Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Implementation Year 7

Reference: CLBMON-45

Lower Columbia River Fish Population Indexing Surveys

Study Period: 2013

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Lower Columbia River Fish Population Indexing Surveys - 2013 Investigations

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Executive Summary

In the mid-1990s, BC Hydro initiated flow management actions from Hugh L. Keenleyside Dam (HLK) during the Mountain Whitefish (*Prosopium williamsoni*) and Rainbow Trout (*Oncorhynchus mykiss*) spawning seasons to reduce egg losses in the lower Columbia River (LCR). Prior to the peak Mountain Whitefish spawning season in early winter, BC Hydro decreases flow from HLK to encourage spawning at lower water level elevations and reduce egg dewatering over the winter egg incubation period. In early spring, flows are reduced and subsequently managed to provide increasing water levels during the Rainbow Trout spawning season, which reduces the likelihood of Rainbow Trout eggs and other larval fishes from becoming stranded during spring flow management.

In 2007, BC Hydro completed the Water Use Planning process for its hydroelectric and storage facilities on the Columbia River. The Water Use Plan Consultative Committee recommended the commissioning of the LCR Fish Population Indexing Program (CLBMON-45) to address data gaps regarding the effects of HLK operations on the downstream fish communities. CLBMON-45 represents a continuation of BC Hydro's LCR Large River Fish Indexing Program (LRFIP), first established in 2001 to gather baseline information on fish distribution, life history characteristics, and population abundance data for select index species [i.e., Mountain Whitefish, Rainbow Trout, and Walleye (*Sanders vitreus*)].

The two key management questions to be answered by CLBMON-45 are:

- What is the abundance, growth rate, survival rate, body condition, age distribution, and spatial distribution of subadult and adult Whitefish, Rainbow Trout, and Walleye in the LCR?
- What is the effect of inter-annual variability in the Whitefish and Rainbow Trout flow regimes on the abundance, growth rate, survival rate, body condition, and spatial distribution of subadult and adult Whitefish, Rainbow Trout, and Walleye in the LCR?

The study area for CLBMON-45 includes the portion of the Columbia River between HLK and the Canada-U.S. border (approximately 56.5 km of river habitat) and the 2.8 km section of the Kootenay River from Brilliant Dam (BRD) downstream to the Columbia River confluence.

Fishes were sampled by boat electroshocking at night within nearshore habitats. In addition to the mark-recapture indexing sites sampled since 2001, additional sample sites were randomly selected in 2011 to 2013 using a Generalized Random Tessellation Stratified (GRTS) survey design. All captured Mountain Whitefish, Rainbow Trout, and Walleye were measured for fork length, weighed, and implanted with a Passive Integrated Transponder (PIT) tag. Hierarchical Bayesian Models (HBMs) were used to estimate temporal and spatial variations in species abundance, spatial distribution, growth, length-at-age, survival, and body condition. Data collected during the early 1990s as part of BC Hydro's Columbia Basin Development Fisheries were included in the HBMs.

In 2013, a visual enumeration survey was also conducted to assess whether this method would provide comparable or potentially more accurate estimates of fish density than the mark-recapture data. The surveys involved an electrofishing pass conducted the same way as the mark-recapture survey except that fish were not captured, but were identified, enumerated, and their fork lengths estimated. The geographic location of all observed fish was recorded using a GPS to gather information about finer-scale distribution of fishes in the LCR.

Multivariate analyses were used to assess relationships between environmental variables and fish population metrics, to test for potential effects of flow regime variability. Dynamic factor analysis was used to identify common trends in the time series for fish population metrics, discharge, and water temperature, where variables that were weighted heavily with the same common trend were interpreted as following similar temporal trends.

The results suggested temporal and spatial trends in abundance, spatial distribution, growth, size-at-age, survival, and body condition for subadult and adult Mountain Whitefish, Rainbow Trout, and Walleye. For instance, between 2001 and 2005 the abundance of subadult Mountain Whitefish and Rainbow Trout decreased, followed by an increase in body condition of these species in subsequent years (2003 - 2006). Linking changes in fish populations to flow regime variability was difficult, possibly because of the many factors that can influence fish survival and growth. However, the multivariate analyses suggested some associations, including subadult Mountain Whitefish body condition that was negatively associated with their abundance and with discharge variability in the spring.

Analysis of the geo-referenced visual enumeration surveys suggested that counts of observed fish from visual surveys corresponded well with mean catches from the mark-recapture surveys. The visual surveys also provided fine-scale distribution data that can be used to identify important fish habitats, and assess the effects of flow regime variations on fish distribution and habitat usage. Additional years of sampling and data analysis are required to better assess and quantify these relationships.

Keywords: Columbia River, Hugh L. Keenleyside Dam (HLK), Density Estimation, Hierarchical Bayesian Models (HBM), Generalized Random Tessellation Stratified (GRTS) Survey

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1.0 INTRODUCTION

In the mid-1990s, BC Hydro initiated water management from Hugh L. Keenleyside Dam (HLK) during the Mountain Whitefish (*Prosopium williamsoni*) and Rainbow Trout (*Oncorhynchus mykiss*) spawning seasons to reduce egg losses downstream of the dam. During the Mountain Whitefish spawning season (December to February), BC Hydro decreases flow from HLK during the peak spawning period (December 24 to January 21; Golder 2010b) to encourage spawning at lower water level elevations and reduce egg dewatering over the winter period and during the early spring when annual minimum flows typically occur. Subsequently, flows are managed (i.e., within the constraints of the Columbia River Treaty and flood protection considerations) to provide stable or increasing water levels during the middle of the Rainbow Trout spawning season (early April to late June) to protect the majority of Rainbow Trout spawners by reducing the likelihood that Rainbow Trout eggs (and other larval fishes) will be stranded during spring flow management.

BC Hydro implemented a Water Use Plan (WUP; BC Hydro 2005) for the Columbia River in 2007. As part of the WUP, the Columbia River Water Use Plan Consultative Committee (WUP CC) recommended the establishment of the Lower Columba River (LCR) Fish Indexing Program to address data gaps regarding the effects of water management at HLK (particularly during the Mountain Whitefish and Rainbow Trout spawning seasons) on downstream fish populations. The LCR Fish Indexing Program represents a continuation of the Large River Fish Indexing Program (LRFIP), a program initiated by BC Hydro in 2001 to develop a reliable and cost-effective method of indexing the fish community downstream of HLK.

In 2001, the LRFIP gathered baseline information on fish distribution, life history characteristics, and population abundance of fish species present in the LCR (Golder 2002). Between 2002 and 2006 (Golder 2003, 2004, 2005, 2006, 2007), the program was refined, based on the results of previous study years, to provide a systematic and repetitive index of fish population parameters for three index species: Mountain Whitefish, Rainbow Trout, and Walleye (*Sanders vitreus*). A detailed summary of the life history requirements for these three species was provided by Golder (2009a, 2010a).

Data collected under the LRFIP (Golder 2002, 2003, 2004, 2005, 2006, 2007) and the current program (Golder 2008, 2009a, 2010a, Ford and Thorley 2011a, Ford and Thorley 2012, Golder and Poisson 2013a) will allow the calculation of fish population parameters at a level of resolution that can be used to identify changes to fish populations and assist in the determination of the biological and statistical significance of these changes in relation to Mountain Whitefish and Rainbow Trout spawning protection flows.

1.1 Study Objectives

The objectives of CLMBON-45 are (BC Hydro 2007):

- To extend time series data on the abundance, distribution, and biological characteristics of nearshore and shallow water fish populations in the LCR;
- To examine long-term trends in key index fish populations (i.e., Whitefish, Walleye, and Rainbow Trout) during the continued implementation of Whitefish and Rainbow Trout flows in the LCR;
- To build upon previous investigations for the further refinement of sampling strategy, sampling program, and analytical procedures to establish a long-term monitoring program for fish populations in the LCR;

- To update the existing electronic storage and retrieval system for fish population and habitat monitoring data for the Columbia River;
- To establish linkages between other biological monitoring programs being undertaken in the LCR, in particular, the Physical Habitat and Ecological Productivity Monitoring Program (CLBMON-44); and,
- To identify gaps in data and understanding of current knowledge about fish populations and procedures for sampling them, and to provide recommendations for future monitoring and fisheries investigations.

1.2 Key Management Questions

Key management questions to be addressed by CLBMON-45 are:

- What is the abundance, growth rate, survival rate, body condition, age distribution, and spatial distribution of subadult and adult Whitefish, Rainbow Trout, and Walleye in the LCR?
- What is the effect of inter-annual variability in the Whitefish and Rainbow Trout flow regimes on the abundance, growth rate, survival rate, body condition, and spatial distribution of subadult and adult Whitefish, Rainbow Trout and Walleye in the LCR?

1.3 Management Hypotheses

Specific hypotheses to be tested under CLBMON-45 include:

- Ho_1: There is no change in the population levels of Whitefish in the LCR over the course of the monitoring period.
    - Ho_{1a}: There is no change in the abundance of adult and subadult Whitefish.
    - Ho_{1b}: There is no change in the mean size-at-age of subadult and adult Whitefish.
    - Ho_{1c}: There is no change in the mean survival of adult and subadult Whitefish.
    - Ho_{1d}: There is no change in the morphological (condition factor) index of body condition of adult and subadult Whitefish.
    - Ho_{1e}: There is no change in the distribution of adult and subadult Whitefish.
- Ho_2: There is no change in the population levels of Rainbow Trout in the LCR over the course of the monitoring period.
    - Ho_{2a}: There is no change in the abundance of adult and subadult Rainbow Trout.
    - Ho_{2b}: There is no change in the mean size-at-age of subadult and adult Rainbow Trout.
    - Ho_{2c}: There is no change in the mean survival of adult and subadult Rainbow Trout.
    - Ho_{2d}: There is no change in the morphological (condition factor) index of body condition of adult and subadult Rainbow Trout.
    - Ho_{2e}: There is no change in the distribution of adult and subadult Rainbow Trout.

- Ho_3: There is no change in the population levels of Walleye in the LCR over the course of the monitoring period.
  - Ho_{3a}: There is no change in the abundance of adult and subadult Walleye.
  - Ho_{3b}: There is no change in the mean size-at-age of subadult and adult Walleye.
  - Ho_{3c}: There is no change in the mean survival of adult and subadult Walleye.
  - Ho_{3d}: There is no change in the morphological (condition factor) index of body condition of adult and subadult Walleye.
  - Ho_{3e}: There is no change in the distribution of adult and subadult Walleye.

1.4 Study Area and Study Period

The study area for the LCR Fish Indexing Program encompassed the 56.5 km section of the riverine habitat from the base of HLK to the Canada-U.S. border (Figure 1). This study area also included the Kootenay River below Brilliant Dam (BRD) and the Columbia-Pend d'Oreille rivers confluence below Waneta Dam.

For the purposes of this study, the study area was divided into three sections. The upstream section of the Columbia River extended from HLK (RKm 0.0) downstream to the Kootenay River confluence (RKm 10.7). The downstream section of the Columbia River extended from the Kootenay River confluence downstream to the Canada-U.S. border (RKm 56.5). The Kootenay River section was established as a separate sample section that extended 2.8 km from the Kootenay-Columbia rivers confluence upstream to BRD.

In 2013, sample sites were distributed throughout the study area in locations similar to all other study years since 2001. In total, nine sites were sampled in the upstream section of the Columbia River (Appendix A, Figure A1), 15 sites were sampled in the downstream section of the Columbia River (Appendix A, Figures A2 and A3), and four sites were sampled in the Kootenay River (Appendix A, Figure A1). Site descriptions and UTM locations for all sites are listed in Appendix A, Table A1. Each of the 28 sites listed above was sampled four times (i.e., 4 sessions) between October 2 and November 6, 2013 (Table 1). Field sampling also was conducted in the late summer to fall during previous study years.

In addition to the standard indexing program described above, 20 additional sites were selected for sampling in Session 5 using a Generalized Random Tessellation Stratified (GRTS) survey (see Section 2.1.5). Session 5 was completed between November 3 and 6, 2013.

Table 1: Annual study periods for boat electroshocking surveys conducted in the LCR, 2001 to 2013.

Year	Start Date	End Date	Number of Sessions	Duration (in days)
2001	August 13	September 23	5	42
2002	September 16	October 27	6	42
2003	September 15	October 26	6	42
2004	September 13	October 30	7	48
2005	September 19	November 1	6	44
2006	September 18	November 2	6	46
2007	September 27	November 6	5	41
2008	September 22	November 3	5	43
2009	September 28	October 30	5	33
2010	September 27	October 30	5	34
2011	September 26	October 30	5	35
2012	September 24	October 25	5	32
2013	October 2	November 6	5	36

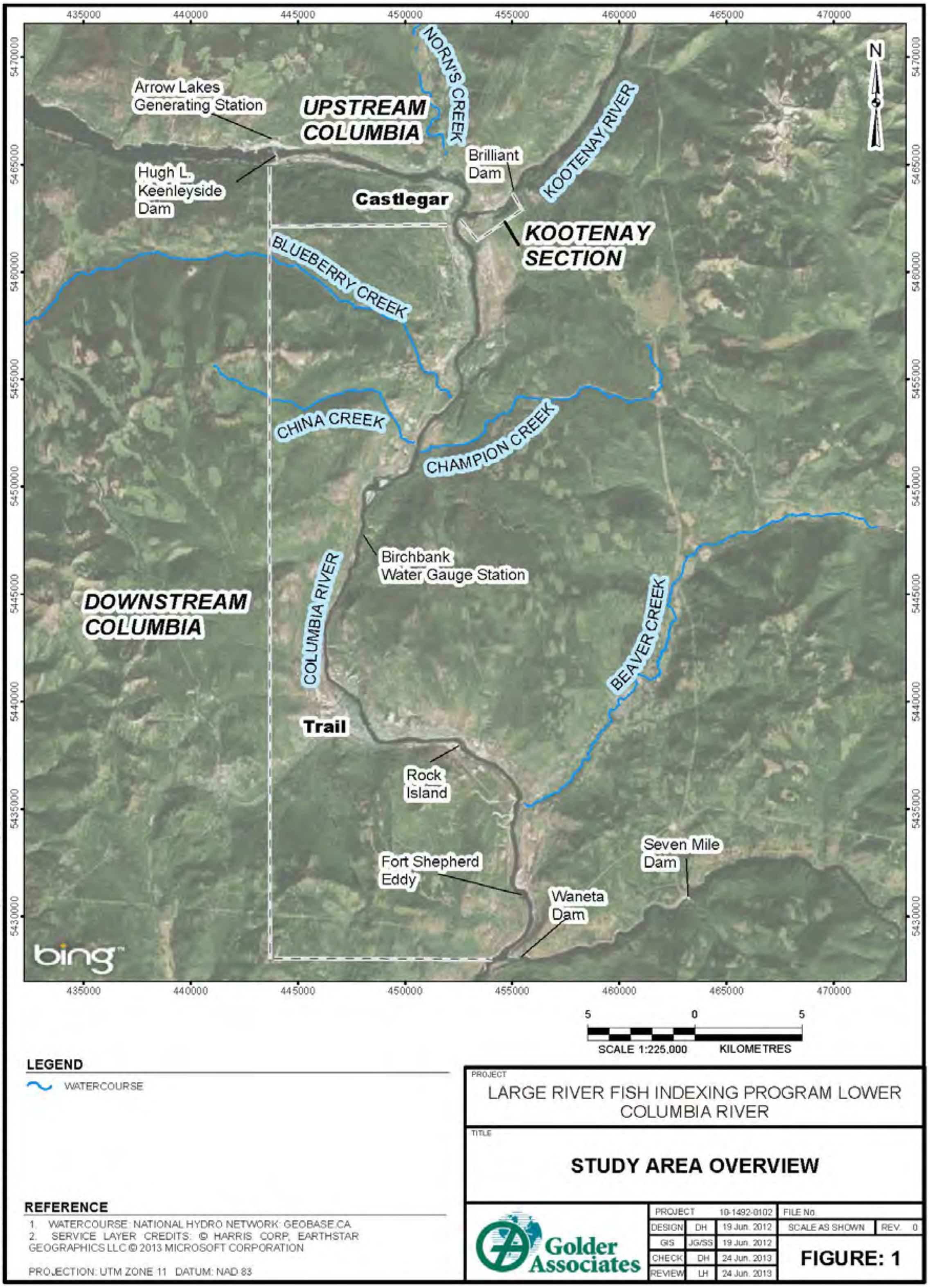

Figure 1: Overview of the Lower Columbia River Fish Population Indexing study area, 2013.

2.0 METHODS

2.1 Data Collection

2.1.1 Discharge

All discharge data were obtained from BC Hydro's Temperature and Discharge database. Data used in this report included discharge for the Columbia River below HLK (combined discharge from HLK and Arrow Lakes Generating Station), the Columbia River at Birchbank (Water Survey of Canada gauging station No. 08NE049), and the Kootenay River [combined discharge through the BRD and Brilliant Expansion (BRX) plants]. Discharges throughout this report are presented as cubic metres per second (m^3/s).

2.1.2 Water Temperature

Water temperatures for the mainstem Columbia River from 2001 to 2011 and 2013 were obtained at hourly intervals using a Lakewood™ Universal temperature probe (accuracy ± 0.5°C) from the Water Survey of Canada gauging station at Birchbank. In 2012, water temperature data from the Birchbank station were not available for a large portion of the year because of a data logger malfunction. Columbia River water temperatures presented for 2012 were measured near Fort Shepherd (used with permission from Columbia Power Corporation; Golder 2013). Hourly water temperature for the Columbia River near Norn's Creek also was obtained from BC Hydro. Water temperatures for the mainstem Kootenay River were obtained at hourly intervals using an Onset Tidbit™ temperature data logger (accuracy ± 0.5°C) installed approximately 1.8 km upstream of the Columbia-Kootenay Rivers confluence.

All available temperature data were summarized to provide daily average temperatures. Spot measurements of water temperature were obtained at all sample sites at the time of sampling using a hull-mounted Airmar® digital thermometer (accuracy ± 0.2°C).

2.1.3 Habitat Conditions

Several habitat variables were qualitatively assessed at all sample sites (Table 2). Variables selected were limited to those for which information had been obtained during previous study years and were intended as a means to detect gross changes in habitat availability or suitability in the sample sites between study years. The data collected were not intended to quantify habitat availability or imply habitat preferences.

The type and amount of instream cover for fish were qualitatively estimated at all sites. Surface water velocities were visually estimated and categorized at each site as low (less than 0.5 m/s), medium (0.5 to 1.0 m/s), or high (greater than 1.0 m/s). Water clarity was visually estimated and categorized at each site as low (less than 1.0 m depth), medium (1.0 to 3.0 m depth), or high (greater than 3.0 m depth). To determine visibility categories, the boat operator called out depths displayed on the boats depth sounder while angling the boat from the thalweg into shore. The netters looked over the bow of the boat to become familiar with how deep they could see based on the depths relayed by the boat operator. Mean and maximum depths were estimated by the boat operator based on the boat's sonar depth display.

Habitat at each site was categorized using the Bank Habitat Types Classification System (Appendix B, Table B1; R.L.&L. 1995). Bank type length within each site was calculated using ArcView® GIS software (Appendix B, Table B2). While electrofishing, netters estimated the number of observed fish that were not captured by species within each bank habitat type. Bank habitat types less than approximately 100 m in length were combined with adjacent bank habitat types to facilitate the netters' ability to remember observed fish counts.

Table 2: List and description of habitat variables recorded at each sample site in the LCR, 2013.

Variable	Description
Date	The date the site was sampled
Time	The time the site was sampled
Air Temp	Air temperature at the time of sampling (to the nearest 1°C)
Water Temp	Water temperature at the time of sampling (to the nearest 1°C)
Conductivity	Water conductivity at the time of sampling (to the nearest 10 µS)
Cloud Cover	A categorical ranking of cloud cover (clear=0-10% cloud cover; partly cloudy=10-50% cloud cover; mostly cloudy=50-90% cloud cover; overcast=90-100% cloud cover)
Weather	A general description of the weather at the time of sampling (e.g., comments regarding wind, rain, or fog)
Water Surface Visibility	A categorical ranking of water surface visibility (low - waves; medium - small ripples; high - flat surface)
Boat Model	The model of boat used during sampling
Range	The range of voltage used during sampling (high or low)
Percent	The estimated duty cycle (as a percent) used during sampling
Amperes	The average amperes used during sampling
Mode	The mode (AC or DC) and frequency (in Hz) of current used during sampling
Length Sampled	The length of shoreline sampled (to the nearest 1 m)
Time Sampled	The time of electroshocker operation (to the nearest 1 second)
Mean Depth	The estimated mean depth sampled (to the nearest 0.1 m)
Maximum Depth	The estimated maximum depth sampled (to the nearest 0.1 m)
Water Clarity	A categorical ranking of water clarity (high - greater than 3.0 m visibility; medium - 1.0 to 3.0 m visibility; low - less than 1 m visibility)
Instream Velocity	A categorical ranking of water velocity (high - greater than 1.0 m/s; medium - 0.5 to 1.0 m/s; low - less than 0.5 m/s)
Instream Cover	The type (i.e., interstices; woody debris; cutbank; turbulence; flooded terrestrial vegetation; aquatic vegetation; shallow water; deep water) and amount (as a percent) of available instream cover
Crew	The field crew that conducted the sample
Sample Comments	Any additional comments regarding the sample

2.1.4 Fish Capture

Fish were captured and sampled using methods similar to previous years of the project (Golder 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009a, 2010a, Ford and Thorley 2011a, Ford and Thorley 2012, Golder and Poisson 2013a). Stress on fish associated with capture and processing is greater at warmer water temperatures (Golder 2002); therefore, sampling in the present study (as in during most other study years) did not commence until after daily maximum water temperatures at Birchbank decreased below 15°C.

Boat electroshocking was conducted at all sites along the channel margin, typically within a range of 0.5 to 4.0 m water depth, which is the approximate range of depths where the electrical field is effective for fish sampling given the settings and equipment used. Boat electroshocking employed a Smith-Root Inc. high-output Generator Powered Pulsator (GPP 5.0) electroshocker operated out of a 160 HP outboard jet-drive riverboat manned by a three-person crew. The electroshocking procedure consisted of manoeuvring the boat downstream along the shoreline of each sample site while travelling slightly faster than the water current. Two crew members positioned on a netting platform at the bow of the boat netted stunned fish, while a third individual operated the boat and electroshocking unit. The two netters attempted to capture all index species. Captured fish were immediately sorted by the Bank Habitat Type they were captured in and placed into an onboard compartmentalized live-well. Index species that avoided capture and all other species that were positively identified but avoided capture were enumerated by Bank Habitat Type and recorded as “observed”. Both time sampled (seconds of electroshocker operation) and length of shoreline sampled (in kilometres) were recorded for each sample site. Electroshocking sites ranged from 0.44 to 3.79 km in length. If, because of logistical reasons, a site could not be completed, the difference in distance between what was sampled and the established site length was estimated and recorded on the site form, and then used as the sampled length in the subsequent analyses.

To reduce fish mortalities and stress on the fish associated with capturing and handling, compressed oxygen was pumped into the livewell through an air stone to maintain dissolved oxygen at levels at or above those in the river water.

Voltage was adjusted as needed to achieve an amperage output of ~1.75 A, at a frequency of 30 Hz direct current as these settings produce less electroshocking-induced injuries on Rainbow Trout (Golder 2004, 2005). Although electrical output is variable (i.e., depending on water conductivity, water depth, and water temperature), field crews attempted to maintain electrical output at similar levels for all sites over all sessions.

To reduce the possibility of capturing the same fish at multiple sites in one session, fish were released near the middle of the site where they were captured.

2.1.5 Generalized Random Tessellation Stratified Survey

In 2001, sites selected for inclusion in the LRFIP (Golder 2002) were based on sites established and data collected during surveys conducted in the early 1980’s (Ash et al. 1981) and early 1990’s (R.L.&L. 1991). During those two programs, virtually all areas of the LCR were surveyed with individual site lengths determined by the length of shoreline traversed by the boat in the amount of time it took netters to fill the livewell with fish (L. Hildebrand, Golder Associates Ltd., pers. comm.). A subsample of sites established during those original programs was selected for inclusion in the LRFIP in 2001 to provide a representative sample of general bank habitat types available throughout the LCR; however, emphasis was placed on sites known to contain higher densities of the three index species. In 2007, this same subsample of sites was selected for annual sampling as part of CLBMON-45 to provide a comparable temporal dataset from 2001 onward. Approximately 30% of the total shoreline habitat available in the LCR was repetitively sampled each year as part of the LRFIP or CLBMON-45.

The stratified sampling design detailed above represents a repeated measures concept, where a mark-recapture program is conducted annually at each site over an approximately five week study period. The same sites are surveyed each year, resulting in annual estimates of abundance with relatively constant temporal and spatial sample design parameters. Stratified sampling programs like this may result in biased estimates because not all portions of a study area are surveyed or potentially available to be surveyed in any particular year. In addition, repetitively sampling the same sites each session (i.e., within a year) may introduce biases due to fish moving between sampled and non-sampled sections of the study areas within or between sessions.

In 2011 to 2013, additional sites were selected using the GRTS survey design (Stevens and Olson 2004) and sampled after field crews completed the conventional mark-recapture program. The GRTS survey was conducted to identify potential biases and to provide a better understanding of the population dynamics of the three index species.

Portions of shoreline habitat that were not sampled as part of CLBMON-45 prior to 2011 were divided up into potential sites. Upstream and downstream boundaries of each site were established using several different criteria, including historic site delineations (i.e., sites surveyed during the 1990s; R.L.&L. 1991), sampling effectiveness (e.g., overall length, ease of access, etc.), natural breaks in habitat, and the location of obvious geographical boundaries (e.g., islands, tributary mouths, bridges, etc.). Established CLBMON-45 indexing sites ranged in length from 0.4 to 3.8 km; these lengths were used as general guidelines when establishing the GRTS survey sites. Overall, 62 new GRTS survey sites from 0.6 to 3.9 km in length, were established in areas of the LCR that were not sampled between 2001 and 2010 (Appendix A, Figures A4 to A8). The same habitat variables recorded for indexing sites also were recorded for GRTS survey sites (Appendix B, Table B3). In general, there was a similar range of habitat types at indexing and GRTS survey sites.

The GRTS sampling design combines the features of stratified sampling with the benefits of a totally random design, ensuring full spatial coverage and randomization so that all potential habitats are surveyed. A unique feature of the GRTS strategy is that new sites may be selected during each study year; therefore, all potential fish habitats are included within the sampling “frame”. A detailed description of the GRTS design strategy is available at http://www.epa.gov/nheerl/arm/designing/design_intro.htm. The GRTS methodology was successfully implemented as part of BC Hydro’s LCR Mountain Whitefish Spawning Ground Topography Survey (CLBMON-47; Golder 2012a.) and as part of a fish stranding study designed to help determine habitat impacts in the LCR as part of the Waneta Expansion Project (Columbia Power Corporation; Golder 2013).

Software used to create the GRTS design included the spsurvey package (Kincaid and Olsen 2011) in the statistical program R 3.1.0 (R Team 2013), and ArcGIS. The GRTS methodology was used to select a subsample of 20 sites from the 62 GRTS survey sites. In addition, 15 over-sample sites also were selected. Over-sample sites were used to replace selected sites that were excluded from sampling due to logistical concerns. For the current project, excluded sites included those located immediately downstream of HLK, BRD, and Waneta Dam and inside the log booms at Zellstoff Celgar (due to safety concerns), the perimeter of Waldie Island (a nature preserve), and the west shore of Zuckerberg Island (too shallow to safely navigate). Oversample sites also were used if the same site was selected more than once by the software. The use of over-sample sites ensured that both randomness and spatial balance were maintained as part of the study design. Selected sites are presented in Appendix A, Table A2.

A single-pass boat electroshocking survey was conducted at each GRTS survey site between November 3 and 6, 2013 using the same procedures described above. Fish captured during GRTS surveys were processed in the same manner as fish captured during the conventional mark-recapture program (Section 2.1.6).

2.1.6 Fish Processing

A site form was completed at the end of each sampled site. Site habitat conditions and the number of fish observed were recorded before the start of fish processing for life history data (Table 3). Fish were measured for fork length (FL) to the nearest 1 mm and weighed to the nearest 1 g using an A&D Weighing™ digital scale (Model SK-5001WP; accuracy ±1 g). Life history data were entered directly into the LCR Fish Indexing Database (Attachment A) using a laptop computer. All sampled fish were automatically assigned a unique identifying number by the database that provided a method of cataloguing associated ageing structures.

All index species between 120 and 160 mm FL that were in good condition following processing were marked with a Passive Integrated Transponder (PIT) tag (tag model Biomark 8.9 mm BIO9.B.01). These tags were implanted into the abdominal cavity of the fish just off the mid-line and anterior to the pelvic girdle using a single shot applicator (model MK7, Biomark Inc., Boise, Idaho, USA) for larger fish or a No. 11 surgical scalpel for smaller fish. All fish >160 mm FL that were in good condition following processing were marked with a Plastic Infusion Process (PIP) PIT tag (12 mm x 2.25 mm, model T-IP8010 polymer shell food safe Datamars FDX-B, Hallprint Pty Ltd., Australia). These tags were inserted with a single shot 12 mm polymer PIT tag applicator gun (Hallprint Pty Ltd., Australia) into the dorsal musculature on the left side below the dorsal fin near the pterygiophores. All tags, tag injectors, and scalpel blades were immersed in an antiseptic (Super Germiphene™) and rinsed with distilled water prior to insertion. Tags were checked to ensure they were inserted securely and the tag number was recorded in the LCR Fish Indexing Database.

Table 3: List and description of variables recorded for each fish captured in the LCR, 2013.

Variable	Description
Species	The species recorded
Size Class	A general size class for observed fish (YOY = age-0; Immature = <250 mm FL; Adult = >250 mm FL)
Length	The fork length to the nearest 1 mm
Weight	The wet weight to the nearest 1 g
Sex and Maturity	The sex and maturity (determine where possible through external examination)
Scale	Whether or not a scale sample was collected for ageing purposes
Tag Colour/Type	The type (i.e., T-bar anchor, PIT, or PIP tag) and colour (for T bar anchor tags only) of tag applied
Tag Number	The number of the applied tag
Condition	The general condition of the fish (e.g., alive, dead, unhealthy, etc.)
Preserve	Details regarding sample collection (e.g., stomach contents, DNA, whole fish, etc.)
Habitat Type	The bank habitat type where the fish was recorded
Comments	Any additional comments

During the 2001 to 2005 studies, fish were marked exclusively with T-bar anchor tags (i.e., PIT tags were not used). Fish captured during the present study that had previously been marked with and retained a T-bar anchor tag did not receive a second tag (i.e., a PIT tag) unless the T-bar anchor tag was not inserted properly, the tag number was illegible, or a large wound was present at the tag's insertion point (on these occasions, the T-bar anchor tag was carefully removed and a PIT tag was applied).

Scale samples were collected from Mountain Whitefish and Rainbow Trout in accordance with the methods outlined in Mackay et al. (1990). All scales were stored in appropriately labelled coin envelopes and air-dried before processing. Scale samples were not collected from Walleye because scales are not a preferred ageing structure for Walleye (Mackay et al. 1990), which are primarily seasonal resident in the LCR and use the study area principally for feeding by adult and subadult cohorts. As a result, sensitive early life stages of Walleye are unlikely to be affected by river regulation in the study area.

2.1.7 Ageing

In previous years of the study, a subsample of Mountain Whitefish and Rainbow Trout were aged using scale samples following methods given in Golder and Poisson (2013a). In 2013, scales were not aged because previous years of the study demonstrated that the length-at-age model (Section 2.2.3) accurately assigned ages to age-0 and age-1 Mountain Whitefish and Rainbow Trout based on fork length and there was a relatively large amount of error and uncertainty in the ages assigned to age-2 and older fish based on scales. Scales collected from Mountain Whitefish and Rainbow Trout in 2013 were archived so that they could be aged in the future if needed (see Section 4.4.1).

2.1.8 Geo-referenced Visual Enumeration Survey

Results from the 2012 monitoring program suggested that the density of adult Rainbow Trout in the LCR varied little between 2001 and 2012 (Golder and Poisson 2013a). These results were not supported by density and survival estimates for subadult Rainbow Trout or by spawner abundance estimates from BC Hydro's LCR Rainbow Trout Spawning Assessment Program (CLBMON-46; Irvine et al. 2014). These conflicting results could indicate potential violation of assumptions in the study methodology (e.g., consistently low recapture rates that provide little information about annual or seasonal variations in capture efficiency), which could make it difficult to detect large changes in efficiency or abundance over time.

To address this potential limitation, a visual enumeration survey was conducted at each index site during the week before the mark-recapture indexing surveys began. The survey consisted of a boat electroshocking pass using the same methods as the mark-recapture survey (Section 2.1.4), except that fish were only counted and not captured with nets. Two observers were positioned in the same location as they would have been for netting, where they identified, enumerated, and estimated the length of all fish observed. Two other individuals recorded all the observation data dictated by the observers, and recorded the geographical location of each observation using a hand-held GPS (Global Positioning System) unit. The rationale behind these geo-referenced visual enumeration surveys was that by not having to net fish and then turn to put captured fish in the livewell (and thereby not counting or capturing additional fish), continuous direct counts of observed fish would be more accurate than the intermittent observations made by netters during the mark-recapture surveys. In addition, the visual surveys provide fine-scale distribution data, which could be used to understand mesohabitat use by fishes in the LCR and better address management questions regarding spatial distribution.

During the visual surveys, observers were instructed to estimate the fork lengths of observed fish. However, given that observers often could not see the actual fork in the tail of the fish (due to the fish position or distance) observers may have been more likely to base their estimates on total length (i.e., the measurement from the tip of the caudal fin rather than the fork). Length estimates were also likely affected by magnification by water, as objects appear larger in water than in air because of the greater refractive index of water (Luria et al. 1967). Potential biases in length estimation were assessed and corrected in the length bias model (Section 2.2.4), and discussed further in Section 4.2.5.

2.1.9 Historical Data

In addition to the data collected between 2001 and 2013, data collected in the study area between 1990 and 1996 (R.L. &L. 1995, 1997) also were used in some analyses. Studies conducted during this period involved boat electroshocking and mark-recapture programs, with protocols very similar to the 2001-2013 monitoring studies, including many of the same sample sites. There were some differences in sampling methodology between the 1990s and the current sampling program including different electrofisher settings and tag types. Despite these relatively minor differences, the 1990s data were considered comparable to data collected between 2001 and 2013 and were combined for many of the analyses in this report. Data from the 1990s were used in the analyses of length-at-age, growth, abundance, and body condition but only years with large enough sample sizes were included. There were not enough data to estimate survival from the 1990s. Incorporating data from the 1990s in the analysis provided a longer time series and historical context to better address management questions about fish population trends in the LCR.

2.2 Data Analyses

2.2.1 Data Compilation and Validation

Data were entered directly into the LCR Fish Indexing Database (Attachment A) using Microsoft® Access 2007 software. The database has several integrated features to ensure that data are entered correctly, consistently, and completely.

Various input validation rules programmed into the database checked each entry to verify that the data met specific criteria for that particular field. For example, all species codes were automatically checked upon entry against a list of accepted species codes that were saved as a reference table in the database; this feature forced the user to enter the correct species code for each species (e.g., Rainbow Trout had to be entered as “RB”; the database would not accept “RT” or “rb”). Combo boxes were used to restrict data entry to a limited list of choices, which kept data consistent and decreased data entry time. For example, a combo box limited the choices for Cloud Cover to: Clear; Partly Cloudy; Mostly Cloudy; or Overcast. The user had to select one of those choices, which decreased data entry time (e.g., by eliminating the need to type out “Partly Cloudy”) and ensured consistency in the data (e.g., by forcing the user to select “Partly Cloudy” instead of typing “Part Cloud” or “P.C.”). The database contained input masks that required the user to enter data in a pre-determined manner. For example, an input mask required the user to enter the Sample Time in 24-hour short-time format (i.e., HH:mm:ss). Event procedures ensured that data conformed to the underlying data in the database. For example, after the user entered the life history information for a particular fish, the database automatically calculated the body condition of that fish. If the body condition was outside a previously determined range for that species (based on the measurements of other fish in the database), a message box would appear on the screen informing the user of a possible data entry error. This allowed the user to double-check the species, length, and weight of the fish before it was released. The database also allowed a direct connection between the PIT tag reader (AVID PowerTracker VIII) and the data entry form, which eliminated transcription errors associated with manually recording a 15-digit PIT tag number.

Various metrics were used to provide background information and to help set initial parameter value estimates in some of the HBMs. Although these summaries are important, they are not presented or specifically discussed in detail in this report. However, these metrics are provided in the Appendices for reference purposes and are referred to when necessary to support or discount results of the HBMs. Metrics presented in the appendices include:

- captured and observed fish count data by site and Bank Habitat Type (Appendix B, Table B4), 2013;
- catch-rates for all sportfish (Appendix E, Table E2) and non-sportfish (Appendix E, Table E3), 2013;
- length-frequency histograms by section for Mountain Whitefish (Appendix F, Figure F1), Rainbow Trout (Appendix F, Figure F2), and Walleye (Appendix F, Figure F3), 2013;
- length-frequency histograms by year for Mountain Whitefish (Appendix F, Figure F4), Rainbow Trout (Appendix F, Figure F5), and Walleye (Appendix F, Figure F6), all years combined; and,
- length-weight relationships by year for Mountain Whitefish (Appendix F, Figure F7), Rainbow Trout (Appendix F, Figure F8), and Walleye (Appendix F, Figure F9), all years combined.

All raw data collected as part of the program between 2001 and 2013 are included in the LCR Fish Indexing Database (Attachment A).

For all figures in this report, sites are ordered by increasing distance from HLK (RKm 0.0) based on the upstream boundary of each site. Unless stated otherwise, black plots represent sites located on the left bank (as viewed facing downstream) and red plots represent sites located on the right bank (as viewed facing downstream).

2.2.2 Hierarchical Bayesian Analyses

The temporal and spatial variation in abundance, growth, body condition, and survival were analyzed using Hierarchical Bayesian Models (HBMs). The book 'Bayesian Population Analysis using WinBUGS: A hierarchical perspective' by Kery and Schaub (2011) provides an excellent reference for hierarchical Bayesian methods and is considered the companion text for the following analyses. In short, a hierarchical Bayesian approach:

- allows complex models to be logically defined using the BUGS language (Kery and Schaub 2011; p.41);
- permits the incorporation of prior information (Kery and Schaub 2011; p.41);
- readily handles missing values;

- provides readily interpretable parameter estimates whose reliability does not depend on the sample size;
- allows derived quantities, such as the percent change in the expected weight of a 200 mm FL Mountain Whitefish at a particular site in a typical year, to be calculated (Kery and Schaub 2011; p.41);
- enables the efficient modelling of spatial and temporal variations and correlations (Kery and Schaub 2011; p.78-82); and,
- permits the separation of ecological and observational processes (Kery and Schaub 2011; p.44).

Hierarchical Bayesian models were fitted to the fish indexing data using R version 3.1.0 (R Team 2013) and JAGS 3.4.0 (Plummer 2012) which interfaced with each other via jaggernaut 1.8.2 (Thorley 2014a) to estimate model parameters.

The technical aspects of the analyses, including the general approach, model definitions in the JAGS (Just Another Gibbs Sampler; Plummer 2003) dialect of the BUGS language, and the resultant parameter estimates are provided in Appendix C. In addition, the statistical methodology, sample code, parameter estimates, and figures of results are available online (Thorley 2014b).

The posterior distributions of the fixed (Kéry and Schaub 2011, p. 75) parameters are summarised in terms of a point estimate (mean), lower and upper 95% credible limits (2.5th and 97.5th percentiles), the standard deviation (SD), percent relative error (half the 95% credible interval as a percent of the point estimate) and significance (Kéry and Schaub 2011, p. 37,42). Variable selection was achieved by dropping uninformative explanatory variables where a variable was considered to be uninformative if its percent relative error was ≥ 100%. In the case of fixed effects this is approximately equivalent to dropping insignificant variables (i.e., those with a significance ≥ 0.05).

The statistical significance of all fixed parameters was assessed from their two-sided Bayesian p-values (Bochkina and Richardson 2007; Lin et al. 2009). The results were displayed graphically by plotting the modeled relationship between a particular variable(s) and the estimated median response (with 95% credible intervals; CRIs) while the remaining variables were held constant. Unless stated otherwise, continuous and discrete fixed variables were held constant at their mean and first level values, respectively, while random variables were held constant at their typical values (i.e., the expected values of the underlying hyperdistributions; Kery and Schaub 2011, p.77-82). Where informative, the influence of particular variables was expressed in terms of the effect size (i.e., the percent change in the response variable) with 95% CRIs (Bradford et al. 2005). Plots were produced using the ggplot2 R package (Wickham 2009).

2.2.3 Length-At-Age

The length-at-age of Mountain Whitefish and Rainbow Trout was estimated from annual length-frequency distributions using a finite mixture distribution model (MacDonald and Pitcher 1979). Because of low numbers of recaptured fish in the 1990s historical data, only years between 1990 and 1996 with sufficient recapture data were used for length-at-age analyses.

Key assumptions of the length-at-age model included:

- three distinguishable age-classes for each species: age-0, age-1 and age-2 and older;
- body length increased with age-class;
- body length varied randomly by year within age-class;
- body length varied as a second-order polynomial of date;
- the proportion of individuals belonging to each age-class remained constant over the course of the study; and,
- individual variations in body length were normally distributed.

For age-0 fish, length-at-age was plotted by showing the estimated fork lengths by year. For age-1 fish, the change in fork length from age-0 fish the previous year to age-1 the current year was plotted. This was done to remove carry-over effects from the first year of growth (hatch to age-0) because it is the interannual differences in growth that are of interest, rather than fork length *per se*.

Length-at-age models were used to estimate the most appropriate cut-offs between age-0, age-1 and age-2 and older individuals by year. For the purposes of estimating other population parameters by life stage, age-0 individuals were classified as fry, age-1 individuals were classified as subadult, and age-2 and older individuals were classified as adult. Walleye could not be separated by life stage due to a lack of discrete modes in the length-frequency distributions for this species. Consequently, all captured Walleye were considered adults.

2.2.4 Length Bias

The bias in the observer's estimates of fish length was quantified using a model with a categorical distribution that compared the length-frequency distributions of fish whose lengths were estimated by observers during the geo-referenced visual survey, to the length-frequency distribution of fish captured and measured by netters during the four mark-recapture sessions. The model calculated a multiplier for each observer that minimized the difference between the estimated fish lengths from the visual surveys, and the measured lengths from the mark-recapture sessions. This multiplier, representing the observation bias, was used to correct the estimated lengths.

Key assumptions of the length bias model include:

- the percent bias varied by observer; and,
- the percent bias was constant by fish length.

The observer's estimated fish lengths were corrected for the estimated bias before being classified as fry, subadult and adult based on the length-at-age cutoffs.

2.2.5 Growth

Annual growth was estimated from inter-annual recaptured fish using the Fabens (1965) method for estimating the von Bertalanffy (1938) growth curve.

Key assumptions of the growth model included:

- the growth coefficient (k) varied randomly with year; and,
- the residual growth variation was normally distributed.

Plots of annual growth show the estimated annual growth for a 200 mm FL fish for Mountain Whitefish, Rainbow Trout, and Walleye. This fork length was selected to illustrate changes in fork length over time for a standard size fish.

2.2.6 Site Fidelity

Site fidelity was the estimated probability of a recaptured fish being caught at the same site where it was previously encountered. Site fidelity was modelled using logistic regression and estimates were used to evaluate the extent to which sites were closed within a sample period (i.e., whether fish remained at the same site between sessions). Site fidelity estimates also were used to adjust the capture efficiencies in the analysis of mark-recapture data (see Section 2.2.7).

Key assumptions of the count model included:

- there was no misidentification of individuals;
- observed site fidelity was described by a Bernoulli distribution; and,
- site fidelity varied with body length.

2.2.7 Capture Efficiency

The probability of capture was estimated using a recapture-based binomial model (Kéry and Schaub 2011, pp. 134-136, 384-388).

Key assumptions of the capture efficiency model include:

- the capture probability varied randomly by session within year;
- there was no tag loss or misidentification of individuals;
- the probability of a marked fish remaining at a site was the estimated site fidelity; and,
- the number of recaptures was described by a binomial distribution.

2.2.8 Abundance

The abundance of each index fish species was estimated using the catch data from mark recapture survey and the observer count data from geo-referenced visual surveys using an overdispersed Poisson model (Kéry and Schaub 2011, pp. 55-56). The model used the estimates of capture efficiency from the mark-recapture data (Section 2.2.7) to generate the estimated density of captured and uncaptured fish at each site. Observer count efficiency was estimated for the geo-referenced visual surveys, and was calculated by adjusting the capture efficiency based on the ratio of counted (visual surveys) to captured fish (four mark-recapture sessions). Count efficiency was then used in the model to estimate the total density of counted and uncounted fish present at each site. Abundance estimates represent the total number of fish at each site including counted observed fish, captured fish, and fish that were present but not observed or captured. The annual abundance estimates represent the total number of fish in all indexing sites combined.

Key assumptions of the abundance model include:

- the capture efficiency was the mean estimate from the capture efficiency model;
- the observer efficiency varied from the capture efficiency;
- the lineal fish density was constant at a site between sessions (i.e., there was no net movement);
- the lineal fish density varied randomly with site, year and site within year; and,
- the catches and counts were described by a Poisson-gamma distribution.

Plots of annual abundance represent the estimated total number of fish at all sites combined. Plots showing the variation in abundance by site show the lineal density (fish/km) at each site. The counts of observed fish during geo-referenced visual surveys were plotted against the mean catches from the four mark-recapture sessions in 2013 to assess how these two metrics of abundance compared. The regression line and confidence bands on these plots represents the linear effect of the model parameter labelled “bType[2]” (Appendix C), which was the multiplier based on the ratio of count to catch in the abundance model.

2.2.9 Survival

The annual survival rate was estimated by fitting a Cormack-Jolly-Seber model (Kéry and Schaub 2011, pp. 172-177) to inter-annual recaptures. Key assumptions of the survival model include:

- survival varied randomly with year within life stage; and,
- the encounter probability was constant across years.

2.2.10 Body Condition

Condition was estimated via an analysis of weight-length relations (He et al. 2008). Key assumptions of the condition model include:

- weight varied with length and date;
- weight varied randomly with year;
- the relationship between length and weight varied with date;

- the relationship between length and weight varies randomly with year;
- the effect of year on weight was correlated with the effect of year on the relationship between length and weight; and,
- the residual weight variation in weight was log-normally distributed.

Only previously untagged fish were included in models to avoid potential effects of tagging on body condition.

2.2.11 Environmental Analyses

The second management question of CLBMON-45 is concerned with the effect of inter-annual variability in the Mountain Whitefish and Rainbow Trout flow regimes on the abundance, growth rate, survival rate, body condition, and spatial distribution of subadult and adult Whitefish, Rainbow Trout, and Walleye in the LCR. To address this question, we assessed the effects of environmental variables on the fish population metrics. Trends common to the annual fish indexing and environmental time series were identified using dynamic factor analysis (Zuur et al. 2003) - a dimension-reduction technique especially designed for time-series data.

The fish indexing time series were growth (Gro..), condition (Con..), survival (Sur..) and abundance (Abu..) by species code and life stage. The annual abundance of adults was excluded as the values are the result of survival and subadult abundance across multiple years.

The environmental variables were the mean discharge (Dis.Me..) and mean hourly discharge difference (Dis.Di..) at Birchbank, and the mean water temperature (Tem.Me..) of the Columbia River near Norn's Creek. Mean hourly discharge difference was calculated as the mean of the absolute values of the hour to hour change. Each of the three environmental variables were summarized by quarterly period (e.g., January to March, April to June, etc.) so there were 12 environmental time series in total. The October to December discharge and temperature time series were lagged by one year such that fish data in a given year were correlated with discharge or temperature data from the year prior to fish sampling. This was done because although November and December occur after the fall surveys were completed, habitat conditions during these months could affect the fish populations sampled in the fall of the following year. All time series variables were standardised by subtracting the mean and dividing by the standard deviation, prior to fitting the model.

Dynamic factor analysis is a multivariate technique to reduce the number of variables and identify common trends among time series of response variables (the fish population metrics) and explanatory variables (the environmental variables). Dynamic factor analysis reduces a large number of time series to a smaller number of common trends. Weightings are calculated to interpret the relationship between the common trends and the variables. The general approach is dimension reduction similar to principal components but that accounts for temporal autocorrelation in the time series data (Zuur et al. 2003). The method is intended for relatively short, non-stationary time series (Zuur et al. 2003), which makes it suitable for the LCR data.

Key assumptions of the dynamic factor analysis model include:

- the trends were described by independent random walks with a shared standard deviation;
- the expected value was the sum of the time series weighted trends;
- the standard deviation of the residual variation varied by time series; and,
- the residual variation was normally distributed.

Preliminary analyses indicated that two common trends provided a reasonable model fit without apparent over-fitting. To visualize the relationships among fish metrics and environmental variables, non-metric multidimensional scaling was used to indicate the clustering of time series based on the absolute values of the dynamic factor analysis trend weightings.

3.0 RESULTS

3.1 Physical Habitat

3.1.1 Columbia River

3.1.1.1 Discharge

Discharge in the LCR in 2013 was within the range of values observed during previous years of the study. Mean daily discharge in the Columbia River at the Birchbank water gauging station was near normal during much of the year but above average during July and below average during the sample period in October and early November (Figure 2; Appendix D, Figure D1). As in previous years of the study, discharge in the LCR followed a bimodal pattern with a peak during spring freshet and a smaller second peak during early winter associated with hydropower generation. In 2013, discharge increased during the majority of the sample period, following by a decrease in discharge during Session 5 (i.e., the GRTS survey; Figure 2).

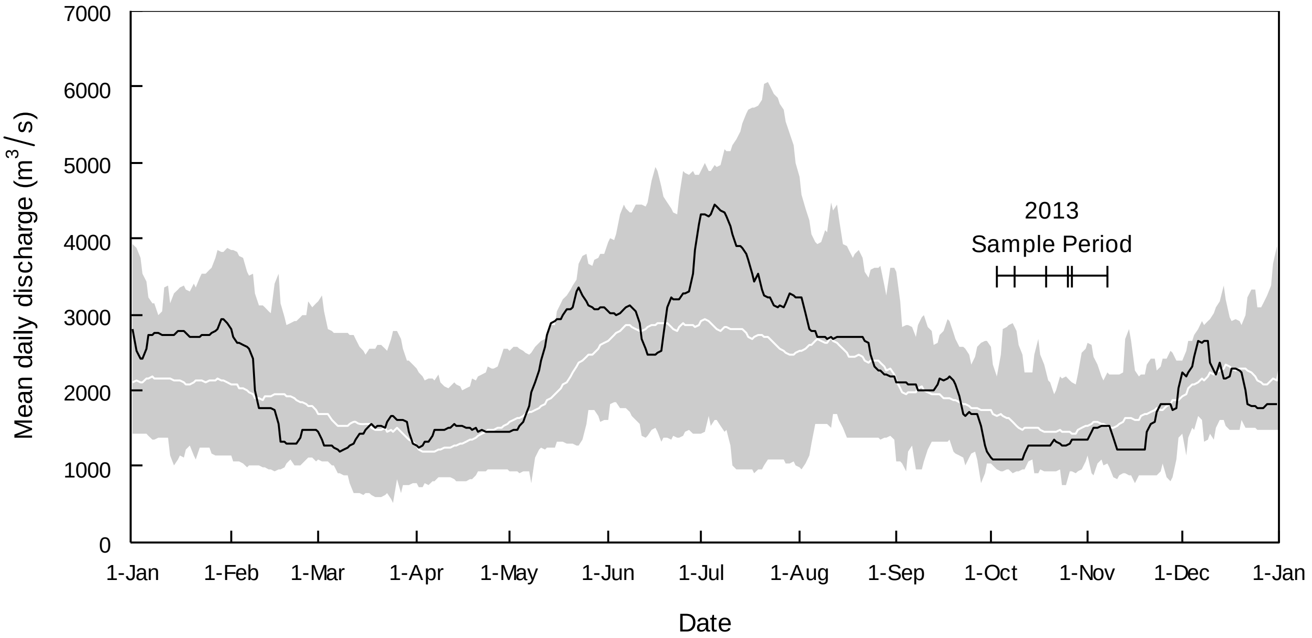

Figure 2: Mean daily discharge (m^3/s) for the Columbia River at the Birchbank water gauging station, 2013 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at Birchbank from 2001 to 2012. The white line represents average mean daily discharge values over the same time period.

In 2013, mean daily discharge in the Columbia River below HLK was near average for most of the year but greater than average during January and July and lower than average during the sample period in October and November (Figure 3; Appendix D, Figure D2).

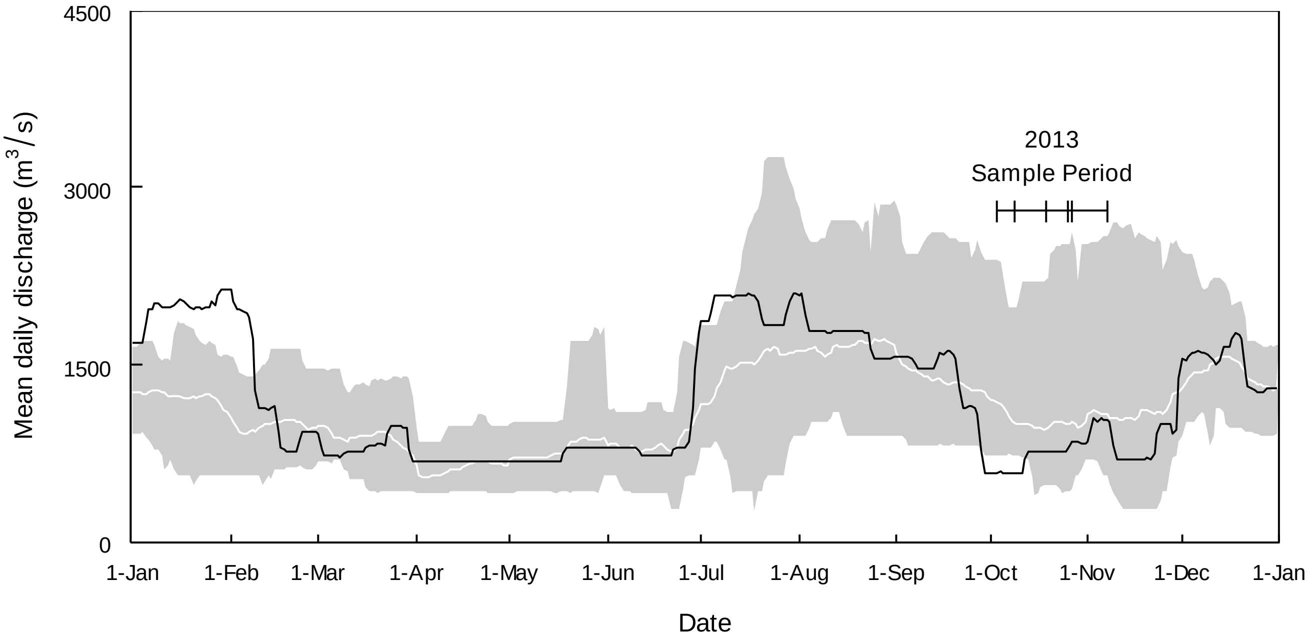

Figure 3: Mean daily discharge (m^3/s) for the Columbia River at Hugh L. Keenleyside Dam, 2013 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2012. The white line represents average mean daily discharge values over the same time period.

3.1.1.2 Temperature

Water temperature in the Columbia River in 2013 was similar to average values from 2011 to 2012 (Figure 4). During the 2013 sample period, water temperatures were near average, and declined throughout the sample period as in previous years (Appendix D, Figure D3). Spot temperature readings for the Columbia River taken at the time of sampling ranged between 8.9°C and 13.4°C (Appendix B, Table B3).

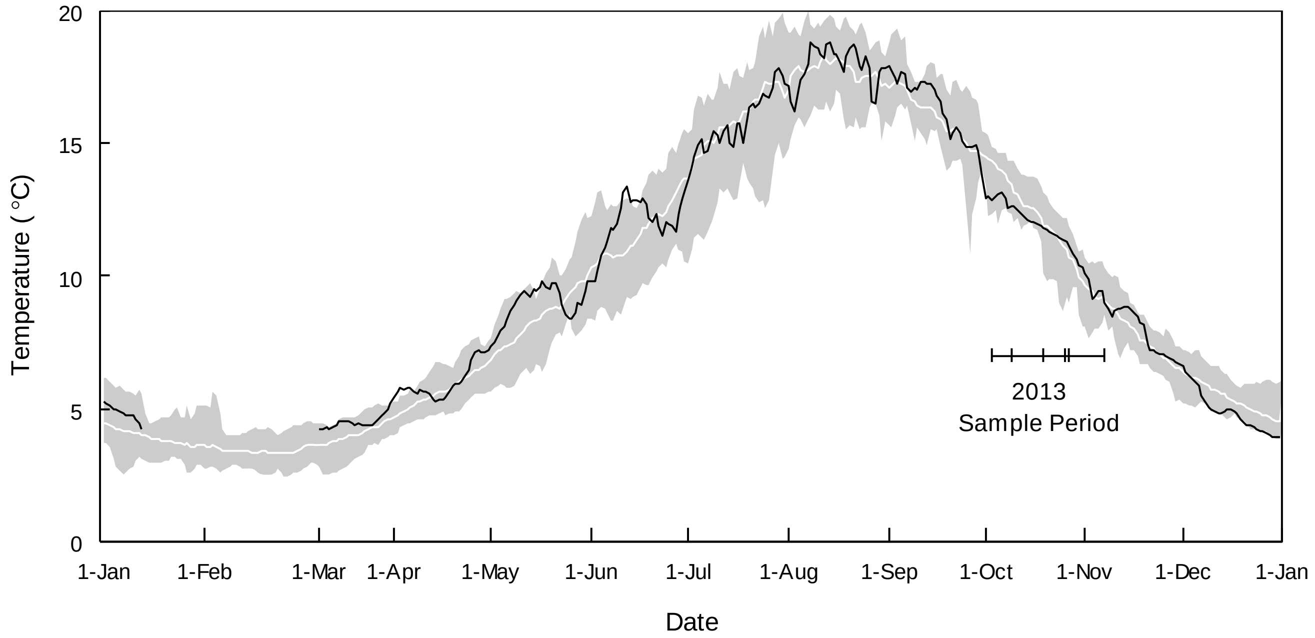

Figure 4: Mean daily water temperature (°C) for the Columbia River at the Birchbank water gauging station, 2013 (black line). The shaded area represents the minimum and maximum mean daily water temperature values from 2001 to 2012. The white line represents the average mean daily water temperature during the same time period.

3.1.2 Kootenay River

3.1.2.1 Discharge

In 2013, mean daily discharge in the Kootenay River downstream of BRD was similar to average values from 2001 to 2012 for most of the year (Figure 5; Appendix D, Figure D4). The exception was that discharge was greater than average during most of May, June and July. During the sample period in October and early November, discharge was very similar to the average values from 2001 to 2012.

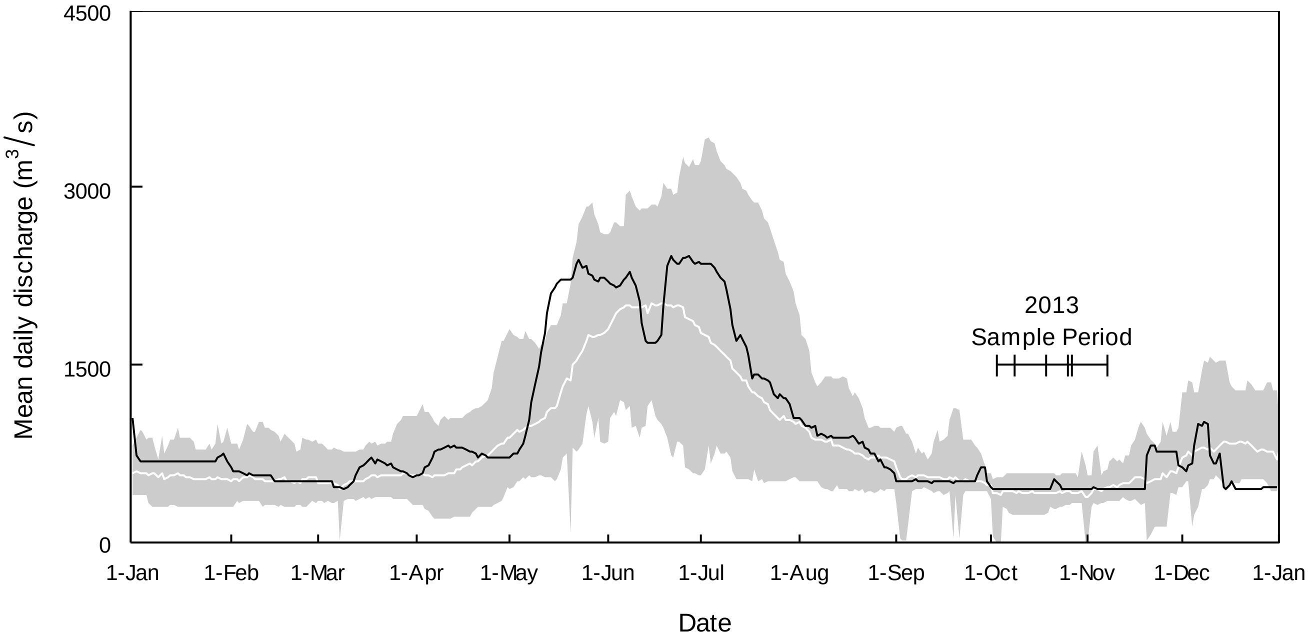

Figure 5: Mean daily discharge (m^3/s) for the Kootenay River at Brilliant Dam (BRD), 2013 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2012. The white line represents average mean daily discharge values over the same time period.

3.1.2.2 Temperature

In most previous sample years, water temperatures in the Kootenay River (downstream of BRD) generally increased from mid-February to mid-August and decreased from mid-August to mid-February (Appendix D, Figure D5). In 2013, water temperatures in the Kootenay River were near average from January through April and above average in May (Figure 6). Water temperature data for the Kootenay River were not available for June through December 2013 because of malfunctioning temperature loggers. Spot temperature readings for the Kootenay River taken at the time of sampling ranged between 9.8°C and 14.0°C (Appendix B, Table B3).

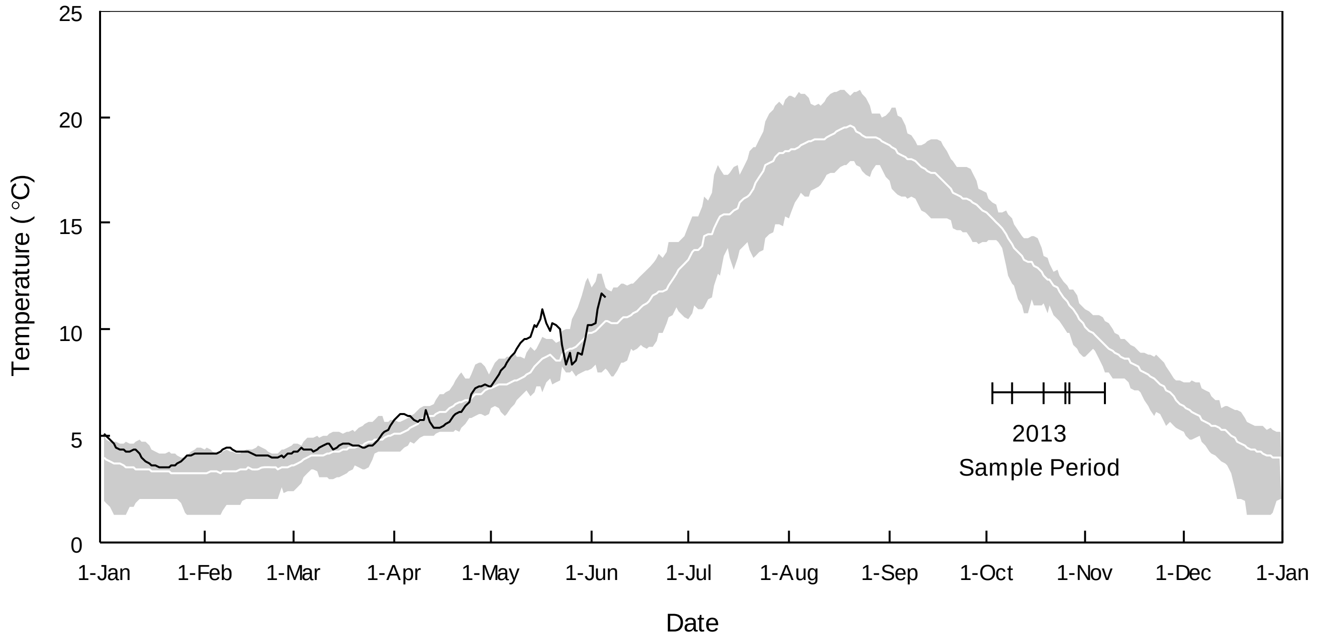

Figure 6: Mean daily water temperature (°C) for the Kootenay River downstream of Brilliant Dam (BRD), 2013 (black line).The shaded area represents minimum and maximum mean daily water temperature values recorded at the dam from 2001 to 2012. The white line represents average mean daily water temperature values over the same time period. Data from June 6 to December 31were not available due to a temperature logger malfunction.

3.1.3 Habitat Variables

Reach habitat descriptions for the LCR are provided by Golder (2002). Habitat data collected since 2001 indicates that a gradual increase in aquatic vegetation (dominantly Eurasian watermilfoil; *Myriophyllum spicatum*) has occurred in low water velocity areas throughout the LCR (Appendix B, Table B3). Sites with higher water velocities continue to support low levels of aquatic vegetation. Although aquatic vegetation cover data were not recorded during programs conducted in the early 1990s (R.L.&L. 1995), vegetation was not a common cover type in any sections of the LCR (L. Hildebrand, Golder Associates Ltd., pers. comm.).

3.2 Catch

In total, 107 741 fishes were recorded in the LCR in 2013. (Appendix E, Table E1). This total included both captured fishes, and observed fishes that were identified to species. Catch was greatest in the upstream section of the Columbia River (57% of the total catch), followed by the downstream section of the Columbia River (32%), and the Kootenay River (11%; Table 4).

Table 4: Number of fishes caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the LCR, October 2 to November 6, 2013.

Species	Columbia River Upstream		Kootenay River		Columbia River Downstream		All Sections	
	n[a]	%[b]	*n*[a]	%[b]	*n*[a]	%[b]	*n*[a]	%[b]
Sportfish								
Mountain Whitefish (*Prosopium williamsoni*)	2079	71	933	62	1868	34	4880	49
Rainbow Trout (*Oncorhynchus mykiss*)	580	20	405	27	3125	56	4110	41
Walleye (*Sanders vitreus*)	130	4	145	10	477	9	752	8
Brook trout (*Salvelinus fontinalis*)	8	<1	0	0	23	<1	31	<1
Brown Trout (*Salmo trutta*)	0	0	0	0	3	<1	3	<1
Bull Trout (*Salvelinus confluentus*)	2	<1	0	0	4	<1	6	<1
Burbot (*Lota lota*)	0	0	0	0	14	<1	14	<1
Cutthroat Trout (*Oncorhynchus clarki*)	0	0	0	0	2	<1	2	<1
Kokanee (*Oncorhynchus nerka*)	6	<1	0	0	12	<1	18	<1
Lake Whitefish (*Coregonus clupeaformis*)	18	1	12	1	41	1	71	1
Northern Pike (*Esox lucius*)	118	4	4	<1	3	<1	125	1
White Sturgeon (*Acipenser transmontanus*)	2	<1	2	<1	3	<1	7	<1
Sportfish Subtotal	2943	100	1501	100	5575	100	10019	100
Non-sportfish								
Dace spp.[c] (*Cyprinidae*)	0	0	0	0	0	0	0	0
Northern Pikeminnow (*Ptychocheilus oregonensis*)	325	1	46	<1	82	<1	453	<1
Peamouth (*Mylocheilus caurinus*)	10	<1	2	<1	0	0	12	<1
Redside Shiner (*Richardsonius balteatus*)	31668	55	2925	27	5558	19	40151	41
Sculpin spp.[c] (*Cottidae*)	16467	28	7335	68	20565	71	44367	45
Sucker spp.[c] (*Catostomidae*)	9447	16	460	4	2829	10	12736	13
Tench (*Tinca tinca*)	2	<1	0	0	0	0	2	<1
Yellow Perch (*Perca flavescens*)	1	<1	0	0	0	0	1	<1
Non-Sportfish Subtotal	57920	100	10768	100	29034	100	97722	100
All Species	60863	57	12269	11	34609	32	107741	100

[a] Includes fish observed and identified to species; does not include intra-year recaptured fish.

[b] Percent composition of sportfish or non-sportfish catch.

[c] Not identified to species or species combined for analysis.

3.3 Length-At-Age and Growth Rate

Outputs from the length-at-age model are presented in Table 5 and represent the most appropriate cut-offs between age-0 (fry), age-1 (subadult), and age-2 and older (adult) Mountain Whitefish and Rainbow Trout during each sample year. All Walleye were classified as adults by the HBMs. A comparison of von Bertlanffy growth curves for the three index species indicated that Rainbow Trout grew the fastest but reached their asympototic length at an earlier age compared to Mountain Whitefish and Walleye (Figure 7).

Table 5: Estimated minimum and maximum fork lengths (in mm) for each life stage by year for Mountain Whitefish and Rainbow Trout in the LCR, 1990 to 1991, 2001 to 2013. Estimates were derived from the length-at-age model (Section 2.2.3).

Year	Mountain Whitefish			Rainbow Trout		
	Fry	Subadult	Adult	Fry	Subadult	Adult
1990	≤156	157-250	≥251	≤150	151-338	≥339
1991	≤141	142-248	≥249	≤141	142-325	≥326
2001	≤136	137-224	≥225	≤126	127-315	≥316
2002	≤157	158-235	≥236	≤154	155-331	≥332
2003	≤160	161-238	≥239	≤161	162-340	≥341
2004	≤160	161-250	≥251	≤149	150-337	≥338
2005	≤168	169-256	≥257	≤168	169-352	≥353
2006	≤166	167-264	≥265	≤166	167-361	≥362
2007	≤171	172-260	≥261	≤169	170-366	≥367
2008	≤169	170-271	≥272	≤150	151-340	≥341
2009	≤165	166-261	≥262	≤151	152-342	≥343
2010	≤172	173-271	≥272	≤148	149-338	≥339
2011	≤162	163-261	≥262	≤152	153-345	≥346
2012	≤157	158-258	≥259	≤161	162-344	≥345
2013	≤176	177-274	≥275	≤172	173-361	≥362

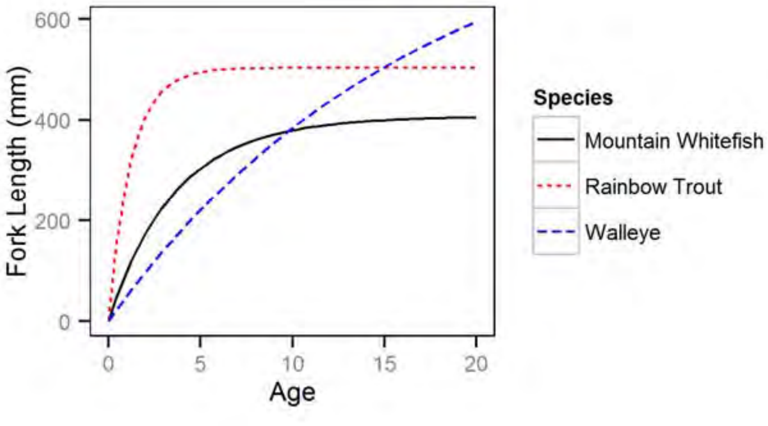

Figure 7: Growth curve showing length-at-age by species as predicted by the von Bertalanffy model for the LCR, 2001-2013.

3.3.1 Mountain Whitefish

The length-at-age models indicated annual variability in the mean length of Mountain Whitefish (Figure 8). Mountain Whitefish fry had the smallest mean fork lengths in 1991 and 2001 and increased in size from 2001 to 2003. Mountain Whitefish fry fluctuated between 110 and 130 mm FL between 2003 and 2013 (Figure 8). The growth of subadult (age-1) Mountain Whitefish, measured as the change in length-at-age compared to fry the previous year, generally increased between 2002 and 2013, except for two years of lower growth in 2010 and 2011 (right panel; Figure 8). The length of adult Mountain Whitefish (i.e., age-2 and older) is not presented here because this group consisted of multiple age-classes.

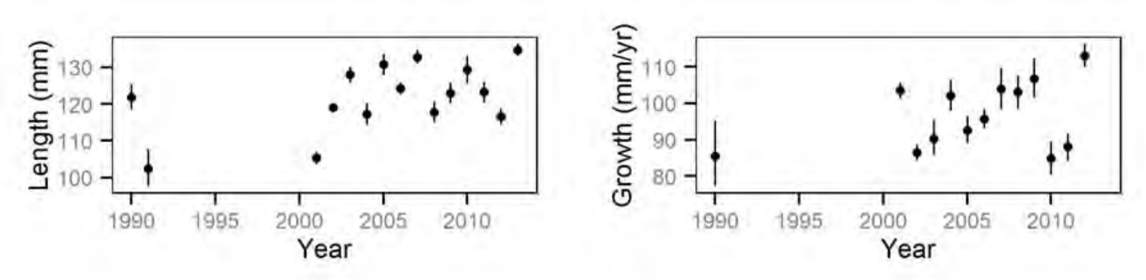

Figure 8: Length-at-age of fry (left) and fry to subadult growth (right) for Mountain Whitefish in the LCR, 1990 to 1991 and 2001 to 2013. Values are means with 95% CRIs.

Analysis of annual growth of recaptured individuals indicated an increase in average annual growth between 2002 and 2008, and variable annual growth between 2008 and 2013, although credible intervals overlapped between most estimates (Figure 9). The average annual growth was lowest between the 2011 and 2012 study years.

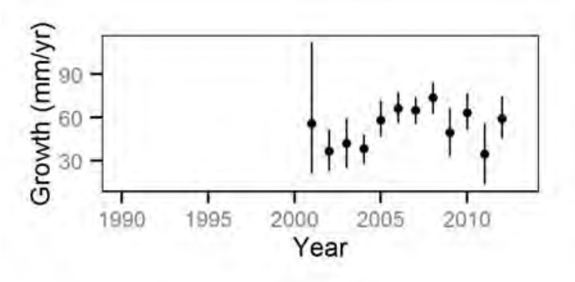

Figure 9: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Mountain Whitefish based on recaptured individuals in the LCR, 2001 to 2013.

3.3.2 Rainbow Trout

The length-at-age models indicated a gradual decrease in the average fork length of Rainbow Trout fry between 2005 and 2010 (left panel; Figure 10) followed by a rapid increase between 2011 and 2012. Rainbow Trout fry were significantly smaller in 2001 when compared to all other study years. This result is consistent with small size of fry Mountain Whitefish in 2001 (Figure 8). The inter-annual growth of subadult (age-1) Rainbow Trout, measured as the change in length-at-age compared to fry the previous year, fluctuated from ~130 to ~170 mm from 2001 to 2006 then steadily increased from 2007 to 2013 (right panel; Figure 10). Length-at-age was not assessed in detail for adult Rainbow Trout (i.e., age-2 and older) because this group consisted of multiple age-classes.

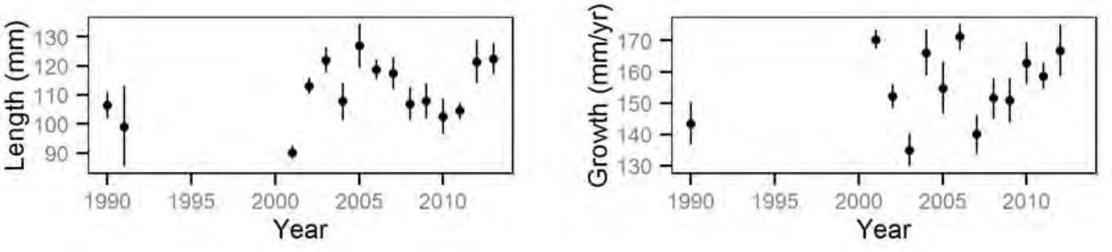

Figure 10: Length-at-age of fry (left) and fry to subadult growth (right) for Rainbow Trout in the LCR, 1990 to 1991 and 2001 to 2013.Values are means with 95% CRIs.

Analysis of annual growth of recaptured individuals indicated slower growth from 2002 to 2004 when compared to later study years (Figure 11). Growth generally declined from 2006 to 2013. Overall, annual growth for this species was variable and changed up to 25% during a one year period.

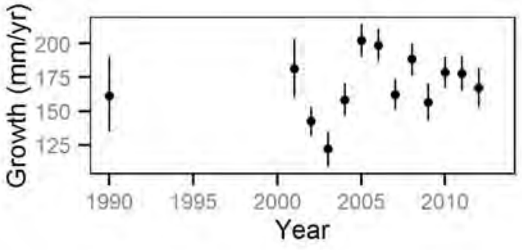

Figure 11: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Rainbow Trout based on recaptured individuals in the LCR, 2001 to 2013.

3.3.3 Walleye

Analysis of annual growth of recaptured Walleye indicated variable growth rates for this species; however, credible intervals overlapped for many of the estimates (Figure 12). Annual growth increased from 2001 to 2006, followed by several years of lower growth from 2009 to 2011. Mean growth was greater in 2013 than all previous years, although uncertainty in this estimate was large (Figure 12).

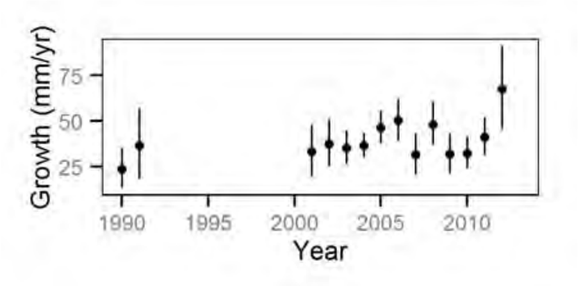

Figure 12: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Walleye based on recaptured individuals in the LCR, 2001 to 2013.

3.3.4 Length Bias

The length bias model used the length-frequency distribution of captured fish to estimate the bias in the estimated lengths of observed fish. The results suggested that observers underestimated fork lengths for all three index species (Figure 13). The bias was similar between observers and for both Mountain Whitefish and Rainbow Trout, with underestimates of approximately 15% (Figure 14). Bias in estimated Walleye fork lengths was lower (~10%). Estimates of observer bias were used to correct estimated fork lengths before classifying fish into age-classes for abundance analyses.

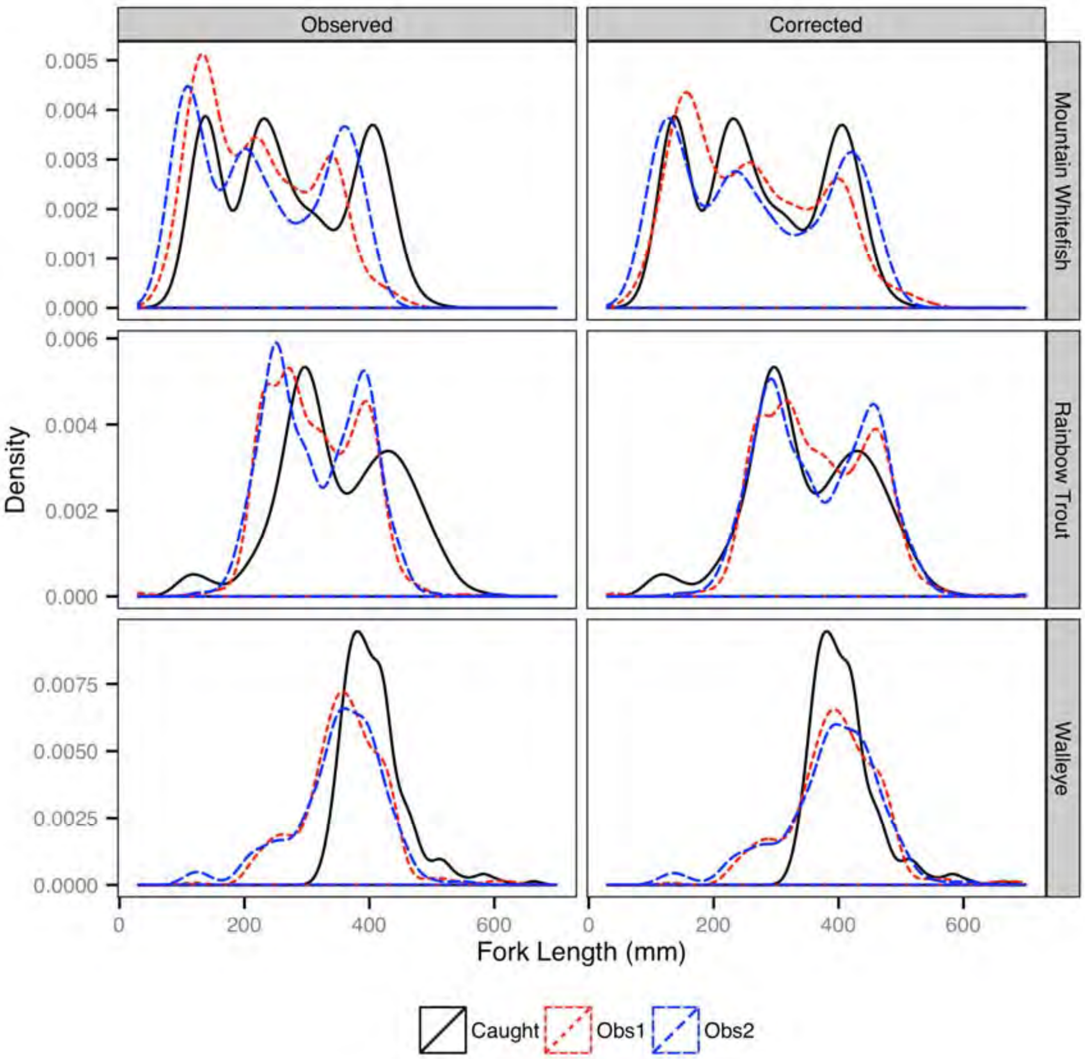

Figure 13: Fork length-density plots for measured and estimated fork lengths of fish caught or observed in the LCR, 2013.

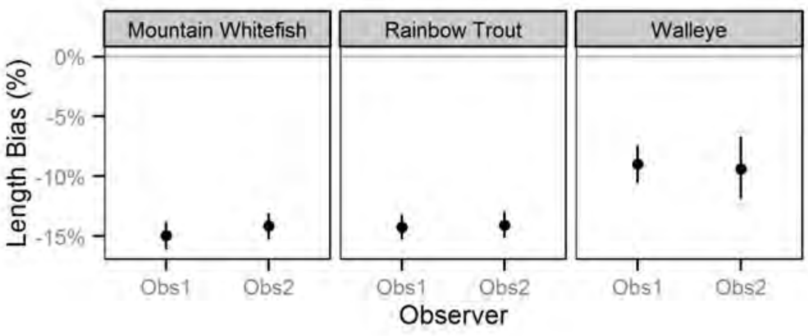

Figure 14: Bias in observer estimated fork lengths of index species based on length bias model of captured (mark-recapture surveys) and estimated (geo-referenced visual surveys) length-frequency distributions from the LCR, 2013.

3.4 Spatial Distribution and Abundance

3.4.1 Site Fidelity

Site fidelity was high (>75%) for Rainbow Trout and Walleye smaller than 200 mm FL but decreased with increased length for both species (Figure 15). However, the effect of length on site fidelity was only statistically significant for Rainbow Trout (*P*<0.001) and not for Walleye (*P*=0.3). Site fidelity was approximately 50% for Mountain Whitefish and did not vary significantly by length (*P*=0.8).

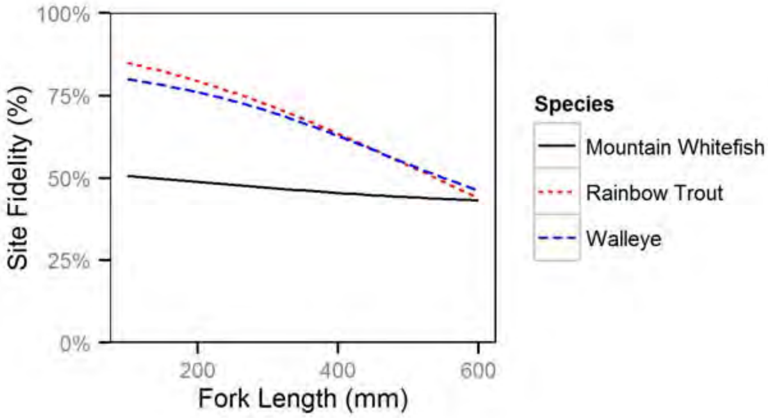

Figure 15: Site fidelity, defined as the expected probability that a fish is recaptured at the same site where it was marked, by species and fork length in the LCR, 2001 to 2013.

3.4.2 Efficiency

Estimated capture efficiency was greatest for Rainbow Trout and lowest for Mountain Whitefish (Figure 16). Capture efficiency was lower for adult than subadult Rainbow Trout but similar between subadult and adult Mountain Whitefish. For most species and age-classes, capture efficiency was similar among sampling sessions and years without any apparent seasonal or temporal trends (Appendix G, Figures G1-G5). One exception was that in some but not all years, the capture efficiency of subadult Rainbow Trout and Walleye decreased in subsequent sample sessions (Appendix G, Figures G3 and G5). Estimates of capture efficiency were used to estimate total abundance in the sample sites (Section 3.4.3)

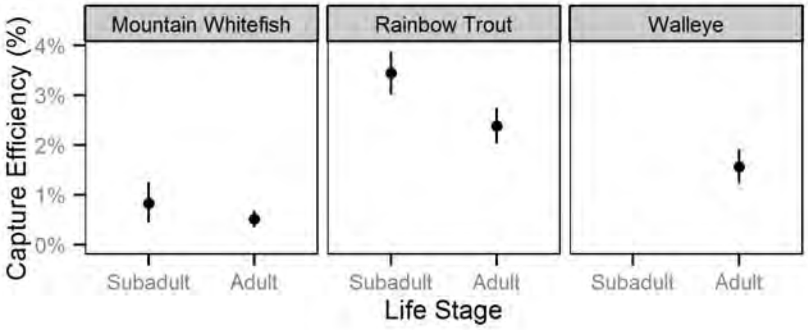

Figure 16: Capture efficiency (mean with 95% CRIs) by species from mark-recapture data from the LCR, 2001-2013.

The count efficiency represents the estimated percentage of fish present at a site that were counted during geo-reference visual enumeration surveys, and was calculated based on the ratio of counted (geo-referenced visual surveys) to captured fish (mean of all sessions of mark-recapture). The count efficiency (Figure 17) showed very similar trends to the capture efficiency (Figure 16) with the lowest efficiency for Mountain Whitefish, the greatest efficiency for Rainbow Trout, and greater efficiency for subadult than adult Rainbow Trout. The model parameter representing counts (labelled “bType[2]” in Appendix C) ranged from 4 to 5.9 for the different species and age-classes , indicating that the number of fish observed during enumeration surveys was approximately 4 to 6 times the number of fish captured at each site, which is also illustrated by the difference in efficiencies shown in Figures 16 and 17.

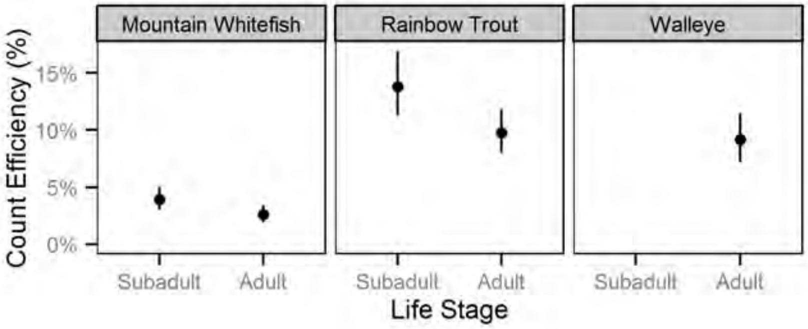

Figure 17: Count efficiency (mean with 95% CRIs) by species from geo-referenced visual enumeration surveys on the LCR, 2001-2013.

3.4.3 Mountain Whitefish

The estimated abundance of subadult Mountain Whitefish in index sites in the LCR decreased from ~90,000 in 2001 to <20,000 in 2005. Subadult abundance increased in 2006-2007 and 2010-2013 but remained much lower than the abundance estimated for the early 2000s and 1993 to 1994. The abundance of adult Mountain Whitefish was much greater in the early 1990s (~346,000-988,000) than any time since 2001 (~84,000-267,000). Estimates suggested a steady decline in abundance of adult Mountain Whitefish between 2001 (>200,000) and 2012 (~84,000).

The density of both subadult and adult Mountain Whitefish was highest near the confluence of the Columbia and Kootenay rivers and lowest near the Canada-US border (Figure 19). Subadult Mountain Whitefish densities were highest in low water velocity areas, such as Balfour Bay (RKm 2.8), just downstream of the log booms near Zelstoff-Celgar (both banks; RKm 4.5), upstream and downstream of Norn's Creek Fan (RKm 7.4), and along the left bank between Waldie Island and Tin Cup Rapids (RKm 9.2; Figure 19). In comparison, subadult Mountain Whitefish densities were low in the Kootenay River and in the Columbia River downstream of the Kootenay River confluence, river sections which typically have higher water velocities.

Adult Mountain Whitefish site-level density estimates (Figure 19) had larger credible intervals than estimates generated for subadult Mountain Whitefish. However, estimates were generally higher in sites known to contain suitable spawning habitat for this species. These areas include Norn's Creek Fan (RKm 7.4) downstream to CPR Island, the Kootenay River, between the Kootenay River confluence (RKm 10.6) and Kinnaird Bridge (RKm 13.4), the Genelle area (RKm 27.0), and upstream of Fort Shepherd Eddy (RKm 49.0).

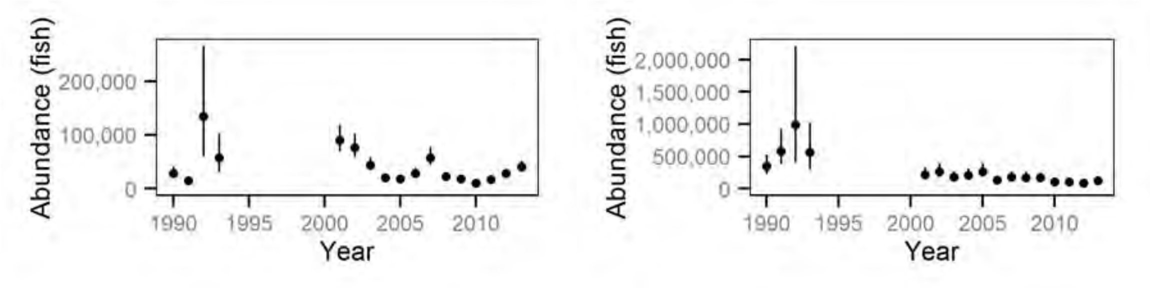

Figure 18: Abundance (means with 95% CRIs) of subadult (left) and adult (right) Mountain Whitefish at index sample sites in the LCR, 2001-2013.

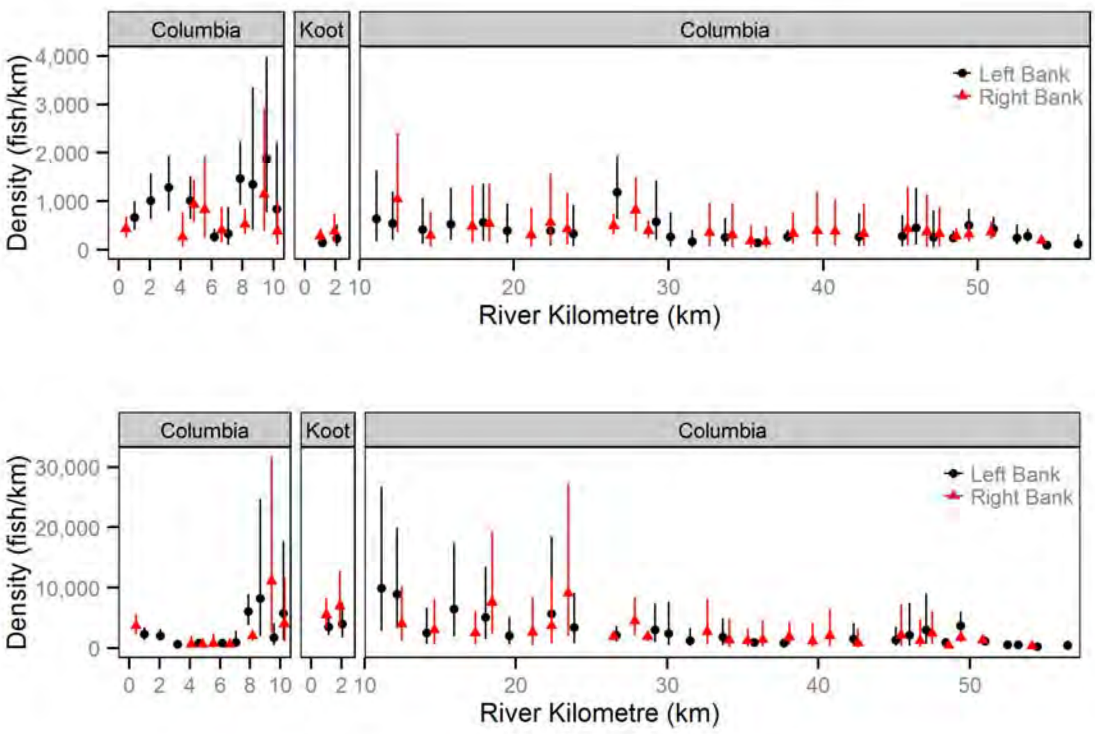

Figure 19: Density (means with 95% CRIs) of subadult (top) and adult (bottom) Mountain Whitefish by river kilometre in the LCR, 2001-2013.

3.4.4 Rainbow Trout

The estimated abundance of both subadult and adult Rainbow Trout increased between 1990 and 1992 (Figure 20). The abundance of subadault Rainbow Trout declined from 2001 to 2005 and fluctuated with no long-term increase or decrease from 2006 to 2013. Adult Rainbow Trout abundance generally increased between 2001 to 2013.

Rainbow Trout site-level density estimates had large credible intervals (Figure 21), particularly at sites that were only sampled in 2012 and 2013. Despite the uncertainty, the analysis suggests higher densities of subadult Rainbow Trout in most sites between the Kootenay River confluence (RKm 10.6) and Beaver Creek (RKm 47.8) than in other sections of the study area (Figure 21). The distribution of adult Rainbow Trout was similar to that of subadults with greater densities in the Columbia River between the Kootenay River confluence and the Beaver Creek confluence and lower densities in the Columbia River upstream of the Kootenay River confluence (Figure 21). Adult Rainbow Trout densities were substantially higher near the Bear Creek confluence (Site C44.7-R), between the Champion Creek and Jordan Creek confluences (Site C23.4-L), and immediately downstream of the Kootenay River confluence (both banks; Sites C10.7-R and C10.9-L) when compared to neighbouring sites.

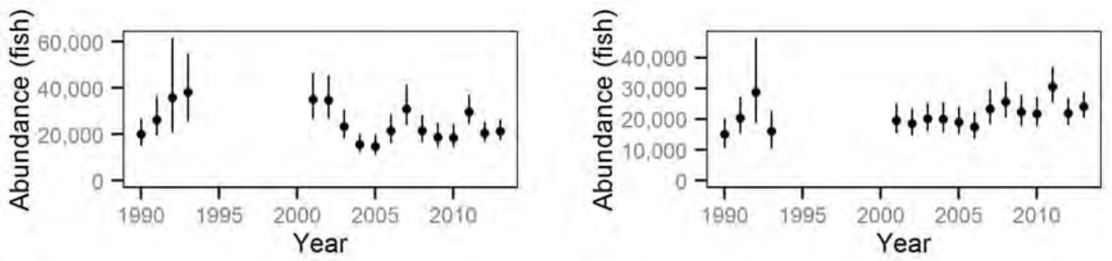

Figure 20: Abundance (means with 95% CRIs) of subadult (left) and adult (right) Rainbow Trout at index sample sites in the LCR, 2001-2013.

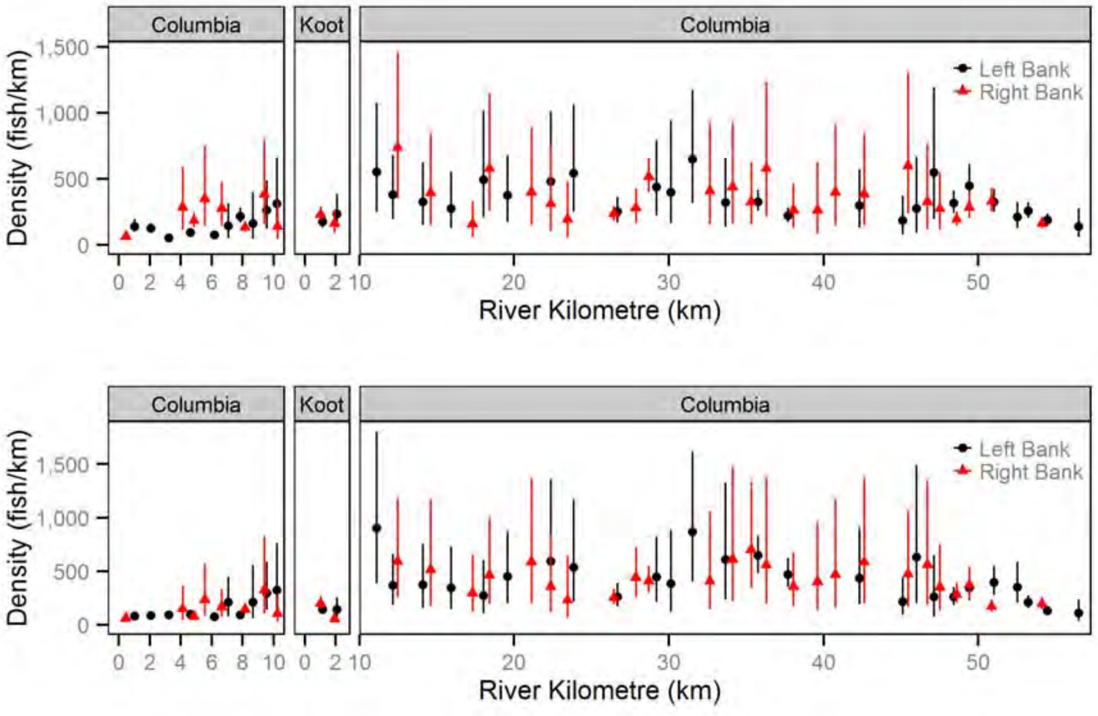

Figure 21: Density (means with 95% CRIs) of subadult (top) and adult (bottom) Rainbow Trout by river kilometre in the LCR, 2001-2013.

3.4.5 Walleye

Estimates of adult Walleye abundance were greater in the early 1990s than from 2001 to 2013, although credible intervals for the 1990s estimates were large (Figure 22). Since 2001, Walleye abundance has fluctuated with peaks in 2004 and 2011 but declined from 2011 to 2013.

Density estimates for Walleye were greatest in the Kootenay River, at the three sites closest to HLK, and at the site adjacent to the Canada-US border (56.0-L; Figure 23). Density estimates for all other areas were similar and did not suggest differences in Walleye densities among sites. The density at synotic sites sampled during the GRTS survey (not sampled prior to 2001) was comparable to the density at index sites.

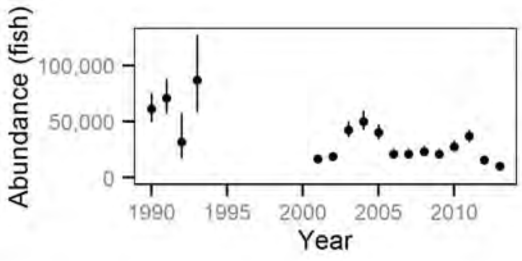

Figure 22: Abundance (means with 95% CRIs) of adult Walleye at index sample sites in the LCR, 2001-2013.

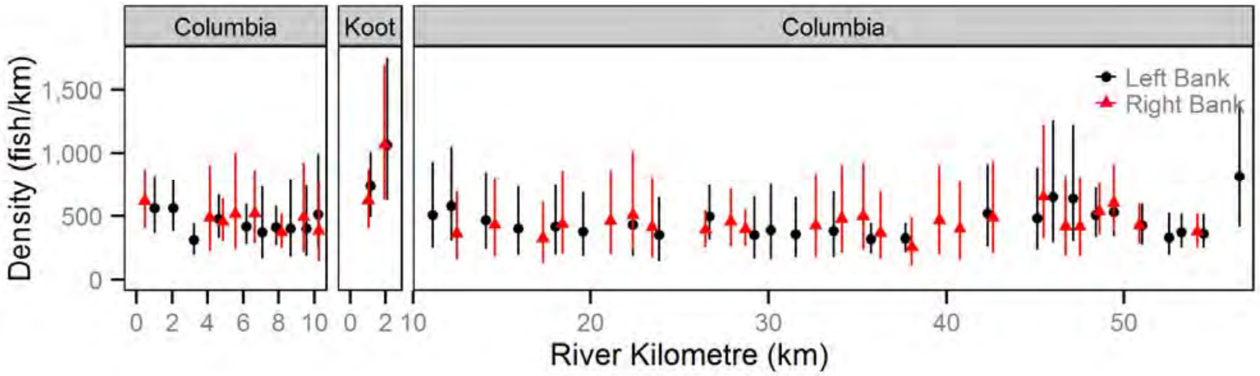

Figure 23: Density (means with 95% CRIs) of adult Walleye by river kilometre in the LCR, 2001-2013.

3.4.6 Geo-referenced Visual Enumeration Surveys

The results show positive relationships between counts of fish during the visual surveys and catches during mark-recapture surveys at the same sites (Figure 24). There appeared to be more variability, indicating a less consistent relationship between count and catch, at higher abundances for Mountain Whitefish and Rainbow Trout. For adult Rainbow Trout and Walleye, the predicted values overestimated mean catches at sites where counts were the largest. The opposite was true for Mountain Whitefish, as the predicted values underestimated catch at most sites with large counts.

Figure 24 shows the mean catches from all four mark-recapture sessions versus the counts from the visual surveys. Exploratory analyses also included comparing catches from the first mark-recapture session to visual survey counts in case potential changes in capture efficiency or avoidance behaviour by fishes affected the relationship in subsequent weeks of electrofishing. The results indicated a very similar relationship (data not shown) regardless of whether the mean catch of all sessions, or only first session data were used. Therefore, the mean of all mark-recapture sessions was presented to better utilize the complete data-set.

The plots in Figure 24 are not intended to provide predictive models but represent preliminary exploration of relationships between the two methods. Further analysis and calibration of the two methods is recommended after additional years of data are collected using both mark-recapture and visual surveys.

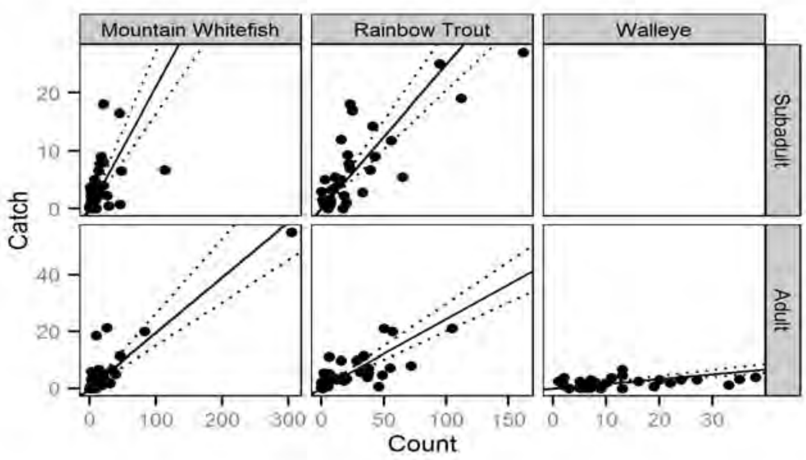

Figure 24: Comparison of counts of observed fish during visual surveys to catch during mark-recapture surveys in the LCR, 2013. Points are the mean number of captured fish during four mark-recapture sessions versus the counts during the geo-referenced visual surveys in 2013. The solid line is the parameter in the abundance model that represents the count:catch efficiency and the dotted lines are its 95% CRIs (Section 2.2.8).

The visual surveys also provided data regarding the within-site distribution of fishes in the LCR. Maps showing the observed densities of the three index species by age-class distributed throughout sample sites are provided as an example of the spatial dataset (Appendix H). This type of map can be used to identify important fish habitats, and compared to future years to assess the effects of flow regime variations on fish distribution and habitat usage.

3.5 Survival

3.5.1 Mountain Whitefish

Inter-annual survival estimates for subadult Mountain Whitefish had wide credible intervals and did not indicate substantial changes since 2001 (left panel; Figure 25). For adult Mountain Whitefish, annual survival estimates varied from 34% to 83%, but generally increased between 2001 and 2012, although with substantial year-to-year variations and large estimate uncertainties (Figure 25). Survival estimates were greater for adult Mountain Whitefish (34 to 83%) than for subadults (15 to 39%). Survival estimates for Mountain Whitefish were less precise than corresponding estimates for Rainbow Trout (see Section 3.5.2).

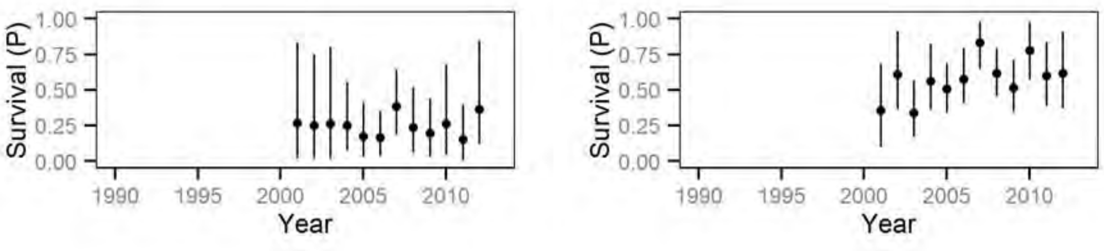

Figure 25: Survival estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Mountain Whitefish in the LCR, 2001-2013.

3.5.2 Rainbow Trout

Estimated inter-annual survival for subadult Rainbow Trout remained stable between 47% and 60% from 2001 to 2011, but declined to 38% between 2011 and 2012, and was 44% from 2012 to 2013 (Figure 26). The survival of adult Rainbow Trout increased gradually from 27% in 2002 to 58% in 2011, but sharply declined to 30% in 2012 and 2013. On average, survival was slightly greater for subadult Rainbow Trout than adults (Figure 26).

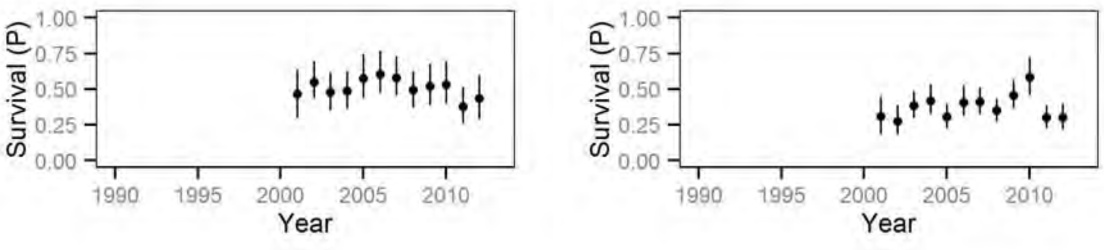

Figure 26: Survival estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Rainbow Trout in the LCR, 2001-2013.

3.5.3 Walleye

Inter-annual survival could not be estimated for Walleye for individual years due to insufficient data. The estimated inter-annual survival from 2001 to 2013 combined was 51% (credible interval = 42 to 58%).

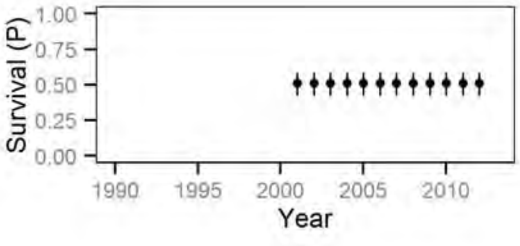

Figure 27: Survival estimates (mean with 95% CRIs) for adult Walleye in the LCR, 2001-2013.

3.6 Body Condition

3.6.1 Mountain Whitefish

The body condition of subadult Mountain Whitefish varied little (≤ 2%) from 2006 to 2013 (left panel; Figure 28). Adult Mountain Whitefish body condition increased from 2003 to 2006, then decreased from 2006 to 2008, and was stable from 2009 to 2013 (right panel; Figure 28). Adult body condition was much lower in the 1990s than between 2001 and 2013, with effect sizes of 9-16% lower than a typical year.

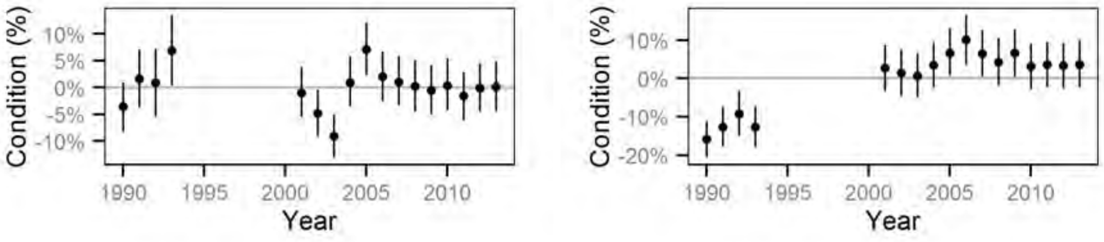

Figure 28: Body condition effect size estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Mountain Whitefish in the LCR, 1990 to 1993 and 2001 to 2013.

3.6.2 Rainbow Trout

The body condition of subadult and adult Rainbow Trout was substantially higher in 2002 and 2006 compared to other study years (Figure 29). For subadults, body condition increased from 2003 to 2006, decreased from 2006 to 2011, and increased from 2011 to 2013. However, credible intervals for most estimates overlapped, indicating that interannual differences were not statistically significant. The body condition of adult Rainbow Trout was similar in all study years, except for the higher values observed in 1993, 2002, and 2006.

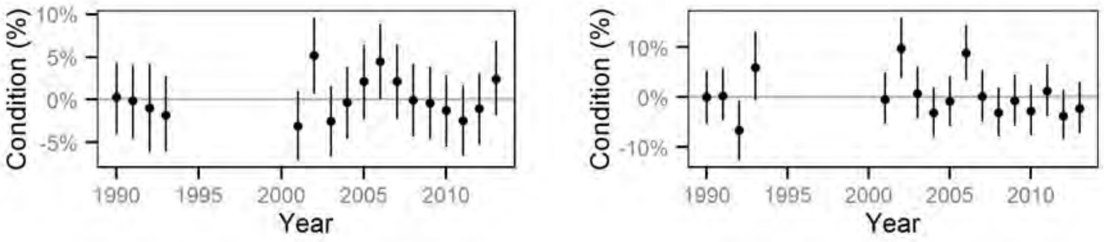

Figure 29: Body condition effect size estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Rainbow Trout in the LCR, 1990 to 1993 and 2001 to 2013.

3.6.3 Walleye

Walleye body condition fluctuated with no consistent trend since the early 1990s (Figure 30). Body condition estimates in 2012 and 2013 were greater than most previous years. Overall, the results suggest relatively little temporal change in the body condition of Walleye since 2001.

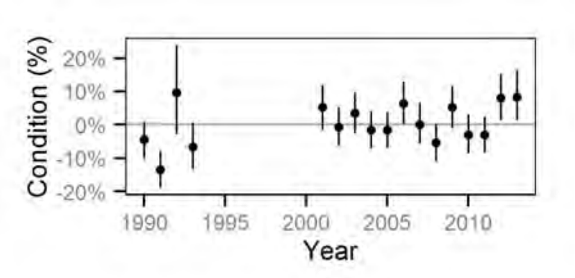

Figure 30: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for Walleye in the LCR, 1990 to 1993 and 2001 to 2013.

3.7 Environmental Analyses

Multivariate analyses were used to assess relationships between the environmental and fish population variables. Dynamic factor analysis reduced the 12 seasonal environmental time series and 14 fish indexing time series to two common trends (Figure 31). Trend 1 decreased from 2001 to 2005 and was fairly stable from 2005 to 2013. Trend 2 increased from 2001 to 2007 and again from 2010 to 2012. Figure 32 shows the standardised values of the environmental and fish indexing time series along with the predicted values and credible intervals produced by the dynamic factor analysis. Weightings of the time series variables on the common trends (Figure 33) indicate that trend 1 was most strongly associated with the abundance of subadult Mountain Whitefish and Rainbow Trout (positive relationship, “+”) and the condition of Mountain Whitefish (subadults and adults; negative relationship, “-“). The environmental variables most strongly associated (all +) with trend 1 were discharge difference in spring (April to June), mean discharge in fall (October to December), and mean water temperature (January to March, July to September, and October to December). The interpretation is that these environmental variables followed similar trends as the fish population variables that were also associated with trend 1.

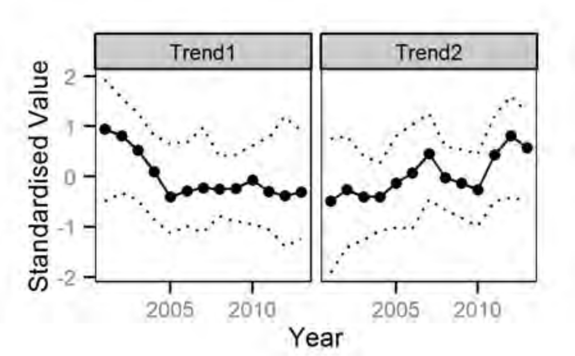

Figure 31: Predicted values (with 95% CRIs) of common trends in the fish and environmental time series variables from the LCR, 2001-2013.

Trend 2 was most strongly associated with the growth of Rainbow Trout and Walleye (both +), the condition of Walleye (+), and the survival of adult Mountain Whitefish (+) and subadult Rainbow Trout (-). The environmental variables most strongly associated with trend 2 were mean discharge (January to March, April to June, and July to September; all +) and mean water temperature (January to March, July to September, and October to December; all -).

Non-metric multi-dimensional scaling was used to visualize the relationships among fish and environmental variables. The underlying values in Figure 34 are based on the absolute values of the weightings from the dynamic factor analysis. High (absolute) correlations, indicated by closeness of points on the figure, can be interpreted as variables that followed similar inter-annual trends. The direction of the relationships (positive or negative) between the variables and the common trends is shown in Figure 33. Figure 34 corroborates and illustrates the trends already discussed based on Figure 33. For example, there was a negative association between the condition of Mountain Whitefish, and the abundance of subadult Mountain Whitefish and Rainbow Trout, and these trends were correlated with discharge difference in spring, mean discharge in the fall, and water temperature (all clustered in the upper right of Figure 34). The results suggested relationships between discharge difference (winter and summer) and several metrics of growth, survival, and condition for Mountain Whitefish and Rainbow Trout (clustering in bottom right of Figure 34). There were also relationships between the growth of Walleye and summer water temperatures, and adult Mountain Whitefish survival and winter water temperature (center-left of Figure 34).

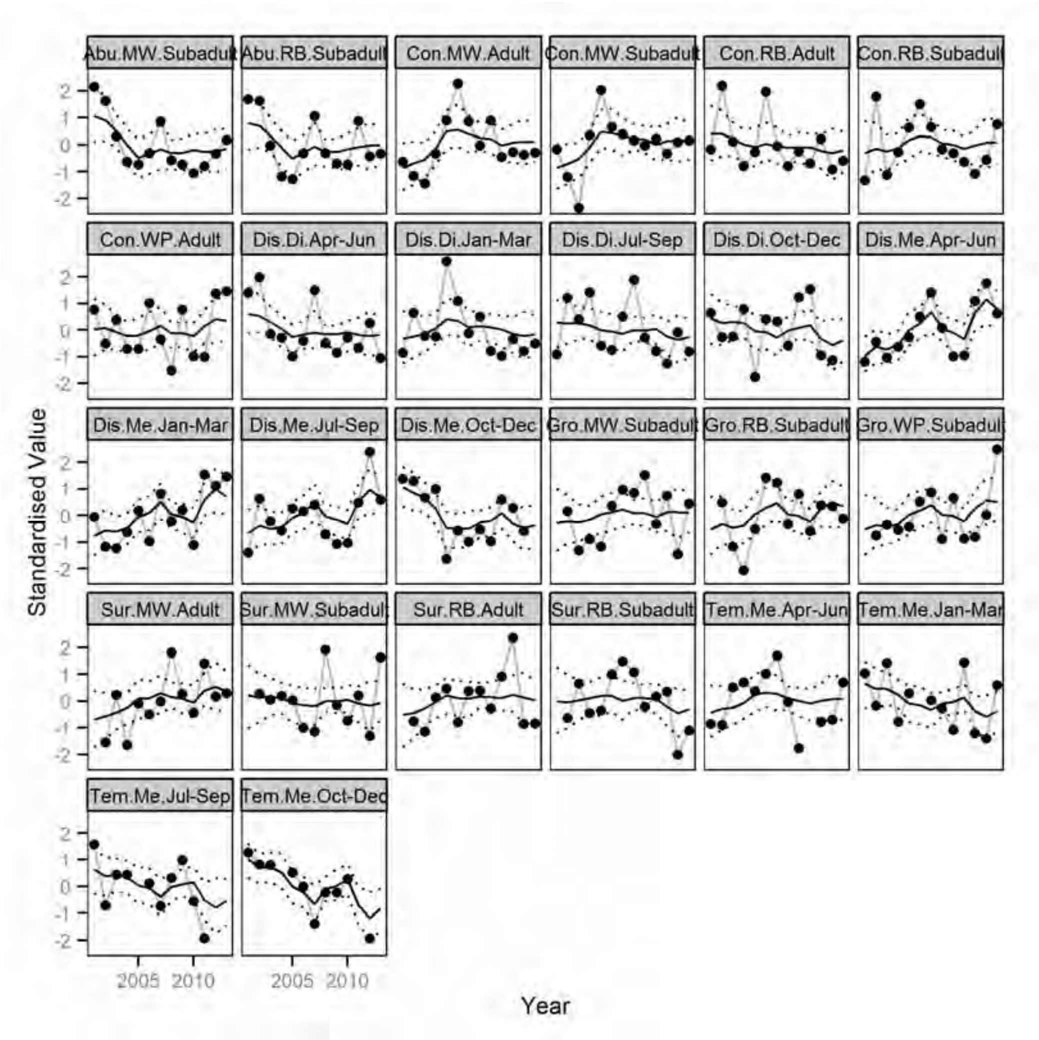

Figure 32: Environmental and fish index time series in the LCR, 2001-2013. Black points are standardised values of the variables and the thicker black line represents predicted values (with 95% CRIs as dotted lines) from the dynamic factor analysis.

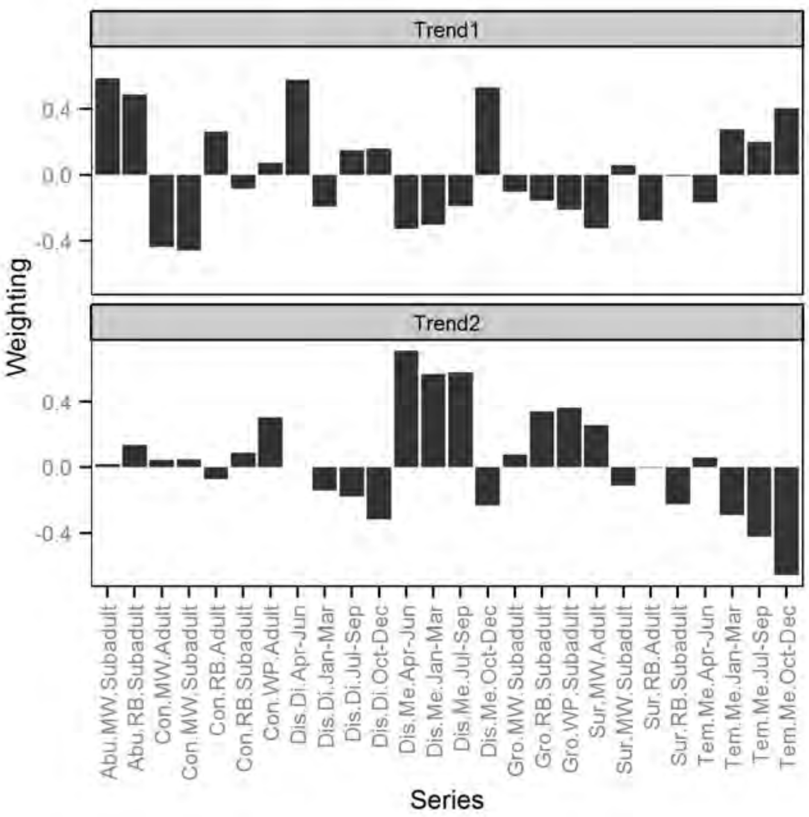

Figure 33: Weightings of the fish and environmental time series variables on the two common trends identified by dynamic factor analysis.

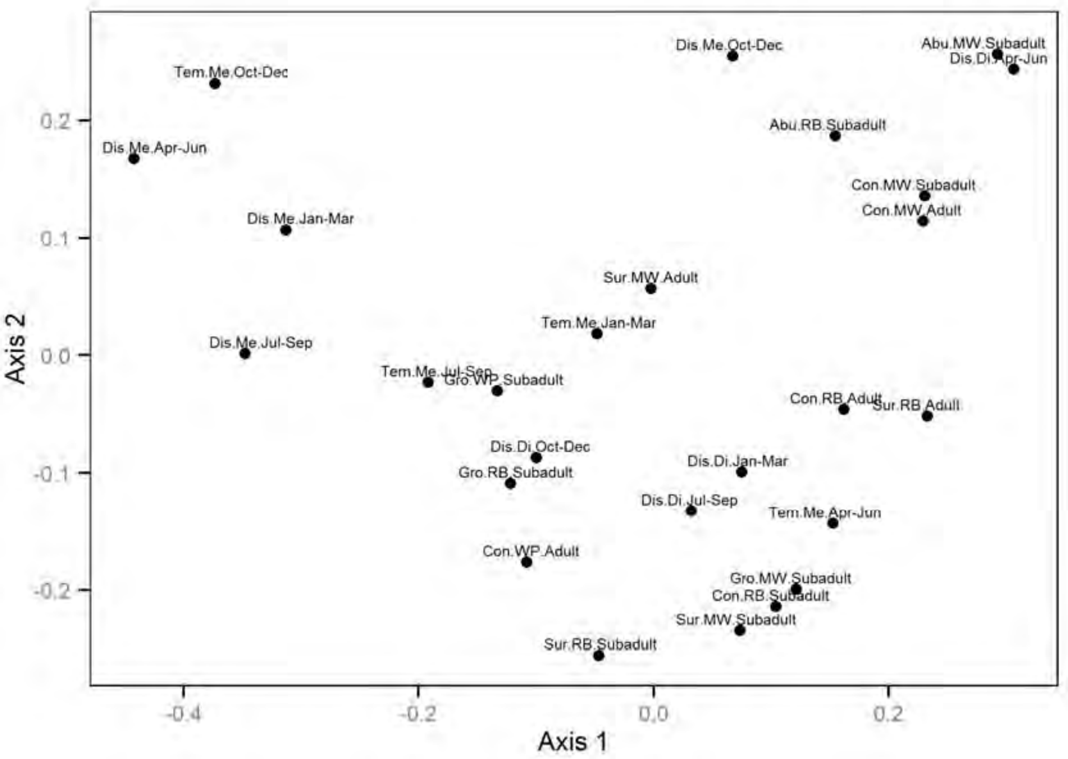

Figure 34: Non-metric multidimensional plot showing clustering of time series variables based on the absolute values of the dynamic factor analysis trend weightings. Proximity of points on the plot indicates variables that followed similar time trends and the direction of the correlation is shown in in Figure 30.

3.8 Other Species

Northern Pike (*Esox Lucius*) were first observed during the LCR fish indexing program in 2010, and the numbers captured and observed have increased in each successive year since then (Table 6). A total of 135 Northern Pike were captured or observed in the study sites in 2013. All of the Northern Pike were recorded in the Columbia River upstream of the Kootenay River confluence. As requested by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO; J. Burrows, pers. comm.), all captured Northern Pike were killed.

Table 6: Number of Nothern Pike captured and observed in the Lower Columbia River Fish Population Indexing program by year.

Year	# Observed	# Captured	Total #
Prior to 2010	0	0	0
2010	3	4	7
2011	1	8	9
2012	10	1	11
2013	90	45	135

In 2013, 15 Burbot were recorded in the LCR, which was within the range recorded between 2001 and 2012 (minimum = 3; maximum = 285. Although Burbot have been recorded in all portions of the study area, in 2013, 87% of all Burbot were recorded downstream of RKm 40, and 100% were downstream of RKm 30.

Nine White Sturgeon (5 adults and 4 juveniles) were recorded (all observed; none captured) during the 2013 survey. Observational information for these fish is provided in Attachment A.

The number of Redside Shiner (*Richardsonius balteatus*) recorded in 2013 (40151; Table 4) was greater than in any previous study year since 2001 and more than seven times the number recorded in 2012 (5280; Golder and Poisson 2013a). Most Redside Shiner were recorded in the section of the Columbia River upstream of the Columbia-Kootenay confluence.

4.0 DISCUSSION

The status of each of the specific management questions and hypotheses to be addressed by CLBMON-45 is summarized in the Executive Summary under Table I.

4.1 Length-At-Age and Growth

4.1.1 Mountain Whitefish

Length-at-age models for fry and subadult Mountain Whitefish suggested increased growth between 2001 and 2007. Growth of Mountain Whitefish based on the model using inter-year recaptures also increased between 2002 and 2007. This period of increasing length-at-age and growth corresponded with declining abundance of subadult and adult Mountain Whitefish, which suggested an inverse relationship between abundance and growth. Density-dependent growth suggests there may be competition for food, habitat or other resources when the abundance of subadult Mountain Whitefish is high in the LCR. Body condition (a short-term proxy for growth) also was greater in 2005 when abundance was low.

Mountain Whitefish fry growth may also be related to water levels. In 2001, when Mountain Whitefish fry length was the smallest of all years, discharge was very low during the spring/summer season when compared to other study years; water temperatures also were lower than normal. Naesje et al. (1995) noted that the hatching of Mountain Whitefish eggs can be delayed due to a lack of a thermal, chemical, and/or mechanical stimulus on the eggs. Lower discharges in 2001 may have delayed hatching, which would have reduced the amount of time that fry could have grown between emergence and the fall sample season. Another possibility is that lower discharges in 2001 resulted in less nutrients entering the system from upstream sources (i.e., Arrow Lakes Reservoir and Kootenay Lake), which would, in turn, have resulted in less food available to Mountain Whitefish fry. Mountain Whitefish fry also were smaller than average in 2004 and 2008; discharge during the spring/summer was lower than average in these two years.

While lower discharges during the spring/summer months may reduce the growth of Mountain Whitefish fry, higher discharges did not appear to result in higher growth rates. During the three study years in which Mountain Whitefish fry size-at-age were the highest (i.e., 2005, 2007, and 2010), discharge was near average. In 2012 and 2013, when flows during the summer were much higher than average (Appendix D, Figure D1), growth of subadults was ~20 mm less than previous and subsequent years (Figure 8). During high discharge years, growth could be lower because of greater energy expenditures from swimming in the higher water velocities, relative to a year with lower discharge. Overall, the results suggest that very low (e.g. 2001) and very high discharges (e.g., 2011 and 2012) may lead to reduced growth of juvenile Mountain Whitefish in the LCR, and optimal growth may occur at intermediate discharges.

Multivariate analyses suggested that variability in discharge may also influence growth. The growth of Mountain Whitefish and the discharge difference (three of four seasonal periods) were positively correlated with trend 2, which suggested an association between growth and discharge variability in the LCR. The growth of Rainbow Trout and Walleye was also positively associated with discharge difference, which suggested that all three index species followed a similar time trend as the discharge difference time series. The weightings suggested that the shared trend was weaker for Mountain Whitefish and stronger for Rainbow Trout and Walleye (Figure 33). Greater growth during years with greater hourly flow variability was not expected. Greater flow variability has been associated with more frequent movements and greater energy use for other salmonid species (Scruton et al. 2008; Korman and Campana 2009). In contrast, Taylor et al. (2012) found in a study of Mountain Whitefish in the Columbia River near Revelstoke Dam that fluctuating flows were not more energetically costly than stable flows, which is consistent with the lack of a negative association between discharge difference and Mountain Whitefish in the LCR. Fluctuating flows may not have resulted in greater energy expenditures for Mountain Whitefish near Revelstoke Dam because fish may reduce energy costs by positioning themselves in lower velocity microhabitats (Taylor et al. 2012).

Among watersheds in Idaho, USA, Meyer et al. (2009) found that Mountain Whitefish growth was positively correlated with mean annual water temperature. The opposite relationship was suggested by our analysis for the LCR, as mean water temperatures were negatively associated with trend 2, and growth of Mountain Whitefish was weakly positively associated with trend 2 (Figure 33). Mountain Whitefish growth was most closely associated with water temperature in the spring (April to July; Figure 34). However, the low weighting of Mountain Whitefish growth does not support a strong relationship with water temperature in the LCR. Overall, water temperature was relatively similar among years (Appendix D, Figure D3), which suggested that inter-annual variation in discharge and dam operations did not result in very large variation in water temperature in the LCR, which could explain the failure to detect strong relationships with fish populations.

4.1.2 Rainbow Trout

Rainbow Trout grew quickly in the MCR compared to other species (Figure 7), with substantial inter-annual variability in annual growth that ranged from 122 to 202 mm between 2001 and 2013, respectively for a 200 mm individual (Figure 11). Length-at-age of fry, subadult growth based on length-at-age, and growth based on inter-annual recaptured did not show similar inter-annual trends. Fry length decreased from 2005 to 2010 while subadult length-at-age increased over much of that time period. Trends in length-at-age for fry and subadult Rainbow Trout may have been different because of different habitat or food preferences of these life stages.

The growth of Rainbow Trout based on interannual recaptures was positively associated with the hourly discharge difference for three of four quarterly periods but was most closely associated with the October to December time series (Figure 34). Discharge variability can result in greater energy expenditure for salmonids in rivers, which can reduce growth, as discussed in Section 4.1.1. On the other hand, increased discharge variability can increase the rates of drifting invertebrates available to drift-feeding fishes such as Rainbow Trout (Miller and Judson 2014).

As with Mountain Whitefish, Rainbow Trout fry were substantially smaller in 2001 when compared to other study years. The Rainbow Trout spawning season is protracted in the LCR; as a result, emergence for this species is variable and can occur over a wide time frame. However, peak emergence generally occurs around mid-July (Hildebrand and McKenzie 1995). The reduced size-at-age in 2001 was likely related to lower growth rates during the mid-July and mid-September period. Discharge in the LCR was below average during that time (Appendix D, Figure D2). Lower discharge during the spring/summer of 2001 may have resulted in lower than normal nutrient loads entering the system from upstream (i.e., Arrow Lakes Reservoir and Kootenay Lake) or local tributary sources, which could have reduced food availability for Rainbow Trout fry.

4.1.3 Walleye

Annual growth of Walleye increased from 2001 to 2006, followed by a decline for a few years, and increased growth from 2010 to 2012. Growth in 2012 (based on change in length from 2012 to 2013) was greater than all other years and coincided with the lowest estimated abundance levels in 2012 and 2013. This suggests a density-dependent relationship with lower growth when Walleye abundance is high. However, there was not a consistent relationship between density and growth in other years of the study. The growth of Walleye, as well as the body condition, was negatively associated with mean water temperature and positively associated with mean discharge. Walleye growth is optimum at water temperatures between 20 and 24°C and growth of adults may cease below 12°C (McMahon et al. 1984). As temperatures in the LCR for most of the year are cooler than this optimum range, a negative association between Walleye growth and water temperature was not expected.

Overall, a lack of age data and limited numbers of inter-year recaptures hinder detailed growth analyses for Walleye. During future study years, substantially more data will be required to detect significant changes in Walleye growth. Walleye feed in the LCR during the summer and fall with a large numbers of individuals migrating out of the LCR and into Lake Roosevelt in the late fall and early winter months (R.L.&L. 1995). Given the seasonal residency of most of the Walleye population and the limited amount of growth-related data available for this species to date, it is unlikely that the program, in its current form, will garner enough data to detect a relationship between Walleye length-at-age or growth, and LCR discharge.

4.2 Abundance

4.2.1 Mountain Whitefish

The estimated abundance of subadult Mountain Whitefish decreased between 2001 and 2004. Reasons for this decline are unknown, but may in part be attributed to changes in sampling methods. During the initial years of the program (i.e., between 2001 and 2003), compressed oxygen was not pumped into the livewell. Lower oxygen levels in the livewell may have resulted in higher subadult Mountain Whitefish mortality rates after marking and release. Higher delayed mortality rates for marked fish would result in overestimated abundance estimates during these study years. However, changes in the rate of delayed capture and handling-related mortality would be expected to affect capture efficiencies over time. The similar capture efficiency estimates from

2001 to 2004 and subsequent years do not support the possibility of oxygenated livewells substantially reducing post-release mortality.

If subadult Mountain Whitefish density truly declined between 2001 and 2004, one would expect either adult Mountain Whitefish densities to decline between 2002 and 2005 or adult Mountain Whitefish survival to increase between 2001 and 2004. Neither adult density nor survival changed enough over that time period to support an approximately 79% reduction in the abundance of subadult Mountain Whitefish. This discrepancy could be partly explained by migration of Mountain Whitefish out of the study area, and the subsequent effect on survival and abundance estimates, which is discussed in further detail in Section 4.4.1. Estimates of subadult Mountain Whitefish abundance from the early 1990s were variable but similar to the range of values observed between 2001 and 2013.

Abundance estimates for adult Mountain Whitefish were more than three times greater in the 1990s compared to 2001 to 2013 estimates. Abundance generally declined between 2001 and 2012 with a small increase in 2013. Although the trends in abundance over time were not identical for subadult and adult Mountain Whitefish, both age-classes generally declined during the current monitoring period and were low when compared to estimates generated using data from the early 1990s.

Little is known about the factors influencing the abundance of Mountain Whitefish in the LCR, but there is some information to suggest that predation on Mountain Whitefish by piscivorous fish species could play a role. Walleye feed on Mountain Whitefish (Wydoski and Bennett 1981), and densities of subadult Mountain Whitefish decreased from 2001 to 2005, while Walleye densities generally increased during that time period. Walleye stomach content data collected in the fall of 2009 (Golder 2010a) and 2010 (Ford and Thorley 2011a) did not indicate that young Mountain Whitefish are a major food source for Walleye. However, young of the year Mountain Whitefish may be more susceptible to Walleye predation during the early to mid-summer (i.e., when they are smaller) than during the fall (i.e., when they are larger). Seasonal Walleye stomach content data are needed to test this idea.

Between 2001 and 2012, 93,524 hatchery-reared juvenile White Sturgeon were released into the LCR (Hildebrand and Parsley 2013). Although most of these fish would have been too small to prey on Mountain Whitefish during the early 2000s, predation by White Sturgeon may have influenced Mountain Whitefish abundance in more recent years. White Sturgeon are capable of feeding on both subadult and adult Mountain Whitefish, and as many as 12 adult Mountain Whitefish have been recorded in the stomach contents of a single adult White Sturgeon (R.L.&L. 2000). White Sturgeon become piscivorous at approximately 500 mm FL (Scott and Crossman 1973). In the LCR, this equates to an approximately age-3 individual (Golder 2009b); therefore, predation by White Sturgeon on Mountain Whitefish is expected to have increased since approximately 2005.

One of the management questions concerns the effects of variation in flow regime on Mountain Whitefish abundance. The environmental variables most highly associated with subadult Mountain Whitefish abundance were discharge difference in the spring and mean discharge in the fall. Reasons for these correlations are unknown but may relate to discharge variability that could affect food availability (drifting invertebrates; as discussed in Section 4.1.2), whereas mean discharge is more likely to influence survival and abundance through effects on habitat, as the overall discharge level could affect the near-shore and backwater habitats that is preferred by juveniles of this species. The effects of discharge variations on spawning and early life-history of

Mountain Whitefish in the LCR were investigated in greater detail as part of other BC Hydro studies (i.e., CLBMON-47 and CLBMON-48; Golder 2012a, 2012b).

4.2.2 Rainbow Trout

The abundance of subadult Rainbow Trout decreased between 2001 and 2004. This decline was similar to the decline in subadult Mountain Whitefish abundance over the same time period and could partly be explained by changes in fish handling techniques in 2004 (see Section 4.2.1). However, the abundance of adult Rainbow Trout did not decrease substantially during this time period.

Estimated abundance of adult Rainbow Trout, although similar between 2001 and 2013, exhibited a small, gradual increase during this time period. This pattern is not supported by the number of Rainbow Trout spawners in the LCR based on visual observations and area-under-the-curve estimates, which more than doubled between 1999 and 2013 (Irvine et al. 2014). One possible reason for the discrepancy between the estimated number adults based on electroshocking surveys and spawner surveys is that abundance estimates were biased by sampling or analytical methodologies. For example, for abundance estimates based on mark-recapture, capture efficiency for adults was always low (<3%), which provided little information about annual or inter-session variation in recapture rates, and could have masked real changes in Rainbow Trout abundance. Another potential sampling bias could be saturation of the ability of netters' to catch and count fish, whereby counts and catches of fish would comprise a smaller proportion of the total number of fish present when densities were high. This would result in underestimated densities when abundance was high. Although based on a small sample size, the plot of catches from mark-recapture surveys versus counts from visual enumeration surveys shows that the linear relationship overestimated catch when counts were high, which supports the idea that saturation of netters at high fish densities could bias abundance estimates low. Additional years of data collection including both mark-recapture and visual surveys are needed to further evaluate the relationship between the two methods.

During a typical year, capture efficiency of subadult Rainbow Trout decreased during each successive sample session. This result is disconcerting, as it may indicate a violation of the HBM's closed population assumption. By comparison, the capture efficiency of adult Rainbow Trout remained stable within each study year. Capture efficiency between study years remained constant for both age-classes.

The probability of a fish being recaptured in the same site was highest for subadult Rainbow Trout, among all index species and cohorts. This indicates that subadult Rainbow Trout exhibited a higher site-fidelity than all other index species and life stages. In addition, estimated capture efficiencies were highest for subadult Rainbow Trout, which indicates that this cohort also was the easiest to catch. Site fidelity decreased with increasing fork length, indicating that older Rainbow Trout were more likely to migrate out of sample sites.

There was some indication that the abundance of Rainbow Trout could be affected by variation in the LCR flow regime. As with Mountain Whitefish, abundance of Rainbow Trout was positively associated with discharge difference in the spring and mean discharge in the fall. It is not clear why greater discharge variability in the spring, when eggs would be spawned and incubated, would be associated with greater subadult abundance but it is possible that variable or increasing flows could deliver more oxygenated water to redds, which could increase survival to hatch. The Rainbow Trout flow management plan for HLK and BRD pertains primarily to flows during spawning and emergence in the spring and summer and aim to avoid the dewatering of redds during flow reductions.

4.2.3 Walleye

Walleye abundance increased substantially between 2002 and 2004 and declined between 2004 and 2006. These results likely reflected a strong year-class of Walleye that migrated into the study area between 2002 and 2004; these individuals gradually decreased in abundance over the next two years. Walleye migrate into the LCR to feed in summer and fall, but spawn and complete early life history in downstream regions (e.g. Lake Roosevelt and its tributaries). Abundance in the LCR depends on suitable feeding conditions, but also largely on factors that influence spawning success and early life stage survival and growth outside of the study area. Based on length-frequency data and Lake Roosevelt length-at-age data (WDFW Unpublished Data), age-1 fish are the most dominant age-class present in the study area during most study years; therefore, the abundance of this species in the study area during any particular year is strongly influenced by the spawning success of this species during the previous spring. Data collected during the 1990s suggests substantially greater Walleye abundance in that period compared to between 2001 and 2013. However, the possibility that differences in sampling contributed to this difference cannot be ruled out.

Because the adult Walleye age grouping consisted of multiple year classes, the abundance was not included in multivariate analyses to assess the effects of environmental variables. Graphical assessment did not suggest any strong relationships between river discharge and Walleye abundance. However, years of high abundance coincided with low body condition, suggesting density-dependent growth and resource competition in years of high abundance in the LCR.

4.2.4 Other Species

The CLBMON-45 management questions refer only to the three index species; numbers of non-index species are generally too low to draw conclusions about population trends in any case. However, electroshocking results during this program clearly demonstrate the recent colonization of non-native Northern Pike in the study area. Northern Pike were not documented in the study area prior to 2010, but this species has been captured or observed during electroshocking surveys every year since 2010. Anecdotal reports from anglers indicate that Northern Pike are now common in the portion of the LCR near HLK, and that angling catches have increased between 2010 and 2013 (D. Ford, personal communication). Northern Pike likely originated from established populations in the Pend d’Oreille River. Very high water levels in 2012 resulted in many areas with flooded terrestrial vegetation in the upper LCR, which may have provided suitable spawning habitat for Northern Pike and further facilitated an increase in their local abundance. In 2013, a targeted gill-netting program by the MFLNRO to reduce the numbers of Northern Pike in the LCR caught 92 individuals, all of which were adults (Bailey 2014). Beyond this recent gill netting information, limited electroshocking data from CLBMON-45, and anecdotal reports from anglers, nothing is known about the abundance, life-history, habitat use, spawning, or movement patterns of Northern Pike in the LCR. This highly efficient piscivore has the potential to alter the populations of index species and other fishes in the LCR. The introduction of a non-native species such as Northern Pike is a large factor contributing to the decline of salmonids in a portion of the Columbia River in the USA (Sanderson et al. 2009). As control or eradication are most effective close to the time of introduction, when abundance and spatial distribution are low (Myers et al. 2000), additional information regarding Northern Pike in the LCR is urgently needed if resource managers wish to control or prevent further invasion by this species. Such studies are beyond the scope of CLBMON-45, but would provide valuable information to help interpret trends and answer management questions regarding index species.

The dramatic increase in the number of Redside Shiner recorded in the section of the Columbia River upstream of the Kootenay River in 2013 suggested a significant change in the abundance of this species. Reasons for this increase in abundance are unclear but possible explanations could be related to either high recruitment of a recent year-class, an increase in habitat availability or suitability in the upper section of the LCR, or a reduction in predation rates on this species. Additional studies are needed to determine if this is a short term increase or represents a longer term trend, possibly back toward the very high abundance levels of the species recorded in the early 1990s (R.L.&L. 1995).

4.2.5 Geo-referenced Visual Enumeration Surveys

The visual surveys were conducted to assess whether the method would provide comparable or more accurate estimates of density of fishes in the LCR. If so, the visual surveys might have several advantages compared to mark-recaptures surveys, including reduced handling of fish, less sampling time per site that could allow more sites to be sampled, and the addition of finer-scale distribution data. Preliminary results from the first year of sampling suggest that counts of observed fish from visual surveys correspond well with mean catches from mark-recapture surveys (Figure 24). Additional years of sampling and data analysis are required to better assess and quantify the relationship.

When estimating the lengths of fish during visual surveys, there were several potential sources of error or bias. Observers were instructed to estimate the fork lengths of observed fish but it may be that observers were more likely to base their estimates on total length when observing fish from a distance. Length estimates were also likely affected by magnification by water, as objects appear larger in water than in air because of the greater refractive index of water (Luria et al. 1963). The depth of fish in the water column is also expected to have an impact on perceived length. Despite all these factors, the results suggest that the observers were reasonably accurate in their estimates of fish length (Figure 13). The length bias model suggested that, on average, observers underestimated fish lengths by 10-15%, depending on species (Figure 14). The length bias model provided a useful method to assess and quantify biases in length estimation and adjust fish lengths before use in other analyses.

4.3 Spatial Distribution

4.3.1 Mountain Whitefish

Subadult Mountain Whitefish densities were greatest in the 10-km reach between HLK and the Kootenay River confluence. This result is likely related more to channel morphology than the presence or operation of the dam. Large bays and backwater areas, which are preferred habitats for subadult Mountain Whitefish, are more common near HLK than downstream of the Kootenay River confluence. Specific examples include Balfour Bay (RKm 2.6), downstream of the log booms near Zelstoff-Celgar (RKm 5.1), and upstream of Norn's Creek Fan (i.e., Lions Head RKm 7.4). These areas have exhibited increases in aquatic vegetation abundance (dominantly Eurasian watermilfoil) between 2001 and 2013 (Attachment A). Most recently, Northern Pike have been captured in increasing numbers in these same areas. Whether these fish were present in these locations to feed on subadult Mountain Whitefish or whether this predation will have a detectable effect on subadult Mountain Whitefish survival is unknown.

The spatial distribution of adult Mountain Whitefish during the fall sample period is related to the location of key spawning areas for this species. Densities of this age-class were highest near Norn’s Creek Fan, in the downstream portions of the Kootenay River, upstream of Sullivan Creek, and near the City of Trail Airport. Norn’s Creek Fan, the Kootenay River, and the City of Trail Airport area are known Mountain Whitefish spawning locations (Golder 2012b), whereas the site located upstream of Sullivan Creek is close to a known spawning area (i.e., Lower Cobble Island), which may indicate that Mountain Whitefish use these areas for holding purposes prior to spawning.

The results did not suggest any large temporal changes in the spatial distributions of subadult and adult Mountain Whitefish between 2001 and 2013. To statistically test for differences in spatial distribution over time, one option would be to include river kilometre as a predictor variable in the abundance models, where an interaction between the year and river kilometre would be interpreted as change in spatial distribution. Exploratory analyses of such models are recommended for future years of study.

4.3.2 Rainbow Trout

Subadult Rainbow Trout densities were noticeably higher in the Columbia River between the Kootenay River confluence and Genelle, and from Birchbank downstream to the Beaver Creek confluence, compared to other portions of the study area. Ford and Thorley (2011a) suggested that these areas supported higher Rainbow Trout densities due to the more suitable habitat characteristics of these areas for this life stage and the presence of major spawning areas immediately upstream (i.e., Norn’s Creek Fan, the Kootenay River, and the Genelle area; Thorley and Baxter 2012).

The densities of subadult and adult Rainbow Trout at synoptic sites (i.e., sites that were not systematically sampled prior to 2011) were generally similar to indexing sites, except at synoptic sites near the Columbia-Kootenay river confluence where densities were very high. This result was not expected. During the initial year of the LRFIP, index site selection was partially based on past capture results; selected sites provided a greater probability of capturing high numbers of each index species. Therefore, lower densities in the synoptic sites compared to index sites were expected. Criteria included in the site selection process are described in Section 2.1.5, but index species catch-rates encountered during the 1990s and the known habitats preferences of each index species were considered during the selection process. If densities are truly as great or greater in synoptic sites compared to index sites and results are not an artefact of sample design, some possible reasons are discussed below.

One hypothesis is a behavioural change that reflects fish avoidance of the electroshocker (i.e., fish in repetitively sampled sections leave the index sites and move to adjacent areas to avoid the effects of repetitive electroshocking). In 2012 and 2013, only three of the 730 Rainbow Trout captured in synoptic sites were initially caught and marked at an index site during the same year. This result does not suggest that large numbers of marked fish are leaving the indexing sites over the course of the survey, which is further supported by site fidelity estimates for Rainbow Trout, which were higher than for Mountain Whitefish and Walleye.

Another hypothesis is that over the last 12 years, the habitat suitability of some portions of the study area (including index and synoptic sites) has changed for some index species life stages. Since 2001, aquatic vegetation has become more dominant in low water velocity areas, Northern Pike have been recorded in the study area with increased frequency during each successive study year, and large numbers of juvenile White Sturgeon have been released into the study area. One or more of these factors may have resulted in shifts in Rainbow Trout distribution in the LCR since 2001.

Regardless of the reasons, the high densities of Rainbow Trout in previously unsampled portions of the study area indicate that a large portion of the overall Rainbow Trout population is potentially unsampled during the typical annual mark-recapture program. Higher densities in these areas than in index sites would result in underestimates of overall population density in the LCR.

4.3.3 Walleye

Walleye densities were high immediately downstream of HLK. Sculpin species and Redside Shiner are a common prey fish for Walleye based on stomach sample analyses (Ford and Thorley 2011a). In 2010, results from the spatial density HBM indicated higher Sculpin species and Redside Shiner densities in this portion of the study area (Ford and Thorley 2011a). In addition, Walleye densities are probably higher immediately downstream of HLK because they are feeding on fishes entrained through the dam. Walleye densities also were high in the Kootenay River downstream of Brilliant Dam, likely for the same reason.

Walleye densities were similar throughout the remaining sections of the LCR. Their wide distribution throughout the study area indicates an ability to utilize a wide variety of habitats and tolerate a wide range of habitat conditions. This reflects the primary use of the LCR as a summer and fall feeding area, and as a result, this species is generally found wherever prey fish are present.

Although not analyzed in detail, the results did not suggest any discernible temporal changes in the spatial distribution of Walleye compared to previous years of the study.

4.4 Survival

4.4.1 Mountain Whitefish

Estimated survival was greater for adult Mountain Whitefish (34-83%) than for subadults (15-39%). Greater survival for adults was not unexpected, as Mountain Whitefish are known to be a relatively long-lived species with most populations containing individuals greater than 10 years of age (McPhail 2007; Meyer et al. 2009).

Currently, each of the management hypotheses is tested using separate HBMs, which simplifies the assessment of the hypotheses. This approach also allows the model outputs to be checked for inconsistencies. When this check was conducted on subadult and adult Mountain Whitefish density estimates, the estimates generated were not compatible with survival estimates. For instance, it is not possible for an adult population of 123 708 fish in 2013 to be supported by a subadult population in 2012 of 23 074 fish with only 37% subadult survival (8 422 fish to be recruited to the adult population) and adult survival of 62% (52 023 fish remaining in the adult population). This indicates that either the abundance or survival model (or possibly both) make at least one unreliable assumption concerning Mountain Whitefish biology or behaviour that biases the estimates.

One possible explanation for this inconsistency between the different models is that the large-scale spawning migrations by adult Mountain Whitefish during the study period results in the loss of tagged fish from sample sites at a substantially greater rate than estimated by the site fidelity model. The site fidelity model estimates the probability that a recaptured fish is caught at the same site as encountered previously, as opposed to being recaptured at a different site. Consequently, if a fish moved from the shallow water margins, where sampling occurred, into the main channel, or moved into an area of the river where sampling was not conducted, that fish would not be available for recapture and the site fidelity model would underestimate the losses of tagged fish. This bias would result in an underestimation of capture efficiency and a concomitant overestimation of abundance.

Mountain Whitefish recapture probabilities were less than half of those for Rainbow Trout and Walleye, which further suggests that fish movements could be influencing recapture estimates. In addition, during BC Hydro’s MCR Fish Population Indexing Program (CLBMON-16), recapture rates for adult Mountain Whitefish were greater in the spring than in fall in 2011 and 2012, possibly because Mountain Whitefish were moving into and out the study area in the fall study period for spawning migrations (Ford and Thorley 2011b; Golder and Poisson 2013b). Based on telemetry data collected under CLBMON-48 (Golder 2009c), a substantial proportion of the adult Mountain Whitefish population in the LCR undertakes spawning related movements, often to other areas of the river during the fall study period. This would explain why abundance estimates are inconsistent with estimates of survival in the LCR and would account for lower recapture estimates for Mountain Whitefish when compared to other species in the LCR.

One way to potentially improve estimates of Mountain Whitefish survival, which currently have fairly large uncertainty, is to use the age information from scale samples to estimate survival using catch curve models. Scales have been collected from Mountain Whitefish and Rainbow Trout in every year since 2001, but scales were only aged from 2001 to 2011. Fish were not assigned ages based on scale analysis in 2012 and 2013 because the first two age-classes (age-0 and age-1) can be discerned using length-frequency analyses and there was a relatively large amount of error and uncertainty in the ages assigned to age-2 and older fish. However, the uncertainty and bias in scale ages could be estimated by assigning ages blindly (i.e., without prior knowledge of recapture and age information) to recaptured fish of known age, and modelling the difference between assigned and true ages. Such a model could be used to correct and estimate uncertainty in ages, and that information could be used in a catch curve analysis, which estimates survival based on the catches of individuals in each age class. A re-analysis of scale samples of recaptured fish, and exploratory analyses of age-assignment model and catch curves are recommended for future years of study to better address the management question concerning survival of index fish species in the LCR.

4.4.2 Rainbow Trout

Survival estimates for subadult Rainbow Trout between 2001 and 2013 fluctuated between 38% and 60%. This generally agreed with subadult densities that fluctuated among years with no consistent increasing or decreasing trend. For adult Rainbow Trout, both survival and abundance increased gradually between 2001 and 2011. Survival declined sharply in 2012 for both subadult and adult Rainbow Trout. Lower Rainbow Trout survival in 2012 could have been related to high river discharge in 2012 that was the highest recorded since the construction of HLK (approximately 40 years). However, survival from 2012 to 2013 remained at low levels even though discharge was close to normal in 2013. Based on these data, it is not possible to ascertain how or if high water levels may have reduced Rainbow Trout survival in 2012 or if the decline could possibly be related to other factors like changes in fish behaviour (e.g., greater movement out of the study sites). The low survival estimates for subadult and adult Rainbow Trout in 2012 and 2013 did not correspond with a decrease in density these cohorts, or with the number of spawners estimated based on visual surveys in 2012 or 2013 (Irvine et al. 2013, 2014).

4.4.3 Walleye

Annual survival of Walleye based on the combined dataset from 2001 to 2013 was 51% (credible interval = 42 to 58%). Survival during each year for Walleye could not be estimated due to insufficient data; therefore, trends in survival over time could not be assessed. As a large portion of the Walleye population is thought to be migratory and spend only part of the year in the LCR before moving downstream into Lake Roosevelt (R.L.&L. 1995), interpretation of annual survival would likely be confounded by fish movements. More information regarding Walleye migrations and their degree of residency in the LCR is needed to better understand factors driving abundance and survival.

4.5 Body Condition

4.5.1 Mountain Whitefish

The body condition of subadult and adult Mountain Whitefish fluctuated between 1990 and 2013 with no consistent trend over this time period. The changes in body condition of adult Mountain Whitefish varied from -16% to 10% (compared to a typical year) between 1990 and 2013 (Figure 28). Fluctuations in body condition are known to affect reproductive potential and population productivity in other fish species (Ratz and Lloret 2003). However, it is not known what percent change in body condition is biologically significant and could affect populations of Mountain Whitefish. The Canadian Environmental Effects Monitoring (EEM) program for mining and pulp and paper effluents considers a 10% change in fish body condition to be the critical threshold for higher risk to the environment (Munkittrick et al. 2009; Environment Canada 2012). This criterion suggests that the 8 - 10% variation in adult Mountain Whitefish body condition could be biologically significant. Studies of the effects of body condition on reproduction and other life-history processes are required to understand the implications of body condition variation in Mountain Whitefish and other index fish species in the LCR.

Of the environmental variables, body condition of subadult and adult Mountain Whitefish was most strongly associated with discharge difference in spring and mean discharge in fall (both negative relationships). There was also a positive relationship between body condition and mean discharge in spring, summer, and winter periods. Annual variation in mean discharge could potentially affect body condition in numerous ways, including changes to habitat, productivity, or energetic costs. Without experimental or adaptive studies to complement the observational indexing program, it is not possible to explain why increased discharge might have a positive influence on body condition in most seasons but a negative influence in the spring season, as suggested by the multivariate analysis. The negative relationship between discharge difference and condition could be related to greater fish movements and energy expenditures during more variable flows.

Little is known about what factors influence changes in body condition or growth of Mountain Whitefish in the LCR. In the Skeena River, a large, unregulated river in British Columbia, food abundance was the main factor limiting growth and abundance for Mountain Whitefish (Godfrey 1955 as cited by Ford et al. 1995). Mountain Whitefish body condition also is likely related to the abundance of invertebrate prey in the LCR. Larval trichoptera and larval diptera are major food sources for Mountain Whitefish in the LCR (Golder 2009a). Invertebrate abundance data are available through BC Hydro's LCR Physical Habitat and Ecological Productivity Monitoring Program (CLBMON-44), but only after 2007, with most sites concentrated between the Norn's Creek confluence and the Kootenay River confluence (TG Eco-Logic 2009, 2010, 2011). To date, data are not sufficient to detect a relationship between food availability and Mountain Whitefish body condition.

In previous years of the study, sample site was included as an explanatory variable in the models of Mountain Whitefish body condition so that estimated condition varied by site (Golder and Poisson 2013a). Although there were some small spatial differences in body condition, sample site explained very little of the variation in body condition. Therefore, sample site was not included in the body condition models for Mountain Whitefish or the other species in 2013. The small spatial differences in body condition suggest that either there is little variation attributable to habitat differences among sites, or that fish do not stay within particular sites long enough to result in large inter-site differences in body condition. The low site fidelity estimates support the idea that fish movements may prevent large inter-site differences in body condition, especially for Mountain Whitefish, which had the lowest site fidelity estimates.

4.5.2 Rainbow Trout

Although there was no sustained temporal trend in body condition for Rainbow Trout, body condition was greater in 2002 and 2006 compared to other study years. Both water temperature and discharge in the Columbia River were near historical averages in 2002 and 2006, and body condition was not significantly correlated with either of these variables. Thus, the results do not suggest that variations in flow regime explain the inter-annual differences in Rainbow Trout body condition. The body condition of adult Rainbow Trout followed a very similar trend as their survival, which is not surprising, and suggests that Rainbow Trout with higher body condition have higher survival. Body condition values of Rainbow Trout in the LCR were generally higher than those recorded downstream of Revelstoke Dam during the same time of the year (CLBMON-16; Ford and Thorley 2011b).

4.5.3 Walleye

Body condition of Walleye in the study area fluctuated between 1990 and 2013 but trends were not strongly related to river discharge or water temperature based on the multivariate analyses. Body condition was greater in 2012 and 2013 than in most previous years, and coincided with very low abundance, suggesting density-dependent growth that could be due to intraspecific competition for food and cover, similar to that reported for this species by other researchers (Hartman and Margraf 1992; Porath and Peters 1997; Forney 2011).

4.6 Summary

The sampling program conducted since 2001 provides a high-quality, long-term dataset to address the management questions regarding monitoring key fish population metrics over time in the LCR. Hierarchical Bayesian models suggested that abundance, spatial distribution, survival and growth of the three index species have fluctuated during the 2001 to 2013 monitoring period. For instance, between 2001 and 2005 the abundance of subadult Mountain Whitefish and Rainbow Trout decreased, followed by an increase in body condition of these species in subsequent years (2003-2006). Historical data from a similar fish sampling program in 1990-1993 were incorporated into the analyses to assess longer term trends in fish populations. These analyses suggested substantial differences in the abundance and survival of index species, including much higher abundance and smaller length of Mountain Whitefish in the early 1990s. Greater abundance of Mountain Whitefish prior to the protection flows (i.e., in 1990 to 1993) was not expected as this flow management plan was intended to increase survival and abundance. However, conclusions based on these comparisons of different datasets should be viewed with caution because of the potential influence of differences in data collection.

The second management question for this monitoring program pertains to the effects of inter-annual flow variability on fish population metrics of the index species. Overall, discharge did not seem to be strongly associated with the fish population metrics assessed although the multivariate analyses did suggest some correlations. For instance, the body condition of subadult Mountain Whitefish was negatively associated with their abundance and with discharge difference in the spring. These results suggest that discharge variability did not reduce abundance but may have resulted in lower body condition, possibly because of greater movements and energy expenditures. The anomalously high discharge in the Columbia River in 2012 could have contributed to the sharp decline in Rainbow Trout survival in 2012, with continued low survival in 2013. The negative association between mean discharge in fall and subadult Rainbow Trout abundance provides some support for this idea although mean discharge in other seasons was not associated with Rainbow Trout abundance.

Water temperature is known to be one of the most important factors influencing the ecology of fishes (Coutant 1976). Multivariate analyses in this study suggested some associations between water temperature in the LCR and fish population metrics, including a negative association between mean water temperatures and the growth of Walleye and Rainbow Trout. As growth was expected to increase with temperature, the mechanism behind this correlation is not clear. With regard to the management questions, the effects of the flow management plan on water temperature are unknown. However, the inter-annual variations in water temperature observed in this study were not likely drivers of change in fish population metrics in the LCR, possibly because of the relatively stable water temperatures observed between 2001 and 2013.

Understanding the effects of local movement patterns of the index species on estimates of the model parameters should be the focus of future studies. The present monitoring program provides important information on abundance, growth and survival of index species but data regarding local movements and seasonal migrations of these species are required to better interpret and understand their population trends. For instance, information about spawning and related movements of Mountain Whitefish (Golder 2012a, b) was helpful in interpreting trends and potential biases in the present study. Further understanding of the migratory behaviour of other index species, especially Rainbow Trout, will provide more insight into addressing CLBMON-45 management questions.

One finding that could indicate potential violation of assumptions or room for improvement in the study methodology was that the abundance of adult Rainbow Trout varied little between 2001 and 2013 whereas subadult density and survival from this study, and estimates of spawner abundance from CLBMON-46 all suggested substantial fluctuations over this same time period. The consistently low recapture rates may provide little information about annual or seasonal variation in capture efficiency, which could make it difficult to detect large changes in efficiency or abundance over time. The geo-referenced visual enumeration survey was conducted to assess whether the data would provide more accurate abundance estimates than mark-recapture surveys, as well as providing fine-scale distributional data. Preliminary analyses suggest that counts from these visual surveys correspond well to mark-recapture abundance estimates with four to six times greater numbers of fish counted than captured at each study site. Additional years of data will allow further assessment of the relationship between mark-recapture and visual enumeration survey data, and whether enumeration data may provide more accurate estimates of fish density. If so, it may eventually be possible to calibrate the efficiency of the method and reduce the number of mark-recapture passes needed during each sample season. In addition, more of the river could be surveyed in any given year since the enumerated fish do not need to be processed, which would be an advantage when examining long-term distributional changes.

In 2011 to 2013, portions of the river that were unsampled during the previous ten study years were sampled for the first time. Results from these portions of the river were very informative and suggest that these areas are used intensively by all three index species during the fall season. Continued sampling in randomly sampled sites outside the index sample sites will improve the ability to detect changes in fish populations in the LCR.

5.0 RECOMMENDATIONS

In consideration of the findings above and the overall objectives of the CLBMON-45, a field sampling program should be conducted in 2014 using the same methodologies employed in 2013. In addition to further sampling, the following recommendations are provided:

- Re-analyze existing scale data from recaptured fish of known age, where analysts would not have information about age or capture history. Data would be used to model the difference between assigned and true ages to quantify uncertainty and bias in the assigned ages. Such a model could be used to correct and estimate uncertainty in ages, and that information could be used in a catch curve analysis, which estimates survival based on the catches of individuals in each age class. This approach would utilize the large number of scales already collected to attempt to improve estimates of survival, which are currently have large uncertainty.
- Continue the GRTS survey following the completion of the fall mark-recapture indexing program.
- Continue the geo-referenced visual enumeration survey at index sites prior to the mark-recapture program. Preliminary analyses suggest that counts from visual surveys provide comparable density estimates to mark-recapture surveys, as well as fine-scale spatial distribution data. Additional years of data are needed to assess the relationship between mark-recapture and visual enumeration survey data, and whether enumeration data may provide more accurate estimates of fish density.
- Conduct a small-scale telemetry program to monitor local movement patterns and their effect on fish population parameters. Studies regarding Rainbow Trout are needed the most.
- Conduct a mark-recapture program during the spring season to provide insight into the seasonal abundance, distribution, and movements of index species (particularly Mountain Whitefish and Walleye).

- Investigate whether data gaps in the study can be addressed or data analysis can be supplemented with data collected under other BC Hydro programs (e.g., Walleye prey fish abundance through CLBMON-43, invertebrate abundance through CLBMON-44, Mountain Whitefish movement patterns through CLBMON-48, or Rainbow Trout spawner abundance through CLBMON-46). To date, only qualitative comparisons to Rainbow Trout spawner abundance have been conducted, whereas raw data from invertebrate or productivity would be required to investigate whether these variables could be used as predictors of fish population metrics.
- Continue analyses using data collected in the 1990s to provide a longer time series of data (i.e., data prior to the implementation of Mountain Whitefish and Rainbow Trout spawning protection flows).
- The feasibility of not implementing Mountain Whitefish and Rainbow Trout protection flows for a single spawning season should be examined. This would provide an opportunity to monitor changes in the parameters of interest under significantly different flow regimes.
- Use results from other WUP programs to develop hypotheses about potential causes for change in fish populations, and test these hypotheses using HBMs that combine the relevant data. Such analyses would depend on the availability and suitability of long-term datasets from the other WUP programs.

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7.0 CLOSURE

We trust that this report meets your current requirements. If you have any further questions, please do not hesitate to contact the undersigned.

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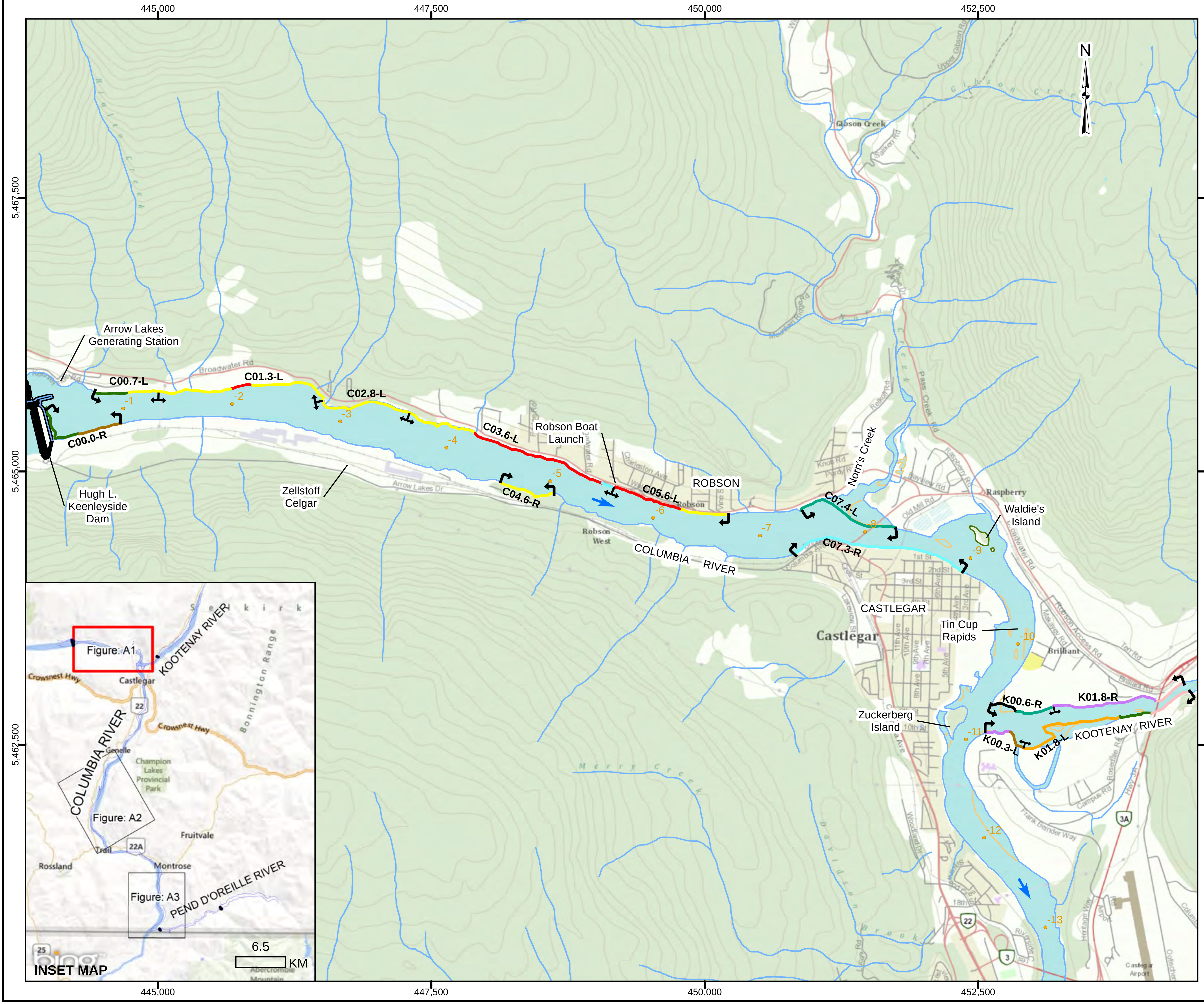
APPENDIX A

Maps and UTM Coordinates



LEGEND

●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
C00.0-R	BOAT ELECTROSHOCKING SITE
→	FLOW DIRECTION
—	WATERCOURSE
—	BREAKWATER
—	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

BANK HABITAT TYPE

—	A1 - ARMOURED COBBLE/GRAVEL
—	A1+A2 - ARMOURED COBBLE/GRAVEL/SMALL BOULDER
—	A2 - ARMOURED COBBLE/SMALL BOULDER
—	A2+A3 - ARMOURED COBBLE/SMALL/LARGE/BOULDER
—	A3 - ARMOURED SMALL/LARGE BOULDER
—	A4 - ARMOURED LARGE BOULDER
—	A5 - BEDROCK BANKS
—	A6 - MAN-MADE RIP-RAP
—	BW - BACKWATER
—	D1 - DEPOSITIONAL SAND/SILT
—	D1+D2 - DEPOSITIONAL SAND/SILT/GRAVEL/COBBLE
—	D2 - DEPOSITIONAL GRAVEL/COBBLE
—	D3 - DEPOSITIONAL LARGE COBBLE
—	EDDY - EDDY

REFERENCE

SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1
KM

SCALE 1:35,000

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE
UPPER SECTION OF STUDY AREA
2013 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102		
DESIGN	SS	13 Jun. 2012
GIS	SS/JG	19 Jun. 2012
CHECK	DF	24 Jun. 2013
REVIEW	LH	24 Jun. 2013

SCALE AS SHOWN
REV. 0

Figure: A1

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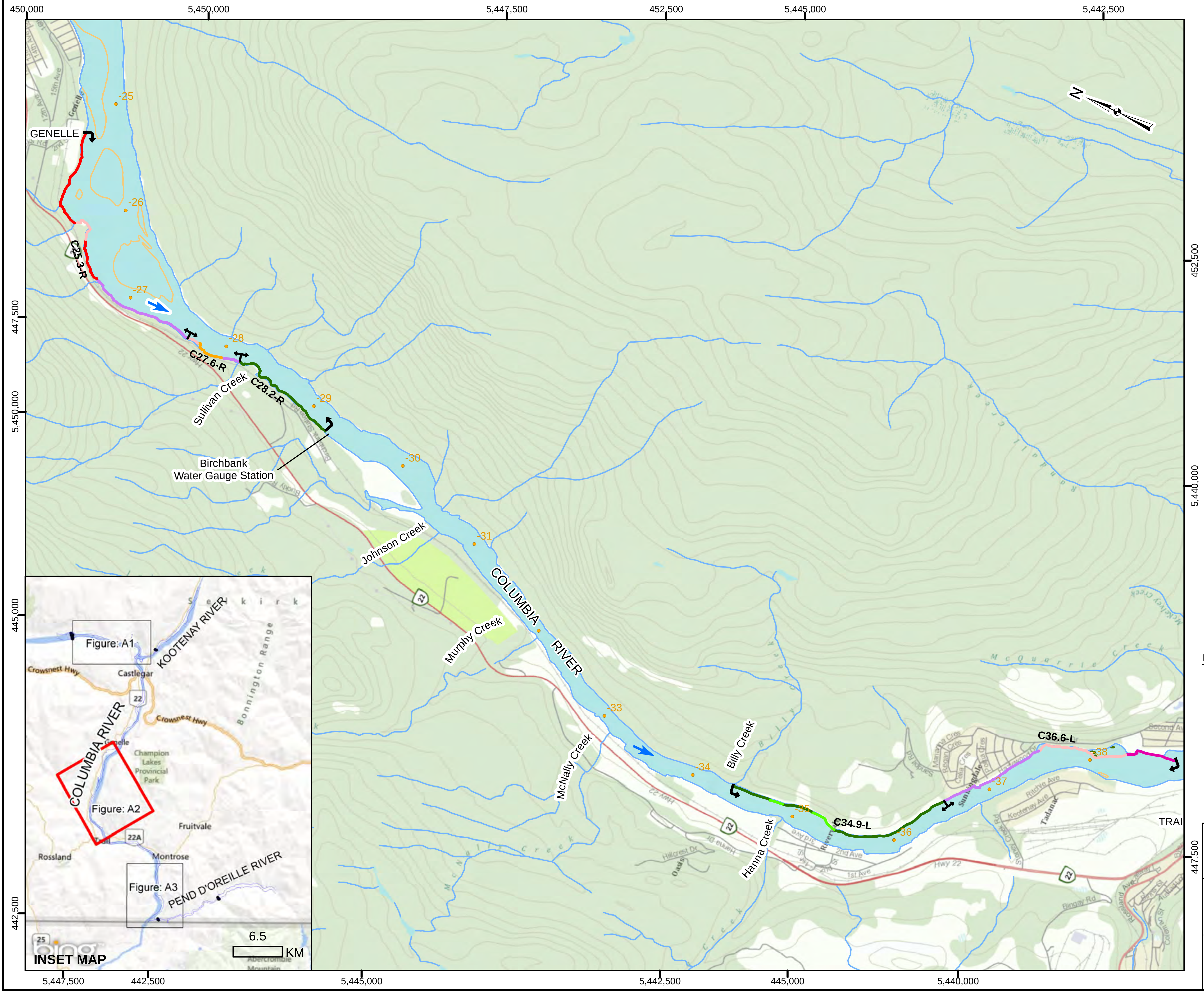

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LEGEND

●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
↱C00.0-R↰	BOAT ELECTROSHOCKING SITE
→	FLOW DIRECTION
—	WATERCOURSE
—	BREAKWATER
—	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

BANK HABITAT TYPE

—	A1 - ARMOURED COBBLE/GRAVEL
—	A1+A2 - ARMOURED COBBLE/GRAVEL/SMALL BOULDER
—	A2 - ARMOURED COBBLE/SMALL BOULDER
—	A2+A3 - ARMOURED COBBLE/SMALL/LARGE/BOULDER
—	A3 - ARMOURED SMALL/LARGE BOULDER
—	A4 - ARMOURED LARGE BOULDER
—	A5 - BEDROCK BANKS
—	A6 - MAN-MADE RIP-RAP
—	BW - BACKWATER
—	D1 - DEPOSITIONAL SAND/SILT
—	D1+D2 - DEPOSITIONAL SAND/SILT/GRAVEL/COBBLE
—	D2 - DEPOSITIONAL GRAVEL/COBBLE
—	D3 - DEPOSITIONAL LARGE COBBLE
—	EDDY - EDDY

REFERENCE

SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1
KM
SCALE 1:35,000

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE
MIDDLE SECTION OF STUDY AREA
2013 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
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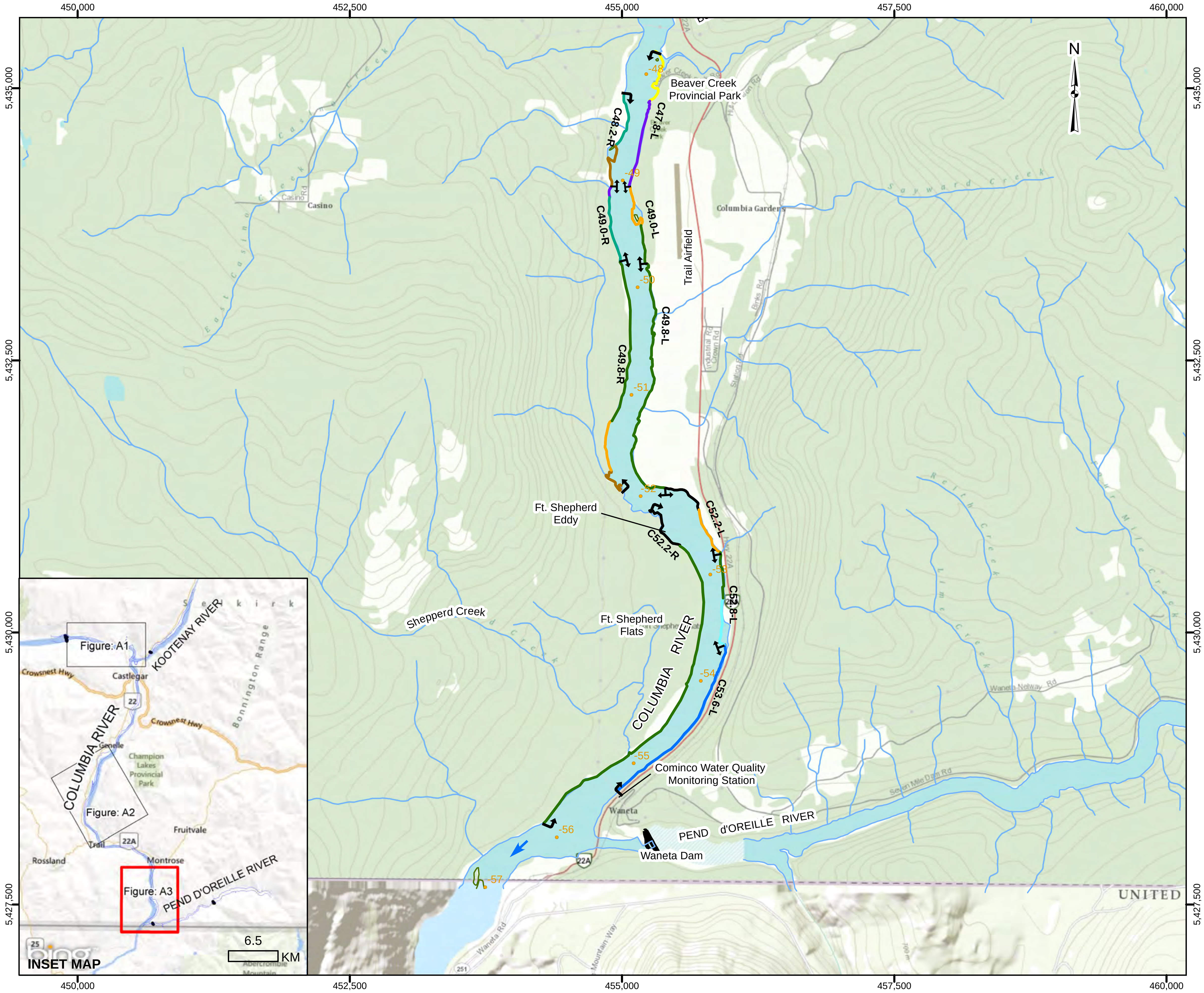
GIS	SS/JG	19 Jun. 2012		
CHECK	DF	24 Jun. 2013		
REVIEW	LH	24 Jun. 2013		



LEGEND

- ● RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
- ↱C00.0-R ↰ BOAT ELECTROSHOCKING SITE
- ➔ FLOW DIRECTION
- ─ WATERCOURSE
- ─ BREAKWATER
- ▬ DAM SECTION
- ─ ISLAND
- ─ SAND OR GRAVEL BAR

BANK HABITAT TYPE

- ─ A1 - ARMOURED COBBLE/GRAVEL
- ─ A1+A2 - ARMOURED COBBLE/GRAVEL/SMALL BOULDER
- ─ A2 - ARMOURED COBBLE/SMALL BOULDER
- ─ A2+A3 - ARMOURED COBBLE/SMALL/LARGE/BOULDER
- ─ A3 - ARMOURED SMALL/LARGE BOULDER
- ─ A4 - ARMOURED LARGE BOULDER
- ─ A5 - BEDROCK BANKS
- ─ A6 - MAN-MADE RIP-RAP
- ─ BW - BACKWATER
- ─ D1 - DEPOSITIONAL SAND/SILT
- ─ D1+D2 - DEPOSITIONAL SAND/SILT/GRAVEL/COBBLE
- ─ D2 - DEPOSITIONAL GRAVEL/COBBLE
- ─ D3 - DEPOSITIONAL LARGE COBBLE
- ─ EDDY - EDDY

REFERENCE

SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1 KM

SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE

LOWER SECTION OF STUDY AREA
2013 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
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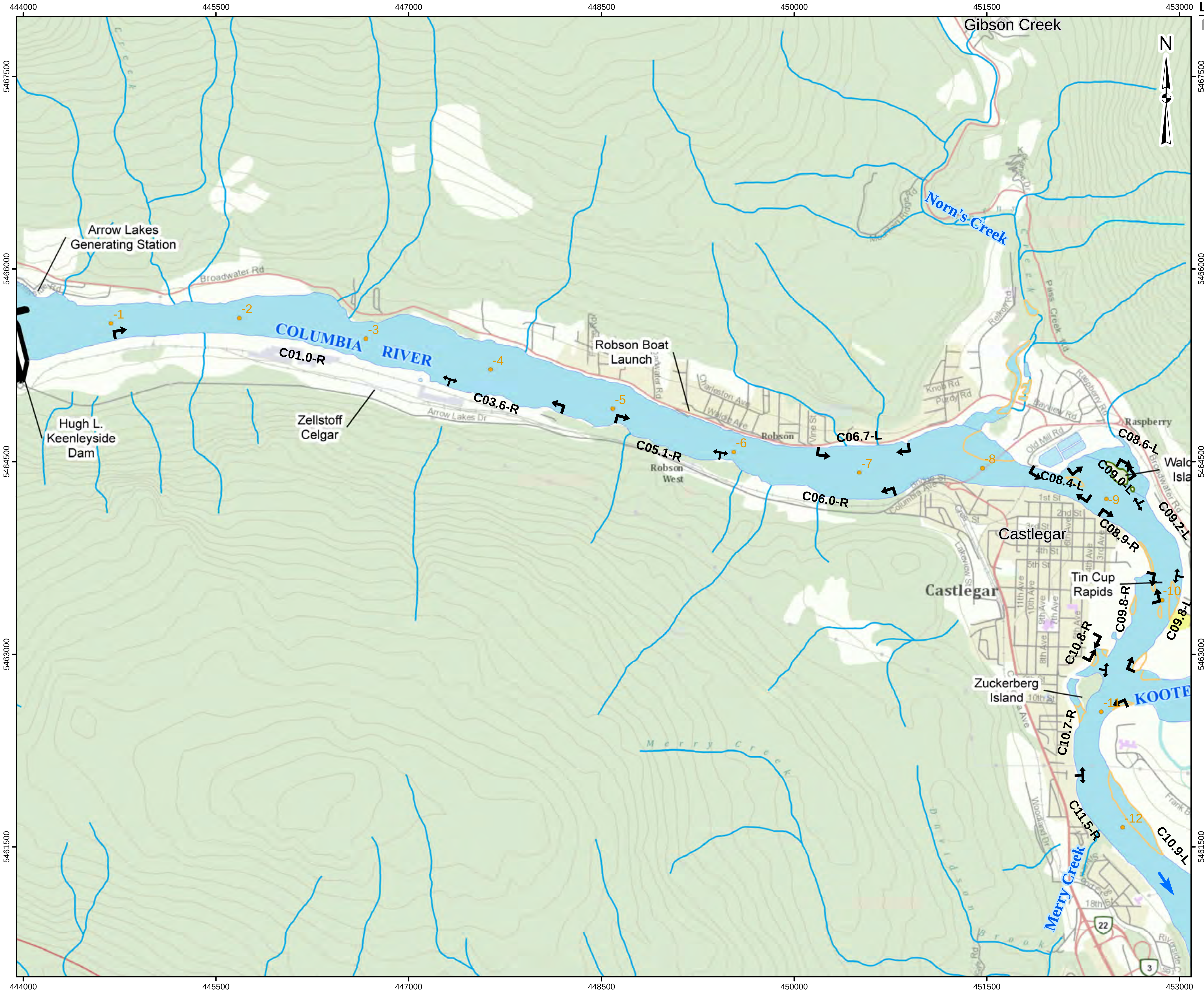

LEGEND

C00.0-R BOAT ELECTROSHOCKING SITE
FLOW DIRECTION
● RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
WATERCOURSE
WATERBODY
BREAKWATER
DAM SECTION
ISLAND
SAND OR GRAVEL BAR

REFERENCE

WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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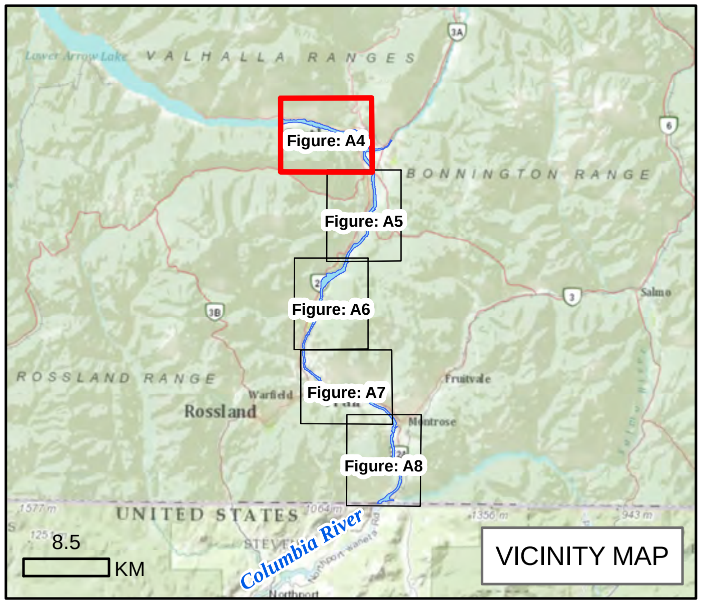
Metres

SCALE 1:30,000



VICINITY MAP

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE
2013 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
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GIS	JG	13 Jun. 2011		
CHECK	DF	24 Jun. 2013		
REVIEW	LH	24 Jun. 2013		

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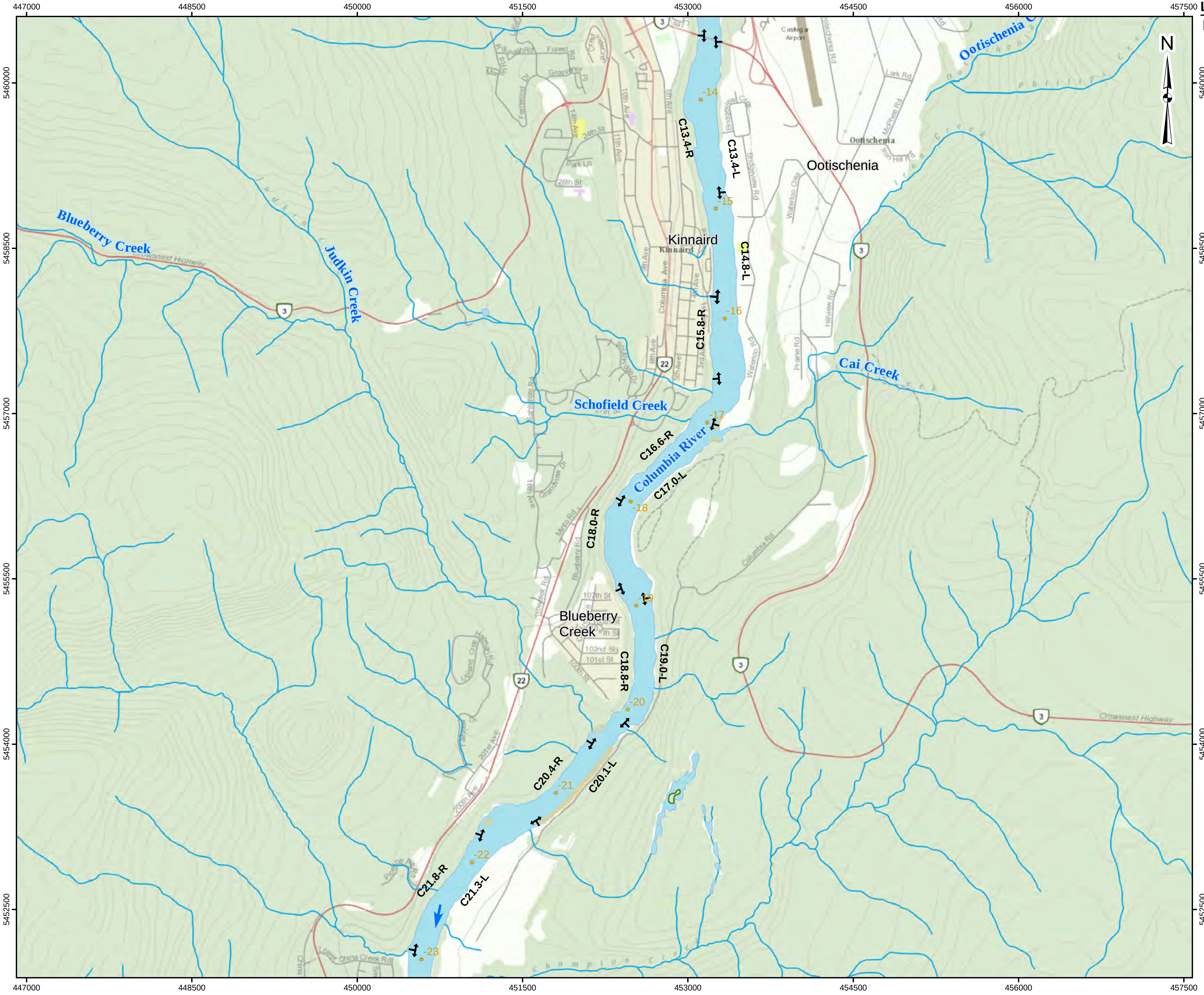

LEGEND

C00.0-R	BOAT ELECTROSHOCKING SITE
➔	FLOW DIRECTION
●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
~	WATERCOURSE
	WATERBODY
—	BREAKWATER
▬	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

REFERENCE

WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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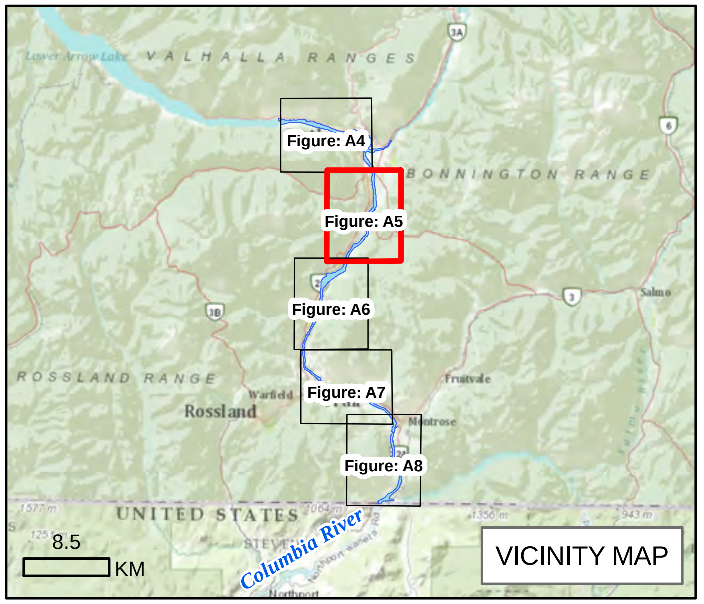
Metres

SCALE 1:35,000



PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE

2013 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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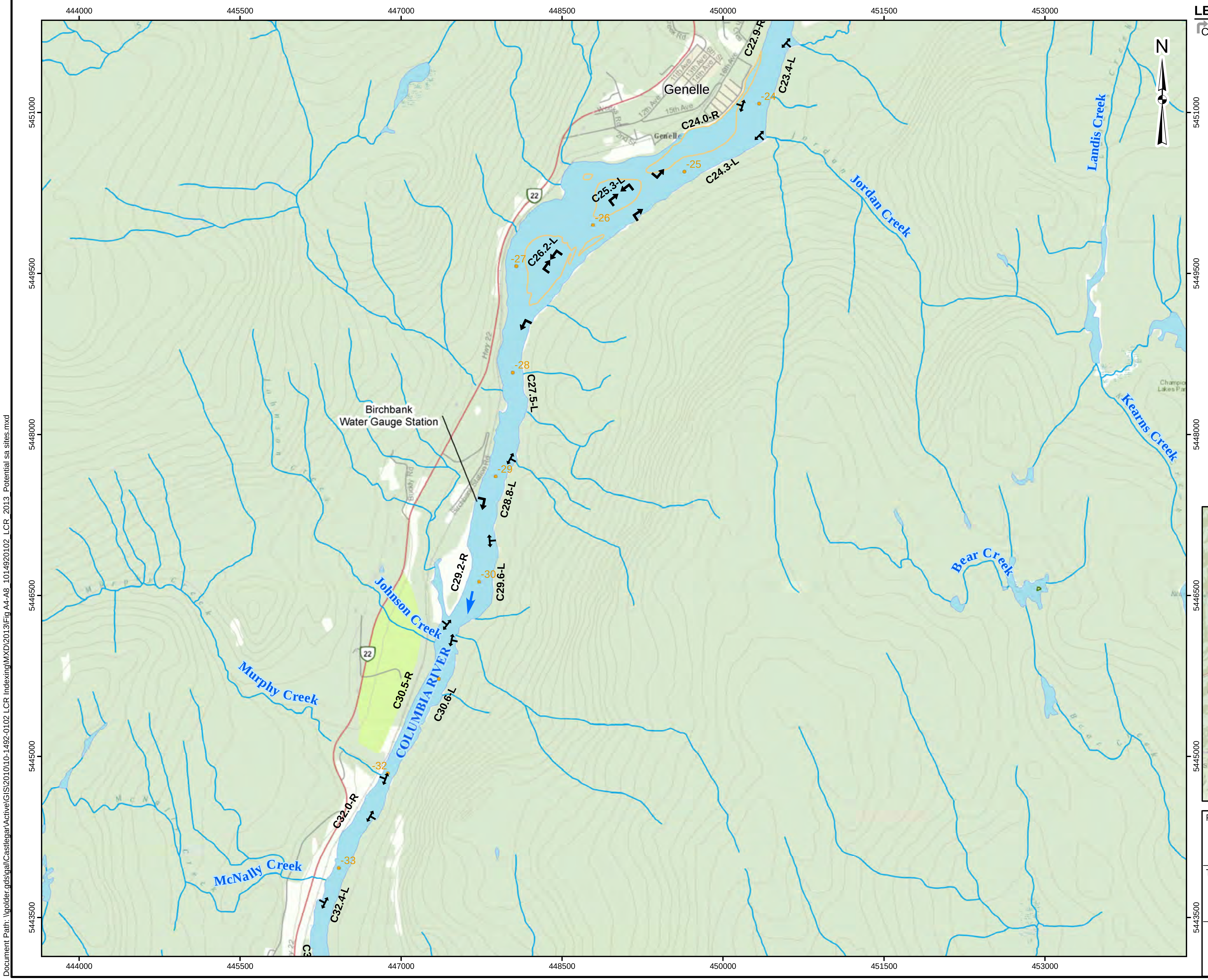

LEGEND

C00.0-R	BOAT ELECTROSHOCKING SITE
➔	FLOW DIRECTION
●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
~	WATERCOURSE
	WATERBODY
—	BREAKWATER
▬	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

REFERENCE

WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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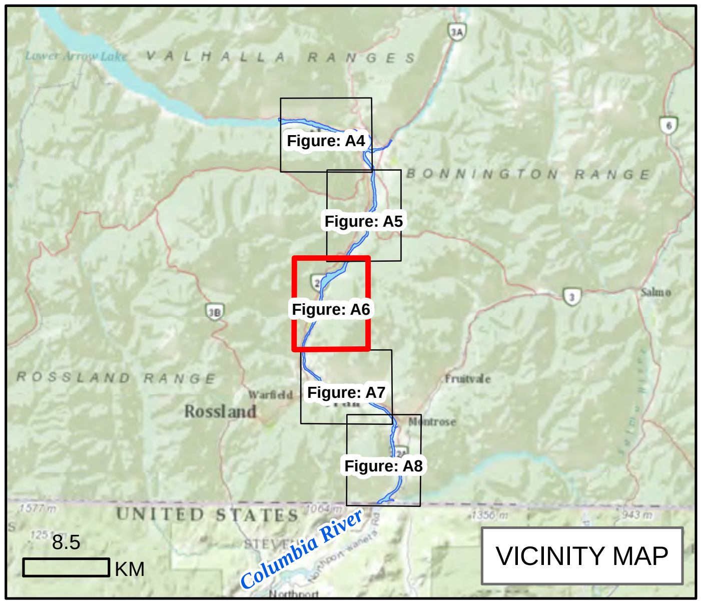
Metres

SCALE 1:35,000



VICINITY MAP

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE
2013 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102		
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GIS	JG	13 Jun. 2011
CHECK	DF	24 Jun. 2013
REVIEW	LH	24 Jun. 2013

SCALE AS SHOWN

REV. 0

Figure: A6

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LEGEND

- C00.0-R BOAT ELECTROSHOCKING SITE
- ➔ FLOW DIRECTION
- ● RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
- WATERCOURSE
- WATERBODY
- BREAKWATER
- DAM SECTION
- ISLAND
- SAND OR GRAVEL BAR

REFERENCE

WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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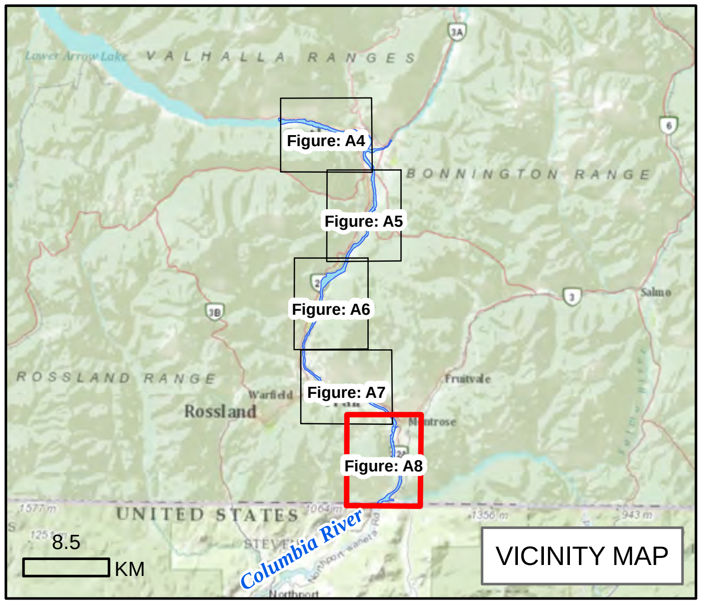

VICINITY MAP

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE

2013 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
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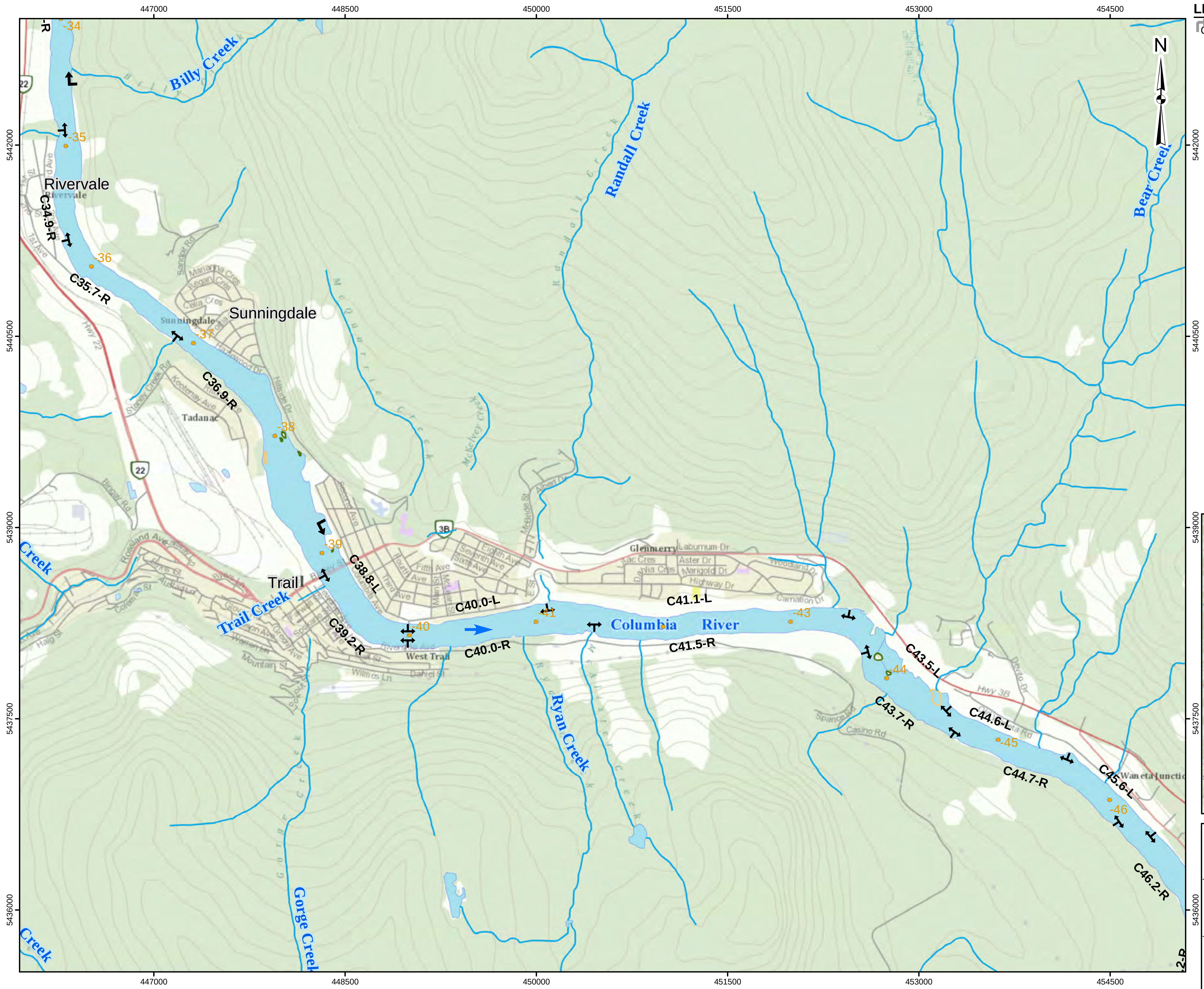


LEGEND

C00.0-R BOAT ELECTROSHOCKING SITE
FLOW DIRECTION
RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
WATERCOURSE
WATERBODY
BREAKWATER
DAM SECTION
ISLAND
SAND OR GRAVEL BAR

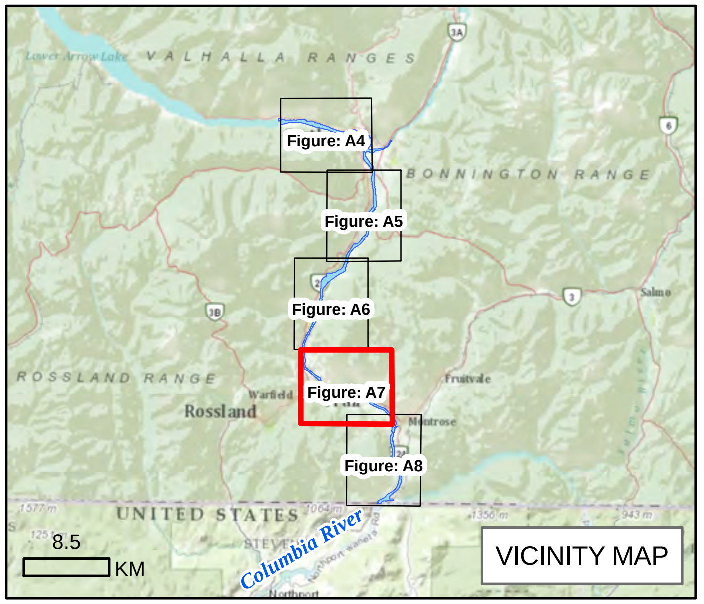
REFERENCE

WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

750 0 750
Metres

SCALE 1:30,000



VICINITY MAP

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE
2013 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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Table A1 Locations and distances from Hugh L. Keenleyside Dam of boat electroshocking sites in the Lower Columbia River, 2013.

Site Designation[a]	**Location (km)**[b]	**Bank**[c]	**UTM Coordinates**		
			Zone	**Easting**	**Northing**
Columbia River Upstream					
C00.0-R U/S	0.0	RDB	11U	443996	5465466
C00.0-R D/S	0.9	RDB	11U	444649	5465448
C00.7-L U/S	0.7	LDB	11U	444387	5465734
C00.7-L D/S	1.3	LDB	11U	445015	5465719
C01.3-L U/S	1.3	LDB	11U	445015	5465719
C01.3-L D/S	2.8	LDB	11U	446504	5465652
C02.8-L U/S	2.8	LDB	11U	446504	5465652
C02.8-L D/S	3.6	LDB	11U	447294	5465482
C03.6-L U/S	3.6	LDB	11U	447294	5465482
C03.6-L D/S	5.6	LDB	11U	449206	5464833
C04.6-R U/S	4.6	RDB	11U	448162	5464921
C04.6-R D/S	5.1	RDB	11U	448614	5464820
C05.6-L U/S	5.6	LDB	11U	449206	5464833
C05.6-L D/S	6.7	LDB	11U	450212	5464594
C07.3-R U/S	7.3	RDB	11U	450808	5464265
C07.3-R D/S	9.0	RDB	11U	452366	5464096
C07.4-L U/S	7.4	LDB	11U	450892	5464632
C07.4-L D/S	8.3	LDB	11U	451742	5464481
Kootenay River					
K00.3-L U/S	0.3	LDB	11U	453656	5462748
K00.3-L D/S	0.0	LDB	11U	452578	5462650
K00.6-R U/S	0.6	RDB	11U	453151	5462849
K00.6-R D/S	0.0	RDB	11U	452627	5462822
K01.8-L U/S	1.8	LDB	11U	454451	5462972
K01.8-L D/S	0.3	LDB	11U	453656	5462748
K01.8-R U/S	1.8	RDB	11U	454398	5463053
K01.8-R D/S	0.6	RDB	11U	453151	5462849
Columbia River Downstream					
C25.3-R U/S	25.3	RDB	11U	449606	5450670
C25.3-R D/S	27.6	RDB	11U	448277	5450106
C27.6-R U/S	27.6	RDB	11U	448277	5450106
C27.6-R D/S	28.1	RDB	11U	447985	5448428
C28.2-R U/S	28.2	RDB	11U	447985	5448428
C28.2-R D/S	29.2	RDB	11U	447749	5447453
C34.9-L U/S	34.9	LDB	11U	446321	5442589
C34.9-L D/S	36.6	LDB	11U	447116	5440687
C36.6-L U/S	36.6	LDB	11U	447116	5440687
C36.6-L D/S	38.8	LDB	11U	448286	5438982
C47.8-L U/S	47.8	LDB	11U	455317	5435244
C47.8-L D/S	49.0	LDB	11U	455121	5434301
C48.2-R U/S	48.2	RDB	11U	455021	5434885
C48.2-R D/S	49.0	RDB	11U	455177	5434013
C49.0-L U/S	49.0	LDB	11U	455121	5434301
C49.0-L D/S	49.8	LDB	11U	455204	5433379
C49.0-R U/S	49.0	RDB	11U	455177	5434013
C49.0-R D/S	49.8	RDB	11U	454993	5433410
C49.8-L U/S	49.8	LDB	11U	455204	5433379
C49.8-L D/S	52.2	LDB	11U	455385	5431291
C49.8-R U/S	49.8	RDB	11U	454993	5433410
C49.8-R D/S	51.9	RDB	11U	454976	5431377
C52.2-L U/S	52.2	LDB	11U	455385	5431291
C52.2-L D/S	52.8	LDB	11U	455888	5430887
C52.2-R U/S	52.2	RDB	11U	455350	5431088
C52.2-R D/S	56.0	RDB	11U	454287	5428238
C52.8-L U/S	52.8	LDB	11U	455888	5430887
C52.8-L D/S	53.6	LDB	11U	455898	5429799

[a] U/S = Upstream limit of site; D/S = Downstream limit of site.

[b] River kilometres downstream from Hugh L. Keenleyside Dam.

[c] LDB=Left bank as viewed facing downstream; RDB=Right bank as viewed facing downstream.

Table A2 Locations of selected sites and available sites included in the Generalized Random Tessellation Stratified (GRTS) survey, 2013.

Site Designation	Location (km)[a]	Bank[b]	Upstream UTM Coordinates			Downstream UTM Coordinates			Sites Selected in 2013
			Zone	Easting	Northing	Zone	Easting	Northing	
Columbia River Upstream									
C01.0-R	1.0	RDB	11U	444717	5465448	11U	447236	5465125	
C03.6-R	3.6	RDB	11U	447236	5465125	11U	448125	5464914	X
C05.1-R	5.1	RDB	11U	448612	5464808	11U	449518	5464513	X
C06.0-R	6.0	RDB	11U	449518	5464513	11U	450804	5464243	
C06.7-L	6.7	LDB	11U	450223	5464603	11U	450876	5464645	
C08.4-L	8.4	LDB	11U	451833	5464445	11U	452304	5464244	
C08.6-L	8.6	LDB	11U	452132	5464468	11U	452720	5464206	
C08.9-R	8.9	RDB	11U	452375	5464074	11U	452797	5463486	
C09.0-L	9.0	LDB	11U	452286	5462718	11U	452286	5462718	
C09.2-L	9.2	LDB	11U	452720	5464206	11U	452987	5463481	
C09.8-L	9.8	LDB	11U	452926	5463604	11U	452620	5462860	
C09.8-R	9.8	RDB	11U	452761	5463608	11U	452416	5462880	
Columbia River Downstream									
C10.7-R	10.7	LDB	11U	452416	5462880	11U	452217	5462050	
C10.8-R	10.8	RDB	11U	452154	5462718	11U	452154	5462718	
C10.9-L	10.9	LDB	11U	452584	5462607	11U	453290	5460373	X
C11.5-R	11.5	RDB	11U	452217	5462050	11U	453103	5460426	X
C13.4-L	13.4	LDB	11U	453290	5460373	11U	453321	5459007	
C13.4-R	13.4	RDB	11U	453103	5460426	11U	453221	5458057	
C14.8-L	14.8	LDB	11U	453321	5459007	11U	453210	5456890	
C15.8-R	15.8	RDB	11U	453221	5458057	11U	453234	5457317	
C16.6-R	16.6	RDB	11U	453234	5457317	11U	452358	5456216	
C17.0-L	17.0	LDB	11U	453210	5456890	11U	452622	5455322	X
C18.0-R	18.0	RDB	11U	452358	5456216	11U	452351	5455401	X
C18.8-R	18.8	RDB	11U	452351	5455401	11U	452122	5454012	
C19.0-L	19.0	LDB	11U	452622	5455322	11U	452444	5454183	X
C20.1-L	20.1	LDB	11U	452444	5454182	11U	451645	5453285	
C20.4-R	20.4	RDB	11U	452122	5454012	11U	451093	5453191	
C21.3-L	21.3	LDB	11U	451645	5453285	11U	450603	5451637	X
C21.8-R	21.8	RDB	11U	451093	5453191	11U	450495	5452148	
C22.9-R	22.9	RDB	11U	450495	5452148	11U	450188	5451058	X
C23.4-L	23.4	LDB	11U	450603	5451637	11U	450368	5450764	
C24.0-R	24.0	RDB	11U	450188	5451058	11U	449356	5450418	
C24.3-L	24.3	LDB	11U	450368	5450764	11U	449178	5449989	
C25.3-L	25.3	MID	11U	448978	5450229	11U	448978	5450229	X
C26.2-L	26.2	MID	11U	448938	5449626	11U	448938	5449626	X
C27.5-L	27.5	LDB	11U	448193	5449036	11U	448064	5447758	
C28.8-L	28.8	LDB	11U	448064	5447758	11U	447820	5446998	
C29.2-R	29.2	RDB	11U	447715	5447420	11U	447397	5446252	
C29.6-L	29.6	LDB	11U	447820	5446998	11U	447491	5446079	
C30.5-R	30.5	RDB	11U	447397	5446252	11U	446817	5444824	
C30.6-L	30.6	LDB	11U	447491	5446079	11U	446746	5444432	X
C32.0-R	32.0	RDB	11U	446817	5444824	11U	446256	5443655	
C32.4-L	32.4	LDB	11U	446746	5444432	11U	446353	5442572	X
C33.3-R	33.3	RDB	11U	446256	5443655	11U	446260	5442116	
C34.9-R	34.9	RDB	11U	446260	5442116	11U	446294	5441253	X
C35.7-R	35.7	RDB	11U	446294	5441253	11U	447152	5440472	
C36.9-R	36.9	RDB	11U	447152	5440472	11U	448305	5438607	
C38.8-L	38.8	LDB	11U	448340	5439017	11U	449001	5438233	
C39.2-R	39.2	RDB	11U	448305	5438607	11U	448995	5438083	
C40.0-L	40.0	LDB	11U	449001	5438233	11U	450090	5438405	
C40.0-R	40.0	RDB	11U	448995	5438083	11U	450459	5438222	X
C41.1-L	41.1	LDB	11U	450090	5438405	11U	452466	5438365	
C41.5-R	41.5	RDB	11U	450459	5438222	11U	452579	5438015	X
C43.5-L	43.5	LDB	11U	452466	5438365	11U	453245	5437597	
C43.7-R	43.7	RDB	11U	452579	5438015	11U	453275	5437384	
C44.6-L	44.6	LDB	11U	453245	5437597	11U	454179	5437228	X
C44.7-R	44.7	RDB	11U	453275	5437384	11U	454560	5436673	
C45.6-L	45.6	LDB	11U	454179	5437228	11U	454855	5436623	X
C46.2-R	46.2	RDB	11U	454560	5436673	11U	455141	5435856	
C46.4-L	46.4	LDB	11U	454855	5436623	11U	455319	5435321	
C47.2-R	47.2	RDB	11U	455141	5435856	11U	455017	5434942	X
C56.0-L	56.0	LDB	11U	454774	5428024	11U	453949	5427733	X

[a] River kilometres downstream from Hugh L. Keenleyside Dam.

[b] LDB=Left bank as viewed facing downstream; RDB=Right bank as viewed facing downstream.

APPENDIX B

Habitat Summary Information

Table B1 Descriptions of categories used in the Lower Columbia River Bank Habitat Types Classification System.

Category	Code	Description
Armoured/Stable	A1	Banks generally stable and at repose with cobble/small boulder/gravel substrates predominating; uniform shoreline configuration with few/minor bank irregularities; velocities adjacent to bank generally low-moderate, instream cover limited to substrate roughness (i.e., cobble/small boulder interstices).
	A2	Banks generally stable and at repose with cobble/small boulder and large boulder substrates predominating; irregular shoreline configuration generally consisting of a series of armoured cobble/boulder outcrops that produce Backwater habitats; velocities adjacent to bank generally moderate with low velocities provided in BW habitats: instream cover provided by BW areas and substrate roughness; overhead cover provided by depth and woody debris; occasionally associated with C2, E4, and E5 banks.
	A3	Similar to A2 in terms of bank configuration and composition although generally with higher composition of large boulders/bedrock fractures; very irregular shoreline produced by large boulders and bed rock outcrops; velocities adjacent to bank generally moderate to high; instream cover provided by numerous small BW areas, eddy pools behind submerged boulders, and substrate interstices; overhead cover provided by depth; exhibits greater depths offshore than found in A1 or A2 banks; often associated with C1 banks.
	A4	Gently sloping banks with predominantly small and large boulders (boulder garden) often embedded in finer materials; shallow depths offshore, generally exhibits moderate to high velocities; instream cover provided by “pocket eddies” behind boulders; overhead cover provided by surface turbulence.
	A5	Bedrock banks, generally steep in profile resulting in deep water immediately offshore; often with large bedrock fractures in channel that provide instream cover; usually associated with moderate to high current velocities; overhead cover provided by depth.
	A6	Man-made banks usually armoured with large boulder or concrete rip-rap; depths offshore generally deep and usually found in areas with moderate to high velocities; instream cover provided by rip-rap interstices; overhead cover provided by depth and turbulence.
Depositional	D1	Low relief, gently sloping bank type with shallow water depths offshore; substrate consists predominantly of fines (i.e., sand/silt); low current velocities offshore; instream cover generally absent or, if present, consisting of shallow depressions produced by dune formation (i.e., in sand substrates) or embedded cobble/boulders and vegetative debris; this bank type was generally associated with bar formations or large backwater areas.
	D2	Low relief, gently sloping bank type with shallow water depths offshore; substrate consists of coarse materials (i.e., gravels/cobbles); low-moderate current velocities offshore; areas with higher velocities usually producing riffle areas; overhead cover provided by surface turbulence in riffle areas; instream cover provided by substrate roughness; often associated with bar formations and shoal habitat.
	D3	Similar to D2 but with coarser substrates (i.e., large cobble/small boulder) more dominant; boulders often embedded in cobble/gravel matrix; generally found in areas with higher average flow velocities than D1 or D2 banks; instream cover abundantly available in form of substrate roughness; overhead cover provided by surface turbulence; often associated with fast riffle transitional bank type that exhibits characteristics of both Armoured and Depositional bank types.
SPECIAL HABITAT FEATURES		
BACKWATER POOLS	-	These areas represent discrete areas along the channel margin where backwater irregularities produce localized areas of counter-current flows or areas with reduced flow velocities relative to the mainstem; can be quite variable in size and are often an integral component of Armoured and erosional bank types. The availability and suitability of Backwater pools are determined by flow level. To warrant separate identification as a discrete unit, must be a minimum of 10 m in length; widths highly variable depending on bank irregularity that produces the pool. Three classes are identified:
	BW-P1	Highest quality pool habitat type for adult and subadult cohorts for feeding/holding functions. Maximum depth exceeding 2.5 m, average depth 2.0 m or greater; high availability of instream cover types (e.g., submerged boulders, bedrock fractures, depth, woody debris); usually with Moderate to High countercurrent flows that provide overhead cover in the form of surface turbulence.
	BW-P2	Moderate quality pool type for adult and subadult cohorts for feeding/holding; also provides moderate quality habitat for smaller juveniles for rearing. Maximum depths between 2.0 to 2.5 m, average depths generally in order of 1.5 m. Moderate availability of instream cover types; usually with Low to Moderate countercurrent flow velocities that provide limited overhead cover.

Continued.

Table B1 Concluded.

	BW-P3	Low quality pool type for adult/subadult classes; moderate-high quality habitat for y-o-y and small juveniles for rearing. Maximum depth <1.0 m. Low availability of instream cover types; usually with Low-Nil current velocities.
EDDY POOL	EDDY	Represent large (<30 m in diameter) areas of counter current flows with depths generally >5 m; produced by major bank irregularities and are available at all flow stages although current velocities within eddy are dependent on flow levels. High quality areas for adult and subadult life stages. High availability of instream cover.
SNYE	SN	A side channel area that is separated from the mainstem at the upstream end but retains a connection at the lower end. SN habitats generally present only at lower flow stages since area is a flowing side channel at higher flows: characterized by low-nil velocity, variable depths (generally <3 m) and predominantly depositional substrates (i.e., sand/silt/gravel); often supports growths of aquatic vegetation; very important areas for rearing and feeding.

Velocity Classifications:

Low: <0.5 m/s
Moderate: 0.5 to 1.0 m/s
High: >1.0 m/s

Table B2 Length of bank habitat types at boat electroshocking sites within the Lower Columbia River, 2012.

Section	**Site**[a]	**Length (m) of Bank Habitat Type**[b]														**Total Length (m)**
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A1+A2**	**A2+A3**	**D1**	**D2**	**D3**	**D1+D2**	**BW**	**Eddy**	
Upstream Columbia	C00.0-R		543											394		**937**
	C00.7-L		290							303						**593**
	C01.3-L	200								1401						**1601**
	C02.8-L									882						**882**
	C03.6-L	1276			121					691						**2087**
	C04.6-R									517						**517**
	C05.6-L	654								447						**1101**
	C07.3-R				1705											**1705**
	C07.4-L												998			**998**
Upstream Columbia Total		2130	833		1826					4241			998	394		**10 422**
Kootenay River	K00.3-L								230					207		**436**
	K00.6-R												364		232	**596**
	K01.8-L		304			387					1179					**1871**
	K01.8-R					326			971							**1296**
Kootenay River Total			304			713			1200		1179		364	207	232	**4199**
Downstream Columbia	C25.3-R	1380				317			1029							**2727**
	C27.6-R					122			185		306					**613**
	C28.2-R		1131													**1131**
	C34.9-L		1740	396												**2136**
	C36.6-L					880			1031			483				**2395**
	C47.8-L								826	613						**1439**
	C48.2-R												495	514		**1009**
	C49.0-L		379								550					**930**
	C49.0-R							101					618			**720**
	C49.8-L		2447													**2447**
	C49.8-R		1511								489			391		**2391**
	C52.2-L										458				431	**889**
	C52.2-R		3272												518	**3790**
	C52.8-L		428		464											**893**
	C53.6-L						1518									**1518**
Downstream Columbia Total		1380	10909	396	464	1320	1518	101	3072	613	1802	483	1113	905	949	**25 026**
Grand Total		**3510**	**12047**	**396**	**2290**	**2033**	**1518**	**101**	**4272**	**4854**	**2982**	**483**	**2475**	**1506**	**1181**	**39 648**

[a] See Appendix A, Figures A1 to A3 for sample site locations.

[b] See Appendix B, Table B1 for bank habitat type descriptions.

Table B3 Summary of habitat variables recorded at boat electroshocking sites in the Lower Columbia River, 6 October to 3 November 2013.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Kootenay	K00.3-L	1	2.00	12.10	160	Clear	High	High	High	30	0	0	0	0	0	70
Kootenay	K00.3-L	2	0.00	12.30	160	Clear	High	High	High	20	0	0	0	0	0	80
Kootenay	K00.3-L	3	2.00	11.10	160	Mostly cloudy	High	High	High	30	0	0	0	0	0	70
Kootenay	K00.3-L	4	2.00	9.90	160	Clear	High	High	High	50	0	0	0	0	0	50
Kootenay	K00.6-R	1	5.00	14.00	160	Clear	High	High	High	20	0	0	30	0	50	0
Kootenay	K00.6-R	2	3.00	12.30	160	Clear	High	High	High	30	0	10	40	0	0	20
Kootenay	K00.6-R	3	6.00	11.20	160	Mostly cloudy	High	High	High	40	0	0	20	0	0	40
Kootenay	K00.6-R	4	2.00	9.90	160	Clear	High	High	High	40	0	0	20	0	0	40
Kootenay	K01.8-L	1	2.00	12.10	160	Clear	High	High	High	0	0	20	0	0	70	10
Kootenay	K01.8-L	2	1.00	12.30	160	Clear	High	High	High	30	0	0	0	0	30	40
Kootenay	K01.8-L	3	4.00	10.70	160	Mostly cloudy	High	High	High	30	0	10	0	0	40	20
Kootenay	K01.8-L	4	2.00	9.90	160	Clear	High	High	High	30	0	0	0	0	0	70
Kootenay	K01.8-R	1	4.00	14.00	160	Clear	High	High	High	20	0	5	0	0	10	65
Kootenay	K01.8-R	2	3.00	12.50	160	Clear	High	High	High	20	0	20	0	0	20	40
Kootenay	K01.8-R	3	6.00	11.10	160	Mostly cloudy	High	High	High	40	0	0	0	0	0	60
Kootenay	K01.8-R	4	2.00	9.80	160	Clear	High	High	High	40	0	0	0	0	0	60
Lower	C10.9-L	5	6.00	9.20	150	Clear	High	High	High	40	0	0	0	0	0	60
Lower	C11.5-R	5	6.00	9.20	130	Mostly cloudy	High	High	High	40	0	10	0	0	30	20
Lower	C17.0-L	5	4.00	9.50	130	Clear	High	High	High	30	0	0	0	0	10	60
Lower	C18.0-R	5	1.00	9.80	130	Clear	High	High	High	40	0	0	0	0	0	60
Lower	C19.0-L	5	1.00	9.80	130	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C21.3-L	5	1.00	9.90	130	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C22.9-R	5	-4.00	9.50	130	Clear	High	High	High	70	0	0	0	0	20	10
Lower	C25.3-L	5	6.00	9.40	130	Mostly cloudy	High	High	High	70	0	0	10	0	0	20
Lower	C25.3-R	1	4.00	13.10	140	Clear	High	High	High	35	0	13	2	0	0	50
Lower	C25.3-R	2	9.00	13.00	140	Mostly cloudy	High	High	High	20	0	10	0	0	20	50
Lower	C25.3-R	3	8.00	12.10	130	Clear	High	High	High	30	0	0	0	0	30	40
Lower	C25.3-R	4	7.00	11.60	120	Mostly cloudy	High	High	High	40	0	10	0	0	0	50
Lower	C26.2-L	5	0.00	9.90	130	Mostly cloudy	Low	High	High	60	0	0	0	0	0	40
Lower	C27.6-R	1	2.00	12.50	130	Clear	High	High	High	35	0	0	0	0	5	60
Lower	C27.6-R	2	5.00	13.00	140	Clear	High	High	High	10	0	10	0	0	70	10

[a] See Appendix B, Figures B1 to B3 for sample site locations.

continued…

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s.

[d] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m.

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Lower	C27.6-R	3	6.00	12.10	130	Clear	High	High	High	30	0	0	0	0	40	30
Lower	C27.6-R	4	3.00	11.60	120	Mostly cloudy	High	High	High	50	0	0	0	0	0	50
Lower	C28.2-R	1	1.00	12.40	140	Clear	High	High	High	10	0	0	0	0	80	10
Lower	C28.2-R	2	4.00	13.00	140	Clear	High	High	High	10	0	0	0	0	80	10
Lower	C28.2-R	3	4.00	12.10	130	Clear	High	High	High	20	0	0	0	0	40	40
Lower	C28.2-R	4	2.00	11.60	120	Mostly cloudy	High	High	High	30	0	0	0	0	20	50
Lower	C30.6-L	5	1.00	9.90	130	Mostly cloudy	High	High	High	40	0	0	0	0	0	60
Lower	C32.4-L	5	1.00	9.80	130	Mostly cloudy	High	High	High	50	0	0	0	0	0	50
Lower	C34.9-L	1	6.00	13.40	140	Clear	High	High	High	50	0	5	0	0	5	40
Lower	C34.9-L	2	8.00	12.90	140	Clear	High	High	High	30	0	10	0	0	20	40
Lower	C34.9-L	3	8.00	12.40	140	Clear	High	High	High	50	0	0	0	0	0	50
Lower	C34.9-L	4	5.00	11.60	120	Mostly cloudy	High	High	High	30	0	0	0	0	0	70
Lower	C34.9-R	5	1.00	9.50	130	Mostly cloudy	High	High	High	20	0	0	0	0	0	80
Lower	C36.6-L	1	2.00	11.30	160	Clear	High	High	High	0	0	0	2	0	49	49
Lower	C36.6-L	2	3.00	12.70	140	Clear	High	High	High	20	0	20	5	0	20	35
Lower	C36.6-L	3	3.00	12.40	140	Clear	High	High	High	30	0	10	5	0	10	45
Lower	C36.6-L	4	3.00	11.60	150	Mostly cloudy	High	High	High	30	0	0	5	0	0	65
Lower	C40.0-R	5	4.00	9.30	130	Mostly cloudy	High	High	High	50	0	0	0	0	0	50
Lower	C41.5-R	5	4.00	9.60	130	Mostly cloudy	High	High	High	40	0	0	0	0	0	60
Lower	C44.6-L	5	2.00	9.60	130	Mostly cloudy	High	High	High	70	0	0	0	0	0	30
Lower	C45.6-L	5	2.00	9.60	130	Mostly cloudy	High	High	High	60	0	0	0	0	0	40
Lower	C47.2-R	5	2.00	9.60	130	Mostly cloudy	High	High	High	70	0	0	0	0	0	30
Lower	C47.8-L	1	7.00	13.20	140	Clear	High	High	High	20	0	10	5	0	10	55
Lower	C47.8-L	2	7.00	12.50	140	Clear	High	High	High	20	0	0	10	0	20	50
Lower	C47.8-L	3	8.00	11.90	130	Clear	High	High	High	40	0	0	5	0	35	20
Lower	C47.8-L	4	6.00	10.90	130	Clear	High	High	High	30	0	0	10	0	40	20
Lower	C48.2-R	1	7.00	13.30	140	Clear	High	High	High	15	0	10	5	0	30	40
Lower	C48.2-R	2	5.00	12.80	140	Clear	High	High	High	35	0	0	5	0	60	0
Lower	C48.2-R	3	5.00	12.00	120	Clear	High	High	High	30	0	0	5	0	35	30
Lower	C48.2-R	4	7.00	11.60	130	Clear	High	High	High	20	0	0	0	0	30	50
Lower	C49.0-L	1	6.00	13.20	140	Clear	High	High	High	20	0	10	0	0	30	40

[a] See Appendix B, Figures B1 to B3 for sample site locations.

continued…

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s.

[d] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m.

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Lower	C49.0-L	2	3.00	12.50	140	Clear	High	High	High	20	0	0	0	0	60	20
Lower	C49.0-L	3	4.00	11.90	130	Clear	High	High	High	40	0	0	0	0	20	40
Lower	C49.0-L	4	3.00	11.10	130	Clear	High	High	High	40	0	0	0	0	20	40
Lower	C49.0-R	1	7.00	13.30	140	Clear	High	High	High	20	0	10	10	0	40	20
Lower	C49.0-R	2	5.00	12.00	140	Clear	High	High	High	90	0	0	0	0	5	5
Lower	C49.0-R	3	4.00	12.00	130	Clear	High	High	High	0	0	0	0	0	0	0
Lower	C49.0-R	4	3.00	11.60	130	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C49.8-L	1	4.00	13.20	140	Clear	High	High	High	10	0	10	0	0	50	30
Lower	C49.8-L	2	3.00	12.50	140	Clear	High	High	High	30	0	10	2	0	18	40
Lower	C49.8-L	3	3.00	11.50	130	Clear	High	High	High	30	0	0	0	0	20	50
Lower	C49.8-L	4	0.00	10.50	130	Clear	High	High	High	50	0	0	0	0	0	50
Lower	C49.8-R	1	6.00	13.30	140	Clear	High	High	High	80	0	0	5	0	0	15
Lower	C49.8-R	2	2.00	12.60	140	Clear	High	High	High	80	0	0	10	0	0	10
Lower	C49.8-R	3	4.00	12.00	130	Clear	High	High	High	30	0	0	0	0	30	40
Lower	C49.8-R	4	2.00	11.20	130	Clear	High	High	High	40	0	0	2	0	20	38
Lower	C52.2-L	1	3.00	13.20	140	Clear	High	High	High	10	0	20	0	0	20	50
Lower	C52.2-L	2	1.00	12.50	140	Clear	High	High	High	20	0	0	0	0	0	80
Lower	C52.2-L	3	2.00	11.50	130	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C52.2-L	4	0.00	10.40	130	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C52.2-R	1	4.00	13.30	140	Clear	High	High	High	60	0	10	0	0	10	20
Lower	C52.2-R	2	-1.00	12.10	140	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C52.2-R	3	4.00	11.60	130	Clear	High	High	High	30	0	0	0	0	20	50
Lower	C52.2-R	4	6.00	11.50	130	Clear	High	High	High	30	0	0	0	0	20	50
Lower	C52.8-L	1	3.00	13.20	140	Clear	High	High	High	20	0	20	0	0	20	40
Lower	C52.8-L	2	-1.00	12.10	140	Clear	High	High	High	30	0	20	0	0	0	50
Lower	C52.8-L	3	2.00	11.50	130	Mostly cloudy	High	High	High	50	0	0	0	0	0	50
Lower	C52.8-L	4	0.00	10.50	130	Clear	High	High	High	50	0	0	0	0	0	50
Lower	C53.6-L	1	3.00	13.20	140	Clear	High	High	High	20	0	10	5	0	25	40
Lower	C53.6-L	2	1.00	12.10	140	Clear	High	High	High	50	0	10	5	0	15	20
Lower	C53.6-L	3	3.00	11.50	130	Mostly cloudy	High	High	High	40	0	0	0	0	0	60
Lower	C53.6-L	4	0.00	10.50	130	Clear	High	High	High	50	0	0	0	0	0	50

[a] See Appendix B, Figures B1 to B3 for sample site locations.

continued…

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s.

[d] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m.

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Lower	C56.0-L	5	4.00	11.20	160	Clear	High	High	High	50	0	0	0	0	0	50
Upper	C00.0-R	1	6.00	12.40	110	Clear	High	Low	High	40	0	0	0	0	20	40
Upper	C00.0-R	2	5.00	12.20	120	Overcast	High	Low	High	70	0	0	4	0	26	0
Upper	C00.0-R	3	8.00	12.10	120	Mostly cloudy	High	Low	High	60	0	0	0	0	20	20
Upper	C00.0-R	4	4.00	11.50	130	Clear	High	Low	High	30	0	0	0	0	0	70
Upper	C00.7-L	1	8.00	12.30	120	Clear	High	Low	High	30	0	0	0	0	30	40
Upper	C00.7-L	2	5.00	12.30	110	Overcast	High	Low	High	70	0	0	20	0	5	5
Upper	C00.7-L	3	6.00	12.10	120	Mostly cloudy	High	Low	High	40	0	0	0	0	20	40
Upper	C00.7-L	4	2.00	11.50	130	Clear	High	Low	High	50	0	0	0	0	0	50
Upper	C01.3-L	1	6.00	12.10	120	Clear	High	Low	High	20	0	0	30	0	30	20
Upper	C01.3-L	2	5.00	12.10	110	Overcast	High	Low	High	15	0	0	65	0	20	0
Upper	C01.3-L	3	6.00	12.10	120	Mostly cloudy	High	Low	High	0	0	0	10	0	80	10
Upper	C01.3-L	4	1.00	10.60	110	Clear	High	Low	High	10	0	0	20	0	60	10
Upper	C02.8-L	1	2.00	12.30	110	Clear	High	Low	High	0	0	0	70	0	20	10
Upper	C02.8-L	2	2.00	12.20	110	Overcast	High	Low	High	0	0	0	80	0	10	10
Upper	C02.8-L	3	5.00	12.00	120	Mostly cloudy	Low	Low	High	0	0	0	80	0	20	0
Upper	C02.8-L	4	1.00	11.00	120	Clear	High	Low	High	0	0	0	85	0	10	5
Upper	C03.6-L	1	2.00	12.30	110	Clear	High	Low	High	10	0	0	40	0	40	10
Upper	C03.6-L	2	2.00	12.00	110	Overcast	High	Low	High	20	0	0	80	0	0	0
Upper	C03.6-L	3	5.00	12.20	120	Mostly cloudy	High	Low	High	10	0	0	20	0	50	20
Upper	C03.6-L	4	1.00	11.10	120	Clear	High	Low	High	0	0	0	25	0	30	45
Upper	C03.6-R	5	7.00	8.90	130	Partly cloudy	High	Low	High	0	0	0	100	0	0	0
Upper	C04.6-R	1	2.00	12.10	130	Clear	High	Low	High	0	0	0	90	0	10	0
Upper	C04.6-R	2	2.00	12.20	120	Overcast	High	Low	High	0	0	0	100	0	0	0
Upper	C04.6-R	3	4.00	12.10	120	Mostly cloudy	High	Low	High	0	0	0	95	0	0	5
Upper	C04.6-R	4	1.00	11.20	130	Clear	High	Low	High	0	0	0	95	0	0	5
Upper	C05.1-R	5	6.00	8.90	130	Clear	High	Low	High	0	0	0	90	0	10	0
Upper	C05.6-L	1	2.00	12.10	130	Clear	High	Low	High	10	0	0	40	0	40	10
Upper	C05.6-L	2	2.00	12.00	120	Overcast	High	Low	High	15	15	0	70	0	0	0
Upper	C05.6-L	3	4.00	12.10	130	Mostly cloudy	High	Low	High	20	0	0	30	0	0	50
Upper	C05.6-L	4	1.00	11.10	130	Clear	High	Low	High	20	0	0	50	0	20	10

[a] See Appendix B, Figures B1 to B3 for sample site locations.

continued…

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s.

[d] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m.

Table B3 Concluded.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Upper	C07.3-R	1	8.00	12.10	120	Clear	High	Low	High	20	0	0	5	0	65	10
Upper	C07.3-R	2	4.00	12.20	120	Clear	High	Low	High	20	0	10	0	0	20	50
Upper	C07.3-R	3	6.00	12.10	130	Mostly cloudy	High	Low	High	30	0	0	0	0	30	40
Upper	C07.3-R	4	4.00	11.10	120	Clear	High	Low	High	40	0	0	0	0	0	60
Upper	C07.4-L	1	6.00	11.80	120	Clear	High	Low	High	0	0	0	10	0	80	10
Upper	C07.4-L	2	8.00	12.30	110	Clear	High	Low	High	40	0	0	15	0	25	20
Upper	C07.4-L	3	7.00	11.90	110	Mostly cloudy	High	Low	High	50	0	0	20	0	10	20
Upper	C07.4-L	4	4.00	10.70	140	Clear	High	Low	High	30	0	0	20	0	0	50

[a] See Appendix B, Figures B1 to B3 for sample site locations.

[b] Clear = <10%; Partly Cloudy = 10-50%; Mostly Cloudy = 50-90%; Overcast = >90%.

[c] High = >1.0 m/s; Medium = 0.5-1.0 m/s; Low = <0.5 m/s.

[d] High = >3.0 m; Medium = 1.0-3.0 m; Low = <1.0 m.

Table B4 Summary of species counts (both captured and observed) by bank habitat types in the Lower Columbia River, 6 October to 3 November 2013.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
Upstream Columbia River	C00.0-R	Kokanee	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Mountain Whitefish	0	13	0	0	0	0	0	0	0	0	0	0	14	0	**27**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	0	6	0	**6**
		Peamouth	0	0	0	0	0	0	0	0	0	0	0	0	2	0	**2**
		Rainbow Trout	0	6	0	0	0	0	0	0	0	0	0	0	6	0	**12**
		Redside Shiner	0	9350	0	0	0	0	0	0	0	0	0	0	3060	0	**12410**
		Sculpin spp.	0	425	0	0	0	0	0	0	0	0	0	0	3642	0	**4067**
		Sucker spp.	0	5	0	0	0	0	0	0	0	0	0	0	53	0	**58**
		Walleye	0	1	0	0	0	0	0	0	0	0	0	0	1	0	**2**
	C00.0-R Total		**0**	**9801**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6784**	**0**	**16585**
	C00.7-L	Kokanee	0	1	0	0	0	0	0	0	1	0	0	0	0	0	**2**
		Lake Whitefish	0	0	0	0	0	0	0	0	2	0	0	0	0	0	**2**
		Mountain Whitefish	0	48	0	0	0	0	0	0	94	0	0	0	0	0	**142**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
		Peamouth	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
		Rainbow Trout	0	14	0	0	0	0	0	0	21	0	0	0	0	0	**35**
		Redside Shiner	0	80	0	0	0	0	0	0	250	0	0	0	0	0	**330**
		Sculpin spp.	0	498	0	0	0	0	0	0	362	0	0	0	0	0	**860**
		Sucker spp.	0	187	0	0	0	0	0	0	199	0	0	0	0	0	**386**
		Walleye	0	3	0	0	0	0	0	0	3	0	0	0	0	0	**6**
	C00.7-L Total		**0**	**831**	**0**	**0**	**0**	**0**	**0**	**0**	**934**	**0**	**0**	**0**	**0**	**0**	**1765**
	C01.3-L	Kokanee	1	0	0	0	0	0	0	0	1	0	0	0	0	0	**2**
		Mountain Whitefish	168	0	0	0	0	0	0	0	398	0	0	0	0	0	**566**
		Northern Pike	1	0	0	0	0	0	0	0	9	0	0	0	0	0	**10**
		Northern Pikeminnow	22	0	0	0	0	0	0	0	71	0	0	0	0	0	**93**
		Peamouth	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
		Rainbow Trout	13	0	0	0	0	0	0	0	61	0	0	0	0	0	**74**
		Redside Shiner	1365	0	0	0	0	0	0	0	9104	0	0	0	0	0	**10469**
		Sculpin spp.	95	0	0	0	0	0	0	0	5218	0	0	0	0	0	**5313**
		Sucker spp.	170	0	0	0	0	0	0	0	1694	0	0	0	0	0	**1864**
		Walleye	2	0	0	0	0	0	0	0	12	0	0	0	0	0	**14**
	C01.3-L Total		**1837**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**16569**	**0**	**0**	**0**	**0**	**0**	**18406**
	C02.8-L	Mountain Whitefish	0	0	0	0	0	0	0	0	90	0	0	0	0	0	**90**
		Northern Pike	0	0	0	0	0	0	0	0	5	0	0	0	0	0	**5**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**
		Rainbow Trout	0	0	0	0	0	0	0	0	22	0	0	0	0	0	**22**
		Redside Shiner	0	0	0	0	0	0	0	0	1020	0	0	0	0	0	**1020**
		Sculpin spp.	0	0	0	0	0	0	0	0	1193	0	0	0	0	0	**1193**
		Sucker spp.	0	0	0	0	0	0	0	0	2772	0	0	0	0	0	**2772**
		Walleye	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**
	C02.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5108**	**0**	**0**	**0**	**0**	**0**	**5108**
	C03.6-L	Brook Trout	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
		Kokanee	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Mountain Whitefish	128	0	0	25	0	0	0	0	78	0	0	0	0	0	**231**
		Northern Pike	16	0	0	0	0	0	0	0	6	0	0	0	0	0	**22**
		Northern Pikeminnow	56	0	0	43	0	0	0	0	21	0	0	0	0	0	**120**
		Peamouth	6	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**
		Rainbow Trout	35	0	0	3	0	0	0	0	29	0	0	0	0	0	**67**
		Redside Shiner	2402	0	0	20	0	0	0	0	677	0	0	0	0	0	**3099**
		Sculpin spp.	390	0	0	70	0	0	0	0	711	0	0	0	0	0	**1171**
		Sucker spp.	585	0	0	151	0	0	0	0	764	0	0	0	0	0	**1500**
		Walleye	26	0	0	4	0	0	0	0	6	0	0	0	0	0	**36**
	C03.6-L Total		**3645**	**0**	**0**	**316**	**0**	**0**	**0**	**0**	**2293**	**0**	**0**	**0**	**0**	**0**	**6254**
	C04.6-R	Mountain Whitefish	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**
		Northern Pike	0	0	0	0	0	0	0	0	22	0	0	0	0	0	**22**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**
		Rainbow Trout	0	0	0	0	0	0	0	0	19	0	0	0	0	0	**19**
		Redside Shiner	0	0	0	0	0	0	0	0	170	0	0	0	0	0	**170**
		Sculpin spp.	0	0	0	0	0	0	0	0	295	0	0	0	0	0	**295**
		Sucker spp.	0	0	0	0	0	0	0	0	474	0	0	0	0	0	**474**
	C04.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**984**	**0**	**0**	**0**	**0**	**0**	**984**
	C05.6-L	Mountain Whitefish	30	0	0	0	0	0	0	0	20	0	0	0	0	0	**50**
		Northern Pike	3	0	0	0	0	0	0	0	20	0	0	0	0	0	**23**
		Northern Pikeminnow	59	0	0	0	0	0	0	0	23	0	0	0	0	0	**82**
		Rainbow Trout	21	0	0	0	0	0	0	0	6	0	0	0	0	0	**27**
		Redside Shiner	300	0	0	0	0	0	0	0	250	0	0	0	0	0	**550**
		Sculpin spp.	245	0	0	0	0	0	0	0	225	0	0	0	0	0	**470**
		Sucker spp.	393	0	0	0	0	0	0	0	286	0	0	0	0	0	**679**
		Walleye	4	0	0	0	0	0	0	0	2	0	0	0	0	0	**6**
	C05.6-L Total		**1055**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**832**	**0**	**0**	**0**	**0**	**0**	**1887**
	C07.3-R	Lake Whitefish	0	0	0	11	0	0	0	0	0	0	0	0	0	0	**11**
		Mountain Whitefish	0	0	0	186	0	0	0	0	0	0	0	0	0	0	**186**
		Northern Pikeminnow	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**2**
		Rainbow Trout	0	0	0	83	0	0	0	0	0	0	0	0	0	0	**83**
		Redside Shiner	0	0	0	1350	0	0	0	0	0	0	0	0	0	0	**1350**
		Sculpin spp.	0	0	0	1415	0	0	0	0	0	0	0	0	0	0	**1415**
		Sucker spp.	0	0	0	428	0	0	0	0	0	0	0	0	0	0	**428**
		Walleye	0	0	0	7	0	0	0	0	0	0	0	0	0	0	**7**
		White Sturgeon	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**
	C07.3-R Total		**0**	**0**	**0**	**3483**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3483**
	C07.4-L	Lake Whitefish	0	0	0	0	0	0	0	0	0	0	0	5	0	0	**5**
		Mountain Whitefish	0	0	0	0	0	0	0	0	0	0	0	306	0	0	**306**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	15	0	0	**15**
		Rainbow Trout	0	0	0	0	0	0	0	0	0	0	0	100	0	0	**100**
		Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	2270	0	0	**2270**
		Sculpin spp.	0	0	0	0	0	0	0	0	0	0	0	1683	0	0	**1683**
		Sucker spp.	0	0	0	0	0	0	0	0	0	0	0	1286	0	0	**1286**
		Walleye	0	0	0	0	0	0	0	0	0	0	0	11	0	0	**11**
		White Sturgeon	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
	C07.4-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5677**	**0**	**0**	**5677**
Upstream Columbia River Total			**6537**	**10632**	**0**	**3799**	**0**	**0**	**0**	**0**	**26720**	**0**	**0**	**5677**	**6784**	**0**	**60149**

continued…

Table B4 Continued.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
Kootenay River	K00.3-L	Mountain Whitefish	0	0	0	0	0	0	0	18	0	0	0	0	15	0	**33**
		Rainbow Trout	0	0	0	0	0	0	0	20	0	0	0	0	6	0	**26**
		Sucker spp.	0	0	0	0	0	0	0	30	0	0	0	0	4	0	**34**
		Walleye	0	0	0	0	0	0	0	3	0	0	0	0	1	0	**4**
		White Sturgeon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
	K00.3-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**72**	**0**	**0**	**0**	**0**	**26**	**0**	**98**
	K00.6-R	Mountain Whitefish	0	0	0	0	0	0	0	0	0	0	0	81	2	12	**95**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	0	0	0	10	0	4	**14**
		Rainbow Trout	0	0	0	0	0	0	0	0	0	0	0	21	3	9	**33**
		Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	250	**250**
		Sculpin spp.	0	0	0	0	0	0	0	0	0	0	0	10	4	150	**164**
		Sucker spp.	0	0	0	0	0	0	0	0	0	0	0	23	3	106	**132**
		Walleye	0	0	0	0	0	0	0	0	0	0	0	8	3	10	**21**
	K00.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**153**	**15**	**541**	**709**
	K01.8-L	Lake Whitefish	0	0	0	0	0	0	0	0	0	5	0	0	0	0	**5**
		Mountain Whitefish	0	100	0	0	6	0	0	0	0	164	0	0	0	0	**270**
		Northern Pike	0	4	0	0	0	0	0	0	0	0	0	0	0	0	**4**
		Northern Pikeminnow	0	4	0	0	0	0	0	0	0	28	0	0	0	0	**32**
		Peamouth	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Rainbow Trout	0	54	0	0	15	0	0	0	0	63	0	0	0	0	**132**
		Redside Shiner	0	550	0	0	50	0	0	0	0	2000	0	0	0	0	**2600**
		Sculpin spp.	0	100	0	0	0	0	0	0	0	7045	0	0	0	0	**7145**
		Sucker spp.	0	27	0	0	0	0	0	0	0	223	0	0	0	0	**250**
		Walleye	0	26	0	0	1	0	0	0	0	42	0	0	0	0	**69**
		White Sturgeon	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
	K01.8-L Total		**0**	**866**	**0**	**0**	**73**	**0**	**0**	**0**	**0**	**9570**	**0**	**0**	**0**	**0**	**10509**
	K01.8-R	Lake Whitefish	0	0	0	0	0	0	0	7	0	0	0	0	0	0	**7**
		Mountain Whitefish	0	0	0	0	14	0	0	286	0	0	0	0	0	0	**300**
		Peamouth	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
		Rainbow Trout	0	0	0	0	39	0	0	78	0	0	0	0	0	0	**117**
		Redside Shiner	0	0	0	0	0	0	0	75	0	0	0	0	0	0	**75**
		Sculpin spp.	0	0	0	0	1	0	0	25	0	0	0	0	0	0	**26**
		Sucker spp.	0	0	0	0	3	0	0	41	0	0	0	0	0	0	**44**
		Walleye	0	0	0	0	2	0	0	8	0	0	0	0	0	0	**10**
	K01.8-R Total		**0**	**0**	**0**	**0**	**60**	**0**	**0**	**520**	**0**	**0**	**0**	**0**	**0**	**0**	**580**
Kootenay River Total			**0**	**866**	**0**	**0**	**133**	**0**	**0**	**592**	**0**	**9570**	**0**	**153**	**41**	**541**	**11896**
Downstream Columbia River	C25.3-R	Lake Whitefish	5	0	0	0	0	0	0	12	0	0	0	0	0	0	**17**
		Mountain Whitefish	88	0	0	0	6	0	0	94	0	0	0	0	0	0	**188**
		Northern Pikeminnow	5	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
		Rainbow Trout	128	0	0	0	13	0	0	93	0	0	0	0	0	0	**234**
		Redside Shiner	690	0	0	0	0	0	0	250	0	0	0	0	0	0	**940**
		Sculpin spp.	400	0	0	0	104	0	0	263	0	0	0	0	0	0	**767**
		Sucker spp.	146	0	0	0	15	0	0	15	0	0	0	0	0	0	**176**
		Walleye	5	0	0	0	6	0	0	6	0	0	0	0	0	0	**17**
	C25.3-R Total		**1467**	**0**	**0**	**0**	**144**	**0**	**0**	**733**	**0**	**0**	**0**	**0**	**0**	**0**	**2344**
	C27.6-R	Mountain Whitefish	0	0	0	0	1	0	0	39	0	37	0	0	0	0	**77**
		Northern Pikeminnow	0	0	0	0	50	0	0	0	0	0	0	0	0	0	**50**
		Rainbow Trout	0	0	0	0	5	0	0	69	0	33	0	0	0	0	**107**
		Redside Shiner	0	0	0	0	50	0	0	50	0	0	0	0	0	0	**100**
		Sculpin spp.	0	0	0	0	305	0	0	150	0	90	0	0	0	0	**545**
		Sucker spp.	0	0	0	0	3	0	0	35	0	0	0	0	0	0	**38**
		Walleye	0	0	0	0	5	0	0	3	0	0	0	0	0	0	**8**
		White Sturgeon	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
	C27.6-R Total		**0**	**0**	**0**	**0**	**420**	**0**	**0**	**346**	**0**	**160**	**0**	**0**	**0**	**0**	**926**
	C28.2-R	Kokanee	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Lake Whitefish	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Mountain Whitefish	0	78	0	0	0	0	0	0	0	0	0	0	0	0	**78**
		Rainbow Trout	0	197	0	0	0	0	0	0	0	0	0	0	0	0	**197**
		Redside Shiner	0	224	0	0	0	0	0	0	0	0	0	0	0	0	**224**
		Sculpin spp.	0	401	0	0	0	0	0	0	0	0	0	0	0	0	**401**
		Sucker spp.	0	145	0	0	0	0	0	0	0	0	0	0	0	0	**145**
		Walleye	0	13	0	0	0	0	0	0	0	0	0	0	0	0	**13**
	C28.2-R Total		**0**	**1060**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1060**
	C34.9-L	Burbot	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Mountain Whitefish	0	117	11	0	0	0	0	0	0	0	0	0	0	0	**128**
		Northern Pike	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**
		Northern Pikeminnow	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
		Rainbow Trout	0	185	49	0	0	0	0	0	0	0	0	0	0	0	**234**
		Redside Shiner	0	6	0	0	0	0	0	0	0	0	0	0	0	0	**6**
		Sculpin spp.	0	100	4	0	0	0	0	0	0	0	0	0	0	0	**104**
		Sucker spp.	0	22	4	0	0	0	0	0	0	0	0	0	0	0	**26**
		Walleye	0	11	1	0	0	0	0	0	0	0	0	0	0	0	**12**
	C34.9-L Total		**0**	**444**	**70**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**514**
	C36.6-L	Bull Trout	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
		Mountain Whitefish	0	0	0	0	24	0	0	44	0	0	24	0	0	0	**92**
		Rainbow Trout	0	0	0	0	78	0	0	102	0	0	33	0	0	0	**213**
		Redside Shiner	0	0	0	0	0	0	0	100	0	0	0	0	0	0	**100**
		Sculpin spp.	0	0	0	0	85	0	0	85	0	0	0	0	0	0	**170**
		Sucker spp.	0	0	0	0	98	0	0	14	0	0	7	0	0	0	**119**
		Walleye	0	0	0	0	17	0	0	5	0	0	4	0	0	0	**26**
	C36.6-L Total		**0**	**0**	**0**	**0**	**302**	**0**	**0**	**351**	**0**	**0**	**68**	**0**	**0**	**0**	**721**

continued…

Table B4 Continued.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
	C47.8-L	Burbot	0	0	0	0	0	0	2	0	0	0	0	0	0	0	**2**
		Lake Whitefish	0	0	0	0	0	0	0	0	3	0	0	0	0	0	**3**
		Mountain Whitefish	0	0	0	0	0	0	22	0	25	0	0	0	0	0	**47**
		Rainbow Trout	0	0	0	0	0	0	53	0	41	0	0	0	0	0	**94**
		Redside Shiner	0	0	0	0	0	0	165	0	150	0	0	0	0	0	**315**
		Sculpin spp.	0	0	0	0	0	0	403	0	193	0	0	0	0	0	**596**
		Sucker spp.	0	0	0	0	0	0	33	0	21	0	0	0	0	0	**54**
		Walleye	0	0	0	0	0	0	25	0	20	0	0	0	0	0	**45**
	C47.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**703**	**0**	**453**	**0**	**0**	**0**	**0**	**0**	**1156**
	C48.2-R	Bull Trout	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
		Mountain Whitefish	0	0	0	0	0	0	0	0	0	0	0	21	25	0	**46**
		Rainbow Trout	0	0	0	0	0	0	0	0	0	0	0	61	61	0	**122**
		Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	0	5	0	**5**
		Sculpin spp.	0	0	0	0	0	0	0	0	0	0	0	60	17	0	**77**
		Sucker spp.	0	0	0	0	0	0	0	0	0	0	0	0	5	0	**5**
		Walleye	0	0	0	0	0	0	0	0	0	0	0	15	7	0	**22**
		White Sturgeon	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
	C48.2-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**158**	**121**	**0**	**279**
	C49.0-L	Burbot	0	3	0	0	0	0	0	0	0	1	0	0	0	0	**4**
		Lake Whitefish	0	2	0	0	0	0	0	0	0	7	0	0	0	0	**9**
		Mountain Whitefish	0	82	0	0	0	0	0	0	0	49	0	0	0	0	**131**
		Northern Pikeminnow	0	0	0	0	0	0	0	0	0	20	0	0	0	0	**20**
		Rainbow Trout	0	73	0	0	0	0	0	0	0	74	0	0	0	0	**147**
		Redside Shiner	0	200	0	0	0	0	0	0	0	80	0	0	0	0	**280**
		Sculpin spp.	0	4090	0	0	0	0	0	0	0	342	0	0	0	0	**4432**
		Sucker spp.	0	242	0	0	0	0	0	0	0	91	0	0	0	0	**333**
		Walleye	0	19	0	0	0	0	0	0	0	21	0	0	0	0	**40**
	C49.0-L Total		**0**	**4711**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**685**	**0**	**0**	**0**	**0**	**5396**
	C49.0-R	Brook Trout	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
		Burbot	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
		Kokanee	0	0	0	0	0	0	0	0	0	0	0	1	0	0	**1**
		Mountain Whitefish	0	0	0	0	0	0	0	0	0	0	0	32	0	0	**32**
		Rainbow Trout	0	0	0	0	0	0	10	0	0	0	0	60	0	0	**70**
		Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	80	0	0	**80**
		Sculpin spp.	0	0	0	0	0	0	0	0	0	0	0	380	0	0	**380**
		Sucker spp.	0	0	0	0	0	0	1	0	0	0	0	23	0	0	**24**
		Walleye	0	0	0	0	0	0	1	0	0	0	0	5	0	0	**6**
	C49.0-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**12**	**0**	**0**	**0**	**0**	**583**	**0**	**0**	**595**
	C49.8-L	Burbot	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
		Kokanee	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
		Mountain Whitefish	0	180	0	0	0	0	0	0	0	0	0	0	0	0	**180**
		Northern Pikeminnow	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Rainbow Trout	0	254	0	0	0	0	0	0	0	0	0	0	0	0	**254**
		Redside Shiner	0	2550	0	0	0	0	0	0	0	0	0	0	0	0	**2550**
		Sculpin spp.	0	7802	0	0	0	0	0	0	0	0	0	0	0	0	**7802**
		Sucker spp.	0	1151	0	0	0	0	0	0	0	0	0	0	0	0	**1151**
		Walleye	0	26	0	0	0	0	0	0	0	0	0	0	0	0	**26**
	C49.8-L Total		**0**	**11968**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11968**
	C49.8-R	Brook Trout	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
		Kokanee	0	0	0	0	0	0	0	0	0	7	0	0	0	0	**7**
		Mountain Whitefish	0	133	0	0	0	0	0	0	0	42	0	0	2	0	**177**
		Northern Pike	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
		Rainbow Trout	0	94	0	0	0	0	0	0	0	74	0	0	43	0	**211**
		Redside Shiner	0	500	0	0	0	0	0	0	0	300	0	0	0	0	**800**
		Sculpin spp.	0	1452	0	0	0	0	0	0	0	1210	0	0	66	0	**2728**
		Sucker spp.	0	304	0	0	0	0	0	0	0	93	0	0	45	0	**442**
		Walleye	0	17	0	0	0	0	0	0	0	12	0	0	19	0	**48**
	C49.8-R Total		**0**	**2500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1740**	**0**	**0**	**175**	**0**	**4415**
	C52.2-L	Burbot	0	0	0	0	0	0	0	0	0	2	0	0	0	0	**2**
		Lake Whitefish	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**
		Mountain Whitefish	0	0	0	0	0	0	0	0	0	3	0	0	0	39	**42**
		Rainbow Trout	0	0	0	0	0	0	0	0	0	27	0	0	0	71	**98**
		Redside Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	55	**55**
		Sculpin spp.	0	0	0	0	0	0	0	0	0	25	0	0	0	30	**55**
		Sucker spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	73	**73**
		Walleye	0	0	0	0	0	0	0	0	0	1	0	0	0	6	**7**
	C52.2-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**59**	**0**	**0**	**0**	**274**	**333**
	C52.2-R	Brook Trout	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
		Burbot	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
		Kokanee	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		Lake Whitefish	0	3	0	0	0	0	0	0	0	0	0	0	0	2	**5**
		Mountain Whitefish	0	93	0	0	0	0	0	0	0	0	0	0	0	7	**100**
		Northern Pikeminnow	0	2	0	0	0	0	0	0	0	0	0	0	0	2	**4**
		Rainbow Trout	0	107	0	0	0	0	0	0	0	0	0	0	0	61	**168**
		Redside Shiner	0	3	0	0	0	0	0	0	0	0	0	0	0	0	**3**
		Sculpin spp.	0	313	0	0	0	0	0	0	0	0	0	0	0	50	**363**
		Sucker spp.	0	48	0	0	0	0	0	0	0	0	0	0	0	34	**82**
		Walleye	0	26	0	0	0	0	0	0	0	0	0	0	0	18	**44**
	C52.2-R Total		**0**	**600**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**174**	**774**

continued…

Table B4 Concluded.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
	C52.8-L	Brook Trout	0	1	0	1	0	0	0	0	0	0	0	0	0	0	**2**
		Lake Whitefish	0	3	0	1	0	0	0	0	0	0	0	0	0	0	**4**
		Mountain Whitefish	0	22	0	58	0	0	0	0	0	0	0	0	0	0	**80**
		Rainbow Trout	0	32	0	72	0	0	0	0	0	0	0	0	0	0	**104**
		Redside Shiner	0	100	0	0	0	0	0	0	0	0	0	0	0	0	**100**
		Sculpin spp.	0	60	0	2050	0	0	0	0	0	0	0	0	0	0	**2110**
		Sucker spp.	0	4	0	156	0	0	0	0	0	0	0	0	0	0	**160**
		Walleye	0	5	0	10	0	0	0	0	0	0	0	0	0	0	**15**
	C52.8-L Total		**0**	**227**	**0**	**2348**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2575**
	C53.6-L	Mountain Whitefish	0	0	0	0	0	15	3	0	0	0	0	0	0	0	**18**
		Rainbow Trout	0	0	0	0	0	61	12	0	0	0	0	0	0	0	**73**
		Sculpin spp.	0	0	0	0	0	5	30	0	0	0	0	0	0	0	**35**
		Sucker spp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
		Walleye	0	0	0	0	0	15	1	0	0	0	0	0	0	0	**16**
		White Sturgeon	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
	C53.6-L Total		**0**	**0**	**0**	**0**	**0**	**98**	**46**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**144**
Downstream Columbia River Total			**1467**	**21510**	**70**	**2348**	**866**	**98**	**761**	**1430**	**453**	**2644**	**68**	**741**	**296**	**448**	**33200**
All Sections Total			**8004**	**33008**	**70**	**6147**	**999**	**98**	**761**	**2022**	**27173**	**12214**	**68**	**6571**	**7121**	**989**	**105245**

APPENDIX C

Modelling Methods, Code, and Parameter Estimates

Lower Columbia River Fish Population Indexing Analysis 2013

Methods

Data Preparation

The fish indexing data were provided by Golder Associates in the form of an Access database. The discharge and temperature data were queried from a BC Hydro database maintained by Poisson Consulting.

The data were prepared for analysis using R version 3.1.0 (Team, 2013).

Statistical Analysis

Hierarchical Bayesian models were fitted to the fish indexing data data using R version 3.1.0 (Team, 2013) and JAGS 3.4.0 (Plummer, 2012) which interfaced with each other via jaggernaut 1.8.2 (Thorley, 2014). For additional information on hierarchical Bayesian modelling in the BUGS language, of which JAGS uses a dialect, the reader is referred to Kery and Schaub (2011) pages 41-44.

Unless specified, the models assumed vague (low information) prior distributions (Kéry and Schaub, 2011, p. 36). The posterior distributions were estimated from a minimum of 1,000 Markov Chain Monte Carlo (MCMC) samples thinned from the second halves of three chains (Kéry and Schaub, 2011, pp. 38-40). Model convergence was confirmed by ensuring that Rhat (Kéry and Schaub, 2011, p. 40) was less than 1.1 for each of the parameters in the model (Kéry and Schaub, 2011, p. 61). Model adequacy was confirmed by examination of residual plots.

The posterior distributions of the *fixed* (Kéry and Schaub, 2011, p. 75) parameters are summarised in terms of a *point* estimate (mean), *lower* and *upper* 95% credible limits (2.5th and 97.5th percentiles), the standard deviation (*SD*), percent relative *error* (half the 95% credible interval as a percent of the point estimate) and *significance* (Kéry and Schaub, 2011, p. 37,42).

Variable selection was achieved by dropping *uninformative* explanatory variables where a variable was considered to be uninformative if its percent relative error was ≥ 100%. In the case of fixed effects this is approximately equivalent to dropping *insignificant* variables, i.e., those with a significance ≥ 0.05.

The results are displayed graphically by plotting the modeled relationships between particular variables and the response with 95% credible intervals (CRIs) with the remaining variables held constant. In general, continuous and discrete fixed variables are held constant at their mean and first level values respectively while random variables are held constant at their typical values (expected values of the underlying hyperdistributions) (Kéry and Schaub, 2011, pp. 77-82). Where informative the influence of particular variables is expressed in terms of the *effect size* (i.e., percent change in the response variable) with

95% CRIs (Bradford et al. 2005). Plots were produced using the ggplot2 R package (Wickham, 2009).

Model Code

The JAGS model code, which uses a series of naming conventions, is presented below.

Condition

Variable/Parameter	Description
`bCorrelation`	Correlation coefficient between `sWeightYear` and `sWeightLengthYear`
`bWeight`	Intercept for `eLogWeight`
`bWeightDayte`	Effect of `Dayte` on `eLogWeight`
`bWeightLength`	Effect of `Length` on `eLogWeight`
`bWeightLengthDayte`	Effect of `Dayte` on effect of `Length` on `eLogWeight`
`bWeightLengthYear`	Effect of `Year` on effect of `Length` on `eLogWeight`
`bWeightYear`	Effect of `Year` on `eLogWeight`
`Dayte[i]`	Day of year *ith* fish was captured
`eLogWeight[i]`	Expected log(weight) of *ith* fish
`Length[i]`	Log length of *ith* fish
`sWeight`	SD of residual variation in `log(Weight)`
`sWeightLengthYear`	SD of effect of `Year` on effect of `Length` on `eLogWeight`
`sWeightYear`	SD of effect of `Year` on `eLogWeight`
`Weight[i]`	Observed weight of *ith* fish
`Year[i]`	Year *ith* fish was captured

Condition - Model1

```
model {

  bWeight ~ dnorm(5, 5^-2)
  bWeightLength ~ dnorm(3, 5^-2)

  bWeightDayte ~ dnorm(0, 5^-2)
  bWeightLengthDayte ~ dnorm(0, 5^-2)

  eMu[1] <- bWeight
  eMu[2] <- bWeightLength

  dR[1,1] <- 0.1
  dR[1,2] <- 0
  dR[2,1] <- 0
  dR[2,2] <- 0.1
```

```
  eOmega ~ dwish(dR, 2)

  for (i in 1:nYear) {
  eYear[i, 1:2] ~ dmnorm(eMu, eOmega)
  bWeightYear[i] <- eYear[i, 1] - bWeight
  bWeightLengthYear[i] <- eYear[i, 2] - bWeightLength
  }

  eS2 <-inverse(eOmega)
  sWeightYear <- sqrt(eS2[1,1])
  sWeightLengthYear <- sqrt(eS2[2,2])
  bCorrelation <- eS2[1,2] / sqrt(eS2[1,1] * eS2[2,2])

  sWeight ~ dunif(0, 5)
  for(i in 1:length(Length)) {

  eLogWeight[i] <- bWeight + bWeightDayte * Dayte[i] +  bWeightYear[Year[i]]
+ (bWeightLength + bWeightLengthDayte * Dayte[i] + bWeightLengthYear[Year[i]]
) * Length[i]

  Weight[i] ~ dlnorm(eLogWeight[i], sWeight^-2)
  }
  }
```

Growth

Variable/Parameter	Description
`bK`	Intercept for `log(eK)`
`bKYear[i]`	Effect of *ith* year on `log(eK)`
`bLinf`	Mean maximum length
`eGrowth[i]`	Expected growth between release and recapture of *ith* recapture
`eK[i]`	Expected von Bertalanffy growth coefficient in *ith* year
`Growth[i]`	Observed growth between release and recapture of *ith* recapture
`LengthAtRelease[i]`	Previous length at release of *ith* recapture
`sGrowth`	SD of residual variation in `Growth`
`sKYear`	SD of effect of *ith* year on `log(eK)`
`Year[i]`	Release year of *ith* recapture
`Years[i]`	Years between release and recapture of *ith* recapture

Growth - Model1

```
model {

  bK ~ dnorm (0, 5^-2)

  sKYear ~ dunif (0, 5)
```

```
  for (i in 1:nYear) {
    bKYear[i] ~ dnorm(0, sKYear^-2)
    log(eK[i]) <- bK + bKYear[i]
  }

  bLinf ~ dunif(100, 1000)
  sGrowth ~ dunif(0, 100)

  for (i in 1:length(Year)) {
    eGrowth[i] <- (bLinf - LengthAtRelease[i]) * (1 - exp(-sum(eK[Year[i]:(Ye
ar[i] + Years[i] - 1)])))

    Growth[i] ~ dnorm(eGrowth[i], sGrowth^-2)
  }
}
```

Length-At-Age

Variable/Parameter	Description
`Age[i]`	Age of i*th* fish observed
`bAgeYear`	Effect of `Age` within `Year` on `eLength`
`bDayte[j]`	Linear effect of `Dayte` on `eLength` for a j*th* aged fish
`bDayte2[j]`	Quadratic effect of `Dayte` on `eLength` for a j*th* aged fish
`bIntercept[j]`	Intercept of `eLength` for a j*th* aged fish
`Dayte[i]`	Day of year i*th* fish was observed
`eIncrement[i]`	Length difference between an i*th* aged fish and an (i-1)*th* aged fish
`eLength[i]`	Expected length of i*th* fish
`Length[i]`	Observed length of i*th* fish
`pAge[i]`	Proportion of fish belonging to j*th* age
`sAgeYear`	SD of effect of `Age` within `Year` on `eLength`
`sLengthAge[j]`	SD of residual variation in `eLength` for a j*th* aged fish
`Year[i]`	Year i*th* fish was observed

Length-At-Age - Model1

```
model {
  for(i in 1:nAge)  {
    dAge[i] <- 1

    eIncrement[i] ~ dunif(50, 250)

    bDayte[i] ~ dnorm(0, 10)
    bDayte2[i] ~ dnorm(0, 10)
```

```
    sAgeYear[i] ~ dunif(0, 50)
    for(j in 1:nYear) {
      bAgeYear[i, j] ~ dnorm(0, sAgeYear[i]^-2)     }
    sLengthAge[i] ~ dunif(0, 100)
  }

  bIntercept[1] <- eIncrement[1]
  for(i in 2:nAge) {
    bIntercept[i] <- bIntercept[i-1] + eIncrement[i]
  }

  pAge[1:nAge] ~ ddirch(dAge[])

  for (i in 1:length(Length)) {
    Age[i] ~ dcat(pAge[])
    eLength[i] <- bIntercept[Age[i]] + bDayte[Age[i]] * Dayte[i] + bDayte2[Ag
e[i]] * Dayte[i]^2 + bAgeYear[Age[i],Year[i]]
    Length[i] ~ dnorm(eLength[i], sLengthAge[Age[i]]^-2)
  }
}
```

Length Bias

Variable/Parameter	Description
`bLength`	Effect of `Observer` on `eLength`
`ClassWidth`	Width of classes
`eLength[i]`	Expected actual length class of *ith* fish
`Length[i]`	Observed length of *ith* fish
`Observer[i]`	Observer of *ith* fish
`sLength`	SD of residual variation in length class

Length Bias - Model1

```
model {
  for(i in 1:Classes) {
    dLengthClass[i] <- 1
  }

  pLengthClass[1:Classes] ~ ddirch(dLengthClass[])

  bLength[1] <- 1
  sLength[1] <- 0.01
  for(i in 2:nObserver) {
    bLength[i] ~ dunif(0.5, 2)
    sLength[i] ~ dunif(0.5, 2)
  }

  for(i in 1:length(Length))  {
```

```
    eLengthClass[i] ~ dcat(pLengthClass[])
    eLength[i] <- bLength[Observer[i]] * eLengthClass[i]
    Length[i] ~ dnorm(eLength[i] * ClassWidth, (sLength[Observer[i]] * ClassW
idth)^-2)
  }
}
```

Survival

Variable/Parameter	Description
`bEfficiency`	Intercept for `logit(eEfficiency)`
`bSurvivalInterceptStage`	Intercept for `logit(eSurvival)` by `Stage`
`bSurvivalStageYear`	Effect of `Year` on `logit(eSurvival)` by `Stage`
`eAlive[i, j]`	Expected state (alive or dead) of *ith* fish in *jth* year
`eEfficiency[i, j]`	Expected recapture probability of *ith* fish in *jth* year
`eSurvival[i, j]`	Expected survival probability of *ith* fish in *jth* year
`FirstYear[i]`	First year *ith* fish was observed
`FishYear[i, j]`	Whether *ith* fish was observed in *jth* year
`sSurvivalStageYear`	SD of effect of `Year` on `logit(eSurvival)` by `Stage`
`StageFishYear[i, j]`	Stage of *ith* fish in *jth* year

Survival - Model1

```
model {

  bEfficiency ~ dnorm (0, 5^-2)

  for (i in 1:nStage) {
    sSurvivalStageYear[i] ~ dunif (0, 5)
  }

  for(i in 1:nStage) {
    bSurvivalInterceptStage[i] ~ dnorm(0, 5^-2)
    for (j in 1:nYear) {
      bSurvivalStageYear[i,j] ~ dnorm (0, sSurvivalStageYear[i]^-2)
    }
  }

  for (i in 1:nFish) {
    eAlive[i, FirstYear[i]] <- 1
    for (j in (FirstYear[i]+1):nYear) {
      logit(eEfficiency[i,j]) <- bEfficiency

      logit(eSurvival[i,j-1]) <- bSurvivalInterceptStage[StageFishYear[i,j-1]
] + bSurvivalStageYear[StageFishYear[i,j-1],j-1]
      eAlive[i,j] ~ dbern (eAlive[i,j-1] * eSurvival[i,j-1])
      FishYear[i,j] ~ dbern (eAlive[i,j] * eEfficiency[i,j])
```

```
    }
  }
}
```

Site Fidelity

Variable/Parameter	Description
`bFidelity`	Intercept for `logit(eFidelity)`
`bLength`	Effect of `Length` on `logit(eFidelity)`
`eFidelity[i]`	Expected site fidelity for *ith* recapture
`Fidelity[i]`	Whether or not *ith* recapture was encounterd at the same site as the previous encounter
`Length[i]`	Length of *ith* recapture at previous encounter

Site Fidelity - Model1

```
model {
  bFidelity ~ dnorm(0, 2^-2)
  bLength ~ dnorm(0, 2^-2)

  for (i in 1:length(Fidelity)) {
    logit(eFidelity[i]) <- bFidelity + bLength * Length[i]
    Fidelity[i] ~ dbern(eFidelity[i])
  }
}
```

Capture Efficiency

Variable/Parameter	Description
`bEfficiency`	Intercept for `logit(eEfficiency)`
`bEfficiencySessionYear`	Effect of `Session` within `Year` on `logit(eEfficiency)`
`eEfficiency[i]`	Expected efficiency on *ith* visit
`eFidelity[i]`	Expected site fidelity on *ith* visit
`Fidelity[i]`	Mean site fidelity on *ith* visit
`FidelitySD[i]`	SD of site fidelity on *ith* visit
`Recaptures[i]`	Number of marked fish recaught during *ith* visit
`sEfficiencySessionYear`	SD of effect of `Session` within `Year` on `logit(eEfficiency)`
`Session[i]`	Session of *ith* visit
`Tagged[i]`	Number of marked fish tagged prior to *ith* visit
`Year[i]`	Year of *ith* visit

Capture Efficiency - Model1

```
model {

  bEfficiency ~ dnorm(0, 5^-2)
```

```
  sEfficiencySessionYear ~ dunif(0, 2)
  for (i in 1:nSession) {
    for (j in 1:nYear) {
      bEfficiencySessionYear[i, j] ~ dnorm(0, sEfficiencySessionYear^-2)
    }
  }

  for(i in 1:length(Year)) {
    logit(eEfficiency[i]) <- bEfficiency + bEfficiencySessionYear[Session[i],
Year[i]]
    eFidelity[i] ~ dnorm(Fidelity[1], FidelitySD[1]^-2) T(0, 1)
    Recaptures[i] ~ dbin(eEfficiency[i] * eFidelity[i], Tagged[i])
  }
}
```

Abundance

Variable/Parameter	Description
`bDensity`	Intercept for `log(eDensity)`
`bDensitySite`	Effect of `Site` on `log(eDensity)`
`bDensitySiteYear`	Effect of `Site` within `Year` on `log(eDensity)`
`bDensityYear`	Effect of `Year` on `log(eDensity)`
`bType`	Effect of `Type` on `Efficiency`
`Count[i]`	Observed count during *ith* visit
`eDensity[i]`	Expected density during *ith* visit
`eDispersion`	Overdispersion of `Count`
`Efficiency[i]`	Survey efficiency during *ith* visit
`ProportionSampled[i]`	Proportion of site surveyed during *ith* visit
`sDensitySite`	SD of effect of `Site` on `log(eDensity)`
`sDensitySiteYear`	SD of effect of `Site` within `Year` on `log(eDensity)`
`sDensityYear`	SD of effect of `Year` on `log(eDensity)`
`sDispersion`	SD of overdispersion term
`Site[i]`	Site of *ith* visit
`SiteLength[i]`	Length of site during *ith* visit
`Type[i]`	Survey type (catch versus count) during *ith* visit
`Year[i]`	Year of *ith* visit

Abundance - Model1

```
model {

  bDensity ~ dnorm(5, 5^-2)
```

```
  bType[1] <- 1
  for (i in 2:nType) {
    bType[i] ~ dunif(0, 10)
  }

  sDensityYear ~ dunif(0, 2)
  for (i in 1:nYear) {
    bDensityYear[i] ~ dnorm(0, sDensityYear^-2)
  }

  sDensitySite ~ dunif(0, 2)
  sDensitySiteYear ~ dunif(0, 2)
  for (i in 1:nSite) {
    bDensitySite[i] ~ dnorm(0, sDensitySite^-2)
    for (j in 1:nYear) {
      bDensitySiteYear[i, j] ~ dnorm(0, sDensitySiteYear^-2)
    }
  }

  sDispersion ~ dunif(0, 5)
  for (i in 1:length(Count)) {
    log(eDensity[i]) <- bDensity + bDensitySite[Site[i]] + bDensityYear[Year[
i]] + bDensitySiteYear[Site[i],Year[i]]

    eDispersion[i] ~ dgamma(1 / sDispersion^2, 1 / sDispersion^2)
    Count[i] ~ dpois(eDensity[i] * SiteLength[i] * ProportionSampled[i] * Eff
iciency[i] * bType[Type[i]] * eDispersion[i])
  }
}
```

Dynamic Factor Analysis

Variable/Parameter	Description
`bTrend[i,j]`	Value of *ith* trend in *jth* `Year`
`bWeighting[i,j]`	Weighting of *ith* Trend for *jth* `Series`
`Series[i]`	Time series of *ith* value
`sSeries[i]`	SD for *ith* `Series`
`sTrend`	SD for `bTrend`
`Value[i]`	*ith* value
`Year[i]`	Year of *ith* value

Dynamic Factor Analysis - Model1

```
model {

  sTrend ~ dunif(0, 1)
  for(i in 1:nTrend) {
    muTrend[i] <- 0
```

```
    for(j in 1:nTrend) {
      oTrend[i,j] <- ifelse(i == j, sTrend^-2, 0)
    }
    for(j in 1:nSeries) {
      eWeighting[i,j] ~ dunif(-1, 1)
      aWeighting[i,j] <- eWeighting[i,j] * ifelse(j < nTrend andand i > j, 0,
1)
      bWeighting[i,j] <- ifelse(j <= nTrend andand i == j, abs(aWeighting[i,j
]), aWeighting[i,j])
    }
  }
  bTrend[1:nTrend, 1] ~ dmnorm(muTrend, oTrend / 25)
  for(j in 2:nYear) {
    bTrend[1:nTrend, j] ~ dmnorm(bTrend[1:nTrend,j-1], oTrend)
  }

  for(i in 1:nSeries) {
    sSeries[i] ~ dunif(0, 1)
  }

  for(i in 1:length(Value)) {
    eValue[i] <- sum(bWeighting[,Series[i]] * bTrend[,Year[i]])
    Value[i] ~ dnorm(eValue[i], sSeries[Series[i]]^-2)
  }
}
```

Results

Model Parameters

The posterior distributions for the *fixed* (Kery and Schaub 2011 p. 75) parameters in each model are summarised below.

Condition - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bCorrelation	0.306968	-0.16785	0.666825	0.2194000	136	0.1816
bWeight	5.547197	5.50269	5.594263	0.0230980	1	0.0000
bWeightDayte	-0.011784	-0.01561	-0.007899	0.0019785	33	0.0000
bWeightLength	3.134591	3.03840	3.224623	0.0449330	3	0.0000
bWeightLengthDayte	-0.006162	-0.01685	0.004363	0.0054859	172	0.2415
sWeight	0.157956	0.15636	0.159650	0.0008547	1	0.0000
sWeightLengthYear	0.182699	0.12772	0.265757	0.0355180	38	0.0000
sWeightYear	0.093583	0.06861	0.133016	0.0163950	34	0.0000

Rhat	Iterations
1.02	10000

Condition - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bCorrelation	0.060458	-0.412049	0.502538	0.2359800	756	0.8004
bWeight	5.878902	5.838802	5.922354	0.0215740	1	0.0000
bWeightDayte	-0.005094	-0.007782	-0.002514	0.0013560	52	0.0000
bWeightLength	2.922928	2.873703	2.970550	0.0248530	2	0.0000
bWeightLengthDayte	0.045655	0.038141	0.053609	0.0040105	17	0.0000
sWeight	0.107653	0.106475	0.108818	0.0005953	1	0.0000
sWeightLengthYear	0.097726	0.070363	0.138916	0.0181660	35	0.0000
sWeightYear	0.084778	0.062172	0.121322	0.0154610	35	0.0000

Rhat	Iterations
1.01	10000

Condition - Walleye

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bCorrelation	-0.10988	-0.54198	0.36549	0.2385000	413	0.6248
bWeight	6.24484	6.20219	6.28973	0.0223700	1	0.0000
bWeightDayte	0.02225	0.01898	0.02534	0.0016434	14	0.0000
bWeightLength	3.22026	3.13712	3.30059	0.0406980	3	0.0000
bWeightLengthDayte	-0.03900	-0.06142	-0.01909	0.0106360	54	0.0000
sWeight	0.10124	0.09975	0.10270	0.0007402	1	0.0000
sWeightLengthYear	0.16141	0.10796	0.24549	0.0345820	43	0.0000
sWeightYear	0.08949	0.06504	0.12349	0.0154620	33	0.0000

Rhat	Iterations
1.06	10000

Growth - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bK	-1.2905	-1.6210	-1.0489	0.1571	22	0
bLinf	407.1709	401.5395	413.6661	3.0719	1	0
sGrowth	13.0331	11.7259	14.5661	0.7174	11	0
sKYear	0.4305	0.1972	0.8534	0.1757	76	0

Rhat	Iterations
1.03	1000

Growth - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bK	-0.2020	-0.3278	-0.02597	0.07509	75	0.0387
bLinf	503.1951	497.3227	509.56730	3.10140	1	0.0000
sGrowth	29.9237	28.4819	31.44126	0.76783	5	0.0000
sKYear	0.2492	0.1571	0.40983	0.06487	51	0.0000

Rhat	Iterations
1.03	2000

Growth - Walleye

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bK	-2.835	-3.1742	-2.4589	0.1902	13	0
bLinf	868.228	740.5727	991.9812	72.3710	14	0
sGrowth	19.117	17.5113	20.8491	0.8693	9	0
sKYear	0.346	0.1769	0.5997	0.1072	61	0

Rhat	Iterations
1.02	8000

Length-At-Age - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDayte[1]	3.0643	2.5615	3.5898	0.265090	17	0.0000
bDayte[2]	2.4962	1.9807	3.0570	0.274810	22	0.0000
bDayte[3]	1.2291	0.6748	1.7754	0.283550	45	0.0000
bDayte2[1]	-0.7242	-1.1463	-0.2779	0.223450	60	0.0000
bDayte2[2]	-0.2143	-0.6268	0.2038	0.207740	194	0.2899
bDayte2[3]	0.8611	0.2994	1.3919	0.273770	63	0.0000
bIntercept[1]	122.8371	117.7878	128.5050	2.586700	4	0.0000
bIntercept[2]	216.6332	210.9520	222.3794	2.912600	3	0.0000
bIntercept[3]	343.7487	330.8458	356.2606	6.206500	4	0.0000
pAge[1]	0.1413	0.1368	0.1460	0.002282	3	0.0000
pAge[2]	0.2812	0.2721	0.2916	0.004970	3	0.0000
pAge[3]	0.5774	0.5670	0.5870	0.005096	2	0.0000
sAgeYear[1]	10.3007	6.8620	15.6720	2.244700	43	0.0000
sAgeYear[2]	12.3079	8.2767	18.8640	2.665600	43	0.0000
sAgeYear[3]	26.8345	18.2715	41.2641	5.784200	43	0.0000
sLengthAge[1]	14.4128	14.0318	14.7997	0.205220	3	0.0000
sLengthAge[2]	19.2555	18.3062	20.3422	0.515260	5	0.0000
sLengthAge[3]	46.2834	45.2307	47.2297	0.504060	2	0.0000

Rhat	Iterations
1.07	20000

Length-At-Age - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDayte[1]	0.83485	0.2667	1.4319	0.295980	70	0.0058
bDayte[2]	2.82445	2.2966	3.3767	0.269910	19	0.0000
bDayte[3]	0.18781	-0.4178	0.8002	0.305660	324	0.5662
bDayte2[1]	0.12760	-0.3879	0.6501	0.271970	407	0.6570

bDayte2[2]	0.88903	0.4148	1.3560	0.239190	53	0.0000
bDayte2[3]	0.03262	-0.5574	0.6076	0.296260	1786	0.9333
bIntercept[1]	111.31571	104.9001	117.1881	3.149600	6	0.0000
bIntercept[2]	264.23428	256.6679	272.1598	3.975900	3	0.0000
bIntercept[3]	432.07894	424.7938	438.6025	3.604100	2	0.0000
pAge[1]	0.06194	0.0584	0.0653	0.001763	6	0.0000
pAge[2]	0.57519	0.5671	0.5837	0.004229	1	0.0000
pAge[3]	0.36287	0.3547	0.3707	0.004079	2	0.0000
sAgeYear[1]	11.86859	7.7817	18.6737	2.807700	46	0.0000
sAgeYear[2]	16.79248	11.3079	25.0632	3.533800	41	0.0000
sAgeYear[3]	13.56393	8.9253	20.6714	3.059400	43	0.0000
sLengthAge[1]	18.24451	17.3153	19.2843	0.489390	5	0.0000
sLengthAge[2]	37.46587	36.7723	38.2000	0.364280	2	0.0000
sLengthAge[3]	54.89435	53.5874	56.2365	0.678480	2	0.0000

Rhat	Iterations
1.06	20000

Length Bias - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bLength[1]	1.0000	1.0000	1.0000	0.000000	0	0
bLength[2]	0.8504	0.8386	0.8620	0.005943	1	0
bLength[3]	0.8585	0.8472	0.8691	0.005534	1	0
sLength[1]	0.0100	0.0100	0.0100	0.000000	0	0
sLength[2]	1.0445	0.9335	1.1595	0.058656	11	0
sLength[3]	0.9473	0.8434	1.0515	0.055764	11	0

Rhat	Iterations
1.04	4000

Length Bias - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bLength[1]	1.0000	1.0000	1.0000	0.000000	0	0
bLength[2]	0.8578	0.8471	0.8680	0.005448	1	0
bLength[3]	0.8589	0.8488	0.8707	0.005622	1	0
sLength[1]	0.0100	0.0100	0.0100	0.000000	0	0
sLength[2]	0.9267	0.7405	1.0967	0.095519	19	0
sLength[3]	0.8559	0.6802	1.0340	0.090910	21	0

Rhat	Iterations
1.08	4000

Length Bias - Walleye

Parameter	Estimate	Lower	Upper	SD	Error	Significance

bLength[1]	1.0000	1.0000	1.0000	0.000000	0	0
bLength[2]	0.9100	0.8940	0.9257	0.008349	2	0
bLength[3]	0.9062	0.8810	0.9334	0.013045	3	0
sLength[1]	0.0100	0.0100	0.0100	0.000000	0	0
sLength[2]	0.7521	0.5061	1.2449	0.210960	49	0
sLength[3]	0.9026	0.5202	1.5465	0.275270	57	0

Rhat	Iterations
1.03	8000

Survival - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-3.9499	-4.21749	-3.7009	0.1300	7	0.0000
bSurvivalInterceptStage[1]	-1.2948	-2.36789	-0.1878	0.5261	84	0.0245
bSurvivalInterceptStage[2]	0.4127	-0.13828	1.2246	0.3255	165	0.1620
sSurvivalStageYear[1]	0.9851	0.08378	2.7799	0.6874	137	0.0000
sSurvivalStageYear[2]	1.0139	0.39298	2.2857	0.4726	93	0.0000

Rhat	Iterations
1.09	80000

Survival - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-2.44003	-2.6086	-2.2772	0.08636	7	0.0000
bSurvivalInterceptStage[1]	0.03347	-0.3650	0.4791	0.21063	1261	0.8928
bSurvivalInterceptStage[2]	-0.53722	-0.8389	-0.2211	0.15700	57	0.0000
sSurvivalStageYear[1]	0.41023	0.1190	0.8020	0.17341	83	0.0000
sSurvivalStageYear[2]	0.49451	0.2568	0.8691	0.16155	62	0.0000

Rhat	Iterations
1.05	20000

Survival - Walleye

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-3.32306	-3.53925	-3.0937	0.1122	7	0.0000
bSurvivalInterceptStage	0.04001	-0.32196	0.3393	0.1689	826	0.7208
sSurvivalStageYear	0.47932	0.07976	1.0022	0.2359	96	0.0000

Rhat	Iterations
1.09	20000

Site Fidelity - Mountain Whitefish

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bFidelity	-0.09846	-0.5000	0.3062	0.2051	409	0.6320
bLength	-0.04619	-0.4341	0.3476	0.2023	846	0.8173

Rhat	Iterations
1.01	1000

Site Fidelity - Rainbow Trout

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bFidelity	0.8226	0.653	0.9928	0.08636	21	0
bLength	-0.3508	-0.523	-0.1857	0.08548	48	0

Rhat	Iterations
1.01	1000

Site Fidelity - Walleye

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bFidelity	0.6536	0.3850	0.9395	0.1425	42	0.00
bLength	-0.1697	-0.4505	0.1433	0.1494	175	0.26

Rhat	Iterations
1.04	1000

Capture Efficiency - Mountain Whitefish - Subadult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-4.8170	-5.40271	-4.367	0.2692	11	0
sEfficiencySessionYear	0.5703	0.04431	1.330	0.3388	113	0

Rhat	Iterations
1.06	10000

Capture Efficiency - Mountain Whitefish - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-5.2853	-5.66073	-4.9779	0.1742	6	0
sEfficiencySessionYear	0.3855	0.03558	0.8872	0.2264	110	0

Rhat	Iterations
1.03	10000

Capture Efficiency - Rainbow Trout - Subadult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-3.3357	-3.4746	-3.2092	0.06822	4	0
sEfficiencySessionYear	0.3926	0.2742	0.5345	0.06522	33	0

Rhat	Iterations
1.02	10000

Capture Efficiency - Rainbow Trout - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-3.7180	-3.87262	-3.5657	0.08039	4	0
sEfficiencySessionYear	0.2078	0.02711	0.4327	0.10866	98	0

Rhat	Iterations
1.03	10000

Capture Efficiency - Walleye - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bEfficiency	-4.151	-4.388	-3.9382	0.1148	5	0
sEfficiencySessionYear	0.579	0.384	0.8191	0.1133	38	0

Rhat	Iterations
1.02	10000

Abundance - Mountain Whitefish - Subadult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDensity	5.2015	4.7361	5.6378	0.21474	9	0
bType[1]	1.0000	1.0000	1.0000	0.00000	0	0
bType[2]	4.7505	3.6595	6.0884	0.61407	26	0
sDensitySite	0.7826	0.5944	1.0080	0.10691	26	0
sDensitySiteYear	0.4884	0.4226	0.5557	0.03536	14	0
sDensityYear	0.7713	0.5189	1.1770	0.16593	43	0
sDispersion	0.5058	0.4648	0.5496	0.02246	8	0

Rhat	Iterations
1.03	40000

Abundance - Mountain Whitefish - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDensity	6.8017	6.3528	7.2390	0.21001	7	0
bType[1]	1.0000	1.0000	1.0000	0.00000	0	0
bType[2]	5.1173	3.7996	6.6144	0.73061	28	0
sDensitySite	1.0025	0.8034	1.2568	0.11283	23	0
sDensitySiteYear	0.5525	0.4868	0.6310	0.03655	13	0
sDensityYear	0.7259	0.4745	1.1102	0.16488	44	0
sDispersion	0.5515	0.5164	0.5867	0.01789	6	0

Rhat	Iterations
1.05	40000

Abundance - Rainbow Trout - Subadult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDensity	4.8690	4.6064	5.1561	0.13901	6	0
bType[1]	1.0000	1.0000	1.0000	0.00000	0	0
bType[2]	4.0132	3.2793	4.9153	0.41477	20	0
sDensitySite	0.7590	0.6151	0.9294	0.08267	21	0
sDensitySiteYear	0.4216	0.3677	0.4811	0.02970	13	0

sDensityYear	0.3436	0.2239	0.5303	0.08206	45	0
sDispersion	0.4073	0.3751	0.4386	0.01642	8	0

Rhat	Iterations
1.03	40000

Abundance - Rainbow Trout - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDensity	4.8597	4.6647	5.0988	0.11264	4	0
bType[1]	1.0000	1.0000	1.0000	0.00000	0	0
bType[2]	4.1082	3.3712	4.9695	0.42115	19	0
sDensitySite	0.6293	0.4984	0.7809	0.07338	22	0
sDensitySiteYear	0.3592	0.2998	0.4171	0.03010	16	0
sDensityYear	0.2316	0.1289	0.3897	0.06712	56	0
sDispersion	0.4022	0.3681	0.4410	0.01861	9	0

Rhat	Iterations
1.09	10000

Abundance - Walleye - Adult

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bDensity	5.3818	5.0240	5.6814	0.16679	6	0
bType[1]	1.0000	1.0000	1.0000	0.00000	0	0
bType[2]	5.8977	4.6130	7.3832	0.71786	23	0
sDensitySite	0.3745	0.2605	0.5100	0.06388	33	0
sDensitySiteYear	0.2936	0.2389	0.3475	0.02776	18	0
sDensityYear	0.6403	0.4477	0.9708	0.13274	41	0
sDispersion	0.4730	0.4398	0.5074	0.01743	7	0

Rhat	Iterations
1.04	80000

Dynamic Factor Analysis

Parameter	Estimate	Lower	Upper	SD	Error	Significance
bWeighting[1,1]	0.577617	0.05077	0.9843	0.2737	81	0.0000
bWeighting[1,10]	-0.085101	-0.89218	0.8496	0.4741	1023	0.8144
bWeighting[1,11]	0.071779	-0.87661	0.9333	0.4641	1261	0.8962
bWeighting[1,12]	-0.189857	-0.91581	0.8759	0.4722	472	0.6108
bWeighting[1,13]	0.160851	-0.85847	0.9269	0.4826	555	0.6727
bWeighting[1,14]	-0.298767	-0.97674	0.8867	0.5720	312	0.5549
bWeighting[1,15]	-0.188213	-0.95382	0.9564	0.5944	507	0.6507
bWeighting[1,16]	0.532144	-0.67496	0.9878	0.4644	156	0.2874
bWeighting[1,17]	-0.103792	-0.87933	0.8133	0.4508	815	0.8024
bWeighting[1,18]	-0.153650	-0.95320	0.9201	0.5353	610	0.7026

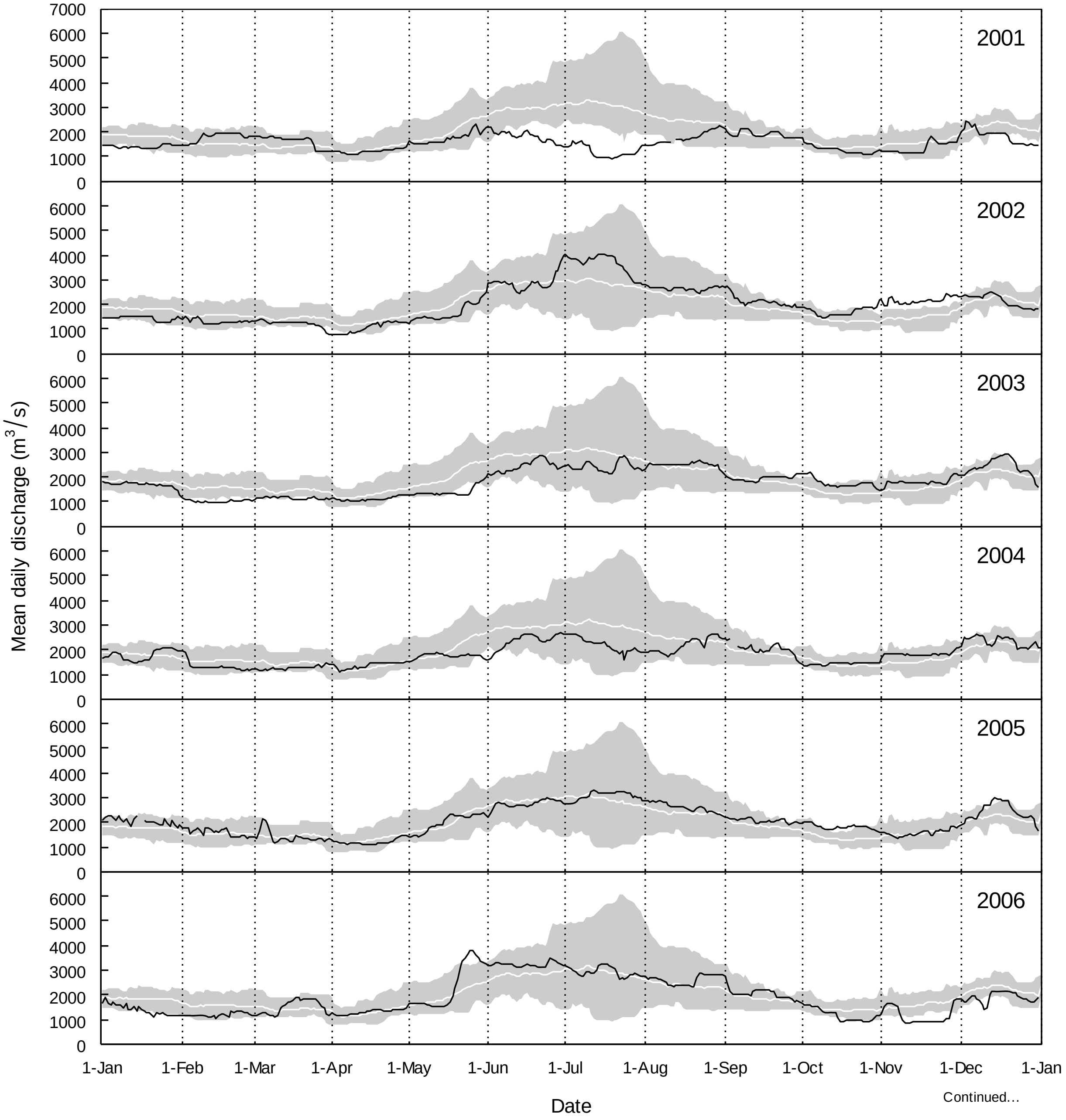
bWeighting[1,19]	-0.208083	-0.93714	0.8348	0.4977	426	0.6148
bWeighting[1,2]	-0.327156	-0.98684	0.9470	0.6577	296	0.5729
bWeighting[1,20]	-0.323232	-0.96072	0.7914	0.4676	271	0.4651
bWeighting[1,21]	0.058175	-0.78085	0.8652	0.4340	1415	0.9042
bWeighting[1,22]	-0.273671	-0.94716	0.7284	0.4419	306	0.5190
bWeighting[1,23]	-0.009480	-0.88749	0.8901	0.4951	9376	0.9581
bWeighting[1,24]	0.275122	-0.68344	0.9525	0.4575	297	0.5369
bWeighting[1,25]	0.200885	-0.93286	0.9628	0.5468	472	0.6248
bWeighting[1,26]	0.405614	-0.91219	0.9861	0.6228	234	0.5190
bWeighting[1,3]	-0.165798	-0.89644	0.8140	0.4388	516	0.6766
bWeighting[1,4]	0.147640	-0.78309	0.8649	0.4210	558	0.6667
bWeighting[1,5]	0.586779	-0.63483	0.9925	0.4210	139	0.2116
bWeighting[1,6]	0.486888	-0.65758	0.9775	0.4081	168	0.2375
bWeighting[1,7]	-0.433779	-0.97640	0.8338	0.4939	209	0.3493
bWeighting[1,8]	-0.455345	-0.97169	0.7090	0.4213	185	0.2575
bWeighting[1,9]	0.262337	-0.62153	0.9142	0.4079	293	0.4930
bWeighting[2,10]	0.088431	-0.86643	0.9193	0.5054	1010	0.8184
bWeighting[2,11]	0.303608	-0.68881	0.9496	0.4448	270	0.4950
bWeighting[2,12]	-0.144052	-0.94638	0.8441	0.5188	621	0.8104
bWeighting[2,13]	-0.316776	-0.94712	0.7166	0.4217	263	0.4112
bWeighting[2,14]	0.569453	-0.50940	0.9830	0.3752	131	0.1577
bWeighting[2,15]	0.578605	-0.44580	0.9851	0.3735	124	0.1657
bWeighting[2,16]	-0.235036	-0.98017	0.8397	0.5539	387	0.7046
bWeighting[2,17]	0.075320	-0.83565	0.8812	0.4561	1140	0.8423
bWeighting[2,18]	0.337802	-0.74539	0.9588	0.4559	252	0.4351
bWeighting[2,19]	0.362365	-0.72363	0.9695	0.4395	234	0.3812
bWeighting[2,2]	0.709341	0.06666	0.9933	0.2558	65	0.0000
bWeighting[2,20]	0.255817	-0.73642	0.9524	0.4612	330	0.5549
bWeighting[2,21]	-0.113696	-0.90363	0.7868	0.4483	743	0.8004
bWeighting[2,22]	-0.002128	-0.92041	0.8602	0.5009	41829	0.9840
bWeighting[2,23]	-0.225565	-0.95801	0.8408	0.5000	399	0.6447
bWeighting[2,24]	-0.291521	-0.94115	0.6534	0.4276	273	0.4671
bWeighting[2,25]	-0.421291	-0.96776	0.6201	0.4280	188	0.3194
bWeighting[2,26]	-0.657478	-0.99012	0.4007	0.3561	106	0.1337
bWeighting[2,3]	0.058152	-0.90652	0.9127	0.5077	1564	0.8802
bWeighting[2,4]	-0.177840	-0.90440	0.7746	0.4234	472	0.6447
bWeighting[2,5]	0.016760	-0.94587	0.9756	0.6091	5732	0.9900
bWeighting[2,6]	0.134194	-0.88813	0.9620	0.5624	689	0.8563
bWeighting[2,7]	0.044478	-0.95459	0.9630	0.6192	2156	0.9202

bWeighting[2,8]	0.048268	-0.93823	0.9394	0.5833	1945	0.9301
bWeighting[2,9]	-0.072251	-0.91480	0.8912	0.4780	1250	0.8323
sTrend	0.534482	0.31231	0.7996	0.1290	46	0.0000

Rhat	Iterations
1.03	1e+05

APPENDIX D

Discharge and Temperature Data



Continued…

Figure D1. Mean daily discharge (m³/s) for the Columbia River at the Birchbank water gauging station (black line), 2001 to 2012. The shaded area represents minimum and maximum mean daily discharge recorded at Birchbank during other study years between 2001 and 2012. The white line represents average mean daily discharge over the same time period.

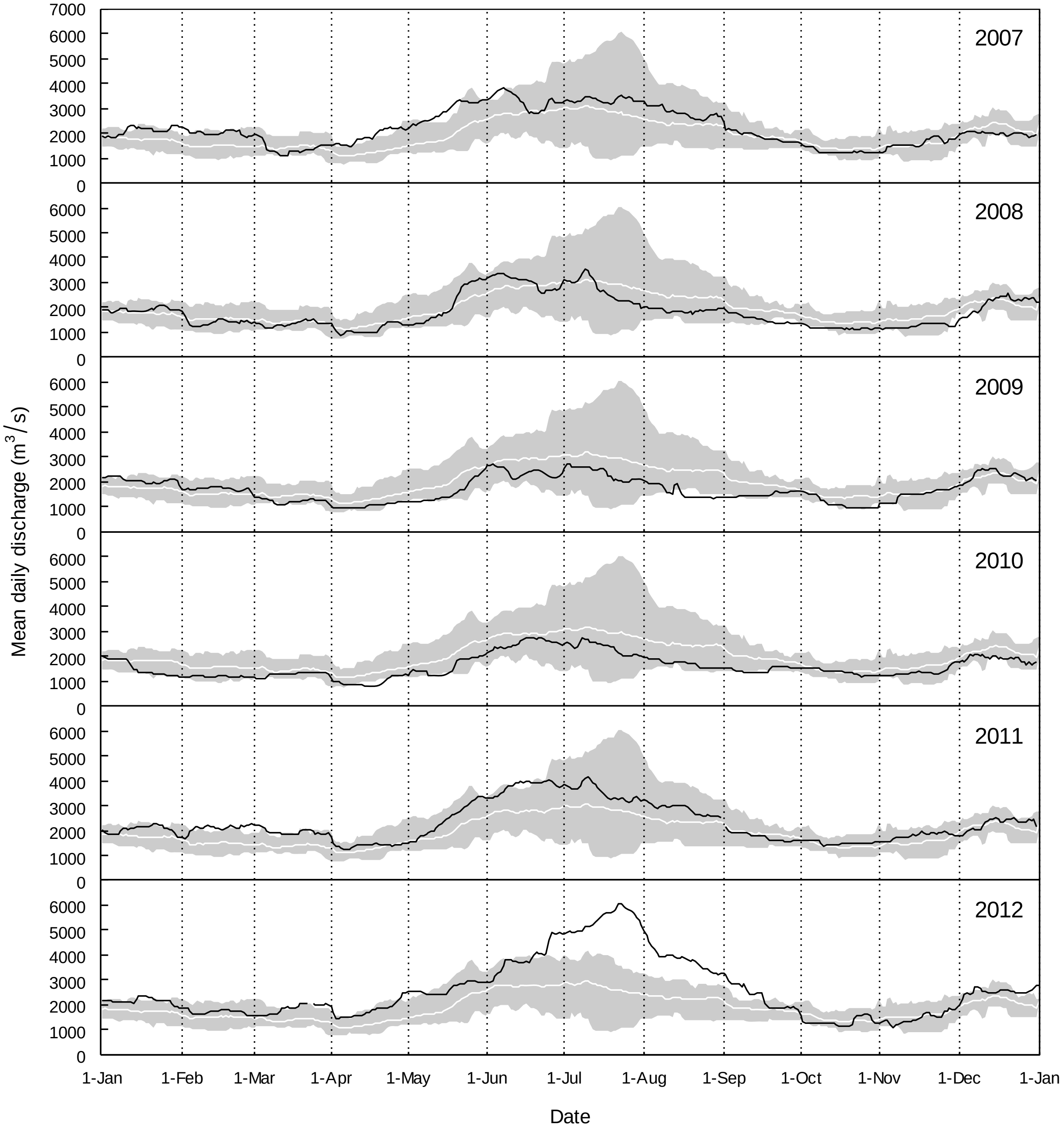


Figure D1. Concluded.

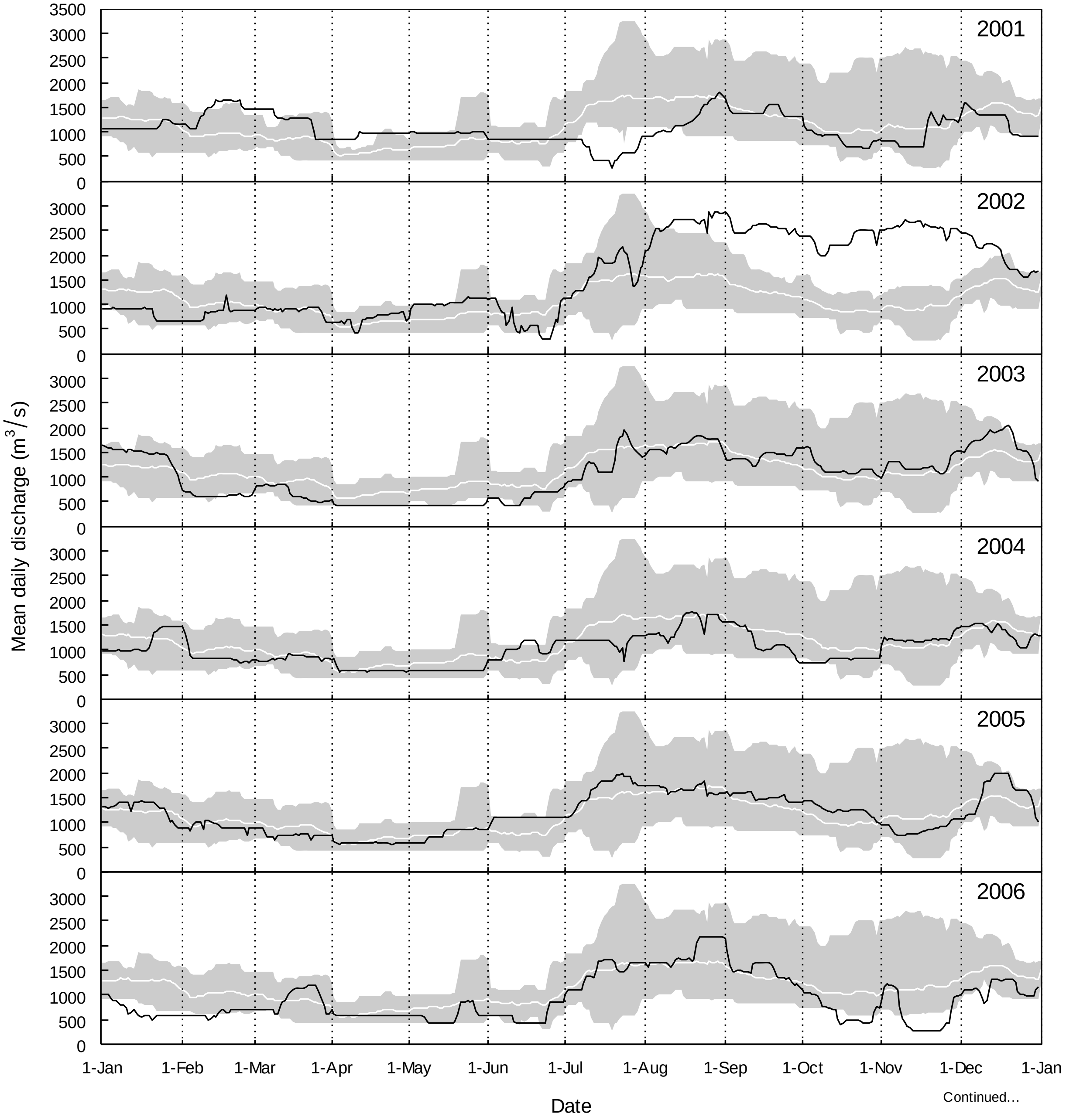


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Figure D2. Mean daily discharge (m³/s) for the Columbia River at Hugh L. Keenleyside Dam (HLK), 2001 to 2012 (black line). The shaded area represents minimum and maximum mean daily discharge recorded at HLK during other study years between 2001 and 2012. The white line represents average mean daily discharge over the same time period.

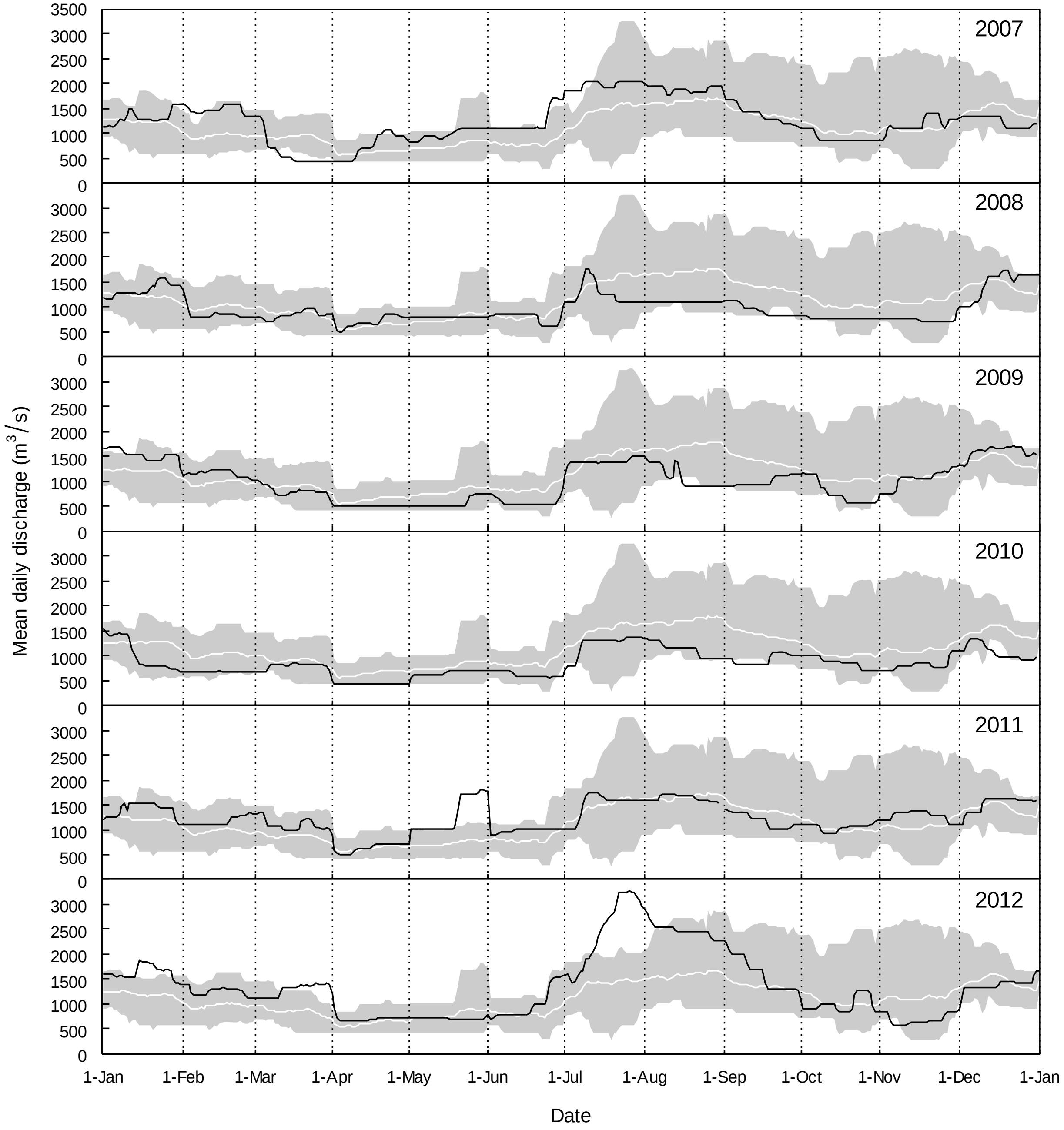

Figure D2. Concluded.

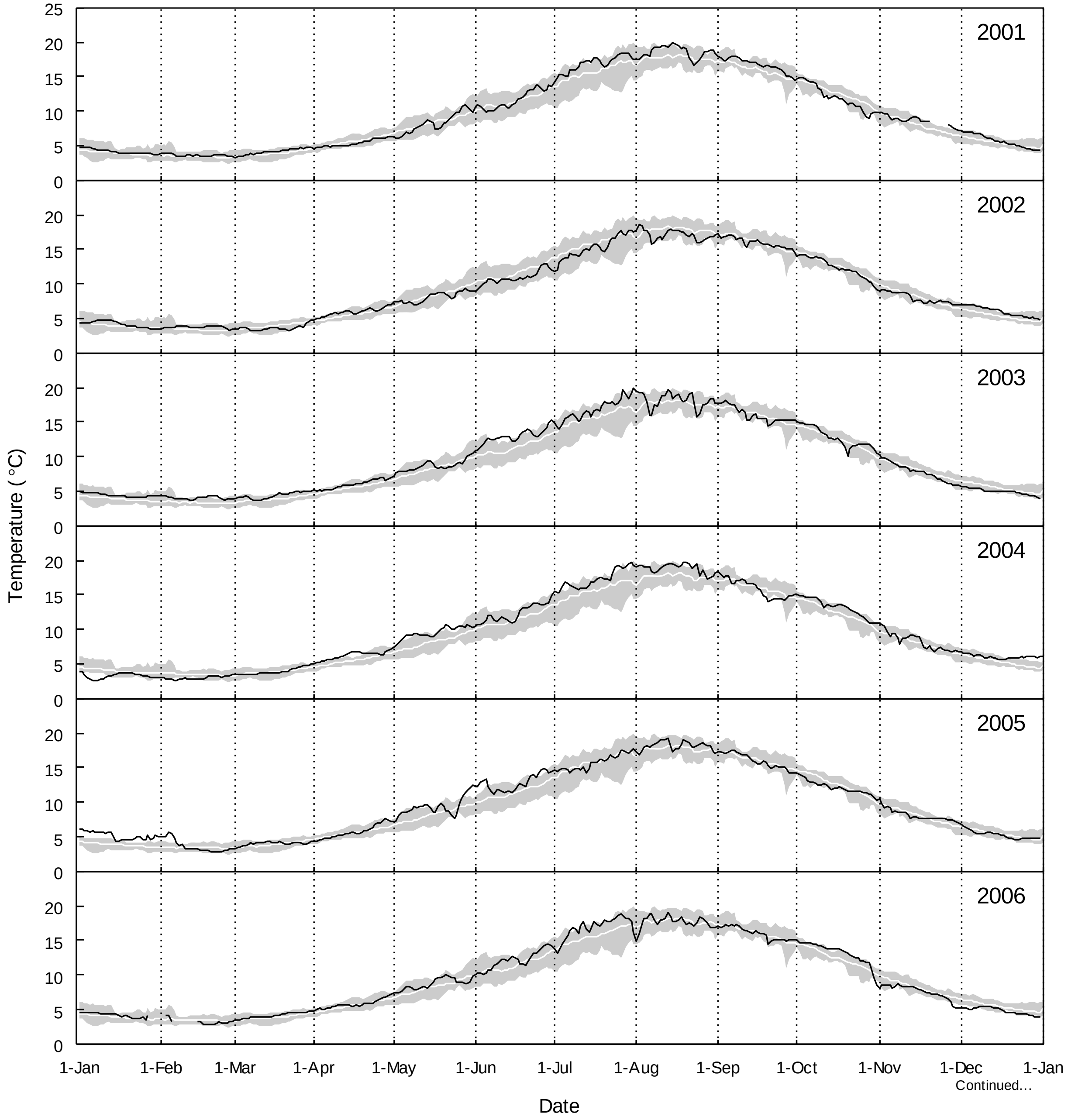

Figure D3. Mean daily water temperatures (°C) for the Columbia River (black line), 2001 to 2012. Data from 2001 to 2011 were recorded at the Birchbank water gauging station and data from 2012 were recorded near Fort Sheperd. The shaded area represents minimum and maximum mean daily water temperatures during other study years between 2001 and 2012. The white line represents average mean daily water temperature over the same time period.

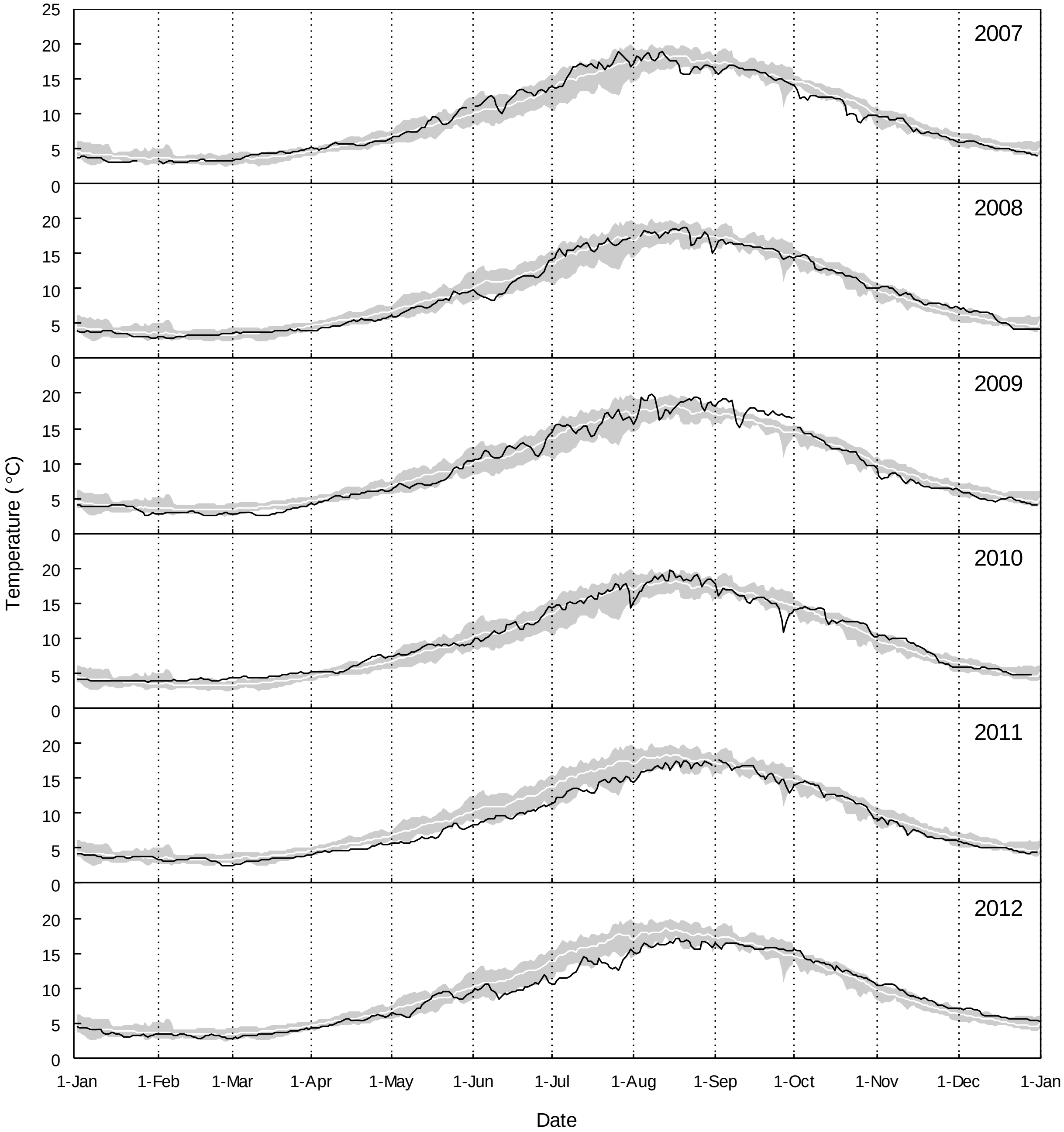

Figure D3. Concluded.

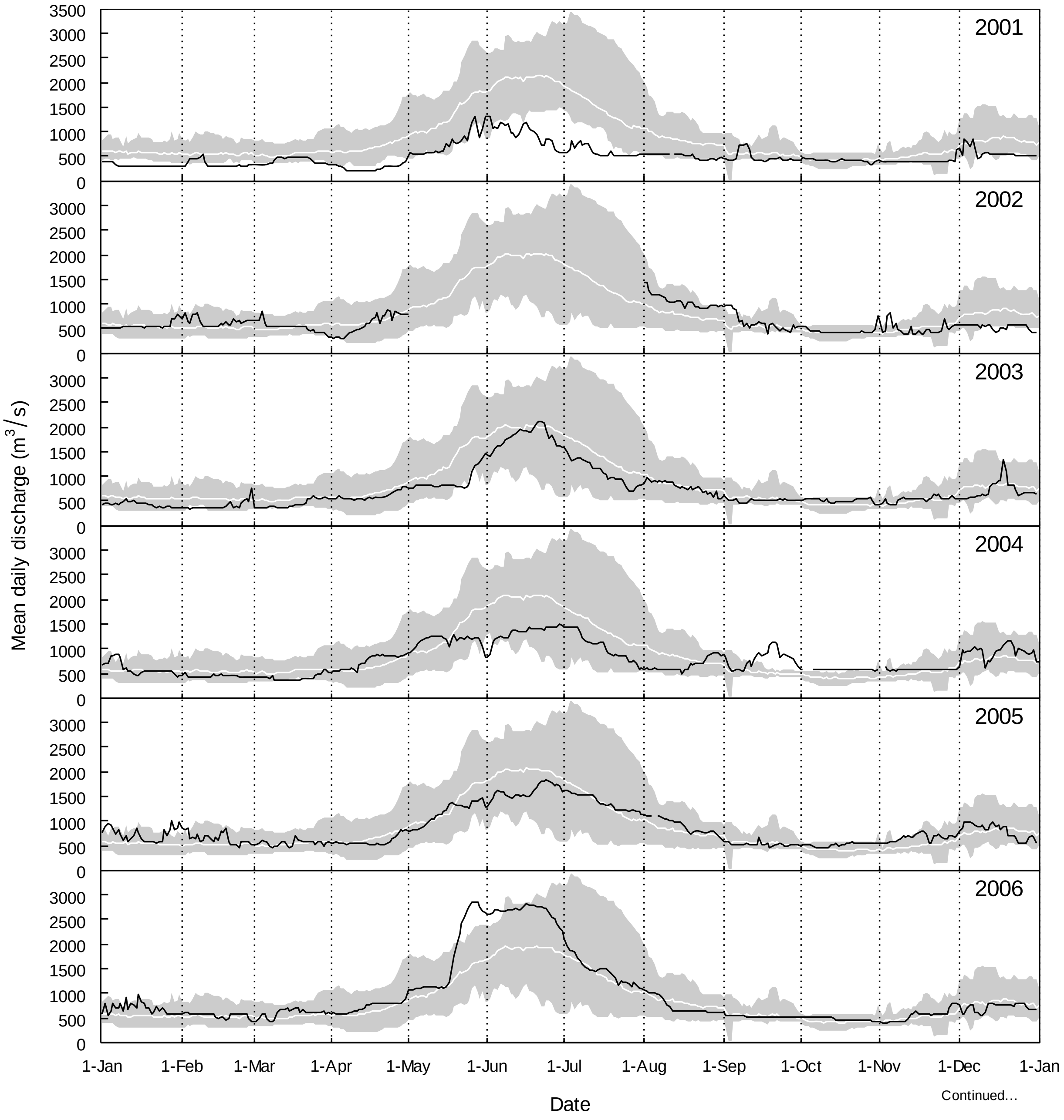

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Figure D4. Mean daily discharge (m³/s) for the Columbia River at Brilliant Dam (BRD), 2001 to 2012 (black line). The shaded area represents minimum and maximum mean daily discharge recorded at BRD during other study years between 2001 and 2012. The white line represents average mean daily discharge over the same time period.

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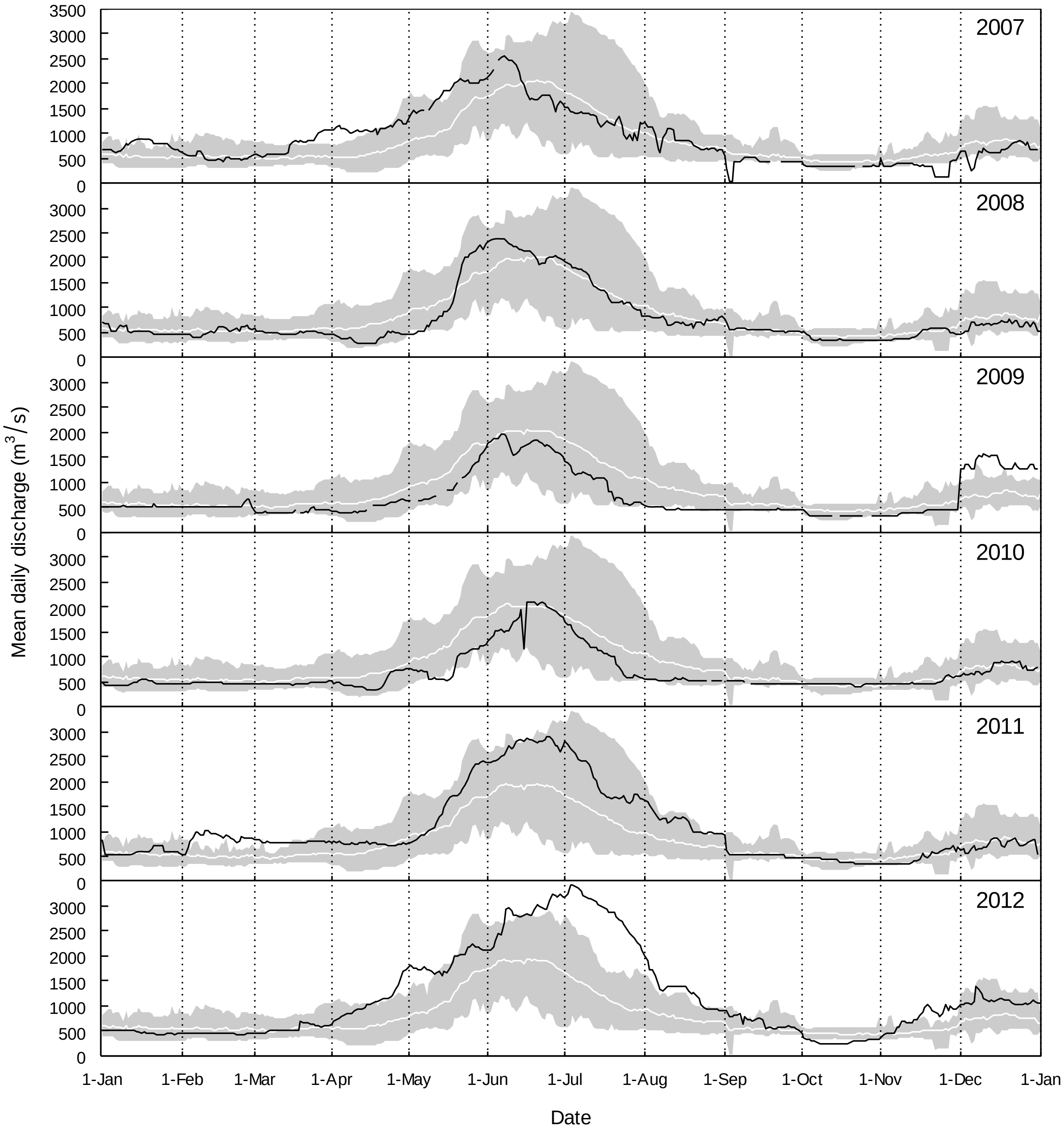

Figure D4. Concluded.

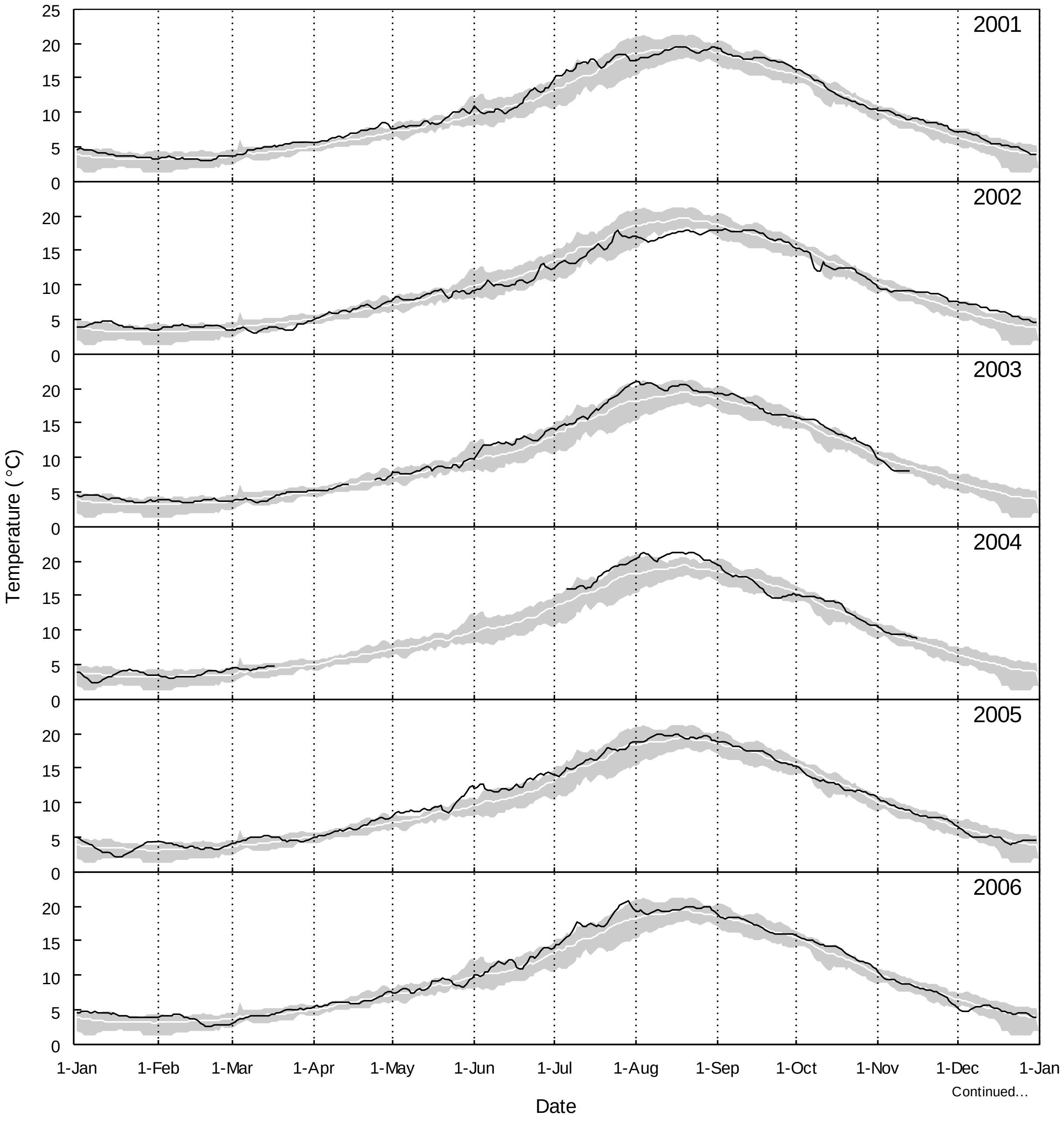

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Figure D5. Mean daily water temperatures (°C) for the Kootenay River at Brilliant Dam (BRD), 2001 to 2012 (black line). The shaded area represents minimum and maximum mean daily water temperatures recorded at BRD during other study years between 2001 and 2012. The white line represents average mean daily water temperature over the same time period.

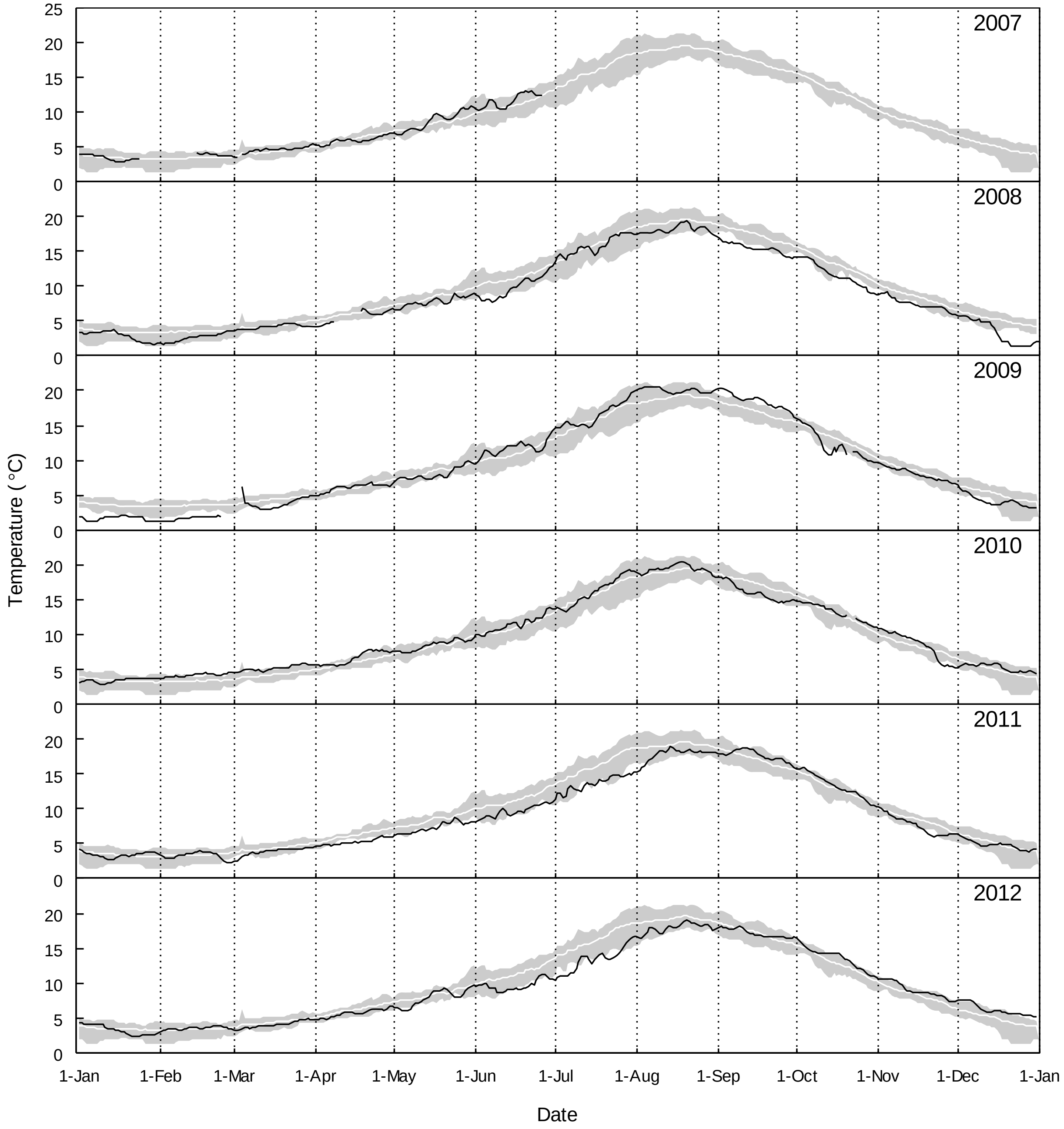


Figure D5. Concluded.

APPENDIX E

Catch and Effort Data Summaries

Table E1 Number of fish caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the Lower Columbia River, 2001 to 2013.

	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		All Years[a]		
Species	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	n^a	%[b]	%[c]
Sportfish																													
Brook Trout	5	<1	8	<1	7	<1	3	<1	3	<1	4	<1	15	<1	8	<1	3	<1	4	<1	14	<1	15	<1	31	<1	120	<1	
Brown Trout	1	<1	2	<1			1	<1	1	<1	2	<1	7	<1	2	<1	3	<1	8	<1	4	<1	2	<1	3	<1	36	<1	
Bull Trout	16	<1	3	<1	18	<1	8	<1	8	<1	11	<1	30	<1	6	<1	9	<1	8	<1	12	<1	13	<1	6	<1	148	<1	
Burbot	3	<1	10	<1	59	<1	208	1	174	2	195	1	191	2	69	1	33	<1	70	1	247	2	39	<1	14	<1	1312	1	
Cutthroat Trout	1	<1	4	<1	2	<1			1	<1	5	<1	8	<1	5	<1	3	<1	6	<1	4	<1	4	<1	2	<1	45	<1	
Kokanee	2562	9	171	1	5180	19	120	1	32	<1	898	7	506	4	148	1	1128	11	57	1	77	1	156	1	18	<1	11 053	6	1
Lake Trout			1	<1											1	<1											2	<1	
Lake Whitefish	61	<1	140	1	230	1	160	1	262	2	290	2	163	1	159	1	192	2	239	3	220	2	61	1	71	1	2248	1	
Mountain Whitefish	14 916	52	12 065	50	9667	35	6020	38	5024	43	5472	40	5595	45	5221	44	3800	36	2748	30	2933	27	4648	41	4880	49	82 989	42	11
Northern Pike																			7	<1	9	<1	11	<1	125	1	152	<1	
Rainbow Trout	9425	33	10 161	42	8436	30	5763	37	3844	33	5338	39	4953	39	5124	43	4219	40	4420	48	5501	51	5401	48	4110	41	76 695	39	10
Smallmouth Bass					4	<1	3	<1	4	<1	53	<1	16	<1	1	<1			1	<1	8	<1					90	<1	
Walleye	1467	5	1478	6	4165	15	3413	22	2230	19	1421	10	1076	9	1208	10	1127	11	1588	17	1814	17	881	8	752	8	22 620	11	3
White Sturgeon	14	<1	6	<1	18	<1	5	<1	11	<1	14	<1	11	<1	9	<1	4	<1	11	<1	23	<1	9	<1	7	<1	142	<1	
Yellow Perch					1	<1	4	<1	1	<1	24	<1	1	<1					12	<1	2	<1			1	<1	46	<1	
Sportfish subtotal	28 471	100	24 049	100	27 787	100	15 708	100	11 595	100	13 727	100	12 572	100	11 961	100	10 521	100	9179	100	10 868	100	11 240	100	10 020	100	197 698	100	25
Non-sportfish																													
Carp spp.	2	<1					1	<1	1	<1	3	<1	1	<1	2	<1			3	<1							13	<1	
Dace spp.	2	<1					3	<1	15	<1	17	<1	1	<1	1	<1			13	<1	3	<1	1	<1			56	<1	
Northern Pikeminnow	570	3	2371	10	969	3	1337	3	522	2	1450	2	845	1	1452	2	241	1	393	1	764	2	681	3	453	<1	12 048	2	2
Peamouth	80	<1	205	1	45	<1	51	<1	33	<1	52	<1	93	<1	3	<1	4	<1	25	<1	192	<1	488	2	12	<1	1283	<1	
Redside Shiner	8520	46	9026	40	5710	20	4605	12	1742	5	13 121	17	3119	5	8156	12	1592	5	2269	7	4626	11	5280	21	40 151	41	107 917	19	14
Sculpin spp.[e]	2724	15	7479	33	16 674	59	26 991	67	25 734	79	51 925	68	45 508	76	49 939	71	23 209	73	21 446	67	29 392	72	16 030	62	44 367	45	361 418	63	47
Sucker spp.[e]	6509	35	3553	16	4779	17	7033	18	4378	14	9235	12	10 012	17	11 028	16	6896	22	7625	24	5949	15	3194	12	12 736	13	92 927	16	12
Tench											1	<1	5	<1	1	<1			2	<1					2	<1	11	<1	
Non-sportfish subtotal	18 407	100	22 634	100	28 177	100	40 021	100	32 425	100	75 804	100	59 584	100	70 582	100	31 942	100	31 776	100	40 926	100	25 674	100	97 721	100	575 673	100	75
All species	46 878		46 683		55 964		55 729		44 020		89 531		72 156		82 543		42 463		40 955		51 794		36 914		107 741		773 371		

[a] Includes fish observed and identified to species; does not include recaptured fish.

[b] Percent composition of sportfish or non-sportfish catch.

[c] Percent composition of the total fish catch.

[d] Species combined for table or not identified to species.

Table E2 Summary of boat electroshocking sportfish catch (includes fish captured and observed and identified to species) and catch-per-unit-effort (CPUE = no. fish/km/hour) in the Lower Columbia River, 06 October to 03 November 2013.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)																										
						Brook Trout		Brown Trout		Bull Trout		Burbot		Cutthroat Trout		Kokanee		Lake Whitefish		Mountain Whitefish		Northern Pike		Rainbow Trout		Walleye		White Sturgeon		Yellow Perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River U/S	1	C00.0-R	06-Oct-13	1061	0.94															12	43.32			2	7.22							14	50.53
		C00.7-L	06-Oct-13	524	0.54															46	585.24			2	25.45							48	610.69
		C01.3-L	06-Oct-13	1930	1.6															308	359.07	8	9.33	16	18.65	3	3.5					335	390.54
		C02.8-L	06-Oct-13	801	0.86															22	114.97			1	5.23	1	5.23					24	125.42
		C03.6-L	07-Oct-13	2801	2.09															78	47.97	3	1.84	14	8.61	5	3.07					100	61.5
		C04.6-R	07-Oct-13	650	0.52															1	10.65			3	31.95							4	42.6
		C05.6-L	07-Oct-13	1385	1.1	1	2.36													9	21.27	13	30.72	7	16.54							30	70.89
		C07.3-R	07-Oct-13	988	1.65	4	8.83													52	114.83			52	114.83	4	8.83	1	2.21			113	249.54
		C07.4-L	07-Oct-13	958	1															200	751.57	1	3.76	41	154.07	10	37.58					252	946.97
	Session Summary			**1233**	**10.3**	**5**	**1.42**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**728**	**206.36**	**25**	**7.09**	**138**	**39.12**	**23**	**6.52**	**1**	**0.28**	**0**	**0**	**920**	**260.79**
	2	C00.0-R	11-Oct-13	1012	0.94															10	37.84	1	3.78	8	30.27	1	3.78					20	75.69
		C00.7-L	11-Oct-13	726	0.59											2	16.81	2	16.81	68	571.51			24	201.71	5	42.02					101	848.86
		C01.3-L	12-Oct-13	1839	1.6															128	156.61	5	6.12	29	35.48	1	1.22					163	199.43
		C02.8-L	12-Oct-13	825	0.88															43	213.22			14	69.42	3	14.88					60	297.52
		C03.6-L	12-Oct-13	2276	2.09															63	47.68	11	8.32	43	32.54	24	18.16					141	106.71
		C04.6-R	12-Oct-13	750	0.52															3	27.69	13	120	8	73.85	1	9.23					25	230.77
		C05.6-L	12-Oct-13	1244	1.1															12	31.57	13	34.2	7	18.42	1	2.63					33	86.82
		C07.3-R	13-Oct-13	925	1.7	1	2.29													70	160.25			44	100.73	4	9.16					119	272.43
		C07.4-L	13-Oct-13	940	1													1	3.83	71	271.91	1	3.83	26	99.57	3	11.49					102	390.64
	Session Summary			**1171**	**10.4**	**1**	**0.3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0.59**	**3**	**0.89**	**468**	**138.34**	**44**	**13.01**	**203**	**60.01**	**43**	**12.71**	**0**	**0**	**0**	**0**	**764**	**225.84**
	3	C00.0-R	23-Oct-13	987	0.94															9	34.92			9	34.92	3	11.64					21	81.48
		C00.7-L	23-Oct-13	710	0.59					1	8.59									40	343.76			5	42.97							46	395.32
		C01.3-L	23-Oct-13	1595	1.6					1	1.41					1	1.41			82	115.67			24	33.86	1	1.41					109	153.76
		C02.8-L	23-Oct-13	857	0.88															4	19.09	4	19.09	1	4.77							9	42.96
		C03.6-L	23-Oct-13	2470	2.09											1	0.7			38	26.5	6	4.18	12	8.37	12	8.37					69	48.12
		C04.6-R	24-Oct-13	671	0.52																	7	72.22	9	92.86					1	10.32	17	175.4
		C05.6-L	24-Oct-13	1070	1.07															11	34.59	4	12.58	6	18.87	4	12.58					25	78.61
		C07.3-R	24-Oct-13	988	1.67	1	2.18											4	8.73	74	161.46			20	43.64	2	4.36					101	220.37
		C07.4-L	24-Oct-13	1036	1													4	13.9	66	229.34			13	45.17							83	288.42
	Session Summary			**1154**	**10.4**	**1**	**0.3**	**0**	**0**	**2**	**0.6**	**0**	**0**	**0**	**0**	**2**	**0.6**	**8**	**2.4**	**324**	**97.19**	**21**	**6.3**	**99**	**29.7**	**22**	**6.6**	**0**	**0**	**1**	**0.3**	**480**	**143.98**
	4	C00.0-R	28-Oct-13	1111	0.94											1	3.45			19	65.5					1	3.45					21	72.39
		C00.7-L	28-Oct-13	643	0.59															43	408.04			12	113.87	2	18.98					57	540.9
		C01.3-L	28-Oct-13	1819	1.6											1	1.24			166	205.33			22	27.21	12	14.84					201	248.63
		C02.8-L	28-Oct-13	861	0.88															44	209.06	2	9.5	8	38.01							54	256.57
		C03.6-L	29-Oct-13	2526	2.09	1	0.68													111	75.69	12	8.18	13	8.86	7	4.77					144	98.19
		C04.6-R	29-Oct-13	685	0.52															4	40.43	9	90.96	12	121.28							25	252.67
		C05.6-L	29-Oct-13	1262	1.1															27	70.02	5	12.97	19	49.27	5	12.97					56	145.22
		C07.3-R	30-Oct-13	1138	1.7													7	13.03	47	87.46			27	50.24	9	16.75					90	167.48
		C07.4-L	30-Oct-13	989	0.98															101	375.15			30	111.43	6	22.29	1	3.71			138	512.58
	Session Summary			**1226**	**10.4**	**1**	**0.28**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0.56**	**7**	**1.98**	**562**	**158.68**	**28**	**7.91**	**143**	**40.38**	**42**	**11.86**	**1**	**0.28**	**0**	**0**	**786**	**221.92**
	5	C03.6-R	03-Nov-13	941	0.91													1	4.2	2	8.41	9	37.84	7	29.43	1	4.2					20	84.08
		C05.1-R	03-Nov-13	1133	0.993															28	89.59	1	3.2	15	48	4	12.8					48	153.59
	Session Summary			**1037**	**1.9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1.83**	**30**	**54.81**	**10**	**18.27**	**22**	**40.2**	**5**	**9.14**	**0**	**0**	**0**	**0**	**68**	**124.25**
Section Total All Samples				**45127**	**43.383**	**8**		**0**		**2**		**0**		**0**		**6**		**19**		**2112**		**128**		**605**		**135**		**2**		**1**		**3018**	
Section Average All Samples				**1188**	**1.14**	**0**	**0.56**	**0**	**0**	**0**	**0.14**	**0**	**0**	**0**	**0**	**0**	**0.42**	**0**	**1.33**	**56**	**147.52**	**3**	**8.94**	**16**	**42.26**	**4**	**9.43**	**0**	**0.14**	**0**	**0.07**	**79**	**210.81**
Section Standard Error of Mean						**0.11**	**0.25**	**0**	**0**	**0.04**	**0.23**	**0**	**0**	**0**	**0**	**0.07**	**0.45**	**0.23**	**0.68**	**10.12**	**29.3**	**0.73**	**4.31**	**2.12**	**7.53**	**0.77**	**1.6**	**0.04**	**0.11**	**0.03**	**0.27**	**11.57**	**34.78**

Table E2 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)																											
						Brook Trout		Brown Trout		Bull Trout		Burbot		Cutthroat Trout		Kokanee		Lake Whitefish		Mountain Whitefish		Northern Pike		Rainbow Trout		Walleye		White Sturgeon		Yellow Perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Kootenay River	1	K00.3-L	08-Oct-13	232	0.44															7	***246.87***			10	***352.66***	4	***141.07***					21	***740.6***
		K00.6-R	08-Oct-13	505	0.6															22	***261.39***			7	***83.17***	12	***142.57***					41	***487.13***
		K01.8-L	08-Oct-13	1291	1.845															53	***80.1***			26	***39.3***	21	***31.74***	1	***1.51***			101	***152.65***
		K01.8-R	08-Oct-13	972	1.3															118	***336.18***			28	***79.77***	7	***19.94***					153	***435.9***
	Session Summary			**750**	**4.2**	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**200**	***228.57***	**0**	***0***	**71**	***81.14***	**44**	***50.29***	**1**	***1.14***	**0**	***0***	**316**	***361.14***
	2	K00.3-L	14-Oct-13	220	0.44															4	***148.76***			5	***185.95***	5	***185.95***					14	***520.66***
		K00.6-R	14-Oct-13	443	0.6															14	***189.62***			14	***189.62***	10	***135.44***					38	***514.67***
		K01.8-L	14-Oct-13	1194	1.87													1	***1.61***	110	***177.36***			21	***33.86***	11	***17.74***					143	***230.56***
		K01.8-R	13-Oct-13	910	1.3															63	***191.72***			35	***106.51***	8	***24.34***					106	***322.57***
	Session Summary			**692**	**4.2**	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**1**	***1.24***	**191**	***236.58***	**0**	***0***	**75**	***92.9***	**34**	***42.11***	**0**	***0***	**0**	***0***	**301**	***372.83***
	3	K00.3-L	25-Oct-13	1147	0.44															8	***57.07***			12	***85.6***			1	***7.13***			21	***149.8***
		K00.6-R	24-Oct-13	534	0.6															30	***337.08***			5	***56.18***	4	***44.94***					39	***438.2***
		K01.8-L	25-Oct-13	1535	1.87													4	***5.02***	109	***136.7***			37	***46.4***	18	***22.57***					168	***210.7***
		K01.8-R	24-Oct-13	1102	1.3													2	***5.03***	93	***233.7***			19	***47.75***							114	***286.47***
	Session Summary			**1080**	**4.2**	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**6**	***4.76***	**240**	***190.48***	**0**	***0***	**73**	***57.94***	**22**	***17.46***	**1**	***0.79***	**0**	***0***	**342**	***271.43***
	4	K00.3-L	31-Oct-13	300	0.44															28	***763.64***			11	***300***							39	***1063.64***
		K00.6-R	31-Oct-13	467	0.58															59	***784.17***			14	***186.07***	8	***106.33***					81	***1076.57***
		K01.8-L	31-Oct-13	1525	1.87															87	***109.83***	4	***5.05***	90	***113.61***	34	***42.92***					215	***271.41***
		K01.8-R	30-Oct-13	910	1.3													5	***15.22***	129	***392.56***			72	***219.1***	3	***9.13***					209	***636.01***
	Session Summary			**800**	**4.2**	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**5**	***5.36***	**303**	***324.64***	**4**	***4.29***	**187**	***200.36***	**45**	***48.21***	**0**	***0***	**0**	***0***	**544**	***582.86***
Section Total All Samples				**13287**	**16.795**	**0**		**0**		**0**		**0**		**0**		**0**		**12**		**934**		**4**		**406**		**145**		**2**		**0**		**1503**	
Section Average All Samples				**830**	**1.05**	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**1**	***3.1***	**58**	***241.21***	**0**	***1.03***	**25**	***104.85***	**9**	***37.45***	**0**	***0.52***	**0**	***0***	**94**	***388.15***
Section Standard Error of Mean						**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0**	***0***	**0.39**	***1***	**10.99**	***53.76***	**0.25**	***0.32***	**6.02**	***24.18***	**2.25**	***15.52***	**0.09**	***0.45***	**0**	***0***	**16.96**	***72.19***

Table E2 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)																											
						Brook Trout		Brown Trout		Bull Trout		Burbot		Cutthroat Trout		Kokanee		Lake Whitefish		Mountain Whitefish		Northern Pike		Rainbow Trout		Walleye		White Sturgeon		Yellow Perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River D/S	1	C25.3-R	03-Oct-13	1453	2.73													5	4.54	67	60.81			90	81.68	5	4.54					167	151.56
		C27.6-R	03-Oct-13	361	0.61															4	65.39			37	604.88			1	16.35			42	686.62
		C28.2-R	03-Oct-13	727	1.13													1	4.38	26	113.94			72	315.52	4	17.53					103	451.36
		C34.9-L	02-Oct-13	1836	2.14							1	0.92							53	48.56	1	0.92	112	102.62	6	5.5					173	158.51
		C36.6-L	03-Oct-13	1501	2.31					1	1.04									52	53.99			79	82.02	14	14.54					146	151.59
		C47.8-L	05-Oct-13	856	1.44							1	2.92							17	49.65			37	108.06	15	43.81					70	204.44
		C48.2-R	04-Oct-13	500	1.01															2	14.26			18	128.32	12	85.54	1	7.13			33	235.25
		C49.0-L	05-Oct-13	593	0.93															52	339.44			58	378.61	25	163.19					135	881.25
		C49.0-R	04-Oct-13	671	0.72	1	7.45													10	74.52			23	171.39	4	29.81					38	283.16
		C49.8-L	05-Oct-13	1540	2.45											2	1.91			92	87.78			118	112.59	12	11.45					224	213.73
		C49.8-R	04-Oct-13	1160	2.39			1	1.3											48	62.33			76	98.69	36	46.75					161	209.06
		C52.2-L	06-Oct-13	611	0.89			1	6.62									1	6.62	29	191.99			56	370.73	2	13.24					89	589.2
		C52.2-R	05-Oct-13	2046	3.79	1	0.46													38	17.64			59	27.39	38	17.64					136	63.14
		C52.8-L	06-Oct-13	542	0.89	2	14.93											2	14.93	8	59.7			25	186.57	6	44.78					43	320.91
		C53.6-L	06-Oct-13	948	1.72															14	30.91			23	50.78	7	15.45	1	2.21			45	99.35
	Session Summary			**1023**	**25.1**	**4**	**0.56**	**2**	**0.28**	**1**	**0.14**	**2**	**0.28**	**0**	**0**	**2**	**0.28**	**9**	**1.26**	**512**	**71.78**	**1**	**0.14**	**883**	**123.8**	**186**	**26.08**	**3**	**0.42**	**0**	**0**	**1605**	**225.02**
	2	C25.3-R	09-Oct-13	1443	2.705													4	3.69	93	85.77			113	104.22	10	9.22					220	202.9
		C27.6-R	09-Oct-13	378	0.61															63	983.61			42	655.74	4	62.45					109	1701.8
		C28.2-R	09-Oct-13	723	1.13															50	220.32			56	246.76	6	26.44					112	493.52
		C34.9-L	08-Oct-13	1819	2.14															15	13.87			113	104.5	9	8.32					137	126.7
		C36.6-L	08-Oct-13	1568	2.34	1	0.98													27	26.49			134	131.48	8	7.85					170	166.8
		C47.8-L	12-Oct-13	1019	1.44	1	2.45			1	2.45									10	24.53			38	93.23	12	29.44					62	152.11
		C48.2-R	10-Oct-13	863	1.01					2	8.26									16	66.08			37	152.82	6	24.78					61	251.94
		C49.0-L	12-Oct-13	640	0.93							1	6.05					1	6.05	34	205.65			45	272.18	2	12.1					83	502.02
		C49.0-R	10-Oct-13	335	0.72															13	194.03			16	238.81	2	29.85					31	462.69
		C49.8-L	12-Oct-13	821	2.45	1	1.79													52	93.07			58	103.81	5	8.95					116	207.61
		C49.8-R	10-Oct-13	1235	2.39	2	2.44							1	1.22					90	109.77			87	106.11	8	9.76					188	229.3
		C52.2-L	13-Oct-13	745	0.89															5	27.15			26	141.17	3	16.29					34	184.6
		C52.2-R	13-Oct-13	1458	3.79									1	0.65			5	3.26	32	20.85			48	31.27	16	10.42					102	66.45
		C52.8-L	13-Oct-13	648	0.89													2	12.48	21	131.09			37	230.96	16	99.88					76	474.41
		C53.6-L	13-Oct-13	1005	1.72															5	10.41			33	68.73	8	16.66					46	95.8
	Session Summary			**980**	**25.2**	**5**	**0.73**	**0**	**0**	**3**	**0.44**	**1**	**0.15**	**2**	**0.29**	**0**	**0**	**12**	**1.75**	**526**	**76.68**	**0**	**0**	**883**	**128.72**	**115**	**16.76**	**0**	**0**	**0**	**0**	**1547**	**225.51**
	3	C25.3-R	20-Oct-13	1475	2.63													8	7.42	34	31.55			64	59.39	8	7.42					114	105.79
		C27.6-R	20-Oct-13	401	0.61															18	264.91			32	470.95							50	735.87
		C28.2-R	20-Oct-13	814	1.13											1	3.91			35	136.98			32	125.24	2	7.83					70	273.97
		C34.9-L	18-Oct-13	1921	2.14															34	29.77			42	36.78							76	66.55
		C36.6-L	18-Oct-13	1378	2.39															15	16.4			31	33.89	4	4.37					50	54.65
		C47.8-L	22-Oct-13	986	1.44	1	2.54											1	2.54	4	10.14			41	103.96	20	50.71					67	169.88
		C48.2-R	21-Oct-13	1342	1.01															31	82.34			52	138.11	4	10.62					87	231.07
		C49.0-L	22-Oct-13	587	0.93															31	204.43			41	270.37	15	98.92					87	573.72
		C49.0-R	21-Oct-13	491	0.72							1	10.18							12	122.2			18	183.3	1	10.18					32	325.87
		C49.8-L	22-Oct-13	1509	2.45							2	1.95							15	14.61			69	67.19	8	7.79					94	91.53
		C49.8-R	21-Oct-13	1207	2.39															28	34.94	1	1.25	39	48.67	4	4.99					72	89.85
		C52.2-L	22-Oct-13	670	0.89							2	12.07							16	96.6			21	126.78	2	12.07					41	247.53
		C52.2-R	21-Oct-13	2225	3.79	1	0.43											1	0.43	20	8.54			59	25.19	14	5.98					95	40.56
		C52.8-L	23-Oct-13	531	0.89															10				12		2						24	
		C53.6-L	23-Oct-13	852	1.62															7	18.26			23	59.99	4	10.43					34	88.68
	Session Summary			**1093**	**25**	**2**	**0.26**	**0**	**0**	**0**	**0**	**5**	**0.66**	**0**	**0**	**1**	**0.13**	**10**	**1.32**	**310**	**40.84**	**1**	**0.13**	**576**	**75.89**	**88**	**11.59**	**0**	**0**	**0**	**0**	**993**	**130.83**

Table E2 Concluded.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)																											
						Brook Trout		Brown Trout		Bull Trout		Burbot		Cutthroat Trout		Kokanee		Lake Whitefish		Mountain Whitefish		Northern Pike		Rainbow Trout		Walleye		White Sturgeon		Yellow Perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River D/S	4	C25.3-R	25-Oct-13	1056	2.69															53	***67.17***			47	***59.56***	3	***3.8***					103	***130.53***
		C27.6-R	25-Oct-13	393	0.61															12	***180.2***			21	***315.35***	7	***105.12***					40	***600.68***
		C28.2-R	25-Oct-13	678	1.13															10	***46.99***			104	***488.68***	5	***23.49***					119	***559.17***
		C34.9-L	25-Oct-13	1643	2.14															53	***54.27***			84	***86.01***	1	***1.02***					138	***141.3***
		C36.6-L	26-Oct-13	1292	2.39	2	***2.33***													31	***36.14***			45	***52.46***	10	***11.66***					88	***102.59***
		C47.8-L	29-Oct-13	1156	1.41	3	***6.63***			1	***2.21***	1	***2.21***					2	***4.42***	26	***57.42***			45	***99.39***	8	***17.67***					86	***189.94***
		C48.2-R	26-Oct-13	893	1.01															16	***63.86***			40	***159.66***	6	***23.95***					62	***247.47***
		C49.0-L	29-Oct-13	711	0.93							3	***16.33***					8	***43.56***	56	***304.89***			55	***299.44***	4	***21.78***					126	***685.99***
		C49.0-R	26-Oct-13	468	0.72	1	***10.68***									1	***10.68***			9	***96.15***			34	***363.25***	2	***21.37***					47	***502.14***
		C49.8-L	29-Oct-13	1608	2.45	1	***0.91***													75	***68.53***			113	***103.26***	19	***17.36***					208	***190.07***
		C49.8-R	26-Oct-13	1333	2.39	1	***1.13***									7	***7.91***			75	***84.75***			50	***56.5***	15	***16.95***					148	***167.24***
		C52.2-L	30-Oct-13	618	0.89															6	***39.27***			25	***163.63***							31	***202.9***
		C52.2-R	26-Oct-13	2187	3.79	3	***1.3***	1	***0.43***			2	***0.87***			1	***0.43***			45	***19.54***			62	***26.93***	8	***3.47***					122	***52.99***
		C52.8-L	30-Oct-13	819	0.89															50	***246.94***	1	***4.94***	65	***321.03***	1	***4.94***					117	***577.85***
		C53.6-L	30-Oct-13	1075	1.72	1	***1.95***													6	***11.68***			25	***48.67***	2	***3.89***					34	***66.2***
	Session Summary			**1062**	**25.2**	**12**	***1.61***	**1**	***0.13***	**1**	***0.13***	**6**	***0.81***	**0**	***0***	**9**	***1.21***	**10**	***1.35***	**523**	***70.35***	**1**	***0.13***	**815**	***109.63***	**91**	***12.24***	**0**	***0***	**0**	***0***	**1469**	***197.61***
	5	C10.9-L	03-Nov-13	1885	2.15	2	***1.78***									1	***0.89***			436	***387.29***			130	***115.48***	9	***7.99***					578	***513.43***
		C11.5-R	04-Nov-13	1320	1.9													1	***1.44***	92	***132.06***			155	***222.49***	3	***4.31***					251	***360.29***
		C17.0-L	04-Nov-13	1325	1.906															103	***146.83***			136	***193.87***	6	***8.55***	1	***1.43***			246	***350.67***
		C18.0-R	04-Nov-13	669	0.85															65	***411.5***			58	***367.19***	4	***25.32***					127	***804.01***
		C19.0-L	04-Nov-13	1080	1.28															24	***62.5***			72	***187.5***	3	***7.81***					99	***257.81***
		C21.3-L	05-Nov-13	1561	2.039															74	***83.7***			128	***144.77***	4	***4.52***					206	***233***
		C22.9-R	05-Nov-13	624	1.221													1	***4.73***	99	***467.78***			46	***217.35***	3	***14.18***					149	***704.03***
		C25.3-L	05-Nov-13	1210	1.82													1	***1.63***	67	***109.53***			19	***31.06***	6	***9.81***					93	***152.03***
		C26.2-L	05-Nov-13	559	0.954															88	***594.05***			11	***74.26***	2	***13.5***					101	***681.81***
		C30.6-L	05-Nov-13	1875	1.84	1	***1.04***													29	***30.26***			145	***151.3***	4	***4.17***					179	***186.78***
		C32.4-L	05-Nov-13	1371	1.997							1	***1.31***							21	***27.61***			89	***117.02***	2	***2.63***					113	***148.58***
		C34.9-R	06-Nov-13	823	0.89															16	***78.64***			59	***289.98***	4	***19.66***					79	***388.28***
		C40.0-R	06-Nov-13	1066	1.466															38	***87.54***			91	***209.63***							129	***297.17***
		C41.5-R	06-Nov-13	1808	2.162	2	***1.84***													37	***34.08***			93	***85.65***	6	***5.53***					138	***127.09***
		C44.6-L	06-Nov-13	818	1.01															18	***78.43***			31	***135.08***	7	***30.5***					56	***244.01***
		C45.6-L	06-Nov-13	536	0.901															25	***186.36***			53	***395.08***	14	***104.36***					92	***685.81***
		C47.2-R	06-Nov-13	802	1.06			1	***4.23***											22	***93.16***			37	***156.68***	2	***8.47***	1	***4.23***			63	***266.79***
		C56.0-L	27-Oct-13	562	0.765	1	***8.37***																	8	***66.99***	3	***25.12***					12	***100.48***
	Session Summary			**1105**	**26.2**	**6**	***0.75***	**1**	***0.12***	**0**	***0***	**1**	***0.12***	**0**	***0***	**1**	***0.12***	**3**	***0.37***	**1254**	***155.93***	**0**	***0***	**1361**	***169.24***	**82**	***10.2***	**2**	***0.25***	**0**	***0***	**2711**	***337.11***
Section Total All Samples				**82258**	**126.706**	**29**		**4**		**5**		**15**		**2**		**13**		**44**		**3125**		**3**		**4518**		**562**		**5**		**0**		**8325**	
Section Average All Samples				**1055**	**1.62**	**0**	***0.78***	**0**	***0.11***	**0**	***0.13***	**0**	***0.4***	**0**	***0.05***	**0**	***0.35***	**1**	***1.18***	**40**	***84.16***	**0**	***0.08***	**58**	***121.67***	**7**	***15.14***	**0**	***0.13***	**0**	***0***	**107**	***224.2***
Section Standard Error of Mean						**0.08**	***0.28***	**0.03**	***0.1***	**0.03**	***0.11***	**0.06**	***0.3***	**0.02**	***0.02***	**0.1**	***0.18***	**0.18**	***0.62***	**5.97**	***16.96***	**0.02**	***0.07***	**4.02**	***15.04***	**0.81**	***3.29***	**0.03**	***0.23***	**0**	***0***	**8.78**	***29.8***
All Sections Total All Samples				**140672**	**186.884**	***37***	***0.01***	***4***	***0***	***7***	***0***	***15***	***0***	***2***	***0***	***19***	***0***	***75***	***0.01***	***6171***	***0.85***	***135***	***0.02***	***5529***	***0.76***	***842***	***0.12***	***9***	***0***	***1***	***0***	***12846***	***1.76***
All Sections Average All Samples						***0***	***0.67***	***0***	***0.07***	***0***	***0.13***	***0***	***0.27***	***0***	***0.04***	***0***	***0.34***	***1***	***1.36***	***47***	***111.55***	***1***	***2.44***	***42***	***99.94***	***6***	***15.22***	***0***	***0.16***	***0***	***0.02***	***97***	***232.2***
All Sections Standard Error of Mean						***0.06***	***0.18***	***0.01***	***0.06***	***0.02***	***0.09***	***0.04***	***0.18***	***0.01***	***0.01***	***0.06***	***0.17***	***0.13***	***0.43***	***4.78***	***15.18***	***0.25***	***1.33***	***3.06***	***10.56***	***0.61***	***2.98***	***0.02***	***0.15***	***0.01***	***0.08***	***6.54***	***22.68***

Table E3 Summary of boat electroshocking non-sportfish catch (includes fish captured and observed and identified to species) and catch-per-unit-effort (CPUE = no. fish/km/hour) in the Lower Columbia River, 06 October to 03 November 2013.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)													
						Northern Pikeminnow		Peamouth		Redside Shiner		Sculpin spp.		Sucker spp.		Tench		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River U/S	1	C00.0-R	06-Oct-13	1061	0.94	2	***7.22***	1	***3.61***	2810	***10142.98***	1750	***6316.8***	3	***10.83***			4566	***16481.44***
		C00.7-L	06-Oct-13	524	0.54			1	***12.72***			20	***254.45***	20	***254.45***			41	***521.63***
		C01.3-L	06-Oct-13	1930	1.6	3	***3.5***	1	***1.17***	544	***634.2***	178	***207.51***	164	***191.19***			890	***1037.56***
		C02.8-L	06-Oct-13	801	0.86					300	***1567.81***	163	***851.84***	36	***188.14***			499	***2607.79***
		C03.6-L	07-Oct-13	2801	2.09	9	***5.53***	2	***1.23***	99	***60.88***	105	***64.57***	149	***91.63***			364	***223.84***
		C04.6-R	07-Oct-13	650	0.52							30	***319.53***	34	***362.13***			64	***681.66***
		C05.6-L	07-Oct-13	1385	1.1	4	***9.45***			5	***11.81***	15	***35.44***	28	***66.16***			52	***122.87***
		C07.3-R	07-Oct-13	988	1.65	2	***4.42***					40	***88.33***	27	***59.62***			69	***152.37***
		C07.4-L	07-Oct-13	958	1	2	***7.52***			930	***3494.78***	453	***1702.3***	331	***1243.84***			1716	***6448.43***
	Session Summary			**1233**	**10.3**	**22**	*6.24*	**5**	*1.42*	**4688**	*1328.89*	**2754**	*780.67*	**792**	*224.51*	**0**	*0*	**8261**	*2341.72*
	2	C00.0-R	11-Oct-13	1012	0.94	4	***15.14***			4000	***15137.5***	2225	***8420.23***	22	***83.26***			6251	***23656.13***
		C00.7-L	11-Oct-13	726	0.59	1	***8.4***			200	***1680.91***	605	***5084.75***	311	***2613.81***			1117	***9387.87***
		C01.3-L	12-Oct-13	1839	1.6	40	***48.94***			1030	***1260.2***	3095	***3786.7***	1445	***1767.94***			5610	***6863.78***
		C02.8-L	12-Oct-13	825	0.88	3	***14.88***			600	***2975.21***	800	***3966.94***	2506	***12426.45***			3909	***19383.47***
		C03.6-L	12-Oct-13	2276	2.09	18	***13.62***	4	***3.03***	1205	***911.95***	920	***696.26***	843	***637.99***			2990	***2262.85***
		C04.6-R	12-Oct-13	750	0.52					150	***1384.62***	150	***1384.62***	362	***3341.54***	1	***9.23***	663	***6120***
		C05.6-L	12-Oct-13	1244	1.1	19	***49.99***			135	***355.16***	110	***289.39***	222	***584.04***			486	***1278.57***
		C07.3-R	13-Oct-13	925	1.7					1000	***2289.35***	1000	***2289.35***	35	***80.13***			2035	***4658.82***
		C07.4-L	13-Oct-13	940	1	3	***11.49***			40	***153.19***	5	***19.15***	52	***199.15***			100	***382.98***
	Session Summary			**1171**	**10.4**	**88**	*26.01*	**4**	*1.18*	**8360**	*2471.26*	**8910**	*2633.84*	**5798**	*1713.92*	**1**	*0.3*	**23161**	*6846.52*
	3	C00.0-R	23-Oct-13	987	0.94					2100	***8148.48***	75	***291.02***	33	***128.05***			2208	***8567.55***
		C00.7-L	23-Oct-13	710	0.59					130	***1117.21***	225	***1933.64***	55	***472.67***			410	***3523.51***
		C01.3-L	23-Oct-13	1595	1.6	43	***60.66***			2500	***3526.65***	1780	***2510.97***	139	***196.08***			4462	***6294.36***
		C02.8-L	23-Oct-13	857	0.88							50	***238.68***	80	***381.88***			130	***620.56***
		C03.6-L	23-Oct-13	2470	2.09	21	***14.64***			1580	***1101.83***	90	***62.76***	352	***245.47***			2043	***1424.71***
		C04.6-R	24-Oct-13	671	0.52	3	***30.95***					90	***928.58***	49	***505.56***			142	***1465.09***
		C05.6-L	24-Oct-13	1070	1.07	57	***179.23***			230	***723.21***	240	***754.65***	369	***1160.28***			896	***2817.36***
		C07.3-R	24-Oct-13	988	1.67					300	***654.56***	325	***709.11***	339	***739.65***			964	***2103.32***
		C07.4-L	24-Oct-13	1036	1					300	***1042.47***	200	***694.98***	340	***1181.47***			840	***2918.92***
	Session Summary			**1154**	**10.4**	**124**	*37.2*	**0**	*0*	**7140**	*2141.71*	**3075**	*922.38*	**1756**	*526.73*	**0**	*0*	**12095**	*3628.02*
	4	C00.0-R	28-Oct-13	1111	0.94			1	***3.45***	3500	***12065.04***	17	***58.6***					3518	***12127.09***
		C00.7-L	28-Oct-13	643	0.59							10	***94.89***					10	***94.89***
		C01.3-L	28-Oct-13	1819	1.6	7	***8.66***			6395	***7910.25***	260	***321.61***	116	***143.49***			6778	***8384***
		C02.8-L	28-Oct-13	861	0.88					120	***570.16***	180	***855.24***	150	***712.7***	1	***4.75***	451	***2142.86***
		C03.6-L	29-Oct-13	2526	2.09	72	***49.1***			215	***146.61***	56	***38.19***	156	***106.38***			499	***340.27***
		C04.6-R	29-Oct-13	685	0.52					20	***202.13***	25	***252.67***	29	***293.09***			74	***747.89***
		C05.6-L	29-Oct-13	1262	1.1	2	***5.19***			180	***466.79***	105	***272.3***	60	***155.6***			347	***899.87***
		C07.3-R	30-Oct-13	1138	1.7					50	***93.04***	50	***93.04***	27	***50.24***			127	***236.33***
		C07.4-L	30-Oct-13	989	0.98	10	***37.14***			1000	***3714.33***	1025	***3807.19***	563	***2091.17***			2598	***9649.82***
	Session Summary			**1226**	**10.4**	**91**	*25.69*	**1**	*0.28*	**11480**	*3241.31*	**1728**	*487.89*	**1101**	*310.86*	**1**	*0.28*	**14402**	*4066.32*
	5	C03.6-R	03-Nov-13	941	0.91					105	***441.43***	53	***222.82***	4	***16.82***			162	***681.06***
		C05.1-R	03-Nov-13	1133	0.993	1	***3.2***			500	***1599.9***	50	***159.99***	15	***48***			566	***1811.09***
	Session Summary			**1037**	**1.9**	**1**	*1.83*	**0**	*0*	**605**	*1105.42*	**103**	*188.19*	**19**	*34.72*	**0**	*0*	**728**	*1330.15*
Section Total All Samples				**45127**	**43.383**	**326**		**10**		**32273**		**16570**		**9466**		**2**		**58647**	
Section Average All Samples				**1188**	**1.14**	**9**	*22.77*	**0**	*0.7*	**849**	*2254.27*	**436**	*1157.41*	**249**	*661.2*	**0**	*0.14*	**1543**	*4096.49*
Section Standard Error of Mean						**2.74**	*5.18*	**0.12**	*0.36*	**222.51**	*586.95*	**113.62**	*316.09*	**75.76**	*336.14*	**0.04**	*0.27*	**307.47**	*914.99*

Table E3 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)													
						Northern Pikeminnow		Peamouth		Redside Shiner		Sculpin spp.		Sucker spp.		Tench		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Kootenay River	1	K00.3-L	08-Oct-13	232	0.44									8	***282.13***			8	***282.13***
		K00.6-R	08-Oct-13	505	0.6	14	***166.34***			250	***2970.3***	150	***1782.18***	116	***1378.22***			530	***6297.03***
		K01.8-L	08-Oct-13	1291	1.845	19	***28.72***	1	***1.51***	50	***75.57***	70	***105.8***					140	***211.6***
		K01.8-R	08-Oct-13	972	1.3			1	***2.85***	25	***71.23***			30	***85.47***			56	***159.54***
	Session Summary			**750**	**4.2**	**33**	***37.71***	**2**	***2.29***	**325**	***371.43***	**220**	***251.43***	**154**	***176***	**0**	***0***	**734**	***838.86***
	2	K00.3-L	14-Oct-13	220	0.44									26	***966.94***			26	***966.94***
		K00.6-R	14-Oct-13	443	0.6							4	***54.18***	3	***40.63***			7	***94.81***
		K01.8-L	14-Oct-13	1194	1.87	2	***3.22***			500	***806.17***	25	***40.31***	7	***11.29***			534	***860.99***
		K01.8-R	13-Oct-13	910	1.3					50	***152.16***	26	***79.12***	12	***36.52***			88	***267.79***
	Session Summary			**692**	**4.2**	**2**	***2.48***	**0**	***0***	**550**	***681.26***	**55**	***68.13***	**48**	***59.45***	**0**	***0***	**655**	***811.31***
	3	K00.6-R	24-Oct-13	534	0.6									5	***56.18***			5	***56.18***
		K01.8-L	25-Oct-13	1535	1.87	11	***13.8***							14	***17.56***			25	***31.35***
		K01.8-R	24-Oct-13	1102	1.3									2	***5.03***			2	***5.03***
	Session Summary			**1057**	**3.8**	**11**	***9.86***	**0**	***0***	**0**	***0***	**0**	***0***	**21**	***18.82***	**0**	***0***	**32**	***28.68***
	4	K00.6-R	31-Oct-13	467	0.58							10	***132.91***	8	***106.33***			18	***239.24***
		K01.8-L	31-Oct-13	1525	1.87					2050	***2587.88***	7050	***8899.8***	229	***289.09***			9329	***11776.77***
	Session Summary			**996**	**2.5**	**0**	***0***	**0**	***0***	**2050**	***2963.86***	**7060**	***10207.23***	**237**	***342.65***	**0**	***0***	**9347**	***13513.73***
Section Total All Samples				**10930**	**14.615**	**46**		**2**		**2925**		**7335**		**460**		**0**		**10768**	
Section Average All Samples				**841**	**1.12**	**4**	***13.47***	**0**	***0.59***	**225**	***856.71***	**564**	***2148.36***	**35**	***134.73***	**0**	***0***	**828**	***3153.86***
Section Standard Error of Mean						**1.82**	***12.72***	**0.1**	***0.24***	**157.35**	***286.31***	**540.61**	***683.85***	**18.21**	***118.69***	**0**	***0***	**710.31**	***966.02***

Table E3 Concluded.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE = no. fish/km/hr)													
						Northern Pikeminnow		Peamouth		Redside Shiner		Sculpin spp.		Sucker spp.		Tench		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River D/S	1	C25.3-R	03-Oct-13	1453	2.73	5	***4.54***			285	***258.65***	203	***184.23***	110	***99.83***			603	***547.26***
		C27.6-R	03-Oct-13	361	0.61							145	***2370.46***	3	***49.04***			148	***2419.51***
		C28.2-R	03-Oct-13	727	1.13					4	***17.53***	76	***333.05***					80	***350.57***
		C34.9-L	02-Oct-13	1836	2.14	2	***1.83***			6	***5.5***	84	***76.97***	26	***23.82***			118	***108.12***
		C36.6-L	03-Oct-13	1501	2.31							90	***93.44***	40	***41.53***			130	***134.97***
		C47.8-L	05-Oct-13	856	1.44							62	***181.07***	16	***46.73***			78	***227.8***
		C48.2-R	04-Oct-13	500	1.01							25	***178.22***	5	***35.64***			30	***213.86***
		C49.0-L	05-Oct-13	593	0.93							160	***1044.44***	40	***261.11***			200	***1305.55***
		C49.0-R	04-Oct-13	671	0.72							60	***447.09***	0	***0***			60	***447.09***
		C49.8-L	05-Oct-13	1540	2.45							502	***478.98***	45	***42.94***			547	***521.92***
		C49.8-R	04-Oct-13	1160	2.39							578	***750.54***	126	***163.61***			704	***914.15***
		C52.2-L	06-Oct-13	611	0.89							55	***364.11***	16	***105.92***			71	***470.03***
		C52.2-R	05-Oct-13	2046	3.79							263	***122.1***	20	***9.29***			283	***131.38***
		C52.8-L	06-Oct-13	542	0.89							60	***447.78***					60	***447.78***
		C53.6-L	06-Oct-13	948	1.72									1	***2.21***			1	***2.21***
	Session Summary			**1023**	**25.1**	**7**	***0.98***	**0**	***0***	**295**	***41.36***	**2363**	***331.3***	**448**	***62.81***	**0**	***0***	**3113**	***436.45***
	2	C25.3-R	09-Oct-13	1443	2.705					500	***461.15***	553	***510.03***	33	***30.44***			1086	***1001.61***
		C27.6-R	09-Oct-13	378	0.61	50	***780.64***			100	***1561.28***	400	***6245.12***	35	***546.45***			585	***9133.49***
		C28.2-R	09-Oct-13	723	1.13					100	***440.64***	200	***881.28***	28	***123.38***			328	***1445.31***
		C34.9-L	08-Oct-13	1819	2.14							5	***4.62***					5	***4.62***
		C36.6-L	08-Oct-13	1568	2.34					100	***98.12***	80	***78.49***	79	***77.51***			259	***254.12***
		C47.8-L	12-Oct-13	1019	1.44					165	***404.81***	144	***353.29***	15	***36.8***			324	***794.9***
		C49.0-L	12-Oct-13	640	0.93	20	***120.97***			50	***302.42***	187	***1131.05***	51	***308.47***			308	***1862.9***
		C49.0-R	10-Oct-13	335	0.72					30	***447.76***	60	***895.52***	20	***298.51***			110	***1641.79***
		C49.8-L	12-Oct-13	821	2.45	1	***1.79***			50	***89.49***	300	***536.93***	54	***96.65***			405	***724.85***
		C49.8-R	10-Oct-13	1235	2.39					500	***609.83***	1700	***2073.42***					2200	***2683.24***
		C52.2-L	13-Oct-13	745	0.89					5	***27.15***			2	***10.86***			7	***38.01***
		C52.2-R	13-Oct-13	1458	3.79	4	***2.61***					100	***65.15***	54	***35.18***			158	***102.93***
		C52.8-L	13-Oct-13	648	0.89					100	***624.22***	50	***312.11***	4	***24.97***			154	***961.3***
	Session Summary			**987**	**22.4**	**75**	***12.21***	**0**	***0***	**1700**	***276.81***	**3779**	***615.34***	**375**	***61.06***	**0**	***0***	**5929**	***965.43***
	3	C25.3-R	20-Oct-13	1475	2.63					150	***139.2***	11	***10.21***	16	***14.85***			177	***164.26***
		C28.2-R	20-Oct-13	814	1.13					20	***78.28***	15	***58.71***	6	***23.48***			41	***160.47***
		C34.9-L	18-Oct-13	1921	2.14							15	***13.14***					15	***13.14***
		C47.8-L	22-Oct-13	986	1.44					150	***380.32***	165	***418.36***	7	***17.75***			322	***816.43***
		C48.2-R	21-Oct-13	1342	1.01					5	***13.28***	2	***5.31***					7	***18.59***
		C49.0-L	22-Oct-13	587	0.93					230	***1516.73***	1060	***6990.16***	28	***184.65***			1318	***8691.54***
		C49.0-R	21-Oct-13	491	0.72					50	***509.16***	250	***2545.82***	3	***30.55***			303	***3085.54***
		C49.8-L	22-Oct-13	1509	2.45					500	***486.87***	1000	***973.75***	5	***4.87***			1505	***1465.49***
		C49.8-R	21-Oct-13	1207	2.39					200	***249.59***	50	***62.4***	255	***318.23***			505	***630.21***
		C52.2-L	22-Oct-13	670	0.89					50	***301.86***			55	***332.05***			105	***633.91***
		C52.2-R	21-Oct-13	2225	3.79					3	***1.28***			6	***2.56***			9	***3.84***
		C52.8-L	23-Oct-13	531	0.89									2	***15.24***			2	***15.24***
		C53.6-L	23-Oct-13	852	1.62							5	***13.04***					5	***13.04***
	Session Summary			**1124**	**22**	**0**	***0***	**0**	***0***	**1358**	***197.7***	**2573**	***374.59***	**383**	***55.76***	**0**	***0***	**4314**	***628.05***
	4	C25.3-R	25-Oct-13	1056	2.69					5	***6.34***			17	***21.54***			22	***27.88***
		C28.2-R	25-Oct-13	678	1.13					100	***469.89***	110	***516.88***	111	***521.58***			321	***1508.34***
		C47.8-L	29-Oct-13	1156	1.41							225	***496.94***	16	***35.34***			241	***532.28***
		C48.2-R	26-Oct-13	893	1.01							50	***199.57***					50	***199.57***
		C49.0-L	29-Oct-13	711	0.93							3025	***16469.31***	214	***1165.1***			3239	***17634.41***
		C49.0-R	26-Oct-13	468	0.72							10	***106.84***	1	***10.68***			11	***117.52***
		C49.8-L	29-Oct-13	1608	2.45					2000	***1827.6***	6000	***5482.79***	1047	***956.75***			9047	***8267.13***
		C49.8-R	26-Oct-13	1333	2.39					100	***113***	400	***452***	61	***68.93***			561	***633.92***
		C52.2-R	26-Oct-13	2187	3.79									2	***0.87***			2	***0.87***
		C52.8-L	30-Oct-13	819	0.89							2000	***9877.76***	154	***760.59***			2154	***10638.35***
		C53.6-L	30-Oct-13	1075	1.72							30	***58.41***					30	***58.41***
	Session Summary			**1089**	**19.1**	**0**	***0***	**0**	***0***	**2205**	***381.64***	**11850**	***2050.97***	**1623**	***280.91***	**0**	***0***	**15678**	***2713.51***
	5	C10.9-L	03-Nov-13	1885	2.15							55	***48.86***	10	***8.88***			65	***57.74***
		C11.5-R	04-Nov-13	1320	1.9							20	***28.71***	1	***1.44***			21	***30.14***
		C17.0-L	04-Nov-13	1325	1.906	2	***2.85***			5	***7.13***	20	***28.51***	10	***14.25***			37	***52.74***
		C18.0-R	04-Nov-13	669	0.85							54	***341.86***	5	***31.65***			59	***373.52***
		C19.0-L	04-Nov-13	1080	1.28	1	***2.6***					3	***7.81***	5	***13.02***			9	***23.44***
		C21.3-L	05-Nov-13	1561	2.039									14	***15.83***			14	***15.83***
		C22.9-R	05-Nov-13	624	1.221	1	***4.73***							85	***401.63***			86	***406.35***
		C25.3-L	05-Nov-13	1210	1.82					40	***65.39***			47	***76.83***			87	***142.22***
		C26.2-L	05-Nov-13	559	0.954									11	***74.26***			11	***74.26***
		C32.4-L	05-Nov-13	1371	1.997									3	***3.94***			3	***3.94***
		C34.9-R	06-Nov-13	823	0.89							6	***29.49***	3	***14.74***			9	***44.23***
		C40.0-R	06-Nov-13	1066	1.466							4	***9.21***					4	***9.21***
		C41.5-R	06-Nov-13	1808	2.162							5	***4.6***	1	***0.92***			6	***5.53***
		C44.6-L	06-Nov-13	818	1.01							4000	***17429.62***	28	***122.01***			4028	***17551.62***
		C45.6-L	06-Nov-13	536	0.901							1075	***8013.48***	3	***22.36***			1078	***8035.85***
		C56.0-L	27-Oct-13	562	0.765	1	***8.37***											1	***8.37***
	Session Summary			**1076**	**23.3**	**5**	***0.72***	**0**	***0***	**45**	***6.46***	**5242**	***752.72***	**226**	***32.45***	**0**	***0***	**5518**	***792.35***
Section Total All Samples				**71988**	**112.046**	**87**		**0**		**5603**		**25807**		**3055**		**0**		**34552**	
Section Average All Samples				**1059**	**1.65**	**1**	***2.64***	**0**	***0***	**82**	***169.99***	**380**	***782.97***	**45**	***92.69***	**0**	***0***	**508**	***1048.29***
Section Standard Error of Mean						**0.79**	***11.58***	**0**	***0***	**31.8**	***44.19***	**117.88**	***407.91***	**16.08**	***27.02***	**0**	***0***	**155.47**	***441.42***
All Sections Total All Samples				**128045**	**170.044**	***459***	***0.08***	***12***	***0***	***40801***	***6.75***	***49712***	***8.22***	***12981***	***2.15***	***2***	***0***	***103967***	***17.19***
All Sections Average All Samples						***4***	***9.03***	***0***	***0.24***	***343***	***802.78***	***418***	***978.11***	***109***	***255.41***	***0***	***0.04***	***874***	***2045.6***
All Sections Standard Error of Mean						***1.04***	***6.93***	***0.04***	***0.12***	***81.22***	***209.06***	***95.27***	***263.39***	***27.21***	***112.68***	***0.01***	***0.09***	***157.41***	***414.77***

APPENDIX F

Life History Summaries

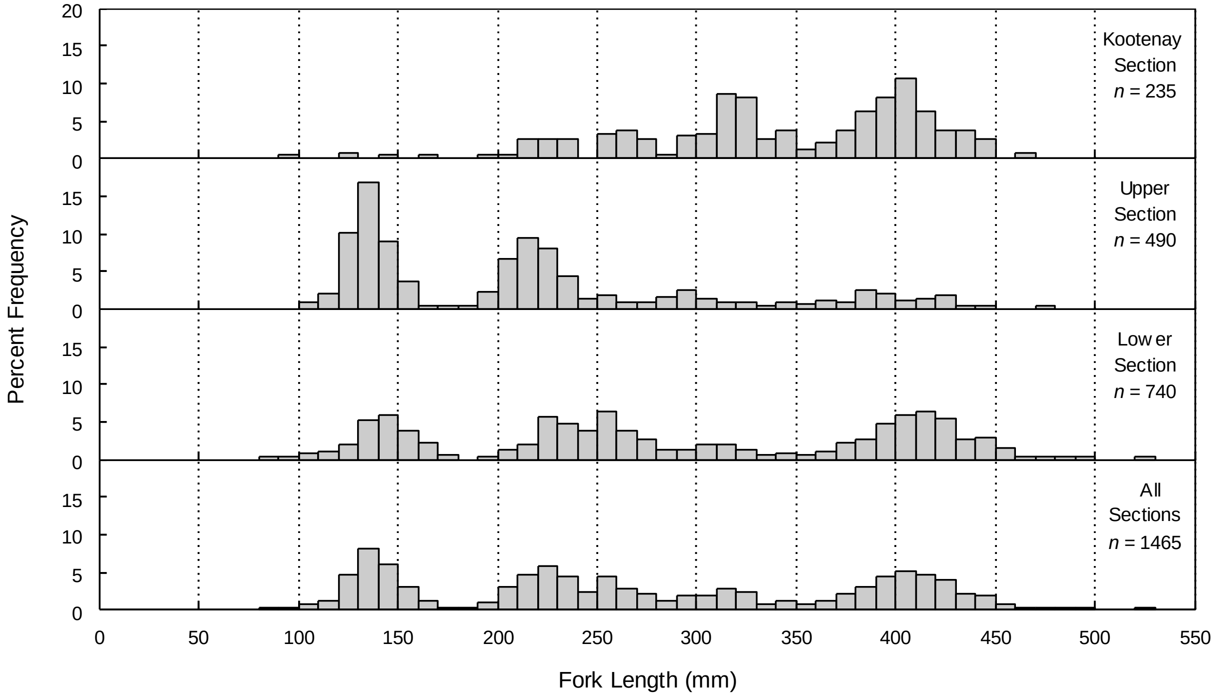


Figure F1. Length-frequency distributions by site for Mountain Whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, October 06 to November 03, 2013.

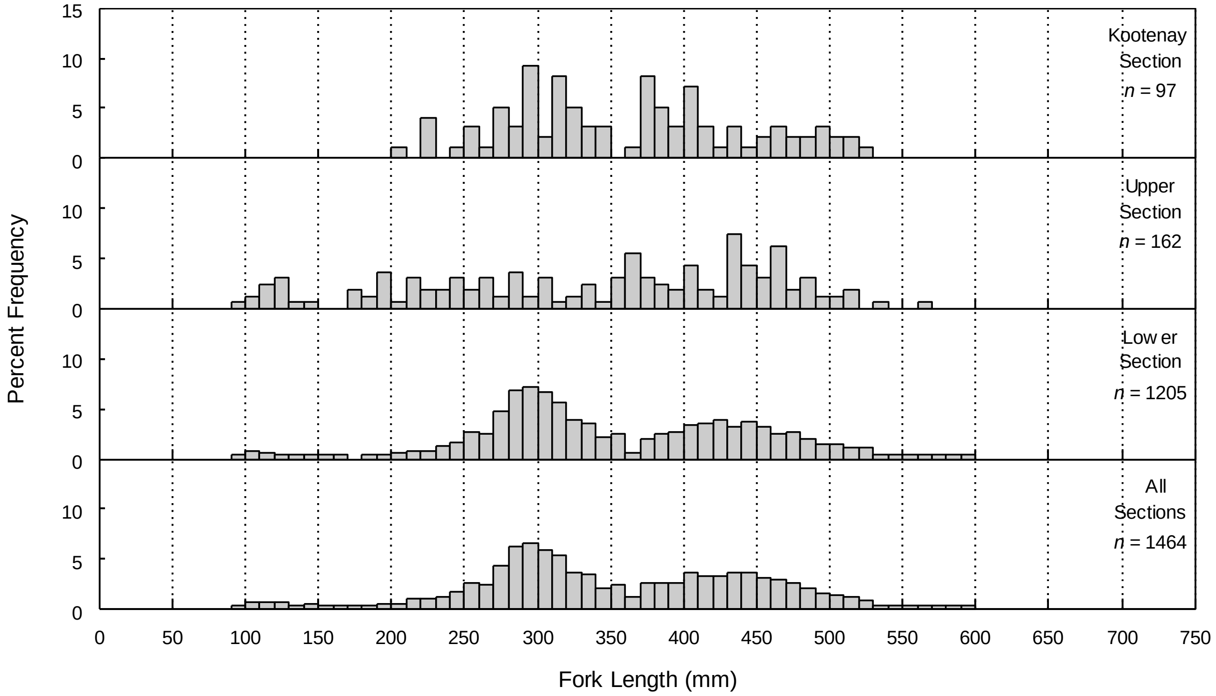


Figure F2. Length-frequency distributions by site for Rainbow Trout captured by boat electroshocking in sampled sections of the Lower Columbia River, October 06 to November 03, 2013.

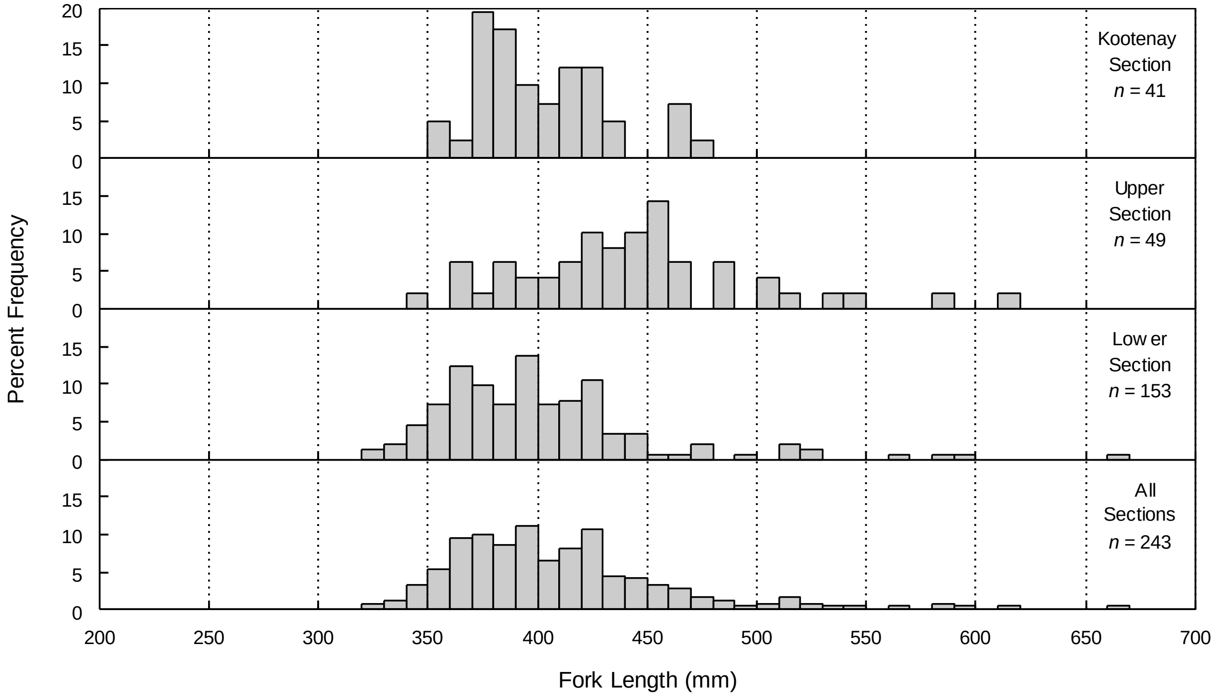
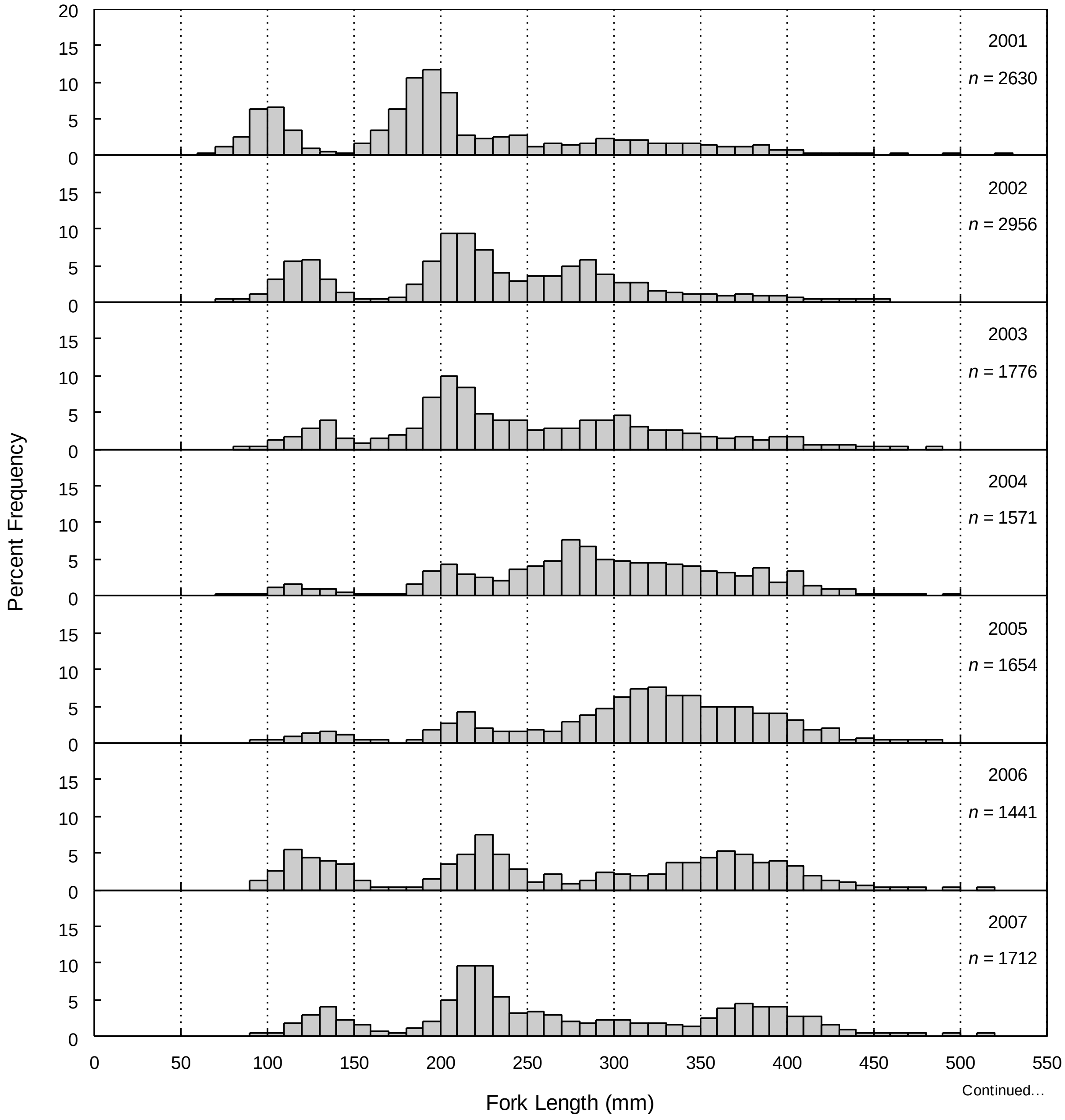


Figure F3. Length-frequency distributions by site for Walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, October 06 to November 03, 2013.



Continued…

Figure F4. Length-frequency distributions by year for Mountain Whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2013.

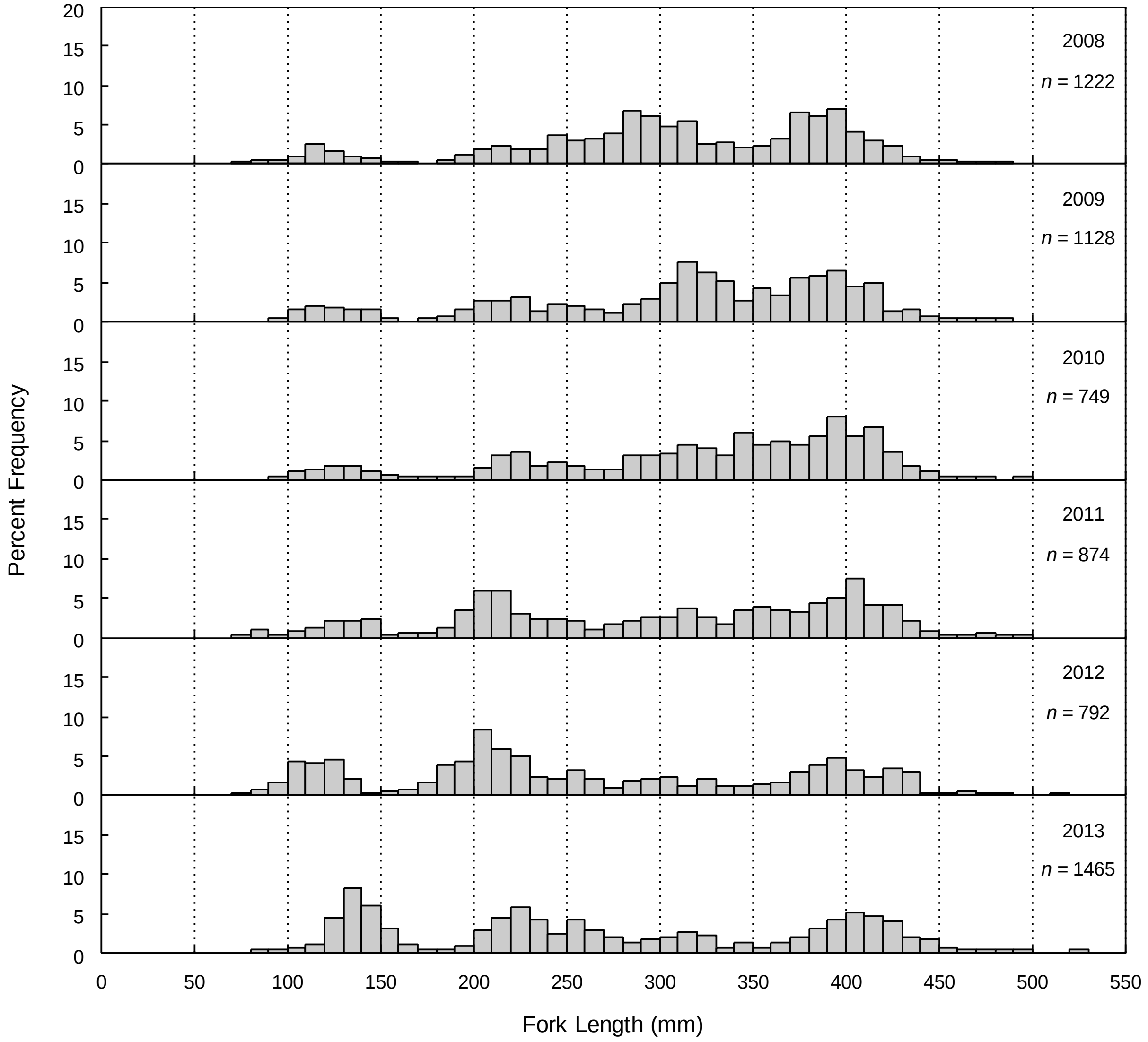


Figure F4. Concluded.

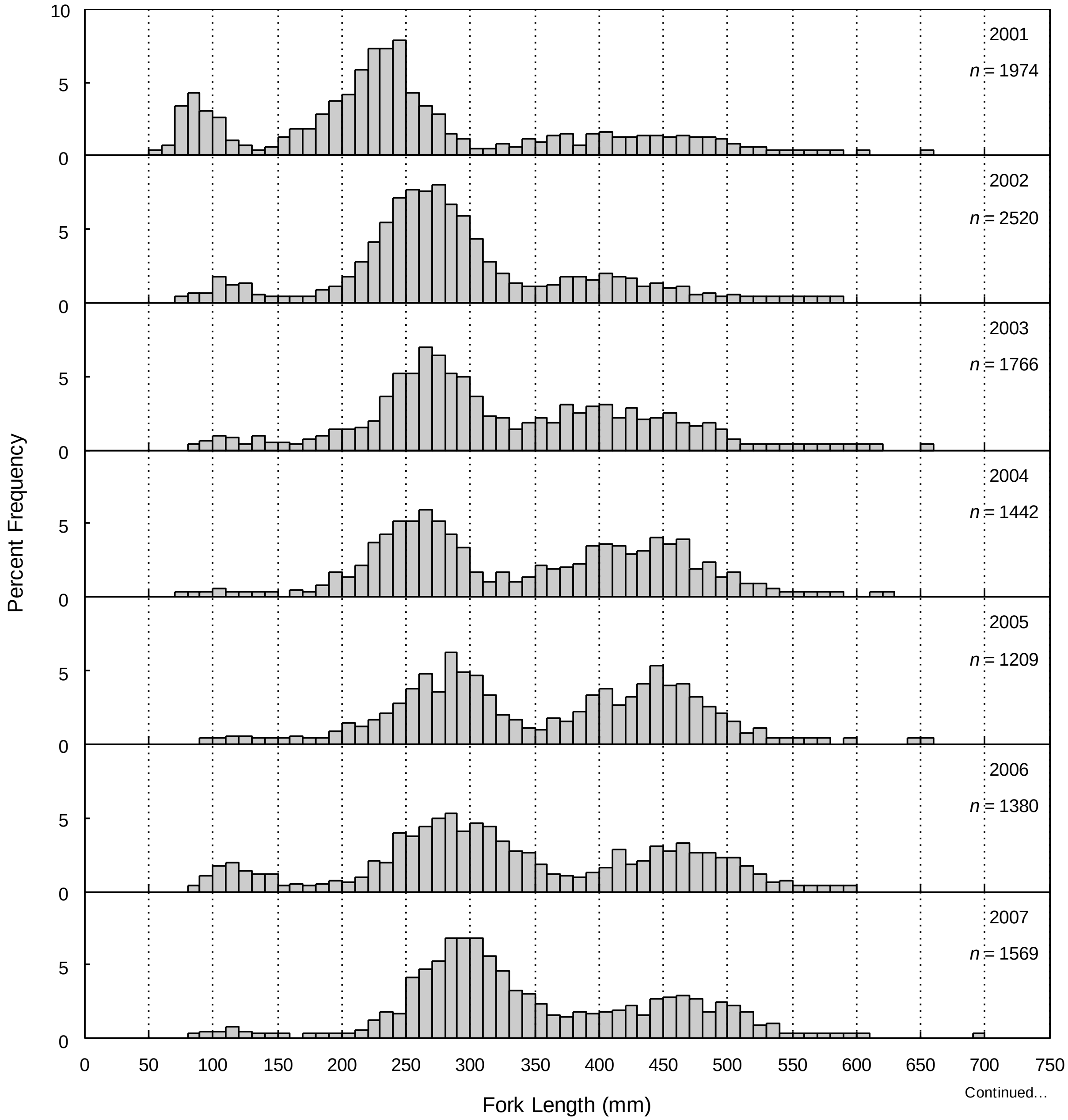


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Figure F5. Length-frequency distributions by year for Rainbow Trout captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2013.

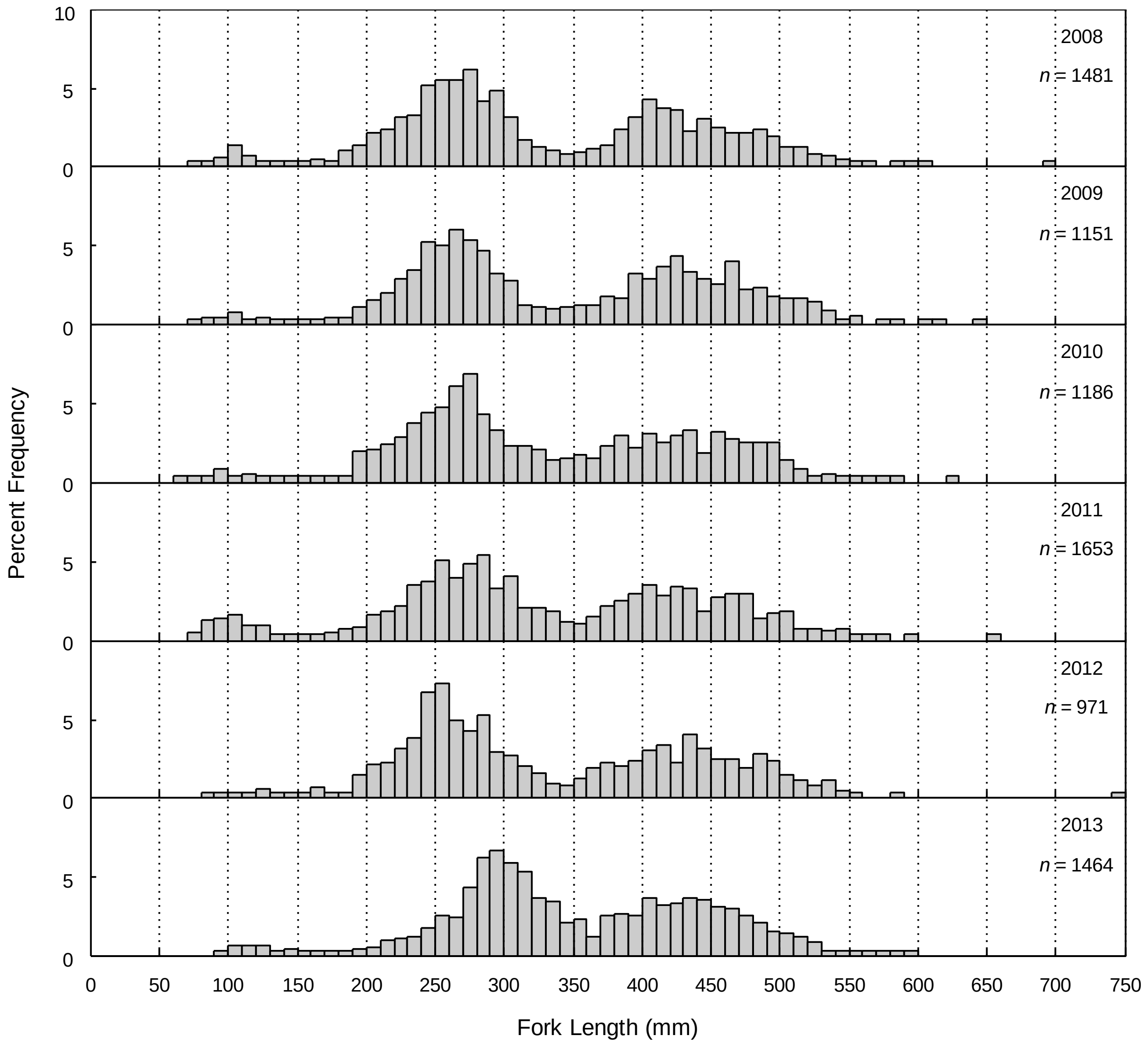
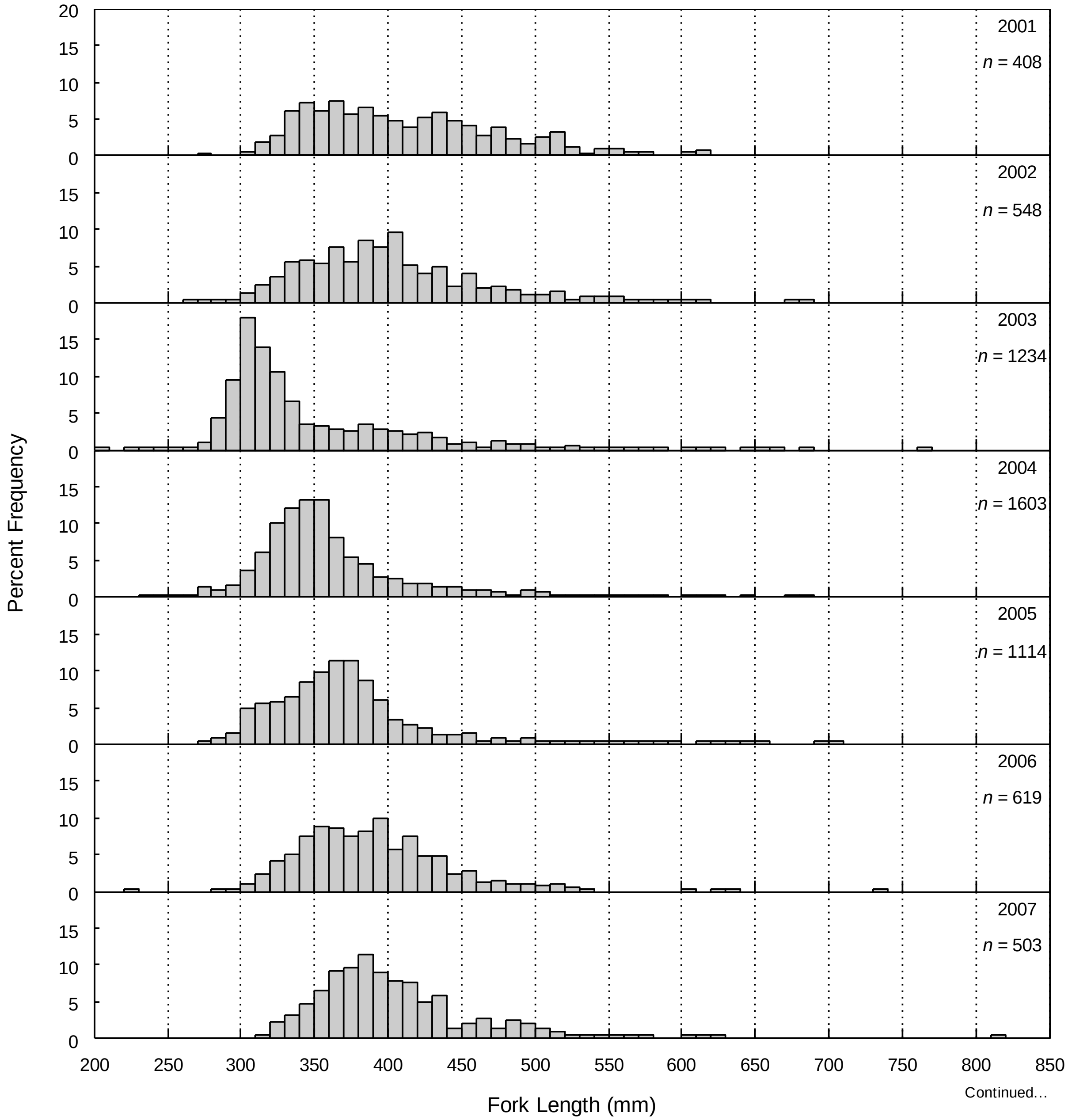


Figure F5. Concluded.



Continued…

Figure F6. Length-frequency distributions by year for Walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2013.

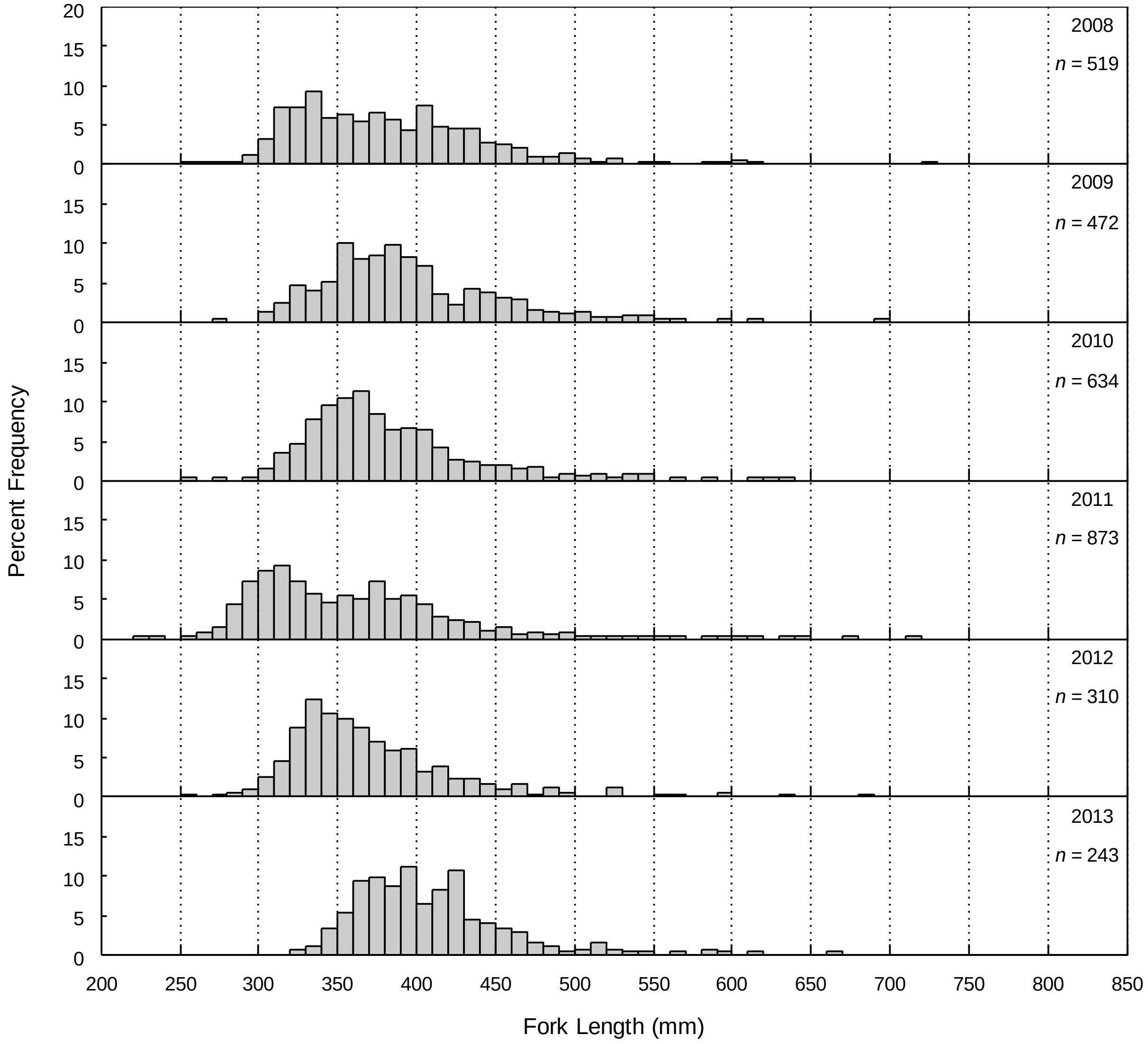


Figure F6. Concluded.

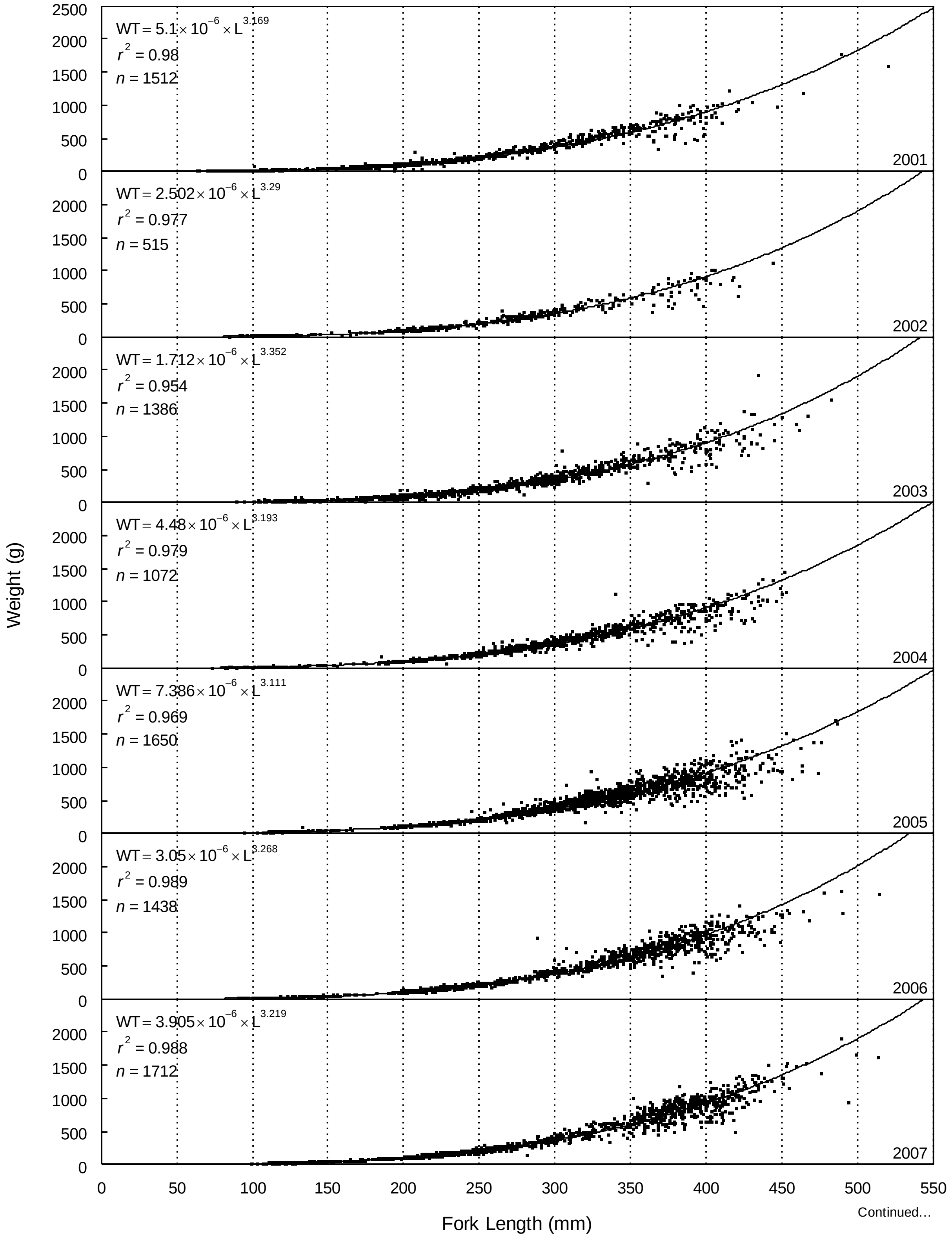


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Figure F7. Length-weight regressions for Mountain Whitefish captured by boat electroshocking in the Lower Columbia River, 2001 to 2013.

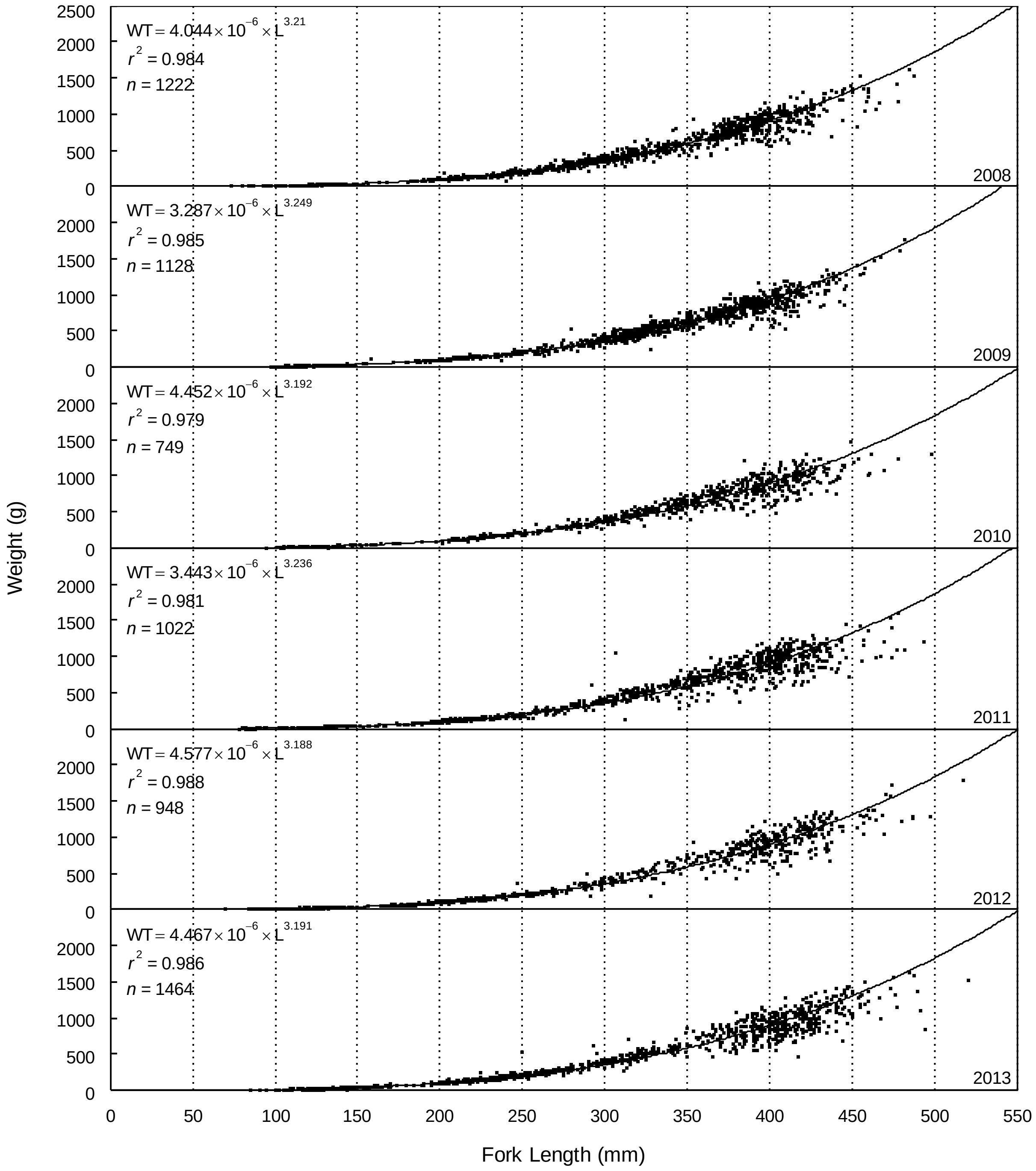
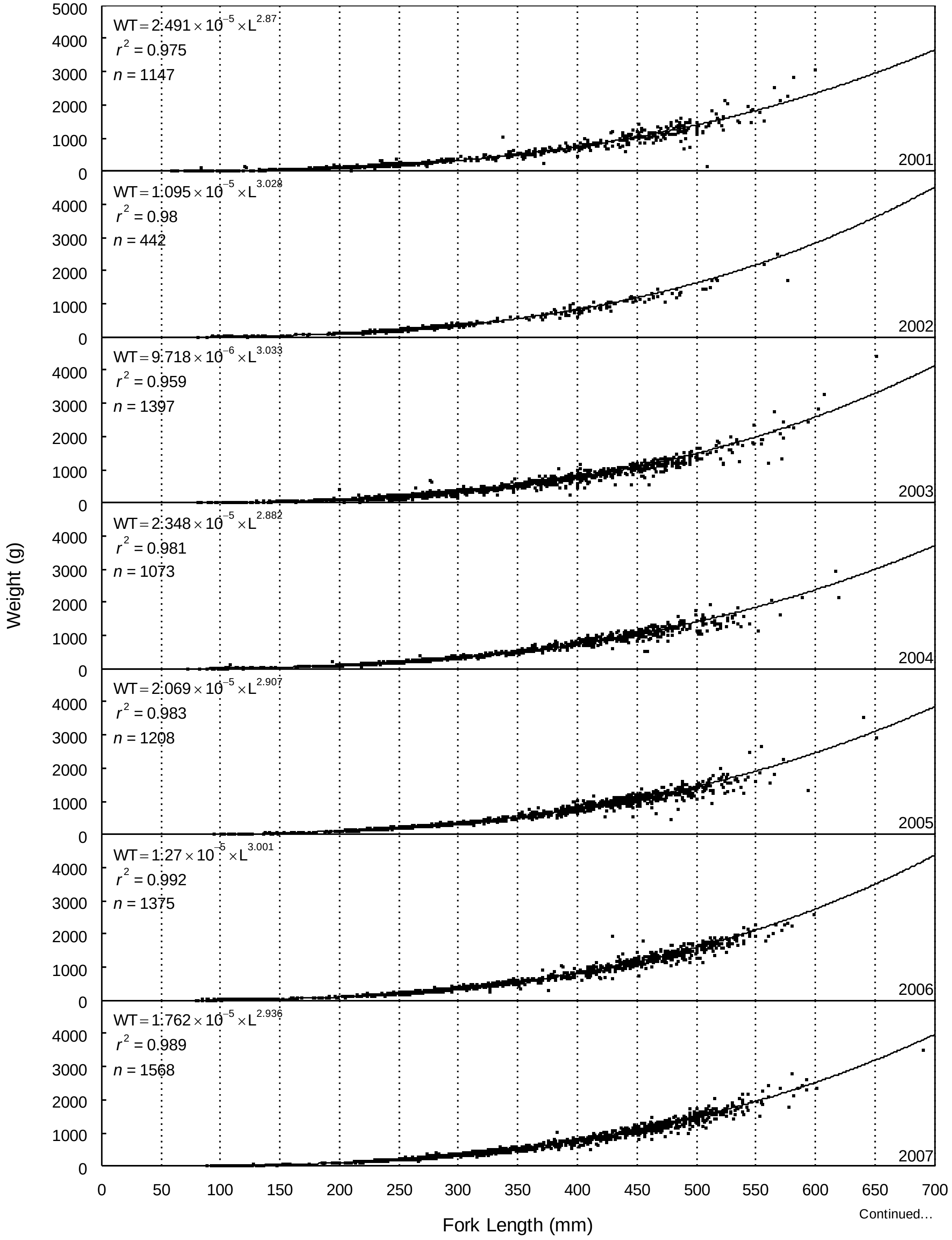


Figure F7. Concluded.



Continued…

Figure F8. Length-weight regressions for Rainbow Trout captured by boat electroshocking in the Lower Columbia River, 2001 to 2013.

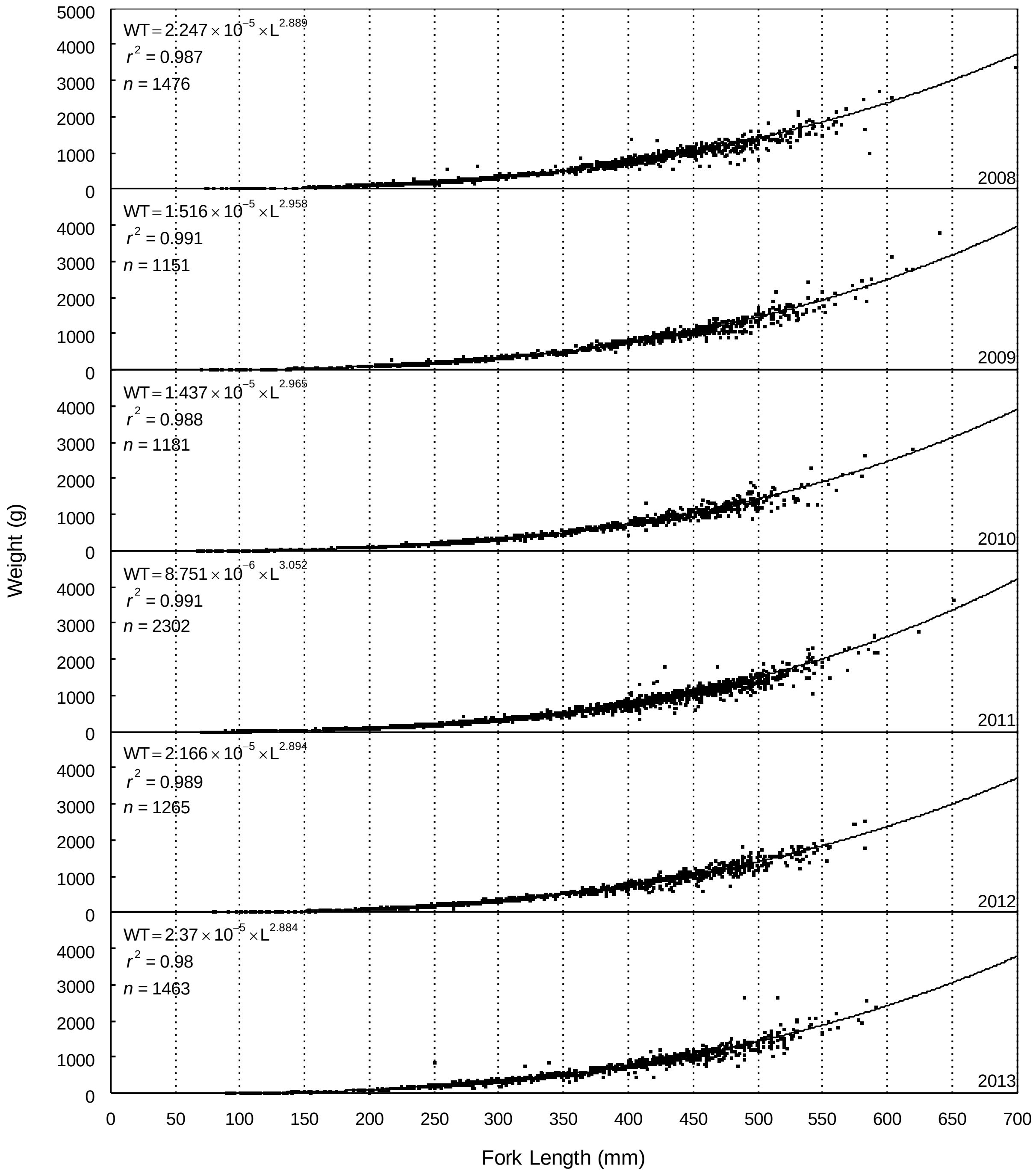


Figure F8. Concluded.

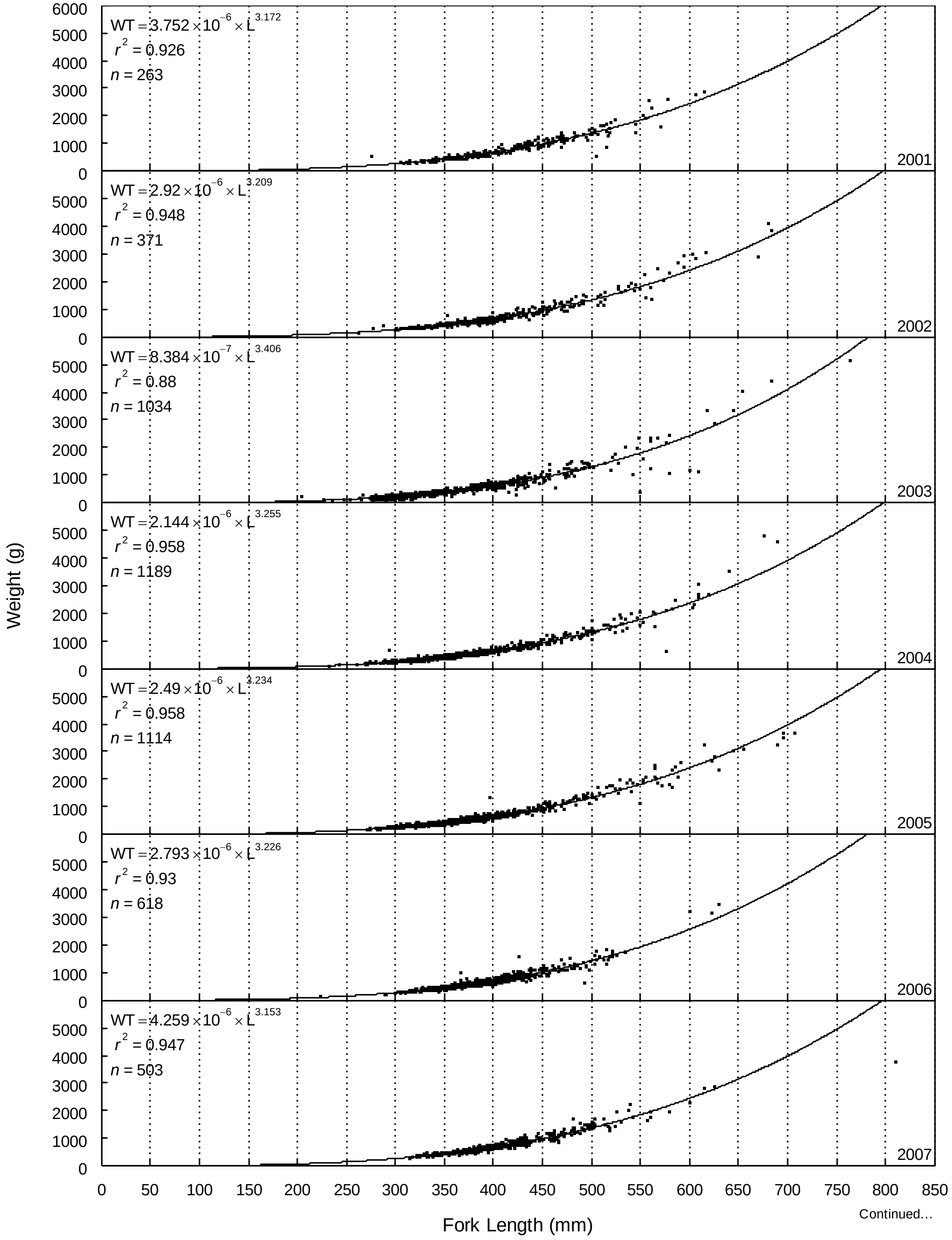


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Figure F9. Length-weight regressions for Walleye captured by boat electroshocking in the Lower Columbia River, 2001 to 2013.

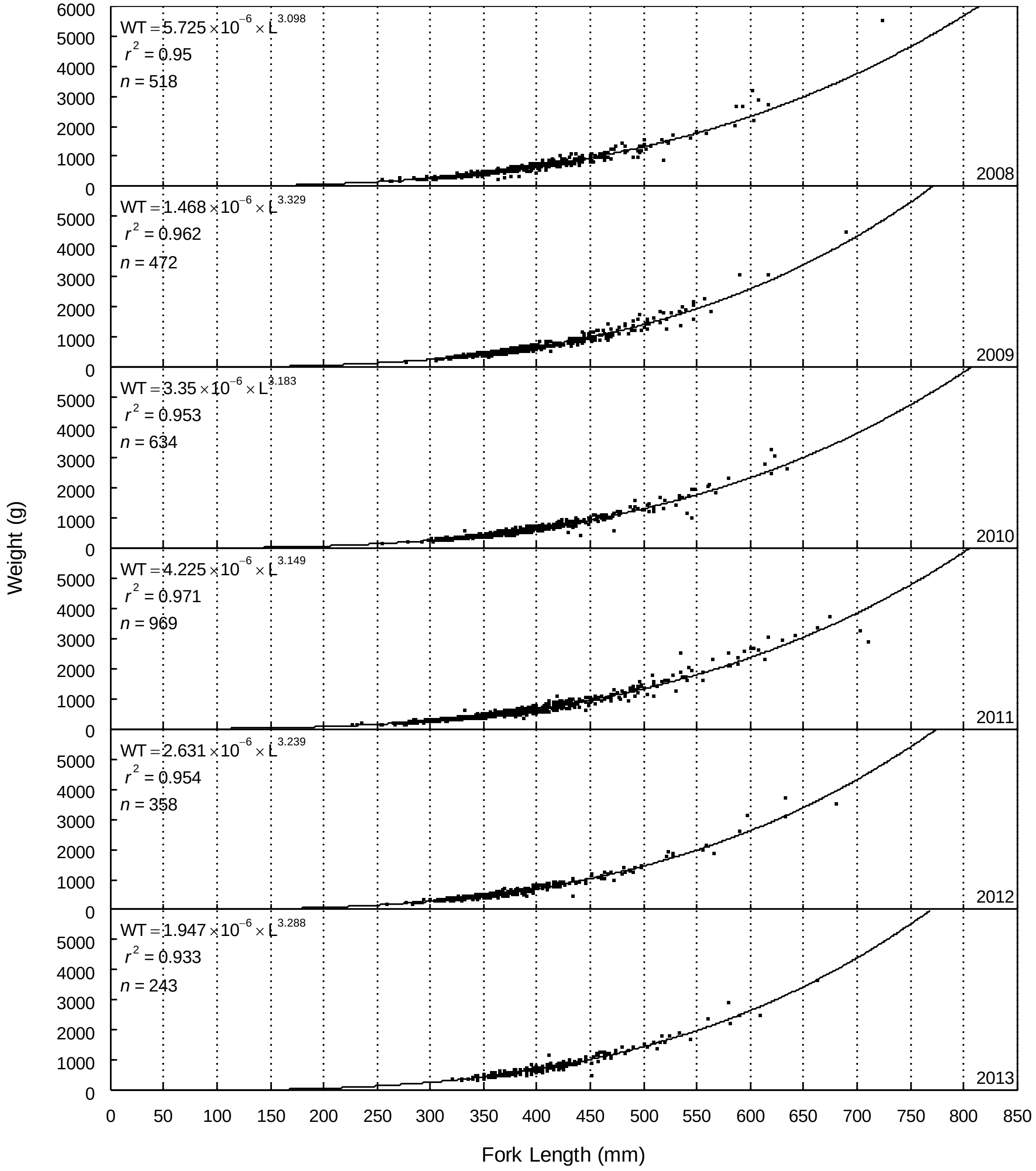

Figure F9. Concluded.

APPENDIX G

Additional Figures

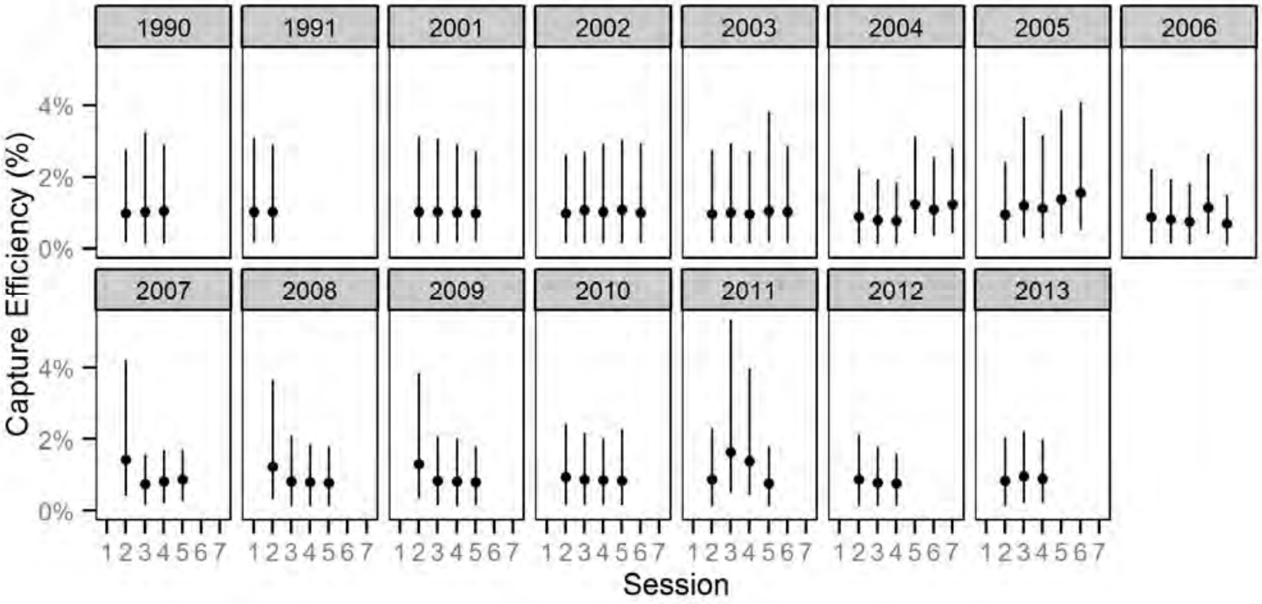

Figure G1: Capture efficiency (mean with 95% credible intervals) of subadult Mountain Whitefish by year and sample session in the Lower Columbia River, 2001-2013.

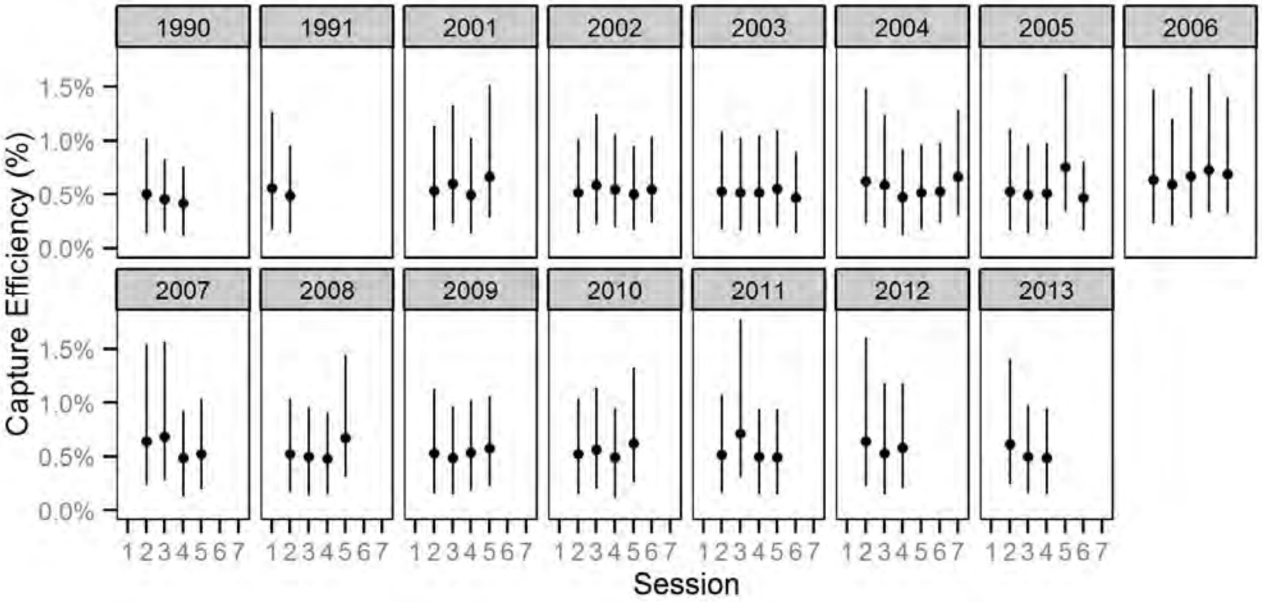

Figure G2: Capture efficiency (mean with 95% credible intervals) of adult Mountain Whitefish by year and sample session in the Lower Columbia River, 2001-2013.

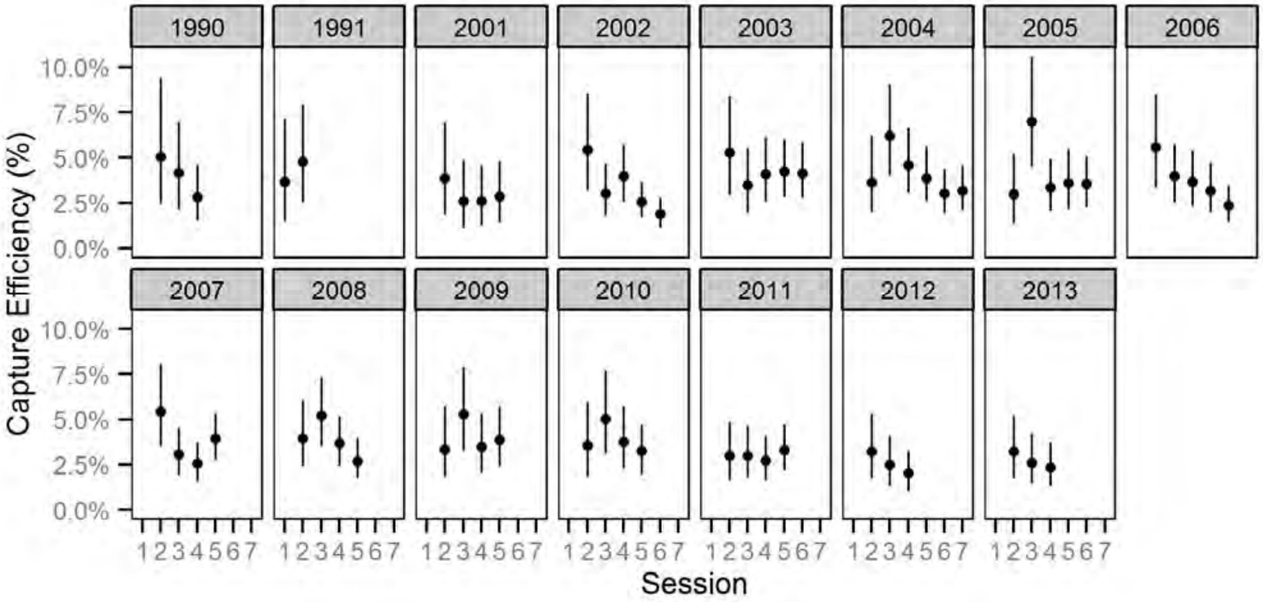

Figure G3: Capture efficiency (mean with 95% credible intervals) of subadult Rainbow Trout by year and sample session in the Lower Columbia River, 2001-2013.

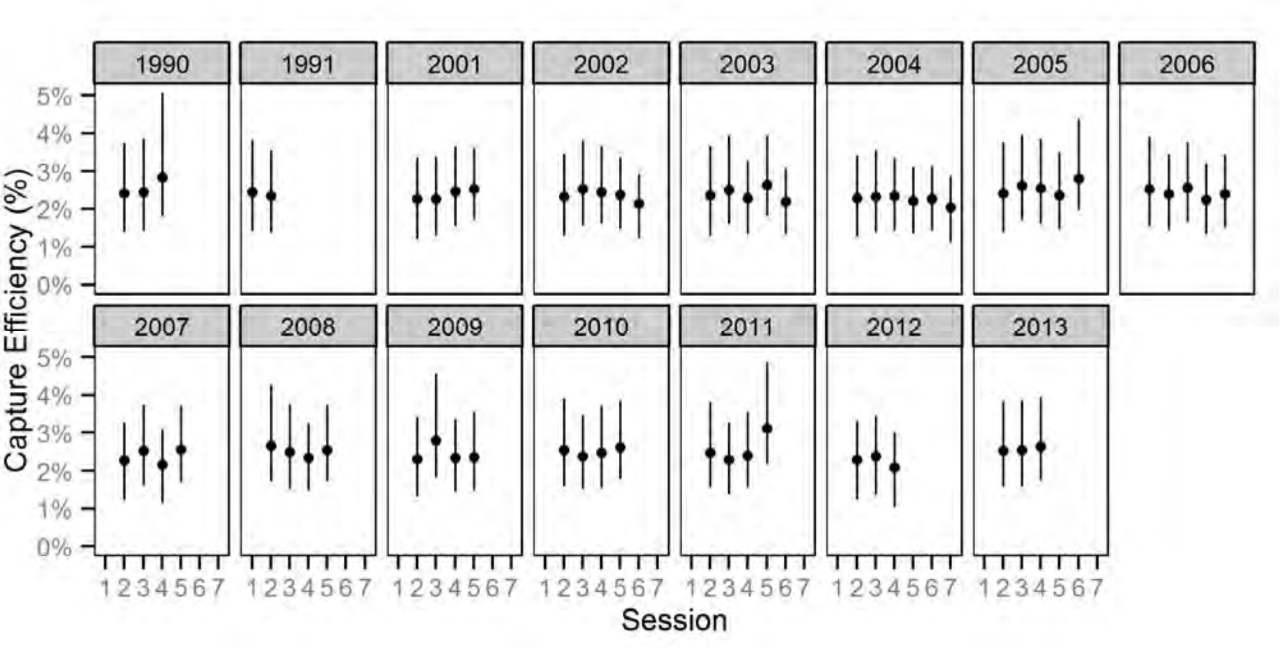

Figure G4: Capture efficiency (mean with 95% credible intervals) of adult Rainbow Trout by year and sample session in the Lower Columbia River, 2001-2013.

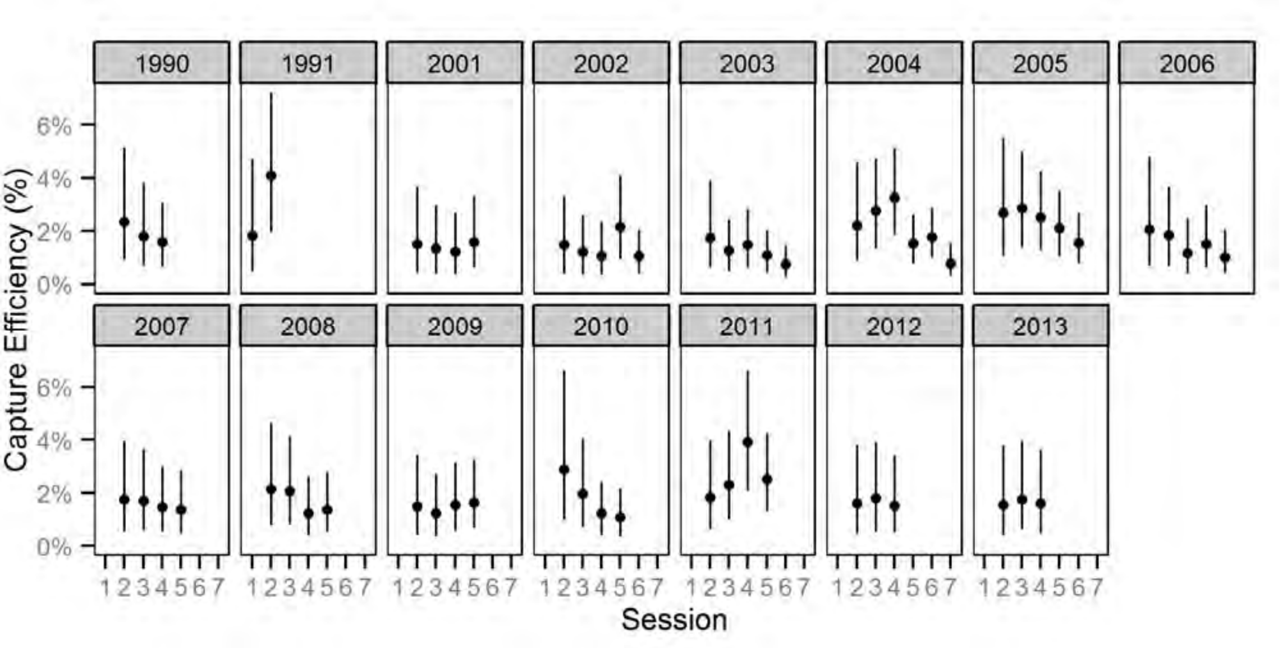

Figure G5: Capture efficiency (mean with 95% credible intervals) of adult Walleye by year and sample session in the Lower Columbia River, 2001-2013.

APPENDIX H

Fish Distribution Maps

This monitoring report has been completed as part of BC Hydro's Water License Requirements. Copies are on file at BC Hydro. In order to protect sensitive information regarding the distribution of fish populations in the study area, a copy of this appendix is not available for viewing through this website. For further information concerning this study or the report, please contact Water License Requirements through the "Contact Us" button located at the top of this webpage.

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