

Based on telemetry detections above rkm 220, 21 sonic tagged females spawned in 2014; 17 were from those with a probability rating prior to the spawn period and the other four were tagged during the 2014 spawn season. The data suggests that our rating conditions were accurate, as none of the 47 females that were not expected to spawn spawned in 2014 and 81% of the females with "High" probability did spawn (Table 1.2). If the sample of sonic tagged females prior to target spawn sampling in 2014 represents an accurate subsample of the female population at large, then 21% of the mature females spawned in 2014. In 2014, of the 82 females with active tags prior to spawn, 16 (19%) had at least one previously documented spawn event. The spawn periodicity for those fish ranged from 3 to 5 years and averaged 4 years (SE=0.16).

Based on transmitter downloads, in 2014, 37 (84%) tagged adult sturgeon moved upstream as far as rkm 240.0 (Below Deep Creek), and 25 (57%) of the migrating adults went upstream as far as rkm 244.5 (Ambush Rock). Additionally, at least 13 (30%, 7 females) of the tagged migrating adult sturgeon went upstream of the Hwy. 95 Bridge in Bonners Ferry into the braided reach in 2014.

Juvenile White Sturgeon Telemetry

We tagged 28 hatchery reared juvenile sturgeon from brood years ranging from 1998 to 2010 with Vemco transmitters between March 28 and September 17, 2014. Of the total 28 tagged sturgeon juveniles, nine were tagged on the Lardeau Delta (rkm 18.0) and 19 fish were tagged on the Creston Delta (rkm 120.0). We stratified tagged fish into two groups for analysis to reflect juvenile and subadults for analysis as follows:(1) ≥10 years old (≤2004 brood year) and (2) ≤8 years old (≥2006 brood year). Sizes of juvenile sturgeon ranged from 41 cm to 113 cm (mean=76 cm; SE=3), weights ranged from 390 g to 10,000 g (mean=3,472; SE=447) (Table 1.3).

Movement data was analyzed from tagging date until the spring 2015 VR2 downloads on March 15, 2015. The data from the most recent download ranged by individual from 203 days to 376 days post tagging. No juvenile sturgeon were detected moving into the Kootenai River upstream of rkm 122.5. Juvenile sturgeon travelled between 0 and 100 km (mean=13 km, SE=4, median=4 km) away from tagging location. On average, juvenile sturgeon travelled 6 km (SE=2) north into the main Kootenay Lake basin from their release location, while the mean southern movement was 7 km (SE=4). This first analysis of the data suggested that the movement was most prevalent in the older age group (>10 years old) and very little movement was seen from the younger juveniles (Figure 1.7).

Substrate Enhancement Pilot Projects

Sampling in 2014 provided a pretreatment dataset from which to compare changes resulting from the SEPP after construction in 2015. A detailed analysis of how the Shorty's Island and Myrtle Creek SEPPs affected habitat selection, spawning site selection, and larval recruitment will not be available until after the SEPPs are built and evaluated in 2015 and beyond. The results listed below serve as a summary of the 2014 pretreatment data collection.

Habitat Selection

The Vemco VPS system was deployed from May 5 through August 25, 2014. Initial exploration of the data revealed some positioning error in the system due to GPS measurement error and unexpected equipment movements. The VPS software was used to determine the timing of unexpected station movements and to calculate new locations for receivers and synctags based on the observed arrival time differences between signals at the receivers. VPS-calculated positions were used instead of the original GPS-measured positions for all stations in the analysis regardless of whether or not equipment moved unexpectedly. Numerous movements in the synctag at station S01 was found to be introducing high error into the system. As a result, synctag S01 (Figure 1.6) was not included in the analysis.

Receivers logged an average of 122,901 detections (49.2 per hour) each for synctags and animal tags combined. Total detections ranged from 106,151 (VR2W receiver S06) to 132,343 (VR2W receiver S02). On average, an individual synctags were detected 72,040 times across all receivers, ranging from 61,768 detections (synctag 55) to 79,532 detections (synctag S02). All synctags were detected frequently on multiple receivers, with each transmission detected over five times on average. Overall, 95.1% of synctag transmissions were logged on three or more receivers. The average percent of synctag transmissions detected at a single receiver between 0 m and 175 m was 77.8%. Time synchronization availability was excellent for the duration of the study period as well. There were 305,167 animal tag detections logged over the course of the data collection period. There were 51 unique tags detected; of these, total detections ranged from 1 (transmitter 403, 813, 917) to 79,716 (transmitter 558). More than 61% of the animal tag transmissions were detected on at least three receivers, and each animal tag transmission was detected 3.3 times on average. A total of 65,037 synctag positions and 44,121 animal tag positions were calculated by the VPS. Positions were calculated for 44 different animals; of these, yields ranged from one position (transmitter 824) to 10,998 positions (transmitter S01).

Spawning Occurrence

We deployed substrate mats in 2014 to evaluate the temporal and spatial extent of White Sturgeon spawning events in the Kootenai River. In 2014, we sampled 81,584 mat h between May 15 and July 17 and collected 343 eggs (Table 1.4). The highest catch and the highest catch rate came from the Myrtle Creek area (rkm 234.5, Table 1.4). The first eggs were collected on June 2, and the last eggs were collected on July 17 (Table 1.5).

Two hundred eighty-six of the 343 (83%) eggs could be staged and may have been viable. Egg stages ranged from 12 to 27, and 143 of the 65 eggs developed to stage 21 (Beer 1981). Based on the 286 viable eggs, we estimate that White Sturgeon spawned at least 22 days in 2014 between June 1 and July 15 (Table 1.5). Water temperature during the egg collection period ranged from 7.8° to 17.0°C (Table 1.6), surface water velocity ranged from 0.5 to 1.2 m/s and Secchi disk depth ranged from 1.2 to 2.5 m.

Hatching Success

We sampled below each proposed SEPP site for White Sturgeon larvae between June 17 and August 2, 2014 for a total of 2365 hours (Table 1.6). Sampling effort was similar between the Shorty's Island and the Myrtle Creek sites. On July 15, following the first overnight set, one larval sturgeon was collected at the Shorty's Island site and two larvae were collected near the Myrtle Creek site. This represents the first documented larval sturgeon captures in the Kootenai River since sampling efforts began in 1977 (Partridge 1983). Non-target larvae were collected at all three sites but were not quantified. Most of the non-target larval fish species belonged to the Catostomidae family.

Juvenile White Sturgeon Sampling

Beginning in 1990 and continuing to the present, the KTOI and BC hatcheries have released over 253,000 juvenile White Sturgeon. The purpose of this sampling was to evaluate trends in: 1) the distribution, stock status, and densities of marked hatchery juveniles, 2) survival and growth rates of marked hatchery juveniles, and 3) any natural recruitment as determined by capture of unmarked juveniles. Since this population is transboundary, data collected in Canada was included. In 2014, IDFG and BCMFLNRO sampled for juvenile White Sturgeon with gill nets between July 23 and September 30, 2014 in Idaho and Canadian sections of the Kootenai River and Kootenay Lake. We sampled 25 sites between rkm 18.0 and 244.5 and collected 1180 juvenile sturgeon (1175 hatchery-reared, 99%) with 474 h of effort (Table 1.1, Table 1.7). The highest catch and highest catch rates came from the Kootenay Lake delta (rkm 120.0) but juvenile sturgeon were captured throughout the River and Lake. Fleming Creek area (rkm 224.5), Rock Creek (rkm 215.0), and Ambush Rock (rkm 244.5) had the highest catch rates 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 4-inch mesh had the highest catch rates at 3.5 sturgeon/net-h (Table 1.8). The 2-inch mesh was fished the most, representing 49% of the sets.

The average fork and total length of the hatchery reared juvenile White Sturgeon was 45.5 cm and 52.8 cm, respectively, and weight of juvenile sturgeon captured in 2014 averaged 0.87 kg (Table 1.9).

Five wild juvenile White Sturgeon were captured while gill netting in Canada and Idaho in 2014 (Table 1.10). The TL of these five individuals ranged from 44.7 to 100.5 cm, and weights ranged from 0.36 to 2.0 kg. All five wild juveniles were aged by sectioning the pectoral fin ray. Year classes from 2000, 2004, 2005, and 2007(2) were represented (Table 1.10). Figure 1.8 shows the year class assignments from a sample of the wild juvenile White Sturgeon collected between 1977 and 2014 that could be aged. Figure 1.9 shows the number of wild juvenile White Sturgeon collected annually from 1977 to 2014.

DISCUSSION

The objective of the 2014 sturgeon augmentation operation was similar to that of 2013, which intended to provide two periods of peak river stages/flows during the spring run-off period. The first peak, timed to low-elevation run-off below Libby Dam, was intended to provide sturgeon cues to begin upstream migration and staging. The second peak, timed to high-elevation run-off above Libby Dam, was intended to provide sturgeon cues to migrate further upstream from their staging areas and spawn towards the end of the second peak and/or on its descending limb. Overall, the goal is to provide conditions that will enable sturgeon to migrate to, and spawn over, rocky substrates that exist upstream of Bonners Ferry. Since the results of the 2013 operation were promising in that a higher proportion of tagged sturgeon migrated above Bonners Ferry in 2013 than in the previous three years, the two peak approach warranted at least another year of testing. Although a much smaller water volume was available in 2014 due to poor snowpack conditions, the augmentation operations in 2014 did follow those of 2013, and results were similar to 2013, with approximately 30 percent of the tagged spawning group migrating above Bonners Ferry in 2014, compared to 31 percent in 2013. These two years represented the two highest percentages of fish moving above Bonners Ferry in the last five, including the spill test years of 2010 – 2012. Although we are still constrained by Libby Dam operations and flood control issues at Bonners Ferry, small-scale adaptive flow management actions are important for understanding how sturgeon respond to different flow regimes and eventually may allow us to enhance upstream movements. The Vemco telemetry array has been in place for 11 years and has greatly improved our understanding of qualitative aspects of sturgeon movements and behaviors. The next step is to incorporate sturgeon movement data with physical habitat variables provided by Libby Dam and attempt to develop a predictive model to help determine how specifically to enhance sturgeon movement upstream of Bonners Ferry.

As described previously, to evaluate upstream sturgeon migrations to and above specific reference points of interest, sturgeon have been grouped into an annual “tagged spawner” group. This classification was based solely on movement behavior and sturgeon that migrated to at least rkm 228, the downstream extent of the spawning reach. Each spring, sturgeon that were located on receivers at rkm 228 were implied to be spawners and placed in the “tagged spawner” group. Although this method of grouping sturgeon has been useful for determining areas of high residency and areas of maximum upstream movement extent, it does not take into account updated capture information and individual fish behaviors in previous years. Recently, BCMFLRO has provided a more detailed analysis of the annual spawning group based not only on behavior to a certain rkm, but also includes capture history and spawning periodicity of individual fish. In the future, this method will be used to more accurately group the annual spawning group so more informed decisions and inferences can be made.

The purpose of tagging juvenile sturgeon in Kootenay Lake was to evaluate data gaps regarding mixing rates within the delta, river, and Kootenay Lake. The data gap was brought to light during the recent MARK analysis, where low capture probabilities and uncertainty regarding closure assumptions were in question. The highest densities of hatchery-reared juvenile sturgeon exist on the Kootenay Lake delta. If juvenile sturgeon freely move between the delta out in the main Kootenay Lake basin, we are violating the closure assumptions of our modeling and not sampling all available sturgeon habitats in our standard juvenile stock assessment program. Depending on the results of this project and more specifically the movement rates on and off the Kootenay Lake delta, our recent estimates of system-wide (Kootenay Lake upstream including the Kootenai River into Montana) juvenile sturgeon abundance may be grossly underestimated (Dinsmore et al. 2015). The longevity of the Vemco transmitters used for this study is a minimum of three years and a maximum of ten. It may take several years of monitoring, but understanding juvenile sturgeon movements on and off the Kootenay Lake delta will add to our understanding of juvenile sturgeon life history in general, and may provide critical data to improving the accuracy of our abundance estimates.

The Vemco VPS system collected pretreatment sturgeon movement data at Shorty’s Island for over 110 days in 2014. Other than a few minor setbacks, the system functioned extremely well. Originally, the Shorty’s Island SEPP was going to be constructed in winter 2014, and Myrtle Creek SEPP in winter 2015, and we planned to collect pretreatment data from Shorty’s Island in 2014 and the Myrtle Creek site in 2015. To save money on construction costs, KTOI decided to build both SEPPs in winter 2014. Unfortunately, we were unable to get necessary equipment procured and built in time to collected pretreatment data at both sites.

Because of the level of expertise needed to quantitatively evaluate habitat use changes for this type of analysis, we are working with experts from Golder and Associates to determine if sturgeon use has increased as a result of these habitat improvement projects.

In recent years, larval sturgeon sampling on the Kootenai River has not been a high priority for monitoring and evaluation efforts. Prior to 2014, the only larvae collected was in 2008, when a 16-day-old larvae was collected while evaluating survival and drift from a free embryo release experiment, where one- to four-day-old larvae were released at the upstream end of a riffle in the Canyon Reach (Rust and Wakkinen 2009). As part of our efforts to evaluate any biological response to the proposed SEPP projects, we once again included larval drift sampling as a method to evaluate hatching success. This year we incorporated new larval sampling methods that have been developed and successfully implemented by sturgeon researchers with the Confederated Colville Tribes in Washington. These new methods increase sampling effort and efficiency, and provide for a more statistically robust evaluation of potential catch. For the first time since the project inception in 1977, this year we collected three wild larval sturgeon (two at Myrtle Creek and one at Shorty's Island) at the lower extent of the two proposed SEPP sites. It is unknown if our success was a result of the new sampling methods, a chance encounter, or exceptionally good environmental conditions for spawning and hatch. Additional years of monitoring will evaluate hatching success with these methods.

RECOMMENDATIONS

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

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.

Incorporate new study designs and collect post-treatment data on SEPPs at Myrtle Creek and Shorty's Island. This will include evaluating habitat use by spawning female sturgeon (Vemco VPS system), spawning occurrence (egg mat sampling), and hatching success (larval sturgeon sampling).

Use advanced modeling techniques to evaluate the effects of environmental covariates on adult sturgeon movements and migration timing.

Collect 200 fin rays (ten per brood year) from hatchery reared juvenile sturgeon to evaluate changes in growth over time using incremental growth analysis.

TABLES

Table 1.1 Sampling effort and number of adult and juvenile White Sturgeon caught by the Idaho Department of Fish and Game, Kootenai Tribe of Idaho or British Columbia Ministry of the Environment personnel, in the Kootenai River, Idaho, and Kootenay Lake, Canada, March 13 to November 4, 2014.

	Crew	Dates	Hours of effort (h)	Number juvenile sturgeon caught (no. recaptures)/ (untraceable recaptures)	Number adult sturgeon caught (no. recaptures)	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Gillnet	BC	7/23-9/30	192.7	558 (395)/(161)	1 (1)[a]	2.896	0.005
	IDFG	8/5- 9/24	281.6	625 (479)	0	2.219	0
	Total Gill net	**7/23-9/30**	**474.3**	**1,180 (871)**	**1 (1)**	**2.494**	**0.002**
Angling[b,c]	BC	3/28-4/16	18.4	0	1 (0)	0	0.054
		9/15-9/24	23.5	0	6 (5)	0	0.255
		Subtotal BC	**41.9**	**0**	**7 (5)**	**0**	**0.167**
	IDFG	5/28-6/10	15.7	0	2 (1)/(1)	0	0.127
		9/29-10/29	27.9	2 (2)	17 (10)/(5)	0.072	0.609
		Subtotal IDFG	**43.6**	**2 (2)**	**19 (11)/(6)**	**0.046**	**0.436**
	KTOI	3/13-6/25	551.7	23 (21)/(1)	48 (43)	0.042	0.087
		9/15-9/17	78.4	0	12 (11)	0	0.153
		Subtotal KTOI	**630.1**	**23 (21)/(1)**	**60 (54)**	**0.037**	**0.095**
	Total Angling	**3/13-10/29**	**715.6**	**25 (23)/(1)**	**86 (70)/(6)**	**0.035**	**0.120**
Setline[d]	BC	3/28-4/16	197.8	1 (1)	4 (3)/(1)	0.005	0.020
		9/24-10/1	118.5	10 (9)/(1)	9 (8)	0.084	0.076
		Subtotal BC	**316.3**	**11 (10)/(1)**	**13 (11)/(1)**	0.035	0.041
	IDFG	3/25-5/22	4,609.2	8 (6)/(2)	36 (26)/(4)	0.002	0.008
		9/29-11/4	145.5	1 (0)	38 (25)/(8)	0.007	0.261
		Subtotal IDFG	**4,754.7**	**9 (6)/(2)**	**74 (51)/(12)**	0.002	0.016
	Total Setline	**3/25-5/22 & 9/24-11/4**	**5,071.0**	**20 (16)/(3)**	**87 (62)/(13)**	**0.004**	**0.017**
Grand Total			**6,260.9**	**1,228 (913)/(165)**	**174 (133)/(19)**		

[a] Defined as adult based on size: >115cm fl and 120cm tl.
[b] There was also one additional juvenile recapture caught during cod trap sampling during the spring.
[c] Angling effort (hours) is for all rods fishing, not per rod total.
[d] Based on 24 hour sets.

Table 1.2. Spawn likelihood and resulting spawn for female sturgeon, Kootenai River, Idaho, 2014.

Spawn rating prior to spawn period	Count of spawning likelihood rating prior to spawn	Count of actual spawners	% of spawning likelihood rating	Count of unconfirmed spawning due to habitual annual movements in spawn area	% of spawning likelihood rating	Count of non-spawners	% of spawning likelihood rating
High probability	16	13	81%	1	6%	2	13%
Low Probability	19	4	21%	7	37%	8	42%

Table 1.3. Tagging results of juvenile sturgeon collected on the Creston (rkm 120) and Lardeau (rkm 18) Deltas, Kootenay Lake, 2014.

Brood year	IDFG ID	PIT	Transmitter ID	Tagging date	# days detected post tagging	Tagging rkm	Min rkm detected	Max rkm detected	Fork length (cm) at capture	Weight (g) at capture
1998	5437	504E140D02	A81-1206-984	16-Sep-14	182	18	18	40	71	2450
1999	8772	423D3F6415	A81-1206-925	15-Sep-14	108	18	18	70	113	10000
1999	7719	42403E1215	A81-1206-980	15-Sep-14	192	18	18	18	93	6250
2000	15727	239F847664	A81-1206-923	15-Sep-14	77	18	18	18	112	9500
2001	24677	131455180A	A81-1206-981	15-Sep-14	115	18	18	18	87	4400
2003	49097	141462386A	A81-1206-982	15-Sep-14	184	18	18	30	74	3000
2003	47878	141249611A	A81-1206-983	15-Sep-14	192	18	18	118	91	5500
*2004	243354	239F8464D4	A81-1206-986	17-Sep-14	141	18	18	18	76	3200
*2006	243353	239F846C93	A81-1206-985	17-Sep-14	104	18	18	18	87	4100
2000	15634	127714570A	A81-1206-915	28-Mar-14	350	119	89.5	118	83	3500
1999	5954	504E627008	A81-1206-920	12-Sep-14	193	120	113	118	82	4100
1999	8864	423D4D2D74	A81-1206-921	12-Sep-14	209	120	113	118	87	4500
1999	8590	1BF2725312	A81-1206-973	12-Sep-14	140	120	118	118	58	1000
2000	12017	423D435A41	A81-1206-922	12-Sep-14	185	120	113	118	86	4400
2000	11456	127711127A	A81-1206-976	12-Sep-14	194	120	118	122.5	85	3850
2000	11543	127669443A	A81-1206-918	08-Sep-14	198	121	113	118	82	3900
2001	20001	133731510A	A81-1206-823	08-Sep-14	186	121	113	118	83	3700
2003	48464	141449443A	A81-1206-919	12-Sep-14	194	120	89.5	118	86	4600
2003	49184	141436364A	A81-1206-974	12-Sep-14	193	120	118	118	69	2450
2003	46749	141262667A	A81-1206-977	12-Sep-14	70	120	118	118	74	3100
2003	48570	141412186A	A81-1206-825	08-Sep-14	163	121	113	122.5	72	2500
2003	47117	127662473A	A81-1206-916	08-Sep-14	195	121	81	118	62	1700
2003	49348	141424470A	A81-1206-970	08-Sep-14	193	121	118	118	59	1150
2007	64461	1BF2785D96	A81-1206-975	12-Sep-14	199	120	118	118	71	2200
2008	72540	1BF272E931	A81-1206-979	12-Sep-14	185	120	118	118	41	390
2009	87939	1BF27340C6	A81-1206-971	08-Sep-14	171	121	118	118	52	700
2009	83142	1BF26FF8BB	A81-1206-972	08-Sep-14	191	121	118	118	50	650
2010	100249	1BF274743D	A81-1206-978	12-Sep-14	132	120	118	118	41	430

* Brood year deduced from scute pattern as there was no traceable release record.

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 2014.

Sample year	River location (rkm)	Depth range (ft)	Temperature range (°C)	Total mat hours	Number White Sturgeon eggs	CPUE
2014	231.0	2.7-12.8	7.8-17.0	32,373.64	87	0.0027
	234.5	3.0-14.6	7.8-17.0	34,090.99	240	0.007
	245.0-245.5	2.7-9.1	7.8-16.7	15,119.82	16	0.0007
2014	**231.0-245.5**	**2.7-14.6**	**7.8-17.0**	**81,584.45**	**343**	**0.0042**

Table 1.5. Stages of White Sturgeon eggs captured by artificial substrate mats, Kootenai River, Idaho, 2014.

Date Pull	**Temp °C Pull**	**No. Egg**	**Egg Stage**																		**Notes**	**Hours from Fertilization (Spawn Date)**
			12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	other		
6/2	11.2	1		1																		3(6/2)
6/2	11.2	2	1						1													27(6/1), 0(6/2)
6/2	11	3			1		2															5,14(6/2)
6/2	11	2							2													27(6/1)
6/2	11	4					3	1														20(6/1), 14(6/2)
6/2	11	3					2	1														20(6/1), 14(6/2)
6/5	11	3	1	2																		0,3(6/5)
6/9	12	15					2	12												1	Dead/broken	13,19(6/8)
6/9	12	10						9	1													19,24(6/8)
6/9	12	8					5	2	1													13,19,24(6/8)
6/9	12	5						1												4	Dead/broken	19(6/8)
6/9	12	3				1		1												1	Dead/broken	19(6/8),8(6/9)
6/9	12	3	2	1																		0,3(6/9)
6/9	11	11	1					3			7											39(6/7),20(6/8),0(6/9)
6/9	11	14						2		7	5											39(6/7);20,33(6/8)
6/9	11	14	3			3	3			5												14,33(6/8);0,8(6/9)
6/9	11	1							1													27(6/8)
6/9	11	22				5	4	5	5											3	Dead/broken	14,20,27(6/8);8(6/9)
6/9	11	37	4			2	27													4	Dead/broken	14(6/8);0,8(6/9)
6/9	11	6					4	1												1	Dead/broken	14,20(6/8)
6/9	11	17		2			7	2												6	Dead/broken	14,20(6/8);3(6/9)
6/9	11	5									4									1	Dead/broken	39(6/7)
6/9	11	11							4		2	4								1	Dead/broken	53(6/7);27,39(6/8)
6/9	11	8									1	4	2	1								67,81(6/6);53(6/7);39 (6/8)
6/12	12	1																		1	Dead/broken	
6/12	12	1																		1	Dead/broken	
6/12	12	1																		1	Dead/broken	
6/12	12	2																		2	Dead/broken	
6/12	12	1																		1	Dead/broken	
6/12	13	2																		2	Dead/broken	

Date Pull	Temp °C Pull	No. Egg	Egg Stage																		Notes	Hours from Fertilization (Spawn Date)
			12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	other		
6/12	13	1									1									1		33(6/11)
6/16	11	5										2		2						1	Dead/broken	81(6/13),53(6/14)
6/16	11	1																1				228(6/7)
6/16	10	4											4									75(6/13)
6/23	12	5				1	2													2	Dead/broken	13(6/22),8(6/23)
6/23	13	1												1								64(6/20)
6/23	13	13									5									8	Dead/broken	33(6/22)
6/23	13	1									1											33(6/22)
6/23	13	3						2	1													17,23(6/22)
6/23	13	3								2										1	Unknown stage	28(6/22)
6/23	13	2							2													23(6/22)
6/23	13	19									16									3	Dead/broken	33(6/22)
6/23	13	1									1											33(6/22)
6/23	13	32										27								5	Dead/broken	43(6/21)
6/23	13	7											4							3	Dead/broken	54(6/21)
6/26	14	1																		1	Dead/broken	
6/26	14	1												1								59(6/24)
6/26	13	2							1											1	Dead/broken	23(6/25)
6/26	13	1					1															12(6/26)
6/26	13	5				2							2							1	Dead/broken	54(6/24),7(6/26)
6/26	13	1										1										43(6/24)
6/30	12	1												1								73(6/27)
6/30	12	2										2										48(6/28)
6/30	12	4									4											35(6/29)
6/30	12	6										5								1	Dead/broken	48(6/28)
6/30	13	4					4															12(6/30)
7/17	15	1												1								53(7/15)
Total collected		2	12	6	1	14	66	42	19	14	47	45	12	7	0	0	0	1	0	57		
Total not staged		57																				

Table 1.6. Idaho Department of Fish and Game White Sturgeon larval sampling effort by sampling location, for June 17 through August 2, 2014, Kootenai River, Idaho, 2014.

Sampling Location	River Kilometer	Sum of Total time (hours)	Sum of Volume sampled (m3)	Sum of No. larva
Myrtle	235.0	1,031.4	661,644.7	2
RR Bridge	245.5	277.0	39,167.7	
Shorty's	230.5	1,057.2	556,702.7	1
Grand Total		2,365.6	1,257,515.0	3

Table 1.7. Idaho Department of Fish and Game and British Columbia Ministry of the Environment juvenile White Sturgeon gill net catch by sampling location from July 23 through September 30, 2014.

Year	River Kilometer	Number of Sets	Effort (net-h)	Adults Captured	Juveniles Captured	Catch rate (fish/net hour)
2014	18.0	13	17.5	3	10	0.7
	81.0	8	6.9	0	2	0.3
	120.0	24	27.7	0	285	10.3
	121.0	28	29.4	1	76	2.6
	123.0	8	9.9	0	32	3.2
	130.0	16	18.8	0	39	2.1
	141.0	8	9.0	0	2	0.2
	145.0	16	19.0	0	42	2.2
	150.0	8	9.1	0	6	0.7
	157.0	8	10.2	0	2	0.2
	161.0	16	17.5	0	32	1.8
	165.0	16	17.8	0	27	1.5
	167.5	1	1.1	0	0	0.0
	176.0	12	21.6	0	9	0.4
	176.5	11	17.8	0	16	0.9
	190.0	24	38.0	0	60	1.6
	192.0	8	10.2	0	5	0.5
	193.0	12	17.7	0	27	1.5
	205.0	20	33.2	0	74	2.2
	207.0	9	16.4	0	42	2.6
	207.5	21	31.8	0	47	1.5
	215.0	16	36.4	0	163	4.5
	224.5	1	3.7	0	23	6.2
	225.0	16	30.7	0	55	1.8
	244.5	14	23.1	0	104	4.5
	Total	**334**	**474.3**	**4**	**1180**	**2.5**
					mean	**2.2**

Table 1.8. Idaho Department of Fish and Game and British Columbia Ministry of the Environment juvenile White Sturgeon gill net catch by mesh size from July 23 through September 30, 2014.

Year	Mesh size (cm)	Sets	Effort (h)	Adults Captured	Juveniles Captured	CPUE
	2	164	231.8	0	518	2.2
	4	88	122.1	1	421	3.5
	6	82	120.3	0	244	2.0
	Total	**334**	**474.3**	**1**	**1183**	**2.5**

Table 1.9. Summary statistics of recaptured juvenile hatchery White Sturgeon from 2014 gill net sampling, Kootenai River, Idaho and Kootenay Lake, B.C.

Year	Statistic	Fork length (cm)	Total length (cm)	Mean weight (kg)
2014	N	1175	1175	1172
	Average	45.5	52.8	0.87
	Standard deviation	16.4	19.1	1.17
	Minimum	18.4	21.4	0.03
	Maximum	113.0	130.0	11.00

Table 1.10. Wild juvenile White Sturgeon captured in gillnets in 2014, Kootenai River, Idaho and Kootenay Lake, B.C. (does <u>not</u> include wild recaptures).

Year	Date	Capture rkm	Fork length (cm)	Total length (cm)	Weight (kg)	Year class
2014	8/7	225.0	43.1	50.2	0.44	2007
	8/18	120.0	86.4	100.5	4.10	2000
	9/8	121.0	58.5	67.6	1.10	2005
	9/17	215.0	70.5	82.7	2.01	2004
	9/24	207.0	39.0	44.7	0.36	2007

FIGURES

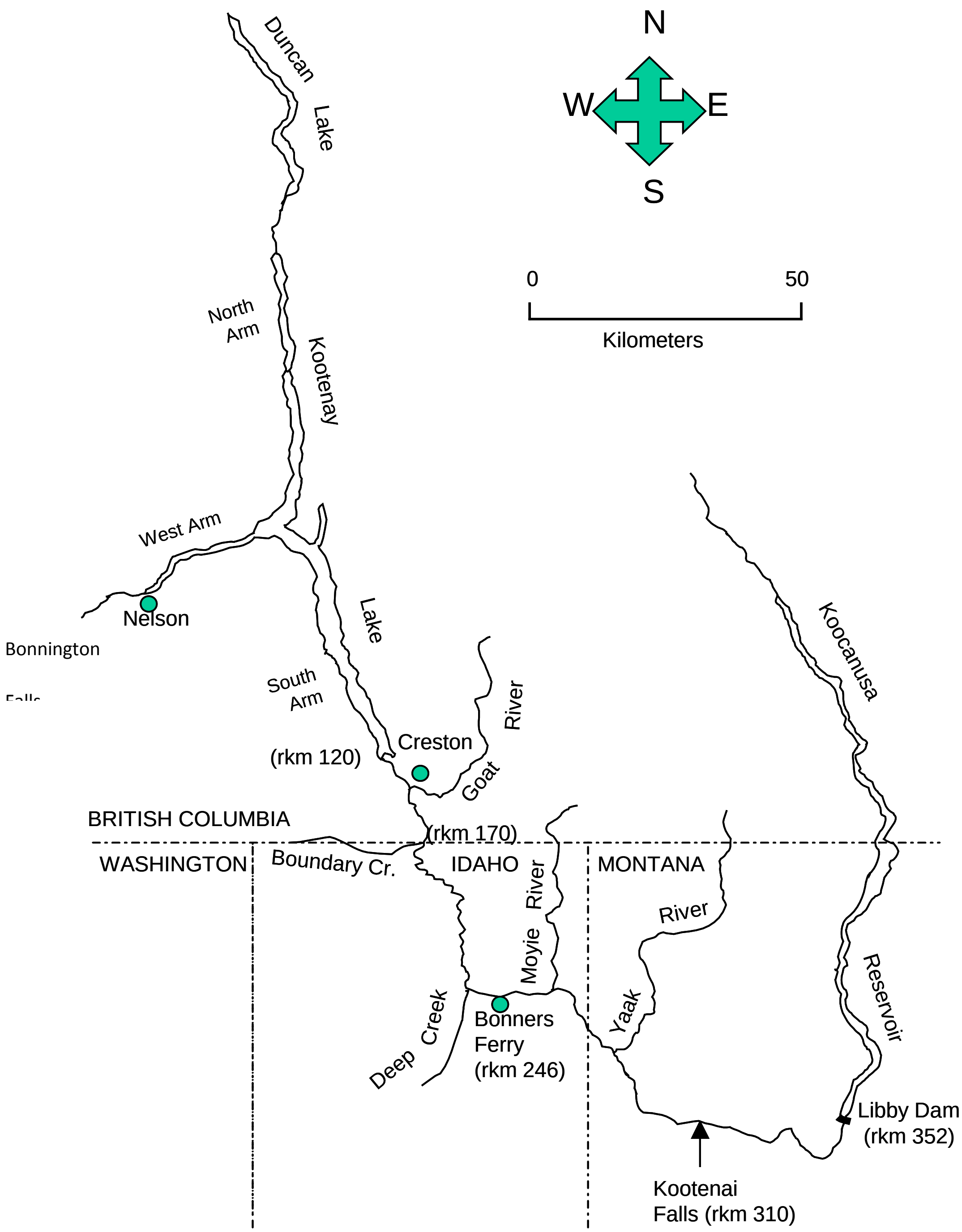

Figure 1.1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

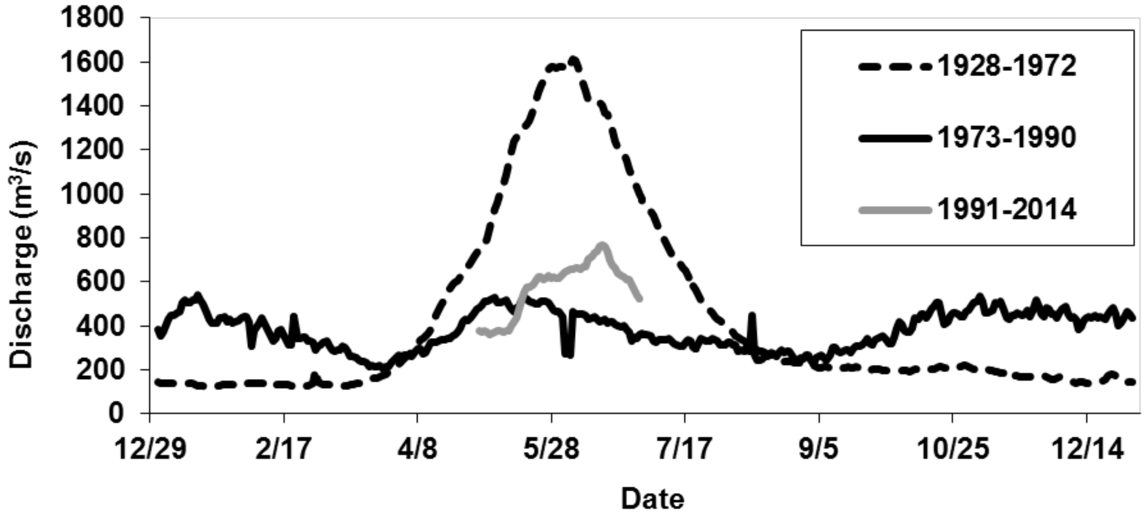

Figure 1.2 Mean daily flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928-1972 (pre-Libby Dam), 1973-1990 (post-Libby Dam), and 1991-2014 (post-Libby Dam with augmented flows, May 1 through June 30).

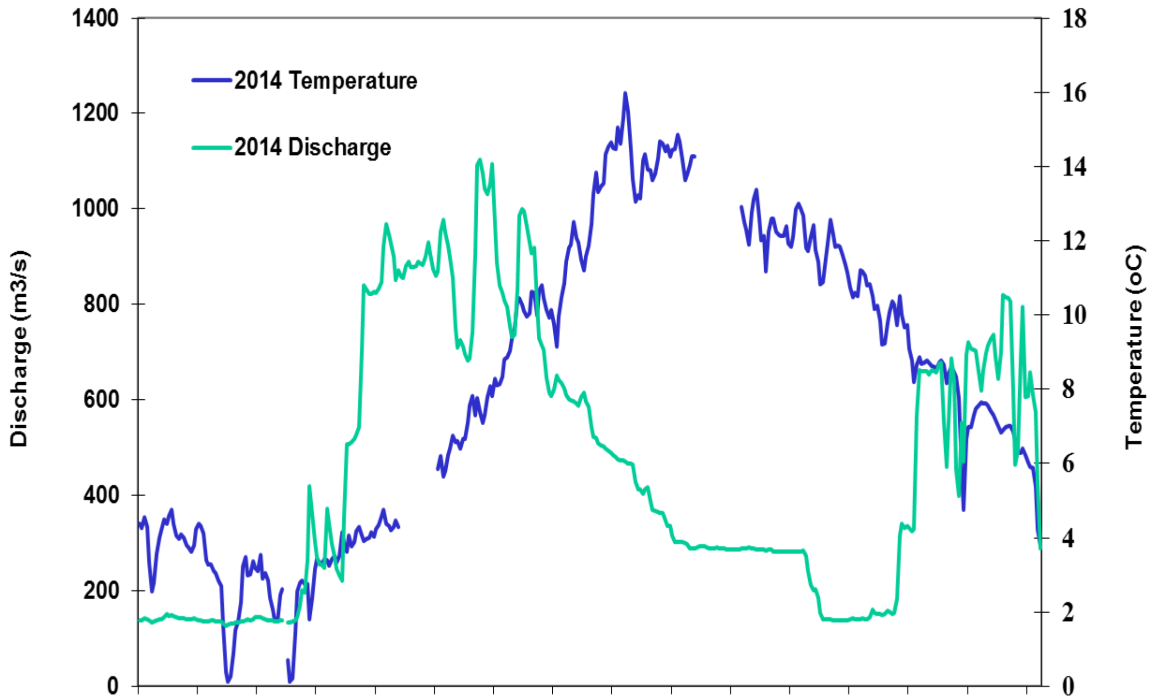

Figure 1.3. Mean daily discharge (m^3/sec) and temperature (°C) for Kootenai River at Bonners Ferry, Idaho, 2014.

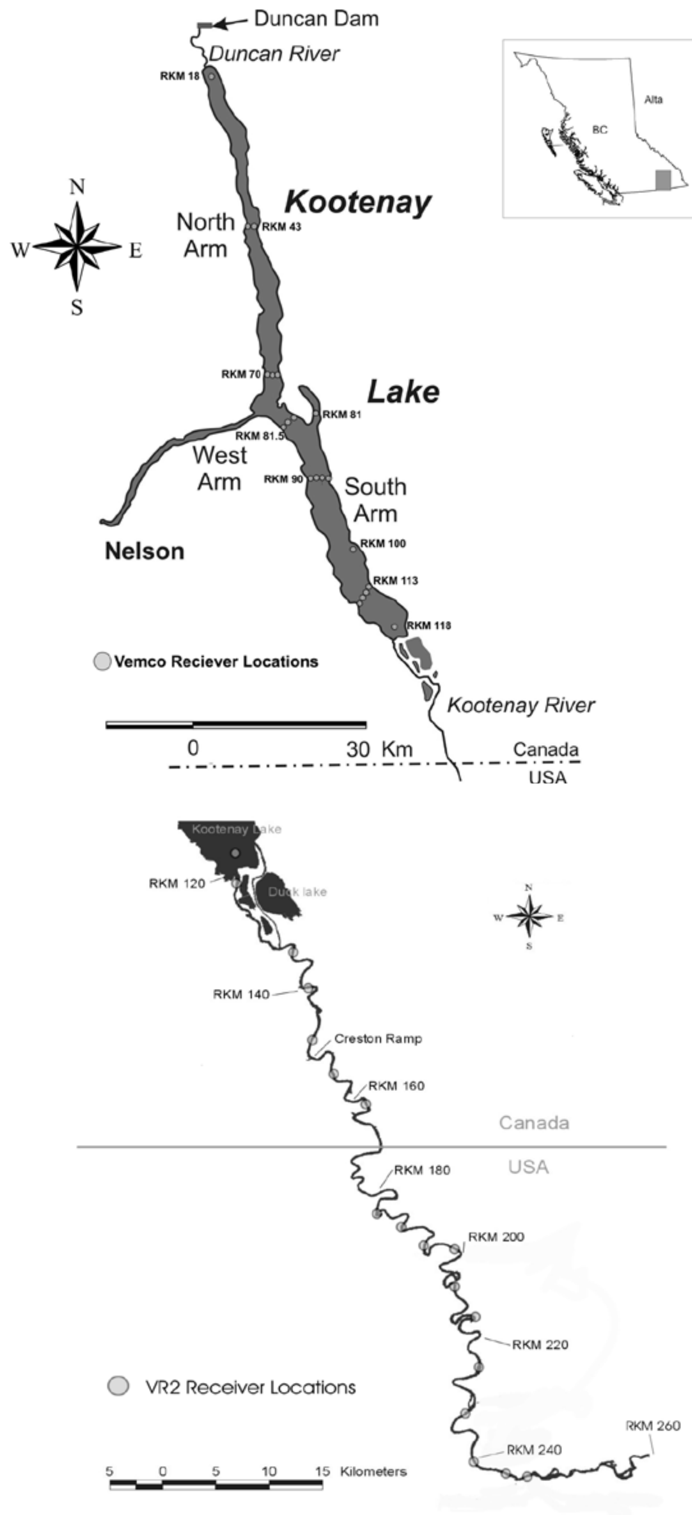

Figure 1.4. Location of Vemco VR2 receivers in Kootenai River/Lake system, Idaho and British Columbia, Canada, 2014 (receivers locations are depicted by circles).

Figure 1.5. Location of proposed Substrate Enhancement Pilot Projects (SEPP), Kootenai River, Idaho, 2014. Top figure is Myrtle Bend project near rkm 234.0. Bottom figure is Shorty's Island project near rkm 231.0. Proposed SEPP boundaries are shaded in white.

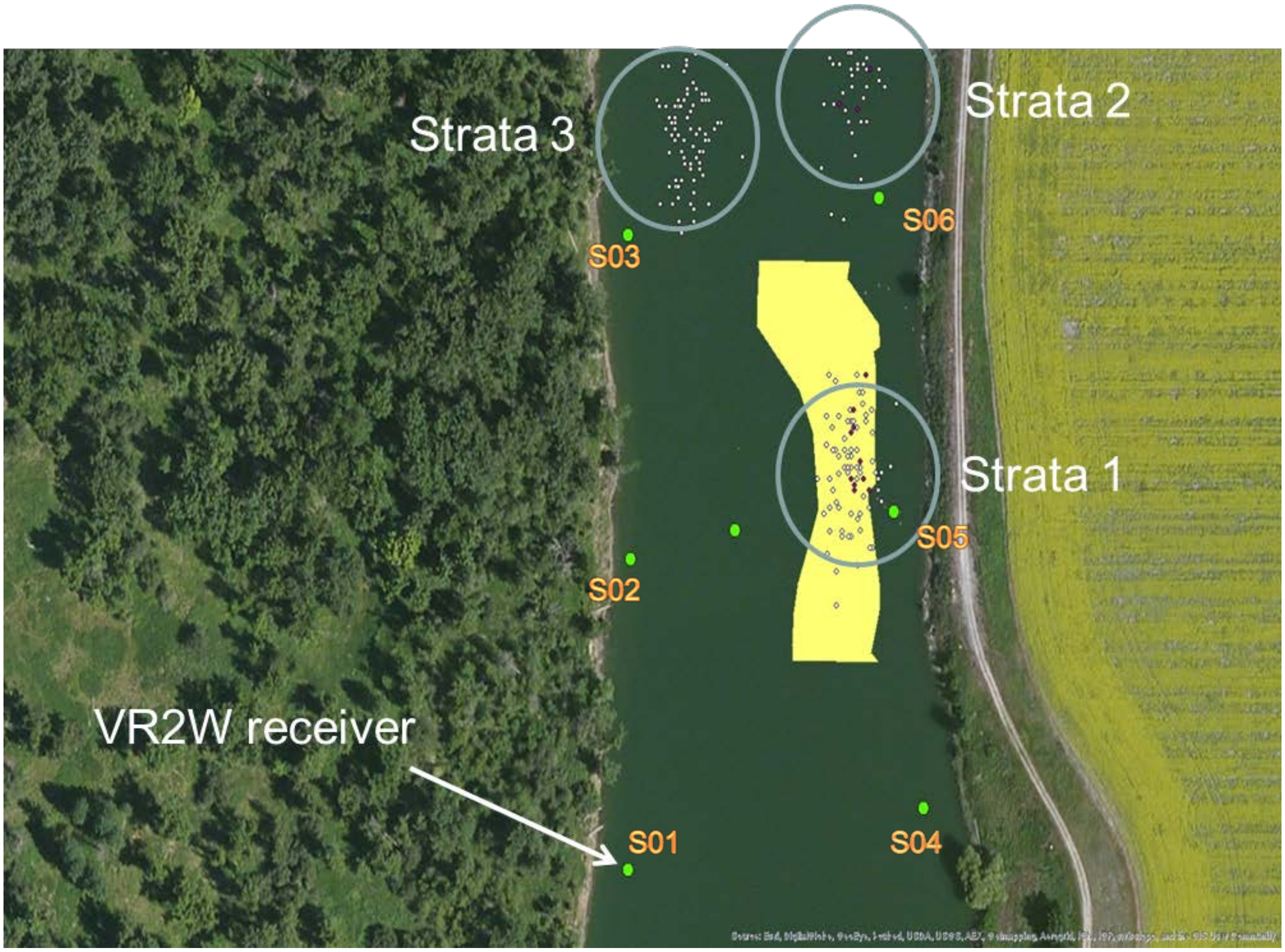

Figure 1.6. Substrate mat sampling design with reference to SEPP area at Shorty's Island. White dots within strata circles denote locations of substrate mats without eggs. Dark red dots within strata circles denote substrate mats containing eggs. Green dots on periphery denote location of Vemco VR2W receivers with co-located sync tags (orange labels) for VPS study.

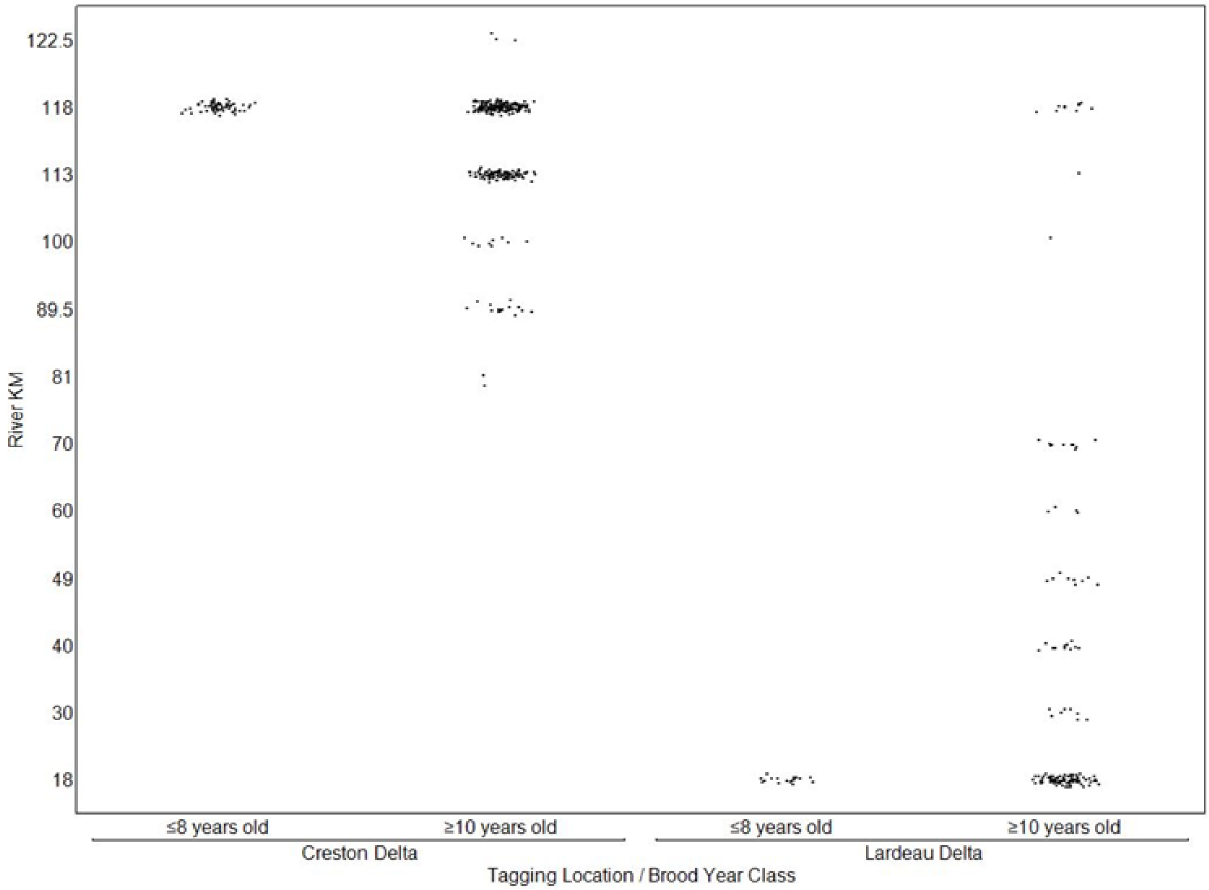

Figure 1.7. Detections from juvenile White Sturgeon tagged in 2014 separated by tagging location and age group, by river kilometer.

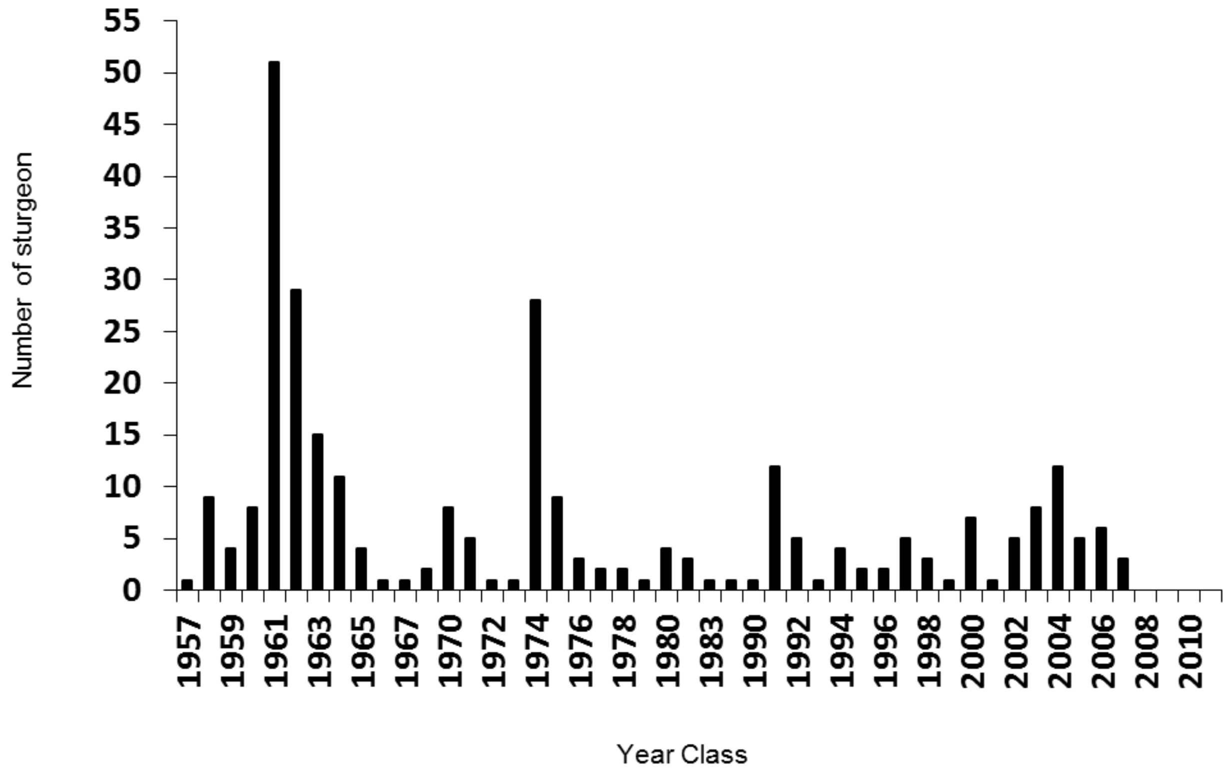

Figure 1.8. Number of wild juvenile White Sturgeon by age class captured in the Kootenai River, Idaho 1977-2014.

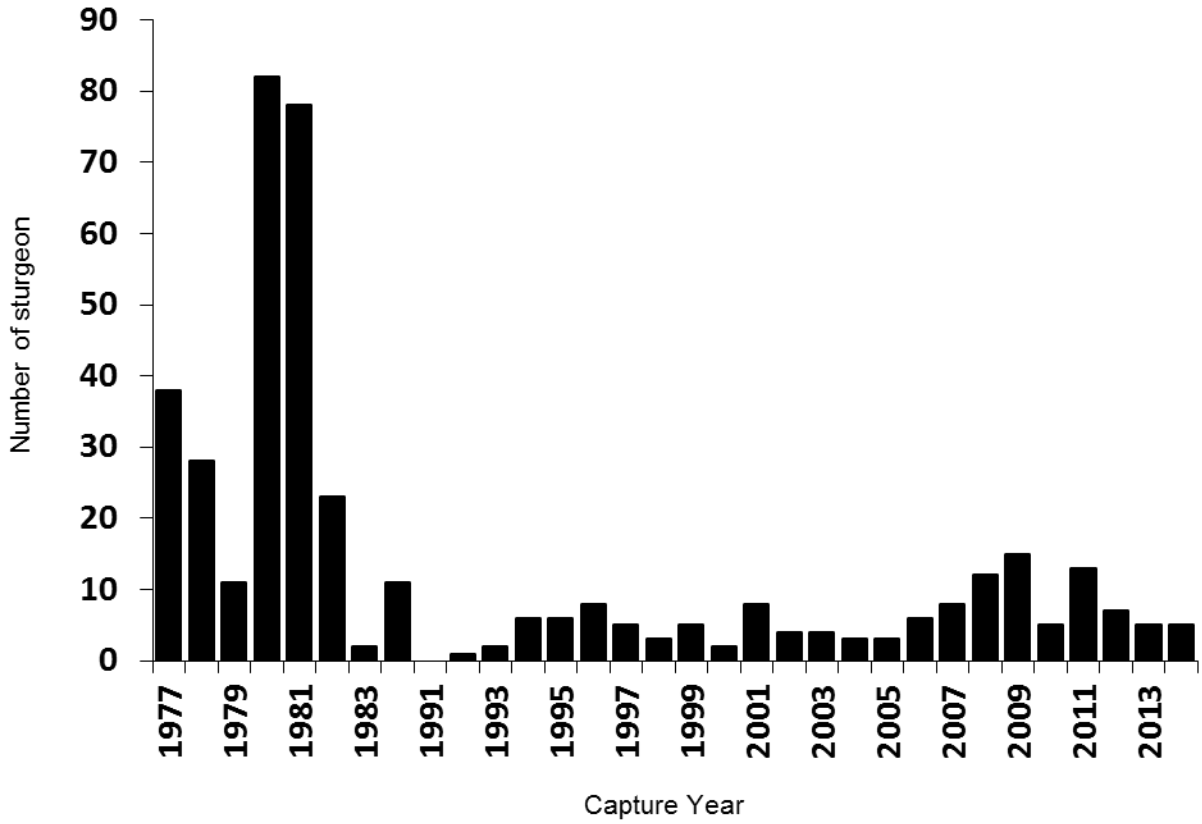

Figure 1.9. Number of wild juvenile White Sturgeon captured annually in the Kootenai River, Idaho, 1977-2014.

CHAPTER 2: BURBOT MONITORING AND EVALUATION

ABSTRACT

Burbot *Lota lota maculosa* numbers in Kootenay Lake and the Kootenai River of British Columbia, Idaho, and Montana have diminished primarily due to (1) overfishing and (2) physical habitat changes in the river, beginning as early as the 1930s. Recent implementation of a conservation strategy included aquaculture to supplement the population using a donor stock from a self-sustaining lake population within the Kootenai watershed. Current evaluation of release strategies (since 2009) indicated that lake-origin Burbot have adapted well to the Kootenai system. Historical hoop-net data indicated that Burbot residing in the river were growing and surviving at rates that were comparable to the historical population. Spawning of hatchery origin fish was detected at a historical riverine spawning location, and current evaluations revealed that lake origin fish were mimicking movement patterns and habitat use of the historical riverine population. The current study, in combination with other recent investigations, provides evidence that Burbot progeny from lacustrine broodstock can successfully survive, grow, disperse, and spawn in a riverine environment. Therefore, conservation aquaculture appears to be a plausible option for restoring the Burbot population in the Kootenai River. However, additional research is needed to quantify the presence (or absence) and subsequent magnitude of natural recruitment of Burbot in the Kootenai River.

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INTRODUCTION

Although Burbot *Lota lota maculosa* are widespread and abundant throughout much of their natural range (Evenson and Hansen 1991), many populations are in severe decline (Arndt and Hutchinson 2000; Paragamian et al. 2000). As a result, restoration efforts have been initiated to mitigate factors that threaten these populations with further decline or localized extirpation (Dillen et al. 2008; Worthington et al. 2009; Stapanian et al. 2010). A primary source of decline has been attributed to significant changes in habitat often stemming from the construction of dams used in flood control or power generation; this is the case in the Kootenai (spelled Kootenay in Canada) River in Idaho. Libby Dam, constructed in the early 1970s, has significantly increased winter discharge and water temperature during the spawning period for Burbot (Partridge 1983), which is thought to have negatively impacted recruitment (Hardy and Paragamian 2013). Additional impacts from the construction of the dam and diking within the Kootenai floodplain include decreases in nutrient availability and loss of habitat from floodplain isolation (Hardy 2003). Following construction of the dam, impacts to the Idaho Burbot population resulted in the fishery rapidly declining in the mid-1980s and ultimately a complete fishery closure in 1992. Concomitant to the collapse in Idaho was the rapid decline of the Burbot fishery in Kootenay Lake and Kootenay River, British Columbia (BC), which resulted in those fisheries also being closed in 1997 (Paragamian et al. 2000).

Due to the widespread cultural and recreational importance of Burbot in the Kootenai River prior to the collapse of the population, an International Burbot Conservation Strategy (Strategy) was developed by a community-wide working group to help restore the population (Paragamian et al. 2002; KVRI 2005; Ireland and Perry 2008). The Strategy outlined rehabilitation measures, including changes to the operation of Libby Dam and development of conservation aquaculture to supplement the wild stock during population rehabilitation. Because the Burbot population was too small to recover on its own or provide gametes for a conservation aquaculture program, managers deemed it necessary to locate and use a donor stock to aid in restoration efforts. Of the many water bodies sampled, Burbot from Moyie Lake, BC were selected as a suitable donor stock because they were found to be of a similar phylogenetic group as the Kootenai River population (Powell et al. 2008), abundant enough to provide sufficient gametes, and had spawning sites that provided access to spawners. Concurrent with studies to locate a broodstock source, intensive rearing techniques were successfully developed at the University of Idaho Aquaculture Research Institute (UIARI; Jensen et al. 2008a). As a result of this success, the Kootenai Tribe of Idaho (KTOI), Idaho Department of Fish and Game (IDFG), and British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) have stocked larval, juvenile, and adult Burbot into the Kootenai River and its tributaries since 2009, in an effort to aid natural production and test specific population-limiting factors.

As identified by Neufeld et al. (2011), one important facet to the success of the conservation aquaculture efforts on the Kootenai River was to determine if hatchery progeny from lake-origin Burbot would adapt well to a riverine environment. Previous telemetry evaluations of lake-origin juvenile Burbot released into the Kootenay River (Neufeld et al. 2011; Stephenson et al. 2013), revealed that adult Burbot (age-2+) dispersed quickly from release tributaries and dispersed great distances, covering up to 235 km, including both lacustrine and riverine habitat. In comparison, the dispersal of age-1 (juvenile) Burbot from release tributaries was slow (or non-existent) and was substantially less than that of older Burbot (Stephenson et al. 2013). These studies provided crucial insight on Burbot early life history and adaptation; however, the long-term adaptation of lake-origin Burbot progeny released into a riverine environment ultimately remains poorly understood. Using a Passive Integrated Transponder

(PIT) array and mark recapture evaluations through hoop-net sampling, research reported herein investigated survival, growth, spawn timing, and broad-scale dispersal of lake-origin Burbot released into the Kootenai River basin and compared these metrics to those of the historical, native population. Such information is particularly important for guiding current and future restoration programs in the Kootenai drainage and across the northwestern United States.

GOAL

The long-term management goal of this study was to restore the Burbot population in the Idaho reach of the Kootenai River in order to (ultimately) provide a sustainable harvest of Burbot.

OBJECTIVES

1. Characterize the status of the Burbot population in the Kootenai River, Idaho.

2. Characterize spatial and temporal occurrence(s) of spawning in the Kootenai River, Idaho.

3. Evaluate the success of various aquaculture stocking strategies, from 2009-2014.

4. Identify and experimentally evaluate potential factors limiting recruitment of Burbot in the Kootenai River, Idaho.

5. Evaluate survival, movement, and habitat use of Burbot in Deep Creek, Idaho.

STUDY AREA

The Kootenai River is the second largest tributary to the Columbia River and its drainage is the third largest (approximately 49,987 km^2; Bonde and Bush 1975). The river originates in Kootenay National Park, BC, and discharges south into Montana, where Libby Dam impounds water into Canada and Montana and forms Lake Koocanusa (Figure 2.1). The river flows west from Libby Dam, northwest into Idaho, then north into BC and Kootenay Lake. The river then drains out of the West Arm of Kootenay Lake, and it eventually joins the Columbia River near Castlegar, BC. The habitat in BC includes river kilometer (rkm) 165 to 121 of riverine habitat and rkm 120 to 18 of lacustrine habitat in Kootenay Lake. Kootenay Lake has a surface area of 390 km^2 and is a fjord-like lake, running north-south in the trench formed between the Selkirk and Purcell mountains. Approximately 105 rkms flow through the Idaho section of the Kootenai basin.

During the study period reported herein, hoop-net sampling for adult Burbot occurred at 18 sites between rkm 144.5 (Nick's Island, near Creston, BC) and rkm 244.5 (Ambush Rock, near Bonners Ferry, Idaho) (Figure 2.1). A PIT tag array was installed in Deep Creek in October 2012, approximately seven km upstream from its confluence with the Kootenai River (Figure 2.1).

METHODS

Burbot Hoop-net Sampling

Burbot Stocking

Following the success of intensive culture at the UIARI, approximately 810,000 Burbot (ranging in age from larvae to age-2) were released into the Kootenai River and its tributaries from 2009-2014. During this same time, approximately 34,000 juveniles (age-0 to -2) were tagged with PIT tags [FDX (2009-2013) and HDX (2014); BioMark Inc.; 9 and 12 mm, respectively] and released into tributaries and the main-stem of the Kootenai River by KTOI, MFLNRO and IDFG personnel (Table 2.1).

Main-stem Hoop-net Sampling

Adult Burbot were sampled at 18 locations using 36 baited hoop-nets during winter 2014/15 (eight Canadian and ten U.S. sites; Figure 2.1) in order to measure relative changes in the population through catch-per-unit-of-effort (CPUE; number of Burbot/net-day) and other population metrics. Six historical index sites (since 1994) along with an additional 12 sites were sampled from December 1, 2014 to March 31, 2015 to collect information on CPUE, growth, year class survival, and spawning activity within the Kootenai River. From 1996-2009, each river site was sampled using hoop-nets (2.00 m x 0.61 m) with 25.4 and 19.1 mm bar-mesh sizes. Beginning in 2010, two hoop-nets of 19.1 and 6.4 mm bar-mesh sizes were paired at each site to evaluate gear selectivity; this has been the standard protocol since 2010. All nets were baited with frozen kokanee *Oncorhynchus nerka* and checked three times per week. Burbot captured in nets deeper than nine meters were re-set to one-half the original depth for approximately 24 hours to allow for fish decompression and reduce barotrauma-related mortality (Neufeld and Spence 2007). All captured Burbot were counted, measured for TL (mm), weighed (g), sex determined (i.e., if flowing milt or eggs), and examined for previous tags. All untagged Burbot were injected with a unique PIT-tag into the right anterior dorsal muscle for future analyses, including: population estimates, growth, survival by brood year, and others. Tissue samples for genetic analysis were collected from the anterior portion of the dorsal fin of all tagged and untagged Burbot to determine origin (i.e., hatchery or wild) and year-class using Parental Based Tagging (PBT) analysis (methods described by Anderson and Garza 2005; Steele and Campbell 2011). Evidence of spawning was determined using 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.

Tributary Release Monitoring

On October 11, 2012, three dual-reader (i.e., FDX and HDX) Biolite BioMark Passover PIT antennas were installed in Deep Creek, Idaho, approximately seven rkms from the confluence with the Kootenai River. Details regarding operations of the array, Burbot PIT tagging protocol, and Burbot release numbers and locations (from 2012-2013) can be found in Ross et al. (2015). A total of 3200 juvenile Burbot was released at two sites upstream from the mouth of Deep Creek (Naples at 21 rkms upstream and McArthur Lake Outlet at 34 rkms upstream) in November 2014. To gather information on growth and survival of age-0 Burbot from stocking events in Deep Creek, five 6.4 mm mesh hoop-nets were set at existing mobile HDX PIT array sites (more detail can be found in the subsequent section of this report titled, *Burbot Survival, Movement, and Habitat Use in Deep Creek, Idaho*).

Burbot Survival, Movement, and Habitat Use in Deep Creek, Idaho

The Idaho Department of Fish and Game began funding a graduate project with the Idaho Cooperative Fish and Wildlife Research at the University of Idaho in summer 2014. The primary objective of the project was to evaluate survival, movement, distribution, and habitat use of Burbot that were stocked into Deep Creek, Idaho. To date, very few of the Burbot stocked into Deep Creek (since 2012) have been (1) captured in main-stem or Deep Creek hoop-netting or (2) detected crossing the Biomark dual reader PIT array in Deep Creek; therefore, the fate of these fish remains unknown. The project is currently underway and scheduled to be completed by fall 2016.

Briefly, methodology for the project included: measuring habitat across transects in Deep Creek, measuring habitat at known Burbot locations, systematic electrofishing surveys, systematic mobile PIT tag reader surveys, and installation and maintenance of five stationary, pass-through HDX PIT tag arrays distributed throughout Deep Creek.

RESULTS

Burbot Hoop-net Sampling

Eighteen river sites were sampled from December 1, 2014 to March 31, 2015, totaling 4,022 net-days and 1374 captured Burbot. Catch-per-unit-of-effort for the 2014/15 season by river site ranged from 0.01-1.46 Burbot/net-day, with an overall CPUE of 0.33 Burbot/net-day. Overall CPUE during the 2014/15 season represented a 154% increase in catch rates from the 2013/14 season, a 371% increase from the 2012/13 season, and a 6,500% increase from the 2006-2011 mean (Figure 2.2a). Catch-per-unit-of-effort for the 2014/15 season by index site ranged from 0.01-0.91 Burbot/net-day, with an overall CPUE of 0.29 Burbot/net-day. The overall CPUE for index sites represented a 61% increase in catch rates from the 2013/14 season, a 207% increase from the 2012/13 season, and a 2,146% increase from the 2006-2011 mean (Figure 2.2b). Catch rates across all sites remained relatively constant (temporally) throughout the sampling period, with the exception of a substantial increase at U.S. sites from mid-February to mid-March (Figure 2.3). During this peak (2012-2015), 768 flowing males (268-798 mm) and 46 gravid females (353-751 mm) were captured, primarily at Ambush Rock (rkm 244.5), Deep Creek Confluence (rkm 240), and Myrtle Creek (rkm 234). The 2012/13, 2013/14, and 2014/15 peaks in CPUE (during spawning) coincided with a substantial amount of weight loss in Burbot recaptured within 14 days of initial handling, which was indirect evidence of spawning (attempts) in the river. Comparison of the 2013 and 2014 catch rate peaks at Ambush Rock (March 11, 2013 and March 4, 2014) with the historically greatest sampling season catch rate for wild Burbot (February 11, 2001) indicated that spawn timing peaked approximately 30 days later for the lake-origin progeny (Figure 2.3). However, peak CPUE at Ambush Rock during the 2014/15 season occurred on February 18, 2015, which was only one week later than when it was recorded for wild Burbot in 2001. Mean water temperatures during the spawn at Ambush Rock were 2.7°C (± 0.12 SE) in 2001, 4.5°C ± 0.15 (SE) in 2013, 2.0°C ± 0.21 in 2014, and 3.8°C ± 0.22 in 2015 (Figure 2.4). Duration of spawning activity observed during the four spawning seasons (i.e., 2000/01, 2012/13, 2013/14, and 2014/15) was similar (i.e., approximately 22 days); however, the duration of spawning during the 2014/15 season (as gauged by catch rates at Ambush Rock) appeared longer by almost ten days (earlier), relative to the previous years.

Of the 1374 total captures in 2014/15, 705 (51%) were unique individuals consisting of 266 Burbot without PIT tags and 439 with PIT tags at first capture. The 439 Burbot recaptured with PIT tags were identifiable to a release location and age-at-release (Figure 2.5). Of the PIT-tagged Burbot that returned to the hoop nets, year class assignments indicated that the majority came from 2009, 2011, and 2012 year classes (Table 2.2; Figure 2.6). However, 2008 and 2009 year classes had the highest proportion of returns (i.e., 5.26% and 7.71%, respectively), based on the total number of Burbot stocked with PIT tags by year class (Table 2.2). Evaluation of 950 Burbot recaptures from the combined 2012/13, 2013/14, and 2014/15 winter hoop-net seasons indicated that hatchery-reared Burbot distributed throughout the sample locations (I.e., river-wide), with the majority being recaptured upstream from the original stocking location (Figure 2.6). The highest return of PIT tags came from Boundary Creek, Porthill, and Deep Creek Confluence release locations with cumulative returns of 1.4%, 2.8%, and 3.4%, respectively (Figure 2.7).

Contradictory to data from the 2013/14 season (Ross et al. 2015), evaluation of mesh size effects on catch rates of Burbot during the 2014/15 season indicated that the 6.4 mm mesh yielded higher CPUE (0.38 fish/net-day) than the 19.1 mm mesh (0.28 fish/net-day; Table 2.3). Similar to data from the 2013/14 season (Ross et al. 2015), data from the 2014/15 season indicated that the 6.4 mm mesh caught smaller fish (465 mm) than the 19.1 mm mesh (482 mm; Table 2.3). In addition, there were no differences in catch rates or size of fish captured for nets set greater or less than 7.6 m during both the 2013/14 and 2014/15 seasons (Table 2.4).

Length-at-age at time of capture indicated that Burbot annual growth of Burbot ranged from 60-114 mm / year. Growth rates appeared to be similar to those from wild Kootenai River Burbot captured and aged using otoliths in the early 1980s, and higher than rates estimated in the late 1950s (Figure 2.8; Partridge 1983).

Tributary Release Monitoring

Between October 1, 2012 and March 31, 2015, 386 unique Burbot were detected by the Deep Creek PIT tag array (Table 2.5). One hundred and seventy-eight of the detections were juvenile Burbot released in Deep Creek from 2012-2014, and the remaining 208 Burbot that were detected originated from main-stem river stocking locations. Of the 208 Burbot that originated from main-stem stocking events, 87 were documented passing the dual reader PIT tag array during the 2014/15 spawning season (i.e., 2/14/2015-3/25/2105; Figure 2.9). Counts of the number of unique detections/day at the PIT tag array indicated that Burbot likely made spawning migrations into Deep Creek during 2014/15. More specifically, the array recorded increased detections in mid-February (i.e., indicating prespawning migration into Deep Creek), followed by few to no detections until mid-March (i.e., indicating residence in Deep Creek during spawning), and lastly increased detections in mid-March (i.e., indicating post-spawning outmigration) (Figure 2.9). In addition, of the 87 unique Burbot detected passing the array in 2014/15, nine fish were captured in main stem) hoop-nets both before and after the spawning migration into Deep Creek. The average percent weight change for these nine fish was a 17.8% decrease, providing further evidence that spawning occurred in Deep Creek during 2014/15. Interestingly, these nine fish were originally stocked from as far downstream as Porthill to as far upstream as the Moyie River, indicating that Burbot were actively pioneering into Deep Creek during the spawning season.

Despite the few recaptures or re-encounters of juvenile Burbot stocked into Deep Creek from 2012-2014, hoop-net sampling at two locations during the 2013/14 season and at five locations during the 2014/15 season confirmed survival of fish from all stocking events. Including recaptures, 102 juvenile Burbot were captured in 598 net-days of sampling during the 2014/15 season, and 14 juvenile Burbot were recaptured in 77 net-days of sampling during the

2013/14 season. Of these (2013/14-2014/15), 12 were from the 2012 age-0 stocking event, 24 were from the 2013 age-0 stocking event, and 21 were from the 2014 age-0 stocking event (Table 2.6). Mean lengths-at-age at time of capture for age-0, age-1, and age-2 Burbot were 88.0 mm ± 13.0 (SE), 138.0 mm ± 10.2, and 321.0 mm ± 7.6, respectively.

Burbot Survival, Movement, and Habitat Use in Deep Creek, Idaho

This study is currently underway and scheduled to be completed by fall 2016. When the study is completed, a Master's thesis and multiple peer-reviewed manuscripts will be cited to reference the findings.

DISCUSSION

Burbot Hoop-net Sampling

Main-stem Hoop-net Sampling

Many lacustrine Burbot populations are adfluvial in nature, residing in a lake environment and migrating to rivers only to spawn (Sorokin 1971); however, results from the present study indicate that Burbot possess an adaptive plasticity to occupy and survive in various habitats, independent of parental origin. Initial estimation based on PIT tag returns revealed that lake-origin hatchery fish survived, grew, and matured following release events into the Kootenai River and tributaries. Trend CPUE (i.e., at index sites) of Burbot captured in hoop-nets increased over 2,000% in the 2014/15 sampling season (0.29 fish/net-day) relative to mean catch rates from 2006-2011 (0.004 fish/net-day). In addition, PIT tag returns revealed that Burbot widely dispersed throughout the Kootenai River system, and the majority of dispersal was in an upstream direction from original stocking location. In the early phases of the Burbot restoration program, managers were concerned that stocking Burbot progeny from lacustrine broodstock would result in fish migrating downstream to reside strictly in Kootenay Lake, BC.

As the density of Burbot increases in the Kootenai River, additional data will become available to further identify and investigate various factors limiting recruitment of the population. It is important to note that although catch rates of Burbot have substantially increased since initial stocking, the Kootenai River population remains low in abundance relative to other Burbot populations, and successful recruitment in the wild has yet to be confirmed. In comparison, catch rates of Burbot in Moyie Lake, B.C. were 0.5 to 2.2 fish/net-day (Prince 2007), the Chena and Tanana rivers of Alaska were 0.9 and 1.2 fish/net-day, respectively (Evenson 1993), and four Alaskan Lakes ranged from 0.5-3.0 fish/net-day (Parker et al. 1988). Abundance of Burbot in the Kootenai River was unknown prior to Libby Dam; therefore, Paragamian and Hansen (2009) used the population and CPUE data in the aforementioned water bodies as surrogate restoration targets to guide the Kootenai River recovery program. Assuming catch rates of Burbot in the Kootenai River continue to increase at the rate documented over the last three sampling seasons, population objectives (Paragamian and Hansen 2009) may be achieved in a relatively short period of time.

Along with increasing densities, the present study also indicated that Burbot stocked into the Kootenai River have located adequate food resources. Growth rates of the lake-origin hatchery stock were similar to those of wild fish historically captured in the Kootenai River in the early 1980s, higher than those captured in the late 1950s (Partridge 1983), and comparable to other northern waterbodies that support healthy Burbot populations (Katzman and Zale 2000).

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). Although few age-1 fish were recaptured in the present study, mean growth across all age groups averaged 96 mm/yr. As density increases, trends in growth rates could potentially decrease. C monitoring (of this rate function) is crucial for balancing release numbers with food and habitat availability.

Multiple lines of evidence suggested that lake-origin, hatchery-reared Burbot adapted to spawn in the Kootenai River near Ambush Rock in mid-February to mid-March of 2013-2015. Additionally, adults from nearly all main-stem stocking locations made distinct movements into and from Deep Creek during the same spawning window, suggesting that Deep Creek may also be a spawning location for Burbot in the Kootenai system. However, catch rates during the 2013 and 2014 seasons (at historically known spawning locations; Paragamian et al. 2000) peaked later and at warmer temperatures than reported for wild Burbot in the Kootenai River (Kozfkay and Paragamian 2002). The observed peak in spawn timing from the 2013 and 2014 seasons was also later than the mid- to late February spawn timing in Moyie Lake, where the original broodstock were collected (Matt Neufeld, MFLNRO, personal communication). During the 2014/15 season, however, the peak in catch rates at Ambush Rock was slightly earlier (i.e., February 18, 2015) than in previous years, suggesting that there may be annual variability in the timing of spawning in the Kootenai River. A shift to later spawn timing could 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, the authors reported the mean time-to-hatching increased from 41 to 46 days when the incubation temperature was reduced from 5°C to 3°C. Temperatures in the Kootenai River (at Ambush Rock) following the 2013 and 2015 spawning events exceeded the lethal temperature (6°C) during the critical 40-45 day incubation period; however, the thermal threshold was not exceeded during the 2014 season. Therefore, if the spawn timing of the newly-stocked Burbot population in the Kootenai River was later than the historical and donor populations, eggs could be subjected to thermal peaks exceeding lethal levels. Identification of hatchery-reared Burbot (1) surviving and then (2) spawning in known historical riverine locations was a significant measure of success for the conservation aquaculture program (for Burbot) in the Kootenai River. In future years, the final steps will be to document natural recruitment and critically evaluate and test the influence of temperature on spawn timing, egg-hatching success, and larval development and survival. Not only will this information help drive identification of potential tributaries for future release efforts, but it may also inform operations of 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 recruitment of Burbot.

Tributary Release Monitoring

Relatively few juvenile Burbot have passed over the PIT tag array in Deep Creek since it was installed in October 2012, which raises questions about the survival of fish from these stocking efforts. Further evaluation with hoop-nets set at multiple locations upstream from the array suggested poor survival of Burbot, post-stocking, in Deep Creek. Results from a previous telemetry study suggested that older Burbot (i.e., age-2 and -3) exhibited wide-ranging dispersal behaviors; whereas, age-1 Burbot remained relatively close to stocking locations (Stephenson et al. 2013). Therefore, it was perhaps not surprising that age-0 and age-1 Burbot in Deep Creek did not out-migrate. However, it was expected that as Burbot recruited to older age-classes, they would out-migrate to the Kootenai River, which has not occurred. Findings from Stephenson et al. (2013) suggested that stocking Burbot at younger ages may increase residence time in targeted tributaries that purportedly have suitable habitat. It is currently unknown whether or not this increased residence time would be beneficial to survival and recruitment to the main-stem Burbot population. On the contrary, detections of 103 (from 2012-2014) additional hatchery-reared Burbot revealed interesting and unexpected movement patterns. These fish were originally stocked in the main stem of the Kootenai River, as far downstream as Porthill (rkm 170) and as far upstream as the Moyie River (rkm 259). Detections of these adult Burbot in Deep Creek indicate that hatchery Burbot have the ability to pioneer. Future assessments of relative survival and movement patterns of tributary- stocked Burbot should aid in determining optimal release strategies to promote survival and bolster recruitment of wild Burbot in the Kootenai River system.

Burbot Survival, Movement, and Habitat Use in Deep Creek, Idaho

Results from this study will address many of the questions and unknowns proposed in the previous section (*Tributary Release Monitoring*). This information will be available in the form of a Master's thesis and multiple peer-reviewed manuscripts.

SUMMARY

The present study, in combination with other recent investigations (Neufeld et al. 2011; Stephenson et al. 2013) provides evidence that Burbot progeny from a lacustrine broodstock can successfully survive, grow, disperse, and spawn in a riverine environment. Similar to many fish species, Burbot express fluvial, adfluvial, and lacustrine forms of migration and homing during their life history (Sorokin 1971, Evenson 1993, McPhail and Paragamian 2000). With potential broodstock sources readily available in many lacustrine environments, the release strategies in the present study may be important to current and future restoration programs across the Northwest.

RECOMMENDATIONS

1. Provide comprehensive analyses and recommendations to management by 2018 that provide clear criteria for opening up a Burbot fishery on the Kootenai River.

2. Fully evaluate natural production and hatchery contribution through using 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, and size structure.

5. Initiate an exploratory larval sampling survey for Burbot in the Kootenai River during spring 2016.

TABLES

Table 2.1. Total number of Burbot released from 2009-2014 into the Kootenai River and its tributaries. Fish were tagged with FDX PIT tags from 2009-2013; fish have been tagged with HDX PIT tags since 2014. Those without tags were primarily larval releases. Untagged fish from 2011 – 2014/15 will be able to have year class assigned by genetic analysis.

Stock Year	Year Class	Tagged Releases	Untagged Releases	Total Release Number
2009	2006	7	-	7
	2007	23	-	23
	2008	1	-	1
	2009	-	178	178
2010	2007	5	-	5
	2008	18	-	18
	2009	551	4	555
	2010	-	1,576	1,576
2011	2009	6	26	32
	2010	30	90	120
	2011	16,289	53,975	70,264
2012	2010	82	-	82
	2011	656	-	656
	2012	3,392	268,305	271,697
2013	2011	71	-	71
	2012	600	1	601
	2013	10,011	450,872	460,883
2014	2010	16	-	16
	2012	16	-	16
	2013	218	-	218
	2014	3,473	-	3,473
Total		**34,465**	**775,027**	**810,492**

Table 2.2. Total number of Burbot stocked from 2009-2014 and recaptured in hoop-nets during the 2014/15 winter season. Year classes from 2006-2008 were stocked in 2009.

Year Class	Total Released	Recaptured	% Return
2006	7	0	0.00
2007	28	0	0.00
2008	19	1	5.26
2009	765	59	7.71
2010	1,794	2	0.11
2011	70,991	458	0.65
2012	272,314	102	0.04
2013	461,101	13	0.00
2014	3,723	0	0.00
Totals	**810,492**	**635**	**0.08**

Table 2.3. Burbot catch, effort, CPUE (Burbot/net-day), mean length (mm), and mean weight (g) with standard error in parentheses (SE), separated by mesh size for 2014/15 season. Recaptures were included in the calculations.

Mesh size (mm)	Count	CPUE	Mean length (SE)	Mean weight (SE)
6.4	768	0.38	464.9 (2.8)	760.5 (18.0)
19.1	582	0.28	481.6 (4.3)	914.6 (29.9)

Table 2.4. Burbot catch, CPUE (Burbot/net-day), mean length (mm), and mean weight (g) with standard error in parentheses (SE), separated by depth of the hoop-net set during the 2014/15 season. Recaptures were included in the calculations.

Depth (m)	Count	CPUE	Mean length (SE)	Mean weight (SE)
≤7.6	615	0.36	466.3 (3.3)	792.5 (21.9)
≥7.6	786	0.36	477.5 (3.5)	867.6 (24.2)

Table 2.5. Number, release location, and direction and distance of movement of Burbot detected at the Deep Creek PIT tag array from 10/1/2012– 1/15/2014.

Release Location	Direction from Array	Distance from Array (rkms)	*n*
Boundary Creek	Downstream	77	4
Boundary Creek/Moyie River	-	-	1
Deep Creek Confluence	Downstream	7	44
Deep Creek at Naples	Upstream	14	119
Deep Creek at Fall Creek	Upstream	13	20
Deep Creek McArthur Outlet	Upstream	27	1
Deep Creek at Naples/McArthur Outlet	Upstream	-	38
Ferry Island	Downstream	42	16
Goat River	Downstream	94	6
Moyie River	Upstream	26	6
Porthill	Downstream	77	40
Unknown	-	-	91
Total			**386**

Table 2.6. Total number of Burbot stocked into Deep Creek from 2012-2014 and recaptured in Deep Creek hoop-nets from 2013-2015.

Year Class	Total Released	Recaptured	% Return
2012	3,000	12	0.40
2013	2,775	24	0.86
2014	3,723	21	0.56
Totals	9,498	57	0.60

FIGURES

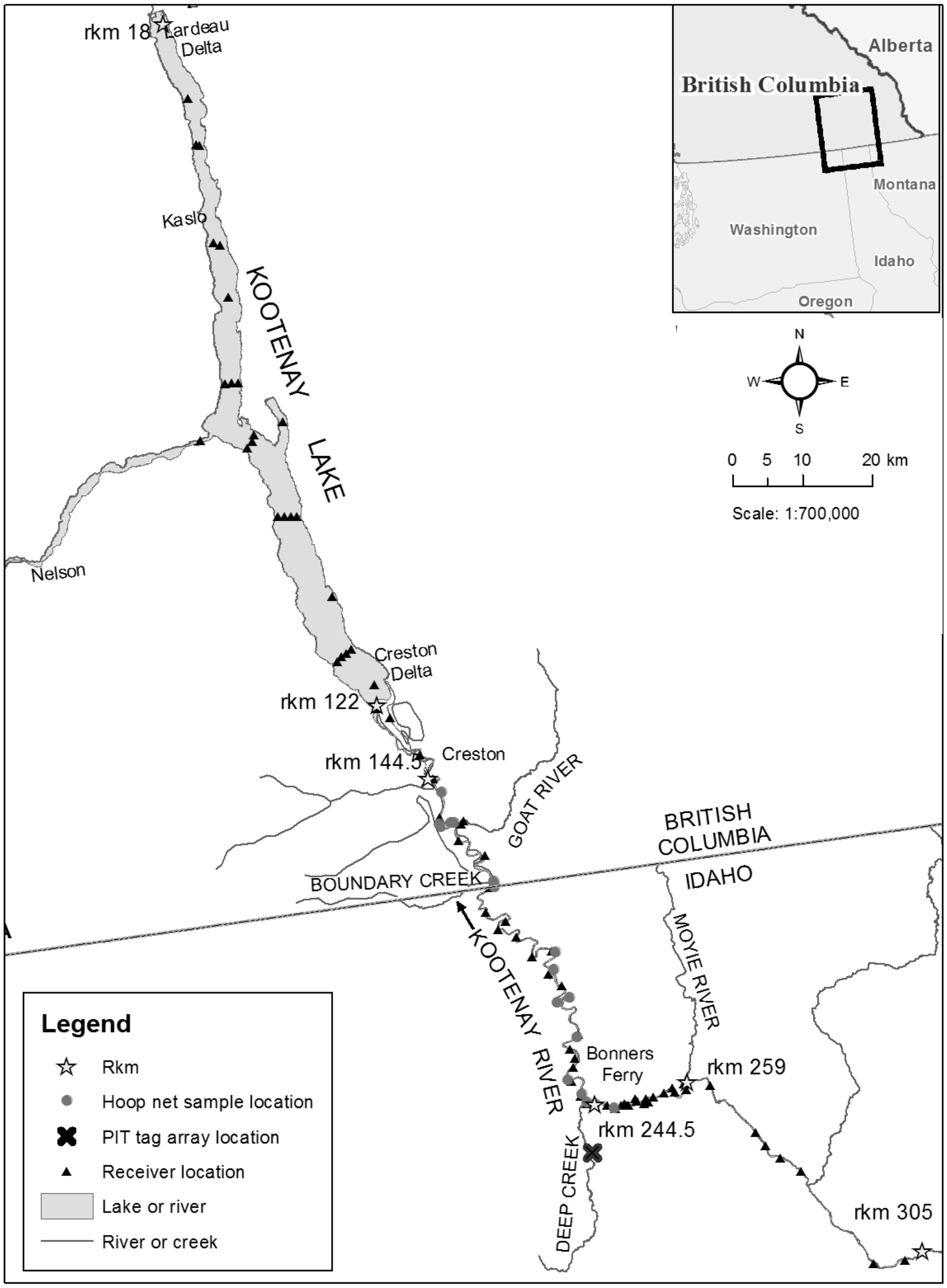

Figure 2.1. Study area overview; locations of hoop-net sample sites during 2012-2014 sample seasons indicated by solid grey circles, Deep Creek PIT tag array location indicated with an X; Vemco receiver locations indicated by triangles, and key river kilometers (rkm) markers noted by stars.

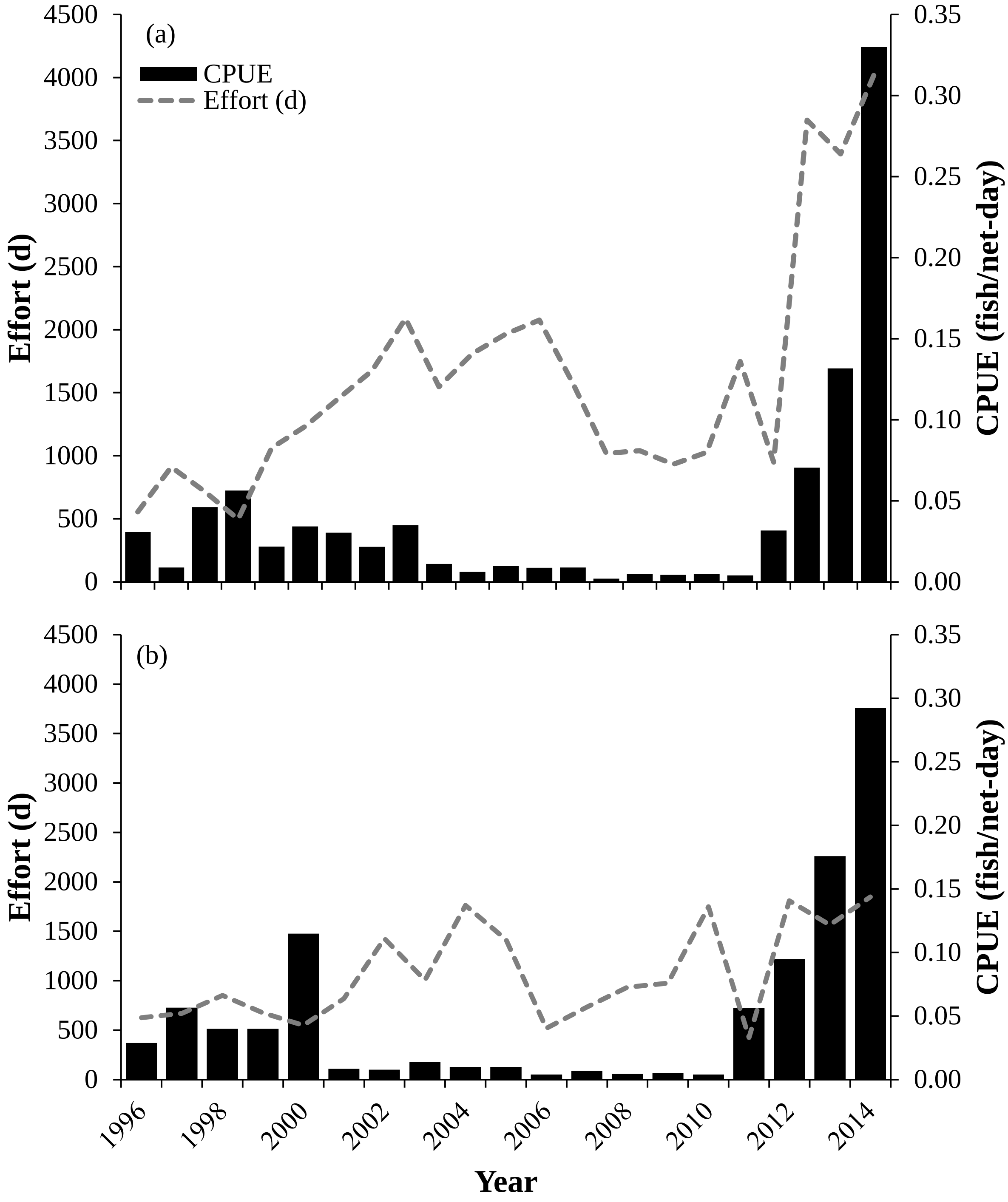

Figure 2.2. Catch-per-unit-of-effort (Burbot/net-day) and effort (d) of hoop-net sampling for all sites (a) and index sites (b) from 1992-2014. Annual sampling started December 1 and ended March 31. Sample year indicates the year sampling started (e.g. 2014/15 season is 2014 on the x-axis).

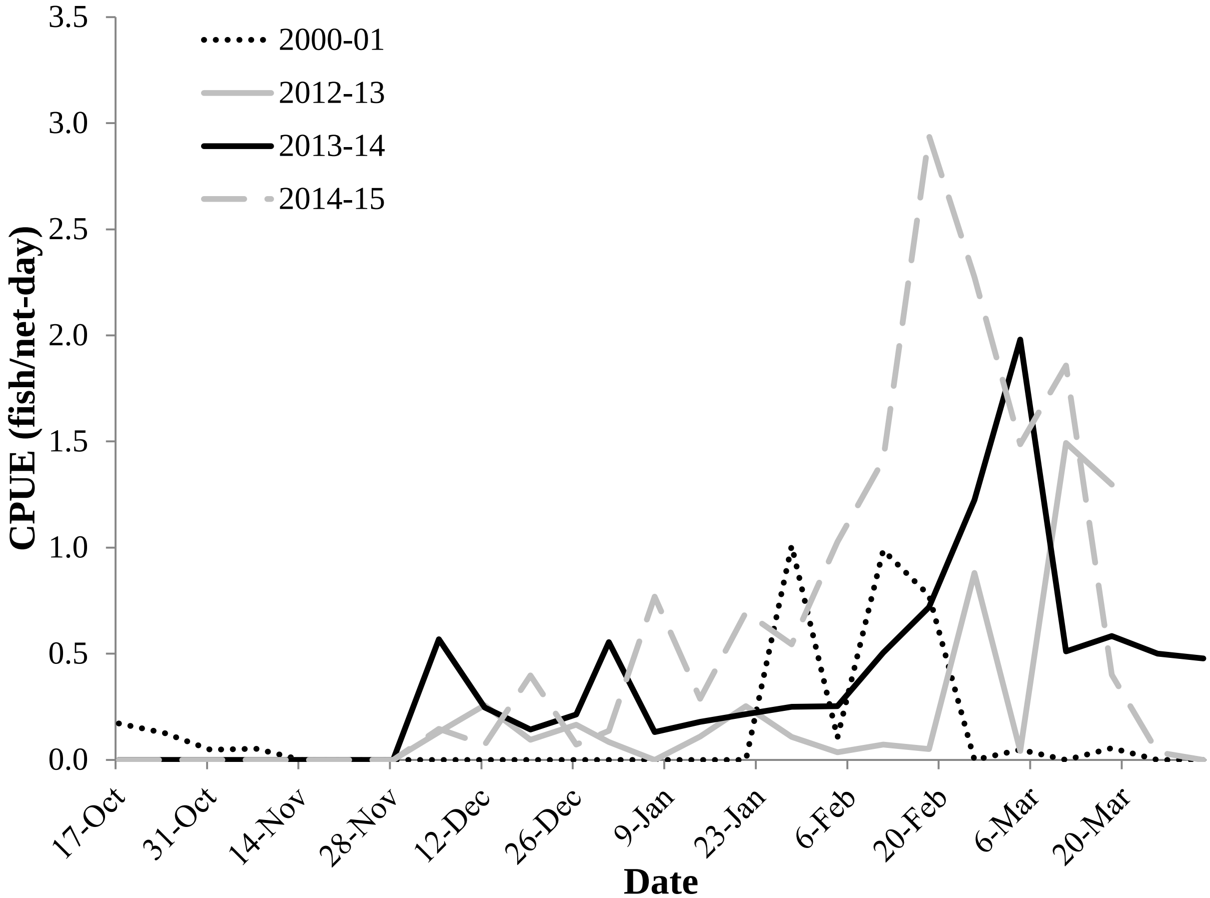

Figure 2.3. Catch-per-unit-of-effort (Burbot/net-day) of Burbot captured in hoop-nets at Ambush Rock (rkm 244.5; historical index location) in the Kootenai River in the 2000/01, 2012/13, 2013/14, and 2014/15 winter sampling seasons.

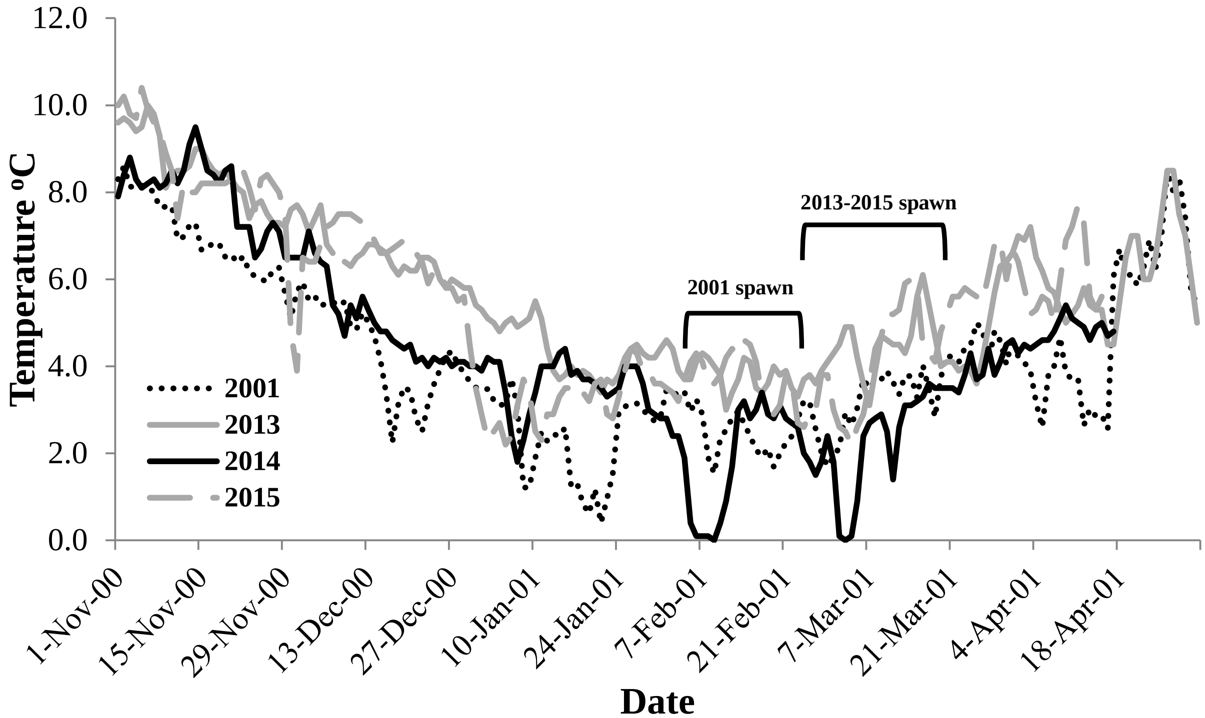

Figure 2.4. Daily mean temperatures (°C) in the Kootenai River at Ambush Rock (rkm 244.5) during identified Burbot spawning events in 2000/01 (2001), 2012/13 (2013), 2012/14 (2014), and 2014/15 (2015).

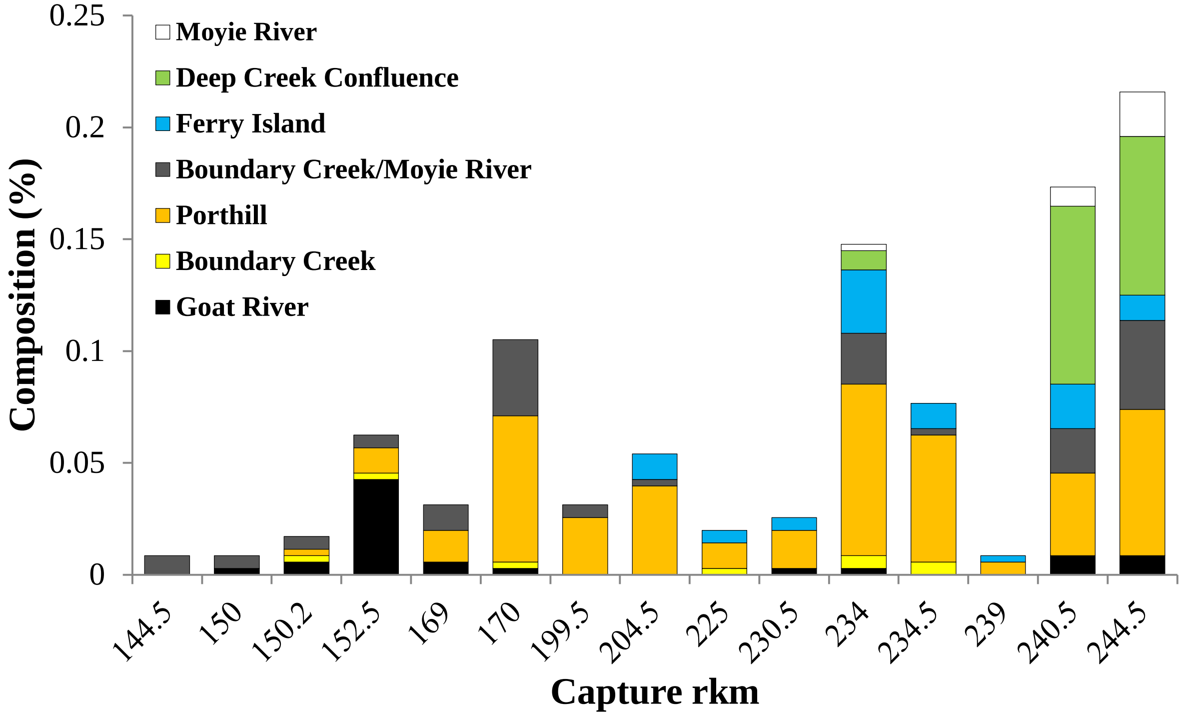

Figure 2.5. Proportion of Burbot recaptured in the 2014/15 winter hoop-net sampling season in relation to their original release location (*n*=352).

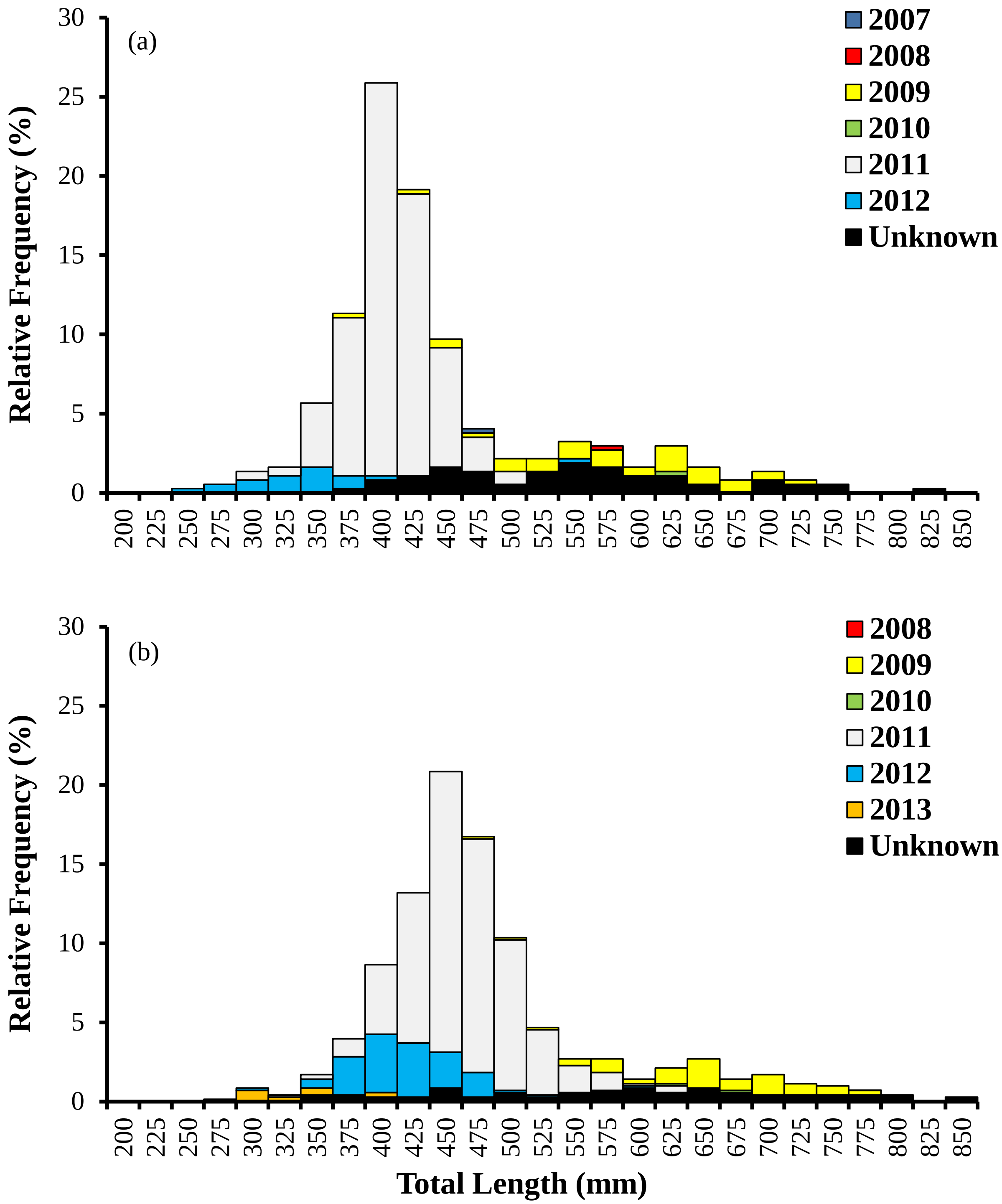

Figure 2.6. Length frequency and year class assignments from PIT-tagged Burbot captured in hoop-nets in the Kootenai River from December 1, 2013 through March 31, 2014 (a), and December 1, 2014 through March 31, 2015 (b).

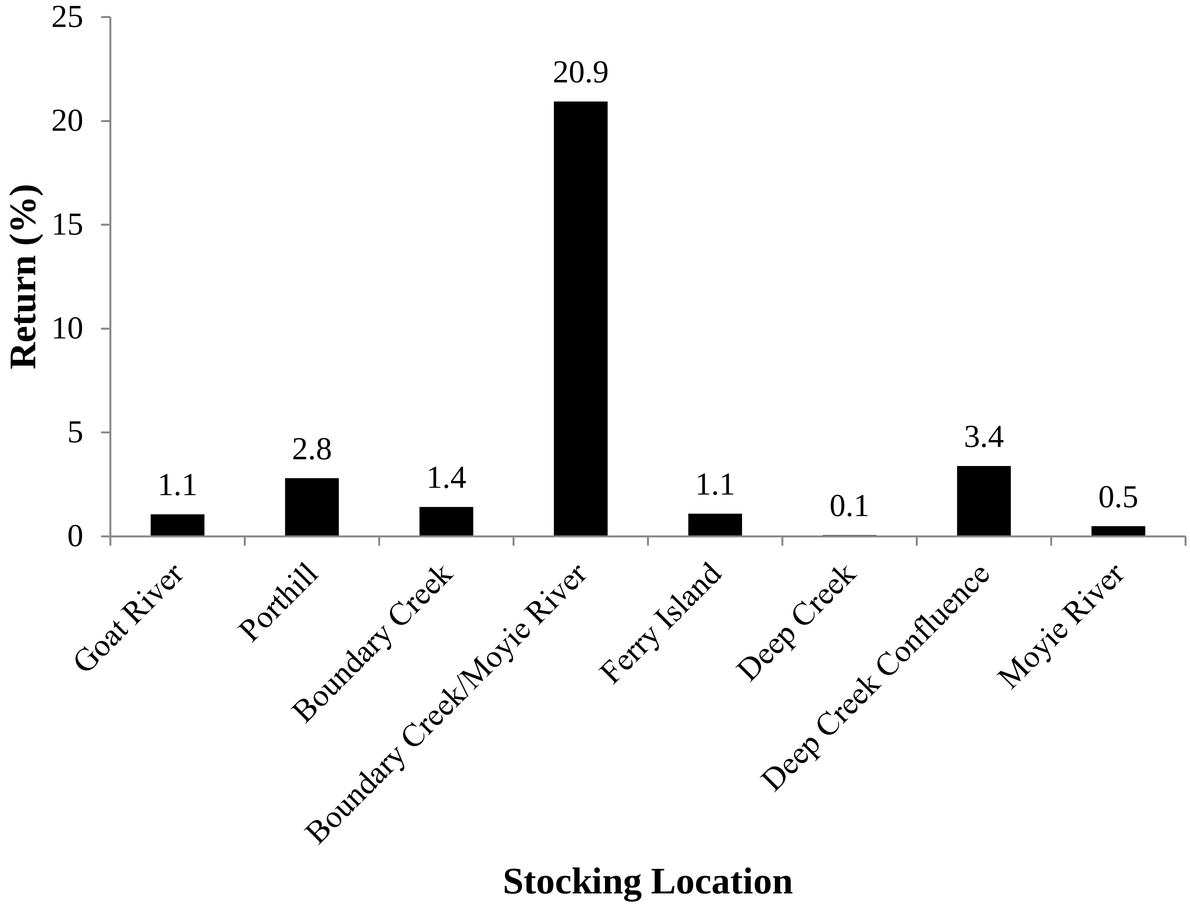

Figure 2.7. Percent return of PIT tagged Burbot from historical stocking locations. Burbot released at the Boundary Creek/Moyie River stocking location were released at either Boundary Creek or Moyie River; however, due to a recording error, it was unknown at which location they were physically released.

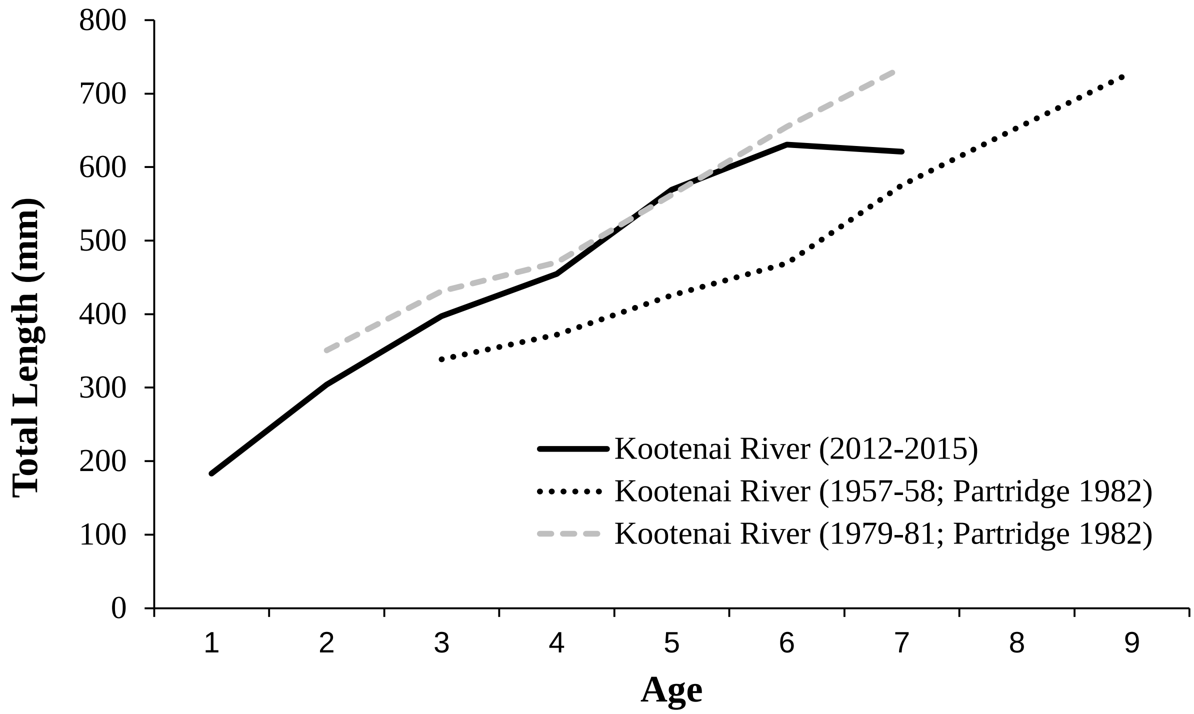

Figure 2.8. Mean length-at-age at time of capture for Burbot captured in hoop-nets from 2012-2015 compared to that of fish captured in 1979-81 and 1957/58.

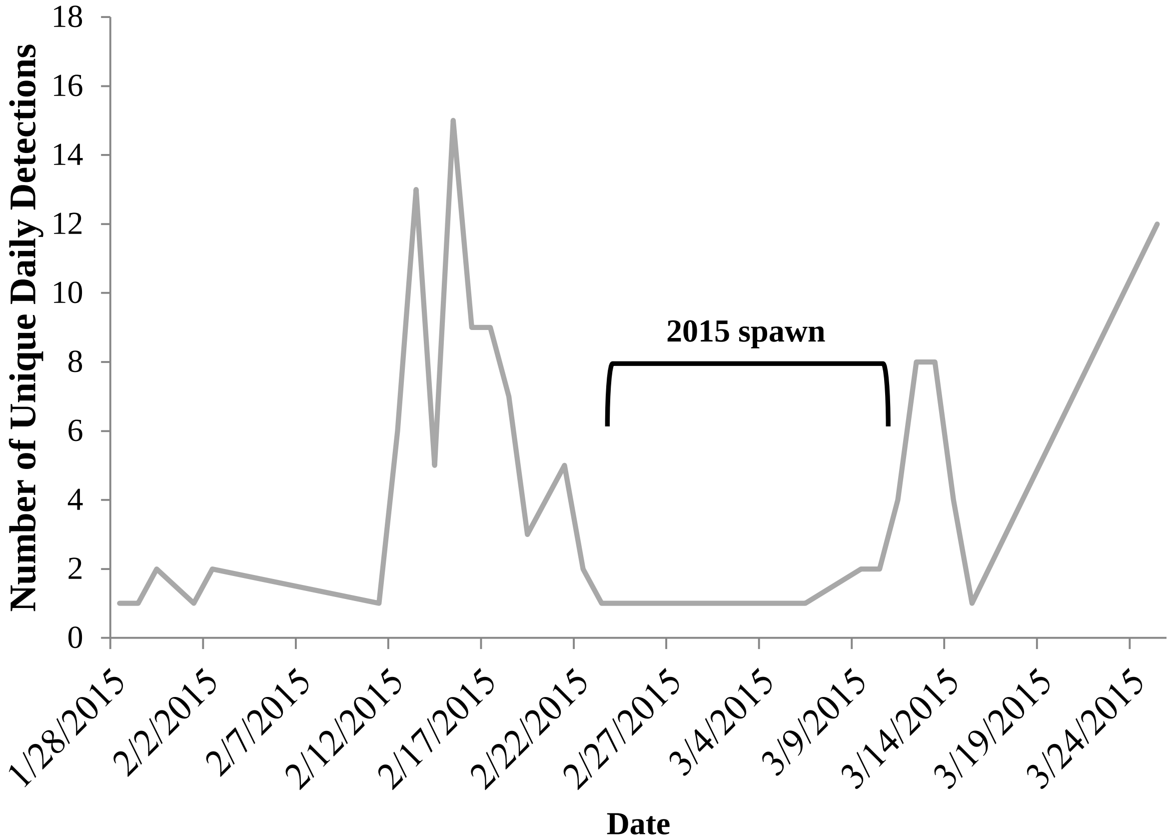

Figure 2.9. Number of unique daily detections at the Deep Creek PIT-tag array during the 2014/15 winter sampling season.

CHAPTER 3: NATIVE SALMONID MONITORING AND EVALUATION

ABSTRACT

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 (along with other factors) via bottom-up trophic cascades. A large-scale nutrient restoration program (using phosphate fertilizer) was implemented in the Idaho portion of the Kootenai River in 2005 to restore various fisheries by increasing primary production. Annual electrofishing surveys were conducted at multiple biomonitoring sites before and after nutrient addition in order to evaluate fish catch-per-unit-of-effort (CPUE), biomass-per-unit-of-effort (BPUE), and various population metrics. An additional biomonitoring site was added and sampled in 2014, and one more site is planned to be added and sampled in 2015. In addition, a mark-recapture population estimate for Rainbow Trout *Oncorhynchus mykiss*, Mountain Whitefish *Prosopium williamsoni*, and Largescale Suckers *Catostomus macrocheilus* was conducted in 2014 in a reach of the Kootenai River directly influenced by the addition of nutrients. Lastly, a basin-wide otolith microchemistry study aimed at determining natal origins of catchable, adult Rainbow Trout in the Kootenai River was initiated in 2014 and will likely be completed by 2016. Collectively, results of this project indicate that the program has largely been successful; however, additional research and analyses are needed to better understand different effect levels.

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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 1970. It has depleted nutrients downstream and caused a decline in primary productivity in the Idaho portion of the river (Woods 1982; Snyder and Minshall 1996). By the 1990s, reduction in productivity translated to a two- to four-fold decrease in the number of Mountain Whitefish *Prosopium williamsoni* compared to 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, nutrients bind to sediments and precipitate out of solution (Snyder and Minshall 1996), unavailable to organisms 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 has likely contributed to poor 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, Kootenai Tribe of Idaho, personal communication). 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, 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 (BC) in 1992 in an attempt to recover declining Kokanee Salmon *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 Salmon, Mountain Whitefish, Burbot *Lota lota*, White Sturgeon *Acipenser transmontanus*, as well as other 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 (KTOI).

Information presented in this report summarized results using (1) 95% confidence intervals and (2) effect sizes (Cohen's *d*; Cohen 1988) for statistically different comparisons (as gauged by 95% confidence intervals), rather than formal analyses. Effect sizes were interpreted as large ($d \geq 0.8$), medium ($0.8 > d > 0.2$), and small ($d \leq 0.2$) (Cohen 1988). Comprehensive and diverse statistical analyses were conducted on data from the nutrient restoration project and summarized in Ross et al. (2015). Similar analyses will be conducted and reported every three years; 95% confidence intervals and effect sizes will be calculated and reported in the off years.

RESEARCH GOAL

Restore fish populations in the Idaho reach of the Kootenai River to densities present prior to Libby Dam.

OBJECTIVES

1. Evaluate whether or not total and species-specific catch and biomass rates have changed from Pre- to Post-treatment periods.

2. Evaluate whether or not relative weight (W_r) of Rainbow Trout, Mountain Whitefish, and Largescale Suckers has changed from Pre- to Post-treatment periods.

3. Evaluate the status of the Rainbow Trout, Mountain Whitefish, and Largescale Sucker populations relative to historical population estimates.

4. Initiate a comprehensive study using strontium ratios (derived from Rainbow Trout otolith microchemistry) to (1) establish tributary-specific strontium signatures and (2) assign adult Rainbow Trout to natal tributaries.

STUDY AREA

The headwaters of the Kootenai River originate in Kootenay National Park in southeastern BC, 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 BC to form Kootenay Lake, and finally to the confluence with the Columbia River at Castlegar, BC. 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 Montana and one in BC).

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, Idaho to the town of Bonners Ferry, Idaho (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 the 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, BC; this site served as an unimpounded control site. Site KR14 markedly differed (in habitat and fish community) from all sites below Libby Dam; therefore, it was not used in any analyses. Sampling of site KR14 was discontinued beginning in fall 2014. The second control site (KR10) was located in the Montana portion of the Kootenai River, termed the Control Zone of the river. Four sites were located within the Nutrient Addition Zone of the river (sites KR9.1, KR9, KR7, and KR6). Site KR9.1, located one km downstream from the nutrient addition site, was added in 2009. Site KR9.1 did not have any pretreatment data, so it was not included in any analyses. Site KR9 was located approximately ten km downstream from the nutrient addition site. Site KR7, located approximately 15 km downstream from the nutrient addition site, was added in 2014. Site KR7 did not have any pretreatment data, so it was not included in any analyses. Site KR6 was located approximately 20 km downstream from the nutrient addition site. The next two sites were downstream from the town of Bonners Ferry, Idaho, 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, Biomass, and Relative Weight

Boat electrofishing was conducted during August and September from 2002-2014 at five biomonitoring sites (sites KR10, KR9, KR6, KR4, and KR2). Site KR14 was added as a biomonitoring site from 2004-2013 (discontinued beginning 2014), site KR9.1 was sampled from 2009-2014, and site KR7 was added in 2014. Collectively, sites that were surveyed in 2014 included KR10, KR9.1, KR9, KR7, KR6, KR4, and KR2 (Figure 3.2). 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 ageing.

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; number of fish/minute), species abundance by weight as biomass-per-unit-of-effort (BPUE; kg of fish/minute) and relative weight (W_r). 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. Relative weight was calculated using the following equation:

$$W_r = \frac{W}{W_s} * 100$$

where:

W was the actual fish weight (g), and

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

Relative weight was calculated for Rainbow Trout, Mountain Whitefish, and Largescale Sucker using the W_s available in literature (Anderson and Neumann 1996; Richter 2007). Minimum total lengths used to calculate W_s were 120 mm for Rainbow Trout (Simpkins and Hubert 1996), 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 length criteria were included in the W_r analysis.

Population Estimate

A mark-recapture population estimate was conducted during August 2014 in the 3.2 km long Hemlock Bar reach of the river (located within the Nutrient Addition Zone; Figure 3.2). This survey has been standardized and consistently conducted since 1980; methods for the survey are detailed in Downs (2000). All sizes of Mountain Whitefish, Largescale Suckers, and Rainbow Trout were marked with fin clips on the nights of August 18, 19, and 20. The recapture effort occurred on the nights of August 25, 26, and 27 to quantify the proportion of marked to unmarked fish in the sample reach. Population estimates were generated using Chapman's modification of the Petersen Method (Ricker 1975; Krebs 1999):

$$N = \frac{(M+1)(C+1)}{R+1} - 1$$

where:

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

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

Population Status

Since the implementation of new regulations for Rainbow Trout in 2002 (two fish, none under 16 inches), proportional stock density (PSD) and quality stock density (QSD) have been calculated annually (Anderson 1976; Gabelhouse 1984) to evaluate changes in the size structure of the population as well as changes in estimated densities. Proportional stock density and QSD standards are species-specific and calculated as:

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

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

Proportional stock density was calculated for Rainbow Trout using 200 mm TL as stock length and 305 mm TL as quality length (Schill 1991). Quality stock density was calculated using 406 mm as the specified length, which is the minimum legal length for harvest in the Kootenai River.

Otolith Microchemistry Study: Natal Origins of Catchable Rainbow Trout

An otolith microchemistry pilot study was conducted on the Kootenai River from 2012-2014 (Ross et al. 2015). The pilot study addressed two questions as a proof-of-concept: (1) could tributaries to the Kootenai River be differentiated from one another using strontium isotopes derived from otoliths of pre-out-migrant, young-of-year (YOY) Rainbow Trout, and (2) could adult Rainbow Trout collected from the main-stem Kootenai River be assigned back to natal tributary using otolith strontium isotopes. Results verified that both questions could be affirmatively answered. Based on these results, the Idaho Department of Fish and Game

(IDFG), Montana Fish, Wildlife and Parks (MFWP), Idaho Cooperative Fish and Wildlife Research Unit, and New Mexico Cooperative Fish and Wildlife Research Unit decided to implement a larger-scale study on the Kootenai River. The study had two objectives, both of which are detailed below in Phases 1 and 2.

Phase 1 —The objective of Phase 1 was to establish baseline strontium signatures for all tributaries to the Kootenai River in Idaho and Montana. During October 2014, YOY Rainbow Trout were sampled from Boulder, Curley, Caboose, Debt, Katka, Cow, Deep (and tributaries), Myrtle (and tributaries), Burton, Fleming, Ball, Rock, Trout, Fischer, Mission, Parker, Long Canyon, Boundary (and tributaries) and Smith creeks and the Moyie River in Idaho (Figure 3.3). Waters in Montana that were sampled included: the Kootenai River (Libby Dam tailrace), Dunn, Wolf, Libby (below Big Cherry creek and upstream of Swamp creek), Big Cherry, Flower, Parmenter, Pipe, Bobtail, Cedar, Quartz, O'Brien, Lake (upstream and downstream of the falls) creeks and the Yaak (upstream and downstream of the falls) and Fisher rivers (below Wolf Creek and upstream of West Fisher) (Figure 3.3). Fish were collected using a Smith-Root backpack electrofishing unit. When possible, all fish were collected a minimum of one km upstream from where the tributary was confluent with the main-stem Kootenai River to ensure that the strontium isotope signatures of each particular tributary would not be confounded by movement of fish between the tributary and Kootenai River. Attempts were made to collect ten YOY Rainbow Trout from each tributary. Collected fish were euthanized, placed into labeled bags, transported on ice, and then frozen. Sagittal otoliths were later removed from each fish and placed (dry) into a labeled vial. Otoliths will be transported to the University of California-Davis where they will be prepped, mounted onto multiple microscope slides, and analyzed for strontium ratios. Each otolith will undergo laser ablation from edge-to-edge, with the laser passing directly through the core of the otolith. Phase 1 is scheduled to be completed by June 2015.

Phase 2—Phase 2 is scheduled to be completed by 2016. The objective of Phase 2 will be to determine the natal (tributary) origins of a representative sample of adult Rainbow Trout collected from the main-stem Kootenai River in Idaho and Montana. Adult Rainbow Trout will be collected during August and September 2015 using boat electrofishing and angling. Rainbow trout will be collected from directly below Libby Dam, Montana to the Idaho-British Columbia border (Figure 3.3). Fish sampling in the Montana portion of the Kootenai River will occur within four sections located at the following river kilometers: 351.1 to 356.7, 343.0 to 346.1, 323.5 to 328.2, and 295.7 to 299.6 (Figure 3.3). Staff with MFWP selected these sites because they coincided with long-term population monitoring sections on the Kootenai River and are the location of a detailed Rainbow Trout mark-recapture study intended to estimate growth and survival. Staff from MFWP will randomly collect 50 adult Rainbow Trout from each of the four sections (200 samples total) for strontium isotope analysis. Sampling sites in Idaho will be located approximately ten km apart, beginning at the Idaho-Montana border and extending to the Idaho-British Columbia Border (Figure 3.3). Sites will be chosen such that they occur between two tributaries that were sampled for YOY rainbow trout, resulting in a total of 15-20 sites being sampled. A target of five adults will be collected at each site, resulting in a total of 75-100 adults being collected for strontium isotope analysis. If the appropriate sample size cannot be achieved via boat electrofishing, angling will be used secondarily to target adult Rainbow Trout. Assignments of adults to natal tributaries will rely on tributary-specific strontium signatures identified during Phase 1. All of the Rainbow Trout collected as part of Phase 2 will be sacrificed, and their sagittal otoliths will be collected, stored, prepped, and processed following the same protocols detailed in Phase 1.

Statistical Analysis

The years from 2002-2005 were considered the Pretreatment Period, and 2006-2014 were considered the Post-treatment Period for all analyses involving data from the biomonitoring sites. 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. Sites KR9.1 and KR7 lacked data from the Pretreatment Period and were not used in any analyses.

RESULTS

Fish Community Assessment

Abundance, Biomass, and Relative Weight

Nineteen species of fish were identified in the catch from 2002-2014, and 30,113 individual fish were captured during the same time. The proportion of species within the catch and the number of species identified in the catch remained relatively consistent across all years. Six species dominated the catch in the Control and Nutrient Addition zones, including Mountain Whitefish, Largescale Sucker, Northern Pikeminnow *Ptychocheilus oregonensis*, Rainbow Trout, Peamouth Chub, and Redside Shiner *Richardsonius balteatus*. Biomass was dominated by the same species as catch, with the exception of Redside Shiner, which contributed little to the biomass because of small body size. Proportion of species dominating catch and biomass in the Downstream Zone was similar to that observed in the Control and Nutrient Addition zones, with the exception of lower proportions of Mountain Whitefish and Rainbow Trout.

Abundance (CPUE**)—**Catch-per-unit-of-effort was calculated for the following species, segregated by Period and river zone (Table 3.1): Brown Bullhead *Ameiurus nebulosus*, Bluegill *Lepomis macrochirus*, Brook Trout *Salvelinus fontinalis*, Brown Trout *Salmo trutta*, Burbot, Black Crappie *Pomoxis nigromaculatus*, Largemouth Bass *Micropterus salmoides*, Longnose Dace *Rhinichthys cataractae*, Longnose Sucker *Catastomus catostomus*, Largescale Sucker, Mountain Whitefish, Northern Pikeminnow, Peamouth Chub, Pumpkinseed *Lepomis gibbosus*, Rainbow Trout, Redside Shiner, Sculpin *Cottus cognatus*, Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, and Yellow Perch *Perca flavescens*. Total CPUE (i.e., all species, combined) was greater and statistically different from Pre- to Post-treatment periods within the Nutrient Addition Zone (Figure 3.4; d=2.45), but not in the Downstream or Control zones. The primary factor affecting catch rates for multiple species was river zone (Table 3.1), which was largely driven by differences in habitat among the river zones (Smith 2013). Catch rates of all species were similar between periods within each river zone, with the exception of Mountain Whitefish, Rainbow Trout, and Largescale Suckers (Table 3.1). Catch rates of Mountain Whitefish and Largescale Suckers were greater and statistically different from Pre- to Post-treatment periods within the Nutrient Addition Zone (Figures 3.5 and 3.6, respectively; d=1.92 and d=0.95, respectively), but not in the Downstream or Control zones. Catch rates of Rainbow Trout were greater and statistically different from Pre- to Post-treatment periods within the Control Zone (Figure 3.7; d=2.41), but not in the Nutrient Addition and Downstream zones. However, CPUE of Rainbow Trout in the Nutrient Addition Zone was still greater from Pre- to Post-treatment periods (d=1.0), but 95% confidence intervals did not indicate statistical differences between the means. It is important to note that the greater catch rates of Rainbow Trout from Pre- to Post-treatment periods in the Control Zone was largely driven by increased numbers of sexually immature individuals (i.e., ≤250 mm; Figure 3.8; d=2.72).

Biomass (BPUE**)**—Biomass-per-unit-of-effort was calculated for the following species, segregated by Period and river Zone (Table 3.2): Brown Bullhead, Bluegill, Brook Trout, Brown Trout, Burbot, Black Crappie, Largemouth Bass, Longnose Dace, Longnose Sucker, Largescale Sucker, Mountain Whitefish, Northern Pikeminnow, Peamouth Chub, Pumpkinseed, Rainbow Trout, Redside Shiner, Sculpin, Westslope Cutthroat Trout, and Yellow Perch. Similar to total CPUE, total BPUE was also greater and statistically different from Pre- to Post-treatment periods within the Nutrient Addition Zone (Figure 3.4; *d*=1.67), but not in the Downstream or Control zones. In addition, the primary factor affecting biomass rates for multiple species was river zone, similar to CPUE (Table 3.2). Biomass rates of all species were similar between periods within each river zone, with the exception of Largescale Suckers (Table 3.2). Catch rates of Largescale Suckers were greater and statistically different from Pre- to Post-treatment periods within the Nutrient Addition Zone (Figure 3.6; *d*=1.20), but not in the Downstream or Control zones. Biomass rates of Mountain Whitefish and Rainbow Trout in the Nutrient Addition Zone were greater from Pre- to Post-treatment periods (*d*=0.86, and *d*=0.91, respectively), but 95% confidence intervals did not indicate statistical differences between the means.

Relative Weight (W_r)—Relative weight was calculated for Mountain Whitefish, Rainbow Trout, and Largescale Suckers (Table 3.3.; Figure 3.9). Mean W_r for Mountain Whitefish and Rainbow Trout was not statistically different from Pre- to Post-treatment periods within any of the river zones (Table 3.3); however, mean W_r of Largescale Suckers was greater and statistically different from Pre- to Post-treatment periods in the Nutrient Addition Zone (Figure 3.9; *d*=2.70).

Population Estimate

A total of 2,373 fish were captured during the marking and recapture efforts at Hemlock Bar in August 2014. Numbers of Mountain Whitefish, Rainbow Trout, and Largescale Suckers were sufficient to estimate the population size and corresponding confidence limits for each species. Mountain Whitefish was the most abundant species at *n*=11,148 (8,148, 15,692; 95% confidence limits), Largescale Suckers were the next most abundant species at *n*=9,899 (6,140, 16,851), and Rainbow Trout were the least abundant species at *n*=512 (353, 776) (Table 3.4; Figure 3.10). In general, estimates for all three species were similar to those generated in previous years; however, they were consistently lower than the estimates generated in 2011.

Population Status

Values for PSD and QSD for Rainbow Trout in the Nutrient Addition Zone of the Kootenai River during 2014 were 54 and 4, respectively. These values were greater than the long-term averages for PSD (43) and QSD (3), indicating a shift in the population size structure.

Otolith Microchemistry Study: Natal Origins of Catchable Rainbow Trout

Samples for Phase 1 of the otolith microchemistry study were collected during October 2014 and will be prepped, processed, analyzed, and summarized in June 2014. Results from Phase 1 will be summarized and presented in the 2015 IDFG annual report.

Samples for Phase 2 of the otolith microchemistry study will be collected during August and September 2015 and prepped, processed, analyzed, and summarized during 2015-2016. Results from Phase 2 will be summarized and presented in the 2015 or 2016 IDFG annual report, contingent upon when data are received from the processing lab.

DISCUSSION

Fish Community Assessment

The proportion of species in the catch during both periods and all river zones indicated that the largest driver of differences in the fish community was river zone. This response has been observed in other studies on the Kootenai River (Smith 2013). Each of the three river zones provided habitats that varied in their suitability for various fish species. For example, habitat conditions in the Downstream Zone were comprised of low flow velocities, fine substrates, and aquatic vegetation. The fish assemblage in the Downstream Zone was dominated by Northern Pikeminnow, Peamouth Chub, and Redside Shiner, all of which were species well suited for these types of habitat conditions. In contrast, the Control and Nutrient Addition zones had higher flow velocities and the substrate was largely comprised of cobble. Mountain Whitefish and Rainbow Trout, species preferring cobble substrate and higher flow velocities, were more predominant in both of these river zones. These results were corroborated by subsequent summaries on and analyses of species-specific catch and biomass rates.

Abundance, Biomass, and Relative Weight

Species-specific CPUE and BPUE changed little from Pre- to Post-treatment periods within each river zone; however, total CPUE and BPUE were greater and statistically different post-treatment (relative to pretreatment) within the Nutrient Addition Zone. Total CPUE and BPUE are generally considered metrics with limited inferential capabilities; however, the nutrient addition project reported herein was implemented under the assumption that any potential effects would be observed at the ecosystem-level. Therefore, these metrics offer important insight when evaluating effects of the project. The majority of species-specific catch and biomass rates revealed small, statistically marginal increases from Pre- to Post-treatment periods within the Nutrient Addition Zone. Although this result, in itself, is not particularly meaningful, the cumulative effect of these incremental increases (by species) resulted in increases in both the total abundance and biomass of fish within the Kootenai River. This has important potential implications for the food web of the Kootenai River, ranging from potentially altering predator-prey interactions and ratios, to altering demand on lower trophic-level forage (i.e., periphyton and macroinvertebrates), to altering the composition of species within the river (Larkin 1978; Carpenter et al. 1985). It is currently unknown whether these potential effects are occurring (in the Kootenai River); however, additional research is needed to better understand larger, more holistic effects of nutrient additions on the food web in the Kootenai River.

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 IDFG was to increase the abundance of Rainbow Trout. Marked increases in CPUE were achieved for Mountain Whitefish, an often undervalued sport fish; however, CPUE of Rainbow Trout did not show the same magnitude of increase (as Mountain Whitefish). Davis et al. (2010) suggested that unexpected predator-prey responses and effects on food web efficiencies could occur with long-term nutrient enrichment projects. It is unknown whether the aforementioned types of responses are occurring in the Kootenai River. It is possible, however, 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 main-stem 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 (in Idaho) 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 perhaps is not surprising 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 currently underway to determine the extent to which spawning habitat may be limiting recruitment of Rainbow Trout.

Catch rates of Rainbow Trout increased from Pre- to Post-treatment periods in both the Control and Nutrient Addition zones of the river. The mechanism(s) driving this response is not entirely understood; however, it is speculated that (specific to Rainbow Trout) the Control and Nutrient Addition zones may not be independent of one another. Several studies have revealed that adult Rainbow Trout residing in Idaho migrate to tributaries (to the Kootenai River) in Montana to spawn, and the adults return to the Idaho portion of the river, post-spawn (Walters et al. 2005). These spawning migrations typically occur in the spring, which does not coincide with the time frame during which sampling for the nutrient project is conducted. Therefore, it is unlikely that movement of adult Rainbow Trout is directly influencing catch rates in the Control Zone. The more probable mechanism may be indirect and related to increased recruitment (as a result of nutrient additions) and variable out-migrant dispersal. A long-term nutrient enhancement project on the Kuparuk River, Alaska found that adult Arctic Grayling had greater reproductive potential within a “treatment reach” relative to a “control reach” (Deegan and Peterson 1992). Therefore, although it has not been directly quantified, it is possible that Rainbow Trout within the Nutrient Addition Zone of the Kootenai River have greater reproductive potential (post-nutrient addition), resulting in a greater potential for increased production from both Idaho and Montana tributaries. Bradford and Taylor (1997) suggested that stream-type Chinook Salmon *Oncorhynchus tshawytscha* exhibited variable post-emergence dispersal patterns, ranging from no dispersal to 100 km downstream. Furthermore, they suggested that newly emerged fry would inhabit all available rearing habitats, independent from dispersal distance. Therefore, it is possible that newly emerged and freshly out-migrated Rainbow Trout that were spawned in Montana tributaries are exhibiting variable dispersal patterns, ranging from remaining within close proximity to natal tributaries to migrating downstream into Idaho. This could ultimately result in increased relative abundances of Rainbow Trout in both Idaho and Montana, under the assumption (based on findings from Bradford and Taylor [1997]) that out-migrants from Montana tributaries are seeding both the Montana and Idaho portions of the Kootenai River. Two lines of inference support this potential mechanism. First, the documented (and statistically different) increase in catch rates of immature Rainbow Trout from Pre- to Post-treatment periods in the Control Zone of the river suggests that recruitment of Rainbow Trout has increased, post-treatment. Second, long-term population monitoring (for Rainbow Trout) conducted by the MFWP has documented increases in the Rainbow Trout population within the Control Zone of the river from pre- to post-treatment (Jim Dunnigan, MWFP, personal communication). In contrast, these monitoring efforts have also indicated that populations are stable or in decline in river reaches located upstream from the Control Zone during the same time frame, potentially eliminating the notion that increases in the Control Zone are due to some background, environmental effect (i.e., climate conditions or dam operations).

Largescale Suckers responded most positively (of all species) to nutrient additions, as gauged by greater CPUE and BPUE and improved W_r from Pre- to Post-treatment periods. The increase in CPUE and BPUE was not observed until recent years and appeared to be a delayed effect of nutrient additions. Largescale Suckers in the Kootenai River do not fully recruit to electrofishing gear until age-7 (Carson Watkins, IDFG, personal communication); therefore, it is logical that increases in CPUE and BPUE of Largescale Suckers were only being documented in recent years. It is expected that this response will continue to be manifested in future years. Relative weight is a metric that gauges ecological and physical optimums (Anderson and Neumann 1996; Blackwell et al. 2000), and when interpreted in the context of relative abundance and growth metrics, can be particularly useful. Growth of Largescale Suckers has been found to be positively and strongly correlated with the addition of nutrients to the Kootenai River (Carson Watkins, IDFG, personal communication), providing an additional line of inference to support the notion that nutrient additions have improved the status of the Largescale Sucker population in the Kootenai River. Largescale Suckers are benthic feeders consuming periphyton, zooplankton, invertebrates, detritus, and plant material. Since nutrient additions began in 2005, the amount of periphyton on substrate in the river has increased, as have macroinvertebrates and levels of chlorophyll a (C. Holderman, KTOI, personal communication). 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 may explain the observed increases in CPUE, BPUE, growth, and W_r.

Population Estimate

Although the 2014 population estimates for Mountain Whitefish, Rainbow Trout, and Largescale Suckers were less than estimates from previous years (e.g., 2011), they were still greater than those documented prior the addition of nutrients to the Kootenai River. Specifically, the Mountain Whitefish and Rainbow Trout populations nearly doubled in size from the Pretreatment Period, and the Largescale Sucker population increased nearly five-fold. One target of the nutrient addition program was to restore the Mountain Whitefish population to levels documented in the 1980-81 estimates (i.e., 14,000-16,000 fish; Partridge 1983). Estimates for Mountain Whitefish during the Post-treatment Period exceeded (2008 and 2011) or were slightly below (2014) this target. Population estimates for all three species corroborated trends observed in species-specific catch rates during Pre- and Post-treatment periods in the Nutrient Addition Zone; however, the estimates were difficult to interpret without the context of similar estimates from the Control Zone.

Estimates from 1999-2011 documented consistent increases in the population sizes of all three species; however, 2014 marked the first year of decline for all species based on the estimated population sizes. Although the 2014 population estimates for each species likely represented typical variability in population cycles, it is possible that these populations have fully capitalized on the newly-established levels of primary production (due to nutrient additions) and are beginning to stabilize at (respective) population maxima. Therefore, it is crucial to continue the population survey at Hemlock Bar in future years.

MANAGEMENT RECOMMENDATIONS

1. Collaboratively continue (with the KTOI) annual addition of ammonium polyphosphate (10-34-0) and ammonium nitrate (32-0-0) to the Kootenai River, following established protocols, through 2017.

2. Continue fall electrofishing at all fish monitoring sites for trend monitoring of sportfish.

3. Complete a spatially extensive study to evaluate natal origins of catchable, adult Rainbow Trout in the Kootenai River.

4. Begin developing plans to quantify (1) the magnitude of main-stem spawning (of Rainbow Trout) and (2) subsequent survival and recruitment to the catchable, adult population.

5. Conduct a mark-recapture population estimate at Hemlock Bar every two years to continue documenting trends in the population sizes of Mountain Whitefish, Rainbow Trout, and Largescale Suckers.

TABLES

Table 3.1. Mean CPUE (fish·minute^{-1}) for 19 species captured during electrofishing sampling from 2002-2014. Values shown are separated by species, Zone and Period and denote mean ± standard deviation. Taxa present in the table include: Brown Bullhead (BBH), Bluegill (BLG), Brook Trout (BKT), Brown Trout (BRT), Burbot (BUR), Black Crappie (BC), Largemouth Bass (LMB) Longnose Dace (LND), Longnose Sucker (LNS), Largescale Sucker (LSS), Mountain Whitefish (MWF), Northern Pikeminnow (NPM), Peamouth Chub (PMC), Pumpkinseed (PMK), Rainbow Trout (RBT), Redside Shiner (RSS), Sculpin (SCU), Westslope Cutthroat Trout (WCT), and Yellow Perch (YEP). Shaded portions of the table highlight LSS, MWF, and RBT, which are the three primary indicator species for the nutrient addition project.

	Control Zone		Nutrient Addition Zone		Downstream Zone	
	Pre	Post	Pre	Post	Pre	Post
BBH	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00
BLG	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BRK	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BRT	0.00 ± 0.01	0.02 ± 0.02	0.00 ± 0.01	0.01 ± 0.02	0.00 ± 0.00	0.00 ± 0.00
BUR	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00
BC	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
LMB	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
LND	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.01	0.03 ± 0.07	0.00 ± 0.00	0.00 ± 0.00
LNS	0.01 ± 0.03	0.01 ± 0.03	0.01 ± 0.01	0.02 ± 0.05	0.05 ± 0.05	0.03 ± 0.05
LSS	0.46 ± 0.22	0.43 ± 0.18	0.53 ± 0.16	1.00 ± 0.68	0.47 ± 0.23	0.56 ± 0.42
MWF	2.25 ± 0.99	3.26 ± 0.93	3.68 ± 1.01	7.32 ± 2.48	0.18 ± 0.18	0.19 ± 0.27
NPM	0.13 ± 0.03	0.19 ± 0.07	0.14 ± 0.05	0.23 ± 0.18	1.53 ± 0.53	1.53 ± 0.74
PMC	0.05 ± 0.06	0.09 ± 0.09	0.03 ± 0.04	0.03 ± 0.04	1.18 ± 0.75	0.82 ± 0.76
PMK	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.02 ± 0.03
RBT	0.37 ± 0.10	0.77 ± 0.21	0.29 ± 0.18	0.52 ± 0.27	0.05 ± 0.05	0.05 ± 0.06
RSS	0.16 ± 0.15	0.22 ± 0.16	0.10 ± 0.10	0.20 ± 0.20	0.87 ± 0.28	0.86 ± 0.67
SCU	0.00 ± 0.00	0.01 ± 0.02	0.00 ± 0.01	0.01 ± 0.02	0.02 ± 0.02	0.01 ± 0.02
WCT	0.02 ± 0.01	0.02 ± 0.02	0.01 ± 0.01	0.01 ± 0.02	0.01 ± 0.02	0.00 ± 0.01
YEP	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.01	0.03 ± 0.08

Table 3.2. Mean BPUE (kg of fish·minute^{-1}) for 19 species captured during electrofishing sampling from 2002-2014. Values shown are separated by species, Zone and Period and denote mean ± standard deviation. Taxa present in the table include: Brown Bullhead (BBH), Bluegill (BLG), Brook Trout (BKT), Brown Trout (BRT), Burbot (BUR), Black Crappie (BC), Largemouth Bass (LMB) Longnose Dace (LND), Longnose Sucker (LNS), Largescale Sucker (LSS), Mountain Whitefish (MWF), Northern Pikeminnow (NPM), Peamouth Chub (PMC), Pumpkinseed (PMK), Rainbow Trout (RBT), Redside Shiner (RSS), Sculpin (SCU), Westslope Cutthroat Trout (WCT), and Yellow Perch (YEP). Shaded portions of the table highlight LSS, MWF, and RBT, which are the three primary indicator species for the nutrient addition project.

	Control Zone		Nutrient Addition Zone		Downstream Zone	
	Pre	Post	Pre	Post	Pre	Post
BBH	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BLG	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BRK	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BRT	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
BUR	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.00 ± 0.00
BC	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
LMB	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
LND	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
LNS	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.03	0.01 ± 0.01	0.01 ± 0.01
LSS	0.28 ± 0.15	0.24 ± 0.09	0.37 ± 0.14	0.86 ± 0.56	0.21 ± 0.08	0.36 ± 0.27
MWF	0.42 ± 0.18	0.49 ± 0.16	0.49 ± 0.21	0.75 ± 0.37	0.00 ± 0.01	0.00 ± 0.00
NPM	0.02 ± 0.01	0.03 ± 0.01	0.04 ± 0.03	0.04 ± 0.03	0.06 ± 0.02	0.06 ± 0.03
PMC	0.01 ± 0.01	0.01 ± 0.01	0.00 ± 0.01	0.00 ± 0.01	0.08 ± 0.04	0.06 ± 0.05
PMK	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
RBT	0.08 ± 0.02	0.13 ± 0.04	0.06 ± 0.04	0.10 ± 0.04	0.01 ± 0.01	0.01 ± 0.01
RSS	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.01
SCU	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
WCT	0.01 ± 0.00	0.01 ± 0.01	0.00 ± 0.01	0.00 ± 0.01	0.00 ± 0.01	0.00 ± 0.00
YEP	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

Table 3.3. Mean W_r for Mountain Whitefish (MWF) and Rainbow Trout (RBT) from 2002-2014. Values shown are separated by species, zone and period and denote mean ± standard deviation.

	Control Zone		Nutrient Addition Zone		Downstream Zone	
	Pre	Post	Pre	Post	Pre	Post
MWF	92.8 ± 1.5	88.7 ± 6.0	85.9 ± 6.2	87.1 ± 4.5	78.5 ± 11.6	77.1 ± 5.7
RBT	90.5 ± 3.7	91.7 ± 2.7	87.8 ± 4.2	89.1 ± 5.8	81.4 ± 7.2	84.7 ± 6.1

Table 3.4. Historical population estimates and upper (Upper) and lower (Lower) 95% confidence limits for Mountain Whitefish, Rainbow Trout, and Largescale Sucker.

	Mountain Whitefish			Rainbow Trout			Largescale Sucker		
Year	N	Lower	Upper	N	Lower	Upper	N	Lower	Upper
1980	16,084	-	-	-	-	-	-	-	-
1981	13,965	-	-	-	-	-	-	-	-
1993	3,440	-	-	98	-	-	-	-	-
1994	6,953	-	-	135	-	-	-	-	-
1998	4,043	3,068	5,459	203	146	295	-	-	-
1999	6,357	4,373	9,611	203	132	331	1,735	708	4,339
2004	8,077	5,994	11,160	332	193	623	2,186	994	5,467
2008	17,569	14,684	21,028	598	409	913	7,540	3,078	18,852
2011	26,385	18,267	39,579	682	323	1,577	14,903	4,516	27,098
2014	11,148	8,148	15,692	512	353	776	9,899	6,140	16,851

FIGURES

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

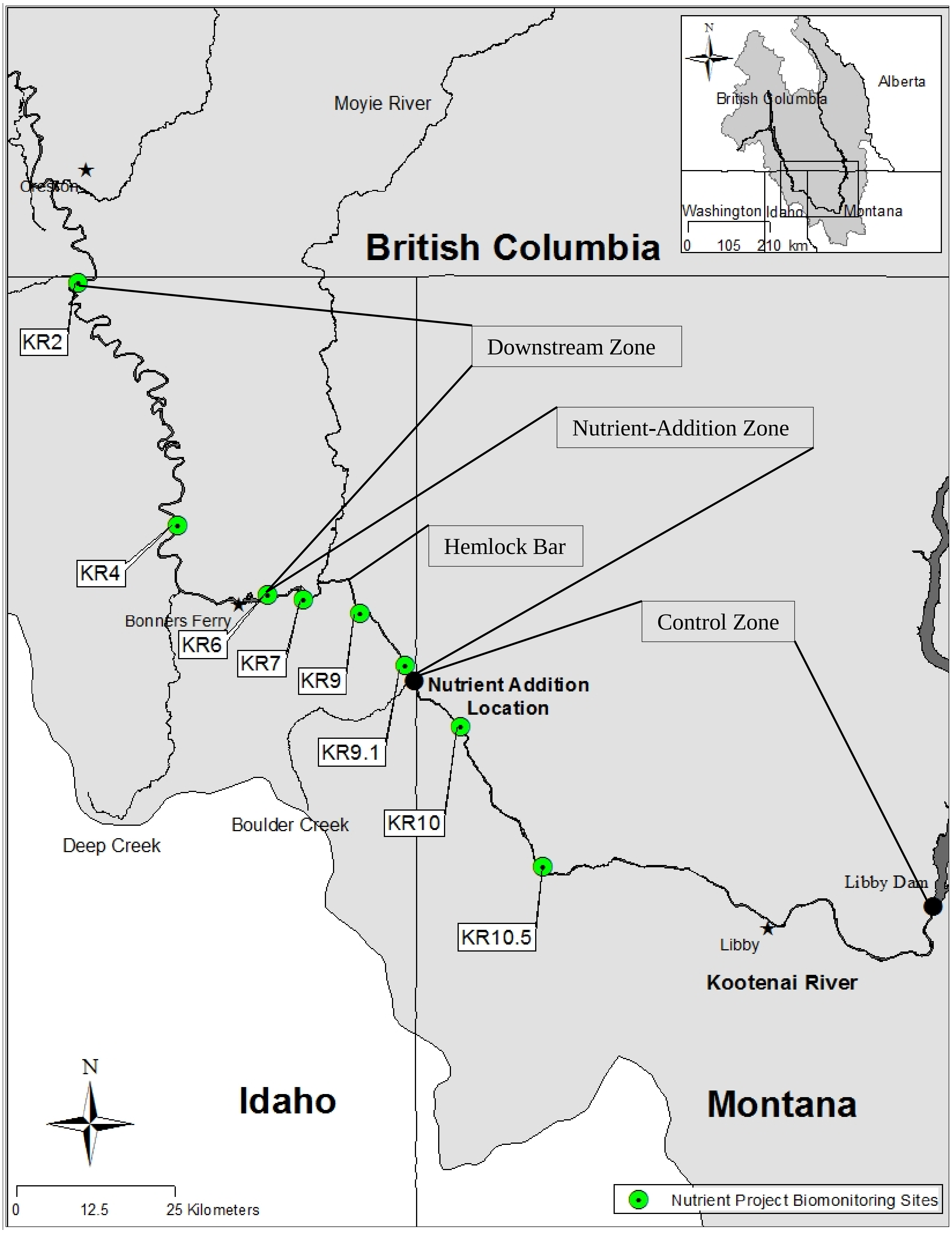

Figure 3.2. Kootenai River ecosystem study area and approximate locations of biomonitoring sites, Hemlock Bar, and the three river zones. Site KR10.5 is scheduled to be sampled in fall 2015.

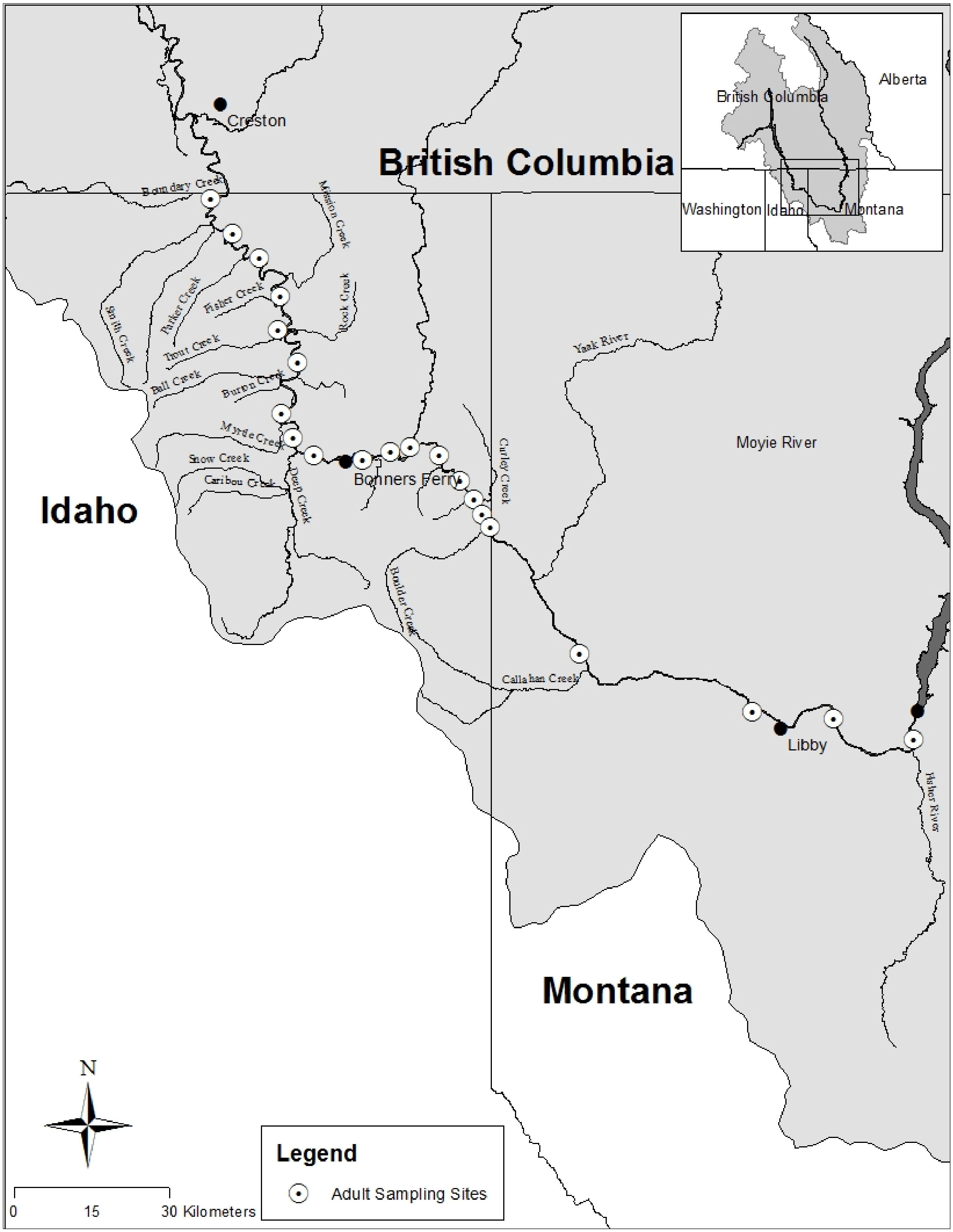

Figure 3.3. Locations of tributaries to and sites in the main-stem Kootenai River, Idaho and Montana that were and will be sampled during Phases 1 and 2 (respectively) of the otolith microchemistry study.

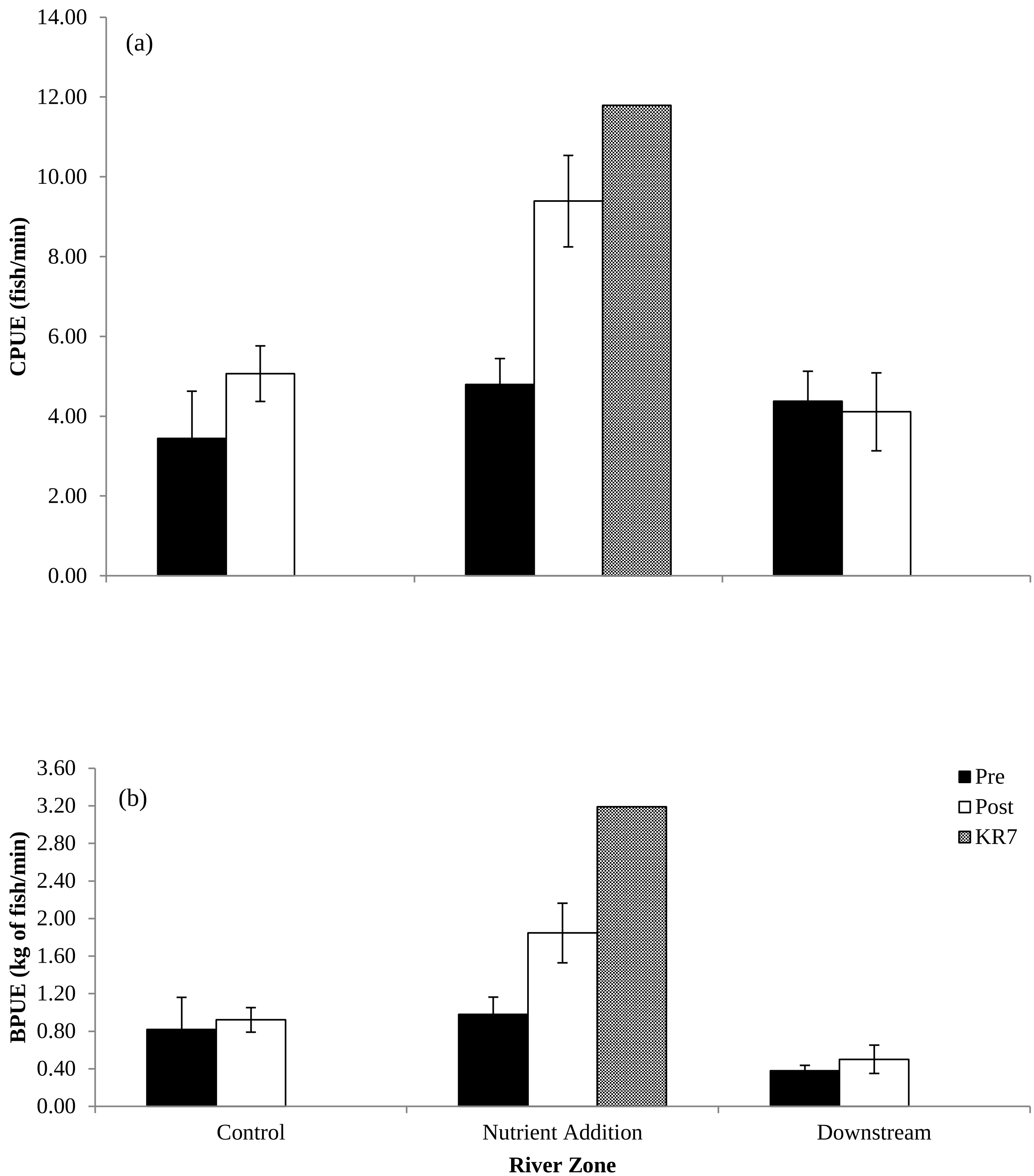

Figure 3.4. Mean total (i.e., all species, combined) CPUE (a) and BPUE (b) from all three river zones, segregated by period. The hatch-marked bar represents mean total CPUE and BPUE from site KR7 in 2014. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

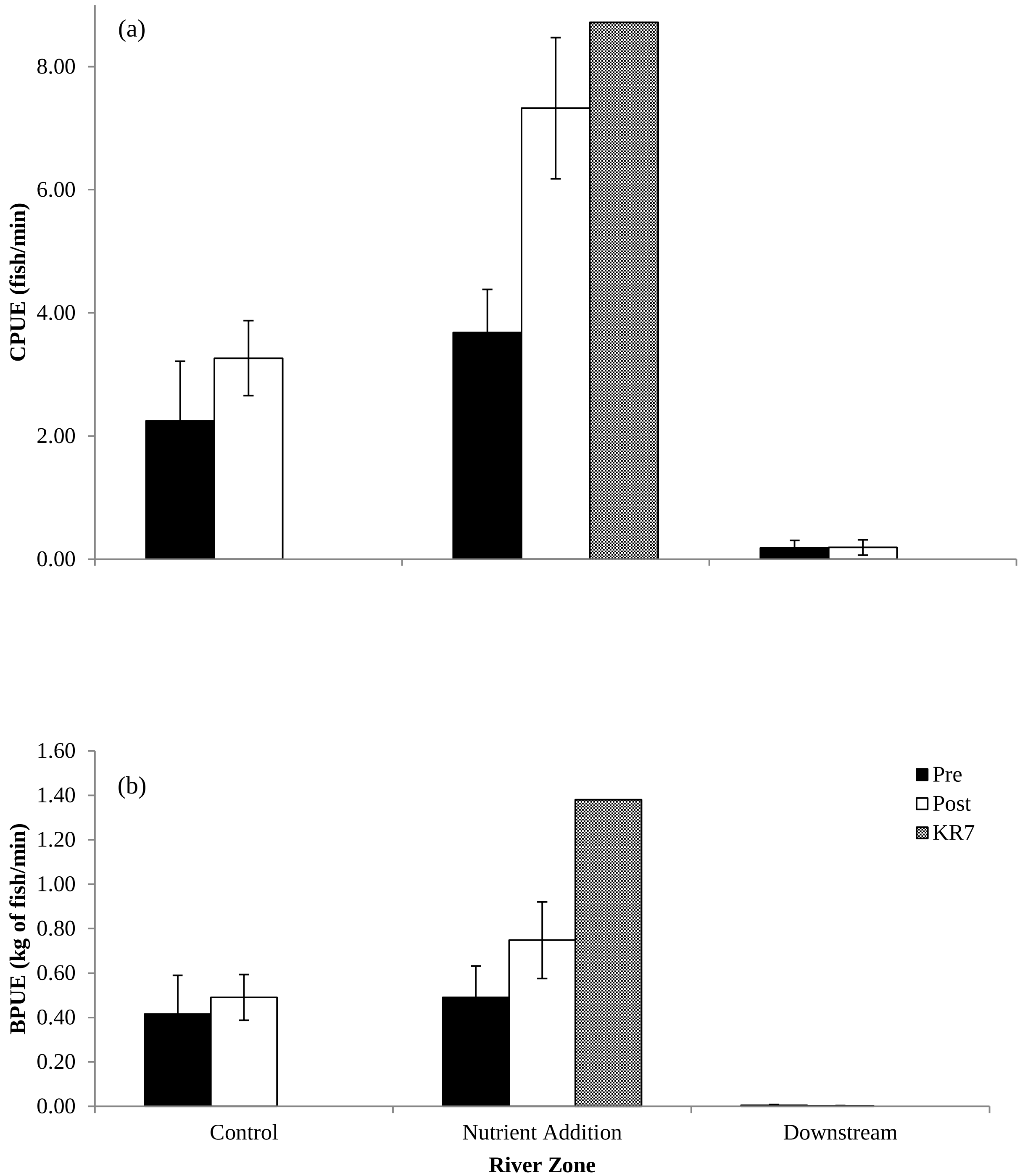

Figure 3.5. Mean CPUE (a) and BPUE (b) of Mountain Whitefish from all three river zones, segregated by period. The hatch-marked bar represents mean CPUE and BPUE of Mountain Whitefish from site KR7 in 2014. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

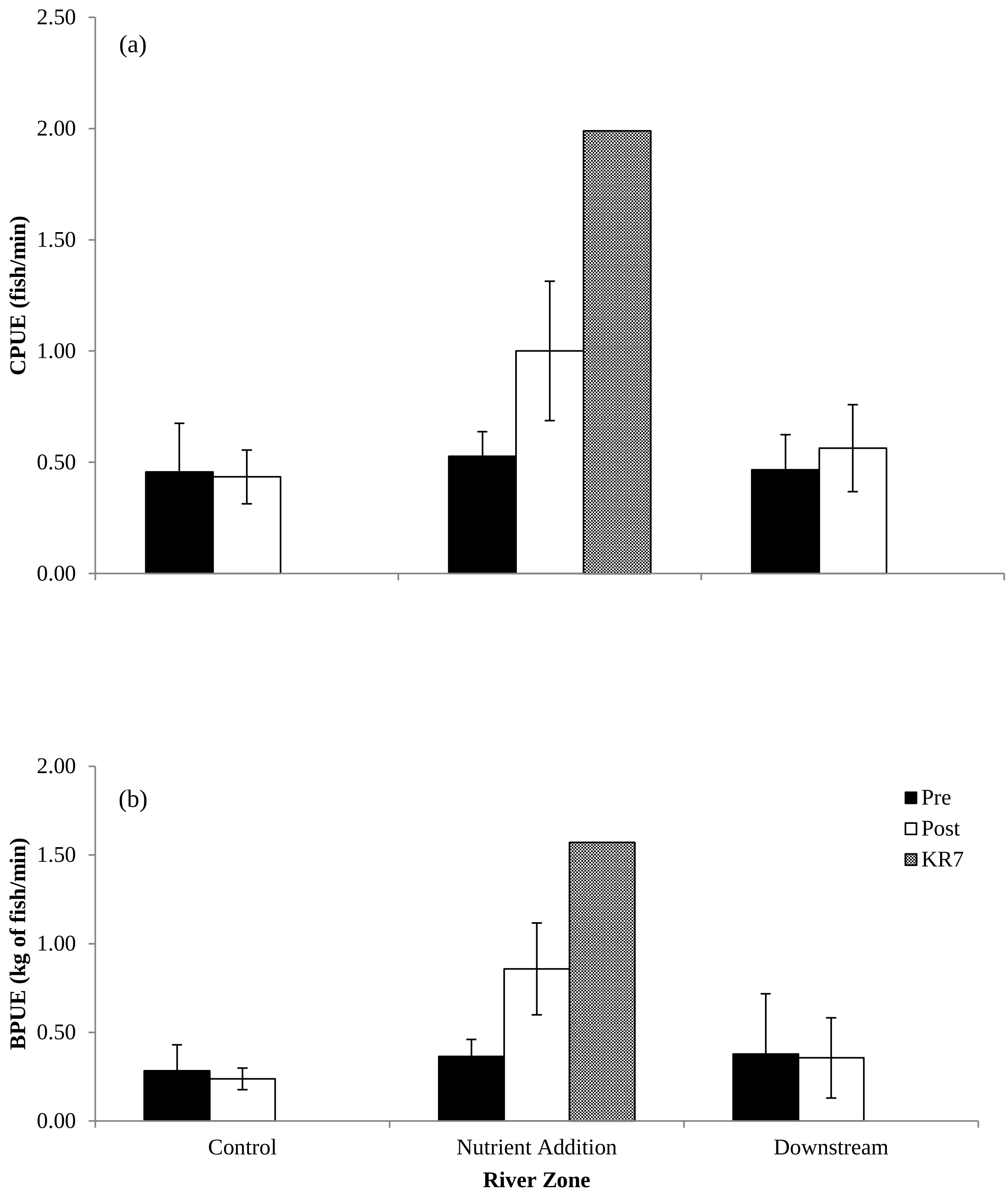

Figure 3.6. Mean CPUE (a) and BPUE (b) of Largescale Sucker from all three river zones, segregated by period. The hatch-marked bar represents mean CPUE and BPUE of Largescale Sucker from site KR7 in 2014. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

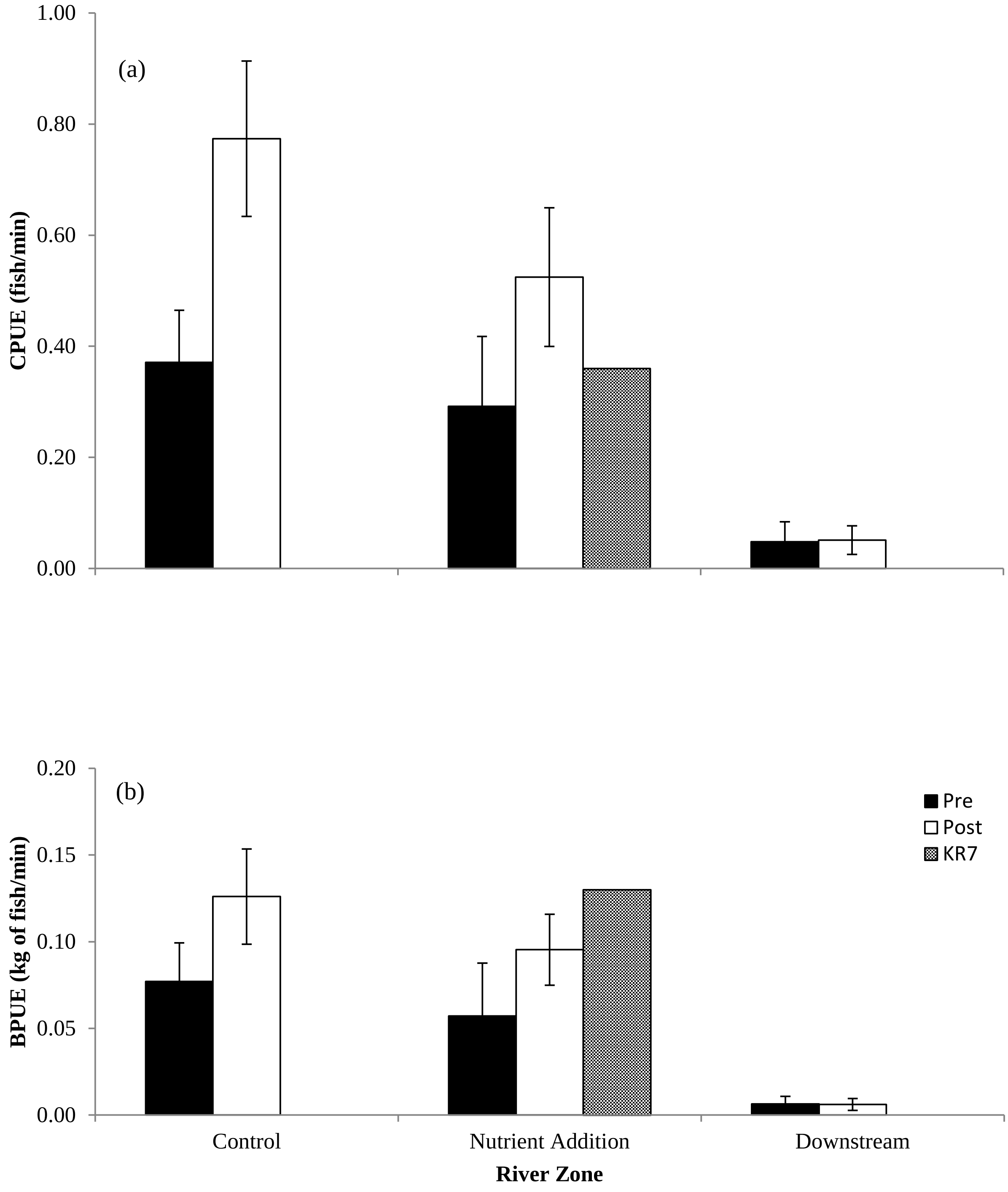

Figure 3.7. Mean CPUE (a) and BPUE (b) of Rainbow Trout from all three river zones, segregated by period. The hatch-marked bar represents mean CPUE and BPUE of Rainbow Trout from site KR7 in 2014. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

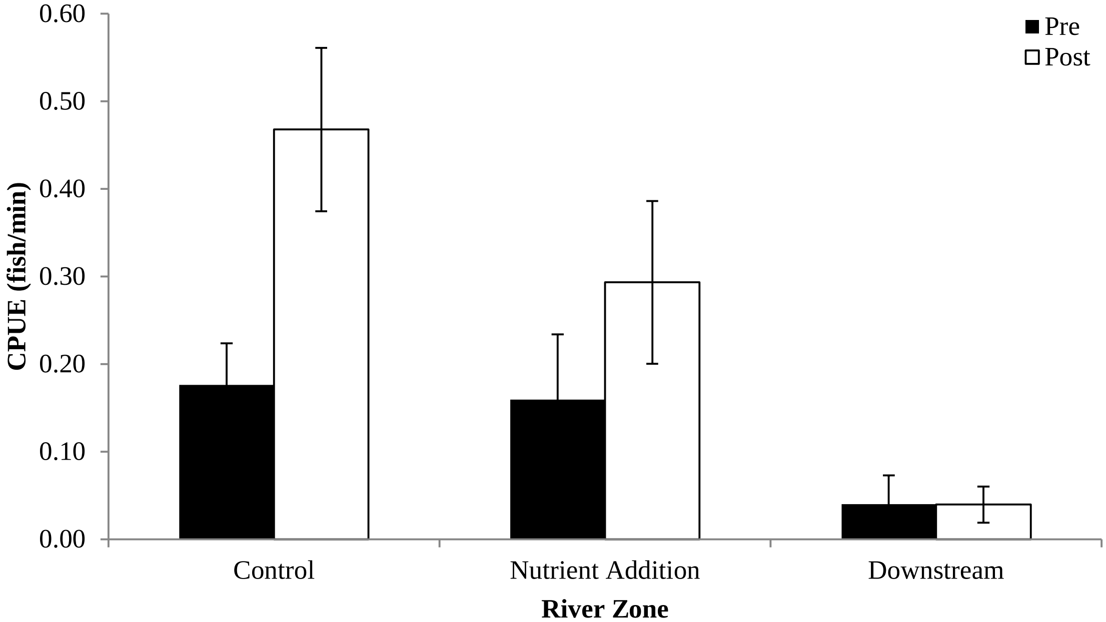

Figure 3.8. Mean CPUE of sexually immature Rainbow Trout (i.e., ≤250 mm) from all three river zones, segregated by period. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

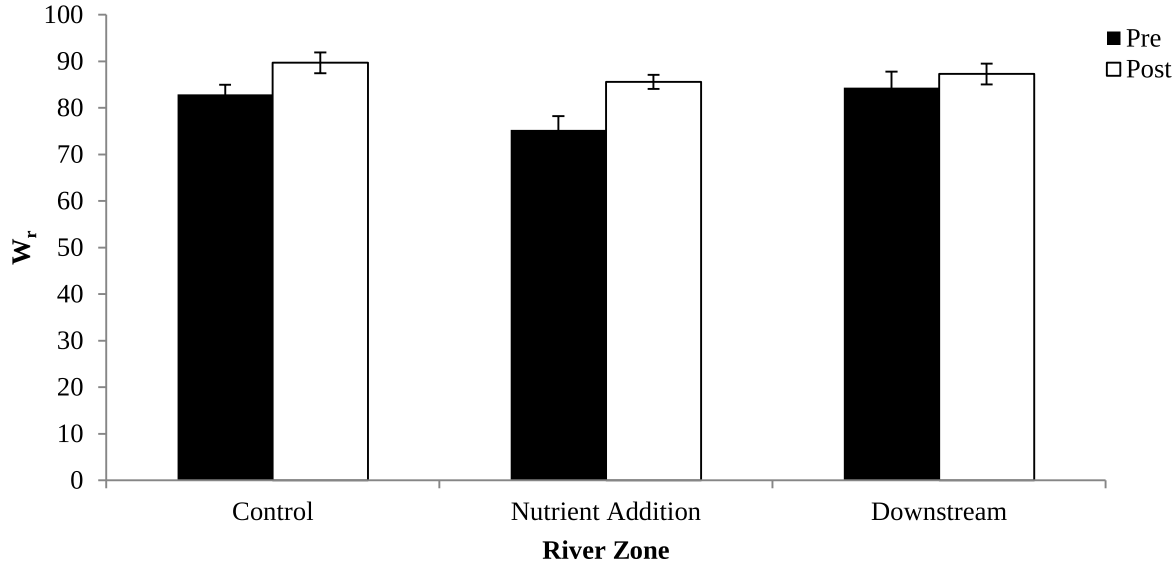

Figure 3.9. Mean W_r for Largescale Sucker from all three river zones, segregated by period. Years represented are 2002-2014. Error bars represent 95% confidence intervals.

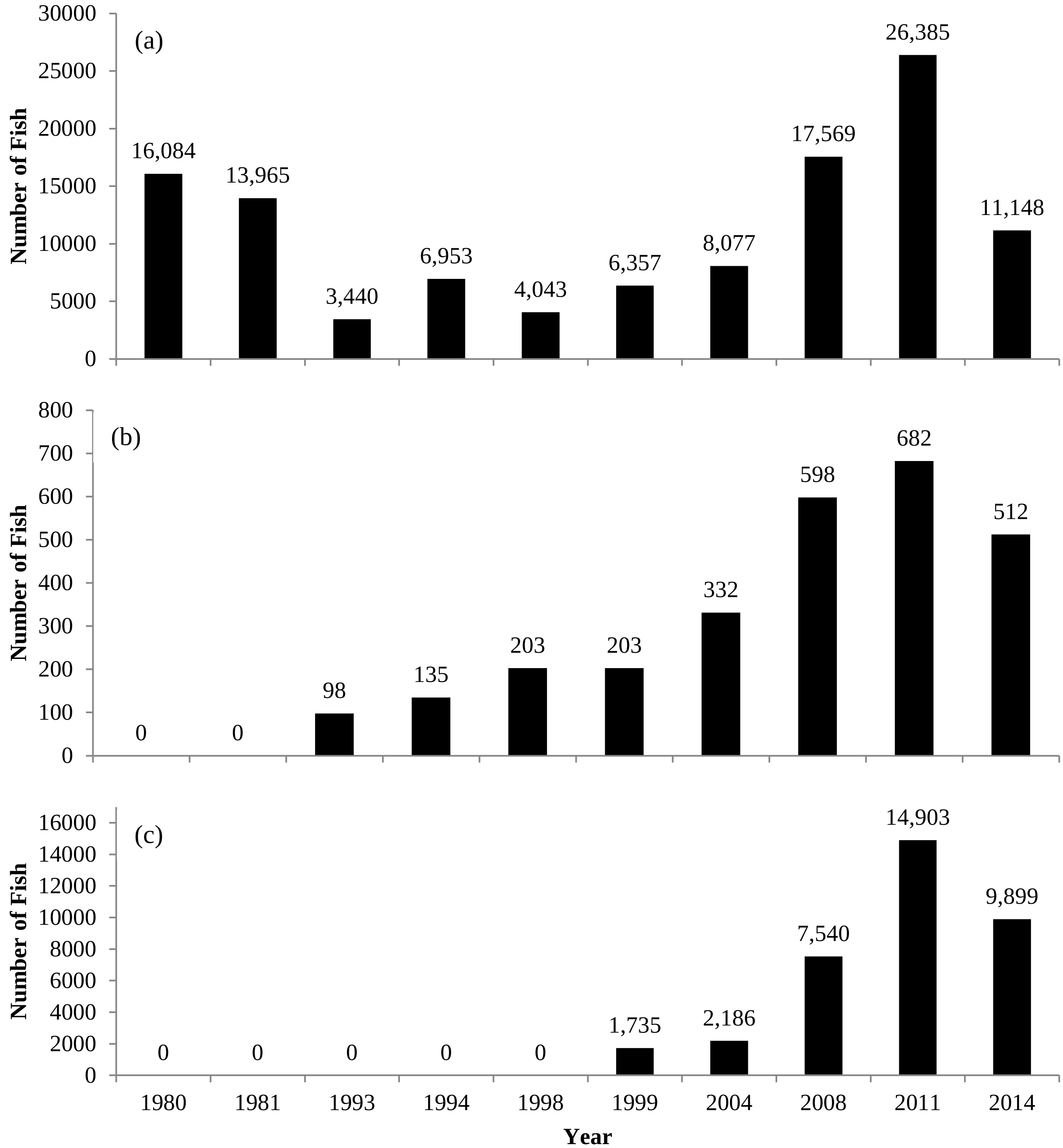

Figure 3.10. Historical population estimates for Mountain Whitefish (a), Rainbow Trout (b), and Largescale Sucker (c) at Hemlock Bar.

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LITERATURE CITED

Anderson, R.O. 1976. Management of small warm water impoundments. Fisheries 1:5-7, 26-28.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. *In*: Fisheries Techniques. (Nielson, L. A., and D. L. Johnson, Eds.). pp. 283-300. American Fisheries Society, Bethesda, Maryland.

Anderson E.C., and J.C. Garza. 2005. The power of single-nucleotide polymorphisms for large-scale parentage inference. Genetics 172: 2567–2582.

Arndt, S.K.A., and J. Hutchinson. 2000. Characteristics of a tributary-spawning population of Burbot from Columbia Lake, British Colombia. Pages 48-60 in V.L. Paragamian and D.W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda.

Ashley, K., L. Thompson, D. Sebastian, D. Lasenby, K. Smokorowski, and H. Andrusak. 1999. Restoration of kokanee salmon in Kootenay Lake, a large intermontane lake, by controlled seasonal addition of limiting nutrients. *In:* Aquatic Restoration in Canada. T. Murphy and M. Munawar, eds. Ecovision World Monograph Series. Backhuys Publishers, Leiden, The Netherlands.

Ashley, K.I., and J.G. Stockner. 2003. Protocol for applying limiting nutrients to inland waters. Pages 245-258 *in* J. Stockner, editor, Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity. American Fisheries Society Symposium 34. American Fisheries Society, Bethesda, Maryland.

Beer, K.E. 1981. Embryonic and larval development of white sturgeon (Acipenser transmontanus). Master's Thesis. University of California at Davis.

Blackwell, B.G., M. Brown, and D. Willis. 2000. Relative weight (W_r) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8:1-44.

Bonde, T.H., and R.M. Bush. 1975. Kootenai River water quality investigations, Libby Dam pre-impoundment study 1967-1972. U.S. Army Corps of Engineers.

Bradford, M.J., and G.C. Taylor. 1997. Individual variation in dispersal behavior of newly emerged Chinook Salmon (*Oncorhynchus tshawytscha*) from the Upper Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 54:1585-1592.

Carpenter, S.R., J.F. Kitchell, and J.R. Hodgson. 1985. Cascading trophic interactions and lake productivity. Bioscience 35:634-639.

Chen, L.C. 1969. The biology and taxonomy of the Burbot, Lota lota leptura, in interior Alaska. Biological Papers of the University of Alaska, No 11, pp. 1–53.

Cohen, J. 1988. Statistical power analysis for the behavioral sciences, second edition. Lawrence Erlbaum. Hillsdale, New Jersey.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and M.E. Strange. 1988. Hatchery manual for the white sturgeon (Acipenser transmontanus) with application to other North American

Acipenseridae. Publication 3322. Agriculture and Natural Resources, University of California, Oakland.

Cross, W.F., C.V. Baxter, K.C. Donner, E.J. Rosi-Marshall, T.A. Kennedy, R.O. Hall, and R.S. Rogers. 2011. Ecosystem ecology meets adaptive management: food web response to a controlled flood on the Colorado River, Glen Canyon. Ecological applications : a publication of the Ecological Society of America 21:2016-33.

Crossman, J. A., and L. R. Hildebrand. 2014. Evaluation of spawning substrate enhancement for white sturgeon in a regulated river: Effects on larval retention and dispersal. *River Research and Applications* 30.1 (2014): 1-10.

Davis, J.M., A.D. Rosemond, S.L. Eggert, W.F. Cross, and J.B. Wallace. 2010. Long-term nutrient enrichment decouples predator and prey production. Proceedings of the National Academy of Sciences of the United States of America 107: 121-6.

Deegan, L.A., and B.J. Peterson. 1992. Whole-River Fertilization Stimulates Fish Production in an Arctic Tundra River. Canadian Journal of Fisheries and Aquatic Sciences 49:1890-1901.

Dillen, A., I. Vught, D. De Charleroy, D. Monnier, J. Coeck 2008. A preliminary evaluation of reintroductions of Burbot in Flanders, Belgium. Pages 179-183, in V. L. Paragamian and D. H. Bennett editors. Burbot ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda.

Dinsmore, S. J., P. J. Rust, R. S. Hardy, T. J. Ross, S. M. Stephenson, and S. P. Young. 2015. Kootenai River Juvenile White Sturgeon Population Analyses.

Downs, C. C. 2000. Kootenai River fisheries investigations: Rainbow Trout recruitment. 1998 Annual report to Bonneville Power Administration. Project 88-65. Idaho Department of Fish and Game, Boise.

Evenson, M.J. 1993. A summary of abundance, catch per unit of effort, and mean length estimates of Burbot sampled in rivers of interior Alaska. Alaska Department of Fish Game, Fisheries Data Series 93–15, Anchorage.

Evenson, M.J., and P. Hansen. 1991. Assessment of harvest characteristics of Tanana River Burbot sport fishery in 1990 using a postal questionnaire. Alaska Department of Fish and Game, Fishery Data Series No. 91-67, Anchorage.

Fosness, R.L. 2013. Bathymetric surveys of the Kootenai River near Bonners Ferry, Idaho, water year 2011: U.S. Geological Survey Data Series 694, 26 p.

Gabelhouse, D.W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:27-285.

Hardy, R.S. 2003. Kootenai River Fisheries Recovery Investigations: Ecosystem Rehabilitation. Annual Progress Report. April 1, 2002-March 31, 2003. IDFG Report Number 04-01. Idaho Department of Fish and Game. Boise.

Hardy, R.S., and V.L. Paragamian. 2013. A synthesis of Kootenai River Burbot stock history and future management goals. Transactions of the American Fisheries Society 142:1662-1670.

Hauer, F.R., and J.A. Stanford. 1997. Long-term influence of Libby Dam operation on ecology of macrozoobenthos of the Kootenai River, Montana and Idaho. Report to Montana Department of Fish, Wildlife and Parks, Helena.

Ireland, S.C., R.C.P. Beamesderfer, V.L. Paragamian, V.D. Wakkinen, and J.T. Siple. 2002. Success of hatchery-reared juvenile white sturgeon (*Acipenser transmontanus*) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18:642-650.

Ireland, S., and P. Perry, 2008. Burbot restoration in the Kootenai River Basin: using agency, tribal, and community collaboration to develop and implement a conservation strategy. Pages 251-256 in V. L. Paragamian and D. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda.

Jensen, N.J, S.R. Williams, S.C. Ireland, J.T. Siple, M.D. Neufeld, and K.D. Cain. 2008a. Preliminary Captive Burbot Spawning Observations. Pages 155-165 *in* V. L. Paragamian and D. H. Bennett, editors, Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda.

Katzman, L.M., and A.V. Zale. 2000. Age and growth of an exploited Burbot population in Upper Red Rock Lake, Montana. Pages 139-146. In V.L. Paragamian and D.W. Willis (editors), Burbot: biology, management, and ecology. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, Maryland.

Kock, T.J., J.L. Congleton, and P.J. Anders. 2006. Effects of sediment cover on survival and development of white sturgeon embryos. North American Journal of Fisheries Management 26:134–141.

Kozfkay, J.R., and V.L. Paragamian, 2002. Kootenai River Fisheries Investigation: Burbot stock status. Boise: Idaho Department of Fish and Game. Annual Progress Report, Project 88-65.

Krebs, C. J. 1999. Ecological methodology, second edition. Addison Wesley. Menlo Park, California.

KTOI (Kootenai Tribe of Idaho). 2013. Kootenai River Habitat Restoration Program - Kootenai Tribe of Idaho - July 2013, 4p. Accessed March 15, 2014, at *http://www.restoringthekootenai.org/resources/Flyers/KRHRP_July_2013.pdf*.

KVRI (Kootenai Valley Resource Initiative) Burbot Committee. 2005. Kootenai River/Kootenay Lake Burbot conservation strategy. Prepared by the Kootenai Tribe of Idaho with assistance from S. P. Cramer and Associates, Bonners Ferry.

Larkin, P.A. 1978. Fisheries management – an essay for ecologists. Annual Review of Ecology, Evolution, and Systematics 9:57-74.

Lewandowski, C. 2014. Kootenai Tribal White Sturgeon Hatchery Broodstock Spawning and Evaluation Report. Kootenai Tribe of Idaho, Bonners Ferry.

McCabe, G.T., and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76 (4):248-250.

McPhail, J.D., and V.L. Paragamian. 2000. Burbot biology and life history. Pages 11-23 In V.L. Paragamian and D.W. Willis (editors), Burbot: biology, management, and ecology. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, Maryland.

Neufeld, M., and P. Rust. 2009. Using passive sonic telemetry methods to evaluate dispersal and subsequent movements of hatchery-reared white sturgeon in the Kootenay River. Journal of Applied Ichthyology 25:27–33.

Neufeld, M., and C. Spence. 2007. Evaluation of a simple decompression procedure to reduce decompression trauma in trap caught Burbot. Transactions of the American Fisheries Society 133:1260-1263.

Neufeld, M.D., K.D. Cain, N.R. Jensen, S.C. Ireland, and V.L. Paragamian. 2011. Movement of lake-origin Burbot reared in a hatchery environment and released into a large river drainage. North American Journal of Fisheries Management 31:56–62.

Northcote, T.C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report Number 2, Ann Arbor, Michigan.

Paragamian, V.L. 1990. Fish populations of Iowa rivers and streams. Technical Bulletin Number 3. Iowa Department of Natural Resources, Des Moines.

Paragamian, V.L. 2002. Changes in the species composition of the fish community in a reach of the Kootenai River, Idaho after construction of Libby Dam. Journal of Freshwater Ecology 17:375-383.

Paragamian, V.L., and M.J. Hansen. 2009. Rehabilitation needs for Burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. North American Journal of Fisheries Management 29:768-777.

Paragamian, V.L., G. Kruse, and V.D. Wakkinen. 1996. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Boise.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 2001. Spawning habitat of Kootenai River white sturgeon, post-Libby Dam. North American Journal of Fisheries Management 21:10-21.

Paragamian, V.L., G. Kruse, and V. Wakkinen. 2002. Spawning location and movement of Kootenai River white sturgeon. Journal of Applied Ichthyology 18:608-616.

Paragamian, V.L., V. Whitman, J. Hammond, and H. Andrusak. 2000. Collapse of the Burbot fisheries in Kootenay Lake, British Columbia, Canada, and the Kootenai River, Idaho, USA, post-Libby Dam. Pages 155-164 in V. L. Paragamian and D.W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda.

Paragamian V.L., S. Yundt, J. Hammond, C. Spence, S. Ireland, G. Hoffman, and J. Laufle. 2002. An International Recovery Strategy for Burbot in the Kootenai River and Kootenay Lake, Idaho and British Columbia. Intermountain Journal of Science 8:178-190.

Parker, J.F., W.D. Potterville, and D.R. Bernard. 1988. Stock assessment and biological characteristics of Burbot in lakes of interior Alaska during 1987. Alaska Department of Fish and Game. Fishery Data Series No. 65.

Parsley, M. J., L. G. Beckman, and G. T. McCabe, Jr. 1993. Spawning and rearing habitat use by White Sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122:217-227.

Partridge, F. 1983. Kootenai River fisheries investigations. Idaho Department of Fish and Game Federal Aid to Fish and Wildlife Restoration Job Completion Report F-73-R-5, Boise.

Peterson, B.J., L. Deegan, J. Helfrich, J.E. Hobbie, M. Hullar, B. Moller, T.E. Ford, A. Hershey, A. Hiltner, G. Kipphut, M.A. Lock, D.M. Fiebig, V. McKinley, M.C. Miller, J.R. Vestal, R. Ventullo, and G. Volk. 1993. Biological responses of a tundra river to fertilization. Ecology 74:653–672.

Powell, M., V.L. Paragamian, and J. Dunnigan. 2008. Mitochondrial variation in Western North American Burbot with special reference to the Kootenai River in Idaho and Montana, USA. Pages 3-28 in V.L. Paragamian and David H. Bennett, editors. Burbot: ecology, management, and culture. American Fisheries Society, Symposium 59, Bethesda.

Prince, A. 2007. East Kootenay Burbot population assessment. Westslope Fisheries, Cranbrook, British Columbia.

Richter, T.J. 2007. Development and evaluation of standard weight equations for bridgelip suckers and largescale suckers. North American Journal of Fisheries Management 27:936-939.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, Bulletin 191, Ottawa.

Rogers, K.B., L.C. Bergstedt, and E.P. Bergersen. 1996. Standard weight equation for mountain whitefish. North American Journal of Fisheries Management 16:207-209.

Ross, T.J., P. Rust, and R.S. Hardy. 2015. Kootenai River Resident Fish Mitigation: White Sturgeon, Burbot, and native salmonid monitoring and evaluation. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 1988-065-00, Boise.

Rust, P.J., and V.D. Wakkinen. 2009. Kootenai River white sturgeon spawning and recruitment evaluation. Annual Progress Report for the period May 1, 2008 - April 30, 2009. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 09-12, Boise. 44 pp.

Rust, P.J., and V.D. Wakkinen. 2010. Kootenai River white sturgeon spawning and recruitment evaluation. Annual Progress Report for the period May 1, 2009 - April 30, 2010. Idaho

Department of Fish and Game. Prepared for Bonneville Power Administration. IDFG Report Number 11-01, Boise. 42 pp.

Sandlund O.T., L. Klyve, and T.F. Naesje. 1985. Growth, habitat and food of Burbot, Lota lota, in Lake Mjosa. Fauna 38: 37-43.

Schill, D.J. 1991. Wild trout investigations. Idaho Department of Fish and Game. Job Performance Report. Project F-73-R-13, Job 1. Boise.

Seber, G.A. 1982. The estimation of animal abundance, 2nd edition. Griffin. London.

Simpkins, D.G., and W.A. Hubert. 1996. Proposed revision of the standard-weight equation for rainbow trout. Journal of Freshwater Ecology 11:319-325.

Smith, C.D. 2013. Assessment of sampling techniques and fish assemblage structure in large western river systems. Master's thesis. University of Idaho, Moscow.

Snyder, E.B., and G.W. Minshall. 1996. Ecosystem metabolism and nutrient dynamics in the Kootenai River in relation to impoundment and flow enhancement for fisheries management. Final Report. Stream Ecology Center, Idaho State University, Pocatello.

Sorokin, V.N., 1971. The spawning and spawning grounds of the Burbot, *Lota lota* (L.) Journal of Ichthyology 11:907–916.

Stapanian, M., V.L. Paragamian, C.P. Madenjian, J.R. Jackson, J. Lappalainen, M.J. Evenson, and M.D. Neufeld, 2010. Worldwide status of Burbot and conservation measures. Fish and Fisheries 11:34–56.

Steele, C., and M. Campbell, 2011. Parentage based tagging of Snake River hatchery steelhead and Chinook salmon. Idaho Department of Fish and Game. 2010 Annual Progress Report, IDFG Report Number 11-111.

Stephenson, S., M. Neufeld, S. Young, S. Ireland, R. Hardy, and P. Rust. 2013. Survival and dispersal of sonic tagged hatchery-reared Burbot released into the Kootenai River. Transactions of the American Fisheries Society 142:1671-1679.

Taylor, J.L., and J.D. McPhail, 2000. Temperature, development, and behavior in the early life history of Burbot from Columbia Lake, British Columbia. Pages 30-37. In V.L. Paragamian and D.W. Willis (editors), Burbot: biology, management, and ecology. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, Maryland.

USACE (U.S. Army Corps of Engineers). 2012. Draft Continuing Authorities Program Section 1135 Detailed Project Report and Integrated Environmental Assessment, Shorty's Island / Meander Reach Ecosystem Restoration Kootenai River, Idaho: U.S. Army Corps of Engineers, Seattle District, June 2012, 260p. plus appendices, accessed April 14, 2014 at http://www.nws.usace.army.mil/Portals/27/docs/civilworks/projects/1._Shorty's_Draft_Report_03July2012_small[1].pdf.

USFWS. 2006. Biological Opinion on Federal Columbia River Power System Operations. U.S. Fish and Wildlife Service. Portland, Oregon. 153 pp. Plus appendices.

Van Eenennaam, J.P., and S.I. Doroshov. 1988. Effects of age and body size on gonadal development of Atlantic sturgeon. Journal of Fish Biology 53:624–637.

Vannote, R.L., G.W. Minshall, and K.W. Cummins. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Science 37:130-137.

Wallace, R.L., and D.W. Zaroban. 2013. Native Fishes of Idaho. American Fisheries Society, Bethesda, Maryland.

Walters, J.P., C.C. Downs, J. Fredericks, and V.L. Paragamian. 2005. Recruitment of Rainbow Trout from tributaries to the Kootenai River, Idaho. Northwest Science 79:1-11.

Woods, P.F. 1982. Annual nutrient loadings, primary productivity, and trophic state of Lake Koocanusa, Montana and British Columbia, 1972-80. Geological Survey Professional Paper 1283, United States Government Printing Office.

Worthington, T., I. Vught, D. De Charleroy, P. Kemp, J. Coeck, P. Osborne, and K. Easton. 2009. The re-introduction of the Burbot to the United Kingdom and Flanders. Pages 26–29 in P. S. Soorae, editor. Global re-introduction perspectives: re-introduction case-studies from around the globe. International Union for Conservation of Nature/Species Survival Commission, Re-introduction Specialist Group, Abu Dhabi, United Arab Emirates.

2015 BIOP REPORT

RPA Rollup Annual Report

Project 1988-065-00

As per BPA instructions, this BIOP report is attached to the end of this report and was to fulfill in-season reporting requirements for the previous calendar year. We are linked to the Libby BIOP, which still has yet to be fully populated in www.cbfish.org.

SECTION 1: IMPLEMENTATION

Operation of Libby Dam for hydropower and flood control has significantly changed the seasonal flows in the Kootenai River relative to historical patterns creating unfavorable ecological conditions for Kootenai River White Sturgeon (*Acipenser transmontanus*.) White Sturgeon need high spring flows for spawning migration, spawning, and rearing. Twenty years of investigations in Idaho indicate recruitment of Kootenai River White Sturgeon has been limited, *at least* during that time frame. This is particularly evident for year classes after completion of Libby Dam on the Kootenai in Libby Montana. The only notable year classes since the operation of Libby Dam were produced in 1974 and 1991, years of exceptional precipitation and river discharge.

The Kootenai River White Sturgeon was listed as an Endangered Species in September of 1994. The listing was consistent with the population abundance and genetic status. Genetic analysis of the Kootenai River White Sturgeon in 1991 indicated this population was genetically distinct from other populations of Sturgeon in the Columbia Basin. At the request of the Kootenai River White Sturgeon Steering Committee (comprised of representatives from the agencies and tribes), the U.S. Army Corps of Engineers has provided mitigative, experimental flows for White Sturgeon spawning and rearing since 1991. The objective of this investigation is to determine flow and habitat conditions that will affect recovery of this population. This study is supported by, and adheres to conditions set by the Recovery Plan for the Kootenai River White Sturgeon.

This information is presented in accordance with the lettered or numbered items identified in the "Special Terms and Conditions" for the Subpermit (dated October 14, 1997). The USFWS has issued three opinions on Libby Dam (1995, 2000, and 2006). In accordance with these Biological Opinions, this project is listed as necessary and appropriate. The 2006 Libby BiOp specifically lists Reasonable and Prudent Alternatives (RPA) that our IDFG sponsored program is directly responsible for either for implementation or monitoring and evaluation of mitigation actions. A list and description of the RPA components and their associated actions in listed in http://www.cbfish.org/Project.mvc/Display/1988-065-00. Results from our 2015 investigations are listed below.

SECTION 2: RESULTS

Sampling in Idaho and Canada by IDFG or British Columbia Ministry of Forest Land and Resource Operations (BCMFLRO) for adult Sturgeon commenced on March 9 and continued through October 26, 2015. Two gear types were used: angling with 6/0 j-hooks and setlines with 12/0, 14/0, and 16/0 circle hooks set with six hooks per line. A total of 105 adult (96 wild adults) and 11 juvenile White Sturgeon were captured in setlines. Sixteen Sturgeon (14 wild adults) were captured by angling. These captures were coordinated with the Kootenai Tribe of Idaho (KTOI) for broodstock collections and two F4 females were given to KTOI for Sturgeon conservation aquaculture activities. The Kootenai River White Sturgeon Recovery Team (KRWSRT) and the USFWS field office, Spokane, Washington, support the action of providing fish to the KTOI. Of the 110 wild adult Sturgeon captured in Idaho and BC in 2015, 102 (93%) were recaptures from previous years. Four adult Sturgeon (all females) were tagged with special Vemco V16 VPS sonic transmitters in 2015 as part of a telemetry system deployed at Shorty's Island to evaluate habitat use of the Shorty's Island and Myrtle Creek Substrate Enhancement Pilot Projects (SEPPs). There were no mortalities from telemetry tagging.

Juvenile sampling with gill nets commenced July 8 and continued to October 1, 2015. We used experimental gill nets with panels including 2.5, 5.1, and 7.6 cm bar mesh. Gill nets were checked every ½ hour to 1 hour. All Sturgeon were measured, weighed, PIT tagged if needed and released. Combining IDFG and BCMFLRO efforts, a total of 1790 (711 in BC) juvenile White Sturgeon were captured in gillnets in 2015. Thirteen of the sampled juveniles were of wild origin, two of which were collected in Canada. Five of the thirteen wild juvenile Sturgeon had been previously captured. Individuals were aged from a 2 cm section of the pectoral fin ray removed upon capture.

We sampled for White Sturgeon eggs from May 14 through July 16, 2015 at three sites between RKM 230.5 and 246.5. Two hundred sixteen White Sturgeon eggs were collected from three areas in 2015. Larval Sturgeon sampling occurred at Shorty's Island and Myrtle Creek to evaluate any potential hatch and drift resulting from the SEPPs. No larval Sturgeon were collected in 2015.

Table 1. Summary of IDFG and BCMFLRO sampling efforts in 2015 under US Fish and Wildlife Service Permit 702631

Sampling Dates; Target	Numbers Caught					Gear Type
	Adults	Juveniles	Larvae	Eggs	Mortality	
03/10 - 10/26; Adult sampling	121	11	0	0	0	Rod & reel, 6/0 hooks. Set lines w/12/0, 14/0, 16/0 hooks
07/8 - 10/1; Juvenile sampling	0	1790	0	0	0	Gill nets
05/14 - 07/16; Egg sampling	0	0	0	216	216	Egg mats
05/25 – 08/01; Larval sampling			0			Larval Plankton Nets
Totals	121	1801	0	216	216	

We consider the current status of the Kootenai River White Sturgeon to be unchanged. The Kootenai River White Sturgeon Recovery Team is concerned because wild juvenile White Sturgeon still comprise a very small portion of the juvenile catch, 50:1. Only eight new wild juveniles were captured in 2015. Although the mitigated discharges from Libby Dam benefit White Sturgeon spawning our studies suggest the primary problem may be spawning location, over silt, clay and sand substrates.

SECTION 3: ADAPTIVE MANAGEMENT

The objective of the 2015 Sturgeon augmentation operation was similar to that of 2013 and 2014, which was to provide two periods of peak river stages/flows during the spring run-off period. The first peak, timed to low-elevation run-off below Libby Dam, was intended to provide Sturgeon cues to begin upstream migration and staging. The second peak, timed to high-elevation run-off above Libby Dam, was intended to provide Sturgeon cues to migrate further upstream from their staging areas and spawn towards the end of the second peak and/or on its descending limb. Overall, the goal is to provide conditions that will enable Sturgeon to migrate to, and spawn over, rocky substrates that exist upstream of Bonners Ferry. Since the results of the 2013 and 2014 operations were promising in that a higher proportion of tagged Sturgeon migrated above Bonners Ferry than in the previous three years, the two peak approach warranted at least another year of testing. Although a much smaller water volume was available in 2015 due to poor snowpack conditions, the augmentation operations in 2015 did follow those of 2014, and results were similar, with approximately 24 percent of the tagged spawning group migrating above Bonners Ferry in 2015, compared to 30 percent in 2014. Although we are still constrained by Libby Dam operations and flood control issues at Bonners Ferry, small-scale adaptive flow management actions are important for understanding how Sturgeon respond to different flow regimes and eventually may allow us to enhance upstream movements.

The Vemco telemetry array has been in place for 12 years and has greatly improved our understanding of qualitative aspects of Sturgeon movements and behaviors. The next step is to incorporate Sturgeon movement data with physical habitat variables auto-correlated by the operation of Libby Dam and attempt to develop a predictive model to help determine how to enhance Sturgeon movement upstream of Bonners Ferry. As described previously, to evaluate upstream Sturgeon migrations to adequate spawning and incubation sites, a select group were tagged with sonic tags to use in this analysis. This “tagged spawner” classification was based solely on movement behavior and Sturgeon that migrated to at least rkm 228.5, the downstream extent of the spawning reach. Each spring, Sturgeon that were located on receivers at rkm 228.5 were counted as a potential spawner and placed in this classification. Although this method of grouping Sturgeon has been useful for determining areas of high residency and determining the maximum extent of upstream movement, it did not take into account updated capture information and individual fish behaviors in previous years. Recently, BCMFLRO has provided a more detailed analysis of the annual spawning group based not only on behavior to a certain rkm, but also includes capture history and spawning periodicity of individual fish. In the future, this method will be used to more accurately analyze the annual spawning group to allow more informed decisions and inferences can be made.

The purpose of tagging juvenile Sturgeon in Kootenay Lake was to evaluate data gaps regarding mixing rates within the delta, river, and Kootenay Lake. The data gap was brought to light during the recent MARK analysis, where low capture probabilities and uncertainty regarding closure assumptions were in question. The highest densities of hatchery-reared juvenile Sturgeon exist on the Kootenay Lake delta. If juvenile Sturgeon freely move between the delta out in the main Kootenay Lake basin, model assumptions of closure may be violated. In addition, we would not be sampling all available Sturgeon habitats equally in our standard stock assessment program. Depending on the results of this evaluation and analysis of specific movement rates at the Kootenay Lake delta, we may find that our recent estimates of system-wide juvenile Sturgeon abundance to be grossly underestimated (Dinsmore et al. 2015). The sonic transmitters used for this study have a longevity of approximately three to ten years. It may take several years of monitoring, but understanding juvenile Sturgeon movements from the river to Kootenay Lake delta will add to our understanding of juvenile Sturgeon life history in general, and may provide critical data to improving the accuracy of our abundance estimates.

The Kootenai River Vemco VPS system collected pretreatment Sturgeon spawning movement data at Shorty’s Island for a 110 day period in 2014. Other than a few minor mechanical setbacks, the system functioned properly during this time frame. Originally, the Shorty’s Island SEPP was going to be constructed in winter 2014, and Myrtle Creek SEPP in winter 2015, and we planned to collect pretreatment data from Shorty’s Island in 2014 and the Myrtle Creek site in 2015. To save money on construction costs, KTOI decided to build both SEPPs in the winter of 2014. Unfortunately, we were unable to get necessary equipment procured and built in time to collected pretreatment data at both sites. Because of the level of expertise needed to quantitatively evaluate habitat use changes from this type of analysis, we are currently working with experts from Golder Associates to determine if Sturgeon use has increased as a result of these habitat improvement projects. The full evaluation of these data should be available in the spring of 2016.

In addition to spawning habitat use, we have moved forward on analysis of specific metrics from hatchery produced juveniles to aid in determining population demographics as it relates to stocking strategies. With the anticipated continued stocking of hatchery-reared sturgeon, it is evident that these fish can fulfill a continued useful role for research. One of our key objectives is to make adequate recommendations to stocking numbers so that it achieves the needs of maintaining the population while not negatively affecting wild production. There is a need for evaluating changes in growth rates over time to determine what, if any, effects stocking density or other habitat improvements are having on growth. This is done by removing fin ray sections from a subsample of juvenile sturgeon and using those in incremental growth modeling. Although this is minimally invasive to juvenile sturgeon, it has been proven to not adversely affect survival or swimming performance. In 2015, we began collecting 10 fin rays from each brood year, with five from juvenile Sturgeon collected upstream of rkm 123 in river sections, and five from juveniles residing in the Kootenay Lake delta. It is anticipated that we will complete fin ray collections in 2016. Analysis will be done through the University of Idaho assisting us on the incremental age and growth as it relates to changes in density and habitat improvements.

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