# Columbia River Project Water Use Plan

## Revelstoke Flow Management Plan

### Implementation Year 5

### Reference: CLBMON-16

### *Middle Columbia River Fish Population Indexing Program*

### Study Period: 2011

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**June 29, 2012**

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CLBMON-16

# Middle Columbia River Fish Population Indexing Surveys 2011 Investigations

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# Executive Summary

A year-round 142 $m^3$/s minimum flow release from Revelstoke Dam was implemented in December 2010 as part of BC Hydro's Water Use Plan for the Columbia River. The implementation of the minimum flow coincided with the commissioning of an additional generation unit at the dam (i.e., REV5). The key environmental objective of the minimum flow release is to increase the abundance and diversity of fish populations in the Middle Columbia River (MCR). In 2011, BC Hydro commissioned Year 5 of the MCR Fish Population Indexing Program, a 13-year study specifically designed to answer four key management questions:

- Is there a change in abundance of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in growth rate of adult life stages of the most common fish species using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in body condition (measured as a function of relative weight to length) of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in spatial distribution of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?

Data collected in Years 1 to 4 was used to provide a baseline against which changes from the flow release were identified and assessed. The study area for the program encompassed the approximately 12 km long portion of the unimpounded Columbia River between Revelstoke Dam and the Illecillewaet River confluence.

Field work was conducted in the spring and fall of 2011 and corresponded approximately to the timing of data collected during earlier years of the current program (i.e., 2007 to 2010) and to data collected between 2001 and 2006 as part of BC Hydro's Large River Fish Indexing Program (a similar program designed to monitor life history characters of fish populations in the MCR). Fish were sampled by boat electroshocking at night within nearshore habitats. All captured fish were measured for fork length and weighed. Select species were implanted with a Passive Integrated Transponder (PIT) tag for a mark-recapture study. Temporal and spatial variations in species richness, species diversity, abundance, spatial distribution, growth, and body condition were estimated using hierarchical Bayesian analyses (HBA).

Outputs from the analyses were precise enough to show both temporal and spatial trends/patterns in abundance, spatial distribution, growth, and body condition for some species. With each successive sample year, more life history and mark-recapture data will become available which will increase the precision of model estimates.

Length-at-age for the age-1 and age-2 mountain whitefish cohorts were significantly smaller in 2011 when compared to study years prior to the implementation of the minimum flow release and REV5 operation. Mountain whitefish body condition also was significantly lower in 2011 when compared to previous study years. Whether these changes were in response to the minimum flow release or REV5 operations remains uncertain.

Recommendations for 2012 include exploring the feasibility of operating REV5 for extended time periods without maintaining the minimum flow release (to provide insight into the effect of the minimum flow release versus the effect of higher peak daily discharges associated with REV5 on the downstream fish community) and inputting key parameters identified under other Revelstoke Flow Management Plan (RFMP) programs into the HBA's as explanatory variables.

**Keywords:** Inventory, Columbia River, Revelstoke Dam, Density Estimation, Hierarchical Bayesian Analysis

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# 1.0 INTRODUCTION

BC Hydro implemented a Water Use Plan (WUP; BC Hydro 2007) 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 a year-round 142 $m^3/s$ minimum flow release from Revelstoke Dam (REV; BC Hydro 2005). The key environmental objective of the minimum flow release is to increase the abundance and diversity of fish populations in the Middle Columbia River (MCR). Implementation of the minimum flow release coincided with the commissioning of a new and additional generating unit (REV5) at Revelstoke Dam on December 20, 2010.

The MCR includes the ~48 km long portion of the Columbia River from the outlet of REV downstream to Beaton Flats. Due to data gaps regarding the status of aquatic communities in the MCR, and uncertainty about the environmental benefits of a minimum flow release on the MCR ecosystem, the WUP CC recommended the development and implementation of the Revelstoke Flow Management Plan (RFMP). The RFMP is designed to measure the productivity of the MCR ecosystem in response to the minimum flow release, and includes a suite of studies, with each study designed to measure a specific aspect of the MCR ecosystem:

- CLBMON-15a – MCR Physical Habitat Monitoring;
- CLBMON-15b – MCR Ecological Productivity Monitoring;
- CLBMON-16 – MCR Fish Population Indexing Surveys;
- CLBMON-17 – MCR Juvenile Fish Habitat Use Assessment;
- CLBMON-18 – MCR Adult  Fish Habitat Use Assessment; and,
- CLBMON-53 – MCR Juvenile Fish Stranding Assessment.

The RFMP specified four years of adult fish monitoring prior to the implementation of the minimum flow release (i.e., 2007-2010). Prior to 2007, adult fish abundance and population structure were monitored in the MCR under the Large River Fish Indexing Program (Golder 2002, 2003, 2004a, 2005a, 2006, 2007). These data, coupled with four years of data collected as part of the RFMP (Golder 2008, 2009, 2010, Ford and Thorley 2011a), provide 10 years of data that will be used as a baseline to help determine the effect of the minimum flow release on adult fish in the MCR. Currently, nine years of study are scheduled after the implementation of the minimum flow release (i.e., 2011 to 2019). The present study year (2011) represents the first year of monitoring following the operation of REV5 and the implementation of the minimum flow (hereafter referred to as the flow regime change).

## 1.1 Study Objectives

The primary objective of the MCR Fish Population Indexing Study (CLBMON-16) is to systematically collect fish population data prior to and following the flow regime change to monitor changes in abundance, growth, diversity, and distribution of fish in the MCR. Secondary objectives of the program are:

- Build on earlier investigations to further refine the sampling strategy, sampling methodology, and analytical procedures required to establish a long-term monitoring program for fish populations in the MCR;
- Identify gaps in understanding, data, and current knowledge about fish populations; and,
- Provide recommendations for future monitoring.

## 1.2 Key Management Questions

Key management questions to be addressed by CLBMON-16 include:

- Is there a change in abundance of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in growth rate of adult life stages of the most common fish species using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in body condition (measured as a function of relative weight to length) of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in spatial distribution of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?

## 1.3 Management Hypotheses

Specific hypotheses to be tested under CLBMON-16 include:

- $Ho_1$: The implementation of a 142 $m^3$/s minimum flow release from Revelstoke Dam will not significantly affect the abundance and diversity of adult fish present in the MCR during index surveys.
- $Ho_2$: The implementation of a 142 $m^3$/s minimum flow release from Revelstoke Dam will not significantly affect the mean growth rate of adult fish present in the MCR during index surveys.
- $Ho_3$: The implementation of a 142 $m^3$/s minimum flow release from Revelstoke Dam will not significantly affect the body condition of adult fish present in the MCR during index surveys.
- $Ho_4$: The implementation of a 142 $m^3$/s minimum flow release from Revelstoke Dam will not significantly alter the distribution of fish present in the MCR during index surveys.

## 1.4 Background

Revelstoke Dam is located on the Columbia River approximately 8 km upstream from the Trans-Canada Highway bridge, which crosses the Columbia River at the City of Revelstoke (Figure 1). The dam and generation facility, brought into service in 1984, were constructed primarily to generate power, using the combined storage capacity of Revelstoke Reservoir and the upstream Kinbasket Reservoir (impounded by Mica Dam). REV was not constructed as one of the Columbia River Treaty dams [i.e., Mica, Hugh L. Keenleyside (HLK), Duncan, and Libby dams]; however, operation of REV is affected by both upstream (Mica Dam) and downstream (HLK Dam) treaty considerations. The Revelstoke Generating Station is the second largest powerplant in BC Hydro's hydroelectric power generation system, providing 21% of BC Hydro's total system capacity (http://www.bchydro.com/energy_in_bc/projects/revelstoke_unit_5.html).

REV is typically operated as a daily peaking plant with flow releases increasing through the daylight hours and peaking in the early evening (BC Hydro 1999). During periods of low power demand, flow through the generation units can be reduced to as low as 142 $m^3$/s (the minimum flow release). Periods of low flow can occur at any time, but mainly occur at night during the spring (March to May) and fall (September to November) when both water availability and electricity demands are typically lowest. Prior to the minimum flow release and the commissioning of REV5, discharge from REV could range from 0 to 1700 $m^3/s$. The installation of REV5 increased maximum discharge to 2124 $m^3/s$, an increase of 424 $m^3/s$. With the commissioning of REV5 (coupled with the minimum flow release), discharge from Revelstoke Dam can now range from 142 to 2124 $m^3/s$.

The quantity and quality of river habitat in the MCR is influenced both by flow releases from REV and by the operation of downstream Arrow Lakes Reservoir (ALR; impounded by HLK). As ALR fills, the length of flowing river in the MCR decreases. At full pool (EL 440 m), ALR backwatering influences the MCR up to the base of REV. Typically, ALR fills to near full pool by early July and is maintained at high pool levels until late November, at which time the reservoir is drafted for downstream power production and as a requirement for flood control during the following spring freshet period. Maximum reservoir elevation, and the duration at which it is maintained, varies annually based on climate conditions, Columbia River Treaty obligations, and/or operational needs. At the minimum reservoir elevation (EL 420 m), the section of flowing river downstream of REV extends for approximately 48 km (i.e., to Arrowhead). Therefore, the influence of the minimum flow release on the MCR ecosystem is expected to be greater during the winter and spring (when reservoir levels are lower) than during the summer and fall (when reservoir levels are higher).

## 1.5 Study Area

The study area for CLBMON-16 encompasses the 11.7 km long section of the Columbia River from the base of REV downstream to the confluence of the Illecillewaet River (Figure 1). The study area is differentiated into two reaches. Reach 4 extends from Revelstoke Dam (RKm 238.0; as measured upstream from the Canada-U.S. border) downstream to the Jordan River confluence (RKm 231.8). Reach 3 extends from the Jordan River confluence downstream to the Illecillewaet River confluence (RKm 226.3).

Reach 2 [the Illecillewaet River confluence to the Akolkolex River confluence (RKm 206.0)] was sampled as part of CLBMON-16 in 2007, 2008, and 2009. This reach has not been sampled since 2009, as it was deemed unlikely to be influenced by the minimum flow release. Sampling in Reach 2 was removed from the Terms of Reference in 2010.

In 2011, sample sites were located throughout Reaches 3 and 4 (similar to 2007, 2008, 2009, and 2010). Between 2001 and 2006 (i.e., prior to the WUP) sampling was limited to Reach 4 and the Big Eddy portion of Reach 3; the section of Reach 3 downstream of Big Eddy was not sampled during these years.

The locations of the eight sites sampled in Reach 4 and the seven sites sampled in Reach 3 in 2011 are illustrated in Appendix A, Figures A1 and A2, respectively. Site descriptions and UTM locations for all sites are listed in Appendix A, Table A1. Each site was sampled four times (i.e., four sessions) between May 30 and June 24 (spring) and four times between October 3 – 27, 2011 (fall; Table 1). Sites were sampled during the spring for the first time in 2011.

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

| Year | Season | Start Date | End Date | Number of Sessions | Duration (in days) |
|---|---|---|---|---|---|
| 2001 | Fall | 12 September | 11 October | 5 | 30 |
| 2002 | Fall | 22 October | 14 November | 4 | 24 |
| 2003 | Fall | 15 October | 30 October | 4 | 16 |
| 2004 | Fall | 13 October | 24 October | 4 | 12 |
| 2005 | Fall | 5 October | 25 October | 4 | 21 |
| 2006 | Fall | 2 October | 24 October | 4 | 23 |
| 2007 | Fall | 27 September | 24 October | 5 | 28 |
| 2008 | Fall | 23 September | 4 November | 5 | 43 |
| 2009 | Fall | 28 September | 30 October | 5 | 33 |
| 2010 | Fall | 4 October | 29 October | 4 | 26 |
| 2011 | Spring | 30 May | 24 June | 4 | 26 |
| 2011 | Fall | 3 October | 27 October | 4 | 25 |

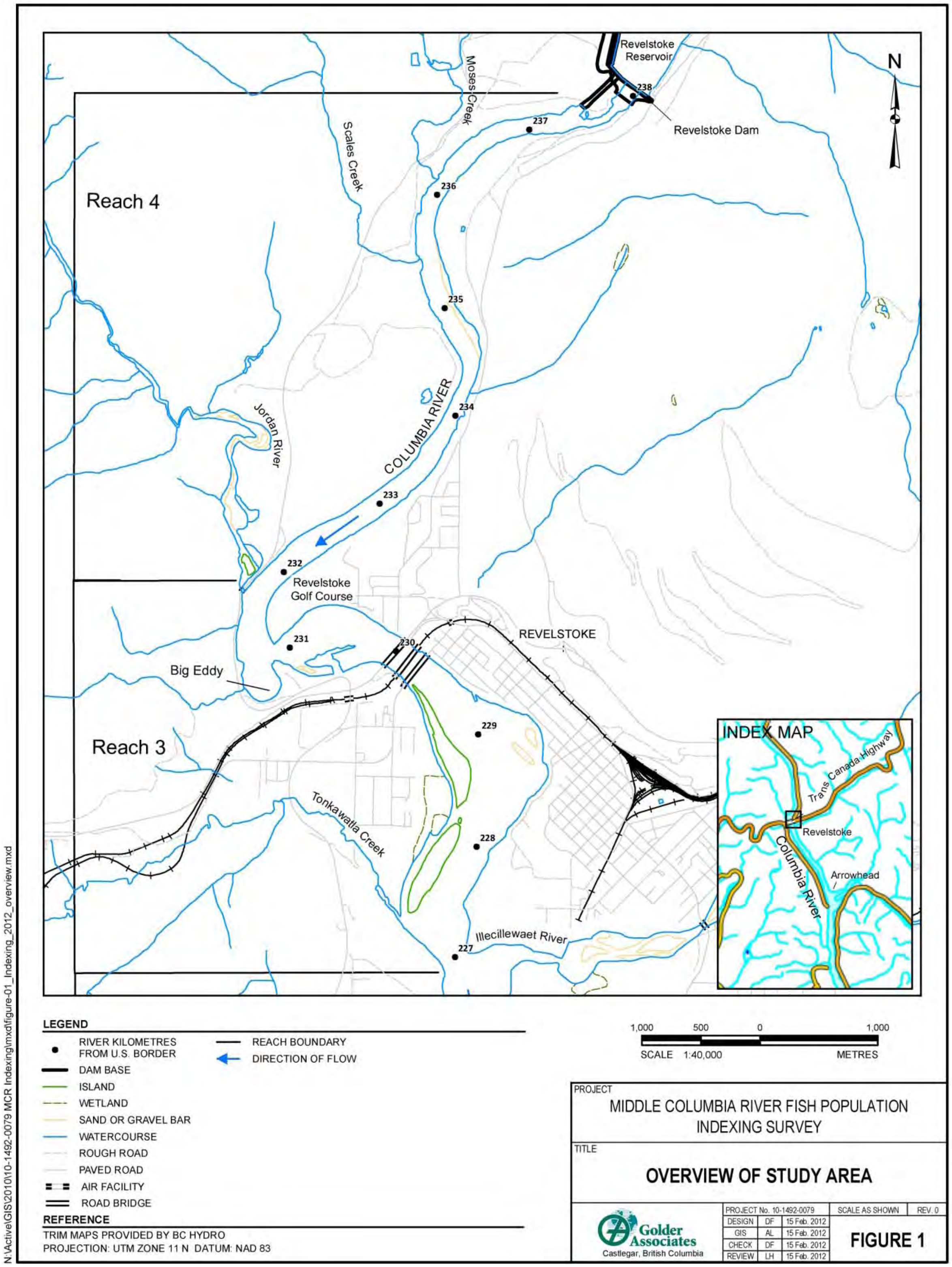


*Figure 1: Overview of the Middle Columbia River study area, 2011.*

# 2.0 METHODS

## 2.1 Data Collection

### 2.1.1 Discharge

Hourly average discharge data for the mainstem Columbia River (discharge through REV) were obtained from BC Hydro for January 1 to December 31, 2011. Discharges throughout this report are presented as cubic metres per second ($m^3/s$).

### 2.1.2 Water Elevation

Hourly water level elevation data for the mainstem Columbia River near Nakusp (RKm 132.2) were obtained from BC Hydro for January 1 to December 31, 2011. Water elevations throughout this report are presented as metres above sea level (masl).

### 2.1.3 Water Temperature

Water temperatures for the mainstem Columbia River were obtained from BC Hydro's Tailrace7 station (located approximately 7 km downstream of REV) and collected at hourly intervals from January 1 to December 31, 2011. These data were averaged daily. Spot measurements of water temperatures were obtained at all sample sites at the time of sampling using a hull-mounted Airmar® digital thermometer (accuracy ± 0.2°C).

### 2.1.4 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 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 was visually 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). 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. 1994, 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 fish counts.

**Table 2: List and description of habitat variables recorded at each sample site in the Middle Columbia River, 2011.**

| Variable | Description |
|---|---|
| Date | The date the site was sampled |
| Time | The time the site was sampled |
| Estimated Flow Category | A categorical ranking of Revelstoke Dam discharge (high; low; transitional) |
| Air Temperature | Air temperature at the time of sampling (to the nearest 1°C) |
| Water Temperature | Water temperature at the time of sampling (to the nearest 1°C) |
| Water 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 mean depth sampled (to the nearest 0.1 m) |
| Maximum Depth | The 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, 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 |

### 2.1.5 Fish Capture

Fish were captured between May 30 and June 24 (i.e., the spring season) and between October 3 – 27, 2011 (i.e., the fall season) using methods similar to previous years of the project (Golder 2002, 2003, 2004a, 2005a, 2006, 2007, 2008, 2009, 2010, Ford and Thorley 2011a).

Boat electroshocking was conducted in Reaches 3 and 4 of the study area to capture fish within nearshore habitats along the channel margins. Boat electroshocking employed a Smith-Root Inc. high-output Generator Powered Pulsator (GPP 5.0) electroshocker operated out of a 140 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 fish stunned by the electrical field. Captured fish were immediately sorted by the Bank Habitat Type they were captured in and placed into an onboard live-well. Fish that could be 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.

Kokanee (*Oncorhynchus nerka*), Redside Shiner (*Richardsonius balteatus*), and Sculpin (*Cottidae*; all species combined) were excluded from the mark-recapture component of the program. The abundance of Kokanee in the study area is highly variable and determined by recruitment processes outside of the study area and entrainment rates through REV. The distribution of Redside Shiner is generally limited to Big Eddy and the Centennial Park Boat Launch areas of Reach 3, limiting the effectiveness of a mark-recapture program for this species. Sculpin species are relatively common throughout the study area; however, they are difficult to capture during boat electroshocking operations and are more amenable to other shallow water sampling techniques. Sculpin species and Redside Shiner also are being studied as part of BC Hydro’s Middle Columbia River Juvenile Habitat Use Program (CLBMON-17; Triton 2009, 2010, 2011). For the above reasons, only 50 Kokanee, 50 Redside Shiner, and 50 Sculpin species were randomly captured and processed for life history data; subsequently, these species were enumerated by the netters and recorded as “observed”.

Boat electroshocking sites varied between 519 m and 2270 m in length. If, due to logistical reasons, a site could not be fully sampled (e.g., public too close to shore, other research activities in the area, wildlife swimming in the site, etc.) 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 subsequent analyses.

Amperage output was set at 1.9 A, at a frequency of 30 Hz direct current as these settings produce less electroshocking-induced injuries on Rainbow Trout (*Oncorhynchus mykiss*; Golder 2004b, 2005b). Although electrical output was 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 multiple times in one session, fish were released upstream after processing, approximately halfway through the site where they were captured when possible.

### 2.1.6 Safety Communications

The operation of REV as a daily peaking plant can result in rapid and unpredictable changes in dam discharges. Real-time dam discharge rate changes were monitored by field crews via text messages automatically sent from the BC Hydro flow operations monitoring computer to the field crew’s cell phone. These messages were sent when dam discharge either increased or decreased by 200 $m^3/s$ over a range of discharge levels from 200 to 1200 $m^3/s$. This real-time discharge information was essential for logistical planning and allowed the crew to maximize sampling effort during the period when discharge was sufficient to allow effective sampling. To prevent the boat and crew from being stranded in shallow water during periods of low flow, sampling efforts were typically terminated upon notification of a flow reduction to a level below 200 $m^3/s$. Following such an event, the boat was moved to the nearest boat launch and removed from the water.

### 2.1.7 Fish Processing

A site form was completed at the end of each sampled site. Site habitat conditions and observed fish were recorded before the start of fish processing for life history data (Table 3). Fish were measured for fork length (FL) or total length (depending on the species) 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 Middle Columbia River Fish Indexing Database (Attachment A) using a laptop computer. All fish sampled were automatically assigned a unique identifying number by the database that provided a method of cataloguing associated ageing structures.

**Table 3: List and description of variables recorded for each fish captured in the Middle 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 |
| Tag Scar | The presence of a scar from a previous tag application |
| 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 in |
| Comments | Any additional comments regarding the fish |

All fish (with the exception of Kokanee, Redside Shiner, and Sculpin species as detailed in Section 2.1.5) between 120 and 170 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 >170 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. 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 Middle Columbia River Fish Indexing Database.

During the 2001 to 2005 studies, fish were marked using T-bar anchor tags. 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 Cutthroat Trout (*Oncorhynchus clarki*), Brook Trout (*Salvelinus fontinalis*), Lake Whitefish (*Coregonus clupeaformis*), Mountain Whitefish (*Prosopium williamsoni*), Northern Pikeminnow

(*Ptychocheilus oregonensis*), Rainbow Trout, Redside Shiner, and Yellow Perch (*Perca flavescens*) in accordance with the methods outlined in Mackay et al. (1990). All scales were stored in appropriately labelled coin envelopes and air-dried before long-term storage. Scale samples were not aged during the current study, but were catalogued for potential future study (archived at BC Hydro in Revelstoke, BC).

## 2.2 Data Analyses

### 2.2.1 Data Compilation and Validation

Data were entered directly into the Middle Columbia River 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 Life Stage Assignment

Bull Trout (*Salvelinus confluentus*), Rainbow Trout, Mountain Whitefish, and Largescale Sucker (*Catostomus macrocheilus*) were assigned a life stage (i.e., fry, juvenile, or adult) based on the fork length values provided in Table 4. These values were derived from modal positions in length-frequency histograms for each species. Fry were excluded from all Hierarchical Bayesian Analyses (HBAs) except for the estimations of occupancy and apparent lineal density; these two analyses included observational data for which it was not always possible to reliably distinguish fry.

**Table 4: Fork length (mm) based life stage classifications used in hierarchical Bayesian analyses for fish captured in the Middle Columbia River, 2001 to 2011.**

| Species | Fry | Juvenile | Adult |
|---|---|---|---|
| Bull trout | <120 | 120 - 399 | ≥400 |
| Largescale sucker | - | <350 | ≥350 |
| Mountain whitefish | <120 (i.e., age-0) | 120 – 174 (i.e., age-1) | ≥175 (i.e., age-2+) |
| Rainbow trout | <120 | 120 - 249 | ≥250 |

### 2.2.3 Hierarchical Bayesian Analysis

Temporal and spatial variation in species richness and diversity, growth, body condition, abundance, and distribution were estimated using HBA. Unlike frequentist analysis, Bayesian analysis:

- Allows the incorporation of prior information;
- Does not depend on large sample sizes to ensure the validity of the estimates (Gazey and Staley 1986);
- Readily handles missing values; and,
- Provides a natural framework for hierarchical analysis (Link and Barker 2004).

Hierarchical analysis, in turn, allows temporal and spatial variation to be efficiently modeled using random effects as well as the separation of the parameters of biological interest from the parameters associated with data collection (Royle and Dorazio 2008). For example, the probability of observing a fish species can be broken into the probability of occupancy (the parameter of interest) and the observer efficiency (i.e., the probability of observing the species given that it is present).

HBAs were performed using the software package R 2.14.1 (R Development Core Team 2012) which interfaced with the Bayesian program JAGS 3.1.0 (Plummer 2003) using the rjags and runjags libraries. JAGS distributions and functions are defined in Table 5. In general, the HBAs assumed low information (Ntzoufras 2009), uniform, or normal prior distributions. The posterior distributions, which were estimated using Gibbs sampling (Ntzoufras 2009), were derived from 1500 Markov Chain Monte Carlo (MCMC) simulations thinned from the second halves of three MCMC chains of between $10^4$ and $10^6$ 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 primary parameters in the model (Gelman & Rubin 1992; Brooks & Gelman 1998; Gelman et al. 2004). The statistical significance of particular primary and derived parameters was assessed through the use of 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).

**Table 5: JAGS distributions and functions used in the hierarchical Bayesian analysis, 2011.**

| Distribution/Function | Definition | Description |
|---|---|---|
| $\text{dbern}(p)$ | $p^x(1-p)^{1-x}$ | Bernoulli distribution |
| $\text{dbin}(p,n)$ | $n!\,p^x(1-p)^{n-x}$ | Binomial distribution |
| $\text{dcat}(p[\,])$ | $p_x$ | Categorical distribution |
| $\text{ddirch}(a[\,])$ | $\Gamma(a)[\Pi_{i=1}^{K}\Gamma(a_i)]^{-1}\Pi_{i=1}^{K}x_i^{a_i-1}$ | Dirichlet distribution |
| $\text{dlnorm}(\mu,\tau)$ | $\sqrt{\tau/(2\pi)}\,x^{-1}\exp\left(-\tau/2(\log(x)-\mu)^2\right)$ | Log-normal distribution |
| $\text{dnorm}(\mu,\tau)$ | $\sqrt{\tau/(2\pi)}\,\exp(-\tau(x-\mu)^2/2)$ | Normal distribution |
| $\text{dpois}(\lambda)$ | $\exp(-\lambda)\lambda^x/x!$ | Poisson distribution |
| $\text{dunif}(a,b)$ | $1/(b-a)$ | Uniform distribution |
| $\exp(x)$ | $e^x$ | Exponent function |
| $\log(x)$ | $\log(x)$ | Natural logarithm function |
| $\text{logit}(x)$ | $\log(x/(1-x))$ | Logit function |
| $\text{pow}(x,z)$ | $x^z$ | Power function |

### 2.2.4 Species Richness and Diversity

Species richness, which is the number of species present, and species diversity, which takes into account both the number of species present and their relative abundance, were estimated from the number of fish captured and observed during each sample using HBA (Royle and Dorazio 2008).

Crew members could not reliably identify observed sucker (*Catostomidae*) and sculpin to the species level; therefore, species of these two families were grouped together and analyzed as “all sucker” and “all sculpin”, respectively.

Species richness was estimated by summing together the MCMC samples of the expected probability of occupancy for the eight fish species with sufficient variation in the frequency of encounters to provide information on changes through time [burbot (*Lota lota*), Mountain Whitefish, Rainbow Trout, Yellow Perch, Northern Pikeminnow, Peamouth (*Mylocheilus caurinus*), Redside Shiner, and all Sculpin]. Similarly, species diversity was estimated by calculating the Shannon index from the MCMC samples of the apparent lineal densities for the seven fish species with sufficient variation in the number of counts (Burbot, Bull trout, Mountain Whitefish, Rainbow Trout, Northern Pikeminnow, all Sculpin, and all Sucker). The Shannon index (H) is given by the following equation:

$$H = -\sum_{i=1}^{S}(p_i \log(p_i))$$

Where $S$ is the number of species and $p_i$ is the proportion of the total number of individuals belonging to the $i^{th}$ species. The probability of occupancy and apparent lineal densities were also calculated for Kokanee but were excluded from the calculations of species richness and diversity because the high temporal variability in Kokanee presence and numbers was not considered to be directly related to dam operations.

As described above, estimates for both species richness and diversity excluded species that were very infrequently encountered. Although this results in slightly lower richness estimates per site, it does result in an index of richness that can be compared statistically against flow regime changes. Inclusion of less abundant species in the richness and diversity estimates would result in a less robust analysis (due to uncertainty regarding the probability of occupancy for uncommon species).

#### 2.2.4.1 Species Richness

Key assumptions of the HBA of occupancy included:

- Flow regime and season were predictors of the probability of occupancy;
- The probability of occupancy varied randomly with site, year, and site with year;
- The probability of detection (given occupancy) varied randomly with year;
- Sites were closed during each sampling period (i.e., the species either did or did not occupy a site for all the sessions in a particular sampling period); and,
- The residual variation of the probability of occupancy was described by a Bernoulli distribution.

Variables and model parameters are listed in Table 6. The prior probability distributions are listed in Table 7 and the relationships (both stochastic and deterministic dependencies) between variables and parameters are listed in Table 8. Together, Tables 6 to 8 provide a full description of the occupancy model. Convergence required between $10^4$ and $10^5$ iterations.

**Table 6: List of key variables and parameters used in the hierarchical Bayesian analysis of site occupancy.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_Y^O$ | The standard deviation of the random effect of year on the probability of occupancy |
| $\sigma_S^O$ | The standard deviation of the random effect of site on the probability of occupancy |
| $\sigma_{SY}^O$ | The standard deviation of the random effect of site within year on the probability of occupancy |
| $\sigma_Y^P$ | The standard deviation of the random effect of year on the probability of detection |
| $\beta_0^O$ | The intercept for the probability of occupancy |
| $\beta_0^P$ | The intercept for the probability of detection |
| $\beta_y^O$ | The random effect of the $y^{th}$ year on the probability of occupancy |
| $\beta_s^O$ | The random effect of the $s^{th}$ site on the probability of occupancy |
| $\beta_{s,y}^O$ | The random effect of the $s^{th}$ site in the $y^{th}$ year on the probability of occupancy |
| $\beta_y^P$ | The random effect of the $y^{th}$ year on the probability of detection |
| $\mu_{s,y}^0$ | The expected probability of occupancy at the $s^{th}$ site in the $y^{th}$ year |
| $\mu_y^P$ | The expected probability of detection in the $y^{th}$ year |
| $O_{v,s,y}$ | Whether or not the species was observed during the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |

**Table 7: Prior probability distributions for key primary parameters used in the hierarchical Bayesian analysis of site occupancy.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_Y^O$ | dunif(0,10) |
| $\sigma_S^O$ | dunif(0,10) |
| $\sigma_{SY}^O$ | dunif(0,10) |
| $\sigma_Y^P$ | dunif(0,10) |
| $\beta_0^O$ | dunif(−10,10) |
| $\beta_M^O$ | dunif(−10,10) |
| $\beta_P^O$ | dunif(−10,10) |
| $\beta_0^P$ | dunif(−10,10) |
| $\beta_y^O$ | dnorm(0,pow($\sigma_Y^O$, −2)) |
| $\beta_s^O$ | dnorm(0,pow($\sigma_S^O$, −2)) |
| $\beta_{s,y}^O$ | dnorm(0,pow($\sigma_{SY}^O$, −2)) |
| $\beta_y^P$ | dnorm(0,pow($\sigma_Y^P$, −2)) |

**Table 8: Dependencies between variables and parameters used in the hierarchical Bayesian analysis of site occupancy.**

| Variable/Parameter | Dependency |
|---|---|
| $\mathrm{logit}(\mu_{s,y}^0)$ | $\beta_0^O + \beta_M^O + \beta_P^O + \beta_y^O + \beta_s^O + \beta_{s,y}^O$ |
| $\mathrm{logit}(\mu_y^P)$ | $\beta_0^P + \beta_y^P$ |
| $O_{i,s,y}$ | $\mathrm{dbern}(\mu_{s,y}^0 * \mu_y^P)$ |

### 2.2.4.2 Species Diversity

Key assumptions of the HBA of apparent lineal densities included:

- Flow regime and season were predictors of apparent lineal density;
- The apparent lineal density varied randomly with site, year, and site with year;
- The expected count (i.e., the number of individuals observed and captured) was the product of the apparent lineal density, the length of the site and the proportion of the site sampled; and,
- The residual variation in the count was described by a combination of a log-normal and a Poisson distribution.

Key variables and model parameters are described in Table 9. The prior probability distributions are listed in Table 10. Dependencies between variables and parameters are listed in Table 11. Convergence required between $10^5$ and $10^6$ iterations.

**Table 9: List of key variables and parameters used in the hierarchical Bayesian analysis of apparent lineal density.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_0$ | The standard deviation of the apparent lineal density |
| $\sigma_Y$ | The standard deviation of the random effect of year on the apparent lineal density |
| $\sigma_S$ | The standard deviation of the random effect of site on the apparent lineal density |
| $\sigma_{SY}$ | The standard deviation of the random effect of site within year on the apparent lineal density |
| $\beta_0$ | The intercept for the apparent lineal density |
| $\beta_M$ | The fixed effect of season on the apparent lineal density |
| $\beta_P$ | The fixed effect of period on the apparent lineal density |
| $\beta_y$ | The random effect of the $y^{th}$ year on the apparent lineal density |
| $\beta_s$ | The random effect of the $s^{th}$ site on the apparent lineal density |
| $\beta_{s,y}$ | The random effect of the $s^{th}$ site in the $y^{th}$ year on the apparent lineal density |
| $\mu_{s,y}$ | The expected apparent lineal density at the $s^{th}$ site in the $y^{th}$ year |
| $L_{s,y}$ | The length of the $s^{th}$ site in the $y^{th}$ year |
| $P_{v,s,y}$ | The proportion of the $s^{th}$ site sampled during the $v^{th}$ session in the $y^{th}$ year |
| $C_{v,s,y}$ | The number of fish observed or captured during the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |

**Table 10: Prior probability distributions for key primary parameters used in the hierarchical Bayesian analysis of apparent lineal density.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_0$ | dunif(0,10) |
| $\sigma_Y$ | dunif(0,10) |
| $\sigma_S$ | dunif(0,10) |
| $\sigma_{SY}$ | dunif(0,10) |
| $\beta_0$ | dunif(−10,10) |
| $\beta_M$ | dunif(−10,10) |
| $\beta_P$ | dunif(−10,10) |
| $\beta_y$ | $\text{dnorm}(0,\text{pow}(\sigma_Y, -2))$ |
| $\beta_s$ | $\text{dnorm}(0,\text{pow}(\sigma_S, -2))$ |
| $\beta_{s,y}$ | $\text{dnorm}(0,\text{pow}(\sigma_{SY}, -2))$ |

**Table 11: Dependencies between variables and parameters used in the hierarchical Bayesian analysis of apparent lineal density.**

| Variable/ Parameter | Dependency |
|---|---|
| $\log(\mu_{s,y})$ | $\beta_0 + \beta_M + \beta_P + \beta_y + \beta_s + \beta_{s,y}$ |
| $C_{v,s,y}$ | $\text{dpois}(\text{dlnorm}(\log(\mu_{s,y}),\text{pow}(\sigma_0, -2)) * L_{s,y} * P_{v,s,y})$ |

## 2.2.5 Spatial Distribution and Abundance

Abundance and spatial distribution were estimated via a hierarchical Bayesian mark-recapture analysis of the lineal density. The total abundance of each species in the MCR was estimated by summing together the products of the lineal density and site length for each of the MCMC samples. Total abundance and lineal density also were calculated for different size cohorts of mountain whitefish, to assess whether life stage was a significant factor influencing sensitivity to flow changes. A similar cohort analysis was not conducted for other species, due to lower densities, overlap in length-frequency histograms, and/or limited life history data.

Key assumptions of the hierarchical Bayesian mark-recapture analysis included:

- Flow regime and season were predictors of lineal density;
- Lineal density varied randomly with site, year, and site with year;
- The probability of capture varied randomly with session and year;
- Marked and unmarked fish had the same probability of capture;
- Losses of unmarked and marked fish due to emigration from a site were compensated for by the immigration of unmarked and marked individuals from other sites; and,
- The residual variation in the numbers of captured, marked, and unmarked fish was described by a binomial distribution.

Key variables and model parameters are described in Table 12. Prior probability distributions are provided in Table 13. The relationships between variables and parameters are provided in Table 14. Convergence required between $10^5$ and $10^6$ iterations.

**Table 12: List of key variables and parameters used in the hierarchical Bayesian mark-recapture analysis of lineal density.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_Y^D$ | The standard deviation of the random effect of year on the lineal density |
| $\sigma_S^D$ | The standard deviation of the random effect of site on the lineal density |
| $\sigma_{SY}^D$ | The standard deviation of the random effect of site with year on the lineal density |
| $\sigma_V^P$ | The standard deviation of the random effect of session on the capture efficiency |
| $\sigma_Y^P$ | The standard deviation of the random effect of year on the capture efficiency |
| $\beta_0^D$ | The intercept for the lineal density |
| $\beta_M^D$ | The fixed effect of season on the lineal density |
| $\beta_P^D$ | The fixed effect of period on the lineal density |
| $\beta_0^P$ | The intercept for the capture efficiency |
| $\beta_y^D$ | The random effect of the $y^{th}$ year on the lineal density |
| $\beta_s^D$ | The random effect of the $s^{th}$ site on the lineal density |
| $\beta_{s,y}^D$ | The random effect of the $s^{th}$ site and the $y^{th}$ year on the lineal density |
| $\beta_v^P$ | The random effect of the $v^{th}$ session on the lineal density |
| $\beta_y^P$ | The random effect of the $y^{th}$ year on the lineal density |
| $\mu_{s,y}^D$ | The expected lineal density at the $s^{th}$ site in the $y^{th}$ year |
| $\mu_{v,y}^P$ | The expected capture efficiency during the $v^{th}$ session in the $y^{th}$ year |
| $\mathcal{N}_{s,y}$ | The number of fish at the $s^{th}$ site in the $y^{th}$ year |
| $u_{v,s,y}$ | The number of unmarked fish at the $s^{th}$ site in the $v^{th}$ session of the $y^{th}$ year |
| $m_{v,s,y}$ | The number of marked fish at the $s^{th}$ site in the $v^{th}$ session of the $y^{th}$ year |
| $L_{s,y}$ | The length of the $s^{th}$ site in the $y^{th}$ year |
| $P_{v,s,y}$ | The proportion of the $s^{th}$ site sampled during the $v^{th}$ session in the $y^{th}$ year |
| $U_{v,s,y}$ | The number of unmarked fish caught during the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |
| $M_{v,s,y}$ | The number of marked fish caught during the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |
| $T_{v,s,y}$ | The number of unmarked fish tagged during the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |

**Table 13: Prior probability distributions for key primary parameters used in the hierarchical Bayesian mark-recapture analysis of lineal density.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_Y^D$ | dunif(0,10) |
| $\sigma_S^D$ | dunif(0,10) |
| $\sigma_{SY}^D$ | dunif(0,10) |
| $\sigma_V^P$ | dunif(0,10) |
| $\sigma_Y^P$ | dunif(0,10) |
| $\beta_0^D$ | dunif(−10,10) |
| $\beta_M^D$ | dunif(−10,10) |
| $\beta_P^D$ | dunif(−10,10) |
| $\beta_0^P$ | dunif(−10,10) |
| $\beta_y^D$ | $\text{dnorm}(0,\text{pow}(\sigma_Y^D,-2))$ |
| $\beta_s^D$ | $\text{dnorm}(0,\text{pow}(\sigma_S^D,-2))$ |
| $\beta_{s,y}^D$ | $\text{dnorm}(0,\text{pow}(\sigma_{SY}^D,-2))$ |
| $\beta_v^P$ | $\text{dnorm}(0,\text{pow}(\sigma_V^P,-2))$ |
| $\beta_y^P$ | $\text{dnorm}(0,\text{pow}(\sigma_Y^P,-2))$ |

**Table 14: Dependencies between variables and parameters used in the hierarchical Bayesian mark-recapture analysis of lineal density.**

| Variable/Parameter | Dependency |
|---|---|
| $\log(\mu_{s,y}^D)$ | $\beta_0^D + \beta_M^D + \beta_P^D + \beta_y^D + \beta_s^D + \beta_{s,y}^D$ |
| $\text{logit}(\mu_{v,y}^P)$ | $\beta_0^P + \beta_v^P + \beta_y^P$ |
| $\mathcal{N}_{s,y}$ | $\text{dpois}(\mu_{s,y}^D * \text{L}_{s,y})$ |
| $u_{1,s,y}$ | $\mathcal{N}_{s,y}$ |
| $m_{1,s,y}$ | 0 |
| $u_{v+1,s,y}$ | $u_{v,s,y} - T_{v,s,y}$ |
| $m_{v+1,s,y}$ | $u_{v,s,y} + T_{v,s,y}$ |
| $U_{v,s,y}$ | $\text{dbin}(\mu_{v,y}^P * P_{v,s,y}, u_{v,s,y})$ |
| $M_{v,s,y}$ | $\text{dbin}(\mu_{v,y}^P * P_{v,s,y}, m_{v,s,y})$ |

### 2.2.6 Capture Efficiency

Capture efficiency is the number of fish caught, expressed as a percentage of the total number of fish estimated to be present. For this study, capture efficiency was calculated using HBA and site-level intra-year mark-recapture data. Bull trout and mountain whitefish were the only two species with mark-recapture data sufficient enough to calculate capture efficiencies.

### 2.2.7 Growth Rate

Change in length of the fish populations were estimated using two approaches. For the first approach, changes in length-at-age were estimated using a hierarchical Bayesian mixture analysis of length-frequency distributions. Mountain whitefish was the only species with sufficiently distinguishable age-classes to allow a mixture analysis. For the second approach, annual growth-rates were estimated using a HBA of annual length increments of recaptured individuals. Bull Trout and Mountain Whitefish were the only species with sufficient inter-annual recaptures to allow detailed growth-related analysis, including length at age and analysis of length increments.

#### *2.2.7.1 Length-At-Age*

Key assumptions of the hierarchical Bayesian mixture analysis of length-frequency distributions included:

- Flow regime was a predictor of the mean length of each age-class;
- The mean length of each age-class varied randomly with year; and,
- The residual variation in individual length was described by a normal distribution.

Variables and model parameters are listed in Table 15, prior probability distributions are listed in Table 16, and the relationships between variables and parameters are listed in Table 17. Convergence required between $10^5$ and $10^6$ iterations.

**Table 15: List of key variables and parameters used in the hierarchical Bayesian mixture analysis of length-frequency distributions.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_a^0$ | The standard deviation of the residual variation in the lengths of the individuals in the $a^{th}$ age-class |
| $\sigma_{a,Y}^L$ | The standard deviation of the random effect of year on the length of the $a^{th}$ age-class |
| $\beta_a^L$ | The length increment of the $a^{th}$ age-class |
| $\beta_{a,P}^L$ | The fixed effect of period on the length of the $a^{th}$ age-class |
| $\beta_a^\rho$ | The proportion of fish belonging to the $a^{th}$ age-class |
| $\beta_{a,y}^L$ | The random effect of the $y^{th}$ year on the length of the $a^{th}$ age-class |
| $\mu_{a,y}^L$ | The expected length of the $a^{th}$ age-class in the $y^{th}$ year |
| $A_{i,y}$ | The expected age-class of the $i^{th}$ fish in the $y^{th}$ year |
| $L_{i,y}$ | The observed length of the $i^{th}$ fish in the $y^{th}$ year |

**Table 16: Prior probability distributions for key primary parameters used in the hierarchical Bayesian mixture analysis of length-frequency distributions.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_a^0$ | dunif(0,50) |
| $\sigma_{a,Y}^L$ | dunif(0,10) |
| $\beta_a^L$ | dunif(10,100) |
| $\beta_{a,P}^L$ | dunif(−50,50) |
| $\beta_a^\rho$ | ddirch(1,1,1,1) |
| $\beta_{a,y}^L$ | $\text{dnorm}\left(0,\text{pow}(\sigma_{a,Y}^L,-2)\right)$ |

**Table 17: Dependencies between variables and parameters used in the hierarchical Bayesian mixture analysis of length-frequency distributions.**

| Variable/Parameter | Relationship |
|---|---|
| $\mu_{a,y}^L$ | $\beta_a^L + \beta_{a-1}^L + \beta_{a,P}^L + \beta_{a,y}^L$ |
| $A_{i,y}$ | $\text{dcat}\left(\beta_{[\,]}^\rho\right)$ |
| $L_{i,y}$ | $\text{dnorm}\left(\mu_{A_{i,y},y}^L,\text{pow}(\sigma_{A_{i,y}}^0,-2)\right)$ |

### 2.2.7.2 Annual Length Increments

The HBA of annual length increments was based on the Faben's approach to estimating the von Bertalanffy growth parameters (Fabens 1965 cited in Hilborn and Walters 1992). Key assumptions of the analysis of annual length increments included:

- Annual length increments were consistent with a von Bertalanffy growth curve;
- Flow regime and tag type were predictors of the mean maximum length ($\mathcal{L}_\infty$);

- Mean maximum length varied randomly with year; and,
- The residual variation in annual length increment was normally distributed;

Variables and model parameters are listed in Table 18, prior probability distributions are listed in Table 19, and the relationships between variables and parameters are listed in Table 20. Convergence required between $10^4$ and $10^5$ iterations.

**Table 18: List of key variables and parameters used in the hierarchical Bayesian analysis of annual length increment.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_0$ | The standard deviation of the residual variation in the length increment |
| $\sigma_Y$ | The standard deviation of the random effect of year on $\mathcal{L}_\infty$ |
| $k$ | The von Bertalanffy rate constant |
| $\mathcal{L}_\infty$ | The von Bertalanffy mean maximum length |
| $\beta_T$ | The fixed effect of tag type on $\mathcal{L}_\infty$ |
| $\beta_P$ | The fixed effect of period on $\mathcal{L}_\infty$ |
| $\beta_y$ | The random effect of the $y^{th}$ year on $\mathcal{L}_\infty$ |
| $\mu_{i,y}$ | The expected length increment of the $i^{th}$ individual in the $y^{th}$ |
| $\mathrm{L}_{i,y}$ | The length at release of the $i^{th}$ individual in the $y^{th}$ |
| $\mathrm{G}_{i,y}$ | The length increment of the $i^{th}$ individual in the $y^{th}$ |

**Table 19: Prior probability distributions for key primary parameters used in the hierarchical Bayesian analysis of annual length increments.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_0$ | dunif(0,100) |
| $\sigma_Y$ | dunif(0,100) |
| $k$ | dunif(0.0,0.5) |
| $\mathcal{L}_\infty$ | dunif(100,1000) |
| $\beta_T$ | dunif(−100,100) |
| $\beta_P$ | dunif(−100,100) |
| $\beta_y$ | $\mathrm{dnorm}(0,\mathrm{pow}(\sigma_Y, -2))$ |

**Table 20: Dependencies between variables and parameters used in the hierarchical Bayesian analysis of annual length increments.**

| Variable/Parameter | Relationship |
|---|---|
| $\mu_{i,y}$ | $(\mathcal{L}_\infty + \beta_T + \beta_P + \beta_y - \mathrm{L}_{i,y}) * (1 - e^{-k})$ |
| $\mathrm{G}_{i,y}$ | $\mathrm{dnorm}(\mu_{i,y},\mathrm{pow}(\sigma_0, -2))$ |

## 2.2.8 Body Condition

Temporal and spatial variation in body condition was estimated via HBA of mass-length relationships (He et al. 2008). To avoid non-independence due to intra-year recaptures only the first capture of an individual in each year was included in the analysis.

Key assumptions of the HBA of body condition included:

- Flow regime, tag type, body length, and day of the year were predictors of body weight;

- Body weight varied randomly with site and year; and,
- The residual variation in body weight was described by a log-normal distribution.

While boat electroshocking occurred at multiple sites over multiple years, it was all undertaken at night. Therefore, randomness in body condition (and all other factors) was tested/controlled for in relation to site and inter-annual variation, but not for diurnal variation.

Key variables and model parameters are described in Table 21. Prior probability distributions are provided in Table 22. The relationships between variables and parameters are provided in Table 23. Convergence required between $10^5$ and $10^6$ iterations.

**Table 21: List of key variables and parameters used in the hierarchical Bayesian analysis of body condition.**

| Variable/Parameter | Description |
|---|---|
| $\sigma_0$ | The standard deviation of the residual variation in weight |
| $\sigma_Y$ | The standard deviation of the random effect of year on weight |
| $\sigma_S$ | The standard deviation of the random effect of site on weight |
| $\beta_0$ | The weight intercept |
| $\beta_L$ | The fixed effect of length on weight |
| $\beta_D$ | The fixed effect of day of the year on weight |
| $\beta_T$ | The fixed effect of tag type on weight |
| $\beta_P$ | The fixed effect of period on weight |
| $\beta_y$ | The random effect of the $y^{th}$ year on weight |
| $\beta_s$ | The random effect of the $s^{th}$ site on weight |
| $\mu_{i,v,s,y}$ | The expected weight of the $i^{th}$ fish from the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |
| $D_{v,s,y}$ | The day of the year of the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |
| $L_{i,v,s,y}$ | The length of the $i^{th}$ fish from the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |
| $W_{i,v,s,y}$ | The weight of the $i^{th}$ fish from the $v^{th}$ session at the $s^{th}$ site in the $y^{th}$ year |

**Table 22: Prior probability distributions for key primary parameters used in the hierarchical Bayesian analysis of body condition.**

| Parameter | Prior Distribution |
|---|---|
| $\sigma_0$ | $\mathrm{dunif}(0,10)$ |
| $\sigma_Y$ | $\mathrm{dunif}(0,10)$ |
| $\sigma_S$ | $\mathrm{dunif}(0,10)$ |
| $\beta_0$ | $\mathrm{dunif}(-10,10)$ |
| $\beta_L$ | $\mathrm{dunif}(-10,10)$ |
| $\beta_D$ | $\mathrm{dunif}(-10,10)$ |
| $\beta_T$ | $\mathrm{dunif}(-10,10)$ |
| $\beta_P$ | $\mathrm{dunif}(-10,10)$ |
| $\beta_y$ | $\mathrm{dnorm}(0,\mathrm{pow}(\sigma_Y\ ,-2))$ |
| $\beta_s$ | $\mathrm{dnorm}(0,\mathrm{pow}(\sigma_S\ ,-2))$ |

**Table 23: Dependencies between variables and parameters used in the hierarchical Bayesian analysis of body condition.**

| Variable/ Parameter | Relationship |
|---|---|
| $\log(\mu_{i,v,s,y})$ | $\beta_0 + \beta_L * \log(L_{i,v,s,y}) + \beta_D * D_{v,s,y} + \beta_T + \beta_P + \beta_y + \beta_s$ |
| $W_{i,v,s,y}$ | $\mathrm{dlnorm}(\log(\mu_{i,v,s,y}),\mathrm{pow}(\sigma_0\ ,-2))$ |

# 3.0 RESULTS

## 3.1 Discharge

In 2011, mean daily discharge of the Columbia River at REV exhibited large fluctuations, a reflection of the primary use of the facility for daily peaking operations (Appendix C, Figure C1). Discharges in 2011 were similar to previous study years (2001 to 2010) for most of the year.

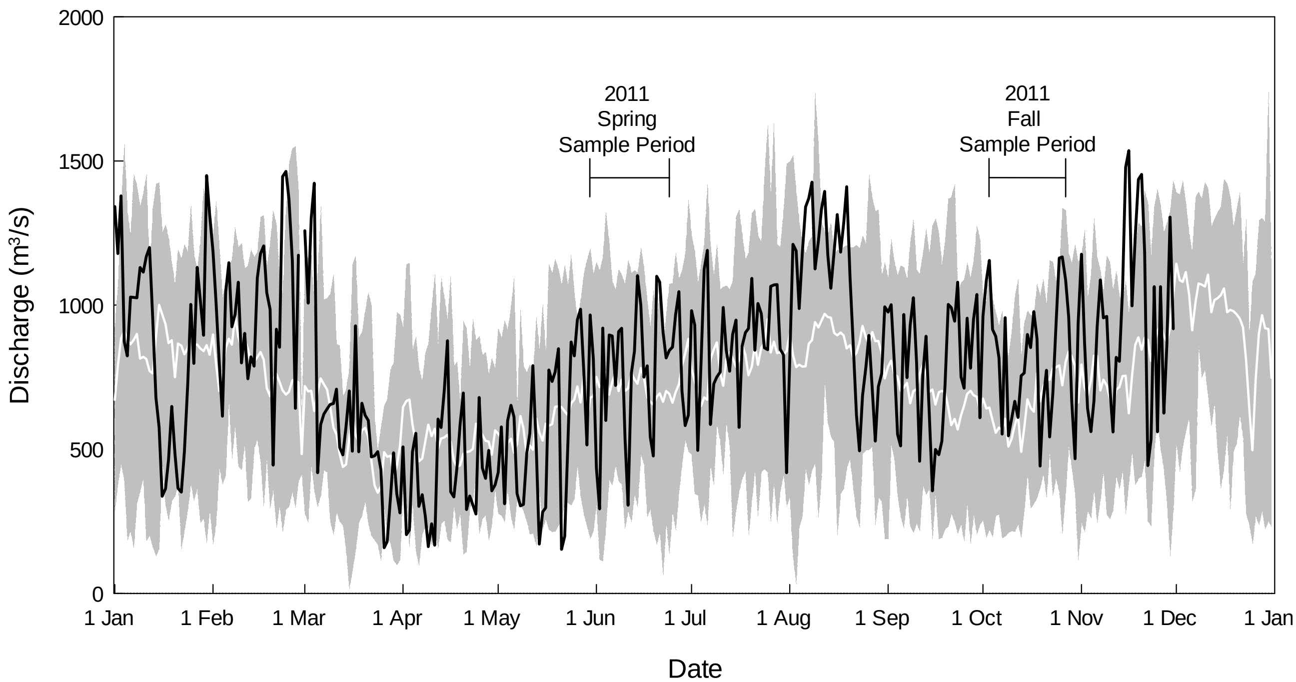


*Figure 2: Mean daily discharge ($m^3/s$) for the Columbia River at Revelstoke Dam, 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at the dam from 2001 to 2010. The white line represents average mean daily discharge values over that same time period.*

During the spring 2011 sample period, peak discharge was 1738 $m^3/s$ on June 6 (Appendix C, Figure C2). Discharge was reduced to the minimum flow during all study nights. Overall, discharges were similar for all four spring 2011 sample sessions.

During the fall 2011 sample period, peak discharge was 1683 $m^3/s$ on October 25 (Appendix C, Figure C3). Discharge was reduced during all study nights, but was never reduced to the minimum flow. Overall, discharges were highest during Sessions 1 and 4 and lowest during Sessions 2 and 3 of the fall sample period.

During both the spring and fall sample period, discharge typically increased in the morning, varied throughout the day, and decreased in the evening. Overall, discharges were higher during the spring sample period than during the fall sample period.

## 3.2 Water Elevation

Water elevations in ALR were higher in 2011 than the average water elevations recorded during all previous study years except 2008 (Appendix C, Figure C4). High water elevations in 2011 resulted in some reservoir backwatering effects in the downstream portions of Reach 3 during both the spring and fall sample periods.

Water level elevations in ALR gradually increased over the duration of the spring sample period, which resulted in greater backwatering effects in the MCR during each successive sample session. Water level elevations in ALR gradually decreased over the duration of the fall sample period, which reduced backwatering effects in the MCR over the fall sample period.

Overall, water elevations in ALR were lower from 2001 to 2006 and higher from 2007 to 2011 (Appendix C, Figure C4).

## 3.3 Water Temperature

Water temperature data are not available for the MCR prior to 2007. Water temperatures recorded in 2011 were similar to those recorded between 2007 and 2010 (Figure 3; Appendix C, Figure C5). During the 2011 spring sample period, daily average water temperature gradually increased from 6.0 to 9.0°C. Spot water temperature readings taken at the time of sampling ranged between 5.0 and 8.0°C (Attachment A). During the 2011 fall sample period, daily average water temperature gradually declined from 11.9 to 10.2°C. Spot water temperature readings taken at the time of sampling ranged between 8.0°C and 10.0°C (Attachment A).

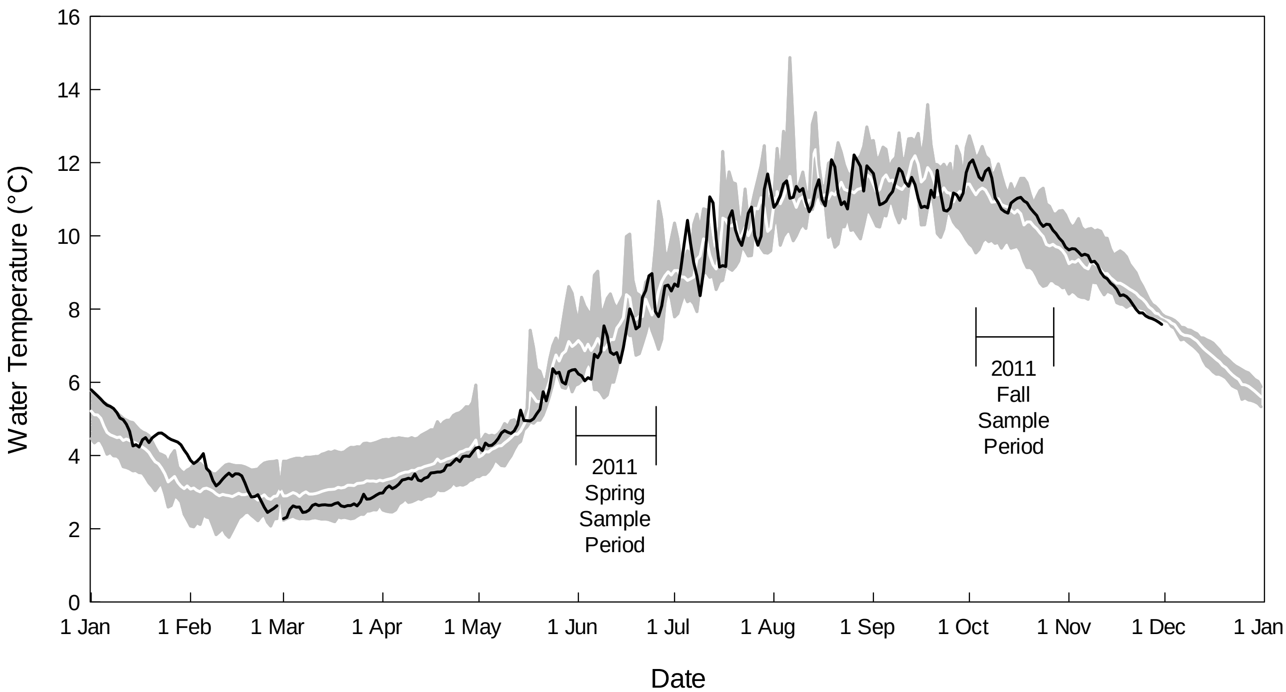


*Figure 3: Mean daily water temperature (°C) for the Columbia River at Revelstoke Dam (Station Tailrace7), 2011. The shaded area represents minimum and maximum mean daily water temperature values recorded at Station Tailrace7 from 2007 to 2010. The white line represents average mean daily water temperature values over that same time period.*

## 3.4 Catch

Overall, 12 970 fish, comprising 13 taxa, were recorded in the Middle Columbia River during the spring 2011 sample period (Appendix D, Table D1) and 18 417 fish, also comprising 13 taxa, were recorded during the fall 2011 sample period (Appendix D, Table D2). These values include captured and observed fish identified to species.

Various metrics were used to provide background information and to help set initial parameter value estimates in some of the HBAs. 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 HBAs. Metrics presented in the appendices include:

- Captured and observed fish count data by site and Bank Habitat Type during the spring (Appendix B, Table B4) and fall (Appendix B, Table B5) sample periods, 2011;
- Catch-rates for all sportfish (Appendix D, Table D2) and non-sportfish (Appendix D, Table D3) during the spring sample period; catch-rates for all sportfish (Appendix D, Table D4) and non-sportfish (Appendix D, Table D5) during the fall sample period, 2011 data;
- Inter-site movement summaries for bull trout (Appendix D, Figure D1), Largescale Sucker (Appendix D, Figure D2), Mountain Whitefish (Appendix D, Figure D3), and Rainbow Trout (Appendix D, Figure D4), all years combined;
- Catch and recapture data summaries by species for the spring (Appendix D, Table D6) and fall (Appendix D, Table D7);
- Length-frequency histograms for Bull Trout (Appendix E, Figure E1) and Mountain Whitefish (Appendix E, Figure E2) from 2001 to 2011, and for Rainbow Trout from 2007 to 2011 (Appendix E, Figure E3);
- Length-frequency histograms for Kokanee (Appendix E, Figure E4), Lake Whitefish (Appendix E, Figure E5), Largescale Sucker (Appendix E, Figure E6), Northern Pikeminnow (Appendix E, Figure E7), Prickly Sculpin (*Cottus asper*; Appendix E, Figure E8), and Redside Shiner (Appendix E, Figure E9) for 2010, spring 2011, and fall 2011 (where applicable);
- Length-weight relationships for Bull Trout (Appendix E, Figure E10) and Mountain Whitefish (Appendix E, Figure E11) from 2001 to 2011, and for Rainbow Trout from 2007 to 2011 (Appendix E, Figure E12); and,
- Length-weight relationships for Kokanee (Appendix E, Figure E13), Lake Whitefish (Appendix E, Figure E14), Largescale Sucker (Appendix E, Figure E15), Northern Pikeminnow (Appendix E, Figure E16), Prickly Sculpin (Appendix E, Figure E17), and Redside Shiner (Appendix E, Figure E18) for 2010, spring 2011, and fall 2011 (where applicable).

All raw data collected as part of the program between 2001 and 2011 are included in the Middle Columbia River Fish Indexing Database (Attachment A).

For all plots in this report, sites are ordered left to right by increasing distance from Revelstoke Dam based on the upstream boundary of each site; red symbols denote sites located on the right bank (as viewed facing downstream); black symbols denote sites located on the left bank. For year-based figures, black symbols denote fall sample periods; red symbols denote spring sample periods.

## 3.5 Species Richness and Diversity

Yearly estimates of species richness (Figure 4) represent the number of species present at a typical site. Although credibility intervals overlapped for all study years, estimates gradually increased between 2001 and 2010, with lower estimates in 2009 and 2011 (during both the spring and fall sample periods). Site estimates of species richness (Figure 5) represent the number of species estimated to be present at each site in a typical year. Species richness was noticeably lower at Site 232.6-R (immediately upstream of the Jordan River confluence) when compared to neighbouring sites. Downstream of Big Eddy (RKm 231.2), species richness was lower along the right bank than along the left bank.

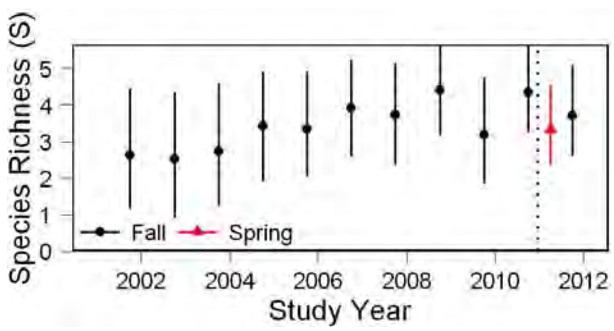


*Figure 4: Median estimates of species richness by year (with 95% credibility intervals) for the Middle Columbia River study area. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

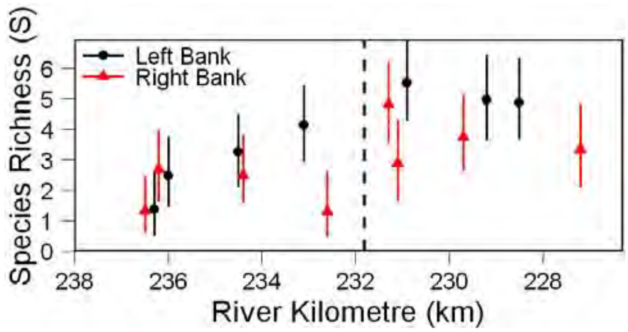


*Figure 5: Median estimates of species richness by site (with 95% credibility intervals) for the Middle Columbia River study area, all years combined. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

Species diversity gradually increased between 2001 and 2006 (Figure 6). Between 2006 and 2011, species diversity was variable with highest diversity in 2008 and lowest diversity during the spring 2011 sample period. During both of these sample periods, ALR water elevation levels were higher (i.e., at or near full pool) than during other study periods (Appendix C, Figure C3). Site 233.1-L appeared to be a particularly diverse site relative to adjacent sites (Figure 7). This pattern of higher diversity at Site 233.1-L was noted by Ford and Thorley (2011a), who noted that this result is due mainly to lower mountain whitefish densities in this site when compared to neighbouring sites (see Section 3.6.4).

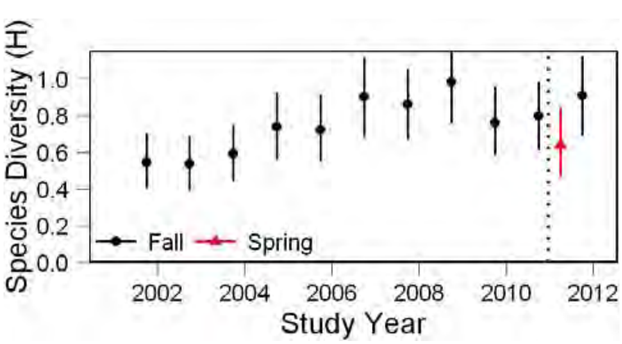


*Figure 6: Median estimates of species diversity by year (with 95% credibility intervals) for the Middle Columbia River study area. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

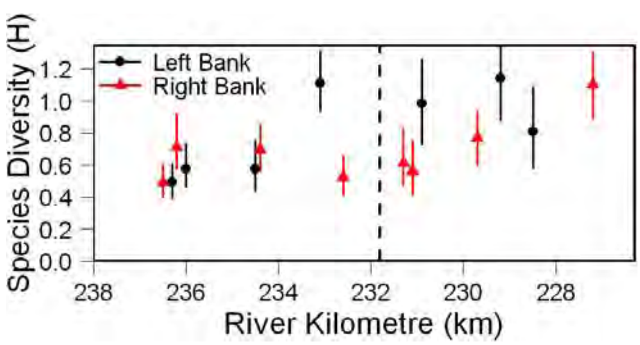


*Figure 7: Median estimates of species diversity by site (with 95% credibility intervals) for the Middle Columbia River study area. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

## 3.6 Spatial Distribution and Abundance

The relative spatial distributions and abundances of each species were estimated from the output of a count-based HBA of relative lineal density (i.e., number of fish per river kilometre) while the absolute spatial distribution and abundance of Bull Trout and Mountain Whitefish (both age-1 and age-2+ individuals) were estimated from the output of a mark-recapture-based HBA of absolute lineal density. Extremely low and/or variable count data for Brook Trout, Cutthroat Trout, Lake Whitefish, Pygmy Whitefish (*Prosopium coulteri*), Peamouth, Redside Shiner, White Sturgeon (*Acipenser transmontanus*), and Yellow Perch yielded poor estimates of distribution and abundance for these species and are not provided. Capture efficiencies for Bull Trout, age-1 and age-2+ Mountain Whitefish are reported together in Section 3.6.9.

### 3.6.1 Bull Trout

Relative (Figure 8) and absolute (Figure 9) estimates of abundance based on the HBA's suggest that the number of Bull Trout in the MCR increased between 2001 and 2007 before levelling off. Estimates for the 2011 spring and fall study periods were similar. Bull Trout densities were highest immediately downstream of REV (between RKm 236 and 237) and downstream of the Jordan River confluence (between RKm 231 and 232; Figures 10 and 11), which was similar to 2010 results. Bull Trout abundance did not vary significantly with flow regime change ($p = 0.444$; HBA, not shown) or season ($p = 0.900$; HBA, not shown).

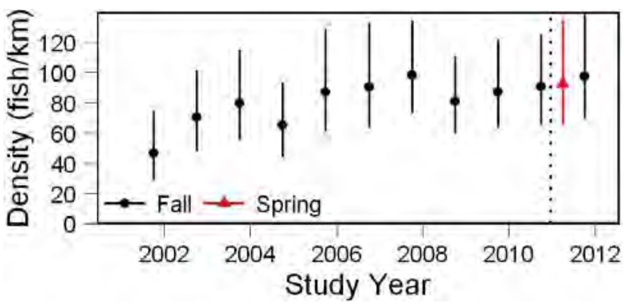


*Figure 8: Median estimates of relative lineal density by year (with 95% credibility intervals) for bull trout in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

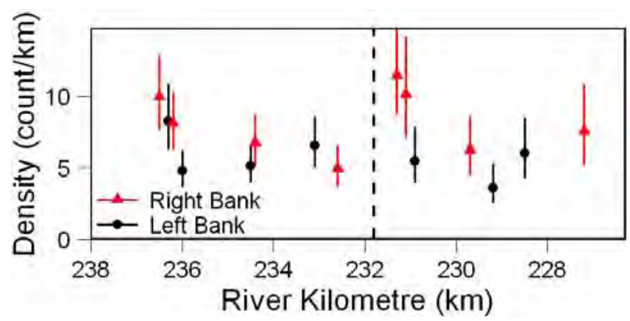


*Figure 10: Median estimates of relative lineal density by site (with 95% credibility intervals) for bull trout in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

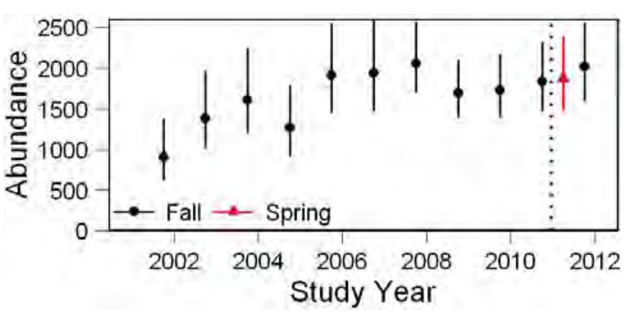


*Figure 9: Median estimates of absolute abundance by year (with 95% credibility intervals) for Bull Trout in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

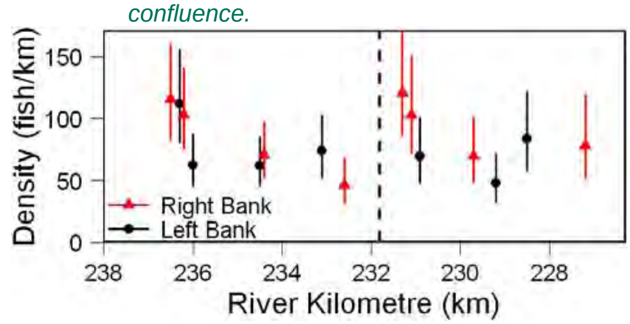


*Figure 11: Median estimates of absolute lineal density by site (with 95% credibility intervals) for Bull Trout in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.2 Burbot

Annual relative lineal density estimates for Burbot suggest that the abundance of this species may have been higher in 2008 and 2011 when compared to other study years (Figure 12). Overall, densities for this species were low compared to densities of most other species caught during all study years. Site-level estimates are relatively uncertain for this species, with no notable trends or patterns (Figure 13). Burbot density did not vary significantly with flow regime (p = 0.277; HBA, not shown), or season (p = 0.089; HBA, not shown).

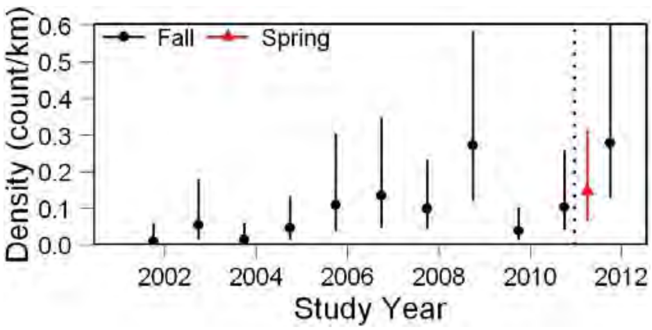


*Figure 12: Median estimates of relative lineal density by year (with 95% credibility intervals) for Burbot in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

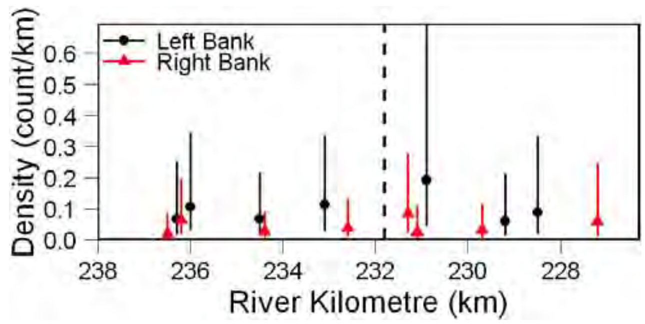


*Figure 13: Median estimates of relative lineal density by site (with 95% credibility intervals) for Burbot in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.3 Kokanee

With the exception of 2008, Kokanee densities were high during all study years between 2006 and 2011 (Figure 14). Kokanee densities varied greatly by sample site but were generally highest in sites located close to major tributaries (i.e., Moses Creek, Scales Creek, Jordan River; Figure 15). There was no relationship between Kokanee density and flow regime (p = 0.557; HBA, not shown); however, there was a significant relationship between Kokanee density and season (p < 0.001; HBA, not shown); with higher densities during the fall than during the spring.

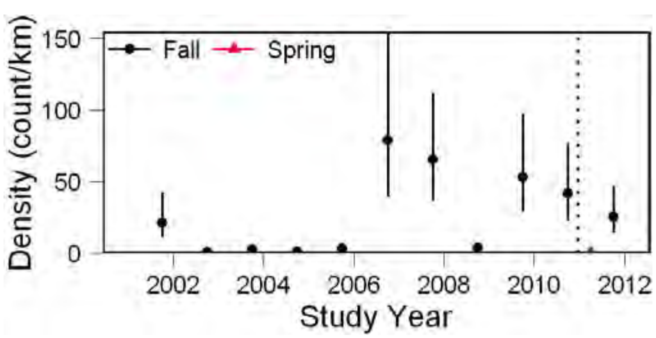


*Figure 14: Median estimates of relative lineal density by year (with 95% credibility intervals) for Kokanee in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

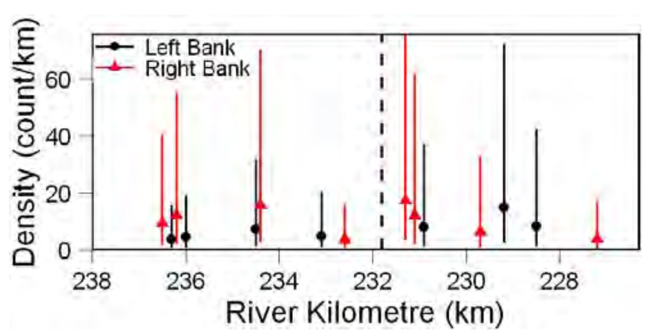


*Figure 15: Median estimates of relative lineal density by site (with 95% credibility intervals) for Kokanee in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.4 Mountain Whitefish

Yearly relative lineal density estimates for Mountain Whitefish (all size-cohorts combined; Figure 16) suggest stable numbers between 2001 and 2011. Season was a significant predictor of Mountain Whitefish relative lineal density ($p = 0.001$; not shown), with higher densities in the spring than in the fall. This is supported by results of the mark-recapture based HBA (Figures 17 and 18), which suggests significantly higher age-1 abundance during the spring season ($p = 0.036$); age-2+ Mountain Whitefish abundance was low during the spring 2011 season. Prior to 2007, Mountain Whitefish less than approximately 180 mm FL were rarely marked, preventing the model from generating abundance estimates for the age-1 cohort from 2001 to 2006 (Figure 18).

Both relative density of all size cohorts combined (Figure 19) and age-2+ relative density (Figure 20) estimates indicated low mountain whitefish densities in Site 233.1-L. The bank along this site, located in Reach 4 adjacent to the Revelstoke Golf Course, was stabilized by BC Hydro in the fall of 2009. Estimates of relative lineal density (all size-cohorts combined; Figure 19) and relative lineal density for the age-2+ cohort (Figure 20) indicate generally higher densities along the right bank from upstream of the Jordan River confluence to the Tonkawatla Creek confluence and generally lower densities along the left bank from the upstream end of the Revelstoke Golf Club to the Centennial Park Boat Launch. Site-level relative density estimates for age-1 Mountain Whitefish were more variable but suggest similar density patterns (Figure 21).

To date, the implementation of the minimum flow release and the operation of REV5 has not resulted in a statistically significant change in the relative lineal density ($p = 0.460$), or abundance of age-1 ($p = 0.441$) or age-2+ ($p = 0.345$) Mountain Whitefish in the MCR.

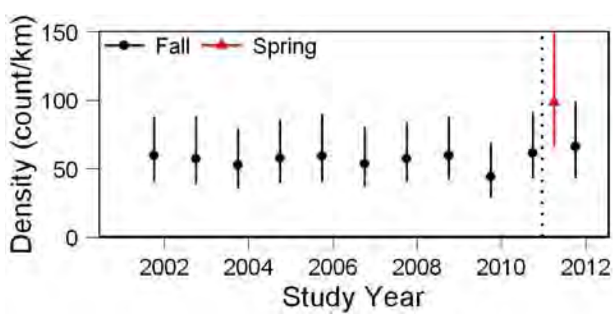


*Figure 16: Median estimates of relative lineal density by year (with 95% credibility intervals) for Mountain Whitefish (all size-cohorts combined) in the Middle Columbia River. The dashed line represents the implementation of the minimum flow release and REV5 operations.*

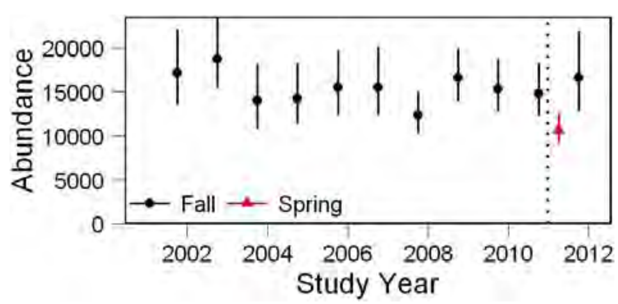


*Figure 17: Median estimates of absolute abundance by year (with 95% credibility intervals) for age-2+ Mountain Whitefish in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

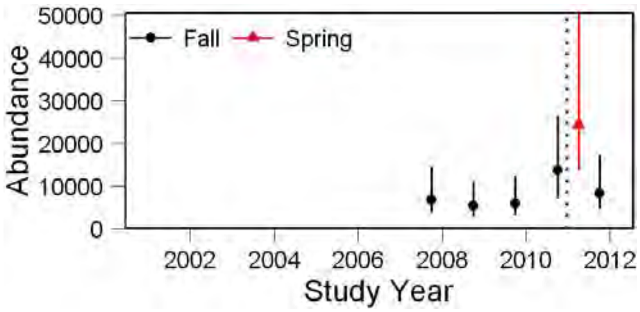


*Figure 18: Median estimates of absolute abundance by year (with 95% credibility intervals) for age-1 Mountain Whitefish in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

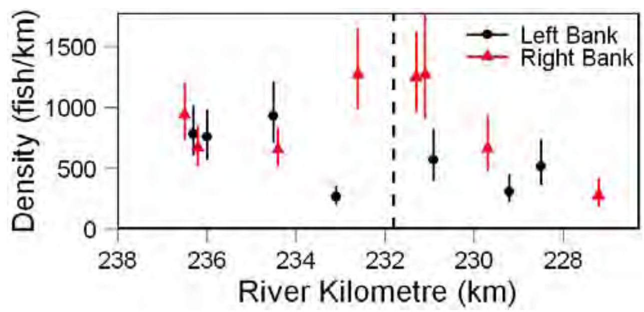


*Figure 20: Median estimates of relative lineal density by site (with 95% credibility intervals) for age-2+ Mountain Whitefish in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

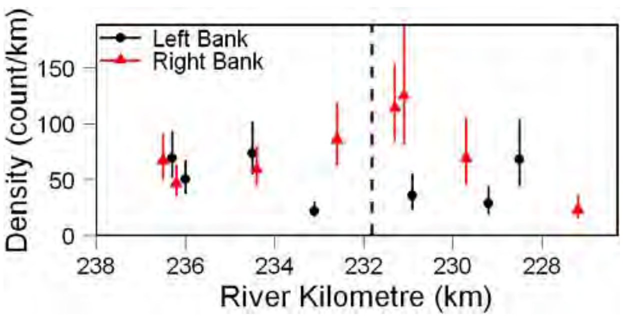


*Figure 19: Median estimates of relative lineal density by site (with 95% credibility intervals) for Mountain Whitefish (all size-cohorts combined) in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

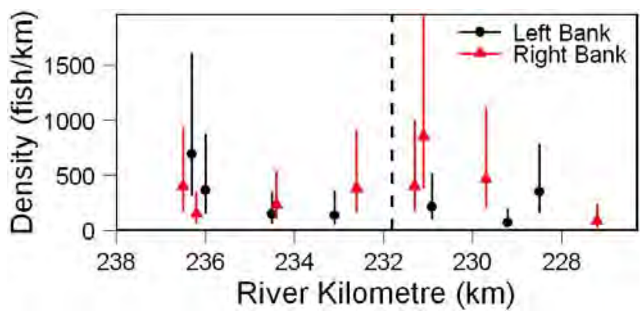


*Figure 21: Median estimates of relative lineal density by site (with 95% credibility intervals) for age-1 Mountain Whitefish in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.5 Rainbow Trout

Mean relative lineal densities estimates for Rainbow Trout suggested a gradual increase between 2001 and 2008 (Figure 22); however, this result is based on a small sample size, as rainbow were rarely captured from 2001 to 2006 because sampling was limited to Reach 4 and to the Big Eddy portion of Reach 3 during these years. Density estimates for Rainbow Trout were lower in 2009 than in other study years. Season was not a significant predictor of Rainbow Trout density ($p = 0.944$; not shown). Rainbow Trout densities were lower in Reach 4 and higher along the left bank in Reach 3 (Figure 23). The left bank of Reach 3 is predominantly rip-rap substrate (Appendix A, Figure A2).

To date, there is no relationship between rainbow trout density and flow regime ($p = 0.233$; not shown).

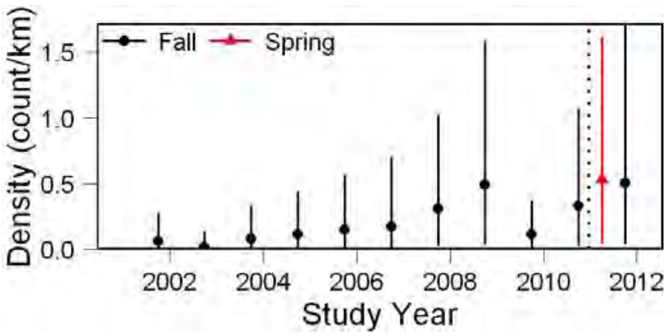


*Figure 22: Median estimates of relative lineal density by year (with 95% credibility intervals) for Rainbow Trout in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

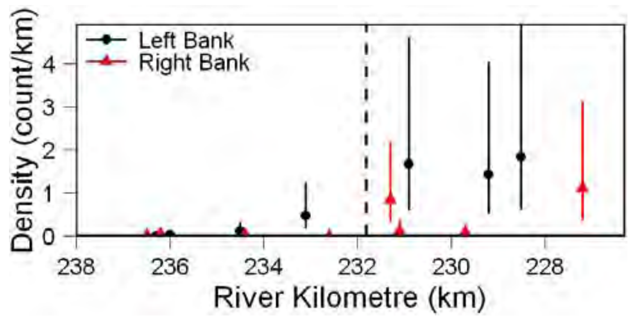


*Figure 23: Median estimates of relative lineal density by site (with 95% credibility intervals) for Rainbow Trout in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.6 Sucker Species

In 2001, 2010, and 2011, Sucker species captured were recorded to the species level. During these years (fall sample periods only), Largescale Sucker accounted for approximately 94% of the total Sucker species catch; the remaining 8% were Longnose Sucker (*Catostomus catostomus*). During the spring 2011 sample period, Largescale Sucker accounted for 47% of the total Sucker species catch; the remaining 53% were Longnose Sucker (Attachment A). Limited and variable mark-recapture data prevented the HBA from generating abundance estimates for either species. Density estimates are based on observational data for both species combined.

Sucker species densities were higher in 2010 and 2011 (fall season only) than in previous study years (count-based HBA; Figure 24). Sucker species densities were generally lowest immediately downstream of REV and highest along the right bank in the upstream portion of Reach 3 (i.e., between the narrows downstream of Big Eddy and the Tonkawatla Creek confluence; Figure 25).

There was no relationship between Sucker species density and flow regime ($p = 0.309$; HBA, not shown); however, season was a significant predictor of Sucker species density ($p = 0.009$; HBA, not shown), with higher densities in the fall and lower densities in the spring.

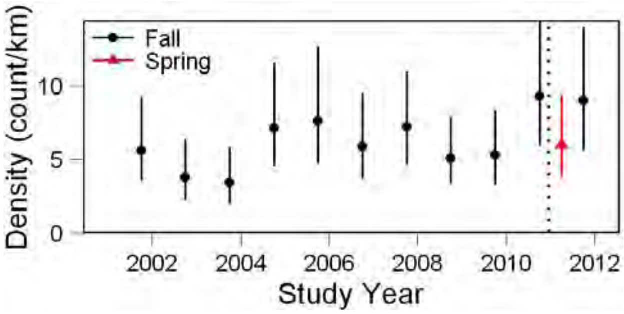


*Figure 24: Median estimates of relative lineal density by year (with 95% credibility intervals) for Sucker species in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

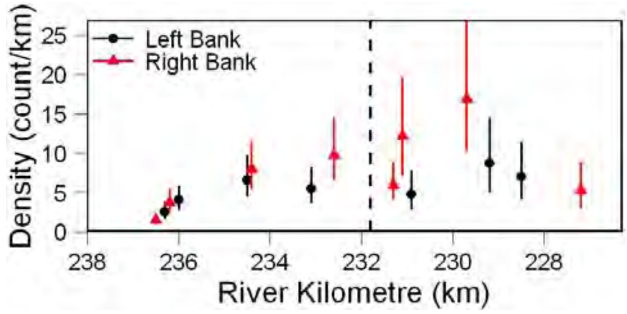


*Figure 25: Median estimates of relative lineal density by site (with 95% credibility intervals) for Sucker species in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.7 Northern Pikeminnow

Northern Pikeminnow densities in the MCR remained relatively low between 2001 and 2006; between 2007 and 2010, the abundance of this species increased substantially (Figure 26). Densities declined between 2010 and 2011. Season was a significant predictor of Northern Pikeminnow density with spring densities approximately 90% lower than fall estimates ($p < 0.001$; not shown). Northern Pikeminnow were relatively uncommon in Reach 4 when compared to Reach 3 (Figure 27).

There was no relationship between Northern Pikeminnow density and flow regime ($p = 0.513$; HBA, not shown).

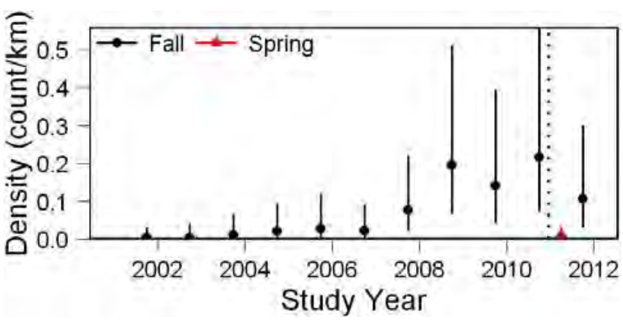


*Figure 26: Median estimates of relative lineal density by year (with 95% credibility intervals) for Northern Pikeminnow in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

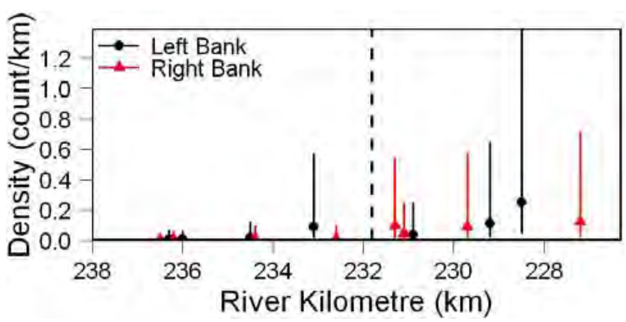


*Figure 27: Median estimates of relative lineal density by site (with 95% credibility intervals) for Northern Pikeminnow in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.8 Sculpin Species

Sculpin species densities in the MCR remained relatively low between 2001 and 2005, increased between 2005 and 2008, declined substantially between 2008 and 2009, and increased between 2009 and 2011 (Figure 28). Site-level density estimates were variable and did not indicate any obvious patterns or trends (Figure 29). There was considerable uncertainty surrounding most of these estimates.

There was no relationship between Sculpin species density and flow regime (p = 0.355; not shown) or season (p = 0.176; HBA, not shown).

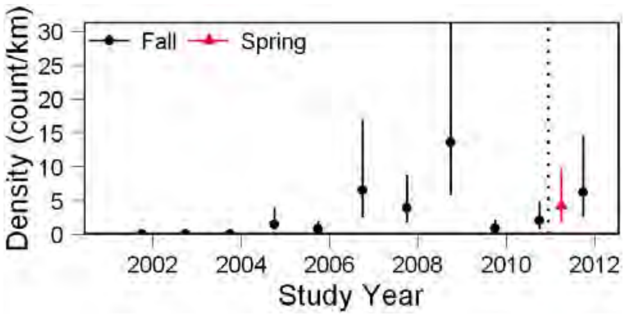


*Figure 28: Median estimates of relative lineal density by year (with 95% credibility intervals) for Sculpin species in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

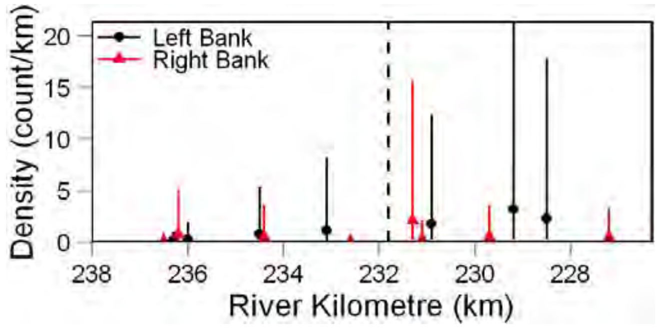


*Figure 29: Median estimates of relative lineal density by site (with 95% credibility intervals) for Sculpin species in the Middle Columbia River, 2001 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

### 3.6.9 Capture Efficiencies

Capture efficiencies for the two species for which a site-level intra-year mark-recapture HBA was performed (Bull Trout and Mountain Whitefish) are plotted in Figure 30. Capture efficiency was substantially higher for age-2+ Mountain Whitefish during the spring than in the fall. This was not replicated for age-1 Mountain Whitefish or Bull Trout, which may indicate that age-2+ Mountain Whitefish are more likely to leave the study area after marking during the fall than they are during the spring. There were no other obvious long-term trends within species although there were substantial differences in capture efficiencies between species and life stage (for Mountain Whitefish). Inter-session variations in capture efficiency do not appear to co-vary substantially among species. This indicates that field crews maintained efficiency within sample sessions.

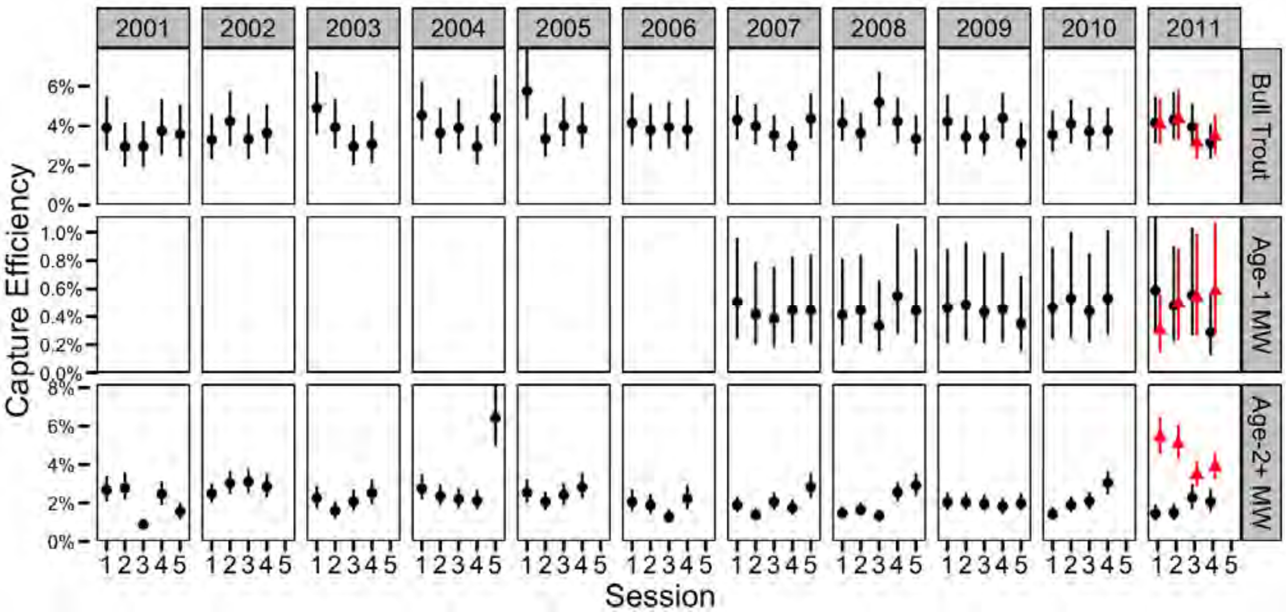


*Figure 30: Median estimates of capture efficiency by year, session, and species (with 95% credibility intervals) in the Middle Columbia River for fish species in which abundance was estimated via a Hierarchical Bayesian Mark-Recapture Analysis, 2001 to 2011. Mountain Whitefish are coded as MW; Red triangles denote data collected during the spring survey.*

## 3.7 Growth Rate

Limited mark-recapture data prevented detailed growth-related analysis for all species with the exception of Bull Trout (Section 3.7.1) and Mountain Whitefish (Section 3.7.2).

Of the 398 Largescale Sucker marked during the fall 2010 study period, 24 were recaptured during the fall 2011 study period. The average annual growth of these individuals was 14 mm and ranged from 0 to 207 mm (Attachment A).

One of the 24 Northern Pikeminnow initially marked during the 2010 study period was recaptured during the fall 2011 study period. This fish had a fork length of 371 mm in 2010 and a fork length of 388 mm in 2011 (Attachment A).

One of the 61 Rainbow Trout initially marked during the 2010 study period was recaptured during the fall 2011 study period. This fish had a fork length of 131 mm in 2010 and a fork length of 232 mm in 2011 (Attachment A).

### 3.7.1 Bull Trout

#### *3.7.1.1 Length-At-Age*

Changes in Bull Trout length-at-age could not be estimated using a Hierarchical Bayesian mixture analysis of length-frequency distributions due to indistinguishable age-classes in length-frequency histograms for this species (Appendix E, Figure E1).

#### 3.7.1.2 Annual Length Increments

Based on an HBA of annual length increments of recaptured individuals, there was a substantial decline in Bull Trout growth rates between 2007 and 2008; however, credibility intervals for these estimates did overlap (Figure 31). There was no other long-term pattern of trends between 2001 and 2011 for this species.

There was no discernible relationship between Bull Trout growth and flow regime (p = 0.616; not shown).

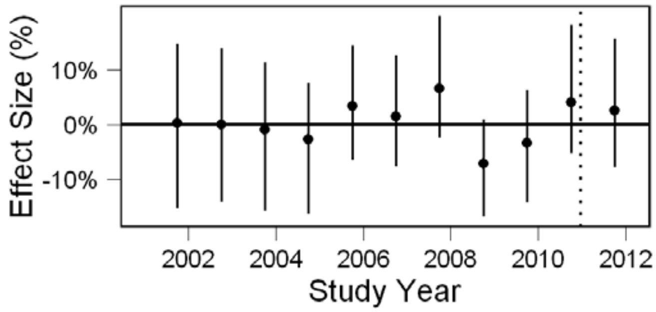


*Figure 31: Median estimates (with 95% credibility intervals) of inter-annual variation in the expected maximum fork length ($L_\infty$) of Bull Trout, expressed as the predicted percent change relative to a typical year in the Middle Columbia River.*

### 3.7.2 Mountain Whitefish

#### 3.7.2.1 Length-At-Age

Results of the hierarchical Bayesian mixture analysis of length-frequency distributions indicated larger lengths-at-age for most mountain whitefish cohorts during the early 2000s and smaller lengths-at-age during the late 2000s (Figure 32). Cohorts with larger lengths-at-age at age-0 typically had larger lengths-at-age during successive study years.

Length-at-age for the age-1 and age-2 cohorts were significantly smaller in 2011 than in study years prior to the flow regime change (p = 0.003; Figure 33). Whether this decline was due to the flow regime change remains uncertain.

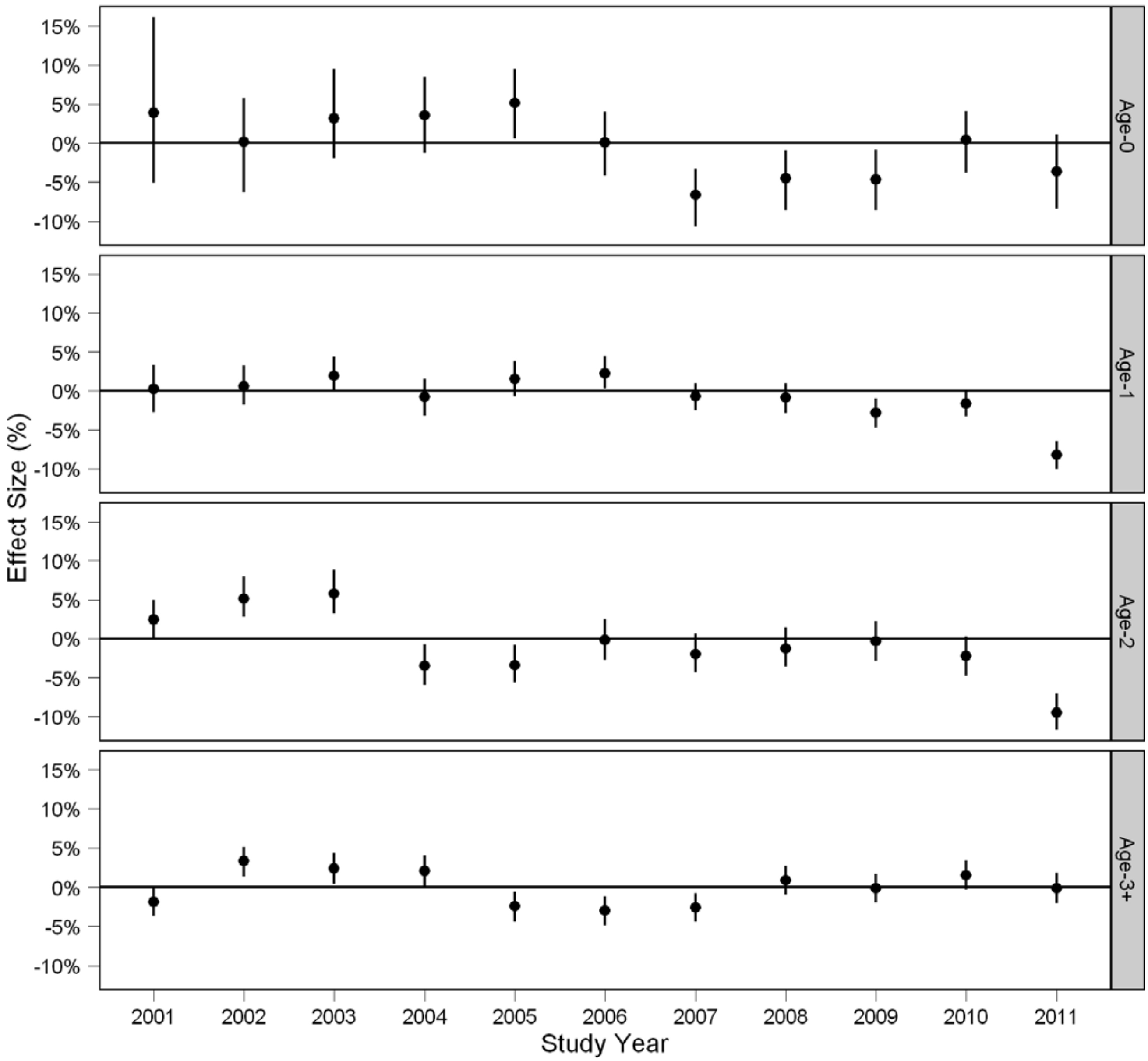


*Figure 32: Median estimates (with 95% credibility intervals) of inter-annual variation in length-at-age for Mountain Whitefish, expressed as the predicted percent change in length-at-age relative to a typical year in the Middle Columbia River.*

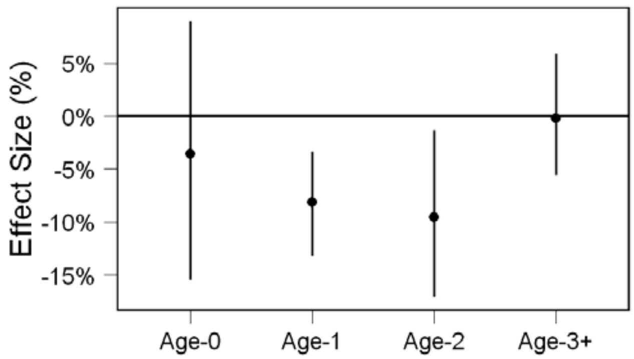


*Figure 33: Median estimates (with 95% credibility intervals) of change in length-at-age for mountain whitefish in 2011, after implementation of the minimum flow release in the Middle Columbia River, relative to typical growth prior to the flow regime change (i.e., from 2001 to 2010).*

### 3.7.2.2 Annual Length Increments

Annual Whitefish length increments of recaptured individuals did not differ between 2001 and 2011; credibility intervals overlapped for all estimates (HBA, Figure 34). There was no change in growth associated with REV5 operations and/or the implementation of the minimum flow release ($p = 0.511$; not shown).

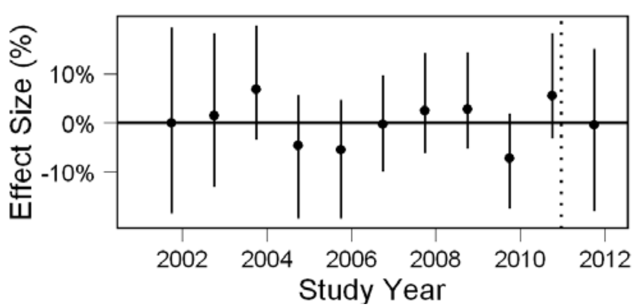


*Figure 34: Median estimates (with 95% credibility intervals) of inter-annual variation in the expected maximum fork length ($L_\infty$) of Mountain Whitefish, expressed as the predicted percent change relative to a typical year in the Middle Columbia River.*

## 3.8 Body Condition

Variation in body condition is presented in terms of the percent change in body weight of a median length individual by species. Body condition estimates were not available for 2001 because fish were not weighed during that study year.

### 3.8.1 Bull Trout

Over all study years, the median length of Bull Trout recorded in the MCR was 479 mm FL. Yearly variation in body condition, which was substantial, appeared to follow a multi-year cycle with higher condition values recorded in the early 2000s and lower body condition values recorded in the late 2000s (Figure 35). Variation in condition between sample sites was negligible (Figure 36).

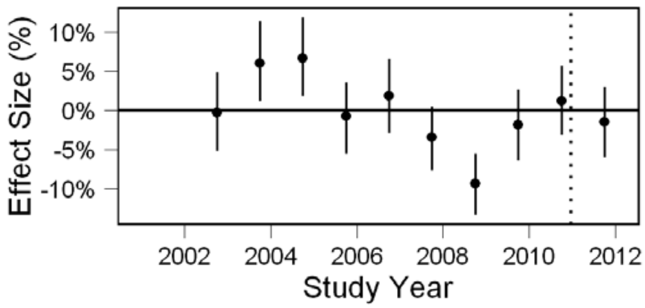


*Figure 35: Median estimates (with 95% credibility intervals) of inter-annual variation in body condition, expressed as the percent change in the expected body weight of a median length (i.e., 479 mm FL) Bull Trout in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

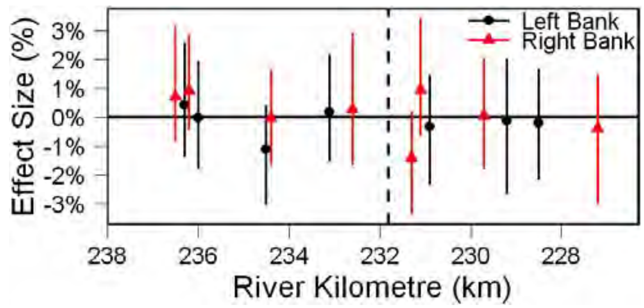


*Figure 36: Median estimates (with 95% credibility intervals) of inter-site variation in body condition, expressed as the percent change in the expected body weight of a median length (i.e., 479 mm FL) Bull Trout in the Middle Columbia River, 2002 to 2011. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

Similar to results presented in previous years (Golder 2010, Ford and Thorley 2011a), a bull trout marked with a T-bar anchor tag during a previous study year tended to be in significantly better condition ($p < 0.001$) than its unmarked equivalent, while a bull trout marked with a PIT tag was not ($p = 0.044$; Figure 37). Body condition declined significantly with day of the year ($p < 0.001$; Figure 38).

There was no significant change in bull trout body condition associated with implementation of the minimum flow release and the operation of REV5.

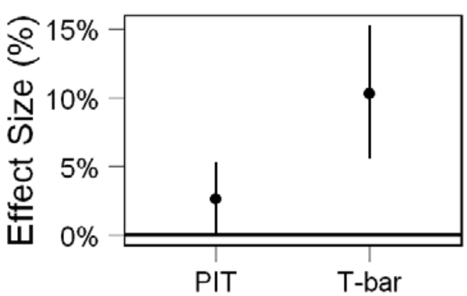


*Figure 37: Median estimates (with 95% credibility intervals) of the effect of tag type on body condition, expressed as the expected percent change in the body weight of a median length (i.e., 479 mm FL) Bull Trout in the Middle Columbia River, 2002 to 2011.*

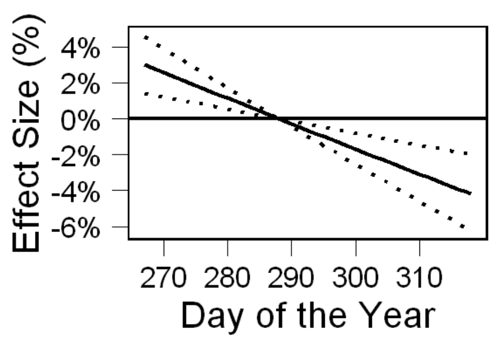


*Figure 38: Median estimates (with 95% credibility intervals) of the effect of day of the year on body condition, expressed as the expected percent change in the body weight of a median length (i.e., 479 mm FL) Bull Trout in the Middle Columbia River, 2002 to 2011.*

### 3.8.2 Mountain Whitefish

Over all study years, the median length of Mountain Whitefish recorded in the MCR was 234 mm FL. With the exception of 2010, the body condition of mountain whitefish declined each year between 2006 and 2011 (Figure 39). For all study years combined, Mountain Whitefish body condition was lower in Reach 4 and higher in Reach 3 for all sample sites (Figure 40).

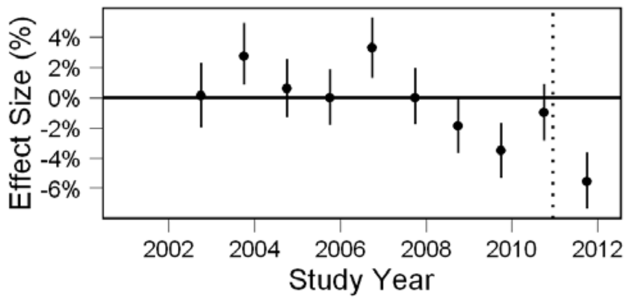


*Figure 39: Median estimates (with 95% credibility intervals) of inter-annual variation in body condition, expressed as the expected percent change in the body weight of a median length (i.e., 234 mm FL) Mountain Whitefish in the Middle Columbia River. The dotted line represents the implementation of the minimum flow release and REV5 operations.*

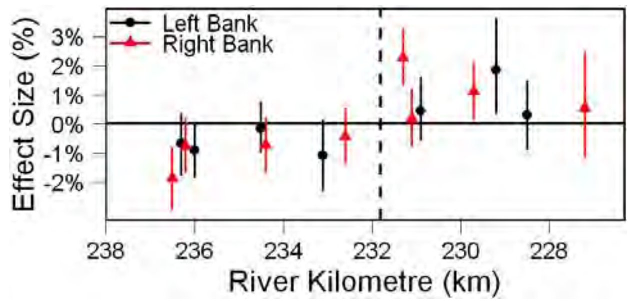


*Figure 40: Median estimates (with 95% credibility intervals) of inter-site variation in body condition, expressed as the expected percent change in the body weight of a median length (i.e., 234 mm FL) Mountain Whitefish in the Middle Columbia River, 2002 to 2012. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

Unlike Bull Trout, Mountain Whitefish with T-bar anchor tags had significantly reduced body condition while fish with PIT tags did not (p = 0.137; Figure 41). For mountain whitefish, body condition did not vary significantly with day of the year (p = 0.265; not presented).

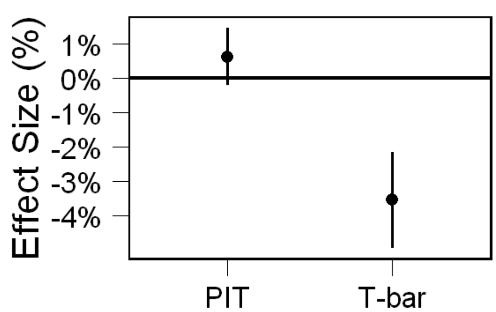


*Figure 41: Median estimates (with 95% credibility intervals) of the effect of tag type on body condition, expressed as the expected percent change in the body weight of a median length (i.e., 234 mm FL) Mountain Whitefish in the Middle Columbia River, 2002 to 2011.*

Mountain Whitefish body condition was significantly lower in 2011 than in previous years (p = 0.047; not shown). It is not known if this decline is due to REV5 operations, the implementation of the minimum flow release, or some other unknown environmental variable.

### 3.8.3 Rainbow Trout

Sparse life history data for Rainbow Trout resulted in relatively uncertain body condition estimates for this species. Estimates of body condition could not be calculated for rainbow trout prior to 2003 because weights were not recorded in 2001 and Rainbow Trout were not encountered in 2002. Over all study years, the median length of Rainbow Trout recorded in the MCR was 177 mm FL. Body condition varied between study years with credibility intervals overlapping for all estimates (Figure 42).

Estimates of body condition could not be calculated for Rainbow Trout at Site 236.4-L or at Site 232.6-R because Rainbow Trout have never been recorded in these sites. There was considerable variation in the body condition of Rainbow Trout among sites (Figure 43). Rainbow Trout body condition was noticeably higher within Site 227.2-R (i.e., Salmon Rocks) when compared to estimates from neighbouring sites.

The presence of a PIT tag was not a significant correlate of body condition for Rainbow Trout (p = 0.459; not shown); T-bar anchor tags were rarely used to mark Rainbow Trout (*n* = 14). Similar to Bull Trout, day of the year was a significant predictor of body condition for Rainbow Trout (p = 0.036; Figure 44).

There was no change in body condition associated with REV5 operations and/or the implementation of the minimum flow release (p = 0.655; not shown).

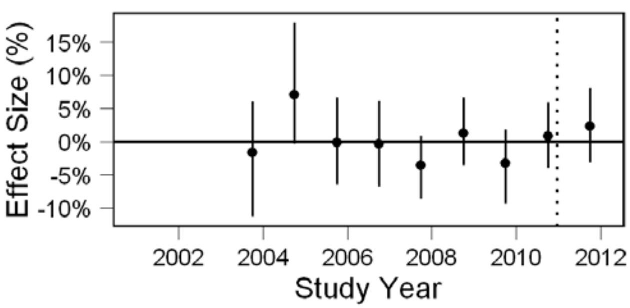


*Figure 42: Median estimates (with 95% credibility intervals) of inter-annual variation in body condition, expressed as the expected percent change in the body weight of a median length (i.e., 177 mm FL) Rainbow Trout in the Middle Columbia River. The dashed line represents the timing of minimum flow implementation and REV5 operations.*

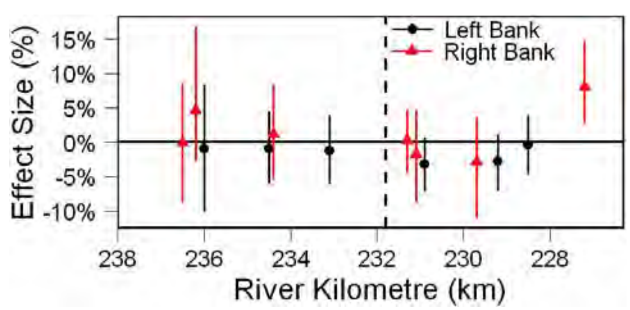


*Figure 43: Median estimates (with 95% credibility intervals) of inter-site variation in body condition, expressed as the expected percent change in the body weight of a median length (i.e., 177 mm FL) Rainbow Trout in the Middle Columbia River, 2002 to 2010. The dashed line represents the divide between Reaches 3 and 4 at the Jordon River confluence.*

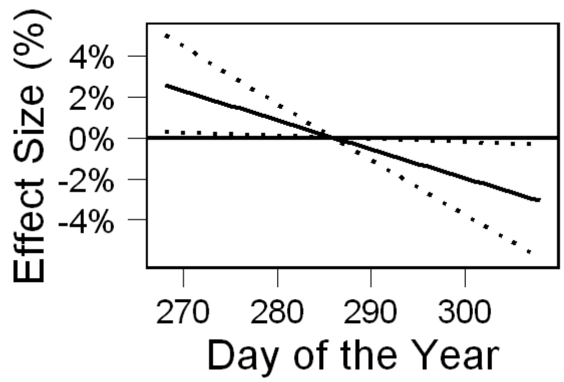


*Figure 44: Median estimates (with 95% credibility intervals) of the effect of day of the year on body condition, expressed as the expected percent change in the body weight of a median length (i.e., 177 mm FL) Rainbow Trout in the Middle Columbia River, 2002 to 2011.*

### 3.8.4 Other Species

Length and weight data were recorded for all species encountered in 2010 and 2011. In addition to Bull Trout, Mountain Whitefish, and Rainbow Trout, body condition also was analyzed using HBA for Lake Whitefish, Largescale Sucker, Northern Pikeminnow, Prickly Sculpin, and Redside shiner. Wide credibility intervals precluded any meaningful interpretation of the results for these species. Estimates from the HBA are expected to become more precise during future study years as additional data are collected.

# 4.0 DISCUSSION

The primary purpose of CLBMON-16 is to answer four key management questions:

- Is there a change in the abundance of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in growth rate of adult life stages of the most common fish species using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in body condition (measured as a function of relative weight to length) of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?
- Is there a change in spatial distribution of adult life stages of fish using the MCR that corresponds with the implementation of a year-round minimum flow?

Another objective of the program, although not specifically identified as a key management question, is to investigate and document changes in species richness or species diversity in the MCR in response to the minimum flow release.

## 4.1 Species Richness and Diversity

Estimates of species richness overlapped for all study years and most sample sites. Overall, species richness generally increased with distance downstream from the dam. Higher species richness downstream is likely a reflection of this portion of the study area serving as a transition zone between the flowing section of the Columbia River and ALR. Species richness was lower in Site 232.6-R (upstream of the Jordan River confluence) than in neighbouring sites. Habitat within this site is very homogenous, encompassing a large, flat, gravel/cobble fan upstream of the confluence. Shallower water depths, a lack of suitable cover, and the uniform nature of the substrate may reduce the suitability of the area for certain species.

For most of the study area, species richness was higher on the left bank than the right bank. The left bank has more armoured substrate (85%) than the right bank (57%; Appendix B, Table B2).

While species richness remained relatively constant between 2001 and 2011, species diversity gradually increased over the same time period (although credibility intervals did overlap for most study years). An increase in species diversity without a change in species richness indicates a change in the relative abundances of individual species. Species diversity increased because less common species became more common. Over the 11 year study period, density estimates showed an increasing trend for Burbot, Rainbow Trout, Northern Pikeminnow, and Sculpin species. Densities estimates of more common species, such as Bull Trout and Mountain Whitefish, remained relatively stable.

Species diversity was significantly higher in Site 233.1-L than in neighbouring sites, in part due to lower Mountain Whitefish densities in this site relative to other sites. During the fall season, Mountain Whitefish generally prefer areas with low water depths and cobble/boulder substrate. Site 233.1-L is located along the left bank in Reach 4 along the Revelstoke Golf Course and is characterized by steep banks, deep water, and large (i.e., rip-rap) substrate.

Overall, Reach 3 represents a transition zone between lacustrine and riverine habitats, particularly during the fall study period when ALR water elevations levels are higher. The complex species assemblage (higher species richness and diversity) in that portion of the study area reflects that transition.

## 4.2 Management Question #1 - Abundance

### 4.2.1 Bull Trout

Bull Ttrout abundance generally increased from 2001 to 2007 and was relatively stable from 2007 to 2011. Given the magnitudes of change observed from 2001 to 2006, these differences in abundance may not reflect actual changes in abundance to the overall population in ALR and may reflect differences in migration rates out of ALR.

Prior to the spring 2011 survey, it was assumed that Bull Trout were more abundant in the MCR during the fall season to feed on spawning Kokanee. Abundance for this species during other portions of the year was expected to be low. This assumption was based on several factors, including relatively low bull trout catch-rates during the 2001 survey (which was conducted several weeks earlier than other surveys), declining Bull Trout catch-rates over the duration of most study periods, and angler tag return data from ALR. However, abundance and density estimates from the spring 2011 sample period were comparable to neighbouring fall estimates and may indicate that Bull Trout are more resident in this area than previously expected. High Bull Trout catch-rates during the spring 2012 survey would help support this argument.

### 4.2.2 Burbot

Annual relative density estimates for Burbot were higher in 2008 and 2011 than in other study years. Based on catch-rates recorded during BC Hydro's Arrow Reservoir Burbot Life History and Habitat Use Study (CLBMON-31; LGL 2009), Burbot are relatively common in Upper Arrow Lake (Reaches 1 and 2) when compared to Reaches 3 and 4. During the 2008 and 2011 field seasons, water elevation levels in ALR were higher than during any other study years (Appendix C, Figure C3), with the reservoir backing up into Reach 4 for most of the field season during both years. Higher water elevation levels during the 2008 and 2011 field seasons may help explain higher Burbot densities observed during those study years.

### 4.2.3 Kokanee

Annual density estimates for Kokanee varied greatly between 2001 and 2010. With the exception of 2008, density estimates for this species declined each year between 2006 and 2011. During the spring 2011 survey, Kokanee density was extremely low (only 26 Kokanee were recorded during the entire spring 2011 survey; Appendix D, Table D1). This result is not surprising; Kokanee migrate into the MCR during the fall season to spawn in adjoining tributaries, but this species generally rears and feeds in large lakes (e.g., ALR; Scott and Crossman 1973).

With use of the study area by kokanee limited to a migratory corridor during the fall, it is unlikely that abundance of this species in the MCR will be influenced by REV5 operations or the minimum flow release. Other dam-related factors, such as entrainment rates through REV, could have a larger impact on MCR Kokanee abundance.

### 4.2.4 Mountain Whitefish

Over the 11 year study period, the absolute abundance of age-2+ Mountain Whitefish in the MCR remained stable at approximately 15 000 individuals, although estimates were slightly higher in 2001 and 2002 and slightly lower in 2007. The model estimated higher age-1 abundance in 2010 when compared to other study years. This result is supported by 2009 catch data that indicated higher abundances of age-0 fish during that study year (Appendix E, Figure E2). This cohort represents recruitment from spawning that occurred over the winter of 2008/2009. During that time period, water temperatures in the MCR and discharge levels through REV were both comparable to all other study years; water level elevations in ALR were higher than all other study years (Appendix C, Figure C3).

Spring 2011 density and abundance estimates for mountain whitefish were higher for the age-1 cohort and lower for the age-2+ cohort than fall estimates. High age-1 abundance during the spring 2011 survey followed by low age-1 abundance during the subsequent fall season indicates either seasonal use of the study area or exceptionally high mortality rates for this cohort. A loss of approximately 65 % of the age-1 cohort between June and October is unlikely; therefore, the former scenario is likely the case, with fish migrating into the study area during the spring from ALR or major tributaries.

The number of age-2+ Mountain Whitefish recorded during the spring 2011 survey was similar to most other fall estimates (Attachment A); however, recapture rates for this cohort were substantially higher during the spring 2011 season when compared to all fall sample seasons. Reasons for an approximately two fold increase in sampling efficiency during the spring are unknown. This change was not noted for any other species or life-stages, which indicates that the increase was not due to a sampling bias (e.g., equipment error, selective netting by the field crew, differences in water conductivity, etc.) but more likely to a change in behaviour for this cohort. Without mark-recapture data the change in sampling efficiency would not have been detected and spring abundance would have been overestimated by a factor of two.

Age-0 Mountain Whitefish catch was substantially lower during the fall 2011 survey than in other study years (Appendix D, Figure E2). These fish represent the cohort that hatched during the winter of 2010/2011 (i.e., the winter in which REV5 went online and the minimum flow release was implemented). During that time period, both discharge from REV (Appendix C, Figure C1) and water level elevations in ALR (Appendix C, Figure C4) were more variable than in other study years. Evidence of Mountain Whitefish spawning in the MCR is limited; however, field crews recorded adult Mountain Whitefish in spawning condition (i.e., gravid or ripe individuals) during most study years (Attachment A).

### 4.2.5 Rainbow trout

Density estimates for Rainbow Trout gradually increased from 2001 to 2008, declined between 2008 and 2009, and gradually increased from 2009 to 2011. Overall, densities estimates for this species were quite low, with wide credibility intervals. The estimate for the spring 2011 survey was comparable to adjacent fall estimates.

Rainbow Trout in the Lower Columbia River (i.e., downstream of HLK; LCR) typically spawn between early March and late June when water temperatures are between 4 and 14°C (Thorley and Baxter 2012). In the MCR, the spring 2011 survey was conducted in June when water temperatures were between 6 and 9°C. If Rainbow Trout in the MCR spawn under conditions similar to those in the LCR, the spring 2011 survey would have occurred during their expected spawning season. Water temperatures in the MCR are rarely higher than approximately 11°C (Appendix C, Figure C5). During the spring 2011 survey, three Rainbow Trout (4% of the total Rainbow Trout catch) were in spawning condition (all three were males; Attachment A). Spawning redds were not observed by the field crew during boat electroshocking surveys. This suggests that the MCR is not a major spawning area for this species; therefore annual variations in Rainbow Trout densities are not likely related to the spawning success of this species in the MCR. The bulk of Rainbow Trout spawning probably occurs in tributaries as high ALR water elevations during the late spring and early summer would flood most potential spawning habitat downstream of the Illecillewaet River confluence. A Rainbow Trout spawning assessment would be required to determine the extent of mainstem spawning for this species.

#### 4.2.6 Sucker Species

Over all study years, the density of Sucker species has been variable, but higher densities were suggested in 2010 and 2011 (fall season only) when compared to other study years. This result is suspect. Due to the long-lived nature of these species (at least age-15; Scott and Crossman 1973) and the number of years it takes for these fish to reach sexual maturity (age-5; Nelson and Paetz 1992), it is unlikely that the population nearly doubled in one year. An alternate explanation for the increase is changes in sampling methods. Field crews did not attempt to capture Sucker species from 2002 to 2009. Density estimates for those years were based entirely on netter observations and Sucker species may have been either consistently misidentified or under estimated. However, Sucker species generally react to electricity by rapidly swimming to the surface and rolling onto their backs, their lips usually distended. This behaviour makes their identification relatively easy, suggesting that netters did not consistently misidentify them. A more probable hypothesis is that in past survey years, the netters underestimated numbers observed. Sucker species tend to aggregate in large groups and when the electrofishing boat passes over these groups, large numbers of fish tend to rise to the surface at once, making enumeration more difficult and therefore, less accurate.

Approximately half (48%) of the Sucker species captured during the spring 2011 survey were identified as spawners through the release of gametal products or the presence of tubercles (both species combined; Attachment A), indicating that the MCR could be a major spawning area for these species. During this survey, Sucker species were routinely observed in shallow water over small gravel substrate (e.g., Sites 232.6-R, 231.0-R, and 229.7-L). If these fish are spawning in these areas, there is the potential for eggs to become stranded during nightly flow reductions or for fry to become stranded prior to emergence (approximately four weeks after spawning; Scott and Crossman 1973) when BC Hydro drafts ALR (which can occur at any time after early July).

#### 4.2.7 Northern Pikeminnow

Northern Pikeminnow density remained relatively constant from 2001 to 2006, gradually increased from 2006 to 2010, and declined slightly between 2010 and 2011. Reasons for the increase in recent years are unknown. Overall, water level elevations in ALR were higher from 2007 to 2011 when compared to earlier study years, particularly during the fall season. Higher Northern Pikeminnow densities record between 2007 and 2011 may be due to higher ALR water levels during those study years. Northern Pikeminnow density was low during the spring 2011 survey.

### 4.2.8 Sculpin Species

Sculpin species densities were higher from 2006 to 2008, and in 2011 than in other study years. Generally, the electrical field is not strong enough to attract Sculpin species to the water surface. This means that most Sculpin species observed in the MCR are usually at depths greater than approximately 1.0 m. Observations or captures made at these depths are influenced by water surface visibility, water clarity, netter efficiency, and water velocity. A preliminary review of habitat data recorded at the time of sampling (Appendix B, Table B3; Attachment A) did not indicate poorer observational conditions during any particular study year.

Given their small-bodied nature and the associated inefficiency of the selected sampling method at capturing Sculpin species, it is unlikely that the program, in its current form, will generate a large enough dataset to answer the management questions for this species. Sculpin species are routinely captured as part of BC Hydro's MCR Juvenile Fish Habitat Use Program (CLBMON-17; Triton 2009, 2010, 2011). If necessary, it may be more practical to answer specific management questions regarding these species under that program.

## 4.3 Management Question #2 - Growth Rate

Growth rates were examined using two separate HBAs. One HBA used a hierarchical Bayesian mixture model to estimate size-at-age based on length-frequency data. Mountain Whitefish was the only species in which adequate length-frequency data were available. Low annual growth rates, which cause individual age-cohorts to overlap in length-frequency histograms, and/or limited life history data, which hinder the interpretation of modes in length-frequency histograms, prevented the application of the HBA for all other species. The second HBA was based on individual growth rates of inter-year recaptured fish. Limited mark-recapture data excluded this analysis for all species except Mountain Whitefish and Bull Trout. Information on annual growth rates for species other than Bull Trout and Mountain Whitefish should become available in future study years as more life history and mark-recapture data are collected. However, given the limited dataset that exists for species other than Mountain Whitefish and Bull Trout prior to the implementation of the minimum flow release and REV5 operations (i.e., prior to 2010), it is unlikely that the HBAs will be able to link any changes in annual growth of these species to changes in the flow regime.

### 4.3.1 Bull Trout

Overall, changes in annual Bull Trout growth were gradual and occurred over multi-year periods. As an example, annual growth for this species gradually increased each year between 2001 and 2004, and gradually increased again between 2008 and 2010 (Figure 31). However, between 2007 and 2008, there was a substantial decline in growth of approximately 10% for this species. Reasons for this decline are unknown, but could be due to differences in prey fish abundance and/or distribution associated with unusually high ALR elevations in 2008 when compared to other study years (Appendix C, Figure C4). There was no change detected in Bull Trout growth rates associated with implementation of the minimum flow release.

### 4.3.2 Mountain Whitefish

Significantly smaller lengths-at-age for the age-1 and age-2 Mountain Whitefish cohorts were recorded after the flow regime change. As only one year of data has been collected after the flow regime change, the reduced lengths-at-age in 2011 may reflect a statistically unusual year-effect as opposed to the flow regime change. Additional years of data are required to confirm a link between length-at-age and flow regime.

Overall, Mountain Whitefish lengths-at-age follow similar annual patterns for most age-cohorts. As an example, all age-cohorts analyzed (i.e., age-0, age-1, age-2, and age-3+) experienced smaller lengths-at-age in 2007 and 2011 and larger lengths-at-age in 2003. This similarity is likely due to most age-cohorts of this species inhabiting similar habitats and feeding on similar prey organisms.

## 4.4 Management Question #3 - Body Condition

Body condition was analyzed using a HBA for Lake Whitefish, Largescale Sucker, Northern Pikeminnow, Prickly Sculpin, and Redside Shiner (in addition to Bull Trout, Mountain Whitefish, and Rainbow Trout; see below); however, limited data for these species resulted in wide credibility intervals surrounding all estimates. Temporal or spatial trends in body condition were not observed for any of the above species. Relationships between body condition and tag type or flow regime also were not evident for these species. Life history data were collected for these species in 2010 and 2011 only, as such, credibility intervals surrounding body condition estimates were extremely wide. However, the credibility of these estimates will likely decrease during future study years as more data become available. Given the limited dataset that exists for these species prior to the flow regime change (i.e., 1 year of data), it is unlikely that the HBA will be able to link any observed changes in body condition for these species to flow regime changes.

### 4.4.1 Bull Trout

Bull Trout appeared to follow a multi-year cycle of body condition; higher in the early 2000s and lower in the late 2000s. Reasons for this cycle are unknown. Mountain Whitefish (see Section 4.4.2) also follow a similar pattern. For years with complete water temperature data (i.e., 2007 to 2011), body condition for this species was generally higher in years when water temperature was higher. Although data are limited, variations in water temperature may have influenced the body condition of fish in the MCR. In order to test this theory, water temperature will be added to the HBA of body condition in 2012 as an explanatory variable.

For Bull Trout, there was very little variation in body condition between sample sites. This suggests that: 1) all sample sites were homogenous in terms of habitat quality; or, 2) individual fish did not remain associated with any particular site for a long enough time prior to capture for the habitat quality of that site to affect their body condition. Based on variability of habitat measurements taken during the field season (e.g., available cover, water velocities, water depths, etc.) the former scenario is unlikely to be true. The latter scenario is more likely to influence body condition. REV operations dewater large portions of the channel margin on a nightly basis, which forces fish to seek refuge in different areas. This diurnal movement coupled with annual migratory patterns for this species support the theory that individual fish do not remain in a particular site long enough for that association to have a measurable impact on body condition.

Based on results of the HBA, the presence of a T-bar anchor tag significantly improved the body condition of Bull Trout by approximately 10%. This result, initially identified in 2010 (Ford and Thorley 2011a), is believed to be a statistical artefact of an unidentified assumption violation. Bull Trout captured during the fall season are commonly observed feeding on adult Kokanee. It is possible that the weight of stomach contents increased Bull Trout weight variability enough to create spurious model results. As an example, while conducting gastric lavage in 2007 (Golder 2008), field crews recovered two recently ingested adult Kokanee from the stomach of one bull trout. An average adult Kokanee in the MCR weighs approximately 127 g (Attachment A); the Bull Trout weighed 1297 g (with the Kokanee in its stomach). The presence of these prey fish in the Bull Trout's stomach resulted in an approximately 20% increase in the body condition value calculated for this Bull Yrout. Whether a Bull Trout is captured immediately before or after feeding has a substantial impact on the weight recorded for that fish. During future study years, it may be beneficial to analyze body condition values for this species using data collected during the spring seasons only. During the spring season, bull trout are less actively feeding on Kokanee and are less likely to be engorged.

Body condition of Bull Trout declined significantly with day of the year. This result is consistent with 2010 results (Ford and Thorley 2011a). During the fall, Bull Trout feed on spawning Kokanee. The body condition of Bull Trout might be expected to increase over the study period as the fish "fatten up" prior to the winter season. However, observational data (Attachment A) indicate that Kokanee abundance generally decreases over the study period as spent fish die. Therefore, Bull Trout captured near the start of the study period may have recently ingested more kokanee than Bull Trout captured near the end of the study period. If so, body condition measurements for Bull trout during the fall season are more a measure of gut fullness than actual body plumpness.

### 4.4.2 Mountain Whitefish

Similar to bull trout, mountain whitefish appeared to follow a multi-year cycle of body condition; with higher body condition in the early 2000s and lower body condition in the late 2000s. Reasons for this cycle are unknown but could be related to water temperatures (see previous section). Mountain whitefish body condition was significantly lower in 2011 when compared to earlier study years. Whether this decline was in response to the minimum flow release or REV5 operations is not known. Additional years of data are required to determine if the decline is due to annual variation or reflects a relationship between mountain whitefish body condition and flow regime.

Overall, mountain whitefish body condition was higher in Reach 3 than in Reach 4. This result may be due to additional nutrients flowing into the MCR from the Jordan River (i.e., the divide line between the two reaches) resulting in higher productivity downstream of the confluence. As recommended by Schleppe et al. (2011; CLBMON-15B), monitoring the benthos upstream and downstream of the confluence would provide valuable insight into this result. Mountain whitefish body condition was highest within Site 231.3-R (Big Eddy). This site is located immediately downstream of the Jordan River confluence. Due to the topography of the area, most of the water flowing out of the Jordan River circulates through the Big Eddy hydraulic before flowing downstream.

Similar to 2010 results, the presence of T-bar anchor tags were associated with significantly lower body condition for a typical mountain whitefish; the presence of a PIT tag had no effect on mountain whitefish body condition. These results are not surprising. Field crews reported large, open wounds at the tag insertion point on some mountain whitefish. The improper healing of these wounds, coupled with concerns over losing the external tags were the main reasons why field crews stopped deploying T-bar anchor tags after the 2005 study year.

For most mountain whitefish marked with PIT tags, the only evidence of marking were irregular scale growth patterns at the tag insertion points caused by regenerated scales. This result is reassuring, as it suggests that PIT tags do not affect the fish's growth.

### 4.4.3 Rainbow Trout

Limited life history data for rainbow trout resulted in low credibility surrounding body condition estimates. Long-term patterns or trends were not evident in annual estimates. Body condition was substantially higher in Site 227.2-R (i.e., Salmon Rocks) than in sites immediately upstream (no sites were located downstream of Salmon Rocks). Reasons for this anomaly are unknown. Site 227.2-R is located at the downstream end of Reach 3 and is close to both the Illecillewaet River and ALR Reservoir. It is possible that rainbow trout in these locations have higher body conditions than rainbow trout in the MCR and that the higher body condition estimates in Site 227.2-R are due to the sites closer proximity to these areas. Boat electroshocking surveys were conducted in Reach 2 in 2008 and 2009. During those surveys, 42 rainbow trout were measured for length and weight. Although based on relatively few data points, a preliminary review of these data did not indicate higher body conditions in Reach 2 when compared to rainbow trout recorded in Reach 3. Boat electroshocking surveys have never been conducted in the Illecillewaet River under the current program.

Overall, the body condition of rainbow trout tended to vary more by site than it did for bull trout and mountain whitefish.

## 4.5 Management Question #4 – Spatial Distribution

### 4.5.1 Bull Trout

Bull trout densities in Reach 4 were highest near the Moses Creek Spawning Channel (RKm 236.4) and tended to decrease with increased distance from REV. Similarly, in Reach 3, bull trout densities were highest near the Jordan River confluence (RKm 231.6) and tended to decrease with distance downstream from the confluence. Both Moses Creek and the Jordan River are spawning areas for kokanee. The pattern of decreasing bull trout densities with increased distance downstream of both tributaries suggests that bull trout are aggregating to feed on pre-spawning kokanee entering these systems or on spent kokanee exiting these systems.

### 4.5.2 Burbot

For burbot, credibility intervals overlapped for all site-level density estimates. Similar to results reported last year (Ford and Thorley 2011a), density was slightly higher at Site 231.0-L (along the left bank between the Revelstoke Golf Course and the Rock Groyne). This site contains rip-rap substrate, steep banks, and high water velocities. Higher catch-rates of burbot were recorded in similar habitats downstream of HLK as part of BC Hydro's Lower Columbia River (LCR) Fish Population Indexing Program (CLBMON-45; Ford and Thorley 2011b).

### 4.5.3 Kokanee

Overall, kokanee densities were higher in sites that encompassed the confluences of major tributaries or sites located immediately downstream of major tributaries (i.e., Moses Creek, Scales Creek, Jordan River). Kokanee are in the study area primarily during the fall season for spawning purposes; for that reason, densities are higher near these tributaries (either spawning at the creek mouths or migrating into the creeks to spawn). Based on field observations, densities generally decreased with distance downstream from the confluences of tributaries.

Only 26 kokanee were recorded during the spring 2011 study period, hindering spatial distribution analyses for this species. Of those 26 fish, 21 were recorded in Reach 4; 5 kokanee were recorded in Reach 3.

### 4.5.4 Mountain Whitefish

One of the key management questions in Section 1.2 relates to the spatial distribution of adult life stages of fish using the MCR. As noted in earlier sections, Mountain Whitefish was the only species with adequate data to robustly analyse age cohorts. Age-2+ Mountain Whitefish were most common from Site 232.6-R (upstream of the Jordan River confluence) to Big Eddy Bridge (Site 227.2-R). Habitat in this portion of the study area is dominated by shallow water depths, high water velocities, and small substrate (i.e., gravel and cobble) and may serve as a holding area for this species prior to spawning. Mountain Whitefish spawning has not been documented in the MCR; however, field crews have noted both gravid and ripe Mountain Whitefish during surveys. Mountain Whitefish densities were noticeably lower on the opposite bank (i.e., between the Revelstoke Golf Course and the Rock Groyne). Habitat in this area is typified by high water velocities, high water depths, and rip-rap or large substrate banks. Site 227.2-R (i.e., Salmon Rocks) has similar habitat characteristics and also had low age-2+ Mountain Whitefish densities.

Age-1 Mountain Whitefish were most common in the upstream portion of Reach 4 (i.e., opposite the Moses Creek Spawning Channel) and in the upstream portion of Reach 3 (i.e., between Big Eddy and Big Eddy Bridge).

### 4.5.5 Rainbow Trout

Between 2001 and 2011, Rainbow Trout densities were highest in Big Eddy, adjacent to the rip-rapped left bank of Reach 3, and at Salmon Rocks (Site 227.2-R). Rainbow Trout densities were low throughout Reach 4 and along the right bank of Reach 3 (with the exception of Big Eddy and Salmon Rocks).

In the fall of 2009, BC Hydro stabilized the bank of the Columbia River by adding large boulders and rip-rap to an approximately 2.5 km section of the bank along the Revelstoke Golf Course (see Appendix A, Figure A2). During the 2010 and 2011 (fall only) surveys, 20 and 28 Rainbow Trout, respectively, were recorded in this portion of the river. Prior to bank stabilization, a total of 23 Rainbow Trout were recorded in eight study seasons (this portion of the river was not sampled in 2009 due to construction of the bank stabilization works). During the spring 2011 study period, 26 Rainbow Trout were recorded in this area; spring data prior to the bank stabilization work is not available. Although based on only two years of data, preliminary results indicate that the bank stabilization work conducted by BC Hydro in 2009 adjacent to Site 233.1-L has made the area more suitable for rainbow trout. Overall, 80% of the rainbow trout captured in Site 233.1-L since bank stabilization were classified as immature; 20% were classified as adult (Attachment A).

### 4.5.6 Sucker Species

For all Sucker species combined, density generally increased with increased distance downstream of REV. Sucker species generally prefer lower water velocity area (except during their spawning season). In general, water velocities in the MCR are lower in Reach 3 than in Reach 4. Reach 3 also contains more backwater habitat areas (e.g., upstream of the Tonkawatla Creek confluence, behind the islands upstream of the Centennial Park Boat Launch, upstream of the Illecillewaet River confluence, and immediately downstream of the Rock Groyne; Appendix A, Figure A2) that are suitable for rearing and feeding.

Sucker species density was lower during the spring 2011 survey than in the fall. However, most of the Sucker species recorded during the spring season were in spawning condition (i.e., had tubercles or spawning colours). Sucker species in spawning condition were most commonly recorded in Site 229.7-R (between Big Eddy Bridge and the Tonkawatla Creek confluence).

### 4.5.7 Northern pikeminnow

Overall, Northern Pikeminnow densities were low, but were slightly higher in Reach 3 than in Reach 4. Credibility intervals overlapped for all estimates, but densities for this species were generally higher in sites that contained backwater habitat areas or had lower water velocities, such as Site 228.5-L (upstream of the Illecillewaet River confluence), Site 231-3-L (Big Eddy), Site 227.2-R (Salmon Rocks), and Site 229.2-L (between the Rock Groyne and the Centennial Park Boat Launch). This distribution reflects this species preference for low velocity habitats (Scott and Crossman 1973).

Northern Pikeminnow were more abundant in the MCR during the fall season than during the spring season. Given the large size of the Northern Pikeminnow present during the fall season, it is possible that these fish were there to feed on spawning Kokanee.

### 4.5.8 Sculpin Species

Overall, Sculpin species densities were highest in Big Eddy and along the rip-rap on the left bank of Reach 3. Of the 88 Sculpin species captured during the fall 2010 and fall 2011 field season, 86 were identified as Prickly Sculpin; the remaining two were Slimy Sculpin. During the spring 2011 field season, 53 Prickly Sculpin and six Slimy Sculpin were recorded. All Slimy Sculpin recorded in the MCR during the current program were captured in Reach 3.

## 4.6 Summary

In 2011, Hierarchical Bayesian Analyses were used to quantify the abundance, body condition, spatial distribution, annual growth rate, and size-at-age of common fish species in the MCR. HBA provide a robust and defensible method of comparing both temporal and spatial data collected before and after the implementation of the minimum flow release and REV5 operations. HBA also are capable of quantifying changes in species richness and species diversity. These two metrics of population health and population structure, although not specifically addressed in any of BC Hydro's management questions, have been identified by BC Hydro as important aspects of the fish community downstream of REV that should be monitored over the duration of the RFMP. In 2012, the HBAs will be further modified to allow the inclusion of various explanatory variables, such as water temperature, REV discharge, ALR water level elevations, or metrics provided by other RFMP programs to help determine the cause of some of the variation that has been observed in the MCR over the last 11 years. Once modified, the HBAs should provide the outputs necessary to answer all four of the management questions.

Overall, the abundances of most species in the MCR have been either stable or increasing over the 11 year study period. Data collected to date indicate seasonal use of the study area by some species (e.g., Kokanee, Lake Whitefish, Northern Pikeminnow, etc.), while other species have shown specific habitat associations (e.g., Mountain Whitefish, Rainbow Trout, Burbot). Large data gaps still exist for all fish species that were not intensively monitored from 2001 to 2009 (i.e., all species except Bull Trout, Mountain Whitefish, and Rainbow Trout); however, long-term patterns and trends for some or most of these species are expected to become clearer with each successive sample year. Low catch-rates for Brook Trout, Cutthroat Trout, Peamouth, Pygmy Whitefish, Yellow Perch and White Sturgeon will hamper monitoring changes for these species. In addition, the sample methods used limit the data collected, and therefore conclusions that can be made for Kokanee, Redside Shiner, and Sculpin species.

The implementation of the minimum flow release coincided with an additional unit (REV5) going online at REV. The increased capacity at REV due to REV5 resulted in both increased daily flow variability and higher peak daily discharge levels. During periods of high energy demand, REV operates at full or near full capacity to maximize power generation, which results in higher discharge levels in the MCR. In order to compensate for the additional water released through REV during periods of high energy demand, the dam operates at lower discharge levels during periods of low energy demand for longer durations (typically at night). This operational change makes it difficult to determine if changes identified in the fish community downstream of REV are the result of the minimum flow release or the result of higher daily peak discharge levels (or a combination of both). One way to determine which input (i.e., the higher peak daily discharge or the minimum flow release) affects the fish community could involve a multi-year study with different input combinations. As an example:

1) Operate REV5 with the minimum flow release; and,

2) Operate REV5 without the minimum flow release.

Operating REV in this manner would require significant changes to the WUP. In addition, the duration of time required under each scenario would be different for each fish species of interest and each management question to be answered. For example, measuring a change in the body condition of Sucker species may require as little as one year under each scenario as food availability for these species would be directly related to primary and secondary productivity. Determining the body condition of Bull Trout would require several years of operation under each scenario as body condition for this species are partially dependent on prey fish abundance, and prey fish abundance would likely require several years to stabilize.

# 5.0 RECOMMENDATIONS

In consideration of the findings above and the overall objectives of CLBMON-16, a field sampling program should be conducted in the spring and fall of 2012 using the same methodologies employed in 2011. In addition to further sampling, the following recommendations are provided:

- The feasibility of operating REV5 for extended time periods without maintaining the minimum flow release should be examined. This would provide insight into the effect on the downstream fish community of both the minimum flow release and the higher peak daily discharges associated with REV5.
- Various parameters should be explored (through a review of available literature and input from other RFMP programs) for the feasibility of including them as explanatory variables in each of the HBAs.
- A Whitefish spawning assessment should be conducted to confirm and/or identify local spawning activity and assist in identifying the source of age-0 Mountain Whitefish found in the study area.
- An aerial survey should be conducted during the rainbow trout spawning season to determine the extent of mainstem spawning for this species. This would provide insight into whether Rainbow Trout in spawning condition recorded during the spring 2011 survey are spawning in the MCR or migrating into tributaries to spawn.
- The feasibility of monitoring the benthos upstream and downstream of the Tonkawatla Creek confluence should be explored. These data may help explain the high body condition values recorded for Rainbow Trout near Salmon Rocks.
- The thalweg of the river in Reaches 3 and 4 should be mapped while REV is operating at the minimum flow release. This information could then be used as a navigational aid by field crews. Ideally, this survey would be conducted when ALR water levels are low enough to prevent backwatering effects in Reach 3.

## 6.0 LITERATURE CITED

BC Hydro. 1999. Revelstoke dam and generating station water use plan. Prepared by BC Hydro Power Supply, Vancouver, BC. Report no. MEP341. 37 p. + 4 app.

BC Hydro. 2005. Consultative Committee report: Columbia River Water Use Plan, Volumes 1 and 2. Report prepared for the Columbia River Water Use Plan Consultative Committee by BC Hydro, Burnaby BC.

BC Hydro. 2007. Columbia River Projects, Water Use Plan. 41 p. + 1 appendix.

Bochkina, N. and S. Richardson (2007). Tail Posterior Probabilities for Inference in Pairwise and Multiclass Gene Expression Data. Biometrics 63: 1117-1125

Bradford, M. J., J. Korman and P. S. Higgins (2005). Using confidence intervals to estimate the response of salmon populations (*Oncorhynchus* spp.) to experimental habitat alterations. Canadian Journal of Fisheries and Aquatic Sciences 62: 2716-2726.

Brooks, S. and A. Gelman (1998). Alternative methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics 7: 434-455

Fabens, A.J. 1965. Properties and fitting of the von Bertalanffy growth curve. Growth. 1965 Sep; 29:265-289.

Ford, D. and J.L. Thorley. 2011a. CLBMON-16 Middle Columbia River Fish Population Indexing Surveys – 2010 Investigations. Report prepared by BC Hydro Generation, Water Licence Requirements, Revelstoke, BC. Golder Report No. 10-1492-0079F: 54 p. + 5 app.

Ford, D. and J.L. Thorley. 2011b. CLBMON-45 Lower Columbia River Fish Population Indexing Surveys – 2010 Investigations. Report prepared by BC Hydro Generation, Water Licence Requirements, Castlegar, BC. Golder Report No. 10-1492-0102F: 54 p. + 5 app.

Gazey, W.J. and M.J. Staley. 1986. Population estimates from mark-recapture experiments using a sequential Bayes algorithm. Ecology 67: 941-951.

Gelman, A., J. B. Carlin, H. S. Stern and D. B. Rubin (2004). Bayesian Data Analysis. Second Edition. Boca Raton, Florida, CRC Press

Gelman, A. and D. Rubin (1992). Inference from iterative simulation using multiple sequences. Statistical Science 7: 457-511

Golder Associates Ltd. 2002. Middle Columbia River Fish Indexing Program. 2001 Phase 1 investigations. Report prepared for BC Hydro, Burnaby, B.C. Golder Report No. 012-8006F: 41p + 4 app.

Golder Associates Ltd. 2003. Large River Fish Indexing Program – Middle Columbia River 2002 Phase 2 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 022-8024F: 39p + 4 app.

Golder Associates Ltd. 2004a. Large River Fish Indexing Program – Middle Columbia River 2003 Phase 3 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 03-1480-022F: 53p + 4 app.

Golder Associates Ltd. 2004b. Large River Fish Indexing Program – Lower Columbia River 2003 Phase 3 Investigations. Report prepared for B.C. Hydro, Burnaby, B.C. Golder Report No. 03-1480-021F: 54p + 6 app.

Golder Associates Ltd. 2005a. Large River Fish Indexing Program – Middle Columbia River 2004 Phase 4 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 04-1480-048F: 66p + 5 app.

Golder Associates Ltd. 2005b. Large River Fish Indexing Program – Lower Columbia River 2004 Phase 4 Investigations. Report prepared for B.C. Hydro, Burnaby, B.C. Golder Report No. 04-1480-047F: 57p + 6 app.

Golder Associates Ltd. 2006. Large River Fish Indexing Program – Middle Columbia River 2005 Phase 5 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 05-1480-037F: 51p + 6 app.

Golder Associates Ltd. 2007. Large River Fish Indexing Program – Middle Columbia River 2006 Phase 6 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 06-1480-032F: 52p + 6 app.

Golder Associates Ltd. 2008. Large River Fish Indexing Program – Middle Columbia River 2007 Phase 7 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 07-1480-068F: 60p + 6 app.

Golder Associates Ltd. 2009. Large River Fish Indexing Program – Middle Columbia River 2008 Phase 8 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 08-1480-047F: 49p + 6 app.

Golder Associates Ltd. 2010. Large River Fish Indexing Program – Middle Columbia River 2009 Phase 9 Investigations. Report prepared for B.C. Hydro Power Supply Environmental Services, Burnaby, B.C. Golder Report No. 09-1480-050F: 64p + 4 app.

He, J. X., J. R. Bence, J. E. Johnson, D. F. Clapp and M. P. Ebener (2008). Modeling Variation in Mass-Length Relations and Condition Indices of Lake Trout and Chinook Salmon in Lake Huron: a Hierarchical Bayesian Approach. Transactions of the American Fisheries Society 137: 801-817.

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Routledge, Chapman & Hall, Inc. New York. 570 p.

LGL Limited. 2009. Arrow Lakes Reservoir Burbot Life History and Habitat Use Study. Year 1. Report prepared for BC Hydro, Revelstoke, BC. 35 p. + 1 app.

Lin, Y., S. Lipsitz, D. Sinha, A. A. Gawande, S. E. Regenbogen and C. C. Greenburg (2009). Using Bayesian p-values in a 2 x 2 table of matches pairs with incompletely classified data. Journal of the Royal Statistical Society Series C 58: 237-246

Link, W. A. and R. J. Barker (2004). Hierarchical mark-recapture models: a framework for inference about demographic processes. Animal Biodiversity and Conservation 27: 441-449.

Mackay, W.C., G.R. Ash and H.J. Norris. 1990. Fish ageing methods for Alberta. R.L. & L. Environmental Services Ltd. in association with Alberta and Wildlife Division and University of Alberta, Edmonton. 133p.

Nelson, J. S. and M. J. Paetz. 1992. The fishes of Alberta. 2nd Edition. The University of Alberta Press. Edmonton Alberta.

Ntzoufras, I. 2009. Bayesian Modeling Using WinBUGS. Hoboken, New Jersey, John Wiley & Sons, Inc.

Plummer, M. 2003. JAGS: A Program for Analysis of Bayesian Graphical Models Using Gibbs Sampling, Proceedings of the 3rd International Workshop on Distributed Statistical Computing (DSC 2003), March 20–22, Vienna, Austria. ISSN 1609-395X

R Development Core Team. 2012. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria

R.L. & L. Environmental Services Ltd. 1994. Fish stock and habitat assessments of the Columbia River below Revelstoke Canyon Dam. Report prepared for BC Hydro, Environmental Resources. R.L. & L. Report No. 340F: 99 p. + app.

R.L. & L. Environmental Services Ltd. 1995. Fish habitat utilization and productive capacity of the Columbia River below Revelstoke Canyon Dam. Draft report prepared for BC Hydro, Environmental Affairs. R.L. & L. Rep. No. 419D: 96 p. + 3 app.

Royle, J. A. and R. M. Dorazio (2008). Hierarchical Modeling and Inference in Ecology: The Analysis of Data from Population, Metapopulations and Communities. London, Academic Press.

Schleppe, J., H. Larratt, and M.A. Olson-Russello. 2011. CLBMON-15b Middle Columbia River Ecological Productivity Monitoring, Annual Report 2010. Ecoscape Environmental Consultants Ltd. & Larratt Aquatic Consulting Ltd. Ecoscape File No. 10-599 Kelowna, BC.

Scott, W. B. and E. J. Crossman 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184:1-966.

Thorley, J.L. and J.T.A. Baxter. 2011. WLR Monitoring Study No. CLBMON-46 (Year 4) Lower Columbia River Rainbow Trout Spawning Assessment. Columbia River Water Use Plan. BC Hydro, Castlegar. Mountain Water Research and Poisson Consulting Ltd.

Triton Environmental Consultants Ltd. 2009. Middle Columbia River Juvenile Fish Habitat Use (Year 1) CLBMON-17. Report prepared for B.C. Hydro Columbia River Project Water Use Plan, Revelstoke, B.C. Triton Project No. 3943: 45p + 6 app.

Triton Environmental Consultants Ltd. 2010. Middle Columbia River Juvenile Fish Habitat Use (Year 2) CLBMON-17. Report prepared for B.C. Hydro Columbia River Project Water Use Plan, Revelstoke, B.C. Triton Project No. 3943: 48p + 6 app.

Triton Environmental Consultants Ltd. 2011. Middle Columbia River Juvenile Fish Habitat Use (Year 3) CLBMON-17. Report prepared for B.C. Hydro Columbia River Project Water Use Plan, Revelstoke, B.C. Triton Project No. 3943: 51p + 6 app.

Wickham, H. (2009). ggplot2: Elegant Graphics for Data Analysis. New York, Springer

# 7.0 CLOSURE

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

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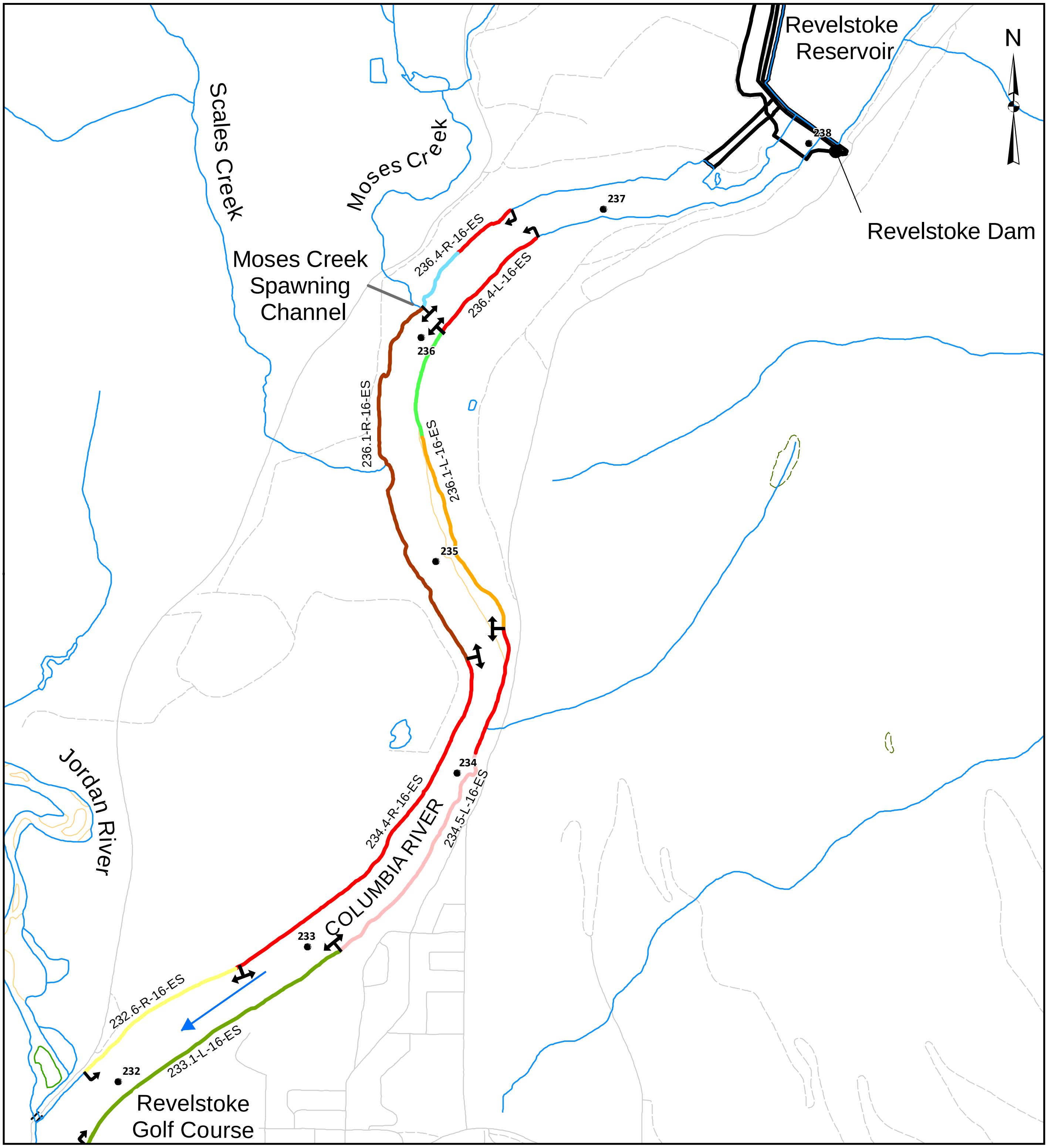
# APPENDIX A

## Maps and UTM Coordinates

Table A1 Locations and distances from Revelstoke Dam of boat electroshocking sites in the Middle Columbia River, 2011.

| Site Designation[a] | Location (km)[b] | Bank[c] | UTM Coordinates | | |
|---|---|---|---|---|---|
| | | | Zone | Easting | Northing |
| **Reach 4** | | | | | |
| 236.4-R-16-ES U/S | 236.4 | Right | 11U | 415126 | 5655641 |
| 236.4-R-16-ES D/S | 236.1 | Right | 11U | 414721 | 5655227 |
| 236.4-L-16-ES U/S | 236.4 | Left | 11U | 415228 | 5655538 |
| 236.4-L-16-ES D/S | 236.1 | Left | 11U | 414821 | 5655127 |
| 236.1-L-16-ES U/S | 236.1 | Left | 11U | 414821 | 5655127 |
| 236.1-L-16-ES D/S | 234.5 | Left | 11U | 415048 | 5653833 |
| 236.1-R-16-ES U/S | 236.1 | Right | 11U | 414721 | 5655227 |
| 236.1-R-16-ES D/S | 234.4 | Right | 11U | 414936 | 5653705 |
| 234.4-R-16-ES U/S | 234.4 | Right | 11U | 414936 | 5653705 |
| 234.4-R-16-ES D/S | 232.6 | Right | 11U | 413944 | 5652387 |
| 234.5-L-16-ES U/S | 234.5 | Left | 11U | 415048 | 5653833 |
| 234.5-L-16-ES D/S | 233.1 | Left | 11U | 414048 | 5652251 |
| 233.1-L-16-ES U/S | 233.1 | Left | 11U | 414380 | 5652467 |
| 233.1-L-16-ES D/S | 231.6 | Left | 11U | 413294 | 5651640 |
| 232.6-R-16-ES U/S | 232.6 | Right | 11U | 413944 | 5652387 |
| 232.6-R-16-ES D/S | 231.9 | Right | 11U | 413292 | 5651941 |
| **Reach 3** | | | | | |
| 231.3-R-16-ES U/S | 231.3 | Right | 11U | 413030 | 5651196 |
| 231.3-R-16-ES D/S | 231.2 | Right | 11U | 413333 | 5651079 |
| 231.0-L-16-ES U/S | 231.0 | Left | 11U | 413408 | 5651353 |
| 231.0-L-16-ES D/S | 229.3 | Left | 11U | 415023 | 5650860 |
| 231.0-R-16-ES U/S | 231.0 | Right | 11U | 413418 | 5651133 |
| 231.0-R-16-ES D/S | 229.7 | Right | 11U | 414486 | 5651009 |
| 229.7-R-16-ES U/S | 229.7 | Right | 11U | 414486 | 5651009 |
| 229.7-R-16-ES D/S | 227.3 | Right | 11U | 414436 | 5648973 |
| 229.2-L-16-ES U/S | 229.2 | Left | 11U | 415089 | 5650679 |
| 229.2-L-16-ES D/S | 228.5 | Left | 11U | 415608 | 5650080 |
| 228.5-L-16-ES U/S | 228.5 | Left | 11U | 415608 | 5650080 |
| 228.5-L-16-ES D/S | 227.4 | Left | 11U | 414942 | 5649059 |
| 227.2-R-16-ES U/S | 227.2 | Right | 11U | 414474 | 5648871 |
| 227.2-R-16-ES D/S | 226.9 | Right | 11U | 414804 | 5648490 |

[a] U/S = Upstream limit of site; D/S = Downstream limit of site.
[b] River kilometres measured upstream from the Canada-U.S. border.
[c] Bank location as viewed facing downstream.




**LEGEND**

- RIVER KILOMETRES FROM U.S. BORDER
- DAM BASE
- ISLAND
- WETLAND
- SAND OR GRAVEL BAR
- WATERCOURSE
- ROUGH ROAD
- PAVED ROAD
- AIR FACILITY
- ROAD BRIDGE
- DIRECTION OF FLOW

**BANK HABITAT TYPE**

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

**REFERENCE**

TRIM MAPS PROVIDED BY BC HYDRO
PROJECTION: UTM ZONE 11 N DATUM: NAD 83

500 250 0 500
SCALE 1:24,000 METRES

PROJECT
MIDDLE COLUMBIA RIVER FISH POPULATION INDEXING SURVEY

TITLE
BANK HABITAT TYPE AND SAMPLE LOCATIONS
REACH 4

Golder Associates
Castlegar, British Columbia

| PROJECT No. 10-1492-0079 | | | SCALE AS SHOWN | REV. 0 |
|---|---|---|---|---|
| DESIGN | DF | 14 Feb. 2012 | FIGURE A1 | |
| GIS | AL | 14 Feb. 2012 | | |
| CHECK | DF | 14 Feb. 2012 | | |
| REVIEW | LH | 14 Feb. 2012 | | |

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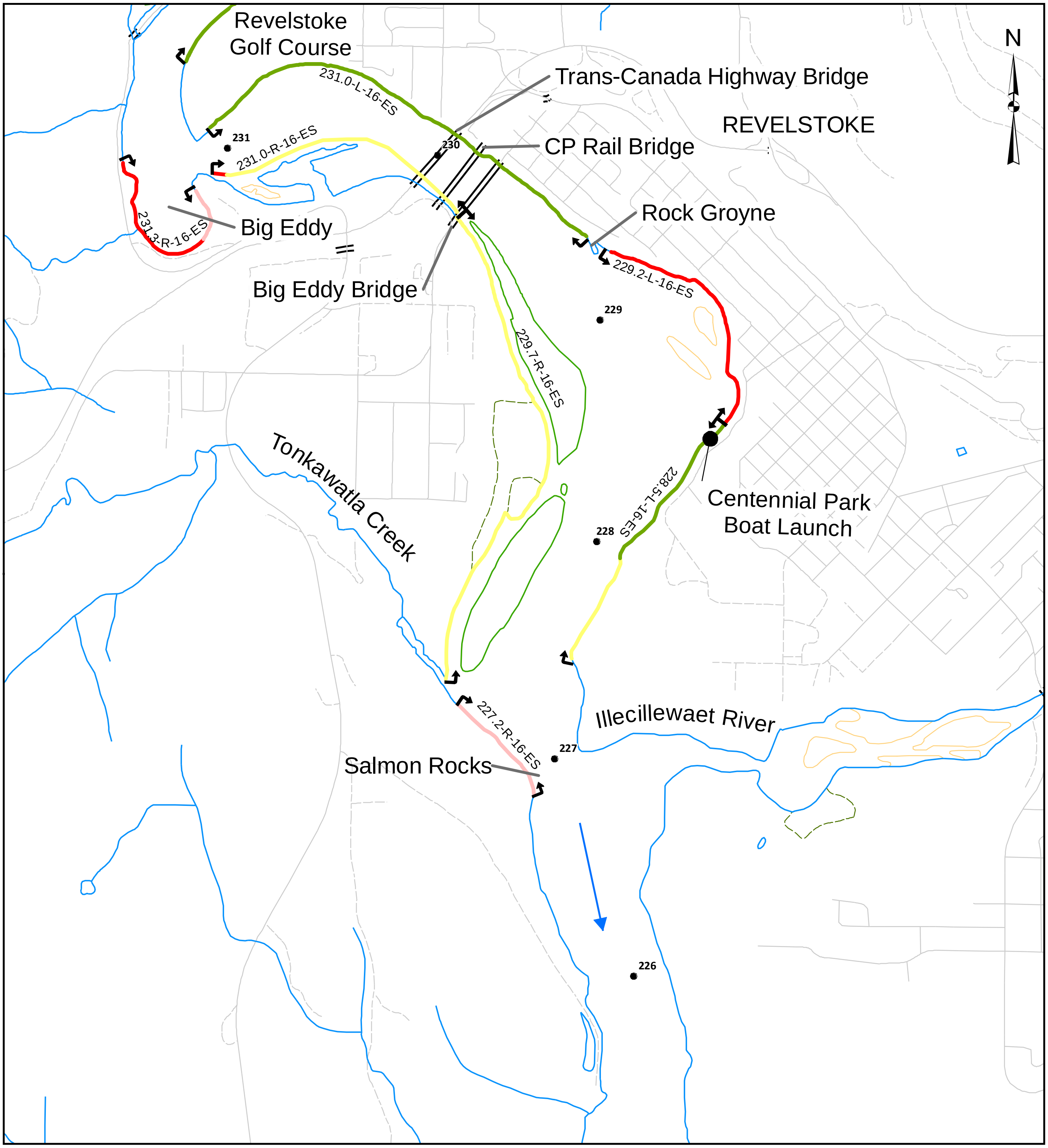




**LEGEND**

| | |
|---|---|
| RIVER KILOMETRES FROM U.S. BORDER | DIRECTION OF FLOW |
| DAM BASE | **BANK HABITAT TYPE** |
| ISLAND | A1- ARMOURED COBBLE/GRAVEL |
| WETLAND | A1+A2- ARMOURED COBBLE/GRAVEL/SMALL BOULDER |
| SAND OR GRAVEL BAR | A3- ARMOURED SMALL/LARGE BOULDER |
| WATERCOURSE | A4- ARMOURED LARGE BOULDER |
| ROUGH ROAD | A5- BEDROCK BANKS |
| PAVED ROAD | A6- MAN-MADE RIP-RAP |
| AIR FACILITY | D1- DEPOSITIONAL SAND/SILT |
| ROAD BRIDGE | D2- DEPOSITIONAL GRAVEL/COBBLE |

**REFERENCE**

TRIM MAPS PROVIDED BY BC HYDRO
PROJECTION: UTM ZONE 11 N DATUM: NAD 83

PROJECT
MIDDLE COLUMBIA RIVER FISH POPULATION INDEXING SURVEY

TITLE
BANK HABITAT TYPE AND SAMPLE LOCATIONS
REACH 3

Golder Associates
Castlegar, British Columbia

| PROJECT No. 10-1492-0079 | | | SCALE AS SHOWN | REV. 0 |
|---|---|---|---|---|
| DESIGN | DF | 14 Feb. 2012 | FIGURE A2 | |
| GIS | AL | 14 Feb. 2012 | | |
| CHECK | DF | 14 Feb. 2012 | | |
| REVIEW | LH | 14 Feb. 2012 | | |

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# APPENDIX B

## Habitat Summary Information

Table B1 Descriptions of categories used in the Middle 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 Lengths of bank habitat types within boat electroshocking sites in the Middle Columbia River, 2011.

| Reach | Site[a] | Length (m) of Bank Habitat Type[b] | | | | | | | | Total Length (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| 4 | 236.4-R-16-ES | 296 | | 298 | | | | | | **594** |
| | 236.4-L-16-ES | 581 | | | | | | | | **581** |
| | 236.1-L-16-ES | | 482 | | | | | | 928 | **1410** |
| | 236.1-R-16-ES | | | | | | 1733 | | | **1733** |
| | 234.4-R-16-ES | 1736 | | | | | | | | **1736** |
| | 234.5-L-16-ES | 559 | | | 1095 | | | | | **1654** |
| | 233.1-L-16-ES | | | | | 1408 | | | | **1408** |
| | 232.6-R-16-ES | | | | | | | 796 | | **796** |
| **Reach 4 Total** | | **3172** | **482** | **298** | **1095** | **1408** | **1733** | **796** | **928** | **9911** |
| 3 | 231.3-R-16-ES | 665 | | | 231 | | | | | **896** |
| | 231.0-L-16-ES | | | | | 1964 | | | | **1964** |
| | 231.0-R-16-ES | 55 | | | | | | 1138 | | **1193** |
| | 229.7-R-16-ES | | | | | | | 2270 | | **2270** |
| | 229.2-L-16-ES | 1101 | | | | | | | | **1101** |
| | 228.5-L-16-ES | | | | | 742 | | 489 | | **1231** |
| | 227.2-R-16-ES | | | | 519 | | | | | **519** |
| **Reach 3 Total** | | **1820** | **0** | **0** | **751** | **2706** | **0** | **3897** | **0** | **9173** |
| **Grand Total** | | **4992** | **482** | **298** | **1845** | **4114** | **1733** | **4693** | **928** | **19 085** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.
[b] See Appendix B, Table B1 for bank habitat type descriptions.

Table B3 Summary of habitat variables recorded at boat electroshocking sites in the Middle Columbia River, 30 May to 24 June 2011.

| Reach | Site[a] | Session | Air Temperature (°C) | Water Temperature (°C) | Conductivity (µS) | Cloud Cover[b] | Water Surface Visibility | Instream Velocity[c] | Water Clarity[d] | Cover Types (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Substrate Interstices | Woody Debris | Turbulence | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| 4 | 236.4-L-16-ES | 1 | 9 | 5 | 130 | Partly cloudy | High | High | High | 98 | 1 | 0 | 0 | 0 | 1 | 0 |
| 4 | 236.4-L-16-ES | 2 | 7.5 | 5.5 | 130 | Clear | High | High | High | 70 | 0 | 0 | 0 | 30 | 0 | 0 |
| 4 | 236.4-L-16-ES | 3 | 8.5 | 5.5 | 120 | Overcast | High | High | High | 30 | 10 | 0 | 0 | 40 | 20 | 0 |
| 4 | 236.4-L-16-ES | 4 | 10.5 | 6.5 | 110 | Partly cloudy | High | Medium | High | 40 | 10 | 0 | 0 | 30 | 20 | 0 |
| 4 | 236.4-R-16-ES | 1 | 9 | 5 | 120 | Partly cloudy | High | High | High | 90 | 0 | 0 | 0 | 5 | 5 | 0 |
| 4 | 236.4-R-16-ES | 2 | 9.5 | 5.5 | 120 | Clear | High | High | High | 70 | 0 | 5 | 0 | 10 | 15 | 0 |
| 4 | 236.4-R-16-ES | 3 | 8 | 5.5 | 120 | Overcast | High | High | High | 30 | 0 | 10 | 0 | 30 | 30 | 0 |
| 4 | 236.4-R-16-ES | 4 | 12.5 | 6.5 | 110 | Overcast | Low | High | High | 50 | 10 | 10 | 0 | 0 | 30 | 0 |
| 4 | 236.1-L-16-ES | 1 | 9 | 5 | 130 | Partly cloudy | High | Medium | High | 70 | 0 | 0 | 0 | 30 | 0 | 0 |
| 4 | 236.1-L-16-ES | 2 | 7.5 | 5.5 | 130 | Partly cloudy | High | Medium | High | 30 | 10 | 0 | 0 | 30 | 30 | 0 |
| 4 | 236.1-L-16-ES | 3 | 8.5 | 5.5 | 120 | Partly cloudy | High | Low | High | 50 | 10 | 0 | 0 | 15 | 25 | 0 |
| 4 | 236.1-L-16-ES | 4 | 8.5 | 7 | 110 | Clear | High | Medium | High | 40 | 10 | 0 | 0 | 40 | 10 | 0 |
| 4 | 236.1-R-16-ES | 1 | 12 | 6 | 110 | Partly cloudy | High | High | High | 50 | 5 | 5 | 0 | 15 | 15 | 10 |
| 4 | 236.1-R-16-ES | 2 | 10 | 5.5 | 130 | Partly cloudy | High | High | High | 35 | 5 | 20 | 0 | 20 | 20 | 0 |
| 4 | 236.1-R-16-ES | 3 | 9 | 5.5 | 120 | Overcast | High | High | High | 30 | 15 | 10 | 0 | 10 | 35 | 0 |
| 4 | 236.1-R-16-ES | 4 | 10.5 | 7 | 100 | Partly cloudy | High | High | High | 10 | 10 | 10 | 20 | 20 | 30 | 0 |
| 4 | 234.4-R-16-ES | 1 | 10 | 5 | 120 | Mostly cloudy | High | High | High | 20 | 70 | 0 | 0 | 10 | 0 | 0 |
| 4 | 234.4-R-16-ES | 2 | 11 | 5.5 | 120 | Partly cloudy | High | High | High | 20 | 20 | 10 | 30 | 0 | 20 | 0 |
| 4 | 234.4-R-16-ES | 3 | 9 | 5.5 | 110 | Overcast | High | High | High | 0 | 30 | 10 | 30 | 0 | 30 | 0 |
| 4 | 234.4-R-16-ES | 4 | 15 | 7 | 100 | Mostly cloudy | High | High | High | 30 | 20 | 0 | 0 | 20 | 30 | 0 |
| 4 | 234.5-L-16-ES | 1 | 9 | 5 | 130 | Partly cloudy | High | Medium | High | 40 | 5 | 5 | 0 | 30 | 20 | 0 |
| 4 | 234.5-L-16-ES | 2 | 7 | 5.5 | 130 | Clear | High | High | High | 10 | 10 | 40 | 0 | 10 | 30 | 0 |
| 4 | 234.5-L-16-ES | 3 | 8.5 | 5.5 | 120 | Mostly cloudy | High | Low | High | 35 | 5 | 10 | 0 | 25 | 25 | 0 |
| 4 | 234.5-L-16-ES | 4 | 13 | 7 | 100 | Partly cloudy | Medium | Low | High | 20 | 15 | 5 | 0 | 30 | 30 | 0 |
| 4 | 232.6-R-16-ES | 1 | 7 | 5 | 130 | Clear | High | Medium | High | 20 | 10 | 0 | 0 | 70 | 0 | 0 |
| 4 | 232.6-R-16-ES | 2 | 8.5 | 5.5 | 130 | Partly cloudy | High | Low | High | 50 | 0 | 0 | 0 | 50 | 0 | 0 |
| 4 | 232.6-R-16-ES | 3 | 8.5 | 5.5 | 120 | Overcast | High | Low | High | 40 | 10 | 0 | 0 | 50 | 0 | 0 |
| 4 | 232.6-R-16-ES | 4 | 8.5 | 7 | 110 | Partly cloudy | High | Low | High | 40 | 20 | 0 | 0 | 40 | 0 | 0 |
| 4 | 233.1-L-16-ES | 1 | 7 | 5 | 130 | Mostly cloudy | High | Low | High | 40 | 40 | 0 | 0 | 20 | 0 | 0 |
| 4 | 233.1-L-16-ES | 2 | 10 | 5.5 | 120 | Partly cloudy | High | High | High | 50 | 10 | 20 | 0 | 0 | 20 | 0 |

continued…

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

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

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

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

Table B3 Concluded.

| Reach | Site[a] | Session | Air Temperature (°C) | Water Temperature (°C) | Conductivity (μS) | Cloud Cover[b] | Water Surface Visibility | Instream Velocity[c] | Water Clarity[d] | Cover Types (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Substrate Interstices | Woody Debris | Turbulence | Terrestrial Vegetation | Shallow Water | Deep Water | Other Cover |
| 4 | 233.1-L-16-ES | 3 | 9 | 5.5 | 110 | Overcast | High | High | High | 40 | 30 | 5 | 0 | 5 | 20 | 0 |
| 4 | 233.1-L-16-ES | 4 | 16.5 | 7 | 100 | Mostly cloudy | High | Low | High | 60 | 30 | 0 | 0 | 10 | 0 | 0 |
| 3 | 231.3-R-16-ES | 1 | 8 | 5 | 120 | Clear | High | High | High | 10 | 45 | 0 | 0 | 20 | 25 | 0 |
| 3 | 231.3-R-16-ES | 2 | 7 | 5 | 110 | Clear | High | Medium | Medium | 30 | 30 | 5 | 0 | 5 | 30 | 0 |
| 3 | 231.3-R-16-ES | 3 | 9.5 | 5.5 | 100 | Overcast | Low | Medium | Medium | 20 | 30 | 10 | 0 | 10 | 30 | 0 |
| 3 | 231.3-R-16-ES | 4 | 9.5 | 6.6 | 90 | Partly cloudy | High | High | Medium | 15 | 30 | 5 | 0 | 20 | 30 | 0 |
| 3 | 231.0-L-16-ES | 1 | 7 | 5 | 110 | Partly cloudy | High | High | High | 70 | 5 | 0 | 0 | 0 | 25 | 0 |
| 3 | 231.0-L-16-ES | 2 | 10.5 | 5.5 | 90 | Overcast | Low | High | Medium | 40 | 40 | 5 | 0 | 0 | 15 | 0 |
| 3 | 231.0-L-16-ES | 3 | 11 | 6.5 | 100 | Overcast | Medium | Low | Medium | 40 | 10 | 0 | 0 | 20 | 30 | 0 |
| 3 | 231.0-L-16-ES | 4 | 9 | 7 | 100 | Overcast | High | Low | High | 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 231.0-R-16-ES | 1 | 12 | 5 | 100 | Partly cloudy | Medium | High | High | 30 | 10 | 20 | 0 | 40 | 0 | 0 |
| 3 | 231.0-R-16-ES | 2 | 9.5 | 6 | 90 | Overcast | High | High | High | 30 | 25 | 15 | 0 | 30 | 0 | 0 |
| 3 | 231.0-R-16-ES | 3 | 8 | 6.5 | 100 | Mostly cloudy | High | Medium | High | 20 | 20 | 25 | 0 | 30 | 5 | 0 |
| 3 | 231.0-R-16-ES | 4 | 10 | 8 | 100 | Overcast | High | Low | Medium | 30 | 10 | 0 | 0 | 40 | 0 | 20 |
| 3 | 229.7-R-16-ES | 1 | 10 | 5 | 110 | Overcast | Medium | Low | High | 45 | 30 | 0 | 0 | 20 | 5 | 0 |
| 3 | 229.7-R-16-ES | 2 | 12.5 | 6 | 110 | Mostly cloudy | High | Medium | High | 0 | 30 | 0 | 10 | 10 | 10 | 40 |
| 3 | 229.7-R-16-ES | 3 | 10.5 | 6.5 | 110 | Overcast | High | Low | High | 0 | 30 | 0 | 0 | 40 | 10 | 20 |
| 3 | 229.7-R-16-ES | 4 | 12 | 6.5 | 100 | Overcast | High | Low | Medium | 0 | 20 | 0 | 10 | 20 | 20 | 30 |
| 3 | 229.2-L-16-ES | 1 | 7.5 | 5 | 120 | Partly cloudy | High | Low | Medium | 30 | 5 | 0 | 0 | 20 | 20 | 25 |
| 3 | 229.2-L-16-ES | 2 | 9.5 | 5.5 | 100 | Partly cloudy | High | Low | Medium | 40 | 5 | 0 | 0 | 20 | 30 | 5 |
| 3 | 229.2-L-16-ES | 3 | 10.5 | 6.5 | 110 | Overcast | Low | Low | Medium | 40 | 10 | 0 | 0 | 25 | 25 | 0 |
| 3 | 229.2-L-16-ES | 4 | 9 | 7 | 100 | Overcast | High | Low | High | 75 | 5 | 0 | 5 | 5 | 10 | 0 |
| 3 | 228.5-L-16-ES | 1 | 8 | 5 | 110 | Partly cloudy | High | Medium | High | 30 | 5 | 20 | 0 | 20 | 10 | 15 |
| 3 | 228.5-L-16-ES | 2 | 10.5 | 5.5 | 110 | Partly cloudy | High | Medium | High | 45 | 5 | 5 | 0 | 10 | 15 | 20 |
| 3 | 228.5-L-16-ES | 3 | 10 | 6.5 | 100 | Overcast | High | Medium | High | 40 | 5 | 0 | 0 | 25 | 30 | 0 |
| 3 | 228.5-L-16-ES | 4 | 9 | 7 | 110 | Mostly cloudy | High | Low | High | 80 | 5 | 0 | 5 | 0 | 10 | 0 |
| 3 | 227.2-R-16-ES | 1 | 12 | 6 | 90 | Partly cloudy | High | Medium | Low | 0 | 0 | 0 | 0 | 0 | 100 | 0 |
| 3 | 227.2-R-16-ES | 2 | 10 | 8 | 80 | Mostly cloudy | High | Medium | Medium | 10 | 10 | 0 | 0 | 10 | 50 | 20 |
| 3 | 227.2-R-16-ES | 3 | 8.5 | 6.5 | 100 | Partly cloudy | High | Low | Medium | 20 | 10 | 0 | 0 | 10 | 40 | 20 |
| 3 | 227.2-R-16-ES | 4 | 10.5 | 8 | 90 | Overcast | High | Low | Low | 10 | 5 | 0 | 0 | 10 | 30 | 45 |

[a] See Appendix A, Figures A1 and A2 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 habitat variables recorded at boat electroshocking sites in the Middle Columbia River, 3 to 27 October 2011.

| Reach | Site[a] | Session | Air Temperature (°C) | Water Temperature (°C) | Conductivity (µS) | Cloud Cover[b] | Water Surface Visibility | Instream Velocity[c] | Water Clarity[d] | Cover Types (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Substrate Interstices | Woody Debris | Turbulence | Terrestrial Vegetation | Shallow Water | Deep Water |
| 4 | 236.4-L-16-ES | 1 | 10.5 | 9.5 | 120 | Overcast | High | High | High | 60 | 10 | 0 | 0 | 30 | 0 |
| 4 | 236.4-L-16-ES | 2 | 11 | 9 | 130 | Overcast | High | High | High | 60 | 5 | 0 | 0 | 25 | 10 |
| 4 | 236.4-L-16-ES | 3 | 5 | 9 | 130 | Clear | High | High | High | 70 | 10 | 0 | 0 | 10 | 10 |
| 4 | 236.4-L-16-ES | 4 | 4 | 8.5 | 140 | Partly cloudy | High | High | High | 60 | 20 | 0 | 0 | 10 | 10 |
| 4 | 236.4-R-16-ES | 1 | 16 | 10 | 110 | Overcast | High | High | High | 75 | 0 | 10 | 0 | 0 | 15 |
| 4 | 236.4-R-16-ES | 2 | 11 | 9 | 130 | Overcast | High | High | High | 70 | 0 | 5 | 0 | 0 | 25 |
| 4 | 236.4-R-16-ES | 3 | 6 | 9 | 120 | Clear | High | High | High | 70 | 0 | 10 | 5 | 0 | 15 |
| 4 | 236.4-R-16-ES | 4 | 4 | 8.5 | 140 | Partly cloudy | High | High | High | 60 | 0 | 10 | 10 | 0 | 20 |
| 4 | 236.1-L-16-ES | 1 | 10 | 9.5 | 120 | Overcast | High | High | High | 40 | 0 | 0 | 0 | 30 | 30 |
| 4 | 236.1-L-16-ES | 2 | 4 | 9 | 120 | Fog | High | High | High | 25 | 15 | 0 | 0 | 30 | 30 |
| 4 | 236.1-L-16-ES | 3 | 7 | 9 | 120 | Overcast | High | Low | High | 50 | 10 | 0 | 0 | 30 | 10 |
| 4 | 236.1-L-16-ES | 4 | 4 | 8 | 130 | Overcast | High | High | High | 30 | 10 | 0 | 0 | 40 | 20 |
| 4 | 236.1-R-16-ES | 1 | 11.5 | 10 | 120 | Overcast | High | High | High | 70 | 10 | 10 | 0 | 5 | 5 |
| 4 | 236.1-R-16-ES | 2 | 4 | 9 | 140 | Clear | High | High | High | 50 | 15 | 5 | 0 | 5 | 25 |
| 4 | 236.1-R-16-ES | 3 | 7 | 9 | 120 | Overcast | High | Low | High | 40 | 10 | 0 | 0 | 30 | 20 |
| 4 | 236.1-R-16-ES | 4 | 4 | 8 | 130 | Overcast | Medium | High | High | 60 | 10 | 10 | 0 | 5 | 15 |
| 4 | 234.4-R-16-ES | 1 | 11.5 | 10 | 120 | Overcast | High | High | High | 10 | 60 | 0 | 0 | 5 | 25 |
| 4 | 234.4-R-16-ES | 2 | 3.5 | 9 | 140 | Fog | High | High | High | 30 | 40 | 0 | 0 | 10 | 20 |
| 4 | 234.4-R-16-ES | 3 | 7 | 9 | 120 | Overcast | High | Medium | Medium | 30 | 50 | 0 | 0 | 10 | 10 |
| 4 | 234.4-R-16-ES | 4 | 3 | 8.5 | 120 | Overcast | Medium | High | High | 25 | 50 | 0 | 0 | 0 | 25 |
| 4 | 234.5-L-16-ES | 1 | 10 | 10 | 120 | Partly cloudy | High | High | High | 60 | 10 | 5 | 0 | 0 | 25 |
| 4 | 234.5-L-16-ES | 2 | 3.5 | 9 | 140 | Clear | High | High | High | 40 | 5 | 5 | 0 | 10 | 40 |
| 4 | 234.5-L-16-ES | 3 | 6 | 9 | 120 | Overcast | High | Low | High | 60 | 10 | 0 | 0 | 20 | 10 |
| 4 | 234.5-L-16-ES | 4 | 4 | 8 | 120 | Overcast | Medium | High | High | 50 | 10 | 15 | 0 | 0 | 25 |
| 4 | 232.6-R-16-ES | 1 | 8 | 10 | 120 | Partly cloudy | High | High | High | 50 | 0 | 0 | 0 | 50 | 0 |
| 4 | 232.6-R-16-ES | 2 | 11 | 9 | 130 | Overcast | High | mk | High | 50 | 10 | 0 | 0 | 40 | 0 |
| 4 | 232.6-R-16-ES | 3 | 5 | 9 | 120 | Clear | High | High | High | 50 | 10 | 0 | 0 | 30 | 10 |
| 4 | 232.6-R-16-ES | 4 | 5 | 8.5 | 140 | Overcast | High | High | High | 60 | 10 | 0 | 0 | 10 | 20 |
| 4 | 233.1-L-16-ES | 1 | 10 | 10 | 120 | Partly cloudy | High | Medium | High | 40 | 40 | 0 | 0 | 10 | 10 |
| 4 | 233.1-L-16-ES | 2 | 3 | 9 | 130 | Clear | High | High | High | 50 | 30 | 0 | 0 | 10 | 10 |

continued…

[a] See Appendix A, Figures A1 and A2 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 Concluded.

| Reach | Site[a] | Session | Air Temperature (°C) | Water Temperature (°C) | Conductivity (µS) | Cloud Cover[b] | Water Surface Visibility | Instream Velocity[c] | Water Clarity[d] | Cover Types (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Substrate Interstices | Woody Debris | Turbulence | Terrestrial Vegetation | Shallow Water | Deep Water |
| 4 | 233.1-L-16-ES | 3 | 7 | 9 | 120 | Overcast | High | High | High | 60 | 25 | 5 | 0 | 10 | 0 |
| 4 | 233.1-L-16-ES | 4 | 1 | 8 | 150 | Clear | High | High | High | 70 | 20 | 0 | 0 | 5 | 5 |
| 3 | 231.3-R-16-ES | 1 | 8.5 | 9.5 | 110 | Overcast | High | Low | Medium | 35 | 45 | 0 | 0 | 20 | 0 |
| 3 | 231.3-R-16-ES | 2 | 10 | 9 | 130 | Overcast | Medium | Medium | High | 15 | 40 | 0 | 0 | 0 | 45 |
| 3 | 231.3-R-16-ES | 3 | 4 | 9 | 140 | Clear | High | High | High | 20 | 50 | 0 | 0 | 0 | 30 |
| 3 | 231.3-R-16-ES | 4 | 4.5 | 8.5 | 140 | Partly cloudy | High | High | High | 30 | 30 | 5 | 0 | 10 | 25 |
| 3 | 231.0-L-16-ES | 1 | 10 | 10 | 120 | Partly cloudy | High | Low | High | 80 | 10 | 0 | 0 | 0 | 10 |
| 3 | 231.0-L-16-ES | 2 | 9 | 9 | 140 | Overcast | Medium | High | Medium | 80 | 10 | 0 | 0 | 5 | 5 |
| 3 | 231.0-L-16-ES | 3 | 4 | 9 | 140 | Clear | Medium | High | High | 80 | 10 | 0 | 0 | 5 | 5 |
| 3 | 231.0-L-16-ES | 4 | 4 | 8.5 | 120 | Partly cloudy | Medium | High | High | 75 | 10 | 5 | 0 | 0 | 10 |
| 3 | 231.0-R-16-ES | 1 | 10 | 10 | 120 | Partly cloudy | Medium | Low | High | 15 | 10 | 0 | 0 | 55 | 20 |
| 3 | 231.0-R-16-ES | 2 | 2 | 9 | 130 | Clear | Medium | Medium | High | 20 | 10 | 0 | 0 | 70 | 0 |
| 3 | 231.0-R-16-ES | 3 | 7 | 9 | 120 | Overcast | High | Low | High | 45 | 20 | 0 | 0 | 35 | 0 |
| 3 | 231.0-R-16-ES | 4 | 2 | 8 | 150 | Overcast | High | High | High | 50 | 10 | 5 | 0 | 10 | 25 |
| 3 | 229.7-R-16-ES | 1 | 15 | 10 | 120 | Overcast | High | Low | High | 15 | 65 | 0 | 10 | 0 | 10 |
| 3 | 229.7-R-16-ES | 2 | 3 | 9 | 140 | Partly cloudy | High | Low | High | 20 | 50 | 0 | 0 | 10 | 20 |
| 3 | 229.7-R-16-ES | 3 | 7 | 9 | 120 | Overcast | High | Low | High | 20 | 60 | 0 | 0 | 20 | 0 |
| 3 | 229.7-R-16-ES | 4 | 1.5 | 8 | 150 | Clear | Medium | Medium | High | 10 | 30 | 0 | 0 | 20 | 40 |
| 3 | 229.2-L-16-ES | 1 | 11 | 10 | 110 | Overcast | High | Low | High | 45 | 5 | 0 | 10 | 20 | 20 |
| 3 | 229.2-L-16-ES | 2 | 11 | 8.5 | 130 | Overcast | Low | Low | Low | 60 | 40 | 0 | 0 | 0 | 0 |
| 3 | 229.2-L-16-ES | 3 | 4 | 9 | 130 | Clear | High | High | Medium | 45 | 10 | 0 | 20 | 0 | 25 |
| 3 | 229.2-L-16-ES | 4 | 2.5 | 8.5 | 140 | Clear | High | Low | High | 30 | 15 | 0 | 0 | 0 | 55 |
| 3 | 228.5-L-16-ES | 1 | 11.5 | 10 | 110 | Overcast | High | Medium | High | 60 | 2 | 0 | 30 | 0 | 8 |
| 3 | 228.5-L-16-ES | 2 | 10 | 9 | 130 | Overcast | Medium | Low | Medium | 55 | 5 | 0 | 0 | 20 | 20 |
| 3 | 228.5-L-16-ES | 3 | 6 | 9 | 120 | Clear | Medium | High | High | 50 | 10 | 0 | 0 | 20 | 20 |
| 3 | 228.5-L-16-ES | 4 | 6 | 8.5 | 140 | Partly cloudy | High | High | High | 50 | 5 | 5 | 0 | 10 | 30 |
| 3 | 227.2-R-16-ES | 1 | 12 | 10 | 120 | Overcast | High | Low | Medium | 20 | 20 | 0 | 0 | 10 | 50 |
| 3 | 227.2-R-16-ES | 2 | 2 | 9 | 130 | Clear | High | Low | High | 20 | 10 | 0 | 0 | 5 | 65 |
| 3 | 227.2-R-16-ES | 3 | 7.5 | 8.5 | 120 | Partly cloudy | High | Low | Medium | 30 | 10 | 0 | 0 | 5 | 55 |
| 3 | 227.2-R-16-ES | 4 | 0 | 8 | 140 | Clear | High | High | High | 20 | 10 | 0 | 0 | 0 | 70 |

[a] See Appendix A, Figures A1 and A2 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 B5 Summary of species counts adjacent to bank habitat types in the Middle Columbia River, 30 May to 24 June 2011.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| 4 | 236.4-R-16-ES | Bull trout | Adult | 7 | | 13 | | | | | | **20** |
| | 236.4-R-16-ES | Bull trout | Immature | 1 | | 2 | | | | | | **3** |
| | 236.4-R-16-ES | Largescale sucker | Adult | 1 | | | | | | | | **1** |
| | 236.4-R-16-ES | Longnose sucker | Adult | | | 1 | | | | | | **1** |
| | 236.4-R-16-ES | Mountain whitefish | Adult | 64 | | 46 | | | | | | **110** |
| | 236.4-R-16-ES | Mountain whitefish | Immature | 89 | | 62 | | | | | | **151** |
| | 236.4-R-16-ES | Rainbow trout | Adult | 1 | | | | | | | | **1** |
| | 236.4-R-16-ES | Sculpin spp. | All | | | 1 | | | | | | **1** |
| | 236.4-R-16-ES | Sucker spp. | Adult | 6 | | 1 | | | | | | **7** |
| | **Site 236.4-R-16-ES Total** | | | **169** | **0** | **126** | **0** | **0** | **0** | **0** | **0** | **295** |
| | 236.4-L-16-ES | Bull trout | Adult | 30 | | | | | | | | **30** |
| | 236.4-L-16-ES | Burbot | Adult | 2 | | | | | | | | **2** |
| | 236.4-L-16-ES | Largescale sucker | Adult | 2 | | | | | | | | **2** |
| | 236.4-L-16-ES | Mountain whitefish | Adult | 49 | | | | | | | | **49** |
| | 236.4-L-16-ES | Mountain whitefish | Immature | 90 | | | | | | | | **90** |
| | 236.4-L-16-ES | Sculpin spp. | All | 7 | | | | | | | | **7** |
| | 236.4-L-16-ES | Sucker spp. | Adult | 6 | | | | | | | | **6** |
| | 236.4-L-16-ES | Sucker spp. | Immature | 1 | | | | | | | | **1** |
| | **Site 236.4-L-16-ES Total** | | | **187** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **187** |
| | 236.1-R-16-ES | Bull trout | Adult | | | | | | 77 | | | **77** |
| | 236.1-R-16-ES | Bull trout | Immature | | | | | | 12 | | | **12** |
| | 236.1-R-16-ES | Burbot | Adult | | | | | | 2 | | | **2** |
| | 236.1-R-16-ES | Kokanee | Adult | | | | | | 2 | | | **2** |
| | 236.1-R-16-ES | Kokanee | Immature | | | | | | 7 | | | **7** |
| | 236.1-R-16-ES | Largescale sucker | Adult | | | | | | 1 | | | **1** |
| | 236.1-R-16-ES | Longnose sucker | Adult | | | | | | 1 | | | **1** |
| | 236.1-R-16-ES | Mountain whitefish | Adult | | | | | | 198 | | | **198** |
| | 236.1-R-16-ES | Mountain whitefish | Immature | | | | | | 278 | | | **278** |
| | 236.1-R-16-ES | Peamouth | Adult | | | | | | 3 | | | **3** |
| | 236.1-R-16-ES | Rainbow trout | Immature | | | | | | 3 | | | **3** |
| | 236.1-R-16-ES | Redside shiner | All | | | | | | 3 | | | **3** |
| | 236.1-R-16-ES | Sculpin spp. | All | | | | | | 52 | | | **52** |
| | 236.1-R-16-ES | Sucker spp. | Adult | | | | | | 10 | | | **10** |
| | 236.1-R-16-ES | Sucker spp. | Immature | | | | | | 1 | | | **1** |
| | **Site 236.1-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **650** | **0** | **0** | **650** |
| | 236.1-L-16-ES | Bull trout | Adult | | 7 | | | | | | 65 | **72** |
| | 236.1-L-16-ES | Bull trout | Immature | | | | | | | | 8 | **8** |
| | 236.1-L-16-ES | Burbot | Adult | | 2 | | | | | | | **2** |
| | 236.1-L-16-ES | Kokanee | Immature | | 1 | | | | | | 1 | **2** |
| | 236.1-L-16-ES | Largescale sucker | Adult | | 1 | | | | | | 1 | **2** |
| | 236.1-L-16-ES | Longnose sucker | Adult | | 1 | | | | | | 1 | **2** |
| | 236.1-L-16-ES | Longnose sucker | Immature | | 1 | | | | | | | **1** |
| | 236.1-L-16-ES | Mountain whitefish | Adult | | 16 | | | | | | 134 | **150** |
| | 236.1-L-16-ES | Mountain whitefish | Immature | | 46 | | | | | 1 | 213 | **260** |
| | 236.1-L-16-ES | Peamouth | Adult | | 3 | | | | | | | **3** |
| | 236.1-L-16-ES | Rainbow trout | Immature | | 2 | | | | | | 1 | **3** |
| | 236.1-L-16-ES | Sculpin spp. | All | | 12 | | | | | | 43 | **55** |
| | 236.1-L-16-ES | Sucker spp. | Adult | | 6 | | | | | | 6 | **12** |
| | **Site 236.1-L-16-ES Total** | | | **0** | **98** | **0** | **0** | **0** | **0** | **1** | **473** | **572** |

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

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

Continued…

Table B5  Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 234.5-L-16-ES | Bull trout | Adult | 23 | | | 40 | | | | | **63** |
| | 234.5-L-16-ES | Bull trout | Immature | 2 | | | 3 | | | | | **5** |
| | 234.5-L-16-ES | Burbot | Adult | 1 | | | 3 | | | | | **4** |
| | 234.5-L-16-ES | Kokanee | Adult | 3 | | | 4 | | | | | **7** |
| | 234.5-L-16-ES | Kokanee | Immature | 1 | | | | | | | | **1** |
| | 234.5-L-16-ES | Largescale sucker | Adult | 1 | | | | | | | | **1** |
| | 234.5-L-16-ES | Largescale sucker | Immature | | | | 2 | | | | | **2** |
| | 234.5-L-16-ES | Longnose sucker | Adult | 1 | | | 1 | | | | | **2** |
| | 234.5-L-16-ES | Mountain whitefish | Adult | 118 | | | 292 | | | | | **410** |
| | 234.5-L-16-ES | Mountain whitefish | Immature | 90 | | | 177 | | | | | **267** |
| | 234.5-L-16-ES | Rainbow trout | Adult | | | | 1 | | | | | **1** |
| | 234.5-L-16-ES | Rainbow trout | Immature | 1 | | | 1 | | | | | **2** |
| | 234.5-L-16-ES | Sculpin spp. | All | 38 | | | 89 | | | | | **127** |
| | 234.5-L-16-ES | Sucker spp. | Adult | 5 | | | 11 | | | | | **16** |
| | 234.5-L-16-ES | Sucker spp. | Immature | 13 | | | | | | | | **13** |
| | **Site 234.5-L-16-ES Total** | | | **297** | **0** | **0** | **624** | **0** | **0** | **0** | **0** | **921** |
| | 234.4-R-16-ES | Bull trout | Adult | 70 | | | 2 | | | | | **72** |
| | 234.4-R-16-ES | Bull trout | Immature | 11 | | | | | | | | **11** |
| | 234.4-R-16-ES | Burbot | Adult | 1 | | | | | | | | **1** |
| | 234.4-R-16-ES | Lake whitefish | Adult | 1 | | | | | | | | **1** |
| | 234.4-R-16-ES | Largescale sucker | Adult | 2 | | | | | | | | **2** |
| | 234.4-R-16-ES | Longnose sucker | Adult | 4 | | | | | | | | **4** |
| | 234.4-R-16-ES | Mountain whitefish | Adult | 270 | | | 37 | | | | | **307** |
| | 234.4-R-16-ES | Mountain whitefish | Immature | 264 | | | 22 | | | | | **286** |
| | 234.4-R-16-ES | Peamouth | Adult | 2 | | | | | | | | **2** |
| | 234.4-R-16-ES | Rainbow trout | Adult | 1 | | | | | | | | **1** |
| | 234.4-R-16-ES | Rainbow trout | Immature | 3 | | | 1 | | | | | **4** |
| | 234.4-R-16-ES | Sculpin spp. | All | 277 | | | 20 | | | | | **297** |
| | 234.4-R-16-ES | Sucker spp. | Adult | 32 | | | | | | | | **32** |
| | 234.4-R-16-ES | Sucker spp. | Immature | 3 | | | | | | | | **3** |
| | **Site 234.4-R-16-ES Total** | | | **941** | **0** | **0** | **82** | **0** | **0** | **0** | **0** | **1023** |
| | 233.1-L-16-ES | Brook trout | Immature | | | 1 | | | | | | **1** |
| | 233.1-L-16-ES | Bull trout | Adult | | | 6 | 15 | 12 | | | | **33** |
| | 233.1-L-16-ES | Bull trout | Immature | | | 5 | | 4 | | | | **9** |
| | 233.1-L-16-ES | Burbot | Adult | | | 1 | 1 | 5 | | | | **7** |
| | 233.1-L-16-ES | Kokanee | Adult | | | | | 2 | | | | **2** |
| | 233.1-L-16-ES | Largescale sucker | Adult | | | 3 | | | | | | **3** |
| | 233.1-L-16-ES | Largescale sucker | Immature | | | 2 | | | | | | **2** |
| | 233.1-L-16-ES | Longnose sucker | Adult | | | 1 | | | | | | **1** |
| | 233.1-L-16-ES | Mountain whitefish | Adult | | | 27 | 68 | 133 | | | | **228** |
| | 233.1-L-16-ES | Mountain whitefish | Immature | | | 120 | 34 | 75 | | | | **229** |
| | 233.1-L-16-ES | Northern pikeminnow | Immature | | | 1 | | | | | | **1** |
| | 233.1-L-16-ES | Peamouth | Adult | | | 1 | | | | | | **1** |
| | 233.1-L-16-ES | Rainbow trout | Adult | | | 3 | | 5 | | | | **8** |
| | 233.1-L-16-ES | Rainbow trout | Immature | | | 6 | 1 | 11 | | | | **18** |
| | 233.1-L-16-ES | Redside shiner | All | | | | | 3 | | | | **3** |
| | 233.1-L-16-ES | Sculpin spp. | All | | | 1 | 32 | 433 | | | | **466** |
| | 233.1-L-16-ES | Sucker spp. | Adult | | | | 15 | 14 | | | | **29** |
| | 233.1-L-16-ES | Sucker spp. | Immature | | | | | 3 | | | | **3** |
| | **Site 233.1-L-16-ES Total** | | | **0** | **0** | **178** | **166** | **700** | **0** | **0** | **0** | **1044** |

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

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

Continued…

Table B5 Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 232.6-R-16-ES | Bull trout | Adult | | | | | | | 17 | | **17** |
| | 232.6-R-16-ES | Bull trout | Immature | | | | | | | 1 | | **1** |
| | 232.6-R-16-ES | Burbot | Adult | | | | | | | 1 | | **1** |
| | 232.6-R-16-ES | Largescale sucker | Adult | | | | | | | 2 | | **2** |
| | 232.6-R-16-ES | Longnose sucker | Adult | | | | | | | 14 | | **14** |
| | 232.6-R-16-ES | Mountain whitefish | Adult | | | | | | | 320 | | **320** |
| | 232.6-R-16-ES | Mountain whitefish | Immature | | | | | | | 522 | | **522** |
| | 232.6-R-16-ES | Peamouth | Adult | | | | | | | 2 | | **2** |
| | 232.6-R-16-ES | Sucker spp. | Adult | | | | | | | 114 | | **114** |
| | 232.6-R-16-ES | Sucker spp. | Immature | | | | | | | 2 | | **2** |
| | **Site 232.6-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **995** | **0** | **995** |
| **Reach 4 Total** | | | | **1594** | **98** | **304** | **872** | **700** | **650** | **996** | **473** | **5687** |
| 3 | 231.3-R-16-ES | Bull trout | Adult | 41 | | | 2 | | | | | **43** |
| | 231.3-R-16-ES | Bull trout | Immature | 3 | | | | | | | | **3** |
| | 231.3-R-16-ES | Kokanee | Adult | 1 | | | | | | | | **1** |
| | 231.3-R-16-ES | Largescale sucker | Adult | 1 | | | | | | | | **1** |
| | 231.3-R-16-ES | Largescale sucker | Immature | 3 | | | | | | | | **3** |
| | 231.3-R-16-ES | Mountain whitefish | Adult | 441 | | | 4 | | | | | **445** |
| | 231.3-R-16-ES | Mountain whitefish | Immature | 373 | | | 6 | | | | | **379** |
| | 231.3-R-16-ES | Rainbow trout | Immature | 4 | | | | | | | | **4** |
| | 231.3-R-16-ES | Redside shiner | All | 1 | | | 21 | | | | | **22** |
| | 231.3-R-16-ES | Sculpin spp. | All | 87 | | | | | | | | **87** |
| | 231.3-R-16-ES | Sucker spp. | Adult | 10 | | | 2 | | | | | **12** |
| | 231.3-R-16-ES | Sucker spp. | Immature | 2 | | | | | | | | **2** |
| | 231.3-R-16-ES | Yellow perch | Immature | 1 | | | | | | | | **1** |
| | **Site 231.3-R-16-ES Total** | | | **968** | **0** | **0** | **35** | **0** | **0** | **0** | **0** | **1003** |
| | 231.0-R-16-ES | Bull trout | Adult | | | | | | | 34 | | **34** |
| | 231.0-R-16-ES | Bull trout | Immature | | | | | | | 1 | | **1** |
| | 231.0-R-16-ES | Burbot | Adult | | | | | | | 1 | | **1** |
| | 231.0-R-16-ES | Largescale sucker | Adult | | | | | | | 4 | | **4** |
| | 231.0-R-16-ES | Longnose sucker | Adult | | | | | | | 5 | | **5** |
| | 231.0-R-16-ES | Mountain whitefish | Adult | | | | | | | 435 | | **435** |
| | 231.0-R-16-ES | Mountain whitefish | Immature | | | | | | | 635 | | **635** |
| | 231.0-R-16-ES | Peamouth | Adult | | | | | | | 2 | | **2** |
| | 231.0-R-16-ES | Redside shiner | All | | | | | | | 1 | | **1** |
| | 231.0-R-16-ES | Sculpin spp. | All | | | | | | | 11 | | **11** |
| | 231.0-R-16-ES | Sucker spp. | Adult | | | | | | | 121 | | **121** |
| | 231.0-R-16-ES | Sucker spp. | Immature | | | | | | | 9 | | **9** |
| | **Site 231.0-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **1259** | **0** | **1259** |
| | 231.0-L-16-ES | Brook trout | Immature | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Bull trout | Adult | | | | | 37 | | | | **37** |
| | 231.0-L-16-ES | Bull trout | Immature | | | | | 15 | | | | **15** |
| | 231.0-L-16-ES | Burbot | Adult | | | | | 9 | | | | **9** |
| | 231.0-L-16-ES | Largescale sucker | Adult | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Largescale sucker | Immature | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Longnose sucker | Adult | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Longnose sucker | Immature | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Mountain whitefish | Adult | 1 | | | | 370 | | | | **371** |
| | 231.0-L-16-ES | Mountain whitefish | Immature | 11 | | | | 380 | | | | **391** |
| | 231.0-L-16-ES | Mountain whitefish | YOY | | | | | 5 | | | | **5** |
| | 231.0-L-16-ES | Northern pikeminnow | Immature | | | | | 2 | | | | **2** |
| | 231.0-L-16-ES | Rainbow trout | Adult | | | | | 8 | | | | **8** |
| | 231.0-L-16-ES | Rainbow trout | Immature | | | | | 53 | | | | **53** |
| | 231.0-L-16-ES | Redside shiner | All | | | | | 5 | | | | **5** |
| | 231.0-L-16-ES | Sculpin spp. | All | 5 | | | | 195 | | | | **200** |
| | 231.0-L-16-ES | Sucker spp. | Adult | | | | | 32 | | | | **32** |
| | 231.0-L-16-ES | Sucker spp. | Immature | | | | | 6 | | | | **6** |
| | **Site 231.0-L-16-ES Total** | | | **17** | **0** | **0** | **0** | **1122** | **0** | **0** | **0** | **1139** |

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

Continued…

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

Table B5  Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 229.7-R-16-ES | Bull trout | Adult | | | | | | | 30 | | **30** |
| | 229.7-R-16-ES | Bull trout | Immature | | | | | | | 14 | | **14** |
| | 229.7-R-16-ES | Largescale sucker | Adult | | | | | | | 42 | | **42** |
| | 229.7-R-16-ES | Largescale sucker | Immature | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Longnose sucker | Adult | | | | | | | 70 | | **70** |
| | 229.7-R-16-ES | Mountain whitefish | Adult | | | | | | | 578 | | **578** |
| | 229.7-R-16-ES | Mountain whitefish | Immature | | | | | | | 813 | | **813** |
| | 229.7-R-16-ES | Peamouth | Adult | | | | | | | 15 | | **15** |
| | 229.7-R-16-ES | Rainbow trout | Immature | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Redside shiner | All | | | | | | | 4 | | **4** |
| | 229.7-R-16-ES | Sculpin spp. | All | | | | | | | 59 | | **59** |
| | 229.7-R-16-ES | Sucker spp. | Adult | | | | | | | 481 | | **481** |
| | 229.7-R-16-ES | Sucker spp. | Immature | | | | | | | 7 | | **7** |
| | **Site 229.7-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **2115** | **0** | **2115** |
| | 229.2-L-16-ES | Brook trout | Immature | 2 | | | | | | | | **2** |
| | 229.2-L-16-ES | Bull trout | Adult | 4 | | | | | | | | **4** |
| | 229.2-L-16-ES | Bull trout | Immature | 19 | | | | | | | | **19** |
| | 229.2-L-16-ES | Kokanee | Immature | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Largescale sucker | Adult | 4 | | | | | | | | **4** |
| | 229.2-L-16-ES | Largescale sucker | Immature | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Mountain whitefish | Adult | 154 | | | | | | | | **154** |
| | 229.2-L-16-ES | Mountain whitefish | Immature | 101 | | | | | | | | **101** |
| | 229.2-L-16-ES | Mountain whitefish | YOY | 2 | | | | | | | | **2** |
| | 229.2-L-16-ES | Northern pikeminnow | Immature | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Rainbow trout | Adult | 6 | | | | | | | | **6** |
| | 229.2-L-16-ES | Rainbow trout | Immature | 18 | | | | | | | | **18** |
| | 229.2-L-16-ES | Redside shiner | All | 115 | | | | | | | | **115** |
| | 229.2-L-16-ES | Sculpin spp. | All | 402 | | | | | | | | **402** |
| | 229.2-L-16-ES | Sucker spp. | Adult | 5 | | | | | | | | **5** |
| | 229.2-L-16-ES | Sucker spp. | Immature | 1 | | | | | | | | **1** |
| | **Site 229.2-L-16-ES Total** | | | **836** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **836** |
| | 228.5-L-16-ES | Brook trout | Immature | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Bull trout | Adult | | | | 3 | 6 | | 5 | | **14** |
| | 228.5-L-16-ES | Bull trout | Immature | | | | 1 | 7 | | 4 | | **12** |
| | 228.5-L-16-ES | Burbot | All | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Kokanee | Immature | | | | | | | 3 | | **3** |
| | 228.5-L-16-ES | Largescale sucker | Adult | | | | | | | 2 | | **2** |
| | 228.5-L-16-ES | Longnose sucker | Adult | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Mountain whitefish | Adult | | | | 15 | 30 | | 77 | | **122** |
| | 228.5-L-16-ES | Mountain whitefish | Immature | | | | 13 | 32 | | 230 | | **275** |
| | 228.5-L-16-ES | Mountain whitefish | YOY | | | | | 2 | | 10 | | **12** |
| | 228.5-L-16-ES | Northern pikeminnow | Immature | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Peamouth | Adult | | | | | | | 1 | | **1** |
| | 228.5-L-16-ES | Rainbow trout | Adult | | | | | 1 | | 1 | | **2** |
| | 228.5-L-16-ES | Rainbow trout | Immature | | | | 6 | 30 | | 18 | | **54** |
| | 228.5-L-16-ES | Redside shiner | All | | | | 1 | 1 | | 3 | | **5** |
| | 228.5-L-16-ES | Sculpin spp. | All | | | | 5 | 18 | | 48 | | **71** |
| | 228.5-L-16-ES | Sucker spp. | Adult | | | | | 1 | | 12 | | **13** |
| | **Site 228.5-L-16-ES Total** | | | **0** | **0** | **0** | **44** | **132** | **0** | **414** | **0** | **590** |

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

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

Continued…

Table B5  Concluded.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 227.2-R-16-ES | Bull trout | Adult | | | | 14 | | | | | **14** |
| | 227.2-R-16-ES | Bull trout | Immature | | | | 2 | | | | | **2** |
| | 227.2-R-16-ES | Largescale sucker | Adult | | | | 16 | | | | | **16** |
| | 227.2-R-16-ES | Longnose sucker | Adult | | | | 1 | | | | | **1** |
| | 227.2-R-16-ES | Mountain whitefish | Adult | | | | 69 | | | | | **69** |
| | 227.2-R-16-ES | Mountain whitefish | Immature | | | | 67 | | | | | **67** |
| | 227.2-R-16-ES | Peamouth | Adult | | | | 1 | | | | | **1** |
| | 227.2-R-16-ES | Rainbow trout | Immature | | | | 16 | | | | | **16** |
| | 227.2-R-16-ES | Redside shiner | All | | | | 12 | | | | | **12** |
| | 227.2-R-16-ES | Sculpin spp. | All | | | | 48 | | | | | **48** |
| | 227.2-R-16-ES | Sucker spp. | Adult | | | | 88 | | | | | **88** |
| | 227.2-R-16-ES | Sucker spp. | Immature | | | | 7 | | | | | **7** |
| | **Site 227.2-R-16-ES Total** | | | **0** | **0** | **0** | **341** | **0** | **0** | **0** | **0** | **341** |
| **Reach 3 Total** | | | | **1821** | **0** | **0** | **420** | **1254** | **0** | **3788** | **0** | **7283** |
| **Grand Total** | | | | **3415** | **98** | **304** | **1292** | **1954** | **650** | **4784** | **473** | **12 970** |

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

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

Table B6 Summary of species counts adjacent to bank habitat types in the Middle Columbia River, 3 to 27 October 2011.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 236.4-R-16-ES | Bull trout | Adult | 8 | | 9 | | | | | | **17** |
| | 236.4-R-16-ES | Sculpin spp. | All | 1 | | 3 | | | | | | **4** |
| | 236.4-R-16-ES | Largescale sucker | Adult | | | 1 | | | | | | **1** |
| | 236.4-R-16-ES | Kokanee | Adult | 60 | | 66 | | | | | | **126** |
| | 236.4-R-16-ES | Kokanee | Immature | | | 3 | | | | | | **3** |
| | 236.4-R-16-ES | Lake whitefish | Adult | 12 | | 2 | | | | | | **14** |
| | 236.4-R-16-ES | Mountain whitefish | Adult | 38 | | 45 | | | | | | **83** |
| | 236.4-R-16-ES | Mountain whitefish | Immature | 49 | | 59 | | | | | | **108** |
| | 236.4-R-16-ES | Mountain whitefish | YOY | 1 | | 2 | | | | | | **3** |
| | **Site 236.4-R-16-ES Total** | | | **169** | **0** | **190** | **0** | **0** | **0** | **0** | **0** | **359** |
| | 236.4-L-16-ES | Burbot | Adult | 3 | | 1 | | | | | | **4** |
| | 236.4-L-16-ES | Bull trout | Adult | 17 | | | | | | | | **17** |
| | 236.4-L-16-ES | Bull trout | Immature | 1 | | | | | | | | **1** |
| | 236.4-L-16-ES | Largescale sucker | Adult | 13 | | | | | | | | **13** |
| | 236.4-L-16-ES | Kokanee | Adult | 28 | | 7 | | | | | | **35** |
| | 236.4-L-16-ES | Kokanee | Immature | 10 | | | | | | | | **10** |
| | 236.4-L-16-ES | Lake whitefish | Adult | 7 | | | | | | | | **7** |
| | 236.4-L-16-ES | Mountain whitefish | Adult | 67 | | 10 | | | | | | **77** |
| | 236.4-L-16-ES | Mountain whitefish | Immature | 106 | | 19 | | | | | | **125** |
| | 236.4-L-16-ES | Mountain whitefish | YOY | 15 | | 1 | | | | | | **16** |
| | 236.4-L-16-ES | Sucker spp. | Adult | 4 | | 1 | | | | | | **5** |
| | **Site 236.4-L-16-ES Total** | | | **271** | **0** | **39** | **0** | **0** | **0** | **0** | **0** | **310** |
| | 236.1-R-16-ES | Burbot | Adult | | | | | | 3 | | | **3** |
| | 236.1-R-16-ES | Bull trout | Adult | | | | | | 68 | | | **68** |
| | 236.1-R-16-ES | Bull trout | Immature | | | | | | 3 | | | **3** |
| | 236.1-R-16-ES | Sculpin spp. | All | | | | | | 156 | | | **156** |
| | 236.1-R-16-ES | Largescale sucker | Adult | | | | | | 25 | | | **25** |
| | 236.1-R-16-ES | Kokanee | Adult | | | | | | 469 | | | **469** |
| | 236.1-R-16-ES | Kokanee | Immature | | | | | | 1 | | | **1** |
| | 236.1-R-16-ES | Longnose sucker | Adult | | | | | | 1 | | | **1** |
| | 236.1-R-16-ES | Lake whitefish | Adult | | | | | | 31 | | | **31** |
| | 236.1-R-16-ES | Mountain whitefish | Adult | | | | | | 126 | | | **126** |
| | 236.1-R-16-ES | Mountain whitefish | Immature | | | | | | 253 | | | **253** |
| | 236.1-R-16-ES | Rainbow trout | Immature | | | | | | 1 | | | **1** |
| | 236.1-R-16-ES | Sucker spp. | Adult | | | | | | 29 | | | **29** |
| | **Site 236.1-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **1166** | **0** | **0** | **1166** |
| | 236.1-L-16-ES | Burbot | Adult | | 1 | | | | | | 5 | **6** |
| | 236.1-L-16-ES | Bull trout | Adult | | 5 | | | | | | 32 | **37** |
| | 236.1-L-16-ES | Bull trout | Immature | | 2 | | | | | | 2 | **4** |
| | 236.1-L-16-ES | Sculpin spp. | All | | 13 | | | | | | 40 | **53** |
| | 236.1-L-16-ES | Largescale sucker | Adult | | 4 | | | | | | 21 | **25** |
| | 236.1-L-16-ES | Kokanee | Adult | | 47 | | | | | | 38 | **85** |
| | 236.1-L-16-ES | Kokanee | Immature | | 1 | | | | | | 2 | **3** |
| | 236.1-L-16-ES | Lake whitefish | Adult | | | | | | | | 2 | **2** |
| | 236.1-L-16-ES | Mountain whitefish | Adult | | 31 | | | | | | 138 | **169** |
| | 236.1-L-16-ES | Mountain whitefish | Immature | | 38 | | | | | | 145 | **183** |
| | 236.1-L-16-ES | Mountain whitefish | YOY | | | | | | | | 5 | **5** |
| | 236.1-L-16-ES | Sucker spp. | Adult | | 2 | | | | | | 21 | **23** |
| | 236.1-L-16-ES | Sucker spp. | Immature | | 1 | | | | | | 1 | **2** |
| | **Site 236.1-L-16-ES Total** | | | **0** | **145** | **0** | **0** | **0** | **0** | **0** | **452** | **597** |

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

Continued…

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

Table B6 Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 234.5-L-16-ES | Burbot | Adult | | | | 5 | | | | | **5** |
| | 234.5-L-16-ES | Bull trout | Adult | 8 | | | 51 | | | | | **59** |
| | 234.5-L-16-ES | Bull trout | Immature | 2 | | | 4 | | | | | **6** |
| | 234.5-L-16-ES | Sculpin spp. | All | 35 | | | 36 | | | | | **71** |
| | 234.5-L-16-ES | Largescale sucker | Adult | 9 | | | 16 | | | | | **25** |
| | 234.5-L-16-ES | Kokanee | Adult | 52 | | | 342 | | | | | **394** |
| | 234.5-L-16-ES | Kokanee | Immature | 6 | | | 2 | | | | | **8** |
| | 234.5-L-16-ES | Longnose sucker | Adult | | | | 1 | | | | | **1** |
| | 234.5-L-16-ES | Lake whitefish | Adult | 2 | | | 92 | | | | | **94** |
| | 234.5-L-16-ES | Mountain whitefish | Adult | 114 | | | 260 | | | | | **374** |
| | 234.5-L-16-ES | Mountain whitefish | Immature | 203 | | | 269 | | | | | **472** |
| | 234.5-L-16-ES | Rainbow trout | Adult | 3 | | | | | | | | **3** |
| | 234.5-L-16-ES | Rainbow trout | Immature | 9 | | | 2 | | | | | **11** |
| | 234.5-L-16-ES | Sucker spp. | Adult | 11 | | | 38 | | | | | **49** |
| | **Site 234.5-L-16-ES Total** | | | **454** | **0** | **0** | **1118** | **0** | **0** | **0** | **0** | **1572** |
| | 234.4-R-16-ES | Burbot | Adult | 1 | | | | | | | | **1** |
| | 234.4-R-16-ES | Bull trout | Adult | 61 | | | | | | | | **61** |
| | 234.4-R-16-ES | Bull trout | Immature | 2 | | | | | | | | **2** |
| | 234.4-R-16-ES | Sculpin spp. | All | 145 | | | | | | | | **145** |
| | 234.4-R-16-ES | Largescale sucker | Adult | 56 | | | | | | | | **56** |
| | 234.4-R-16-ES | Kokanee | Adult | 1174 | | | | | | | | **1174** |
| | 234.4-R-16-ES | Kokanee | Immature | 4 | | | | | | | | **4** |
| | 234.4-R-16-ES | Longnose sucker | Immature | 1 | | | | | | | | **1** |
| | 234.4-R-16-ES | Lake whitefish | Adult | 38 | | | | | | | | **38** |
| | 234.4-R-16-ES | Mountain whitefish | Adult | 191 | | | | | | | | **191** |
| | 234.4-R-16-ES | Mountain whitefish | Immature | 257 | | | | | | | | **257** |
| | 234.4-R-16-ES | Mountain whitefish | YOY | 2 | | | | | | | | **2** |
| | 234.4-R-16-ES | Sucker spp. | Adult | 60 | | | | | | | | **60** |
| | **Site 234.4-R-16-ES Total** | | | **1992** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1992** |
| | 233.1-L-16-ES | Burbot | Adult | | | 2 | | 20 | | | | **22** |
| | 233.1-L-16-ES | Bull trout | Adult | | | 35 | | 25 | | | | **60** |
| | 233.1-L-16-ES | Bull trout | Immature | | | 3 | | 7 | | | | **10** |
| | 233.1-L-16-ES | Sculpin spp. | All | | | 3 | | 224 | | | | **227** |
| | 233.1-L-16-ES | Largescale sucker | Adult | | | 22 | | | | | | **22** |
| | 233.1-L-16-ES | Kokanee | Adult | | | | | 82 | | | | **82** |
| | 233.1-L-16-ES | Kokanee | Immature | | | | | 1 | | | | **1** |
| | 233.1-L-16-ES | Longnose sucker | Adult | | | 2 | | | | | | **2** |
| | 233.1-L-16-ES | Longnose sucker | Immature | | | 2 | | | | | | **2** |
| | 233.1-L-16-ES | Lake whitefish | Adult | | | 5 | | 8 | | | | **13** |
| | 233.1-L-16-ES | Mountain whitefish | Adult | | | 23 | | 80 | | | | **103** |
| | 233.1-L-16-ES | Mountain whitefish | Immature | | | 33 | | 58 | | | | **91** |
| | 233.1-L-16-ES | Mountain whitefish | YOY | | | | | 2 | | | | **2** |
| | 233.1-L-16-ES | Northern pikeminnow | Adult | | | 2 | | | | | | **2** |
| | 233.1-L-16-ES | Rainbow trout | Adult | | | 3 | | 1 | | | | **4** |
| | 233.1-L-16-ES | Rainbow trout | Immature | | | 1 | | 23 | | | | **24** |
| | 233.1-L-16-ES | Redside shiner | All | | | | | 11 | | | | **11** |
| | 233.1-L-16-ES | Sucker spp. | Adult | | | | | 33 | | | | **33** |
| | **Site 233.1-L-16-ES Total** | | | **0** | **0** | **136** | **0** | **575** | **0** | **0** | **0** | **711** |

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

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

Continued…

Table B6 Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 232.6-R-16-ES | Burbot | Adult | | | | | | | 1 | | **1** |
| | 232.6-R-16-ES | Bull trout | Adult | | | | | | | 15 | | **15** |
| | 232.6-R-16-ES | Sculpin spp. | All | | | | | | | 2 | | **2** |
| | 232.6-R-16-ES | Largescale sucker | Adult | | | | | | | 18 | | **18** |
| | 232.6-R-16-ES | Kokanee | Adult | | | | | | | 46 | | **46** |
| | 232.6-R-16-ES | Kokanee | Immature | | | | | | | 2 | | **2** |
| | 232.6-R-16-ES | Mountain whitefish | Adult | | | | | | | 124 | | **124** |
| | 232.6-R-16-ES | Mountain whitefish | Immature | | | | | | | 518 | | **518** |
| | 232.6-R-16-ES | Mountain whitefish | YOY | | | | | | | 2 | | **2** |
| | 232.6-R-16-ES | Sucker spp. | Adult | | | | | | | 25 | | **25** |
| | 232.6-R-16-ES | Sucker spp. | Immature | | | | | | | 1 | | **1** |
| | **Site 232.6-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **754** | **0** | **754** |
| **Reach 4 Total** | | | | **2886** | **145** | **365** | **1118** | **575** | **1166** | **754** | **452** | **7461** |
| 3 | 231.3-R-16-ES | Bull trout | Adult | 18 | | | 12 | | | | | **30** |
| | 231.3-R-16-ES | Bull trout | Immature | 6 | | | 1 | | | | | **7** |
| | 231.3-R-16-ES | Sculpin spp. | All | 63 | | | 2 | | | | | **65** |
| | 231.3-R-16-ES | Largescale sucker | Adult | 15 | | | | | | | | **15** |
| | 231.3-R-16-ES | Kokanee | Adult | 587 | | | 14 | | | | | **601** |
| | 231.3-R-16-ES | Kokanee | Immature | 6 | | | | | | | | **6** |
| | 231.3-R-16-ES | Longnose sucker | Adult | 1 | | | | | | | | **1** |
| | 231.3-R-16-ES | Lake whitefish | Adult | 23 | | | 1 | | | | | **24** |
| | 231.3-R-16-ES | Mountain whitefish | Adult | 243 | | | 4 | | | | | **247** |
| | 231.3-R-16-ES | Mountain whitefish | Immature | 189 | | | 6 | | | | | **195** |
| | 231.3-R-16-ES | Mountain whitefish | YOY | 4 | | | | | | | | **4** |
| | 231.3-R-16-ES | Rainbow trout | Adult | 9 | | | | | | | | **9** |
| | 231.3-R-16-ES | Rainbow trout | Immature | 5 | | | | | | | | **5** |
| | 231.3-R-16-ES | Redside shiner | All | 4 | | | | | | | | **4** |
| | 231.3-R-16-ES | Sucker spp. | Adult | 19 | | | 1 | | | | | **20** |
| | 231.3-R-16-ES | Sucker spp. | Immature | 2 | | | | | | | | **2** |
| | **Site 231.3-R-16-ES Total** | | | **1194** | **0** | **0** | **41** | **0** | **0** | **0** | **0** | **1235** |
| | 231.0-R-16-ES | Bull trout | Adult | | | | | | | 80 | | **80** |
| | 231.0-R-16-ES | Bull trout | Immature | | | | | | | 2 | | **2** |
| | 231.0-R-16-ES | Sculpin spp. | All | | | | | | | 11 | | **11** |
| | 231.0-R-16-ES | Largescale sucker | Adult | | | | | | | 32 | | **32** |
| | 231.0-R-16-ES | Kokanee | Adult | | | | | | | 905 | | **905** |
| | 231.0-R-16-ES | Kokanee | Immature | | | | | | | 9 | | **9** |
| | 231.0-R-16-ES | Lake whitefish | Adult | | | | | | | 1 | | **1** |
| | 231.0-R-16-ES | Mountain whitefish | Adult | | | | | | | 216 | | **216** |
| | 231.0-R-16-ES | Mountain whitefish | Immature | | | | | | | 274 | | **274** |
| | 231.0-R-16-ES | Mountain whitefish | YOY | | | | | | | 38 | | **38** |
| | 231.0-R-16-ES | Redside shiner | All | | | | | | | 1 | | **1** |
| | 231.0-R-16-ES | Sucker spp. | Adult | | | | | | | 49 | | **49** |
| | 231.0-R-16-ES | Sucker spp. | Immature | | | | | | | 1 | | **1** |
| | **Site 231.0-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **1619** | **0** | **1619** |

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

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

Continued…

Table B6 Continued.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 231.0-L-16-ES | Burbot | Adult | | | | | 14 | | | | **14** |
| | 231.0-L-16-ES | Bull trout | Adult | | | | | 38 | | | | **38** |
| | 231.0-L-16-ES | Bull trout | Immature | | | | | 10 | | | | **10** |
| | 231.0-L-16-ES | Sculpin spp. | All | | | | | 353 | | | | **353** |
| | 231.0-L-16-ES | Largescale sucker | Adult | | | | | 45 | | | | **45** |
| | 231.0-L-16-ES | Kokanee | Adult | | | | | 1046 | | | | **1046** |
| | 231.0-L-16-ES | Lake whitefish | Adult | | | | | 2 | | | | **2** |
| | 231.0-L-16-ES | Mountain whitefish | Adult | | | | | 217 | | | | **217** |
| | 231.0-L-16-ES | Mountain whitefish | Immature | | | | | 179 | | | | **179** |
| | 231.0-L-16-ES | Mountain whitefish | YOY | | | | | 1 | | | | **1** |
| | 231.0-L-16-ES | Northern pikeminnow | Adult | | | | | 3 | | | | **3** |
| | 231.0-L-16-ES | Rainbow trout | Adult | | | | | 9 | | | | **9** |
| | 231.0-L-16-ES | Rainbow trout | Immature | | | | | 43 | | | | **43** |
| | 231.0-L-16-ES | Redside shiner | All | | | | | 5 | | | | **5** |
| | 231.0-L-16-ES | Sucker spp. | Adult | | | | | 38 | | | | **38** |
| | 231.0-L-16-ES | Sucker spp. | Immature | | | | | 2 | | | | **2** |
| | 231.0-L-16-ES | Yellow perch | All | | | | | 1 | | | | **1** |
| | **Site 231.0-L-16-ES Total** | | | **0** | **0** | **0** | **0** | **2006** | **0** | **0** | **0** | **2006** |
| | 229.7-R-16-ES | Burbot | Adult | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Bull trout | Adult | | | | | | | 60 | | **60** |
| | 229.7-R-16-ES | Bull trout | Immature | | | | | | | 5 | | **5** |
| | 229.7-R-16-ES | Sculpin spp. | All | | | | | | | 120 | | **120** |
| | 229.7-R-16-ES | Largescale sucker | Adult | | | | | | | 113 | | **113** |
| | 229.7-R-16-ES | Brook trout | Adult | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Kokanee | Adult | | | | | | | 2190 | | **2190** |
| | 229.7-R-16-ES | Kokanee | Immature | | | | | | | 57 | | **57** |
| | 229.7-R-16-ES | Lake whitefish | Adult | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Mountain whitefish | Adult | | | | | | | 296 | | **296** |
| | 229.7-R-16-ES | Mountain whitefish | Immature | | | | | | | 367 | | **367** |
| | 229.7-R-16-ES | Mountain whitefish | YOY | | | | | | | 147 | | **147** |
| | 229.7-R-16-ES | Northern pikeminnow | Adult | | | | | | | 5 | | **5** |
| | 229.7-R-16-ES | Rainbow trout | Adult | | | | | | | 3 | | **3** |
| | 229.7-R-16-ES | Rainbow trout | Immature | | | | | | | 1 | | **1** |
| | 229.7-R-16-ES | Redside shiner | All | | | | | | | 5 | | **5** |
| | 229.7-R-16-ES | Sucker spp. | Adult | | | | | | | 111 | | **111** |
| | 229.7-R-16-ES | Sucker spp. | Immature | | | | | | | 2 | | **2** |
| | **Site 229.7-R-16-ES Total** | | | **0** | **0** | **0** | **0** | **0** | **0** | **3485** | **0** | **3485** |
| | 229.2-L-16-ES | Burbot | Adult | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Bull trout | Adult | 7 | | | | | | | | **7** |
| | 229.2-L-16-ES | Bull trout | Immature | 4 | | | | | | | | **4** |
| | 229.2-L-16-ES | Sculpin spp. | All | 329 | | | | | | | | **329** |
| | 229.2-L-16-ES | Largescale sucker | Adult | 31 | | | | | | | | **31** |
| | 229.2-L-16-ES | Brook trout | Immature | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Kokanee | Adult | 536 | | | | | | | | **536** |
| | 229.2-L-16-ES | Kokanee | Immature | 54 | | | | | | | | **54** |
| | 229.2-L-16-ES | Lake whitefish | Adult | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Mountain whitefish | Adult | 42 | | | | | | | | **42** |
| | 229.2-L-16-ES | Mountain whitefish | Immature | 30 | | | | | | | | **30** |
| | 229.2-L-16-ES | Mountain whitefish | YOY | 24 | | | | | | | | **24** |
| | 229.2-L-16-ES | Northern pikeminnow | Adult | 6 | | | | | | | | **6** |
| | 229.2-L-16-ES | Peamouth | Adult | 1 | | | | | | | | **1** |
| | 229.2-L-16-ES | Rainbow trout | Adult | 3 | | | | | | | | **3** |
| | 229.2-L-16-ES | Rainbow trout | Immature | 43 | | | | | | | | **43** |
| | 229.2-L-16-ES | Redside shiner | All | 188 | | | | | | | | **188** |
| | 229.2-L-16-ES | Sucker spp. | Adult | 22 | | | | | | | | **22** |
| | **Site 229.2-L-16-ES Total** | | | **1323** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1323** |

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

Continued…

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

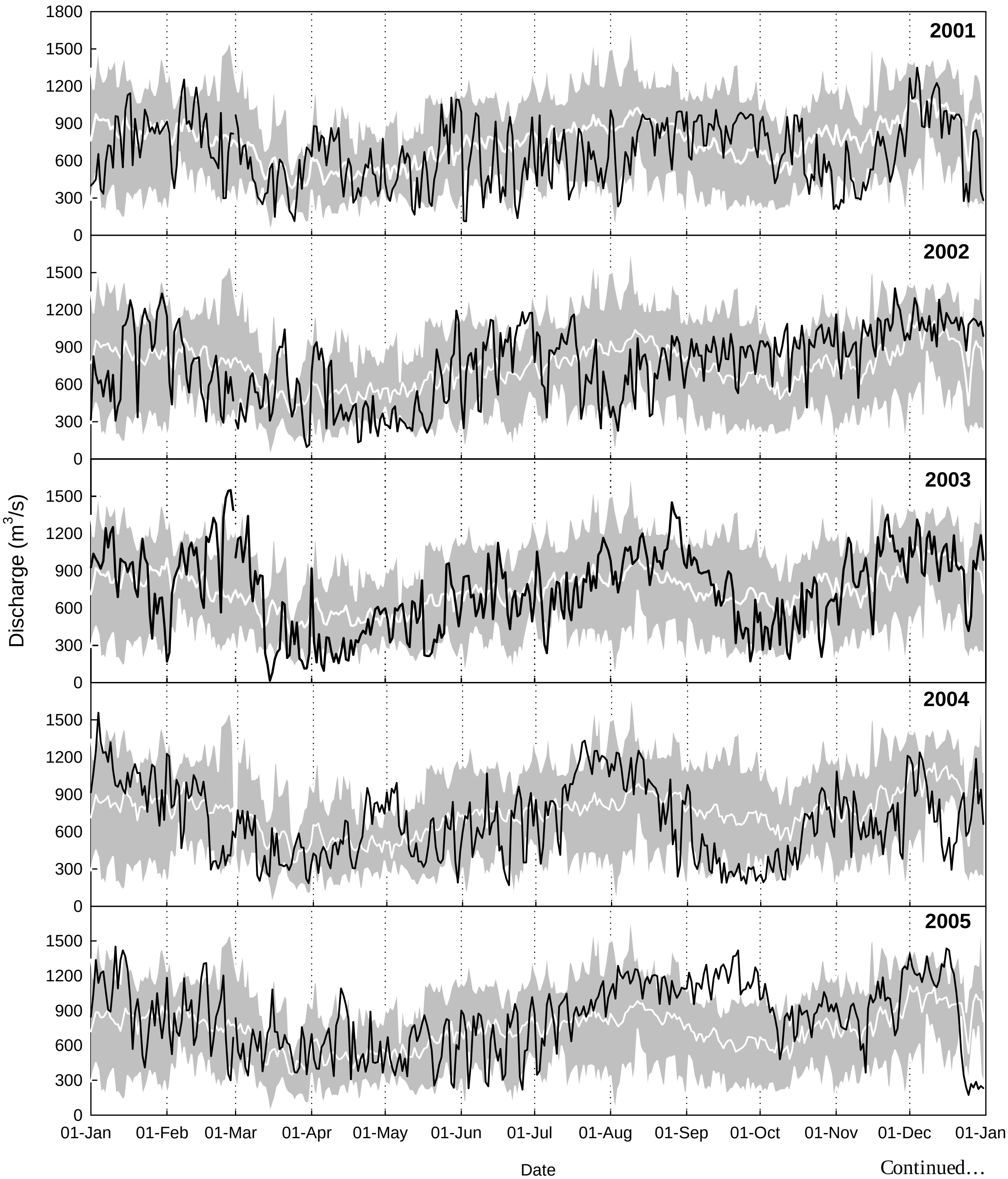
Table B6 Concluded.

| Reach | Site[a] | Species | Size Class | Bank Habitat Type[b] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A1 | A3 | A4 | A5 | A6 | A1+A2 | D1 | D2 | |
| | 228.5-L-16-ES | Burbot | Adult | | | | | 1 | | 1 | | **2** |
| | 228.5-L-16-ES | Bull trout | Adult | | | | | 19 | | 18 | | **37** |
| | 228.5-L-16-ES | Bull trout | Immature | | | | | 5 | | 1 | | **6** |
| | 228.5-L-16-ES | Sculpin spp. | All | | | | | 60 | | 145 | | **205** |
| | 228.5-L-16-ES | Largescale sucker | Adult | | | | | 7 | | 21 | | **28** |
| | 228.5-L-16-ES | Largescale sucker | Immature | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Brook trout | Immature | | | | | 1 | | | | **1** |
| | 228.5-L-16-ES | Kokanee | Adult | | | | | 93 | | 132 | | **225** |
| | 228.5-L-16-ES | Kokanee | Immature | | | | | 22 | | 31 | | **53** |
| | 228.5-L-16-ES | Lake whitefish | Adult | | | | | | | 1 | | **1** |
| | 228.5-L-16-ES | Mountain whitefish | Adult | | | | | 24 | | 88 | | **112** |
| | 228.5-L-16-ES | Mountain whitefish | Immature | | | | | 8 | | 96 | | **104** |
| | 228.5-L-16-ES | Mountain whitefish | YOY | | | | | | | 161 | | **161** |
| | 228.5-L-16-ES | Northern pikeminnow | Adult | | | | | 6 | | 12 | | **18** |
| | 228.5-L-16-ES | Northern pikeminnow | Immature | | | | | | | 1 | | **1** |
| | 228.5-L-16-ES | Rainbow trout | Adult | | | | | 4 | | 2 | | **6** |
| | 228.5-L-16-ES | Rainbow trout | Immature | | | | | 24 | | 12 | | **36** |
| | 228.5-L-16-ES | Redside shiner | All | | | | | 15 | | 7 | | **22** |
| | 228.5-L-16-ES | Sucker spp. | Adult | | | | | 5 | | 23 | | **28** |
| | 228.5-L-16-ES | Yellow perch | Immature | | | | | | | 1 | | **1** |
| | **Site 228.5-L-16-ES Total** | | | **0** | **0** | **0** | **0** | **295** | **0** | **753** | **0** | **1048** |
| | 227.2-R-16-ES | Burbot | Adult | | | | 1 | | | | | **1** |
| | 227.2-R-16-ES | Bull trout | Adult | | | | 10 | | | | | **10** |
| | 227.2-R-16-ES | Bull trout | Immature | | | | 3 | | | | | **3** |
| | 227.2-R-16-ES | Sculpin spp. | All | | | | 66 | | | | | **66** |
| | 227.2-R-16-ES | Largescale sucker | Adult | | | | 3 | | | | | **3** |
| | 227.2-R-16-ES | Kokanee | Adult | | | | 37 | | | | | **37** |
| | 227.2-R-16-ES | Kokanee | Immature | | | | 11 | | | | | **11** |
| | 227.2-R-16-ES | Lake whitefish | Adult | | | | 1 | | | | | **1** |
| | 227.2-R-16-ES | Mountain whitefish | Adult | | | | 35 | | | | | **35** |
| | 227.2-R-16-ES | Mountain whitefish | Immature | | | | 27 | | | | | **27** |
| | 227.2-R-16-ES | Mountain whitefish | YOY | | | | 14 | | | | | **14** |
| | 227.2-R-16-ES | Northern pikeminnow | Adult | | | | 4 | | | | | **4** |
| | 227.2-R-16-ES | Rainbow trout | Adult | | | | 3 | | | | | **3** |
| | 227.2-R-16-ES | Rainbow trout | Immature | | | | 13 | | | | | **13** |
| | 227.2-R-16-ES | Redside shiner | All | | | | 1 | | | | | **1** |
| | 227.2-R-16-ES | Sucker spp. | Adult | | | | 11 | | | | | **11** |
| | **Site 227.2-R-16-ES Total** | | | **0** | **0** | **0** | **240** | **0** | **0** | **0** | **0** | **240** |
| **Reach 3 Total** | | | | **2517** | **0** | **0** | **281** | **2301** | **0** | **5857** | **0** | **10 956** |
| **Grand Total** | | | | **5403** | **145** | **365** | **1399** | **2876** | **1166** | **6611** | **452** | **18 417** |

[a] See Appendix A, Figures A1 and A2 for sample site locations.
[b] See Appendix B, Table B1 for bank habitat type descriptions.

# APPENDIX C

## Discharge, Temperature, and Water Elevation Data




Continued…

Figure C1 Mean daily discharge ($m^3/s$) for the Columbia River at Revelstoke Dam, 2001 to 2011. The shaded area represents minimum and maximum mean daily discharge values recorded at Revelstoke Dam during other study years (between 2001 and 2011). The white line represents average mean daily discharge values over the same time period.

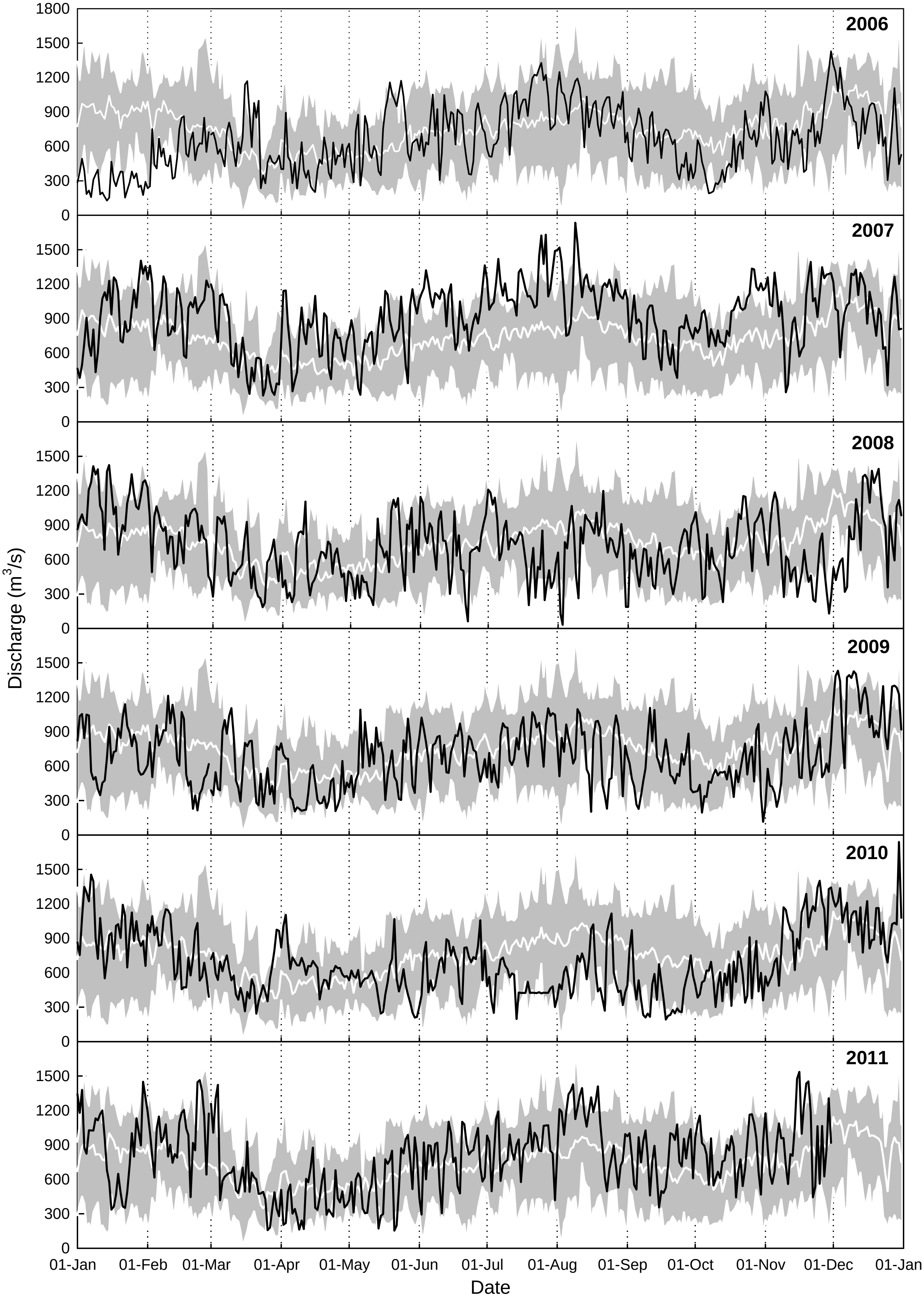



Figure C1 Concluded.

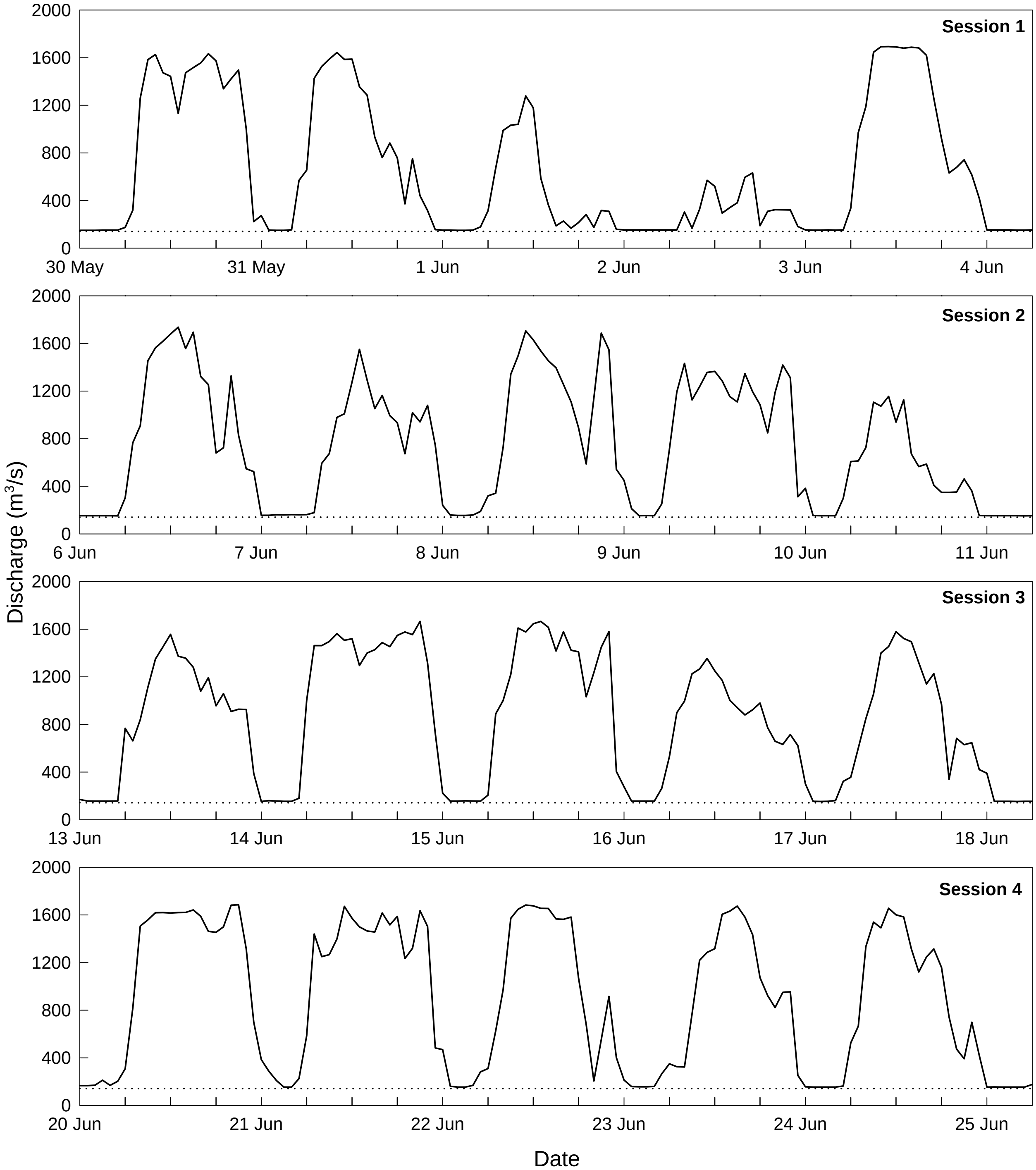



Figure C2 Mean hourly discharge ($m^3/s$) for the Columbia River at Revelstoke Dam by sample session, 30 May to 25 June 2011. The dotted line denotes the 142 $m^3/s$ minimum flow release.

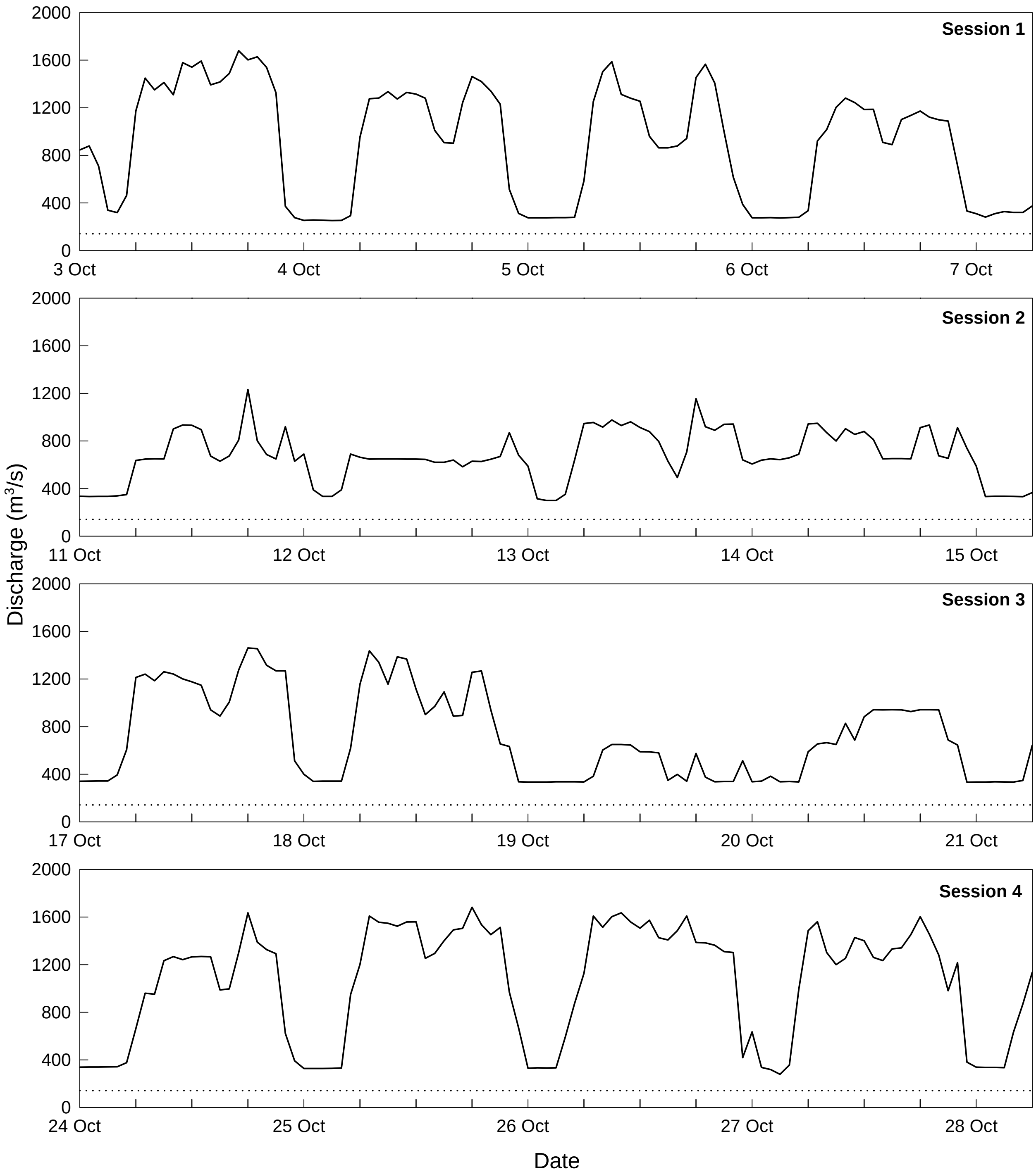
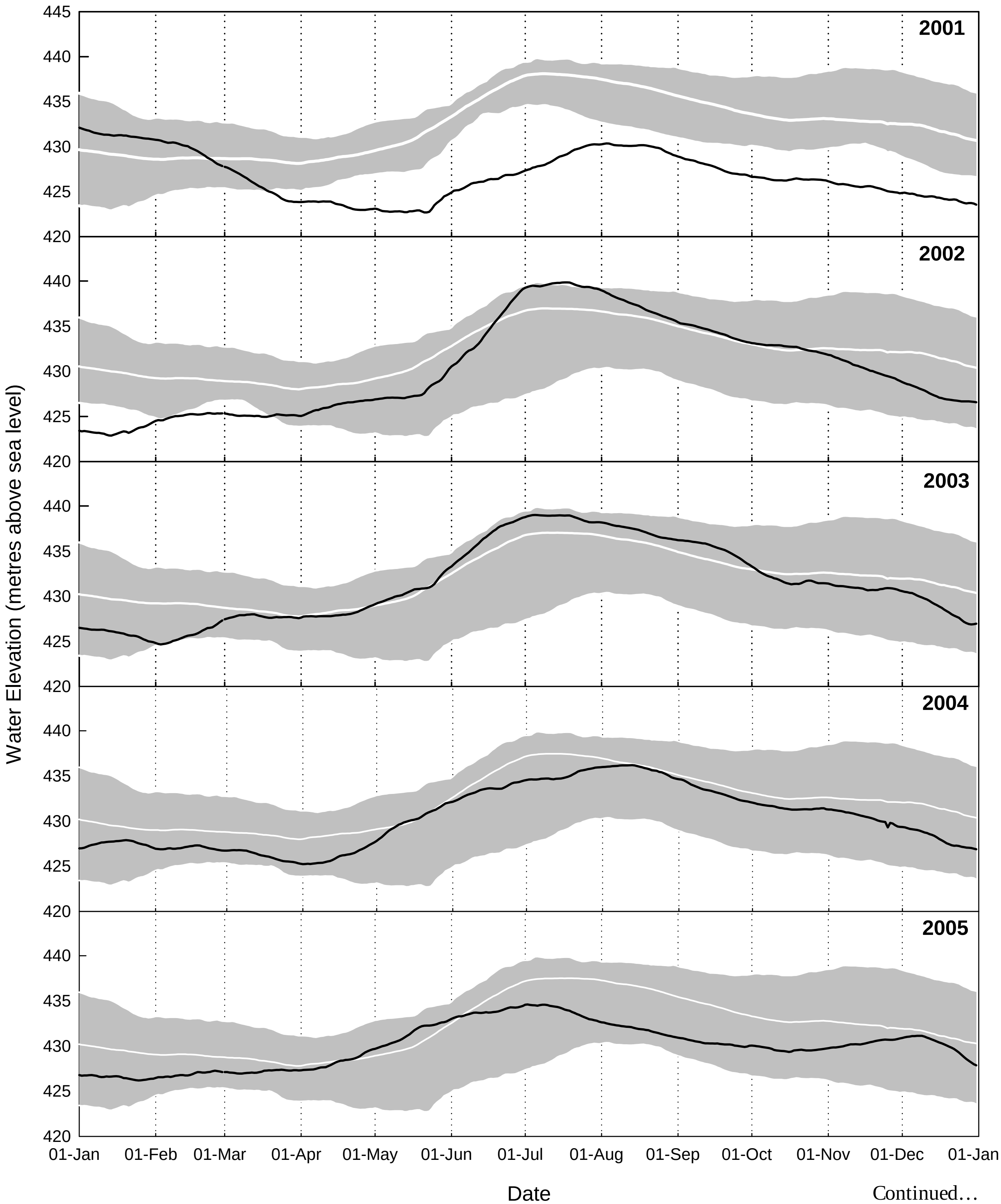



Figure C3 Mean hourly discharge ($m^3/s$) for the Columbia River at Revelstoke Dam by sample session, 3 to 28 October 2011. The dotted line denotes the 142 $m^3/s$ minimum flow release.




Continued…

Figure C4 Mean daily water level elevation (in metres above sea level) for the Columbia River at Nakusp, 2001 to 2011. The shaded area represents minimum and maximum mean daily water elevations recorded at Nakusp during other study years (between 2001 and 2011). The white line represents average mean daily water elevation over the same time period.

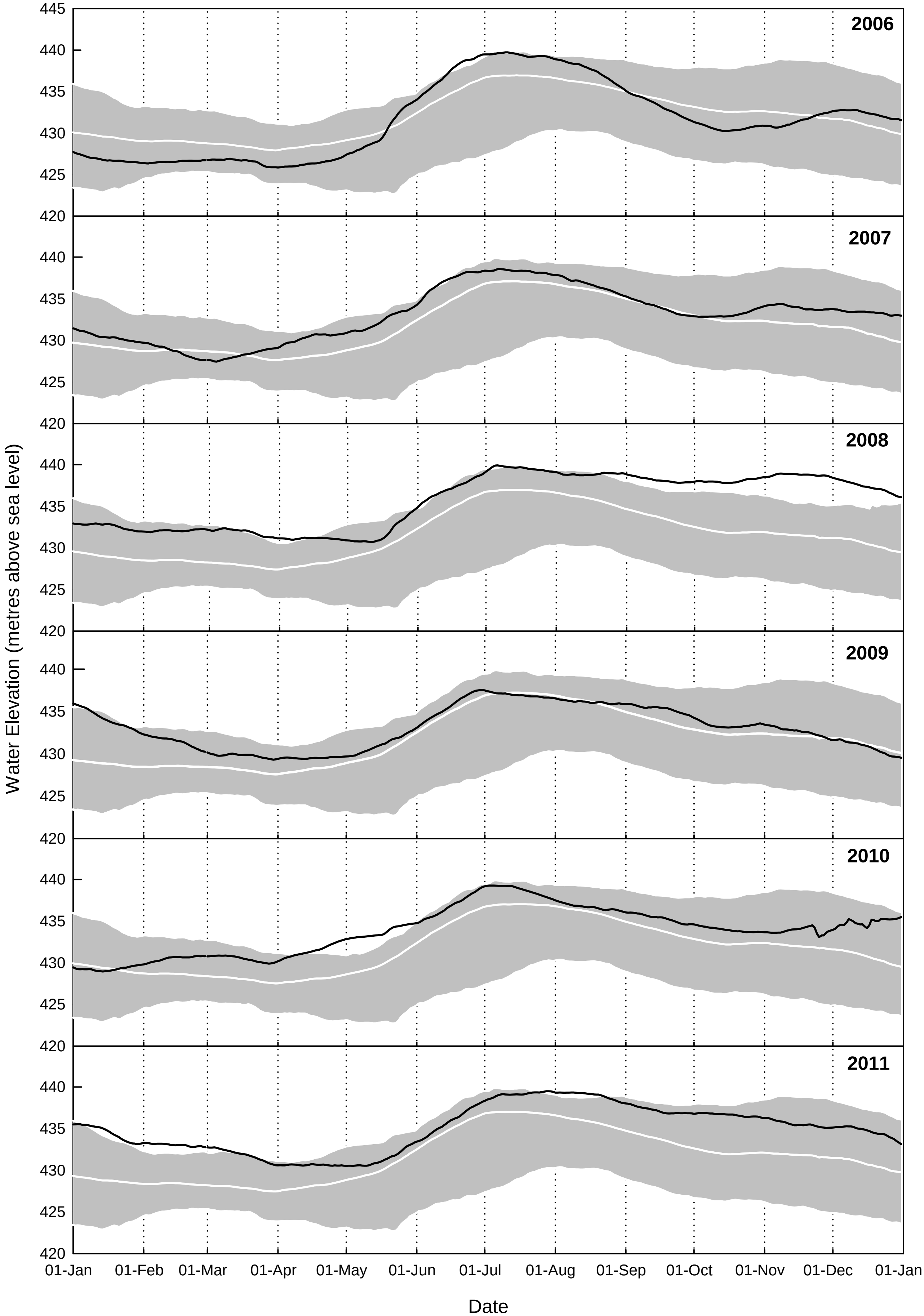



Figure C4 Concluded.

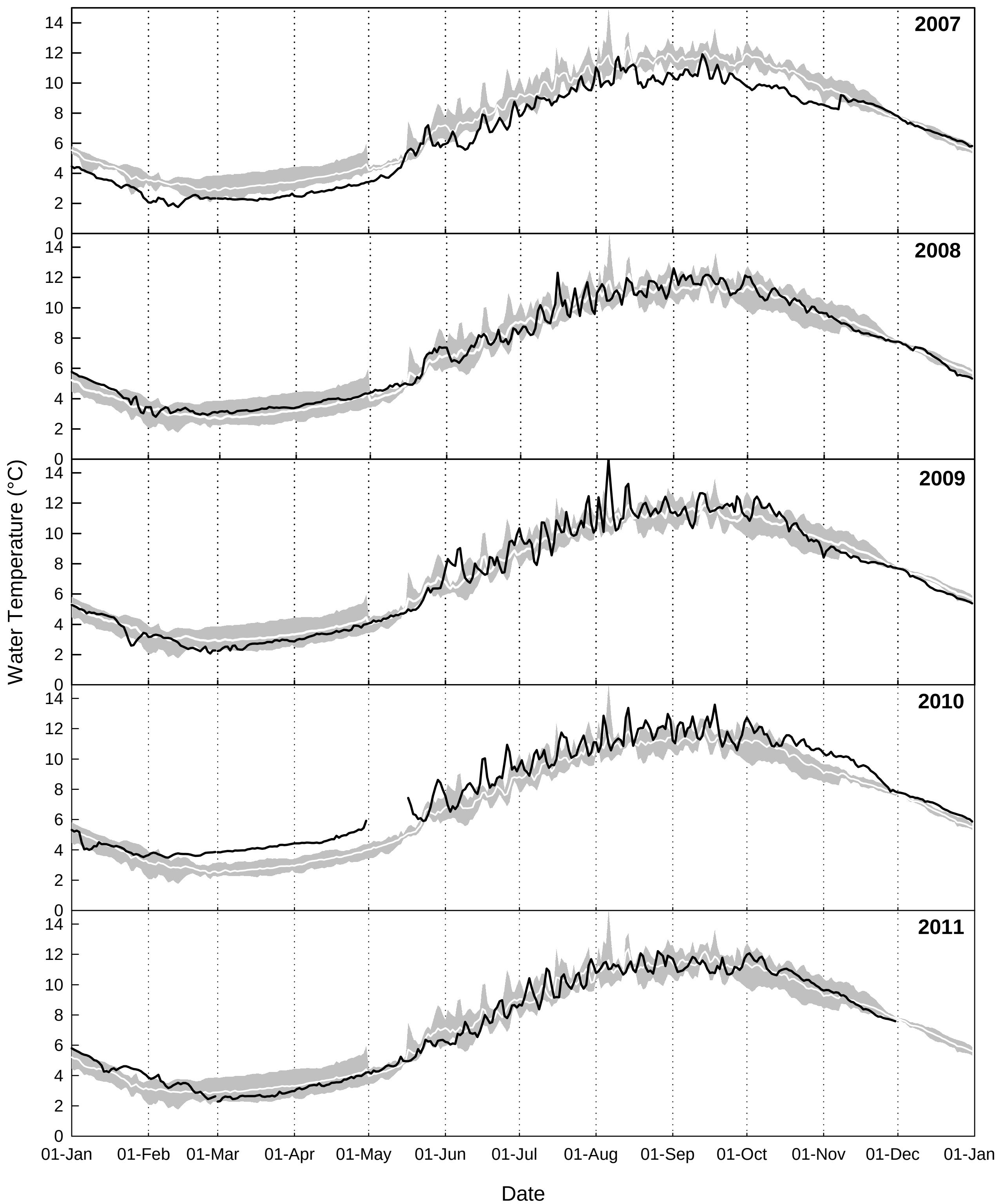



Figure C5 Mean daily water temperature (°C) for the Columbia River at Revelstoke Dam (Station Tailrace7), 2007 to 2011. The shaded area represents minimum and maximum mean daily water temperatures recorded at Revelstoke Dam during other study years (between 2007 and 2011). The white line represents average mean daily water elevation over the same time period.

# APPENDIX D

## Catch and Effort Data Summaries

Table D1 Number of fish caught and observed during boat electroshocking surveys and their frequency of occurrence in sampled sections of the Middle Columbia River, 2001 to 2011.

| Species | 2001[a] | | 2002[a] | | 2003[a] | | 2004[a] | | 2005[a] | | 2006[a] | | 2007[a] | | 2008[a] | | 2009[a] | | 2010[a] | | 2011 - Spring[a] | | 2011 - Fall[a] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] | *n* [b] | %[c] |
| **Sportfish** | | | | | | | | | | | | | | | | | | | | | | | | |
| Brook trout | | | | | 1 | <1 | 1 | <1 | | | | | 1 | <1 | | | | | 1 | <1 | 5 | <1 | 3 | <1 |
| Bull trout | 311 | 3 | 300 | 6 | 416 | 12 | 349 | 9 | 440 | 7 | 358 | 4 | 882 | 3 | 780 | 7 | 570 | 3 | 532 | 2 | 675 | 7 | 659 | 4 |
| Burbot | | | 7 | <1 | 1 | <1 | 6 | <1 | 14 | <1 | 14 | <1 | 32 | <1 | 61 | <1 | 9 | <1 | 22 | <1 | 30 | <1 | 61 | <1 |
| Cutthroat trout | | | | | | | | | | | | | 1 | <1 | | | | | 1 | <1 | | | | |
| Kokanee | 5326 | 45 | 41 | <1 | 263 | 8 | 107 | 3 | 1861 | 30 | 5874 | 62 | 20 602 | 70 | 1890 | 17 | 16 425 | 79 | 18 304 | 68 | 26 | <1 | 8173 | 53 |
| Lake whitefish | 5 | <1 | 34 | <1 | 53 | 2 | 63 | 2 | 275 | 4 | 60 | <1 | 12 | <1 | 42 | <1 | 17 | <1 | 983 | 4 | 1 | <1 | 230 | 1 |
| Mountain whitefish | 6228 | 52 | 4234 | 92 | 2706 | 79 | 3369 | 86 | 3509 | 57 | 3133 | 33 | 7861 | 27 | 8219 | 72 | 3846 | 18 | 6720 | 25 | 8709 | 90 | 6014 | 39 |
| Pygmy whitefish | | | 1 | <1 | | | | | | | | | | | | | | | | | | | | |
| Rainbow trout | 5 | <1 | | | 5 | <1 | 14 | <1 | 11 | <1 | 15 | <1 | 157 | <1 | 305 | 3 | 49 | <1 | 111 | <1 | 203 | 2 | 217 | 1 |
| White sturgeon | 1 | <1 | | | | | | | | | | | | | | | 1 | <1 | | | | | | |
| Yellow perch | | | | | | | 8 | <1 | 2 | <1 | 3 | <1 | 9 | <1 | 134 | 1 | 1 | <1 | 104 | <1 | 1 | <1 | 2 | <1 |
| **Sportfish Subtotal** | **11 876** | **100** | **4617** | **100** | **3445** | **100** | **3917** | **100** | **6112** | **100** | **9457** | **100** | **29 557** | **100** | **11 431** | **100** | **20 918** | **100** | **26 778** | **100** | **9650** | **100** | **15 359** | **100** |
| **Non-sportfish** | | | | | | | | | | | | | | | | | | | | | | | | |
| Northern pikeminnow | | | | | 1 | <1 | 2 | <1 | 3 | <1 | 2 | <1 | 35 | 1 | 78 | 1 | 62 | 4 | 52 | 2 | 5 | <1 | 39 | 1 |
| Peamouth | | | | | | | | | | | 1 | <1 | 1 | <1 | | | 1 | <1 | | | 30 | <1 | 1 | <1 |
| Redside shiner | | | 11 | 6 | 1 | <1 | 239 | 26 | 246 | 29 | 97 | 8 | 553 | 18 | 2050 | 26 | 146 | 10 | 976 | 33 | 170 | 5 | 237 | 8 |
| Sculpin spp.[d] | 1 | <1 | 7 | 4 | 4 | 2 | 268 | 30 | 179 | 21 | 849 | 67 | 1387 | 45 | 4801 | 62 | 469 | 32 | 772 | 26 | 1883 | 57 | 1807 | 59 |
| Sucker spp.[d] | 419 | 100 | 162 | 90 | 206 | 97 | 393 | 44 | 426 | 50 | 318 | 25 | 1088 | 36 | 845 | 11 | 796 | 54 | 1168 | 39 | 1232 | 37 | 974 | 32 |
| **Non-sportfish Subtotal** | **420** | **100** | **180** | **100** | **212** | **100** | **902** | **100** | **854** | **100** | **1267** | **100** | **3064** | **100** | **7774** | **100** | **1474** | **100** | **2968** | **100** | **3320** | **100** | **3058** | **100** |
| **All species** | **12 296** | | **4797** | | **3657** | | **4819** | | **6966** | | **10 724** | | **32 621** | | **19 205** | | **22 392** | | **29 746** | | **12 970** | | **18 417** | |

[a] From 2001 to 2006, the study area included all of Reach 4 and the Big Eddy section of Reach 3; from 2007 to 2010 the study area included all of Reaches 4 and 3.

[b] Includes fish observed and identified to species.

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

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

Table D2 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) during the spring season in the Middle Columbia River, 30 May to 24 June 2011.

| Reach | Section | Session | Site | Date | Time Sampled (s) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/hr) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brook trout | | Bull trout | | Burbot | | Kokanee | | Lake whitefish | | Mountain whitefish | | Rainbow trout | | Yellow perch | | All Species | |
| | | | | | | | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE |
| 4 | Upper | | | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 232.6-R | 01-Jun-11 | 762 | 0.80 | 0 | 0.00 | 9 | 53.15 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 143 | 844.49 | 0 | 0.00 | 0 | 0.00 | **152** | **897.64** |
| | | | 233.1-L | 02-Jun-11 | 1054 | 1.41 | 1 | 2.42 | 11 | 26.65 | 5 | 12.11 | 2 | 4.84 | 0 | 0.00 | 157 | 380.31 | 2 | 4.84 | 0 | 0.00 | **178** | **431.18** |
| | | | 234.4-R | 01-Jun-11 | 1247 | 1.74 | 0 | 0.00 | 62 | 102.87 | 1 | 1.66 | 0 | 0.00 | 0 | 0.00 | 260 | 431.38 | 1 | 1.66 | 0 | 0.00 | **324** | **537.57** |
| | | | 234.5-L | 01-Jun-11 | 1440 | 1.65 | 0 | 0.00 | 22 | 33.33 | 2 | 3.03 | 8 | 12.12 | 0 | 0.00 | 202 | 306.06 | 1 | 1.52 | 0 | 0.00 | **235** | **356.06** |
| | | | 236.1-L | 01-Jun-11 | 1031 | 1.41 | 0 | 0.00 | 7 | 17.33 | 0 | 0.00 | 1 | 2.48 | 0 | 0.00 | 37 | 91.63 | 0 | 0.00 | 0 | 0.00 | **45** | **111.44** |
| | | | 236.1-R | 31-May-11 | 1392 | 1.73 | 0 | 0.00 | 30 | 44.85 | 1 | 1.49 | 0 | 0.00 | 0 | 0.00 | 108 | 161.45 | 2 | 2.99 | 0 | 0.00 | **141** | **210.78** |
| | | | 236.4-L | 30-May-11 | 290 | 0.58 | 0 | 0.00 | 5 | 107.02 | 1 | 21.40 | 0 | 0.00 | 0 | 0.00 | 15 | 321.05 | 0 | 0.00 | 0 | 0.00 | **21** | **449.46** |
| | | | 236.4-R | 30-May-11 | 380 | 0.59 | 0 | 0.00 | 7 | 112.40 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 63 | 1011.60 | 0 | 0.00 | 0 | 0.00 | **70** | **1124.00** |
| | | **Session Summary** | | | **950** | **9.9** | **1** | **0.38** | **153** | **58.54** | **10** | **3.83** | **11** | **4.21** | **0** | **0.00** | **985** | **376.85** | **6** | **2.30** | **0** | **0.00** | **1166** | **446.10** |
| | | 2 | 232.6-R | 08-Jun-11 | 727 | 0.80 | 0 | 0.00 | 3 | 18.57 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 195 | 1207.02 | 0 | 0.00 | 0 | 0.00 | **198** | **1225.58** |
| | | | 233.1-L | 08-Jun-11 | 908 | 1.41 | 0 | 0.00 | 10 | 28.12 | 1 | 2.81 | 0 | 0.00 | 0 | 0.00 | 92 | 258.69 | 7 | 19.68 | 0 | 0.00 | **110** | **309.31** |
| | | | 234.4-R | 08-Jun-11 | 900 | 1.74 | 0 | 0.00 | 9 | 20.69 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 52 | 119.54 | 1 | 2.30 | 0 | 0.00 | **62** | **142.53** |
| | | | 234.5-L | 09-Jun-11 | 1221 | 1.65 | 0 | 0.00 | 13 | 23.23 | 1 | 1.79 | 0 | 0.00 | 0 | 0.00 | 144 | 257.32 | 2 | 3.57 | 0 | 0.00 | **160** | **285.91** |
| | | | 236.1-L | 08-Jun-11 | 1085 | 1.41 | 0 | 0.00 | 21 | 49.42 | 2 | 4.71 | 0 | 0.00 | 0 | 0.00 | 107 | 251.79 | 0 | 0.00 | 0 | 0.00 | **130** | **305.91** |
| | | | 236.1-R | 07-Jun-11 | 1702 | 1.73 | 0 | 0.00 | 15 | 18.34 | 0 | 0.00 | 7 | 8.56 | 0 | 0.00 | 87 | 106.37 | 1 | 1.22 | 0 | 0.00 | **110** | **134.49** |
| | | | 236.4-L | 06-Jun-11 | 463 | 0.58 | 0 | 0.00 | 9 | 120.65 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 41 | 549.64 | 0 | 0.00 | 0 | 0.00 | **50** | **670.29** |
| | | | 236.4-R | 06-Jun-11 | 489 | 0.59 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 57 | 711.24 | 1 | 12.48 | 0 | 0.00 | **58** | **723.72** |
| | | **Session Summary** | | | **937** | **9.9** | **0** | **0.00** | **80** | **31.02** | **4** | **1.55** | **7** | **2.71** | **0** | **0.00** | **775** | **300.50** | **12** | **4.65** | **0** | **0.00** | **878** | **340.44** |
| | | 3 | 232.6-R | 15-Jun-11 | 742 | 0.80 | 0 | 0.00 | 0 | 0.00 | 1 | 6.06 | 0 | 0.00 | 0 | 0.00 | 236 | 1431.27 | 0 | 0.00 | 0 | 0.00 | **237** | **1437.33** |
| | | | 233.1-L | 15-Jun-11 | 855 | 1.41 | 0 | 0.00 | 5 | 14.93 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 70 | 209.03 | 15 | 44.79 | 0 | 0.00 | **90** | **268.76** |
| | | | 234.4-R | 15-Jun-11 | 859 | 1.74 | 0 | 0.00 | 6 | 14.45 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 106 | 255.31 | 2 | 4.82 | 0 | 0.00 | **114** | **274.58** |
| | | | 234.5-L | 16-Jun-11 | 1304 | 1.65 | 0 | 0.00 | 12 | 20.08 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 103 | 172.34 | 0 | 0.00 | 0 | 0.00 | **115** | **192.41** |
| | | | 236.1-L | 15-Jun-11 | 1251 | 1.41 | 0 | 0.00 | 28 | 57.15 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 155 | 316.34 | 0 | 0.00 | 0 | 0.00 | **183** | **373.49** |
| | | | 236.1-R | 14-Jun-11 | 1521 | 1.73 | 0 | 0.00 | 35 | 47.88 | 1 | 1.37 | 0 | 0.00 | 0 | 0.00 | 188 | 257.21 | 0 | 0.00 | 0 | 0.00 | **224** | **306.46** |
| | | | 236.4-L | 13-Jun-11 | 676 | 0.58 | 0 | 0.00 | 4 | 36.73 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 35 | 321.36 | 0 | 0.00 | 0 | 0.00 | **39** | **358.09** |
| | | | 236.4-R | 13-Jun-11 | 412 | 0.59 | 0 | 0.00 | 4 | 59.24 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 71 | 1051.51 | 0 | 0.00 | 0 | 0.00 | **75** | **1110.75** |
| | | **Session Summary** | | | **953** | **9.9** | **0** | **0.00** | **94** | **35.85** | **2** | **0.76** | **0** | **0.00** | **0** | **0.00** | **964** | **367.66** | **17** | **6.48** | **0** | **0.00** | **1077** | **410.75** |
| | | 4 | 232.6-R | 22-Jun-11 | 736 | 0.80 | 0 | 0.00 | 6 | 36.68 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 268 | 1638.59 | 0 | 0.00 | 0 | 0.00 | **274** | **1675.27** |
| | | | 233.1-L | 23-Jun-11 | 996 | 1.41 | 0 | 0.00 | 16 | 41.02 | 1 | 2.56 | 0 | 0.00 | 0 | 0.00 | 138 | 353.76 | 2 | 5.13 | 0 | 0.00 | **157** | **402.46** |
| | | | 234.4-R | 22-Jun-11 | 1210 | 1.74 | 0 | 0.00 | 6 | 10.26 | 0 | 0.00 | 0 | 0.00 | 1 | 1.71 | 175 | 299.23 | 1 | 1.71 | 0 | 0.00 | **183** | **312.91** |
| | | | 234.5-L | 23-Jun-11 | 1175 | 1.65 | 0 | 0.00 | 21 | 38.99 | 1 | 1.86 | 0 | 0.00 | 0 | 0.00 | 228 | 423.37 | 0 | 0.00 | 0 | 0.00 | **250** | **464.22** |
| | | | 236.1-L | 21-Jun-11 | 1087 | 1.41 | 0 | 0.00 | 24 | 56.37 | 0 | 0.00 | 1 | 2.35 | 0 | 0.00 | 111 | 260.72 | 3 | 7.05 | 0 | 0.00 | **139** | **326.49** |
| | | | 236.1-R | 21-Jun-11 | 1203 | 1.73 | 0 | 0.00 | 9 | 15.57 | 0 | 0.00 | 2 | 3.46 | 0 | 0.00 | 93 | 160.87 | 0 | 0.00 | 0 | 0.00 | **104** | **179.90** |
| | | | 236.4-L | 21-Jun-11 | 388 | 0.58 | 0 | 0.00 | 12 | 191.97 | 1 | 16.00 | 0 | 0.00 | 0 | 0.00 | 48 | 767.86 | 0 | 0.00 | 0 | 0.00 | **61** | **975.83** |
| | | | 236.4-R | 20-Jun-11 | 421 | 0.59 | 0 | 0.00 | 12 | 173.92 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 70 | 1014.53 | 0 | 0.00 | 0 | 0.00 | **82** | **1188.45** |
| | | **Session Summary** | | | **902** | **9.9** | **0** | **0.00** | **106** | **42.69** | **3** | **1.21** | **3** | **1.21** | **1** | **0.40** | **1131** | **455.50** | **6** | **2.42** | **0** | **0.00** | **1250** | **503.42** |
| | **Upper Section Total All Samples** | | | | **29927** | **39.64** | **1** | | **433** | | **19** | | **21** | | **1** | | **3855** | | **41** | | **0** | | **4371** | |
| | **Upper Section Average All Samples** | | | | **935** | **1.24** | **0** | **0.10** | **14** | **42.05** | **1** | **1.85** | **1** | **2.04** | **0** | **0.10** | **120** | **374.35** | **1** | **3.98** | **0** | **0.00** | **137** | **555.10** |
| | **Upper Section Standard Error of Mean** | | | | | | **0.03** | **0.08** | **2.19** | **8.30** | **0.18** | **0.88** | **0.33** | **0.48** | **0.03** | **0.05** | **12.29** | **72.38** | **0.51** | **1.52** | **0.00** | **0.00** | **13.41** | **74.36** |

Table D2 Continued.

| Reach | Section | Session | Site | Date | Time Sampled (s) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/hr) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brook trout | | Bull trout | | Burbot | | Kokanee | | Lake whitefish | | Mountain whitefish | | Rainbow trout | | Yellow perch | | All Species | |
| | | | | | | | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE |
| 3 | Eddy | | | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 231.3-R | 31-May-11 | 720 | 0.90 | 0 | *0.00* | 11 | *61.11* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 248 | *1377.78* | 0 | *0.00* | 0 | *0.00* | **259** | ***1438.89*** |
| | | **Session Summary** | | | **720** | **0.9** | **0** | ***0.00*** | **11** | ***61.11*** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **248** | ***1377.78*** | **0** | ***0.00*** | **0** | ***0.00*** | **259** | ***1438.89*** |
| | | 2 | 231.3-R | 07-Jun-11 | 886 | 0.90 | 0 | *0.00* | 9 | *40.63* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 225 | *1015.80* | 0 | *0.00* | 1 | *4.51* | **235** | ***1060.95*** |
| | | **Session Summary** | | | **886** | **0.9** | **0** | ***0.00*** | **9** | ***40.63*** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **225** | ***1015.80*** | **0** | ***0.00*** | **1** | ***4.51*** | **235** | ***1060.95*** |
| | | 3 | 231.3-R | 14-Jun-11 | 951 | 0.90 | 0 | *0.00* | 12 | *50.47* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 178 | *748.69* | 1 | *4.21* | 0 | *0.00* | **191** | ***803.36*** |
| | | **Session Summary** | | | **951** | **0.9** | **0** | ***0.00*** | **12** | ***50.47*** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **178** | ***748.69*** | **1** | ***4.21*** | **0** | ***0.00*** | **191** | ***803.36*** |
| | | 4 | 231.3-R | 21-Jun-11 | 962 | 0.90 | 0 | *0.00* | 14 | *58.21* | 0 | *0.00* | 1 | *4.16* | 0 | *0.00* | 173 | *719.33* | 3 | *12.47* | 0 | *0.00* | **191** | ***794.18*** |
| | | **Session Summary** | | | **962** | **0.9** | **0** | ***0.00*** | **14** | ***58.21*** | **0** | ***0.00*** | **1** | ***4.16*** | **0** | ***0.00*** | **173** | ***719.33*** | **3** | ***12.47*** | **0** | ***0.00*** | **191** | ***794.18*** |
| | **Eddy Section Total All Samples** | | | | **3519** | **3.60** | **0** | | **46** | | **0** | | **1** | | **0** | | **824** | | **4** | | **1** | | **876** | |
| | **Eddy Section Average All Samples** | | | | **880** | **0.90** | **0** | ***0.00*** | **12** | ***52.29*** | **0** | ***0.00*** | **0** | ***1.14*** | **0** | ***0.00*** | **206** | ***936.63*** | **1** | ***4.55*** | **0** | ***1.14*** | **219** | ***1024.35*** |
| | **Eddy Section Standard Error of Mean** | | | | | | **0.00** | ***0.00*** | **1.04** | ***4.58*** | **0.00** | ***0.00*** | **0.25** | ***1.04*** | **0.00** | ***0.00*** | **18.25** | ***152.78*** | **0.71** | ***2.94*** | **0.25** | ***1.13*** | **16.89** | ***151.38*** |
| 3 | Middle | | | | | | | | | | | | | | | | | | | | | | | |
| | | 1 | 227.2-R | 03-Jun-11 | 247 | 0.52 | 0 | *0.00* | 4 | *112.11* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 21 | *588.60* | 0 | *0.00* | 0 | *0.00* | **25** | ***700.72*** |
| | | | 228.5-L | 03-Jun-11 | 855 | 1.23 | 0 | *0.00* | 2 | *6.85* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 94 | *321.78* | 13 | *44.50* | 0 | *0.00* | **109** | ***373.13*** |
| | | | 229.2-L | 04-Jun-11 | 1445 | 1.10 | 0 | *0.00* | 4 | *9.06* | 0 | *0.00* | 1 | *2.26* | 0 | *0.00* | 45 | *101.92* | 7 | *15.85* | 0 | *0.00* | **57** | ***129.10*** |
| | | | 229.7-R | 02-Jun-11 | 1912 | 2.27 | 0 | *0.00* | 5 | *4.15* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 139 | *115.29* | 0 | *0.00* | 0 | *0.00* | **144** | ***119.44*** |
| | | | 231.0-L | 04-Jun-11 | 1474 | 1.96 | 0 | *0.00* | 9 | *11.21* | 4 | *4.98* | 0 | *0.00* | 0 | *0.00* | 225 | *280.37* | 19 | *23.68* | 0 | *0.00* | **257** | ***320.24*** |
| | | | 231.0-R | 03-Jun-11 | 958 | 0.99 | 0 | *0.00* | 15 | *56.94* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 158 | *599.73* | 0 | *0.00* | 0 | *0.00* | **173** | ***656.67*** |
| | | **Session Summary** | | | **1149** | **8.1** | **0** | ***0.00*** | **39** | ***15.15*** | **4** | ***1.55*** | **1** | ***0.39*** | **0** | ***0.00*** | **682** | ***264.90*** | **39** | ***15.15*** | **0** | ***0.00*** | **765** | ***297.14*** |
| | | 2 | 227.2-R | 10-Jun-11 | 659 | 0.52 | 0 | *0.00* | 4 | *42.02* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 74 | *777.40* | 13 | *136.57* | 0 | *0.00* | **91** | ***955.99*** |
| | | | 228.5-L | 10-Jun-11 | 1321 | 1.23 | 1 | *2.22* | 4 | *8.86* | 0 | *0.00* | 1 | *2.22* | 0 | *0.00* | 68 | *150.66* | 14 | *31.02* | 0 | *0.00* | **88** | ***194.97*** |
| | | | 229.2-L | 11-Jun-11 | 1304 | 1.10 | 1 | *2.51* | 11 | *27.61* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 94 | *235.92* | 13 | *32.63* | 0 | *0.00* | **119** | ***298.66*** |
| | | | 229.7-R | 09-Jun-11 | 1791 | 2.27 | 0 | *0.00* | 14 | *12.40* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 557 | *493.21* | 1 | *0.89* | 0 | *0.00* | **572** | ***506.50*** |
| | | | 231.0-L | 11-Jun-11 | 1309 | 1.66 | 0 | *0.00* | 9 | *14.91* | 1 | *1.66* | 0 | *0.00* | 0 | *0.00* | 159 | *263.42* | 18 | *29.82* | 0 | *0.00* | **187** | ***309.81*** |
| | | | 231.0-R | 10-Jun-11 | 1010 | 0.99 | 0 | *0.00* | 8 | *28.80* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 485 | *1746.17* | 0 | *0.00* | 0 | *0.00* | **493** | ***1774.98*** |
| | | **Session Summary** | | | **1232** | **7.8** | **2** | ***0.75*** | **50** | ***18.80*** | **1** | ***0.38*** | **1** | ***0.38*** | **0** | ***0.00*** | **1437** | ***540.27*** | **59** | ***22.18*** | **0** | ***0.00*** | **1550** | ***582.75*** |
| | | 3 | 227.2-R | 17-Jun-11 | 545 | 0.52 | 0 | *0.00* | 6 | *76.22* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 14 | *177.84* | 2 | *25.41* | 0 | *0.00* | **22** | ***279.46*** |
| | | | 228.5-L | 17-Jun-11 | 1132 | 1.20 | 0 | *0.00* | 13 | *34.45* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 102 | *270.32* | 10 | *26.50* | 0 | *0.00* | **125** | ***331.27*** |
| | | | 229.2-L | 18-Jun-11 | 1246 | 1.10 | 0 | *0.00* | 2 | *5.25* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 52 | *136.58* | 4 | *10.51* | 0 | *0.00* | **58** | ***152.34*** |
| | | | 229.7-R | 16-Jun-11 | 2273 | 2.27 | 0 | *0.00* | 7 | *4.88* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 222 | *154.89* | 0 | *0.00* | 0 | *0.00* | **229** | ***159.78*** |
| | | | 231.0-L | 18-Jun-11 | 1569 | 1.96 | 0 | *0.00* | 17 | *19.90* | 4 | *4.68* | 0 | *0.00* | 0 | *0.00* | 191 | *223.59* | 9 | *10.54* | 0 | *0.00* | **221** | ***258.71*** |
| | | | 231.0-R | 17-Jun-11 | 1113 | 1.04 | 0 | *0.00* | 4 | *12.44* | 1 | *3.11* | 0 | *0.00* | 0 | *0.00* | 288 | *895.71* | 0 | *0.00* | 0 | *0.00* | **293** | ***911.26*** |
| | | **Session Summary** | | | **1313** | **8.1** | **0** | ***0.00*** | **49** | ***16.61*** | **5** | ***1.69*** | **0** | ***0.00*** | **0** | ***0.00*** | **869** | ***294.52*** | **25** | ***8.47*** | **0** | ***0.00*** | **948** | ***321.29*** |
| | | 4 | 227.2-R | 24-Jun-11 | 652 | 0.52 | 0 | *0.00* | 2 | *21.24* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 27 | *286.69* | 1 | *10.62* | 0 | *0.00* | **30** | ***318.55*** |
| | | | 228.5-L | 24-Jun-11 | 1354 | 1.23 | 0 | *0.00* | 7 | *15.13* | 1 | *2.16* | 2 | *4.32* | 0 | *0.00* | 145 | *313.43* | 19 | *41.07* | 0 | *0.00* | **174** | ***376.12*** |
| | | | 229.2-L | 25-Jun-11 | 1554 | 1.10 | 1 | *2.11* | 6 | *12.64* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 66 | *139.00* | 0 | *0.00* | 0 | *0.00* | **73** | ***153.74*** |
| | | | 229.7-R | 23-Jun-11 | 2106 | 2.27 | 0 | *0.00* | 18 | *13.55* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 473 | *356.19* | 0 | *0.00* | 0 | *0.00* | **491** | ***369.74*** |
| | | | 231.0-L | 25-Jun-11 | 2020 | 1.96 | 1 | *0.91* | 17 | *15.46* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 192 | *174.58* | 15 | *13.64* | 0 | *0.00* | **225** | ***204.59*** |
| | | | 231.0-R | 24-Jun-11 | 1208 | 1.14 | 0 | *0.00* | 8 | *20.91* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 139 | *363.37* | 0 | *0.00* | 0 | *0.00* | **147** | ***384.28*** |
| | | **Session Summary** | | | **1482** | **8.2** | **2** | ***0.59*** | **58** | ***17.14*** | **1** | ***0.30*** | **2** | ***0.59*** | **0** | ***0.00*** | **1042** | ***307.86*** | **35** | ***10.34*** | **0** | ***0.00*** | **1140** | ***336.81*** |
| | **Middle Section Total All Samples** | | | | **31057** | **32.15** | **4** | | **196** | | **11** | | **4** | | **0** | | **4030** | | **158** | | **0** | | **4403** | |
| | **Middle Section Average All Samples** | | | | **1294** | **1.34** | **0** | ***0.35*** | **8** | ***16.96*** | **0** | ***0.95*** | **0** | ***0.35*** | **0** | ***0.00*** | **168** | ***348.72*** | **7** | ***13.67*** | **0** | ***0.00*** | **183** | ***426.67*** |
| | **Middle Section Standard Error of Mean** | | | | | | **0.08** | ***0.16*** | **1.03** | ***5.18*** | **0.23** | ***0.31*** | **0.10** | ***0.21*** | **0.00** | ***0.00*** | **30.31** | ***73.03*** | **1.47** | ***5.92*** | **0.00** | ***0.00*** | **30.59** | ***74.90*** |
| **All Sections Total All Samples** | | | | | **64503** | **75.39** | **5** | ***0.00*** | **675** | ***0.50*** | **30** | ***0.02*** | **26** | ***0.02*** | **1** | ***0.00*** | **8709** | ***6.45*** | **203** | ***0.15*** | **1** | ***0.00*** | **9650** | ***7.14*** |
| **All Sections Average All Samples** | | | | | | | **0** | ***0.22*** | **11** | ***29.98*** | **1** | ***1.33*** | **0** | ***1.15*** | **0** | ***0.04*** | **145** | ***386.84*** | **3** | ***9.02*** | **0** | ***0.04*** | **161** | ***428.63*** |
| **All Sections Standard Error of Mean** | | | | | | | **0.04** | ***0.08*** | **1.28** | ***5.12*** | **0.13** | ***0.50*** | **0.18** | ***0.28*** | **0.02** | ***0.03*** | **14.14** | ***52.09*** | **0.72** | ***2.66*** | **0.02** | ***0.08*** | **14.49** | ***53.44*** |

Table D3 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) during the spring season in the Middle Columbia River, 30 May to 24 June 2011.

| Reach | Section | Session | Site | Date | Time Sampled (seconds) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/h) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Northern pikeminnow | | Peamouth | | Redside shiner | | Sculpin spp. | | Sucker spp. | | All Species | |
| | | | | | | | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* |
| 4 | Upper | | | | | | | | | | | | | | | | | |
| | | 1 | 232.6-R-16-ES | 01-Jun-11 | 762 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *11.81* | 2 | *11.81* |
| | | | 233.1-L-16-ES | 02-Jun-11 | 1054 | 1.41 | 0 | *0.00* | 0 | *0.00* | 3 | *7.27* | 421 | *1019.82* | 3 | *7.27* | 427 | *1034.36* |
| | | | 234.4-R-16-ES | 01-Jun-11 | 1247 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 231 | *383.26* | 4 | *6.64* | 235 | *389.90* |
| | | | 234.5-L-16-ES | 01-Jun-11 | 1440 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 106 | *160.61* | 4 | *6.06* | 110 | *166.67* |
| | | | 236.1-L-16-ES | 01-Jun-11 | 1031 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 3 | *7.43* | 0 | *0.00* | 3 | *7.43* |
| | | | 236.1-R-16-ES | 31-May-11 | 1392 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 14 | *20.93* | 0 | *0.00* | 14 | *20.93* |
| | | **Session 1 Summary** | | | **1154** | **8.74** | **0** | ***0.00*** | **0** | ***0.00*** | **3** | ***1.07*** | **775** | ***276.54*** | **13** | ***4.64*** | **791** | ***282.25*** |
| | | 2 | 232.6-R-16-ES | 08-Jun-11 | 727 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 46 | *284.73* | 46 | *284.73* |
| | | | 233.1-L-16-ES | 08-Jun-11 | 908 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 13 | *36.55* | 13 | *36.55* | 26 | *73.11* |
| | | | 234.4-R-16-ES | 08-Jun-11 | 900 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 11 | *25.29* | 11 | *25.29* |
| | | | 234.5-L-16-ES | 09-Jun-11 | 1221 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 15 | *26.80* | 9 | *16.08* | 24 | *42.89* |
| | | | 236.1-L-16-ES | 08-Jun-11 | 1085 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 26 | *61.18* | 6 | *14.12* | 32 | *75.30* |
| | | | 236.1-R-16-ES | 07-Jun-11 | 1702 | 1.73 | 0 | *0.00* | 0 | *0.00* | 3 | *3.67* | 35 | *42.79* | 6 | *7.34* | 44 | *53.80* |
| | | | 236.4-L-16-ES | 06-Jun-11 | 463 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 7 | *93.84* | 1 | *13.41* | 8 | *107.25* |
| | | | 236.4-R-16-ES | 06-Jun-11 | 489 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 1 | *12.48* | 0 | *0.00* | 1 | *12.48* |
| | | **Session 2 Summary** | | | **937** | **9.91** | **0** | ***0.00*** | **0** | ***0.00*** | **3** | ***1.16*** | **97** | ***37.61*** | **92** | ***35.67*** | **192** | ***74.45*** |
| | | 3 | 232.6-R-16-ES | 15-Jun-11 | 742 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 78 | *473.05* | 78 | *473.05* |
| | | | 233.1-L-16-ES | 15-Jun-11 | 855 | 1.41 | 1 | *2.99* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *11.94* | 5 | *14.93* |
| | | | 234.4-R-16-ES | 15-Jun-11 | 859 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 26 | *62.62* | 0 | *0.00* | 26 | *62.62* |
| | | | 234.5-L-16-ES | 16-Jun-11 | 1304 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 13 | *21.75* | 13 | *21.75* |
| | | | 236.1-L-16-ES | 15-Jun-11 | 1251 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 7 | *14.29* | 1 | *2.04* | 8 | *16.33* |
| | | | 236.1-R-16-ES | 14-Jun-11 | 1521 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *5.47* | 4 | *5.47* |
| | | | 236.4-L-16-ES | 13-Jun-11 | 676 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 1 | *9.18* | 1 | *9.18* |
| | | | 236.4-R-16-ES | 13-Jun-11 | 412 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *29.62* | 2 | *29.62* |
| | | **Session 3 Summary** | | | **953** | **9.91** | **1** | ***0.38*** | **0** | ***0.00*** | **0** | ***0.00*** | **33** | ***12.59*** | **103** | ***39.28*** | **137** | ***52.25*** |
| | | 4 | 232.6-R-16-ES | 22-Jun-11 | 736 | 0.80 | 0 | *0.00* | 2 | *12.23* | 0 | *0.00* | 0 | *0.00* | 6 | *36.68* | 8 | *48.91* |
| | | | 233.1-L-16-ES | 23-Jun-11 | 996 | 1.41 | 0 | *0.00* | 1 | *2.56* | 0 | *0.00* | 32 | *82.03* | 18 | *46.14* | 51 | *130.74* |
| | | | 234.4-R-16-ES | 22-Jun-11 | 1210 | 1.74 | 0 | *0.00* | 2 | *3.42* | 0 | *0.00* | 40 | *68.40* | 26 | *44.46* | 68 | *116.27* |
| | | | 234.5-L-16-ES | 23-Jun-11 | 1175 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 6 | *11.14* | 8 | *14.85* | 14 | *26.00* |
| | | | 236.1-L-16-ES | 21-Jun-11 | 1087 | 1.41 | 0 | *0.00* | 3 | *7.05* | 0 | *0.00* | 19 | *44.63* | 10 | *23.49* | 32 | *75.16* |
| | | | 236.1-R-16-ES | 21-Jun-11 | 1203 | 1.73 | 0 | *0.00* | 3 | *5.19* | 0 | *0.00* | 3 | *5.19* | 3 | *5.19* | 9 | *15.57* |
| | | | 236.4-L-16-ES | 21-Jun-11 | 388 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 7 | *111.98* | 7 | *111.98* |
| | | | 236.4-R-16-ES | 20-Jun-11 | 421 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 7 | *101.45* | 7 | *101.45* |
| | | **Session 4 Summary** | | | **902** | **9.91** | **0** | ***0.00*** | **11** | ***4.43*** | **0** | ***0.00*** | **100** | ***40.27*** | **85** | ***34.23*** | **196** | ***78.94*** |
| | **Upper Section Total All Samples** | | | | **29257** | **38.47** | **1** | | **11** | | **6** | | **1005** | | **293** | | **1316** | |
| | **Upper Section Average All Samples** | | | | **975** | **1.28** | **0** | ***0.10*** | **0** | ***1.06*** | **0** | ***0.58*** | **34** | ***96.44*** | **10** | ***28.12*** | **44** | ***126.28*** |
| | **Upper Section Standard Error of Mean** | | | | | | **0.03** | ***0.10*** | **0.16** | ***0.50*** | **0.14** | ***0.27*** | **15.70** | ***35.44*** | **2.90** | ***17.82*** | **15.70** | ***37.57*** |
| 3 | Eddy | | | | | | | | | | | | | | | | | |
| | | 1 | 231.3-R-16-ES | 31-May-11 | 720 | 0.90 | 0 | *0.00* | 0 | *0.00* | 20 | *111.11* | 24 | *133.33* | 0 | *0.00* | 44 | *244.44* |
| | | **Session 1 Summary** | | | **720** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **20** | ***111.11*** | **24** | ***133.33*** | **0** | ***0.00*** | **44** | ***244.44*** |
| | | 2 | 231.3-R-16-ES | 07-Jun-11 | 886 | 0.90 | 0 | *0.00* | 0 | *0.00* | 2 | *9.03* | 35 | *158.01* | 7 | *31.60* | 44 | *198.65* |
| | | **Session 2 Summary** | | | **886** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **2** | ***9.03*** | **35** | ***158.01*** | **7** | ***31.60*** | **44** | ***198.65*** |
| | | 3 | 231.3-R-16-ES | 14-Jun-11 | 951 | 0.90 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 9 | *37.85* | 5 | *21.03* | 14 | *58.89* |
| | | **Session 3 Summary** | | | **951** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **9** | ***37.85*** | **5** | ***21.03*** | **14** | ***58.89*** |
| | | 4 | 231.3-R-16-ES | 21-Jun-11 | 962 | 0.90 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 19 | *79.00* | 6 | *24.95* | 25 | *103.95* |
| | | **Session 4 Summary** | | | **962** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **19** | ***79.00*** | **6** | ***24.95*** | **25** | ***103.95*** |
| | **Eddy Section Total All Samples** | | | | **3519** | **3.60** | **0** | | **0** | | **22** | | **87** | | **18** | | **127** | |
| | **Eddy Section Average All Samples** | | | | **880** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **6** | ***25.01*** | **22** | ***98.89*** | **5** | ***20.46*** | **32** | ***144.36*** |
| | **Eddy Section Standard Error of Mean** | | | | | | **0.00** | ***0.00*** | **0.00** | ***0.00*** | **4.86** | ***27.11*** | **5.41** | ***27.02*** | **1.55** | ***6.82*** | **7.42** | ***42.52*** |
| 3 | Middle | | | | | | | | | | | | | | | | | |
| | | 1 | 227.2-R-16-ES | 03-Jun-11 | 247 | 0.52 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 10 | *280.29* | 10 | *280.29* |
| | | | 228.5-L-16-ES | 03-Jun-11 | 855 | 1.23 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 5 | *17.12* | 4 | *13.69* | 9 | *30.81* |
| | | | 229.2-L-16-ES | 04-Jun-11 | 1445 | 1.10 | 1 | *2.26* | 0 | *0.00* | 33 | *74.74* | 179 | *405.41* | 0 | *0.00* | 213 | *482.42* |
| | | | 229.7-R-16-ES | 02-Jun-11 | 1912 | 2.27 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *1.66* | 39 | *32.35* | 41 | *34.01* |
| | | | 231.0-L-16-ES | 04-Jun-11 | 1474 | 1.96 | 1 | *1.25* | 0 | *0.00* | 0 | *0.00* | 37 | *46.11* | 6 | *7.48* | 44 | *54.83* |
| | | | 231.0-R-16-ES | 03-Jun-11 | 958 | 0.99 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *15.18* | 76 | *288.48* | 80 | *303.66* |
| | | **Session 1 Summary** | | | **1149** | **8.07** | **2** | ***0.78*** | **0** | ***0.00*** | **33** | ***12.82*** | **227** | ***88.17*** | **135** | ***52.44*** | **397** | ***154.20*** |
| | | 2 | 227.2-R-16-ES | 10-Jun-11 | 659 | 0.52 | 0 | *0.00* | 1 | *10.51* | 12 | *126.07* | 39 | *409.71* | 64 | *672.35* | 116 | *1218.63* |
| | | | 228.5-L-16-ES | 10-Jun-11 | 1321 | 1.23 | 0 | *0.00* | 0 | *0.00* | 2 | *4.43* | 37 | *81.98* | 1 | *2.22* | 40 | *88.62* |
| | | | 229.2-L-16-ES | 11-Jun-11 | 1304 | 1.10 | 0 | *0.00* | 0 | *0.00* | 52 | *130.51* | 184 | *461.80* | 2 | *5.02* | 238 | *597.32* |
| | | | 229.7-R-16-ES | 09-Jun-11 | 1791 | 2.27 | 0 | *0.00* | 2 | *1.77* | 3 | *2.66* | 8 | *7.08* | 398 | *352.42* | 411 | *363.93* |
| | | | 231.0-L-16-ES | 11-Jun-11 | 1309 | 1.66 | 0 | *0.00* | 0 | *0.00* | 5 | *8.28* | 56 | *92.78* | 10 | *16.57* | 71 | *117.63* |
| | | | 231.0-R-16-ES | 10-Jun-11 | 1010 | 0.99 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 5 | *18.00* | 22 | *79.21* | 27 | *97.21* |
| | | **Session 2 Summary** | | | **1232** | **7.77** | **0** | ***0.00*** | **3** | ***1.13*** | **74** | ***27.82*** | **329** | ***123.69*** | **497** | ***186.86*** | **903** | ***339.50*** |
| | | 3 | 227.2-R-16-ES | 17-Jun-11 | 545 | 0.52 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *50.81* | 33 | *419.20* | 37 | *470.01* |
| | | | 228.5-L-16-ES | 17-Jun-11 | 1132 | 1.20 | 0 | *0.00* | 0 | *0.00* | 1 | *2.65* | 27 | *71.55* | 8 | *21.20* | 36 | *95.41* |
| | | | 229.2-L-16-ES | 18-Jun-11 | 1246 | 1.10 | 0 | *0.00* | 0 | *0.00* | 30 | *78.80* | 18 | *47.28* | 4 | *10.51* | 52 | *136.58* |
| | | | 229.7-R-16-ES | 16-Jun-11 | 2273 | 2.27 | 0 | *0.00* | 3 | *2.09* | 0 | *0.00* | 44 | *30.70* | 111 | *77.45* | 158 | *110.24* |
| | | | 231.0-L-16-ES | 18-Jun-11 | 1569 | 1.96 | 1 | *1.17* | 0 | *0.00* | 0 | *0.00* | 34 | *39.80* | 18 | *21.07* | 53 | *62.04* |
| | | | 231.0-R-16-ES | 17-Jun-11 | 1113 | 1.04 | 0 | *0.00* | 0 | *0.00* | 1 | *3.11* | 2 | *6.22* | 24 | *74.64* | 27 | *83.97* |
| | | **Session 3 Summary** | | | **1313** | **8.09** | **1** | ***0.34*** | **3** | ***1.02*** | **32** | ***10.85*** | **129** | ***43.72*** | **198** | ***67.10*** | **363** | ***123.03*** |
| | | 4 | 227.2-R-16-ES | 24-Jun-11 | 652 | 0.52 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 5 | *53.09* | 5 | *53.09* | 10 | *106.18* |
| | | | 228.5-L-16-ES | 24-Jun-11 | 1354 | 1.23 | 1 | *2.16* | 1 | *2.16* | 2 | *4.32* | 2 | *4.32* | 3 | *6.48* | 9 | *19.45* |
| | | | 229.2-L-16-ES | 25-Jun-11 | 1554 | 1.10 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 21 | *44.23* | 5 | *10.53* | 26 | *54.76* |
| | | | 229.7-R-16-ES | 23-Jun-11 | 2106 | 2.27 | 0 | *0.00* | 10 | *7.53* | 1 | *0.75* | 5 | *3.77* | 53 | *39.91* | 69 | *51.96* |
| | | | 231.0-L-16-ES | 25-Jun-11 | 2020 | 1.96 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 73 | *66.38* | 8 | *7.27* | 81 | *73.65* |
| | | | 231.0-R-16-ES | 24-Jun-11 | 1208 | 1.14 | 0 | *0.00* | 2 | *5.23* | 0 | *0.00* | 0 | *0.00* | 17 | *44.44* | 19 | *49.67* |
| | | **Session 4 Summary** | | | **1482** | **8.22** | **1** | ***0.30*** | **13** | ***3.84*** | **3** | ***0.89*** | **106** | ***31.32*** | **91** | ***26.89*** | **214** | ***63.23*** |
| | **Middle Section Total All Samples** | | | | **31057** | **32.15** | **4** | | **19** | | **142** | | **791** | | **921** | | **1877** | |
| | **Middle Section Average All Samples** | | | | **1294** | **1.34** | **0** | ***0.35*** | **1** | ***1.64*** | **6** | ***12.29*** | **33** | ***68.45*** | **38** | ***79.70*** | **78** | ***162.42*** |
| | **Middle Section Standard Error of Mean** | | | | | | **0.08** | ***0.14*** | **0.43** | ***0.56*** | **2.71** | ***8.18*** | **10.19** | ***27.68*** | **16.64** | ***34.91*** | **19.11** | ***55.11*** |
| **All Sections Total All Samples** | | | | | **63833** | **74.22** | **5** | | **30** | | **170** | | **1883** | | **1232** | | **3320** | |
| **All Sections Average All Samples** | | | | | **1101** | **1.28** | **0** | ***0.22*** | **1** | ***1.32*** | **3** | ***7.49*** | **32** | ***82.99*** | **21** | ***54.30*** | **57** | ***146.32*** |
| **All Sections Standard Error of Mean** | | | | | | | **0.04** | ***0.08*** | **0.20** | ***0.34*** | **1.21** | ***3.96*** | **9.08** | ***21.50*** | **7.22** | ***17.46*** | **11.47** | ***30.28*** |

Table D4 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) during the fall season in the Middle Columbia River, 3 to 27 October 2011.

| Reach | Section | Session | Site | Date | Time Sampled (s) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/hr) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brook trout | | Bull trout | | Burbot | | Kokanee | | Lake whitefish | | Mountain whitefish | | Rainbow trout | | Yellow perch | | All Species | |
| | | | | | | | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* | No. | *CPUE* |
| 4 | Upper | | | | | | | | | | | | | | | | | | | | | | | |
| | | 9 | 232.6-R | 04-Oct-11 | 631 | 0.80 | 0 | *0.00* | 9 | *64.18* | 0 | *0.00* | 25 | *178.29* | 0 | *0.00* | 418 | *2980.98* | 0 | *0.00* | 0 | *0.00* | **452** | ***3223.45*** |
| | | | 233.1-L | 06-Oct-11 | 906 | 1.41 | 0 | *0.00* | 18 | *50.73* | 4 | *11.27* | 55 | *155.00* | 0 | *0.00* | 46 | *129.63* | 17 | *47.91* | 0 | *0.00* | **140** | ***394.53*** |
| | | | 234.4-R | 06-Oct-11 | 1009 | 1.74 | 0 | *0.00* | 19 | *38.96* | 0 | *0.00* | 618 | *1267.22* | 0 | *0.00* | 108 | *221.46* | 0 | *0.00* | 0 | *0.00* | **745** | ***1527.63*** |
| | | | 234.5-L | 06-Oct-11 | 1144 | 1.65 | 0 | *0.00* | 12 | *22.89* | 0 | *0.00* | 243 | *463.45* | 4 | *7.63* | 291 | *554.99* | 5 | *9.54* | 0 | *0.00* | **555** | ***1058.49*** |
| | | | 236.1-L | 04-Oct-11 | 1011 | 1.41 | 0 | *0.00* | 18 | *45.46* | 4 | *10.10* | 66 | *166.68* | 0 | *0.00* | 90 | *227.29* | 0 | *0.00* | 0 | *0.00* | **178** | ***449.52*** |
| | | | 236.1-R | 06-Oct-11 | 1332 | 1.73 | 0 | *0.00* | 21 | *32.81* | 0 | *0.00* | 236 | *368.69* | 0 | *0.00* | 139 | *217.15* | 0 | *0.00* | 0 | *0.00* | **396** | ***618.65*** |
| | | | 236.4-L | 04-Oct-11 | 411 | 0.58 | 0 | *0.00* | 7 | *105.71* | 2 | *30.20* | 29 | *437.96* | 1 | *15.10* | 74 | *1117.54* | 0 | *0.00* | 0 | *0.00* | **113** | ***1706.52*** |
| | | | 236.4-R | 04-Oct-11 | 383 | 0.59 | 0 | *0.00* | 8 | *127.45* | 0 | *0.00* | 73 | *1162.99* | 0 | *0.00* | 58 | *924.02* | 0 | *0.00* | 0 | *0.00* | **139** | ***2214.45*** |
| | | **Session Summary** | | | **853** | **9.9** | **0** | ***0.00*** | **112** | ***47.68*** | **10** | ***4.26*** | **1345** | ***572.55*** | **5** | ***2.13*** | **1224** | ***521.04*** | **22** | ***9.37*** | **0** | ***0.00*** | **2718** | ***1157.01*** |
| | | 10 | 232.6-R | 11-Oct-11 | 571 | 0.80 | 0 | *0.00* | 2 | *15.76* | 0 | *0.00* | 12 | *94.57* | 0 | *0.00* | 98 | *772.33* | 0 | *0.00* | 0 | *0.00* | **112** | ***882.66*** |
| | | | 233.1-L | 14-Oct-11 | 791 | 1.41 | 0 | *0.00* | 21 | *67.78* | 6 | *19.37* | 20 | *64.56* | 0 | *0.00* | 24 | *77.47* | 3 | *9.68* | 0 | *0.00* | **74** | ***238.86*** |
| | | | 234.4-R | 13-Oct-11 | 1027 | 1.74 | 0 | *0.00* | 13 | *26.19* | 0 | *0.00* | 347 | *699.06* | 0 | *0.00* | 52 | *104.76* | 0 | *0.00* | 0 | *0.00* | **412** | ***830.00*** |
| | | | 234.5-L | 14-Oct-11 | 1234 | 1.65 | 0 | *0.00* | 18 | *31.83* | 1 | *1.77* | 117 | *206.87* | 0 | *0.00* | 115 | *203.33* | 0 | *0.00* | 0 | *0.00* | **251** | ***443.79*** |
| | | | 236.1-L | 13-Oct-11 | 739 | 1.41 | 0 | *0.00* | 7 | *24.18* | 1 | *3.45* | 21 | *72.55* | 0 | *0.00* | 47 | *162.38* | 0 | *0.00* | 0 | *0.00* | **76** | ***262.57*** |
| | | | 236.1-R | 13-Oct-11 | 1348 | 1.73 | 0 | *0.00* | 24 | *37.05* | 0 | *0.00* | 185 | *285.59* | 0 | *0.00* | 54 | *83.36* | 1 | *1.54* | 0 | *0.00* | **264** | ***407.54*** |
| | | | 236.4-L | 11-Oct-11 | 393 | 0.58 | 0 | *0.00* | 5 | *78.97* | 1 | *15.79* | 9 | *142.14* | 0 | *0.00* | 36 | *568.57* | 0 | *0.00* | 0 | *0.00* | **51** | ***805.48*** |
| | | | 236.4-R | 11-Oct-11 | 434 | 0.59 | 0 | *0.00* | 3 | *42.18* | 0 | *0.00* | 32 | *449.89* | 0 | *0.00* | 59 | *829.49* | 0 | *0.00* | 0 | *0.00* | **94** | ***1321.57*** |
| | | **Session Summary** | | | **817** | **9.9** | **0** | ***0.00*** | **93** | ***41.35*** | **9** | ***4.00*** | **743** | ***330.32*** | **0** | ***0.00*** | **485** | ***215.62*** | **4** | ***1.78*** | **0** | ***0.00*** | **1334** | ***593.06*** |
| | | 11 | 232.6-R | 17-Oct-11 | 556 | 0.80 | 0 | *0.00* | 2 | *16.19* | 1 | *8.09* | 11 | *89.03* | 0 | *0.00* | 77 | *623.20* | 0 | *0.00* | 0 | *0.00* | **91** | ***736.51*** |
| | | | 233.1-L | 20-Oct-11 | 902 | 1.41 | 0 | *0.00* | 21 | *59.44* | 4 | *11.32* | 8 | *22.64* | 0 | *0.00* | 62 | *175.50* | 5 | *14.15* | 0 | *0.00* | **100** | ***283.06*** |
| | | | 234.4-R | 19-Oct-11 | 1214 | 1.74 | 0 | *0.00* | 27 | *46.01* | 1 | *1.70* | 212 | *361.30* | 1 | *1.70* | 170 | *289.72* | 0 | *0.00* | 0 | *0.00* | **411** | ***700.45*** |
| | | | 234.5-L | 20-Oct-11 | 1264 | 1.65 | 0 | *0.00* | 26 | *44.88* | 4 | *6.90* | 42 | *72.50* | 3 | *5.18* | 233 | *402.19* | 9 | *15.54* | 0 | *0.00* | **317** | ***547.18*** |
| | | | 236.1-L | 19-Oct-11 | 900 | 1.41 | 0 | *0.00* | 6 | *17.02* | 1 | *2.84* | 1 | *2.84* | 2 | *5.67* | 121 | *343.26* | 0 | *0.00* | 0 | *0.00* | **131** | ***371.63*** |
| | | | 236.1-R | 19-Oct-11 | 1196 | 1.73 | 0 | *0.00* | 11 | *19.14* | 2 | *3.48* | 48 | *83.52* | 5 | *8.70* | 84 | *146.15* | 0 | *0.00* | 0 | *0.00* | **150** | ***260.99*** |
| | | | 236.4-L | 17-Oct-11 | 360 | 0.58 | 0 | *0.00* | 1 | *17.24* | 1 | *17.24* | 7 | *120.69* | 0 | *0.00* | 50 | *862.07* | 0 | *0.00* | 0 | *0.00* | **59** | ***1017.24*** |
| | | | 236.4-R | 17-Oct-11 | 381 | 0.59 | 0 | *0.00* | 1 | *16.01* | 0 | *0.00* | 24 | *384.36* | 0 | *0.00* | 43 | *688.64* | 0 | *0.00* | 0 | *0.00* | **68** | ***1089.02*** |
| | | **Session Summary** | | | **847** | **9.9** | **0** | ***0.00*** | **95** | ***40.76*** | **14** | ***6.01*** | **353** | ***151.47*** | **11** | ***4.72*** | **840** | ***360.43*** | **14** | ***6.01*** | **0** | ***0.00*** | **1327** | ***569.39*** |
| | | 12 | 232.6-R | 24-Oct-11 | 416 | 0.80 | 0 | *0.00* | 2 | *21.63* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 51 | *551.68* | 0 | *0.00* | 0 | *0.00* | **53** | ***573.32*** |
| | | | 233.1-L | 27-Oct-11 | 843 | 1.41 | 0 | *0.00* | 10 | *30.29* | 8 | *24.23* | 0 | *0.00* | 13 | *39.37* | 64 | *193.84* | 3 | *9.09* | 0 | *0.00* | **98** | ***296.81*** |
| | | | 234.4-R | 26-Oct-11 | 813 | 1.74 | 0 | *0.00* | 4 | *10.18* | 0 | *0.00* | 1 | *2.54* | 37 | *94.16* | 120 | *305.38* | 0 | *0.00* | 0 | *0.00* | **162** | ***412.27*** |
| | | | 234.5-L | 26-Oct-11 | 999 | 1.65 | 0 | *0.00* | 9 | *19.66* | 0 | *0.00* | 0 | *0.00* | 87 | *190.01* | 207 | *452.09* | 0 | *0.00* | 0 | *0.00* | **303** | ***661.75*** |
| | | | 236.1-L | 26-Oct-11 | 883 | 1.41 | 0 | *0.00* | 10 | *28.91* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 99 | *286.26* | 0 | *0.00* | 0 | *0.00* | **109** | ***315.17*** |
| | | | 236.1-R | 26-Oct-11 | 1080 | 1.73 | 0 | *0.00* | 15 | *28.90* | 1 | *1.93* | 1 | *1.93* | 26 | *50.10* | 102 | *196.53* | 0 | *0.00* | 0 | *0.00* | **145** | ***279.38*** |
| | | | 236.4-L | 24-Oct-11 | 320 | 0.58 | 0 | *0.00* | 5 | *96.98* | 0 | *0.00* | 0 | *0.00* | 6 | *116.38* | 58 | *1125.00* | 0 | *0.00* | 0 | *0.00* | **69** | ***1338.36*** |
| | | | 236.4-R | 24-Oct-11 | 353 | 0.59 | 0 | *0.00* | 5 | *86.43* | 0 | *0.00* | 0 | *0.00* | 14 | *241.99* | 34 | *587.70* | 0 | *0.00* | 0 | *0.00* | **53** | ***916.12*** |
| | | **Session Summary** | | | **713** | **9.9** | **0** | ***0.00*** | **60** | ***30.55*** | **9** | ***4.58*** | **2** | ***1.02*** | **183** | ***93.19*** | **735** | ***374.28*** | **3** | ***1.53*** | **0** | ***0.00*** | **992** | ***505.15*** |
| | **Upper Section Total All Samples** | | | | **25844** | **39.64** | **0** | | **360** | | **42** | | **2443** | | **199** | | **3284** | | **43** | | **0** | | **6371** | |
| | **Upper Section Average All Samples** | | | | **808** | **1.24** | **0** | ***0.00*** | **11** | ***40.48*** | **1** | ***4.72*** | **76** | ***274.72*** | **6** | ***22.38*** | **103** | ***369.29*** | **1** | ***4.84*** | **0** | ***0.00*** | **199** | ***818.28*** |
| | **Upper Section Standard Error of Mean** | | | | | | **0.00** | ***0.00*** | **1.39** | ***5.18*** | **0.35** | ***1.43*** | **23.43** | ***55.55*** | **2.98** | ***10.18*** | **14.76** | ***96.01*** | **0.62** | ***1.63*** | **0.00** | ***0.00*** | **29.84** | ***114.47*** |

Table D4 Continued.

| Reach | Section | Session | Site | Date | Time Sampled (s) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/hr) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brook trout | | Bull trout | | Burbot | | Kokanee | | Lake whitefish | | Mountain whitefish | | Rainbow trout | | Yellow perch | | All Species | |
| | | | | | | | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE |
| 3 | Eddy | | | | | | | | | | | | | | | | | | | | | | | |
| | | 9 | 231.3-R | 05-Oct-11 | 1111 | 0.90 | 0 | *0.00* | 10 | *36.00* | 0 | *0.00* | 531 | *1911.79* | 5 | *18.00* | 41 | *147.61* | 1 | *3.60* | 0 | *0.00* | **588** | ***2117.01*** |
| | | **Session Summary** | | | **1111** | **0.9** | **0** | ***0.00*** | **10** | ***36.00*** | **0** | ***0.00*** | **531** | ***1911.79*** | **5** | ***18.00*** | **41** | ***147.61*** | **1** | ***3.60*** | **0** | ***0.00*** | **588** | ***2117.01*** |
| | | 10 | 231.3-R | 11-Oct-11 | 896 | 0.90 | 0 | *0.00* | 16 | *71.43* | 0 | *0.00* | 36 | *160.71* | 3 | *13.39* | 51 | *227.68* | 0 | *0.00* | 0 | *0.00* | **106** | ***473.21*** |
| | | **Session Summary** | | | **896** | **0.9** | **0** | ***0.00*** | **16** | ***71.43*** | **0** | ***0.00*** | **36** | ***160.71*** | **3** | ***13.39*** | **51** | ***227.68*** | **0** | ***0.00*** | **0** | ***0.00*** | **106** | ***473.21*** |
| | | 11 | 231.3-R | 17-Oct-11 | 842 | 0.90 | 0 | *0.00* | 5 | *23.75* | 0 | *0.00* | 40 | *190.02* | 9 | *42.76* | 193 | *916.86* | 12 | *57.01* | 0 | *0.00* | **259** | ***1230.40*** |
| | | **Session Summary** | | | **842** | **0.9** | **0** | ***0.00*** | **5** | ***23.75*** | **0** | ***0.00*** | **40** | ***190.02*** | **9** | ***42.76*** | **193** | ***916.86*** | **12** | ***57.01*** | **0** | ***0.00*** | **259** | ***1230.40*** |
| | | 12 | 231.3-R | 24-Oct-11 | 743 | 0.90 | 0 | *0.00* | 6 | *32.30* | 0 | *0.00* | 0 | *0.00* | 7 | *37.69* | 161 | *866.76* | 1 | *5.38* | 0 | *0.00* | **175** | ***942.13*** |
| | | **Session Summary** | | | **743** | **0.9** | **0** | ***0.00*** | **6** | ***32.30*** | **0** | ***0.00*** | **0** | ***0.00*** | **7** | ***37.69*** | **161** | ***866.76*** | **1** | ***5.38*** | **0** | ***0.00*** | **175** | ***942.13*** |
| | **Eddy Section Total All Samples** | | | | **3592** | **3.60** | **0** | | **37** | | **0** | | **607** | | **24** | | **446** | | **14** | | **0** | | **1128** | |
| | **Eddy Section Average All Samples** | | | | **898** | **0.90** | **0** | ***0.00*** | **9** | ***41.20*** | **0** | ***0.00*** | **152** | ***675.95*** | **6** | ***26.73*** | **112** | ***496.66*** | **4** | ***15.59*** | **0** | ***0.00*** | **282** | ***1190.69*** |
| | **Eddy Section Standard Error of Mean** | | | | | | **0.00** | ***0.00*** | **2.50** | ***10.50*** | **0.00** | ***0.00*** | **126.74** | ***450.66*** | **1.29** | ***7.22*** | **38.43** | ***204.19*** | **2.84** | ***13.55*** | **0.00** | ***0.00*** | **106.69** | ***345.95*** |
| 3 | Middle | | | | | | | | | | | | | | | | | | | | | | | |
| | | 9 | 227.2-R | 05-Oct-11 | 571 | 0.52 | 0 | *0.00* | 2 | *24.25* | 1 | *12.12* | 25 | *303.11* | 0 | *0.00* | 15 | *181.87* | 10 | *121.24* | 0 | *0.00* | **53** | ***642.60*** |
| | | | 228.5-L | 03-Oct-11 | 1346 | 1.23 | 0 | *0.00* | 11 | *23.92* | 0 | *0.00* | 172 | *374.01* | 1 | *2.17* | 131 | *284.85* | 3 | *6.52* | 0 | *0.00* | **318** | ***691.48*** |
| | | | 229.2-L | 03-Oct-11 | 1613 | 1.10 | 1 | *2.03* | 3 | *6.09* | 0 | *0.00* | 302 | *612.75* | 1 | *2.03* | 29 | *58.84* | 8 | *16.23* | 0 | *0.00* | **344** | ***697.97*** |
| | | | 229.7-R | 05-Oct-11 | 2047 | 2.27 | 1 | *0.77* | 24 | *18.59* | 0 | *0.00* | 1443 | *1117.96* | 1 | *0.77* | 232 | *179.74* | 4 | *3.10* | 0 | *0.00* | **1705** | ***1320.94*** |
| | | | 231.0-L | 06-Oct-11 | 1771 | 1.96 | 0 | *0.00* | 16 | *16.59* | 5 | *5.19* | 925 | *959.33* | 1 | *1.04* | 109 | *113.05* | 15 | *15.56* | 1 | *1.04* | **1072** | ***1111.79*** |
| | | | 231.0-R | 05-Oct-11 | 918 | 1.14 | 0 | *0.00* | 25 | *86.00* | 0 | *0.00* | 524 | *1802.55* | 0 | *0.00* | 190 | *653.59* | 0 | *0.00* | 0 | *0.00* | **739** | ***2542.14*** |
| | | **Session Summary** | | | **1378** | **8.2** | **2** | ***0.64*** | **81** | ***25.75*** | **6** | ***1.91*** | **3391** | ***1077.99*** | **4** | ***1.27*** | **706** | ***224.44*** | **40** | ***12.72*** | **1** | ***0.32*** | **4231** | ***1345.02*** |
| | | 10 | 227.2-R | 14-Oct-11 | 600 | 0.52 | 0 | *0.00* | 3 | *34.62* | 0 | *0.00* | 8 | *92.31* | 0 | *0.00* | 14 | *161.54* | 2 | *23.08* | 0 | *0.00* | **27** | ***311.54*** |
| | | | 228.5-L | 12-Oct-11 | 1376 | 1.23 | 0 | *0.00* | 16 | *34.03* | 0 | *0.00* | 60 | *127.62* | 0 | *0.00* | 96 | *204.20* | 18 | *38.29* | 1 | *2.13* | **191** | ***406.27*** |
| | | | 229.2-L | 12-Oct-11 | 1474 | 1.10 | 0 | *0.00* | 1 | *2.22* | 0 | *0.00* | 150 | *333.05* | 0 | *0.00* | 12 | *26.64* | 16 | *35.52* | 0 | *0.00* | **179** | ***397.43*** |
| | | | 229.7-R | 14-Oct-11 | 1991 | 2.27 | 0 | *0.00* | 24 | *19.12* | 0 | *0.00* | 705 | *561.56* | 0 | *0.00* | 146 | *116.29* | 0 | *0.00* | 0 | *0.00* | **875** | ***696.97*** |
| | | | 231.0-L | 13-Oct-11 | 1329 | 1.96 | 0 | *0.00* | 11 | *15.20* | 4 | *5.53* | 65 | *89.83* | 0 | *0.00* | 79 | *109.18* | 11 | *15.20* | 0 | *0.00* | **170** | ***234.95*** |
| | | | 231.0-R | 14-Oct-11 | 902 | 1.14 | 0 | *0.00* | 24 | *84.02* | 0 | *0.00* | 300 | *1050.30* | 0 | *0.00* | 127 | *444.63* | 0 | *0.00* | 0 | *0.00* | **451** | ***1578.95*** |
| | | **Session Summary** | | | **1279** | **8.2** | **0** | ***0.00*** | **79** | ***27.06*** | **4** | ***1.37*** | **1288** | ***441.15*** | **0** | ***0.00*** | **474** | ***162.35*** | **47** | ***16.10*** | **1** | ***0.34*** | **1893** | ***648.37*** |
| | | 11 | 227.2-R | 20-Oct-11 | 358 | 0.52 | 0 | *0.00* | 5 | *96.69* | 0 | *0.00* | 7 | *135.37* | 1 | *19.34* | 25 | *483.46* | 1 | *19.34* | 0 | *0.00* | **39** | ***754.19*** |
| | | | 228.5-L | 18-Oct-11 | 897 | 1.23 | 0 | *0.00* | 5 | *16.31* | 2 | *6.53* | 29 | *94.62* | 0 | *0.00* | 70 | *228.40* | 5 | *16.31* | 0 | *0.00* | **111** | ***362.18*** |
| | | | 229.2-L | 18-Oct-11 | 1287 | 1.10 | 0 | *0.00* | 2 | *5.09* | 0 | *0.00* | 112 | *284.81* | 0 | *0.00* | 19 | *48.32* | 16 | *40.69* | 0 | *0.00* | **149** | ***378.89*** |
| | | | 229.7-R | 20-Oct-11 | 2400 | 2.27 | 0 | *0.00* | 9 | *5.95* | 1 | *0.66* | 99 | *65.42* | 0 | *0.00* | 185 | *122.25* | 0 | *0.00* | 0 | *0.00* | **294** | ***194.27*** |
| | | | 231.0-L | 18-Oct-11 | 1398 | 1.96 | 0 | *0.00* | 13 | *17.08* | 5 | *6.57* | 55 | *72.26* | 0 | *0.00* | 116 | *152.40* | 17 | *22.34* | 0 | *0.00* | **206** | ***270.65*** |
| | | | 231.0-R | 20-Oct-11 | 848 | 1.14 | 0 | *0.00* | 28 | *104.27* | 0 | *0.00* | 90 | *335.15* | 1 | *3.72* | 202 | *752.23* | 0 | *0.00* | 0 | *0.00* | **321** | ***1195.38*** |
| | | **Session Summary** | | | **1198** | **8.2** | **0** | ***0.00*** | **62** | ***22.67*** | **8** | ***2.92*** | **392** | ***143.30*** | **2** | ***0.73*** | **617** | ***225.56*** | **39** | ***14.26*** | **0** | ***0.00*** | **1120** | ***409.44*** |
| | | 12 | 227.2-R | 27-Oct-11 | 590 | 0.52 | 0 | *0.00* | 3 | *35.20* | 0 | *0.00* | 8 | *93.87* | 0 | *0.00* | 22 | *258.15* | 3 | *35.20* | 0 | *0.00* | **36** | ***422.43*** |
| | | | 228.5-L | 25-Oct-11 | 967 | 1.23 | 1 | *3.03* | 11 | *33.29* | 0 | *0.00* | 17 | *51.45* | 0 | *0.00* | 80 | *242.14* | 16 | *48.43* | 0 | *0.00* | **125** | ***378.34*** |
| | | | 229.2-L | 25-Oct-11 | 1203 | 1.10 | 0 | *0.00* | 5 | *13.60* | 1 | *2.72* | 26 | *70.73* | 0 | *0.00* | 36 | *97.94* | 6 | *16.32* | 0 | *0.00* | **74** | ***201.31*** |
| | | | 229.7-R | 27-Oct-11 | 1710 | 2.27 | 0 | *0.00* | 8 | *7.42* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 247 | *229.07* | 0 | *0.00* | 0 | *0.00* | **255** | ***236.49*** |
| | | | 231.0-L | 25-Oct-11 | 1096 | 1.96 | 0 | *0.00* | 8 | *13.41* | 0 | *0.00* | 1 | *1.68* | 1 | *1.68* | 93 | *155.85* | 9 | *15.08* | 0 | *0.00* | **112** | ***187.70*** |
| | | | 231.0-R | 27-Oct-11 | 640 | 1.14 | 0 | *0.00* | 5 | *24.67* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 9 | *44.41* | 0 | *0.00* | 0 | *0.00* | **14** | ***69.08*** |
| | | **Session Summary** | | | **1034** | **8.2** | **1** | ***0.42*** | **40** | ***16.94*** | **1** | ***0.42*** | **52** | ***22.02*** | **1** | ***0.42*** | **487** | ***206.20*** | **34** | ***14.40*** | **0** | ***0.00*** | **616** | ***260.83*** |
| | **Middle Section Total All Samples** | | | | **29332** | **32.88** | **3** | | **262** | | **19** | | **5123** | | **7** | | **2284** | | **160** | | **2** | | **7860** | |
| | **Middle Section Average All Samples** | | | | **1222** | **1.37** | **0** | ***0.27*** | **11** | ***23.47*** | **1** | ***1.70*** | **213** | ***458.95*** | **0** | ***0.63*** | **95** | ***204.61*** | **7** | ***14.33*** | **0** | ***0.18*** | **328** | ***636.83*** |
| | **Middle Section Standard Error of Mean** | | | | | | **0.07** | ***0.15*** | **1.74** | ***6.14*** | **0.32** | ***0.65*** | **72.40** | ***92.59*** | **0.09** | ***0.81*** | **15.24** | ***37.96*** | **1.35** | ***5.33*** | **0.06** | ***0.10*** | **81.71** | ***115.66*** |
| **All Sections Total All Samples** | | | | | **58768** | **76.12** | **3** | ***0.00*** | **659** | ***0.53*** | **61** | ***0.05*** | **8173** | ***6.58*** | **230** | ***0.19*** | **6014** | ***4.84*** | **217** | ***0.17*** | **2** | ***0.00*** | **15359** | ***12.36*** |
| **All Sections Average All Samples** | | | | | | | **0** | ***0.14*** | **11** | ***31.82*** | **1** | ***2.95*** | **136** | ***394.63*** | **4** | ***11.11*** | **100** | ***290.39*** | **4** | ***10.48*** | **0** | ***0.10*** | **256** | ***741.61*** |
| **All Sections Standard Error of Mean** | | | | | | | **0.03** | ***0.06*** | **1.02** | ***3.79*** | **0.23** | ***0.84*** | **33.15** | ***55.12*** | **1.63** | ***5.62*** | **10.13** | ***57.43*** | **0.73** | ***2.64*** | **0.02** | ***0.04*** | **37.34** | ***80.65*** |

Table D5 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) during the fall season in the Middle Columbia River, 3 to 27 October 2011.

| Reach | Section | Session | Site | Date | Time Sampled (seconds) | Length Sampled (km) | Number Caught (CPUE=no. fish/km/h) Northern pikeminnow | | Peamouth | | Redside shiner | | Sculpin spp. | | Sucker spp. | | All Species | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE | No. | CPUE |
| 4 | Upper | | | | | | | | | | | | | | | | | |
| | | 9 | 232.6-R-16-ES | 04-Oct-11 | 631 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *14.26* | 25 | *178.29* | 27 | *192.55* |
| | | | 233.1-L-16-ES | 06-Oct-11 | 906 | 1.41 | 2 | *5.64* | 0 | *0.00* | 0 | *0.00* | 77 | *216.99* | 20 | *56.36* | 99 | *278.99* |
| | | | 234.4-R-16-ES | 06-Oct-11 | 1009 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 3 | *6.15* | 33 | *67.67* | 36 | *73.82* |
| | | | 234.5-L-16-ES | 06-Oct-11 | 1144 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 3 | *5.72* | 20 | *38.14* | 23 | *43.87* |
| | | | 236.1-L-16-ES | 04-Oct-11 | 1011 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 9 | *22.73* | 16 | *40.41* | 25 | *63.14* |
| | | | 236.1-R-16-ES | 06-Oct-11 | 1332 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 27 | *42.18* | 10 | *15.62* | 37 | *57.80* |
| | | | 236.4-L-16-ES | 04-Oct-11 | 411 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 8 | *120.82* | 8 | *120.82* |
| | | | 236.4-R-16-ES | 04-Oct-11 | 383 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *31.86* | 0 | *0.00* | 2 | *31.86* |
| | | **Session 9 Summary** | | | **853** | **9.91** | **2** | ***0.85*** | **0** | ***0.00*** | **0** | ***0.00*** | **123** | ***52.36*** | **132** | ***56.19*** | **257** | ***109.40*** |
| | | 10 | 232.6-R-16-ES | 11-Oct-11 | 571 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 10 | *78.81* | 10 | *78.81* |
| | | | 233.1-L-16-ES | 14-Oct-11 | 791 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 38 | *122.66* | 11 | *35.51* | 49 | *158.16* |
| | | | 234.4-R-16-ES | 13-Oct-11 | 1027 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *4.03* | 21 | *42.31* | 23 | *46.34* |
| | | | 234.5-L-16-ES | 14-Oct-11 | 1234 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 6 | *10.61* | 11 | *19.45* | 17 | *30.06* |
| | | | 236.1-L-16-ES | 13-Oct-11 | 739 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 21 | *72.55* | 4 | *13.82* | 25 | *86.37* |
| | | | 236.1-R-16-ES | 13-Oct-11 | 1348 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 39 | *60.20* | 9 | *13.89* | 48 | *74.10* |
| | | | 236.4-L-16-ES | 11-Oct-11 | 393 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *63.17* | 4 | *63.17* |
| | | | 236.4-R-16-ES | 11-Oct-11 | 434 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 1 | *14.06* | 0 | *0.00* | 1 | *14.06* |
| | | **Session 10 Summary** | | | **817** | **9.91** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **107** | ***47.57*** | **70** | ***31.12*** | **177** | ***78.69*** |
| | | 11 | 232.6-R-16-ES | 17-Oct-11 | 556 | 0.80 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 9 | *72.84* | 9 | *72.84* |
| | | | 233.1-L-16-ES | 20-Oct-11 | 902 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 19 | *53.78* | 19 | *53.78* | 38 | *107.56* |
| | | | 234.4-R-16-ES | 19-Oct-11 | 1214 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 140 | *238.60* | 42 | *71.58* | 182 | *310.17* |
| | | | 234.5-L-16-ES | 20-Oct-11 | 1264 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 62 | *107.02* | 19 | *32.80* | 81 | *139.82* |
| | | | 236.1-L-16-ES | 19-Oct-11 | 900 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 23 | *65.25* | 19 | *53.90* | 42 | *119.15* |
| | | | 236.1-R-16-ES | 19-Oct-11 | 1196 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 90 | *156.59* | 21 | *36.54* | 111 | *193.13* |
| | | | 236.4-L-16-ES | 17-Oct-11 | 360 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *68.97* | 4 | *68.97* |
| | | | 236.4-R-16-ES | 17-Oct-11 | 381 | 0.59 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 1 | *16.01* | 1 | *16.01* | 2 | *32.03* |
| | | **Session 11 Summary** | | | **847** | **9.91** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **335** | ***143.74*** | **134** | ***57.50*** | **469** | ***201.24*** |
| | | 12 | 233.1-L-16-ES | 27-Oct-11 | 843 | 1.41 | 0 | *0.00* | 0 | *0.00* | 11 | *33.32* | 93 | *281.67* | 9 | *27.26* | 113 | *342.24* |
| | | | 234.4-R-16-ES | 26-Oct-11 | 813 | 1.74 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 21 | *53.44* | 21 | *53.44* |
| | | | 234.5-L-16-ES | 26-Oct-11 | 999 | 1.65 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 25 | *54.60* | 25 | *54.60* |
| | | | 236.1-L-16-ES | 26-Oct-11 | 883 | 1.41 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 11 | *31.81* | 11 | *31.81* |
| | | | 236.1-R-16-ES | 26-Oct-11 | 1080 | 1.73 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 15 | *28.90* | 15 | *28.90* |
| | | | 236.4-L-16-ES | 24-Oct-11 | 320 | 0.58 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 2 | *38.79* | 2 | *38.79* |
| | | **Session 12 Summary** | | | **823** | **8.52** | **0** | ***0.00*** | **0** | ***0.00*** | **11** | ***5.65*** | **93** | ***47.75*** | **83** | ***42.61*** | **187** | ***96.01*** |
| | **Upper Section Total All Samples** | | | | **25075** | **38.25** | **2** | | **0** | | **11** | | **658** | | **419** | | **1090** | |
| | **Upper Section Average All Samples** | | | | **836** | **1.27** | **0** | ***0.23*** | **0** | ***0.00*** | **0** | ***1.24*** | **22** | ***74.09*** | **14** | ***47.18*** | **36** | ***122.74*** |
| | **Upper Section Standard Error of Mean** | | | | | | **0.07** | ***0.19*** | **0.00** | ***0.00*** | **0.37** | ***1.11*** | **6.51** | ***14.19*** | **1.81** | ***6.55*** | **7.62** | ***15.59*** |
| 3 | Eddy | | | | | | | | | | | | | | | | | |
| | | 9 | 231.3-R-16-ES | 05-Oct-11 | 1111 | 0.90 | 0 | *0.00* | 0 | *0.00* | 2 | *7.20* | 44 | *158.42* | 12 | *43.20* | 58 | *208.82* |
| | | **Session 9 Summary** | | | **1111** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **2** | ***7.20*** | **44** | ***158.42*** | **12** | ***43.20*** | **58** | ***208.82*** |
| | | 10 | 231.3-R-16-ES | 11-Oct-11 | 896 | 0.90 | 0 | *0.00* | 0 | *0.00* | 2 | *8.93* | 8 | *35.71* | 3 | *13.39* | 13 | *58.04* |
| | | **Session 10 Summary** | | | **896** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **2** | ***8.93*** | **8** | ***35.71*** | **3** | ***13.39*** | **13** | ***58.04*** |
| | | 11 | 231.3-R-16-ES | 17-Oct-11 | 842 | 0.90 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 13 | *61.76* | 13 | *61.76* | 26 | *123.52* |
| | | **Session 11 Summary** | | | **842** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **13** | ***61.76*** | **13** | ***61.76*** | **26** | ***123.52*** |
| | | 12 | 231.3-R-16-ES | 24-Oct-11 | 743 | 0.90 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 10 | *53.84* | 10 | *53.84* |
| | | **Session 12 Summary** | | | **743** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **0** | ***0.00*** | **10** | ***53.84*** | **10** | ***53.84*** |
| | **Eddy Section Total All Samples** | | | | **3592** | **3.60** | **0** | | **0** | | **4** | | **65** | | **38** | | **107** | |
| | **Eddy Section Average All Samples** | | | | **898** | **0.90** | **0** | ***0.00*** | **0** | ***0.00*** | **1** | ***4.45*** | **16** | ***72.38*** | **10** | ***42.32*** | **27** | ***119.15*** |
| | **Eddy Section Standard Error of Mean** | | | | | | **0.00** | ***0.00*** | **0.00** | ***0.00*** | **0.58** | ***2.35*** | **9.63** | ***33.93*** | **2.25** | ***10.59*** | **10.98** | ***36.28*** |
| 3 | Middle | | | | | | | | | | | | | | | | | |
| | | 9 | 227.2-R-16-ES | 05-Oct-11 | 571 | 0.52 | 1 | *12.12* | 0 | *0.00* | 1 | *12.12* | 24 | *290.99* | 4 | *48.50* | 30 | *363.73* |
| | | | 228.5-L-16-ES | 03-Oct-11 | 1346 | 1.23 | 8 | *17.40* | 0 | *0.00* | 2 | *4.35* | 35 | *76.11* | 25 | *54.36* | 70 | *152.21* |
| | | | 229.2-L-16-ES | 03-Oct-11 | 1613 | 1.10 | 3 | *6.09* | 1 | *2.03* | 43 | *87.25* | 75 | *152.17* | 12 | *24.35* | 134 | *271.88* |
| | | | 229.7-R-16-ES | 05-Oct-11 | 2047 | 2.27 | 2 | *1.55* | 0 | *0.00* | 0 | *0.00* | 43 | *33.31* | 54 | *41.84* | 99 | *76.70* |
| | | | 231.0-L-16-ES | 06-Oct-11 | 1771 | 1.96 | 2 | *2.07* | 0 | *0.00* | 0 | *0.00* | 161 | *166.98* | 33 | *34.22* | 196 | *203.27* |
| | | | 231.0-R-16-ES | 05-Oct-11 | 918 | 1.14 | 0 | *0.00* | 0 | *0.00* | 1 | *3.44* | 7 | *24.08* | 28 | *96.32* | 36 | *123.84* |
| | | **Session 9 Summary** | | | **1378** | **8.22** | **16** | ***5.09*** | **1** | ***0.32*** | **47** | ***14.94*** | **345** | ***109.67*** | **156** | ***49.59*** | **565** | ***179.61*** |
| | | 10 | 227.2-R-16-ES | 14-Oct-11 | 600 | 0.52 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 3 | *34.62* | 1 | *11.54* | 4 | *46.15* |
| | | | 228.5-L-16-ES | 12-Oct-11 | 1376 | 1.23 | 8 | *17.02* | 0 | *0.00* | 14 | *29.78* | 76 | *161.66* | 10 | *21.27* | 108 | *229.72* |
| | | | 229.2-L-16-ES | 12-Oct-11 | 1474 | 1.10 | 0 | *0.00* | 0 | *0.00* | 23 | *51.07* | 31 | *68.83* | 8 | *17.76* | 62 | *137.66* |
| | | | 229.7-R-16-ES | 14-Oct-11 | 1991 | 2.27 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 51 | *40.62* | 42 | *33.45* | 93 | *74.08* |
| | | | 231.0-L-16-ES | 13-Oct-11 | 1329 | 1.96 | 1 | *1.38* | 0 | *0.00* | 4 | *5.53* | 51 | *70.48* | 19 | *26.26* | 75 | *103.65* |
| | | | 231.0-R-16-ES | 14-Oct-11 | 902 | 1.14 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 4 | *14.00* | 21 | *73.52* | 25 | *87.52* |
| | | **Session 10 Summary** | | | **1279** | **8.22** | **9** | ***3.08*** | **0** | ***0.00*** | **41** | ***14.04*** | **216** | ***73.98*** | **101** | ***34.59*** | **367** | ***125.70*** |
| | | 11 | 227.2-R-16-ES | 20-Oct-11 | 358 | 0.52 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 30 | *580.15* | 6 | *116.03* | 36 | *696.18* |
| | | | 228.5-L-16-ES | 18-Oct-11 | 897 | 1.23 | 3 | *9.79* | 0 | *0.00* | 0 | *0.00* | 58 | *189.25* | 9 | *29.37* | 70 | *228.40* |
| | | | 229.2-L-16-ES | 18-Oct-11 | 1287 | 1.10 | 0 | *0.00* | 0 | *0.00* | 98 | *249.21* | 156 | *396.69* | 11 | *27.97* | 265 | *673.87* |
| | | | 229.7-R-16-ES | 20-Oct-11 | 2400 | 2.27 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 12 | *7.93* | 79 | *52.20* | 91 | *60.13* |
| | | | 231.0-L-16-ES | 18-Oct-11 | 1398 | 1.96 | 0 | *0.00* | 0 | *0.00* | 1 | *1.31* | 121 | *158.97* | 24 | *31.53* | 146 | *191.82* |
| | | | 231.0-R-16-ES | 20-Oct-11 | 848 | 1.14 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 24 | *89.37* | 24 | *89.37* |
| | | **Session 11 Summary** | | | **1198** | **8.22** | **3** | ***1.10*** | **0** | ***0.00*** | **99** | ***36.19*** | **377** | ***137.82*** | **153** | ***55.93*** | **632** | ***231.04*** |
| | | 12 | 227.2-R-16-ES | 27-Oct-11 | 590 | 0.52 | 3 | *35.20* | 0 | *0.00* | 0 | *0.00* | 9 | *105.61* | 3 | *35.20* | 15 | *176.01* |
| | | | 228.5-L-16-ES | 25-Oct-11 | 967 | 1.23 | 0 | *0.00* | 0 | *0.00* | 6 | *18.16* | 36 | *108.96* | 13 | *39.35* | 55 | *166.47* |
| | | | 229.2-L-16-ES | 25-Oct-11 | 1203 | 1.10 | 3 | *8.16* | 0 | *0.00* | 24 | *65.29* | 67 | *182.27* | 22 | *59.85* | 116 | *315.57* |
| | | | 229.7-R-16-ES | 27-Oct-11 | 1710 | 2.27 | 3 | *2.78* | 0 | *0.00* | 5 | *4.64* | 14 | *12.98* | 51 | *47.30* | 73 | *67.70* |
| | | | 231.0-L-16-ES | 25-Oct-11 | 1096 | 1.96 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 20 | *33.52* | 9 | *15.08* | 29 | *48.60* |
| | | | 231.0-R-16-ES | 27-Oct-11 | 640 | 1.14 | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 0 | *0.00* | 9 | *44.41* | 9 | *44.41* |
| | | **Session 12 Summary** | | | **1034** | **8.22** | **9** | ***3.81*** | **0** | ***0.00*** | **35** | ***14.82*** | **146** | ***61.82*** | **107** | ***45.31*** | **297** | ***125.76*** |
| | **Middle Section Total All Samples** | | | | **29332** | **32.88** | **37** | | **1** | | **222** | | **1084** | | **517** | | **1861** | |
| | **Middle Section Average All Samples** | | | | **1222** | **1.37** | **2** | ***3.31*** | **0** | ***0.09*** | **9** | ***19.89*** | **45** | ***97.11*** | **22** | ***46.32*** | **78** | ***166.72*** |
| | **Middle Section Standard Error of Mean** | | | | | | **0.48** | ***1.73*** | **0.04** | ***0.08*** | **4.42** | ***10.95*** | **9.33** | ***28.29*** | **3.86** | ***5.39*** | **12.69** | ***35.70*** |
| **All Sections Total All Samples** | | | | | **57999** | **74.73** | **39** | | **1** | | **237** | | **1807** | | **974** | | **3058** | |
| **All Sections Average All Samples** | | | | | **1000** | **1.29** | **1** | ***1.88*** | **0** | ***0.05*** | **4** | ***11.42*** | **31** | ***87.05*** | **17** | ***46.92*** | **53** | ***147.32*** |
| **All Sections Standard Error of Mean** | | | | | | | **0.22** | ***0.77*** | **0.02** | ***0.03*** | **1.91** | ***4.71*** | **5.34** | ***14.52*** | **1.92** | ***4.07*** | **7.10** | ***17.81*** |

Table D6 Summary of fish captured and recaptured in sampled sections of the Middle Columbia River, 30 May to 24 June 2011.

| Species | Size-class | Session | Number of Fish Captured | Number of Fish Marked | Number of Fish Recaptured (within year) | Number of Fish Recaptured (between years) |
|---|---|---|---|---|---|---|
| Brook trout | All | 1 | 1 | 1 | - | 0 |
| | | 2 | 2 | 2 | 0 | 0 |
| | | 3 | 0 | 0 | 0 | 0 |
| | | 4 | 2 | 2 | 0 | 0 |
| **Brook trout Total** | | | **5** | **5** | **0** | **0** |
| Bull trout | All | 1 | 79 | 77 | - | 9 |
| | | 2 | 85 | 84 | 4 | 10 |
| | | 3 | 54 | 53 | 3 | 6 |
| | | 4 | 65 | 64 | 7 | 4 |
| **Bull trout Total** | | | **283** | **278** | **14** | **29** |
| Burbot | All | 1 | 3 | 3 | - | 0 |
| | | 2 | 2 | 2 | 0 | 0 |
| | | 3 | 3 | 2 | 0 | 0 |
| | | 4 | 0 | 0 | 0 | 0 |
| **Burbot Total** | | | **8** | **7** | **0** | **0** |
| Mountain whitefish | All | 1 | 645 | 617 | - | 68 |
| | | 2 | 655 | 635 | 34 | 64 |
| | | 3 | 503 | 487 | 42 | 41 |
| | | 4 | 583 | 566 | 63 | 35 |
| **Mountain whitefish Total** | | | **2386** | **2305** | **139** | **208** |
| Rainbow trout | All | 1 | 22 | 22 | - | 2 |
| | | 2 | 28 | 25 | 3 | 1 |
| | | 3 | 12 | 11 | 2 | 0 |
| | | 4 | 18 | 17 | 0 | 0 |
| **Rainbow trout Total** | | | **80** | **75** | **5** | **3** |
| Yellow perch | All | 1 | 0 | 0 | - | 0 |
| | | 2 | 1 | 1 | 0 | 0 |
| | | 3 | 0 | 0 | 0 | 0 |
| | | 4 | 0 | 0 | 0 | 0 |
| **Yellow perch Total** | | | **1** | **1** | **0** | **0** |
| Northern pikeminnow | All | 1 | 2 | 2 | - | 0 |
| | | 2 | 0 | 0 | 0 | 0 |
| | | 3 | 2 | 2 | 0 | 0 |
| | | 4 | 1 | 1 | 0 | 0 |
| **Northern pikeminnow Total** | | | **5** | **5** | **0** | **0** |
| Peamouth | All | 1 | 0 | 0 | - | 0 |
| | | 2 | 3 | 3 | 0 | 0 |
| | | 3 | 3 | 3 | 0 | 0 |
| | | 4 | 21 | 21 | 0 | 0 |
| **Peamouth Total** | | | **27** | **27** | **0** | **0** |
| Sucker species | All | 1 | 36 | 33 | - | 1 |
| | | 2 | 79 | 77 | 0 | 1 |
| | | 3 | 38 | 33 | 0 | 0 |
| | | 4 | 46 | 40 | 1 | 1 |
| **Sucker species Total** | | | **199** | **183** | **1** | **3** |

Table D7 Summary of fish captured and recaptured in sampled sections of the Middle Columbia River, 26 September to 30 October 2011.

| Species | Size-class | Session | Number of Fish Captured | Number of Fish Marked | Number of Fish Recaptured (within year) | Number of Fish Recaptured (between years) |
|---|---|---|---|---|---|---|
| Brook trout | All | 1 | 2 | 2 | - | 0 |
| | | 2 | 0 | 0 | 0 | 0 |
| | | 3 | 0 | 0 | 0 | 0 |
| | | 4 | 1 | 1 | 0 | 0 |
| **Brook trout Total** | | | **3** | **3** | **0** | **0** |
| Bull trout | All | 1 | 86 | 84 | - | 10 |
| | | 2 | 91 | 91 | 5 | 17 |
| | | 3 | 80 | 80 | 11 | 10 |
| | | 4 | 59 | 59 | 4 | 10 |
| **Bull trout Total** | | | **316** | **314** | **20** | **47** |
| Burbot | All | 1 | 4 | 3 | - | 0 |
| | | 2 | 4 | 4 | 0 | 0 |
| | | 3 | 1 | 1 | 0 | 0 |
| | | 4 | 0 | 0 | 0 | 0 |
| **Burbot Total** | | | **9** | **8** | **0** | **0** |
| Lake whitefish | All | 1 | 5 | 5 | - | 0 |
| | | 2 | 0 | 0 | 0 | 0 |
| | | 3 | 8 | 8 | 0 | 0 |
| | | 4 | 27 | 27 | 0 | 0 |
| **Lake whitefish Total** | | | **40** | **40** | **0** | **0** |
| Mountain whitefish | All | 1 | 295 | 289 | - | 39 |
| | | 2 | 302 | 278 | 4 | 41 |
| | | 3 | 439 | 419 | 12 | 60 |
| | | 4 | 364 | 352 | 11 | 53 |
| **Mountain whitefish Total** | | | **1400** | **1338** | **27** | **193** |
| Rainbow trout | All | 1 | 19 | 17 | - | 2 |
| | | 2 | 20 | 19 | 1 | 2 |
| | | 3 | 23 | 22 | 2 | 3 |
| | | 4 | 9 | 8 | 2 | 0 |
| **Rainbow trout Total** | | | **71** | **66** | **5** | **7** |
| Yellow perch | All | 1 | 0 | 0 | - | 0 |
| | | 2 | 1 | 1 | 0 | 0 |
| | | 3 | 0 | 0 | 0 | 0 |
| | | 4 | 0 | 0 | 0 | 0 |
| **Yellow perch Total** | | | **1** | **1** | **0** | **0** |
| Northern pikeminnow | All | 1 | 14 | 14 | - | 1 |
| | | 2 | 6 | 6 | 0 | 0 |
| | | 3 | 2 | 2 | 1 | 0 |
| | | 4 | 4 | 4 | 0 | 0 |
| **Northern pikeminnow Total** | | | **26** | **26** | **1** | **1** |
| Peamouth | All | 1 | 1 | 1 | - | 0 |
| | | 2 | 0 | 0 | 0 | 0 |
| | | 3 | 0 | 0 | 0 | 0 |
| | | 4 | 0 | 0 | 0 | 0 |
| **Peamouth Total** | | | **1** | **1** | **0** | **0** |
| Sucker species | All | 1 | 116 | 116 | - | 4 |
| | | 2 | 103 | 103 | 3 | 9 |
| | | 3 | 140 | 137 | 9 | 6 |
| | | 4 | 102 | 102 | 9 | 5 |
| **Sucker species Total** | | | **461** | **458** | **21** | **24** |

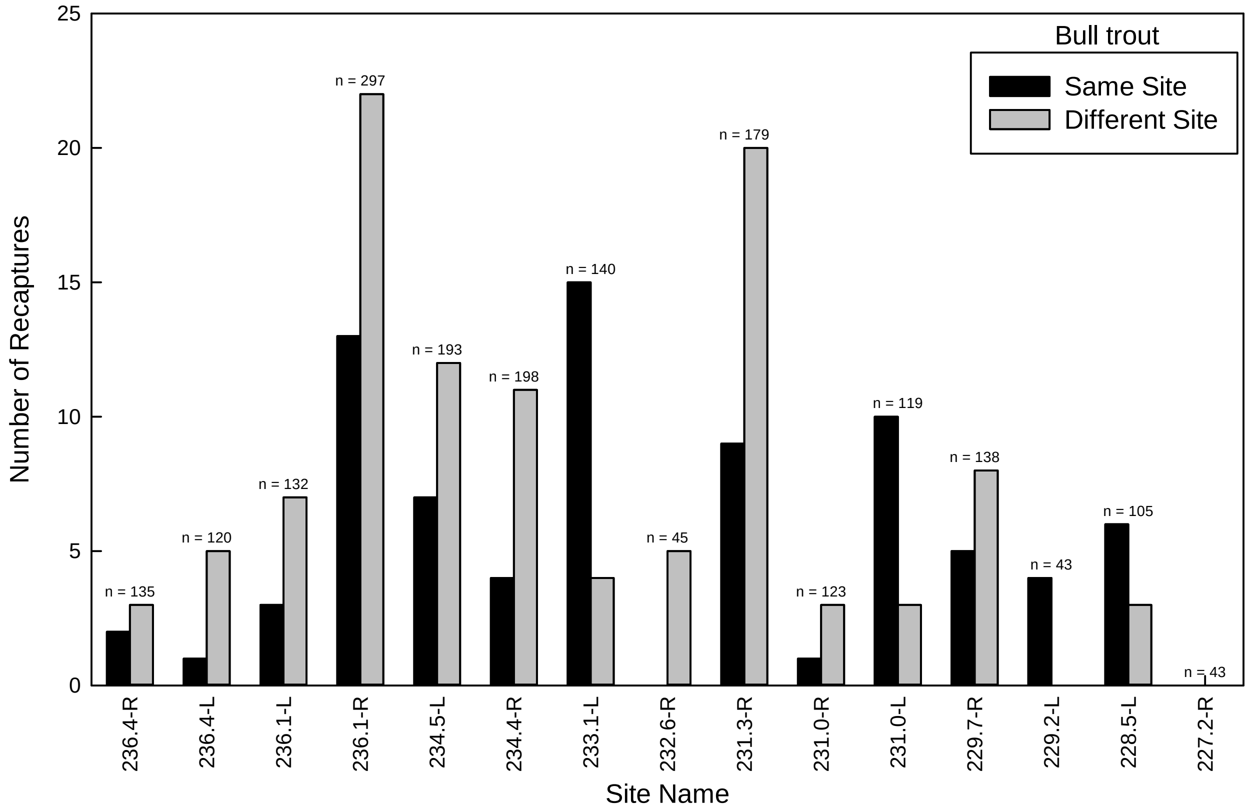



Figure D1 Summary of intra-year site movement by bull trout in the Middle Columbia River relative to site of initial release, 2001 to 2011 data combined. The "n" value located above each site represents the number of fish marked at that site (all years combined); excludes fish marked during the last session of each year.

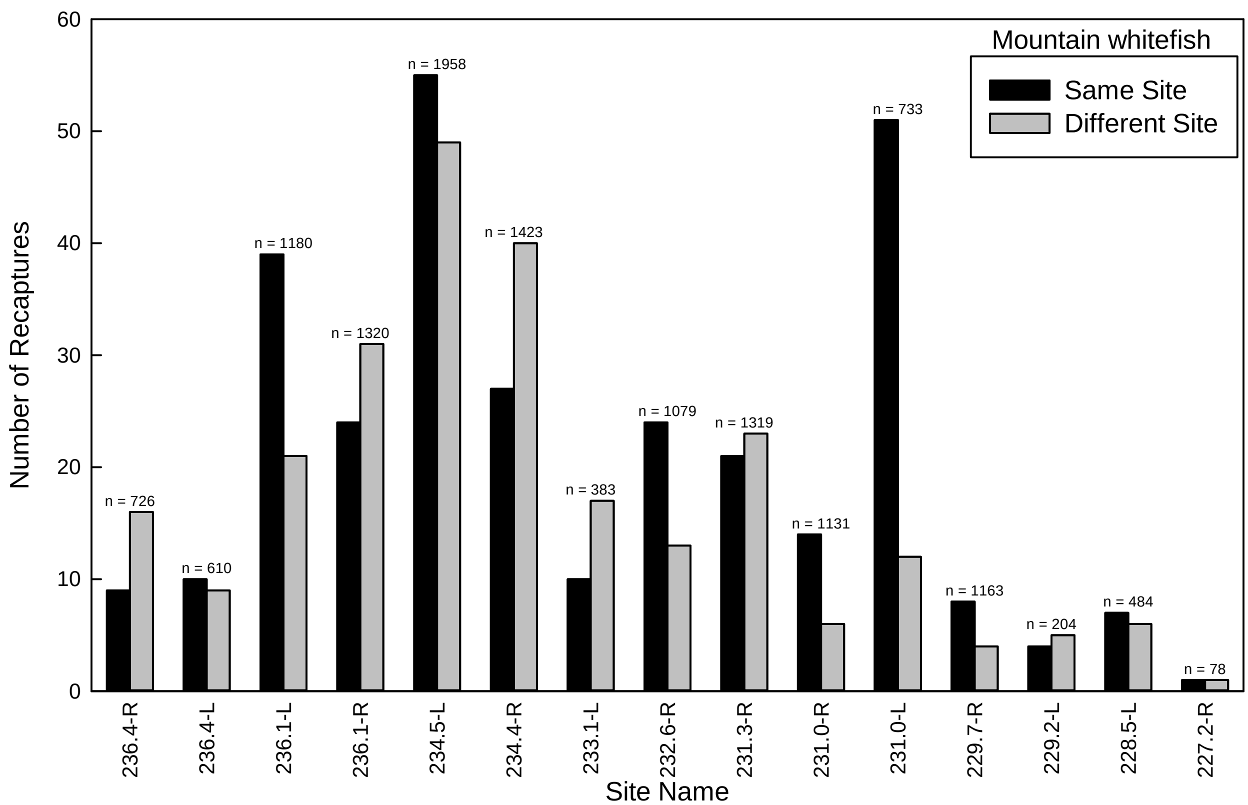



Figure D2 Summary of intra-year site movement by mountain whitefish in the Middle Columbia River relative to site of initial release, 2001 to 2011 data combined. The "n" value located above each site represents the number of fish marked at that site (all years combined); excludes fish marked during the last session of each year.

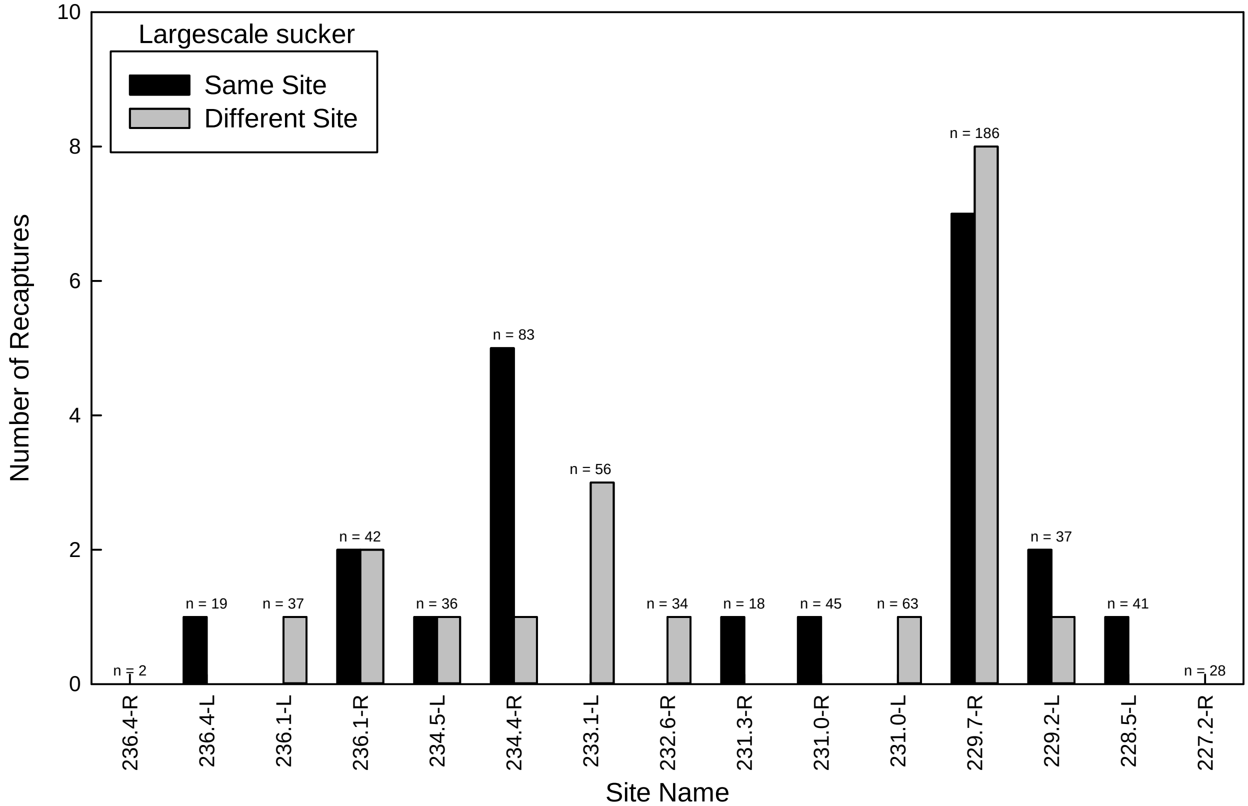



Figure D3 Summary of intra-year site movement by largescale sucker in the Middle Columbia River relative to site of initial release, 2010 and 2011 data combined. The "n" value located above each site represents the number of fish marked at that site (all years combined); excludes fish marked during the last session of each year.

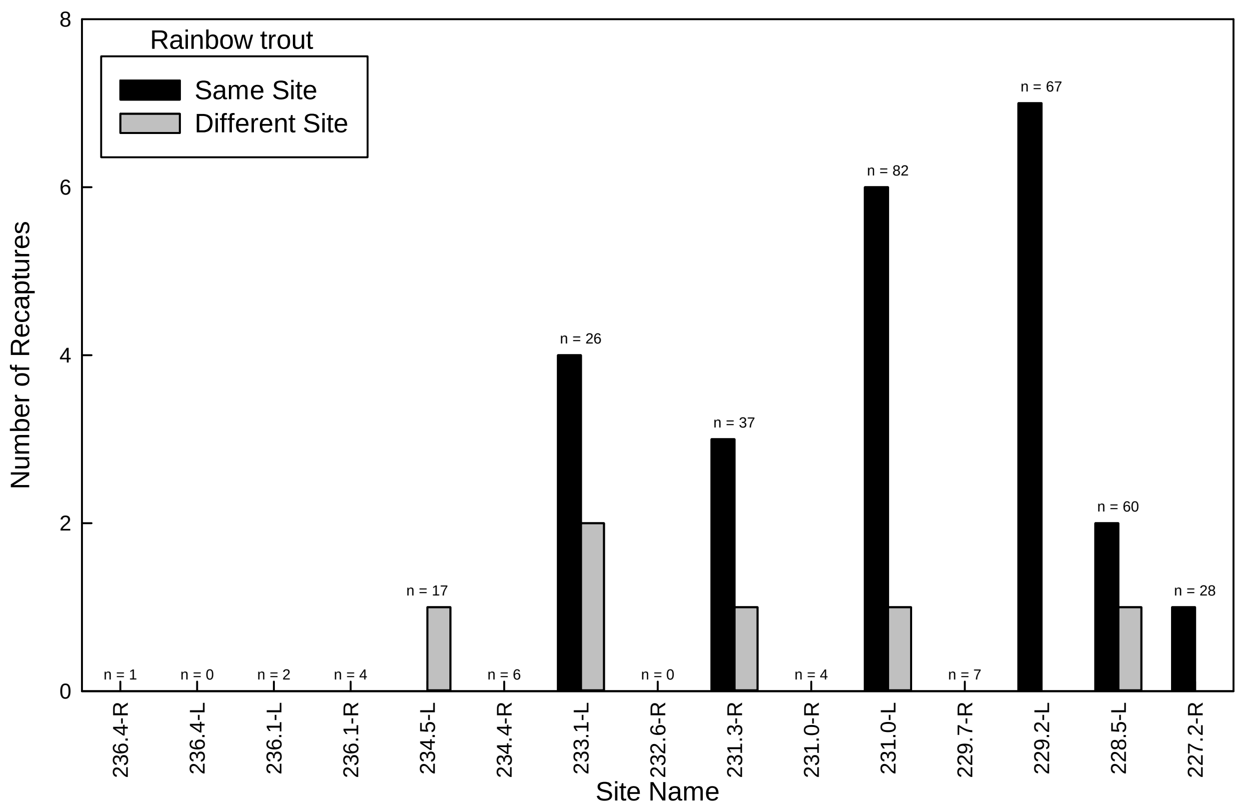



Figure D4 Summary of intra-year site movement by rainbow trout in the Middle Columbia River relative to site of initial release, 2001 to 2011 data combined. The "n" value located above each site represents the number of fish marked at that site (all years combined); excludes fish marked during the last session of each year.

# APPENDIX E

## Life History Data

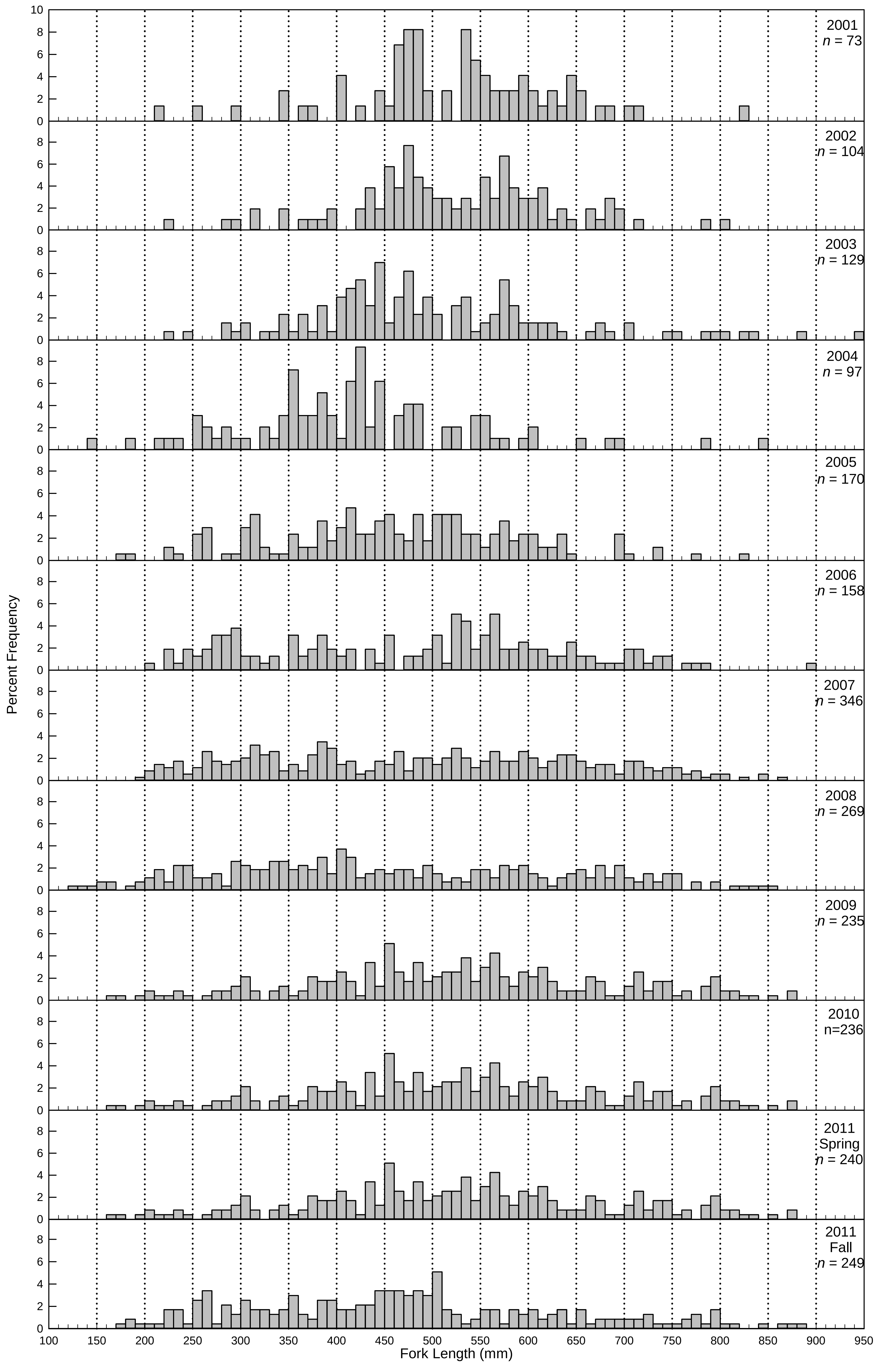



Figure E1 Length-frequency distributions for bull trout captured by boat electroshocking in the Middle Columbia River, 2001 to 2011. Bull trout that were initially marked during an earlier year of the program (i.e., 2001 to 2010) were excluded from the analysis due to potential tagging effects on growth. Boat electroshocking surveys were not conducted downstream of Big Eddy for all years prior to 2007.

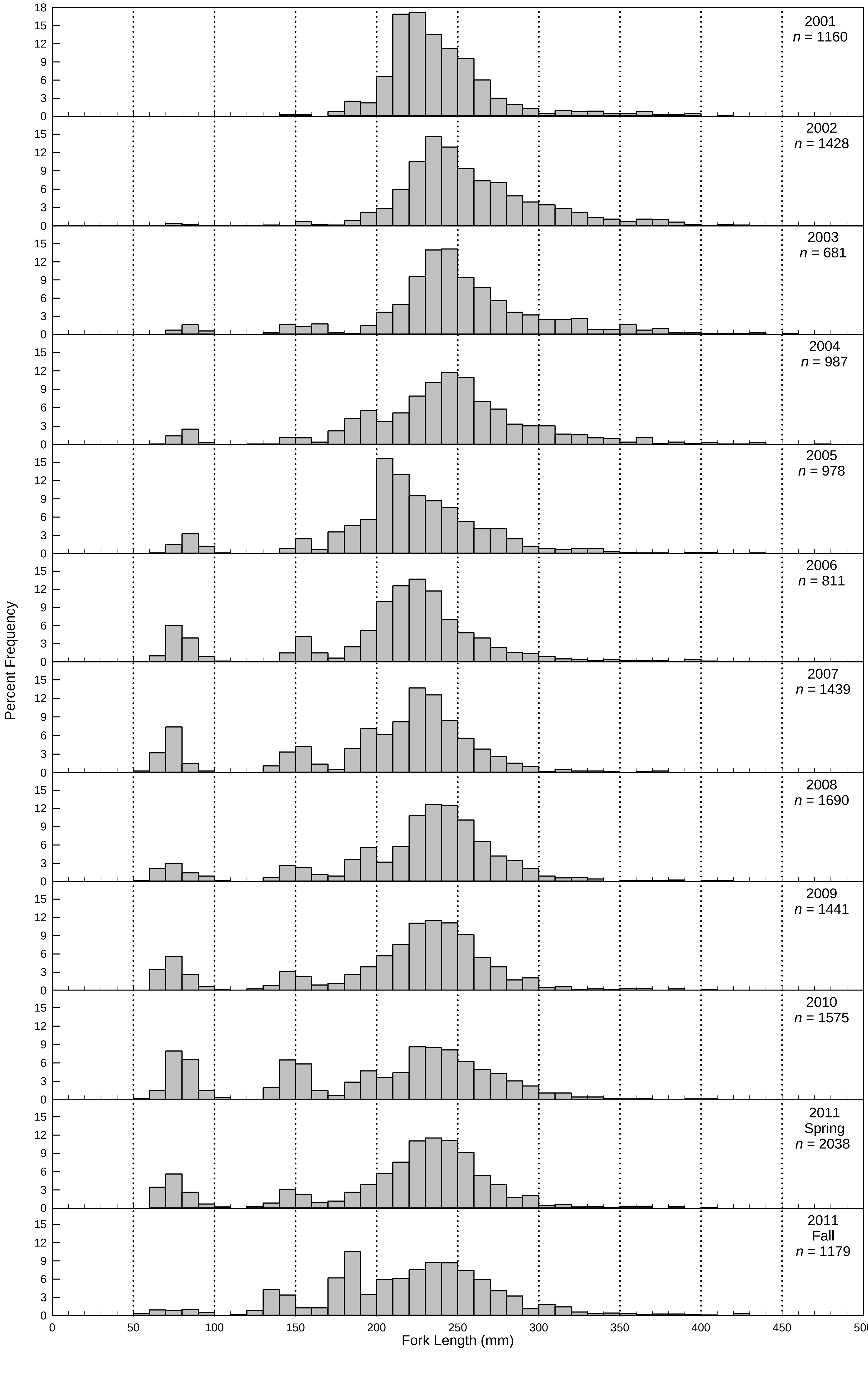



Figure E2 Length-frequency distributions for mountain whitefish captured by boat electroshocking in the Middle Columbia River, 2001 to 2011. Mountain whitefish that were initially marked during an earlier year of the program (i.e., 2001 to 2010) were excluded from the analysis due to potential tagging effects on growth. Boat electroshocking surveys were not conducted downstream of Big Eddy for all years prior to 2007.

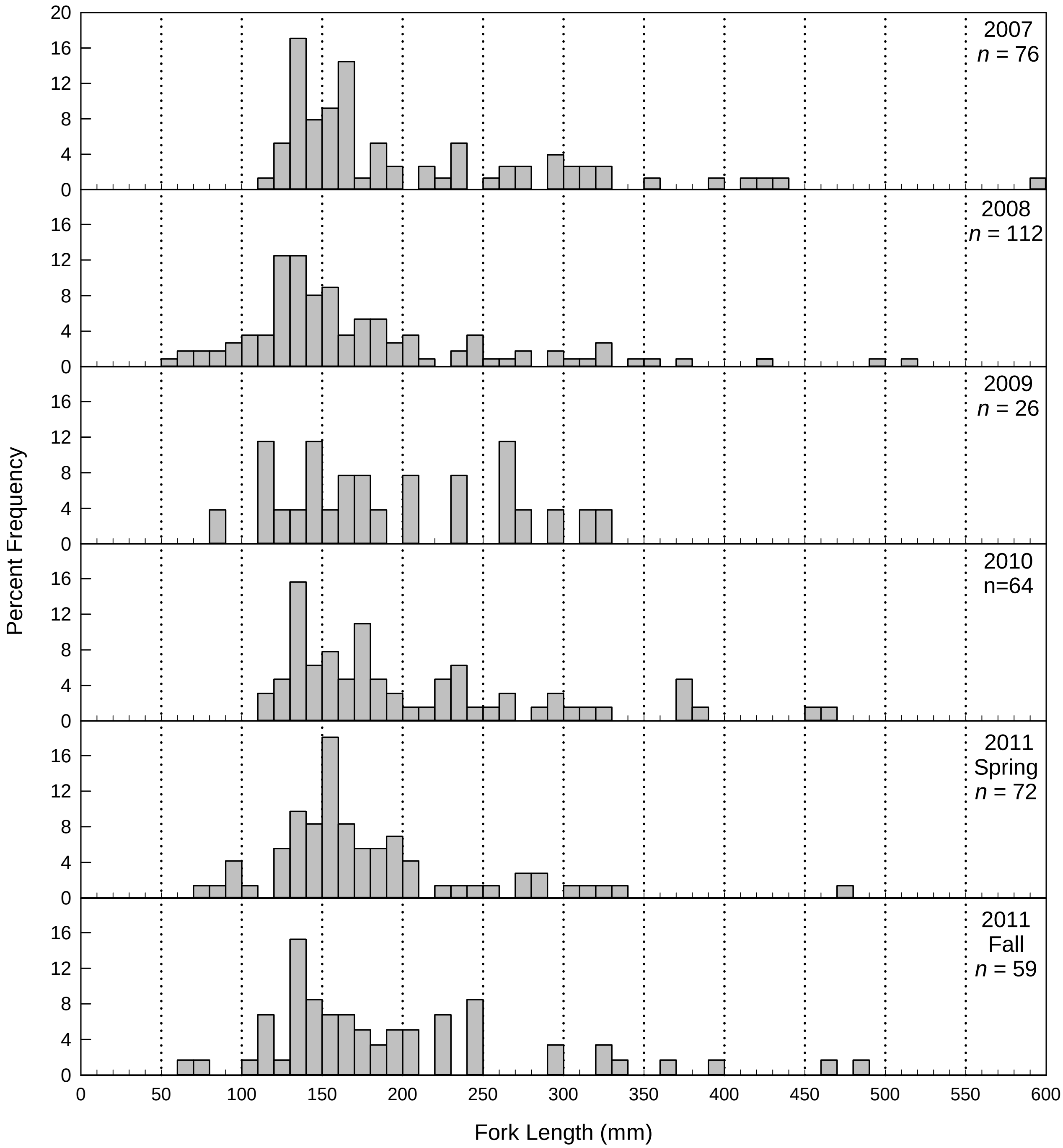



Figure E3 Length-frequency distributions for rainbow trout captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2007 to 2011. Rainbow trout that were initially marked during an earlier year of the program (i.e., 2006 to 2010) were excluded from the analysis due to potential tagging effects on growth.

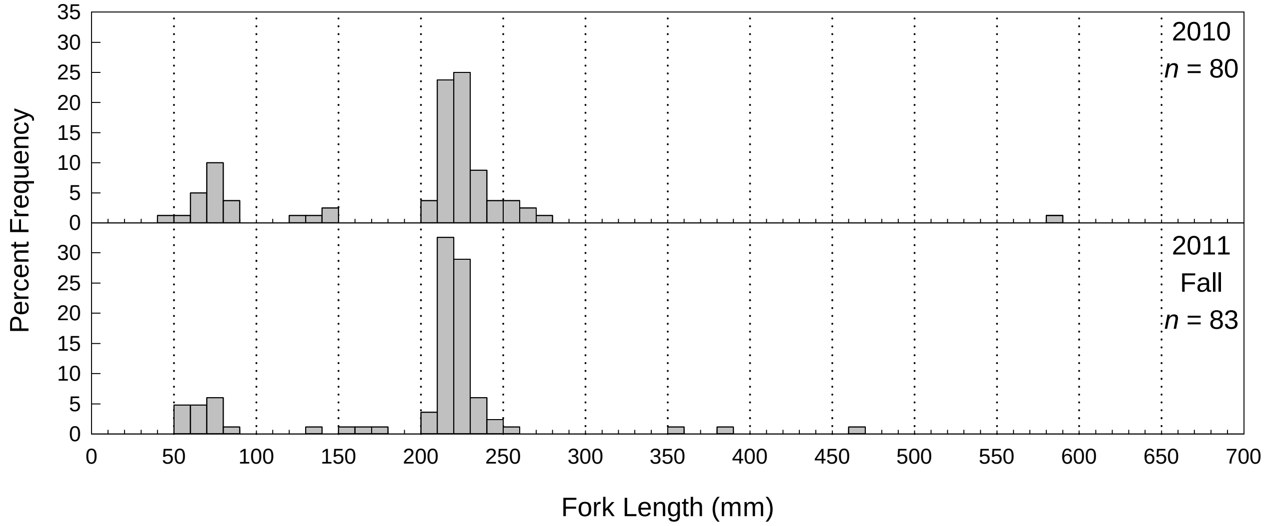



Figure E4 Length-frequency distributions for kokanee captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (fall only).

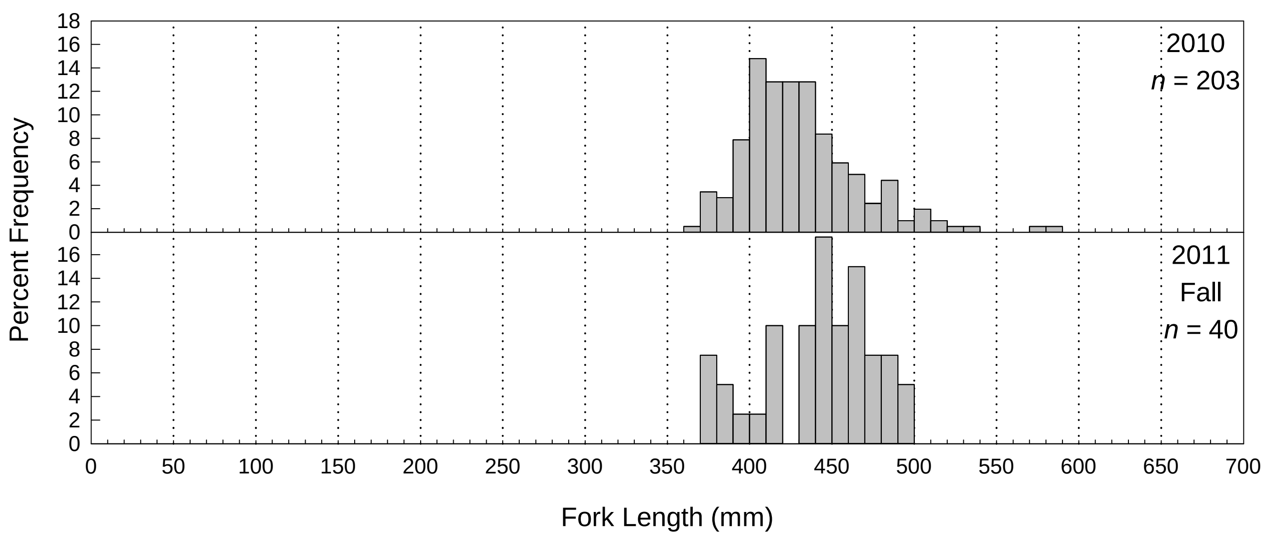



Figure E5 Length-frequency distributions for lake whitefish captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (fall only).

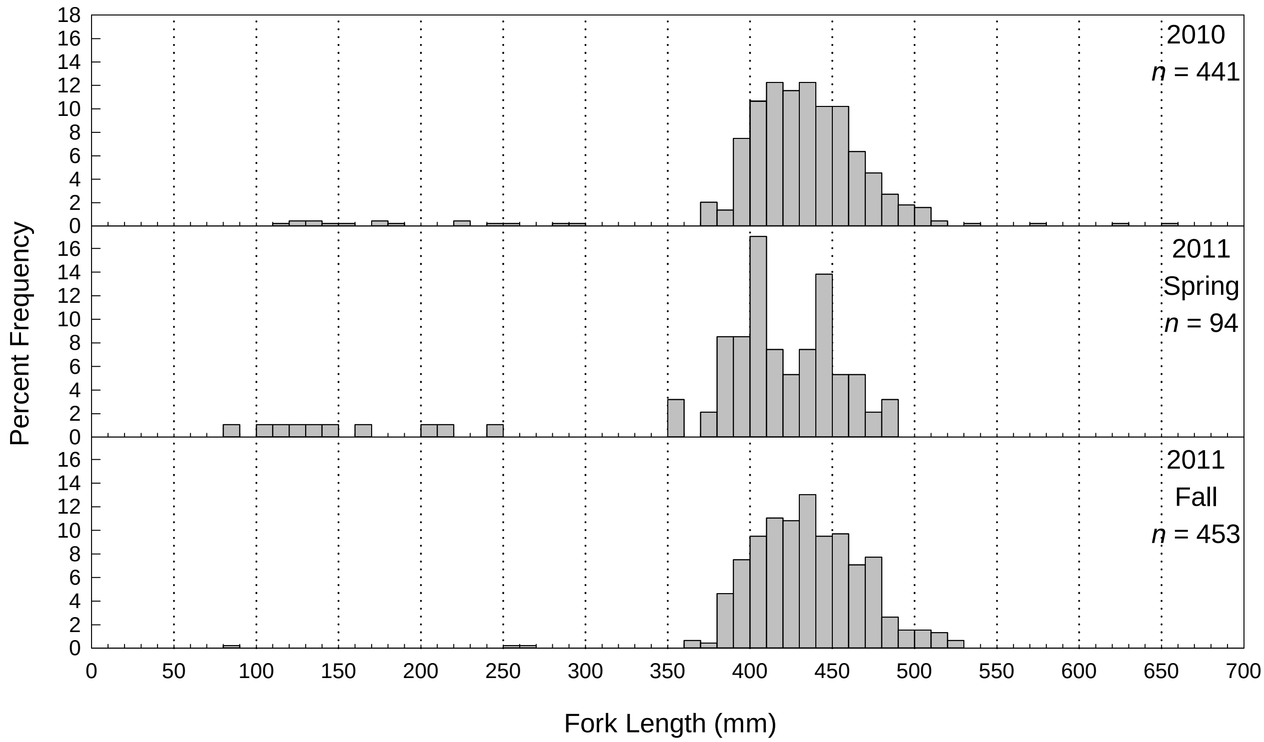



Figure E6 Length-frequency distributions for largescale sucker captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (spring and fall).

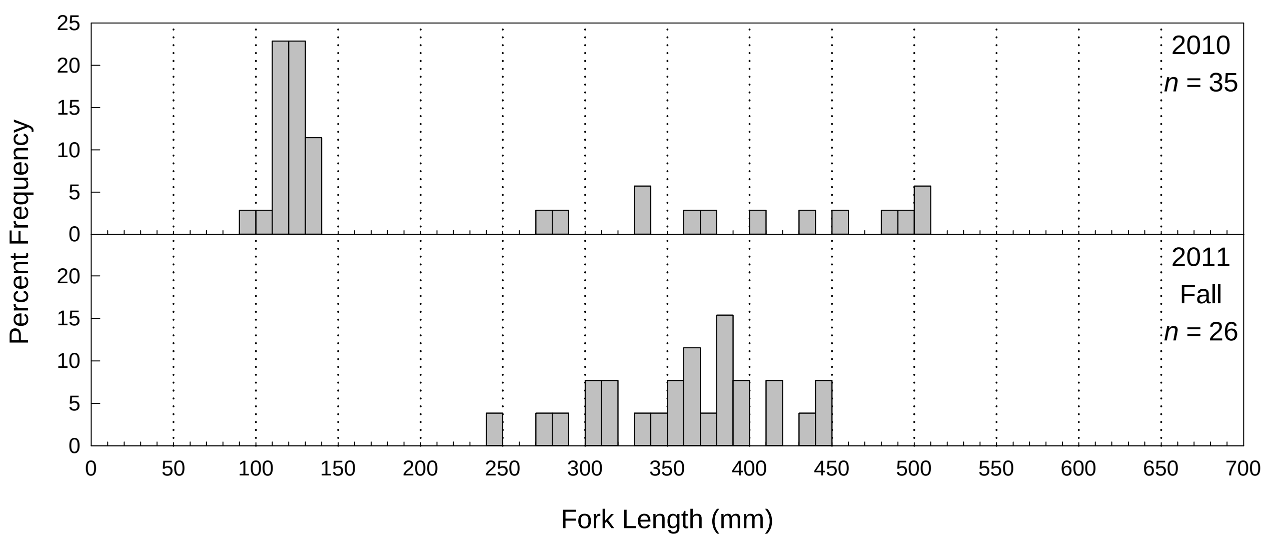



Figure E7 Length-frequency distributions for northern pikeminnow captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (fall only).

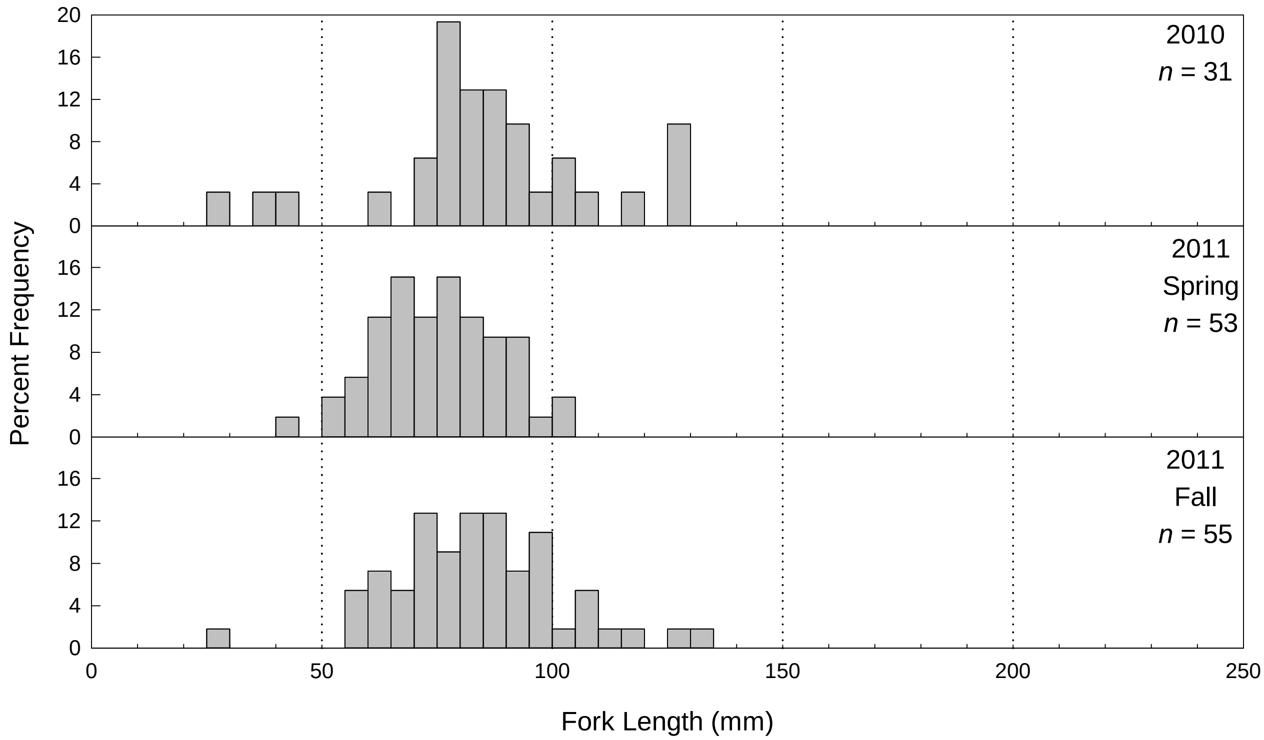



Figure E8 Length-frequency distributions for prickly sculpin captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (spring and fall).

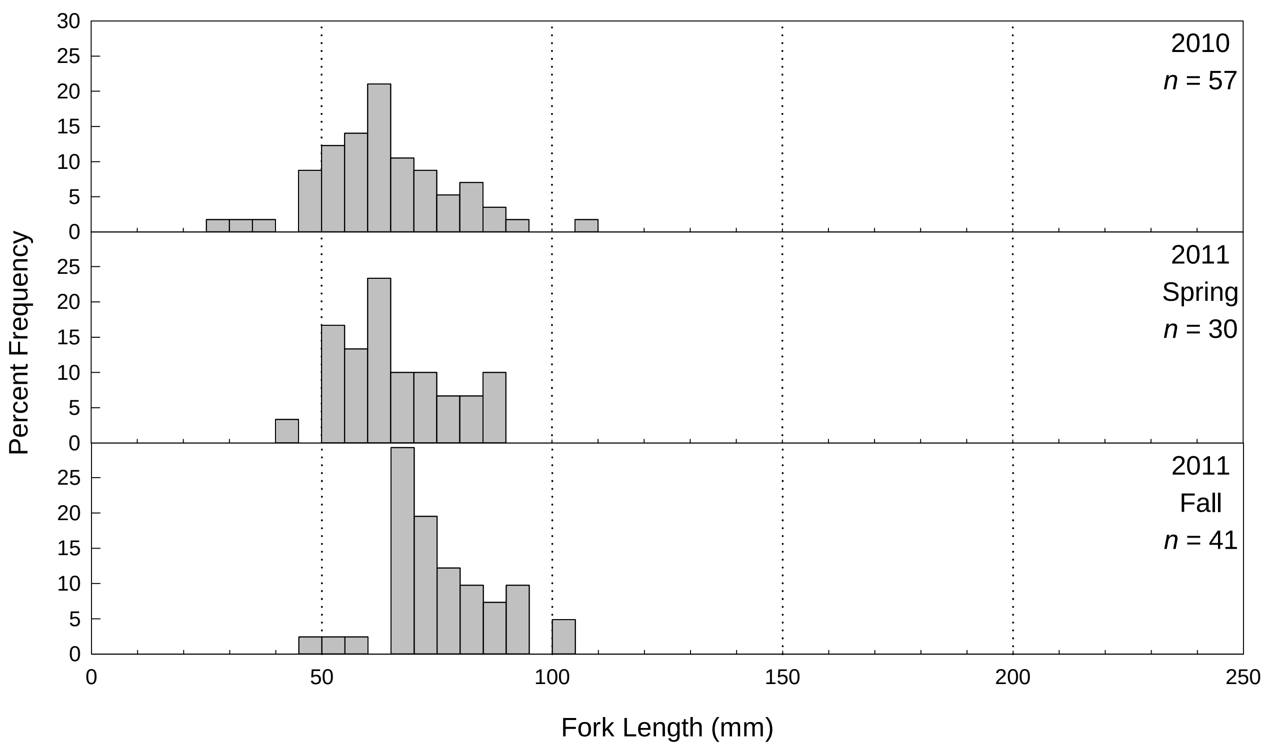



Figure E9 Length-frequency distributions for redside shiner captured by boat electroshocking in Reaches 3 and 4 of the Middle Columbia River, 2010 and 2011 (spring and fall).

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