Columbia River Project Water Use Plan

Columbia White Sturgeon Management Plan

CLBMON-21 – Mid-Columbia River Juvenile Sturgeon Detection and Habitat Use Study

Study Period: 2007 to 2023 Synthesis Report

Implementation Year: 17

BC Hydro and Power Authority

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SYNTHESIS REPORT

FINAL

CLBMON-21: Juvenile ċəmtus (White Sturgeon) Detection and Habitat Study in the Middle nx̌ʷəntkʷitkʷ (Columbia River)

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Cover Photos:

Top: Juvenile ċəmtus captured in the middle nx̌ʷəntkʷitkʷ in August 2017. Photo by Evan Smith, Okanagan Nation Alliance.

Bottom: Eight juvenile ċəmtus captured in the middle nx̌ʷəntkʷitkʷ during the first session of 2022. Photos by Eleanor Duifhuis, Okanagan Nation Alliance.

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Executive Summary

The population of ċəmtus (white sturgeon; *Acipenser transmontanus*) in the nx̌ʷəntkʷitkʷ (Columbia River) in southeastern British Columbia (BC) was listed as endangered under the federal Species at Risk Act (SARA) in 2006 due to recruitment failure. One segment of this population resides in the middle nx̌ʷəntkʷitkʷ (MCR), a section between Hugh L. Keenleyside Dam (HLK) in snɬuxwqnm (Castlegar, BC) and Revelstoke Dam (REV) in snkx̌yknt̓n (Revelstoke, BC) that encompasses the Arrow Lakes Reservoir (ALR). In 2006, an estimate of 52 adult ċəmtus (37 - 92 individuals at 95% CI) were thought to remain within the MCR, and all individuals aged were found to be older than the construction date of HLK Dam (1968). The primary reason for recruitment failure in the MCR is unknown as it is uncertain the extent that the area was used historically for all life stages.

In 2005, BC Hydro's Water Use Planning Consultative Committee (WUP CC) recommended a 10-year work plan (modified in 2013, 2018, and 2021) to better understand juvenile ċəmtus habitat capabilities in the MCR, and to investigate the potential for either building a self-sustaining or failsafe population in the ALR through releases of juvenile ċəmtus from a conservation aquaculture program. In December 2010, REV implemented minimum flow operations of 142 m^3/s, which coincided with the commissioning of an additional generation unit at Revelstoke Dam (REV5). As a result, the maximum generation discharge capacity of the dam increased from 1,700 m^3/s to 2,124 m^3/s; this was reflected in a mean daily discharge increase of approximately 200 m^3/s. The combined effects of these changes in dam operations are treated as one operational change in this report.

The management questions developed for CLBMON-21 Mid-Columbia River Juvenile White Sturgeon Detection and Habitat Program are:

1. Where are the habitat locations utilized by juvenile Sturgeon in the mid-Columbia?
2. What are the physical and hydraulic properties of this habitat that define its suitability as juvenile Sturgeon habitat?
3. What is the quantity of available habitat meeting these conditions in the mid-Columbia?
4. How do hydraulic conditions resulting from dam and reservoir operations relate to habitat suitability for juvenile White Sturgeon in the mid-Columbia?
5. What are the survival rates of juvenile White Sturgeon in the mid-Columbia?
6. Can modifications be made to the operations of REV and/or ALR to protect or enhance juvenile White Sturgeon habitat?

The program developed using two approaches to evaluate the above objectives:

1. Growth and Survival (2007-2023) – evaluating growth and survival of hatchery-origin ċəmtus through direct capture efforts; size at release has generally increased over the 15 years of the program to evaluate the influence on survival in the wild. This study initially focused on the snkx̌yknt̓n Reach section of the nx̌ʷəntkʷitkʷ (snkx̌yknt̓n to qwspíc'aʔ [Arrowhead]) but has expanded to include the upper Arrow Lakes Narrows and Upper ALR.
2. Habitat Use (2007-2023) – collection of background data on habitat use by juvenile ċəmtus and describing the attributes of those habitats. Acoustic telemetry was used to describe ċəmtus movements using both large (2007-2010) and fine-scale (2011-2012) receiver arrays. Additional habitat use through direct captures (2007-2023) was used to complement telemetry data.

CLBMON-21 was initiated in 2007 and at that time focused on acoustic telemetry to locate juvenile and adult ċəmtus to identify habitat use, and to capture juveniles released by the conservation aquaculture program (marked with passive integrative transponder [PIT] tags) to assess growth and survival. In 2007, a conservation aquaculture program specific to ċəmtus in the middle nx̌ʷəntkʷitkʷ was also initiated with the objective of determining whether a failsafe population could be established. To date, 63,752 juvenile ċəmtus have been released between Shelter Bay (RKm 177) and snkx̌ykntn (RKm 230).

A capture program was run from 2007-2023 using gillnets and setlines throughout the study area in an attempt to capture juveniles. Despite considerable sampling efforts, only 80 (<0.01%) individual ċəmtus have been recaptured since release from the hatchery with three individuals recaptured multiple times, resulting in a total of 83 ċəmtus captures. Of these individuals, 62 were captured over one year after release, 49 of which were captured 2 – 10 years after release. No fish have been captured from the 2010, 2017, 2019, 2020, or 2022 year classes. The remainder (21) were caught in the same year they were released. Growth rates of all MCR juvenile ċəmtus captured one year or more after release were 6.01 cm / year ± 0.65 cm / year (95% CI; n = 61) and 0.25 kg / year ± 0.03 kg / year (95% CI; n = 60). As a result of low capture rates of juvenile ċəmtus, survival estimates could not be determined.

A study design involving three phases of data collection was developed to assess juvenile ċəmtus habitat use and movements. During the first phase (2007-2010), data on movements and macro-habitat use were obtained from acoustic-tagged juvenile ċəmtus using both mobile tracking and passive receivers. During this phase, 200 (50 in each year) acoustic-tagged juvenile ċəmtus were released in the upper section of the MCR and data was collected from receivers placed ~5 km apart along the thalweg of the study area. Based on the rapid downstream movements of fish post-release in the first two years, the release sites were distributed at 10 km intervals throughout the upper 50 km of the study area for years 3 and 4. Fish released in less suitable habitat (fast and shallow) upstream habitats (upper 20 km) still exhibited rapid downstream movements until they reached deeper, slower sections while fish released in the lower 30 km had lower rates of movement post-release. Many juveniles used the area between Greenslide Creek (RKm 212) and qwspíc’aʔ Flats (Rkm 180) during the summer months and tended to make downstream movements in the fall. The mean net movement of tagged fish was similar in all years, and fish remained within a 21 – 26 km length of the reservoir despite differences in release patterns, which suggests juvenile ċəmtus are selecting for specific habitats. This work also identified that juvenile ċəmtus in the MCR prefer deep (>10 m), slow moving areas with fine substrates, and tend to be most active at night. Following these results, hatchery releases were moved to Shelter Bay (rkm 177).

The second phase, implemented in 2011 (Year 5), was to determine the feasibility and best location of a Vemco Positioning System (VPS) array that would describe localized movements and habitat use which was used to inform capture efforts. The data collected from the fine-scale array allowed analysis of movements related to daylight, habitat type, REV discharge, ALR elevation in 2012, and seasons. Tag locations clearly showed that juvenile ċəmtus have a preference for thalweg areas in all seasons but did use shallow and floodplain sites in summer and fall (when reservoir levels were high). Overall, results from the VPS telemetry array helped refine capture efforts for phase three of data collection by showing that juvenile ċəmtus used a wider range of depths, and made more frequent, longer, and faster movements in the summer (reservoir is full) compared to spring (reservoir filling) or fall (reservoir emptying).

The third phase of data collection occurred through the whole program and focused on direct captures of individuals to inform habitat use. In 2023, sampling occurred from Aug 21 to Oct 22, and resulted in the capture of one juvenile ċəmtus. This individual was captured within a year of release near Crawford Creek – Tree Island (RKm 192.1 to RKm 197.5). Gastric lavage was performed on the ċəmtus captured prior to release and a substrate grab was taken at its capture location to determine substrate type – substrate was later analyzed for invertebrate presence. Eight rock baskets were deployed to aid in the identification of potential ċəmtus prey presence, each associated with a substrate grab to determine substrate type.

The most common bycatch species in 2023 were spəqʷlic (burbot; *Lota lota*), suckers (*Catostomus sp.*), northern pikeminnow (*Ptychocheilus oregonensis*), and peamouth chub (*Mylocheilus caurinus*). Two ʕaẏckst (bull trout; *Salvenlinus confluentus*) were also captured.

The current state of knowledge for the juvenile ċəmtus program in the middle nx̌ʷəntkʷitkʷ with respect to BC Hydro's Management Questions is provided in the table below.

Management Question	Status
1. Where are the habitat locations utilized by juvenile Sturgeon in the Middle-Columbia?	Based on data collected using both acoustic telemetry and direct capture efforts, juvenile ċəmtus exhibit highest use of riverine habitats near Greenslide Cr. (RKm 212) downstream to Shelter Bay (RKm 177) and, to a lesser extent, further south into the Arrow Lakes Reservoir. To date only a few individuals have been documented further downstream towards nqʷisp (Nakusp) though sampling effort has been less in this area compared to the upstream riverine area.
2. What are the physical and hydraulic properties of this habitat that define its suitability as juvenile Sturgeon habitat?	Juvenile ċəmtus use deep (>10 m), low velocity (<0.5 m/s) habitats with fine substrates (sand/silt/clay). This is based primarily on movements of acoustically tagged juveniles (n=250) and general locations of capture (n=83). When releases occurred in snkx̌yknt́n (RKm 229, 2007-2012), juveniles were found to move quickly downstream to Mulvehill and Greenslide Creeks, and Akolkolex River areas and further downstream into the reservoir where conditions are more favorable. Accordingly, the release site was moved to Shelter Bay (RKm 177) in 2013 to target release in closer proximity to suitable habitats.
3. What is the quantity of available habitat meeting these conditions in the Middle-Columbia?	The amount of available deeper, slower, habitat for juvenile ċəmtus varies depending on discharge from REV and backwatering from the ALR. Thalweg habitats are available during all water elevations however the depth of the thalweg varies accordingly. During high water levels, shallows and floodplain habitats become available, though fine-scale movement work found that those habitats are used less than the deeper thalweg when both are available. Most juvenile ċəmtus captures have occurred within a 35 km section of river from approximately Shelter Bay (RKm 177) to Greenslide Creek (RKm 212).
4. How do hydraulic conditions resulting from dam and reservoir operations relate to habitat suitability	Both REV discharges and ALR operations influence habitat quality and quantity in the MCR. Discharge from REV influences the quantity and type of habitat available in riverine sections; however, the effects diminish with downstream

for juvenile White Sturgeon in the Middle-Columbia?	distance and are attenuated by the Greenslide Creek (Rkm 212) area where ċəmtus have been found to reside. High reservoir elevations backwatering the river section results in greater availability of deeper, low velocity habitats further upstream. ALR levels can influence ċəmtus movements in the river section during the summer when more habitat is available.
5. What are the survival rates of juvenile White Sturgeon in the Middle-Columbia River?	Survival cannot be directly estimated at this time due to low capture rates, attributed to a large study area and low capture efficiency. However, most of the individuals captured survived at least two years in the MCR (60%), with 6 having survived over 9 years before capture, showing capacity for survival in the MCR. On average, for all fish captured one or more years after release, total annual growth was 6.01 cm / year ± 0.65 cm / year in length and 0.25 kg / year ± 0.03 kg / year in weight. At this time, additional captures are required to estimate survival.
6. Can modifications be made to the operations of Revelstoke Dam and/or Arrow Lakes Reservoir to protect or enhance juvenile White Sturgeon habitat?	The implementation of minimum flows (142 cms) at Revelstoke Dam is the only hydroelectric modification since the program began. Based on the preference for deeper (> 10 m) habitats, primarily > 25 km downstream of Revelstoke Dam, it is unlikely the minimum flows significantly improved physical habitat availability. It is unlikely that additional operational improvements or modifications at REV can be made when it concerns physical habitat availability. At this distance from the dam, large changes in flows do not influence flow dynamics to the point where ċəmtus avoid the area. The landforms around the preferred area of the Walter Hardman Generation Station and Akolkolex River (RKm 200) constrict the nx̌ʷəntkʷitkʷ, which may be creating conditions that are more suitable to juvenile rearing. In the reservoir, maintaining ALR water elevations at levels that ensure a deep thalweg (425-430 masl) around Greenslide Creek (RKm 212) will maximize the amount of preferred habitat that is currently being used by juveniles in this area.

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Glossary

nsyilxcen waterbody names

nx̌ʷəntkʷitkʷ	Columbia River
ntx̌ʷitkʷ	Lower Columbia River (below HLK)

nsyilxcen place names

snkx̌ykntn	Revelstoke
qwspíc'aʔ	Arrowhead
nqʷisp	Nakusp
nq̓ʷəq̓ʷl'iwtn	Edgewood
snɬuxʷqnm	Castlegar
stqaʔtkʷɬniw̓t	Westbank

nsyilxcen fish names

c̓əmtus	White sturgeon
ʕay̓ckst	Bull trout
kəkni	Kokanee
spəqʷlic	Burbot

1.0 Introduction

ċəmtus (white sturgeon; *Acipenser transmontanus*) are the largest and longest-lived freshwater fish species in North America and are native to the nx̌ʷəntkʷitkʷ (Columbia River) drainage in British Columbia (BC), Canada. The population of ċəmtus in the upper nx̌ʷəntkʷitkʷ was listed as Endangered under the Canadian Species at Risk Act (SARA) in 2006 due to recruitment failure (DFO 2014). A small segment of the population from the pre-dam era occurs within the Arrow Lakes Reservoir (ALR), a section of the middle nx̌ʷəntkʷitkʷ (MCR) spanning from the Revelstoke Dam (REV) in snkx̌ykntn (Revelstoke BC) to the Hugh L. Keenleyside Dam (HLK) in snɬuxʷqnm (Castlegar). In 2006, the ALR adult ċəmtus population was estimated at approximately 52 adults (37 – 92 individuals at 95% confidence level; Golder 2006), all of which are assumed to have been present prior to the building of HLK Dam in 1968. In 2023, the estimated population of adult ċəmtus may be around 25 individuals, calculated assuming a 97% annual adult survival rate (DFO 2014). There have been no wild juvenile ċəmtus detected in this section of river, suggesting natural recruitment is not occurring.

In 2007, BC Hydro's Water Use Plan Consultative Committee implemented minimum flow release requirements at REV to 142 m^3/s that coincided with the commissioning of an additional fifth generating unit (REV5) at REV on Dec 20 2010. The addition of REV5 increased the maximum generation discharge capacity of the REV from 1,700 m^3/s to 2,124 m^3/s. The combined effects of the minimum flow release and the increased maximum discharge capacity from REV are collectively referred to as the 'flow regime change'.

As part of the Water License Requirements Program, BC Hydro implemented the MCR Juvenile White Sturgeon Management Plan under the Columbia River Water Use Plan. The purpose was to determine the suitability of the MCR as a second recovery area for ċəmtus in the Upper Columbia River Basin and to evaluate the potential for a self-sustaining or failsafe population (i.e., a second population supported by supplementation of juvenile ċəmtus from conservation aquaculture to provide future broodstock or genetic biodiversity in the event of a catastrophic failure of the primary population).

An experimental conservation aquaculture program was initiated in 2007 with releases of hatchery-origin juveniles occurring annually. A monitoring program was developed to investigate juvenile survival, growth, movement, habitat use, and habitat availability to support building a self-sustaining population in this section of the nx̌ʷəntkʷitkʷ. The program has been implemented adaptively, and as the monitoring progressed questions around ċəmtus movements to preferred habitats and optimal body size at release were incorporated into the study design.

1.1 Management Questions

The management questions defined by the Consultative Committee and associated with CLBMON-21 as per the Terms of Reference and Scope of Services (BC Hydro 2007) are:

1. Where are the habitat locations utilized by juvenile Sturgeon in the MCR?
2. What are the physical and hydraulic properties of this habitat that define its suitability as juvenile Sturgeon habitat?
3. What is the quantity of available habitat meeting these conditions in the MCR?
4. How do hydraulic conditions resulting from dam and reservoir operations relate to habitat suitability for juvenile White Sturgeon in the MCR?
5. What are the survival rates of juvenile White Sturgeon in the Middle Columbia River?

6. Can modifications be made to the operations of REV and/or Arrow Lakes Reservoir to protect or enhance juvenile White Sturgeon habitat?

1.2 Management Hypotheses

Hypotheses for the above management questions have been developed to guide the juvenile c̓əmtus study, and are as follows:

H1: The recruitment of c̓əmtus in Arrow Lakes Reservoir is limited by the quality and quantity of juvenile habitat below Revelstoke Dam.

> **$H1_A$:** Quality and quantity of c̓əmtus juvenile habitat in the MCR is directly related to discharge from the dam.
>
> **$H1_B$:** Quality and quantity of c̓əmtus juvenile habitat in the MCR is directly related to water elevation in Arrow Lakes Reservoir.
>
> **$H1_C$:** Quality and quantity of c̓əmtus juvenile habitat in the MCR is directly related to the interaction between discharge from the dam and water elevation in Arrow Lakes Reservoir.

H2: Quality and quantity of c̓əmtus juvenile habitat in the MCR can be significantly improved through changes in dam and reservoir operations.

$H3_A$: Juvenile c̓əmtus do not survive in the MCR in significant numbers from release as post-hatch larvae to year 1.

$H3_B$: Juvenile c̓əmtus do not survive in the MCR in significant numbers from release as late sub-yearling stage to year 2+ or older.

This report summarizes the key findings of the CLBMON-21 Program since its inception in 2007. This report also summarizes methods and results specific to juvenile c̓əmtus capture, capture efforts, growth and survival estimates, and diet analyses from 2007 to 2023. Methods and results of completed aspects of CLBMON-21 are available in the 2022 synthesis report (ONA 2023). These include the 2007 – 2010 large-scale juvenile c̓əmtus movement study, the 2011 – 2012 fine-scale juvenile c̓əmtus movement study, the 2007 and 2009 underwater video surveys, and the 2016 gear efficacy study. Additional details are provided in annual reports (Golder 2008, 2009, 2010, 2011, and 2012; Golder and ONA 2013; ONA 2016, 2017, 2018, 2019, 2020, 2021, 2022, and 2023), that are referenced collectively as the CLBMON-21 annual report series[1].

1.3 Key Water Use Decision

The key operating decision affected by the results of this monitoring program is the implementation of seasonal flow treatments from Revelstoke Dam. A seasonal flow treatment was to be implemented if age 0+ and 1+ juvenile c̓əmtus releases show relatively strong survival during the first four years of study (BC Hydro 2007). Results are being used to inform BC Hydro on the value of the 142 m^3/s minimum flow at the end of the review period for the Columbia WUP. The juvenile c̓əmtus monitoring program will provide evidence towards determining if natural recruitment and rearing can be re-established for the MCR c̓əmtus population.

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[1] https://www.bchydro.com/toolbar/about/sustainability/environmental_responsibility/water-use-plans/southern-interior/columbia-river/columbia-sturgeon.html

2.0 Methods

The following provides a brief discussion of the methods used over the course of the study program and highlights any changes in methodology that took place. Additional details are provided in the CLBMON-21 annual report series.

2.1 Study Location and Period

The MCR is a portion of the nx̌ʷəntkʷitkʷ spanning 230 km from REV downstream to HLK. The MCR includes the ALR (Upper Arrow Lake, Lower Arrow Lake, and Arrow Lakes Narrows) and snkx̌ykntn Reach, defined as the section of the nx̌ʷəntkʷitkʷ from REV downstream to qwspíc’aʔ (Arrowhead; Figure 1). snkx̌ykntn Reach is approximately 50 km in length and varies in width from approximately 150 m at points below Revelstoke Dam (RKm 234.9) to over 2 km at qwspíc’aʔ (RKm 184). This section of river is influenced by discharge from REV, experiencing water level changes of over 3.0 – 5.0 m and large daily velocity changes. An additional effect in this area is the filling and draining of the ALR, which dictates the location of the river-reservoir interface throughout the year due to backwatering. Immediately downstream of snkx̌ykntn Reach is the qwspíc’aʔ Flats area (described as Beaton Flats in previous CLBMON-21 annual report series), where the Beaton Arm confluences with the MCR (RKm 184 – 180) and is a transitional zone between the river and the deeper ALR. The Beaton Arm extends east 17.9 km to the Incomappleux River. The upstream 3.5 km of the Beaton Arm is characterized by shallow water and is called Beaton Flats (not sampled as a part of CLBMON-21 prior to 2019). The Upper Arrow Lake extends approximately 61 km from the qwspíc’aʔ Flats (RKm 180) to the Arrow Lakes Narrows (RKm 119). The entire study area of CLBMON-21 extends from REV downstream into the Arrow Lakes Narrows (157 km in length) and has been split into 17 River Sections, including two sections in the Beaton Arm (Table 1). The CLBMON-21 juvenile c̓əmtus study location and study periods have varied for different components of the study over the years of the program.

Table 1. Middle nx̌ʷəntkʷitkʷ River Section descriptions with downstream and upstream river kilometers (RKm).

River Sections	Description	Downstream RKm	Upstream RKm
1	Big Eddy - Rev Dam	228.4	234.9
2	1 km d/s Hwy 1 bridge - Big Eddy	226.1	228.3
3	1 km d/s Wells Creek - 1 km d/s Hwy 1 bridge	220.0	226.0
4	3.5 km d/s Begbie Creek - 1 km d/s Wells Creek	214.1	219.9
5	0.8 km d/s Greenslide Creek - 3.5 km d/s Begbie Creek	209.8	214.0
6	0.7 km u/s Blanket Creek - 0.8 km d/s Greenslide Creek	205.6	209.7
7	0.6 km u/s Walter Hardman - 0.7 km u/s Blanket Creek	201.9	205.5
8	Tree Island - 0.6 km u/s Walter Hardman	197.6	201.8
9	1 km u/s Crawford Creek - Tree Island	192.1	197.5
10	1.5 km d/s Wallis Creek - 1 km u/s Crawford Creek	186.6	192.0
11	qwspíc’aʔ - 1.5 km d/s Wallis Creek	182.1	186.5
12	Shelter Bay - qwspíc’aʔ	176.9	182.0
13	nqʷisp - Shelter Bay	129.1	176.8
14	Arrow Lakes Narrows - nqʷisp	119.0	129.0
15	Arrow Lakes Narrows	77.6	118.9
B1	Beaton Arm	2.2	14.3
B2	Beaton Flats	14.4	17.4

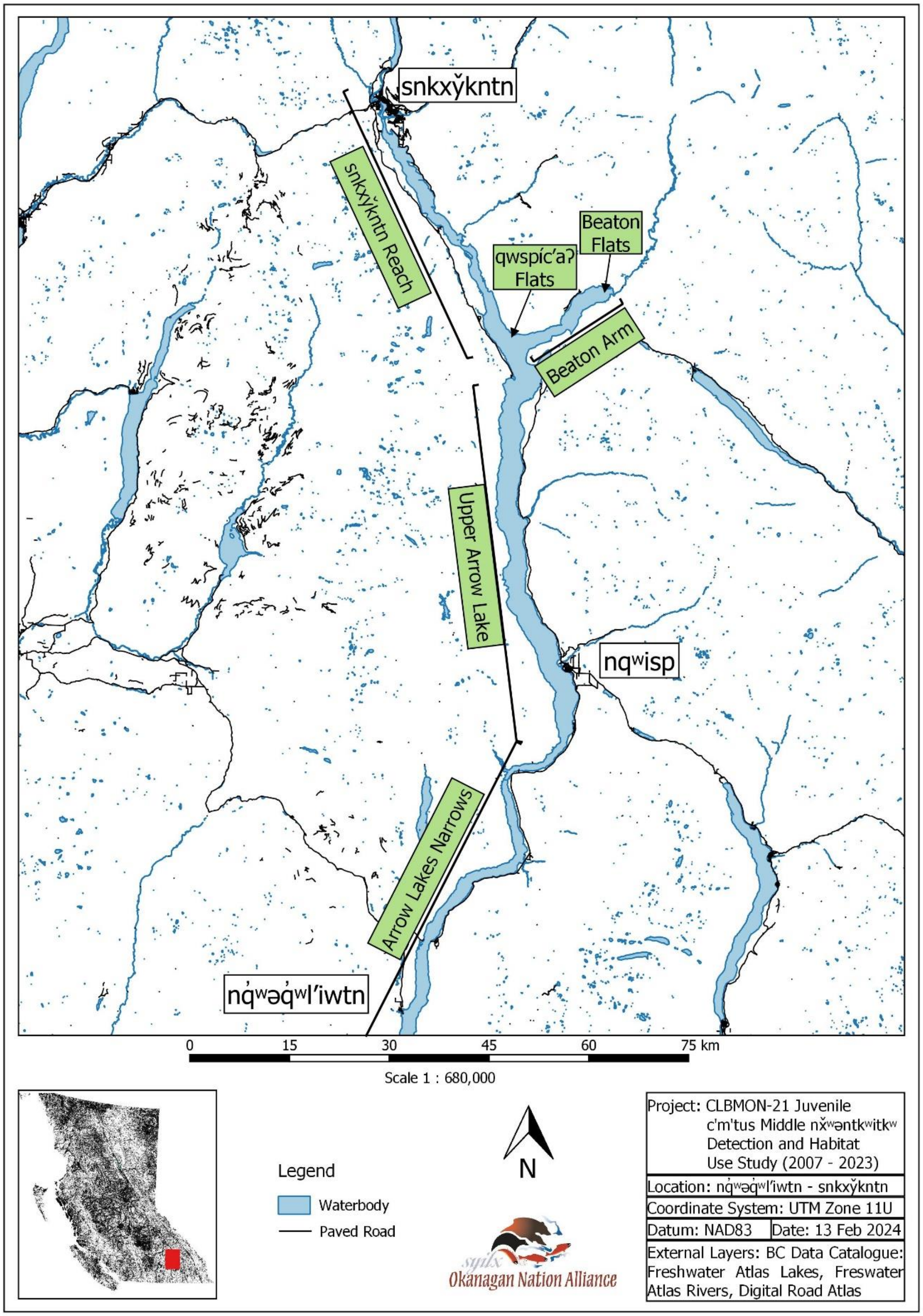

Figure 1. Map of the CLBMON-21 study area (2007-2023) in the middle nx̌ʷəntkʷitkʷ from snkx̌yknt downstream to nq̓ʷəq̓ʷl'iwtn.

Detailed maps of River Sections, river kilometers, and temperature station locations are available in Appendix A.

2.2 Physical Habitat Parameters

2.2.1 Discharge, Water Temperature, and Reservoir Elevation

Hourly discharge data for the nx̌ʷəntkʷitkʷ at REV were obtained from BC Hydro Power recording stations and water elevation data for ALR were obtained from the Water Survey of Canada (WSC) at nqʷisp (Nakusp BC; Station: 08NE104; WSC 2023). Water temperature data were obtained from various sources. Thermistors were deployed in selected locations within the study area to collect water temperatures representative of the different areas being studied each year (Table 2).

Table 2. Description of temperature stations locations and logger types used throughout CLBMON-21 from 2007 to 2023.

Year	Station	Logger Type
2007, 2009 – 2014	CLBMON-15A Station 6 (RKm 216)	Solinst data loggers
2011 – 2012	VR2W Receiver Stations	Onset StowAway Tidbits™
2013	CLBMON-15A Station 5 (RKm 219.9)	Solinst data loggers
2015	CLBMON-15A Station 3 (RKm 227.9)	
2016	CLBMON-21 Temp Stations (nqʷisp, Greenslide Creek, Shelter Bay)	Hobo™ Tidbits
2017	CLBMON-21 Temp Stations (nqʷisp, Greenslide Creek, Shelter Bay)	
2018	CLBMON-21 Temp Stations (Greenslide Creek, Shelter Bay)	
2019	CLBMON-21 Temp Stations (Greenslide Creek, qwspíc'aʔ Flats, Beaton Flats, Mosquito Creek)	
2020	CLBMON-21 Temp Stations (Greenslide Creek, qwspíc'aʔ Flats, Beaton Flats, Burton)	
2021 – 2023	CLBMON-21 Temp Stations (Greenslide Creek, qwspíc'aʔ Flats)	

2.2.2 Meso-Habitat Measurements

Over the 16 years of the program, a range of meso-habitat parameters were recorded in the immediate vicinity of where acoustic-tagged juvenile ċəmtus were detected and at gillnet and setline capture sites (Table 3; Table 4).

Table 3. Instruments used to collect meso-habitat parameters (including available precision and accuracy values) near juvenile ċəmtus detection and capture sites in during CLBMON-21 from 2007 to 2023.

Parameter	Instrument(s)	Precision	Accuracy
Depth	Boat depth sounder	0.1 m	
Current velocity	Marsh-McBirney electromagnetic flowmeter		± 2 % of reading
Surface water temperature	Alcohol thermometer		± 0.1 °C
	Boat depth sounder	0.1 °C	
	YSI Pro2030	0.1 °C	
Mid-column water sample	Van Dorn sampler		
Turbidity	Orbeco-Hellige Model 966 portable turbidity meter		0.01 NTU in the lowest range
Water clarity	Secchi disc	0.1 m	
Substrate sample	Ponar Grab sampler or Petite Ponar Grab sampler		
Cover assessment	Underwater video camera		
UTM coordinates	Trimble differential GPS unit		
	Garmin Handheld unit	1 m	± 3 m
Surface dissolved oxygen	YSI Pro2030	0.01 mg/L	± 2 % of the reading or ± 0.2 mg/L, whichever is greater

Table 4. Summary of meso-habitat measurements taken near juvenile ċəmtus detection and capture sites in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 from 2007 to 2023.

Study Year	Depth (m)	Water Temperature		Turbidity	Secchi Depth (m)	Current Velocity		Substrate Type	UTM	Dissolved Oxygen
		Surface	Bottom			No. of Locations	Seasonal Data [a]			
2007	√	√		√	√	12 sites		√	√	
2008	√	√							√	
2009	√	√				√			√	
2010	√	√		√	√	32 sites		√	√	
2011	√	√		√		2 sites	√		√	
2012	√	√	√	√	√	32 sites			√	
2013	√	√							√	
2014 – 2015	√	√						√	√	
2016 – 2018	√	√	√		√			√	√	
2019	√	√							√	
2020	√	√			√			√	√	
2021 – 2023	√	√			√			√	√	√

[a] Seasonal sampling consisted of sampling once during each session selected to represent the spring summer and fall seasons.

Benthic substrates were collected at a sub-sample of ċəmtus capture sites from 2014 to 2023 using a Ponar Grab with a grab capacity of 2,376 cm^3. Grab samples were stored with ethanol or isopropyl alcohol preservative until processing. Substrate sample volume was recorded prior to sorting. Samples were sorted using size 105 or 500 micron stainless steel screening depending on sample type. Samples were differentiated by dominant and secondary substrate types (fine, medium, coarse; clay, silt, sand, gravel) and invertebrate contents were recorded.

2.3 Juvenile ċəmtus Releases

2.3.1 Conservation Aquaculture

In 2007, the WUP Consultative Committee identified knowledge gaps for recruitment of juvenile ċəmtus in the MCR (BC Hydro 2007). Following this, a conservation aquaculture program was initiated to release juvenile ċəmtus annually in the MCR. The Upper Columbia White Sturgeon Recovery Initiative Technical Working Group (UCWSRI-TWG), which is responsible for the White Sturgeon Recovery Plan for the nx̌ʷəntkʷitkʷ upstream of Grand Coulee Dam, was involved in the WLR process and contributed to designing the hatchery program.

Since 2007, juvenile ċəmtus have been produced from either direct gamete crosses (broodstock; 2007-2014) or from eggs and larvae collected from natural spawning events in the wild (2014-present). From 2007 to 2014, mature adult ċəmtus (broodstock) captured in the ntx̌ʷitkʷ (Lower Columbia River; LCR; HLK to the Canada-US Border) were transported to the Kootenay Trout and Sturgeon Hatchery (KTSH), spawned, and returned to the river. More recently, research has identified that genetic diversity can be increased in supplemental ċəmtus progeny by collecting naturally produced eggs and larvae in the wild (Crossman et al. 2011) and this was confirmed for the nx̌ʷəntkʷitkʷ population (Jay et al. 2014). This led to a change in the conservation aquaculture program and the broodstock program was ceased in 2014. Juvenile ċəmtus reared from eggs or larvae captured from natural spawning events are referred to as 'wild origin' juveniles. The first wild origin juveniles (approximately 10 months old) for release in the MCR originated from collections on the nx̌ʷəntkʷitkʷ south of the border in Washington with the objective of testing size at release effects on survival. These were surplus fish to the US juvenile release program and were transported across the border to the KTSH for an additional year of rearing and subsequent release (as 22-month-old fish) in the MCR in 2016 – 2018. Releases in more recent years have included surplus wild origin progeny from spawning in the LCR.

Natural spawning of ċəmtus in snkx̌ykntn has been observed through the capture of eggs and larvae since 1999 during CLBMON-23A. Beginning in 2018, viable eggs and larvae from this stock were sent to the KTSH (89 in 2018, 7 in 2019, 203 in 2020, 679 in 2021, 20 in 2022, and 47 in 2023; Wood 2019; ONA 2024). A sub-set of these fish were reared to hatchery targets and released at Shelter Bay in following years.

2.3.2 Marking and Tagging

In March of each year, juvenile ċəmtus were individually marked at the KTSH using a Passive Integrated Transponder (PIT) tag into the dorsal musculature at the midpoint between the dorsal and lateral scute line and inferior to the anterior margin of the dorsal fin (Figure 2). All juveniles also received a secondary mark by the removal of selected scutes. Scute removal marking has been conducted since the inception of the White Sturgeon Conservation Aquaculture Program to ensure hatchery fish can be identified if PIT tags fail. For hatchery origin fish, scute removal patterns used from 2001 to 2014 involved scutes removed on the fishes left side below the dorsal fin: two scutes removed prior to 2011 and three scutes since 2011, or a combination thereof. Prior to 2011, it was always the first scute and then a second one, taken after counting the number of scutes that corresponded to the year class. For example, a fish born in 2002 would be missing the first and the fourth scutes on the left side. ċəmtus collected in the wild as fertilized embryos or larvae, and then reared in the hatchery before release, had a strip of three scutes taken from the right side of the fish directly below the dorsal fin.

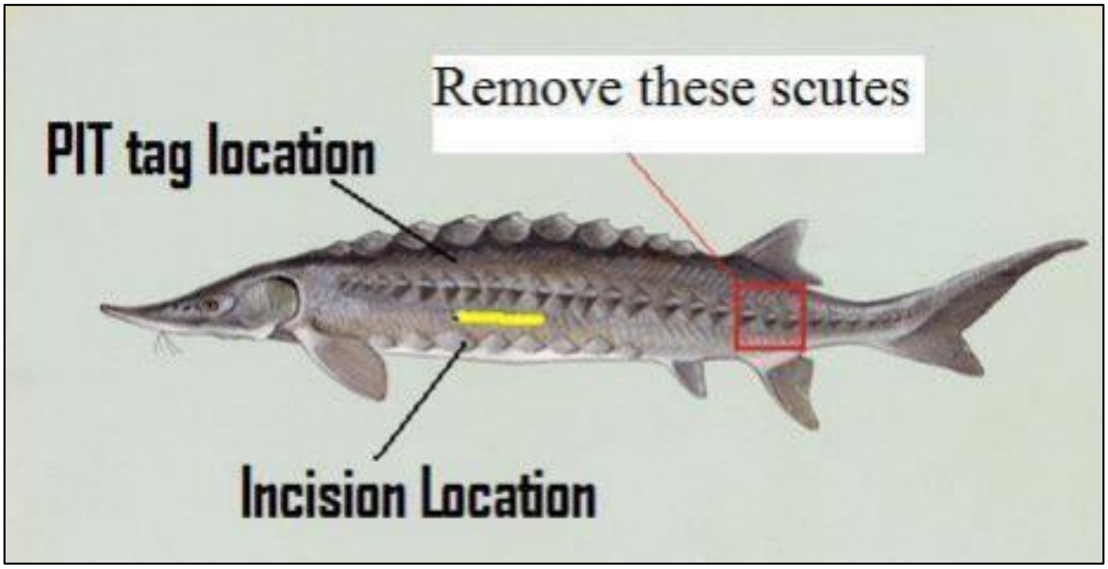

Figure 2. Juvenile ċəmtus showing Passive Integrated Transponder (PIT) tag, sonic tag incision, and scute removal locations. Figure from FFSBC (2017).

PIT tag number, scute pattern removal, fork length (cm), weight (g), and fin deformities were recorded for each individual fish at the hatchery in mid-April, as close as possible to their release. This was done to ensure no additional growth occurred in-hatchery that may be attributed to post-release growth. Each individual fish can subsequently be identified to its release location and date of release in addition to family record. Juveniles were transported in Freshwater Fisheries Society of British Columbia (FFSBC) fish transport vehicles according to UCWSRI-TWG transport protocols.

2.3.3 Size at Release Study

The size of fish being released from the conservation aquaculture program has varied over the years to determine the most successful size-at-release for hatchery-raised juveniles. Five different hatchery size target categories have been released within the snkx̌ykntn Reach (Table 5). There was an additional size category for anomaly releases (size category 6); however, these were not hatchery target releases.

Hatchery size target categories were adjusted based on results from capture efforts in the study area, from results from other programs (e.g., LCR (Crossman et al. 2023), Nechako River, and nx̌wyaɫpítkw [Kootenai River]), and through discussions with the UCWSRI-TWG. From 2007 to 2015, hatchery origin ċəmtus juveniles were reared at the KTSH to 10 months of age before they were transported to the MCR for release. These 10-month-old (~Age-1) fish can be further categorized into small-bodied form (2007-2012; grown to ~ 50-70 g) and large-bodied form (2013-2015; grown to ~ 150 g) fish. Juveniles released in 2016-2023 were reared in the hatchery for either 10 months (~Age-1) or 22 months (~Age-2).

Table 5. Size categories of all ċəmtus released in the middle nx̌ʷəntkʷitkʷ from 2007 to 2023, including hatchery release size targets, age, study years released, and total number.

Size Category	Hatchery Release Weight Target (g)	Age at Release	Study Year Released	Number Released
1	n/a	1 to 60 days	2008 – 2010	1,370,749
2	50 – 75	10 months	2007 – 2012	42,828
3	150	10 months	2013 – 2015	15,495
4	350	10 months	2016 – present	1,460
5	700	22 months	2016 – present	3,965
6	Anomaly	84 months	2021	4
			2007 – 2023 Total	**1,434,501**

In 2008, the UCWSRI-TWG approved the release of fed and unfed larvae below REV (FFSBC 2010). A dedicated portable hatchery facility, located at the KTSH, housed six three-meter aluminum troughs with four MacDonald jars per trough that contained eggs from ċəmtus broodstock. Approximately 619,480 larvae (fed and unfed combined) from this facility were released at the confluence of the nx̌ʷəntkʷitkʷ and Jordan River in 2008 and 260,000 (fed and unfed) larvae were released in 2009. In 2010, 336,270 unfed day-old larvae were released in the upper snkx̌ykntn Reach as part of an experiment to assess the effects of substrate modifications on larval retention and growth (Crossman and Hildebrand 2014). The monitoring described in this report was expected to detect any survival of these larvae to the juvenile life stage.

2.4 Juvenile ċəmtus Capture Efforts to Estimate Growth and Survival

2.4.1 Study Design

The objective of the juvenile ċəmtus capture program was to estimate the growth and survival of fish released from the conservation aquaculture program. Golder led the program for the first four years (2007 – 2010) with capture and habitat assessment components limited to snkx̌ykntn Reach, between Shelter Bay and REV (RKm 179 – 233). Capture efforts were closely informed by movement monitoring results (Table 6). Capture activities for juvenile ċəmtus were conducted from mid-August to mid-October with the exception of one overnight set at Mulvehill Creek (RKm 207.2) from Mar 12 – 13 2008 (Table 7).

In 2013, ONA became the program lead and conducted an abbreviated sampling period from the last week of September to the first week of October with sample sites from the Arrow Lakes Narrows to qwspíc’aʔ Flats (RKm 116 – 183).

BC Hydro complimented sampling effort in 2013 with additional capture activities in early October from Wallis Creek upstream to Greenslide Creek (RKm 187 – 212). In 2014 and 2015, BC Hydro conducted sampling in late September to early October from upstream of Tank Creek to Greenslide Creek (RKm 194 – 210).

Since 2014, the annual sampling period has varied from early June to mid- to late-October and sampling location has varied from the Fauquier BC (RKm 79) to Greenslide Creek (RKm 211). In 2016, sample sites at the qwspíc’aʔ Flats extended into the Beaton Arm, while in 2019 and 2020, Beaton Arm sampling was more intentional, with a focus at the Beaton Flats.

Table 6. Site distribution of juvenile ċəmtus capture effort by year and for each River Section of the middle nx̌ʷəntkʷitkʷ (1 – 15) and Beaton Arm (B1 – B2), including downstream (d/s) and upstream (u/s) river kilometer (RKm). Capture effort conducted (grey shaded cells) from 2007 to 2023 by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro. Effort not conducted in 2011 and 2012.

River Section	RKm d/s	RKm u/s	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	228.4	234.9	X														
2	226.1	228.3	X	X	X												
3	220.0	226.0		X	X												
4	214.1	219.9	X	X	X	X											
5	209.8	214.0	X	X	X	X			X			X	X	X	X	X	
6	205.6	209.7	X	X	X	X		X	X	X	X	X	X	X	X	X	X
7	201.9	205.5	X	X	X	X		X	X	X	X	X	X	X	X	X	X
8	197.6	201.8		X	X	X		X	X	X	X	X	X	X	X	X	X
9	192.1	197.5			X	X		X	X	X	X	X	X	X	X	X	X
10	186.6	192.0		X	X	X		X	X	X	X	X	X	X	X	X	X
11	182.1	186.5		X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	176.9	182.0			X	X	X	X	X	X	X	X	X	X	X	X	X
13	129.1	176.8					X	X	X	X	X						
14	119.0	129.0					X	X	X	X	X						
15	77.6	118.9					X	X			X		X	X			
B1	2.2	14.3								X			X				
B2	14.4	17.4											X	X			

Table 7. Seasonal distribution of juvenile ċəmtus capture effort by year and for each month quarter (1 = 1st – 8th; 2 = 9th – 16th; 3 = 17th – 24th; 4 = 25th – the last day of the month). Capture effort conducted (grey shaded cells) from 2007 to 2023 by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro. Effort not conducted in 2011 and 2012.

Month	Quarter	2007	2008	2009	2010	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Mar	**2**		X													
Jun	1								X	X						
	2									X						
	3								X							
	4								X	X						
Jul	1								X	X		X	X			
	2							X	X	X			X			
	3						X	X		X						
	4						X			X						
Aug	1								X	X		X	X			
	2						X	X	X	X		X	X	X	X	
	3			X			X	X	X	X				X	X	X
	4			X				X		X	X		X	X	X	X
Sep	1		X					X	X	X	X	X	X	X	X	X
	2		X	X	X			X	X	X	X	X	X		X	X
	3		X	X	X		X	X	X		X	X	X	X	X	X
	4	X	X		X	X		X	X		X		X	X		X
Oct	1	X			X	X	X						X			
	2				X		X								X	X
	3														X	X

2.5.2 Equipment

Gillnets were chosen as the primary method for initial sampling based on the success of this method to capture juvenile ċəmtus in the Transboundary Reach (nx̌ʷəntkʷitkʷ between HLK and Grand Coulee Dam). Gillnet sites were selected based on gear limitation (i.e., lower velocity habitats where gillnets can be fished effectively) and the presence of habitat types (deep, slow moving eddies) known to be used by juvenile ċəmtus in the LCR (Golder 2007). Gillnets were also deployed in the immediate vicinity of where acoustic-tagged juvenile ċəmtus were located during mobile tracking surveys. Based on the results of other juvenile ċəmtus monitoring programs in the nx̌ʷəntkʷitkʷ (i.e., Keenleyside Reach and the Roosevelt Reach; Golder 2007; Howell and McLellan 2013) sampling was focused on the thalweg, but shallower areas were also sampled to assess juvenile use of these habitats. Capture sessions were not conducted in 2011 and 2012 (Years 5 and 6) to focus efforts on the fine-scale movement study.

During 2014 to 2023 (Years 8 to 17), sampling sites were generated using the generalized random tessellation stratified (GRTS; Stevens and Olsen 2004) method design in the statistical package R (R Development Core Team 2013). This method provided spatially balanced, randomly chosen, sampling locations, distributed along the centerline MCR and Beaton Arm, and assigned a sampling gear type (gillnet or setline). Extra sites were also generated, that allowed for substitutions of sites that were rejected in the field due to logistical concerns (depth, velocity, obstructions) to ensure that randomness and spatial representation were maintained with the study design. The generated GRTS sites were used as a guideline, and once in the field, near shore sample locations were selected perpendicular to the centerline at targeted water depths (10 – 30 m). From 2014 to 2021, 200 gillnet and 200 setline sites were generated. In 2022 and 2023, only 200 setline sites were generated as gillnets were not utilized.

2.5.2.1 Gillnets

Gillnets were 5.1 cm stretch measure monofilament, horizontal nets, but net dimensions varied over the course of the program.

All years of gillnet effort used monofilament, horizontal gillnets with a mesh size of 5.1 cm, with the exceptions of 2008 (also used mesh sizes of 10.2 and 15.2 cm) and 2009 (also used a mesh size of 7.6 cm). From 2007, nets measured 15.2 m long by 1.8 m deep (27.9 m^2) and 45.7 m long by 1.8 m deep (83.6 m^2). In 2008, the smaller nets were replaced by larger nets measuring 30.5 m long and 1.8 m deep (55.7 m^2). From 2009 to 2015, nets measured 91.5 m long by 1.8 m deep (167.2 m^2). In 2016 and 2017, six different nets were used with varying dimensions; additional deeper nets were added as well measuring 91.5 m long by 3.0 m deep (278.7 m^2). These deep nets were used in 2017 and 2018 before they were cut in half to reduce potential for field worker injury. From 2019 to 2021 the same nets were in use, measuring 45.7 m long by 3.0 m deep (139.4 m^2) and 30.5 m long by 3.0 m deep (92.9 m2). Gillnets were deployed at the bottom of the water column, with a float and float line and anchors attached to each end of the net. Habitat measurements were recorded at each gillnet site (see Section 2.2.2).

Because of the potential risks of injury or mortality to adult ċəmtus and in consideration of the endangered status of the population, overnight gillnet sets were not used in 2007 (Year 1) of the study. Based on the lack of capture success using daytime gillnets in 2007, the SARA sampling permit was amended to allow the use of overnight gillnets (with a target 12 hour set duration) in areas where adult ċəmtus were not likely to be present. During 2008 (Year 2) sampling, gillnets were initially deployed overnight, but direct mortality of ʕay̓ckst (bull trout; *Salvelinus confluentus*) capture in these overnight sets was high (Golder 2009). Due to this high bycatch mortality, gillnet sampling in 2009 and 2010 was changed to short nighttime duration sets of approximately four hours, which reduced bycatch mortality. Both full overnight and short duration nighttime gillnets were used in 2010. From 2013 to 2021, four or five gillnets would typically be set out each day in the morning and retrieved mid-afternoon, with a target soak time of four hours. Occasionally, sections of net were damaged, generally due to submerged woody debris. These nets were repaired, replaced, or the percent broken was noted to properly alter effort results. A list of UTM coordinates for all gillnet sites are provided in the CLBMON-21 annual report series.

Since 2022, gillnets have not been deployed due to a lack of recent ċəmtus captures (last occurred in 2017 via gillnet), risk to bycatch (e.g. ʕaẏckst), and issues with damage and entanglement (generally associated with high flows).

2.5.2.2 Setlines

In 2009 (Year 3), baited setlines were tested as an additional method to gillnetting for capturing juvenile ċəmtus. Setlines were used in other ċəmtus programs and were able to be deployed longer than gillnets (up to 24 hours rather than 4-hour sets for gillnets; BC Hydro 2022). Setlines were originally deployed similar to gillnets, but fewer in number (e.g. eight gillnets and two setlines per night).

Setlines initially consisted of 90 m mainline with 30 hooks spaced 3 m apart, an anchor, float line, and an LD-2 float affixed to each end. The mainline was marked at 3 m intervals to ensure that hooks were spaced evenly along the length of each setline during deployment. During Session 1 in 2009, barbless halibut hooks that were smaller (size 10, 11, and 12) than normally used (e.g., 14-0 to 20-0; Crossman et al. 2023) for ċəmtus baited with worms, roe bags, or kəkṅi (kokanee; *Oncorhynchus nerka*) were clipped to the setlines. Based on a lack of captures using these hooks, smaller barbless “J” hooks (size 6 and 7) baited with worms, roe bags, kəkṅi, mountain whitefish (*Prosopium williamsoni*) or spəqʷlic (burbot; *Lota lota*) were used in Session 2. Setlines were deployed perpendicular to the current to increase downstream scent dispersal and were fished overnight. Fishing setlines overnight was initially conducted within a specific session, not randomized over the entire study area.

Setlines became the main sample method used from 2013 to 2023 (Years 7 to 17) due to lower bycatch mortality compared to gillnetting. Each day, a target of five to twelve setlines were deployed (up to 14 per day in 2013). Setlines ranged from 50 to 120 m in length with 10 – 20 size 5 or 6 barbless “J” hooks per line baited with worms (night crawlers). Since 2013, mainlines were marked at 4 m intervals to ensure hooks were evenly spaced on the line. Setlines were generally set perpendicular to the flow, left to fish overnight, and pulled the following day (ideally within 24-hours). An anchor, float line and LD-2 float were attached to either end of the setlines.

Habitat measurements were recorded at each site (see Section 2.2.2). In addition, hook size and number, bait type, and the number of baited, baitless, fouled, and lost hooks upon retrieval were recorded. A list of UTM coordinates for setline sites are provided in the CLBMON-21 annual report series.

2.5.3 Fish Handling

Captured ċəmtus were weighed to the nearest 0.1 kg, measured for fork length to the nearest 0.1 centimeter, photographed, examined for health and external markings (missing scutes), and scanned for the presence of a PIT tag. Handling methods were consistent with those set by the UCWSRI in the Upper Columbia River Adult White Sturgeon Capture, Transport and Handling Manual (2006). All bycatch were identified to species, measured for length, and, if in good condition, released. One juvenile ċəmtus captured was sacrificed for stomach content analysis and the digestive tract fixed in 10% formalin in 2010 (Golder 2011).

2.5.3.1 Gastric Lavage

In 2016, gastric lavage was attempted on two of the captured ċəmtus with the objective of flushing the individual's stomach to identify prey items (Crossman et al. 2016). In 2017 to 2023, all captured ċəmtus were lavaged except one that was captured in an unplanned overnight gillnet set in 2017. To reduce handling stress, this fish was only weighed and measured.

Gastric lavages were conducted using a Chapin SureSpray Select 8.0 L pump/bladder and a VWR size 8 standard testing sieve (#140). Food items collected were placed in jars, preserved with ≥ 90% ethanol, and labelled with the following information: date of collection, collection site, site UTM's, ċəmtus fork length (cm), and ċəmtus weight (kg).

2.5.3.2 Fin Clip

Since 2022, dorsal fin clips were collected for DNA analysis. A section of dorsal fin (roughly 1 cm x 1 cm) was cut with sterilized scissors, following the contours of the fin, and placed in a coin envelope to dry using forceps. Envelopes were labelled with the following information: date of collection, collection site, site UTMs, unique ċəmtus identification number, PIT tag number, fork length (cm), and weight (kg).

2.5.4 Capture Effort and Catch-Per-Unit-Effort

Catch-per-unit-effort (CPUE) was calculated for each year as total juvenile ċəmtus captures per effort depending on gear type. Gillnet hours were calculated to compare different gillnet lengths, with and without damage panels, over the years of the program. Gillnet soaking hours (Net-Units; NU) were calculated using the area of the gillnet fishing and time soaking. Setline hook-hours (Hook-Hours; HH) were calculated based on the number of hooks set with bait and time and did not take into consideration how many retrieved were baitless, baited, broken, or lost. This method was standardized across all years of data.

Gillnet soaking hours were calculated using Equation 1 and setline soaking hours were calculated using Equation 2.

Equation 1. Gillnet soaking hours (Net-Units) calculated using gillnet fishing area and time fishing.

$$Soaking\ Hours = \left(\frac{A}{100\ m^2}\right) \times \left(\frac{T}{24\ h}\right) \times D$$

$$\begin{aligned} &where, \\ &A = net\ length\ (m)\ \times net\ depth\ (m) \\ &T = soak\ time\ (hours) \\ &D = intact\ net\ (\%) \end{aligned}$$

Equation 2. Setline hook – hours calculated using number of hooks set and time fishing.

$$Hook - Hours = \#\ hooks\ set\ \times T$$

$$\begin{aligned} &where, \\ &T = time\ (hours) \end{aligned}$$

2.5.5 Relative Weight

The relative weight index (Wr) is a commonly used method for comparing the body condition of different fish populations of the same species (Murphy et al. 1991; Beamesderfer 1993). The relative weight index is expressed as a percent and is modelled on the 75th percentile weight data of the species' entire geographic range, therefore a Wr of 100% would represent a c̓əmtus in better condition than 75% of the fish that were used as the basis for developing the length-specific standard weight value (Equation 3). Relative weight is not affected by size-at-age, but rather provides an indication of condition based on length and weight. Because researchers often use different methods to measure the length of c̓əmtus and only fork length data were available from previously released hatchery juveniles, relative weights were calculated using fork during this program.

Equation 3. Relative weight index equation

$$Wr = \left(\frac{W}{W_S}\right) \times 100$$

$where,$
$Wr = relative\ weight$
$W = individual\ weight\ (kg)$
$W_S = length - specific\ standard - weight\ value$

For this report, the W_S used for calculating Wr was from Beamesderfer (1993; Equation 4).

Equation 4. Beamesderfer (1993) equation

$$W_S = \alpha \times L^{\beta}$$

$where,$
$\alpha = 2.735^{-6}$
$L = individual\ fork\ length\ (cm)$

This growth relationship was calculated using growth information from 15 populations of c̓əmtus from the Fraser River, Sacramento River, and nx̌ʷəntkʷitkʷ (Beamesderfer 1993).

2.5.6 Growth

Total and annual growth (fork length [cm] and weight [kg]) were calculated for each individual and combined into mean growth metrics by age and year class. Total growth was calculated by subtracting the size at release (length and weight) from the capture size. Annual growth was calculated by dividing the total growth by the number of days since release and multiplying by 365 days. The assumption for annual growth is the total daily growth is constant between release and capture; growth may vary seasonally and / or with size, but this assumption allows for the comparison of fish captured after more than one year after release.

Average annual length, weight, and relative weight were graphed, and a linear regression was used to identify significance.

2.5.7 Survival

To date, capture and capture rates are too low to enable an estimate of survival. Low capture rates were attributed to a large study area and low capture efficiency. A larger number of captures are required to effectively estimate survival. Survival was qualitatively assessed by looking at the number of years at large a fish had been at large at the time of capture as an indication of survival potential.

2.5.8 Diet Analysis

The numbers of individual prey items within each taxon represented in the foregut were counted. Only foregut contents were enumerated and identified. Hindgut contents were not relied upon for accurate taxonomic identification, as digestive processes made identification efforts difficult.

Benthic substrates were physically collected at a subsample of c̓əmtus capture sites from 2014 to 2018 using a Petite Ponar Grab (232 cm^2) and were stored in glass containers with ethanol preservative until processing. Samples were sorted using size 105 to 500 micron stainless steel screening depending on sample type. All invertebrates in the sorted samples were stored in micro-centrifuges tubes with ethanol preservative. Invertebrates were identified to preliminary taxonomic order in the Freshwater Invertebrates of North American (Voshell 2002). In 2019, substrate grabs were not taken in association with c̓əmtus capture locations. In 2020, it became standard to take benthic grabs at c̓əmtus capture locations after individual fish processing (preferably the same day) and preserve samples for later analysis similar to that described above.

As benthic grabs were not seen to effectively sample larger substrate types (i.e., large gravel or shale), in 2019 to 2023, rock baskets were deployed (8 – 10 each year) in the snkx̌yknt̓n Reach to identify a wider array of invertebrates potentially available to juvenile c̓əmtus. Rock basket samplers consisted of a wire “chicken barbeque” basket measuring 30 cm x 14 cm x 14 cm (planar surface area = 0.042 m^2), previously used in the Middle Columbia River Ecological Productivity Monitoring Program (CLBMON-15b; Perrin et al. 2008). The baskets were filled with clean gravel (size range of 2.5 – 2.5 cm) and closed with cable ties. Rock baskets were deployed near the beginning of annual c̓əmtus capture effort and retrieved during the last session. Upon retrieval, the basket and rocks were placed into a 5-gallon pail filled with water and scrubbed to loosen invertebrates. The water was processed through the same sieve used for benthic grab samples and remaining contents were preserved with denatured ethanol until processing. Benthic grabs were taken at each rock basket location to determine substrate type, but samples were not preserved. At each rock basket, date and time of deploy and retrieval were recorded along with location, water depth, Secchi depth, dissolved oxygen, conductivity, substrate characterization (from benthic grab), and other comments including if the station had to be moved.

2.5.9 Incidental Catch

All incidentally captured species were identified, measured (fork length; mm), and, depending on species, weighed (grams). Several species (particularly salmonids) were scanned for the presence of a PIT tag that may have been applied during concurrently sampling programs in the study area (CLBMON-16; Golder et al. 2019). Individuals were also scanned to identify tags applied to hatchery juvenile c̓əmtus that may have been predated upon. From 2008 to 2010, scale and otolith samples were collected from ʕay̓ckst that succumbed to sampling, as well as reviewing stomach contents for evidence of juvenile c̓əmtus. Since 2019, most salmonids and spəqʷlic that succumbed to sampling had their stomach contents examined for evidence of sturgeon.

3.0 Results

3.1 Physical Habitat Parameters

3.1.1 Discharge and Reservoir Elevations

Mean daily discharge levels (cubic meters per second; m^3/s) from May to October recorded at REV showed different trends when grouped before the REV5 flow regime change (Years 1 to 4; 2007 to 2010; pre-flow regime change) and after the flow regime change (beginning Year 5 – 2011; post-flow regime change). During the pre-flow regime change, mean daily discharge averages from REV ranged from 460 to 1070 m^3/s, with longer periods of lower discharge, (corresponding to reduced power demand) in July and August (Figure 3). Pre-flow regime change, during the ċəmtus spawning period (late July to early August), REV operations experienced variable mean daily discharge averages between 480 and 910 m^3/s. During the post-flow regime change, mean daily discharge averages from REV ranged from 590 and 1120 m^3/s (Figure 3).

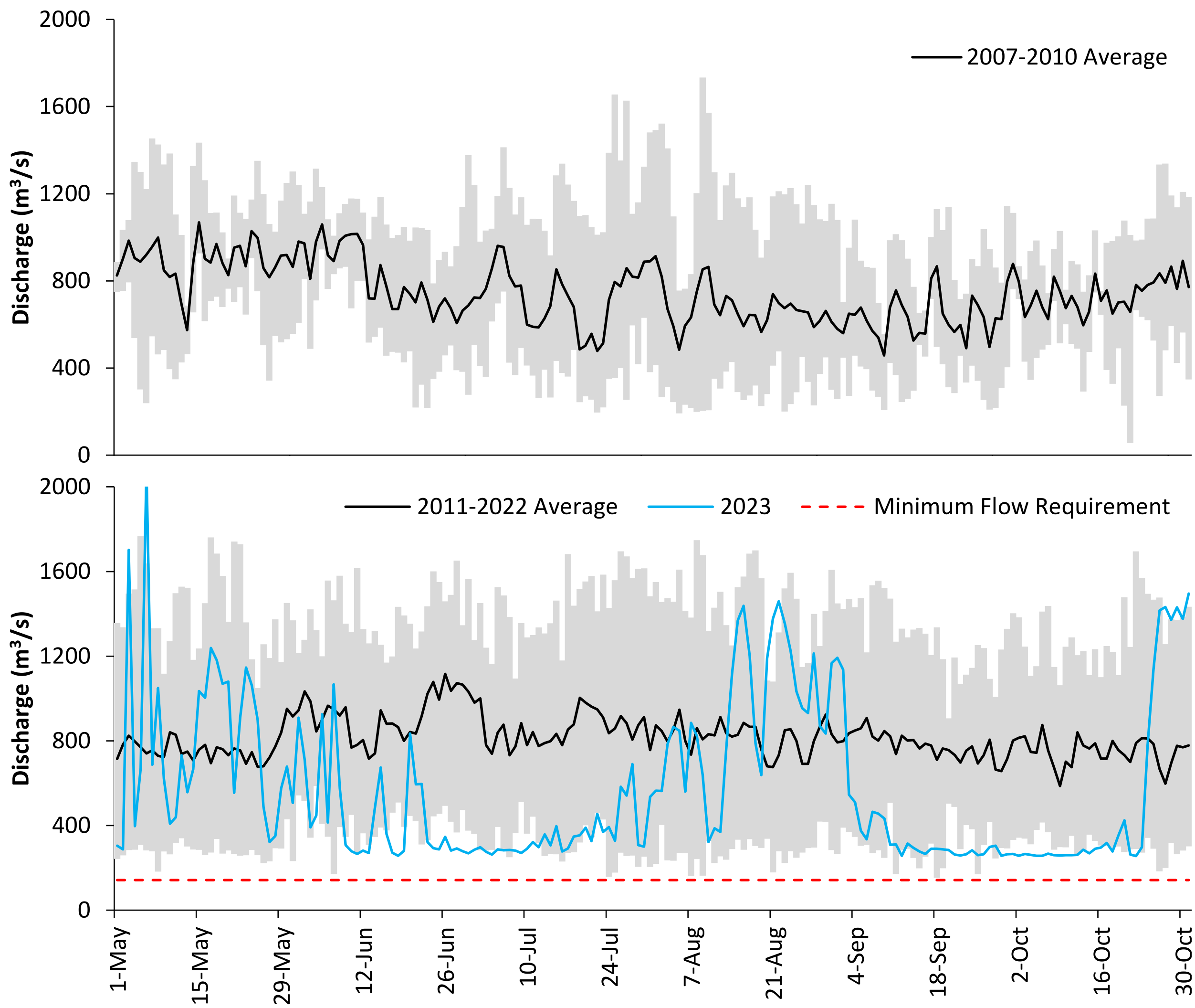

Figure 3. Revelstoke Dam daily discharge average (mean ± min and max average data) during the CLBMON-21 study period before the implementation of flow regime change (2007 to 2010; top graph) and after the implementation of flow regime change (2011 to 2023; bottom graph). Unpublished data from BC Hydro., including the minimum flow requirement (142.0 m3/s).

Post-flow regime change, during the c̓əmtus spawning period, REV operations experienced variable mean daily discharge averages between 735 and 980 m³/s. Juvenile c̓əmtus were generally captured in mid- to late September when mean daily discharge averages were less variable and similar between pre- and post-flow regime changes.

ALR water surface elevations (meters above sea level, masl) from 2007 to 2023 during the May to October study period varied greatly regarding summer peaks and fall reductions (Figure 4). Reservoir elevations peak between early June to early August and, over the program study years, were highest from Jul 04 – Aug 01 2012 (440.6 masl peak on Jul 22 2012). Reservoir elevations then experience reductions, but do not generally bottom out until after the study period ends in October. In 2023, beginning on Jul 31, reservoir elevation was lower than any other study year. This resulted in all sampling sessions in 2023 occurring at lower reservoir elevations than previously sampled. Based on 2012 habitat depth calculations, by Aug 12 2023, shallow area habitats were unavailable, and by Oct 14, only thalweg area habitats were available. From Oct 15 – 21 (last 2023 session), crews were unable to sample past Tree Island and noted that REV discharge impacted water depths over the course of a day.

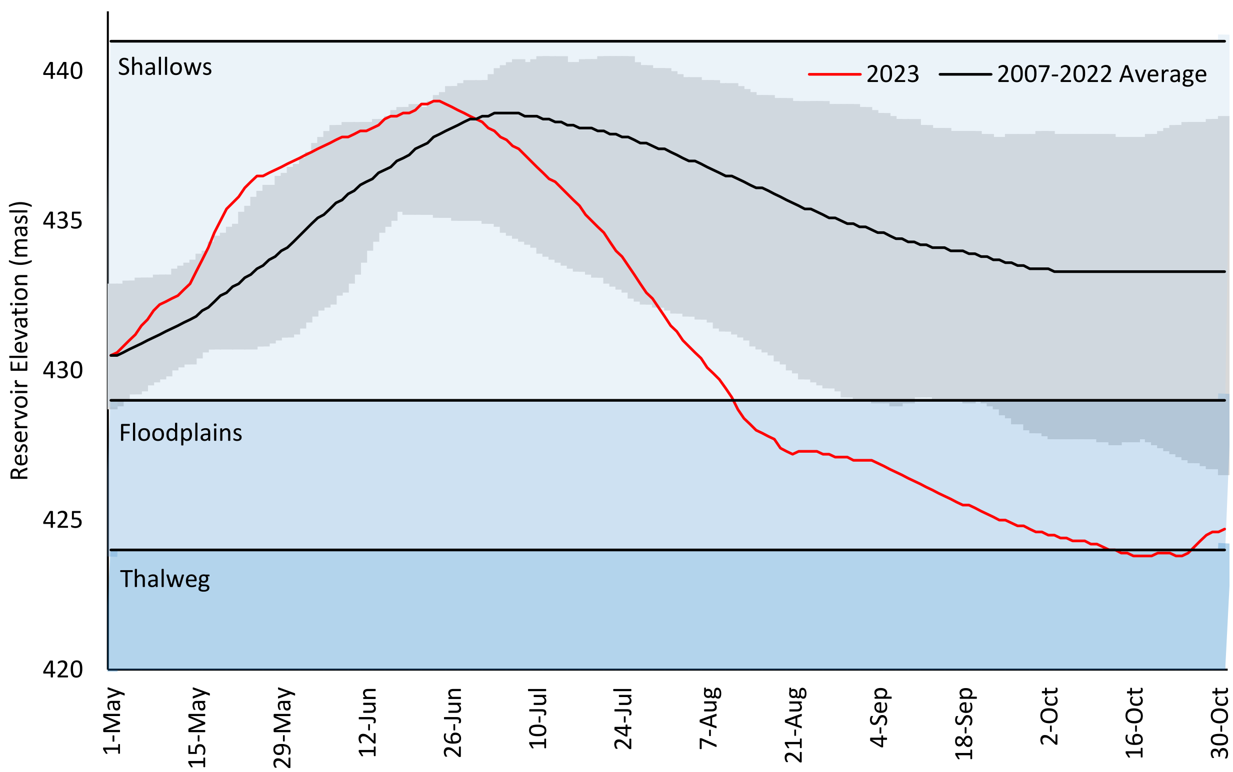

Figure 4. Reservoir elevation (masl) at nqʷisp during CLBMON-21 from May 01 to Oct 31 from 2007 to 2023. Greyed area shows the variability of the data over all study years, including habitat classifications summarized near the Walter Hardman Generating Station during fine-scale movement work (Golder and ONA 2013). Hydrometric data from the Government of Canada Water Office website.

During Session 1 (Aug 22 – 28 2023), reservoir elevations were 427.2 masl and sampling occurred upstream to Mulvehill Creek (River Section 6). Sampling further upstream to Greenslide Creek was not possible due to water depths. There was a 0.8 m reduction in reservoir elevation to the next sampling session (Sep 06 – 13), which restricted access past a shallow section downstream of Blanket Creek (RKm

204). An additional 1.2 m reduction to the third sampling session (Sep 18 – 25) restricted access upstream of RKm 202, and a 1.3 m reduction to the fourth sampling session (Oct 15 – 22) restricted access upstream of the power lines at 200.2 RKm, 1 km downstream of the Water Hardman Generating Station. Only including sample sites in the riverine section (excluding River Sections 11 and 12), average sampling depth decreased each session from 6.7 m average depth in session 1 to 3.8 m average depth in session 4. These depths are shallower than the generally targeted 11 – 13 m depths.

3.1.2 Water Temperatures

As warming temperatures have been observed to correlate to increased ċəmtus movements during previous CLBMON-21 studies, the effect of the REV5 flow regime changes on the downstream water temperatures and monitored temperatures in the ALR was reviewed. Main daily water temperatures over the May 01 to Oct 30 period were calculated separately for the pre-flow regime change (2007 to 2010) and post-flow regime change (2011 to 2023; Figure 5).

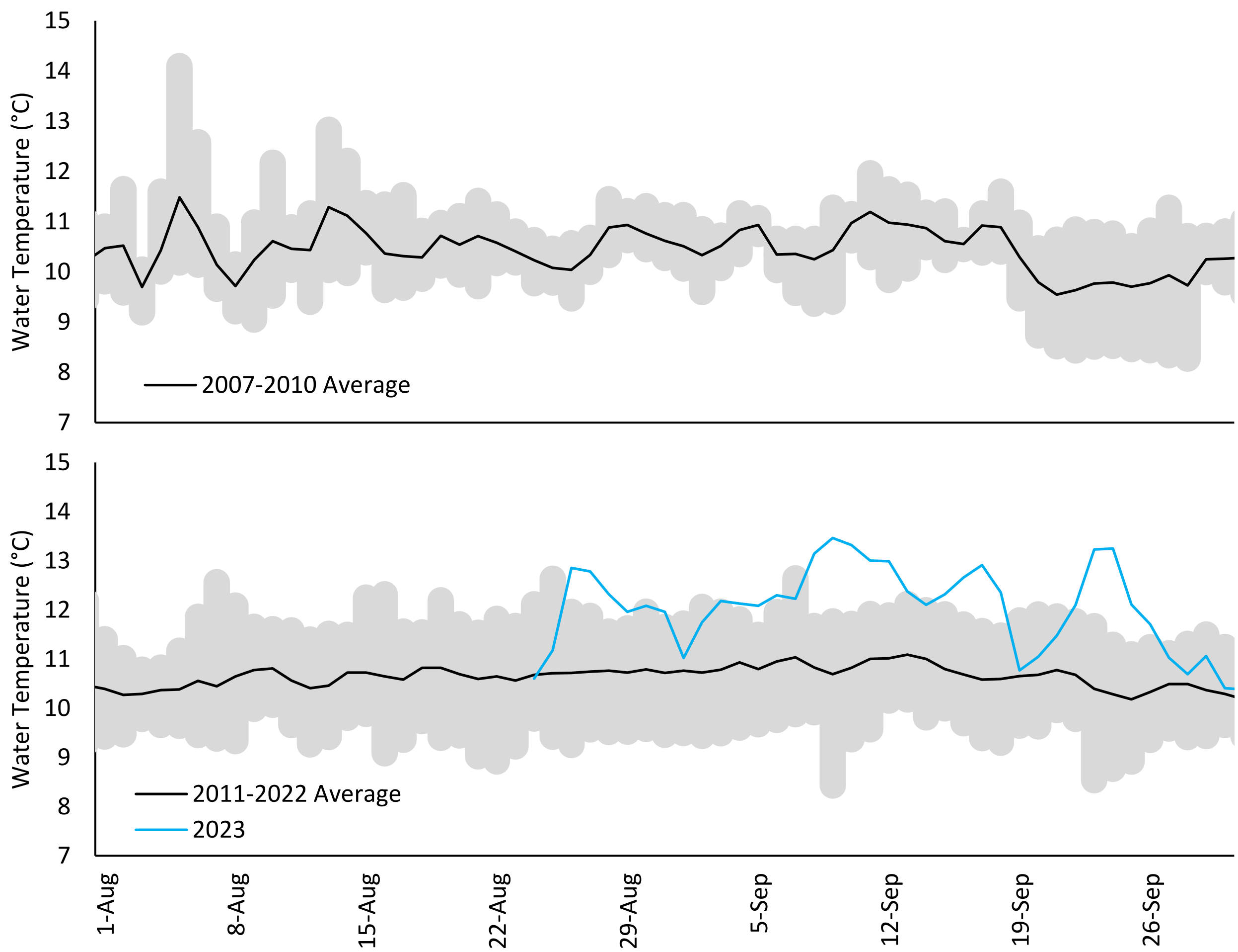

Figure 5. snkx̌ykntn Reach average daily water temperature during the CLBMON-21 study period before the implementation of flow regime change (2007 to 2010; top graph) and after the implementation of flow regime change (2011 to 2023; bottom graph). Data for 2007 and 2009 to 2014 are from Station 6 (CLBMON-15); data for 2008 are from Station 5 (CLBMON-15a); data for 2015 are from Station 3 (BC Hydro unpublished data); data for 2016 to 2019, 2021, and 2022 are from downstream of Greenslide Creek (ONA 2017, 2018, 2019, 2020, 2022, and 2023); data from 2020 and 2023 are from qwspíc'aʔ Flats (ONA 2021).

In general, both periods had similar water temperature patterns with increases during the summer months. Temperature peaks were evident in 2009, 2010, 2016, and 2023, which may be attributed to either reductions in ALR levels, or changes in the water layer REV intakes are drawing from (i.e., epilimnion, metalimnion, hypolimnion).

3.2 Juvenile c̓əmtus Releases

An important aspect of the CLBMON-21 program has been to evaluate juvenile growth and survival after release from the hatchery, as well as describe the availability and suitability of habitat for juvenile c̓əmtus in the ALR. These data gaps have been investigated through monitoring of juveniles following release using acoustic telemetry or by direct capture.

3.2.1 Larval Releases

Under a different program (CLBWORKS-24) the BC Hydro WUP required the release of larval c̓əmtus (under 60 days old) into the upper snkx̌yknt̓n Reach (Table 8). From 2008 to 2009, larval c̓əmtus were to either a stage just before hatchery feeding would commence (unfed larvae), or after a few weeks of feeding had occurred (fed larvae; FFSBC 2011). These larvae were released at the confluence of the Jordan River and the nx̌ʷəntkʷitkʷ.

In 2010, larval releases also occurred as part of an experiment to assess the effects of substrate modifications in the c̓əmtus spawning area below REV on larval retention and growth (Table 8). One day old unfed larvae were raised at the KTSH then transported to the MCR for release over modified (clean coarse materials placed on the river bottom) and unmodified (natural riverbed) substrates (Crossman and Hildebrand 2014).

Results from this study demonstrated that modifications to embedded substrates at known c̓əmtus spawning locations can enhance conditions required for hiding at the yolk sac larvae stage (Crossman and Hildebrand 2014). Fed larvae also were released in 2010 at the Centennial Park boat launch in snkx̌yknt̓n (Table 8).

All of the ~1.3 million larvae released in the MCR were unmarked. No unmarked juveniles have been captured during the sampling program.

Table 8. Summary of unfed and fed c̓əmtus larvae from the Kootenay Trout and Sturgeon Hatchery and release locations in the middle nx̌ʷəntkʷitkʷ.

Study Year	Date of Release	Release Location	River Kilometer	No. Juvenile Sturgeon Released	Larval Stage	Number of Families
2008	4-Jul	Jordon River mouth	229	335,631	unfed	2
	25-Jul	Jordon River mouth	229	283,848	fed	
2009	5-Jul	Jordon River mouth	229	180,000	unfed	1
	8-Aug	Jordon River mouth	229	80,000	fed	
2010	3-Jul	Revelstoke Spawning Area - Control Site (first release)	228.5	168,135	unfed	6
	3-Jul	Revelstoke Spawning Area - Control Site (second release)	228.5	168,135	unfed	
	21-Aug	Centennial Park	225.2	155,000	fed	
		Total Released		**1,370,749**		

3.2.2 Juvenile Releases

In total, 63,752 juvenile PIT-tagged juvenile ċəmtus have been released into the MCR from 2007 to 2023 (Table 9). The number of juveniles released annually between REV and Shelter Bay has varied between 144 and 9,575 individuals. Between 2007 and 2012, the annual releases included 50 acoustic-tagged fish (250 fish in total; Table 10).

The first snkx̌yknt̓n origin juvenile ċəmtus (2019 year class) were released at Shelter Bay in 2021 (3 individuals). In 2023, an additional 71 snkx̌yknt̓n origin juveniles (2021 year class) were released at the Centennial boat launch (1 individual) and Shelter Bay (70 individuals).

3.2.3 Size at Release

The release size of juvenile ċəmtus has changed over the 17 years of the program. Six hatchery release target categories were classified over the study period to attempt to observe the effects of size at release.

Due to low capture rates of fish released into the MCR, it has been difficult to determine the effect of size at release on survival, excluding 2016 and later data. Of note, four of the ten juveniles captured between 2007 and 2010 were implanted with sonic tags at release. These fish were larger at release (230 – 390 g) compared to fish released without a sonic tag (40 – 120 g) and grew faster (15.18 ± 3.06 mm / year and 362 ± 292 g / year) compared to fish without sonic tags (9.08 ± 2.51 mm / year and 81 ± 57 g / year). This initial result suggested that size at release may influence survival in the MCR and led to different size at release targets being developed. This question still requires further evaluation through capture efforts to confirm if more recent year classes, released at larger sizes, are surviving better.

Table 9. Summary of PIT-tagged juvenile ċəmtus released in the nx̌ʷəntkʷitkʷ, including life-history and geographic origin, release date, location, number released, and average length (mm) and weight (g). Acoustic-tagged individuals not included.

Release Year	Year Class	Age (months)	Life-History Origin	Geographic Origin	Hatchery Release Target	Release Date	Average Length (mm)	Average Weight (g)	Release Location	RKm	Number of ċəmtus Released
2007	2006	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	3-May	19.9	59.0	Moses Creek	233.0	4,056
2008	2007	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	29-Apr	20.0	61.0	Big Eddy Centennial Launch	228.3 225.8	5,884 600
2009	2008	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	23-Apr	20.8	67.0	Big Eddy Centennial Launch	228.3 225.8	7,518 600
2010	2009	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	23-Apr	21.6	81.0	Big Eddy Centennial Launch	228.3 225.8	9,175 400
2011	2010	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	20-Apr	20.0	55.0	Shelter Bay Centennial Launch	177.0 225.8	7,578 500
2012	2011	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	2	8-May	22.2	81.0	Shelter Bay	177.0	6,517
2013	2012	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	8-May	27.4	159.0	Shelter Bay	177.0	5,944
2014	2013	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	8-May	28.0	202.0	Shelter Bay	177.0	3,288
2015	2014	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	5-May	27.2	144.0	Shelter Bay	177.0	6,013
2016	2014	22	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	5	3-May 5-May	40.3 39.6	451.0 442.0	Shelter Bay	177.0	750 575
2017	2015	22	Wild	Washington	5	7-May	38.0	313.0	Shelter Bay	177.0	1,589
2018	2016	22	Wild	Washington	5	8-May	39.5	423.0	Shelter Bay	177.0	977
2019	2018	10	Wild	Waneta	4	7-May 8-Aug	37.6 36.0	385.5 327.5	Shelter Bay	177.0	540 183
2020	2019	10	Wild	Waneta	4	8-May 17-Jul	35.7 36.0	328.3 326.3	Shelter Bay	177.0	63 32
	2014	84	Wild	Washington	6		58.0	1100.0			4
2021	2019	22	Wild	Revelstoke	5	12-May	49.0 42.0	896.0 404.0	Shelter Bay	177.0	1 2
	2020	10	Wild	Waneta	4		40.0	385.0			278

Release Year	Year Class	Age (months)	Life-History Origin	Geographic Origin	Hatchery Release Target	Release Date	Average Length (mm)	Average Weight (g)	Release Location	RKm	Number of c̓əmtus Released
2022	2021	10	Wild	Waneta	4	18-May	37.5	368.1	Centennial Launch	231.0	15
						18-May	43.0	612.1	Shelter Bay	177.0	104
						6-Sep	39.8	461.0			172
2023	2021	22	Wild	Revelstoke	5	17-May	43.0	580.0	Centennial Launch	231.0	1
						17-May	43.3	716.1	Shelter Bay	177.0	70
				Waneta	4	17-May	41.5	598.0	Centennial Launch	231.0	29
						17-May	43.0	555.0	Shelter Bay	177.0	4
	2022	10	Wild	Waneta	4	17-May	34.3	274.6	Shelter Bay	177.0	40
							Total PIT-tagged juvenile c̓əmtus released				**63,502**

Table 10. Summary of acoustic-tagged juvenile c̓əmtus origin, release date, release location, number of juveniles released and average length (mm) and weight (g).

Release Year	Year Class	Age (months)	Life-History Origin	Geographic Origin	Hatchery Release Target	Release Date	Average Length (mm)	Average Weight (g)	Release Location	RKm	Number of c̓əmtus Released
2007	2006	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	3-May	31.0	211.0	Moses Creek	233.0	50
2008	2007	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	29-Apr	31.6	229.2	Big Eddy	228.3	50
2009	2008	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	23-Apr	35.1	280.9	Big Eddy	228.3	10
									Begbie Creek	216.0	10
									Mulvehill Creek	206.1	10
									Tree Island	194.1	10
									qwspíc’aʔ	184.0	10
2010	2009	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	22-Apr	31.5	244.8	Big Eddy	228.3	10
									Begbie Creek	216.0	10
									Mulvehill Creek	206.1	10
									Tree Island	194.1	10
									qwspíc’aʔ	184.0	10
2011											
2012	2011	10	Hatchery	Upper nx̌ʷəntkʷitkʷ Broodstock	3	15-May	32.0	250.0	Akolkolex / Walter Hardman	203.0	50
							Total acoustic-tagged juvenile c̓əmtus released				**250**

3.4 Juvenile ċəmtus Capture Efforts to Estimate Growth and Survival

3.4.1 Capture Effort

Effort has varied for both gillnets and setlines over the 17 years that fish sampling activities occurred (Table 11). For the first four years of the study, the fishing effort was focused on locations where acoustic-tagged fish were detected and in areas considered to have a high probability of encountering a ċəmtus (e.g., the channel thalweg, sandy flats) and areas where tagged ċəmtus were previously captured. Both full overnight (n = 52) and short duration nighttime (n = 64) gillnets were used in 2010. During 2014 to 2023, a GRTS stratified sampling design was introduced to ensure random coverage in the snkx̌ykntn Reach and the upper ALR to determine if juvenile ċəmtus were using other habitat types and locations. Effort was increased in these years with the objective of capturing sufficient numbers of juvenile ċəmtus to determine growth and survival metrics. Even with this increased level of effort, few juvenile ċəmtus have been captured. Setline CPUE was increased in 2019 to 2023; however, 2023 saw the lowest setline CPUE of any study year where ċəmtus were captured. Details on within-year gillnet and setline efforts are available in the CLBMON-21 annual report series. Details on 2023 fish sampling effort and results are located in Appendix D.

Table 11. Gillnet effort (Net-Units = NU) and setline effort (Hook-Hours = HH), number of juvenile ċəmtus captured, and catch-per-unit-effort (CPUE; higher values indicated by darker shades) from 2007 to 2023. Data collected from the middle nx̌ʷəntkʷitkʷ by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

Study Year	Gillnet Effort: Soak Time (Hours)	Gillnet Effort: Effort (NU)	Gillnet Effort: ċəmtus	Gillnet Effort: CPUE (ċəmtus / NU)	Setline Effort: Soak Time (Hours)	Setline Effort: Effort (HH)	Setline Effort: ċəmtus	Setline Effort: CPUE (ċəmtus / 100 HH)	Total ċəmtus
2007	71.3	2.1							0
2008	642.2	22.3	4	0.180					4
2009	521.4	36.3	2	0.055	54.6	1085.1			2
2010	1041.0	72.5	4	0.055	470.0	14100.5			4
2011	No capture effort undertaken - Sonic tracking range testing								
2012	No capture effort undertaken - 2D sonic array tracking								
2013	121.9	8.5			900.7	14368.5			0
2014	365.2	25.4	7	0.275	2620.4	53192.5	4	0.008	11
2015	704.4	49.1	1	0.020	3289.2	66534.4			1
2016	914.4	82.4			4810.5	96140.7	8	0.008	8
2017	743.2	59.1	3	0.051	5156.9	101496.0	5	0.005	8
2018	332.8	25.0			2242.4	44379.7	2	0.005	2
2019	478.9	26.3			2458.6	49084.0	2	0.004	2
2020	378.9	19.6			4054.5	81024.7	9	0.011	9
2021	231.8	12.0			2969.4	58502.7	7	0.012	7
2022					6661.6	133231.0	24	0.018	24
2023					5898.5	117947.3	1	0.001	1
Total	**6547.3**	**440.8**	**21**	**0.048**	**41587.1**	**831087.0**	**62**	**0.007**	**83**

[a] 2014 gillnet efforts in September were estimated to have 3:15 average soaking times at 20 sites

[b] 2014 setline efforts in September were estimated to have 20:48 average soaking times at 22 sites

[c] 2017 and 2022 within-year re-capture events included

Juvenile ċəmtus have not been captured in the Beaton Arm, although sampling effort in this area has been relatively low (Table 12). Juvenile ċəmtus have been encountered most often in River Section 9: 1 km upstream of Crawford Creek (RKm 192.2) upstream to Tree Island (RKm 197.5). River Section 10: 1.5 km downstream of Wallis Creek (RKm 186.6) to 1 km upstream of Crawford Creek (RKm 192.1) saw the second highest ċəmtus captures, with 87.5% of captures in that River Section occurring in 2022 (Table 12). Maps of capture locations, effort, and CPUE by River Section can be found in Appendix E.

Table 12. Gillnet effort (Net-Units = NU) and setline effort (Hook-Hours = HH), number of juvenile ċəmtus captured, and catch-per-unit-effort (CPUE; higher values indicated by darker shades) by River Section from 2007 to 2023; excluding September 2014 effort and capture data as location data were lacking. Data collected from the middle nx̌ʷəntkʷitkʷ (1 – 15) and Beaton Arm (B1 – B2) by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

River Section	Gillnet Effort				Setline Effort				Total ċəmtus
	Soak Time (Hours)	Effort (NU)	ċəmtus	CPUE (ċəmtus / NU)	Soak Time (Hours)	Effort (HH)	ċəmtus	CPUE (ċəmtus / 100 HH)	
1	8.4	0.1							0
2	15.1	0.6							0
3	39.1	1.5							0
4	57.5	3.6							0
5	226.1	10.9	4	0.366	595.6	12103.5	1	0.008	5
6	753.1	37.4	4	0.107	4128.5	82101.5	6	0.007	10
7	357.7	25.3	1	0.040	4235.3	83909.2	8	0.010	9
8	517.2	34.3	1	0.029	4762.2	94310.4	8	0.008	9
9	695.8	47.4	4	0.084	5565.5	109877.3	11	0.010	15
10	536.7	35.8	1	0.028	5166.7	102721.6	14	0.014	15
11	603.0	41.6			5188.3	105457.8	11	0.010	11
12	697.7	49.1	1	0.020	2364.9	48510.1	1	0.002	2
13	1075.4	84.8			5698.4	114376.9			0
14	495.1	38.2	1	0.026	1612.7	32648.6			1
15	301.4	18.5			1235.7	24469.4			0
B1	89.8	7.2			43.5	826.4			0
B2	58.9	3.1			532.3	10622.5			0
Total	**6527.9**	**439.4**	**17**	**0.039**	**41129.5**	**821935.0**	**60**	**0.007**	**77**

[a] Data from Sep 2014 were lost; ċəmtus and effort from that month are not included in this table
[b] 2017 and 2022 within-year re-capture events included

Juvenile ċəmtus captures have also varied depending on sample timing, with 69% of captures occurring between Sep 01 and Oct 31, and 51% of captures occurring solely in September. Although effort has not been prioritized between Oct 09 and 16 (Month Quarter = Oct 2), the capture of ċəmtus resulted in the highest CPUE for both gillnet and setline effort compared to all other sample time periods (Table 13). Effort from Sep 17 to 24 (Month Quarter = Sep 3) has been relatively high for both gillnets and setlines and has resulted in the highest juvenile ċəmtus captures overall.

Table 13. Gillnet effort (Net-Units = NU) and setline effort (Hook-Hours = HH), number of juvenile ċəmtus captured, and catch-per-unit-effort (CPUE; higher values indicated by darker shades) by month quarter (quarter 1 is the 1st – 8th, 2 is the 9th – 16th, 3 is the 17th – 24th, and 4 is the 25th – the last day of the month) from 2007 to 2023. Data collected from the middle nx̌ʷəntkʷitkʷ by Golder Associates Inc., the Okanagan Nation Alliance, and BC Hydro.

Quarter Month	Gillnet Effort				Setline Effort				Total ċəmtus
	Soak Time (Hours)	Effort (NU)	ċəmtus	CPUE (ċəmtus / NU)	Soak Time (Hours)	Effort (HH)	ċəmtus	CPUE (ċəmtus / 100 HH)	
Mar 2	25.5	0.9							0
No capture effort undertaken from Apr - May and Nov - Feb									
Jun 1	145.9	13.5			839.5	16744.2			0
Jun 2					722.7	13956.8			0
Jun 3	60.7	5.7			415.1	8279.3			0
Jun 4	253.0	20.4	1	0.049	581.8	11618.0			1
Jul 1	240.4	17.5			1286.2	25616.8			0
Jul 2	226.9	17.3			1353.2	27455.7			0
Jul 3	140.3	10.6			699.8	13913.7			0
Jul 4	166.5	11.7			747.6	14905.3			0
Aug 1	218.6	15.4			1012.0	20262.9	1	0.005	1
Aug 2	494.3	33.2			3642.5	72581.8	9	0.012	9
Aug 3	448.1	32.6	3	0.092	3687.2	73868.7	2	0.003	5
Aug 4	469.5	33.4			3676.2	73907.6	10	0.014	10
Sep 1	423.4	23.4	3	0.128	3322.8	66070.6	4	0.006	7
Sep 2	1389.6	92.0	3	0.033	4500.1	89965.8	7	0.008	10
Sep 3	831.4	48.5	6	0.124	7405.0	147877.4	16	0.011	22
Sep 4	482.4	29.1			2629.5	53195.4	3	0.006	3
Oct 1	502.3	33.5	4	0.119	2068.2	40024.2	2	0.005	6
Oct 2	74.4	5.2	1	0.193	1391.9	28727.3	7	0.024	8
Oct 3					1605.8	32115.7	1	0.003	1
Total	**6592.9**	**43.9**	**21**	**0.047**	**41587.1**	**831087.0**	**62**	**0.007**	**83**

* 2017 and 2022 within-year re-capture events included

3.4.2 Juvenile ċəmtus Captures

Over the 17 years of the program, all juvenile ċəmtus have been captured within a 32.7 km stretch of river, from Shelter Bay (RKm 178.1) to just upstream of Greenslide Creek (RKm 210.8), with the exception of the individual caught downstream of nqʷisp at RKm 124.1 (Table 14). In 2021, effort was limited to eight River Sections within the snkx̌ykntn Reach (River Section 5 to 12) and had the highest capture location variability (63% of sections sampled experienced captures). In 2015, although ten River Sections were sampled, only one section experienced a capture, the lowest of all years that experienced at least one capture. Interestingly, in 2022, 14 captures occurred in River Section 10, which had been sampled over 11 previous years and only resulted in two captures. A map of capture locations can be found in Appendix C.

Timing of effort and captures has varied between years (Table 15). In 2022, ċəmtus were captured in seven of eight month quarters sampled (capture rate of 88%) resulting in the highest variable capture timing of all study years. All other years experienced more condensed capture timing in relation to sampling effort. In 2015, capture timing was the least variable (ċəmtus were captured in one of nine sampled month quarters; 11%) of all years with one ċəmtus capture.

Table 14. Number of juvenile ċəmtus caught (numbers with green shaded cells) by River Section (descriptions in Section 2.1) during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ from 2007 – 2023 (sampling not conducted in 2011 or 2012), including effort (grey shaded cells; GN = gillnet; SL = setline). Data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

River Section	U/S RKm	D/S RKm	2007	2008	2009		2010		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022	2023	Total ċəmtus Captures
			GN	GN	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	SL	SL	
1	228.4	234.9																											**0**
2	226.1	228.3																											**0**
3	220.0	226.0																											**0**
4	214.1	219.9																											**0**
5	209.8	214.0		3			1																	1					**5**
6	205.6	209.7		1			2				2	1				1		1		1				2		1			**12**
7	201.9	205.5			1							2				4						1					1		**9**
8	197.6	201.8									2					1		3						1		1	2		**10**
9	192.2	197.5			1						2	1				2	2	1		1		1		4		1		1	**17**
10	186.6	192.1					1				1																14		**16**
11	182.1	186.5																						1		3	7		**11**
12	176.9	182.0											1													1			**2**
13	129.1	176.8																											**0**
14	119.0	129.0															1												**1**
15	77.6	118.9																											**0**
B1	2.2	14.3																											**0**
B2	14.4	17.4																											**0**
Total ċəmtus Captures			**0**	**4**	**2**	**0**	**4**	**0**	**0**	**0**	**7**	**4**	**1**	**0**	**0**	**8**	**3***	**5**	**0**	**2**	**0**	**2**	**0**	**9**	**0**	**7**	**24***	**1**	**83**

*2017 and 2022 within-year re-capture events included

Table 15. Number of juvenile ċəmtus caught (numbers with green shaded cells) by year and month quarter (period 1 is the 1st – 8th, 2 is the 9th – 16th, 3 is the 17th – 24th, and 4 is the 25th – the last day of the month) during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ from 2007 – 2023 (sampling not conducted in 2011 or 2012), including effort (grey shaded cells; GN = gillnet; SL = setline). Data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

Month	Period	2007	2008	2009		2010		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022	2023	Total ċəmtus Captures
		GN	GN	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	GN	SL	SL	SL	
Mar	**2**																											**0**
Jun	1																											**0**
	2																											**0**
	3																											**0**
	4															1												**1**
Jul	1																											**0**
	2																											**0**
	3																											**0**
	4																											**0**
Aug	1																						1					**1**
	2																						1		1	7		**9**
	3			2						1															1	1		**5**
	4																3		1						2	3	1	**10**
Sep	1											1			2	2	2									2		**9**
	2		2			1									2				1		1		1					**8**
	3		2							4	2				2						1		4		3	4		**22**
	4														2								1					**3**
Oct	1					3				1	1												1					**6**
	2									1	1															6		**8**
	3																									1		**1**
Total ċəmtus Captures		**0**	**4**	**2**	**0**	**4**	**0**	**0**	**0**	**7**	**4**	**1**	**0**	**0**	**8**	**3***	**5**	**0**	**2**	**0**	**2**	**0**	**9**	**0**	**7**	**24***	**1**	**83**

*2017 and 2022 within-year re-capture events included

From 2007 to 2023, juvenile c̓əmtus have been captured at reservoir elevations between 427.3 masl (low in 2023) to 438.9 masl (high in 2017; Figure 6). In 2015, 2016, and 2023, sampling occurred when reservoir levels were between 424.0 – 429.0 masl (floodplains habitat classification) and five individuals were captured. The remainder of individuals were captured at reservoir levels above 429.0 masl; with over 50% of captures occurring between 432.0 – 435.9 masl. In 2023, sampling occurred at reservoir elevations below 424.0 masl (thalweg habitat classification); however, c̓əmtus were not encountered during this time.

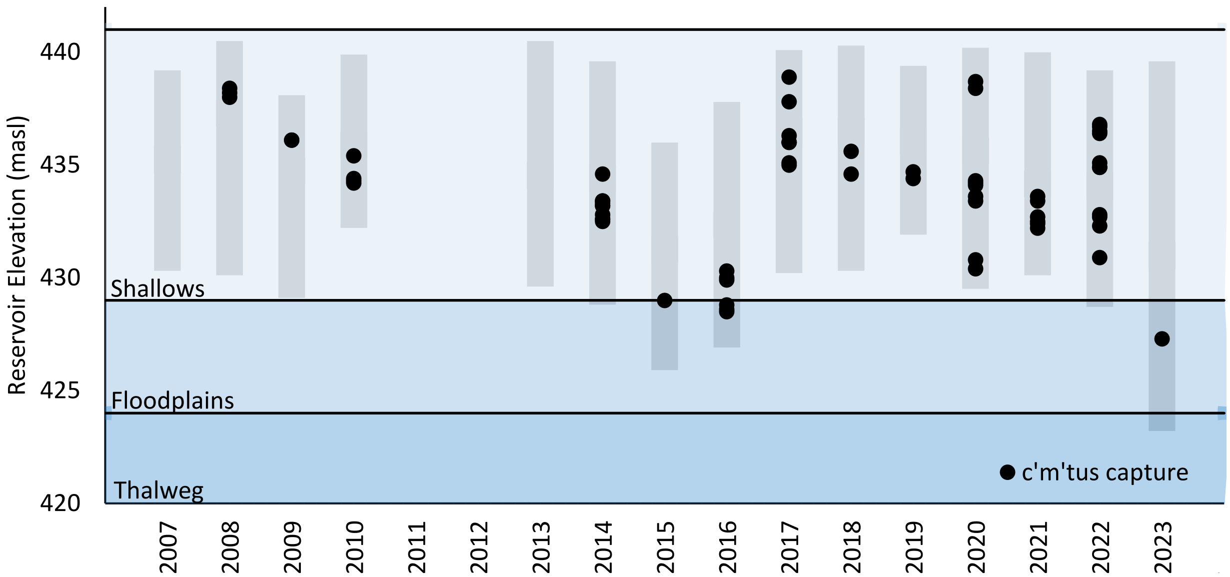

Figure 6. Juvenile c̓əmtus captures during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ, including reservoir elevation at nqʷisp (greyed area) between May 01 and Oct 31 of each year and habitat classifications summarized near the Walter Hardman Generating Station during fine-scale movement work (Golder and ONA 2013). Capture data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro. Hydrometric data from the Government of Canada Water Office website

3.4.4 Growth and Condition

All growth and condition results exclude three fish captures, (1) “2017-8” and (2) “2022-16”, as they were caught within the same year and had the same measurements, and (3) “2022_14”, as they were a United States release fish (initially released in the United States in 2007 [2006 year class], encountered in 2015 and 2017 at Kettle Falls, WA). This individual did not have an acoustic tag and therefore movement timing into Canada and through the navigational lock at HLK Dam is unknown. This individual’s growth and relative weight may not be comparable to individuals released and reared in the MCR.

The relationship between length and weight of MCR juvenile c̓əmtus was best described using the power function equation below (R^2 = 0.98; Equation 5; Figure 7):

Equation 5. MCR juvenile c̓əmtus growth.

$$W = 2 \times 10^{-6} \times L^{3.2629}$$

$$\begin{aligned} &where, \\ &W = cəm'tus\ weight\ (kg) \\ &L = cəm'tus\ length\ (cm) \end{aligned}$$

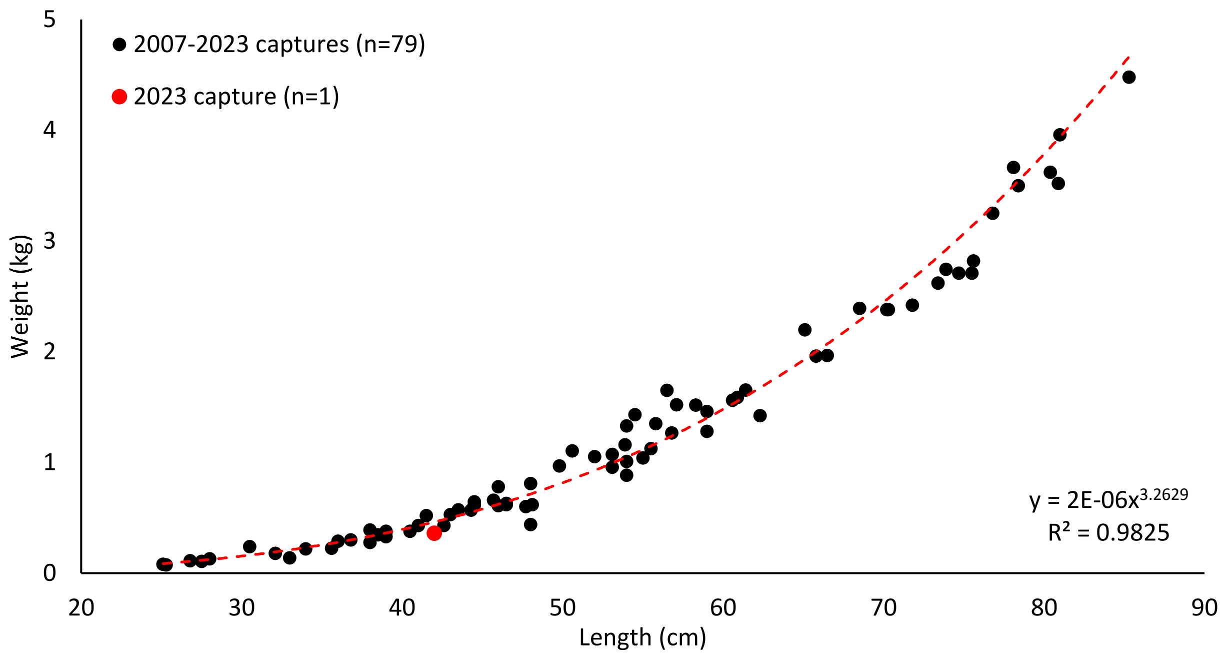

Figure 7. Length-weight regression of juvenile c̓əmtus captured during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ between 2007 and 2023, including sample size (n). Data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

Relative weights for juvenile c̓əmtus captured in the MCR ranged from 59.3% to 140.0% (Figure 8). The average relative weight for all the MCR juvenile c̓əmtus captured between 2007 and 2023 was 97.3% ± 3.1%, which is higher than the 85.7% ± 7.4% reported in the first four years of sampling (Golder 2011).

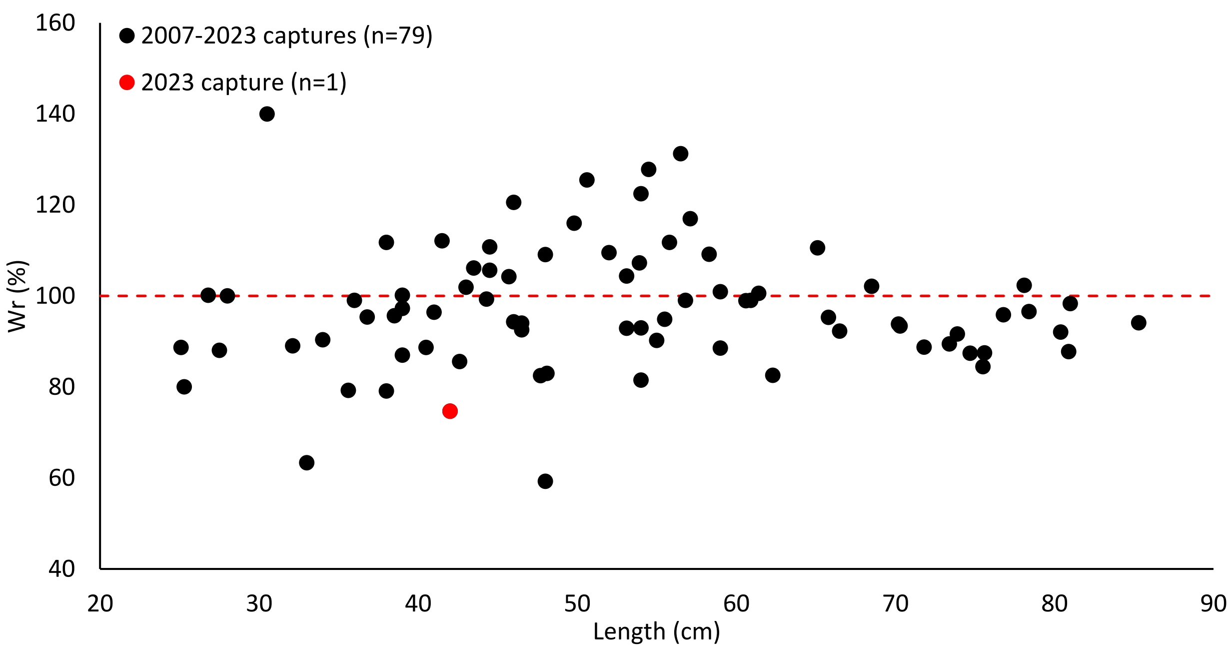

Figure 8. Relative weight (Wr) of juvenile c̓əmtus compared to length (cm) during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ from 2007 – 2023, including 100% Wr and sample size (n). Data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

Length and weight measurements and growth calculations of all c̓əmtus captured during Years 1 to 17 (2007-2023) were split into three categories depending on the time between release and capture (< 1 year, 1 year, > 2 years). This was done as fish captured less than two years after release appeared to have higher growth rates on average (particularly length) and were more variable (standard deviation) even with more data points (n values; Figure 9).

Since 2007, 19 out of 80 (24%) juvenile c̓əmtus have been captured within one year of release, 13 (16%) were captured one year after release, and the remainder (48; 60%) were captured two year or more after release (Figure 9).

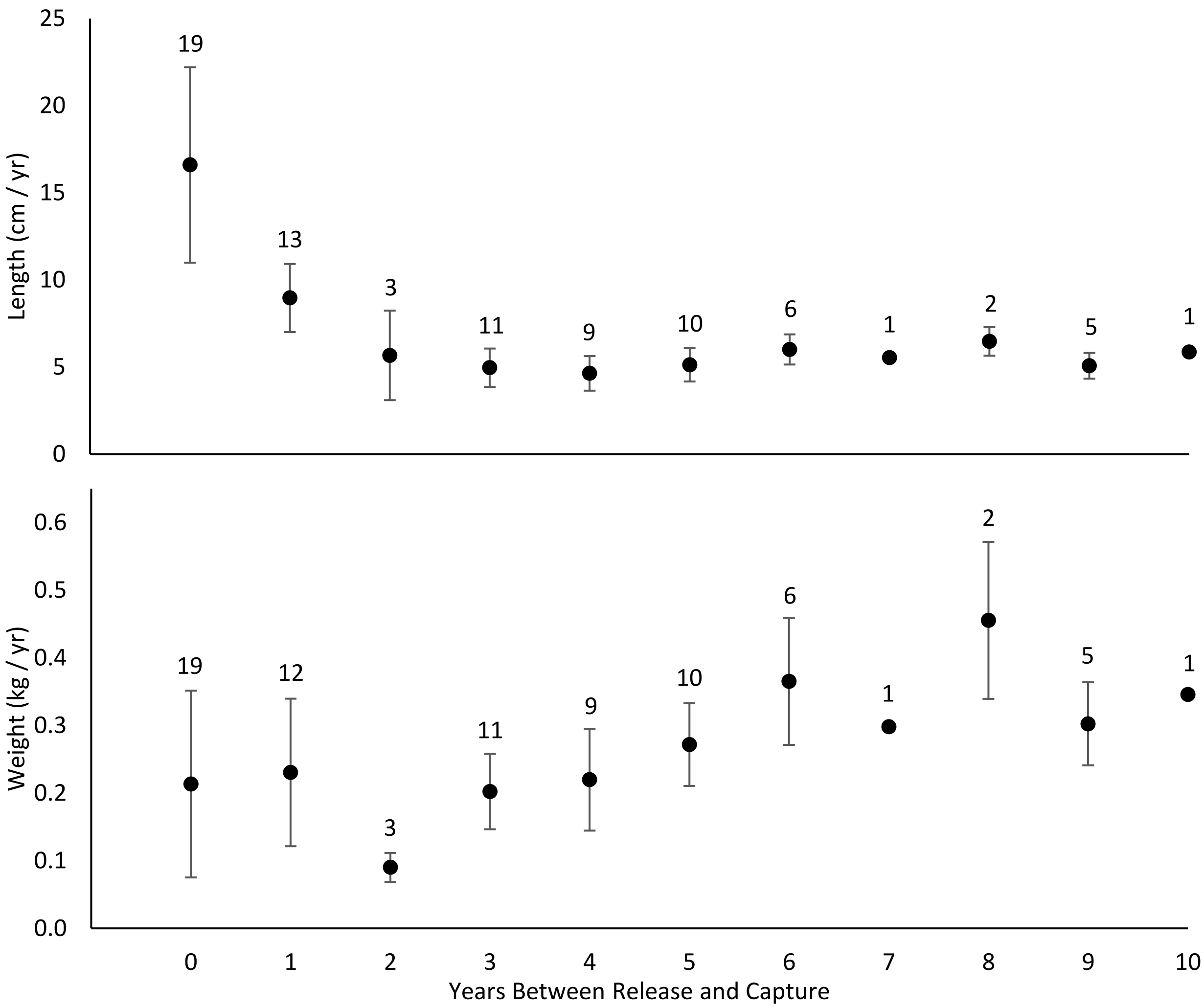

Figure 9. Growth measures for juvenile c̓əmtus compared to the number of years between release and capture during CLBMON-21 in the middle nx̌ʷəntkʷitkʷ from 2007 – 2023, including sample sizes. Data collected by Golder Associates Inc., Okanagan Nation Alliance, and BC Hydro.

Since 2007, there have been no captures from the 2010, 2017, 2019, 2020, or 2022 year classes. Representation of captured year classes varied from a low of one from year class 2011 (0.02% capture rate) to a high of 19 from year class 2015 (1.20% capture rate).

The individual encountered in 2023 was caught within one year of release and was 42.0 cm and 0.36 kg, with a relative weight of 74.65%. Between release and capture, this individual grew 4 cm and lost 0.06 kg (over 100 days); these are the second lowest length and weight changes of all captures. The individual with the lowest length and weight changes was caught in 2014 and recorded to have a length change of 0 cm and a weight change of -0.07 kg (over 154 days).

The average length and weight of fish captured within one year of release were 37.29 cm ± 3.03 cm (95% CI) and 0.34 kg ± 0.08 kg (95% CI). When captured, they had grown an average of 6.26 cm ± 2.17 cm (95% CI) and 0.08 kg ± 0.05 kg (95% CI). Captured fish appeared to have similar relative weights (93.42% ± 8.10%) compared to fish capture one year after release (94.84% ± 5.97), but lower than fish caught two years or more after release (99.52% ± 3.53%). Annual growth rates for fish captured less than one year after release were not calculated as results are extrapolated from a small time-frame and do not accurately show growth for a full year.

Average annual growth (mean ± 95% confidence interval) of fish captured one year after release was 8.96 cm / year ± 1.95 cm / year (95% CI) and 0.23 kg / year ± 0.11 kg / year (95% CI); while fish captured two years or more after release grew 5.21 cm / year ± 0.42 cm / year (95% CI) and 0.26 kg / year ± 0.03 kg / year (95% CI). Of all the MCR juvenile ċəmtus that were captured one year or more after release, average annual growth was 6.01 cm / year ± 0.65 cm / year (95% CI; n = 61) and 0.25 kg / year ± 0.03 kg / year (95% CI; n = 60).

One individual was captured in 2021 (2021_2; 59.0 cm and 1.46 kg) and re-captured in 2022 (2022_3; 60.6 cm and 1.56 kg). This was the first inter-year re-capture of the project and allowed for additional growth measures to be assessed. This individual grew 16.0 cm and 0.92 kg over 4.3 years (3.74 cm / year and 0.22 kg / year) to its first capture and 1.60 cm and 0.10 kg over 1.0 year to its re-capture in 2022.

Since 2008, there appeared to have been a positive increase in capture fork length, however this increase was not significant (R^2 = 0.45). Average fork length of juveniles in the MCR by capture year have been consistently lower than juveniles from the ntx̌ʷitkʷ (102.6 ± 28.1 cm SD to 160 ± 41.5 cm SD from 2013 to 2022; BC Hydro 2023); however, methods may target different sizes. Since 2008, there appeared to have been a positive increase in capture weight, however this increase was not significant (R^2 = 0.32). Average weight of juveniles in the MCR by capture year have been consistently lower than juveniles from the ntx̌ʷitkʷ (9.0 ± 11.9 kg SD to 40.2 ± 25.1 kg SD from 2013 to 2022; BC Hydro 2023). Average relative weight has not significantly changed over capture years in the MCR (R^2 < 0.01), but 2014 to 2022 average appear to be higher than juveniles from the ntx̌ʷitkʷ (78.3 ± 7.3 % SD to 88.9 ± 10.3 % SD from 2013 to 2022; BC Hydro 2023).

3.4.5 Survival

Survival has not been estimated due to low capture rates, which are attributed to a large study area and low capture efficiency. Additional captures are required to adequately address the survival question.

3.4.6 Diet

Stomach contents were analyzed to determine juvenile ċəmtus prey in the MCR. Stomach contents of sampled juvenile ċəmtus have remained similar between years. Samples from 2010, and 2016 to 2023 were composed of:

- Mysis diluviana, an introduced freshwater shrimp species,

- Chironomide, non-biting midges,
- Sphaeriidae, pea clams or fingernail clams,
- Gastropoda, snails and
- Unidentifiable fish (spinal column, flesh, and internal organs; skin and head not present).

c̓əmtus are difficult to gastric lavage for a complete stomach content analysis. Crossman et.al. (2016) compared gastric lavage to a complete stomach removal in the ntx̌ʷitkʷ in Canada and observed that on average, gastric lavage obtains 67% of the actual stomach contents. In 2017, the one recaptured juvenile c̓əmtus was gastric lavaged twice over a four-day period. Both samples contained large numbers of mysid shrimp, which indicated active feeding between capture events in September.

The decapod *Mysis diluviana* was abundant in some sections of the MCR study area (qwspíc'aʔ Flats and downstream of Walter Hardman) during underwater video surveys in 2009 (Golder 2010). Mysids are a key component of the diet of juvenile c̓əmtus downstream of HLK (Golder 2009b) and based on the stomach contents of lavaged fish in 2016-2023, are an important food source to MCR fish as well. Mysids were also the largest invertebrate identified, ranging from 9 – 20 mm during 2019 to 2023 analyses. Oligochaeta were the second largest invertebrate identified (1 – 16 mm), but individuals have not been identified in lavage samples. Chrionomidae were the second most common prey item identified in lavage samples and were generally small (3 – 9 mm), with the exception of an 18 mm individual in identified 2021.

Ponar Grab substrate samples were taken at both c̓əmtus capture locations as well as representative habitat locations from 2016-2023. The primary taxon identified in these substrate samples since 2014 was Oligochaeta, followed by Chironomidae. From 2019-2023, 42 ponar grabs have been conducted, 28 resulting in positive invertebrate identifications (Table 16). In 2023, invertebrates were detected in one (of seven) ponar grabs (17%). Prior to this, 2020 had the lowest invertebrate detection (57% of samples); 2021 had the highest invertebrate detection (86% of samples).

Prior to 2023, rock baskets resulted in more species identified and total individual invertebrates collected, all rock baskets resulted in the positive identification of at least one invertebrate (one rock basket was lost in 2019 and is not included in number of samples analysed). Chironomidae were the most abundant invertebrate detected in rock baskets (Table 16); full rock basket results are available in Appendix F.

In 2023, eight rock baskets were successfully deployed from qwspíc'aʔ Flats (RKm 182.0) to just upstream of Mulvehile Creek (RKm 207.6). Rock Baskets 1 to 4 became inaccessible due to water depths and were not recovered, 5 and 6 were successfully retrieved, 7 was lost, and 8 was dewatered and therefore not processed. From 2019 to 2022, average rock basket set depths varied from 10.1 m (± 2.9 m) to 13.4 m (± 1.7 m). In 2023, average rock basket set depth was 4.4 m (± 0.9 m). Invertebrates were not detected in rock basket samples from 2023.

Table 16. Number of invertebrates identified by sample type, including the number of samples analysed and the number of samples with positive invertebrate identification. Data collected from the middle nx̌ʷəntkʷitkʷ during CLBMON-21 from 2019 – 2023.

Sample Type	Lavage	Ponar Grab	Rock Basket
Samples Analysed	38	42	41
Samples with Invertebrates	25	28	39
Oligochaeta		116	89
Hirudinea	1		5
Mysis	1051		
Chironomidae	436	81	601
Heptageniidae			1
Ephemerellidae			14
Trichoptera			52
Culcidae	1	2	1
Hydrachnidia	1		2
Plecoptera			1
Sphaeriidae	2	2	1
Platyhelminthes			83
Planorbidae			2
Physidae	1		
Hydrobiidae		1	

3.4.7 Incidental Catch

Bycatch summaries for Years 1 to 17 of the program can be found in the CLBMON-21 annual report series. Data for Year 17 (2023) are provided in Appendix D. Over the years the most common bycatch species captured in gillnets were ʕaỷckst, mountain whitefish, lake whitefish (*Coregonus clupeaformis*), peamouth chub (*Mylocheilus caurinus*), kəkṅi, and northern pikeminnow (*Ptychocheilus oregonensis*).

Setline bycatch consisted mainly of spəqʷlic; in past years, spəqʷlic mortality on setlines was high due to the depth of setline sets and resultant swim bladder ruptures when the lines were retrieved. Fewer mortalities occurred when spəqʷlic were captured in the shallower snkx̌ykntn Reach. To reduce spəqʷlic mortality, setlines in recent years were not set at depths greater than 25 m and were retrieved at a slow rate. In October 2023, crews used a fish descending device to release spəqʷlic, to further aid in reducing mortality. Other common species captured on setlines were suckers (*Catostomus sp.*), northern pikeminnow, and peamouth chub. Most peamouth chub encountered on setlines were dead and partially digested, and therefore assumed to be prey items of spəqʷlic. One common carp (*Cyprinus carpio*) was captured on a setline in 2021 and removed from the system as it is a non-native species.

Boat electrofishing was conducted in the upper section of the MCR (from REV down to RKm 224) from 2001 to 2019 for a different sampling program (CLBMON-16). A total of three c̓əmtus have been observed during that program; one juvenile (Oct 30 2009 at Big Eddy; ~ 80 cm total length) and two adults (Sep 13 2001 at the spawning area adjacent the snkx̌ykntn golf course and Oct 25 2018 near the rock groyne downstream of the snkx̌ykntn boat launch; Golder et al. 2019; MCR Fish Indexing Database).

4.0 Discussion

4.1 Management Questions

4.1.1 Where are the habitat locations utilized by juvenile White Sturgeon in the Middle Columbia River?

To date, the results of CLBMON-21 indicate that habitat preferences of juvenile ċəmtus vary depending on the time of year and corresponding water levels as there were defined seasonal differences in meso-habitat use and movements within the MCR. In spring, juvenile ċəmtus were detected almost exclusively in the thalweg. During summer months, juveniles were detected in all three meso-habitat areas (thalweg, floodplain, and shallows), although habitat use was primarily in the thalweg and floodplain habitats during summer. In the fall, the highest usage was again recorded in the thalweg, although limited use of the available floodplain also was observed. The low use of non-thalweg areas in the fall by juvenile ċəmtus may suggest other factors such as temperature may affect habitat use in that period.

Seasonal variation in the use of thalweg habitats has also been observed in juvenile ċəmtus in the Lake Roosevelt Reservoir (McLellan et al. 2011, Howell and McLellan 2013). In that area, the probability of occupancy in the thalweg, based on models using VPS telemetry data, was high in the spring (86%) and winter (71%) and lower in the summer (33%). Although there are distinct seasonal trends in juvenile ċəmtus habitat use patterns in the MCR, the small number of fish left in the study area by fall limited the strength of conclusions presented here.

The 2009 movement studies indicated the qwspíc'aʔ Flats area (RKm 180-182) had the highest use by tagged ċəmtus (by total tag days); this may suggest a decrease in available habitat upstream at ALR elevations of 434-436 masl. In contrast, juvenile ċəmtus showed increased use of areas near Mulvehill Creek (RKm 207) during the higher ALR elevations in summer and fall of 2008, when water elevations remained near 439 masl for an extended period. In 2007 and 2010, high use habitat was located between Blanket Creek (RKm 203.1) and Akolkolex River (RKm 200.0) when ALR elevations were approximately 436 to 438 masl. ALR elevations may help to identify high use locations that can direct future capture efforts.

The analysis of fish movement near the Akolkolex River mouth did provide some information on ċəmtus use of shallow habitat in the MCR outside of the VPS array. Throughout all three seasons, the majority of estimated positions were classified as fish that remained within the VPS array near the Akolkolex River mouth. Use of the Akolkolex Bay area was likely to be higher during daytime, since the daytime counts of fish that left the VPS array (presumably into the Akolkolex Bay area) were higher than nighttime counts of similar behaviour throughout all three seasons. Further analysis of the data would be needed to determine if the daytime movement was in the morning, mid-day or evening, as the juveniles potentially move into the shallows to feed.

4.1.2 What are the physical and hydraulic properties of this habitat that define its suitability as juvenile White Sturgeon habitat?

Within the MCR, juvenile ċəmtus appear to prefer calm (<0.5 m/s), deep (average capture set depth of 11.5 – 12.8 m; total capture set depth ranged from 4.7 – 21.4 m) areas with fine substrates (clay and sand). While preference was for the deeper thalweg, use of floodplain and shallow habitats occurred in late June within the positional array. In October, a shift from using the floodplains and shallows back to mainly using thalweg habitat occurred (Golder and ONA 2013). The timing of these movement patterns generally follows the spring increase and fall decrease in water surface elevations of ALR.

Several studies suggest that the assumption of juvenile c̓əmtus mostly occupying benthic habitats is reasonable. In a study in Lake Roosevelt Reservoir, McLellan et al. (2011) found that depth measurements of tagged adult and juvenile c̓əmtus typically corresponds to the total depth at the location. Diet analyses of juvenile c̓əmtus in the LCR and Lake Roosevelt showed a high proportion of benthic invertebrates, which also suggested benthic orientation of juveniles (Crossman et al. 2016; Parsley et al. 2010). However, juvenile c̓əmtus in the ALR are known to forage on mysid shrimp that are known to make vertical diel migrations within the water column. The diel movement analysis conducted in 2009 (Golder 2010) indicates that juveniles are more active at night, which may indicate: 1) juvenile c̓əmtus may feed higher in the water column when foraging on mysids or 2) that mysid shrimp could have moved into shallower benthic areas during nighttime hours.

4.1.3 What is the quantity of available habitat meeting these conditions in the Middle Columbia River?

All c̓əmtus captures have been between RKm 178.1-210.7 with the exception of one individual captured near nqʷisp at RKm 124.1. The dispersal analysis identified that juvenile c̓əmtus made rapid movements downstream to the riverine section of the river (RKm 207-212) following release at upstream sites (Big Eddy [RKm 228.3] and Moses Creek [RKm 233]) and upstream following release at qwspíc'aʔ (RKm 184). Available habitat in the preferred riverine section varies throughout the year depending on water elevations as a result of operations at REV and backwatering from the ALR. However, this section of river is generally deeper, has finer substrates and has available eddy habitat (slower water) compared to the upstream habitat (RKm 212 and upstream). The program to date has not quantified the availability of meso-habitat that is preferred by juvenile c̓əmtus in the MCR but given that juveniles are selecting calm (<0.5 m/s), deep (>10 m) areas with fine substrates within the MCR it is not expected that habitat is limiting. Habitat suitability as measured through food availability remains uncertain throughout the reservoir.

4.1.4 How do hydraulic conditions resulting from dam and reservoir operations relate to habitat suitability for juvenile White Sturgeon in the Middle Columbia River?

In general, habitat use for juvenile c̓əmtus is concentrated in the thalweg (< 10 m) of the riverine section in the MCR (RKm 190-212). Throughout the year, dam and reservoir operations alter the amount and type of habitat available in this section of river; when water elevations are high, the thalweg becomes deeper and other habitats including floodplain and shallows become available. When water elevations are low, the thalweg is the primary habitat available for juvenile c̓əmtus. Juvenile c̓əmtus movements and habitat use generally coincide with habitat availability; they increase as water levels increase, and become more concentrated during low water elevations.

Studies on juvenile c̓əmtus in other areas of the upper Columbia River Basin have shown a preference for depths greater than 10 m (Golder 2009, McLellan et al. 2011), which suggests depth is a factor in influencing seasonal habitat selection by juveniles in the MCR; additional habitat data would be required to test this hypothesis. The only observed trend in fish behaviour related to reservoir elevation (i.e., emptying, filling, full, or stable) was that distances traveled in the shallow habitat type were greater during the emptying phase of ALR than during the stable or filling reservoir phases (Golder and ONA 2013).

Juvenile c̓əmtus also utilize the downstream section of the snkx̌ykntn Reach study area in the vicinity of the river-reservoir transition zone where the effects of REV discharge fluctuations are attenuated by ALR elevations. Similarly, c̓əmtus juveniles are found at the transition zone in higher numbers in Lake

Roosevelt Reach during sampling (Howell and McLellan 2013). Further work that summarizes key locations preferred by juvenile ċəmtus at different ALR elevations could help understand how to target habitat restoration projects in the future.

4.1.5 What are the survival rates of juvenile White Sturgeon in the Middle Columbia River?

Capture rates of juveniles in the MCR have been low in all years of sampling (total individual captures = 79 of 63,752 released juvenile fish; 2007-2023) excluding two fish recaptured in the same session, one recaptured in subsequent sampling events, and one fish immigrating to the study area. The capture of individuals up to 10 years after release (including four captured over 9 years after release in 2022) does indicate the capacity for ċəmtus to survive in the MCR; however, the lack of captures precludes estimating year class-specific survival. Individual 2022_14 was captured over 15 years after release and migrated over 300 km from Kettle Falls to access habitat in the MCR.

Juvenile ċəmtus CPUEs in the MCR ranged from 0.0 to 0.275 fish/net-hour for gillnets and 0.0 to 0.018 fish/hook-hour for setlines. These rates are very low compared to capture rates recorded for similar juvenile ċəmtus monitoring programs elsewhere in the Columbia drainage. For example, efforts in the Columbia River below HLK monitoring program using setlines have recorded CPUE values of 0.086 and 0.159 in the spring and fall stock assessments in 2022, respectively (BC Hydro 2023). In the Kootenay River and Kootenay Lake in 2019, one-hour daytime gillnet lines produced a CPUE of 2.0 fish/net-hour (Stephenson et al. 2020). Complimentary setline efforts had recorded CPUE values of 0.07 and 0.13 in the spring and fall sampling sessions in 2019, respectively (Stephenson et al. 2020).

Mean relative weight for all the MCR juvenile ċəmtus captured to date is 97.2% ± 3.0%, which may indicate that growth is near normal for those individuals that were captured. This finding does not support a hypothesis that food resources are limiting growth and survival of juvenile ċəmtus in the MCR. The mean relative weights of juvenile ċəmtus in the ntx̌ʷitkʷ in 2019 (Wr = 77.8 – 82.3%; riverine habitat; BC Hydro 2020) were lower than in the MCR total average for that year (Wr = 95%; reservoir habitat). This is similar to findings reported by Miller and Beckman (1992) who reported that juveniles in the reservoir upstream of Bonneville Dam had higher mean growth for the first 7 year classes than juveniles captured in the riverine section below Bonneville Dam.

This program has not yet captured any of the juveniles released in the 2010, 2017, 2019, 2020, or 2022 year classes. The program has also not captured any untagged fish that might have been released from the hatchery as larvae or recruiting from wild spawning events. Therefore, the effects of releasing early life-stage or larger juveniles on growth and survival cannot be determined at this time.

In order to address juvenile survival in this program, a substantial increase in captures and/or further understanding of mechanisms influencing sources of mortality is needed. Increasing sampling effort and targeting areas of previous capture in all seasons should help to capture more juvenile ċəmtus. Efforts to reduce bycatch mortality, especially for ʕay̓ckst, have limited the duration of sets and sampling locations depending on time of year (see Golder 2010). However, setlines can be easily used in the riverine section between Shelter Bay and Greenslide Creek and are less likely to capture ʕay̓ckst.

4.1.6 Can modifications be made to the operations of Revelstoke Dam and/or Arrow Lakes Reservoir to protect or enhance juvenile White Sturgeon habitat?

Based on captures and movements of acoustic-tagged individuals, juvenile ċəmtus prefer the section of the MCR between Greenslide Creek (RKm 212) to Shelter Bay (RKm 177) and downstream. During very low ALR levels, this section of river can experience substantial daily fluctuations in water levels and velocities resulting from REV operations. However, based on the results to date in this program, juvenile ċəmtus that reside in this area utilize deep, slow moving habitats associated with the thalweg of the nx̌ʷəntkʷitkʷ. These deep-water habitats are less prone to effects of REV discharge variations. Therefore, at present, there are no specific modifications to REV operations that could protect or enhance juvenile habitats.

Juvenile ċəmtus in the Snake River downstream of Hells Canyon Dam in Idaho were studied for changes in oxygen respiration and movement over the range of discharge flows (Geist et al. 2005). The overall trend was for swim speeds and oxygen consumption to be less during lower, stable flows, but the differences between seasons were related to temperature and daylight factors. Higher flows from load shaping were shown to restrict juvenile Sturgeon movement but did not increase oxygen consumption, likely due to morphological and behaviour adaptions of living in high flow habitats.

Macro-habitats with similar depth, velocity, and substrate characteristics as that selected by the 80 individual juvenile ċəmtus captured during this study program, is abundant in the ALR throughout the year and in the MCR during periods of high ALR levels. The results of the first four years of study (2007 to 2010) indicate that juvenile ċəmtus rarely use the upstream portion of the study area, where Revelstoke Dam and ALR operations have the greatest influence on habitat availability and suitability. Depths and velocities in the river/reservoir transition zone, where many juveniles have been detected, would be influenced to a lesser degree, however this influence would decrease with increased downstream distance from Revelstoke Dam.

5.0 Recommendations

The following recommendations are a result of the technical forum held for the Mid-Columbia White Sturgeon Management Plan in December 2018 (BC Hydro 2018):

- The primary uncertainty remaining in this program is survival of fish released from the conservation aquaculture program. As well, larger sizes at release have been tested over the course of the program, with the largest release sizes only occurring in recent years. Additional sampling is required to assess survival and evaluate the effects of size at release on survival.
  - Direct capture remains critical with a focus on qwspíc’aʔ Flats.
  - Consider telemetry as a tool to understand habitat use and movements if efforts to directly capture juveniles are not successful. Could provide additional distribution data for older larger ċəmtus if encountered and the recommendation is that application of telemetry in the future is focused on captured fish that have survived for several years following release.
  - Review eDNA experimental work done by UVic/UBC/BC Hydro to determine if it could be a tool in the future to help guide direct sampling efforts or understand habitat use.
- Further assess food availability and distribution for juvenile ċəmtus in all habitat types and throughout the year in the riverine section of the MCR.
  - Conduct plankton tows to determine seasonal and diel plankton (primarily mysids) availability

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Appendix A – Detailed Maps of River Kilometers, ċəmtus Release Sites, and Temperature Stations

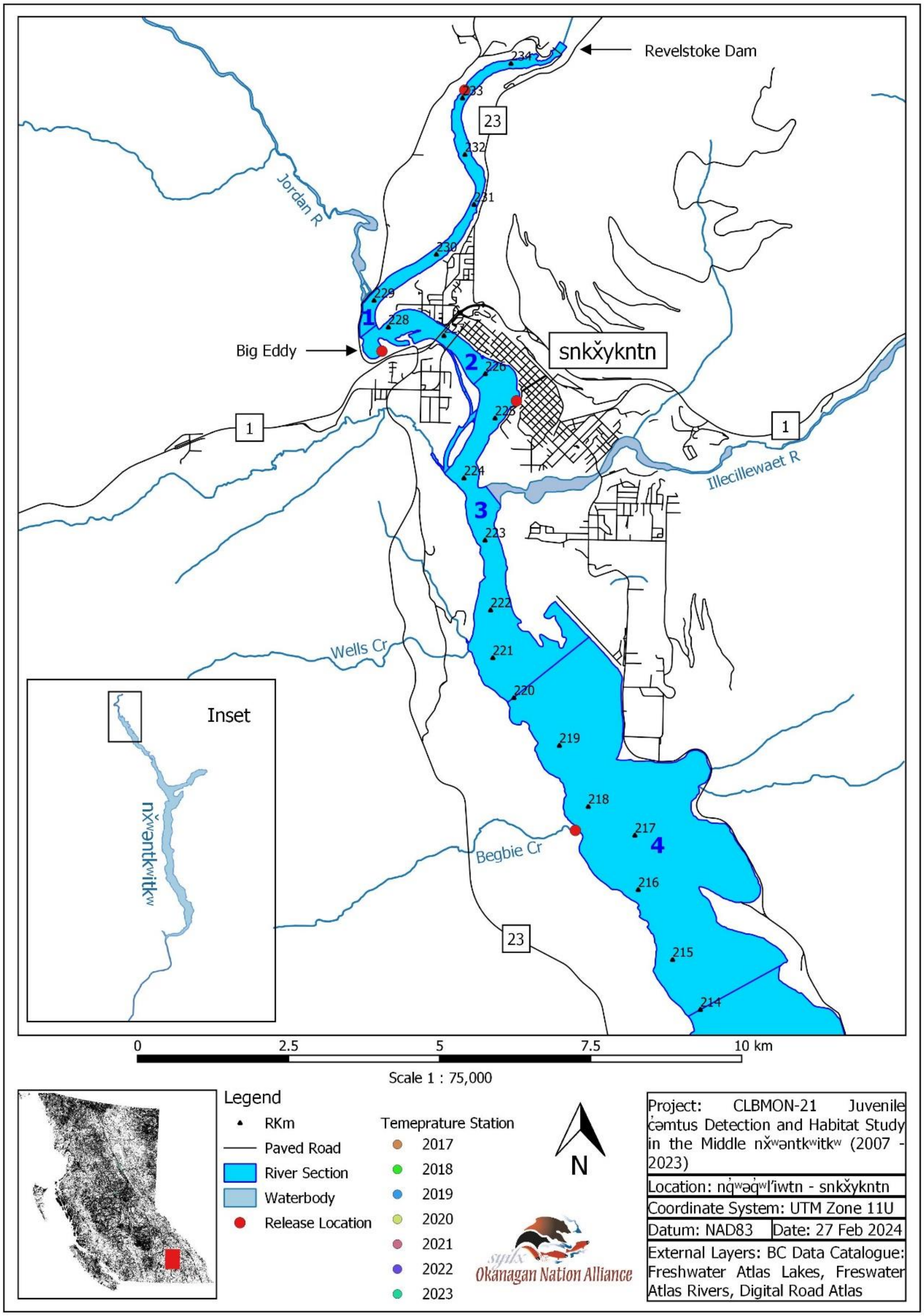

Figure 10. Juvenile ċəmtus release locations (2007 – 2023) and temperature stations (2017 – 2023) from 3.5 km downstream of Begbie Creek to Revelstoke Dam. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

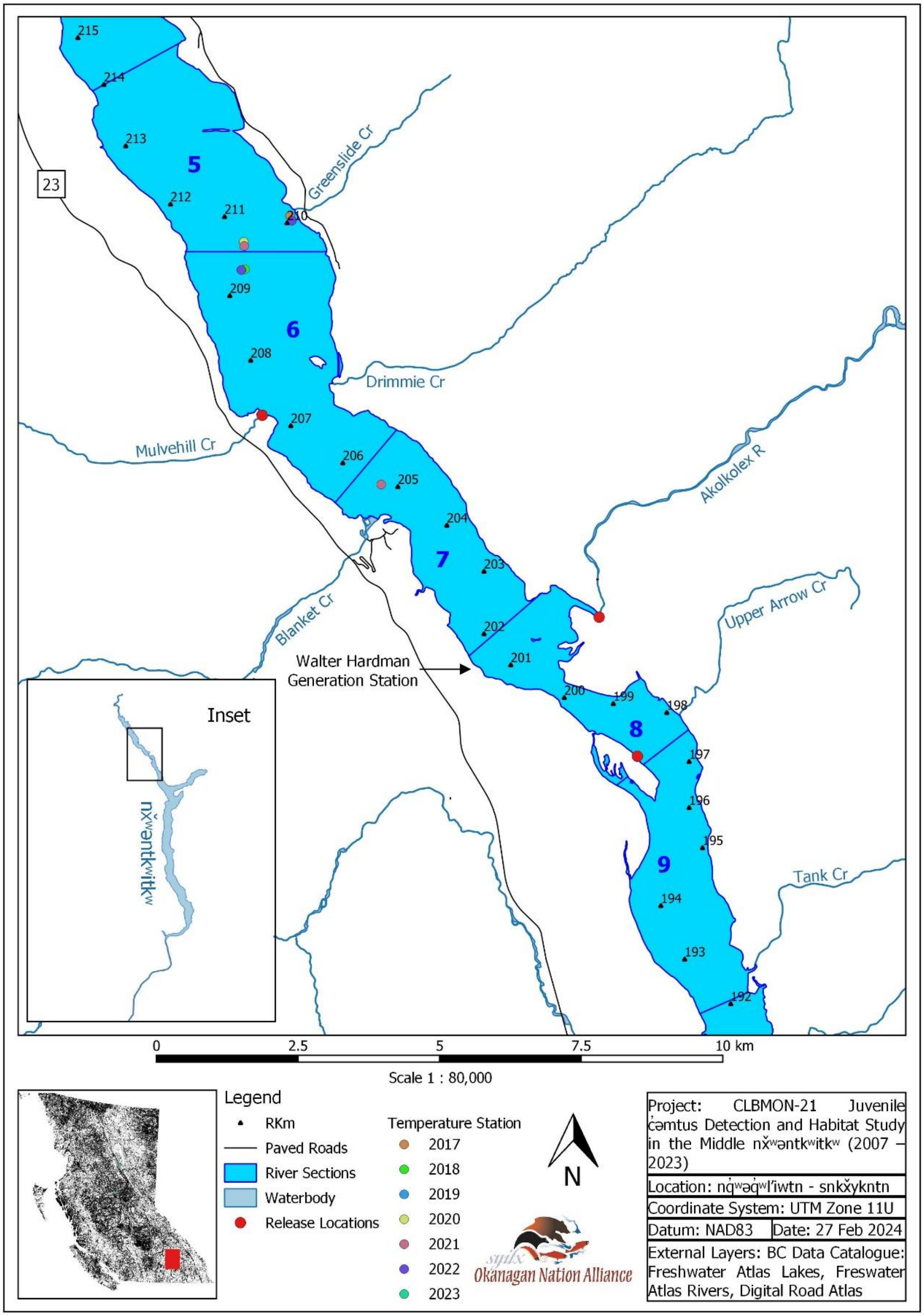

Figure 11. Juvenile c̓əmtus release locations (2007 – 2023) and temperature stations (2017 – 2023) from 1 km upstream of Crawford Creek to 3.5 km downstream of Begbie Creek. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

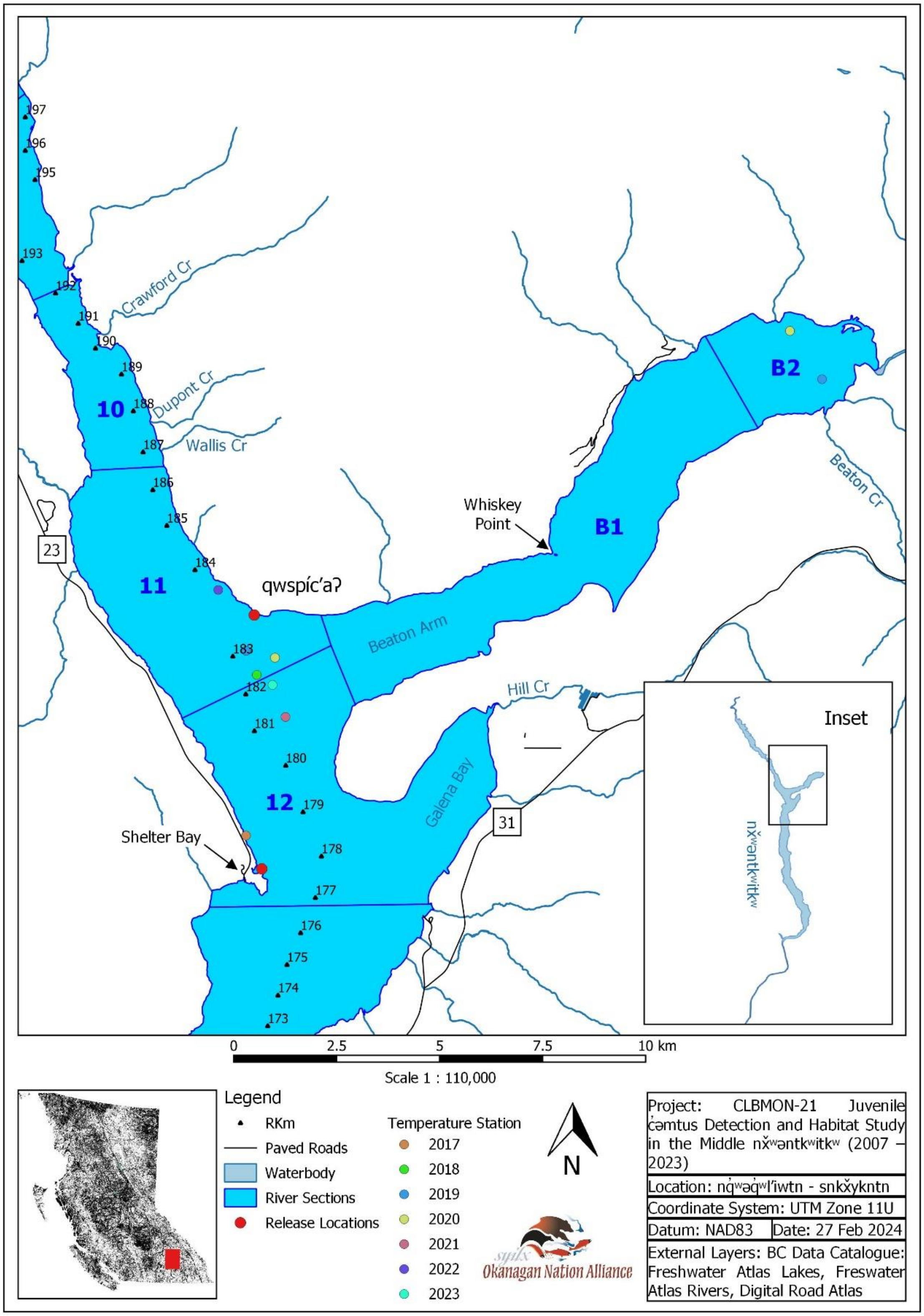

Figure 12. Juvenile c̓əmtus release locations (2007 – 2023) and temperature stations (2017 – 2023) from Shelter Bay to 1 km upstream of Crawford Creek and the Beaton Arm. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

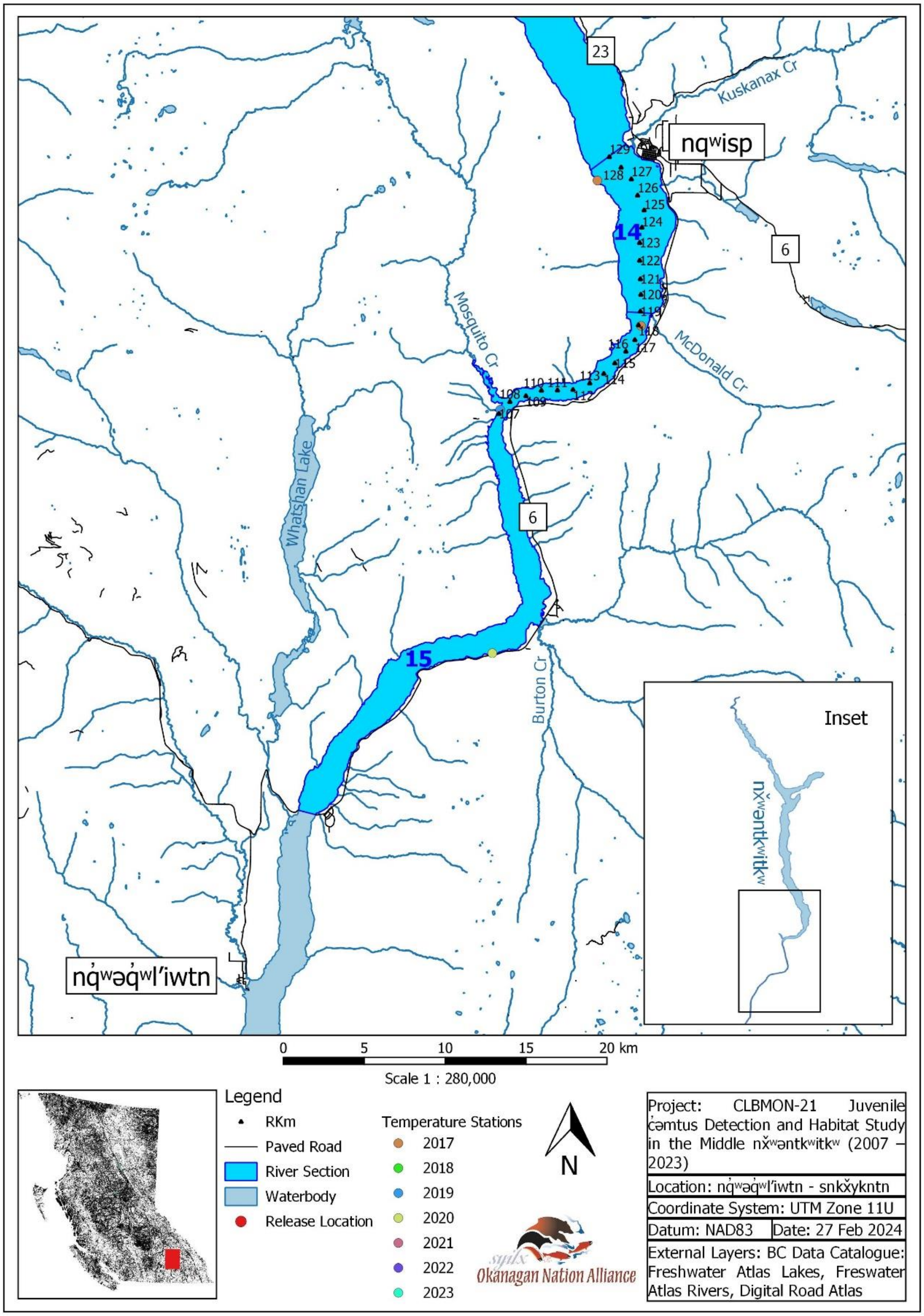

Figure 13. Juvenile ċəmtus release locations (2007 – 2023) and temperature stations (2017 – 2023) from the Arrow Lakes Narrows to nqʷisp. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

Appendix B – Summary of Habitat Conditions Measured at Juvenile ċəmtus Capture Locations

Table 17. Summary of habitat conditions measured at juvenile ċəmtus capture locations in the middle nx̌ʷəntkʷitkʷ from 2008 – 2023 during CLBMON-21. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

Year	RKm	Water Temp (°C)	Average Water Depth (m)	Secchi Depth (m)	Mean Velocity	Substrate	Turbidity	Contents in Substrate Sample
2008-1	207.4	-	18.3					
2008-2	210.2	-	10.1					
2008-3	210.6	-	10.9					
2008-4	210.8	-	11.8					
2009-1	192.5	-	16.4					
2009-2	202.2	-	11.1					
2010-1	205.9	10.5	14.3	3.5	0.28	fines/SG	-	
2010-2	210.5	10.5	7.7		0.2	fines	4.2	
2010-3	206.4	10	13.4		0.17	fines	2.9	
2010-4	190.7	10.5	13.1	3.95	0.18	fines/some OD	2.4	
2014-1	196.2	-	-			Sand		None
2014-2	192.0	-	-			Sand		Biting Midge
2014-3	195.4	-	-			Clay (sand)		Biting Midge
2014-4	196.0	-	-			Sand		None
2014-5	200.1	-	-			Pebbles (Sand)		None
2014-6	207.7	-	-			Sand		None
2014-7	208.5	-	-			Sand		6 Non-biting Midges
2014-8	207.5	-	-			Sand (Clay)		None
2014-9	208.0	10	10.8			Sand (Pebble)		Non-Biting Midge and Larvae
2014-10	206.0	10.1	8.9			Sand		3 red Non-Biting Midgets
2014-11	199.5	10.3	11.7					
2015-1	177.8	11.2	9			Clay		None
2016-1	205.5	10.5	10.8			Sand		None
2016-2	207.5	11	9.5			Pebbles (Sand)		Biting Midge
2016-3	195.5	9.8	10			Sand		None
2016-4	195.5	9.8	10					
2016-5	205.5	10.6	8.3			Sand (Pebble)		None
2016-6	205.5	10.6	8.3					
2016-7	201.5	9.5	7					
2016-8	202.6	9.5	6.3					
2017-1	124.1	15.4	13.6			Clay (Sand)		None
2017-2	199.5	10.1	15.5			Sand		1 Caddisfly
2017-3	192.8	12.2	15.3			Sand (Clay)		None
2017-4	192.8	12.2	15.3			Sand (Clay)		None
2017-5	193.0	11.1	17			Sand (Pebbles)		None
2017-6	199.4	11.7	15.8			Sand		None
2017-7	205.8	10.6	15.2			Sand		None
2017-8	200.7	11.5	13.7			Sand (Clay)		None
2018-1	193.2	11.4	15.1	3		Coarse sand		1 Diptera
2018-2	207	10.5	15.5			Medium sand		Nothing
2019-1	204.8	12	9.6					
2019-2	196	12.3	13.0					
2020-1	210	12	12.4			Coarse sand (medium sand)		Midges & 1 aquatic worm
2020-2	206.6	12.6	18.2					None
2020-3	207	10.1	10.6			Coarse gravel (coarse sand)		1 midge & 1 aquatic worm
2020-4	199.4	11.1	12.7	3		Coarse sand (fine gravel)		
2020-5	196.3	12.1	14.6			Medium sand (fine gravel)		

Year	RKm	Water Temp (°C)	Average Water Depth (m)	Secchi Depth (m)	Mean Velocity	Substrate	Turbidity	Contents in Substrate Sample
2020-6	194.8	11.8	15.2			Medium sand (silt)		
2020-7	194.8	11.8	15.2			Medium sand (silt)		
2020-8	183.5	13	10.0			Silt (fine sand)		Midges & aquatic worms
2020-9	192.5	10	10.5			Fine gravel (coarse sand)		Midges
2021-1	185	17.1	14.6			Medium sand (fine sand)		Aquatic worms
2021-2	192.6	11.1	13.1			Medium sand (silt)		Midges & aquatic worms
2021-3	185	11.9	11.1			Silt (fine sand)		Midges & aquatic worms
2021-4	186.4	12.1	11.1			Fine sand (silt)		1 midge & 1 aquatic worm
2021-5	199.4	10.2	10.2			Medium sand (fine sand)		None
2021-6	208.4	10.6	5.3			Coarse sand (fine gravel)		Midges, aquatic worms, and 1 fingernail clam
2021-7	181	12.4	12.4			Silt (clay)		1 midge & aquatic worms
2022-1	184.9	13.2				Silt		Midges, aquatic worms, 1 hydrozoa & 1 fingernail clam
2022-2	186.8	11.7				Silt, (medium sand), ((medium gravel))		Aquatic worms
2022-3	186.8	11.7						
2022-4	186.3	11.7				Silt, (fine sand), ((OM))		Aquatic worms
2022-5	187.9	11.6				Medium sand, (fine sand), ((OM))		1 midge
2022-6	189.2	11.7				Silt, (fine gravel), ((medium sand))		Midges, aquatic worms
2022-7	201.7	11				Coarse sand, (fine gravel), ((silt))		Midges & aquatic worms
2022-8	202.6	11.3				Coarse sand, (medium sand), ((silt)		1 midge, 1 aquatic worm
2022-9	186.7	11.6				Silt, (fine sand), ((OM))		Midges & aquatic worms
2022-10	186.7	11.6						
2022-11	190.1	11.5				Medium sand, coarse sand		None
2022-12	191	11.8				Medium sand, (OM), ((silt))		1 hydrozoa
2022-13	185.9	12.1				Fine sand, (medium sand), ((silt))		1 midge & 2 aquatic worms
2022-14	190.6	11.2				Fine sand, (silt)		Aquatic worms
2022-15	191.3	11.3				Medium sand, (silt)		None
2022-16	200.3	11.9				Coarse sand, (medium sand), ((medium gravel))		1 midge, 1 aquatic worm
2022-17	186.2	12.2				Fine sand, (silt), ((OM))		1 midge, 1 aquatic worm
2022-18	183.4	13.3				Silt, (fine sand)		Midges & aquatic worms
2022-19	184.1	11.9				Silt, (fine sand)		Midges & aquatic worms
2022-20	189.6	10.8				Fine sand , (silt), ((OM))		1 snail, aquatic worms
2022-21	190	10.8				Medium sand, (fine sand)		None
2022-22	190	10.8				Medium sand, (silt)		None
2022-23	191.7	10.7				Medium sand, (silt)		None
2022-24	184	10.7				Silt, (fine sand), ((OM))		Midges & aquatic worms
2023-01	193	10.9				Coarse sand, (medium sand), ((OM))		None

Appendix C – Location Map of Juvenile ćəmtus Captures (2007 – 2023)

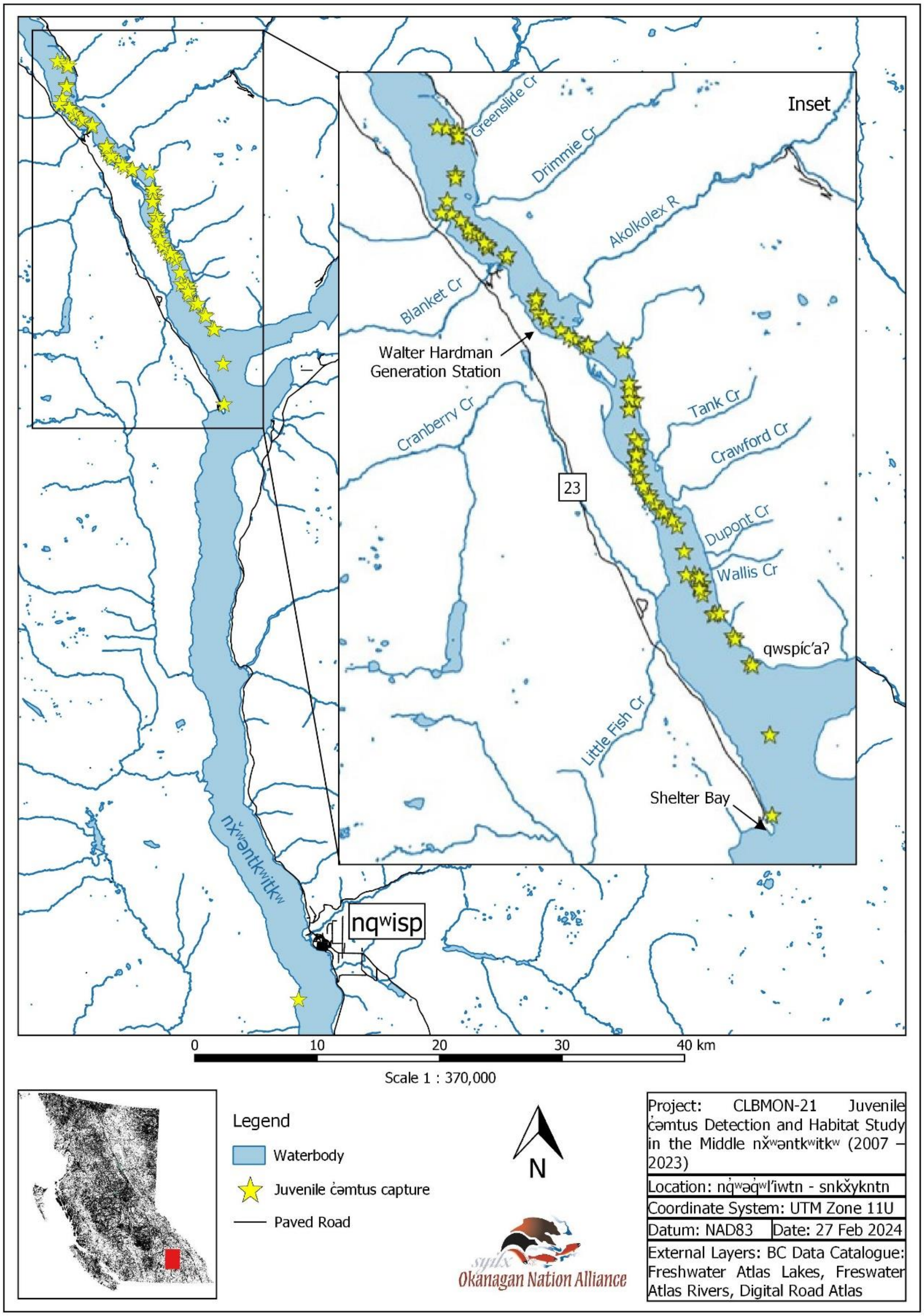

Figure 14. Locations of all juvenile c̓əmtus captures in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 from 2007 to 2022. Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

Appendix D – 2023 Sample Data

Appendix D1 – 2023 Setline Data

Table 18. Setline sample site data collected in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 in 2023, with juvenile c̓əmtus captures highlighted in yellow and sets soak times over 24 hours highlighted in red.

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	c̓əmtus Catch
1	ASL027	434090	5612988	Rain	Perpendicular	4.8	5.7	22-Aug	10:39	14.0	23-Aug	9:07	13.0	22:28	20	0
2	ASL030	434425	5613673	Rain	Perpendicular	2.8	3.4	22-Aug	10:59	11.6	23-Aug	9:18	11.5	22:19	20	0
3	ASL033	434309	5614414	Rain	Oblique	1.6	1.7	22-Aug	11:56	11.5	23-Aug	9:30	10.8	21:34	20	0
4	ASL036	434278	5614589	Rain	Oblique	1.4	7.4	22-Aug	12:02	11.3	23-Aug	9:37	10.8	21:35	20	0
5	ASL039	434156	5615310	Rain	Oblique	6.4	6.8	22-Aug	12:11	11.3	23-Aug	9:48	10.7	21:37	20	0
6	ASL042	434153	5615998	Rain	Oblique	5.2	5.7	22-Aug	12:22	11.3	23-Aug	9:55	10.7	21:33	20	0
7	ASL045	433826	5616371	Rain	Parallel	7.2	8.4	22-Aug	14:22	11.7	23-Aug	12:48	10.8	22:26	20	0
8	ASL048	433493	5616848	Rain	Parallel	8.4	9.0	22-Aug	14:31	11.5	23-Aug	12:57	10.7	22:26	20	0
9	ASL052	433135	5617319	Rain	Parallel	6.0	6.4	22-Aug	14:38	11.5	23-Aug	13:09	10.8	22:31	20	0
10	ASL055	432997	5617566	Rain	Parallel	6.2	6.5	22-Aug	14:46	11.4	23-Aug	13:21	10.7	22:35	20	0
11	ASL058	432794	5617772	Rain	Oblique	5.8	7.4	22-Aug	14:53	11.4	23-Aug	13:31	10.7	22:38	20	0
12	ASL061	432392	5618308	Rain	Oblique	5.8	6.4	22-Aug	15:12	11.3	23-Aug	14:32	10.6	23:20	20	0
13	ASL064	431889	5618903	Overcast	Perpendicular	3.2	7.0	23-Aug	10:48	10.7	24-Aug	10:43	10.3	23:55	20	0
14	ASL067	431703	5619373	Overcast	Perpendicular	5.2	6.6	23-Aug	10:57	10.7	24-Aug	10:51	10.2	23:54	20	0
15	ASL070	431839	5619924	Overcast	Oblique	5.2	5.8	23-Aug	11:06	10.6	24-Aug	11:01	10.2	23:55	20	0
16	ASL073	431658	5620383	Overcast	Oblique	6.0	6.4	23-Aug	11:15	10.7	24-Aug	11:10	10.2	23:55	20	0
17	ASL077	431218	5620948	Overcast	Parallel	5.2	5.4	23-Aug	11:23	10.6	24-Aug	11:18	10.2	23:55	20	0
18	ASL080	430998	5621499	Overcast	Parallel	7.1	7.5	23-Aug	11:33	10.6	24-Aug	11:28	10.2	23:55	20	0
19	ASL083	430926	5621727	Overcast	Oblique	6.5	7.2	23-Aug	15:12	10.6	24-Aug	13:30	10.7	22:18	20	0
20	ASL086	430603	5622200	Overcast	Parallel	5.4	6.2	23-Aug	15:21	10.7	24-Aug	13:44	10.7	22:23	19	0
21	ASL089	430230	5622264	Overcast	Oblique	6.1	6.2	23-Aug	15:31	10.6	24-Aug	13:55	10.8	22:24	20	0
22	ASL092	429839	5622699	Overcast	Oblique	5.4	7.2	23-Aug	15:43	10.6	24-Aug	14:07	10.9	22:24	20	0
23	ASL095	429492	5623268	Overcast	Parallel	8.1	8.4	23-Aug	15:52	10.7	24-Aug	14:14	11.0	22:22	20	0
24	ASL098	429229	5624090	Overcast	Parallel	7.1	7.7	23-Aug	16:01	10.7	24-Aug	14:24	11.0	22:23	20	0
25	ASL102	429276	5624709	Overcast	Parallel	6.4	6.5	24-Aug	12:05	10.6	25-Aug	9:47	11.1	21:42	20	0
26	ASL105	429240	5625092	Overcast	Oblique	5.8	6.2	24-Aug	12:13	10.7	25-Aug	9:56	11.1	21:43	20	1
27	ASL108	429432	5625611	Overcast	Oblique	8.9	10.2	24-Aug	12:23	10.8	25-Aug	10:31	11.2	22:08	20	0
28	ASL111	429150	5626340	Overcast	Parallel	5.2	5.6	24-Aug	12:32	10.8	25-Aug	10:42	11.3	22:10	20	0
29	ASL114	428919	5626665	Overcast	Oblique	7.7	8.0	24-Aug	12:40	10.9	25-Aug	10:57	11.4	22:17	20	0
30	ASL117	428922	5627004	Overcast	Perpendicular	5.4	6.3	24-Aug	12:47	10.9	25-Aug	11:07	11.3	22:20	20	0
31	ASL120	429032	5627513	Overcast	Oblique	6.7	8.0	24-Aug	15:06	11.1	25-Aug	13:22	12.0	22:16	20	0
32	ASL123	429077	5628360	Overcast	Perpendicular	6.0	8.9	24-Aug	15:14	11.1	25-Aug	13:31	12.1	22:17	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	c̓əmtus Catch
33	ASL127	428796	5628764	Overcast	Oblique	6.6	7.6	24-Aug	15:22	11.1	25-Aug	13:39	12.1	22:17	20	0
34	ASL130	427971	5629104	Overcast	Oblique	4.0	4.6	24-Aug	15:30	11.1	25-Aug	13:48	12.3	22:18	20	0
35	ASL133	427395	5629057	Overcast	Parallel	6.4	8.0	24-Aug	15:37	11.1	25-Aug	14:02	12.6	22:25	20	0
36	ASL136	426936	5629086	Overcast	Oblique	6.4	7.5	24-Aug	15:43	11.0	25-Aug	14:17	12.6	22:34	20	0
37	ASL139	426735	5629209	Sunny	Parallel	5.6	5.9	25-Aug	11:48	11.7	26-Aug	10:06	12.7	22:18	20	0
38	ASL142	426331	5629791	Sunny	Parallel	5.1	5.4	25-Aug	11:56	11.8	26-Aug	10:17	12.9	22:21	20	0
39	ASL145	425812	5630002	Sunny	Parallel	6.1	7.1	25-Aug	12:04	11.9	26-Aug	10:30	12.7	22:26	20	0
40	ASL148	425565	5630240	Sunny	Parallel	4.3	4.9	25-Aug	12:11	12.1	26-Aug	10:42	12.8	22:31	20	0
41	ASL152	425247	5631055	Sunny	Parallel	4.5	4.8	25-Aug	12:19	12.1	26-Aug	10:54	12.8	22:35	20	0
42	ASL155	425244	5631846	Sunny	Parallel	4.9	5.3	25-Aug	12:26	12.3	26-Aug	11:07	12.9	22:41	20	0
43	ASL158	425253	5631920	Sunny	Parallel	4.6	6.0	25-Aug	15:01	13.1	26-Aug	14:01	13.4	23:00	20	0
44	ASL161	425042	5632379	Sunny	Parallel	8.3	11.5	25-Aug	15:08	13.1	26-Aug	14:16	13.5	23:08	20	0
45	ASL164	424631	5632421	Sunny	Parallel	3.7	4.0	25-Aug	15:17	13.1	26-Aug	14:24	13.4	23:07	20	0
46	ASL167	423930	5632815	Sunny	Parallel	2.6	4.8	25-Aug	15:26	13.2	26-Aug	14:35	13.4	23:09	20	0
47	ASL170	423317	5633115	Sunny	Parallel	7.1	7.8	25-Aug	15:33	13.2	26-Aug	14:45	13.5	23:12	20	0
48	ASL173	422975	5633384	Sunny	Parallel	7.2	7.9	25-Aug	15:40	13.3	26-Aug	15:10	13.4	23:30	20	0
49	ASL175	422723	5633660	Sunny	Parallel	7.4	8.0	26-Aug	11:58	13.0	27-Aug	10:47	11.9	22:49	20	0
50	ASL178	422485	5633742	Sunny	Parallel	7.1	7.4	26-Aug	12:06	13.0	27-Aug	10:58	11.9	22:52	20	0
51	ASL181	421974	5634269	Sunny	Parallel	5.0	7.2	26-Aug	12:16	13.1	27-Aug	11:06	12.0	22:50	20	0
52	ASL183	421719	5634421	Sunny	Parallel	6.6	15.4	26-Aug	12:25	13.1	27-Aug	11:18	12.1	22:53	20	0
53	ASL185	421537	5634491	Sunny	Parallel	8.1	14.4	26-Aug	12:32	13.4	27-Aug	11:29	12.1	22:57	20	0
54	ASL187	421242	5634562	Sunny	Parallel	5.0	6.7	26-Aug	12:43	13.1	27-Aug	11:42	12.1	22:59	20	0
55	ASL100	429190	5624628	Sunny	Oblique	4.0	8.0	27-Aug	9:57	11.4	28-Aug	9:28	11.3	23:31	20	0
56	ASL103	429332	5624980	Sunny	Oblique	6.2	6.6	27-Aug	10:06	11.5	28-Aug	9:38	11.3	23:32	20	0
57	ASL106	429406	5625338	Sunny	Oblique	7.0	8.0	27-Aug	10:14	11.5	28-Aug	9:50	11.6	23:36	20	0
58	ASL109	429410	5625845	Sunny	Oblique	8.0	8.6	27-Aug	10:23	11.5	28-Aug	10:01	11.5	23:38	20	0
59	ASL113	429008	5626520	Sunny	Oblique	7.7	9.0	27-Aug	13:46	12.2	28-Aug	10:11	11.5	20:25	20	0
60	ASL097	429353	5623758	Sunny	Parallel	7.2	7.9	27-Aug	13:56	12.1	28-Aug	10:28	11.4	20:32	20	0
61	ASL094	429603	5623162	Sunny	Oblique	6.2	8.9	27-Aug	14:04	12.1	28-Aug	10:40	11.4	20:36	20	0
62	ASL091	430006	5622753	Sunny	Oblique	5.4	6.4	27-Aug	14:15	12.1	28-Aug	10:49	11.5	20:34	20	0
63	ASL088	430333	5622245	Sunny	Oblique	6.0	6.4	27-Aug	14:23	12.1	28-Aug	11:00	11.4	20:37	20	0
64	ASL084	430665	5621827	Sunny	Oblique	4.5	5.4	27-Aug	14:31	12.1	28-Aug	11:10	11.5	20:39	20	0
65	BSL025	434988	5613341	Sunny	Perpendicular	7.2	7.8	6-Sep	16:11	18.4	7-Sep	9:40	15.6	17:29	20	0
66	BSL029	435052	5614023	Sunny	Oblique	4.6	5.0	6-Sep	16:20	17.8	7-Sep	9:50	15.4	17:30	20	0
67	BSL032	434983	5614156	Sunny	Perpendicular	4.1	4.8	6-Sep	16:25	18.0	7-Sep	10:00	13.5	17:35	20	0
68	BSL035	434256	5614946	Sunny	Oblique	4.8	5.8	6-Sep	16:35	14.3	7-Sep	10:09	12.2	17:34	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	ċəmtus Catch
69	BSL038	434042	5615396	Sunny	Oblique	5.2	5.7	6-Sep	16:42	13.6	7-Sep	10:20	12.0	17:38	20	0
70	BSL041	433996	5615733	Sunny	Parallel	5.5	5.8	6-Sep	16:48	13.3	7-Sep	10:31	12.0	17:43	20	0
71	BSL044	434026	5616238	Partly cloudy	Oblique	5.3	6.2	7-Sep	12:09	12.8	8-Sep	9:02	13.9	20:53	20	0
72	BSL047	433636	5616618	Partly cloudy	Oblique	6.7	8.3	7-Sep	12:20	12.7	8-Sep	9:11	13.9	20:51	20	0
73	BSL050	433250	5617161	Partly cloudy	Oblique	5.3	6.4	7-Sep	12:31	12.7	8-Sep	9:20	13.9	20:49	20	0
74	BSL054	432890	5617438	Partly cloudy	Oblique	5.2	6.2	7-Sep	12:40	12.8	8-Sep	9:31	13.8	20:51	20	0
75	BSL057	432551	5617864	Partly cloudy	Oblique	6.9	7.8	7-Sep	12:50	12.7	8-Sep	9:45	13.7	20:55	20	0
76	BSL060	432269	5618281	Partly cloudy	Oblique	7.6	9.3	7-Sep	12:59	12.7	8-Sep	9:54	13.6	20:55	20	0
77	BSL063	432287	5618557	Sunny	Oblique	3.8	4.2	7-Sep	14:37	12.7	8-Sep	11:59	13.5	21:22	20	0
78	BSL066	432136	5618983	Sunny	Oblique	4.9	5.2	7-Sep	14:46	12.4	8-Sep	12:08	13.5	21:22	20	0
79	BSL069	431861	5619484	Sunny	Oblique	5.6	6.2	7-Sep	14:55	12.3	8-Sep	12:18	13.3	21:23	20	0
80	BSL072	431547	5620181	Sunny	Oblique	4.9	5.7	7-Sep	15:04	12.4	8-Sep	12:31	13.2	21:27	20	0
81	BSL075	431283	5620539	Sunny	Oblique	3.9	5.9	7-Sep	15:14	12.5	8-Sep	12:40	13.3	21:26	20	0
82	BSL079	431048	5621127	Sunny	Oblique	4.4	5.3	7-Sep	15:21	12.6	8-Sep	12:49	13.2	21:28	20	0
83	BSL082	430763	5621695	Sunny	Oblique	4.2	6.2	8-Sep	10:37	13.2	9-Sep	9:14	13.1	22:37	20	0
84	BSL085	430618	5621887	Sunny	Oblique	4.8	5.4	8-Sep	10:45	13.1	9-Sep	9:22	13.1	22:37	20	0
85	BSL088	430284	5622503	Sunny	Oblique	4.8	6.4	8-Sep	10:54	13.1	9-Sep	9:36	13.1	22:42	20	0
86	BSL091	429955	5622810	Sunny	Oblique	4.8	5.7	8-Sep	11:01	13.1	9-Sep	9:50	12.6	22:49	20	0
87	BSL094	429489	5623483	Sunny	Perpendicular	4.0	4.6	8-Sep	11:10	13.1	9-Sep	10:00	12.4	22:50	20	0
88	BSL097	429388	5623789	Sunny	Parallel	4.6	5.2	8-Sep	11:17	13.0	9-Sep	10:08	12.4	22:51	20	0
89	BSL097B	429218	5624030	Sunny	Oblique	5.8	6.2	8-Sep	13:34	13.1	9-Sep	13:10	12.6	23:36	20	0
90	BSL100	429373	5624556	Sunny	Oblique	4.8	5.2	8-Sep	13:42	13.1	9-Sep	13:21	12.5	23:39	20	0
91	BSL104	429189	5624893	Sunny	Oblique	5.2	5.6	8-Sep	13:49	13.3	9-Sep	13:29	12.6	23:40	20	0
92	BSL107	429332	5625343	Sunny	Parallel	4.8	5.6	8-Sep	13:59	13.2	9-Sep	13:38	12.4	23:39	20	0
93	BSL110	429428	5625810	Sunny	Parallel	6.0	7.9	8-Sep	14:08	13.3	9-Sep	13:46	12.8	23:38	20	0
94	BSL113	428983	5626406	Sunny	Oblique	4.9	7.2	8-Sep	14:17	13.4	9-Sep	13:57	12.8	23:40	20	0
95	BSL116	428925	5626862	Sunny	Oblique	5.0	5.2	9-Sep	11:01	12.2	10-Sep	9:18	12.0	22:17	20	0
96	BSL119	429033	5627458	Sunny	Oblique	4.3	6.0	9-Sep	11:11	12.2	10-Sep	9:26	11.8	22:15	20	0
97	BSL122	429058	5628130	Sunny	Parallel	4.7	6.0	9-Sep	11:20	12.2	10-Sep	9:45	11.6	22:25	20	0
98	BSL125	429004	5628387	Sunny	Oblique	4.1	4.7	9-Sep	11:28	12.2	10-Sep	10:00	11.6	22:32	20	0
99	BSL129	428874	5628746	Sunny	Parallel	7.2	9.1	9-Sep	11:36	12.2	10-Sep	10:07	11.3	22:31	20	0
100	BSL132	428545	5629018	Sunny	Parallel	4.8	5.5	9-Sep	11:46	12.2	10-Sep	10:13	11.7	22:27	20	0
101	BSL135	428340	5629175	Sunny	Parallel	4.6	8.2	9-Sep	14:38	12.9	10-Sep	13:09	12.0	22:31	20	0
102	BSL138	426465	5629523	Sunny	Oblique	3.4	4.1	9-Sep	14:49	13.0	10-Sep	13:22	12.0	22:33	20	0
103	BSL141	426434	5629747	Sunny	Parallel	3.9	5.0	9-Sep	14:56	13.4	10-Sep	13:29	12.4	22:33	20	0
104	BSL144	425905	5629897	Sunny	Parallel	1.9	5.7	9-Sep	15:05	13.1	10-Sep	13:40	12.1	22:35	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	c̓əmtus Catch
105	BSL147	425525	5630376	Sunny	Parallel	1.6	2.3	9-Sep	15:12	13.1	10-Sep	13:48	12.1	22:36	20	0
106	BSL150	425266	5630686	Sunny	Parallel	3.7	4.4	9-Sep	15:19	13.1	10-Sep	13:58	12.1	22:39	20	0
107	BSL154	425274	5631296	Sunny	Oblique	2.9	4.0	10-Sep	11:00	11.6	11-Sep	10:57	11.1	23:57	20	0
108	BSL157	425213	5631783	Sunny	Oblique	3.3	3.7	10-Sep	11:08	11.6	11-Sep	11:07	11.1	23:59	20	0
109	BSL160	425144	5632118	Sunny	Oblique	5.3	6.0	10-Sep	11:17	11.6	11-Sep	11:15	11.1	23:58	20	0
110	BSL163	425039	5632377	Sunny	Parallel	7.3	9.0	10-Sep	11:28	11.6	11-Sep	11:26	11.1	23:58	20	0
111	BSL133	426971	5629035	Sunny	Oblique	6.1	7.6	10-Sep	11:40	11.8	11-Sep	11:38	11.1	23:58	20	0
112	BSL130	427552	5629036	Sunny	Oblique	4.5	5.6	10-Sep	11:47	11.7	11-Sep	11:51	11.2	24:04	20	0
113	BSL127	428769	5628833	Sunny	Oblique	7.1	9.9	10-Sep	14:40	12.1	11-Sep	14:03	11.5	23:23	20	0
114	BSL124	429047	5628144	Sunny	Oblique	5.8	6.7	10-Sep	14:48	12.1	11-Sep	14:14	11.5	23:26	20	0
115	BSL121	428995	5627813	Sunny	Oblique	6.4	7.4	10-Sep	14:55	12.1	11-Sep	14:24	11.6	23:29	20	0
116	BSL118	428927	5627176	Sunny	Oblique	3.8	4.2	10-Sep	15:06	12.1	11-Sep	14:36	11.5	23:30	20	0
117	BSL114	428933	5626585	Sunny	Oblique	6.5	7.8	10-Sep	15:14	12.2	11-Sep	14:45	11.8	23:31	20	0
118	BSL111	429060	5626252	Sunny	Oblique	6.4	6.8	10-Sep	15:20	12.2	11-Sep	14:56	11.7	23:36	20	0
119	BSL108	429420	5625395	Partly cloudy	Oblique	5.3	6.5	11-Sep	12:37	11.7	12-Sep	9:34	11.2	20:57	20	0
120	BSL105	429242	5624981	Partly cloudy	Parallel	4.6	4.8	11-Sep	12:44	11.6	12-Sep	9:42	11.1	20:58	20	0
121	BSL102	429319	5624464	Partly cloudy	Parallel	4.4	4.6	11-Sep	12:50	11.7	12-Sep	9:52	11.2	21:02	20	0
122	BSL099	429187	5624063	Partly cloudy	Oblique	4.2	5.6	11-Sep	12:56	11.9	12-Sep	10:01	11.3	21:05	20	0
123	BSL096	429314	5623647	Partly cloudy	Oblique	4.2	7.0	11-Sep	13:03	12.0	12-Sep	10:17	11.3	21:14	20	0
124	BSL093	429851	5623114	Partly cloudy	Oblique	1.5	2.7	11-Sep	13:10	12.1	12-Sep	10:26	11.6	21:16	20	0
125	BSL089	430255	5622448	Cloudy	Oblique	5.8	6.3	11-Sep	15:30	12.4	12-Sep	12:59	12.2	21:29	20	0
126	BSL086	430535	5621975	Cloudy	Oblique	4.6	5.1	11-Sep	15:36	12.4	12-Sep	13:08	11.6	21:32	20	0
127	BSL083	430941	5621262	Cloudy	Oblique	2.6	4.0	11-Sep	15:45	12.1	12-Sep	13:15	11.7	21:30	20	0
128	BSL080	431290	5621112	Cloudy	Oblique	4.9	5.6	11-Sep	15:49	12.2	12-Sep	13:27	12.3	21:38	20	0
129	BSL077	431267	5620840	Sunny	Parallel	3.8	4.2	12-Sep	11:09	11.6	13-Sep	9:26	12.1	22:17	20	0
130	BSL074	431426	5620356	Sunny	Parallel	3.7	4.3	12-Sep	11:17	11.8	13-Sep	9:34	12.1	22:17	20	0
131	BSL071	431553	5619937	Sunny	Oblique	3.7	4.2	12-Sep	11:23	11.9	13-Sep	9:45	12.1	22:22	20	0
132	BSL068	431780	5619561	Sunny	Parallel	4.8	5.4	12-Sep	11:29	11.8	13-Sep	9:55	12.1	22:26	20	0
133	BSL064	432118	5618745	Sunny	Parallel	5.3	6.0	12-Sep	11:38	11.9	13-Sep	10:05	12.1	22:27	20	0
134	BSL061	432372	5618334	Sunny	Oblique	4.7	5.7	12-Sep	11:45	12.0	13-Sep	10:14	12.1	22:29	20	0
135	CSL032	435881	5615054	Cloudy / wind	Oblique	16.1	18.5	18-Sep	10:27	16.7	19-Sep	9:50	13.4	23:23	20	0
136	CSL035	435745	5615226	Cloudy / wind	Oblique	13.0	15.6	18-Sep	10:38	13.5	19-Sep	10:15	14.0	23:37	20	0
137	CSL038	435821	5615415	Cloudy / wind	Oblique	2.8	10.0	18-Sep	10:50	16.4	19-Sep	10:26	14.1	23:36	20	0
138	CSL045	433825	5616332	Cloudy / wind	Oblique	3.8	5.6	18-Sep	11:06	12.2	19-Sep	10:51	10.8	23:45	20	0
139	CSL048	433554	5616771	Cloudy / wind	Oblique	3.8	7.9	18-Sep	11:17	12.1	19-Sep	11:00	10.7	23:43	20	0
140	CSL051	433427	5616939	Cloudy / wind	Oblique	3.4	7.0	18-Sep	11:25	12.1	19-Sep	11:10	10.6	23:45	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	c̓əmtus Catch
141	CSL054	433184	5617296	Cloudy	Oblique	3.3	4.6	19-Sep	12:05	10.6	20-Sep	9:33	10.6	21:28	20	0
142	CSL057	433100	5617444	Cloudy	Oblique	4.1	4.7	19-Sep	12:12	10.6	20-Sep	9:44	10.4	21:32	20	0
143	CSL060	432709	5618034	Cloudy	Oblique	3.3	3.6	19-Sep	12:22	10.5	20-Sep	9:53	10.3	21:31	20	0
144	CSL063	432286	5618481	Cloudy	Parallel	3.3	4.2	19-Sep	12:32	10.6	20-Sep	10:03	10.5	21:31	20	0
145	CSL066	431976	5619146	Cloudy	Oblique	3.9	4.6	19-Sep	12:42	10.5	20-Sep	10:13	10.6	21:31	20	0
146	CSL070	431827	5619797	Cloudy	Oblique	3.8	4.3	19-Sep	12:51	10.5	20-Sep	10:23	10.6	21:32	20	0
147	CSL073	431680	5620231	Cloudy	Oblique	3.7	4.2	19-Sep	15:20	10.4	20-Sep	12:54	10.7	21:34	20	0
148	CSL076	431237	5620716	Cloudy	Oblique	3.3	3.7	19-Sep	15:30	10.2	20-Sep	13:05	10.9	21:35	20	0
149	CSL079	431079	5621180	Cloudy	Parallel	3.1	3.6	19-Sep	15:38	10.2	20-Sep	13:19	10.7	21:41	20	0
150	CSL082	430977	5621607	Cloudy	Parallel	3.4	5.4	19-Sep	15:51	10.2	20-Sep	13:29	10.8	21:38	20	0
151	CSL085	430529	5622060	Cloudy	Oblique	4.2	4.5	19-Sep	16:02	10.1	20-Sep	13:41	10.7	21:39	20	0
152	CSL088	430275	5622408	Cloudy	Parallel	4.8	5.3	19-Sep	16:11	10.1	20-Sep	13:50	10.7	21:39	20	0
153	CSL091	429899	5622827	Partly cloudy	Oblique	4.1	4.9	20-Sep	11:17	10.5	21-Sep	9:21	11.1	22:04	20	0
154	CSL095	429549	5623484	Partly cloudy	Perpendicular	1.8	2.7	20-Sep	11:25	10.5	21-Sep	9:30	10.9	22:05	20	0
155	CSL098	429232	5624222	Partly cloudy	Perpendicular	4.4	5.4	20-Sep	11:33	10.5	21-Sep	9:42	10.8	22:09	20	0
156	CSL102	429195	5624730	Partly cloudy	Perpendicular	4.3	4.8	20-Sep	11:41	10.5	21-Sep	9:51	10.6	22:10	20	0
157	CSL105	429234	5625034	Partly cloudy	Perpendicular	3.6	4.3	20-Sep	11:49	10.5	21-Sep	10:00	10.7	22:11	20	0
158	CSL109	429402	5625735	Partly cloudy	Parallel	6.0	8.1	20-Sep	11:59	10.6	21-Sep	10:11	10.6	22:12	20	0
159	CSL112	429026	5626389	Partly cloudy	Oblique	4.6	6.1	20-Sep	14:53	11.1	21-Sep	12:51	10.9	21:58	20	0
160	CSL115	428931	5626677	Partly cloudy	Parallel	5.5	5.7	20-Sep	15:04	11.1	21-Sep	12:59	11.1	21:55	20	0
161	CSL118	428894	5626991	Partly cloudy	Oblique	4.8	5.7	20-Sep	15:12	11.2	21-Sep	13:09	11.1	21:57	20	0
162	CSL121	428993	5627947	Partly cloudy	Oblique	4.5	5.7	20-Sep	15:21	11.1	21-Sep	13:27	11.2	22:06	20	0
163	CSL124	429060	5628309	Partly cloudy	Parallel	3.8	4.9	20-Sep	15:29	11.1	21-Sep	13:36	11.2	22:07	20	0
164	CSL127	429007	5628498	Partly cloudy	Oblique	4.2	5.6	20-Sep	15:36	11.1	21-Sep	13:45	11.2	22:09	20	0
165	CSL130	428802	5628868	Sunny	Parallel	6.9	7.5	21-Sep	11:05	10.8	22-Sep	9:34	12.0	22:29	20	0
166	CSL134	428595	5629067	Sunny	Parallel	6.9	11.0	21-Sep	11:11	10.8	22-Sep	9:47	12.0	22:36	20	0
167	CSL137	428419	5629161	Sunny	Parallel	7.1	11.6	21-Sep	11:18	10.8	22-Sep	10:00	11.9	22:42	20	0
168	CSL140	428134	5629188	Sunny	Parallel	2.0	3.1	21-Sep	11:24	10.9	22-Sep	10:09	12.0	22:45	20	0
169	CSL143	426468	5629375	Sunny	Perpendicular	1.9	3.7	21-Sep	11:34	11.1	22-Sep	10:26	12.1	22:52	20	0
170	CSL146	425645	5630055	Sunny	Oblique	2.1	4.3	21-Sep	11:42	11.1	22-Sep	10:41	12.1	22:59	20	0
171	CSL149	425464	5630401	Sunny	Parallel	1.2	1.5	21-Sep	15:03	11.9	22-Sep	13:30	12.7	22:27	20	0
172	CSL148	426172	5629694	Sunny	Parallel	3.1	3.6	21-Sep	15:12	11.9	22-Sep	13:39	12.7	22:27	20	0
173	CSL141	426446	5629585	Sunny	Oblique	2.4	3.6	21-Sep	15:19	11.9	22-Sep	13:48	12.7	22:29	20	0
174	CSL138	426636	5629258	Sunny	Parallel	3.4	4.6	21-Sep	15:26	11.9	22-Sep	13:59	12.7	22:33	20	0
175	CSL135	427860	5629114	Sunny	Parallel	1.7	1.9	21-Sep	15:34	11.8	22-Sep	14:10	12.7	22:36	20	0
176	CSL132	428088	5629264	Sunny	Parallel	1.2	3.5	21-Sep	15:42	11.8	22-Sep	14:22	12.6	22:40	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	ċəmtus Catch
177	CSL129	428280	5629164	Sunny	Parallel	2.4	3.7	22-Sep	11:36	12.1	23-Sep	9:28	12.5	21:52	20	0
178	CSL126	428849	5628700	Sunny	Parallel	5.0	5.4	22-Sep	11:43	12.1	23-Sep	9:40	12.4	21:57	20	0
179	CSL123	429038	5628231	Sunny	Parallel	2.8	6.0	22-Sep	11:50	12.1	23-Sep	9:56	12.3	22:06	20	0
180	CSL120	429022	5627547	Sunny	Oblique	4.5	5.6	22-Sep	11:57	12.1	23-Sep	10:08	12.4	22:11	20	0
181	CSL116	428870	5626861	Sunny	Oblique	4.1	5.2	22-Sep	12:03	12.1	23-Sep	10:16	12.5	22:13	20	0
182	CSL113	429035	5626374	Sunny	Parallel	5.4	5.6	22-Sep	12:09	12.1	23-Sep	10:23	12.5	22:14	20	0
183	CSL110	429311	5625904	Sunny	Oblique	4.5	4.8	22-Sep	15:07	12.6	23-Sep	12:49	12.4	21:42	20	0
184	CSL107	429394	5625388	Sunny	Oblique	4.9	6.0	22-Sep	15:15	12.5	23-Sep	12:59	12.4	21:44	20	0
185	CSL104	429342	5624824	Sunny	Oblique	4.0	4.4	22-Sep	15:21	12.5	23-Sep	13:08	12.4	21:47	20	0
186	CSL100	429259	5624450	Sunny	Parallel	4.3	4.7	22-Sep	15:29	12.4	23-Sep	13:19	12.5	21:50	20	0
187	CSL097	429296	5623771	Sunny	Oblique	4.8	6.3	22-Sep	15:38	12.4	23-Sep	13:29	12.6	21:51	20	0
188	CSL094	429461	5623377	Sunny	Oblique	5.4	5.6	22-Sep	15:45	12.4	23-Sep	13:37	12.6	21:52	20	0
189	CSL093	429631	5623036	Rain	Oblique	5.4	5.8	23-Sep	11:17	12.8	24-Sep	9:27	11.6	22:10	20	0
190	CSL090	429789	5622815	Rain	Parallel	5.0	5.9	23-Sep	11:25	12.9	24-Sep	9:37	11.6	22:12	20	0
191	CSL087	430123	5622429	Rain	Oblique	3.8	4.1	23-Sep	11:35	12.9	24-Sep	9:49	11.6	22:14	20	0
192	CSL084	430797	5621843	Rain	Perpendicular	1.5	5.3	23-Sep	11:46	13.1	24-Sep	9:58	11.7	22:12	20	0
193	CSL080	431129	5621377	Rain	Oblique	4.3	4.8	23-Sep	11:56	13.1	24-Sep	10:06	11.7	22:10	20	0
194	CSL077	431418	5620912	Rain	Oblique	3.5	4.2	23-Sep	12:04	13.1	24-Sep	10:15	11.7	22:11	20	0
195	CSL074	431416	5620407	Rain	Perpendicular	1.9	3.8	23-Sep	14:24	13.2	24-Sep	12:06	11.9	21:42	20	0
196	CSL071	431614	5620061	Rain	Perpendicular	3.4	4.1	23-Sep	14:31	13.1	24-Sep	12:17	11.7	21:46	20	0
197	CSL068	431841	5619519	Rain	Oblique	3.8	4.7	23-Sep	14:37	13.1	24-Sep	12:25	11.8	21:48	20	0
198	CSL064	432066	5618721	Rain	Perpendicular	4.7	6.1	23-Sep	14:45	13.1	24-Sep	12:37	11.9	21:52	20	0
199	CSL061	432304	5618353	Rain	Oblique	2.5	4.7	23-Sep	14:52	13.3	24-Sep	12:45	12.0	21:53	20	0
200	CSL058	432740	5617788	Rain	Oblique	4.6	5.4	23-Sep	14:58	13.4	24-Sep	12:57	12.0	21:59	20	0
201	CSL055	433077	5617586	Overcast	Parallel	2.6	4.3	24-Sep	10:59	12.1	25-Sep	9:38	11.3	22:39	20	0
202	CSL052	433284	5617186	Overcast	Parallel	4.2	4.6	24-Sep	11:03	12.1	25-Sep	9:48	11.3	22:45	20	0
203	CSL049	433534	5616728	Overcast	Oblique	3.3	4.1	24-Sep	11:09	12.1	25-Sep	10:00	11.3	22:51	20	0
204	CSL046	433801	5616484	Overcast	Parallel	5.2	6.1	24-Sep	11:16	12.1	25-Sep	10:11	11.3	22:55	20	0
205	CSL043	434301	5616134	Overcast	Parallel	2.6	3.6	24-Sep	11:22	12.1	25-Sep	10:29	11.3	23:07	20	0
206	CSL040	434092	5615312	Overcast	Oblique	3.2	4.0	24-Sep	11:28	12.2	25-Sep	10:39	11.4	23:11	20	0
207	DSL021	436320	5613119	Cloudy	Parallel	5.8	6.4	15-Oct	11:21	12.7	16-Oct	9:40	12.7	22:19	20	0
208	DSL025	435841	5613600	Cloudy	Perpendicular	10.0	15.2	15-Oct	11:33	12.6	16-Oct	9:54	12.6	22:21	20	0
209	DSL028	434987	5614043	Cloudy	Parallel	1.9	2.1	15-Oct	12:07	11.3	16-Oct	10:14	10.8	22:07	20	0
210	DSL031	434293	5614545	Cloudy	Oblique	4.1	5.7	15-Oct	12:16	11.1	16-Oct	10:30	10.8	22:14	20	0
211	DSL034	434173	5614817	Cloudy	Parallel	2.7	3.4	15-Oct	13:11	11.3	16-Oct	10:40	10.8	21:29	20	0
212	DSL037	434139	5615441	Cloudy	Parallel	3.0	3.4	15-Oct	13:19	11.1	16-Oct	10:50	10.8	21:31	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	ċəmtus Catch
213	DSL040	433975	5615791	Cloudy	Perpendicular	2.6	3.1	15-Oct	14:44	11.2	16-Oct	14:24	10.9	23:40	20	0
214	DSL043	434106	5616287	Cloudy	Perpendicular	2.9	3.6	15-Oct	14:52	11.1	16-Oct	14:31	10.8	23:39	20	0
215	DSL046	433671	5616592	Cloudy	Parallel	4.9	5.6	15-Oct	15:02	11.1	16-Oct	14:38	10.7	23:36	20	0
216	DSL050	433351	5617072	Cloudy	Oblique	3.0	4.0	15-Oct	15:12	11.1	16-Oct	14:47	10.7	23:35	20	0
217	DSL053	432968	5617601	Cloudy	Parallel	2.6	3.1	15-Oct	15:19	11.1	16-Oct	14:57	10.7	23:38	20	0
218	DSL056	432617	5617773	Cloudy	Perpendicular	3.6	4.3	15-Oct	15:27	11.1	16-Oct	15:05	10.7	23:38	20	0
219	DSL059	432352	5618175	Overcast	Parallel	4.5	5.1	16-Oct	11:54	10.6	17-Oct	10:15	10.4	22:21	20	0
220	DSL062	432150	5618531	Overcast	Parallel	5.0	5.4	16-Oct	12:01	10.7	17-Oct	10:24	10.4	22:23	20	0
221	DSL065	431883	5619160	Overcast	Parallel	2.6	3.2	16-Oct	12:11	10.6	17-Oct	10:32	10.4	22:21	20	0
222	DSL068	431770	5619774	Overcast	Parallel	2.5	3.1	16-Oct	12:19	10.6	17-Oct	10:42	10.4	22:23	20	0
223	DSL071	431635	5620070	Overcast	Parallel	2.2	2.8	16-Oct	12:26	10.6	17-Oct	10:51	10.4	22:25	20	0
224	DSL075	431396	5620810	Overcast	Parallel	2.1	2.6	16-Oct	12:35	10.6	17-Oct	11:03	10.3	22:28	20	0
225	DSL078	431203	5621215	Partly cloudy	Parallel	3.1	3.5	17-Oct	9:35	10.3	18-Oct	9:40	9.9	24:05	20	0
226	DSL081	431015	5621498	Partly cloudy	Parallel	3.7	4.2	17-Oct	9:44	10.4	18-Oct	9:49	9.8	24:05	20	0
227	DSL084	430712	5621987	Partly cloudy	Parallel	3.7	4.2	17-Oct	9:51	10.3	18-Oct	9:58	9.7	24:07	20	0
228	DSL087	430329	5622413	Partly cloudy	Oblique	3.4	4.1	17-Oct	10:01	10.2	18-Oct	10:07	9.8	24:06	20	0
229	DSL090	429897	5622800	Partly cloudy	Parallel	3.1	3.3	17-Oct	12:16	10.3	18-Oct	10:19	9.7	22:03	20	0
230	DSL093	429565	5623224	Partly cloudy	Parallel	4.0	4.3	17-Oct	12:12	10.3	18-Oct	10:31	9.7	22:19	20	0
231	DSL096	429325	5623739	Partly cloudy	Parallel	4.3	4.7	17-Oct	12:29	10.3	18-Oct	12:44	9.6	24:15	20	0
232	DSL100	429209	5624533	Partly cloudy	Parallel	3.7	4.5	17-Oct	12:36	10.4	18-Oct	13:07	9.5	24:31	20	0
233	DSL103	429352	5625005	Partly cloudy	Parallel	3.1	3.7	17-Oct	12:44	10.3	18-Oct	13:12	9.5	24:28	20	0
234	DSL106	429398	5625494	Partly cloudy	Parallel	4.7	5.7	17-Oct	12:51	10.3	18-Oct	13:17	9.6	24:26	20	0
235	DSL109	429415	5625781	Rain	Parallel	4.6	6.6	18-Oct	11:44	9.5	19-Oct	9:42	8.6	21:58	20	0
236	DSL112	429092	5626289	Rain	Perpendicular	4.0	4.2	18-Oct	11:53	9.6	19-Oct	9:52	8.5	21:59	20	0
237	DSL115	428920	5626805	Rain	Parallel	3.4	4.0	18-Oct	12:00	9.6	19-Oct	10:05	8.6	22:05	20	0
238	DSL118	429044	5627539	Rain	Parallel	3.7	4.8	18-Oct	12:09	9.5	19-Oct	10:16	8.4	22:07	20	0
239	DSL121	429084	5628195	Rain	Parallel	4.0	8.0	18-Oct	12:19	9.5	19-Oct	10:44	8.4	22:25	20	0
240	DSL125	429050	5628420	Rain	Parallel	2.4	3.1	18-Oct	12:26	9.5	19-Oct	10:57	8.4	22:31	20	0
241	DSL128	428841	5628772	Rain	Parallel	5.1	7.2	18-Oct	14:44	9.5	19-Oct	11:17	8.3	20:33	20	0
242	DSL131	428486	5629120	Rain	Parallel	1.6	2.6	18-Oct	14:29	9.5	19-Oct	11:31	8.4	21:02	20	0
243	DSL134	427209	5629103	Rain	Parallel	1.9	2.6	18-Oct	15:13	9.3	19-Oct	12:55	8.3	21:42	20	0
244	DSL137	426785	5629180	Rain	Parallel	2.5	3.0	18-Oct	15:22	9.5	19-Oct	13:09	8.4	21:47	20	0
245	DSL026	435836	5613771	Overcast	Parallel	4.6	5.9	19-Oct	15:12	9.2	20-Oct	9:35	8.8	18:23	20	0
246	DSL023	435834	5613548	Overcast	Perpendicular	16.1	19.3	19-Oct	15:20	9.6	20-Oct	9:50	12.1	18:30	20	0
247	DSL020	436339	5612968	Overcast	Perpendicular	7.4	11.3	19-Oct	15:28	12.1	20-Oct	10:03	12.2	18:35	20	0
248	DSL017	436450	5612367	Overcast	Parallel	5.1	5.7	19-Oct	15:35	12.2	20-Oct	10:12	12.1	18:37	20	0

Set #	Site	Easting	Northing	Weather	Orientation to Flow	Depth Min (m)	Depth Max (m)	Set Date	Set Time	Set Water Temp (°C)	Pull Date	Pull Time	Pull Water Temp (°C)	Soak Time (h:mm)	# of Hooks	c̓əmtus Catch
249	DSL014	436405	5612028	Overcast	Perpendicular	14.6	19.1	19-Oct	15:42	12.3	20-Oct	11:50	12.3	20:08	20	0
250	DSL011	436540	5611806	Overcast	Parallel	3.0	17.4	19-Oct	15:49	12.4	20-Oct	12:13	12.3	20:24	20	0
251	DSL007	437147	5611480	Overcast	Parallel	4.0	15.6	19-Oct	15:57	12.5	20-Oct	12:50	12.4	20:53	20	0
252	DSL004	437715	5611379	Overcast	Parallel	9.4	11.1	19-Oct	16:05	12.6	20-Oct	13:00	12.5	20:55	20	0
253	DSL029	436128	5613558	Overcast	Perpendicular	4.1	4.3	20-Oct	10:53	11.7	21-Oct	9:54	11.8	23:01	20	0
254	DSL018	436509	5612652	Overcast	Oblique	6.4	15.0	20-Oct	11:03	12.1	21-Oct	10:04	11.8	23:01	20	0
255	DSL015	436426	5612121	Overcast	Oblique	3.9	10.4	20-Oct	11:11	12.2	21-Oct	10:09	11.8	22:58	20	0
256	DSL012	436507	5611948	Overcast	Parallel	4.5	19.2	20-Oct	11:21	12.3	21-Oct	10:47	11.9	23:26	20	0
257	DSL009	437049	5611530	Overcast	Parallel	6.4	12.6	20-Oct	13:35	12.5	21-Oct	12:09	12.1	22:34	20	0
258	DSL006	437197	5611428	Overcast	Parallel	6.4	16.2	20-Oct	13:41	12.6	21-Oct	12:20	12.2	22:39	20	0
259	DSL003	437478	5611426	Overcast	Oblique	4.0	19.0	20-Oct	13:47	12.6	21-Oct	12:37	12.2	22:50	20	0
260	DSL001	437872	5611376	Overcast	Perpendicular	4.1	12.4	20-Oct	13:53	12.7	21-Oct	12:51	12.2	22:58	20	0
261	DSL030	435943	5613636	Overcast	Perpendicular	6.3	9.3	21-Oct	11:32	11.6	22-Oct	9:54	10.6	22:22	20	0
262	DSL027	435780	5613659	Overcast	Perpendicular	5.7	8.9	21-Oct	11:42	11.1	22-Oct	9:59	9.4	22:17	20	0
263	DSL024	436380	5613007	Overcast	Oblique	6.0	9.0	21-Oct	11:51	11.8	22-Oct	10:15	11.5	22:24	20	0
264	DSL016	436446	5612187	Overcast	Perpendicular	4.0	5.2	21-Oct	11:57	11.9	22-Oct	10:26	11.7	22:29	20	0
265	DSL005	437610	5611404	Overcast	Oblique	11.1	13.4	21-Oct	13:15	12.2	22-Oct	10:37	12.1	21:22	20	0
266	DSL002	437944	5611305	Overcast	Oblique	11.3	13.1	21-Oct	13:22	12.2	22-Oct	10:48	12.0	21:26	20	0

Appendix D2 – 2023 Setline Bycatch

Table 19. Setline bycatch in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 in 2023, including juvenile c̓əmtus captures highlighted in yellow and sets with no fish caught (NFC) as grey-shaded cells.

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
1	ASL027	23-Aug	NFC							
2	ASL030	23-Aug	NFC							
3	ASL033	23-Aug	NFC							
4	ASL036	23-Aug	NFC							
5	ASL039	23-Aug	NFC							
6	ASL042	23-Aug	NFC							
7	ASL045	23-Aug	NFC							
8	ASL048	23-Aug	NFC							
9	ASL052	23-Aug	NFC							
10	ASL055	23-Aug	NFC							
11	ASL058	23-Aug	NFC							
12	ASL061	23-Aug	NFC							
13	ASL064	24-Aug	NFC							
14	ASL067	24-Aug	NFC							
15	ASL070	24-Aug	NFC							
16	ASL073	24-Aug	Burbot	Adult	1	1	635			
17	ASL077	24-Aug	NFC							
18	ASL080	24-Aug	NFC							
19	ASL083	24-Aug	NFC							
20	ASL086	24-Aug	Longnose Sucker	Adult	1	1	398			
21	ASL089	24-Aug	NFC							
22	ASL092	24-Aug	NFC							
23	ASL095	24-Aug	NFC							
24	ASL098	24-Aug	Burbot	Adult	1	1	552			
25	ASL102	25-Aug	NFC							
26	ASL105	25-Aug	WSG	Juvenile	1	1	420	420	360	360
26	ASL105	25-Aug	Burbot	Adult	1	1	533			
27	ASL108	25-Aug	NFC							
28	ASL111	25-Aug	Peamouth Chub	Adult	1	0				
29	ASL114	25-Aug	Burbot	Adult	2	2	395	428		
30	ASL117	25-Aug	Northern Pikeminnow	Adult	1	1	397			
31	ASL120	25-Aug	NFC							
32	ASL123	25-Aug	Peamouth Chub	Adult	1	1	238			
33	ASL127	25-Aug	NFC							
34	ASL130	25-Aug	NFC							
35	ASL133	25-Aug	Northern Pikeminnow	Adult	1	1	345			
36	ASL136	25-Aug	NFC							
37	ASL139	26-Aug	NFC							
38	ASL142	26-Aug	Burbot	Adult	1	1	650			
38	ASL142	26-Aug	Longnose Sucker	Adult	1	1	400			
39	ASL145	26-Aug	NFC							
40	ASL148	26-Aug	NFC							
41	ASL152	26-Aug	NFC							
42	ASL155	26-Aug	Northern Pikeminnow	Adult	1	1	280			
43	ASL158	26-Aug	NFC							
44	ASL161	26-Aug	NFC							
45	ASL164	26-Aug	Northern Pikeminnow	Adult	1	1	400			

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
45	ASL164	26-Aug	Longnose Sucker	Adult	1	1	465			
46	ASL167	26-Aug	Peamouth Chub	Adult	1	0				
47	ASL170	26-Aug	NFC							
48	ASL173	26-Aug	NFC							
49	ASL175	27-Aug	NFC							
50	ASL178	27-Aug	NFC							
51	ASL181	27-Aug	NFC							
52	ASL183	27-Aug	NFC							
53	ASL185	27-Aug	Burbot	Adult	1	1	440			
54	ASL187	27-Aug	NFC							
55	ASL100	28-Aug	NFC							
56	ASL103	28-Aug	NFC							
57	ASL106	28-Aug	Bull Trout	Adult	1	0				
58	ASL109	28-Aug	NFC							
59	ASL113	28-Aug	NFC							
60	ASL097	28-Aug	NFC							
61	ASL094	28-Aug	Peamouth Chub	Adult	1	1	253			
62	ASL091	28-Aug	NFC							
63	ASL088	28-Aug	NFC							
64	ASL084	28-Aug	NFC							
65	BSL025	7-Sep	NFC							
66	BSL029	7-Sep	NFC							
67	BSL032	7-Sep	NFC							
68	BSL035	7-Sep	NFC							
69	BSL038	7-Sep	NFC							
70	BSL041	7-Sep	Longnose Sucker	Adult	1	1	461			
71	BSL044	8-Sep	NFC							
72	BSL047	8-Sep	NFC							
73	BSL050	8-Sep	NFC							
74	BSL054	8-Sep	Northern Pikeminnow	Adult	1	1				
75	BSL057	8-Sep	Longnose Sucker	Adult	1	1	396			
76	BSL060	8-Sep	NFC							
77	BSL063	8-Sep	NFC							
78	BSL066	8-Sep	NFC							
79	BSL069	8-Sep	NFC							
80	BSL072	8-Sep	Largescale Sucker	Adult	1	1				
81	BSL075	8-Sep	NFC							
82	BSL079	8-Sep	Longnose Sucker	Adult	1	1	412			
83	BSL082	9-Sep	NFC							
84	BSL085	9-Sep	NFC							
85	BSL088	9-Sep	NFC							
86	BSL091	9-Sep	NFC							
87	BSL094	9-Sep	NFC							
88	BSL097	9-Sep	NFC							
89	BSL097B	9-Sep	Bull Trout	Adult	1	0	396		549	
90	BSL100	9-Sep	NFC							
91	BSL104	9-Sep	NFC							
92	BSL107	9-Sep	NFC							
93	BSL110	9-Sep	NFC							
94	BSL113	9-Sep	NFC							
95	BSL116	10-Sep	NFC							

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
96	BSL119	10-Sep	Northern Pikeminnow	Adult	1	1	350			
97	BSL122	10-Sep	Largescale Sucker	Adult	1	1	449			
98	BSL125	10-Sep	NFC							
99	BSL129	10-Sep	Longnose Sucker	Adult	1	1	393			
100	BSL132	10-Sep	NFC							
101	BSL135	10-Sep	NFC							
102	BSL138	10-Sep	NFC							
103	BSL141	10-Sep	NFC							
104	BSL144	10-Sep	NFC							
105	BSL147	10-Sep	Largescale Sucker	Adult	2	2	440	483		
106	BSL150	10-Sep	NFC							
107	BSL154	11-Sep	Largescale Sucker	Adult	2	2	390	465		
108	BSL157	11-Sep	Largescale Sucker	Adult	1	1	428			
109	BSL160	11-Sep	NFC							
110	BSL163	11-Sep	Peamouth Chub	Adult	2	1	423	428		
111	BSL133	11-Sep	NFC							
112	BSL130	11-Sep	NFC							
113	BSL127	11-Sep	NFC							
114	BSL124	11-Sep	NFC							
115	BSL121	11-Sep	NFC							
116	BSL118	11-Sep	Burbot	Adult	1	1	500			
117	BSL114	11-Sep	Largescale Sucker	Adult	1	1				
118	BSL111	11-Sep	NFC							
119	BSL108	12-Sep	NFC							
120	BSL105	12-Sep	NFC							
121	BSL102	12-Sep	NFC							
122	BSL099	12-Sep	NFC							
123	BSL096	12-Sep	Largescale Sucker	Adult	1	1	434			
124	BSL093	12-Sep	Northern Pikeminnow	Adult	1	1	390			
125	BSL089	12-Sep	NFC							
126	BSL086	12-Sep	NFC							
127	BSL083	12-Sep	NFC							
128	BSL080	12-Sep	NFC							
129	BSL077	13-Sep	NFC							
130	BSL074	13-Sep	Northern Pikeminnow	Adult	1	1	339			
131	BSL071	13-Sep	Largescale Sucker	Adult	1	1	430			
132	BSL068	13-Sep	Peamouth Chub	Adult	1	0	211			
133	BSL064	13-Sep	NFC							
134	BSL061	13-Sep	NFC							
135	CSL032	19-Sep	Burbot	Adult	2	2	575	679		
136	CSL035	19-Sep	Burbot	Adult	1	1	561			
137	CSL038	19-Sep	NFC							
138	CSL045	19-Sep	NFC							
139	CSL048	19-Sep	NFC							
140	CSL051	19-Sep	NFC							
141	CSL054	20-Sep	NFC							
142	CSL057	20-Sep	NFC							
143	CSL060	20-Sep	NFC							
144	CSL063	20-Sep	NFC							
145	CSL066	20-Sep	NFC							
146	CSL070	20-Sep	NFC							

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
147	CSL073	20-Sep	NFC							
148	CSL076	20-Sep	Northern Pikeminnow	Adult	1	1	389			
149	CSL079	20-Sep	NFC							
150	CSL082	20-Sep	NFC							
151	CSL085	20-Sep	NFC							
152	CSL088	20-Sep	NFC							
153	CSL091	21-Sep	NFC							
154	CSL095	21-Sep	NFC							
155	CSL098	21-Sep	NFC							
156	CSL102	21-Sep	NFC							
157	CSL105	21-Sep	NFC							
158	CSL109	21-Sep	NFC							
159	CSL112	21-Sep	Northern Pikeminnow	Adult	1	1	389			
160	CSL115	21-Sep	NFC							
161	CSL118	21-Sep	NFC							
162	CSL121	21-Sep	NFC							
163	CSL124	21-Sep	NFC							
164	CSL127	21-Sep	NFC							
165	CSL130	22-Sep	Peamouth Chub	Adult	1	0	230			
166	CSL134	22-Sep	Peamouth Chub	Adult	1	0	223			
167	CSL137	22-Sep	NFC							
168	CSL140	22-Sep	NFC							
169	CSL143	22-Sep	Longnose Sucker	Adult	1	1	463			
170	CSL146	22-Sep	NFC							
171	CSL149	22-Sep	NFC							
172	CSL148	22-Sep	NFC							
173	CSL141	22-Sep	NFC							
174	CSL138	22-Sep	Longnose Sucker	Adult	1	1	437			
175	CSL135	22-Sep	Sucker	Adult	1	1				
176	CSL132	22-Sep	NFC							
177	CSL129	23-Sep	NFC							
178	CSL126	23-Sep	Burbot	Adult	1	1	531			
179	CSL123	23-Sep	NFC							
180	CSL120	23-Sep	NFC							
181	CSL116	23-Sep	NFC							
182	CSL113	23-Sep	NFC							
183	CSL110	23-Sep	NFC							
184	CSL107	23-Sep	NFC							
185	CSL104	23-Sep	NFC							
186	CSL100	23-Sep	NFC							
187	CSL097	23-Sep	NFC							
188	CSL094	23-Sep	NFC							
189	CSL093	24-Sep	NFC							
190	CSL090	24-Sep	NFC							
191	CSL087	24-Sep	Largescale Sucker	Adult	1	1				
192	CSL084	24-Sep	NFC							
193	CSL080	24-Sep	NFC							
194	CSL077	24-Sep	NFC							
195	CSL074	24-Sep	NFC							
196	CSL071	24-Sep	Northern Pikeminnow	Adult	1	1	365			
197	CSL068	24-Sep	NFC							

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
198	CSL064	24-Sep	Largescale Sucker	Adult	1	1	425			
199	CSL061	24-Sep	NFC							
200	CSL058	24-Sep	NFC							
201	CSL055	25-Sep	NFC							
202	CSL052	25-Sep	NFC							
203	CSL049	25-Sep	Largescale Sucker	Adult	1	1				
204	CSL046	25-Sep	NFC							
205	CSL043	25-Sep	Northern Pikeminnow	Adult	1	1	416			
206	CSL040	25-Sep	NFC							
207	DSL021	16-Oct	NFC							
208	DSL025	16-Oct	Burbot	Adult	2	2	485	535		
209	DSL028	16-Oct	Longnose Sucker	Adult	1	1	510			
210	DSL031	16-Oct	Northern Pikeminnow	Adult	1	1	608			
210	DSL031	16-Oct	Longnose Sucker	Adult	1	1	410			
211	DSL034	16-Oct	NFC							
212	DSL037	16-Oct	Longnose Sucker	Adult	3	3	394	430		
213	DSL040	16-Oct	Longnose Sucker	Adult	1	1	360			
214	DSL043	16-Oct	NFC							
215	DSL046	16-Oct	NFC							
216	DSL050	16-Oct	NFC							
217	DSL053	16-Oct	NFC							
218	DSL056	16-Oct	NFC							
219	DSL059	17-Oct	NFC							
220	DSL062	17-Oct	Largescale Sucker	Adult	1	1	385			
221	DSL065	17-Oct	NFC							
222	DSL068	17-Oct	NFC							
223	DSL071	17-Oct	NFC							
224	DSL075	17-Oct	Longnose Sucker	Adult	1	1	465			
224	DSL075	17-Oct	Peamouth Chub	Adult	2	0	218	270		
225	DSL078	18-Oct	NFC							
226	DSL081	18-Oct	NFC							
227	DSL084	18-Oct	NFC							
228	DSL087	18-Oct	Northern Pikeminnow	Adult	1	1	305			
229	DSL090	18-Oct	NFC							
230	DSL093	18-Oct	NFC							
231	DSL096	18-Oct	Peamouth Chub	Adult	1	1	235			
231	DSL096	18-Oct	Burbot	Adult	1	1	460			
232	DSL100	18-Oct	Largescale Sucker	Adult	1	1	420			
233	DSL103	18-Oct	Northern Pikeminnow	Adult	1	1	420			
234	DSL106	18-Oct	Peamouth Chub	Adult	1	0	225			
234	DSL106	18-Oct	Northern Pikeminnow	Adult	1	1	269			
235	DSL109	19-Oct	NFC							
236	DSL112	19-Oct	NFC							
237	DSL115	19-Oct	NFC							
238	DSL118	19-Oct	Longnose Sucker	Adult	1	1	360			
239	DSL121	19-Oct	NFC							
240	DSL125	19-Oct	Northern Pikeminnow	Adult	1	0	305			
241	DSL128	19-Oct	NFC							
242	DSL131	19-Oct	NFC							
243	DSL134	19-Oct	NFC							
244	DSL137	19-Oct	NFC							

Set #	Site	Pull Date	Species	Life Stage	Quantity	Released	Length Min (mm)	Length Max (mm)	Weight Min (g)	Weight Max (g)
245	DSL026	20-Oct	NFC							
246	DSL023	20-Oct	Burbot	Adult	3	1	545	780		
247	DSL020	20-Oct	NFC							
248	DSL017	20-Oct	NFC							
249	DSL014	20-Oct	Burbot	Adult	7	5	540	630		
250	DSL011	20-Oct	Burbot	Adult	1	1	520			
251	DSL007	20-Oct	Burbot	Adult	7	6	460	600		
252	DSL004	20-Oct	NFC							
253	DSL029	21-Oct	NFC							
254	DSL018	21-Oct	Northern Pikeminnow	Adult	1	0	405			
255	DSL015	21-Oct	NFC							
256	DSL012	21-Oct	Burbot	Adult	9	5	480	590		
257	DSL009	21-Oct	Burbot	Adult	2	2	500	520		
258	DSL006	21-Oct	NFC							
259	DSL003	21-Oct	Northern Pikeminnow	Adult	1	1	390			
259	DSL003	21-Oct	Burbot	Adult	2	1	530	580		
260	DSL001	21-Oct	Peamouth Chub	Adult	1	0	205			
261	DSL030	22-Oct	Northern Pikeminnow	Adult	1	1	375			
262	DSL027	22-Oct	NFC							
263	DSL024	22-Oct	Northern Pikeminnow	Adult	2	2	385	455		
263	DSL024	22-Oct	Longnose Sucker	Adult	1	1	380			
264	DSL016	22-Oct	NFC							
265	DSL005	22-Oct	NFC							
266	DSL002	22-Oct	NFC							

Appendix E – Maps of Sampling Effort and Juvenile ćəmtus Captures by River Section (2007 – 2023)

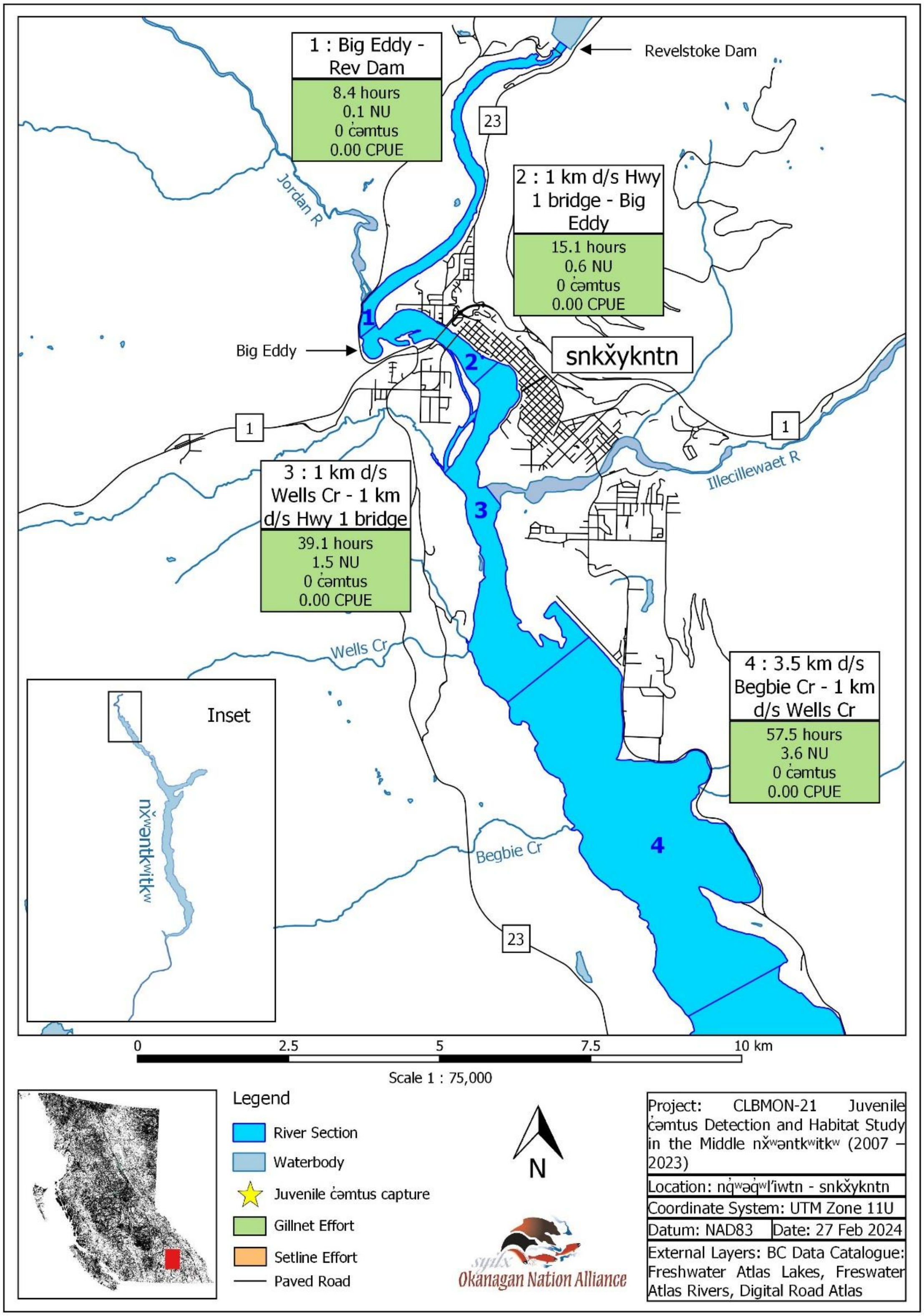

Figure 15. Juvenile c̓əmtus capture locations, effort, and associated catch-per-unit-effort (CPUE) from 3.5 km downstream of Begbie Creek to Revelstoke Dam (2007 – 2023). Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

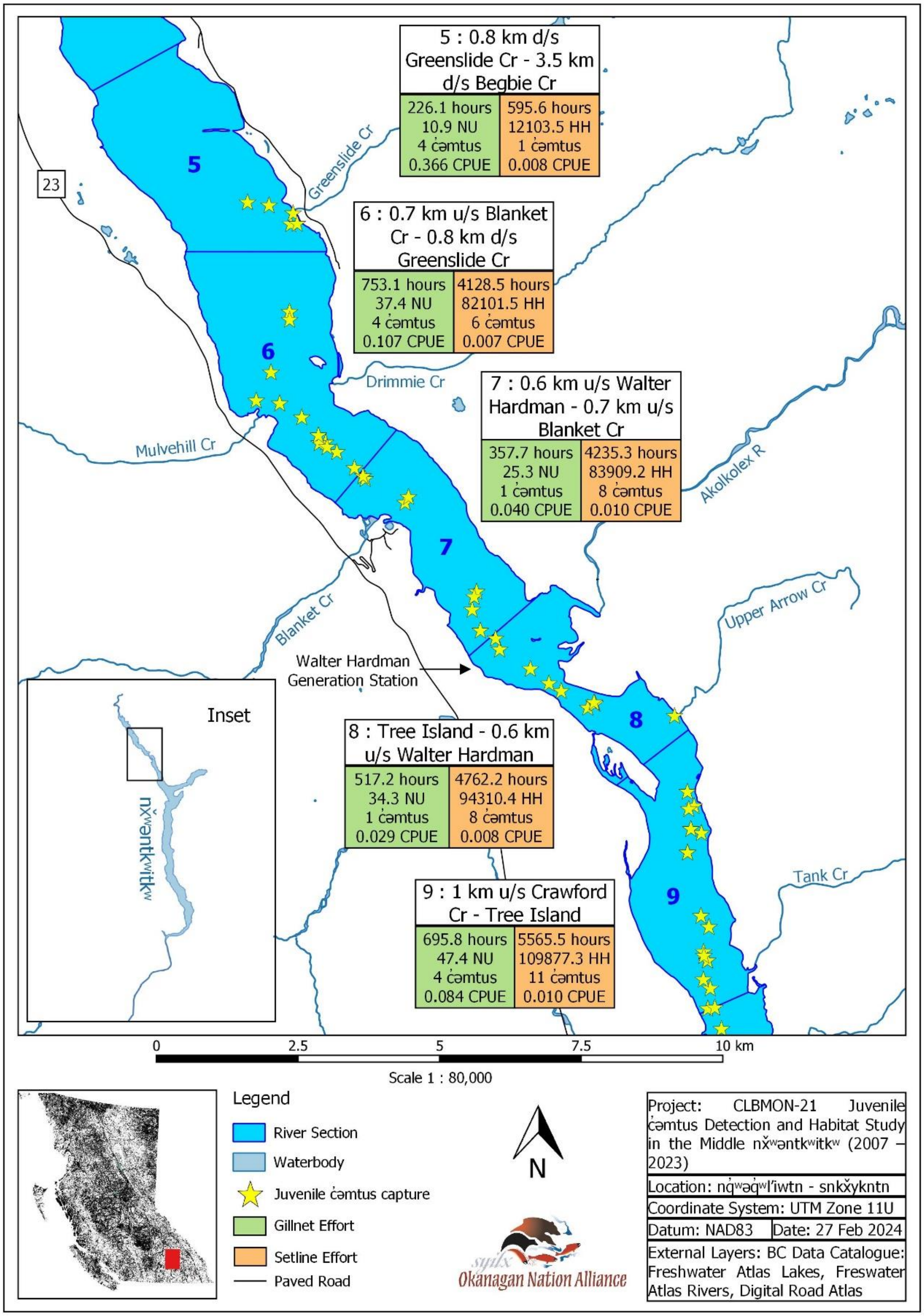

Figure 16. Juvenile ċəmtus capture locations, effort, and associated catch-per-unit-effort (CPUE) from 1 km upstream of Crawford Creek to 3.5 km downstream of Begbie Creek (2007 – 2023). Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

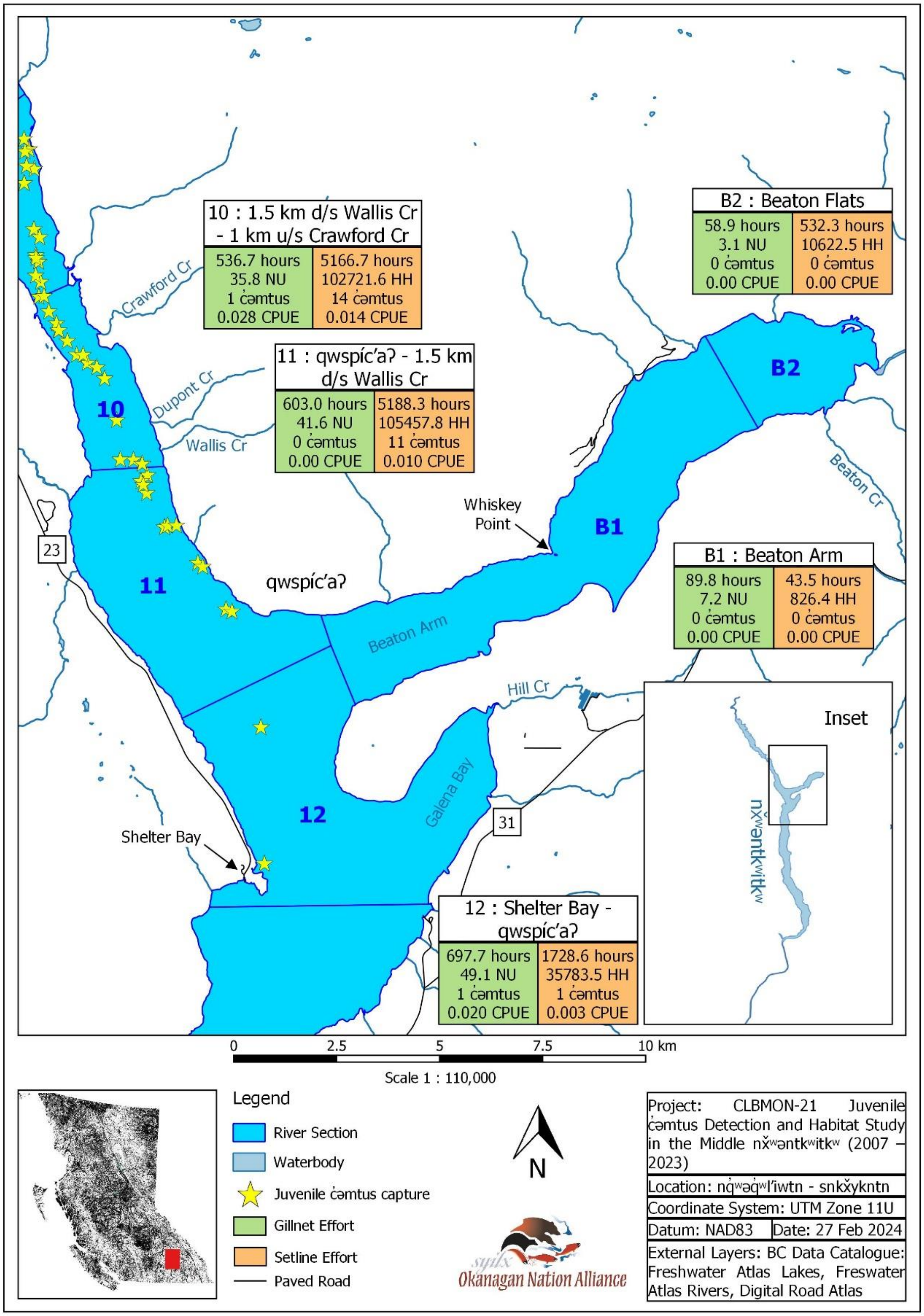

Figure 17. Juvenile ċəmtus capture locations, effort, and associated catch-per-unit-effort (CPUE) from Shelter Bay to 1 km upstream of Crawford Creek and the Beaton Arm (2007 – 2023). Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

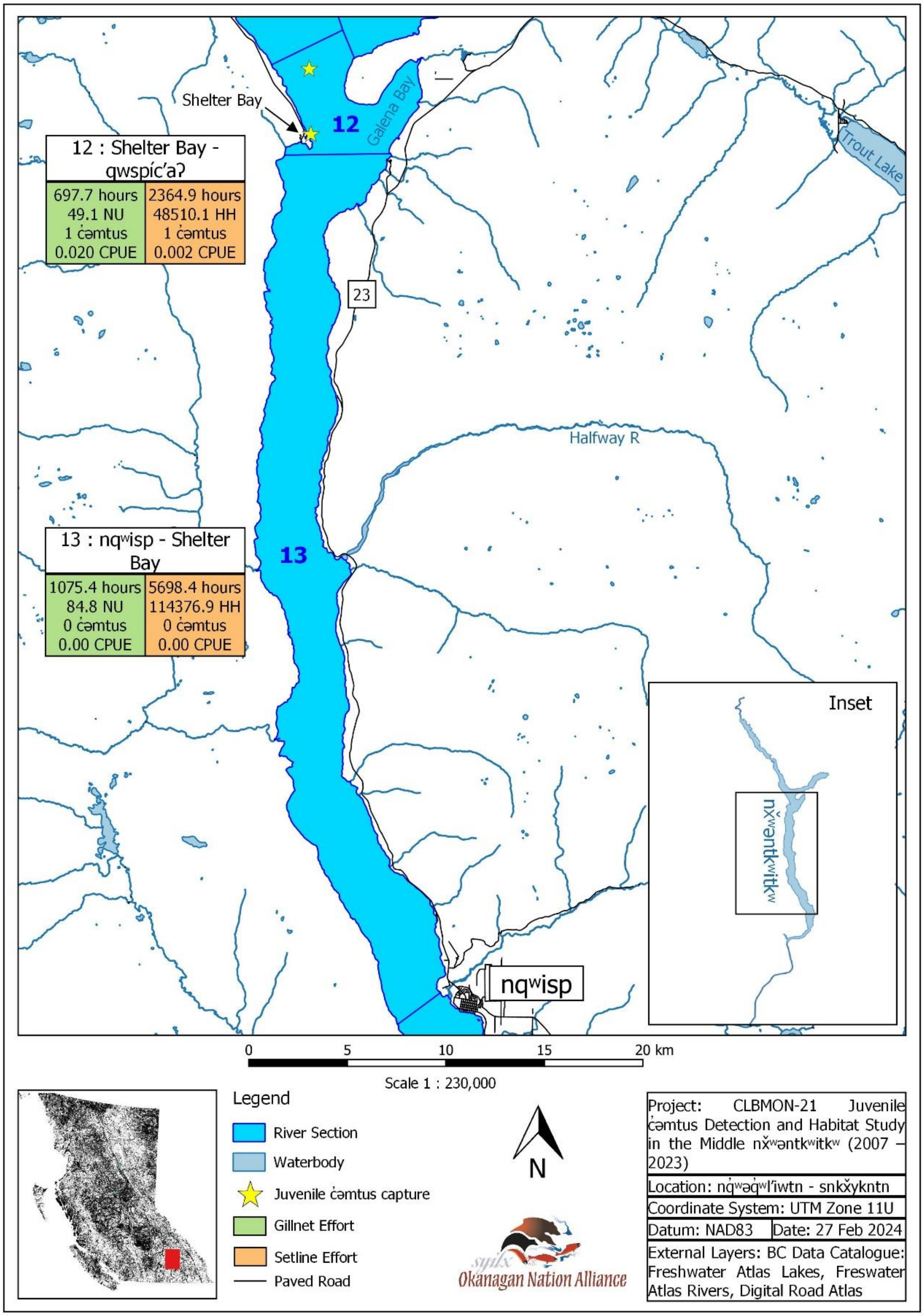

Figure 18. Juvenile c̓əmtus capture locations, effort, and associated catch-per-unit-effort (CPUE) from nqʷisp to qwspíc'aʔ (2007 – 2023). Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

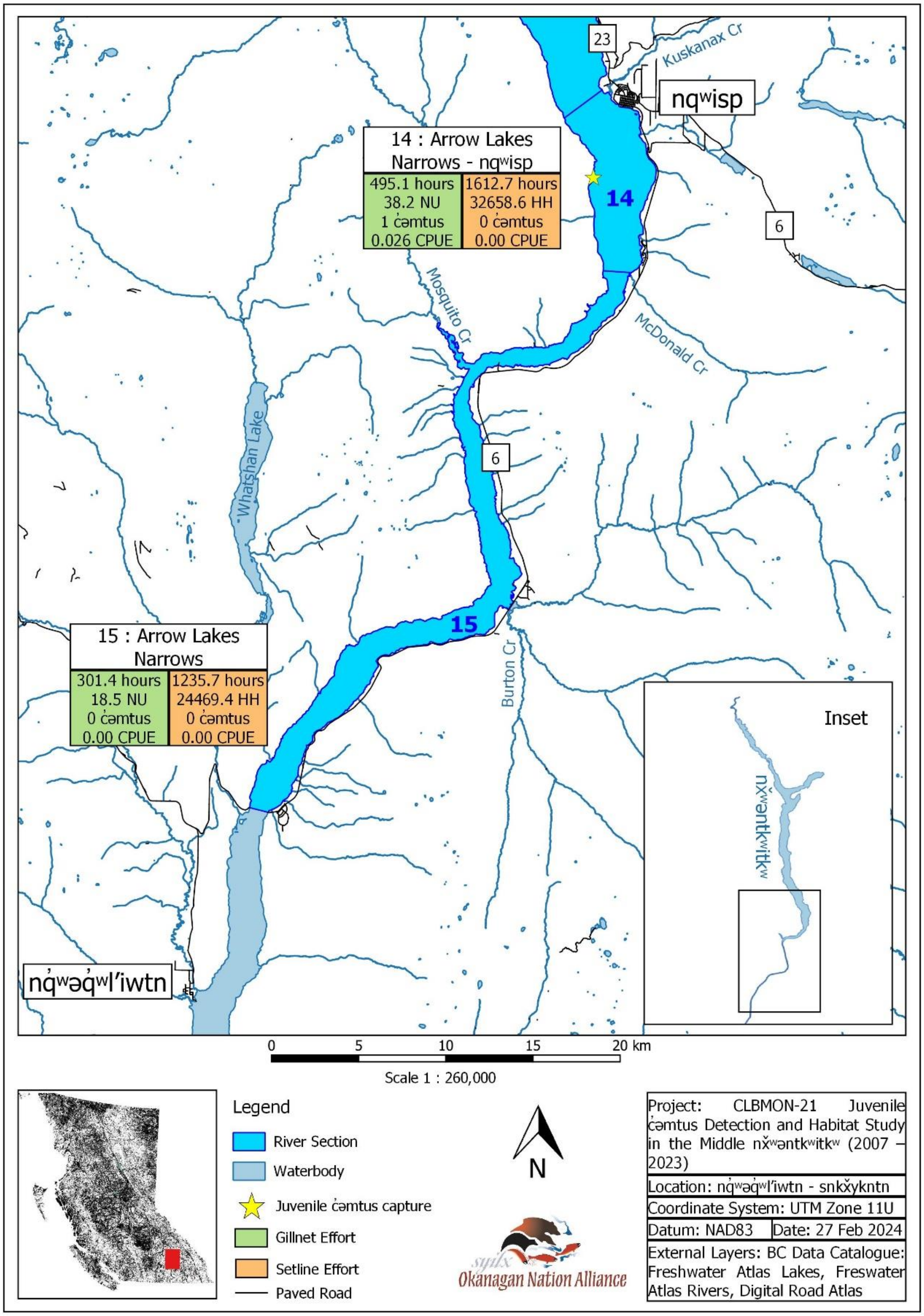

Figure 19. Juvenile c̓əmtus capture locations, effort, and associated catch-per-unit-effort (CPUE) from the Arrow Lakes Narrows to nqʷisp (2007 – 2023). Data collected by BC Hydro, Golder Associates Ltd., and Okanagan Nation Alliance.

Appendix F – Map of Rock Basket Sample Locations and Data Summary

Appendix F1 – Rock Basket Locations

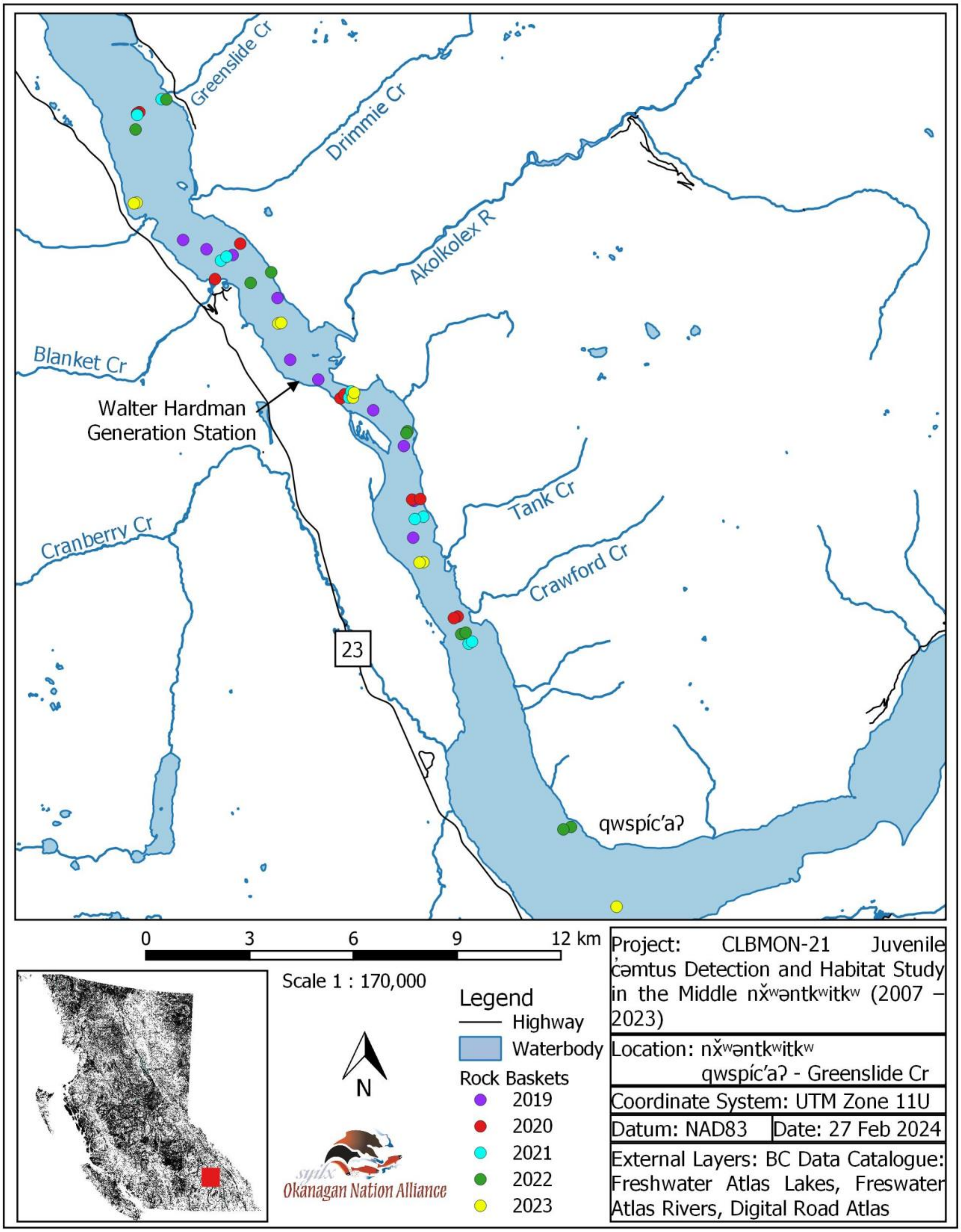

Figure 20. Locations of rock baskets for benthic invertebrate monitoring in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 from 2019 to 2023. Data collected Okanagan Nation Alliance.

Appendix F2 – Rock Basket Data

Table 20. Summary data for rock baskets monitored in the middle nx̌ʷəntkʷitkʷ during CLBMON-21 from 2019 to 2023.

Year	Site Name	Easting	Northing	Set Date	Set Depth (m)	Substrate Description	Retrieve Date	Retrieve Depth (m)	Contents
2019	2019_RB_01_S	422472	5633573	Jul 05	5.7		Sep 24		Oligochaeta (7), Chironomidae (35), Platyhelminthes (1)
	2019_RB_02_D	423148	5633304	Jul 05	15.9		Sep 24		Platyhelminthes (3)
	2019_RB_03_S	423905	5633136	Jul 05	9.0		Sampler lost		
	2019_RB_04_D	425202	5631895	Jul 05	17.1		Sep 24		Chironomidae (1), Platyhelminthes (5)
	2019_RB_05_D	425568	5630109	Jul 05	18.0		Sep 24		Platyhelminthes (1)
	2019_RB_06_D	426380	5629537	Jul 05	15.8		Sep 24		Platyhelminthes (2)
	2019_RB_07_S	427970	5628650	Jul 05	8.5		Sep 24		Oligochaeta (3), Ephemerellidae (1), Platyhelminthes (5)
	2019_RB_08_D	428854	5627616	Jul 05	12.0		Sep 24		Platyhelminthes (11)
	2019_RB_09_D	429144	5626030	Jul 05	11.6		Sep 24		Platyhelminthes (2)
	2019_RB_10_S	429123	5624966	Jul 05	7.5		Sep 24		Oligochaeta (17), Hirudinea (3), Chironomidae (17), Trombidiformes (1), Platyhelminthes (3)
2020	2020_RB_01_S	421379	5637387	Aug 05	5.8	Silt (70%), sand (20%), OM (10%)	Oct 02	1.9	Chironomidae (256)
	2020_RB_02_D	421140	5637259	Aug 05	14.9	Silt (80%), OM (20%)	Oct 02	7.0	Oligochaeta (1), Chironomidae (2)
	2020_RB_03_D	424123	5633459	Aug 05	11.2	Sand (100%)	Oct 02	5.5	Oligochaeta (2), Chironomidae (1), Platyhelminthes (2)
	2020_RB_04_S	423484	5632550	Aug 05	4.8	Silt (50%), terrestrial veg (50%)	Oct 02	4.2	Oligochaeta (6), Chironomidae (7),
	2020_RB_05_D	427120	5629130	Aug 06	16.8	Sand (100%)	Oct 02	10.0	Oligochaeta (1), Chironomidae (38), Platyhelminthes (1)
	2020_RB_06_S	427005	5628984	Aug 06	6.5	Sand (90%), silt (10%)	Oct 02	3.7	Chironomidae (65), Trichoptera (1), Trombidiformes (1)
	2020_RB_07_S	429014	5626110	Aug 08	6.2	Silt (70%), sand (25%), OM (5%)	Oct 01	3.7	Chironomidae (49)
	2020_RB_08_D	429339	5626105	Aug 08	15.8	Sand (90%), OM (10%)	Oct 01	10.0	Oligochaeta (3), Chironomidae (4), Platyhelminthes (1)
	2020_RB_09_D	430301	5622641	Aug 08	12.9	Silt (80%), sand (20%)	Oct 01	7.5	Chironomidae (17)
	2020_RB_10_S	430525	5622721	Aug 08	5.9	Silt (100%)	Oct 01	2.7	Chironomidae (45)
2021	2021_RB_01_S	421850	5637642	Jul 21	10.0	Coarse gravel (50%), fine sand (30%), veg (didymo) (20%)	Sep 23	5.0	Oligochaeta (12), Chironomidae (2), Ephemerellidae (1), Platyhelminthes (1)
	2021_RB_01_D	421147	5637187	Jul 21	12.0	Silt (80%), OM (15%), fine sand (5%)	Sep 23	8.0	Oligochaeta (17), Chironomidae (27), Ephemerellidae (1), Diptera (1)

Year	Site Name	Easting	Northing	Set Date	Set Depth (m)	Substrate Description	Retrieve Date	Retrieve Depth (m)	Contents
	2021_RB_02_S	423727	5633090	Jul 21	10.0	Fine sand (80%), med gravel (20%)	Sep 22	10.6	Sphaeriidae (1), Platyhelminthes (3)
	2021_RB_02_D	423566	5632978	Jul 21	16.0	Med sand (90%), silt (5%), WD (5%)	Sep 22	11.3	Oligochaeta (1), Ephemerellidae (2), Platyhelminthes (1)
	2021_RB_03_S	427334	5629192	Jul 21	10.0	Fine sand (95%), WD (5%)	Sep 24	5.4	Trichoptera (4)
	2021_RB_03_D	427269	5629017	Jul 21	16.0	Veg (50%), WD (50%)	Sep 24	11.4	Oligochaeta (9), Chironomidae (2), Ephemerellidae (2)
	2021_RB_04_S	429172	5625505	Jul 21	10.0	Silt (80%), fine sand (10%), coarse sand (5%), fine gravel (5%)	Sep 22	5.9	Oligochaeta (2), Platyhelminthes (13)
	2021_RB_04_D	429415	5625572	Jul 21	19.4	Coarse gravel (100%)	Sep 22	15.0	Chironomidae (1), Ephemerellidae (1), Trichoptera (47)
	2021_RB_05_S	430825	5621963	Jul 21	8.0	Silt (70%), med sand (30%)	Sep 24	2.9	Chironomidae (18), Heptageniidae (1)
	2021_RB_05_D	430729	5621905	Jul 21	17.0	Med sand (100%)	Sep 24	12.2	Oligochaeta (1)
2022	2022_RB_01_D	421098	5636765	Aug 18	12.0	Silt (85%), fine sand (15%)	Oct 16	5.3	Chironomidae (2)
	2022_RB_01_S	421990	5637635	Aug 18	8.2	Coarse sand (100%)	Oct 16	2.5	Chironomidae (6), Ephemerellidae (2), Plecoptera (1)
	2022_RB_02_D	424425	5632331	Aug 16	15.6	Fine sand (50%), silt (40%), OM (5%), fine gravel (5%)	Oct 17	9.5	Oligochaeta (4), Platyhelminthes (11)
	2022_RB_02_S	425020	5632639	Aug 16	12.0	Med sand (80%), fine gravel (10%), Silt (5%), OM (5%)	Oct 17	6.4	Chironomidae (2), Ephemerellidae (3), Planorbidae (1)
	2022_RB_03_D	428959	5628043	Aug 18	16.5	Silt (93%), OM (5%), fine sand (2%)	Oct 17	10.4	Platyhelminthes (6)
	2022_RB_03_S	428930	5627987	Aug 18	12.4	Med sand (50%), coarse sand (40%), OM (7%), silt (3%)	Oct 17	6.3	Oligochaeta (3), Hirudinea (1), Platyhelminthes (11), Planorbidae (1)
	2022_RB_04_D	430514	5622177	Aug 19	15.5	Med sand (98%), silt (2%)	Oct 18	9.9	
	2022_RB_04_S	430642	5622224	Aug 19	12.0	Silt (100%)	Oct 18	4.7	Chironomidae (5)
	2022_RB_05_D	433687	5616605	Aug 19	17.5	Fine sand (80%), silt (20%)	Oct 13	12.2	Ephemerellidae (1)
	2022_RB_05_S	433466	5616533	Aug 19	12.5	Silt (99%), med gravel (1%)	Oct 13	6.6	
2023	2023_RB_01	421129	5634650	Aug 26	5.5		Unable to retrieve due to water level		
	2023_RB_02	421052	5634631	Aug 26	3.1				
	2023_RB_03	425227	5631157	Aug 26	5.4				
	2023_RB_04	425305	5631176	Aug 26	3.2				
	2023_RB_05	427382	5629015	Aug 26	5.5	90% sand; 10% gravel	Oct 23	3.4	None
	2023_RB_06	427415	5629157	Aug 26	3.0	100% sand	Oct 23	0.2	None
	2023_RB_07	429419	5624258	Aug 26	4.8		Sampler lost		
	2023_RB_08	435004	5614299	Aug 24	2.8	100% sand	Dewatered, not processed		