Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Implementation Year 6

Reference: CLBMON-45

Lower Columbia River Fish Population Indexing Surveys

Study Period: 2012

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CLBMON-45

Lower Columbia River Fish Population Indexing Surveys - 2012 Investigations

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Executive Summary

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

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

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

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

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

Field work was conducted in the fall of 2012, which corresponded approximately to the timing of data collected during earlier study years (i.e., 2007 to 2011) and to data collected between 2001 and 2006 as part of the LCR LRFIP. Fishes were sampled by boat electroshocking at night within nearshore habitats. In 2011, a Generalized Random Tessellation Stratified (GRTS) survey was conducted in addition to the standard mark recapture program. 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, size-at-age, survival, and body condition. In 2012, data collected during the early 1990s as part of BC Hydro's Columbia Basin Development Fisheries were included in the HBMs.

Correlation analysis was used to assess relationships between water temperature and discharge, and fish population metrics.

Outputs from the HBMs were precise enough to show temporal and spatial trends/patterns in abundance, spatial distribution, growth, size-at-age, survival, and body condition for subadult and adult Mountain Whitefish, Rainbow Trout, and Walleye.

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 Mountain Whitefish, Rainbow Trout and Walleye was not determined.

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

Table EI: Status of management questions and hypotheses after Year 6 of the Lower Columbia River Fish Population Indexing Survey (CLBMON-45).

Management Questions	Management Hypotheses	Sub-Hypotheses	Year 6 (2012) Status
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 Lower Columbia River?	**Ho_1:** There is no change in the population levels of Whitefish in the Lower Columbia River over the course of the monitoring period.	**Ho_{1a}:** There is no change in the abundance of subadult and adult Mountain Whitefish.	The hypothesis is rejected. Population levels of Mountain Whitefish have changed over the course of the monitoring period. For example, subadult Mountain Whitefish abundance decreased by 68% from 2001 to 2005; adult Mountain Whitefish abundance decreased by 51% from 2002 to 2012. Results in Section 3.4.2 Discussion in Section 4.2.1
		Ho_{1b}: There is no change in the mean size-at-age of subadult and adult Mountain Whitefish.	The hypothesis is rejected. The mean size-at-age of the fry and subadult Mountain Whitefish cohorts were substantially lower in 2001 when compared to other study years. Results in Section 3.3.1 Discussion in Section 4.1.1
		Ho_{1c}: There is no change in the mean survival of subadult and adult Mountain Whitefish.	The hypothesis cannot be rejected at this time. Annual survival estimates were variable and uncertain for both the subadult and adult Mountain Whitefish cohorts. Results in Section 3.5.1 Discussion in Section 4.4.1
		Ho_{1d}: There is no change in the morphological (condition factor) index of body condition of subadult and adult Mountain Whitefish.	The hypothesis is rejected. The body condition of subadult and adult Mountain Whitefish has varied (e.g., lowest in 2002 and 2003 and highest in 2005 and 2006) among study years. Results in Section 3.6.1 Discussion in Section 4.5.1
		Ho_{1e}: There is no change in the distribution of subadult and adult Mountain Whitefish.	The hypothesis cannot be rejected at this time. Subadult and adult Mountain Whitefish densities were generally consistent between study years. Data collected to date does indicate substantial annual changes in spatial distribution for this species. Results in Section 3.4.2 Discussion in Section 4.2.1
	Ho_2: There is no change in the population levels of Rainbow Trout in the Lower Columbia River over the course of the monitoring period.	**Ho_{2a}:** There is no change in the abundance of subadult and adult Rainbow Trout	The hypothesis is rejected. Population levels of subadult Rainbow Trout have changed over the course of the monitoring period. Subadult Rainbow Trout abundance has changed by as much as 47% over a 1 year period; adult Rainbow Trout abundance has changed by as much as 17% over a 1 year period. Results in Section 3.4.3 Discussion in Section 4.2.2
		Ho_{2b}: There is no change in the mean size-at-age of subadult and adult Rainbow Trout	The hypothesis is rejected. The average size-at-age of the fry and subadult Rainbow Trout cohorts were substantially lower in 2001 when compared to other study years. Results in Section 3.3.2 Discussion in Section 4.1.2
		Ho_{2c}: There is no change in the mean survival of subadult and adult Rainbow Trout	The hypothesis cannot be rejected at this time. However, annual survival estimates for adult Rainbow Trout were substantially lower from 2011 to 2012 when compared to 2010 to 2011 results. Subadult Rainbow Trout survival estimates were variable. Results in Section 3.5.2 Discussion in Section 4.4.2
		Ho_{2d}: There is no change in the morphological (condition factor) index of body condition of subadult and adult Rainbow Trout	The hypothesis is rejected. Body condition estimates for subadult and adult rainbow trout varied annually, but were higher for both cohorts in 2002 and 2006 when compared to other study years. Results in Section 3.6.2 Discussion in Section 4.5.2

Table E1 - Concluded.

Management Questions	Management Hypotheses	Sub-Hypotheses	Year 6 (2012) Status
		Ho_{2e}: There is no change in the distribution of subadult and adult Rainbow Trout	The hypothesis cannot be rejected at this time. Subadult and adult Rainbow Trout densities were generally consistent between study years. Data collected to date does indicate substantial annual changes in spatial distribution for this species. Results in Section 3.4.3 Discussion in Section 4.2.2
	Ho_3: There is no change in the population levels of Walleye in the Lower Columbia River over the course of the monitoring period.	**Ho_{3a}:** There is no change in the abundance of subadult and adult Walleye.	The hypothesis is rejected. Population levels of Walleye have changed over the course of the monitoring period. Walleye abundance has more than doubled with a single year. Results in Section 3.4.4 Discussion in Section 4.2.3
		Ho_{3b}: There is no change in the mean size-at-age of subadult and adult Walleye.	The hypothesis cannot be rejected at this time. Analysis was limited to data collected from inter-year recaptured Walleye. Annual growth estimates were variable and uncertain for this species. Results in Section 3.3.3 Discussion in Section 4.1.3
		Ho_{3c}: There is no change in the mean survival of subadult and adult Walleye.	Hypothesis cannot be rejected at this time. Limited data prevented the HBM from properly converging. Results in Section 3.5.3 Discussion in Section 4.4.3
		Ho_{3d}: There is no change in the morphological (condition factor) index of body condition of subadult and adult Walleye.	This hypothesis is rejected. Walleye body condition changes and is inversely related to walleye abundance. Results in Section 3.6.3 Discussion in Section 4.5.3
		Ho_{3e}: Whitefish and Rainbow Trout flows do not alter the distribution of subadult and adult Walleye.	Hypothesis cannot be rejected at this time. Patterns or trends in Walleye distribution were not discernible. Results in Section 3.4.4 Discussion in Section 4.2.3
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 Lower Columbia River?			Hypothesis cannot be rejected at this time. However, cross-correlation analysis indicated relationships between discharge (variance and/or mean values) and growth (for Mountain Whitefish, Rainbow Trout, and Walleye), absolute density (subadult Rainbow Trout), and length-at-age (Rainbow Trout fry).

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1.0 INTRODUCTION

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

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

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

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

1.1 Study Objectives

The objectives of CLMBON-45 include (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 include:

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

1.3 Management Hypotheses

Specific hypotheses to be tested under CLBMON-45 include:

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

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

1.4 Study Area and Study Period

The study area for the LCR Fish Indexing Program encompassed the approximately 56.5 km section of the riverine habitat from the base of HLK to the Canada-U.S. border (Figure 1). This study area also included the 2.8 km of 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 from the Kootenay-Columbia rivers confluence upstream to BRD (approximately 2.8 km).

In 2012, sample sites were distributed throughout the study area in locations similar to all other study years. 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., four sessions) between September 24 and October 22, 2012 (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, in 2012, 20 additional sites were sampled using a Generalized Random Tessellation Stratified (GRTS) survey (see Section 2.1.5). The GRTS survey (i.e., Session 5) was completed between October 19 and 26, 2013.

Table 1: Annual study periods for boat electroshocking surveys conducted in the Lower Columbia River, 2001 to 2012.

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	31

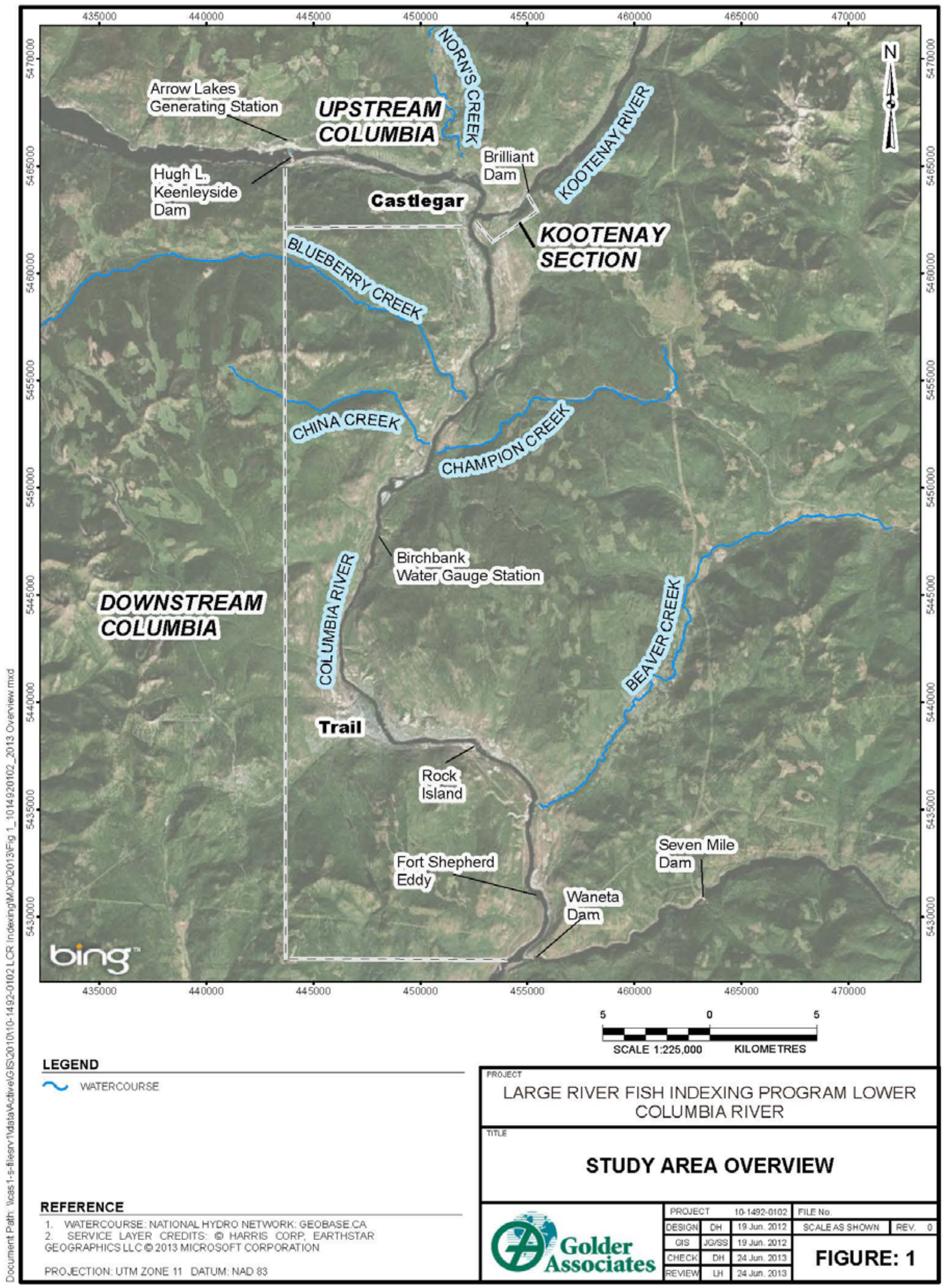

Figure 1: Overview of the Lower Columbia River Fish Population Indexing study area, 2012.

2.0 METHODS

2.1 Data Collection

2.1.1 Discharge

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

2.1.2 Water Temperature

Water temperatures for the mainstem Columbia River from 2001 to 2011 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 malfunctioning data logger. Water temperatures presented for 2012 were measured near Fort Shepherd (used with permission from Columbia Power Corporation; Golder in prep.). Hourly water temperature for the Columbia River near Norn's Creek also was obtained from BC Hydro. Water temperatures for the mainstem Kootenay River were obtained at hourly intervals using an Onset Tidbit™ temperature data logger (accuracy ± 0.5°C) installed approximately 1.8 km upstream of the Columbia-Kootenay Rivers confluence.

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

2.1.3 Habitat Conditions

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

The type and amount of instream cover for fish were qualitatively estimated at all sites. 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 verify water depth measurements, the boat operator called out depths displayed on the boats depth sounder while angling the boat 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.

Each site was categorized into various habitat types 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). Netters estimated the number of fish 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 Lower Columbia River, 2012.

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). 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. 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 440 to 3790 m in length. If, because of logistical reasons, a site could not be completed, the difference in distance between what was sampled and the established site length was estimated and recorded on the site form, and then used as the sampled length in the subsequent analyses.

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

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

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

2.1.5 Generalized Random Tessellation Stratified Survey

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

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

In 2011 and 2012, additional sites that were selected using the GRTS survey design (Stevens and Olson 2004) were sampled after field crews completed the conventional mark-recapture program. This 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 indexing sites sampled as part of CLBMON-45 range in length from 0.4 to 3.8 km; these lengths were used as general guidelines when establishing new sites. Overall, 62 new sites that ranged in length from 0.6 to 3.9 km, were established in areas of the LCR that were not sampled between 2001 and 2010 (Appendix A, Figures A4 to A9). The same habitat variables recorded for indexing sites also were recorded for GRTS survey sites (Appendix B, Table B3). In general, there was a similar range of habitat types at indexing and GRTS survey sites.

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

Software used to create the GRTS design included the spsurvey package (Kincaid and Olsen 2011) in the statistical program R 2.15.1 (R Core Team 2012), and ArcGIS. The GRTS methodology was used to select a subsample of 20 sites from the 62 newly established sites. In addition, 15 over-sample sites also were selected. Over-sample sites were used to replace selected sites that were excluded from sampling due to logistical concerns. For the current project, excluded sites included those located immediately downstream of HLK, BRD, and Waneta Dam and inside the log booms at Zellstoff Celgar (due to safety concerns), the perimeter of Waldie Island (a nature preserve), and the west shore of Zuckerberg Island (too shallow to safely navigate). Oversample sites also were used if the same site was selected more than once by the software. The use of over-sample sites ensured that both randomness and spatial balance were maintained as part of the study design. Selected sites are presented in Appendix A, Table A2.

A single-pass boat electroshocking survey was conducted at each GRTS survey site between October 19 and 26, 2013 using the same procedures described above. Fish captured during GRTS surveys were processed in the same manner as fish captured during the conventional mark-recapture program (Section 2.1.6).

2.1.6 Fish Processing

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

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

Table 3: List and description of variables recorded for each fish captured in the Lower Columbia River, 2012.

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).

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 Stomach Content and Carcass Collection

At BC Hydro's request, stomach content and fish carcasses were collected during sampling and provided to other researchers for other studies (Table 4). Analysis of these samples was not conducted as part of the current program.

Stomach content samples were collected and provided to Ecoscape Environmental Consultants Ltd. for analysis as part of the Lower Columbia River Physical Habitat and Ecological Productivity Monitoring study (CLBMON-44). In total, 101 stomach samples from various species were collected by gastric lavage (Bowen 1989, Brosse et al. 2002, Baldwin et al. 2003, Budy et al. 2007) using an apparatus modified from that described by Light et al. (1983). The apparatus consisted of a pressurised sprayer and wand fitted with a tubing adapter soldered to the adjustable spray nozzle from the bottle. Different sizes of veterinary grade intravenous tubing were selected to match the mouth opening of the fish.

The sprayer reservoir was filled with river water and pressurised using the hand pump. The free end of the tubing was inserted into the fish's mouth and gently inserted down into the stomach. The fish was held, head down, over a 250 µm mesh sieve to capture discharge during lavage. The flow of water was then opened using the flow control lever on the spray handle. The small diameter of the tubing served to regulate the flow at a pressure that did not damage the internal organs of the fish. Each fish's stomach was flushed with river water for approximately 30 seconds until the water exiting the fish's mouth ran clear. The tubing was gently extracted from the stomach and mouth with the water still flowing to ensure that all stomach contents were flushed from the buccal cavity. Sampled fish were returned to the river. Collected samples were washed from the sieve into a collection jar and preserved in Prefer™.

One Northern Pikeminnow, 11 Rainbow Trout, and 12 Walleye were sacrificed and provided to Environment Canada for tissue analysis. In total, 121 fishes (41 Mountain Whitefish, 40 Rainbow Trout, and 40 Walleye) also were sacrificed and provided to Teck Metals Ltd. for tissue analysis.

Table 4: Summary of fish stomach content and carcass samples collected during the Lower Columbia River Fish Population Indexing study and provided to other groups for analysis in 2012.

Species	Ecoscape Environmental Consultants Ltd. (Stomach Content Samples)[a]	Environment Canada (Carcasses)	Teck Metals Ltd. (Carcasses)
Bull Trout	3		
Cutthroat Trout	1		
Brook Trout	1		
Brown Trout	1		
Kokanee	4		
Lake Whitefish	2		
Mountain Whitefish	41		41
Northern Pike		1	
Northern Pikeminnow	3		
Peamouth	5		
Rainbow Trout	40	11	40
Walleye		12	40
Total	101	24	121

[a] Stomach contents were collected using gastric lavage. Fish were released after processing.

2.1.8 Ageing

Scales were processed in accordance with procedures described in Mackay et al. (1990). Samples were temporarily mounted between two slides and examined using a microfiche reader. Where possible, several scales were examined and the highest quality scale was digitally scanned and saved as a JPEG-type picture file in the LCR Fish Indexing Database.

A subsample of approximately 54% (n = 499) of all collected Mountain Whitefish scale samples were examined independently by three experienced readers and ages assigned. If assigned ages differed between readers, the sample was re-examined jointly by all readers to establish a final age.

Rainbow Trout that were captured during an earlier year of the project (2001 to 2011) and recaptured during the current year (n = 66) were aged using scale samples from both years to increase ageing accuracy. Both scale samples were examined by three experienced readers and ages were assigned. If assigned ages differed between the three readers, or if a scale sample from 2012 was not the appropriate number of years older than the corresponding 2001 to 2011 scale sample, both samples were re-examined jointly by all readers to establish a final age.

A digital copy of all scale images is provided in Attachment A. The actual scale samples collected from Mountain Whitefish and Rainbow Trout during the 2012 study have been provided to BC Hydro for archiving.

2.1.9 Historical Data

In addition to the data collected between 2001 and 2012, 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 2001-2012 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 2012 and were combined for many of the analyses in this report. Count data (i.e., fish that were observed and identified to species but not captured) were not recorded in the 1990s; therefore, this dataset was not included in count-based analyses. Limited mark-recapture data from the 1990s dataset prevented its inclusion in survival and growth related analyses. Due to relatively low numbers of captures, the 1990s data were pooled for the purposes of estimating length-at-age. For catch curve estimates of survival (Section 2.2.12) data from studies conducted from 1990 to 1996 were included in the analysis. 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), 2012;
- catch-rates for all sportfish (Appendix E, Table E2) and non-sportfish (Appendix E, Table E3), 2012;
- length-frequency histograms by section for Mountain Whitefish (Appendix F, Figure F1), Rainbow Trout (Appendix F, Figure F2), and Walleye (Appendix F, Figure F3), 2012;
- 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 2012 are included in the LCR Fish Indexing Database (Attachment A).

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

2.2.2 Hierarchical Bayesian Analyses

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

- allows complex models to be logically defined using the BUGS language (Kery and Schaub 2011; p.41);
- permits the incorporation of prior information (Kery and Schaub 2011; p.41);
- readily handles missing values;
- provides readily interpretable parameter estimates whose reliability does not depend on the sample size;
- allows derived quantities, such as the percent change in the expected weight of a 250 mm FL Mountain Whitefish at a particular site in a typical year, to be calculated (Kery and Schaub 2011; p.41);
- enables the efficient modelling of spatial and temporal variations and correlations (Kery and Schaub 2011; p.78-82); and,
- permits the separation of ecological and observational processes (Kery and Schaub 2011; p.44).

The technical aspects of the analyses, including the general approach and model definitions in the JAGS (Just Another Gibbs Sampler; Plummer 2003) dialect of the BUGS language, are provided in Appendix C. The resultant parameter estimates are tabulated in Appendix G.

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

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). Due to low numbers of captures, the historical 1990s data were pooled.

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

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

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

2.2.4 Growth

Annual growth was estimated from inter-annual recaptured fish using the Fabens (1965) method for estimating the von Bertalanffy (1938) growth curve. For simplicity, only recaptured fish that were at large for a single year were included in the model.

Key assumptions of the growth model included:

- mean maximum length (L_∞) varied randomly with year; and,
- observed growth (change in length) was normally distributed.

Plots of annual growth show the estimated annual growth for a 300 mm FL Mountain Whitefish, a 350 mm FL Rainbow Trout and a 400 mm FL Walleye. These fork lengths were selected as representative examples to illustrate changes in fork length over time for a standard size fish.

2.2.5 Count Density

Counts of each species were obtained by summing all fish captured or observed at a particular site and sampling session. Count data were analysed using an overdispersed Poisson model (Kery and Schaub 2011, p.55-56). Unlike Kery and Schaub (2011), who used a log-normal distribution to account for the extra-Poisson variation, the current model used a gamma distribution with identical shape and scale parameters because it has a mean of 1 and therefore, no overall effect on the expected count. The model did not distinguish between abundance and observer efficiency (i.e., it estimated the count, which is the product of the two). As such, it was necessary to assume that changes in observer efficiency were negligible in order to interpret estimates as relative abundance. The model estimated the number of fish expected to be captured or observed at each site per river kilometre based on the sample data, the influence of other variables in the model, and the prior distributions of model parameters. These estimates were used as an indicator of relative density and are referred to in this report as count density, in fish counted per kilometre (count/km).

Key assumptions of the count model included:

- count density (count/km) varied with flow regime (period) and season;
- count density (count/km) varied randomly with site, year, and the interaction between site and year;
- expected counts were the product of the count density (count/km) and the length of bank sampled;
- sites were closed (i.e., the expected count at a site was constant for all the sessions in a particular season of a year); and,
- observed counts were described by a Poisson-gamma distribution.

2.2.6 Catch Density

Catch data included all fishes captured during electroshocking but did not include observed fishes. The catch data were analyzed using the same overdispersed Poisson model as the count data (Section 2.2.5). Estimates of relative density from this model are referred to as catch density, in fishes captured per kilometre (catch/km).

2.2.7 Site Fidelity

Site fidelity was the estimated probability of a recaptured fish being caught at the same site at which it was previously encountered. These 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) and also to adjust the capture efficiencies in the analysis of densities using mark-recapture data (see Section 2.2.8).

A key assumption of the site fidelity model was that observed site fidelity was described by a Bernoulli distribution.

2.2.8 Absolute Density

Catch data also were analyzed using a mark-recapture-based binomial mixture model (Kery and Schaub 2011, p.134-136, 384-388) to provide estimates of capture efficiency and absolute density. Site fidelity (Section 2.2.7) was used to adjust capture efficiency for marked fish. Estimates of absolute abundance per kilometre from this model are referred to as absolute density, in the number of fish per kilometre (fish/km).

Key assumptions of the abundance model included:

- absolute density (fish/km) varied randomly with site, year, and the interaction between site and year;
- efficiency (the probability of capture) varied randomly by session within year;
- the proportion of marked fishes remaining at a site is described by the median estimates from the site fidelity model;
- marked and unmarked fishes had the same probability of capture;
- there was no tag loss, mortality, or misidentification of fish;
- other than the straying of marked fish, sites were closed (i.e., emigration of unmarked fish was accounted for by immigration of unmarked fish);
- the abundance at a site was described by a Poisson distribution; and,
- the number of marked and unmarked fish caught at a site was described by a binomial distribution.

2.2.9 Capture Efficiency

In order to estimate capture efficiency independent of abundance, a recapture-based binomial model (Kery and Schaub 2011, p.134-136, 384-388) was fitted only to marked fish. This model was equivalent to the abundance model without the estimation of the numbers of unmarked fish.

Key assumptions of the capture efficiency model included:

- efficiency (the probability of capture) varied randomly by session within year and season;
- the proportion of marked fish remaining at a site by season was described by the median estimates from the site fidelity model;

- there was no tag loss, mortality, or misidentification of fish; and,
- the number of marked fish caught at a site was described by a binomial distribution.

2.2.10 Survival

The annual survival rate was estimated by fitting a Cormack-Jolly-Seber model (Kery and Schaub 2011, p.172-177) to inter-annual recaptures. A key assumption of the survival model was that log-odds survival (i.e., the logarithm of the ratio between the probability of surviving and not surviving) varied with year and life stage (i.e., subadult versus adult).

2.2.11 Body Condition

Condition was estimated via an analysis of weight-length relations (He et al. 2008).

Key assumptions of the condition model included:

- weight varied with length and a second-order polynomial of day of the year;
- weight varied randomly with site, year, and the interaction between site and year; and,
- weight was log-normally distributed.

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

2.2.12 Catch Curve Analysis

Catch curve analysis was used as a supplementary method of estimating fish survival in the LCR and corroborate estimates produced by the Cormack-Jolly-Seber model (Section 2.2.10). Catch curve analysis is a common technique that is widely applied for stock assessments in fisheries biology (Hilborn and Walters 1992). The analysis estimates the annual survival probability of fish based on the age distribution of a random sample of individuals from the studied population.

Data collected in the LCR during the early 1990s were used to produce catch curves for adult Mountain Whitefish as a proxy to estimate inter-cohort survival. Due to the high variability in sample timing, captured cohort abundances were not compared between years, but within years, which required the assumption of no yearly variability in survival. In the Bayesian implementation of the model, the number of fish captured in each age cohort, N[year, age], was binomially distributed as a function of the number of fish present in the preceding age cohort, N[year, age-1] and survival (S). In addition to within-year analysis of the data, an analysis also was performed on combined-year data, where the number of Mountain Whitefish captured between 1990 and 1996 were summed within their respective age cohorts to create a single stratum of cohorts.

Catch curve analysis also was performed using data from 2001 to 2012, where inter-year, inter-cohort survival of adult Mountain Whitefish was estimated separately for each sample section (Upper, Lower, Kootenay). In the Bayesian implementation of the model, the number of fish captured in each year and each age cohort N[year, age] was binomially distributed as a function of the number of fish present in the preceding year and the preceding age cohort N[year - 1, age - 1] and survival (S). Survival was modeled as a hierarchical variable (i.e., a random factor that varied among years). Details, including the prior distributions, model specification, and code, are provided in Appendix D.

2.2.13 Environmental Correlations

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. In order to address this question and examine other possible effects of environmental variables, correlation analysis was used to assess relationships between water temperature and discharge, and fish population metrics. The discharge of the Columbia River at the Birchbank water gauging station and Columbia River water temperatures near Norn's Creek were broken into bimonthly periods for each year (e.g., January to February, March to April, May to June, etc.). As discharge can affect fish populations through a range of different mechanisms, three different measures of Columbia River discharge were calculated for each bi-monthly period:

1) mean of hourly discharge;
2) mean of the hourly absolute difference in discharge, as a measure of hour-to-hour variability; and,
3) variance of the hourly discharge, as a measure of overall discharge variability.

Only the mean of water temperature was calculated for each bi-monthly period. The November 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 time lag was done to account for the fact that the months of November and December occur after the fall surveys and reflect habitat conditions that could impact the fish populations sampled in the fall of the following year.

Relationships between absolute density, growth, length-at-age, condition, survival, and the discharge and temperature variables were assessed using Pearson correlation. Instead of comparing absolute values of fish population metrics and environmental variables each year, the analysis assessed correlations between the year-to-year differences in these values (i.e., correlations were assessed between the changes in fish metrics and environmental variables from one year to the next). This approach was less likely to result in spurious correlations caused by time series data that followed similar trends by chance. To partially account for multiple comparisons, significance was assessed at the 0.001 level. Only significant correlations that included fish population metrics selected for analysis are presented and discussed in this report (i.e., correlated environmental variables are not presented).

3.0 RESULTS

3.1 Physical Habitat

3.1.1 Columbia River

3.1.1.1 Discharge

Discharge in the LCR was greater in 2012 than during any previous study year (Figure 2). Mean daily discharge in the Columbia River at the Birchbank water gauging station was greater than average from January to May, but was extremely high from mid-June through August, when discharge reached the highest levels observed since the closure of HLK in 1968. Discharges recorded from mid to late July were more than double the average values recorded from 2001 to 2011 (Appendix D, Figures D1 and D2). These higher discharges were due to above average rainfalls during the spring and larger than normal snowpacks in the Columbia Basin (Province of British Columbia River Forecast Centre 2013). 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.

During the 2012 sample period, discharge decreased during Session 1, remained at similar levels in Sessions 2 and 3, increased in Session 4, and remained stable in Session 5 (i.e., the GRTS survey; Figure 2).

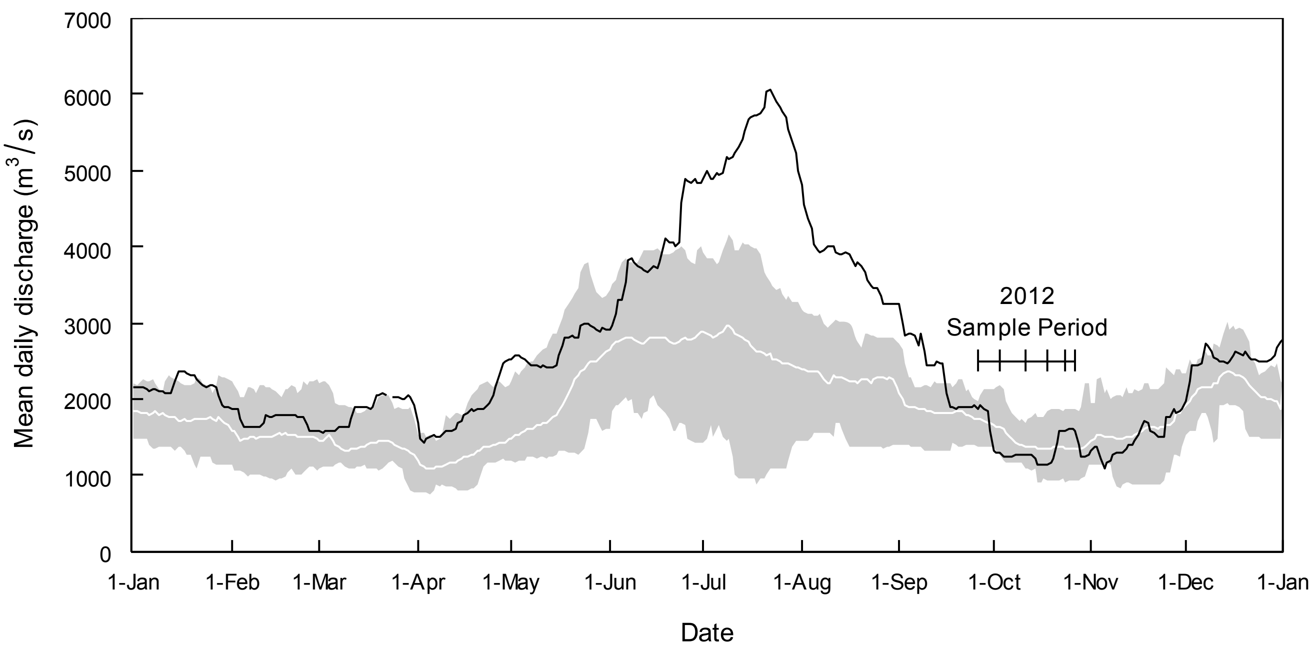

Figure 2: Mean daily discharge (m^3/s) for the Columbia River at the Birchbank water gauging station, 2012 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at Birchbank from 2001 to 2011. The white line represents average mean daily discharge values over the same time period.

In 2012, peak discharge from HLK also was much greater than previous years of the study during July and August (Figure 3). However, during the 2012 sample period, discharge was similar to average values and within the range recorded between 2001 and 2011 (Appendix D, Figure D2).

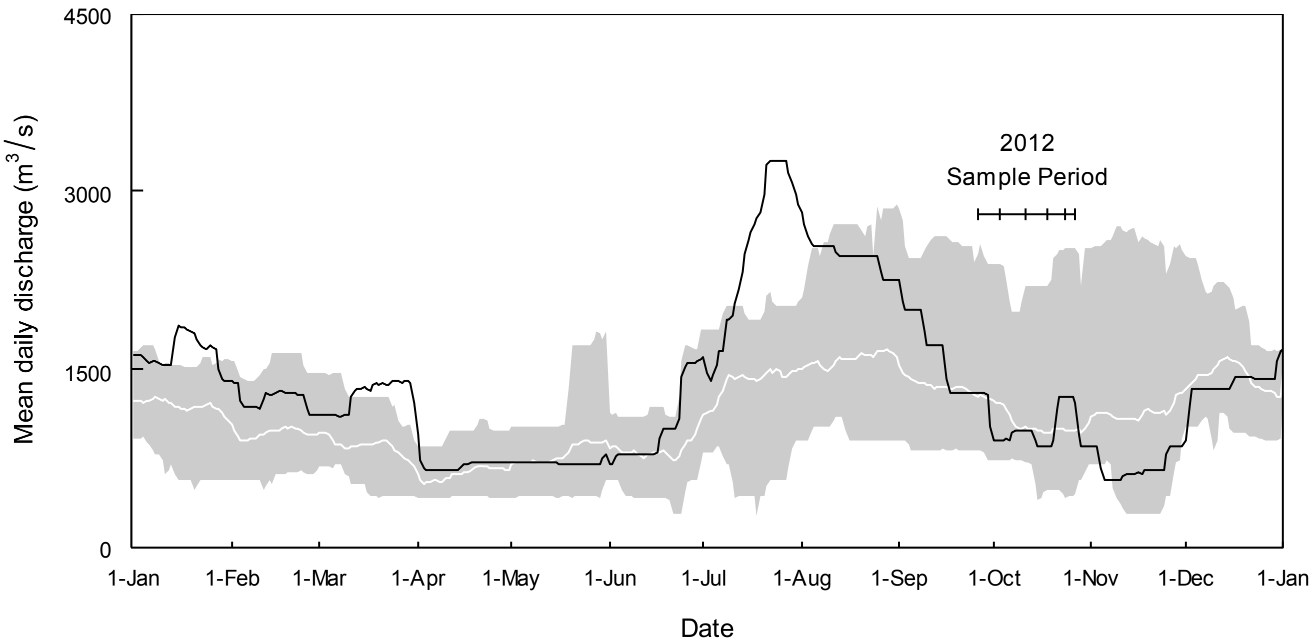

Figure 3: Mean daily discharge (m^3/s) for the Columbia River at Hugh L. Keenleyside Dam, 2012 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2011. The white line represents average mean daily discharge values over the same time period.

3.1.1.2 Temperature

Water temperature in the Columbia River was lower than average from mid-June to mid-September (Figure 4), which coincided with the period of higher than normal discharges (Figure 2). During the 2012 sample period, water temperatures were similar to average values recorded between 2001 and 2011 (Appendix D, Figure D3). Water temperatures measured at Fort Shepherd decreased from ~15°C to ~ 11°C during the fall sample period. Spot temperature readings for the Columbia River taken at the time of sampling ranged between 10.5°C and 15.3°C (Appendix B, Table B3).

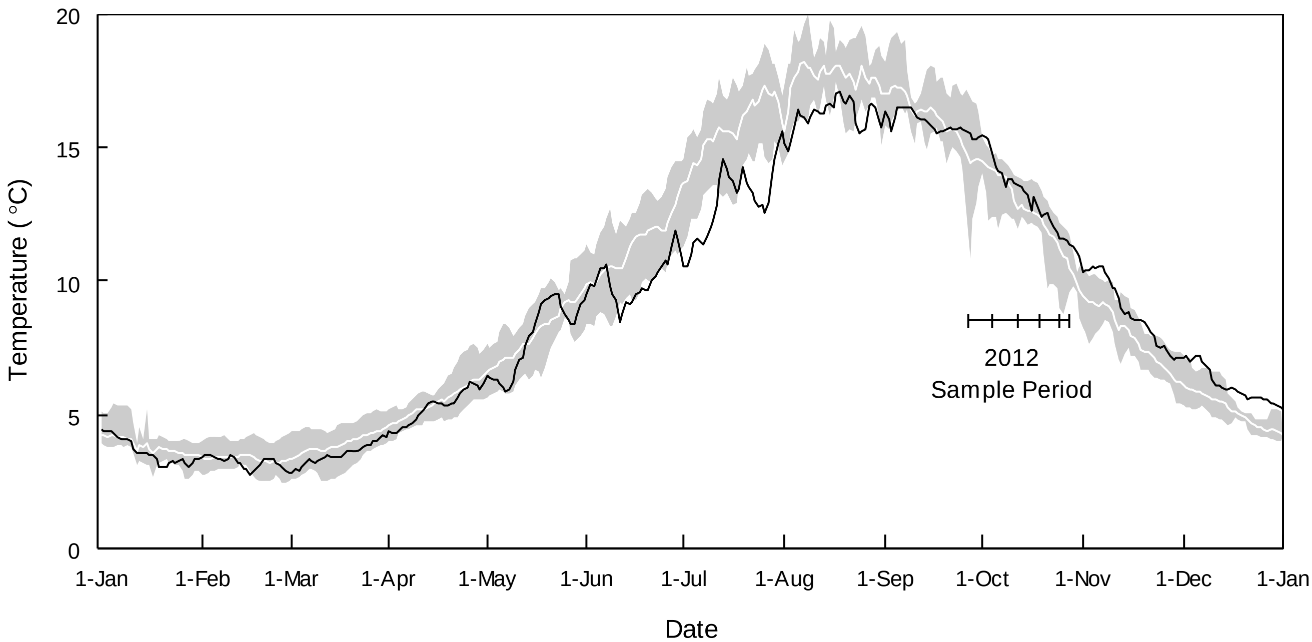

Figure 4: Mean daily water temperature (°C) for the Columbia River at Fort Shepherd, 2012 (black line). The shaded area represents the minimum and maximum mean daily water temperature values recorded in the Columbia River at Hugh L. Keenleyside Dam (HLK) from 2001 to 2011. The white line represents the average mean daily water temperature during the same time period. Temperature data from Fort Shepherd were used in 2012 because temperature data were not available near HLK in 2012.

3.1.2 Kootenay River

3.1.2.1 Discharge

From April to September 2012, mean daily discharge for the Kootenay River downstream of BRD was higher than the average discharge recorded over the same period between 2001 and 2011 (Figure 5). Between 2001 and 2011, peak flows in the Kootenay were reached by early June for most years (Appendix D, Figure D4), whereas in 2012, high discharges during the spring freshet persisted over a longer duration and peaked in early July. Although Kootenay River flows were greater than average for most of 2012, discharge during the fall sample period was near average at the start of the sample period, declined to below the previous minimum discharge recorded between 2001 and 2011, and then rose to near average conditions at the end of the sample period.

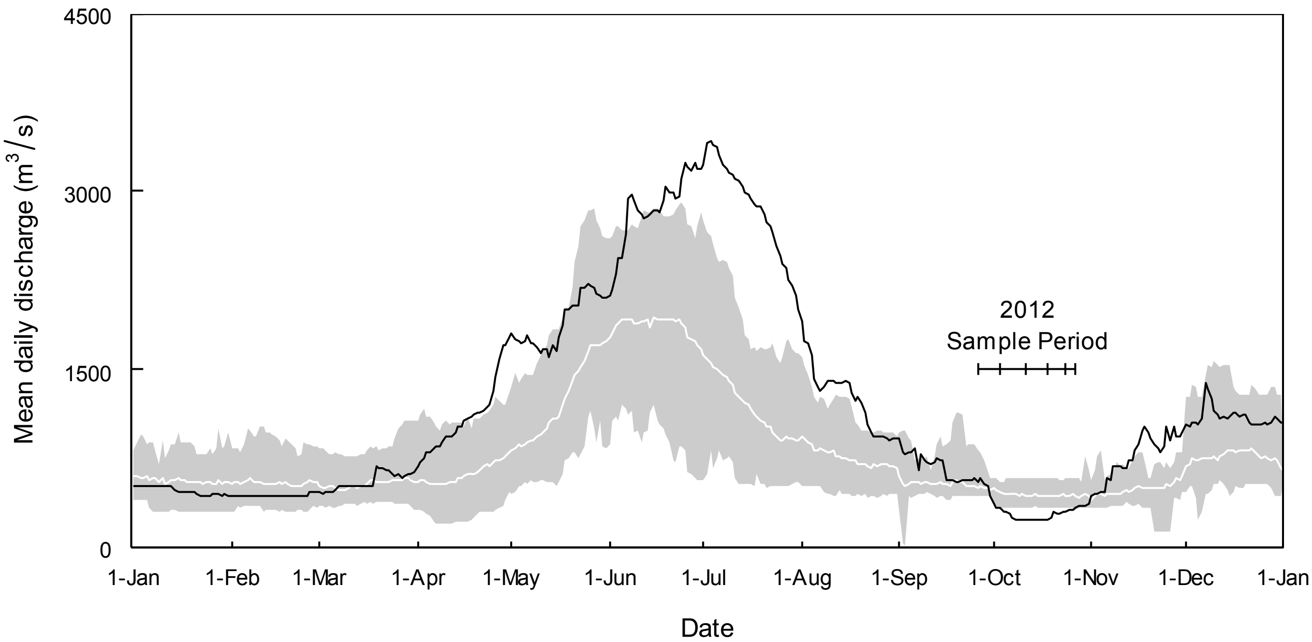

Figure 5: Mean daily discharge (m^3/s) for the Kootenay River at Brilliant Dam (BRD), 2012 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2011. The white line represents average mean daily discharge values over the same time period.

3.1.2.2 Temperature

Water temperatures in the Kootenay River (downstream of BRD) generally increased from mid-February to mid-August and decreased from mid-August to mid-February (Appendix D, Figure D5). In 2012, water temperatures were lower than recorded in most other study years from June to September but similar to previous years during the fall sample period (Figure 6).

Spot temperature readings for the Kootenay River taken at the time of sampling ranged between 7.0°C and 15.5°C (Appendix B, Table B3).

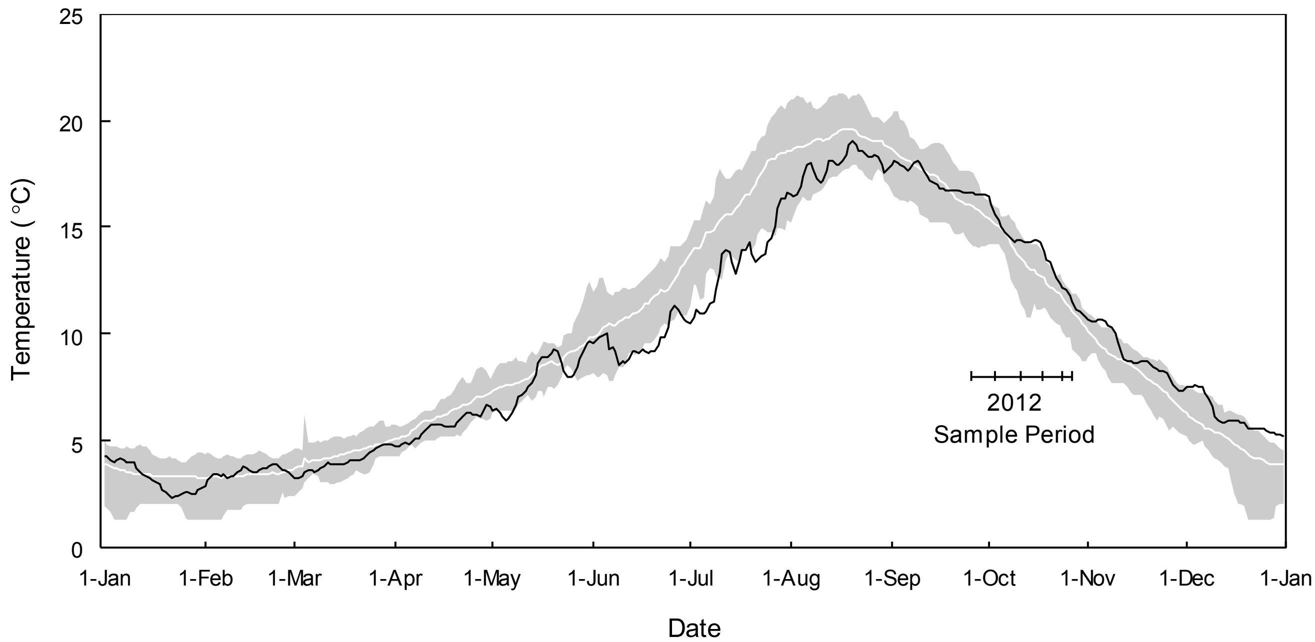

Figure 6: Mean daily water temperature (°C) for the Kootenay River downstream of Brilliant Dam (BRD), 2012, (black line).The shaded area represents minimum and maximum mean daily water temperature values recorded at the dam from 2001 to 2011. The white line represents average mean daily water temperature values over the same time period.

3.1.3 Habitat Variables

Reach habitat descriptions for the LCR are provided by Golder (2002). Habitat data collected since 2001 indicates 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 2012, 40,838 fishes were recorded in the LCR (Appendix E, Table E1). This includes captured and observed fishes that were identified to species. Catch was greatest in the downstream section of the Columbia River (51% of the total catch), followed by the upstream section of the Columbia River (36%), and the Kootenay River (14%; Table 5).

Table 5: Number of fishes caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the Lower Columbia River, September 24 to October 25, 2012.

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*)	1,833	61	774	49	2,041	31	**4,648**	**41**
Rainbow trout (*Oncorhynchus mykiss*)	878	29	547	35	3,976	60	**5,401**	**48**
Walleye (*Sanders vitreus*)	210	7	207	13	464	7	**881**	**8**
Brook trout (*Salvelinus fontinalis*)					15	<1	**15**	**<1**
Brown trout (*Salmo trutta*)					2	<1	**2**	**<1**
Bull trout (*Salvelinus confluentus*)	6	<1			7	<1	**13**	**<1**
Burbot (*Lota lota*)	2	<1	1	<1	36	<1	**39**	**<1**
Cutthroat trout (*Oncorhynchus clarki*)					4	<1	**4**	**<1**
Kokanee (*Oncorhynchus nerka*)	74	2	45	3	37	<1	**156**	**1**
Lake whitefish (*Coregonus clupeaformis*)	3	<1	4	<1	54	<1	**61**	**<1**
Northern pike (*Esox lucius*)	11	<1					**11**	**<1**
White sturgeon (*Acipenser transmontanus*)	3	<1	2	<1	4	<1	**9**	**<1**
Sportfish Subtotal	**3,020**	**27**	**1,580**	**14**	**6,640**	**59**	**11,240**	**100**
Non-sportfish								
Dace spp.[c] (*Cyprinidae*)					1	<1	**1**	**<1**
Northern pikeminnow (*Ptychocheilus oregonensis*)	417	4	205	6	59	<1	**681**	**3**
Peamouth (*Mylocheilus caurinus*)	473	5	12	<1	3	<1	**488**	**2**
Redside shiner (*Richardsonius balteatus*)	3851	38	474	14	955	8	**5280**	**21**
Sculpin spp.[c] (*Cottidae*)	3,629	36	1,972	58	10,429	86	**16,030**	**62**
Sucker spp.[c] (*Catostomidae*)	1,772	17	765	22	657	5	**3194**	**12**
Non-Sportfish Subtotal	**10,142**	**40**	**3,428**	**13**	**12,104**	**47**	**25,674**	**100**
All Species	**13,162**		**5,008**		**18,744**		**36,914**	

[a] Includes fish observed and identified to species; does not include inter-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

Output from the length-at-age model are presented in Table 6 and represent the most appropriate cut-offs between age-0 (fry), age-1 (subadult), and age-2 and older (adult) Mountain Whitefish and Rainbow Trout during each sample year. All Walleye were classified as adults by the HBMs.

Table 6: Hierarchical Bayesian model generated estimates of minimum and maximum fork lengths (in mm) for each life stage by year for Mountain Whitefish and Rainbow Trout in the Lower Columbia River, 1990 to 1993, 2001 to 2012.

Year	Mountain Whitefish			Rainbow Trout		
	Fry	Subadult	Adult	Fry	Subadult	Adult
1990	≤152	153-250	≥251	≤148	149-329	≥330
1991	≤148	149-247	≥248	≤146	147-325	≥326
1992	≤155	156-253	≥254	≤153	154-331	≥332
1993	≤140	141-243	≥244	≤145	146-316	≥317
2001	≤137	138-225	≥226	≤128	129-315	≥316
2002	≤157	158-232	≥233	≤154	155-326	≥327
2003	≤159	160-233	≥234	≤161	162-338	≥339
2004	≤159	160-249	≥250	≤149	150-336	≥337
2005	≤169	170-257	≥258	≤169	170-353	≥354
2006	≤167	168-264	≥265	≤167	168-362	≥363
2007	≤171	172-261	≥262	≤169	170-367	≥368
2008	≤170	171-273	≥274	≤150	151-339	≥340
2009	≤165	166-262	≥263	≤151	152-342	≥343
2010	≤174	175-273	≥274	≤147	148-338	≥339
2011	≤162	163-261	≥262	≤153	154-345	≥346
2012	≤157	158-259	≥260	≤161	162-344	≥345

3.3.1 Mountain Whitefish

Results of the hierarchical Bayesian mixture analysis of length-frequency distributions indicate annual variability in the length of Mountain Whitefish fry (Figure 7). Mountain Whitefish fry were substantially smaller in 2001 when compared to all other study years. On average, Mountain Whitefish fry grew rapidly until approximately mid-October, at which point growth slowed considerably (Figure 7).

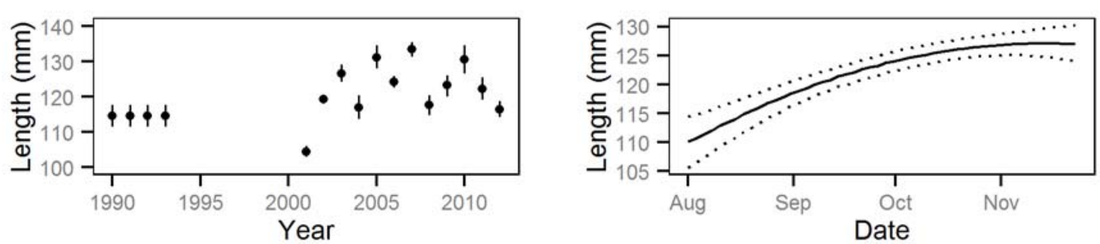

Figure 7: Length-at-age (median with 95% CRIs) by year (left) and date (right) for Mountain Whitefish fry in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

The length-at-age of subadult Mountain Whitefish generally increased between 2001 and 2008 and generally decreased between 2008 and 2012 (Figure 8). Similar to results presented for Mountain Whitefish fry (Figure 7), subadult Mountain Whitefish were substantially smaller in 2001 when compared to all other study years. Subadult Mountain Whitefish continued to grow throughout the fall study period (Figure 8).

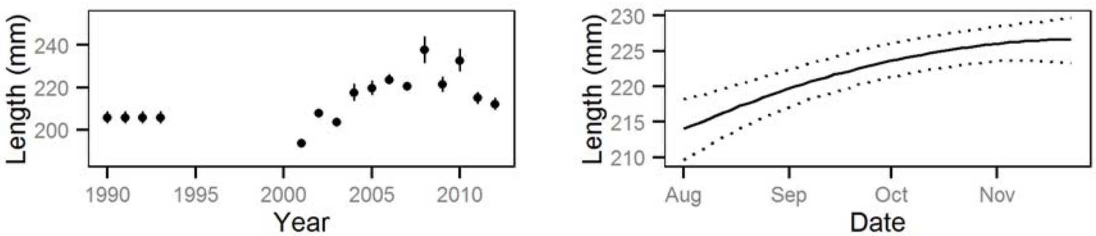

Figure 8: Length-at-age (median with 95% CRIs) by year (left) and date (right) for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

The length of adult Mountain Whitefish (i.e., age-2 and older) is not presented here because this group consists of multiple age-classes.

Results of the hierarchical Bayesian analysis of annual growth of recaptured individuals indicated an increase in average annual growth between 2002 and 2006, and variable annual growth between 2006 and 2012, although credibility intervals overlapped between most estimates (Figure 9). The average annual growth of fish initially marked in 2001 (i.e., annual growth between 2001 and 2002) was noticeably greater than growth rates recorded during immediately subsequent study years.

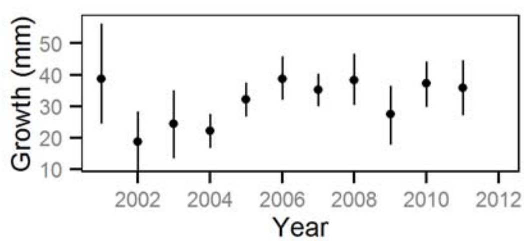

Figure 9: Expected inter-annual growth (median with 95% CRIs) for a 300 mm FL Mountain Whitefish in the Lower Columbia River, 2001 to 2012.

3.3.2 Rainbow Trout

Results of the hierarchical Bayesian mixture analysis of length-frequency distributions indicate a gradual decrease in the average fork length of Rainbow Trout fry between 2005 and 2010 (Figure 10) followed by a rapid increase between 2011 and 2012. Rainbow Trout fry were substantially smaller in 2001 when compared to all other study years. This result is consistent with results for fry and subadult Mountain Whitefish (Figure 7 and Figure 8, respectively). Length-at-age of Rainbow Trout fry exhibited a seasonal U-shaped curve with greater length-at-age in August and November and lower length-at-age in October (Figure 10). It is unlikely that the length-at-age of Rainbow Trout fry declined between August and October and that their period of highest growth occurred in November. Possible explanations for this pattern in length-at-age estimates are discussed in Section 4.1.2.

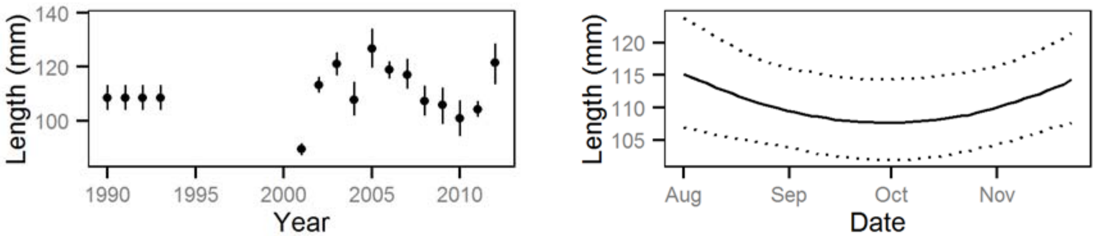

Figure 10: Length-at-age (median with 95% CRIs) by year (left) and date (right) for Rainbow Trout fry in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

The length-at-age of subadult Rainbow Trout increased between 2001 and 2007, declined substantially between 2007 and 2008, and was similar from 2008 to 2012 (Figure 11). Similar to results presented for other species and age-classes, subadult Rainbow Trout were substantially smaller in 2001 when compared to all other study years (Figure 15). During a typical study year, growth declined through October and virtually stopped by early November (Figure 11).

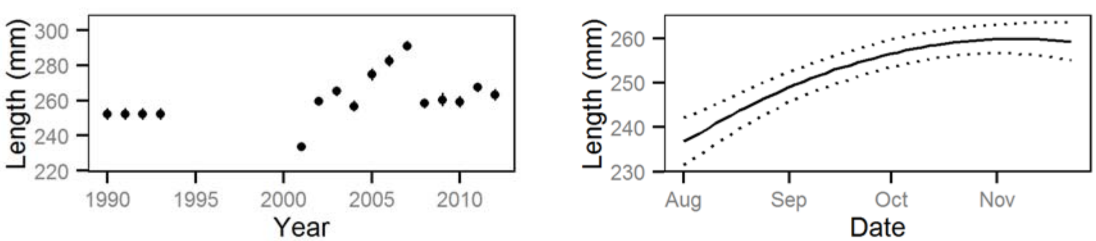

Figure 11: Length-at-age (median with 95% CRIs) by year (left) and date (right) for subadult Rainbow Trout in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

Length-at-age was not assessed in detail for adult Rainbow Trout (i.e., age-2 and older) because this group consists of multiple age-classes.

Results of the hierarchical Bayesian analysis of annual growth of recaptured individuals indicated slower growth from 2002 to 2004 when compared to latter study years (Figure 12). Overall, annual growth for this species was variable, changing by as much as 25% during a one year period.

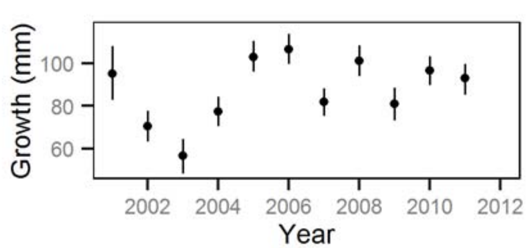

Figure 12: Expected inter-annual growth for a 350 mm FL Rainbow Trout in the Lower Columbia River, 2001 to 2012.

3.3.3 Walleye

Results of the hierarchical Bayesian analysis of annual growth of recaptured Walleye indicated variable growth rates for this species; however, credibility intervals overlapped for most estimates (Figure 13). Annual growth for this species generally declined between 2006 and 2012.

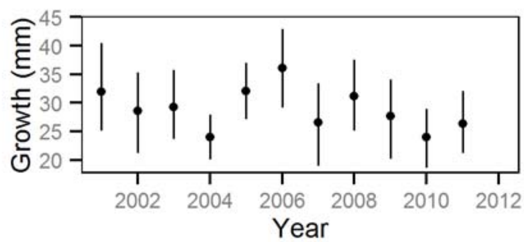

Figure 13: Expected inter-annual growth for a 400 mm FL Walleye in the Lower Columbia River, 2001 to 2012.

3.4 Spatial Distribution and Abundance

3.4.1 Site Fidelity

There were no substantial differences in site fidelity between subadult (53%) and adult (42%) Mountain Whitefish. The probability of both these life stages being recaptured within the same site where they were initially marked was approximately 50% (Figure 14). Site fidelity exhibited by subadult Rainbow Trout (75%) was higher than adult Rainbow Trout (59%). The probability of recapturing a Walleye within its original release site was 67%.

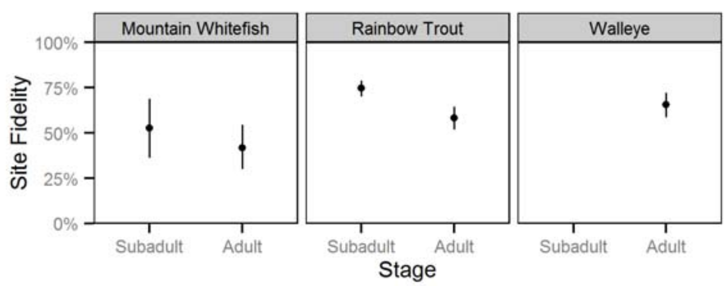

Figure 14: Expected probability that a fish is recaptured at the same site where it was marked by species and life stage in the Lower Columbia River, 2001 to 2012. The point estimates are median expected values while lower and upper 95% CRIs are the 2.5% and 97.5% quantiles, respectively.

3.4.2 Mountain Whitefish

The count density of Mountain Whitefish (all age-classes combined) in the LCR decreased by 68% between 2001 and 2005, increased by 24% between 2005 and 2007, and remained relatively stable between 2008 and 2012 (Figure 15). The same pattern was observed for catch density and absolute density estimates for subadult Mountain Whitefish (Figure 16). For subadult Mountain Whitefish, estimates of catch density and absolute density from early 1990s data were within the range of values observed from 2001 to 2012; however, the 1992 estimates were greater and more variable when compared to all other study years (Figure 16). The estimated number of subadult Mountain Whitefish in the LCR in 2010 to 2012 was approximately half of what it was a decade earlier.

Estimates of absolute density for adult Mountain Whitefish were greater and more variable in the 1990s (range = 1724 to 3150 fish/km) when compared to estimates from 2001 to 2012 (range = 533 to 1090 fish/km; Figure 17). Estimates for adult Mountain Whitefish between 2001 and 2012 had wide credibility intervals which limited the strength of conclusions about trends over time. However, catch density and absolute density estimates suggest a steady decline in adult Mountain Whitefish abundance since the 1990, with lower densities in 2010 and 2012 compared all previous study years (Figure 17).

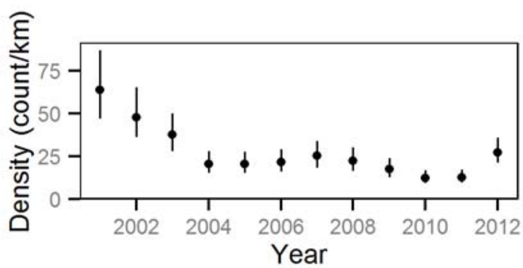

Figure 15: Count density estimates (median with 95% CRIs) for Mountain Whitefish (all age-classes combined) in the Lower Columbia River, 2001 to 2012.

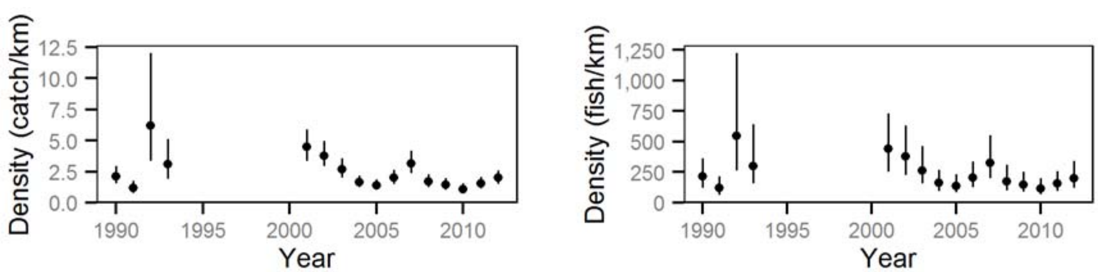

Figure 16: Catch density (left panel) and absolute density (right panel) estimates (median with 95% CRIs) for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

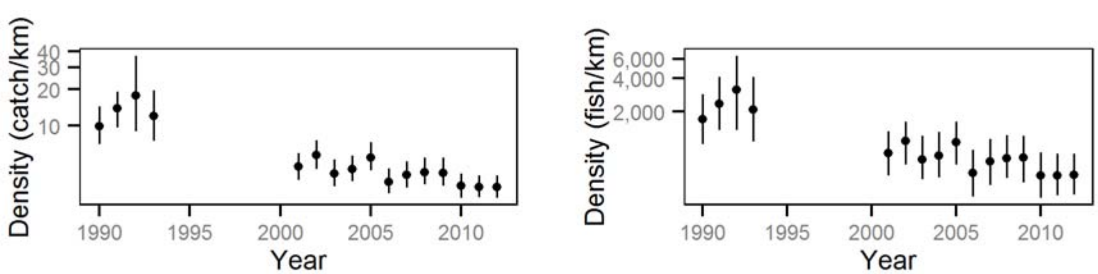

Figure 17: Catch density (left panel) and absolute density (right panel) estimates (median with 95% CRIs) for adult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012. Note that the y-axis shows density on a log-scale because adult Mountain Whitefish estimates were substantially higher in the early 1990s when compared to 2001 to 2012 estimates.

Count density estimates for Mountain Whitefish (all age-classes combined) were highest near the confluence of the Columbia and Kootenay rivers and lowest close to 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 Zelstoff-Celgar (both banks; RKm 4.5), upstream and downstream of Norn's Creek Fan (RKm 7.4), and along the left bank between Waldie Island and Tin Cup Rapids (RKm 9.2; Figure 19). In comparison, subadult Mountain Whitefish densities were low in the Kootenay River and in the Columbia River downstream of the Kootenay River confluence, river sections which typically have higher water velocities.

Adult Mountain Whitefish site-level density estimates (Figure 20) were more uncertain than estimates generated for subadult Mountain Whitefish. However, estimates were generally higher in sites known to contain suitable spawning habitat for this species. These areas include Norn's Creek Fan (RKm 7.4) downstream to CPR Island, the Kootenay River, between the Kootenay River confluence (RKm 10.6) and Kinnaird Bridge (RKm 13.4), the Genelle area (RKm 27.0), and upstream of Fort Shepherd Eddy (RKm 49.0).

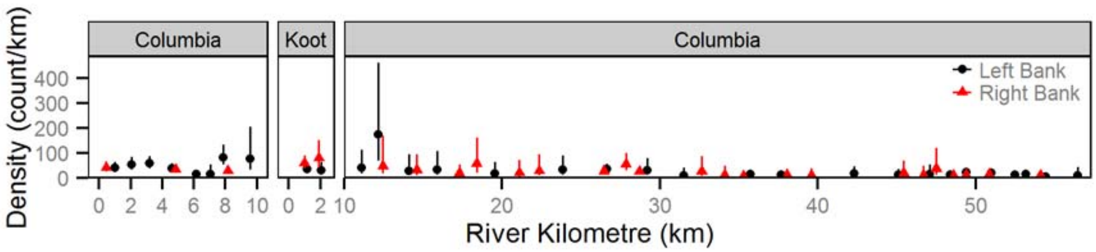

Figure 18: Count density estimates (median with 95% CRIs) for Mountain Whitefish (all age-classes combined) in the Lower Columbia River, 2001-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

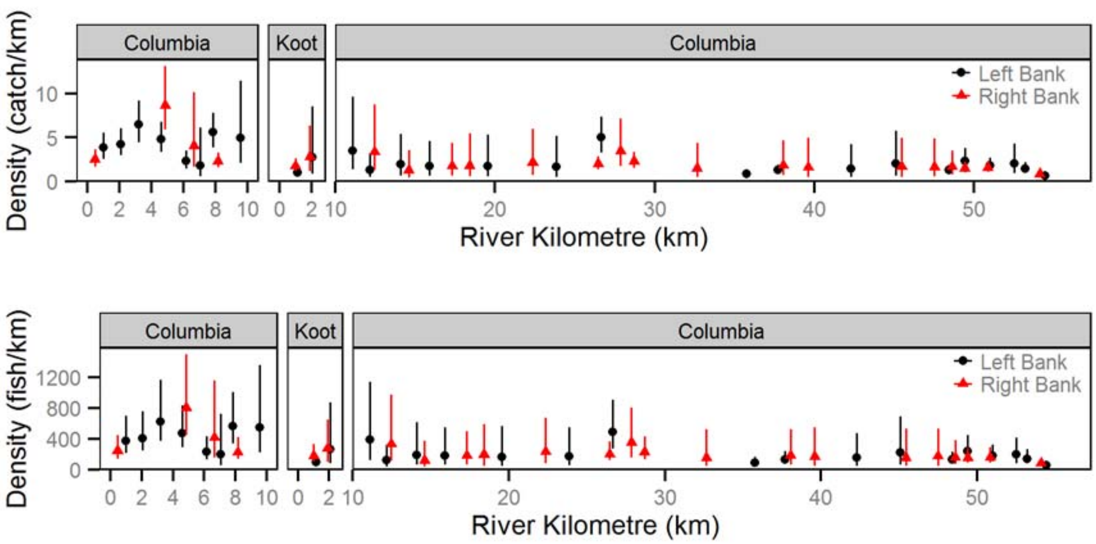

Figure 19: Catch density (top panel) and absolute density (bottom panel) estimates (median with 95% CRIs) for subadult Mountain Whitefish in the Lower Columbia River, 1990-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

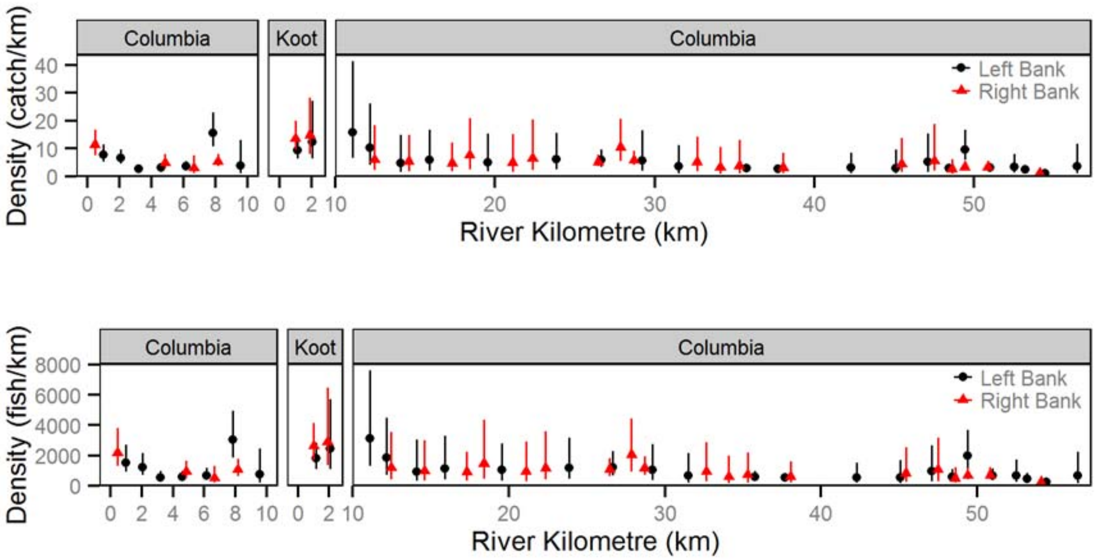

Figure 20: Catch density (top panel) and absolute density (bottom panel) estimates (median with 95% CRIs) for adult Mountain Whitefish in the Lower Columbia River, 1990-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

Plots of density by site and year did not suggest any changes in the spatial distribution of subadult or adult Mountain Whitefish over time (Appendix H, Figures H1 to H3).

The capture efficiency of subadult Mountain Whitefish was similar across sample sessions and years (~1.0%; Appendix H, Figure H4). Capture efficiency was slightly lower for subadults Mountain Whitefish (~0.5%) but was similar among sessions and sample years with no obvious seasonal or temporal trends (Appendix H, Figure H5). Overall, results indicate low capture efficiency for this species but no substantial changes in efficiency over time.

3.4.3 Rainbow Trout

Count density estimates for Rainbow Trout decreased from 53 fish/km in 2001 to 16 fish/km in 2005, then gradually increased to 39 fish/km in 2012 (Figure 21). The decrease in count density for Rainbow Trout between 2001 and 2005 was likely related to the density of subadult Rainbow Trout, which also decreased during this time period (Figure 22); adult density and absolute density estimates were fairly stable during this time (Figure 23). For adult Rainbow Trout, estimates of catch density and absolute density varied little between 1990 and 2012. Estimates of catch density and absolute density for subadult Rainbow Trout increased during the early 1990s. Catch density in the 1990s was greater than from 2001 to 2012 (Figure 23).

Rainbow Trout site-level density estimates had large credibility intervals (Figure 24), particularly at sites that were only sampled in 2012. 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 (the top panels of Figure 25 and Figure 26). Adult Rainbow Trout densities were noticeably higher in the Columbia River between the Kootenay River confluence and the Beaver Creek confluence and were lower in the Columbia River upstream of the Kootenay River confluence (the bottom panels of Figure 25 and Figure 26). Adult Rainbow Trout densities were substantially higher near the Bear Creek confluence (Site C44.7-R), between the Champion Creek and Jordan Creek confluences (Site C23.4-L), and immediately downstream of the Kootenay River confluence (both banks; Sites C10.7-R and C10.9-L) when compared to neighbouring sites.

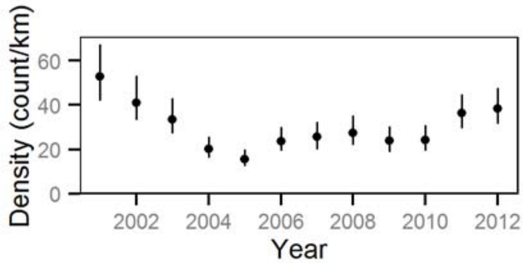

Figure 21: Count density estimates (median with 95% CRIs) for Rainbow Trout (all age-classes combined) in the Lower Columbia River, 2001 to 2012.

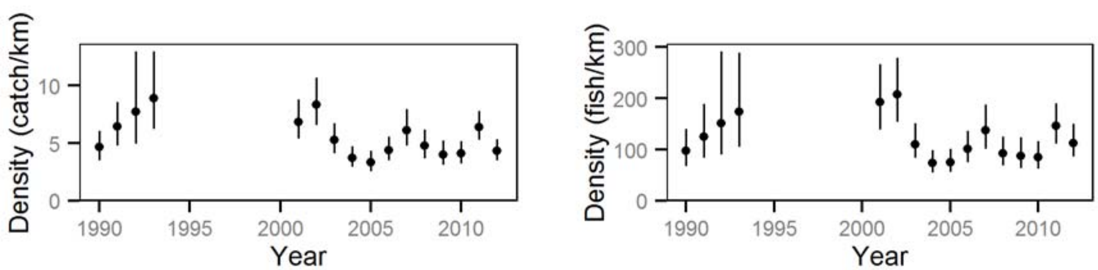

Figure 22: Catch density (left panel) and absolute density (right panel) estimates (median with 95% CRIs) for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

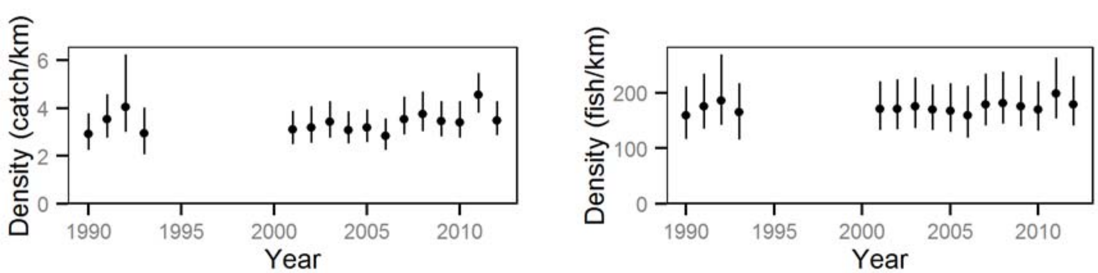

Figure 23: Catch density (left panel) and absolute density (right panel) estimates (median with 95% CRIs) for adult Rainbow Trout in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

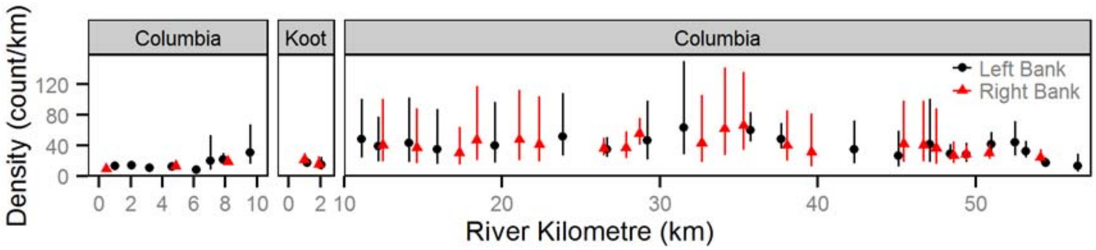

Figure 24: Count density estimates (median with 95% CRIs) for Rainbow Trout (all age-classes combined) in the Lower Columbia River, 2001-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

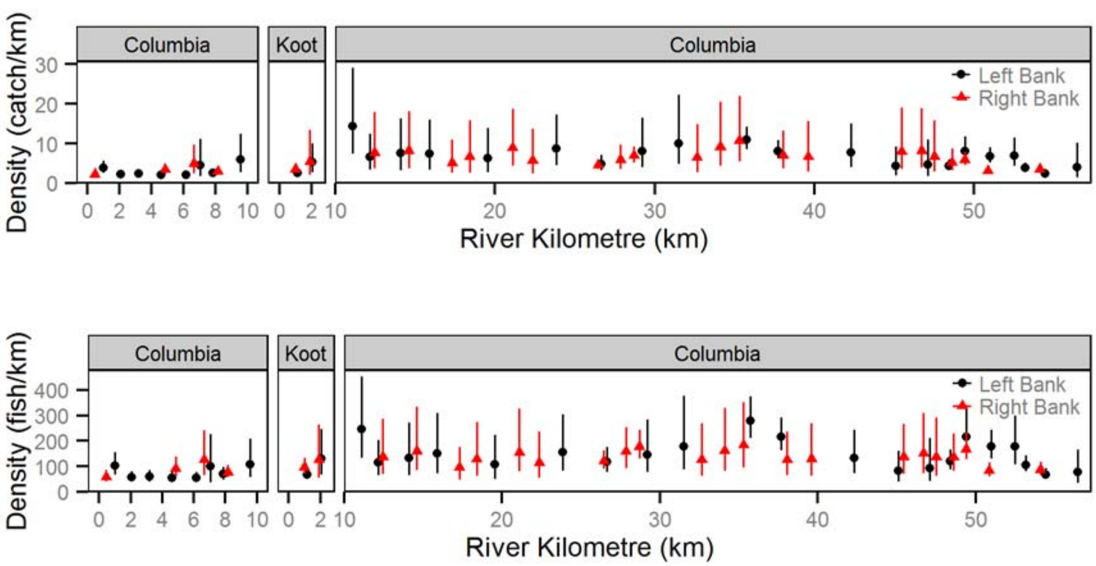

Figure 25: Catch density (top panel) and absolute density (bottom panel) estimates (median with 95% CRIs) for subadult Rainbow Trout in the Lower Columbia River, 1990-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

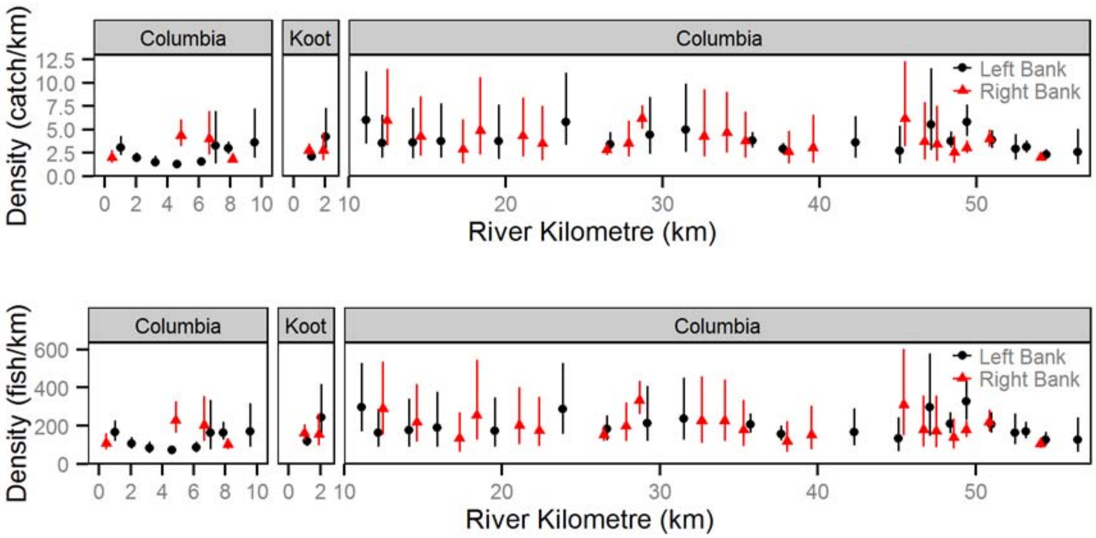

Figure 26: Catch density (top panel) and absolute density (bottom panel) estimates (median with 95% CRIs) for adult Rainbow Trout in the Lower Columbia River, 1990-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

Plots of density by site and year suggested few changes in the spatial distribution of subadult or adult Rainbow Trout over time (Appendix H, Figures H6 to H8). One exception was that the density of subadult and adult Rainbow Trout between Sullivan Creek and the Birchbank water gauging station (Site C28.2-R; Appendix H, Figures H6 to H8) was greater in the 2000s than in the 1990s.

Capture efficiency for subadult Rainbow Trout was similar among years (~2 to 7%) but decreased in subsequent sample sessions during many study years (Appendix H, Figure H9). Adult Rainbow Trout capture efficiency was lower than that of subadult Rainbow Trout, but values were consistent among years between 1990 and 2012 (~1 to 2%) and did not decline in subsequent sessions of a given year (Appendix H, Figure H10).

3.4.4 Walleye

Walleye count, catch, and absolute density estimates all showed a substantial increase between 2002 and 2003 followed by a gradual decline between 2003 and 2007 (Figure 27 and Figure 28). Densities estimates for Walleye were similar with some fluctuations between 2008 and 2012. These results likely indicate a strong year-class of Walleye that migrated into the study area between 2002 and 2003 and gradually decreased in abundance over the next four years. Estimates of catch density and absolute density indicate greater densities in 1990 to 1993 when compared to 2001 to 2012, although credibility intervals for estimates from the 1990s were large.

Count, catch, and absolute density estimates for Walleye were greatest in the Kootenay River and at the three sites closest to HLK (Figure 29 and Figure 30). Density estimates for all other areas were similar and did not suggest differences in Walleye densities among sites.

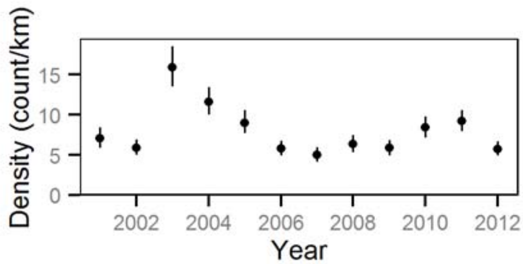

Figure 27: Count density estimates (median with 95% CRIs) for Walleye (all age-classes combined) in the Lower Columbia River, 2001 to 2012

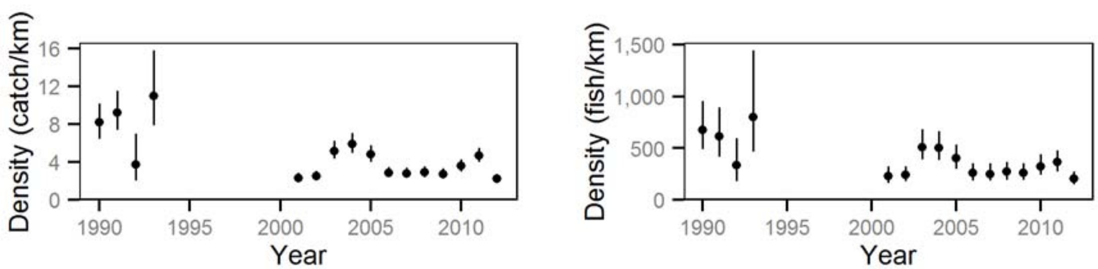

Figure 28: Catch density (left panel) and absolute density (right panel) estimates (median with 95% CRIs) for Walleye in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

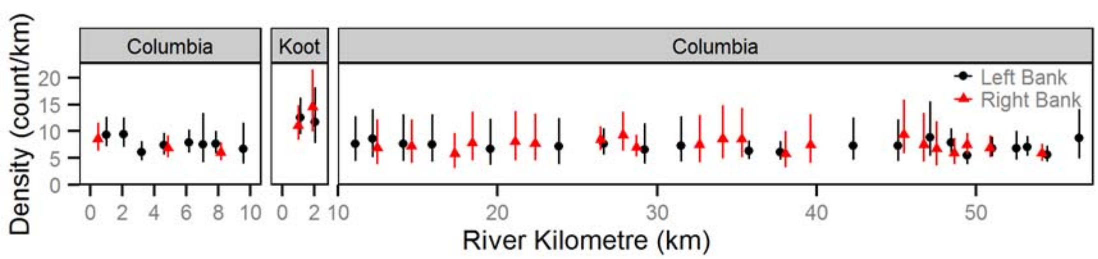

Figure 29: Count density estimates (median with 95% CRIs) for Walleye (all age-classes combined) in the Lower Columbia River, 2001-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

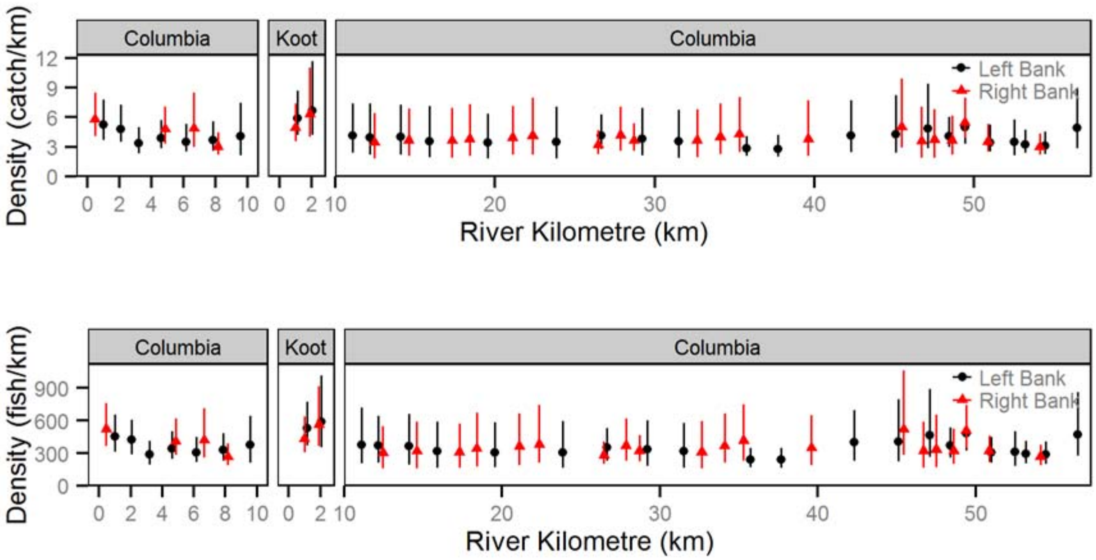

Figure 30: Catch density (top panel) and absolute density (bottom panel) estimates (median with 95% CRIs) for Walleye in the Lower Columbia River, 1990-2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

Plots of Walleye density by site and year did not suggest any changes in spatial distribution over time (Appendix H, Figures H11-H12). The greater densities of Walleye observed in the 1990s when compared to the 2000s was partly related to very high densities between Beaver and Hayward creeks (Sites C49.0-L and C49.0-R) in the 1990s; densities at these sites were low in recent years.

Capture efficiency for Walleye ranged from 0.7% to 1.6% across all sessions and years (Appendix H, Figure H13). Capture efficiency declined in successive sample sessions in many years (e.g., 2002, 2004 to 2008) but not in other years (e.g., 2001, 2011, and 2012).

3.5 Survival

3.5.1 Mountain Whitefish

Survival estimates for subadult Mountain Whitefish had wide credibility intervals and did not indicate substantial changes over time (Figure 31). For adult Mountain Whitefish, survival estimates varied widely, ranging from 32% to 80% but suggested generally increasing survival between 2001 and 2012 but with substantial year-to-year variations and large estimate uncertainties (Figure 31). Survival estimates were greater for adult Mountain Whitefish (32 to 80%) than for subadults (14 to 35%). Survival estimates for Mountain Whitefish were less precise than corresponding estimates for Rainbow Trout (see Section 3.5.2).

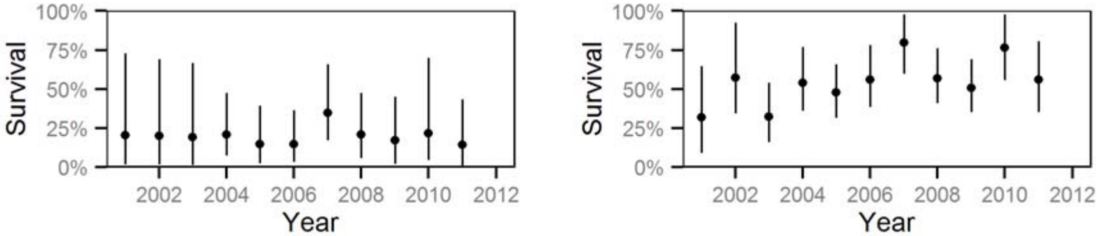

Figure 31: Inter-annual survival estimates (median with 95% CRIs) for subadult (left panel) and adult (right panel) Mountain Whitefish in the Lower Columbia River, 2001-2012.

3.5.2 Rainbow Trout

Estimates of inter-annual survival for subadult Rainbow Trout remained stable between 45% and 60% from 2001 to 2011, but declined to 32% between 2011 and 2012 (Figure 32). The survival of adult Rainbow Trout increased gradually from <30% in 2001 to 56% in 2011, but sharply declined to 28% in 2012. On average, survival was slightly greater for subadult Rainbow Trout when compared to adult life stages (Figure 32).

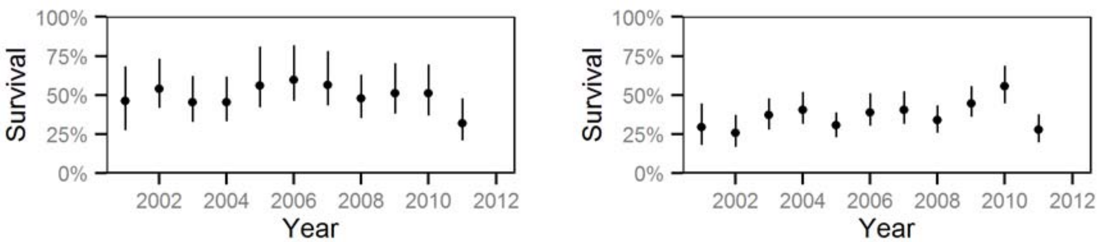

Figure 32: Inter-annual survival estimates (median with 95% CRIs) for subadult (left panel) and adult (right panel) Rainbow Trout in the Lower Columbia River, 2001-2012.

3.5.3 Walleye

Inter-annual survival estimates could not be estimated for Walleye for individual years due to insufficient data. However, the estimated inter-annual survival from 2001 to 2012 combined was 52% (credibility interval = 43 to 61%).

3.7 Catch Curve Analysis

Catch curve analysis was used as a supplementary method of assessing temporal and spatial trends in survival in the LCR. Catch curve analysis was the only method used for estimating survival for data collected in the 1990s, as these data were not appropriate for the analysis using the Cormack-Jolly-Seber (CJS) model. Mountain Whitefish were the only species with enough data to conduct the catch curve analyses.

Mountain Whitefish survival estimates between 2001 and 2012 fluctuated between ~40% and 92% (Figure 33). These estimates were similar but slightly higher than survival estimates based the CJS model of inter-annual recaptures (32-80%; Section 3.5.1). Both the catch curve analysis and the CJS model had wide credibility intervals associated with estimates, and did not indicate any trends over time. Based on the results of the catch curve analysis, survival was greater, on average, during the early 1990s (between 70% and 80%: Figure 34) compared to 2001 to 2012 (between 40% and 92%; Figure 33).

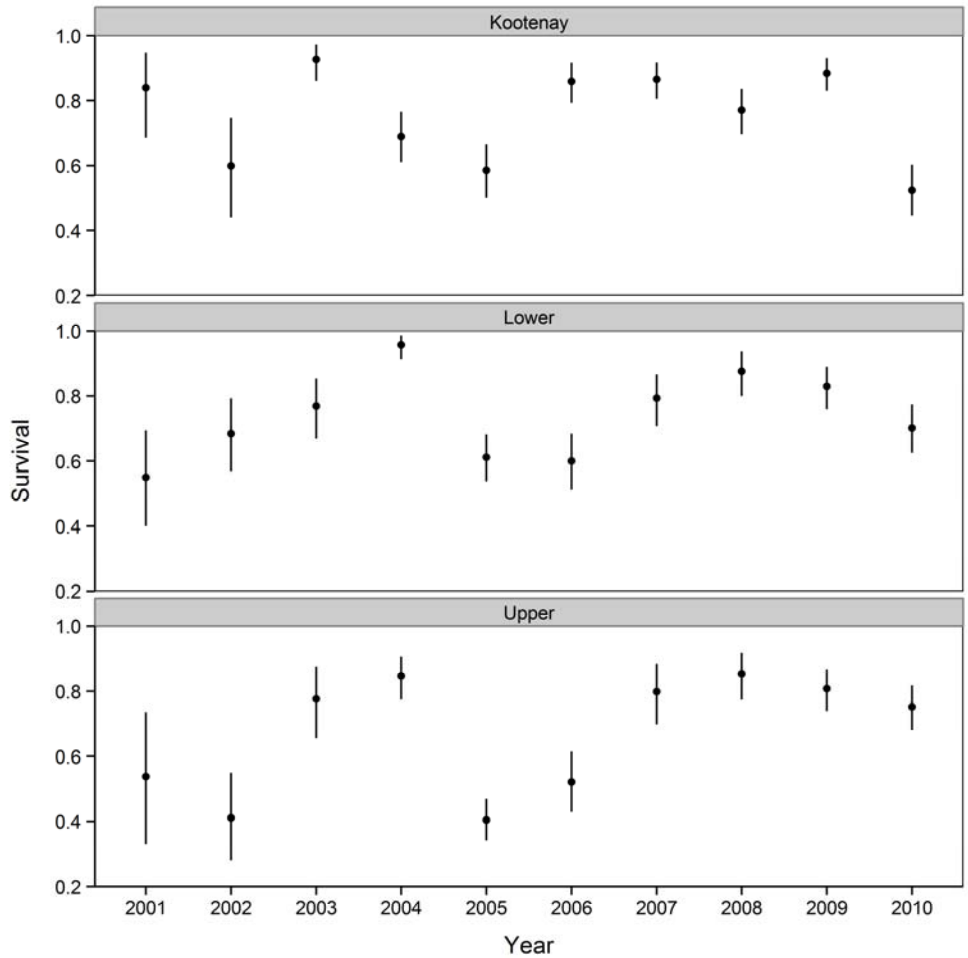

Figure 33: Survival estimates for Mountain Whitefish based on catch curve analysis (median with 95% CRIs) in the Lower Columbia River, 2001-2012.

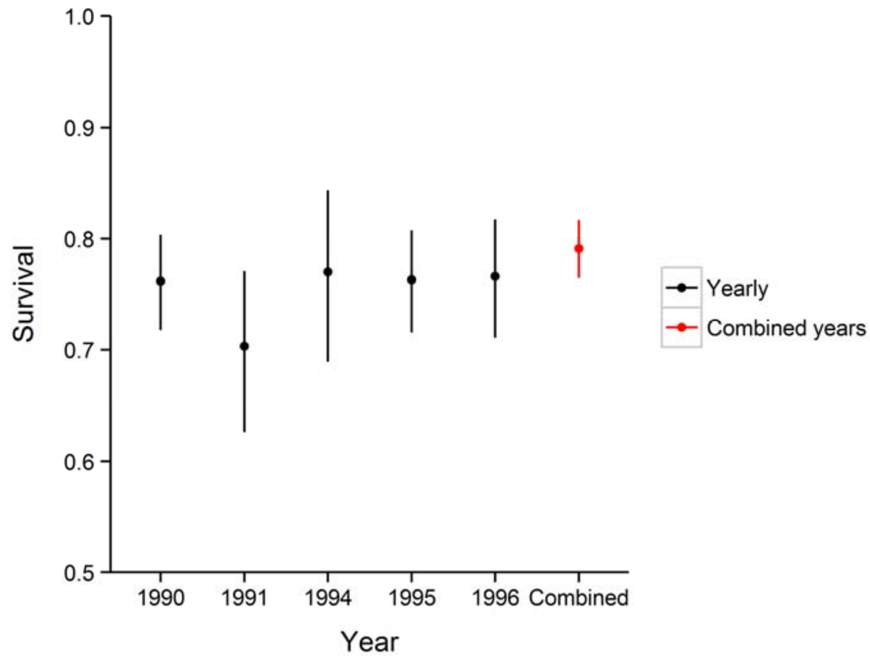

Figure 34: Survival estimates for Mountain Whitefish based on catch curve analysis (median with 95% CRIs) in the Lower Columbia River, 1990 to 1996.

3.6 Body Condition

3.6.1 Mountain Whitefish

Between 1990 and 2012, estimates of body condition for Mountain Whitefish varied. However, both subadult and adult fish followed the same general pattern. Body condition increased during the early 1990s, decreased between 2001 and 2003, and increased between 2003 and 2006 (the left panels of Figure 35 and Figure 36). Body condition increased for subadult Mountain Whitefish between 2008 and 2012 but was stable during this time period for adult Mountain Whitefish. The body condition of subadult Mountain Whitefish declined linearly between August and November of a typical year (P=0.01) but uncertainty around these estimates was large (the left panel of Figure 35). Adult Mountain Whitefish body condition estimates were greatest in late September and lowest in August and November (the right panel of Figure 36). For the month of October, the body condition of subadult and adult Mountain Whitefish declined slightly.

Site-level estimates suggested greater body condition for Mountain Whitefish in the Kootenay River relative to all other sites for both subadult (Figure 37) and adult (Figure 38) cohorts. Mountain Whitefish body condition was lowest at sites nearest to HLK (Rkm 0.0 to 6.0). There were no apparent differences in body condition in Mountain Whitefish among sites in the Columbia River downstream of the Kootenay River confluence.

Plots of Mountain Whitefish body condition by site and year did not suggest any substantial changes in spatial patterns of body condition over time (Appendix H, Figures H14 to H15). Low body condition for adult Mountain Whitefish in the early 1990s appeared to be related to low body condition at sites in the downstream portions of the Columbia River (RKm 25.0 to 50.0) between 1990 and 1992, whereas body condition was more similar among years at other sites (Appendix H, Figures H15).

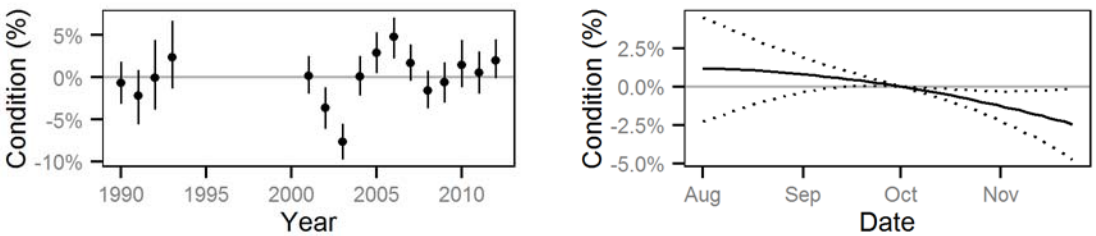

Figure 35: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

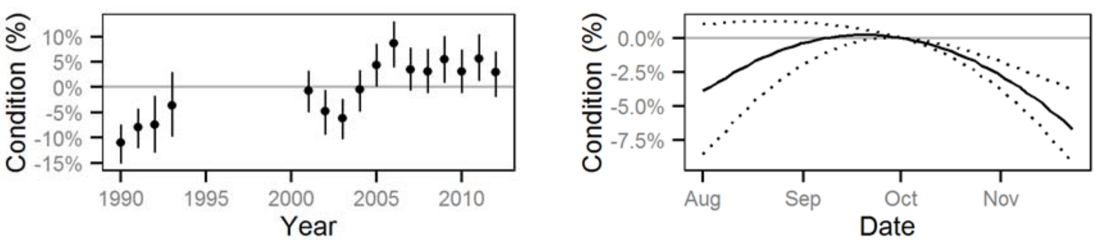

Figure 36: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for adult Mountain Whitefish in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

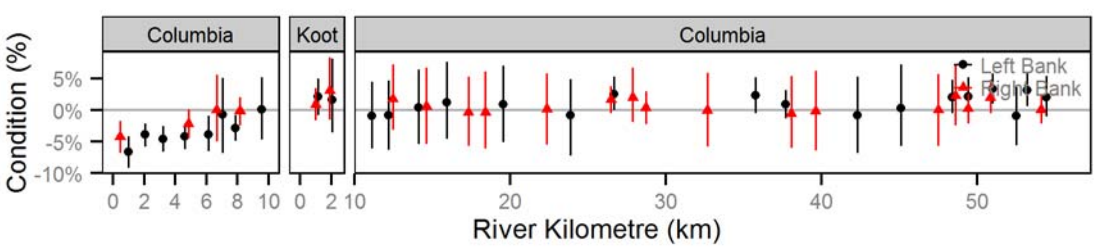

Figure 37: Body condition effect size estimates (median with 95% CRIs) by site for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 1993, 2001 to 2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

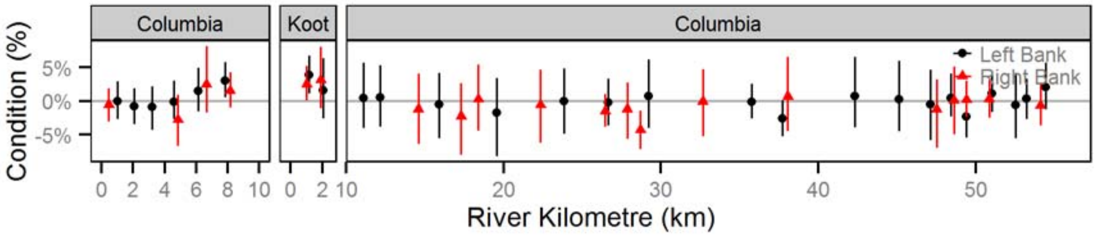

Figure 38: Body condition effect size estimates (median with 95% CRIs) by site for adult Mountain Whitefish in the Lower Columbia River, 1990 to 1993, 2001 to 2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

3.6.2 Rainbow Trout

The body condition of a subadult and adult Rainbow Trout was substantially higher in 2002 and 2006 compared to other study years (Figure 39 and Figure 40, respectively). Body condition was similar in all other study years with no substantial increasing or decreasing trends over time for either life stage. In a typical year, the body condition of subadult Rainbow Trout decreased slowly between August and November (*P*=0.002; Figure 39, right panel) whereas the body condition of adult Rainbow Trout increased during those months (Figure 40, right panel).

Site-level estimates of body condition for Rainbow Trout suggested lower body condition in the Columbia River upstream of the Kootenay River confluence, higher body condition in the Kootenay River, and intermediate but variable body condition in the Columbia River downstream of the Kootenay River confluence (Figure 41 and Figure 42).

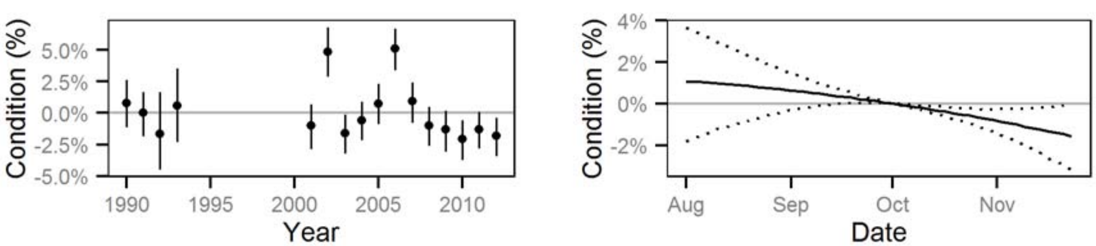

Figure 39: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for subadult Rainbow Trout in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

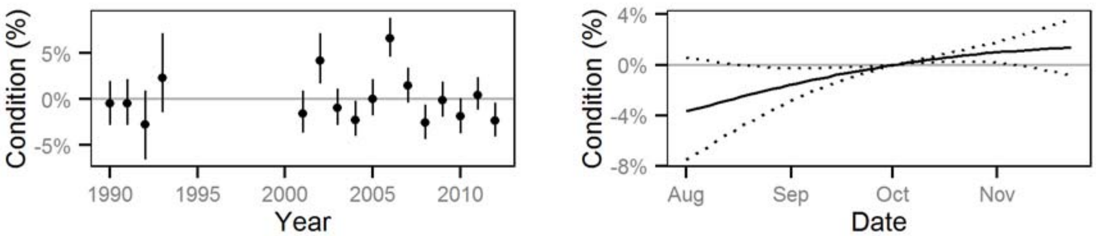

Figure 40: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for adult Rainbow Trout in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

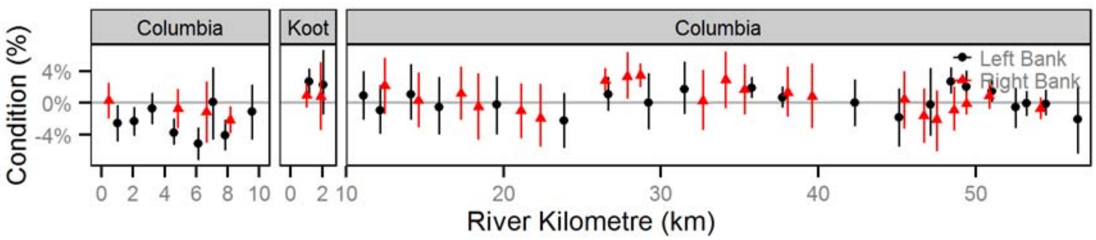

Figure 41: Body condition effect size estimates (median with 95% CRIs) by site for subadult Rainbow Trout in the Lower Columbia River, 1990 to 1993, 2001 to 2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

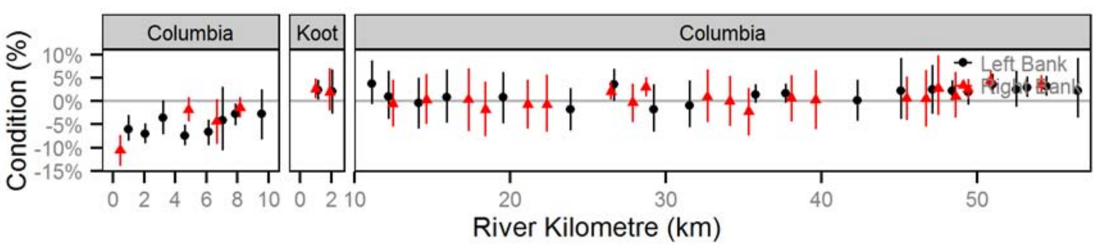

Figure 42: Body condition effect size estimates (median with 95% CRIs) by site for adult Rainbow Trout in the Lower Columbia River, 1990 to 1993, 2001 to 2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

Plots of Mountain Whitefish body condition by site and year did not suggest any substantial changes in the spatial patterns of body condition over time (Appendix H, Figures H16 to H17). In 2002 and 2006, Rainbow Trout body condition was higher at nearly all sites within the study area.

3.6.3 Walleye

Walleye body condition showed a similar fluctuating trend to that observed for Mountain Whitefish and Rainbow Trout. Body condition of Walleye increased in the early 1990s, decreased between 2001 and 2003, increased between 2003 and 2006, decreased from 2006 to 2010 and then increased from 2010 to 2012 (the left panel of Figure 43). Body condition increased between August and November (the right panel of Figure 43). Walleye body condition was higher in the Kootenay River, and lower near HLK and downstream of RKm 50; however, differences were small (<2%), suggesting similar body condition in different river sections (Figure 44).

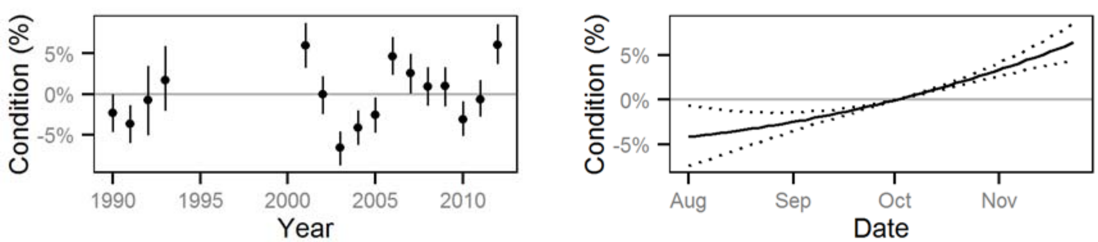

Figure 43: Body condition effect size estimates (median with 95% CRIs) by year (left panel) and date (right panel) for Walleye in the Lower Columbia River, 1990 to 1993 and 2001 to 2012.

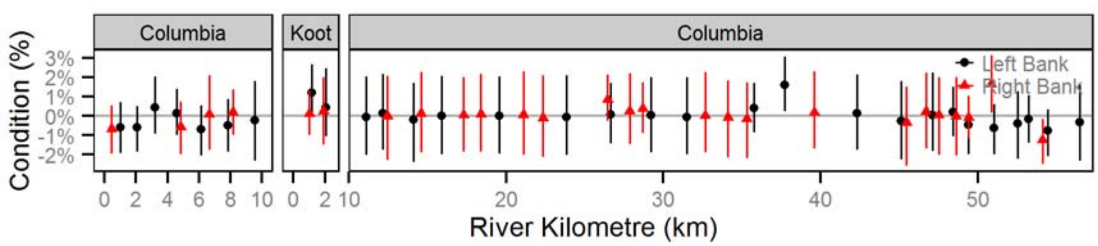

Figure 44: Body condition effect size estimates (median with 95% CRIs) by site for Walleye in the Lower Columbia River, 1990 to 1993, 2001 to 2012. The Kootenay River is coded as Koot; the Columbia River is split by sites located upstream (left panel) and downstream (right panel) of the Kootenay River confluence. River kilometres refer to the distance downstream of Hugh L. Keenleyside Dam.

3.7 Environmental Correlations

Cross-correlations of the year-to-year differences in density, condition, growth, survival, water temperature, and discharge revealed nine relationships that were significant at the *P*<0.001 level (Table 7)). There were six significant correlations for Rainbow Trout population metrics, four of which included discharge during fall or winter months (the remaining two correlations related condition to growth). The absolute density of subadult Rainbow Trout was negatively correlated with mean discharge (November and December) and variance in discharge (January and February). The length-at-age of Rainbow Trout fry was positively correlated with mean discharge (September and October). The growth of Rainbow Trout was negatively correlated with variance in discharge (January and February). For Mountain Whitefish, growth was negatively correlated with variance in discharge during January and February. Walleye growth was positively correlated with variance in discharge (November and December). None of the significant correlations included water temperature in the Columbia River.

Table 7: Cross-correlations among fish abundance, condition, life-history, and environmental variables from the Lower Columbia River, 2001-2012. Only correlations significant at the 0.001 level are presented.

Variable 1	Variable 2	Coefficient	P-Value
Condition (Adult Rainbow Trout)	Condition (Subadult Rainbow Trout)	0.90	0.00003
Discharge (Variance, Jan.-Feb.)	Growth (Mountain Whitefish)	-0.90	0.00004
Discharge (Mean, Nov.-Dec.)	Absolute Density (Subadult Rainbow Trout)	-0.86	0.00014
Discharge (Variance, Nov.-Dec.)	Growth (Walleye)	0.84	0.00031
Discharge (Variance, Jan.-Feb.)	Absolute Density (Subadult Rainbow Trout)	-0.83	0.00040
Discharge (Mean, Sep.-Oct.)	Length-at-age (Rainbow Trout Fry)	0.82	0.00056
Condition (Adult Rainbow Trout)	Growth (Rainbow Trout)	0.81	0.00071
Discharge (Variance, Jan.-Feb.)	Growth (Rainbow Trout)	-0.81	0.00086
Condition (Adult Walleye)	Absolute Density (Adult Walleye)	-0.80	0.00097

3.8 Other Species

Northern Pike were not captured or observed in the LCR prior to 2010. In 2010, seven Northern Pike were recorded (4 captured; 3 observed); nine Northern Pike were recorded in 2011 (8 captured; 1 observed). In 2012, 11 Northern Pike (*Esox Lucius*) were recorded in the LCR (1 captured; 10 observed). All of these fish were recorded in the Columbia River upstream of the Kootenay River confluence. As requested by the Ministry of Forests, Lands and Natural Resource Operations (J. Burrows, pers. comm.), all captured Northern Pike were killed.

In 2012, 51 Burbot were recorded in the LCR, which was within the range recorded between 2001 and 2012 (minimum = 3; maximum = 247). Although Burbot have been recorded in all portions of the study area, in 2012, 88% of all burbot were recorded downstream of RKm 40.

Eleven White Sturgeon (4 adults and 7 juveniles) were recorded (all observed; none captured) during the 2012 survey. Observational information for these fish is provided in Attachment A.

4.0 DISCUSSION

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

4.1 Length-At-Age and Growth

4.1.1 Mountain Whitefish

In the LCR, the length-at-age of fry and subadult Mountain Whitefish increased between 2001 and 2007. The growth of Mountain Whitefish, based on the model using inter-year recaptures, also increased between 2002 and 2006. 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 higher from 2004 to 2006 when abundance was low.

However, Mountain Whitefish fry growth may also be related to water levels. In 2001, discharge was very low during the spring/summer season when compared to other study years; water temperatures also were lower than normal. Naesje et al. (1995) noted that the hatching of Mountain Whitefish eggs can be delayed due to a lack of a thermal, chemical, and/or mechanical stimulus on the eggs. Lower discharges in 2001 may have delayed hatching, which would have reduced the amount of time that fry could have grown between emergence and the fall sample season.

Another possibility is that lower discharges in 2001 resulted in less nutrients entering the system from upstream sources (i.e., Arrow Lakes Reservoir and Kootenay Lake), which would, in turn, have resulted in less food available to Mountain Whitefish fry. The median length-at-age of subadult Mountain Whitefish also was lower in 2001, which may provide some support for the latter hypothesis. Mountain Whitefish fry also were smaller than average in 2004 and 2008; discharge during the spring/summer was lower than average in these two years.

While lower discharges during the spring/summer months may reduce the growth of Mountain Whitefish fry, higher discharges did not appear to result in higher growth rates. During the three study years in which Mountain Whitefish fry size-at-age were the highest (i.e., 2005, 2007, and 2010), discharge was near average, and in 2012 when flows were extremely high, length-at-age decreased when compared to the previous two study years. 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. In the Columbia River near Revelstoke Dam, higher mean hourly discharges were significantly correlated with greater swimming muscle activity in Bull Trout (Taylor et al. 2012). Mean discharge was not significantly correlated with the growth or length-at-age of Mountain Whitefish but variance in discharge during the winter (January and February) was negatively correlated with growth. Growth would be expected to be low during the winter due to low water temperatures and low food availability, but in general, more variable flows could result in greater energy expenditure and slower growth.

The seasonal trend in length-at-age was similar for fry and subadult Mountain Whitefish, with rapid growth in August and September and slower growth in November. Stomach content data collected from Mountain Whitefish in 2008 indicated that fry fed primarily on cladocerans (*Daphnia* species and *Eurycercus* species) and copepods (*Cyclops* species) during the fall study period, whereas subadults and adults fed primarily on mayflies

(Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) during the fall season (Golder 2009a). Over the duration of the fall study period, water temperatures in the LCR decrease and are generally around 12°C by mid-October. Low water and air temperatures could reduce zooplankton productivity rates and availability of insect prey, which would likely contribute to decreased Mountain Whitefish growth rates during the fall. Growth slowed in October more for fry than for subadults, which could be because zooplankton productivity decreased with decreasing water temperature, whereas caddisfly hatches occur frequently during the fall surveys, which indicates this food source is still abundant for subadult fish during this period.

Among watersheds in Idaho, USA, Meyer et al. (2009) found that Mountain Whitefish growth was positively correlated with mean annual water temperature. However, results from the current study indicate that mountain whitefish growth is not significantly correlated with water temperatures in the LCR study area.

4.1.2 Rainbow Trout

During the program's 12-year study period, median length-at-age for Rainbow Trout fry during the fall season ranged from 90 to 130 mm FL. Length-at-age of Rainbow Trout fry decreased from 2005 to 2010, followed by small increases in 2011 and 2012. The trend in length-at-age of subadult Rainbow Trout was different than for fry, with increasing length-at-age from 2001 to 2007 then smaller but stable length-at-age from 2008 to 2012. Annual growth of Rainbow Trout, based on data from recaptured fish, did not indicate any consistent trends over time, and did not seem to correspond closely to trends observed in length-at-age estimates. 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. One similarity among trends in growth and length-at-age of fry and subadult Rainbow Trout was that all these metrics increased during the early 2000s, a period when the density of subadults was decreasing. These trends suggest density-dependent growth rates which could indicate competition for resources among juvenile Rainbow Trout in the LCR.

Environmental variables were not strongly associated with trends in length-at-age and growth of Rainbow Trout. Growth was negatively correlated with variance in discharge during January and February but there were no other significant correlations among water temperature and discharge variables, and growth or size metrics for this species. These results do not suggest that flow regime had a substantial effect on the length-at-age and growth of Rainbow Trout in the LCR between 2001 and 2012.

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

4.1.3 Walleye

Annual growth for this species generally declined between 2006 and 2012. Growth was lowest in 2004, a year with relatively high walleye densities and low body condition, suggesting a density-dependent relationship with lower growth when Walleye abundance is high. However, there was not a consistent relationship between density and growth in other years of the study. The growth of Walleye was positively correlated with variance in discharge during November to December, suggesting a possible effect of flow regime on Walleye growth, although the correlation analysis does not imply a causal relationship. Walleye are thought to feed in the LCR during the 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). Why growth would be related to discharge variance during the winter months, when the bulk of the population resides in Lake Roosevelt, is unknown. For this reason, this correlation should be interpreted with caution, and could be due to chance rather than a real ecological interaction.

Overall, a lack of age data and limited numbers of inter-year recaptured fish hinder detailed growth analyses for Walleye. During future study years, substantially more data will be required to detect significant changes in Walleye growth. Given the seasonal residency of most of the Walleye population (R.L.&L. 1995) and the limited amount of growth-related data available for this species to date, it is unlikely that the program, in its current form, will garner enough data to detect a relationship between Walleye length-at-age or growth, and LCR discharge.

4.2 Abundance

4.2.1 Mountain Whitefish

The estimated density of subadult Mountain Whitefish decreased between 2001 and 2004. Reasons for this decline are unknown, but may in part be attributed to changes in sampling methods. During the initial years of the program (i.e., between 2001 and 2003), compressed oxygen was not pumped into the livewell. Lower oxygen levels in the livewell may have resulted in higher subadult Mountain Whitefish mortality rates after marking and release. Higher delayed mortality rates for marked fish would result in overestimated absolute density estimates during these study years. If subadult Mountain Whitefish density truly declined between 2001 and 2004, one would expect either adult Mountain Whitefish densities to decline between 2002 and 2005 or adult Mountain Whitefish survival to increase between 2001 and 2004. Neither adult density nor survival changed enough over that time period to support an approximately 68% reduction in the density 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 density estimates, which is discussed in further detail in Section 4.4.1. The fact that count density estimates for Mountain Whitefish (all age-classes combined) declined between 2001 and 2004 supports a real decline in Mountain Whitefish abundance, and not just bias due to changes in sampling protocols in 2004. Count density estimates consist primarily of unmarked fish and would not be seriously affected by changes in fish handling and sampling procedures. Estimates of subadult Mountain Whitefish density from the early 1990s were within the range of values observed from 2001 to 2012.

Estimates of density for adult Mountain Whitefish were approximately three times greater in the 1990s compared to 2001 to 2012 estimates. Densities generally declined between 2001 and 2012 and were lower in 2010 to 2012 than in all previous study years. Although the trends in density over time were not identical for subadult and adult Mountain Whitefish, both age-classes generally declined during the current monitoring period and were low when compared to estimates generated using data from the early 1990s.

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

Between 2001 and 2012, 93 524 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 correlation analysis did not reveal any significant relationships between Mountain Whitefish densities in the LCR and river discharge or water temperature. The effects of discharge variations on spawning and early life-history of Mountain Whitefish in the LCR are currently being investigated in greater detail as part of other BC Hydro studies (i.e., CLBMON-47 and CLBMON-48; Golder 2012a, 2012b).

4.2.2 Rainbow Trout

The density of subadult Rainbow Trout decreased between 2001 and 2004. This decline correlated with a decline in subadult Mountain Whitefish densities over the same time period and could partly be explained by changes in fish handling techniques in 2004 (see Section 4.2.1). However, count densities of Rainbow Trout, which would not be drastically influenced by tagging and handling effects, also declined from 2001 to 2005, followed by increasing densities until 2012, factors that suggest fluctuations in the abundance of subadult Rainbow Trout during the study are real.

Estimated densities of adult Rainbow Trout fluctuated little between 2001 and 2012, but suggested a very small, gradual increase in abundance during this time period. This pattern is not supported by the number of Rainbow Trout spawners in the LCR based on visual observations and area-under-the-curve estimates, which more than doubled between 1999 and 2012 (Thorley and Baxter in prep.). There are several possible reasons for the discrepancy between trends in the estimated number adults based on electroshocking surveys and spawner surveys. One explanation could be that some of the Rainbow Trout classified as adults in this study based on the HBM of length-at-age were not actually mature spawners during the preceding spring spawning season, leading to overestimates of the number of adults during earlier years, when the minimum length-at-age for adults was lower. Although this is possible, it is unlikely that relatively small differences in the estimated minimum length-at age for an adult Rainbow Trout resulted in the large differences observed in the adult and spawner estimates. Another possibility is that catches, counts, and density estimates were biased by sampling or analytical methodologies. For example, for absolute density estimates based on mark-recapture, capture efficiency for adults was always low (<3%), which provided little information about annual or inter-session variation in recapture rates, and could have masked real changes in Rainbow Trout abundance. Another potential sampling bias could be saturation of the ability of netters' to catch and count fish, whereby counts and catches of fish would comprise a smaller proportion of the total number of fish present when densities were high. This would result in underestimated densities when abundance was high. To test whether saturation of netters at high fish densities could bias estimates, additional sampling could be conducted during which fish would be enumerated and immediately recorded (but not captured). The potential benefits of an enumeration pass are discussed more in Section 4.6.

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

The probability of a fish being recaptured in the same site was highest for subadult Rainbow Trout, among all index species and cohorts. This indicates that subadult Rainbow Trout exhibited a higher site-fidelity than all other index species and life stages. In addition, estimated capture efficiencies were highest for subadult Rainbow Trout, which indicates that this cohort also was the easiest to catch.

There was some indication that the abundance of Rainbow Trout could be affected by variation in the LCR flow regime. The absolute density of subadult Rainbow Trout was negatively correlated with mean discharge in November and December and variance in discharge in January to February. 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. The correlation results presented here suggest that flow variations during the overwintering period could affect survival of subadult Rainbow Trout in the LCR.

4.2.3 Walleye

Walleye densities increased substantially between 2002 and 2003 and declined between 2003 and 2007. These results likely reflect a strong year-class of Walleye that migrated into the study area between 2002 and 2003; these individuals gradually decreased in abundance over the next four years. Walleye migrate into the LCR to feed, 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 and early life history outside of the study area. Based on length-frequency data and Lake Roosevelt length-at-age data (WDFW Unpublished Data), the age-1 cohort is the most dominant age-class present in the study area during most study years; therefore, the abundance of this species in the study area during any particular year is strongly influenced by the spawning success of this species during the previous spring.

Estimates of Walleye density were greater in the early 1990s compared to between 2001 and 2012. Data collected during the 1990s suggests substantially greater Walleye densities in that period compared to recent years. However, the possibility that differences in sampling contributed to this difference cannot be ruled out.

The absolute density of Walleye was negatively correlated with body condition, suggesting density-dependent growth and resource competition in years of high abundance in the LCR. There was no evidence to suggest significant effects of discharge or temperature variation on Walleye densities between 2001 and 2012.

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 2012 (D. Ford, personal communication). Northern Pike likely migrated into the LCR from the Pend d'Oreille River, where established populations exist. Very high water levels in 2012 resulted in many areas with flooded terrestrial vegetation, which may have provided suitable spawning habitat for Northern Pike and further facilitated an increase in their local abundance. Beyond limited electroshocking data from CLBMON-45, and anecdotal reports from anglers, nothing is known about the abundance, life-history, habitat use, spawning, or movement patterns of Northern Pike in the LCR. This highly efficient piscivore has the potential to alter the populations of index species and other fishes in the LCR. The introduction of a non-native species such as Northern Pike is a large factor contributing to the decline of salmonids in 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.

4.3 Spatial Distribution

4.3.1 Mountain Whitefish

Subadult Mountain Whitefish densities were greatest in the 10 km reach between HLK and the Kootenay River confluence. This result is likely related more to channel morphology than the presence or operation of the dam. Large bays and backwater areas, which are preferred habitats for subadult Mountain Whitefish, are more common near HLK than downstream of the Kootenay River confluence. Specific examples include Balfour Bay (RKm 2.6), downstream of the log booms near Zelstoff-Celgar (RKm 5.1), and upstream of Norn's Creek Fan (i.e., Lions Head RKm 7.4). These areas have exhibited increases in aquatic vegetation abundance (dominantly Eurasian watermilfoil) between 2001 and 2012 (Attachment A). Most recently, Northern Pike have been captured in increasing numbers in these same areas. Whether these fish were present in these locations to feed on subadult Mountain Whitefish or whether this predation will have a detectable effect on subadult Mountain Whitefish survival is unknown.

The spatial distribution of adult Mountain Whitefish during the fall sample period is related to the location of key spawning areas for this species. Densities of this age-class were highest near Norn's Creek Fan, in the downstream portions of the Kootenay River, upstream of Sullivan Creek, and near the City of Trail Airport.

Norn's Creek Fan, the Kootenay River, and the City of Trail Airport area are known Mountain Whitefish spawning locations (Golder 2012b), whereas the site located upstream of Sullivan Creek is close to a known spawning area (i.e., Lower Cobble Island), which may indicate that Mountain Whitefish use these areas for holding purposes prior to spawning.

There were no discernible temporal changes in the spatial distributions of subadult and adult Mountain Whitefish between 2001 and 2012.

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 existence of major spawning areas immediately upstream (i.e., Norn's Creek Fan, the Kootenay River, and the Genelle area; Thorley and Baxter 2012).

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

One hypothesis is a behavioural change that reflects fish avoiding 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, only one of the 299 Rainbow Trout captured in synoptic sites was a marked individual that was initially captured in 2012 in an index site. This result does not suggest that large numbers of marked fish are leaving the indexing sites over the course of the survey and is further supported by site fidelity estimates for Rainbow Trout (which were higher than Mountain Whitefish and Walleye estimates).

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

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

4.3.3 Walleye

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

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.

The only change observed in the spatial distribution of Walleye over time was that there were higher densities of Walleye at sites C49.0-L and C49.0-R (between Beaver and Hayward creeks) in the 1990s, whereas densities were low at these sites in recent study years. These changes are likely real, as it is unlikely that the differences in methods or analyses between the two programs would only affect these two sites. Credibility intervals were wide for all estimates. There were no discernible temporal changes in the spatial distribution of walleye between 2001 and 2012.

4.4 Survival

4.4.1 Mountain Whitefish

Estimated survival was greater for adult Mountain Whitefish (32-80%) than for subadults (14-35%). Greater survival for adults is not unexpected, as Mountain Whitefish are known to be a relatively long-lived species with most populations containing individuals greater than 10 years of age (McPhail 2007; Meyer et al. 2009).

Currently, each of the management hypotheses is tested using separate HBMs, which simplifies the assessment of the hypotheses. This approach also allows the model outputs to be checked for inconsistencies. When this check was conducted on subadult and adult Mountain Whitefish density estimates, the estimates generated were not compatible with survival estimates. Specifically, it is not possible for adult population densities of 538 fish/km (2012) to be supported by subadult densities of 158 fish/km (2011) with only 14% subadult survival (22 fish/km to be recruited to adult population) and adult survival of 56% (301 fish/km remaining in adult population). This suggests 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 HBMs 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 movement model. The movement 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 movement model would underestimate the losses of tagged fish. This bias would result in an underestimation of capture efficiency and a concomitant overestimation of absolute density.

Mountain Whitefish recapture probabilities are less than half of those for Rainbow Trout and Walleye, which suggests that fish movements could be influencing recapture estimates. In addition, during BC Hydro's MCR Fish Population Indexing Program (CLBMON-16), recapture rates for adult Mountain Whitefish were greater in the spring than in fall in 2011 and 2012, possibly because Mountain Whitefish were moving into and out the study area in the fall study period for spawning migrations (Ford and Thorley 2011b; Golder and Poisson 2012 in prep.) 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 density 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.

Catch curve analysis provided a method to corroborate survival estimates generated by the CJS model and made it possible to estimate survival during the early 1990s. Between 2001 and 2012, the range of survival estimates from catch curve analysis (~40-85%) generally agreed with CJS survival estimates (32-80%). Catch curve analysis indicated higher survival rates of adult Mountain Whitefish in the early 1990s (between 70% and 80%) compared to between 2001 and 2012 (between 40% and 92%). Catch and absolute density estimates for adult Mountain Whitefish were approximately three times greater in the 1990s than between 2001 and 2012 and catch curve analysis suggests that greater survival in the early 1990s could explain the difference.

4.4.2 Rainbow Trout

Survival estimates for subadult Rainbow Trout between 2001 and 2011 were fairly stable, fluctuating between 45% and 60%. This trend generally agreed with subadult densities that fluctuated among years with no consistent increasing or decreasing trend. For adult Rainbow Trout, both survival and absolute density increased gradually between 2001 and 2011. Survival declined sharply in 2012 for both subadult and adult Rainbow Trout. Lower Rainbow Trout survival in 2012 could have been related to high river discharge in 2012 that was the highest recorded since the construction of HLK (approximately 40 years). Based on these data, it is not possible to ascertain how or if high water levels may have reduced Rainbow Trout survival or if the decline could possibly be related to other factors like changes in fish behaviour (e.g. greater movement out of the study sites). The substantial decline in estimated survival of subadult or adult Rainbow Trout in 2012 did not correspond with a decrease in density these cohorts, or with the number of spawners estimated based on visual surveys in 2012 (Thorley and Baxter in prep.).

4.4.3 Walleye

Annual survival of Walleye based on the combined dataset from 2001 to 2012 was 52% (credibility interval = 43 to 61%). Survival during each year for Walleye could not be estimated due to insufficient data; therefore, trends in survival over time could not be assessed. As a large portion of the Walleye population is thought to be migratory and spend only part of the year in the LCR before moving downstream into Lake Roosevelt (R.L.&L. 1995), interpretation of annual survival would likely be confounded by fish movements. More information regarding Walleye migrations and their degree of residency in the LCR is needed to better understand factors driving abundance and survival.

4.5 Body Condition

4.5.1 Mountain Whitefish

The body condition of subadult and adult Mountain Whitefish fluctuated between 1990 and 2012 with no consistent increasing or decreasing trend over this time period. The changes in body condition of adult Mountain Whitefish varied from -10% to 8% (compared to a typical year) between 1990 and 2012 (Figure 36). Fluctuations in body condition are known to affect reproductive potential and population productivity in other fish species (Ratz and Lloret 2003). However, it is not known what percent change in body condition is biologically significant and could affect populations of Mountain Whitefish. The Canadian Environmental Effects Monitoring (EEM) program for mining and pulp and paper effluents considers a 10% change in fish body condition to be the critical threshold for higher risk to the environment (Munkittrick et al. 2009; Environment Canada 2012). This criterion suggests that the 8-10% variation in adult Mountain Whitefish body condition could be biologically significant. Studies of the effects of body condition on reproduction and other life-history processes are required to understand the implications of body condition variation in Mountain Whitefish and other index fish species in the LCR.

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

During the fall, the body condition of adult Mountain Whitefish in the Columbia River increased until approximately late September after which time body condition decreased by 7%. During that time however, the body condition of adult Mountain Whitefish would be expected to increase as adults produce gametes and subadults and adults put on weight for the winter. The decrease in body condition during the fall suggested by the model is suspect and could have been the result of sexually mature fish migrating out of some sample sites prior to the spawning season, thereby reducing the body condition of the remaining population. This possibility is supported by the increase in body condition of adult Mountain Whitefish recorded over the surveyed period in the Kootenay River (Ford and Thorley 2011a), which is a known spawning and staging location for this species.

The body condition of subadult Mountain Whitefish was lowest in the Columbia River upstream of the Kootenay River confluence. The higher body condition of subadult Mountain Whitefish observed in the Kootenay River and in the Columbia River downstream of the Kootenay River confluence could be due to warmer water temperatures and/or higher nutrients loads in the Kootenay River when compared to the Columbia River. The spatial differences in body condition were similar but less pronounced for adult Mountain Whitefish compared to subadults. Increases in body weight due to increased gamete production and/or pre-spawning movement patterns may have influenced spatial patterns in body condition for adults.

The spatial patterns in the body condition of Mountain Whitefish did not change substantially between 1990 and 2012. One exception was that body condition was lower in downstream sections of the LCR (RKm 25-50) in the early 1990s compared to recent years. Habitat conditions or food availability in the downstream section may have changed since the 1990s and contributed to the difference in Mountain Whitefish body condition.

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 conditions of subadult and adult Rainbow Trout were highly correlated, suggesting that similar factors may influence the condition of both of these cohorts.

Results suggest body condition of subadult Rainbow Trout decreased between August and November. This result may indicate that energy resources are being put toward increasing length instead of increasing weight. Rainbow trout length-at-age data suggest increasing length during the late fall season, supporting this hypothesis. 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).

As was reported for Mountain Whitefish, the body condition of Rainbow Trout was relatively low in the Columbia River upstream of the Kootenay River and higher in the Kootenay River. This result could be due to warmer water temperatures and higher nutrient loads in the Kootenay River when compared to the Columbia River. The high body condition values for subadult Rainbow Trout in middle portion of the LCR (~Rkm 25-35) suggests that this area had environmental conditions that were favourable for juvenile rearing. The spatial patterns of body condition of Rainbow Trout were similar between 1990 and 2012.

4.5.3 Walleye

Body condition of Walleye in the study area fluctuated between 1990 and 2012 but trends were not related to river discharge or water temperature based on correlation analysis. The body condition of Walleye was negatively correlated with their absolute density, suggesting density-dependent growth which 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).

Walleye body condition increased over the fall study period. This result was expected, as this species is in the study area during this time period to feed prior to migrating downstream to overwinter in Lake Roosevelt (R.L.&L. 1995).

There was little difference in Walleye body condition among different river sections, although condition was slightly greater in the Kootenay River than in the Columbia River. A large portion of the LCR Walleye population migrates into the study area from Lake Roosevelt during the late spring and summer to feed (R.L.&L. 1995); this could result in low site fidelity if most Walleye do not remain at one site long enough for habitat characteristics to influence their body condition.

4.6 Summary

The sampling program conducted since 2001 provides a high-quality, long-term dataset to address the management question regarding monitoring key fish population metrics over time in the LCR. Hierarchical Bayesian models suggested that abundance, spatial distribution, survival and growth of the three index species have fluctuated during the 2001 to 2012 monitoring period. For instance, between 2001 and 2007 the abundance of Mountain Whitefish decreased while growth, length and condition all increased at some point during this time. Historical data from a similar fish sampling program in 1990-1993 were incorporated into the analyses to assess longer term trends in fish populations. These analyses suggested substantial differences in the abundance and survival of index species, including much higher abundance and lower survival of Mountain Whitefish in the early 1990s. Greater abundance of Mountain Whitefish prior to the protection flows (i.e., in 1990 to 1993) was not expected as the flow management plan was intended to increase survival and abundance. However, conclusions based on these comparisons of different datasets should be viewed with caution because of the potential influence of differences in data collection.

The second management question for this monitoring program pertains to the effects of inter-annual variability in flow regimes on fish population metrics of the index species. Overall, discharge did not seem to be strongly associated with the fish population metrics assessed, although there were some associations between the mean or variance in discharge in the fall/winter months, and growth or density of all three index species. Although discharge in the Columbia River was anomalously high in 2012, the effects of high discharge on fish populations was not clear, but could have been related to the sharp decline in estimated Rainbow Trout survival observed between 2011 and 2012. Additional years of data may provide further insight.

Although water temperature is known to be one of the most important factors influencing the ecology of fishes (Coutant 1976), water temperature was not correlated with any of the fish population metrics. Correlation analysis in this study used mean temperature values from bimonthly periods, and it could be that the upper or lower temperatures experienced could have a greater influence on fishes. With regard to the management questions, the effects of the flow management plan on water temperature are unknown, but the inter-annual variations in water temperature observed in this study were not likely drivers of change in fish population metrics in the LCR.

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. Further understanding of the migratory behaviour of index species will provide more insight into addressing CLBMON-45 management questions.

Another key focus of future years of the study should be to further identify and address which assumptions are being violated in the data analyses. For example, it may be possible to use body condition information to identify sexually mature fish and to test whether sexually mature fish are recaptured less frequently than non-spawners. Alternatively it may be possible to refine movement models to take into account the date and distance moved by a fish between captures to identify whether broader scale movements are taking place, although such an approach may be limited by the relatively low numbers of recaptured individuals.

One finding that could indicate potential violation of assumptions or room for improvement in the study methodology was that the absolute density of adult Rainbow Trout varied little between 2001 and 2012 whereas subadult density and survival from this study, and estimates of spawner abundance from CLBMON-46 all suggested substantial fluctuations over this same time period. The consistently low recapture rates may provide little information about annual or seasonal variation in capture efficiency, which could make it difficult to detect large changes in efficiency or abundance over time. One possible change to the sampling program that could potentially improve count data and density estimates would be an additional electroshocking pass at each site during which fish would be enumerated but not captured. This enumeration pass would allow the collection of fine-scale spatial distribution data (by geo-referencing the location of fish within the site using a hand-held GPS) and more accurate count data (observers would focus on counting instead of capturing). This approach would not only improve count data, but also provide valuable information on the fine-scale distribution of fish. In addition, if several years of enumeration are conducted in parallel with mark-recapture, it may eventually prove 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.

Overall, the HBMs have outlined the difficulty of interpreting population dynamics in a large study area when sample sites are limited to specific areas. In 2011 and 2012, 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 (Appendix H, Figures H1 to H3, H6 to H8, H11, and H12) were very informative and suggest that these areas are used intensively by all three index species during the fall season. Reverting back to the original study design (i.e., repetitively sampling the same sites five times) and continuing to exclude the remaining ~66% of the study area may limit the HBMs ability to detect significant changes in the parameters of interest.

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 2013 using the same methodologies employed in 2012. In addition to further sampling, the following recommendations are provided:

- Explore the use of body condition to identify sexually mature Mountain Whitefish and to test whether sexually mature fish are recaptured less frequently than their non-spawning equivalents.
- Continue to use age-data to estimate adult survival from a catch-curve analysis to confirm that survival estimates generated by the HBM are unbiased.
- Continue the GRTS survey following the completion of the fall mark-recapture indexing program. This survey could be conducted within the same budget by reducing the number of annual sessions to four (i.e., four mark-recapture sessions with one GRTS session instead of five mark-recapture sessions).
- An additional electroshocking pass should be conducted at each site during which fish would be enumerated but not captured. This enumeration pass would allow the collection of fine-scale spatial distribution data (by geo-referencing the location of fish within the site using a hand-held GPS) and more accurate count data (observers would focus on counting instead of capturing). This approach would provide valuable information on the fine-scale abundance, diversity, and distribution of fish. In addition, if several years of enumeration are conducted in parallel with mark-recapture, it may eventually prove possible to calibrate the efficiency of the method and reduce the number of mark-recapture passes needed during each sample season.
- Conduct a small-scale telemetry program to monitor local movement patterns and their effect on fish population parameters.
- Conduct a mark-recapture program during the spring season to provide insight into the seasonal movements of each 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).
- Continue analyses using data collected in the 1990s in the HBMs to provide a longer time series of data (i.e., data prior to the implementation of Mountain Whitefish and Rainbow Trout spawning protection flows).
- The feasibility of not implementing Mountain Whitefish and Rainbow Trout protection flows for a single spawning season should be examined. This would provide an opportunity to monitor changes in the parameters of interest under significantly different flow regimes.
- Use results from other WUP programs to develop hypotheses about potential causes for change in fish populations, and test these hypotheses using HBMs that combine the relevant data. Such analyses depend on the availability and suitability of long-term datasets from the other WUP programs.

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7.0 CLOSURE

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

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APPENDIX A

Maps and UTM Coordinates

Table A1 Locations and distances from Hugh L. Keenleyside Dam of boat electroshocking sites in the Lower Columbia River, 2012.

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.

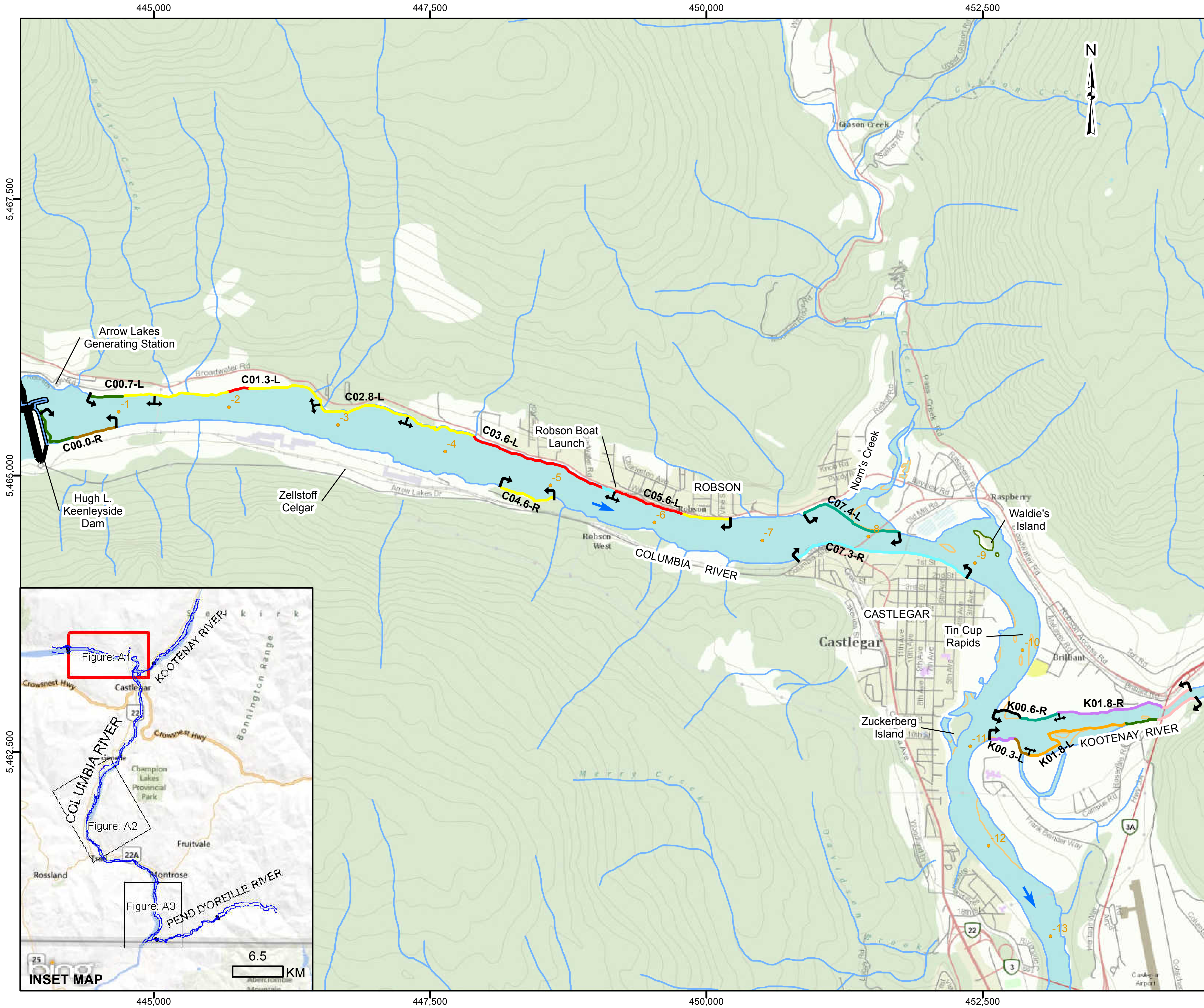
[c] LDB=Left bank as viewed facing downstream; RDB=Right bank as viewed facing downstream.

Table A2 Locations of selected sites and available sites included in the Generalized Random Tessellation Stratified (GRTS) survey, 2012.

Site Designation	Location (km)[a]	Bank[b]	Upstream UTM Coordinates			Downstream UTM Coordinates			GRTS Selection Order
			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	20
C08.4-L	8.4	LDB	11U	451833	5464445	11U	452304	5464244	
C08.6-L	8.6	LDB	11U	452132	5464468	11U	452720	5464206	
C08.9-R	8.9	RDB	11U	452375	5464074	11U	452797	5463486	
C09.0-L	9.0	LDB	11U	452286	5462718	11U	452286	5462718	
C09.2-L	9.2	LDB	11U	452720	5464206	11U	452987	5463481	6
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	7
C10.8-R	10.8	RDB	11U	452154	5462718	11U	452154	5462718	
C10.9-L	10.9	LDB	11U	452584	5462607	11U	453290	5460373	16
C11.5-R	11.5	RDB	11U	452217	5462050	11U	453103	5460426	
C13.4-L	13.4	LDB	11U	453290	5460373	11U	453321	5459007	
C13.4-R	13.4	RDB	11U	453103	5460426	11U	453221	5458057	18
C14.8-L	14.8	LDB	11U	453321	5459007	11U	453210	5456890	10
C15.8-R	15.8	RDB	11U	453221	5458057	11U	453234	5457317	
C16.6-R	16.6	RDB	11U	453234	5457317	11U	452358	5456216	14
C17.0-L	17.0	LDB	11U	453210	5456890	11U	452622	5455322	
C18.0-R	18.0	RDB	11U	452358	5456216	11U	452351	5455401	3
C18.8-R	18.8	RDB	11U	452351	5455401	11U	452122	5454012	
C19.0-L	19.0	LDB	11U	452622	5455322	11U	452444	5454183	
C20.1-L	20.1	LDB	11U	452444	5454182	11U	451645	5453285	
C20.4-R	20.4	RDB	11U	452122	5454012	11U	451093	5453191	
C21.3-L	21.3	LDB	11U	451645	5453285	11U	450603	5451637	
C21.8-R	21.8	RDB	11U	451093	5453191	11U	450495	5452148	13
C22.9-R	22.9	RDB	11U	450495	5452148	11U	450188	5451058	
C23.4-L	23.4	LDB	11U	450603	5451637	11U	450368	5450764	9
C24.0-R	24.0	RDB	11U	450188	5451058	11U	449356	5450418	
C24.3-L	24.3	LDB	11U	450368	5450764	11U	449178	5449989	
C25.3-L	25.3	MID	11U	448978	5450229	11U	448978	5450229	
C26.2-L	26.2	MID	11U	448938	5449626	11U	448938	5449626	
C27.5-L	27.5	LDB	11U	448193	5449036	11U	448064	5447758	
C28.8-L	28.8	LDB	11U	448064	5447758	11U	447820	5446998	5
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	
C32.0-R	32.0	RDB	11U	446817	5444824	11U	446256	5443655	11
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	15
C35.7-R	35.7	RDB	11U	446294	5441253	11U	447152	5440472	
C36.9-R	36.9	RDB	11U	447152	5440472	11U	448305	5438607	4
C38.8-L	38.8	LDB	11U	448340	5439017	11U	449001	5438233	
C39.2-R	39.2	RDB	11U	448305	5438607	11U	448995	5438083	1
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	8
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	19
C44.7-R	44.7	RDB	11U	453275	5437384	11U	454560	5436673	
C45.6-L	45.6	LDB	11U	454179	5437228	11U	454855	5436623	
C46.2-R	46.2	RDB	11U	454560	5436673	11U	455141	5435856	
C46.4-L	46.4	LDB	11U	454855	5436623	11U	455319	5435321	17
C47.2-R	47.2	RDB	11U	455141	5435856	11U	455017	5434942	12
C56.0-L	56.0	LDB	11U	454774	5428024	11U	453949	5427733	2

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

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



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

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PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1 KM

SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE

UPPER SECTION OF STUDY AREA
2012 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	SS	13 Jun. 2012	**Figure: A1**	
GIS	SS/JG	19 Jun. 2012		
CHECK	DF	24 Jun. 2013		
REVIEW	LH	24 Jun. 2013		

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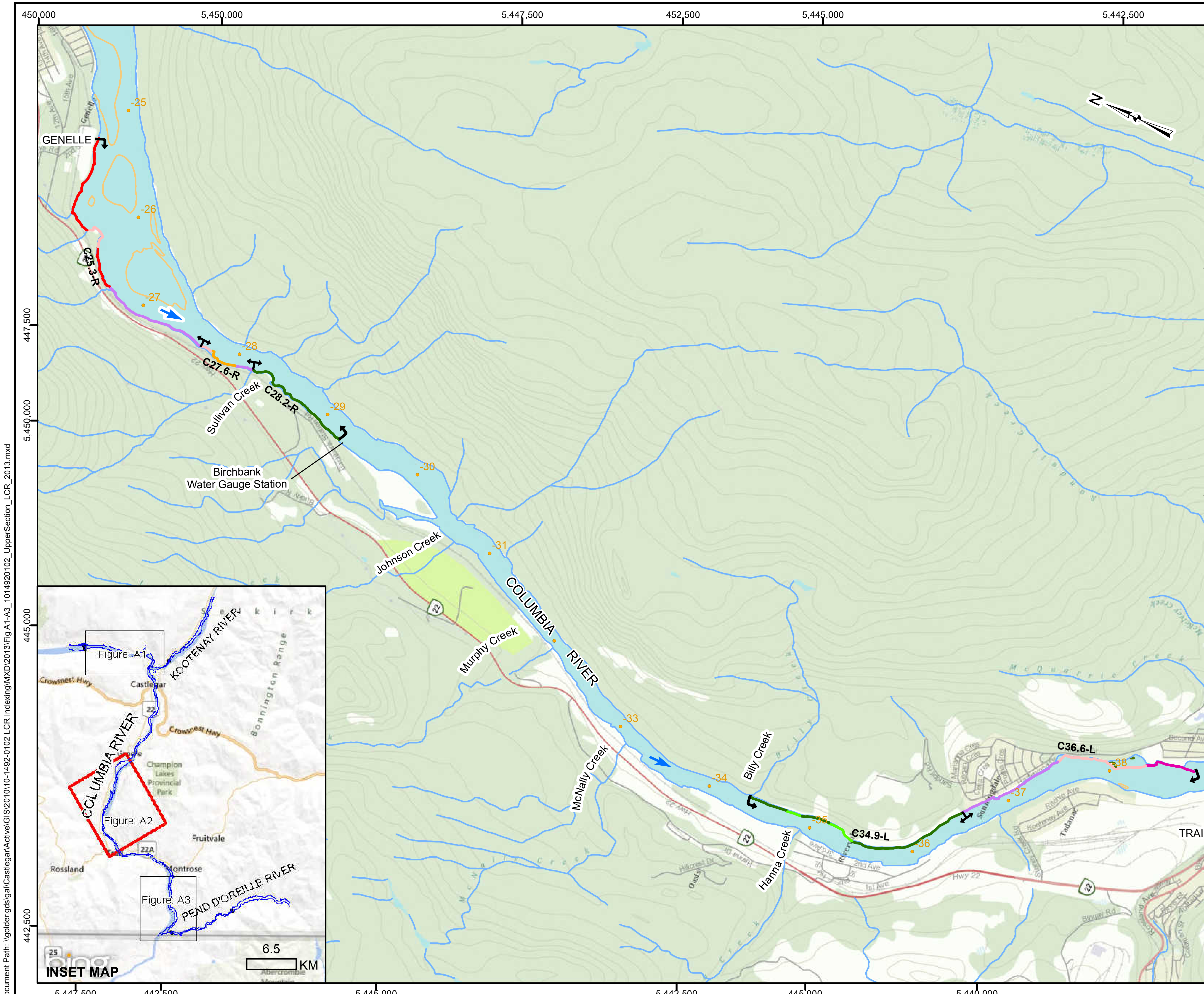


LEGEND

- 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: © 2013 NOKIA © AND © 2013 MICROSOFT CORPORATION
SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY

PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1 KM

SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

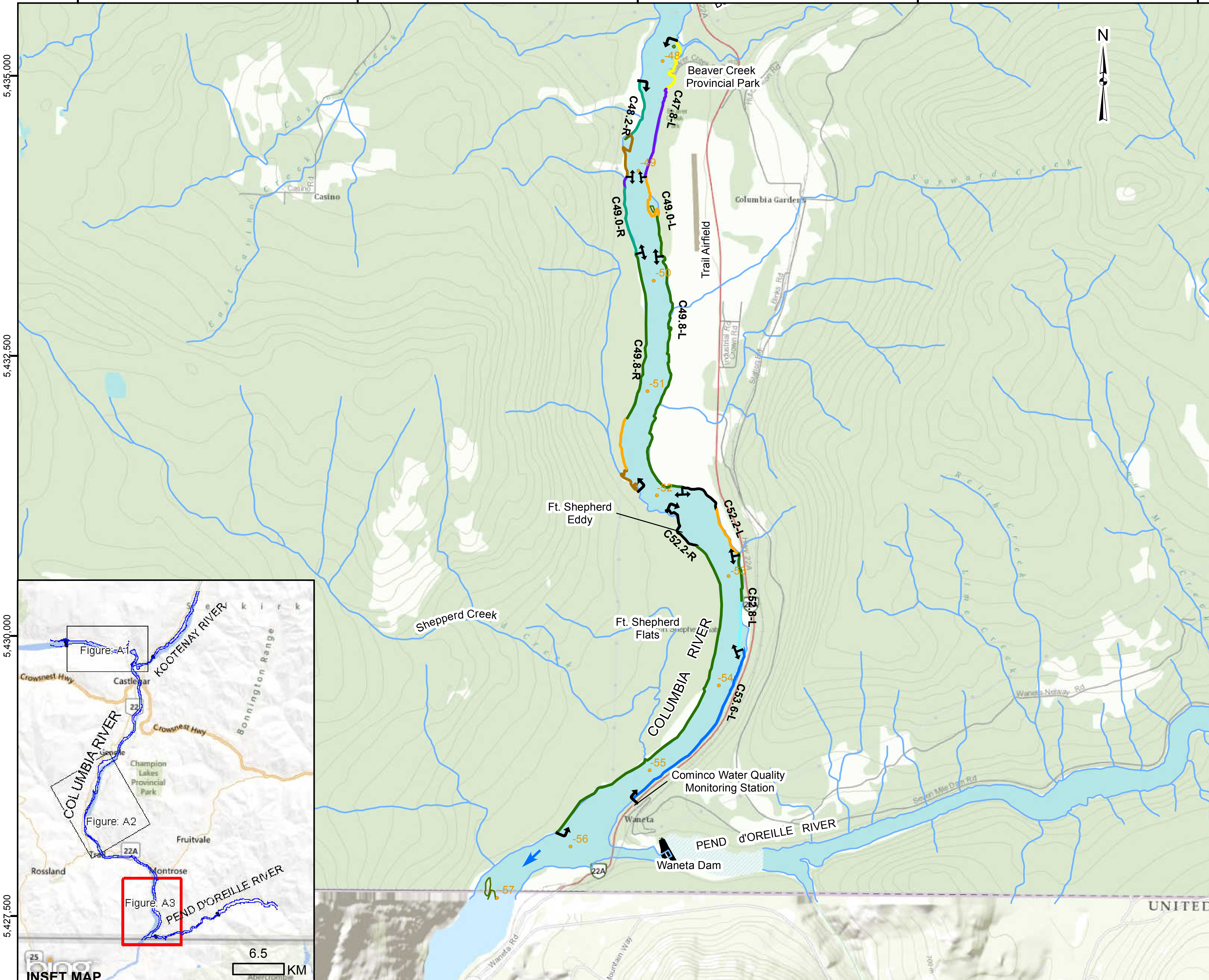
TITLE

MIDDLE SECTION OF STUDY AREA
2012 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	SS	13 Jun. 2012		
GIS	SS/JG	19 Jun. 2012		
CHECK	DF	24 Jun. 2013		
REVIEW	LH	24 Jun. 2013		

Figure: A2



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: © 2013 NOKIA © AND © 2013 MICROSOFT CORPORATION
SOURCES: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, AND THE GIS USER COMMUNITY

PROJECTION: UTM ZONE 11 DATUM: NAD 83

1 0 1 KM

SCALE 1:35,000

PROJECT

LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER

TITLE

LOWER SECTION OF STUDY AREA
2012 SAMPLE SITE LOCATIONS

Golder Associates

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

Figure: A3

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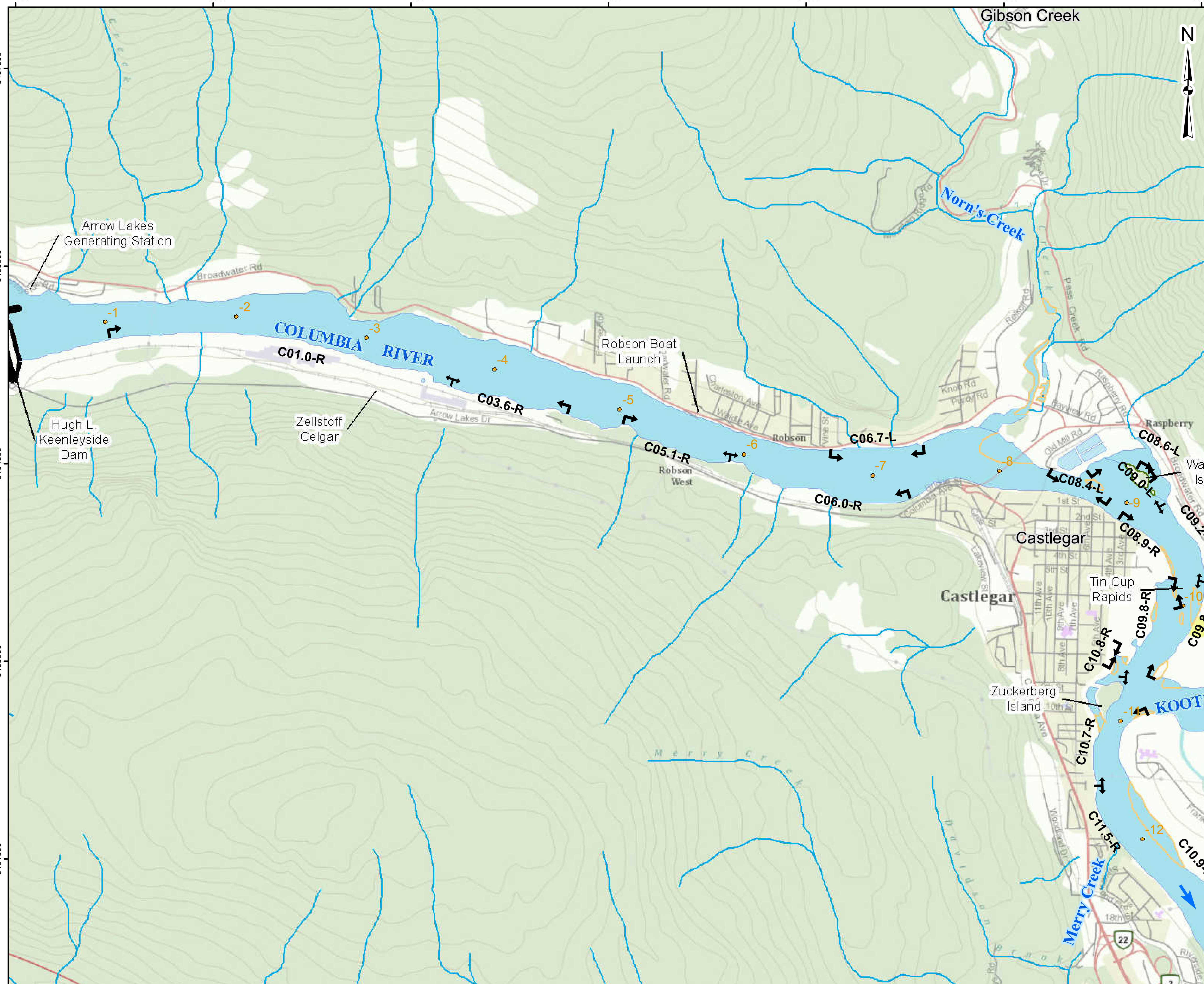

LEGEND

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

REFERENCE

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

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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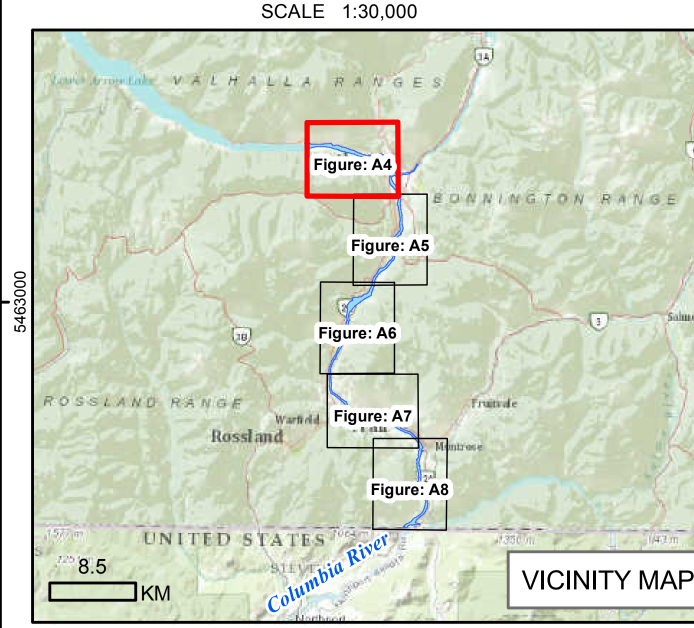

PROJECT

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

TITLE

2012 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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GIS	JG	13 Jun. 2011		
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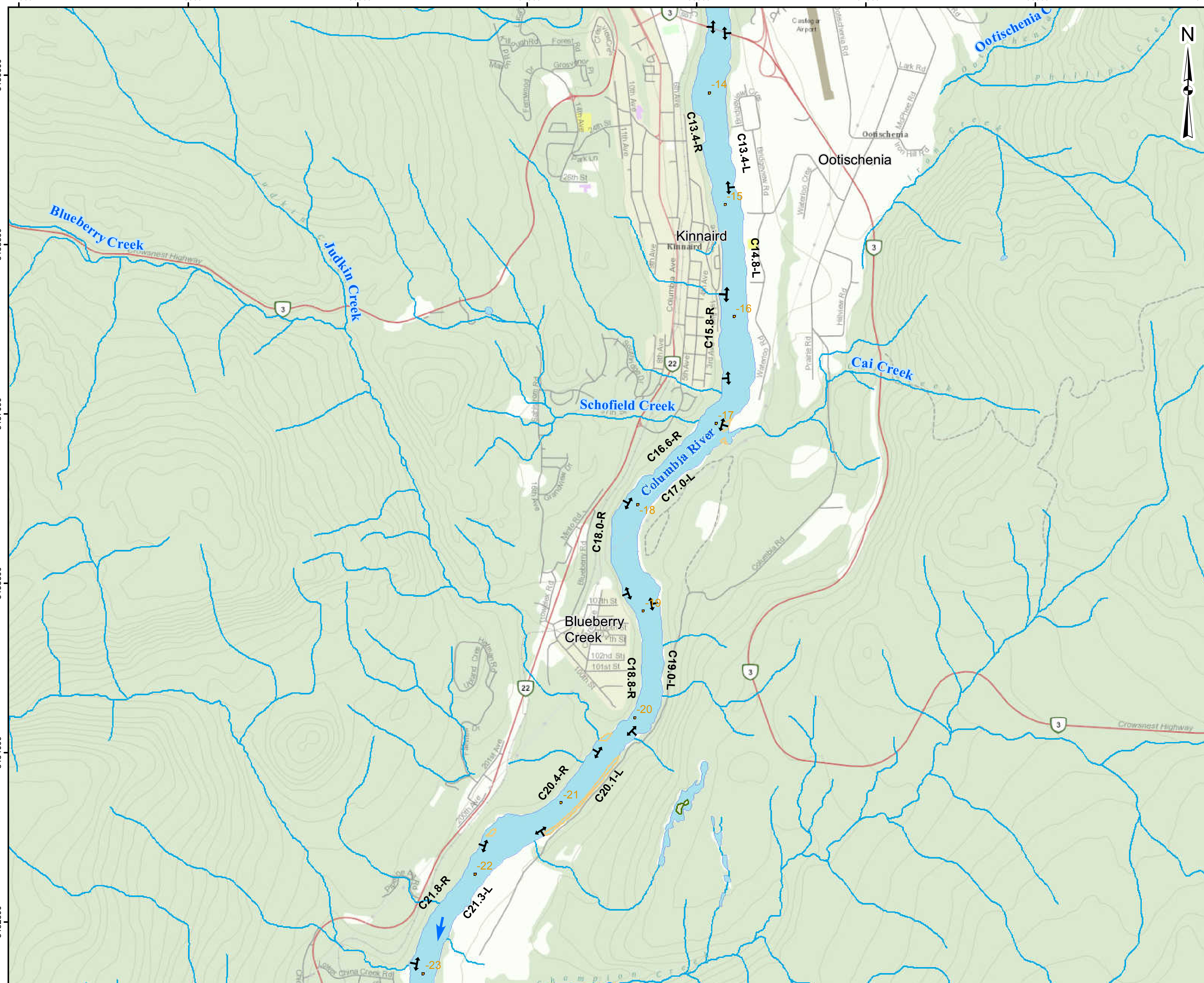
REVIEW	LH	24 Jun. 2013		

Figure: A4



LEGEND

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

REFERENCE

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

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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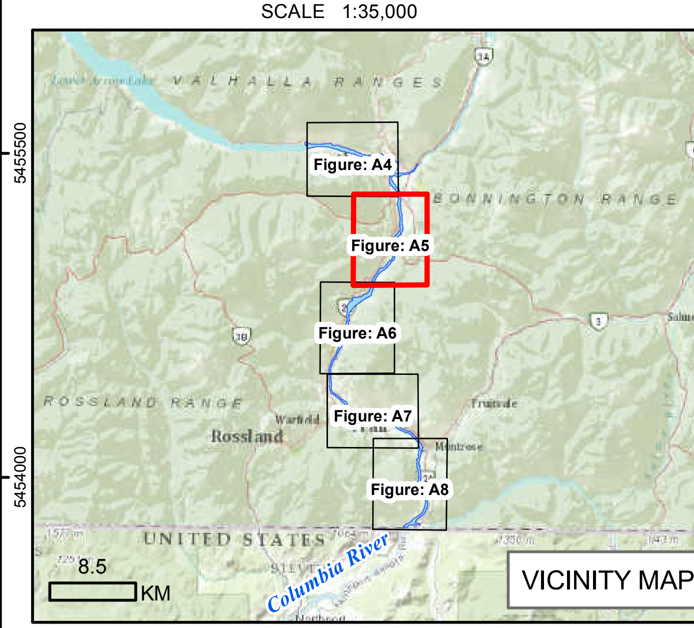

PROJECT

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

TITLE

2012 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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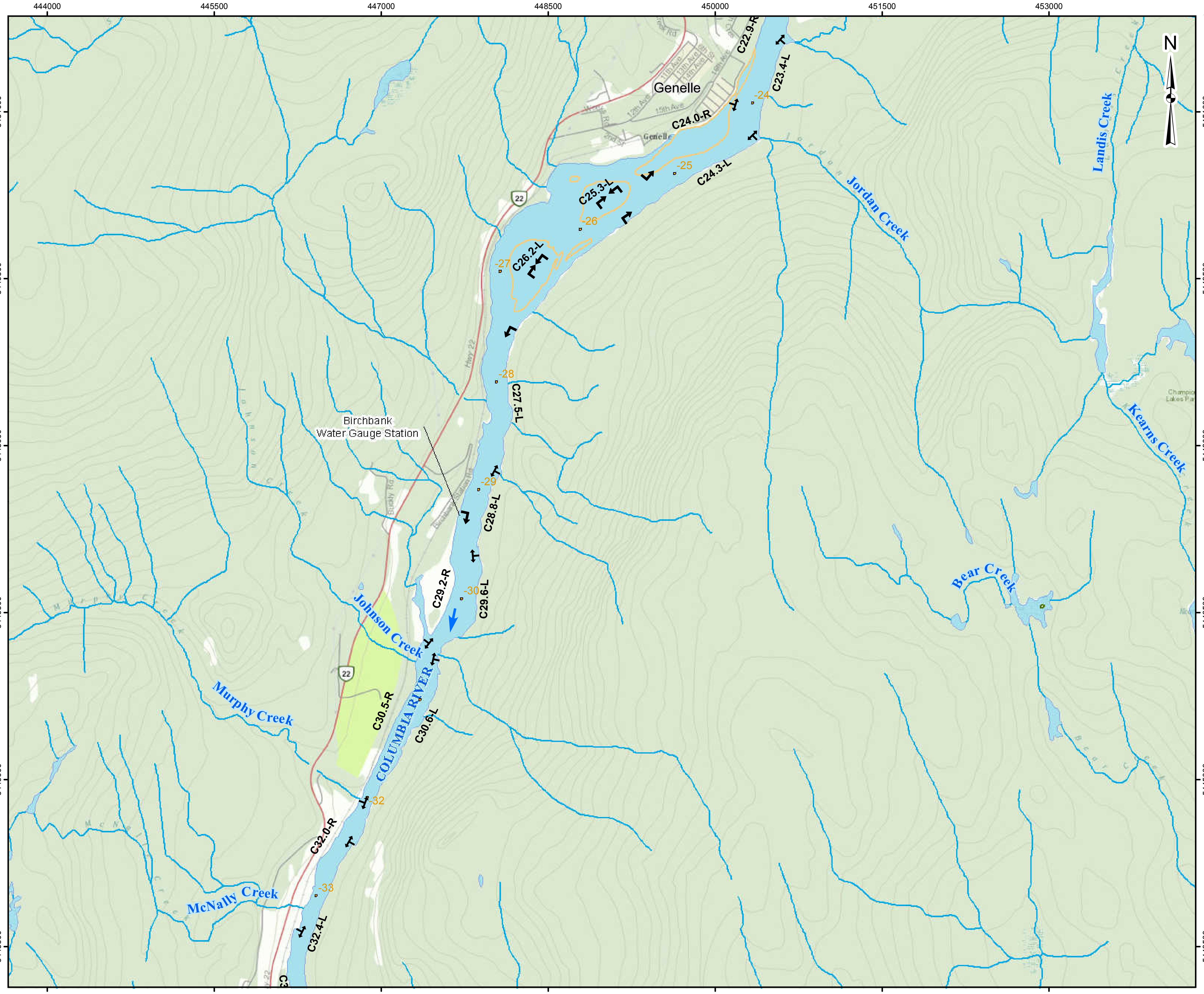
GIS	JG	13 Jun. 2011		
CHECK	DF	24 Jun. 2013		
REVIEW	LH	24 Jun. 2013		

Figure: A5

Document Path: \\golder.gds\gal\Castlegar\Active\GIS\2010\10-1492-0102 LCR Indexing\MXD\2013\Fig A4-A8_1014920102_LCR_2013_Potential sa sites.mxd



LEGEND

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

REFERENCE

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

PROJECTION: UTM ZONE 11 DATUM: NAD 83

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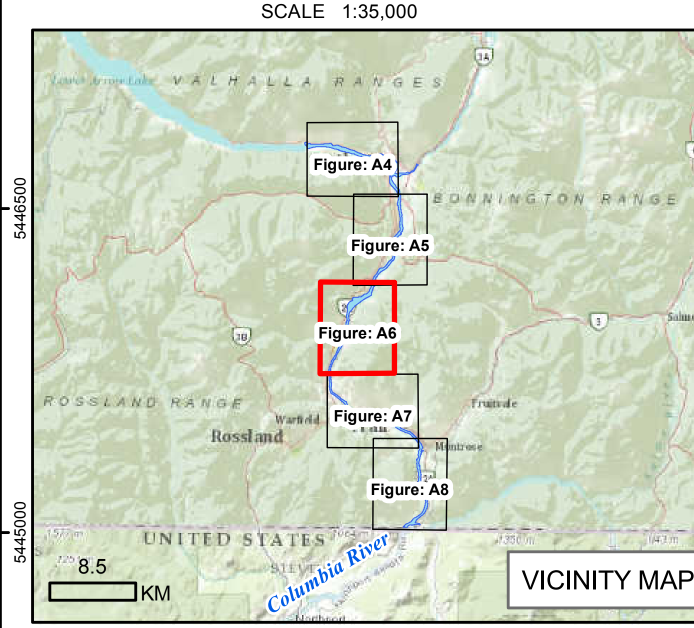
SCALE 1:35,000



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

TITLE
2012 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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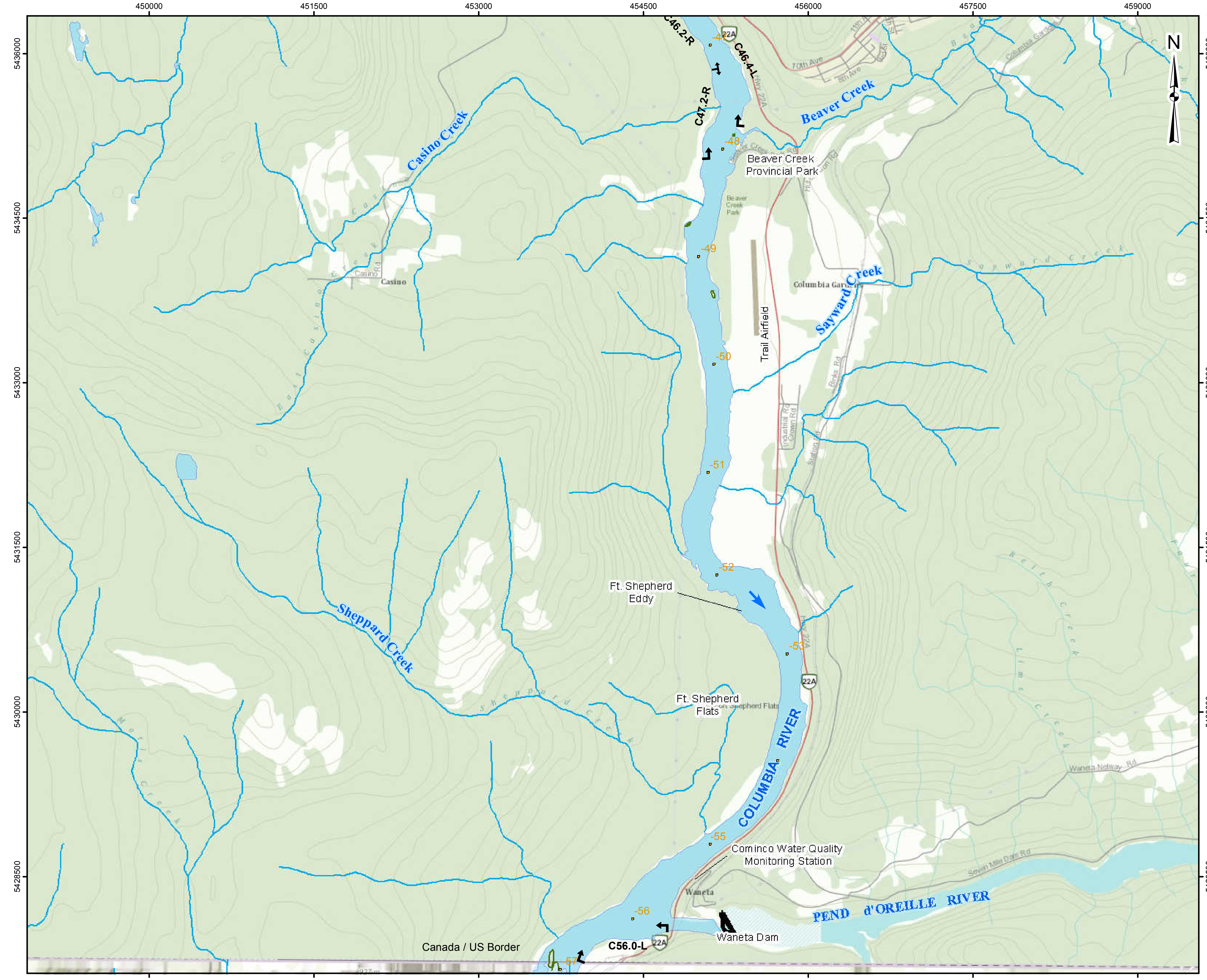
REVIEW	LH	24 Jun. 2013		

Figure: A6



LEGEND

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

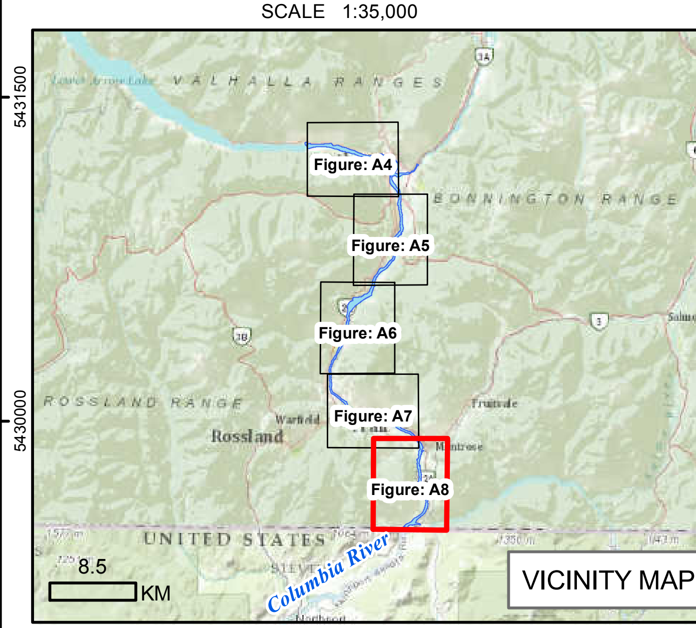
REFERENCE

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

PROJECTION: UTM ZONE 11 DATUM: NAD 83

750 0 750 Metres

SCALE 1:35,000



VICINITY MAP

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

TITLE
2012 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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

Figure: A8

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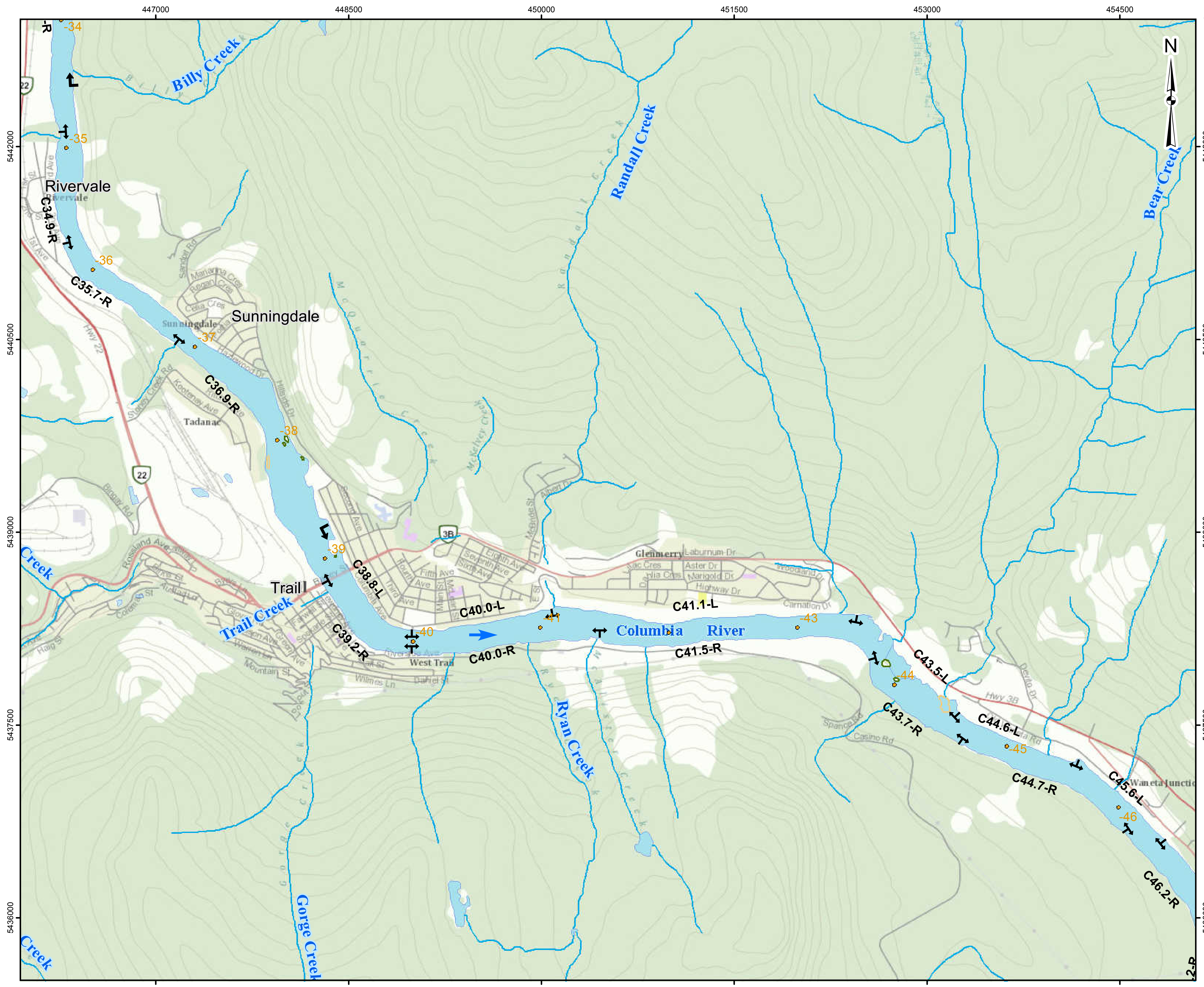


Document Path: \\golder.gds\gal\Castlegar\Active\GIS\2010\10-1492-0102 LCR Indexing\MXD\2013\Fig A4-A8_1014920102_LCR_2013_Potential sa sites.mxd

LEGEND

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

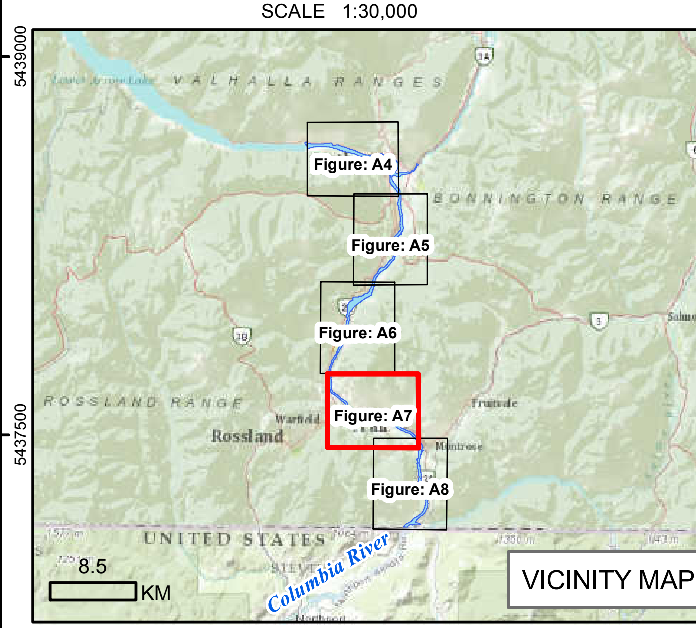
REFERENCE

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

PROJECTION: UTM ZONE 11 DATUM: NAD 83

750 0 750 Metres

SCALE 1:30,000



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

TITLE
2012 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

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

Figure: A7

APPENDIX B

Habitat Summary Information

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

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

Continued.

Table B1 Concluded.

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

Velocity Classifications:

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

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

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

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

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

Table B3 Summary of habitat variables recorded at boat electroshocking sites in the Lower Columbia River, 24 September to 26 October 2012.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Kootenay	K00.3-L	1	12.00	15.50	140	Clear	High	High	High	80	0	5	0	0	15	0
Kootenay	K00.3-L	2	1.00	13.40	150	Clear	High	High	High	20	0	0	0	0	0	80
Kootenay	K00.3-L	3	8.00	13.30	100	Overcast	High	Low	High	30	0	0	0	0	40	30
Kootenay	K00.3-L	4	5.00	11.70	140	Partly cloudy	Medium	Medium	High	40	0	0	0	0	30	30
Kootenay	K00.6-R	1	10.00	15.30	140	Partly cloudy	High	High	High	90	0	10	0	0	0	0
Kootenay	K00.6-R	2	9.00	13.70	150	Clear	High	High	High	0	0	0	10	0	90	0
Kootenay	K00.6-R	3	8.00	12.90	100	Overcast	High	High	High	30	0	0	0	0	40	30
Kootenay	K00.6-R	4	11.70	7.00	140	Partly cloudy	Medium	Low	High	30	0	0	0	0	40	30
Kootenay	K01.8-L	1	15.00	15.50	140	Clear	High	High	High	40	0	0	0	0	20	40
Kootenay	K01.8-L	2	9.00	13.70	150	Clear	High	High	High	15	0	0	0	0	75	10
Kootenay	K01.8-L	3	9.00	13.50	100	Overcast	High	High	High	10	0	10	0	0	70	10
Kootenay	K01.8-L	4	6.00	11.70	140	Partly cloudy	Medium	Low	High	30	0	0	0	0	50	20
Kootenay	K01.8-R	1	10.00	15.50	140	Partly cloudy	High	High	High	40	0	0	0	0	0	60
Kootenay	K01.8-R	2	11.00	13.70	150	Clear	High	High	High	20	0	0	0	0	70	10
Kootenay	K01.8-R	3	8.00	13.30	100	Overcast	High	High	High	30	0	0	0	0	50	20
Kootenay	K01.8-R	4	8.00	12.10	140	Partly cloudy	High	Medium	High	40	0	0	0	0	30	30
Lower	C47.8-L	1	12.00	14.70	110	Clear	High	High	High	75	0	5	10	0	10	0
Lower	C47.8-L	2	1.00	13.70	110	Clear	High	High	High	10	0	0	0	0	85	5
Lower	C47.8-L	3	7.00	12.90	110	Clear	High	High	High	15	0	5	5	0	70	5
Lower	C47.8-L	4	8.00	12.00	120	Clear	High	High	High	30	0	0	5	0	25	40
Lower	C48.2-R	1	16.00	14.50	110	Clear	High	High	High	20	0	0	5	0	75	0
Lower	C48.2-R	2	11.00	13.70	110	Clear	High	High	High	10	0	0	5	0	80	5
Lower	C48.2-R	3	12.00	12.90	110	Clear	High	High	High	20	0	0	0	0	70	10
Lower	C48.2-R	4	10.00	11.70	110	Partly cloudy	High	High	High	0	0	0	5	0	80	15
Lower	C49.0-L	1	10.00	14.50	110	Clear	High	High	High	40	0	5	5	0	50	0
Lower	C49.0-L	2	1.00	13.70	110	Clear	High	High	High	15	0	0	0	0	80	5
Lower	C49.0-L	3	8.00	12.90	110	Clear	High	High	High	25	0	0	0	0	70	5
Lower	C49.0-L	4	6.00	12.00	120	Clear	High	High	High	20	0	0	0	0	80	0
Lower	C49.0-R	1	13.00	14.50	110	Partly cloudy	High	High	High	90	0	0	0	0	10	0
Lower	C49.0-R	2	7.00	13.70	110	Clear	High	High	High	10	0	0	0	0	80	10
Lower	C49.0-R	3	9.00	12.90	110	Clear	High	High	High	20	0	0	0	0	70	10

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

continued…

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (μS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Lower	C49.0-R	4	9.00	11.70	110	Partly cloudy	High	High	High	10	0	0	0	0	60	30
Lower	C49.8-L	1	10.00	14.50	110	Clear	High	High	High	85	0	5	10	0	0	0
Lower	C49.8-L	2	1.00	13.70	110	Clear	High	High	High	15	0	5	0	0	80	0
Lower	C49.8-L	3	7.00	12.70	110	Clear	High	High	High	10	0	5	0	0	75	10
Lower	C49.8-L	4	6.00	12.00	120	Clear	High	High	High	10	0	10	0	0	40	40
Lower	C49.8-R	1	12.00	14.50	110	Clear	High	High	High	50	0	0	10	0	20	20
Lower	C49.8-R	2	2.00	13.50	120	Clear	High	High	High	10	0	0	0	0	80	10
Lower	C49.8-R	3	8.00	12.90	110	Clear	High	High	High	10	0	0	0	0	70	20
Lower	C49.8-R	4	8.00	11.70	110	Partly cloudy	High	High	High	15	0	0	0	0	60	25
Lower	C52.2-L	1	5.00	14.50	110	Clear	High	High	High	80	0	5	15	0	0	0
Lower	C52.2-L	2	0.00	13.70	110	Clear	High	High	High	10	0	10	0	0	70	10
Lower	C52.2-L	3	6.00	12.70	120	Clear	High	High	High	30	0	30	0	0	30	10
Lower	C52.2-L	4	4.00	12.00	120	Clear	High	High	High	10	0	0	5	0	20	65
Lower	C52.2-R	1	10.00	14.50	110	Clear	High	High	High	50	0	20	0	0	10	20
Lower	C52.2-R	2	2.00	13.50	120	Partly cloudy	High	High	High	10	0	15	0	0	70	5
Lower	C52.2-R	3	6.00	12.90	110	Clear	High	High	High	10	0	5	1	0	65	19
Lower	C52.2-R	4	7.00	11.70	120	Overcast	Medium	High	Medium	20	0	20	0	0	30	30
Lower	C52.8-L	1	5.00	14.50	110	Clear	High	High	High	0	0	0	0	0	0	0
Lower	C52.8-L	2	0.00	13.70	110	Clear	High	High	High	10	0	20	0	0	60	10
Lower	C52.8-L	3	5.00	12.70	120	Clear	High	High	High	30	0	0	0	0	30	40
Lower	C52.8-L	4	5.00	12.00	120	Clear	High	High	High	30	0	0	0	0	0	70
Lower	C53.6-L	1	5.00	14.50	110	Clear	High	High	High	95	0	5	0	0	0	0
Lower	C53.6-L	2	0.00	13.70	110	Clear	High	High	High	30	0	30	0	0	20	20
Lower	C53.6-L	3	4.00	12.70	120	Clear	High	High	High	30	0	0	0	0	30	40
Lower	C53.6-L	4	6.00	12.00	120	Clear	High	High	High	50	0	0	0	0	0	50
Middle	C25.3-R	1	15.00	14.70	110	Partly cloudy	High	High	Medium	40	1	19	5	0	10	25
Middle	C25.3-R	2	8.00	13.70	110	Partly cloudy	High	High	High	5	0	0	5	0	85	5
Middle	C25.3-R	3	10.00	12.90	110	Clear	High	High	High	20	0	10	0	0	40	30
Middle	C25.3-R	4	6.30	12.10	110	Clear	High	High	High	20	5	0	5	0	40	30
Middle	C27.6-R	1	13.00	14.50	110	Clear	High	Low	High	55	0	0	5	0	40	0
Middle	C27.6-R	2	8.00	13.70	110	Partly cloudy	High	High	High	25	0	0	0	0	75	0

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

continued…

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Middle	C27.6-R	3	9.00	12.90	110	Clear	High	High	High	30	0	20	0	0	50	0
Middle	C27.6-R	4	5.00	12.10	110	Clear	High	High	High	40	0	10	0	0	40	10
Middle	C28.2-R	1	12.00	14.10	110	Clear	High	Low	High	55	0	0	5	0	30	10
Middle	C28.2-R	2	8.00	13.70	110	Clear	High	High	High	0	0	0	0	0	100	0
Middle	C28.2-R	3	8.00	12.90	110	Clear	High	High	High	20	0	0	0	0	80	0
Middle	C28.2-R	4	4.00	12.10	110	Clear	High	High	High	20	0	0	0	0	60	20
Middle	C34.9-L	1	15.00	15.30	110	Clear	High	Medium	High	70	0	0	0	0	15	15
Middle	C34.9-L	2	12.00	14.50	120	Clear	High	High	High	50	0	30	0	0	20	0
Middle	C34.9-L	3	12.90	12.90	110	Clear	High	High	High	30	0	0	0	0	40	30
Middle	C34.9-L	4	4.00	12.10	110	Partly cloudy	High	High	High	40	0	0	0	0	30	30
Middle	C36.6-L	1	10.00	14.50	110	Clear	High	Medium	High	50	0	20	5	0	0	25
Middle	C36.6-L	2	8.00	14.50	120	Clear	Medium	High	High	30	0	10	0	0	0	60
Middle	C36.6-L	3	7.00	12.90	110	Clear	High	High	High	30	0	0	0	0	0	70
Middle	C36.6-L	4	3.00	12.10	120	Clear	High	High	High	0	0	30	0	0	30	40
Upper	C00.0-R	1	14.00	13.90	90	Partly cloudy	High	High	High	0	0	0	5	0	75	20
Upper	C00.0-R	2	7.10	13.30	110	Clear	High	Low	High	10	5	0	10	0	70	5
Upper	C00.0-R	3	10.00	12.30	100	Mostly cloudy	High	Low	High	20	0	0	2	0	68	10
Upper	C00.0-R	4	10.00	11.30	110	Partly cloudy	High	Low	High	0	2	0	0	0	40	58
Upper	C00.7-L	1	10.00	13.90	90	Mostly cloudy	Medium	Low	High	0	0	0	20	0	80	0
Upper	C00.7-L	2	4.00	13.30	110	Clear	High	Low	High	10	0	0	15	0	75	0
Upper	C00.7-L	3	10.00	12.10	100	Mostly cloudy	High	Low	High	20	0	0	5	0	70	5
Upper	C00.7-L	4	9.00	11.30	110	Partly cloudy	High	Low	High	0	0	0	10	0	70	20
Upper	C01.3-L	1	14.00	13.90	100	Partly cloudy	High	Low	High	0	0	0	15	0	85	0
Upper	C01.3-L	2	3.00	12.90	100	Clear	High	Low	High	10	5	0	40	0	40	5
Upper	C01.3-L	3	10.00	12.10	100	Overcast	High	Low	High	0	0	0	10	0	85	5
Upper	C01.3-L	4	8.00	11.30	110	Partly cloudy	High	Low	High	10	0	0	10	0	70	10
Upper	C02.8-L	1	13.00	13.90	100	Mostly cloudy	High	Low	High	0	0	0	70	0	30	0
Upper	C02.8-L	2	1.00	13.30	110	Clear	High	Low	High	0	0	0	70	0	30	0
Upper	C02.8-L	3	9.00	12.10	100	Overcast	High	Low	High	10	0	0	10	0	80	0
Upper	C02.8-L	4	2.00	10.90	110	Clear	High	Low	High	10	0	0	10	0	75	5
Upper	C03.6-L	1	10.00	14.00	100	Mostly cloudy	High	Low	High	0	0	0	65	0	35	0

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

continued…

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Upper	C03.6-L	2	0.00	13.10	110	Clear	High	Low	High	20	0	0	40	0	20	20
Upper	C03.6-L	3	9.00	12.10	100	Overcast	Medium	Low	High	10	0	0	40	0	50	0
Upper	C03.6-L	4	3.00	10.90	110	Clear	High	Low	High	10	0	0	0	0	80	10
Upper	C04.6-R	1	8.00	14.00	100	Clear	High	Low	High	0	0	0	100	0	0	0
Upper	C04.6-R	2	0.00	13.30	110	Clear	High	Low	High	0	0	0	100	0	0	0
Upper	C04.6-R	3	8.00	12.10	100	Overcast	High	Low	High	0	1	0	99	0	0	0
Upper	C04.6-R	4	3.00	10.90	110	Clear	High	Low	High	0	0	0	80	0	10	10
Upper	C05.6-L	1	8.00	14.10	100	Clear	High	Low	High	0	2	0	18	0	80	0
Upper	C05.6-L	2	0.00	12.60	110	Clear	High	Low	High	0	0	0	10	0	90	0
Upper	C05.6-L	3	10.00	12.30	100	Overcast	High	Low	High	20	0	0	40	0	40	0
Upper	C05.6-L	4	3.00	10.90	110	Clear	High	Low	High	10	5	0	0	0	10	75
Upper	C07.3-R	1	10.00	14.00	140	Partly cloudy	High	High	High	90	0	5	5	0	0	0
Upper	C07.3-R	2	1.00	12.90	110	Clear	High	High	High	30	0	0	0	0	70	0
Upper	C07.3-R	3	9.00	12.30	100	Overcast	High	High	High	40	0	10	0	0	30	20
Upper	C07.3-R	4	4.00	10.90	110	Partly cloudy	Medium	High	High	40	0	0	0	0	40	20
Upper	C07.4-L	1	10.00	14.10	100	Partly cloudy	High	High	High	60	0	5	20	0	15	0
Upper	C07.4-L	2	1.00	12.60	110	Clear	High	High	High	0	0	0	20	0	80	0
Upper	C07.4-L	3	10.00	12.30	100	Overcast	High	Low	High	10	0	10	30	0	40	10
Upper	C07.4-L	4	3.00	10.90	100	Partly cloudy	Medium	High	High	40	0	0	10	0	30	20
Lower	C16.6-R	GRTS	4.00	10.90	110	Overcast	High	High	High	0	0	0	0	0	80	20
Lower	C41.1-L	GRTS	5.00	10.90	110	Mostly cloudy	High	High	High	0	0	0	0	0	90	10
Lower	C44.6-L	GRTS	4.00	10.90	110	Mostly cloudy	High	High	High	0	0	0	0	0	90	10
Lower	C46.4-L	GRTS	4.00	10.90	110	Mostly cloudy	High	High	High	10	0	0	0	0	20	70
Lower	C47.2-R	GRTS	3.00	10.90	110	Overcast	High	High	High	10	0	0	0	0	70	20
Lower	C56.0-L	GRTS	6.00	12.10	120	Overcast	Medium	High	Medium	20	0	0	0	0	0	80
Middle	C21.8-R	GRTS	7.00	10.90	110	Overcast	High	Low	High	40	0	10	0	0	40	10
Middle	C23.4-L	GRTS	6.00	10.90	110	Overcast	High	Medium	High	60	0	0	0	0	30	10
Middle	C28.8-L	GRTS	4.00	10.90	110	Overcast	High	Medium	High	50	0	0	0	0	30	20
Middle	C32.0-R	GRTS	4.00	10.90	110	Overcast	High	Medium	High	50	0	0	0	0	10	40
Middle	C34.9-R	GRTS	3.00	10.90	110	Overcast	High	Medium	High	40	0	0	0	0	30	30
Middle	C36.9-R	GRTS	6.00	10.90	120	Overcast	High	High	High	10	0	30	0	0	30	30

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

continued…

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

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

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

Table B3 Concluded.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (μS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Middle	C39.2-R	GRTS	6.00	10.90	110	Overcast	High	High	High	40	0	10	0	0	20	30
Upper	C06.7-L	GRTS	6.00	10.50	100	Overcast	High	Low	High	0	0	0	60	0	40	0
Upper	C09.2-L	GRTS	3.00	10.50	100	Overcast	High	High	High	50	0	0	0	0	40	10
Upper	C10.7-R	GRTS	4.00	10.90	100	Overcast	Medium	High	High	60	0	20	0	0	20	0
Upper	C10.9-L	GRTS	3.00	10.90	100	Overcast	Medium	High	High	30	0	20	0	0	30	20
Upper	C13.4-R	GRTS	7.00	10.90	110	Overcast	High	High	High	10	0	10	0	0	30	50
Upper	C14.8-L	GRTS	6.00	10.90	110	Overcast	Medium	High	High	10	0	0	0	0	60	30
Upper	C18.0-R	GRTS	1.00	10.90	110	Overcast	Medium	High	High	30	0	0	0	0	40	30

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

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

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

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

Table B4 Summary of species counts (both captured and observed) by bank habitat types in the Lower Columbia River, 24 September to 25 October 2012.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
Upstream Columbia River	C00.0-R	Bull Trout		2											1		**3**
		Kokanee													21		**21**
		Mountain Whitefish		105											126		**231**
		Northern Pikeminnow		26											69		**95**
		Peamouth		45											29		**74**
		Rainbow Trout		17											39		**56**
		Redside Shiner		2415											178		**2593**
		Sculpin spp.		120											881		**1001**
		Sucker spp.		111											10		**121**
		Walleye		19											10		**29**
		White Sturgeon													1		**1**
	C00.0-R Total		**0**	**2860**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1365**	**0**	**4225**
	C00.7-L	Bull Trout		1													**1**
		Kokanee									2						**2**
		Mountain Whitefish		19							85						**104**
		Northern Pikeminnow		12							30						**42**
		Peamouth		70							85						**155**
		Rainbow Trout		19							35						**54**
		Redside Shiner		31							374						**405**
		Sculpin spp.		250							727						**977**
		Sucker spp.		26							36						**62**
		Walleye		1							7						**8**
	C00.7-L Total		**0**	**429**	**0**	**0**	**0**	**0**	**0**	**0**	**1381**	**0**	**0**	**0**	**0**	**0**	**1810**
	C01.3-L	Burbot									1						**1**
		Kokanee	1								21						**22**
		Mountain Whitefish	76								228						**304**
		Northern Pike	5														**5**
		Northern Pikeminnow	9								111						**120**
		Peamouth	26								139						**165**
		Rainbow Trout	20								133						**153**
		Redside Shiner	205								153						**358**
		Sculpin spp.	53								355						**408**
		Sucker spp.	32								324						**356**
		Walleye	4								46						**50**
	C01.3-L Total		**431**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1511**	**0**	**0**	**0**	**0**	**0**	**1942**
	C02.8-L	Mountain Whitefish									322						**322**
		Northern Pikeminnow									14						**14**
		Peamouth									8						**8**
		Rainbow Trout									44						**44**
		Redside Shiner									100						**100**
		Sculpin spp.									105						**105**
		Sucker spp.									218						**218**
		Walleye									11						**11**
	C02.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**822**	**0**	**0**	**0**	**0**	**0**	**822**
	C03.6-L	Bull Trout	1														**1**
		Burbot	1														**1**
		Kokanee	4								2						**6**
		Lake Whitefish	1														**1**
		Mountain Whitefish	141			5					253						**399**
		Northern Pikeminnow	23			8					24						**55**
		Peamouth	20			5					28						**53**
		Rainbow Trout	77			3					71						**151**
		Redside Shiner	44			10					52						**106**
		Sculpin spp.	228			120					120						**468**
		Sucker spp.	183			92					113						**388**
		Walleye	34								19						**53**
	C03.6-L Total		**757**	**0**	**0**	**243**	**0**	**0**	**0**	**0**	**682**	**0**	**0**	**0**	**0**	**0**	**1682**
	C04.6-R	Mountain Whitefish									3						**3**
		Northern Pike									4						**4**
		Northern Pikeminnow									5						**5**
		Rainbow Trout									28						**28**
		Redside Shiner									30						**30**
		Sculpin spp.									12						**12**
		Sucker spp.									69						**69**
		Walleye									8						**8**
	C04.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**159**	**0**	**0**	**0**	**0**	**0**	**159**
	C05.6-L	Kokanee	6								1						**7**
		Mountain Whitefish	18								14						**32**
		Northern Pikeminnow	22								6						**28**
		Peamouth	1								1						**2**
		Rainbow Trout	37								34						**71**
		Redside Shiner	21								166						**187**
		Sculpin spp.	210								132						**342**
		Sucker spp.	118								113						**231**
		Walleye	15								5						**20**
	C05.6-L Total		**448**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**472**	**0**	**0**	**0**	**0**	**0**	**920**
	C07.3-R	Bull Trout				1											**1**
		Kokanee				8											**8**
		Lake Whitefish				2											**2**
		Mountain Whitefish				138											**138**
		Northern Pikeminnow				8											**8**
		Peamouth				7											**7**
		Rainbow Trout				180											**180**
		Redside Shiner				2											**2**
		Sculpin spp.				126											**126**
		Sucker spp.				73											**73**
		Walleye				17											**17**
		White Sturgeon				1											**1**
	C07.3-R Total		**0**	**0**	**0**	**563**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**563**
	C07.4-L	Kokanee												8			**8**
		Mountain Whitefish												303			**303**
		Northern Pike												2			**2**
		Northern Pikeminnow												50			**50**
		Peamouth												9			**9**
		Rainbow Trout												144			**144**
		Redside Shiner												70			**70**
		Sculpin spp.												190			**190**
		Sucker spp.												254			**254**
		Walleye												15			**15**
		White Sturgeon												1			**1**
	C07.4-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1046**	**0**	**0**	**1046**
Upstream Columbia River Total			**1636**	**3289**	**0**	**806**	**0**	**0**	**0**	**0**	**5027**	**0**	**0**	**1046**	**1365**	**0**	**13169**

continued…

Table B4 Continued.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
Kootenay River	K00.3-L	Kokanee								1							**1**
		Mountain Whitefish								5							**5**
		Northern Pikeminnow								1					5		**6**
		Rainbow Trout								11					8		**19**
		Redside Shiner								2							**2**
		Sculpin spp.								34					20		**54**
		Sucker spp.								37					12		**49**
		Walleye								17					6		**23**
	K00.3-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**108**	**0**	**0**	**0**	**0**	**51**	**0**	**159**
	K00.6-R	Kokanee												3			**3**
		Lake Whitefish												1		1	**2**
		Mountain Whitefish												111		21	**132**
		Northern Pikeminnow												18		17	**35**
		Rainbow Trout												40		14	**54**
		Redside Shiner												25		25	**50**
		Sculpin spp.												150		101	**251**
		Sucker spp.												119		107	**226**
		Walleye												20		21	**41**
	K00.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**487**	**0**	**307**	**794**
	K01.8-L	Burbot		1													**1**
		Kokanee										12					**12**
		Lake Whitefish		1			1										**2**
		Mountain Whitefish		134			79					154					**367**
		Northern Pikeminnow		40			14					70					**124**
		Peamouth		6			2					4					**12**
		Rainbow Trout		105			52					129					**286**
		Redside Shiner		4			282					40					**326**
		Sculpin spp.		307			20					920					**1247**
		Sucker spp.		48			19					223					**290**
		Walleye		35			4					70					**109**
		White Sturgeon										2					**2**
	K01.8-L Total		**0**	**681**	**0**	**0**	**473**	**0**	**0**	**0**	**0**	**1624**	**0**	**0**	**0**	**0**	**2778**
	K01.8-R	Kokanee					7			22							**29**
		Mountain Whitefish					34			236							**270**
		Northern Pikeminnow					3			37							**40**
		Rainbow Trout					40			149							**189**
		Redside Shiner					90			6							**96**
		Sculpin spp.					50			370							**420**
		Sucker spp.					9			191							**200**
		Walleye					1			37							**38**
	K01.8-R Total		**0**	**0**	**0**	**0**	**234**	**0**	**0**	**1048**	**0**	**0**	**0**	**0**	**0**	**0**	**1282**
Kootenay River Total			**0**	**681**	**0**	**0**	**707**	**0**	**0**	**1156**	**0**	**1624**	**0**	**487**	**51**	**307**	**5013**
Downstream Columbia River	C25.3-R	Bull Trout	1							2							**3**
		Kokanee	15							1							**16**
		Lake Whitefish								7							**7**
		Mountain Whitefish	102				16			307							**425**
		Northern Pikeminnow					4			8							**12**
		Peamouth	1														**1**
		Rainbow Trout	191				20			281							**492**
		Redside Shiner	697							35							**732**
		Sculpin spp.	452				25			245							**722**
		Sucker spp.	10				4			19							**33**
		Walleye	33				4			22							**59**
	C25.3-R Total		**1502**	**0**	**0**	**0**	**73**	**0**	**0**	**927**	**0**	**0**	**0**	**0**	**0**	**0**	**2502**
	C27.6-R	Mountain Whitefish								22		78					**100**
		Rainbow Trout					6			81		61					**148**
		Sculpin spp.					25			10		24					**59**
		Sucker spp.								1		1					**2**
		Walleye					4			10		8					**22**
	C27.6-R Total		**0**	**0**	**0**	**0**	**35**	**0**	**0**	**124**	**0**	**172**	**0**	**0**	**0**	**0**	**331**
	C28.2-R	Kokanee		1													**1**
		Mountain Whitefish		195													**195**
		Northern Pikeminnow		11													**11**
		Rainbow Trout		299													**299**
		Redside Shiner		82													**82**
		Sculpin spp.		395													**395**
		Sucker spp.		71													**71**
		Walleye		26													**26**
		White Sturgeon		1													**1**
	C28.2-R Total		**0**	**1081**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1081**
	C34.9-L	Brook Trout		1													**1**
		Brown Trout		1													**1**
		Bull Trout		1													**1**
		Kokanee		3	1												**4**
		Lake Whitefish		1	1												**2**
		Mountain Whitefish		116	21												**137**
		Northern Pikeminnow		2	2												**4**
		Peamouth		1													**1**
		Rainbow Trout		432	99												**531**
		Redside Shiner		53													**53**
		Sculpin spp.		194	8												**202**
		Sucker spp.		8	5												**13**
		Walleye		25	10												**35**
		White Sturgeon			1												**1**
	C34.9-L Total		**0**	**838**	**148**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**986**
	C36.6-L	Burbot								2							**2**
		Kokanee					1			2							**3**
		Lake Whitefish								1							**1**
		Mountain Whitefish					49			68			44				**161**
		Northern Pikeminnow					2			8							**10**
		Peamouth								1							**1**
		Rainbow Trout					183			258			20				**461**
		Redside Shiner					2			25							**27**
		Sculpin spp.					131			306							**437**
		Sucker spp.					1			4			3				**8**
		Walleye					6			6							**12**
	C36.6-L Total		**0**	**0**	**0**	**0**	**375**	**0**	**0**	**681**	**0**	**0**	**67**	**0**	**0**	**0**	**1123**

continued…

Table B4 Continued.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
	C47.8-L	Brook Trout							1		7						**8**
		Burbot							3								**3**
		Cutthroat Trout							1								**1**
		Kokanee							1		6						**7**
		Lake Whitefish							2		7						**9**
		Longnose Dace							1								**1**
		Mountain Whitefish							15		39						**54**
		Northern Pikeminnow							2		2						**4**
		Rainbow Trout							98		127						**225**
		Redside Shiner							5		2						**7**
		Sculpin spp.							2110		61						**2171**
		Sucker spp.							18		16						**34**
		Walleye							7		30						**37**
	C47.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**2264**	**0**	**297**	**0**	**0**	**0**	**0**	**0**	**2561**
	C48.2-R	Burbot												1			**1**
		Mountain Whitefish												24	4		**28**
		Northern Pikeminnow												1			**1**
		Rainbow Trout												86	45		**131**
		Redside Shiner												3			**3**
		Sculpin spp.												105	38		**143**
		Sucker spp.												5	1		**6**
		Walleye												9	4		**13**
	C48.2-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**234**	**92**	**0**	**326**
	C49.0-L	Brook Trout		1								1					**2**
		Kokanee		1													**1**
		Lake Whitefish		4													**4**
		Mountain Whitefish		138								1					**139**
		Rainbow Trout		80								8					**88**
		Sculpin spp.		255								101					**356**
		Sucker spp.		42								2					**44**
		Walleye		11								2					**13**
	C49.0-L Total		**0**	**532**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**115**	**0**	**0**	**0**	**0**	**647**
	C49.0-R	Burbot												1			**1**
		Cutthroat Trout												1			**1**
		Kokanee												1			**1**
		Mountain Whitefish							8					32			**40**
		Rainbow Trout							40					77			**117**
		Redside Shiner												3			**3**
		Sculpin spp.							57					266			**323**
		Sucker spp.							3					2			**5**
		Walleye							3					5			**8**
	C49.0-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**111**	**0**	**0**	**0**	**0**	**388**	**0**	**0**	**499**
	C49.8-L	Burbot		7													**7**
		Cutthroat Trout		1													**1**
		Kokanee		3													**3**
		Lake Whitefish		10													**10**
		Mountain Whitefish		203													**203**
		Rainbow Trout		330													**330**
		Redside Shiner		15													**15**
		Sculpin spp.		4530													**4530**
		Sucker spp.		80													**80**
		Walleye		38													**38**
		White Sturgeon		1													**1**
	C49.8-L Total		**0**	**5218**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5218**
	C49.8-R	Burbot		3								1			1		**5**
		Kokanee													1		**1**
		Lake Whitefish		2													**2**
		Mountain Whitefish		151								49			2		**202**
		Northern Pikeminnow		10								5					**15**
		Rainbow Trout		192								116			53		**361**
		Redside Shiner		1											32		**33**
		Sculpin spp.		180								175			28		**383**
		Sucker spp.		127								53			49		**229**
		Walleye		21								7			15		**43**
	C49.8-R Total		**0**	**687**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**406**	**0**	**0**	**181**	**0**	**1274**
	C52.2-L	Brook Trout														2	**2**
		Brown Trout														1	**1**
		Bull Trout														2	**2**
		Burbot										1				3	**4**
		Lake Whitefish										5					**5**
		Mountain Whitefish										39				16	**55**
		Rainbow Trout										41				96	**137**
		Sculpin spp.														85	**85**
		Sucker spp.										5				77	**82**
		Walleye										4				13	**17**
	C52.2-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**95**	**0**	**0**	**0**	**295**	**390**
	C52.2-R	Brook Trout		1												1	**2**
		Burbot		12													**12**
		Cutthroat Trout		1													**1**
		Lake Whitefish		9												3	**12**
		Mountain Whitefish		206												13	**219**
		Northern Pikeminnow		1													**1**
		Rainbow Trout		287												124	**411**
		Sculpin spp.		210												116	**326**
		Sucker spp.		26												8	**34**
		Walleye		46												20	**66**
		White Sturgeon		1													**1**
	C52.2-R Total		**0**	**800**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**285**	**1085**

continued…

Table B4 Concluded.

Section	Site Name	Species	A1	A2	A3	A4	A5	A6	A1+A2	A2+A3	D1	D2	D3	D1+D2	BW	Eddy	Total
	C52.8-L	Bull Trout				1											**1**
		Lake Whitefish		1													**1**
		Mountain Whitefish		8		47											**55**
		Rainbow Trout		33		84											**117**
		Sucker spp.		7		8											**15**
		Walleye		11		32											**43**
	C52.8-L Total		**0**	**60**	**0**	**172**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**232**
	C53.6-L	Burbot						1									**1**
		Lake Whitefish						1									**1**
		Mountain Whitefish						32									**32**
		Northern Pikeminnow						1									**1**
		Rainbow Trout						111									**111**
		Sculpin spp.						297									**297**
		Sucker spp.						1									**1**
		Walleye						31									**31**
	C53.6-L Total		**0**	**0**	**0**	**0**	**0**	**475**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**475**
Downstream Columbia River Total			**1502**	**9216**	**148**	**172**	**483**	**475**	**2375**	**1732**	**297**	**788**	**67**	**622**	**273**	**580**	**18730**
All Sections Total			**3138**	**13186**	**148**	**978**	**1190**	**475**	**2375**	**2888**	**5324**	**2412**	**67**	**2155**	**1689**	**887**	**36912**

APPENDIX C

HBM Methods

Hierarchical Bayesian Analysis

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10 May 2013

Contents

1 General Approach

Hierarchical Bayesian models were fitted to the fish indexing data for the Lower Columbia River using the software packages R 2.15.3[8] and JAGS 3.3.0[7] which interfaced with each other via jaggernaut 0.1.6[9]. For additional information on hierarchical Bayesian modelling in the BUGS language, of which JAGS uses a dialect, the reader is referred to Kery and Schuab (2011)[5, p.41-44].

Unless specified, the models assumed vague (low information) prior distributions [5, p.36]. The posterior distributions were estimated from a minimum of 1,000 Markov Chain Monte Carlo (MCMC) samples thinned from the second halves of three chains[5, p.38-40]. Model convergence was confirmed by ensuring that Rhat[5, p.40] was less than 1.1 for each of the parameters in the model[5, p.61]. Posterior distributions were summarised in terms of a point *estimate* (median), *lower* and *upper* 95% credibility limits (2.5th and 97.5th percentiles), percent relative *error* (half the 95% credibility interval as a percent of the point estimate) and *significance* (Bayesian equivalent of two-sided frequentist p-value)[5, p.37,42].

The results were displayed graphically by plotting the modeled relationship between the particular variable(s) and the response (with 95% credibility intervals) while the remaining variables were held constant. Unless stated otherwise, continuous and discrete fixed variables were held constant at their mean and first level values respectively while random variables were held constant at their typical values (expected values of the underlying hyperdistributions) [5, p.77-82]. Where informative the influence of particular variables was expressed in terms of the effect size (i.e., percent change in the response variable) with 95% credibility intervals[1]. Plots were produced using the ggplot2 R package [11].

2 JAGS Distributions, Functions and Operators

JAGS distributions, functions and operators are defined in the following three tables. For additional information on the JAGS dialect of the BUGS language see the JAGS User Manual[7].

JAGS Distribution	Description
dbern(p)	Bernoulli distribution
dbin(p, n)	Binomial distribution
dcat(pi)	Categorical distribution
ddirch(alpha)	Dirichlet distribution
dgamma(shape, rate)	Gamma distribution
dlnorm(mu, sd^-2)	Log-normal distribution
dnorm(mu, sd^-2)	Normal distribution
dpois(lambda)	Poisson distribution
dunif(a, b)	Uniform distribution

JAGS Function	Description
log(x)	Log of x
logit(x)	Log odds of x
max(x,y)	Maximum of x and y
min(x,y)	Minimum of x and y
round(x)	Round to integer away from zero
sum(a)	Sum of elements of a
T(x,y)	Truncate distribution so that values lie between x and y

JAGS Operator	Description
<-	Deterministic relationship
~	Stochastic relationship
1:n	Vector of integers from 1 to n
a[1:n]	Subset of first n values in a
for (i in 1:n) {...}	Repeat ... for 1 to n times incrementing i each time
x^y	Power where x is raised to the power of y

3 JAGS Models

The following sections provide the key assumptions, variable and parameter definitions and JAGS model code for the analyses. By convention variables are named using CamelCase and the number of levels of a discrete variable (factor) `ObservedFactor` is referenced by `nObservedFactor`. The following variables occur in multiple models.

Variable	Description
ProportionSampled[i]	Proportion of site surveyed on ith survey(s)
Site[i]	Site of ith survey(s)
SiteLength[i]	Length of site on ith survey(s)
Year[i]	Year of ith survey(s)

3.1 Length-at-Age

Length-at-age was estimated from the yearly fall length-frequency distributions using a finite mixture distribution model [6].

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

- Length-at-age varies randomly with year.
- Length-at-age is normally-distributed.

3.1.1 Length-at-Age Model - Variables and Parameters

Variable/Parameter	Description
Age[i]	Age of ith fish
bAgeYear[ag,yr]	Effect of yrth year on length of an agth age fish
bDayte[ag]	Effect of day of year on length of an agth age fish
bDayte2[ag]	Effect of 2-order polynomial of day of year on length of an ath age fish
bIncrement[ag]	Length difference between an agth age fish and an ag-1th age fish
bIntercept[ag]	Length of an agth age fish
Dayte[i]	Day of year ith fish was observed
eLength[i]	Expected length of ith fish
Length[i]	Length of ith fish
pAge[ag]	Proportion of fish belonging to agth age
sAgeYear[ag]	SD of effect of year on length of fish belong to agth age
sLengthAge[ag]	SD of residual variation in length of fish belong to agth age
Year[i]	Year ith fish was observed

3.1.2 Length-at-Age Model - JAGS Code

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

    sLengthAge[ag] ~ dunif(0, 100)
    sAgeYear[ag] ~ dunif(0, 50)

    bIncrement[ag] ~ dunif(50, 250)
```

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

    for(yr in 1:nYear) {
      bAgeYear[ag,yr] ~ dnorm(0, sAgeYear[ag]^-2)
    }
  }

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

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

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

3.2 Growth

Annual growth was estimated from the inter-annual recaptures using the Fabens method[2] for estimating the von Bertalanffy growth curve[10].

Key assumptions of the growth model include:

- Mean maximum length (L_∞) varies randomly with year.
- Observed growth (change in length) is normally distributed.

3.2.1 Growth Model - Variables and Parameters

Variable/Parameter	Description
bYear[yr]	Effect of yrth year on mean maximum length
eGrowth[i]	Expected growth of the ith fish
Growth[i]	Change in length (growth) of the ith fish from the previous year
k	Von Bertalanffy growth rate coefficient
LengthAtRelease[i]	Length of the ith fish when released the previous year
Linf	Mean maximum length (length-at-infinity)
sGrowth	SD of residual variation in growth
sYear	SD of effect of year on mean maximum length
Year[i]	Year the ith fish was released

3.2.2 Growth Model - JAGS Code

```
model {
  sGrowth ~ dunif(0, 100)
  sYear ~ dunif (0, 100)
```

```
  k ~ dunif (0, 1)
  Linf ~ dunif(100, 1000)

  for (yr in 1:nYear) {
    bYear[yr] ~ dnorm(0, sYear^-2)
  }

  for (i in 1:nrow) {
    eGrowth[i]<-(Linf + bYear[Year[i]] - LengthAtRelease[i])
                  * (1-exp(-k))
    Growth[i] ~ dnorm(eGrowth[i], sGrowth^-2)
  }
}
```

3.3 Count

The count data were analysed using an overdispersed Poisson model[4, p.168-170,180][5, p.55-56]. Unlike Kery[4] and Kery and Schaub[5], which used a log-normal distribution to account for the extra-Poisson variation, the current model used a gamma distribution with identical shape and scale parameters because it has a mean of 1 and therefore no overall effect on the expected count. The model does not distinguish between the abundance and observer efficiency, i.e., it estimates the count which is the product of the two. As such it is necessary to assume that changes in observer efficiency are negligible in order to interpret the estimates as relative abundance.

Key assumptions of the count model include:

- Count density (count/km) varies randomly with site, year, and the interaction between site and year.
- Expected counts are the product of the count density (count/km) and the length of bank sampled.
- Sites are closed, i.e., the expected count at a site is constant for all the sessions in a particular season of a year.
- Observed counts are described by a Poisson-gamma distribution.

3.3.1 Count Model - Variables and Parameters

Variable/Parameter	Description
bDensityIntercept	Log density intercept
bDensitySite[st]	Effect of stth site on log density
bDensitySiteYear[st, yr]	Effect of stth site in yrth year on log density
bDensityYear[yr]	Effect of yrth year on log density
Count[st, yr, ss]	Count at stth site in yrth year on ssth session
eCount[st, yr, ss]	Expected count at stth site in yrth year on ssth session
eDensity[st, yr, ss]	Expected density at stth site in yrth year on ssth session
eU[st, yr, ss]	Extra-poisson variation in count at stth site in yrth year on ssth session
r	Overdispersion parameter
sDensitySite	SD of effect of site on log density
sDensitySiteYear	SD of effect of site within year on log density
sDensityYear	SD of effect of year on log density

3.3.2 Count Model - JAGS Code

```
model {
  r ~ dgamma(0.1, 0.1)

  sDensityYear ~ dunif(0, 2)
  sDensitySite ~ dunif(0, 2)
  sDensitySiteYear ~ dunif(0, 2)

  bDensityIntercept ~ dnorm(0, 5^-2)

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

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

  for (st in 1:nSite) {
    for (yr in 1:nYear) {
      log(eCount[st,yr]) <- bDensityIntercept + bDensitySite[st]
        + bDensityYear[yr] + bDensitySiteYear[st,yr] + log(LengthSite[st])

      for (ss in 1:nSession) {
        eU[st,yr,ss] ~ dgamma(r,r)

        Count[st,yr,ss] ~ dpois(eCount[st,yr]
                              * ProportionSampled[st,yr,ss]
                              * eU[st,yr,ss])
      }
    }
  }
}
```

3.4 Catch

The catch data were analysed using the same overdispersed Poisson model as the count data to provide estimates of relative abundance.

3.5 Site Fidelity

The extent to which sites are closed, i.e., fish remain at the same site between sessions, was evaluated from a binomial "t-test" [4, p.211-213]. The "t-test" estimated the probability that intra-annual recaptures were caught at the same site as previously encountered (site fidelity) for the fall and spring seasons.

Key assumptions of the site fidelity model include:

- Observed site fidelity is described by a Bernoulli distribution.

3.5.1 Site Fidelity Model - Variables and Parameters

Variable/Parameter	Description
bIntercept	Log-odds of probability of recapture at same site
eRemained[i]	Expected probability of ith recapture being caught at same site as previously
Remained[i]	Was ith recapture recorded at same site as previously encountered

3.5.2 Site Fidelity Model - JAGS Code

```
model {
  bIntercept ~ dnorm(0, 5^-2)

  for (i in 1:nrow) {
    logit(eRemained[i]) <- bIntercept
    Remained[i] ~ dbern(eRemained[i])
  }
}
```

3.6 Abundance

The catch data were also analysed using a capture-recapture-based binomial mixture model[4, p.253-257][5, p.134-136,384-388] to provide estimates of capture efficiency and absolute abundance. The expected density was converted into an expected abundance using an offset[4, p.188-189] on site length. The site fidelity (probability that a recapture was encountered at the same site) was used to adjust the capture efficiency for marked fish by season.

Key assumptions of the abundance model include:

- Abundance density (fish/km) varies randomly with site, year and the interaction between site and year.
- Efficiency (probability of capture) varies randomly by session within year.
- The proportion of marked fish remaining at a site by season is described by the median estimates from the site fidelity model.
- Marked and unmarked fish have the same probability of capture.
- There is no tag loss, mortality or misidentification of fish.
- Other than the straying of marked fish, sites are closed, i.e., emigration of unmarked fish is accounted for by immigration of unmarked fish.
- The abundance at a site is described by a Poisson distribution.
- The number of marked and unmarked fish caught at a site is described by a binomial distribution.

3.6.1 Abundance Model - Variables and Parameters

Variable/Parameter	Description
bDenIntercept	Log density intercept
bDenSite[st]	Effect of stth site on log density
bDenSiteYear[st, yr]	Effect of stth site in yrth year on log density
bDenYear[yr]	Effect of yrth year on log density
bEffIntercept	Log-odds efficiency intercept
bEffYearSession[yr,ss]	Effect of ssth session in yrth year on log-odds efficiency
eAbundance[i]	Expected abundance on ith surveys
eEfficiency[i,ss]	Expected efficiency on ssth session of ith surveys
eMarkedN[i, ss]	Abundance of marked fish on ssth session of ith surveys
eUnmarkedN[i, ss]	Expected abundance of unmarked fish on ssth session of ith surveys
Fish[i]	Minimum abundance on ith surveys
Marked[i,ss]	Number of marked fish caught in ssth session of ith surveys
Remained	Site fidelity for marked fish
sDenSite	SD of effect of site on log density
sDenSiteYear	SD of effect of site within year on log density
sDenYear	SD of effect of year on log density
sEffYearSession	SD of effect of session and year on log density
Tagged[i,ss]	Number of unmarked fish tagged in ssth session of ith surveys
Unmarked[i,ss]	Number of unmarked fish caught in ssth session of ith surveys

3.6.2 Abundance Model - JAGS Code

```
model {

  sDenYear ~ dunif(0, 5)
  sDenSite ~ dunif(0, 5)
  sDenSiteYear ~ dunif(0, 2)
  sEffYearSession ~ dunif(0, 2)

  bDenIntercept ~ dnorm(0, 5^-2)
  bEffIntercept ~ dnorm(0, 5^-2)

  for (yr in 1:nYear) {
    bDenYear[yr] ~ dnorm(0, sDenYear^-2)
    for (ss in 1:nSession) {
      bEffYearSession[yr,ss] ~ dnorm(0, sEffYearSession^-2)
    }
  }

  for (st in 1:nSite) {
    bDenSite[st] ~ dnorm(0, sDenSite^-2)
    for (yr in 1:nYear) {
      bDenSiteYear[st, yr] ~ dnorm(0, sDenSiteYear^-2)
    }
  }

  for (i in 1:nVisit) {
    log(eAbundance[i]) <- bDenIntercept + bDenYear[Year[i]] + bDenSite[Site[i]]
```

```
      + bDenSiteYear[Site[i], Year[i]] + log(SiteLength[i])

    eN[i] ~ dpois(eAbundance[i])
    eUnmarkedN[i,1] <- eN[i]
    eMarkedN[i,1] <- 0

    for (ss in 1:nSessionVisit[i]) {
      logit(eEfficiency[i,ss]) <- bEffIntercept + bEffYearSession[Year[i],ss]

      eSamplingEff[i,ss] <- eEfficiency[i,ss] * ProportionSampled[i,ss]

      eMarkedEff[i,ss] <- eSamplingEff[i,ss]
        * step(eMarkedN[i,ss]-1) * Remained

      Unmarked[i,ss] ~ dbin(eSamplingEff[i,ss],eUnmarkedN[i,ss])
      Marked[i,ss] ~ dbin(eMarkedEff[i,ss], max(eMarkedN[i,ss],1))

      eMarkedN[i,ss+1] <- eMarkedN[i,ss] + Tagged[i,ss]
      eUnmarkedN[i,ss+1] <- eUnmarkedN[i,ss] - Tagged[i,ss]
    }
  }
}
```

3.7 Capture Efficiency

In order to estimate the capture efficiency independent of abundance a recapture-based binomial model[4, p.253-257][5, p.134-136,384-388] was fitted to just the marked fish. The model was equivalent to the abundance model without the estimation of the numbers of unmarked fish.

Key assumptions of the efficiency model include:

- Efficiency (probability of capture) varies randomly by session within year.
- The proportion of marked fish remaining at a site by season is described by the median estimates from the site fidelity model.
- There is no tag loss, mortality or misidentification of fish.
- The number of marked fish caught at a site is described by a binomial distribution.

3.7.1 Capture Efficiency Model - Variables and Parameters

The variables and parameters in the efficiency model are the same as those in the abundance model.

3.7.2 Capture Efficiency Model - JAGS Code

```
model {

  sEffYearSession ~ dunif(0, 2)

  bEffIntercept ~ dnorm(0, 5^-2)

  for (yr in 1:nYear) {
    for (ss in 1:nSession) {
```

```
      bEffYearSession[yr,ss] ~ dnorm(0, sEffYearSession^-2)
    }
  }

  for (i in 1:nVisit) {

    eMarkedN[i,1] <- 0

    for (ss in 1:nSessionVisit[i]) {
      logit(eEfficiency[i,ss]) <- bEffIntercept + bEffYearSession[Year[i],ss]

      eSamplingEff[i,ss] <- eEfficiency[i,ss] * ProportionSampled[i,ss]

      eMarkedEff[i,ss] <- eSamplingEff[i,ss]
        * step(eMarkedN[i,ss]-1) * Remained

      Marked[i,ss] ~ dbin(eMarkedEff[i,ss], max(eMarkedN[i,ss],1))

      eMarkedN[i,ss+1] <- eMarkedN[i,ss] + Tagged[i,ss]
    }
  }
}
```

3.8 Survival

The annual survival rate was estimated by fitting a Cormack-Jolly-Seber model[5, p.172-177] to inter-annual recaptures. Key assumptions of the survival model include:

- Log-odds survival varies with year.

3.8.1 Survival Model - Variables and Parameters

Variable/Parameter	Description
bEfficiencyIntercept	Log-odds efficiency
bSurvivalInterceptStage[st]	Log-odds survival of stth stage
bSurvivalStageYear[st,yr]	Effect of yrth year on log-odds survival of stth stage
eAlive[i,yr]	Expected state (alive or dead) of ith fish in yrth year
eEfficiency[i, yr]	Expected recapture probability of ith fish in yrth year
eSurvival[i,yr-1]	Expected probability of survival of ith fish in yr-1th year
FirstYear[i]	The first year ith fish was encountered
FishYear[i,yr]	Whether the ith fish was encountered in the yrth year
sSurvivalStageYear[st]	SD of effect of year on log-odds survival of stth stage
Stage[i]	Stage of ith fish when first encountered
StageFishYear[i,yr]	Stage of ith fish in yrth year

3.8.2 Survival Model - JAGS Code

```
model {

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

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

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

  for (i in 1:nFish) {
    eAlive[i, FirstYear[i]] <- 1
    for (j in (FirstYear[i]+1):nYear) {
      logit(eSurvival[i,j-1]) <- bSurvivalInterceptStage[StageFishYear[i,j-1]]
                                  + bSurvivalStageYear[StageFishYear[i,j-1],j-1]
      eAlive[i,j] ~ dbern (eAlive[i, j-1] * eSurvival[i,j-1])
      logit(eEfficiency[i,j]) <- bEfficiencyIntercept
      FishYear[i,j] ~ dbern (eAlive[i,j] * eEfficiency[i,j])
    }
  }
}
```

3.9 Condition

Condition was estimated via an analysis of weight-length relations [3].

Key assumptions of the condition model include:

- Weight varies with length.
- Weight varies randomly with site, year and the interaction between site and year.
- Weight is log-normally distributed.

3.9.1 Condition Model - Variables and Parameters

Variable/Parameter	Description
bDayte	Effect of day of year on log weight
bDayte2	Effect of 2nd order polynomial of day of year on log weight
bIntercept	Log weight
bLength	Effect of log length on log weight
bSite[st]	Effect of stth site on log weight
bYear[yr]	Effect of yrth year on log weight
bYearSite[yr,st]	Effect of stth site in yrth year on log weight
Dayte[i]	Day of year ith fish was encountered
eLogWeight[i]	Expected log weight of ith fish
Length[i]	Log length of ith fish
sSite	SD of effect of site on log weight
sWeight	SD of residual variation in log weight
sYear	SD of effect of year on log weight
sYearSite	SD of effect of site within year on log weight
Weight[i]	Weight of ith fish

3.9.2 Condition Model - JAGS Code

```
model {
  sWeight ~ dunif(0, 5)
  sSite ~ dunif(0, 5)
  sYear ~ dunif(0, 5)
  sYearSite ~ dunif(0, 5)

  bIntercept ~ dnorm(5, 5^-2)
  bLength ~ dnorm(3, 5^-2)
  bDayte ~ dnorm(0, 5^-2)
  bDayte2 ~ dnorm(0, 5^-2)

  for(st in 1:nSite) {
    bSite[st] ~ dnorm(0, sSite^-2)
  }

  for(yr in 1:nYear) {
    bYear[yr] ~ dnorm(0, sYear^-2)
    for(st in 1:nSite) {
      bYearSite[yr,st] ~ dnorm(0, sYearSite^-2)
    }
  }

  for(i in 1:nrow) {
    eLogWeight[i] <- bIntercept + bLength * Length[i] + bDayte * Dayte[i]
                     + bDayte2 * Dayte[i]^2 + bSite[Site[i]] + bYear[Year[i]]
                     + bYearSite[Year[i],Site[i]]
    Weight[i] ~ dlnorm(eLogWeight[i], sWeight^-2)
  }
}
```

References

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[4] Marc Kéry. *Introduction to WinBUGS for Ecologists: A Bayesian approach to regression, ANOVA, mixed models and related analyses*. Elsevier, Amsterdam; Boston, 2010.

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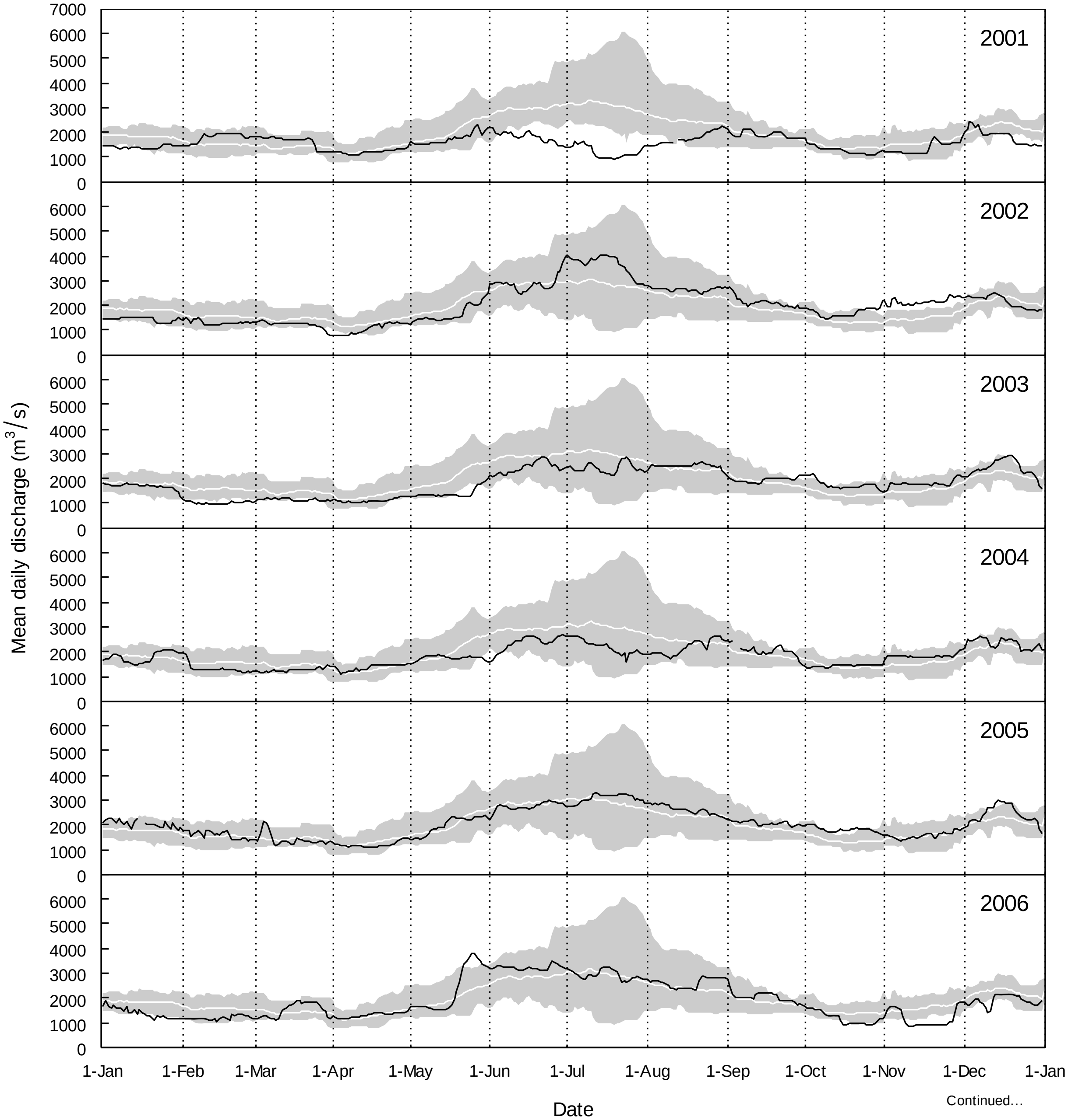
[10] L. von Bertalanffy. A quantitative theory of organic growth (inquiries on growth laws ii). *Human Biology*, 10:181–213, 1938.

[11] Hadley Wickham. *ggplot2 elegant graphics for data analysis*. Springer, Dordrecht; New York, 2009.

APPENDIX D

Discharge and Temperature Data



Continued…

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

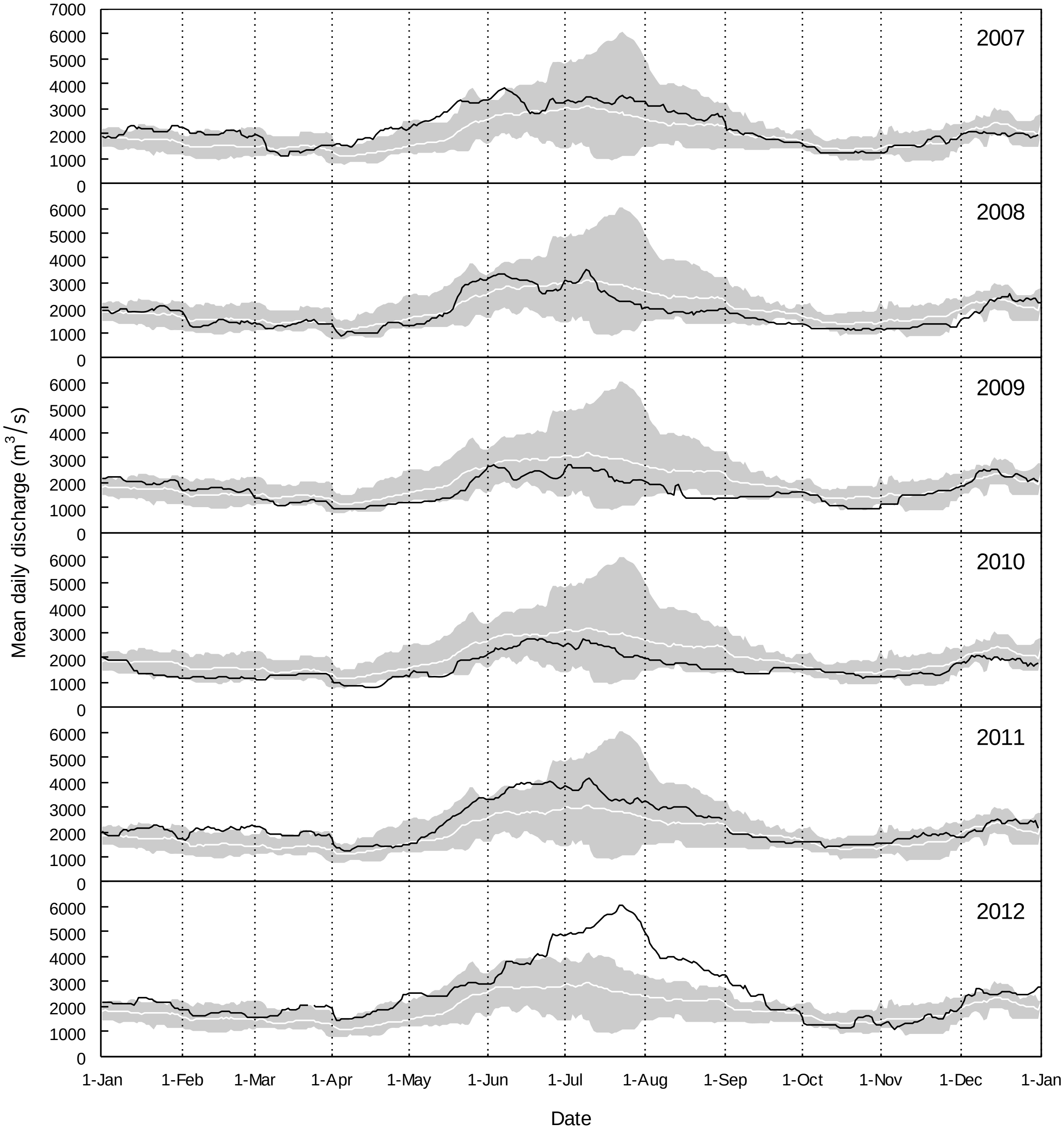
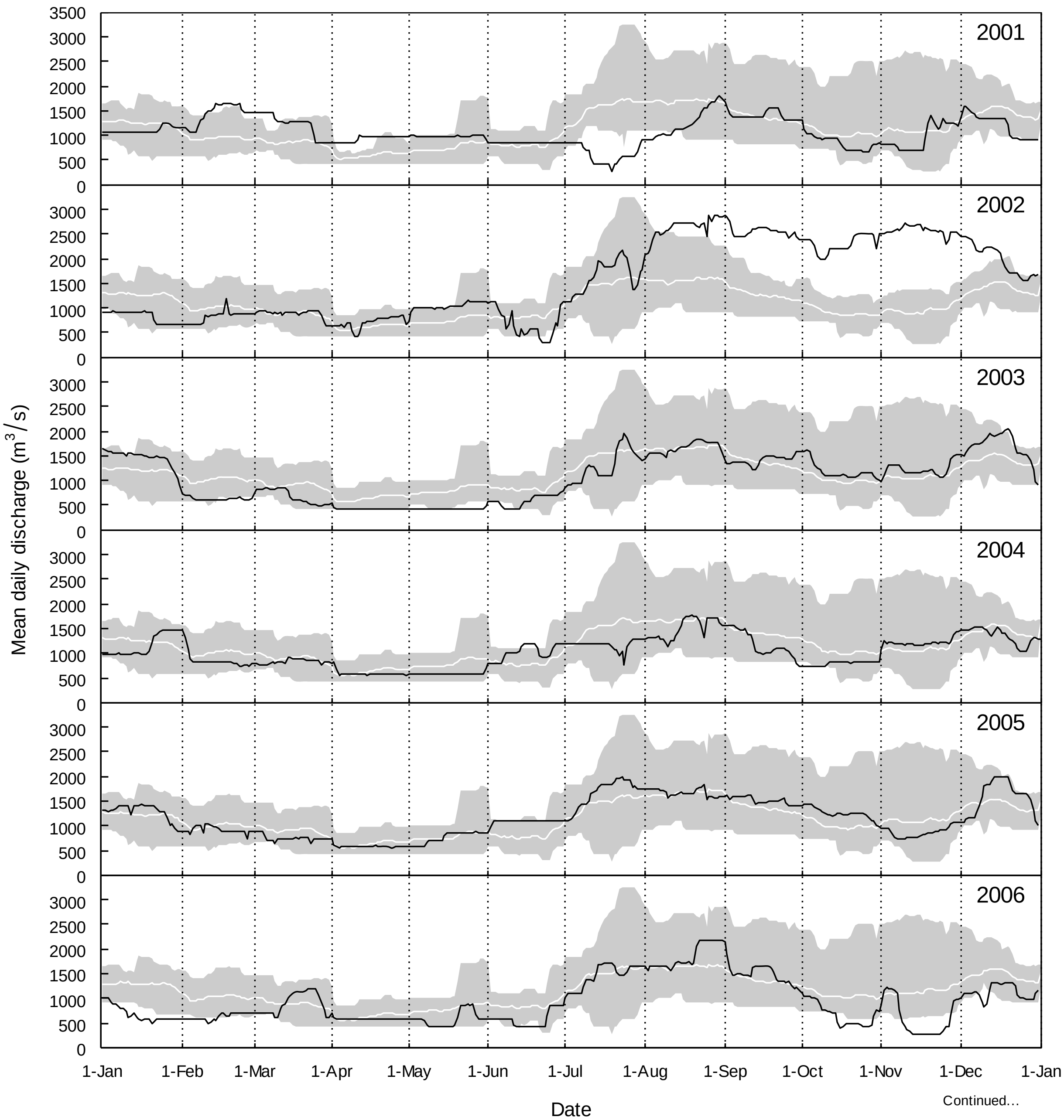


Figure D1. Concluded.



Continued…

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

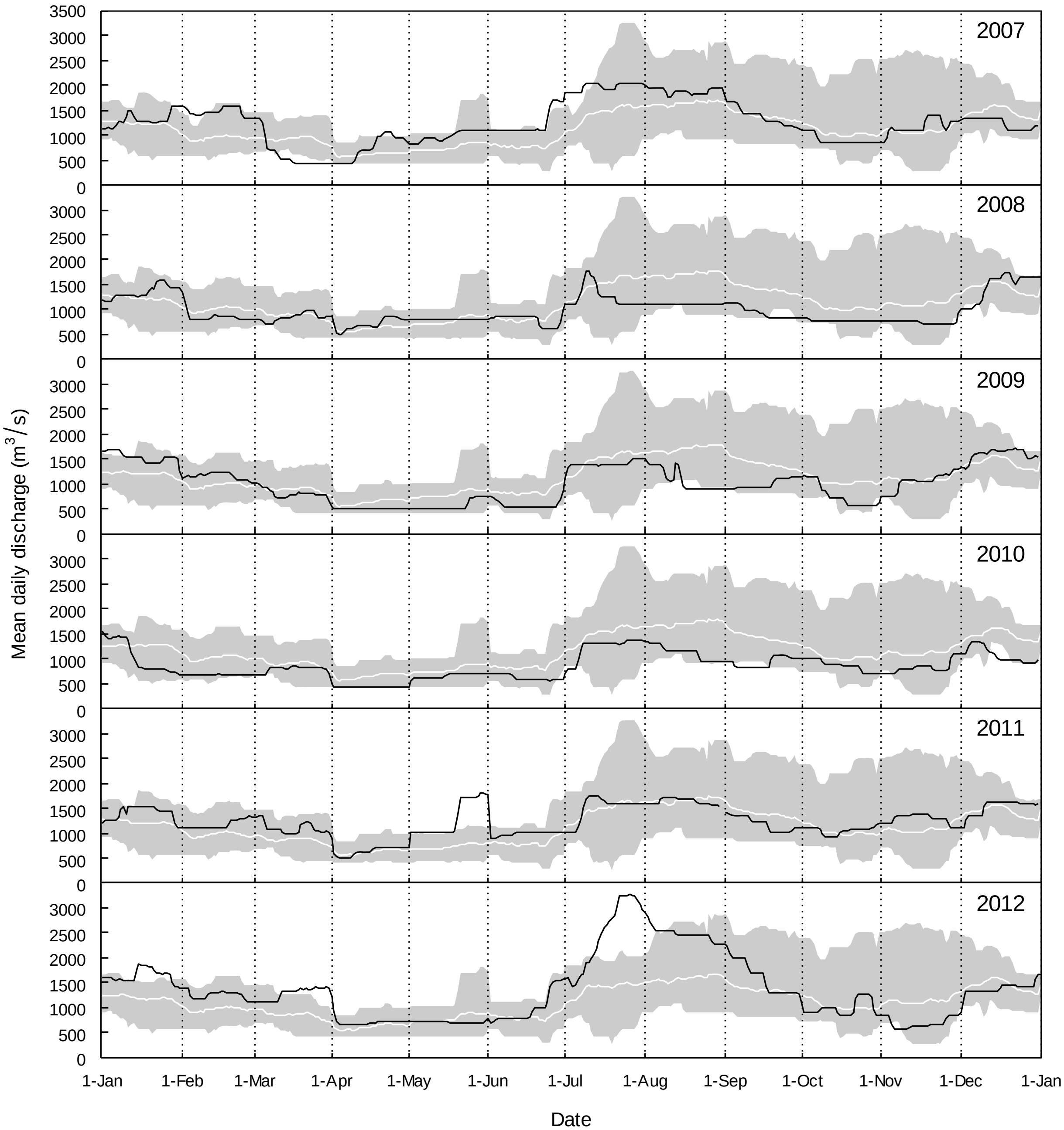


Figure D2. Concluded.

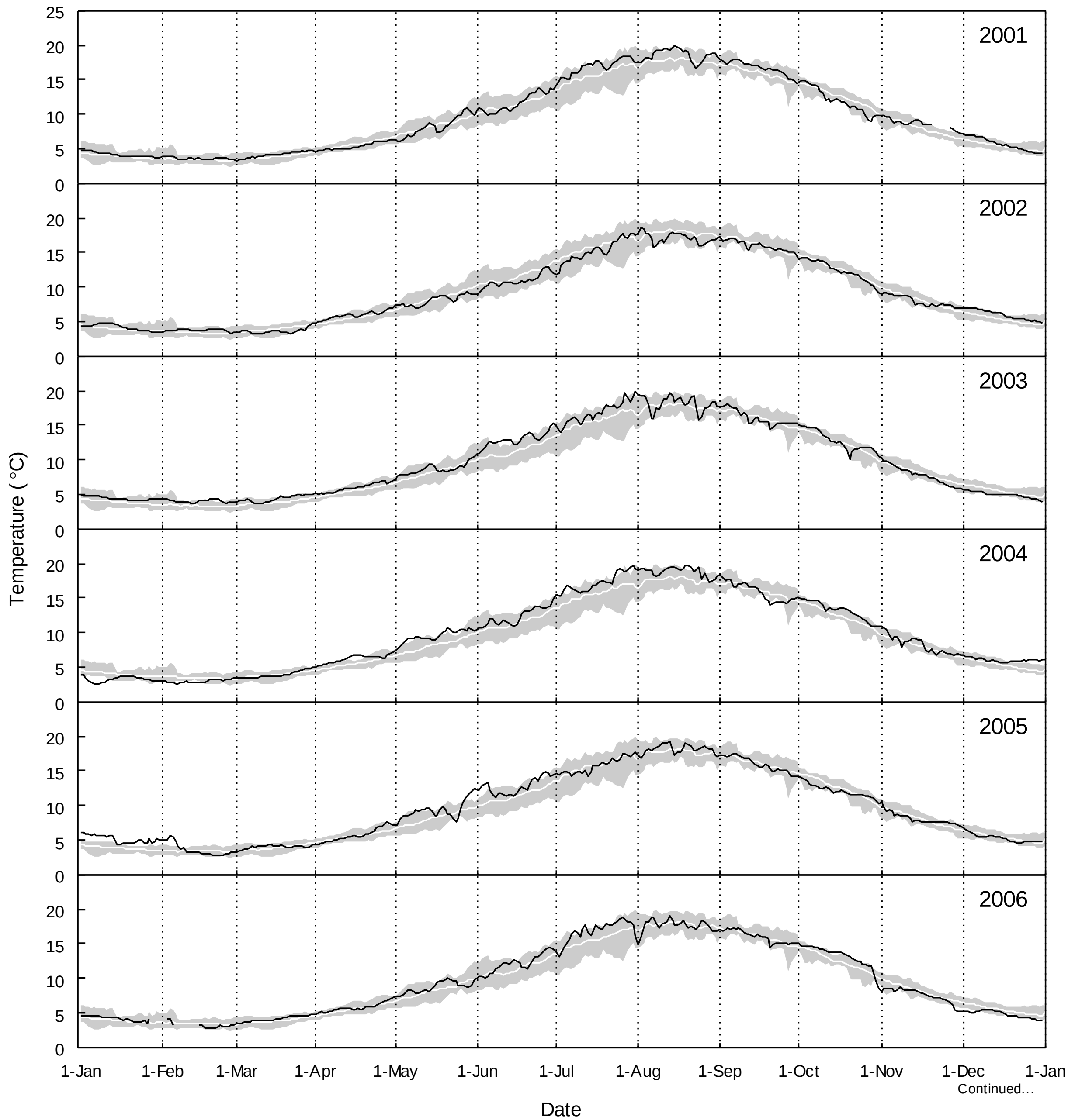


Figure D3. Mean daily water temperatures (°C) for the Columbia River (black line), 2001 to 2012. Data from 2001 to 2011 were recorded at the Birchbank water gauging station and data from 2012 were recorded near Fort Sheperd. The shaded area represents minimum and maximum mean daily water temperatures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

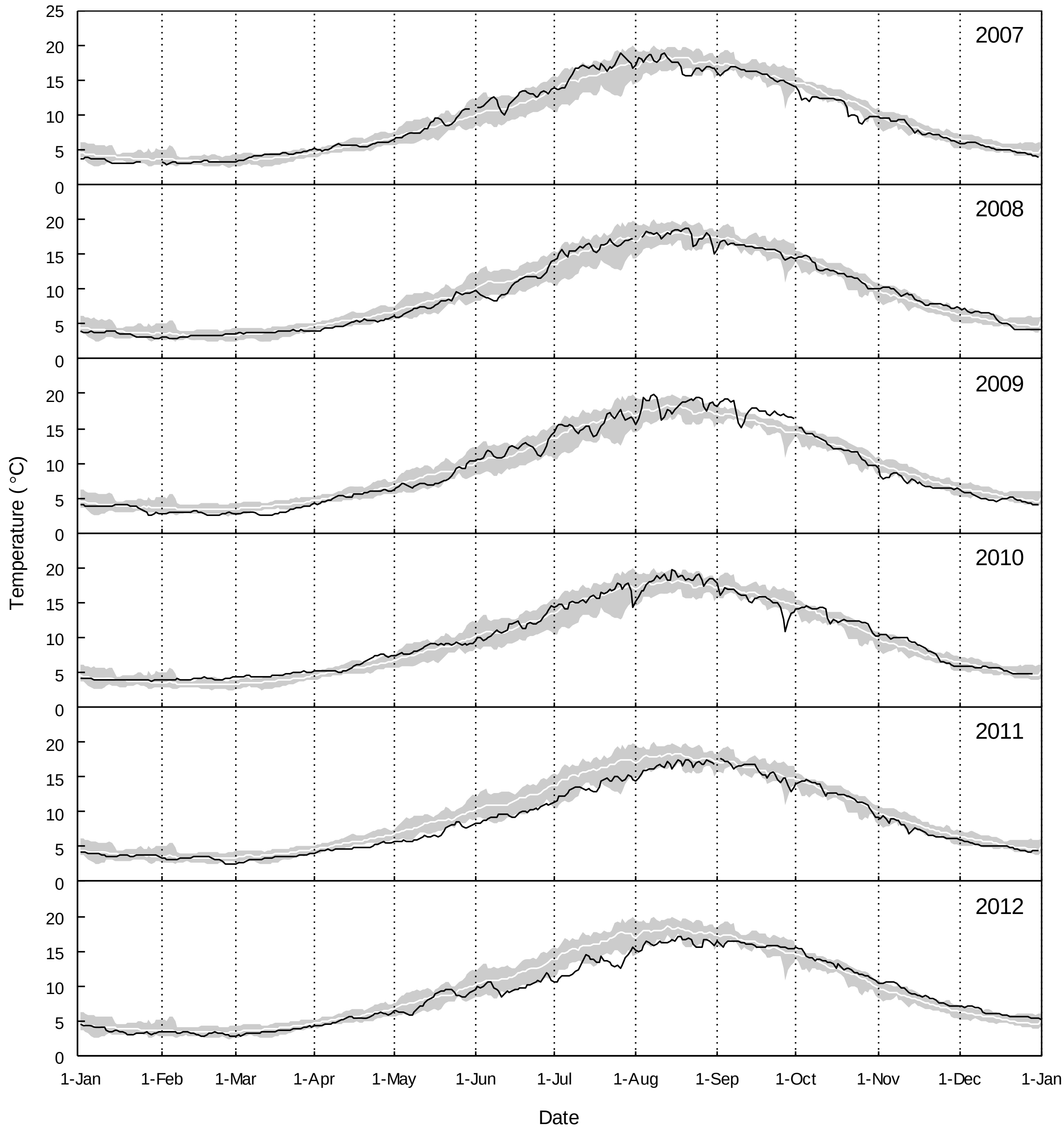
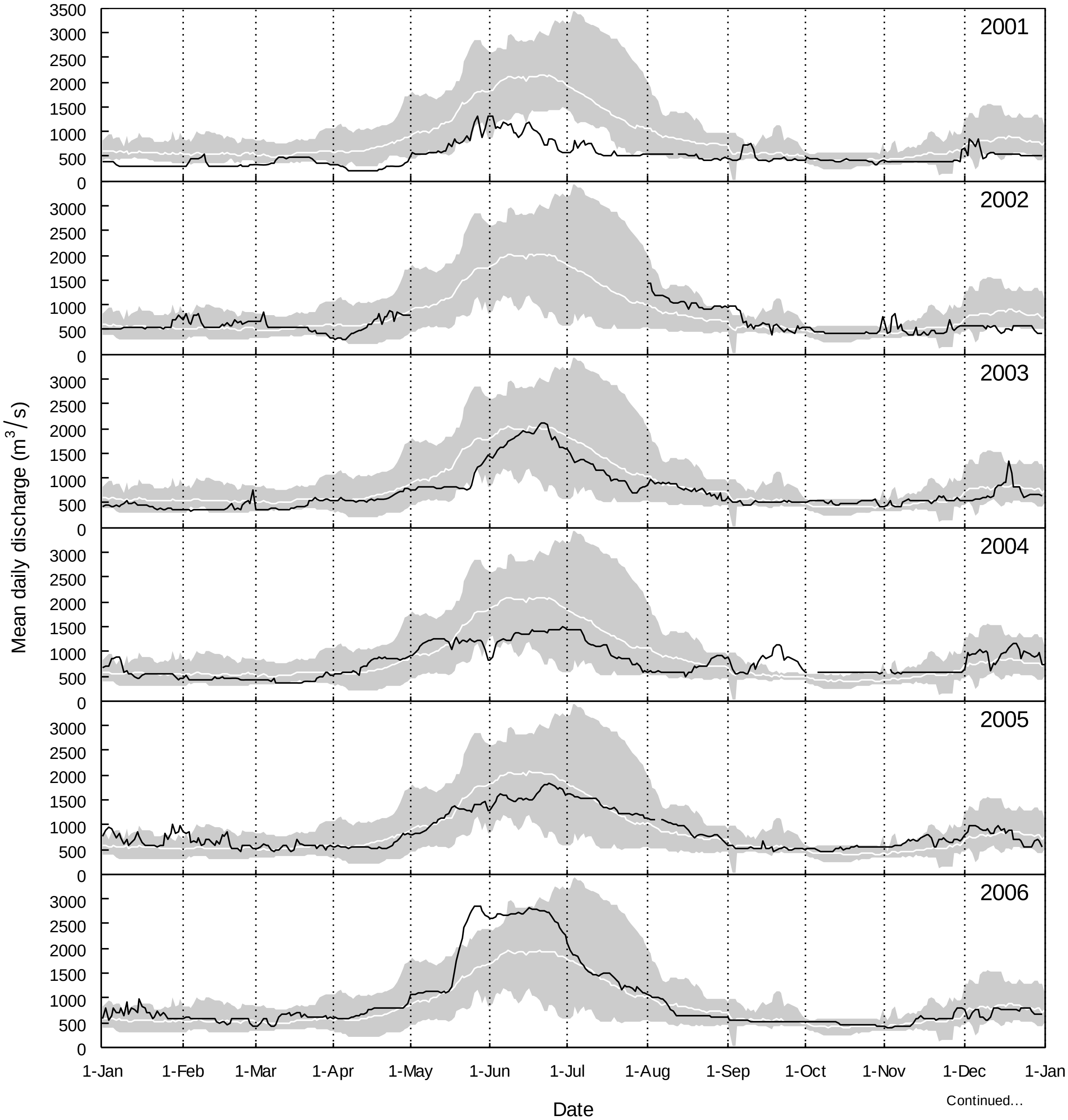


Figure D3. Concluded.



Continued…

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

`

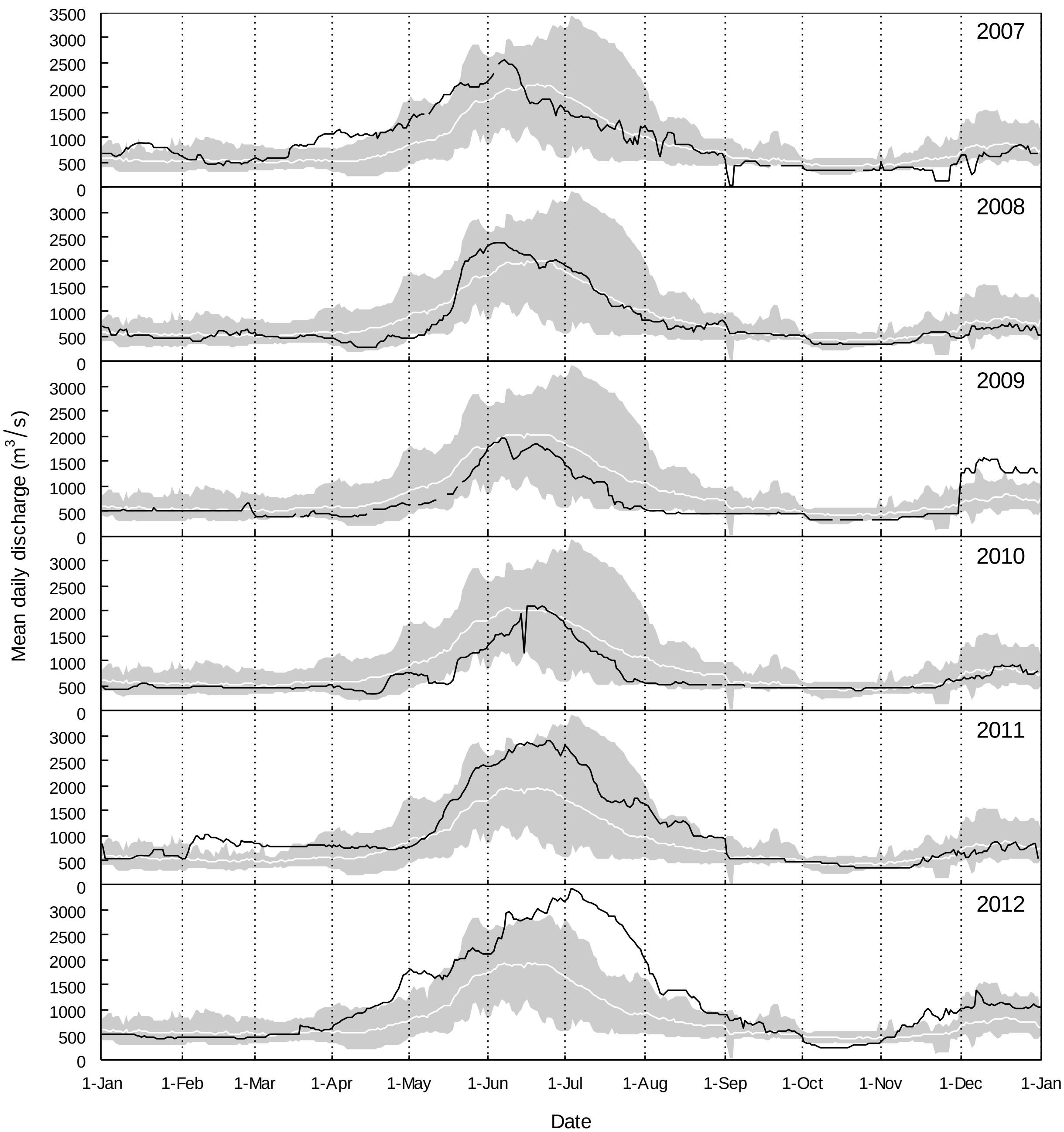
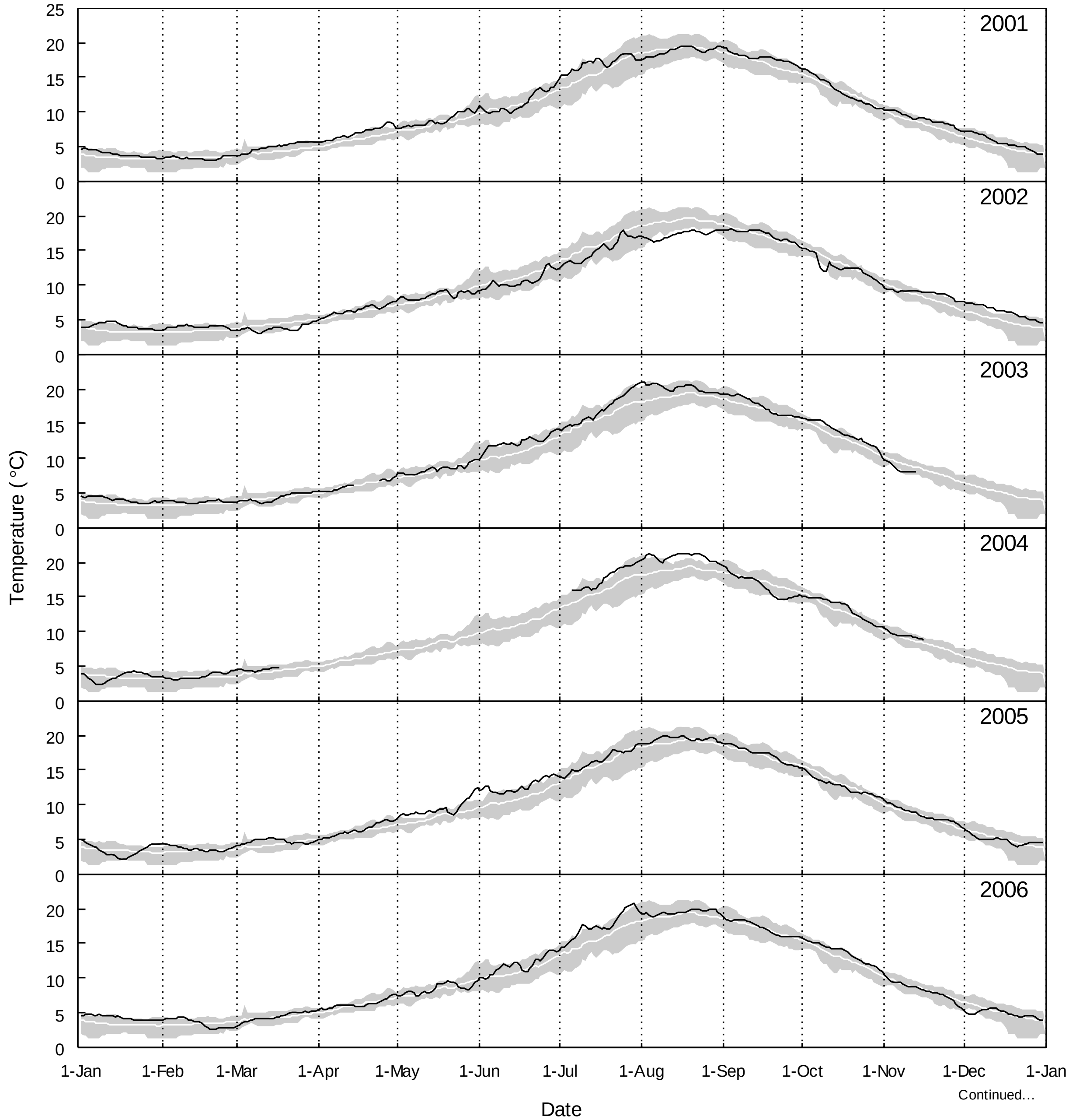


Figure D4. Concluded.



Continued…

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

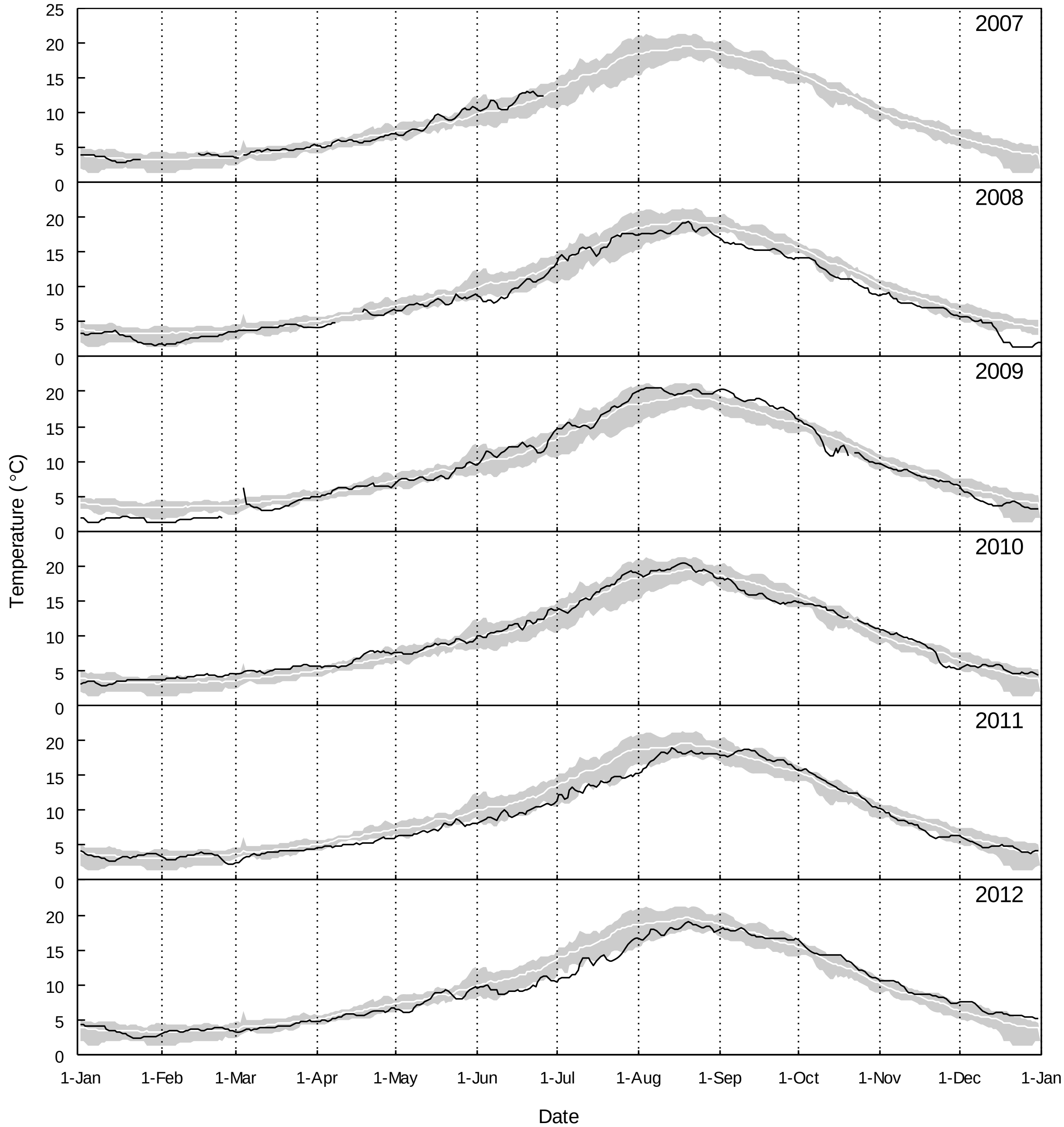


Figure D5. Concluded.

APPENDIX E

Catch and Effort Data Summaries

Table E1 Number of fish caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the Lower Columbia River, 2001 to 2012.

Species	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		All Years		
	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																											
Mountain whitefish	14 916	52	12 065	50	9667	35	6021	38	5024	43	5472	40	5595	45	5221	44	3800	36	2748	30	2933	27	4648	41	**78 110**	**42**	**12**
Rainbow trout	9425	33	10 161	42	8436	30	5763	37	3844	33	5338	39	4953	39	5124	43	4219	40	4419	48	5501	51	5401	48	**72 584**	**39**	**11**
Walleye	1467	5	1478	6	4165	15	3413	22	2230	19	1421	10	1076	9	1208	10	1127	11	1588	17	1814	17	881	8	**21 868**	**12**	**3**
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	**89**	**<1**	**<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	**33**	**<1**	**<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	**142**	**<1**	**<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	**1298**	**<1**	**<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	**43**	**<1**	**<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	**11 035**	**6**	**2**
Lake trout			1	<1											1	<1									**2**	**<1**	**<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	**2177**	**1**	**<1**
Northern pike																			7	<1	9	<1	11	<1	**27**	**<1**	**<1**
Smallmouth bass					4	<1	3	<1	4	<1	53	<1	16	<1	1	<1			1	<1	8	<1			**90**	**<1**	**<1**
White sturgeon	14	<1	6	<1	18	<1	5	<1	11	<1	14	<1	11	<1	9	<1	4	<1	11	<1	23	<1	9	<1	**135**	**<1**	**<1**
Yellow perch					1	<1	4	<1	1	<1	24	<1	1	<1					12	<1	2	<1			**45**	**<1**	**<1**
Sportfish Subtotal	**28 471**	**100**	**24 049**	**100**	**27 787**	**100**	**15 709**	**100**	**11 595**	**100**	**13 727**	**100**	**12 572**	**100**	**11 961**	**100**	**10 521**	**100**	**9178**	**100**	**10 868**	**100**	**11 240**	**100**	**187 678**	**100**	**28**
Non-sportfish																											
Common carp	2	<1					1	<1	1	<1	3	<1	1	<1	2	<1			3	<1					**13**	**<1**	**<1**
Dace spp.[d]	2	<1					3	<1	15	<1	17	<1	1	<1	1	<1			13	<1	3	<1	1	<1	**56**	**<1**	**<1**
Northern pikeminnow	570	3	2371	10	969	3	1337	3	522	2	1450	2	845	1	1452	2	241	<1	376	1	764	2	681	3	**11 578**	**2**	**2**
Peamouth	80	<1	205	<1	45	<1	51	<1	33	<1	52	<1	93	<1	3	<1	4	<1	24	<1	192	<1	488	2	**1270**	**<1**	**<1**
Redside shiner	8520	46	9026	40	5710	20	4605	12	1742	5	13 121	17	3119	5	8156	12	1592	5	2266	7	4626	11	5280	21	**67 763**	**14**	**10**
Sculpin spp.[d]	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	21 087	66	29 392	72	16 030	62	**316 692**	**66**	**48**
Sucker spp.[d]	6509	35	3553	16	4779	17	7033	18	4378	14	9235	12	10 012	17	11 028	16	6896	22	7984	25	5949	15	3194	12	**80 550**	**17**	**12**
Tench											1	<1	5	<1	1	<1			2	<1					**9**	**<1**	**<1**
Non-sportfish Subtotal	**18 407**	**100**	**22 634**	**100**	**28 177**	**100**	**40 021**	**100**	**32 425**	**100**	**75 804**	**100**	**59 584**	**100**	**70 582**	**100**	**31 942**	**100**	**31 755**	**100**	**40 926**	**100**	**25 674**	**100**	**477 931**	**100**	**72**
All species	**46 878**		**46 683**		**55 964**		**55 730**		**44 020**		**89 531**		**72 156**		**82 543**		**42 463**		**40 933**		**51 794**		**36 914**		**665 609**		**100**

[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, 24 September to 25 October 2012.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/hr) Brook trout No.	Brook trout CPUE	Brown trout No.	Brown trout CPUE	Bull trout No.	Bull trout CPUE	Burbot No.	Burbot CPUE	Cutthroat trout No.	Cutthroat trout CPUE	Kokanee No.	Kokanee CPUE	Lake whitefish No.	Lake whitefish CPUE	Mountain whitefish No.	Mountain whitefish CPUE	Northern pike No.	Northern pike CPUE	Rainbow trout No.	Rainbow trout CPUE	Smallmouth Bass No.	Smallmouth Bass CPUE	Walleye No.	Walleye CPUE	White sturgeon No.	White sturgeon CPUE	All Species No.	All Species CPUE
Columbia River U/S																																	
	1	C00.0-R	29-Sep-12	1278	0.94	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	143	428.53	0	0.00	11	32.96	0	0.00	10	29.97	0	0.00	**164**	**491.46**
		C00.7-L	29-Sep-12	1106	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	5.52	0	0.00	36	198.61	0	0.00	11	60.69	0	0.00	0	0.00	0	0.00	**48**	**264.81**
		C01.3-L	29-Sep-12	2059	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8	8.74	0	0.00	87	95.07	5	5.46	23	25.13	0	0.00	5	5.46	0	0.00	**128**	**139.87**
		C02.8-L	30-Sep-12	1320	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	129	399.79	0	0.00	7	21.69	0	0.00	2	6.20	0	0.00	**138**	**427.69**
		C03.6-L	30-Sep-12	2609	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.66	0	0.00	49	32.35	0	0.00	20	13.20	0	0.00	6	3.96	0	0.00	**76**	**50.18**
		C04.6-R	30-Sep-12	830	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	25.02	8	66.73	0	0.00	3	25.02	0	0.00	**14**	**116.77**
		C05.6-L	30-Sep-12	1261	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.60	0	0.00	4	10.38	0	0.00	12	31.14	0	0.00	2	5.19	0	0.00	**19**	**49.31**
		C07.3-R	29-Sep-12	934	1.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	4.53	1	2.27	19	43.08	0	0.00	45	102.03	0	0.00	3	6.80	0	0.00	**70**	**158.71**
		C07.4-L	29-Sep-12	1027	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	14.02	0	0.00	94	329.50	0	0.00	56	196.30	0	0.00	5	17.53	1	3.51	**160**	**560.86**
	Session Summary			**1380**	**10.4**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**17**	**4.25**	**1**	**0.25**	**561**	**140.40**	**8**	**2.00**	**193**	**48.30**	**0**	**0.00**	**36**	**9.01**	**1**	**0.25**	**817**	**204.47**
	2	C00.0-R	05-Oct-12	1140	0.94	0	0.00	0	0.00	2	6.72	0	0.00	0	0.00	0	0.00	0	0.00	59	198.21	0	0.00	16	53.75	0	0.00	6	20.16	1	3.36	**84**	**282.19**
		C00.7-L	05-Oct-12	647	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	41	386.66	0	0.00	26	245.20	0	0.00	3	28.29	0	0.00	**70**	**660.15**
		C01.3-L	05-Oct-12	1845	1.60	0	0.00	0	0.00	0	0.00	1	1.22	0	0.00	0	0.00	0	0.00	57	69.51	0	0.00	59	71.95	0	0.00	24	29.27	0	0.00	**141**	**171.95**
		C02.8-L	06-Oct-12	950	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	79	340.19	0	0.00	10	43.06	0	0.00	4	17.22	0	0.00	**93**	**400.48**
		C03.6-L	06-Oct-12	2371	2.09	0	0.00	0	0.00	1	0.73	0	0.00	0	0.00	1	0.73	1	0.73	145	105.34	0	0.00	71	51.58	0	0.00	21	15.26	0	0.00	**240**	**174.36**
		C04.6-R	07-Oct-12	378	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	54.95	0	0.00	7	128.21	0	0.00	1	18.32	0	0.00	**11**	**201.47**
		C05.6-L	07-Oct-12	1209	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	11	29.78	0	0.00	26	70.38	0	0.00	4	10.83	0	0.00	**41**	**110.99**
		C07.3-R	07-Oct-12	866	1.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.45	0	0.00	40	97.81	0	0.00	39	95.37	0	0.00	4	9.78	1	2.45	**85**	**207.85**
		C07.4-L	07-Oct-12	970	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	66	244.95	0	0.00	22	81.65	0	0.00	3	11.13	0	0.00	**91**	**337.73**
	Session Summary			**1153**	**10.4**	**0**	**0.00**	**0**	**0.00**	**3**	**0.90**	**1**	**0.30**	**0**	**0.00**	**2**	**0.60**	**1**	**0.30**	**501**	**150.14**	**0**	**0.00**	**276**	**82.71**	**0**	**0.00**	**70**	**20.98**	**2**	**0.60**	**856**	**256.52**
	3	C00.0-R	12-Oct-12	887	0.94	0	0.00	0	0.00	1	4.32	0	0.00	0	0.00	1	4.32	0	0.00	9	38.86	0	0.00	23	99.31	0	0.00	8	34.54	0	0.00	**42**	**181.34**
		C00.7-L	12-Oct-12	490	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8	99.62	0	0.00	13	161.88	0	0.00	3	37.36	0	0.00	**24**	**298.86**
		C01.3-L	12-Oct-12	2021	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	4.45	0	0.00	66	73.48	0	0.00	30	33.40	0	0.00	15	16.70	0	0.00	**115**	**128.03**
		C02.8-L	12-Oct-12	913	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	60	268.84	0	0.00	24	107.54	0	0.00	5	22.40	0	0.00	**89**	**398.79**
		C03.6-L	13-Oct-12	2550	2.09	0	0.00	0	0.00	0	0.00	1	0.68	0	0.00	0	0.00	0	0.00	77	52.01	0	0.00	42	28.37	0	0.00	23	15.54	0	0.00	**143**	**96.59**
		C04.6-R	13-Oct-12	429	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	96.83	0	0.00	4	64.55	0	0.00	**10**	**161.38**
		C05.6-L	13-Oct-12	1476	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	11.09	0	0.00	10	22.17	0	0.00	12	26.61	0	0.00	5	11.09	0	0.00	**32**	**70.95**
		C07.3-R	13-Oct-12	870	1.70	0	0.00	0	0.00	1	2.43	0	0.00	0	0.00	0	0.00	1	2.43	60	146.04	0	0.00	68	165.52	0	0.00	6	14.60	0	0.00	**136**	**331.03**
		C07.4-L	13-Oct-12	1101	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	13.08	0	0.00	71	232.15	2	6.54	33	107.90	0	0.00	0	0.00	0	0.00	**110**	**359.67**
	Session Summary			**1193**	**10.4**	**0**	**0.00**	**0**	**0.00**	**2**	**0.58**	**1**	**0.29**	**0**	**0.00**	**14**	**4.05**	**1**	**0.29**	**361**	**104.54**	**2**	**0.58**	**251**	**72.69**	**0**	**0.00**	**69**	**19.98**	**0**	**0.00**	**701**	**203.01**
	4	C00.0-R	20-Oct-12	1168	0.94	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	20	65.58	0	0.00	20	65.58	0	0.00	6	19.67	0	0.00	5	16.39	0	0.00	**51**	**167.23**
		C00.7-L	20-Oct-12	636	0.59	0	0.00	0	0.00	1	9.59	0	0.00	0	0.00	1	9.59	0	0.00	19	182.28	0	0.00	4	38.38	0	0.00	2	19.19	0	0.00	**27**	**259.03**
		C01.3-L	20-Oct-12	2310	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	10	9.74	0	0.00	94	91.56	0	0.00	41	39.94	0	0.00	6	5.84	0	0.00	**151**	**147.08**
		C02.8-L	20-Oct-12	820	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	54	269.40	0	0.00	3	14.97	0	0.00	0	0.00	0	0.00	**57**	**284.37**
		C03.6-L	21-Oct-12	2704	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	2.55	0	0.00	128	81.54	0	0.00	18	11.47	0	0.00	3	1.91	0	0.00	**153**	**97.46**
		C04.6-R	21-Oct-12	708	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	9.78	7	68.45	0	0.00	0	0.00	0	0.00	**8**	**78.23**
		C05.6-L	21-Oct-12	1268	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.58	0	0.00	7	18.07	0	0.00	21	54.20	0	0.00	9	23.23	0	0.00	**38**	**98.08**
		C07.3-R	22-Oct-12	702	1.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	15.08	0	0.00	19	57.32	0	0.00	28	84.46	0	0.00	4	12.07	0	0.00	**56**	**168.93**
		C07.4-L	22-Oct-12	1066	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	72	243.15	0	0.00	33	111.44	0	0.00	7	23.64	0	0.00	**112**	**378.24**
	Session Summary			**1265**	**10.4**	**0**	**0.00**	**0**	**0.00**	**1**	**0.27**	**0**	**0.00**	**0**	**0.00**	**41**	**11.20**	**0**	**0.00**	**413**	**112.83**	**1**	**0.27**	**161**	**43.98**	**0**	**0.00**	**36**	**9.83**	**0**	**0.00**	**653**	**178.39**
	5	C06.7-L	22-Oct-12	638	0.66	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	51.30	0	0.00	9	76.94	0	0.00	0	0.00	0	0.00	**15**	**128.24**
		C09.2-L	22-Oct-12	783	0.81	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	84	476.80	0	0.00	18	102.17	0	0.00	1	5.68	0	0.00	**103**	**584.65**
	Session Summary			**711**	**1.5**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**90**	**310.22**	**0**	**0.00**	**27**	**93.06**	**0**	**0.00**	**1**	**3.45**	**0**	**0.00**	**118**	**406.73**
Section Total All Samples				**46340**	**43.15**	**0**		**0**		**6**		**2**		**0**		**74**		**3**		**1926**		**11**		**908**		**0**		**212**		**3**		**3145**	
Section Average All Samples				**1219**	**1.14**	**0**	**0.00**	**0**	**0.00**	**0**	**0.41**	**0**	**0.14**	**0**	**0.00**	**2**	**5.06**	**0**	**0.21**	**51**	**131.77**	**0**	**0.75**	**24**	**62.12**	**0**	**0.00**	**6**	**14.50**	**0**	**0.21**	**83**	**242.76**
Section Standard Error of Mean						**0.00**	**0.00**	**0.00**	**0.00**	**0.07**	**0.32**	**0.04**	**0.04**	**0.00**	**0.00**	**0.62**	**1.80**	**0.04**	**0.09**	**6.85**	**21.94**	**0.16**	**0.72**	**2.90**	**8.60**	**0.00**	**0.00**	**0.96**	**2.12**	**0.04**	**0.14**	**8.97**	**25.42**

Table E2 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/hr)																									
						Brook trout		Brown trout		Bull trout		Burbot		Cutthroat trout		Kokanee		Lake whitefish		Mountain whitefish		Northern pike		Rainbow trout		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*
Kootenay River																															
	1	K00.3-L	28-Sep-12	241	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*33.95*	0	*0.00*	2	*67.90*	0	*0.00*	6	*203.70*	0	*0.00*	**9**	***305.55***
		K00.6-R	29-Sep-12	601	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*29.95*	0	*0.00*	24	*239.60*	0	*0.00*	20	*199.67*	0	*0.00*	6	*59.90*	0	*0.00*	**53**	***529.12***
		K01.8-L	28-Sep-12	1645	1.87	0	*0.00*	0	*0.00*	0	*0.00*	1	*1.17*	0	*0.00*	6	*7.02*	0	*0.00*	73	*85.43*	0	*0.00*	100	*117.03*	0	*0.00*	21	*24.58*	2	*2.34*	**203**	***237.57***
		K01.8-R	28-Sep-12	1338	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	29	*60.02*	0	*0.00*	76	*157.30*	0	*0.00*	76	*157.30*	0	*0.00*	5	*10.35*	0	*0.00*	**186**	***384.96***
	Session Summary			**956**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**1**	***0.89***	**0**	***0.00***	**38**	***33.98***	**0**	***0.00***	**174**	***155.60***	**0**	***0.00***	**198**	***177.06***	**0**	***0.00***	**38**	***33.98***	**2**	***1.79***	**451**	***403.30***
	2	K00.3-L	06-Oct-12	271	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*30.19*	0	*0.00*	8	*241.53*	0	*0.00*	**9**	***271.72***
		K00.6-R	06-Oct-12	642	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*18.69*	41	*383.18*	0	*0.00*	9	*84.11*	0	*0.00*	12	*112.15*	0	*0.00*	**64**	***598.13***
		K01.8-L	06-Oct-12	1694	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*2.27*	81	*92.05*	0	*0.00*	28	*31.82*	0	*0.00*	33	*37.50*	0	*0.00*	**144**	***163.65***
		K01.8-R	06-Oct-12	1420	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	76	*148.21*	0	*0.00*	13	*25.35*	0	*0.00*	13	*25.35*	0	*0.00*	**102**	***198.92***
	Session Summary			**1007**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**4**	***3.40***	**198**	***168.18***	**0**	***0.00***	**51**	***43.32***	**0**	***0.00***	**66**	***56.06***	**0**	***0.00***	**319**	***270.95***
	3	K00.3-L	14-Oct-12	299	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	14	*383.10*	0	*0.00*	6	*164.18*	0	*0.00*	**20**	***547.28***
		K00.6-R	14-Oct-12	576	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	21	*218.75*	0	*0.00*	13	*135.42*	0	*0.00*	8	*83.33*	0	*0.00*	**42**	***437.50***
		K01.8-L	14-Oct-12	1719	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	121	*135.51*	0	*0.00*	67	*75.03*	0	*0.00*	32	*35.84*	0	*0.00*	**220**	***246.38***
		K01.8-R	14-Oct-12	1142	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	72	*174.59*	0	*0.00*	33	*80.02*	0	*0.00*	6	*14.55*	0	*0.00*	**111**	***269.16***
	Session Summary			**934**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**214**	***195.92***	**0**	***0.00***	**127**	***116.27***	**0**	***0.00***	**52**	***47.61***	**0**	***0.00***	**393**	***359.80***
	4	K00.3-L	21-Oct-12	263	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*31.11*	0	*0.00*	4	*124.44*	0	*0.00*	2	*62.22*	0	*0.00*	3	*93.33*	0	*0.00*	**10**	***311.10***
		K00.6-R	21-Oct-12	583	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	46	*473.41*	0	*0.00*	12	*123.50*	0	*0.00*	15	*154.37*	0	*0.00*	**73**	***751.29***
		K01.8-L	21-Oct-12	1522	1.82	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	6	*7.80*	0	*0.00*	92	*119.57*	0	*0.00*	91	*118.27*	0	*0.00*	23	*29.89*	0	*0.00*	**212**	***275.52***
		K01.8-R	21-Oct-12	1193	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	46	*106.78*	0	*0.00*	67	*155.52*	0	*0.00*	14	*32.50*	0	*0.00*	**127**	***294.80***
	Session Summary			**890**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**7**	***6.80***	**0**	***0.00***	**188**	***182.75***	**0**	***0.00***	**172**	***167.20***	**0**	***0.00***	**55**	***53.46***	**0**	***0.00***	**422**	***410.21***
Section Total All Samples				**15149**	**16.79**	**0**		**0**		**0**		**1**		**0**		**45**		**4**		**774**		**0**		**548**		**0**		**211**		**2**		**1585**	
Section Average All Samples				**947**	**1.05**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.23***	**0**	***0.00***	**3**	***10.19***	**0**	***0.91***	**48**	***175.28***	**0**	***0.00***	**34**	***124.10***	**0**	***0.00***	**13**	***47.78***	**0**	***0.45***	**99**	***363.91***
Section Standard Error of Mean						**0.00**	***0.00***	**0.00**	***0.00***	**0.00**	***0.00***	**0.06**	***0.07***	**0.00**	***0.00***	**1.82**	***4.29***	**0.17**	***1.17***	**9.41**	***31.72***	**0.00**	***0.00***	**8.49**	***21.79***	**0.00**	***0.00***	**2.36**	***18.17***	**0.13**	***0.15***	**18.97**	***41.08***

Table E2 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/hr)																											
						Brook trout		Brown trout		Bull trout		Burbot		Cutthroat trout		Kokanee		Lake whitefish		Mountain whitefish		Northern pike		Rainbow trout		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*
Columbia River D/S																																	
	1	C25.3-R	25-Sep-12	2219	2.73	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	108	*64.18*	0	*0.00*	259	*153.92*	0	*0.00*	37	*21.99*	0	*0.00*	**404**	***240.08***
		C27.6-R	25-Sep-12	346	0.61	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	25	*426.42*	0	*0.00*	101	*1722.73*	0	*0.00*	17	*289.96*	0	*0.00*	**143**	***2439.12***
		C28.2-R	26-Sep-12	939	1.13	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*3.39*	0	*0.00*	41	*139.10*	0	*0.00*	88	*298.57*	0	*0.00*	10	*33.93*	0	*0.00*	**140**	***474.99***
		C34.9-L	24-Sep-12	2395	2.14	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*1.40*	59	*41.44*	0	*0.00*	180	*126.43*	0	*0.00*	9	*6.32*	0	*0.00*	**250**	***175.60***
		C36.6-L	25-Sep-12	1830	2.39	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*0.82*	47	*38.69*	0	*0.00*	155	*127.58*	0	*0.00*	3	*2.47*	0	*0.00*	**206**	***169.56***
		C47.8-L	27-Sep-12	1181	1.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*2.12*	1	*2.12*	0	*0.00*	7	*14.82*	0	*0.00*	73	*154.53*	0	*0.00*	1	*2.12*	0	*0.00*	**83**	***175.70***
		C48.2-R	26-Sep-12	1040	1.01	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	11	*37.70*	0	*0.00*	30	*102.82*	0	*0.00*	5	*17.14*	0	*0.00*	**46**	***157.65***
		C49.0-L	27-Sep-12	516	0.93	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*7.50*	0	*0.00*	48	*360.09*	0	*0.00*	23	*172.54*	0	*0.00*	4	*30.01*	0	*0.00*	**76**	***570.14***
		C49.0-R	26-Sep-12	442	0.72	0	*0.00*	0	*0.00*	0	*0.00*	1	*11.31*	0	*0.00*	0	*0.00*	0	*0.00*	18	*203.62*	0	*0.00*	34	*384.62*	0	*0.00*	4	*45.25*	0	*0.00*	**57**	***644.80***
		C49.8-L	27-Sep-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	1	*0.95*	0	*0.00*	0	*0.00*	0	*0.00*	29	*27.69*	0	*0.00*	101	*96.43*	0	*0.00*	4	*3.82*	0	*0.00*	**135**	***128.89***
		C49.8-R	26-Sep-12	1117	2.39	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	32	*43.15*	0	*0.00*	133	*179.35*	0	*0.00*	7	*9.44*	0	*0.00*	**172**	***231.94***
		C52.2-L	28-Sep-12	807	0.89	0	*0.00*	0	*0.00*	1	*5.01*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	26	*130.32*	0	*0.00*	93	*466.15*	0	*0.00*	3	*15.04*	0	*0.00*	**123**	***616.52***
		C52.2-R	27-Sep-12	2137	3.79	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	80	*35.56*	0	*0.00*	168	*74.67*	0	*0.00*	22	*9.78*	1	*0.44*	**271**	***120.46***
		C52.8-L	28-Sep-12	577	0.89	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*21.03*	0	*0.00*	31	*217.32*	0	*0.00*	3	*21.03*	0	*0.00*	**37**	***259.38***
		C53.6-L	28-Sep-12	933	1.72	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	15	*33.65*	0	*0.00*	26	*58.33*	0	*0.00*	1	*2.24*	0	*0.00*	**42**	***94.22***
	Session Summary			**1201**	**25.2**	**0**	***0.00***	**0**	***0.00***	**1**	***0.12***	**2**	***0.24***	**1**	***0.12***	**3**	***0.36***	**3**	***0.36***	**549**	***65.21***	**0**	***0.00***	**1495**	***177.59***	**0**	***0.00***	**130**	***15.44***	**1**	***0.12***	**2185**	***259.55***
	2	C25.3-R	02-Oct-12	1898	2.73	0	*0.00*	0	*0.00*	1	*0.69*	0	*0.00*	0	*0.00*	15	*10.42*	2	*1.39*	227	*157.71*	0	*0.00*	123	*85.46*	0	*0.00*	8	*5.56*	0	*0.00*	**376**	***261.24***
		C27.6-R	02-Oct-12	342	0.61	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	5	*86.28*	0	*0.00*	12	*207.08*	0	*0.00*	1	*17.26*	0	*0.00*	**18**	***310.61***
		C28.2-R	02-Oct-12	916	1.13	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	70	*243.46*	0	*0.00*	89	*309.54*	0	*0.00*	0	*0.00*	0	*0.00*	**159**	***553.00***
		C34.9-L	01-Oct-12	2175	2.09	0	*0.00*	1	*0.79*	0	*0.00*	0	*0.00*	0	*0.00*	2	*1.58*	0	*0.00*	42	*33.26*	0	*0.00*	184	*145.72*	0	*0.00*	10	*7.92*	0	*0.00*	**239**	***189.28***
		C36.6-L	01-Oct-12	1592	2.19	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	66	*68.15*	0	*0.00*	131	*135.27*	0	*0.00*	4	*4.13*	0	*0.00*	**201**	***207.54***
		C47.8-L	04-Oct-12	1260	1.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*3.97*	3	*5.95*	0	*0.00*	23	*45.63*	0	*0.00*	7	*13.89*	0	*0.00*	**35**	***69.44***
		C48.2-R	03-Oct-12	920	1.01	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*11.62*	0	*0.00*	27	*104.61*	0	*0.00*	3	*11.62*	0	*0.00*	**33**	***127.85***
		C49.0-L	04-Oct-12	506	0.93	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	40	*306.01*	0	*0.00*	12	*91.80*	0	*0.00*	3	*22.95*	0	*0.00*	**55**	***420.76***
		C49.0-R	03-Oct-12	352	0.72	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	8	*113.64*	0	*0.00*	28	*397.73*	0	*0.00*	1	*14.20*	0	*0.00*	**37**	***525.57***
		C49.8-L	04-Oct-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	2	*1.91*	0	*0.00*	0	*0.00*	2	*1.91*	92	*87.84*	0	*0.00*	109	*104.07*	0	*0.00*	13	*12.41*	0	*0.00*	**218**	***208.14***
		C49.8-R	03-Oct-12	1274	2.39	0	*0.00*	0	*0.00*	0	*0.00*	1	*1.18*	0	*0.00*	0	*0.00*	0	*0.00*	73	*86.31*	0	*0.00*	55	*65.03*	0	*0.00*	15	*17.73*	0	*0.00*	**144**	***170.25***
		C52.2-L	05-Oct-12	863	0.89	1	*4.69*	1	*4.69*	1	*4.69*	2	*9.37*	0	*0.00*	0	*0.00*	0	*0.00*	13	*60.93*	0	*0.00*	31	*145.30*	0	*0.00*	0	*0.00*	0	*0.00*	**49**	***229.67***
		C52.2-R	04-Oct-12	2308	3.79	1	*0.41*	0	*0.00*	0	*0.00*	5	*2.06*	0	*0.00*	0	*0.00*	0	*0.00*	50	*20.58*	0	*0.00*	67	*27.57*	0	*0.00*	16	*6.58*	0	*0.00*	**139**	***57.21***
		C52.8-L	05-Oct-12	603	0.89	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	45	*301.86*	0	*0.00*	24	*160.99*	0	*0.00*	7	*46.96*	0	*0.00*	**76**	***509.81***
		C53.6-L	05-Oct-12	1091	1.72	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	8	*15.35*	0	*0.00*	22	*42.21*	0	*0.00*	8	*15.35*	0	*0.00*	**38**	***72.90***
	Session Summary			**1176**	**25.0**	**2**	***0.25***	**2**	***0.25***	**2**	***0.25***	**10**	***1.23***	**0**	***0.00***	**17**	***2.08***	**6**	***0.74***	**745**	***91.30***	**0**	***0.00***	**937**	***114.83***	**0**	***0.00***	**96**	***11.77***	**0**	***0.00***	**1817**	***222.68***
	3	C25.3-R	09-Oct-12	1576	2.73	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*0.84*	2	*1.67*	33	*27.61*	0	*0.00*	40	*33.47*	0	*0.00*	5	*4.18*	0	*0.00*	**81**	***67.77***
		C27.6-R	09-Oct-12	373	0.61	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	33	*522.13*	0	*0.00*	12	*189.87*	0	*0.00*	3	*47.47*	0	*0.00*	**48**	***759.46***
		C28.2-R	09-Oct-12	796	1.13	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	53	*212.12*	0	*0.00*	50	*200.12*	0	*0.00*	6	*24.01*	0	*0.00*	**109**	***436.25***
		C34.9-L	09-Oct-12	1811	2.14	1	*0.93*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*0.93*	0	*0.00*	21	*19.51*	0	*0.00*	75	*69.67*	0	*0.00*	5	*4.64*	0	*0.00*	**103**	***95.68***
		C36.6-L	10-Oct-12	1415	2.39	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	28	*29.81*	0	*0.00*	94	*100.06*	0	*0.00*	1	*1.06*	0	*0.00*	**123**	***130.93***
		C47.8-L	11-Oct-12	1256	1.44	6	*11.94*	0	*0.00*	0	*0.00*	1	*1.99*	0	*0.00*	6	*11.94*	4	*7.96*	24	*47.77*	0	*0.00*	66	*131.37*	0	*0.00*	15	*29.86*	0	*0.00*	**122**	***242.83***
		C48.2-R	10-Oct-12	956	1.01	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	8	*29.83*	0	*0.00*	59	*219.98*	0	*0.00*	2	*7.46*	0	*0.00*	**69**	***257.26***
		C49.0-L	11-Oct-12	505	0.93	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	4	*30.66*	32	*245.29*	0	*0.00*	32	*245.29*	0	*0.00*	4	*30.66*	0	*0.00*	**72**	***551.90***
		C49.0-R	10-Oct-12	666	0.72	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	7	*52.55*	0	*0.00*	36	*270.27*	0	*0.00*	3	*22.52*	0	*0.00*	**46**	***345.35***
		C49.8-L	11-Oct-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*0.95*	3	*2.86*	3	*2.86*	29	*27.69*	0	*0.00*	57	*54.42*	0	*0.00*	12	*11.46*	1	*0.95*	**106**	***101.21***
		C49.8-R	10-Oct-12	1406	2.39	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*1.07*	0	*0.00*	78	*83.56*	0	*0.00*	123	*131.77*	0	*0.00*	8	*8.57*	0	*0.00*	**210**	***224.98***
		C52.2-L	12-Oct-12	806	0.89	0	*0.00*	0	*0.00*	0	*0.00*	1	*5.02*	0	*0.00*	0	*0.00*	0	*0.00*	8	*40.15*	0	*0.00*	25	*125.46*	0	*0.00*	6	*30.11*	0	*0.00*	**40**	***200.74***
		C52.2-R	11-Oct-12	2305	3.79	0	*0.00*	0	*0.00*	0	*0.00*	5	*2.06*	0	*0.00*	0	*0.00*	7	*2.88*	64	*26.37*	0	*0.00*	116	*47.80*	0	*0.00*	20	*8.24*	0	*0.00*	**212**	***87.36***
		C52.8-L	12-Oct-12	556	0.89	0	*0.00*	0	*0.00*	1	*7.28*	0	*0.00*	0	*0.00*	0	*0.00*	1	*7.28*	7	*50.93*	0	*0.00*	25	*181.88*	0	*0.00*	11	*80.03*	0	*0.00*	**45**	***327.38***
		C53.6-L	12-Oct-12	1008	1.72	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	7	*14.53*	0	*0.00*	26	*53.99*	0	*0.00*	8	*16.61*	0	*0.00*	**41**	***85.13***
	Session Summary			**1132**	**25.2**	**7**	***0.88***	**0**	***0.00***	**1**	***0.13***	**7**	***0.88***	**1**	***0.13***	**12**	***1.51***	**21**	***2.65***	**432**	***54.47***	**0**	***0.00***	**836**	***105.41***	**0**	***0.00***	**109**	***13.74***	**1**	***0.13***	**1427**	***179.94***

Table E2 Continued.

Section	Session	Site	Date	Time Sampled (s)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/hr)																									
						Brook trout		Brown trout		Bull trout		Burbot		Cutthroat trout		Kokanee		Lake whitefish		Mountain whitefish		Northern pike		Rainbow trout		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
	4	C25.3-R	16-Oct-12	1898	2.73	0	0.00	0	0.00	2	1.39	0	0.00	0	0.00	0	0.00	3	2.08	57	39.60	0	0.00	70	48.63	0	0.00	9	6.25	0	0.00	141	97.96
		C27.6-R	16-Oct-12	324	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	37	673.95	0	0.00	23	418.94	0	0.00	1	18.21	0	0.00	61	1111.11
		C28.2-R	16-Oct-12	1205	1.13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	31	81.96	0	0.00	72	190.36	0	0.00	10	26.44	1	2.64	114	301.40
		C34.9-L	17-Oct-12	1943	2.14	0	0.00	0	0.00	1	0.87	0	0.00	0	0.00	1	0.87	0	0.00	15	12.99	0	0.00	92	79.65	0	0.00	11	9.52	1	0.87	121	104.76
		C36.6-L	17-Oct-12	1459	2.39	0	0.00	0	0.00	0	0.00	2	2.06	0	0.00	3	3.10	0	0.00	20	20.65	0	0.00	81	83.62	0	0.00	4	4.13	0	0.00	110	113.56
		C47.8-L	17-Oct-12	1274	1.44	2	3.92	0	0.00	0	0.00	2	3.92	0	0.00	0	0.00	3	5.89	20	39.25	0	0.00	63	123.63	0	0.00	14	27.47	0	0.00	104	204.08
		C48.2-R	18-Oct-12	807	1.01	0	0.00	0	0.00	0	0.00	1	4.42	0	0.00	0	0.00	0	0.00	6	26.50	0	0.00	15	66.25	0	0.00	3	13.25	0	0.00	25	110.42
		C49.0-L	17-Oct-12	520	0.93	2	14.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	19	141.44	0	0.00	21	156.33	0	0.00	2	14.89	0	0.00	44	327.54
		C49.0-R	18-Oct-12	526	0.72	0	0.00	0	0.00	0	0.00	0	0.00	1	9.51	1	9.51	0	0.00	7	66.54	0	0.00	19	180.61	0	0.00	0	0.00	0	0.00	28	266.16
		C49.8-L	17-Oct-12	1539	2.45	0	0.00	0	0.00	0	0.00	4	3.82	0	0.00	0	0.00	5	4.77	53	50.60	0	0.00	63	60.15	0	0.00	9	8.59	0	0.00	134	127.94
		C49.8-R	18-Oct-12	1299	2.39	0	0.00	0	0.00	0	0.00	4	4.64	0	0.00	0	0.00	2	2.32	19	22.03	0	0.00	50	57.98	0	0.00	13	15.07	0	0.00	88	102.04
		C52.2-L	18-Oct-12	751	0.89	1	5.39	0	0.00	0	0.00	1	5.39	0	0.00	0	0.00	5	26.93	8	43.09	0	0.00	18	96.95	0	0.00	10	53.86	0	0.00	43	231.60
		C52.2-R	18-Oct-12	2062	3.79	1	0.46	0	0.00	0	0.00	2	0.92	1	0.46	0	0.00	5	2.30	25	11.52	0	0.00	60	27.64	0	0.00	8	3.69	0	0.00	102	46.99
		C52.8-L	18-Oct-12	571	0.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	37	262.11	0	0.00	22	155.85	0	0.00	59	417.95
		C53.6-L	18-Oct-12	1001	1.72	0	0.00	0	0.00	0	0.00	1	2.09	0	0.00	0	0.00	1	2.09	2	4.18	0	0.00	37	77.36	0	0.00	14	29.27	0	0.00	55	115.00
	Session Summary			**1145**	**25.2**	**6**	**0.75**	**0**	**0.00**	**3**	**0.37**	**17**	**2.12**	**2**	**0.25**	**5**	**0.62**	**24**	**2.99**	**319**	**39.74**	**0**	**0.00**	**721**	**89.83**	**0**	**0.00**	**130**	**16.20**	**2**	**0.25**	**1229**	**153.12**
	5	C10.7-R	22-Oct-12	940	0.91	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	61	256.72	0	0.00	57	239.89	0	0.00	6	25.25	0	0.00	124	521.86
		C10.9-L	22-Oct-12	700	2.18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	294	693.58	0	0.00	111	261.86	0	0.00	12	28.31	0	0.00	417	983.75
		C13.4-R	23-Oct-12	1907	2.52	0	0.00	0	0.00	0	0.00	1	0.75	0	0.00	0	0.00	0	0.00	94	70.42	0	0.00	135	101.13	0	0.00	10	7.49	0	0.00	240	179.79
		C14.8-L	23-Oct-12	2164	2.26	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.74	94	69.19	0	0.00	107	78.76	0	0.00	13	9.57	0	0.00	215	158.26
		C16.6-R	23-Oct-12	1361	1.44	1	1.84	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	1.84	46	84.50	0	0.00	28	51.43	0	0.00	2	3.67	0	0.00	78	143.28
		C18.0-R	24-Oct-12	710	0.85	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	5.97	84	501.08	0	0.00	74	441.43	0	0.00	6	35.79	0	0.00	165	984.26
		C21.8-R	24-Oct-12	1107	1.27	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	39	99.87	0	0.00	84	215.10	0	0.00	8	20.49	0	0.00	131	335.45
		C23.4-L	24-Oct-12	743	0.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	44	229.24	0	0.00	65	338.64	0	0.00	0	0.00	1	5.21	110	573.09
		C28.8-L	24-Oct-12	524	0.82	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	42	351.89	0	0.00	32	268.11	0	0.00	2	16.76	0	0.00	76	636.75
		C32.0-R	24-Oct-12	1105	1.37	0	0.00	0	0.00	2	4.76	0	0.00	0	0.00	0	0.00	1	2.38	33	78.48	0	0.00	98	233.05	0	0.00	7	16.65	0	0.00	141	335.30
		C34.9-R	25-Oct-12	864	0.89	1	4.68	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	18.73	0	0.00	33	154.49	0	0.00	4	18.73	0	0.00	42	196.63
		C36.9-R	25-Oct-12	1317	2.27	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	28	33.72	0	0.00	18	21.68	0	0.00	74	89.11	0	0.00	5	6.02	0	0.00	125	150.52
		C39.2-R	25-Oct-12	736	1.18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.15	5	20.73	0	0.00	45	186.53	0	0.00	5	20.73	0	0.00	56	232.13
		C41.1-L	25-Oct-12	1754	2.41	0	0.00	0	0.00	0	0.00	1	0.85	0	0.00	0	0.00	0	0.00	27	22.99	0	0.00	61	51.95	0	0.00	12	10.22	0	0.00	101	86.02
		C44.6-L	25-Oct-12	755	1.01	0	0.00	0	0.00	0	0.00	2	9.44	0	0.00	0	0.00	1	4.72	12	56.65	0	0.00	30	141.63	0	0.00	4	18.88	0	0.00	49	231.33
		C46.4-L	25-Oct-12	1178	1.59	0	0.00	0	0.00	0	0.00	1	1.92	0	0.00	1	1.92	0	0.00	14	26.91	0	0.00	100	192.20	0	0.00	19	36.52	0	0.00	135	259.47
		C47.2-R	26-Oct-12	678	1.06	0	0.00	0	0.00	0	0.00	1	5.01	0	0.00	0	0.00	0	0.00	53	265.49	0	0.00	52	260.48	0	0.00	2	10.02	0	0.00	108	540.99
		C56.0-L	19-Oct-12	781	0.94	0	0.00	0	0.00	0	0.00	6	29.42	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	29.42	1	4.90	14	68.65	1	4.90	28	137.30
	Session Summary			**1074**	**25.9**	**2**	**0.26**	**0**	**0.00**	**2**	**0.26**	**12**	**1.55**	**0**	**0.00**	**29**	**3.75**	**6**	**0.78**	**964**	**124.81**	**0**	**0.00**	**1192**	**154.33**	**1**	**0.13**	**131**	**16.96**	**2**	**0.26**	**2341**	**303.10**
Section Total All Samples				**89134**	**126.57**	**17**		**2**		**9**		**48**		**4**		**66**		**60**		**3009**		**0**		**5181**		**1**		**596**		**6**		**8999**	
Section Average All Samples				**1143**	**1.62**	**0**	**0.42**	**0**	**0.05**	**0**	**0.22**	**1**	**1.19**	**0**	**0.10**	**1**	**1.64**	**1**	**1.49**	**39**	**74.89**	**0**	**0.00**	**66**	**128.95**	**0**	**0.02**	**8**	**14.83**	**0**	**0.15**	**115**	**316.55**
Section Standard Error of Mean						**0.09**	**0.27**	**0.02**	**0.06**	**0.04**	**0.14**	**0.14**	**0.45**	**0.03**	**0.12**	**0.41**	**0.49**	**0.17**	**0.54**	**5.10**	**16.89**	**0.00**	**0.00**	**5.40**	**23.22**	**0.01**	**0.06**	**0.72**	**4.26**	**0.03**	**0.10**	**9.50**	**37.54**
All Sections Total All Samples				**150623**	**186.51**	**17**	**0.00**	**2**	**0.00**	**15**	**0.00**	**51**	**0.01**	**4**	**0.00**	**185**	**0.02**	**67**	**0.01**	**5709**	**0.73**	**11**	**0.00**	**6637**	**0.85**	**1**	**0.00**	**1019**	**0.13**	**11**	**0.00**	**13729**	**1.76**
All Sections Average All Samples						**0**	**0.29**	**0**	**0.03**	**0**	**0.25**	**0**	**0.86**	**0**	**0.07**	**1**	**3.13**	**1**	**1.13**	**43**	**96.57**	**0**	**0.19**	**50**	**112.27**	**0**	**0.02**	**8**	**17.24**	**0**	**0.19**	**104**	**232.23**
All Sections Standard Error of Mean						**0.05**	**0.16**	**0.01**	**0.04**	**0.03**	**0.13**	**0.09**	**0.27**	**0.01**	**0.07**	**0.37**	**0.81**	**0.11**	**0.35**	**3.78**	**12.44**	**0.05**	**0.21**	**3.84**	**14.68**	**0.01**	**0.04**	**0.61**	**3.81**	**0.03**	**0.07**	**6.67**	**24.03**

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, 24 September to 25 October 2012.

Section	Session	Site	Date	Time Sampled (seconds)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/h)[a]											
						Northern pikeminnow		Peamouth		Redside shiner		Sculpin spp.		Sucker spp.		All Species	
						No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*
Columbia River U/S																	
	1	C00.0-R	29-Sep-12	1278	0.94	85	*254.72*	10	*29.97*	2030	*6083.31*	250	*749.18*	101	*302.67*	2476	*7419.84*
		C00.7-L	29-Sep-12	1106	0.59	10	*55.17*	55	*303.43*	350	*1930.92*	580	*3199.80*	25	*137.92*	1020	*5627.24*
		C01.3-L	29-Sep-12	2059	1.60	41	*44.80*	38	*41.53*	300	*327.83*	110	*120.20*	114	*124.58*	603	*658.94*
		C02.8-L	30-Sep-12	1320	0.88	0	*0.00*	0	*0.00*	75	*232.44*	10	*30.99*	58	*179.75*	143	*443.18*
		C03.6-L	30-Sep-12	2609	2.09	4	*2.64*	5	*3.30*	83	*54.80*	48	*31.69*	115	*75.92*	255	*168.35*
		C04.6-R	30-Sep-12	830	0.52	0	*0.00*	0	*0.00*	30	*250.23*	0	*0.00*	17	*141.80*	47	*392.03*
		C05.6-L	30-Sep-12	1261	1.10	2	*5.19*	0	*0.00*	70	*181.67*	21	*54.50*	44	*114.20*	137	*355.56*
		C07.3-R	29-Sep-12	934	1.70	1	*2.27*	0	*0.00*	0	*0.00*	6	*13.60*	34	*77.09*	41	*92.96*
		C07.4-L	29-Sep-12	1027	1.00	2	*7.01*	0	*0.00*	0	*0.00*	0	*0.00*	85	*297.96*	87	*304.97*
	Session 1 Summary			**1380**	**10.42**	**145**	***36.29***	**108**	***27.03***	**2938**	***735.31***	**1025**	***256.53***	**593**	***148.41***	**4809**	***1203.57***
	2	C00.0-R	05-Oct-12	1140	0.94	4	*13.44*	20	*67.19*	310	*1041.43*	580	*1948.49*	10	*33.59*	924	*3104.14*
		C00.7-L	05-Oct-12	647	0.59	5	*47.15*	40	*377.23*	30	*282.92*	262	*2470.86*	28	*264.06*	365	*3442.22*
		C01.3-L	05-Oct-12	1845	1.60	12	*14.63*	52	*63.41*	17	*20.73*	93	*113.41*	113	*137.80*	287	*350.00*
		C02.8-L	06-Oct-12	950	0.88	4	*17.22*	2	*8.61*	5	*21.53*	50	*215.31*	43	*185.17*	104	*447.85*
		C03.6-L	06-Oct-12	2371	2.09	12	*8.72*	43	*31.24*	2	*1.45*	200	*145.30*	127	*92.26*	384	*278.97*
		C04.6-R	07-Oct-12	378	0.52	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	10	*183.15*	10	*183.15*
		C05.6-L	07-Oct-12	1209	1.10	1	*2.71*	2	*5.41*	101	*273.40*	110	*297.77*	36	*97.45*	250	*676.74*
		C07.3-R	07-Oct-12	866	1.70	0	*0.00*	5	*12.23*	0	*0.00*	0	*0.00*	21	*51.35*	26	*63.58*
		C07.4-L	07-Oct-12	970	1.00	0	*0.00*	1	*3.71*	20	*74.23*	100	*371.13*	55	*204.12*	176	*653.20*
	Session 2 Summary			**1153**	**10.42**	**38**	***11.39***	**165**	***49.45***	**485**	***145.34***	**1395**	***418.04***	**443**	***132.76***	**2526**	***756.97***
	3	C00.0-R	12-Oct-12	887	0.94	3	*12.95*	24	*103.62*	233	*1006.02*	162	*699.47*	8	*34.54*	430	*1856.60*
		C00.7-L	12-Oct-12	490	0.59	26	*323.76*	35	*435.84*	10	*124.52*	135	*1681.08*	6	*74.71*	212	*2639.92*
		C01.3-L	12-Oct-12	2021	1.60	50	*55.67*	64	*71.25*	26	*28.95*	105	*116.90*	82	*91.29*	327	*364.05*
		C02.8-L	12-Oct-12	913	0.88	8	*35.85*	6	*26.88*	20	*89.61*	45	*201.63*	112	*501.84*	191	*855.82*
		C03.6-L	13-Oct-12	2550	2.09	36	*24.32*	5	*3.38*	10	*6.75*	190	*128.34*	124	*83.76*	365	*246.55*
		C04.6-R	13-Oct-12	429	0.52	5	*80.69*	0	*0.00*	0	*0.00*	12	*193.65*	21	*338.89*	38	*613.23*
		C05.6-L	13-Oct-12	1476	1.10	25	*55.43*	0	*0.00*	16	*35.48*	185	*410.20*	102	*226.16*	328	*727.27*
		C07.3-R	13-Oct-12	870	1.70	5	*12.17*	0	*0.00*	0	*0.00*	110	*267.75*	13	*31.64*	128	*311.56*
		C07.4-L	13-Oct-12	1101	1.00	47	*153.68*	1	*3.27*	50	*163.49*	75	*245.23*	90	*294.28*	263	*859.95*
	Session 3 Summary			**1193**	**10.42**	**205**	***59.37***	**135**	***39.10***	**365**	***105.70***	**1019**	***295.10***	**558**	***161.60***	**2282**	***660.86***
	4	C00.0-R	20-Oct-12	1168	0.94	3	*9.84*	20	*65.58*	20	*65.58*	9	*29.51*	2	*6.56*	54	*177.06*
		C00.7-L	20-Oct-12	636	0.59	1	*9.59*	25	*239.85*	15	*143.91*	0	*0.00*	3	*28.78*	44	*422.13*
		C01.3-L	20-Oct-12	2310	1.60	17	*16.56*	11	*10.71*	15	*14.61*	100	*97.40*	47	*45.78*	190	*185.06*
		C02.8-L	20-Oct-12	820	0.88	2	*9.98*	0	*0.00*	0	*0.00*	0	*0.00*	5	*24.94*	7	*34.92*
		C03.6-L	21-Oct-12	2704	2.09	3	*1.91*	0	*0.00*	11	*7.01*	30	*19.11*	22	*14.01*	66	*42.04*
		C04.6-R	21-Oct-12	708	0.52	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	21	*205.35*	21	*205.35*
		C05.6-L	21-Oct-12	1268	1.10	0	*0.00*	0	*0.00*	0	*0.00*	26	*67.11*	49	*126.47*	75	*193.58*
		C07.3-R	22-Oct-12	702	1.70	2	*6.03*	2	*6.03*	2	*6.03*	10	*30.17*	5	*15.08*	21	*63.35*
		C07.4-L	22-Oct-12	1066	1.00	1	*3.38*	7	*23.64*	0	*0.00*	15	*50.66*	24	*81.05*	47	*158.72*
	Session 4 Summary			**1265**	**10.42**	**29**	***7.92***	**65**	***17.76***	**63**	***17.21***	**190**	***51.91***	**178**	***48.63***	**525**	***143.42***
	5	C06.7-L	22-Oct-12	638	0.66	4	*34.20*	0	*0.00*	25	*213.74*	0	*0.00*	55	*470.22*	84	*718.15*
		C09.2-L	22-Oct-12	783	0.81	0	*0.00*	0	*0.00*	15	*85.14*	5	*28.38*	1	*5.68*	21	*119.20*
	Session 5 Summary			**711**	**1.47**	**4**	***13.79***	**0**	***0.00***	**40**	***137.87***	**5**	***17.23***	**56**	***193.02***	**105**	***361.92***
Columbia River U/S Section Total All Samples				**46340**	**43.15**	**421**		**473**		**3891**		**3634**		**1828**		**10247**	
Columbia River U/S Section Average All Samples				**1219**	**1.14**	**11**	***28.80***	**12**	***32.36***	**102**	***266.20***	**96**	***248.62***	**48**	***125.06***	**270**	***701.05***
Columbia River U/S Section Standard Error of Mean						**2.98**	***11.07***	**2.98**	***17.22***	**54.14**	***166.75***	**22.35**	***118.04***	**6.67**	***19.99***	**70.42**	***255.04***
Kootenay River																	
	1	K00.3-L	28-Sep-12	241	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	23	*780.84*	23	*780.84*
		K00.6-R	29-Sep-12	601	0.60	10	*99.83*	0	*0.00*	0	*0.00*	20	*199.67*	12	*119.80*	42	*419.30*
		K01.8-L	28-Sep-12	1645	1.87	50	*58.51*	4	*4.68*	0	*0.00*	235	*275.02*	60	*70.22*	349	*408.43*
		K01.8-R	28-Sep-12	1338	1.30	29	*60.02*	0	*0.00*	0	*0.00*	75	*155.23*	69	*142.81*	173	*358.05*
	Session 1 Summary			**956**	**4.21**	**89**	***79.59***	**4**	***3.58***	**0**	***0.00***	**330**	***295.10***	**164**	***146.65***	**587**	***524.91***
	2	K00.3-L	06-Oct-12	271	0.44	0	*0.00*	0	*0.00*	0	*0.00*	4	*120.76*	10	*301.91*	14	*422.68*
		K00.6-R	06-Oct-12	642	0.60	5	*46.73*	0	*0.00*	15	*140.19*	156	*1457.94*	54	*504.67*	230	*2149.53*
		K01.8-L	06-Oct-12	1694	1.87	19	*21.59*	3	*3.41*	200	*227.29*	152	*172.74*	72	*81.82*	446	*506.85*
		K01.8-R	06-Oct-12	1420	1.30	0	*0.00*	0	*0.00*	50	*97.51*	300	*585.05*	26	*50.70*	376	*733.26*
	Session 2 Summary			**1007**	**4.21**	**24**	***20.38***	**3**	***2.55***	**265**	***225.08***	**612**	***519.82***	**162**	***137.60***	**1066**	***905.43***
	3	K00.3-L	14-Oct-12	299	0.44	1	*27.36*	0	*0.00*	0	*0.00*	0	*0.00*	10	*273.64*	11	*301.00*
		K00.6-R	14-Oct-12	576	0.60	4	*41.67*	0	*0.00*	10	*104.17*	65	*677.08*	120	*1250.00*	199	*2072.92*
		K01.8-L	14-Oct-12	1719	1.87	42	*47.04*	1	*1.12*	120	*134.39*	655	*733.54*	101	*113.11*	919	*1029.20*
		K01.8-R	14-Oct-12	1142	1.30	4	*9.70*	0	*0.00*	41	*99.42*	0	*0.00*	80	*193.99*	125	*303.11*
	Session 3 Summary			**934**	**4.21**	**51**	***46.69***	**1**	***0.92***	**171**	***156.56***	**720**	***659.18***	**311**	***284.73***	**1254**	***1148.08***
	4	K00.3-L	21-Oct-12	263	0.44	5	*155.55*	0	*0.00*	2	*62.22*	50	*1555.48*	6	*186.66*	63	*1959.90*
		K00.6-R	21-Oct-12	583	0.60	16	*164.67*	0	*0.00*	25	*257.29*	10	*102.92*	40	*411.66*	91	*936.54*
		K01.8-L	21-Oct-12	1522	1.82	13	*16.90*	4	*5.20*	6	*7.80*	205	*266.42*	57	*74.08*	285	*370.39*
		K01.8-R	21-Oct-12	1193	1.30	7	*16.25*	0	*0.00*	5	*11.61*	45	*104.46*	25	*58.03*	82	*190.34*
	Session 4 Summary			**890**	**4.16**	**41**	***39.85***	**4**	***3.89***	**38**	***36.94***	**310**	***301.34***	**128**	***124.42***	**521**	***506.45***
Kootenay River Section Total All Samples				**15149**	**16.79**	**205**		**12**		**474**		**1972**		**765**		**3428**	
Kootenay River Section Average All Samples				**947**	**1.05**	**13**	***46.42***	**1**	***2.72***	**30**	***107.34***	**123**	***446.58***	**48**	***173.24***	**214**	***776.30***
Kootenay River Section Standard Error of Mean						**3.82**	***12.85***	**0.37**	***0.45***	**13.78**	***21.25***	**42.60**	***122.40***	**8.65**	***81.01***	**58.20**	***166.28***

Table E3 Continued.

Section	Session	Site	Date	Time Sampled (seconds)	Length Sampled (km)	Number Caught (CPUE=no. fish/km/h) [a]											
						Northern pikeminnow		Peamouth		Redside shiner		Sculpin spp.		Sucker spp.		All Species	
						No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*
Columbia River D/S																	
	1	C25.3-R	25-Sep-12	2219	2.73	0	*0.00*	0	*0.00*	2	*1.19*	55	*32.68*	11	*6.54*	68	*40.41*
		C27.6-R	25-Sep-12	346	0.61	0	*0.00*	0	*0.00*	0	*0.00*	34	*579.93*	2	*34.11*	36	*614.04*
		C28.2-R	26-Sep-12	939	1.13	0	*0.00*	0	*0.00*	0	*0.00*	25	*84.82*	9	*30.54*	34	*115.36*
		C34.9-L	24-Sep-12	2395	2.14	0	*0.00*	1	*0.70*	0	*0.00*	0	*0.00*	2	*1.40*	3	*2.11*
		C36.6-L	25-Sep-12	1830	2.39	1	*0.82*	0	*0.00*	2	*1.65*	5	*4.12*	0	*0.00*	8	*6.58*
		C47.8-L	27-Sep-12	1181	1.44	0	*0.00*	0	*0.00*	0	*0.00*	153	*323.88*	10	*21.17*	163	*345.05*
		C49.0-L	27-Sep-12	516	0.93	0	*0.00*	0	*0.00*	0	*0.00*	1	*7.50*	35	*262.57*	36	*270.07*
		C49.0-R	26-Sep-12	442	0.72	0	*0.00*	0	*0.00*	0	*0.00*	15	*169.68*	1	*11.31*	16	*181.00*
		C49.8-L	27-Sep-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	2200	*2100.49*	15	*14.32*	2215	*2114.81*
		C49.8-R	26-Sep-12	1117	2.39	1	*1.35*	0	*0.00*	5	*6.74*	0	*0.00*	96	*129.46*	102	*137.55*
		C52.2-L	28-Sep-12	807	0.89	0	*0.00*	0	*0.00*	0	*0.00*	5	*25.06*	5	*25.06*	10	*50.12*
		C52.2-R	27-Sep-12	2137	3.79	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	15	*6.67*	15	*6.67*
		C52.8-L	28-Sep-12	577	0.89	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*21.03*	3	*21.03*
		C53.6-L	28-Sep-12	933	1.72	0	*0.00*	0	*0.00*	0	*0.00*	2	*4.49*	0	*0.00*	2	*4.49*
	Session 1 Summary			**1213**	**24.22**	**2**	***0.25***	**1**	***0.12***	**9**	***1.10***	**2495**	***305.80***	**204**	***25.00***	**2711**	***332.28***
	2	C25.3-R	02-Oct-12	1898	2.73	0	*0.00*	1	*0.69*	0	*0.00*	320	*222.33*	12	*8.34*	333	*231.36*
		C27.6-R	02-Oct-12	342	0.61	0	*0.00*	0	*0.00*	0	*0.00*	20	*345.13*	0	*0.00*	20	*345.13*
		C28.2-R	02-Oct-12	916	1.13	0	*0.00*	0	*0.00*	2	*6.96*	95	*330.41*	4	*13.91*	101	*351.28*
		C34.9-L	01-Oct-12	2175	2.09	2	*1.58*	0	*0.00*	0	*0.00*	32	*25.34*	3	*2.38*	37	*29.30*
		C36.6-L	01-Oct-12	1592	2.19	4	*4.13*	1	*1.03*	25	*25.81*	67	*69.18*	1	*1.03*	98	*101.19*
		C47.8-L	04-Oct-12	1260	1.44	0	*0.00*	0	*0.00*	3	*5.95*	655	*1299.60*	17	*33.73*	675	*1339.29*
		C48.2-R	03-Oct-12	920	1.01	0	*0.00*	0	*0.00*	1	*3.87*	35	*135.60*	1	*3.87*	37	*143.35*
		C49.0-L	04-Oct-12	506	0.93	0	*0.00*	0	*0.00*	0	*0.00*	80	*612.01*	2	*15.30*	82	*627.31*
		C49.0-R	03-Oct-12	352	0.72	0	*0.00*	0	*0.00*	0	*0.00*	128	*1818.18*	0	*0.00*	128	*1818.18*
		C49.8-L	04-Oct-12	1539	2.45	0	*0.00*	0	*0.00*	15	*14.32*	760	*725.62*	51	*48.69*	826	*788.64*
		C49.8-R	03-Oct-12	1274	2.39	0	*0.00*	0	*0.00*	26	*30.74*	39	*46.11*	35	*41.38*	100	*118.23*
		C52.2-L	05-Oct-12	863	0.89	0	*0.00*	0	*0.00*	0	*0.00*	30	*140.61*	7	*32.81*	37	*173.42*
		C52.2-R	04-Oct-12	2308	3.79	1	*0.41*	0	*0.00*	0	*0.00*	116	*47.74*	10	*4.12*	127	*52.27*
		C52.8-L	05-Oct-12	603	0.89	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	5	*33.54*	5	*33.54*
		C53.6-L	05-Oct-12	1091	1.72	0	*0.00*	0	*0.00*	0	*0.00*	45	*86.33*	0	*0.00*	45	*86.33*
	Session 2 Summary			**1176**	**24.98**	**7**	***0.86***	**2**	***0.25***	**72**	***8.82***	**2422**	***296.83***	**148**	***18.14***	**2651**	***324.89***
	3	C25.3-R	09-Oct-12	1576	2.73	11	*9.20*	0	*0.00*	190	*158.98*	110	*92.04*	3	*2.51*	314	*262.73*
		C27.6-R	09-Oct-12	373	0.61	0	*0.00*	0	*0.00*	0	*0.00*	2	*31.64*	0	*0.00*	2	*31.64*
		C28.2-R	09-Oct-12	796	1.13	11	*44.03*	0	*0.00*	80	*320.18*	0	*0.00*	30	*120.07*	121	*484.28*
		C34.9-L	09-Oct-12	1811	2.14	2	*1.86*	0	*0.00*	50	*46.45*	150	*139.34*	0	*0.00*	202	*187.64*
		C36.6-L	10-Oct-12	1415	2.39	3	*3.19*	0	*0.00*	0	*0.00*	135	*143.71*	0	*0.00*	138	*146.90*
		C47.8-L	11-Oct-12	1256	1.44	1	*1.99*	0	*0.00*	2	*3.98*	540	*1074.84*	4	*7.96*	547	*1088.77*
		C48.2-R	10-Oct-12	956	1.01	1	*3.73*	0	*0.00*	2	*7.46*	108	*402.67*	3	*11.19*	114	*425.04*
		C49.0-L	11-Oct-12	505	0.93	0	*0.00*	0	*0.00*	0	*0.00*	205	*1571.38*	2	*15.33*	207	*1586.71*
		C49.0-R	10-Oct-12	666	0.72	0	*0.00*	0	*0.00*	0	*0.00*	155	*1163.66*	3	*22.52*	158	*1186.19*
		C49.8-L	11-Oct-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	1050	*1002.51*	8	*7.64*	1058	*1010.14*
		C49.8-R	10-Oct-12	1406	2.39	14	*15.00*	0	*0.00*	0	*0.00*	212	*227.12*	58	*62.14*	284	*304.25*
		C52.2-L	12-Oct-12	806	0.89	0	*0.00*	0	*0.00*	0	*0.00*	30	*150.56*	70	*351.30*	100	*501.85*
		C52.2-R	11-Oct-12	2305	3.79	0	*0.00*	0	*0.00*	0	*0.00*	70	*28.85*	4	*1.65*	74	*30.49*
		C53.6-L	12-Oct-12	1008	1.72	0	*0.00*	0	*0.00*	0	*0.00*	250	*519.10*	1	*2.08*	251	*521.18*
	Session 3 Summary			**1173**	**24.34**	**43**	***5.42***	**0**	***0.00***	**324**	***40.86***	**3017**	***380.51***	**186**	***23.46***	**3570**	***450.25***
	4	C25.3-R	16-Oct-12	1898	2.73	1	*0.69*	0	*0.00*	540	*375.18*	237	*164.66*	7	*4.86*	785	*545.40*
		C27.6-R	16-Oct-12	324	0.61	0	*0.00*	0	*0.00*	0	*0.00*	3	*54.64*	0	*0.00*	3	*54.64*
		C28.2-R	16-Oct-12	1205	1.13	0	*0.00*	0	*0.00*	0	*0.00*	275	*727.06*	28	*74.03*	303	*801.09*
		C34.9-L	17-Oct-12	1943	2.14	0	*0.00*	0	*0.00*	3	*2.60*	20	*17.32*	8	*6.93*	31	*26.84*
		C36.6-L	17-Oct-12	1459	2.39	2	*2.06*	0	*0.00*	0	*0.00*	230	*237.45*	7	*7.23*	239	*246.74*
		C47.8-L	17-Oct-12	1274	1.44	3	*5.89*	0	*0.00*	2	*3.92*	823	*1614.99*	3	*5.89*	832	*1632.65*
		C48.2-R	18-Oct-12	807	1.01	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*8.83*	2	*8.83*
		C49.0-L	17-Oct-12	520	0.93	0	*0.00*	0	*0.00*	0	*0.00*	70	*521.09*	5	*37.22*	75	*558.31*
		C49.0-R	18-Oct-12	526	0.72	0	*0.00*	0	*0.00*	3	*28.52*	25	*237.64*	1	*9.51*	29	*275.67*
		C49.8-L	17-Oct-12	1539	2.45	0	*0.00*	0	*0.00*	0	*0.00*	520	*496.48*	6	*5.73*	526	*502.21*
		C49.8-R	18-Oct-12	1299	2.39	0	*0.00*	0	*0.00*	2	*2.32*	132	*153.06*	40	*46.38*	174	*201.76*
		C52.2-L	18-Oct-12	751	0.89	0	*0.00*	0	*0.00*	0	*0.00*	20	*107.72*	0	*0.00*	20	*107.72*
		C52.2-R	18-Oct-12	2062	3.79	0	*0.00*	0	*0.00*	0	*0.00*	140	*64.49*	5	*2.30*	145	*66.79*
		C52.8-L	18-Oct-12	571	0.89	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	7	*49.59*	7	*49.59*
		C53.6-L	18-Oct-12	1001	1.72	1	*2.09*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*2.09*
	Session 4 Summary			**1145**	**25.23**	**7**	***0.87***	**0**	***0.00***	**550**	***68.52***	**2495**	***310.85***	**119**	***14.83***	**3172**	***395.20***
	5	C10.7-R	22-Oct-12	940	0.91	0	*0.00*	0	*0.00*	0	*0.00*	20	*84.17*	12	*50.50*	32	*134.67*
		C10.9-L	22-Oct-12	700	2.18	0	*0.00*	3	*7.08*	0	*0.00*	0	*0.00*	27	*63.70*	30	*70.77*
		C13.4-R	23-Oct-12	1907	2.52	3	*2.25*	1	*0.75*	5	*3.75*	61	*45.70*	8	*5.99*	78	*58.43*
		C14.8-L	23-Oct-12	2164	2.26	9	*6.62*	11	*8.10*	30	*22.08*	160	*117.78*	9	*6.62*	219	*161.21*
		C16.6-R	23-Oct-12	1361	1.44	0	*0.00*	5	*9.18*	0	*0.00*	60	*110.21*	18	*33.06*	83	*152.46*
		C18.0-R	24-Oct-12	710	0.85	2	*11.93*	7	*41.76*	0	*0.00*	120	*715.82*	16	*95.44*	145	*864.95*
		C21.8-R	24-Oct-12	1107	1.27	0	*0.00*	0	*0.00*	10	*25.61*	40	*102.43*	25	*64.02*	75	*192.05*
		C23.4-L	24-Oct-12	743	0.93	0	*0.00*	0	*0.00*	5	*26.05*	37	*192.77*	8	*41.68*	50	*260.50*
		C28.8-L	24-Oct-12	524	0.82	0	*0.00*	0	*0.00*	0	*0.00*	25	*209.46*	0	*0.00*	25	*209.46*
		C32.0-R	24-Oct-12	1105	1.37	1	*2.38*	0	*0.00*	0	*0.00*	0	*0.00*	3	*7.13*	4	*9.51*
		C34.9-R	25-Oct-12	864	0.89	0	*0.00*	0	*0.00*	0	*0.00*	10	*46.82*	3	*14.04*	13	*60.86*
		C36.9-R	25-Oct-12	1317	2.27	0	*0.00*	0	*0.00*	0	*0.00*	30	*36.13*	2	*2.41*	33	*39.74*
		C39.2-R	25-Oct-12	736	1.18	0	*0.00*	0	*0.00*	0	*0.00*	20	*82.90*	0	*0.00*	20	*82.90*
		C41.1-L	25-Oct-12	1754	2.41	0	*0.00*	2	*1.70*	0	*0.00*	18	*15.33*	0	*0.00*	20	*17.03*
		C44.6-L	25-Oct-12	755	1.01	0	*0.00*	2	*9.44*	0	*0.00*	210	*991.41*	14	*66.09*	226	*1066.95*
		C46.4-L	25-Oct-12	1178	1.59	0	*0.00*	0	*0.00*	0	*0.00*	20	*38.44*	11	*21.14*	31	*59.58*
		C47.2-R	26-Oct-12	678	1.06	1	*5.01*	0	*0.00*	0	*0.00*	20	*100.18*	0	*0.00*	21	*105.19*
		C56.0-L	19-Oct-12	781	0.94	0	*0.00*	0	*0.00*	0	*0.00*	225	*1103.33*	0	*0.00*	225	*1103.33*
	Session 5 Summary			**1074**	**25.90**	**16**	***2.07***	**31**	***4.01***	**50**	***6.47***	**1076**	***139.31***	**156**	***20.20***	**1330**	***172.20***
Columbia River D/S Section Total All Samples				**87538**	**124.67**	**75**		**34**		**1005**		**11505**		**813**		**13434**	
Columbia River D/S Section Average All Samples				**1152**	**1.64**	**1**	***1.88***	**0**	***0.85***	**13**	***25.20***	**151**	***288.43***	**11**	***20.38***	**177**	***336.79***
Columbia River D/S Section Standard Error of Mean						**0.30**	***0.64***	**0.19**	***0.59***	**7.56**	***6.74***	**35.68**	***54.08***	**1.95**	***6.21***	**36.81**	***53.91***
All Sections Total All Samples				**149027**	**184.61**	**701**		**519**		**5370**		**17111**		**3406**		**27109**	
All Sections Average All Samples				**1146**	**1.42**	**5**	***11.92***	**4**	***8.83***	**41**	***91.35***	**132**	***291.07***	**26**	***57.94***	**209**	***461.15***
All Sections Standard Error of Mean						**1.09**	***3.93***	**0.99**	***5.38***	**16.74**	***50.11***	**22.48**	***48.83***	**2.95**	***14.19***	**30.63**	***85.91***

[a] **Excludes 1 longnose dace captured on 17 October 2012 at Site C47.8-L and 1 longnose dace captured on 25 October 2012 at Site C36.9-R).**

APPENDIX F

Life History Summaries

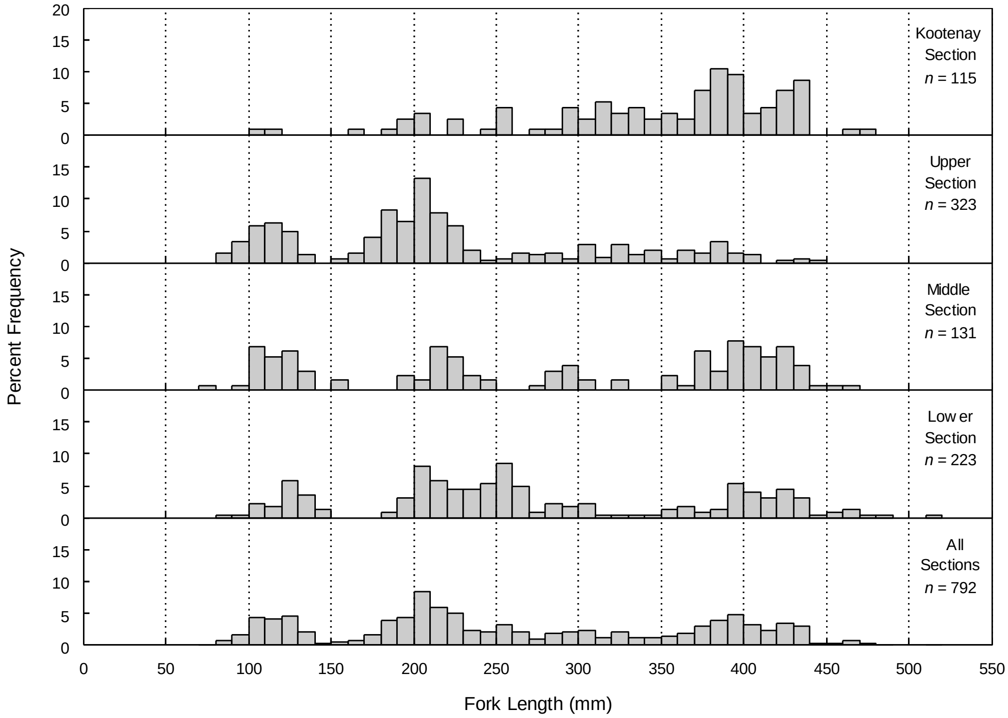


Figure F1. Length-frequency distributions by site for Mountain Whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, September 24 to October 26, 2012.

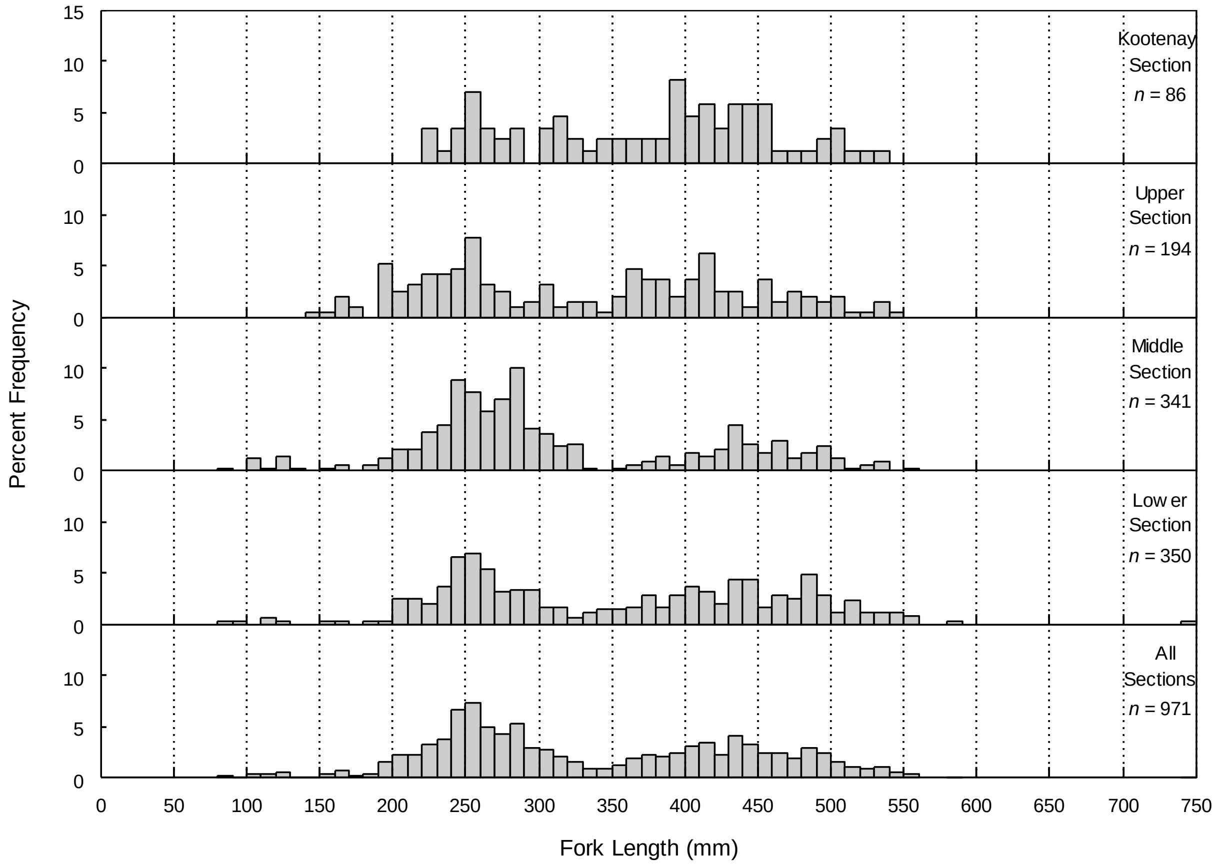


Figure F2. Length-frequency distributions by site for Rainbow Trout captured by boat electroshocking in sampled sections of the Lower Columbia River, September 24 to October 26, 2012.

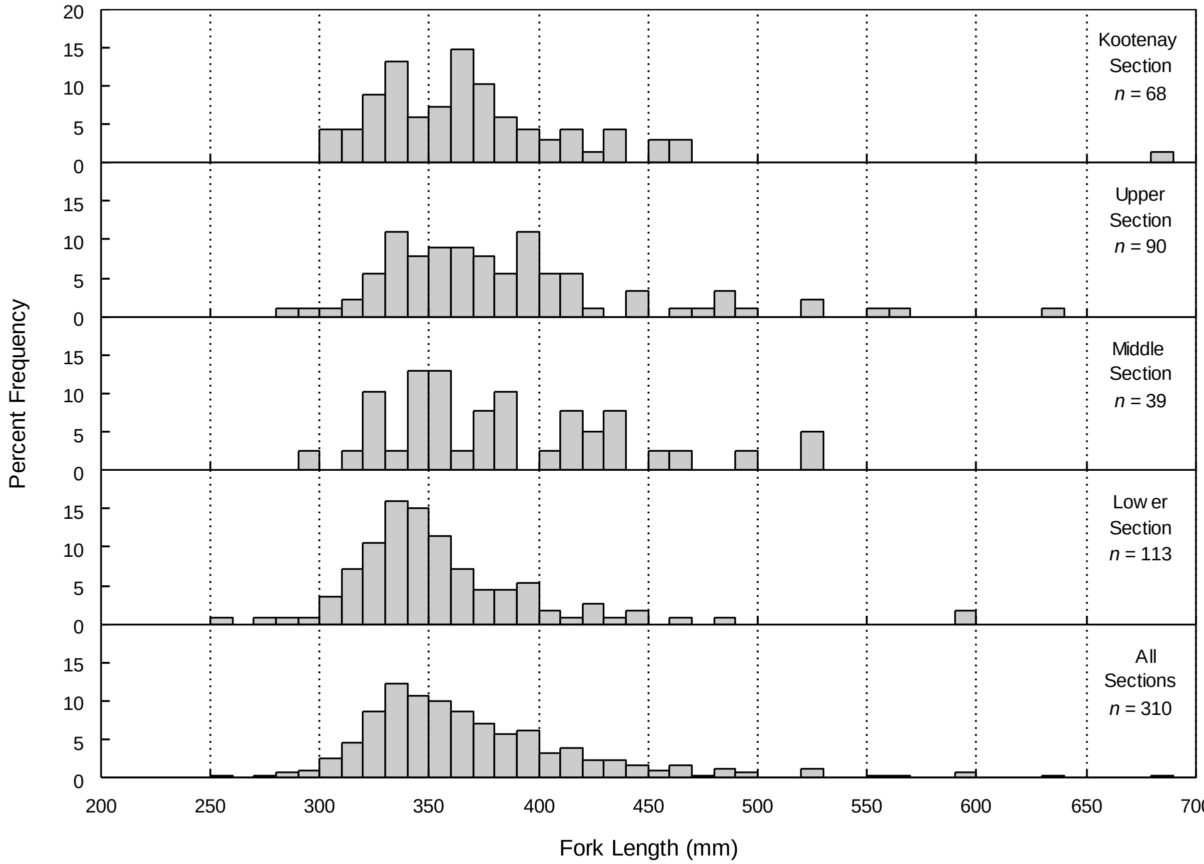


Figure F3. Length-frequency distributions by site for Walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, September 24 to October 26, 2012.

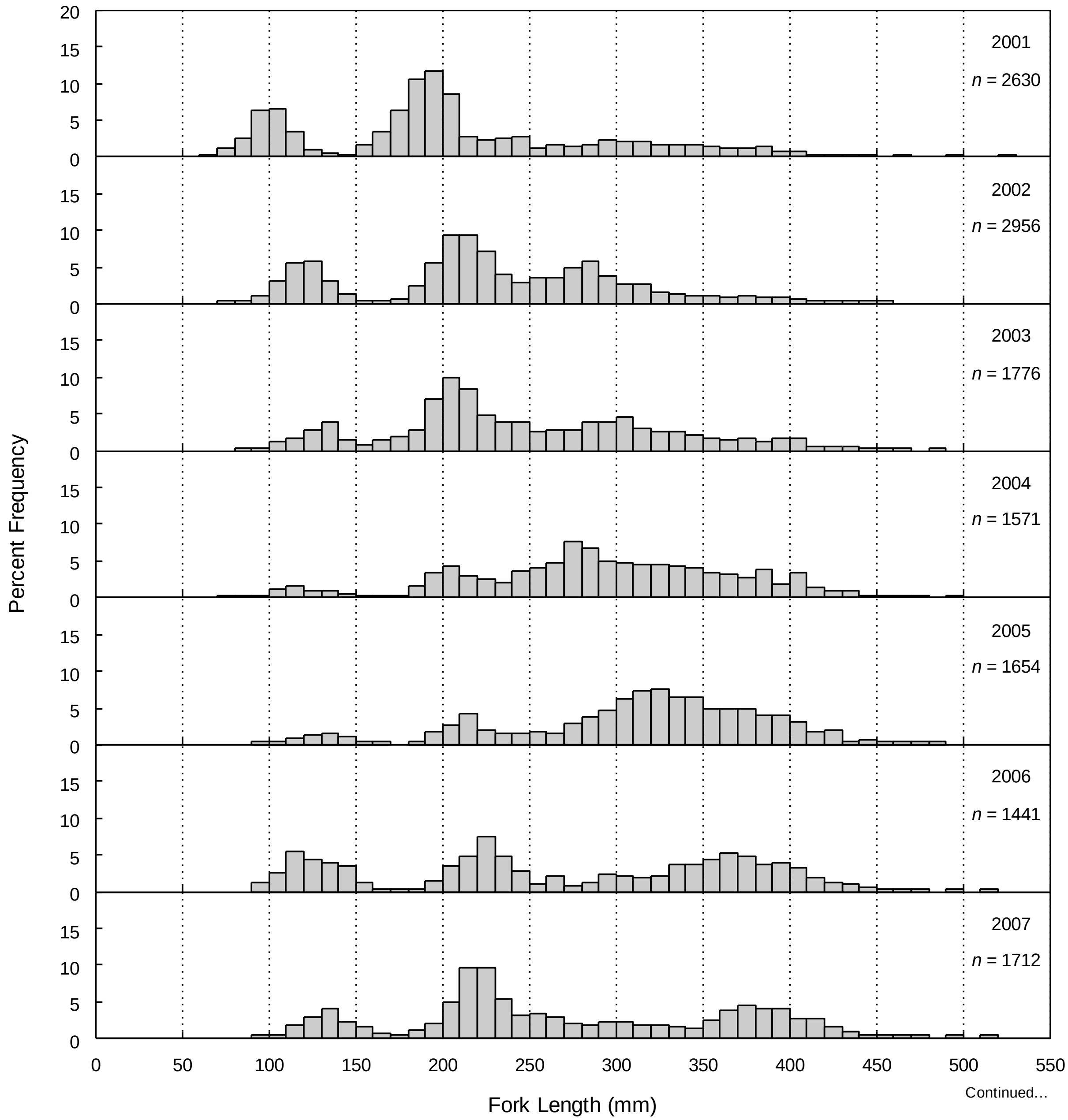


Figure F4. Length-frequency distributions by year for Mountain Whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2012.

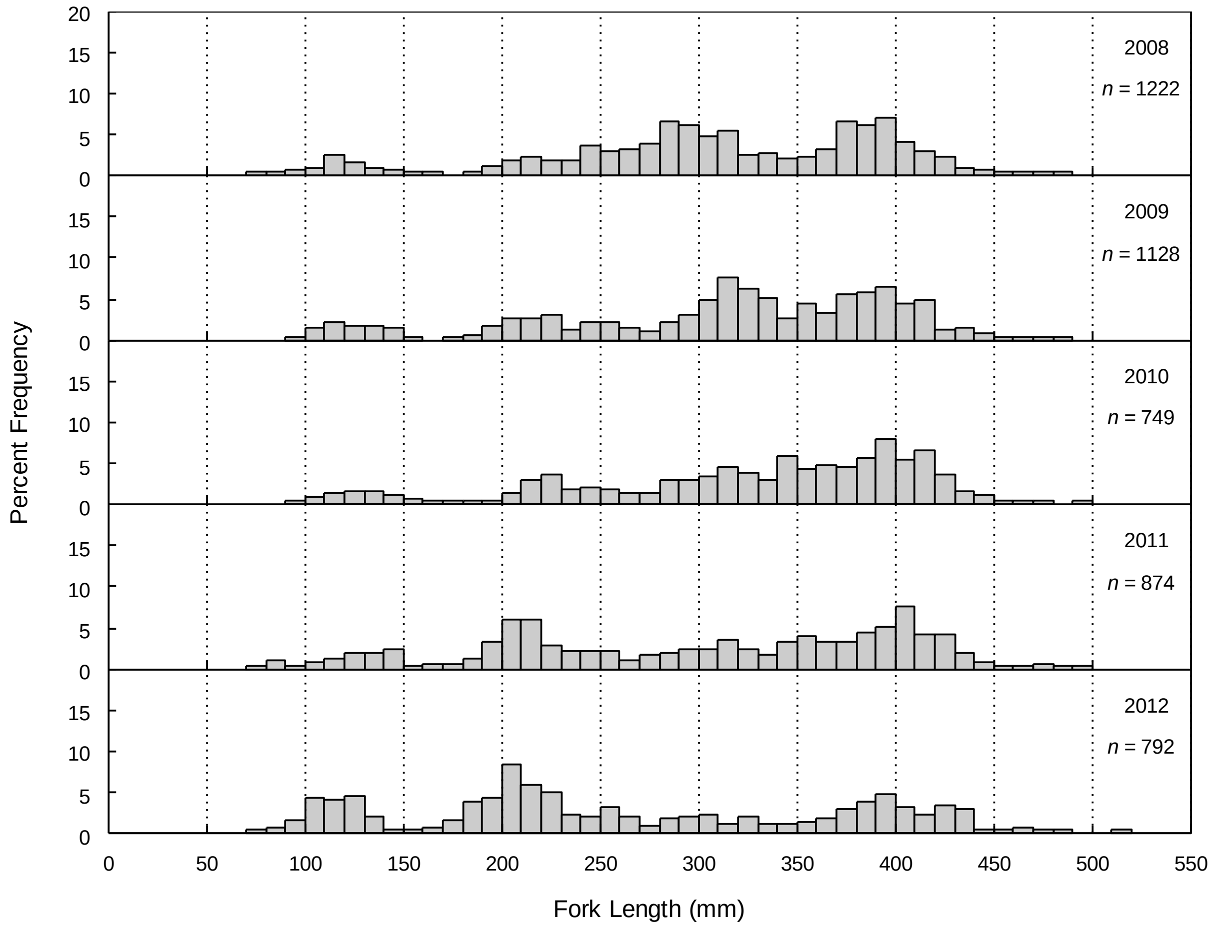


Figure F4. Concluded.

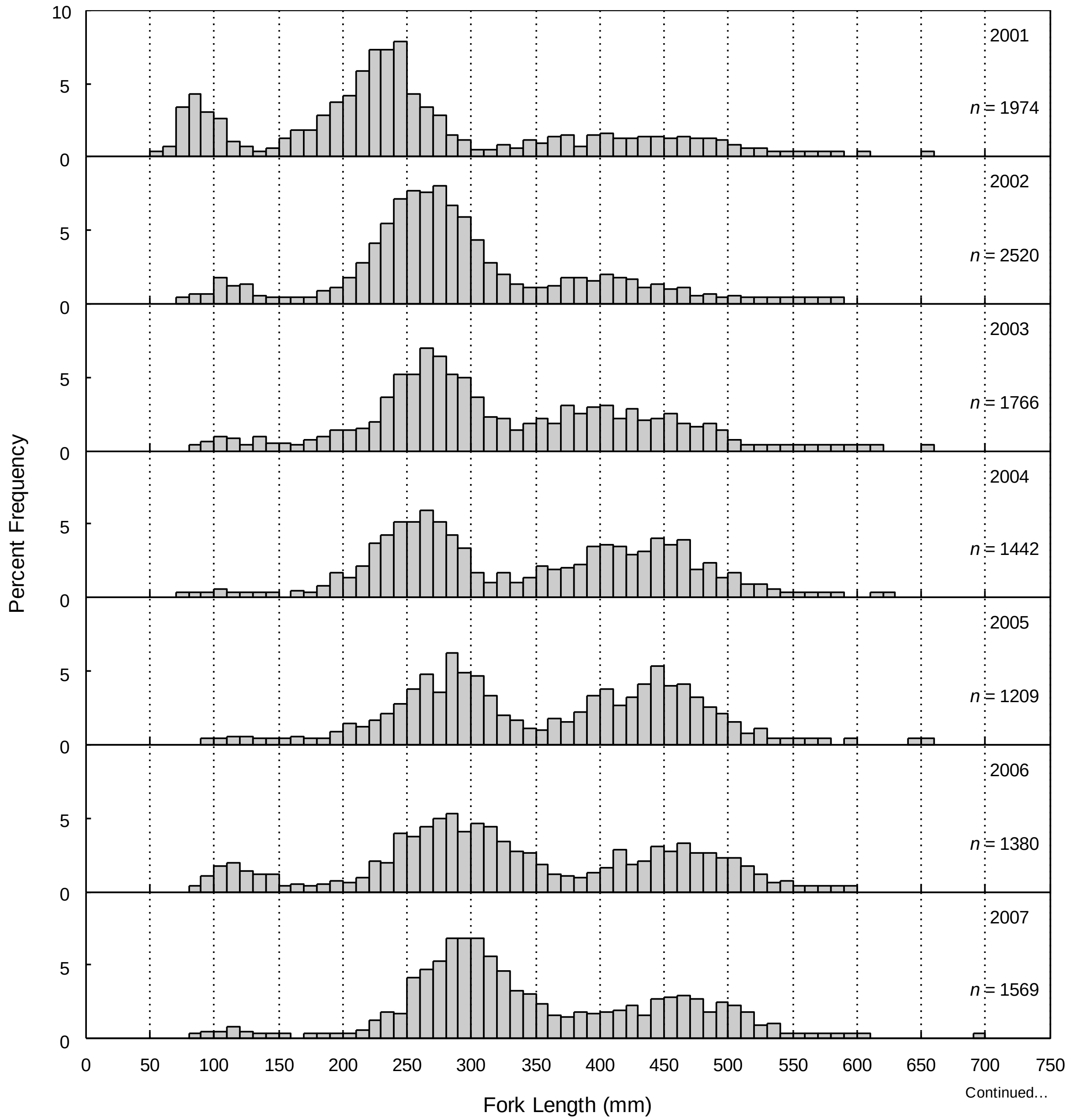


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Figure F5. Length-frequency distributions by year for Rainbow Trout captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2012.

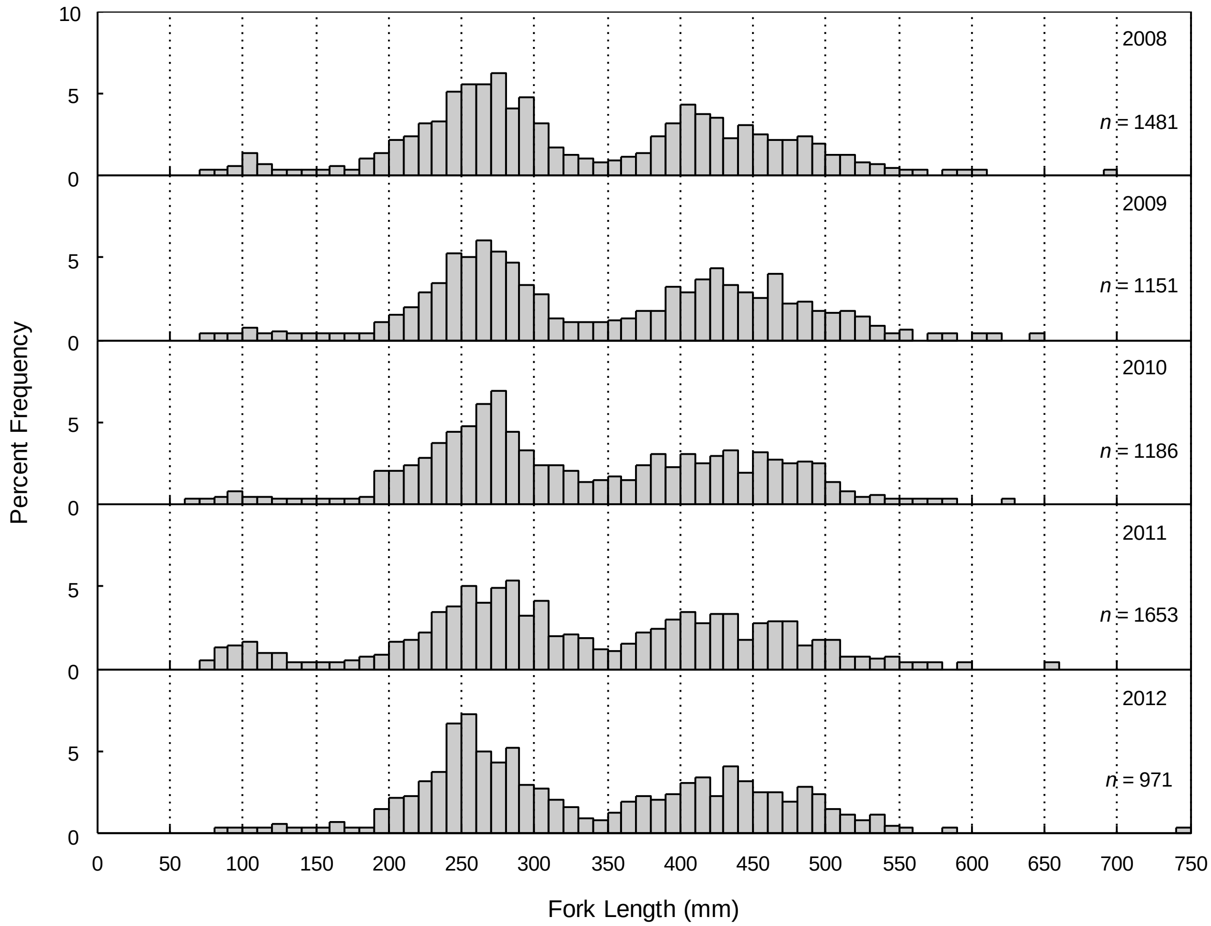

Figure F5. Concluded.

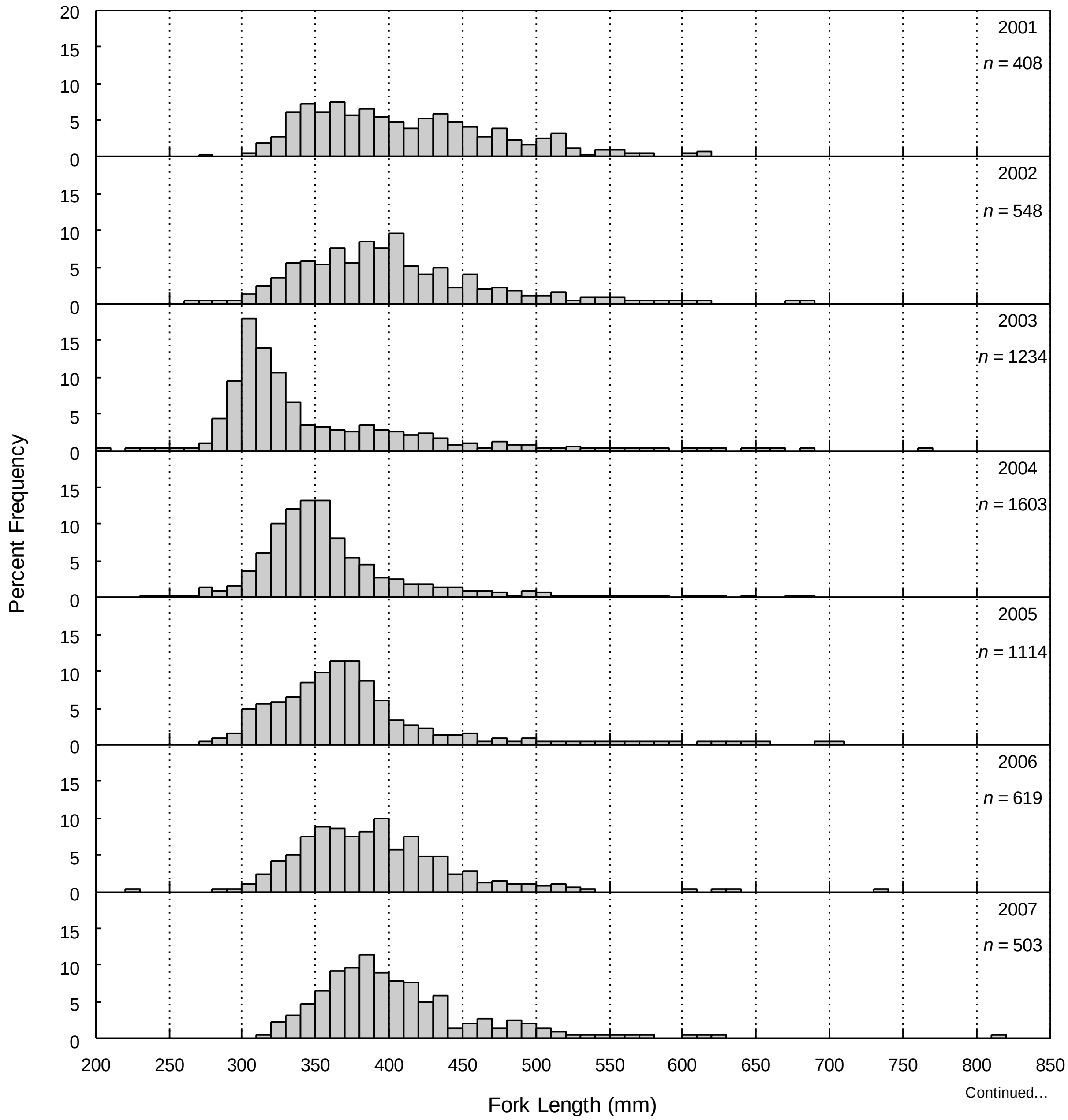

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Figure F6. Length-frequency distributions by year for Walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2012.

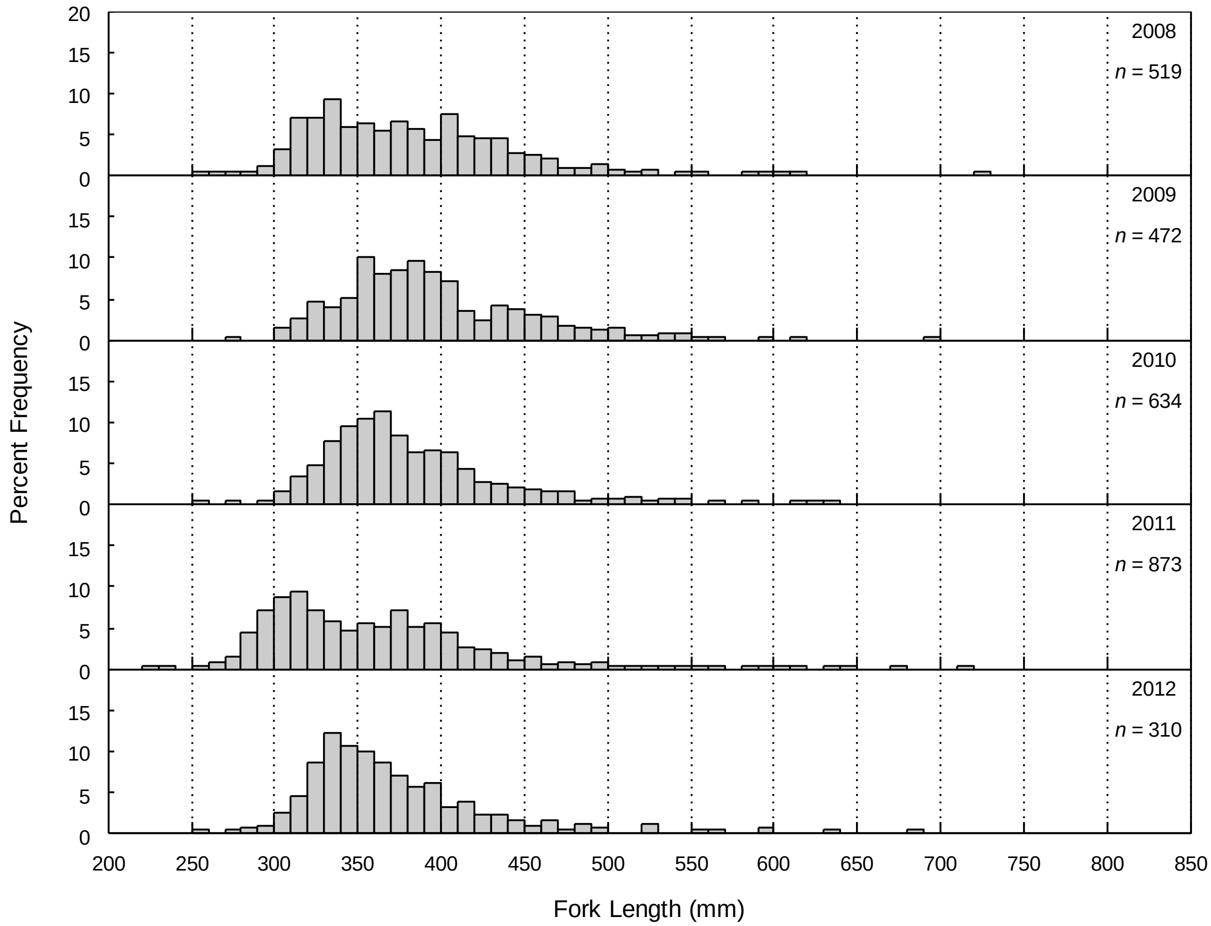

Figure F6. Concluded.

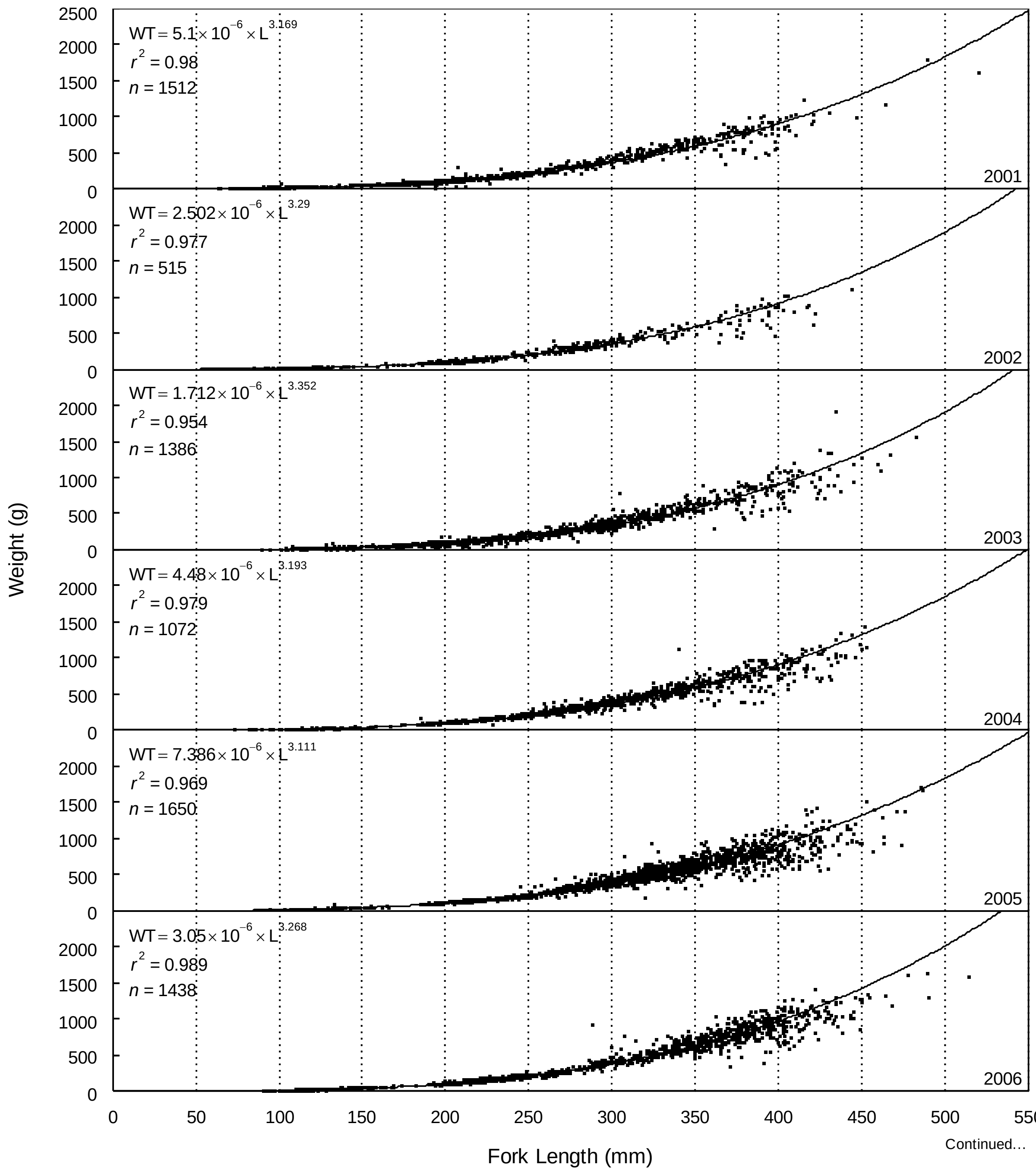

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Figure F7. Length-weight regressions for Mountain Whitefish captured by boat electroshocking in the Lower Columbia River, 2001 to 2012.

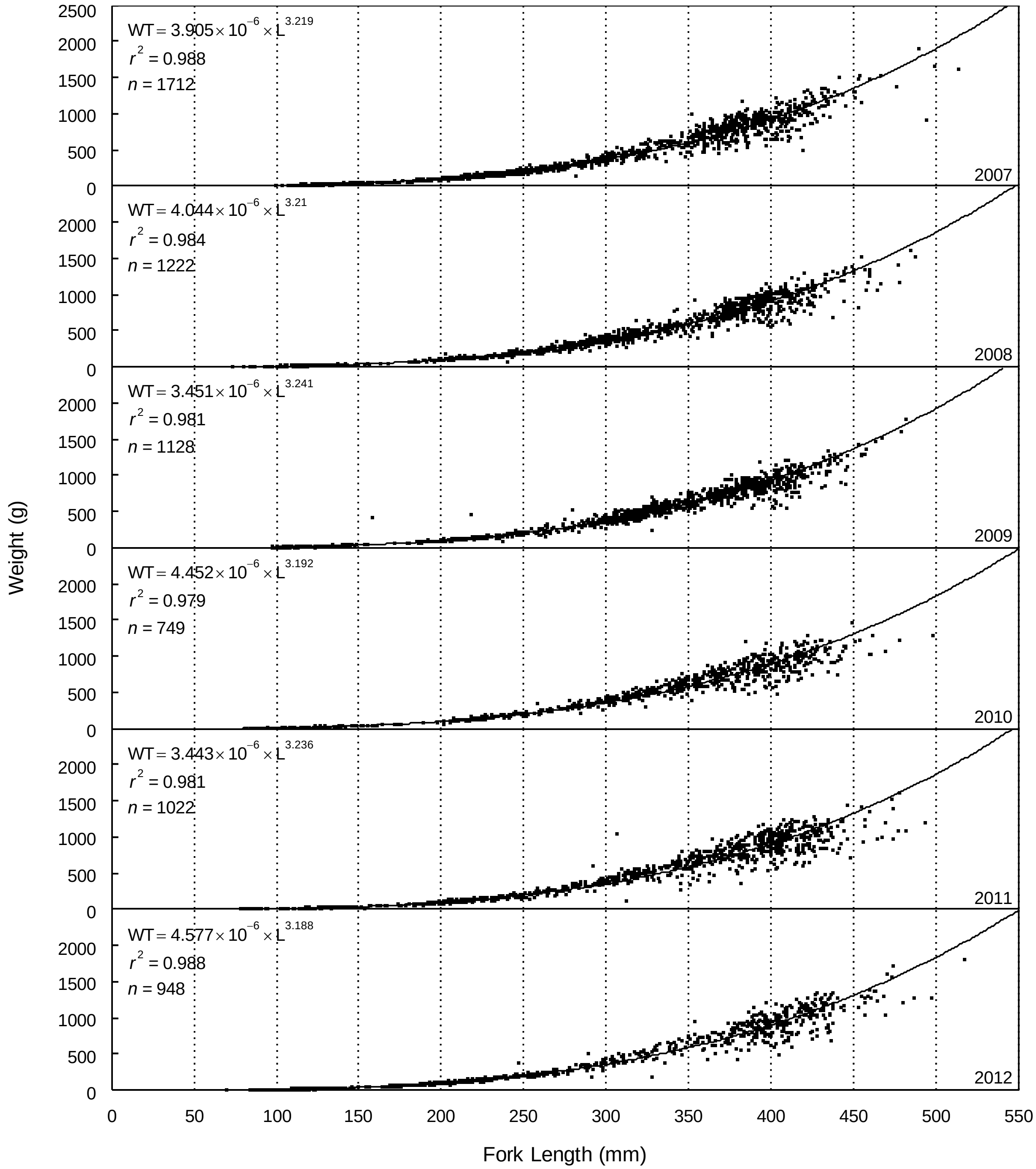
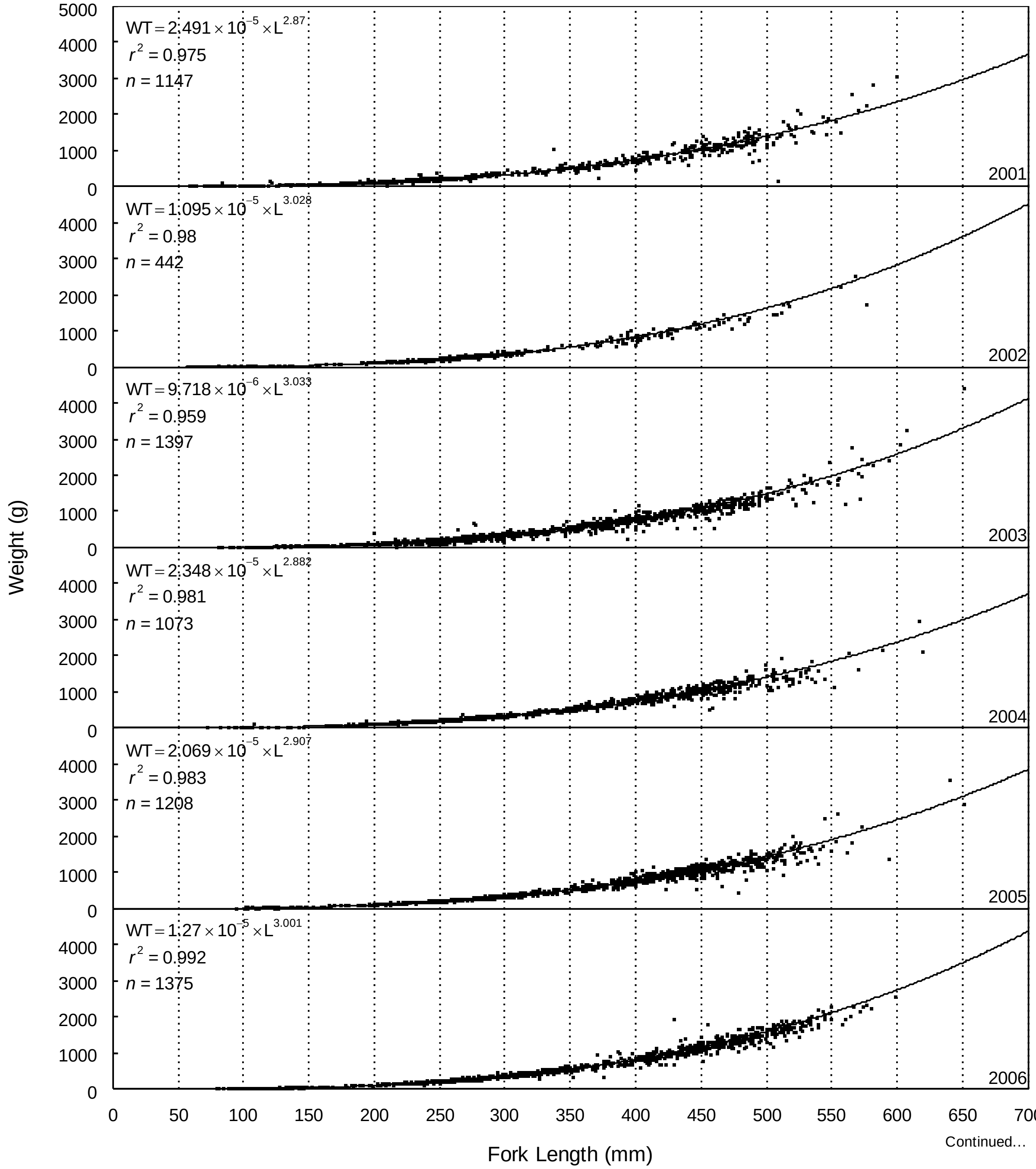


Figure F7. Concluded.



Continued…

Figure F8. Length-weight regressions for Rainbow Trout captured by boat electroshocking in the Lower Columbia River, 2001 to 2012.

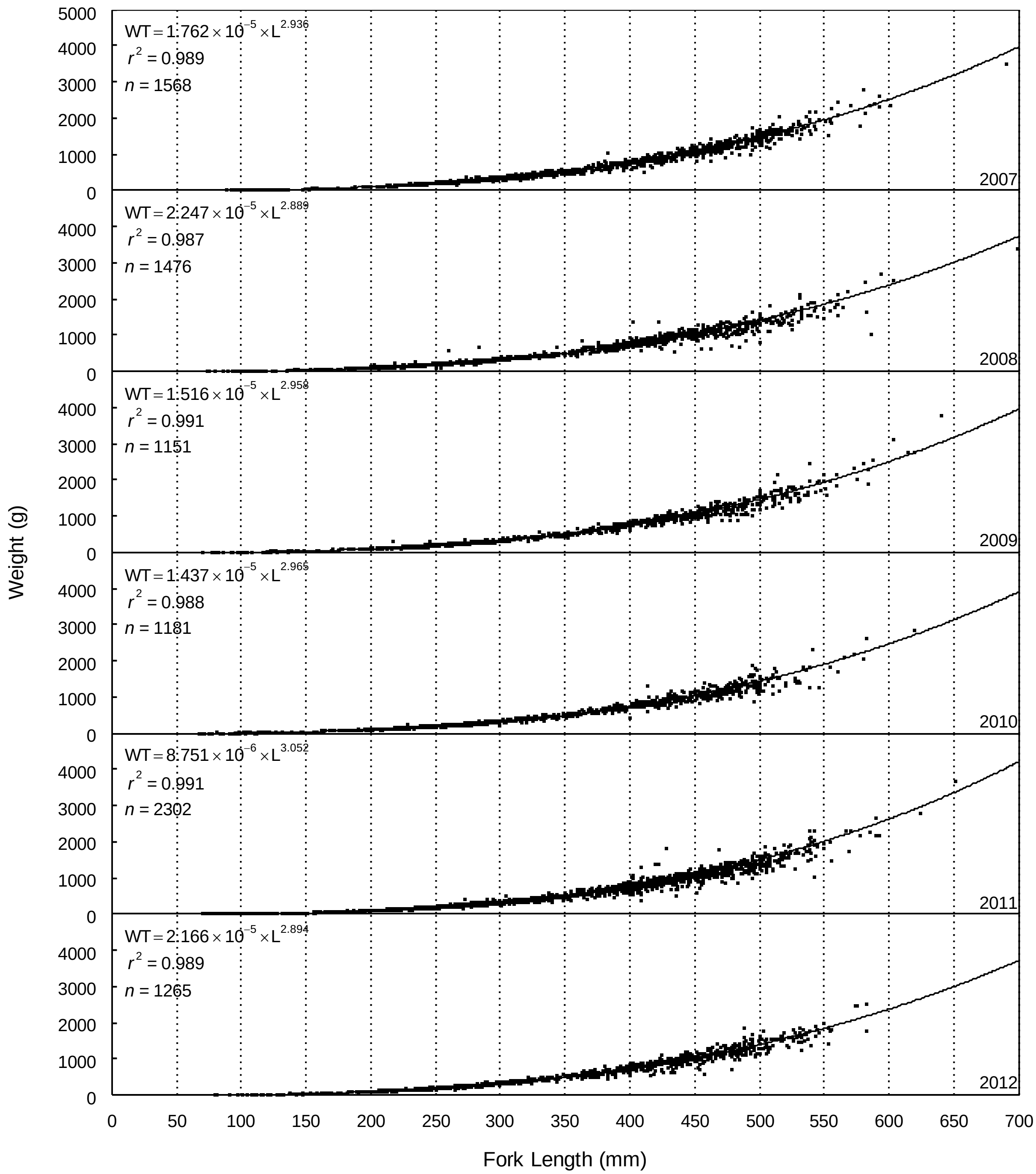


Figure F8. Concluded.

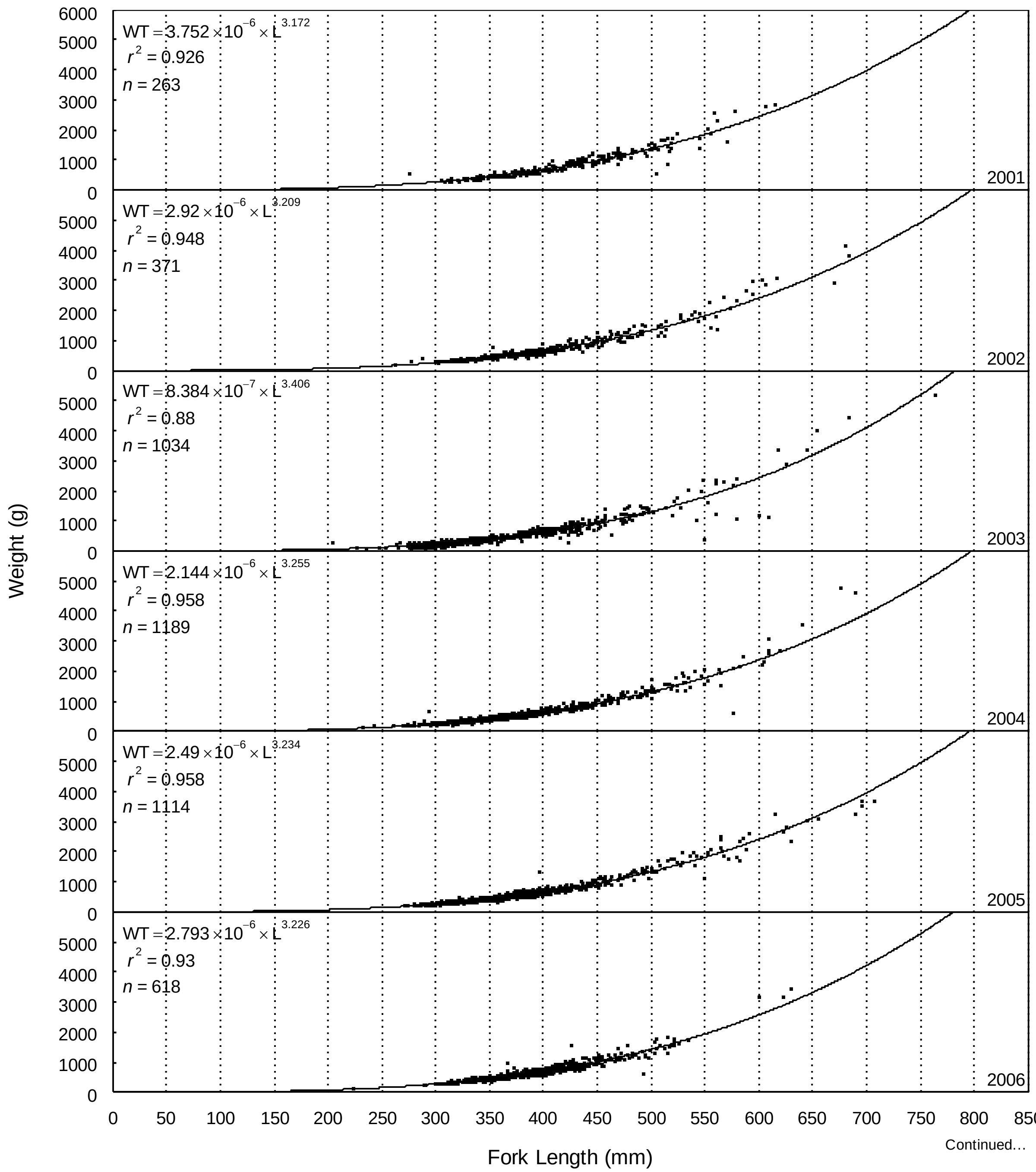


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Figure F9. Length-weight regressions for Walleye captured by boat electroshocking in the Lower Columbia River, 2001 to 2012.

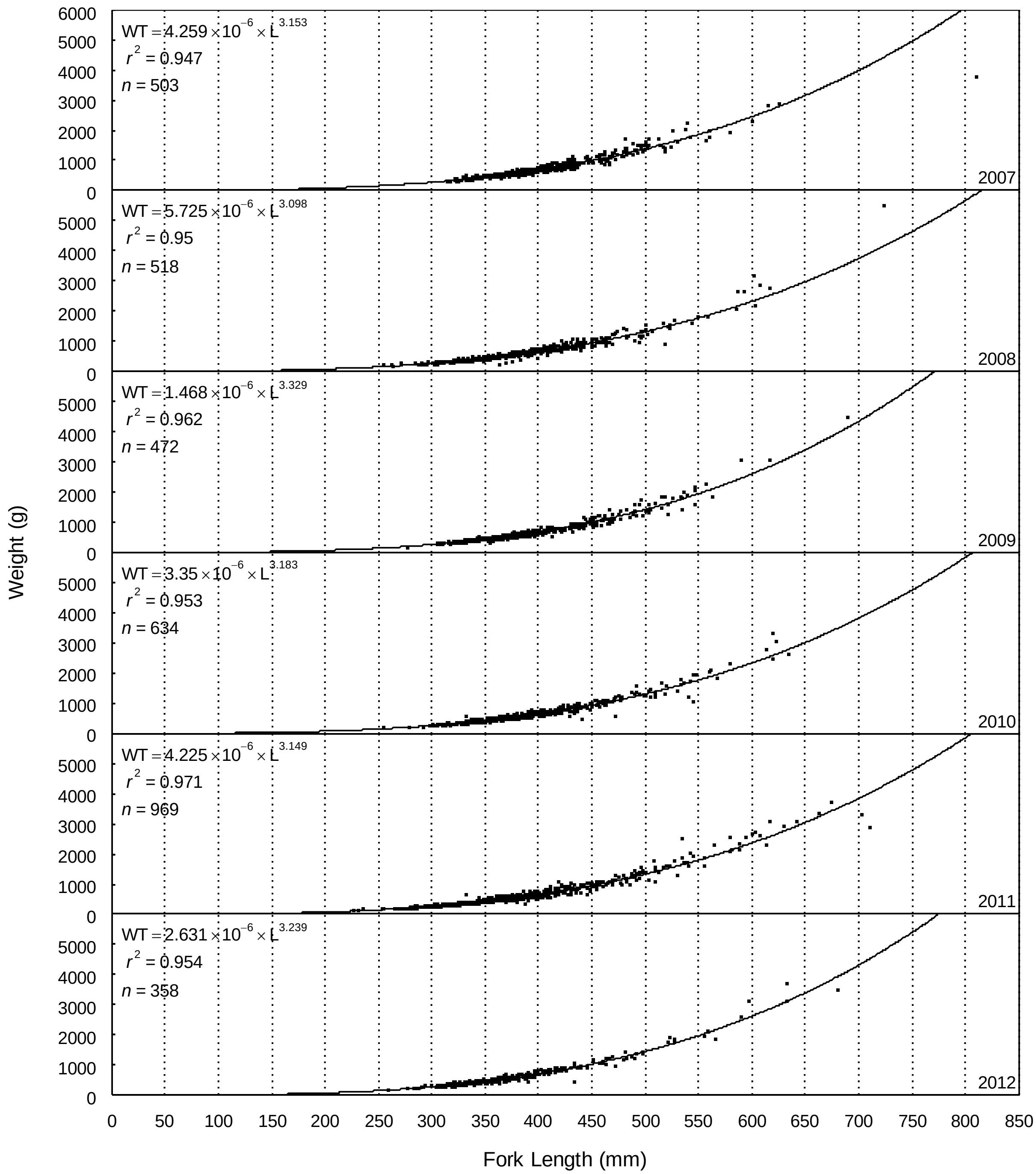

Figure F9. Concluded.

APPENDIX G

HBM Results

Hierarchical Bayesian Analysis - Results

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10 May 2013

Contents

1 General Approach

The following appendix summarises the posterior distributions for the fixed[1, p.75] parameters in each model. As described in the accompanying Methods Appendix the posterior distributions are summarised in terms of a point *estimate* (median), *lower* and *upper* 95% credibility limits (2.5th and 97.5th percentiles), percent relative *error* (half the 95% credibility interval as a percent of the point estimate) and *significance* (Bayesian equivalent of two-sided frequentist p-value)[1, p.37,42].

2 Length-at-Age

2.1 Mountain Whitefish

Parameter	estimate	lower	upper	error	significance
bDayte[1]	2.92	2.4	3.47	11	0
bDayte[2]	2.21	1.66	2.74	16	0
bDayte[3]	0.984	0.443	1.52	60	0
bDayte2[1]	-0.733	-1.21	-0.255	20	0
bDayte2[2]	-0.426	-0.854	-0.0335	23	0.0208
bDayte2[3]	0.116	-0.366	0.609	67	0.644
bIncrement[1]	122	117	127	2	0
bIncrement[2]	94	84.7	104	6	0
bIncrement[3]	123	105	141	8	0
bIntercept[1]	122	117	127	2	0
bIntercept[2]	216	208	224	2	0
bIntercept[3]	339	324	355	2	0
pAge[1]	0.135	0.13	0.14	2	0
pAge[2]	0.281	0.271	0.293	2	0
pAge[3]	0.584	0.573	0.594	1	0
sAgeYear[1]	8.74	5.85	14.1	46	0
sAgeYear[2]	12.9	8.76	21.5	49	0
sAgeYear[3]	28.8	19.9	44.3	39	0
sLengthAge[1]	14.8	14.3	15.2	2	0
sLengthAge[2]	19.2	18.2	20.5	3	0
sLengthAge[3]	44.7	43.6	45.6	1	0

2.2 Rainbow Trout

Parameter	estimate	lower	upper	error	significance
bDayte[1]	0.456	-0.115	1.02	244	0.12
bDayte[2]	3.19	2.64	3.75	11	0
bDayte[3]	0.158	-0.424	0.754	70	0.601
bDayte2[1]	0.826	0.265	1.41	111	0.0078
bDayte2[2]	-0.929	-1.32	-0.504	16	0
bDayte2[3]	0.0386	-0.529	0.618	55	0.891
bIncrement[1]	112	105	119	4	0
bIncrement[2]	152	140	160	3	0
bIncrement[3]	168	157	181	4	0
bIntercept[1]	112	105	119	4	0
bIntercept[2]	263	253	271	2	0
bIntercept[3]	431	423	441	1	0
pAge[1]	0.0642	0.0607	0.0682	3	0
pAge[2]	0.581	0.572	0.591	1	0
pAge[3]	0.354	0.346	0.363	1	0
sAgeYear[1]	11.4	7.5	18.1	45	0
sAgeYear[2]	15.5	10.4	26.6	53	0
sAgeYear[3]	16.4	11	27.7	51	0
sLengthAge[1]	18.4	17.4	19.4	3	0
sLengthAge[2]	37.2	36.5	37.9	1	0
sLengthAge[3]	56.1	54.7	57.6	1	0

3 Growth

3.1 Mountain Whitefish

Parameter	estimate	lower	upper	error	significance
k	0.399	0.352	0.45	7	0
Linf	396	373	421	3	0
sGrowth	10.9	9.31	13	11	0
sYear	27.9	15.1	55.6	92	0

3.2 Rainbow Trout

Parameter	estimate	lower	upper	error	significance
k	0.81	0.752	0.868	4	0
Linf	508	488	529	2	0
sGrowth	26	24.5	27.6	3	0
sYear	31	20.1	53.8	57	0

3.3 Walleye

Parameter	estimate	lower	upper	error	significance
k	0.0773	0.0513	0.114	36	0
Linf	788	649	976	14	0
sGrowth	12.7	11.3	14.5	8	0
sYear	67.3	30.2	97.9	51	0

4 Count

4.1 Mountain Whitefish

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	3.23	2.79	3.67	8	0
r	2.77	2.55	3.02	5	0
sDensitySite	0.82	0.652	1.05	17	0
sDensitySiteYear	0.368	0.318	0.424	9	0
sDensityYear	0.55	0.36	0.938	54	0

4.2 Rainbow Trout

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	3.42	3.11	3.71	5	0
r	3.71	3.4	4.06	5	0
sDensitySite	0.599	0.471	0.756	17	0
sDensitySiteYear	0.268	0.222	0.314	10	0
sDensityYear	0.385	0.249	0.655	54	0

4.3 Walleye

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	2.02	1.78	2.26	7	0
r	3.8	3.4	4.17	6	0
sDensitySite	0.278	0.203	0.389	27	0
sDensitySiteYear	0.196	0.149	0.25	18	0
sDensityYear	0.382	0.256	0.649	52	0

5 Catch

5.1 Mountain Whitefish - Subadult

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	0.761	0.4	1.07	39	0
r	7.44	6.1	9.32	15	0
sDensitySite	0.66	0.508	0.855	19	0
sDensitySiteYear	0.361	0.302	0.421	10	0
sDensityYear	0.545	0.361	0.872	45	0

5.2 Mountain Whitefish - Adult

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	1.59	1.31	1.97	15	0
r	4.23	3.73	4.86	8	0
sDensitySite	0.699	0.556	0.894	18	0
sDensitySiteYear	0.473	0.408	0.538	8	0
sDensityYear	0.659	0.444	1.04	43	0

5.3 Rainbow Trout - Subadult

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	1.67	1.39	1.93	9	0
r	7.56	6.4	9.13	12	0
sDensitySite	0.563	0.437	0.719	18	0
sDensitySiteYear	0.315	0.265	0.371	11	0
sDensityYear	0.34	0.228	0.53	42	0

5.4 Rainbow Trout - Adult

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	1.22	1.03	1.41	9	0
r	9.45	7.68	11.8	15	0
sDensitySite	0.449	0.343	0.6	22	0
sDensitySiteYear	0.298	0.248	0.353	11	0
sDensityYear	0.161	0.0931	0.297	73	0

5.5 Walleye - Adult

Parameter	estimate	lower	upper	error	significance
bDensityIntercept	1.36	1.11	1.75	18	0
r	6.2	5.27	7.25	10	0
sDensitySite	0.285	0.206	0.402	28	0
sDensitySiteYear	0.287	0.24	0.339	11	0
sDensityYear	0.561	0.382	0.865	40	0

6 Site Fidelity

6.1 Mountain Whitefish - Subadult

Parameter	estimate	lower	upper	error	significance
bIntercept	0.111	-0.562	0.799	61	0.759

6.2 Mountain Whitefish - Adult

Parameter	estimate	lower	upper	error	significance
bIntercept	-0.324	-0.851	0.182	30	0.237

6.3 Rainbow Trout - Subadult

Parameter	estimate	lower	upper	error	significance
bIntercept	1.1	0.855	1.33	13	0

6.4 Rainbow Trout - Adult

Parameter	estimate	lower	upper	error	significance
bIntercept	0.34	0.0768	0.601	170	0.0066

6.5 Walleye - Adult

Parameter	estimate	lower	upper	error	significance
bIntercept	0.652	0.343	0.946	43	0

7 Abundance

7.1 Mountain Whitefish - Subadult

Parameter	estimate	lower	upper	error	significance
bDenIntercept	5.38	4.86	5.93	6	0
bEffIntercept	-4.61	-5.07	-4.22	4	0
sDenSite	0.657	0.526	0.858	19	0
sDenSiteYear	0.407	0.358	0.457	7	0
sDenYear	0.531	0.348	0.835	44	0
sEffYearSession	0.199	0.157	0.26	20	0

7.2 Mountain Whitefish - Adult

Parameter	estimate	lower	upper	error	significance
bDenIntercept	6.86	6.39	7.37	4	0
bEffIntercept	-5.33	-5.61	-5.06	2	0
sDenSite	0.7	0.563	0.913	19	0
sDenSiteYear	0.579	0.526	0.638	6	0
sDenYear	0.619	0.404	0.961	42	0
sEffYearSession	0.2	0.164	0.246	14	0

7.3 Rainbow Trout - Subadult

Parameter	estimate	lower	upper	error	significance
bDenIntercept	4.77	4.49	5.06	3	0
bEffIntercept	-3.25	-3.35	-3.15	1	0
sDenSite	0.47	0.362	0.593	17	0
sDenSiteYear	0.38	0.339	0.427	7	0
sDenYear	0.38	0.251	0.613	46	0
sEffYearSession	0.268	0.22	0.335	15	0

7.4 Rainbow Trout - Adult

Parameter	estimate	lower	upper	error	significance
bDenIntercept	5.15	4.95	5.39	2	0
bEffIntercept	-4	-4.14	-3.86	2	0
sDenSite	0.428	0.325	0.569	22	0
sDenSiteYear	0.352	0.304	0.398	8	0
sDenYear	0.101	0.00943	0.232	697	0
sEffYearSession	0.185	0.143	0.235	18	0

7.5 Walleye - Adult

Parameter	estimate	lower	upper	error	significance
bDenIntercept	5.88	5.55	6.22	3	0
bEffIntercept	-4.5	-4.66	-4.34	2	0
sDenSite	0.299	0.211	0.425	30	0
sDenSiteYear	0.367	0.33	0.407	6	0
sDenYear	0.476	0.312	0.74	42	0
sEffYearSession	0.232	0.185	0.292	16	0

8 Capture Efficiency

8.1 Mountain Whitefish - Subadult

Parameter	estimate	lower	upper	error	significance
bEffIntercept	-4.78	-5.49	-4.33	4	0
sEffYearSession	0.599	0.088	1.42	468	0

8.2 Mountain Whitefish - Adult

Parameter	estimate	lower	upper	error	significance
bEffIntercept	-5.3	-5.71	-5.01	3	0
sEffYearSession	0.36	0.0245	0.882	1.06e+03	0

8.3 Rainbow Trout - Subadult

Parameter	estimate	lower	upper	error	significance
bEffIntercept	-3.33	-3.47	-3.19	2	0
sEffYearSession	0.408	0.29	0.547	24	0

8.4 Rainbow Trout - Adult

Parameter	estimate	lower	upper	error	significance
bEffIntercept	-4.02	-4.2	-3.86	2	0
sEffYearSession	0.292	0.0728	0.506	147	0

8.5 Walleye - Adult

Parameter	estimate	lower	upper	error	significance
bEffIntercept	-4.67	-4.94	-4.44	2	0
sEffYearSession	0.654	0.434	0.93	32	0

9 Survival

9.1 Mountain Whitefish

Parameter	estimate	lower	upper	error	significance
bEfficiencyIntercept	-3.86	-4.13	-3.61	3	0
bSurvivalInterceptStage[1]	-1.45	-2.74	-0.543	17	0.0076
bSurvivalInterceptStage[2]	0.25	-0.428	1.17	108	0.427
sSurvivalStageYear[1]	0.805	0.0631	2.55	1.38e+03	0
sSurvivalStageYear[2]	0.911	0.368	2.31	189	0

9.2 Rainbow Trout

Parameter	estimate	lower	upper	error	significance
bEfficiencyIntercept	-2.38	-2.62	-2.19	4	0
bSurvivalInterceptStage[1]	-0.00377	-0.513	1.64	160	0.986
bSurvivalInterceptStage[2]	-0.551	-0.888	-0.198	20	0
sSurvivalStageYear[1]	0.455	0.178	1.38	261	0
sSurvivalStageYear[2]	0.469	0.25	0.936	94	0

9.3 Walleye

Parameter	estimate	lower	upper	error	significance
bEfficiencyIntercept	-3.3	-3.54	-3.08	3	0
bSurvivalInterceptStage	0.0647	-0.287	0.463	69	0.709
sSurvivalStageYear	0.382	0.035	0.987	865	0

10 Condition

10.1 Mountain Whitefish - Subadult

Parameter	estimate	lower	upper	error	significance
bDayte	-0.00802	-0.0139	-0.0021	21	0.012
bDayte2	-0.00135	-0.00589	0.0029	36	0.551
bIntercept	4.76	4.74	4.78	0	0
bLength	3.18	3.15	3.22	1	0
sSite	0.032	0.023	0.0429	24	0
sWeight	0.0982	0.096	0.1	1	0
sYear	0.0332	0.0227	0.0519	41	0
sYearSite	0.0235	0.0175	0.0294	17	0

10.2 Mountain Whitefish - Adult

Parameter	estimate	lower	upper	error	significance
bDayte	-0.0105	-0.0169	-0.00504	16	0
bDayte2	-0.00904	-0.0148	-0.00287	21	0.002
bIntercept	6.3	6.26	6.34	0	0
bLength	2.85	2.82	2.87	0	0
sSite	0.026	0.0156	0.0412	49	0
sWeight	0.151	0.149	0.153	1	0
sYear	0.0639	0.0441	0.107	49	0
sYearSite	0.0425	0.0368	0.0487	8	0

10.3 Rainbow Trout - Subadult

Parameter	estimate	lower	upper	error	significance
bDayte	-0.0051	-0.00827	-0.00193	19	0.002
bDayte2	-0.000511	-0.00313	0.00211	42	0.717
bIntercept	5.38	5.37	5.4	0	0
bLength	2.95	2.93	2.96	0	0
sSite	0.0239	0.018	0.0315	21	0
sWeight	0.0821	0.0809	0.0832	1	0
sYear	0.0241	0.0167	0.0377	41	0
sYearSite	0.0188	0.0154	0.022	10	0

10.4 Rainbow Trout - Adult

Parameter	estimate	lower	upper	error	significance
bDayte	0.00699	0.00285	0.0108	67	0
bDayte2	-0.00104	-0.00389	0.00201	39	0.453
bIntercept	6.85	6.83	6.87	0	0
bLength	2.77	2.74	2.79	0	0
sSite	0.0394	0.0314	0.0517	20	0
sWeight	0.0975	0.0956	0.0993	1	0
sYear	0.0286	0.0199	0.0474	47	0
sYearSite	0.0227	0.0177	0.0276	14	0

10.5 Walleye - Adult

Parameter	estimate	lower	upper	error	significance
bDayte	0.0186	0.0152	0.0219	11	0
bDayte2	0.00157	-0.00125	0.00439	112	0.309
bIntercept	6.23	6.21	6.25	0	0
bLength	3.22	3.2	3.23	0	0
sSite	0.00992	0.00571	0.0151	46	0
sWeight	0.0957	0.0943	0.0972	1	0
sYear	0.0401	0.0281	0.0631	41	0
sYearSite	0.0196	0.0164	0.0234	12	0

References

[1] Marc Kéry and Michael Schaub. *Bayesian population analysis using WinBUGS : a hierarchical perspective*. Academic Press, Boston, 2011.

APPENDIX H

HBM Additional Figures

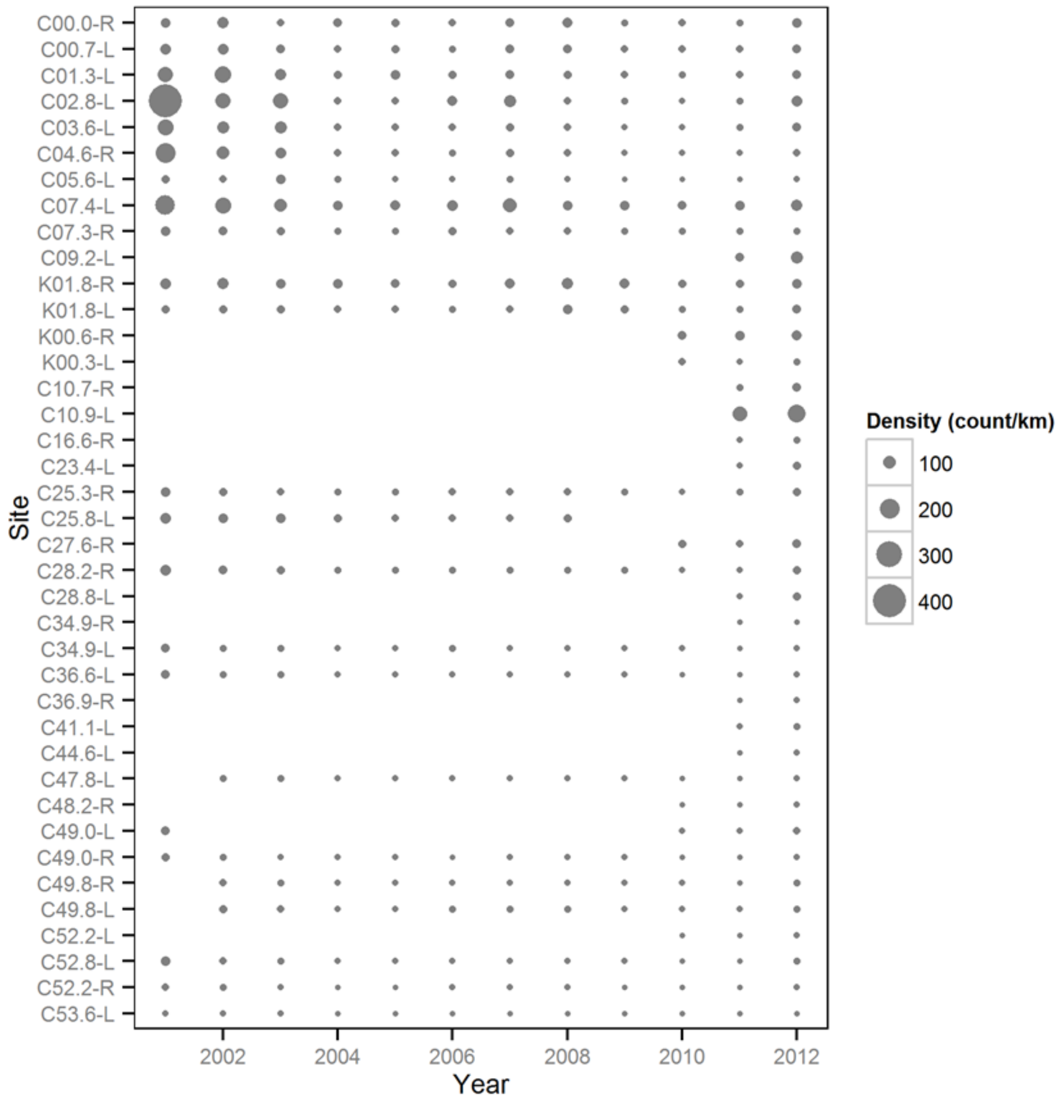

Figure H1: Count density of Mountain Whitefish (all age-classes combined) by year and site in the Lower Columbia River, 2001-2012.

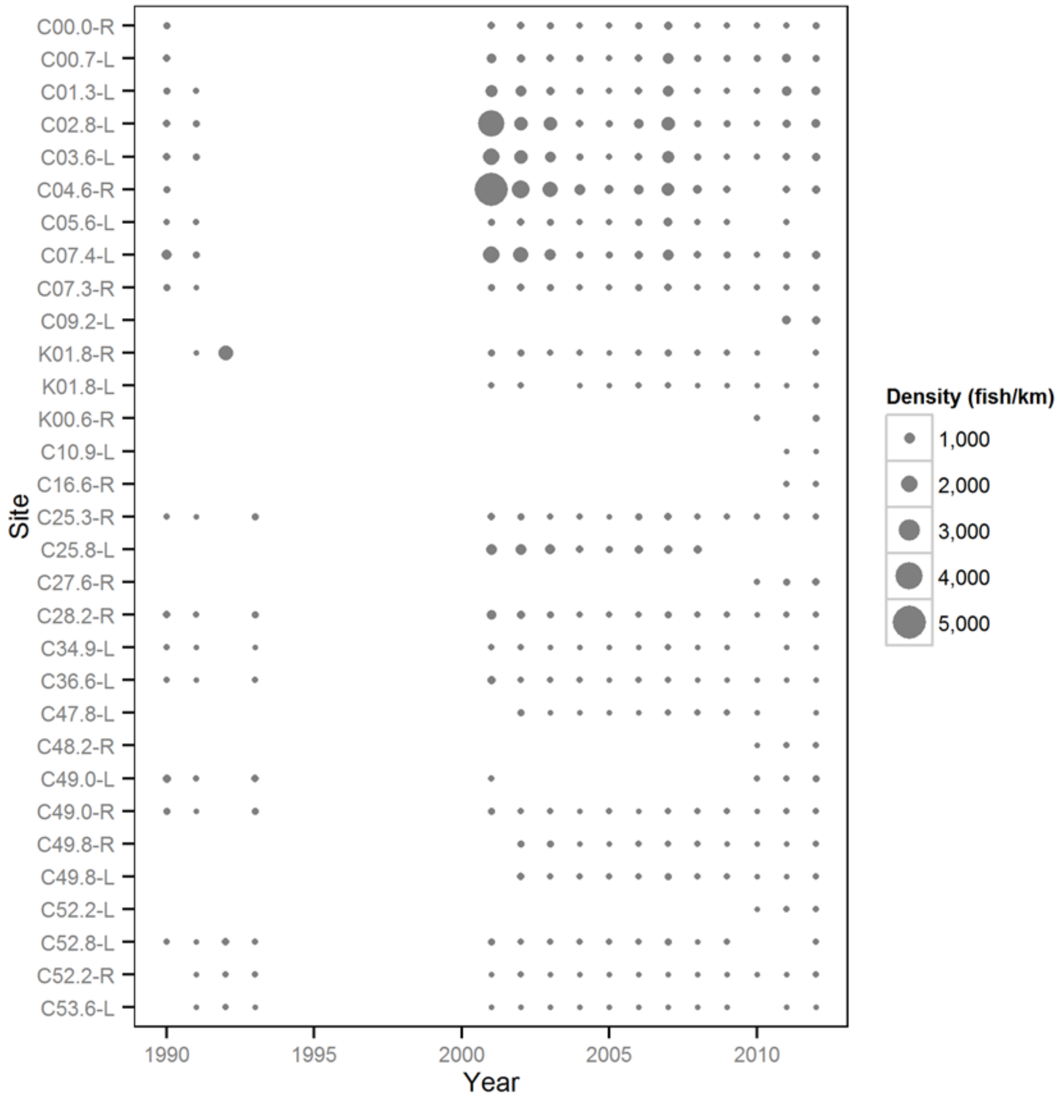

Figure H2: Absolute density of subadult Mountain Whitefish by year and site in the Lower Columbia River, 1990-2012.

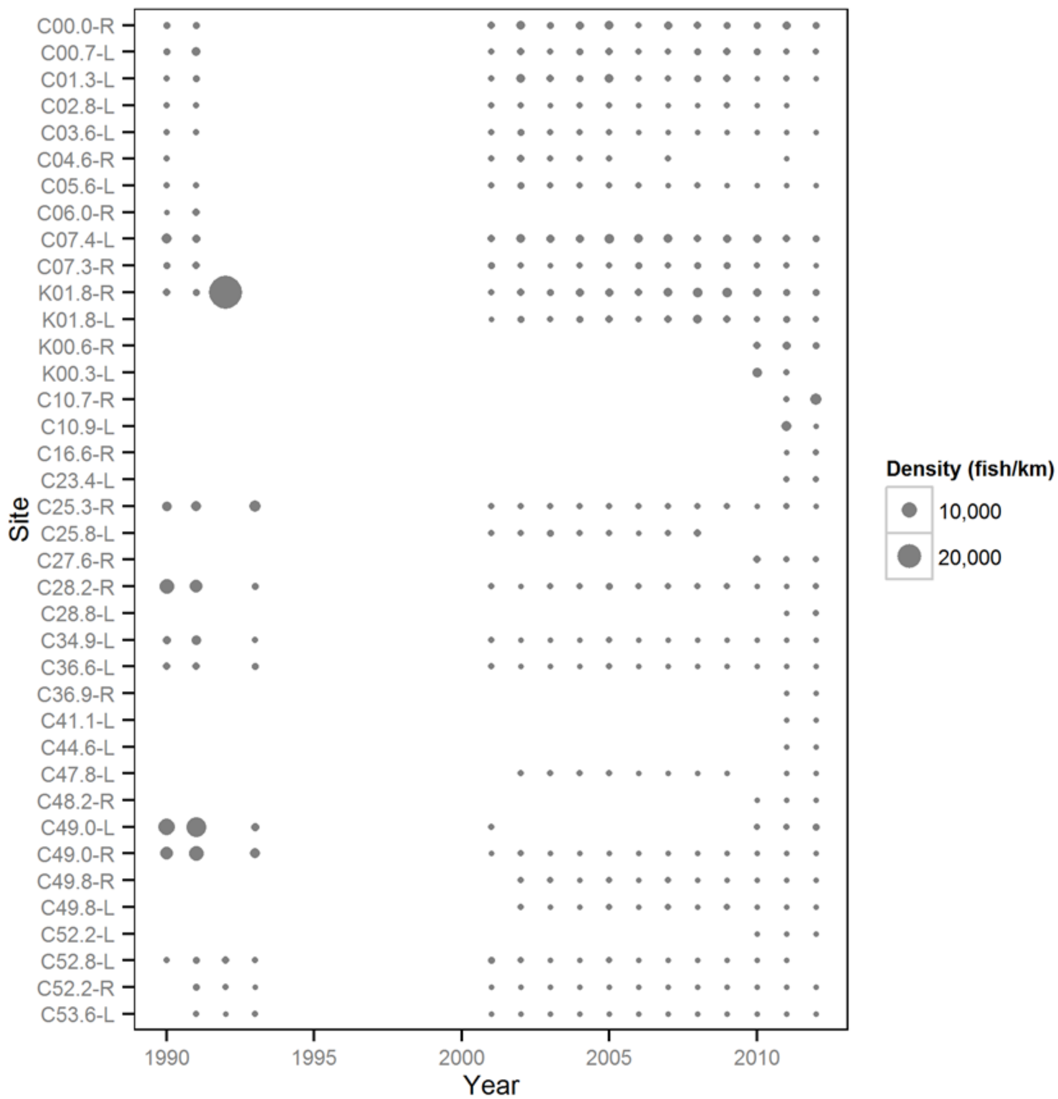

Figure H3: Absolute density of adult Mountain Whitefish by year and site in the Lower Columbia River, 1990-2012.

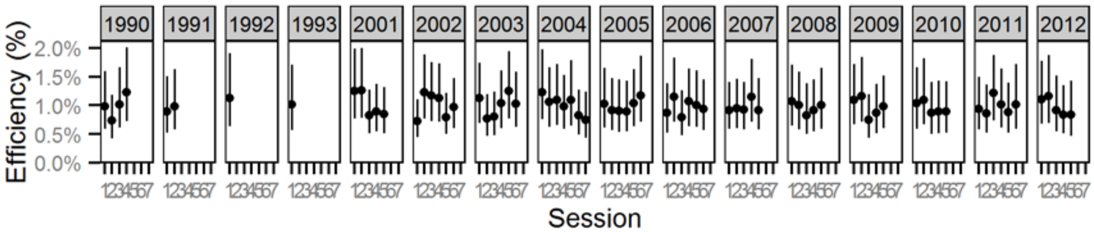

Figure H4: Capture efficiency (median with 95% credible intervals) by sampling session and year based on mark-recapture data for subadult Mountain Whitefish in the Lower Columbia River, 1990-2012.

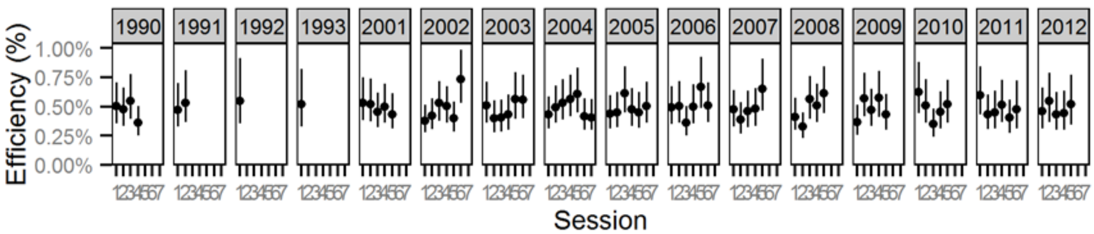

Figure H5: Capture efficiency (median with 95% credible intervals) by sampling session and year based on mark-recapture data for adult Mountain Whitefish in the Lower Columbia River, 1990-2012.

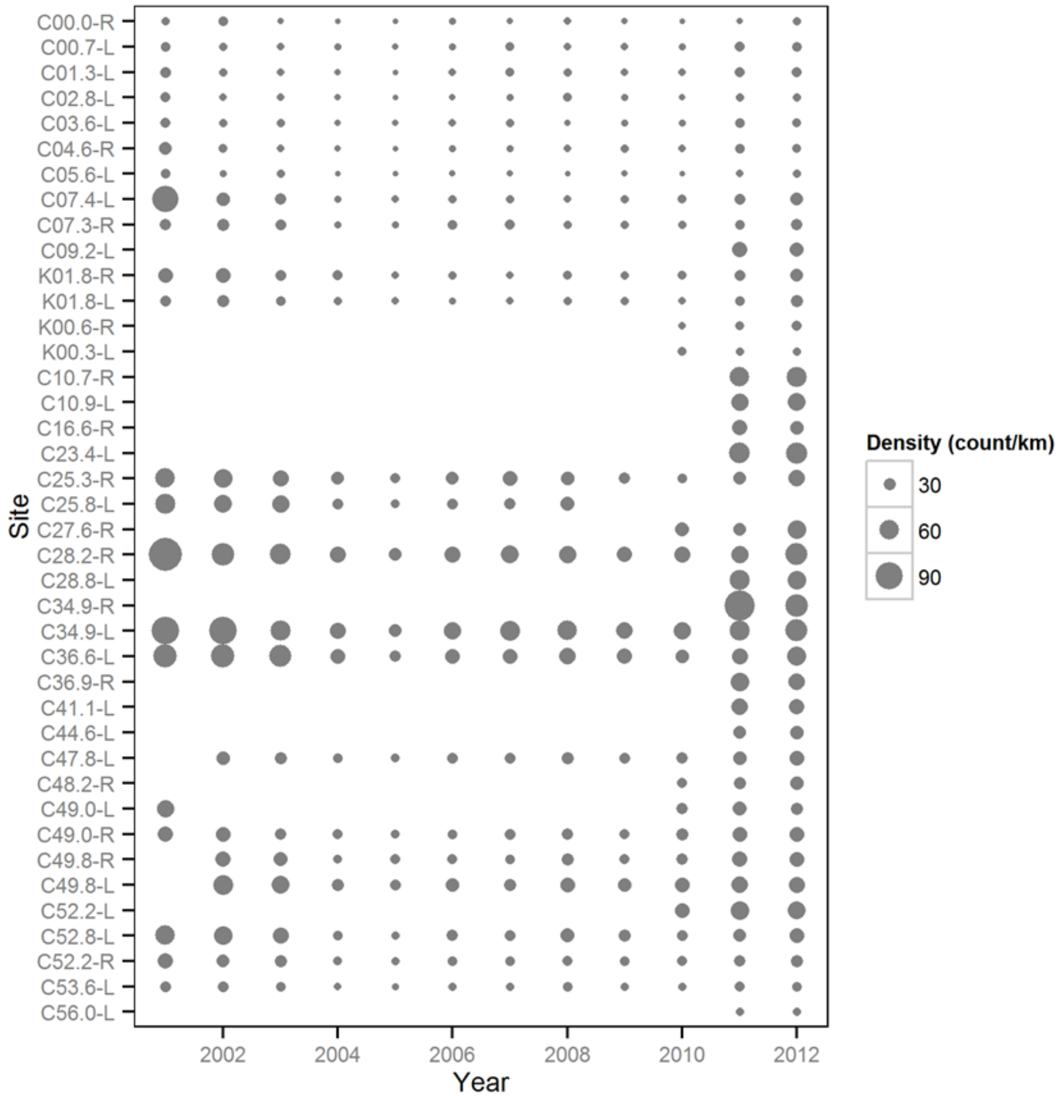

Figure H6: Count density of Rainbow Trout (all age-classes combined) by year and site in the Lower Columbia River, 2001-2012.

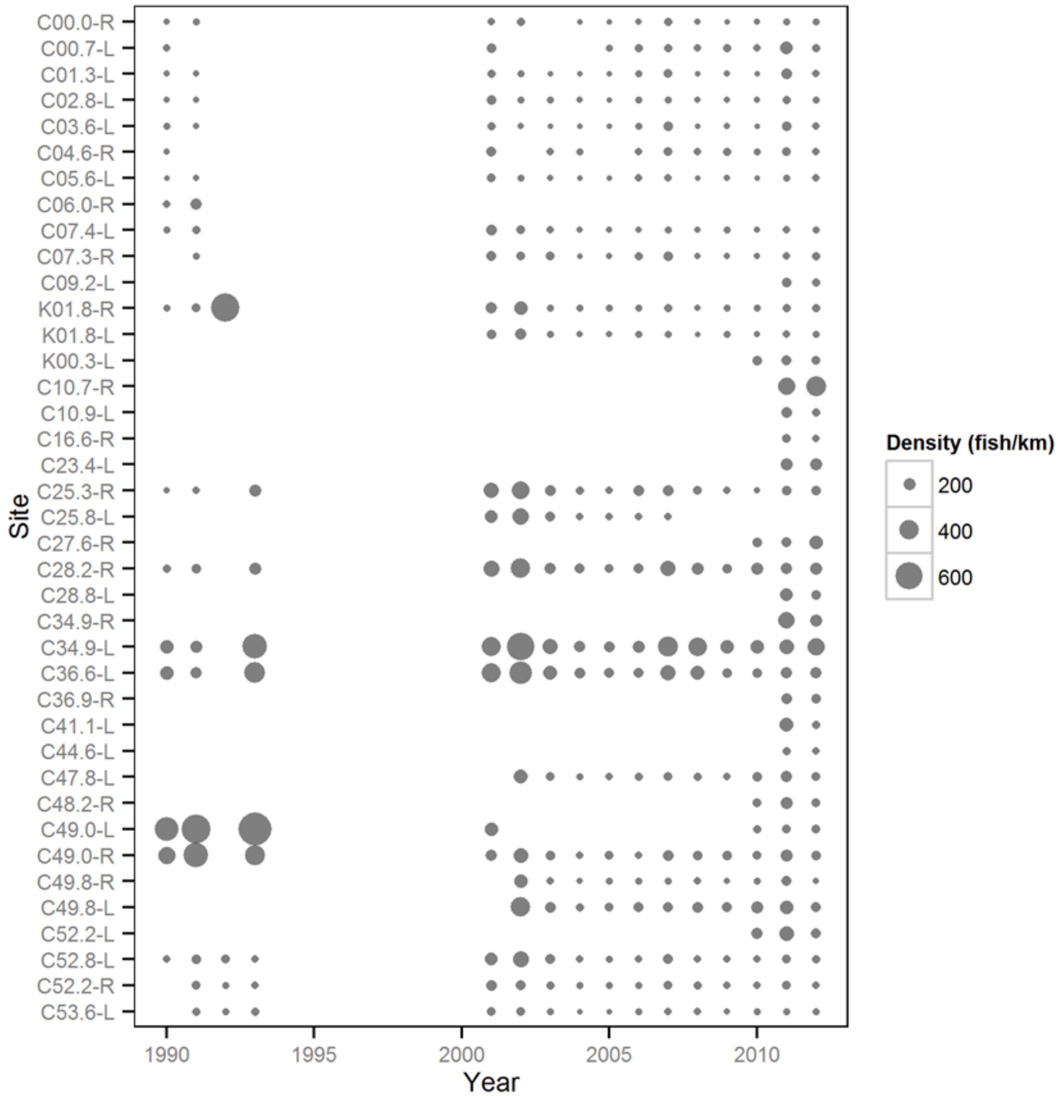

Figure H7: Absolute density of subadult Rainbow Trout by year and site in the Lower Columbia River, 2001-2012.

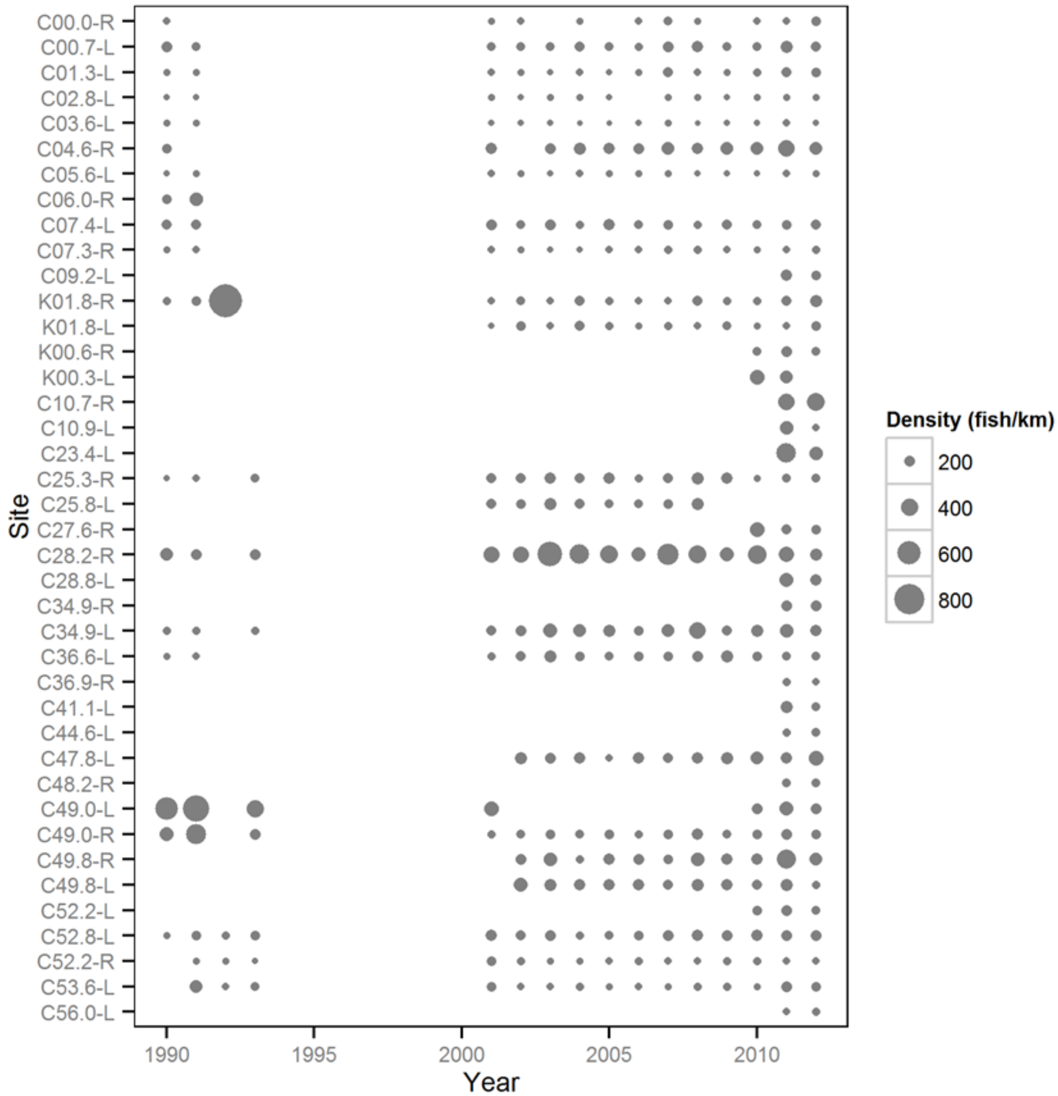

Figure H8: Absolute density of adult Rainbow Trout by year and site in the Lower Columbia River, 2001-2012.

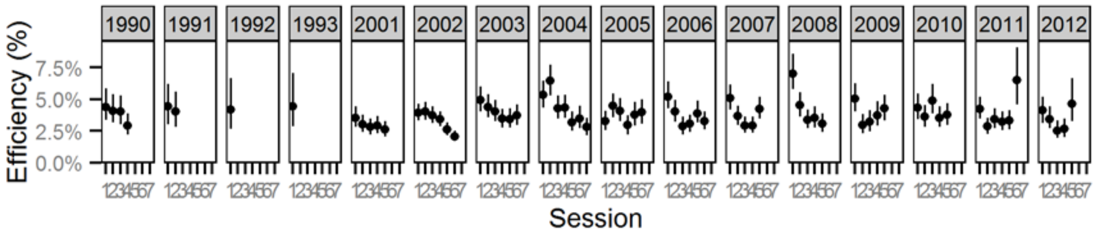

Figure H9: Capture efficiency (median with 95% credible intervals) by sampling session and year based on mark-recapture data for subadult Rainbow Trout in the Lower Columbia River, 1990-2012.

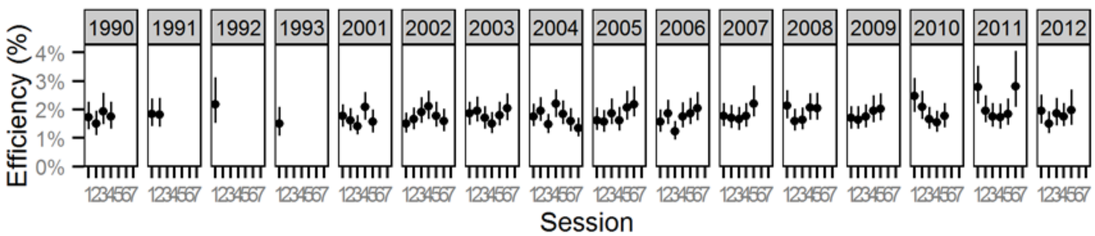

Figure H10: Capture efficiency (median with 95% credible intervals) by sampling session and year based on mark-recapture data for adult Rainbow Trout in the Lower Columbia River, 1990-2012.

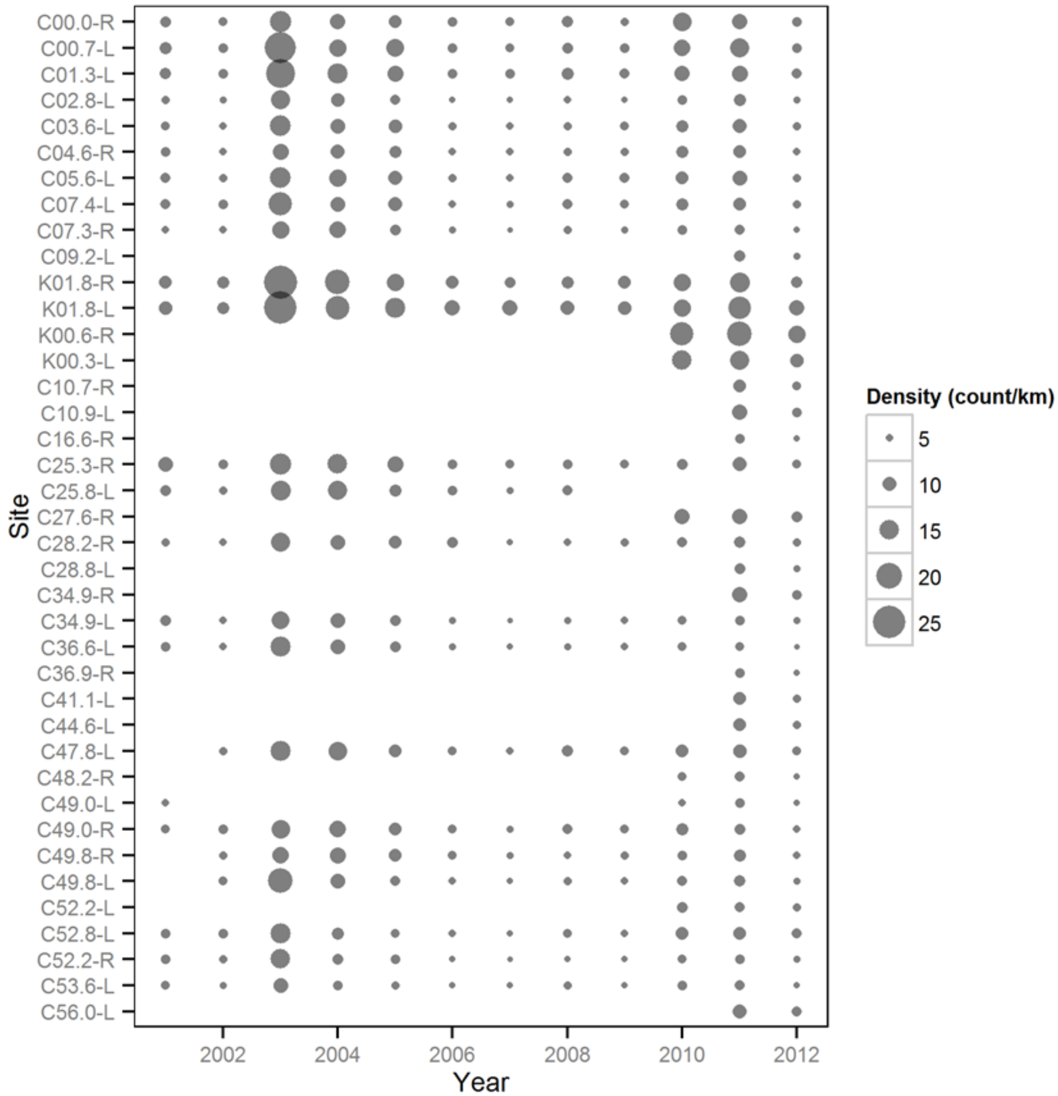

Figure H11: Count density of Walleye (all age-classes combined) by year and site in the Lower Columbia River, 2001-2012.

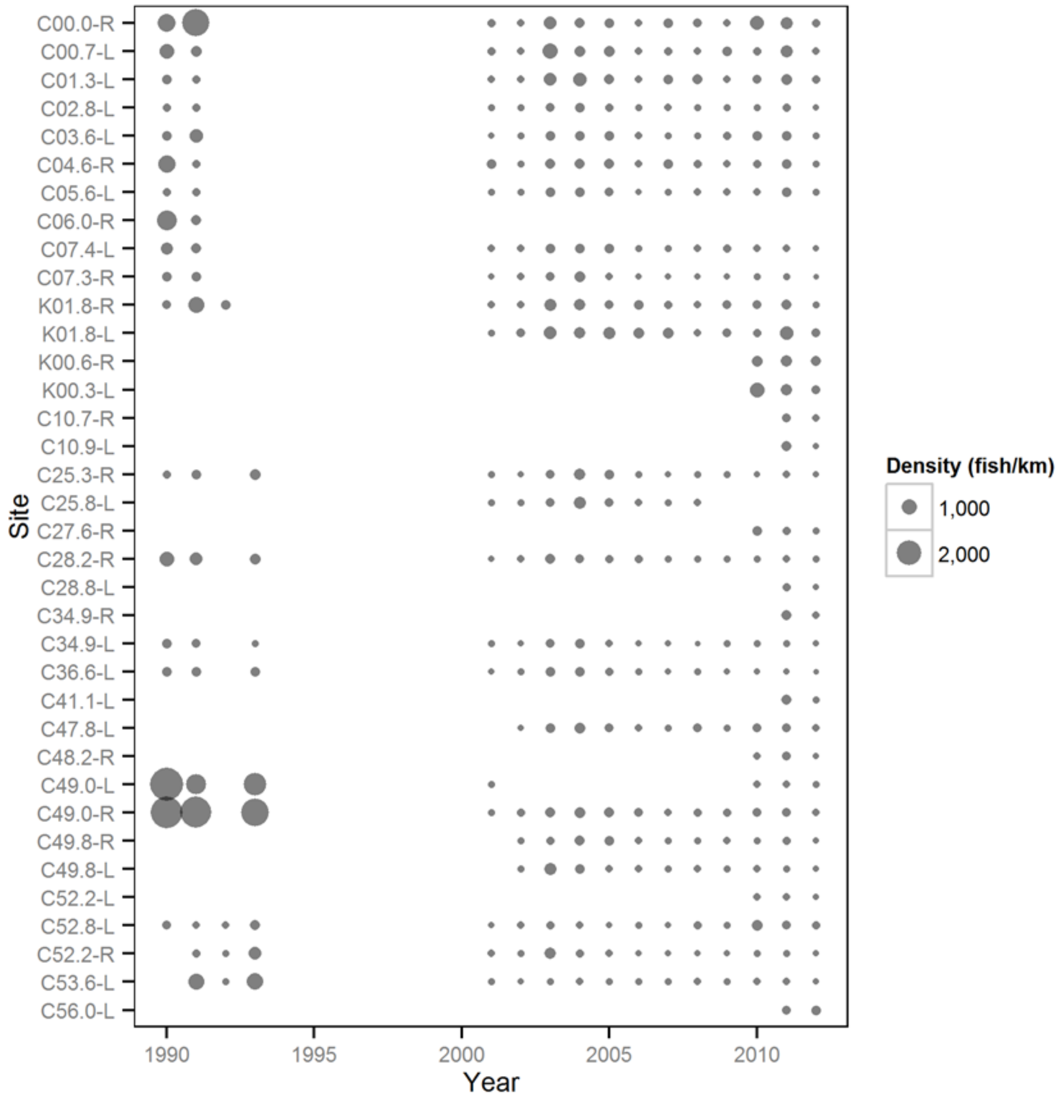

Figure H12: Absolute density of adult Walleye by year and site in the Lower Columbia River, 2001-2012.

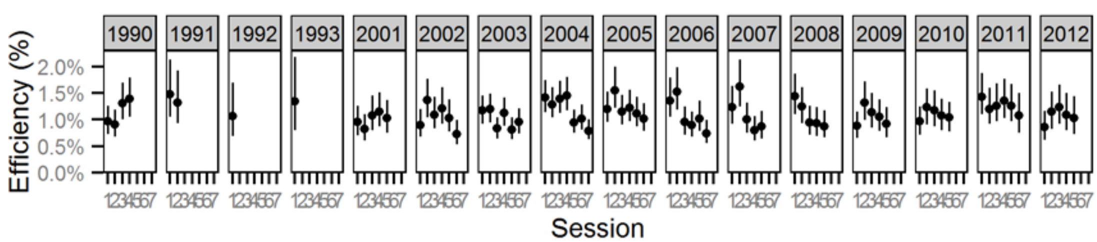

Figure H13: Capture efficiency (median with 95% credible intervals) by sampling session and year based on mark-recapture data for adult Walleye in the Lower Columbia River, 1990-2012.

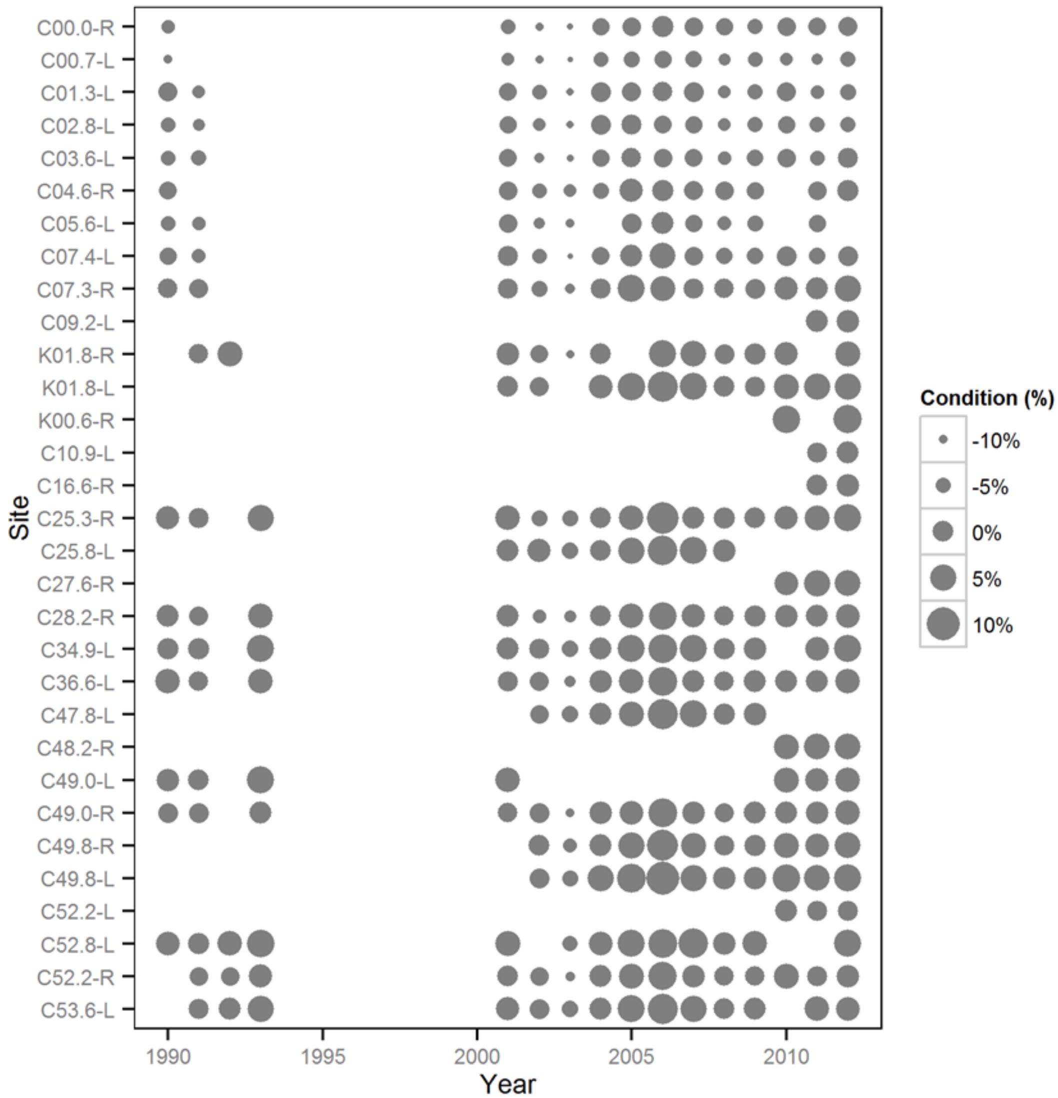

Figure H14: Body condition effect size estimate (median with 95% credible interval) by site and year for subadult Mountain Whitefish in the Lower Columbia River, 1990 to 2012.

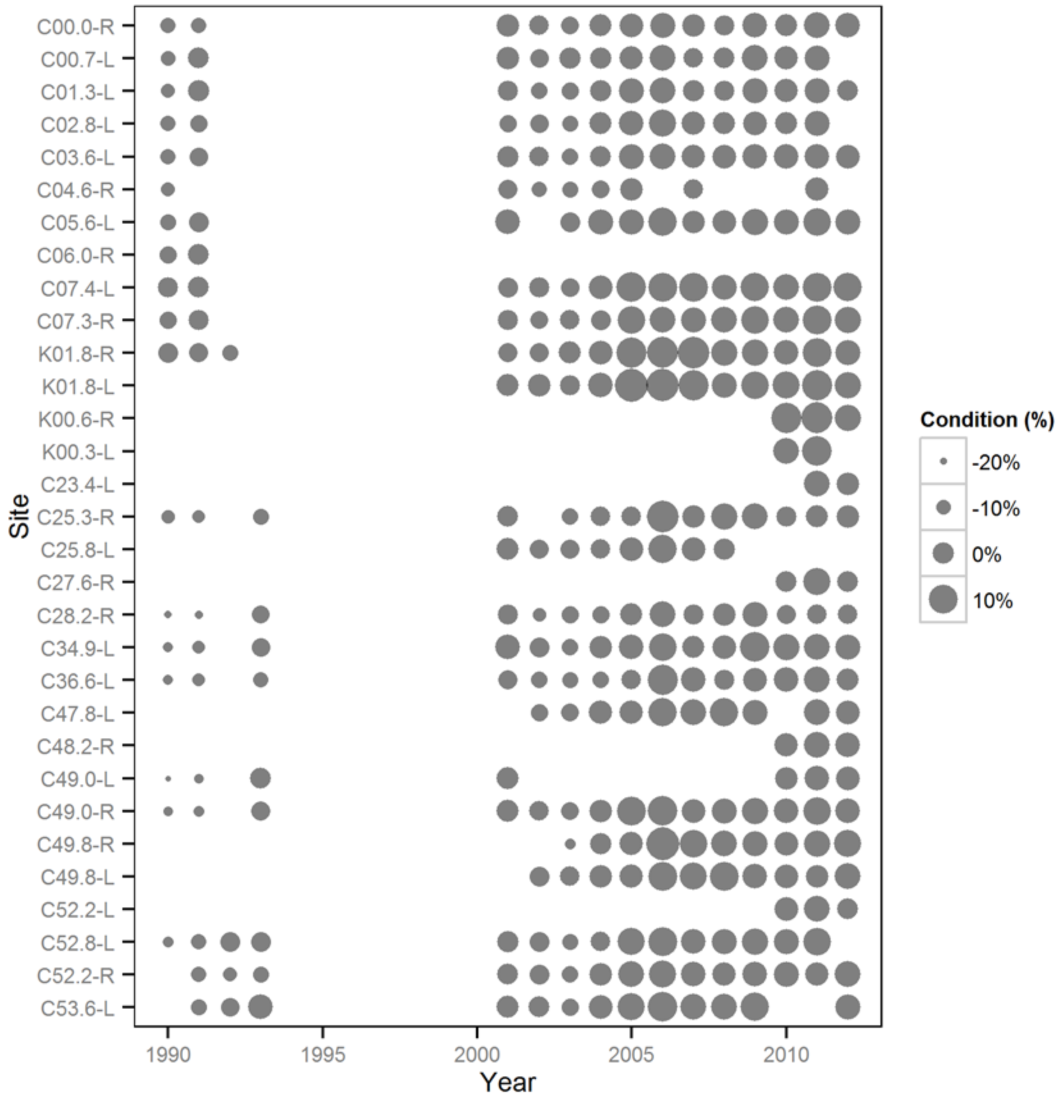

Figure H15: Body condition effect size estimate (median with 95% credible interval) by site and year for adult Mountain Whitefish in the Lower Columbia River, 1990 to 2012.

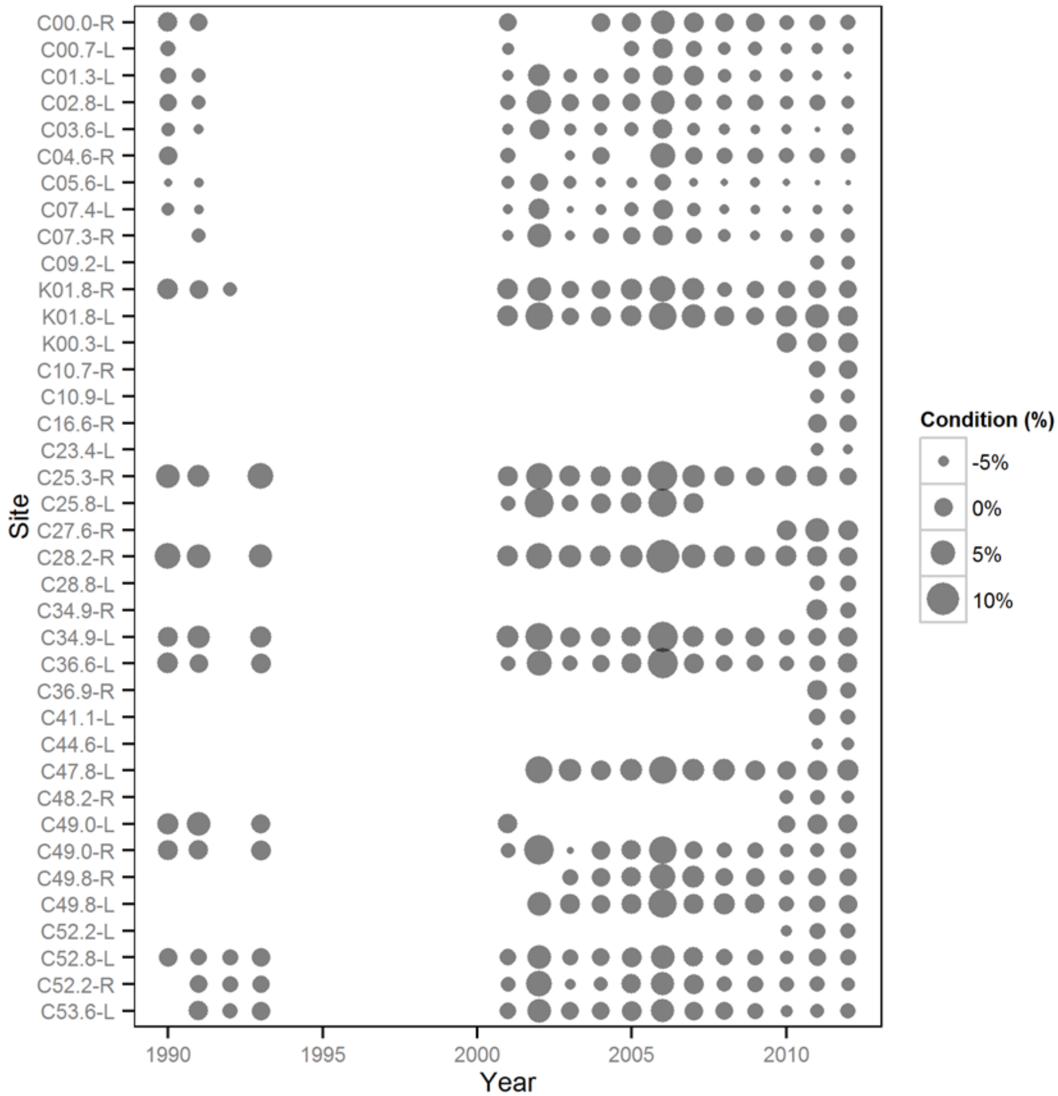

Figure H16: Body condition effect size estimate (median with 95% credible interval) by site and year for subadult Rainbow Trout in the Lower Columbia River, 1990 to 2012.

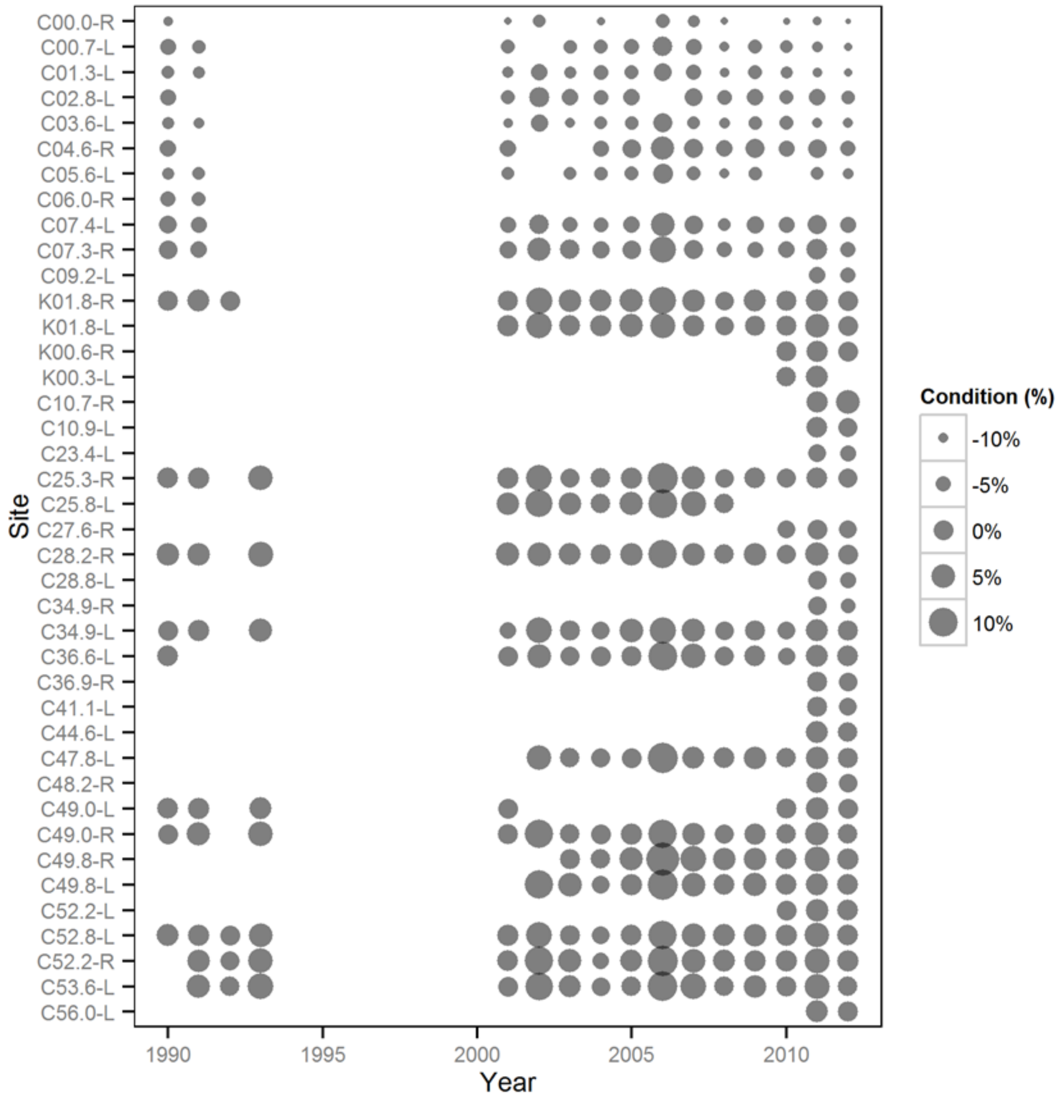

Figure H17: Body condition effect size estimate (median with 95% credible interval) by site and year for adult Rainbow Trout in the Lower Columbia River, 1990 to 2012.

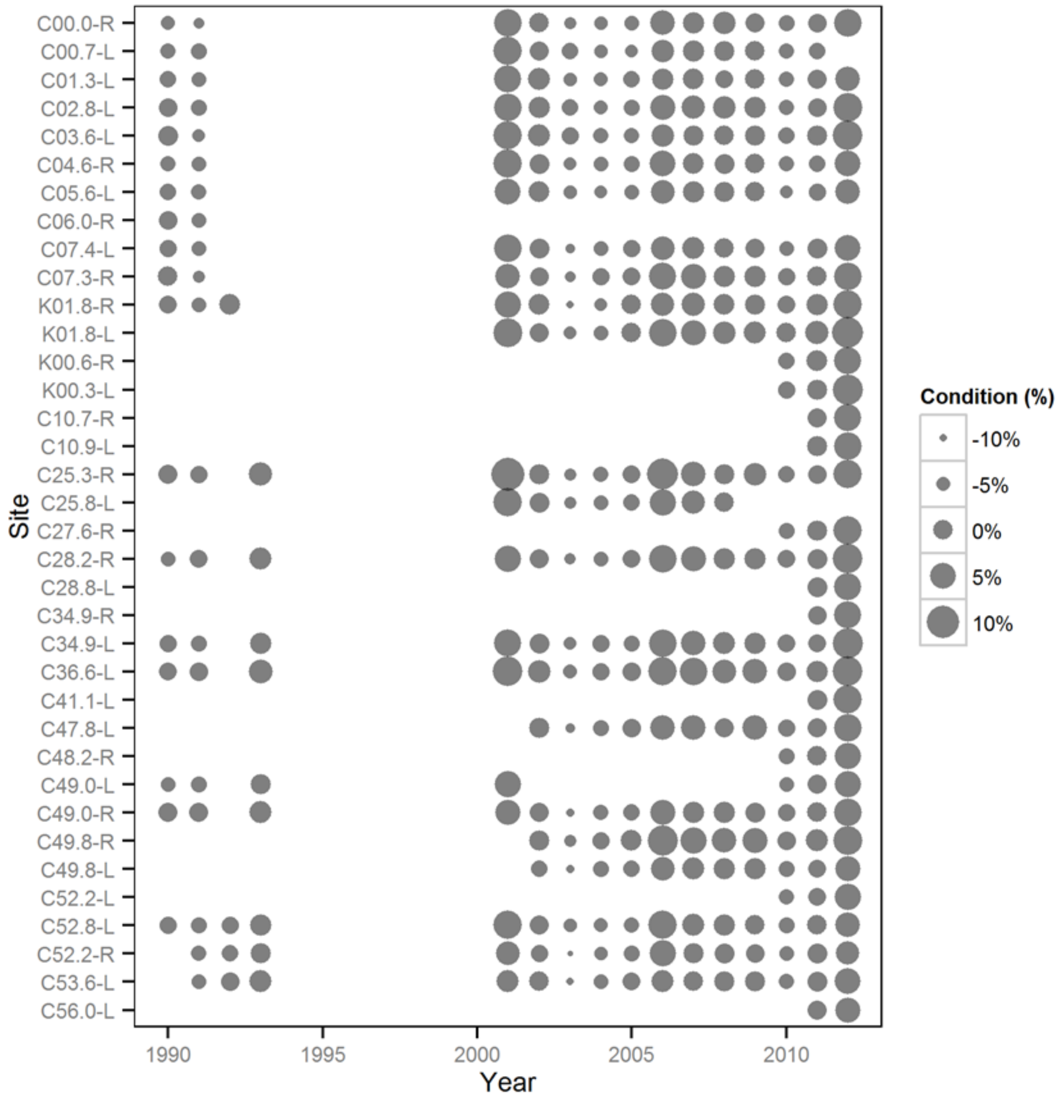

Figure H18: Body condition effect size estimate (median with 95% credible interval) by site and year for adult Walleye in the Lower Columbia River, 1990 to 2012.

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