Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Implementation Year 5

Reference: CLBMON-45

Lower Columbia River Fish Population Indexing Surveys

Study Period: 2011

Dustin Ford, Joseph Thorley, Larry Hildebrand, Dana Schmidt

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CLBMON-45

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Executive Summary

Starting 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 spawning season in early winter, BC Hydro decreases flow from HLK to encourage spawning at lower water level elevations and reduce egg dewatering over the winter egg incubation period. In early spring, flows are reduced and subsequently managed to provide increasing water levels during the rainbow trout spawning season, which reduces the likelihood of rainbow trout eggs and other larval fishes from becoming stranded during spring flow management.

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

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

- What is the abundance, growth rate, survival rate, body condition, age distribution, and spatial distribution of subadult and adult whitefish, rainbow trout, and walleye in the LCR?
- What is the effect of inter-annual variability in the whitefish and rainbow trout flow regimes on the abundance, growth rate, survival rate, body condition, and spatial distribution of subadult and adult whitefish, rainbow trout, and walleye in the LCR?

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

Field work was conducted in the fall of 2011, which corresponded approximately to the timing of data collected during earlier study years (i.e., 2007 to 2010) 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 (HBM) were used to estimate temporal and spatial variations in species abundance, spatial distribution, growth, size-at-age, survival, and body condition.

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 adult 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.

Recommendations include refining the survival-based HBM to provide more accurate estimates, explore the use of body condition to identify sexually mature mountain whitefish and test whether sexually mature fish are recaptured less frequently than their non-spawning equivalents, refine movement models to take into account the date and distance travelled by fish between encounters, continue with a Generalized Random Tessellation Stratified (GRTS)-based survey design, conduct a spring mark-recapture program, and expand the HBM datasets to include fish capture data collected in the 1990s along with discharge, water temperature, and other habitat variables.

Table EI: Status of management questions and hypotheses after Year 5 of the Lower Columbia River Fish Population Indexing Survey (CLBMON-45).

Management Questions	Management Hypotheses	Sub-Hypotheses	Year 5 (2011) 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 whitefish have changed over the course of the monitoring period. Subadult mountain whitefish abundance decreased by approximately 65% between 2001 and 2005 and remained relatively stable between 2005 and 2011. Adult mountain whitefish abundance also has varied between years with no obvious long-term trends. Results in Section 4.3.1 Discussion in Section 5.2.1
		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 subadult mountain whitefish cohort was substantially lower in 2001 when compared to other study years. Results in Section 4.2.1 Discussion in Section 5.1.1
		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. The HBM will be further refined in 2012 to address this hypothesis. Results in Section 4.4.1 Discussion in Section 5.4.1
		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 4.5.1 Discussion in Section 5.5.1
		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 4.3.1 Discussion in Section 5.3.1
	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 decreased by approximately 60% between 2001 and 2005, remained relatively stable between 2005 and 2010, and increased substantially between 2010 and 2011. Adult rainbow trout abundance, however, has remained stable between 2001 and 2011. Results in Section 4.3.2 Discussion in Section 5.2.2

Management Questions	Management Hypotheses	Sub-Hypotheses	Year 5 (2011) Status
		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 4.2.2 Discussion in Section 5.1.2
		Ho$_{2c}$: There is no change in the mean survival of subadult and adult rainbow trout	The hypothesis cannot be rejected at this time. Annual survival estimates for subadult and adult rainbow trout were relatively stable between 2001 and 2011. The HBM will be further refined in 2012. Results in Section 4.2.2 Discussion in Section 5.1.2
		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 4.5.2 Discussion in Section 5.5.2
		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 4.3.2 Discussion in Section 5.3.2
	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. Abundance increased substantially between and 2002 and 2003 and gradually decreased between 2003 and 2006. The abundance of this species remained relatively constant between 2006 and 2011. Results in Section 4.3.3 Discussion in Section 5.3.3
		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 4.2.3 Discussion in Section 5.1.3
		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. The HBM will be further refined in 2012. Results in Section 4.4.3 Discussion in Section 5.4.3
		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 4.5.3 Discussion in Section 5.5.3

Management Questions	Management Hypotheses	Sub-Hypotheses	Year 5 (2011) Status
		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 discernable. Results in Section 4.3.3 Discussion in Section 5.3.3
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?			Unknown. Flow variability will be included as an explanatory variable in the HBMs during future years of the study.

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

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Dustin Ford, R.P. Bio.	Project Manager/Author
Larry Hildebrand, R.P. Bio.	Senior Fisheries Biologist/Project Advisor/Editor
Dana Schmidt, R.P. Bio.	Senior Fisheries Biologist/Project Director
Demitria Burgoon	Biologist
Bob Chapman, R.P. Bio.	Biologist
Mike Hildebrand	Biologist
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Megan Crozier	Biological Technician
Chris King	Biological Technician
James Goodier	GIS Technician
Angel LeBlanc	GIS Technician
Laura Ford	Administrative Assistant
Carrie McAllister	Administrative Assistant

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1.0 INTRODUCTION

Starting 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 bulk 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).

Ideally, data collected under the LRFIP (Golder 2002, 2003, 2004, 2005, 2006, 2007) and the current program (Golder 2008, 2009a, 2010a, Ford and Thorley 2011a) 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 is the abundance, growth rate, survival rate, body condition, age distribution, and spatial distribution of subadult and adult whitefish, rainbow trout, and walleye in the LCR?
- What is the effect of inter-annual variability in the whitefish and rainbow trout flow regimes on the abundance, growth rate, survival rate, body condition, and spatial distribution of subadult and adult whitefish, rainbow trout and walleye in the LCR?

1.3 Management Hypotheses

Specific hypotheses to be tested under CLBMON-45 include:

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

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

1.4 Study Area and Study Period

The study area for the LCR Fish Indexing Program encompassed the 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 2011, 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 4 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 five times (i.e., 5 sessions) between September 26 and October 30, 2011 (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 2011, additional sites were sampled using a Generalized Random Tessellation Stratified (GRTS) survey (discussed in detail in Section 2.1.4). The GRTS survey was completed between November 1 and 5, 2011.

Table 1: Annual study periods for boat electroshocking surveys conducted in the Lower Columbia River, 2001 to 2011.

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

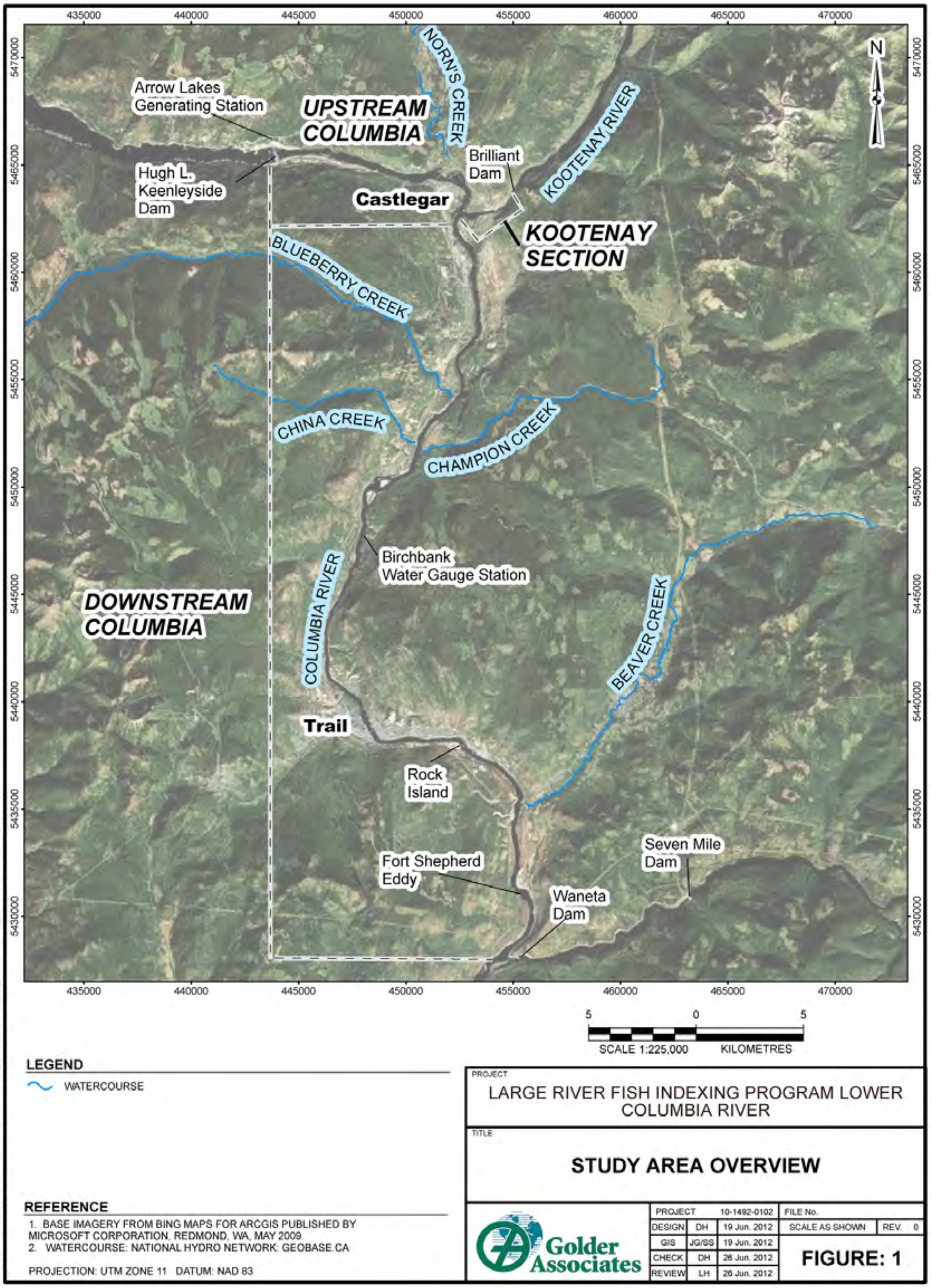

Figure 1: Overview of the Lower Columbia River study area, 2011.

2.0 METHODS

2.1 Data Collection

2.1.1 Discharge

Discharge data for the mainstream Columbia River were obtained from BC Hydro [discharge through HLK and Arrow Lakes Generating Station (ALGS)] and from the Water Survey of Canada gauging station (No. 08NE049) at Birchbank (Figure 1). Discharge data for the Kootenay River were obtained from FortisBC (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 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. 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 and by 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, 2011.

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)
Effectiveness	A categorical ranking of how effectively the site was sampled (1 - good; 2 - moderately good; 3 - moderately poor; 4 - poor); influenced by boat operation, eddy navigation, percent of site sampled, current patterns, etc.
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). Stress on fish associated with capture and processing is greater at warmer water temperatures (Golder 2002); therefore, sampling during most 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 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.

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 pers. comm.). A subsample of sites established during those original programs was selected for inclusion in the LRFIP in 2001 that provided 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, providing 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 be biased due to fish migrating into non-sampled sections of the study areas between sessions.

In 2011, a GRTS survey was conducted after field crews completed the conventional mark-recapture program. This survey was conducted to determine the extent of the above biases and to provide a better understanding of the population dynamics of the three index species.

Portions of shoreline habitat not currently surveyed under CLBMON-45 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 sites currently sampled under 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 currently unsampled portions of the LCR (Appendix A, Figures A4 to A9).

The GRTS strategy (Stevens and Olson 2004) 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 in prep.) 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 psurvey.design, Program R statistical software, 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, these included sites 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 survey was conducted at each GRTS survey site between November 1 and 5, 2011 using the same boat electroshocking procedures described above. Fish captured during GRTS surveys were processed in the same manner as fish captured during the conventional mark-recapture program (Section 2.1.5).

2.1.5 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 fish 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 through an incision made using a No. 11 scalpel blade just off the mid-line of the fish anterior to the pelvic girdle. All fish >160 mm FL that were in good condition following processing were marked with a Plastic Infusion Process (PIP) PIT tag (tag model ENSID Fusion 11 mm FDX-B). These tags were inserted with a Simcro Tech Ltd. single shot applicator into the dorsal musculature on the left side below the dorsal fin near the pterygiophores. In addition to a PIT tag, walleye also were implanted with a brown, green, or purple T-bar anchor tag (depending on supply; Hallprint™ Model TBA-2). These tags were inserted using a Dennison Mark II applicator gun, into the dorsal musculature on the right side below the dorsal fin and between 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, 2011.

Variable	Description
Species	The species of fish recorded
Size Class	A general size class for observed fish (YOY for age-0 fish, Immature for fish <250 mm FL, Adult for fish >250 mm FL)
Length	The fork length of the fish to the nearest 1 mm
Weight	The wet weight of the fish to the nearest 1 g
Sex and Maturity	The sex and maturity of a fish (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 the fish was recorded near
Comments	Any additional comments regarding the fish

During the 2001 to 2005 studies, fish were marked exclusively with T-bar anchor tags (i.e., PIT tags were not employed). 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 and this species is primarily a seasonal resident and uses 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.

2.1.6 Stomach Content Collection and Analysis

At BC Hydro's request, stomach contents were collected from a subsample of walleye (*n* = 101) using 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. Prey fish that could be positively identified were recorded in the LCR Fish Indexing Database and discarded. Prey fish that could not be positively identified (due to their small size or stage of digestion) were washed from the sieve into a collection jar and preserved (Prefer™) for later identification and enumeration. Anecdotal data on other material present in the sample, such as the presence of vegetation, insects, or fish bones, were recorded in the LCR Fish Indexing Database.

Prey fish that could not be identified in the field were analyzed in the lab using a dissecting microscope. Fork lengths of these fish were recorded where possible.

2.1.7 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 62% (*n* = 644) of all collected mountain whitefish scale samples were examined independently by three experienced individuals and ages assigned. If assigned ages differed between examiners the sample was re-examined jointly by all examiners to establish a final age.

Rainbow trout that were captured during an earlier year of the project (2001 to 2010) and recaptured during the current year (*n* = 95) were aged using scale samples from both years to increase ageing accuracy. Both scale samples were examined simultaneously by 3 experienced individuals and ages assigned. If assigned ages differed between the 3 examiners, or if a scale sample from 2011 was not the appropriate number of years older than the corresponding 2001 to 2010 scale sample, both samples were re-examined jointly by all examiners 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 2011 study have been provided to BC Hydro for archiving.

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.

2.2.2 Hierarchical Bayesian Analysis

The temporal (and where possible, spatial) variation in size-at-age, abundance, spatial distribution, growth rate, survival rate, and body condition of the three index species were estimated via hierarchical Bayesian models (HBMs). Unlike their frequentist equivalents, Bayesian models:

- do not depend on large sample sizes to ensure the validity of their estimates (Gazey and Staley 1986);
- allow the incorporation of prior information;
- readily handle missing values; and,
- provide a natural framework for hierarchical modelling (Link and Barker 2004).

Hierarchical modelling, in turn:

- allows parameters of biological and management interest to be separated from ‘nuisance’ parameters associated with data collection (Royle and Dorazio 2008); and,
- allows the temporal and spatial variation to be efficiently modeled as random effects (Royle and Dorazio 2008).

Hierarchical Bayesian models were fitted using the software package R 2.15.0 (R Development Core Team 2012) which interfaced with JAGS 3.2 (Just Another Gibbs Sampler; Plummer 2003) using the rjags package. In general, models assumed low information (Ntzoufras 2009), uniform, or normal prior distributions. The posterior distributions were estimated from a minimum of 1000 Markov Chain Monte Carlo (MCMC) simulations thinned from the second halves of three MCMC chains of between $1\text{x}10^3$ and $1\text{x}10^6$ iterations in length (depending on the analysis). Model convergence was confirmed by ensuring that R-hat (the Gelman-Rubin Brooks potential scale reduction factor) was less than 1.1 for each of the parameters in the model (Gelman & Rubin 1992; Brooks & Gelman 1998; Gelman et al. 2004). The statistical significance of particular parameters was assessed from their two-sided Bayesian p-values (Bochkina and Richardson 2007; Lin et al. 2009). Following Bradford et al. (2005), the influence of particular variables was quantified in terms of the effect size (i.e., percent differences in the response variable) with 95% credibility intervals. When the predictor of interest is a random effect the effect size is plotted with respect to the ‘typical’ value (i.e., the expected value of the underlying distribution from which the observed values represent random draws). Plots of parameter estimates and effect sizes were produced using the ggplot2 R library (Wickham 2009). For each analysis, the JAGS model code is defined in Appendix C with a description of the data variables and model parameters.

2.2.3 Size-At-Age and Growth Rate

The size-at-age of mountain whitefish and rainbow trout was estimated from yearly length-frequency distributions (Macdonald and Pitcher 1979). Key assumptions of the analyses included:

- there were three distinguishable age-classes for each species: age-0, age-1 and age-2+;
- body length increased with age-class;
- body length varied randomly with year;
- 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.

Size-at-age models were used to estimate the most appropriate cut-offs between age-0, age-1 and age-2+ 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+ 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 to be adults.

The growth rate of mountain whitefish, rainbow trout, and walleye was inferred from inter-annual recaptures using the Fabens method for estimating the von Bertalanffy growth curve (Fabens 1965 cited in Hilborn and Walters 1992). For simplicity, only recaptured fish that were at large for a single year were included in the model.

Key assumptions of the growth rate analyses included:

- mean maximum length (length-at-infinity) varied randomly with year;
- mean maximum length varied with tag type; and,
- individual variation in the mean maximum length was normally distributed.

2.2.4 Spatial Distribution and Abundance

The absolute abundance and spatial distribution of subadult and adult mountain whitefish, rainbow trout, and adult walleye were estimated from a mark-recapture analysis of intra-annual captures (Royle and Dorazio 2008).

Key assumptions of the mark-recapture analyses included:

- lineal density varied randomly with site, year, and site within year;
- lineal density did not vary with session;
- capture efficiency varied randomly with year and session; and,
- marked and unmarked individuals had the same probability of capture.

To account for sites not being closed between sessions, the probability that a marked fish had left the site was incorporated into the analyses through an informative prior distribution. The informative prior distribution was estimated from an analysis of intra-year movement, which estimated the probability that an intra-annual recapture was recaptured at the same site it was previously encountered in.

A key assumption of the analysis of intra-year movement was that the probability of a fish being recaptured at the same site varied with the number of days since the fish was initially released at that site.

2.2.5 Survival

The survival rate of subadult and adult mountain whitefish, rainbow trout, and adult walleye was estimated via a Cormack-Jolly-Seber (CJS) model of inter-annual recaptures (Royle and Dorazio 2008).

Key assumptions of the CJS models included:

- efficiency of recapture varied randomly with year;
- survival rate varied randomly with year; and,
- for mountain whitefish and rainbow trout, survival rate varied with life-stage (i.e., subadult versus adult).

2.2.6 Body Condition

The body condition of subadult and adult mountain whitefish, rainbow trout, and adult walleye was estimated via a hierarchical Bayesian analysis of body weight conditional on body length (He et al. 2008). To avoid non-independence among intra-annual recaptured individuals, only the first capture of an individual during each study year was included in the analysis.

Key assumptions of the HBM of body condition included:

- body weight varied with body length;
- body weight varied randomly with section, year, and site within year;
- body weight varied with tag type (i.e., no tag, T-bar anchor tag, or PIT tag);
- body length varied as a second-order polynomial of date; and,
- individual variation in body weight was log-normally distributed.

3.0 PHYSICAL PARAMETERS

3.1 Columbia River

3.1.1 Discharge

In 2011, average daily discharge for the Columbia River at the Birchbank Water Gauging Station was higher than the average daily discharge recorded during other study years from January to September (Figure 2; Appendix D, Figures D1 and D2). After September, average daily discharge was similar to previous study years. In June 2011, average daily discharges were substantially higher than during all previous study years. Similar to most years (post-regulation), in 2011, discharges in the LCR followed a bimodal pattern, with higher discharges in the summer and winter, and lower discharges in the spring and fall.

During the 2011 sample period, discharge remained stable for Session 1, decreased during Session 2, and gradually increased over Sessions 3 through 5 (Figure 2).

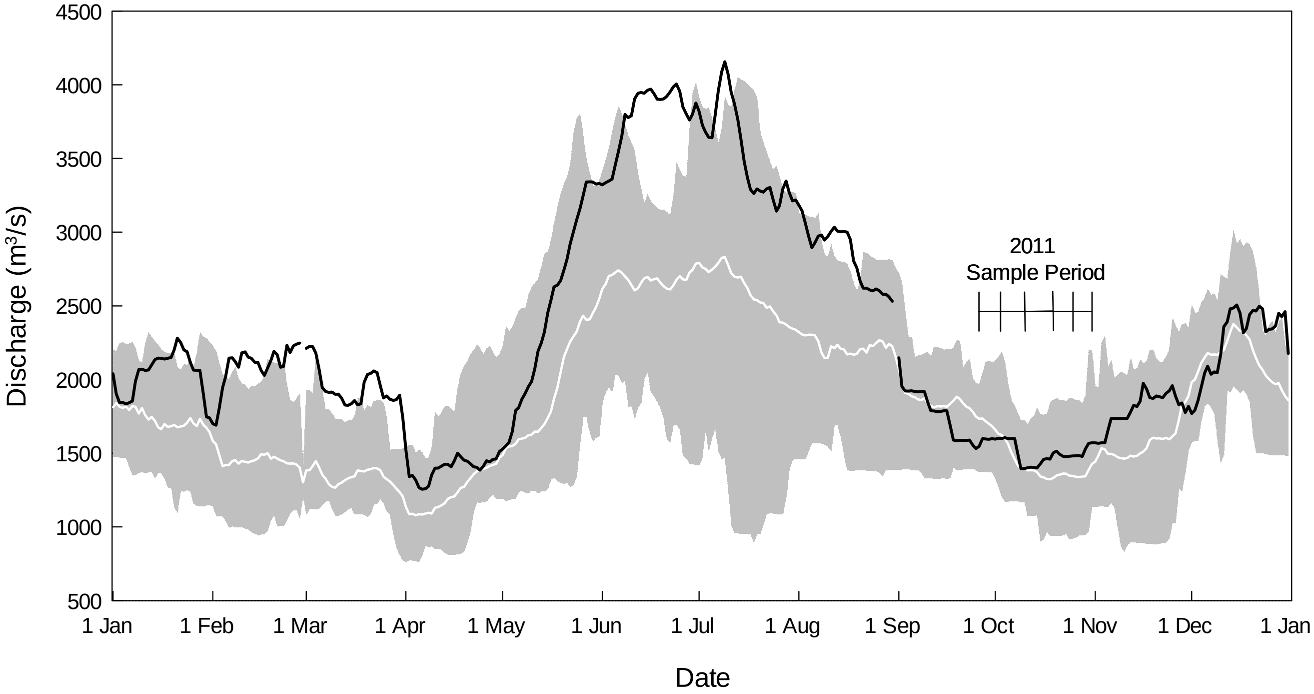

Figure 2: Mean daily discharge (m^3/s) for the Columbia River at the Birchbank Water Gauging Station (black line), 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at Birchbank from 2001 to 2010. The white line represents average mean daily discharge values over the same time period.

Between 2001 and 2011, discharge for the Columbia River at the Birchbank Water Gauging Station was more variable in the summer and winter and less variable in the spring and fall (Appendix D, Figure D2).

In 2011, discharge from HLK was lower during Session 3 (915 m^3/s) when compared to the average of all other sessions (1090 m^3/s; Figure 3, Appendix D, Figure D3).

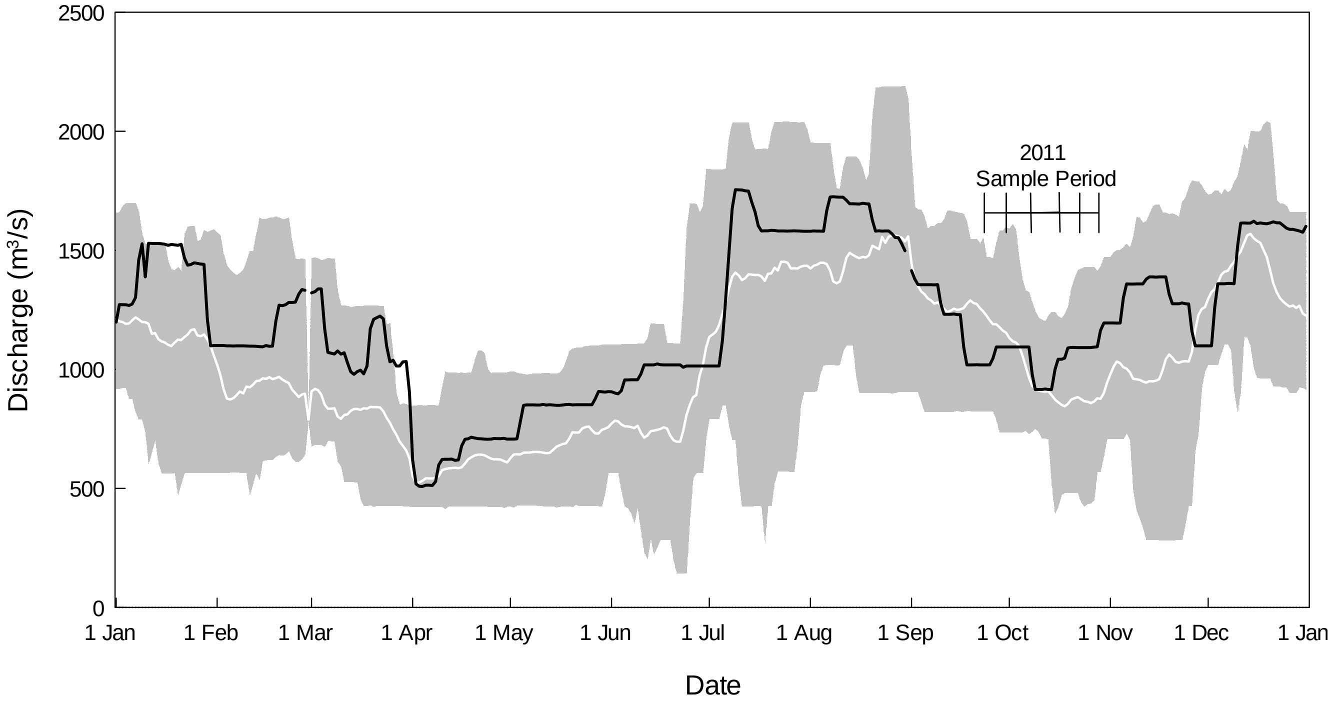

Figure 3: Mean daily discharge (m^3/s) for the Columbia River at Hugh L. Keenleyside Dam (HLK; black line), 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2010. The white line represents average mean daily discharge values over the same time period.

3.1.2 Water Temperature

Water temperatures in the Columbia River (at the Birchbank Water Gauging Station) generally increase from mid-February to mid-August and decrease from mid-August to mid-February (Figure 4, Appendix D, Figures D4 and D5). Based on data collected between 2001 and 2011, the average minimum water temperature for the Columbia River was approximately 3.3°C; the average maximum water temperature was approximately 18.5°C. In 2011, water temperature was substantially lower than in most other study years from late February to early September. Over the 2011 study period, Columbia River water temperatures gradually declined from 14.9°C (on September 26) to 9.2°C (on October 30).

Spot temperature readings for the Columbia River taken at the time of sampling ranged between 7.6°C and 14.3°C (Appendix B, Table B3).

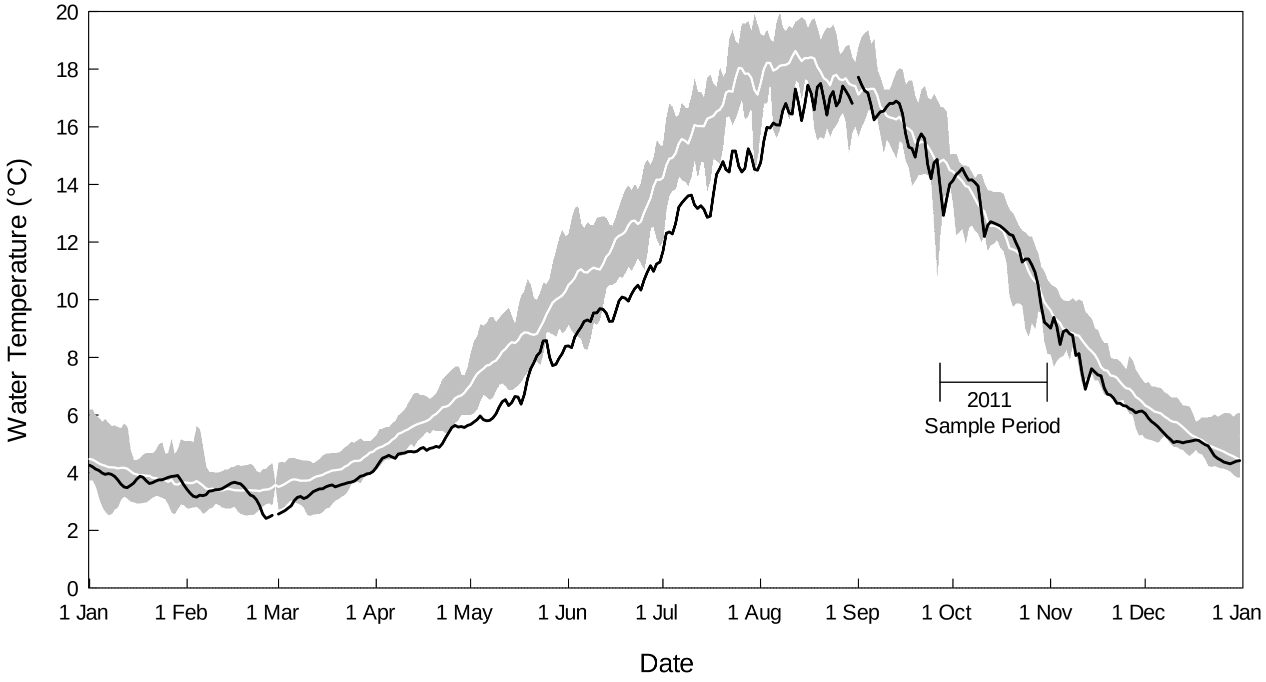

Figure 4: Mean daily water temperature (°C) for the Columbia River at the Birchbank Water Gauging Station (black line), 2011. The shaded area represents minimum and maximum mean daily water temperature values recorded at Birchbank from 2001 to 2010. The white line represents average mean daily water temperature values over the same time period.

3.2 Kootenay River

3.2.1 Discharge

In 2011, average daily discharge for the Kootenay River downstream of BRD was higher than the average daily discharge recorded during other study years from early February to early September and similar to other study years from early September to the end of December (Figure 5, Appendix D, Figure D6). For this portion of the Kootenay River, discharge is generally high from April to August and low during all other times of the year.

During the 2011 sample period, Kootenay River discharge remained stable for Sessions 1 and 2, decreased during Sessions 3 and 4, and remained stable during Session 5 (Figure 5).

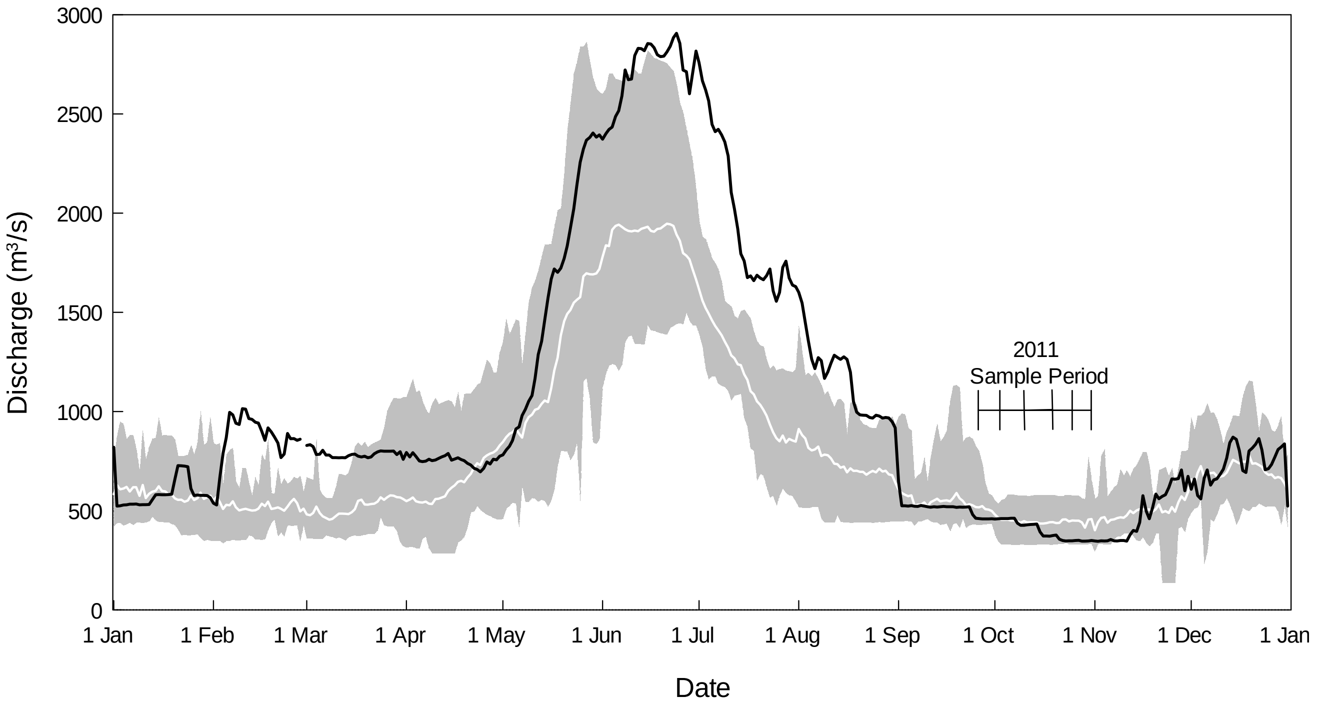

Figure 5: Mean daily discharge (m^3/s) for the Kootenay River at Brilliant Dam (BRD; black line), 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2010. The white line represents average mean daily discharge values over the same time period.

3.2.2 Water Temperature

Water temperatures in the Kootenay River (downstream of BRD) generally increase from mid-February to mid-August and decrease from mid-August to mid-February (Figure 6). Based on data collected between 2001 and 2011, the average water temperature for the Kootenay River ranged from approximately 3°C to 20°C (Appendix D, Figure D7). In 2011, water temperatures were substantially lower than in most other study years from late February to early September.

Spot temperature readings for the Kootenay River taken at the time of sampling ranged between 9.3°C and 14.7°C (Appendix B, Table B3).

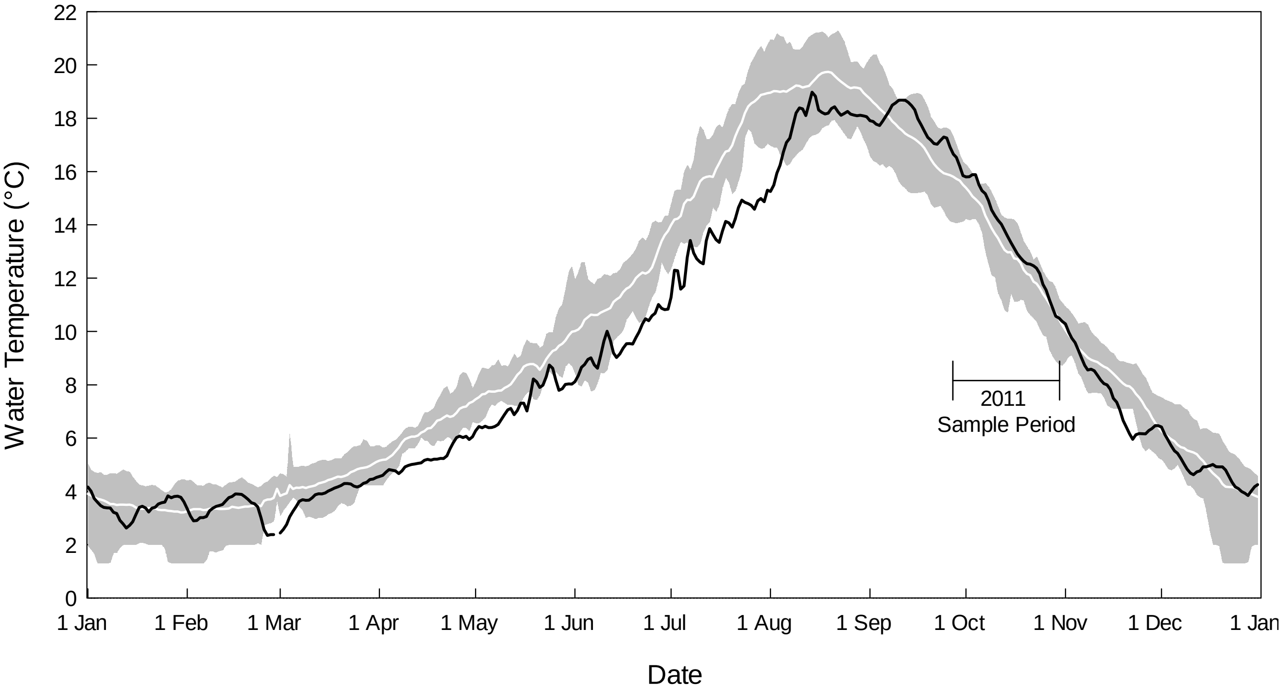

Figure 6: Mean daily water temperature (°C) for the Kootenay River downstream of Brilliant Dam (BRD; black line), 2011. The shaded area represents minimum and maximum mean daily water temperature values recorded at the dam from 2001 to 2010. The white line represents average mean daily water temperature values over the same time period.

3.3 Habitat Conditions

Reach habitat descriptions for the LCR are provided by Golder (2002). Habitat data collected between 2001 and 2011 suggest a gradual increase in aquatic vegetation (dominantly Eurasian watermilfoil; *Myriophyllum spicatum*) in low water velocity areas of the upstream section of the Columbia River (Appendix B, Table B3). Sites in the upstream section of the Columbia River where water velocities were higher (i.e., C07.3-R and the portion of C07.4-L located downstream of the Norn's Creek confluence) and sites C00.0-R (located along the face of HLK) and C00.7-L (located directly downstream of ALGS) 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 pers. comm.).

4.0 RESULTS

4.1 Catch

In the present study, 51 950 fishes were recorded in the LCR (Appendix E, Table E1). This includes captured and observed fish that were identified to species. Catch was greatest in the downstream section of the Columbia River (56% of the total catch), followed by the upstream section of the Columbia River (37%), and the Kootenay River (6%; Table 4).

Table 4: Number of fishes caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the Lower Columbia River, September 26 to October 30, 2011.

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*)	1198	43	698	48	1037	16	**2933**	**27**
Rainbow trout (*Oncorhynchus mykiss*)	960	34	340	23	4201	64	**5501**	**51**
Walleye (*Sanders vitreus*)	560	20	387	27	867	13	**1814**	**17**
Brook trout (*Salvelinus fontinalis*)					14	<1	**14**	**<1**
Brown trout (*Salmo trutta*)					4	<1	**4**	**<1**
Bull trout (*Salvelinus confluentus*)	6	<1			6	<1	**12**	**<1**
Burbot (*Lota lota*)	7	<1	2	<1	238	4	**247**	**2**
Cutthroat trout (*Oncorhynchus clarki*)					4	<1	**4**	**<1**
Kokanee (*Oncorhynchus nerka*)	58	2	12	<1	7	<1	**77**	**<1**
Lake whitefish (*Coregonus clupeaformis*)	13	<1	7	<1	200	3	**220**	**2**
Northern pike (*Esox lucius*)	9	<1					**9**	**<1**
Smallmouth bass (*Micropterus dolomieu*)					8	<1	**8**	**<1**
White sturgeon (*Acipenser transmontanus*)	3	<1	5	<1	15	<1	**23**	**<1**
Yellow perch (*Perca flavescens*)			1	<1	1	<1	**2**	**<1**
Sportfish Subtotal	**2814**	**26**	**1452**	**13**	**6602**	**61**	**10 868**	**100**
Non-sportfish								
Dace spp.[c] (*Cyprinidae*)					3	<1	**3**	**<1**
Northern pikeminnow (*Ptychocheilus oregonensis*)	471	3	158	5	135	<1	**764**	**2**
Peamouth (*Mylocheilus caurinus*)	188	1	3	<1	1	<1	**192**	**<1**
Redside shiner (*Richardsonius balteatus*)	3965	27	120	4	541	2	**4626**	**11**
Sculpin spp.[c] (*Cottidae*)	6715	46	1923	66	20 754	89	**29 392**	**72**
Sucker spp.[c] (*Catostomidae*)	3362	23	713	24	1874	8	**5949**	**15**
Non-Sportfish Subtotal	**14 701**	**36**	**2917**	**7**	**23 308**	**57**	**40 926**	**100**
All Species	**17 515**		**4369**		**29 910**		**51 794**	

[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.

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), 2011;
- catch-rates for all sportfish (Appendix E, Table E2) and non-sportfish (Appendix E, Table E3), 2011;
- inter-site movement summaries for mountain whitefish (Appendix E, Figure E1), rainbow trout (Appendix E, Figure E2), and walleye (Appendix E, Figure E3), all years combined;
- length-frequency histograms by section for mountain whitefish (Appendix F, Figure F1), rainbow trout (Appendix F, Figure F2), and walleye (Appendix F, Figure F3), 2011;
- 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 2011 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 that are sampled annually (i.e., index sites); red plots represent synoptic sites (i.e., sites sampled during the 2011 GRTS survey).

4.2 Size-At-Age and Growth Rate

Output from the size-at-age model are presented in Table 5 and represent the most appropriate cut-offs between age-0 (fry), age-1 (subadult), and age-2+ (adult) mountain whitefish and rainbow trout during each sample year. As identified in Section 2.2.3, all walleye were classified as adults by the HBMs.

Table 5: 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, 2001 to 2011.

Year	Mountain Whitefish			Rainbow Trout		
	Fry	Subadult	Adult	Fry	Subadult	Adult
2001	60-138	139-221	222-520	53-125	126-314	315-656
2002	77-156	157-231	232-458	77-153	154-324	325-589
2003	88-160	161-231	232-483	81-160	161-336	337-651
2004	73-160	161-244	245-490	73-148	149-335	336-620
2005	95-169	170-251	252-487	95-168	169-351	352-651
2006	91-168	169-259	260-515	80-165	166-360	361-599
2007	99-172	173-255	256-514	88-168	169-365	366-690
2008	73-169	170-265	266-488	74-149	150-338	339-699
2009	98-166	167-256	257-482	70-149	150-341	342-640
2010	95-175	176-266	267-498	68-146	147-336	337-620
2011	78-163	164-254	255-493	70-151	152-343	344-651

4.2.1 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, after which time, growth slowed considerably (Figure 8).

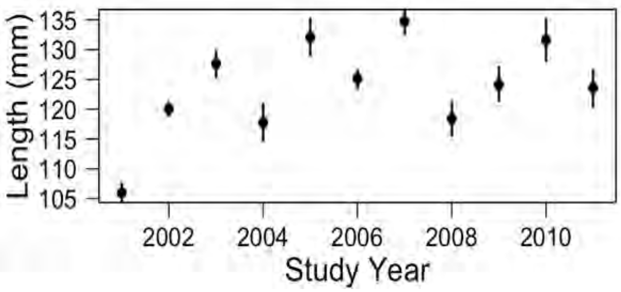

Figure 7: Expected fork length by year with 95% credibility intervals for mountain whitefish fry in the Lower Columbia River, 2001 to 2011.

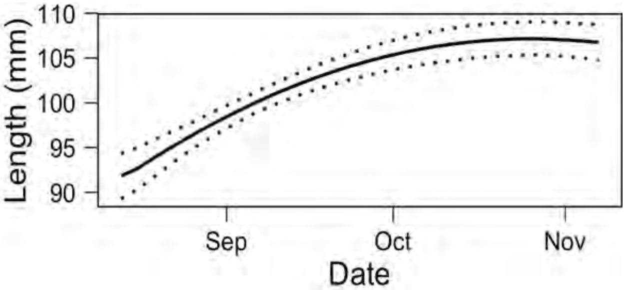

Figure 8: Expected fork length by date with 95% credibility intervals for mountain whitefish fry in the Lower Columbia River, 2001 to 2011.

The length-at-age of subadult mountain whitefish generally increased between 2001 and 2008 and was variable between 2008 and 2011 (Figure 9). 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 grew throughout the fall study period (Figure 10).

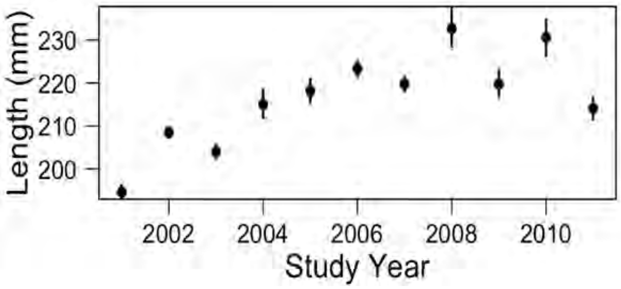

Figure 9: Expected fork length by year with 95% credibility intervals for subadult mountain whitefish in the Lower Columbia River, 2001 to 2011.

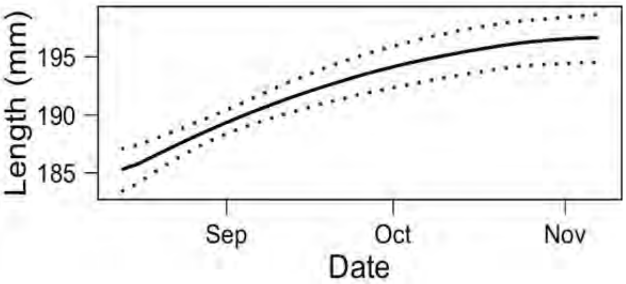

Figure 10: Expected fork length by date with 95% credibility intervals for subadult mountain whitefish in 2006 in the Lower Columbia River, 2001 to 2011.

Results of the hierarchical Bayesian analysis of annual length increments of recaptured individuals indicated an increase in average annual growth between 2002 and 2006, and variable annual growth between 2006 and 2011, although credibility intervals overlapped between most estimates (Figure 11). 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.

For mountain whitefish, there was no discernible difference in annual growth for a fish marked with a T-bar anchor tag when compared to the annual growth of a fish marked with a PIT tag (p = 0.986; Figure 12).

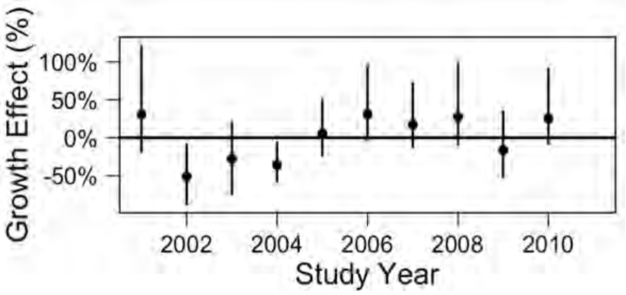

Figure 11: *Expected percent change in inter-annual growth by year with 95% credibility intervals for an average length (319 mm FL) PIT tagged mountain whitefish in the Lower Columbia River. The point estimates are median expected values while the lower and upper 95% credibility limits are 2.5% and 97.5% quantiles, respectively.*

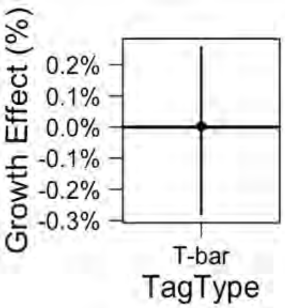

Figure 12: *Expected percent change in inter-annual growth for a T-bar anchor tagged fish relative to a PIT tagged fish with 95% credibility intervals for an average length (319 mm FL) mountain whitefish in the Lower Columbia River.*

4.2.2 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 2011 (Figure 13); credibility intervals overlapped for some estimates. 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 (Figures 7 and 9, respectively). However, unlike mountain whitefish fry (Figure 8), rainbow trout fry exhibited low growth rates during the fall study period (Figure 14).

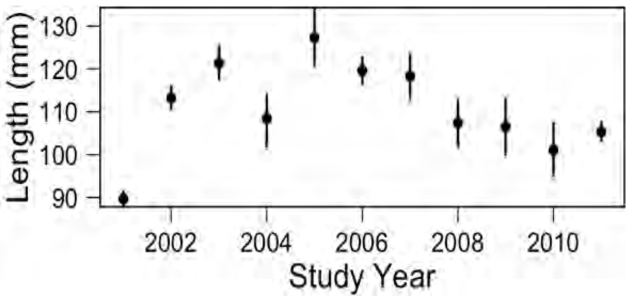

Figure 13: *Expected fork length by year with 95% credibility intervals for rainbow trout fry in the Lower Columbia River, 2001 to 2011.*

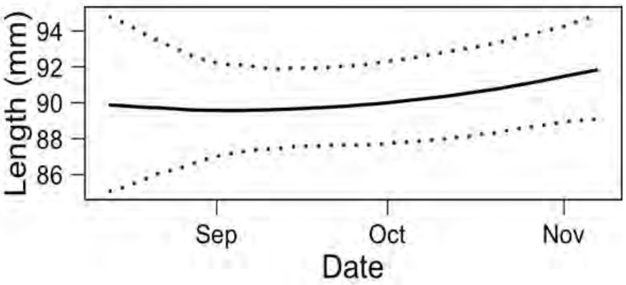

Figure 14: *Expected fork length by date with 95% credibility intervals for rainbow trout fry in the Lower Columbia River, 2001 to 2011.*

The length-at-age of subadult rainbow trout generally increased between 2001 and 2007, followed by a substantial decline between 2007 and 2008 (Figure 15). Growth for this cohort was stable between 2008 and 2010 and slightly higher in 2011. Similar to results presented for other species and cohorts (Figures 7, 9, and 13), subadult rainbow trout were substantially smaller in 2001 when compared to all other study years (Figure 15). During a typically study year, subadult rainbow trout continued to grow well into November (Figure 16).

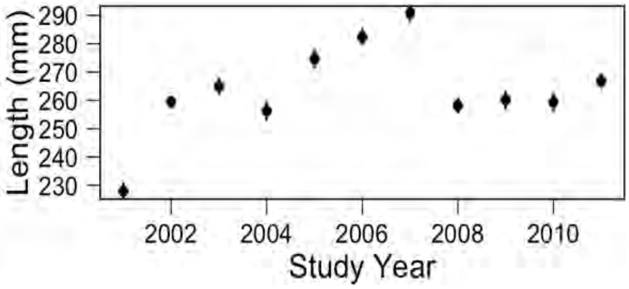

Figure 15: Expected fork length by year with 95% credibility intervals for subadult rainbow trout in the Lower Columbia River, 2001 to 2011.

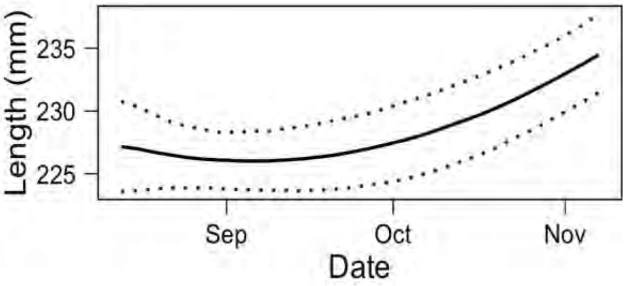

Figure 16: Expected fork length by date with 95% credibility intervals for subadult rainbow trout in the Lower Columbia River, 2001 to 2011.

Results of the hierarchical Bayesian analysis of annual length increments of recaptured individuals indicated slower growth from 2002 to 2004 when compared to latter study years (Figure 17). Overall, annual growth for this species was variable, changing by as much as 25% during a one year period.

There was no discernible difference in annual growth for a rainbow trout marked with a T-bar anchor tag when compared to the annual growth of a fish marked with a PIT tag (p = 0.999; Figure 18).

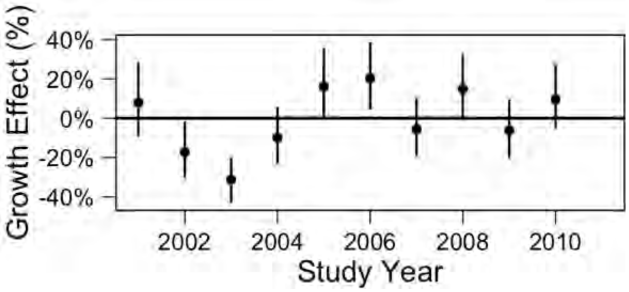

Figure 17: Expected percent change in inter-annual growth by year with 95% credibility intervals for an average length (330 mm FL) PIT tagged rainbow trout in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

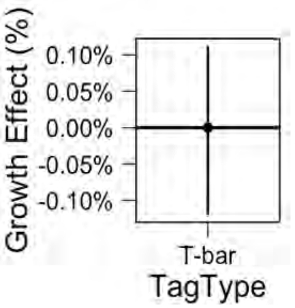

Figure 18: Expected percent change in inter-annual growth for a T-bar anchor tagged fish relative to a PIT tagged fish with 95% credibility intervals for an average length (330 mm FL) rainbow trout in the Lower Columbia River.

4.2.3 Walleye

Results of the hierarchical Bayesian analysis of annual length increments of recaptured individuals indicated slightly higher walleye growth in 2001, 2005, and 2006 when compared to other study years (Figure 19);

however, credibility intervals overlapped for most estimates. Annual growth for this species generally declined between 2006 and 2011.

For walleye, there was no discernible difference in annual growth for a fish marked with a T-bar anchor tag when compared to the annual growth of a fish marked with a PIT tag (p = 0.982; Figure 20).

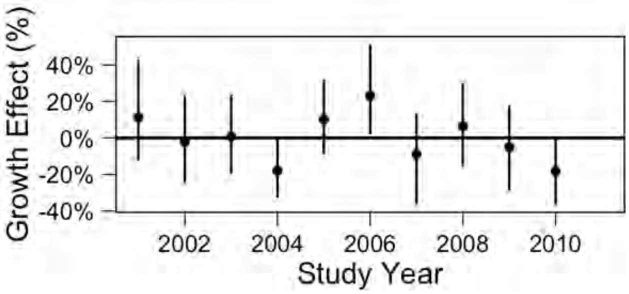

Figure 19: *Expected percent change in inter-annual growth by year with 95% credibility intervals for an average length (379 mm FL) PIT tagged walleye in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

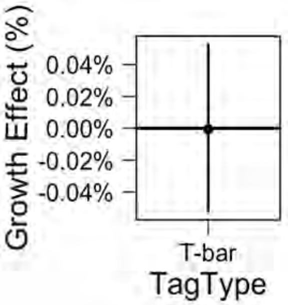

Figure 20: *Expected percent change in inter-annual growth for a T-bar anchor tagged fish relative to a PIT tagged fish with 95% credibility intervals for an average length (379 mm FL) walleye in the Lower Columbia River.*

4.3 Spatial Distribution and Abundance

There was no substantial differences in site fidelity between subadult and adult mountain whitefish; the probability of both these life stages of mountain whitefish being recaptured within the same site where initially marked was estimated at approximately 50% (Figure 21). Subadult rainbow trout exhibited higher site fidelity than adult rainbow trout. The probability of recapturing a walleye within its original release site was estimated at 68%.

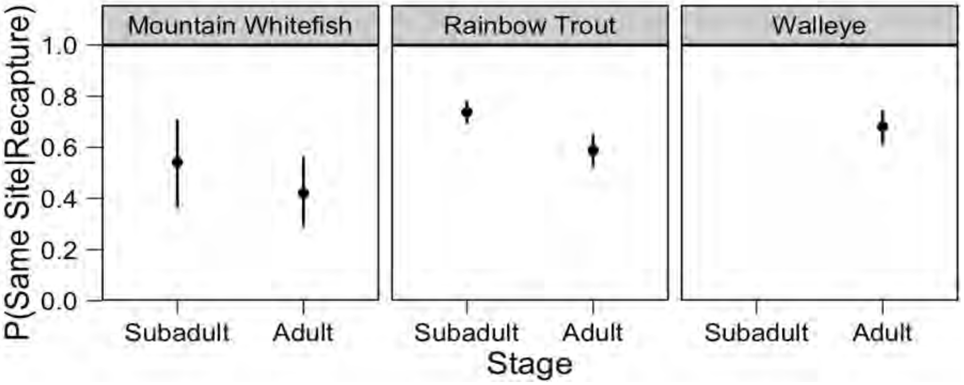

Figure 21: *Expected probability that a recaptured fish is captured at the same site it was previously encountered in by species and life-stage in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

4.3.1 Mountain Whitefish

Capture efficiencies for subadult and adult mountain whitefish were approximately 1% and 0.6%, respectively and remained relatively consistent during all sample years and sample sessions (Figures 22 to 25).

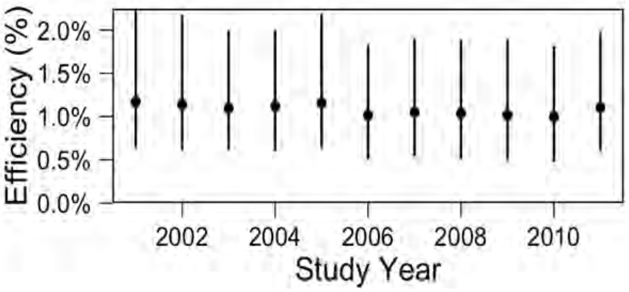

Figure 22: Expected percent capture efficiency by year with 95% credibility intervals for subadult mountain whitefish during a typical session in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

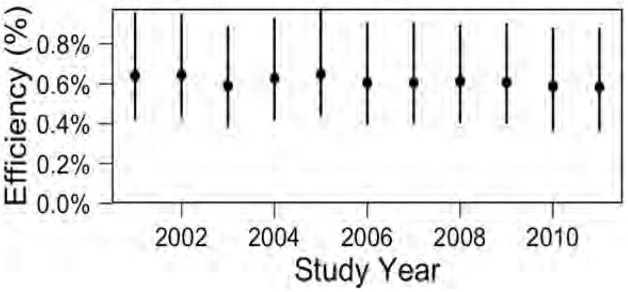

Figure 24: Expected percent capture efficiency by year with 95% credibility intervals for adult mountain whitefish during a typical session in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

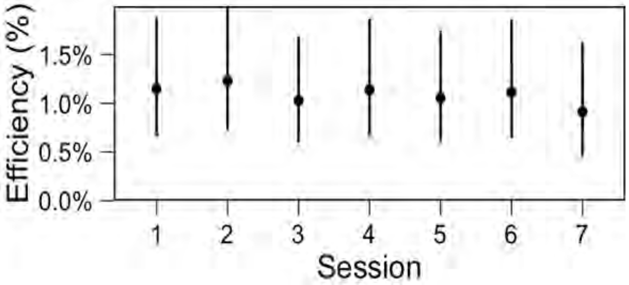

Figure 23: Expected percent capture efficiency by session with 95% credibility intervals for subadult mountain whitefish during a typical year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

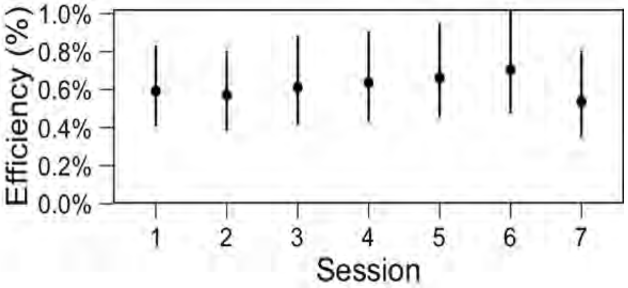

Figure 25: Expected percent capture efficiency by session with 95% credibility intervals for adult mountain whitefish during a typical year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

For subadult mountain whitefish in the LCR, patterns of annual relative density and abundance estimates (Figures 26 and 27, respectively) suggests that the number of subadult mountain whitefish in the study area declined by approximately 65% between 2001 to 2005, increased between 2005 and 2007, and remained relatively stable between 2008 and 2011. Credibility intervals overlapped for all estimates. Overall, the estimated number of subadult mountain whitefish in the LCR in 2011 was approximately 40% of what it was a decade earlier.

Abundance and density estimates generated for adult mountain whitefish (Figures 28 and 29, respectively) exhibited wide credibility limits that confounded interpretation of trends; however, estimates were slightly lower in 2010 and 2011 than in most previous study years.

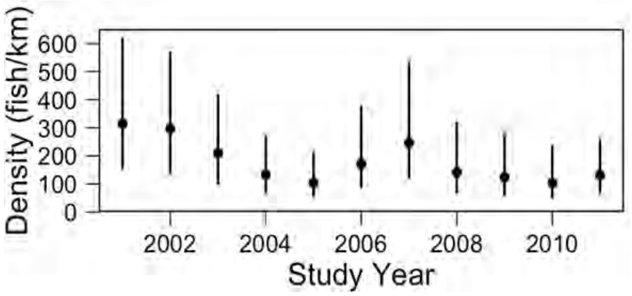

Figure 26: *Expected lineal density by year with 95% credibility intervals for subadult mountain whitefish at a typical site in the Lower Columbia River. The point estimates are the median expected values while the lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

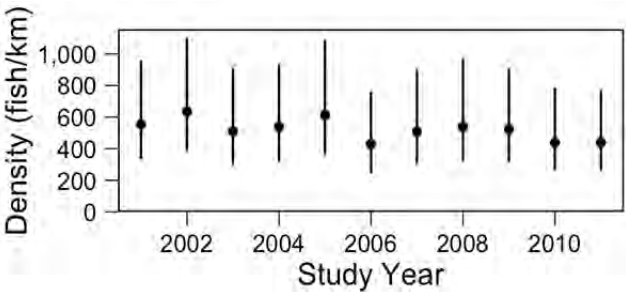

Figure 28: *Expected lineal density by year with 95% credibility intervals for adult mountain whitefish at a typical site in the Lower Columbia River. The point estimates are the median expected values while the lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

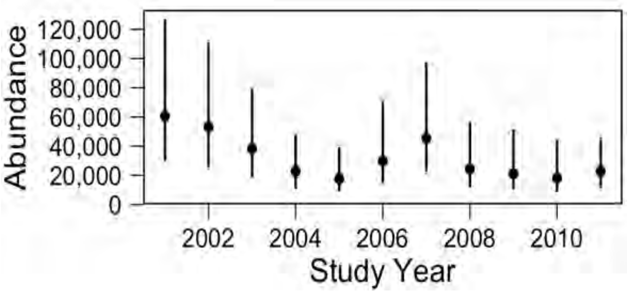

Figure 27: *Expected population abundance by year with 95% credibility intervals for subadult mountain whitefish in the Lower Columbia River. The point estimates are the median expected values while the lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

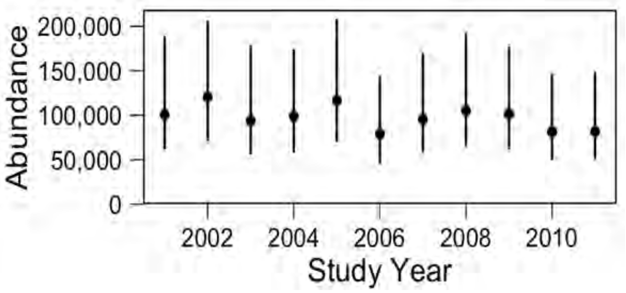

Figure 29: *Expected population abundance by year with 95% credibility intervals for adult mountain whitefish in the Lower Columbia River. The point estimates are the median expected values while the lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

Subadult mountain whitefish densities were noticeably higher 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 30). In comparison, subadult mountain whitefish densities were lower in the Kootenay River and in the Columbia River downstream, river sections with high water velocities.

Adult mountain whitefish site level density estimates (Figure 31) were more uncertain than estimates generated for subadult mountain whitefish, but were generally higher in sites known to contain suitable spawning habitat for this species. These included; Norn’s Creek Fan (RKm 7.4), 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).

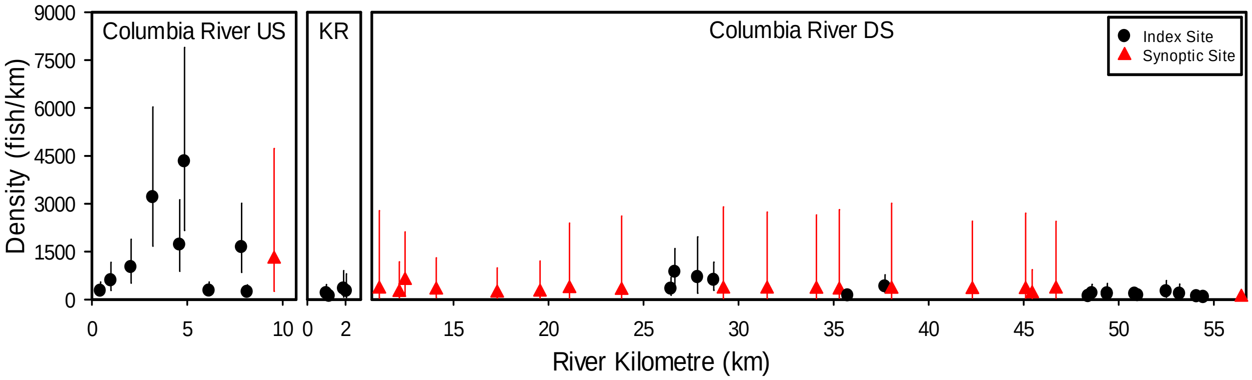

Figure 30: Expected lineal density by site with 95% credibility intervals for subadult mountain whitefish in a typical year in the Lower Columbia River, 2001 to 2011. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively. The Kootenay River is coded as KR; the Columbia River is split by sites located upstream (US) and downstream (DS) of the Kootenay River confluence.

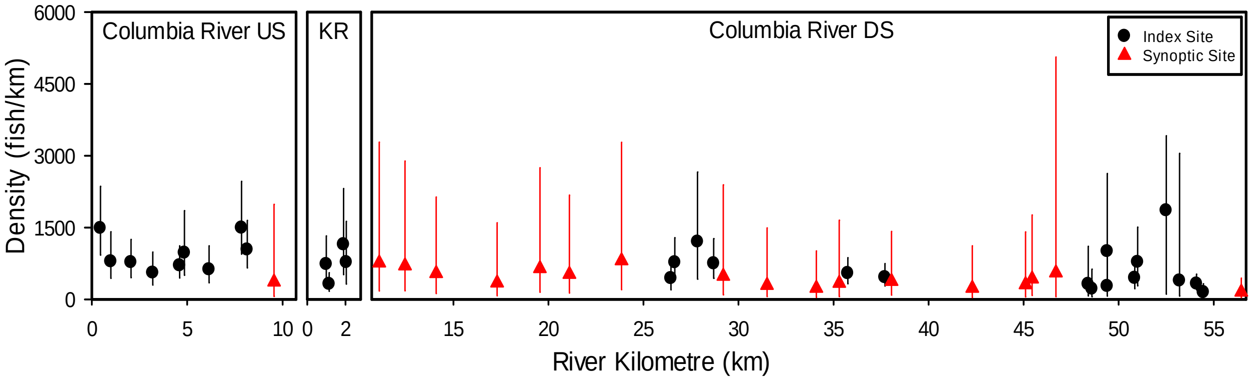

Figure 31: Expected lineal density by site with 95% credibility intervals for adult mountain whitefish in a typical year in the Lower Columbia River, 2001 to 2011. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively. The Kootenay River is coded as KR; the Columbia River is split by sites located upstream (US) and downstream (DS) of the Kootenay River confluence.

4.3.2 Rainbow Trout

Subadult rainbow trout capture efficiency remained relatively constant at approximately 4% between 2001 and 2011 (Figure 32). However, within each sample year, the capture efficiency of this cohort decreased during each successive sample session (Figure 33). Capture efficiencies for adult rainbow trout remained stable between 2001 and 2010 at approximately 2.2%, but were slightly higher in 2011 (3.0%; Figure 34). Within each sample year, the capture efficiency of adult rainbow trout was similar during the first 6 sessions, but lower during the 7th session (Figure 35).

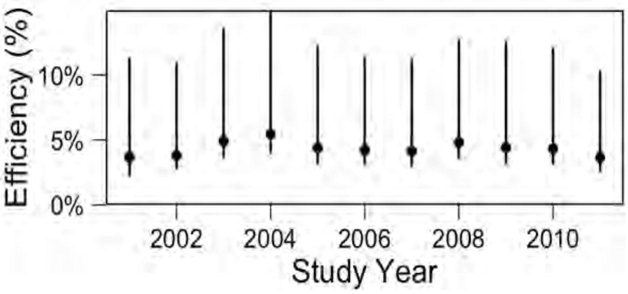

Figure 32: Expected percent capture efficiency by year with 95% credibility intervals for subadult rainbow trout during a typical session in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

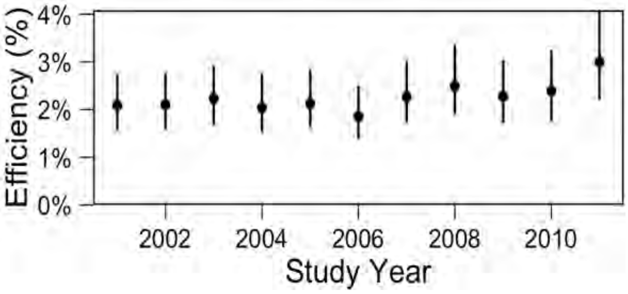

Figure 34: Expected percent capture efficiency by year with 95% credibility intervals for adult rainbow trout during a typical session in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

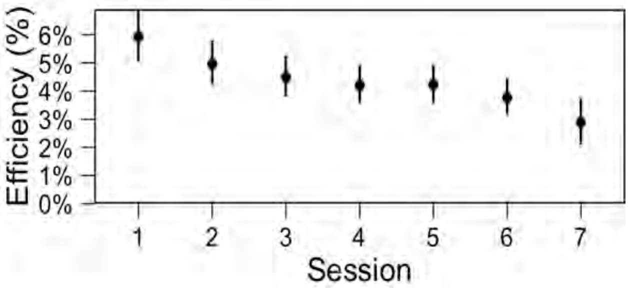

Figure 33: Expected percent capture efficiency by session with 95% credibility intervals for subadult rainbow trout during a typical year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

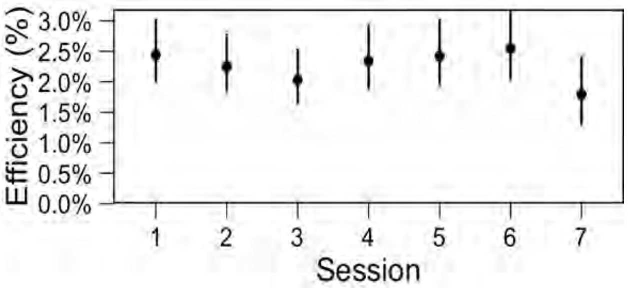

Figure 35: Expected percent capture efficiency by session with 95% credibility intervals for adult rainbow trout during a typical year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

The estimated number of subadult rainbow trout in the LCR declined between 2001 and 2005, increased between 2005 and 2007, and remained stable between 2008 and 2010 (Figures 36 and 37). A similar pattern was observed for mountain whitefish (Figures 26 and 27). Unlike subadult mountain whitefish, however, the abundance of subadult rainbow trout approximately doubled between 2010 and 2011, which suggested strong recruitment from the 2010 brood year. Length-frequency data collected in 2010 does not suggest a greater abundance of age-0 rainbow trout relative to other study years (Appendix F, Figure F5); however, the estimated number of rainbow trout that spawned in the LCR was higher in 2010 than any other year between 1999 and 2011 (CLBMON-46; Thorley and Baxter 2012).

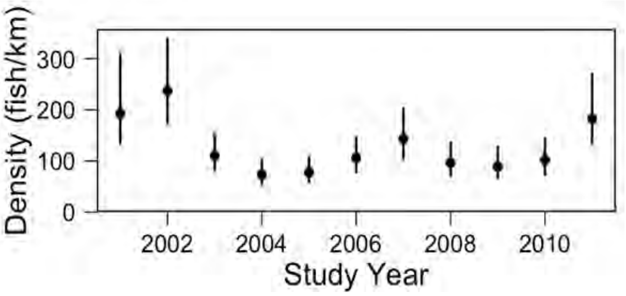

Figure 36: Expected lineal density by year with 95% credibility intervals for subadult rainbow trout at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

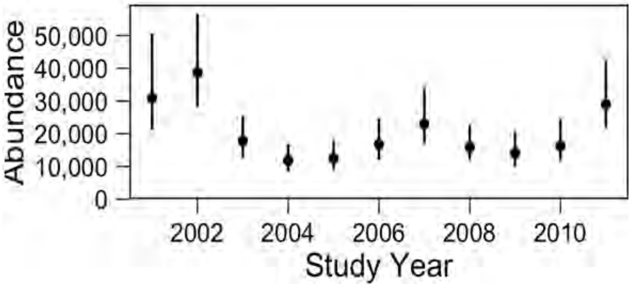

Figure 37: Expected population abundance by year with 95% credibility intervals for subadult rainbow trout in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

Annual estimates of adult rainbow trout in the LCR remained relatively stable at approximately 20,000 individuals between 2001 and 2011 (Figures 38 and 39). This stability is unexpected given the much greater annual variability in the abundance of subadult rainbow over the same time period.

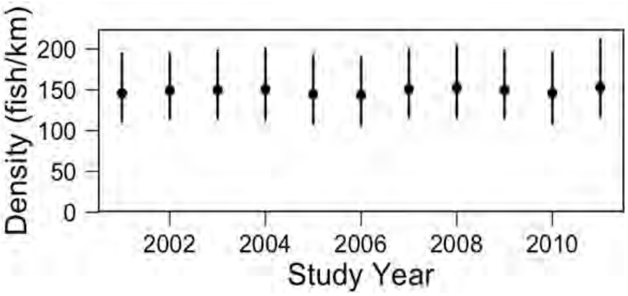

Figure 38: Expected lineal density by year with 95% credibility intervals for adult rainbow trout at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

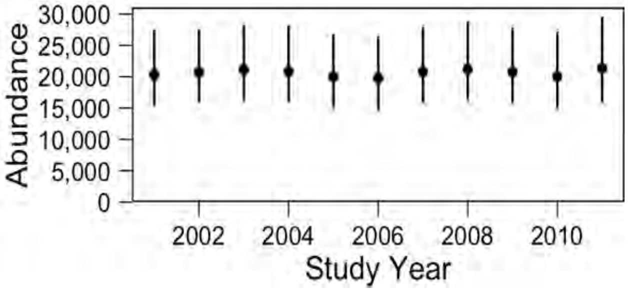

Figure 39: Expected population abundance by year with 95% credibility intervals for adult rainbow trout in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

The wide credibility intervals around the subadult rainbow trout site-level lineal density estimates (Figure 40), particularly for sites that were sampled in 2011 only, hindered the interpretation of the HBM results for this cohort. Despite the uncertainty, the analysis does suggest higher subadult rainbow trout densities in most sites between the Kootenay River confluence (RKm 10.6) and Beaver Creek (RKm 47.8).

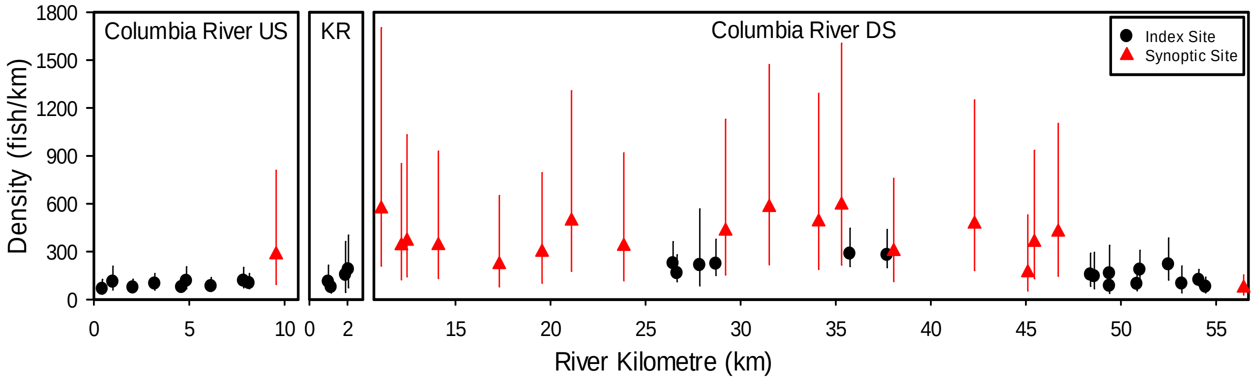

Figure 40: Expected lineal density by site with 95% credibility intervals for subadult rainbow trout in a typical year in the Lower Columbia River, 2001 to 2011. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively. The Kootenay River is coded as KR; the Columbia River is split by sites located upstream (US) and downstream (DS) of the Kootenay River confluence.

Adult rainbow trout densities (Figure 41) were noticeably higher in the Columbia River between the Kootenay River confluence and the Beaver Creek confluence and lower in the Columbia River upstream of the Kootenay River confluence. Adult rainbow trout densities were substantially higher at sites C44.7-R (near the Bear Creek confluence) and C23.4-L (between the Champion Creek and Jordan Creek confluences) and immediately downstream of the Kootenay River confluence when compared to neighbouring sites.

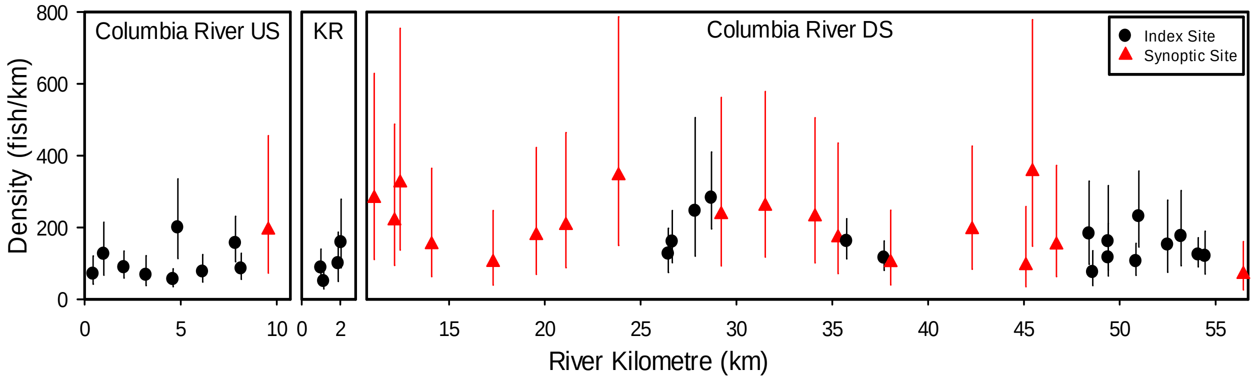

Figure 41: Expected lineal density by site with 95% credibility intervals for adult rainbow trout in a typical year in the Lower Columbia River, 2001 to 2011. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively. The Kootenay River is coded as KR; the Columbia River is split by sites located upstream (US) and downstream (DS) of the Kootenay River confluence.

4.3.3 Walleye

Walleye capture efficiency varied from 0.7% in 2001 to 1.8% in 2011 (Figure 42). Capture efficiencies were higher in 2004, 2005, and 2011 compared to other study years. On average, walleye capture efficiency declined during each successive sample session (Figure 43).

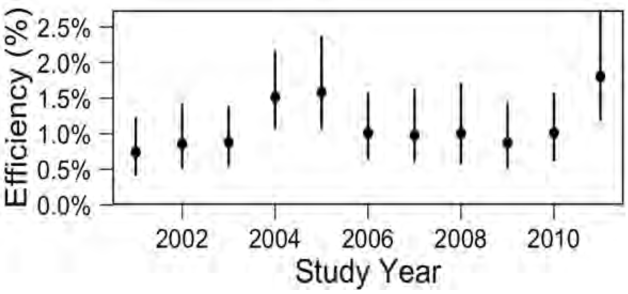

Figure 42: *Expected percent capture efficiency by year with 95% credibility intervals for walleye during a typical session in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

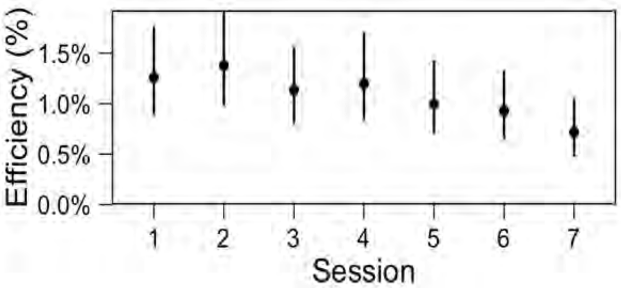

Figure 43: *Expected percent capture efficiency by session with 95% credibility intervals for walleye during a typical year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

Both relative lineal density estimates and absolute abundance estimates for walleye (Figures 44 and 45, respectively) indicate a substantial increase in abundance between 2002 and 2003 and a gradual decrease between 2003 and 2007. These results likely indicate a strong year-class of walleye that migrated into the study area between 2002 and 2003, and these individuals gradually decreased in abundance over the next four years. Both models also indicate slightly higher walleye abundance in 2010.

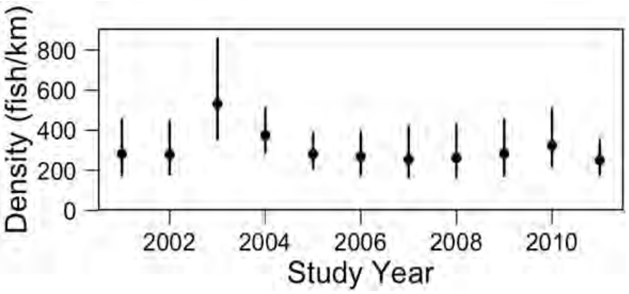

Figure 44: *Expected lineal density by year with 95% credibility intervals for walleye at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

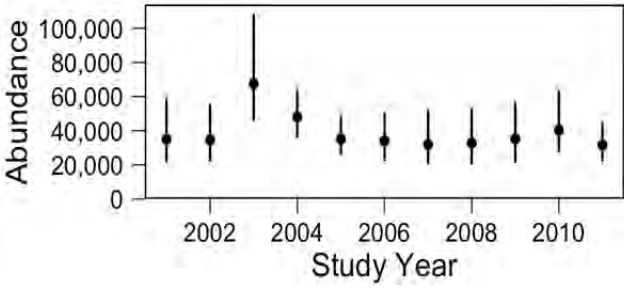

Figure 45: *Expected population abundance by year with 95% credibility intervals for walleye in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

Credibility intervals surrounding walleye site-level densities estimates overlapped for most sites in the LCR (Figure 46) and did not suggest a strong selection for any particular location in the study area.

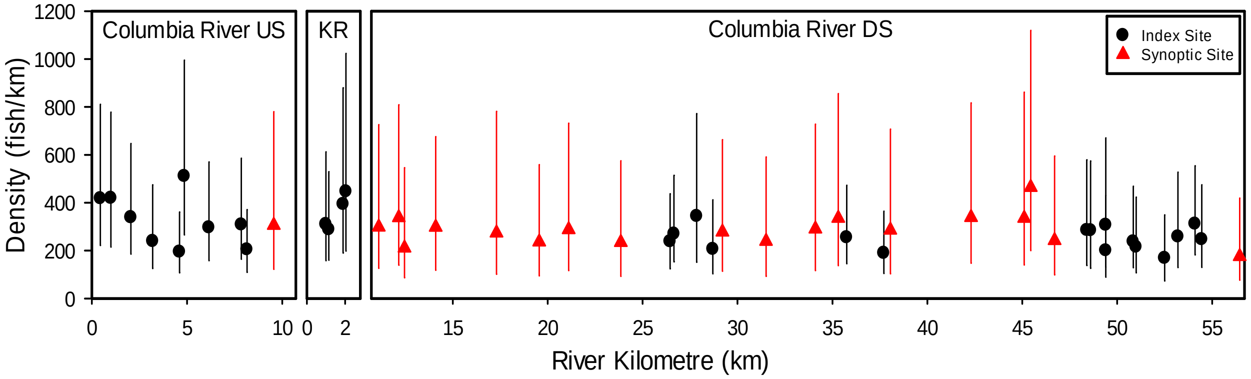

Figure 46: *Expected lineal density by site with 95% credibility intervals for walleye in a typical year in the Lower Columbia River, 2001 to 2011. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively. The Kootenay River is coded as KR; the Columbia River is split by sites located upstream (US) and downstream (DS) of the Kootenay River confluence.*

4.4 Survival

4.4.1 Mountain Whitefish

Overall, subadult mountain whitefish survival estimates exhibited wide credibility intervals that limited the identification of annual patterns (Figure 47); however, the analysis does suggest lower inter-year survival for subadult mountain whitefish between 2005 and 2006 (i.e., the 2003 brood year) and between 2006 and 2007 (i.e., the 2005 brood year). For all years combined, inter-annual survival for this cohort was approximately 23%.

The survival of adult mountain whitefish (Figure 48) gradually increased from 2001 to 2007; however, credibility intervals overlapped for all estimates. Between 2001 and 2011, inter-annual survival for this cohort ranged from 32% (in 2003) to 76% (in 2007), which was generally higher than subadult mountain whitefish survival.

Overall, survival estimates generated for mountain whitefish were less precise than corresponding estimates for rainbow trout (see Section 4.4.2).

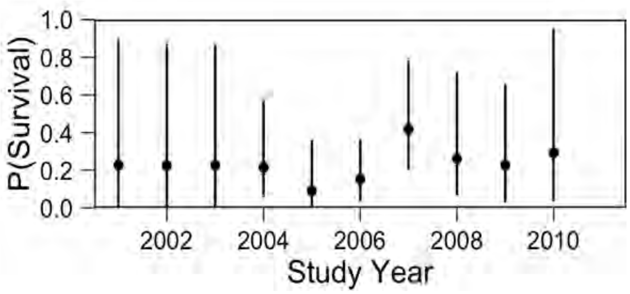

Figure 47: *Expected inter-annual survival of subadult mountain whitefish by year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

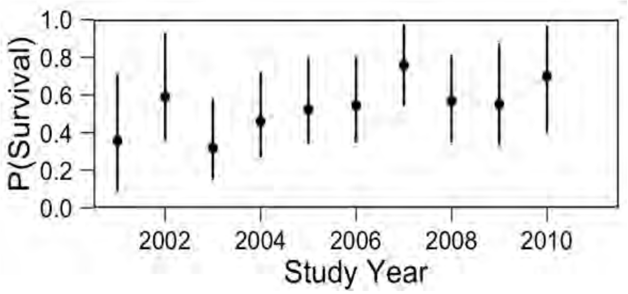

Figure 48: *Expected inter-annual survival of adult mountain whitefish by year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.*

4.4.2 Rainbow Trout

Inter-annual survival for subadult rainbow trout remained stable at approximately 51% between 2001 and 2011 (Figure 49). Inter-annual survival was lower for adult rainbow trout than for subadult rainbow trout over the same time period (Figure 50). Although credibility intervals overlapped, median survival values for adult rainbow trout increased each year between 2008 and 2010.

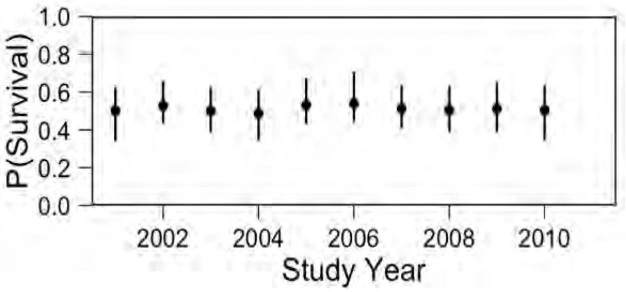

Figure 49: Expected inter-annual survival of subadult rainbow trout by year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

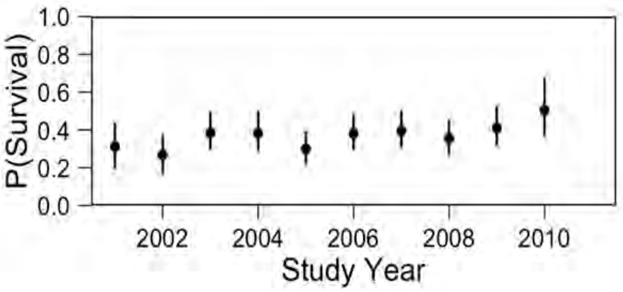

Figure 50: Expected inter-annual survival of adult rainbow trout by year in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

4.4.3 Walleye

Annual estimates of inter-annual survival for walleye could not be estimated due to insufficient data. However, inter-annual survival from 2001 to 2011 combined was estimated at approximately 51% (42-67% Credibility Intervals).

4.5 Body Condition

4.5.1 Mountain Whitefish

Variations in annual body condition estimates of subadult and adult mountain whitefish (Figures 51 and 52, respectively) were similar and generally declined between 2001 and 2003, increased between 2003 and 2006, and were stable between 2007 and 2011.

The body condition of subadult mountain whitefish did not change substantially over the course of a typical sample season (Figure 53). However, the body condition of adult mountain whitefish in the Columbia River upstream and downstream of the Kootenay River confluence increased until mid-September and then declined substantially (Figure 54). During the fall season, sexually mature mountain whitefish develop gametes for the upcoming spawning season, which should lead to an increase in body condition; therefore, the reduction in body condition observed during the fall period is suspect for this cohort. The decline is likely the result of sexually mature fish migrating out of some sample sites to hold prior to the spawning season, thereby reducing the body condition of the remaining population. The Kootenay River, a known holding and spawning area for this species, exhibited increasing body conditions for the duration of the sample season (Figure 54).

The presence of a T-bar anchor tag or PIT tag did not decrease the body condition of a typical subadult mountain whitefish (p = 0.703 and 0.910, respectively; Figure 55). An adult mountain whitefish marked with a

T-bar anchor tag was significantly thinner than its unmarked equivalent ($p < 0.001$), while a fish marked with a PIT tag was not ($p = 0.683$; Figure 56).

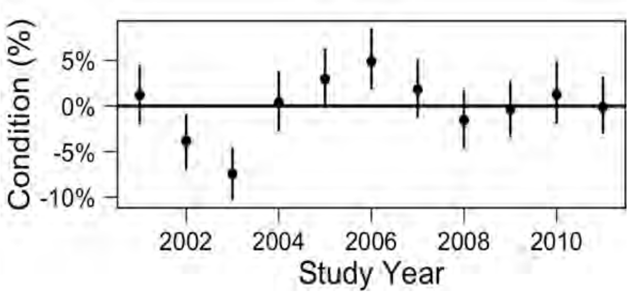

Figure 51: Expected percent change in body condition by year with 95% credibility intervals for an average length (210 mm FL) subadult mountain whitefish on October 1 at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

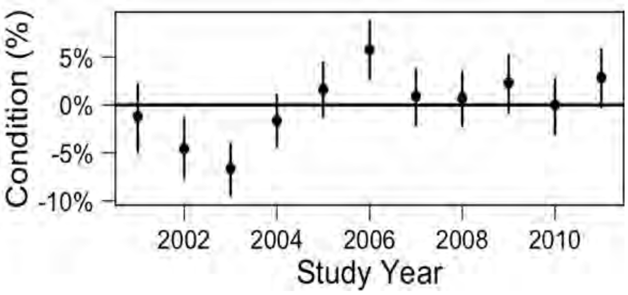

Figure 52: Expected percent change in body condition by year with 95% credibility intervals for an average length (340 mm FL) adult mountain whitefish on October 9 at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

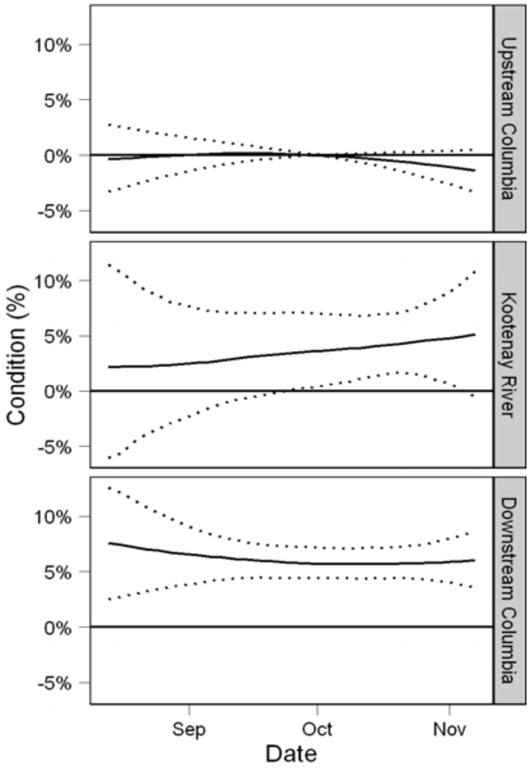

Figure 53: Expected percent change in body condition by date with 95% credibility intervals for an average length (210 mm FL) subadult mountain whitefish in a typical year at a typical site by section. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

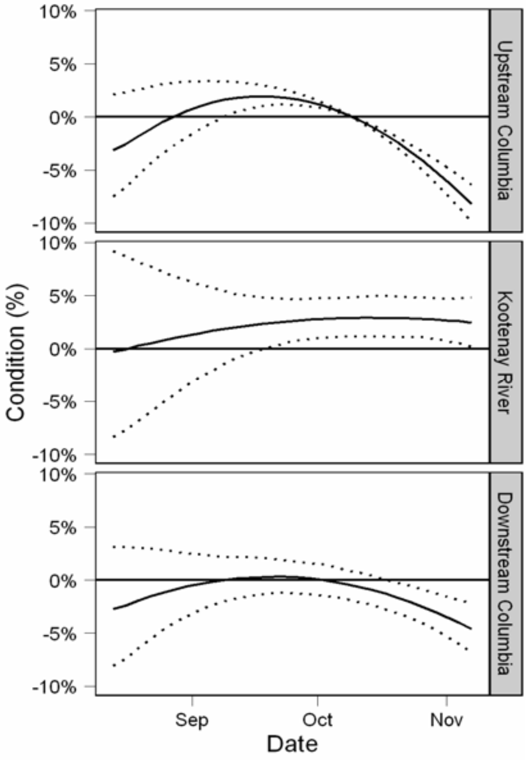

Figure 54: Expected percent change in body condition by date with 95% credibility intervals for an average length (340 mm FL) adult mountain whitefish in a typical year at a typical site by section. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

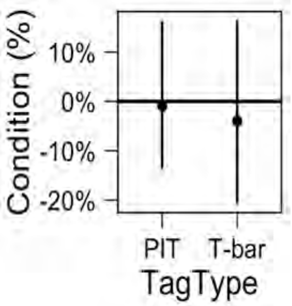

Figure 55: Expected percent change in body condition by tag type with 95% credibility intervals for an average length (210 mm FL) subadult mountain whitefish in a typical year at a typical site on October 1 in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

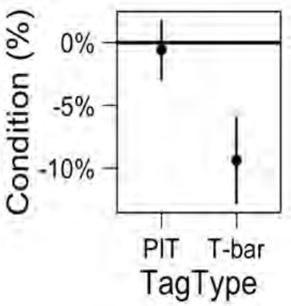

Figure 56: Expected percent change in body condition by tag type with 95% credibility intervals for an average length (340 mm FL) adult mountain whitefish in a typical year at a typical site on October 9 in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

4.5.2 Rainbow Trout

The average body condition of a subadult rainbow trout was substantially higher in 2002 and 2006 compared to other study years (Figure 57). Overall, body condition for this cohort gradually increased from 2003 to 2006 and then gradually declined from 2006 to 2011. The body condition of adult rainbow trout also was substantially higher in 2002 and 2006 (Figure 58).

The body condition of subadult rainbow trout declined in all three areas sampled over the duration of a typical sample period (Figure 59). This result is unexpected. During the fall season, subadult rainbow trout would be expected to increase body reserves as they prepare for the upcoming winter season. In addition, during the fall sample period, growth for this cohort is substantial (Figure 16). For adult rainbow trout, body condition increased over the duration of a typical sample period in the Columbia River, but remained relatively stable in the Kootenay River (Figure 60).

The presence of a PIT tag or T-bar anchor tag did not have an impact on the body condition of subadult rainbow trout ($p = 0.149$ and 0.0946, respectively; Figure 61). For adult rainbow trout, the body condition of a fish marked with a T-bar anchor tag was significantly lower than an un-tagged equivalent ($p < 0.001$), while the body condition of a fish marked with a PIT tag was not ($p = 0.130$; Figure 62).

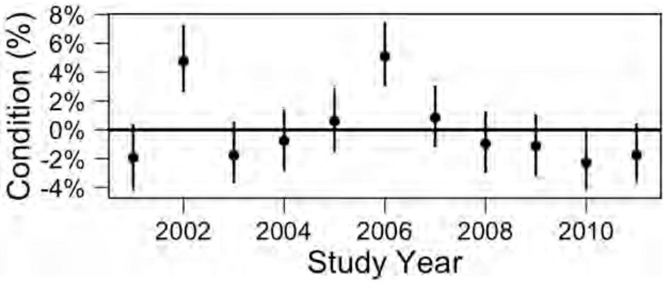

Figure 57: Expected percent change in body condition by year with 95% credibility intervals for an average length (265 mm FL) subadult rainbow trout on October 5 at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

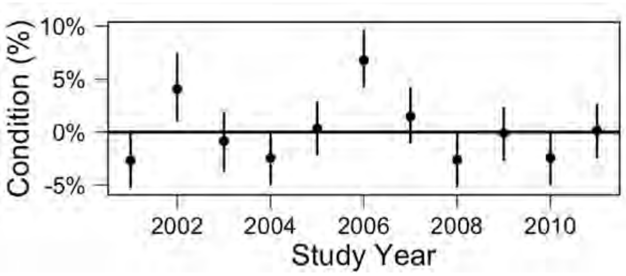

Figure 58: Expected percent change in body condition by year with 95% credibility intervals for an average length (439 mm FL) adult rainbow trout on October 9 at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

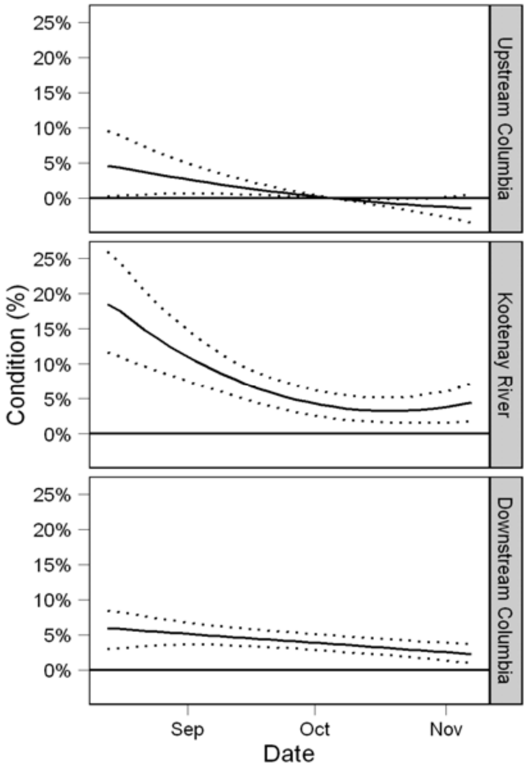

Figure 59: Expected percent change in body condition by date with 95% credibility intervals for an average length (265 mm FL) subadult rainbow trout in a typical year at a typical site in the Columbia River upstream of the Kootenay River confluence. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

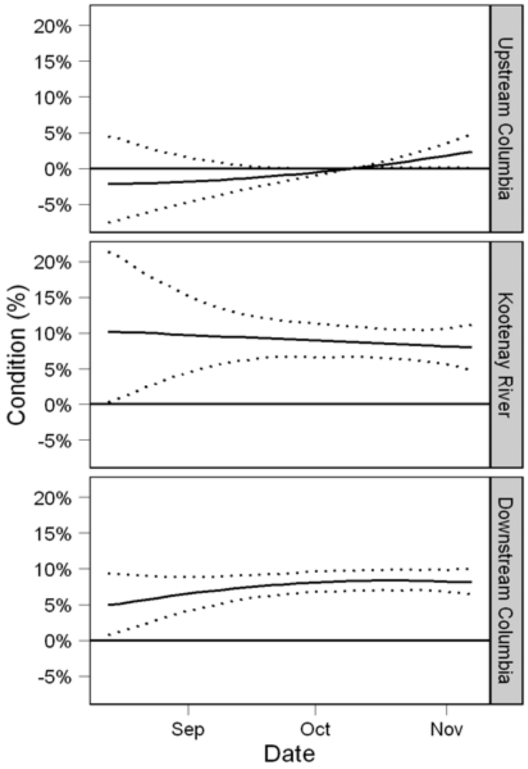

Figure 60: Expected percent change in body condition by date with 95% credibility intervals for an average length (439 mm FL) adult rainbow trout in a typical year at a typical site in the Columbia River upstream of the Kootenay River confluence. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

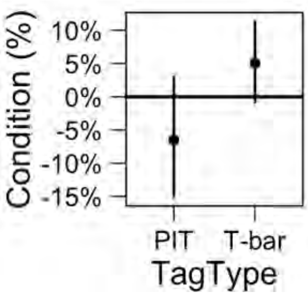

Figure 61: Expected percent change in body condition by tag type with 95% credibility intervals for an average length (265 mm FL) subadult rainbow trout in a typical year at a typical site on October 5 in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

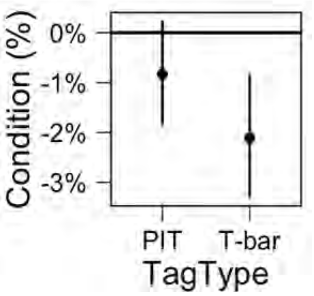

Figure 62: Expected percent change in body condition by tag type with 95% credibility intervals for an average length (439 mm FL) adult rainbow trout in a typical year at a typical site on October 9 in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

4.5.3 Walleye

Walleye body condition increased each year between 2003 and 2006 and generally decreased each year between 2006 and 2010 (Figure 63).

The presence of a T-bar anchor tag (p = 0.904) or a PIT tag (p = 0.099) did not have a significant effect on the body condition of walleye when compared to an unmarked equivalent (Figure 64). The body condition of walleye increased substantially over the fall sampling period in all portions of the study area (Figure 65).

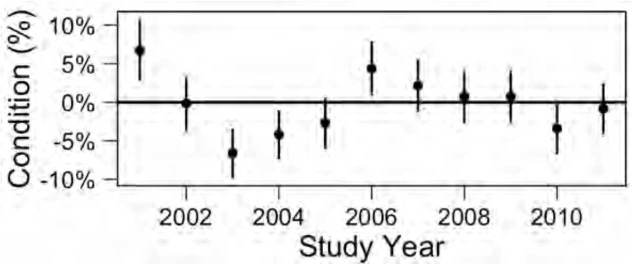

Figure 63: Expected percent change in body condition by year with 95% credibility intervals for an average length (374 mm FL) walleye on October 6 at a typical site in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

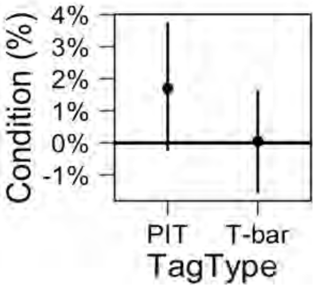

Figure 64: Expected percent change in body condition by tag type with 95% credibility intervals for an average length (374 mm FL) walleye in a typical year at a typical site on October 6 in the Lower Columbia River. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

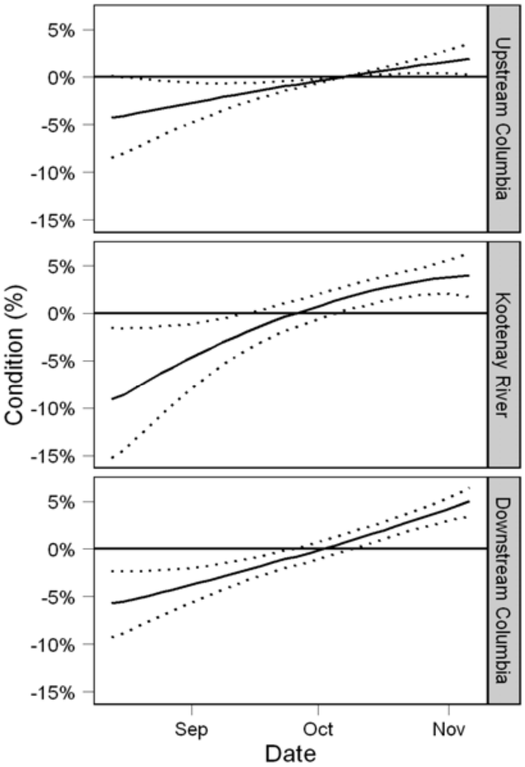

Figure 65: Expected percent change in body condition by date with 95% credibility intervals for an average length (374 mm FL) walleye in a typical year at a typical site by section. The point estimates are median expected values while lower and upper 95% credibility limits are the 2.5% and 97.5% quantiles, respectively.

4.6 Walleye Stomach Content Analysis

Although not specifically outlined in the Terms of Reference for CLBMON-45, BC Hydro requested that gastric lavage be performed on a subsample of all captured walleye to garner information on walleye diet in the LCR. A summary of these data are presented below as a means of providing background information for other studies currently being conducted under the LCR Fish Management Plan. Raw gastric lavage data are included in the LCR Fish Indexing Database (Attachment A).

During the 2011 study, gastric lavage was performed on 101 walleye. Overall (all samples combined), 130 prey fish (or portions of prey fish) were obtained from 59 different stomachs (i.e., 42 stomach did not contain prey fish). Of those 130 prey fish analyzed, 61 (47%) were too digested to allow positive identification (e.g., consisted of vertebrae segments, fin rays, small pieces of tissue, etc.). Prey fish that could be positively identified included: redside shiner (41% of the total prey fish catch); sculpin species (5%); longnose dace (*Rhinichthys cataractae*; 3%); sucker species (2%); rainbow trout (2%); and, mountain whitefish (<1%).

4.7 Other Species

In 2011, nine northern pike were recorded within the LCR (8 captured; 1 observed), all in the Columbia River upstream of the Kootenay River confluence. Fork lengths of captured northern pike ranged between 409 to 623 mm; weights ranged between 541 to 2325 g (Table 6). All captured northern pike were either age-2 or age- 3, representing the 2009 and 2008 brood years, respectively. These two brood years also were recorded in 2010 (Ford and Thorley 2011a). As requested by the Ministry of Environment (J. Burrows pers. comm.), all captured northern pike were killed.

Table 6: Life history information for northern pike captured by boat electroshocking in the Lower Columbia River, September 26 to October 30, 2011.

Sample Number	Fork Length (mm)	Weight (g)	Ageing Method	Age
772	457	731	SC	2
773	623	2325	SC	3
1386	409	541	SC	2
1401	475	919	SC	2
2096	431	644	SC	2
2706	510	1114	SC	2
3428	492	1098	SC	2
3443	510	1030	SC	2

Substantially more burbot were recorded in 2011 (*n* = 247) than in any other study year (previously ranged between 3 and 208 individuals annually). Although burbot have been recorded in all portions of the study area, in 2011 most (92%) were recorded downstream of approximately RKm 47.8 (Table 5).

Three juvenile white sturgeon were recorded during the 2011 survey. Two of these fish were captured on October 27, 2011 at Site 52.2-R; the remaining fish was captured on October 14, 2011 at Site 25.3-R. All three fish were hatchery released individuals. Life history data are provided in Attachment A. Field crews observed an additional eight juvenile, and nine adult white sturgeon during the 2011 survey. Location information for these fish also is provided in Attachment A.

5.0 DISCUSSION

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

5.1 Size-At-Age and Growth

5.1.1 Mountain Whitefish

Over the 11 year study period, the average fork length of mountain whitefish fry during the fall sample period ranged from 105 to 135 mm FL. Mountain whitefish were substantially smaller in 2001 when compared to other study years. Possible explanations for their smaller size in 2001 are discussed below.

In 2001, discharge was substantially lower 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. Typically, these stimuli occur during freshet events. 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 average size-at-age of subadult mountain whitefish cohort 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 for these two years.

While lower discharges during the spring/summer months may reduce mountain whitefish fry growth, higher discharges do not appear to result in higher growth rates for this cohort. 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.

The size-at-age of subadult mountain whitefish generally increased between 2001 and 2006, a result that was supported by the HBM that used length data collected from recaptured individuals. Between 2001 and 2006, abundance estimates for subadult mountain whitefish decreased, suggesting an inverse relationship between these two metrics. Most likely, when subadult mountain whitefish abundance is high, competition for food, preferred habitats, and other available resources, such as cover, is greater. Body condition (a short-term proxy for growth) also was higher from 2004 to 2006 (i.e., when abundance was low).

During a typical study year, mountain whitefish fry growth slowed considerably in mid-October. Over the duration of the fall study period, water temperatures in the LCR decrease and are generally around 12°C by mid-October. Stomach content data collected from mountain whitefish fry in 2008 (Golder 2009a) indicated that this cohort fed primarily on cladocerans (*Daphnia* species and *Eurycercus* species) and copepods (*Cyclops* species) during the fall study period. Decreasing growth rates for this cohort in the fall season may be a result of decreasing zooplankton productivity rates due to colder water temperatures. Unfortunately, data are not available to support this theory.

Unlike fry, subadult mountain whitefish continued to grow late into the fall season (i.e., early November), which likely reflects a different dietary preference. The diet of subadult and adult mountain whitefish consists primarily of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) during the fall season (Golder 2009a). Caddisfly hatches occur frequently during the fall survey, indicating that this food source is still abundant during this time period.

Analyses conducted in 2010 (Ford and Thorley 2011a) indicated that the presence of a T-bar anchor tag significantly reduced the body condition of mountain whitefish in the LCR ($p = <0.001$). At that time, it was hypothesized that the presence of a T-bar anchor tag may also limit growth for this species. Despite a nearly 10% decrease in the average body condition of a mountain whitefish marked with a T-bar anchor tag, a significant decrease in annual growth was not detected ($p = 0.986$).

5.1.2 Rainbow Trout

During the program's 11 year study period, rainbow trout fry size-at-age during the fall season ranged from 90 to 130 mm FL. 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). Based on these data, the reduced size-at-age in 2001 was likely related to lower growth rates during the mid-July and mid-September period. As discussed in Section 5.1.1, discharge in the LCR was below average during that time period (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 sources (i.e., Arrow Lakes Reservoir and Kootenay Lake), which could have reduced food availability for rainbow trout fry.

The average size-at-age of rainbow trout fry decreased between 2005 and 2010. Catch-rate data did not indicate any definitive patterns in abundance over this time period for this cohort that would suggest a density dependent relationship with growth. Insufficient data prevented the HBM from generating annual abundance estimates for rainbow trout fry. Reasons for the decline are currently unknown.

Subadult rainbow trout were substantially smaller in 2001 and larger in 2005, 2006, and 2007, when compared to other years. Possible reasons for the decline identified in 2001 are discussed in Section 5.1.1. Reasons for the larger size-at-age from 2005 to 2007 are unknown. Water levels were slightly higher during those study years, which may have resulted in higher nutrient loads relative to other study years; however, substantially more data are required to confirm this relationship.

5.1.3 Walleye

For walleye, indistinguishable age-class modes in annual length-frequency histograms prevented the HBM from accurately estimating size-at-age values for this species.

The mark-recapture based HBM indicated that walleye annual growth was variable and substantially lower between 2003 and 2004. During that time period, walleye abundance was higher and body condition was lower than during any other study year (Section 5.5.3). These data suggest a strong relationship between walleye abundance, body condition, and growth, with higher growth rates and body conditions expected in years when densities are low.

Overall, a lack of age data and limited numbers of inter-year recaptured fish hinders 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 growth and LCR discharge.

5.2 Abundance

5.2.1 Mountain Whitefish

Based on the HBM, the abundance of subadult mountain whitefish decreased between 2001 and 2004. Reasons for this decline are unknown, but may in part be attributed to changes in sampling methodology. During the initial years of the program (i.e., between 2001 and 2003), compressed oxygen was not pumped into the livewell. Lower oxygen levels in the livewell may have resulted in higher subadult mountain whitefish mortality rates after marking and release. Higher delayed mortality rates for marked fish would result in overestimated abundance estimates during these study years. If subadult mountain whitefish abundance truly declined between 2001 and 2004, one would expect either adult mountain whitefish abundance to decline between 2002 and 2005 or adult mountain whitefish survival to increase between 2001 and 2004. These two metrics did not change enough over that time period to support an approximately 66% reduction in subadult mountain whitefish abundance. Reasons for this apparent discrepancy are discussed in greater detail in Section 5.5.

Although credibility intervals overlapped, the abundance of both subadult and adult mountain whitefish generally declined between 2007 and 2011. The fact that both cohorts declined during the same time period suggests that this result is valid (unlike the subadult mountain whitefish decline noted in the early 2000s; see above).

Between 2001 and 2011, abundance patterns for subadult mountain whitefish and rainbow trout were similar. Spawning and early rearing for these species occur during different seasons under different environmental conditions (mountain whitefish spawn from December to January, rainbow trout spawn from March to June). Given the similarities in these species' annual abundance patterns over the past 11 years, it is unlikely that subadult abundance estimates generated for these species during the fall season are related to spawning success a year and a half prior to capture. More likely, the abundance of these cohorts for both species is related to mortality rates after emergence and during the following summer growth period.

Walleye feed on mountain whitefish (Wydoski and Bennett 1981), which likely contributes to mortality of subadult mountain whitefish. Partial support for this hypothesis is provided by the inverse relationship between subadult mountain whitefish abundance and walleye abundance. 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 smaller) than during the fall (i.e., when larger). Seasonal walleye stomach content data is needed to prove or discount this theory. In 2011, walleye abundance was lower than any other study year. The occurrence of higher subadult mountain whitefish abundance estimates in 2012 would tend to support this argument.

Between 2001 and 2011, 118 164 juvenile white sturgeon were released into the LCR (BC Hydro unpublished data). Although most of these fish would have been too small to prey on mountain whitefish during the early 2000's, subsequent predation by white sturgeon may have contributed to reductions observed 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.

An examination of discharge and water temperature data did not suggest a relationship between either of these two parameters and subadult or adult mountain whitefish abundance. However, the effect of discharge and water temperature variations on mountain whitefish abundance will be further examined in 2012.

5.2.2 Rainbow Trout

Based on the HBM, the abundance of subadult rainbow trout in the LCR declined between 2001 and 2004. Reasons for this decline are unknown, but as discussed in Section 5.2.1, may in part be attributed to changes in sampling methodologies.

Between 2003 and 2010, credibility intervals surrounding all subadult rainbow trout abundance estimates overlapped. Adult rainbow trout abundance estimates also were stable over this time period. The 2011 abundance estimate for subadult rainbow trout was higher than all previous estimates for this cohort (excluding 2001 and 2002 for the reasons identified in Section 5.2.1). Based on these data, adult rainbow trout abundance should be substantially higher in 2012 when compared to preceding estimates for this cohort, provided survival remains stable between 2011 and 2012.

Overall, adult rainbow trout abundance has remained stable at approximately 20 000 individuals between 2001 and 2011. This pattern is not supported by the number of spawning rainbow trout observed over the same time period (Thorley and Baxter 2012), which has approximately doubled between 2001 and 2011. However, differences in assumptions related to each abundance estimate limit direct comparisons between these data sets. Minimum fork lengths included in the abundance HBM were established using the output from the size-at-age based HBM. Minimum fork lengths included in the HBM varied between years, and ranged from a low of 315 mm FL in 2001 to a high of 366 mm FL in 2007. Given the rapid growth rainbow trout undergo in the LCR, it is possible that not all rainbow trout included in the HBM were sexually mature during the preceding spring spawning season.

As discussed in Section 5.2.1, the abundance of subadult rainbow trout in the LCR tracked closely with the abundance of subadult mountain whitefish, which suggests that factors influencing survival for these two species during the first two years of their lifecycle may be similar.

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 efficiency of adult rainbow trout remained stable within each study year. Efficiency between study years remained constant for both cohorts.

For all index species and cohorts, the probability of a fish being recaptured in the same site was highest for subadult rainbow trout. 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.

5.2.3 Walleye

With the exception of 2003 and 2004, walleye abundance remained stable at approximately 35 000 individuals between 2001 and 2011. 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.

5.3 Spatial Distribution

5.3.1 Mountain Whitefish

In the Columbia River upstream of the Kootenay River confluence, subadult mountain whitefish densities in all study years generally increased with increased distance downstream from HLK. This result is likely related more to channel morphology than the presence or operation of the dam. Large bays and backwater areas (preferred habitat areas for subadult mountain whitefish) are more common in the downstream portion of this section. 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 2011 (Attachment A). Most recently, northern pike have been captured in increasing numbers from 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 for this cohort 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 2010b, Golder in prep.), while 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 the area for holding purposes prior to spawning.

There were no discernible temporal changes in the general spatial distributions of subadult and adult mountain whitefish between 2001 and 2011.

5.3.2 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. In 2010, Golder (Ford and Thorley 2011a) suggested that these areas supported higher rainbow trout densities due to the habitat characteristics of these areas 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).

Although credibility intervals were wide, both subadult and adult rainbow trout densities in 2011 were highest in the synoptic sites (i.e., river sections that were not systematically sampled prior to 2011). Reasons for this are unknown. During the initial year of the LRFIP, the index sites were selected based on past capture results to provide the greatest probability of capturing high numbers of each index species to allow the analysis of the selected population metrics. Criteria included in the selection process are described in Section 2.1.4, 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 higher in the synoptic sites and results are not an artefact of sample design, some possible reasons are discussed below.

One hypothesis is that the shift is behavioural and 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). Overall (all size cohorts combined), 5 of the 657 rainbow trout captured in synoptic sites were marked individuals that were initially captured in 2011 in an index site, which does not suggest that high numbers of marked fish are leaving the indexing sites over the course of the survey.

Another hypothesis is that over the last 11 years, the habitat suitability of some areas of the study area has changed for some index species cohorts. Since 2001, aquatic vegetation has become more dominant in low water velocity areas, northern pike have been recorded in the study area with encounter frequencies increasing during each successive study year, and large numbers of juvenile white sturgeon have been introduced to the study area. One or more of these factors may have forced rainbow trout to use other portions of the study area.

Regardless of the reasons, the high densities of rainbow trout present in previously unsampled portions of the study area indicates 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 when compared to index sites would result in underestimates of overall population abundance.

5.3.3 Walleye

Walleye densities were noticeably higher immediately downstream of HLK. Sculpin species and redside shiner were a common prey fish for walleye (Ford and Thorley 2011a; Section 4.6). In 2010, results from the spatial density HBM indicated higher sculpin spp. 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.

There were no discernible temporal changes in the general spatial distribution of walleye between 2001 and 2011.

5.4 Survival

5.4.1 Mountain Whitefish

Estimates of subadult and adult mountain whitefish annual survival generated by the HBM were variable and exhibited wide credibility intervals.

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 population abundance estimates, the estimates generated were not compatible with HBM generated survival estimates. More specifically, it is not possible for an adult population of approximately 100 000 individuals to be supported by a subadult population of approximately 40 000 individuals if 40% of the adults die each year (i.e., 40 000 fish) and only 20% of the subadults (i.e., 8000 fish) survive to replace them. 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 magnitude of 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 recaptured 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 abundance. Mountain whitefish capture probabilities are less than half of those for rainbow trout and walleye, which suggests that this may be a factor. In addition, preliminary data collected under BC Hydro’s MCR Fish Population Indexing Program (CLBMON-16; Ford and Thorley 2011b) during the spring of 2012 (D. Ford pers. comm.) suggest recapture rates for mountain whitefish tagged during the previous spring or fall, are much higher than the recapture rates of mountain whitefish caught in the fall (both within the same year and between years). This suggests that the mountain whitefish population that is monitored in the fall may be in a state of transition where fish are continually emigrating and immigrating during the study period. Based on telemetry data collected under CLBMON-48 (Golder 2009c), the LCR mountain whitefish population is likely in a similar state of transition during fall study period. This would explain why abundance estimates are inconsistent with estimates of survival in the LCR and would also account for lower recapture estimates for this species.

5.4.2 Rainbow Trout

Annual survival (i.e., survival between age-1 and age-2) of subadult rainbow trout remained stable at approximately 50% between 2001 and 2011. This stability supports adult abundance estimates, which also were stable over this time period. Overall, credibility intervals surrounding survival estimates were narrow, a reflection of this species’ high site fidelity (Section 5.2.2).

For adult rainbow trout, credibility intervals were wide relative to estimates generated for subadult rainbow trout and overlapped for all study years. However, point estimates increased each year between 2008 and 2011.

5.4.3 Walleye

Survival estimates generated for walleye were uninformative with regard to inter-annual variation. The model for this species will be further refined in 2012.

5.5 Body Condition

5.5.1 Mountain Whitefish

For both subadult and adult mountain whitefish, body condition was substantially lower in 2002 and 2003 and higher in 2006 than in other study years. The body condition of both cohorts remained relatively stable between 2007 and 2011. Larval trichoptera and larval diptera are a major food source for mountain whitefish in the LCR (Golder 2009a). Mountain whitefish body condition is likely related to the abundance of specific invertebrates. 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 body condition for this species.

Over the course of a typical sample season, the body condition of adult mountain whitefish in the Columbia River increased until approximately late September after which time, body condition decreased substantially. During that time period however, the body condition of adult mountain whitefish should increase as adults produce gametes and subadults and adults put on weight for the winter. This apparently spurious result is likely due to adult mountain whitefish migrating out of sampled sites to congregate at or near spawning locations, which would result in a reduction of the average body condition value for the remaining mountain whitefish population. This is supported by the general increase over the surveyed period in the body condition of adult mountain whitefish in the Kootenay River, a known spawning and staging location for this species.

The body condition of subadult mountain whitefish was lower in the Columbia River upstream of the Kootenay River confluence. The higher body condition observed for this cohort in the Kootenay River and in the Columbia River downstream of the Kootenay River confluence was likely due to warmer water temperatures and/or higher nutrients loads in the Kootenay River when compared to the Columbia River. Adult mountain whitefish body condition did not appear to have the same spatial distribution as for subadults. However, as previously discussed, sampling occurred immediately prior to the spawning season, and an increase in body weight due to increased gamete production coupled with pre-spawning movement patterns may have influenced results for this life stage.

5.5.2 Rainbow Trout

For both subadult and adult rainbow trout, body condition was higher than average in 2002 and 2006. Higher body condition during these two study years is likely a reflection of higher invertebrate numbers during these two study years (most notably mayflies, stoneflies, and/or caddisflies; Golder 2009a). BC Hydro's LCR Physical Habitat and Ecological Productivity Monitoring Program (CLBMON-44) was implemented in 2008 (T.G. Eco-Logic 2009); invertebrate density data prior to 2008 are not available. The body condition of both the adult and subadult cohorts remained stable between 2007 and 2011.

The body condition of subadult rainbow trout decreased throughout the 2011 fall season in all portions of the study area. This result was counter to results from other cohorts and index species. Despite the apparent decrease in body condition over the fall season, values were still higher than those recorded downstream of Revelstoke Dam during the same time of the year (CLBMON-16; Ford and Thorley 2011b).

The body condition of subadult and adult rainbow trout was lower in the Columbia River upstream of the Kootenay River confluence, a pattern similar to that observed for subadult mountain whitefish. This result is likely due to warmer water temperatures and higher nutrient loads in the Kootenay River when compared to the Columbia River (see Section 5.5.1).

The presence of T-bar anchor tags had a noticeable effect on the body condition of adult rainbow trout. As detailed in Section 5.5.1, a T-bar anchor tag may increase energy demands (due to an infection at the tag's insertion point or by impacting swimming performance), thereby reducing body condition.

5.5.3 Walleye

Body condition for walleye decreased substantially between 2002 and 2003 and gradually increased from 2003 to 2006. Abundance estimates for this species increased substantially between 2003 and gradually decreased from 2003 to 2006. This indicates an inverse relationship between body condition and absolute abundance, likely 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). Body condition remained relatively stable between 2007 and 2011.

There was no apparent relationship between walleye body condition estimates and river section. The bulk 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 results in low site fidelity, with most walleye failing to remain at one site long enough for habitat characteristics to influence their body condition.

In all sections of the study area, 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).

5.6 Summary

Understanding the effects of local movement patterns of the index species on estimates of the model parameters should be the focus of future studies. Current investigations, coupled with results from similar studies in the MCR, have provided valuable insights into the biology of mountain whitefish that was previously not understood. As these investigations develop in the future, further understanding of the migratory behaviour of this species will provide more insight into addressing CLBMON-45 management questions.

Another key focus of the 2012 study program 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. A third option might be to use age-data to estimate adult survival from a catch-curve analysis to confirm that survival estimates generated are unbiased.

Multiple alternative HBMs should be fitted for each management hypothesis and compared using the Deviance Information Criterion (DIC), the Bayesian equivalent of Akaike's Information Criterion (AIC). Currently, a single HBM is fitted to all species and life-stages for each hypothesis; however, this one-size-fits-all approach can result in models over- or under-fitting. For example, the current abundance model is unable to detect inter-annual variation in adult rainbow trout abundance, which suggests that it is over parameterized. A simpler model may be more appropriate for this species and life-stage, a possibility that could be confirmed through comparisons of the model's DIC values.

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, portions of the river that were unsampled during the previous ten study years were sampled for the first time. Results from these portions of the river were very informative and suggest that these areas are used intensively by all three index species during the fall season. Reverting back to the original study design (i.e., repetitively sampling the same sites 5 times) and continuing to exclude the remaining ~66% of the study area may limit the HBM's ability to detect significant changes in the parameters of interest.

6.0 RECOMMENDATIONS

In consideration of the findings above and the overall objectives of the CLBMON-45, a field sampling program should be conducted in 2012 using the same methodologies employed in 2011. In addition to further sampling, the following recommendations are provided:

- Refine the survival-based HBM to provide more accurate estimates of inter-annual survival.
- 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.
- Refine movement models to take into account the date and distance travelled by fish between encounters to identify whether broader scale movements are occurring. This information will help better understand the extent to which sites are open, which could, in turn, be used to inform the abundance model.
- Use age-data to estimate adult survival from a catch-curve analysis to confirm that survival estimates generated by the HBM are unbiased.
- Conduct a 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).
- 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).
- Investigate whether data collected in the 1990s can be included 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.
- Investigate the inclusion of various environmental parameters into the HBMs as explanatory variables.

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8.0 CLOSURE

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

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Dustin Ford,B.Sc., R.P. Bio.
Project Biologist

ORIGINAL SIGNED

Larry Hildebrand, B.Sc., R.P. Bio.
Principal, Project Advisor

ORIGINAL SIGNED

Dana Schmidt, Ph.D., R.P. Bio.
Associate, Project Director

POISSON CONSULTING LTD.

ORIGINAL SIGNED

Joseph Thorley, Ph.D., R.P. Bio.
Fish Population Biologist

DF/LH/lf

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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, 2011.

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.

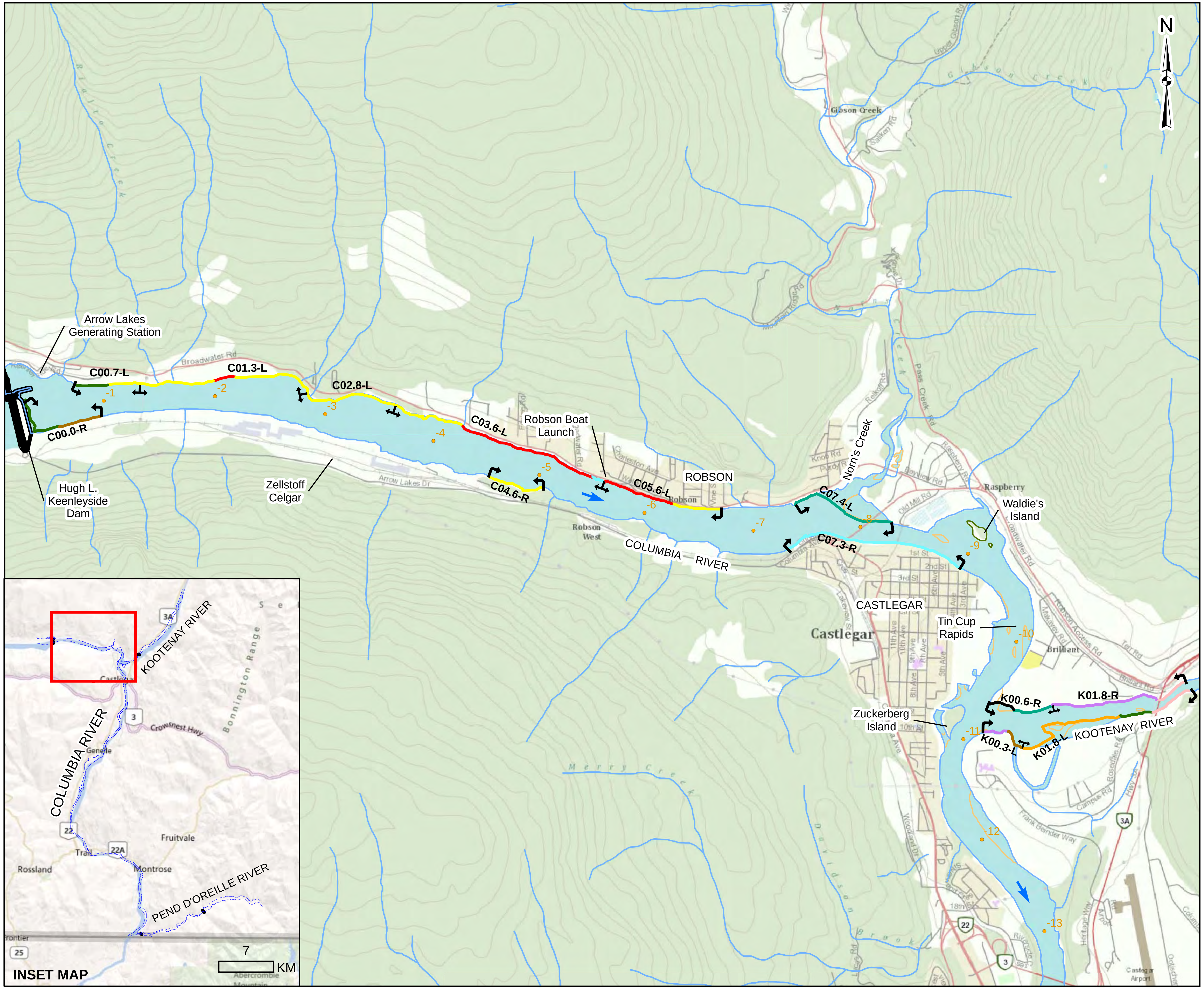
[c] LDB=Left bank as viewed facing downstream; RDB=Right bank as viewed facing downstream.

Table A2 Locations of selected sites and available sites included in the Generalized Random Tessellation Stratified (GRTS) survey, 2011.

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	
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	16
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	19
C10.8-R	10.8	RDB	11U	452154	5462718	11U	452154	5462718	
C10.9-L	10.9	LDB	11U	452584	5462607	11U	453290	5460373	12
C11.5-R	11.5	RDB	11U	452217	5462050	11U	453103	5460426	5
C13.4-L	13.4	LDB	11U	453290	5460373	11U	453321	5459007	9
C13.4-R	13.4	RDB	11U	453103	5460426	11U	453221	5458057	
C14.8-L	14.8	LDB	11U	453321	5459007	11U	453210	5456890	
C15.8-R	15.8	RDB	11U	453221	5458057	11U	453234	5457317	
C16.6-R	16.6	RDB	11U	453234	5457317	11U	452358	5456216	13
C17.0-L	17.0	LDB	11U	453210	5456890	11U	452622	5455322	
C18.0-R	18.0	RDB	11U	452358	5456216	11U	452351	5455401	
C18.8-R	18.8	RDB	11U	452351	5455401	11U	452122	5454012	
C19.0-L	19.0	LDB	11U	452622	5455322	11U	452444	5454183	17
C20.1-L	20.1	LDB	11U	452444	5454182	11U	451645	5453285	
C20.4-R	20.4	RDB	11U	452122	5454012	11U	451093	5453191	6
C21.3-L	21.3	LDB	11U	451645	5453285	11U	450603	5451637	
C21.8-R	21.8	RDB	11U	451093	5453191	11U	450495	5452148	
C22.9-R	22.9	RDB	11U	450495	5452148	11U	450188	5451058	
C23.4-L	23.4	LDB	11U	450603	5451637	11U	450368	5450764	10
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	2
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	14
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[a]	LDB	11U	447491	5446079	11U	446746	5444432	8
C32.0-R	32.0	RDB	11U	446817	5444824	11U	446256	5443655	
C32.4-L	32.4	LDB	11U	446746	5444432	11U	446353	5442572	
C33.3-R	33.3	RDB	11U	446256	5443655	11U	446260	5442116	1
C34.9-R	34.9	RDB	11U	446260	5442116	11U	446294	5441253	4
C35.7-R	35.7	RDB	11U	446294	5441253	11U	447152	5440472	
C36.9-R	36.9	RDB	11U	447152	5440472	11U	448305	5438607	3
C38.8-L	38.8	LDB	11U	448340	5439017	11U	449001	5438233	
C39.2-R	39.2	RDB	11U	448305	5438607	11U	448995	5438083	
C40.0-L	40.0	LDB	11U	449001	5438233	11U	450090	5438405	
C40.0-R	40.0	RDB	11U	448995	5438083	11U	450459	5438222	
C41.1-L	41.1	LDB	11U	450090	5438405	11U	452466	5438365	7
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	15
C44.7-R	44.7	RDB	11U	453275	5437384	11U	454560	5436673	11
C45.6-L	45.6	LDB	11U	454179	5437228	11U	454855	5436623	
C46.2-R	46.2	RDB	11U	454560	5436673	11U	455141	5435856	18
C46.4-L	46.4	LDB	11U	454855	5436623	11U	455319	5435321	
C47.2-R	47.2	RDB	11U	455141	5435856	11U	455017	5434942	
C56.0-L	56.0	LDB	11U	454774	5428024	11U	453949	5427733	20

[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

BASE IMAGERY FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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

UPPER SECTION OF STUDY AREA
2011 SAMPLE SITE LOCATIONS

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	26 Jun. 2012		
REVIEW	LH	26 Jun. 2012		

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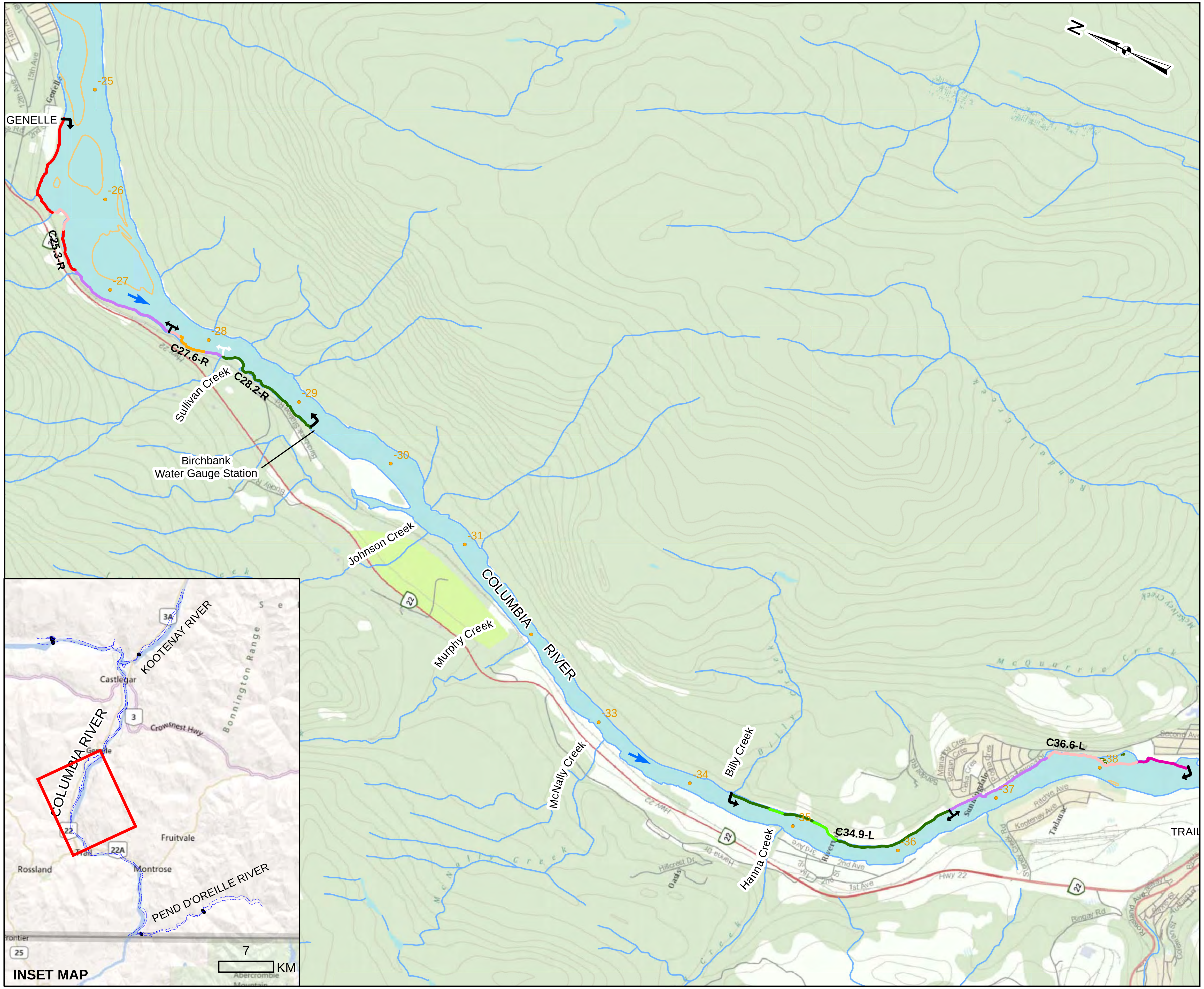

LEGEND

● 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

BASE IMAGERY FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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
2011 SAMPLE SITE LOCATIONS

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
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GIS	SS/JG	19 Jun. 2012		
CHECK	DF	26 Jun. 2012		
REVIEW	LH	26 Jun. 2012		

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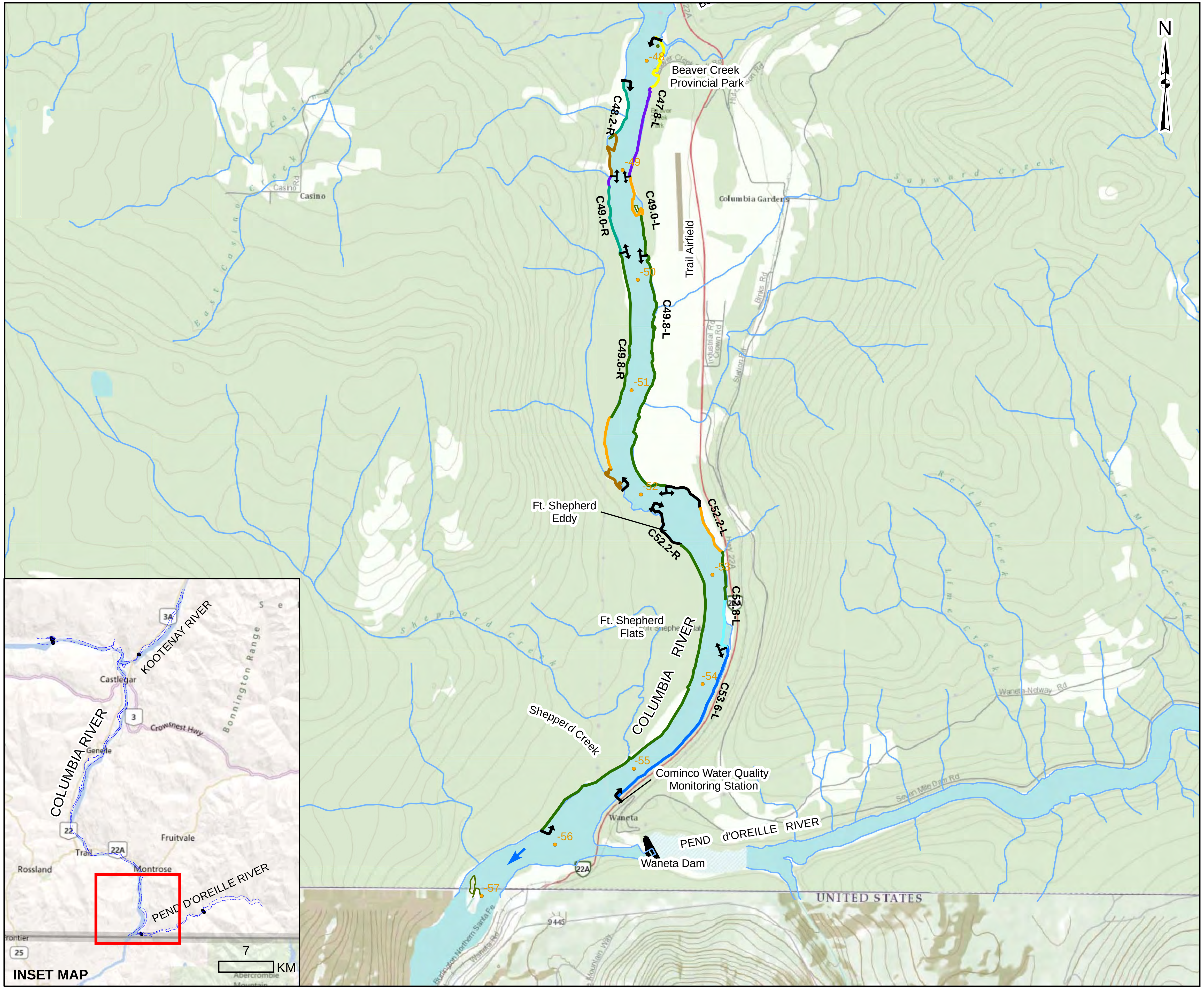

LEGEND

- ● 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

BASE IMAGERY FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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
2011 SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	SS	13 Jun. 2012	Figure: A3	
GIS	SS/JG	19 Jun. 2012		
CHECK	DF	26 Jun. 2012		
REVIEW	LH	26 Jun. 2012		

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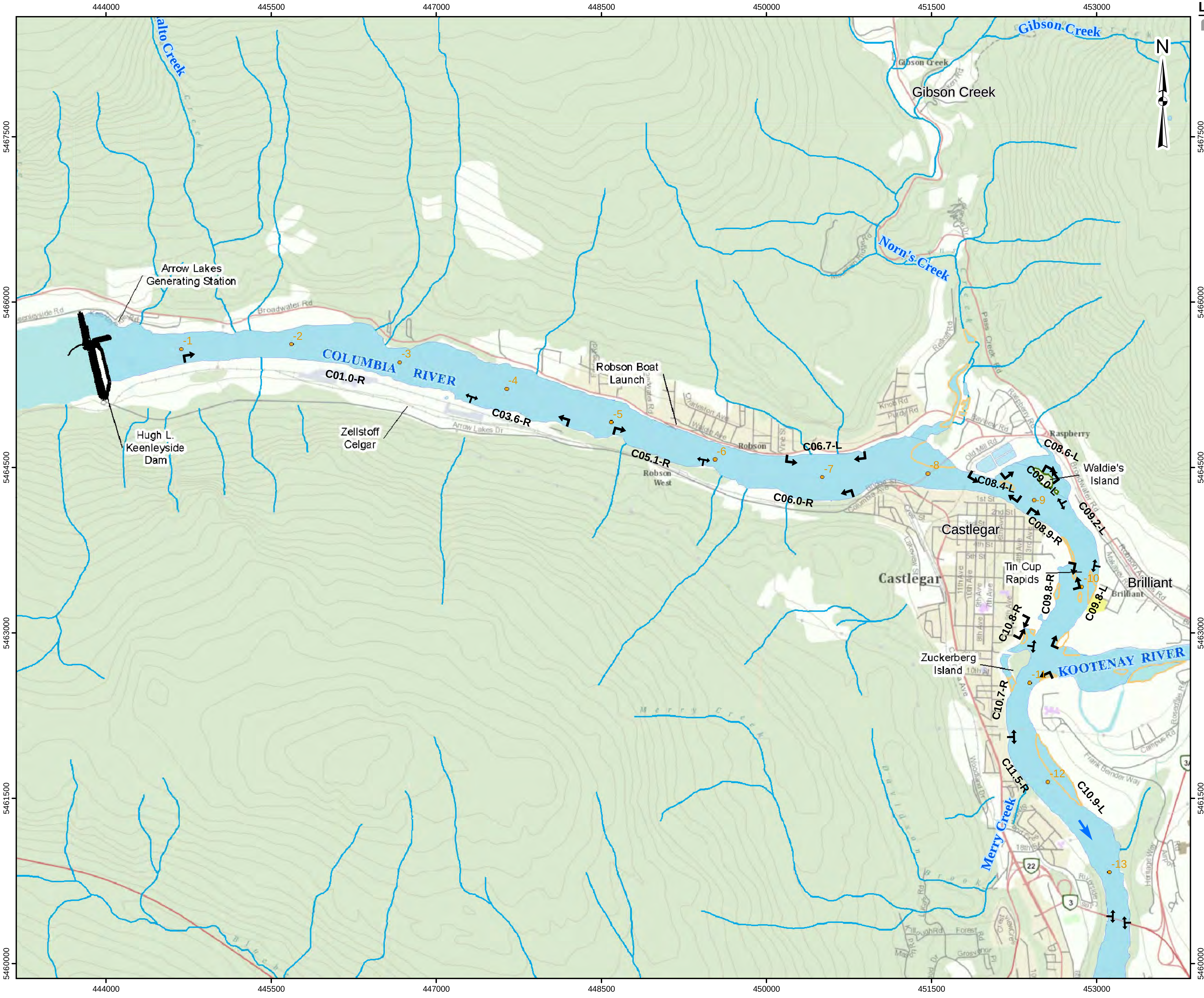


LEGEND

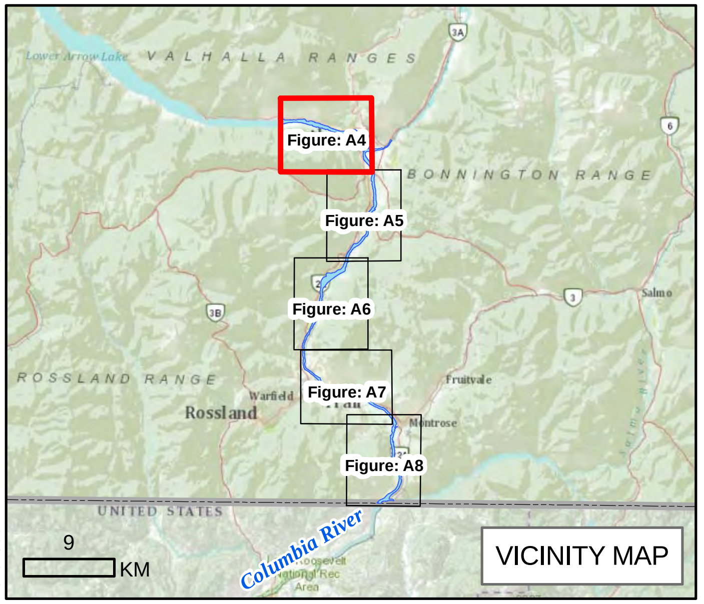
C00.0-R BOAT ELECTROSHOCKING SITE
FLOW DIRECTION
RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
WATERCOURSE
WATERBODY
CANADA / US BORDER
BREAKWATER
DAM SECTION
ISLAND
SAND OR GRAVEL BAR

REFERENCE

1. BASE IMAGERY FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, MAY 2009.
2. WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
3. PROVINCIAL BOUNDARY: DMTI SPATIAL INC.
4. INSET IMAGE FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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
2011 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	DH	13 Jun. 2011	Figure: A4	
GIS	JG	13 Jun. 2011		
CHECK	DF			
REVIEW	LH			

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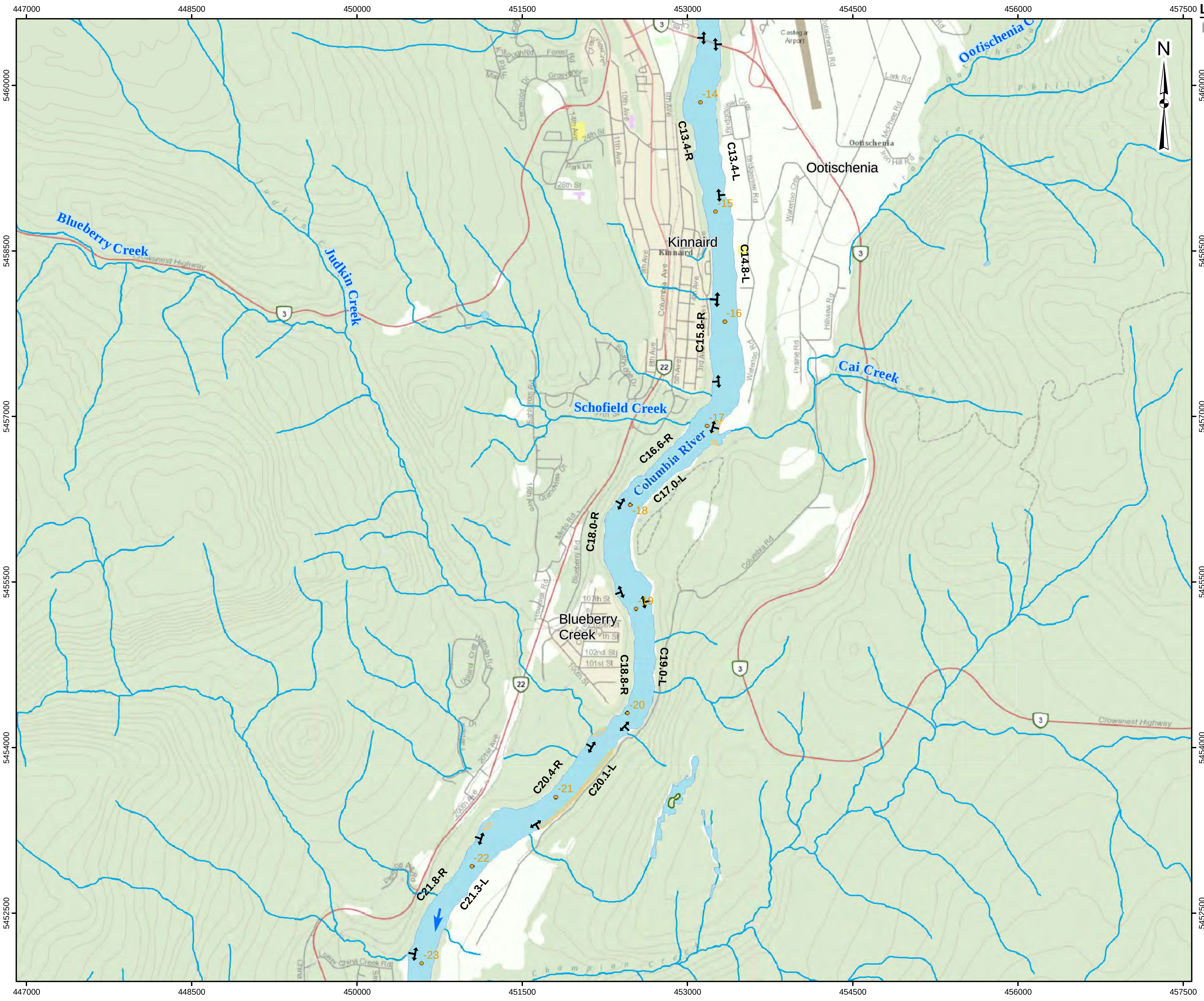


LEGEND

C00.0-R	BOAT ELECTROSHOCKING SITE
→	FLOW DIRECTION
●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
〜	WATERCOURSE
▨	WATERBODY
▭	CANADA / US BORDER
—	BREAKWATER
━	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

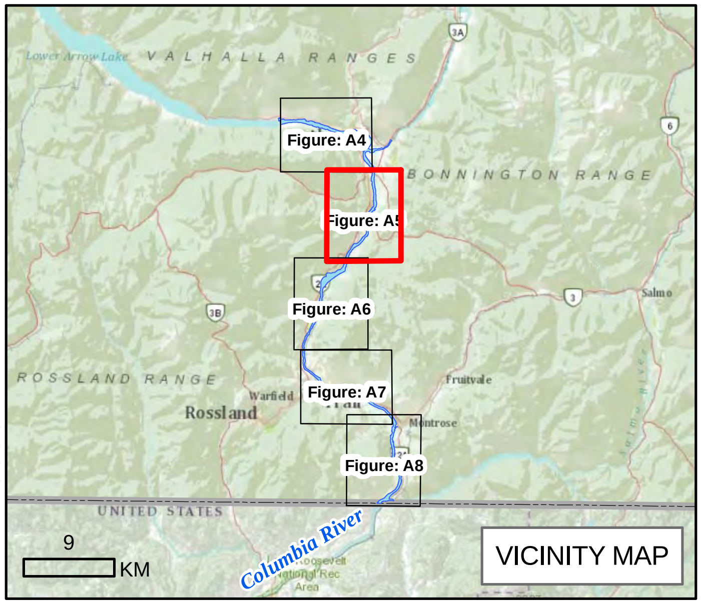
REFERENCE

1. BASE IMAGERY FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, MAY 2009.
2. WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
3. PROVINCIAL BOUNDARY: DMTI SPATIAL INC.
4. INSET IMAGE FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), AND THE GIS USER COMMUNITY.

PROJECTION: UTM ZONE 11 DATUM: NAD 83

750 0 750
Metres

SCALE 1:35,000



VICINITY MAP

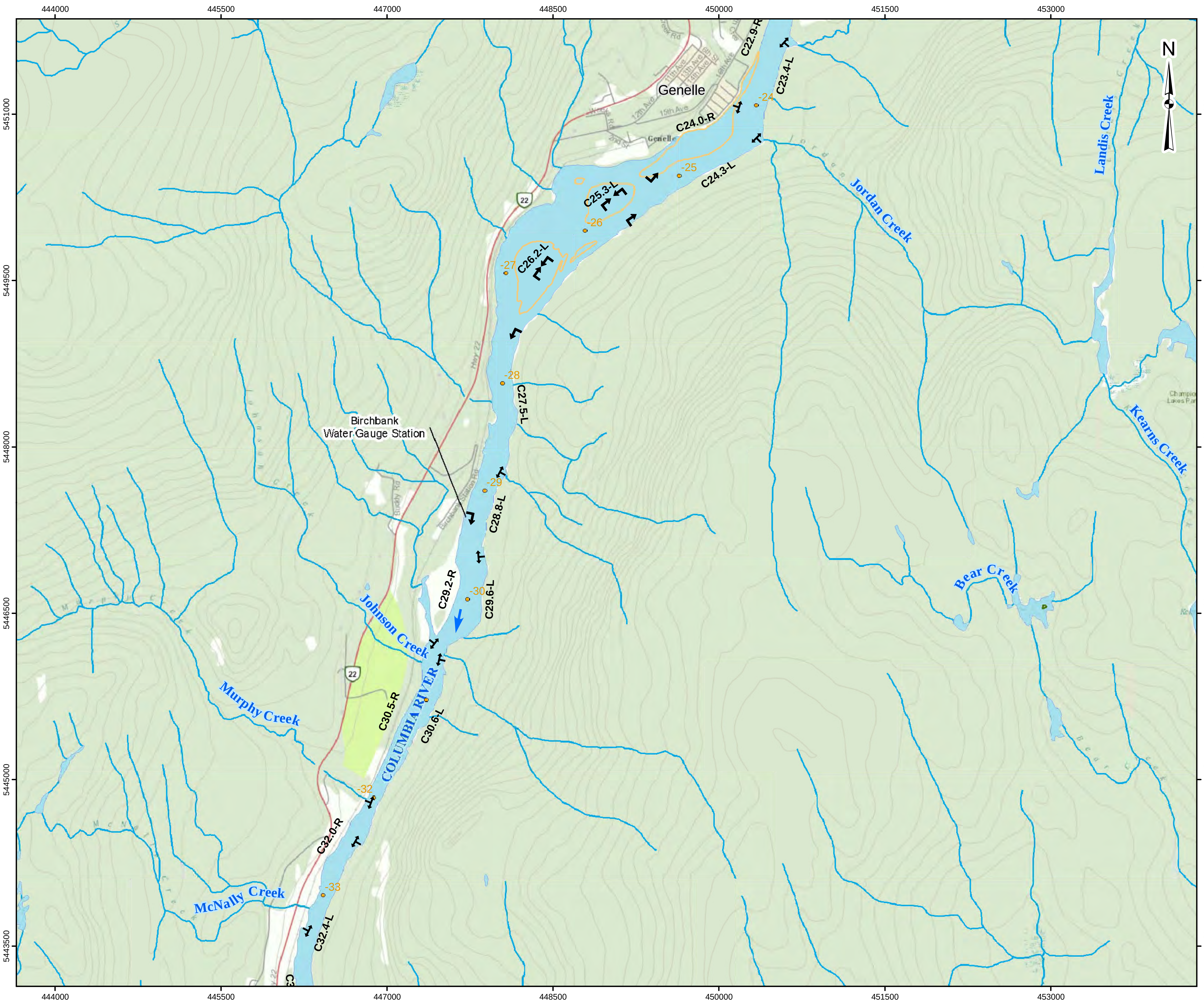
PROJECT
LARGE RIVER FISH INDEXING PROGRAM
LOWER COLUMBIA RIVER, BC
CLBMON-45

TITLE
2011 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	DH	13 Jun. 2011	Figure: A5	
GIS	JG	13 Jun. 2011		
CHECK	DF			
REVIEW	LH			

N:\Active\GIS\2010\10-1492-0102 LCR Indexing\MXD\2012\Fig A4-A8 1014920102 LCR 2012 Potential sa sites.mxd



LEGEND

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

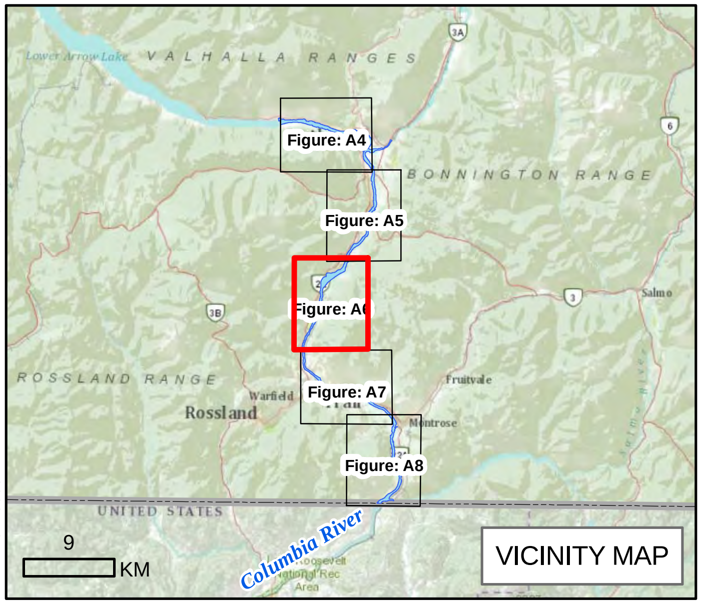
REFERENCE

1. BASE IMAGERY FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, MAY 2009.
2. WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
3. PROVINCIAL BOUNDARY: DMTI SPATIAL INC.
4. INSET IMAGE FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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
2011 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	DH	13 Jun. 2011	Figure: A6	
GIS	JG	13 Jun. 2011		
CHECK	DF			
REVIEW	LH			

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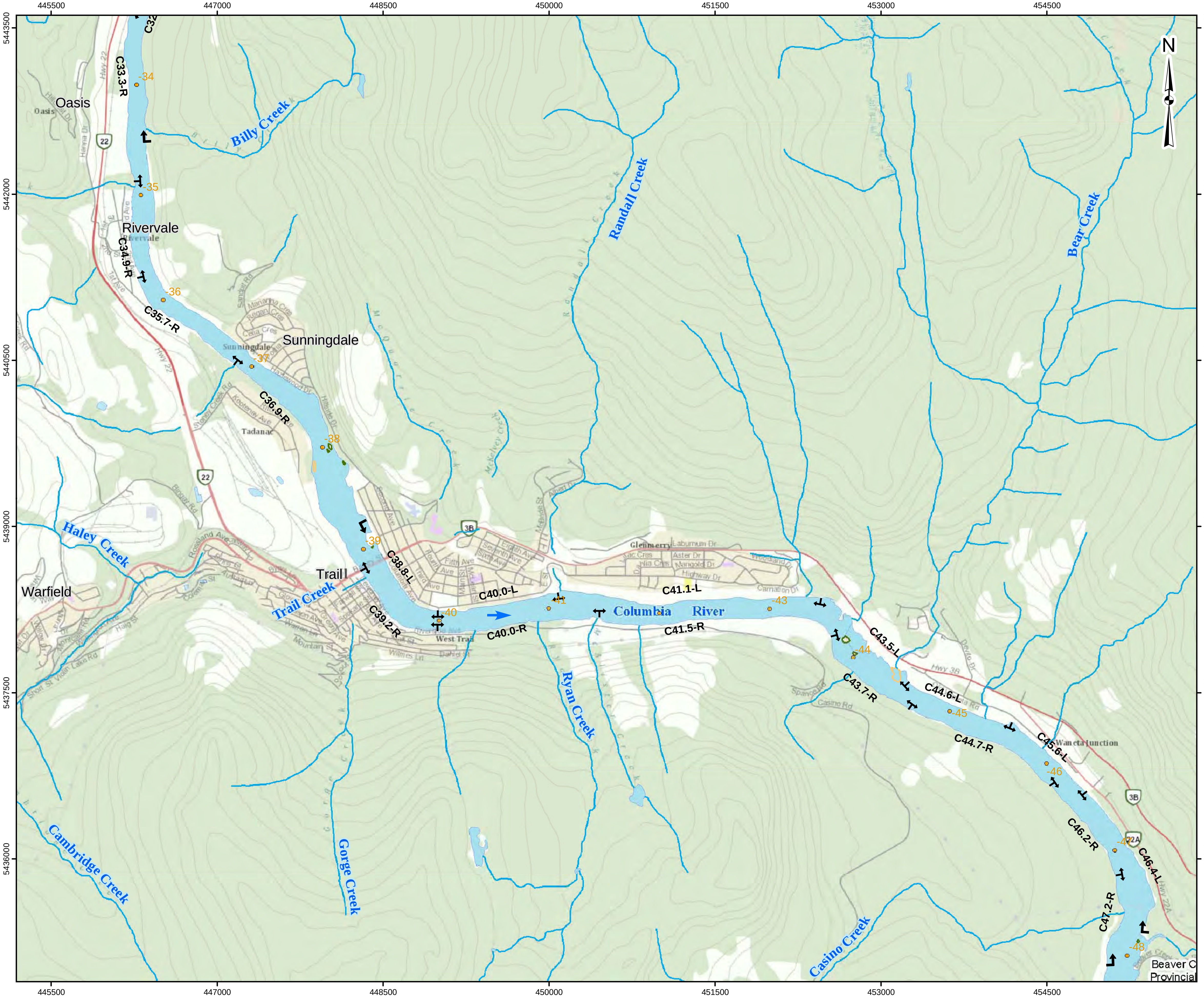


LEGEND

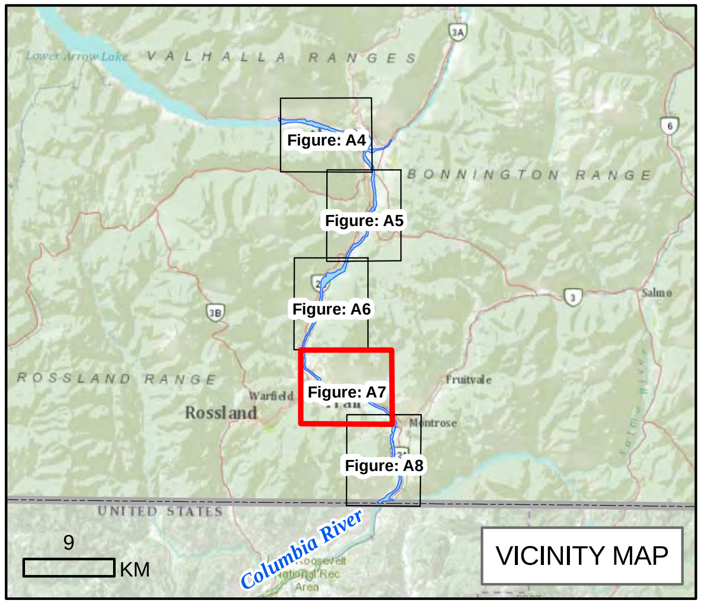
- C00.0-R BOAT ELECTROSHOCKING SITE
- ➔ FLOW DIRECTION
- • RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
- ∼ WATERCOURSE
- ▨ WATERBODY
- ▭ CANADA / US BORDER
- — BREAKWATER
- ▬ DAM SECTION
- — ISLAND
- — SAND OR GRAVEL BAR

REFERENCE

1. BASE IMAGERY FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, MAY 2009.
2. WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
3. PROVINCIAL BOUNDARY: DMTI SPATIAL INC.
4. INSET IMAGE FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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

2011 POTENTIAL SAMPLE SITE LOCATIONS

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

SCALE AS SHOWN
REV. 0

Figure: A7

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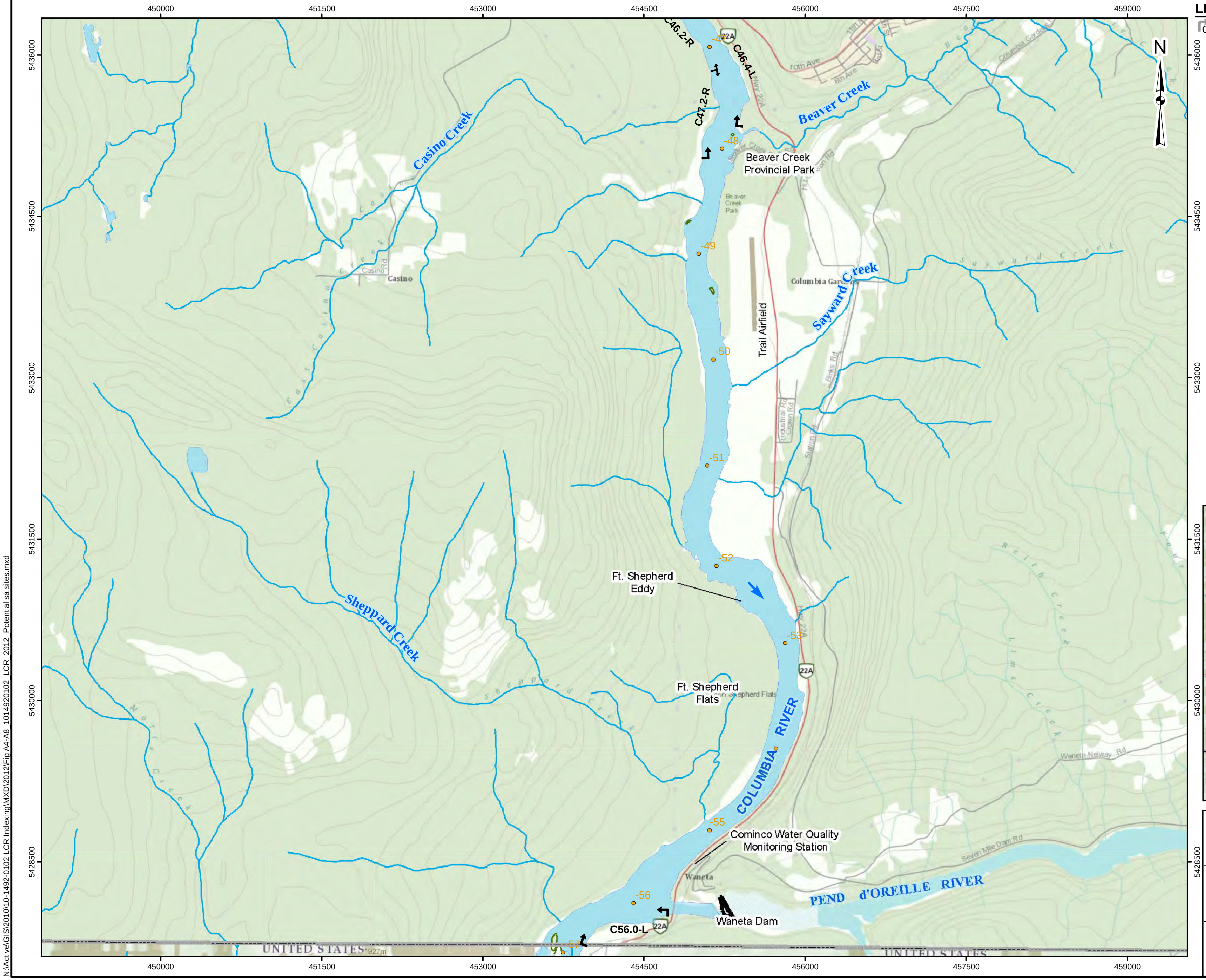


LEGEND

C00.0-R	BOAT ELECTROSHOCKING SITE
➔	FLOW DIRECTION
●	RIVER KILOMETRE DOWNSTREAM OF HUGH L. KEENLEYSIDE DAM
∼	WATERCOURSE
▨	WATERBODY
▭	CANADA / US BORDER
—	BREAKWATER
▬	DAM SECTION
—	ISLAND
—	SAND OR GRAVEL BAR

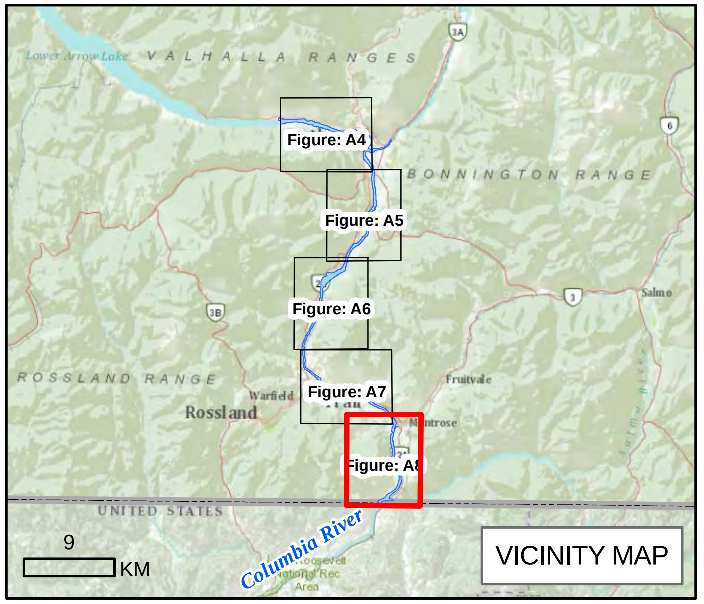
REFERENCE

1. BASE IMAGERY FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, MAY 2009.
2. WATERCOURCE AND WATERBODY: NATIONAL HYDRO NETWORK, GEOBASE.CA.
3. PROVINCIAL BOUNDARY: DMTI SPATIAL INC.
4. INSET IMAGE FROM: ESRI, DELORME, NAVTEQ, TOMTOM, INTERMAP, IPC USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), 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

2011 POTENTIAL SAMPLE SITE LOCATIONS

Golder Associates

PROJECT No. 10-1492-0102			SCALE AS SHOWN	REV. 0
DESIGN	DH	13 Jun. 2011	Figure: A8	
GIS	JG	13 Jun. 2011		
CHECK	DF			
REVIEW	LH			

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APPENDIX B

Habitat Summary Information

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

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

Continued.

Table B1 Concluded.

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

Velocity Classifications:

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

Table B2 Length of bank habitat types at boat electroshocking sites within the Lower Columbia River, 2011.

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, 26 September to 5 November 2011.

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	13.0	14.7	140	Mostly cloudy	High	High	High	0	0	0	0	0	70	30
Kootenay	K00.3-L	2	7.0	13.7	140	Partly cloudy	High	High	High	20	0	20	0	0	30	30
Kootenay	K00.3-L	3	6.0	12.1	150	Clear	High	High	High	20	0	0	0	0	50	30
Kootenay	K00.3-L	4	8.0	11.3	140	Clear	High	High	High	30	0	0	0	0	60	10
Kootenay	K00.3-L	5	6.0	9.3	140	Overcast	High	High	High	50	0	10	0	0	20	20
Kootenay	K00.6-R	1	10.0	14.5	140	Mostly cloudy	High	High	High	10	0	0	30	0	60	0
Kootenay	K00.6-R	2	7.0	13.7	140	Partly cloudy	High	High	High	0	0	0	20	0	40	40
Kootenay	K00.6-R	3	6.0	12.1	150	Clear	Medium	High	High	20	0	0	50	0	20	10
Kootenay	K00.6-R	4	8.0	10.9	140	Clear	High	High	High	50	0	0	40	0	10	0
Kootenay	K00.6-R	5	6.0	9.3	140	Overcast	High	High	High	30	0	0	50	0	20	0
Kootenay	K01.8-L	1	15.0	14.7	140	Mostly cloudy	High	Medium	High	20	0	10	0	0	60	10
Kootenay	K01.8-L	2	11.0	13.7	140	Clear	High	High	High	40	0	10	0	0	0	50
Kootenay	K01.8-L	3	8.0	12.1	150	Clear	High	High	High	30	0	10	0	0	20	40
Kootenay	K01.8-L	4	8.0	11.3	140	Clear	High	High	High	30	0	10	0	0	50	10
Kootenay	K01.8-L	5	8.0	9.3	140	Overcast	High	High	High	50	0	10	5	0	25	10
Kootenay	K01.8-R	1	13.0	14.7	140	Mostly cloudy	High	High	High	30	0	0	0	0	70	0
Kootenay	K01.8-R	2	8.0	13.7	140	Partly cloudy	High	High	High	20	0	20	0	0	20	40
Kootenay	K01.8-R	3	6.0	12.1	150	Clear	High	High	High	10	0	20	0	0	20	50
Kootenay	K01.8-R	4	9.0	11.3	140	Clear	High	High	High	30	0	10	0	0	30	30
Kootenay	K01.8-R	5	6.0	9.3	140	Overcast	High	High	High	30	0	20	0	0	30	20
Lower	C47.8-L	1	14.0	13.1	130	Clear	Medium	High	High	80	2	0	18	0	0	0
Lower	C47.8-L	2	17.0	14.1	120	Partly cloudy	High	High	High	70	0	0	20	0	5	5
Lower	C47.8-L	3	10.0	11.7	120	Mostly cloudy	High	High	High	40	0	5	5	0	10	40
Lower	C47.8-L	4	8.0	11.7	120	Clear	High	High	High	0	0	10	0	0	80	10
Lower	C47.8-L	5	5.0	10.5	120	Clear	High	High	High	40	0	30	20	0	0	10
Lower	C48.2-R	1	17.0	13.1	120	Overcast	Low	High	High	0	0	0	85	0	10	5
Lower	C48.2-R	2	13.0	14.1	120	Partly cloudy	High	High	High	0	0	0	45	0	55	0
Lower	C48.2-R	3	14.0	12.1	120	Partly cloudy	High	High	High	30	0	0	20	0	30	20
Lower	C48.2-R	4	10.0	11.7	120	Clear	High	High	High	30	0	0	60	0	10	0
Lower	C48.2-R	5	5.0	10.1	120	Clear	High	High	High	20	0	0	30	0	40	10
Lower	C49.0-L	1	14.0	12.9	130	Clear	Medium	High	High	50	0	0	20	0	30	0
Lower	C49.0-L	2	16.0	14.1	120	Clear	High	High	High	60	0	0	10	0	30	0
Lower	C49.0-L	3	9.0	11.7	120	Partly cloudy	High	High	High	70	0	5	5	0	0	20
Lower	C49.0-L	4	6.0	11.7	120	Clear	High	High	High	0	0	0	15	0	85	0
Lower	C49.0-L	5	2.0	10.5	120	Partly cloudy	High	High	High	50	0	0	10	0	30	10
Lower	49.0-R	1	16.0	13.1	120	Partly cloudy	High	High	High	0	0	0	15	0	80	5
Lower	49.0-R	2	10.0	14.1	120	Clear	High	High	High	30	0	0	0	0	65	5
Lower	49.0-R	3	12.0	12.1	120	Partly cloudy	High	High	High	55	0	0	15	0	30	0
Lower	49.0-R	4	8.0	11.7	120	Clear	High	High	High	50	0	0	5	0	25	20
Lower	49.0-R	5	4.0	10.1	120	Clear	High	High	High	20	0	0	20	0	30	30
Lower	49.8-L	1	13.0	13.1	130	Clear	Medium	High	High	60	0	10	10	0	10	10

continued…

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

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Lower	49.8-L	2	16.0	14.1	120	Clear	High	High	High	40	0	20	20	0	10	10
Lower	49.8-L	3	9.0	11.7	120	Partly cloudy	High	High	High	80	0	5	5	0	0	10
Lower	49.8-L	4	6.0	11.7	120	Clear	High	High	High	0	0	0	5	0	90	5
Lower	49.8-L	5	2.0	10.5	120	Clear	High	High	High	40	0	20	10	0	20	10
Lower	49.8-R	1	7.0	12.5	120	Clear	High	High	High	15	0	0	5	0	80	0
Lower	49.8-R	2	8.0	13.7	130	Clear	High	High	High	20	0	0	5	0	75	0
Lower	49.8-R	3	12.0	12.1	120	Partly cloudy	High	High	High	40	0	0	20	0	40	0
Lower	49.8-R	4	8.0	11.7	120	Clear	High	High	High	60	0	0	10	0	30	0
Lower	49.8-R	5	4.0	10.1	120	Clear	High	High	High	20	0	0	20	0	30	30
Lower	52.2-L	1	10.0	12.9	140	Clear	High	High	High	50	0	10	30	0	0	10
Lower	52.2-L	2	16.0	13.7	120	Clear	High	High	High	50	0	10	20	0	10	10
Lower	52.2-L	3	9.0	11.7	120	Overcast	High	High	High	70	0	10	5	0	0	15
Lower	52.2-L	4	9.0	11.7	120	Clear	High	High	High	25	0	25	0	0	40	10
Lower	52.2-L	5	0.0	10.2	120	Clear	Medium	High	High	10	0	40	5	0	0	45
Lower	52.2-R	1	7.0	12.5	120	Clear	High	High	High	60	0	10	5	0	20	5
Lower	52.2-R	2	6.0	13.7	130	Clear	High	High	High	20	0	0	0	0	75	5
Lower	52.2-R	3	8.0	12.1	120	Partly cloudy	High	High	High	60	0	0	10	0	10	20
Lower	52.2-R	4	6.0	11.7	120	Clear	High	High	High	40	0	20	10	0	10	20
Lower	52.2-R	5	0.0	9.8	120	Clear	High	High	High	20	0	40	0	0	10	30
Lower	52.8-L	1	10.0	12.5	140	Overcast	High	High	High	70	0	5	5	0	10	10
Lower	52.8-L	2	16.0	13.7	120	Clear	High	Medium	High	70	0	10	5	0	10	5
Lower	52.8-L	3	9.0	11.7	120	Overcast	High	High	High	80	0	20	0	0	0	0
Lower	52.8-L	4	10.0	11.7	120	Clear	High	High	High	0	0	15	0	0	80	5
Lower	52.8-L	5	0.0	10.2	120	Clear	Medium	High	High	20	0	0	10	0	0	70
Lower	53.6-L	1	10.0	12.9	140	Clear	High	High	High	70	0	10	10	0	5	5
Lower	53.6-L	2	14.0	13.7	120	Overcast	High	High	High	70	0	20	5	0	0	5
Lower	53.6-L	3	9.0	11.7	120	Overcast	High	High	High	99	0	0	1	0	0	0
Lower	53.6-L	4	14.0	11.7	120	Clear	High	High	High	0	0	0	5	0	75	20
Lower	53.6-L	5	0.0	10.2	120	Clear	Medium	High	High	20	0	20	10	0	25	25
Middle	C25.3-R	1	13.0	12.5	120	Clear	High	High	High	45	0	20	20	0	5	10
Middle	C25.3-R	2	16.0	13.5	120	Mostly cloudy	High	High	High	0	0	20	10	0	40	30
Middle	C25.3-R	3	9.0	11.7	140	Overcast	High	High	High	60	2	13	3	0	2	20
Middle	C25.3-R	4	12.0	10.9	110	Partly cloudy	Medium	High	High	20	0	30	10	0	10	30
Middle	C25.3-R	5	5.0	8.5	130	Partly cloudy	High	High	High	0	0	20	0	0	10	70
Middle	C27.6-R	1	12.0	12.5	120	Clear	High	High	High	80	0	0	0	0	10	10
Middle	C27.6-R	2	10.0	13.3	120	Mostly cloudy	High	High	High	20	0	10	0	0	70	0
Middle	C27.6-R	3	6.0	11.7	140	Overcast	High	High	High	80	0	10	0	0	10	0
Middle	C27.6-R	4	10.0	10.9	110	Partly cloudy	High	High	High	0	0	50	0	0	20	30
Middle	C27.6-R	5	6.0	8.9	130	Partly cloudy	High	High	High	30	0	20	0	0	25	25
Middle	C28.2-R	1	10.0	12.5	120	Clear	High	High	High	50	10	0	20	0	10	10
Middle	C28.2-R	2	8.0	13.3	120	Mostly cloudy	High	High	High	0	0	0	15	0	80	5

continued…

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

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (μS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)							
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Middle	C28.2-R	3	6.0	11.7	140	Overcast	High	High	High	80	5	0	10	0	0	5
Middle	C28.2-R	4	10.0	10.9	110	Partly cloudy	High	High	High	20	0	10	10	0	20	40
Middle	C28.2-R	5	5.0	8.5	130	Partly cloudy	High	High	High	20	0	20	0	0	30	30
Middle	C34.9-L	1	16.0	14.3	120	Overcast	High	High	High	70	0	10	2	0	8	10
Middle	C34.9-L	2	10.0	13.7	120	Overcast	High	Medium	High	50	0	10	2	0	0	38
Middle	C34.9-L	3	9.0	12.1	130	Partly cloudy	High	High	High	30	0	10	20	0	30	10
Middle	C34.9-L	4	10.0	11.3	120	Partly cloudy	High	High	High	30	0	10	10	0	25	25
Middle	C34.9-L	5	3.0	10.9	130	Clear	High	High	High	0	0	10	0	0	80	10
Middle	C36.6-L	1	14.0	14.3	120	Overcast	High	High	High	50	0	20	5	0	10	15
Middle	C36.6-L	2	8.0	13.3	120	Overcast	High	Medium	High	30	0	20	2	0	0	48
Middle	C36.6-L	3	8.0	12.1	130	Overcast	High	High	High	40	0	30	20	0	0	10
Middle	C36.6-L	4	12.0	11.6	120	Partly cloudy	High	High	High	20	0	20	10	0	20	30
Middle	C36.6-L	5	2.0	10.9	130	Clear	High	High	High	0	0	5	5	0	80	10
Upper	C00.0-R	1	17.0	12.8	110	Partly cloudy	High	High	Low	60	15	0	0	0	10	15
Upper	C00.0-R	2	15.0	13.3	100	Clear	High	High	Low	70	2	3	5	0	10	10
Upper	C00.0-R	3	8.0	11.7	110	Clear	High	High	Low	50	5	5	20	0	10	10
Upper	C00.0-R	4	12.0	10.9	110	Overcast	High	High	Low	30	0	0	20	0	25	25
Upper	C00.0-R	5	5.0	9.7	110	Overcast	Medium	High	Low	40	0	0	10	0	25	25
Upper	C00.7-L	1	15.0	12.9	110	Partly cloudy	High	High	Low	60	15	0	0	20	0	5
Upper	C00.7-L	2	14.0	13.3	100	Clear	Medium	High	Low	50	0	0	40	0	10	0
Upper	C00.7-L	3	8.0	11.7	110	Clear	High	High	Low	60	0	0	30	0	10	0
Upper	C00.7-L	4	10.0	10.9	110	Overcast	High	High	Low	30	0	0	20	0	30	20
Upper	C00.7-L	5	5.0	9.7	110	Clear	Medium	High	Low	30	0	0	20	0	50	0
Upper	C01.3-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	20	15	0	60	0	0	5
Upper	C01.3-L	2	14.0	13.3	110	Clear	Medium	High	Low	50	2	0	30	0	10	8
Upper	C01.3-L	3	8.0	11.7	110	Clear	High	High	Low	20	0	0	60	0	20	0
Upper	C01.3-L	4	10.0	10.9	120	Overcast	High	High	Low	20	5	0	50	0	20	5
Upper	C01.3-L	5	6.0	9.3	110	Overcast	Medium	High	Low	30	0	0	30	0	30	10
Upper	C02.8-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	10	0	0	70	0	20	0
Upper	C02.8-L	2	7.0	12.9	110	Clear	High	Medium	Low	20	0	0	70	0	10	0
Upper	C02.8-L	3	6.0	11.7	110	Clear	High	High	Low	30	0	0	50	0	20	0
Upper	C02.8-L	4	10.0	10.9	120	Overcast	High	High	Low	0	5	0	90	0	5	0
Upper	C02.8-L	5	6.0	9.7	110	Overcast	Medium	High	Low	20	0	0	60	0	20	0
Upper	C03.6-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	20	0	0	80	0	0	0
Upper	C03.6-L	2	6.0	13.3	110	Clear	High	High	Low	20	2	0	60	0	10	8
Upper	C03.6-L	3	6.0	11.7	110	Clear	High	High	Low	10	0	0	80	0	10	0
Upper	C03.6-L	4	10.0	10.9	120	Overcast	High	High	Low	10	5	0	80	0	5	0
Upper	C03.6-L	5	5.0	9.7	110	Overcast	High	High	Low	20	0	0	70	0	10	0
Upper	C04.6-R	1	12.0	13.1	110	Partly cloudy	High	High	Low	10	0	0	90	0	0	0
Upper	C04.6-R	2	4.0	13.3	130	Clear	Medium	High	Low	0	0	0	90	0	5	5
Upper	C04.6-R	3	5.0	12.1	110	Clear	High	High	Low	2	3	0	95	0	0	0

continued…

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

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

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

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

Table B3 Continued.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Upper	C04.6-R	4	9.0	10.9	120	Overcast	High	High	Low	0	0	0	100	0	0	0
Upper	C04.6-R	5	5.0	9.7	110	Overcast	High	High	Low	0	1	0	99	0	0	0
Upper	C05.6-L	1	11.0	12.8	110	Partly cloudy	High	High	Low	10	20	0	70	0	0	0
Upper	C05.6-L	2	4.0	13.1	110	Clear	Medium	High	Low	50	10	0	30	0	0	10
Upper	C05.6-L	3	5.0	11.7	110	Clear	High	High	Low	30	0	0	50	0	10	10
Upper	C05.6-L	4	8.0	10.9	120	Overcast	High	High	Low	40	20	0	40	0	0	0
Upper	C05.6-L	5	4.0	9.3	110	Overcast	High	High	Low	40	0	0	10	0	10	40
Upper	C07.3-R	1	10.0	13.1	110	Mostly cloudy	High	High	High	20	0	0	10	0	70	0
Upper	C07.3-R	2	5.0	12.9	110	Partly cloudy	High	High	High	20	0	0	0	0	20	60
Upper	C07.3-R	3	5.0	11.4	140	Clear	High	High	High	0	0	0	70	0	30	0
Upper	C07.3-R	4	5.0	10.5	120	Clear	High	High	High	40	0	10	10	0	10	30
Upper	C07.3-R	5	6.0	8.5	120	Overcast	High	High	High	50	0	10	0	0	20	20
Upper	C07.4-L	1	10.0	13.1	100	Mostly cloudy	High	High	High	0	0	0	40	0	60	0
Upper	C07.4-L	2	6.0	12.9	110	Partly cloudy	High	High	High	0	0	0	50	0	20	30
Upper	C01.3-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	20	15	0	60	0	0	5
Upper	C01.3-L	2	14.0	13.3	110	Clear	Medium	High	Low	50	2	0	30	0	10	8
Upper	C01.3-L	3	8.0	11.7	110	Clear	High	High	Low	20	0	0	60	0	20	0
Upper	C01.3-L	4	10.0	10.9	120	Overcast	High	High	Low	20	5	0	50	0	20	5
Upper	C01.3-L	5	6.0	9.3	110	Overcast	Medium	High	Low	30	0	0	30	0	30	10
Upper	C02.8-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	10	0	0	70	0	20	0
Upper	C02.8-L	2	7.0	12.9	110	Clear	High	Medium	Low	20	0	0	70	0	10	0
Upper	C02.8-L	3	6.0	11.7	110	Clear	High	High	Low	30	0	0	50	0	20	0
Upper	C02.8-L	4	10.0	10.9	120	Overcast	High	High	Low	0	5	0	90	0	5	0
Upper	C02.8-L	5	6.0	9.7	110	Overcast	Medium	High	Low	20	0	0	60	0	20	0
Upper	C03.6-L	1	15.0	12.8	110	Partly cloudy	High	High	Low	20	0	0	80	0	0	0
Upper	C03.6-L	2	6.0	13.3	110	Clear	High	High	Low	20	2	0	60	0	10	8
Upper	C03.6-L	3	6.0	11.7	110	Clear	High	High	Low	10	0	0	80	0	10	0
Upper	C03.6-L	4	10.0	10.9	120	Overcast	High	High	Low	10	5	0	80	0	5	0
Upper	C03.6-L	5	5.0	9.7	110	Overcast	High	High	Low	20	0	0	70	0	10	0
Upper	C04.6-R	1	12.0	13.1	110	Partly cloudy	High	High	Low	10	0	0	90	0	0	0
Upper	C04.6-R	2	4.0	13.3	130	Clear	Medium	High	Low	0	0	0	90	0	5	5
Upper	C04.6-R	3	5.0	12.1	110	Clear	High	High	Low	2	3	0	95	0	0	0
Upper	C04.6-R	4	9.0	10.9	120	Overcast	High	High	Low	0	0	0	100	0	0	0
Upper	C04.6-R	5	5.0	9.7	110	Overcast	High	High	Low	0	1	0	99	0	0	0
Upper	C05.6-L	1	11.0	12.8	110	Partly cloudy	High	High	Low	10	20	0	70	0	0	0
Upper	C05.6-L	2	4.0	13.1	110	Clear	Medium	High	Low	50	10	0	30	0	0	10
Upper	C05.6-L	3	5.0	11.7	110	Clear	High	High	Low	30	0	0	50	0	10	10
Upper	C05.6-L	4	8.0	10.9	120	Overcast	High	High	Low	40	20	0	40	0	0	0
Upper	C05.6-L	5	4.0	9.3	110	Overcast	High	High	Low	40	0	0	10	0	10	40
Upper	C07.3-R	1	10.0	13.1	110	Mostly cloudy	High	High	High	20	0	0	10	0	70	0
Upper	C07.3-R	2	5.0	12.9	110	Partly cloudy	High	High	High	20	0	0	0	0	20	60

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

continued…

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

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

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

Table B3 Concluded.

Section	Site[a]	Session	Air Temperature (°C)	Water Temperature (°C)	Conductivity (µS)	Cloud Cover[b]	Water Surface Visibility	Instream Velocity[c]	Water Clarity[d]	Cover Types (%)						
										Substrate Interstices	Woody Debris	Turbulence	Aquatic Vegetation	Terrestrial Vegetation	Shallow Water	Deep Water
Upper	C07.3-R	3	5.0	11.4	140	Clear	High	High	High	0	0	0	70	0	30	0
Upper	C07.3-R	4	5.0	10.5	120	Clear	High	High	High	40	0	10	10	0	10	30
Upper	C07.3-R	5	6.0	8.5	120	Overcast	High	High	High	50	0	10	0	0	20	20
Upper	C07.4-L	1	10.0	13.1	100	Mostly cloudy	High	High	High	0	0	0	40	0	60	0
Upper	C07.4-L	2	6.0	12.9	110	Partly cloudy	High	High	High	0	0	0	50	0	20	30
Upper	C07.4-L	3	5.0	11.0	140	Clear	High	High	High	20	0	10	0	0	30	40
Upper	C07.4-L	4	6.0	10.2	120	Clear	High	High	High	20	0	0	70	0	10	0
Upper	C07.4-L	5	6.0	8.0	110	Overcast	High	High	High	20	0	0	50	0	30	0
Lower	C56.0-L	1	0.0	9.8	170	Clear	High	High	High	10	0	40	0	0	0	50
Lower	C41.1-L	1	5.0	8.5	120	Clear	Medium	High	High	70	0	10	10	0	5	5
Lower	C44.6-L	1	2.0	8.5	120	Clear	High	High	High	100	0	0	0	0	0	0
Lower	C44.7-R	1	0.0	8.2	130	Clear	High	High	High	70	0	0	20	0	0	10
Lower	C46.2-R	1	0.0	8.2	130	Clear	Medium	High	High	80	0	0	20	0	0	0
Middle	C30.6-L	1	5.0	8.9	130	Clear	High	High	High	50	0	5	5	0	10	30
Middle	C33.3-R	1	5.0	8.9	130	Clear	High	High	High	20	0	30	5	0	5	40
Middle	C34.9-R	1	4.0	8.5	120	Clear	High	High	High	40	0	10	5	0	5	40
Middle	C36.9-R	1	4.0	8.5	120	Overcast	High	High	High	60	0	10	20	0	5	5
Middle	C28.8-L	1	5.0	8.0	120	Overcast	High	High	High	0	0	20	0	0	70	10
Middle	C25.3-L	1	3.0	7.6	120	Mostly cloudy	High	High	High	0	0	15	30	0	55	0
Upper	C20.4-R	1	2.0	7.6	120	Mostly cloudy	High	High	High	0	0	10	30	0	50	10
Middle	C23.4-L	1	1.0	7.6	120	Mostly cloudy	High	High	High	0	0	0	0	0	90	10
Upper	C10.9-L	1	6.0	8.5	130	Mostly cloudy	High	High	High	80	0	10	0	0	10	0
Upper	C10.7-R	1	1.0	8.2	140	Clear	High	High	High	95	0	5	0	0	0	0
Upper	C11.5-R	1	0.0	7.6	130	Clear	High	High	High	80	0	5	0	0	5	10
Upper	C09.2-L	1	-3.0	7.8	120	Clear	High	Low	High	70	0	0	20	0	10	0
Upper	C13.4-L	1	3.0	8.0	130	Clear	High	High	High	70	0	10	0	0	10	10
Upper	C16.6-R	1	-1.0	8.0	120	Clear	High	High	High	60	0	0	0	0	40	0
Upper	C19.0-L	1	-1.0	8.0	120	Overcast	High	High	High	50	0	10	0	0	10	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, 26 September to 30 October 2011.

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	Brook trout													1		**1**
		Bull trout													2		**2**
		Kokanee		4											8		**12**
		Mountain whitefish		57											99		**156**
		Northern pikeminnow		5											11		**16**
		Peamouth		9											11		**20**
		Rainbow trout		3											30		**33**
		Redside shiner		3284											766		**4050**
		Sculpin spp.		167											1039		**1206**
		Sucker spp.		37											79		**116**
		Walleye		27											41		**68**
		White sturgeon													1		**1**
	C00.0-R Total		**0**	**3593**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2088**	**0**	**5681**
	C00.7-L	Kokanee		4							5						**9**
		Mountain whitefish		18							69						**87**
		Northern pikeminnow		7							29						**36**
		Peamouth		15							35						**50**
		Rainbow trout		15							68						**83**
		Redside shiner		44							77						**121**
		Sculpin spp.		175							440						**615**
		Sucker spp.		23							65						**88**
		Walleye		18							38						**56**
	C00.7-L Total		**0**	**319**	**0**	**0**	**0**	**0**	**0**	**0**	**826**	**0**	**0**	**0**	**0**	**0**	**1145**
	C01.3-L	Bull trout									3						**3**
		Kokanee									17						**17**
		Mountain whitefish	58								164						**222**
		Northern pikeminnow	13								118						**131**
		Peamouth	18								80						**98**
		Rainbow trout	27								175						**202**
		Redside shiner	38								114						**152**
		Sculpin spp.	85								805						**890**
		Sucker spp.	61								442						**503**
		Walleye	7								90						**97**
	C01.3-L Total		**307**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2008**	**0**	**0**	**0**	**0**	**0**	**2315**
	C02.8-L	Bull trout									1						**1**
		Kokanee									3						**3**
		Mountain whitefish									81						**81**
		Northern pikeminnow									23						**23**
		Peamouth									17						**17**
		Rainbow trout									59						**59**
		Redside shiner									125						**125**
		Sculpin spp.									462						**462**
		Sucker spp.									290						**290**
		Walleye									45						**45**
		White sturgeon									1						**1**
	C02.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1107**	**0**	**0**	**0**	**0**	**0**	**1107**
	C03.6-L	Kokanee	12								3						**15**
		Mountain whitefish	88			1					67						**156**
		Northern pike	2														**2**
		Northern pikeminnow	89			34					8						**131**
		Peamouth	4								5						**9**
		Rainbow trout	116			6					122						**244**
		Redside shiner	54			41					39						**134**
		Sculpin spp.	926			71					188						**1185**
		Sucker spp.	393			57					225						**675**
		Walleye	65			14					48						**127**
		White sturgeon				1											**1**
	C03.6-L Total		**1749**	**0**	**0**	**225**	**0**	**0**	**0**	**0**	**705**	**0**	**0**	**0**	**0**	**0**	**2679**
	C04.6-R	Kokanee									1						**1**
		Mountain whitefish									19						**19**
		Northern pike									6						**6**
		Rainbow trout									60						**60**
		Redside shiner									19						**19**
		Sculpin spp.									30						**30**
		Sucker spp.									179						**179**
		Walleye									27						**27**
	C04.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**341**	**0**	**0**	**0**	**0**	**0**	**341**
	C05.6-L	Kokanee									1						**1**
		Mountain whitefish	24								3						**27**
		Northern pike									1						**1**
		Northern pikeminnow	66								33						**99**
		Peamouth	4														**4**
		Rainbow trout	41								27						**68**
		Redside shiner	55								50						**105**
		Sculpin spp.	398								113						**511**
		Sucker spp.	205								95						**300**
		Walleye	52								20						**72**
	C05.6-L Total		**845**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**343**	**0**	**0**	**0**	**0**	**0**	**1188**
	C07.3-R	Burbot				5											**5**
		Kokanee				7											**7**
		Lake whitefish				10											**10**
		Mountain whitefish				190											**190**
		Northern pikeminnow				15											**15**
		Peamouth				1											**1**
		Rainbow trout				130											**130**
		Redside shiner				20											**20**
		Sculpin spp.				2423											**2423**
		Sucker spp.				307											**307**
		Walleye				57											**57**
	C07.3-R Total		**0**	**0**	**0**	**3165**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3165**
	C07.4-L	Burbot												2			**2**
		Kokanee												1			**1**
		Lake whitefish												3			**3**
		Mountain whitefish												329			**329**
		Northern pikeminnow												31			**31**
		Rainbow trout												113			**113**
		Redside shiner												5			**5**
		Sculpin spp.												432			**432**
		Sucker spp.												983			**983**
		Walleye												40			**40**
		White sturgeon												1			**1**
	C07.4-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1940**	**0**	**0**	**1940**
Upstream Columbia River Total			**2901**	**3912**	**0**	**3390**	**0**	**0**	**0**	**0**	**5330**	**0**	**0**	**1940**	**2088**	**0**	**19561**

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**
		Lake whitefish								1							**1**
		Mountain whitefish								21					3		**24**
		Northern pikeminnow								3					1		**4**
		Rainbow trout								10					12		**22**
		Redside shiner													7		**7**
		Sculpin spp.								16					56		**72**
		Sucker spp.								30					2		**32**
		Walleye								14					11		**25**
	K00.3-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**96**	**0**	**0**	**0**	**0**	**92**	**0**	**188**
	K00.6-R	Lake whitefish												1			**1**
		Mountain whitefish												174		4	**178**
		Northern pikeminnow												7		20	**27**
		Peamouth												1			**1**
		Rainbow trout												24		13	**37**
		Redside shiner														30	**30**
		Sculpin spp.												36		165	**201**
		Sucker spp.												89		401	**490**
		Walleye												34		31	**65**
		Yellow perch														1	**1**
	K00.6-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**366**	**0**	**665**	**1031**
	K01.8-L	Kokanee					1					3					**4**
		Lake whitefish		1								4					**5**
		Mountain whitefish		69			13					174					**256**
		Northern pikeminnow		16			14					28					**58**
		Rainbow trout		29			25					100					**154**
		Redside shiner		7			28					15					**50**
		Sculpin spp.		190			59					910					**1159**
		Sucker spp.		6								101					**107**
		Walleye		28			8					165					**201**
		White sturgeon		2								1					**3**
	K01.8-L Total		**0**	**348**	**0**	**0**	**148**	**0**	**0**	**0**	**0**	**1501**	**0**	**0**	**0**	**0**	**1997**
	K01.8-R	Burbot					1			1							**2**
		Kokanee					2			5							**7**
		Mountain whitefish					9			236							**245**
		Northern pikeminnow					1			69							**70**
		Peamouth					1			1							**2**
		Rainbow trout					29			113							**142**
		Redside shiner					13			27							**40**
		Sculpin spp.					44			503							**547**
		Sucker spp.					2			84							**86**
		Walleye					18			90							**108**
		White sturgeon								2							**2**
	K01.8-R Total		**0**	**0**	**0**	**0**	**120**	**0**	**0**	**1131**	**0**	**0**	**0**	**0**	**0**	**0**	**1251**
Kootenay River Total			**0**	**348**	**0**	**0**	**268**	**0**	**0**	**1227**	**0**	**1501**	**0**	**366**	**92**	**665**	**4467**
Downstream Columbia River	C25.3-R	Bull trout	1														**1**
		Burbot								2							**2**
		Kokanee	4							2							**6**
		Lake whitefish	1							30							**31**
		Mountain whitefish	40				2			219							**261**
		Northern pikeminnow	1							3							**4**
		Rainbow trout	93				4			207							**304**
		Redside shiner	78														**78**
		Sculpin spp.	146				8			251							**405**
		Sucker spp.	202				3			30							**235**
		Walleye	67				8			50							**125**
		White sturgeon								1							**1**
	C25.3-R Total		**633**	**0**	**0**	**0**	**25**	**0**	**0**	**795**	**0**	**0**	**0**	**0**	**0**	**0**	**1453**
	C27.6-R	Lake whitefish										1					**1**
		Mountain whitefish								30		56					**86**
		Northern pikeminnow					1			5							**6**
		Rainbow trout					8			55		16					**79**
		Sculpin spp.					5			31							**36**
		Sucker spp.					3			1							**4**
		Walleye					15			10		6					**31**
	C27.6-R Total		**0**	**0**	**0**	**0**	**32**	**0**	**0**	**132**	**0**	**79**	**0**	**0**	**0**	**0**	**243**
	C28.2-R	Brook trout		1													**1**
		Burbot		1													**1**
		Lake whitefish		2													**2**
		Mountain whitefish		105													**105**
		Northern pikeminnow		9													**9**
		Peamouth		1													**1**
		Rainbow trout		199													**199**
		Redside shiner		7													**7**
		Sculpin spp.		636													**636**
		Sucker spp.		130													**130**
		Walleye		43													**43**
	C28.2-R Total		**0**	**1134**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1134**
	C34.9-L	Brook trout		1													**1**
		Burbot		4													**4**
		Lake whitefish		4													**4**
		Mountain whitefish		24	6												**30**
		Northern pikeminnow		6	1												**7**
		Rainbow trout		482	116												**598**
		Redside shiner		41	47												**88**
		Sculpin spp.		834	150												**984**
		Sucker spp.		51	7												**58**
		Walleye		41	15												**56**
	C34.9-L Total		**0**	**1488**	**342**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1830**
	C36.6-L	Brook trout					2			1							**3**
		Bull trout								2							**2**
		Burbot					1			1			1				**3**
		Lake whitefish					1			3			4				**8**
		Mountain whitefish					17			8			12				**37**
		Northern pikeminnow					53			3							**56**
		Rainbow trout					154			237			9				**400**
		Redside shiner					18			32							**50**
		Sculpin spp.					247			1044			60				**1351**
		Sucker spp.					89			14			1				**104**
		Walleye					28			23							**51**
	C36.6-L Total		**0**	**0**	**0**	**0**	**610**	**0**	**0**	**1368**	**0**	**0**	**87**	**0**	**0**	**0**	**2065**

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								2	3						**5**
		Burbot								8							**8**
		Lake whitefish									10						**10**
		Mountain whitefish								14	2						**16**
		Northern pikeminnow								4	7						**11**
		Prickly sculpin								9	1						**10**
		Rainbow trout								154	70						**224**
		Redside shiner								25	28						**53**
		Sculpin spp.								1960	312						**2272**
		Sucker spp.								20	125						**145**
		Torrent sculpin								2							**2**
		Umatilla dace									2						**2**
		Walleye								41	25						**66**
		White sturgeon								1	2						**3**
	C47.8-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2240**	**587**	**0**	**0**	**0**	**0**	**0**	**2827**
	C48.2-R	Burbot												6			**6**
		Lake whitefish												3	1		**4**
		Mountain whitefish												25	9		**34**
		Northern pikeminnow												5			**5**
		Rainbow trout												129	52		**181**
		Redside shiner												15	62		**77**
		Sculpin spp.												62	34		**96**
		Sucker spp.												211	173		**384**
		Walleye												31	11		**42**
	C48.2-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**487**	**342**	**0**	**829**
	C49.0-L	Burbot		2								3					**5**
		Lake whitefish		6								14					**20**
		Mountain whitefish		38								39					**77**
		Rainbow trout		53								126					**179**
		Sculpin spp.		605								1080					**1685**
		Smallmouth bass										1					**1**
		Sucker spp.		30								105					**135**
		Walleye		12								16					**28**
	C49.0-L Total		**0**	**746**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1384**	**0**	**0**	**0**	**0**	**2130**
	C49.0-R	Brook trout							1								**1**
		Brown trout												2			**2**
		Bull trout												1			**1**
		Burbot												9			**9**
		Lake whitefish												5			**5**
		Mountain whitefish							3					21			**24**
		Northern pikeminnow							10								**10**
		Rainbow trout							39					113			**152**
		Redside shiner							39					19			**58**
		Sculpin spp.							53					247			**300**
		Sucker spp.							65					67			**132**
		Walleye							9					7			**16**
		White sturgeon												1			**1**
	C49.0-R Total		**0**	**0**	**0**	**0**	**0**	**0**	**219**	**0**	**0**	**0**	**0**	**492**	**0**	**0**	**711**
	C49.8-L	Burbot		41													**41**
		Kokanee		1													**1**
		Lake whitefish		21													**21**
		Mountain whitefish		139													**139**
		Northern pikeminnow		17													**17**
		Prickly sculpin		3													**3**
		Rainbow trout		524													**524**
		Redside shiner		105													**105**
		Sculpin spp.		5770													**5770**
		Sucker spp.		252													**252**
		Umatilla dace		1													**1**
		Walleye		92													**92**
		White sturgeon		2													**2**
	C49.8-L Total		**0**	**6968**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6968**
	C49.8-R	Bull trout		2													**2**
		Burbot		14								19			4		**37**
		Cutthroat trout		1													**1**
		Lake whitefish		13								1					**14**
		Mountain whitefish		55								17					**72**
		Northern pikeminnow		4								1			10		**15**
		Rainbow trout		353								183			34		**570**
		Redside shiner		60								5			62		**127**
		Sculpin spp.		3655								680			76		**4411**
		Sucker spp.		83								22			466		**571**
		Walleye		72								28			30		**130**
		Yellow perch													1		**1**
	C49.8-R Total		**0**	**4312**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**956**	**0**	**0**	**683**	**0**	**5951**
	C52.2-L	Brown trout										1					**1**
		Burbot										12				2	**14**
		Cutthroat trout														1	**1**
		Lake whitefish										18				1	**19**
		Mountain whitefish										22				3	**25**
		Northern pikeminnow														1	**1**
		Rainbow trout										66				177	**243**
		Redside shiner														15	**15**
		Sculpin spp.										39				242	**281**
		Smallmouth bass														1	**1**
		Sucker spp.										5				57	**62**
		Walleye										6				16	**22**
		White sturgeon										1					**1**
	C52.2-L Total		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**170**	**0**	**0**	**0**	**516**	**686**
	C52.2-R	Brook trout		1													**1**
		Burbot		83												1	**84**
		Cutthroat trout		1													**1**
		Lake whitefish		41												2	**43**
		Mountain whitefish		91												8	**99**
		Northern pikeminnow		2												1	**3**
		Rainbow trout		318												100	**418**
		Redside shiner														7	**7**
		Sculpin spp.		2260												36	**2296**
		Smallmouth bass		1												1	**2**
		Sucker spp.		51												104	**155**
		Walleye		82												24	**106**
		White sturgeon		6													**6**
	C52.2-R Total		**0**	**2937**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**284**	**3221**

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	Burbot		5		5											**10**
		Cutthroat trout				1											**1**
		Lake whitefish		13		2											**15**
		Mountain whitefish		13		13											**26**
		Northern pikeminnow		1													**1**
		Rainbow trout		45		58											**103**
		Sculpin spp.		51		52											**103**
		Sucker spp.		4		22											**26**
		Walleye		16		27											**43**
	C52.8-L Total		**0**	**148**	**0**	**180**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**328**
	C53.6-L	Brook trout						2									**2**
		Brown trout						1									**1**
		Burbot						18									**18**
		Lake whitefish						4									**4**
		Mountain whitefish						16									**16**
		Rainbow trout						188									**188**
		Sculpin spp.						222									**222**
		Smallmouth bass						4									**4**
		Sucker spp.						120									**120**
		Walleye						65									**65**
		White sturgeon						1									**1**
		Yellow perch						1									**1**
	C53.6-L Total		**0**	**0**	**0**	**0**	**0**	**642**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**642**
Downstream Columbia River Total			**633**	**17733**	**342**	**180**	**667**	**642**	**219**	**4535**	**587**	**2589**	**87**	**979**	**1025**	**800**	**31018**
All Sections Total			**3534**	**21993**	**342**	**3570**	**935**	**642**	**219**	**5762**	**5917**	**4090**	**87**	**3285**	**3205**	**1465**	**55046**

APPENDIX C

Hierarchical Bayesian Model Parameters

JAGS implements a dialect of the BUGS modelling language. Consequently, the following model code should, in general, be interpretable by WinBUGS or OpenBUGS after a few minor modifications. For addition information see the JAGS Version 3.1.0 user manual (Plummer 2011) which is available at http://sourceforge.net/projects/mcmc-jags/files/Manuals/3.x/.

JAGS distributions used in the Bayesian analyses are listed in Table C1. It is important to note that following the Bayesian convention, JAGS distributions are defined in terms of their precision, as opposed to their standard deviation. As the precision is the inverse of the variance, the precision can be calculated by raising the standard deviation to the power of -2. The JAGS functions (Plummer 2011) used in the Bayesian analyses are listed in Table C2.

Table C1: Distributions in the Bayesian models.

JAGS Code	Distribution
dbern(p)	Bernoulli distribution where p is the probability
dbin(p,n)	Binomial distribution where p is the probability and n is the sample size
dlnorm(mu,tau)	Log-normal distribution where mu is the mean and tau is the precision
dnorm(mu,tau)	Normal distribution where mu is the mean and tau is the precision
dpois(lambda)	Poisson distribution where lambda is the mean count
dunif(a,b)	Uniform distribution where a is the lower limit and b is the upper limit

Table C2: Functions in the Bayesian models.

JAGS Code	Function
exp(x)	Exponential of x
log(x)	Natural logarithm of x
logit(p)	Log-odds of p
max(x,y)	Greater of x or y
sum(x)	Sum of values in x
x^y	Power where x is raised to the power of y
1:n	Vector of integers from 1 to n
x[1:n]	Subset of first n values in x

SIZE-AT-AGE

Table C3: Variables in the size-at-age analysis.

Variable	Description
Year[i]	Year the i^{th} fish was observed
Date[i]	Date the i^{th} fish was observed
Length[i]	Length of the i^{th} fish

Table C4: Parameters in the size-at-age analysis.

Parameter	Description
bAgeYear[ag,yr]	Effect of the yr^{th} year on the length of an ag^{th} age fish
bDate[ag]	Effect of date on the length of an ag^{th} age fish
bDate2[ag]	Effect of the second order polynomial of date on the length of an a^{th} age fish
bIncrement[ag]	Length difference between an ag^{th} age fish and an $ag\text{-}1^{th}$ age fish
bIntercept[ag]	Length of an ag^{th} age fish
eAge[i]	Expected age of the i^{th} fish
eLength[i]	Expected length of the i^{th} fish
pAge[ag]	Proportion of the fish belonging to the ag^{th} age
sLengthAge[ag]	Standard deviation of the residual variation in the length of fish belong to the ag^{th} age
sAgeYear[ag]	Standard deviation of the effect of year on the length of fish belong to the ag^{th} age

Model C1: JAGS model definition for the size-at-age analysis.

```
model {
 for(ag in 1:nAge)  {
   dAge[ag] <- 1
   sLengthAge[ag] ~ dunif(0, 100)
   sAgeYear[ag] ~ dunif(0, 50)
   bIncrement[ag] ~ dunif(50, 250)
   bDate[ag] ~ dnorm(0, 10)
   bDate2[ag] ~ dnorm(0, 10)
   for(yr in 1:nYear) {
     bAgeYear[ag, yr] ~ dnorm(0, sAgeYear[i]^-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]] + bDate[Age[i]]*Date[i] + bDate2[Age[i]]*Date[i]^2
   Length[i] ~ dnorm(eLength[i], sLengthAge[Age[i]]^-2)
 }
```

MOVEMENT

Table C5: Variables in the movement analysis.

Variable	Description
Days[i]	Days since the i^{th} recapture was previously encountered
Remained[i]	Whether or not the i^{th} recapture was recorded at the same site as previously encountered

Table C6: Parameters in the movement analysis.

Parameter	Description
bDays	Effect of days since last encounter on the log-odds of the probability of recapture at the same site
bIntercept	Log-odds of the probability of recapture at the same site
eRemained[i]	Expected probability of the i^{th} recapture being caught at the same site as previously

Model C2: JAGS model definition for the movement analysis.

```
model {
  bIntercept ~ dnorm(0, 5^-2)
  bDays ~ dnorm(0, 5^-2)
  for (i in 1:nrow)  {
    logit(eRemained[i]) <- bIntercept + bDays * Days[i]
    Remained[i] ~ dbern(eRemained[i])
  }
}
```

ABUNDANCE

Table C7: The variables in the abundance analysis.

Variable	Description
DeadMarked[st,yr,ss]	Number of marked mortalities at the stth site in the yrth year during the ssth session
Fish[st,yr]	Minimum abundance at the stth site in the yrth year based on the number of fish caught
Marked[st,yr,ss]	Number of marked fish caught at the stth site in the yrth year in the ssth session
ProportionSampled[st,yr,ss]	Proportion of the stth site sampled in the ssth session of the yrth year
SiteLength[st]	Length of the stth site
Tagged[st,yr,ss]	Number of fish tagged at the stth site in the yrth year in the ssth session
Unmarked[st,yr,ss]	Number of unmarked fish caught at the stth site in the yrth year in the ssth session

Table C8: The parameters in the abundance analysis.

Parameter	Description
bDensityIntercept	Log lineal density
bDensitySite[st]	Effect of the stth site on the log lineal density
bDensityYear[yr]	Effect of the yrth year on the log lineal density
bDensityYearSite[yr,st]	Effect of the stth site in the yrth year on the log lineal density
bEfficiencyIntercept	Log-odds efficiency
bEfficiencySession[ss]	Effect of the ssth session on the log-odds efficiency
bEfficiencyYear[yr]	Effect of the yrth year on the log-odds efficiency
bPopulation[yr]	Population abundance in the yrth year
eAbundance	Expected abundance at the stth site in the yrth year
eDensity[st,yr]	Expected lineal density at the stth site in the yrth year
eEfficiency[st,yr,ss]	Expected efficiency at the stth site in the yrth year during the ssth session
eEfficiencySampling[st,yr,ss]	Expected efficiency at the stth site in the yrth year during the ssth session given the proportion sampled
eMarkedAbundance[st,yr,ss]	Expected abundance of marked fish at the stth site in the ssth year prior to the ssth session
eMarkedSamplingEfficiency[st,yr,ss]	Expected recapture efficiency at the stth site in the ssth year during the ssth session
eRemained	Expected proportion of the marked fish remaining at the site based on the movement analysis
eUnmarkedAbundance[st,yr,ss]	Expected abundance of unmarked fish at the stth site in the ssth year prior to the ssth session
sDensitySite	Standard deviation of the effect of site on log lineal density
sDensityYear	Standard deviation of the effect of year on log lineal density
sDensityYearSite	Standard deviation of the effect of site within year on log lineal density
sEfficiencySession	Standard deviation of the effect of session on log-odds efficiency
sEfficiencyYear	Standard deviation of the effect of year on log-odds efficiency

Model C3: JAGS model definition for the abundance analysis.

```
model {
  sDensityYear ~ dunif(0, 10)
  sDensitySite ~ dunif(0, 10)
  sDensityYearSite ~ dunif(0, 10)
  sEfficiencyYear ~ dunif(0, 10)
  sEfficiencySession ~ dunif(0, 10)
  bDensityIntercept ~ dnorm(0, 5^-2)
  bEfficiencyIntercept ~ dnorm(0, 5^-2)
  for (yr in 1:nYear) {
    bDensityYear[yr] ~ dnorm(0, sDensityYear^-2)
    bEfficiencyYear[yr] ~ dnorm(0, sEfficiencyYear^-2)
    for (st in 1:nSite) {
      bDensityYearSite[yr, st] ~ dnorm(0, sDensityYearSite^-2)
    }
  }
  for (st in 1:nSite) {
    bDensitySite[st] ~ dnorm(0, sDensitySite^-2)
  }
  for (ss in 1:nSession) {
    bEfficiencySession[ss] ~ dnorm(0, sEfficiencySession^-2)
  }
  iRemained ~ dunif(1, nRemained)
  eRemained <- Remained[round(iRemained)]
  for (st in 1:nSingleSite) {
    for (yr in 1:nYear) {
      log(eDensity[st, yr]) <- bDensityIntercept + bDensitySite[st] + bDensityYear[yr] + bDensityYearSite[yr, st]
      eAbundance[st, yr] <- round(eDensity[st, yr] * SiteLength[st])
      eUnmarkedAbundance[st, yr, 1] <- max(eAbundance[st, yr],Fish[st, yr])
      eMarkedAbundance[st, yr, 1] <- 0
      for (ss in 1:nSession) {
        logit(eEfficiency[st, yr, ss]) <- bEfficiencyIntercept + bEfficiencyYear[yr] + bEfficiencySession[ss]
        eSamplingEfficiency[st, yr, ss] <- eEfficiency[st, yr, ss] * ProportionSampled[st, yr, ss]
        eMarkedSamplingEfficiency[st,yr,ss] <- eSamplingEfficiency[st,yr,ss] * eRemained * step(eMarkedAbundance[st,yr,ss]-1)
        Unmarked[st, yr, ss] ~ dbin(eSamplingEfficiency[st, yr, ss], eUnmarkedAbundance[st, yr, ss])
        Marked[st,yr,ss] ~ dbin(eMarkedSamplingEfficiency[st,yr,ss], max(eMarkedAbundance[st,yr,ss],1))
        eMarkedAbundance[st, yr, ss+1] <- eMarkedAbundance[st, yr, ss] + Tagged[st,yr,ss] - DeadMarked[st, yr, ss]
        eUnmarkedAbundance[st,yr,ss+1] <- eUnmarkedAbundance[st,yr,ss] - Tagged[st,yr,ss]
      }
    }
  }
  for(yr in 1:nYear) {
    bPopulation[yr] <- sum(eAbundance[1:nSingleSite,yr])
  }
  for(yr in 1:nYear) {
    eAbundance[92,yr] <- eAbundance[23,yr] + eAbundance[25,yr]
    eAbundance[93,yr] <- eAbundance[22,yr] + eAbundance[24,yr]
    eAbundance[94,yr] <- eAbundance[49,yr] + eAbundance[51,yr]
    eAbundance[95,yr] <- eAbundance[81,yr] + eAbundance[83,yr]
    eAbundance[96,yr] <- eAbundance[82,yr] + eAbundance[84,yr]
    eAbundance[97,yr] <- eAbundance[81,yr] + eAbundance[83,yr] + eAbundance[86,yr]
    eAbundance[98,yr] <- eAbundance[82,yr] + eAbundance[84,yr] + eAbundance[85,yr]
    eAbundance[99,yr] <- eAbundance[87,yr] + eAbundance[88,yr]
    eAbundance[100,yr] <- eAbundance[90,yr] + eAbundance[91,yr]
  }
  for (st in (nSingleSite + 1):nSite) {
    for (yr in 1:nYear) {
      eUnmarkedAbundance[st,yr,1] <- max(eAbundance[st,yr],Fish[st,yr])
      eMarkedAbundance[st,yr,1] <- 0
      for (ss in 1:nSession) {
        logit(eEfficiency[st, yr, ss]) <- bEfficiencyIntercept + bEfficiencyYear[yr] + bEfficiencySession[ss]
        eSamplingEfficiency[st,yr,ss] <- eEfficiency[st, yr, ss] * ProportionSampled[st, yr, ss]
        eMarkedSamplingEfficiency[st,yr,ss] <- eSamplingEfficiency[st,yr,ss] * eRemained * step(eMarkedAbundance[st, yr, ss]-1)
        Unmarked[st, yr, ss] ~ dbin(eSamplingEfficiency[st, yr, ss], eUnmarkedAbundance[st, yr, ss])
        Marked[st, yr, ss] ~ dbin(eMarkedSamplingEfficiency[st, yr, ss], max(eMarkedAbundance[st, yr, ss],1))
        eMarkedAbundance[st,yr,ss+1] <- eMarkedAbundance[st,yr,ss] + Tagged[st,yr,ss] - DeadMarked[st,yr,ss]
        eUnmarkedAbundance[st,yr,ss+1] <- eUnmarkedAbundance[st,yr,ss] - Tagged[st,yr,ss]
      }
    }
  }
}
```

COUNT

Table C9: The variables in the count analysis.

Variable	Description
Count[i]	The i^{th} count
ProportionSampled[i]	Proportion of the site surveyed when the i^{th} count was made
Session[i]	Session the i^{th} count was made in
Site[i]	Site the i^{th} count was made at
SiteLength[i]	Length of the site at which the i^{th} count was made
Year[i]	Year the i^{th} count was made

Table C10: The parameters in the count analysis.

Parameter	Description
bIntercept	Log lineal apparent density
bSite[st]	Effect of the st^{th} site on the log lineal apparent density
bYear[yr]	Effect of the yr^{th} year on the log lineal apparent density
bYearSite[yr,st]	Effect of the st^{th} site in the yr^{th} year on the log lineal apparent density count
eCount[i]	Expected i^{th} count
eLogDensity[i]	Expected log lineal apparent density for that site in that year
eSessionDensity[i]	Expected lineal apparent density for that session at that site in that year
sSite	Standard deviation of the effect of site on the log lineal apparent density
sYear	Standard deviation of the effect of year on the log lineal apparent density
sYearSite	Standard deviation of the effect of site within year on the log lineal apparent density
sYearSiteSession	Standard deviation of the effect of session within site within year on the log lineal apparent density

Model C4: JAGS model definition for the count analysis.

```
model {
 sYear ~ dunif(0, 10)
 sSite ~ dunif(0, 10)
 sYearSite ~ dunif(0, 10)
 sYearSiteSession ~ dunif(0, 10)
 bIntercept ~ dnorm(0, 10^-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(st in 1:nSite) {
  bSite[st] ~ dnorm(0, sSite^-2)
 }
 for (i in 1:nrow) {
  eLogDensity[i] <- bIntercept + bYear[Year[i]] + bSite[Site[i]] + bYearSite[Year[i], Site[i]]
  eSessionDensity[i] ~ dlnorm(eLogDensity[i], sYearSiteSession^-2)
  eCount[i] <- eSessionDensity[i] * SiteLength[i] * ProportionSampled[i]
  Count[i] ~ dpois(eCount[i])
 }
}
```

GROWTH

Table C11: Variables in the growth analysis.

Variable	Description
Growth[i]	Change in length of the ith fish from the previous year
LengthAtRelease[i]	Length of the ith fish when released the previous year
TagType[i]	Tag type of the ith fish when released the previous year
Year[i]	Year the ith fish was released

Table C12: Parameters in the growth analysis.

Parameter	Description
bTagType[tt]	Effect of ttth tagtype on the mean maximum length
bYear[yr]	Effect of the yrth year on the mean maximum length
eGrowth[i]	Expected change in length of the ith fish from the previous year
k	Von Bertalanffy growth rate coefficient
Linf	Mean maximum length (length-at-infinity)
sGrowth	Standard deviation of the residual variation in change in length from the previous year
sYear	Standard deviation of the effect of year on the mean maximum length

Model C5: JAGS model definition for the growth analysis.

```
model {
 sGrowth ~ dunif(0, 100)
 sYear ~ dunif (0, 100)
 k ~ dunif (0, 1)
 Linf ~ dunif(100, 1000)
 bTagType[1] <- 0
 for(tt in 2:nTagType) {
  bTagType[tt] ~ dnorm (0, 100)
 }
 for (yr in 1:nYear) {
  bYear[yr] ~ dnorm(0, sYear^-2)
 }
 for (i in 1:nrow) {
  eGrowth[i] <- (Linf + bYear[Year[i]] + bTagType[TagType[i]] - LengthAtRelease[i]) * (1-exp(-k))
  Growth[i] ~ dnorm(eGrowth[i], sGrowth^-2)
 }
}
```

SURVIVAL

Table C13: Variables in the survival analysis.

Variable	Description
FishYear[i,yr]	Whether or not the ith fish was encountered in the yrth year
FirstYear[i]	The first year the ith fish was encountered
StageFishYear[i,yr]	The stage of the ith fish in the yrth year
Stage[i]	The stage of the ith fish when first encountered

Table C14: Parameters in the survival analysis.

Parameter	Description
bEfficiencyIntercept	Log-odds efficiency
bEfficiencyYear[yr]	Effect of the yrth year on the log-odds efficiency
bSurvivalInterceptStage[sg]	Log-odds survival of the sgth stage
bSurvivalStageYear[sg, yr]	Effect of the yrth year on the log-odds survival of the sgth stage
eAlive[i, yr]	Wether or not the ith fish is expected to be alive in the yrth year
eEfficiency[i, yr]	Expected probability of recapture of the ith fish in the yrth year
eSurvival[i, yr-1]	Expected probability of survival of the ith fish from the yr-1th to yrth year
sEfficiencyYear	Standard deviation of the effect of year on the log-odds efficiency
sSurvivalStageYear[sg]	Standard deviation of the effect of year on the log-odds survival of the sgth stage

Model C6: JAGS model definition for the survival analysis.

```
model {
  sEfficiencyYear ~ dunif(0, 5)
  for (sg in 1:nStage) {
    sSurvivalStageYear[sg] ~ dunif (0, 5)
  }
  bEfficiencyIntercept ~ dnorm (0, 5^-2)
  for (yr in 1:nYear) {
    bEfficiencyYear[yr] ~ dnorm(0, sEfficiencyYear^-2)
  }
  for(sg in 1:nStage) {
    bSurvivalInterceptStage[sg] ~ dnorm(0, 5^-2)
    for (yr in 1:nYear) {
      bSurvivalStageYear[sg, yr] ~ dnorm (0, sSurvivalStageYear[yr]^-2)
    }
  }
  for (i in 1:nFish) {
    eAlive[i, FirstYear[i]] <- 1
    for (yr in (FirstYear[i]+1):nYear) {
    logit(eSurvival[i, yr-1]) <- bSurvivalInterceptStage[StageFishYear[i,yr-1]] + bSurvivalStageYear[StageFishYear[i,yr-1],j-1]
      eAlive[i, yr] ~ dbern (eAlive[i, yr-1] * eSurvival[i, yr-1])
      logit(eEfficiency[i, yr]) <- bEfficiencyIntercept + bEfficiencyYear[yr]
      FishYear[i, yr] ~ dbern (eAlive[i, yr] * eEfficiency[i, yr])
    }
  }
}
```

CONDITION

Table C15: Variables in the condition analysis.

Variable	Description
Date[i]	Day of the year the ith fish was encountered
LogLength[i]	Log length of the ith fish
Section[i]	Section the ith fish was encountered in
Site[i]	Site the ith fish was encountered in
TagType[i]	Tagtype of the ith fish
Weight[i]	Weight of the ith fish
Year[i]	Year the ith fish was encountered

Table C16: Parameters in the condition analysis.

Parameter	Description
bDateSection[sc]	Effect of date in the scth section on the log weight
bDate2Section[sc]	Effect of second-order polynomial of date in the scth section on the log weight
bIntercept	Log weight
bLength	Effect of length on the log weight
bSection[sc]	Effect of the scth section on the log weight
bTagType[tt]	Effect of the ttth tag type on the log weight
bYear[yr]	Effect of the yrth year on the log weight
bYearSite[yr,st]	Effect of the yrth year and stth site on the log weight
eLogWeight[i]	Expected log weight of the ith fish
sWeight	Standard deviation of the residual variation in the log weight
sYear	Standard deviation of the effect of year on the log weight
sYearSite	Standard deviation of the effect of site within year on the log weight

Model C7: JAGS model definition for the condition analysis.

```
model {
  sWeight ~ dunif(0, 5)
  sYear ~ dunif(0, 5)
  sYearSite ~ dunif(0, 5)
  bIntercept ~ dnorm(5, 5^-2)
  bLength ~ dnorm(0, 5^-2)
  for(yr in 1:nYear) {
    bYear[yr] ~ dnorm(0, sYear^-2)
    for(st in 1:nSite) {
      bYearSite[yr, st] ~ dnorm(0, sYearSite^-2)
    }
  }
  bSection[1] <- 0
  bDateSection[1] ~ dnorm(0, 5^-2)
  bDate2Section[1] ~ dnorm(0, 5^-2)
  for(sc in 2:nSection) {
    bSection[sc] ~ dnorm(0, 5^-2)
    bDateSection[sc] ~ dnorm(0, 5^-2)
    bDate2Section[sc] ~ dnorm(0, 5^-2)
  }
  bTagType[1] <- 0
  for(tt in 2:nTagType) {
    bTagType[tt] ~ dnorm(0, 5^-2)
  }
  for(i in 1:nrow){
    eLogWeight[i] <- bIntercept + bLength*LogLength[i] + bTagType[TagType[i]] + bDateSection[Section[i]]*Date[i] + bDate2Section[Section[i]]*Date[i]^2 + bYear[Year[i]] + bSection[Section[i]] + bYearSite[Year[i],Site[i]]
    Weight[i] ~ dlnorm(eLogWeight[i], sWeight^-2)
  }
}
```

JAGS implements a dialect of the BUGS modelling language. Consequently, the following model code should, in general, be interpretable by WinBUGS or OpenBUGS after a few minor modifications. For addition information see the JAGS Version 3.1.0 user manual (Plummer 2011) which is available at http://sourceforge.net/projects/mcmc-jags/files/Manuals/3.x/.

JAGS distributions used in the Bayesian analyses are listed in Table C1. It is important to note that following the Bayesian convention, JAGS distributions are defined in terms of their precision, as opposed to their standard deviation. As the precision is the inverse of the variance, the precision can be calculated by raising the standard deviation to the power of -2. The JAGS functions (Plummer 2011) used in the Bayesian analyses are listed in Table C2.

Table C1: Distributions in the Bayesian models.

JAGS Code	Distribution
dbern(p)	Bernoulli distribution where p is the probability
dbin(p,n)	Binomial distribution where p is the probability and n is the sample size
dlnorm(mu,tau)	Log-normal distribution where mu is the mean and tau is the precision
dnorm(mu,tau)	Normal distribution where mu is the mean and tau is the precision
dpois(lambda)	Poisson distribution where lambda is the mean count
dunif(a,b)	Uniform distribution where a is the lower limit and b is the upper limit

Table C2: Functions in the Bayesian models.

JAGS Code	Function
exp(x)	Exponential of x
log(x)	Natural logarithm of x
logit(p)	Log-odds of p
max(x,y)	Greater of x or y
sum(x)	Sum of values in x
x^y	Power where x is raised to the power of y
1:n	Vector of integers from 1 to n
x[1:n]	Subset of first n values in x

SIZE-AT-AGE

Table C3: Variables in the size-at-age analysis.

Variable	Description
Year[i]	Year the i^{th} fish was observed
Date[i]	Date the i^{th} fish was observed
Length[i]	Length of the i^{th} fish

Table C4: Parameters in the size-at-age analysis.

Parameter	Description
bAgeYear[ag,yr]	Effect of the yr^{th} year on the length of an ag^{th} age fish
bDate[ag]	Effect of date on the length of an ag^{th} age fish
bDate2[ag]	Effect of the second order polynomial of date on the length of an a^{th} age fish
bIncrement[ag]	Length difference between an ag^{th} age fish and an $ag\text{-}1^{th}$ age fish
bIntercept[ag]	Length of an ag^{th} age fish
eAge[i]	Expected age of the i^{th} fish
eLength[i]	Expected length of the i^{th} fish
pAge[ag]	Proportion of the fish belonging to the ag^{th} age
sLengthAge[ag]	Standard deviation of the residual variation in the length of fish belong to the ag^{th} age
sAgeYear[ag]	Standard deviation of the effect of year on the length of fish belong to the ag^{th} age

Model C1: JAGS model definition for the size-at-age analysis.

```
model {
 for(ag in 1:nAge)  {
   dAge[ag] <- 1
   sLengthAge[ag] ~ dunif(0, 100)
   sAgeYear[ag] ~ dunif(0, 50)
   bIncrement[ag] ~ dunif(50, 250)
   bDate[ag] ~ dnorm(0, 10)
   bDate2[ag] ~ dnorm(0, 10)
   for(yr in 1:nYear) {
     bAgeYear[ag, yr] ~ dnorm(0, sAgeYear[i]^-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]] + bDate[Age[i]]*Date[i] + bDate2[Age[i]]*Date[i]^2
   Length[i] ~ dnorm(eLength[i], sLengthAge[Age[i]]^-2)
 }
```

MOVEMENT

Table C5: Variables in the movement analysis.

Variable	Description
Days[i]	Days since the i^{th} recapture was previously encountered
Remained[i]	Whether or not the i^{th} recapture was recorded at the same site as previously encountered

Table C6: Parameters in the movement analysis.

Parameter	Description
bDays	Effect of days since last encounter on the log-odds of the probability of recapture at the same site
bIntercept	Log-odds of the probability of recapture at the same site
eRemained[i]	Expected probability of the i^{th} recapture being caught at the same site as previously

Model C2: JAGS model definition for the movement analysis.

```
model {
  bIntercept ~ dnorm(0, 5^-2)
  bDays ~ dnorm(0, 5^-2)
  for (i in 1:nrow)  {
    logit(eRemained[i]) <- bIntercept + bDays * Days[i]
    Remained[i] ~ dbern(eRemained[i])
  }
}
```

ABUNDANCE

Table C7: The variables in the abundance analysis.

Variable	Description
DeadMarked[st,yr,ss]	Number of marked mortalities at the stth site in the yrth year during the ssth session
Fish[st,yr]	Minimum abundance at the stth site in the yrth year based on the number of fish caught
Marked[st,yr,ss]	Number of marked fish caught at the stth site in the yrth year in the ssth session
ProportionSampled[st,yr,ss]	Proportion of the stth site sampled in the ssth session of the yrth year
SiteLength[st]	Length of the stth site
Tagged[st,yr,ss]	Number of fish tagged at the stth site in the yrth year in the ssth session
Unmarked[st,yr,ss]	Number of unmarked fish caught at the stth site in the yrth year in the ssth session

Table C8: The parameters in the abundance analysis.

Parameter	Description
bDensityIntercept	Log lineal density
bDensitySite[st]	Effect of the stth site on the log lineal density
bDensityYear[yr]	Effect of the yrth year on the log lineal density
bDensityYearSite[yr,st]	Effect of the stth site in the yrth year on the log lineal density
bEfficiencyIntercept	Log-odds efficiency
bEfficiencySession[ss]	Effect of the ssth session on the log-odds efficiency
bEfficiencyYear[yr]	Effect of the yrth year on the log-odds efficiency
bPopulation[yr]	Population abundance in the yrth year
eAbundance	Expected abundance at the stth site in the yrth year
eDensity[st,yr]	Expected lineal density at the stth site in the yrth year
eEfficiency[st,yr,ss]	Expected efficiency at the stth site in the yrth year during the ssth session
eEfficiencySampling[st,yr,ss]	Expected efficiency at the stth site in the yrth year during the ssth session given the proportion sampled
eMarkedAbundance[st,yr,ss]	Expected abundance of marked fish at the stth site in the ssth year prior to the ssth session
eMarkedSamplingEfficiency[st,yr,ss]	Expected recapture efficiency at the stth site in the ssth year during the ssth session
eRemained	Expected proportion of the marked fish remaining at the site based on the movement analysis
eUnmarkedAbundance[st,yr,ss]	Expected abundance of unmarked fish at the stth site in the ssth year prior to the ssth session
sDensitySite	Standard deviation of the effect of site on log lineal density
sDensityYear	Standard deviation of the effect of year on log lineal density
sDensityYearSite	Standard deviation of the effect of site within year on log lineal density
sEfficiencySession	Standard deviation of the effect of session on log-odds efficiency
sEfficiencyYear	Standard deviation of the effect of year on log-odds efficiency

Model C3: JAGS model definition for the abundance analysis.

```
model {
  sDensityYear ~ dunif(0, 10)
  sDensitySite ~ dunif(0, 10)
  sDensityYearSite ~ dunif(0, 10)
  sEfficiencyYear ~ dunif(0, 10)
  sEfficiencySession ~ dunif(0, 10)
  bDensityIntercept ~ dnorm(0, 5^-2)
  bEfficiencyIntercept ~ dnorm(0, 5^-2)
  for (yr in 1:nYear) {
    bDensityYear[yr] ~ dnorm(0, sDensityYear^-2)
    bEfficiencyYear[yr] ~ dnorm(0, sEfficiencyYear^-2)
    for (st in 1:nSite) {
      bDensityYearSite[yr, st] ~ dnorm(0, sDensityYearSite^-2)
    }
  }
  for (st in 1:nSite) {
    bDensitySite[st] ~ dnorm(0, sDensitySite^-2)
  }
  for (ss in 1:nSession) {
    bEfficiencySession[ss] ~ dnorm(0, sEfficiencySession^-2)
  }
  iRemained ~ dunif(1, nRemained)
  eRemained <- Remained[round(iRemained)]
  for (st in 1:nSingleSite) {
    for (yr in 1:nYear) {
      log(eDensity[st, yr]) <- bDensityIntercept + bDensitySite[st] + bDensityYear[yr] + bDensityYearSite[yr, st]
      eAbundance[st, yr] <- round(eDensity[st, yr] * SiteLength[st])
      eUnmarkedAbundance[st, yr, 1] <- max(eAbundance[st, yr],Fish[st, yr])
      eMarkedAbundance[st, yr, 1] <- 0
      for (ss in 1:nSession) {
        logit(eEfficiency[st, yr, ss]) <- bEfficiencyIntercept + bEfficiencyYear[yr] + bEfficiencySession[ss]
        eSamplingEfficiency[st, yr, ss] <- eEfficiency[st, yr, ss] * ProportionSampled[st, yr, ss]
        eMarkedSamplingEfficiency[st,yr,ss] <- eSamplingEfficiency[st,yr,ss] * eRemained * step(eMarkedAbundance[st,yr,ss]-1)
        Unmarked[st, yr, ss] ~ dbin(eSamplingEfficiency[st, yr, ss], eUnmarkedAbundance[st, yr, ss])
        Marked[st,yr,ss] ~ dbin(eMarkedSamplingEfficiency[st,yr,ss], max(eMarkedAbundance[st,yr,ss],1))
        eMarkedAbundance[st, yr, ss+1] <- eMarkedAbundance[st, yr, ss] + Tagged[st,yr,ss] - DeadMarked[st, yr, ss]
        eUnmarkedAbundance[st,yr,ss+1] <- eUnmarkedAbundance[st,yr,ss] - Tagged[st,yr,ss]
      }
    }
  }
  for(yr in 1:nYear) {
    bPopulation[yr] <- sum(eAbundance[1:nSingleSite,yr])
  }
  for(yr in 1:nYear) {
    eAbundance[92,yr] <- eAbundance[23,yr] + eAbundance[25,yr]
    eAbundance[93,yr] <- eAbundance[22,yr] + eAbundance[24,yr]
    eAbundance[94,yr] <- eAbundance[49,yr] + eAbundance[51,yr]
    eAbundance[95,yr] <- eAbundance[81,yr] + eAbundance[83,yr]
    eAbundance[96,yr] <- eAbundance[82,yr] + eAbundance[84,yr]
    eAbundance[97,yr] <- eAbundance[81,yr] + eAbundance[83,yr] + eAbundance[86,yr]
    eAbundance[98,yr] <- eAbundance[82,yr] + eAbundance[84,yr] + eAbundance[85,yr]
    eAbundance[99,yr] <- eAbundance[87,yr] + eAbundance[88,yr]
    eAbundance[100,yr] <- eAbundance[90,yr] + eAbundance[91,yr]
  }
  for (st in (nSingleSite + 1):nSite) {
    for (yr in 1:nYear) {
      eUnmarkedAbundance[st,yr,1] <- max(eAbundance[st,yr],Fish[st,yr])
      eMarkedAbundance[st,yr,1] <- 0
      for (ss in 1:nSession) {
        logit(eEfficiency[st, yr, ss]) <- bEfficiencyIntercept + bEfficiencyYear[yr] + bEfficiencySession[ss]
        eSamplingEfficiency[st,yr,ss] <- eEfficiency[st, yr, ss] * ProportionSampled[st, yr, ss]
        eMarkedSamplingEfficiency[st,yr,ss] <- eSamplingEfficiency[st,yr,ss] * eRemained * step(eMarkedAbundance[st, yr, ss]-1)
        Unmarked[st, yr, ss] ~ dbin(eSamplingEfficiency[st, yr, ss], eUnmarkedAbundance[st, yr, ss])
        Marked[st, yr, ss] ~ dbin(eMarkedSamplingEfficiency[st, yr, ss], max(eMarkedAbundance[st, yr, ss],1))
        eMarkedAbundance[st,yr,ss+1] <- eMarkedAbundance[st,yr,ss] + Tagged[st,yr,ss] - DeadMarked[st,yr,ss]
        eUnmarkedAbundance[st,yr,ss+1] <- eUnmarkedAbundance[st,yr,ss] - Tagged[st,yr,ss]
      }
    }
  }
}
```

COUNT

Table C9: The variables in the count analysis.

Variable	Description
Count[i]	The i^{th} count
ProportionSampled[i]	Proportion of the site surveyed when the i^{th} count was made
Session[i]	Session the i^{th} count was made in
Site[i]	Site the i^{th} count was made at
SiteLength[i]	Length of the site at which the i^{th} count was made
Year[i]	Year the i^{th} count was made

Table C10: The parameters in the count analysis.

Parameter	Description
bIntercept	Log lineal apparent density
bSite[st]	Effect of the st^{th} site on the log lineal apparent density
bYear[yr]	Effect of the yr^{th} year on the log lineal apparent density
bYearSite[yr,st]	Effect of the st^{th} site in the yr^{th} year on the log lineal apparent density count
eCount[i]	Expected i^{th} count
eLogDensity[i]	Expected log lineal apparent density for that site in that year
eSessionDensity[i]	Expected lineal apparent density for that session at that site in that year
sSite	Standard deviation of the effect of site on the log lineal apparent density
sYear	Standard deviation of the effect of year on the log lineal apparent density
sYearSite	Standard deviation of the effect of site within year on the log lineal apparent density
sYearSiteSession	Standard deviation of the effect of session within site within year on the log lineal apparent density

Model C4: JAGS model definition for the count analysis.

```
model {
 sYear ~ dunif(0, 10)
 sSite ~ dunif(0, 10)
 sYearSite ~ dunif(0, 10)
 sYearSiteSession ~ dunif(0, 10)
 bIntercept ~ dnorm(0, 10^-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(st in 1:nSite) {
   bSite[st] ~ dnorm(0, sSite^-2)
 }
 for (i in 1:nrow) {
   eLogDensity[i] <- bIntercept + bYear[Year[i]] + bSite[Site[i]] + bYearSite[Year[i], Site[i]]
   eSessionDensity[i] ~ dlnorm(eLogDensity[i], sYearSiteSession^-2)
   eCount[i] <- eSessionDensity[i] * SiteLength[i] * ProportionSampled[i]
   Count[i] ~ dpois(eCount[i])
 }
}
```

GROWTH

Table C11: Variables in the growth analysis.

Variable	Description
Growth[i]	Change in length of the i^{th} fish from the previous year
LengthAtRelease[i]	Length of the i^{th} fish when released the previous year
TagType[i]	Tag type of the i^{th} fish when released the previous year
Year[i]	Year the i^{th} fish was released

Table C12: Parameters in the growth analysis.

Parameter	Description
bTagType[tt]	Effect of tt^{th} tagtype on the mean maximum length
bYear[yr]	Effect of the yr^{th} year on the mean maximum length
eGrowth[i]	Expected change in length of the i^{th} fish from the previous year
k	Von Bertalanffy growth rate coefficient
Linf	Mean maximum length (length-at-infinity)
sGrowth	Standard deviation of the residual variation in change in length from the previous year
sYear	Standard deviation of the effect of year on the mean maximum length

Model C5: JAGS model definition for the growth analysis.

```
model {
  sGrowth ~ dunif(0, 100)
  sYear ~ dunif (0, 100)
  k ~ dunif (0, 1)
  Linf ~ dunif(100, 1000)
  bTagType[1] <- 0
  for(tt in 2:nTagType) {
    bTagType[tt] ~ dnorm (0, 100)
  }
  for (yr in 1:nYear) {
    bYear[yr] ~ dnorm(0, sYear^-2)
  }
  for (i in 1:nrow) {
    eGrowth[i] <- (Linf + bYear[Year[i]] + bTagType[TagType[i]] - LengthAtRelease[i]) * (1-exp(-k))
    Growth[i] ~ dnorm(eGrowth[i], sGrowth^-2)
  }
}
```

SURVIVAL

Table C13: Variables in the survival analysis.

Variable	Description
FishYear[i,yr]	Whether or not the i^{th} fish was encountered in the yr^{th} year
FirstYear[i]	The first year the i^{th} fish was encountered
StageFishYear[i,yr]	The stage of the i^{th} fish in the yr^{th} year
Stage[i]	The stage of the i^{th} fish when first encountered

Table C14: Parameters in the survival analysis.

Parameter	Description
bEfficiencyIntercept	Log-odds efficiency
bEfficiencyYear[yr]	Effect of the yr^{th} year on the log-odds efficiency
bSurvivalInterceptStage[sg]	Log-odds survival of the sg^{th} stage
bSurvivalStageYear[sg, yr]	Effect of the yr^{th} year on the log-odds survival of the sg^{th} stage
eAlive[i, yr]	Wether or not the i^{th} fish is expected to be alive in the yr^{th} year
eEfficiency[i, yr]	Expected probability of recapture of the i^{th} fish in the yr^{th} year
eSurvival[i, yr-1]	Expected probability of survival of the i^{th} fish from the $yr\text{-}1^{th}$ to yr^{th} year
sEfficiencyYear	Standard deviation of the effect of year on the log-odds efficiency
sSurvivalStageYear[sg]	Standard deviation of the effect of year on the log-odds survival of the sg^{th} stage

Model C6: JAGS model definition for the survival analysis.

```
model {
  sEfficiencyYear ~ dunif(0, 5)
  for (sg in 1:nStage) {
    sSurvivalStageYear[sg] ~ dunif (0, 5)
  }
  bEfficiencyIntercept ~ dnorm (0, 5^-2)
  for (yr in 1:nYear) {
    bEfficiencyYear[yr] ~ dnorm(0, sEfficiencyYear^-2)
  }
  for(sg in 1:nStage) {
    bSurvivalInterceptStage[sg] ~ dnorm(0, 5^-2)
    for (yr in 1:nYear) {
      bSurvivalStageYear[sg, yr] ~ dnorm (0, sSurvivalStageYear[yr]^-2)
    }
  }
  for (i in 1:nFish) {
    eAlive[i, FirstYear[i]] <- 1
    for (yr in (FirstYear[i]+1):nYear) {
    logit(eSurvival[i, yr-1]) <- bSurvivalInterceptStage[StageFishYear[i,yr-1]] + bSurvivalStageYear[StageFishYear[i,yr-1],j-1]
      eAlive[i, yr] ~ dbern (eAlive[i, yr-1] * eSurvival[i, yr-1])
      logit(eEfficiency[i, yr]) <- bEfficiencyIntercept + bEfficiencyYear[yr]
      FishYear[i, yr] ~ dbern (eAlive[i, yr] * eEfficiency[i, yr])
    }
  }
}
```

CONDITION

Table C15: Variables in the condition analysis.

Variable	Description
Date[i]	Day of the year the i^{th} fish was encountered
LogLength[i]	Log length of the i^{th} fish
Section[i]	Section the i^{th} fish was encountered in
Site[i]	Site the i^{th} fish was encountered in
TagType[i]	Tagtype of the i^{th} fish
Weight[i]	Weight of the i^{th} fish
Year[i]	Year the i^{th} fish was encountered

Table C16: Parameters in the condition analysis.

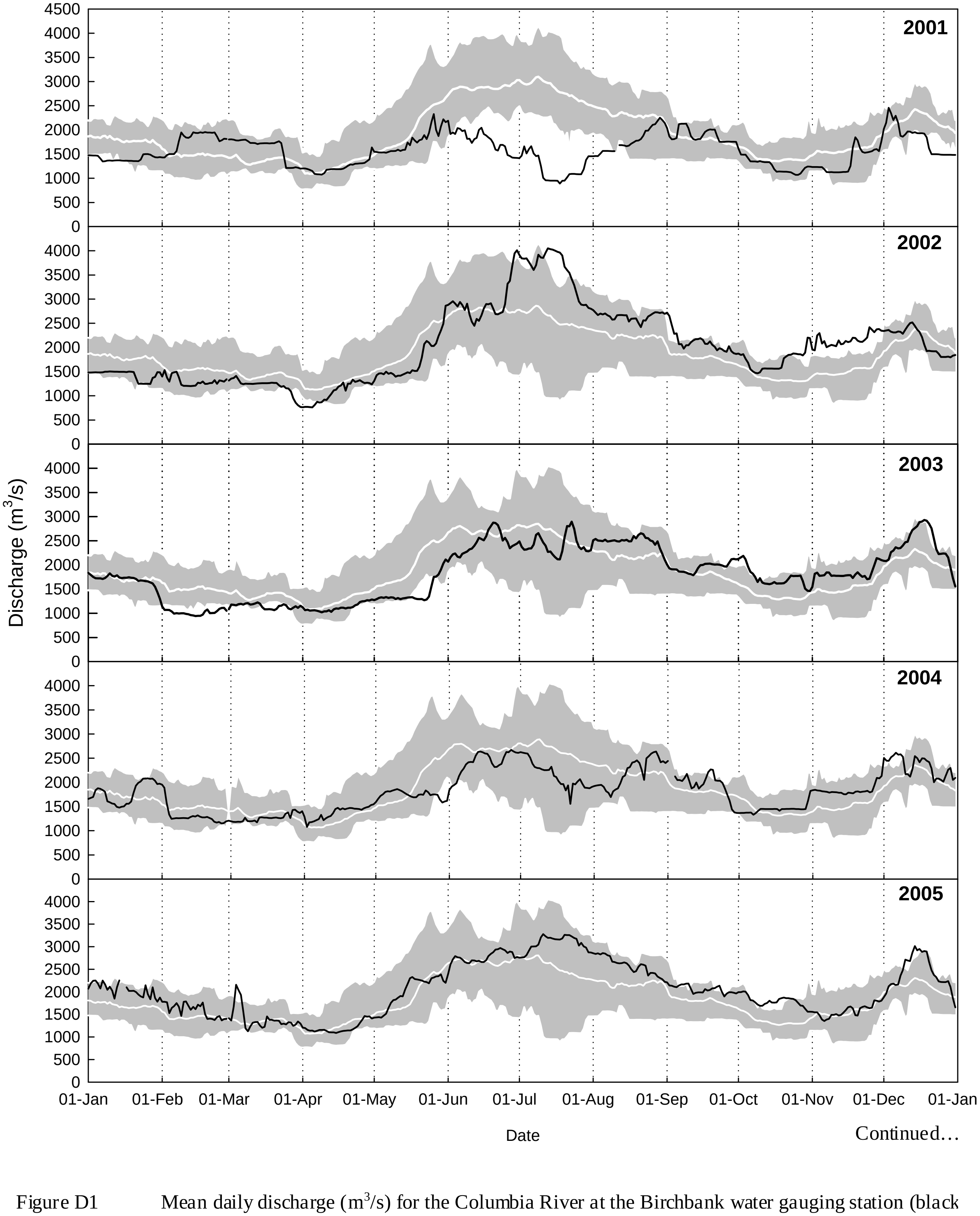
Parameter	Description
bDateSection[sc]	Effect of date in the sc^{th} section on the log weight
bDate2Section[sc]	Effect of second-order polynomial of date in the sc^{th} section on the log weight
bIntercept	Log weight
bLength	Effect of length on the log weight
bSection[sc]	Effect of the sc^{th} section on the log weight
bTagType[tt]	Effect of the tt^{th} tag type on the log weight
bYear[yr]	Effect of the yr^{th} year on the log weight
bYearSite[yr,st]	Effect of the yr^{th} year and st^{th} site on the log weight
eLogWeight[i]	Expected log weight of the i^{th} fish
sWeight	Standard deviation of the residual variation in the log weight
sYear	Standard deviation of the effect of year on the log weight
sYearSite	Standard deviation of the effect of site within year on the log weight

Model C7: JAGS model definition for the condition analysis.

```
model {
  sWeight ~ dunif(0, 5)
  sYear ~ dunif(0, 5)
  sYearSite ~ dunif(0, 5)
  bIntercept ~ dnorm(5, 5^-2)
  bLength ~ dnorm(0, 5^-2)
  for(yr in 1:nYear) {
    bYear[yr] ~ dnorm(0, sYear^-2)
    for(st in 1:nSite) {
      bYearSite[yr, st] ~ dnorm(0, sYearSite^-2)
    }
  }
  bSection[1] <- 0
  bDateSection[1] ~ dnorm(0, 5^-2)
  bDate2Section[1] ~ dnorm(0, 5^-2)
  for(sc in 2:nSection) {
    bSection[sc] ~ dnorm(0, 5^-2)
    bDateSection[sc] ~ dnorm(0, 5^-2)
    bDate2Section[sc] ~ dnorm(0, 5^-2)
  }
  bTagType[1] <- 0
  for(tt in 2:nTagType) {
    bTagType[tt] ~ dnorm(0, 5^-2)
  }
  for(i in 1:nrow){
    eLogWeight[i] <- bIntercept + bLength*LogLength[i] + bTagType[TagType[i]] + bDateSection[Section[i]]*Date[i] +
bDate2Section[Section[i]]*Date[i]^2 + bYear[Year[i]] + bSection[Section[i]] + bYearSite[Year[i],Site[i]]
    Weight[i] ~ dlnorm(eLogWeight[i], sWeight^-2)
  }
}
```

APPENDIX D

Discharge and Temperature Data



Continued…

Figure D1 Mean daily discharge (m^3/s) for the Columbia River at the Birchbank water gauging station (black line), 2001 to 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at Birchbank during other study years (between 2001 and 2011). The white line represents average mean daily discharge values over the same time period.

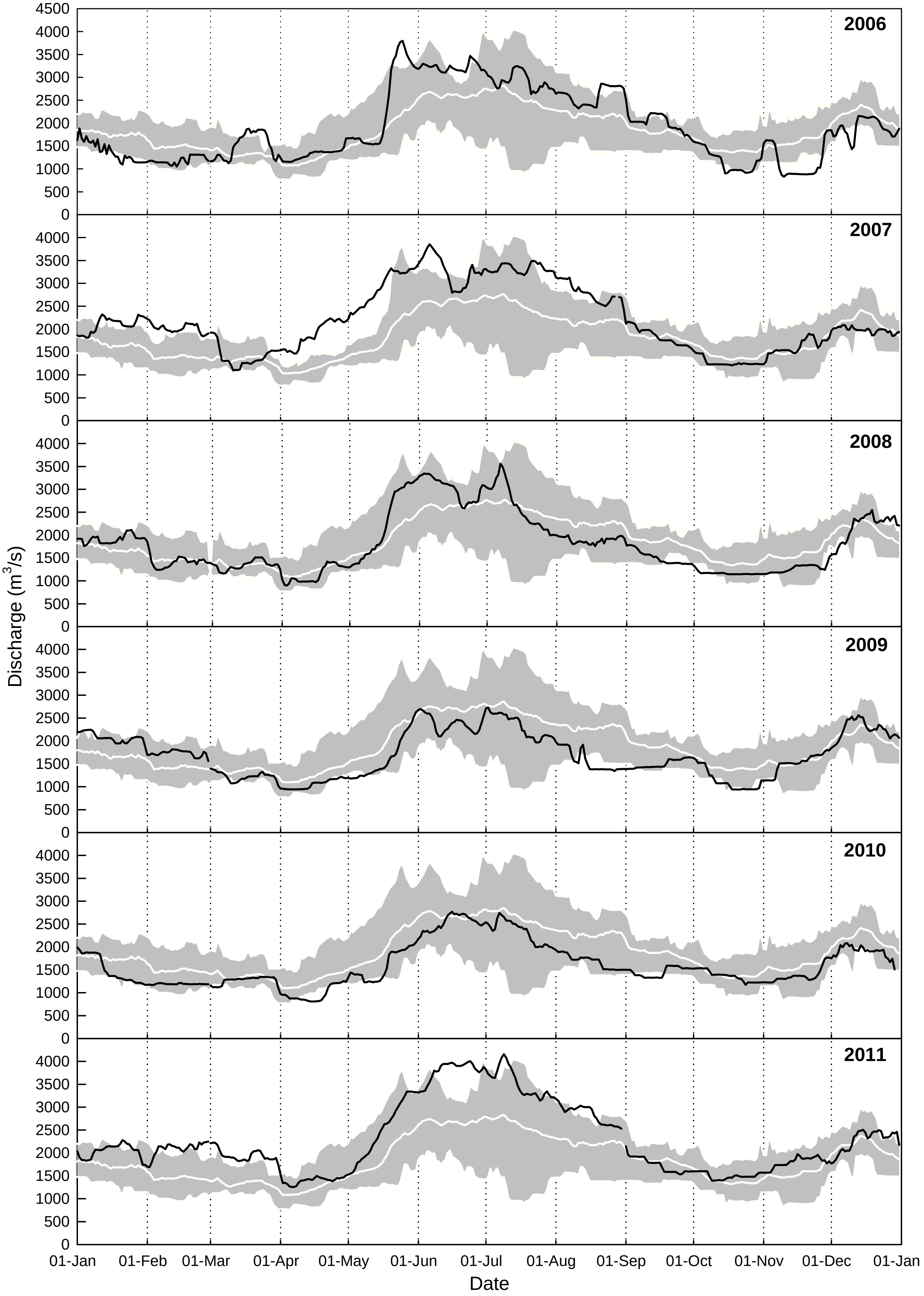


Figure D1 Concluded.

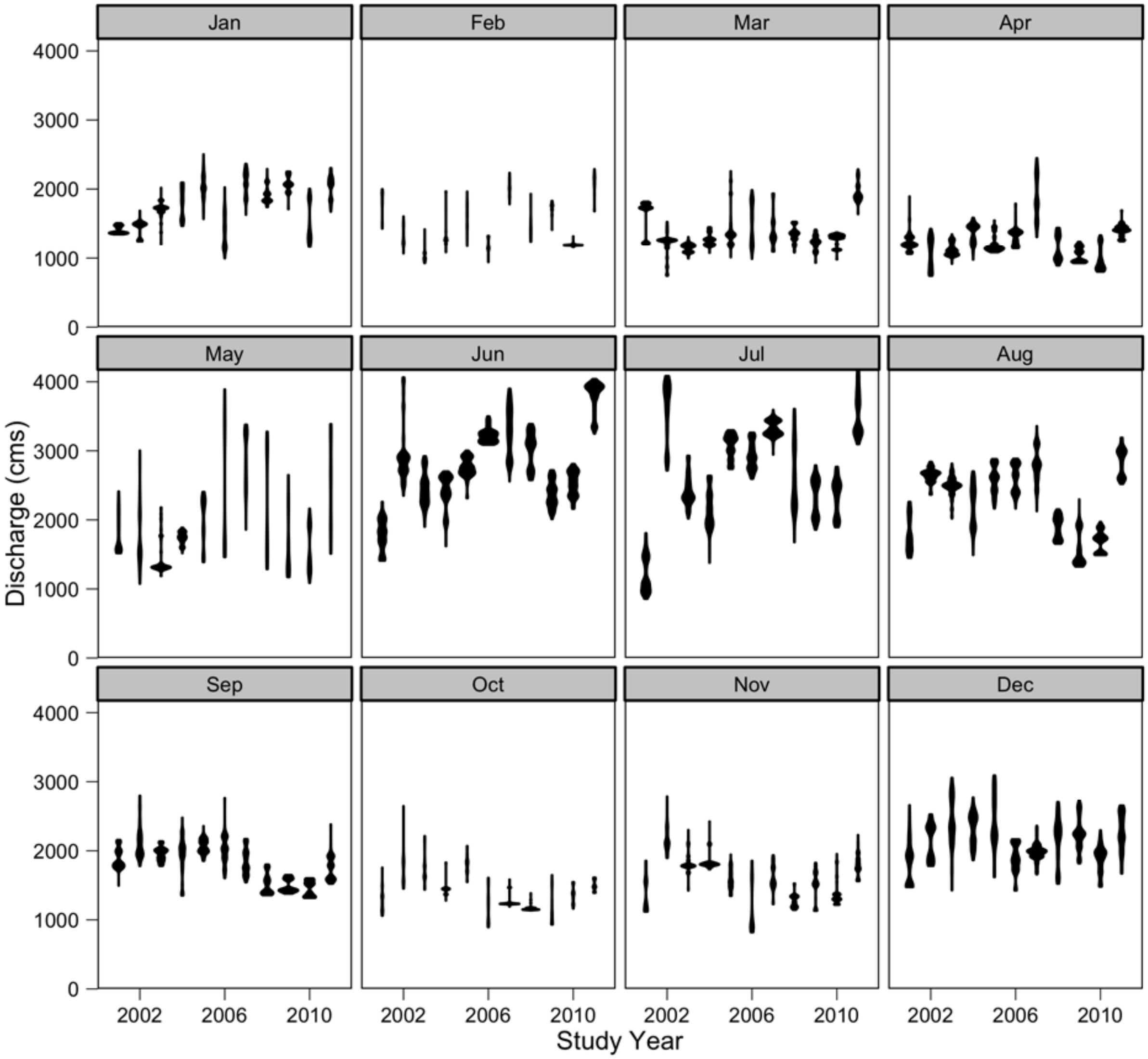
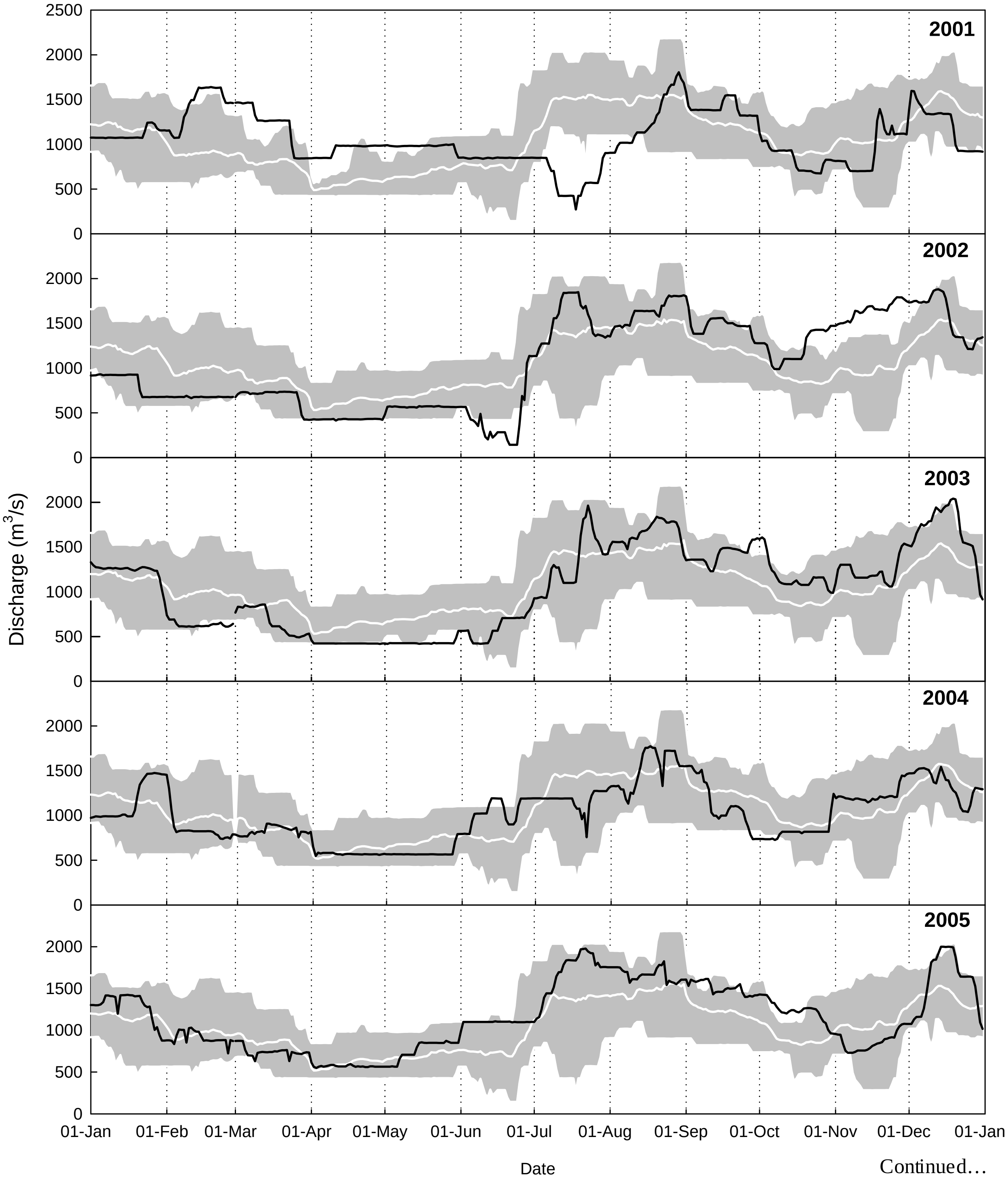


Figure D2 Hourly variability in discharge (m^3/s) by month for the Columbia River at the Birchbank water gauging station, 2001 to 2011.



Continued…

Figure D3 Mean daily discharge (m^3/s) for the Columbia River at Hugh L. Keenleyside Dam (HLK), 2001 to 2011 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at the dam during other study years (between 2001 and 2011). The white line represents average mean daily discharge values over the same time period.

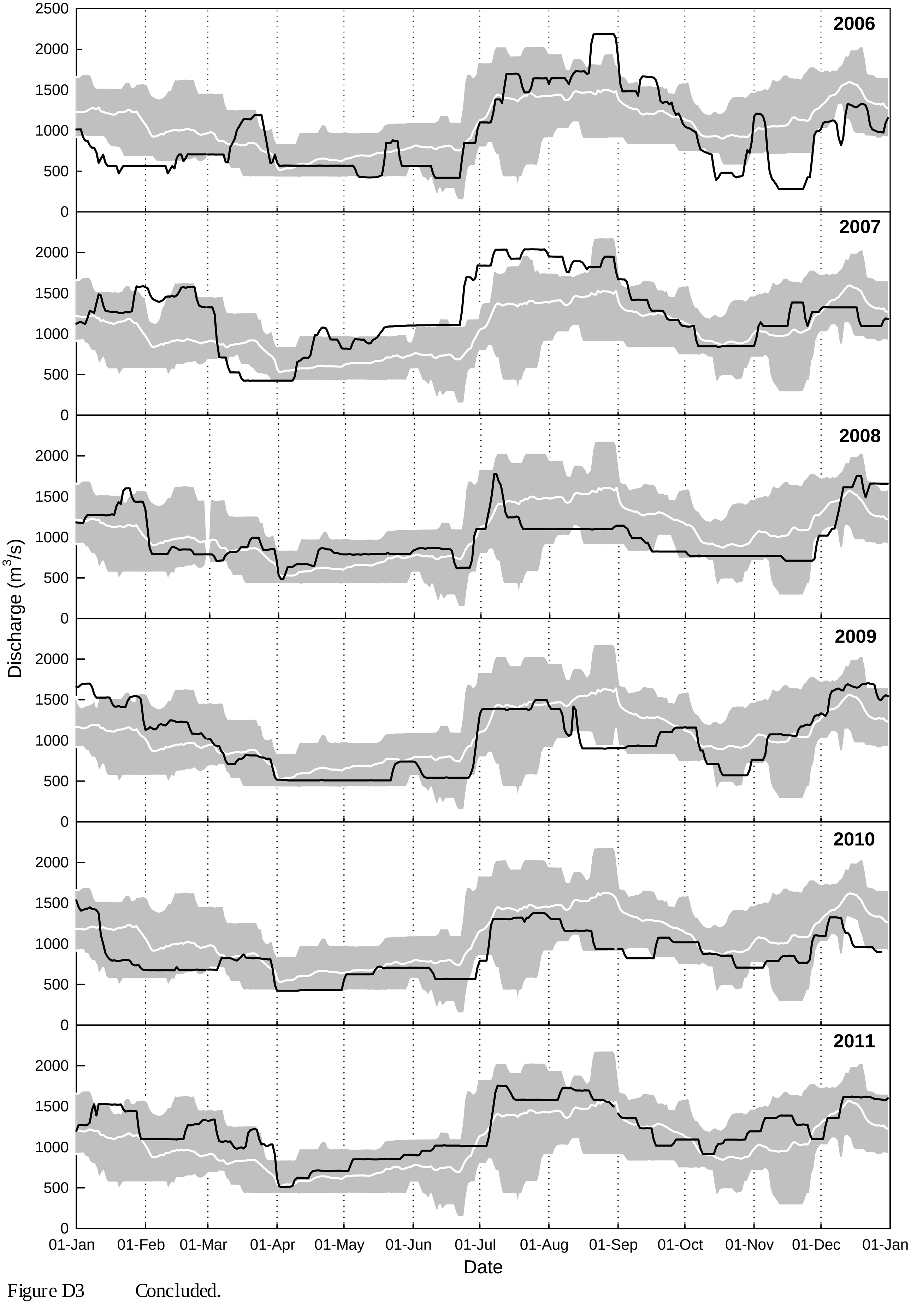
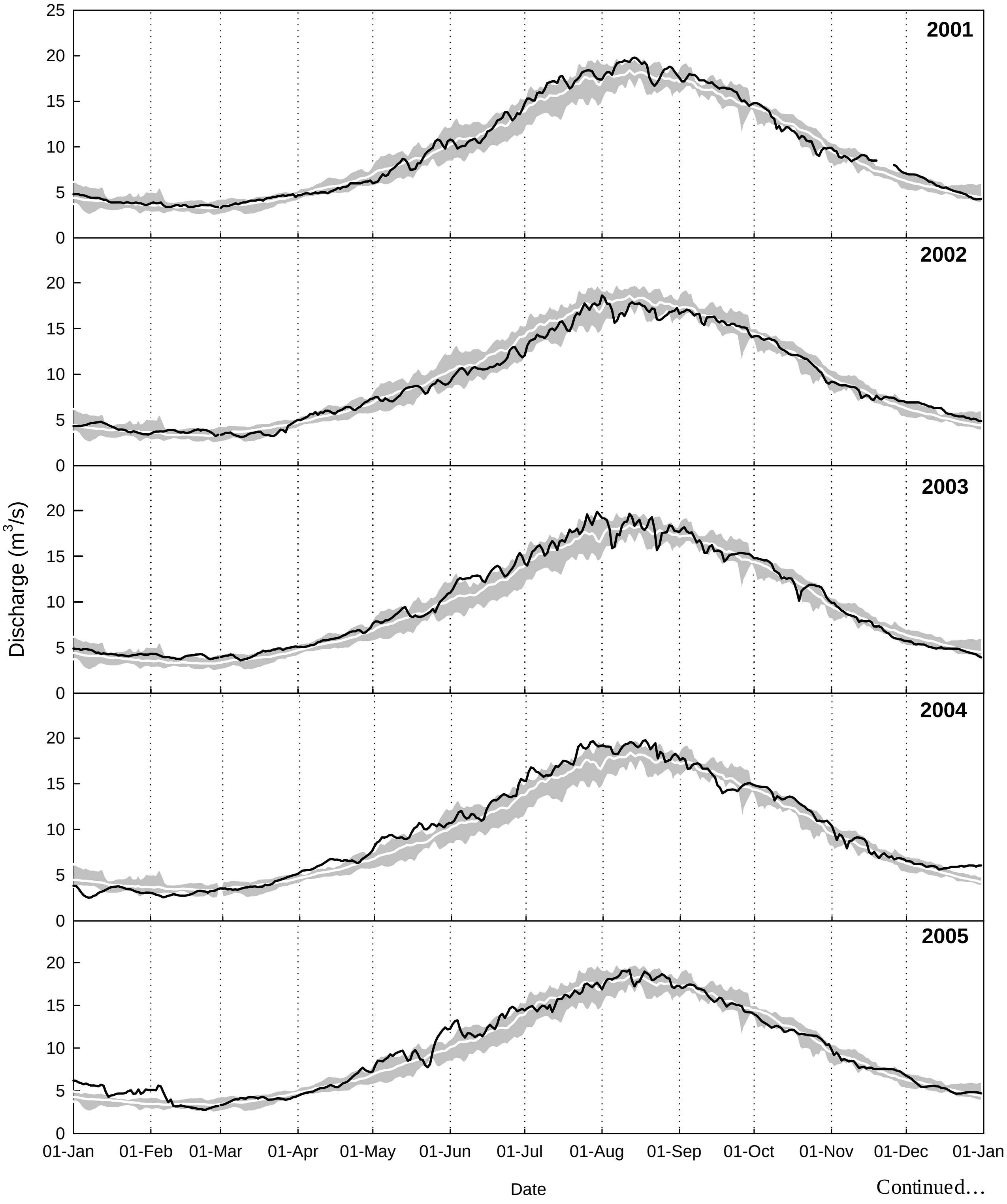


Figure D3 Concluded.



Continued…

Figure D4 Mean daily water temperatures (°C) for the Columbia River at the Birchbank water gauging station (black line), 2001 to 2011. The shaded area represents minimum and maximum mean daily water temperatures recorded at Birchbank during other study years (between 2001 and 2011). The white line represents average mean daily water temperature values over the same time period.

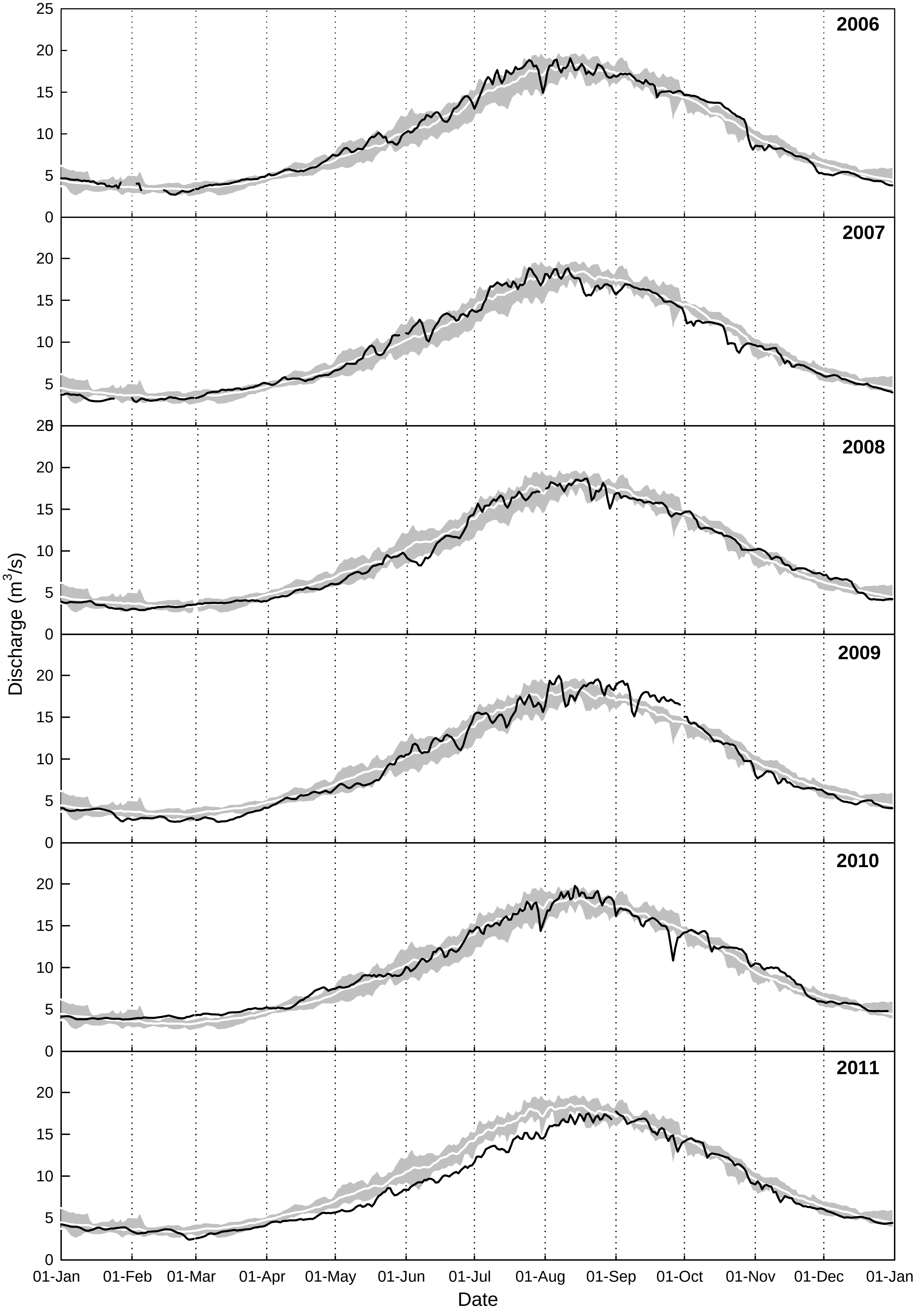


Figure D4 Concluded.

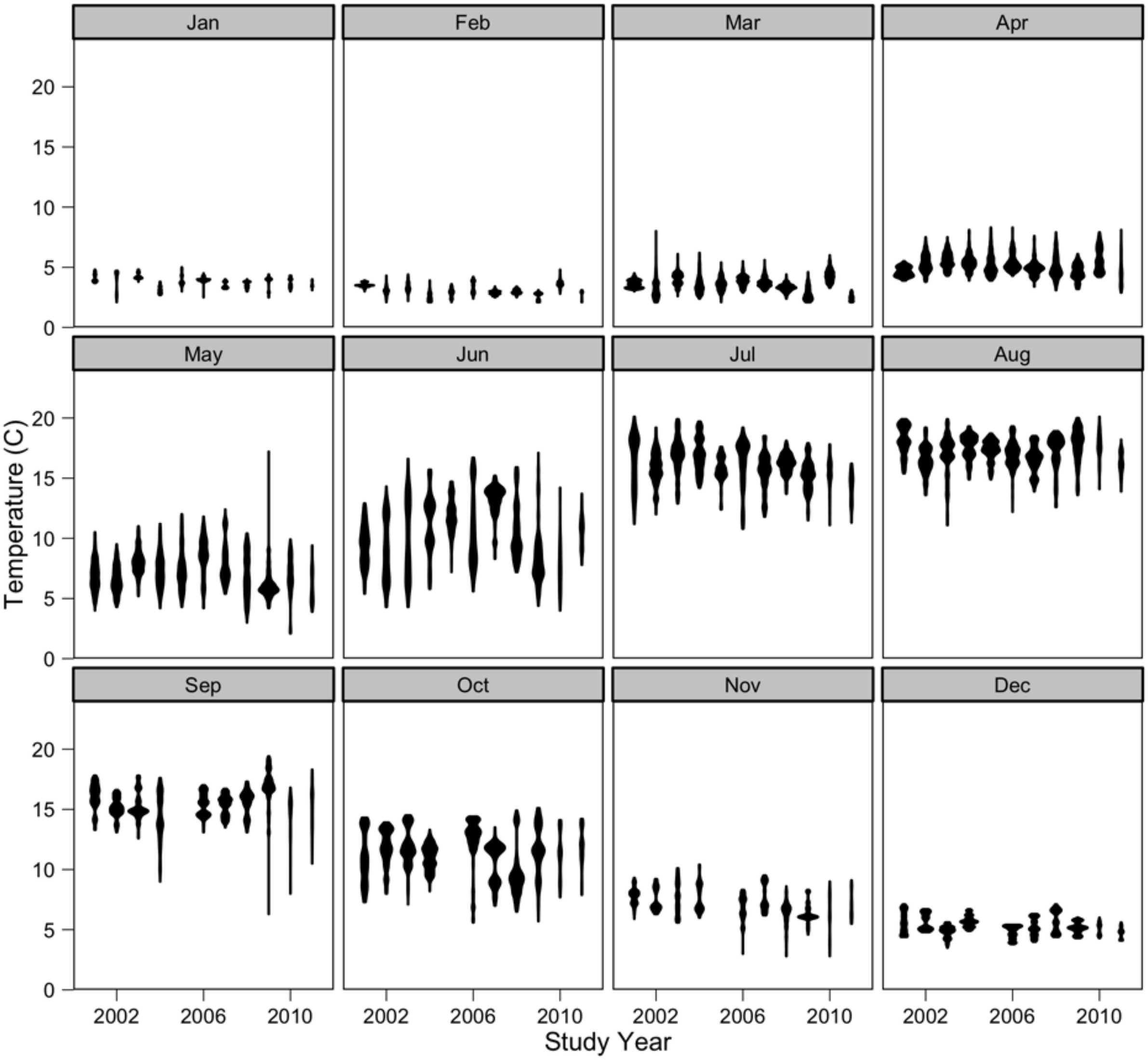
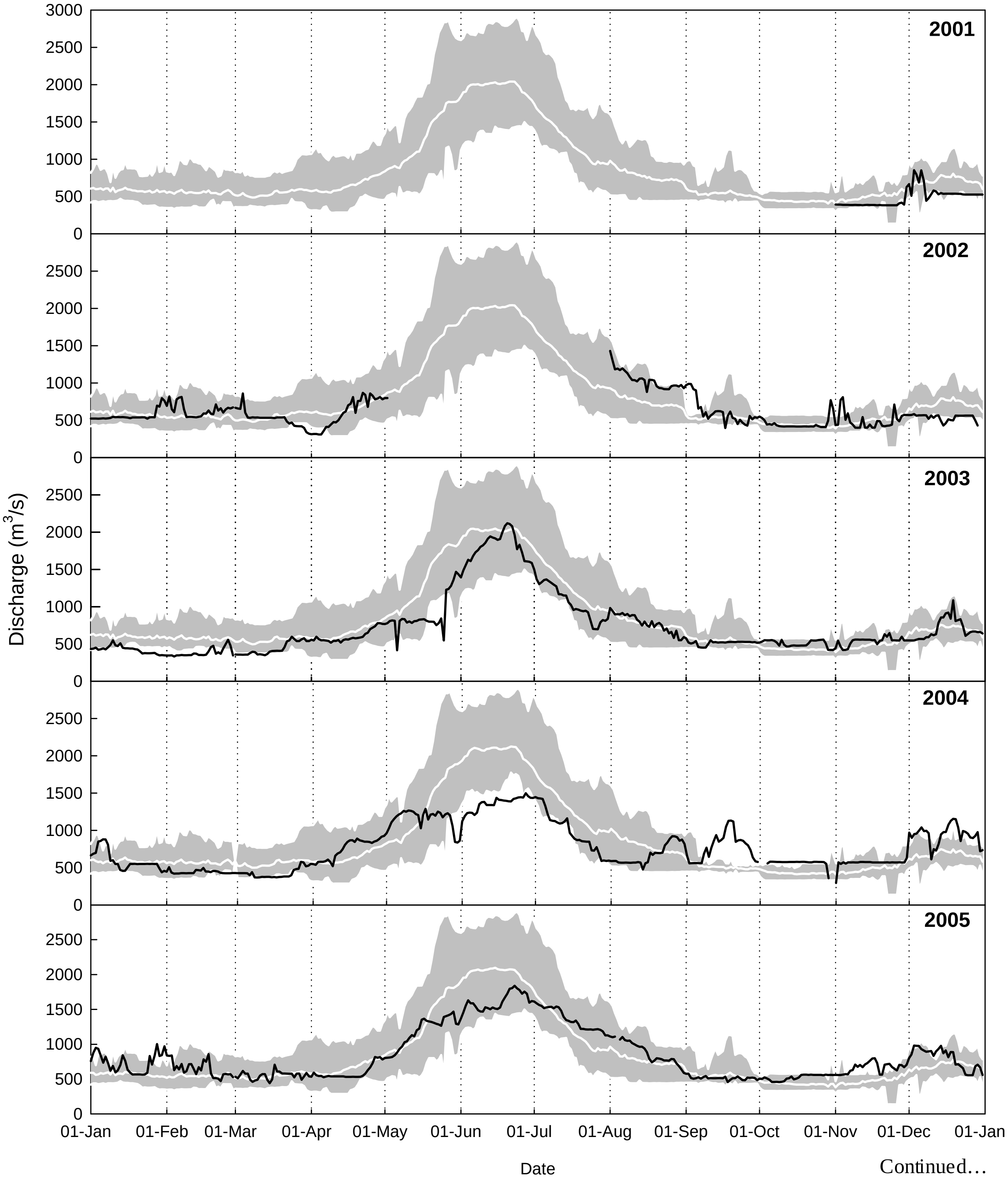


Figure D5 Hourly variability in water temperature (°C) by month for the Columbia River at the Birchbank water gauging station, 2001 to 2011.



Continued…

Figure D6 Mean daily discharge (m^3/s) for the Kootenay River at Brilliant Dam (BRD), 2001 to 2011 (black line). The shaded area represents minimum and maximum mean daily discharge values recorded at BRD during other study years (between 2001 and 2011). The white line represents average mean daily discharge values over the same time period.

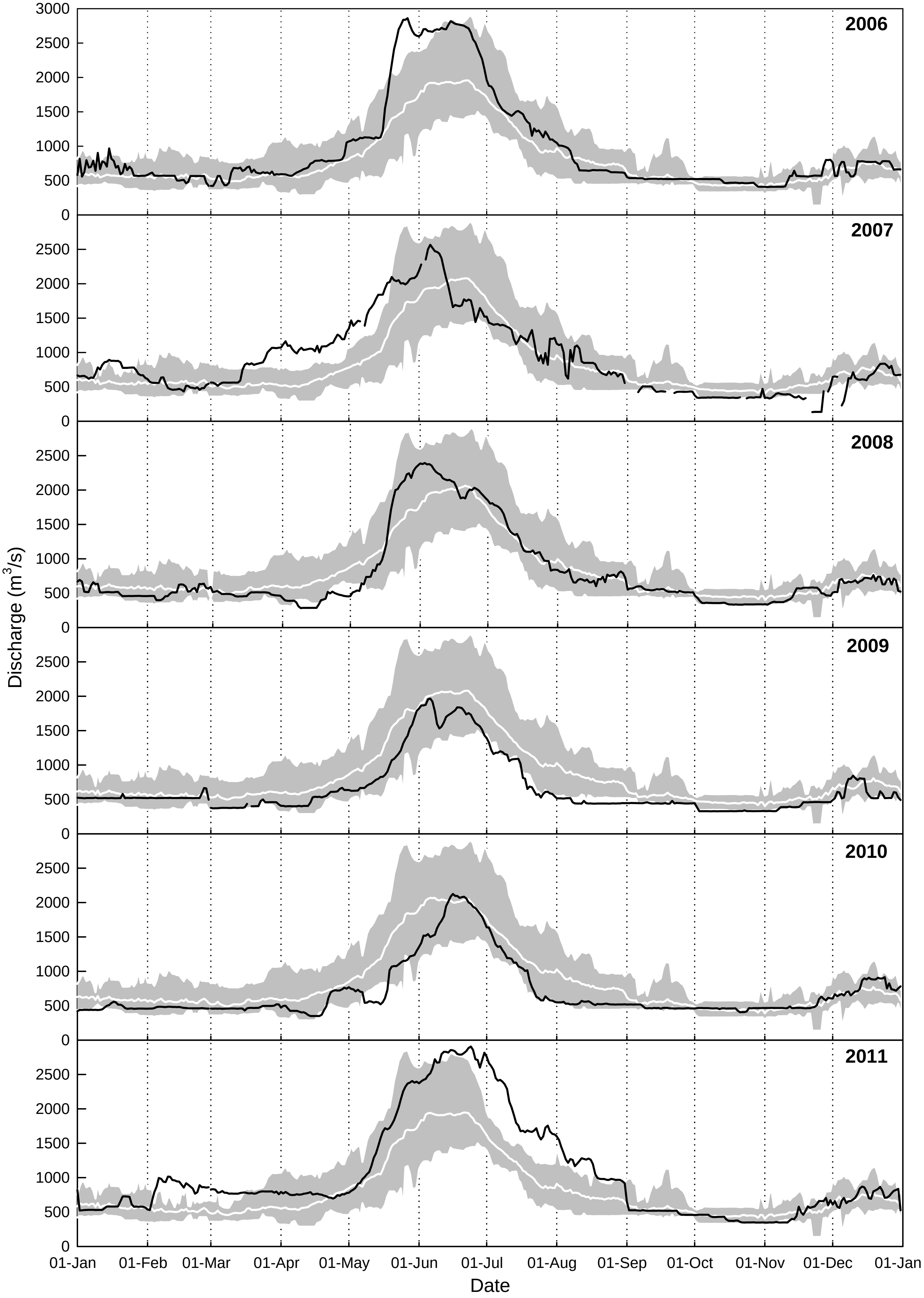
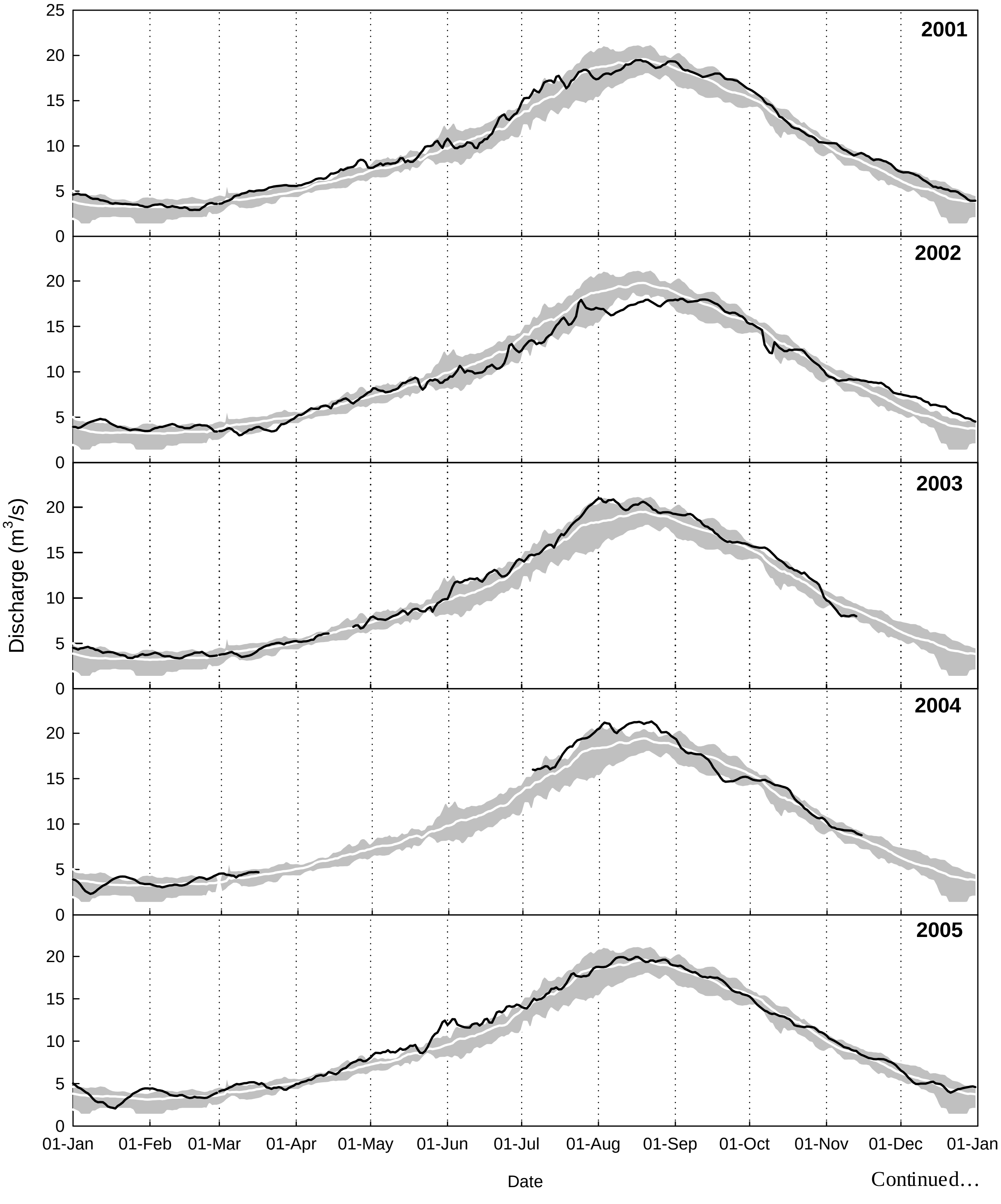


Figure D6 Concluded.



Continued…

Figure D7 Mean daily water temperatures (°C) for the Kootenay River downstream of Brilliant Dam (black line), 2001 to 2011. The shaded area represents minimum and maximum mean daily water temperatures recorded downstream of the dam during other study years (between 2001 and 2011). The white line represents average mean daily water temperature values over the same time period.

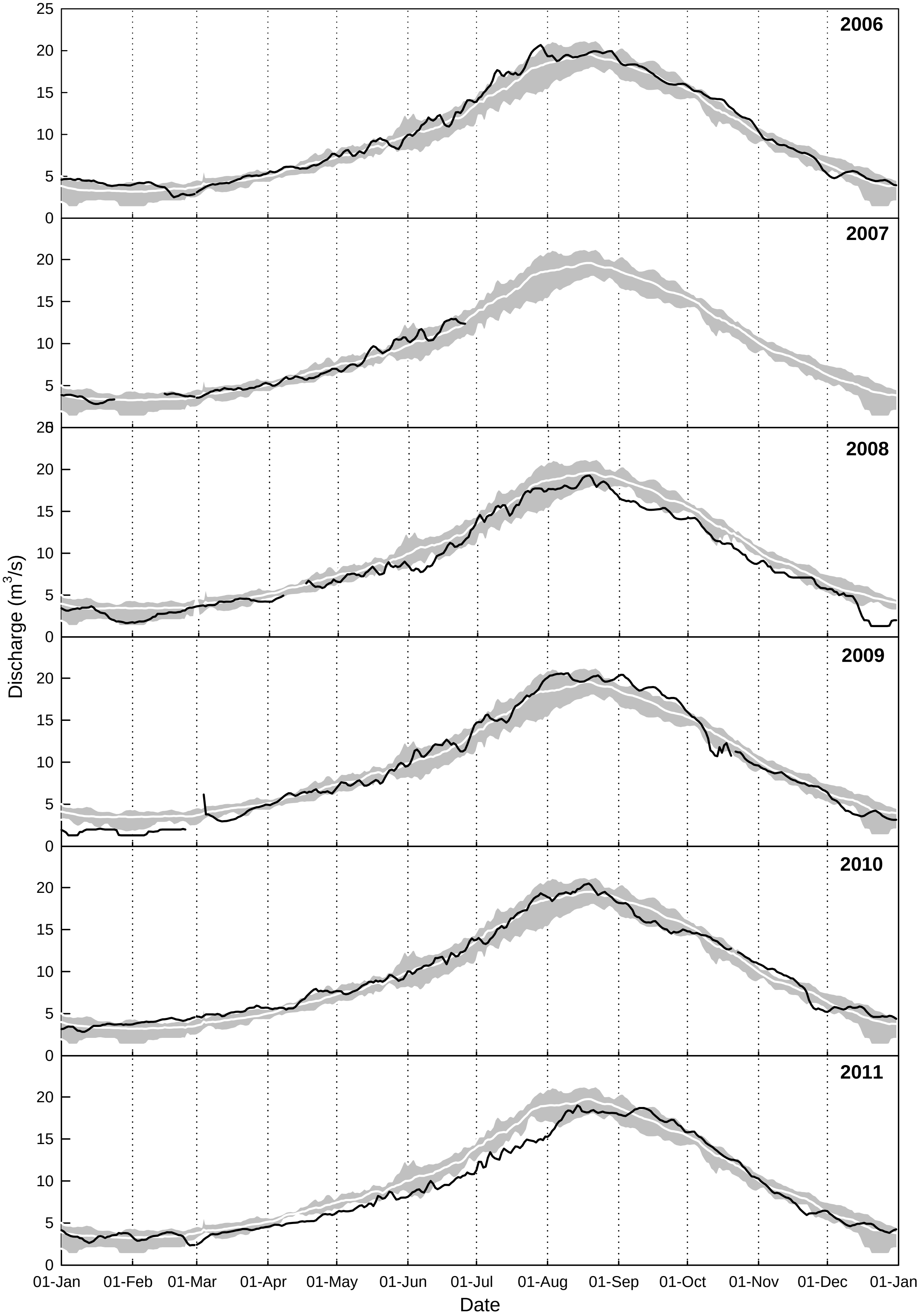


Figure D7 Concluded.

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 2011.

Species	**2001**		**2002**		**2003**		**2004**		**2005**		**2006**		**2007**		**2008**		**2009**		**2010**		**2011**	
	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]
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
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
Walleye	1467	5	1478	6	4165	15	3413	22	2230	19	1421	10	1076	9	1208	10	1127	11	1588	17	1814	17
Brook trout	5	<1	8	<1	7	<1	3	<1	3	<1	4	<1	15	<1	8	<1	3	<1	4	<1	14	<1
Brown trout	1	<1	2	<1			1	<1	1	<1	2	<1	7	<1	2	<1	3	<1	8	<1	4	<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
Burbot	3	<1	10	<1	59	<1	208	1	174	2	195	1	191	2	69	<1	33	<1	70	<1	247	2
Cutthroat trout	1	<1	4	<1	2	<1			1	<1	5	<1	8	<1	5	<1	3	<1	6	<1	4	<1
Kokanee	2562	9	171	<1	5180	19	120	<1	32	<1	898	7	506	4	148	1	1128	11	57	<1	77	<1
Lake trout			1	<1											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
Northern pike																			7	<1	9	<1
Smallmouth bass					4	<1	3	<1	4	<1	53	<1	16	<1	1	<1			1	<1	8	<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
Yellow perch					1	<1	4	<1	1	<1	24	<1	1	<1					12	<1	2	<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**
Non-sportfish																						
Common carp	2	<1					1	<1	1	<1	3	<1	1	<1	2	<1			3	<1		
Dace spp.[c]	2	<1					3	<1	15	<1	17	<1	1	<1	1	<1			13	<1	3	<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
Peamouth	80	<1	205	<1	45	<1	51	<1	33	<1	52	<1	93	<1	3	<1	4	<1	24	<1	192	<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
Sculpin spp.[c]	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
Sucker spp.[c]	6509	35	3553	16	4779	17	7033	18	4378	14	9235	12	10 012	17	11 028	16	6896	22	7984	25	5949	15
Tench											1	<1	5	<1	1	<1			2	<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**
All species	**46 878**		**46 683**		**55 964**		**55 730**		**44 020**		**89 531**		**72 156**		**82 543**		**42 463**		**40 933**		**51 794**	

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

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

[c] 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, 26 September to 30 October 2011.

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		Yellow perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River U/S																																			
	1	C00.0-R	30-Sep-11	907	0.84	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.73	0	0.00	33	155.93	0	0.00	3	14.18	0	0.00	12	56.70	0	0.00	0	0.00	49	231.53
		C00.7-L	30-Sep-11	664	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	36.76	0	0.00	36	330.81	0	0.00	36	330.81	0	0.00	14	128.65	0	0.00	0	0.00	90	827.04
		C01.3-L	30-Sep-11	2157	1.60	0	0.00	0	0.00	1	1.04	0	0.00	0	0.00	7	7.30	0	0.00	89	92.84	0	0.00	58	60.50	0	0.00	31	32.34	0	0.00	0	0.00	186	194.02
		C02.8-L	01-Oct-11	1222	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	25	83.69	0	0.00	14	46.87	0	0.00	11	36.82	1	3.35	0	0.00	51	170.73
		C03.6-L	01-Oct-11	2960	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	2.33	0	0.00	44	25.60	0	0.00	48	27.93	0	0.00	31	18.04	0	0.00	0	0.00	127	73.90
		C04.6-R	01-Oct-11	764	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	9.06	0	0.00	8	72.49	3	27.18	19	172.17	0	0.00	5	45.31	0	0.00	0	0.00	36	326.22
		C05.6-L	01-Oct-11	1257	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	16	41.66	0	0.00	11	28.64	0	0.00	17	44.26	0	0.00	0	0.00	44	114.56
		C07.3-R	03-Oct-11	1000	1.70	0	0.00	0	0.00	0	0.00	3	6.35	0	0.00	1	2.12	1	2.12	64	135.53	0	0.00	25	52.94	0	0.00	25	52.94	0	0.00	0	0.00	119	252.00
		C07.4-L	03-Oct-11	754	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	89	424.93	0	0.00	14	66.84	0	0.00	7	33.42	0	0.00	0	0.00	110	525.20
	Session Summary			**1298**	**10.3**	**0**	**0.00**	**0**	**0.00**	**1**	**0.27**	**3**	**0.81**	**0**	**0.00**	**18**	**4.84**	**1**	**0.27**	**404**	**108.55**	**3**	**0.81**	**228**	**61.26**	**0**	**0.00**	**153**	**41.11**	**1**	**0.27**	**0**	**0.00**	**812**	**218.17**
	2	C00.0-R	07-Oct-11	874	0.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	24	111.07	0	0.00	0	0.00	0	0.00	11	50.91	0	0.00	0	0.00	35	161.98
		C00.7-L	07-Oct-11	629	0.51	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	11.22	0	0.00	4	44.89	0	0.00	12	134.67	0	0.00	12	134.67	0	0.00	0	0.00	29	325.45
		C01.3-L	07-Oct-11	2239	1.60	0	0.00	0	0.00	2	2.01	0	0.00	0	0.00	1	1.00	0	0.00	37	37.18	0	0.00	55	55.27	0	0.00	26	26.13	0	0.00	0	0.00	121	121.59
		C02.8-L	08-Oct-11	1035	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	18	71.15	0	0.00	13	51.38	0	0.00	14	55.34	0	0.00	0	0.00	45	177.87
		C03.6-L	08-Oct-11	2800	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	7	4.31	0	0.00	49	30.14	1	0.62	90	55.37	0	0.00	42	25.84	0	0.00	0	0.00	189	116.27
		C04.6-R	08-Oct-11	846	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	40.92	1	8.18	18	147.30	0	0.00	8	65.47	0	0.00	0	0.00	32	261.87
		C05.6-L	08-Oct-11	1220	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.68	0	0.00	4	10.73	0	0.00	28	75.11	0	0.00	18	48.29	0	0.00	0	0.00	51	136.81
		C07.3-R	09-Oct-11	1004	1.67	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.15	17	36.50	0	0.00	47	100.91	0	0.00	9	19.32	0	0.00	0	0.00	74	158.89
		C07.4-L	09-Oct-11	966	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	98	365.22	0	0.00	20	74.53	0	0.00	8	29.81	0	0.00	0	0.00	126	469.57
	Session Summary			**1290**	**10.3**	**0**	**0.00**	**0**	**0.00**	**2**	**0.54**	**0**	**0.00**	**0**	**0.00**	**10**	**2.72**	**1**	**0.27**	**256**	**69.61**	**2**	**0.54**	**283**	**76.96**	**0**	**0.00**	**148**	**40.25**	**0**	**0.00**	**0**	**0.00**	**702**	**190.89**
	3	C00.0-R	15-Oct-11	1297	0.94	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	13	38.39	0	0.00	2	5.91	0	0.00	8	23.62	0	0.00	0	0.00	23	67.91
		C00.7-L	15-Oct-11	903	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	6.76	0	0.00	20	135.14	0	0.00	10	67.57	0	0.00	13	87.84	0	0.00	0	0.00	44	297.31
		C01.3-L	15-Oct-11	2633	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	1.71	0	0.00	38	32.47	0	0.00	44	37.60	0	0.00	12	10.25	0	0.00	0	0.00	96	82.04
		C02.8-L	15-Oct-11	1131	0.88	0	0.00	0	0.00	1	3.62	0	0.00	0	0.00	0	0.00	0	0.00	24	86.81	0	0.00	12	43.40	0	0.00	1	3.62	0	0.00	0	0.00	38	137.45
		C03.6-L	16-Oct-11	3300	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	24	12.53	1	0.52	46	24.01	0	0.00	15	7.83	1	0.52	0	0.00	87	45.41
		C04.6-R	16-Oct-11	676	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	20.48	0	0.00	12	122.89	0	0.00	3	30.72	0	0.00	0	0.00	17	174.10
		C05.6-L	16-Oct-11	1513	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.16	0	0.00	9	19.47	0	0.00	8	17.30	0	0.00	0	0.00	18	38.94
		C07.3-R	16-Oct-11	1036	1.70	0	0.00	0	0.00	0	0.00	1	2.04	0	0.00	0	0.00	0	0.00	78	159.44	0	0.00	21	42.93	0	0.00	10	20.44	0	0.00	0	0.00	110	224.85
		C07.4-L	17-Oct-11	1108	1.00	0	0.00	0	0.00	0	0.00	2	6.50	0	0.00	0	0.00	1	3.25	12	38.99	0	0.00	48	155.96	0	0.00	12	38.99	0	0.00	0	0.00	75	243.68
	Session Summary			**1511**	**10.4**	**0**	**0.00**	**0**	**0.00**	**1**	**0.23**	**3**	**0.69**	**0**	**0.00**	**3**	**0.69**	**1**	**0.23**	**212**	**48.48**	**1**	**0.23**	**204**	**46.65**	**0**	**0.00**	**82**	**18.75**	**1**	**0.23**	**0**	**0.00**	**508**	**116.17**
	4	C00.0-R	21-Oct-11	1050	0.94	0	0.00	0	0.00	1	3.65	0	0.00	0	0.00	2	7.29	0	0.00	9	32.83	0	0.00	5	18.24	0	0.00	11	40.12	0	0.00	0	0.00	28	102.13
		C00.7-L	21-Oct-11	704	0.54	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	18.94	0	0.00	4	37.88	0	0.00	19	179.92	0	0.00	5	47.35	0	0.00	0	0.00	30	284.09
		C01.3-L	21-Oct-11	2255	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	5.99	0	0.00	33	32.93	0	0.00	22	21.95	0	0.00	15	14.97	0	0.00	0	0.00	76	75.83
		C02.8-L	21-Oct-11	1183	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	6.92	0	0.00	8	27.66	0	0.00	10	34.58	0	0.00	11	38.04	0	0.00	0	0.00	31	107.20
		C03.6-L	22-Oct-11	2866	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	2.40	0	0.00	29	17.43	0	0.00	26	15.63	0	0.00	23	13.82	0	0.00	0	0.00	82	49.28
		C04.6-R	22-Oct-11	795	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	26.12	1	8.71	2	17.42	0	0.00	7	60.96	0	0.00	0	0.00	13	113.21
		C05.6-L	22-Oct-11	1380	1.10	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	7	16.60	0	0.00	12	28.46	0	0.00	0	0.00	19	45.06
		C07.3-R	24-Oct-11	902	1.69	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	2.36	11	25.98	0	0.00	20	47.23	0	0.00	6	14.17	0	0.00	0	0.00	38	89.74
		C07.4-L	24-Oct-11	1042	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	3.45	1	3.45	68	234.93	0	0.00	14	48.37	0	0.00	8	27.64	0	0.00	0	0.00	92	317.85
	Session Summary			**1353**	**10.4**	**0**	**0.00**	**0**	**0.00**	**1**	**0.26**	**0**	**0.00**	**0**	**0.00**	**17**	**4.37**	**2**	**0.51**	**165**	**42.38**	**1**	**0.26**	**125**	**32.10**	**0**	**0.00**	**98**	**25.17**	**0**	**0.00**	**0**	**0.00**	**409**	**105.04**
	5	C00.0-R	28-Oct-11	1113	0.92	0	0.00	0	0.00	1	3.52	0	0.00	0	0.00	1	3.52	0	0.00	14	49.22	0	0.00	2	7.03	0	0.00	14	49.22	0	0.00	0	0.00	32	112.50
		C00.7-L	28-Oct-11	760	0.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	8.03	0	0.00	23	184.66	0	0.00	6	48.17	0	0.00	12	96.34	0	0.00	0	0.00	42	337.20
		C01.3-L	28-Oct-11	1998	1.60	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	1.13	0	0.00	25	28.15	0	0.00	23	25.90	0	0.00	13	14.64	0	0.00	0	0.00	62	69.82
		C02.8-L	28-Oct-11	835	0.88	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.90	0	0.00	6	29.40	0	0.00	10	48.99	0	0.00	8	39.19	0	0.00	0	0.00	25	122.48
		C03.6-L	28-Oct-11	2625	2.09	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	10	6.56	0	0.00	34	22.31	0	0.00	16	10.50	0	0.00	0	0.00	60	39.37
		C04.6-R	29-Oct-11	767	0.52	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	9.03	1	9.03	9	81.24	0	0.00	4	36.10	0	0.00	0	0.00	15	135.39
		C05.6-L	29-Oct-11	1268	1.10	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	15.49	1	2.58	13	33.55	0	0.00	17	43.88	0	0.00	0	0.00	37	95.50
		C07.3-R	31-Oct-11	1020	1.70	0	0.00	0	0.00	0	0.00	1	2.08	0	0.00	6	12.46	7	14.53	20	41.52	0	0.00	17	35.29	0	0.00	7	14.53	0	0.00	0	0.00	58	120.42
		C07.4-L	30-Oct-11	821	1.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.38	62	271.86	0	0.00	17	74.54	0	0.00	5	21.92	1	4.38	0	0.00	86	377.10
	Session Summary			**1245**	**10.4**	**0**	**0.00**	**0**	**0.00**	**1**	**0.28**	**1**	**0.28**	**0**	**0.00**	**10**	**2.78**	**8**	**2.22**	**167**	**46.42**	**2**	**0.56**	**131**	**36.42**	**0**	**0.00**	**96**	**26.69**	**1**	**0.28**	**0**	**0.00**	**417**	**115.92**
Columbia River U/S Total All Samples				**60279**	**51.76**	**0**		**0**		**6**		**7**		**0**		**58**		**13**		**1204**		**9**		**971**		**0**		**577**		**3**		**0**		**2848**	
Columbia River U/S Average All Samples				**1340**	**1.15**	**0**	**0.00**	**0**	**0.00**	**0**	**0.31**	**0**	**0.36**	**0**	**0.00**	**1**	**3.01**	**0**	**0.67**	**27**	**62.51**	**0**	**0.47**	**22**	**50.42**	**0**	**0.00**	**13**	**39.04**	**0**	**0.18**	**0**	**0.00**	**63**	**190.03**
Columbia River U/S Standard Error of Mean						**0.00**	**0.00**	**0.00**	**0.00**	**0.06**	**0.14**	**0.08**	**0.21**	**0.00**	**0.00**	**0.29**	**0.98**	**0.16**	**0.35**	**3.87**	**14.90**	**0.08**	**0.67**	**2.74**	**9.02**	**0.00**	**0.00**	**1.20**	**4.22**	**0.04**	**0.12**	**0.00**	**0.00**	**6.37**	**22.45**

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		Yellow perch		All Species	
						No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*	No.	*CPUE*
Kootenay River																																			
	1	K00.3-L	02-Oct-11	208	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*39.34*	0	*0.00*	0	*0.00*	0	*0.00*	1	*39.34*	0	*0.00*	0	*0.00*	2	*78.67*
		K00.6-R	02-Oct-11	445	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	54	*728.09*	0	*0.00*	5	*67.42*	0	*0.00*	10	*134.83*	0	*0.00*	0	*0.00*	69	*930.34*
		K01.8-L	02-Oct-11	1438	1.85	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	53	*71.72*	0	*0.00*	36	*48.72*	0	*0.00*	33	*44.66*	3	*4.06*	0	*0.00*	125	*169.15*
		K01.8-R	02-Oct-11	1052	1.30	0	*0.00*	0	*0.00*	0	*0.00*	2	*5.26*	0	*0.00*	7	*18.43*	0	*0.00*	86	*226.38*	0	*0.00*	14	*36.85*	0	*0.00*	17	*44.75*	2	*5.26*	0	*0.00*	128	*336.94*
	Session Summary			**786**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**2**	***2.19***	**0**	***0.00***	**7**	***7.65***	**0**	***0.00***	**194**	***212.13***	**0**	***0.00***	**55**	***60.14***	**0**	***0.00***	**61**	***66.70***	**5**	***5.47***	**0**	***0.00***	**324**	***354.28***
	2	K00.3-L	09-Oct-11	227	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	6	*216.26*	0	*0.00*	4	*144.17*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	10	*360.43*
		K00.6-R	09-Oct-11	510	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	13	*152.94*	0	*0.00*	3	*35.29*	0	*0.00*	14	*164.71*	0	*0.00*	0	*0.00*	30	*352.94*
		K01.8-L	08-Oct-11	1407	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*4.10*	0	*0.00*	58	*79.36*	0	*0.00*	37	*50.63*	0	*0.00*	39	*53.36*	0	*0.00*	0	*0.00*	137	*187.45*
		K01.8-R	08-Oct-11	996	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	38	*105.65*	0	*0.00*	25	*69.51*	0	*0.00*	30	*83.41*	0	*0.00*	0	*0.00*	93	*258.57*
	Session Summary			**785**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**3**	***3.27***	**0**	***0.00***	**115**	***125.27***	**0**	***0.00***	**69**	***75.16***	**0**	***0.00***	**83**	***90.41***	**0**	***0.00***	**0**	***0.00***	**270**	***294.11***
	3	K00.3-L	16-Oct-11	223	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*73.38*	0	*0.00*	5	*183.45*	0	*0.00*	8	*293.52*	0	*0.00*	0	*0.00*	15	*550.35*
		K00.6-R	16-Oct-11	561	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	12	*128.34*	0	*0.00*	0	*0.00*	0	*0.00*	14	*149.73*	0	*0.00*	0	*0.00*	26	*278.07*
		K01.8-L	16-Oct-11	1669	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*1.15*	26	*29.99*	0	*0.00*	35	*40.37*	0	*0.00*	37	*42.68*	0	*0.00*	0	*0.00*	99	*114.19*
		K01.8-R	16-Oct-11	1358	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	53	*108.08*	0	*0.00*	47	*95.84*	0	*0.00*	26	*53.02*	0	*0.00*	0	*0.00*	126	*256.94*
	Session Summary			**953**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**1**	***0.90***	**93**	***83.47***	**0**	***0.00***	**87**	***78.08***	**0**	***0.00***	**85**	***76.29***	**0**	***0.00***	**0**	***0.00***	**266**	***238.74***
	4	K00.3-L	23-Oct-11	261	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*31.35*	1	*31.35*	10	*313.48*	0	*0.00*	3	*94.04*	0	*0.00*	6	*188.09*	0	*0.00*	0	*0.00*	21	*658.31*
		K00.6-R	23-Oct-11	580	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*10.34*	67	*693.10*	0	*0.00*	7	*72.41*	0	*0.00*	13	*134.48*	0	*0.00*	1	*10.34*	89	*920.69*
		K01.8-L	23-Oct-11	1767	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*1.09*	2	*2.18*	72	*78.44*	0	*0.00*	27	*29.42*	0	*0.00*	52	*56.65*	0	*0.00*	0	*0.00*	154	*167.78*
		K01.8-R	23-Oct-11	1272	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	29	*63.13*	0	*0.00*	23	*50.07*	0	*0.00*	13	*28.30*	0	*0.00*	0	*0.00*	65	*141.51*
	Session Summary			**970**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**2**	***1.76***	**4**	***3.53***	**178**	***156.92***	**0**	***0.00***	**60**	***52.89***	**0**	***0.00***	**84**	***74.05***	**0**	***0.00***	**1**	***0.88***	**329**	***290.03***
	5	K00.3-L	30-Oct-11	272	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	3	*90.24*	0	*0.00*	1	*30.08*	0	*0.00*	7	*210.56*	0	*0.00*	0	*0.00*	11	*330.88*
		K00.6-R	30-Oct-11	611	0.60	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	32	*314.24*	0	*0.00*	22	*216.04*	0	*0.00*	14	*137.48*	0	*0.00*	0	*0.00*	68	*667.76*
		K01.8-L	30-Oct-11	1481	1.87	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	2	*2.60*	47	*61.09*	0	*0.00*	19	*24.70*	0	*0.00*	41	*53.30*	0	*0.00*	0	*0.00*	109	*141.69*
		K01.8-R	30-Oct-11	1406	1.30	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	39	*76.81*	0	*0.00*	33	*65.00*	0	*0.00*	22	*43.33*	0	*0.00*	0	*0.00*	94	*185.14*
	Session Summary			**943**	**4.2**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**2**	***1.81***	**121**	***109.78***	**0**	***0.00***	**75**	***68.05***	**0**	***0.00***	**84**	***76.21***	**0**	***0.00***	**0**	***0.00***	**282**	***255.85***
Kootenay River Total All Samples				**17744**	**21.03**	**0**		**0**		**0**		**2**		**0**		**12**		**7**		**701**		**0**		**346**		**0**		**397**		**5**		**1**		**1471**	
Kootenay River Average All Samples				**887**	**1.05**	**0**	***0.00***	**0**	***0.00***	**0**	***0.00***	**0**	***0.39***	**0**	***0.00***	**1**	***2.32***	**0**	***1.35***	**35**	***135.26***	**0**	***0.00***	**17**	***66.76***	**0**	***0.00***	**20**	***97.81***	**0**	***0.47***	**0**	***0.52***	**74**	***354.39***
Kootenay River Standard Error of Mean						**0.00**	***0.00***	**0.00**	***0.00***	**0.00**	***0.00***	**0.10**	***0.26***	**0.00**	***0.00***	**0.37**	***1.77***	**0.15**	***1.61***	**5.75**	***44.40***	**0.00**	***0.00***	**3.35**	***12.61***	**0.00**	***0.00***	**3.25**	***16.86***	**0.18**	***0.32***	**0.05**	***0.52***	**10.92**	***57.51***

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		Yellow perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Columbia River D/S																																			
	1	C25.3-R	28-Sep-11	1751	2.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.75	51	38.41	0	0.00	63	47.45	0	0.00	42	31.63	0	0.00	0	0.00	157	118.24
		C27.6-R	28-Sep-11	383	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	15.41	8	123.27	0	0.00	15	231.13	0	0.00	5	77.04	0	0.00	0	0.00	29	446.86
		C28.2-R	28-Sep-11	782	1.13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	15	61.11	0	0.00	54	219.99	0	0.00	8	32.59	0	0.00	0	0.00	77	313.70
		C34.9-L	26-Sep-11	2008	2.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	26	21.78	0	0.00	127	106.40	0	0.00	21	17.59	0	0.00	0	0.00	174	145.77
		C36.6-L	26-Sep-11	1558	2.39	1	0.97	0	0.00	0	0.00	1	0.97	0	0.00	0	0.00	1	0.97	20	19.34	0	0.00	75	72.51	0	0.00	17	16.44	0	0.00	0	0.00	115	111.18
		C47.8-L	29-Sep-11	1042	1.44	4	9.60	0	0.00	0	0.00	1	2.40	0	0.00	0	0.00	0	0.00	10	23.99	0	0.00	58	139.16	0	0.00	18	43.19	1	2.40	0	0.00	92	220.73
		C48.2-R	27-Sep-11	1034	1.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	13.79	0	0.00	29	99.97	0	0.00	6	20.68	0	0.00	0	0.00	39	134.44
		C49.0-L	29-Sep-11	571	0.93	0	0.00	0	0.00	0	0.00	1	6.78	0	0.00	0	0.00	1	6.78	30	203.38	0	0.00	49	332.18	0	0.00	5	33.90	0	0.00	0	0.00	86	583.02
		C49.0-R	27-Sep-11	671	0.72	1	7.45	1	7.45	0	0.00	2	14.90	0	0.00	0	0.00	0	0.00	15	111.77	0	0.00	42	312.97	0	0.00	1	7.45	0	0.00	0	0.00	62	462.00
		C49.8-L	29-Sep-11	1851	2.45	0	0.00	0	0.00	0	0.00	7	5.56	0	0.00	0	0.00	0	0.00	61	48.42	0	0.00	120	95.26	0	0.00	20	15.88	1	0.79	0	0.00	209	165.91
		C49.8-R	28-Sep-11	1816	2.39	0	0.00	0	0.00	0	0.00	7	5.81	1	0.83	0	0.00	6	4.98	19	15.76	0	0.00	190	157.59	0	0.00	26	21.57	0	0.00	0	0.00	249	206.53
		C52.2-L	30-Sep-11	821	0.89	0	0.00	0	0.00	0	0.00	0	0.00	1	4.93	0	0.00	0	0.00	17	83.76	0	0.00	56	275.90	0	0.00	9	44.34	0	0.00	0	0.00	83	408.93
		C52.2-R	28-Sep-11	2505	3.79	1	0.38	0	0.00	0	0.00	14	5.31	1	0.38	0	0.00	16	6.07	27	10.24	0	0.00	168	63.70	1	0.38	30	11.38	1	0.38	0	0.00	259	98.21
		C52.8-L	30-Sep-11	616	0.89	0	0.00	0	0.00	0	0.00	1	6.57	1	6.57	0	0.00	5	32.83	19	124.76	0	0.00	42	275.79	0	0.00	13	85.36	0	0.00	0	0.00	81	531.88
		C53.6-L	30-Sep-11	1044	1.72	0	0.00	0	0.00	0	0.00	2	4.01	0	0.00	0	0.00	1	2.00	12	24.06	0	0.00	49	98.24	0	0.00	14	28.07	0	0.00	0	0.00	78	156.38
	Session Summary			**1230**	**25.2**	**7**	**0.81**	**1**	**0.12**	**0**	**0.00**	**36**	**4.18**	**4**	**0.46**	**0**	**0.00**	**32**	**3.71**	**334**	**38.74**	**0**	**0.00**	**1137**	**131.88**	**1**	**0.12**	**235**	**27.26**	**3**	**0.35**	**0**	**0.00**	**1790**	**207.62**
	2	C25.3-R	06-Oct-11	1624	2.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	3.25	41	33.29	0	0.00	55	44.66	0	0.00	21	17.05	0	0.00	0	0.00	121	98.25
		C27.6-R	06-Oct-11	442	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	33	440.62	0	0.00	9	120.17	0	0.00	6	80.11	0	0.00	0	0.00	48	640.90
		C28.2-R	06-Oct-11	465	1.13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	39	267.20	0	0.00	34	232.94	0	0.00	14	95.92	0	0.00	0	0.00	87	596.06
		C34.9-L	05-Oct-11	2004	2.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	1.68	0	0.00	107	89.82	0	0.00	10	8.39	0	0.00	0	0.00	119	99.89
		C36.6-L	05-Oct-11	1432	2.39	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	5.26	0	0.00	65	68.37	0	0.00	8	8.41	0	0.00	0	0.00	78	82.05
		C47.8-L	03-Oct-11	1178	1.44	0	0.00	0	0.00	0	0.00	1	2.12	0	0.00	0	0.00	5	10.61	2	4.24	0	0.00	38	80.65	0	0.00	10	21.22	0	0.00	0	0.00	56	118.85
		C48.2-R	04-Oct-11	747	1.01	0	0.00	0	0.00	0	0.00	2	9.54	0	0.00	0	0.00	2	9.54	4	19.09	0	0.00	28	133.60	0	0.00	5	23.86	0	0.00	0	0.00	41	195.63
		C49.0-L	03-Oct-11	566	0.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8	54.71	8	54.71	0	0.00	28	191.50	1	6.84	12	82.07	0	0.00	0	0.00	57	389.83
		C49.0-R	04-Oct-11	559	0.72	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	35.78	0	0.00	30	268.34	0	0.00	1	8.94	0	0.00	0	0.00	35	313.06
		C49.8-L	03-Oct-11	1833	2.45	0	0.00	0	0.00	0	0.00	1	0.80	0	0.00	0	0.00	0	0.00	26	20.84	0	0.00	92	73.75	0	0.00	27	21.64	1	0.80	0	0.00	147	117.84
		C49.8-R	04-Oct-11	1479	2.39	0	0.00	0	0.00	0	0.00	3	3.06	0	0.00	0	0.00	0	0.00	16	16.30	0	0.00	73	74.35	0	0.00	15	15.28	0	0.00	0	0.00	107	108.97
		C52.2-L	04-Oct-11	922	0.89	0	0.00	1	4.39	0	0.00	0	0.00	0	0.00	0	0.00	7	30.71	0	0.00	0	0.00	47	206.20	1	4.39	4	17.55	0	0.00	0	0.00	60	263.23
		C52.2-R	05-Oct-11	2206	3.79	0	0.00	0	0.00	0	0.00	12	5.17	0	0.00	0	0.00	6	2.58	34	14.64	0	0.00	82	35.31	0	0.00	21	9.04	0	0.00	0	0.00	155	66.74
		C52.8-L	04-Oct-11	486	0.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	49.94	4	33.29	0	0.00	3	24.97	0	0.00	1	8.32	0	0.00	0	0.00	14	116.52
		C53.6-L	04-Oct-11	1082	1.72	0	0.00	0	0.00	0	0.00	2	3.87	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	29	56.10	2	3.87	9	17.41	1	1.93	1	1.93	44	85.11
	Session Summary			**1135**	**25.2**	**0**	**0.00**	**1**	**0.13**	**0**	**0.00**	**21**	**2.64**	**0**	**0.00**	**0**	**0.00**	**38**	**4.78**	**218**	**27.41**	**0**	**0.00**	**720**	**90.52**	**4**	**0.50**	**164**	**20.62**	**2**	**0.25**	**1**	**0.13**	**1169**	**146.96**
	3	C25.3-R	14-Oct-11	1935	2.73	0	0.00	0	0.00	1	0.68	0	0.00	0	0.00	0	0.00	12	8.18	86	58.61	0	0.00	76	51.79	0	0.00	17	11.59	1	0.68	0	0.00	193	131.53
		C27.6-R	14-Oct-11	370	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	22	350.91	0	0.00	18	287.11	0	0.00	6	95.70	0	0.00	0	0.00	46	733.72
		C28.2-R	14-Oct-11	943	1.13	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	3.38	23	77.70	0	0.00	32	108.11	0	0.00	7	23.65	0	0.00	0	0.00	63	212.84
		C34.9-L	13-Oct-11	2335	2.12	1	0.73	0	0.00	0	0.00	2	1.45	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	216	157.08	0	0.00	8	5.82	0	0.00	0	0.00	227	165.08
		C36.6-L	13-Oct-11	1804	2.39	2	1.67	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	1.67	4	3.34	0	0.00	94	78.49	0	0.00	7	5.84	0	0.00	0	0.00	109	91.01
		C47.8-L	11-Oct-11	1159	1.44	0	0.00	0	0.00	0	0.00	2	4.31	0	0.00	0	0.00	0	0.00	3	6.47	0	0.00	64	138.05	0	0.00	4	8.63	0	0.00	0	0.00	73	157.46
		C48.2-R	12-Oct-11	602	1.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6	35.53	0	0.00	8	47.37	0	0.00	5	29.60	0	0.00	0	0.00	19	112.50
		C49.0-L	11-Oct-11	593	0.93	0	0.00	0	0.00	0	0.00	3	19.58	0	0.00	0	0.00	1	6.53	12	78.33	0	0.00	50	326.39	0	0.00	2	13.06	0	0.00	0	0.00	68	443.89
		C49.0-R	12-Oct-11	692	0.72	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	21.68	0	0.00	25	180.64	0	0.00	3	21.68	0	0.00	0	0.00	31	223.99
		C49.8-L	11-Oct-11	1952	2.45	0	0.00	0	0.00	0	0.00	4	3.01	0	0.00	1	0.75	0	0.00	7	5.27	0	0.00	141	106.14	0	0.00	9	6.77	0	0.00	0	0.00	162	121.95
		C49.8-R	12-Oct-11	2268	2.39	0	0.00	0	0.00	2	1.33	2	1.33	0	0.00	0	0.00	2	1.33	7	4.65	0	0.00	102	67.74	0	0.00	28	18.60	0	0.00	0	0.00	143	94.97
		C52.2-L	11-Oct-11	946	0.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	12.83	0	0.00	68	290.76	0	0.00	2	8.55	0	0.00	0	0.00	73	312.14
		C52.2-R	12-Oct-11	2475	3.79	0	0.00	0	0.00	0	0.00	8	3.07	0	0.00	0	0.00	5	1.92	21	8.06	0	0.00	42	16.12	1	0.38	24	9.21	0	0.00	0	0.00	101	38.76
		C52.8-L	12-Oct-11	719	0.89	0	0.00	0	0.00	0	0.00	2	11.25	0	0.00	0	0.00	2	11.25	1	5.63	0	0.00	25	140.64	0	0.00	9	50.63	0	0.00	0	0.00	39	219.41
		C53.6-L	12-Oct-11	1274	1.72	2	3.29	1	1.64	0	0.00	1	1.64	0	0.00	0	0.00	0	0.00	1	1.64	0	0.00	35	57.50	2	3.29	8	13.14	0	0.00	0	0.00	50	82.14
	Session Summary			**1338**	**25.2**	**5**	**0.53**	**1**	**0.11**	**3**	**0.32**	**24**	**2.56**	**0**	**0.00**	**1**	**0.11**	**25**	**2.67**	**199**	**21.24**	**0**	**0.00**	**996**	**106.32**	**3**	**0.32**	**139**	**14.84**	**1**	**0.11**	**0**	**0.00**	**1397**	**149.12**

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		Yellow perch		All Species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
	4	C25.3-R	22-Oct-11	1847	2.73	0	0.00	0	0.00	0	0.00	1	0.71	0	0.00	6	4.28	7	5.00	54	38.55	0	0.00	48	34.27	0	0.00	24	17.14	0	0.00	0	0.00	140	99.95
		C27.6-R	22-Oct-11	432	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	18	245.90	0	0.00	19	259.56	0	0.00	4	54.64	0	0.00	0	0.00	41	560.11
		C28.2-R	22-Oct-11	854	1.13	1	3.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	7	26.11	0	0.00	39	145.49	0	0.00	6	22.38	0	0.00	0	0.00	53	197.72
		C34.9-L	20-Oct-11	2217	2.14	0	0.00	0	0.00	0	0.00	1	0.76	0	0.00	0	0.00	3	2.28	1	0.76	0	0.00	81	61.46	0	0.00	7	5.31	0	0.00	0	0.00	93	70.57
		C36.6-L	20-Oct-11	1697	2.39	0	0.00	0	0.00	1	0.89	0	0.00	0	0.00	0	0.00	3	2.66	4	3.55	0	0.00	52	46.16	0	0.00	13	11.54	0	0.00	0	0.00	73	64.80
		C47.8-L	18-Oct-11	1193	1.44	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	4.19	0	0.00	0	0.00	29	60.77	0	0.00	19	39.82	2	4.19	0	0.00	52	108.97
		C48.2-R	19-Oct-11	715	1.01	0	0.00	0	0.00	0	0.00	2	9.97	0	0.00	0	0.00	0	0.00	5	24.93	0	0.00	31	154.54	0	0.00	10	49.85	0	0.00	0	0.00	48	239.29
		C49.0-L	18-Oct-11	554	0.93	0	0.00	0	0.00	0	0.00	1	6.99	0	0.00	0	0.00	6	41.92	16	111.80	0	0.00	23	160.71	0	0.00	5	34.94	0	0.00	0	0.00	51	356.35
		C49.0-R	19-Oct-11	686	0.72	0	0.00	0	0.00	1	7.29	4	29.15	0	0.00	0	0.00	2	14.58	2	14.58	0	0.00	34	247.81	0	0.00	1	7.29	1	7.29	0	0.00	45	327.99
		C49.8-L	19-Oct-11	1847	2.45	0	0.00	0	0.00	0	0.00	10	7.96	0	0.00	0	0.00	15	11.93	29	23.07	0	0.00	40	31.82	0	0.00	14	11.14	0	0.00	0	0.00	108	85.92
		C49.8-R	19-Oct-11	1397	2.39	0	0.00	0	0.00	0	0.00	10	10.78	0	0.00	0	0.00	5	5.39	14	15.10	0	0.00	75	80.87	0	0.00	10	10.78	0	0.00	0	0.00	114	122.92
		C52.2-L	18-Oct-11	933	0.89	0	0.00	0	0.00	0	0.00	11	47.69	0	0.00	0	0.00	12	52.03	3	13.01	0	0.00	34	147.40	0	0.00	3	13.01	1	4.34	0	0.00	64	277.47
		C52.2-R	19-Oct-11	2477	3.79	0	0.00	0	0.00	0	0.00	35	13.42	0	0.00	0	0.00	11	4.22	8	3.07	0	0.00	70	26.84	0	0.00	16	6.14	1	0.38	0	0.00	141	54.07
		C52.8-L	18-Oct-11	649	0.89	0	0.00	0	0.00	0	0.00	1	6.23	0	0.00	0	0.00	1	6.23	1	6.23	0	0.00	20	124.65	0	0.00	17	105.95	0	0.00	0	0.00	40	249.30
		C53.6-L	18-Oct-11	1103	1.72	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	1.90	2	3.80	0	0.00	32	60.72	0	0.00	14	26.57	0	0.00	0	0.00	49	92.98
	Session Summary			**1240**	**25.2**	**1**	**0.12**	**0**	**0.00**	**2**	**0.23**	**76**	**8.74**	**0**	**0.00**	**6**	**0.69**	**68**	**7.82**	**164**	**18.87**	**0**	**0.00**	**627**	**72.15**	**0**	**0.00**	**163**	**18.76**	**5**	**0.58**	**0**	**0.00**	**1112**	**127.95**
	5	C25.3-R	29-Oct-11	1819	2.63	0	0.00	0	0.00	0	0.00	1	0.75	0	0.00	0	0.00	7	5.27	29	21.82	0	0.00	62	46.66	0	0.00	21	15.80	0	0.00	0	0.00	120	90.30
		C27.6-R	29-Oct-11	402	0.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	73.40	0	0.00	7	102.76	0	0.00	10	146.81	0	0.00	0	0.00	22	322.98
		C28.2-R	29-Oct-11	927	1.13	0	0.00	0	0.00	0	0.00	1	3.44	0	0.00	0	0.00	1	3.44	21	72.17	0	0.00	40	137.47	0	0.00	8	27.49	0	0.00	0	0.00	71	244.01
		C34.9-L	25-Oct-11	2286	2.14	0	0.00	0	0.00	0	0.00	1	0.74	0	0.00	0	0.00	1	0.74	1	0.74	0	0.00	67	49.30	0	0.00	10	7.36	0	0.00	0	0.00	80	58.87
		C36.6-L	25-Oct-11	1663	2.39	0	0.00	0	0.00	1	0.91	2	1.81	0	0.00	0	0.00	2	1.81	4	3.62	0	0.00	114	103.26	0	0.00	6	5.43	0	0.00	0	0.00	129	116.84
		C47.8-L	26-Oct-11	1294	1.44	1	1.93	0	0.00	0	0.00	4	7.73	0	0.00	0	0.00	3	5.80	1	1.93	0	0.00	35	67.62	0	0.00	15	28.98	0	0.00	0	0.00	59	113.99
		C48.2-R	27-Oct-11	827	1.01	0	0.00	0	0.00	0	0.00	2	8.62	0	0.00	0	0.00	1	4.31	6	25.86	0	0.00	43	185.33	0	0.00	9	38.79	0	0.00	0	0.00	61	262.91
		C49.0-L	26-Oct-11	542	0.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	28.57	11	78.56	0	0.00	29	207.12	0	0.00	4	28.57	0	0.00	0	0.00	48	342.82
		C49.0-R	27-Oct-11	781	0.72	0	0.00	1	6.40	0	0.00	3	19.21	0	0.00	0	0.00	3	19.21	0	0.00	0	0.00	21	134.44	0	0.00	10	64.02	0	0.00	0	0.00	38	243.28
		C49.8-L	26-Oct-11	1854	2.45	0	0.00	0	0.00	0	0.00	19	15.06	0	0.00	0	0.00	6	4.76	16	12.68	0	0.00	131	103.82	0	0.00	22	17.44	0	0.00	0	0.00	194	153.75
		C49.8-R	27-Oct-11	1471	2.39	0	0.00	0	0.00	0	0.00	11	11.26	0	0.00	0	0.00	1	1.02	16	16.38	0	0.00	102	104.45	0	0.00	31	31.74	0	0.00	0	0.00	161	164.86
		C52.2-L	27-Oct-11	957	0.89	0	0.00	0	0.00	0	0.00	3	12.68	0	0.00	0	0.00	0	0.00	2	8.45	0	0.00	38	160.61	0	0.00	4	16.91	0	0.00	0	0.00	47	198.65
		C52.2-R	27-Oct-11	2702	3.79	0	0.00	0	0.00	0	0.00	15	5.27	0	0.00	0	0.00	5	1.76	9	3.16	0	0.00	56	19.69	0	0.00	15	5.27	4	1.41	0	0.00	104	36.56
		C52.8-L	27-Oct-11	567	0.89	0	0.00	0	0.00	0	0.00	6	42.80	0	0.00	0	0.00	1	7.13	1	7.13	0	0.00	13	92.74	0	0.00	3	21.40	0	0.00	0	0.00	24	171.21
		C53.6-L	27-Oct-11	1296	1.72	0	0.00	0	0.00	0	0.00	13	20.99	0	0.00	0	0.00	2	3.23	1	1.61	0	0.00	43	69.44	0	0.00	20	32.30	0	0.00	0	0.00	79	127.58
	Session Summary			**1293**	**25.1**	**1**	**0.11**	**1**	**0.11**	**1**	**0.11**	**81**	**8.98**	**0**	**0.00**	**0**	**0.00**	**37**	**4.10**	**123**	**13.63**	**0**	**0.00**	**801**	**88.78**	**0**	**0.00**	**188**	**20.84**	**4**	**0.44**	**0**	**0.00**	**1237**	**137.10**
Columbia River D/S Total All Samples				**93534**	**126.03**	**14**		**4**		**6**		**238**		**4**		**7**		**200**		**1038**		**0**		**4281**		**8**		**889**		**15**		**1**		**6705**	
Columbia River D/S Average All Samples				**1247**	**1.68**	**0**	**0.32**	**0**	**0.09**	**0**	**0.14**	**3**	**5.45**	**0**	**0.09**	**0**	**0.16**	**3**	**4.58**	**14**	**23.77**	**0**	**0.00**	**57**	**98.05**	**0**	**0.18**	**12**	**28.66**	**0**	**0.33**	**0**	**0.03**	**89**	**214.60**
Columbia River D/S Standard Error of Mean						**0.07**	**0.17**	**0.03**	**0.14**	**0.04**	**0.10**	**0.65**	**1.03**	**0.03**	**0.11**	**0.08**	**0.06**	**0.42**	**1.43**	**1.85**	**9.08**	**0.00**	**0.00**	**4.80**	**9.53**	**0.04**	**0.13**	**0.97**	**3.18**	**0.07**	**0.13**	**0.01**	**0.03**	**6.41**	**18.08**
All Sections Total All Samples				**171557**	**198.82**	**14**	**0.00**	**4**	**0.00**	**12**	**0.00**	**247**	**0.03**	**4**	**0.00**	**77**	**0.01**	**220**	**0.02**	**2943**	**0.31**	**9**	**0.00**	**5598**	**0.59**	**8**	**0.00**	**1863**	**0.20**	**23**	**0.00**	**2**	**0.00**	**11024**	**1.16**
All Sections Average All Samples						**0**	**0.21**	**0**	**0.06**	**0**	**0.18**	**2**	**3.65**	**0**	**0.06**	**1**	**1.14**	**2**	**3.25**	**21**	**43.49**	**0**	**0.13**	**40**	**82.72**	**0**	**0.12**	**13**	**27.53**	**0**	**0.34**	**0**	**0.03**	**79**	**162.89**
All Sections Standard Error of Mean						**0.04**	**0.09**	**0.01**	**0.08**	**0.03**	**0.07**	**0.37**	**0.60**	**0.01**	**0.06**	**0.12**	**0.42**	**0.25**	**0.84**	**1.90**	**10.00**	**0.03**	**0.22**	**3.16**	**6.67**	**0.02**	**0.07**	**0.82**	**3.76**	**0.05**	**0.09**	**0.01**	**0.08**	**4.38**	**15.15**

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, 26 September to 30 October 2011.

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	30-Sep-11	907	0.84	1	*4.73*	1	*4.73*	16	*75.60*	125	*590.64*	27	*127.58*	170	*803.28*
		C00.7-L	30-Sep-11	664	0.59	23	*211.35*	4	*36.76*	7	*64.33*	111	*1020.01*	53	*487.03*	198	*1819.48*
		C01.3-L	30-Sep-11	2157	1.60	65	*67.80*	9	*9.39*	22	*22.95*	323	*336.93*	167	*174.20*	586	*611.27*
		C02.8-L	01-Oct-11	1222	0.88	7	*23.43*	4	*13.39*	10	*33.48*	95	*318.03*	52	*174.08*	168	*562.42*
		C03.6-L	01-Oct-11	2960	2.09	10	*5.82*	0	*0.00*	1	*0.58*	39	*22.69*	97	*56.45*	147	*85.54*
		C04.6-R	01-Oct-11	764	0.52	0	*0.00*	0	*0.00*	2	*18.12*	7	*63.43*	33	*299.03*	42	*380.59*
		C05.6-L	01-Oct-11	1257	1.10	1	*2.60*	0	*0.00*	0	*0.00*	13	*33.85*	44	*114.56*	58	*151.01*
		C07.3-R	03-Oct-11	1000	1.70	6	*12.71*	1	*2.12*	0	*0.00*	107	*226.59*	46	*97.41*	160	*338.82*
		C07.4-L	03-Oct-11	754	1.00	5	*23.87*	0	*0.00*	0	*0.00*	0	*0.00*	185	*883.29*	190	*907.16*
	Session 1 Summary			**1298**	**10.32**	**118**	***31.70***	**19**	***5.10***	**58**	***15.58***	**820**	***220.32***	**704**	***189.15***	**1719**	***461.86***
	2	C00.0-R	07-Oct-11	874	0.89	1	*4.63*	1	*4.63*	3	*13.88*	6	*27.77*	2	*9.26*	13	*60.17*
		C00.7-L	07-Oct-11	629	0.51	5	*56.11*	22	*246.89*	2	*22.44*	5	*56.11*	5	*56.11*	39	*437.67*
		C01.3-L	07-Oct-11	2239	1.60	12	*12.06*	11	*11.05*	31	*31.15*	21	*21.10*	44	*44.22*	119	*119.58*
		C02.8-L	08-Oct-11	1035	0.88	5	*19.76*	4	*15.81*	80	*316.21*	25	*98.81*	88	*347.83*	202	*798.42*
		C03.6-L	08-Oct-11	2800	2.09	30	*18.46*	0	*0.00*	66	*40.60*	46	*28.30*	240	*147.64*	382	*235.00*
		C04.6-R	08-Oct-11	846	0.52	0	*0.00*	0	*0.00*	0	*0.00*	1	*8.18*	58	*474.63*	59	*482.82*
		C05.6-L	08-Oct-11	1220	1.10	21	*56.33*	0	*0.00*	0	*0.00*	10	*26.83*	64	*171.68*	95	*254.84*
		C07.3-R	09-Oct-11	1004	1.67	1	*2.15*	0	*0.00*	0	*0.00*	2000	*4294.20*	10	*21.47*	2011	*4317.82*
		C07.4-L	09-Oct-11	966	1.00	5	*18.63*	0	*0.00*	0	*0.00*	15	*55.90*	215	*801.24*	235	*875.78*
	Session 2 Summary			**1290**	**10.26**	**80**	***21.75***	**38**	***10.33***	**182**	***49.49***	**2129**	***578.93***	**726**	***197.42***	**3155**	***857.93***
	3	C00.0-R	15-Oct-11	1297	0.94	2	*5.91*	2	*5.91*	3000	*8858.41*	6	*17.72*	4	*11.81*	3014	*8899.75*
		C00.7-L	15-Oct-11	903	0.59	2	*13.51*	13	*87.84*	90	*608.14*	365	*2466.36*	17	*114.87*	487	*3290.73*
		C01.3-L	15-Oct-11	2633	1.60	42	*35.89*	24	*20.51*	61	*52.13*	215	*183.73*	159	*135.87*	501	*428.12*
		C02.8-L	15-Oct-11	1131	0.88	5	*18.09*	5	*18.09*	15	*54.26*	150	*542.56*	60	*217.02*	235	*850.01*
		C03.6-L	16-Oct-11	3300	2.09	58	*30.27*	2	*1.04*	50	*26.10*	612	*319.44*	186	*97.09*	908	*473.95*
		C04.6-R	16-Oct-11	676	0.52	0	*0.00*	0	*0.00*	0	*0.00*	6	*61.45*	20	*204.82*	26	*266.27*
		C05.6-L	16-Oct-11	1513	1.10	48	*103.83*	0	*0.00*	100	*216.31*	384	*830.62*	98	*211.98*	630	*1362.74*
		C07.3-R	16-Oct-11	1036	1.70	3	*6.13*	0	*0.00*	20	*40.88*	35	*71.54*	220	*449.69*	278	*568.25*
		C07.4-L	17-Oct-11	1108	1.00	20	*64.98*	0	*0.00*	5	*16.25*	400	*1299.64*	98	*318.41*	523	*1699.28*
	Session 3 Summary			**1511**	**10.42**	**180**	***41.16***	**46**	***10.52***	**3341**	***764.03***	**2173**	***496.93***	**862**	***197.12***	**6602**	***1509.77***
	4	C00.0-R	21-Oct-11	1050	0.94	1	*3.65*	4	*14.59*	15	*54.71*	27	*98.48*	3	*10.94*	50	*182.37*
		C00.7-L	21-Oct-11	704	0.54	6	*56.82*	8	*75.76*	18	*170.45*	94	*890.15*	11	*104.17*	137	*1297.35*
		C01.3-L	21-Oct-11	2255	1.60	9	*8.98*	32	*31.93*	18	*17.96*	138	*137.69*	73	*72.84*	270	*269.40*
		C02.8-L	21-Oct-11	1183	0.88	4	*13.83*	1	*3.46*	15	*51.87*	175	*605.16*	62	*214.40*	257	*888.73*
		C03.6-L	22-Oct-11	2866	2.09	29	*17.43*	4	*2.40*	13	*7.81*	415	*249.42*	88	*52.89*	549	*329.95*
		C04.6-R	22-Oct-11	795	0.52	0	*0.00*	0	*0.00*	15	*130.62*	12	*104.50*	36	*313.50*	63	*548.62*
		C05.6-L	22-Oct-11	1380	1.10	21	*49.80*	0	*0.00*	0	*0.00*	54	*128.06*	48	*113.83*	123	*291.70*
		C07.3-R	24-Oct-11	902	1.69	3	*7.08*	0	*0.00*	0	*0.00*	31	*73.21*	13	*30.70*	47	*111.00*
		C07.4-L	24-Oct-11	1042	1.00	0	*0.00*	0	*0.00*	0	*0.00*	10	*34.55*	152	*525.14*	162	*559.69*
	Session 4 Summary			**1353**	**10.36**	**73**	***18.75***	**49**	***12.58***	**94**	***24.14***	**956**	***245.53***	**486**	***124.82***	**1658**	***425.82***
	5	C00.0-R	28-Oct-11	1113	0.92	0	*0.00*	1	*3.52*	250	*878.94*	3	*10.55*	1	*3.52*	255	*896.52*
		C00.7-L	28-Oct-11	760	0.59	0	*0.00*	3	*24.09*	4	*32.11*	40	*321.14*	2	*16.06*	49	*393.40*
		C01.3-L	28-Oct-11	1998	1.60	3	*3.38*	22	*24.77*	20	*22.52*	193	*217.34*	60	*67.57*	298	*335.59*
		C02.8-L	28-Oct-11	835	0.88	2	*9.80*	3	*14.70*	5	*24.50*	17	*83.29*	28	*137.18*	55	*269.46*
		C03.6-L	28-Oct-11	2625	2.09	4	*2.62*	3	*1.97*	4	*2.62*	73	*47.90*	64	*42.00*	148	*97.12*
		C04.6-R	29-Oct-11	767	0.52	0	*0.00*	0	*0.00*	2	*18.05*	4	*36.10*	32	*288.84*	38	*342.99*
		C05.6-L	29-Oct-11	1268	1.10	8	*20.65*	4	*10.32*	5	*12.91*	50	*129.05*	46	*118.73*	113	*291.65*
		C07.3-R	31-Oct-11	1020	1.70	2	*4.15*	0	*0.00*	0	*0.00*	250	*519.03*	18	*37.37*	270	*560.55*
		C07.4-L	30-Oct-11	821	1.00	1	*4.38*	0	*0.00*	0	*0.00*	7	*30.69*	333	*1460.17*	341	*1495.25*
	Session 5 Summary			**1245**	**10.40**	**20**	***5.56***	**36**	***10.01***	**290**	***80.62***	**637**	***177.08***	**584**	***162.34***	**1567**	***435.60***
Columbia River U/S Section Total All Samples				**60279**	**51.76**	**471**		**188**		**3965**		**6715**		**3362**		**14701**	
Columbia River U/S Section Average All Samples				**1340**	**1.15**	**10**	***24.46***	**4**	***9.76***	**88**	***205.87***	**149**	***348.66***	**75**	***174.56***	**327**	***763.31***
Columbia River U/S Section Standard Error of Mean						**2.36**	***5.49***	**1.10**	***5.93***	**66.49**	***196.78***	**47.07**	***111.30***	**11.27**	***40.72***	**78.28**	***217.88***
Kootenay River																	
	1	K00.3-L	02-Oct-11	208	0.44	3	*118.01*	0	*0.00*	0	*0.00*	0	*0.00*	14	*550.70*	17	*668.71*
		K00.6-R	02-Oct-11	445	0.60	1	*13.48*	0	*0.00*	0	*0.00*	0	*0.00*	69	*930.34*	70	*943.82*
		K01.8-L	02-Oct-11	1438	1.85	24	*32.48*	0	*0.00*	1	*1.35*	83	*112.32*	57	*77.13*	165	*223.28*
		K01.8-R	02-Oct-11	1052	1.30	5	*13.16*	1	*2.63*	1	*2.63*	0	*0.00*	0	*0.00*	7	*18.43*
	Session 1 Summary			**786**	**4.19**	**33**	***36.08***	**1**	***1.09***	**2**	***2.19***	**83**	***90.76***	**140**	***153.08***	**259**	***283.21***
	2	K00.3-L	09-Oct-11	227	0.44	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	1	*36.04*	1	*36.04*
		K00.6-R	09-Oct-11	510	0.60	1	*11.76*	0	*0.00*	0	*0.00*	0	*0.00*	15	*176.47*	16	*188.24*
		K01.8-L	08-Oct-11	1407	1.87	6	*8.21*	0	*0.00*	0	*0.00*	102	*139.56*	19	*26.00*	127	*173.77*
		K01.8-R	08-Oct-11	996	1.30	2	*5.56*	0	*0.00*	0	*0.00*	0	*0.00*	19	*52.83*	21	*58.39*
	Session 2 Summary			**785**	**4.21**	**9**	***9.80***	**0**	***0.00***	**0**	***0.00***	**102**	***111.11***	**54**	***58.82***	**165**	***179.74***
	3	K00.3-L	16-Oct-11	223	0.44	0	*0.00*	0	*0.00*	0	*0.00*	4	*146.76*	5	*183.45*	9	*330.21*
		K00.6-R	16-Oct-11	561	0.60	20	*213.90*	0	*0.00*	25	*267.38*	121	*1294.12*	96	*1026.74*	262	*2802.14*
		K01.8-L	16-Oct-11	1669	1.87	19	*21.92*	0	*0.00*	49	*56.52*	566	*652.86*	6	*6.92*	640	*738.22*
		K01.8-R	16-Oct-11	1358	1.30	56	*114.20*	0	*0.00*	30	*61.18*	138	*281.41*	56	*114.20*	280	*570.98*
	Session 3 Summary			**953**	**4.21**	**95**	***85.26***	**0**	***0.00***	**104**	***93.34***	**829**	***744.04***	**163**	***146.29***	**1191**	***1068.94***
	4	K00.3-L	23-Oct-11	261	0.44	0	*0.00*	0	*0.00*	0	*0.00*	3	*94.04*	8	*250.78*	11	*344.83*
		K00.6-R	23-Oct-11	580	0.60	2	*20.69*	1	*10.34*	0	*0.00*	42	*434.48*	159	*1644.83*	204	*2110.34*
		K01.8-L	23-Oct-11	1767	1.87	8	*8.72*	0	*0.00*	0	*0.00*	256	*278.91*	16	*17.43*	280	*305.06*
		K01.8-R	23-Oct-11	1272	1.30	6	*13.06*	1	*2.18*	9	*19.59*	308	*670.54*	2	*4.35*	326	*709.72*
	Session 4 Summary			**970**	**4.21**	**16**	***14.10***	**2**	***1.76***	**9**	***7.93***	**609**	***536.87***	**185**	***163.09***	**821**	***723.76***
	5	K00.3-L	30-Oct-11	272	0.44	0	*0.00*	0	*0.00*	0	*0.00*	9	*270.72*	2	*60.16*	11	*330.88*
		K00.6-R	30-Oct-11	611	0.60	3	*29.46*	0	*0.00*	5	*49.10*	38	*373.16*	151	*1482.82*	197	*1934.53*
		K01.8-L	30-Oct-11	1481	1.87	1	*1.30*	0	*0.00*	0	*0.00*	152	*197.58*	9	*11.70*	162	*210.58*
		K01.8-R	30-Oct-11	1406	1.30	1	*1.97*	0	*0.00*	0	*0.00*	101	*198.93*	9	*17.73*	111	*218.62*
	Session 5 Summary			**943**	**4.21**	**5**	***4.54***	**0**	***0.00***	**5**	***4.54***	**300**	***272.18***	**171**	***155.14***	**481**	***436.40***
Kootenay River Section Total All Samples				**17744**	**21.03**	**158**		**3**		**120**		**1923**		**713**		**2917**	
Kootenay River Section Average All Samples				**887**	**1.05**	**8**	***30.49***	**0**	***0.58***	**6**	***23.15***	**96**	***371.04***	**36**	***137.57***	**146**	***562.83***
Kootenay River Section Standard Error of Mean						**3.00**	***12.21***	**0.08**	***0.53***	**2.95**	***13.65***	**31.77**	***71.20***	**10.85**	***115.37***	**35.71**	***170.61***

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	28-Sep-11	1751	2.73	0	0.00	0	0.00	18	13.56	125	94.14	48	36.15	191	143.84
		C27.6-R	28-Sep-11	383	0.61	0	0.00	0	0.00	0	0.00	1	15.41	0	0.00	1	15.41
		C28.2-R	28-Sep-11	782	1.13	4	16.30	1	4.07	2	8.15	301	1226.26	41	167.03	349	1421.81
		C34.9-L	26-Sep-11	2008	2.14	4	3.35	0	0.00	2	1.68	15	12.57	13	10.89	34	28.48
		C36.6-L	26-Sep-11	1558	2.39	1	0.97	0	0.00	12	11.60	59	57.04	14	13.54	86	83.14
		C47.8-L	29-Sep-11	1042	1.44	8	19.19	0	0.00	0	0.00	215	515.83	33	79.17	256	614.20
		C48.2-R	27-Sep-11	1034	1.01	0	0.00	0	0.00	0	0.00	1	3.45	28	96.52	29	99.97
		C49.0-L	29-Sep-11	571	0.93	0	0.00	0	0.00	0	0.00	50	338.96	35	237.27	85	576.24
		C49.0-R	27-Sep-11	671	0.72	0	0.00	0	0.00	14	104.32	155	1154.99	13	96.87	182	1356.18
		C49.8-L	29-Sep-11	1851	2.45	5	3.97	0	0.00	45	35.72	350	277.84	112	88.91	512	406.44
		C49.8-R	28-Sep-11	1816	2.39	4	3.32	0	0.00	20	16.59	2260	1874.55	47	38.98	2331	1933.44
		C52.2-L	30-Sep-11	821	0.89	0	0.00	0	0.00	0	0.00	0	0.00	1	4.93	1	4.93
		C52.2-R	28-Sep-11	2505	3.79	0	0.00	0	0.00	0	0.00	501	189.97	18	6.83	519	196.80
		C52.8-L	30-Sep-11	616	0.89	0	0.00	0	0.00	0	0.00	29	190.43	0	0.00	29	190.43
		C53.6-L	30-Sep-11	1044	1.72	0	0.00	0	0.00	0	0.00	30	60.14	49	98.24	79	158.38
	Session 1 Summary			**1230**	**25.23**	**26**	**3.02**	**1**	**0.12**	**113**	**13.11**	**4092**	**474.62**	**452**	**52.43**	**4684**	**543.28**
	2	C25.3-R	06-Oct-11	1624	2.73	1	0.81	0	0.00	0	0.00	10	8.12	23	18.68	34	27.61
		C27.6-R	06-Oct-11	442	0.61	5	66.76	0	0.00	0	0.00	0	0.00	0	0.00	5	66.76
		C28.2-R	06-Oct-11	465	1.13	2	13.70	0	0.00	0	0.00	5	34.26	9	61.66	16	109.62
		C34.9-L	05-Oct-11	2004	2.14	1	0.84	0	0.00	1	0.84	57	47.85	11	9.23	70	58.76
		C36.6-L	05-Oct-11	1432	2.39	26	27.35	0	0.00	1	1.05	30	31.56	16	16.83	73	76.79
		C47.8-L	03-Oct-11	1178	1.44	1	2.12	0	0.00	0	0.00	46	97.62	27	57.30	74	157.05
		C48.2-R	04-Oct-11	747	1.01	5	23.86	0	0.00	0	0.00	20	95.43	38	181.32	63	300.61
		C49.0-L	03-Oct-11	566	0.93	0	0.00	0	0.00	0	0.00	525	3590.56	16	109.43	541	3699.99
		C49.0-R	04-Oct-11	559	0.72	0	0.00	0	0.00	0	0.00	45	402.50	3	26.83	48	429.34
		C49.8-L	03-Oct-11	1833	2.45	1	0.80	0	0.00	25	20.04	2050	1643.34	41	32.87	2117	1697.05
		C49.8-R	04-Oct-11	1479	2.39	0	0.00	0	0.00	0	0.00	161	163.97	5	5.09	166	169.06
		C52.2-L	04-Oct-11	922	0.89	0	0.00	0	0.00	0	0.00	102	447.49	12	52.65	114	500.13
		C52.2-R	05-Oct-11	2206	3.79	0	0.00	0	0.00	0	0.00	0	0.00	1	0.43	1	0.43
		C52.8-L	04-Oct-11	486	0.89	0	0.00	0	0.00	0	0.00	0	0.00	4	33.29	4	33.29
		C53.6-L	04-Oct-11	1082	1.72	0	0.00	0	0.00	0	0.00	75	145.08	3	5.80	78	150.88
	Session 2 Summary			**1135**	**25.23**	**42**	**5.28**	**0**	**0.00**	**27**	**3.39**	**3126**	**392.99**	**209**	**26.27**	**3404**	**427.94**
	3	C25.3-R	14-Oct-11	1935	2.73	0	0.00	0	0.00	15	10.22	67	45.66	41	27.94	123	83.82
		C27.6-R	14-Oct-11	370	0.61	1	15.95	0	0.00	0	0.00	5	79.75	2	31.90	8	127.60
		C28.2-R	14-Oct-11	943	1.13	0	0.00	0	0.00	5	16.89	80	270.27	54	182.43	139	469.60
		C34.9-L	13-Oct-11	2335	2.12	1	0.73	0	0.00	85	61.82	645	469.07	7	5.09	738	536.71
		C36.6-L	13-Oct-11	1804	2.39	9	7.51	0	0.00	20	16.70	525	438.36	28	23.38	582	485.95
		C47.8-L	11-Oct-11	1159	1.44	1	2.16	0	0.00	31	66.87	830	1790.34	29	62.55	893	1926.23
		C48.2-R	12-Oct-11	602	1.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
		C49.0-L	11-Oct-11	593	0.93	0	0.00	0	0.00	0	0.00	315	2056.25	30	195.83	345	2252.08
		C49.0-R	12-Oct-11	692	0.72	0	0.00	0	0.00	20	144.51	37	267.34	76	549.13	133	960.98
		C49.8-L	11-Oct-11	1952	2.45	11	8.28	0	0.00	35	26.35	1800	1354.97	46	34.63	1893	1424.97
		C49.8-R	12-Oct-11	2268	2.39	0	0.00	0	0.00	15	9.96	302	200.57	11	7.31	328	217.84
		C52.2-L	11-Oct-11	946	0.89	1	4.28	0	0.00	0	0.00	114	487.45	2	8.55	117	500.27
		C52.2-R	12-Oct-11	2475	3.79	0	0.00	0	0.00	2	0.77	14	5.37	9	3.45	25	9.59
		C52.8-L	12-Oct-11	719	0.89	1	5.63	0	0.00	0	0.00	73	410.68	21	118.14	95	534.45
		C53.6-L	12-Oct-11	1274	1.72	0	0.00	0	0.00	0	0.00	80	131.43	34	55.86	114	187.29
	Session 3 Summary			**1338**	**25.21**	**25**	**2.67**	**0**	**0.00**	**228**	**24.34**	**4887**	**521.65**	**390**	**41.63**	**5533**	**590.61**
	4	C25.3-R	22-Oct-11	1847	2.73	3	2.14	0	0.00	20	14.28	128	91.39	104	74.25	255	182.06
		C27.6-R	22-Oct-11	432	0.61	0	0.00	0	0.00	0	0.00	3	40.98	2	27.32	5	68.31
		C28.2-R	22-Oct-11	854	1.13	1	3.73	0	0.00	0	0.00	215	802.06	25	93.26	241	899.05
		C34.9-L	20-Oct-11	2217	2.14	1	0.76	0	0.00	0	0.00	131	99.40	26	19.73	158	119.89
		C36.6-L	20-Oct-11	1697	2.39	20	17.75	0	0.00	12	10.65	335	297.35	46	40.83	413	366.58
		C47.8-L	18-Oct-11	1193	1.44	0	0.00	0	0.00	0	0.00	552	1156.75	4	8.38	556	1165.13
		C48.2-R	19-Oct-11	715	1.01	0	0.00	0	0.00	0	0.00	25	124.63	45	224.33	70	348.96
		C49.0-L	18-Oct-11	554	0.93	0	0.00	0	0.00	0	0.00	45	314.43	43	300.45	88	614.88
		C49.0-R	19-Oct-11	686	0.72	10	72.89	0	0.00	0	0.00	20	145.77	30	218.66	60	437.32
		C49.8-L	19-Oct-11	1847	2.45	0	0.00	0	0.00	0	0.00	70	55.69	17	13.52	87	69.21
		C49.8-R	19-Oct-11	1397	2.39	1	1.08	0	0.00	0	0.00	1150	1239.96	35	37.74	1186	1278.77
		C52.2-L	18-Oct-11	933	0.89	0	0.00	0	0.00	0	0.00	0	0.00	7	30.35	7	30.35
		C52.2-R	19-Oct-11	2477	3.79	1	0.38	0	0.00	0	0.00	760	291.44	78	29.91	839	321.74
		C53.6-L	18-Oct-11	1103	1.72	0	0.00	0	0.00	0	0.00	10	18.98	22	41.75	32	60.72
	Session 4 Summary			**1282**	**24.34**	**37**	**4.27**	**0**	**0.00**	**32**	**3.69**	**3444**	**397.25**	**484**	**55.83**	**3997**	**461.03**
	5	C25.3-R	29-Oct-11	1819	2.63	0	0.00	0	0.00	25	18.81	75	56.44	19	14.30	119	89.55
		C27.6-R	29-Oct-11	402	0.61	0	0.00	0	0.00	0	0.00	27	396.38	0	0.00	27	396.38
		C28.2-R	29-Oct-11	927	1.13	2	6.87	0	0.00	0	0.00	36	123.72	1	3.44	39	134.03
		C34.9-L	25-Oct-11	2286	2.14	0	0.00	0	0.00	0	0.00	136	100.08	1	0.74	137	100.82
		C36.6-L	25-Oct-11	1663	2.39	0	0.00	0	0.00	5	4.53	402	364.11	0	0.00	407	368.64
		C47.8-L	26-Oct-11	1294	1.44	1	1.93	0	0.00	22	42.50	641	1238.41	52	100.46	716	1383.31
		C48.2-R	27-Oct-11	827	1.01	0	0.00	0	0.00	15	64.65	16	68.96	100	431.00	131	564.61
		C49.0-L	26-Oct-11	542	0.93	0	0.00	0	0.00	0	0.00	750	5356.51	11	78.56	761	5435.07
		C49.0-R	27-Oct-11	781	0.72	0	0.00	0	0.00	24	153.65	43	275.29	10	64.02	77	492.96
		C49.8-L	26-Oct-11	1854	2.45	0	0.00	0	0.00	0	0.00	1503	1191.20	36	28.53	1539	1219.73
		C49.8-R	27-Oct-11	1471	2.39	0	0.00	0	0.00	30	30.72	462	473.08	7	7.17	499	510.97
		C52.2-L	27-Oct-11	957	0.89	0	0.00	0	0.00	15	63.40	65	274.73	40	169.07	120	507.20
		C52.2-R	27-Oct-11	2702	3.79	2	0.70	0	0.00	5	1.76	1021	358.92	49	17.23	1077	378.61
		C52.8-L	27-Oct-11	567	0.89	0	0.00	0	0.00	0	0.00	1	7.13	1	7.13	2	14.27
		C53.6-L	27-Oct-11	1296	1.72	0	0.00	0	0.00	0	0.00	27	43.60	12	19.38	39	62.98
	Session 5 Summary			**1293**	**25.13**	**5**	**0.55**	**0**	**0.00**	**141**	**15.63**	**5205**	**576.88**	**339**	**37.57**	**5690**	**630.64**
Columbia River D/S Section Total All Samples				**92885**	**125.14**	**135**		**1**		**541**		**20754**		**1874**		**23308**	
Columbia River D/S Section Average All Samples				**1255**	**1.69**	**2**	**3.09**	**0**	**0.02**	**7**	**12.40**	**280**	**475.66**	**25**	**42.95**	**315**	**534.19**
Columbia River D/S Section Standard Error of Mean						**0.50**	**1.44**	**0.01**	**0.06**	**1.61**	**3.50**	**54.95**	**98.39**	**2.91**	**11.35**	**56.43**	**100.29**
All Sections Total All Samples				**170908**	**197.93**	**764**		**192**		**4626**		**29392**		**5949**		**40926**	
All Sections Average All Samples				**1230**	**1.42**	**5**	**11.30**	**1**	**2.84**	**33**	**68.43**	**211**	**434.78**	**43**	**88.00**	**294**	**605.40**
All Sections Standard Error of Mean						**0.97**	**2.74**	**0.39**	**2.00**	**21.62**	**64.06**	**33.77**	**64.45**	**4.63**	**23.31**	**39.77**	**92.01**

[a] Excludes 3 dace species captured on 11 Oct 2011 (2 at Site C47.8-L and 1 at Site C49.8-L).

APPENDIX F

Life History Summaries

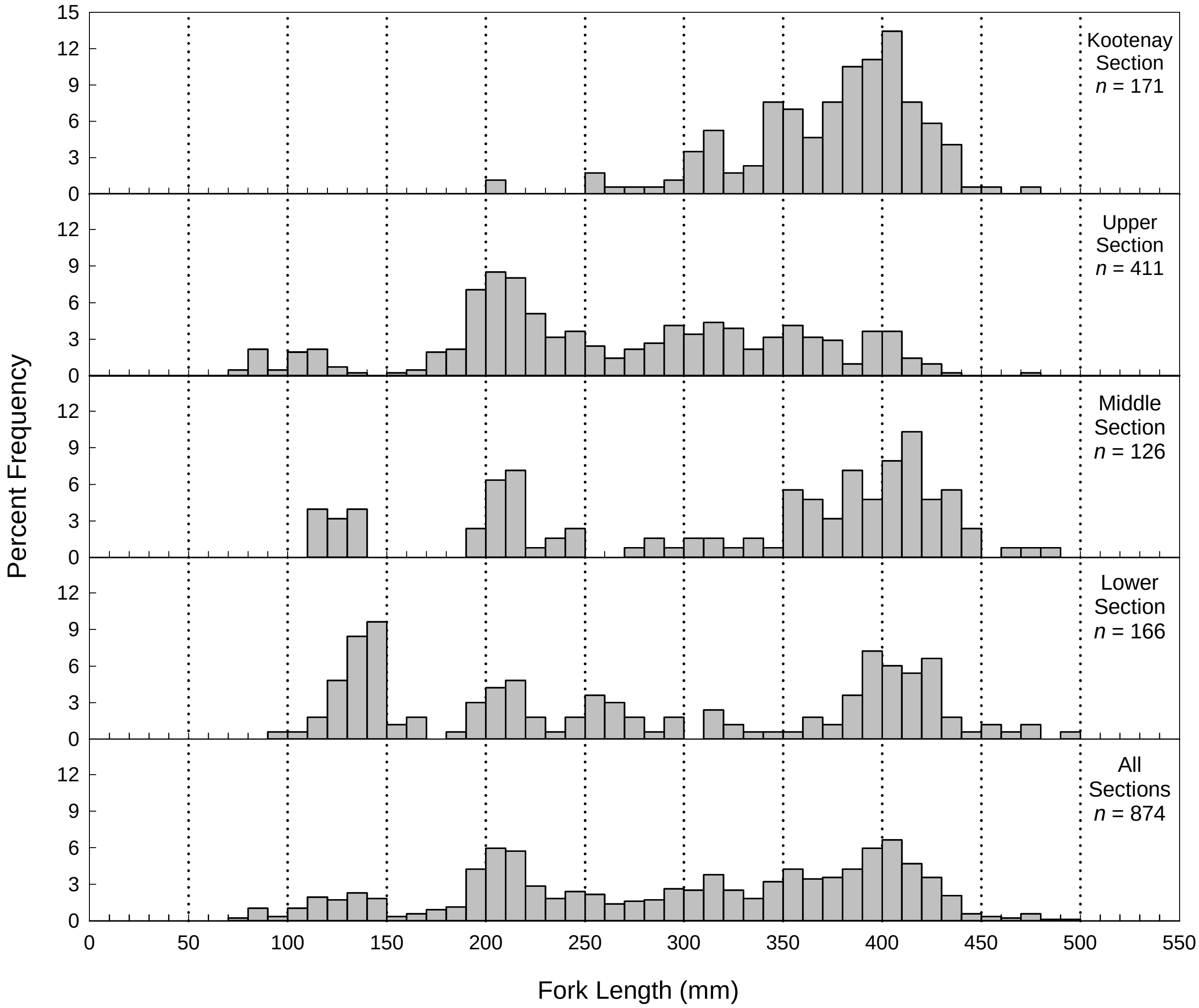


Figure F1 Length-frequency distributions for mountain whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, 26 September to 30 October 2011.

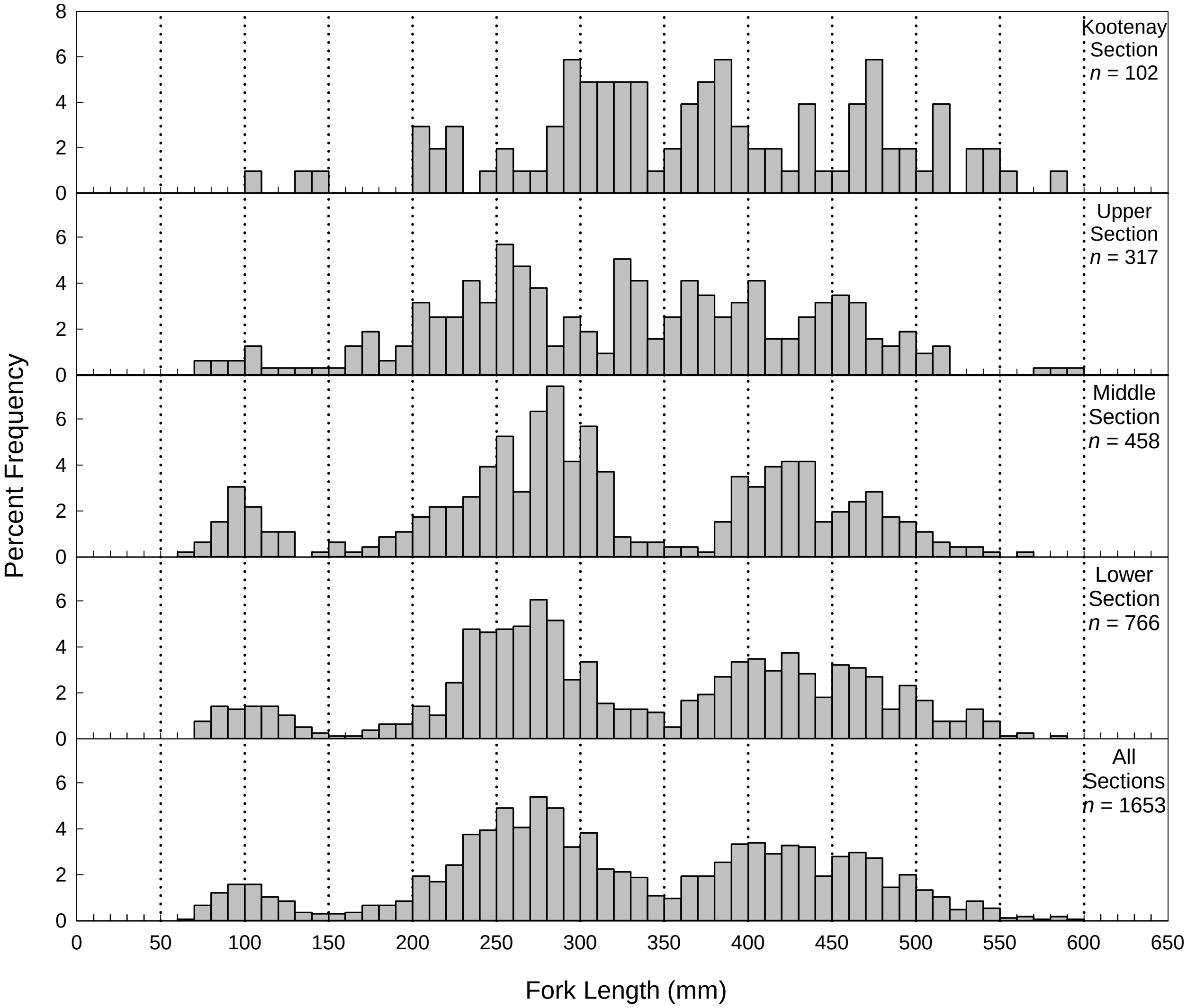


Figure F2 Length-frequency distributions for rainbow trout captured by boat electroshocking in sampled sections of the Lower Columbia River, 26 September to 30 October 2011.

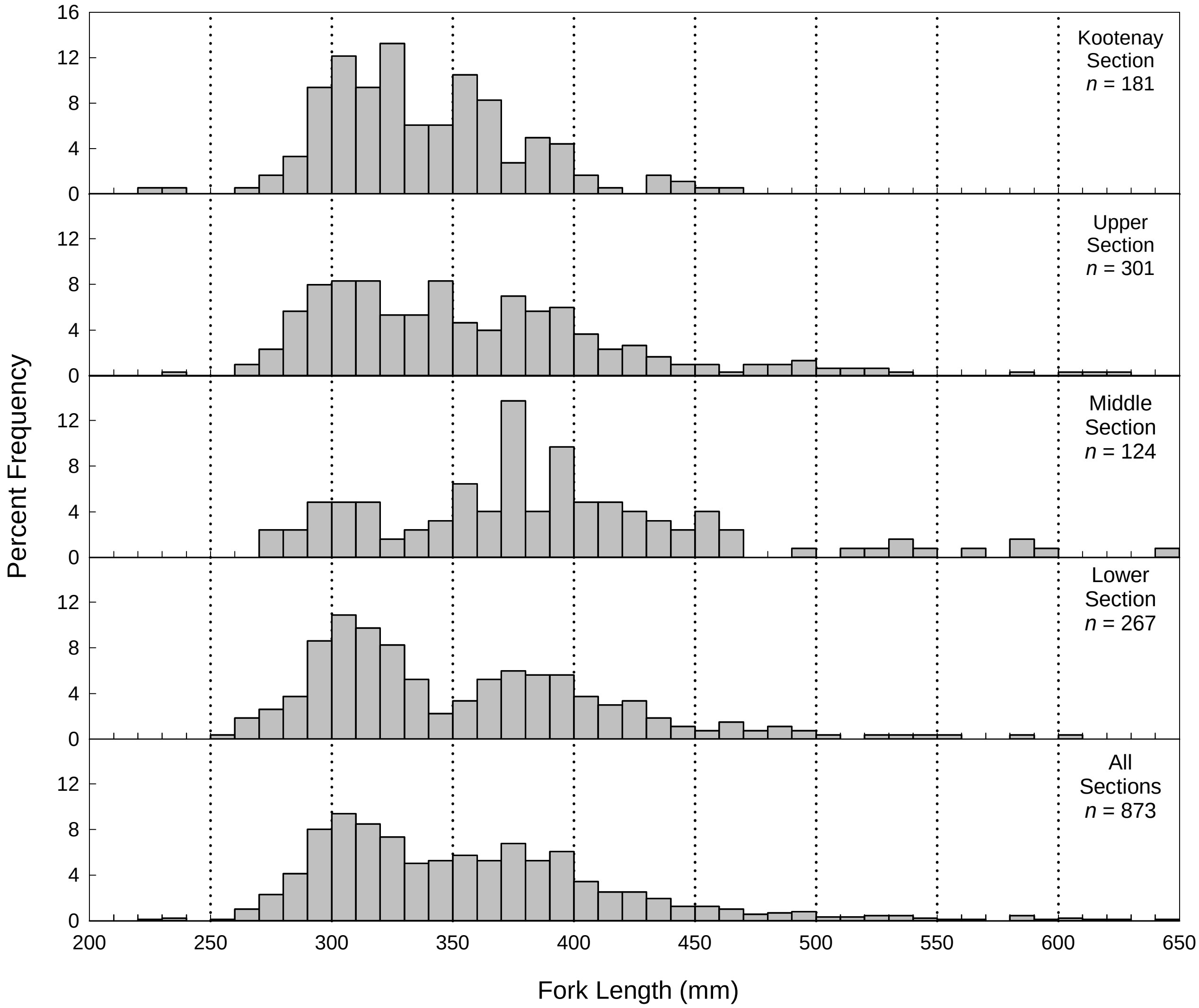
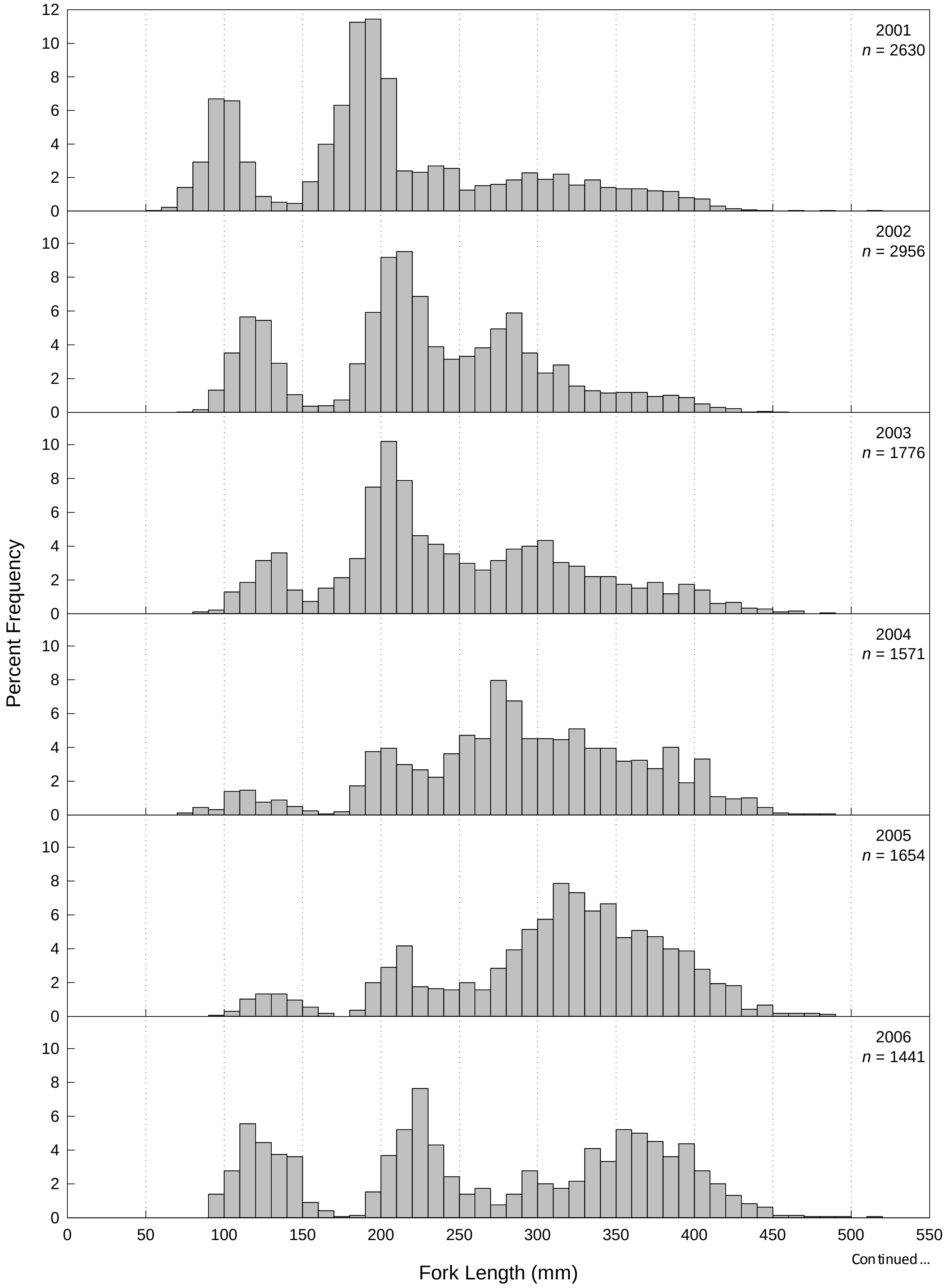


Figure F3 Length-frequency distributions for walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, 26 September to 30 October 2011.



Continued ...

Figure F4 Length-frequency distributions for mountain whitefish captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2011.

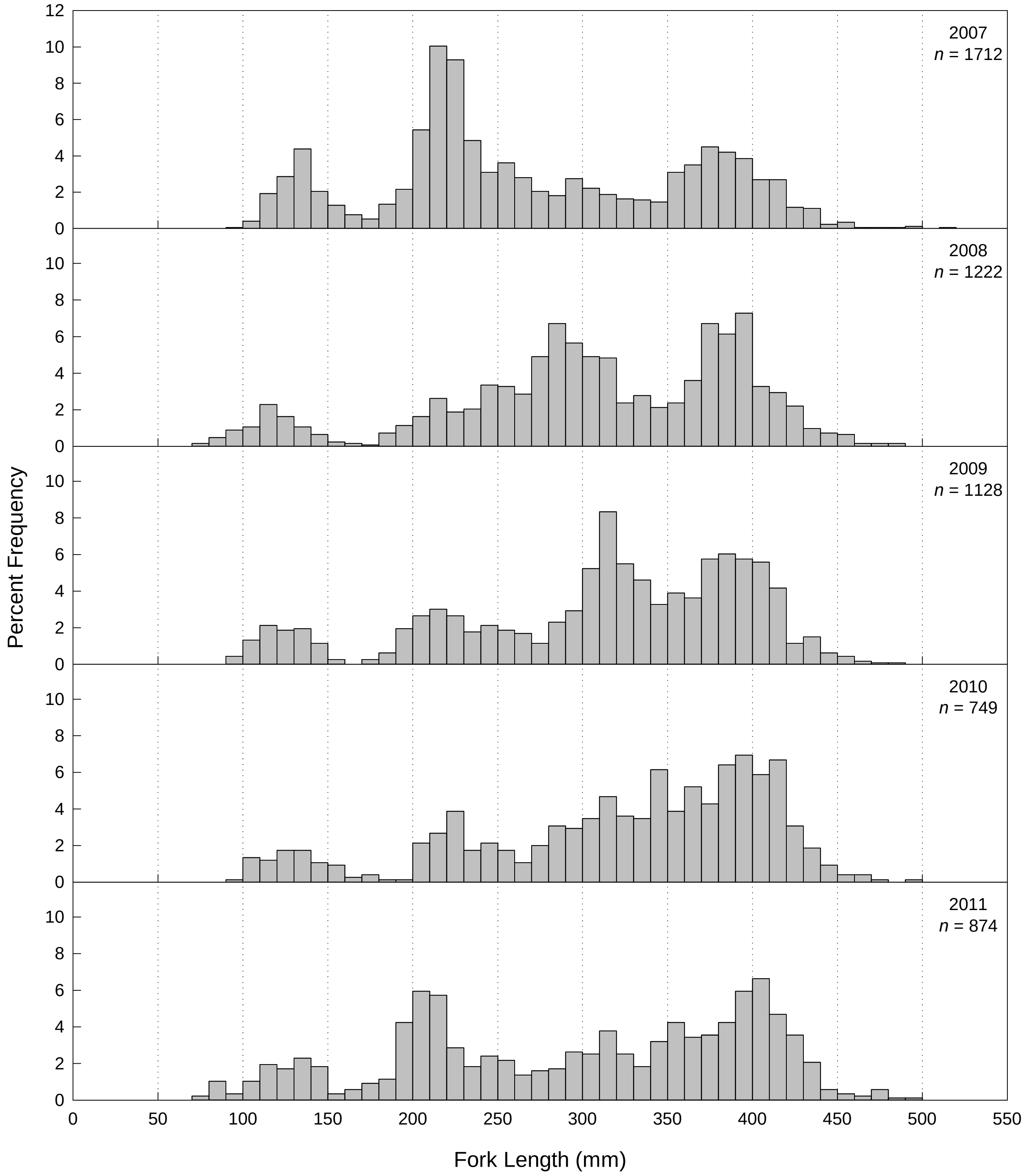


Figure F4 Concluded.

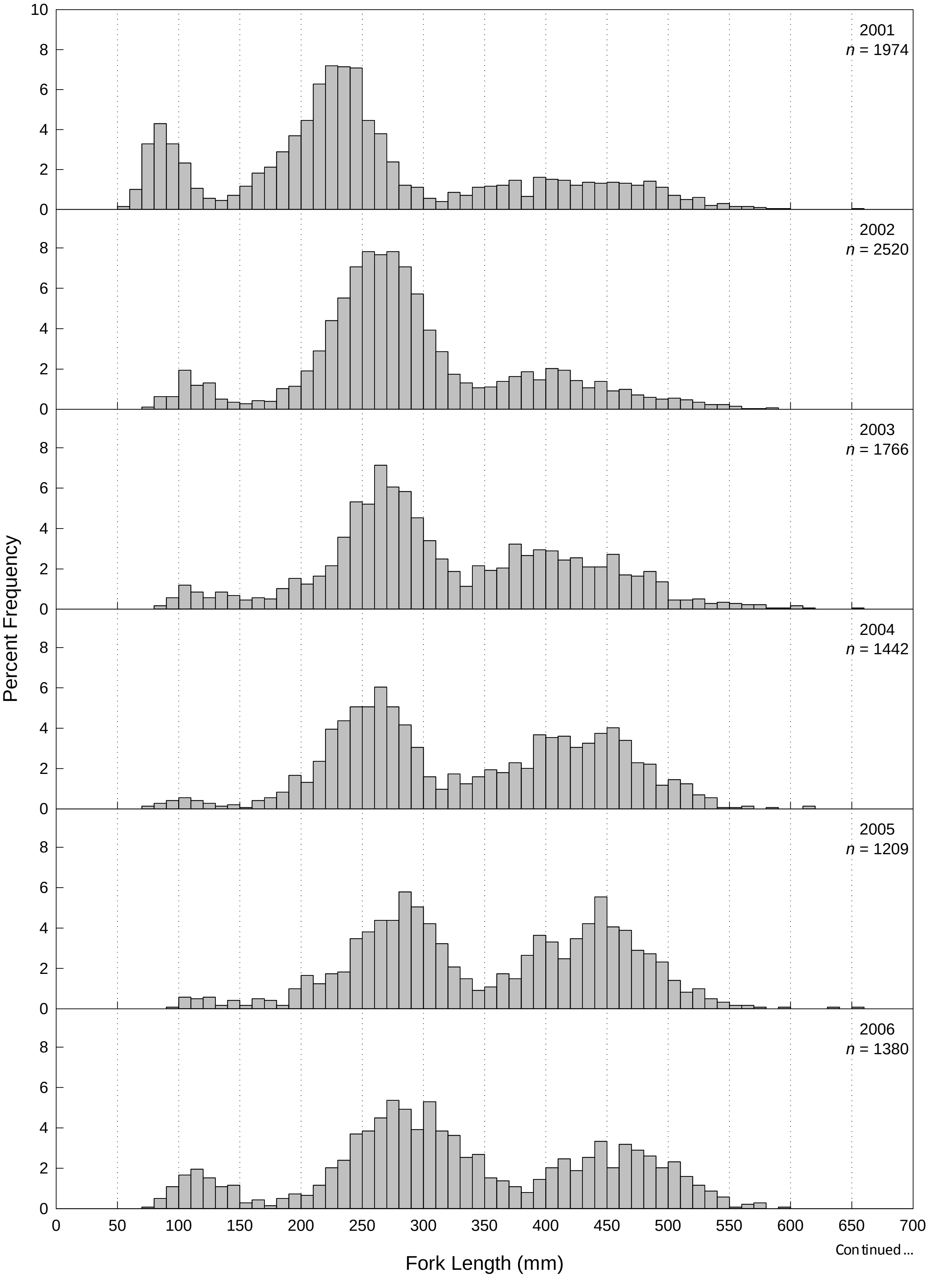


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Figure F5 Length-frequency distributions for rainbow trout captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2011.

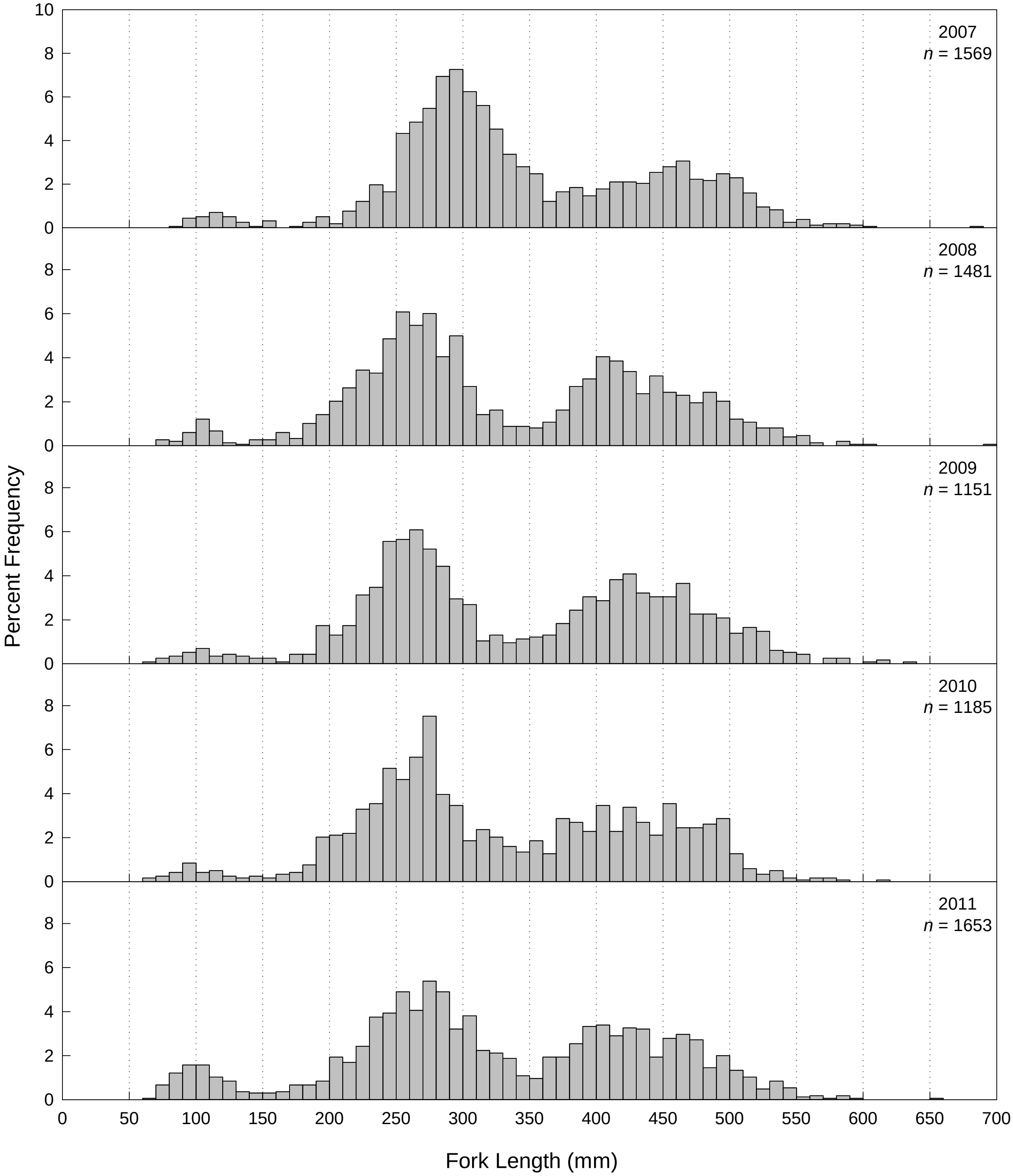

Figure F5 Concluded.

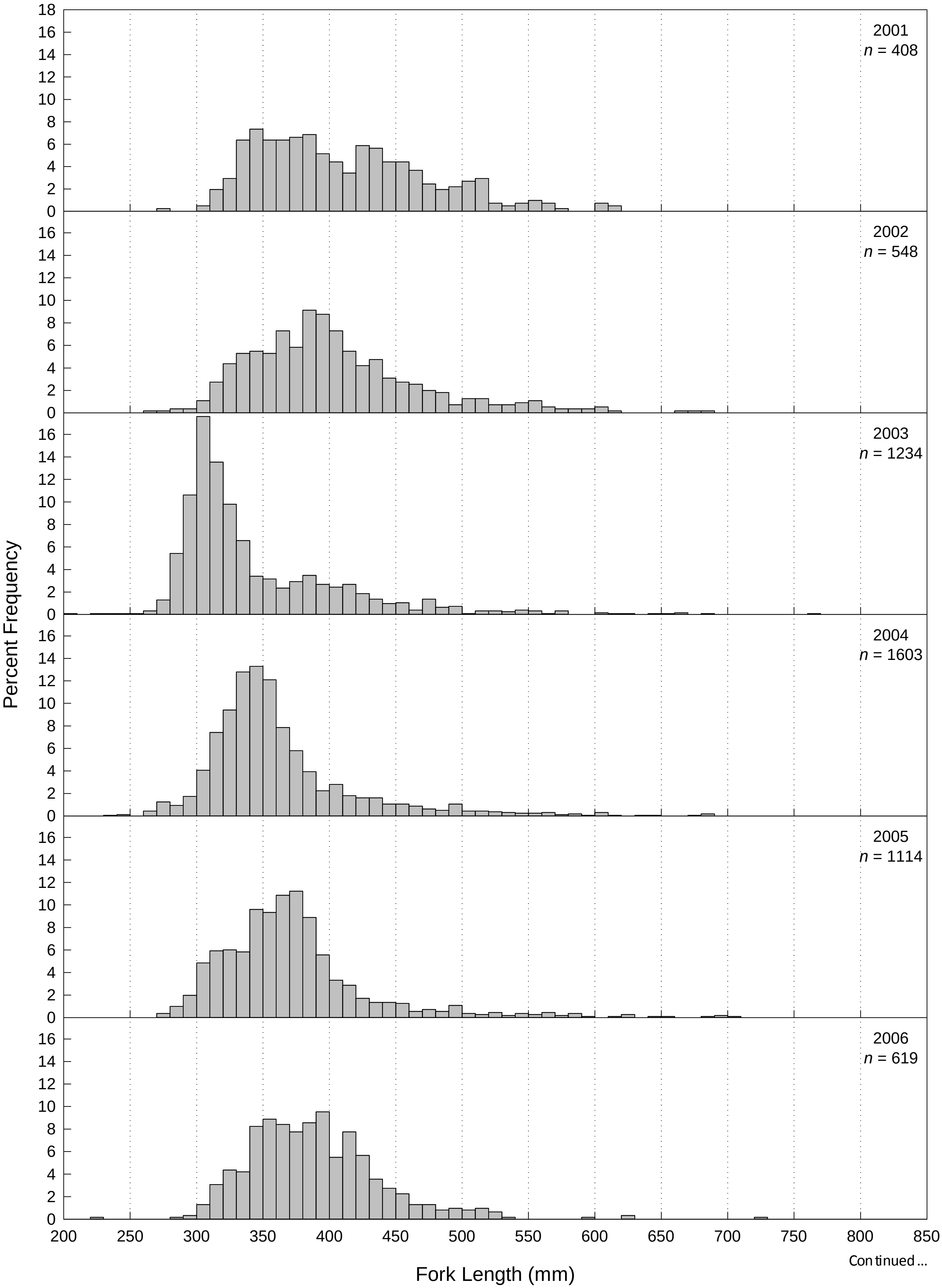

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Figure F6 Length-frequency distributions for walleye captured by boat electroshocking in sampled sections of the Lower Columbia River, 2001 to 2011.

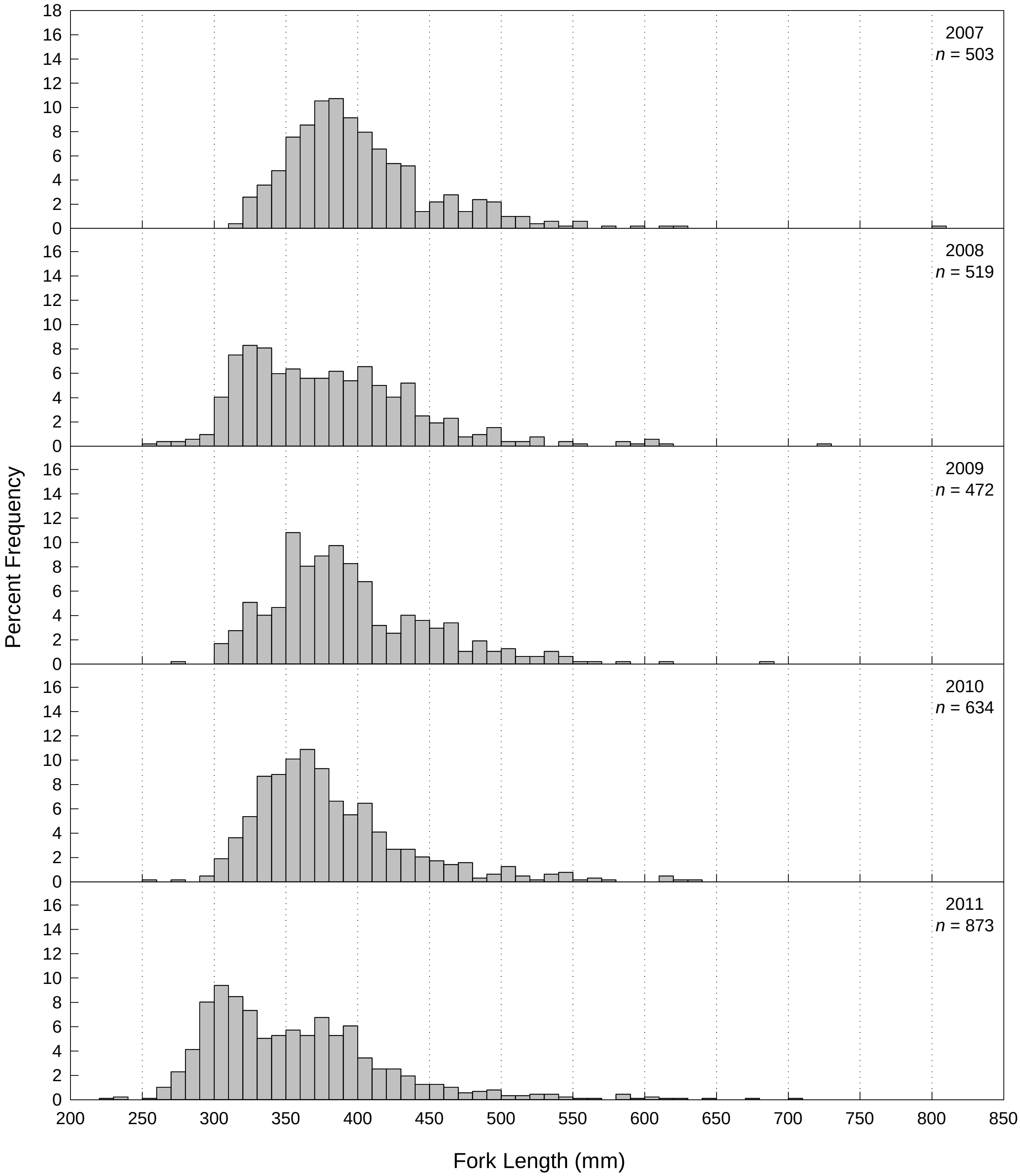

Figure F6 Concluded.

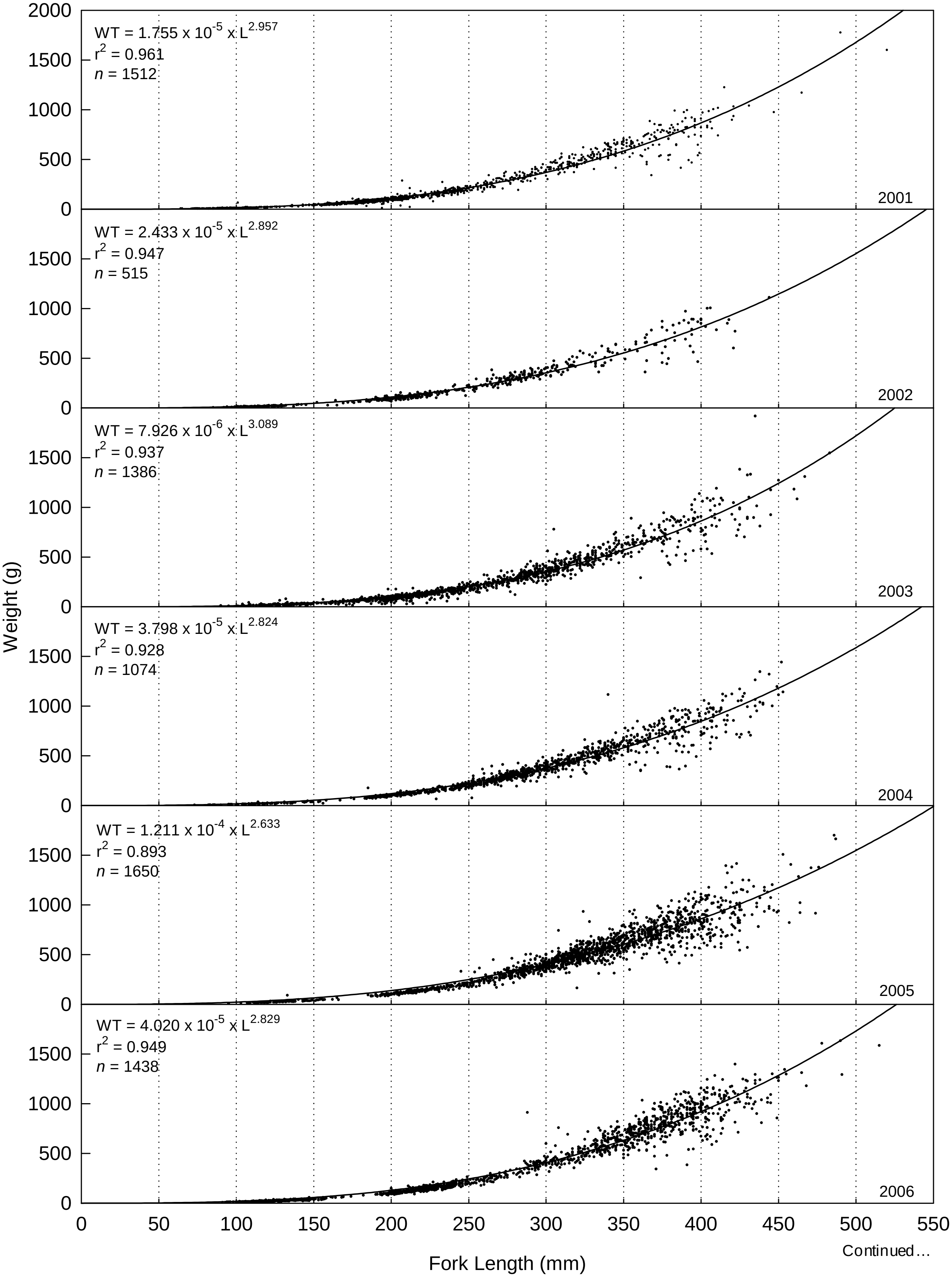

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Figure F7 Length-weight regressions for mountain whitefish captured by boat electroshocking in the Lower Columbia River, 2001 to 2011.

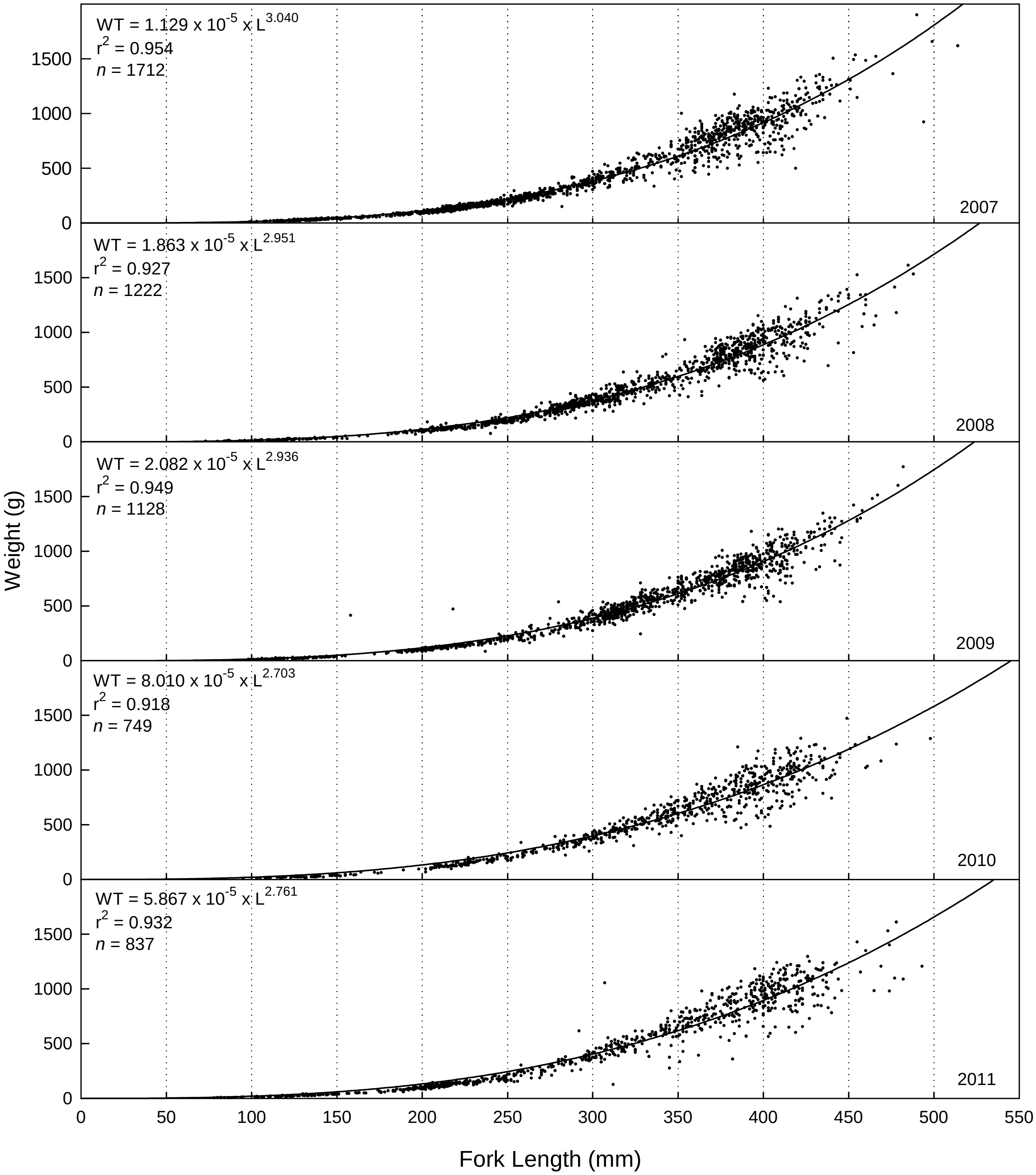

Figure F7 Concluded.

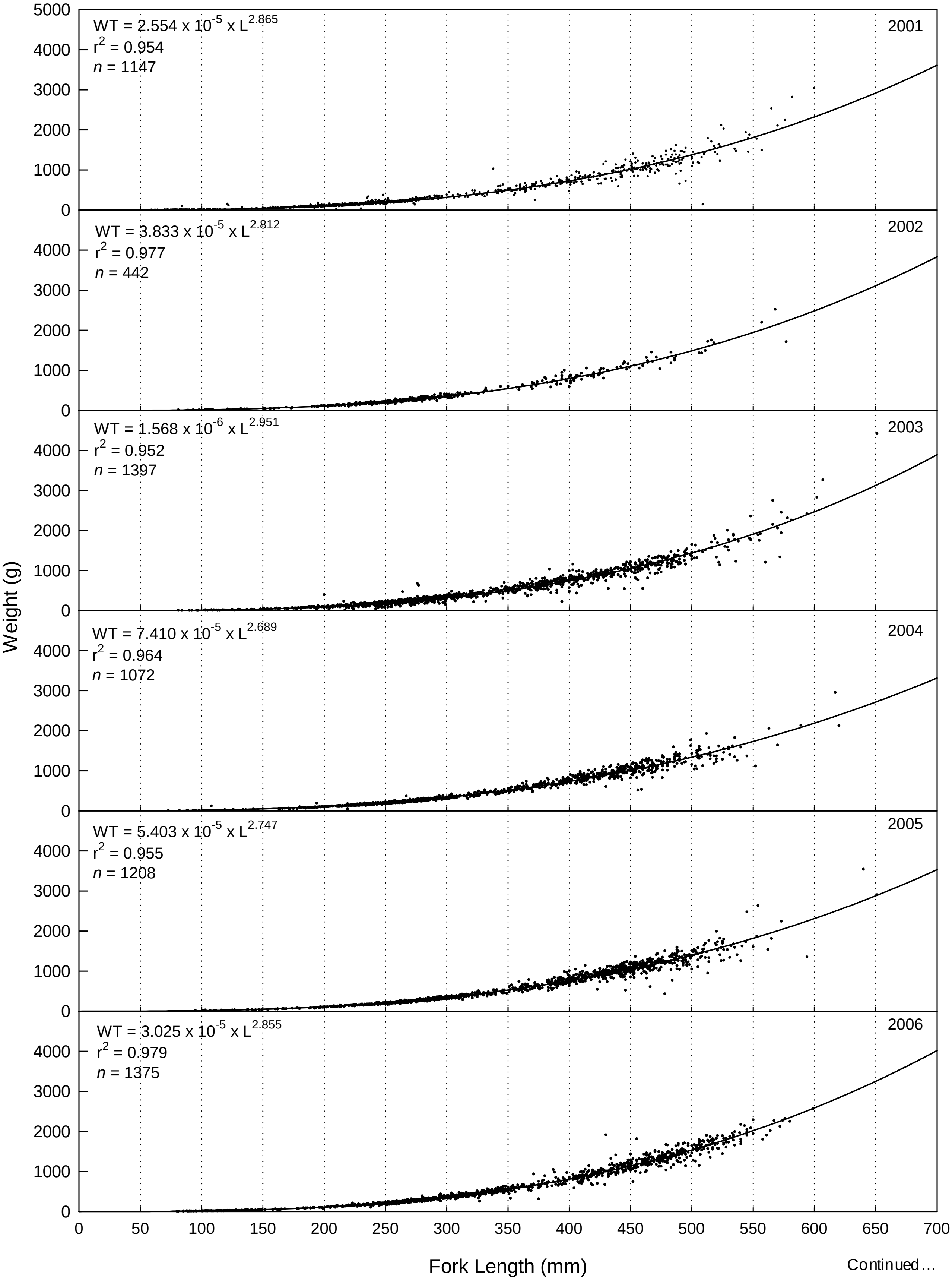

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Figure F8 Length-weight regressions for rainbow trout captured by boat electroshocking in the Lower Columbia River, 2001 to 2011.

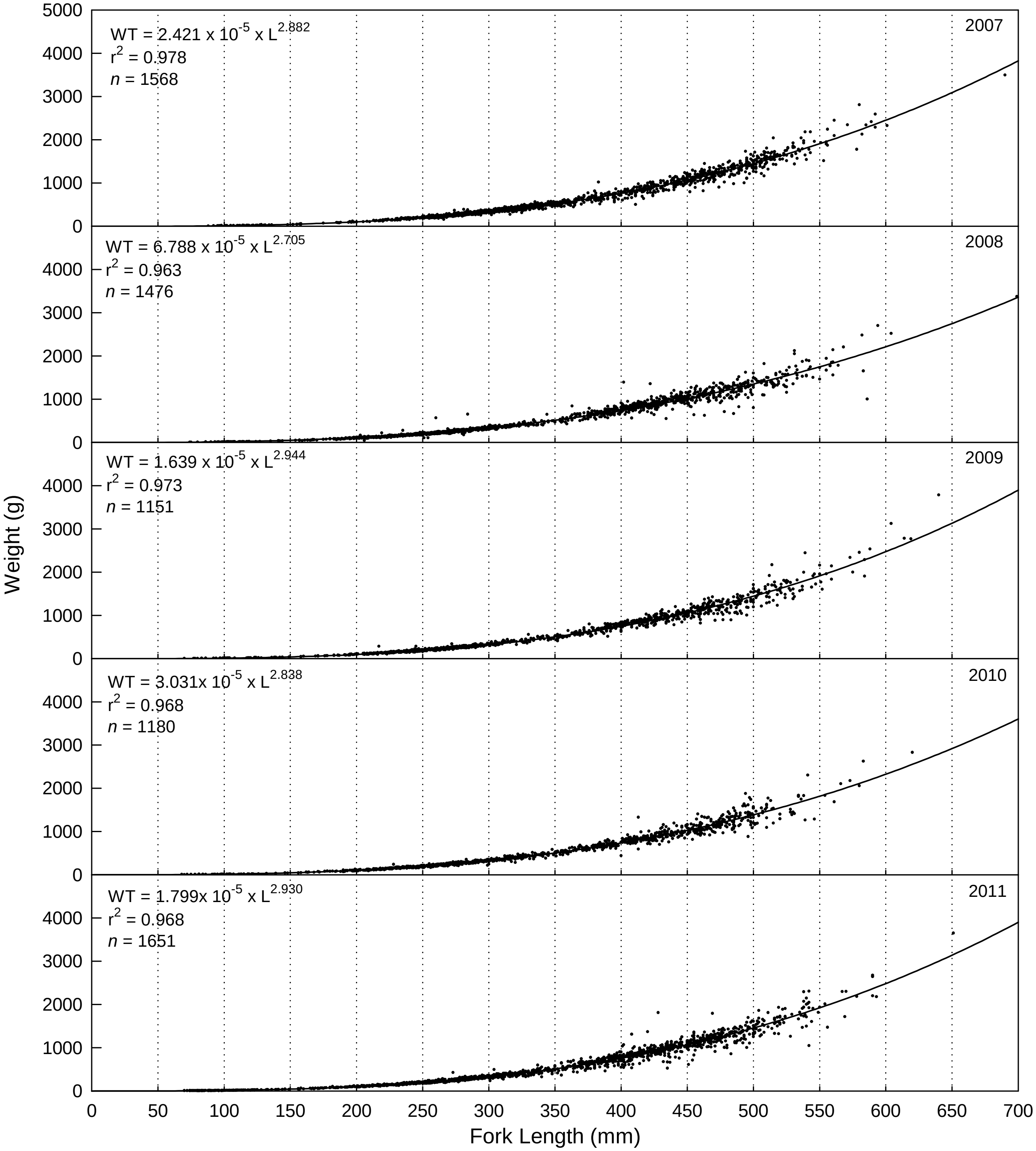

Figure F8 Concluded.

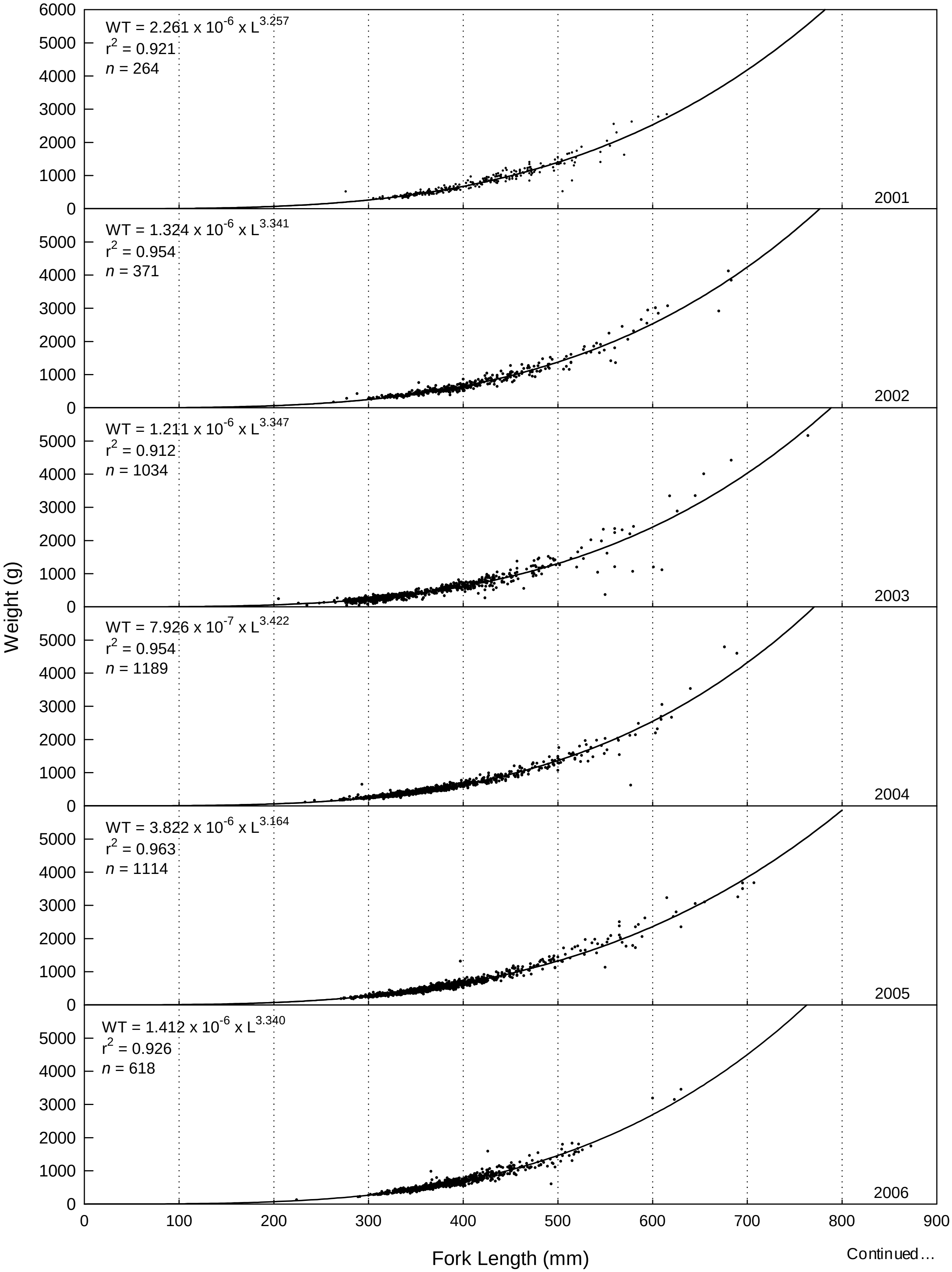

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Figure F9 Length-weight regressions for walleye captured by boat electroshocking in the Lower Columbia River, 2001 to 2011.

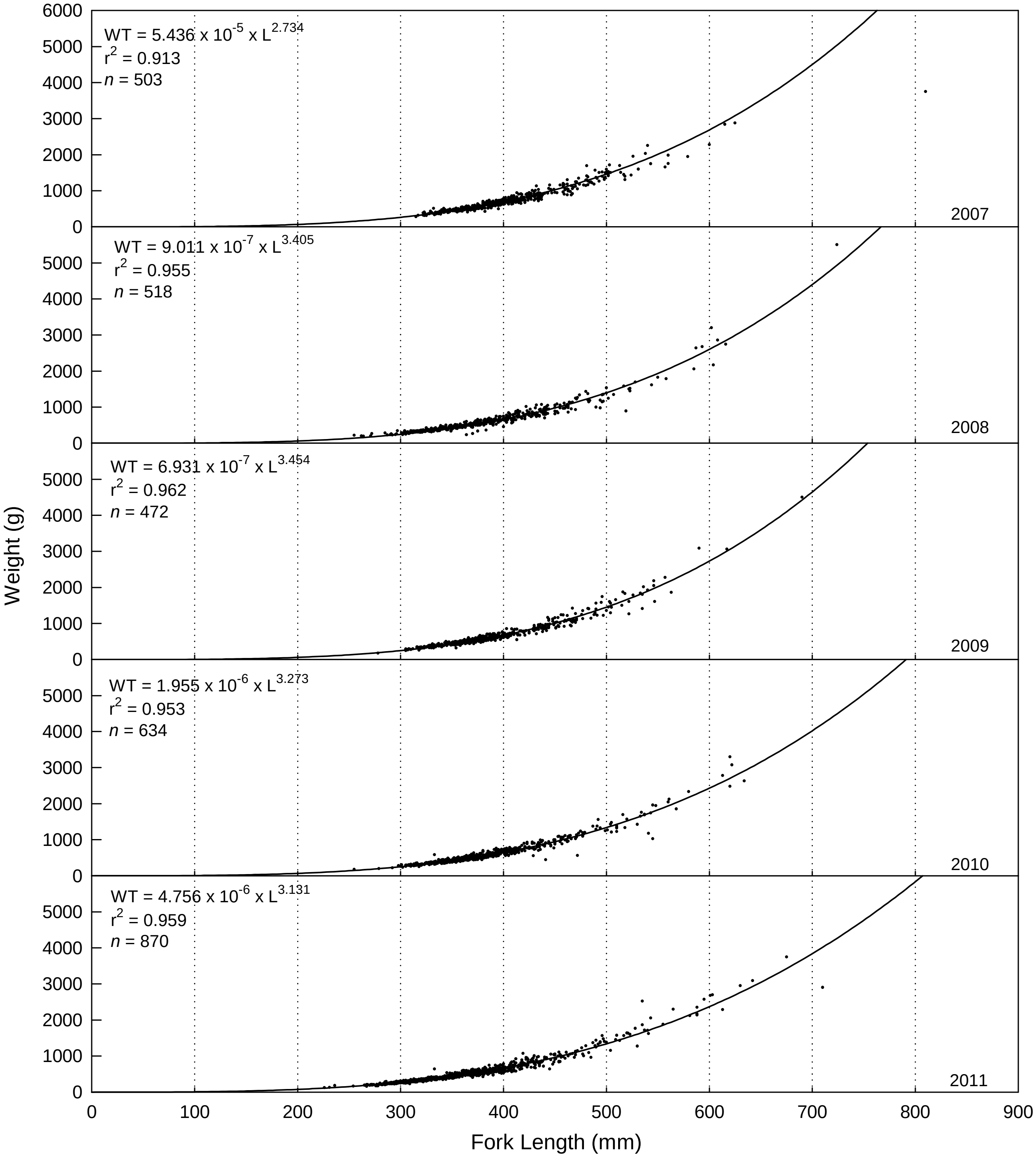

Figure F9 Concluded.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
201 Columbia Avenue
Castlegar, British Columbia, V1N 1A8
Canada
T: +1 (250) 365 0344