Campbell River Project Water Use Plan

Upper and Lower Campbell Lake Fish Spawning Success Assessment

Implementation Year 1

Reference: JHTMON-3

JHTMON-3: Upper and Lower Campbell Lake Fish Spawning Success Assessment Year 1 Annual Monitoring Report

Study Period: 2014

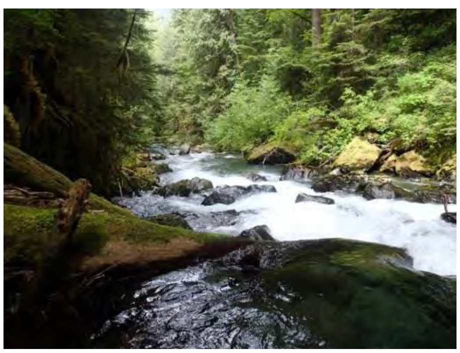
Laich-Kwil-Tach Environmental Assessment Ltd. Partnership
Ecofish Research

July 13, 2015

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

Year 1 Annual Monitoring Report



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July 13, 2015

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Published by Ecofish Research Ltd., Suite F, 450 8th St., Courtenay, B.C., V9N 1N5

Citation:

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-Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., July 13, 2015.

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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. 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.

Gill netting surveys on August 21 and 22, 2014 in Upper Campbell Reservoir resulted in the capture of 361 fish. Rainbow Trout comprised the majority of the catch, followed by Cutthroat Trout, with low numbers of Cutthroat Trout/Rainbow Trout hybrids, Prickly Sculpin, Dolly Varden, and Threespine Stickleback. CPUE ranged from 0.00 to 1.40 fish/net hour for Rainbow Trout and from 0.00 to 0.79 fish/net hour for Cutthroat Trout. Minnow trap sampling was carried out in Upper Campbell Reservoir from August 26 to 30, 2014; resulting in the capture of Prickly Sculpin only. CPUE ranged from 0.00 to 0.39 fish/trap hour.

A length-age relationship was developed for both Cutthroat Trout and Rainbow Trout captured during the Year 1 gill netting surveys. Age breaks were determined for 1+ and 2+ parr, with adult fish grouped as $\geq$3+. Average condition factor ranged from 1.1 to 1.2 for Cutthroat Trout and from 1.2 to 1.4 for Rainbow Trout, across all age classes.

Catch rates relative to net depth and lake bottom-depth indicated that Rainbow Trout densities were high in the shallow layers of the nearshore zone and in an offshore layer at 15-20 m depth; this species was also found near the lake surface in the offshore zone at low density. Cutthroat Trout were concentrated in the nearshore zone, with highest densities at the 20 m depth contour. Cutthroat/Rainbow hybrids were only found shoreward of the 15 m depth contour. The 15-20 m layer coincided with the thermocline where the water temperature was about 10-17°C.

Rainbow Trout were the predominant species at the reservoir surface, and at all depths of the main and south reservoir basins. Cutthroat Trout predominated in the Elk River bay and, except in the main basin, their relative abundance increased with depth. Hybrid trout made up a small but appreciable fraction of fish in the south and Elk River bays, but they were almost absent from the north bay and main basin. Neither gill netting nor minnow trapping provided useful information for the quantitative apportionment of the acoustic estimate of fish < 100 mm in length.

The length-age relationship derived for both Rainbow Trout and Cutthroat Trout was used to allow aging of fish sizes recorded during acoustic surveys. Acoustic surveys were undertaken at night between August 17 and 21, 2014. The majority of the fish were recorded from the main basin of Upper Campbell Reservoir at depths between 5 and 20 m, and not below 45 m, small numbers of fish were recorded in the north bay. In the shallower south bay and Elk River bay fish were found in all depth layers. The majority of fish were calculated to be within a small size group of <100 mm; i.e., smaller than the minimum effective capture size of the gill nets deployed. A second, larger size group of fish seen with acoustics was represented by three modes corresponding to lengths of 100 mm, 687 mm, and 376 mm; corresponding to fish captured in RISC gill nets. Fish densities and distribution patterns were distinctly different during day and night acoustic sampling, with especially high densities recorded at night in the south bay, and a distinct mid-water layer in the main basin. Densities were relatively low in the 0-5 m surface layer in all basins, with higher densities at 5-20 m. In the north bay and main basin, densities were low below 20 m. Most larger fish were detected between 15 m and 20 m in all basins. In all reservoir basins 99-100% of the fish were in the upper 20 m of the water column, with 61-98% between 5 and 15m. The main basin and the south bay contained the most fish.

The total fish abundance estimate (species combined) for the whole reservoir was 424,783 fish ± 60%. Total areal density for fish of all sizes in the reservoir was 148 fish/ha, dominated by small fish < 100 mm (137 fish/ha). Areal densities of other fish were 9 Rainbow Trout/ha, 1.8 Cutthroat Trout/ha, and 0.1 hybrid trout/ha. Small fish < 100 mm were the most abundant type of fish at most depths throughout the reservoir. Their reservoir-wide abundance was 393,118 fish. A whole reservoir estimate of 26,485 Rainbow Trout, and 5,027 Cutthroat Trout. The abundance estimate for Cutthroat/Rainbow hybrids was 152 fish for the whole reservoir, solely from the south and Elk River bays. Abundances for Dolly Varden could not be estimated due to very low numbers in the reservoir.

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. The snorkel surveys have not been conducted consistently from year to year for several of the tributaries. The size limit used to define 'adult' fish during historic surveys is not known, precluding direct comparisons with 2014 data. In summary, there is high variability in adult Rainbow Trout counts among years for individual tributaries. There is no clear indication of a consistent trend over time in any of the tributaries. Snorkel surveys for adult spawners were undertaken in the tributaries of the Upper Campbell Reservoir, Buttle Lake and Lower Campbell Reservoir between June 9 and 12, 2014 under optimal conditions. Rainbow Trout redds were recorded in all tributaries, except for Thelwood Creek where high numbers of observed fish made it difficult to accurately estimate the number of redds. High numbers of redds (>100 redds) were observed in Elk River, Ralph River, Wolf River and Campbell River (Strathcona Dam tailrace). Cutthroat Trout and Dolly Varden redds were not observed, reflecting survey timing that was designed to coincide with Rainbow Trout spawning. The majority of adult Rainbow Trout recorded were in mid-spawning condition and highest numbers were recorded from Thelwood Creek, Elk River and Ralph River, in that order. Low numbers of adult Rainbow Trout were recorded from Henshaw Creek and Philips Creek, and no adult Rainbow Trout were recorded from the remaining tributaries surveyed. Observed densities of Rainbow Trout were greatest in Wolf River (1,280 fish/km), Thelwood Creek (1,027 fish/km), and Ralph River (928 fish/km). Low numbers of adult Cutthroat Trout were observed in the majority of tributaries, with small numbers recorded in spawning condition in the upper and lower reaches of Elk River, and in Ralph River. The greatest number of adult Dolly Varden were observed in Wolf River (30 fish), followed by Campbell River (24 fish), and Phillips Creek (18 fish). Dolly Varden were also recorded in the Ralph River and the upper Elk River. The data presented for 2014 is from surveys that targeted Rainbow Trout spawning, so any trends in Cutthroat Trout or Dolly Varden should be interpreted cautiously.

The Effective Spawning Habitat (ESH) model was run for Cutthroat Trout, Rainbow Trout, and Dolly Varden. Lower Campbell Reservoir spawning index values for Rainbow Trout, Cutthroat Trout and Dolly Varden were variable from year to year. Upper Campbell Reservoir spawning index values were more stable across years for Rainbow and Cutthroat Trout, and oscillated for Dolly Varden. There was little change in habitat loss among years for Lower Campbell Reservoir in comparison to Upper Campbell Reservoir, which oscillated for all species. ESH values for both Lower and Upper Campbell reservoirs were variable among years for all three species.

The ESH Performance Measure (PM), along with the adult abundance data and snorkel survey results, were used to perform a critical assessment of the experimental design. Three analyses were completed: a before after (BA) power analysis, a correlation analysis using a population model simulation, and a correlation analysis using data from the hydroacoustic estimate of adult Rainbow Trout in 2014.

The power analysis was performed to assess the number of sampling years required to statistically detect an increase up to 100% in ESH or observed adult Rainbow Trout abundance based on snorkel data from 1990 to 2012. The results demonstrated that greater statistical power could be achieved by increasing the number of monitoring years after the WUP or by altering assumptions regarding potential effect size from the WUP implementation. The power analysis using the ESH and tributary snorkel data demonstrated that only large effect changes in ESH for Rainbow Trout (≥60%), Cutthroat Trout (≥100%), and Dolly Varden (≥100%) could be detected with a power of 0.8 after 20 years of monitoring. Results for the Rainbow Trout abundances in the reservoir tributaries were similar as only large effect changes in Rainbow Trout abundance (≥80%) could be detected with a power of 0.8 after 20 years of monitoring for the majority of snorkelled tributaries. Due to the required assumptions in this analysis, the true likelihood of detecting a large (100%) increase in adult abundance may be lower than our reported power estimates.

The correlation analysis using population model simulation results was performed to evaluate the effectiveness of comparing a single year's effect (ESH) against a grouped cohort dataset (adult abundance). When comparing the correlation results, the grouped adult abundance did not have the same correlation strength (r^2 value) vs. ESH values, in comparison to YOY abundance. The only scenario that had a high r^2 value ($r^2 = 0.83$) and a positive slope was when adult abundance was compared against lagged ESH values (ESH t-3); however, the likelihood that such an r^2 value would be detected under natural conditions is low. The results demonstrate that if a true correlation between productivity and ESH exists, it may not be detected using adult abundance to measure response to changes in ESH.

A correlation analysis using the hydroacoustic estimate of adult Rainbow Trout was conducted to determine the magnitude of effect (correlation slope) between ESH and adult abundance that could be detected. Simulated population estimates were generated based on the 2014 hydroacoustic estimate of adult Rainbow Trout and correlations were evaluated to determine the proportion of iterations that resulted in a significant correlation based on various slope values. The results indicated that only relationships that had intermediate magnitude of effect or greater (slope value $\geq$ 8) between ESH and adult abundance have a strong likelihood (>0.80) of being detected. These results demonstrated that a moderately strong relationship between ESH and adult abundance is required for a response to WUP operations to be detected with some certainty.

Recommendations are provided to improve the methods for hydroacoustic surveys, snorkel surveys, and the ESH PM. In addition, the experimental design for JHTMON-3 should be reconsidered.

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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, which 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 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 is expected to be monitoring to address outstanding management questions in the years following the implementation of a WUP.

As the Campbell River Water Use Plan 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 to effectively manage water uses to protect and enhance aquatic resources. To address this uncertainty, 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. JHTMON-3 focuses on a test of salmonid recruitment (trout and char) in the Upper Campbell Reservoir (Upper Campbell Reservoir and Buttle Lake) and Lower Campbell Reservoir; this will help to better understand the potential biological effects of BC Hydro operations.

1.2. BC Hydro Infrastructure, Operations and the Monitoring Context

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. Details of the diversion infrastructure and operations are provided in BC Hydro (2013).

1.2.1. 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 the 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.

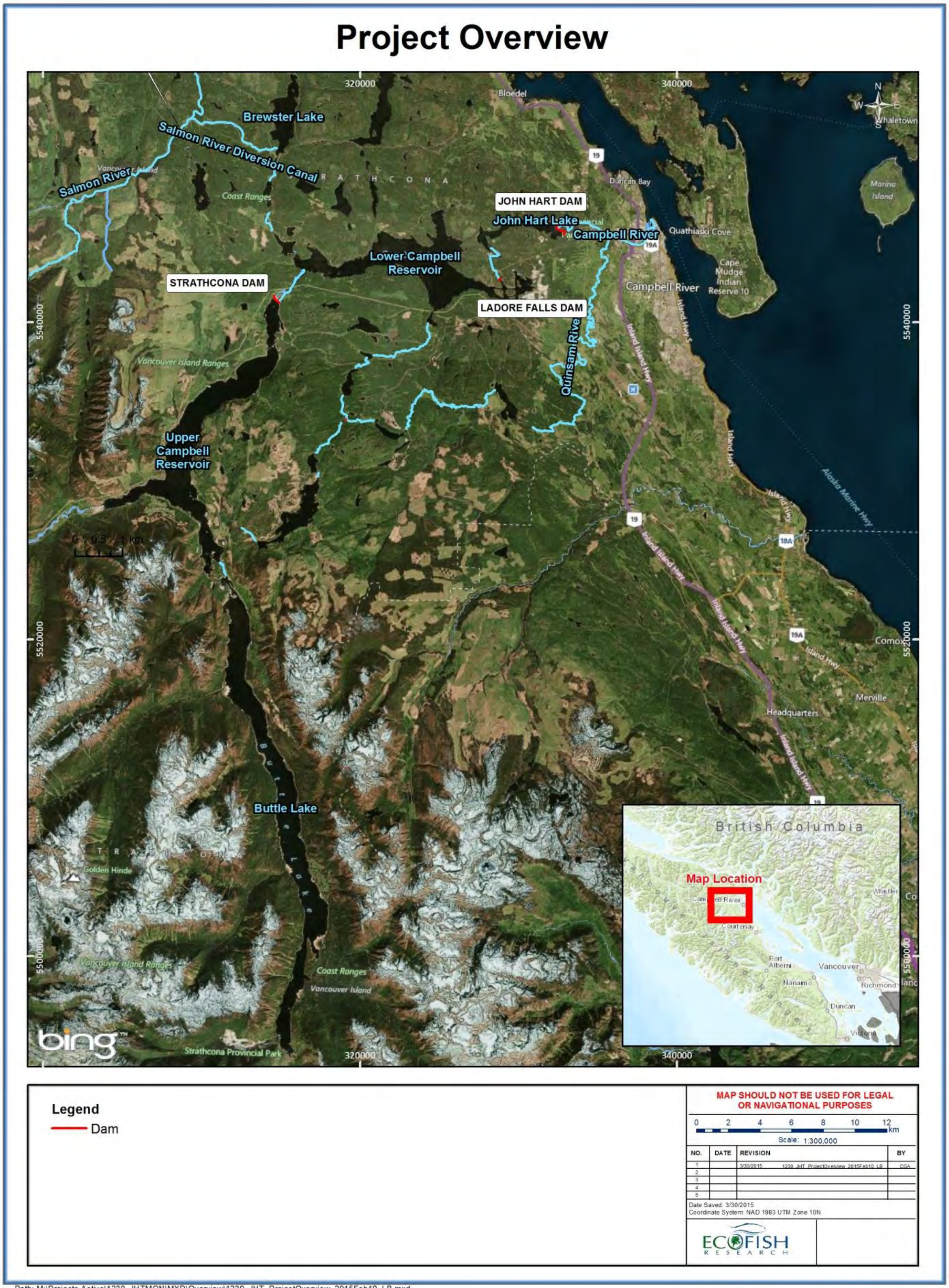
Upper Campbell Reservoir is impounded by the Strathcona Dam. The dam also provides primary flow regulation for the Ladore and John Hart Dams, which are located downstream. The Strathcona Dam was constructed between 1955 and 1958 with a second generating unit installed in 1968. Upper Campbell Reservoir's historic operational water elevation has been between 221.0 m and 210.0 m.

The storage licence for operations in Buttle Lake and Upper Campbell Lake Reservoir are between 212.00 m to 220.98 m and 192.00 to 220.98, respectively; giving a combined estimated active storage in the reservoirs of 880.18 m^3 (as measured at Strathcona Dam) (BC Hydro 2012).

1.2.2. 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 m and 174.0 m, while the current storage licence limits for operation are between 178.3 m and 163.65 m (BC Hydro 2012).

Map 1. Overview of the JHTMON-3 study area.



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1.3. Management questions and hypotheses

The overall 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 effective spawning habitat. The three species of primary interest are Rainbow Trout, Cutthroat Trout and Dolly Varden. 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 functional spawning habitat is sufficient to allow the salmonid populations to fully seed the reservoirs. During the Campbell River WUP process an "Effective Spawning Habitat" (ESH) Performance Measure was developed for Upper and Lower Campbell reservoirs. The ESH Performance Measure quantifies the amount of spawning habitat within the reservoir drawdown zone that is available during the spawning period, and is subsequently not inundated by rising water elevation during incubation. In other words, the Performance Measure tracks the amount of available spawning habitat that remains effective throughout the incubation period. The Performance Measure can be calculated separately for the three salmonid species of interest. Implementation of the WUP is predicted to increase the area of effective spawning habitat for both Cutthroat Trout and Rainbow Trout. Comparisons of measurements of fish abundance and spawning success before and after the WUP implementation are meant to test the assumption that salmonid recruitment is limited by availability of effective spawning habitat as positive salmonid population responses are expected to occur if the area of functional spawning habitat is indeed a limiting factor.

The JHTMON-3 monitoring program aims to address the following three management questions (BC Hydro 2013):

1. 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?

By corollary:

2. Are the trout populations in Upper and Lower Campbell reservoirs 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 Monitor, as well as in future WUP investigations?

In addressing the questions, the Monitor is designed to test the following four alternate null hypotheses:

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

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

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

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

b. Abundance of adult trout in Lower Campbell 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 and Lower Campbell reservoirs is not biologically significant. [Note that this will be tested by undertaking redd surveys, which were not a component of the Year 1 pilot studies.]

$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. [Note that this will be tested by undertaking incubation studies, which were not a component of the Year 1 pilot studies.]

1.4. Scope of the JHTMON-3 Study

JHTMON-3 is proposed as a ten year study with the following study components:

1. Annual (Years 1-9) hydroacoustic 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 experimental study to understand flow and incubation conditions within the drawdown zone of tributary deltas.

Year 1 comprised a pilot year that involved testing study methods (LKT 2014) focussed on $H_0$1 and $H_0$2, and had the following three components:

1. Estimating fish abundance for individual salmonid species in Upper Campbell Reservoir, using mobile hydroacoustic surveys and sampling with gill nets and minnow traps;
2. Estimating abundance of spawning adfluvial trout using snorkel surveys in tributaries to Buttle Lake and Upper and Lower Campbell reservoirs; and
3. Critical assessment of current experimental design for determining relationships between ESH and adult fish abundance.

This report describes the methods, results and conclusions of the Year 1 study. Where possible, results from Year 1 are compared with historic data to provide information about trends over time.

2. METHODS

2.1. Study Locations

The components of JHTMON-3 are focussed on Upper Campbell (including Buttle Lake) and Lower Campbell reservoirs and tributaries. The survey and sampling locations are presented in Map 2 and Map 3.

2.2. Population Estimate for Upper Campbell Reservoir

2.2.1. Field and Laboratory Work

The 2014 acoustic and gill net surveys of Upper Campbell Reservoir was conducted as a pilot study with the following primary objectives:

1. Conduct coordinated acoustic and gill net surveys of the fish in Upper Campbell Reservoir during August of 2014;
2. Estimate fish abundance in the reservoir by species, with Rainbow Trout and Cutthroat Trout the main species of interest; and
3. Describe spatial characteristics of the fish community.

In August 2014 coordinated mobile acoustic and gill net surveys were conducted in Upper Campbell Reservoir (excluding Buttle Lake) to estimate fish abundance and describe fish distribution in the reservoir. Protocols for this type of sampling scheme are described in Beauchamp *et al.* (2009). Acoustic sampling was used to estimate absolute abundance of fish and to describe spatial and temporal patterns of the fish assemblage. Gill netting was used to describe day and night spatial patterns of individual fish species, to apportion the acoustic estimate among species, and to provide age, size, diet, and other biological information. Temperature and dissolved oxygen profiles were measured in the main reservoir basin at the time of the gill net survey to aid interpretation of vertical distributions of fish. Minnow traps were set at nearshore stations concurrently with gill netting; however, resulting trap data were not used for apportionment of the acoustic estimate because this gear mainly fished the littoral zone, an area that was under-sampled by the acoustic survey.

2.2.1.1. Temperature and DO profiles

A YSI Sonde (YSI model 6920v2 Sonde, YSI Inc., Yellow Springs, Ohio, USA) was used for instantaneous measurements of temperature and dissolved oxygen concentrations over the depth profile at each of stations GN03/T-05GN, GN05, and GN03 (Map 2). Measurement depths were taken every meter for the first 10 m, every 2 m over the interval of 10 to 20 m, every 5 m at depths between 20 m and 30 m and every 10 m at depths >30 m. The dissolved oxygen sensor was air calibrated immediately before measurements were taken at each station.

2.2.1.2. Gill Netting

Gill netting was undertaken at seven littoral sites and one pelagic site between August 26 and 30, 2014, to obtain representative fish samples from Upper Campbell Reservoir (Map 2). Both floating and sinking gill nets were used to target various strata within the water column. At the littoral sites, nets were set perpendicular to shore with sinking nets set on the bed and floating nets set on the surface. At pelagic sites, nets were set perpendicular to depth contours with sinking nets set on the bed, as well as suspended in the water column close to the thermocline, and at the surface. RISC standard gill nets were used; the nets consist of six panels, each 15.2 m long and of different mesh sizes (76 mm, 51 mm, 89 mm, 38 mm, and 64 mm), strung together in a "gang" to form a net 91.2 m long and 2.4 m deep. Two 'Nordic' nets were used in addition to the RISC nets at sites UCR-LKGN04 and UCR-LKGN07; these nets were 15.8 m long by 1.5 m wide and 15.8 m long by 3.7m wide. The Nordic net panel mesh sizes were: 12.5 mm, 20 mm, 16 mm, and 25 mm. This sequence of mesh sizes captures a range of size classes of fish.

Table 1. Sampling dates and location for gill netting surveys on Upper Campbell Reservoir, August, 2014.

Site	Sampling Date	UTM			Location	Turbidity
		Zone	Easting	Northing		
UCR-LKGN01	28-Aug-2014	10U	314096	5539930	Littoral	Clear
UCR-LKGN02	28-Aug-2014	10U	314629	5537246	Littoral	Clear
UCR-LKGN03	28-Aug-2014	10U	313301	5536669	Pelagic	Clear
UCR-LKGN04	30-Aug-2014	10U	308638	5533904	Littoral	Clear
UCR-LKGN05	26-Aug-2014	10U	309356	5530967	Littoral	Clear
UCR-LKGN06	26-Aug-2014	10U	309419	5527967	Littoral	Clear
UCR-LKGN07	27-Aug-2014	10U	310848	5526008	Littoral	Clear
UCR-LKGN08	27-Aug-2014	10U	305645	5529532	Littoral	Clear

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 16-20 hours. Floating lights were attached to each net to mark their location overnight for boater safety. Individual fish processing is described in Section 2.2.2.1.

2.2.1.3. Minnow Trapping

Minnow trapping was undertaken between August 26 and 30, 2014 to obtain representative fish samples from littoral areas in Upper Campbell Reservoir (Map 2). Three Gee-type minnow traps were set at each of the seven gill-netting littoral sites and left overnight. A second sampling event was undertaken during daytime hours at UCR-LKMT08 on August 30. In total 24 traps were deployed during the course of the survey. Trap sets targeted the following depth ranges; 0-2 m, 3-6 m, and 7-10 m.

Each trap was baited with a small amount fish roe placed in a film container perforated with holes, which allowed the scent to escape but prevented the attractant from being consumed. Traps were marked with a float, and UTM coordinates, depth, time, and mesh size of trap were recorded. Traps were fished overnight with soak times ranging from 16-20 hours. Captured fish were separated by site and trap number and then brought back to shore for processing. Individual fish analysis is described in Section 2.2.2.1 above.

Table 2. Sampling dates and location for minnow trapping surveys on Upper Campbell Reservoir, August, 2014.

Site	Sampling Date	UTM		
		Zone	Easting	Northing
UCR-LKMT01	28-Aug-2014	10U	314096	5539930
UCR-LKMT02	28-Aug-2014	10U	314629	5537246
UCR-LKMT04	26-Aug-2014	10U	308638	5533904
UCR-LKMT05	26-Aug-2014	10U	309356	5530967
UCR-LKMT06	27-Aug-2014	10U	305645	5529532
UCR-LKMT07	27-Aug-2014	10U	310848	5526008
UCR-LKMT08	26-Aug-2014	10U	309419	5527967
UCR-LKMT08	30-Aug-2014	10U	309419	5527967

2.2.1.4. Acoustic Surveys

Day and night mobile acoustic surveys were conducted August 17-21, 2014 to measure fish abundance and distribution patterns in the reservoir. Bathymetric data collected during the surveys were also used to construct a digital bathymetric map of the reservoir. The night-time sampling period was used for the abundance estimates. Daytime sampling was used to loosely describe differences in day-night fish distribution patterns, and to confirm that night was indeed the best period from which to develop a population estimate. Day sampling took place from 07:00 hrs to 17:30 hrs and night sampling was from 22:00 hrs to 05:30 hrs. Survey methods generally followed protocols described in standard fisheries acoustics texts (Thorne 1983, Brandt 1996, Simmonds and MacLennan 2005) with special measures to ensure thorough coverage of the upper water column due to the presence of trout (Johnston 1981, Yule 2000). These methods were similar to those employed to sample resident fish in John Hart Reservoir, BC in 2010 and 2013 (Stables and Perrin 2011, Stables *et al.* 2013).

Hydroacoustic surveys were performed from a 9 m covered aluminium workboat with a dual transducer echo sounding system. A downward facing transducer sampled the water column from 2 m beneath the water surface to the reservoir bottom (down-looking mode), while a second transducer was aimed sideways from the boat, nearly horizontally (tilted down 7°) to cover the upper 5 m of the water column (side-looking mode). The collection of side-looking data was deemed necessary because trout are often found near the reservoir surface where the sampling volume of a down-looking transducer is very small (Johnston 1981, Yule 2000). The two transducers sampled simultaneously at a rate of 6-9 pings per second per transducer depending on transect depth. Transecting speeds were 1.4-1.7 m/s (5.0-6.0 km/hour; Table 3).

The echo sounding system consisted of a BioSonics DTX echo sounder and two split-beam transducers paired with a Garmin model 546 differential GPS. Both transducers had 6.7° circular beams (full angle). Operating frequencies were 206 kHz for the down-looking transducer and 201 kHz for the side-looking transducer. The echo sounder was operated by a laptop computer, which also served as a data logger and allowed monitoring of data quality on echograms during collection. Latitude and longitude from the GPS were added to acoustic data files as they were logged. Data collection thresholds were -100 dB for down-looking and -80 dB for side-looking. Additional equipment specifications and data collection settings are shown in Table 3.

Sixteen acoustic transects were sampled during each diel period (day and night) during the study. There were seven transects in the main reservoir basin and three transects each in the three smaller basins (Map 2). Due to the size of the reservoir and frequent windy conditions, night sampling was completed over the course of two nights, while day sampling took two days (side-looking acoustics requires relatively smooth water). An additional day was spent collecting supplementary bathymetric data at previously unsampled locations. Transects for the fish survey were approximately perpendicular to the longitudinal axis of the reservoir, spaced at regular intervals of approximately 0.8 to 2.1 km, depending on the basin, constituting a stratified systematic survey design. Transects were sampled shoreward to the 2 m depth contour if safety allowed. In practice, steep drop-offs, stumps, and dead-heads along the shore caused most transects to be started and ended in deeper water, with 81% of start and end points offshore of the 5 m depth contour (mean start and end depth 8.1 m for night sampling).

Table 3. Equipment specifications and settings for collection and processing of acoustic data collected from Upper Campbell Reservoir, August 2014. D = down-looking, S = sidelooking, unspecified = both.

Project Phase	Category	Parameter	Value
Data collection	Transducers	Type[1]	Split-beam
		Sound frequency (kHz)	206 D, 201 S
		Nominal (full) beam angle	6.7° D, 6.7° S
		Depth below lake surface	0.5 m
	Settings	Pulse width	0.4 ms
		Transmit power (dB)	0
		Collection threshold (dB)	-100 D, -80 S
		Minimum data range[2]	1.0 m
		Time varied threshold	none
		Ping rate per transducer	6-9 pps
	GPS	Type[3]	Differential
		Datum	NAD83
	Other	Transecting speed	1.4-1.7 m/s (5.0-6.0 km/h)
Data Analysis	General	Calibration offset (dB)	0
		Time varied gain	40 log R
		Minimum threshold (dB)[4]	-65 D, -55 S
		Maximum threshold (dB)[4]	-20
		Beam pattern thresh.(dB)	-6
		Beam full angle	6.7°
		Single target filters	0.5-1.5 @ -6 dB
	Range processed[2]	For fish abundance	5-65 m D, 10-25 m S
		For TS	2-65 m D
	Fish tracks (per fish)	Minimum # echoes	1 D, 2 S
		Max range change	0.2 m
		Max ping gap	1

[1] BioSonics DT-X split-beam. [2] Range from transducer. [3] WAAS differential GPS.

[4] Processing threshold after application of calibration offset.

2.2.2. Data Analysis

2.2.2.1. Data Analysis for Fish Sampling

Individual Fish Analysis

All fish captured during gill netting and minnow trapping sampling surveys were identified to species, weighed, and measured to the nearest mm (fork length) in the field; fish were anaesthetized as necessary. Scales were taken from Rainbow Trout and Cutthroat Trout and fin rays were taken from Dolly Varden; however, age classes were only ascribed to the two trout species. The study attempted to ensure all live fish were returned to the reservoir unharmed. Otoliths and excised stomachs contents were taken from already dead fish to a maximum of five fish per each species and age class. The excised stomachs were preserved in 10% formalin for later analysis in the lab. Observations of sex and stage of sexual maturity were also recorded in the field.

A subset of the scale samples was measured: five samples per 10 cm length interval in each reservoir. The remainder were stored in case additional samples are required. Aging of fish was undertaken by experienced Ecofish fisheries biologists, by examination of growth rings on scales and fin rays. Ecofish's ageing protocols are provided in Appendix A.

Other biological statistics computed for individual species in the gill net catch include mean and standard deviation of length and weight, length-frequency and age distributions, weight-length regressions, and Fulton's condition factor (100 g/cm^3, Ricker 1975). Age distributions have been calculated for trout only. Analyses of individual fish caught in gillnets and minnow traps are presented in Section 3.1.2.

According to the Terms of Reference for the study, diets of fish are to be ascertained through identification and enumeration of stomach contents of sampled fish (salmonids) every other year; therefore this was not completed in Year 1.

Fish Analysis for Population Abundance Estimates

Catch per unit effort (CPUE) from gill netting, an indicator of relative abundance was used to describe spatial patterns of fish in Upper Campbell Reservoir and to apportion the acoustic estimate among species. Catch and CPUE (fish per set-hour) was computed for stations, set zones (nearshore, mid-reservoir), and set periods (day, overnight) to describe general spatial and temporal abundance patterns. Catch and CPUE (fish per panel-hour) was computed by individual net panel to estimate species composition by 5 m depth intervals for use in the analyses of acoustic surveys. Trap results by station and set depth are summarized for the acoustic survey population abundance estimate in Section 3.1.2.4.

2.2.2.2. Data Analysis for Acoustic Surveys

Fish were counted on electronic echograms according to standard echo-trace counting methods (Thorne 1983, Simmonds and MacLennan 2005). Computer files were processed in the office using Echoview© software to extract fish traces, to measure target strength (TS), defined as the acoustic size of fish, and to determine sampling volumes. Down-looking data were used to compute fish density at depths greater than 5 m, and side-looking data were used to represent the uppermost 5 m of the water column. Fish traces were recognized on echograms by their shape, cohesiveness, TS, and number of echoes. Traces with mean TS greater than -20 dB, characteristic of woody debris and larger than expected from any fish in the reservoir, were not counted as fish. Echoes smaller than -65 dB (down-looking) and -55 dB (side-looking) were excluded from processing to eliminate noise and unwanted targets such as plankton. This approach allowed detection of fish as small as 30 mm in length with the down-looking transducer >100 mm with the side-looking transducer. Other fish tracking settings are listed in Table 3. Bubbles rising through the water column are easily recognized on down-looking echograms by the characteristic slope of their traces and a tendency to form columns, but they are difficult to recognize on side-looking echograms. Where they occurred during the survey (only in Elk River bay), bubbles were excluded from down-looking fish counts and a ratio of fish traces to bubble traces was computed and used to proportionately reduce the side-looking fish counts.

TS was determined by the split-beam method (Simmonds and MacLennan 2005). Accuracy of acoustic measurements was assured by field calibration tests. In situ TS measurements of a -39.5 dB standard sphere were within 1 dB of the expected value, so no calibration correction was applied for either transducer. Lengths of individual fish detected with acoustics were estimated from down-looking TS using Love's (1977) equation for fish insonified dorsally:

length (mm) = 10 * 10((TS + 0.9 log (kHz) + 62) / 19.1)

Because TS is affected by factors other than fish size (Simmonds and MacLennan 2005) and Love's (1977) equation is a generalization from many fish species and sizes, this equation provides an estimate of fish length that is less precise than a hands-on physical measurement. The relationship between side-looking TS and fish length is highly variable (Love 1977, Kubecka and Duncan 1998, Yule 2000), so fish length was not estimated from side-looking TS data.

TS data were used to subdivide fish detected with acoustics into small fish (< 100 mm long) and large fish (≥ 100 mm long) to facilitate apportionment among species. Per Love's (1977) dorsal model, fish with mean TS < -45.0 dB were considered to be < 100 mm long. Corresponding size groups from acoustic and gill net data were matched for apportionment of the acoustic estimate among species.

Depth intervals for data analysis were 0-5 m, 5-10 m, 10-15 m, and so forth to 65 m, the greatest depth encountered during the surveys, and each of the four basins was analyzed separately, so the population estimate was stratified by depth and reservoir basin. Fish densities were summarized as fish/m^3 within depth intervals of transects for the population estimate, and as fish/ha in 50 m long segments of transects for spatial analysis. For each spatial cell of interest, fish density was calculated as the total number of fish counted divided by the volume sampled. The volume sampled in each spatial cell was calculated using the acoustic beam angle, distance transected, and a correction for bottom intrusion. The wedge model (Keiser and Mulligan 1984) was used for all depth intervals. The effective beam angle for each depth interval was modelled considering the nominal beam angle, boat speed, ping rate, and hits required per fish trace, and the sampling volume was adjusted accordingly at ranges where the effective beam angle was less than the nominal beam angle. Under the conditions of the surveys, the effective beam angle was at least 5.2° at all ranges of interest. A complete list of data analysis settings appears in Table 3.

For population estimates, each transect provided one replicate of each depth interval within a reservoir basin. Mean fish density of each depth interval was expanded in proportion to its volume, and resulting abundance estimates were summed to obtain the total population estimate. Variance and 95% confidence intervals were calculated for a stratified random sample with depth intervals and reservoir basins as strata (Cochran 1977). Depth interval volumes were calculated from a bathymetric map constructed from data collected during this survey coupled with data from earlier surveys. Whole-reservoir fish density (number/ha) and biomass (kg/ha) estimates were computed using an area of 2,869 ha, the reservoir surface area at the time of the acoustic survey (at elevation 217.1 m).

Relative abundance of fish captured in RISC gill nets (CPUE by species) was used to apportion the acoustic estimate among species for fish ≥ 100 mm in length, with gill net and acoustic data from corresponding 5 m depth intervals paired for these calculations (Section 2.2.2.1). Species composition of layers that were not sampled with RISC nets was estimated by linear interpolation between layers that were sampled, or for layers beyond the maximum depth of sampling, by extrapolation from the deepest layer that was sampled. Acoustic sampling was limited in areas shoreward of the 5 m depth contour; therefore gill net data from this zone were excluded from species composition estimates.

In the main basin, where nearshore and offshore gill net sets were made, species composition was computed for each depth layer using data from both zones, with weighting in proportion to the volume of each zone. For a species within a layer, weighted species composition (WSC) was computed as:

$WSC = [(SC_n \cdot V_n) + (SC_o \cdot V_o)] / (V_n + V_o)$, where

SC = species composition of a set zone

V = volume of a set zone

n = nearshore set zone

o = offshore set zone

The acoustic estimate of fish < 100 mm long could not be apportioned among species. Although a few fish of this size group were captured in RISC and small-mesh gill net panels, the sample size was too small for quantitative estimation of species composition (see Section 3.1.2.1). Minnow trapping captured mainly benthic species that are seldom detected with acoustics, so these data were not useful either for apportioning the acoustic estimate of small fish.

2.3. Snorkel Survey of Spawners in Reservoir Tributaries

Snorkel surveys of spawners and redds were undertaken in the lower reaches of tributaries of Buttle Lake, Upper Campbell Reservoir, and Lower Campbell Reservoir during June 2014. These tributaries were selected based on their reported spawning value for Rainbow Trout (LKT 2014) and included seven survey reaches upstream of Buttle Lake and Upper Campbell Reservoir that have been surveyed historically since the early 1990s. Historical data were also available for one of the three surveyed tributaries of Lower Campbell Reservoir (Fry Creek), which had been sampled in two previous years. 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; therefore the statistical power of the comparison may be weak. Rainbow Trout were targeted for the Year 1 surveys, as outlined in LKT (2014) and coincided with the peak spawning period for this species. The contract for JHTMON-3 was finalized after the peak spawning period for Cutthroat Trout, so surveys for Cutthroat were not completed as part of Year 1 studies. Cutthroat Trout spawning surveys will be completed and reported as part of the Year 2 program.

Snorkel surveys were undertaken in the following six tributaries of Buttle Lake and Upper Campbell Reservoir: Elk River (upper and lower reaches), Thelwood Creek, Wolf River, Henshaw Creek, Phillips Creek, and Ralph River. In addition, snorkel surveys were undertaken in the following three tributaries of Lower Campbell Reservoir: Campbell River (Strathcona Dam tailrace), Miller Creek, and Fry Creek. Surveys were conducted from June 9 to June 12, 2014 (Table 4). Each stream section was surveyed once by two experienced technicians swimming in pairs. A range of variables was measured (Table 5). To allow for comparison between years, the 2014 surveys followed standardized survey methods within each reach, as conducted historically by MFLNRO and BCCF (Pellett 2013).

Table 4. Snorkel survey reach details for Year 1 surveys, June 2014.

Watershed	Stream	Survey Distance (km)	Date	Survey Start Location	Survey End Location
Upper Campbell	Upper Elk River	6.0	09-Jun-14	Drum Creek 200 m US confluence	HWY 28 take out/ put in
	Lower Elk River	5.4	09-Jun-14	HWY 28 take out/put in	Upper Campbell Lake
Buttle	Ralph River	0.9	10-Jun-14	50 m u/s Shepard Creek	Buttle Lake
	Thelwood Creek	2.5	10-Jun-14	Falls at powerhouse	Bridge at Buttle Lake
	Wolf River	0.3	09-Jun-14	Falls Pool	Buttle Lake
	Phillips Creek	0.3	09-Jun-14	300 m u/s lake	Buttle Lake
	Henshaw Creek	0.5	10-Jun-14	Cascades	Buttle Lake
Lower Campbell	Campbell River	0.5	11-Jun-14	Strathcona Tailrace	Lower Campbell Lake
	Miller Creek	0.4	12-Jun-14	Cascades	Fry Lake
	Fry Creek	1.2	11-Jun-14	Barrier DS logging road	Lower Campbell Lake

Table 5. Variables measured during snorkel surveys in the selected tributaries of Upper Campbell Reservoir, Buttle Lake, and Lower Campbell Reservoir, June 2014.

Variable	Unit/Classification
Weather	Observation
Water temperature	°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
Site photographs	–

2.4. Critical Assessment of Current Experimental Design Using Statistical Modelling

The statistical modelling exercise was split into two components, the calculation of the ESH Performance Measure (PM) and statistical analyses using the ESH results and available fish abundance data to provide a critical assessment of the experimental design. The ESH PM was developed during the Campbell River Water Use Plan to estimate the amount of effective spawning habitat present in Upper and Lower Campbell reservoirs under alternate reservoir management scenarios. The term "effective spawning habitat" was used to refer to habitat that maintains its quality sufficiently to allow successful spawning and incubation. For example, tributary stream habitat that is used for spawning, but becomes inundated by increasing reservoir water levels prior to complete incubation is not considered *effective* spawning habitat. The ESH model tracks habitat through time to measure amount of habitat (ha) that can be used for spawning, while also receiving sufficient flow during incubation periods.

The ESH PM along with the adult abundance data and snorkel survey results were used to complete a critical assessment of the experimental design. Adult abundance data for Upper Campbell Reservoir are limited to a single estimate in 2014 using hydroacoustic data (see Section 3.1.3.2), and snorkel surveys in reservoir tributaries since 1990 (see Section 3.2.3). These data are grouped by species and size bins that include multiple cohorts (i.e., there are no age-specific abundance estimates). We completed three analyses:

1. A Before After (BA) power analysis using the snorkel estimates from 1990 to 2012;
2. A correlation analysis using a population model simulation; and
3. A correlation analysis using data properties from the hydroacoustic estimate of adult Rainbow Trout in Upper Campbell Reservoir in 2014.

2.4.1. Effective Spawning Habitat (ESH)

The ESH model was run separately for Cutthroat Trout, Rainbow Trout, and Dolly Varden by considering the life history timing of each species (Table 6, Figure 1). This periodicity was assumed to be fixed across years. The amount of spawning habitat present at the time of spawning was determined from reservoir water levels (Figure 2), and this spawning habitat was tracked over the incubation period (estimated from temperature data in Figure 3) to determine if it became inundated for long enough to cause egg mortality. Assumptions were made in the model that relate length of inundation to egg mortality rate.

For each species and each day within the spawning period, the following steps were completed:

1. The reservoir elevation ("spawning elevation") was determined;
2. The "effective spawning elevation" was set to the spawning elevation, the total ATU was set to the water temperature for the spawning day (Figure 3);
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 – 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 6, or on the incubation end date in Table 6; whichever comes first) the effective spawning habitat area was determined from the effective spawning elevation (Figure 2);
5. Effective spawning habitat (area days, expressed as m^2d) was calculated by multiplying the effective spawning habitat area by the spawning intensity, which was provided as a function of calendar date (Figure 1);
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 effective spawning habitat from the initial spawning habitat.

Effective spawning habitat and loss of effective habitat were summed over each day of spawning to determine the total effective spawning habitat and total habitat loss for the year. The effective spawning habitat value is based on the remaining effective spawning habitat available after the habitat loss has occurred. In cases where effective spawning habitat is completely lost, the ESH value would be 0. An effective spawning index was also calculated for each year, which provided a rank between 0 (complete habitat loss relative to total potential habitat) and 1 (no habitat loss relative to total potential habitat) for each year. The formula for the spawning index is as follows:

$$Effective\ Spawning\ Index = 0.5 \times \left(1 + \left(\frac{ESH - Habitat\ Loss}{Total\ Potential\ Habitat}\right)\right)$$

Where total potential habitat reflects the maximum amount of habitat the system could support based on the amount of habitat calculated at the lowest elevation point.

Table 6. Spawning and incubation timing information used in the spawning intensity function and ESH model.

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					

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

Figure 1. Spawning intensity for Cutthroat Trout, Rainbow Trout, and Dolly Varden used in the ESH model

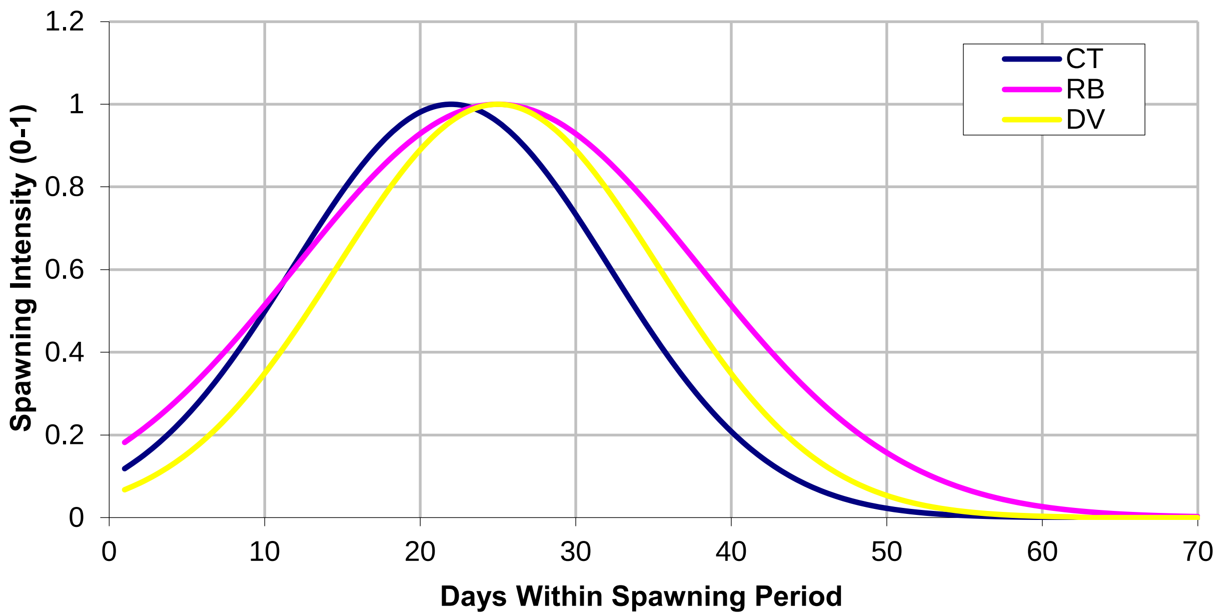


Figure 2. Relationships between spawning habitat and reservoir elevation for Upper Campbell Reservoir at Strathcona Dam (SCA) and Lower Campbell Reservoir at Ladore Dam (LDR).

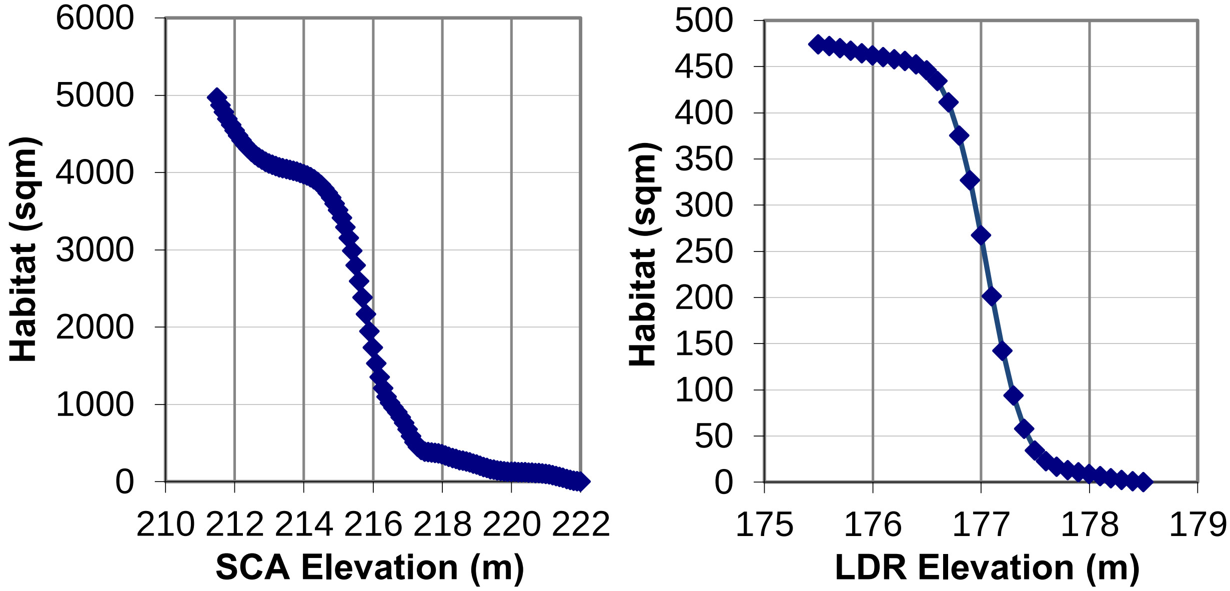
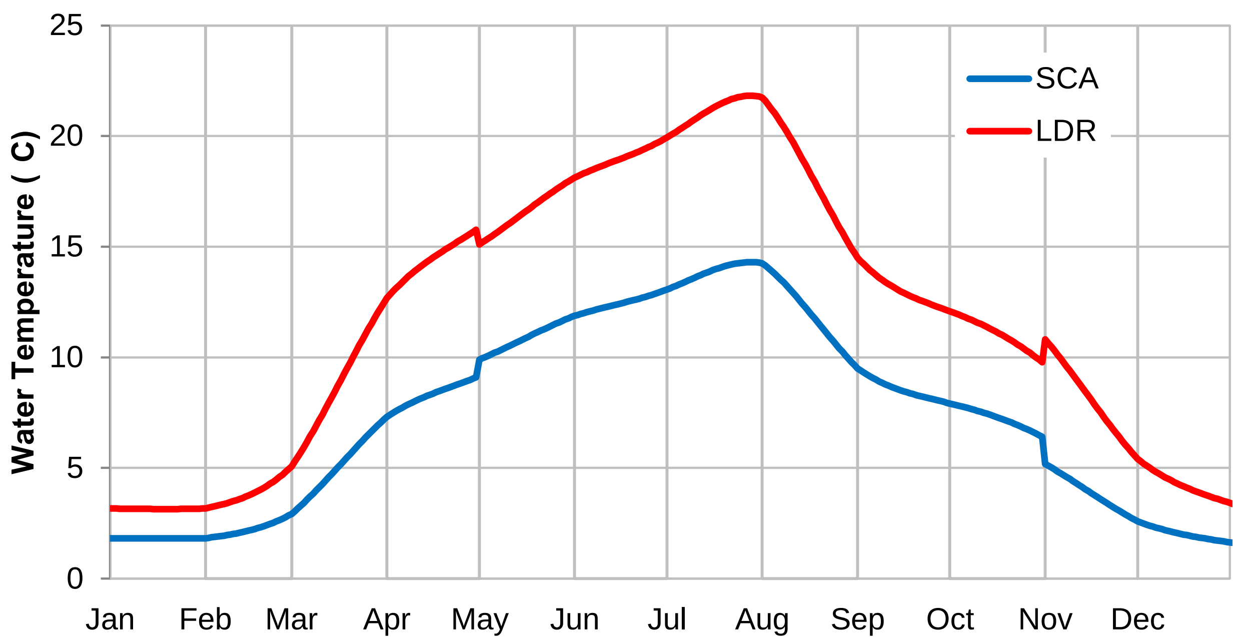


Figure 3. Water temperature trends used for ESH model for Upper Campbell Reservoir at Strathcona Dam (SCA) and Lower Campbell Reservoir at Ladore Dam (LDR).



2.4.2. Power Analysis Using Snorkel Data

A power analysis was performed to assess the number of sampling years required to statistically detect an increase of up to 100% in ESH or observed adult Rainbow Trout abundance. The analysis was based on historic ESH (see Section 3.3.1) and reservoir tributary snorkel data (see Section 3.2.3). The WUP was implemented in late 2012, so we used data from 1990 to 2012 as representative of baseline conditions.

The power to detect a response to WUP operations was estimated using a BA power analysis routine for t-tests implemented in R (Champely 2012). The BA power analysis routine requires three sets of parameters:

1. Number of monitoring periods;
2. Baseline mean abundance; and
3. Variance components.

The parameter values used for the analysis are based on the following information and estimates:

1. Adult snorkel sampling has been completed for Upper Campbell Reservoir and Lower Campbell Reservoir tributaries from 1990 through 2014 with varying frequency. Based on a 2012 start date for implementation of the WUP, baseline data included any sampling occurring from 1990 to 2012. We considered adult abundances, so a change in spawning habitat would take about three years or more to influence adult abundance;
2. Baseline mean abundance was estimated for baseline conditions using all baseline data. After effect mean abundance was set based on the effect size being considered; and
3. Variances were estimated from the before data; variance of the after data was assumed to be the same as the before data. To conduct a power analysis the within variance was calculated as:

$$Var_{within} = \frac{(n_1 - 1) * \sigma_1^2 + (n_2 - 1) * \sigma_2^2}{(n_1 + n_2 - 2)}$$

where n_1 and n_2 are the number of years, and σ_1^2 and σ_2^2 are the variances for before and after periods, respectively.

For each analysis, a one-tailed test was performed to evaluate the ability to detect positive effects in the impacted tributaries. This test assumes a net benefit of WUP operations, since that was the intent of the implemented operational changes. Results are reported at the α=0.05 significance level as this is the level recommended by the long-term monitoring protocols (Lewis *et al.* 2013). For each metric, the post-WUP monitoring duration (up to 20 years) that would be required to detect a 20%, 40%, 60%, 80%, or 100% increase in mean adult abundance was calculated.

2.4.3. Correlation Analysis Using Population Model Simulation

To assess the effectiveness of comparing adult abundance vs. ESH metrics, as specified in the TOR, we performed a simulation where ESH values were compared against mathematically modelled adult populations. We randomly generated a 16-year time series of ESH values with values ranging from 3,000 m^2d to 18,000 m^2d; this range is based on the historic range of ESH values for Upper Campbell Reservoir. To generate fish population estimates, we assumed a perfect positive correlation ($r^2 = 1.0$) between ESH and productivity (i.e., high ESH produces high recruitment and low ESH produces low recruitment) and that production of Young-of-Year (YOY) fish was 150 fish/m^2d. To estimate the number of adults (ages 3-7 fish), we assumed an annual survival rate of 0.05 for YOY and an annual survival of 0.4 for every subsequent year. These productivity and life history values are arbitrary and were selected for modelling purposes.

For each year of the simulated 16 years, a cohort's abundance was multiplied by the appropriate survival rate to calculate the abundance of the cohort for the next year. Based on a simulation length of 16 years, there were nine years with fish present up to age 7 (i.e., it would take nine years after implementation of an operational change for all fish in the population to have been produced under that management regime). The abundance of 3 to 7 year old fish were summed to obtain a total adult abundance for each year.

To evaluate the relationship between adult abundance and ESH, a correlation was calculated between the adult abundance at year t and ESH at year t. Since, based on the model structure, it would take a minimum of three years for individuals to be recruited into the adult population, we also considered the lagged correlation where adult abundance at year t was compared against previous year ESH values. We evaluated lags of zero to five years.

2.4.4. Correlation Analysis Using Hydroacoustic Population Data

The purpose of the correlation analysis with the hydroacoustic estimate of adult Rainbow Trout was to evaluate how the strength of the relationship between ESH and adult abundance influences our ability to detect a response to WUP operational changes. During the WUP it was assumed that ESH had a strong influence on recruitment of salmonids in the reservoirs, and WUP operations were designed with this in mind, using the ESH performance measure as a guide. At present we have no information on the relationship between ESH and adult abundance; however, it is assumed that adult abundance would be influenced by changes in recruitment. Conceptually, the relationship between ESH and adult abundance can be expressed as strong, weak, or intermediate, where the strength of the relationship is expressed as the slope (Figure 4). In this analysis, we assess the effect of slope in the ESH vs. adult abundance relationship, using the variance structure estimates from the hydroacoustic data (see Section 3.1.3.2). The analysis provides an exploration of whether a biological response to WUP operations is likely to be detected within a reasonable timeframe.

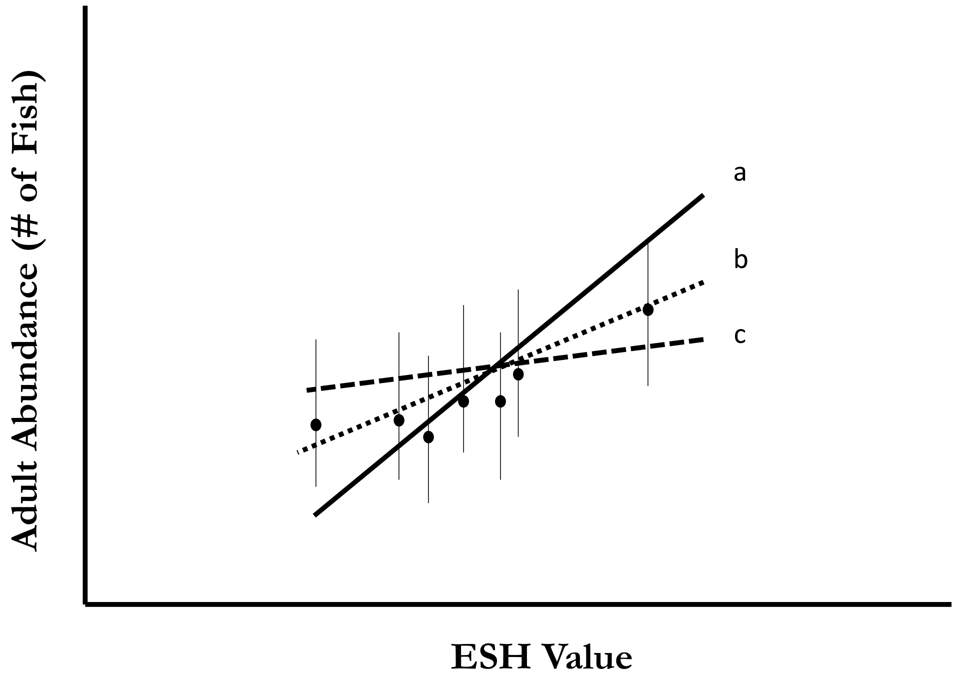
Total fish abundance for Upper Campbell Reservoir was estimated to be 424,783 with a 95% confidence interval of 168,778 to 680,788 (see Section 3.1.3.2). Intuitively, high uncertainty of population estimates will hamper the ability to detect a statistically significant correlation between adult abundance and ESH. As uncertainty increases, the minimum magnitude of effect (slope) that can be detected increases as well. Using simulations we determined the minimum magnitude of effect of ESH on adult abundance that would be detectable based on the current levels of uncertainty. For this analysis, we used the current estimate of adult Rainbow Trout in Upper Campbell Reservoir (26,385). Since there was no 95% confidence limit available for this species, we assumed that the estimate of Rainbow Trout would have the same proportional level of uncertainty as the total fish abundance.

In this analysis, we assumed a perfect linear correlation between ESH and adult abundance (i.e., we did not assess non-linear relationships between ESH and recruitment). We assumed that the 2014 adult Rainbow Trout abundance was the direct result of the 2012 ESH value. The intercept for the linear correlation function was calculated using a known slope value, the 2014 Rainbow Trout abundance, and the 2012 ESH value. For this analysis, we tested 30 different linear correlation slopes ranging from 1 to 30. Adult abundances for 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, and 2014 ESH values were calculated using the known slope and calculated intercept for the linear correlation function. The adult abundances for each year were calculated for each slope value.

We incorporated Rainbow Trout abundance uncertainty based on the 95% confidence limits estimated for the total fish abundance in 2014. The 95% confidence limit for Upper Campbell Reservoir was 256,005, which was 60% of the fish abundance estimate of 424,783. We assumed that fish abundance uncertainty was proportionally similar for adult abundance estimates for all years, therefore the 95% confidence limit for each abundance estimate was calculated by multiplying the calculated adult abundance by 60%.

For each correlation slope value, 10,000 iterations were run where adult Rainbow Trout abundance values were randomly selected from the 95% confidence interval for each year assuming a uniform distribution. The p-value was calculated to determine if a statistically significant correlation was detected (alpha = 0.05) based on the abundance data generated for the 2005 to 2014 ESH values. The p-value was calculated for each iteration and the proportion of iterations where a statistically significant correlation was detected was calculated. This proportion was calculated for each slope value.

Figure 4. Hypothetical correlations (i.e., slopes) between ESH and adult abundance based on a strong (a), intermediate (b), or weak (c) relationship.



3. RESULTS

3.1. Population Estimate for Upper and Lower Campbell Reservoirs

3.1.1. Temperature and DO profiles

During acoustic surveys on August 26 and 30, 2014 the reservoir was strongly stratified, with a similar thermal profile at the three water quality stations (Figure 5). The epilimnion (20-21°C) extended to 12-14 m, below which the temperature dropped rapidly in the thermocline to about 8°C at 25 m, below which it decreased slowly to a minimum of about 7°C at the greatest depth sampled (52 m). DO was > 8 mg/l throughout the epilimnion, and > 10 mg/l at most depths below that (Figure 5, Figure 6).

Figure 5. Temperature profiles at Stations GN03, GN05, and GN03/T-05GN in Upper Campbell Reservoir, August 26 and 30, 2014.

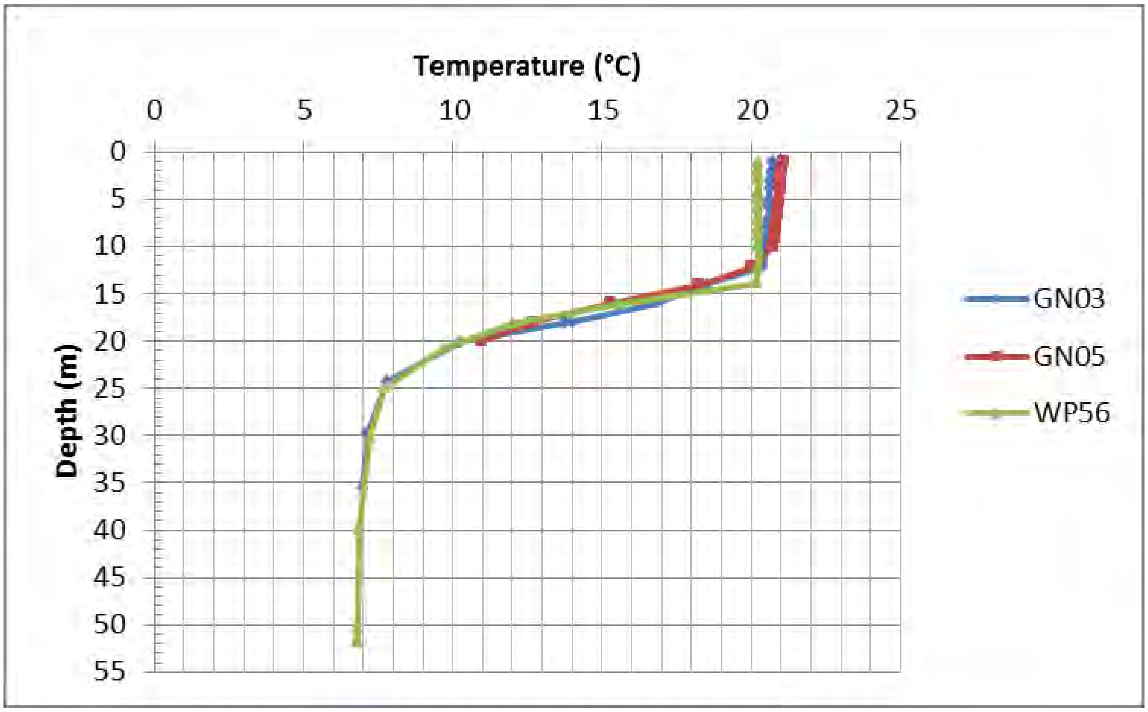
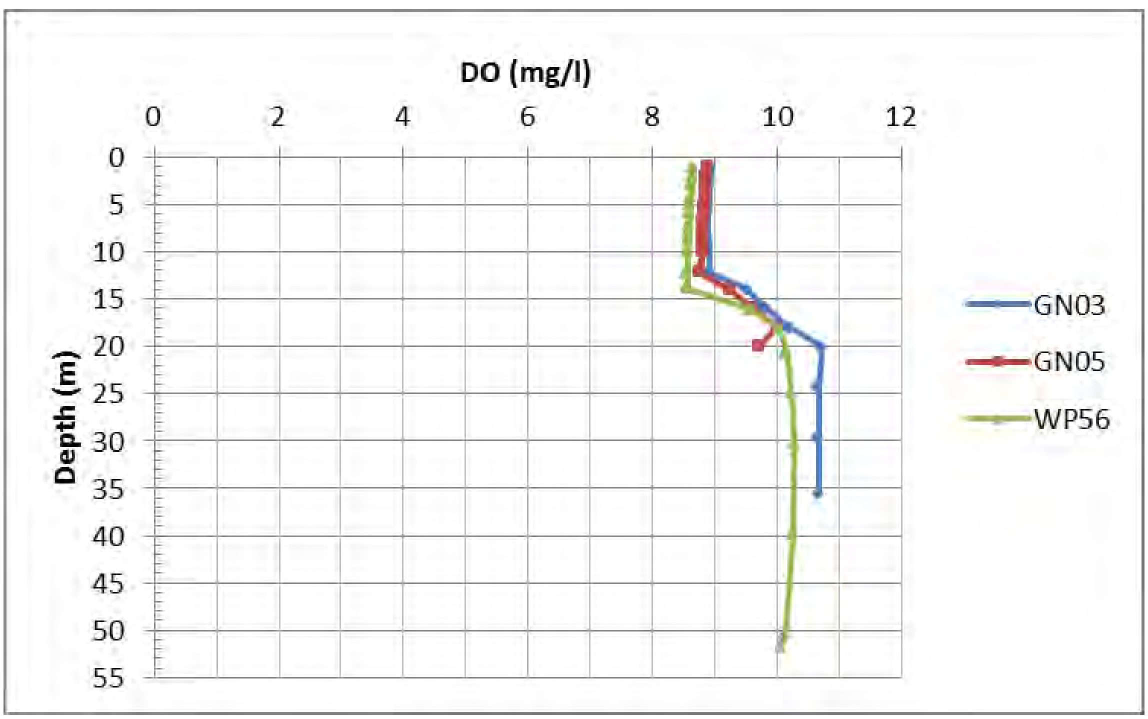


Figure 6. DO profiles at Stations GN03, GN05, and GN03/T-05GN in Upper Campbell Reservoir, August 26 and 30, 2014.



3.1.2. Fish survey results

3.1.2.1. Gill Net Summary Results

A total of 361 fish were captured from gill net sampling during August 21 and 22, 2014. The set and catch details are available in Table 7. The total gill netting effort at a site ranged from 31.1 to 51.64 hours. Gill net capture data are presented in Appendix B.

Rainbow Trout comprised the majority of the catch with a total of 259 fish captured. A total of 93 Cutthroat Trout were captured and four suspected Cutthroat Trout/Rainbow Trout hybrids were identified. Two Prickly Sculpin were captured at two different sites, and one Dolly Varden and one Threespine Stickleback were caught. A single fish was recorded as 'unknown'; this fish could not be fully identified as it was missing its head and caudal tail. Tissue voucher samples of fish captured were kept, including vouchers of the hybrid and unknown fish to allow for future identification.

CPUE ranged from 0.00 to 1.40 fish/net hour for Rainbow Trout and from 0.00 to 0.79 fish/net hour for Cutthroat Trout (Table 7). Rainbow Trout had the greatest mean CPUE, followed by Cutthroat Trout; 0.806 fish/net hour and 0.297 fish/net hour, respectively (Table 8). In general, sites with high Rainbow Trout CPUE (e.g., sites UCR-LKGN07 and UCR-LKGN03) had relatively low Cutthroat Trout CPUE and sites with higher Cutthroat Trout CPUE (e.g., sites UCR-LKGN01 and UCR-LKGN04) had relatively lower Rainbow Trout CPUE.

Table 7. Summary of gill net survey effort, catch statistics and CPUE from the Upper Campbell Reservoir, August 2014.

Site	Sampling Date	No. of Sets	Gill Netting Effort (hrs)	Gill Net Catch (# of fish)[1]								Gill Net CPUE (# of fish/net hr)[1]							
				CT	RB	DV	CO	CAS	TSB	CT/RB	UNK	CT	RB	DV	CO	CAS	TSB	CT/RB	UNK
UCR-LKGN01	28-Aug-2014	2	32.76	26	17	1	0	0	0	0	0	0.79	0.52	0.03	0.00	0.00	0.00	0.00	0.00
UCR-LKGN02	28-Aug-2014	2	32.91	1	36	0	0	0	0	0	0	0.03	1.09	0.00	0.00	0.00	0.00	0.00	0.00
UCR-LKGN03	28-Aug-2014	4	40.97	2	53	0	0	0	0	0	0	0.05	1.29	0.00	0.00	0.00	0.00	0.00	0.00
UCR-LKGN04	30-Aug-2014	3	51.64	24	38	0	0	0	0	1	0	0.46	0.74	0.00	0.00	0.00	0.00	0.02	0.00
UCR-LKGN05	26-Aug-2014	2	34.83	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCR-LKGN06	26-Aug-2014	2	31.10	13	31	0	0	1	0	0	0	0.42	1.00	0.00	0.00	0.03	0.00	0.00	0.00
UCR-LKGN07	27-Aug-2014	3	47.72	6	67	0	0	1	1	2	0	0.13	1.40	0.00	0.00	0.02	0.02	0.04	0.00
UCR-LKGN08	27-Aug-2014	4	42.40	21	17	0	0	0	0	1	1	0.50	0.40	0.00	0.00	0.00	0.00	0.02	0.02
	Total	**22**	**314.33**	**93**	**259**	**1**	**0**	**2**	**1**	**4**	**1**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
	Average	**2.75**	**39.29**	**12**	**32**	**0**	**0**	**0**	**0**	**1**	**0**	**0.30**	**0.81**	**0.00**	**0.00**	**0.01**	**0.00**	**0.01**	**0.00**
	SD	**n/a**	**7.62**	**11**	**21**	**0**	**0**	**0**	**0**	**1**	**0**	**0.29**	**0.48**	**0.01**	**0.00**	**0.01**	**0.01**	**0.02**	**0.01**

[1] CT- Cutthroat Trout, RB - Rainbow Trout, DV - Dolly Varden, CO - Coho Salmon, CAS - Prickly Sculpin, TSB - Threespine Stickleback, CT/RB - Cutthroat Trout/Rainbow Trout Hybrid, UNK - Unknown

Table 8. Summary of CPUE results by species for Upper Campbell Reservoir, August 2014.

Species[1]	CPUE (# of fish/net hr)[2]		
	Mean	SD	SE
CT	0.297	0.288	0.102
RB	0.806	0.480	0.170
DV	0.004	0.011	0.004
CO	0.000	0.000	0.000
CAS	0.007	0.013	0.004
TSB	0.003	0.007	0.003
CT/RB	0.011	0.016	0.006
UNK	0.003	0.008	0.003

[1] CT- Cutthroat Trout, RB - Rainbow Trout, DV - Dolly Varden, CO - Coho Salmon, CAS - Prickly Sculpin, TSB - Threespine Stickleback, CT/RB - Cutthroat Trout/Rainbow Trout Hybrid, UNK - Unknown

[2] SD - Standard Deviation, SE - Standard Error

3.1.2.2. Minnow Trapping Summary Results

A total of 32 fish were captured from minnow trap sampling from August 26 to 30, 2014. The effort and catch details are presented in Table 9. Total minnow trapping effort ranged from 12.88 to 51.4 hours. Minnow trap capture data are presented in Appendix B. Only Prickly Sculpin were captured during the minnow trap sampling surveys.

CPUE ranged from 0.00 to 0.39 fish/trap hour, with a mean CPUE of 0.12 fish/trap hour (Table 9). The highest CPUE rates occurred during the daytime sets at site UCR-LMT08 on August 30; where minnow traps were only set for approximately four hours (Table 9). Excluding the daytime sets, the mean CPUE was 0.08 fish/trap hour.

Table 9. Summary of minnow trap sampling effort, catch statistics and CPUE from the Upper Campbell Reservoir, August 2014.

Site	Sampling Date	No. of Minnow Traps	Minnow Trapping Effort (hrs)	Minnow Trap Catch (# of CAS)	Minnow Trap CPUE (# of CAS/trap hr)
UCR-LKMT01	28-Aug-2014	3	49.48	0	0.00
UCR-LKMT02	28-Aug-2014	3	48.57	4	0.08
UCR-LKMT04	26-Aug-2014	3	45.62	3	0.07
UCR-LKMT05	26-Aug-2014	3	51.4	4	0.08
UCR-LKMT06	27-Aug-2014	3	47.18	9	0.19
UCR-LKMT07	27-Aug-2014	3	48.1	2	0.04
UCR-LKMT08	26-Aug-2014	3	50.59	5	0.10
UCR-LKMT08	30-Aug-2014	3	12.88	5	0.39
	Total	**24**	**354**	**32**	**0.95**
	Average	**3**	**44**	**4**	**0.12**
	SD	**n/a**	**12.8**	**3**	**0.12**

3.1.2.3. Fish Size, Age and Condition

A total of 93 Cutthroat Trout and 259 Rainbow Trout were captured using gill nets in the Upper Campbell Reservoir during the August 2014 surveys. The length-frequency distribution for both species is presented in Figure 7. The fork length and weights obtained for both Cutthroat Trout and Rainbow Trout during the Year 1 gill netting surveys are presented graphically in Figure 8. The relationships are best explained by a power function; where fork length accounted for 99.14% and 98.7% of the variability in Cutthroat Trout weight and Rainbow Trout weight, respectively, in 2014.

A total of 18 Cutthroat Trout and 15 Rainbow Trout were aged and a length-age relationship was plotted for both species (Figure 9). Based on the age data and the length-frequency histograms, fish age breaks were determined from Cutthroat Trout and Rainbow Trout parr (1+ and 2+). Due to the overlap of fork length for across adult age classes (≥3+), we could not generate confident age breaks for adult fish based on fork length, all adult fish were therefore grouped into a single age class (Figure 9; Figure 10).

Based on these age breaks, the summary of fork length, weight and condition of Cutthroat Trout and Rainbow Trout captured during gill net surveys of Upper Campbell Reservoir, August 2014 is presented in Table 11 and Table 12, respectively. Average condition factor for Cutthroat Trout and Rainbow across all age classes ranged from 1.1 to 1.2 and 1.2 to 1.4, respectively. Condition factor was similar for all age classes; condition was slightly higher for the 1+ cohort in both Cutthroat Trout and Rainbow Trout.

Figure 7. Length-Frequency histogram for Cutthroat Trout (CT) and Rainbow Trout (RB) recorded during the gill-netting surveys on Upper Campbell Reservoir, August 2014.

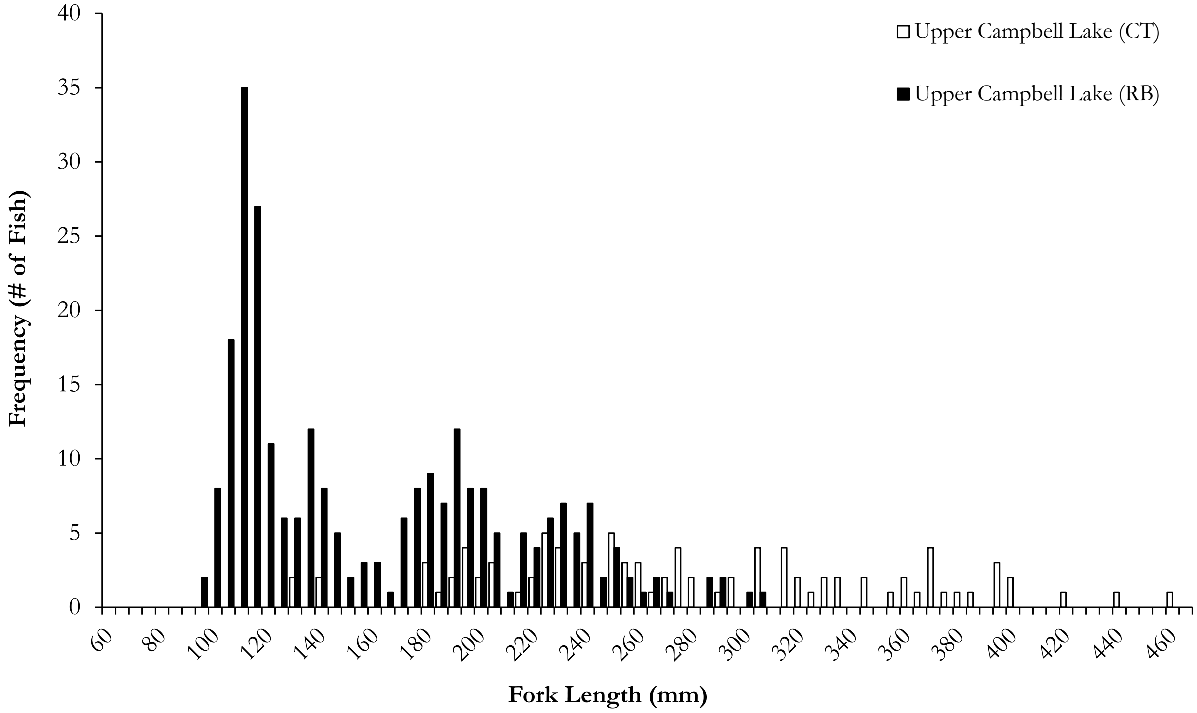


Figure 8. Length-weight relationship for Cutthroat Trout/Rainbow Trout captured during gill net surveys in the Upper Campbell Reservoir, August 2014.

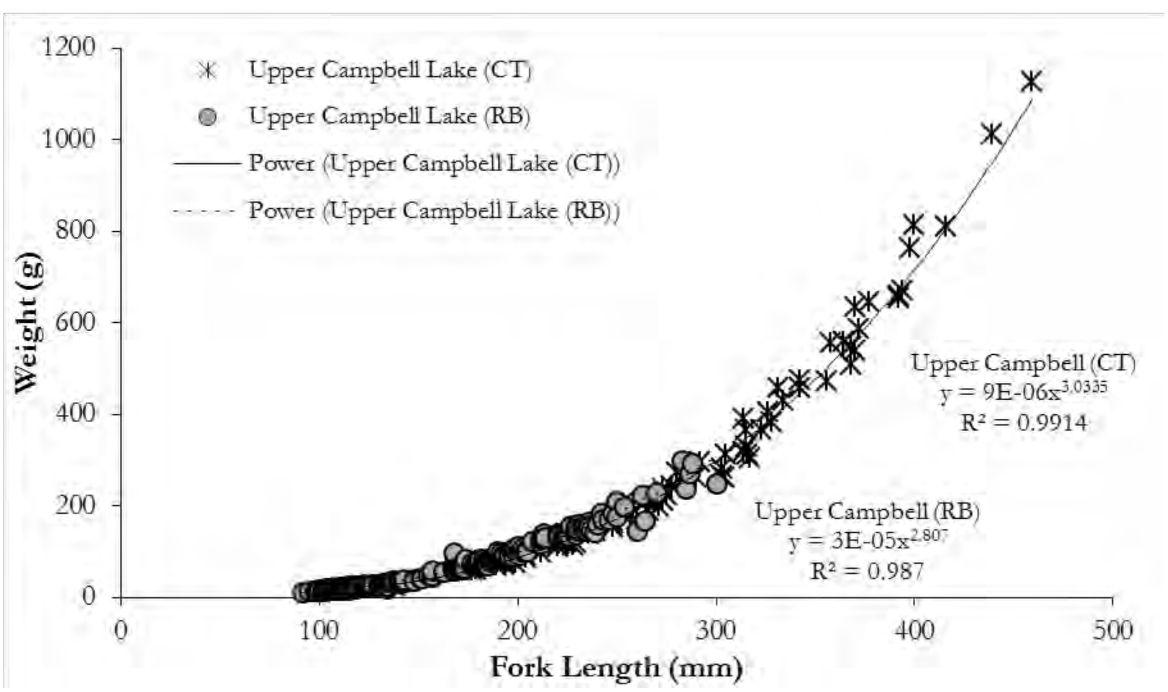


Figure 9. **Length at age of Cutthroat Trout and Rainbow Trout captured during gill netting surveys in Upper Campbell Reservoir, August 2014. Ages based on scale data from collected fish.**

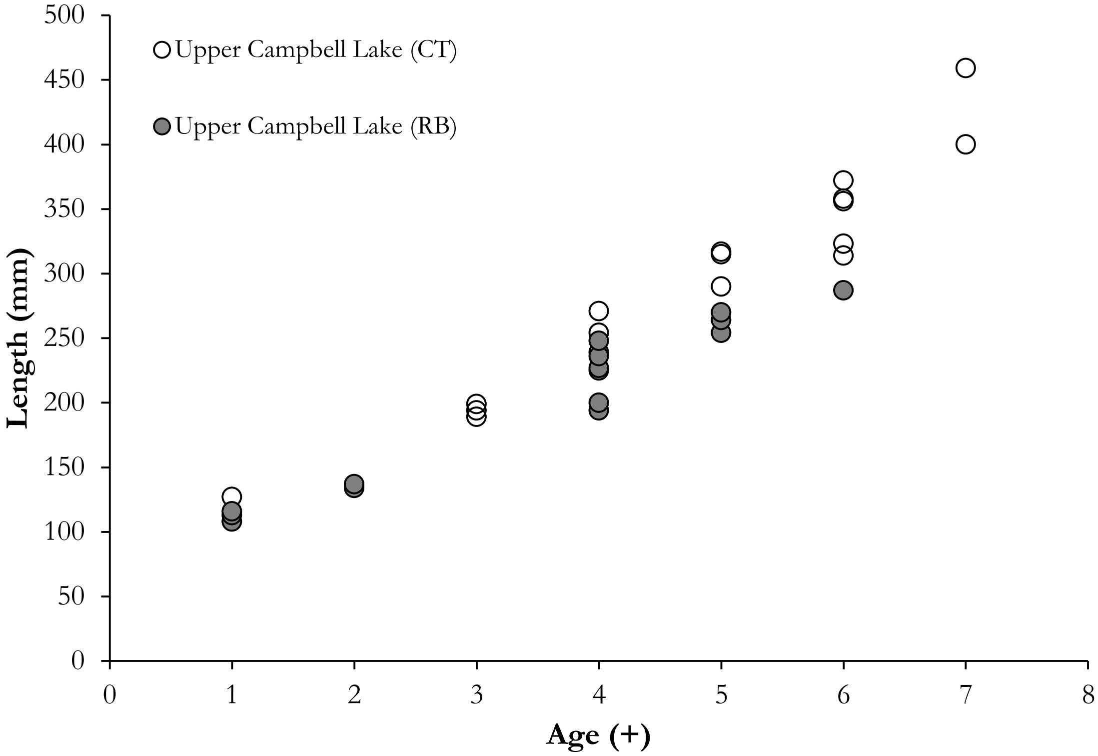


Table 10. **Fork lengths used to define age classes for population analysis of Cutthroat Trout/Rainbow Trout captured during gill netting surveys in Upper Campbell Reservoir, August 2014.**

Age Class	Fork Length Range (mm)	
	Upper Campbell Lake (CT)	Upper Campbell Lake (RB)
Fry 0+	-	-
Parr (1+)	127 - 135	92 - 125
Parr (2+)	136 - 165	126 - 165
Adult (3+)	166+	166+

Table 11. Summary of fork length, weight and condition of Cutthroat Trout captured during gill netting surveys in Upper Campbell Reservoir, August 2014.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
0+	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
1+	2	127	127	127	2	25	22	28	2	1.2	1.1	1.4
2+	2	137	136	138	2	29	26	31	2	1.1	1.0	1.2
3+	89	282	177	459	84	297	59	1,125	84	1.1	0.9	1.3
Combined	**93**	**276**	**127**	**459**	**88**	**285**	**22**	**1,125**	**88**	**1.1**	**0.9**	**1.4**

Table 12. Summary of fork length, weight and condition of Rainbow Trout captured during gill netting surveys in Upper Campbell Reservoir, August 2014.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
0+	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
1+	107	110	92	125	93	19	12	28	93	1.4	1.1	1.7
2+	40	139	126	163	37	33	2	57	37	1.2	0.8	2.0
3+	112	209	167	300	111	119	57	300	110	1.2	0.8	2.1
Combined	**259**	**157**	**92**	**300**	**241**	**67**	**2**	**300**	**240**	**1.3**	**0.8**	**2.1**

3.1.2.4. Fish Analysis for Population Abundance Estimates

Summary of the Gill Netting Catch Results used in the Analysis

Although Rainbow Trout were the dominant species in the catch of both net types, the RISC nets were more effective at capturing larger fish including trout and char species while the small-mesh nets were more effective at capturing smaller fish. Cutthroat Trout, Cutthroat/Rainbow hybrids, and Dolly Varden were only captured with the RISC nets while Prickly Sculpin were captured in both net types and Threespine Stickleback were captured only in the small-mesh nets (Table 13). The Rainbow Trout captured in the RISC nets were slightly larger than Rainbow Trout captured in the small-mesh nets (average length of 157 mm and 122 mm, respectively) (Table 14). Nine Threespine Sticklebacks from the stomach of a 315 mm Cutthroat Trout from Station GN04 were approximately 30 mm in length, much smaller than any fish captured in gill nets (Table 14).

Rainbow Trout captured in RISC nets were 72-300 mm in length and 13-300 g in weight (Table 14). Their length-frequency distribution showed a major mode at 100-125 mm, with less prominent modes at 175-200 and 225-250 mm (Figure 10). Cutthroat Trout captured in RISC nets were 127-459 mm in length and 22-1125 g in weight (Table 14). Their length-frequency distribution had several minor modes at 125-150 mm, 175-200 mm, 250-275 mm, 300-325 mm, and 350-375 mm (Figure 10). Cutthroat/Rainbow hybrids were 183-302 mm in length and 64-264 g in weight (Table 14); with only four fish captured their length frequency distribution was uninformative.

Catch rates (CPUE) with RISC nets for species combined were similar (about 0.75 fish/hour) at the one nearshore and one offshore station sampled during the day (Table 13). During daytime sampling, only Rainbow Trout were caught offshore, whereas Rainbow and Cutthroat Trout were similarly abundant at the nearshore station (Table 13; Figure 11). During night sampling, when all eight stations were fished, catch rates for species combined ranged from 2.3 fish/hour at nearshore station GN07 in the south bay to 0.0 fish/hour at main basin offshore station GN05 (Table 13; Figure 11). At the GN04, the other offshore station sampled at night, the catch rate for species combined was the second highest of any station. Rainbow Trout were the most abundant species at all stations throughout the lake, except at GN01 (north bay) and GN08 (Elk River bay) where Cutthroat Trout were present in greatest numbers.

Catch rates in overnight RISC net sets with respect to depth of capture in the water column and lake bottom depth at the point of capture showed that Cutthroat Trout were concentrated in the nearshore zone, with highest densities at the 20 m depth contour, and few fish farther offshore. Cutthroat/Rainbow hybrids were only found shoreward of the 15 m depth contour. Rainbow Trout densities were high in the shallow layers of the nearshore zone and in an offshore layer at 15-20 m depth; this species was also found near the lake surface in the offshore zone at low density. The 15 - 20 m layer coincided with the thermocline where the water temperature was about 10-17°C (Figure 5). Small Rainbow Trout (<150 mm in length) were concentrated in the littoral zone (Figure 12), although this trend may have been exaggerated by a high proportion of sets (12 of 14) with the smallest RISC mesh panel (25 mm stretched mesh) set to shore. The water temperature exceeded 20°C at this depth of the water column (Figure 5).

Table 13. Catch, effort, and CPUE by station and species from gill netting in Upper Campbell Reservoir, August 2014. RISC net CPUE is colour coded in proportion to catch rate.

Net Type	Period	Station	Lake Basin	Habitat Zone[1]	Number of Sets	Combined Set Hours	Catch[2]							Catch per Set-Hour						
							CT	CT/RB	RB	DV	CAS	TSB	Total	CT	CT/RB	RB	DV	CAS	TSB	Total
RISC	Day	GN03	North	Offshore	2	8.5	0	0	6	0	0	0	6	0.00	0.00	0.71	0.00	0.00	0.00	0.71
		GN08	Elk R.	Nearshore	2	8.7	3	0	4	0	0	0	7	0.34	0.00	0.46	0.00	0.00	0.00	0.81
		RISC day total			**4**	**17.2**	**3**	**0**	**10**	**0**	**0**	**0**	**13**	**0.17**	**0.00**	**0.58**	**0.00**	**0.00**	**0.00**	**0.76**
	Overnight	GN01	North	Nearshore	2	32.8	26	0	17	1	0	0	44	0.79	0.00	0.52	0.03	0.00	0.00	1.34
		GN02	Main	Nearshore	2	32.9	1	0	36	0	0	0	37	0.03	0.00	1.09	0.00	0.00	0.00	1.12
		GN03	Main	Offshore	2	32.5	2	0	47	0	0	0	49	0.06	0.00	1.45	0.00	0.00	0.00	1.51
		GN04	Main	Nearshore	2	35.3	24	1	36	0	0	0	61	0.68	0.03	1.02	0.00	0.00	0.00	1.73
		GN05	Main	Offshore	2	34.8	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		GN06	Main	Nearshore	2	31.1	13	0	31	0	1	0	45	0.42	0.00	1.00	0.00	0.03	0.00	1.45
		GN07	South	Nearshore	2	32.4	6	2	66	0	0	0	74	0.19	0.06	2.03	0.00	0.00	0.00	2.28
		GN08	Elk R.	Nearshore	2	33.7	18	1	13	0	0	0	32	0.53	0.03	0.39	0.00	0.00	0.00	0.95
		RISC Overnight Total			**16**	**265.6**	**90**	**4**	**246**	**1**	**1**	**0**	**342**	**0.34**	**0.02**	**0.93**	**0.00**	**0.00**	**0.00**	**1.29**
		RISC Grand Total			**20**	**282.8**	**93**	**4**	**256**	**1**	**1**	**0**	**355**	**0.33**	**0.01**	**0.91**	**0.00**	**0.00**	**0.00**	**1.26**
Small-mesh	Overnight	GN04	Main	Nearshore	1	16.3	0	0	2	0	0	0	2	0.00	0.00	0.12	0.00	0.00	0.00	0.12
		GN07	South	Nearshore	1	15.3	0	0	1	0	1	1	3	0.00	0.00	0.07	0.00	0.07	0.07	0.20
		Small-mesh Overnight Total			**2**	**31.6**	**0**	**0**	**3**	**0**	**1**	**1**	**5**	**0.00**	**0.00**	**0.10**	**0.00**	**0.03**	**0.03**	**0.16**
RISC and Small-mesh Combined Total					**22**	**314.3**	**93**	**4**	**259**	**1**	**2**	**1**	**360**							

[1]Offshore = surface & midwater RISC net pairs; nearshore = surface and bottom RISC net pairs.

[2]Species codes: CT=Cutthroat Trout, RB=Rainbow Trout, CT/RB=Cutthroat/Rainbow Trout hybrid, DV=Dolly Varden, CAS=Prickly Sculpin, TSB=Threespine Stickleback.

Table 14. Length and weight of fish captured in gill nets during August 2014 sampling of Upper Campbell Reservoir. The size of fish contained in the stomach of a Cutthroat Trout captured at Station GN04 are also included.

Species	Net Type	Length (mm)					Weight (g)				
		n	Mean	Min	Max	SD	n	Mean	Min	Max	SD
Rainbow Trout	RISC	256	157	72	300	51.5	238	67.6	13	300	59.7
	Small-mesh	3	122	92	138	26	3	25.3	12	33	11.6
	Combined	259	157	72	300	51.4	241	67.1	12	300	59.5
Cutthroat Trout	RISC	93	276	127	459	74.7	88	285	22	1125	233.3
Cutthroat/Rainbow Hybrid	RISC	4	240	183	302	50.6	4	160.5	64	264	88.7
Dolly Varden	RISC	1	196	196	196	-	1	76	76	76	-
Prickly Sculpin	RISC	1	88	88	88	-	1	8	8	8	-
	Small-mesh	1	84	84	84	-	1	6.4	6.4	6.4	-
	Combined	2	86	84	88	2.8	2	7.2	6.4	8	1.1
Threespine Stickleback	Small-mesh	1	58	58	58	-	1	1.3	1.3	1.3	-
	In Cutthroat stomach*	9	~30	-	-	-	-	-	-	-	-

* A 315 mm Cutthroat Trout from GN04 contained nine 30 mm long (estimated) Threespine Sticklebacks.

Figure 10. Length frequency distributions of fish species captured in day and overnight RISC gill net sets at Upper Campbell Reservoir during August 2014. Note: the frequency scale for Rainbow Trout has been adjusted, relative to the other species.

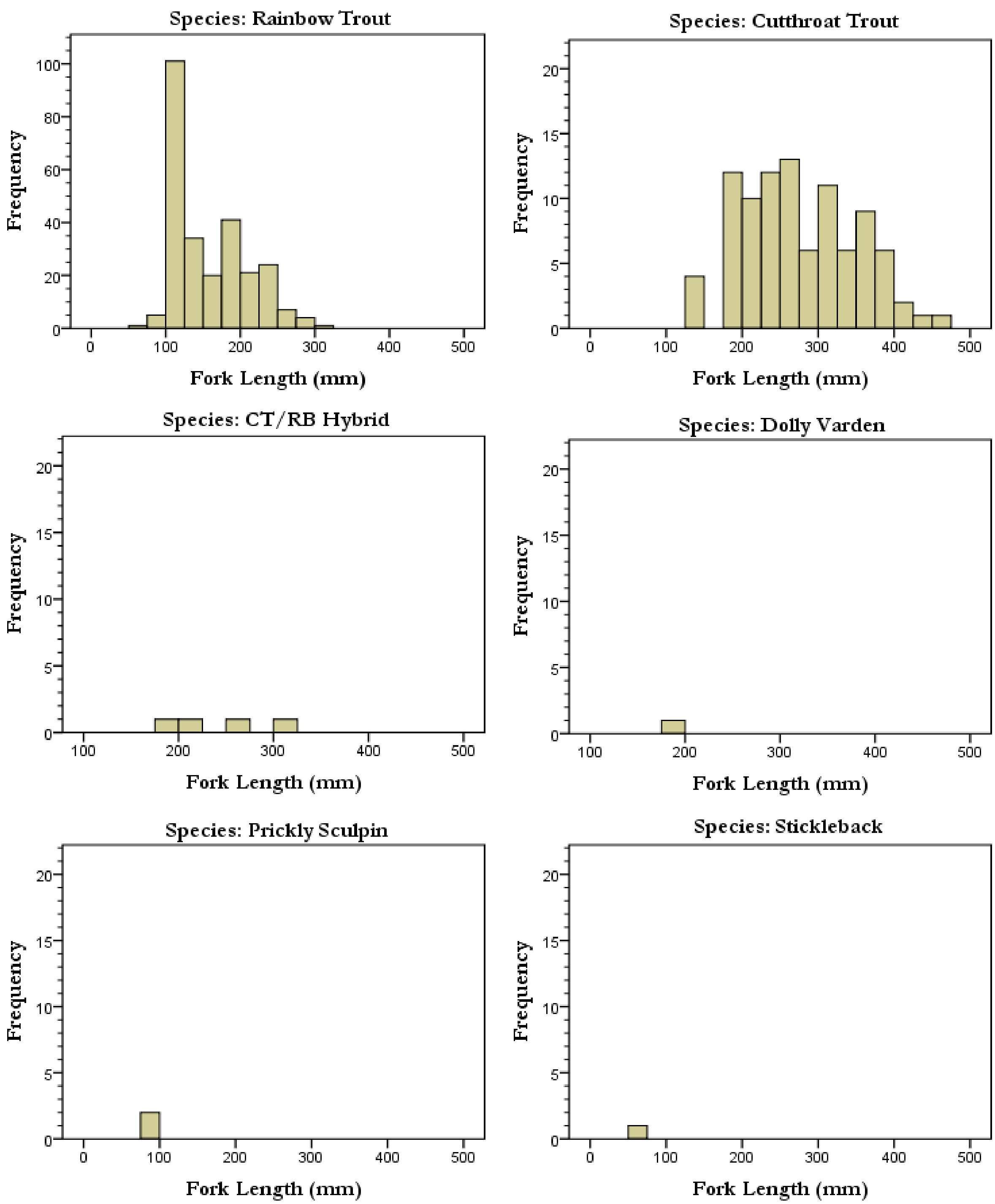


Figure 11. Relative abundance of fish (catch per set-hour) at RISC gill net sampling stations in Upper Campbell Reservoir (north, main, south, and Elk River basins) during day time (upper panel) and overnight (lower panel), August 2014. Stations were in the nearshore stratum unless labelled "offshore".

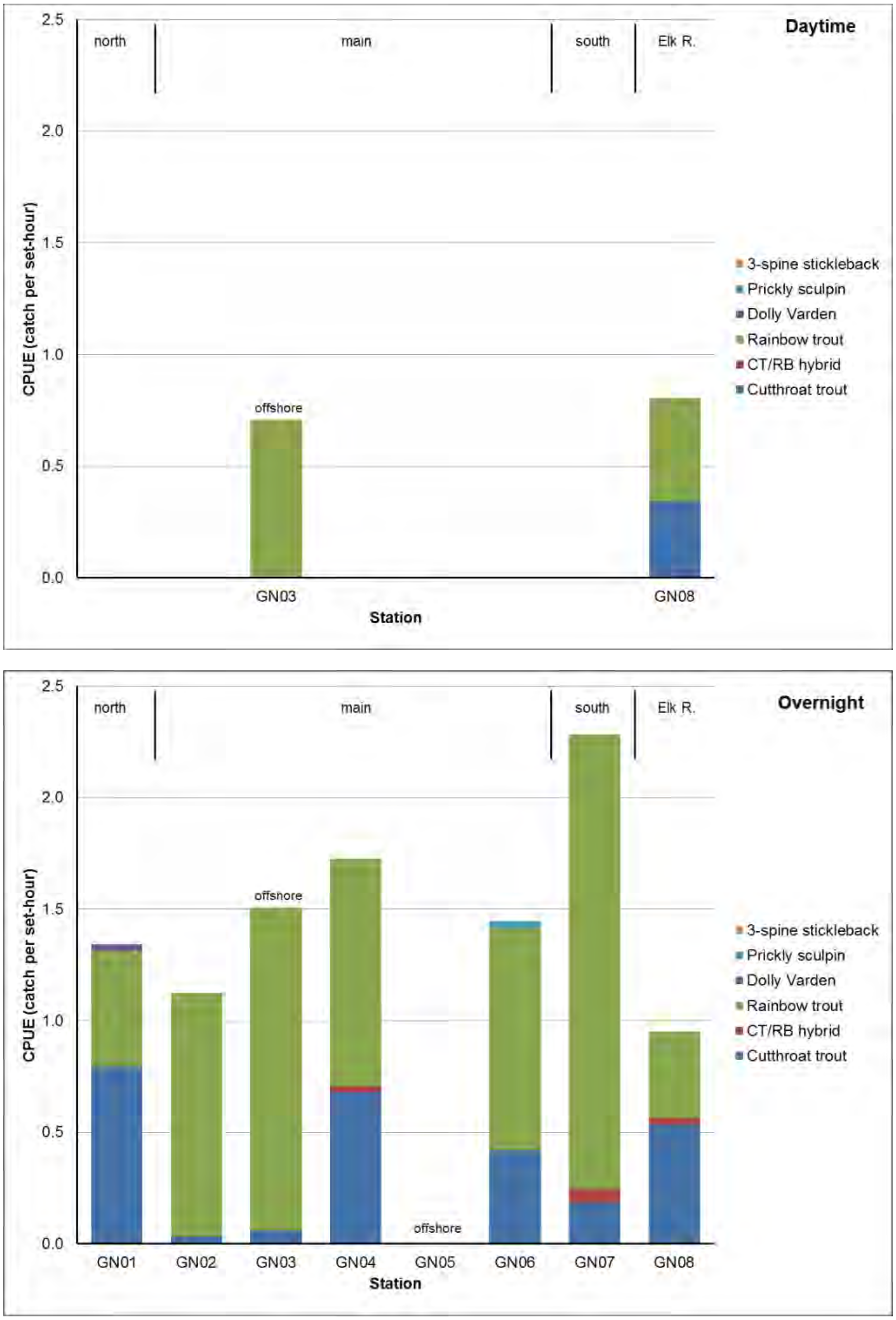
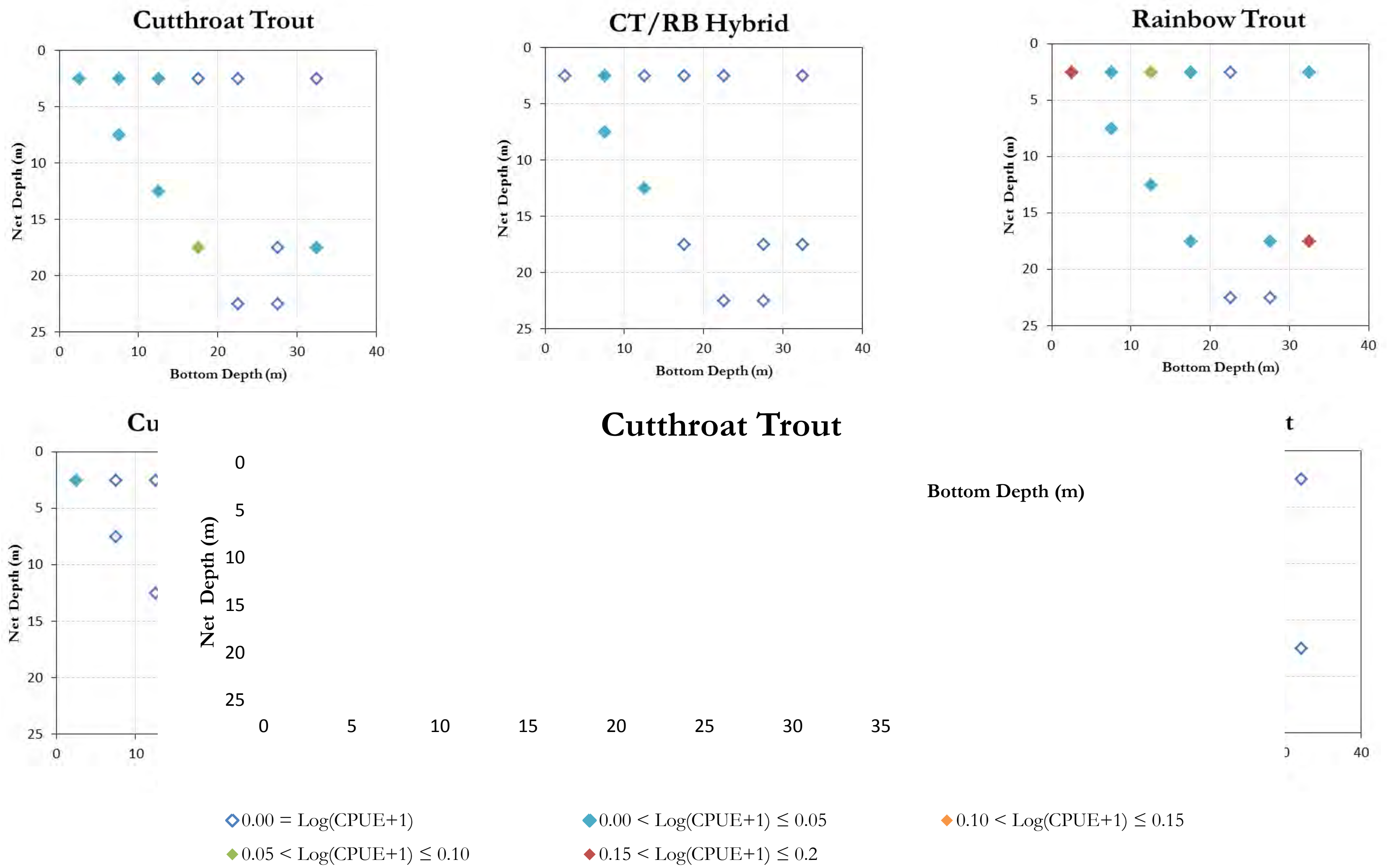


Figure 12. **Night-time relative abundance (catch/panel-hour) of trout of all sizes (top row) and trout < 150 mm long (bottom row) versus net depth and reservoir bottom depth at the point of capture. Data are from all overnight RISC gill nets sets from Upper Campbell Reservoir in August 2014. Empty boxes indicate spatial cells that were fished without any catch.**



Species Composition for the Acoustic Estimate

Estimates of species composition were constructed from the subset of data that best corresponded to the acoustic data used for the population estimate. Species composition of fish ≥ 100 mm came from overnight RISC sets, since only night-time acoustic transects were used for the population estimate, and catches shoreward of the 5 m depth contour were excluded because acoustics did not effectively sample this zone (see Section 3.1.3). Catches of Prickly Sculpin (a benthic species seldom detected with acoustics), fish < 100 mm in length, and fish caught in small-mesh nets were also excluded from the analysis for this size group. The resulting estimates of species composition of fish ≥ 100 mm are provided in Table 15, while actual catch, effort, and CPUE of gill net data, and weighting factors for nearshore and offshore zone volumes are provided in Appendix C. Rainbow Trout were generally the predominant species at the reservoir surface (up to 100% of layer total), and at all depths of the main and south reservoir basins (Table 15). Cutthroat Trout generally predominated in the Elk River bay (66.7% of fish below 5 m), and, except in the main basin, their relative abundance increased with depth. Hybrid trout made up a small but appreciable fraction of fish (up to 17%) in the south and Elk River bays, but they were almost absent from the north bay and main basin (Table 15). Dolly Varden only occurred in the 10-15 m layer of the north bay where they made up only 4.3% of the layer total (Table 15).

Neither gill netting nor minnow trapping provided useful information for the quantitative apportionment of the acoustic estimate of fish < 100 mm in length. Because of the small catch (5 fish) and limited spatial coverage of small-mesh nets (2 sets at 2 stations), species composition information about small fish can only be considered qualitative (presence/absence) and is unsuitable for assigning exact percentages of abundance by species. Therefore, fish < 100 mm are considered an unknown mix of sticklebacks and Rainbow Trout, the two non-benthic species of which individuals < 100 mm in length were captured. Stomach contents of a 315 mm Cutthroat Trout from GN04 that contained 9 sticklebacks about 30 mm long showed that fish of this species much smaller than the single one captured in a small-mesh net (70 mm) are present in the reservoir.

Table 15. Species composition for apportionment of the August 2014 acoustic estimate of fish abundance in Upper Campbell Reservoir. Data are from overnight nearshore and offshore RISC gill net results pooled, weighted by the volume of each zone in each depth layer.

Lake basin	Depth range (m)	Pooled species composition				
		Fish < 100 mm	Fish ≥ 100 mm			
		(spp. unspecified)	Rainbow Trout	Cutthroat Trout	CT/RB Hybrid	Dolly Varden
North Bay	0-5	100.0%	100.0%	0.0%	0.0%	0.0%
	5-10	100.0%	50.0%	50.0%	0.0%	0.0%
	10-15	100.0%	4.3%	91.3%	0.0%	4.3%
	15-20	100.0%	0.0%	100.0%	0.0%	0.0%
	20-25	100.0%	0.0%	100.0%	0.0%	0.0%
	25-30	100.0%	0.0%	100.0%	0.0%	0.0%
	30-35	100.0%	0.0%	100.0%	0.0%	0.0%
	35-40	100.0%	0.0%	100.0%	0.0%	0.0%
	40-45	100.0%	0.0%	100.0%	0.0%	0.0%
Main Basin	0-5	100.0%	90.1%	8.6%	1.2%	0.0%
	5-10	100.0%	82.8%	17.2%	0.0%	0.0%
	10-15	100.0%	91.5%	8.5%	0.0%	0.0%
	15-20	100.0%	87.2%	12.8%	0.0%	0.0%
	20-25	100.0%	95.6%	4.4%	0.0%	0.0%
	25-30	100.0%	95.6%	4.4%	0.0%	0.0%
	30-35	100.0%	95.6%	4.4%	0.0%	0.0%
	35-40	100.0%	95.6%	4.4%	0.0%	0.0%
	40-45	100.0%	95.6%	4.4%	0.0%	0.0%
	45-50	100.0%	95.6%	4.4%	0.0%	0.0%
	50-55	100.0%	95.6%	4.4%	0.0%	0.0%
	55-60	100.0%	95.6%	4.4%	0.0%	0.0%
	60-65	100.0%	95.6%	4.4%	0.0%	0.0%
South Bay	0-5	100.0%	71.4%	14.3%	14.3%	0.0%
	5-10	100.0%	66.5%	22.6%	11.0%	0.0%
	10-15	100.0%	61.5%	30.8%	7.7%	0.0%
	15-20	100.0%	61.5%	30.8%	7.7%	0.0%
Elk River Bay	0-5	100.0%	50.0%	50.0%	0.0%	0.0%
	5-10	100.0%	16.7%	66.7%	16.7%	0.0%
	10-15	100.0%	16.7%	66.7%	16.7%	0.0%
	15-20	100.0%	16.7%	66.7%	16.7%	0.0%

3.1.3. Acoustic Survey Results

3.1.3.1. Spatial and temporal distribution of fish

A frequency distribution of target strength data (TS) showed that two main size groups of fish were seen with acoustics (Figure 13). The bulk of the fish (86.4%) had a TS < 45 dB, with a major mode at -58 dB. These values correspond to fish lengths of 100 mm and 21 mm, respectively, according to Love's (1977) dorsal aspect model, indicating that most fish seen with acoustics were smaller than the minimum effective capture size of RISC gill nets (100 mm) or small-mesh gill nets (70 mm). This is apparent in a comparison of TS frequency distributions from acoustics and gill net data, where lengths of fish captured in gill nets were converted to TS using Love's (1977) dorsal model (Figure 13). The estimated TS of nine 30 mm Sticklebacks (-55 dB) found in the stomach of a Cutthroat Trout at station GN04 was close to the -58 dB mode for acoustic data. The other size group of fish seen with acoustics ranged from -45 dB to -29 dB, with a mode at -34 dB. These values represent lengths of 100, 687, and 376 mm according to Love's (1977) dorsal aspect model. This size group in the acoustic estimate corresponded to fish captured in RISC gill nets, though the TS of the acoustic sample was slightly larger than expected from the length of fish in the catch (Figure 13). The reason for this difference is not clear; however, TS is known to be an imprecise indicator of fish size that can be affected by many factors (Simmonds and MacLennan 2005). Also, the prominent mode at -44 dB in the gill net frequency distribution was missing from the acoustic plot. This TS range corresponded to the 100-125 mm fish that gill netting showed to be concentrated in the littoral zone where there was almost no acoustic coverage. In summary, all available information suggests that the very small fish seen in high numbers with acoustics were small Sticklebacks, that the larger fish were trout, and that small trout concentrated in the shallows were mostly missed by acoustics.

Fish densities and distribution patterns were distinctly different during day and night acoustic sampling. Few fish were seen on daytime echograms, whereas night-time echograms showed many more fish, with especially high densities in the south bay and a distinct mid-water layer in the main basin (Figure 14 to Figure 17). Because so few fish were seen during the day, the fish abundance estimate was constructed exclusively from night-time acoustic data, and no further analysis of daytime acoustic data was performed.

Mapping of areal fish density (fish/ha) from 50 m transect segments showed that fish densities were highest close to shore on many transects, and that densities were especially high in the extreme south end of the south bay where values reached 7,074 fish/ha (Map 4).

Figure 13. Frequency distribution of TS from night acoustic survey transects pooled (upper panel) compared to frequency distribution of fish lengths in the overnight RISC gill net catch converted to TS (lower panel). Data are from acoustic and gill net sampling August 17-21, 2014.

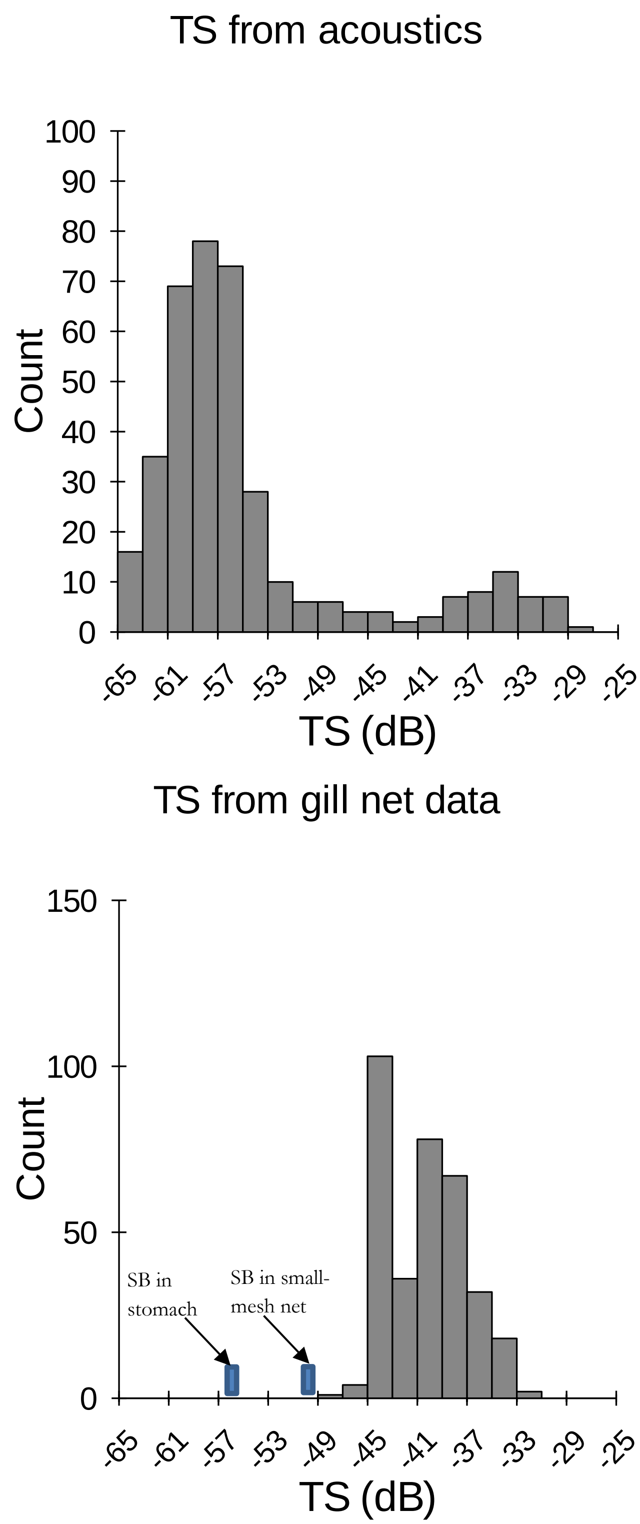


Figure 14. Echograms from T7 in the main reservoir basin at night, Upper Campbell Reservoir, August 21, 2014. The night echogram shows a layer of fish at 15-20 m across a transect and shallower groups of fish near the shoreline that were not observed during the day. Data threshold -65 dB, capable of detecting fry-size fish (e.g., 25 mm).

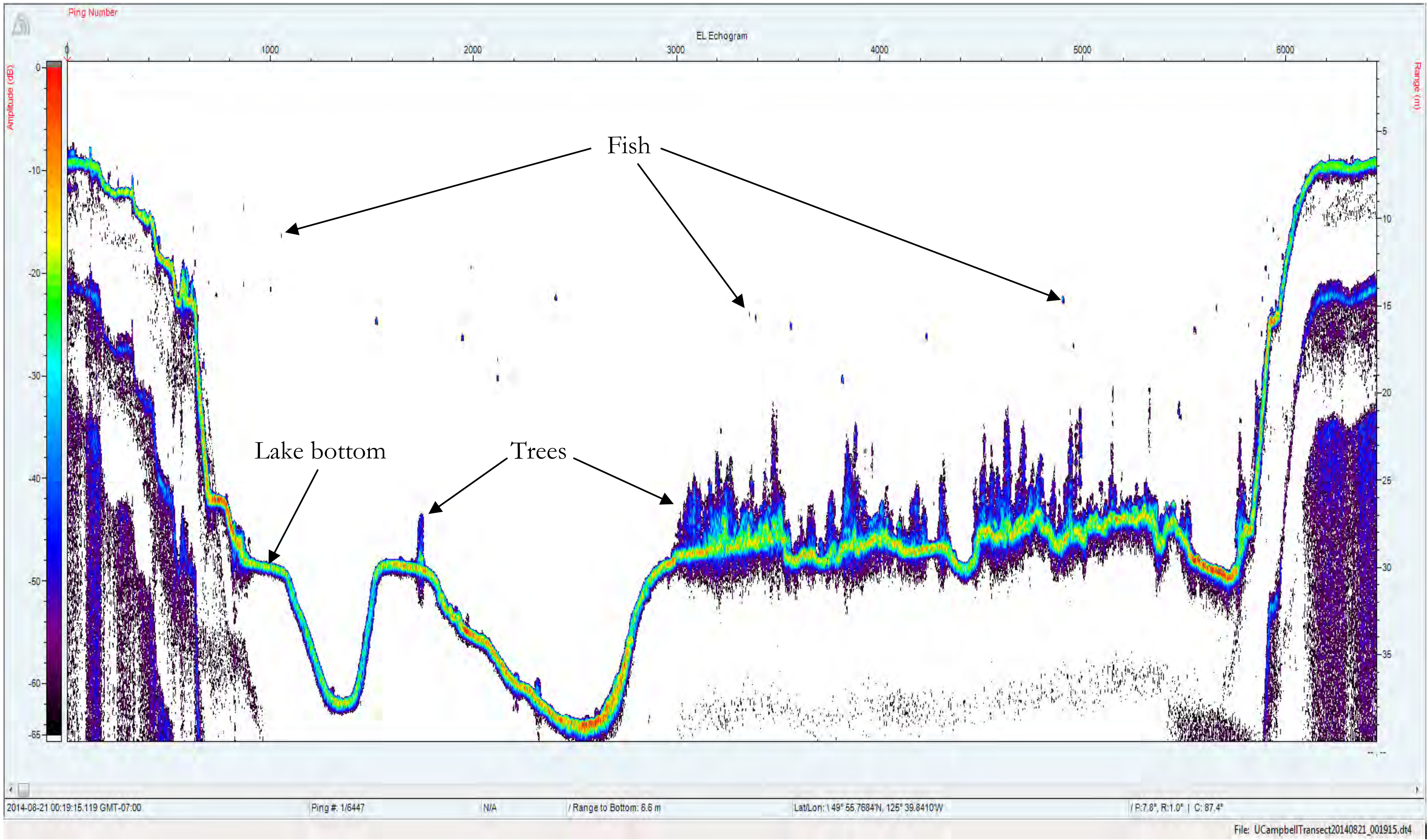


Figure 15. **Echograms from T7 in the main reservoir basin during the day, Upper Campbell Reservoir, August 18, 2014. The night echogram shows a layer of fish at 15-20 m across a transect and shallower groups of fish near the shoreline that were not observed during the day. Data threshold -65 dB, capable of detecting fry-size fish (e.g., 25 mm).**

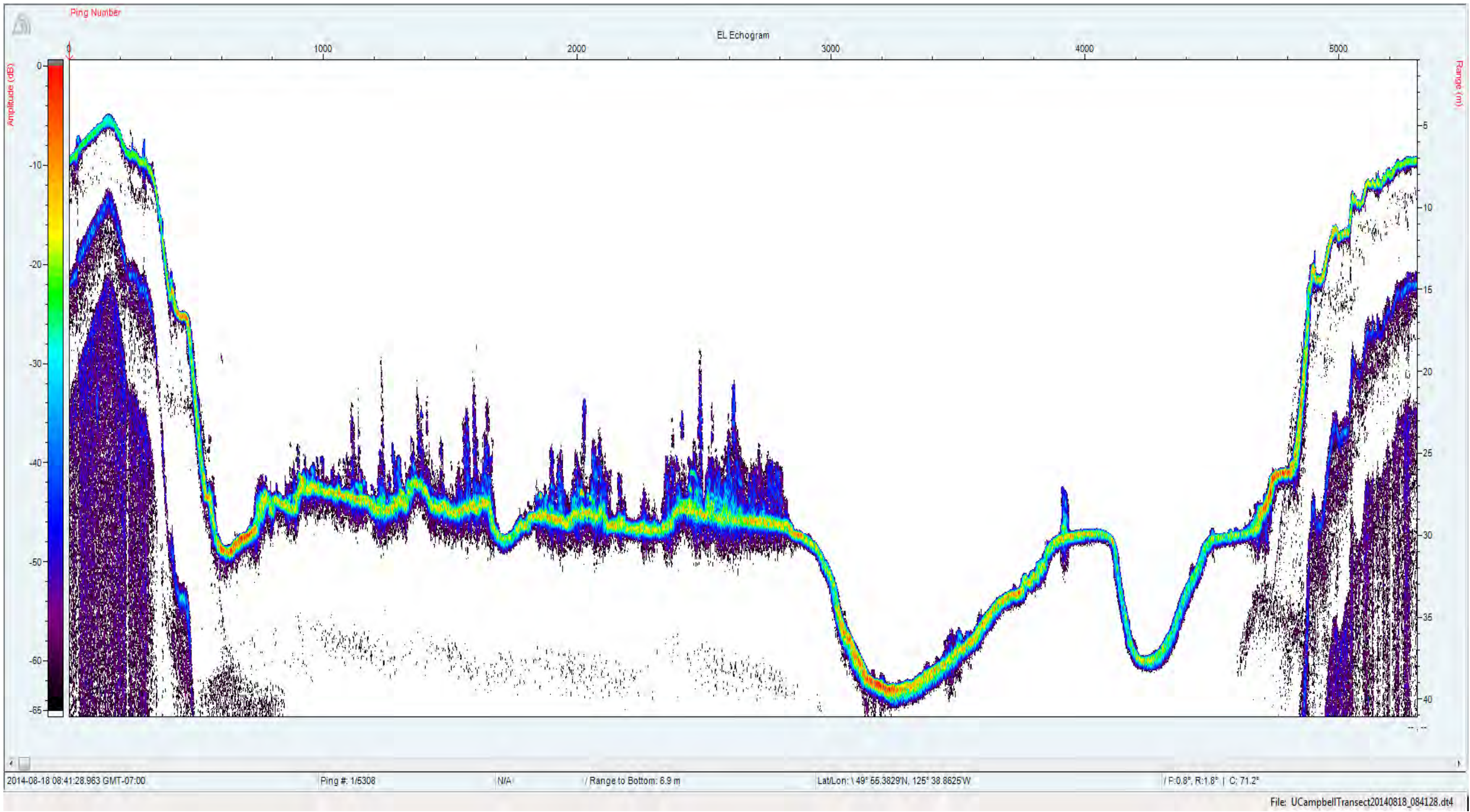


Figure 16. Echograms from T13 at night from the acoustic survey of Upper Campbell Reservoir, August 20, 2014. At night there was a high density of small fish across the transect that was nearly absent during the day. Data threshold -65 dB, capable of detecting fry-size fish (e.g., 25 mm).

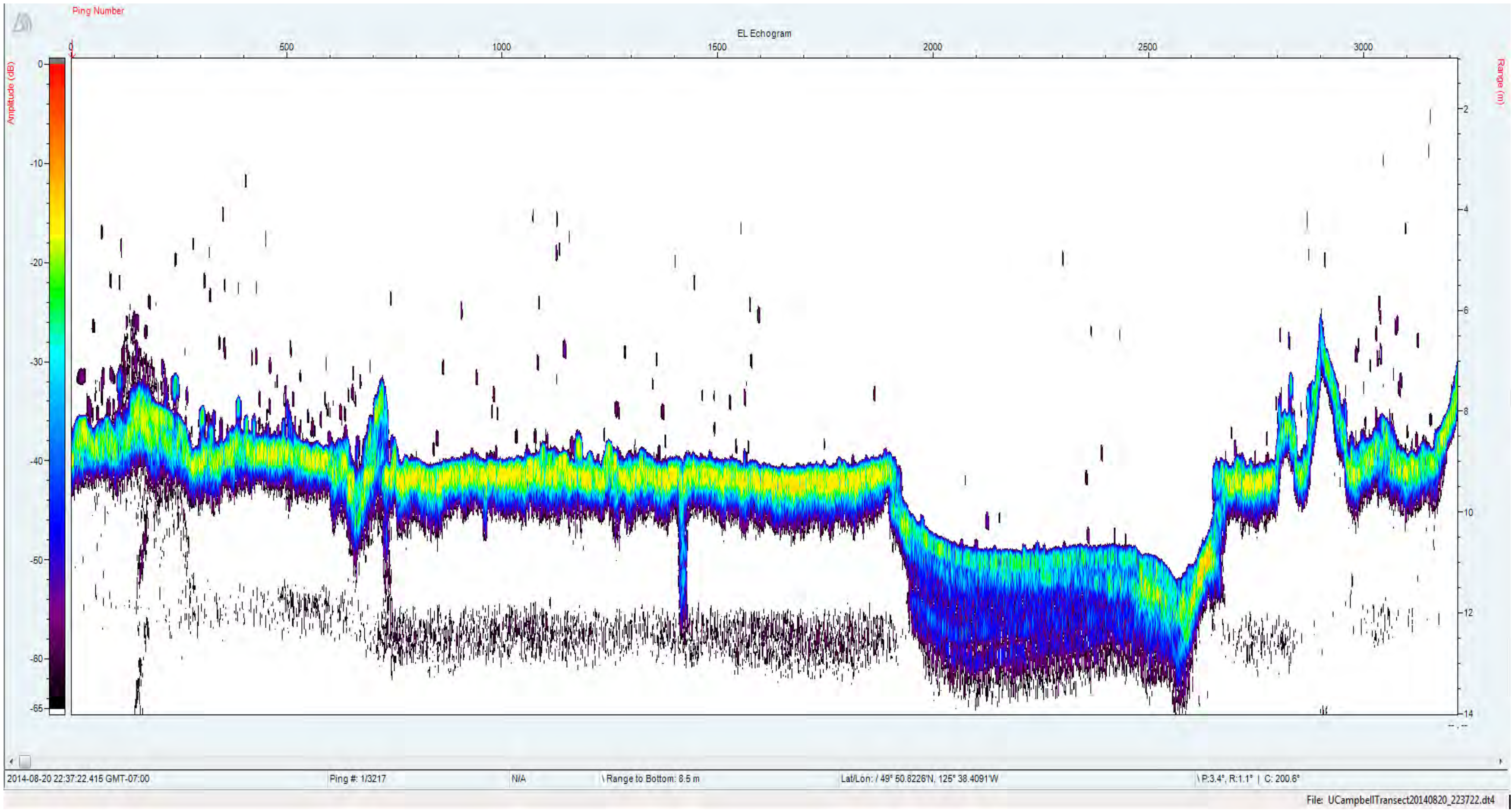
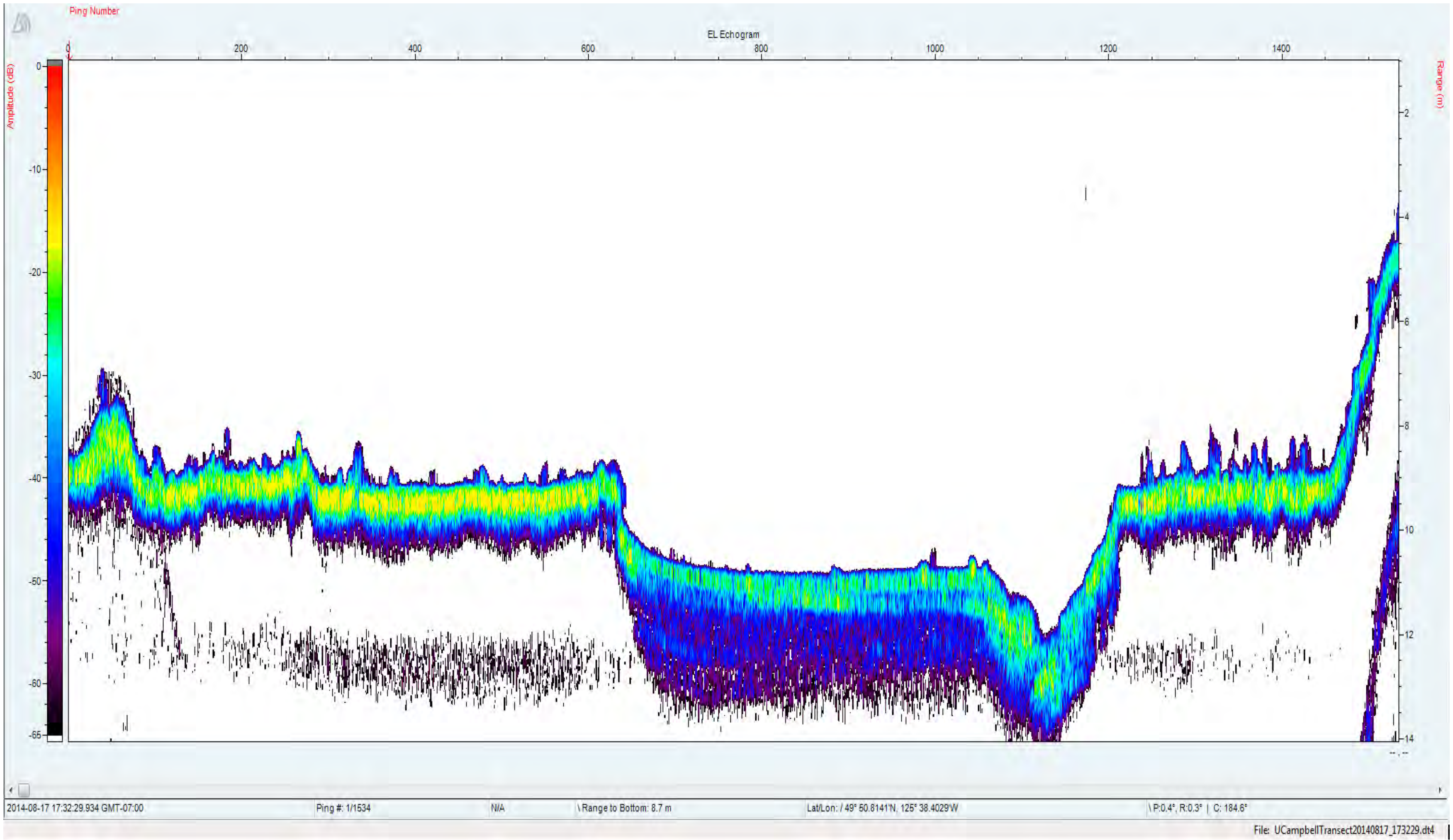


Figure 17. Echograms from T13 during the day from the August 2014 acoustic survey of Upper Campbell Reservoir. At night there was a high density of small fish across the transect that was nearly absent during the day. Data threshold -65 dB, capable of detecting fry-size fish (e.g., 25 mm).



3.1.3.2. Formulation of the Fish Abundance Estimate

Counts of fish detections by transect and depth layer formed the basis of the acoustic estimate of fish abundance and its confidence intervals. A total of 339 fish were detected during the night acoustic survey; fish were observed on every transect, but numbers of detections were low or nil in a number of depth strata (Table 16). Only 8 fish were detected in the north bay, and none were detected below 20 m there. In the main basin, 154 fish were detected, nearly all of them between 5 and 20 m, and no fish were found below 45 m. In the shallower south bay and Elk River bay fish were found in all depth layers, with most detected between 5 and 15 m. Fish densities by transect-layer cells showed a pattern similar to counts. Cell densities ranged from 0.0 to 0.0518 fish/m^3 (Table 17). Densities were relatively low in the 0-5 m surface layer in all basins (0.0-0018 fish/m^3), with higher densities at 5-20 m (up to 0.0518 fish/m^3). In the north bay and main basin, densities were low below 20 m (0.0-0.0002 fish/m^3). The highest fish densities of the survey occurred in south bay and Elk River bay between 5 and 20 m. Analysis of TS data by basin × depth layer cells showed that fish < 100 mm in length predominated in most cells, and most larger fish were detected between 15 m and 20 m in all basins (Table 18).

Table 16. Counts of fish from echograms by transect and depth interval, from the night-time acoustic survey of Upper Campbell Reservoir, August 17-21, 2014. Data are from side-looking (0-5 m depth range) and down-looking (5-25 m) transducers. Cells with entries indicate depth strata that were sampled (all strata present were sampled), and dashed lines indicate missing data due to surface conditions too rough for use of side-looking observations.

Lake basin	Depth range (m)	Fish Count by Transect																Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
North Bay	0-5	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5
	5-10	0	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	10-15	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	15-20	1	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	20-25	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	25-30	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	30-35	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	35-40	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	40-45	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
North Bay Total	**0-45**	**2**	**4**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**8**
Main Basin	0-5	-	-	-	0	0	0	1	0	0	1	-	-	-	-	-	-	2
	5-10	-	-	-	0	0	1	3	7	6	5	-	-	-	-	-	-	22
	10-15	-	-	-	8	2	3	15	15	6	12	-	-	-	-	-	-	61
	15-20	-	-	-	4	10	4	8	11	23	5	-	-	-	-	-	-	65
	20-25	-	-	-	0	0	0	0	0	1	0	-	-	-	-	-	-	1
	25-30	-	-	-	0	0	1	0	0	0	-	-	-	-	-	-	-	1
	30-35	-	-	-	1	0	0	0	0	-	-	-	-	-	-	-	-	1
	35-40	-	-	-	0	0	0	0	-	-	-	-	-	-	-	-	-	0
	40-45	-	-	-	0	0	1	-	-	-	-	-	-	-	-	-	-	1
	45-50	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	0
	50-55	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	0
	55-60	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0
	60-65	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0
Main Basin Total	**0-65**	**-**	**-**	**-**	**13**	**12**	**10**	**27**	**33**	**36**	**23**	**-**	**-**	**-**	**-**	**-**	**-**	**154**
South Bay	0-5	-	-	-	-	-	-	-	-	-	-	2	-	11	-	-	-	13
	5-10	-	-	-	-	-	-	-	-	-	-	3	13	69	-	-	-	85
	10-15	-	-	-	-	-	-	-	-	-	-	3	22	4	-	-	-	29
	15-20	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	4
South Bay Total	**0-20**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**12**	**35**	**84**	**-**	**-**	**-**	**131**
Elk River Bay	0-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	7	11
	5-10	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8	0	16
	10-15	-	-	-	-	-	-	-	-	-	-	-	-	-	18	0	-	18
	15-20	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Elk River Bay Total	**0-20**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**27**	**12**	**7**	**46**
Net Total		**2**	**4**	**2**	**13**	**12**	**10**	**27**	**33**	**36**	**23**	**12**	**35**	**84**	**27**	**12**	**7**	**339**

Table 17. **Fish density (fish/m^3) of all species combined by transect and depth interval from the acoustic survey of Upper Campbell Reservoir on nights of August 17-21, 2014. Data are from side-looking (0-5 m depth range) and down-looking (5-25 m) transducers. Blank cells are where the reservoir was shallower than the depth interval.**

Lake basin	Depth range	Mean fish density by transect (fish/m^3)																Total		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	n	Mean	Var
North Bay	0-5	0.0001	0.0002	0.0002														3	0.00014	5.47E-09
	5-10	0	0.0004	0														3	0.00012	4.39E-08
	10-15	0	0	0														3	0	0.00E+00
	15-20	0.0004	0	0.0006														3	0.00032	8.99E-08
	20-25	0	0	0														3	0	0.00E+00
	25-30	0	0	0														3	0	0.00E+00
	30-35	0	0	0														3	0	0.00E+00
	35-40	0	0	0														3	0	0.00E+00
	40-45	0																1	0	
North Bay Total	**0-45**	**0**	**0.0001**	**0.0001**														**25**		
Main Basin	0-5				0	0	0	0	0	0	0.0001							7	0.00001	6.47E-10
	5-10				0	0	0.0002	0.0006	0.0011	0.0008	0.0015							7	0.00061	3.32E-07
	10-15				0.0016	0.0002	0.0003	0.0017	0.0012	0.0004	0.002							7	0.00108	5.69E-07
	15-20				0.0006	0.0006	0.0004	0.0007	0.0007	0.0014	0.001							7	0.00075	1.18E-07
	20-25				0	0	0	0	0	0.0002	0							7	0.00003	4.38E-09
	25-30				0	0	0.0001	0	0	0								6	0.00001	1.16E-09
	30-35				0.0001	0	0	0	0									5	0.00002	3.07E-09
	35-40				0	0	0	0										4	0	0.00E+00
	40-45				0	0	0.0001											3	0.00003	1.96E-09
	45-50				0	0	0											3	0	0.00E+00
	50-55					0	0											2	0	0.00E+00
	55-60						0											1	0	
	60-65						0											1	0	
Main Basin Total	**0-65**				**0.0002**	**0.0001**	**0.0001**	**0.0004**	**0.0004**	**0.0005**	**0.0009**							**60**		
South Bay	0-5											0.0002		0.0014				2	0.00082	7.75E-07
	5-10											0.0012	0.0039	0.0518				3	0.01897	8.11E-04
	10-15											0.0008	0.0138	0.0186				3	0.01106	8.47E-05
	15-20											0.0041						1	0.00407	
South Bay Total	**0-20**											**0.0016**	**0.0089**	**0.024**				**9**		
Elk River Bay	0-5															0.0002	0.0018	2	0.00099	1.25E-06
	5-10														0.002	0.0068	0	3	0.00295	1.23E-05
	10-15														0.0035	0		2	0.00174	6.04E-06
	15-20														0.0038			1	0.00379	
Elk River Bay Total	**0-20**														**0.0031**	**0.0023**	**0.0009**	**8**		
All basins & depths		**0**	**0.0001**	**0.0001**	**0.0002**	**0.0001**	**0.0001**	**0.0004**	**0.0004**	**0.0005**	**0.0009**	**0.0016**	**0.0089**	**0.024**	**0.0031**	**0.0023**	**0.0009**	**102**	**0.00272**	

Table 18. Counts and percentages of small (<100 mm) and large (≥100 mm) fish by 5-10 m depth layer, from the acoustic survey of Upper Campbell Reservoir on nights of August 17-21, 2014. Assignment to size groups was based on size estimated from TS using Love's (1977) dorsal model.

Lake basin	Depth range (m)	Counts			Percentage	
		<100 mm	≥100 mm	Total	<100 mm	≥100 mm
North Bay	0 - 5	1	1	2	50.00%	50.00%
	5-10	1	0	1	100.00%	0.00%
	10-15	0	0	0	0.00%	0.00%
	15 - 20	1	1	2	50.00%	50.00%
	20 - 25	0	0	0	0.00%	0.00%
	25 - 30	0	0	0	0.00%	0.00%
	30 - 35	0	0	0	0.00%	0.00%
	35 - 40	0	0	0	0.00%	0.00%
	40 - 45	0	0	0	0.00%	0.00%
Main Basin	0 - 5	1	0	1	100.00%	0.00%
	5-10	27	0	27	100.00%	0.00%
	10-15	66	2	68	97.10%	2.90%
	15 - 20	49	42	91	53.80%	46.20%
	20 - 25	7	1	8	87.50%	12.50%
	25 - 30	1	1	2	50.00%	50.00%
	30 - 35	1	0	1	100.00%	0.00%
	35 - 40	0	0	0	0.00%	0.00%
	40 - 45	1	0	1	100.00%	0.00%
South Bay	0 - 5	11	0	11	100.00%	0.00%
	5-10	85	0	85	100.00%	0.00%
	10-15	29	0	29	100.00%	0.00%
	15 - 20	2	2	4	50.00%	50.00%
	20 - 25	0	0	0	0.00%	0.00%
Elk R.iver Bay	0 - 5	8	0	8	100.00%	0.00%
	5-10	16	0	16	100.00%	0.00%
	10-15	18	0	18	100.00%	0.00%
	15 - 20	0	1	1	0.00%	100.00%
	20 - 25	0	0	0	0.00%	0.00%

The total fish abundance estimate (species combined) for the whole reservoir was 424,783 fish ± 60% (Table 19). In all reservoir basins 99-100% of the fish were in the upper 20 m of the water column, with 61-98% between 5 and 15m (Table 19). The main basin and the south bay contained the most fish by a wide margin; 212,298 and 180,102 fish, respectively (Table 19). Areal density for the whole reservoir was 148 fish/ha, with by far the highest density in the south bay at 637 fish/ha

(Table 20). The south bay also had the broadest 95% confidence limits of any reservoir basin (±158%), due to high among-transect variability with especially high fish density on transect 13 (Table 17 and Table 20). Confidence limits were tightest for the main reservoir basin (±32%).

Table 19. Fish abundance of all species combined by reservoir basin and depth layer, from the acoustic survey of Upper Campbell Reservoir on nights of August 17-21, 2014. Data are from side-looking (0-5 m depth range) and down-looking (5-25 m) transducers.

Lake basin	Depth range (m)	Mean no. per m^3	Variance	Sample size*	Stratum volume (m^3)	Abundance estimate	SE of estimate	95% CL	
								Lower	Upper
North Bay	0-5	0.00014	5.50E-09	3	1.00E+07	1,442	428	-397	3,282
	5-10	0.00012	4.40E-08	3	8.12E+06	982	982	-3,243	5,206
	10-15	0	0.00E+00	3	6.70E+06	0	0	0	0
	15-20	0.00032	9.00E-08	3	5.46E+06	1,764	945	-2,303	5,831
	20-25	0	0.00E+00	3	4.41E+06	0	0	0	0
	25-30	0	0.00E+00	3	3.54E+06	0	0	0	0
	30-35	0	0.00E+00	3	2.34E+06	0	0	0	0
	35-40	0	0.00E+00	3	2.15E+05	0	0	0	0
	40-45	0		1	7.77E+03	0			
North Bay Total	**0-45**			**25**	**4.08E+07**	**4,188**	**1,428**	**1,240**	**7,136**
Main Basin	0-5	0.00001	6.50E-10	7	1.03E+08	1,405	989	-1,016	3,825
	5-10	0.00061	3.30E-07	7	9.61E+07	58,528	20,940	7,291	109,765
	10-15	0.00108	5.70E-07	7	8.77E+07	94,308	25,010	33,111	155,506
	15-20	0.00075	1.20E-07	7	7.38E+07	55,587	9,563	32,187	78,987
	20-25	0.00003	4.40E-09	7	5.58E+07	1,397	1,397	-2,022	4,816
	25-30	0.00001	1.20E-09	6	4.33E+07	603	603	-946	2,152
	30-35	0.00002	3.10E-09	5	2.15E+07	534	534	-948	2,015
	35-40	0	0.00E+00	4	4.31E+06	0	0	0	0
	40-45	0.00003	2.00E-09	3	1.07E+06	27	27	-90	145
	45-50	0	0.00E+00	3	5.32E+05	0	0	0	0
	50-55	0	0.00E+00	2	2.68E+05	0	0	0	0
	55-60	0		1	1.08E+05	0			
	60-65	0		1	1.02E+04	0			
Main Basin Total	**0-65**			**60**	**4.87E+08**	**212,389**	**34,044**	**144,267**	**280,511**
South Bay	0-5	0.00082	7.80E-07	2	1.28E+07	10,473	7,957	-90,625	111,572
	5-10	0.01897	8.10E-04	3	7.44E+06	141,068	122,277	-385,049	667,185
	10-15	0.01106	8.50E-05	3	2.50E+06	27,662	13,285	-29,499	84,823
	15-20	0.00407		1	2.21E+05	899			
South Bay Total	**0-20**			**9**	**2.29E+07**	**180,102**	**123,254**	**-104,123**	**464,326**
Elk River Bay	0-5	0.00099	1.20E-06	2	1.10E+07	10,895	8,677	-99,351	121,141
	5-10	0.00295	1.20E-05	3	4.51E+06	13,299	9,156	-26,096	52,694
	10-15	0.00174	6.00E-06	2	1.84E+06	3,203	3,203	-37,493	43,899
	15-20	0.00379		1	1.87E+05	707			
Elk River Bay Total	**0-20**			**8**	**1.75E+07**	**28,104**	**13,014**	**-2,670**	**58,878**
Combined Total				**102**	**5.69E+08**	**424,783**	**128,538**	**168,778**	**680,789**

Table 20. Fish abundance (species combined), confidence limits, and areal density by reservoir basin from the August 2014 acoustic survey of Upper Campbell Reservoir.

Lake basin	Fish abundance	95% CL as ±		Surface area (ha)	Fish/ha
		Number	% of abundance		
North bay	4,188	2,948	70%	214	20
Main basin	212,389	68,122	32%	2,094	101
South bay	180,102	284,224	158%	283	637
West bay	28,104	30,774	109%	278	101
Combined	424,783	256,005	60%	2,869	148

Small fish < 100 mm, probably mostly Sticklebacks, were the most abundant type of fish at most depths throughout the reservoir (Table 21). Their reservoir-wide abundance was 393,118 fish, with the similar numbers in the main and south basins (about 180,000 fish) where they were most abundant between 5 and 15 m. Rainbow Trout were the next most abundant species, with a whole reservoir estimate of 26,485 fish that were mostly found in the 15-20 m layer of the main basin (Table 21). The abundance of Cutthroat Trout in the reservoir was estimated to be 5,027 fish, again mostly in the 15-20 m layer of the main basin. The abundance estimate for Cutthroat/Rainbow hybrids was 152 fish for the whole reservoir, but all were found in the south and Elk River bays. Although one Dolly Varden was captured in the 10-15 m layer of the north bay, the abundance of this species could not be estimated because no fish were detected in that sampling stratum with acoustics. Although no numerical estimate is available for Dolly Varden, it is clear that the abundance of this species is very low in the reservoir. Total areal density for fish of all sizes in the reservoir was 148 fish/ha (Table 21). Most were small fish < 100 mm, probably Sticklebacks (137 fish/ha). Areal densities of other fish were 9 Rainbow Trout/ha, 1.8 Cutthroat Trout/ha, and 0.1 hybrid trout/ha (Table 21).

Table 21. Fish abundance by species, reservoir basin, and depth layer for large and small size groups of fish, from the acoustic survey of Upper Campbell Reservoir on nights of August 17-21, 2014. Fish ≥100 mm long were apportioned using species composition data from August 2014 overnight RISC gill net sampling.

Lake basin	Depth range (m)	Fish abundance					
		Fish < 100 mm (spp. unspecified)	Fish ≥ 100 mm				Size groups combined
			Rainbow Trout	Cutthroat Trout	CT/RB Hybrid	Dolly Varden	
North Bay	0-5	721	721	0	0	0	1,442
	5-10	982	0	0	0	0	982
	10-15	0	0	0	0	-	0
	15-20	882	0	882	0	0	1,764
	20-25	0	0	0	0	0	0
	25-30	0	0	0	0	0	0
	30-35	0	0	0	0	0	0
	35-40	0	0	0	0	0	0
	40-45	0	0	0	0	0	0
North Bay Total	**0-45**	**2,585**	**721**	**882**	**0**	**-**	**4,188**
Main Basin	0-5	1,405	0	0	0	0	1,405
	5-10	58,528	0	0	0	0	58,528
	10-15	91,535	2,537	236	0	0	94,308
	15-20	29,932	22,377	3,278	0	0	55,587
	20-25	1,223	167	8	0	0	1,397
	25-30	301	288	13	0	0	603
	30-35	534	0	0	0	0	534
	35-40	0	0	0	0	0	0
	40-45	27	0	0	0	0	27
	45-50	0	0	0	0	0	0
	50-55	0	0	0	0	0	0
	55-60	0	0	0	0	0	0
	60-65	0	0	0	0	0	0
Main Basin Total	**0-65**	**183,484**	**25,370**	**3,536**	**0**	**0**	**212,389**
South Bay	0-5	10,473	0	0	0	0	10,473
	5-10	141,068	0	0	0	0	141,068
	10-15	27,662	0	0	0	0	27,662
	15-20	449	276	138	35	0	899
South Bay Total	**0-20**	**179,652**	**276**	**138**	**35**	**0**	**180,102**
Elk River Bay	0-5	10,895	0	0	0	0	10,895
	5-10	13,299	0	0	0	0	13,299
	10-15	3,203	0	0	0	0	3,203
	15-20	0	118	471	118	0	707
Elk River Bay Total	**0-20**	**27,397**	**118**	**471**	**118**	**0**	**28,104**
Basins & depths combined		**393,118**	**26,485**	**5,027**	**152**	**-**	**424,783**
Fish/ha		**137**	**9**	**1.8**	**0.1**	**-**	**148**

3.2. Snorkel Survey of Spawners in Reservoir Tributaries

3.2.1. Survey conditions

Snorkel surveys were undertaken in the tributaries of the Upper Campbell Reservoir, Buttle Lake and Lower Campbell Reservoir on dates between June 09 and 12, 2014. Discharge measured in the Elk River at Water Survey of Canada gauge 08HD018 has historically been used as an index to assess suitability, based on the criterion that suitable conditions correspond to a discharge of < 20 m^3/s (Pellett 2013). Mean daily discharge at the gauge during the survey dates ranged between 6.9 m^3/s and 8.6 m^3/s; similar to the conditions observed in 2013 (Pellett 2013), corresponding to optimal hydrologic conditions for the snorkelling surveys.

Details of survey locations, dates, effort, and conditions are presented in Table 22. Effective visibility was estimated as 6.0 to 9.0 m in the tributaries of Buttle Lake and Upper Campbell Reservoir and was 3.5 to 5.0 m in the tributaries of Lower Campbell Reservoir (Table 22). No recent rainfall had occurred prior to the surveys. Water temperatures ranged between 7.0°C and 11.0°C in the tributaries of Buttle Lake and Upper Campbell Reservoir, and were between 11.0°C and 17.0°C in the tributaries of Lower Campbell Reservoir (Table 22). Water temperatures were typically as high, or greater than, water temperatures measured in any of the previous surveys (Pellett 2013). Representative photographs collected during surveys are presented in Appendix D.

Table 22. Sampling effort and conditions for Year 1 snorkel surveys. Survey distances are from LKT (2014). Survey effort only recorded for separate sections of the upper Elk River.

Watershed	Stream	Survey Distance (km)	Date	Survey Duration (hh:mm)	Total Effort (hh:mm)	Water Temp. (° C)	Air Temp. (° C)	Estimated Visibility (m)	Mean Daily Discharge (m^3/s)	Weather
Upper Campbell	Upper Elk River	6.0	09-Jun-14	03:10	06:20	11.0	19.0	8.0	8.6	Sunny
	Lower Elk River	5.4	09-Jun-14	-	-	11.0	19.0	8.0	8.6	Sunny
Buttle	Ralph River	0.9	10-Jun-14	-	-	9.5	17.0	8.0	8.0	Overcast
	Thelwood Creek	2.5	10-Jun-14	02:30	05:00	-	-	9.0	8.0	Overcast
	Wolf River	0.3	09-Jun-14	01:30	03:00	8.0	15.0	6.0	8.6	Sunny/windy
	Phillips Creek	0.3	09-Jun-14	01:00	02:00	7.0	15.0	8.0	8.6	Sunny/windy
	Henshaw Creek	0.5	10-Jun-14	-	-	10.0	16.0	8.0	8.0	Overcast
Lower Campbell	Campbell River	0.5	11-Jun-14	00:55	01:50	11.0	15.0	5.0	7.2	Overcast
	Miller Creek	0.4	12-Jun-14	-	-	15.0	14.0	3.5	6.9	Sunny
	Fry Creek	1.2	11-Jun-14	01:35	03:10	17.0	15.0	4.0	7.2	Overcast

"-" Dashes indicated that data were not collected.

3.2.2.2014 Survey Results

Year 1 snorkel survey data are summarized below; raw data are presented in tabular form in Appendix D. For the Year 1 snorkel surveys, a fork length of 150 mm was designated as the boundary between juvenile classifications and adult fish. The estimated fork lengths of juvenile fish ranged from 30 mm to 55 mm for fry, and from 80 mm to 120 mm for parr, during the 2014 surveys.

Rainbow Trout redds were recorded in all tributaries, except for Thelwood Creek (Figure 18). The highest number of redds (300 redds) was observed in the lower Elk River, which had the second longest survey section (5.4 km; Table 22). High numbers of redds (>100 redds) were also observed in Ralph River (125 redds), Wolf River (157 redds) and Campbell River (Strathcona Dam tailrace; 190 redds). Cutthroat Trout and Dolly Varden redds were not observed, reflecting the survey timing. There was evidence that peak timing of Rainbow Trout spawning varied among tributaries. Field observations made by the survey crews indicated that the timing of the surveys was well-aligned with the timing of peak spawning in Elk River, whereas abundant periphyton growing on redds in other tributaries (Fry Creek and Miller Creek) indicated that peak spawning in these tributaries likely occurred in March, more than two months previous.

Total Rainbow Trout density per km of stream (juvenile and adult fish combined) varied considerably between the ten stream reaches, with observed densities greatest in Wolf River (1,280 fish/km), Thelwood Creek (1,027 fish/km) and Ralph River (928 fish/km), as presented in Figure 19. When interpreting these results, note that variability in channel width hinders direct comparison of this metric between tributaries. In addition, distinguishing between Rainbow Trout and Cutthroat Trout in the field can be difficult, and the data presented in Figure 19 for Fry Creek and Miller Creek include fish observations that were classed as generally as 'trout'; potentially including both Rainbow Trout and Cutthroat Trout. Adult Rainbow Trout observations and spawning condition class for each tributary are presented in Figure 20. The highest number of adult Rainbow Trout observations was from Thelwood Creek (2,567 fish); the majority of these fish were in mid-spawn (60%) or moderately coloured (30%) condition (Figure 20). High numbers of adult Rainbow Trout were also observed in the lower Elk River (1,742 fish) and upper Elk River (1,147 fish), while the majority of fish in lower Elk River were in mid-spawn condition, fish in upper Elk River were more evenly distributed across bright, moderately coloured, and mid-spawn condition (Figure 20). Lower numbers of adults Rainbow Trout were observed in Ralph River (836 fish), Wolf River (384 fish), Campbell River (391 fish), Phillips Creek (223 fish), and Henshaw Creek (26 fish) No adult Rainbow Trout were observed in Fry Creek (Figure 20).

The numbers of adult Cutthroat Trout and Dolly Varden observed were much lower than the number of observed Rainbow Trout. This reflects the timing of the Year 1 surveys, which targeted Rainbow Trout spawning. Two adult Cutthroat Trout were observed in both the upper and lower reaches of Elk River, and one adult Cutthroat Trout was observed in Ralph River (Figure 21). In addition, there were two adult Cutthroat Trout captured in Phillips Creek, three adults in Wolf River, and one adult in Miller Creek (Figure 21).

The greatest number of adult Dolly Varden were observed in Wolf River (30 fish), followed by Campbell River (24 fish), and Phillips Creek (18 fish) (Figure 22). There were four adult Dolly Varden observed in Ralph River and one adult observed in the upper Elk River.

Figure 18. Number of Rainbow Trout redds observed during Year 1 snorkel surveys. Redds were not counted in Thelwood Creek, although a high number of fish in mid-spawning condition were observed (Figure 20).

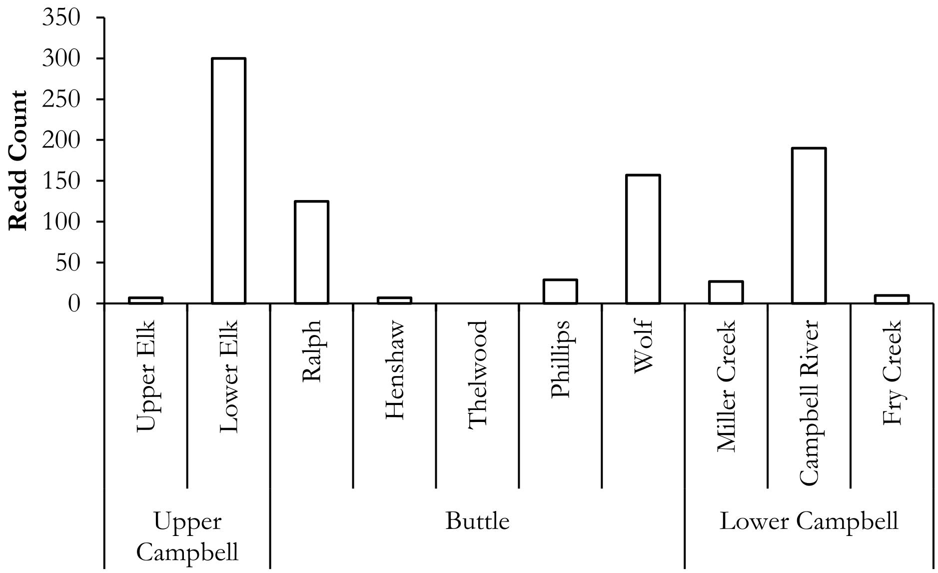


Figure 19. Total numbers of Rainbow Trout (all life stages) per km observed during Year 1 snorkel surveys.

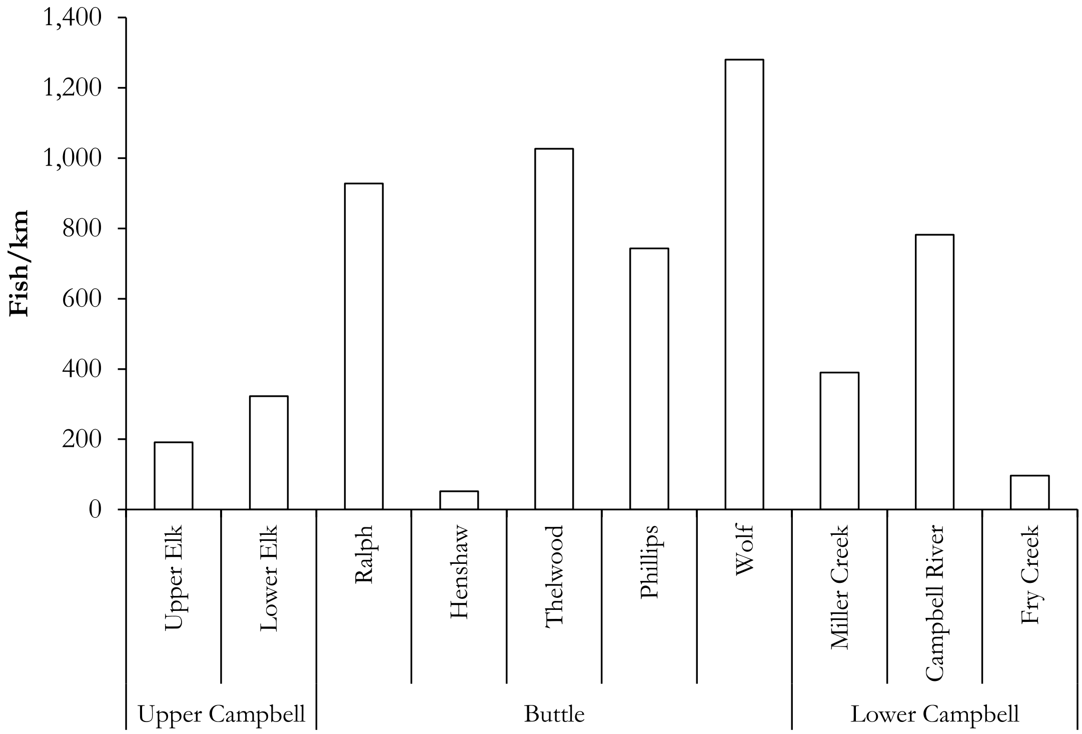


Figure 20. Counts of adult Rainbow Trout observed during Year 1 snorkel surveys, by condition classes.

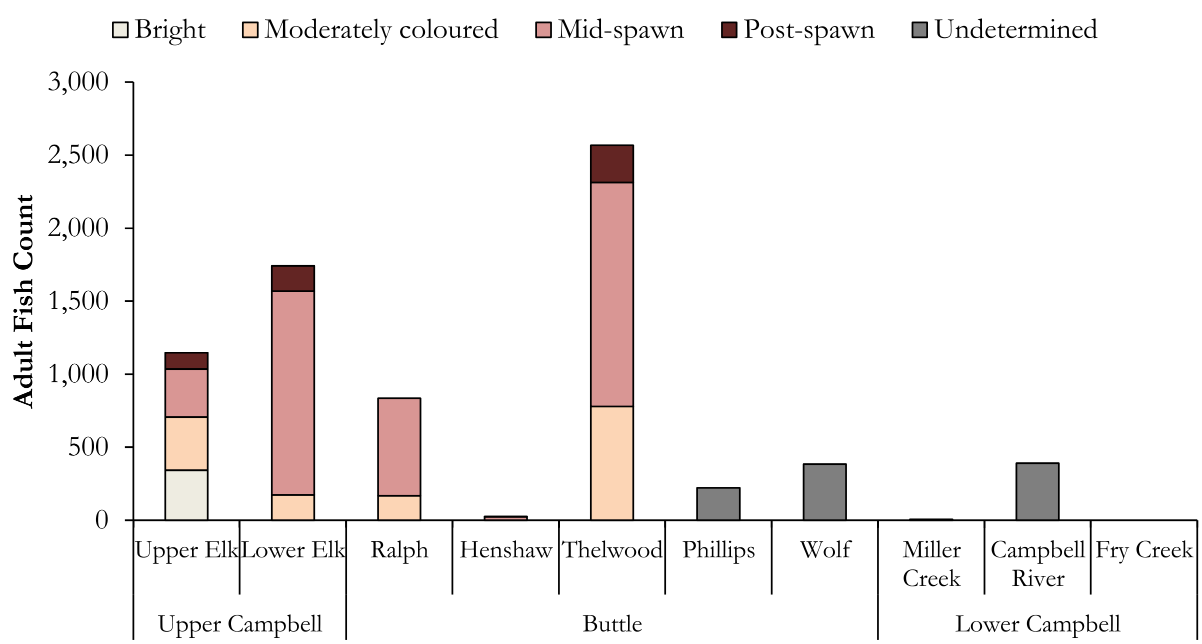


Figure 21. Counts of adult Cutthroat Trout observed during Year 1 snorkel surveys.

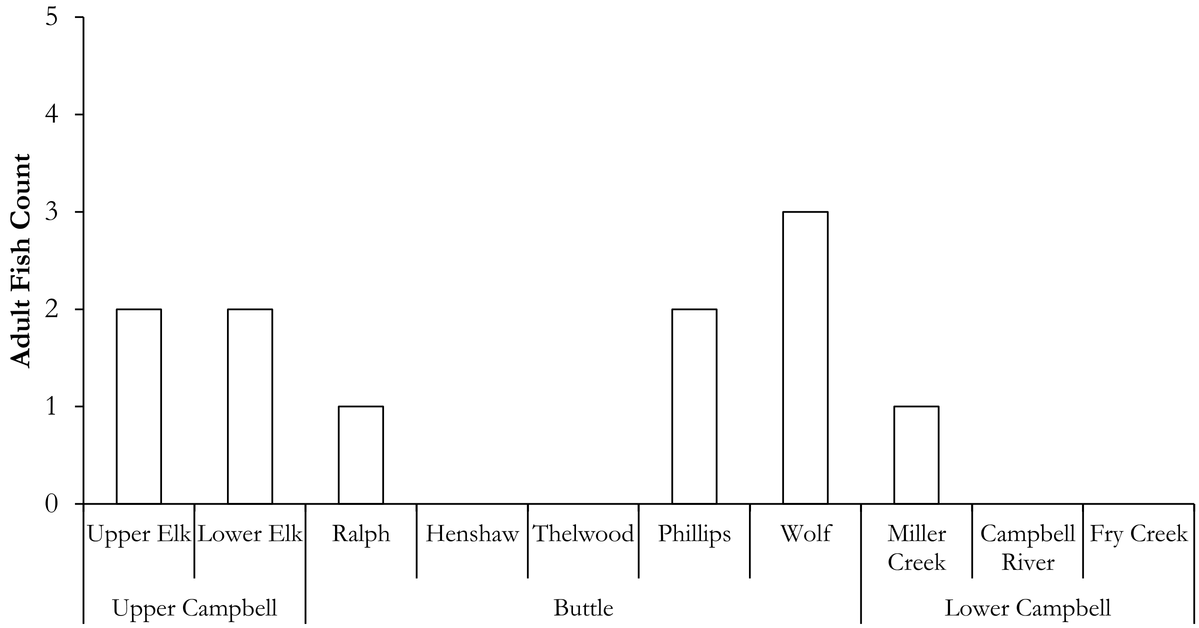
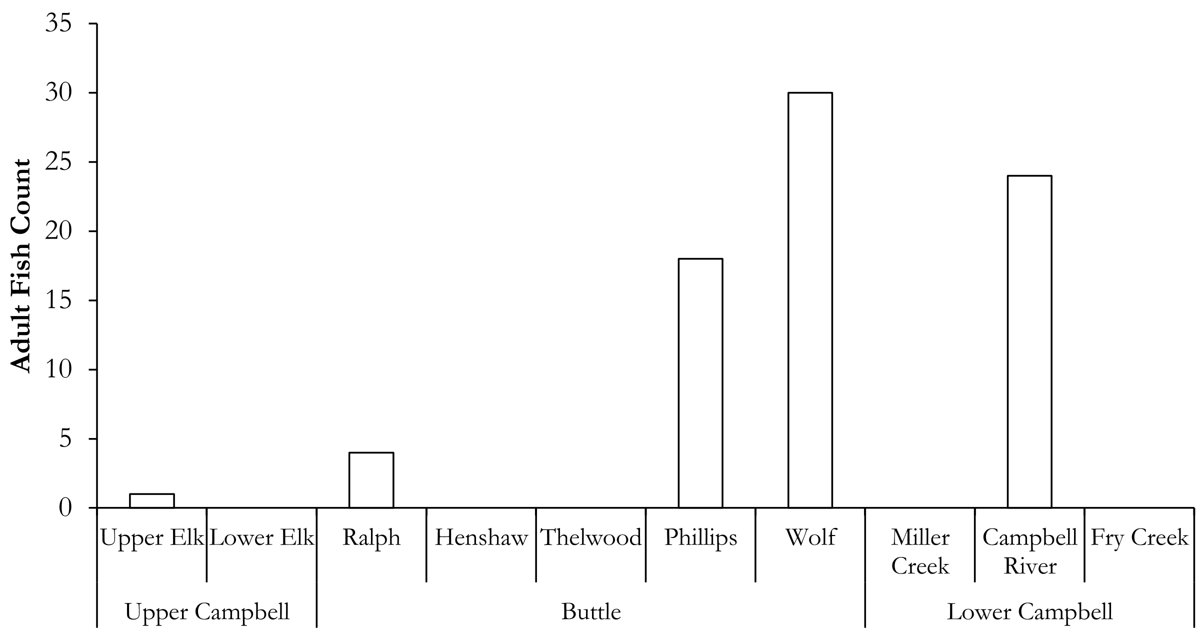


Figure 22. Counts of adult Dolly Varden observed during Year 1 snorkel surveys.



3.2.3. Comparison with historic data

3.2.3.1. 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, these surveys have been completed by BCCF with funding from BC Hydro (Pellett 2013). The data are used by the Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) for monitoring purposes. The snorkel surveys have not been conducted consistently 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).

Table 23 presents Year 1 and historic 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). Rainbow Trout counts for these six tributaries are also presented graphically in Figure 23 to Figure 29. Of the three species enumerated, counts have historically been highest for Rainbow Trout (Table 23).

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 or Campbell River (Strathcona Dam tailrace); however, surveys were undertaken in Fry Creek in 2003 and 2004. These historic data are derived from surveys undertaken across a range of months, and are thus presented separately in Table 24; note that no fish were recorded during the 2014 survey of Fry Creek.

Table 23. Summary of adult fish count data in six tributaries that were surveyed (1990–2014). Historic data 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
Upper Campbell[3]	Upper Elk	RB	-	436	1,475	487	960	542	370	-	-	-	-	428	168	337	728	-	1,586	1,066	1,562	1,847	1,445	-	716	551	877	1,147
		CT	-	8	7	0	19	11	1	-	-	-	-	3	2	0	5	-	4	0	2	5	10	-	11	10	8	2
		DV	-	0	5	0	0	2	-	-	-	1	-	6	0	0	0	-	6	1	1	1	2	-	1	0	1	1
	Lower Elk	RB	823	1,134	1,087	1,194	1,411	773	1,044	-	-	-	-	1,089	1,184	1,259	1,784	-	5,340	4,862	5,630	2,501	3,919	-	3,980	1,537	1,204	1,742
		CT	7	16	11	1	26	2	8	-	-	-	-	3	2	1	3	-	3	3	11	4	20	-	5	5	7	2
		DV	0	0	4	0	13	0	-	-	-	0	-	6	2	1	2	-	9	2	0	2	1	-	0	1	0	0
Buttle	Ralph	RB	-	300	1,300	965	2,100	-	-	-	2,620	-	1,175	420	724	532	910	-	650	690	1,103	1,181	708	-	479	536		835
		CT	-	0	0	4	0	-	-	-	2	-	2	0	0	2	10	-	2	0	2	0	0	-	1	2		1
		DV	-	10	10	4	4	-	-	-	30	-	8	0	3	0	17	-	4	56	0	9	4	-	0	13		4
	Henshaw	RB	-	98	-	-	-	-	-	-	-	-	-	4	24	7	78	-	5	42	24	93	27	-	8	37		26
		CT	-	0	-	-	-	-	-	-	-	-	-	0	0	0	0	-	0	0	1	0	0	-	0	0		0
		DV	-	0	-	-	-	-	-	-	-	-	-	0	0	0	2	-	0	0	0	0	0	-	0	0		0
	Thelwood	RB	-	1,000	2,500	3,220	3,975	-	2,300	-	-	4,915	2,840	2,501	3,374	3,032	2,590	-	3,105	3,921	4,408	4,128	4,892	1,123	3,748	4,104		2,567
		CT	-	200	15	88	347	-	53	-	-	141	53	441	34	64	20	-	25	10	12	4	17	32	26	15		0
		DV	-	225	1	0	30	-	2	-	-	28	0	0	8	3	6	-	24	6	4	9	5	2	0	0		0
	Phillips	RB	-	-	750	-	-	800	-	-	-	500	148	132	111	65	109	94	-	-	162	624	540	106	145	191		223
		CT	-	-	0	-	-	6	-	-	-	2	0	6	0	5	1	0	-	-	1	0	0	0	2	0		2
		DV	-	-	20	-	-	50	-	-	-	10	1	16	1	5	0	11	-	-	3	4	40	21	3	8		18
	Wolf	RB	-	-	-	-	-	800	-	-	-	450	-	361	228	170	576	335	-	-	1,250	1,210	1,590	140	192	666		384
		CT	-	-	-	-	-	2	-	-	-	1	-	3	0	0	0	0	-	-	6	1	0	0	2	3		3
		DV	-	-	-	-	-	30	-	-	-	12	-	4	0	30	41	23	-	-	25	90	90	30	5	18		30

[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.

"-" Dashes indicate that surveys were not undertaken.

Figure 23. Adult Rainbow Trout counts on Upper Elk River (1990-2014). No surveys were completed in 1990, 1997, 1998, 1999, 2000, 2005, and 2011.

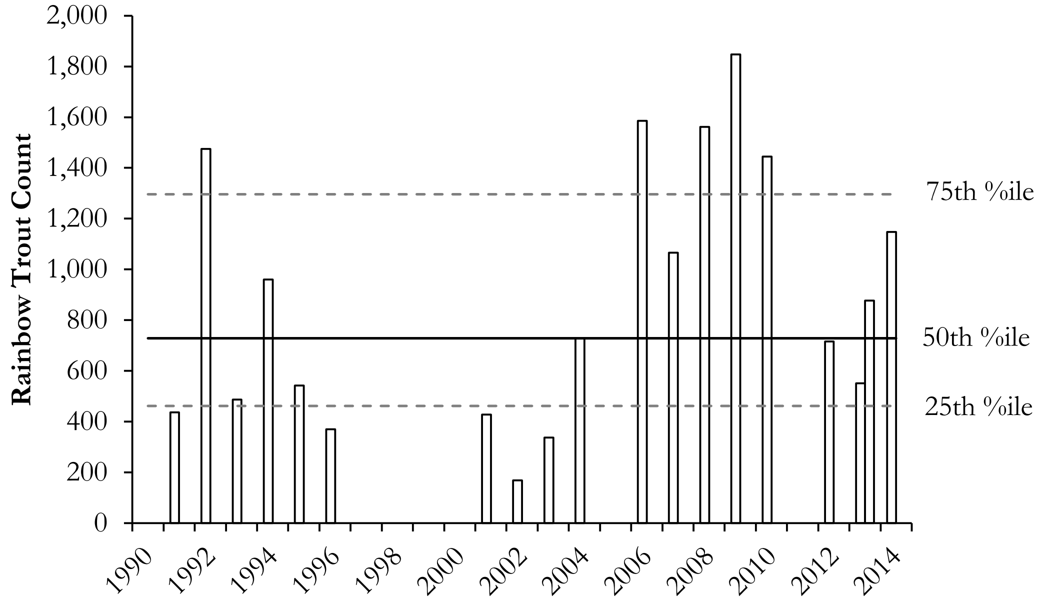


Figure 24. Adult Rainbow Trout counts on Lower Elk River (1990-2014). No surveys were completed in 1997, 1998, 1999, 2000, 2005, and 2011.

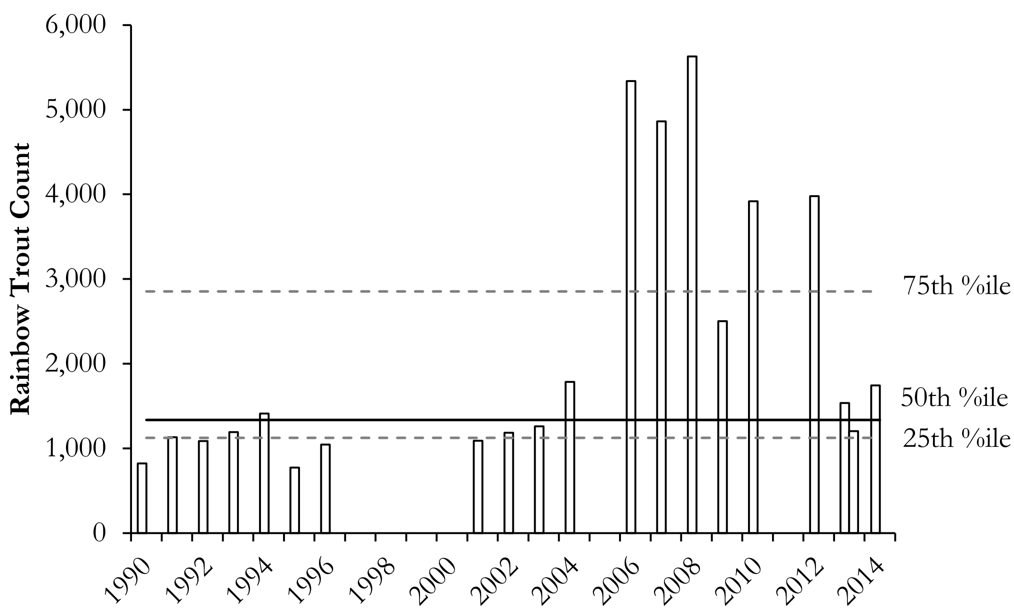


Figure 25. Adult Rainbow Trout counts in Ralph River (1990-2014). No surveys were completed in 1990, 1995-1997, 1999, 2005, and 2011.

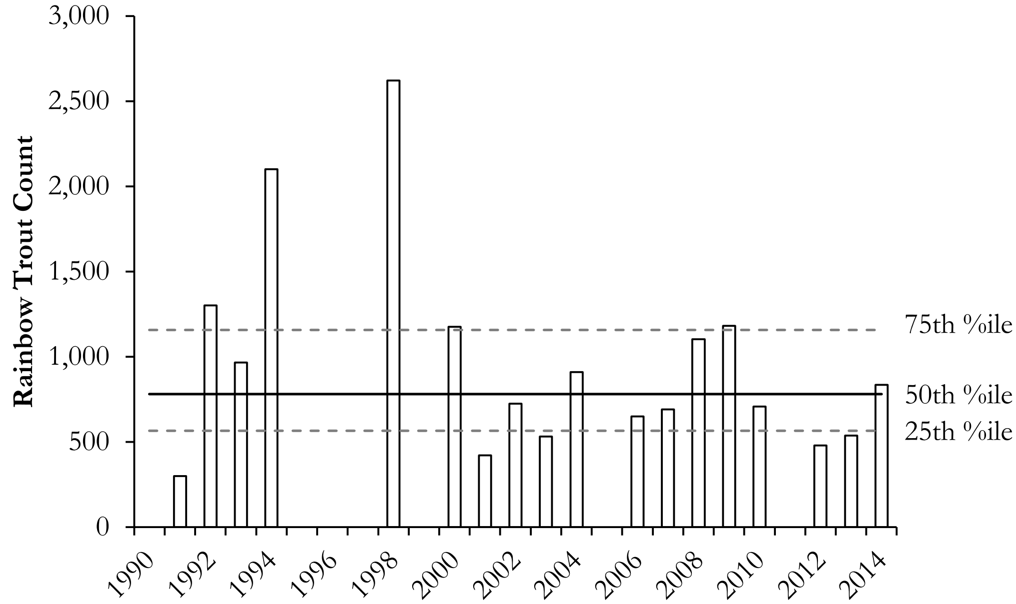


Figure 26. Adult Rainbow Trout counts in Henshaw Creek (1990-2014). No surveys were completed in 1990, 1992-2000, 2005, and 2011.

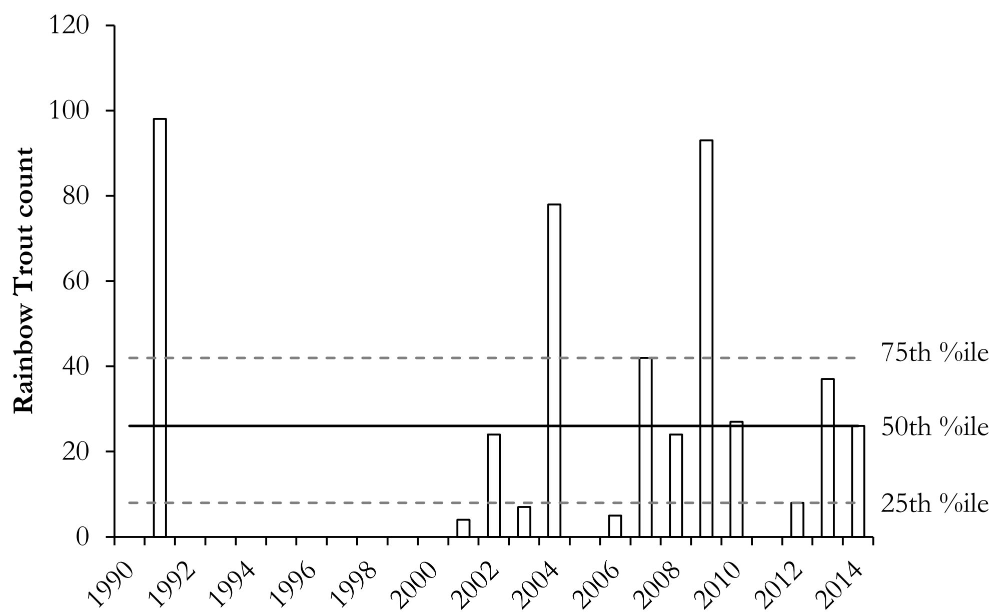


Figure 27. **Adult Rainbow Trout counts in Thelwood Creek (1990-2014). No surveys were completed in 1990, 1995, 1997, 1998, and 2005.**

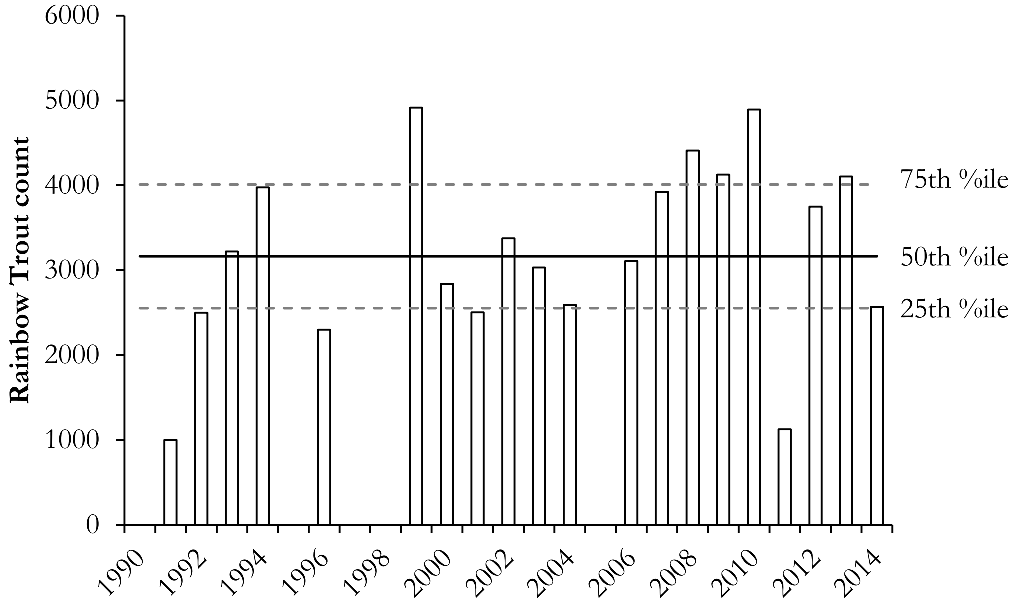


Figure 28. **Adult Rainbow Trout counts in Phillips Creek (1990-2014). No surveys were completed in 1990-1991, 1993-1994, 1996-1998, and 2006-2007.**

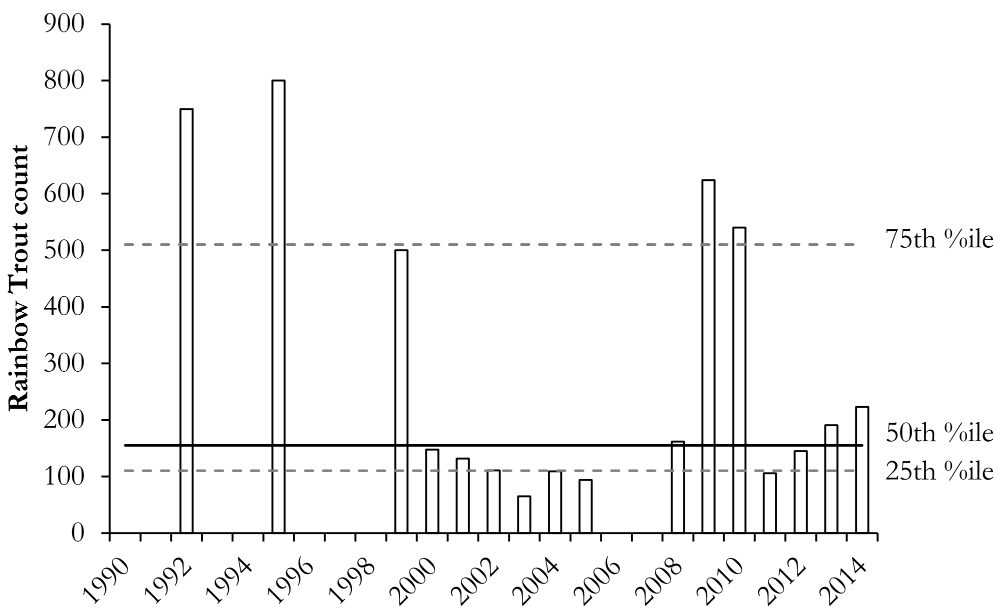


Figure 29. Adult Rainbow Trout counts in Wolf River (1990-2014). No surveys were completed in 1990-1994, 1996-1998, 2000, and 2006-2007.

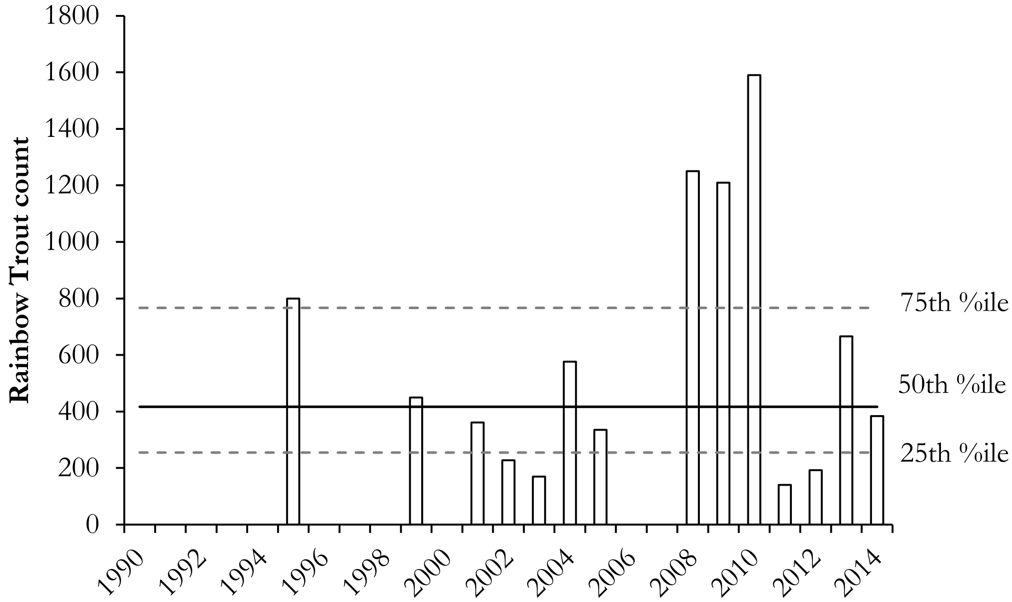


Table 24. Historic adult fish count data (2003 and 2004) and Year 1 (2014) adult fish counts for Fry Creek.

Waterbody	Year	Month	Fish Count[1,2]		
			RB	CT	DV
Fry Creek	2003	Feburary	0	18	0
		March	0	287	0
		April	0	9	0
		May	48	573	1
		June	20	3	0
		October	0	140	0
	2004	Feburary	0	15	0
		April	0	3	0
		May	0	185	14
	2014	June	0	0	0

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

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

Rainbow Trout

There is high variability in adult Rainbow Trout counts among years for individual tributaries (Table 23; Figure 23 to Figure 29). There is no clear indication of a consistent trend over time in any of the tributaries, although Rainbow Trout counts in the Elk River were generally higher during the second half of the record (2003-2014), particularly in the lower section of the river (Figure 23; Figure 24). Rainbow Trout counts during the 2014 surveys were all within the interquartile range of historic counts for the six tributaries of Buttle Lake and Upper Campbell Reservoir, with no notably high or low counts observed relative to the historic records. No adult Rainbow Trout were recorded in Fry Creek during 2014, although juvenile trout were recorded. Historic data for Rainbow Trout spawning in Fry Creek are limited to results from 2003; where 48 and 20 Rainbow Trout were counted during surveys undertaken in May and June of that year, respectively. Note that a lower fork length was used to differentiate adult fish in that year, potentially affecting comparisons with other historical and current data (Table 24).

Cutthroat Trout

The low 2014 adult Cutthroat Trout counts (zero to three fish) are generally consistent with historic observations, with the exception of Thelwood Creek for which the 2014 count (zero fish) was lower than any of the previous 19 counts undertaken since 1991 (range = 4 to 441; median = 32; Table 23). The 2014 adult Cutthroat Trout count (two fish) was also relatively low for lower Elk River; lower than those of the previous eight surveys, and was one of the lowest counts since 1990 (range = 1 to 26; median = 5; *n* = 19; Table 23). The highest 2014 adult Cutthroat Trout count was at Wolf Creek (three fish) and was comparable with historic data for this stream (range = 0 to 6; median = 1; *n* = 13). In Fry Creek, high numbers of Cutthroat Trout have previously been recorded (maximum count = 573; fork length > 100 mm; Table 24), but only during surveys undertaken earlier in the year during the peak Cutthroat Trout spawning period. The only comparable survey data from the month of June was from 2003, where three Cutthroat Trout were recorded. The data presented here are from surveys that targeted Rainbow Trout spawning, so any trends in Cutthroat Trout should be interpreted cautiously.

Dolly Varden

The 2014 adult Dolly Varden counts were also generally low (range = 0 to 30) and broadly comparable with historic surveys (Table 23). Of the seven survey reaches in Buttle Lake and Upper Campbell Reservoir, the 2014 adult Dolly Varden counts were slightly below the historical median values for the following three survey reaches: lower Elk River, Ralph River, and Thelwood Creek. The 2014 count for lower Elk River was zero fish (historical range = 0 to 13; median = 1; *n* = 19), the 2014 count for Ralph River was one fish (historical range = 0 to 56; median = 4; *n* = 17), and the 2014 count for Thelwood Creek was three fish (historical range = 0 to 225; median = 4; *n* = 19). The 2014 adult Dolly Varden count (zero fish) was equal to the historic median count for Henshaw Creek, for which fish have only been observed once in the 12 historic surveys. The 2014 count (one fish) was slightly above the historical median count for the upper Elk River (historical range = 0 to

6; median = 1; *n* = 18). The 2014 adult Dolly Varden count (18 fish) was relatively high for Philips Creek (historical range = 0 to 50; median = 8; *n* = 15), while the highest count (30 fish) was for Wolf Creek, consistent with historic results (historical range = 0 to 90; median = 25; *n* = 13). No adult Dolly Varden were counted in Fry Creek in 2014, consistent with the one previous survey conducted in the month of June, in 2003 (Table 24). The data presented here are from surveys that targeted Rainbow Trout spawning, so any trends in Dolly Varden should be interpreted cautiously.

3.3. Critical Assessment of Current Experimental Design Using Statistical Modelling

3.3.1. Effective Spawning Habitat (ESH)

The effective spawning index, habitat loss, and effective spawning habitat for Rainbow Trout, Cutthroat Trout, and Dolly Varden are presented in Figure 30, Figure 31, and Figure 32; respectively.

3.3.1.1. Rainbow Trout

Lower Campbell Reservoir spawning index values for Rainbow Trout were variable from year to year and ranged from 0.46 to 0.90 (mean = 0.59). Upper Campbell Reservoir spawning index values were more stable across years and ranged from 0.34 to 0.54 (mean = 0.48). There was little change in habitat loss among years for Lower Campbell Reservoir (range of 0 to 4,810 m^2d; mean = 1,074 m^2d) in comparison to Upper Campbell Reservoir (range of 13 to 68,352 m^2d; mean = 68,352 m^2d). ESH values for both Lower and Upper Campbell reservoirs were variable among years; Lower Campbell Reservoir ESH ranged from 188 to 12,233 m^2d (mean = 3,847 m^2d) and Upper Campbell Reservoir ESH ranged from 1,619 to 21,674 m^2d (mean = 5,702 m^2d).

3.3.1.2. Cutthroat Trout

Lower Campbell Reservoir spawning index values for Cutthroat Trout were variable from year to year and ranged from 0.14 to 0.92 (mean = 0.55). Upper Campbell Reservoir spawning index values were also variable from year to year and ranged from 0.11 to 0.88 (mean = 0.50). There was little change in habitat loss among years for Lower Campbell Reservoir which ranged from 0 to 9,398 m^2d (mean = 1,088 m^2d) in comparison to Upper Campbell Reservoir, which displayed relatively regular oscillations in habitat loss and ranged from 44 to 106,046 m^2d (mean = 20,824 m^2d). ESH values for both Lower and Upper Campbell reservoirs were variable among years; Lower Campbell Reservoir ESH ranged from 198 to 10,043 m^2d (mean = 2,220 m^2d) and Upper Campbell Reservoir ESH ranged from 1,675 to 100,111 m^2d (mean = 21,150 m^2d).

3.3.1.3. Dolly Varden

Lower Campbell Reservoir spawning index values for Dolly Varden were variable from year to year and ranged from 0.08 to 0.64 (mean = 0.42). Upper Campbell Reservoir spawning index values appear to oscillate across years and ranged from 0.10 to 0.62 (mean = 0.40). There was little change in habitat loss among years for Lower Campbell Reservoir which ranged from 55 to 10,973 m^2d (mean = 3,255 m^2d) in comparison to Upper Campbell Reservoir, which displayed relatively regular oscillations in habitat loss and ranged from 73 to 104,159 m^2d (mean = 31,324 m^2d). ESH values for both Lower and Upper Campbell reservoirs were variable among years; Lower Campbell Reservoir ESH ranged from 223 to 6,747 m^2d (mean = 1,202 m^2d) and Upper Campbell Reservoir ESH ranged from 1,295 to 36,389 m^2d (mean = 5,866 m^2d).

Figure 30. ESH time series for Rainbow Trout.

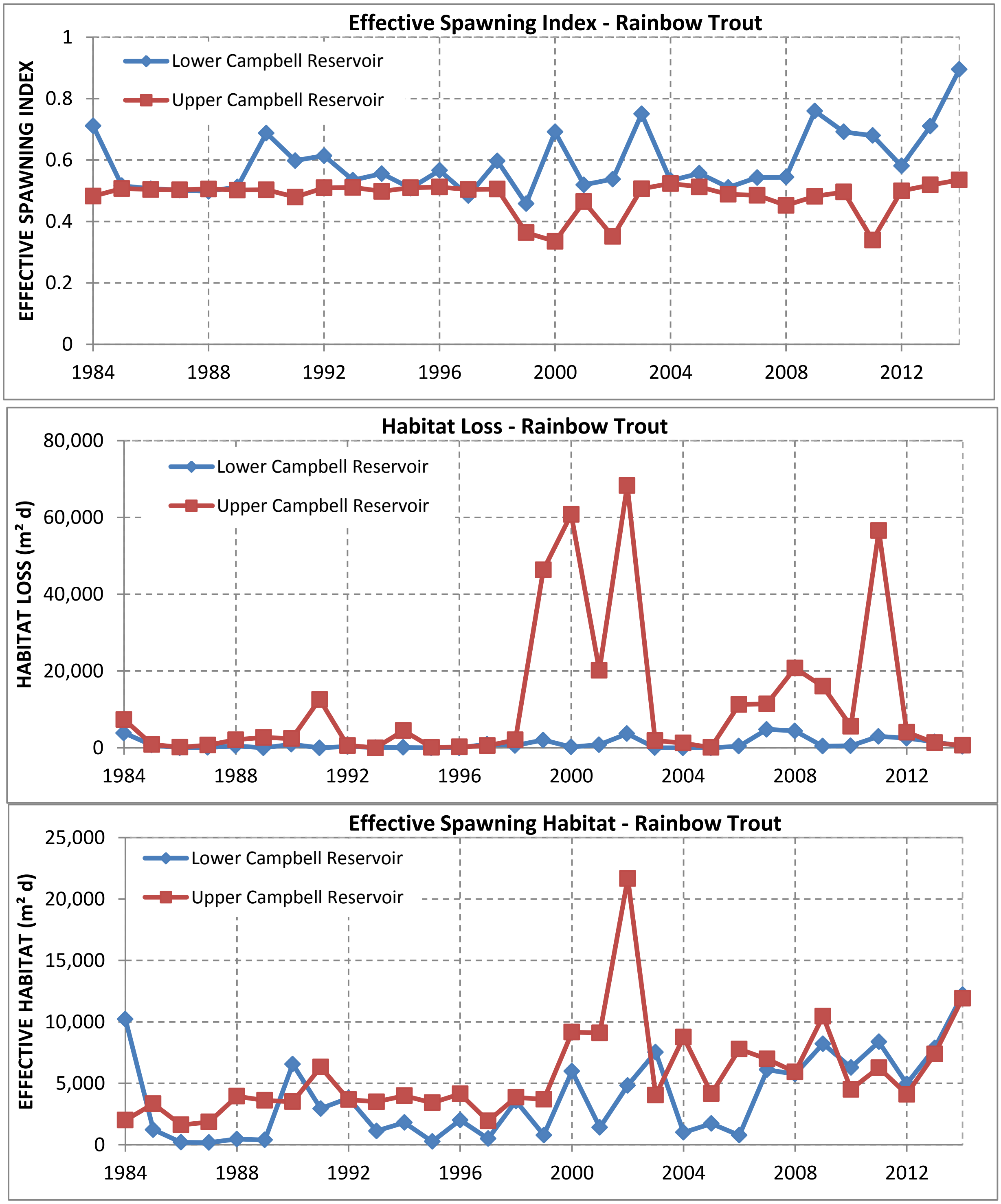


Figure 31. ESH model results for Cutthroat Trout.

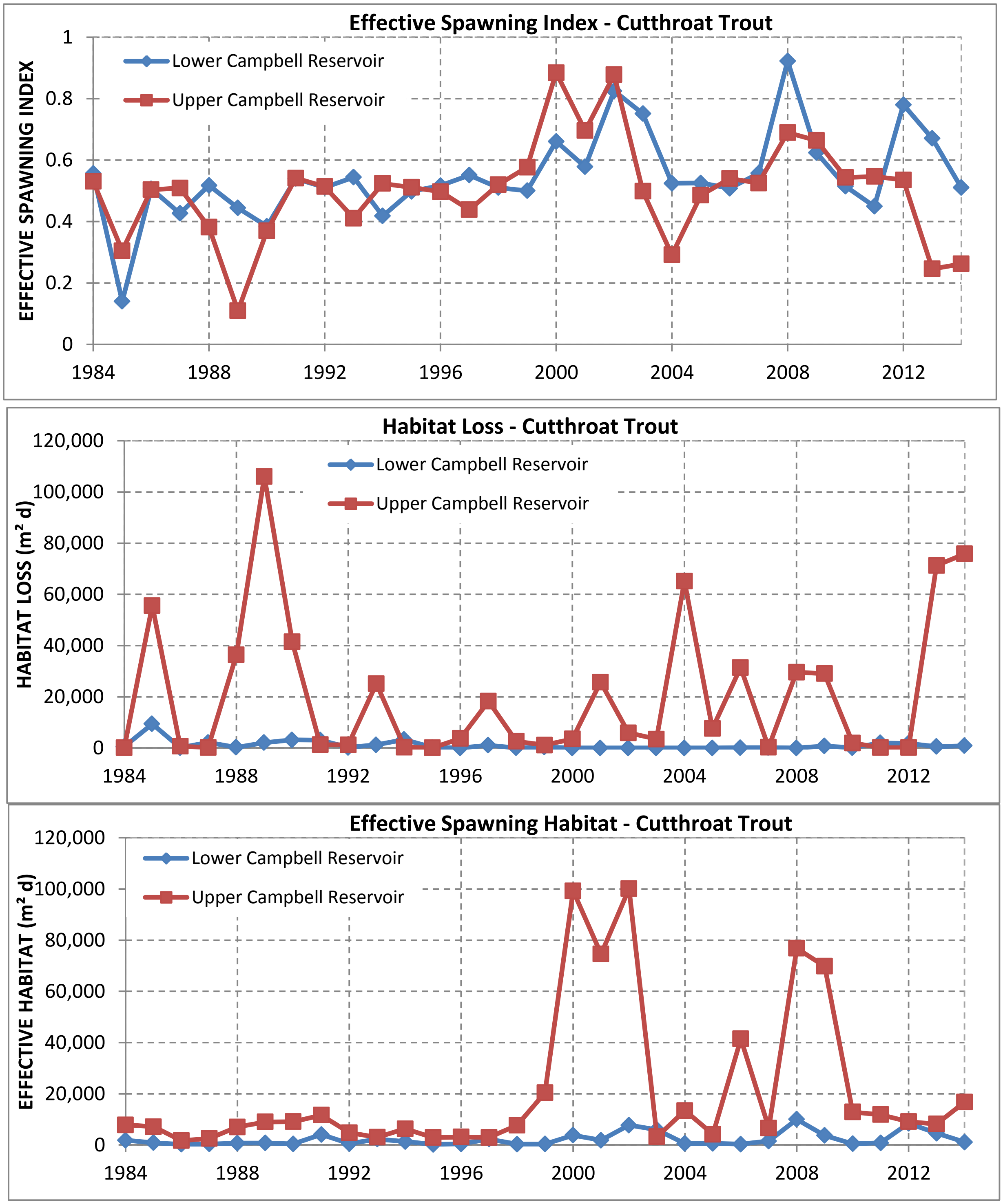
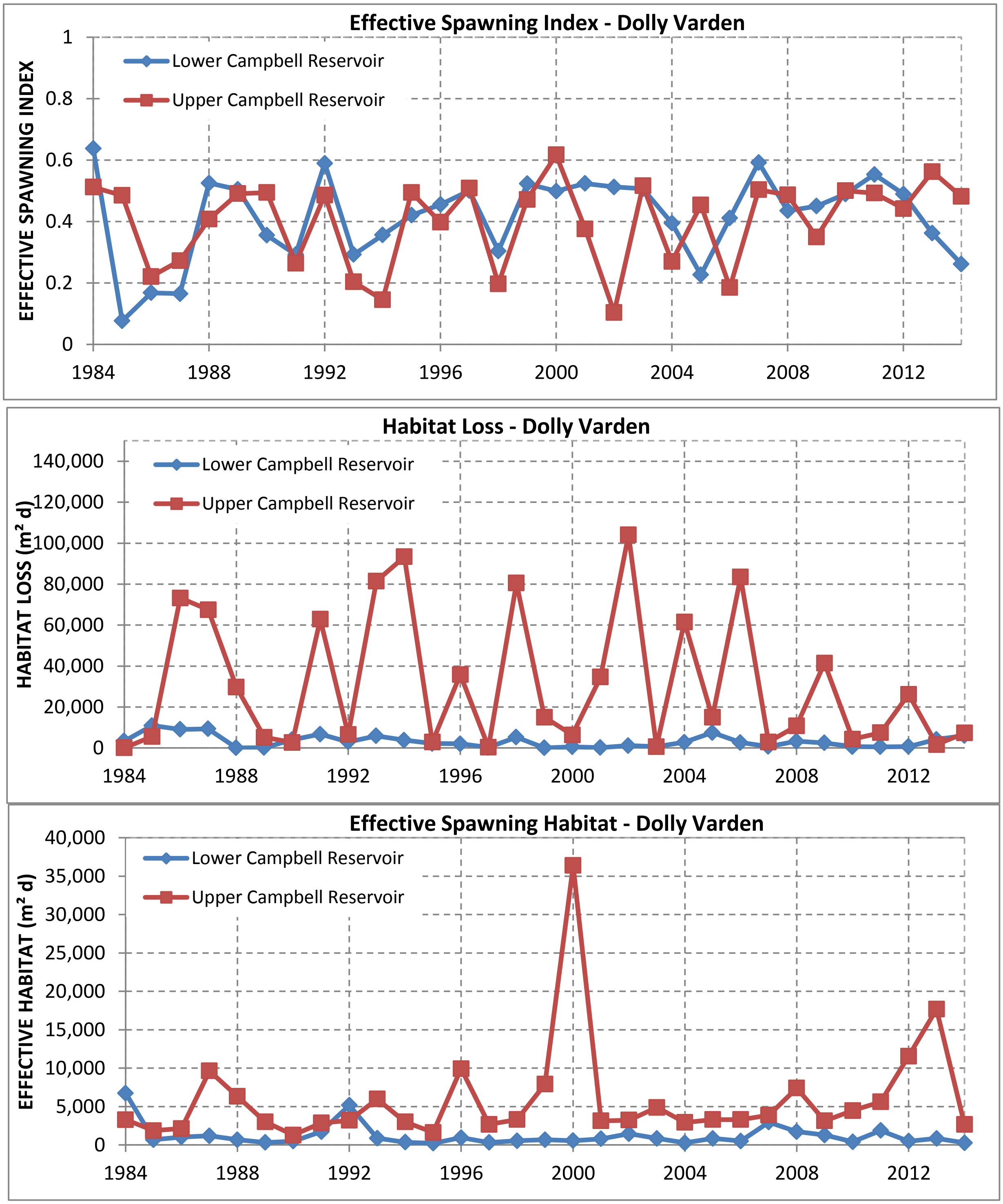


Figure 32. ESH model results for Dolly Varden.



3.3.2. Power Analysis Using Snorkel Data

The purpose of the power analysis using the ESH and tributary snorkel data was to evaluate if an effect from the WUP could be detected within a reasonable sampling timeframe (20 years or less). Based on the power analysis results for the ESH data (Figure 33) and the tributary snorkel data (Figure 34 and Figure 35), greater statistical power could be achieved by increasing the number of monitoring years after the WUP or by altering assumptions regarding potential effect size from the WUP implementation.

Based on the available ESH time series data, we would be able to detect a smaller effect for Rainbow Trout ESH than for Cutthroat Trout ESH or Dolly Varden ESH (Figure 33). We could detect an 80% increase in Rainbow Trout ESH in eleven years for Lower Campbell Reservoir, and in six years for Upper Campbell Reservoir, with a power of 0.8. Additional monitoring years would be required to detect a 100% increase in Cutthroat Trout or Dolly Varden ESH for Lower and Upper Campbell reservoirs with a power of 0.8.

For every tributary except Henshaw Creek, an effect size of 100% could be detected for Rainbow Trout abundance after 20 years of post-WUP monitoring. Thelwood Creek had the greatest power compared to the other tributaries and an effect size of 60% could be detected within six years with a power of 0.8 (Figure 35) while upper Elk River had the second greatest power where an effect size of 60% could be detected within 20 years with a power of 0.8 (Figure 34). For all tributaries except for Thelwood Creek and upper Elk River, an extensive monitoring period of 20 years could only detect large magnitude changes (>80%) in Rainbow Trout abundances based on available snorkel data.

Although these results suggest that a large (100%) increase in adult abundance could be detected for several systems with a power of 0.8 within 20 years of monitoring, there are methodological and biological reasons that a change in adult abundance may not be detected using the current snorkel methods. For the analysis, we made the following assumptions regarding the snorkel observations:

1. Observer efficiencies do not differ between sampling years;
2. The proportion of adults that return to each stream is fixed across years and does not change in relation to abundance, flow, temperature, or other factors;
3. Snorkel surveys are completed at the same time each year during the Rainbow Trout spawning period and spawning periodicity is assumed to be constant;
4. Size bin designation differences between snorkel sampling years do not result in varying adult observations;
5. Varying values in ESH are fixed proportionally across tributaries across years. Therefore, two years with the same ESH value are likely to have the same amount of habitat within each tributary; and
6. Any harvest rates that occur in the Upper and Lower Campbell reservoirs are consistent across years and any changes in adult observations are not caused by varying harvest effort.

It is unlikely that all these assumptions are valid. Therefore, the true likelihood of detecting a large (100%) increase in adult abundance may be lower than our power estimates imply.

Figure 33. Power to detect changes in ESH as a function of monitoring years post WUP implementation. Results are presented separately by species and reservoir.

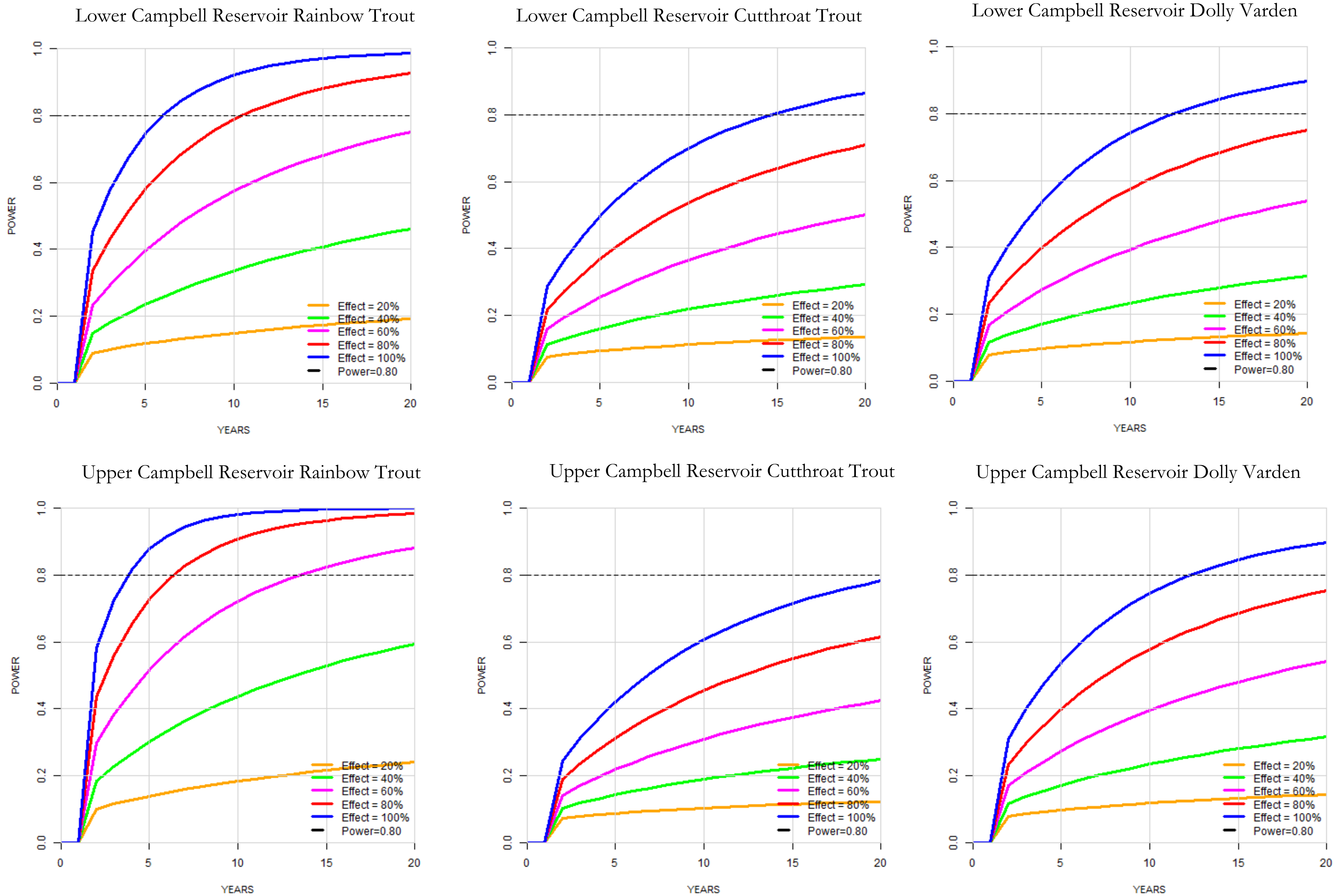


Figure 34. Power to detect changes in Elk River, Ralph Creek and Henshaw Creek adult Rainbow Trout fish abundance using current snorkel methods.

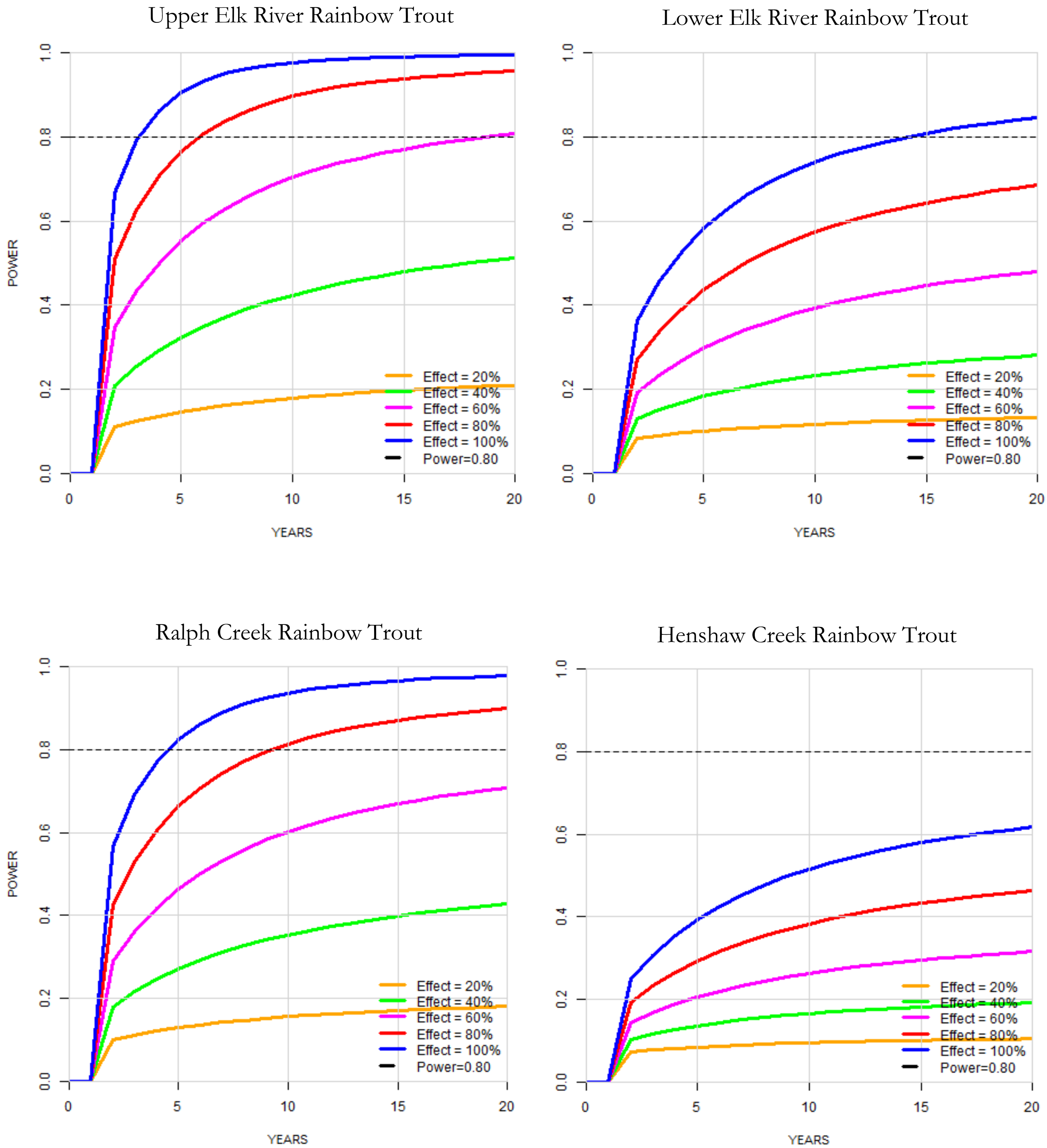
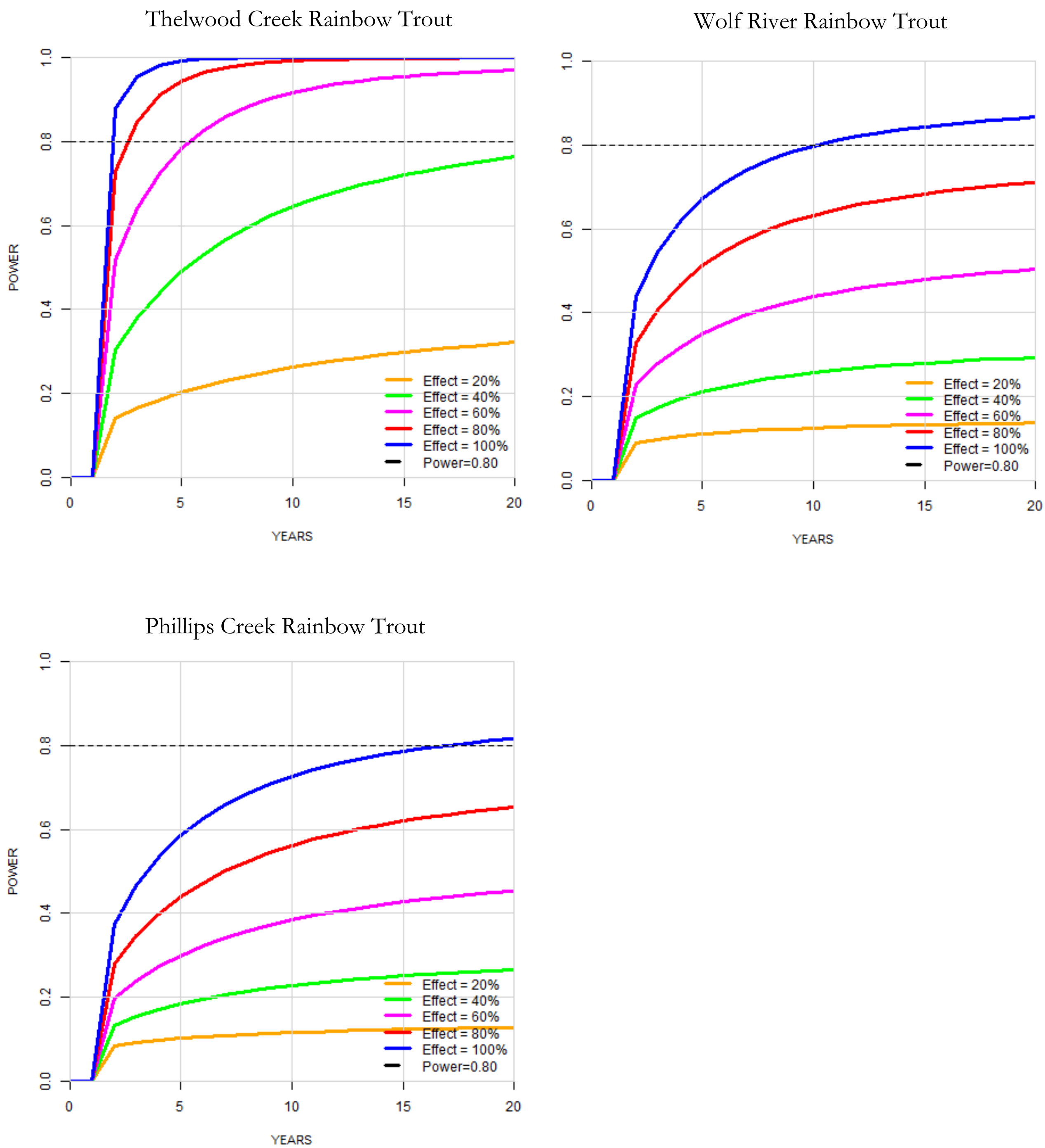


Figure 35. Power to detect changes in Thelwood Creek, Wolf River, and Phillips Creek adult Rainbow Trout fish abundance using current snorkel methods.



3.3.3. Correlation Analysis Using Population Model Simulation

The purpose of the correlation analysis using population model simulation results was to evaluate the effectiveness of comparing a single year's effect (ESH) against a grouped cohort dataset (adult abundance). When comparing the correlation results, the grouped adult abundance did not have the same correlation strength (r^2 value) vs. ESH values, in comparison to YOY abundance (Figure 36). Assuming that annual survival was consistent across all years, no scenario had a correlation with a similar r^2 value to the YOY result. Several scenarios (ESH t-1 and ESH t-5) had slopes that were negative (Figure 36), suggesting that an increase in ESH will result in a decrease in adult abundance; which is incorrect based on the model structure. This demonstrates that potential false correlations could be detected using grouped adult data against ESH data.

The only scenario that had a high r^2 value ($r^2 = 0.83$) and a positive slope was when adult abundance was compared against ESH values that were lagged by three years (ESH t-3). This was likely due to the ESH t-3 values corresponding to the year where the age 3 cohort emerged. The adult fish abundance was primarily (60%) composed of age 3 fish since the adult abundance estimate was composed of age 3+ fish and a relatively low annual survival rate of 0.4 was assumed. Since a low annual survival rate was used, the entire adult population would primarily be composed of a single age cohort. If the annual survival rate was high (0.6), then age 3 fish would only represent 43% of the adult population and the correlation strength between adult abundance and ESH t-3 would likely decrease.

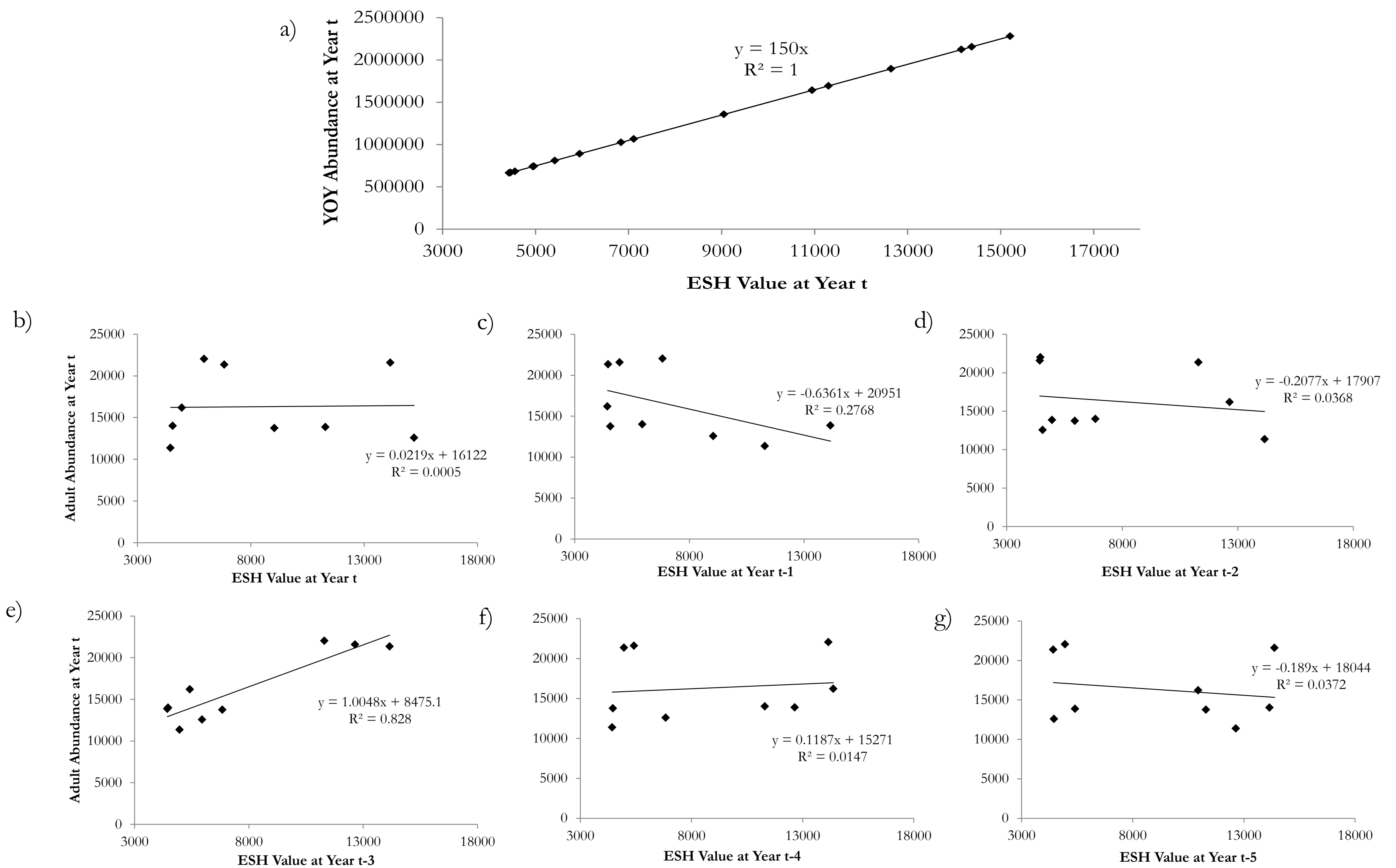
Although the r^2 value and positive slope for the comparison of adult abundance and ESH t-3 support the expected results, there are numerous considerations that suggest that the high observed r^2 for adult abundance may be optimistic compared to natural conditions. The first consideration is that we used a perfect correlation ($r^2= 1.0$) between YOY abundance and ESH. It is unlikely that a perfect correlation between YOY production and ESH exists, as other influences and random variation would weaken the correlation. A weaker correlation between YOY abundance ESH is expected to further weaken the correlation strength between adult abundance and ESH. This suggests that an r^2 value of 0.8 for a comparison between adult abundance and ESH is unlikely and that detection of a true correlation between YOY production and ESH would be difficult using adult abundance to infer a change in productivity.

Another consideration is the fixed survival rates between years. In the model simulations, we assumed fixed survival rates and therefore any change in adult abundance between years was solely due to changes in ESH. Under natural conditions, we would expect annual variation in survival rates across age classes due to changes in environmental conditions such as flow and temperatures, changes in predator, prey, and competitor abundances, and changes in harvest effort in the reservoirs. All of these factors can result in variable survival across years and weaken the correlation strength between ESH and adult abundance.

A final consideration is that this simple model assumes no uncertainty in adult abundance for each year. Uncertainty in abundance can be created from the uncertainty from sampling collection methods (i.e., observation error). The exact cause or mechanism of this uncertainty is inconsequential; however, the effect of this uncertainty will likely reduce the correlation strength between ESH and adult abundance.

These results demonstrate that the correlation strength between fish abundance and ESH decreases when multiple age cohorts are grouped together. Although we were able to detect a correlation between adult abundance and ESH for one of the time lags, the likelihood that such an r^2 value would be detected under natural conditions is low. This suggests that if a true correlation between productivity and ESH exists, it may not be detected using adult abundance to measure response to changes in ESH.

Figure 36. Correlation results for (a) YOY abundance and adult abundances against Effective Spawning Habitat (ESH) (b) for the current year (Year t), (c) lagged one year (Year t-1), (d) lagged two years (Year t-2), (e) lagged three years (Year t-3), (f) lagged four years (Year t-4), and (g) lagged five years (Year t-5).



3.3.4. Correlation with Current Rainbow Trout Estimate

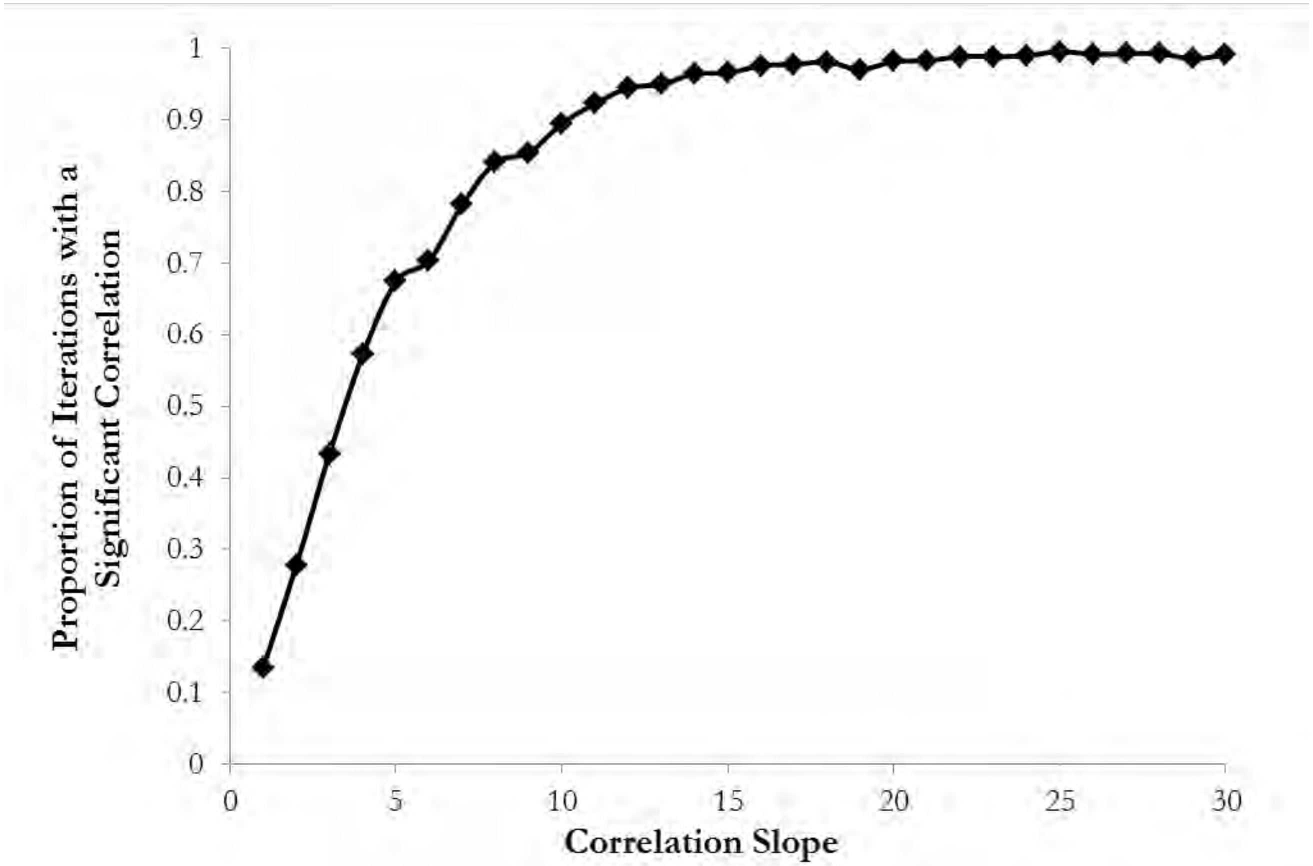
The purpose of the correlation simulation using the 2014 hydroacoustic estimate of Rainbow Trout in Upper Campbell Reservoir was to evaluate if the level of uncertainty present in the reservoir adult abundance estimate is too great to detect relatively small magnitudes of effect (correlation slope) between ESH and adult abundance. The proportion of iterations in which a statistically significant correlation was detected increased as the slope increased (Figure 37). The greatest incremental change in the proportion values was observed at low slope values, where an increase in slope had a much greater effect for a low slope value than an equal magnitude of increase at a higher slope value. Based on these results, only relationships that had intermediate magnitude of effect or greater (slope values $\geq$ 8) between ESH and adult abundance have a strong likelihood (>0.80) of being detected. These results demonstrate that a moderately strong relationship between ESH and adult abundance is required for a response to WUP operations to be detected with some certainty.

There are multiple reasons why these results may underestimate the minimum magnitude of effect that would likely be detected. The results are based on the assumption that the population estimate's 95% confidence limit remains 60% of the mean value and is consistent between years. The 60% value was based on results for the entire fish population within Upper Campbell Reservoir. Confidence limits for individual species are likely to be greater, particularly for the least abundant species. A broader 95% confidence limit would result in a higher minimum detected magnitude of effect.

We assumed a linear relationship between mean abundance of adult fish and the ESH value, with no variance in this relationship. Under natural conditions, there would be variance in the correlation, which would likely further decrease the probability of detecting a significant response. The results of this analysis are also dependent on the ESH values used in the analysis. We used values from the past ten years (2005-2014) as a sample of the possible ESH values that may be observed in subsequent years; however, the ability to detect a significant correlation depends on the range of observations in the independent variable data (ESH). If the range of ESH values is less than that assumed here, then the probability of detecting a statistically significant correlation will be less. These results also depend on the number of data points included in this analysis. We used ten data points; however, if fewer sampling years are analysed, then this will reduce the likelihood of detecting a significant correlation.

In summary, these results demonstrate that there is a low likelihood of detecting a small magnitude of effect given the level of uncertainty in adult abundance estimated from the 2014 hydroacoustic survey. Several factors were not directly accounted for in this analysis, such as larger confidence limits, variance in the ESH vs. recruitment relationship, a small range of ESH values, and fewer sampling data. These factors are expected to further decrease the likelihood of detecting an effect.

Figure 37. Correlation slope against the proportion of simulation iterations with a significant correlation for adult Rainbow Trout in the Upper Campbell Reservoir.



4. CONCLUSIONS

4.1. Population Estimate for Upper and Lower Campbell Reservoirs

Coordinated acoustic and gill net surveys were successfully completed in August 2014, with sampling of all the planned acoustic transects and gill net stations during the prescribed day and night periods. In the time allotted for the acoustic survey weather conditions were suitable for down and side-looking observations on nearly all transects (side-looking data was unsuitable on just two transects due to rough reservoir surface conditions), which was sufficient for the data analysis requirements. The preliminary gill netting sampling plan was altered to sample an offshore midwater fish layer observed with acoustics that proved to hold an important part of the Rainbow Trout population. After acoustics showed a sizeable component of fish < 100 mm long in the reservoir, limited small-mesh gill netting was added to the sampling program to obtain some species information about this size group.

Estimates of fish abundance in Upper Campbell Reservoir are low compared to those from three other BC reservoirs that have been surveyed using similar techniques (night-time coordinated acoustics and gill netting). The whole-reservoir total areal abundance estimate (all species combined) of 148 fish/ha for Upper Campbell Reservoir is considered to be comparably low, based on estimates of 137-522 fish/ha in 2005-2013 from the Stave Reservoir (Stables and Perrin 2014), and estimates of 538 fish/ha from the Coquitlam Reservoir (Bussanich *et al.* 2005). This estimate is also much lower than historical estimates from John Hart Reservoir of 681 fish/ha in October 2010, and 1,009 fish/ha in August 2013 (Stables and Perrin 2011; Stables *et al.* 2013). Abundance of Rainbow Trout (9 fish/ha) in Upper Campbell Reservoir was in the range of estimates for John Hart Reservoir (17.3 fish/ha in 2010 and 7.24 fish/ha in 2013), but Cutthroat Trout abundance in Upper Campbell Reservoir (1.8 fish/ha) was much lower than in John Hart Reservoir (13.4 fish/ha in 2010 and 21.6 fish/ha in 2013). The total abundance estimate for Upper Campbell Reservoir is considered accurate because it was largely composed of small fish, probably Threespine Stickleback, for which acoustic survey spatial coverage was adequate (these fish appeared to move into the water column at night). The precision of this total estimate (95% CL ±60% of the estimate) was poorer than is typical (e.g. ±14% in 2010 and ±39% in 2013 at John Hart Reservoir) due to a patchy distribution of fish in the reservoir at the time of the survey. The estimate of trout abundance is very likely an underestimate because, except for the midwater layer of larger Rainbow Trout in the main reservoir basin, many trout were concentrated in the nearshore zone that was under-sampled by the chosen acoustic survey design, and most trout < 150 mm long were in the littoral zone that is impractical to sample with mobile acoustics.

Gill netting provided satisfactory species composition for large fish but not for small ones. Species composition data were good for fish ≥ 100 mm long, which were sampled by RISC nets, although the number of stations and sets was small for a 2,869 ha reservoir. However, the amount of RISC gill net effort that was expended was in keeping with the plan that the survey should be a pilot study.

The minimal sampling effort expended with small-mesh nets (2 sets) was in insufficient for obtaining a good estimate of species composition of the 70-100 mm size category, which included small trout. Considering differences of catchability of trout and sticklebacks in gill nets, this goal may be difficult to achieve in any case. Also, if trout of this size are mostly littoral in their distribution, they are not suitable for assessment with acoustics. Lack of quantitative species composition information about the smallest size group of fish observed with acoustics (≈10-30 mm long) was probably less important because they were almost certainly too small to be salmonids, and were probably sticklebacks. In future studies it would be advisable to confirm identity of these, at least qualitatively.

This study provided considerable detailed information about the night-time spatial distribution of fish in the reservoir during late summer in the warm, highly stratified conditions that existed during the surveys. The following comments refer to the night-time period when most sampling was conducted. Small fish, probably Threespine Stickleback, were found in all the reservoir basins, but their densities were especially high in the south bay. Both Rainbow Trout and Cutthroat Trout were also found in all reservoir basins, whereas only a single Dolly Varden was captured in the north bay. Throughout the reservoir, Cutthroat Trout were concentrated in the nearshore zone, with highest densities at the 20 m depth contour, and few fish farther offshore. In contrast, Rainbow Trout densities were high in shallow layers of the nearshore zone and in an offshore layer at 15-20 m, though this species was also found in low density near the reservoir surface of the offshore zone. When defined in terms of this pattern, there was a clear boundary between nearshore and offshore zones at the 20 m depth contour. Small Rainbow Trout < 150 mm long were concentrated in the littoral zone where temperatures were near or above 20°C (surface temperatures at mid-reservoir water quality stations were 20-21°C), whereas larger trout in the 15-20 m depth range experienced temperatures of 10-17°C. These spatial patterns are characteristic of interactive segregation and thermal habitat partitioning typical of coexisting Rainbow Trout and Cutthroat Trout populations in Pacific Northwest lakes (Nilsson and Northcote 1981; Stables and Thomas 1992; Stables and Perrin 2011). Size-related temperature preferences of Rainbow Trout have also been noted by others (e.g., Spigarelli and Thommes 1979).

4.2. 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 reservoirs. The 2014 snorkel survey results were similar to historic survey results for all tributaries except for Fry Creek where no adult fish were observed during the snorkel survey in 2014.

4.3. Critical Assessment of Current Experimental Design Using Statistical Modelling

The ESH PM was calculated for Rainbow Trout, Cutthroat Trout, and Dolly Varden and these results, along with the hydroacoustic adult abundance data and snorkel survey results, were used to complete three statistical analyses to inform a critical assessment of the current experimental design.

The power analysis using the ESH and tributary snorkel data demonstrated that only large effect changes in ESH for Rainbow Trout (≥60%), Cutthroat Trout (≥100%), and Dolly Varden (≥100%) could be detected with a power of 0.8 after 20 years of monitoring. The power analysis using Rainbow Trout abundances in the reservoir tributaries were similar, as only large effect size in Rainbow Trout abundance (≥80%) could be detected with a power of 0.8 after 20 years of monitoring for the majority of snorkelled tributaries. The correlation analysis using the population model simulation results demonstrate that the correlation strength between fish abundance and ESH decreases when multiple age cohorts are grouped together and that a true correlation between productivity and ESH may not be detected when using adult abundance to measure response to changes in ESH. Finally, the correlation analysis using the Rainbow Trout abundance estimate from the 2014 hydroacoustic survey demonstrated that there is a low likelihood of detecting a small magnitude of effect from changes in ESH.

Results of the statistical modelling analyses demonstrate that based on the current experimental design it is likely that only large changes in ESH or adult fish abundance would be detected.

5. RECOMMENDATIONS

5.1. Population Estimate for Upper and Lower Campbell Reservoirs

The gill netting, minnow trapping and acoustic survey findings established that minnow trapping was ineffective for capturing juvenile salmonids in all locations surveyed and that night-time was optimal for acoustic sampling, as is true for many but not all trout populations, including that of nearby John Hart Reservoir (Stables and Thomas 1992; Yule 2000; Stables and Perrin 2011). The high proportion of trout close to shore in Upper Campbell Reservoir was problematic for acoustics. This was unexpected because previous acoustic surveys of John Hart Reservoir found that trout were much more midwater and pelagic at night, and were therefore amenable to acoustic assessment (Stables and Perrin 2011; Stables *et al.* 2013). Some modifications to the acoustic survey design for Upper Campbell Reservoir could help with this problem. Adding a nearshore stratum to the sampling design and allocating a significant amount of acoustic sampling effort to it would improve coverage for trout. Sampling parallel to shore (or zigzagging) with the transducer pointed shoreward might be a useful approach in the nearshore zone (e.g., Stables 2013). Trout may be less shore oriented at other times of year than they were in late August, so a change in survey timing should be considered. However, if trout in Upper Campbell Reservoir remain close to shore at all times, these measures would be ineffective and sampling methods other than acoustics might be better for assessing trout in this waterbody. For example, fyke netting, short duration gill net sets, or electrofishing performed individually or in some combination can be effective for sampling trout in shallow water to estimate their abundance by mark-recapture methods.

5.2. Snorkel Survey of Spawners in Reservoir Tributaries

Snorkel surveys during the Year 1 study were limited to Rainbow Trout spawning. This will be followed in Year 2 by surveys to include both the Rainbow Trout and Cutthroat Trout spawning seasons. The addition of a project-specific snorkel survey program, moving away from the BCCF study scope to include detailed redd-counts and an improved methodology to increase the accuracy of adult abundance in the spawning tributaries is recommended. Snorkel surveys alone may not be sufficient to quantify age-specific abundances in the tributaries, and additional enumeration of juvenile fish should also be considered in these tributaries to provide greater confidence to the statistical analysis.

5.3. Critical Assessment of Current Experimental Design Using Statistical Modelling

The results of the ESH model, in view of the model structure and input, would be improved using additional temperature data; the use of year-specific temperatures is recommended, when available. Incorporating more recent, updated temperature data will improve the accuracy of the ATU estimates and in turn, improve the ESH estimates. It is recommended that appropriate metrics for calculation are adopted. The effective spawning index is not an appropriate index, as the amount of habitat loss and ESH both influence the index value; therefore the effective spawning index for each year should no longer be used as a metric.

The results of the three separate statistical explorations demonstrate that a correlation between ESH and adult abundance is unlikely to be detected, unless adult abundance is affected solely (or predominantly) by ESH and there is at least an intermediate magnitude of effect (i.e., slope of abundance vs. ESH is moderately steep, and range of observed ESH is fairly broad; see Figure 36). This result is due to the high uncertainty in adult abundance estimates (i.e., observation error), as well as methodological weaknesses of comparing multiple age cohorts (adult abundance) against single year ESH values. Currently, we have insufficient data to quantitatively assess whether adult abundance is affected solely (or mostly) by ESH, or by other factors, or whether the slope of the correlation is moderately high. However, we believe it would be risky to assume either, especially given that there is considerable spawning habitat above the reservoir drawdown zone that is unaffected by WUP operations. We recommend that the experimental design for JHTMON-3 be reconsidered.

The two most substantive improvements to the current experimental design include:

1. Gathering juvenile fish abundance data as well as adult abundance data during reservoir population sampling; and
2. Determining the abundance of age cohorts for each species by collecting and analysing scale or fin ray samples of sampled fish during tributary and reservoir sampling.

Collecting age-specific abundance data for both adult and juvenile fish would greatly improve the experimental approach. Implementing these improvements would allow single year cohort data to be compared against single year ESH values. Comparing single year cohort data against ESH values instead of grouped cohort data would improve the likelihood of detecting a statistically significant correlation between productivity and ESH.

The cost implications of these improvements have not been explored in detail, and it may not be feasible to implement these changes within the current scope and budget. Providing detailed recommendations for substantive changes in experimental design is beyond the scope of this report. A critical review of these and other scope changes is recommended prior to implementing the Year 2 program.

5.4. Summary of Year 1 Recommendations

The Year 1 recommendations provided out for each component of the JHTMON-3 study are summarized in Table 25.

Table 25. Summary of Year 1 Recommendations for JHTMON-3.

Number	Study Component	Recommendation
1	Population Estimate	Modification to the acoustic survey design to account for, or capture, fish in shallow, near-shore areas. Adding a nearshore stratum to the sampling design and allocating a significant amount of acoustic sampling effort to it would improve coverage for trout.
2		If trout in Upper Campbell Reservoir remain close to shore at all times, acoustic sampling effort would be ineffective and alternative sampling methods should be considered for assessing trout in this waterbody.
3	Snorkel Surveys	A project-specific snorkel survey program should be developed to address the data gaps identified in the Year 1 statistical analysis.
4	Critical Assessment of Experimental Design	The results of the ESH model would be improved using additional year-specific temperature data.
5		The effective spawning index for each year should not be used as metric for the ESH calculation.
6		The statistical analysis demonstrated that the JHTMON-3 experimental design should be re-evaluated.

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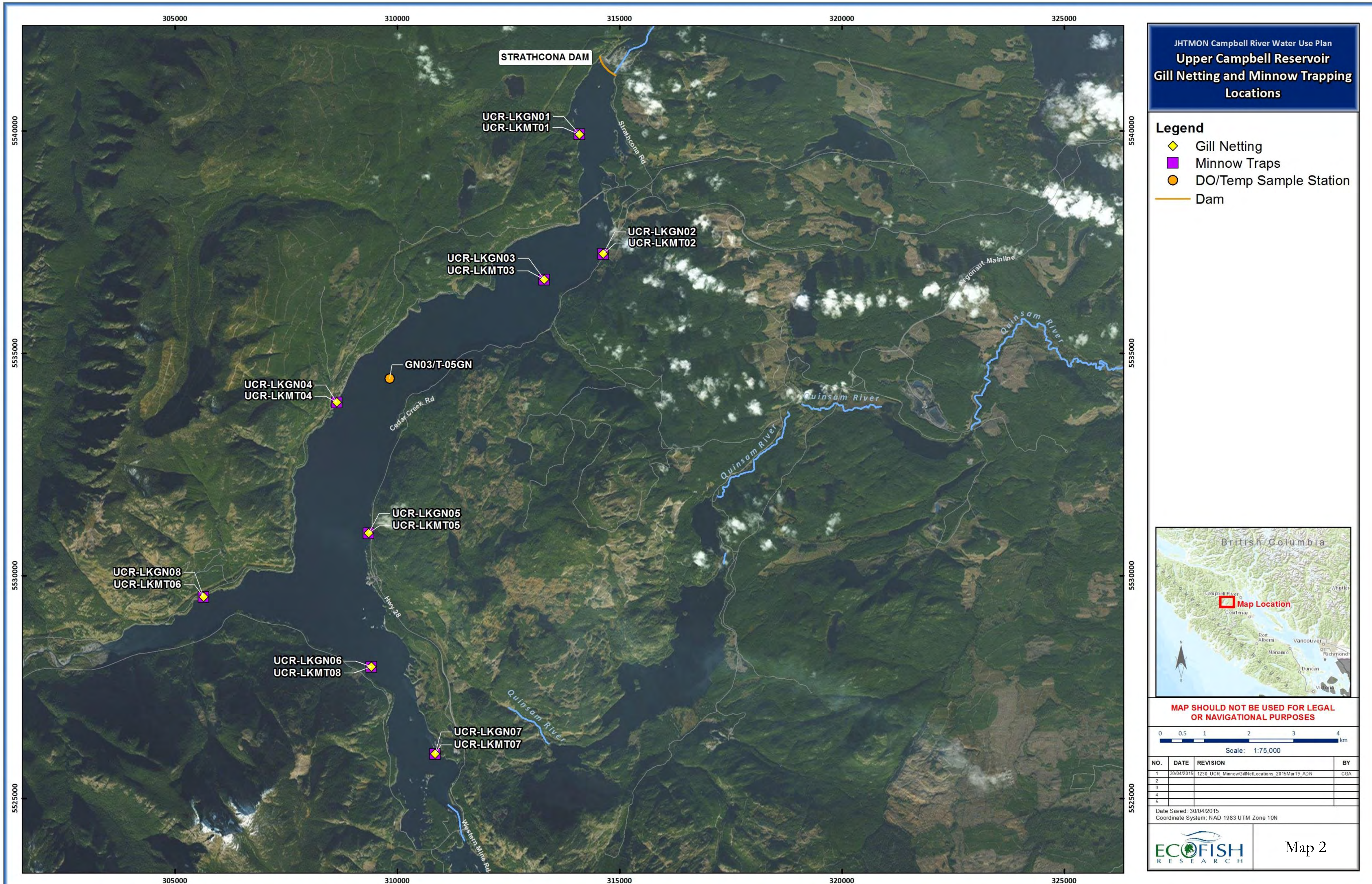
PROJECT MAPS



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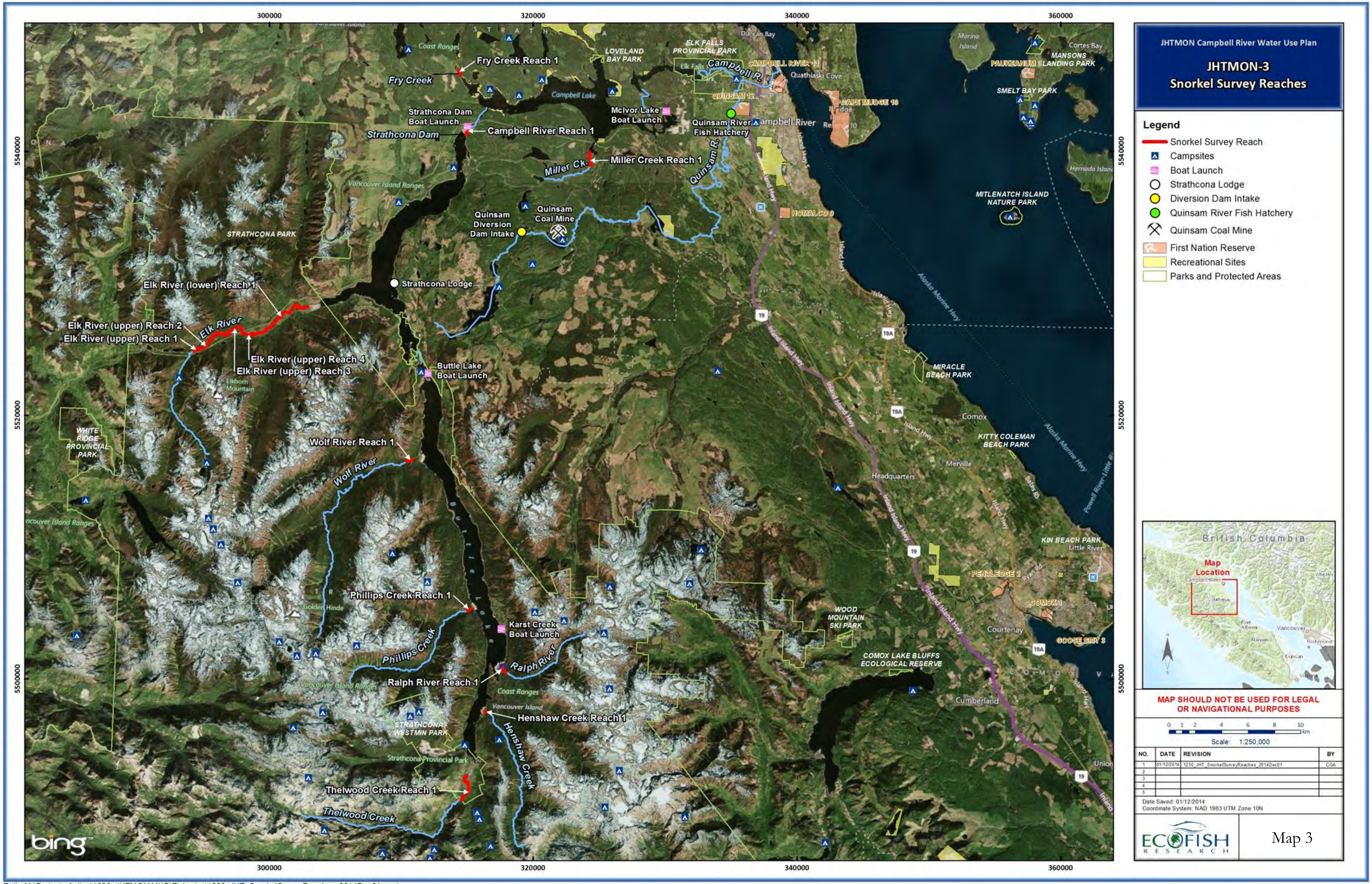

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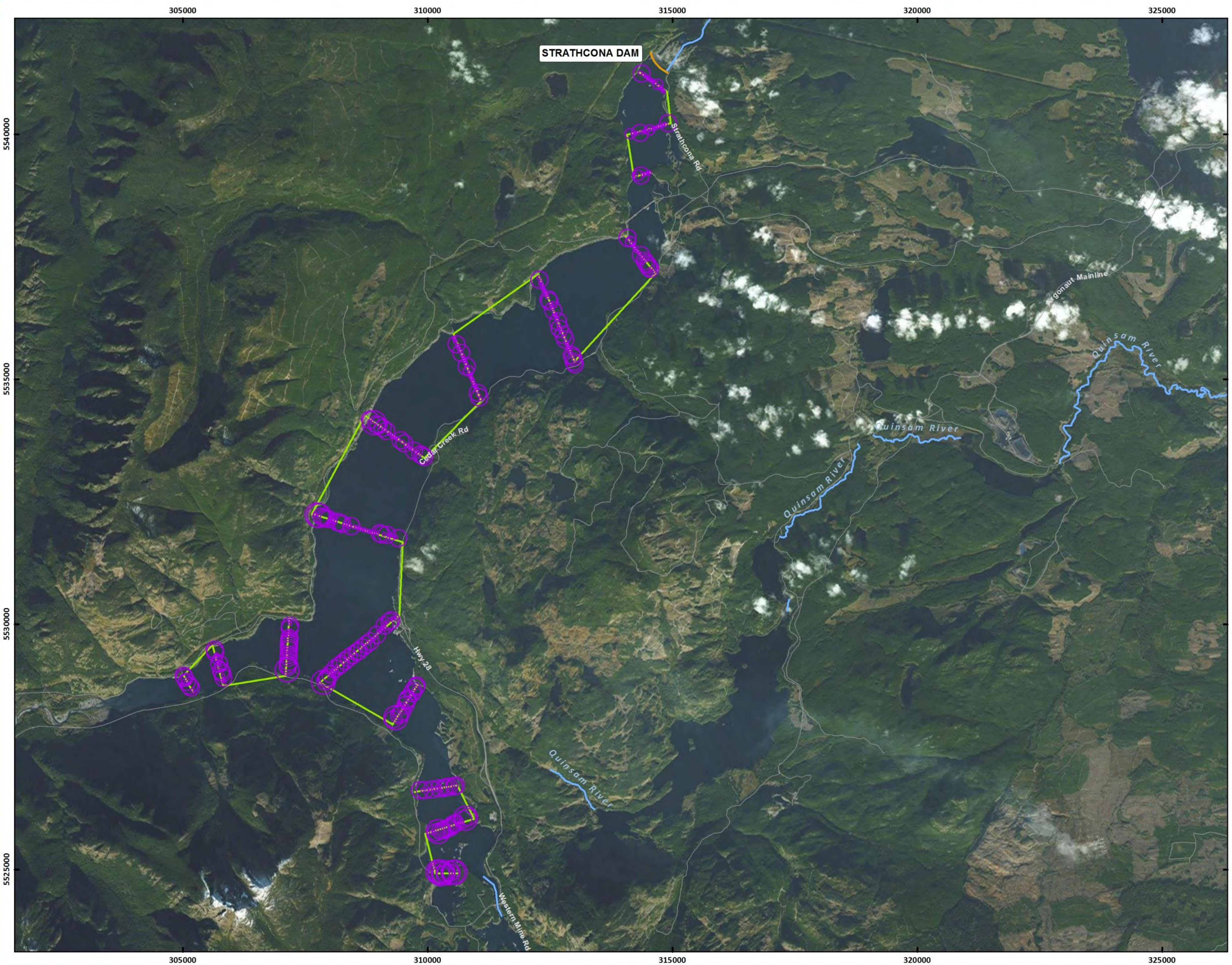

JHTMON Campbell River Water Use Plan

Upper Campbell Reservoir Acoustic Sampling Fish Density

Legend

Fish Density

- <10 fish/ha
- 10 - 100 fish/ha
- 100 - 1,000 fish/ha
- 1,000 - 10,000 fish/ha
- Acoustic Sampling Transects
- 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	30/04/2015	1230_JHT_UpperCampbell_AcousticFishSampling_2015Mar24	CGA
2			
3			
4			
5			

Date Saved: 30/04/2015
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 4

Path: M:\Projects-Active\1230_JHTMON\MXD\Fisheries\1230_JHT_UpperCampbell_AcousticFishSampling_2015Mar24.mxd

APPENDICES

Appendix A. Ecofish Aging Structure Collection and Analysis Protocol.

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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).

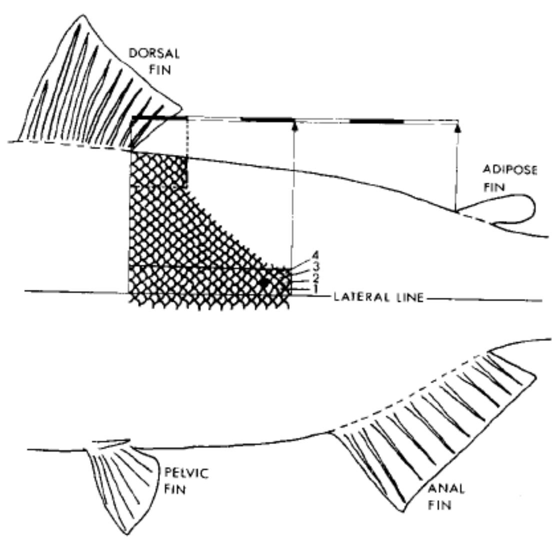
2. METHODS

2.1. Sample Collection and Preparation

2.1.1.Scales

The method for collecting scales depends on fish size. 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 same area. The scales are smeared or placed onto a microscope slide, taking care to separate overlapping scales. A second slide is placed over the scales to sandwich them between the two slides. The slides are then taped together with scotch tape. Each sample placed within a labelled scale envelope. Scale samples are stored in a plastic container (specific to the Project file) inside a locked metal filing cabinet.

Figure 1. The preferred area for removing scales from a fish (crosshatched area posterior to dorsal fin) (Sjolund 1974).



2.1.2. Fin Ray

Fin ray samples can be taken from either the pectoral or pelvic fins. Two or three of the longest rays are removed from the fin by clipping them near the base of the fin and peeling the fin ray back. Fin rays are placed in a labelled scale envelope.

Fin ray samples are dried in the laboratory and cut into 0.5-1.0 mm sections using a fine cut-off blade. If the fin rays are small and brittle, they are be covered in epoxy so that they stay together when cut. Electricians tape is wrapped around the fin ray to prevent the cuttings from flying away. Sections are cut from the base of the fin ray. Eye protection is worn when sectioning fin rays. The cut cross-sections are polished and mounted on microscope slides with Krazy Glue. A drop of thin oil or water can be applied to the fin ray to enhance the appearance of winter annuli when viewing through the microscope.

2.1.3. 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.

2.2. 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.

2.3. 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 (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. Each technician ages the samples independently without any other aging information or biological data (length or weight) for the fish. The independent ages provided by each technician are compared to identify any discrepancies. Where ages for a single sample are different between technicians, the sample will be reviewed by a senior biologist.

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

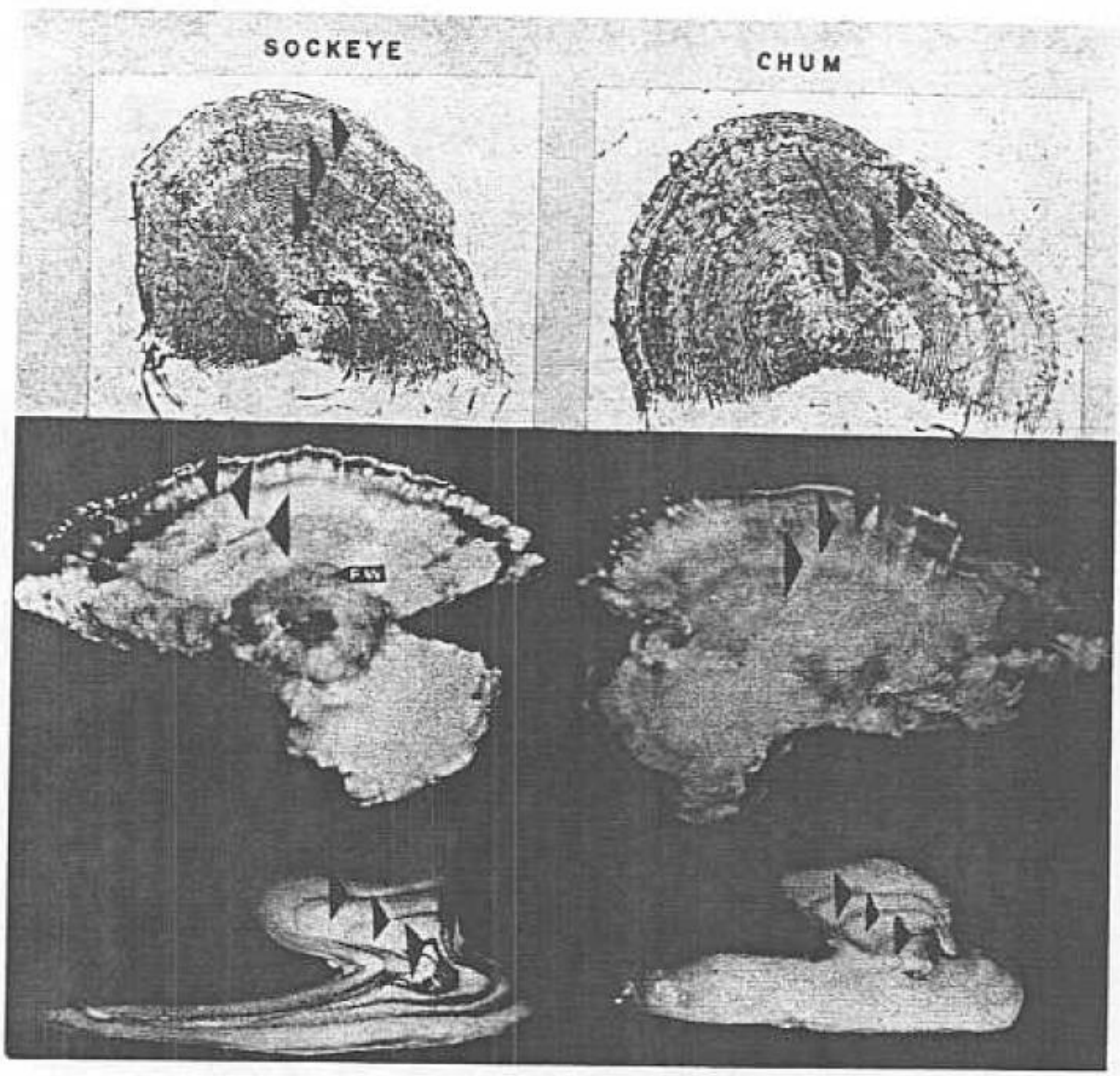


FIG. 4. Scale, otolith, and fin ray from a 1.3 sockeye and a 0.3 chum salmon: FW indicates freshwater annulus; arrows indicate ocean annuli.

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

2.4. Data

Ages are recorded in an MS Excel file (copy of the raw fish file) that is stored within the scale images folder. Once all structures have been aged, the file will be saved as a PDF within the network data sheet archive drive. An RNQA number is created and a copy of the age data is printed and filed in the appropriate Project folder and binder. If access to a computer is limited, the data is recorded onto a datasheet (Figure 3). The sheet contains information on the technician aging samples, date of aging, location, site, date collected, species, length, weight, and sample number. Once complete the datasheet is RNQAed, scanned, and filed in the appropriate Project folder and binder.

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

REFERENCES

RISC (Resources 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.

Bilton, H.T. and D.W. Jenkinson. 1969. Age determination of sockeye (*Oncorhynchus nerka*) and chum (*O. keta*) salmon from examination of pectoral fin rays. J. Fish. Res. Bd. Canada 26: 1199-1203.

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 online at: http://www.env.gov.bc.ca/wld/documents/fisheriesrpts/FTC12.pdf. Accessed on April 23, 2015.

Appendix B. Gill Net and Minnow Trap Capture Data and Representative Photographs.

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

Waterbody	Site	Habitat	Set #	Net Type	Net Length (m)	Time In	Time Out	Catch (CT)	Catch (RB)	Catch (DV)	Catch (CO)	Catch (CAS)	Catch (TSB)	Catch (CT/RB)	Catch (UNK)	Set time (hr)
Upper Campbell Lake	UCR-LKGN01	Littoral	28	Floating	91.2	17:22:00	10:15:00	0	15	0	0	0	0	0	0	16.88
Upper Campbell Lake	UCR-LKGN01	Littoral	29	Sinking	91.2	17:47:00	09:40:00	26	2	1	0	0	0	0	0	15.88
Upper Campbell Lake	UCR-LKGN02	Littoral	33	Floating	91.2	18:20:00	11:10:00	1	26	0	0	0	0	0	0	16.83
Upper Campbell Lake	UCR-LKGN02	Littoral	34	Sinking	91.2	18:35:00	10:40:00	0	10	0	0	0	0	0	0	16.08
Upper Campbell Lake	UCR-LKGN03	Pelagic	38	Floating	91.2	19:20:00	11:40:00	0	4	0	0	0	0	0	0	16.33
Upper Campbell Lake	UCR-LKGN03	Pelagic	39	Sinking	91.2	20:00:00	12:10:00	2	43	0	0	0	0	0	0	16.17
Upper Campbell Lake	UCR-LKGN03	Pelagic	45	Floating	91.2	10:10:00	14:38:00	0	1	0	0	0	0	0	0	4.47
Upper Campbell Lake	UCR-LKGN03	Pelagic	46	Sinking	91.2	10:20:00	14:20:00	0	5	0	0	0	0	0	0	4.00
Upper Campbell Lake	UCR-LKGN04	Littoral	1	Floating	91.2	15:46:00	09:56:00	7	29	0	0	0	0	1	0	18.17
Upper Campbell Lake	UCR-LKGN04	Littoral	2	Sinking	91.2	16:10:00	09:20:00	17	7	0	0	0	0	0	0	17.17
Upper Campbell Lake	UCR-LKGN04	Littoral	3	Sinking	15.8	16:55:00	09:13:00	0	2	0	0	0	0	0	0	16.30
Upper Campbell Lake	UCR-LKGN05	Littoral	4	Floating	91.2	17:15:00	10:57:00	0	0	0	0	0	0	0	0	17.70
Upper Campbell Lake	UCR-LKGN05	Littoral	5	Sinking	91.2	17:35:00	10:43:00	0	0	0	0	0	0	0	0	17.13
Upper Campbell Lake	UCR-LKGN06	Littoral	17	Floating	91.2	17:30:00	09:05:00	2	14	0	0	0	0	0	0	15.58
Upper Campbell Lake	UCR-LKGN06	Littoral	18	Sinking	91.2	17:54:00	09:25:00	11	17	0	0	1	0	0	0	15.52
Upper Campbell Lake	UCR-LKGN07	Littoral	22	Floating	91.2	18:20:00	10:51:00	2	58	0	0	0	0	1	0	16.52
Upper Campbell Lake	UCR-LKGN07	Littoral	23	Sinking	91.2	18:35:00	10:30:00	4	8	0	0	0	0	1	0	15.92
Upper Campbell Lake	UCR-LKGN07	Littoral	24	Sinking	15.8	18:55:00	10:12:00	0	1	0	0	1	1	0	0	15.28
Upper Campbell Lake	UCR-LKGN08	Littoral	9	Floating	91.2	18:25:00	11:23:00	6	9	0	0	0	0	0	0	16.97
Upper Campbell Lake	UCR-LKGN08	Littoral	10	Sinking	91.2	18:46:00	11:30:00	12	4	0	0	0	0	1	1	16.73
Upper Campbell Lake	UCR-LKGN08	Littoral	40	Floating	91.2	09:05:00	13:25:00	0	4	0	0	0	0	0	0	4.33
Upper Campbell Lake	UCR-LKGN08	Littoral	41	Sinking	91.2	09:20:00	13:42:00	3	0	0	0	0	0	0	0	4.37

[1] CT- Cutthroat Trout, RB - Rainbow Trout, DV - Dolly Varden, CO - Coho Salmon, CAS - Prickly Sculpin, TSB - Threespine Stickleback, CT/RB - Cutthroat Trout/Rainbow Trout Hybrid, UNK - Unknown

Table 2. Individual trap set and capture data for Upper Campbell Lake minnow trapping.

Waterbody	Site	Trap #	Mesh Size (in)	Set Date	Time In	Time Out	Depth (m)	Catch (CAS[1])	Soak time (hr)
Upper Campbell Lake	UCR-LKMT01	30	0.125	28-Aug-14	17:55:00	10:25:00	0.5	0	16.50
Upper Campbell Lake	UCR-LKMT01	31	0.125	28-Aug-14	18:01:00	10:30:00	5.0	0	16.48
Upper Campbell Lake	UCR-LKMT01	32	0.125	28-Aug-14	18:04:00	10:34:00	7.0	0	16.50
Upper Campbell Lake	UCR-LKMT02	35	0.125	28-Aug-14	18:48:00	11:00:00	0.5	0	16.20
Upper Campbell Lake	UCR-LKMT02	36	0.125	28-Aug-14	18:50:00	11:02:00	6.0	1	16.20
Upper Campbell Lake	UCR-LKMT02	37	0.125	28-Aug-14	18:55:00	11:05:00	8.0	3	16.17
Upper Campbell Lake	UCR-LKMT04	14	0.125	26-Aug-14	19:09:00	10:25:00	2.0	0	15.27
Upper Campbell Lake	UCR-LKMT04	15	0.125	26-Aug-14	19:13:00	10:22:00	5.5	1	15.15
Upper Campbell Lake	UCR-LKMT04	16	0.125	26-Aug-14	19:17:00	10:29:00	7.9	2	15.20
Upper Campbell Lake	UCR-LKMT05	6	0.125	26-Aug-14	17:52:00	11:01:00	6.0	1	17.15
Upper Campbell Lake	UCR-LKMT05	7	0.125	26-Aug-14	18:00:00	11:07:00	0.5	2	17.12
Upper Campbell Lake	UCR-LKMT05	8	0.125	26-Aug-14	18:02:00	11:10:00	13.0	1	17.13
Upper Campbell Lake	UCR-LKMT06	19	0.125	27-Aug-14	18:04:00	09:52:00	6.0	1	15.80
Upper Campbell Lake	UCR-LKMT06	20	0.125	27-Aug-14	18:05:00	09:50:00	2.3	7	15.75
Upper Campbell Lake	UCR-LKMT06	21	0.125	27-Aug-14	18:07:00	09:45:00	7.8	1	15.63
Upper Campbell Lake	UCR-LKMT07	25	0.125	27-Aug-14	19:05:00	11:05:00	0.5	0	16.00
Upper Campbell Lake	UCR-LKMT07	26	0.125	27-Aug-14	19:09:00	11:12:00	8.0	1	16.05
Upper Campbell Lake	UCR-LKMT07	27	0.125	27-Aug-14	19:12:00	11:15:00	7.0	1	16.05
Upper Campbell Lake	UCR-LKMT08	11	0.125	26-Aug-14	18:50:00	11:48:00	1.5	0	16.97
Upper Campbell Lake	UCR-LKMT08	12	0.125	26-Aug-14	18:55:00	11:47:00	6.0	0	16.87
Upper Campbell Lake	UCR-LKMT08	13	0.125	26-Aug-14	19:00:00	11:45:00	6.8	5	16.75
Upper Campbell Lake	UCR-LKMT08	42	0.125	30-Aug-14	09:25:00	13:50:00	1.5	0	4.42
Upper Campbell Lake	UCR-LKMT08	43	0.125	30-Aug-14	09:30:00	13:35:00	5.0	0	4.08
Upper Campbell Lake	UCR-LKMT08	44	0.125	30-Aug-14	09:35:00	13:58:00	7.0	5	4.38

[1]CAS = Prickly Sculpin

Table 3. Raw fish data from gillnet and minnow trap sampling.

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	177	61	1.1	M	I	SC	282	FC	282
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	185	74	1.2						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	190	79	1.2	F	I	SC	283	FC	283
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	194	83	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	4	CT	212	97	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	220	110	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	220	111	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	223	120	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	2	CT	224	136	1.2						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	229	121	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	248	154	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	248	162	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	268	217	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	3	CT	273	212	1.0	F	I	SC	270		
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	3	CT	275	223	1.1	F	I				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	CT	278	244	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	3	CT	303	264	0.9	F	I				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	6	CT	315	328	1.0	F	M				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	6	CT	316	312	1.0						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	3	CT	331	458	1.3	M	I	SC	271		
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	6	CT	334	430	1.2	M	I				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	6	CT	364	558	1.2	F	M				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	4	CT	368	547	1.1	F	M				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	4	CT	392	659	1.1	M	I	SC	272		
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	4	CT	392	654	1.1	F	M				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	4	CT	394	670	1.1	M	I				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	DV	196	76	1.0	F	I	FR	281	FC	281
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	3	NFC									
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	6	NFC									

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Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	98	13	1.4						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	106	16	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	106	16	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	108	16	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	109	16	1.2						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	1	RB	110	18	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	110	17	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	110	18	1.4						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	110	17	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	110	18	1.4						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	111	16	1.2						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	112	18	1.3						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	130	25	1.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	1	RB	133	28	1.2						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	5	RB	168	98	2.1						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	28	5	RB	198	107	1.4						
Upper Campbell Lake	2014	UCR-LKGN01	14-08-26	GN	29	5	RB	202	101	1.2	F	I	SC	290	FC	290
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	3	CT	223	125	1.1						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	1	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	105	15	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	105	16	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	105	16	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	105	15	1.3		UNK	SC	315		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	106	15	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	108	18	1.4		UNK	SC	317		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	109	19	1.5						

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	110	15	1.1						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	111	18	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	112	19	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	112	21	1.5						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	112	19	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	112	17	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	115	20	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	115	17	1.1						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	118	24	1.5						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	118	19	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	122	26	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	148	40	1.2		UNK	SC	316		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	148	36	1.1		UNK	SC	318		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	152	41	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	5	RB	157	57	1.5	M	I	SC	341		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	1	RB	168	58	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	5	RB	171	66	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	5	RB	172	61	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	5	RB	177	76	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	5	RB	180	81	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	5	RB	189	93	1.4	F	I	SC	342		
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	5	RB	192	96	1.4						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	3	RB	212	128	1.3						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	3	RB	221	130	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	3	RB	230	151	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	3	RB	233	147	1.2						
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	3	RB	240								
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	34	6	RB	243	169	1.2	F	I	SC	340	FC	340
Upper Campbell Lake	2014	UCR-LKGN02	14-08-26	GN	33	5	RB	263	222	1.2		UNK	SC	321		
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	CT	199	74	0.9	M	I	SC	241	FC	241
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	CT	260	171	1.0	F	I	SC	237	FC	237

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	5	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	5	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	1	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	5	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	169	64	1.3	F	I	SC	254		
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	170	60	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	173	64	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	45	3	RB	173	63	1.2	M	I	SC	355	FC	355
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	177	70	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	179	71	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	179	71	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	180	74	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	1	RB	181	83	1.4	M	M	SC	263		
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	183	75	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	184	79	1.3	M	I	SC	246		
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	184	73	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	186	77	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	186	83	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	187	85	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	188	83	1.2						

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	189	90	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	189	86	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	1	RB	189	83	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	192	88	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	193	92	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	193	91	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	196	93	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	3	RB	197	102	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	198	101	1.3						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	198	88	1.1						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	200	95	1.2						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	201	92	1.1						
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	205	99	1.1	M	I	SC	234	FC	234
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	4	RB	207	123	1.4	M	I	SC	233	FC	233
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	220	139	1.3	F	M	SC	228	FC	228
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	3	RB	220	133	1.2	M	M	SC	352	FC	352
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	221	126	1.2	M	I	SC	232	FC	232
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	223	128	1.2	M	M	SC	227	FC	227
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	224	133	1.2	F	M	SC	224	FC	224
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	224	135	1.2	F	M	SC	229	FC	229
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	226	134	1.2	M	M	SC	231	FC	231
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	227	155	1.3	F	M	SC	223	FC	223
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	229	136	1.1	F	I	SC	238	FC	238
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	3	RB	229	149	1.2	F	M	SC	351	FC	351
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	231	144	1.2	F	M	SC	225	FC	225
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	3	RB	235	145	1.1	M	M	SC	353	FC	353
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	236	157	1.2	F	M	SC	222	FC	222
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	236	153	1.2	F	M	SC	226	FC	226
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	237	147	1.1	F	M	SC	230	FC	230
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	3	RB	239	142	1.0	F	I	SC	265	FC	265
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	38	3	RB	240	158	1.1	F	M	SC	266	FC	266

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	5	RB	246	170	1.1			SC	239	FC	239
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	250	175	1.1	M	I	SC	221	FC	221
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	260	145	0.8	F	M	SC	219	FC	219
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	39	3	RB	270	230	1.2	M	I	SC	220	FC	220
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	1	RB	288	294	1.2	M	I	SC	350	FC	350
Upper Campbell Lake	2014	UCR-LKGN03	14-08-26	GN	46	3	RB	300	249	0.9	F	M	SC	354	FC	354
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	CT	127	22	1.1		UNK	SC	39	FC	39
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	CT	136	31	1.2		UNK	SC	44	FC	44
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	177	59	1.1	M	I	SC	23	FC	23
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	189	70	1.0	F	I	SC	16	FC	16
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	194	75	1.0	F	I	SC	13	FC	13
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	228	115	1.0	F	I	SC	21	FC	21
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	CT	230	145	1.2	M	M	SC	55	FC	55
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	CT	239	146	1.1	F	I	SC	7	FC	7
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	246								
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	6	CT	248	168	1.1	M	I	SC	60	FC	60
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	250	190	1.2	M	I	SC	12	FC	12
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	CT	254	190	1.2	F	I	SC	9	FC	9
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	265	209	1.1	M	I	SC	14	FC	14
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	CT	266	189	1.0	M	I	SC	19	FC	19
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	CT	271	197	1.0	F	I	SC	8	FC	8
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	6	CT	280	273	1.2	F	M	SC	59	FC	59
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	CT	290	262	1.1	M	I	SC	6	FC	6
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	6	CT	303	281	1.0	F	M	SC	61	FC	61
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	CT	305	314	1.1	M	I	SC	25	FC	25
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	6	CT	314	390	1.3	M	I	SC	1	FC	1
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	6	CT	315	366	1.2	F	I	SC	3	FC	3
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	CT	317	304	1.0	M	I	SC	4	FC	4
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	2	CT	372	588	1.1	F	M	SC	11	FC	11
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	2	CT	400	813	1.3	M	I	SC	10	FC	10
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	4	NFC									

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	1	NFC									
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	104	17	1.5		UNK	SC	42	FC	42
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	104	16	1.4		UNK	SC	48	FC	48
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	104	17	1.5		UNK	SC	49	FC	49
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	106	17	1.4		UNK	SC	40	FC	40
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	106	16	1.3		UNK	SC	43	FC	43
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	106	18	1.5		UNK	SC	45	FC	45
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	106	17	1.4		UNK	SC	46	FC	46
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	108	16	1.3		UNK	SC	32	FC	32
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	108	18	1.4		UNK	SC	37	FC	37
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	110	19	1.4		UNK	SC	36	FC	36
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	111	20	1.5		UNK	SC	47	FC	47
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	113	20	1.4		UNK	SC	35	FC	35
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	114	18	1.2		UNK	SC	30	FC	30
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	116	20	1.3		UNK	SC	31	FC	31
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	120	21	1.2		UNK	SC	27	FC	27
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	120	24	1.4		UNK	SC	29	FC	29
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	124	23	1.2		UNK	SC	28	FC	28
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	130	27	1.2		UNK	SC	26	FC	26
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	134	31	1.3		UNK	SC	33	FC	33
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	134	31	1.3		UNK	SC	41	FC	41
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	3	1	RB	136	33	1.3		UNK	SC	62	FC	62
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	137	33	1.3		UNK	SC	34	FC	34
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	1	RB	138	37	1.4		UNK	SC	38	FC	38
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	3	1	RB	138	31	1.2		UNK	SC	63	FC	63
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	RB	173	62	1.2	F	I	SC	17	FC	17
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	RB	183	84	1.4	M	I	SC	53	FC	53
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	RB	190	89	1.3	F	M	SC	18	FC	18
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	RB	190	88	1.3	F	M	SC	20	FC	20

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	RB	190	99	1.4	M	I	SC	54	FC	54
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	RB	191	92	1.3	M	I	SC	56	FC	56
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	RB	194	93	1.3	F	M	SC	15	FC	15
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	RB	199	105	1.3	M	I	SC	57	FC	57
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	3	RB	213	132	1.4	M	M	SC	51	FC	51
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	3	RB	220	130	1.2	M	M	SC	52	FC	52
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	5	RB	225	135	1.2	M	M	SC	22	FC	22
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	5	RB	234	159	1.2	F	M	SC	58	FC	58
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	3	RB	254	199	1.2	F	M	SC	5	FC	5
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	2	6	RB	287	270	1.1	M	M	SC	2	FC	2
Upper Campbell Lake	2014	UCR-LKGN04	14-08-26	GN	1	3	RB/CT	302	264	1.0	M	M	SC	50	FC	50
Upper Campbell Lake	2014	UCR-LKGN05	14-08-26	GN	5		NFC									
Upper Campbell Lake	2014	UCR-LKGN05	14-08-26	GN	4		NFC									
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	CAS	88	8	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	CT	138	26	1.0						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	179	60	1.0						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	192	79	1.1						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	193	71	1.0						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	2	CT	196	87	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	204	85	1.0						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	204								
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	CT	204	92	1.1						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	CT	226	136	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	CT	236	152	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	CT	251	188	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	CT	273	236	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	CT	377	644	1.2	F	M				
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	4	NFC									

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	1	RB	100	15	1.5						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	102	16	1.5						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	109	19	1.5						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	111	18	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	112	18	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	116	22	1.4						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	120	24	1.4						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	125	23	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	126	27	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	127	27	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	131	27	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	133	26	1.1						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	134	30	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	134	20	0.8						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	1	RB	135	33	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	140	34	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	3	RB	151	42	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	2	RB	157	47	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	167	67	1.4						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	5	RB	172	62							
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	178	69	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	180	68	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	180	73	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	5	RB	192	91	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	193	90	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	212	118	1.2						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	RB	226	145	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	RB	230	158	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	5	RB	236	165	1.3						
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	18	3	RB	250	208	1.3						

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN06	14-08-26	GN	17	5	RB	283	300	1.3						
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	24	1	CAS	84	6.4	1.1		UNK			FC	157
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	CT	127	28	1.4		UNK	SC	122	FC	122
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	CT	236	139	1.1	F	I	SC	113	FC	113
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	6	CT	323	365	1.1	M	I	SC	98	FC	98
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	6	CT	356	473	1.0	M	I	SC	99	FC	99
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	6	CT	358	556	1.2	M	I	SC	97	FC	97
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	4	CT	370	634	1.3	M	I	SC	100	FC	100
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	24	1	RB	92	12	1.5		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	98	14	1.5		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	100	17	1.7		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	100								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	100								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	100								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	102	13	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	102	14	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	102	14	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	103	15	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	103	18	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	103	17	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	104	18	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	104	16	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	105	18	1.6		UNK	SC	121	FC	121
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	105	16	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	106				UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	107	20	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	107	19	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	108	22	1.7		UNK	SC	124	FC	124

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	108	19	1.5		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110				UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110	20	1.5		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110	18	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	110								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	111	20	1.5		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	111	22	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	112	23	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	112	18	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	112	20	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	112	23	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	113	20	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	114	25	1.7		UNK	SC	123	FC	123
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	114	21	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	1	RB	115	24	1.6		I	SC	105	FC	105
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	115	19	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	115								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	115								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	117	19	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	119	22	1.3		UNK	SC	119	FC	119
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	120	26	1.5		UNK	SC	126	FC	126
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	120								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	1	RB	123	28	1.5		I	SC	104	FC	104
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	1	RB	124	26	1.4		I	SC	103	FC	103
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	124	24	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	130								

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	130								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	138	32	1.2		UNK	SC	118	FC	118
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	143	40	1.4		UNK	SC	125	FC	125
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	145								
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	157	45	1.2	M	I	SC	120	FC	120
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	1	RB	163	56	1.3		UNK	SC	117	FC	117
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	RB	174	82	1.6	M	I	SC	116	FC	116
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	5	RB/CT	183	64	1.0	F	I	SC	108	FC	108
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	5	RB	185	69	1.1	M	I	SC	107	FC	107
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	RB	187	86	1.3	M	I	SC	114	FC	114
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	3	RB	200	110	1.4	F	I	SC	102	FC	102
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	RB	213	140	1.4	F	M	SC	111	FC	111
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	RB	214	130	1.3	M	M	SC	112	FC	112
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	5	RB/CT	220	115	1.1	M	I	SC	115	FC	115
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	5	RB	235	154	1.2	F	M	SC	106	FC	106
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	2	RB	242	183	1.3	F	M	SC	109	FC	109
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	23	3	RB	248	183	1.2	F	M	SC	101	FC	101
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	22	3	RB	264	167	0.9	F	M	SC	110	FC	110
Upper Campbell Lake	2014	UCR-LKGN07	14-08-26	GN	24	1	TSB	58	1.3	0.7		UNK			FC	158
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	4	CT	221	116	1.1	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	5	CT	225	140	1.2	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	3	CT	253	207	1.3	F	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	3	CT	257	180	1.1		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	3	CT	258	180	1.0	F	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	3	CT	292	296	1.2	M	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	41	4	CT	295								
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	3	CT	304	262	0.9	F	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	6	CT	314	318	1.0	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	3	CT	326	406	1.2	F	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	6	CT	328	382	1.1	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	4	CT	342	458	1.1	M	M				

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	5	CT	342	475	1.2	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	41	6	CT	354								
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	4	CT	368	507	1.0	F	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	4	CT	370	538	1.1	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	41	4	CT	382								
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	5	CT	398	762	1.2	F	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	6	CT	416	811	1.1	M	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	6	CT	439	1011	1.2	M	M				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	4	CT	459	1125	1.2	F	M	SC	79	FC	79
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	1	UNK					UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	6	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	5	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	4	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	2	NFC									
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	1	RB	95	14	1.6		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	99	14	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	131	27	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	1	RB	131	24	1.1						
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	1	RB	132	23	1.0						
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	1	RB	134	25	1.0	M	I	SC	357	FC	357
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	136	33	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	137	37	1.4		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	40	3	RB	141	35	1.2	M	I	SC	356	FC	356
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	1	RB	142	33	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	143	33	1.1		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	1	RB	155	50	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	5	RB	168	57	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	5	RB	172	65	1.3		UNK				

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	3	RB	203	108	1.3		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	5	RB	205	106	1.2		UNK				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	10	5	RB/CT	254	199	1.2	M	I				
Upper Campbell Lake	2014	UCR-LKGN08	14-08-26	GN	9	6	RB	285	238	1.0	F	M				
Upper Campbell Lake	2014	UCR-LKMT01	14-08-28	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT01	14-08-28	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT01	14-08-28	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT02	14-08-28	MT			CAS	52	1	0.7						26
Upper Campbell Lake	2014	UCR-LKMT02	14-08-28	MT			CAS	62	2	0.8						25
Upper Campbell Lake	2014	UCR-LKMT02	14-08-28	MT			CAS	64	3	1.1						27
Upper Campbell Lake	2014	UCR-LKMT02	14-08-28	MT			CAS	105	13	1.1						24
Upper Campbell Lake	2014	UCR-LKMT02	14-08-28	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT04	14-08-26	MT			CAS	66	2.8	1.0					FC	3
Upper Campbell Lake	2014	UCR-LKMT04	14-08-26	MT			CAS	82	5	0.9					FC	2
Upper Campbell Lake	2014	UCR-LKMT04	14-08-26	MT			CAS	103	11.7	1.1					FC	1
Upper Campbell Lake	2014	UCR-LKMT04	14-08-26	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT05	14-08-26	MT			CAS	66	2.9	1.0					FC	7
Upper Campbell Lake	2014	UCR-LKMT05	14-08-26	MT			CAS	69	3.6	1.1					FC	6
Upper Campbell Lake	2014	UCR-LKMT05	14-08-26	MT			CAS	98	8.6	0.9					FC	5
Upper Campbell Lake	2014	UCR-LKMT05	14-08-26	MT			CAS	106	12.7	1.1					FC	4
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	67	2.6	0.9					FC	23
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	75	4	0.9					FC	21
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	76	4.4	1.0					FC	19
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	82	4.8	0.9					FC	20
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	82	5.6	1.0					FC	22
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	86	6.8	1.1					FC	17
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	98	8.6	0.9					FC	18
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	100	10.1	1.0					FC	16
Upper Campbell Lake	2014	UCR-LKMT06	14-08-27	MT			CAS	109	15	1.2					FC	13
Upper Campbell Lake	2014	UCR-LKMT07	14-08-27	MT			CAS	76	4.7	1.1					FC	15
Upper Campbell Lake	2014	UCR-LKMT07	14-08-27	MT			CAS	88	5.8	0.9					FC	14

Table 3. (Continued).

Water Body	Year	Site Name	Date	Capture Method[1]	Set Number	Panel Number	Species[2]	Measured Length (mm)	Weight (g)	K	Sex	Sexual Maturity (I, M, UNK)	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number
Upper Campbell Lake	2014	UCR-LKMT07	14-08-27	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			CAS	58	2	1.0					FC	32
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			CAS	66	3.1	1.1					FC	30
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			CAS	66	3.3	1.1					FC	28
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			CAS	68	3.4	1.1					FC	31
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			CAS	70	3.4	1.0					FC	29
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			CAS	72	4.5	1.2					FC	9
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			CAS	90	9.3	1.3					FC	11
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			CAS	94	9.3	1.1					FC	12
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			CAS	99	11.3	1.2					FC	8
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			CAS	120	18.4	1.1					FC	10
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT08	14-08-30	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			NFC									
Upper Campbell Lake	2014	UCR-LKMT08	14-09-26	MT			NFC									

[1] GN = Gillnet, MT = Minnow Trap

[2] CAS = Prickly Sculpin, RB = Rainbow Trout, CT = Cutthroat Trout, RB/CT = Rainbow Trout Cutthroat Trout Hybrid, NFC = No fish caught, TSB = Threespine Stickleback, DV = Dolly Varden

Figure 1. A 317 mm Cutthroat Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 2. A 290 mm Cutthroat Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 3. A 400 mm Cutthroat Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 4. A 194 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 5. A 173 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 6. A 120 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 7. A 137 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 8. A 136 mm Cutthroat Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 9. A 111 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

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Figure 10. A 302 mm CT/RB hybrid captured at UCR-LKGN04 on August 26, 2014.

Figure 11. A 234 mm Rainbow Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 12. A 248 mm Cutthroat Trout captured at UCR-LKGN04 on August 26, 2014.

Figure 13. A 137 mm Rainbow Trout captured at UCR-LKGN08 on August 26, 2014.

Figure 14. A 459 mm Cutthroat Trout captured at UCR-LKGN08 on August 26, 2014.

Figure 15. A 416 mm Cutthroat Trout captured at UCR-LKGN08 on August 26, 2014.

Figure 16. A 163 mm Rainbow Trout captured at UCR-LKGN07 on August 26, 2014.

Figure 17. A 84 mm Prickly Sculpin captured at UCR-LKGN07 on August 26, 2014.

Figure 18. A 58 mm stickleback captured at UCR-LKGN07 on August 26, 2014.

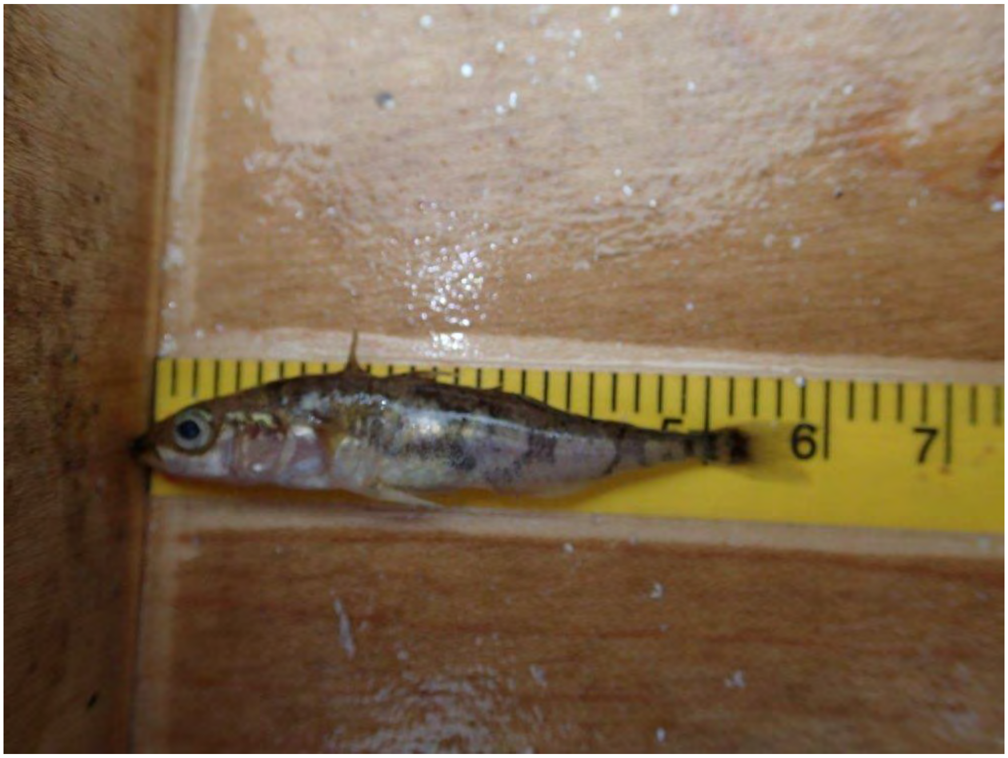

Figure 19. A 283 mm Rainbow Trout captured at UCR_LKGN06 on August 26, 2014.

Figure 20. A 116 mm Rainbow Trout captured at UCR-LKGN06 on August 26, 2014.

Figure 21. A 377 mm Cutthroat Trout captured at UCR-LKGN06 on August 26, 2014.

Figure 22. A 331 mm Cutthroat Trout captured at UCR-LKGN01 on August 26, 2014.

Figure 23. A 382 mm Cutthroat Trout captured at UCR-LKGN08 on August 26, 2014.

Figure 24. Sculpin captured at UCR-LKMT08 on August 30, 2014.

Figure 25. Sculpin captured at UCR-LKMT02 on August 28, 2014.

Figure 26. Sculpin captured at UCR-LKMT02 on August 28, 2014.

Figure 27. Sculpin captured at UCR-LKMT07 on August 27, 2014.

Figure 28. Sculpin captured at UCR-LKMT06 on August 27, 2014.

Figure 29. Sculpin captured at UCR-LKMT05 on August 26, 2014.

Figure 30. Sculpin captured at UCR-LKMT08 on August 26, 2014.

Figure 31. Sculpin captured at UCR-LKMT04 on August 26, 2014.

Appendix C. Acoustic Survey Weighting Factors and Sampling Data.

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Table 1. Weighting factors used for calculating pooled species composition from nearshore and offshore gill net CPUE for the main lake basin. Weights are based on % of layer volume in each zone, with the 20 m depth contour used as the nearshore-offshore zone boundary.

Lake Basin	Depth Range (m)	Volume (m^3)			Weighting factor	
		Nearshore	Offshore	Combined	Nearshore	Offshore
Main Basin	0-5	40,609,245	62,263,750	102,872,995	39.50%	60.50%
	5-10	33,852,770	62,263,750	96,116,520	35.20%	64.80%
	10-15	25,438,861	62,263,750	87,702,611	29.00%	71.00%
	15-20	11,510,134	62,263,750	73,773,884	15.60%	84.40%
	20-25	0	55,843,307	55,843,307	0.00%	100.00%
	25-30	0	43,328,213	43,328,213	0.00%	100.00%
	30-35	0	21,549,029	21,549,029	0.00%	100.00%
	35-40	0	4,306,743	4,306,743	0.00%	100.00%
	40-45	0	1,066,032	1,066,032	0.00%	100.00%
	45-50	0	531,765	531,765	0.00%	100.00%
	50-55	0	268,267	268,267	0.00%	100.00%
	55-60	0	107,777	107,777	0.00%	100.00%
	60-65	0	10,207	10,207	0.00%	100.00%

Table 2. Areas (m²) and volumes (m³) of sampling strata used for the August 17-21, 2014 acoustic estimate of fish abundance in Upper Campbell Lake. The lake surface elevation was 217.1 m above sea level at the time of the survey.

Lake Basin	Layer	Depth Range (m)	Surface Elevation (m)	Surface Area (m²)	Surface Area (ha)	Layer Volume (m³)
North Bay	1	0-5	217.1	2,136,625	214	10,011,698
	2	5-10	212.1			8,118,166
	3	10-15	207.1			6,702,552
	4	15-20	202.1			5,459,246
	5	20-25	197.1			4,410,638
	6	25-30	192.1			3,536,563
	7	30-35	187.1			2,340,424
	8	35-40	182.1			214,697
	9	40-45	177.1			7,772
Main Basin	1	0-5	217.1	20,942,275	2,094	102,872,995
	2	5-10	212.1			96,116,520
	3	10-15	207.1			87,702,611
	4	15-20	202.1			73,773,884
	5	20-25	197.1			55,843,307
	6	25-30	192.1			43,328,213
	7	30-35	187.1			21,549,029
	8	35-40	182.1			4,306,743
	9	40-45	177.1			1,066,032
	10	45-50	172.1			531,765
	11	50-55	167.1			268,267
	12	55-60	162.1			107,777
	13	60-65	157.1			10,207
South Bay	1	0-5	217.1	2,825,850	283	12,781,012
	2	5-10	212.1			7,436,938
	3	10-15	207.1			2,500,865
	4	15-20	202.1			220,811
	5	20-25	197.1			347
Elk R. Bay	1	0-5	217.1	2,781,975	278	10,980,964
	2	5-10	212.1			4,513,571
	3	10-15	207.1			1,843,094
	4	15-20	202.1			186,658
Combined				***28,686,725***	***2,869***	***568,743,365***

Appendix D. Snorkel Survey Observations and Representative Photographs.

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Table 1. Fish observation results for the 2014 snorkel surveys.

Watershed	Waterbody	Section	Species[1]	Total Count	Count (#) Per Size Class (mm)						Condition Factor of Adult Fish					Redd
					Fry	Parr	151-250	251-350	351-450	450+	C1	C2	C3	C4	C5	Count
Upper Campbell	Upper Elk	1	RB	36	0	11	12	13	0	0	13	10	2	0	0	7
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	RB	588	0	6	21	556	5	0	175	175	175	58	0	0
			CT	2	0	0	0	0	2	0	2	0	0	0	0	0
			DV	2	0	2	0	0	0	0	0	0	0	0	0	0
		3	RB	235	0	0	7	225	3	0	94	59	59	24	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	1	0	0	1	0	0	0	1	0	0	0	0	0
		4	RB	305	0	0	8	297	0	0	61	122	92	31	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lower Elk		RB	1,742	0	0	254	1,423	65	0	0	174	1,394	174	0	300
			CT	2	0	0	0	2	0	0	0	2	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
Buttle	Ralph	1	RB	258	0	0	0	207	51	0	0	58	200	0	0	45
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	1	0	0	0	1	0	0	0	1	0	0	0	0
		2	RB	121	0	0	10	96	15	0	0	10	111	0	0	20
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	RB	456	0	0	0	426	30	0	0	100	356	0	0	60
			CT	1	0	0	0	0	1	0	0	1	0	0	0	0
			DV	3	0	0	0	3	0	0	0	3	0	0	0	0
	Henshaw	1	RB	12	0	0	0	12	0	0	0	0	11	1	0	2
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	RB	6	0	0	0	6	0	0	0	0	5	1	0	1
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	RB	8	0	0	0	8	0	0	0	0	8	0	0	4
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Thelwood	1	RB	2,241	0	0	0	2,232	8	1	0	672	1,345	224	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	1	0	1	0	0	0	0	0	0	0	0	0	0
		2	RB	128	0	0	8	120	0	0	0	38	77	13	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	RB	127	0	0	7	119	1	0	0	38	76	13	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		4	RB	71	0	0	0	71	0	0	0	32	36	3	0	0
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	2	0	2	0	0	0	0	0	0	0	0	0	0
	Phillips	1	RB	19	0	0	2	17	0	0	0	0	0	0	0	14
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	RB	37	0	0	7	30	0	0	0	0	0	0	0	10
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	2	0	0	1	1	0	0	0	0	0	0	0	0
		3	RB	167	0	0	60	107	0	0	0	0	0	0	0	5
			CT	2	0	0	0	2	0	0	0	0	0	0	0	0
			DV	16	0	0	5	11	0	0	0	0	0	0	0	0
	Wolf	1	RB	307	0	0	56	251	0	0	0	0	0	0	0	145
			CT	3	0	0	3	0	0	0	0	0	0	0	0	0
			DV	22	0	0	21	1	0	0	0	0	0	0	0	0
		2	RB	77	0	0	7	70	0	0	0	0	0	0	0	12
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	8	0	0	8	0	0	0	0	0	0	0	0	0

[1] RB = Rainbow Trout, CT = Cutthroat Trout, DV = Dolly Varden

[2] Includes counts of fish labelled 'TR', i.e., trout of unknown species

Table 1. (Continued).

Watershed	Waterbody	Section	Species[1]	Total Count	Count (#) Per Size Class (mm)						Condition Factor of Adult Fish					Redd
					Fry	Parr	151-250	251-350	351-450	450+	C1	C2	C3	C4	C5	Count
Lower Campbell	**Miller Creek**	**1**	**RB[2]**	85	48	31	6	0	0	0	0	0	0	0	0	11
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		2	**RB[2]**	48	28	20	0	0	0	0	0	0	0	0	0	8
			CT	1	0	0	1	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
		3	**RB[2]**	23	21	1	1	0	0	0	0	0	0	0	0	8
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Campbell River (Strathcona tailrace)		**RB**	391	0	0	81	300	10	0	0	0	0	0	0	190
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	24	0	0	20	4	0	0	0	0	0	0	0	0
	Fry Creek		**RB[1]**	116	61	55	0	0	0	0	0	0	0	0	0	10
			CT	0	0	0	0	0	0	0	0	0	0	0	0	0
			DV	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] RB = Rainbow Trout, CT = Cutthroat Trout, DV = Dolly Varden

[2] Includes counts of fish labelled 'TR', i.e., trout of unknown species

Figure 1. Representative photo of Rainbow Trout observed at Ralph River on June 10, 2014.

Figure 2. Looking upstream at snorkel survey start location on Henshaw Creek on June 10, 2014.

Figure 3. **Looking downstream at snorkel survey start location on Henshaw Creek on June 10, 2014.**

Figure 4. **Looking upstream at snorkel survey start location on Phillips River on June 9, 2014.**

Figure 5. **Looking downstream at snorkel survey start location on Phillips River on June 9, 2014.**

Figure 6. **Looking upstream at snorkel survey start location on Wolf River on June 9, 2014.**

Figure 7. Looking downstream at snorkel survey start location on Wolf River on June 9, 2014.

Photograph not available

Figure 8. Looking upstream from snorkel survey start location at Miller Creek on June 12, 2014.

Figure 9. Looking downstream from snorkel survey start location at Miller Creek on June 12, 2014.

Figure 10. Dewatered redds in Miller Creek in Reach 2 (downstream 200 to 300 m from cascades) on June 12, 2014.

Figure 11. Looking upstream from snorkel survey start location at Fry Creek on June 11, 2014.

Figure 12. Looking downstream from snorkel survey start location at Fry Creek on June 11, 2014.