# Columbia River Project Water Use Plan

## Kinbasket Reservoir Fish And Wildlife Information Plan

## Mica Tailrace Fish Indexing Study

## Annual Report – Year 6

## Reference: CLBMON-60

***Mica Tailrace Fish Indexing Study (Year 6)***

**Study Period: October 2017 – October 2018**

**Ktunaxa Nation Council**
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# WLR Monitoring Study No. CLBMON-60

## Mica Tailrace Fish Indexing Study (Year 6)

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KTUNAXA NATION

Cover Photo:

Fish capture session in the Mica Dam tailrace (October 2018). Photos in this document © Katrina Caley and Jon Bisset, KNC.

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## EXECUTIVE SUMMARY

During the development of BC Hydro's Water Use Plan (WUP) for the Columbia River Mica Dam Hydroelectric Project (BC Hydro 2007) and the Environmental Impact Assessment (EIA) process for the installation of two new turbines (Mica 5 and 6), two key concerns were identified:

1. Changes in the distribution of ichthyofauna downstream of the tailrace; and
2. The effects of the addition of Mica 5 and 6 turbines on water temperatures downstream of the Mica Dam Tailrace (BC Hydro 2011).

It was anticipated that the addition of the two turbines would elevate surface water levels and increase water velocities in tailrace. As well, it was suspected that the additional two turbines may increase surface water temperatures in the tailrace. To address these key concerns two field surveys were initiated: 1) an ichthyofauna survey of the section of Columbia River between the Mica Dam tailrace and the Blue Bridge ~2.5 km downstream, and 2) a temperature study which deployed temperature loggers at six to eight locations along the two banks between the tailrace and the Blue Bridge.

Prior to the installation and operation of Mica 5/6, fish surveys were conducted in October 2012 and 2013. The additional turbines, Mica 5 and 6, became operational on January 28th, 2015 and December 22nd, 2015, respectively. Post-operation fish surveys were intended to be completed in 2017 and 2018; however, due to safety concerns, boat electrofishing was delayed by a year. This report presents the data from the first year of post-operation boat electrofishing (October 2018) and two years of backpackelectrofishing (October 2017 and 2018). A final year of surveys (boat and backpack electrofishing) will be completed in fall 2019. The temperature logger deployment was initiated in September 2012 and will continue until the end of the study in October 2019.

This study employed three types of survey methods to evaluate the fish community in the Mica tailrace - boat electrofishing observations and netting, and backpackelectrofishing. Boat electrofishing was used to enumerate and characterize the ichthyofauna within the study area, while backpack electrofishing targeted small-bodied and juvenile fishes along the shoreline. Discharges of 400-800 $m^3/s$ from Mica Dam were targeted for the fish surveys; however, due to unpredictable flow patterns, three of eight sites were surveyed under high flow conditions (~1,300 $m^3/s$).

A total of 1,256 fishes were observed. Mountain Whitefish accounted for 83% (N=1,046) of observed fish. Other species observed were Kokanee (N=119), Rainbow Trout (N=6), Bull Trout (N=63), Sculpins (N=3), Suckers (N=15), and unidentified salmonids (N=4). During the capture passes, a total of 139 fish of four species were captured, including 102 Mountain Whitefish, 22 Kokanee, 14 Bull Trout and one Longnose Sucker. Higher densities of Mountain Whitefish and Bull Trout were observed in 2018 than in pre-construction sampling years (2012 and 2013). Very few observations of Rainbow Trout were made in all three years. Overall, the Mica Dam tailrace is a Mountain Whitefish-dominated system.

Due to high water levels and unconsolidated sediments, only one of four sites was backpack electrofished in 2017 and 2018. No fish were captured in either year. Attempts were made to move sampling sites to new locations in the study reach; however, no suitable areas were identified. It is

possible that higher flows have intensified sediment transport and deposition processes altering the availability of shallow habitats throughout the study area.

Temperature monitoring in the tailrace continued in 2017 and 2018. The configuration of the headpond array was updated to improve coverage of the water column. The temperature patterns in the tailrace continue to follow a typical seasonal pattern. Temperature differences between the right and left banks, as well as 1-3 km downstream from the dam, were all within the error of the temperature loggers (±0.2°C).

Based on the results of this study to date, the operation of the two additional turbines in the Mica dam, Mica 5/6, has not produced a significant impact on the ichthyofauna or the temperature regime in the tailrace. However, this study is currently limited by data and would benefit from additional years of sampling to better understand the population dynamics in the tailrace and long-term effects of the new operating regime of Mica dam.

## ACKNOWLEDGEMENTS

We thank Bill Green, Karen Bray, Guy Martel, and Gerry Oliver for review and discussion of methodology and safety programs for this project.

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Jon Bisset (KNC) for the management of the project from 2012 to 2018.

Last but not least, thank you to Jason Watson, Trish Joyce and Mark Sherrington at BC Hydro for management of this project.

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# INTRODUCTION

## Background

In 2007, BC Hydro completed a Water Use Plan (WUP) for the Columbia River (RL & L 2001; BC Hydro 2004, 2007), along with the Kinbasket Reservoir Fish and Wildlife Information Plan (BC Hydro 2011b), which outlined the Terms of Reference (TOR) for monitoring programs required for all of its operations. The WUP seeks to balance power generation with other water uses that provide social, environmental and economic benefits to British Columbians. Subsequently, a Monitoring Program TOR (BC Hydro 2011a) was developed to implement and assess recommendations from the WUP.

In 2009, an Environmental Impact Assessment was triggered by the proposed addition of two turbines to the Mica Dam (Mica 5/6). In accordance with the BC Environmental Assessment Act, BC Hydro submitted two Environmental Assessment Certificate Applications (EACAs), one for each of the proposed Mica Unit 5 and Mica Unit 6 projects. The four-turbine generating station has the capacity to generate 1,805 megawatts (MW) of power, however maximum generation capacity is limited by available flow (BC Hydro 2007; KCB 2009). The proposed expansion will increase generating capacity to 2,805 MW. The application identified that the potential effects of the operation of the proposed project on the downstream fish community in the Columbia River are unknown. This study, CLBMON-60, was then designed to assess the impacts to fish and fish habitat and monitor the thermal regime in the Mica Dam Tailrace as a result of the proposed expansion (KCP 2009; BC Hydro 2011c).

As stated in the Mica Tailrace Fish Indexing Study TOR (CLBMON-60) and monitoring program requirements (BC Hydro 2011b), “There are no management hypotheses associated with this program, as hypotheses are unlikely to be falsified within the time frame allocated for the project. The primary objectives of the monitoring program are to monitor the ichthyofauna and thermal regime in the Mica Dam tailrace during the two summers before and the two summers after the service date for full operations of Mica 5 and 6” (*cf.* Schedule, section 2.5), as described in the RFP (BC Hydro 2011a).

Pre-operation monitoring was completed in 2012 (Irvine et al 2013) and 2013 (Bisset et al 2015) to characterize the ichthyofauna in the tailrace. Temperature monitoring was also conducted during that time and then continued throughout the construction phase of the project. The additional turbines, Mica 5 and 6, became operational on January 28th, 2015 and December 22nd, 2015, respectively. The first of two years of post-operation studies was initiated in 2017-18. The purpose of the current program is to assess the potential impacts of operation of turbines 5 and 6 on the thermal regime and fish distribution within the ~2.5 km section between the tailrace and the Blue Bridge (Figure 1). Other studies have been or are currently being completed with respect to flows, temperature, fish habitat and fish distribution in the Kinbasket Reservoir and Columbia River downstream of the dam, including CLBMON-1 (Total Gas Pressure Monitoring), CLBMON-2 (Kokanee population monitoring, and others.

**Hydrology and fish patterns**

The hydrograph peak is dominated by snowmelt runoff in the spring, while secondary rainfall events in the summer and fall also increase seasonal flow variation (KCB 2009). There are currently two operating Water Survey of Canada (WSC) gauging stations (WSC 08NE049, 08NB005) and several historic stations that provide baseline hydrology information. Poisson Consulting Ltd. (Poisson) has developed and maintains a database to consolidate flow, elevation and temperature data for WLR projects. There is also a continuous gauge above the Mica Dam at Donald operated by BC Hydro which characterises flow patterns and precipitation within the Columbia River. The WSC data showed that the Columbia River is a snowmelt dominated system, with peak runoff/freshet conditions typically observed in late May through to early July and winter low flows from October to April. Low flow periods are typically observed in the late winter, when the dominant precipitation form occurs as snowfall. The annual peak monthly inflow for the period from 1940 to 1999 at Mica averaged 574.25 $m^3/s$, with winter low flows ranging from mean monthly inflows of 103 to 132 $m^3/s$ (BC Hydro 2007).

These background data were used to develop hydrographs for the Columbia River and inform hydrological studies. The hydrologic studies were then used to identify constraints and determine operational requirements for the facility, identify periods of low (i.e., critical) flows relative to fish habitat use and develop minimum flow requirements.

Previous fish studies suggest that the Columbia River below Mica Dam supports populations of Rainbow Trout (*Oncorhynchus mykiss*), Kokanee (*O. nerka*), Bull Trout (*Salvelinus confluentus*) and Mountain Whitefish (*Prosopium williamsoni*), as well as Slimy (*Cottus cognatus)*, Torrent (*C. rhotheus*) and Prickly Sculpins (*C. asper*) as outlined in Table 1. Fish species documented in the Columbia River downstream of the Mica Dam.

Table 1. Fish species documented in the Columbia River downstream of the Mica Dam (RL & L 2001; Ford and Hildebrand 2008; BC Hydro 2007, 2011b).

| Common Name | Scientific Name |
|---|---|
| Rainbow Trout | *Oncorhynchus mykiss* |
| Bull Trout | *Salvelinus confluentus* |
| Kokanee | *O. nerka* |
| Mountain Whitefish | *Prosopium williamsoni* |
| Slimy Sculpin | *Cottus cognatus* |
| Torrent Sculpin | *C. rhotheus* |
| Prickly Sculpin | *C. asper* |
| Burbot | *Lota lota* |
| Lake Whitefish | *Coregonus clupeaformis* |
| Yellow Perch | *Perca flavescens* |
| White Sturgeon | *Acipenser transmontanus* |
| Pygmy Whitefish | *P. coulteri* |
| Cutthroat Trout | *O. clarkii* |
| Lake Chub | *Couesius plumbeus* |
| Bridgelip Sucker | *Catostomus columbianus* |

# METHODS

## Overview, study objectives and limitations

The goal of the program is to evaluate potential impacts of the addition of two generating units to the Mica Dam Project (Mica 5 and 6) on the ichthyofauna and the thermal regime immediately below Mica Dam. The management questions are to detect whether the operation of Mica 5/6 change the aquatic thermal regime and/or ichthyofauna in the tailrace. No management hypotheses were provided in the TOR as it was thought to be unlikely that the hypotheses could be falsified during the time span of the study. Therefore, this study is limited by the duration of the pre- and post-operation sampling windows. A longer timeframe would be required to establish pre-operation variability in the fish community structure and thermal regime to compare with post-operation conditions. An additional stated objective was to collect opportunistic information about rare or invasive species. The objectives of the monitoring program are described in detail in the BC Hydro Columbia River Project Water Use Plan Monitoring Program Terms of Reference – Mica Units 5 and 6 Project Commitments – CLBMON-60 Mica Tailrace Fish Indexing Study (BC Hydro 2011a, 2011b).

The management questions are being addressed through two monitoring programs: 1) a fishing indexing study below the Mica Dam, and 2) temperature monitoring above and below the Mica Dam. The fish indexing study is composed of three components: 1) boat electrofishing observations, 2) boat electrofishing capture, and 3) backpack electofishing. The boat electrofishing programs target larger-bodied fishes and are intended to enumerate and characterize the ichthyofauna within the study area. The backpack electrofishing program is carried out along the shoreline and targets juvenile and small-bodied fishes. The purpose of the temperature monitoring program is to understand how the thermal regime downstream of the Mica Dam responds to the operation of two additional turbines.

In 2012, the study was implemented as a four-year monitoring program with two years of pre-construction monitoring (2012-2013), no monitoring during the two years of construction (2014-2015), and two years of post-construction monitoring (2016-2017). Discussions between then CCRIFC (Canadian Colmbia River Inter-tribal Fisheries Commission) staff and BC Hydro resulted in the continuation of the temperature monitoring program throughout the construction phase. The boat electrofishing program was planned to resume in 2016; however, several factors, including safety concerns, delayed the program until fall 2018. Backpack electrofishing was completed in 2017 and 2018. Therefore, this report presents the first year of post-construction data for the full electrofishing program, as well as an additional year of backpack electrofishing. Table 2 provides a summary of all field work activities completed between 2012 and 2018.

Table 2. Summary of field work activities for CLBMON-60.

| Year | Description | Activity | | |
|---|---|---|---|---|
| | | Boat Electrofishing | Backpack Electrofishing | Temperature Logging |
| 2012 | Pre-construction of Mica 5/6 | X | X | X |
| 2013 | Pre-construction of Mica 5/6 | X | X | X |
| 2014 | Construction Phase | | | X |
| 2015 | Construction Phase | | | X |
| 2016 | Post-construction of Mica 5/6 | | | X |
| 2017 | Post-construction of Mica 5/6 | | X | X |
| 2018 | Post-construction of Mica 5/6 | X | X | X |
| 2019 | Post-construction of Mica 5/6 | X[a] | X[a] | X[a] |

[a] Program to be completed in fall 2019.

**Study Area**

The Columbia River Mica Dam hydroelectric project is part of BC Hydro's integrated generation system and is located approximately 137 km north of Revelstoke on Highway 23 (Figure 1 inset). The Mica Dam impounds the Columbia River and forms Kinbasket Reservoir. The study area includes Kinbasket Reservoir immediately above the Mica Dam (the headpond) and the Columbia River from 1 km downstream of the dam to the Blue Bridge (approximately 2.5 km downstream of the dam).

**Discharge**

The target range of discharge values for the fish sampling program is between 400 and 800 $m^3/s$. In order to assess the range of discharge values over which sampling was conducted, hourly discharge values were averaged for the 3 hours prior to sampling and during sampling to obtain the approximate mean discharge at which fish were counted or captured.

During the pre-Mica 5/6 fish surveys (2012 and 2013), the boat electrofishing was planned to correspond to periods of lowest possible flow. This was achieved by waiting until flows dropped at approximately 22:00h and waiting for 4-6 hours before sampling (Bisset et al 2015). In 2018, it was not possible to schedule a period of low flow. It was determined that the week of September 29th to October 6th, 2018 would provide the lowest possible flows as average flows were expected to be approximately 525 $m^3/s$.

**Fish Observation and Capture**

This study utilized boat electrofishing to enumerate and characterize the ichthyofauna within the study area. Electrofishing was conducted on October 2nd and 3rd, 2018 at all five sites previously established by Ford and Hildebrand (2008) and used during pre-operation of Mica 5/6 (Figure 1). In 2018, the sampling locations for ES01 and ES03 had to be modified as a safety boom had been installed slightly downstream (~100 m) of the original start locations. It is not expected that this minor alteration in the study design will impact the results as counts are georeferenced and fish densities are calculated based on lineal distance traveled during the sampling run.

The program was completed in two phases. An initial pass with the boat electrofisher was completed at all five sites to observe fish and record the species and estimate the size (to the nearest 10 cm). All fish observations were georeferenced. During the initial observation passes the observers were stationed in standard netting positions and each observer was paired with a recorder who had a watch synchronized to the time displayed by the GPS unit. Each recorder noted the fish data as well as the exact time of the observation. Two GPS units (Garmin 62S/64S) ran track logs during the sampling session to reduce the chances of data loss in the case of equipment failure. The primary device was on the console of the electrofishing vessel with an external antenna (the distance from the console GPS to the midpoint of the anode and boom when extended was 6.2 m). The backup device was in a backpack carried by one of the observers.

Standard boat electrofishing capture was then completed at each of the five sites. Observation and capture passes were conducted on separate nights to minimize the likelihood of frightening the fish and improve capture efficiency. Fish of all targeted indexing species were captured, transferred to the live well, and at the end of each site, were measured, weighted and sexed (if possible). Crew members were also aware of the study program's stated objective to collect opportunistic information about rare or invasive species. The boat electrofisher settings were consistent between all observation and capture sessions (400 volts, 30 Hertz and a pulse width of 38%).

Small-bodied fishes were targeted along the shoreline using a Smith-Root LR 24 backpack electrofisher (300 volts, 60 Hertz and a pulse width of 25%) with a three-person crew during daylight hours. Two backpack electrofishing sessions occurred throughout the study year. One on October 27$^{th}$, 2017 and another on October 4$^{th}$, 2018. Originally, four sites had been demarcated for backpack electrofishing based on work by Ford and Hildebrand (2008; Figure 1). Only one of the four sites (EF01) could be accessed during both visits. Water depths at the other three sites were too high to access or safely electrofish. During the 2018 program, an attempt was made to move site EF03 to upstream of Nagle Creek. It was found that the sediments were too unconsolidated to safely electrofish. Photos and descriptions of all backpack electrofishing sites are provided in Appendix 1.

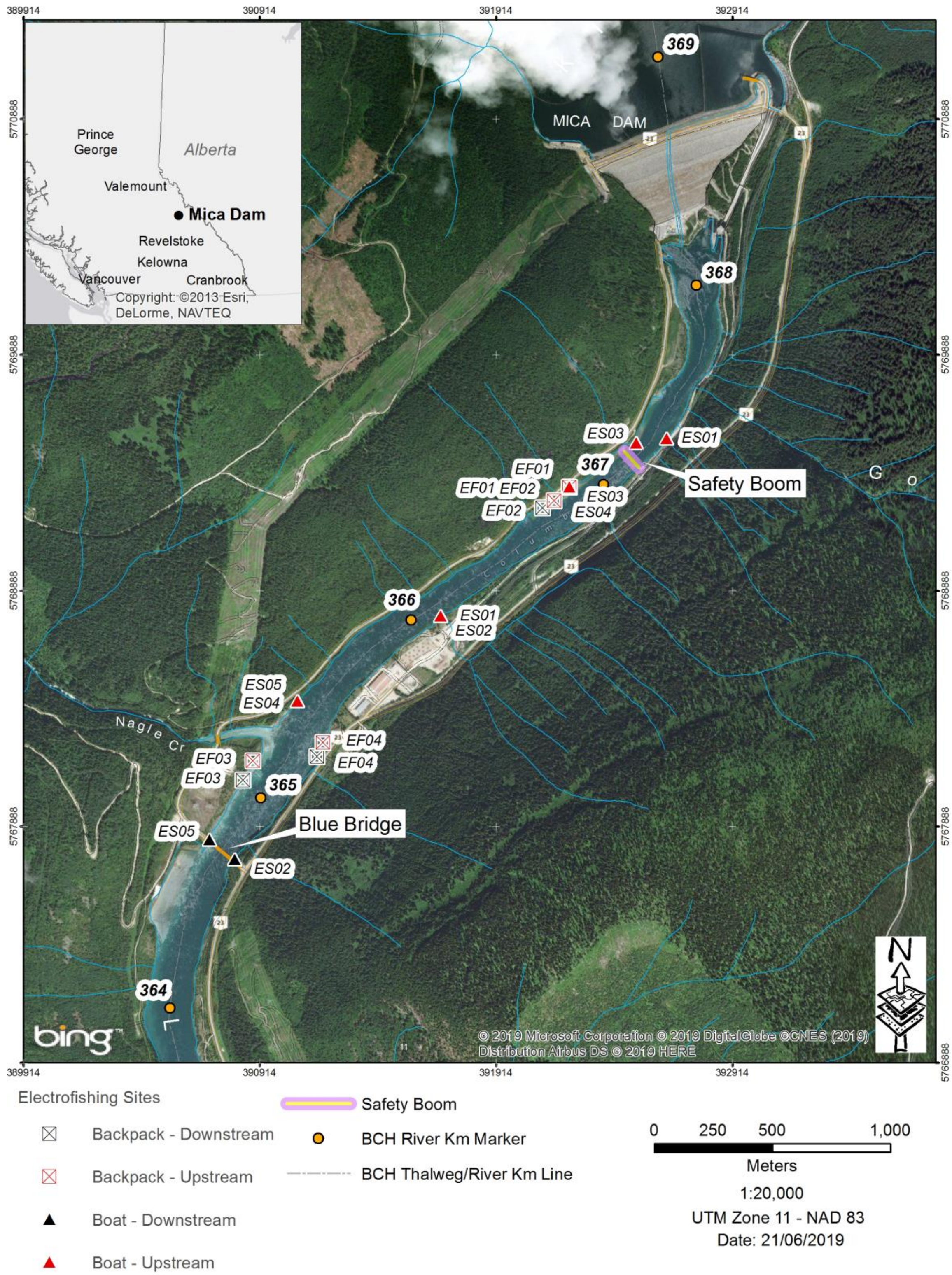


Figure 1. Electrofishing locations and study area (inset) for the Mica Tailrace Fish Indexing study.

**Water Temperature**

Temperature loggers have been installed in both the headpond and tailrace since the beginning of the study (October 2012). Minor changes have been made to their locations and configurations which are described in previous reports (Irvine et al 2013; Bisset et al 2015). Current locations of temperature loggers are shown in Figure 3


Figure 3. Four arrays are located on each bank of the river downstream of the dam located approximately across from each other and dispersed along the length of the study reach. Each array has

duplicate loggers (16 loggers in total). The headpond array was modified in May 2018 to address ongoing issues with the cable becoming tangled during the drawdown and refilling of the Kinbasket Reservoir. The configuration used by AMEC and Poisson (2012; Figure 2) in DDMMON-7 was used in this study as it does not result in the collapsing of the array during drawdown reducing the chance of tangling. Both arrays were connected to the log boom in the headpond slightly offset from one another. 16 tidbits were attached to the top-down array at 2 m intervals, except for the top-most tidbit which was placed at 0.2 m below the surface. 15 tidbits were attached to the bottom-up array starting at 1.1 m above the bottom of the reservoir and then spaced at 2 m intervals thereafter.

In the current study year, the loggers were downloaded on October 27th, 2017, and on May 11th and October 3rd-4th, 2018. Temperature data from all study years are analyzed in this report.

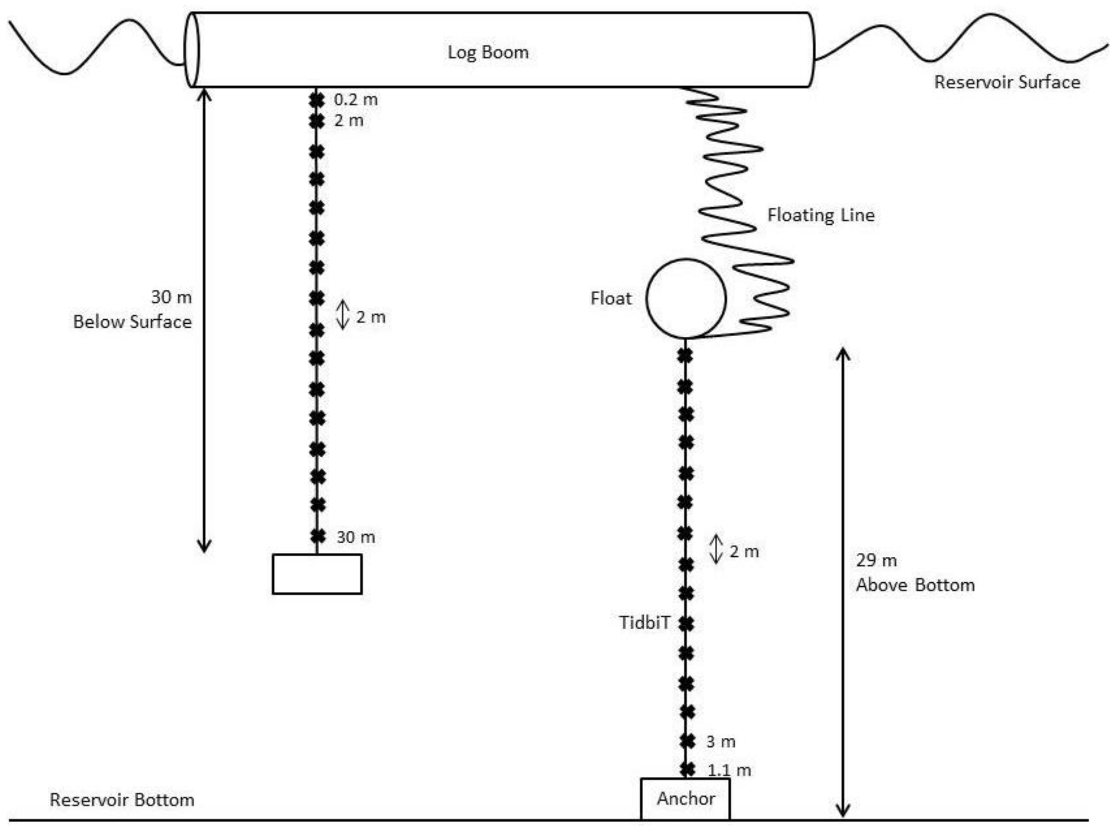


Figure 2. Diagram showing the configuration of the two temperature arrays installed in the headpond above the Mica Dam. Adapted from AMEC and Poisson (2012).


Figure 3. Temperature deployment locations in the Mica Dam headpond and tailrace.

**Data Management**

Temperature data were downloaded as .hobo files and exported to Excel spreadsheets for inclusion into the database. Fish faunal data were entered into Excel spreadsheets and underwent QA/QC procedures as outlined in the study plan for this project then imported into the database. The historical indexing information was obtained from the database for the 2008 study in the Mica Dam tailrace (Ford and Hildebrand 2008).

The information about temperature loggers' deployment, individual logger's identification and locations as well as all downloaded temperature data from historical studies in the area and the current program were imported into the database. The discharge and elevation information for Kinbasket and Revelstoke Reservoirs were extracted from the Columbia Basin Hydrological Database which is maintained by Poisson Consulting Ltd. for BC Hydro.

Spatial data from the Garmin 62S and 64S GPS units were downloaded after each night's survey into Garmin BaseCamp software and were saved as .gpx files. A shape file provided by Karen Bray of BC Hydro provided a center line down the thalweg of the river and river kilometer references that will be common to all Water License Requirement projects on the Columbia River (K. Bray, Pers. Comm.). The observations of individual fish were spatially located by taking the exact time of the recorded observation from the data sheet and matching that to the spatial point on the time referenced .gpx file to give a UTM coordinate in the river for that fish. The specific locations were then assigned a river kilometer by drawing a perpendicular line from the fish's location to the provided thalweg line and assessing where on the line it was located.

**Data Analysis**

As per the Terms of Reference (BC Hydro 2011c), the following variables were assessed from the fish observation and capture data: relative abundance, condition, and spatial distribution throughout the study area.

The annual variation in fish condition (body weight when accounting for body length) was estimated from the boat and backpack electrofishing captures using a mass-length model (He et al. 2008). Preliminary analyses indicated that site and day of the year were not informative predictors of condition so they were not included in the final model.

Key assumptions of the condition model include:

- Weight ($W$) varies with body length ($L$) as an allometric relationship, i.e., $W = \alpha L^{\beta}$
- $\alpha$ varies with year.
- $\beta$ varies with year.
- The residual variation in weight is log-normally distributed.

The annual variation in relative abundance was estimated from the boat count and catch data using an over-dispersed Poisson model (Kéry 2010; Kéry and Schaub 2011). Lineal densities are calculated by kilometre of river as extracted from the river centre line.

Key assumptions of the relative abundance model include:

- Lineal density varies with year.
- Lineal catch density is a fixed proportion of lineal count density.
- Expected counts (and catches) are the product of the count (catch) density and the length of river (half the length of bank) sampled.
- Observed counts (and catches) are described by an overdispersed Poisson distribution which accounts for clustering of fish.

Preliminary analyses indicated that site was not an informative predictor of lineal density.

The model estimates the count of fish, which is the product of estimated abundance and observer efficiency, and therefore does not distinguish between abundance and observer efficiency. Consequently, it is necessary to assume that changes in observer efficiency by year are negligible in order to interpret the estimates as relative abundance.

Model parameters were estimated using Bayesian methods. The Bayesian estimates were produced using JAGS (Plummer 2015). For additional information on Bayesian estimation the reader is referred to McElreath (2016).

Unless indicated otherwise, the Bayesian analyses used normal and uniform prior distributions that were vague in the sense that they did not constrain the posteriors (Kéry and Schaub 2011). The posterior distributions were estimated from 1500 Markov Chain Monte Carlo (MCMC) samples thinned from the second halves of 3 chains (Kéry and Schaub 2011, 38–40). Model convergence was confirmed by ensuring that the potential scale reduction factor $\hat{R} \leq 1.05$ (Kéry and Schaub 2011) and the effective sample size (Brooks et al. 2011) $ESS \geq 150$ for each of the monitored parameters (Kéry and Schaub 2011).

The parameters are summarised in terms of the point *estimate*, standard deviation (*sd*), the *z-score*, *lower* and *upper* 95% confidence/credible limits (CLs) and the *p-value* (Kéry and Schaub 2011). The estimate is the median (50th percentile) of the MCMC samples, the z-score is mean/sd and the 95% CLs are the 2.5th and 97.5th percentiles. A p-value of 0.05 indicates that the lower or upper 95% CL is 0.

The results are displayed graphically by plotting the modeled relationships between particular variables and the response(s) with the remaining variables held constant. In general, continuous and discrete fixed variables are held constant at their mean and first level values, respectively, while random variables are held constant at their typical values (expected values of the underlying hyperdistributions) (Kéry and Schaub 2011). When informative the influence of particular variables is expressed in terms of the *effect size* (i.e., percent change in the response variable) with 95% confidence/credible intervals (CIs; Bradford et al 2005).

The analyses were implemented using R version 3.5.1 (R Core Team 2018) and the mbr family of packages. For more information see *http://www.poissonconsulting.ca/f/1725152849*.

# RESULTS

## Discharge

Annual discharge from Mica Dam for 2008 to 2018 is summarized in Figure 4. Additional turbines, Mica 5 and 6 became operational on January 28th, 2015 and December 22nd, 2015, respectively. Boat electrofishing occurred over a range of flows (Figure 5). Generally, sampling was conducted within the desired range (400-800 $m^3/s$); however, unexpectedly high flows (~1,300 $m^3/s$) were encountered during the capture sessions at sites EF01, ES03 and ES04. Backpack electrofishing, in both 2017 and 2018, was attempted at flows within the target range (Figure 6).

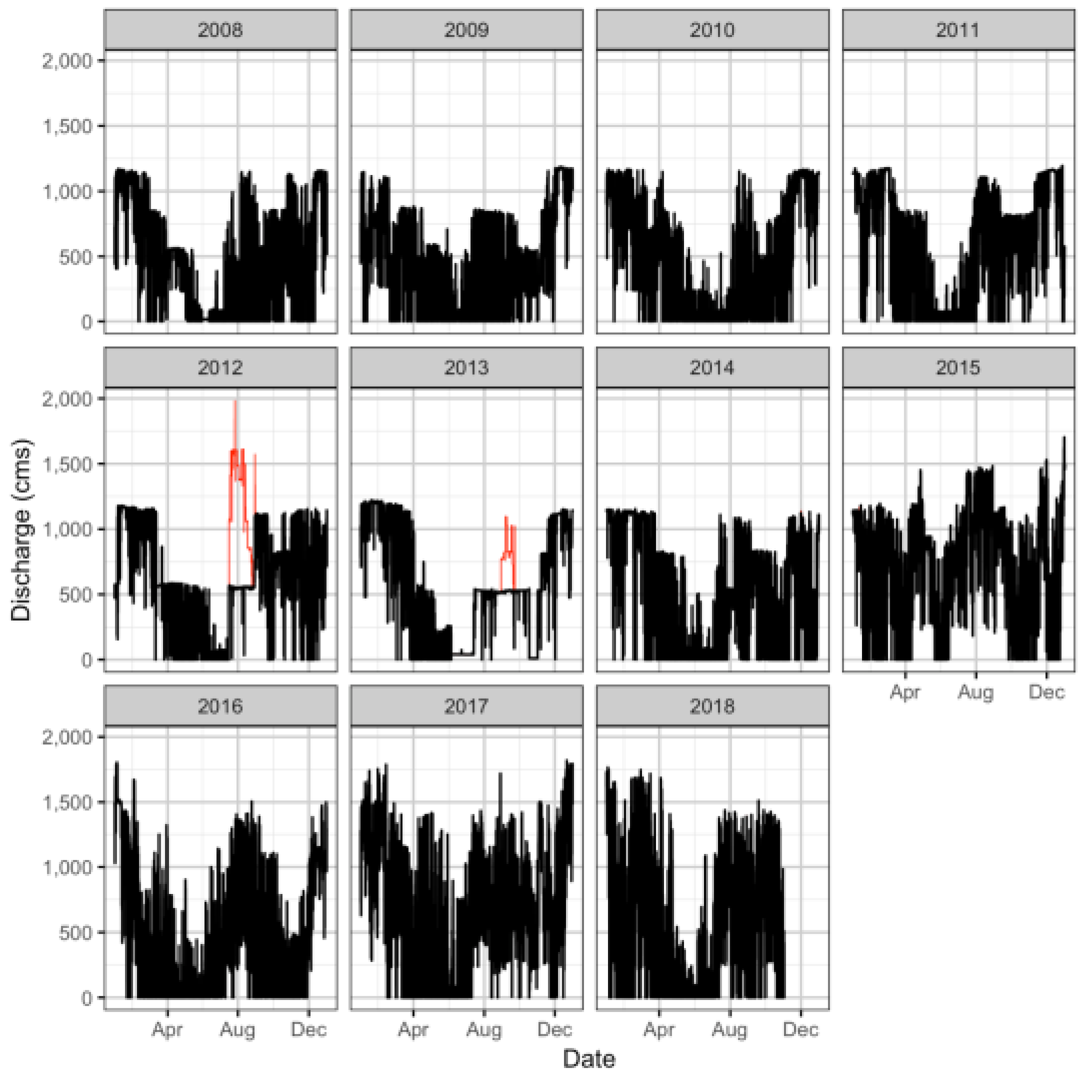


Figure 4. Hourly discharge from Mica Dam by turbines (black) and turbines plus spill (red), 2008-2018. Fish surveys were completed in October of 2012, 2013, 2017 (backpack electrofishing only) and 2018.

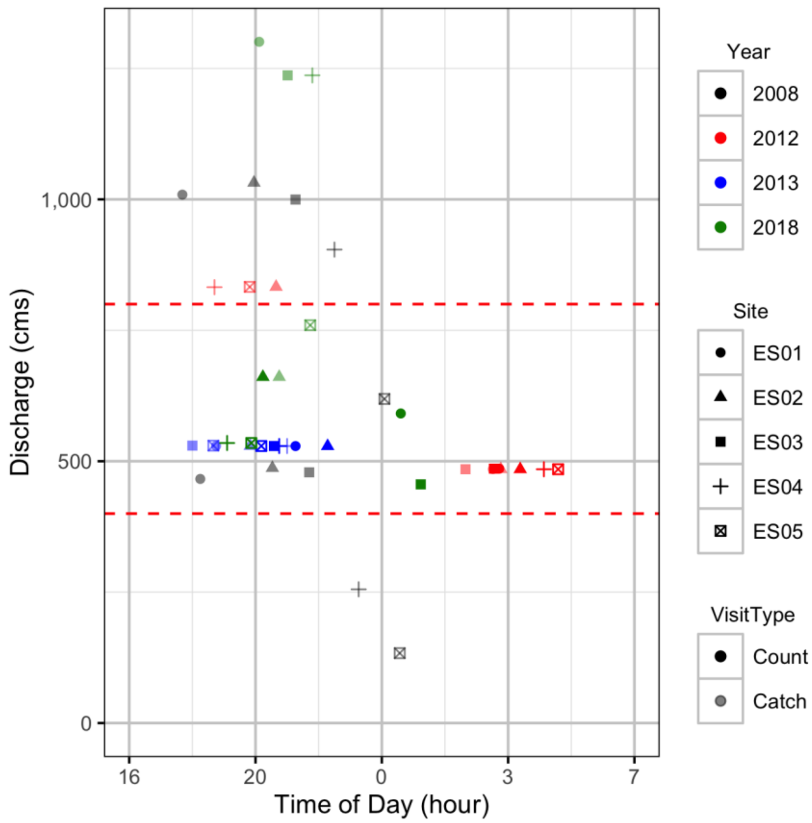


Figure 5. Mean discharge for the period three hours before and during each boat visit.

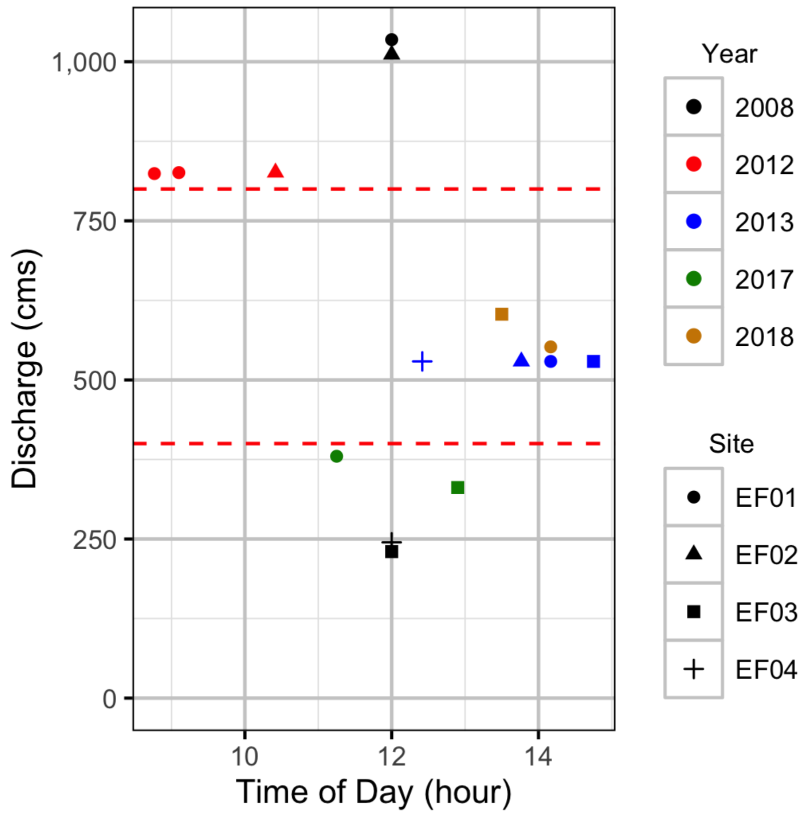


Figure 6. Mean discharge for the period three hours before and during each backpack visit.

**Fish Observation and Capture**

The initial counts of the five boat electroshocking sites took place on October 2nd, 2018. Sites ES01 and ES03 were counted during the first session (02:36h to 03:18h) while the remaining three sites were counted during the second session (22:06h to 22:30h). Across all five sites, 1,256 fish were observed. The most common species observed was Mountain Whitefish with 1,046 individuals enumerated (83% of all observations). Kokanee were also numerous with 119 individuals counted (9%). Other species observed were Rainbow Trout (N=6), Bull Trout (N=63), Sculpins (N=3), Suckers (N=15), and unidentified salmonids (N=4).

Boat electrofishing capture was completed on October 2nd (22:45h to 23:12h) and October 3rd, 2018 (22:07h to 00:09h). 139 fish were captured for assessing biometric data and verifying the observers' estimated sizes. 14 adult Bull Trout were captured ranging from 415-723 mm in length and 835-4,500 g in weight. 22 Kokanee (6 fry, 1 juvenile, 15 adults) were captured ranging from 36-380 mm and <1-1,170 g in weight. 102 Mountain Whitefish (1 juvenile, 101 adults) were captured ranging from 168-372 mm in length and 44-472 g in weight. A single Longnose Sucker was captured that was 460 mm in length and 1,800 g in weight.

The length frequency data for the four salmonid species counted by observers and caught by netters in 2018 are plotted with adult and juvenile length cut-off values (Figure 7). The observers were generally good at size estimation as shown by the overlap of the observation vs. catch curves; however, there was a slight underestimation of the size of Kokanee. No Rainbow Trout were captured to compare to the estimated lengths of the observed individuals. Individuals were classified as fry (age-0), juvenile (age-1 and older sub-adults) or adult (sexually mature) based on the length cut-offs by species outlined in Table 3.

Table 3. Size cut-offs for life stages of four salmonid species observed and captured.

| Species | Fry | Juvenile | Adult |
|---|---|---|---|
| Bull Trout | <120 | 120-399 | >400 |
| Mountain Whitefish | <120 | 120-174 | >175 |
| Rainbow Trout | <120 | 120-249 | >250 |
| Kokanee | <100 | 120-249 | >250 |

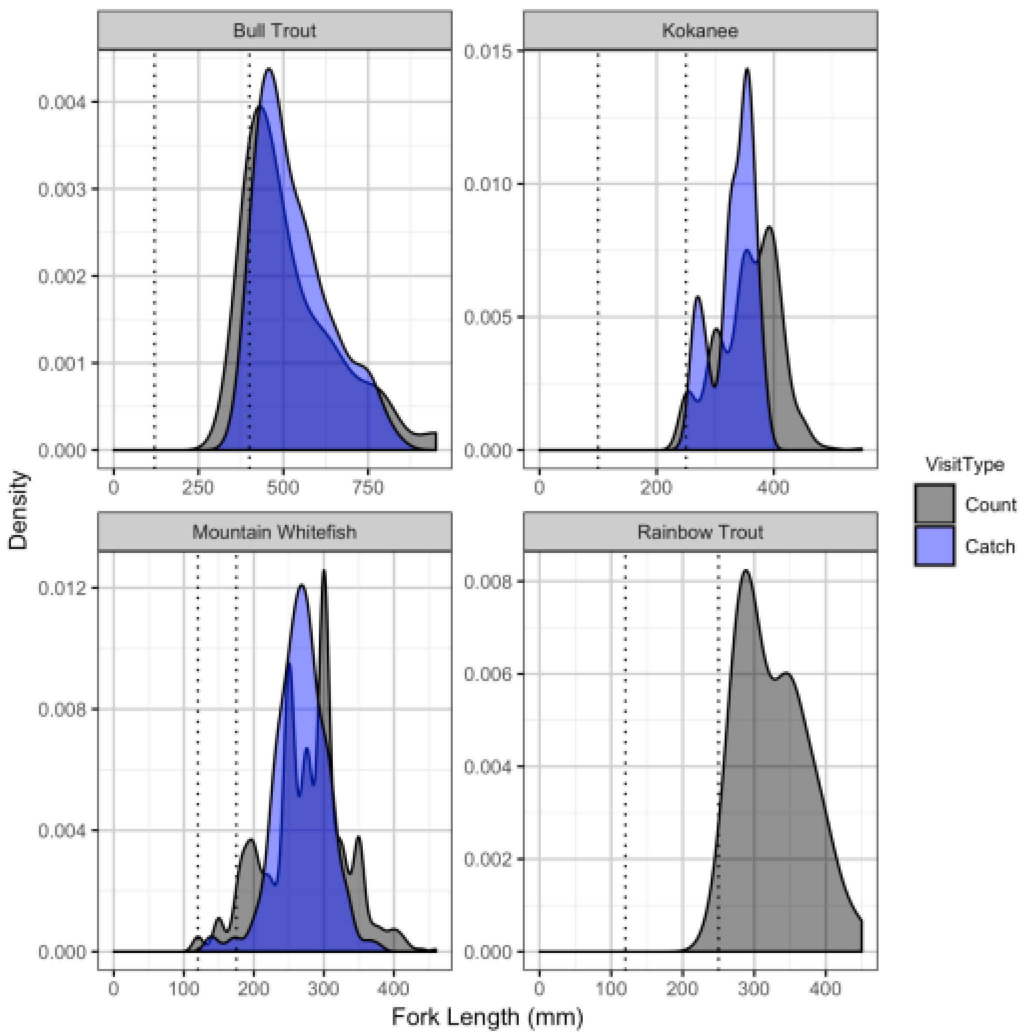


Figure 7. Length density by species and for boat count (observed) versus boat catch with fry and juvenile cut-offs indicated by dotted vertical lines. Sample sizes for observed and caught fish are: Bull Trout – 63, 14; Kokanee – 119, 22; Mountain Whitefish – 1,046, 102; and Rainbow Trout – 6, 0.

The lineal count density for all four salmonid species (adult and juvenile) is provided is Figure 8. No substantial difference between pre- and post-operation of Mica 5/6 was observed in any species. The post-operation lineal count density for Mountain Whitefish was slightly higher than in all sampled pre-operation years. Data for juveniles were only available for Mountain Whitefish. Densities were consistently low across all sampling years. Overall, densities of Kokanee between the three sampling years were highly variable.

No Rainbow Trout have been captured in the past two years while Kokanee densities are highly variable and driven by top-down and bottom-up reservoir dynamics, in addition to water temperature and degree day of the survey. Of the remaining two species the vast majority are Mountain Whitefish. Consequently, species evenness, which is very low (< 0.2), was not calculated for each year as it is almost exclusively driven by changes in the density of Mountain Whitefish.

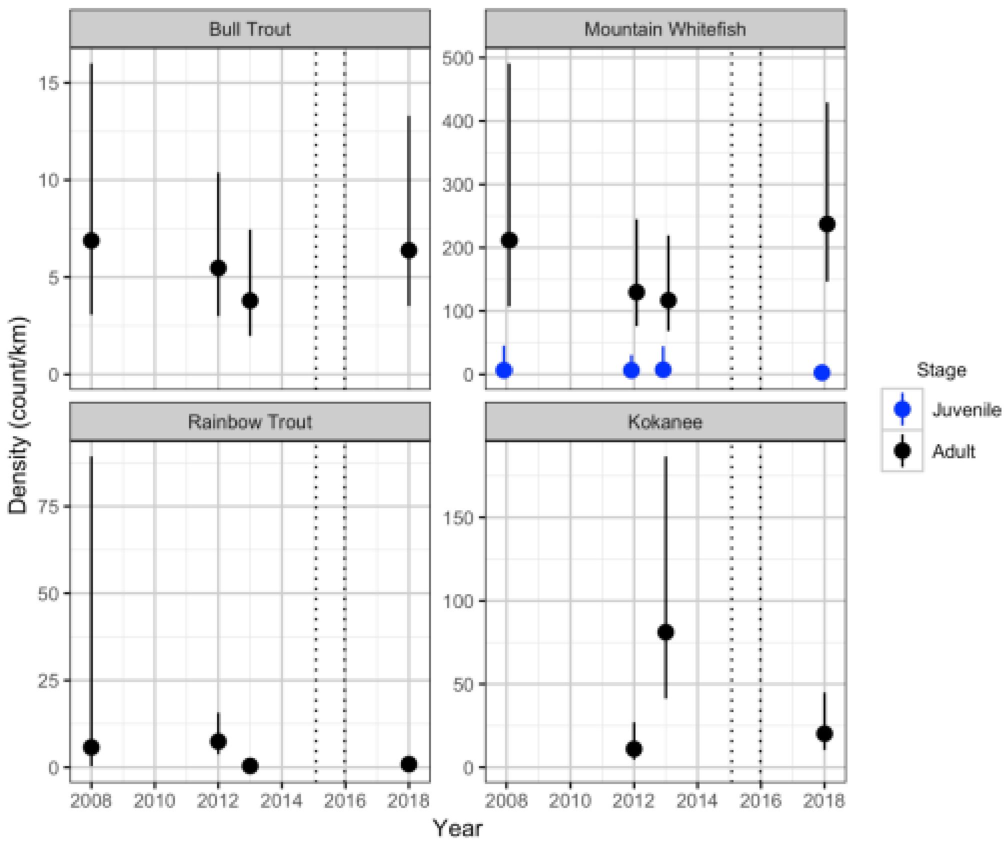


Figure 8. Predicted lineal count density (with 95% CRIs). Dotted lines represent the dates when Mica 5 and 6 became operational (January 28th, 2015 and December 22nd, 2015, respectively).

The body condition of BT and MW was assessed with respect to their percent change in weight for a typical fish within a size class as compared to 2012 condition values. A typical fish for the small size class was 300 mm for BT, 80 mm for MW and 80 mm for KO. A typical fish for the large size class was 600 mm for BT, 250 mm for MW and 250 mm for KO. Figure 9 presents fish body condition for each sampling year compared to the first year of the program (2012). In 2018, a small decrease in body condition was observed for BT for both small and large fish. KO juveniles were smaller than in 2012, while the juveniles showed a slight increase in body condition. Body condition of MW juveniles was lower in 2018 than in 2012 and significantly higher for MW adults.

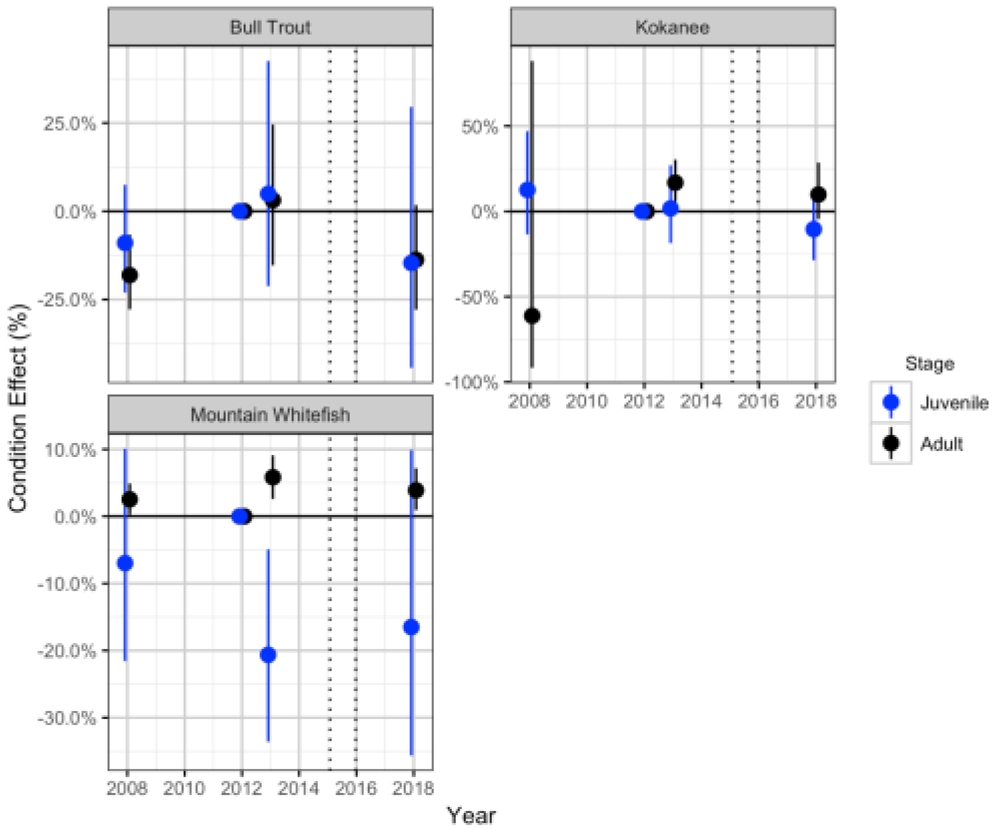


Figure 9. Expected percent change in body condition with respect to 2012 (with 95% CRIs).

The actual fish counts are plotted by bank, river km and year in Figure 10 to Figure 14. A general pattern of higher counts along the left downstream bank was observed in 2018 in most species. Bull Trout were more evenly distributed between the two banks, although, Bull Trout were only observed on the left bank above river km 366.5 (Figure 10). Kokanee were primarily observed along the left bank, however, the number of observations along the right bank increased below river km 365.5 (about halfway in the area; Figure 11). Adult Mountain Whitefish observations were more numerous along the left bank in all years of the study (Figure 12). The number of observations along both banks increased drastically above river km 366.5 in 2018. Few observations of juvenile Mountain Whitefish (Figure 13) and adult Rainbow Trout (Figure 14) were made in 2018 and the majority were from along the left bank.

These distribution data are also shown on maps with each fish's georeferenced location marked spatially (Appendix 2).

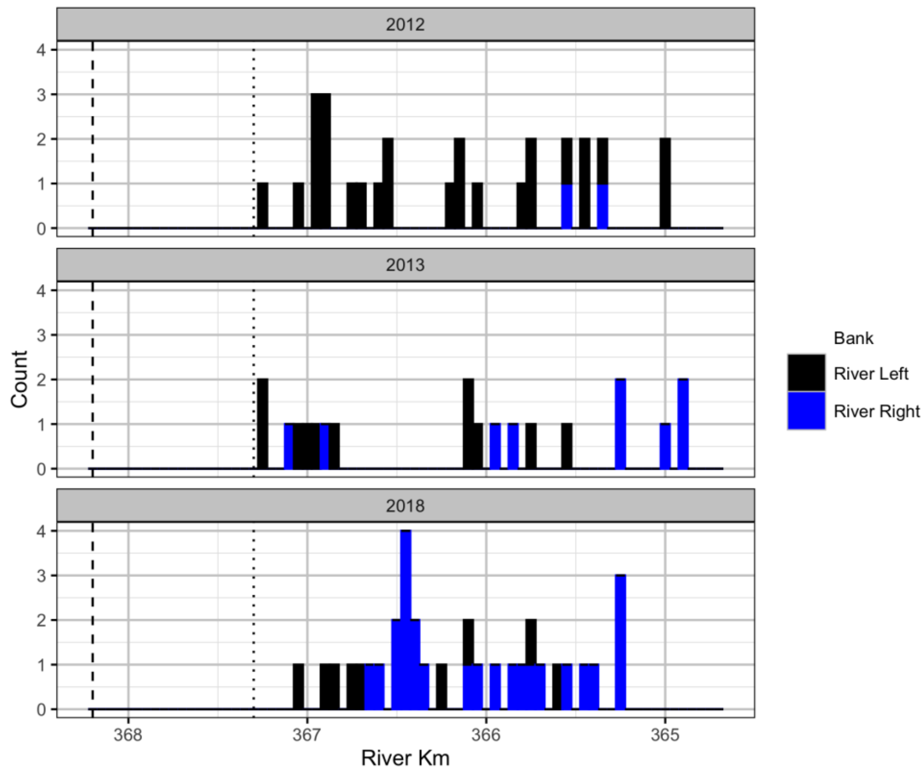


Figure 10. Boat counts by river km and bank for adult Bull Trout. Mica Dam is indicated by the vertical dashed line and the log boom by the vertical dotted line.

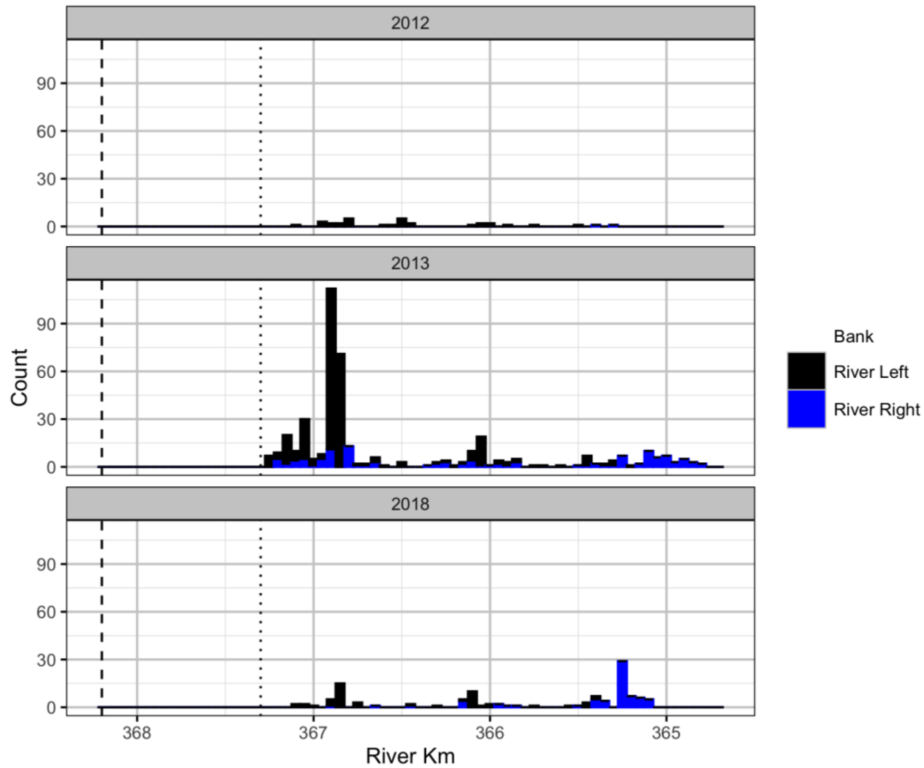


Figure 11. Boat counts by river km and bank for adult Kokanee. Mica Dam is indicated by the vertical dashed line and the log boom by the vertical dotted line.

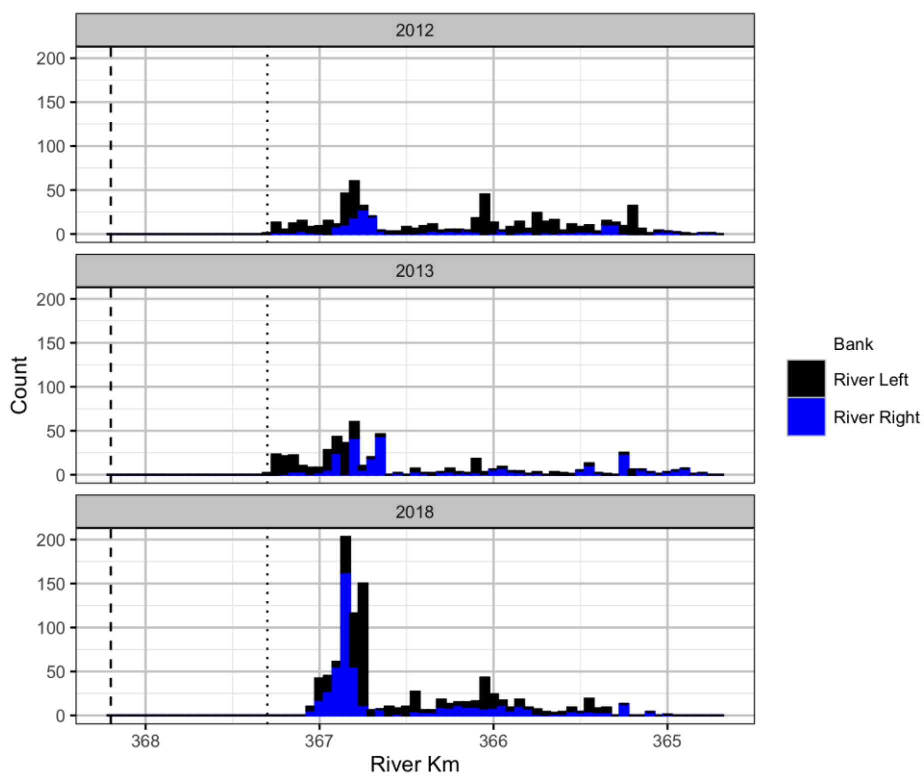


Figure 12. Boat counts by river km and bank for adult Mountain Whitefish.

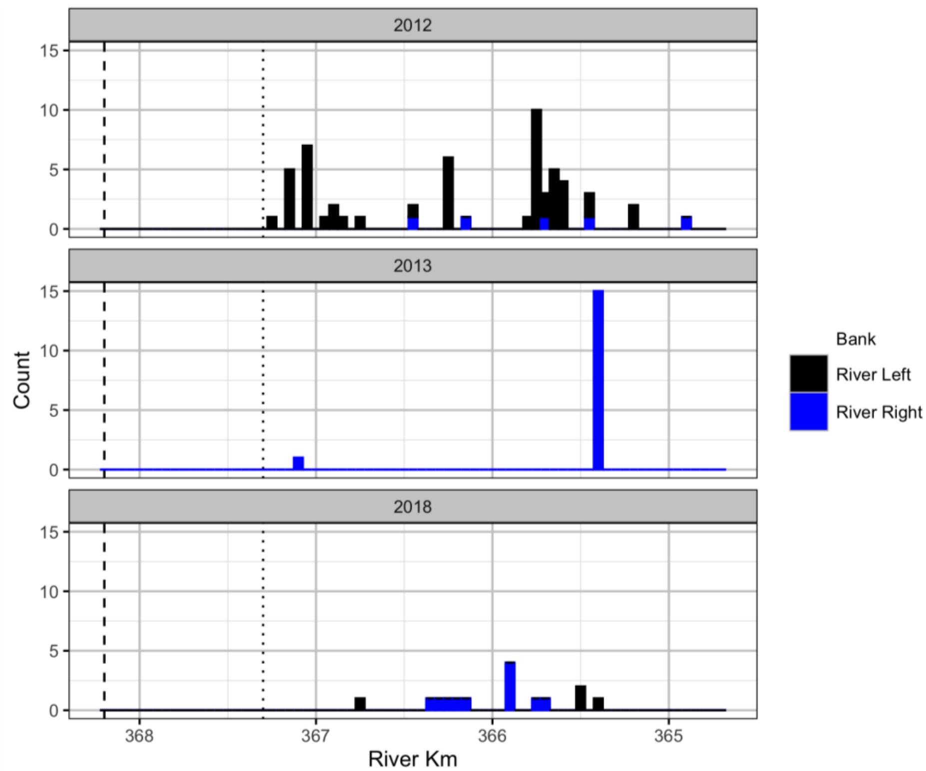


Figure 13. Boat counts by river km and bank for juvenile Mountain Whitefish. Mica Dam is indicated by the vertical dashed line and the log boom by the vertical dotted line.

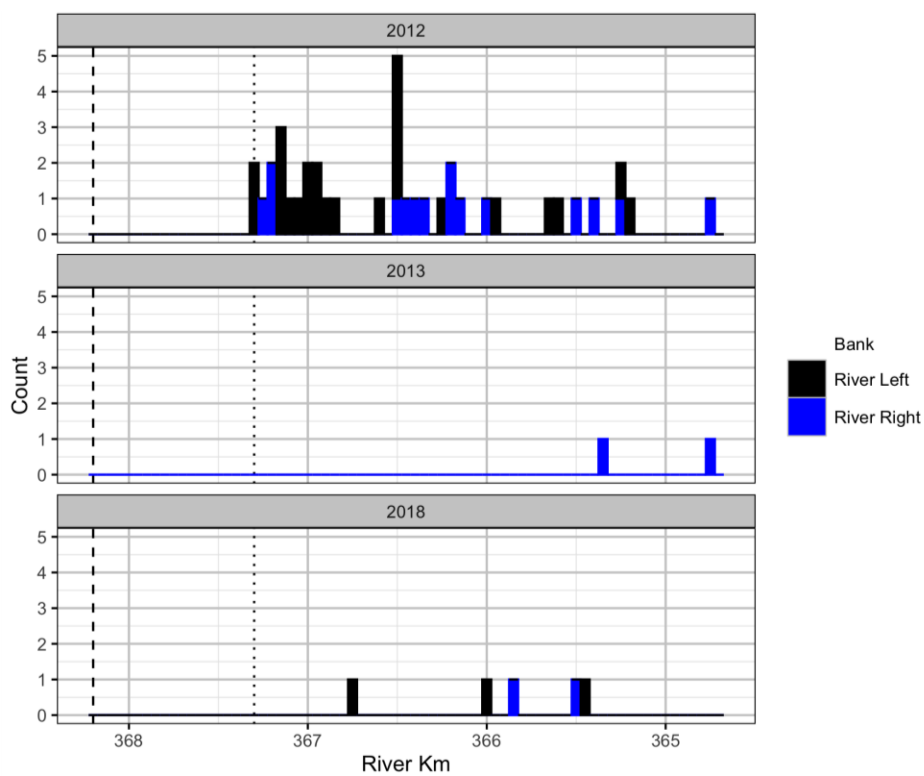


Figure 14. Boat counts by river km and bank for adult Rainbow Trout. Mica Dam is indicated by the vertical dashed line and the log boom by the vertical dotted line.

The relative abundance model estimated how efficient counting was relative to netting (Figure 15). Overall the netters caught 53% of the observed Bull Trout, 18% of the observed adult Mountain Whitefish, 10% of the observed juvenile Mountain Whitefish, and 33% of the observed Kokanee. Less than 10% of the Rainbow Trout observed were netted.

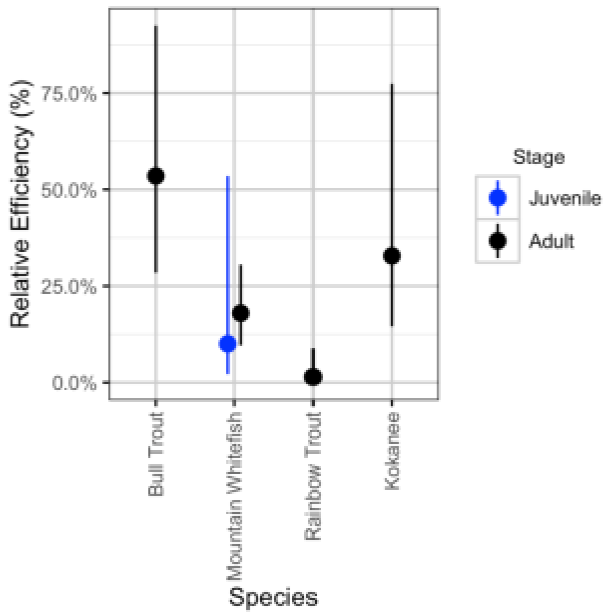


Figure 15. Predicted boat catch to count relative efficiency (with 95% CRI).

No fish were observed or captured during the backpack electrofishing passes at site EF01 in 2017 or 2018. A total of 683 electrofishing seconds were used over the site in 2017 and 945 electrofishing seconds in 2018.

**Water Temperature**

All the available reliable temperature data are presented in this report. Temperature loggers in the tailrace show typical seasonal patterns (Figure 16).

The differences in water temperature between the left and right bank by river km 365-367 and discharge are presented for each operating scenario (4, 5 and 6 turbines) in Figure 17. The observed differences between the right and left bank were all within the accuracy of the temperature loggers (±0.2°C). The operation of the additional two turbines does not appear to have detectable effect on the temperature differences between the two banks.

The differences in water temperature between sections of the tailrace (by river km) were also examined across discharge and the three operating scenarios (Figure 18). The observed differences between river km were all within the accuracy of the temperature loggers. Increases in discharge due to the addition of two turbines do not appear to have had a detectable effect on temperature gradients in the Columbia River upstream of the Blue Bridge.

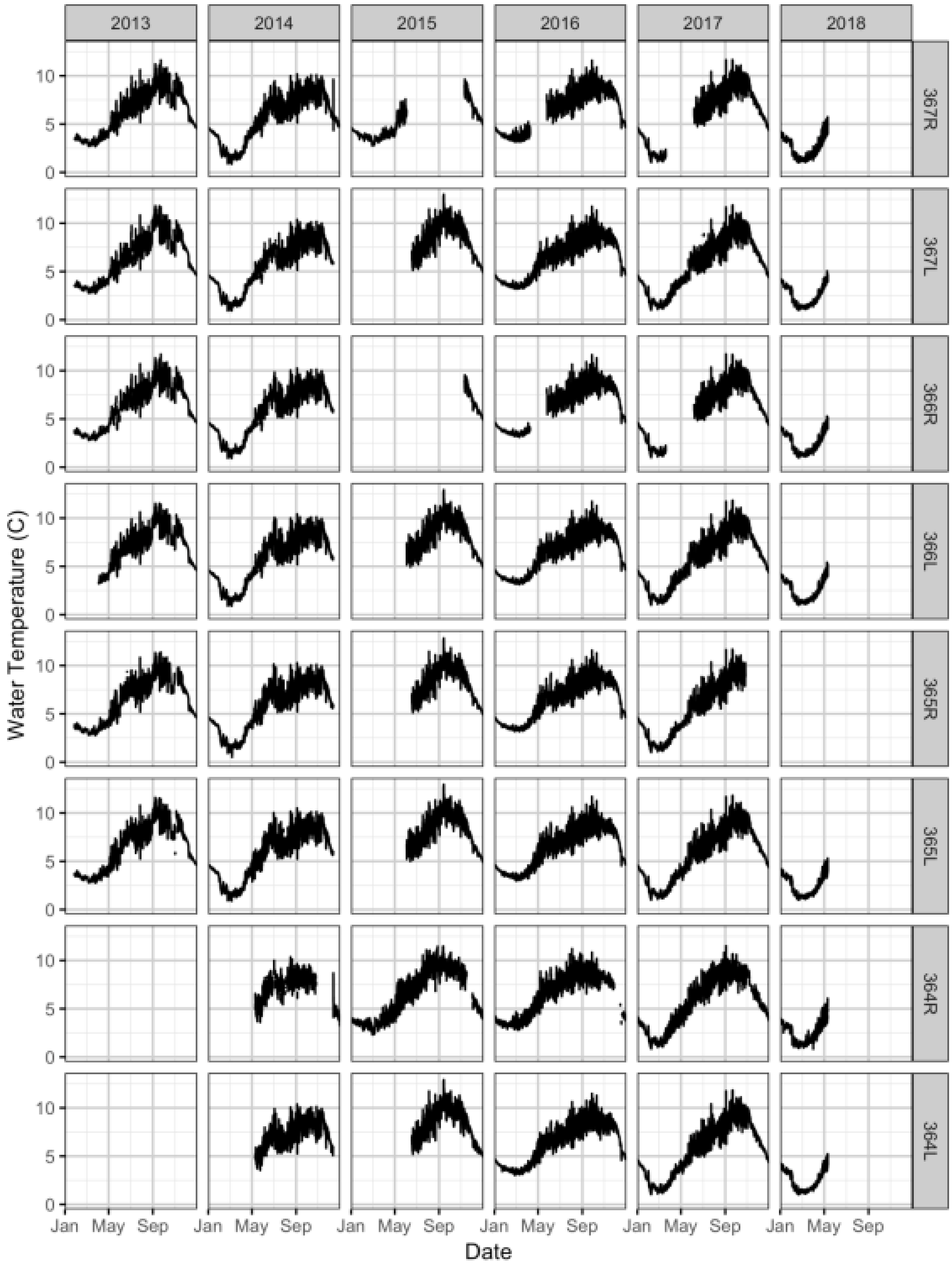


Figure 16. Hourly water temperature in the Mica Dam tailrace by date, year and site.

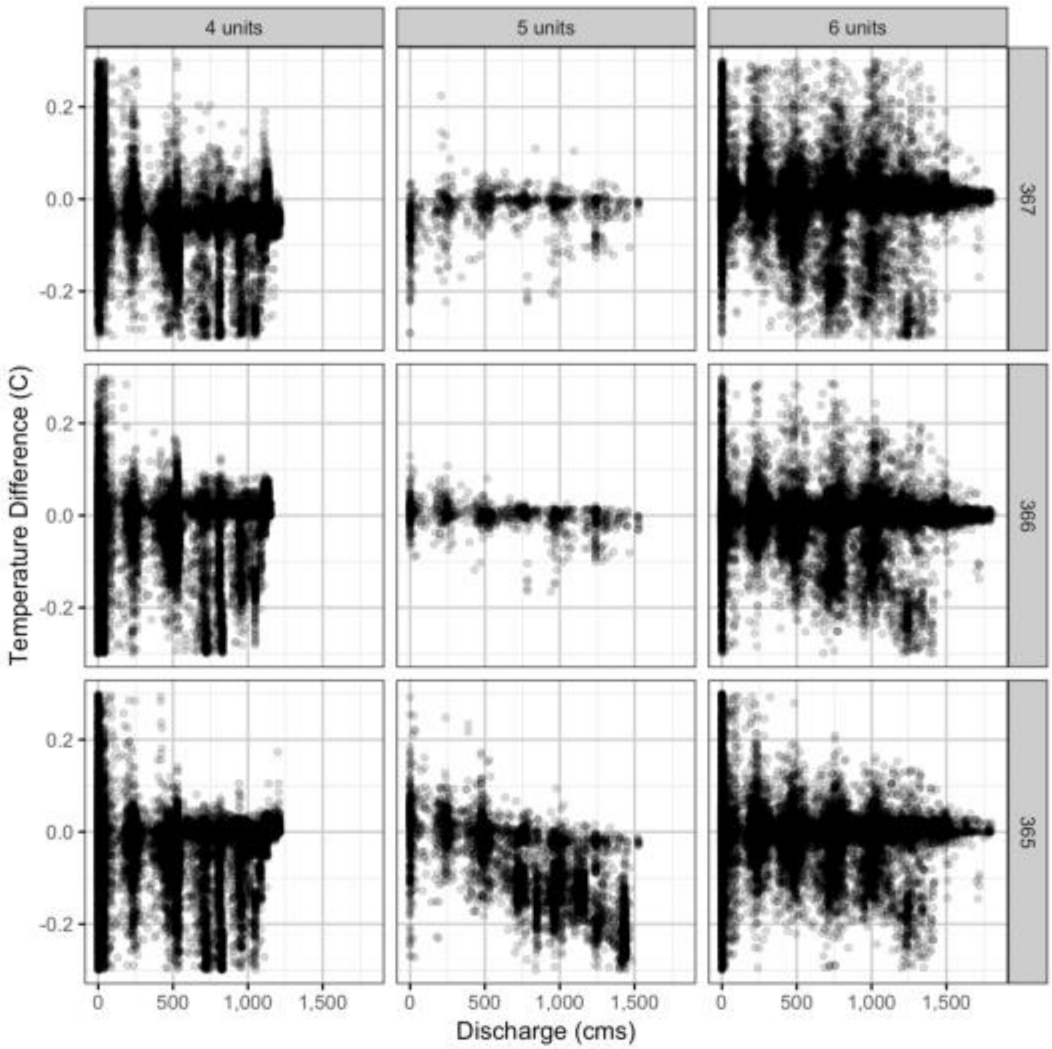


Figure 17. The hourly water temperature difference between the right versus left bank by discharge, regime and river km.

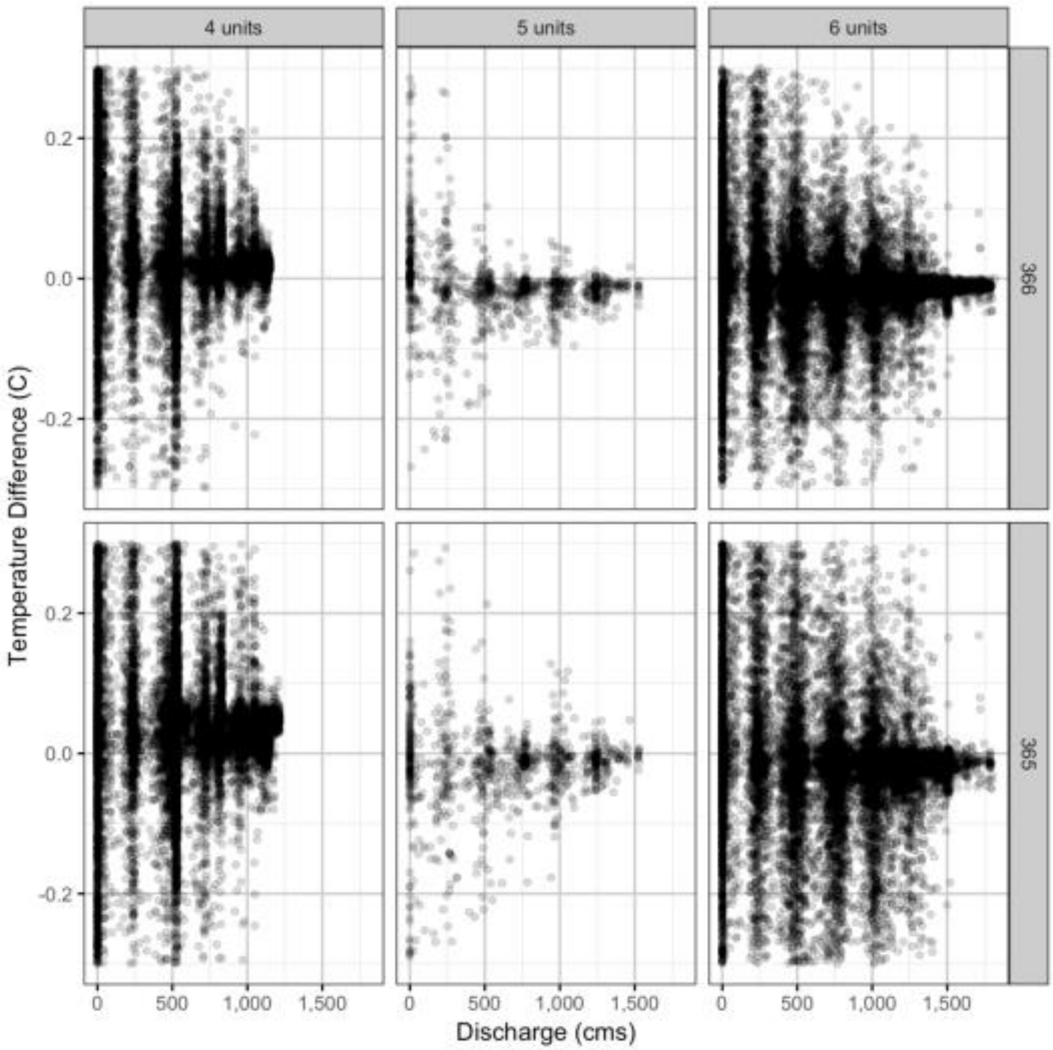


Figure 18. The hourly water temperature difference compared to 367 river km by discharge, regime and river km.

Water temperature profiles for the headpond from 2016 to 2018 are plotted in Figure 19. A general trend of colder temperatures in the winter and then warming throughout the late summer and early fall is observed across all depths and years. The most recent temperature headpond data has yet to be downloaded. Next year, we will test whether the level of discharge influences the temperature difference between the water at the intake versus that immediately downstream of the dam.

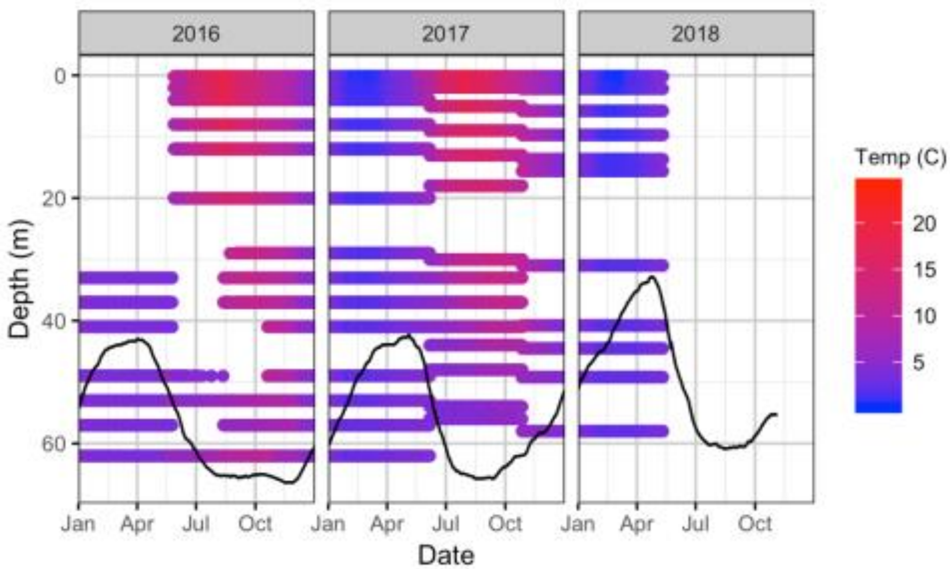


Figure 19. Hourly water temperature in the Mica Dam headpond by date, depth and year. The black line represents the location of the turbine intakes in the water column relative to the vertical arrays.

## DISCUSSION

### Fish species diversity and distribution

The boat electrofishing strategies used to enumerate the fish populations throughout the tailrace were effective overall. The observation pass was more efficient for counting the individual fish while the capture pass provided more detailed information regarding biological characteristics. Ultimately it was critical to have a consistent set of experienced observers for the observation passes to obtain accurate length estimates and species identification. There was good agreement between observer estimates and measurements of captured fish, indicating that observer data can be confidently used (Figure 7).

As only two years of pre-operation and one year of post-operation data are available for this project it is difficult to evaluate the changes in population and determine if a meaningful change in species composition and distribution has occurred as a result of the operation of Mica 5/6. Based on both observation and capture sessions, species diversity is low across all five sites. The tailrace of the Mica Dam is predominantly composed of Mountain Whitefish, Kokanee and Bull Trout, with Mountain Whitefish being the most abundant species. Rainbow Trout were also observed, but their numbers were consistently low across all sites and sampling years.

Sampling location did not appear to have an impact on the distribution of the fish (Figures 10 to 14 and Appendix 2). With respect to the right and left banks of the tailrace, no specific pattern of fish distribution is evident between pre- and post-operation years. It was noted that adult Bull Trout and adult Mountain Whitefish were more numerous between km 365.5 and 366.5, however, it is unclear what is driving that increase. As this observation was only made in 2018, it is possible that it was a single event and not related to any specific environmental conditions. The results of the 2019 field program may help to verify whether or not this is a pattern under post-operation conditions.

The annual variation in fish body conditions was generally low across all fish species (Figure 9). Body condition of Bull Trout decreased compared to 2012, but was not significantly different.

No juveniles were captured during the backpack electrofishing sessions in both 2017 and 2018. Overall there was a lack of suitable locations for backpack electrofishing throughout the 2.5 km of study area originally established for this project. Only one of the original index sites could be accessed in each year which was due to unconsolidated sediments at the sampling locations and elevated water levels. High water conditions were also encountered in 2012 which prevented access to the two sites along the left bank.

Pre-operation backpack electrofishing efforts along the right bank did result in the capture of small-bodied fishes and juveniles. In 2012 and 2013, Kokanee fry, Prickly Sculpins, Slimy Sculpins and unidentified Sculpins were captured. The tailrace is a dynamic system that is continually eroding and depositing sediment downstream. Over time this action results in habitat loss or modification, as well as the creation of new habitat downstream. Freeman et al (2001) found that habitat persistence in regulated rivers was low. While the study did not include any salmonids, it did find that juvenile abundance was correlated with habitat persistence rather than with availability. It is possible that regular erosion and modification of shallow water habitats as a result of flow regulation and increased flows has decreased the stability of the index sites in the study area below the Mica dam. Suitable shallow water habitats may be created downstream in areas that are less affected by flow regulation where sediment can be deposited; however, the spatial scope of this study does not extend downstream of the blue bridge.

**Thermal regime**

The second part of this study has been designed to assess the impact of the operation of Mica 5/6 on the thermal regime in the tailrace. In the tailrace, temperature differences between left and right bank, as well as along river km sections, are all within the error of the temperature loggers (±0.2°C). These results indicate the addition of two turbines has not detectably altered the temperature difference between the two banks, nor the temperature gradient immediately downstream of the dam. In the final year we will examine the effect of turbine operations on the water temperature differential between the headpond at the intakes and the tailrace.

## NEXT STEPS

Year 6 of the CLBMON-60 project represented the first year of thermal monitoring above and below the Mica Dam following the installation of Mica 5/6. The second set of post-operation monitoring will occur in the 2019 implementation year. The final summary report for the project will examine all data collected since 2012 and provide an analysis of the pre- and post-operation monitoring. Fish community data will be analyzed to estimate the percent changes in relative abundance, condition (weight relative to length) and distribution to estimate any effect due to the installation of Mica 5/6. The temperature analysis will look at: 1) the rate of change in water temperature and the water temperatures associated with different operational strategies and turbine configurations and how that changes with season, and 2) the spatial structure and variability in temperature changes throughout the study reach.

## RECOMMENDATIONS

Based on the 2017-2018 results and the absence of shallow habitats, it is recommended that a third year of post-operation backpack electrofishing be completed in 2019. If current index sites cannot be safely accessed then attempts should be made to move the sites to alternate locations within the designated study area. Additionally, index sites should be evaluated in terms of their habitat features and the habitat needs of the small-bodied fish and juveniles present in the study area.

## REFERENCES

AMEC and Poisson. 2012. Lower Duncan River Water Quality Monitoring (DDMMON-7). Year 2 Report. Report Prepared for: BC Hydro, Castlegar. Prepared by: AMEC Environment & Infrastructure Ltd. and Poisson Consulting Ltd. 51 pp + 4 app.

BC Hydro. 2004. Columbia River Water Use Plan Consultative Committee (Canada) Consultative Committee report: Columbia River Water Use Plan. BC Hydro.

BC Hydro. 2007. Columbia River Projects Water Use Plan. BC Hydro. 41 pp + 1 app.

BC Hydro. 2011a. Columbia River Water Use Plan Monitoring Program Terms of Reference Mica Units 5 and 6 Project Commitments. CLBMON-60 Mica Tailrace Fish Indexing Study. 8 pp.

BC Hydro. 2011b. Columbia River Water Use Plan – Kinbasket Reservoir Fish and Wildlife Information Plan – Monitoring Program Terms of Reference. BC Hydro. 8 pp.

BC Hydro. 2011c. Mica Tailrace Fish Indexing Study Terms of Reference. BC Hydro.

Bisset, J., R.L. Irvine and J.L. Thorley. 2015. Mica Tailrace Fish Indexing Study – Second Interim Report (Year 2). Report prepared for BC Hydro, Vancouver, B.C. Report prepared by the Columbia River Inter-tribal Fisheries Commission and Poisson Consulting Ltd. 51 pp + 6 app.

Bradford, M.J., Korman, J., and Higgins, P.S. 2005.Using confidence intervals to estimate the response of salmon populations (Oncorhynchus spp.) to experimental habitat alterations. Canadian Journal of Fisheries and Aquatic Sciences **62**: 2716–2726. doi: 10.1139/f05-179.

Ford, D., and L. Hildebrand. 2008. Mica Dam Tailwater Seasonal Fish Community Indexing Program: 2008 Investigations - Draft Report. A Golder Associates Ltd. Report, BC Hydro, Burnaby, B.C.

Freeman, M.C., Z.H. Bowen, K.D. Bovee and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications. **11**(1): 179-190.

He, J.X., J.R. Bence, J.E. Johnson, D.F. Clapp and M.P. Ebener. 2008. Modeling Variation in Mass-Length Relations and Condition Indices of Lake Trout and Chinook Salmon in Lake Huron: A Hierarchical Bayesian Approach. Transactions of the American Fisheries Society **137**: 801–817. doi: 10.1577/T07-012.1.

Irvine, R., J. Thorley and J. Bisset. 2013. Mica Tailrace Fish Indexing Study – Interim Report (Year 1). Report prepared for BC Hydro, Vancouver, B.C. Report Prepared by the Columbia River Inter-tribal Fisheries Commission and Poisson Consulting Ltd. 34 pp + 7 app.

Kéry, M. 2010. Introduction to WinBUGS for Ecologists: A Bayesian approach to regression, ANOVA, mixed models and related analyses. Elsevier, Amsterdam; Boston. Available from http://public.eblib.com/EBLPublic/PublicView.do?ptiID=629953 [accessed 7 July 2012].

Kéry, M. and M. Schaub. 2011. Bayesian population analysis using WinBUGS : a hierarchical perspective. Academic Press, Boston. Available from http://www.vogelwarte.ch/bpa.html.

Klohn Crippen Berger (KCB). 2009. Mica Generating Station Unit 5 and Mica Generating Station Unit 6 Project: Environmental Assessment Certificate Applications, Section 6. Prepared for BDC Hydro and Power Authority, Burnaby, B.C. Available for download from the Project Information Centre on the Environmental Assessment Office website, <http://www.eao.gov.bc.ca/>

Plummer, M. 2003. JAGS: A Program for Analysis of Bayesian Graphical Models Using Gibbs Sampling. In Proceedings of the 3rd International Workshop on Distributed Statistical Computing (DSC 2003). Vienna, Austria.

R Core Team. 2018. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from http://www.R-project.org.

RL & L Environmental Services Ltd. 2001. Water Use Plans – Environmental information review and data gap analysis. Volume 1: Upper Columbia – Mica and Revelstoke Projects. Prepared for BC Hydro, Burnaby, BC by RL&L Environmental Services in Association with Robertson Environmental Services Ltd., Pandion Ecological Research Ltd., Haggerstone Landscape Architect, Pomeroy & Neil Consulting Inc. and DVH Consulting. RL&L Report No. 858V1-F: 498 pp.

## APPENDIX A.1 – Photographs and descriptions of backpack electrofishing sites

Photograph A.1-1: Backpack electrofishing site EF01.

Photograph A.1-2: Backpack electrofishing site EF02. The water was too deep to safely electrofish the site.

Photograph A.1-3: Backpack electrofishing site EF03. Located slightly downstream of Nagle Creek. The water was too deep to safely electrofish the site.

Photograph A.1-4: Alternate backpack electrofishing site for EF03. Located slightly upstream of Nagle Creek. The water was too deep and the bed sediment was too unstable to safely electrofish the site.

Photograph A.1-5: Backpack electrofishing sites EF04. The site was determined to be unsafe to backpack electrofish due to high water and steep drop-offs.

**APPENDIX A.2 – Fish distribution maps**


Figure A.2-1: Distribution of Bull Trout observations in the study area below Mica Dam.

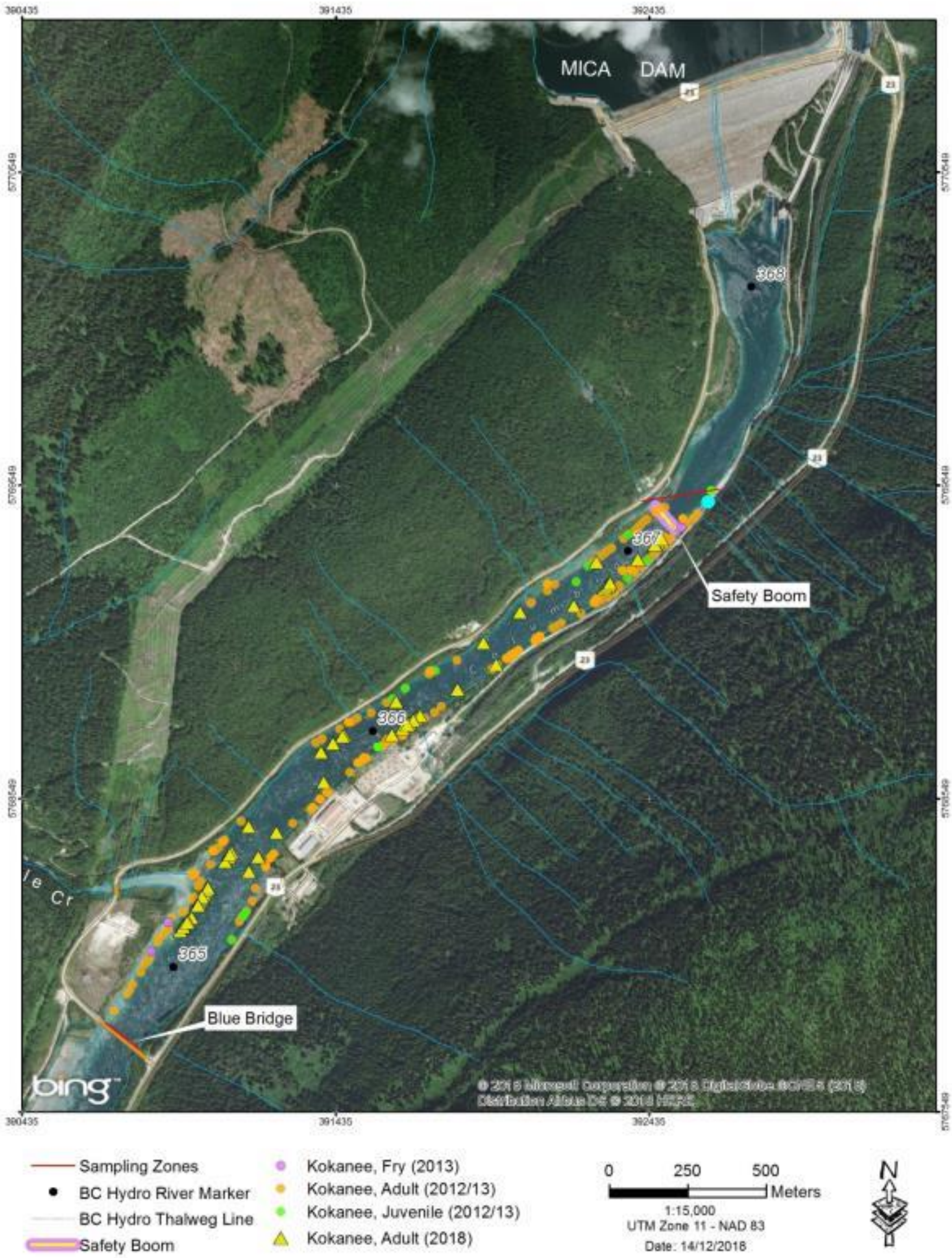


Figure A.2-2: Distribution of Kokanee observations in the study area below the Mica Dam.


Figure A.2-3: Distribution of adult Mountain Whitefish observations in the study area below the Mica Dam.

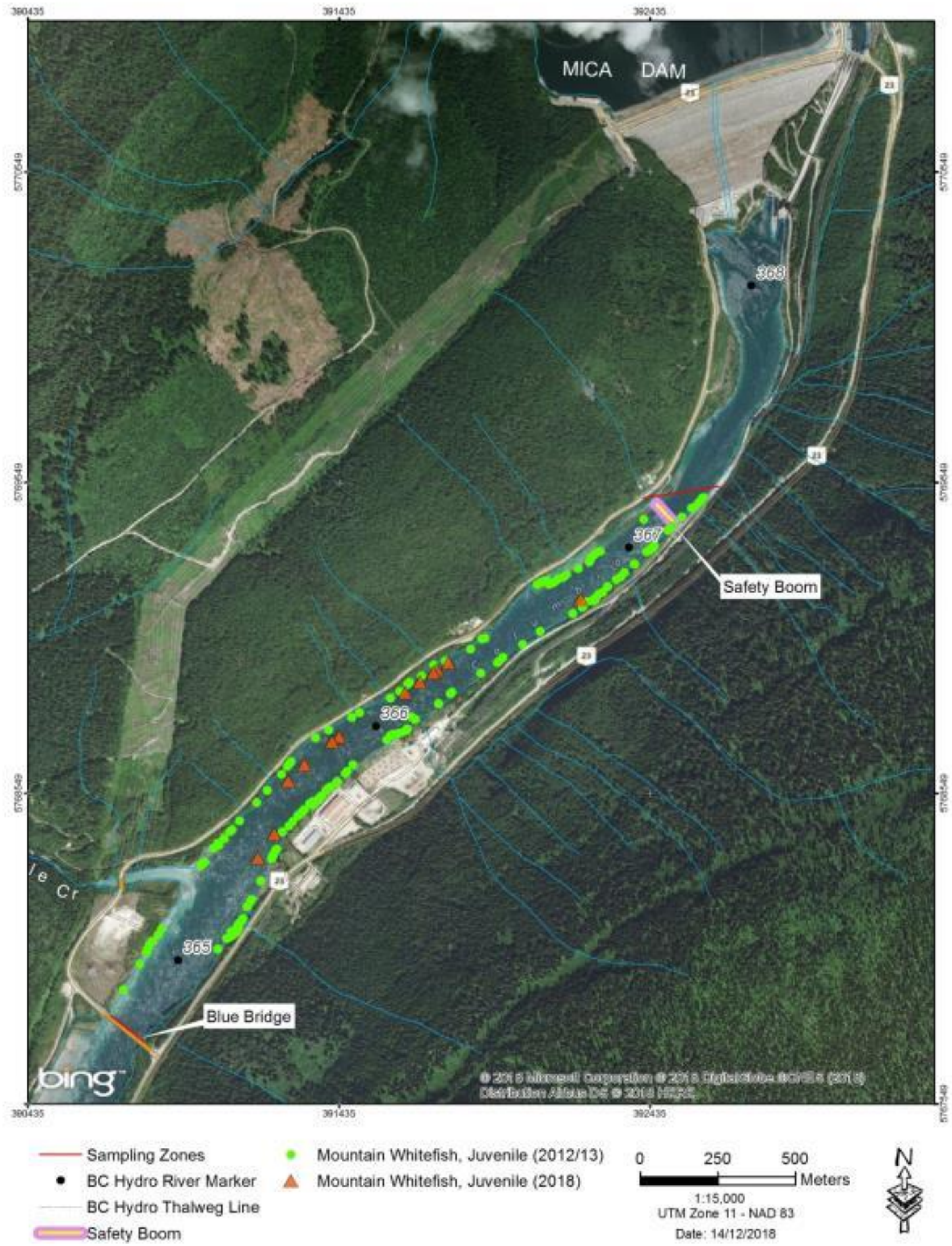


Figure A.2-4: Distribution of juveniles Mountain Whitefish observations in the study area below the Mica Dam.


Figure A.2-5: Distribution of Rainbow Trout observations in the study area below the Mica Dam.

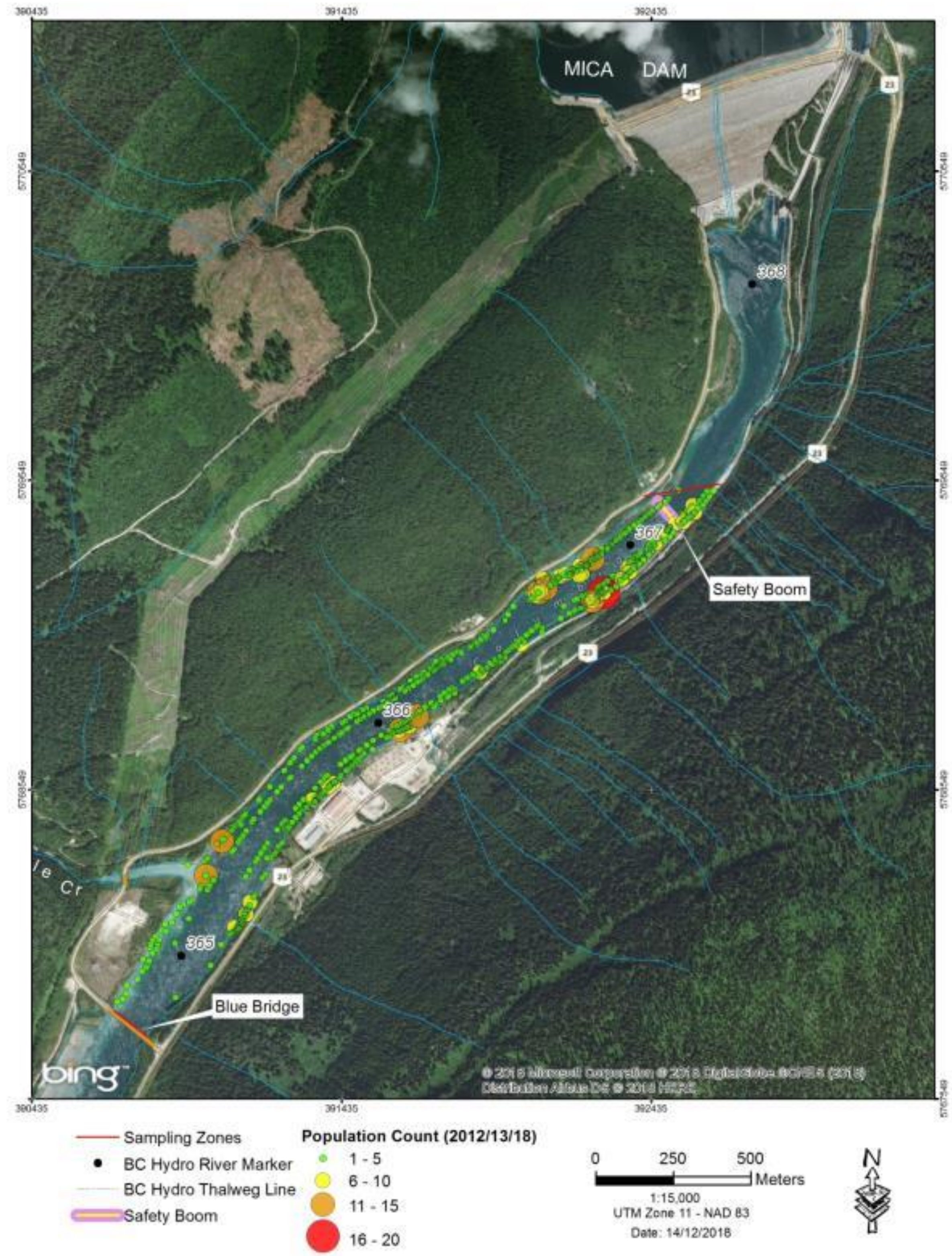


Figure A.2-6: Counts of adult and juvenile Mountain Whitefish in the study area below the Mica Dam.

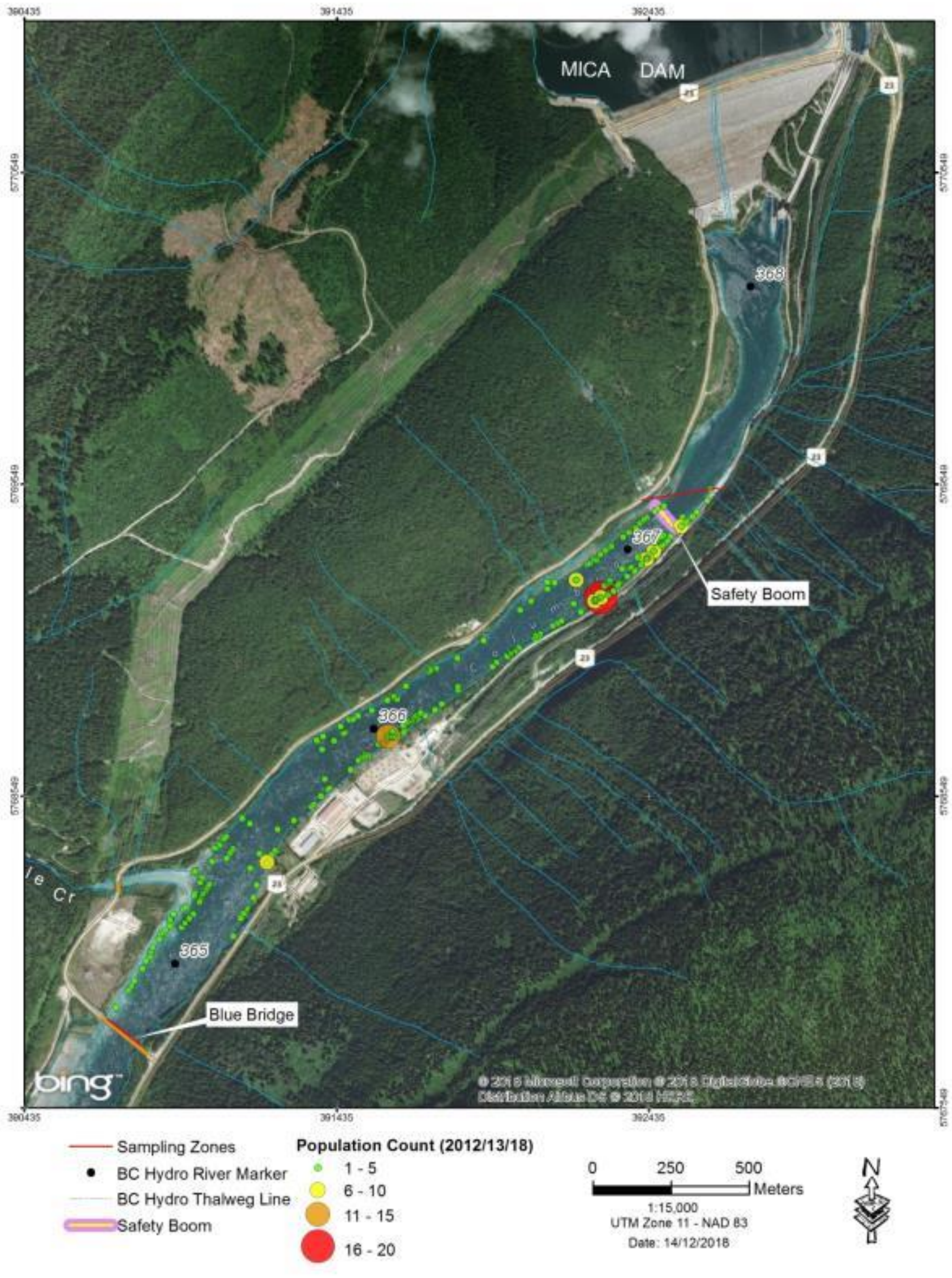


Figure A.2-7: Counts of adult and juvenile Kokanee in the study area below the Mica Dam.