# Columbia River Project Water Use Plan

## Lower Columbia River Fish Management Plan

### Implementation Year 8

### Reference: CLBMON-45

*Lower Columbia River Fish Population Indexing Surveys*

**Study Period: 2014**

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**November 11, 2015**

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## CLBMON-45

# Lower Columbia River Fish Population Indexing Surveys - 2014 Investigations

Submitted to:

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REPORT

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# Executive Summary

BC Hydro has conducted flow management actions to reduce egg losses in the lower Columbia River (LCR) during the Mountain Whitefish (*Prosopium williamsoni*) and Rainbow Trout (*Oncorhynchus mykiss*) spawning seasons since the mid-1990s. These actions include decreasing flows from Hugh L. Keenleyside Dam (HLK) in early winter to encourage Mountain Whitefish spawning at lower water level elevations and reduce egg dewatering over the winter egg incubation period. In early spring, flows are managed to provide stable or increasing water levels during the Rainbow Trout spawning season, which reduces the likelihood of Rainbow Trout eggs and other larval fish 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-US 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.

Fish 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 2014 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. Multivariate analyses were used to assess relationships between environmental variables and fish population metrics, to test for potential effects of flow regime variability.

A visual enumeration survey was conducted to assess whether this method would provide comparable or potentially more precise 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.

The abundance of subadult Mountain Whitefish and Rainbow Trout decreased between 2001 and 2005 followed by an increase in body condition of these species in subsequent years (2003 - 2006). Adult Rainbow Trout abundance increased from ~26 000 in 2001 to ~35 000 in 2014, with a peak of ~42 000 in 2011. Adult Mountain Whitefish abundance declined by approximately half between 2001 (>200 000) and 2012 (~100 000) and remained at similar levels between 2012 and 2014. Walleye had lower abundance in the most recent three years than all earlier years, which corresponded with the highest observed body condition.

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 analyses suggested some associations, including subadult Mountain Whitefish body condition that was negatively associated with their abundance and with discharge variability in the spring. The survival and abundance of adult Walleye were correlated with the trend in mean discharge during the fall (October to December).

Counts of observed fish from visual surveys correlated 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 decreased 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 have been 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) were 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; Golder and Poisson 2014) will be used to identify changes in 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 encompasses 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 includes 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 2014, 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 6 and November 4, 2014 (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 4 and 7, 2014.

**Table 1: Annual study periods for boat electroshocking surveys conducted in the LCR, 2001 to 2014.**

| 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 |
| 2014 | October 6 | November 7 | 5 | 33 |

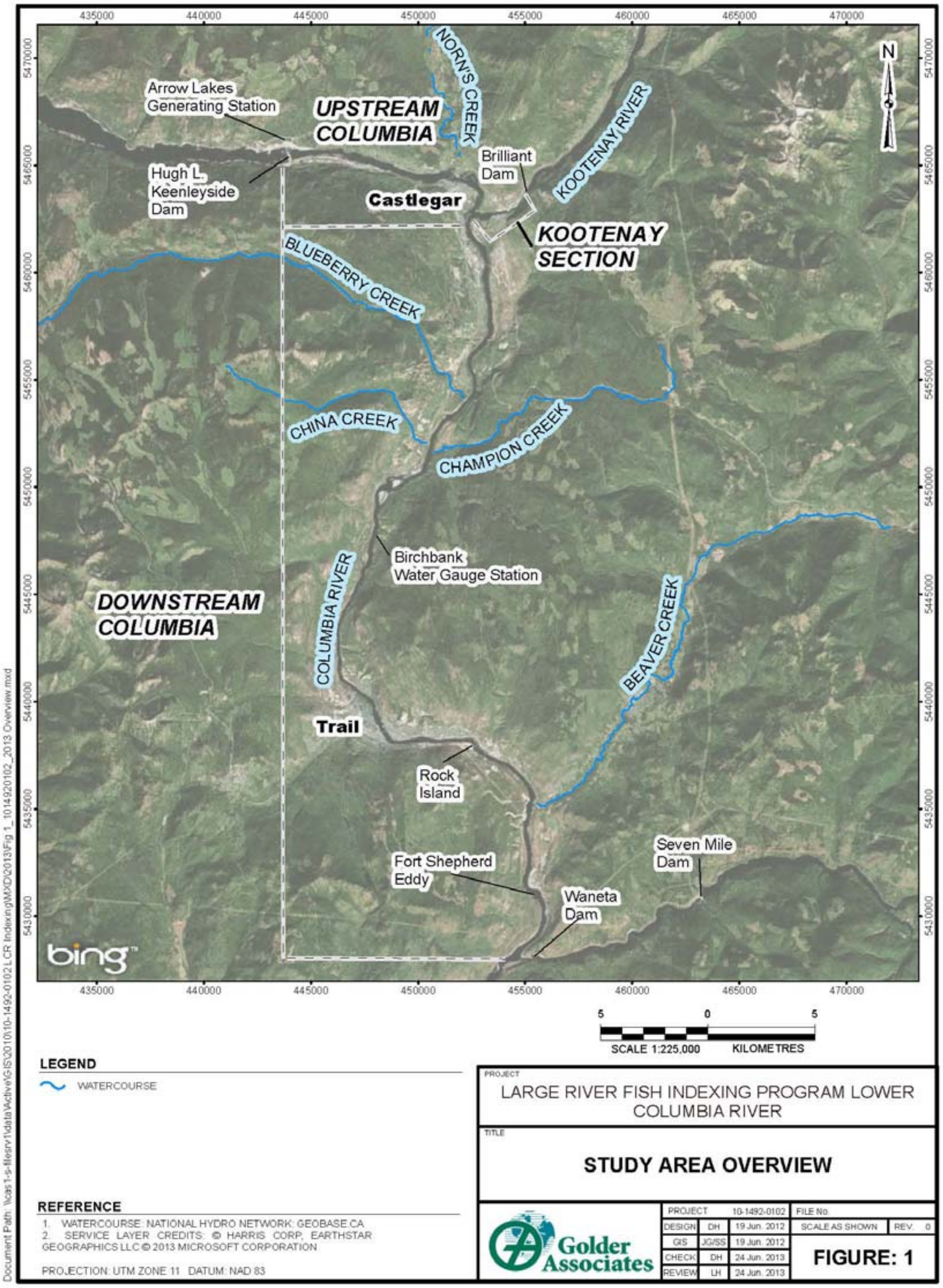

*Figure 1: Overview of the lower Columbia River Fish Population Indexing study area, 2014.*

# 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 2014 (except 2012) 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 2013a). Hourly water temperatures for the Columbia River near Norn's Creek also were 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 summarised 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, 2014.**

| 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, Golder and Poisson 2014). 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 water temperatures 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. 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. 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 distance that was actually sampled 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 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. This same subsample of sites has been used for annual sampling since 2001, including the continuation of the survey program as part of CLBMON-45, which was initiated in 2007.

Approximately 30% of the total shoreline habitat available in the LCR was repetitively sampled each year as part of the LRFIP and 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. This bias can arise if inter-annual fish distribution changes with abundance rather than only fish density. Additionally, 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.

Starting in 2011, additional sites were selected using the GRTS survey design (Stevens and Olsen 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.

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 oversample sites also were selected. Oversample 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 oversample 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 4 and 7, 2014 using the same procedures described above. The GRTS surveys were always conducted after sampling at index sites was completed from 2011 to 2014. 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, 2014.**

| 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 2014, 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 2014 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 previous years of the monitoring program suggested that the density of adult Rainbow Trout in the LCR varied little between 2001 and 2013. 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 fishes 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 fishes. 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 2014, 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 2001-2014 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 2014 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. Data from the 1990s from sites less than 500 m in length were not included in the analysis because of potential biases in the site selection. 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), 2014;
- catch-rates for all sportfish (Appendix E, Table E2) and non-sportfish (Appendix E, Table E3), 2014;
- length-frequency histograms by section for Mountain Whitefish (Appendix F, Figure F1), Rainbow Trout (Appendix F, Figure F2), and Walleye (Appendix F, Figure F3), 2014;
- 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 2014 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 Kéry 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 (Kéry and Schaub 2011; p.41);
- permits the incorporation of prior information (Kéry 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 (Kéry and Schaub 2011; p.41);
- enables the efficient modelling of spatial and temporal variations and correlations (Kéry and Schaub 2011; p.78-82); and,
- permits the separation of ecological and observational processes (Kéry and Schaub 2011; p.44).

Hierarchical Bayesian models were fitted to the fish indexing data using R version 3.2.0 (R Team 2013) and JAGS 3.4.0 (Plummer 2012) which interfaced with each other via jaggernaut 2.2.11 (Thorley 2013).

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 and Hogan 2015).

The posterior distributions of the fixed (Kéry and Schaub 2011, 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, 37, 42).

In general variable selection was achieved by dropping insignificant (Kéry and Schaub 2011, 37, 42) fixed (Kéry and Schaub 2011, 77–82) variables and uninformative random variables. A fixed variable was considered to be insignificant if its two-sided Bayesian p-value ≥ 0.05 (Bochkina and Richardson 2007; Lin et al. 2009) while a random variable was considered to be uninformative if its percent relative error was ≥ 80%.

The results are displayed graphically by plotting the modelled 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, 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).

### 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 include:

- three distinguishable age-classes for each species: age-0, age-1 and age-2 and older;
- the proportion of fish in each age-class varied randomly with year;
- the expected growth between age-classes varied with age-class;
- the expected growth between age-classes was allowed to vary randomly with age-class within year;
- body length varied as a second-order polynomial of date;
- the relationship between length and date varied randomly with age-class;
- the residual variation in length was normally distributed; and,
- the standard deviation of this normal distribution varied randomly with age-class.

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 the previous year (fall age-0 fish) to the current year was plotted. This was done to remove carry-over effects from the first year of growth (hatch to capture in the fall) because it is the inter-annual 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. The results include plots of the age-class density for each year by length as predicted by the length-at-age model. Density is a measure of relative frequency for continuous values.

### 2.2.4 Length Bias

The bias (accuracy) and error (precision) in the observers' 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 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 proportion of fish in each length-class varied with year;
- the expected length bias varied with observer;
- the expected length error varied with observer;

- the expected length bias and error for a given observer did not vary by year; and,
- the residual variation in length was normally distributed.

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 include:

- the mean maximum length was constant;
- the growth coefficient (k) varied randomly with year; and,
- the residual variation in growth 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 include:

- observed site fidelity was described by a Bernoulli distribution; and,
- expected site fidelity varied with body length.

Length as a second-order polynomial was not found to be a significant predictor for site fidelity so was not included in the model.

### 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;
- 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 over-dispersed 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 in the study area.

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 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 mark-recapture sessions 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.

The annual distribution of each species was assessed using the Shannon index of evenness ($E$), using the following equation, where $S$ was the number of sites and $p_i$ was the proportion of the population belonging to the i*th* site.

$$E=-\sum p_i \log(p_i) \ln(S)$$

Evenness was used to assess inter-annual changes in spatial distribution, where a greater values of the index indicates more similar abundances among sites, and a lower value of the index indicates less even abundances among sites and a more “clumped” distribution.

### 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;
- the encounter probability varied with the total bank length sampled; and,
- survival was constant for subadults.

### 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 varied randomly with year; and,
- the residual 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, multivariate analyses were used to examine long-term and short-term relationships between environmental and fish population time series variables.

The fish index time series were the condition (Con), growth (Grw) length-at-age (Len), survival (Sur), and Abundance (Abn) by species (MW = Mountain Whitefish, RB = Rainbow Trout, WP = Walleye) and life stage (Sub = Subadult, Ad = Adult) or age (Age0, Age1).

The environmental time series included the mean discharge (DisMe) and average hourly absolute discharge difference (DisDi) in the Columbia River at Birchbank, and the average water temperature (TemMe) of the Columbia River at 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 discharge and temperature variables were summarised by quarterly period (e.g., January to February, March to April, May to June, etc.). 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. The estimated annual proportional egg loss through dewatering (Regime) by species (MW = Mountain Whitefish, RB = Rainbow Trout) was also included as a variable. Estimated egg loss is based on models of substrate dewatering because of flow reductions during the spawning season and was obtained from Irvine et al. (2015) for Rainbow Trout and from BC Hydro for Mountain Whitefish, based on the model described in Golder (2013b). The Mountain Whitefish egg loss time series was lagged by one year to account for the fact that they occur over winter and would affect fish metrics in the following year. All time series variables were standardised by subtracting the mean and dividing by the standard deviation, prior to fitting the model.

Long-term trends common to the annual fish indexing and environmental time series were identified using dynamic factor analysis (DFA; Zuur et al. 2003) - a dimension-reduction technique especially designed for time-series data. 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 time series were described by three underlying trends;
- the random walk processes in the trends were normally distributed; and,
- the residual variation in the standardised variables was normally distributed.

A limitation of dynamic factor analysis as currently implemented in a Bayesian framework is that it is not possible to identify the individual common trends (although it is possible to identify the relationships between time series), which has been referred to as the rotation problem (Abmann et al. 2014). To visualize the relationships among fish metrics and environmental variables, non-metric multidimensional scaling (NMDS) was used to indicate the clustering of time series based on the absolute values of the dynamic factor analysis trend weightings. The more similar two time series, the closer they will tend to be on the resultant NMDS plot.

To assess short-term correlations between the fish population metrics and the environmental variables, the pair-wise distances between the residuals from the DFA model were calculated as 1−abs[cor(x,y)] where cor is the Pearson correlation, abs the absolute value and x and y are the two time series being compared. The short-term similarities were represented visually by using NMDS to map the distances onto two-dimensional space. The objective of the short-term trend analysis was to assess inter-annual associations among variables, after removing the effect of long-term trends in the variables.

# 3.0 RESULTS

## 3.1 Physical Habitat

### 3.1.1 Columbia River

#### *3.1.1.1 Discharge*

Discharge in the LCR in 2014 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 or below average for approximately half of the year, including during the sample period. During the remaining half of the year, discharge was above average (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 2014, discharge decreased during the majority of the sample period, but started to increase during Session 4 (Figure 2).

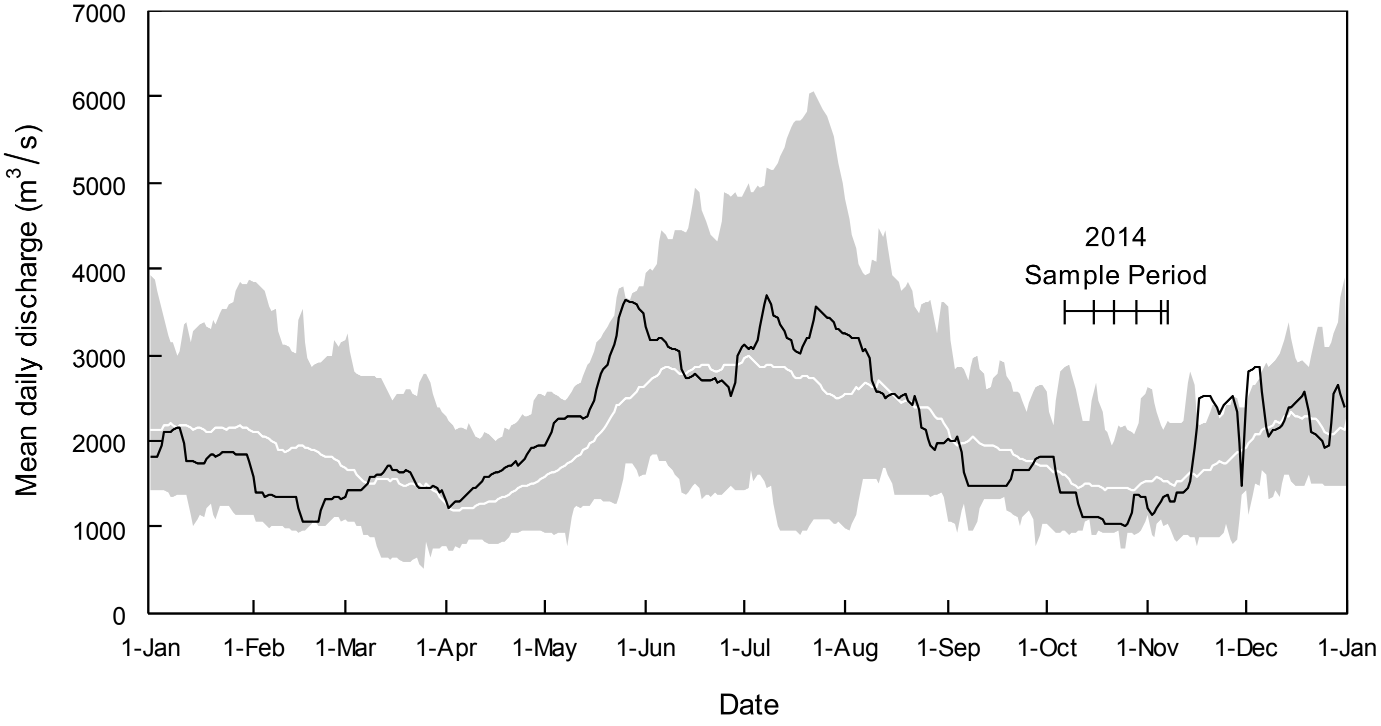

*Figure 2: Mean daily discharge ($m^3/s$) for the Columbia River at the Birchbank water gauging station, 2014 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at Birchbank from 2001 to 2013. The white line represents average mean daily discharge values over the same time period.*

In 2014, mean daily discharge in the Columbia River below HLK was near average for most of the year but greater than average during July, August, end of November and beginning of December. Discharge during half of September, October and beginning of November was lower than average, this included the sample period for 2014. (Figure 3; Appendix D, Figure D2).

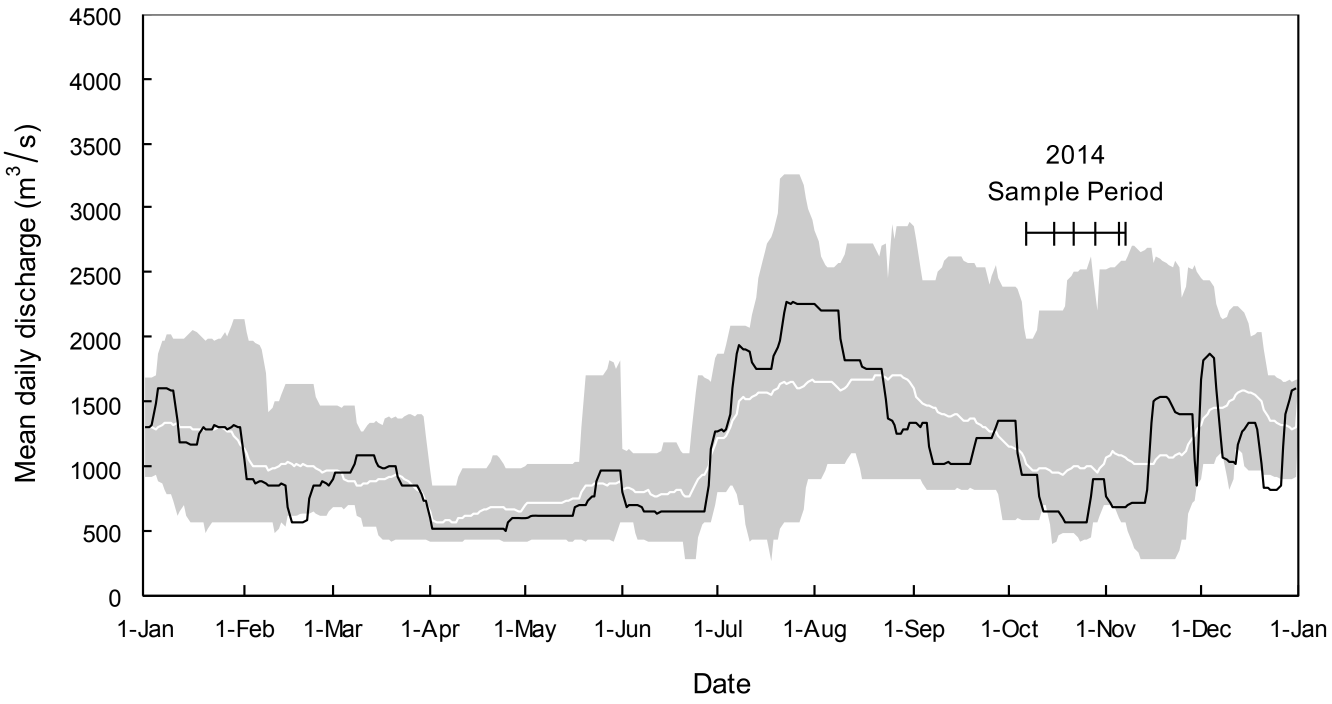

*Figure 3: Mean daily discharge ($m^3/s$) for the Columbia River at Hugh L. Keenleyside Dam, 2014 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2013. The white line represents average mean daily discharge values over the same time period.*

### 3.1.1.2 Temperature

Water temperature in the Columbia River in 2014 was similar to average values from 2011 to 2013 (Figure 4), but below average from January to mid-May and above average from October to December. During the 2014 sample period, water temperatures were above average, but 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 10.1°C and 15.0°C (Appendix B, Table B3).

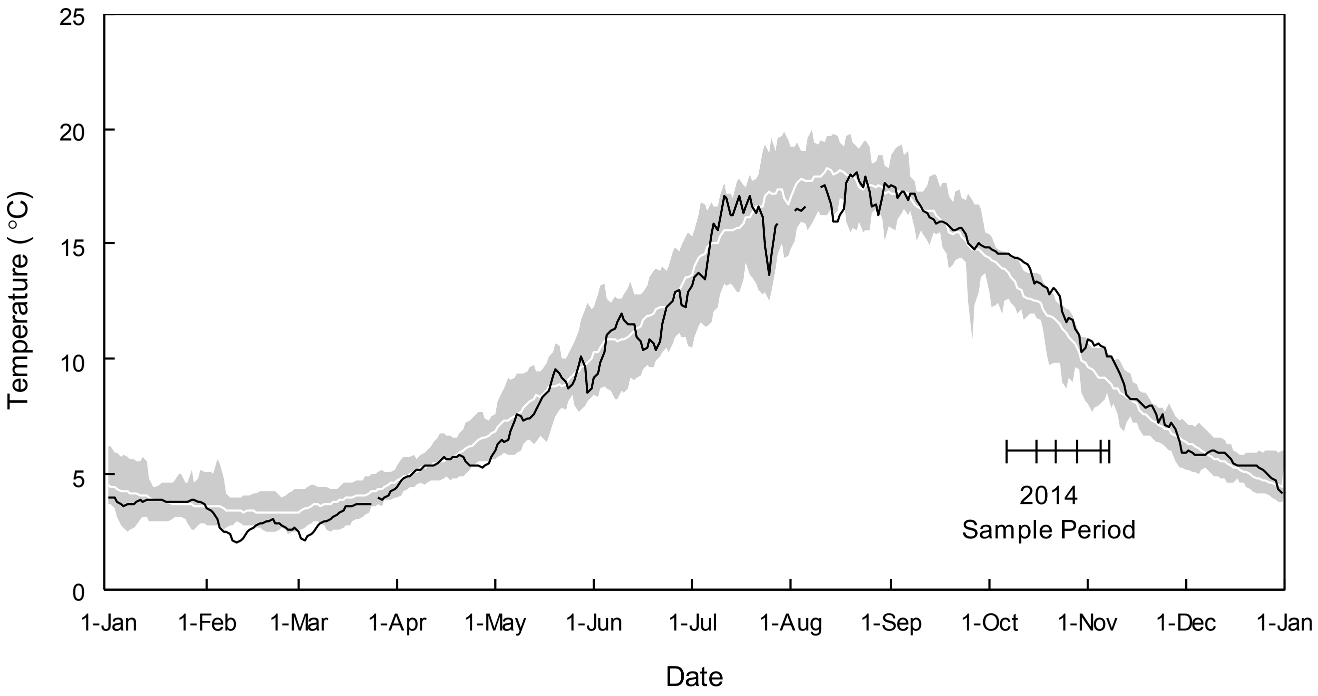

*Figure 4: Mean daily water temperature (°C) for the Columbia River at the Birchbank water gauging station, 2014 (black line). The shaded area represents the minimum and maximum mean daily water temperature values from 2001 to 2013. The white line represents the average mean daily water temperature during the same time period.*

## 3.1.2 Kootenay River

### *3.1.2.1 Discharge*

In 2014, mean daily discharge in the Kootenay River downstream of BRD was similar to average values from 2001 to 2013 for most of the year (Figure 5; Appendix D, Figure D4). The exception was that discharge was greater than average from April until mid-June and November to January. The spring freshet period indicated by the first peak of the bimodal pattern was earlier this year than average. During the sample period in October and early November, discharge was very similar to the average values from 2001 to 2013.

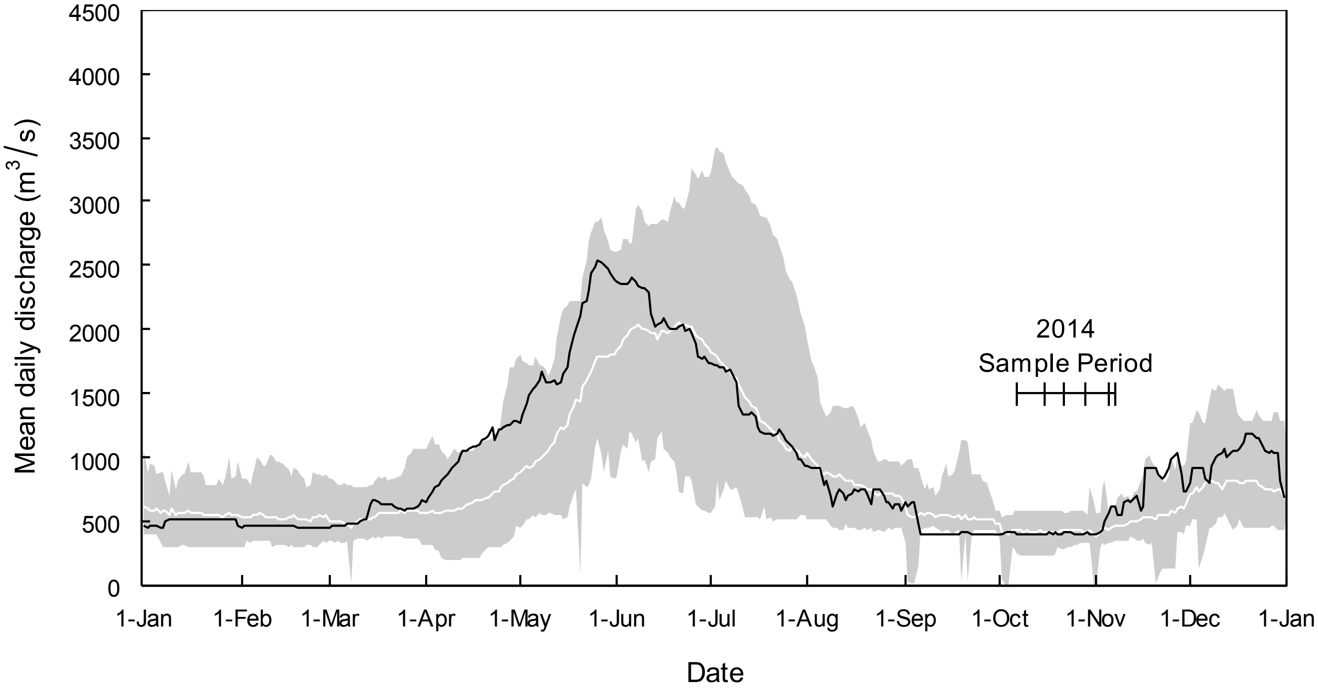

*Figure 5: Mean daily discharge (m$^3$/s) for the Kootenay River at Brilliant Dam (BRD), 2014 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2013. The white line represents average mean daily discharge values over the same time 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). Water temperature during the sampling period in 2014 was greater than the average from 2001 to 2013 (Figure 6). Water temperature data for the Kootenay River were not available for January to mid-June of 2014 because of malfunctioning temperature loggers. Spot temperature readings for the Kootenay River taken at the time of sampling ranged between 10.3°C and 15.3°C (Appendix B, Table B3).

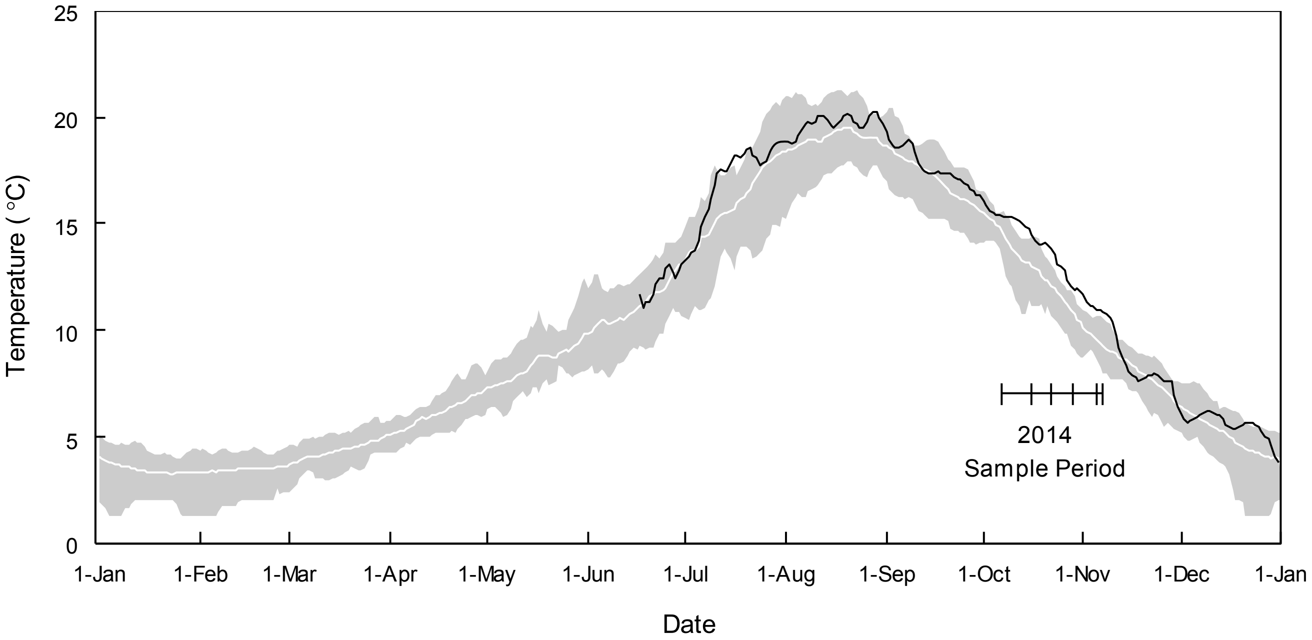

*Figure 6: Mean daily water temperature (°C) for the Kootenay River downstream of Brilliant Dam, 2014 (black line).The shaded area represents minimum and maximum mean daily water temperature values recorded at the dam from 2001 to 2013. The white line represents average mean daily water temperature values over the same time period. Data from January 1 to June 15, 2014 were 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, 27 190 fish were recorded in the LCR in 2014. (Appendix E, Table E2). This total included both captured fish, and observed fish that were identified to species. This number was fish captured or observed in both the Index and GRTS sites combined. Catch was greatest in the downstream section of the Columbia River (52% of the total catch), followed by the upstream section of the Columbia River (38%), and the Kootenay River (10%) (Table 4).

**Table 4:** **Number of fish caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the LCR, October 6 to November 7, 2014. This table includes data from Index and GRTS sites.**

| 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*) | 2258 | 76 | 937 | 74 | 2252 | 36 | 5447 | 52 |
| Rainbow Trout (*Oncorhynchus mykiss*) | 462 | 16 | 230 | 18 | 3546 | 56 | 4238 | 40 |
| Walleye (*Sanders vitreus*) | 188 | 6 | 74 | 6 | 374 | 6 | 636 | 6 |
| Brook trout (*Salvelinus fontinalis*) | 1 | <1 | 1 | <1 | 17 | <1 | 19 | <1 |
| Brown Trout (*Salmo trutta*) | 0 | | 0 | | 5 | <1 | 5 | <1 |
| Bull Trout (*Salvelinus confluentus*) | 2 | <1 | 0 | | 3 | <1 | 5 | <1 |
| Burbot (*Lota lota*) | 2 | <1 | 0 | | 21 | <1 | 23 | <1 |
| Kokanee (*Oncorhynchus nerka*) | 7 | <1 | 0 | | 1 | <1 | 8 | <1 |
| Lake Trout (*Salvelinus namaycush)* | 0 | | 0 | | 1 | <1 | 1 | <1 |
| Lake Whitefish (*Coregonus clupeaformis*) | 22 | <1 | 10 | <1 | 82 | 1 | 114 | 1 |
| Largemouth Bass (*Micropterus salmoides*) | 0 | | 1 | <1 | 0 | | 1 | <1 |
| Northern Pike (*Esox lucius*) | 22 | <1 | 3 | <1 | 0 | | 25 | <1 |
| Smallmouth Bass (*Micropterus dolomieu*) | 0 | | 0 | | 9 | <1 | 9 | <1 |
| White Sturgeon (*Acipenser transmontanus*) | 7 | <1 | 5 | <1 | 2 | <1 | 14 | <1 |
| **Sportfish Subtotal** | **2971** | **100** | **1261** | **100** | **6313** | **100** | **10545** | **100** |
| **Non-sportfish** | | | | | | | | |
| Northern Pikeminnow (*Ptychocheilus oregonensis*) | 19 | <1 | 28 | 2 | 22 | <1 | 69 | <1 |
| Peamouth (*Mylocheilus caurinus*) | 6 | <1 | 2 | <1 | 17 | <1 | 25 | <1 |
| Redside Shiner (*Richardsonius balteatus*) | 2896 | 40 | 349 | 24 | 422 | 5 | 3667 | |
| Sculpin spp.[c] (*Cottidae*) | 2917 | 40 | 769 | 53 | 7026 | 89 | 10712 | |
| Sucker spp.[c] (*Catostomidae*) | 1419 | 20 | 314 | 22 | 438 | 6 | 2171 | |
| Tench (*Tinca tinca*) | 1 | <1 | 0 | | 0 | | 1 | <1 |
| **Non-Sportfish Subtotal** | **7258** | **100** | **1462** | **100** | **7925** | **100** | **16645** | **100** |
| **All Species** | **10229** | **38** | **2723** | **10** | **14238** | **52** | **27190** | **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. Length-density plots show the relative frequency of lengths by age-class (Figures G9 and G10, Appendix G). All Walleye were classified as adults by the HBMs. A comparison of von Bertalanffy growth curves for the three index species indicated that Rainbow Trout grew the fastest but reached their asymptotic 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 2014. 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 | ≤151 | 152-241 | ≥242 | ≤151 | 152-352 | ≥353 |
| 1991 | ≤136 | 137-230 | ≥231 | ≤131 | 132-339 | ≥340 |
| 2001 | ≤135 | 136-242 | ≥243 | ≤131 | 132-326 | ≥327 |
| 2002 | ≤156 | 157-249 | ≥250 | ≤153 | 154-349 | ≥350 |
| 2003 | ≤157 | 158-250 | ≥251 | ≤160 | 161-344 | ≥345 |
| 2004 | ≤153 | 154-241 | ≥242 | ≤144 | 145-336 | ≥337 |
| 2005 | ≤164 | 165-246 | ≥247 | ≤163 | 164-350 | ≥351 |
| 2006 | ≤166 | 167-268 | ≥269 | ≤168 | 169-368 | ≥369 |
| 2007 | ≤168 | 169-272 | ≥273 | ≤165 | 166-376 | ≥377 |
| 2008 | ≤163 | 164-260 | ≥261 | ≤146 | 147-342 | ≥343 |
| 2009 | ≤162 | 163-256 | ≥257 | ≤147 | 148-342 | ≥343 |
| 2010 | ≤169 | 170-264 | ≥265 | ≤143 | 144-340 | ≥341 |
| 2011 | ≤159 | 160-264 | ≥265 | ≤153 | 154-346 | ≥347 |
| 2012 | ≤155 | 156-267 | ≥268 | ≤153 | 154-347 | ≥348 |
| 2013 | ≤176 | 177-282 | ≥283 | ≤169 | 170-359 | ≥360 |
| 2014 | ≤169 | 170-277 | ≥278 | ≤156 | 157-341 | ≥342 |

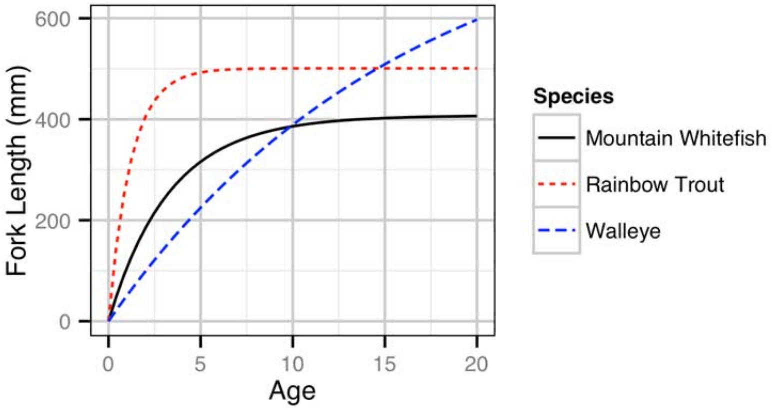

*Figure 7: Growth curve showing length-at-age by species as predicted by the von Bertalanffy model for the LCR, 2001-2014.*

### 3.3.1 Mountain Whitefish

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 116 and 135 mm FL between 2003 and 2014 (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). In 2014, there was a reduction in growth of subadult Mountain Whitefish compared to the previous year. The length of adult Mountain Whitefish (i.e., age-2 and older) is not presented because this group consisted of multiple age-classes.

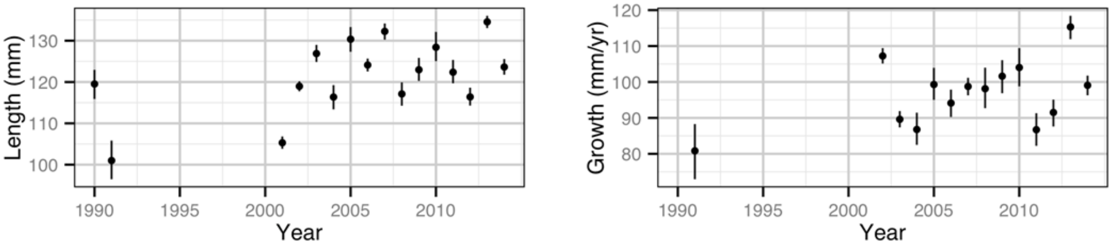

*Figure 8: Length-at-age of fry (left) and fry to subadult growth (right) for Mountain Whitefish in the LCR, 1990 to 1991 and 2001 to 2014. Values are means with 95% CRIs.*

Analysis of annual growth of recaptured individuals indicated an increase in average annual growth between 2003 and 2009, and variable annual growth between 2010 and 2014, although credible intervals overlapped between most estimates (Figure 9). The average annual growth was lowest during 2012.

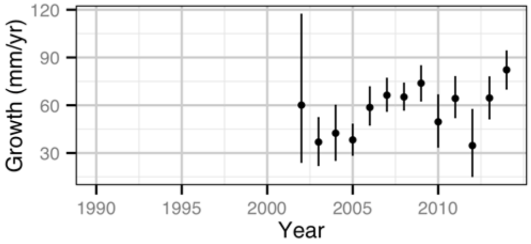

*Figure 9: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Mountain Whitefish based on recaptured individuals in the LCR, 2001 to 2014.*

## 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) and relatively large size of fry in 2012 to 2014. Rainbow Trout fry were significantly smaller in 2001 when compared to all other study years. This result is consistent with small size of Mountain Whitefish fry 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 135 to 173 mm from 2001 to 2007 then steadily increased from 2008 to 2013 (right panel; Figure 10). Similar to Mountain Whitefish (Figure 8), there was a reduction in subadult Rainbow Trout growth in 2014. 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.

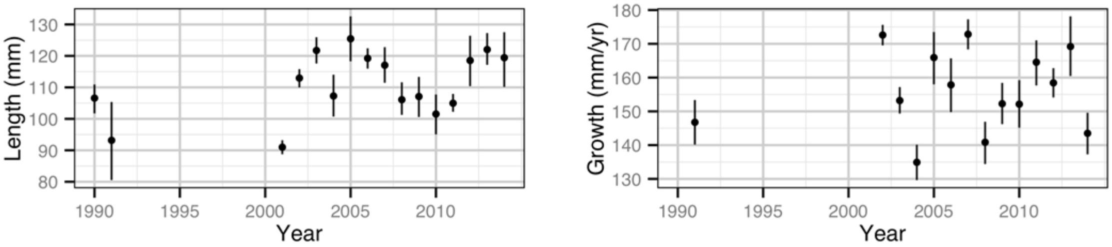

*Figure 10: Length-at-age of fry (left) and fry to subadult growth (right) for Rainbow Trout in the LCR, 1990 to 1991 and 2001 to 2014.Values are means with 95% CRIs.*

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 2014. Overall, annual growth for this species was variable and changed up to 25% during a one year period.

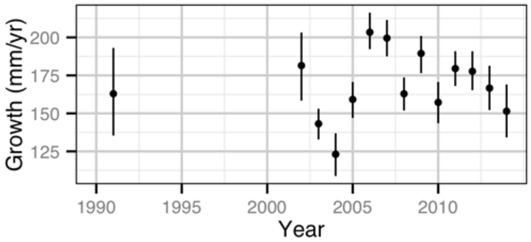

*Figure 11: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Rainbow Trout based on recaptured individuals in the LCR, 2001 to 2014.*

### 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 greatest in 2013 then decreased in 2014, although uncertainty in these years was large (Figure 12).

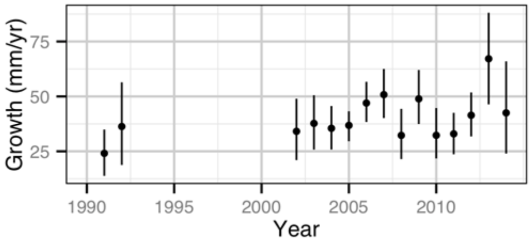

*Figure 12: Expected inter-annual growth (mean with 95% CRIs) for a 200 mm FL Walleye based on recaptured individuals in the LCR, 2001 to 2014.*

### 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 in 2013 and 2014 underestimated fork lengths for all three index species (Figure 13). The bias was similar between observers for Mountain Whitefish with underestimates of approximately 15-20% (Figure 14). Underestimates of Rainbow Trout lengths varied between 13 and 23%. Bias in estimated Walleye fork lengths was the lowest (~10%). Estimates of observer bias were used to correct estimated fork lengths before classifying fish into age-classes for abundance analyses.

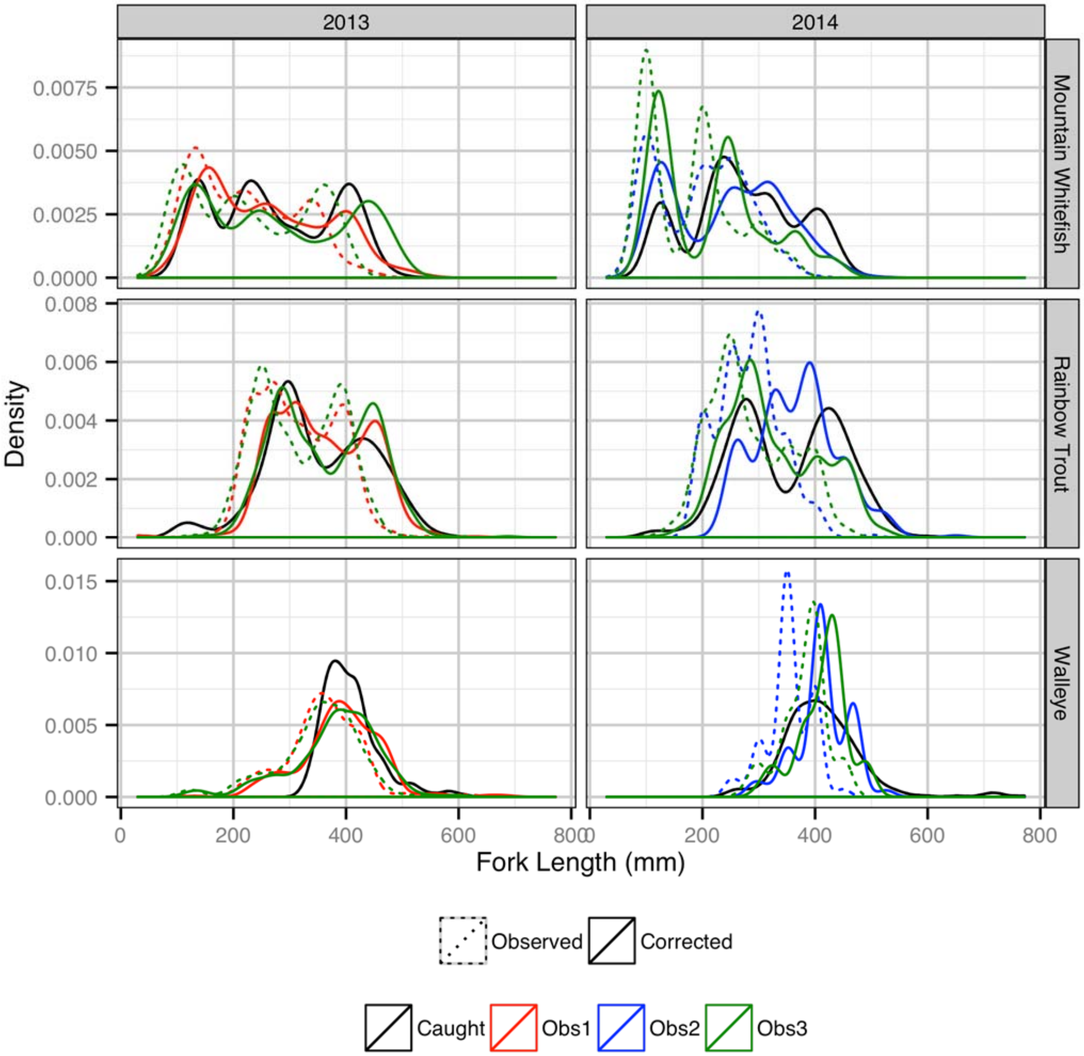

*Figure 13: Fork length-density plots for measured and estimated fork lengths of fish caught or observed in the LCR, 2013 and 2014.*

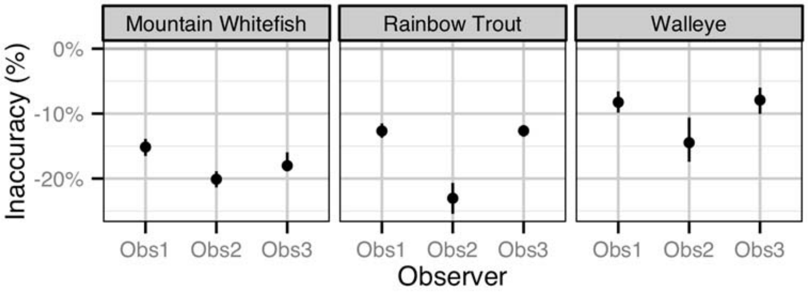

*Figure 14: Bias in observer estimated fork lengths of index species based on length bias model of captured (mark-recapture surveys) and estimated (geo-referenced visual surveys) length-frequency distributions from the LCR, 2014.*

## 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 increasing 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* = 0.5). Site fidelity was approximately 50% for Mountain Whitefish and did not vary significantly by length (*P* = 0.7).

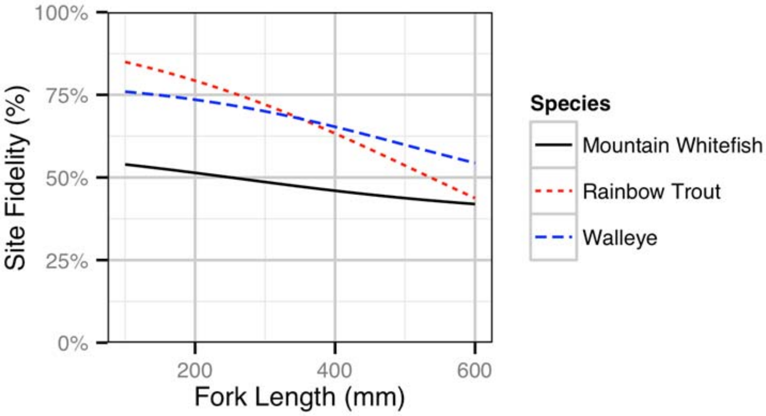

*Figure 15: Site fidelity, defined as the expected probability that a fish is recaptured at the same site where it was marked, by species and fork length in the LCR, 2001 to 2014.*

### 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 3.4.3-3.4.5).

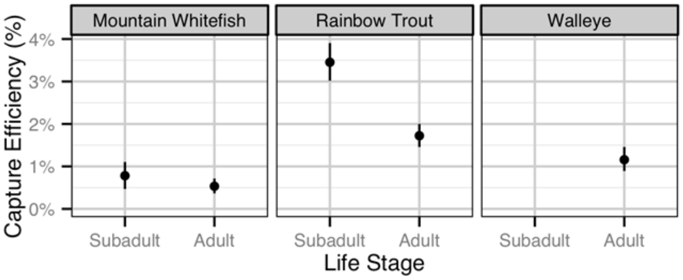

*Figure 16: Capture efficiency (mean with 95% CRIs) by species from mark-recapture data from the LCR, 2001-2014.*

### 3.4.3 Mountain Whitefish

The estimated abundance of subadult Mountain Whitefish in index sites in the LCR decreased from ~125 000 in 2001 to <20 000 in 2005. Subadult abundance increased in 2006-2007 and 2010-2014 but remained much lower than the abundance estimated for the early 2000s. Estimates suggested a steady decline in abundance of adult Mountain Whitefish between 2001 (>200 000) and 2012 (~100,000).

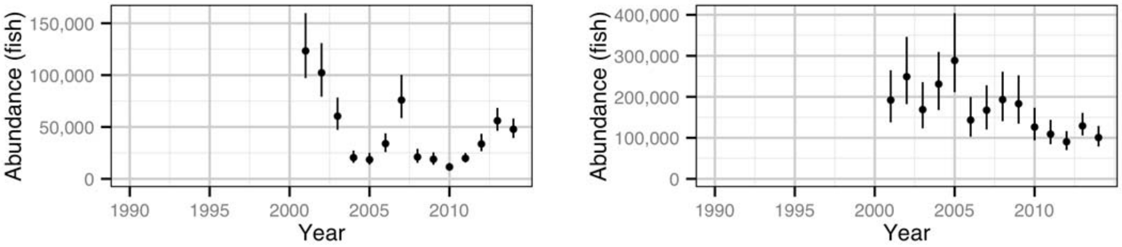

*Figure 17: Abundance (means with 95% CRIs) of subadult (left) and adult (right) Mountain Whitefish at index sample sites in the LCR, 2001-2014.*

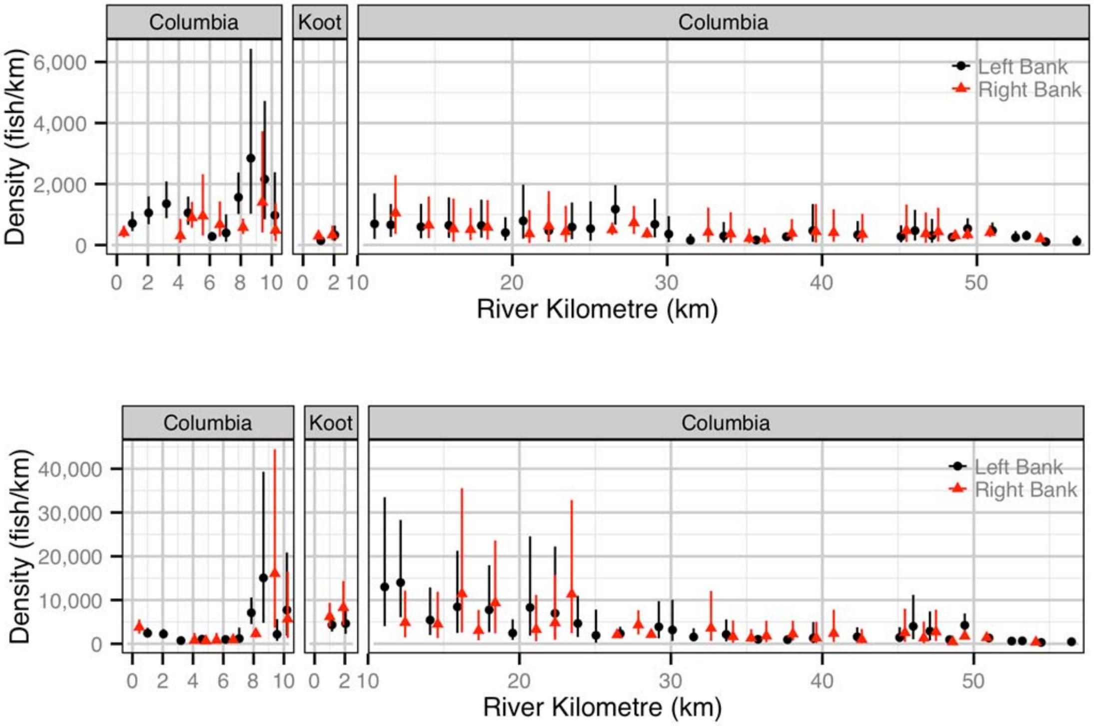

*Figure 18: Density (means with 95% CRIs) of subadult (top) and adult (bottom) Mountain Whitefish by river kilometre in the LCR, 2001-2014.*

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 18). 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 Zellstoff-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 18). 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 18) 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). Shannon’s index of evenness did not suggest any inter-annual differences in distribution of abundance among sites for subadult or adult Mountain Whitefish (Figure G6, Appendix G).

### 3.4.4 Rainbow Trout

The estimated abundance of both subadult and adult Rainbow Trout increased between 1990 and 1992 (Figure 19). The abundance of subadult Rainbow Trout declined from 2001 to 2005 and fluctuated with no long-term increase or decrease from 2006 to 2014. Adult Rainbow Trout abundance increased from ~26 000 in 2001 to ~35 000 in 2014, with a peak of ~42 000 in 2011.

Rainbow Trout site-level density estimates had large credible intervals (Figure 20), particularly at sites that were only sampled between 2012 and 2014. 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 20). 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 20). 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. Shannon's index of evenness did not suggest any inter-annual differences in distribution of abundance among sites for subadult or adult Rainbow Trout (Figure G7, Appendix G).

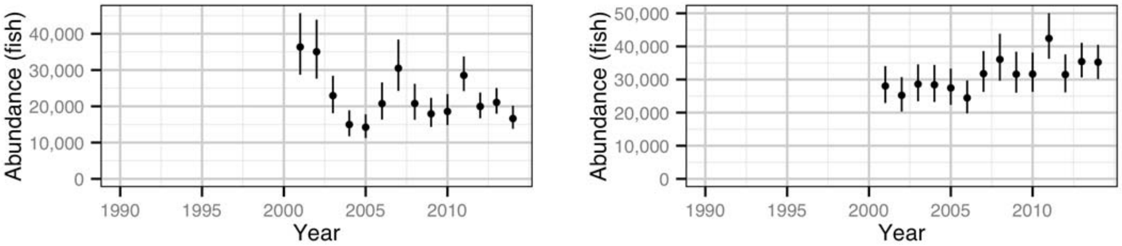

*Figure 19: Abundance (means with 95% CRIs) of subadult (left) and adult (right) Rainbow Trout at index sample sites in the LCR, 2001-2014.*

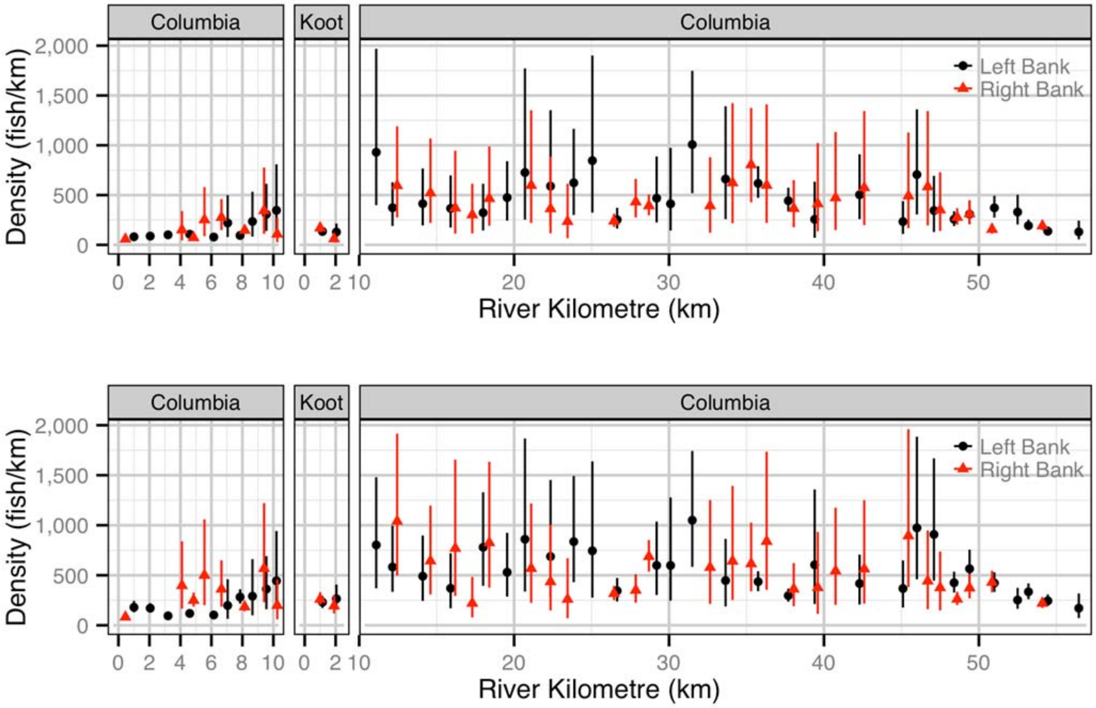

*Figure 20: Density (means with 95% CRIs) of subadult (top) and adult (bottom) Rainbow Trout by river kilometre in the LCR, 2001-2014.*

### 3.4.5 Walleye

Since 2001, Walleye abundance has fluctuated with peaks in 2004 and 2011. Walleye abundance declined from 2011 to 2014 (Figure 21). 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 22). Density estimates for all other areas were similar and did not suggest differences in Walleye densities among sites. The density at synoptic sites sampled during the GRTS survey (not sampled prior to 2012) was comparable to the density at index sites. Shannon's index of evenness did not suggest any inter-annual differences in distribution of abundance among sites for Walleye (Figure G8, Appendix G).

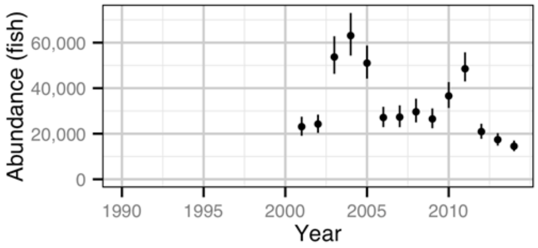

*Figure 21: Abundance (means with 95% CRIs) of adult Walleye at index sample sites in the LCR, 2001-2014.*

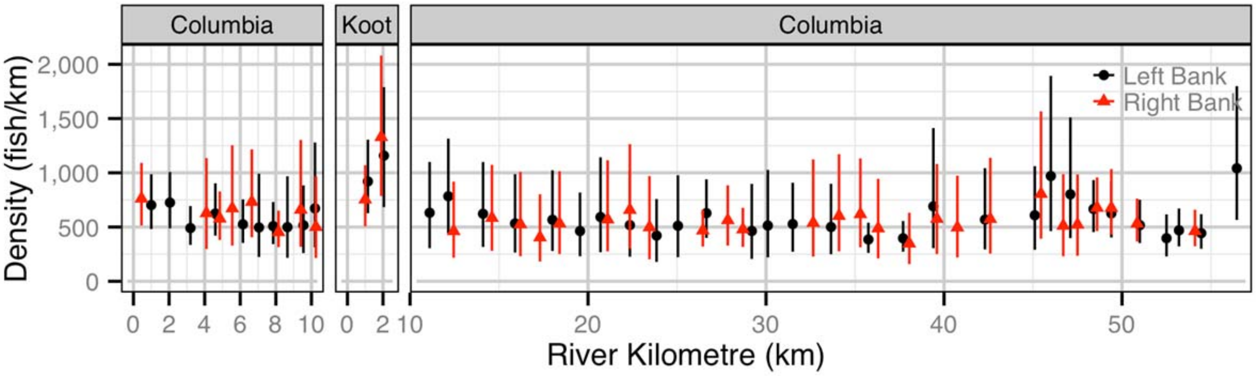

*Figure 22: Density (means with 95% CRIs) of adult Walleye by river kilometre in the LCR, 2001-2014.*

### 3.4.6 Geo-referenced Visual Enumeration Surveys

The results show positive relationships between counts of fish during the visual surveys and mean catches during mark-recapture surveys at the same sites (Figure 23). The count:catch ratio was generally greater in 2013 and lower in 2014 for adult Mountain Whitefish, adult Rainbow Trout, and Walleye but similar between years for subadult Mountain Whitefish and subadult Rainbow Trout. There appeared to be more variability, indicating a less consistent relationship between count and catch, at higher abundances for Walleye, especially in 2013.

Figure 23 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 fish 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 23 are not intended to provide predictive models but represent preliminary exploration of relationships between the two methods.

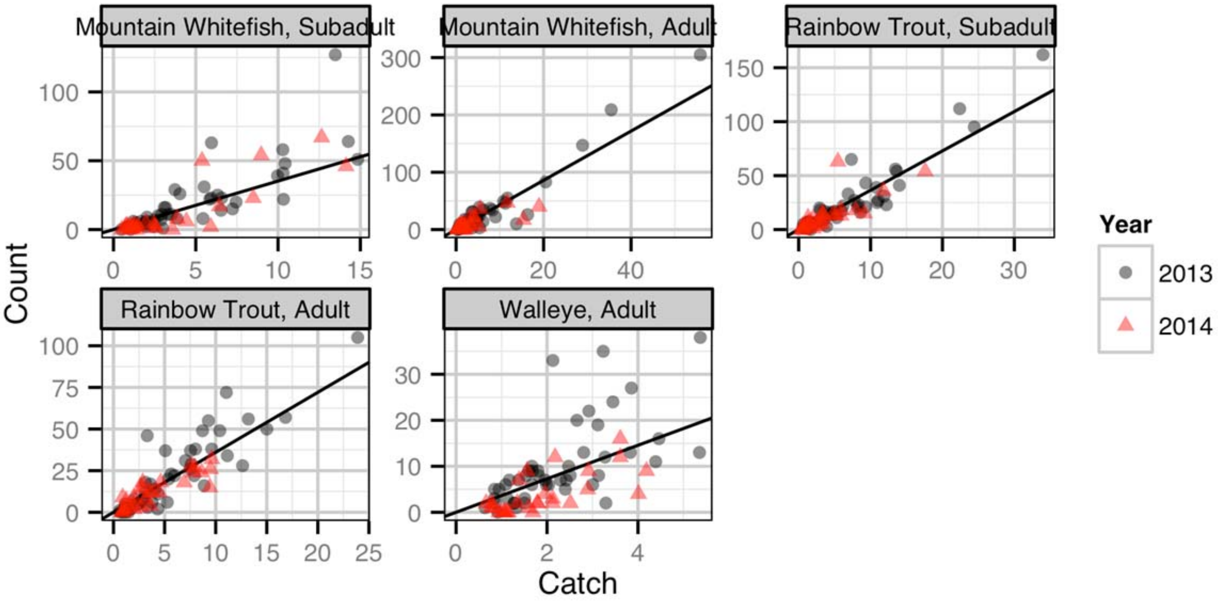

*Figure 23: Comparison of counts of observed fish during visual surveys to catch during mark-recapture surveys in the LCR Points are the mean number of captured fish during four mark-recapture sessions versus the counts during the geo-referenced visual surveys in 2013 and 2014. The solid line is the 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 fish 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

The survival estimate for subadult Mountain Whitefish from 2001 to 2014 was 25% (left panel; Figure 24). Survival of subadults was constant in the model because inter-annual variability in survival could not be reliably estimated due to large uncertainty. For adult Mountain Whitefish, annual survival estimates varied from 29% to 85%. Adult survival generally increased between 2001 and 2008, and decreased from 2011 to 2013, although there were substantial year-to-year variations and large uncertainty in the estimates (right panel; Figure 24). Survival was greater for adult Mountain Whitefish (29 to 85%) than for subadults (25%). Survival estimates for Mountain Whitefish were less precise than corresponding estimates for Rainbow Trout (see Section 3.5.2).

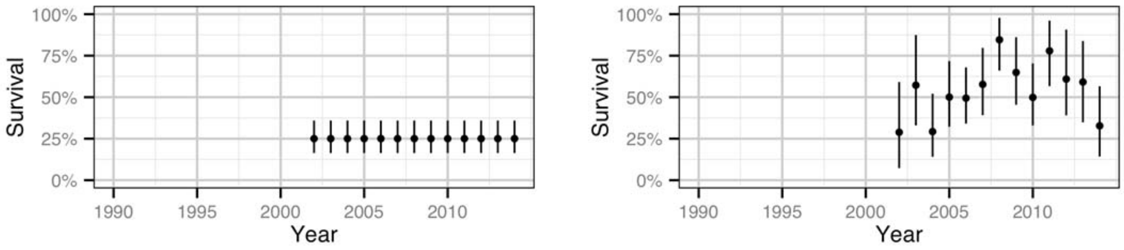

*Figure 24: Survival estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Mountain Whitefish in the LCR, 2001-2014.*

### 3.5.2 Rainbow Trout

The survival estimate for subadult Rainbow Trout from 2001 to 2014 was 51% (left panel; Figure 25). Survival of subadults was constant in the model because inter-annual variability in survival could not be reliably estimated. The survival of adult Rainbow Trout increased gradually from 25% in 2003 to 62% in 2011, but sharply declined to 30-36% in 2012 to 2014. On average, survival was slightly greater for subadult Rainbow Trout than adults (Figure 25).

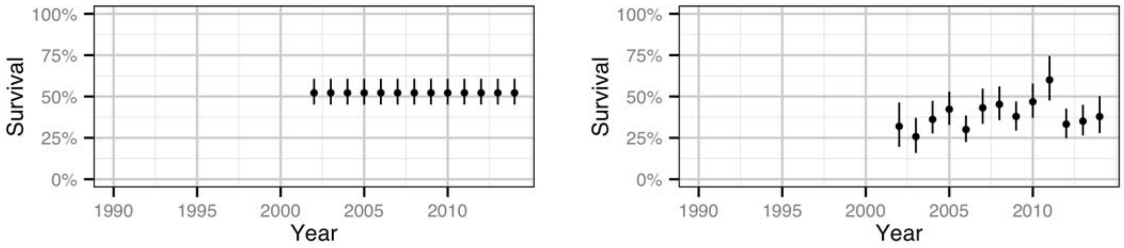

*Figure 25: Survival estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Rainbow Trout in the LCR, 2001-2014.*

### 3.5.3 Walleye

Survival estimates for Walleye were lower in 2012 to 2014 (34-64%) than most earlier years (Figure 26). However, credibility intervals overlapped for all years.

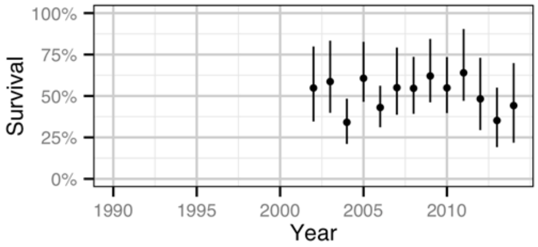

*Figure 26: Survival estimates (mean with 95% CRIs) for adult Walleye in the LCR, 2001-2014.*

## 3.6 Body Condition

### 3.6.1 Mountain Whitefish

The body condition of subadult Mountain Whitefish varied little (~2%) from 2008 to 2014 (left panel; Figure 27). Adult Mountain Whitefish body condition increased from 2003 to 2006, then decreased from 2006 to 2008, and was stable from 2009 to 2014 (right panel; Figure 27). Adult body condition was much lower in the 1990s than between 2001 and 2013, with effect sizes of 7-14% lower than a typical year.

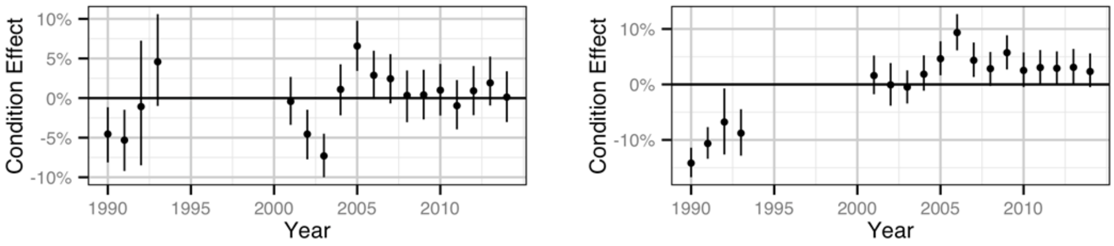

*Figure 27: Body condition effect size estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Mountain Whitefish in the LCR, 1990 to 1993 and 2001 to 2014.*

### 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 28). 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 inter-annual 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. Adult body condition was lower in 2014 for than all previous study years except for 1992.

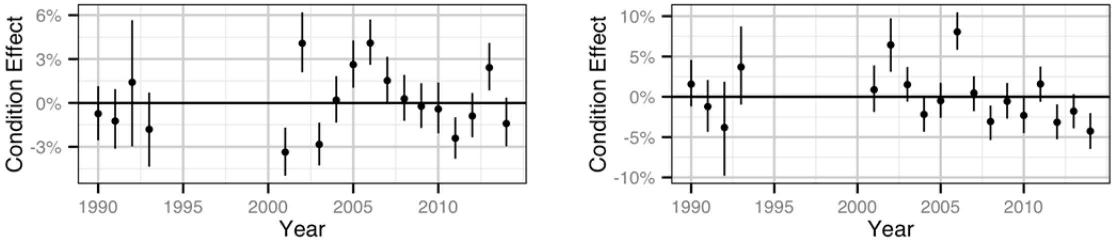

*Figure 28: Body condition effect size estimates (mean with 95% CRIs) for subadult (left panel) and adult (right panel) Rainbow Trout in the LCR, 1990 to 1993 and 2001 to 2014.*

### 3.6.3 Walleye

Walleye body condition fluctuated with no consistent trend since the early 1990s (Figure 29). Body condition estimates in 2012 to 2014 were greater than most previous years. Overall, the results suggest relatively little temporal change in the body condition of Walleye since 2001.

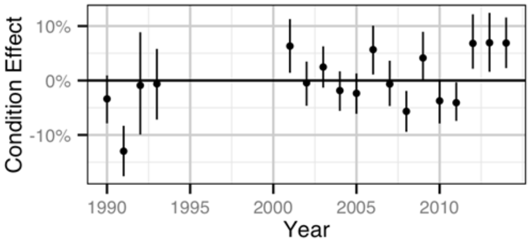

*Figure 29: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for Walleye in the LCR, 1990 to 1993 and 2001 to 2014.*

## 3.7 Environmental Analyses

### 3.7.1 Long-Term Trends

Multivariate analyses were used to assess relationships between the environmental and fish population variables (Table 6). Dynamic factor analysis reduced the 14 seasonal environmental time series and 20 fish indexing time series to three common trends. Figure 30 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. NMDS was used to graphically assess variables that had the most similar trends over time, as indicated by proximity on the NMDS plot. The results suggested that mean discharge in the Columbia River (January to March, April to June, and July to September) was correlated with the body condition of subadult and adult Mountain Whitefish and the length of age-0 Mountain Whitefish and Rainbow Trout (cluster on left side of Figure 31). The smoothed, long-term trends in these variables all increased between 2001 and 2014 (Figure 30), indicating a positive correlation. The survival and abundance of adult Walleye was correlated with the trend in mean discharge during the fall (October to December). Hourly discharge variability in the spring (April to June) was correlated with the abundance of subadult Mountain Whitefish and Rainbow Trout and the condition of adult Rainbow Trout (lower right of Figure 31). The estimated annual proportion of Mountain Whitefish egg loss (“RegimeMW”) was not closely related to any of the other time series, but was closest to the length of age-0 Mountain Whitefish. The estimated proportion of Rainbow Trout egg loss was most closely related to the length of age-1 Rainbow Trout, and the condition and growth of Rainbow Trout were also relatively close on the plot.

**Table 6: Definitions of abbreviated names used in analysis of environmental and fish variables.**

| Abbreviation | Definition | Abbreviation | Definition |
|---|---|---|---|
| AbnAdMW | Abundance of Adult Mountain Whitefish | DisMeOctDec | Mean Discharge, October to December |
| AbnAdRB | Abundance of Adult Rainbow Trout | GrwMW | Growth of Mountain Whitefish |
| AbnAdWP | Abundance of Adult Walleye | GrwRB | Growth of Rainbow Trout |
| AbnSubMW | Abundance of Subadult Mountain Whitefish | GrwWP | Growth of Walleye |
| AbnSubRB | Abundance of Subadult Rainbow Trout | LenAge0MW | Length of Age-0 Mountain Whitefish |
| ConAdMW | Condition of Adult Mountain Whitefish | LenAge0RB | Length of Age-0 Rainbow Trout |
| ConAdRB | Condition of Adult Rainbow Trout | LenAge1MW | Change in Length For Age-0 to Age-1 Mountain Whitefish |
| ConAdWP | Condition of Adult Walleye | LenAge1RB | Change in Length For Age-0 to Age-1 Rainbow Trout |
| ConSubMW | Condition of Subadult Mountain Whitefish | RegimeMW | Estimated Proportional Annual Egg Loss, Mountain Whitefish |
| ConSubRB | Condition of Subadult Rainbow Trout | RegimeRB | Estimated Proportional Annual Egg Loss, Rainbow Trout |
| DisDiAprJun | Mean of Hourly Discharge Difference, April to June | SurAdMW | Survival of Adult Mountain Whitefish |
| DisDiJanMar | Mean of Hourly Discharge Difference, January to March | SurAdRB | Survival of Adult Rainbow Trout |
| DisDiJulSep | Mean of Hourly Discharge Difference, July to September | SurAdWP | Survival of Adult Walleye |
| DisDiOctDec | Mean of Hourly Discharge Difference, October to December | TemMeAprJun | Mean Water Temperature, April to June |
| DisMeAprJun | Mean Discharge, April to June | TemMeJanMar | Mean Water Temperature, January to March |
| DisMeJanMar | Mean Discharge, January to March | TemMeJulSep | Mean Water Temperature, July to September |
| DisMeJulSep | Mean Discharge, July to September | TemMeOctDec | Mean Water Temperature, October to December |

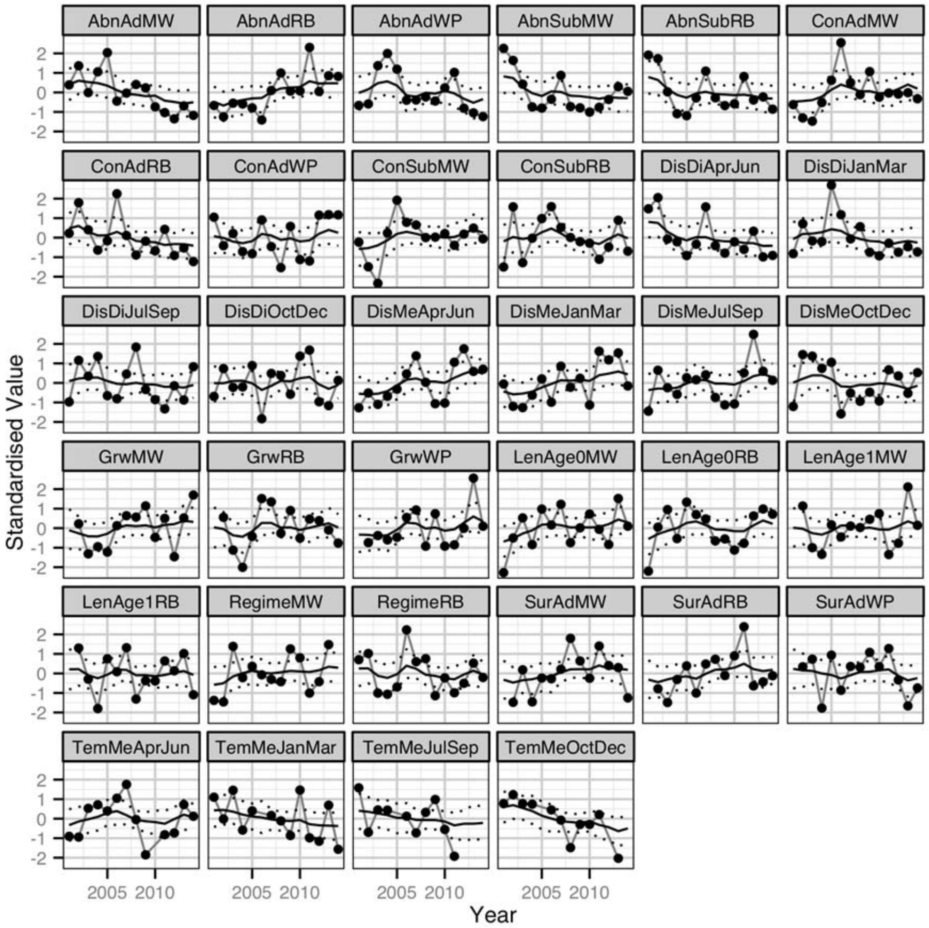

*Figure 30: Environmental and fish index time series in the LCR, 2001-2014. Black points are standardised values of the variables and the thicker black line represents predicted values (with 95% CRIs as dotted lines) from the dynamic factor analysis.*

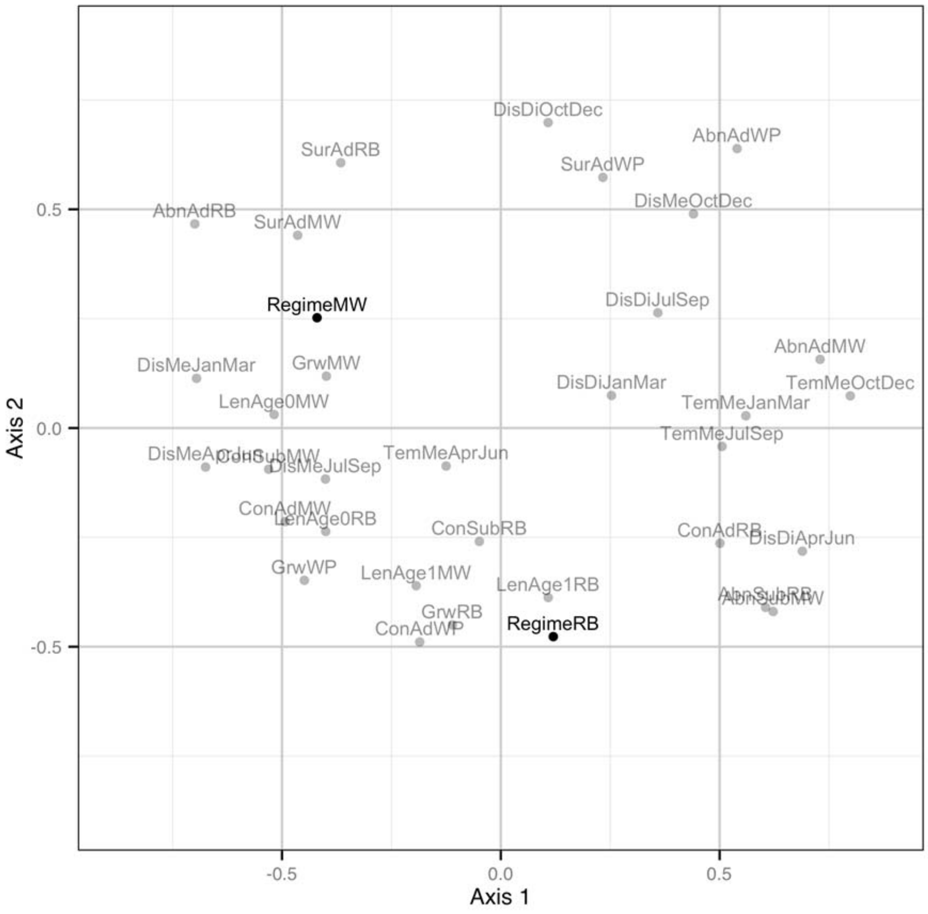

*Figure 31: Non-metric multidimensional plot showing clustering of standardized variables by trend weightings from the dynamic factor analysis used to assess common long-term trends in the environmental and fish variables.*

### 3.7.2 Short-Term Trends

Correlations between the residuals of the dynamic factor analysis model were calculated to assess short-term inter-annual associations among variables, after removing the effect of long-term trends (Figure 30). The analysis did not suggest a large number of short-term associations, as indicated by relatively spread-out points on the NMDS plot (Figure 32). Although there were no large groupings of variables, there were some environmental variables with residual variability that was similar to that of fish metrics. For instance, the estimated Rainbow Trout egg loss, which is a function of discharge variability and reduction during the spawning season, was close on the plot to the body condition and growth of Rainbow Trout. The estimated Mountain Whitefish egg loss was closely related to variability in length of age-0 and age-1 Mountain Whitefish, as well as mean discharge from January through June. Overall, the analysis did not suggest any strong short-term associations in the data but did indicate a few correlations that are biologically plausible.

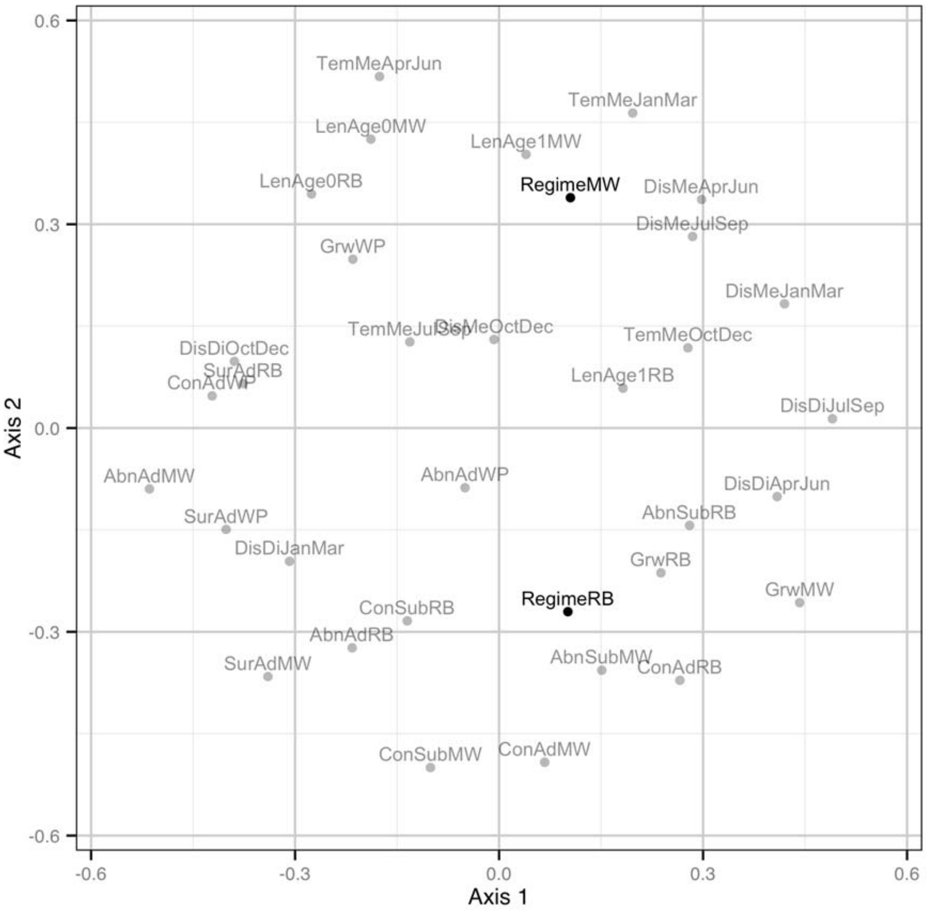

*Figure 32: Non-metric multidimensional scaling plot showing clustering of variables by absolute correlations of short-term variation in environmental and fish variables.*

## 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 7), except during the 2014 sample period where a total of 25 Northern Pike were captured of observed in the study sites. In 2014 a Northern Pike gill netting suppression program was conducted by Mountain Water Research for the Ministry of Forests Land and Natural Resources Operations (MFLNRO) and Teck Metals Ltd. A total of 133 Northern Pike were removed during the gill netting program and an additional 21 were captured by anglers. During the LCR fish indexing program in 2014, all of the Northern Pike were captured in the Columbia River upstream of the Kootenay River confluence, except for three individuals that were captured or observed in the Kootenay River. As requested by the MFLNRO (J. Burrows, pers. comm.), all captured Northern Pike were euthanized.

**Table 7: Number of Northern 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 |
| 2014 | 16 | 9 | 25 |

In 2014, 23 Burbot were recorded in the LCR, which was within the range recorded between 2001 and 2013 (minimum = 3; maximum = 285). Although Burbot have been recorded in all portions of the study area, in 2014, 83% of all Burbot were recorded downstream of RKm 40, and 91% were downstream of RKm 30.

Fourteen White Sturgeon (11 adults and 3 juveniles) were recorded (all observed; none captured) during the 2014 survey. Observational information for these fish is provided in Attachment A.

The first Largemouth Bass was recorded during the 2014 sampling period and captured in the Kootenay River. None were recorded between 2001 and 2013. This fish was an adult with a fork length of 298 mm and weighed 382 g. Smallmouth Bass have been captured and observed in the Columbia and Kootenay River sites since 2003. All but one of the 102 Smallmouth Bass were captured or observed in the downstream sites (below RKm 30).

# 4.0 DISCUSSION

The status of each of the specific management questions and hypotheses to be addressed by CLBMON-45 is summarised 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 2003 and 2007. This period of increasing length-at-age and growth corresponded with declining abundance of subadult 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. Lower than normal temperature or discharge may delay Mountain Whitefish egg hatching (Naesje et al. 1995), which would have reduced the amount of time that fry could have grown between emergence and the fall sample season. During the study years in which Mountain Whitefish fry size-at-age was the highest (i.e., 2005, 2007, 2010, and 2013), discharge was near average. In 2011 and 2012 when flows during the summer were higher than average (Appendix D, Figure D1), growth of age-0 and age-1 Mountain Whitefish was lower 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.

A potential link between river discharge and growth of Mountain Whitefish was supported by the multivariate analyses, which suggested a positive correlation among the long-term trends in mean discharge (January through June), the body length of fry, and the body condition of subadults and adults. The estimated proportion of Mountain Whitefish egg loss due to dewatering was weakly correlated with the length of fry, although the distance on the NDMS plot did not suggest a strong relationship. If the similar trends in egg dewatering and fry length were not simply due to chance, it could be that the discharge reductions during the egg incubation, emergence, or early rearing period could have a negative effect on subsequent growth and size-at-age.

Among watersheds in Idaho, USA, Meyer et al. (2009) found that Mountain Whitefish growth was positively correlated with mean annual water temperature. Water temperature was not correlated with long or short-term trends in Mountain Whitefish size or growth. 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 LCR compared to other species (Figure 7), with substantial inter-annual variability in growth that ranged from 123 to 203 mm between 2001 and 2014 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.

Multivariate analyses suggested than mean discharge (January to June) was correlated with the length of Rainbow Trout fry and the similar trends of these time series in Figure 30 suggested a positive association. The estimated proportion of Rainbow Trout egg loss was correlated with length-at-age (age-1), growth, and body condition of Rainbow Trout. Egg dewatering cannot plausibly have directs effects on adult body condition or length of age-1 Rainbow Trout. However, the results suggest that changes in the size and condition of adult Rainbow Trout were correlated with discharge reductions that dewater eggs in the spring and summer.

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 (March to July); as a result, emergence for this species is variable and can occur over a wide time frame (June to August; Irvine et al. 2015). Peak emergence occurs around mid-June (Irvine et al. 2015). 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 2002 to 2007, followed by a decline for a few years, and increased growth in 2013. Growth in 2013 (based on change in length from fall 2012 to fall 2013) was greater than all other years and followed a year with low abundance in 2012. This suggests a density-dependent relationship with greater growth of Walleye when abundance is low. However, there was not a consistent relationship between density and growth in other years of the study.

Overall, a lack of age data and limited numbers of inter-year recaptures hinder 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 into Lake Roosevelt in the late fall and early winter months (R.L.&L. 1995). The seasonal residency of a proportion of the Walleye population means that factors outside of the LCR likely also influence the growth of Walleye in the study area.

## 4.2 Abundance

### 4.2.1 Mountain Whitefish

The estimated abundance of subadult Mountain Whitefish decreased between 2001 and 2004. 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 abundance nor survival changed enough over that time period to support an approximately 83% 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.

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 estimated proportion of Mountain Whitefish egg loss, which reflects annual variability in discharge reductions, was not associated with the abundance of subadult (age-1) or adult (age-2 and older) Mountain Whitefish, based on this analysis. The proportion of egg loss would be expected to be related to the abundance of fry during the following year but reliable estimates of fry density were not possible using the current sampling method because boat electrofishing is not efficient for sampling very shallow (< 30 cm) habitats that are likely preferred by fry.

The environmental variable most closely associated with the abundance of adult Mountain Whitefish was mean water temperature during the fall. Mountain Whitefish spawn in the late fall and winter and the onset of spawning is linked to water temperature (Golder 2014). Therefore, the association between water temperature and abundance could be related to Mountain Whitefish moving into the study area for spawning purposes. A better understanding of Mountain Whitefish migrations in the study area would be necessary to discern whether the correlation with water temperature reflects changes in abundances or fish movements in the study area.

### 4.2.2 Rainbow Trout

The abundance of subadult Rainbow Trout decreased between 2001 and 2004 whereas the abundance of adults was relatively stable during this time period. The abundance of adults exhibited a gradual increase from ~26 000 in 2001 to ~35 000 in 2014, with a peak of ~42 000 in 2011. In comparison, estimates of spawner abundance based on visual observations and an area-under-the-curve model increased nearly ten-fold from ~1600 spawners in 1999 to ~13 000 in 2014 (Irvine et al. 2015). It is not clear why spawner estimates increased so dramatically but adult population estimates increased much less (~35%) and subadult abundance did not increase at all over the same time period. Possible reasons for this discrepancy include:

1) 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;
2) at very high fish densities, the electrofishing field crew becomes overwhelmed and are able to catch or count a smaller proportion of the number of fish, which could result in underestimated abundance if the estimates of recapture rates are not precise enough to account for the change;
3) some of the adults counted during the spawner surveys migrate into the study area to spawn but leave before the fall and are therefore not sampled by the indexing program; and,
4) with increasing total abundance Rainbow Trout could be more widely distributed in the river during the non-spawning season, with little change in density in the index sites, which would result in underestimates of total abundance based on only indexing sites.

Increasing adult abundance (spawner survey and indexing) during periods of declining or similar subadult abundance (indexing study) is also reflected in the annual length frequency plots, which show increasing proportion of larger fish during the study period (Appendix F, Figure F5).

In many years, capture efficiency of subadult Rainbow Trout decreased during each successive sample session (Appendix G, Figure G3). 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 small Rainbow Trout, among all index species and fish lengths. 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. The abundance of subadult Rainbow Trout was associated with discharge difference in the spring and the trends indicated a positive relationship. 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-2 and age-3 fish are the most dominant age-classes 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 two to three years.

Years with high abundance (e.g., 2004 - 2005, 2011) generally were associated with lower than normal body condition and survival, suggesting density-dependence and resource competition in years of high abundance in the LCR. Multivariate analyses suggested that the survival and abundance of Walleye was associated with the long-term trend in mean discharge during the fall. 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). The association with mean discharge in the fall could be related to actual abundance and survival of Walleye, or could reflect the effects of river discharge on Walleye migrating out of the study area in the late fall.

### 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). Gill-netting by the MFLNRO continued in 2014 and the lower numbers of Northern Pike caught and observed during the indexing program in 2014 than prior years suggest that gill-netting has reduced Northern Pike abundance in the study area. 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 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. However, high abundance of Redside Shiner did not persist in 2014, when levels were similar to previous years between 2001 and 2012. Reasons for the high abundance in 2013 are unclear but possible explanations include high recruitment of a recent year-class, an increase in habitat availability or suitability in the upper section of the LCR, or inaccurate counting by different observers among years. The high abundance of Redside Shiner observed in 2013 was similar to the high abundance of this 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 fish 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 two years of sampling suggest that counts of observed fish from visual surveys generally correspond well with mean catches from mark-recapture surveys (Figure 23). The higher count:catch ratio in 2013 than 2014 suggests some inter-annual variation, which could be attributed to differences in sampling conditions or observers that affected observation or capture efficiency.

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. 1967). 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 ~10-20%, 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 Zellstoff-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 water-milfoil) between 2001 and 2014 (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 yet 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 2014. Shannon's index of evenness, which represents the similarity of abundance among sites, did not differ among years during the study period.

### 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). Shannon's index of evenness did not indicate any changes in the relative abundance among sites, which suggests similar spatial distribution across index sites during the study period.

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 catch-rates of index species 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. In 2014, seven of the 503 Rainbow Trout captured in synoptic sites were initially caught and marked at index sites 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 since 2001, 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 colonized the study area and increased in abundance, 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 mark-recapture sampling at index sites. Higher densities in these areas than in index sites would result in underestimates of overall population density in the LCR and might explain the discrepancy with the spawner counts.

### 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 fish 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.

Shannon’s index of evenness did not indicate any changes in the relative abundance among sites, which suggests no temporal change in the spatial distribution across index sites during the study period.

## 4.4 Survival

### 4.4.1 Mountain Whitefish

Estimated survival was greater for adult Mountain Whitefish (29 - 85%) than for subadults (25%). Greater survival of 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 testing 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 ~120 000 fish in 2014 to be supported by a subadult population in 2013 of 56 000 fish with only 25% subadult survival (14 000 fish to be recruited to the adult population) and adult survival of 29% (34 800 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 from 2011 to 2014, possibly because Mountain Whitefish were moving into and out the study area in the fall study period for spawning migrations (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 to 2014 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

Estimated survival of subadult Rainbow Trout was 51% and was constant across years in the model because inter-annual variation could not be estimated due to large uncertainty. Adult survival was lower than subadult survival in most years, ranging from 25 to 62%. For adult Rainbow Trout, both survival and abundance increased gradually between 2001 and 2011, but decreased in 2012 and remained low in 2013 and 2014. The decrease in survival in 2012 was initially hypothesized to be related to the anomalously high water levels in the Columbia that year but survival only increased a small amount 2013 and 2014, which were years with near normal discharge. One interpretation is that high river levels in 2012 could have contributed to the decline in survival estimates in 2012 but other unknown factors were also contributing to decreased survival in 2012, 2013 and 2014. Reduced survival of adult Rainbow Trout in 2012 to 2014 is also reflected by a slight decrease in mark-recapture abundance estimates during these years, but does not agree with the number of spawners based on visual surveys, which increased during each successive year between 2011 and 2014 (Irvine et al. 2015).

### 4.4.3 Walleye

Walleye survival increased from 2006 to 2011 and was lower in 2012 to 2014. 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 could be confounded by fish movements. Multivariate analyses suggested that the survival and abundance of Walleye were associated with the long-term trend in mean discharge during the fall. The association with mean discharge in the fall could be related to actual abundance and survival of Walleye, or could reflect the effects of river discharge on Walleye migrating out of the study area in the late fall. 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 2014 with no consistent trend over this time period. The changes in body condition of adult Mountain Whitefish varied from -14% to 9% (compared to a typical year) between 1990 and 2014 (Figure 27). 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 range of 23% variation (-14 to 9%) 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.

Lower body condition (~-10% effect size) in the early 1990s compared to between 2001 and 2014 could be related to lower water quality and industrial pollution. A number of industries including a pulp and paper mill, a fertilizer plant, and a metal smelter contributed to much poorer water quality in the 1980s and early 1990s than since the mid-1990s (MacDonald Environmental Services Ltd. 1997). Fish health monitoring studies in the early 1990s found that Mountain Whitefish had higher rates of stress-related abnormalities compared to fish from reference sites, which was thought to be related to degraded water quality (Nener et al. 1995). Reductions in industrial pollution have resulted in improved water quality and fish health in the LCR since the mid-1990s (CRIEMP 2005), which likely explains the greater body condition in 2001 to 2014 than during the early 1990s.

Body condition of subadult and adult Mountain Whitefish was associated with mean discharge in winter, spring and summer, with the trends suggesting positive relationships. 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.

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 assess the relationship between food availability and Mountain Whitefish body condition.

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. Therefore, sample site was not included in the body condition models for Mountain Whitefish or the other species. 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. For instance, lower body condition in 2012 to 2014 coincided with lower survival during these years. 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).

After accounting for long-term trends in the time-series, there was a short-term correlation between the estimated annual proportion of Rainbow Trout egg loss and the body condition and growth of Rainbow Trout. Estimated egg loss is a function of variability and reductions in discharge during the spring. However, discharge difference during the spring, a measure of hourly variability, was not associated with Rainbow Trout growth or condition, based on these analyses. This suggests that discharge variability on the scale on days to weeks could affect body condition more than hourly variability.

### 4.5.3 Walleye

Body condition of Walleye in the study area fluctuated between 1990 and 2014 but trends were not strongly related to river discharge or water temperature based on the multivariate analyses. Body condition was greater in 2012 to 2014 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, survival, growth and condition of the three index species have fluctuated during the 2001 to 2014 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 to 2006). Data for Walleye also suggested density-dependence with a decrease in abundance and increase in body condition in the most recent three years (2012 to 2014).

Historical data from a similar fish sampling program in 1990-1993 were incorporated into the analyses to assess longer term trends in fish population metrics. These analyses suggested lower body condition of Mountain Whitefish in the early 1990s. The lower observed body condition in the early 1990s could have been related low water quality due to industrial pollution in the LCR, which has improved since the mid 1990s

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 long-term trend in mean discharge during three of four seasonal periods (January to June) was associated with the body condition Mountain Whitefish and the length of age-0 Mountain Whitefish and Rainbow Trout, suggesting a link between river discharge and the growth of juveniles of these index species. The estimated proportion of egg loss for Mountain Whitefish and Rainbow Trout was not strongly associated with fish population time series. However, this could be because egg loss is expected to be linked to abundance of age-0 fish, and the indexing study design is likely not effective for estimating fry abundance, because boat electrofishing in the LCR only captures a small number of fry.

Water temperature is known to be one of the most important factors influencing the ecology of fishes (Coutant 1976). Multivariate analyses in this study did not suggest any associations between water temperature in the LCR and fish population metrics. This suggests that 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 2014.

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, 2012b) was helpful in interpreting trends and potential biases in the present study. Further understanding of the migratory behaviour of the other index species, Rainbow Trout and Walleye, 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 increased slightly (~35%) between 2001 and 2014 whereas estimates of spawner abundance from CLBMON-46 suggested a much greater increase (ten-fold) 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 results from two years of sampling suggest that counts of observed fish from visual surveys generally correspond well with mean catches from mark-recapture surveys, with variation in the count:catch relationship varying by species (e.g. less consistent relationship for Walleye) and year (higher count:catch ratio in 2013 than 2014). 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 precise 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 2014, 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 2015 using the same methodologies employed in 2014. 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 precise 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.
- 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.

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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

Table A1 Locations and distances from Hugh L. Keenleyside Dam of boat electroshocking sites in the lower Columbia River, 2014.

| 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.

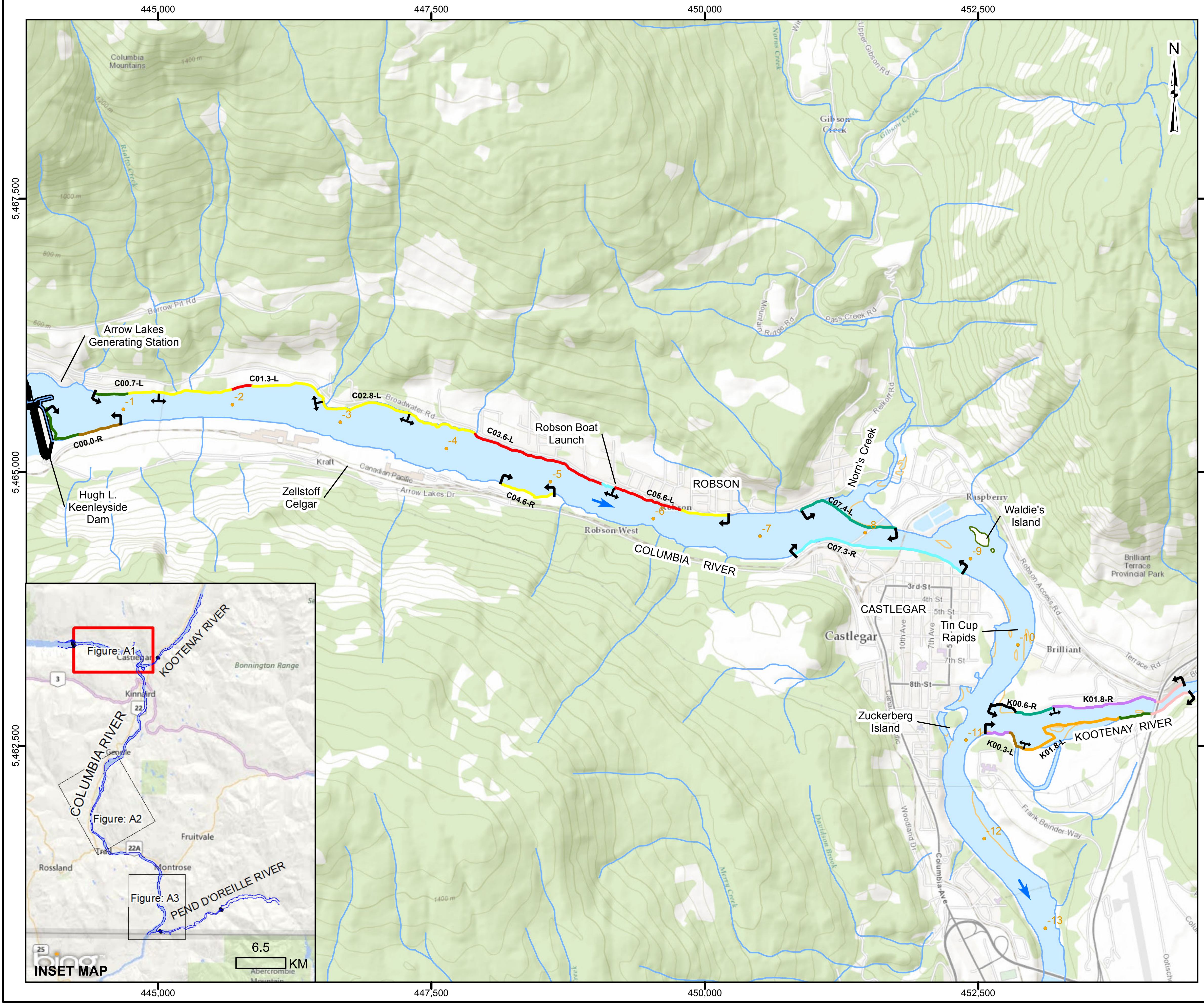
[c] LDB=Left bank as viewed facing downstream; RDB=Right bank as viewed facing downstream.

Table A2 Locations of selected sites and available sites included in the Generalized Random Tessellation Stratified (GRTS) survey, 2014.

| Site Designation | Location (km)[a] | Bank[b] | Upstream UTM Coordinates | | | Downstream UTM Coordinates | | | Sites Selected in 2014 |
|---|---|---|---|---|---|---|---|---|---|
| | | | 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 | |
| C05.1-R | 5.1 | RDB | 11U | 448612 | 5464808 | 11U | 449518 | 5464513 | |
| 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 | X |
| 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 | |
| C13.4-L | 13.4 | LDB | 11U | 453290 | 5460373 | 11U | 453321 | 5459007 | X |
| C13.4-R | 13.4 | RDB | 11U | 453103 | 5460426 | 11U | 453221 | 5458057 | X |
| C14.8-L | 14.8 | LDB | 11U | 453321 | 5459007 | 11U | 453210 | 5456890 | |
| C15.8-R | 15.8 | RDB | 11U | 453221 | 5458057 | 11U | 453234 | 5457317 | X |
| 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 | |
| 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 | X |
| C20.4-R | 20.4 | RDB | 11U | 452122 | 5454012 | 11U | 451093 | 5453191 | |
| C21.3-L | 21.3 | LDB | 11U | 451645 | 5453285 | 11U | 450603 | 5451637 | |
| C21.8-R | 21.8 | RDB | 11U | 451093 | 5453191 | 11U | 450495 | 5452148 | |
| C22.9-R | 22.9 | RDB | 11U | 450495 | 5452148 | 11U | 450188 | 5451058 | |
| C23.4-L | 23.4 | LDB | 11U | 450603 | 5451637 | 11U | 450368 | 5450764 | X |
| C24.0-R | 24.0 | RDB | 11U | 450188 | 5451058 | 11U | 449356 | 5450418 | |
| C24.3-L | 24.3 | LDB | 11U | 450368 | 5450764 | 11U | 449178 | 5449989 | X |
| 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 | |
| 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 | X |
| 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 | |
| C41.1-L | 41.1 | LDB | 11U | 450090 | 5438405 | 11U | 452466 | 5438365 | X |
| C41.5-R | 41.5 | RDB | 11U | 450459 | 5438222 | 11U | 452579 | 5438015 | |
| 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 | X |
| C47.2-R | 47.2 | RDB | 11U | 455141 | 5435856 | 11U | 455017 | 5434942 | |
| 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.



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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), AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

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SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE

# UPPER SECTION OF STUDY AREA
# 2014 SAMPLE SITE LOCATIONS

Golder Associates

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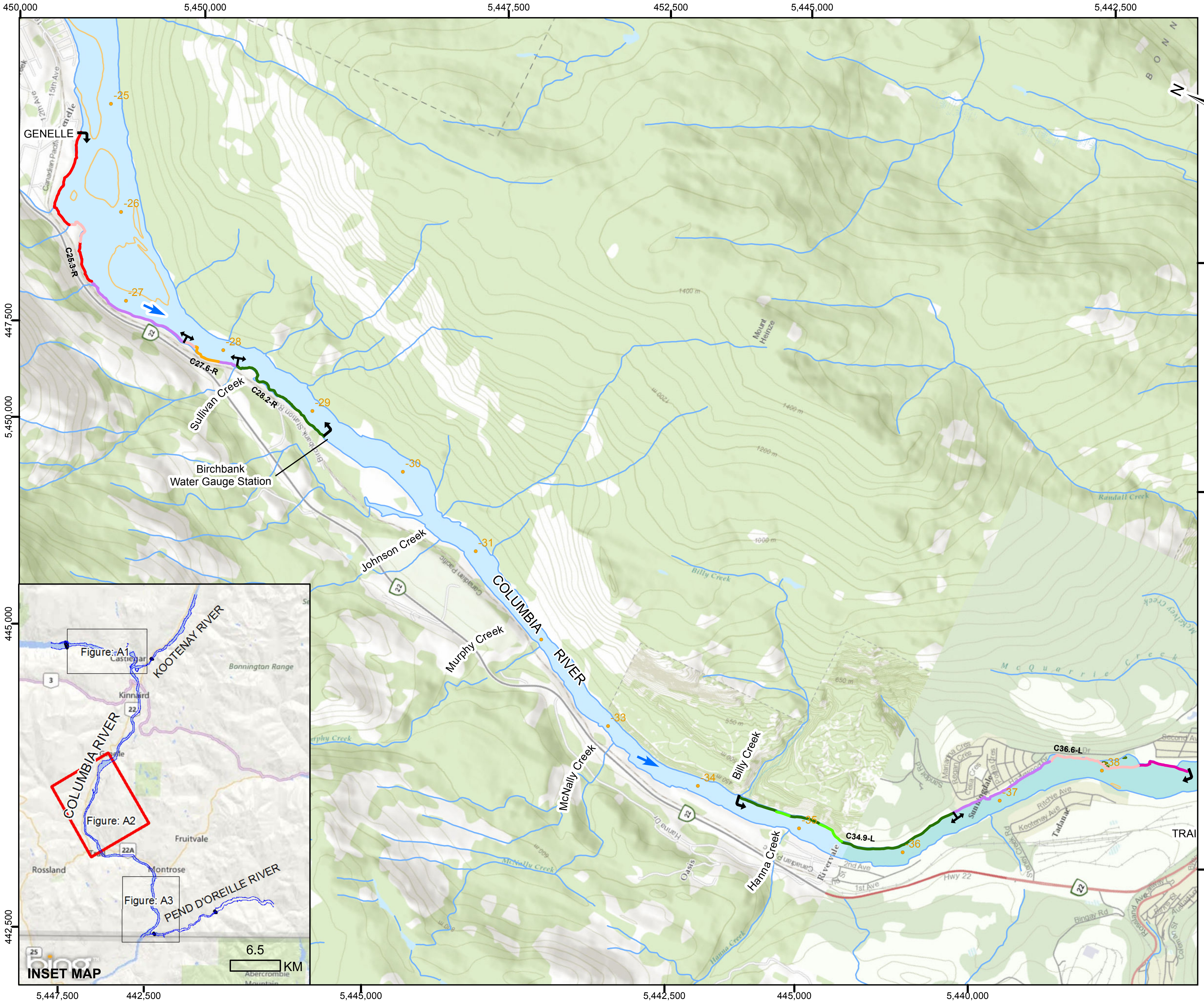

## LEGEND

● 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), AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

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KM
SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE

MIDDLE SECTION OF STUDY AREA
2014 SAMPLE SITE LOCATIONS

Golder Associates

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| REVIEW | LH | 26 Jun. 2015 | | |

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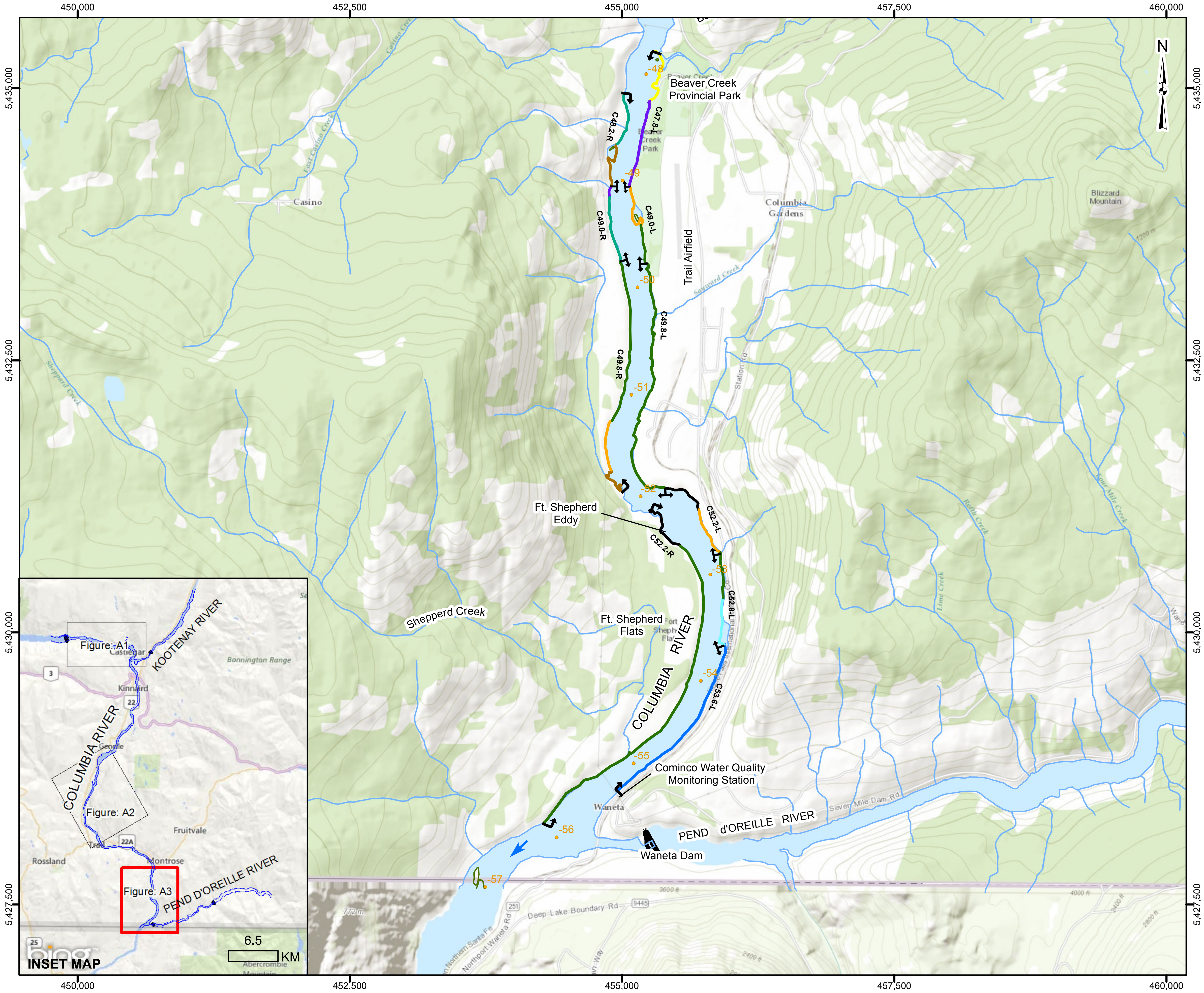

## LEGEND

- 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), AND THE GIS USER COMMUNITY
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PROJECTION: UTM ZONE 11 DATUM: NAD 83

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KM
SCALE 1:35,000

PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE
**LOWER SECTION OF STUDY AREA**
**2014 SAMPLE SITE LOCATIONS**

Golder Associates

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|---|---|---|---|---|
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| CHECK | DB | 15 Jun. 2015 | | |
| REVIEW | LH | 26 Jun. 2015 | | |

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# 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, 2014.

| **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 Middle Columbia River, 06 October to 07 November 2014.

| 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 | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| Kootenay | K01.8-R | 1 | 13 | 15.30 | 160 | Mostly cloudy | High | High | High | 20 | 0 | 0 | 0 | 0 | 80 | 0 |
| Kootenay | K01.8-R | 2 | 8 | 14.00 | 160 | Clear | High | High | High | 80 | 0 | 0 | 0 | 0 | 20 | 0 |
| Kootenay | K01.8-R | 3 | 12 | 13.10 | 150 | Partly cloudy | High | High | High | 80 | 0 | 0 | 0 | 0 | 20 | 0 |
| Kootenay | K01.8-R | 4 | 8 | 10.60 | 150 | Overcast | High | High | High | 85 | 0 | 0 | 0 | 0 | 15 | 0 |
| Kootenay | K01.8-L | 1 | 15 | 15.20 | 160 | Partly cloudy | High | High | High | 60 | 0 | 0 | 0 | 10 | 30 | 0 |
| Kootenay | K01.8-L | 2 | 13 | 14.00 | 160 | Mostly cloudy | High | High | High | 80 | 0 | 0 | 0 | 5 | 15 | 0 |
| Kootenay | K01.8-L | 3 | 9 | 13.20 | 150 | Mostly cloudy | High | High | High | 50 | 0 | 20 | 0 | 10 | 20 | 0 |
| Kootenay | K01.8-L | 4 | 7 | 10.30 | 150 | Overcast | High | High | High | 73 | 0 | 5 | 0 | 0 | 20 | 2 |
| Kootenay | K00.6-R | 1 | 9 | 15.30 | 160 | Mostly cloudy | High | High | High | 70 | 0 | 0 | 0 | 20 | 0 | 10 |
| Kootenay | K00.6-R | 2 | 5 | 14.00 | 160 | Clear | High | High | High | 75 | 0 | 0 | 0 | 0 | 10 | 15 |
| Kootenay | K00.6-R | 3 | 9 | 13.10 | 150 | Partly cloudy | High | High | High | 40 | 0 | 10 | 0 | 0 | 0 | 50 |
| Kootenay | K00.6-R | 4 | 8 | 10.40 | 150 | Overcast | High | High | High | 50 | 0 | 0 | 0 | 0 | 10 | 40 |
| Kootenay | K00.3-L | 1 | 14 | 15.20 | 160 | Mostly cloudy | High | High | High | 80 | 0 | 0 | 0 | 10 | 10 | 0 |
| Kootenay | K00.3-L | 2 | 9 | 14.00 | 160 | Partly cloudy | High | High | High | 95 | 0 | 5 | 0 | 0 | 0 | 0 |
| Kootenay | K00.3-L | 3 | 8 | 13.20 | 150 | Mostly cloudy | High | High | High | 85 | 0 | 0 | 0 | 0 | 15 | 0 |
| Kootenay | K00.3-L | 4 | 5 | 10.40 | 150 | Overcast | High | High | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Lower | C56.0-L | 4 | 7 | 11.30 | 160 | Overcast | High | High | Medium | 25 | 0 | 15 | 0 | 0 | 60 | 0 |
| Lower | C53.6-L | 1 | 10 | 14.50 | 120 | Clear | High | High | High | 85 | 0 | 0 | 0 | 0 | 15 | 0 |
| Lower | C53.6-L | 2 | 8 | 13.40 | 130 | Overcast | High | High | High | 90 | 0 | 5 | 0 | 0 | 5 | 0 |
| Lower | C53.6-L | 3 | 9 | 12.00 | 130 | Partly cloudy | High | High | High | 60 | 0 | 0 | 0 | 0 | 40 | 0 |
| Lower | C53.6-L | 4 | 7 | 10.40 | 130 | Overcast | High | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Lower | C52.8-L | 1 | 10 | 14.50 | 120 | Clear | High | High | High | 80 | 0 | 5 | 0 | 15 | 0 | 0 |
| Lower | C52.8-L | 2 | 9 | 13.40 | 130 | Overcast | High | High | High | 50 | 0 | 20 | 0 | 30 | 0 | 0 |
| Lower | C52.8-L | 3 | 9 | 12.00 | 130 | Partly cloudy | High | High | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Lower | C52.8-L | 4 | 8 | 10.40 | 130 | Overcast | High | High | High | 80 | 0 | 10 | 0 | 0 | 10 | 0 |
| Lower | C52.2-R | 1 | 7 | 13.50 | 130 | Clear | High | High | High | 65 | 0 | 20 | 0 | 10 | 5 | 0 |
| Lower | C52.2-R | 2 | 8 | 13.30 | 130 | Overcast | Medium | High | High | 70 | 0 | 25 | 0 | 0 | 5 | 0 |
| Lower | C52.2-R | 3 | 9 | 11.30 | 130 | Overcast | High | High | High | 75 | 0 | 20 | 0 | 0 | 5 | 0 |
| Lower | C52.2-R | 4 | 8 | 10.70 | 130 | Overcast | High | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Lower | C52.2-L | 1 | 11 | 14.50 | 120 | Clear | High | High | High | 75 | 0 | 5 | 0 | 0 | 20 | 0 |
| Lower | C52.2-L | 2 | 9 | 13.30 | 130 | Overcast | High | High | High | 50 | 0 | 0 | 0 | 0 | 50 | 0 |
| Lower | C52.2-L | 3 | 8 | 12.00 | 130 | Partly cloudy | High | High | High | 40 | 0 | 0 | 0 | 0 | 60 | 0 |
| Lower | C52.2-L | 4 | 8 | 10.40 | 130 | Overcast | High | High | High | 65 | 0 | 0 | 0 | 0 | 30 | 5 |
| Lower | C49.8-R | 1 | 8 | 13.50 | 130 | Clear | High | High | High | 73 | 0 | 10 | 0 | 5 | 10 | 2 |
| Lower | C49.8-R | 2 | 9 | 13.30 | 130 | Clear | High | High | High | 90 | 0 | 5 | 0 | 0 | 0 | 5 |
| Lower | C49.8-R | 3 | 9 | 11.30 | 130 | Overcast | High | High | High | 60 | 0 | 0 | 0 | 15 | 15 | 10 |
| Lower | C49.8-R | 4 | 8 | 10.70 | 130 | Overcast | High | High | High | 83 | 0 | 10 | 0 | 5 | 0 | 2 |
| Lower | C49.8-L | 1 | 13 | 14.50 | 120 | Clear | High | High | High | 75 | 0 | 0 | 0 | 20 | 5 | 0 |
| Lower | C49.8-L | 2 | 9 | 13.30 | 130 | Overcast | High | High | High | 75 | 0 | 10 | 0 | 10 | 5 | 0 |
| Lower | C49.8-L | 3 | 9 | 12.00 | 130 | Mostly cloudy | High | High | High | 70 | 0 | 10 | 0 | 10 | 5 | 5 |

[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.

Continued...

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 | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| Lower | C49.8-L | 4 | 9 | 10.40 | 130 | Overcast | High | High | High | 70 | 0 | 0 | 0 | 29 | 0 | 1 |
| Lower | C49.0-R | 1 | 10 | 13.50 | 130 | Clear | High | High | High | 90 | 0 | 0 | 0 | 5 | 5 | 0 |
| Lower | C49.0-R | 2 | 10 | 13.30 | 130 | Clear | High | High | High | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lower | C49.0-R | 3 | 9 | 11.50 | 130 | Overcast | High | High | High | 75 | 0 | 0 | 0 | 0 | 25 | 0 |
| Lower | C49.0-R | 4 | 9 | 10.70 | 130 | Overcast | High | High | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Lower | C49.0-L | 1 | 15 | 14.50 | 120 | Clear | High | High | High | 70 | 0 | 20 | 0 | 10 | 0 | 0 |
| Lower | C49.0-L | 2 | 13 | 13.40 | 130 | Overcast | High | High | High | 88 | 0 | 0 | 0 | 0 | 7 | 5 |
| Lower | C49.0-L | 3 | 9 | 12.00 | 130 | Partly cloudy | High | High | High | 95 | 0 | 0 | 0 | 5 | 0 | 0 |
| Lower | C49.0-L | 4 | 8 | 11.10 | 130 | Overcast | High | High | High | 75 | 0 | 5 | 0 | 5 | 0 | 15 |
| Lower | C48.2-R | 1 | 13 | 13.50 | 130 | Clear | High | High | High | 85 | 0 | 0 | 0 | 10 | 0 | 5 |
| Lower | C48.2-R | 2 | 13 | 13.20 | 130 | Clear | High | High | High | 70 | 0 | 0 | 0 | 0 | 20 | 10 |
| Lower | C48.2-R | 3 | 11 | 11.60 | 130 | Overcast | High | High | High | 74 | 0 | 5 | 0 | 0 | 20 | 1 |
| Lower | C48.2-R | 4 | 10 | 10.70 | 130 | Overcast | High | High | High | 60 | 0 | 0 | 0 | 0 | 30 | 10 |
| Lower | C47.8-L | 1 | 15 | 15.00 | 130 | Overcast | High | High | High | 77 | 0 | 0 | 0 | 20 | 0 | 3 |
| Lower | C47.8-L | 2 | 14 | 13.40 | 130 | Overcast | High | High | High | 90 | 0 | 0 | 0 | 0 | 0 | 10 |
| Lower | C47.8-L | 3 | 9 | 12.00 | 130 | Partly cloudy | High | High | High | 70 | 0 | 0 | 0 | 0 | 10 | 20 |
| Lower | C47.8-L | 4 | 10 | 11.10 | 130 | Overcast | High | High | High | 60 | 0 | 0 | 0 | 10 | 10 | 20 |
| Lower | C46.4-L | 5 | 7 | 10.50 | 150 | Clear | High | High | High | 80 | 0 | 0 | 0 | 0 | 20 | 0 |
| Lower | C45.6-L | 5 | 8 | 10.50 | 150 | Clear | High | High | High | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lower | C44.6-L | 5 | 7 | 10.50 | 150 | Clear | High | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Lower | C41.1-L | 5 | 9 | 10.50 | 140 | Mostly cloudy | High | High | High | 80 | 0 | 5 | 0 | 5 | 9 | 1 |
| Middle | C38.8-L | 5 | 9 | 10.50 | 150 | Mostly cloudy | High | High | High | 90 | 0 | 4 | 0 | 0 | 5 | 1 |
| Middle | C36.6-L | 1 | 9 | 14.50 | 120 | Partly cloudy | High | High | High | 40 | 0 | 10 | 0 | 0 | 50 | 0 |
| Middle | C36.6-L | 2 | 6 | 13.00 | 130 | Clear | High | High | High | 69 | 0 | 0 | 0 | 0 | 30 | 1 |
| Middle | C36.6-L | 3 | 5 | 11.70 | 130 | Clear | High | High | High | 50 | 0 | 10 | 0 | 0 | 35 | 5 |
| Middle | C36.6-L | 4 | 7 | 10.70 | 130 | Overcast | Medium | High | High | 65 | 0 | 5 | 0 | 0 | 25 | 5 |
| Middle | C34.9-R | 5 | 9 | 10.70 | 130 | Mostly cloudy | High | High | High | 80 | 0 | 0 | 0 | 0 | 20 | 0 |
| Middle | C34.9-L | 1 | 13 | 15.00 | 130 | Partly cloudy | High | High | High | 60 | 0 | 10 | 0 | 10 | 20 | 0 |
| Middle | C34.9-L | 2 | 9 | 13.00 | 130 | Clear | High | High | High | 75 | 0 | 0 | 0 | 0 | 25 | 0 |
| Middle | C34.9-L | 3 | 4 | 11.70 | 130 | Clear | High | High | High | 78 | 0 | 2 | 0 | 0 | 20 | 0 |
| Middle | C34.9-L | 4 | 7 | 10.70 | 130 | Overcast | Medium | High | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Middle | C30.6-L | 5 | 7 | 10.50 | 130 | Overcast | Medium | High | High | 50 | 0 | 0 | 0 | 0 | 50 | 0 |
| Middle | C28.2-R | 1 | 8 | 13.50 | 130 | Overcast | High | High | High | 0 | 0 | 0 | 0 | 50 | 50 | 0 |
| Middle | C28.2-R | 2 | 8 | 13.00 | 130 | Clear | High | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Middle | C28.2-R | 3 | 6 | 11.70 | 130 | Clear | High | High | High | 75 | 0 | 0 | 0 | 10 | 15 | 0 |
| Middle | C28.2-R | 4 | 7 | 10.70 | 130 | Overcast | Medium | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Middle | C27.6-R | 1 | 8 | 13.80 | 130 | Overcast | High | High | High | 50 | 0 | 20 | 0 | 0 | 30 | 0 |
| Middle | C27.6-R | 2 | 9 | 13.00 | 130 | Clear | High | High | High | 80 | 0 | 0 | 0 | 0 | 20 | 0 |
| Middle | C27.6-R | 3 | 8 | 11.70 | 130 | Clear | High | High | High | 95 | 0 | 5 | 0 | 0 | 0 | 0 |
| Middle | C27.6-R | 4 | 8 | 10.70 | 130 | Overcast | Medium | High | High | 90 | 0 | 10 | 0 | 0 | 0 | 0 |

Continued...

[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 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 | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| Middle | C26.2-L | 5 | 8 | 10.40 | 130 | Overcast | Medium | High | High | 90 | 0 | 5 | 0 | 0 | 5 | 0 |
| Middle | C25.3-R | 1 | 10 | 13.80 | 130 | Overcast | High | High | High | 75 | 0 | 0 | 0 | 0 | 23 | 2 |
| Middle | C25.3-R | 2 | 11 | 13.00 | 130 | Clear | High | High | High | 78 | 0 | 2 | 0 | 0 | 20 | 0 |
| Middle | C25.3-R | 3 | 9 | 11.70 | 130 | Clear | High | High | High | 82 | 0 | 2 | 0 | 0 | 16 | 0 |
| Middle | C25.3-R | 4 | 9 | 10.70 | 130 | Overcast | High | High | High | 70 | 0 | 5 | 0 | 0 | 25 | 0 |
| Middle | C25.3-L | 5 | 8 | 10.40 | 130 | Mostly cloudy | Medium | High | High | 60 | 0 | 0 | 0 | 35 | 0 | 5 |
| Middle | C24.3-L | 5 | 8 | 10.40 | 130 | Overcast | Medium | High | High | 75 | 0 | 5 | 0 | 0 | 20 | 0 |
| Middle | C23.4-L | 5 | 8 | 10.40 | 130 | Overcast | Medium | High | High | 90 | 0 | 0 | 0 | 0 | 10 | 0 |
| Middle | C20.1-L | 5 | 9 | 10.50 | 130 | Overcast | High | High | High | 95 | 0 | 0 | 0 | 0 | 3 | 2 |
| Upper | C19.0-L | 5 | 10 | 10.50 | 130 | Overcast | High | High | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Upper | C17.0-L | 5 | 7 | 10.30 | 110 | Mostly cloudy | High | High | High | 47 | 1 | 0 | 0 | 5 | 47 | 0 |
| Upper | C15.8-R | 5 | 7 | 10.30 | 110 | Mostly cloudy | High | High | High | 48 | 0 | 0 | 0 | 0 | 50 | 2 |
| Upper | C13.4-R | 5 | 9 | 10.40 | 120 | Mostly cloudy | High | High | High | 50 | 0 | 0 | 0 | 0 | 50 | 0 |
| Upper | C13.4-L | 5 | 9 | 10.40 | 110 | Overcast | High | High | High | 68 | 0 | 2 | 0 | 0 | 30 | 0 |
| Upper | C10.9-L | 5 | 9 | 10.50 | 140 | Overcast | High | High | High | 65 | 0 | 0 | 0 | 5 | 30 | 0 |
| Upper | C08.4-L | 5 | 10 | 10.10 | 120 | Overcast | High | High | High | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper | C07.4-L | 1 | 9 | 14.20 | 110 | Partly cloudy | High | Low | High | 60 | 0 | 0 | 0 | 20 | 10 | 10 |
| Upper | C07.4-L | 2 | 5 | 12.70 | 110 | Clear | High | Low | High | 78 | 0 | 0 | 0 | 5 | 2 | 15 |
| Upper | C07.4-L | 3 | 13 | 11.90 | 110 | Overcast | Medium | Low | High | 80 | 0 | 0 | 0 | 0 | 5 | 15 |
| Upper | C07.4-L | 4 | 10 | 10.40 | 120 | Partly cloudy | High | Low | High | 75 | 0 | 0 | 0 | 0 | 5 | 20 |
| Upper | C07.3-R | 1 | 8 | 14.20 | 120 | Mostly cloudy | High | Low | High | 55 | 0 | 5 | 0 | 5 | 35 | 0 |
| Upper | C07.3-R | 2 | 5 | 12.70 | 120 | Clear | High | High | High | 75 | 0 | 10 | 0 | 0 | 15 | 0 |
| Upper | C07.3-R | 3 | 9 | 12.30 | 110 | Overcast | Medium | Low | High | 60 | 0 | 0 | 0 | 0 | 40 | 0 |
| Upper | C07.3-R | 4 | 7 | 10.50 | 130 | Clear | High | Low | High | 60 | 0 | 0 | 0 | 0 | 40 | 0 |
| Upper | C05.6-L | 1 | 8 | 14.60 | 110 | Partly cloudy | High | Low | High | 30 | 13 | 0 | 0 | 25 | 30 | 2 |
| Upper | C05.6-L | 2 | 7 | 13.00 | 110 | Partly cloudy | High | Low | High | 40 | 5 | 0 | 0 | 0 | 15 | 40 |
| Upper | C05.6-L | 3 | 9 | 12.80 | 110 | Partly cloudy | High | Low | High | 20 | 2 | 0 | 0 | 0 | 10 | 68 |
| Upper | C05.6-L | 4 | 7 | 11.10 | 110 | Overcast | High | Low | High | 58 | 10 | 0 | 2 | 0 | 20 | 10 |
| Upper | C04.6-R | 1 | 8 | 14.60 | 110 | Partly cloudy | High | Low | High | 0 | 0 | 0 | 0 | 0 | 5 | 95 |
| Upper | C04.6-R | 2 | 9 | 13.00 | 110 | Overcast | High | Low | High | 0 | 2 | 88 | 0 | 0 | 10 | 0 |
| Upper | C04.6-R | 3 | 9 | 12.90 | 110 | Partly cloudy | High | Low | High | 0 | 0 | 0 | 0 | 0 | 5 | 95 |
| Upper | C04.6-R | 4 | 7 | 11.10 | 110 | Overcast | High | Low | High | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Upper | C03.6-L | 1 | 8 | 14.60 | 110 | Partly cloudy | High | Low | High | 10 | 0 | 0 | 0 | 10 | 10 | 70 |
| Upper | C03.6-L | 2 | 10 | 13.00 | 110 | Overcast | High | Low | High | 30 | 0 | 0 | 0 | 0 | 10 | 60 |
| Upper | C03.6-L | 3 | 9 | 12.80 | 110 | Partly cloudy | High | Low | High | 15 | 0 | 0 | 0 | 0 | 15 | 70 |
| Upper | C03.6-L | 4 | 7 | 11.10 | 110 | Overcast | High | Low | High | 20 | 0 | 0 | 0 | 0 | 20 | 60 |
| Upper | C02.8-L | 1 | 9 | 14.60 | 110 | Partly cloudy | High | Low | High | 0 | 0 | 0 | 0 | 30 | 10 | 60 |
| Upper | C02.8-L | 2 | 10 | 13.00 | 110 | Overcast | High | Low | High | 0 | 0 | 0 | 0 | 0 | 30 | 70 |
| Upper | C02.8-L | 3 | 9 | 12.80 | 110 | Partly cloudy | High | Low | High | 0 | 0 | 0 | 0 | 0 | 35 | 65 |
| Upper | C02.8-L | 4 | 7 | 11.10 | 110 | Overcast | High | Low | High | 0 | 0 | 0 | 0 | 0 | 60 | 40 |

Continued...

[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 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 | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| Upper | C01.3-L | 1 | 13 | 14.60 | 110 | Partly cloudy | High | Low | High | 10 | 0 | 0 | 0 | 20 | 0 | 70 |
| Upper | C01.3-L | 2 | 11 | 13.00 | 110 | Overcast | High | Low | High | 0 | 1 | 0 | 0 | 0 | 5 | 94 |
| Upper | C01.3-L | 3 | 13 | 12.80 | 110 | Overcast | High | Low | High | 30 | 0 | 0 | 0 | 0 | 10 | 60 |
| Upper | C01.3-L | 4 | 7 | 11.10 | 110 | Overcast | High | Low | High | 15 | 0 | 0 | 0 | 10 | 5 | 70 |
| Upper | C00.7-L | 1 | 15 | 14.60 | 110 | Partly cloudy | High | Low | High | 5 | 0 | 0 | 0 | 80 | 10 | 5 |
| Upper | C00.7-L | 2 | 12 | 13.00 | 130 | Overcast | High | Low | High | 70 | 0 | 0 | 0 | 0 | 30 | 0 |
| Upper | C00.7-L | 3 | 14 | 12.80 | 110 | Overcast | High | Low | High | 69 | 0 | 0 | 0 | 0 | 30 | 1 |
| Upper | C00.7-L | 4 | 8 | 11.10 | 110 | Overcast | High | Low | High | 60 | 0 | 0 | 0 | 0 | 30 | 10 |
| Upper | C00.0-R | 1 | 15 | 14.60 | 110 | Partly cloudy | Medium | Low | High | 70 | 0 | 0 | 0 | 25 | 5 | 0 |
| Upper | C00.0-R | 2 | 12 | 13.00 | 110 | Overcast | High | Low | High | 72 | 3 | 0 | 0 | 0 | 20 | 5 |
| Upper | C00.0-R | 3 | 13 | 12.80 | 110 | Overcast | High | Low | High | 69 | 1 | 0 | 0 | 0 | 15 | 15 |
| Upper | C00.0-R | 4 | 9 | 11.10 | 110 | Clear | High | Low | High | 63 | 2 | 0 | 0 | 25 | 10 | 0 |

[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 adjacent to bank habitat types in the Middle Columbia River, 06 October to 07 November 2014.

| Section | Site[a] | Species | Bank Habitat Type[a] | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A1 | A2 | A3 | A4 | A5 | A6 | A1+A2 | A2+A3 | D1 | D2 | D3 | D1+D2 | BW | Eddy | |
| Upstream Columbia River | C00.0-R | Mountain Whitefish | | 37 | | | | | | | | | | | 36 | | **73** |
| | C00.0-R | Northern Pikeminnow | | 3 | | | | | | | | | | | 4 | | **7** |
| | C00.0-R | Rainbow Trout | | 18 | | | | | | | | | | | 8 | | **26** |
| | C00.0-R | Redside Shiner | | 962 | | | | | | | | | | | 450 | | **1412** |
| | C00.0-R | Sculpin spp. | | 288 | | | | | | | | | | | 130 | | **418** |
| | C00.0-R | Sucker spp. | | 9 | | | | | | | | | | | 8 | | **17** |
| | C00.0-R | Walleye | | 11 | | | | | | | | | | | 3 | | **14** |
| | **Site C00.0-R Total** | | **0** | **1328** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **639** | **0** | **1967** |
| | C00.7-L | Bull Trout | | 1 | | | | | | | | | | | | | **1** |
| | C00.7-L | Kokanee | | 1 | | | | | | | | | | | | | **1** |
| | C00.7-L | Mountain Whitefish | | 66 | | | | | | | 96 | | | | | | **162** |
| | C00.7-L | Northern Pikeminnow | | | | | | | | | 2 | | | | | | **2** |
| | C00.7-L | Peamouth | | | | | | | | | 2 | | | | | | **2** |
| | C00.7-L | Rainbow Trout | | 9 | | | | | | | 12 | | | | | | **21** |
| | C00.7-L | Redside Shiner | | 45 | | | | | | | 8 | | | | | | **53** |
| | C00.7-L | Sculpin spp. | | 79 | | | | | | | 12 | | | | | | **91** |
| | C00.7-L | Sucker spp. | | 33 | | | | | | | 10 | | | | | | **43** |
| | C00.7-L | Walleye | | 5 | | | | | | | 7 | | | | | | **12** |
| | **Site C00.7-L Total** | | **0** | **239** | **0** | **0** | **0** | **0** | **0** | **0** | **149** | **0** | **0** | **0** | **0** | **0** | **388** |
| | C01.3-L | Kokanee | 1 | | | | | | | | 3 | | | | | | **4** |
| | C01.3-L | Mountain Whitefish | 164 | | | | | | | | 412 | | | | | | **576** |
| | C01.3-L | Northern Pike | 2 | | | | | | | | 4 | | | | | | **6** |
| | C01.3-L | Northern Pikeminnow | | | | | | | | | 2 | | | | | | **2** |
| | C01.3-L | Peamouth | 2 | | | | | | | | 1 | | | | | | **3** |
| | C01.3-L | Rainbow Trout | 14 | | | | | | | | 53 | | | | | | **67** |
| | C01.3-L | Redside Shiner | 26 | | | | | | | | 445 | | | | | | **471** |
| | C01.3-L | Sculpin spp. | 65 | | | | | | | | 425 | | | | | | **490** |
| | C01.3-L | Sucker spp. | 52 | | | | | | | | 226 | | | | | | **278** |
| | C01.3-L | Walleye | 3 | | | | | | | | 43 | | | | | | **46** |
| | C01.3-L | White Sturgeon | | | | | | | | | 1 | | | | | | **1** |
| | **Site C01.3-L Total** | | **329** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1615** | **0** | **0** | **0** | **0** | **0** | **1944** |
| | C02.8-L | Bull Trout | | | | | | | | | 1 | | | | | | **1** |
| | C02.8-L | Mountain Whitefish | | | | | | | | | 181 | | | | | | **181** |
| | C02.8-L | Northern Pike | | | | | | | | | 3 | | | | | | **3** |
| | C02.8-L | Northern Pikeminnow | | | | | | | | | 1 | | | | | | **1** |
| | C02.8-L | Rainbow Trout | | | | | | | | | 15 | | | | | | **15** |
| | C02.8-L | Redside Shiner | | | | | | | | | 295 | | | | | | **295** |
| | C02.8-L | Sculpin spp. | | | | | | | | | 660 | | | | | | **660** |
| | C02.8-L | Sucker spp. | | | | | | | | | 228 | | | | | | **228** |
| | C02.8-L | Tench | | | | | | | | | 1 | | | | | | **1** |
| | C02.8-L | Walleye | | | | | | | | | 22 | | | | | | **22** |
| | **Site C02.8-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1407** | **0** | **0** | **0** | **0** | **0** | **1407** |
| | C03.6-L | Burbot | | | | 1 | | | | | | | | | | | **1** |
| | C03.6-L | Kokanee | | | | | | | | | 1 | | | | | | **1** |
| | C03.6-L | Mountain Whitefish | 113 | | | 40 | | | | | 159 | | | | | | **312** |
| | C03.6-L | Northern Pike | 3 | | | | | | | | 2 | | | | | | **5** |
| | C03.6-L | Northern Pikeminnow | 2 | | | 1 | | | | | | | | | | | **3** |
| | C03.6-L | Rainbow Trout | 33 | | | | | | | | 40 | | | | | | **73** |
| | C03.6-L | Redside Shiner | 60 | | | 70 | | | | | 10 | | | | | | **140** |
| | C03.6-L | Sculpin spp. | 105 | | | 86 | | | | | 95 | | | | | | **286** |
| | C03.6-L | Sucker spp. | 149 | | | 18 | | | | | 160 | | | | | | **327** |
| | C03.6-L | Walleye | 20 | | | 4 | | | | | 16 | | | | | | **40** |
| | **Site C03.6-L Total** | | **485** | **0** | **0** | **220** | **0** | **0** | **0** | **0** | **483** | **0** | **0** | **0** | **0** | **0** | **1188** |
| | C04.6-R | Mountain Whitefish | | | | | | | | | 17 | | | | | | **17** |
| | C04.6-R | Northern Pike | | | | | | | | | 5 | | | | | | **5** |
| | C04.6-R | Northern Pikeminnow | | | | | | | | | 1 | | | | | | **1** |
| | C04.6-R | Rainbow Trout | | | | | | | | | 24 | | | | | | **24** |
| | C04.6-R | Sculpin spp. | | | | | | | | | 19 | | | | | | **19** |
| | C04.6-R | Sucker spp. | | | | | | | | | 84 | | | | | | **84** |
| | C04.6-R | Walleye | | | | | | | | | 14 | | | | | | **14** |
| | **Site C04.6-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **164** | **0** | **0** | **0** | **0** | **0** | **164** |
| | C05.6-L | Mountain Whitefish | 28 | | | | | | | | 14 | | | | | | **42** |
| | C05.6-L | Northern Pike | 2 | | | | | | | | 1 | | | | | | **3** |
| | C05.6-L | Northern Pikeminnow | | | | | | | | | 2 | | | | | | **2** |
| | C05.6-L | Peamouth | | | | | | | | | 1 | | | | | | **1** |
| | C05.6-L | Rainbow Trout | 23 | | | | | | | | 24 | | | | | | **47** |
| | C05.6-L | Redside Shiner | 210 | | | | | | | | 240 | | | | | | **450** |
| | C05.6-L | Sculpin spp. | 185 | | | | | | | | 65 | | | | | | **250** |
| | C05.6-L | Sucker spp. | 84 | | | | | | | | 43 | | | | | | **127** |
| | C05.6-L | Walleye | 11 | | | | | | | | 2 | | | | | | **13** |
| | **Site C05.6-L Total** | | **543** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **392** | **0** | **0** | **0** | **0** | **0** | **935** |
| | C07.3-R | Brook Trout | | | | 1 | | | | | | | | | | | **1** |
| | C07.3-R | Lake Whitefish | | | | 5 | | | | | | | | | | | **5** |
| | C07.3-R | Mountain Whitefish | | | | 292 | | | | | | | | | | | **292** |
| | C07.3-R | Northern Pikeminnow | | | | 1 | | | | | | | | | | | **1** |
| | C07.3-R | Rainbow Trout | | | | 127 | | | | | | | | | | | **127** |
| | C07.3-R | Redside Shiner | | | | 20 | | | | | | | | | | | **20** |
| | C07.3-R | Sculpin spp. | | | | 620 | | | | | | | | | | | **620** |
| | C07.3-R | Sucker spp. | | | | 52 | | | | | | | | | | | **52** |
| | C07.3-R | Walleye | | | | 15 | | | | | | | | | | | **15** |
| | **Site C07.3-R Total** | | **0** | **0** | **0** | **1133** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1133** |
| | C07.4-L | Burbot | | | | | | | | | | | | 1 | | | **1** |
| | C07.4-L | Kokanee | | | | | | | | | | | | | | | **0** |
| | C07.4-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C07.4-L | Mountain Whitefish | | | | | | | | | | | | 262 | | | **262** |
| | C07.4-L | Rainbow Trout | | | | | | | | | | | | 16 | | | **16** |
| | C07.4-L | Redside Shiner | | | | | | | | | | | | 25 | | | **25** |
| | C07.4-L | Sculpin spp. | | | | | | | | | | | | 40 | | | **40** |
| | C07.4-L | Sucker spp. | | | | | | | | | | | | 57 | | | **57** |
| | C07.4-L | Walleye | | | | | | | | | | | | 6 | | | **6** |
| | C07.4-L | White Sturgeon | | | | | | | | | | | | | | | **0** |
| | **Site C07.4-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **407** | **0** | **0** | **407** |
| | C08.4-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C08.4-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C08.4-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C08.4-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C08.4-L | White Sturgeon | | | | | | | | | | | | | | | **0** |
| | **Site C08.4-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Upstream Columbia River Total** | | | **1357** | **1567** | **0** | **1353** | **0** | **0** | **0** | **0** | **4210** | **0** | **0** | **407** | **639** | **0** | **9533** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.

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

Continued...

Table B4 Continued.

| Section | Site[a] | Species | Bank Habitat Type[a] | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A1 | A2 | A3 | A4 | A5 | A6 | A1+A2 | A2+A3 | D1 | D2 | D3 | D1+D2 | BW | Eddy | |
| Kootenay | K00.3-L | Brook Trout | | | | | | | | 1 | | | | | | | **1** |
| | K00.3-L | Mountain Whitefish | | | | | | | | 11 | | | | | 32 | | **43** |
| | K00.3-L | Rainbow Trout | | | | | | | | 8 | | | | | 8 | | **16** |
| | K00.3-L | Sucker spp. | | | | | | | | 12 | | | | | 17 | | **29** |
| | K00.3-L | Walleye | | | | | | | | 1 | | | | | 2 | | **3** |
| | **Site K00.3-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **33** | **0** | **0** | **0** | **0** | **59** | **0** | **92** |
| | K00.6-R | Largemouth Bass | | | | | | | | | | | | | | 1 | **1** |
| | K00.6-R | Mountain Whitefish | | | | | | | | | | | | 37 | | 4 | **41** |
| | K00.6-R | Northern Pike | | | | | | | | | | | | | | 2 | **2** |
| | K00.6-R | Northern Pikeminnow | | | | | | | | | | | | | | 2 | **2** |
| | K00.6-R | Peamouth | | | | | | | | | | | | | | 1 | **1** |
| | K00.6-R | Rainbow Trout | | | | | | | | | | | | 7 | | 11 | **18** |
| | K00.6-R | Redside Shiner | | | | | | | | | | | | | | 14 | **14** |
| | K00.6-R | Sculpin spp. | | | | | | | | | | | | | | 17 | **17** |
| | K00.6-R | Sucker spp. | | | | | | | | | | | | 20 | | 20 | **40** |
| | K00.6-R | Walleye | | | | | | | | | | | | 2 | | 15 | **17** |
| | K00.6-R | White Sturgeon | | | | | | | | | | | | | | | **0** |
| | **Site K00.6-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **66** | **0** | **87** | **153** |
| | K01.8-L | Mountain Whitefish | | 67 | | | 15 | | | | | 220 | | | | | **302** |
| | K01.8-L | Northern Pike | | 1 | | | | | | | | | | | | | **1** |
| | K01.8-L | Northern Pikeminnow | | 9 | | | 7 | | | | | 8 | | | | | **24** |
| | K01.8-L | Rainbow Trout | | 42 | | | 8 | | | | | 38 | | | | | **88** |
| | K01.8-L | Redside Shiner | | 10 | | | 260 | | | | | 5 | | | | | **275** |
| | K01.8-L | Sculpin spp. | | 15 | | | | | | | | 662 | | | | | **677** |
| | K01.8-L | Sucker spp. | | 36 | | | | | | | | 88 | | | | | **124** |
| | K01.8-L | Walleye | | 18 | | | 2 | | | | | 14 | | | | | **34** |
| | K01.8-L | White Sturgeon | | | | | | | | | 1 | 2 | | | | | **3** |
| | **Site K01.8-L Total** | | **0** | **198** | **0** | **0** | **292** | **0** | **0** | **0** | **1** | **1037** | **0** | **0** | **0** | **0** | **1528** |
| | K01.8-R | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | K01.8-R | Mountain Whitefish | | | | | 22 | | | 205 | | | | | | | **227** |
| | K01.8-R | Northern Pikeminnow | | | | | 1 | | | | | | | | | | **1** |
| | K01.8-R | Peamouth | | | | | | | | | | | | | | | **0** |
| | K01.8-R | Rainbow Trout | | | | | 35 | | | 32 | | | | | | | **67** |
| | K01.8-R | Redside Shiner | | | | | 60 | | | | | | | | | | **60** |
| | K01.8-R | Sculpin spp. | | | | | 5 | | | 50 | | | | | | | **55** |
| | K01.8-R | Sucker spp. | | | | | 6 | | | 18 | | | | | | | **24** |
| | K01.8-R | Walleye | | | | | 4 | | | 6 | | | | | | | **10** |
| | **Site K01.8-R Total** | | **0** | **0** | **0** | **0** | **133** | **0** | **0** | **311** | **0** | **0** | **0** | **0** | **0** | **0** | **444** |
| **Kootenay Total** | | | **0** | **198** | **0** | **0** | **425** | **0** | **0** | **344** | **1** | **1037** | **0** | **66** | **59** | **87** | **2217** |
| Downstream Columbia River | C10.9-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C10.9-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C10.9-L | Northern Pikeminnow | | | | | | | | | | | | | | | **0** |
| | C10.9-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C10.9-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C10.9-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C10.9-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C13.4-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C13.4-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C13.4-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C13.4-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C13.4-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C13.4-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C13.4-R | Bull Trout | | | | | | | | | | | | | | | **0** |
| | C13.4-R | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C13.4-R | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C13.4-R | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C13.4-R | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C13.4-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C15.8-R | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C15.8-R | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C15.8-R | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C15.8-R | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C15.8-R | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C15.8-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C17.0-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C17.0-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C17.0-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C17.0-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C17.0-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C17.0-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C17.0-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C19.0-L | Brook Trout | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Northern Pikeminnow | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Redside Shiner | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C19.0-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C19.0-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C20.1-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C20.1-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C20.1-L | Redside Shiner | | | | | | | | | | | | | | | **0** |
| | C20.1-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C20.1-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C20.1-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C20.1-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C23.4-L | Brook Trout | | | | | | | | | | | | | | | **0** |
| | C23.4-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C23.4-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C23.4-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | **Site C23.4-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C24.3-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C24.3-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C24.3-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C24.3-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C24.3-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C24.3-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C24.3-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.

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

Continued...

Table B4 Continued.

| Section | Site[a] | Species | Bank Habitat Type[a] | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A1 | A2 | A3 | A4 | A5 | A6 | A1+A2 | A2+A3 | D1 | D2 | D3 | D1+D2 | BW | Eddy | |
| | C25.3-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C25.3-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C25.3-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C25.3-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C25.3-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C25.3-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C25.3-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C25.3-R | Bull Trout | | | | | | | | | | | | | | | **0** |
| | C25.3-R | Lake Whitefish | 4 | | | | | | | | | | | | | | **4** |
| | C25.3-R | Mountain Whitefish | 28 | | | | 1 | | | 35 | | | | | | | **64** |
| | C25.3-R | Peamouth | 15 | | | | | | | | | | | | | | **15** |
| | C25.3-R | Rainbow Trout | 92 | | | | 1 | | | 34 | | | | | | | **127** |
| | C25.3-R | Redside Shiner | 190 | | | | | | | | | | | | | | **190** |
| | C25.3-R | Sculpin spp. | 277 | | | | 2 | | | | | | | | | | **279** |
| | C25.3-R | Sucker spp. | 31 | | | | 1 | | | | | | | | | | **32** |
| | C25.3-R | Walleye | 4 | | | | 6 | | | 3 | | | | | | | **13** |
| | C25.3-R | White Sturgeon | 1 | | | | | | | | | | | | | | **1** |
| | **Site C25.3-R Total** | | **642** | **0** | **0** | **0** | **11** | **0** | **0** | **72** | **0** | **0** | **0** | **0** | **0** | **0** | **725** |
| | C26.2-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C26.2-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C26.2-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C26.2-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C26.2-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | **Site C26.2-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C27.6-R | Lake Whitefish | | | | | | | | | | 3 | | | | | **3** |
| | C27.6-R | Mountain Whitefish | | | | | 1 | | | 1 | | 31 | | | | | **33** |
| | C27.6-R | Peamouth | | | | | 1 | | | | | | | | | | **1** |
| | C27.6-R | Rainbow Trout | | | | | 12 | | | 16 | | 17 | | | | | **45** |
| | C27.6-R | Sculpin spp. | | | | | 50 | | | | | | | | | | **50** |
| | C27.6-R | Sucker spp. | | | | | | | | | | 6 | | | | | **6** |
| | C27.6-R | Walleye | | | | | 6 | | | | | | | | | | **6** |
| | **Site C27.6-R Total** | | **0** | **0** | **0** | **0** | **70** | **0** | **0** | **17** | **0** | **57** | **0** | **0** | **0** | **0** | **144** |
| | C28.2-R | Mountain Whitefish | | 64 | | | | | | | | | | | | | **64** |
| | C28.2-R | Northern Pikeminnow | | 1 | | | | | | | | | | | | | **1** |
| | C28.2-R | Rainbow Trout | | 151 | | | | | | | | | | | | | **151** |
| | C28.2-R | Sculpin spp. | | 335 | | | | | | | | | | | | | **335** |
| | C28.2-R | Sucker spp. | | 17 | | | | | | | | | | | | | **17** |
| | C28.2-R | Walleye | | 6 | | | | | | | | | | | | | **6** |
| | **Site C28.2-R Total** | | **0** | **574** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **574** |
| | C30.6-L | Burbot | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Kokanee | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Redside Shiner | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C30.6-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C30.6-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C34.9-L | Burbot | | 1 | | | | | | | | | | | | | **1** |
| | C34.9-L | Mountain Whitefish | | 37 | 11 | | | | | | | | | | | | **48** |
| | C34.9-L | Rainbow Trout | | 296 | 89 | | | | | | | | | | | | **385** |
| | C34.9-L | Sculpin spp. | | 212 | 30 | | | | | | | | | | | | **242** |
| | C34.9-L | Sucker spp. | | 2 | | | | | | | | | | | | | **2** |
| | C34.9-L | Walleye | | 5 | 3 | | | | | | | | | | | | **8** |
| | **Site C34.9-L Total** | | **0** | **553** | **133** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **686** |
| | C34.9-R | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C34.9-R | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C34.9-R | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C34.9-R | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C34.9-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C36.6-L | Brook Trout | | | | | | | | 1 | | | | | | | **1** |
| | C36.6-L | Brown Trout | | | | | 1 | | | | | | | | | | **1** |
| | C36.6-L | Lake Whitefish | | | | | | | | | | | 5 | | | | **5** |
| | C36.6-L | Mountain Whitefish | | | | | 7 | | | 9 | | | 11 | | | | **27** |
| | C36.6-L | Northern Pikeminnow | | | | | | | | | | | 10 | | | | **10** |
| | C36.6-L | Rainbow Trout | | | | | 112 | | | 42 | | | 7 | | | | **161** |
| | C36.6-L | Sculpin spp. | | | | | 20 | | | | | | | | | | **20** |
| | C36.6-L | Sucker spp. | | | | | 10 | | | | | | 11 | | | | **21** |
| | C36.6-L | Walleye | | | | | 12 | | | 5 | | | | | | | **17** |
| | **Site C36.6-L Total** | | **0** | **0** | **0** | **0** | **162** | **0** | **0** | **57** | **0** | **0** | **44** | **0** | **0** | **0** | **263** |
| | C38.8-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C38.8-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C38.8-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C38.8-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C38.8-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C41.1-L | Burbot | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C41.1-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C41.1-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C44.6-L | Burbot | | | | | | | | | | | | | | | **0** |
| | C44.6-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C44.6-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C44.6-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C44.6-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C44.6-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C45.6-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C45.6-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C45.6-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C45.6-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C45.6-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C45.6-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| | C46.4-L | Mountain Whitefish | | | | | | | | | | | | | | | **0** |
| | C46.4-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C46.4-L | Sculpin spp. | | | | | | | | | | | | | | | **0** |
| | C46.4-L | Sucker spp. | | | | | | | | | | | | | | | **0** |
| | C46.4-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C46.4-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.

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

Continued...

Table B4 Concluded.

| Section | Site[a] | Species | Bank Habitat Type[a] | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A1 | A2 | A3 | A4 | A5 | A6 | A1+A2 | A2+A3 | D1 | D2 | D3 | D1+D2 | BW | Eddy | |
| | C47.8-L | Brook Trout | | | | | | | 1 | | 4 | | | | | | **5** |
| | C47.8-L | Brown Trout | | | | | | | | | 1 | | | | | | **1** |
| | C47.8-L | Burbot | | | | | | | 1 | | | | | | | | **1** |
| | C47.8-L | Lake Trout | | | | | | | | | 1 | | | | | | **1** |
| | C47.8-L | Lake Whitefish | | | | | | | | | 2 | | | | | | **2** |
| | C47.8-L | Mountain Whitefish | | | | | | | 5 | | 16 | | | | | | **21** |
| | C47.8-L | Rainbow Trout | | | | | | | 22 | | 78 | | | | | | **100** |
| | C47.8-L | Redside Shiner | | | | | | | | | | | | | | | **0** |
| | C47.8-L | Sculpin spp. | | | | | | | | | 32 | | | | | | **32** |
| | C47.8-L | Smallmouth Bass | | | | | | | | | 1 | | | | | | **1** |
| | C47.8-L | Sucker spp. | | | | | | | | | 52 | | | | | | **52** |
| | C47.8-L | Walleye | | | | | | | 8 | | 24 | | | | | | **32** |
| | **Site C47.8-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **37** | **0** | **211** | **0** | **0** | **0** | **0** | **0** | **248** |
| | C48.2-R | Lake Whitefish | | | | | | | | | | | | | 2 | | **2** |
| | C48.2-R | Mountain Whitefish | | | | | | | | | | | | 4 | 3 | | **7** |
| | C48.2-R | Rainbow Trout | | | | | | | | | | | | 11 | 49 | | **60** |
| | C48.2-R | Sculpin spp. | | | | | | | | | | | | | 25 | | **25** |
| | C48.2-R | Smallmouth Bass | | | | | | | | | | | | 1 | | | **1** |
| | C48.2-R | Sucker spp. | | | | | | | | | | | | | 3 | | **3** |
| | C48.2-R | Walleye | | | | | | | | | | | | 7 | 8 | | **15** |
| | **Site C48.2-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **23** | **90** | **0** | **113** |
| | C49.0-L | Brook Trout | | | | | | | | | | | | 1 | | | **1** |
| | C49.0-L | Lake Whitefish | | 5 | | | | | | | | 7 | | | | | **12** |
| | C49.0-L | Mountain Whitefish | | 75 | | | | | | | | 30 | | 1 | | | **106** |
| | C49.0-L | Rainbow Trout | | 63 | | | | | | | | 49 | | 3 | | | **115** |
| | C49.0-L | Sculpin spp. | | 355 | | | | | | | | 65 | | | | | **420** |
| | C49.0-L | Sucker spp. | | 19 | | | | | | | | 9 | | | | | **28** |
| | C49.0-L | Walleye | | 9 | | | | | | | | 9 | | 1 | | | **19** |
| | C49.0-L | White Sturgeon | | 1 | | | | | | | | | | | | | **1** |
| | **Site C49.0-L Total** | | **0** | **527** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **169** | **0** | **6** | **0** | **0** | **702** |
| | C49.0-R | Lake Whitefish | | | | | | | | | | | | | | | **0** |
| | C49.0-R | Mountain Whitefish | | | | | | | 2 | | | 3 | | 16 | | | **21** |
| | C49.0-R | Northern Pikeminnow | | | | | | | | | | | | 1 | | | **1** |
| | C49.0-R | Rainbow Trout | | | | | | | 2 | | | 4 | | 28 | | | **34** |
| | C49.0-R | Sculpin spp. | | | | | | | | | | | | 5 | | | **5** |
| | C49.0-R | Sucker spp. | | | | | | | | | | | | 1 | | | **1** |
| | C49.0-R | Walleye | | | | | | | | | | | | 1 | | | **1** |
| | **Site C49.0-R Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **4** | **0** | **0** | **7** | **0** | **52** | **0** | **0** | **63** |
| | C49.8-L | Brook Trout | | 2 | | | | | | | | | | | | | **2** |
| | C49.8-L | Bull Trout | | 1 | | | | | | | | | | | | | **1** |
| | C49.8-L | Burbot | | 4 | | | | | | | | | | | | | **4** |
| | C49.8-L | Lake Whitefish | | 2 | | | | | | | | | | | | | **2** |
| | C49.8-L | Mountain Whitefish | | 161 | | | | | | | | | | | | | **161** |
| | C49.8-L | Northern Pikeminnow | | 1 | | | | | | | | | | | | | **1** |
| | C49.8-L | Rainbow Trout | | 211 | | | | | | | | | | | | | **211** |
| | C49.8-L | Sculpin spp. | | 1450 | | | | | | | | | | | | | **1450** |
| | C49.8-L | Smallmouth Bass | | 2 | | | | | | | | | | | | | **2** |
| | C49.8-L | Sucker spp. | | 27 | | | | | | | | | | | | | **27** |
| | C49.8-L | Walleye | | 17 | | | | | | | | | | | | | **17** |
| | **Site C49.8-L Total** | | **0** | **1878** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1878** |
| | C49.8-R | Burbot | | | | | | | | | | 2 | | | | | **2** |
| | C49.8-R | Lake Whitefish | | 2 | | | | | | | | 1 | | | | | **3** |
| | C49.8-R | Mountain Whitefish | | 70 | | | | | | | | 50 | | | 4 | | **124** |
| | C49.8-R | Peamouth | | 1 | | | | | | | | | | | | | **1** |
| | C49.8-R | Rainbow Trout | | 41 | | | | | | | | 39 | | | 48 | | **128** |
| | C49.8-R | Sculpin spp. | | 200 | | | | | | | | 105 | | | 5 | | **310** |
| | C49.8-R | Sucker spp. | | 1 | | | | | | | | 2 | | | 48 | | **51** |
| | C49.8-R | Walleye | | 1 | | | | | | | | 4 | | | 11 | | **16** |
| | **Site C49.8-R Total** | | **0** | **316** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **203** | **0** | **0** | **116** | **0** | **635** |
| | C52.2-L | Brown Trout | | 1 | | | | | | | | | | | | | **1** |
| | C52.2-L | Lake Whitefish | | | | | | | | | | 1 | | | | | **1** |
| | C52.2-L | Mountain Whitefish | | 1 | | | | | | | | 7 | | | | 12 | **20** |
| | C52.2-L | Northern Pikeminnow | | | | | | | | | | | | | | 1 | **1** |
| | C52.2-L | Rainbow Trout | | 1 | | 3 | | | | | | 8 | | | | 44 | **56** |
| | C52.2-L | Sculpin spp. | | | | | | | | | | | | | | 10 | **10** |
| | C52.2-L | Sucker spp. | | | | | | | | | | 5 | | | | 1 | **6** |
| | C52.2-L | Walleye | | | | 1 | | | | | | 2 | | | | 7 | **10** |
| | **Site C52.2-L Total** | | **0** | **3** | **0** | **4** | **0** | **0** | **0** | **0** | **0** | **23** | **0** | **0** | **0** | **75** | **105** |
| | C52.2-R | Brook Trout | | 2 | | | | | | | | | | | | | **2** |
| | C52.2-R | Brown Trout | | 2 | | | | | | | | | | | | | **2** |
| | C52.2-R | Burbot | | 10 | | | | | | | | | | | | | **10** |
| | C52.2-R | Lake Whitefish | | 5 | | | | | | | | | | | | | **5** |
| | C52.2-R | Mountain Whitefish | | 61 | | | | | | | | | | | | 10 | **71** |
| | C52.2-R | Northern Pikeminnow | | 3 | | | | | | | | | | | | | **3** |
| | C52.2-R | Rainbow Trout | | 135 | | | | | | | | | | | | 84 | **219** |
| | C52.2-R | Sculpin spp. | | 103 | | | | | | | | | | | | 35 | **138** |
| | C52.2-R | Smallmouth Bass | | 1 | | | | | | | | | | | | | **1** |
| | C52.2-R | Sucker spp. | | 7 | | | | | | | | | | | | 5 | **12** |
| | C52.2-R | Walleye | | 20 | | | | | | | | | | | | 9 | **29** |
| | **Site C52.2-R Total** | | **0** | **349** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **143** | **492** |
| | C52.8-L | Mountain Whitefish | | 4 | | 3 | | | | | | | | | | | **7** |
| | C52.8-L | Rainbow Trout | | 15 | | 30 | | | | | | | | | | | **45** |
| | C52.8-L | Sculpin spp. | | | | 10 | | | | | | | | | | | **10** |
| | C52.8-L | Walleye | | 1 | | 7 | | | | | | | | | | | **8** |
| | **Site C52.8-L Total** | | **0** | **20** | **0** | **50** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **70** |
| | C53.6-L | Brook Trout | | | | | | 1 | | | | | | | | | **1** |
| | C53.6-L | Mountain Whitefish | | | | | | 6 | | | | | | | | | **6** |
| | C53.6-L | Rainbow Trout | | | | | | 82 | | | | | | | | | **82** |
| | C53.6-L | Sculpin spp. | | | | | | 190 | | | | | | | | | **190** |
| | C53.6-L | Smallmouth Bass | | | | | | 4 | | | | | | | | | **4** |
| | C53.6-L | Walleye | | | | | | 12 | | | | | | | | | **12** |
| | **Site C53.6-L Total** | | **0** | **0** | **0** | **0** | **0** | **295** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **295** |
| | C56.0-L | Rainbow Trout | | | | | | | | | | | | | | | **0** |
| | C56.0-L | Walleye | | | | | | | | | | | | | | | **0** |
| | **Site C56.0-L Total** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Downstream Columbia River Total** | | | **642** | **4220** | **133** | **54** | **243** | **295** | **41** | **146** | **211** | **459** | **44** | **81** | **206** | **218** | **6993** |
| **Grand Total** | | | **1999** | **5985** | **133** | **1407** | **668** | **295** | **41** | **490** | **4422** | **1496** | **44** | **554** | **904** | **305** | **18743** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.

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

# APPENDIX C

## Modelling Methods, Code, and Parameter Estimates

# Lower Columbia River Fish Population Indexing Analysis 2014

## 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 3.2.0 (R Core Team 2014).

### Statistical Analysis

Hierarchical Bayesian models were fitted to the fish indexing data using R version 3.2.0 (Team 2013) and JAGS 3.4.0 (Plummer 2012) which interfaced with each other via jaggernaut 2.2.11 (J. L. Thorley 2013). 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, 41–44).

Unless specified, the models assumed vague (low information) prior distributions (Kery and Schaub 2011, 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 of at least 1,000 iterations in length (Kery and Schaub 2011, 38–40). Model convergence was confirmed by ensuring that Rhat (Kery and Schaub 2011, 40) was less than 1.1 for each of the parameters in the model (Kery and Schaub 2011, 61). Model adequacy was confirmed by examination of residual plots.

The posterior distributions of the *fixed* (Kery and Schaub 2011, 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* (Kery and Schaub 2011, 37, 42).

In general variable selection was achieved by dropping *insignificant* (Kery and Schaub 2011, 37, 42) fixed (Kery and Schaub 2011, 77–82) variables and *uninformative* random variables. A fixed variable was considered to be insignificant if its significance was $\geq 0.05$ while a random variable was considered to be uninformative if its percent relative error was $\geq 80\%$.

The results are displayed graphically by plotting the modelled 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)

(Kery and Schaub 2011, 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, Korman, and Higgins 2005).

## Model Code

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

### Condition

| Variable/Parameter | Description |
|---|---|
| `bCorrelation` | Correlation coefficient between `bWeightYear` and `bWeightLengthYear` |
| `bWeight` | Intercept of `eLogWeight` |
| `bWeightDayte` | Linear effect of dayte on `eLogWeight` |
| `bWeightLength` | Linear effect of length on `eLogWeight` |
| `bWeightLengthDayte` | Effect of dayte on effect of length on `eLogWeight` |
| `bWeightLengthYear[i]` | Effect of `i`th year on effect of length on `eLogWeight` |
| `bWeightYear[i]` | Effect of `i`th year on `eLogWeight` |
| `Dayte[i]` | Day of year `i`th fish was captured |
| `eLogWeight[i]` | Expected `log(Weight)` of `i`th fish |
| `Length[i]` | `log(Length)` of `i`th 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 `i`th fish |
| `Year[i]` | Year `i`th fish was captured |

#### *Condition - Model1*

```
model {

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

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

  sWeightYear ~ dunif(0, 1)
  sWeightLengthYear ~ dunif(0, 1)
  for (i in 1:nYear) {
    bWeightYear[i] ~ dnorm(0, sWeightYear^-2)
    bWeightLengthYear[i] ~ dnorm(0, sWeightLengthYear^-2)
  }
```

```
  sWeight ~ dunif(0, 1)
  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 of `log(eK)` |
| `bKYear[i]` | Random effect of `i`th year on `log(eK)` |
| `bLinf` | Mean maximum length |
| `eGrowth[i]` | Expected growth between release and recapture of `i`th recapture |
| `eK[i]` | Expected von Bertalanffy growth coefficient in `i`th year |
| `Growth[i]` | Observed growth between release and recapture of `i`th recapture |
| `LengthAtRelease[i]` | Length at previous release of `i`th recapture |
| `sGrowth` | SD of residual variation in `Growth` |
| `sKYear` | SD of effect of year on `log(eK)` |
| `Year[i]` | Release year of `i`th recapture |
| `Years[i]` | Years between release and recapture of `i`th 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[ii]` | Observed age-class of `ii`th fish |
| `bAge[ii]` | Effect of `ii`th age-class on `logit(pAgeYear)` |
| `bAgeYear[ii, jj]` | Effect of `ii`th age-class within `jj`th year on `logit(pAgeYear)` |
| `bDayte[ii]` | Effect of `ii`th age-class on linear effect of dayte on `eLength` |
| `bDayte2[ii]` | Effect of `ii`th age-class on quadratic effect of dayte on `eLength` |
| `bGrowthAge[ii]` | Growth of fish to `ii`th age-class |
| `bGrowthAgeYear[ii, jj]` | Growth of fish to `ii`th age-class within `jj`th year |
| `bLengthAgeYear[ii, jj]` | Effect of `ii`th age-class within `jj`th year on `eLength` |
| `eGrowthAgeYear[ii, jj]` | Total growth of fish to `ii`th age-class in `jj`th year |
| `eLength[ii]` | Expected length of `ii`th fish |
| `Length[ii]` | Observed length of `ii`th fish |
| `pAgeYear[ii, jj]` | Proportion of fish in `ii`th age-class within `jj`th year |
| `sAgeYear` | SD of effect of age-class within year on `bAgeYear` |
| `sGrowthAgeYear[ii]` | SD of effect of age-class within year on fish growth |
| `sLengthAge[ii]` | SD of residual variation in `eLength` of fish in `ii`th age-class |
| `Year[ii]` | Year in which `ii`th fish was caught |

#### *Length-At-Age - Model1*

```
model{

  for(ii in 1:nAge){
    bGrowthAge[ii] ~ dunif(10, 100)
    sGrowthAgeYear[ii] ~ dunif(0, 25)
    for(jj in 1:nYear) {
      bGrowthAgeYear[ii, jj] ~ dnorm(0, sGrowthAgeYear[ii]^-2)
      eGrowthAgeYear[ii, jj] <- bGrowthAge[ii] + bGrowthAgeYear[ii, jj]
    }
  }

  bLengthAgeYear[1, 1] <- eGrowthAgeYear[1, 1]
  for(ii in 2:nAge){
    bLengthAgeYear[ii, 1] <- bLengthAgeYear[ii-1, 1] - bGrowthAgeYear[ii-1, 1
] + eGrowthAgeYear[ii, 1]
  }
```

```
  for(jj in 2:nYear){
    bLengthAgeYear[1, jj] <- eGrowthAgeYear[1, jj]
    for(ii in 2:nAge){
      bLengthAgeYear[ii, jj] <- bLengthAgeYear[ii-1, jj-1] + eGrowthAgeYear[i
i, jj]
    }
  }

  for(ii in 1:nAge)  {
    bDayte[ii] ~ dnorm(0, 10)
    bDayte2[ii] ~ dnorm(0, 10)
    }

  sAgeYear ~ dunif(0, 5)
  for(ii in 1:(nAge - 1)){
    bAge[ii] ~ dnorm(0, 2^-2)
    for(jj in 1:nYear){
      bAgeYear[ii, jj] ~ dnorm(0, sAgeYear^-2)
    }
  }

  for(jj in 1:nYear){
    logit(pAgeYear[1, jj]) <- bAge[1] + bAgeYear[1, jj]
    for(ii in 2:(nAge - 1)){
      pAgeYear[ii, jj] <- (1 - sum(pAgeYear[1:ii-1, jj])) * ilogit(bAge[ii] +
bAgeYear[ii, jj])
    }
    pAgeYear[nAge, jj] <- (1 - sum(pAgeYear[1:nAge - 1, jj]))
  }

    for(ii in 1:nAge){
    sLengthAge[ii] ~ dunif(0, 50)
  }

    for(ii in 1:length(Length)){
    Age[ii] ~ dcat(pAgeYear[1:nAge, Year[ii]])
    eLength[ii] <-  bLengthAgeYear[Age[ii], Year[ii]]
                  + bDayte[Age[ii]] * Dayte[ii]
                  + bDayte2[Age[ii]] * Dayte[ii]^2
    Length[ii] ~ dnorm(eLength[ii], sLengthAge[Age[ii]]^-2)
  }
}
```

## Observer Length Correction

| Variable/Parameter | Description |
|---|---|
| `bLength[i]` | Relative inaccuracy of `i`th observer |
| `ClassLength[i]` | Mean length of fish belonging to `i`th class |

| | |
|---|---|
| `dClass[i]` | Prior value for the proportion of fish in the `i`$^{th}$ class |
| `eClass[i]` | Expected class of `i`$^{th}$ fish |
| `eLength[i]` | Expected length of `i`$^{th}$ fish |
| `eSLength[i]` | Expected SD of residual variation in length of `i`$^{th}$ fish |
| `Length[i]` | Observed fork length of `i`$^{th}$ fish |
| `Observer[i]` | Observer of `i`$^{th}$ fish where the first observer used a length board |
| `pClass[i]` | Proportion of fish in the `i`$^{th}$ class |
| `sLength[i]` | Relative imprecision of `i`$^{th}$ observer |
| `Year[i]` | Year `i`$^{th}$ fish was observed |

### *Observer Length Correction - Model1*

```
model{

  for(j in 1:nYear){
    for(i in 1:nClass) {
      dClass[i, j] <- 1
    }
    pClass[1:nClass, j] ~ ddirch(dClass[, j])
  }

  bLength[1] <- 1
  sLength[1] <- 1

  for(i in 2:nObserver) {
    bLength[i] ~ dunif(0.5, 2)
    sLength[i] ~ dunif(2, 10)
  }

  for(i in 1:length(Length)){
    eClass[i] ~ dcat(pClass[, Year[i]])
    eLength[i] <- bLength[Observer[i]] * ClassLength[eClass[i]]
    eSLength[i] <- sLength[Observer[i]] * ClassSD
    Length[i] ~ dnorm(eLength[i], eSLength[i]^-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 i*th* fish from j-1*th* to j*th* year |
| `FirstYear[i]` | First year i*th* fish was observed |
| `FishYear[i, j]` | Whether i*th* fish was observed in j*th* year |
| `sSurvivalStageYear` | SD of effect of `Year` on `logit(eSurvival)` by `Stage` |
| `StageFishYear[i, j]` | Stage of i*th* fish in j*th* year |

### *Survival - Model1*

```
model {

  bEfficiency ~ dnorm(0, 5^-2)

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

  sSurvivalStageYear[1] <- 0
  for(j in 1:nYear) {
    bSurvivalStageYear[1,j] <- 0
  }

  for(i in 2:nStage) {
     sSurvivalStageYear[i] ~ dunif(0, 5)
     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]) <- bSurvivalInterceptStage[StageFishYear[i,j-1]]
+ bSurvivalStageYear[StageFishYear[i,j-1],j]
      eAlive[i,j] ~ dbern(eAlive[i,j-1] * eSurvival[i,j])
      FishYear[i,j] ~ dbern(eAlive[i,j] * eEfficiency[i,j])
     }
   }
}
```

## Site Fidelity

| Variable/Parameter | Description |
|---|---|
| `bFidelity` | Intercept of `logit(eFidelity)` |
| `bLength` | Effect of length on `logit(eFidelity)` |
| `eFidelity[i]` | Expected site fidelity of ith recapture |

| | |
|---|---|
| `Fidelity[i]` | Whether the `i`th recapture was encountered at the same site as the previous encounter |
| `Length[i]` | Length at previous encounter of `i`th recapture |

### *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 `i`th visit |
| `eFidelity[i]` | Expected site fidelity on `i`th visit |
| `Fidelity[i]` | Mean site fidelity on `i`th visit |
| `FidelitySD[i]` | SD of site fidelity on `i`th visit |
| `Recaptures[i]` | Number of marked fish recaught during `i`th visit |
| `sEfficiencySessionYear` | SD of effect of `Session` within `Year` on `logit(eEfficiency)` |
| `Session[i]` | Session of `i`th visit |
| `Tagged[i]` | Number of marked fish tagged prior to `i`th visit |
| `Year[i]` | Year of `i`th 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(Recaptures)) {
```

```
    logit(eEfficiency[i]) <- bEfficiency + bEfficiencySessionYear[Session[i],
Year[i]]

    eFidelity[i] ~ dnorm(Fidelity[i], FidelitySD[i]^-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)` |
| `bVisitType` | Effect of `VisitType` on `Efficiency` |
| `eDensity[i]` | Expected density during *ith* visit |
| `eDispersion` | Overdispersion of `Fish` |
| `Efficiency[i]` | Survey efficiency during *ith* visit |
| `Fish[i]` | Observed count 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 |
| `VisitType[i]` | Survey type (catch versus count) during *ith* visit |
| `Year[i]` | Year of *ith* visit |

#### *Abundance - Model1*

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

  bVisitType[1] <- 1
  for (i in 2:nVisitType) {
    bVisitType[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(Fish)) {
    log(eDensity[i]) <- bDensity + bDensitySite[Site[i]] + bDensityYear[Year[i]] + bDensitySiteYear[Site[i],Year[i]]

    eDispersion[i] ~ dgamma(1 / sDispersion^2, 1 / sDispersion^2)
    Fish[i] ~ dpois(eDensity[i] * SiteLength[i] * ProportionSampled[i] * Efficiency[i] * bVisitType[VisitType[i]] * eDispersion[i])
  }
}
```

## Long-Term Trends

| Variable/Parameter | Description |
|---|---|
| `bDistance[i,j]` | Euclidean distance between $i^{th}$ and $j^{th}$ `Variable` |
| `bTrendYear[t,y]` | Expected value for $t^{th}$ trend in $y^{th}$ `Year` |
| `eValue[v,y,t]` | Expected standardised value for $v^{th}$ `Variable` in $y^{th}$ `Year` considering $t^{th}$ trends |
| `sTrend` | SD in trend random walks |
| `sValue` | SD for residual variation in `Value` |
| `Value[i]` | Standardised value for $i^{th}$ data point |
| `Variable[i]` | Variable for $i^{th}$ data point |
| `Year[i]` | Year of $i^{th}$ data point |
| `Z[v,y]` | Expected weighting for $v^{th}$ `Variable` in $y^{th}$ `Year` |

### *Long-Term Trends - Model1*

```
model{

  sTrend ~ dunif(0, 1)
  for (t in 1:nTrend) {
    bTrendYear[t,1] ~ dunif(-1,1)
    for(y in 2:nYear){
      bTrendYear[t,y] ~ dnorm(bTrendYear[t,y-1], sTrend^-2)
    }
  }
```

```
  for(v in 1:nVariable){
    for(t in 1:nTrend) {
      Z[v,t] ~ dunif(-1,1)
    }
    for(y in 1:nYear){
      eValue[v,y,1] <- Z[v,1] * bTrendYear[1,y]
      for(t in 2:nTrend) {
        eValue[v,y,t] <- eValue[v,y,t-1] + Z[v,t] * bTrendYear[t,y]
      }
    }
  }

  sValue ~ dunif(0, 1)
  for(i in 1:length(Value)) {
    Value[i] ~ dnorm(eValue[Variable[i], Year[i], nTrend], sValue^-2)
  }

  for(i in 1:nVariable) {
    for(j in 1:nVariable) {
      bDistance[i,j] <- sqrt(sum((Z[i,]-Z[j,])^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 |
|---|---|---|---|---|---|---|
| bWeight | 5.43202 | 5.40935 | 5.45443 | 0.01145 | 0 | 0.0010 |
| bWeightDayte | -0.01408 | -0.01863 | -0.00991 | 0.00217 | 31 | 0.0010 |
| bWeightLength | 3.15480 | 3.09620 | 3.20430 | 0.02700 | 2 | 0.0010 |
| bWeightLengthDayte | -0.00383 | -0.01466 | 0.00810 | 0.00581 | 300 | 0.4771 |
| sWeight | 0.15564 | 0.15365 | 0.15777 | 0.00103 | 1 | 0.0010 |
| sWeightLengthYear | 0.11343 | 0.07683 | 0.16857 | 0.02452 | 40 | 0.0010 |
| sWeightYear | 0.04737 | 0.03280 | 0.06837 | 0.00939 | 38 | 0.0010 |

| Convergence | Iterations |
|---|---|
| 1.02 | 10000 |

### Condition - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bWeight | 5.93291 | 5.92213 | 5.94329 | 0.00569 | 0 | 0.001 |
| bWeightDayte | -0.00396 | -0.00682 | -0.00100 | 0.00148 | 73 | 0.008 |
| bWeightLength | 2.92900 | 2.89692 | 2.95973 | 0.01530 | 1 | 0.001 |
| bWeightLengthDayte | 0.04578 | 0.03627 | 0.05452 | 0.00469 | 20 | 0.001 |
| sWeight | 0.11152 | 0.11005 | 0.11302 | 0.00078 | 1 | 0.001 |
| sWeightLengthYear | 0.05738 | 0.03662 | 0.08999 | 0.01427 | 47 | 0.001 |
| sWeightYear | 0.02380 | 0.01637 | 0.03528 | 0.00488 | 40 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.02 | 10000 |

### Condition - Walleye

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bWeight | 6.28395 | 6.26506 | 6.30392 | 0.00997 | 0 | 0.0010 |
| bWeightDayte | 0.01788 | 0.01494 | 0.02092 | 0.00153 | 17 | 0.0010 |
| bWeightLength | 3.22000 | 3.16780 | 3.27360 | 0.02610 | 2 | 0.0010 |
| bWeightLengthDayte | -0.01627 | -0.03562 | 0.00289 | 0.01005 | 120 | 0.0999 |
| sWeight | 0.09913 | 0.09766 | 0.10066 | 0.00079 | 2 | 0.0010 |
| sWeightLengthYear | 0.10466 | 0.06692 | 0.16206 | 0.02379 | 45 | 0.0010 |
| sWeightYear | 0.04148 | 0.02907 | 0.06152 | 0.00844 | 39 | 0.0010 |

| Convergence | Iterations |
|---|---|
| 1.02 | 10000 |

### Growth - Mountain Whitefish

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bK | -1.2048 | -1.5017 | -0.9398 | 0.1467 | 23 | 7e-04 |
| bLinf | 407.6700 | 401.6500 | 414.4300 | 3.2300 | 2 | 7e-04 |
| sGrowth | 12.9270 | 11.6910 | 14.3740 | 0.6840 | 10 | 7e-04 |
| sKYear | 0.4461 | 0.2302 | 0.8066 | 0.1451 | 65 | 7e-04 |

| Convergence | Iterations |
|---|---|
| 1.04 | 4000 |

### Growth - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bK | -0.1902 | -0.2932 | -0.0613 | 0.0613 | 61 | 0.0014 |
| bLinf | 500.8000 | 495.4300 | 506.3200 | 2.8000 | 1 | 0.0007 |
| sGrowth | 29.7730 | 28.4550 | 31.2920 | 0.7280 | 5 | 0.0007 |

| | | | | | | |
|---|---|---|---|---|---|---|
| sKYear | 0.2392 | 0.1534 | 0.3665 | 0.0597 | 45 | 0.0007 |

| Convergence | Iterations |
|---|---|
| 1.04 | 1000 |

### Growth - Walleye

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bK | -2.7953 | -3.1163 | -2.4123 | 0.2005 | 13 | 7e-04 |
| bLinf | 855.1000 | 732.9000 | 987.0000 | 72.1000 | 15 | 7e-04 |
| sGrowth | 19.0060 | 17.4680 | 20.7440 | 0.8240 | 9 | 7e-04 |
| sKYear | 0.3341 | 0.1829 | 0.5509 | 0.0955 | 55 | 7e-04 |

| Convergence | Iterations |
|---|---|
| 1.03 | 2000 |

### Length-At-Age - Mountain Whitefish

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bAge[1] | -2.0171 | -2.4440 | -1.5490 | 0.2250 | 22 | 0.0010 |
| bAge[2] | -0.7937 | -1.2146 | -0.2639 | 0.2351 | 60 | 0.0078 |
| bDayte[1] | 3.1560 | 2.6400 | 3.6770 | 0.2630 | 16 | 0.0010 |
| bDayte[2] | 2.3960 | 1.8470 | 2.9560 | 0.2850 | 23 | 0.0010 |
| bDayte[3] | 1.3680 | 0.8720 | 1.9050 | 0.2710 | 38 | 0.0010 |
| bDayte2[1] | -0.7014 | -1.1140 | -0.3124 | 0.2072 | 57 | 0.0010 |
| bDayte2[2] | -0.1293 | -0.5348 | 0.2649 | 0.1996 | 310 | 0.5083 |
| bDayte2[3] | 1.1590 | 0.6220 | 1.6710 | 0.2710 | 45 | 0.0010 |
| bGrowthAge[1] | 98.8160 | 94.9540 | 99.9690 | 1.2480 | 3 | 0.0010 |
| bGrowthAge[2] | 96.4960 | 92.1720 | 99.7600 | 2.0580 | 4 | 0.0010 |
| bGrowthAge[3] | 98.9290 | 95.9890 | 99.9720 | 1.0650 | 2 | 0.0010 |
| sAgeYear | 0.8934 | 0.6917 | 1.1979 | 0.1277 | 28 | 0.0010 |
| sGrowthAgeYear[1] | 22.2460 | 17.8750 | 24.8640 | 1.9500 | 16 | 0.0010 |
| sGrowthAgeYear[2] | 9.8520 | 6.6160 | 14.8060 | 2.0880 | 42 | 0.0010 |
| sGrowthAgeYear[3] | 23.9120 | 21.5990 | 24.9690 | 0.9460 | 7 | 0.0010 |
| sLengthAge[1] | 14.1186 | 13.7330 | 14.5212 | 0.1964 | 3 | 0.0010 |
| sLengthAge[2] | 21.1020 | 20.3580 | 21.9210 | 0.3970 | 4 | 0.0010 |
| sLengthAge[3] | 45.5000 | 44.8110 | 46.2680 | 0.3800 | 2 | 0.0010 |

| Convergence | Iterations |
|---|---|
| 1.08 | 20000 |

### Length-At-Age - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| bAge[1] | -3.0744 | -3.3730 | -2.7692 | 0.1498 | 10 | 0.0010 |
| bAge[2] | 0.4898 | 0.1597 | 0.8234 | 0.1659 | 68 | 0.0010 |
| bDayte[1] | 0.8530 | 0.2570 | 1.4410 | 0.3010 | 69 | 0.0020 |
| bDayte[2] | 2.9410 | 2.3720 | 3.4660 | 0.2720 | 19 | 0.0010 |
| bDayte[3] | 0.2110 | -0.3830 | 0.7800 | 0.3020 | 280 | 0.4947 |
| bDayte2[1] | 0.0940 | -0.4290 | 0.6170 | 0.2830 | 550 | 0.7382 |
| bDayte2[2] | 0.7923 | 0.3325 | 1.2812 | 0.2461 | 60 | 0.0020 |
| bDayte2[3] | 0.2540 | -0.2900 | 0.7910 | 0.2770 | 210 | 0.3421 |
| bGrowthAge[1] | 99.0670 | 96.2510 | 99.9770 | 0.9690 | 2 | 0.0010 |
| bGrowthAge[2] | 99.4290 | 97.8780 | 99.9810 | 0.5530 | 1 | 0.0010 |
| bGrowthAge[3] | 99.5010 | 98.1120 | 99.9920 | 0.5440 | 1 | 0.0010 |
| sAgeYear | 0.5897 | 0.4443 | 0.7867 | 0.0898 | 29 | 0.0010 |
| sGrowthAgeYear[1] | 16.9000 | 11.6300 | 23.4300 | 3.0900 | 35 | 0.0010 |
| sGrowthAgeYear[2] | 24.6750 | 23.8490 | 24.9910 | 0.3140 | 2 | 0.0010 |
| sGrowthAgeYear[3] | 24.8226 | 24.3900 | 24.9951 | 0.1700 | 1 | 0.0010 |
| sLengthAge[1] | 18.0360 | 17.1460 | 18.9980 | 0.4760 | 5 | 0.0010 |
| sLengthAge[2] | 38.2450 | 37.5830 | 38.9190 | 0.3410 | 2 | 0.0010 |
| sLengthAge[3] | 49.9233 | 49.7243 | 49.9975 | 0.0749 | 0 | 0.0010 |

| Convergence | Iterations |
|---|---|
| 1.1 | 20000 |

### Observer Length Correction - Mountain Whitefish

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bLength[2] | 0.84855 | 0.83481 | 0.86114 | 0.00681 | 2 | 0.001 |
| bLength[3] | 0.79893 | 0.78635 | 0.81142 | 0.00636 | 2 | 0.001 |
| bLength[4] | 0.81988 | 0.81098 | 0.84049 | 0.00680 | 2 | 0.001 |
| sLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| sLength[2] | 3.59370 | 3.22800 | 4.01110 | 0.19890 | 11 | 0.001 |
| sLength[3] | 2.02309 | 2.00081 | 2.08460 | 0.02326 | 2 | 0.001 |
| sLength[4] | 2.01283 | 2.00039 | 2.04996 | 0.01354 | 1 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.01 | 40000 |

### Observer Length Correction - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |

| | | | | | | |
|---|---|---|---|---|---|---|
| bLength[2] | 0.87327 | 0.86285 | 0.88502 | 0.00560 | 1 | 0.001 |
| bLength[3] | 0.76966 | 0.74565 | 0.79334 | 0.01175 | 3 | 0.001 |
| bLength[4] | 0.87359 | 0.86434 | 0.88246 | 0.00460 | 1 | 0.001 |
| sLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| sLength[2] | 2.80700 | 2.15500 | 3.45800 | 0.33500 | 23 | 0.001 |
| sLength[3] | 4.36100 | 3.17400 | 5.53300 | 0.59600 | 27 | 0.001 |
| sLength[4] | 2.04270 | 2.00110 | 2.16750 | 0.04560 | 4 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.03 | 10000 |

### Observer Length Correction - Walleye

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bLength[2] | 0.91751 | 0.90139 | 0.93430 | 0.00867 | 2 | 0.001 |
| bLength[3] | 0.85530 | 0.82577 | 0.89388 | 0.01776 | 4 | 0.001 |
| bLength[4] | 0.92086 | 0.89945 | 0.93999 | 0.01036 | 2 | 0.001 |
| sLength[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| sLength[2] | 2.70700 | 2.02200 | 4.41300 | 0.69100 | 44 | 0.001 |
| sLength[3] | 2.81400 | 2.02100 | 5.06600 | 0.81400 | 54 | 0.001 |
| sLength[4] | 3.18300 | 2.04500 | 4.69000 | 0.73400 | 42 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.02 | 10000 |

### Survival - Mountain Whitefish

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -3.9106 | -4.1704 | -3.688 | 0.1225 | 6 | 0.0010 |
| bSurvivalInterceptStage[1] | -1.1440 | -1.6840 | -0.582 | 0.2740 | 48 | 0.0010 |
| bSurvivalInterceptStage[2] | 0.2000 | -0.3760 | 0.874 | 0.2990 | 310 | 0.4806 |
| sSurvivalStageYear[2] | 0.9910 | 0.4700 | 1.893 | 0.3680 | 72 | 0.0010 |

| Convergence | Iterations |
|---|---|
| 1.1 | 40000 |

### Survival - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -2.4925 | -2.6686 | -2.3365 | 0.0851 | 7 | 0.0010 |
| bSurvivalInterceptStage[1] | 0.0398 | -0.2748 | 0.4008 | 0.1655 | 850 | 0.8444 |
| bSurvivalInterceptStage[2] | -0.4969 | -0.7913 | -0.2252 | 0.1508 | 57 | 0.0010 |
| sSurvivalStageYear[2] | 0.5044 | 0.2705 | 0.8263 | 0.1496 | 55 | 0.0010 |

| Convergence | Iterations |
|---:|---:|
| 1.05 | 10000 |

## Survival - Walleye

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---:|---:|---:|---:|---:|---:|
| bEfficiency | -3.3248 | -3.5363 | -3.1320 | 0.1043 | 6 | 0.0010 |
| bSurvivalInterceptStage[1] | -0.0500 | -9.9400 | 9.7600 | 5.0500 | 21000 | 0.9991 |
| bSurvivalInterceptStage[2] | 0.0093 | -0.3551 | 0.3784 | 0.1819 | 3900 | 0.9801 |
| sSurvivalStageYear[2] | 0.5320 | 0.2032 | 0.9574 | 0.2038 | 71 | 0.0010 |

| Convergence | Iterations |
|---:|---:|
| 1.02 | 40000 |

## Site Fidelity - Mountain Whitefish

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---:|---:|---:|---:|---:|---:|
| bFidelity | -0.0300 | -0.4017 | 0.3643 | 0.1951 | 1300 | 0.8667 |
| bLength | -0.0752 | -0.4663 | 0.3196 | 0.1990 | 520 | 0.6960 |

| Convergence | Iterations |
|---:|---:|
| 1 | 1000 |

## Site Fidelity - Rainbow Trout

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---:|---:|---:|---:|---:|---:|
| bFidelity | 0.8157 | 0.6559 | 0.9766 | 0.0843 | 20 | 7e-04 |
| bLength | -0.3527 | -0.5164 | -0.1847 | 0.0836 | 47 | 7e-04 |

| Convergence | Iterations |
|---:|---:|
| 1 | 1000 |

## Site Fidelity - Walleye

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---:|---:|---:|---:|---:|---:|
| bFidelity | 0.7131 | 0.4206 | 1.0016 | 0.1474 | 41 | 0.0007 |
| bLength | -0.1098 | -0.3932 | 0.1607 | 0.1463 | 250 | 0.4680 |

| Convergence | Iterations |
|---:|---:|
| 1 | 1000 |

## Capture Efficiency - Mountain Whitefish - Subadult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---:|---:|---:|---:|---:|---:|
| bEfficiency | -4.8698 | -5.3917 | -4.4559 | 0.231 | 10 | 0.001 |
| sEfficiencySessionYear | 0.4420 | 0.0500 | 1.0850 | 0.287 | 120 | 0.001 |

| Convergence | Iterations |
|---:|---:|
| 1.06 | 10000 |

### Capture Efficiency - Mountain Whitefish - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -5.4041 | -5.8359 | -5.0716 | 0.1915 | 7 | 0.001 |
| sEfficiencySessionYear | 0.4550 | 0.0995 | 0.9977 | 0.2453 | 99 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.04 | 10000 |

### Capture Efficiency - Rainbow Trout - Subadult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -3.3260 | -3.4521 | -3.1986 | 0.0641 | 4 | 0.001 |
| sEfficiencySessionYear | 0.3679 | 0.2513 | 0.4979 | 0.0650 | 34 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.01 | 10000 |

### Capture Efficiency - Rainbow Trout - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -4.0427 | -4.2041 | -3.882 | 0.0807 | 4 | 0.001 |
| sEfficiencySessionYear | 0.2510 | 0.0132 | 0.485 | 0.1190 | 94 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.06 | 10000 |

### Capture Efficiency - Walleye - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bEfficiency | -4.3949 | -4.6307 | -4.1696 | 0.1172 | 5 | 0.001 |
| sEfficiencySessionYear | 0.6234 | 0.3956 | 0.8967 | 0.1292 | 40 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.01 | 10000 |

### Abundance - Mountain Whitefish - Subadult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bDensity | 5.36800 | 5.02560 | 5.73410 | 0.1850 | 7 | 0.001 |
| bVisitType[1] | 1.00000 | 1.00000 | 1.00000 | 0.0000 | 0 | 0.001 |
| bVisitType[2] | 3.53200 | 2.90100 | 4.24000 | 0.3440 | 19 | 0.001 |
| sDensitySite | 0.78050 | 0.62020 | 1.00370 | 0.0954 | 25 | 0.001 |
| sDensitySiteYear | 0.47570 | 0.40940 | 0.54660 | 0.0343 | 14 | 0.001 |
| sDensityYear | 0.74050 | 0.52570 | 1.12480 | 0.1458 | 40 | 0.001 |
| sDispersion | 0.51404 | 0.47331 | 0.55881 | 0.0219 | 8 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.09 | 20000 |

### Abundance - Mountain Whitefish - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bDensity | 7.01200 | 6.60060 | 7.44920 | 0.20680 | 6 | 0.001 |
| bVisitType[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bVisitType[2] | 4.40700 | 3.54700 | 5.42100 | 0.47700 | 21 | 0.001 |
| sDensitySite | 1.08670 | 0.87380 | 1.33910 | 0.11800 | 21 | 0.001 |
| sDensitySiteYear | 0.53670 | 0.47620 | 0.59960 | 0.03270 | 11 | 0.001 |
| sDensityYear | 0.74290 | 0.50010 | 1.09440 | 0.15630 | 40 | 0.001 |
| sDispersion | 0.55465 | 0.52032 | 0.59088 | 0.01809 | 6 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.05 | 40000 |

### Abundance - Rainbow Trout - Subadult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bDensity | 4.91970 | 4.69240 | 5.13530 | 0.11920 | 5 | 0.001 |
| bVisitType[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bVisitType[2] | 3.64000 | 3.11100 | 4.21900 | 0.28500 | 15 | 0.001 |
| sDensitySite | 0.77630 | 0.63020 | 0.93750 | 0.07960 | 20 | 0.001 |
| sDensitySiteYear | 0.40590 | 0.35590 | 0.45740 | 0.02590 | 13 | 0.001 |
| sDensityYear | 0.34390 | 0.22590 | 0.51450 | 0.07450 | 42 | 0.001 |
| sDispersion | 0.39812 | 0.36695 | 0.43191 | 0.01638 | 8 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.05 | 20000 |

### Abundance - Rainbow Trout - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| bDensity | 5.22520 | 4.99950 | 5.42510 | 0.10500 | 4 | 0.001 |
| bVisitType[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bVisitType[2] | 3.59500 | 3.10300 | 4.11700 | 0.25800 | 14 | 0.001 |
| sDensitySite | 0.66380 | 0.53990 | 0.81940 | 0.07090 | 21 | 0.001 |
| sDensitySiteYear | 0.31820 | 0.26740 | 0.37160 | 0.02650 | 16 | 0.001 |
| sDensityYear | 0.23900 | 0.14760 | 0.37590 | 0.06020 | 48 | 0.001 |
| sDispersion | 0.40135 | 0.36714 | 0.43643 | 0.01796 | 9 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.1 | 10000 |

### Abundance - Walleye - Adult

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| bDensity | 5.61180 | 5.31010 | 5.92480 | 0.16820 | 5 | 0.001 |
| bVisitType[1] | 1.00000 | 1.00000 | 1.00000 | 0.00000 | 0 | 0.001 |
| bVisitType[2] | 3.68300 | 3.06400 | 4.46600 | 0.36500 | 19 | 0.001 |
| sDensitySite | 0.36250 | 0.25710 | 0.48690 | 0.06090 | 32 | 0.001 |
| sDensitySiteYear | 0.28384 | 0.23637 | 0.33448 | 0.02574 | 17 | 0.001 |
| sDensityYear | 0.67680 | 0.47270 | 1.01930 | 0.14080 | 40 | 0.001 |
| sDispersion | 0.48354 | 0.45056 | 0.51786 | 0.01716 | 7 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.09 | 10000 |

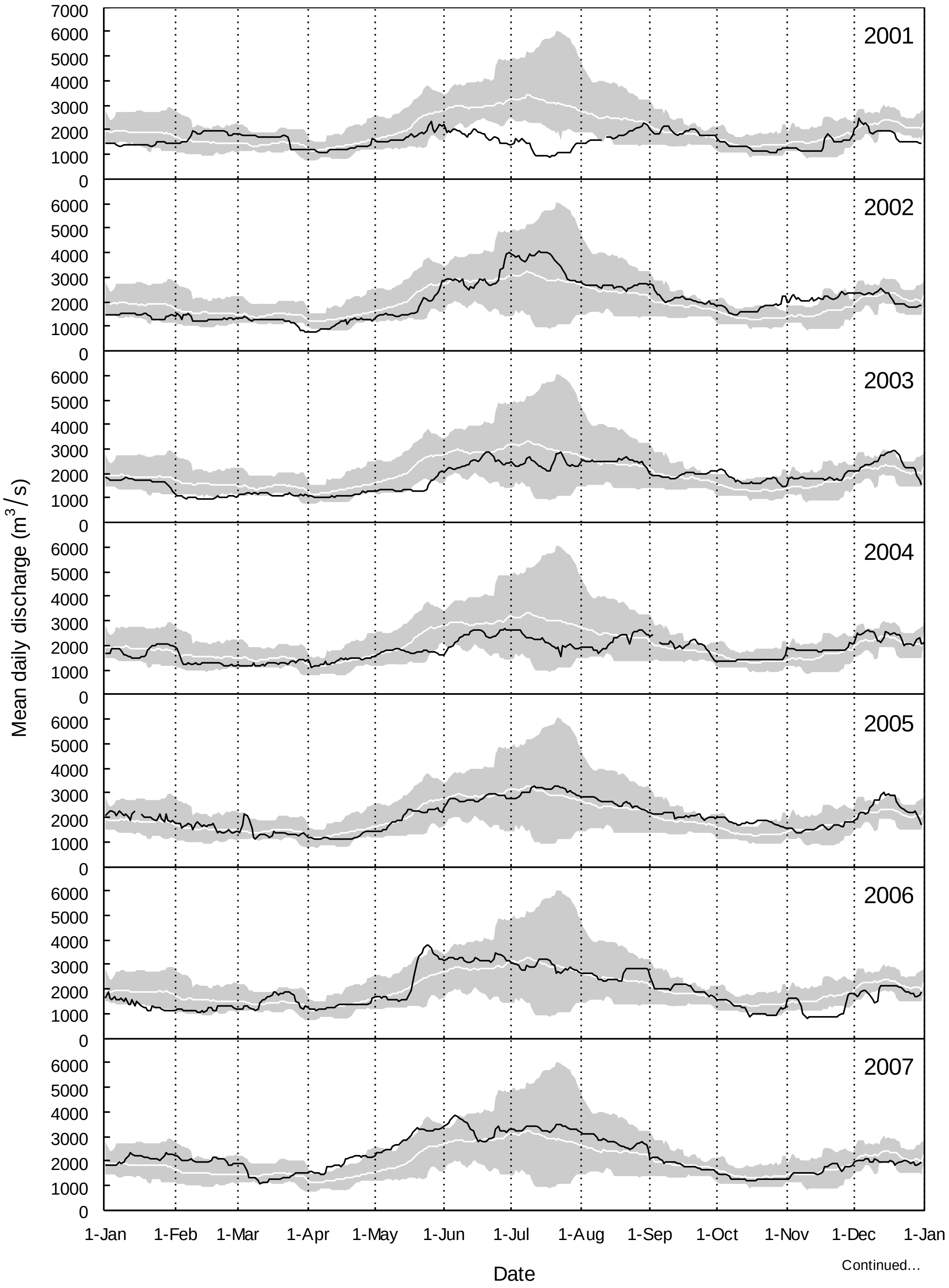
### Long-Term Trends

| Parameter | Estimate | Lower | Upper | SD | Error | Significance |
|---|---|---|---|---|---|---|
| sTrend | 0.3733 | 0.1763 | 0.5947 | 0.1090 | 56 | 0.001 |
| sValue | 0.8573 | 0.7824 | 0.9460 | 0.0408 | 10 | 0.001 |

| Convergence | Iterations |
|---|---|
| 1.02 | 20000 |

# 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 2014. The shaded area represents minimum and maximum mean daily discharge recorded at Birchbank during other study years between 2001 and 2014. The white line represents average mean daily discharge over the same time period.*

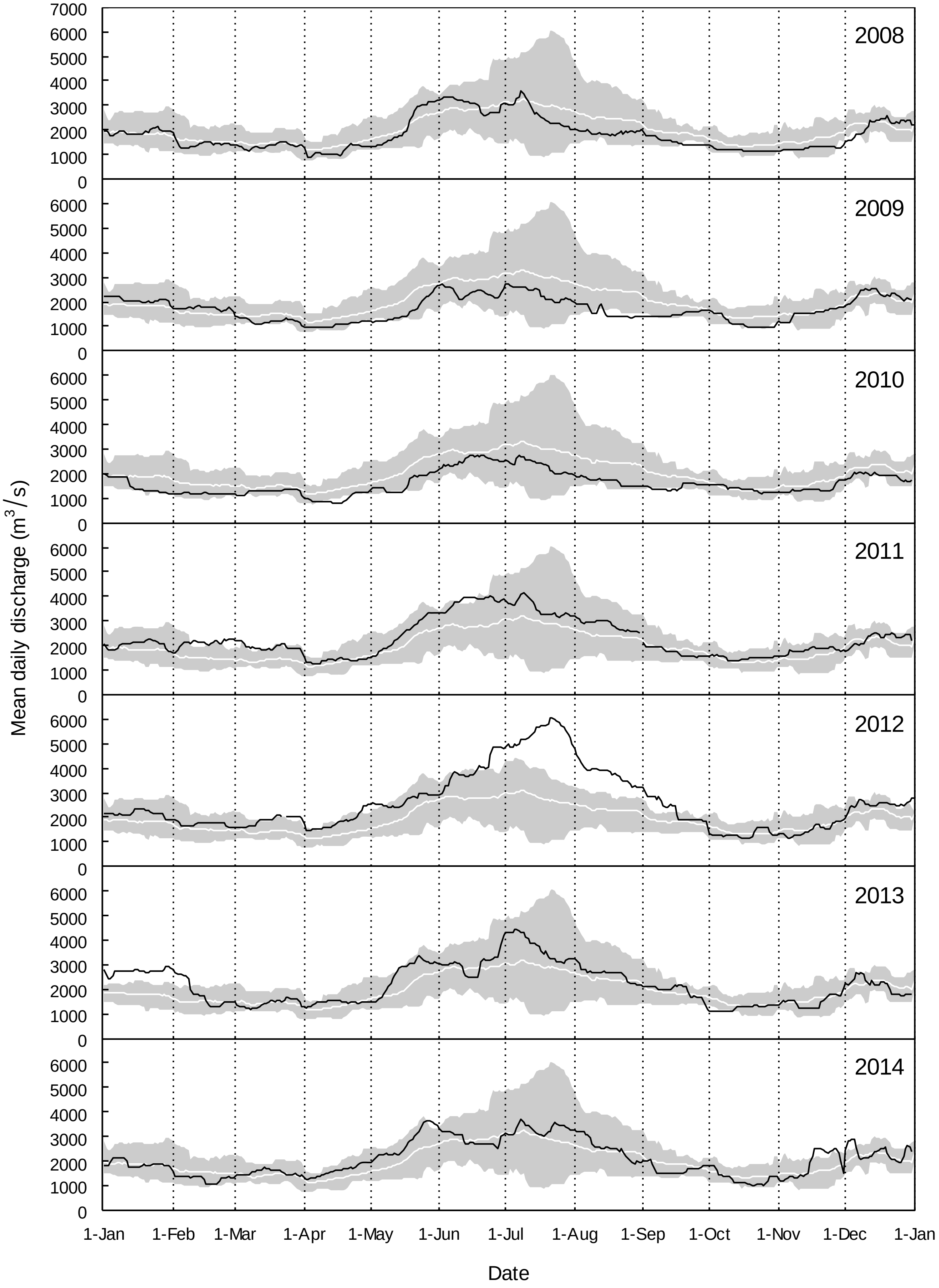
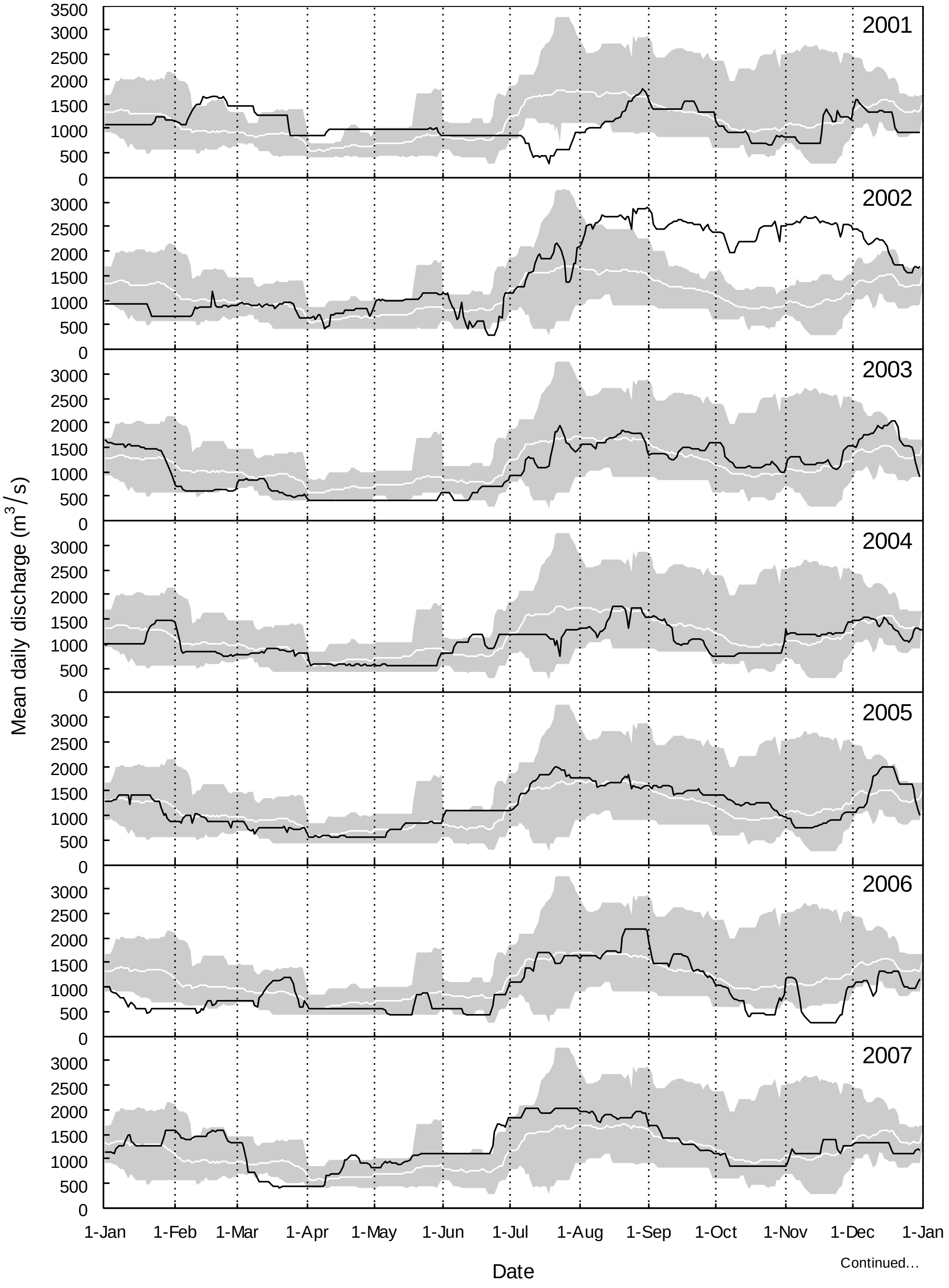


*Figure D1. Concluded.*



Continued...

*Figure D2. Mean daily discharge (m³/s) for the Columbia River at Hugh L. Keenleyside Dam (HLK), 2001 to 2014 (black line). The shaded area represents minimum and maximum mean daily discharge recorded at HLK during other study years between 2001 and 2014. The white line represents average mean daily discharge over the same time period.*

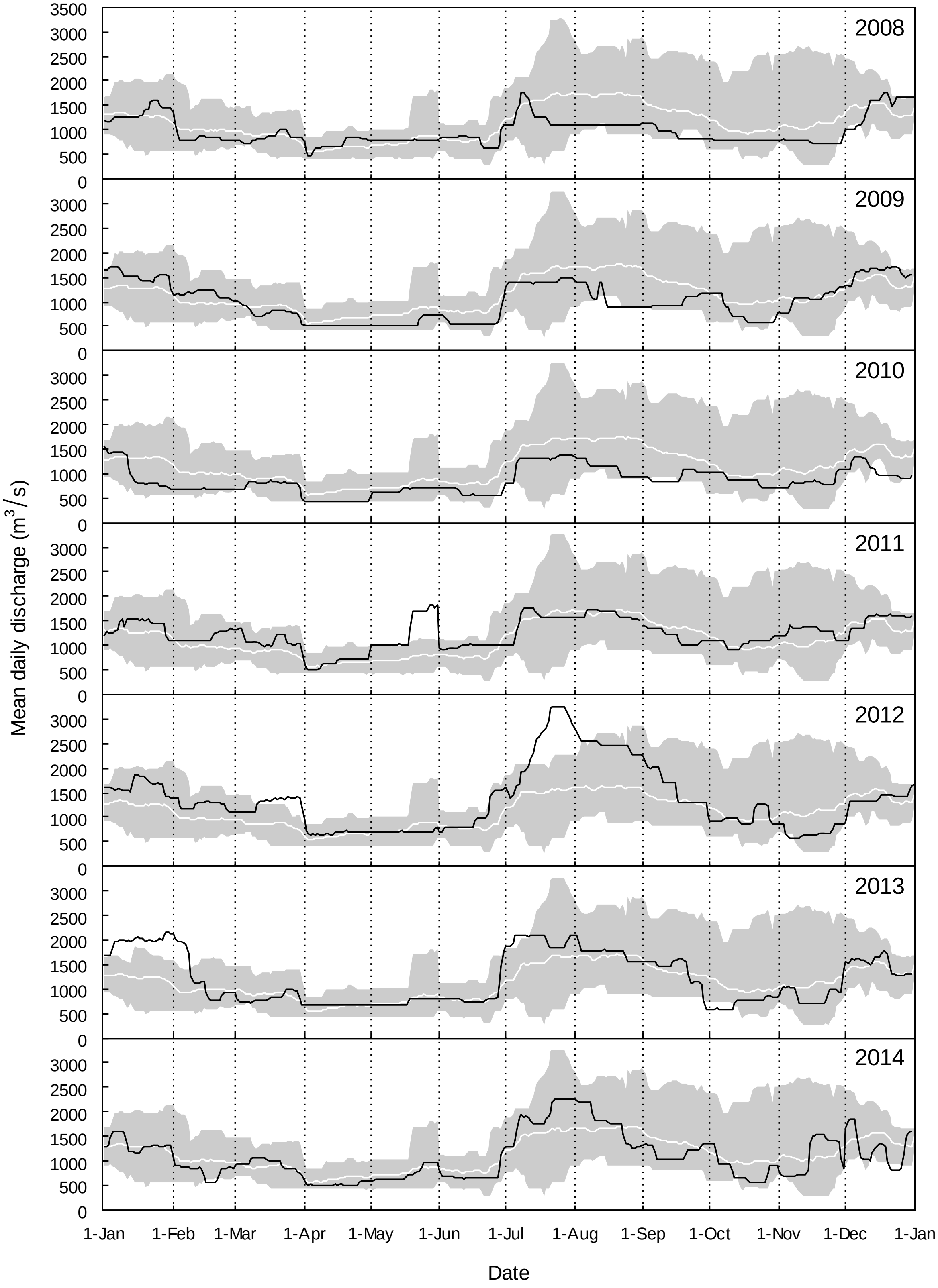
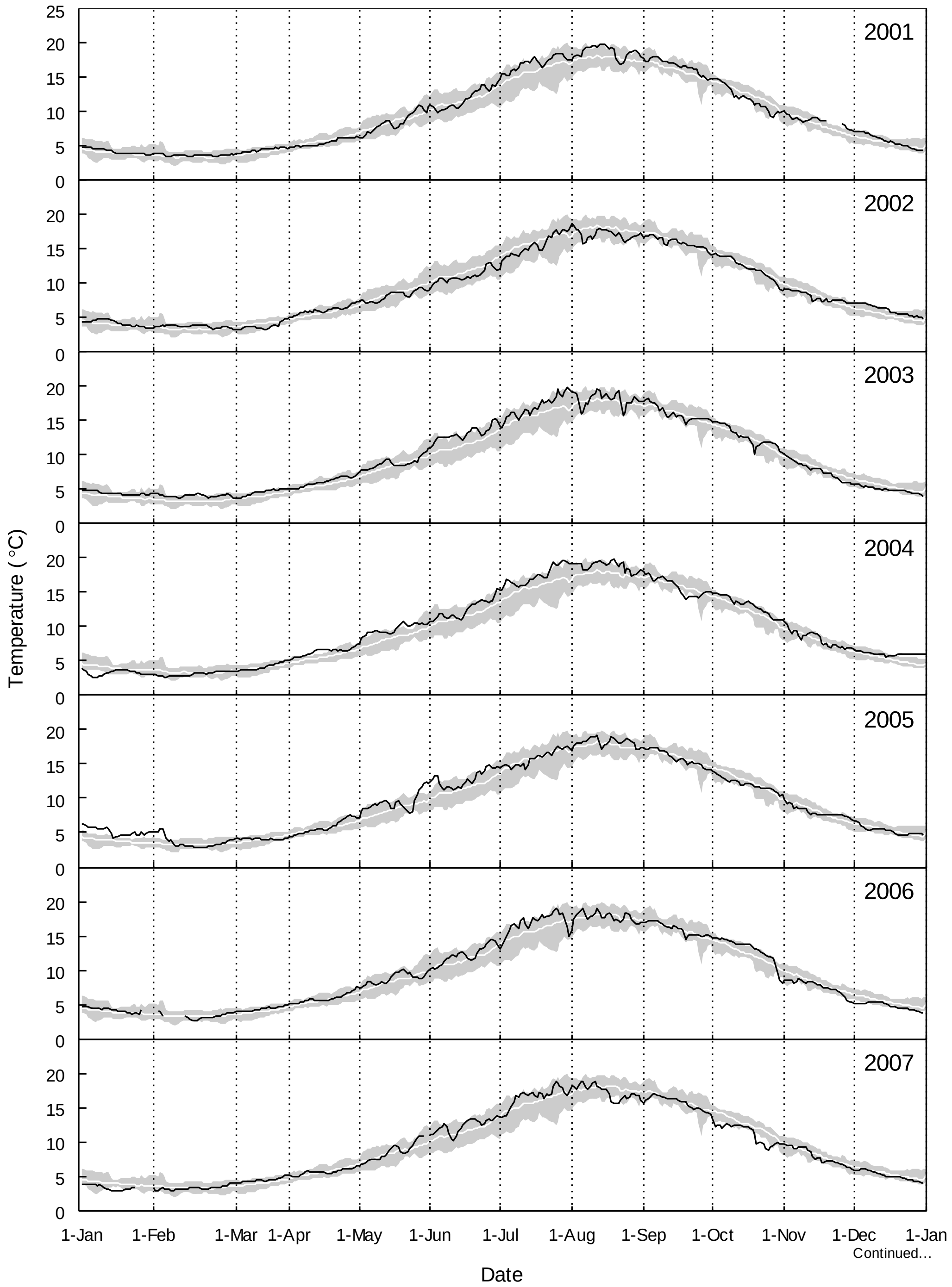


*Figure D2. Concluded.*



Continued…

*Figure D3. Mean daily water temperatures (°C) for the Columbia River (black line), 2001 to 2014. Data from all years except 2012 were recorded at the Birchbank water gauging station. Data from 2012 were recorded near Fort Shepherd. The shaded area represents minimum and maximum mean daily water temperatures during other study years between 2001 and 2014. The white line represents average mean daily water temperature over the same time period.*

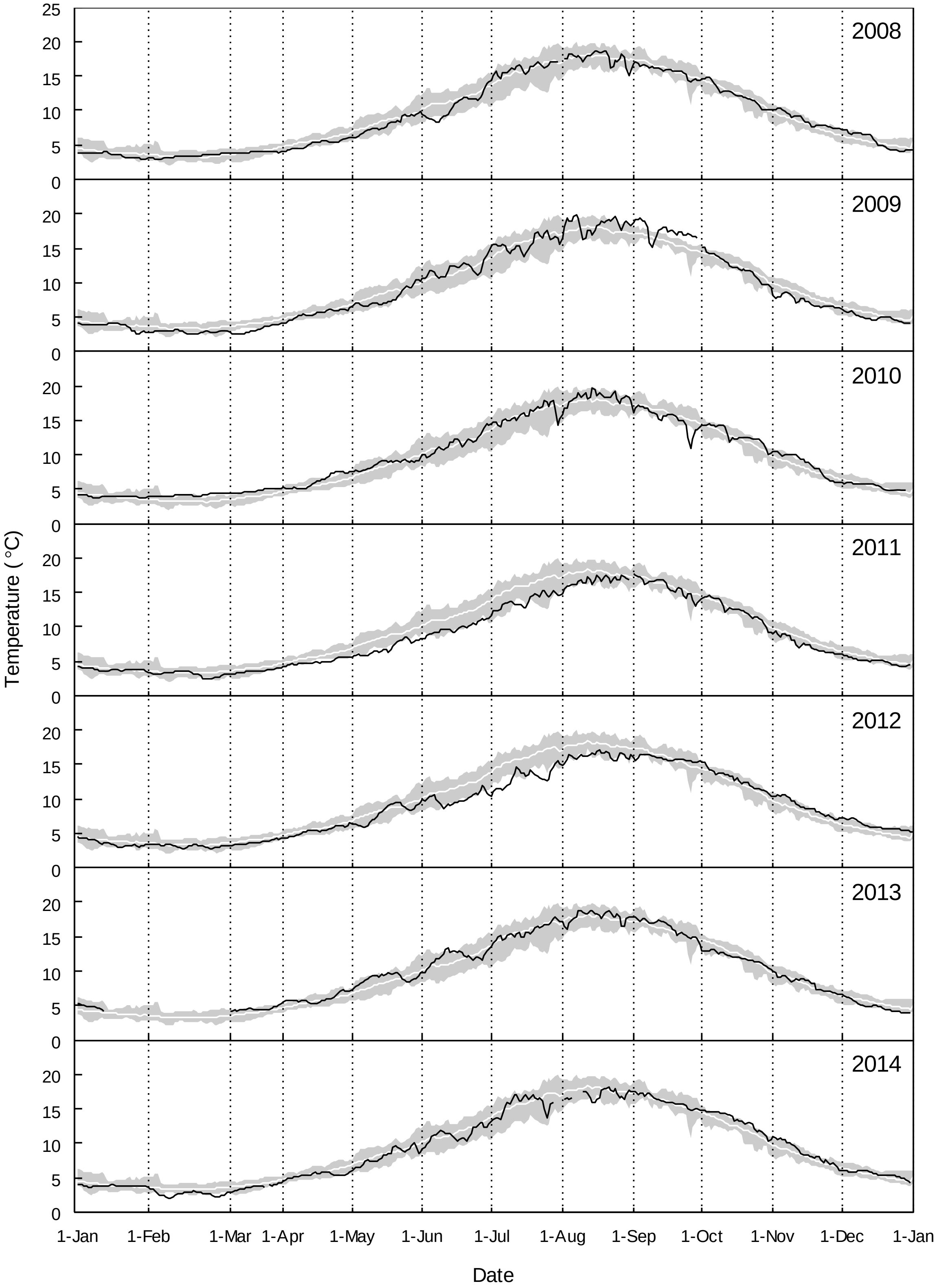
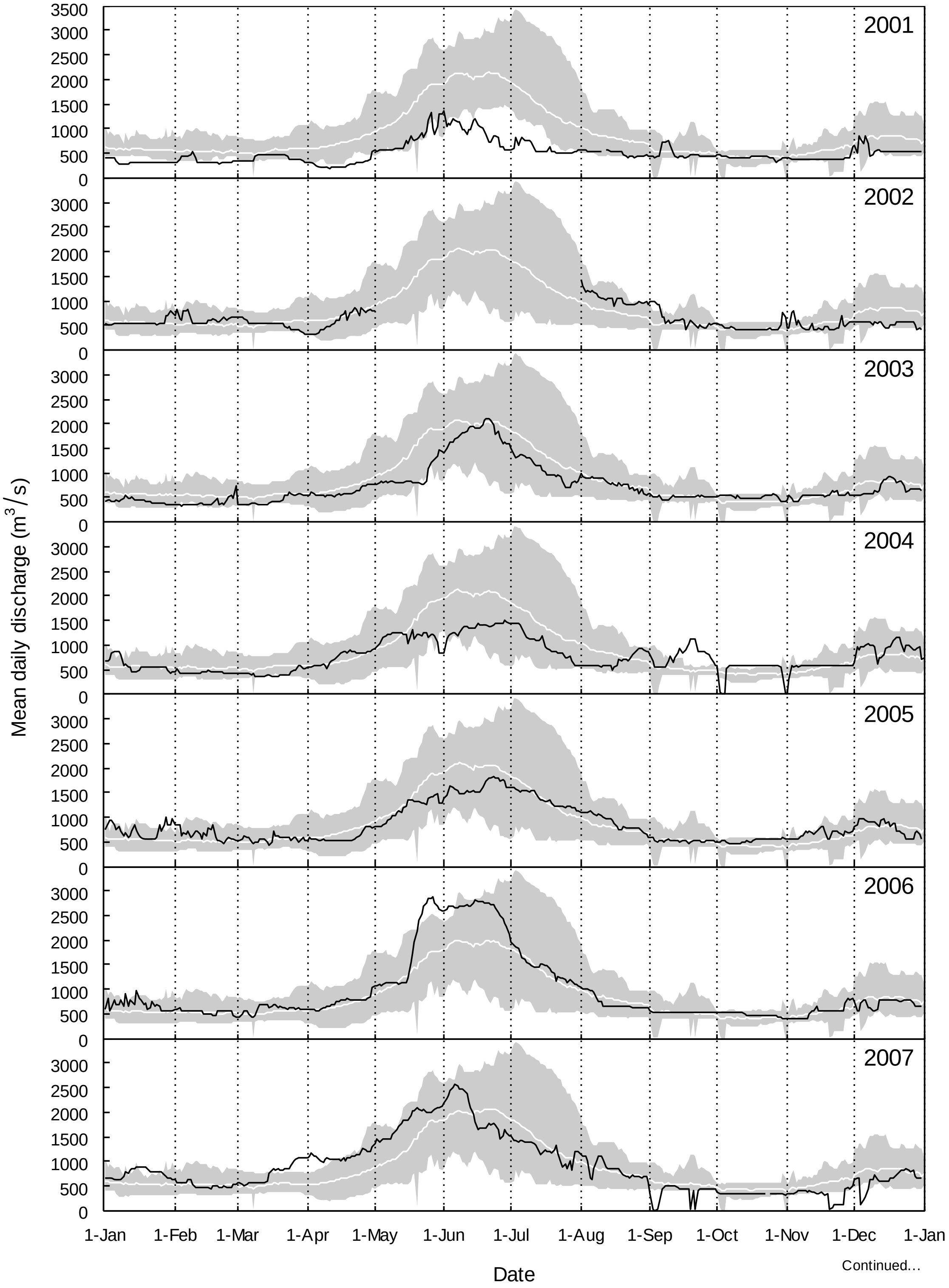


*Figure D3. Concluded.*



Continued…

*Figure D4. Mean daily discharge (m³/s) for the Kootenay River at Brilliant Dam (BRD), 2001 to 2014 (black line). The shaded area represents minimum and maximum mean daily discharge recorded at BRD during other study years between 2001 and 2014. The white line represents average mean daily discharge over the same time period.*

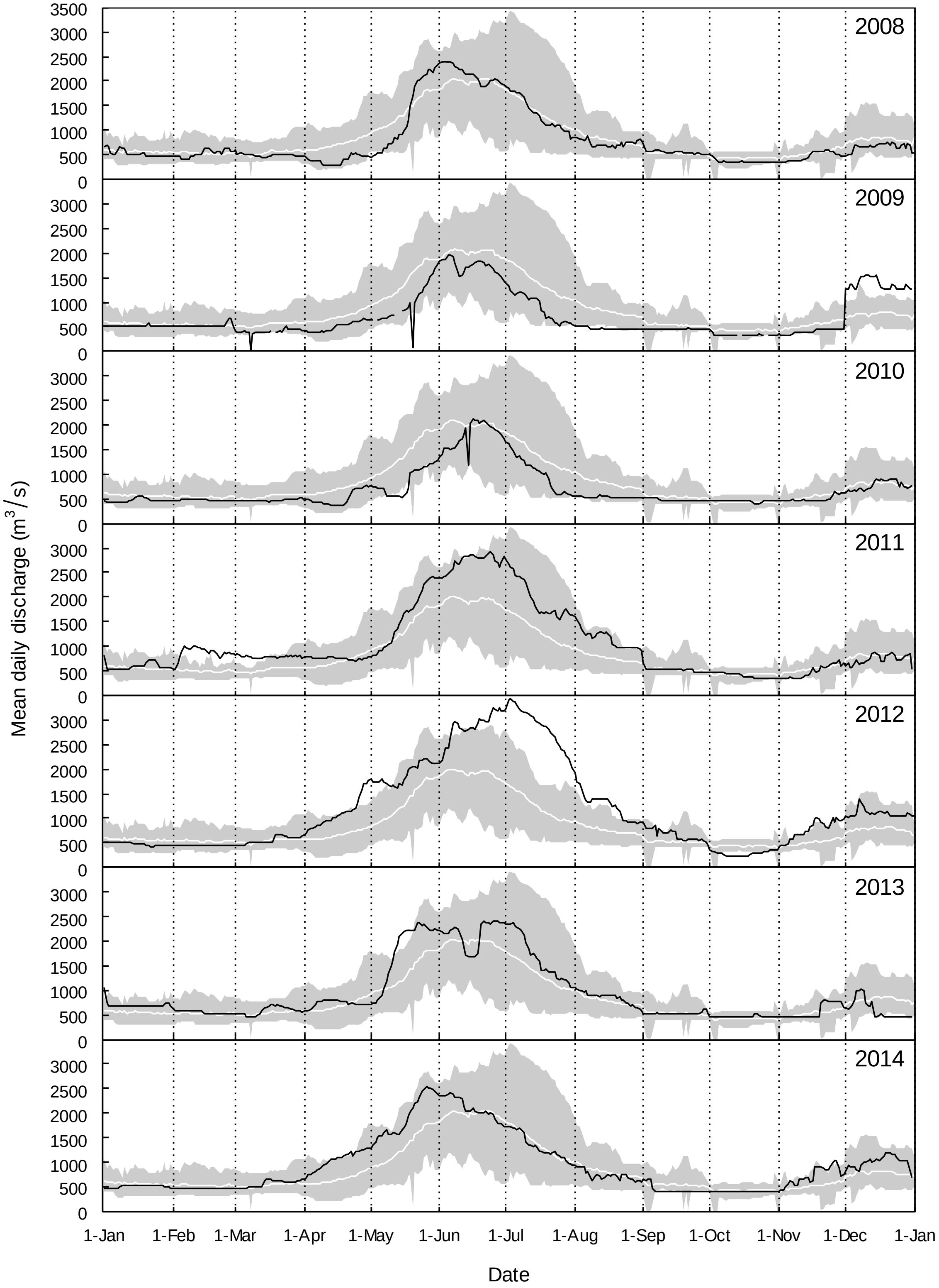
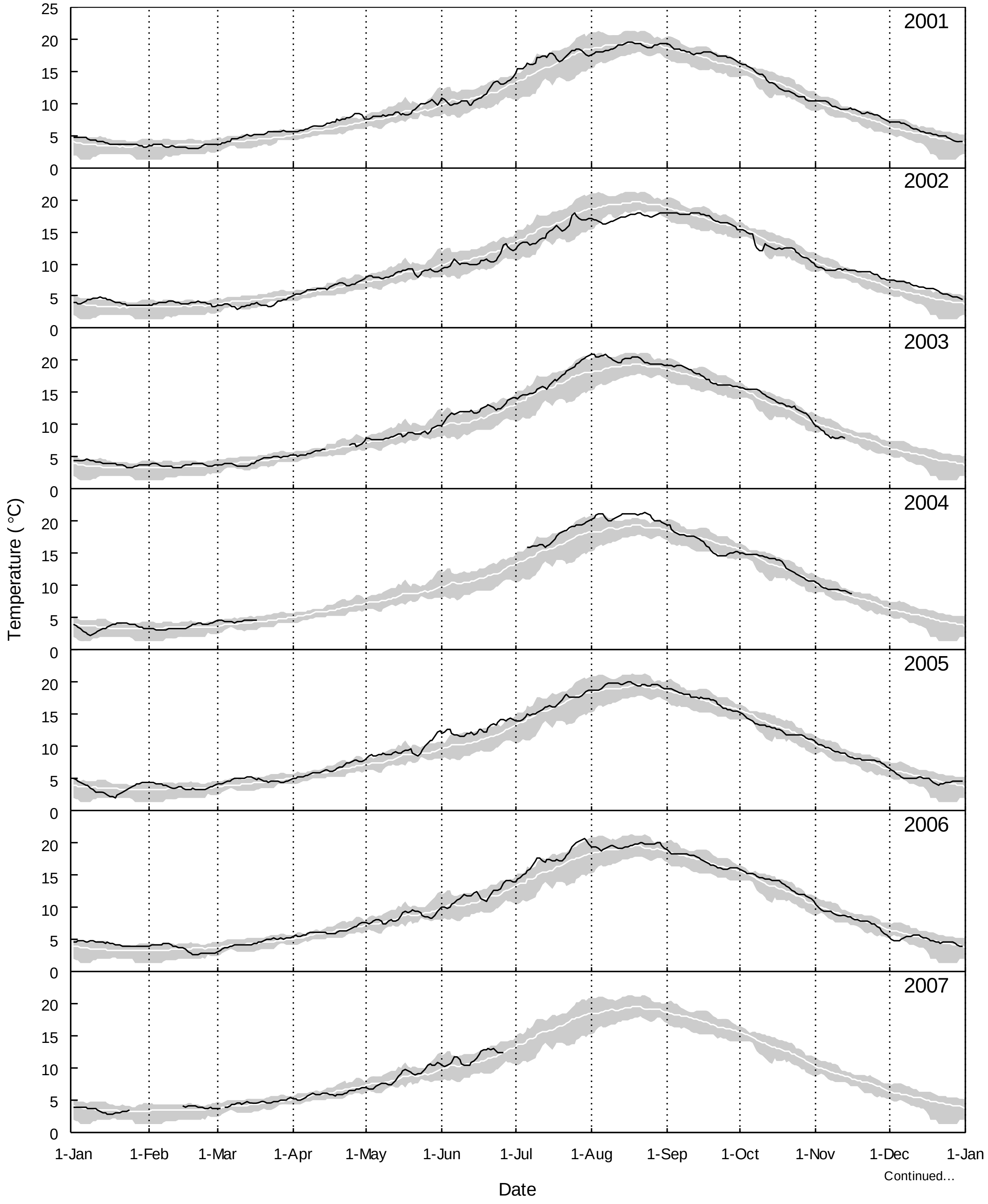


*Figure D4. Concluded.*



Continued…

*Figure D5. Mean daily water temperatures (°C) for the Kootenay River at Brilliant Dam (BRD), 2001 to 2014 (black line). The shaded area represents minimum and maximum mean daily water temperatures recorded at BRD during other study years between 2001 and 2014. The white line represents average mean daily water temperature over the same time period.*

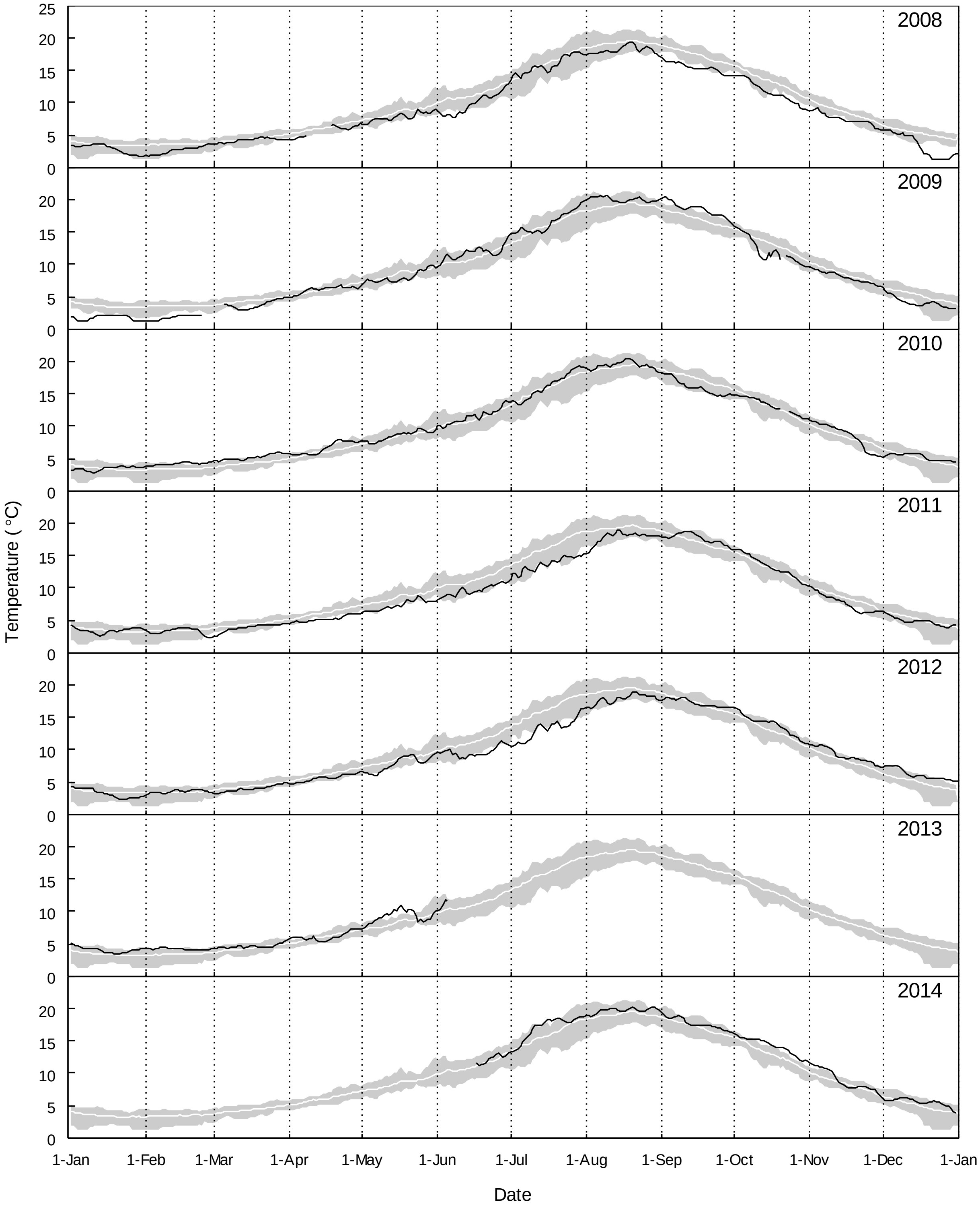


*Figure D5. Concluded.*

# 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 2014. Data include index sites only; all data from GRTS sites were removed.

| | 2001 | | 2002 | | 2003 | | 2004 | | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 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] | *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 | 17 | <1 | 137 | <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 | 5 | <1 | 41 | <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 | 4 | <1 | 152 | <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 | 20 | <1 | 1332 | 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 | 7 | <1 | 11 060 | 5 | 1 |
| Lake Trout | | | 1 | <1 | | | | | | | | | | | 1 | <1 | | | | | | | | | | | 1 | <1 | 3 | <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 | 70 | 1 | 2318 | 1 | |
| Largemouth Bass | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | <1 | 1 | <1 | |
| Mountain Whitefish | 14 916 | 52 | 10 678 | 49 | 8973 | 33 | 5974 | 38 | 5024 | 43 | 5472 | 40 | 5595 | 45 | 5221 | 44 | 3800 | 36 | 2748 | 30 | 2933 | 27 | 4648 | 41 | 4880 | 49 | 4020 | 53 | 84 882 | 42 | 11 |
| Northern Pike | | | | | | | | | | | | | | | | | | | 7 | <1 | 9 | <1 | 11 | <1 | 125 | 1 | 25 | <1 | 177 | <1 | |
| Rainbow Trout | 9425 | 33 | 9448 | 43 | 8132 | 30 | 5751 | 37 | 3845 | 33 | 5338 | 39 | 4953 | 39 | 5124 | 43 | 4219 | 40 | 4420 | 48 | 5501 | 51 | 5401 | 48 | 4110 | 41 | 2937 | 39 | 78 604 | 39 | 10 |
| Smallmouth Bass | | | | | 4 | <1 | 3 | <1 | 4 | <1 | 53 | <1 | 16 | <1 | 1 | <1 | | | 1 | <1 | 8 | <1 | | | | | 9 | <1 | 99 | <1 | |
| Walleye | 1467 | 5 | 1478 | 7 | 4165 | 16 | 3413 | 22 | 2230 | 19 | 1421 | 10 | 1076 | 9 | 1208 | 10 | 1127 | 11 | 1588 | 17 | 1814 | 17 | 881 | 8 | 752 | 8 | 484 | 6 | 23 104 | 11 | 3 |
| White Sturgeon | 14 | <1 | 6 | <1 | 18 | <1 | 6 | <1 | 11 | <1 | 14 | <1 | 11 | <1 | 9 | <1 | 4 | <1 | 11 | <1 | 23 | <1 | 9 | <1 | 7 | <1 | 13 | <1 | 156 | <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 | 21 949 | 100 | 26 789 | 100 | 15 651 | 100 | 11 596 | 100 | 13 727 | 100 | 12 572 | 100 | 11 961 | 100 | 10 521 | 100 | 9179 | 100 | 10 868 | 100 | 11 240 | 100 | 10 020 | 100 | 7613 | 100 | 202 157 | 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 | 64 | <1 | 12 112 | 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 | 25 | <1 | 1308 | <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 | 3437 | 26 | 111 354 | 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 | 7856 | 59 | 369 274 | 63 | 47 |
| Sucker spp.[e] | 6507 | 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 | 2029 | 15 | 94 954 | 16 | 12 |
| Tench | | | | | | | | | | | 1 | <1 | 5 | <1 | 1 | <1 | | | 2 | <1 | | | | | 2 | <1 | 1 | <1 | 12 | <1 | |
| **Non-sportfish subtotal** | 18 405 | 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 | 13 412 | 100 | 589 083 | 100 | 75 |
| **All species** | 46 876 | | 44 583 | | 54 966 | | 55 672 | | 44 021 | | 89 531 | | 72 156 | | 82 543 | | 42 463 | | 40 955 | | 51 794 | | 36 914 | | 107 741 | | 21 025 | | 791 240 | | |

[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 06 November 2014.

| Section | Session | Site | Date | Time Sampled (s) | Length Sampled (km) | Number Caught (CPUE = no. fish/km/hr) | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brook Trout | | Brown Trout | | Bull Trout | | Burbot | | Kokanee | | Lake Trout | | Lake Whitefish | | Largemouth Bass | | Mountain Whitefish | | Northern Pike | | Rainbow Trout | | Smallmouth Bass | | Walleye | | White Sturgeon | | 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 | No. | CPUE |
| Columbia River U/S | 1 | C00.0-R | 06-Oct-14 | 830 | 0.94 | | | | | | | | | | | | | | | | | 41 | 189.18 | | | 2 | 9.23 | | | 4 | 18.46 | | | 47 | 216.87 |
| | | C00.7-L | 06-Oct-14 | 618 | 0.59 | | | | | | | | | 1 | 9.87 | | | | | | | 56 | 552.9 | | | 5 | 49.37 | | | 1 | 9.87 | | | 63 | 622.02 |
| | | C01.3-L | 06-Oct-14 | 1644 | 1.6 | | | | | | | | | | | | | | | | | 133 | 182.03 | | | 7 | 9.58 | | | 22 | 30.11 | | | 162 | 221.72 |
| | | C02.8-L | 07-Oct-14 | 739 | 0.88 | | | | | 1 | 5.54 | | | | | | | | | | | 98 | 542.5 | | | | | | | 7 | 38.75 | | | 106 | 586.79 |
| | | C03.6-L | 07-Oct-14 | 1983 | 2.09 | | | | | | | | | 1 | 0.87 | | | | | | | 66 | 57.33 | | | 25 | 21.72 | | | 22 | 19.11 | | | 114 | 99.02 |
| | | C04.6-R | 07-Oct-14 | 491 | 0.52 | | | | | | | | | | | | | | | | | 3 | 42.3 | 4 | 56.4 | 6 | 84.6 | | | 6 | 84.6 | | | 19 | 267.9 |
| | | C05.6-L | 07-Oct-14 | 882 | 1.1 | | | | | | | | | | | | | | | | | 6 | 22.26 | | | 17 | 63.08 | | | 5 | 18.55 | | | 28 | 103.9 |
| | | C07.3-R | 08-Oct-14 | 1063 | 1.7 | | | | | | | | | | | | | | | | | 71 | 141.44 | | | 31 | 61.76 | | | 5 | 9.96 | | | 107 | 213.16 |
| | | C07.4-L | 08-Oct-14 | 969 | 1 | | | | | | | | | | | | | | | | | 131 | 486.69 | | | 13 | 48.3 | | | 5 | 18.58 | 2 | 7.43 | 151 | 560.99 |
| | **Session Summary** | | | **1024** | **10.4** | **0** | ***0*** | **0** | ***0*** | **1** | ***0.34*** | **0** | ***0*** | **2** | ***0.68*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **605** | ***204.51*** | **4** | ***1.35*** | **106** | ***35.83*** | **0** | ***0*** | **77** | ***26.03*** | **2** | ***0.68*** | **797** | ***269.42*** |
| | 2 | C00.0-R | 15-Oct-14 | 901 | 0.94 | | | | | | | | | | | | | | | | | 16 | 68.01 | | | 12 | 51.01 | | | 5 | 21.25 | | | 33 | 140.27 |
| | | C00.7-L | 15-Oct-14 | 540 | 0.59 | | | | | 1 | 11.3 | | | | | | | | | | | 56 | 632.77 | | | 7 | 79.1 | | | 5 | 56.5 | | | 69 | 779.66 |
| | | C01.3-L | 15-Oct-14 | 1563 | 1.6 | | | | | | | | | | | | | | | | | 230 | 331.09 | 3 | 4.32 | 14 | 20.15 | | | 11 | 15.83 | | | 258 | 371.4 |
| | | C02.8-L | 15-Oct-14 | 830 | 0.88 | | | | | | | | | | | | | | | | | 50 | 246.44 | 1 | 4.93 | 7 | 34.5 | | | 11 | 54.22 | | | 69 | 340.09 |
| | | C03.6-L | 16-Oct-14 | 1964 | 2.06 | | | | | | | | | | | | | | | | | 178 | 158.38 | 3 | 2.67 | 26 | 23.13 | | | 8 | 7.12 | | | 215 | 191.31 |
| | | C04.6-R | 16-Oct-14 | 536 | 0.52 | | | | | | | | | | | | | | | | | 14 | 180.83 | 1 | 12.92 | 5 | 64.58 | | | 5 | 64.58 | | | 25 | 322.9 |
| | | C05.6-L | 16-Oct-14 | 1114 | 1.1 | | | | | | | | | | | | | | | | | 29 | 85.2 | 3 | 8.81 | 14 | 41.13 | | | 6 | 17.63 | | | 52 | 152.77 |
| | | C07.3-R | 17-Oct-14 | 1018 | 1.63 | | | | | | | | | | | | | | | | | 95 | 206.11 | | | 40 | 86.78 | | | 1 | 2.17 | | | 136 | 295.06 |
| | | C07.4-L | 17-Oct-14 | 1009 | 1 | | | | | | | | | | | | | | | | | 160 | 570.86 | | | 9 | 32.11 | | | 1 | 3.57 | | | 170 | 606.54 |
| | **Session Summary** | | | **1053** | **10.3** | **0** | ***0*** | **0** | ***0*** | **1** | ***0.33*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **828** | ***274.83*** | **11** | ***3.65*** | **134** | ***44.48*** | **0** | ***0*** | **53** | ***17.59*** | **0** | ***0*** | **1027** | ***340.88*** |
| | 3 | C00.0-R | 21-Oct-14 | 1100 | 0.94 | | | | | | | | | | | | | | | | | 10 | 34.82 | | | 7 | 24.37 | | | | | | | 17 | 59.19 |
| | | C00.7-L | 21-Oct-14 | 449 | 0.49 | | | | | | | | | | | | | | | | | 26 | 425.44 | | | 3 | 49.09 | | | 2 | 32.73 | | | 31 | 507.25 |
| | | C01.3-L | 21-Oct-14 | 1250 | 1.6 | | | | | | | | | 1 | 1.8 | | | | | | | 140 | 252 | 2 | 3.6 | 23 | 41.4 | | | 3 | 5.4 | 1 | 1.8 | 170 | 306 |
| | | C02.8-L | 21-Oct-14 | 842 | 0.88 | | | | | | | | | | | | | | | | | 25 | 121.46 | 2 | 9.72 | 6 | 29.15 | | | 1 | 4.86 | | | 34 | 165.19 |
| | | C03.6-L | 22-Oct-14 | 2595 | 2.09 | | | | | | | 1 | 0.66 | | | | | | | | | 52 | 34.52 | 2 | 1.33 | 8 | 5.31 | | | 5 | 3.32 | | | 68 | 45.14 |
| | | C04.6-R | 22-Oct-14 | 561 | 0.52 | | | | | | | | | | | | | | | | | | | | | 4 | 49.36 | | | 3 | 37.02 | | | 7 | 86.38 |
| | | C05.6-L | 22-Oct-14 | 1076 | 1.1 | | | | | | | | | | | | | | | | | 7 | 21.29 | | | 6 | 18.25 | | | 1 | 3.04 | | | 14 | 42.58 |
| | | C07.3-R | 22-Oct-14 | 999 | 1.7 | | | | | | | | | | | | | | | | | 62 | 131.43 | | | 31 | 65.71 | | | 2 | 4.24 | | | 95 | 201.38 |
| | | C07.4-L | 22-Oct-14 | 967 | 1 | | | | | | | | | | | | | | | | | 142 | 528.65 | | | 6 | 22.34 | | | 4 | 14.89 | 1 | 3.72 | 153 | 569.6 |
| | **Session Summary** | | | **1093** | **10.3** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **1** | ***0.32*** | **1** | ***0.32*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **464** | ***148.38*** | **6** | ***1.92*** | **94** | ***30.06*** | **0** | ***0*** | **21** | ***6.72*** | **2** | ***0.64*** | **589** | ***188.35*** |
| | 4 | C00.0-R | 28-Oct-14 | 1021 | 0.94 | | | | | | | | | | | | | | | | | 6 | 22.51 | | | 5 | 18.76 | | | 5 | 18.76 | | | 16 | 60.02 |
| | | C00.7-L | 28-Oct-14 | 606 | 0.59 | | | | | | | | | | | | | | | | | 24 | 241.65 | | | 6 | 60.41 | | | 4 | 40.28 | | | 34 | 342.34 |
| | | C01.3-L | 28-Oct-14 | 1931 | 1.6 | | | | | | | | | 3 | 3.5 | | | | | | | 73 | 85.06 | 1 | 1.17 | 23 | 26.8 | | | 10 | 11.65 | | | 110 | 128.17 |
| | | C02.8-L | 29-Oct-14 | 821 | 0.87 | | | | | | | | | | | | | | | | | 8 | 40.32 | | | 2 | 10.08 | | | 3 | 15.12 | | | 13 | 65.52 |
| | | C03.6-L | 29-Oct-14 | 2473 | 2.06 | | | | | | | | | | | | | | | | | 16 | 11.31 | | | 14 | 9.89 | | | 5 | 3.53 | | | 35 | 24.73 |
| | | C04.6-R | 29-Oct-14 | 732 | 0.52 | | | | | | | | | | | | | | | | | | | | | 9 | 85.12 | | | | | | | 9 | 85.12 |
| | | C05.6-L | 29-Oct-14 | 1137 | 1.07 | | | | | | | | | | | | | | | | | | | | | 10 | 29.59 | | | 1 | 2.96 | | | 11 | 32.55 |
| | | C07.3-R | 02-Nov-14 | 1148 | 1.7 | 1 | 1.84 | | | | | | | | | | | 5 | 9.22 | | | 64 | 118.06 | | | 25 | 46.12 | | | 7 | 12.91 | | | 102 | 188.15 |
| | | C07.4-L | 02-Nov-14 | 975 | 1 | | | | | | | 1 | 3.69 | 1 | 3.69 | | | 5 | 18.46 | | | 84 | 310.15 | | | 21 | 77.54 | | | 2 | 7.38 | 2 | 7.38 | 116 | 428.31 |
| | **Session Summary** | | | **1205** | **10.3** | **1** | ***0.29*** | **0** | ***0*** | **0** | ***0*** | **1** | ***0.29*** | **4** | ***1.16*** | **0** | ***0*** | **10** | ***2.9*** | **0** | ***0*** | **275** | ***79.76*** | **1** | ***0.29*** | **115** | ***33.36*** | **0** | ***0*** | **37** | ***10.73*** | **2** | ***0.58*** | **446** | ***129.36*** |
| | 5 | C08.4-L | 06-Nov-14 | 386 | 0.5 | | | | | | | | | | | | | 12 | 223.83 | | | 86 | 1604.15 | | | 13 | 242.49 | | | | | 1 | 18.65 | 112 | 2089.12 |
| | **Session Summary** | | | **386** | **0.5** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **12** | ***223.83*** | **0** | ***0*** | **86** | ***1604.15*** | **0** | ***0*** | **13** | ***242.49*** | **0** | ***0*** | **0** | ***0*** | **1** | ***18.65*** | **112** | ***2089.12*** |
| **Section Total All Samples** | | | | **39763** | **41.91** | **1** | | **0** | | **2** | | **2** | | **7** | | **0** | | **22** | | **0** | | **2258** | | **22** | | **462** | | **0** | | **188** | | **7** | | **2971** | |
| **Section Average All Samples** | | | | **1075** | **1.13** | **0** | ***0.08*** | **0** | ***0*** | **0** | ***0.16*** | **0** | ***0.16*** | **0** | ***0.56*** | **0** | ***0*** | **1** | ***1.76*** | **0** | ***0*** | **61** | ***180.43*** | **1** | ***1.76*** | **12** | ***36.92*** | **0** | ***0*** | **5** | ***15.02*** | **0** | ***0.56*** | **80** | ***237.4*** |
| **Section Standard Error of Mean** | | | | | | **0.03** | ***0.05*** | **0** | ***0*** | **0.04** | ***0.34*** | **0.04** | ***0.1*** | **0.09** | ***0.3*** | **0** | ***0*** | **0.37** | ***6.05*** | **0** | ***0*** | **9.48** | ***49.12*** | **0.18** | ***1.57*** | **1.59** | ***6.8*** | **0** | ***0*** | **0.83** | ***3.28*** | **0.09** | ***0.57*** | **10.53** | ***59.31*** |

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 | | Kokanee | | Lake Trout | | Lake Whitefish | | Largemouth Bass | | Mountain Whitefish | | Northern Pike | | Rainbow Trout | | Smallmouth Bass | | Walleye | | White Sturgeon | | 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 | No. | CPUE |
| Kootenay River | 1 | K00.3-L | 07-Oct-14 | 197 | 0.44 | | | | | | | | | | | | | | | | | 8 | ***332.26*** | | | 1 | ***41.53*** | | | | | | | 9 | ***373.79*** |
| | | K00.6-R | 07-Oct-14 | 508 | 0.6 | | | | | | | | | | | | | | | 1 | ***11.81*** | 11 | ***129.92*** | | | 6 | ***70.87*** | | | 8 | ***94.49*** | | | 26 | ***307.09*** |
| | | K01.8-L | 07-Oct-14 | 1312 | 1.85 | | | | | | | | | | | | | | | | | 37 | ***54.88*** | | | 23 | ***34.11*** | | | 12 | ***17.8*** | 1 | ***1.48*** | 73 | ***108.27*** |
| | | K01.8-R | 07-Oct-14 | 1019 | 1.3 | | | | | | | | | | | | | | | | | 104 | ***282.63*** | | | 25 | ***67.94*** | | | 9 | ***24.46*** | | | 138 | ***375.03*** |
| | **Session Summary** | | | **759** | **4.2** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **1** | ***1.13*** | **160** | ***180.69*** | **0** | ***0*** | **55** | ***62.11*** | **0** | ***0*** | **29** | ***32.75*** | **1** | ***1.13*** | **246** | ***277.81*** |
| | 2 | K00.3-L | 16-Oct-14 | 190 | 0.44 | | | | | | | | | | | | | | | | | 11 | ***473.68*** | | | 11 | ***473.68*** | | | 2 | ***86.12*** | | | 24 | ***1033.49*** |
| | | K00.6-R | 16-Oct-14 | 504 | 0.6 | | | | | | | | | | | | | | | | | 14 | ***166.67*** | | | 7 | ***83.33*** | | | 4 | ***47.62*** | | | 25 | ***297.62*** |
| | | K01.8-L | 16-Oct-14 | 1332 | 1.87 | | | | | | | | | | | | | | | | | 59 | ***85.27*** | 1 | ***1.45*** | 26 | ***37.58*** | | | 9 | ***13.01*** | 2 | ***2.89*** | 97 | ***140.19*** |
| | | K01.8-R | 16-Oct-14 | 957 | 1.3 | | | | | | | | | | | | | | | | | 113 | ***326.98*** | | | 18 | ***52.09*** | | | 1 | ***2.89*** | | | 132 | ***381.96*** |
| | **Session Summary** | | | **746** | **4.2** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **197** | ***226.35*** | **1** | ***1.15*** | **62** | ***71.24*** | **0** | ***0*** | **16** | ***18.38*** | **2** | ***2.3*** | **278** | ***319.42*** |
| | 3 | K00.3-L | 24-Oct-14 | 235 | 0.44 | 1 | ***34.82*** | | | | | | | | | | | | | | | 9 | ***313.35*** | | | 7 | ***243.71*** | | | 1 | ***34.82*** | | | 18 | ***626.69*** |
| | | K00.6-R | 23-Oct-14 | 493 | 0.6 | | | | | | | | | | | | | | | | | 44 | ***535.5*** | 1 | ***12.17*** | 9 | ***109.53*** | | | 7 | ***85.19*** | | | 61 | ***742.39*** |
| | | K01.8-L | 23-Oct-14 | 1223 | 1.8 | | | | | | | | | | | | | | | | | 72 | ***117.74*** | | | 19 | ***31.07*** | | | 6 | ***9.81*** | | | 97 | ***158.63*** |
| | | K01.8-R | 23-Oct-14 | 1024 | 1.3 | | | | | | | | | | | | | | | | | 111 | ***300.18*** | | | 30 | ***81.13*** | | | 7 | ***18.93*** | | | 148 | ***400.24*** |
| | **Session Summary** | | | **744** | **4.1** | **1** | ***1.18*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **236** | ***278.52*** | **1** | ***1.18*** | **65** | ***76.71*** | **0** | ***0*** | **21** | ***24.78*** | **0** | ***0*** | **324** | ***382.38*** |
| | 4 | K00.3-L | 03-Nov-14 | 228 | 0.44 | | | | | | | | | | | | | | | | | 28 | ***1004.78*** | | | | | | | | | | | 28 | ***1004.78*** |
| | | K00.6-R | 03-Nov-14 | 561 | 0.6 | | | | | | | | | | | | | | | | | 48 | ***513.37*** | 1 | ***10.7*** | 3 | ***32.09*** | | | | | 2 | ***21.39*** | 54 | ***577.54*** |
| | | K01.8-L | 03-Nov-14 | 1501 | 1.87 | | | | | | | | | | | | | | | | | 134 | ***171.86*** | | | 20 | ***25.65*** | | | 7 | ***8.98*** | | | 161 | ***206.49*** |
| | | K01.8-R | 02-Nov-14 | 1131 | 1.3 | | | | | | | | | | | | | 10 | ***24.48*** | | | 134 | ***328.1*** | | | 25 | ***61.21*** | | | 1 | ***2.45*** | | | 170 | ***416.24*** |
| | **Session Summary** | | | **855** | **4.2** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **10** | ***10.03*** | **0** | ***0*** | **344** | ***344.86*** | **1** | ***1*** | **48** | ***48.12*** | **0** | ***0*** | **8** | ***8.02*** | **2** | ***2.01*** | **413** | ***414.04*** |
| **Section Total All Samples** | | | | **12415** | **16.75** | **1** | | **0** | | **0** | | **0** | | **0** | | **0** | | **10** | | **1** | | **937** | | **3** | | **230** | | **0** | | **74** | | **5** | | **1261** | |
| **Section Average All Samples** | | | | **776** | **1.05** | **0** | ***0.28*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **1** | ***2.77*** | **0** | ***0.28*** | **59** | ***259.52*** | **0** | ***0.83*** | **14** | ***63.7*** | **0** | ***0*** | **5** | ***20.5*** | **0** | ***1.38*** | **79** | ***349.25*** |
| **Section Standard Error of Mean** | | | | | | **0.06** | ***2.18*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0** | ***0*** | **0.62** | ***1.53*** | **0.06** | ***0.74*** | **11.65** | ***58.68*** | **0.1** | ***0.97*** | **2.48** | ***28.99*** | **0** | ***0*** | **0.99** | ***8.23*** | **0.18** | ***1.33*** | **14.09** | ***70.75*** |

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 | | Kokanee | | Lake Trout | | Lake Whitefish | | Largemouth Bass | | Mountain Whitefish | | Northern Pike | | Rainbow Trout | | Smallmouth Bass | | Walleye | | White Sturgeon | | 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 | No. | CPUE |
| Columbia River D/S | 1 | C25.3-R | 14-Oct-14 | 1489 | 2.73 | | | | | | | | | | | | | | | | | 58 | 51.37 | | | 82 | 72.62 | | | 4 | 3.54 | | | 144 | 127.53 |
| | | C27.6-R | 14-Oct-14 | 326 | 0.61 | | | | | | | | | | | | | | | | | 8 | 144.83 | | | 14 | 253.44 | | | 1 | 18.1 | | | 23 | 416.37 |
| | | C28.2-R | 14-Oct-14 | 1021 | 1.13 | | | | | | | | | | | | | | | | | 33 | 102.97 | | | 39 | 121.69 | | | 1 | 3.12 | | | 73 | 227.78 |
| | | C34.9-L | 08-Oct-14 | 1826 | 2.14 | | | | | | | | | | | | | | | | | 12 | 11.06 | | | 132 | 121.61 | | | 4 | 3.69 | | | 148 | 136.35 |
| | | C36.6-L | 09-Oct-14 | 1337 | 2.34 | | | | | | | | | | | | | 2 | 2.3 | | | 14 | 16.11 | | | 89 | 102.41 | | | 8 | 9.21 | | | 113 | 130.03 |
| | | C47.8-L | 08-Oct-14 | 1068 | 1.44 | 4 | 9.36 | | | | | | | | | | | 2 | 4.68 | | | 18 | 42.13 | | | 70 | 163.86 | | | 13 | 30.43 | | | 107 | 250.47 |
| | | C48.2-R | 11-Oct-14 | 822 | 1.01 | | | | | | | | | | | | | | | | | 9 | 39.03 | | | 29 | 125.75 | | | 4 | 17.34 | | | 42 | 182.12 |
| | | C49.0-L | 09-Oct-14 | 687 | 0.93 | | | | | | | | | | | | | | | | | 30 | 169.04 | | | 32 | 180.31 | | | 4 | 22.54 | | | 66 | 371.88 |
| | | C49.0-R | 11-Oct-14 | 327 | 0.72 | | | | | | | | | | | | | | | | | 12 | 183.49 | | | 25 | 382.26 | | | | | | | 37 | 565.75 |
| | | C49.8-L | 09-Oct-14 | 1450 | 2.45 | | | | | | | 1 | 1.01 | | | | | | | | | 45 | 45.6 | | | 50 | 50.67 | 1 | 1.01 | 1 | 1.01 | | | 98 | 99.31 |
| | | C49.8-R | 11-Oct-14 | 1211 | 2.39 | | | | | | | | | | | | | | | | | 55 | 68.41 | | | 31 | 38.56 | | | 3 | 3.73 | | | 89 | 110.7 |
| | | C52.2-L | 09-Oct-14 | 759 | 0.89 | | | | | | | | | | | | | 1 | 5.33 | | | 2 | 10.66 | | | 14 | 74.61 | | | 2 | 10.66 | | | 19 | 101.26 |
| | | C52.2-R | 12-Oct-14 | 2266 | 3.79 | | | | | | | | | | | | | | | | | 30 | 12.58 | | | 42 | 17.61 | | | 6 | 2.52 | | | 78 | 32.7 |
| | | C52.8-L | 09-Oct-14 | 428 | 0.89 | | | | | | | | | | | | | | | | | | | | | 13 | 122.86 | | | | | | | 13 | 122.86 |
| | | C53.6-L | 10-Oct-14 | 1169 | 1.52 | | | | | | | | | | | | | | | | | | | | | 19 | 38.49 | 3 | 6.08 | 2 | 4.05 | | | 24 | 48.62 |
| | **Session Summary** | | | **1079** | **25** | **4** | **0.53** | **0** | **0** | **0** | **0** | **1** | **0.13** | **0** | **0** | **0** | **0** | **5** | **0.67** | **0** | **0** | **326** | **43.51** | **0** | **0** | **681** | **90.88** | **4** | **0.53** | **53** | **7.07** | **0** | **0** | **1074** | **143.33** |
| | 2 | C25.3-R | 19-Oct-14 | 1435 | 2.73 | | | | | | | | | | | | | | | | | 13 | 11.95 | | | 33 | 30.33 | | | 4 | 3.68 | | | 50 | 45.95 |
| | | C27.6-R | 19-Oct-14 | 300 | 0.61 | | | | | | | | | | | | | | | | | 16 | 314.75 | | | 28 | 550.82 | | | | | | | 44 | 865.57 |
| | | C28.2-R | 19-Oct-14 | 678 | 1.13 | | | | | | | | | | | | | | | | | 3 | 14.1 | | | 29 | 136.27 | | | 1 | 4.7 | | | 33 | 155.06 |
| | | C34.9-L | 20-Oct-14 | 1681 | 2.14 | | | | | | | 1 | 1 | | | | | | | | | 5 | 5 | | | 69 | 69.05 | | | 2 | 2 | | | 77 | 77.06 |
| | | C36.6-L | 20-Oct-14 | 1345 | 2.39 | | | 1 | 1.12 | | | | | | | | | | | | | 12 | 13.44 | | | 67 | 75.03 | | | 2 | 2.24 | | | 82 | 91.83 |
| | | C47.8-L | 18-Oct-14 | 844 | 1.44 | | | | | | | | | | | | | | | | | 5 | 14.81 | | | 21 | 62.2 | | | 10 | 29.62 | | | 36 | 106.64 |
| | | C48.2-R | 17-Oct-14 | 891 | 1.01 | | | | | | | | | | | | | | | | | 6 | 24 | | | 25 | 100.01 | 1 | 4 | 7 | 28 | | | 39 | 156.02 |
| | | C49.0-L | 18-Oct-14 | 628 | 0.93 | 1 | 6.16 | | | | | | | | | | | 5 | 30.82 | | | 17 | 104.79 | | | 28 | 172.59 | | | 6 | 36.98 | | | 57 | 351.35 |
| | | C49.0-R | 17-Oct-14 | 377 | 0.72 | | | | | | | | | | | | | 1 | 13.26 | | | 5 | 66.31 | | | 5 | 66.31 | | | | | | | 11 | 145.89 |
| | | C49.8-L | 18-Oct-14 | 1600 | 2.45 | 1 | 0.92 | | | | | 2 | 1.84 | | | | | | | | | 59 | 54.18 | | | 54 | 49.59 | 1 | 0.92 | 3 | 2.76 | | | 120 | 110.2 |
| | | C49.8-R | 17-Oct-14 | 1246 | 2.39 | | | | | | | | | | | | | | | | | 23 | 27.8 | | | 27 | 32.64 | | | 6 | 7.25 | | | 56 | 67.7 |
| | | C52.2-L | 19-Oct-14 | 714 | 0.89 | | | 1 | 5.67 | | | | | | | | | | | | | 7 | 39.66 | | | 16 | 90.64 | | | 1 | 5.67 | | | 25 | 141.63 |
| | | C52.2-R | 17-Oct-14 | 2227 | 3.79 | | | | | | | 5 | 2.13 | | | | | 3 | 1.28 | | | 8 | 3.41 | | | 54 | 23.03 | 1 | 0.43 | 13 | 5.54 | | | 84 | 35.83 |
| | | C52.8-L | 19-Oct-14 | 546 | 0.89 | | | | | | | | | | | | | | | | | 3 | 22.22 | | | 12 | 88.9 | | | 3 | 22.22 | | | 18 | 133.35 |
| | | C53.6-L | 19-Oct-14 | 1049 | 1.52 | 1 | 2.26 | | | | | | | | | | | | | | | 2 | 4.52 | | | 20 | 45.16 | 1 | 2.26 | 2 | 4.52 | | | 26 | 58.7 |
| | **Session Summary** | | | **1037** | **25** | **3** | **0.42** | **2** | **0.28** | **0** | **0** | **8** | **1.11** | **0** | **0** | **0** | **0** | **9** | **1.25** | **0** | **0** | **184** | **25.55** | **0** | **0** | **488** | **67.76** | **4** | **0.56** | **60** | **8.33** | **0** | **0** | **758** | **105.26** |
| | 3 | C25.3-R | 27-Oct-14 | 1515 | 2.73 | | | | | | | | | | | | | 4 | 3.48 | | | 33 | 28.72 | | | 62 | 53.97 | | | 1 | 0.87 | 1 | 0.87 | 101 | 87.91 |
| | | C27.6-R | 27-Oct-14 | 401 | 0.61 | | | | | | | | | | | | | | | | | 12 | 176.61 | | | 24 | 353.22 | | | 6 | 88.3 | | | 42 | 618.13 |
| | | C28.2-R | 27-Oct-14 | 780 | 1.13 | | | | | | | | | | | | | | | | | 8 | 32.68 | | | 38 | 155.21 | | | 2 | 8.17 | | | 48 | 196.05 |
| | | C34.9-L | 28-Oct-14 | 2110 | 2.14 | | | | | | | | | | | | | | | | | 9 | 7.18 | | | 99 | 78.93 | | | 2 | 1.59 | | | 110 | 87.7 |
| | | C36.6-L | 28-Oct-14 | 1581 | 2.39 | 1 | 0.95 | | | | | | | | | | | | | | | 7 | 6.67 | | | 64 | 60.98 | | | 9 | 8.57 | | | 81 | 77.17 |
| | | C47.8-L | 24-Oct-14 | 884 | 1.44 | 2 | 5.66 | | | | | | | | | | | | | | | 7 | 19.8 | | | 23 | 65.05 | 1 | 2.83 | 10 | 28.28 | | | 43 | 121.61 |
| | | C48.2-R | 25-Oct-14 | 891 | 1.01 | | | | | | | | | | | | | 2 | 8 | | | 3 | 12 | | | 29 | 116.01 | | | 3 | 12 | | | 37 | 148.01 |
| | | C49.0-L | 24-Oct-14 | 562 | 0.93 | | | | | | | | | | | | | 3 | 20.66 | | | 15 | 103.32 | | | 16 | 110.21 | | | 5 | 34.44 | | | 39 | 268.63 |
| | | C49.0-R | 25-Oct-14 | 253 | 0.72 | | | | | | | | | | | | | | | | | 3 | 59.29 | | | 12 | 237.15 | | | | | | | 15 | 296.44 |
| | | C49.8-L | 24-Oct-14 | 1667 | 2.45 | | | | | 1 | 0.88 | | | | | | | 2 | 1.76 | | | 24 | 21.15 | | | 36 | 31.73 | | | 7 | 6.17 | | | 70 | 61.7 |
| | | C49.8-R | 25-Oct-14 | 1226 | 2.39 | | | | | | | 2 | 2.46 | | | | | 1 | 1.23 | | | 32 | 39.32 | | | 40 | 49.14 | | | 3 | 3.69 | | | 78 | 95.83 |
| | | C52.2-L | 25-Oct-14 | 689 | 0.89 | | | | | | | | | | | | | | | | | 6 | 35.22 | | | 11 | 64.58 | | | 2 | 11.74 | | | 19 | 111.54 |
| | | C52.2-R | 25-Oct-14 | 2341 | 3.79 | 2 | 0.81 | 2 | 0.81 | | | 1 | 0.41 | | | | | | | | | 14 | 5.68 | | | 54 | 21.91 | | | 5 | 2.03 | | | 78 | 31.65 |
| | | C52.8-L | 25-Oct-14 | 494 | 0.89 | | | | | | | | | | | | | | | | | | | | | 11 | | | | 5 | | | | 16 | |
| | | C53.6-L | 25-Oct-14 | 1124 | 1.72 | | | | | | | | | | | | | | | | | 4 | 7.45 | | | 23 | 42.83 | | | 5 | 9.31 | | | 32 | 59.59 |
| | **Session Summary** | | | **1101** | **25.2** | **5** | **0.65** | **2** | **0.26** | **1** | **0.13** | **3** | **0.39** | **0** | **0** | **0** | **0** | **12** | **1.56** | **0** | **0** | **177** | **22.97** | **0** | **0** | **542** | **70.33** | **1** | **0.13** | **65** | **8.43** | **1** | **0.13** | **809** | **104.97** |

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 | | Kokanee | | Lake Trout | | Lake Whitefish | | Largemouth Bass | | Mountain Whitefish | | Northern Pike | | Rainbow Trout | | Smallmouth Bass | | Walleye | | White Sturgeon | | 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 | No. | CPUE |
| Columbia River D/S | 4 | C25.3-R | 03-Nov-14 | 1595 | 2.73 | | | | | 1 | 0.83 | | | | | | | 8 | 6.61 | | | 28 | 23.15 | | | 22 | 18.19 | | | 8 | 6.61 | | | 67 | 55.39 |
| | | C27.6-R | 03-Nov-14 | 460 | 0.61 | | | | | | | | | | | | | 3 | 38.49 | | | 6 | 76.98 | | | 19 | 243.76 | | | 1 | 12.83 | | | 29 | 372.06 |
| | | C28.2-R | 03-Nov-14 | 821 | 1.13 | | | | | | | | | | | | | | | | | 20 | 77.61 | | | 45 | 174.62 | | | 2 | 7.76 | | | 67 | 259.99 |
| | | C34.9-L | 03-Nov-14 | 1981 | 2.14 | | | | | | | | | | | | | | | | | 22 | 18.68 | | | 85 | 72.18 | | | | | | | 107 | 90.86 |
| | | C36.6-L | 04-Nov-14 | 1438 | 2.39 | | | | | | | | | | | | | 3 | 3.14 | | | 10 | 10.47 | | | 55 | 57.61 | | | 2 | 2.09 | | | 70 | 73.32 |
| | | C47.8-L | 29-Oct-14 | 1159 | 1.44 | 2 | 4.31 | 1 | 2.16 | | | 1 | 2.16 | | | 1 | 2.16 | | | | | | | | | 48 | 103.54 | | | 5 | 10.79 | | | 58 | 125.11 |
| | | C48.2-R | 31-Oct-14 | 957 | 1.01 | | | | | | | | | | | | | | | | | 5 | 18.62 | | | 19 | 70.77 | | | 6 | 22.35 | | | 30 | 111.74 |
| | | C49.0-L | 29-Oct-14 | 628 | 0.93 | | | | | | | | | | | | | 4 | 24.66 | | | 44 | 271.21 | | | 39 | 240.39 | | | 4 | 24.66 | 1 | 6.16 | 92 | 567.08 |
| | | C49.0-R | 31-Oct-14 | 373 | 0.72 | | | | | | | | | | | | | 2 | 26.81 | | | 11 | 147.45 | | | 15 | 201.07 | | | 2 | 26.81 | | | 30 | 402.14 |
| | | C49.8-L | 30-Oct-14 | 1600 | 2.45 | 1 | 0.92 | | | | | 1 | 0.92 | | | | | | | | | 33 | 30.31 | | | 71 | 65.2 | | | 6 | 5.51 | | | 112 | 102.86 |
| | | C49.8-R | 31-Oct-14 | 1259 | 2.39 | | | | | | | | | | | | | 2 | 2.39 | | | 24 | 28.71 | | | 35 | 41.87 | | | 4 | 4.79 | | | 65 | 77.77 |
| | | C52.2-L | 30-Oct-14 | 758 | 0.89 | | | | | | | | | | | | | | | | | 5 | 26.68 | | | 15 | 80.05 | | | 5 | 26.68 | | | 25 | 133.41 |
| | | C52.2-R | 31-Oct-14 | 2398 | 3.79 | | | | | | | 4 | 1.58 | | | | | 2 | 0.79 | | | 19 | 7.53 | | | 69 | 27.33 | | | 5 | 1.98 | | | 99 | 39.21 |
| | | C52.8-L | 31-Oct-14 | 505 | 0.89 | | | | | | | | | | | | | | | | | 4 | 32.04 | | | 9 | 72.09 | | | | | | | 13 | 104.13 |
| | | C53.6-L | 30-Oct-14 | 1059 | 1.72 | | | | | | | | | | | | | | | | | | | | | 20 | 39.53 | | | 3 | 5.93 | | | 23 | 45.46 |
| | | C56.0-L | 01-Nov-14 | 549 | 0.89 | | | | | | | | | | | | | | | | | | | | | 12 | 88.41 | | | 2 | 14.74 | | | 14 | 103.15 |
| | **Session Summary** | | | **1096** | **26.1** | **3** | 0.38 | **1** | 0.13 | **1** | 0.13 | **6** | 0.76 | **0** | 0 | **1** | 0.13 | **24** | 3.02 | **0** | 0 | **231** | 29.07 | **0** | 0 | **578** | 72.74 | **0** | 0 | **55** | 6.92 | **1** | 0.13 | **901** | 113.39 |
| | 5 | C10.9-L | 06-Nov-14 | 1355 | 2.18 | | | | | | | | | | | | | 16 | 19.5 | | | 607 | 739.77 | | | 79 | 96.28 | | | 14 | 17.06 | | | 716 | 872.61 |
| | | C13.4-L | 06-Nov-14 | 896 | 1.39 | | | | | | | | | | | | | | | | | 124 | 358.43 | | | 57 | 164.76 | | | 11 | 31.8 | | | 192 | 554.98 |
| | | C13.4-R | 07-Nov-14 | 1183 | 2.52 | | | | | 1 | 1.21 | | | | | | | | | | | 69 | 83.32 | | | 99 | 119.55 | | | 17 | 20.53 | | | 186 | 224.61 |
| | | C15.8-R | 07-Nov-14 | 530 | 0.82 | | | | | | | | | | | | | | | | | 49 | 405.89 | | | 37 | 306.49 | | | 3 | 24.85 | | | 89 | 737.23 |
| | | C17.0-L | 07-Nov-14 | 1343 | 1.91 | | | | | | | | | | | | | 1 | 1.4 | | | 120 | 168.41 | | | 85 | 119.29 | | | 14 | 19.65 | | | 220 | 308.76 |
| | | C19.0-L | 05-Nov-14 | 973 | 1.28 | 1 | 2.89 | | | | | | | | | | | | | | | 17 | 49.14 | | | 72 | 208.12 | | | 4 | 11.56 | | | 94 | 271.71 |
| | | C20.1-L | 05-Nov-14 | 1099 | 1.27 | | | | | | | | | | | | | | | | | 37 | 95.43 | | | 85 | 219.24 | | | 5 | 12.9 | | | 127 | 327.57 |
| | | C23.4-L | 05-Nov-14 | 619 | 0.93 | 1 | 6.25 | | | | | | | | | | | | | | | 35 | 218.88 | | | 53 | 331.44 | | | | | | | 89 | 556.57 |
| | | C24.3-L | 05-Nov-14 | 865 | 1.29 | | | | | | | | | | | | | 4 | 12.9 | | | 6 | 19.36 | | | 96 | 309.72 | | | 1 | 3.23 | | | 107 | 345.21 |
| | | C25.3-L | 06-Nov-14 | 1065 | 1.78 | | | | | | | | | | | | | 6 | 11.39 | | | 83 | 157.62 | | | 63 | 119.64 | | | 9 | 17.09 | | | 161 | 305.74 |
| | | C26.2-L | 06-Nov-14 | 912 | 1.25 | | | | | | | | | | | | | 4 | 12.63 | | | 92 | 290.53 | | | 6 | 18.95 | | | | | | | 102 | 322.11 |
| | | C30.6-L | 06-Nov-14 | 1637 | 1.84 | | | | | | | 1 | 1.2 | 1 | 1.2 | | | | | | | 17 | 20.32 | | | 134 | 160.16 | | | 16 | 19.12 | | | 169 | 201.99 |
| | | C34.9-R | 04-Nov-14 | 825 | 0.89 | | | | | | | | | | | | | | | | | 3 | 14.71 | | | 86 | 421.65 | | | 3 | 14.71 | | | 92 | 451.07 |
| | | C38.8-L | 04-Nov-14 | 807 | 1.3 | | | | | | | | | | | | | | | | | 6 | 20.59 | | | 30 | 102.95 | | | 9 | 30.88 | | | 45 | 154.42 |
| | | C41.1-L | 04-Nov-14 | 1853 | 2.41 | | | | | | | 1 | 0.81 | | | | | 1 | 0.81 | | | 30 | 24.18 | | | 78 | 62.88 | | | 2 | 1.61 | | | 112 | 90.29 |
| | | C44.6-L | 05-Nov-14 | 650 | 1.01 | | | | | | | 1 | 5.48 | | | | | | | | | 3 | 16.45 | | | 43 | 235.8 | | | 6 | 32.9 | | | 53 | 290.63 |
| | | C45.6-L | 04-Nov-14 | 728 | 0.9 | | | | | | | | | | | | | | | | | 23 | 126.37 | | | 80 | 439.56 | | | 13 | 71.43 | | | 116 | 637.36 |
| | | C46.4-L | 05-Nov-14 | 1269 | 1.59 | | | | | | | | | | | | | | | | | 13 | 23.19 | | | 74 | 132.03 | | | 14 | 24.98 | | | 101 | 180.2 |
| | **Session Summary** | | | **1034** | **26.6** | **2** | 0.26 | **0** | 0 | **1** | 0.13 | **3** | 0.39 | **1** | 0.13 | **0** | 0 | **32** | 4.19 | **0** | 0 | **1334** | 174.6 | **0** | 0 | **1257** | 164.53 | **0** | 0 | **141** | 18.46 | **0** | 0 | **2771** | 362.69 |
| **Section Total All Samples** | | | | **84414** | **127.92** | **17** | | **5** | | **3** | | **21** | | **1** | | **1** | | **82** | | **0** | | **2252** | | **0** | | **3546** | | **9** | | **374** | | **2** | | **6313** | |
| **Section Average All Samples** | | | | **1069** | **1.62** | **0** | 0.45 | **0** | 0.13 | **0** | 0.08 | **0** | 0.55 | **0** | 0.03 | **0** | 0.03 | **1** | 2.16 | **0** | 0 | **29** | 59.29 | **0** | 0 | **45** | 93.35 | **0** | 0.24 | **5** | 9.85 | **0** | 0.05 | **80** | 166.2 |
| **Section Standard Error of Mean** | | | | | | **0.07** | 0.19 | **0.03** | 0.08 | **0.02** | 0.02 | **0.09** | 0.09 | **0.01** | 0.02 | **0.01** | 0.03 | **0.26** | 0.86 | **0** | 0 | **7.94** | 12.95 | **0** | 0 | **3.35** | 12.2 | **0.05** | 0.1 | **0.47** | 1.73 | **0.02** | 0.08 | **9.66** | 21.86 |
| **All Sections Total All Samples** | | | | **136592** | **186.58** | 19 | 0 | 5 | 0 | 5 | 0 | 23 | 0 | 8 | 0 | 1 | 0 | 114 | 0.02 | 1 | 0 | 5447 | 0.77 | 25 | 0 | 4238 | 0.6 | 9 | 0 | 636 | 0.09 | 14 | 0 | 10545 | 1.49 |
| **All Sections Average All Samples** | | | | | | 0 | 0.35 | 0 | 0.09 | 0 | 0.09 | 0 | 0.43 | 0 | 0.15 | 0 | 0.02 | 1 | 2.13 | 0 | 0.02 | 41 | 101.56 | 0 | 0.47 | 32 | 79.02 | 0 | 0.17 | 5 | 11.86 | 0 | 0.26 | 80 | 196.62 |
| **All Sections Standard Error of Mean** | | | | | | 0.04 | 0.28 | 0.02 | 0.05 | 0.02 | 0.1 | 0.06 | 0.06 | 0.03 | 0.09 | 0.01 | 0.02 | 0.2 | 1.77 | 0.01 | 0.09 | 5.75 | 19.05 | 0.06 | 0.46 | 2.48 | 8.85 | 0.03 | 0.06 | 0.38 | 1.74 | 0.03 | 0.23 | 6.67 | 23.55 |

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 06 November 2014.

| 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-14 | 830 | 0.94 | | | | | 155 | ***715.2*** | 20 | ***92.28*** | 5 | ***23.07*** | | | 180 | ***830.56*** |
| | | C00.7-L | 06-Oct-14 | 618 | 0.59 | 2 | ***19.75*** | | | 28 | ***276.45*** | 16 | ***157.97*** | 5 | ***49.37*** | | | 51 | ***503.54*** |
| | | C01.3-L | 06-Oct-14 | 1644 | 1.6 | | | | | 15 | ***20.53*** | 10 | ***13.69*** | 19 | ***26*** | | | 44 | ***60.22*** |
| | | C02.8-L | 07-Oct-14 | 739 | 0.88 | 1 | ***5.54*** | | | 35 | ***193.75*** | 20 | ***110.71*** | 30 | ***166.07*** | | | 86 | ***476.07*** |
| | | C03.6-L | 07-Oct-14 | 1983 | 2.09 | 1 | ***0.87*** | | | 5 | ***4.34*** | 42 | ***36.48*** | 68 | ***59.07*** | | | 116 | ***100.76*** |
| | | C04.6-R | 07-Oct-14 | 491 | 0.52 | 1 | ***14.1*** | | | | | 4 | ***56.4*** | 13 | ***183.3*** | | | 18 | ***253.8*** |
| | | C05.6-L | 07-Oct-14 | 882 | 1.1 | | | 1 | ***3.71*** | 100 | ***371.06*** | 45 | ***166.98*** | 41 | ***152.13*** | | | 187 | ***693.88*** |
| | | C07.3-R | 08-Oct-14 | 1063 | 1.7 | | | | | | | | | 9 | ***17.93*** | | | 9 | ***17.93*** |
| | | C07.4-L | 08-Oct-14 | 969 | 1 | | | | | 15 | ***55.73*** | 20 | ***74.3*** | 140 | ***520.12*** | | | 175 | ***650.15*** |
| | **Session Summary** | | | **1024** | **10.4** | **5** | *1.69* | **1** | *0.34* | **353** | *119.33* | **177** | *59.83* | **330** | *111.55* | **0** | *0* | **866** | *292.74* |
| | 2 | C00.0-R | 15-Oct-14 | 901 | 0.94 | | | | | 690 | ***2932.91*** | 50 | ***212.53*** | 6 | ***25.5*** | | | 746 | ***3170.94*** |
| | | C00.7-L | 15-Oct-14 | 540 | 0.59 | | | 2 | ***22.6*** | 25 | ***282.49*** | 25 | ***282.49*** | 10 | ***112.99*** | | | 62 | ***700.56*** |
| | | C01.3-L | 15-Oct-14 | 1563 | 1.6 | 2 | ***2.88*** | 1 | ***1.44*** | 135 | ***194.34*** | 200 | ***287.91*** | 75 | ***107.97*** | | | 413 | ***594.53*** |
| | | C02.8-L | 15-Oct-14 | 830 | 0.88 | | | | | 40 | ***197.15*** | 520 | ***2562.98*** | 118 | ***581.6*** | 1 | ***4.93*** | 679 | ***3346.66*** |
| | | C03.6-L | 16-Oct-14 | 1964 | 2.06 | 2 | ***1.78*** | | | 135 | ***120.12*** | 205 | ***182.41*** | 120 | ***106.78*** | | | 462 | ***411.09*** |
| | | C04.6-R | 16-Oct-14 | 536 | 0.52 | | | | | | | 15 | ***193.74*** | 30 | ***387.49*** | | | 45 | ***581.23*** |
| | | C05.6-L | 16-Oct-14 | 1114 | 1.1 | 2 | ***5.88*** | | | 260 | ***763.83*** | 135 | ***396.61*** | 37 | ***108.7*** | | | 434 | ***1275.01*** |
| | | C07.3-R | 17-Oct-14 | 1018 | 1.63 | | | | | | | 30 | ***65.09*** | 12 | ***26.03*** | | | 42 | ***91.12*** |
| | | C07.4-L | 17-Oct-14 | 1009 | 1 | | | | | 25 | ***89.2*** | 40 | ***142.72*** | 57 | ***203.37*** | | | 122 | ***435.28*** |
| | **Session Summary** | | | **1053** | **10.3** | **6** | *1.99* | **3** | *1* | **1310** | *434.82* | **1220** | *404.95* | **465** | *154.34* | **1** | *0.33* | **3005** | *997.43* |
| | 3 | C00.0-R | 21-Oct-14 | 1100 | 0.94 | 7 | ***24.37*** | | | 560 | ***1949.71*** | 330 | ***1148.94*** | | | | | 897 | ***3123.02*** |
| | | C00.7-L | 21-Oct-14 | 449 | 0.49 | | | | | | | 50 | ***818.14*** | 26 | ***425.44*** | | | 76 | ***1243.58*** |
| | | C01.3-L | 21-Oct-14 | 1250 | 1.6 | | | 2 | ***3.6*** | 320 | ***576*** | 270 | ***486*** | 142 | ***255.6*** | | | 734 | ***1321.2*** |
| | | C02.8-L | 21-Oct-14 | 842 | 0.88 | | | | | 220 | ***1068.88*** | 115 | ***558.73*** | 74 | ***359.53*** | | | 409 | ***1987.15*** |
| | | C03.6-L | 22-Oct-14 | 2595 | 2.09 | | | | | | | 35 | ***23.23*** | 103 | ***68.37*** | | | 138 | ***91.6*** |
| | | C04.6-R | 22-Oct-14 | 561 | 0.52 | | | | | | | | | 30 | ***370.22*** | | | 30 | ***370.22*** |
| | | C05.6-L | 22-Oct-14 | 1076 | 1.1 | | | | | 90 | ***273.74*** | 70 | ***212.91*** | 39 | ***118.62*** | | | 199 | ***605.27*** |
| | | C07.3-R | 22-Oct-14 | 999 | 1.7 | | | | | | | 50 | ***105.99*** | 8 | ***16.96*** | | | 58 | ***122.95*** |
| | | C07.4-L | 22-Oct-14 | 967 | 1 | | | | | | | | | 21 | ***78.18*** | | | 21 | ***78.18*** |
| | **Session Summary** | | | **1093** | **10.3** | **7** | *2.24* | **2** | *0.64* | **1190** | *380.53* | **920** | *294.19* | **443** | *141.66* | **0** | *0* | **2562** | *819.26* |
| | 4 | C00.0-R | 28-Oct-14 | 1021 | 0.94 | | | | | 7 | ***26.26*** | 18 | ***67.52*** | 6 | ***22.51*** | | | 31 | ***116.28*** |
| | | C00.7-L | 28-Oct-14 | 606 | 0.59 | | | | | | | | | 2 | ***20.14*** | | | 2 | ***20.14*** |
| | | C01.3-L | 28-Oct-14 | 1931 | 1.6 | | | | | 1 | ***1.17*** | 10 | ***11.65*** | 42 | ***48.94*** | | | 53 | ***61.76*** |
| | | C02.8-L | 29-Oct-14 | 821 | 0.87 | | | | | | | 5 | ***25.2*** | 6 | ***30.24*** | | | 11 | ***55.44*** |
| | | C03.6-L | 29-Oct-14 | 2473 | 2.06 | | | | | | | 4 | ***2.83*** | 36 | ***25.44*** | | | 40 | ***28.27*** |
| | | C04.6-R | 29-Oct-14 | 732 | 0.52 | | | | | | | | | 11 | ***104.04*** | | | 11 | ***104.04*** |
| | | C05.6-L | 29-Oct-14 | 1137 | 1.07 | | | | | | | | | 10 | ***29.59*** | | | 10 | ***29.59*** |
| | | C07.3-R | 02-Nov-14 | 1148 | 1.7 | 1 | ***1.84*** | | | 20 | ***36.89*** | 540 | ***996.11*** | 23 | ***42.43*** | | | 584 | ***1077.27*** |
| | | C07.4-L | 02-Nov-14 | 975 | 1 | | | | | 15 | ***55.38*** | 23 | ***84.92*** | 38 | ***140.31*** | | | 76 | ***280.62*** |
| | **Session Summary** | | | **1205** | **10.3** | **1** | *0.29* | **0** | *0* | **43** | *12.47* | **600** | *174.03* | **174** | *50.47* | **0** | *0* | **818** | *237.26* |
| | 5 | C08.4-L | 06-Nov-14 | 386 | 0.5 | | | | | | | | | 7 | ***130.57*** | | | 7 | ***130.57*** |
| | **Session Summary** | | | **386** | **0.5** | **0** | *0* | **0** | *0* | **0** | *0* | **0** | *0* | **7** | *130.57* | **0** | *0* | **7** | *130.57* |
| **Section Total All Samples** | | | | **39763** | **41.91** | **19** | | **6** | | **2896** | | **2917** | | **1419** | | **1** | | **7258** | |
| **Section Average All Samples** | | | | **1075** | **1.13** | **1** | *1.52* | **0** | *0.48* | **78** | *231.41* | **79** | *233.08* | **38** | *113.39* | **0** | *0.08* | **196** | *579.95* |
| **Section Standard Error of Mean** | | | | | | **0.21** | *0.91* | **0.08** | *0.62* | **25.5** | *97.54* | **22.1** | *78.62* | **6.6** | *24.79* | **0.03** | *0.13* | **41.05** | *146.15* |

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 | 07-Oct-14 | 197 | 0.44 |  |  |  |  |  |  |  |  | 8 | ***332.26*** |  |  | 8 | ***332.26*** |
|  |  | K00.6-R | 07-Oct-14 | 508 | 0.6 |  |  |  |  | 2 | ***23.62*** | 7 | ***82.68*** | 16 | ***188.98*** |  |  | 25 | ***295.28*** |
|  |  | K01.8-L | 07-Oct-14 | 1312 | 1.85 | 7 | ***10.38*** |  |  |  |  | 20 | ***29.66*** | 36 | ***53.39*** |  |  | 63 | ***93.44*** |
|  |  | K01.8-R | 07-Oct-14 | 1019 | 1.3 |  |  |  |  |  |  |  |  | 22 | ***59.79*** |  |  | 22 | ***59.79*** |
|  | **Session Summary** |  |  | **759** | **4.2** | **7** | ***7.91*** | **0** | ***0*** | **2** | ***2.26*** | **27** | ***30.49*** | **82** | ***92.6*** | **0** | ***0*** | **118** | ***133.26*** |
|  | 2 | K00.3-L | 16-Oct-14 | 190 | 0.44 |  |  |  |  |  |  |  |  | 12 | ***516.75*** |  |  | 12 | ***516.75*** |
|  |  | K00.6-R | 16-Oct-14 | 504 | 0.6 |  |  | 1 | ***11.9*** |  |  |  |  | 23 | ***273.81*** |  |  | 24 | ***285.71*** |
|  |  | K01.8-L | 16-Oct-14 | 1332 | 1.87 | 9 | ***13.01*** |  |  | 155 | ***224.02*** | 50 | ***72.26*** | 35 | ***50.59*** |  |  | 249 | ***359.88*** |
|  |  | K01.8-R | 16-Oct-14 | 957 | 1.3 |  |  |  |  | 5 | ***14.47*** | 50 | ***144.68*** | 18 | ***52.09*** |  |  | 73 | ***211.24*** |
|  | **Session Summary** |  |  | **746** | **4.2** | **9** | ***10.34*** | **1** | ***1.15*** | **160** | ***183.84*** | **100** | ***114.9*** | **88** | ***101.11*** | **0** | ***0*** | **358** | ***411.34*** |
|  | 3 | K00.3-L | 24-Oct-14 | 235 | 0.44 |  |  |  |  |  |  |  |  | 11 | ***382.98*** |  |  | 11 | ***382.98*** |
|  |  | K00.6-R | 23-Oct-14 | 493 | 0.6 |  |  |  |  |  |  |  |  | 22 | ***267.75*** |  |  | 22 | ***267.75*** |
|  |  | K01.8-L | 23-Oct-14 | 1223 | 1.8 | 5 | ***8.18*** |  |  |  |  | 12 | ***19.62*** | 21 | ***34.34*** |  |  | 38 | ***62.14*** |
|  |  | K01.8-R | 23-Oct-14 | 1024 | 1.3 | 1 | ***2.7*** | 1 | ***2.7*** | 5 | ***13.52*** | 5 | ***13.52*** | 7 | ***18.93*** |  |  | 19 | ***51.38*** |
|  | **Session Summary** |  |  | **744** | **4.1** | **6** | ***7.08*** | **1** | ***1.18*** | **5** | ***5.9*** | **17** | ***20.06*** | **61** | ***71.99*** | **0** | ***0*** | **90** | ***106.22*** |
|  | 4 | K00.3-L | 03-Nov-14 | 228 | 0.44 |  |  |  |  |  |  |  |  | 24 | ***861.24*** |  |  | 24 | ***861.24*** |
|  |  | K00.6-R | 03-Nov-14 | 561 | 0.6 | 2 | ***21.39*** |  |  | 12 | ***128.34*** | 15 | ***160.43*** | 16 | ***171.12*** |  |  | 45 | ***481.28*** |
|  |  | K01.8-L | 03-Nov-14 | 1501 | 1.87 | 3 | ***3.85*** |  |  | 120 | ***153.91*** | 595 | ***763.13*** | 32 | ***41.04*** |  |  | 750 | ***961.93*** |
|  |  | K01.8-R | 02-Nov-14 | 1131 | 1.3 | 1 | ***2.45*** |  |  | 50 | ***122.42*** | 15 | ***36.73*** | 11 | ***26.93*** |  |  | 77 | ***188.53*** |
|  | **Session Summary** |  |  | **855** | **4.2** | **6** | ***6.02*** | **0** | ***0*** | **182** | ***182.46*** | **625** | ***626.57*** | **83** | ***83.21*** | **0** | ***0*** | **896** | ***898.25*** |
| **Section Total All Samples** |  |  |  | **12415** | **16.75** | **28** |  | **2** |  | **349** |  | **769** |  | **314** |  | **0** |  | **1462** |  |
| **Section Average All Samples** |  |  |  | **776** | **1.05** | **2** | ***7.76*** | **0** | ***0.55*** | **22** | ***96.66*** | **48** | ***212.99*** | **20** | ***86.97*** | **0** | ***0*** | **91** | ***404.92*** |
| **Section Standard Error of Mean** |  |  |  |  |  | **0.71** | ***1.57*** | **0.09** | ***0.75*** | **11.82** | ***17.95*** | **36.69** | ***47.19*** | **2.27** | ***57.71*** | **0** | ***0*** | **46.23** | ***66.5*** |

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 | 14-Oct-14 | 1489 | 2.73 | | | 15 | ***13.28*** | 30 | ***26.57*** | 195 | ***172.7*** | 2 | ***1.77*** | | | 242 | ***214.32*** |
| | | C27.6-R | 14-Oct-14 | 326 | 0.61 | | | | | | | 40 | ***724.13*** | 3 | ***54.31*** | | | 43 | ***778.44*** |
| | | C28.2-R | 14-Oct-14 | 1021 | 1.13 | | | | | | | 45 | ***140.41*** | 4 | ***12.48*** | | | 49 | ***152.9*** |
| | | C34.9-L | 08-Oct-14 | 1826 | 2.14 | | | | | | | 57 | ***52.51*** | | | | | 57 | ***52.51*** |
| | | C36.6-L | 09-Oct-14 | 1337 | 2.34 | | | | | | | | | 12 | ***13.81*** | | | 12 | ***13.81*** |
| | | C47.8-L | 08-Oct-14 | 1068 | 1.44 | | | | | 2 | ***4.68*** | 30 | ***70.22*** | 43 | ***100.66*** | | | 75 | ***175.56*** |
| | | C48.2-R | 11-Oct-14 | 822 | 1.01 | | | | | | | | | 7 | ***30.35*** | | | 7 | ***30.35*** |
| | | C49.0-L | 09-Oct-14 | 687 | 0.93 | | | | | | | 115 | ***647.98*** | 10 | ***56.35*** | | | 125 | ***704.32*** |
| | | C49.0-R | 11-Oct-14 | 327 | 0.72 | 1 | ***15.29*** | | | | | 5 | ***76.45*** | 1 | ***15.29*** | | | 7 | ***107.03*** |
| | | C49.8-L | 09-Oct-14 | 1450 | 2.45 | | | | | | | 350 | ***354.68*** | 13 | ***13.17*** | | | 363 | ***367.85*** |
| | | C49.8-R | 11-Oct-14 | 1211 | 2.39 | | | 1 | ***1.24*** | | | 25 | ***31.1*** | 17 | ***21.15*** | | | 43 | ***53.48*** |
| | | C52.2-L | 09-Oct-14 | 759 | 0.89 | | | | | | | | | 2 | ***10.66*** | | | 2 | ***10.66*** |
| | | C52.2-R | 12-Oct-14 | 2266 | 3.79 | 2 | ***0.84*** | | | | | 18 | ***7.55*** | 2 | ***0.84*** | | | 22 | ***9.22*** |
| | | C52.8-L | 09-Oct-14 | 428 | 0.89 | | | | | | | 10 | ***94.51*** | | | | | 10 | ***94.51*** |
| | | C53.6-L | 10-Oct-14 | 1169 | 1.52 | | | | | | | 20 | ***40.52*** | | | | | 20 | ***40.52*** |
| | **Session Summary** | | | **1079** | **25** | **3** | ***0.4*** | **16** | ***2.14*** | **32** | ***4.27*** | **910** | ***121.45*** | **116** | ***15.48*** | **0** | ***0*** | **1077** | ***143.73*** |
| | 2 | C25.3-R | 19-Oct-14 | 1435 | 2.73 | | | | | 160 | ***147.03*** | 22 | ***20.22*** | 15 | ***13.78*** | | | 197 | ***181.03*** |
| | | C27.6-R | 19-Oct-14 | 300 | 0.61 | | | | | | | 1 | ***19.67*** | 1 | ***19.67*** | | | 2 | ***39.34*** |
| | | C28.2-R | 19-Oct-14 | 678 | 1.13 | | | | | | | 200 | ***939.78*** | 3 | ***14.1*** | | | 203 | ***953.87*** |
| | | C34.9-L | 20-Oct-14 | 1681 | 2.14 | | | | | | | 50 | ***50.04*** | 2 | ***2*** | | | 52 | ***52.04*** |
| | | C36.6-L | 20-Oct-14 | 1345 | 2.39 | 10 | ***11.2*** | | | | | 50 | ***56*** | 11 | ***12.32*** | | | 71 | ***79.51*** |
| | | C47.8-L | 18-Oct-14 | 844 | 1.44 | | | | | | | 90 | ***266.59*** | 2 | ***5.92*** | | | 92 | ***272.51*** |
| | | C48.2-R | 17-Oct-14 | 891 | 1.01 | | | | | | | 30 | ***120.01*** | 10 | ***40*** | | | 40 | ***160.02*** |
| | | C49.0-L | 18-Oct-14 | 628 | 0.93 | | | | | | | 230 | ***1417.71*** | 10 | ***61.64*** | | | 240 | ***1479.35*** |
| | | C49.0-R | 17-Oct-14 | 377 | 0.72 | | | | | | | 5 | ***66.31*** | | | | | 5 | ***66.31*** |
| | | C49.8-L | 18-Oct-14 | 1600 | 2.45 | | | | | | | 650 | ***596.94*** | 5 | ***4.59*** | | | 655 | ***601.53*** |
| | | C49.8-R | 17-Oct-14 | 1246 | 2.39 | | | | | | | 340 | ***411.02*** | 1 | ***1.21*** | | | 341 | ***412.23*** |
| | | C52.2-L | 19-Oct-14 | 714 | 0.89 | | | | | | | | | 4 | ***22.66*** | | | 4 | ***22.66*** |
| | | C52.2-R | 17-Oct-14 | 2227 | 3.79 | | | | | | | 60 | ***25.59*** | 1 | ***0.43*** | | | 61 | ***26.02*** |
| | **Session Summary** | | | **1074** | **22.6** | **10** | ***1.48*** | **0** | ***0*** | **160** | ***23.73*** | **1728** | ***256.29*** | **65** | ***9.64*** | **0** | ***0*** | **1963** | ***291.15*** |
| | 3 | C25.3-R | 27-Oct-14 | 1515 | 2.73 | | | | | | | 97 | ***84.43*** | 2 | ***1.74*** | | | 99 | ***86.17*** |
| | | C27.6-R | 27-Oct-14 | 401 | 0.61 | | | 1 | ***14.72*** | | | 25 | ***367.93*** | | | | | 26 | ***382.65*** |
| | | C28.2-R | 27-Oct-14 | 780 | 1.13 | 1 | ***4.08*** | | | | | 75 | ***306.33*** | 10 | ***40.84*** | | | 86 | ***351.26*** |
| | | C34.9-L | 28-Oct-14 | 2110 | 2.14 | | | | | | | 65 | ***51.82*** | | | | | 65 | ***51.82*** |
| | | C36.6-L | 28-Oct-14 | 1581 | 2.39 | | | | | | | 35 | ***33.35*** | 2 | ***1.91*** | | | 37 | ***35.25*** |
| | | C47.8-L | 24-Oct-14 | 884 | 1.44 | | | | | | | 35 | ***98.98*** | 11 | ***31.11*** | | | 46 | ***130.09*** |
| | | C48.2-R | 25-Oct-14 | 891 | 1.01 | | | | | | | 3 | ***12*** | 8 | ***32*** | | | 11 | ***44*** |
| | | C49.0-L | 24-Oct-14 | 562 | 0.93 | | | | | | | 25 | ***172.2*** | | | | | 25 | ***172.2*** |
| | | C49.0-R | 25-Oct-14 | 253 | 0.72 | | | | | | | 1 | ***19.76*** | | | | | 1 | ***19.76*** |
| | | C49.8-L | 24-Oct-14 | 1667 | 2.45 | | | | | | | 150 | ***132.22*** | 2 | ***1.76*** | | | 152 | ***133.98*** |
| | | C49.8-R | 25-Oct-14 | 1226 | 2.39 | | | | | | | 75 | ***92.15*** | 31 | ***38.09*** | | | 106 | ***130.23*** |
| | | C52.2-L | 25-Oct-14 | 689 | 0.89 | 1 | ***5.87*** | | | | | 10 | ***58.71*** | | | | | 11 | ***64.58*** |
| | | C52.2-R | 25-Oct-14 | 2341 | 3.79 | | | | | | | 20 | ***8.12*** | 6 | ***2.43*** | | | 26 | ***10.55*** |
| | | C53.6-L | 25-Oct-14 | 1124 | 1.72 | | | | | | | 30 | ***55.86*** | | | | | 30 | ***55.86*** |
| | **Session Summary** | | | **1145** | **24.3** | **2** | ***0.26*** | **1** | ***0.13*** | **0** | ***0*** | **646** | ***83.58*** | **72** | ***9.32*** | **0** | ***0*** | **721** | ***93.29*** |
| | 4 | C25.3-R | 03-Nov-14 | 1595 | 2.73 | | | | | | | 45 | ***37.2*** | 17 | ***14.05*** | | | 62 | ***51.26*** |
| | | C27.6-R | 03-Nov-14 | 460 | 0.61 | | | | | | | 9 | ***115.47*** | 4 | ***51.32*** | | | 13 | ***166.79*** |
| | | C28.2-R | 03-Nov-14 | 821 | 1.13 | | | | | | | 15 | ***58.21*** | | | | | 15 | ***58.21*** |
| | | C34.9-L | 03-Nov-14 | 1981 | 2.14 | | | | | | | 70 | ***59.44*** | | | | | 70 | ***59.44*** |
| | | C47.8-L | 29-Oct-14 | 1159 | 1.44 | | | | | | | 39 | ***84.12*** | 9 | ***19.41*** | | | 48 | ***103.54*** |
| | | C48.2-R | 31-Oct-14 | 957 | 1.01 | | | | | | | 25 | ***93.11*** | | | | | 25 | ***93.11*** |
| | | C49.0-L | 29-Oct-14 | 628 | 0.93 | | | | | | | 50 | ***308.2*** | 8 | ***49.31*** | | | 58 | ***357.51*** |
| | | C49.0-R | 31-Oct-14 | 373 | 0.72 | | | | | | | 3 | ***40.21*** | | | | | 3 | ***40.21*** |
| | | C49.8-L | 30-Oct-14 | 1600 | 2.45 | 1 | ***0.92*** | | | | | 300 | ***275.51*** | 7 | ***6.43*** | | | 308 | ***282.86*** |
| | | C49.8-R | 31-Oct-14 | 1259 | 2.39 | | | | | | | 150 | ***179.46*** | 2 | ***2.39*** | | | 152 | ***181.85*** |
| | | C52.2-R | 31-Oct-14 | 2398 | 3.79 | 1 | ***0.4*** | | | | | 40 | ***15.84*** | 3 | ***1.19*** | | | 44 | ***17.43*** |
| | | C53.6-L | 30-Oct-14 | 1059 | 1.72 | | | | | | | 140 | ***276.7*** | | | | | 140 | ***276.7*** |
| | **Session Summary** | | | **1191** | **21.1** | **2** | ***0.29*** | **0** | ***0*** | **0** | ***0*** | **886** | ***126.92*** | **50** | ***7.16*** | **0** | ***0*** | **938** | ***134.37*** |
| | 5 | C10.9-L | 06-Nov-14 | 1355 | 2.18 | 4 | ***4.87*** | | | | | | | 9 | ***10.97*** | | | 13 | ***15.84*** |
| | | C13.4-L | 06-Nov-14 | 896 | 1.39 | | | | | | | 20 | ***57.81*** | 1 | ***2.89*** | | | 21 | ***60.7*** |
| | | C13.4-R | 07-Nov-14 | 1183 | 2.52 | | | | | | | 400 | ***483.03*** | | | | | 400 | ***483.03*** |
| | | C15.8-R | 07-Nov-14 | 530 | 0.82 | | | | | | | 710 | ***5881.27*** | 7 | ***57.98*** | | | 717 | ***5939.25*** |
| | | C17.0-L | 07-Nov-14 | 1343 | 1.91 | | | | | | | 50 | ***70.17*** | 18 | ***25.26*** | | | 68 | ***95.43*** |
| | | C19.0-L | 05-Nov-14 | 973 | 1.28 | 1 | ***2.89*** | | | 100 | ***289.05*** | 40 | ***115.62*** | 17 | ***49.14*** | | | 158 | ***456.71*** |
| | | C20.1-L | 05-Nov-14 | 1099 | 1.27 | | | | | 30 | ***77.38*** | 175 | ***451.38*** | 22 | ***56.74*** | | | 227 | ***585.5*** |
| | | C23.4-L | 05-Nov-14 | 619 | 0.93 | | | | | | | 45 | ***281.41*** | | | | | 45 | ***281.41*** |
| | | C24.3-L | 05-Nov-14 | 865 | 1.29 | | | | | | | 12 | ***38.71*** | 1 | ***3.23*** | | | 13 | ***41.94*** |
| | | C25.3-L | 06-Nov-14 | 1065 | 1.78 | | | | | | | 51 | ***96.85*** | 26 | ***49.37*** | | | 77 | ***146.23*** |
| | | C26.2-L | 06-Nov-14 | 912 | 1.25 | | | | | | | 6 | ***18.95*** | 1 | ***3.16*** | | | 7 | ***22.11*** |
| | | C30.6-L | 06-Nov-14 | 1637 | 1.84 | | | | | 100 | ***119.52*** | 35 | ***41.83*** | 13 | ***15.54*** | | | 148 | ***176.89*** |
| | | C34.9-R | 04-Nov-14 | 825 | 0.89 | | | | | | | 40 | ***196.12*** | | | | | 40 | ***196.12*** |
| | | C38.8-L | 04-Nov-14 | 807 | 1.3 | | | | | | | 110 | ***377.47*** | | | | | 110 | ***377.47*** |
| | | C41.1-L | 04-Nov-14 | 1853 | 2.41 | | | | | | | 92 | ***74.16*** | 15 | ***12.09*** | | | 107 | ***86.26*** |
| | | C44.6-L | 05-Nov-14 | 650 | 1.01 | | | | | | | 295 | ***1617.67*** | | | | | 295 | ***1617.67*** |
| | | C45.6-L | 04-Nov-14 | 728 | 0.9 | | | | | | | 450 | ***2472.53*** | 1 | ***5.49*** | | | 451 | ***2478.02*** |
| | | C46.4-L | 05-Nov-14 | 1269 | 1.59 | | | | | | | 325 | ***579.87*** | 4 | ***7.14*** | | | 329 | ***587*** |
| | **Session Summary** | | | **1034** | **26.6** | **5** | ***0.65*** | **0** | ***0*** | **230** | ***30.1*** | **2856** | ***373.82*** | **135** | ***17.67*** | **0** | ***0*** | **3226** | ***422.25*** |
| **Section Total All Samples** | | | | **79075** | **119.56** | **22** | | **17** | | **422** | | **7026** | | **438** | | **0** | | **7925** | |
| **Section Average All Samples** | | | | **1098** | **1.66** | **0** | ***0.6*** | **0** | ***0.47*** | **6** | ***11.57*** | **98** | ***192.67*** | **6** | ***12.01*** | **0** | ***0*** | **110** | ***217.33*** |
| **Section Standard Error of Mean** | | | | | | **0.15** | ***0.28*** | **0.21** | ***0.27*** | **2.96** | ***4.85*** | **16.94** | ***91.48*** | **0.96** | ***2.48*** | **0** | ***0*** | **17.02** | ***92.02*** |
| **All Sections Total All Samples** | | | | **131253** | **178.22** | ***69*** | ***0.01*** | ***25*** | ***0*** | ***3667*** | ***0.56*** | ***10712*** | ***1.65*** | ***2171*** | ***0.33*** | ***1*** | ***0*** | ***16645*** | ***2.56*** |
| **All Sections Average All Samples** | | | | | | ***1*** | ***1.33*** | ***0*** | ***0.48*** | ***29*** | ***70.54*** | ***86*** | ***206.07*** | ***17*** | ***41.76*** | ***0*** | ***0.02*** | ***133*** | ***320.21*** |
| **All Sections Standard Error of Mean** | | | | | | ***0.15*** | ***0.38*** | ***0.12*** | ***0.26*** | ***8.32*** | ***30.75*** | ***12.64*** | ***58.05*** | ***2.4*** | ***12.28*** | ***0.01*** | ***0.04*** | ***16.95*** | ***69.94*** |

# APPENDIX F

## Life History Summaries

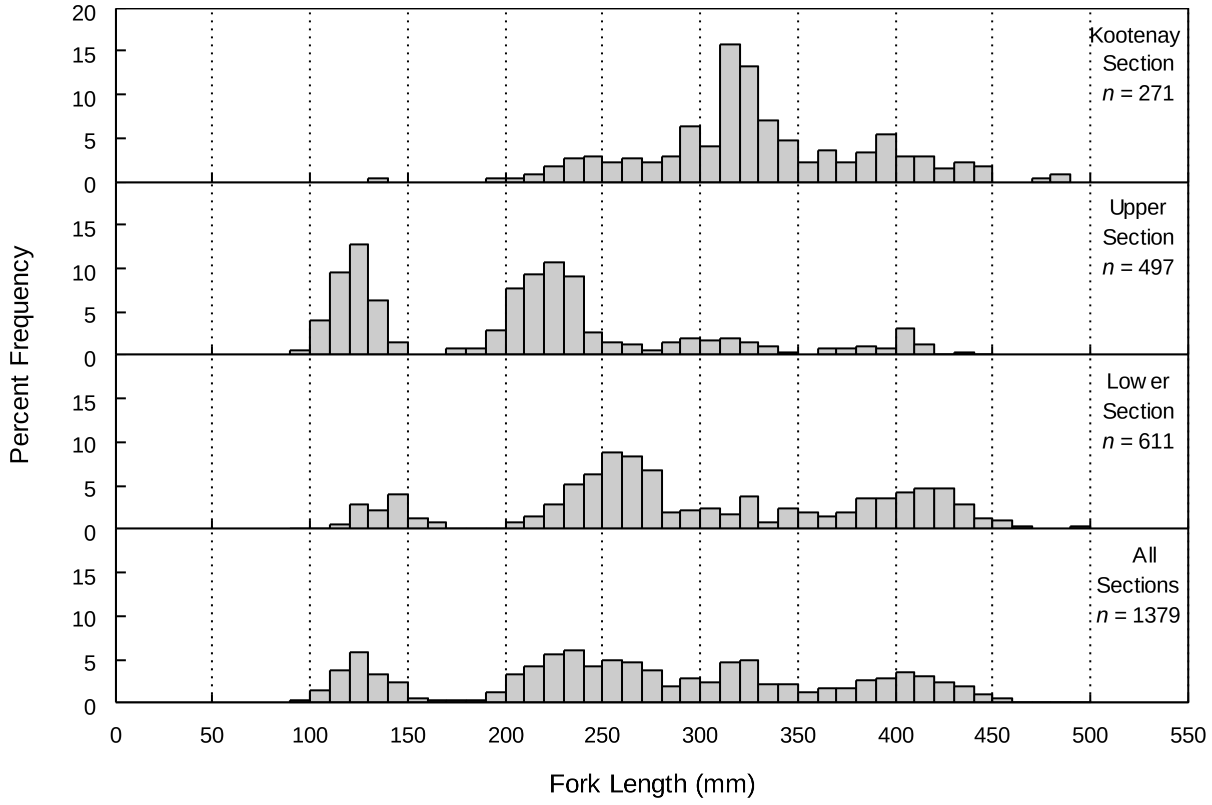


*Figure F1. Length-frequency distributions by site for Mountain Whitefish captured by boat electroshocking in sampled sections of the lower Columbia River, October 06 to November 06, 2014.*

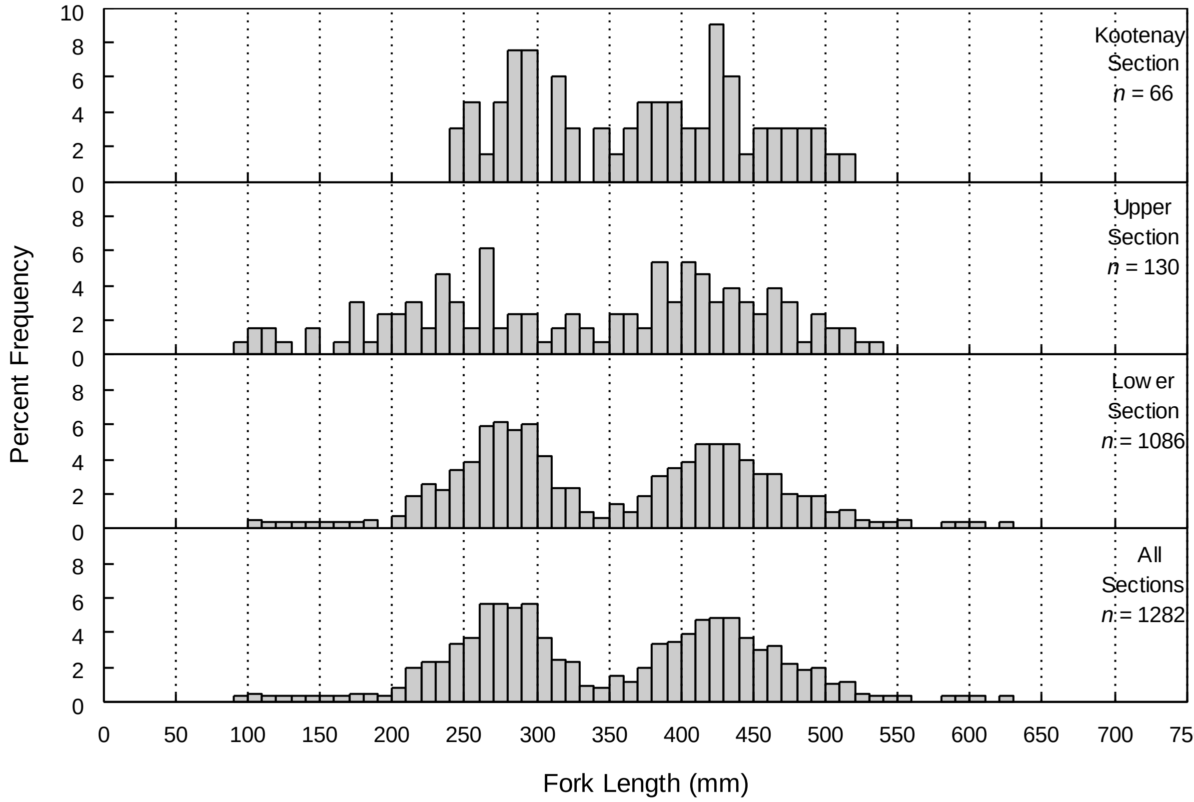


*Figure F2. Length-frequency distributions by site for Rainbow Trout captured by boat electroshocking in sampled sections of the lower Columbia River, October 06 to November 06, 2014.*

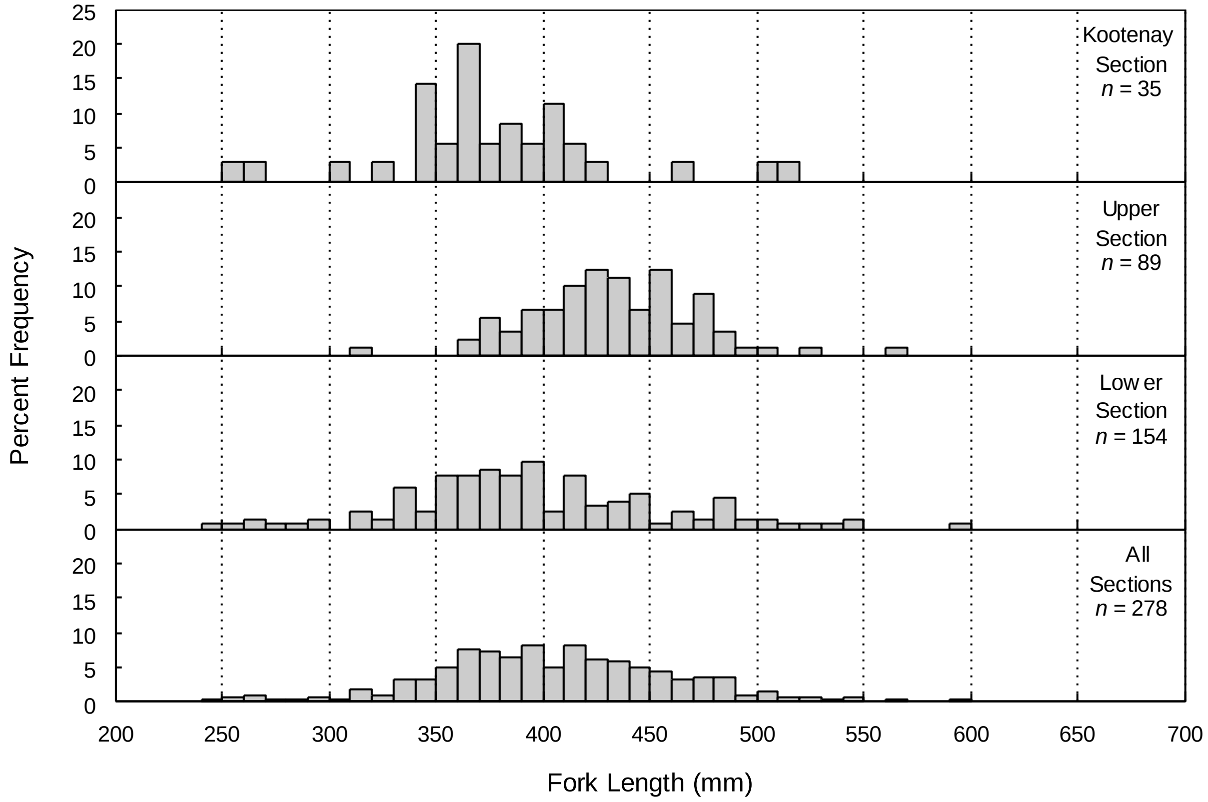
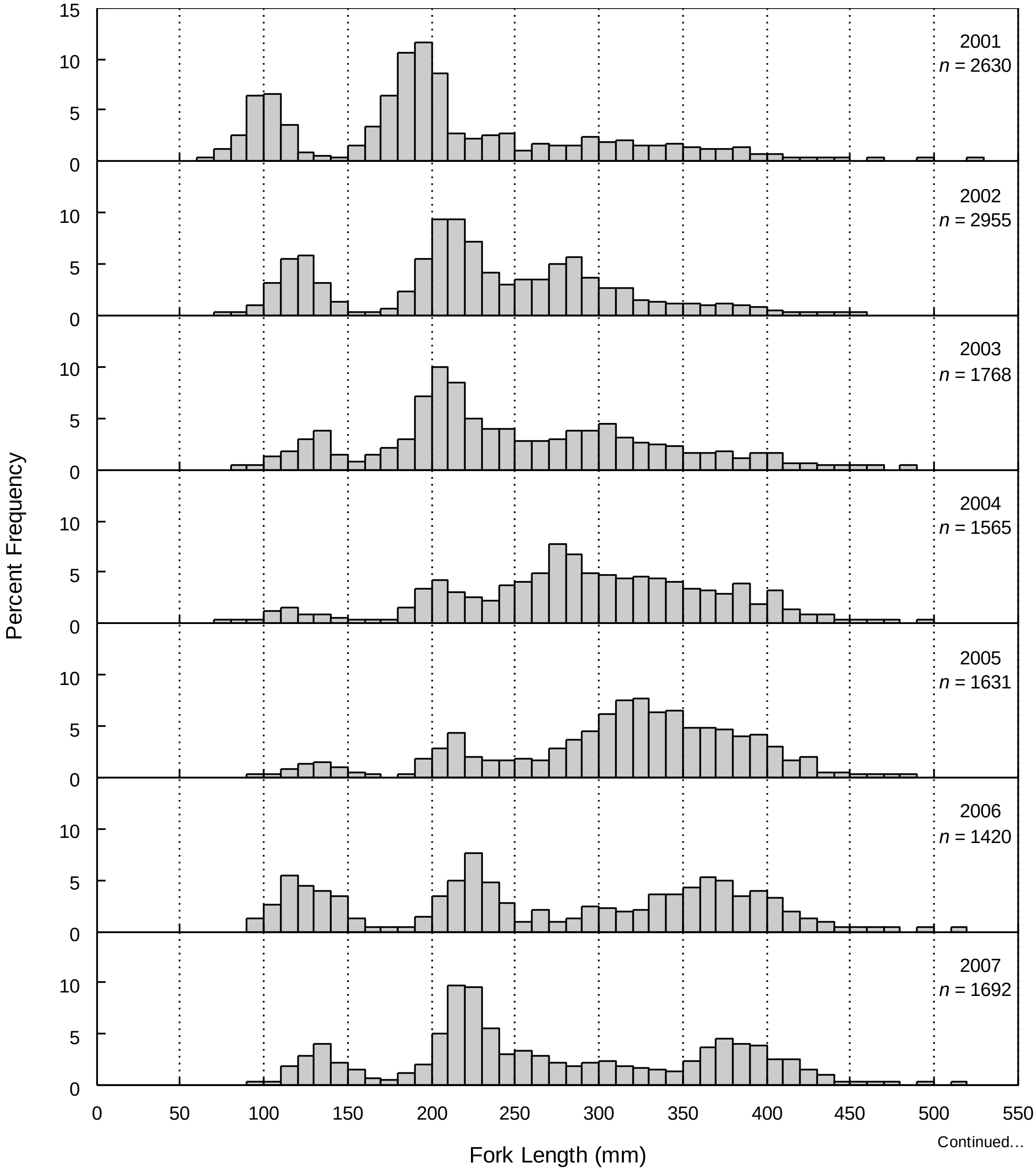


*Figure F3. Length-frequency distributions by site for Walleye captured by boat electroshocking in sampled sections of the lower Columbia River, October 06 to November 06, 2014.*



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 2014.*

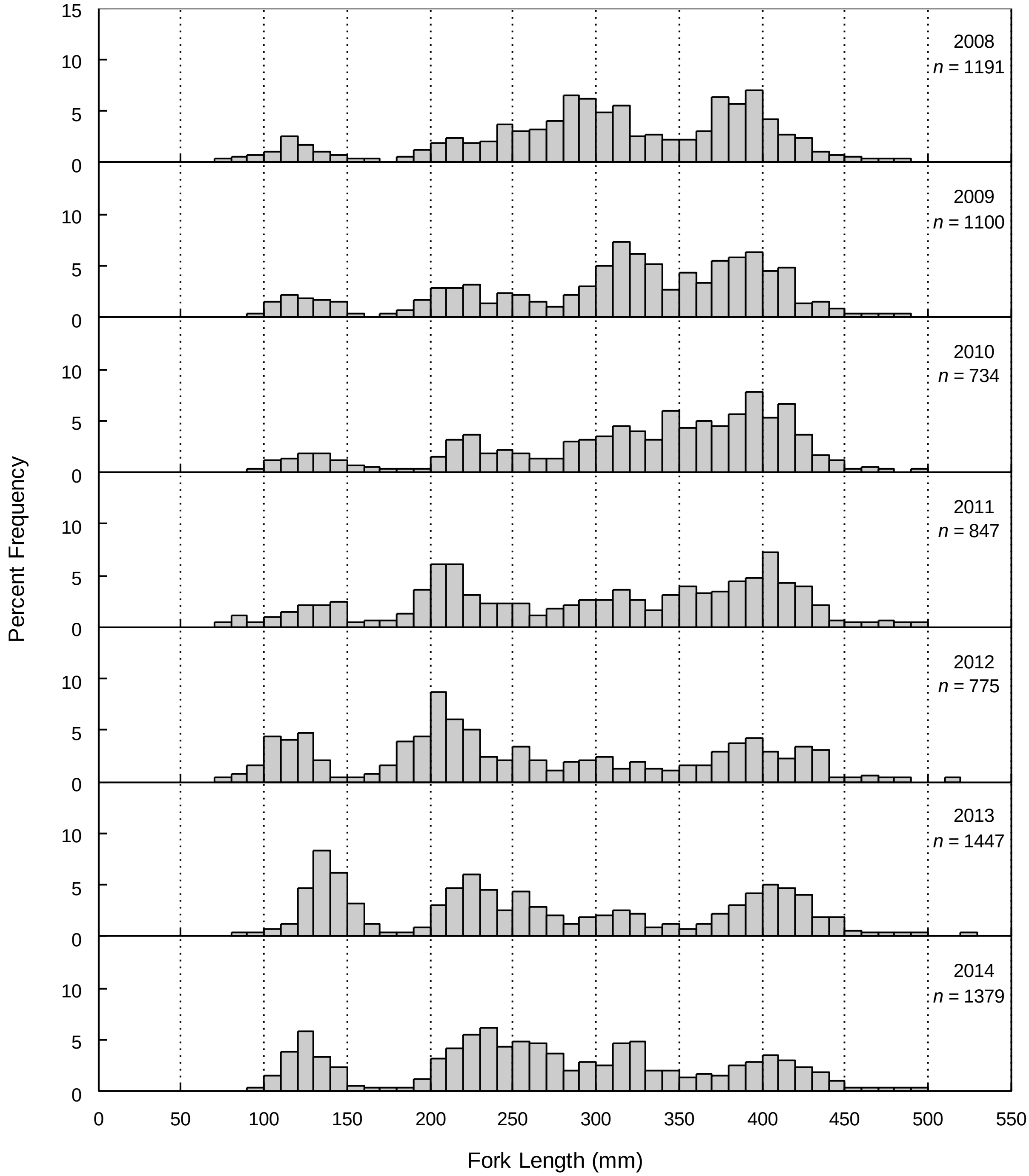
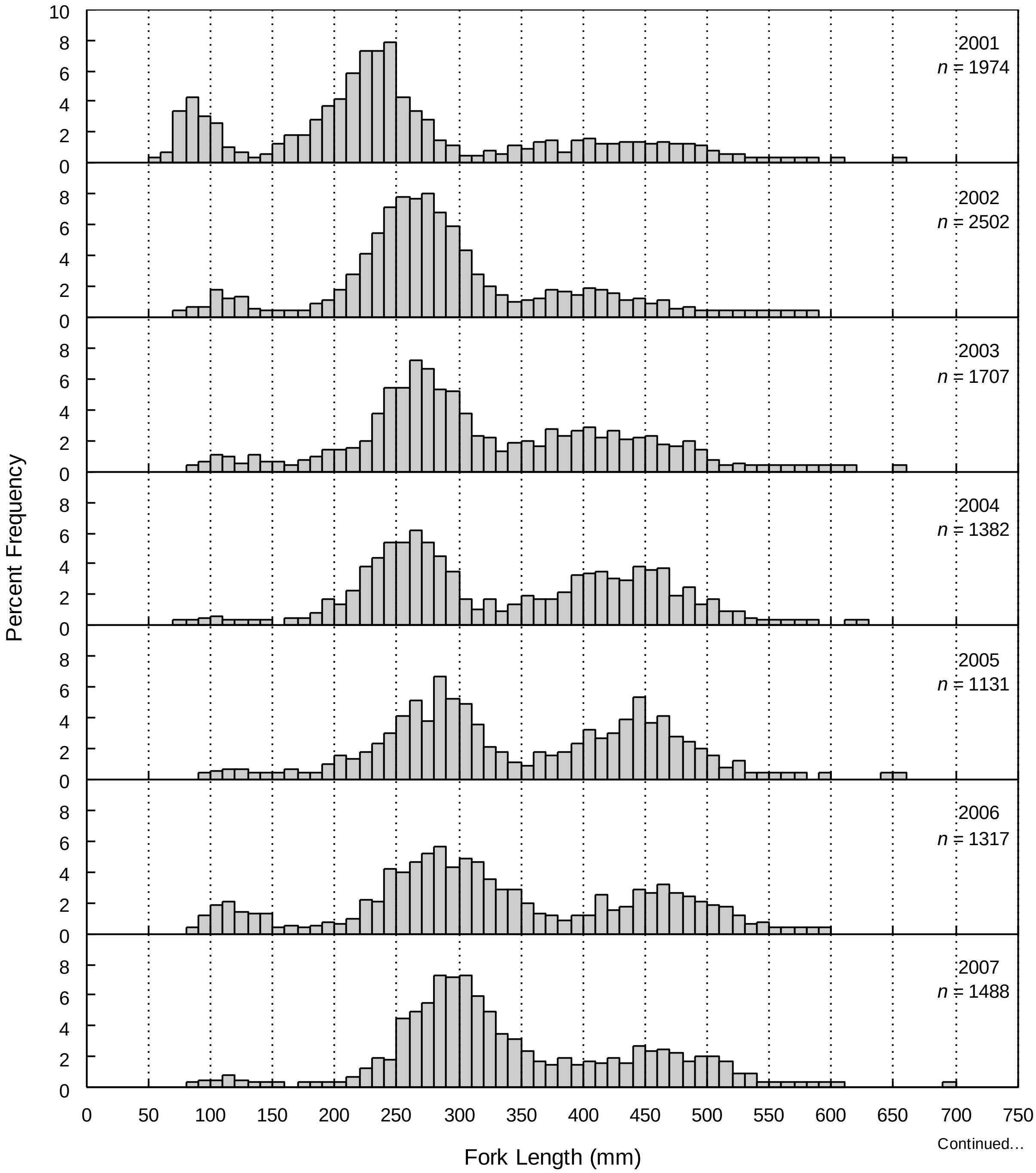


*Figure F4. Concluded.*



Continued…

*Figure F5. Length-frequency distributions by year for Rainbow Trout captured by boat electroshocking in sampled sections of the lower Columbia River, 2001 to 2014.*

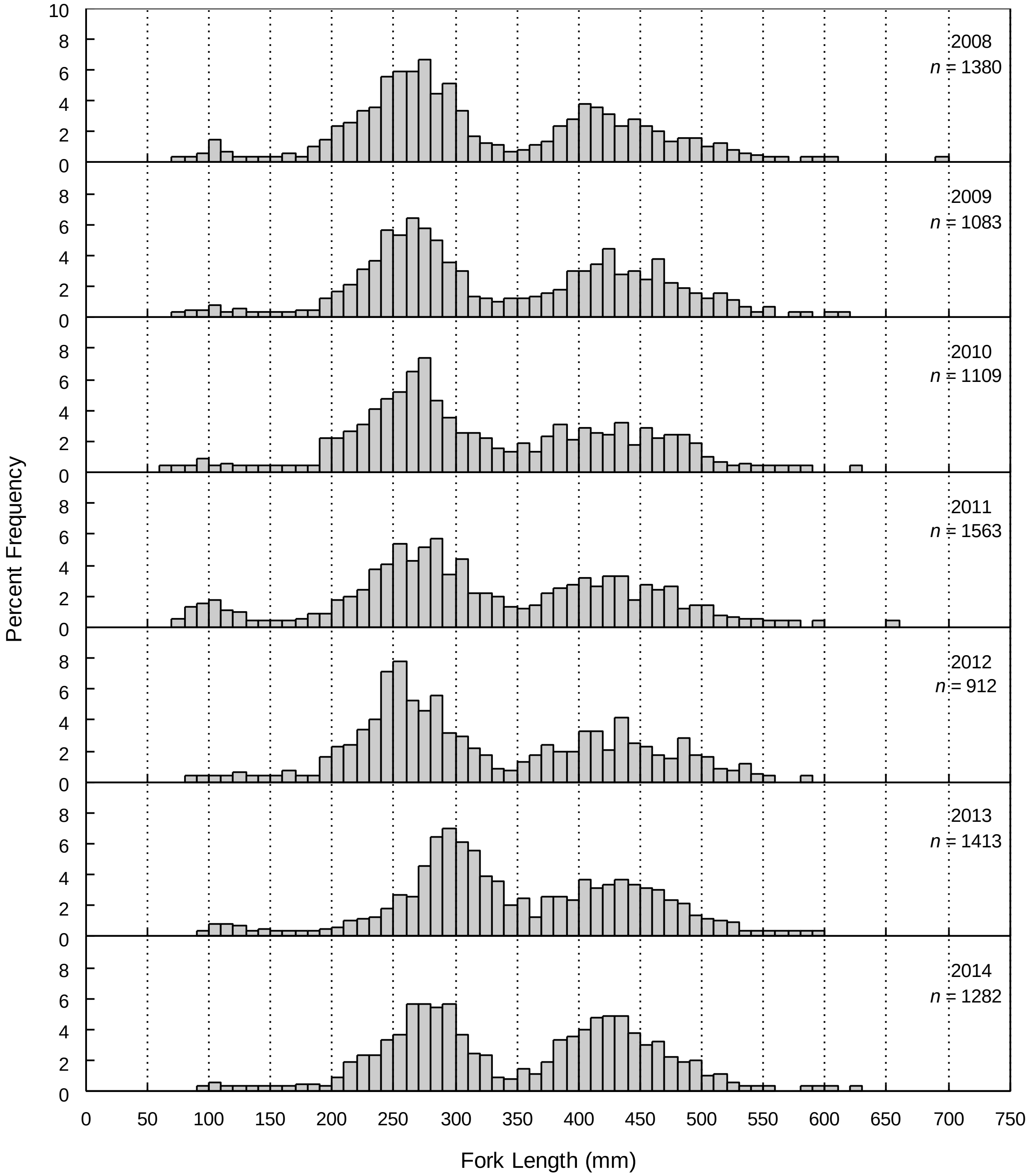
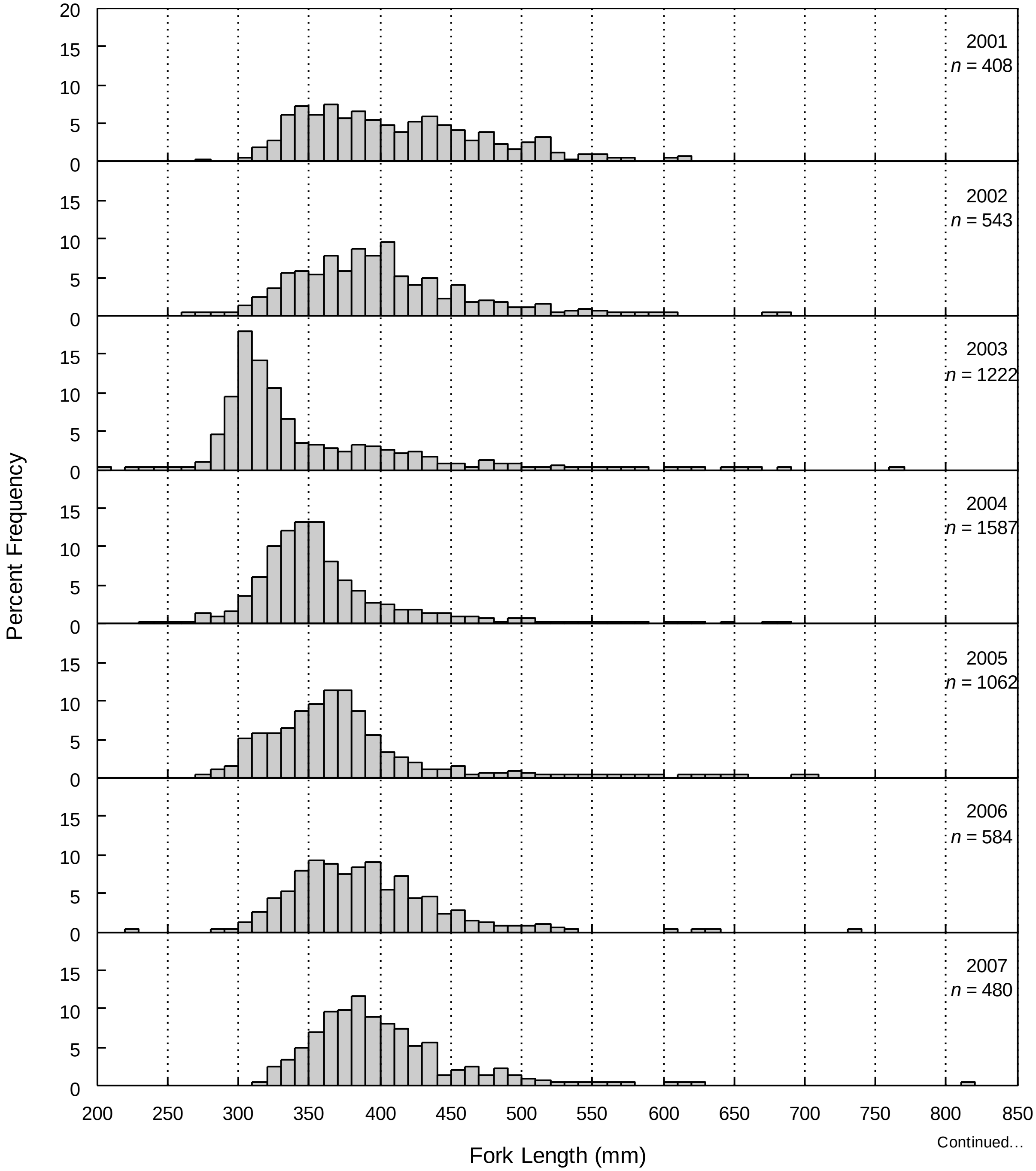


*Figure F5. Concluded.*



Continued…

*Figure F6. Length-frequency distributions by year for Walleye captured by boat electroshocking in sampled sections of the lower Columbia River, 2001 to 2014.*

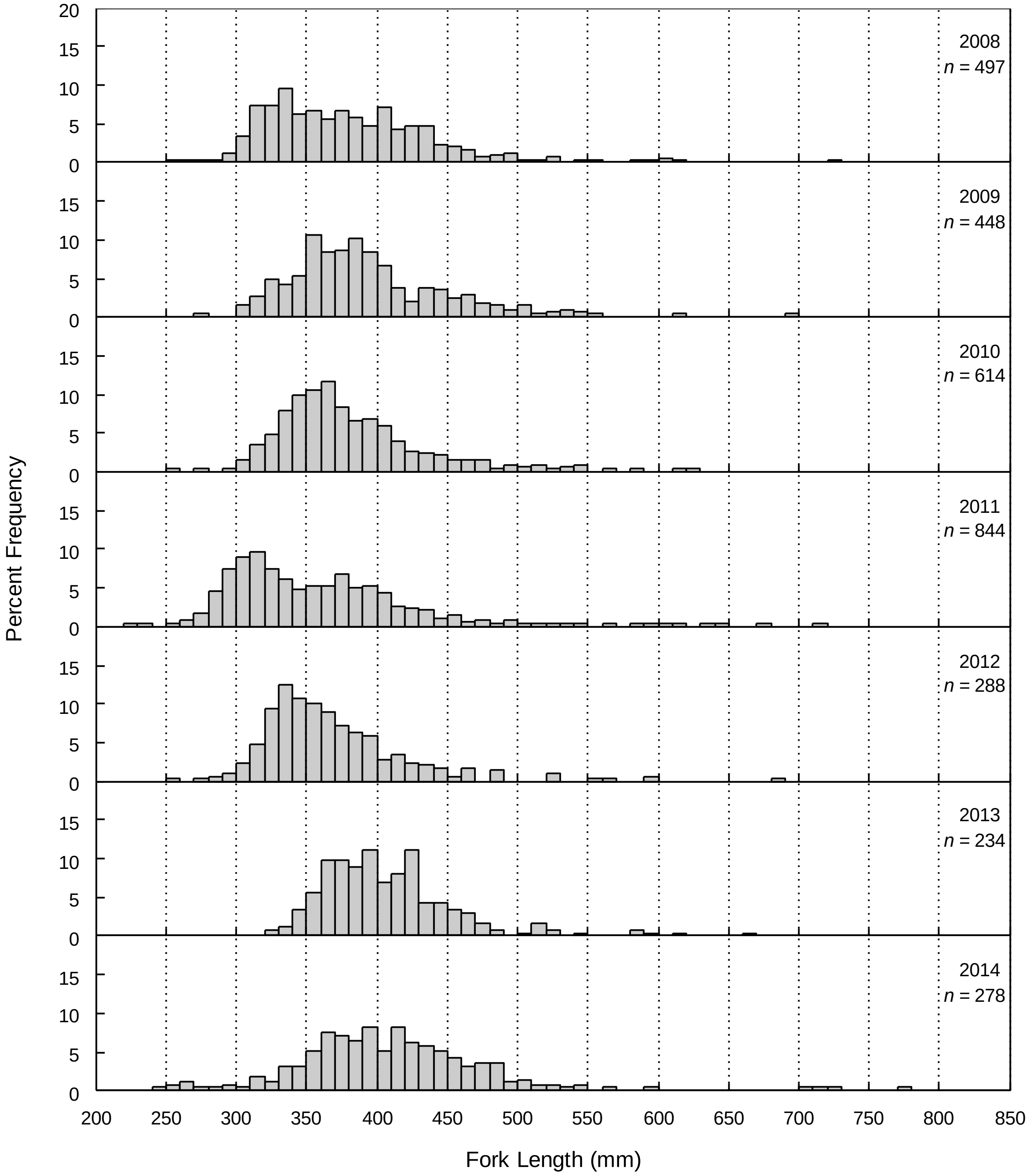
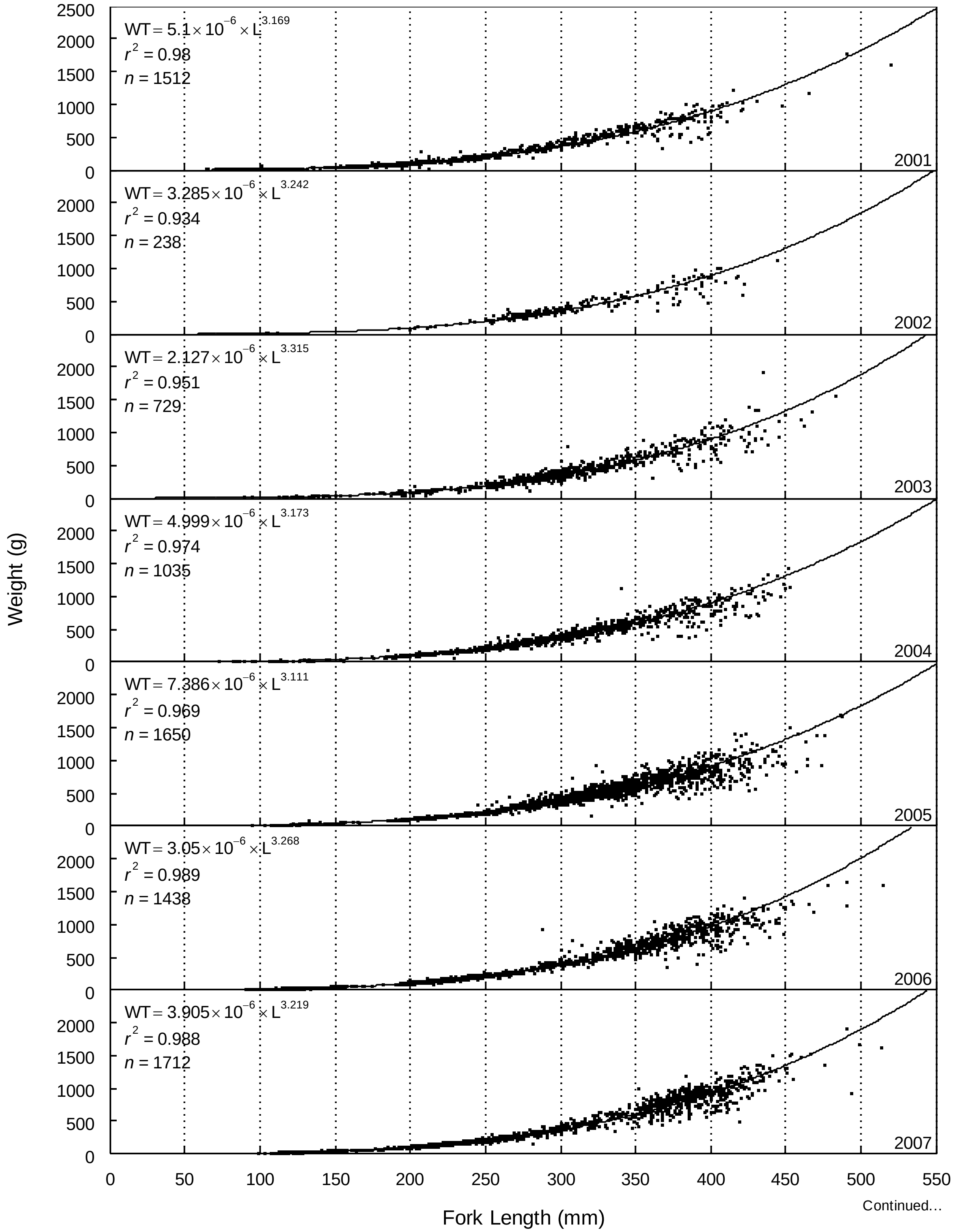


*Figure F6. Concluded.*



Continued…

*Figure F7. Length-weight regressions for Mountain Whitefish captured by boat electroshocking in the lower Columbia River, 2001 to 2014.*

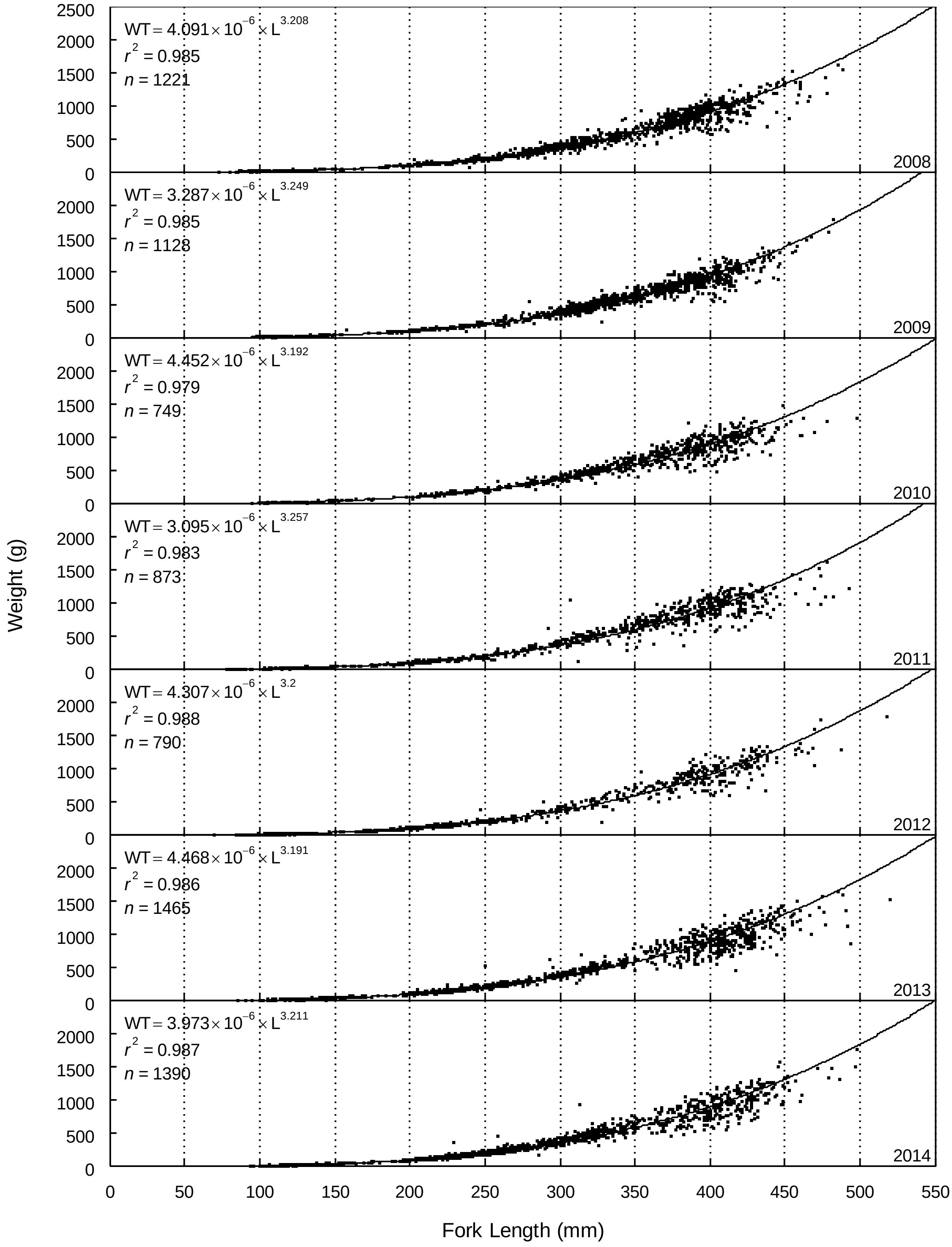
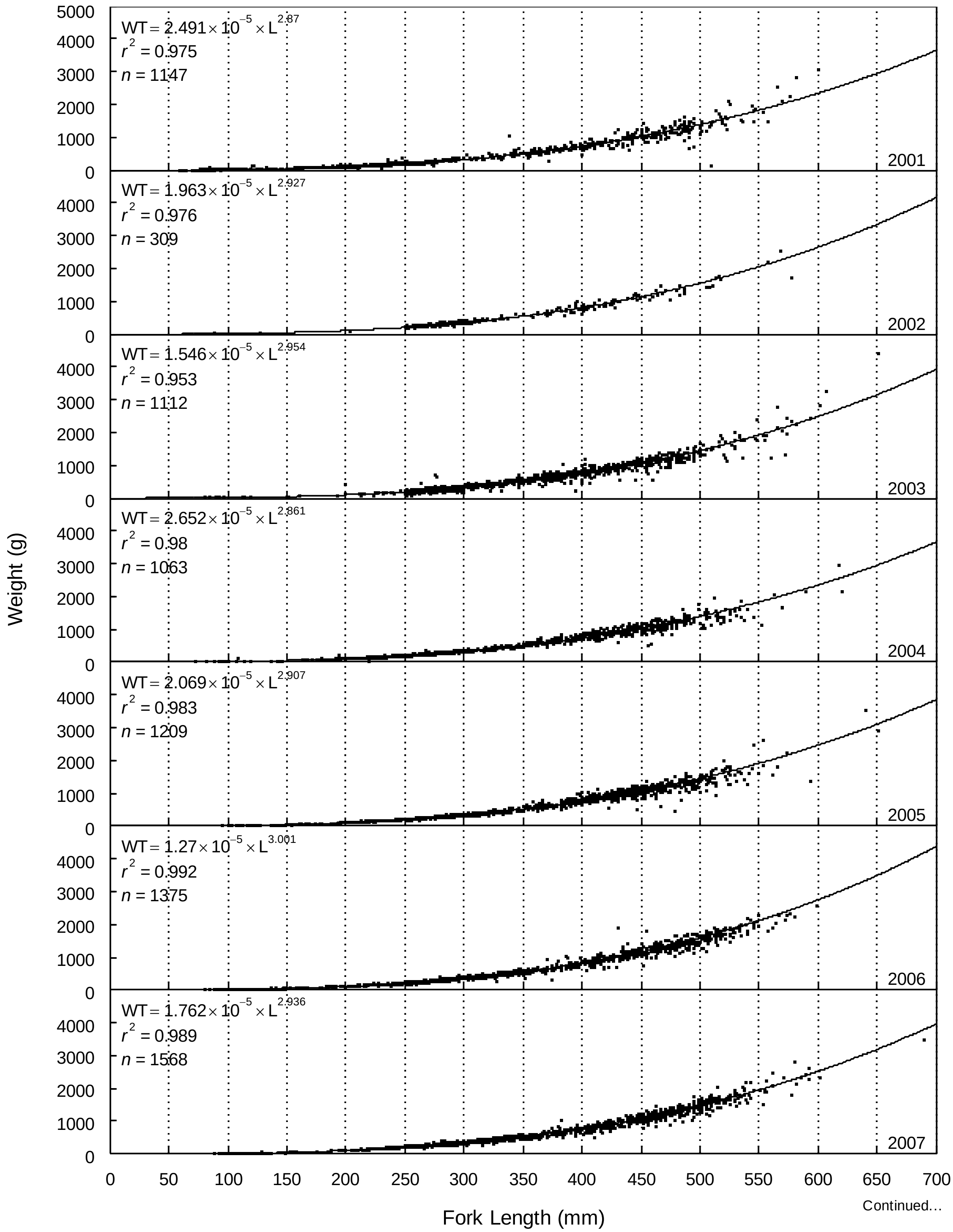


*Figure F7. Concluded.*



Continued…

*Figure F8. Length-weight regressions for Rainbow Trout captured by boat electroshocking in the lower Columbia River, 2001 to 2014.*

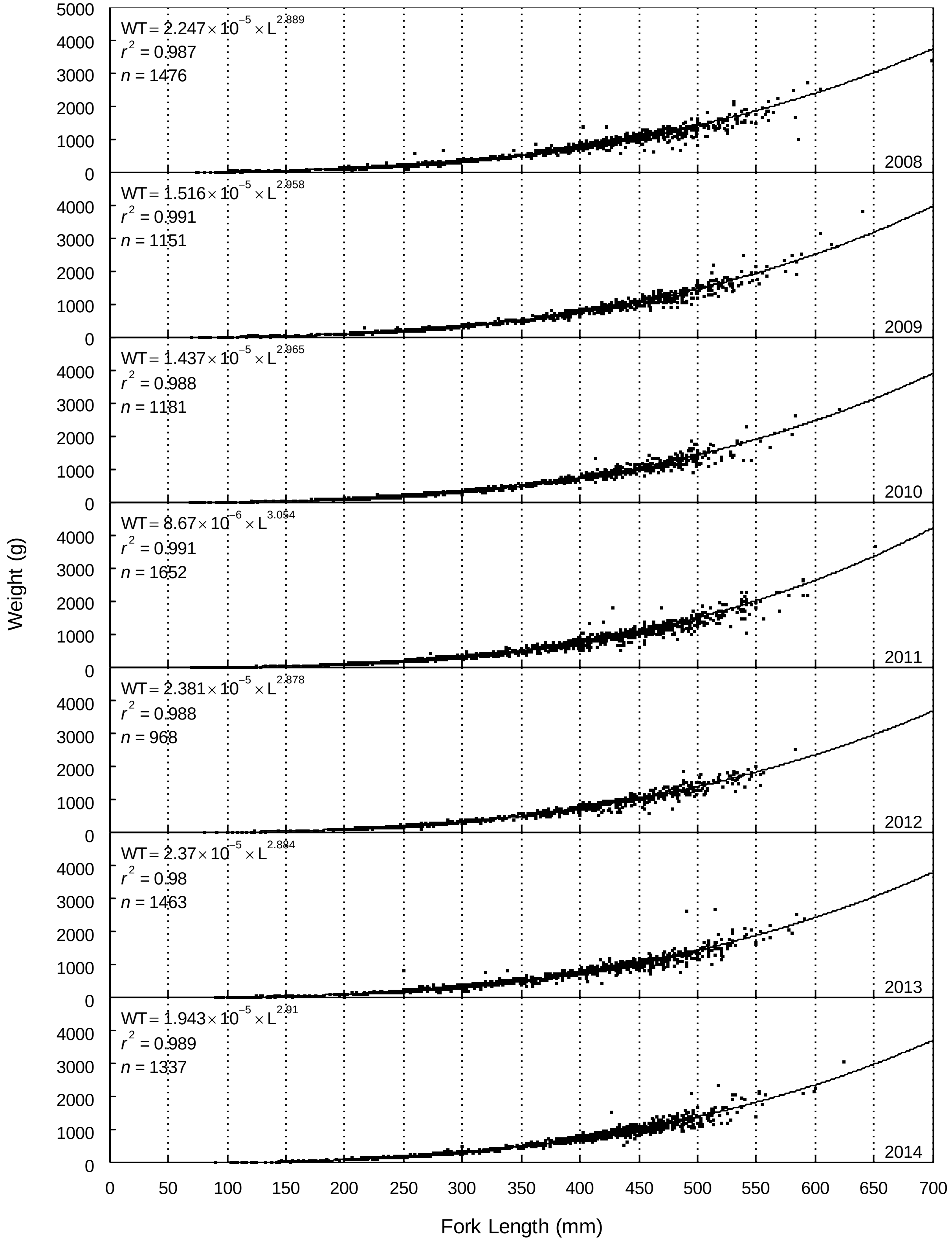
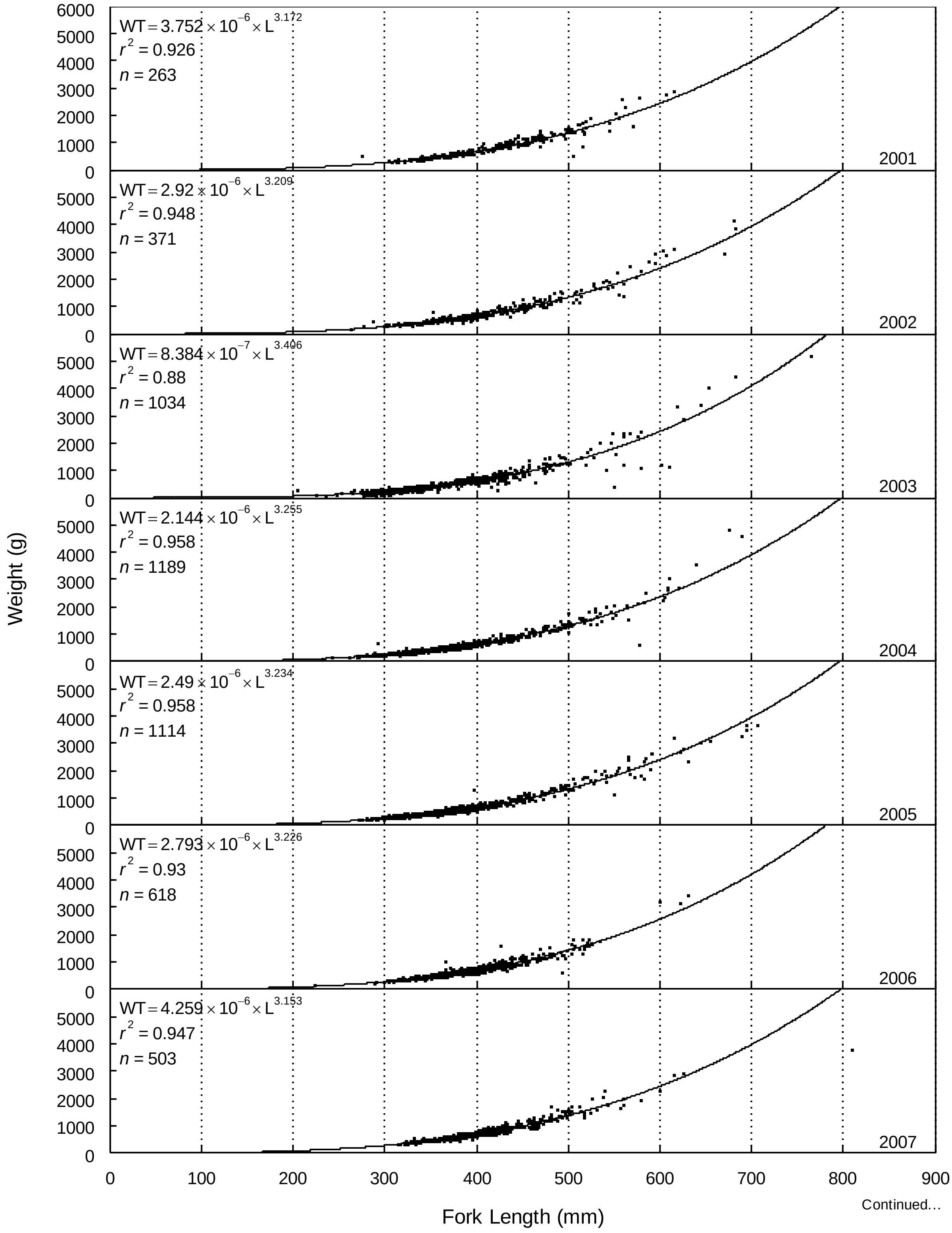


*Figure F8. Concluded.*



Continued…

*Figure F9. Length-weight regressions for Walleye captured by boat electroshocking in the lower Columbia River, 2001 to 2014.*

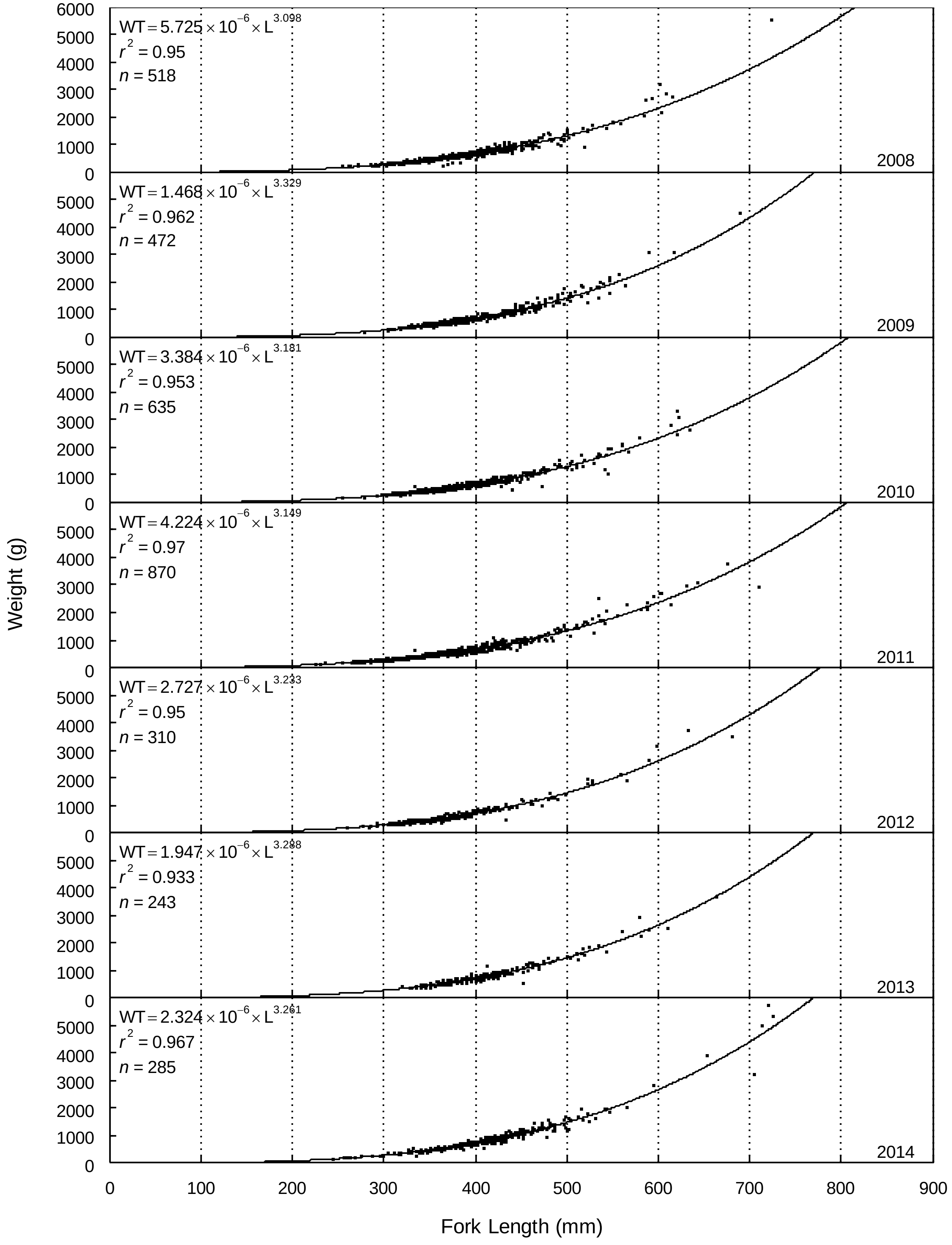


*Figure F9. Concluded.*

# APPENDIX G

## Additional Figures

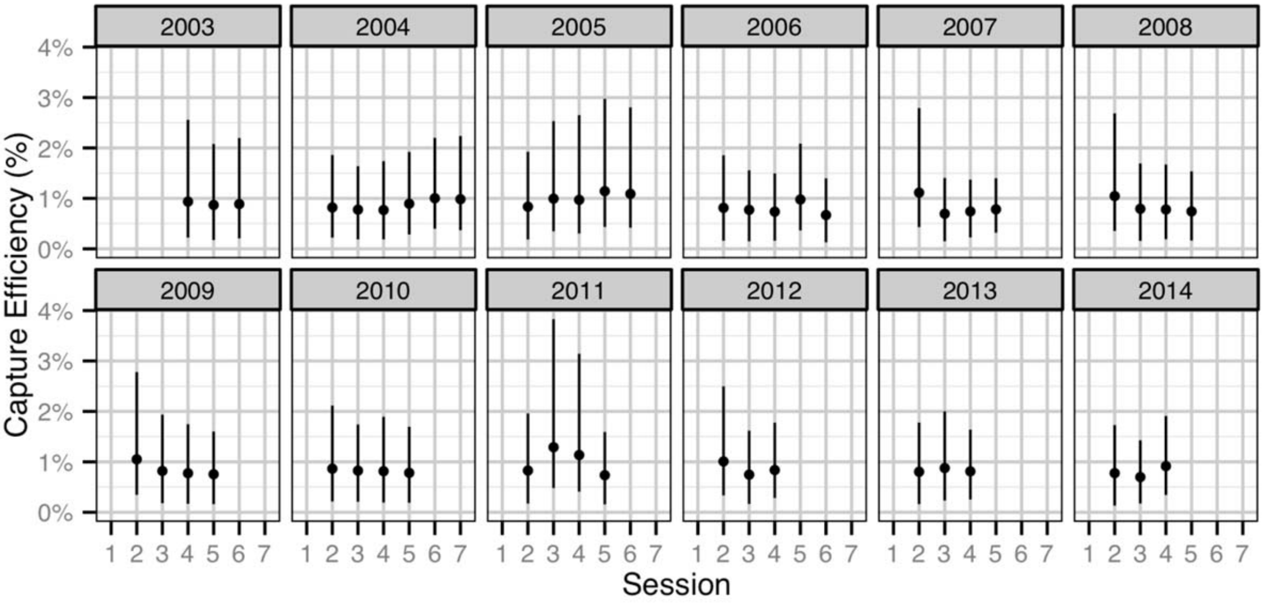


*Figure G1: Capture efficiency (mean with 95% credible intervals) of subadult Mountain Whitefish by year and sample session in the lower Columbia River, 2001-2014.*

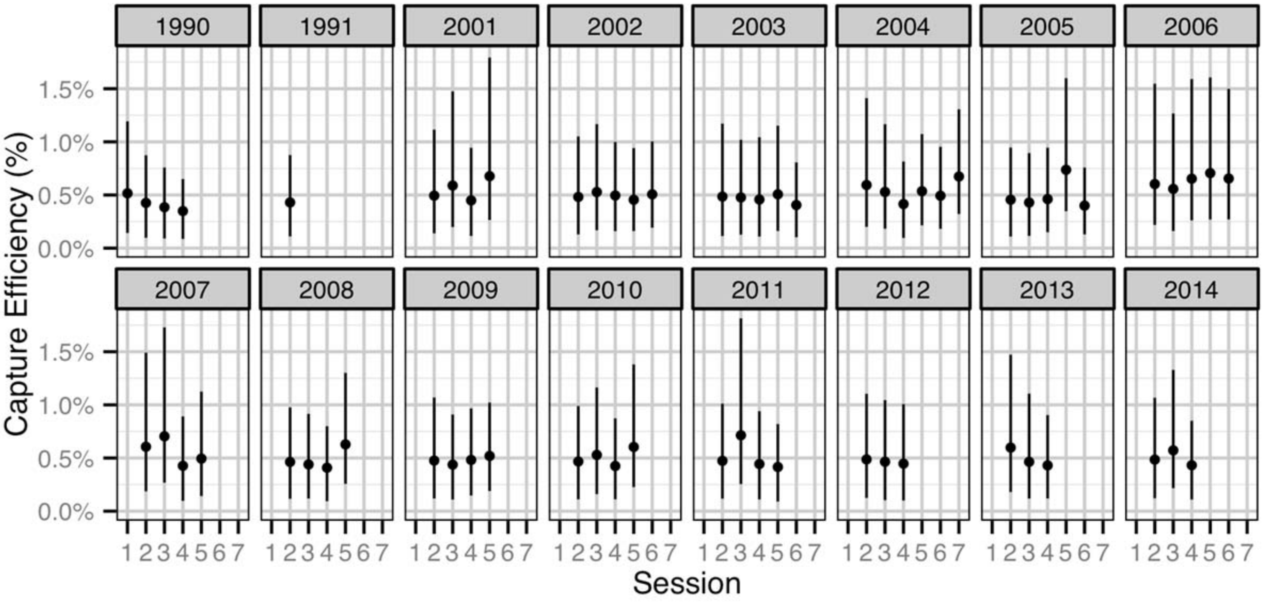


*Figure G2: Capture efficiency (mean with 95% credible intervals) of adult Mountain Whitefish by year and sample session in the lower Columbia River, 2001-2014.*

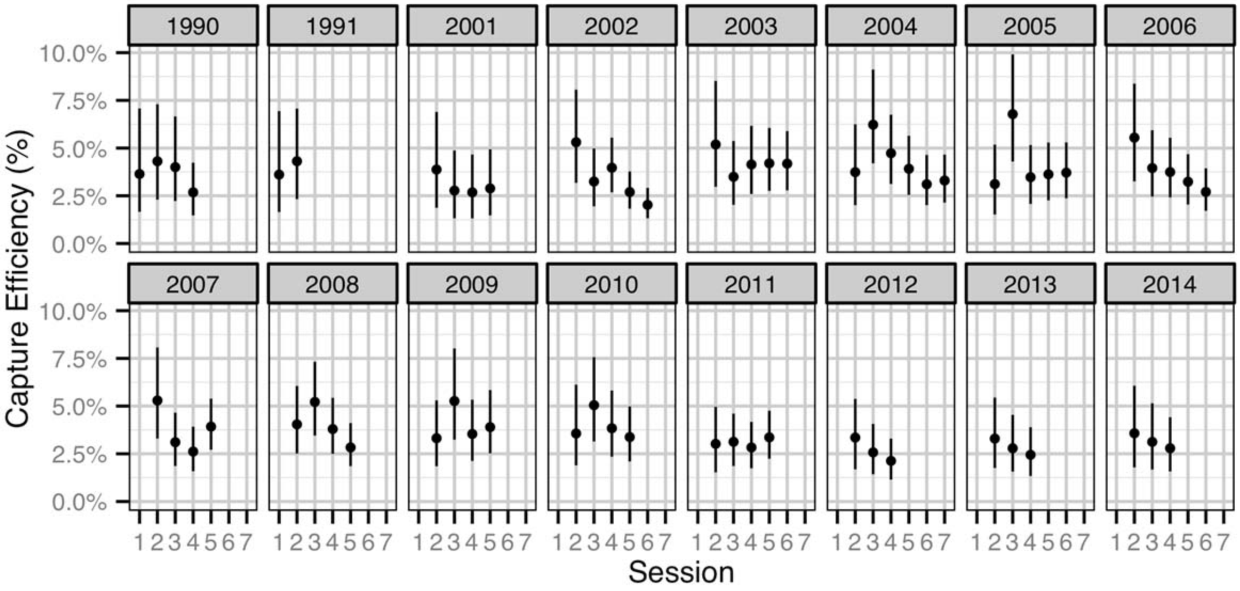


*Figure G3: Capture efficiency (mean with 95% credible intervals) of subadult Rainbow Trout by year and sample session in the lower Columbia River, 2001-2014.*

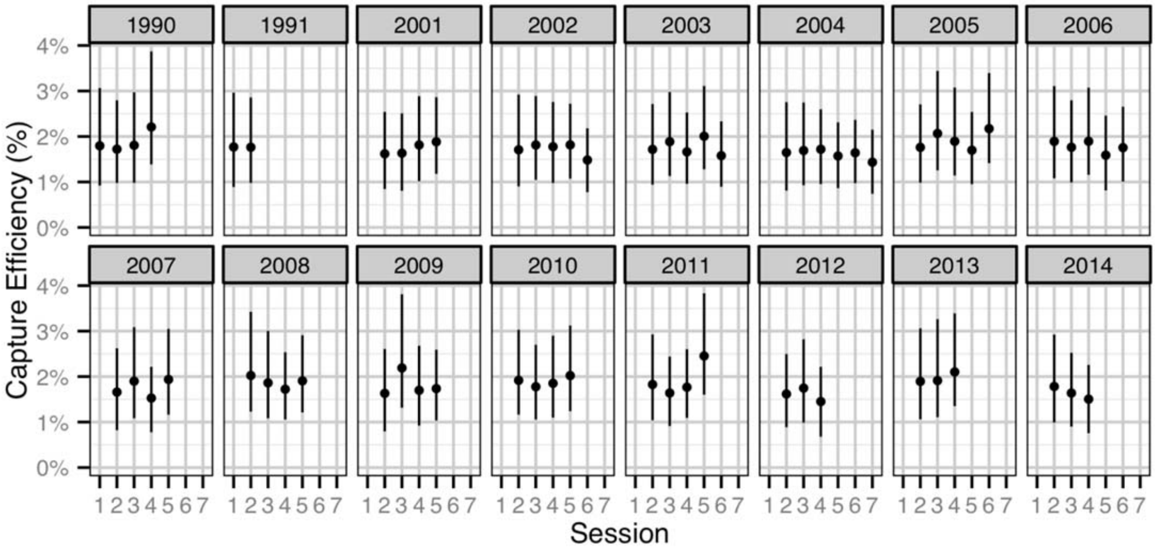


*Figure G4: Capture efficiency (mean with 95% credible intervals) of adult Rainbow Trout by year and sample session in the lower Columbia River, 2001-2013.*

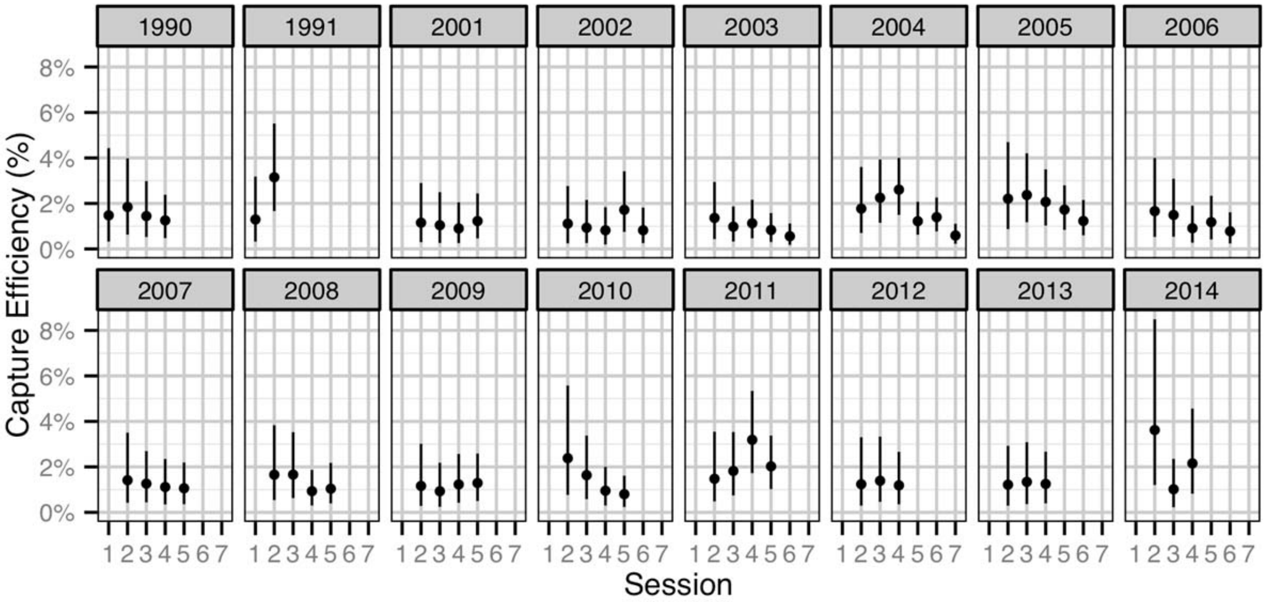


*Figure G5: Capture efficiency (mean with 95% credible intervals) of adult Walleye by year and sample session in the lower Columbia River, 2001-2014.*

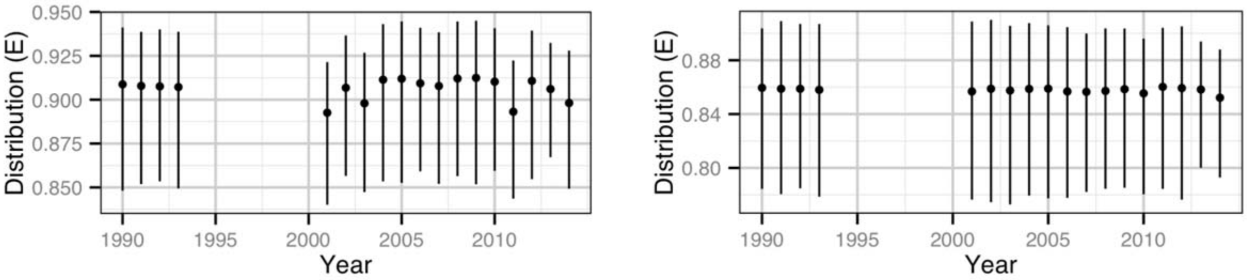


*Figure G6: Predicted evenness of spatial distribution for sub-adult (left) and adult (right) Mountain Whitefish by year (with 95% CRIs).*

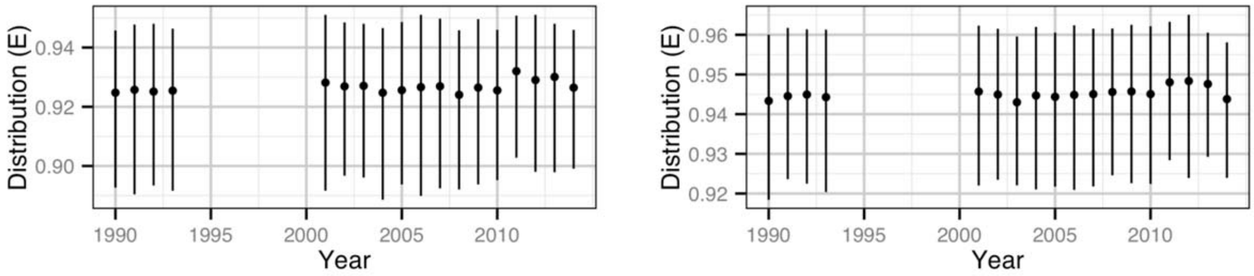


*Figure G7: Predicted evenness of spatial distribution for sub-adult (left) and adult (right) Rainbow Trout by year (with 95% CRIs).*

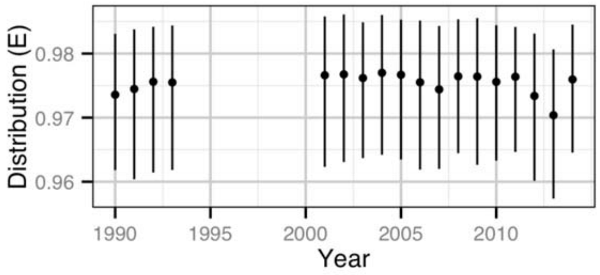


*Figure G8: Predicted evenness of spatial distribution for adult Walleye by year (with 95% CRIs).*

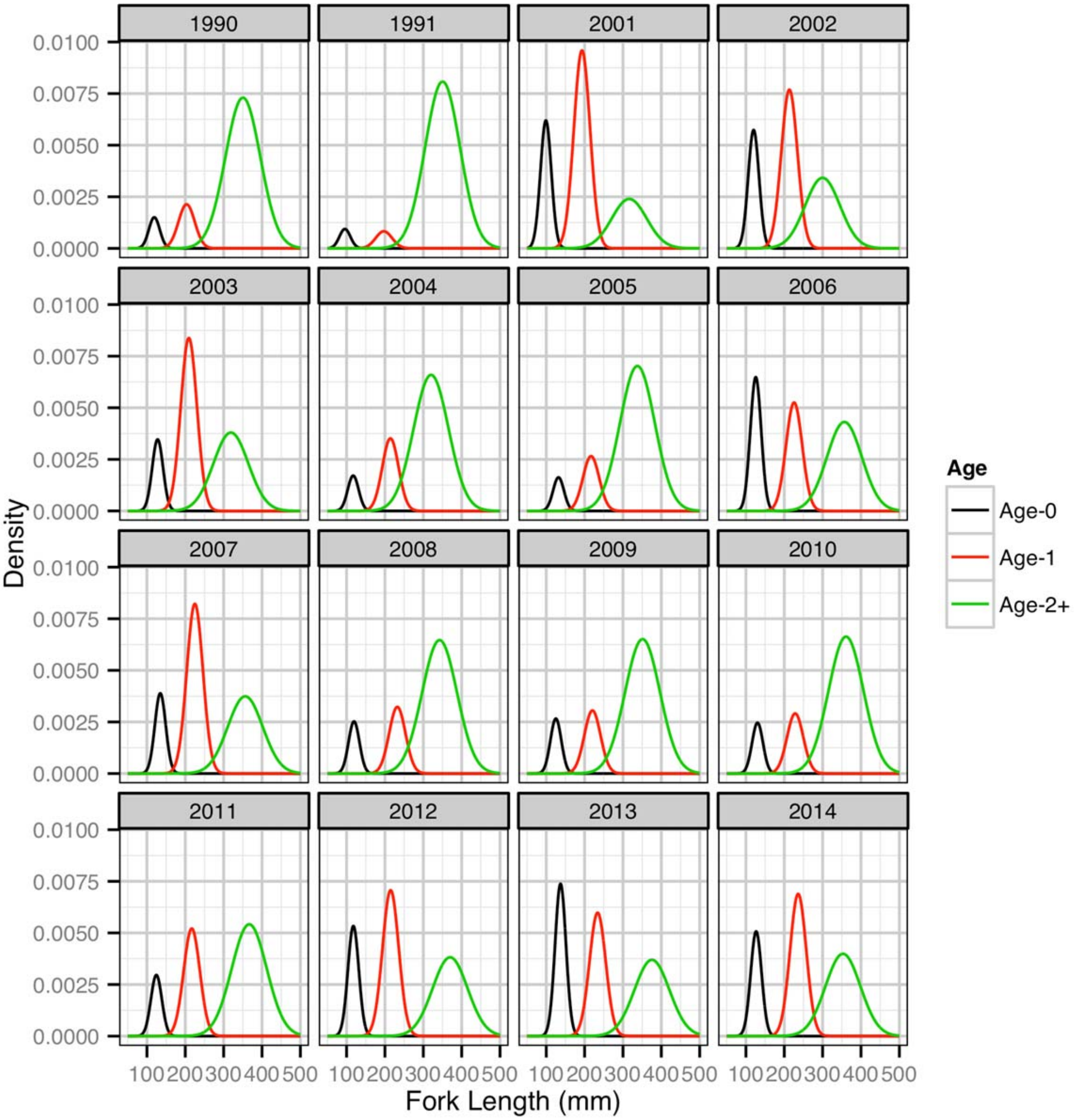


*Figure G9: Predicted length-density plot for Mountain Whitefish by life-stage and year.*

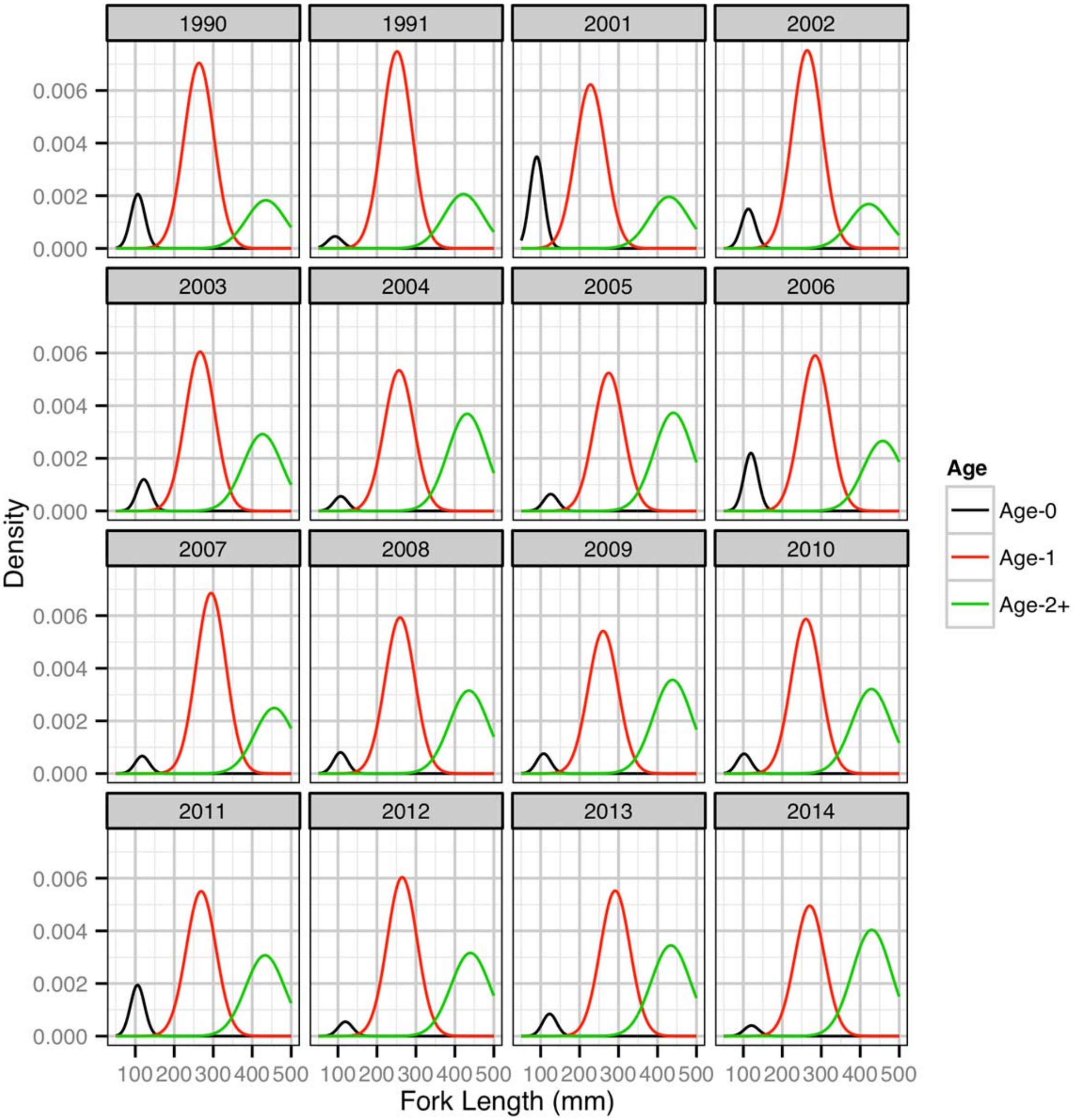


*Figure G10: Predicted length-density plot for Rainbow Trout by life-stage and year.*

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# 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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