# Campbell River Project Water Use Plan

## Upper and Lower Campbell Lake Reservoirs Fish Spawning Success

## Implementation Year 6

## Reference: JHTMON-03

*Annual Monitoring Report*

**Study Period: 2019**

**Laich-Kwil-Tach Environmental Assessment Ltd. Partnership**
**Ecofish Research Ltd.**

**October 14, 2020**

# JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment

## Year 6 Annual Monitoring Report

Prepared for:

**BC Hydro Water License Requirements**
**6911 Southpoint Drive, 11th Floor**
**Burnaby, BC V3n 4X8**

October 14, 2020

Prepared by:


**Laich-Kwil-Tach Environmental Assessment Ltd. Partnership**

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## EXECUTIVE SUMMARY

Water Use Plans (WUPs) were developed for all of BC Hydro's hydroelectric facilities through a consultative process and have implemented monitoring to address outstanding management questions. To address uncertainty around factors limiting fish abundance, monitoring programs were designed to assess whether fish benefits are being realized under the WUP operating regime and to evaluate whether limits to fish production could be improved by modifying operations in the future. The *Upper and Lower Campbell Lake Fish Spawning Success Assessment* (JHTMON-3) comprises one component of the wider effectiveness monitoring studies within the Campbell River WUP. The overall aim of JHTMON-3 is to test the assumption that recruitment of salmonids (trout and char) in Upper Campbell Reservoir (Upper Campbell Reservoir and Buttle Lake) and Lower Campbell Reservoir is limited by availability of Effective Spawning Habitat (ESH) (i.e., spawning habitat that remains 'suitable' for the duration of the spawning and following incubation periods). The three species of primary interest are Rainbow Trout, Cutthroat Trout and Dolly Varden. JHTMON-3 involves assessing the extent of spawning habitat both within and above the drawdown zone, evaluating overall habitat utilization and spawning success, and determining whether the area of functional spawning habitat is sufficient to allow the salmonid populations to fully seed the reservoirs. Results obtained thus far, particularly incubation tests and population modelling carried out during Year 5, suggest that recruitment of salmonids is limited by availability of ESH, although not to the extent assumed during the development of the Water Use Plan. Continued monitoring of critical components of the JHTMON-3 monitoring program will inform conclusions for the final Year 10 report.

*Effective Spawning Habitat Model Results*

The ESH Performance Measure Model quantifies the amount of spawning habitat within the drawdown zone that is available to fish, and is not inundated by rising reservoir levels during the egg incubation period. Because life histories and the timing of spawning and incubation vary among species, separate ESH models were run for Cutthroat Trout, Rainbow Trout and Dolly Varden.

ESH values for both Lower and Upper Campbell reservoirs were highly variable among years for all three species, particularly in the Upper Campbell Reservoir, and particularly for Cutthroat Trout. ESH values calculated for 2019 in the Upper Campbell Reservoir for both Rainbow Trout and Cutthroat Trout were the maximum values calculated for the extent of the JHTMON-3 monitoring program.

*Gill Netting Surveys*

Gill netting surveys between August 26 and August 28, 2019 (6$^{th}$ year of gillnetting surveys) in Upper Campbell Reservoir resulted in the capture of 41 Cutthroat Trout, 126 Rainbow Trout, no Dolly Varden, five sculpin, and eight Cutthroat Trout/Rainbow Trout hybrids. Catch per unit effort (CPUE) ranged from 0.053 to 0.354 fish/net hour for Cutthroat Trout and 0.19 to 1.01 fish/net hour for Rainbow Trout.

Species-specific inverse von Bertalanffy growth functions were developed during Year 5 and refined in Year 6 to assign ages of unaged fish, based on their fork length. These functions use all available

data from the monitoring program (Years 1 to 6), and therefore will progressively improve as more data is collected through this monitoring program.

Cutthroat Trout were captured in sinking nets, suggesting a benthic life style. Rainbow Trout were most abundant in floating gill nets, suggesting a pelagic life style.

*Snorkel Surveys*

Snorkel surveys were undertaken in the Lower Campbell Reservoir during March and April 2019 (6th year of snorkel surveys), to target the Cutthroat Trout spawning period, and in the Buttle Lake and Upper Campbell Reservoir in June 2019, to target the Rainbow Trout spawning period. The survey results for Rainbow Trout were incorporated into the existing enumeration of adult spawning fish in the six tributaries of Buttle Lake and Upper Campbell Reservoir since 1990.

Snorkel surveys were undertaken at three tributaries of Lower Campbell Reservoir for adult Cutthroat Trout spawners in 2019. Miller Creek and Fry Creek were sampled on March 4, 2019; Greenstone River was sampled on April 30, 2019 due to colder water conditions. Adult Cutthroat Trout were observed in Greenstone River ($n$ = 14), but none in Fry Creek or Miller Creek. However, Cutthroat Trout redds were observed in all three tributaries and were most abundant in Miller Creek ($n$ = 115), followed by Fry Creek ($n$ = 110) and Greenstone River ($n$ = 71). Juvenile Cutthroat Trout were not observed during Spring snorkel surveys. The majority of adult Cutthroat observed were either brightly coloured or undetermined, indicating spawning activity at the time of the surveys. Snorkel surveys targeting adult Rainbow Trout spawners were undertaken in tributaries to Buttle Lake and Upper Campbell Reservoir during low flow conditions from June 4 to 7, 2019. Rainbow Trout redds were recorded in all sampled tributaries. The highest number of redds was observed in Thelwood Creek (1,782 redds), followed by Upper Elk River (1,450 redds), Lower Elk River (921 redds), Wolf River (493 redds), and Ralph River (296 redds). The majority of adult Rainbow Trout observed were in mid-spawning or moderately coloured condition, and the highest numbers of adults were recorded in the Lower Elk River and Thelwood Creek. Low numbers of adult Rainbow Trout were recorded in Henshaw Creek. Observed densities of Rainbow Trout were greatest in Wolf River (2,817 fish/km), Ralph River (872 fish/km), Thelwood Creek (740 fish/km), and Philips Creek (627 fish/km). These patterns were similar to those observed during previous years of this monitoring program (2014-2018).

**MON-3 Status of Objectives, Management Questions and Hypotheses after Year 6.**

| Study Objectives | Management Questions | Management Hypotheses | Year 6 (fiscal year 2019) Status |
|---|---|---|---|
| The aim of JHTMON-3 is to test the assumption that recruitment of salmonids (trout and char) in Upper and Lower Campbell reservoirs is limited by availability of ESH. The Monitor involves assessing the extent of spawning habitat both within and above the drawdown zone; evaluating overall habitat utilization and spawning success; and determining whether the area of ESH is sufficient to allow the salmonid populations to fully seed the reservoirs.<br><br>Implementation of the WUP in the Upper and Lower Campbell Reservoirs is predicted to increase the area of ESH for both Cutthroat Trout and Rainbow Trout.<br><br>Analysis of fish abundance and spawning success before and after the WUP implementation will test the assumption that salmonid recruitment is limited by availability of ESH. | Following implementation of the Campbell River WUP, does the population of Rainbow Trout, Cutthroat Trout and Dolly Varden in Upper and Lower Campbell reservoirs increase as a result of the expected gains in functional spawning habitat? | $H_01$: Following implementation of the Campbell River WUP the abundance of adult trout does not change in Upper and Lower Campbell Reservoirs. | Data were collected as planned, from standardized snorkel surveys of spawning fish in tributaries, and gill netting of multiple cohorts in reservoirs. This was the 6th year of gillnetting and snorkel surveys.<br><br>Trends in adult trout abundance require a long period of monitoring to test this management hypothesis. However, a preliminary population model was developed and implemented as part of the Year 5 summary. Preliminary results suggest that effects of reservoir inundation on embryo mortality may be strong enough to affect the dynamics of Cutthroat Trout in the Upper Campbell Reservoir.<br><br>The approach is standard in fisheries science and is expected to answer the hypothesis. |
| | Are the trout populations in Upper and Lower Campbell reservoirs limited by the availability of ESH? | $H_02$: Following implementation of the Campbell River WUP the abundance of adult trout in Upper and Lower Campbell Reservoirs is not | Preliminary results from population modelling indicate that the availability of ESH may be a limiting factor to recruitment of salmonids |

| Study Objectives | Management Questions | Management Hypotheses | Year 6 (fiscal year 2019) Status |
|---|---|---|---|
| | | correlated with ESH at the time of the cohort's emergence. | in the Upper Campbell Reservoir.<br><br>Robust analysis of the effects of ESH on population abundance will require data collection over a longer time frame.<br><br>The current study design is appropriate to address this hypothesis. |
| | Is the ESH performance measure a reliable measure of spawning habitat, and therefore useful in the present Monitor, as well as in future WUP investigations? | $H_0$3: The proportion of mature adults that spawn in the drawdown zones of Upper and Lower Campbell reservoirs is not biologically significant.<br><br>$H_0$4: There is insufficient groundwater movement in areas of the drawdown zone suitable for trout spawning to replenish local oxygen supply and flush away metabolic waste. | Data on spawning habitat use were collected during Year 5, and integrated with information on spawning habitat availability collected during Year 4. The majority of spawning takes place in areas upstream of the drawdown zone, but it is highly variable among waterbodies. In some tributaries a considerable portion of spawning occurs within the drawdown zone.<br><br>An experimental incubation test to asses mortality rate of eggs in relation to inundation by rising reservoir water elevation was carried out during Year 5. Hydrology and water quality data were also collected to support interpretation of the experimental results. |

| Study Objectives | Management Questions | Management Hypotheses | Year 6 (fiscal year 2019) Status |
|---|---|---|---|
| | | | Survival and hatch rates differed among streams and depths, from almost no effect of inundation to a substantial effect of inundation. High mortality rate was linked to stream conditions (i.e. groundwater exchange rate, surface water flow, and percentage of fines in the substrate). |

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# 1. INTRODUCTION

## 1.1. Background to Water Use Planning

Water use planning exemplifies sustainable work in practice at BC Hydro. The goal is to provide a balance between the competing uses of water that include fish and wildlife, recreation and power generation. Water Use Plans (WUPs) were developed for all of BC Hydro's hydroelectric facilities through a consultative process involving BC Hydro, local stakeholders, government agencies and First Nations. The framework for water use planning requires that a WUP be reviewed on a periodic basis and there may be monitoring to address outstanding management questions in the years following implementation of a WUP.

As the Campbell River Water Use Plan (BC Hydro 2012) process reached completion, a number of uncertainties remained with respect to the effects of BC Hydro operations on aquatic resources. A key question throughout the WUP process was "what limits fish abundance?" For example, are fish abundance and biomass limited by available habitat, food, environmental perturbations or ecological interactions? Answering this question is an important step to better understanding how human activities in the watershed affect fisheries, and in effectively managing water uses to protect and enhance aquatic resources. To address uncertainty in our understanding of the factors that limit fish abundance and biomass, monitoring programs were designed to assess whether fish benefits are being realized under the WUP operating regime and to evaluate whether limits to fish production could be improved by modifying operations in the future.

Salmonid (trout and char) recruitment (i.e., number of fish surviving to enter a particular life stage) is assumed to be limited by the availability of suitable spawning habitat. BC Hydro affects the amount of spawning habitat through reservoir filling and drawdown. The drawdown zone refers to the area within the elevation band of the reservoir between the high and low waterlines that is susceptible to becoming either inundated or exposed from water use operations. Each tributary draining directly into the reservoirs can be divided into an upstream section above the upper limit of the drawdown zone and a lower section within the drawdown zone. Observations suggest that some resident Rainbow Trout and Cutthroat Trout spawn in tributaries and alluvial fans within the drawdown zone of Upper Campbell Lake and Buttle Lake Reservoir and Lower Campbell Lake Reservoir (Lough 2000). During the Campbell River WUP development, it was hypothesized that rising reservoir water levels during spring freshet inundate and thereby kill incubating eggs, limiting the area of ESH[1] for salmonids, and ultimately recruitment to populations in Upper Reservoir and the Lower Reservoir. The main premise for the impact hypothesis is that these fish typically dig their redds during late winter and spring when reservoir levels are low, and the redds are then susceptible to inundation from rising reservoir levels during the freshet period (Anon. 2004). In the absence of groundwater upwelling, standing water

[1] The term 'effective spawning habitat' refers to spawning habitat that remains 'suitable' for the duration of the spawning and following incubation periods.

(i.e., non-flowing water) within a redd is thought to kill incubating embryos in the pre-eyed stage because it prevents replenishment of oxygen at the egg-water interface.

The *Upper and Lower Campbell Lake Fish Spawning Success Assessment* (JHTMON-3) is one of a number of effectiveness monitoring studies within the Campbell River WUP. The objective of JHTMON-3 is to test salmonid recruitment (trout and char) in the Upper Campbell Reservoir (Upper Campbell Reservoir and Buttle Lake) and Lower Campbell Reservoir to help resource managers better understand the potential biological effects of BC Hydro operations. JHTMON-3 assesses the relationship between salmonid recruitment in the reservoirs and drawdown, specifically assessing whether population abundance of salmonids is limited by spawning habitat within the drawdown zone.

During the Campbell River WUP, an "ESH" Performance Measure (PM) was devised for trout spawners in the Upper Reservoir and the Lower Reservoir, which calculated the amount of spawning habitat inundated during the spawning and incubation period of different salmonid species. During the WUP, the ESH PM was used to evaluate reservoir operations by assuming that more spawning habitat would result in greater recruitment to Campbell River reservoirs and their tributaries. In essence, this PM assumed that recruitment of trout in the reservoirs is limited by functional spawning habitat. The aim of the JHTMON-3 monitoring study is to test this assumption.

## 1.2. BC Hydro Infrastructure, Operations, and Monitoring Context

### 1.2.1. Overview

The Campbell River WUP project area is complex and includes facilities and operations in the Campbell and Quinsam watersheds. The Upper and Lower Campbell reservoirs are located due west of the city of Campbell River on the east coast of Vancouver Island, British Columbia (Map 1). Details of BC Hydro's Campbell River infrastructure and operations are provided in the Campbell River System WUP (BC Hydro 2012).

### 1.2.2. Upper Campbell Reservoir

Buttle Lake and Upper Campbell Reservoir are effectively a single reservoir that is the largest in the Campbell River hydroelectric system. The largest tributaries are Thelwood Creek, entering the system at the south end of Buttle Lake, and the Elk River, which enters the west side of Upper Campbell Reservoir. Upper Campbell Reservoir is impounded by the Strathcona Dam, which was constructed between 1955 and 1958 and had a second generating unit installed in 1968. The dam also provides primary flow regulation for the Ladore and John Hart Dams, which are located downstream. Upper Campbell Reservoir's historic operational water elevation has been between 221.0 m and 210.0 m. The licenced storage for operations in Buttle Lake and Upper Campbell Lake Reservoir are 212.00 masl to 220.98 masl and 192.00 masl to 220.98 masl, respectively (BC Hydro 2012).

### 1.2.3. Lower Campbell Reservoir

Lower Campbell Reservoir is located 15 km east of Campbell River. It is located to the east, and at the outflow of, the Upper Campbell Reservoir (Map 1). Lower Campbell Reservoir is impounded by the Ladore Dam. The Ladore Dam was originally completed in 1949, and two generating units were added in 1957. The reservoir's historic operational water elevation has been between 178.3 masl and 174.0 masl, while the current storage licence limits for operation is 178.3 masl to 163.65 masl (BC Hydro 2012).

## 1.3. Historical Reservoir Elevations, and Implementation of the Interim Flow Management Strategy

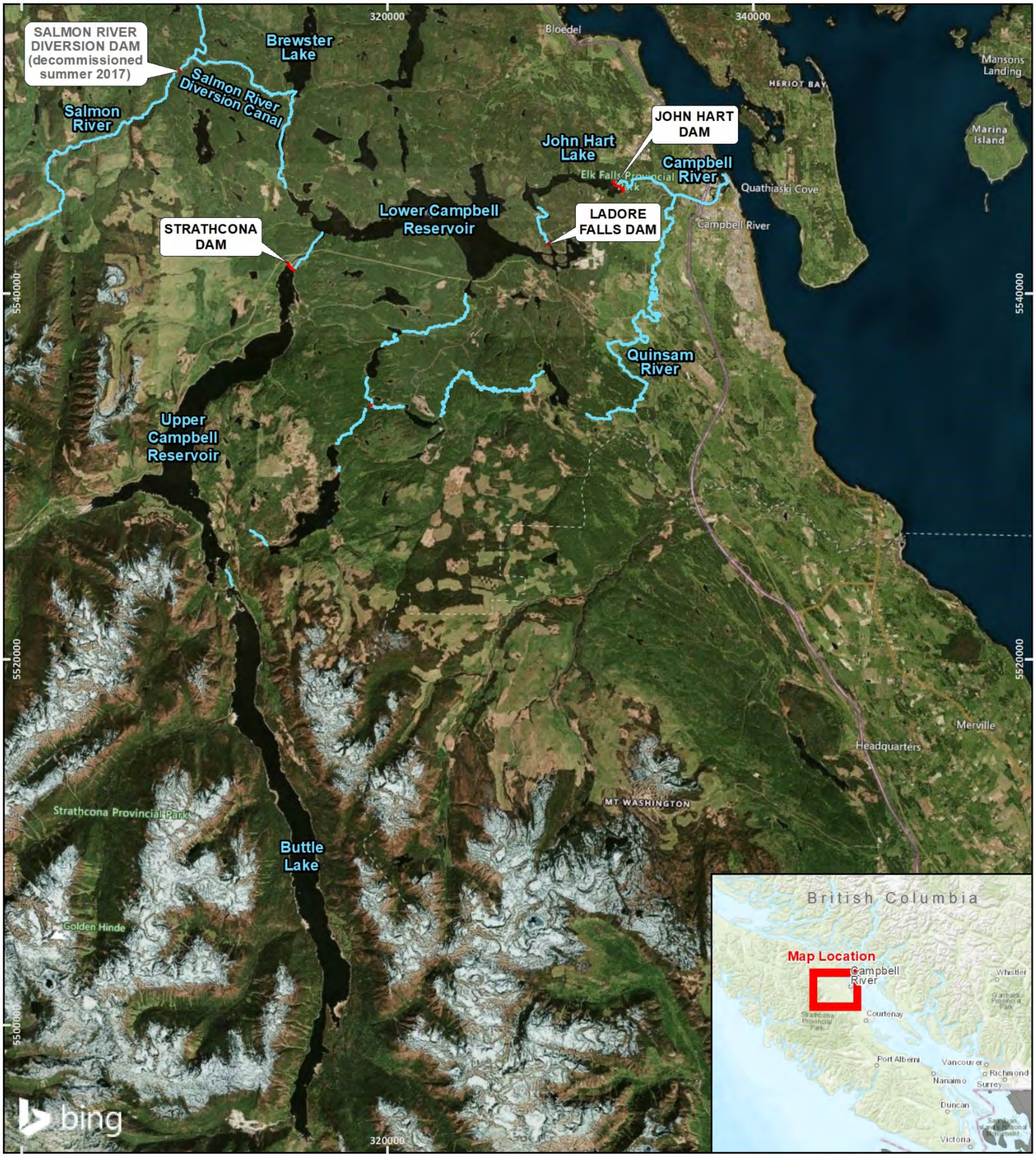
The Upper Campbell Reservoir experiences water level fluctuations of 4 to 10 m within years. (Figure 1). Fluctuations differ among years depending on hydrological conditions; however, in general, the reservoir is drawn down in late winter and early spring and recharges during late spring and early summer. A second drawdown typically occurs in late summer and early fall, prior to recharge due to fall rains. Seasonal changes are much less pronounced in Lower Campbell Reservoir, which is operated within a narrower range of elevations (Figure 2).

BC Hydro implemented an Interim Flow Management Strategy (IFMS) in October 1997, with the aim of balancing power generation with fisheries and wildlife habitat, shoreline conditions, flood control, and recreation interests. The IFMS was later replaced by the WUP, although impacts on reservoir elevations were minimal with respect to those outlined in the IFMS. Figure 1 and 2 show the impact that the implementation of the IFMS had on elevations of the Upper and Lower Campbell Reservoirs. Following implementation of the IFMS, seasonality in elevation of the Upper Campbell Reservoir remained relatively stable, except for an increased duration of the period of high elevations during the summer, and a change in the seasonality of the elevation of the reservoirs in the spring, with a slightly longer period of low reservoir elevation and lower elevations. In general, the mean, $10^{th}$ and $90^{th}$ quantiles of reservoir elevations were ~2m lower post-implementation of the IFMS (Figure 1). The implementation of the IFMS did not affect elevation of the Lower Campbell Reservoir (Figure 2).

## 1.4. Management Questions and Hypotheses

The overall objective of JHTMON-3 is to test the assumption that recruitment of salmonids (trout and char) in Upper and Lower Campbell reservoirs is limited by availability of ESH. Testing this assumption was conducted by: 1) assessing the extent of spawning habitat both within and above the drawdown zone; 2) evaluating overall habitat utilization and spawning success; and 3) determining whether the area of functional spawning habitat is sufficient to allow the salmonid populations to fully seed the reservoirs. The three species of primary interest for the study are Rainbow Trout, Cutthroat Trout, and Dolly Varden.

# Project Overview




**Legend**

Dam

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 2 4 6 8 10 12 km

Scale: 1:300,000

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ECOFISH RESEARCH

Map 1

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The JHTMON-3 monitoring program aims to address the following three management questions (BC Hydro 2015):

1. Following implementation of the Campbell River WUP, do the populations of Rainbow Trout, Cutthroat Trout, and Dolly Varden in the Upper Reservoir and Lower Reservoir increase as a result of the expected gains in functional spawning habitat?

And, by corollary:

2. Are the trout populations in Upper Reservoir and the Lower Reservoir limited by the availability of functional spawning habitat?
3. Is the ESH Performance Measure a reliable measure of spawning habitat, and therefore useful in the present monitoring study, as well as in future WUP investigations?

In addressing these questions, the monitoring study is designed to test the following four null hypotheses:

$H_0$1: Following implementation of the Campbell River WUP:

a. The abundance of adult trout does not change in Upper Reservoir.
b. The abundance of adult trout does not change in Lower Reservoir.

$H_0$2: Following implementation of the Campbell River WUP:

a. Abundance of adult trout in Upper Reservoir is not correlated with ESH at the time of the cohort's emergence.
b. Abundance of adult trout in Lower Reservoir is not correlated with ESH at the time of the cohort's emergence.

$H_0$3: The proportion of mature adults that spawn in the drawdown zones of Upper Reservoir and the Lower Reservoir is not biologically significant.

$H_0$4: There is insufficient groundwater movement in areas of the drawdown zone suitable for trout spawning to replenish local oxygen supply and flush away metabolic waste.

### 1.5. Scope of the JHTMON-3 Study

The current JHTMON-3 TOR proposes a 10-year study with the following study components:

1. Annual (Years 1-9) trap and gill net surveys of fish abundance and biomass in the reservoirs;
2. A two-year survey of spawning distribution in reservoir tributaries; and
3. A two-year detailed analysis of flow and incubation conditions within the drawdown zone of tributaries.

Methods for this multi-year study have changed in accordance with results from previous years. Results from the Year 1 studies (Hatfield *et al.* 2015) indicated that hydro-acoustic surveys provide coarse estimates of adult population, but do not yield age-specific abundances and therefore are not useful for assessing the effects of varying ESH values over time. Trap netting was found to be most effective at catching sculpin and stickleback, while gill nets are most effective at catching salmonids including Cutthroat Trout and Rainbow Trout. The additional sampling effort and cost associated with calibration of the gill net catches with trap net catches was determined to be not feasible. Trap net sampling was therefore discontinued for the 2016 (Year 3) monitoring program and only gill net sampling was continued.

The implemented Year 6 program followed the approach adopted for Years 3 to Year 5. Methods related to $H_0 1$ and $H_0 2$ in Year 6 involved:

1. Estimating fish abundance for salmonid species in Upper Campbell Reservoir, using sampling with gill nets.
2. Estimating abundance of spawning adfluvial trout (Cutthroat and Rainbow) using snorkel surveys in tributaries to Buttle Lake and Upper and Lower Campbell reservoirs.

Results from tests of null hypotheses $H_0 3$ and $H_0 4$ were presented in the JHTMON-3 Year 5 monitoring report (Buren *et al.* 2019). Briefly, results related to $H_0 3$ indicated that the majority of spawning takes place in areas upstream of the drawdown zone, but it is highly variable among waterbodies. In some tributaries a considerable portion of spawning occurs within the drawdown zone. Related to $H_0 4$, we carried out experimental incubation tests to asses mortality rate of eggs in relation to inundation. The incubation tests suggest that the modeling assumptions used during the WUP (i.e., reservoir inundation led to complete and instantaneous death of incubating Rainbow Trout embryos) were conservative and likely overestimated the effects of reservoir inundation. However, we observed high mortality of eggs at some sites, which provided some support to the assumption. These elevated mortality rates were tentatively linked to stream conditions (i.e., groundwater exchange rate, surface water flow, and percentage of fines in the substrate).

**Figure 1.** **Elevation of Upper Campbell Reservoir (recorded at Strathcona Dam), pre- and post-implementation of the Interim Flow Management Strategy. Grey lines represent elevations for individual years, blue lines represent mean elevations, red lines represent the 90th percentile elevations, and green lines represent the 10th %ile elevations. Timing of salmonid spawning and incubation periods are shown.**

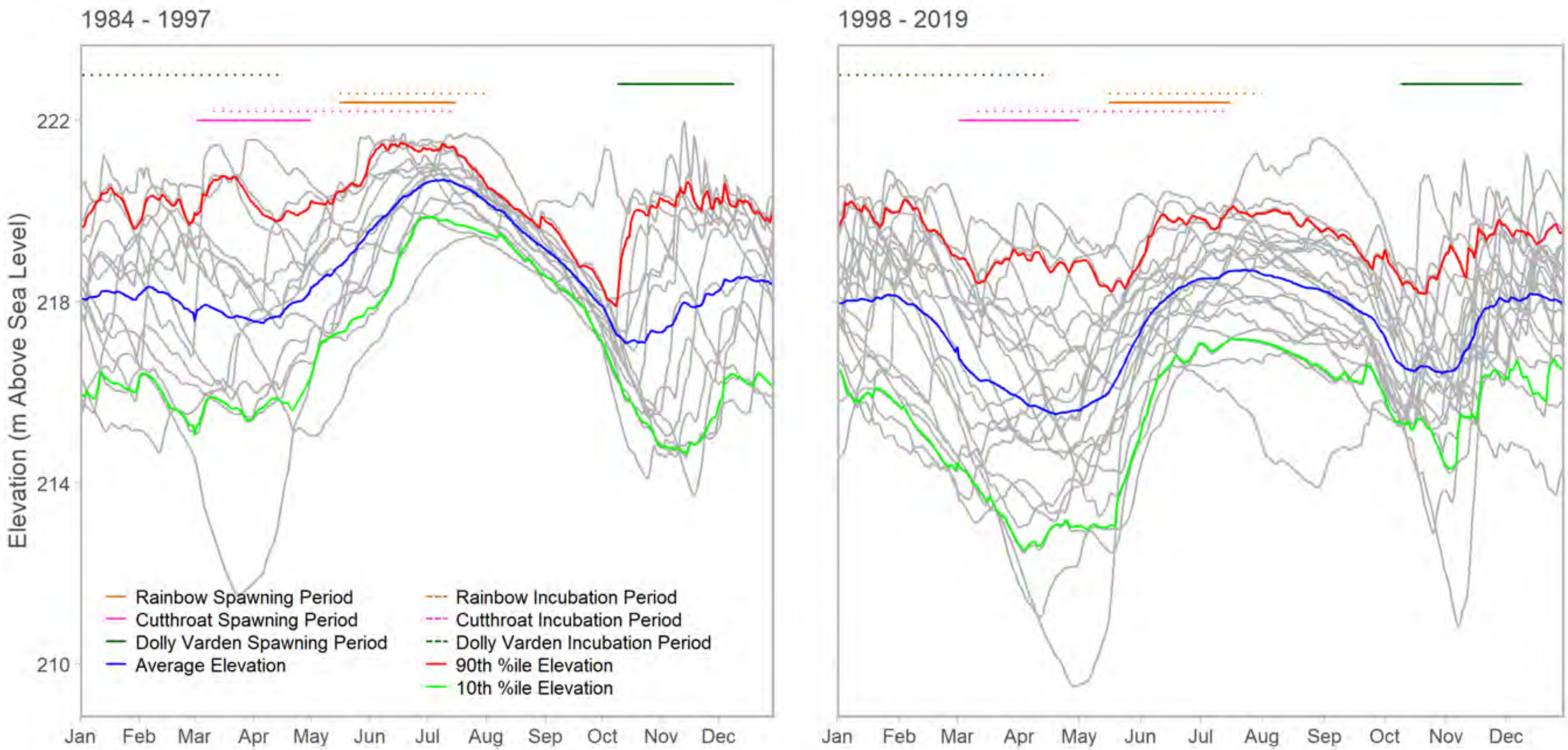
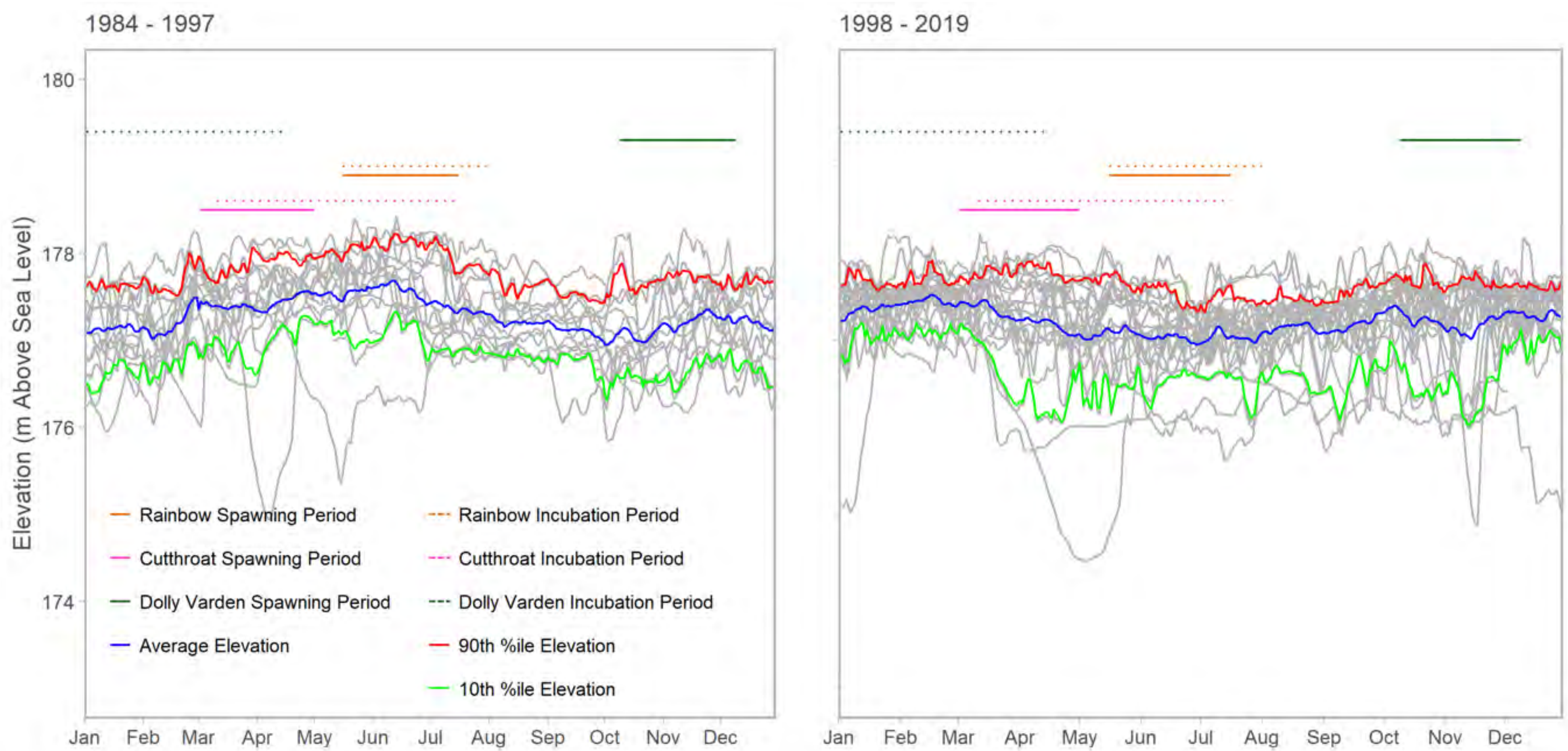


Figure 2. Elevation of Lower Campbell Reservoir (recorded at Ladore Dam), pre- and post-implementation of the Interim Flow Management Strategy. Grey lines represent elevations for individual years, blue lines represent mean elevations, red lines represent the 90th percentile elevations, and green lines represent the 10th %ile elevations. Timing of salmonid spawning and incubation periods are shown.



# 2. METHODS

## 2.1. Effective Spawning Habitat (ESH)

To quantify how reservoir elevations may affect the success of spawning in tributary sections of the drawdown zones, an ESH performance measure was developed in the WUP (FTC 2003). The term "ESH" is used to refer to habitat that maintains its quality sufficiently to allow successful spawning and incubation. This performance measure is used to evaluate mortality of eggs following inundation, caused by accumulation of by-products of metabolism and insufficient oxygen replenishment. BC Hydro developed an ESH model to quantify ESH and to track the amount of habitat available for spawning that also receives sufficient flow during incubation periods (Leake, pers. comm. 2015).

The amount of spawning habitat present for each day of spawning, and remaining habitat thereafter during incubation, was determined from reservoir-specific relationships between reservoir level and available spawning habitat (provided by BC Hydro, (Leake, pers. comm. 2015)) (Figure 3). Mean daily reservoir elevations for Strathcona Dam (Upper Campbell Reservoir) and Ladore Dam (Lower Campbell Reservoir) used in ESH modelling were provided by BC Hydro (Leake, pers. comm. 2015).

The incubation period was defined separately for the three species of interest, given their different life histories (Table 2); each species differs in the date of start and duration of incubation. Life history parameters were assumed to be constant across years. Incubation begins on the day of spawning and is assumed to last until a species-specific threshold in accumulated thermal units (ATU; i.e., daily accumulation of water temperature) is reached: 550 ATU for Cutthroat Trout, 600 ATU for Rainbow Trout, and 700 ATU for Dolly Varden (Table 2). Once this threshold is reached, eggs hatch. The metric Accumulated Thermal Units (ATU) was defined as the cumulative sum of daily average water temperature (Figure 4) (Leake, pers. comm. 2015). The ATU was tracked for each species during the corresponding incubation period and when the threshold ATU was reached (or on the incubation date end, whichever comes first), incubation was assumed to cease.

For each day of the incubation period, an effective spawning elevation was derived from the daily average reservoir elevation. If this elevation exceeded the reservoir elevation on the day of spawning by 25 cm for two consecutive days, then a portion of habitat was assumed to be lost. ESH area was determined from the effective spawning elevation and reservoir-specific relationships (Figure 3).

To obtain overall ESH, the daily ESH area was weighted by species-specific spawning intensities (Figure 5), to account for seasonality in the use of spawning habitat. Spawning intensities were assumed to be constant across years, and follow a normal distribution with species-specific mean and standard deviations provided in Table 2. Standard deviation in mean spawning date was assumed to be equal to spawning duration divided by six.

Total annual ESH was calculated as the cumulative sum of the daily ESH during the spawning period. Similarly, total annual loss of effective habitat was calculated as the cumulative sum of the daily habitat loss during the spawning period.

The model is presented below as pseudo code. For each species, year, and day within the spawning period, the following steps were completed:

1. The mean daily reservoir elevation ("spawning elevation") was determined (data provided by BC Hydro);
2. The "effective spawning elevation" was set to the spawning elevation, the total ATU was set to the water temperature for the spawning day;
3. For each day of the incubation period:
    a. The reservoir elevation was compared to the effective spawning elevation;
    b. If the reservoir elevation exceeds effective spawning elevation by 25 cm for two consecutive days, then the effective spawning elevation was set to the reservoir elevation minus 25 cm;
    c. The ATU for the incubation day was added to the total ATU.
4. At the end of incubation (when the total ATU meets the values in Table 1, or on the incubation end date in Table 1; whichever comes first) the ESH area was determined from the effective spawning elevation (Figure 3) (Leake, pers. comm. 2015);
5. ESH (area days, expressed as $m^2d$) was calculated by multiplying the ESH area by the spawning intensity, which was provided as a function of calendar date (Figure 5);
6. The initial spawning habitat was calculated by determining the habitat area for the spawning elevation and multiplying by the spawning intensity; and
7. Loss of habitat was calculated by subtracting the ESH from the initial spawning habitat.

The above calculations were computed for each day of the spawning period and summed over each year to obtain total ESH and habitat loss.

Information pertaining to reservoir-specific relationship between reservoir elevation and available habitat (Figure 3), water temperature in the Upper and Lower Campbell Reservoirs (Figure 4), species-specific life histories (Figure 5 and Table 2), as well as mean daily reservoir elevations for Strathcona Dam (Upper Campbell Reservoir) and Ladore Dam (Lower Campbell Reservoir) used in ESH modelling were provided by BC Hydro.

**Table 1. Spawning and incubation timing information used in the effective spawning habitat model for Cutthroat Trout, Rainbow Trout, and Dolly Varden (Leake, pers. comm. 2015).**

| Species | Period | Start | End | Peak | μ (days) | σ (days) | Duration (days) | Total ATUs for Fish |
|---|---|---|---|---|---|---|---|---|
| Cutthroat Trout | Spawning | 01-Mar | 30-Apr | 22-Mar | 22 | 10.2 | 61 | 550 |
| | Incubation | 01-Mar | 15-Jul | | | | | |
| Rainbow Trout | Spawning | 15-May | 31-Jul | 08-Jun | 25 | 13 | 78 | 600 |
| | Incubation | 15-May | 15-Aug | | | | | |
| Dolly Varden | Spawning | 08-Oct | 08-Dec | 01-Nov | 25 | 10.3 | 62 | 700 |
| | Incubation | 08-Oct | 15-Apr | | | | | |

$$\text{Spawning Intensity} = e^{-\left(\frac{(Day - Start\ Day + 1 - \mu)^2}{(2\sigma^2)}\right)} / (\sigma\sqrt{2\pi})$$

μ: Peak - Start Day + 1
σ: Duration/6

**Figure 3. Relationships between spawning habitat within the drawdown zone and reservoir elevation for Upper Campbell Reservoir at Strathcona Dam (SCA) and Lower Campbell Reservoir at Ladore Dam (LDR). Additional spawning habitat above the drawdown zone is not accounted for in the model (Leake, pers. comm. 2015).**

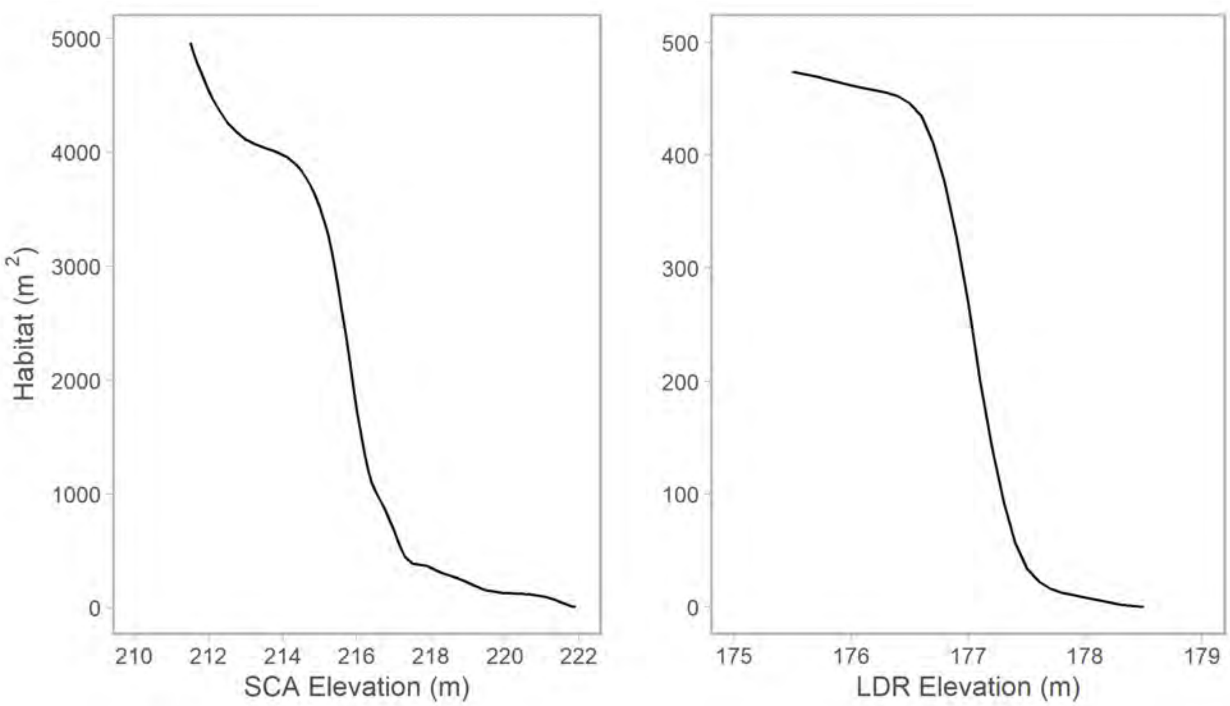


**Figure 4. Water temperature trends used for effective spawning habitat model for Upper Campbell Reservoir at Strathcona Dam (SCA) and Lower Campbell Reservoir at Ladore Dam (LDR) (Leake, pers. comm. 2015).**

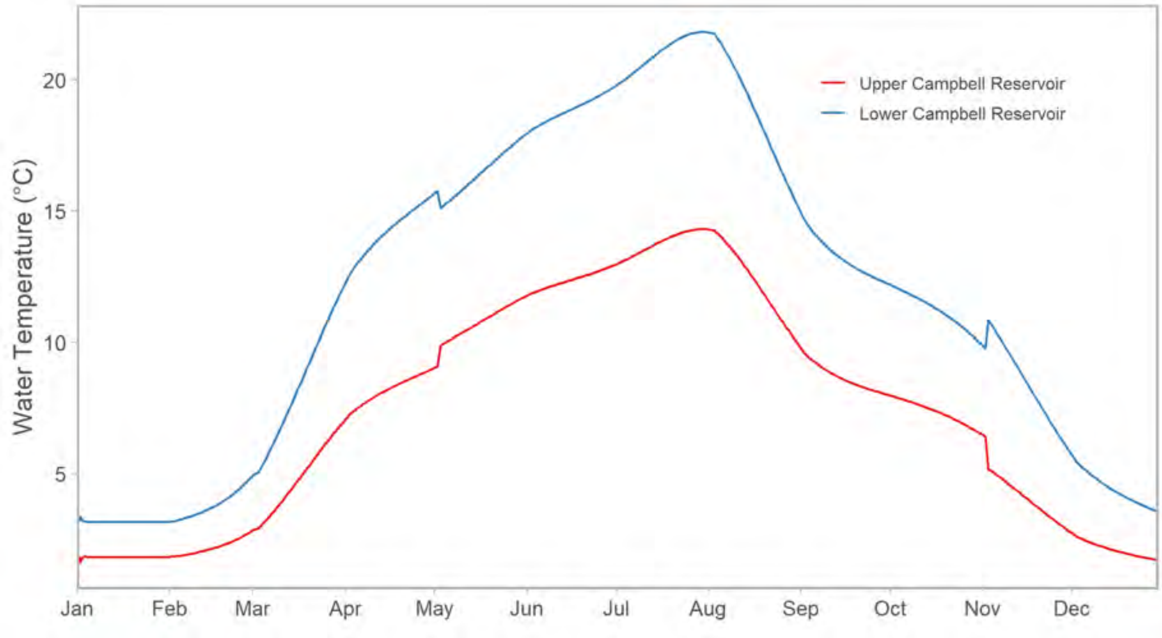
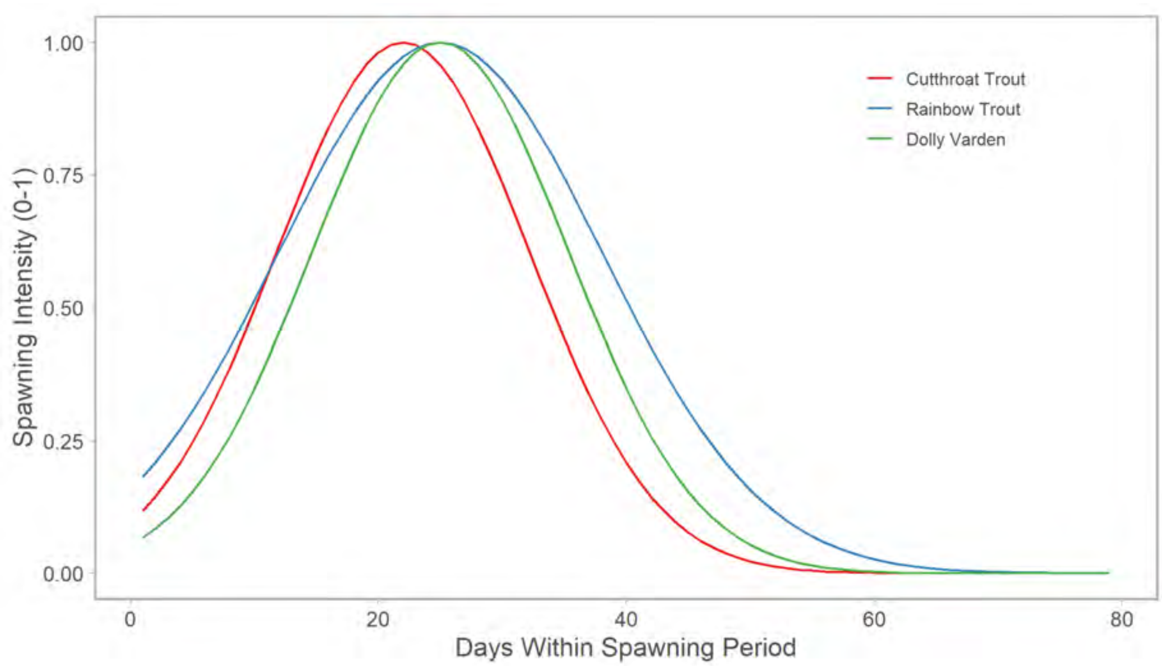



**Figure 5. Timing of spawning intensity for Cutthroat Trout, Rainbow Trout, and Dolly Varden used in the effective spawning habitat model (Leake, pers. comm. 2015).**



## 2.2. Population Index for Upper Campbell Reservoir

### 2.2.1. Field and Laboratory Work

#### 2.2.1.1. Gill Netting

The study areas for JHTMON-3 are the Upper Campbell (including Buttle Lake) and Lower Campbell reservoirs and tributaries. Sample sites within the study areas were selected based on location within the drawdown zone and are presented in Map 2. Bathymetric maps were reviewed to identify sampling sites with suitable depth profiles. Site locations were selected in 2014 and the same locations were resampled in from 2015 to 2019.

The Year 6 gill netting surveys of Upper Campbell Reservoir were conducted using the same methods as Years 2 to 5 (2015-2018) studies. The gill netting sampling objective was to produce a fish abundance index by species and age. Gill netting targeted rearing areas for younger fish. To maintain consistency, the same six sites as in previous years were sampled, and during similar dates; i.e., late summer (between August 26 and August 28, 2018) (Table 2). Both floating and sinking gill nets were used to target specific strata within the water column.

At each site, one surface and one bottom overnight gill net was set, for a total of 12 overnight RISC nets sets in Upper Campbell Reservoir. The catch and depth fished for each panel of each net was recorded. Nets were set perpendicular to shore with sinking nets set on the bed and floating nets set on the surface. RISC-standard gill nets were used (91.2 m long); the nets consist of six panels, each 15.2 m long and of different mesh sizes (25 mm, 76 mm, 51 mm, 89 mm, 38 mm, and 64 mm) strung together to form a 91.2 m long and 2.4 m deep net. Two Nordic nets were used in addition to the RISC nets at sites UCR-LKGN04 and UCR-LKGN07; these nets were 13.0 m long by 1.8 m wide, with varying mesh sizes (12.5 mm, 19 mm, 16 mm and 25 mm) sequenced to capture a range of size classes of fish.

When setting a net, the boat operator ensured the proper location and depth of the site using a GPS and depth sounder and positioned the net according to depth contours and wind conditions. The net was held in place with a net anchor at each end of the net. Nets were set overnight with soak times of 18 to 21 hours. Floating lights were attached to each net to mark their location overnight for boater safety. All fish captured from 80 mm to 150 mm for parr (with the exception of Miller Creek; 90 mm to 180 mm for parr), during gill netting were identified to species, weighed, and measured to the nearest mm (fork length) in the field. Scales and otoliths were taken from Rainbow Trout and Cutthroat Trout to allow for age classes to be assigned to both species. The aim of field protocols associated with this sampling was to ensure that all live fish were returned to the reservoir in good condition. Captured live fish were anaesthetized as necessary to reduce handling stress.

**Table 2. Sampling dates, site locations, and site conditions for Year 6 gill netting surveys on Upper Campbell Reservoir, August 2019.**

| Waterbody | Site | Sampling Date | UTM Zone | UTM Easting | UTM Northing | Set # | Net Type | Net Position[1] | Net Length | Water Temp. (°C) | Turbidity[2] | Estimated Visibility (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | UCR-LKGN01 | 26-Aug-19 | 10U | 314096 | 5539930 | 1 | RISC | SK | 91.2 | 20.5 | C | 6 |
| | | 26-Aug-19 | 10U | 314096 | 5539930 | 2 | RISC | FL | 91.2 | 20.5 | C | 6 |
| | UCR-LKGN02 | 26-Aug-19 | 10U | 314629 | 5537246 | 1 | RISC | SK | 91.2 | 20.1 | C | 6 |
| | | 26-Aug-19 | 10U | 314629 | 5537246 | 2 | RISC | FL | 91.2 | 20.1 | C | 6 |
| | UCR-LKGN04 | 27-Aug-19 | 10U | 308638 | 5533904 | 1 | RISC | SK | 91.2 | 20.7 | C | 6 |
| | | 27-Aug-19 | 10U | 308638 | 5533904 | 2 | RISC | FL | 91.2 | 20.7 | C | 6 |
| | | 27-Aug-19 | 10U | 308638 | 5533904 | 3 | Nordic | SK | 13 | 20.7 | C | 6 |
| | UCR-LKGN06 | 27-Aug-19 | 10U | 309419 | 5527967 | 1 | RISC | SK | 91.2 | 21.2 | C | 6 |
| | | 27-Aug-19 | 10U | 309419 | 5527967 | 2 | RISC | FL | 91.2 | 21.2 | C | 6 |
| | UCR-LKGN07 | 28-Aug-19 | 10U | 310848 | 5526008 | 1 | RISC | SK | 91.2 | 21 | C | 6 |
| | | 28-Aug-19 | 10U | 310848 | 5526008 | 2 | RISC | FL | 91.2 | 21 | C | 6 |
| | | 28-Aug-19 | 10U | 310848 | 5526008 | 3 | Nordic | SK | 13 | 21 | C | 6 |
| | UCR-LKGN08 | 28-Aug-19 | 10U | 305645 | 5529532 | 1 | RISC | SK | 91.2 | 21.3 | C | 6 |
| | | 28-Aug-19 | 10U | 305645 | 5529532 | 2 | RISC | FL | 91.2 | 21.3 | C | 6 |

[1] SK - Sinking, FL - Floating

[2] C - Clear, L - Lightly turbid, M - Moderately turbid, T - Turbid

### 2.2.2. Data Analysis

#### 2.2.2.1. Population Index

*Catch Per Unit Effort*

Catch per unit effort (CPUE) from gill netting, measured as fish caught per set-hour, was used as the metric of relative abundance in Upper Campbell Reservoir. CPUE was computed by individual net panel to estimate species relative abundance by 5 m depth intervals.

*Individual Fish Analysis*

Biological statistics computed for each species in the gill net catch include mean and standard deviation of length and weight, length-frequency and age distributions, weight-length regressions, and relative condition factor ($K_r$). To overcome limitations of dependencies of the condition factor on fish length, the relative condition factor ($K_r$) was calculated as:

$$K_r = \left(\frac{W}{\widehat{W}}\right)$$

where $W$ is the weight of the fish in g, and $\hat{W}$ is the predicted body weight from a length-weight relationship (Le Cren 1951) (species-specific relationships shown in Figures 13 and 15). If $K_r$ is equal to 1, the fish is in average condition, if $K_r$ is below 1 the fish is in condition lower than average, and if $K_r$ is larger than 1 then the fish is in condition better than average.

Age distributions were calculated for trout only. Partially consumed individuals were excluded from analyses to ensure accuracy of fork length and/or weight measurements. Aging of fish by examination of the scales, and otoliths was undertaken by experienced Ecofish fisheries biologists, with the assistance of A-Tlegay staff. A subset of the samples was measured while the remainder of samples were stored in case additional samples are required. Aging protocols are provided in Appendix A .

Selection of the appropriate anatomical structure (scales, fin rays, or otoliths) to determine age of fish requires balancing precision and accuracy of the method with sample size limitations. Reading scales is easier, faster and cheaper, but less accurate than the other methods. Otoliths are more laborious and expensive to read but require lethal sampling. Fin rays are in between in terms of both accuracy and cost (e.g., Williamson and Macdonald 1997, Zymonas and McMahon 2009).

Assessments of the relative accuracy and feasibility of assigning age classes from the measured fork length was carried out during Years 4 and 5 of the monitoring program (Bayly *et al.* 2018, Buren *et al.* 2019). Age breaks can be confidently assigned based on scale ages for younger age classes. However, it is challenging for older age classes given that growth plateaus and therefore the separation between age classes in an age-length plot becomes less distinct (Bayly *et al.* 2018). Assessment of the utility of fin rays to assign age revealed considerable variability, indicating they are of lower utility for accurate determination of age (Buren *et al.* 2019). Consequently, to maximise the information obtained given budgetary constraints reading of fin rays was discontinued for the Year 6 monitoring.

*Age Cohort Analysis*

Age information obtained from the subsample of fish that were aged during the six years of the monitoring project was used to assign ages to all Cutthroat Trout and Rainbow Trout caught. We fit species-specific length-at-age curves (Beverton, 1954; Beverton and Holt, 1957):

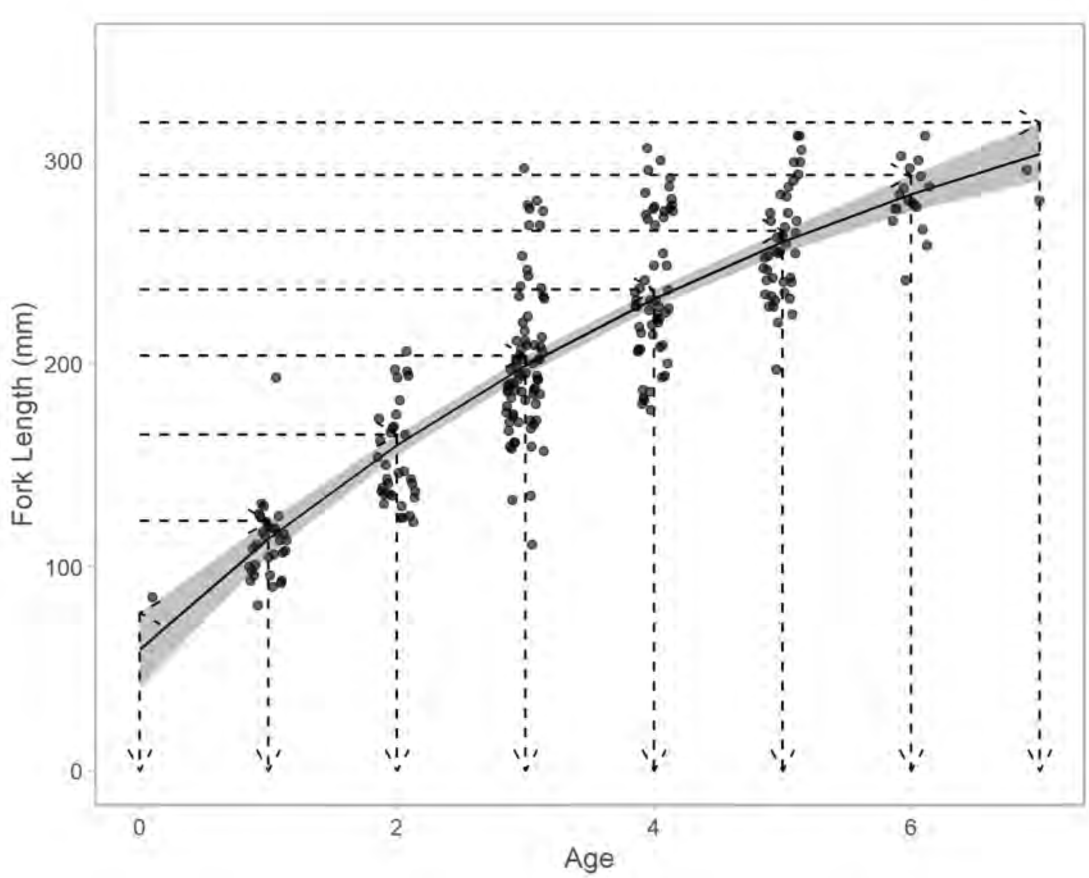
$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$$

where:

- $L_t$ is the expected or average length at age $t$;
- $L_\infty$ is the asymptotic average length;
- $K$ is the body growth rate coefficient (units are $yr^{-1}$); and
- $t_0$ is a modeling artifact that is said to represent the time or age when the average length was zero.

We computed non-parametric bootstrap estimates ($n_{boot}$ = 50,000 iterations) 95% confidence intervals of the average length at age. We then carried out a form of inverse inference, where we estimate the age of unaged fish, given their length and the expected length at age. The lengths of fish age $t$ are bounded by the upper confidence interval of the lengths of fish age $t$-1 and the upper confidence interval of fish of age length $t$ (see an illustration in Figure 6).

**Figure 6. Illustration of the methods for assigning ages to unaged fish. A length at age curve (solid line) is fit to the age-length data, and the 95% Confidence Interval of the expected length-at-age is estimated through non-parametric bootstrap (shaded region). These curves are used to find the range of length that correspond to a given age *t* (arrows going from y-axis to upper confidence interval and then down to age).**



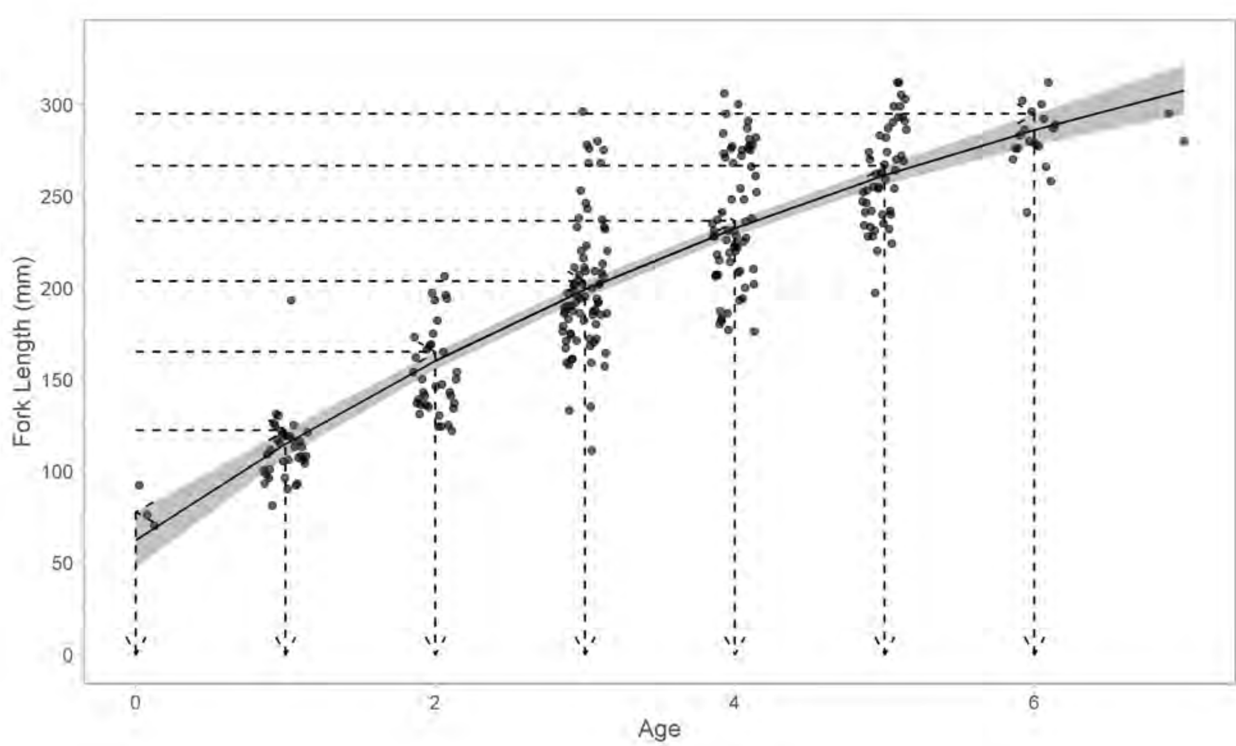

## Rainbow Trout

A total of 292 scales, 37 fin rays, and 27 Rainbow Trout otoliths were read during Years 1 to 6 of the monitoring program (Table 3). This excludes fish that suffered total or partial damage due to e.g. being partially consumed by crayfish, and therefore an accurate fork length could not be measured. Most aged fish were between the ages of 1+ and 6+, with only 6 fish aged as 0+ and 3 as 7+. Therefore, we grouped fish aged 6 and older into a cumulative age class ≥6+. Given the differences in sample sizes among hard structures (Table 3), we based the length at age curve for Rainbow Trout on ages read from scales (Figure 7).

**Table 3. Sample size of aged Rainbow Trout structures, by age, during Years 1 to 6 of the monitoring program.**

| Species | Structure | Age | n |
|---|---|---|---|
| Rainbow Trout | Scales | 0 | 6 |
| | | 1 | 36 |
| | | 2 | 36 |
| | | 3 | 79 |
| | | 4 | 64 |
| | | 5 | 49 |
| | | 6 | 19 |
| | | 7 | 3 |
| | Fin Rays | 0 | 0 |
| | | 1 | 0 |
| | | 2 | 3 |
| | | 3 | 11 |
| | | 4 | 12 |
| | | 5 | 8 |
| | | 6 | 3 |
| | | 7 | 0 |
| | | 0 | 0 |
| | Otoliths | 1 | 0 |
| | | 2 | 0 |
| | | 3 | 2 |
| | | 4 | 14 |
| | | 5 | 8 |
| | | 6 | 3 |
| | | 7 | 0 |

**Figure 7. Rainbow Trout length at age curve used for assigning age classes to fish of unknown age, based on their fork length.**




### Cutthroat Trout

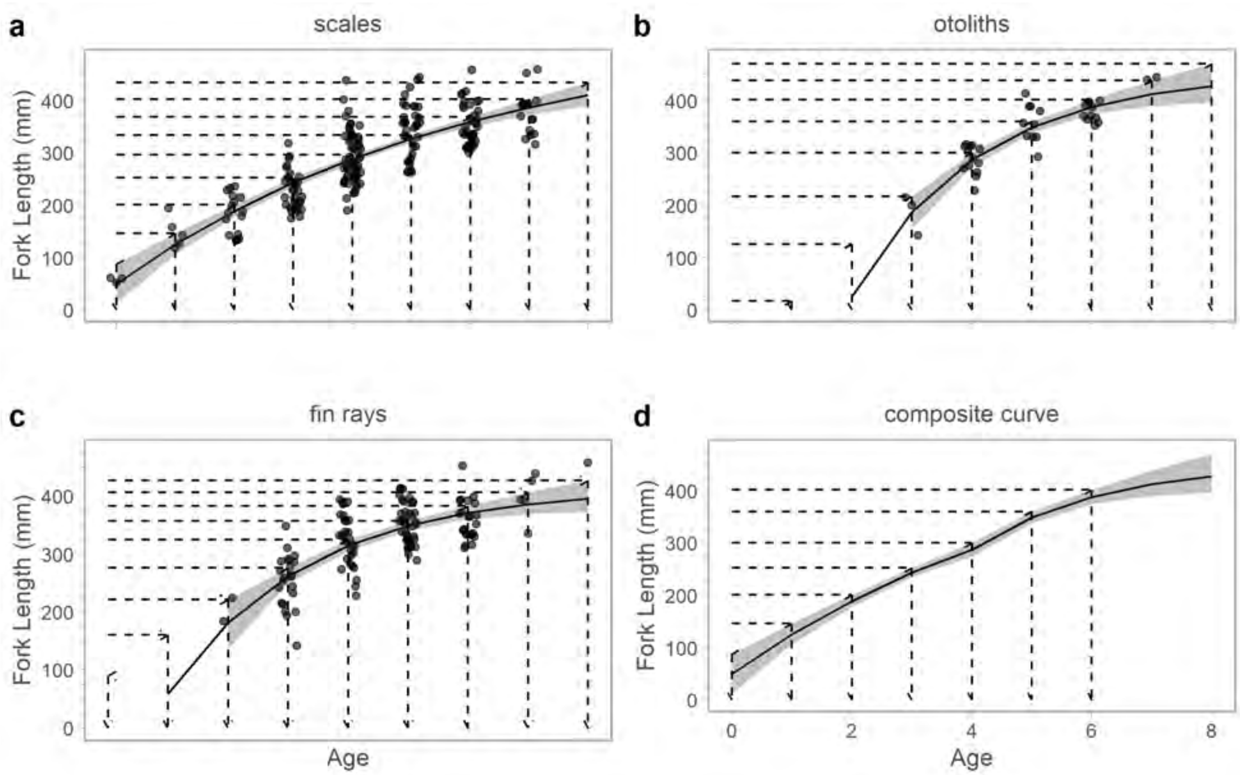
A total of 195 scales, 118 fin rays, and 38 Cutthroat Trout otoliths were read during Years 1 to 6 of the monitoring program (Table 3). This excludes fish that suffered total or partial damage due to e.g. being consumed by crayfish, and therefore an accurate fork length could not be measured. Most aged fish were between the ages of 1+ and 6+, with only 3 fish aged as 0+, 23 as 7+, and 1 as 8+. Therefore, we grouped fish aged 6 and older into a cumulative age class ≥6+.

The most accurate age readings are those based on otoliths. Thus, despite the relative smaller sample size we fit separate age at length curves by structure (Figure 8). All age readings carried out on otoliths were of relatively older fish (4+ and older). Hence, we created a composite curve, where the age breaks for young fish (3+ and younger) were obtained from scale data and age breaks for older fish (4+ and older) from otolith data (Figure 8d).

**Table 4. Sample size of aged Cutthroat Trout structures, by age, during Years 1 to 6 of the monitoring program.**

| Species | Structure | Age | n |
|---|---|---|---|
| Cutthroat Trout | Scales | 0 | 3 |
| | | 1 | 5 |
| | | 2 | 16 |
| | | 3 | 30 |
| | | 4 | 55 |
| | | 5 | 35 |
| | | 6 | 35 |
| | | 7 | 16 |
| | | 8 | 0 |
| | Scales | 0 | 0 |
| | | 1 | 0 |
| | | 2 | 2 |
| | | 3 | 22 |
| | | 4 | 28 |
| | | 5 | 36 |
| | | 6 | 24 |
| | | 7 | 5 |
| | | 8 | 1 |
| | Fin Rays | 0 | 0 |
| | | 1 | 0 |
| | | 2 | 0 |
| | | 3 | 3 |
| | | 4 | 13 |
| | | 5 | 10 |
| | | 6 | 10 |
| | | 7 | 2 |
| | | 8 | 0 |

**Figure 8. Cutthroat Trout length at age curves, a) curve based on ages from scales, b) curve based on ages from otoliths, c) curve based on ages from fin rays, d) composite curve based on ages read on otoliths and scales. The composite curve was used for assigning age classes to fish of unknown age, based on their fork length.**




## 2.3. Snorkel Surveys of Spawners in Reservoir Tributaries

Snorkel surveys of spawners and redds were undertaken in the lower reaches of the tributaries of Buttle Lake, Upper Campbell Reservoir, and Lower Campbell Reservoir during the Cutthroat Trout and Rainbow Trout spawning periods. The tributaries were selected based on their reported spawning value for both trout species, and included seven survey reaches upstream of Buttle Lake and Upper Campbell Reservoir that have been surveyed historically since the early 1990s and were included in all previous years of the monitoring program. Snorkel surveys were undertaken in the following six tributaries of Buttle Lake and Upper Campbell Reservoir: Elk River (upper and lower reaches): Ralph Creek, Thelwood Creek, Wolf River, Phillips Creek, and Henshaw Creek (Table 5). In addition, snorkel surveys were undertaken in the following three tributaries of Lower Campbell Reservoir: Miller Creek, Fry Creek, and Greenstone River. Spring snorkel surveys were completed in tributaries of the Lower Campbell Reservoir in March and April to assess Cutthroat Trout spawning activity, and snorkel surveys of Upper Campbell Reservoir tributaries were completed in the late spring/early summer (June) to assess Rainbow Trout spawning.

On each survey date, individual stream sections were surveyed once by two experienced technicians swimming in pairs. To allow for comparison between years, the 2019 surveys followed standardized survey methods within each reach, as conducted during Years 1 to 5 (2014 to 2018) surveys, and historically by MFLNRO and BCCF (Pellett 2013). It is worth noting that Thelwood Creek (Buttle Lake) has undergone morphology changes during the time span covered by the JHTMON-3 monitoring project. We carried out snorkel surveys in such a manner as to maintain data consistency to enable temporal comparisons. A summary of morphological changes is provided in Appendix B. A number of variables were measured (Table 6) and photographs were taken of each site. Rainbow Trout was the target species for these historic surveys in Upper Campbell Reservoir tributaries and this focus was maintained for JHTMON-3 snorkel surveys to maximize comparability with historic records.

Similar to previous years, a fork length of 150 mm was designated as the boundary between juvenile and adult fish, based on the Provincial snorkel form template. The estimated fork lengths of juvenile fish ranged from 0 mm to 80 mm for fry, and from 80 mm to 150 mm for parr, during the 2019 surveys.

Surveys for the Cutthroat Trout spawning period were carried out in tributaries of the Lower Campbell Reservoir on March 4, 2019. An additional survey of the Greenstone River was carried out on April 30, 2019 due to the relatively cold conditions of this river compared to Miller and Fry creeks. Tributaries of Buttle Lake and Upper Campbell Reservoir were not sampled during the Cutthroat Trout spawning period, as described in Hatfield *et al.* (2016). Due to low Cutthroat Trout densities in the surveyed tributaries, redd counts were used to provide a reference for adult spawning effort.

Surveys for the Rainbow Trout spawning period were undertaken from June 4 to 7, 2019 in the tributaries of Buttle Lake and Upper Campbell Reservoir. Data recorded from the 2019 Rainbow Trout spawning surveys were compared to the Years 1 to 5 (2014 to 2018) dataset and available historical data for the Upper and Lower Campbell Reservoir. This historical record allows a quantitative comparison of abundance change over time, although it is noted that the data record is short, and sampling has not been undertaken during all years. Tributaries of Lower Campbell Reservoir were not sampled during the Rainbow Trout spawning period (Hatfield *et al.* 2016).

Discharge measured in the Elk River at Water Survey of Canada gauge 08HD018 has historically been used as a reference to assess suitability for the Rainbow Trout snorkel surveys; based on the criterion that suitable survey conditions correspond to a discharge of $< 20\ m^3/s$ (Pellett 2013). This was also used for spring surveys, to determine suitable flows for access and visibility. Mean daily discharge at the gauge during the spring and summer survey dates were below this $< 20\ m^3/s$ guidance value; suggesting that conditions were acceptable for conducting snorkelling surveys.

**Table 5. Snorkel survey reach details for Year 6 surveys.**

| Watershed | Stream | Survey Distance | Survey Start Location | Survey End Location |
|---|---|---|---|---|
| Upper Campbell | Upper Elk River | 6.0 | Drum Creek 200 m US confluence | HWY 28 take out/ put in |
| | Lower Elk River | 5.4 | HWY 28 take out/put in | Upper Campbell Lake |
| Buttle | Ralph River | 0.9 | 50 m u/s Shepard Creek | Buttle Lake |
| | Thelwood Creek | 2.5 | Falls at powerhouse | Bridge at Buttle Lake |
| | Wolf River | 0.3 | Falls Pool | Buttle Lake |
| | Phillips Creek | 0.3 | 300 m u/s lake | Buttle Lake |
| | Henshaw Creek | 0.5 | Cascades | Buttle Lake |
| Lower Campbell | Miller Creek | 0.4 | Cascades | Fry Lake |
| | Fry Creek | 1.2 | Barrier DS logging road | Lower Campbell Lake |
| | Greenstone River | 2.4 | ~1.0km u/s of Bridge | Lower Campbell Lake |

**Table 6. Variables measured during the Year 6 snorkel surveys in the selected tributaries of Upper Campbell Reservoir, Buttle Lake, and Lower Campbell Reservoir.**

| Variable | Unit/Classification |
|---|---|
| Weather | Conditions recorded |
| Water temperature | $^{o}$C |
| Effective Visibility | Measured or estimated in meters |
| Fish size class | fry/parr/adults; 150-250mm, 251-350mm, 351-450mm, and >450mm |
| Fish species | Cutthroat Trout (CT)/Rainbow Trout (RB)/Dolly Varden (DV) |
| Fish condition | Bright/moderately coloured/mid-spawn/post-spawn/undetermined |
| Redd observations | Location/size/number/species |

# 3. RESULTS

## 3.1. Effective Spawning Habitat (ESH)

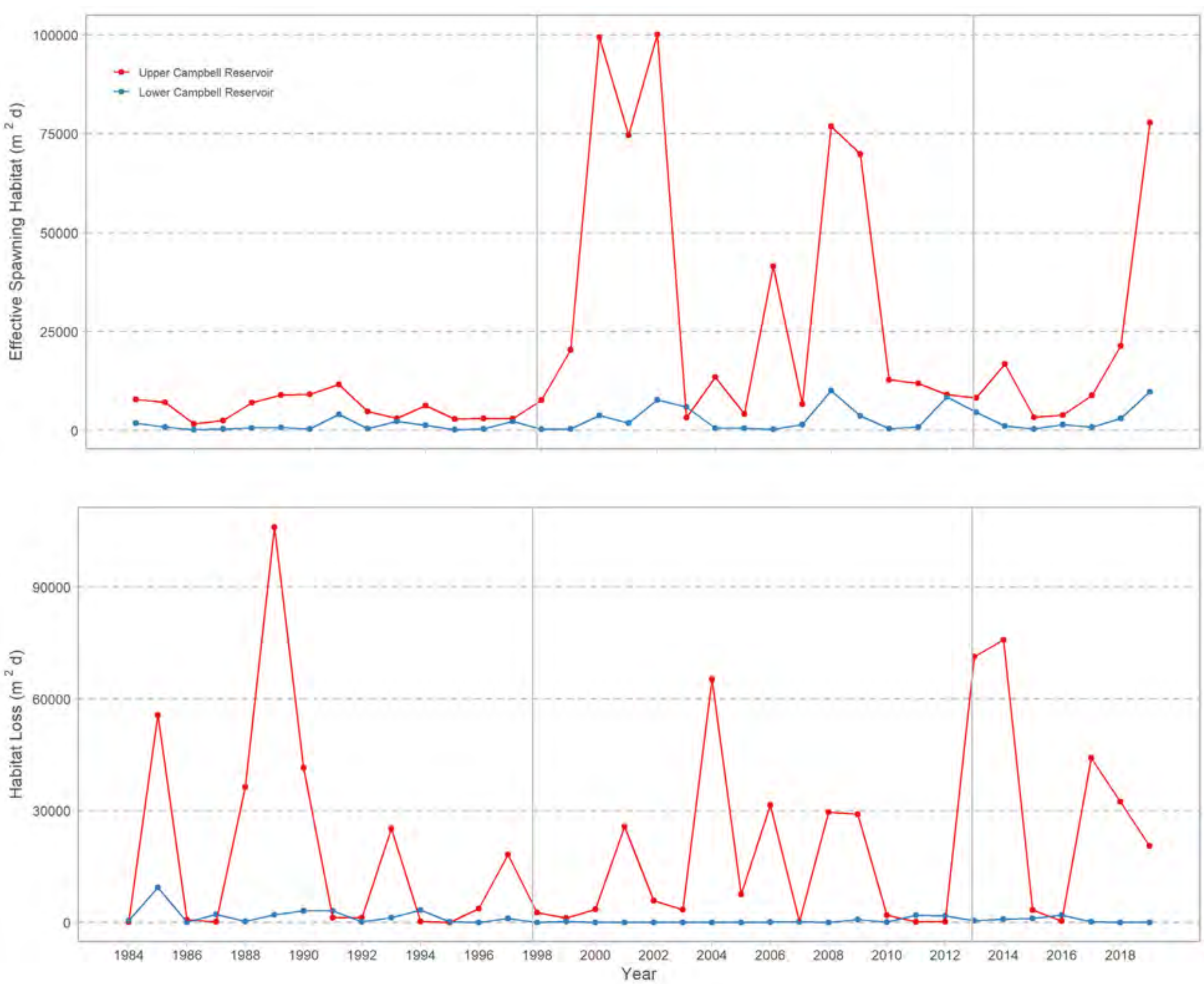
### 3.1.1. Cutthroat Trout

ESH values for both Lower and Upper Campbell reservoirs were variable among years, with much greater variability in the Upper Campbell Reservoir ESH (range of 1,676 to 100,111 m²d; mean = 21,418 m²d) than the Lower Campbell Reservoir ESH (range of 198 to 10,043 m²d; mean = 2,346 m²d) (Figure 9). Following the implementation of the Interim Flow Management Strategy there were several years when ESH for Cutthroat Trout in the Upper Campbell Reservoir reached high levels (up to 100,000 m²d). In 2019, the ESH for Cutthroat Trout in the Upper Campbell

Reservoir was among the highest values recorded (over 75,000 m²d). During this monitoring program (2014-2019), ESH in the Upper Campbell Reservoir was highest in 2019, followed by 2018, while values observed during 2015-2017 were an order of magnitude lower (Figure 9).

ESH loss was calculated as the difference between ESH and initial spawning habitat during the spawning and incubation period. Oscillations in the water level of the Upper Campbell Reservoir are associated with ESH losses ranging from 44 to 106,046 $m^2$d (mean = 20,733 $m^2$d). Water levels in the Lower Campbell Reservoir are less variable, resulting in relatively minimal loss of ESH (range of 0 to 9,398 m²d; mean = 1,028 m²d; Figure 9). ESH loss in the Upper Campbell Reservoir is variable and does not seem to have been affected by the implementation of the Interim Flow Management Strategy. During this monitoring program, the ESH loss was minimal during 2015 (3,371 $m^2$d) and 2016 ($m^2$d), and higher in 2014 (75,823 $m^2$d), 2017 (44,131 $m^2$d), 2018 (32,389 $m^2$d), and 2019 (20,579 $m^2$d).

**Figure 9. Results of effective spawning habitat and loss of effective spawning habitat models for Cutthroat Trout from 1984 to 2019. Vertical lines denote dates of implementation of the Interim Flow Management Strategy (October 1997), and the Water Use Plan (November 2012).**

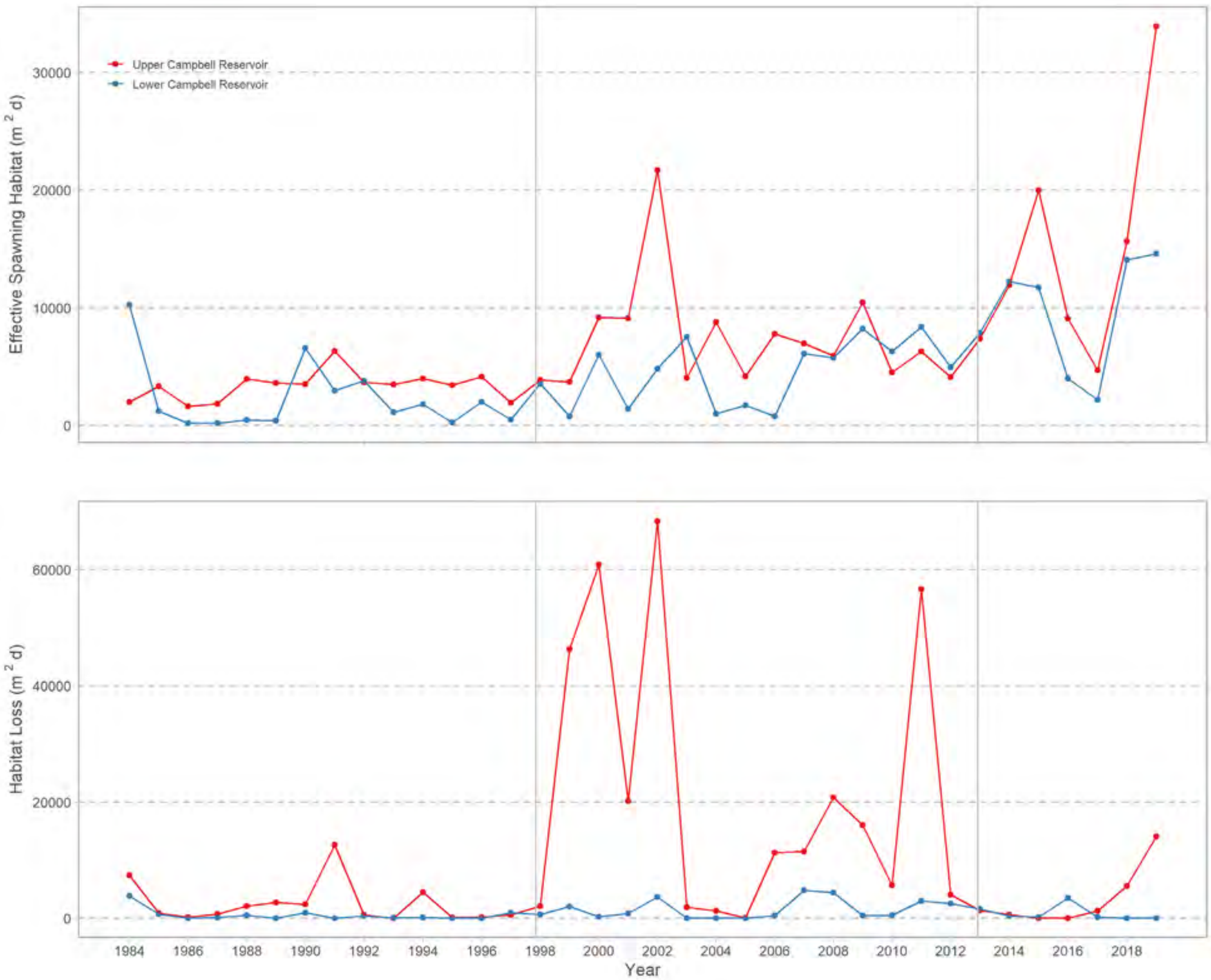


### 3.1.2. Rainbow Trout

ESH values for both Lower and Upper Campbell reservoirs were variable among years, with greater variability in the Upper Campbell Reservoir ESH (range of 1,619 to 33,919 $m^2d$; mean = 7,225 $m^2d$) than the Lower Campbell Reservoir ESH (range of 188 to 14,583 $m^2d$; mean = 4,606 $m^2d$). Following the implementation of the Interim Flow Management Strategy ESH increased more than two-fold in both reservoirs (Upper Campbell Reservoir: $mean_{pre\text{-}IFMS}$: 3,350 $m^2d$, $mean_{post\text{-}IFMS}$: 9,691 $m^2d$; Lower Campbell Reservoir: $mean_{pre\text{-}IFMS}$: 2,271 $m^2d$, $mean_{post\text{-}IFMS}$: 6,092 $m^2d$). ESH in both reservoirs during this monitoring program was high, reaching a peak in 2019, followed by 2018, 2014, and 2015. During 2016 and 2017 it was smaller, although it was at average or above average values (Figure 10).

Oscillations in the water level of the Upper Campbell Reservoir are associated with effective Rainbow Trout spawning habitat losses ranging from 0 to 68,352 $m^2d$ (mean = 10,697 $m^2d$). Water levels in the Lower Campbell Reservoir are less variable, resulting in relatively minimal loss of ESH (range of 0 to 4,810 $m^2d$; mean = 1,033 $m^2d$) (Figure 10). It is noteworthy that ESH for Rainbow Trout in both reservoirs are completely in sync since at least 2007. ESH loss in the Lower Campbell Reservoir is variable and does not seem to have been affected by the implementation of the Interim Flow Management Strategy. ESH loss habitat in the Lower Campbell Reservoir was highest immediately following the implementation of the IFMS, and was until recently positively associated with the ESH (i.e., there were large losses in years when ESH was high). During this monitoring program this pattern does not hold as ESH was high and habitat loss was very small (range: 0 – 14,083 $m^2d$) (Figure 10).

**Figure 10. Results of effective spawning habitat and loss of effective spawning habitat models for Rainbow Trout from 1984 to 2019. Vertical lines denote dates of implementation of the Interim Flow Management Strategy (October 1997), and the Water Use Plan (November 2012).**

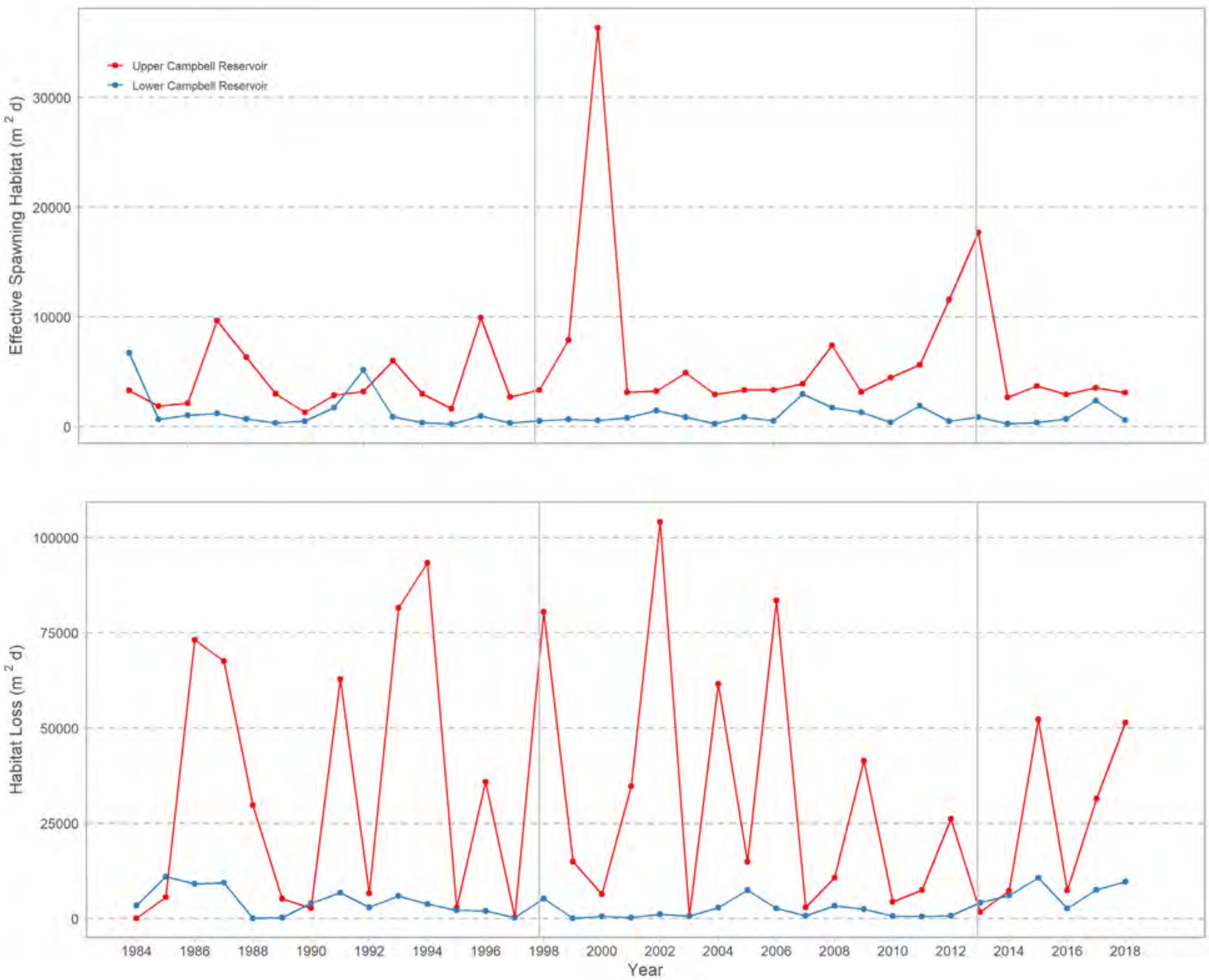


### 3.1.3. Dolly Varden

Given the timing of spawning and incubation of Dolly Varden (Figure 1) relative to reporting requirements, ESH metrics could be calculated until 2018 (Figure 11). Effective habitat values for both Lower and Upper Campbell reservoirs were variable among years with much greater variability for the Upper Campbell Reservoir ESH (range of 1,295 to 36,389 $m^2$d; mean = 5,575 $m^2$d) than the Lower Campbell Reservoir ESH (range of 223 to 6,747 $m^2$d; mean = 1,179 $m^2$d) (Figure 11). The implementation of the Interim Flow Management Strategy does not seem to have affected the values of ESH for Dolly Varden, except for a couple of very high values in the Upper Campbell Reservoir in 2000 (36,389 $m^2$d) and 2013 (17,690 $m^2$d). ESH in the Upper Campbell Reservoir during this monitoring program (2014-2018) was consistently around 3,000 $m^2$d, while in the Lower Campbell Reservoir was low during 2014-2016 (~400 $m^2$d), increased an order of magnitude in 2017, and dropped again in 2018 (Figure 11).

Fluctuations in the water level of the Upper Campbell Reservoir are associated with relatively regular oscillations in losses of effective Dolly Varden spawning habitat ranging from 73 to 104,159 $m^2$d (mean = 31,816 $m^2$d). In contrast, there has been comparatively little change in effective Dolly Varden spawning habitat loss among years in Lower Campbell Reservoir (range of 55 to 10,973 $m^2$d; mean = 3,760 $m^2$d) (Figure 11). ESH loss in both reservoirs is variable and does not seem to have been affected by the implementation of the Interim Flow Management Strategy. During this monitoring program, the ESH loss was variable, reaching a peak of 52,331 $m^2$d in 2015 in the upper Campbell Reservoir and a low of 2,707 $m^2$d in 2016 in the Lower Campbell Reservoir (Figure 11).

**Figure 11. Results of effective spawning habitat and loss of effective spawning habitat models for Dolly Varden from 1984 to 2018. Vertical lines denote dates of implementation of the Interim Flow Management Strategy (October 1997), and the Water Use Plan (November 2012).**




## 3.2. Population Index for Upper and Lower Campbell Reservoirs

### 3.2.1. Summary of Gillnet Sampling Results

Fish sampling from the six gill net monitoring sites recorded a total of 41 Cutthroat Trout, 126 Rainbow Trout, five Sculpin, eight Cutthroat Trout/Rainbow Trout hybrids (Table 7). No Dolly Varden or Threespine Stickleback were captured in 2019. Rainbow Trout had the greatest mean CPUE (0.49 fish/net hour), followed by Cutthroat Trout (0.16 fish/net hour). CPUE for Cutthroat Trout and Rainbow Trout varied among sites although site conditions were relatively similar (Table 7). CPUE for Rainbow Trout was at least double the CPUE for Cutthroat Trout at all sites (Table 7). Representative photographs and raw data collected during gillnet surveys are presented in Appendix C.

**Table 7. Summary of gill net survey effort, catch statistics, and CPUE from the Upper Campbell Reservoir, August 2019.**

| Site | Sampling Date | # of Sets | Gill Netting Effort (hrs) | Gill Net Catch (# of Fish) | | | | | Gill Net CPUE (# of Fish / net hr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CT | RB | DV | CC | CT/RB | CT | RB | DV | CC | CT/RB |
| UCR-LKGN01 | 26-Aug-19 | 2 | 41.1 | 4 | 8 | 0 | 0 | 2 | 0.097 | 0.19 | 0 | 0 | 0.05 |
| UCR-LKGN02 | 26-Aug-19 | 2 | 41.2 | 3 | 12 | 0 | 0 | 0 | 0.073 | 0.29 | 0 | 0.00 | 0 |
| UCR-LKGN04 | 27-Aug-19 | 3 | 56.5 | 3 | 19 | 0 | 2 | 1 | 0.053 | 0.34 | 0 | 0 | 0.02 |
| UCR-LKGN06 | 27-Aug-19 | 2 | 37.7 | 7 | 24 | 0 | 0 | 1 | 0.186 | 0.64 | 0 | 0 | 0.03 |
| UCR-LKGN07 | 28-Aug-19 | 3 | 56.1 | 11 | 26 | 0 | 3 | 0 | 0.196 | 0.46 | 0 | 0.05 | 0.00 |
| UCR-LKGN08 | 28-Aug-19 | 2 | 36.7 | 13 | 37 | 0 | 0 | 4 | 0.354 | 1.01 | 0 | 0.00 | 0.11 |
| | **Total** | **14** | **269.3** | **41** | **126** | **0** | **5** | **8** | | | | | |
| | **Average** | | **44.9** | **6.8** | **21.0** | **0** | **0.8** | **1.3** | **0.160** | **0.49** | **0** | **0.01** | **0.03** |
| | **SD** | | **9.0** | **4.3** | **10.4** | **0** | **1.3** | **1.5** | **0.112** | **0.30** | **0** | **0.02** | **0.04** |

### 3.2.2. Cutthroat Trout

#### 3.2.2.1. CPUE

Cutthroat Trout were caught at every gill net sampling site; however, CPUE was variable across gill netting sites as well as gill net depth. The sampling site CPUE ranged from 0.07 to 0.35 fish/net hour at the gill netting sites, with an overall mean CPUE of 0.16 fish/net hour (Table 7). CPUE in floating nets was low (0.003 and 0.007 fish/hr), and Cutthroat were only captured in floating nets where bottom depths were less than 10m (Table 8). Cutthroat Trout were captured at all but the deepest depth in sinking nets. CPUE was an order of magnitude higher than for floating nets and CPUE in sinking nets seems to increase with depth (Table 8). These data suggest that Cutthroat Trout have a benthic-oriented distribution (as opposed to pelagic).

**Table 8. CPUE (no. fish / hour) of all Cutthroat Trout based on gill net type and bottom depth. Catches from Nordic gill nets were not included in this analysis.**

| Net Type | Bottom Depth (m) | | | |
|---|---|---|---|---|
| | 2.5 | 7.5 | 12.5 | 17.5 |
| Floating | 0.007 | 0.003 | 0 | 0 |
| Sinking | 0.017 | 0.021 | 0.035 | 0 |

Net depth for sinking nets is equal to bottom depth, and 2.5 m for floating nets

3.2.2.2. Individual Fish Analysis

A total of 41 Cutthroat Trout were captured during gill netting surveys in the Upper Campbell Reservoir and size of captured fish ranged from 178 to 444 mm (Figure 12). This range encompass a similar range sampled throughout Years 1-6 (Figure 12). The weight of Cutthroat Trout caught in the Upper Campbell Reservoir followed an isometric growth curve (i.e., the exponent of the length-weight relationship is 3) (Figure 13).

**Figure 12.** **Length-frequency histogram for Cutthroat Trout (CT) captured during the gill-netting surveys on Upper Campbell Reservoir, 2019. Grey bars represent data collected during the six years of monitoring, and black bars represent data collected during 2019.**

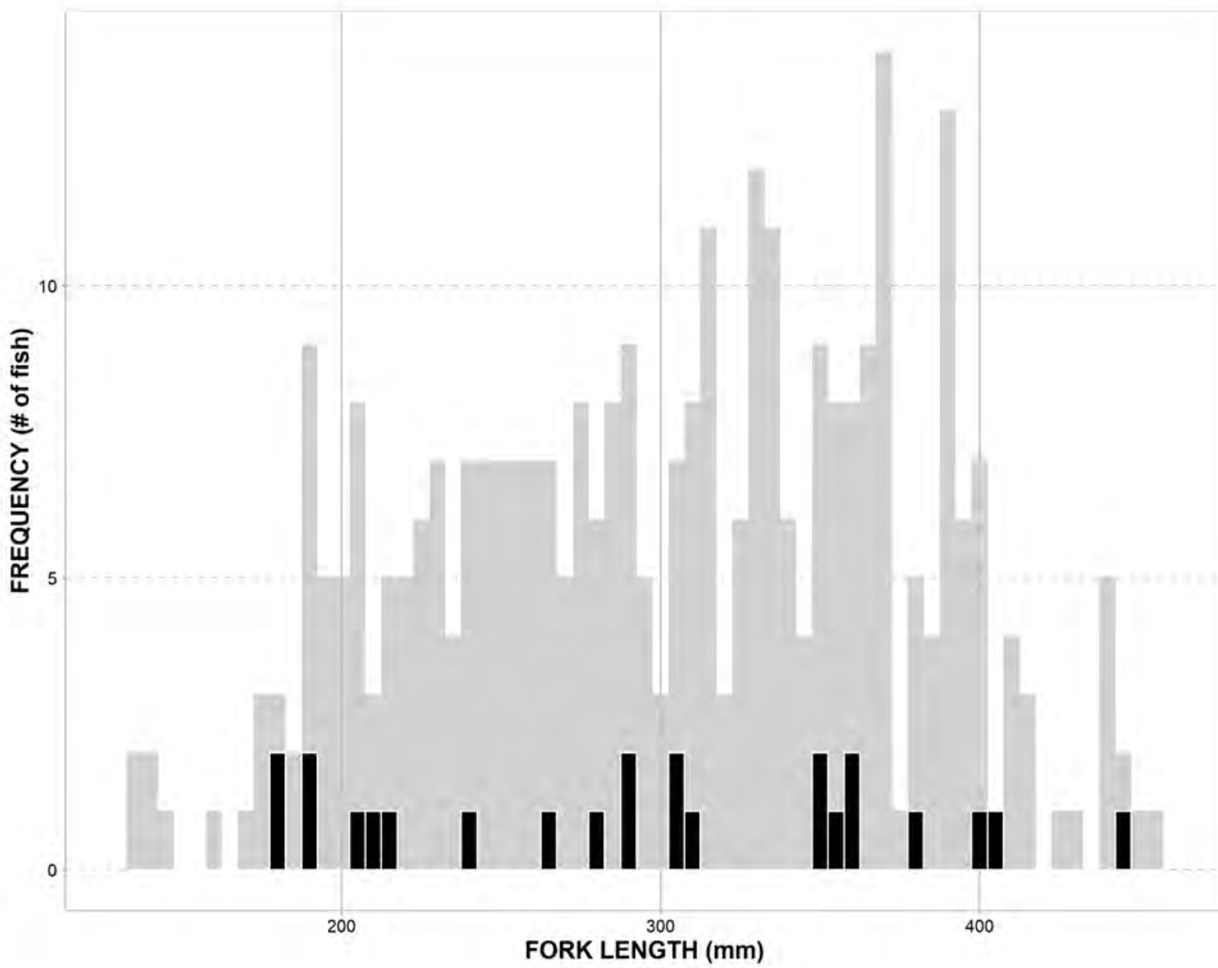
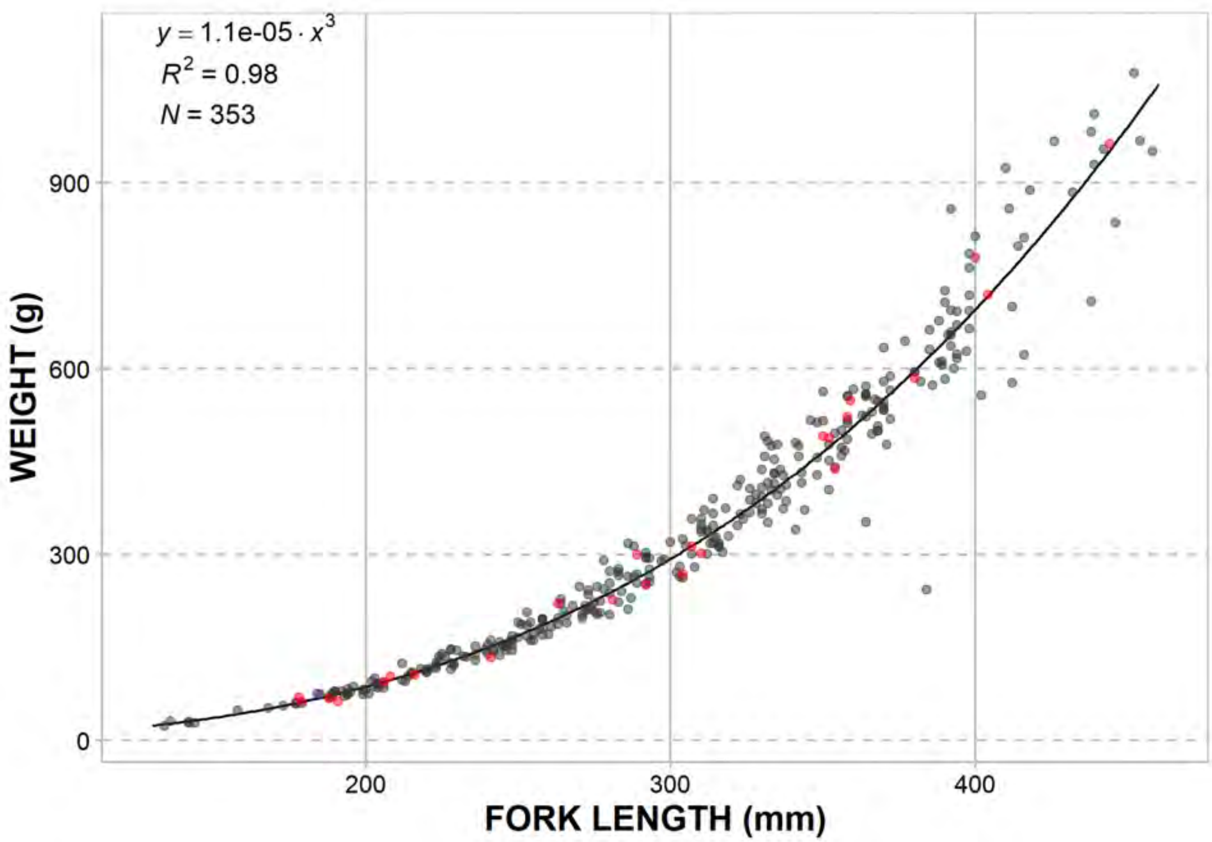


**Figure 13. Length-weight relationship for Cutthroat Trout captured during gill net surveys in the Upper Campbell Reservoir, 2014-2018. Grey dots represent data collected during 2014-2018, and red dots represent data collected during 2019.**




3.2.2.3. Age Cohort Analysis

The age of Cutthroat Trout caught in gill nets in Year 6 (n: 24 fish) ranged in age from 2+ to 6+, spread evenly across age classes (Table 9). Mean relative condition of Cutthroat Trout of all ages was good; the mean K was close to 1 for all ages(Table 9), and there were no big departures from the expected weight from the length-weight relationship (Figure 13).

The relative abundance of older fish was higher; the CPUE for fish age 5+ and ≥6+ fish were 0.059 and 0.033 fish/net hour, respectively. The relative abundance of fish ages 2+ to 4+ ranged from 0.019 to 0.02 fish/net hour. No fish ages 0+ or 1+ were caught (Table 10).

**Table 9. Summary of fork length, weight, and relative condition of Cutthroat Trout captured during gill netting surveys in Upper Campbell Reservoir, 2019, excluding partially consumed fish (n = 17).**

| Age | Fork Length (mm) | | | | Weight (g) | | | | Relative Condition ($K_r$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean | Min | Max | n | Mean | Min | Max | n | Mean | Min | Max |
| 0+ | - | - | - | - | - | - | - | - | - | - | - | - |
| 1+ | - | - | - | - | - | - | - | - | - | - | - | - |
| 2+ | 4 | 184 | 178 | 191 | 4 | 66 | 63 | 69 | 4 | 0.98 | 0.83 | 1.14 |
| 3+ | 4 | 218 | 206 | 241 | 4 | 109 | 94 | 134 | 4 | 0.98 | 0.89 | 1.06 |
| 4+ | 4 | 281 | 263 | 292 | 4 | 250 | 221 | 300 | 4 | 1.04 | 0.94 | 1.15 |
| 5+ | 8 | 337 | 304 | 359 | 8 | 421 | 268 | 548 | 8 | 1.00 | 0.88 | 1.10 |
| ≥6+ | 4 | 407 | 380 | 444 | 4 | 762 | 585 | 963 | 4 | 1.04 | 0.99 | 1.13 |

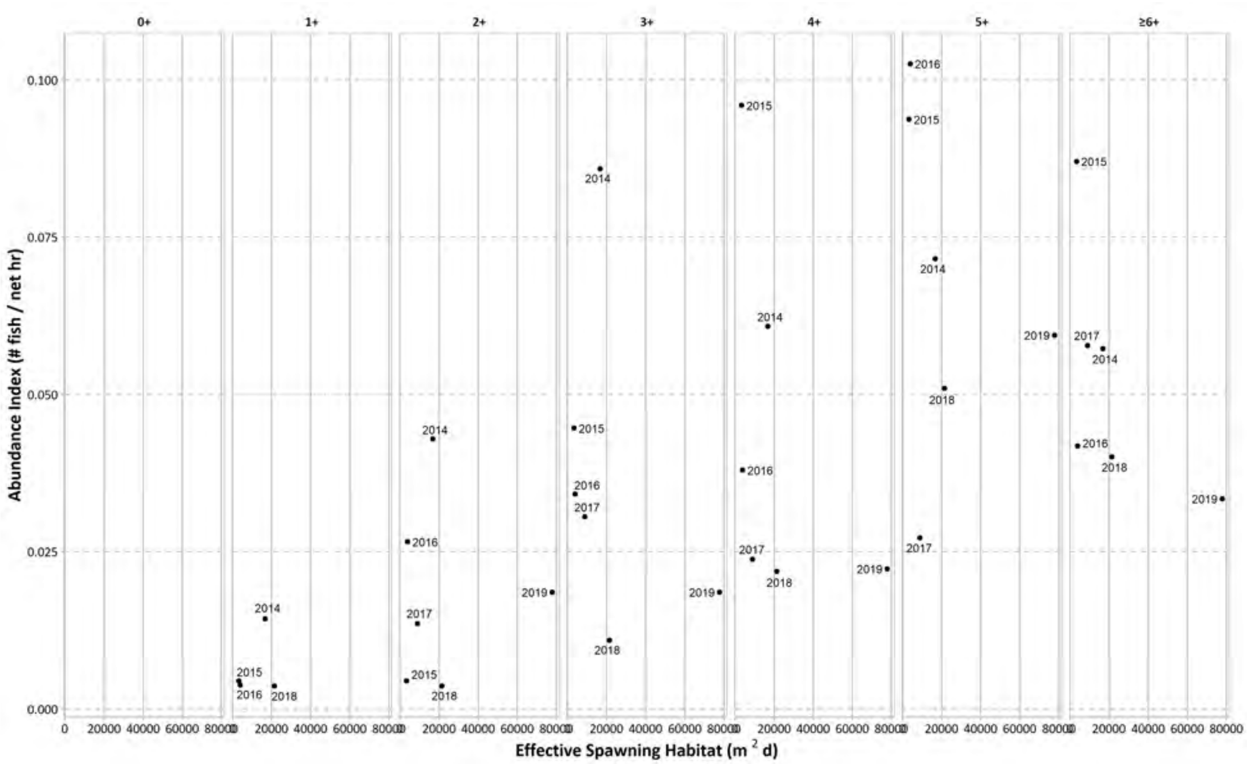
**Table 10. CPUE of Cutthroat Trout age cohorts captured during gill netting surveys in Upper Campbell Reservoir, 2019.**

| Age | Number of Fish Caught | CPUE # of Fish/net hr) |
|---|---|---|
| 0+ | 0 | 0.000 |
| 1+ | 0 | 0.000 |
| 2+ | 5 | 0.019 |
| 3+ | 5 | 0.019 |
| 4+ | 6 | 0.022 |
| 5+ | 16 | 0.059 |
| ≥6+ | 9 | 0.033 |

#### 3.2.2.4. Comparison of Abundance Index to Effective Spawning Habitat

There is no clear relationship between age-specific abundance indices of Cutthroat Trout and ESH in the Upper Campbell Reservoir (Figure 14). There are substantial inter annual differences in CPUE; the largest values of CPUE were recorded for age 5+ fish in 2016 (0.102 fish/net hr), 4+, 5+ fish and 6+ fish in 2015 (0.096, 0.094, and 0.087 fish/net hr, respectively), with age-specific CPUE values in the last three years reduced substantially. In contrast, the values of ESH were high during 2008 and 2009 (~70,000 $m^2$d), dropping an order of magnitude in 2010 and remaining relatively stable until 2018 when it increased to around ~20,000 $m^2$d, and saw a further increase in 2019 to values similar to those observed a decade ago (77,797 $m^2$d).

**Figure 14. Effective Spawning Habitat values of the Upper Campbell Reservoir in relation to Cutthroat Trout abundance index for each age cohort.**




3.2.3. Rainbow Trout

3.2.3.1. CPUE

Rainbow Trout were caught at every sampling site; however, CPUE was variable across gill netting sites and gill net depth. The sampling site CPUE ranged from 0.19 to 1.01 fish/net hour at the gill netting sites, with an overall mean CPUE of 0.49 fish/net hour (Table 7).

Rainbow Trout (all and adult only) were captured at all depths in floating nets, whereas no adults were caught in the two deepest sinking nets (12.5 and 17.5 m) and no Rainbow Trout were caught in the deepest sinking net (17.5 m). CPUE was higher for floating nets than for sinking nets, at all bottom depths (Table 11). There is no clear pattern of varying CPUE with depth for floating nets, whereas there is not enough information from sinking assess to assess relationship between depth and CPUE (Table 11). These data suggest that Rainbow Trout are distributed primarily in open (i.e., pelagic) water.

**Table 11. CPUE (no. fish / hour) of a) all Rainbow Trout and b) adult Rainbow Trout (>150 mm) based on gill net type and bottom depth. Catches from Nordic gill nets were not included in this analysis.**

a) All Rainbow Trout

| Net Type | Bottom Depth (m) | | | |
|---|---|---|---|---|
| | 2.5 | 7.5 | 12.5 | 17.5 |
| Floating | 0.046 | 0.050 | 0.050 | 0.051 |
| Sinking | 0.036 | 0.032 | 0.018 | 0 |

Net depth for sinking nets is equal to bottom depth, and 2.5 m for floating nets

b) Adult Rainbow Trout

| Net Type | Bottom Depth (m) | | | |
|---|---|---|---|---|
| | 2.5 | 7.5 | 12.5 | 17.5 |
| Floating | 0.033 | 0.049 | 0.050 | 0.025 |
| Sinking | 0.036 | 0.029 | 0 | 0 |

Net depth for sinking nets is equal to bottom depth, and 2.5 m for floating nets

#### 3.2.3.2. Individual Fish Analysis

A total of 126 Rainbow Trout were captured during gill netting surveys ranging from sizes of 70 to 303 mm (Figure 15). The length frequency distribution of all Rainbow Trout caught in the Upper Campbell Reservoir had 4 modes at around 110 mm, 180 mm, 230 mm, and 270 mm (Figure 15). Length of fish caught during Year 6 coincides with the modes of the fish caught during the 6 years of the monitor. The weight of Rainbow Trout caught in the Upper Campbell Reservoir during the length of the monitoring program (2014-2019) followed an allometric growth curve, with an exponent of 2.8 (Figure 16).

**Figure 15.** **Length-frequency histogram for Rainbow Trout captured during the gill-netting surveys on Upper Campbell Reservoir, 2019. Grey bars represent data collected during the six years of monitoring, and black bars represent data collected during 2019.**

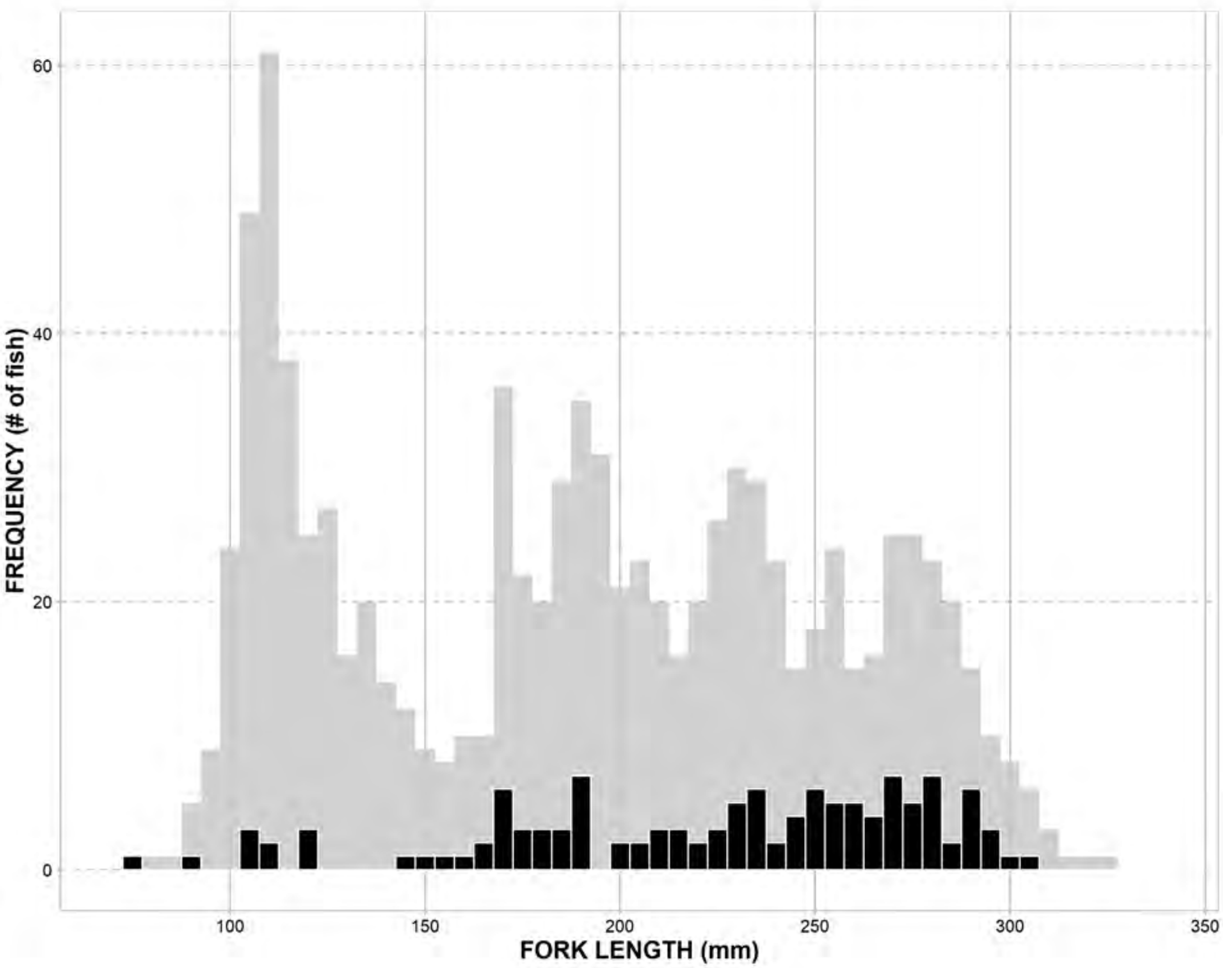
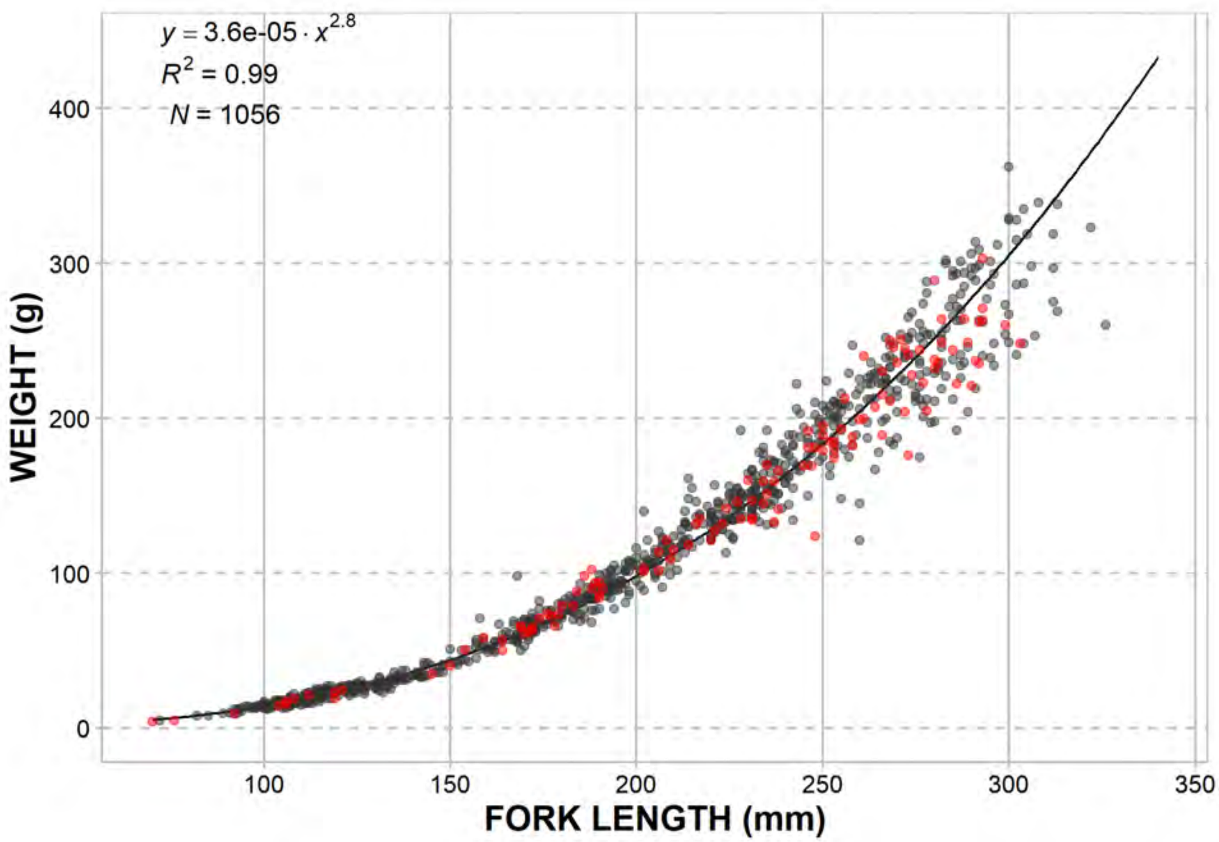


**Figure 16. Length-weight relationship for Rainbow Trout captured during gill net surveys in the Upper Campbell Reservoir, 2014-2019. Grey dots represent data collected during 2014-2018, and red dots represent data collected during 2019.**




3.2.3.3. Age Cohort Analysis

The age of Rainbow Trout caught in gill nets in Year 6 ranged in age from 0+ to 6+ (Table 12). Most fish captured during Year 5 gill netting were ages 3+ and older (Table 12). Mean relative condition of Rainbow Trout was close to 1 for all ages (Table 12), and there were no marked departures from the expected weight from the length-weight relationship (Figure 16). The only exception to this were Rainbow Trout age 0+, whose mean relative condition was low (0.76). However, it should be noted that this mean relative condition is based on a very small sample size (n = 2), and that these fish were among the smallest fish caught during the 6 years of the JHTMON-3 monitoring program. The fact that these are among the smallest fish caught tempers the interpretation of the low mean relative condition on two accounts: a) given that these values are on the extremes of the observed data, the expectation is that the modelled weight does not capture the "real" mean weight as well as it does for fish of average length, and b) relatively small differences in weight (<2g) represent over 20% of the expected weight.

There was a decreasing trend of relative abundance of Rainbow Trout with age; the relative abundance of older fish was higher; CPUE of fish age ≥6+ was the highest (0.146 fish/net hr), followed by that of 5+ and 4+ fish (0.104 and 0.082 fish/net hr, respectively). The CPUE of fish ages 3+ and younger ranged from 0.007 to 0.007 fish/net hr.

**Table 12. Summary of fork length, weight, and relative condition of Rainbow Trout captured during gill netting surveys in Upper Campbell Reservoir, 2019, excluding partially consumed fish (n = 3).**

| Age | Fork Length (mm) | | | | Weight (g) | | | | Relative Condition ($K_r$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | Mean | Min | Max | n | Mean | Min | Max | n | Mean | Min | Max |
| 0+ | 2 | 73 | 70 | 76 | 2 | 4.45 | 4.1 | 4.8 | 2 | 0.76 | 0.73 | 0.79 |
| 1+ | 9 | 109.67 | 92 | 121 | 9 | 18.189 | 9.6 | 24.3 | 9 | 0.97 | 0.83 | 1.10 |
| 2+ | 6 | 156 | 145 | 164 | 6 | 48.283 | 34.7 | 58 | 6 | 0.98 | 0.87 | 1.12 |
| 3+ | 24 | 182.08 | 169 | 202 | 24 | 80.275 | 61 | 103 | 24 | 1.05 | 0.93 | 1.24 |
| 4+ | 22 | 222.27 | 206 | 235 | 22 | 134.1 | 101.4 | 170 | 22 | 1.01 | 0.91 | 1.10 |
| 5+ | 28 | 252.21 | 237 | 266 | 28 | 184.23 | 124 | 240 | 28 | 0.98 | 0.69 | 1.16 |
| ≥6+ | 32 | 281.88 | 268 | 303 | 32 | 242.09 | 176 | 303 | 32 | 0.95 | 0.75 | 1.15 |

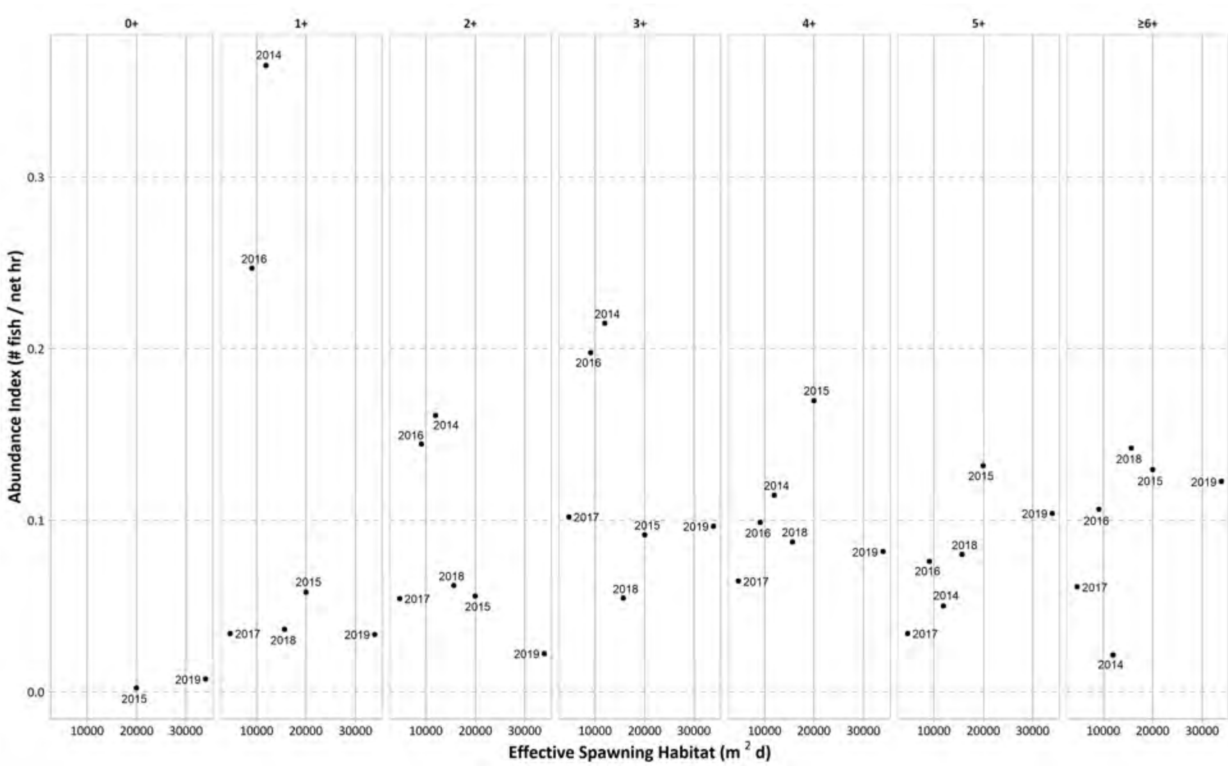
**Table 13. CPUE (fish / net hour) of Rainbow Trout age cohorts captured during gill netting surveys in Upper Campbell Reservoir, 2019.**

| Age | Number of Fish Caught | CPUE (# of Fish/net |
|---|---|---|
| 0+ | 2 | 0.007 |
| 1+ | 9 | 0.033 |
| 2+ | 6 | 0.022 |
| 3+ | 26 | 0.097 |
| 4+ | 22 | 0.082 |
| 5+ | 28 | 0.104 |
| ≥6+ | 33 | 0.123 |

### 3.2.3.4. Comparison of Abundance Index to Effective Spawning Habitat

There is no clear relationship between age specific abundance indices of young (1+ to 3+) Rainbow Trout and the ESH in the Upper Campbell Reservoir ( Figure 17). However, the age specific abundance indices of 4+ to 6+ fish are positively correlated to the ESH in the Upper Campbell Reservoir ( Figure 17). There are substantial inter annual differences in CPUE; the largest values of CPUE were recorded for age 1+ fish in 2014 (0.365 fish/net hr), and age 1+ fish in 2016 (0.247 fish/net hr). The CPUE values for the other age classes in those same years were relatively high. The values of ESH during this monitoring project (2014-2019) were variable; they initially increased from ~10,000 m$^2$d to ~20,000 m$^2$d in 2015, then decreased to a low in 2017 of ~5,000 m$^2$d, and then increased through 2019 to a maximum of ~35,000 m$^2$d. (Figure 17).

**Figure 17. Effective Spawning Habitat values of the Upper Campbell Reservoir in relation to Rainbow Trout abundance index for each age cohort.**



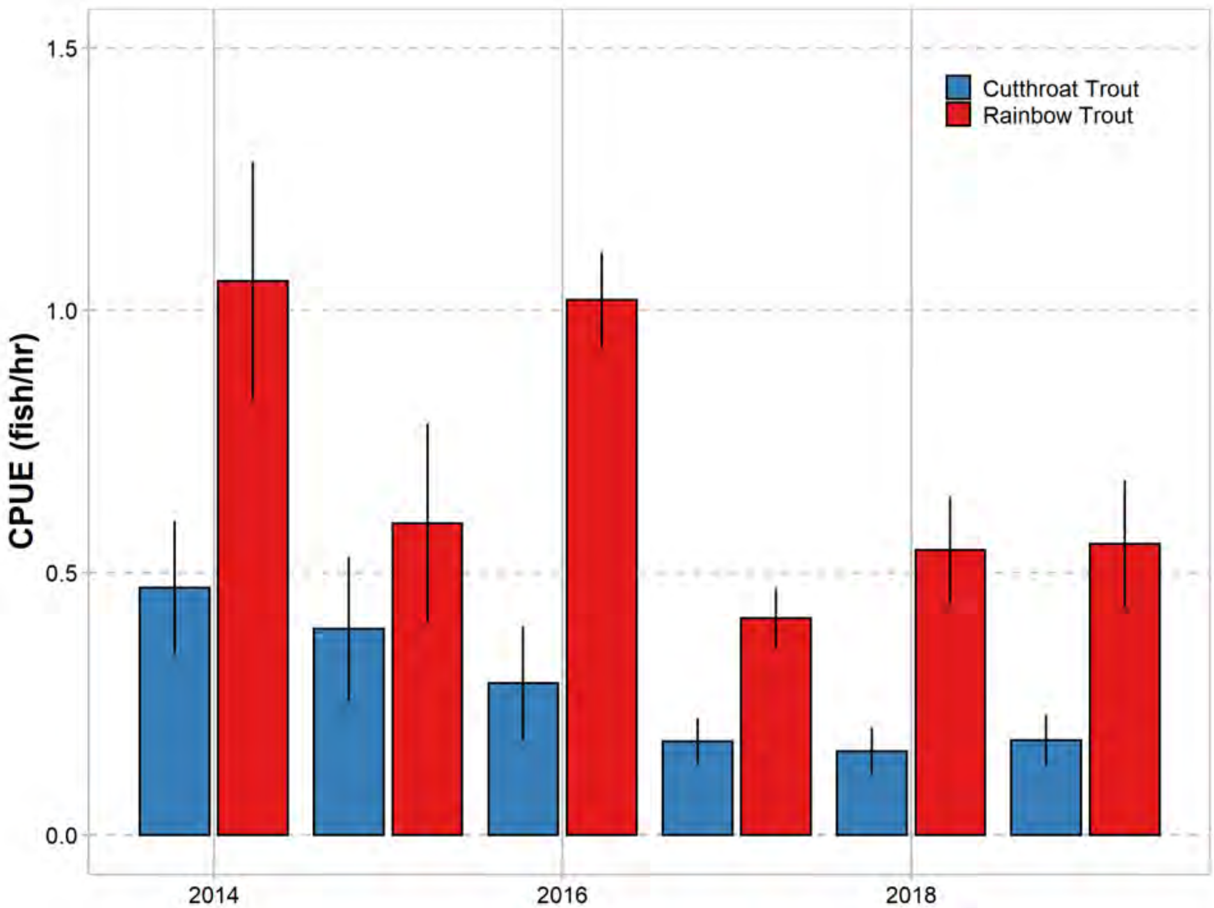

### 3.2.4. Historical Comparison

In this section, we provide brief summaries of historic gill net catch data for Cutthroat and Rainbow trout for both species for the Upper Campbell Reservoir overall, and by sample site for each species separately.

#### 3.2.4.1. Upper Campbell Reservoir

Sampling results from Year 1 to Year 6 (2014 to 2019) suggests that mean Cutthroat Trout CPUE is in a declining trend, while average Rainbow Trout CPUE is highly variable (Figure 18) in the Upper Campbell Reservoir. Cutthroat Trout CPUE has declined since Year 1. Rainbow Trout CPUE is variable among years with no discernible trend in CPUE. It is worth noting that Year 4 CPUE for Rainbow Trout (0.41 fish/net hour) and Cutthroat Trout (0.18 fish/net hour) was the lowest on record since 2014. Since then, Cutthroat Trout CPUE has remained stable, whereas Rainbow Trout recovered during Year 5 and it remained stable at about 0.55 fish/net hour during Year 6.

**Figure 18. Comparison of Cutthroat and Rainbow Trout CPUE from littoral gill net surveys in the Upper Campbell Reservoir among the six years of this program to date (2014-2019).**

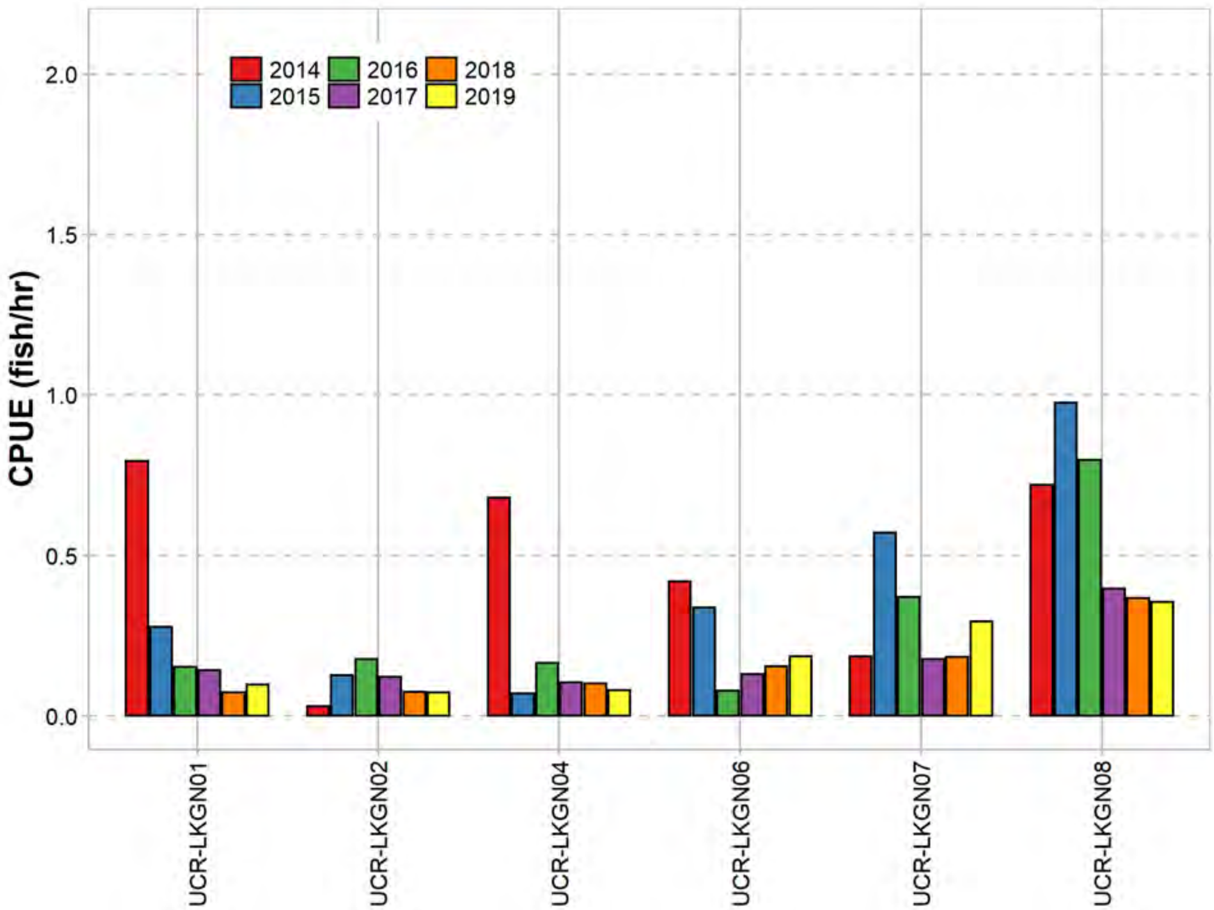



*Cutthroat Trout*

Results from the Year 6 Population Index are comparable to past years. UCR-LKGN02 had consistently lower Cutthroat Trout CPUE compared to the other sites, whereas UCR-LKGN08 had relatively moderate to high Cutthroat Trout CPUE for all six years.

Cutthroat Trout appeared to have a consistent preference for some sites over others, but trends for Cutthroat Trout CPUE are not apparent within sampling sites or across years. In fact, the only site with a consistent trend across all sampling years is UCR-LKGN01, for which CPUE has decreased annually since 2014, although it increased slightly in 2019. Compared to previous years, CPUE values remained very similar across sites, with a slight increase in site UCR-LKGN07. Assuming CPUE is an indication of habitat preference, it would appear that habitat at UCR-LKGN08 is preferred over that at the other sites, while UCR-LKGN02 and UCR-LKGN04 are less-preferred sites.

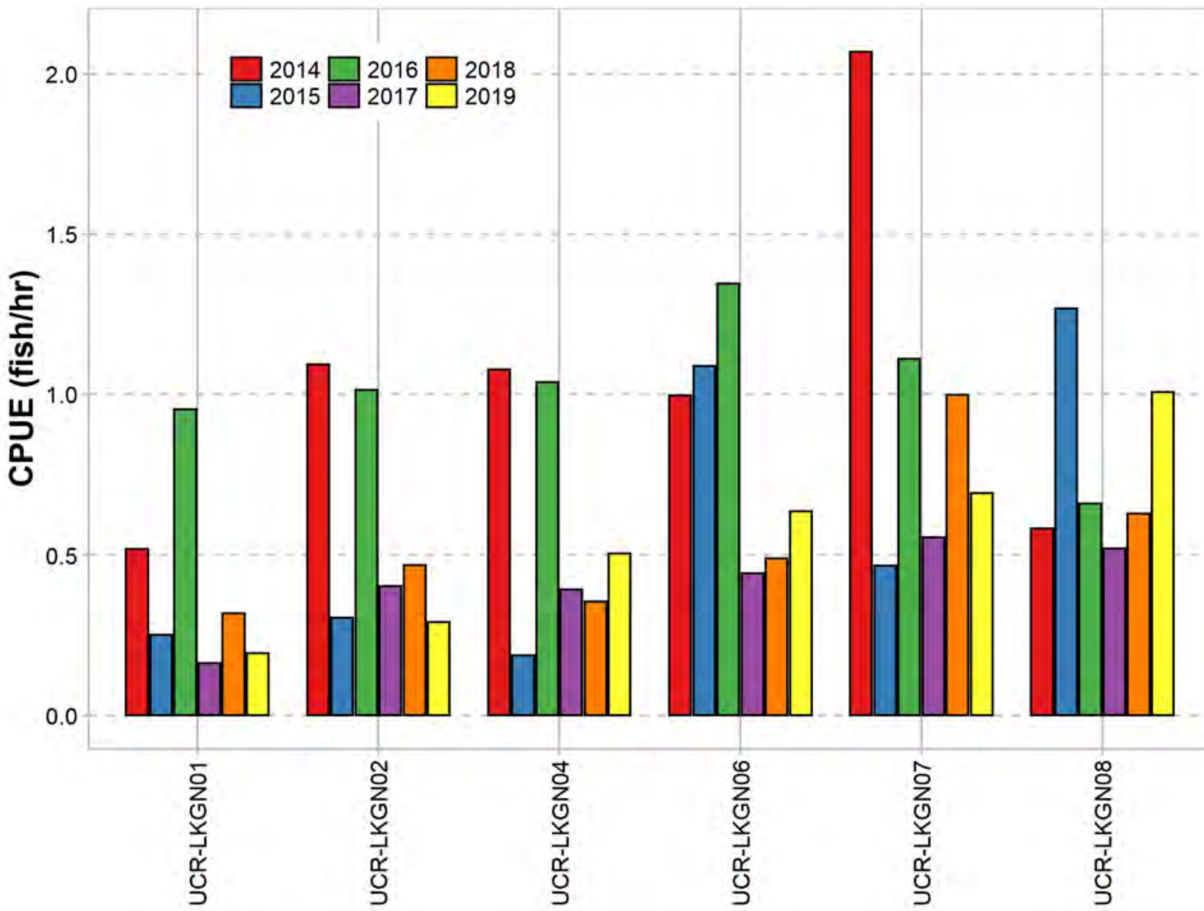
**Figure 19. Comparison of Cutthroat Trout CPUE from littoral RISC gill net surveys by sample site among the six years of this program to date (2014-2019).**




*Rainbow Trout*

There is no consistent trend in CPUE results for Rainbow Trout among the sampling sites or across sampling years (Figure 20). In general terms, CPUE was highest in 2014 and 2016. The CPUE in 2019 increased in 3 sites and decreased in the remaining three. This variation was minimal at most sites, except for UCR-LKGN08 where it increased by 30% (Figure 20).

**Figure 20. Comparison of Rainbow Trout CPUE from littoral RISC gill net surveys by sample site among the six years of this program to date (2014-2019).**




3.3. Snorkel Survey of Spawners in Reservoir Tributaries

3.3.1. Survey Conditions

Details of survey locations, dates, effort, and conditions are presented for spring (Table 14) and summer surveys (Table 15). All parameters (discharge, visibility, and temperature) during the spring surveys were influenced by seasonal freshet and precipitation with varying effective visibility from 4 m in March to 6.0 m in April and with temperatures ranging between 1.5°C and 4°C (Table 14). Relative to the spring, increased water temperature and visibility was experienced during summer surveys (Table 15). Representative photographs collected during snorkel surveys are presented in Appendix D.

**Table 14. Sampling effort and conditions for Year 6 snorkel surveys in tributaries of the Lower Campbell Reservoir during spring surveys in 2019. Survey distances for Fry and Miller Creek are from LKT (2015) and Greenstone River survey distances are based on satellite images.**

| Watershed | Stream | Survey Distance (km) | Date | Survey Duration (hrs) | Total Effort (hrs) | Water Temp. (°C) | Air Temp (°C) | Estimated Visibility (m) | Mean Daily Discharge ($m^3/s$)[1] | Weather |
|---|---|---|---|---|---|---|---|---|---|---|
| Lower Campbell | Fry Creek | 1.2 | 04-Mar-19 | 0.5 | 1.0 | 3.5 | 2.5 | 4.0 | 2.0 | Sunny |
| | Miller Creek | 0.4 | 04-Mar-19 | 1.8 | 3.5 | 1.5 | -2.0 | 4.0 | 2.0 | Sunny |
| | Greenstone River | 2.4 | 30-Apr-19 | 1.6 | 3.3 | 4.0 | 9.0 | 6.0 | 5.6 | Sunny |

[1] Data from the Gauge 08HD018 form Government of Canada Wateroffice site

**Table 15. Sampling effort and conditions for Year 6 snorkel surveys during summer 2019. Survey distances are from LKT (2015).**

| Watershed | Stream | Survey Distance (km) | Date | Survey Duration (hrs) | Total Effort (hrs) | Water Temp. (°C) | Air Temp (°C) | Estimated Visibility (m) | Mean Daily Discharge ($m^3/s$)[1] | Weather |
|---|---|---|---|---|---|---|---|---|---|---|
| Buttle Lake | Henshaw Creek | 0.5 | 04-Jun-19 | 0.7 | 1.3 | 6.0 | 9.0 | 6.0 | 7.3 | Partly Cloudy |
| | Phillips Creek | 0.3 | 05-Jun-19 | 0.5 | 1.0 | 6.0 | 8.0 | 6.0 | 6.9 | Overcast/Light Rain |
| | Ralph River | 0.9 | 04-Jun-19 | 0.6 | 1.3 | 7.0 | 14.0 | 6.0 | 7.3 | Partly Cloudy |
| | Thelwood Creek | 2.5 | 07-Jun-19 | 1.4 | 2.7 | 9.0 | 10.0 | 6.0 | 6.4 | Partly Cloudy |
| | Wolf River | 0.3 | 05-Jun-19 | 1.1 | 2.2 | 8.0 | 10.0 | 6.0 | 6.9 | Partly Cloudy |
| Upper Campbell | Lower Elk River | 5.4 | 06-Jun-19 | 1.8 | 3.5 | 8.0 | 12.0 | 8.0 | 6.9 | Overcast/Rain |
| | Upper Elk River | 6 | 06-Jun-19 | 1.6 | 3.2 | 7.0 | 8.0 | 6.0 | 6.9 | Partly Cloudy |

[1] Data from the Gauge 08HD018 form Government of Canada Wateroffice site.

### 3.3.2. Survey Results

#### 3.3.2.1. Cutthroat Trout Results

Year 6 snorkel survey data for the Cutthroat Trout spring spawning period are summarized below (Table 16). Redds observed during March and April were assumed to be Cutthroat Trout redds, even if fish were not observed.

Snorkel surveys for spawning Cutthroat Trout were conducted in tributaries of the Lower Campbell River in March and April, 2019. During these Lower Campbell River snorkel surveys adult Cutthroat Trout were observed only in Greenstone River; however, redds were observed in all three tributaries of Lower Campbell Reservoir (Table 16).

Densities of Cutthroat Trout were low in all tributaries, reaching maximums of 63.3 fish/km and 10 fish/km in Wolf River and Philips Creek, respectively (Figure 21). The majority of adult Cutthroat observed in 2019 were either bright ($n$ = 54) or undetermined ($n$ = 22) (Figure 24). Only a few fish in mid-spawn condition ($n$ = 10) were observed in Greenstone River, and only two fish in post-spawn condition (Figure 24).

**Table 16. Cutthroat Trout counts during 2019 snorkel surveys in the tributaries of Upper and Lower Campbell Reservoirs and Buttle Lake.**

| Watershed | Month | Waterbody | Date | Cutthroat Trout Observations (# of fish)[1] | | | | | | | Redds[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Fry | Parr | 151-250 | 251-350 | 351-450 | 450+ | |
| Buttle Lake | June | Henshaw Creek | 04-Jun-19 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | n/a |
| | | Phillips Creek | 05-Jun-19 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | n/a |
| | | Ralph River | 04-Jun-19 | 6 | 0 | 0 | 1 | 1 | 4 | 0 | n/a |
| | | Thelwood Creek | 07-Jun-19 | 19 | 0 | 0 | 0 | 5 | 14 | 0 | n/a |
| | | Wolf River | 05-Jun-19 | 19 | 0 | 0 | 1 | 6 | 12 | 0 | n/a |
| Lower Campbell | March | Fry Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 110 |
| | | Miller Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 115 |
| | April | Greenstone River | 30-Apr-19 | 14 | 0 | 3 | 3 | 5 | 3 | 0 | 71 |
| Upper Campbell | June | Lower Elk River | 06-Jun-19 | 23 | 0 | 0 | 2 | 16 | 5 | 0 | n/a |
| | | Upper Elk River | 06-Jun-19 | 4 | 0 | 0 | 0 | 1 | 3 | 0 | n/a |

[1] Fry = <80 mm fork length, Parr = 81-150 mm fork length, All others are categorized as mm fork length

[2] All redds observed in March and April are assumed to be Cutthroat Trout redds. Redds observed in June are assumed to be Rainbow Trout. "n/a" reflects no sampling for redds since sampling occurred outside of spawning period.

**Figure 21. Cutthroat Trout observed density (fish/km; all life stages) during Year 6 snorkel surveys in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir.**

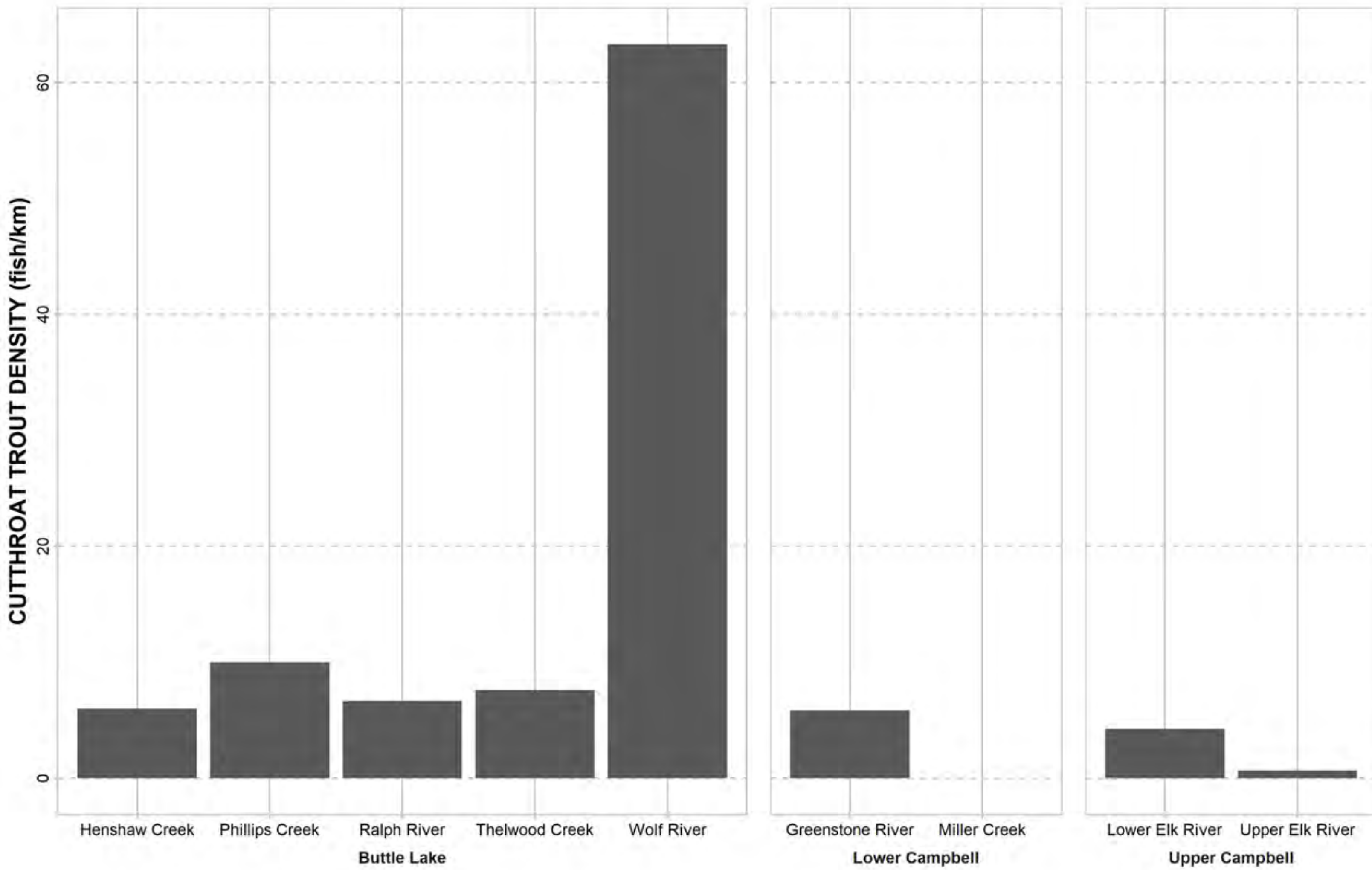
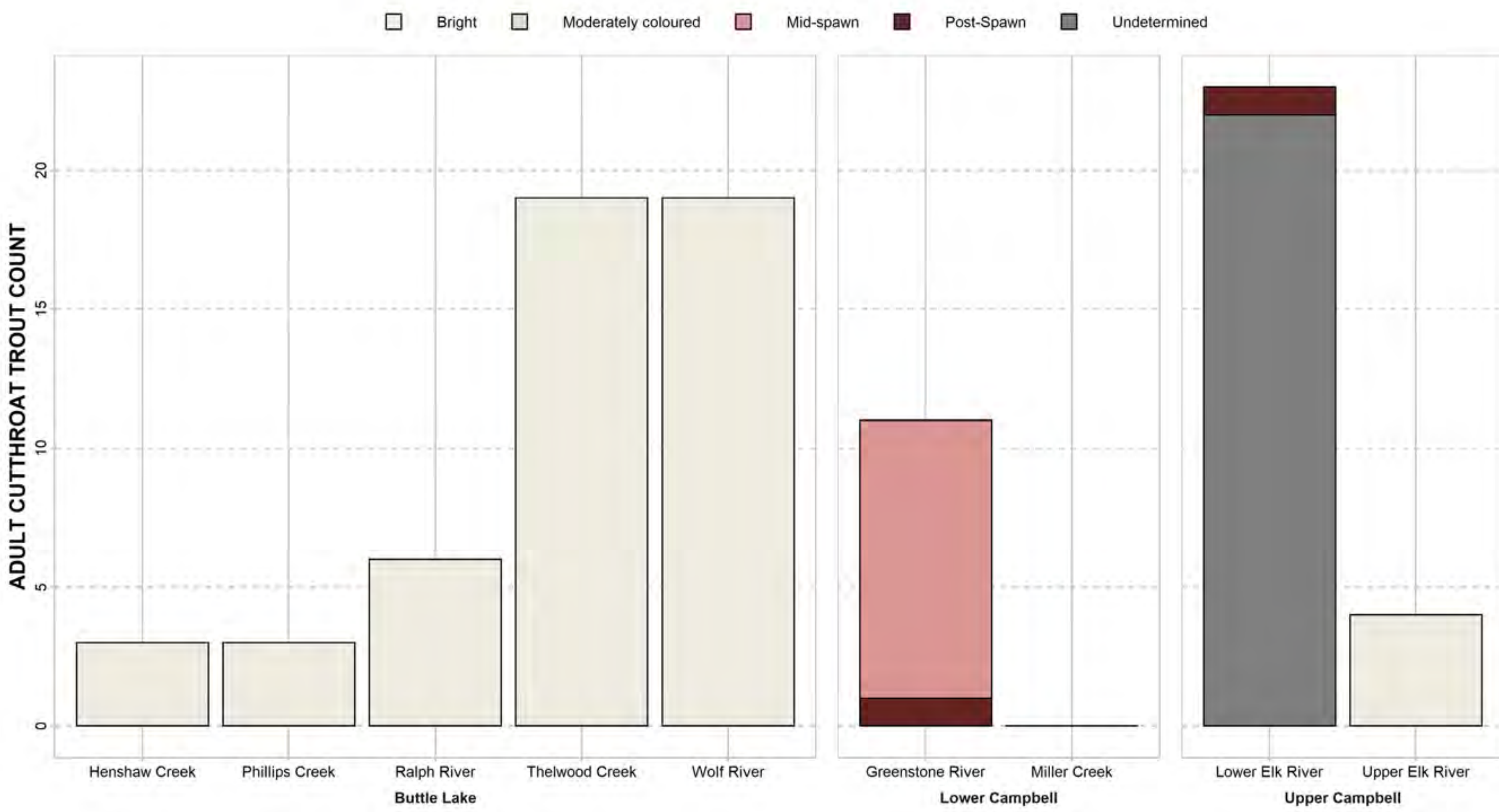


Figure 22. Counts of adult Cutthroat Trout observed during Year 6 snorkel surveys in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir, by condition classes.



#### 3.3.2.2. Rainbow Trout Results

Rainbow Trout redds were recorded in all surveyed tributaries of Upper Campbell and Buttle Lake (Table 17). The highest number of redds was observed in Thelwood Creek (1782 redds), followed by Upper Elk River (1450 redds), and Lower Elk River (921 redds). The number of Rainbow Trout redds recorded in Thelwood Creek in Year 6 were higher than in previous years (Year 5: 1,519, Year 4: 576, Year 3: 1,217, Year 2: 1,441) (Buren *et al.* 2019, Bayly *et al.* 2018, Smyth and Hatfield 2017, Hatfield *et al.* 2016)[2]. The total number of Rainbow Trout redds recorded in the Elk River in Year 6 (2,379) was higher than in the previous 4 years (Year 5: 2,110, Year 4: 1,087, Year 3: 1833, Year 2: 1846) (Buren *et al.* 2019, Bayly *et al.* 2018, Smyth and Hatfield 2017, Hatfield *et al.* 2016). Redds were observed during snorkel surveys in tributaries of the Lower Campbell Reservoir in March and April; however, they are assumed to have been excavated by Cutthroat Trout.

Total Rainbow Trout density per km of stream (juvenile and adult fish combined) varied considerably among stream reaches, with observed densities greatest in Wolf River (2,817 fish/km), Ralph River (872 fish/km), Thelwood Creek (740 fish/km), and Philips Creek (627 fish/km) (Figure 23). When interpreting these results, note that variability in channel width hinders direct comparison of this metric between tributaries.

Adult Rainbow Trout counts were much higher than Cutthroat Trout, which may have been a result of effective survey timing in relation to Rainbow Trout spawning, or due to differences in effective population size between the species. Highest count numbers of adult Rainbow Trout observations were recorded from lower Elk River (2,112 fish); Thelwood Creek (1,850 fish); and upper Elk River (1,534 fish) (Figure 24). These watercourses also correspond to the highest counts from previous years. The majority of the observed Rainbow Trout were in mid-spawn (47%) or of moderately coloured (24%) condition, suggesting that these surveys occurred during spawning (Figure 24). Appreciable numbers of fish in post-spawn condition were observed in Upper Elk River ($n$ = 460, 30% of adult Rainbow Trout in that stream), Lower Elk River ($n$ = 2,112, 20% of adult Rainbow Trout in that stream), Thelwood Creek ($n$ = 1,850, 19.6% of adult Rainbow Trout in that stream), Wolf River ($n$ = 844, 10.7% of adult Rainbow Trout in that stream), and Ralph River ($n$ = 785, 8.4% of adult Rainbow Trout in that stream) (Figure 24).

[2] Redd counts were not consistently recorded for all survey reaches in Year 1, hence no comparison is made with Year 1 data here.

**Table 17. Rainbow Trout counts during 2019 snorkel surveys in the tributaries of Upper and Lower Campbell Reservoirs and Buttle Lake.**

| Watershed | Month | Waterbody | Date | Rainbow Trout Observations (# of fish)[1] | | | | | | | Redds[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Fry | Parr | 151-250 | 251-350 | 351-450 | 450+ | |
| Buttle Lake | June | Henshaw Creek | 04-Jun-19 | 77 | 0 | 0 | 9 | 68 | 0 | 0 | 49 |
| | | Phillips Creek | 05-Jun-19 | 188 | 0 | 1 | 53 | 133 | 2 | 0 | 64 |
| | | Ralph River | 04-Jun-19 | 785 | 0 | 0 | 160 | 611 | 14 | 0 | 296 |
| | | Thelwood Creek | 07-Jun-19 | 1,850 | 0 | 0 | 167 | 1,540 | 143 | 0 | 1,782 |
| | | Wolf River | 05-Jun-19 | 845 | 0 | 1 | 172 | 641 | 31 | 0 | 493 |
| Lower Campbell | March | Fry Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | | Miller Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | April | Greenstone River | 30-Apr-19 | 13 | 0 | 0 | 0 | 13 | 0 | 0 | n/a |
| Upper Campbell | June | Lower Elk River | 06-Jun-19 | 2,112 | 0 | 0 | 535 | 1,577 | 0 | 0 | 921 |
| | | Upper Elk River | 06-Jun-19 | 1,534 | 0 | 0 | 453 | 974 | 107 | 0 | 1,450 |

[1] Fry = <80 mm fork length, Parr = 81-150 mm fork length, All others are categorized as mm fork length

[2] All redds observed in June are assumed to be Rainbow Trout redds

"n/a" reflects no sampling for redds since sampling occurred outside of spawning period

**Figure 23. Rainbow Trout observed density (fish/km; all life stages) during Year 6 summer snorkel in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir. Rainbow Trout observed incidentally during snorkel surveys for Cutthroat Trout in the Lower Campbell Reservoir are not included.**

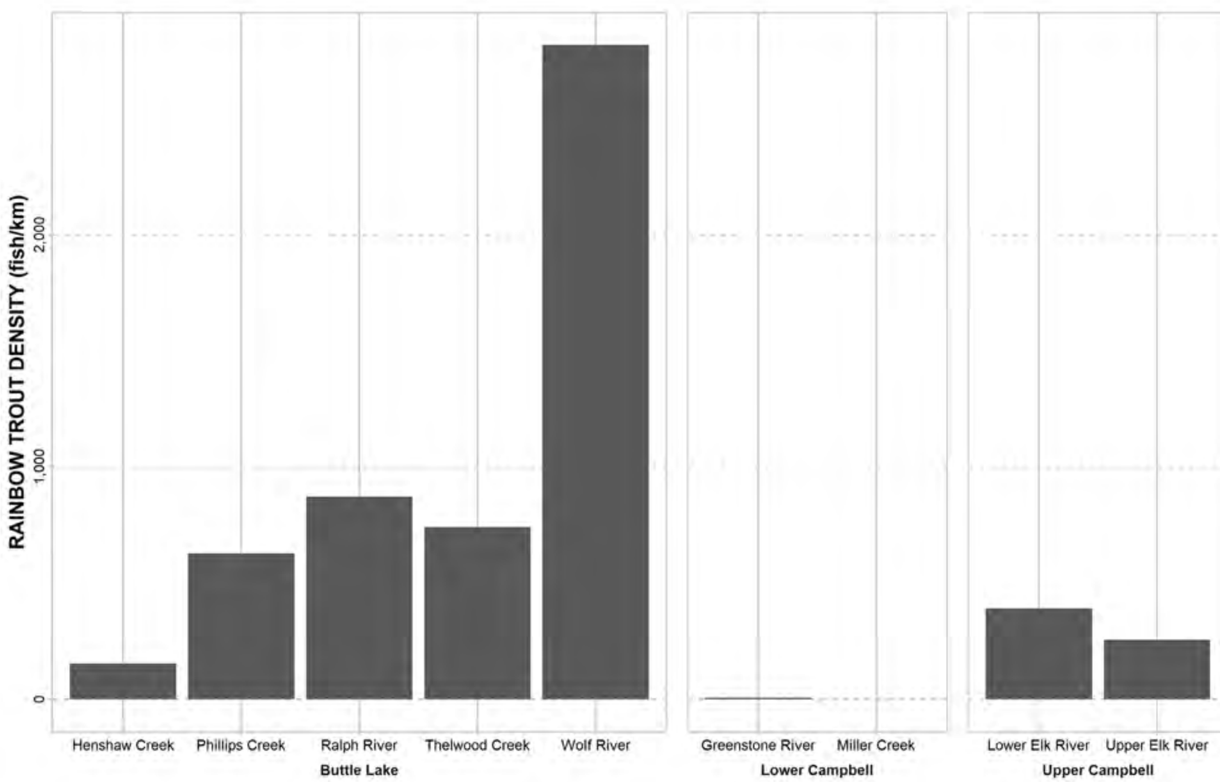
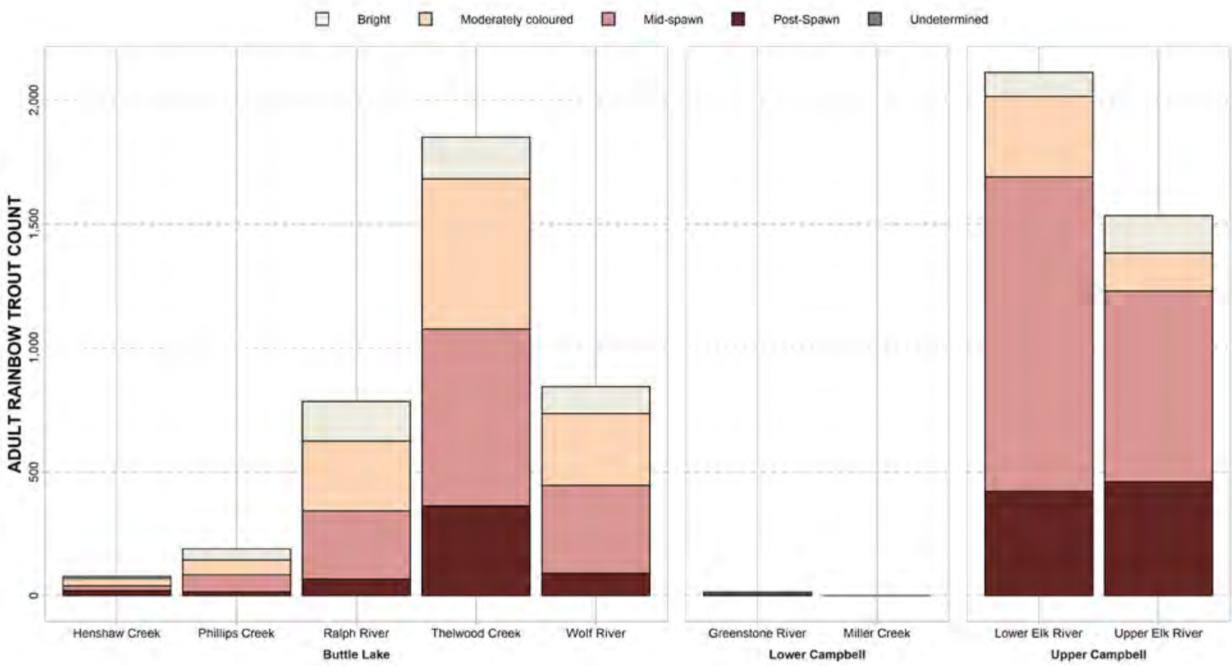


**Figure 24. Counts of adult Rainbow Trout observed during Year 6 summer snorkel surveys in the tributaries of Upper Campbell Reservoir and Buttle Lake, by condition classes. Rainbow Trout observed incidentally during snorkel surveys for Cutthroat Trout in Lower Campbell Reservoir are not included.**




3.3.2.3. Dolly Varden and Unidentified Salmonids

The numbers of adult Dolly Varden observed were much lower than the number of observed Cutthroat or Rainbow trout. This reflects the timing of the surveys, which targeted Cutthroat Trout and Rainbow Trout spawning during the spring and summer, respectively. Snorkel surveys targeting the Dolly Varden spawning period (October to early December) were not undertaken and are not within the scope of this monitoring program; therefore, all observations of Dolly Varden are classified as incidental.

Only five Dolly Varden parr were observed during spring surveys in Greenstone River, and few observations occurred during the summer surveys (Table 18). The greatest number of adult Dolly Varden were observed in Wolf River (11 fish) which was the second lowest number recorded through the 6 years of monitoring, being only higher than the number of Dolly Varden observed in Wolf River during Year 3 (*n* = 5), (Year 1: 30, Year 3: 25, Year 4: 51, Year 5: 29) (Buren *et al.* 2019, Bayly *et al.* 2018, Smyth and Hatfield 2017, Hatfield *et al.* 2016). Consequently, the density of Wolf River Dolly Varden (36.6 fish/km) was the second smallest through the 6 years of monitoring. Densities observed in other streams were below 10 fish/km, and were comparable to those recorded previously.

**Figure 25. Dolly Varden observed density (fish/ km) from 2019 summer snorkel surveys in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir**

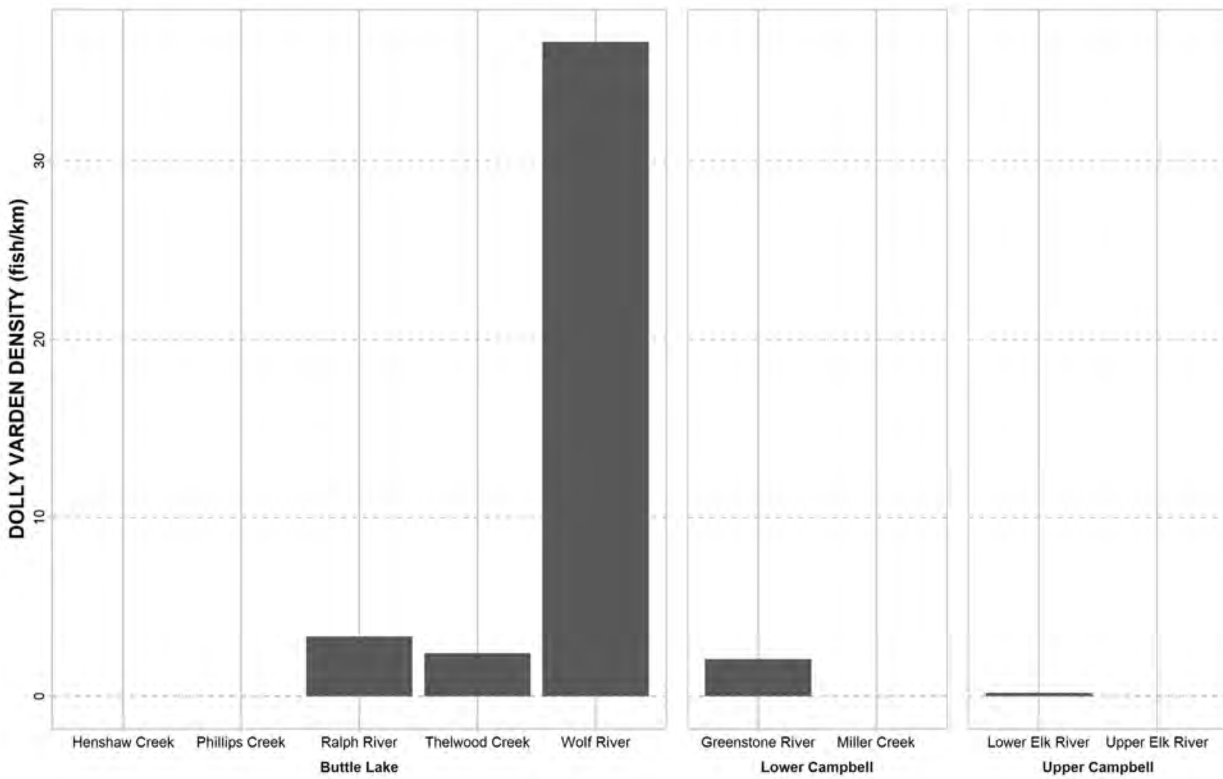


**Table 18. Dolly Varden population counts (incidental) from 2019 snorkel surveys in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir.**

| Watershed | Month | Waterbody | Date | Rainbow Trout Observations (# of fish)[1] | | | | | | | Redds[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Fry | Parr | 151-250 | 251-350 | 351-450 | 450+ | |
| Buttle Lake | June | Henshaw Creek | 04-Jun-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | | Phillips Creek | 05-Jun-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | | Ralph River | 04-Jun-19 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | n/a |
| | | Thelwood Creek | 07-Jun-19 | 6 | 0 | 0 | 2 | 4 | 0 | 0 | n/a |
| | | Wolf River | 05-Jun-19 | 11 | 0 | 0 | 2 | 8 | 1 | 0 | n/a |
| Lower Campbell | March | Fry Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | | Miller Creek | 04-Mar-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |
| | April | Greenstone River | 30-Apr-19 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | n/a |
| Upper Campbell | June | Lower Elk River | 06-Jun-19 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | n/a |
| | | Upper Elk River | 06-Jun-19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | n/a |

[1] Fry = <80 mm fork length, Parr = 81-150 mm fork length, All others are categorized as mm fork length

"n/a" reflects no sampling for redds since sampling occurred outside of spawning period

### 3.3.3. Comparison With Historic Data

#### 3.3.3.1. Overview

Snorkel surveys targeting the Rainbow Trout spawning period have been undertaken to enumerate adult spawning fish in the six tributaries of Buttle Lake and Upper Campbell Reservoir since 1990. In recent years, prior to 2014, these surveys were completed by BCCF with funding from BC Hydro (Pellett 2013). The frequency of snorkel surveys prior to 2014 was not been consistent from year to year for several of the tributaries. The size limit used to define "adult" fish during historic surveys is not known, with the exception of Fry Creek (fork length > 100 mm). Fish count data for the six tributaries that are part of this monitoring program (data for the survey reaches in the upper and lower Elk River are presented separately) are presented in Table 19; of the three species enumerated, counts have historically been highest for Rainbow Trout, which was also true for the June 2019 surveys.

Regular annual snorkel surveys have not been undertaken in the three sampled tributaries of Lower Campbell Reservoir, and no historical data are available for Miller Creek (Strathcona Dam tailrace); however, surveys were undertaken in Fry Creek in 2003 and 2004 and were re-commenced as part of the JHTMON-3 monitoring program in 2014 (Pellett 2013). These historic data are derived from surveys undertaken across a range of months and are thus presented separately in Table 20; note that only one fish has been recorded since 2014.

**Table 19. Summary of adult fish count data in six tributaries of Upper Campbell Reservoir and Buttle Lake that were surveyed (1990-2019). Historic data (prior to 2014) were provided by BCCF (Pellett 2013).**

| Watershed[1] | Waterbody | Species[2] | Year | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Upper Campbell[3] | Upper Elk | RB | n/a | 436 | 1,475 | 487 | 960 | 542 | 370 | n/a | n/a | n/a | n/a | 428 | 168 | 337 | 728 | n/a | 1,586 | 1,066 | 1,562 | 1,847 | 1,445 | n/a | 716 | 551 | 877 | 1,147 | 764 | 900 | 1,304 | 1,164 | 1,534 |
| | | CT | n/a | 8 | 7 | 0 | 19 | 11 | 1 | n/a | n/a | n/a | n/a | 3 | 2 | 0 | 5 | n/a | 4 | 0 | 2 | 5 | 10 | n/a | 11 | 10 | 8 | 2 | 3 | 2 | 21 | 13 | 4 |
| | | DV | n/a | 0 | 5 | 0 | 0 | 2 | n/a | n/a | n/a | 1 | n/a | 6 | 0 | 0 | 0 | n/a | 6 | 1 | 1 | 1 | 2 | n/a | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | Lower Elk | RB | 823 | 1,134 | 1,087 | 1,194 | 1,411 | 773 | 1,044 | n/a | n/a | n/a | n/a | 1,089 | 1,184 | 1,259 | 1,784 | n/a | 5,340 | 4,862 | 5,630 | 2,501 | 3,919 | n/a | 3,980 | 1,537 | 1,204 | 1,742 | 886 | 2,104 | 2,774 | 2,541 | 2,112 |
| | | CT | 7 | 16 | 11 | 1 | 26 | 2 | 8 | n/a | n/a | n/a | n/a | 3 | 2 | 1 | 3 | n/a | 3 | 3 | 11 | 4 | 20 | n/a | 5 | 5 | 7 | 2 | 4 | 6 | 11 | 19 | 23 |
| | | DV | 0 | 0 | 4 | 0 | 13 | 0 | n/a | n/a | n/a | 0 | n/a | 6 | 2 | 1 | 2 | n/a | 9 | 2 | 0 | 2 | 1 | n/a | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 2 | 1 |
| Buttle | Ralph | RB | n/a | 300 | 1,300 | 965 | 2,100 | n/a | n/a | n/a | 2,620 | n/a | 1,175 | 420 | 724 | 532 | 910 | n/a | 650 | 690 | 1,103 | 1,181 | 708 | n/a | 479 | 536 | | 835 | 407 | 419 | 421 | 647 | 785 |
| | | CT | n/a | 0 | 0 | 4 | 0 | n/a | n/a | n/a | 2 | n/a | 2 | 0 | 0 | 2 | 10 | n/a | 2 | 0 | 2 | 0 | 0 | n/a | 1 | 2 | | 1 | 0 | 3 | 8 | 5 | 6 |
| | | DV | n/a | 10 | 10 | 4 | 4 | n/a | n/a | n/a | 30 | n/a | 8 | 0 | 3 | 0 | 17 | n/a | 4 | 56 | 0 | 9 | 4 | n/a | 0 | 13 | | 4 | 1 | 3 | 4 | 5 | 3 |
| | Thelwood | RB | n/a | 1,000 | 2,500 | 3,220 | 3,975 | n/a | 2,300 | n/a | n/a | 4,915 | 2,840 | 2,501 | 3,374 | 3,032 | 2,590 | n/a | 3,105 | 3,921 | 4,408 | 4,128 | 4,892 | 1,123 | 3,748 | 4,104 | | 2,567 | 800 | 1,110 | 1,633 | 1,571 | 1,850 |
| | | CT | n/a | 200 | 15 | 88 | 347 | n/a | 53 | n/a | n/a | 141 | 53 | 441 | 34 | 64 | 20 | n/a | 25 | 10 | 12 | 4 | 17 | 32 | 26 | 15 | | 0 | 11 | 11 | 14 | 28 | 19 |
| | | DV | n/a | 225 | 1 | 0 | 30 | n/a | 2 | n/a | n/a | 28 | 0 | 0 | 8 | 3 | 6 | n/a | 24 | 6 | 4 | 9 | 5 | 2 | 0 | 0 | | 0 | 7 | 8 | 3 | 8 | 6 |
| | Wolf | RB | n/a | n/a | n/a | n/a | n/a | 800 | n/a | n/a | n/a | 450 | n/a | 361 | 228 | 170 | 576 | 335 | n/a | n/a | 1,250 | 1,210 | 1,590 | 140 | 192 | 666 | | 384 | 410 | 345 | 327 | 625 | 844 |
| | | CT | n/a | n/a | n/a | n/a | n/a | 2 | n/a | n/a | n/a | 1 | n/a | 3 | 0 | 0 | 0 | 0 | n/a | n/a | 6 | 1 | 0 | 0 | 2 | 3 | | 3 | 0 | 10 | 26 | 12 | 19 |
| | | DV | n/a | n/a | n/a | n/a | n/a | 30 | n/a | n/a | n/a | 12 | n/a | 4 | 0 | 30 | 41 | 23 | n/a | n/a | 25 | 90 | 90 | 30 | 5 | 18 | | 30 | 25 | 5 | 51 | 29 | 11 |
| | Phillips | RB | n/a | n/a | 750 | n/a | n/a | 800 | n/a | n/a | n/a | 500 | 148 | 132 | 111 | 65 | 109 | 94 | n/a | n/a | 162 | 624 | 540 | 106 | 145 | 191 | | 223 | 157 | 153 | 79 | 93 | 188 |
| | | CT | n/a | n/a | 0 | n/a | n/a | 6 | n/a | n/a | n/a | 2 | 0 | 6 | 0 | 5 | 1 | 0 | n/a | n/a | 1 | 0 | 0 | 0 | 2 | 0 | | 2 | 0 | 0 | 1 | 2 | 3 |
| | | DV | n/a | n/a | 20 | n/a | n/a | 50 | n/a | n/a | n/a | 10 | 1 | 16 | 1 | 5 | 0 | 11 | n/a | n/a | 3 | 4 | 40 | 21 | 3 | 8 | | 18 | 0 | 0 | 0 | 3 | 0 |
| | Henshaw | RB | n/a | 98 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 4 | 24 | 7 | 78 | n/a | 5 | 42 | 24 | 93 | 27 | n/a | 8 | 37 | | 26 | 29 | 44 | 17 | 26 | 77 |
| | | CT | n/a | 0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0 | 0 | 0 | 0 | n/a | 0 | 0 | 1 | 0 | 0 | n/a | 0 | 0 | | 0 | 0 | 0 | 3 | 1 | 3 |
| | | DV | n/a | 0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0 | 0 | 0 | 2 | n/a | 0 | 0 | 0 | 0 | 0 | n/a | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |

[1] Historical data for Fry Creek (Lower Campbell Reservoir) are presented separately.

[2] RB - Rainbow Trout, CT - Cutthroat Trout, and DV - Dolly Varden.

[3] Elk River reaches were sampled on June 11 and June 12, 2013. Both values are presented.

"n/a" indicate that surveys were not undertaken.

**Table 20. Historic adult fish count data for Fry Creek, from survey dates 2003, 2004, 2014-2019. Data collected in 2003 and 2004 were provided by BCCF (Pellett 2013).**

| Waterbody | Year | Month | Fish Count[1,2] | | |
|---|---|---|---|---|---|
| | | | RB | CT | DV |
| Fry Creek | 2003 | February | 0 | 18 | 0 |
| | | March | 0 | 287 | 0 |
| | | April | 0 | 9 | 0 |
| | | May | 48 | 573 | 1 |
| | | June | 20 | 3 | 0 |
| | | October | 0 | 140 | 0 |
| | 2004 | February | 0 | 15 | 0 |
| | | April | 0 | 3 | 0 |
| | | May | 0 | 185 | 14 |
| | 2014 | June | 0 | 0 | 0 |
| | 2015 | June | 1 | 0 | 0 |
| | 2016 | March | 0 | 0 | 0 |
| | 2017 | March | 0 | 0 | 0 |
| | 2018 | March | 0 | 0 | 0 |
| | 2019 | March | 0 | 0 | 0 |

[1] Fish counts for 2003 and 2004 include fish ≥ 100 mm and fish counts from 2014 onwards include fish ≥ 150 mm

[2] RB - Rainbow Trout, CT - Cutthroat Trout, and DV - Dolly Varden

#### 3.3.3.2. Cutthroat Trout

The data presented here for June 2019 are from Rainbow Trout spawning surveys, so any trends in Cutthroat Trout should be interpreted cautiously. Adult Cutthroat Trout counts in 2019 (ranging from 3 to 23 fish) are generally consistent with historic observations for the period 1990 to 2016 (Table 19). Noteworthy are Thelwood Creek, where an order of magnitude decrease was recorded in 2002, and counts have remained low since, Lower Elk River where there is an increasing trend in the number of Cutthroat Trout since 2014 (although it seems to have stabilized in 2019), and Wolf River where over 10 fish were observed during 2016-2018 (maximum observed prior to 2016: six fish, mean observed prior to 2016: 1.5 fish), although none were observed in 2019.

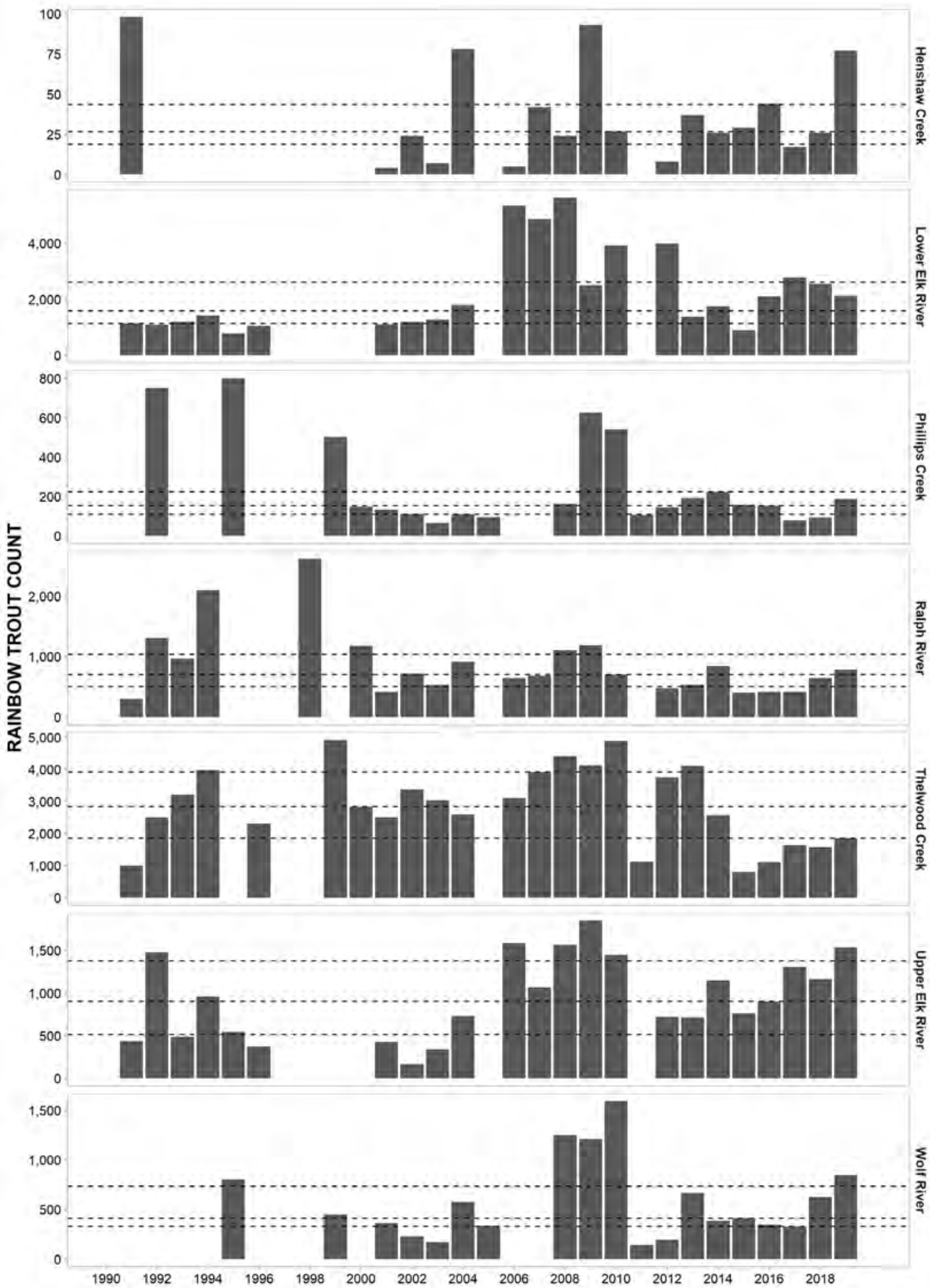
In Fry Creek, comparable survey data for March are only available in 2003 when 287 Cutthroat Trout were observed, and in 2016-2018 when no fish were observed (Table 20). However, as mentioned in Section 3.3.2.1, surveys were likely conducted following 2019 Cutthroat Trout spawning which means that the 2019 counts are not an accurate measure of the spawner abundances in Fry Creek.

#### 3.3.3.3. Rainbow Trout

There is high variability in adult Rainbow Trout counts among years for individual tributaries, and no clear trends across the entire time series (Table 19, Figure 26). There is an incipient increasing trend during the last five years in three tributaries: Wolf River, Upper Elk River, and Thelwood Creek (Figure 26).

Counts of Rainbow Trout in 2019 were above the 75$^{th}$ percentile in three of the streams surveyed: Henshaw Creek, Upper Elk River, and Wolf River, at or above the 50$^{th}$ percentile in three streams: Lower Elk River, Philips Creek, and Ralph River, and at the 25$^{th}$ percentile in Thelwood Creek (Figure 26). No adult Rainbow Trout were recorded in Fry Creek in March 2019; however, this was comparable to sampling results from March in previous years (Table 20).

**Figure 26.** **Adult Rainbow Trout counts in the tributaries of Buttle Lake, Lower Campbell Reservoir and Upper Campbell Reservoir (1990-2019). Dotted horizontal lines represent 25th, 50th and 75th quantiles. Not all waterbodies were surveyed all years. Historic data (prior to 2014) were provided by BCCF (Pellett 2013).**



#### 3.3.3.4. Dolly Varden

The data presented here are from surveys completed during the month of June which targeted Rainbow Trout spawning, so any trends in Dolly Varden should be interpreted cautiously. The 2019 adult Dolly Varden counts were low (range = 0 to 6), similar to the results of the surveys carried out since 2014, broadly comparable with historic surveys, although the count in Wolf River was lower than previously recorded (Table 19). Of the seven survey reaches in Buttle Lake and Upper Campbell Reservoir, the 2019 adult Dolly Varden counts were in line with the median values for the majority of tributaries (Table 19), but was substantially below the historical median value for Wolf River (2019, $n = 0$; historical range = 0 to 90; median = 25). No adult Dolly Varden were counted in Fry Creek in 2019, consistent with the previous surveys conducted in the month of March (Table 20).

# 4. DISCUSSION

## 4.1. Overview

The overall objective of JHTMON-3 is to test the assumption that recruitment of salmonids (trout and char) in Upper and Lower Campbell reservoirs is limited by availability of ESH. Results obtained thus far, particularly incubation tests and population modelling carried out during Year 5, suggest that recruitment of salmonids is limited by availability of ESH, although not to the extent assumed during the development of the Water Use Plan. The following sections highlight the main conclusions for each component of the study conducted in Year 6.

## 4.2. Effective Spawning Habitat (ESH)

The Year 6 ESH study builds on results from previous years and was successful in providing an improved understanding of trends in habitat loss and ESH for the two target species, Cutthroat Trout and Rainbow Trout, as well as for Dolly Varden.

The work plan focuses most of the ESH investigative effort on Cutthroat Trout in Upper Campbell Reservoir because the potential population response is expected to be greatest due to the considerably larger drawdown (and therefore larger potential impact on egg mortality) and the general trend of rising water levels during the Cutthroat Trout incubation period (Figure 1). Any effect observed in Upper Campbell Reservoir is assumed to apply to Lower Campbell and John Hart reservoirs; however, the magnitude of response is expected to be less due to the more stable water levels in these two reservoirs (Figure 2). Additionally, it is advisable to focus on one reservoir rather than spread the same effort across two or more reservoirs, because this approach will improve the statistical strength of any relationship observed between ESH and fish CPUE.

We carried out a preliminary analysis of the relationship between ESH and fish population index for Cutthroat trout in the Upper Campbell Reservoir for the Year 5 report, as proof of concept. Preliminary results suggest that effects of reservoir inundation on embryo mortality may be strong enough to affect the dynamics of Cutthroat Trout in the Upper Campbell Reservoir. Consistent with the terms of reference, this analysis will be updated for the Year 10 report, as ESH trends across fish age and abundance are anticipated to become more informative.

### 4.3. Population Index for Upper and Lower Campbell Reservoirs

The Year 6 sampling results (2019) provide a sixth year of data on population abundance, recruitment, and effective spawning metrics. The results allow for the preliminary determination of an abundance index for each age cohort for both trout species. This approach will be built upon in future years to develop abundance measures for individual ages and test the management hypotheses described in Section 1.4.

We refined the species-specific inverse von Bertalanffy growth function (ivBGF) developed during Year 5 to assign ages of unaged fish, based on their fork length. This approach makes use of all age and length information collected during this monitoring program. We assigned ages to all fish with a measured fork length captured during the six years of the monitoring program. Given that the method developed and implemented makes use of all data of the monitoring program, sampling can be designed to cover the age classes with fewer observations. Consistent with Year 5 conclusions, we suggest focusing aging efforts on young (ages 0+ and 1+) and older fish (age ≥6+) to improve accuracy of the age bins. These age readings will incrementally add to the existing age readings. Therefore, we will assess the accuracy of the age bins annually to determine if the requirements for successfully implementing the ivBGF functions are met, or further age readings are needed.

This component is critical to addressing the management questions and testing the impact hypotheses. We therefore suggest that gill net surveys continue for the next four years as per the terms of reference.

### 4.4. Snorkel Survey of Spawners in Reservoir Tributaries

Snorkel surveys were completed in five tributaries to Buttle Lake, one tributary to Upper Campbell Reservoir, and three tributaries to Lower Campbell Reservoir during the Year 6 surveys in 2019. Spring snorkel surveys carried out in March and April targeted the Cutthroat Trout spawning period in the tributaries of Lower Campbell Reservoir. Few Cutthroat Trout were recorded during the spring snorkel surveys; however, high numbers of redds were identified, attributed to early Cutthroat Trout spawning.

The summer snorkel survey results for spawning Rainbow Trout in tributaries of Buttle Lake and Upper Campbell Reservoir identified counts above historical median averages in three streams: Henshaw Creek, Wolf River, and Upper Elk River, similar to historical median averages in three streams: Philips Creek, Ralph River, and Lower Elk River, while it was below historical median averages in Thelwood Creek. No adult Rainbow Trout were recorded in Fry Creek (tributary to Lower Campbell Reservoir) during 2019, representing low count numbers that matched the previous reference number of zero Rainbow Trout observed in 2004, 2014, and 2016-2018.

Overall, the 2019 snorkel program was successful and we suggest that the snorkel surveys of spawners continue for the next four years as per the terms of reference.

## REFERENCES


Anon. 2004. Campbell River Water Use Plan: Consultative Committee Report. Prepared on behalf of the Consultative Committee for the Campbell River Water Use Plan. 132 pp. + App

Bayly, M., E. Vogt, A. Marriner, M. Thornton, N. Swain, T. Hatfield and J. Abell. 2018. JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment – Year 4 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., July 23, 2018.

BC Hydro. 2012. Campbell River System Water Use Plan Revised for Acceptance by the Comptroller of Water Rights. November 21, 2012 v6. 46 p.

BC Hydro. 2015 Campbell River Water Use Plan Monitoring Program Terms of Reference. JHTMON-3 Upper and Lower Campbell Lake Fish Spawning Success Assessment. Revision 1. 31 p.

Beverton, R. J. H. 1954. Notes on the use of theoretical models in the study of the dynamics of exploited fish populations. U.S. Fishery Lab., Beaufort, N.C., Misc. Contr., No.2, 159 pp.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries Investigations Series II, volume 19. Ministry of Agriculture, Fisheries, and Food, Her Majesty's Stationery Office, London.

Buren, A., M. Thornton, A. Marriner, M. Bayly, N. Wright, R. Day, D. West, P. Dinn, and T. Hatfield. 2019. JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment – Year 5 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., November 22, 2019.

FTC (Fisheries Technical Committee). 2003. Performance Measure Information Sheet; Reservoirs; Effective Spawning Habitat. Developed for JHT WUP Project, Burnaby, BC.

Government of Canada Wateroffice Site. 2019. Extracted from the Environment and Climate Change Canada Historical Hydrometric Data website. Available online at: https://wateroffice.ec.gc.ca/mainmenu/historical_data_index_e.html. Accessed on October 21, 2019

Hatfield, T., D. McDonnell, E. Smyth, J. Abell and B. Stables. 2015. JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment – Year 1 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., July 13, 2015.

Hatfield, T., D. McDonnell, and E. Smyth. 2016. JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment – Year 2 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., April 29, 2016.

Le Cren, EDL. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 20:201-219.

LKT (Laich–Kwil–Tach Environmental Assessment Ltd. Partnership). 2015. JHTMON-3 Proposal: Upper and Lower Campbell Lake Fish Spawning Success Assessment Year 2. July 16, 2015.

Lough, M.J. 2000. Redd inundation studies at Greenstone Creek. Letter Report to BC Hydro by MJL Environmental Consultants. July 13, 2000. 2 pp.

Pellet, K. 2012. Campbell River (Elk Falls) Canyon Spawning Gravel Placement, 2011, BCRP Project Number 11.CBR.05. Report prepared by K. Pellett, Fisheries Biologist, British Columbia Conservation Foundation, Nanaimo BC for BC Hydro, Fish and Wildlife Compensation Program, Campbell River Salmon Foundation, and Living Rivers – Georgia Basin/Vancouver Island in March 2012, available online at: http://www.livingrivers.ca/gbvi/dox/2011%20Elk%20Falls%20Canyon%20Report.pdf. Accessed on April 26, 2018.

Pellett, K. 2013. Snorkel Survey Observations of Adfluvial Trout and Char in Tributaries to Buttle and Upper Campbell Lakes, June 11–12, 2013. Report prepared for BC Hydro and the Ministry of Forests, Lands, and Natural Resource Operations. British Columbia Conservation Foundation. 32 p.

Smyth, E., and T. Hatfield. 2017. JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment – Year 3 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tech Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., November 12, 2017.

Williamson, C.J. and J.S. Macdonald. 1997. The use of three ageing techniques to estimate the growth rates of rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) from selected locations near, Takla Lake, B.C. Can. Tech, Rep. Fish. Aquat. Sci. 2191: 20p.

Zymonas, N.D. and T.E. McMahon. 2009. Comparison of pelvic fin rays, scales and otoliths for estimating age and growth of bull trout, *Salvelinus confluentus*. Fisheries Management and Ecology, 16: 155-164.

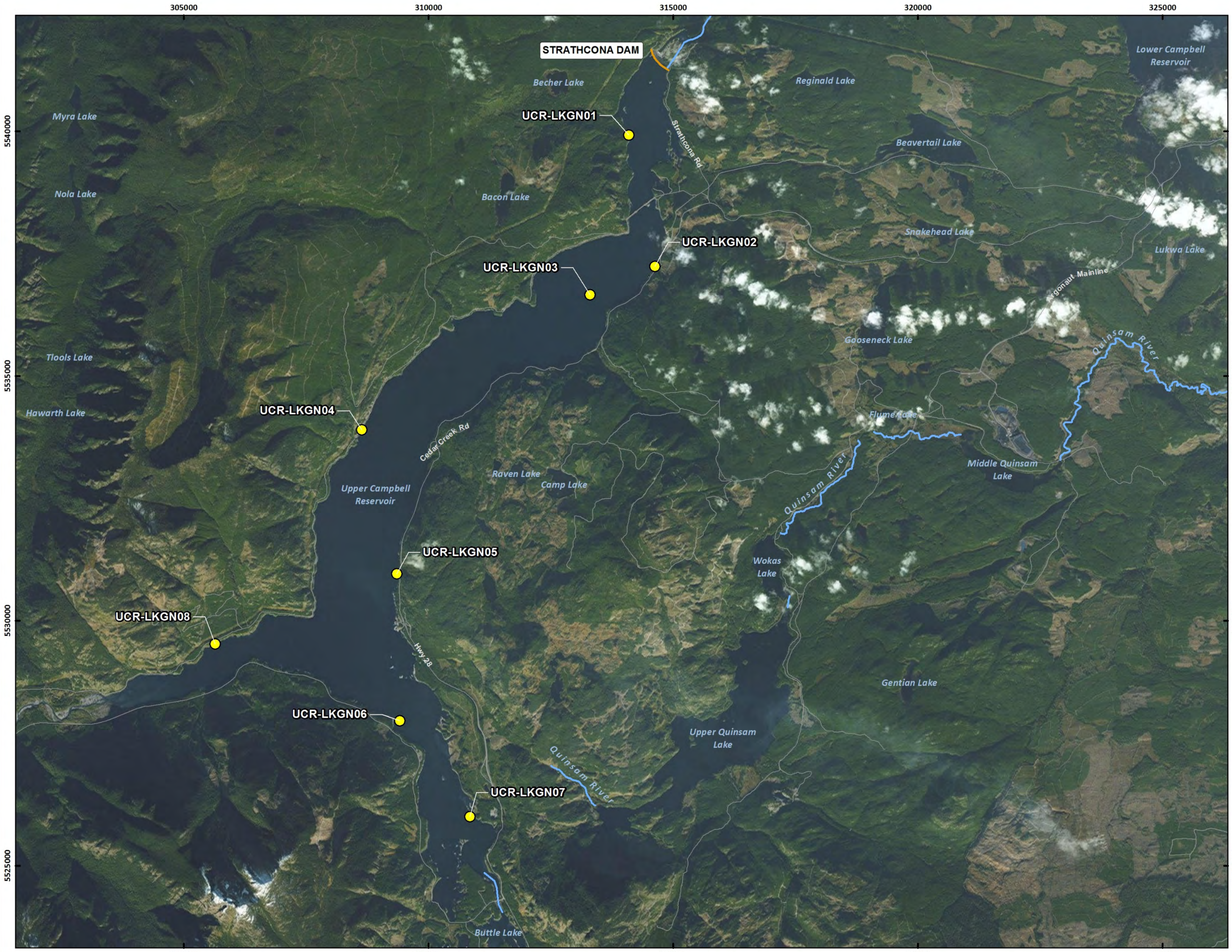
**Personal Communications**

Leake, A. 2015. Environmental Specialist, BC Hydro, Vancouver, BC. Personal Communication. Email to Todd Hatfield, February 13, 2015.

## PROJECT MAPS

JHTMON Campbell River Water Use Plan

## Upper Campbell Reservoir Gill Netting Locations




**Legend**

**Sample Sites**

- Gill Netting
- Dam


MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.5 1 2 3 4 km

Scale: 1:75,000

| NO. | DATE | REVISION | BY |
|---|---|---|---|
| 1 | 16/11/2016 | 1230_UCR_GillNetLocations_2016Nov16 | CGA |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Date Saved: 16/11/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 2

Path: M:\Projects-Active\1230_JHTMON\MXD\Fisheries\1230_UCR_GillNetLocations_2016Nov16.mxd


JHTMON Campbell River Water Use Plan

## JHTMON-3
## Snorkel Survey Reaches

**Legend**

- Snorkel Survey Reach
- Campsites
- Boat Launch
- Strathcona Lodge
- Diversion Dam Intake
- Quinsam River Fish Hatchery
- Quinsam Coal Mine
- First Nation Reserve
- Recreational Sites
- Parks and Protected Areas


MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 10 km

Scale: 1:250,000

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| 5 | | | |

Date Saved: 16/11/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 3

Path: M:\Projects-Active\1230_JHTMON\MXD\Fisheries\1230_JHT_SnorkelSurveyReaches_2014Dec01.mxd

# APPENDICES

# Appendix A. Aging Structure Collection and Reading Protocol - 2019

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## LIST OF FIGURES

# 1. BACKGROUND

Fish scales, fin rays, otoliths, and other bony structures are commonly collected during fish sampling programs to determine fish age. Scales and fin rays can be collected without harming fish, while the fish must be killed to remove otoliths and other bony structures. Ideally, aging structures are collected from a representative sample of each size class and species during sampling programs. For a more complete discussion of the collection and preparation of aging structures see BC Resource Inventory Standards Committee Fish Collection Methods and Standards (RISC 1997) and Sjolund (1974).

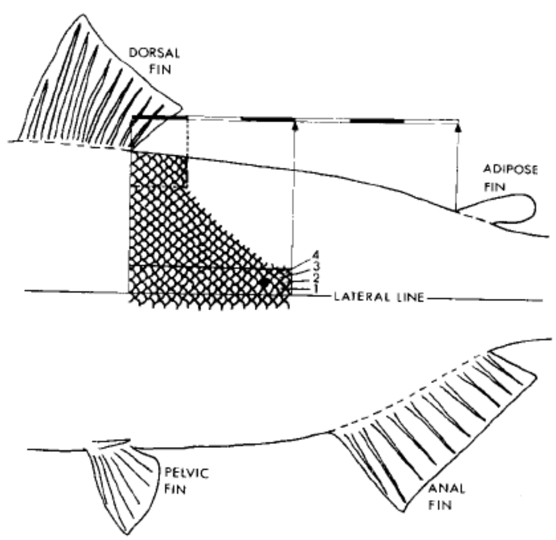
# 2. METHODS

## 2.1. Sample Collection and Preparation

### 2.1.1. Scales

The method for collecting scales depends on the size of the fish that is being sampled. For small and juvenile fish a few scales are scraped off with a scalpel from the area described in Figure 1. For larger fish tweezers are used to pull individual scales off the fish from the area described in Figure 1. The scales from the scalpel are smeared or placed onto a microscope slide, taking care to spread the scales out and avoid them overlapping. A second slide is placed over the scale to sandwich it between the two slides and the slides are taped together with scotch tape. Each sample is labelled and placed within a labelled scale envelope. Scale samples are stored in a plastic container that is specific to each project file, inside a locked metal filing cabinet.

**Figure 1. The preferred area for removing scales from a fish (outlined in black) (Sjolund 1974).**



### 2.1.2. Otoliths and Other Bony Structures

Fish must be dead to collect otoliths and other bony structures. Fish are typically euthanized by overdosing in anaesthetic. Once euthanized, the structures are removed by dissecting the fish as per the methods outlined in Section 6 of the BC Resource Inventory Standards Committee Fish Collection Methods and Standards (RISC 1997). Bony structures are stored dry in labelled scale envelopes, or in labelled vials filled with a solution of glycerine and water.

Otoliths and other bony structure samples are dried in the lab and are processed in a similar fashion to fin rays.

### 2.1.3. Sample Archiving

For each sample, a minimum of two scales or fin ray sections, or one otolith section, are photographed from each individual fish using a digital camera and a compound microscope. The two photographed scales or fin rays should be representative of the sample and not display any significant deformity or damage. Photographs are stored on the Ecofish Research Ltd. network in the appropriate Project folder, and all sample slides and structures are archived in a locked metal cabinet.

### 2.1.4. Aging

Fish age is determined by examining the structures for winter annuli. The winter annuli in scales is characterized by the noticeably tighter spacing of growth rings (circuli) that are formed during winter growth. In fin rays, otoliths and other bony structures, winter annuli are apparent as thin translucent bands. An example of each of these structures is given in Figure 2 (from Bilton and Jenkinson, 1969). Fish age is given as counts of winter annuli. Juveniles that emerged in the same year that they were collected and have not gone through a winter are classified as 0+; fish that exhibit one winter annulus are classified as 1+; and so on. Damaged structures that cannot be accurately aged are recorded as 'damaged'.

Aging of fish samples is conducted by a minimum of two qualified technicians, one primary ager and one QA technician. Each technician ages the samples independently using only sampling date and biological data (length or weight) for the fish. The QA technician records the ages of the scales in an excel spreadsheet and compares these ages to the first agers' results entered into EcoDAT (or into an Excel file if done by external personnel, see example in Figure 3). Where ages for a single sample are different between technicians and an age cannot be agreed upon, the sample will be reviewed by a senior biologist. The Excel spreadsheet is saved in the same network folder as the scale images and TPS files.

**Figure 2. Example of sockeye and chum salmon scales, otoliths and fin rays (from Bilton and Jenkinson 1969).**

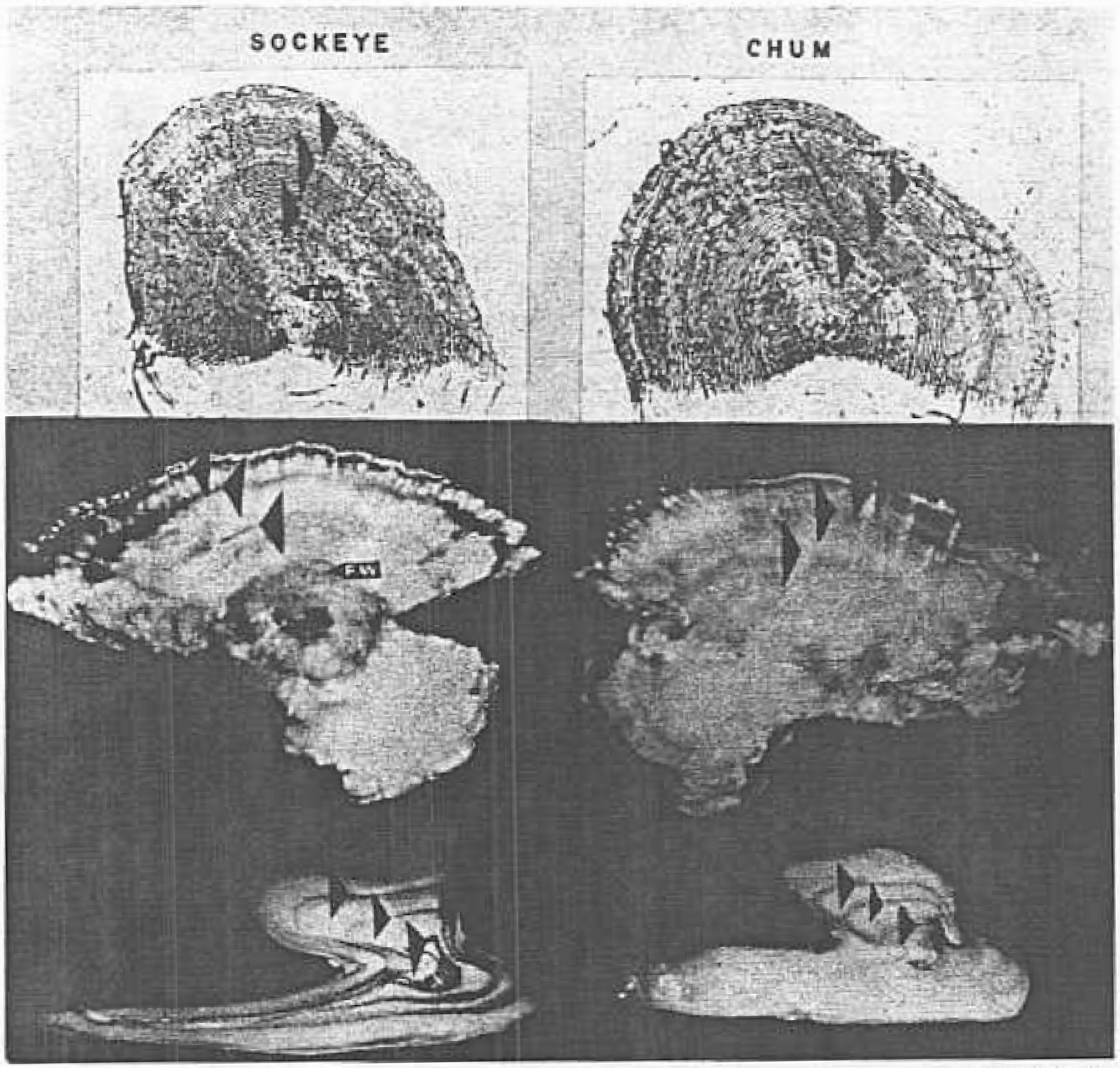



FIG. 4. Scale, otolith, and fin ray from a 1.3 sockeye and a 0.3 chum salmon: FW indicates freshwater annulus; arrows indicate ocean annuli.

Bilton and Jenkinson — J. Fish. Res. Bd. Canada

**Figure 3. Example datasheet for age entry.**

Technician: Date:

| Location | Site | Date | Species | Length | Weight | Sample # | Age |
|---|---|---|---|---|---|---|---|
| North Creek | NTH-DVEF02 | 04-Oct-10 | BT | 169 | 53.1 | FR-1 | X |
| | | | | | | | |
| | | | | | | | |
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| | | | | | | | |
| | | | | | | | |

## REFERENCES

Bilton, HT and DW, Jenkinson. 1969. Age determination of sockeye (Oncorhynchus nerka) and chum (O. keta) salmon from examination of pectoral fin rays. J Fish Res Board Can 26:1199-1203.

RISC (BC Resource Inventory Committee). 1997. Fish Collection Methods and Standards. Version 4. Prepared by the BC Ministry of Fisheries, Fisheries Inventory Section, for the Resources Inventory Committee.

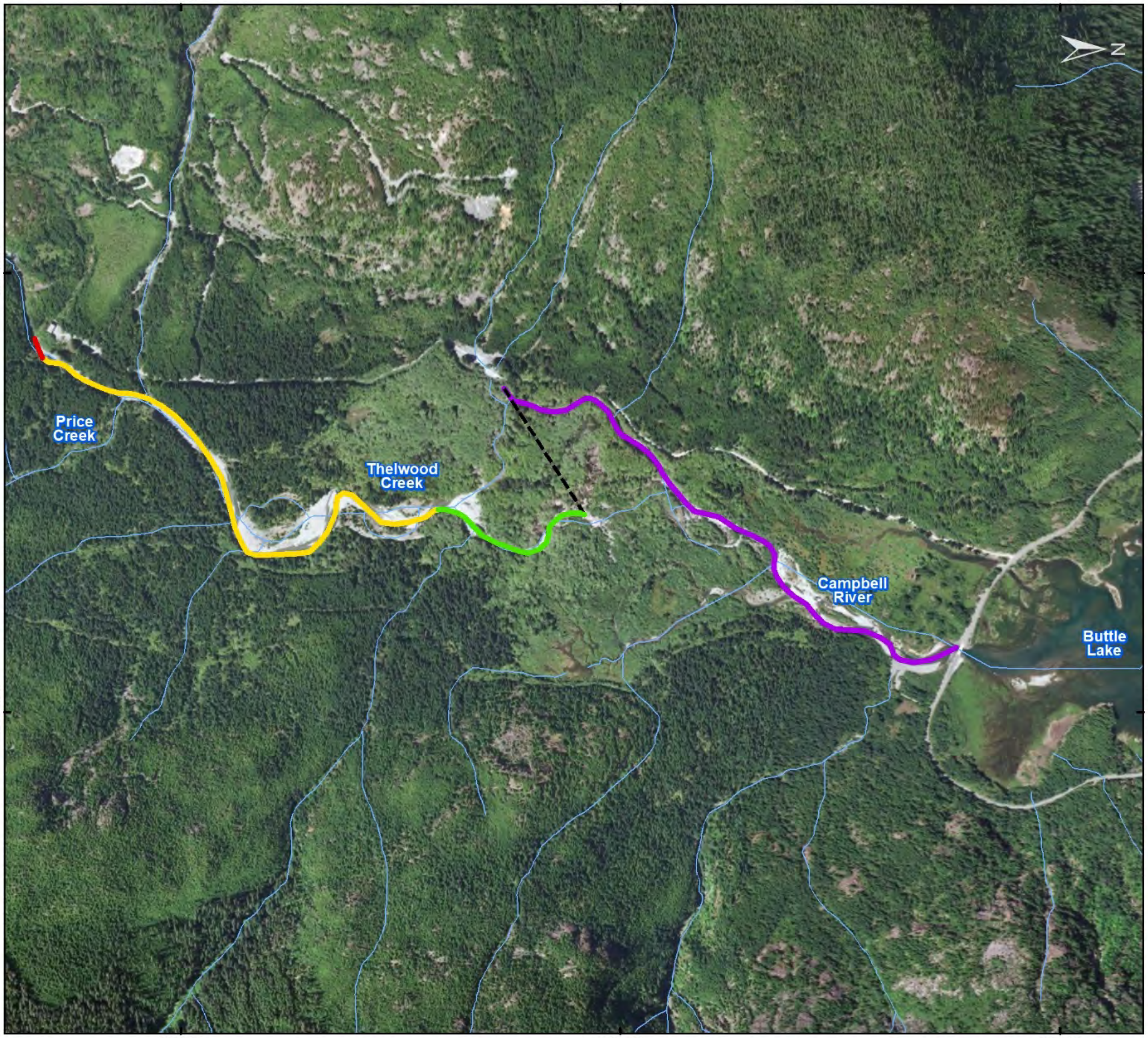
Sjolund, W.R. 1974. Collection and preparation of scales, otoliths and fin rays for fish age determination. Fisheries Technical Circular No. 12. British Columbia Fish and Wildlife Branch. 22pp. (Available at: http://wlapwww.gov.bc.ca/wld/documents/fisheriesrpts/FTC12.pdf)

# Appendix B. Thelwood Creek Geomorphological Changes (2014-2016, 2017-2018, 2019)

## LIST OF MAPS

JHTMON CAMPBELL RIVER WATER USE PLAN

**Thelwood Creek**
**Snorkel Sections (2014-2016)**




**Legend**

**Snorkel Section (2014-2016)**

- Section 1
- Section 2
- Section 3
- Section 4
- Hike to RL Channel


MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.5 1 km

Scale: 1:25,000

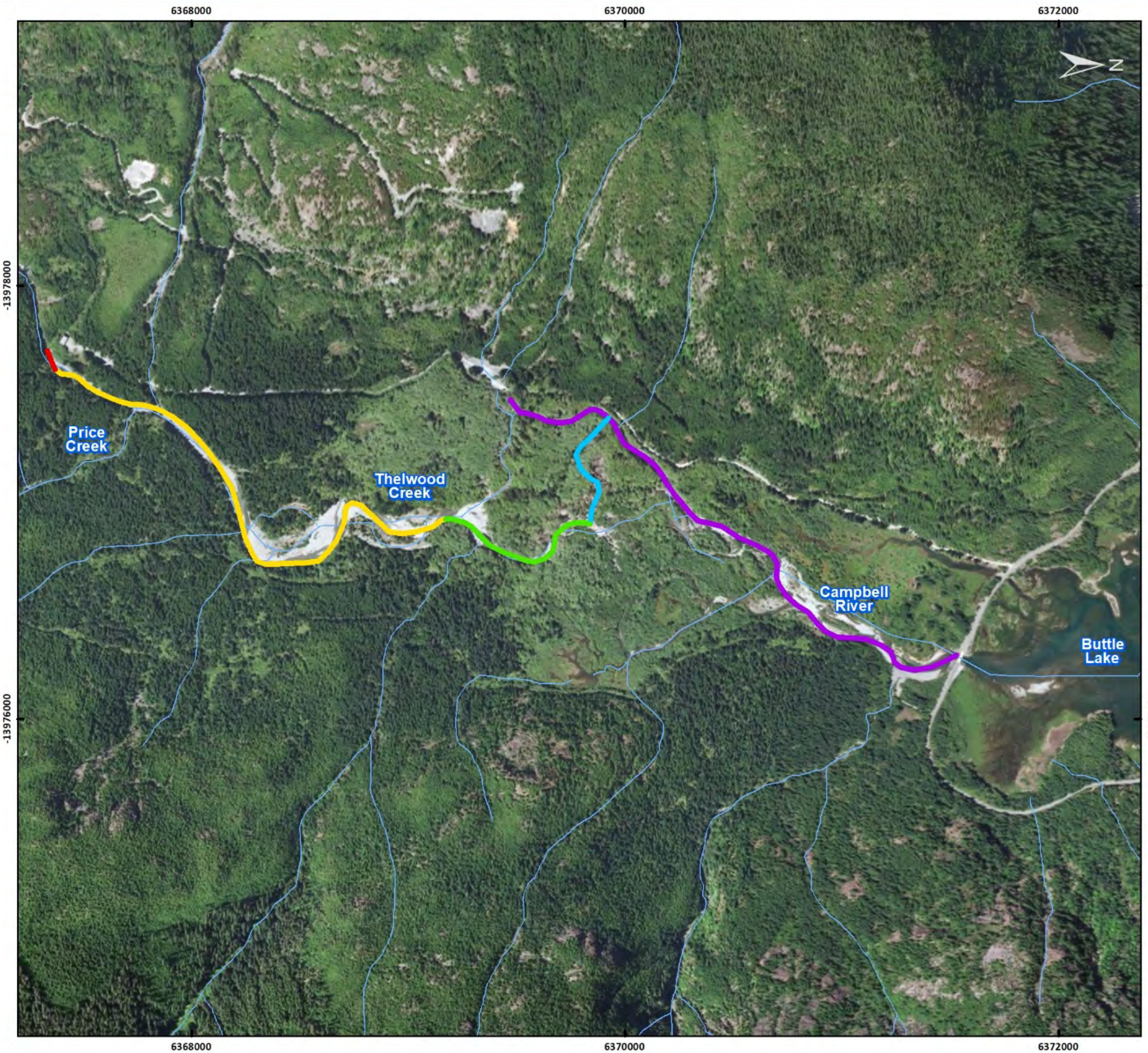
| NO. | DATE | REVISION | BY |
|---|---|---|---|
| 1 | 2020-01-27 | 1230_ThelwoodCreekSnorkelSections_3579_20200127 | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Date Saved: 2020-01-27
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere

ECOFISH RESEARCH

Map 1

Path: M:\Projects-Active\1230_JHTMON\MXD\Fisheries\1230_ThelwoodCreekSnorkelSections_3579_20200127.mxd




JHTMON CAMPBELL RIVER WATER USE PLAN

**Thelwood Creek Snorkel Sections (2017-2018)**

**Legend**

**Snorkel Section (2017-2018)**

- Section 1
- Section 2
- Section 3
- Section 4
- Newly Discovered Channel


**MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES**

0 0.5 1 km

Scale: 1:25,000

| NO. | DATE | REVISION | BY |
|---|---|---|---|
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| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Date Saved: 2020-01-27
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere

ECOFISH RESEARCH

Map 2

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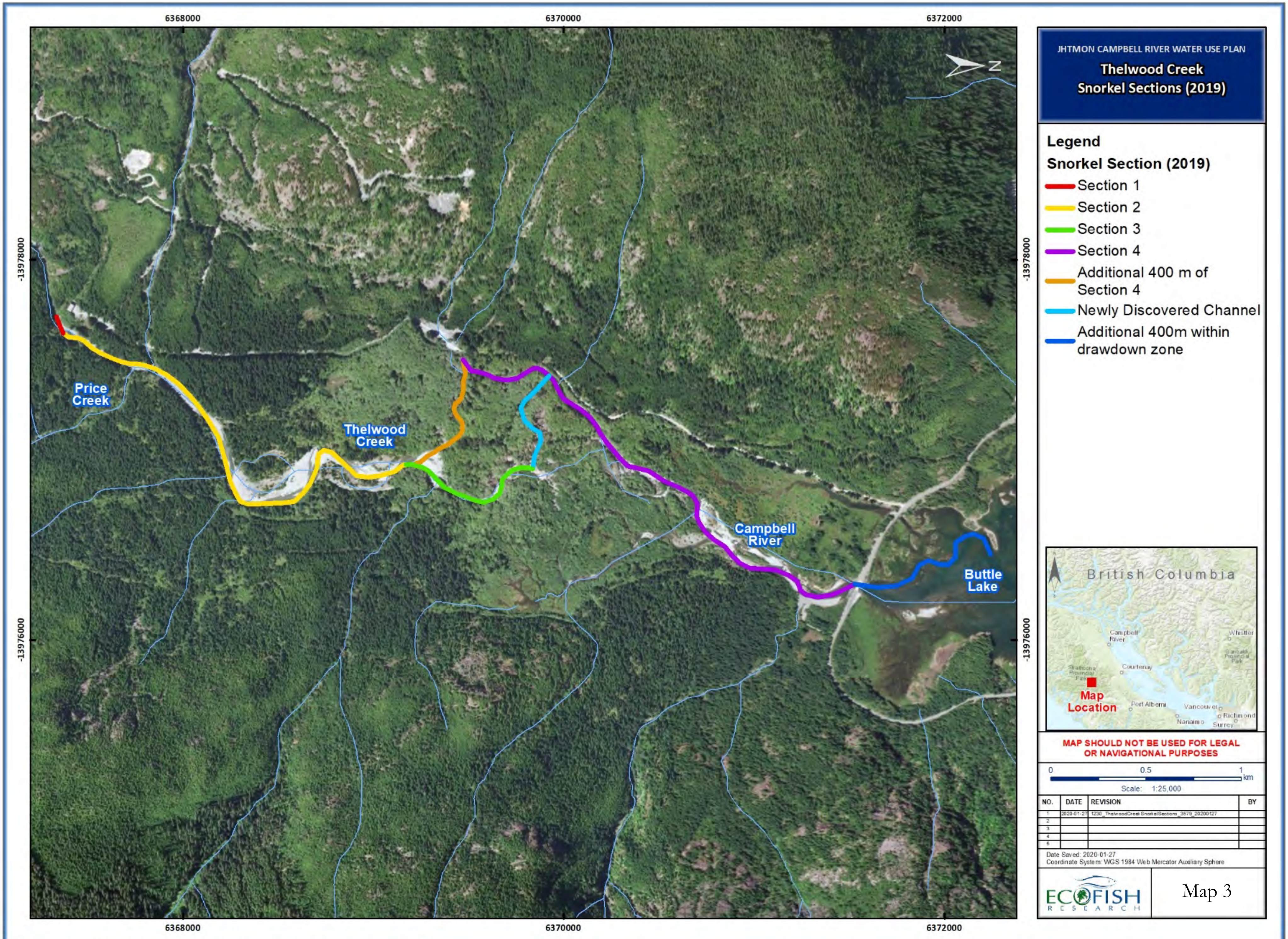


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# Appendix C. Gill Net Capture Data and Representative Photographs - 2019

## LIST OF TABLES



## LIST OF FIGURES

**Table 1. Individual net set and capture data for Upper Campbell Lake gill netting.**

| Waterbody | Site | Set Number | Net Type | Net Position[1] | Net Length (m) | Water Temp (°C) | Turbidity[2] | Estimated Visibility (m) | Time In | Time Out | Catch[3] | | | | Soak Time (hrs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | CT | RB | CC | CT/RB | |
| Upper Campbell Reservoir | UCR-LKGN01 | 1 | RISC | SK | 91.2 | 20.5 | C | 6 | 13:22:00 | 09:58:00 | 4 | 3 | | 1 | 20.6 |
| | UCR-LKGN01 | 2 | RISC | FL | 91.2 | 20.5 | C | 6 | 13:38:00 | 10:10:00 | | 5 | | 1 | 20.53 |
| | UCR-LKGN02 | 1 | RISC | SK | 91.2 | 20.1 | C | 6 | 14:00:00 | 10:31:00 | 2 | 1 | | | 20.52 |
| | UCR-LKGN02 | 2 | RISC | FL | 91.2 | 20.1 | C | 6 | 14:17:00 | 10:57:00 | 1 | 11 | | | 20.67 |
| | UCR-LKGN04 | 1 | RISC | SK | 91.2 | 20.7 | C | 6 | 13:58:00 | 08:48:00 | 3 | 4 | 1 | | 18.83 |
| | UCR-LKGN04 | 2 | RISC | FL | 91.2 | 20.7 | C | 6 | 14:14:00 | 09:01:00 | | 11 | 1 | 1 | 18.78 |
| | UCR-LKGN04 | 3 | RISC | SK | 13 | 20.7 | C | 6 | 14:22:00 | 09:14:00 | | 4 | | | 18.87 |
| | UCR-LKGN06 | 1 | RISC | SK | 91.2 | 21.2 | C | 6 | 14:51:00 | 09:41:00 | 7 | 12 | | | 18.83 |
| | UCR-LKGN06 | 2 | RISC | FL | 91.2 | 21.2 | C | 6 | 15:02:00 | 09:53:00 | | 12 | | 1 | 18.85 |
| | UCR-LKGN07 | 1 | RISC | SK | 91.2 | 21 | C | 6 | 14:08:00 | 08:58:00 | 9 | 13 | 1 | | 18.83 |
| | UCR-LKGN07 | 2 | RISC | FL | 91.2 | 21 | C | 6 | 14:31:00 | 09:12:00 | 1 | 12 | | | 18.68 |
| | UCR-LKGN07 | 3 | RISC | SK | 13 | 21 | C | 6 | 14:47:00 | 09:22:00 | 1 | 1 | 2 | | 18.58 |
| | UCR-LKGN08 | 1 | RISC | SK | 91.2 | 21.3 | C | 6 | 15:20:00 | 09:43:00 | 12 | 28 | | 4 | 18.38 |
| | UCR-LKGN08 | 2 | RISC | FL | 91.2 | 21.3 | C | 6 | 15:37:00 | 09:58:00 | 1 | 9 | | | 18.35 |

[1]SK- Sinking, FL-Floating

[2]C- Clear

[3]CT- Cutthroat Trout, RB- Rainbow Trout, CC- Sculpin Species, CT/RB- Cutthroat Trout/Rainbow Trout

**Table 2. Raw fish data from gill net sampling (1 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 2 | RB | 169 | 65 | 1.35 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 2 | RB | 293 | 263 | 1.05 | F | M | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 6 | RB | 280 | 289 | 1.32 | M | M | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 3 | RB | 299 | 260 | 0.97 | F | M | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 3 | CT | 297 | 303 | 1.16 | F | I | SC | 05 | OT | 05 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 5 | RB | 245 | 169 | 1.15 | F | M | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 5 | RB | 154 | 50.5 | 1.38 | | I | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 5 | RB | 231 | 147 | 1.19 | | | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 5 | RB | 220 | 121 | 1.14 | M | I | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 5 | RB | 235 | 151 | 1.16 | M | I | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | FL | 2 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT | 284 | 214 | 0.93 | M | I | | | OT | 01 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT | 304 | 268 | 0.95 | F | I | | | OT | 02 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT | 333 | | | | | SC | 03 | OT | 03 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT | 304 | 298 | 1.06 | M | I | SC | 04 | OT | 04 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT | 307 | 313 | 1.08 | M | I | SC | 05 | OT | 05 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | CT/RB | 224 | 112.4 | 1.00 | M | I | SC | 06 | | | FC | 06 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 216 | 132 | 1.31 | M | M | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 206 | 101.4 | 1.16 | M | M | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 221 | 127.4 | 1.18 | F | M | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 247 | 169.3 | 1.12 | | UNK | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 246 | 191.9 | 1.29 | | UNK | SC | 11 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 250 | 195.3 | 1.25 | F | I | SC | 12 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 280 | 238 | 1.08 | F | M | SC | 13 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 258 | 188 | 1.09 | | UNK | SC | 14 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 253 | 185 | 1.14 | | UNK | SC | 15 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 258 | 182 | 1.06 | M | M | SC | 16 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 285 | 244 | 1.05 | M | M | SC | 17 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 252 | 185 | 1.16 | | UNK | SC | 18 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 277 | 223 | 1.05 | F | M | SC | 19 | | | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

Table 2. Continued (2 of 7).

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 253 | 174 | 1.07 | F | M | SC | 20 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 274 | 228 | 1.11 | F | M | SC | 21 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 223 | 132 | 1.19 | F | M | SC | 22 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB | 293 | 271 | 1.08 | M | I | SC | 23 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 3 | RB/CT | 269 | 222 | 1.14 | M | I | SC | 24 | OT | 24 | FC | 24 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | CT | 191 | 62.8 | 0.90 | M | I | SC | 25 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | CT | 216 | 105.5 | 1.05 | F | I | SC | 26 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | RB | 214 | 117.9 | 1.20 | M | I | SC | 27 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | RB | 253 | 180 | 1.11 | F | I | SC | 28 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | RB | 282 | 249 | 1.11 | F | M | SC | 29 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | RB | 234 | 159 | 1.24 | | UNK | SC | 30 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 5 | RB | 237 | 159 | 1.19 | M | I | SC | 31 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB | 276 | 244 | 1.16 | M | M | SC | 32 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB | 266 | 230 | 1.22 | F | M | SC | 33 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB | 288 | 264 | 1.11 | F | M | SC | 34 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB | 268 | 250 | 1.30 | F | M | SC | 35 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB/CT | 312 | 341 | 1.12 | F | I | SC | 36 | OT | 36 | FC | 36 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | RB/CT | 341 | 341 | 0.86 | M | I | SC | 37 | OT | 37 | FC | 37 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | CT | 354 | 438 | 0.99 | F | M | SC | 38 | OT | 38 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 6 | CT | 352 | 488 | 1.12 | F | M | SC | 39 | OT | 39 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 2 | RB | 260 | 199 | 1.13 | M | M | SC | 40 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 2 | CT | 382 | 557 | 1.00 | M | M | SC | 41 | OT | 41 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 2 | CT | 404 | 719 | 1.09 | F | M | SC | 42 | OT | 42 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 1 | RB | 121 | 24.3 | 1.37 | | I | SC | 43 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN08 | 08/28/19 | SK | 1 | 1 | CT | 400 | 779 | 1.22 | F | M | SC | 44 | OT | 44 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 177 | 72.2 | 1.30 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 188 | 102.4 | 1.54 | M | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 179 | 73.1 | 1.27 | | I | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 169 | 65.7 | 1.36 | M | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 164 | 56.5 | 1.28 | F | I | SC | 05 | | | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Table 2. Continued (3 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | RB | 172 | 63.1 | 1.24 | M | I | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 5 | CT | 178 | 69.4 | 1.23 | M | I | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 4 | RB | 231 | 135.4 | 1.10 | M | I | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 6 | RB | 261 | 240 | 1.35 | M | M | SC | 09 | OT | 09 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 3 | RB | 250 | 189 | 1.21 | M | M | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 3 | RB | 281 | 236 | 1.06 | M | M | SC | 11 | OT | 11 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 3 | RB | 282 | 264 | 1.18 | M | M | SC | 12 | OT | 12 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 3 | RB | 268 | 211 | 1.10 | F | M | SC | 13 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | FL | 2 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 4 | RB | 112 | 21.4 | 1.52 | | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 4 | CC | 94 | 8.4 | 1.01 | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 4 | CC | 128 | 25.3 | 1.21 | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 4 | CT | 289 | 300 | 1.24 | F | I | SC | 02 | OT | 02 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 3 | 3 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | CT | 212 | 99.7 | 1.05 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | CT | 241 | 134.2 | 0.96 | M | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | CT | 184 | 65.5 | 1.05 | F | I | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | CT | 263 | 221 | 1.21 | F | I | SC | 04 | OT | 04 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 224 | 142 | 1.26 | F | I | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 264 | 207 | 1.13 | | | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 273 | 241 | 1.18 | | | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 235 | 170 | 1.31 | F | M | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 180 | 79 | 1.35 | | I | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 191 | 90 | 1.29 | M | I | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 209 | 109 | 1.19 | M | I | SC | 11 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | RB | 202 | 101 | 1.23 | M | M | SC | 12 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 5 | CT | 206 | 94 | 1.08 | M | I | SC | 13 | | | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Table 2. Continued (4 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 1 | RB | 119 | 23.4 | 1.39 | | I | SC | 14 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 1 | RB | 145 | 34.7 | 1.14 | | I | SC | 15 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 2 | CT | 380 | 585 | 1.07 | M | I | SC | 16 | OT | 16 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 2 | CT | 354 | 530 | 1.19 | F | M | SC | 17 | OT | 17 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | CC | 172 | 74 | 1.45 | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | CT | 281 | 227 | 1.02 | F | I | SC | 19 | OT | 19 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | CT | 368 | 536 | 1.08 | M | I | SC | 20 | OT | 20 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | RB | 292 | 235 | 0.94 | F | M | SC | 21 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | RB | 266 | 189 | 1.00 | F | M | SC | 22 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 3 | RB | 261 | 200 | 1.12 | | | SC | 23 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN07 | 08/28/19 | SK | 1 | 6 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 4 | RB | 183 | 79.1 | 1.29 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 3 | RB | 256 | 213 | 1.27 | M | M | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 3 | CT | 350 | 491 | 1.15 | F | M | SC | 03 | OT | 03 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 3 | CT | 346 | 460 | 1.11 | F | M | SC | 04 | OT | 04 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 217 | 135 | 1.32 | M | M | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 246 | 181 | 1.22 | F | M | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 230 | 160 | 1.32 | F | M | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 208 | 121 | 1.34 | F | M | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 184 | 88 | 1.41 | F | I | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 202 | 103 | 1.25 | M | M | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 190 | 86 | 1.25 | M | I | SC | 11 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 273 | 176 | 0.87 | M | M | SC | 12 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 206 | 114 | 1.30 | M | M | SC | 13 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | RB | 248 | 181 | 1.19 | F | I | SC | 14 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 5 | CT | 188 | 68 | 1.02 | M | I | SC | 15 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 6 | CT | 324 | 334 | 0.98 | M | M | SC | 16 | OT | 16 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 2 | CT | 344 | 410 | 1.01 | M | I | SC | 17 | OT | 17 | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Table 2. Continued (5 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 2 | CT | 358 | 522 | 1.14 | F | M | SC | 18 | OT | 18 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | SK | 1 | 2 | CT | 359 | 548 | 1.18 | F | M | SC | 19 | OT | 19 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 6 | RB | 159 | 58 | 1.44 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 6 | RB/CT | 308 | 304 | 1.04 | M | I | SC | 02 | OT | 02 | FC | 02 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 186 | 98 | 1.52 | M | I | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 227 | 146 | 1.25 | M | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 171 | 62 | 1.24 | M | I | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 178 | 66 | 1.17 | F | I | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 190 | 86 | 1.25 | M | I | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 5 | RB | 176 | 74 | 1.36 | M | I | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 1 | RB | 108 | 19 | 1.51 | | I | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 3 | RB | 292 | 262 | 1.05 | M | M | SC | 10 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 3 | RB | 270 | 236 | 1.20 | M | M | SC | 11 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 3 | RB | 255 | 193 | 1.16 | F | M | SC | 12 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN06 | 08/27/19 | FL | 2 | 2 | RB | 231 | 134 | 1.09 | M | I | SC | 13 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 1 | RB | 106 | 15.6 | 1.31 | | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 1 | RB | 104 | 14.4 | 1.28 | | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 4 | CT | 444 | 963 | 1.10 | M | M | SC | 03 | OT | 03 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 3 | CT | 310 | 302 | 1.01 | F | M | SC | 04 | OT | 04 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 3 | RB | 190 | 94 | 1.37 | M | I | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 3 | RB | 190 | 84 | 1.22 | M | I | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 5 | CT | 179 | 63 | 1.10 | M | I | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 5 | CC | 126 | 26 | 1.30 | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 1 | 6 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 6 | RB | 172 | 65 | 1.28 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 1 | RB | 210 | 115 | 1.24 | M | I | SC | 02 | | | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Table 2. Continued (6 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 5 | CC | 126 | 28 | 1.40 | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 5 | RB | 170 | 61 | 1.24 | M | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 5 | RB | 234 | 145 | 1.13 | F | M | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 5 | RB | 174 | 71 | 1.35 | M | I | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 188 | 90 | 1.35 | | I | SC | 07 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 250 | 179 | 1.15 | M | I | SC | 08 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 248 | 124 | 0.81 | F | M | SC | 09 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 271 | 251 | 1.26 | M | M | SC | 10 | OT | 10 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 272 | 245 | 1.22 | F | M | SC | 11 | OT | 11 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | RB | 289 | 249 | 1.03 | F | M | SC | 12 | OT | 12 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | FL | 2 | 3 | CT/RB | 274 | 213 | 1.04 | F | I | SC | 13 | OT | 13 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 3 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 3 | 2 | RB | 92 | 9.6 | 1.23 | | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 3 | 3 | RB | 76 | 4.8 | 1.09 | | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 3 | 3 | RB | 70 | 4.1 | 1.20 | | | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN04 | 08/27/19 | SK | 3 | 4 | RB | 177 | 59.5 | 1.07 | M | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 6 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 5 | CT | 208 | 103 | 1.14 | M | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 5 | RB | 150 | 40 | 1.19 | M | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 5 | RB | 237 | 133 | 1.00 | M | I | SC | 03 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 5 | RB | 228 | 135 | 1.14 | F | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 5 | RB | 238 | 141 | 1.05 | M | I | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 1 | RB | 189 | 94 | 1.39 | M | I | SC | 06 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 269 | 246 | 1.26 | F | M | SC | 07 | OT | 07 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 290 | 221 | 0.91 | F | I | SC | 08 | OT | 08 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 291 | 237 | 0.96 | F | M | SC | 09 | OT | 09 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 303 | 248 | 0.89 | F | M | SC | 10 | OT | 10 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 286 | 222 | 0.95 | F | M | SC | 11 | OT | 11 | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Table 2. Continued (7 of 7).**

| Waterbody | Year | Site Name | Date | Net Type | Set # | Panel # | Species[1] | Measured Length (mm) | Weight (g) | K | Sex | Sexual Maturity (I, M, UNK) | Age Sample (Type 1) | Age Sample Number 1 | Age Sample (Type 2) | Age Sample Number 2 | DNA Sample Type | DNA Sample Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | FL | 2 | 3 | RB | 278 | 205 | 0.95 | F | M | SC | 12 | OT | 12 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 3 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 5 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 2 | CT | 406 | 579 | 0.87 | M | M | SC | 01 | OT | 01 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 6 | CT | 333 | 343 | 0.93 | F | M | SC | 02 | OT | 02 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN02 | 08/26/19 | SK | 1 | 4 | RB | 296 | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 1 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 2 | CT | 380 | 543 | 0.99 | F | M | SC | 01 | OT | 01 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 5 | CT | 292 | 251 | 1.01 | F | I | SC | 02 | OT | 02 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 3 | CT | 316 | 341 | 1.08 | M | I | SC | 03 | OT | 03 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 3 | RB/CT | 292 | 246 | 0.99 | F | M | SC | 04 | OT | 04 | FC | 04 |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 3 | RB | 266 | 215 | 1.14 | F | M | SC | 05 | OT | 05 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 3 | RB | 272 | 204 | 1.01 | F | M | SC | 06 | OT | 06 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 6 | CT | 374 | 449 | 0.86 | F | M | SC | 07 | OT | 07 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | SK | 1 | 6 | RB | 280 | 232 | 1.06 | M | I | SC | 08 | OT | 08 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 2 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 4 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 6 | NFC | | | | | | | | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 5 | RB | 238 | 166 | 1.23 | F | I | SC | 01 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 5 | RB | 164 | 50 | 1.13 | M | I | SC | 02 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 5 | RB | 293 | 303 | 1.20 | M | M | SC | 03 | OT | 03 | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 1 | RB | 106 | 17 | 1.43 | | I | SC | 04 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 1 | RB | 119 | 19 | 1.13 | | I | SC | 05 | | | | |
| Upper Campbell Reservoir | 2019 | UCR-LKGN01 | 08/26/19 | FL | 2 | 3 | RB/CT | 310 | 309 | 1.04 | M | M | SC | 06 | OT | 06 | | |

[1]NFC- No fish caught, RB- Rainbow Trout, CT-Cutthroat Trout

**Figure 1. Example of typical gill net gear deployment location (UCR-LKGN01) during 2019 gill net surveys.**

**Figure 2. 238 mm Rainvow Trout captured at UCR-LKGN01 on August 26, 2019.**

Figure 3. 272 mm Rainbow Trout captured at UCR-LKGN01 on August 26, 2019.

Figure 4. 316 mm Cutthroat Trout captured at UCR-LKGN01 on August 26, 2019.

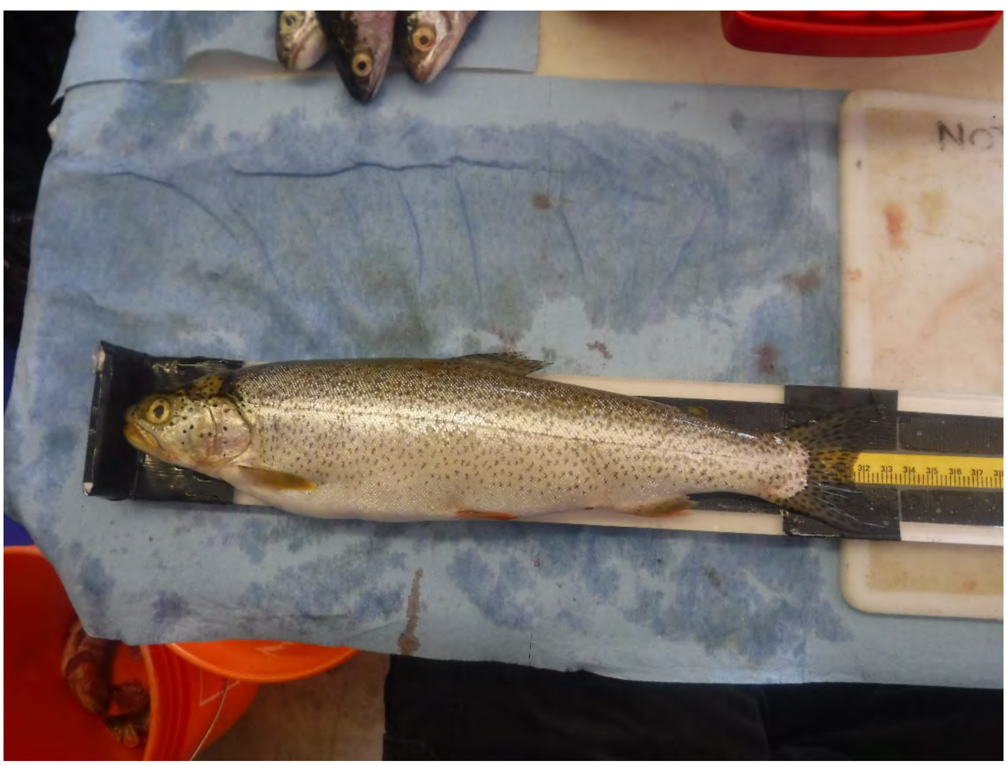

Figure 5. 208 mm Cutthroat Trout captured at UCR-LKGN02 on August 26, 2019.

Figure 6. 303 mm Rainbow Trout captured at UCR-LKGN02 on August 26, 2019.

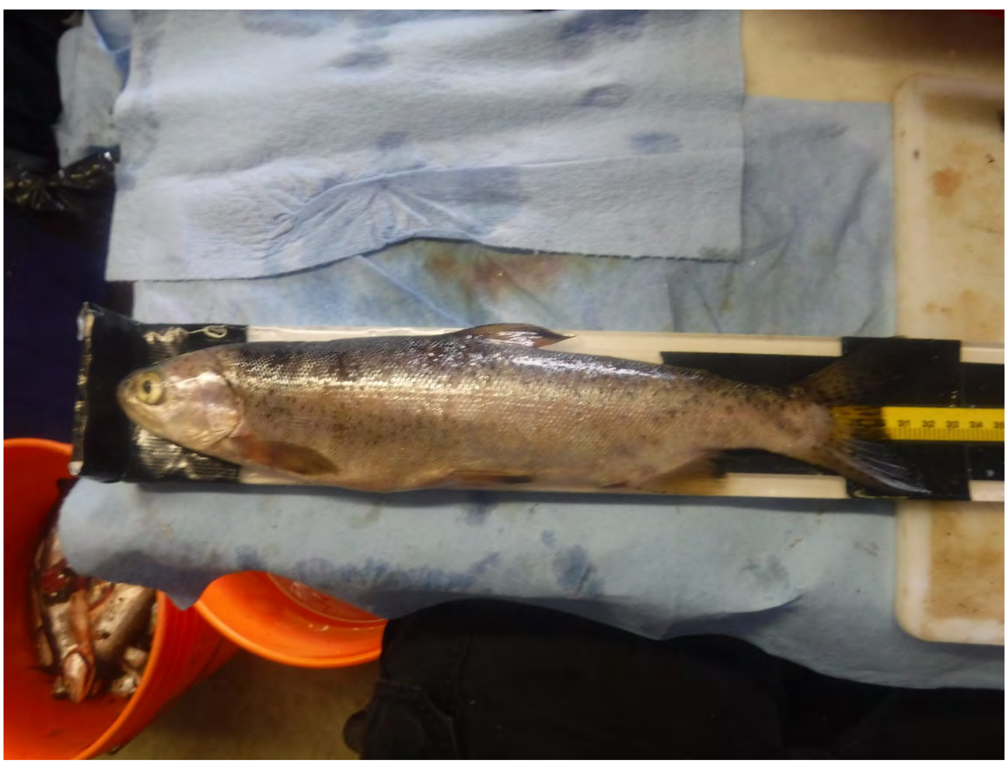

Figure 7. 406 mm Cutthroat Trout captured at UCR-LKGN02 on August 26, 2019.

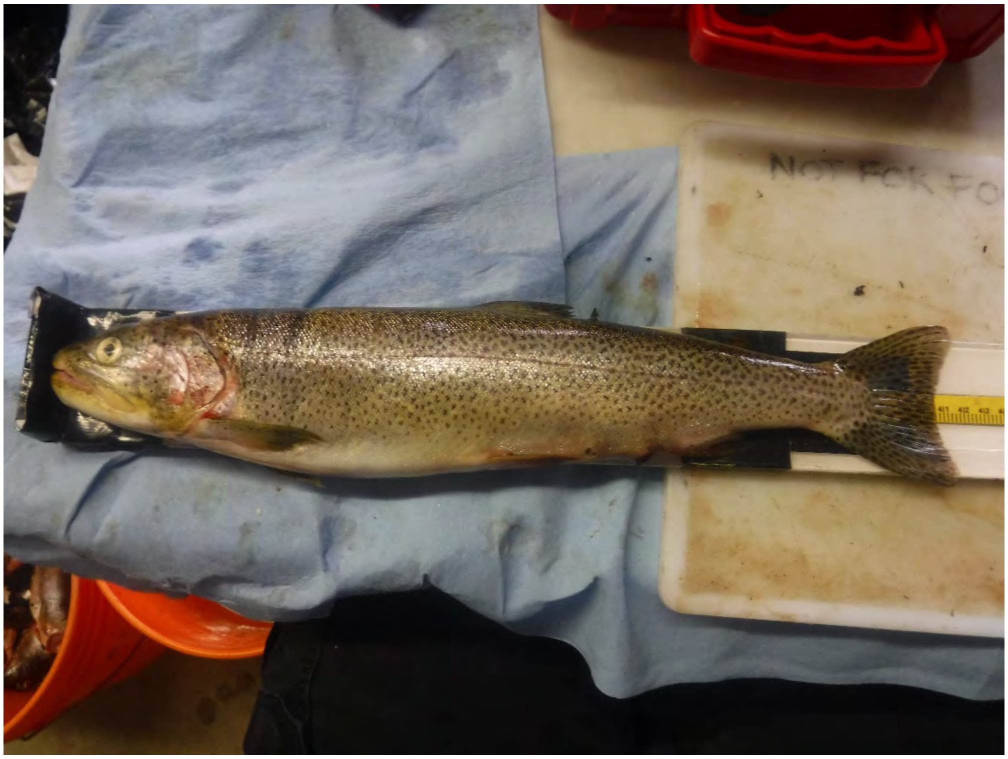

Figure 8. 126 mm sculpin captured at UCR-LKGN04 on August 27, 2019.

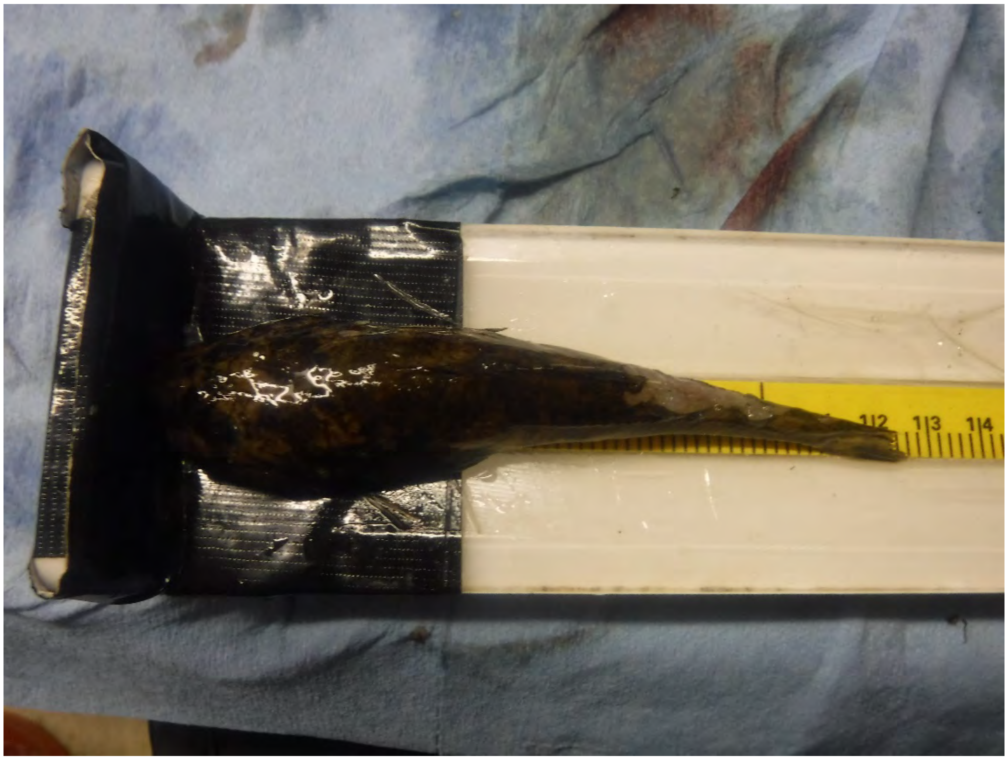

**Figure 9.** 444 mm Cutthroat Trout captured at UCR-LKGN04 on August 27, 2019.

**Figure 10.** 92 mm Rainbow Trout captured at UCR-LKGN04 on August 27, 2019.

**Figure 11. 274 mm Rainbow Trout/Cutthroat Trout captured at UCR-LKGN04 on August 27, 2019.**

**Figure 12. 256 mm Rainbow Trout captured at UCR-LKGN06 on August 27, 2019.**

Figure 13. 359 mm Cutthroat Trout captured at UCO-LKGN06 on August 27, 2019.


Figure 14. 128 mm Sculpin captured at UCR-LKGN07 on August 28, 2019.

Figure 15. 368 mm Cutthroat Trout captured at UCR-LKGN07 on August 28, 2019.

Figure 16. 235 mm Rainbow Trout captured at UCR-LKGN08 on August 28, 2019.

# Appendix D. Snorkel Survey Observations and Representative Photographs - 2019

## LIST OF FIGURES

**Figure 1. Looking downstream at Greenstone River snorkel section start on April 30, 2019.**

**Figure 2. Looking downstream at Greenstone River snorkel section end on April 30, 2019.**

Figure 3. Looking upstream at Miller Creek snorkel section start on March 4, 2019.

Figure 4. Looking upstream at Fry Creek snorkel section start on March 4, 2019.

**Figure 5. Looking downstream at Fry Creek snorkel section start on March 4, 2019.**

**Figure 6. Looking downstream from bridge at Ralph River snorkel section start on June 4, 2019.**

**Figure 7. Looking upstream from bridge at Ralph River middle snorkel section on June 4, 2019.**

**Figure 8. Looking at drawdown zone area at Ralph River on June 4, 2019.**

Figure 9. Looking upstream at Henshaw Creek on June 4, 2019.

Figure 10. Looking downstream at Henshaw Creek on June 4, 2019.

**Figure 11. Looking upstream at Wolf River on June 5, 2019.**

**Figure 12. Looking downstream at Wolf River on June 5, 2019.**

**Figure 13. Looking at Cutthroat Trout during snorkel survey in Wolf River on June 5, 2019.**

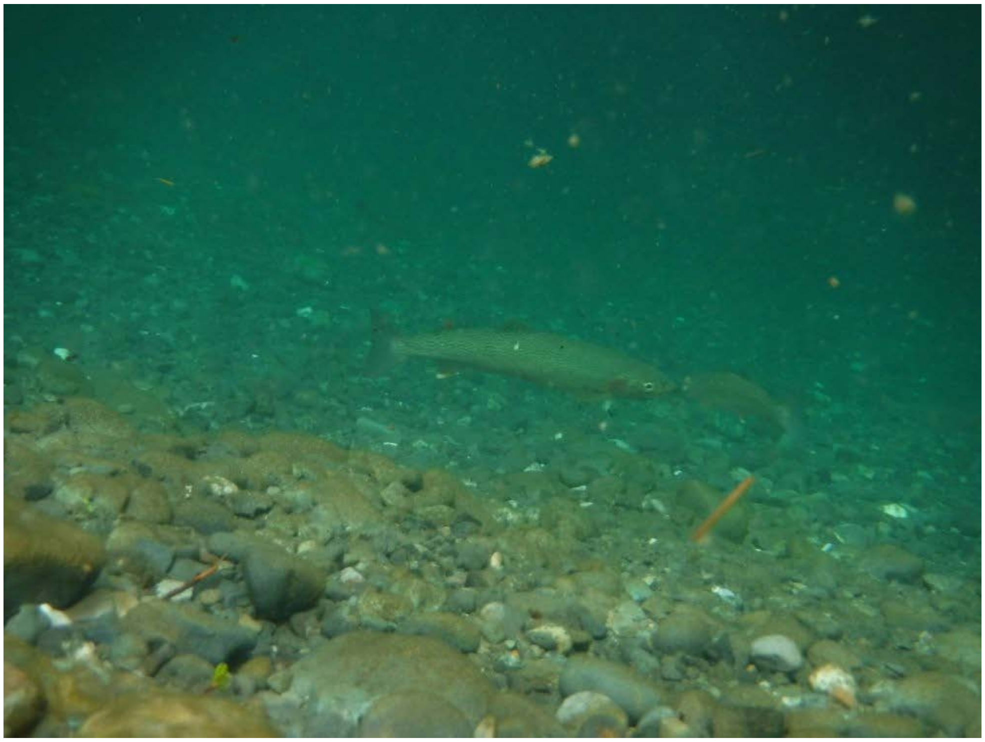

**Figure 14. Looking upstream at Phillips Creek on June 5, 2019.**

Figure 15. Looking downstream at Phillips Creek on June 5, 2019.

Figure 16. Looking upstream at Elk River snorkel section on June 6, 2019.

Figure 17. Looking downstream at Elk River on June 6, 2019.

Figure 18. Fry present in gravel during snorkel survey in Elk River on June 6, 2019.

Figure 19. Looking upstream at Thelwood Creek on June 7, 2019.

Figure 20. Looking downstream at Thelwood Creek on June 7, 2019.

Figure 21. Looking at fish during snorkel survey in Thelwood Creek near lake level showing on June 7, 2019.