Columbia River Water Use Plan

CLBMON-23A Egg Mat Monitoring Program

Implementation Year 18

Reference: CLBMON-23A

Study Period: 2024

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c̓əmtus | *White Sturgeon* | *Acipenser transmontanus*

Spawn Monitoring Program in the nx̌ʷntkʷitkʷ , Columbia River near snkx̌ykntn, Revelstoke, BC

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2024 Final Report

CLBMON-23A

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Cover Photos:

Top - Okanagan Nation Alliance Fisheries Technicians Sewecn Oly Clarke and Shelley Hackett retrieving a D-Ring Drift Net in nx̌ʷntkʷitkʷ near snkx̌ykntn in search of c̓əmtus progeny. Photo: Evan Smith, Okanagan Nation Alliance.

Bottom - Late stage c̓əmtus eggs captured in nx̌ʷntkʷitkʷ near snkx̌ykntn. Photo: Evan Smith, Okanagan Nation Alliance.

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Executive Summary

The population of c̓əmtus (White Sturgeon; *Acipenser transmontanus*) in the Canadian portion of nx̌ʷntkʷitkʷ (Columbia River) are listed as Endangered under the federal Species at Risk Act. A small segment of this population reside between Revelstoke Dam and Hugh L. Keenleyside Dam in saltík̓ʷt (Arrow Lakes Reservoir) and nx̌ʷntkʷitkʷ near snkx̌yknt̓n (Revelstoke BC). The only known spawning location for this segment of the population is located approximately 6 km downstream of Revelstoke Dam adjacent to the snkx̌yknt̓n golf course. Spawning has been documented at this location intermittently but recruitment to the juvenile stage from these spawning events has not been detected.

The c̓əmtus Spawn Monitoring Program (CLBMON-23A) under the Columbia Water Use Plan has been conducted annually since 2008, with monitoring occurring previously between 1999 and 2007 as part of other programs. The main objectives of CLBMON-23A are to document the timing, duration, and frequency of spawning, and to identify important early life stage habitat conditions. In addition, CLBMON-23A supports a conservation aquaculture program by transferring live eggs and larvae captured during monitoring to the Kootenay Trout Hatchery for rearing and subsequent release back into nx̌ʷəntkʷitkʷ near snkx̌yknt̓n. Additional objectives were added to the program in 2019 to address key uncertainties identified by the Mid-Columbia River White Sturgeon Technical Forum and included:

- Describe the timing and spatial extent of larval dispersal
- Assess the risk of eggs or larvae becoming stranded due to hydroelectric operations

In 2024, egg collection mats and drift nets were used to sample for eggs and larvae in the primary spawning area during the spawning season (late July to mid-September), as defined by previous years of the monitoring program. In total, 155 eggs (including 38 mortalities) and 13 larvae (all mortalities) were collected using drift nets. An additional 3 eggs (all mortalities) were collected with egg mats. All live eggs were transferred to a streamside hatchery facility located at the snkx̌yknt̓n golf course for incubation and early rearing. Progeny were then transferred to the traditional hatchery for rearing. Based on the developmental stages at the time of capture and water temperatures, the eggs and the larvae were estimated to be from two spawning events that occurred on Aug 01 and Aug 04 2024. As sampling effort was prioritized for maximizing egg collection when spawning was detected, less effort was expended to describe larval dispersal later in the season.

The Arrow Lakes Reservoir elevation was below 437 MASL for the full duration of 2024 field sampling; therefore, survey area was not backwatered by the reservoir during the period when adults were spawning. The stranding risk was considered high (95% of the days during the risk period) based on the spawn timing, lack of backwatering from the Arrow Lakes Reservoir, and discharge from Revelstoke Dam.

Acknowledgement

The Okanagan Nation Alliance would like to acknowledge BC Hydro as the funding source for this project and the opportunity to increase our skills and capacity through the award of this project. Thank you to WSP (formerly Golder Associates Ltd.) for their mentorships, technical and logistical support in previous years of CLBMON-23A.

The following employees of **BC Hydro** contributed to this project in 2024-25:

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Glossary

nsyilxcen Place Names	English
snkx̌ykntn	Revelstoke
snɬuxʷqnm	Castlegar
nx̌ʷntkʷitkʷ	Columbia River
nqʷisp	Nakusp
salt̓ik̓ʷt.	Arrow Lakes
stqaʔtkʷɬniw̓t	Westbank
nsyilxcen Species Names	**English**
ċəmtus	White Sturgeon

1.0 Introduction

The population of ċəmtus (White Sturgeon; *Acipenser transmontanus*) in the Canadian section of nx̌ʷəntkʷitkʷ (Columbia River) was listed as Endangered under the federal Species at Risk Act in 2006. A segment of this population exists between Hugh L. Keenleyside Dam (HLK) near snɫuxʷqnm (Castlegar BC) and Revelstoke Dam (REV) near snkx̌ykntn (Revelstoke BC). This portion of the nx̌ʷəntkʷitkʷ includes Arrow Lakes Reservoir (ALR) and an approximately 48 km section of salt̓ik̓ʷt (Arrow Lakes Reservoir) between the ALR and REV that transitions between riverine and reservoir depending on ALR elevations. 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 2021, the estimated population of adult ċəmtus may be around 25 individuals, calculated with a 97% annual adult survival rate (DFO 2014). The only known spawning area for this population is located adjacent to the snkx̌ykntn golf course, approximately 2 km downstream of REV. Spawning has been documented intermittently at this location through the collection of ċəmtus eggs and larvae between 1999 and 2023 (Golder and ONA 2024). However, wild juvenile ċəmtus recruitment from these spawning events have not been detected, suggesting recruitment failure at the juvenile life stage for this population (Hildebrand and Parsley 2013).

Initiated in 2007, BC Hydro's CLBMON-23 Mid-Columbia River White Sturgeon Egg Mat Monitoring and Feasibility Study was developed to monitor the annual spawning of ċəmtus at the only known spawning site between REV and HLK. CLBMON-23A includes two components: (1) the Mid-Columbia River White Sturgeon Spawn Monitoring Program (CLBMON-23A) which uses egg collection mats and drift nets, and (2) the Mid-Columbia River White Sturgeon Underwater Videography Feasibility Study (CLBMON-23B), which evaluated the feasibility of monitoring ċəmtus using sonar (Johnson et *al.* 2010; Crossman et *al*. 2011). Eighteen years of monitoring have been completed in the CLBMON-23A program to date (2007 to 2024). This report describes the methods and results of egg mat and drift net monitoring for CLBMON-23A in 2024 (Year 18).

CLBMON-23A meets the requirement of the nx̌ʷəntkʷitkʷ Project Water License Order to document spawn timing, duration, and frequency, and to identify important early life stage habitat conditions (BC Hydro 2019). In addition, CLBMON-23A supports a conservation aquaculture program through the on-site incubation of eggs and transfer of larvae to the Freshwater Fisheries Society Kootenay Trout Hatchery Facility in Fort Steel BC for rearing and subsequent release back into the salt̓ik̓ʷt.

Specific management questions associated with CLBMON-23A as per the Terms of Reference (BC Hydro 2007) are as follows:

1. Where are the primary ċəmtus incubation sites below Revelstoke Dam?
2. How do dam and reservoir operations affect egg and larvae survival in this area? Specifically, do significant numbers of eggs become dewatered as a result of operations?
3. Can underwater videography or other remote sensing methods be used to effectively monitor staging and spawning of ċəmtus?

4. What is the most effective method for monitoring spawning of c̓əmtus?
5. Can modifications be made to operation of Revelstoke Dam and Arrow Lakes Reservoir to protect or enhance c̓əmtus incubation habitat?

Management Question 3 has been addressed by a different monitoring program (CLBMON-23B; Johnson et *al*. 2010). Management Questions 1, 2, 4, and 5 are relevant to the CLBMON-23A monitoring program.

A review of CLBMON-23A in 2018 identified the following key uncertainties (BC Hydro 2019):

1. The number of adults contributing to spawning events
2. Survival of early life stages
3. The risk of eggs or larvae becoming stranded due to operations

Following the review, an additional objective of the monitoring program was to provide information to address the key uncertainties listed above, where possible. Genetic analyses to address uncertainty #1 are captured under CLBMON-24 (Mid-Columbia River White Sturgeon Genetic Assessment; BC Hydro 2021). Non-viable (deceased) egg and larval specimens collected during CLBMON-23a were preserved and provided to BC Hydro for CLBMON-24. Survival of early life stages (uncertainty #2) cannot be directly measured or estimated using the data provided by this monitoring program but given natural recruitment has not been identified in this sub-population, survival is expected to be low. Stranding risk (uncertainty #3) has been assessed by examining river discharge data and ALR surface elevation data for large flow reductions during periods when there were known to be c̓əmtus eggs or larvae present in the spawning and incubation area.

In addition to the main objective of annual spawn monitoring and addressing these uncertainties, two additional objectives were identified at the Mid-Columbia River White Sturgeon Technical Forum in December 2018 (BC Hydro 2018):

- Increasing the number of progeny (eggs or larvae) collected and transferred to the conservation aquaculture program to capture the genetic diversity of the wild adults in saltʼikʼʷt; and
- Describe the timing and spatial extent of larval dispersal through additional sampling.

This report summarizes the results from the 2024 study year and compares them to previous years of this program. Recommendations for future sampling years are also provided. Detailed background information, interpretation of previous years' results, and discussion of the status of management questions are available in historical annual reports of this program[1].

2.0 Methods

In response to the objectives identified at the Mid-Columbia River White Sturgeon Technical Forum, the study design of CLBMON-23A was modified in 2020 to include more adaptive

[1] Reports from previous years of the monitoring program are available online at: https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/columbia-sturgeon.html

management to prioritize the collection of ċəmtus progeny for conservation aquaculture. Sample sites and effort were adjusted during the sampling season based on the timing and location of captured eggs or larvae. This differed from previous years, where the index sample sites, and schedule were set. Due to the prioritization of ċəmtus progeny collection, the larval dispersal component of this program became a secondary objective.

2.1 Study Area

The study area for CLBMON-23A extends from the upstream end of the primary spawning area (river kilometer [rKm] 230.3, as measured upstream from HLK) downstream to the Trans-Canada Highway Bridge (rKm 227). In 2024, the program was focused in the area that all ċəmtus eggs and larvae have been captured in previous years of this program (between rKm 229.9 and 226.3; Wood 2019; Golder and ONA 2020; ONA 2021; ONA 2022; ONA 2023; ONA 2024). To maximize captures in 2024, sampling was concentrated during the primary spawning and incubation period.

2.2 Sampling Equipment

Egg collection mats ('egg mats') and drift nets were used to capture ċəmtus eggs and larvae. This was consistent with all previous years of the monitoring program (Wood 2019; Golder and ONA 2020; ONA 2021; ONA 2022; ONA 2023; ONA 2024). Egg mats consisted of a 0.77 x 0.92 m steel frame filled with latex-coated animal hair filter material. When deployed in the river, egg mats rest on the substrate and eggs or larvae may adhere to or become lodged in the filter material. Egg mats were deployed either as 'shore-sets' or 'mid-sets'. Shore-sets were anchored with line to a natural feature above the high water mark (e.g., boulder or tree), allowing sets to be retrieved from shore. Line spanned from the anchor point to the egg mat and was connected via a rope or cable bridle (i.e., approximated 0.5 m rope or cable attached in a V-formation to one end of the end mat). Egg mats had a float line (10 – 20 m) with a LD2 buoy attached as a secondary retrieval method in case the primary anchor line was compromised.

To sample locations further from shore, egg mats were deployed as mid-sets that were held in place by a portable anchor system (two 30 kg claw anchors connected by steel chain). Mid-sets had a float line and LD2 buoy connected to the upstream anchor, and a second float line and LD2 buoy connected to the egg mat. The egg mat was connected to the downstream anchor by approximately 10 m of line.

Drift nets consisted of a D-shaped metal frame (0.8 m wide at the base and 0.6 m high) to which a drift net was attached (3.6 m long, 0.16 cm knotless mesh, tapered to an 11.4 cm diameter collection cup). The D-ring frame was weighted at the front corners or base of the frame and a flow meter was affixed to the D-ring frame (over the opening) to measure the volume of water sampled over time. All drift nets were deployed using the mid-set anchor system described above.

Egg mats and drift nets were deployed and retrieved from a jet-drive river boat by a three-person crew. Shore-sets were retrieved from shore and mid-sets were retrieved by the downstream float line attached to the egg mat or drift net. Egg mats and drift nets were pulled from the bow winch or side-mounted winch on a davit, depending on the site. Generally, the side winch was used when possible to allow for better crew ergonomics. Use of the bow winch was limited to sites situated in very high water velocities or if a greater force was required to retrieve (i.e. equipment or anchors were stuck).

2.3 Spawn Monitoring

The majority of monitoring took place in August 2024. Egg mats were deployed on Jul 31 2024 through Aug 19 2024. Drift nets were deployed daily during each sampling session until Sep 04 2024. Timing of sampling and the amount of effort expended was prioritized to cover the historical peak of the spawning period when most eggs and larvae had been captured in past years of monitoring. Following the review of CLBMON-23A in 2018, the study plan became "adaptive" with the objective of maximizing effort around the period when spawning was detected. This was due to the significant reduction in embryo or larval captures in the weeks following spawning events in previous years. Additional sampling was conducted at sites where eggs or larvae were captured; additional sites were installed adjacent to, or downstream, of the capture location when possible. If significant numbers of eggs or larvae were captured, the session would be extended up to three days to continue sampling with drift nets; which often catch more eggs/larvae than egg mats and maximize catch during periods when spawning was occurring. During each sampling session, egg mats were brought on board (with the exception of the first sampling session), checked for eggs / embryos, and redeployed. When possible, egg mats were replaced with drift nets that were fished for a short duration (1 – 3 hours) while the crew was on site sampling, or overnight between the two days of weekly sampling (16 – 24 hours). Drift nets created more drag in the water current than egg mats, therefore, were only deployed at locations and during discharge conditions where it was feasible and safe to do so. After retrieving the drift nets, they were replaced with egg mats that were left to sample until the following week. Larval dispersal sampling occurred on Sep 03 – 04 2024 using drift nets within rKm 228.

Sample sites were located between rKm 225.0 and 229.0 between mid-channel and downstream river left (Figure 1). Eleven sites were sampled in 2024 (rKm 225.0M, 225.5Ma, 227.8M, 227.9L, 228.1M, 228.5M, 228.5Ma, 228.5Mb, 228.6M, 228.8L, 228.9M). Labels included "M" (mid-channel), and "L" (shore-set); a lowercase "a" or "b" were used when one site had two sets of sampling gear. Exact locations may have been modified slightly in the field depending on river conditions. Sampling did not occur on river right or upstream of rkm 229.0 since eggs and larvae were not captured at these locations between 2012 and 2019 (Wood 2019). This study design was intended to provide comparable monitoring to previous years, while not expending effort in areas unlikely to catch eggs and larvae. For complete site location data see Appendix B – 2024 Data.

Due to high water velocities and fluctuating flows from REV, some of the mid-set anchor systems were dislodged and moved downstream while crews were not on site. If displaced anchor systems were still located within the spawning area and situated where the equipment could effectively sample, the anchor systems were left at the new location. Anchor systems that were displaced to locations where catching eggs or larvae was unlikely were re-set at their original locations.

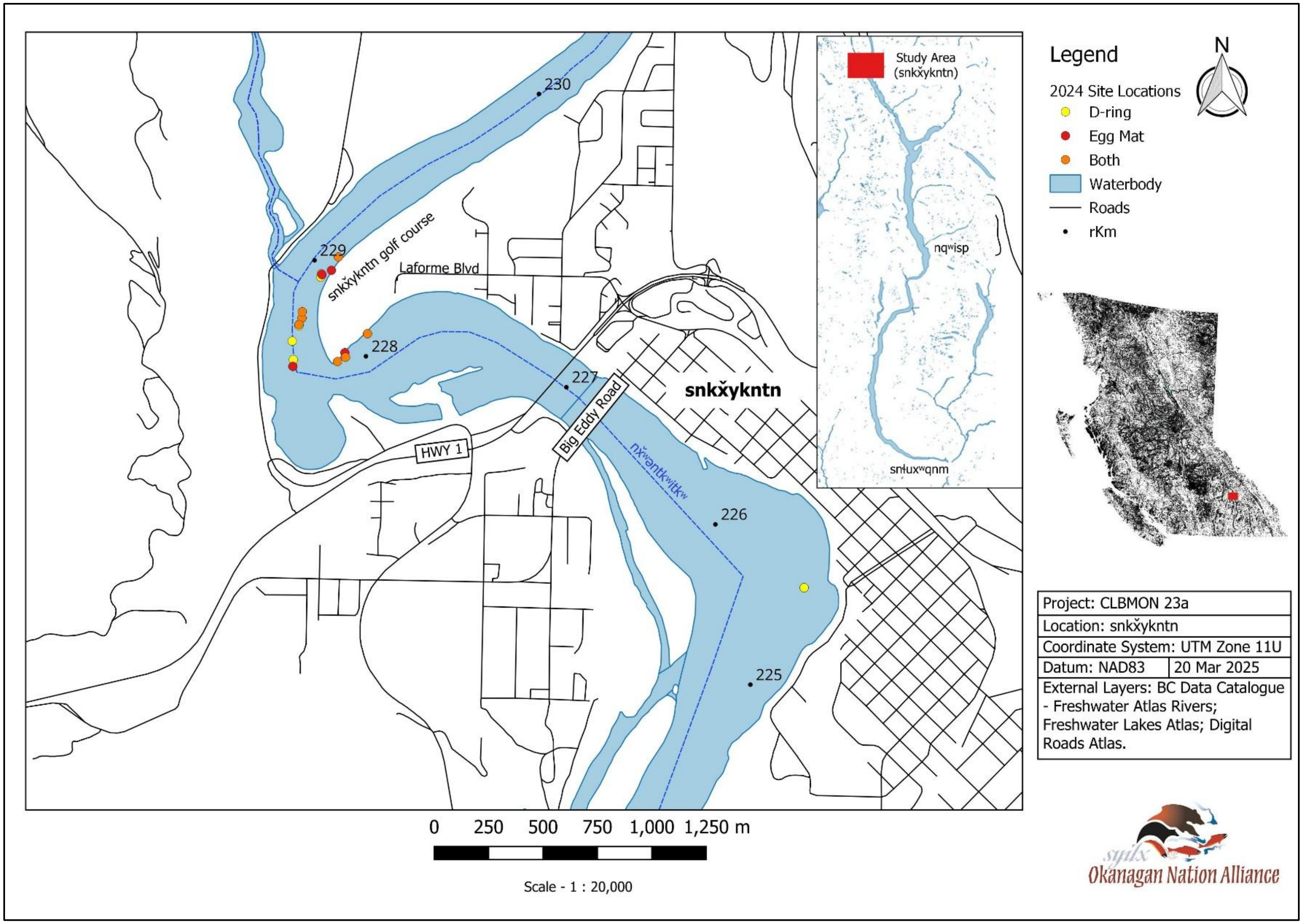

Figure 1. Location of drift net and egg mat sampling in the nx̌ʷəntkʷitkʷ near snkx̌yknt̓n during CLBMON-23A in 2024 (some sites overlap).

2.4 Study Period

Activities and the timing of sampling in 2024 were consistent with previous years. Sampling occurred during the suspected spawning window and early life history phases of c̓əmtus (Table 1). Larval (yolk sac) dispersal monitoring occurred briefly in early September, as larvae were detected at rKm 228.5.

Table 1. Summary of CLBMON-23A sampling activities in the nx̌ʷəntkʷitkʷ near snkx̌yknt n during 2024 relative to the suspected timing of c̓əmtus spawning and early life developmental stages.

CLBMON-23A Sampling			c̓əmtus Early Life History (suspected)[1]			
Session	Activity	Date	Spawning	Yolk Sac / Hiding Phase	Larval Dispersal	Date Range
1	Deploy egg mats; drift net sampling	Jul 31 - Aug 02				Jul 24 - Aug 1
2	Egg mat and drift net sampling	Aug 06 - 08				
3	Egg mat and drift net sampling	Aug 13 - 15				Aug 7 - 22
4	Egg mat retrieval; drift net sampling	Aug 19 - 20				
5	Drift net sampling	Aug 26 - 27				Aug 28 - Sep 13
6	Drift net sampling	Sep 03 - 04				
No sampling conducted						Sep 18 - Oct 2
No sampling conducted						Oct 09 - Nov 13

[1]These are approximate timings based on typical nx̌ʷəntkʷitkʷ water temperature of approximately 9 – 11°C and the developmental rates reported in the literature (Beer 1981; Wang et *al.* 1985; Wang et *al.* 1987; Parsley et *al.* 2011). These authors reported 13 days to hatch and 30 days to completion of yolk absorption at 11°C. With the slightly cooler temperatures in the nx̌ʷəntkʷitkʷ near snkx̌yknt n, this table assumes 14 – 20 days post fertilization for hatch and 30 - 40 days post fertilization for completion of yolk sac absorption.

2.5 Egg and Larval Samples

All c̓əmtus eggs collected were developmentally staged in the field. Eggs were removed from egg mats or drift nets and carefully transferred using forceps or spoons to small containers filled with river water. Eggs were examined using a hand magnifying lens and developmental stages were assigned using the stages (1 to 36) identified by Dettlaff et *al.* (1993) and further described by Jay et *al.* (2016). Eggs captured between July 31 and Aug 02 were transported directly to the hatchery, as forest fires in the Slocan Valley delayed operation of the streamside facility. Following Aug 02, all live eggs were held in insulated coolers filled with ambient river water and transferred the day of capture to the streamside facility located at the snkx̌yknt n golf course. Any deceased eggs were preserved in 90% ethanol and provided to BC Hydro for future genetic analysis.

2.6 Data Collection

Hourly discharge from REV and reservoir water surface elevation in ALR at nqʷisp (Nakusp BC; 08NE104) were obtained from BC Hydro's Columbia Basin Hydrological Database. Two temperature loggers (HOBO TidbiT v2) were deployed to sample water temperature every hour and were secured to a sampling set anchor at rKm 228.6M and 228.1M.

Data recorded at each sample site during egg mat and drift net sampling included the following:

- Site Name
- GPS location
- Deploy and retrieval date/time
- Deploy and retrieval water temperature (°C)
- Deploy water depth
- Number of eggs and larvae collected (live)
- Number off eggs and larvae preserved
- Developmental Stage of eggs and Larvae
- Set/pull comments

Data was recorded in the field on standardized datasheets, digitized as a back-up, and later entered into Microsoft Excel for analyses.

2.7 Stranding Risk

The risk of egg stranding due to hydroelectric operations was identified as a key uncertainty (BC Hydro 2019) and was qualitatively assessed for all years of the monitoring program (2007 to 2024). The incidence, timing, and developmental stage of captured eggs or embryos were used to identify time periods when early life stages were present in the study area and would be vulnerable to stranding during discharge reductions. The periods when early life stages were present were calculated using the developmental stage of eggs/larvae captured and temperature-dependent developmental rates to cover the entire developmental period from fertilization to yolk sac absorption and dispersal. For these calculations, spawn timing was obtained from the present report for 2024 and from annual reports of the monitoring program for previous years (2007–2022).

There is some uncertainty in developmental rates of ċəmtus in the cool water temperatures of the nx̌ʷəntkʷitkʷ near snkx̌ykntn (Parsley et *al.* 2011). Beer (1981) found that egg hatch occurred 11 days after fertilization at 10°C, which is similar to typical water temperature in the nx̌ʷəntkʷitkʷ near snkx̌ykntn during the spawning period. However, a study mimicking the temperature regime of the nx̌ʷəntkʷitkʷ near snkx̌ykntn found that hatch occurred 13 to 16 days post-fertilization at water temperatures of approximately 10 – 11°C (Parsley et *al*. 2011). During the yolk-sac larva phase, development took 14 days post hatch to reach the exogenous feeding and larval dispersal phase at 12.5°C (Jay et *al*. 2020). As water temperature in some years in the nx̌ʷəntkʷitkʷ near snkx̌ykntn can be cooler (9 – 11°C) than these laboratory studies, it was assumed that it takes 13 to 20 days post-fertilization for hatch, and 30 to 40 days post-fertilization for complete absorption of the yolk sac, swim-up, and beginning of dispersal. Therefore, for the stranding assessment it was assumed that there were early life stages (eggs or yolk-sac larvae) present in the spawning and incubation area from the first detected spawning event until 40 days after the last detected spawning event in each year.

For the period when early life stages were present (hereafter, the “risk period”), hourly discharge data from REV and ALR surface elevation data were used to identify periods when there were reductions in river stage that could have stranded eggs or larvae of ċəmtus. Hourly discharge values were compared to the maximum of previous hourly discharges that year to infer whether the river stage was lower than it had been previously during the spawning and incubation period.

Based on the magnitude of the difference in river discharge, the river stage, and the assumed backwatering effect of ALR, stranding risk was categorized as “No Risk”, “Low”, “Medium”, “High”, or “Very High” for each hour of the risk period.

When developing rules to assign stranding risk, it was assumed that relatively larger differences between current and previous maximum discharge resulted in relatively larger amounts of substrate being dewatered, which in turn resulted in relatively higher stranding risk. In addition, it was assumed that stranding risk was generally higher when the river stage was lower, especially during discharges lower than the current minimum flow of 142 m^3/s (implemented in 2010). This second assumption was based on locations of egg capture and egg stranding surveys from earlier years of the monitoring program, which suggested that a greater proportion of eggs are deposited at lower elevations of the river bed close to the thalweg than in upper elevations. A third assumption was that the magnitude of reduction that increased risk depended on river stage, where smaller reductions resulted in more risk at low river stage than at high river stage. The rules used to assign stranding risk are presented below and summarized in Table 2:

- If ALR surface elevation was greater than or equal to 437 masl (metres above sea level), the spawning and incubation areas were backwatered, which moderated the effect of discharge reductions (Wood 2019), resulting in a classification of “No Risk”.
- If discharge was high (≥1000 m^3/s), it was assumed that the spawning and incubation areas were not dewatered, and stranding risk was classified as “Low”, regardless of how much higher discharge had been previously.
- If discharge was medium (500–999 m^3/s), stranding risk was “Low” if the difference between the current and previous maximum discharge was less than 200 m^3/s and “Medium” if the difference was greater than 200 m^3/s.
- If discharge was low (142–499 m^3/s), stranding risk was “Low” if the difference between the current and previous maximum discharge was less than 99 m^3/s, “Medium” if the difference was between 100 and 199 m^3/s, and “High” if the difference was greater than 200 m^3/s.
- If discharge was very low (<142 m^3/s), stranding risk was “Very High” if the difference between the current and previous maximum discharge was greater than 100 m^3/s, “High” if the difference was between 50 and 99 m^3/s, and “Medium” if the difference was less than 50 m^3/s.

Table 2. Definitions of relative stranding risk based on discharge and the difference between current discharge and previous maximum hourly discharge during the risk period for c̓əmtus eggs and larvae.

River Stage	Discharge (m^3/s)	Difference between current hourly discharge and previous maximum of hourly discharge that year (m^3/s)			
		<50	50-99	100-199	>200
Very Low	<142	Medium	High	Very High	Very High
Low	142 - 499	Low	Low	Medium	High
Medium	500 - 999	Low	Low	Low	Medium
High	>1000	Low	Low	Low	Low

Stranding risk was assigned to each hour of the risk period using these rules. For each day, stranding risk was assigned based on the highest risk category assigned to hourly observations that day. The values used in these rules assigning stranding risk were based on best judgement but were somewhat arbitrary because informative data (hydraulic modelling, densities of eggs stranded at different river stages, etc.) were not available. Therefore, risk rankings should not be interpreted in an absolute sense, such as “High Risk” meaning that a large number of eggs or larvae were stranded. These rankings provide an initial effort to categorize the potential for stranding in historical years and should be used for comparisons of the relative risk within and between years. If informative data, such as substrate dewatering by discharge level and egg densities, are gathered in the future, then the values used in the stranding risk classification could be adjusted accordingly. Alternative cutoff values for the classification rules could also be trialed to assess sensitivity to these assumptions and how they affect predictions of stranding risk.

This relatively simple risk ranking made numerous simplifying assumptions that were untested. Some of these assumptions include the following:

- Eggs and yolk-sac larvae were present at all elevations of the riverbed on all subsequent days of the risk period after the river stage had reached that level once. This is a large and potentially influential assumption but was required because the extent of egg deposition, and how operations may affect this distribution in the study area are not known. In addition, the discharges at which various incubation substrates were dewatered would require a hydraulic model (which was not available for this analysis). Classification rules reflect that it is less likely that eggs and larvae were distributed into higher elevation substrates during daily maximum discharges, and that eggs and larvae were more likely to be found in lower elevation substrates. These rules were intended to minimize the influence of this assumption on the stranding risk assessment.
- Eggs and yolk-sac larvae were equally vulnerable.
- The duration or frequency of substrate dewatering did not influence the risk. As such, the risk rankings should be considered the relative risk of being dewatered at least once, for at least one hour in duration.
- High reservoir surface elevations (i.e., greater than 437 masl) eliminated substrate dewatering and stranding risk in the incubation area.

The degree to which violations of these assumptions affect relative risk is not known. Therefore, the risk classification should be interpreted as the potential for egg or larvae stranding in relative sense only. Standing risk analyses and subsequent figures and tables provided in this report were completed via R-Project (version 4.2.2) using a script developed by Golder Associates Ltd. (now WSP; Golder and ONA 2020). This script is available in Appendix A.

A brief stranding survey, consisting of six one-meter by one-meter plots next to the wetted edge of the exposed bar, occurred on August 13 2025 when discharge from REV was ~ 325 cms (Figure 2). The exposed interstitial substrate was carefully inspected for c̓əmtus eggs; rocks were carefully overturned and inspected, ensuring eggs were not stuck to the bottom.

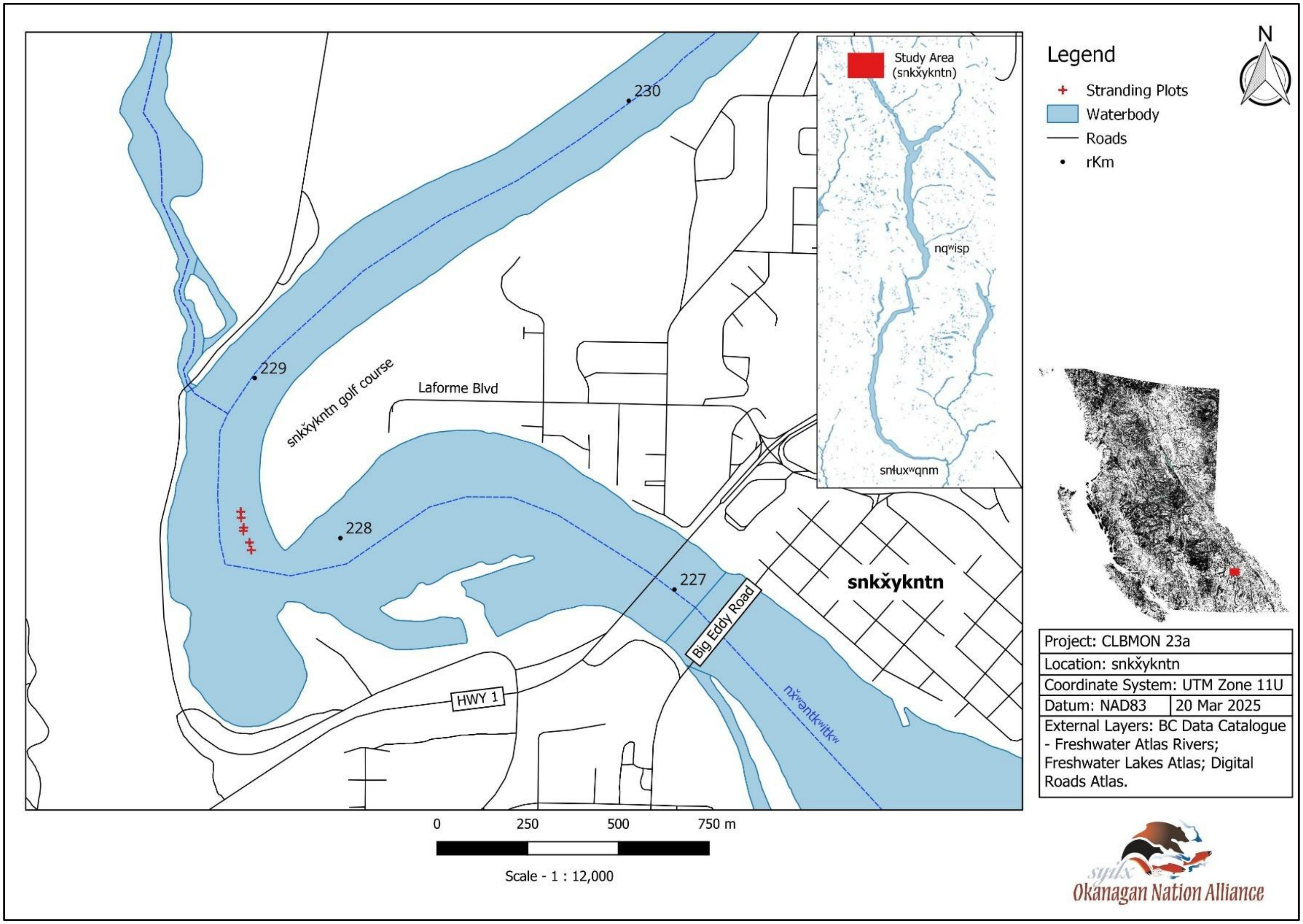

Figure 2. Stranding survey locations for c̓əmtus eggs on August 13 2024 (wetted area of nx̌ʷəntkʷitkʷ pictured not representative of conditions).

2.8 Data Analysis

Spawn timing (spawning dates) was estimated from the date of egg collection using the egg developmental stage, the mean-daily water temperature (via Tid-bits), and temperature-dependent rates of development reported in the literature (Dettlaff et *al.* 1993; Parsley et *al.* 2011). The number of discrete spawning events was then estimated based on the estimated spawning times within 24 hours.

Sampling effort (hours) was calculated from deploy and retrieval dates and times. Catch-per-unit-effort (CPUE) was calculated by dividing the total number of eggs/larvae by the total sampling effort for both egg mats and drift nets. QGIS software (version 3.28.3) was used to map the location of sample sites and egg and larvae capture locations.

3.0 Results

3.1 Sampling Effort and Catch

From Jul 31 – Aug 19 2024, seven to ten sites were sampled each session for a total of 24 egg mat sets (Table 3) resulting in the capture of 3 deceased ċəmtus eggs.

Table 3. Egg mat sampling effort in the nx̌ʷəntkʷitkʷ near snkx̌ykntn during CLBMON-23A in 2024.

Dates	Effort (mat-hours)	# Sites Actual
Jul 31 – Aug 07	868	10
Aug 07 – 14	1,127	7
Aug 14 - 19	792	7

From Jul 30 – Sep 04 2024, nine sites were sampled with 42 drift net sets (23 day sets and 19 night sets), which resulted in the capture of 155 ċəmtus eggs (116 alive and 39 mortalities) and 13 larvae (all mortalities; Table 4). Total drift net CPUE was 0.41 ċəmtus/hour with a total effort of 408 hours. Day sets were deployed for 2 – 6 hours while night sets were deployed for 15 – 20 hours. Two nets were damaged during the 2024 season (night sets) resulting in 31 hours of lost effort. The majority of eggs were captured at stations 228.5M (79% of catch), with 99% of eggs captured in rKm 228 (Figure 3; Table 5).

Table 4. Drift net sampling effort for day and night sets including catch of ċəmtus progeny and associated Catch-Per-Unit-Effort (CPUE) in the nx̌ʷəntkʷitkʷ near snkx̌ykntn.

Dates	Day / Night	Effort (net-hours)	# of Sets	# Eggs Live (Dead)	# Larvae Live (Dead)	CPUE (#/h)
Jul 30 – Aug 02	Day	26	8	37 (11)	0	1.86
	Night	63	4	54 (3)	0	0.90
Aug 06 – 08	Day	18	4	4 (4)	0	0.44
	Night	101	6	21 (21)	0	0.41
Aug 13 – 15	Day	23	5	0	0 (1)	0.04
	Night	56	3	0	0 (2)	0.04
Aug 19 – 20	Day	8	3	0	0 (1)	0.12
	Night	34	2	0	0 (8)	0.24
Aug 26 - 27	Day	9	3	0	0	0
	Night	35	2	0	0 (1)	0.03
Sep 03 - 04	Day	0	0	0	0	0
	Night	34	2	0	0	0

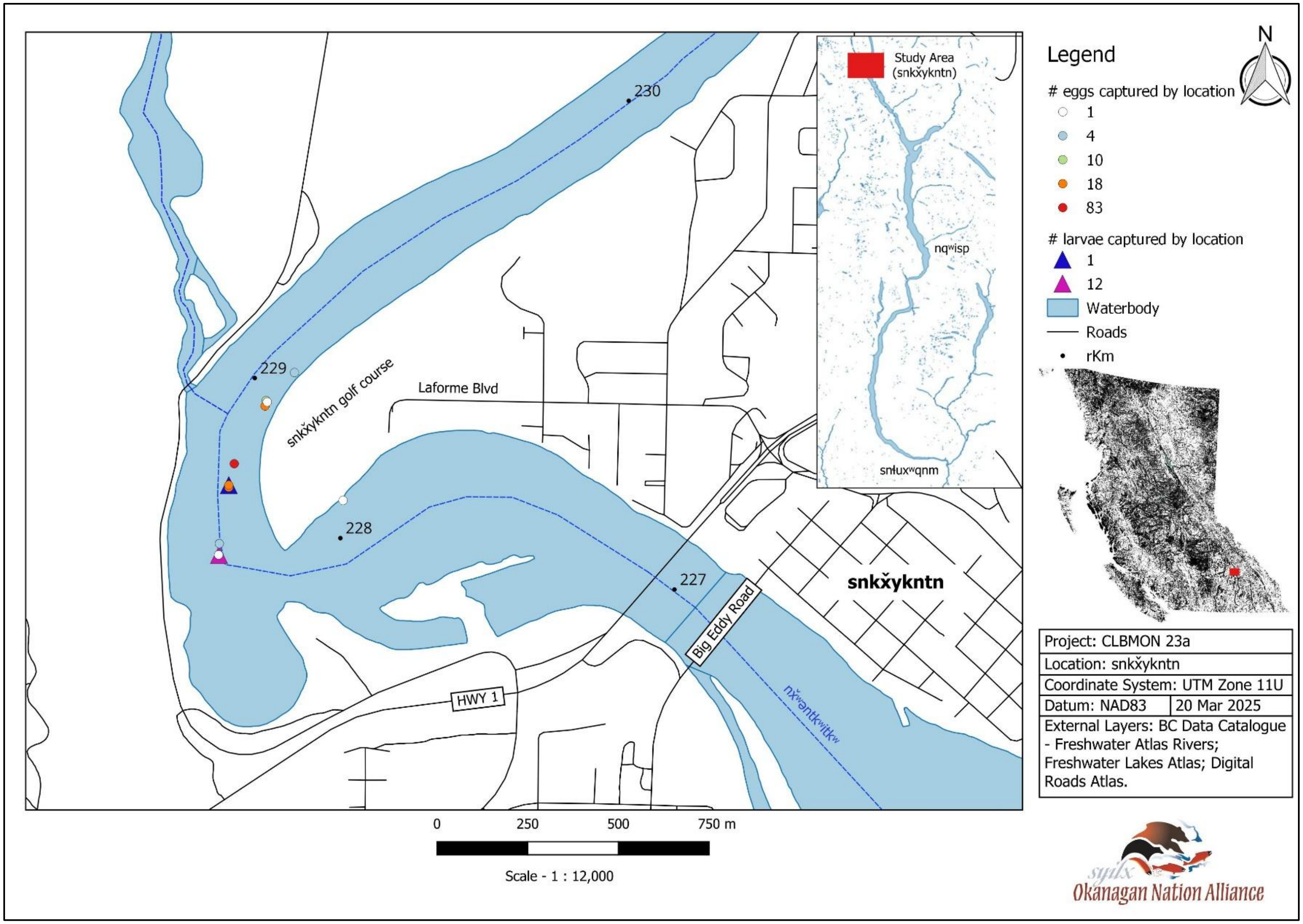

Figure 3. **Capture locations of c̓əmtus eggs and larvae via drift net sampling in the nx̌ʷəntkʷitkʷ near snkx̌yknt̓n during CLBMON-23A in 2024.**

Table 5. **Temporal (columns) and geographical (rows) data of all drift net sampling effort (greyed boxes) including the number of c̓əmtus egg captures (green boxes) followed by larval captures in brackets. Data collected in the nx̌ʷəntkʷitkʷ near snkx̌yktn.**

Station	July	August										September	Total
	31	01	02	07	08	14	15	19	20	26	27	04	
225.0M													
225.4M													
225.5M													
227.8M		1											1
228.1M													
228.5M		81	13	13	15	0(1)	0(2)	0(1)	0(8)		0(1)		122(13)
228.6M		10		18									28
228.8M													
228.9M				4									4

3.2 Developmental Staging and Estimated Spawn Timing

Based on capture dates, water temperature, and egg development stages, two spawning events occurred in 2024 (Aug 01 and Aug 04; Table 6).

Table 6. **Estimated c̓əmtus spawn dates based on developmental stages (Parsely et *al*. 2011; Dettlaff et *al*. 1993) of eggs and larvae captured in the nx̌ʷəntkʷitkʷ near snkx̌yktn during CLBMON-23A in 2024. Hours post fertilization calculated using daily-average water temperature (from the day before capture) and developmental stage (Parsely et *al*. 2011).**

Capture Date	Type	# Captured Eggs (Larvae)	Dettlaff / Parsely Stage	Hours Post Fertilization	Estimated Spawn Date
Aug 01 AM	Eggs	44	1,2/15,16	0 - 3	Aug 01
Aug 01 PM	Eggs	48	2,6,7/12,15,16	0 - 15	Aug 01
Aug 02	Eggs	13	8,9/16,17	15 - 22	Aug 01
Aug 08	Eggs	15	17 – 29/22 - 26	75 - 128	Aug 04
Aug 14/15	Larvae	0 (3)	36/27+	256+	Aug 04

3.3 Discharge, Reservoir Elevation, and Water Temperature

During sampling in 2024, discharge in nx̌ʷəntkʷitkʷ near snkx̌yktn exhibited large daily fluctuations that are typical for the hydropeaking operations at REV (Figure 4). Daily peak discharge during the sampling period ranged from 302 – 1,734 cms and minimum discharge ranged from 255 – 391 cms.

In 2024, ALR water surface elevation averaged 433.7 MASL at the start of the sample period on Jul 31 and gradually declined to 428.9 MASL by the end of the sample period on Sep 04 (Figure 5). The ALR water surface elevation did not reach 437 MASL, the level above which the spawning area is backwatered, from May 01 to Oct 31. Therefore, the spawning area was not backwatered at any time during sampling.

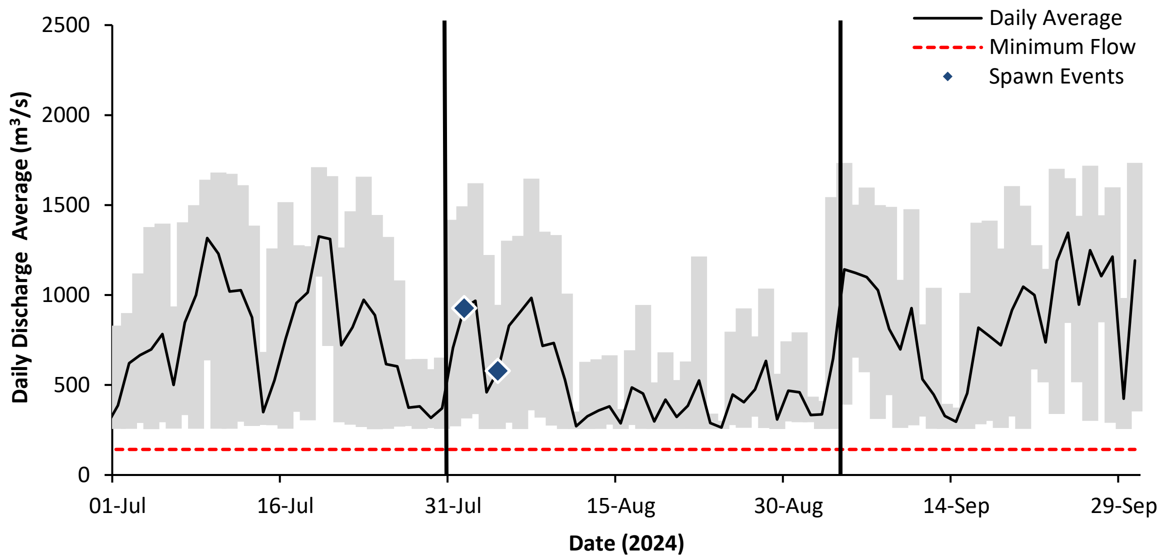

Figure 4. **Average-daily discharge (black; cms) from Revelstoke Dam in 2024 compared to the minimum flow requirement (142 cms) with daily minimum and maximum flows shaded in grey. CLBMON-23A c̓əmtus monitoring occurred between vertical black lines and the dates of the suspected c̓əmtus spawning events are identified by blue diamonds.**

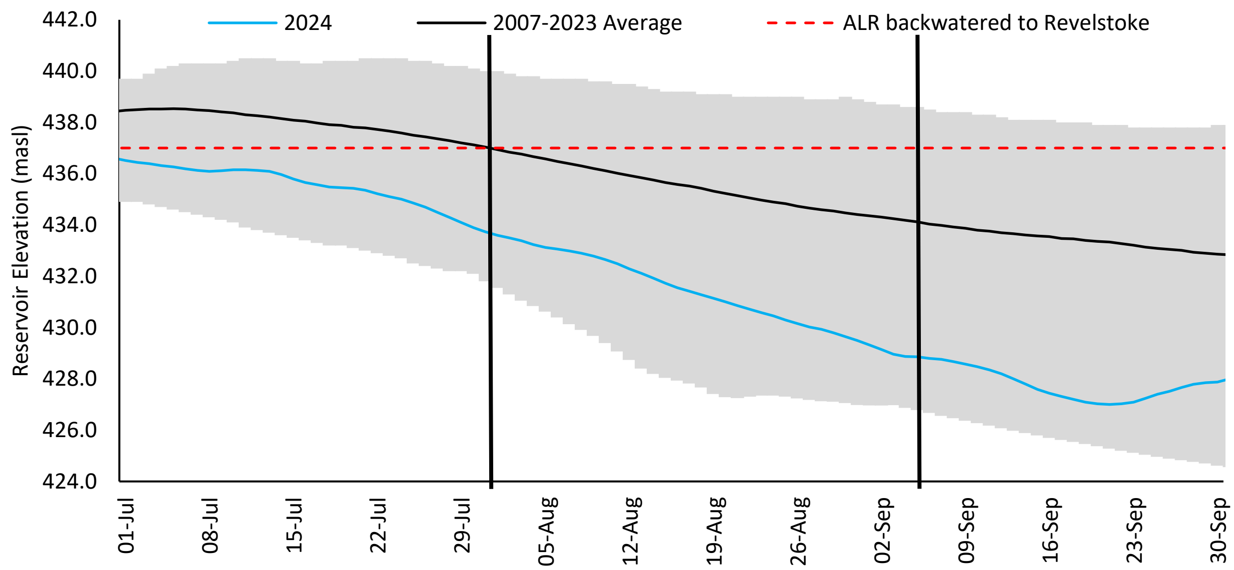

Figure 5. **Average-daily Arrow Lakes Reservoir (ALR) water surface elevation at nqʷisp from July to September 2024 compared to the level at which the reservoir is backwaters the spawning and incubation area (red dashed line) of c̓əmtus near snkx̌ykntn (437 MASL; Hildebrand et *al*. 2014). The greyed area shows the variation in reservoir elevation from 2007 – 2024 (minimum and maximum average daily values). CLBMON-23A c̓əmtus monitoring occurred between vertical black lines (approximate).**

Water temperature tidbits were deployed at 228.1M and 228.6M between Jul 31 and Sep 04 2024. However, upon retrieval, these units were both corrupted or damaged. Water temperature data was provided by BC Hydro from station TR2 near snkx̌ykntn golf course. Data from this station may not be calibrated or QA/QC'd. Water temperature during the sampling period ranged from 9.4°C (Aug 05) to 12.7°C (Aug 07) and averaged 10.6°C ± 0.22°C (with 95% confidence; n = 32; Figure 6).

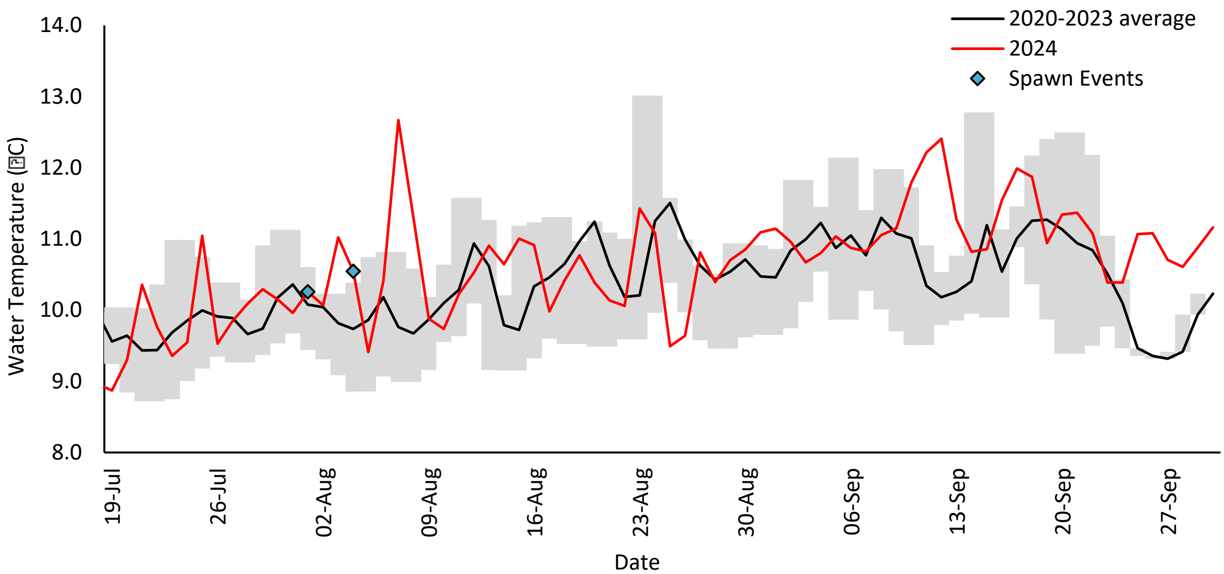

Figure 6. **Average-daily water temperature in the nx̌ʷəntkʷitkʷ near snkx̌ykntn measured at BC Hydro Station TR2. The greyed area shows the variation in water temperature (minimum and maximum average daily values). The timing of the c̓əmtus spawning event is identified by a blue diamond.**

3.4 Stranding Risk

In 2024, relative stranding risk was assessed as High for the majority of the risk period, except for a brief time in September, when it was Medium. In total, 95% of days during the risk period were identified as "High" risk, while 5% were "Medium" risk. However, when assessing the risk period by hour 17% of hours were considered "Low" risk, with 27% of hours "Medium" risk, and 56% of hours were "High" risk. Stranding was not detected during surveys in 2024.

4.0 Discussion

c̓əmtus spawning was documented in nx̌ʷəntkʷitkʷ near snkx̌ykntn in 2024 and was estimated to have taken place between Aug 01 and Aug 04. In previous years of the program, spawning dates have ranged between Jul 21 and Sep 05 and up to six spawning events have been detected within a year. Spawning has now been detected in 18 of the 23 years that monitoring has been conducted in nx̌ʷəntkʷitkʷ near snkx̌ykntn, and annually since 2015. This suggests a large enough adult population for annual spawning. Assuming the adult c̓əmtus population sex ratio in saltiḱʷt is similar to the population downstream of HLK Dam (1:1; Hildebrand and Parsley 2013), there may be more than the estimated 25 adults remaining in nx̌ʷəntkʷitkʷ near snkx̌ykntn; based on the intermittent spawning (2 – 4 years, increasing with age) of female c̓əmtus and annual spawning capability of male c̓əmtus. On-going genetics analyses using collected c̓əmtus eggs and larvae will provide an estimate of the number of adult c̓əmtus that have contributed to collected progeny.

A total of 171 c̓əmtus progeny (158 eggs and 13 larvae) were captured in 2024; mostly in drift nets (98%) and the majority in overnight sets (65%). 42 eggs were visibly deceased and preserved in ethyl alcohol for DNA analysis while the other 116 were placed in the streamside facility before being transferred to the Freshwater Fisheries Society on Sep 04 for transportation to the Kootenay Trout Hatchery near Wardner, BC. Prior to 2020, crews followed a set schedule and sampled set locations. Maintaining an adaptive schedule is recommended to increase capture success in future years of the program.

4.1 Management Questions

The Management Questions outlined in the Terms of Reference for CLBMON-23A have been addressed in previous years of this program (Wood et *al.* 2019); however, results from 2024 can be used to update Management Questions 2 and 4:

Management Question 2:

How do dam and reservoir operations affect egg and larval survival in this area? Specifically, do significant numbers of eggs become dewatered as a result of operations?

> Survival of eggs or larvae can't be estimated given limited numbers of progeny collected and the expected naturally high rates of mortality for early c̓əmtus life stages. The stranding risk analyses were updated through 2024. ALR backwatering of the nx̌ʷəntkʷitkʷ near snkx̌ykntn did not occur in 2024 due to abnormally low reservoir levels; as a result, 95% of the spawning period was considered "High" risk. This matches the highest observed risk since 2008 (95.0% in 2019). "Very High" risk has not been documented since minimum flows at REV were implemented. This assessment is based on several untested assumptions and the rankings should be considered as the potential for stranding due to discharge variability, and only in a relative sense within and between years. Stranding was assessed during the high-risk period in 2024, but no stranding was observed.

Management Question 4:

What is the most effective method for monitoring spawning of c̓əmtus?

> The most effective methods for monitoring c̓əmtus in the MCR is a combination of drift nets and egg mats (Wood 2019; Golder and ONA 2020). While capture efficiency is lower with egg mats, they can be deployed continuously throughout the spawning period to detect events. Drifts nets are more labour intensive but have higher catch rates to further describe timing and frequency of spawning events and provide progeny to meet conservation aquaculture objectives. Throughout this program, a total of 112 progeny have been captured using egg mats (CPUE = 0.01 c̓əmtus /24 hours) and 1,386 using

drift nets (CPUE = 5.85 c̓əmtus /24 hours). In 9 of the 18 years of this program, egg mats were the initial method of capture for c̓əmtus progeny and were the only method of capture for two of those years. Drift nets were the initial method of capture in six years; three of those years being the only method of capture.

This data report is intended to detail the methods and results of monitoring in 2024. For further discussion of the status of management questions and comparisons between previous study years, readers are referred to the interpretive reports from previous years of this monitoring program (Wood 2019; Golder and ONA 2020).

4.2 Summary of Effort, Catch, and Survival (2007 – 2024)

Egg mat effort was relatively consistent between 2007 and 2018, with the exception of 2012. In 2019 an adaptive study design was adopted, and as a result egg mat effort was focused on sites with previous c̓əmtus captures. Therefore, the amount of egg mat sample sites was reduced in 2019 – 2024 compared to 2007 – 2018 (Table 7; Figure 7). In contrast, drift net effort has increased in 2020 – 2024 compared to 2007 – 2019. This is due to overnight sampling effort and the frequent re-deployment of sets that slip or drift due to high flows (rather than removing those sets).

Table 7. Summary of annual expected effort, c̓əmtus (WSG) egg and larvae captures, and associated Catch-Per-Unit-Effort (CPUE) in nx̌ʷəntkʷitkʷ near snkx̌ykntn during CLBMON-23A from 2007 to 2024.

Year	Egg Mats				Drift Nets				Total
	Egg Mats Deployed	Effort (hours)	# WSG	CPUE (# / h)	Drift Nets Deployed	Effort (hours)	# WSG	CPUE (# / h)	
2024	24	2,787	3	0.0011	42	407.7	168	0.41	171
2023	27	3,859	0	-	47	627.9	47	0.07	47
2022	25	3,743	0	-	58	537.4	20	0.04	20
2021	27	6,378	1	0.0002	53	578.6	701	1.21	702
2020	30	4,215	1	0.0002	67	825.5	230	0.28	231
2019	82	11,569	2	0.0002	52	148.5	10	0.07	12
2018	140	23,068	6	0.0003	71	387.2	93	0.24	99
2017	143	23,263	7	0.0003	66	379.5	2	0.01	9
2016	140	22,771	1	< 0.0001	55	341.6	0	-	1
2015	132	21,560	0	-	60	311.0	0	-	0
2014	123	20,850	19	0.0009	64	375.9	38	0.10	57
2013	135	20,019	2	0.0001	67	424.3	0	-	2
2012	61	8,773	0	-	28	106.8	8	0.07	8
2011	128	22,169	30	0.0014	23	61.2	18	0.29	48
2010	96	20,514	0	-	15	67.4	0	-	0
2009	115	18,860	36	0.0019	22	65.3	47	0.72	83
2008	164	27,009	4	0.0001	6	12.6	4	0.32	8
2007	136	25,818	0	-	8	24.7	0	-	0
WSG Total			**112**				**1,386**		**1,498**

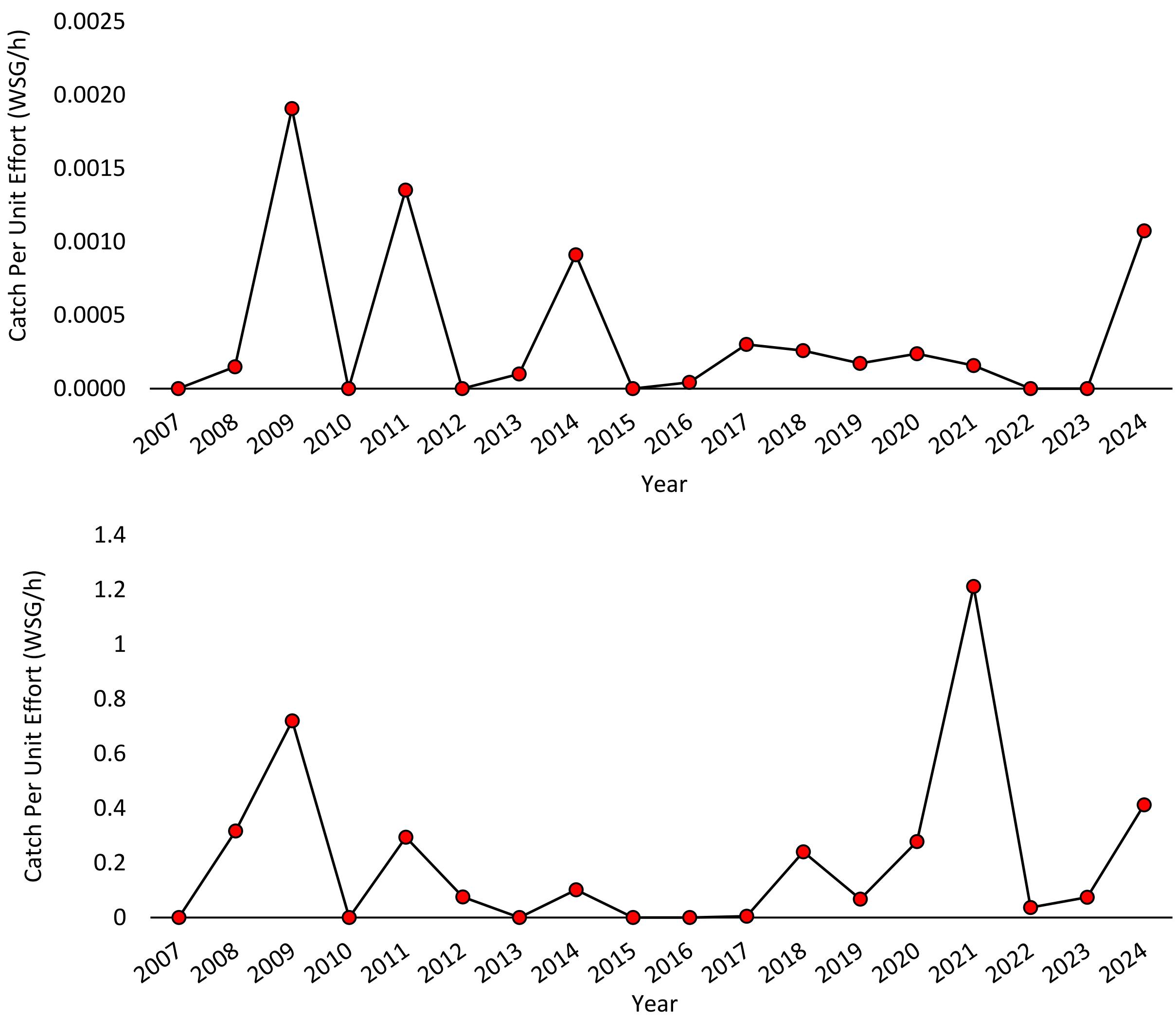

Figure 7. **Catch per Unit Effort of c̓əmtus (WSG) in c̓əmtus per hour (h) using egg mats (top) and drift nets (D-ring; bottom) between 2007 and 2024 in nx̌ʷəntkʷitkʷ near snkx̌yknt̓n on CLBMON 23a.**

c̓əmtus capture success appeared to be highest between Jul 22 and Aug 25, typically at rkm 228.1, 228.5, and 228.6 (Table 8). Effort in 2019 – 2024 has been focused on rkm 227.8 and 229.0, which may skew results.

Table 8. ċəmtus captures (egg and larvae) by week from July 22 to September 15 (2007 – 2024) and rkm for all capture methods.

Site (rKm)	Date (2007 - 2024)								Total (Location)
	July 22 - 28	July 29 - Aug 4	Aug 5 - Aug 11	Aug 12 - Aug 18	Aug 19 - Aug 25	Aug 26 - Sep 1	Sep 2 - Sep 8	Sep 9 - Sep 15	
230.6					1				**1**
230.3					1		1		**2**
230				7	14	3			**24**
229.9				4	3				**7**
229.8			1		1	1	1		**4**
229.7				1					**1**
229.5			3	1					**4**
229.4		2	2	2	8	17			**31**
229.3			14	1	1		2		**18**
229.2			2						**2**
229.1		2	6			1			**9**
229			3		2				**5**
228.9		11	16		4				**31**
228.8		5	4	8	2	5	10		**34**
228.7			3	1	1				**5**
228.6	45	39	70	2	27				**183**
228.5	101	125	94	48	543*	7		1	**919**
228.2				1	3				**4**
228.1	11	39	82	15	3				**150**
227.9		1	10	4	1	2		11	**29**
227.8	3	8	13	3	4				**31**
227.4							1		**1**
226.8				3					**3**
Total (Date)	**160**	**232**	**323**	**101**	**619**	**35**	**15**	**12**	

* 529 of 543 ċəmtus captured at this location in this week were from 2021.

Over the program, egg mats were the method of initial capture in 9 of the 18 years and were the only method of capture in two years (Table 9). In years where initial capture of ċəmtus progeny occurred on the same day with both methods, it was assumed egg mats were checked before drift nets. Drift nets were the only method of capture in three years and were the method of first capture for the past four years.

Table 9. Date of initial ċəmtus capture (eggs or larvae) by method; the first capture for the year is highlighted in green.

Year	Egg Mat	D-Ring
2007	-	-
2008	31-Jul	1-Aug
2009	6-Aug	13-Aug
2010	-	-
2011	31-Jul	10-Aug
2012	-	1-Aug
2013	7-Aug	-
2014	30-Jul	29-Jul
2015	-	-
2016	11-Aug	-
2017	26-Jul	3-Aug
2018	8-Aug	8-Aug
2019	1-Aug	1-Aug
2020	28-Jul	-
2021	10-Aug	4-Aug
2022	-	15-Aug
2023	-	9-Aug
2024	6-Aug	1-Aug

* Reports from previous years of the monitoring program are available online at: https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/columbia-sturgeon.html

Survival rate (to release from the hatchery) of collected ċəmtus progeny has ranged from 11% to 27% (2018 – 2022), while survival of progeny collected in 2023 and 2024 appear to be outliers at 87% survival and 0% survival respectively (as of April 14 2025; pers. comm., Mike Keehn, Freshwater Fisheries Society of British Columbia, 2025; Table 10). The ċəmtus progeny captured in 2024 did not survive to the feeding stage (pers. comm., Mike Keehn, Freshwater Fisheries Society of British Columbia, 2025).

Table 10. **The number of eggs and larvae received by the Freshwater Fisheries Society by year and the number of c̓əmtus that survived to release the respective release year; where red indicates survival to April 14 2025 (pers. comm., Mike Keehn, Freshwater Fisheries Society of British Columbia, 2025).**

Year	# Eggs Received	# Larvae Received	# Survive to Release	Release Year
2018	89	0	16	2018*
2019	7	2	1	2021
2020	195	2	42	2022
2021	685	0	78	2023
2022	19	0	7	2024
2023	0	32	28	2025
2024	64	0	0	2026

* pre two-year hold back.

Factors contributing to post-collection mortality are suspected to include:

- Harm from substrate and/or debris while in collection cups
- Harm from equipment drift (anchor tines disrupting substrate in high velocity flows)
- Harm from didymo (suffocation)
- Stress from immediate transport from collection site to hatchery

4.3 Summary of Stranding Risk (2007 – 2024)

Relative stranding risk was assessed when spawning events were detected between 2007 – 2024 (all years except 2007, 2010, and 2015; Figure 8). Some years (2008 and 2017) were classified as “No Risk” for the entire risk period. In years when ALR backwatered the incubation area for only part of the risk period (2011, 2012, 2018, and 2020), relative risk was classified as “No Risk” during the early part of the risk period while backwatering occurred, whereas relative risk was typically classified as “High” during the period when backwatering did not occur. In years when backwatering did not occur at all during the risk period (2013, 2014, 2016, 2019, and 2021 to 2024), relative risk was classified as “High” for most days with a small number of days classified as “Medium” risk. In 2009, relative stranding risk was “Very High” for most of the risk period due to the lack of a minimum flow release during that study year (minimum flows were implemented in 2010). In 2009, discharge was frequently reduced from between 500 to 1200 m^3/s to less than 0 m^3/s (Golder 2010).

A summary of the percentage of days during the risk period assigned to each risk category are shown in Table 11. The “High” risk category comprised the greatest percentage of days in years when ALR was not backwatering the incubation area (63% to 100% of days). The “Low” and “Medium” risk categories were assigned to a small percentage of days (≤7%) in all years except 2016 and 2020 – 2023 when 24 - 38% of the risk period was assigned “Medium” risk. In years before the implementation of a minimum flow release (2008 and 2009), daily risk was classified as “No Risk” for 100% of the days in 2008, when ALR elevation was high (>437 masl) and was classified as “Very High” for most (85.5%) days in 2009, when ALR elevation was low and backwatering of the incubation area was limited.

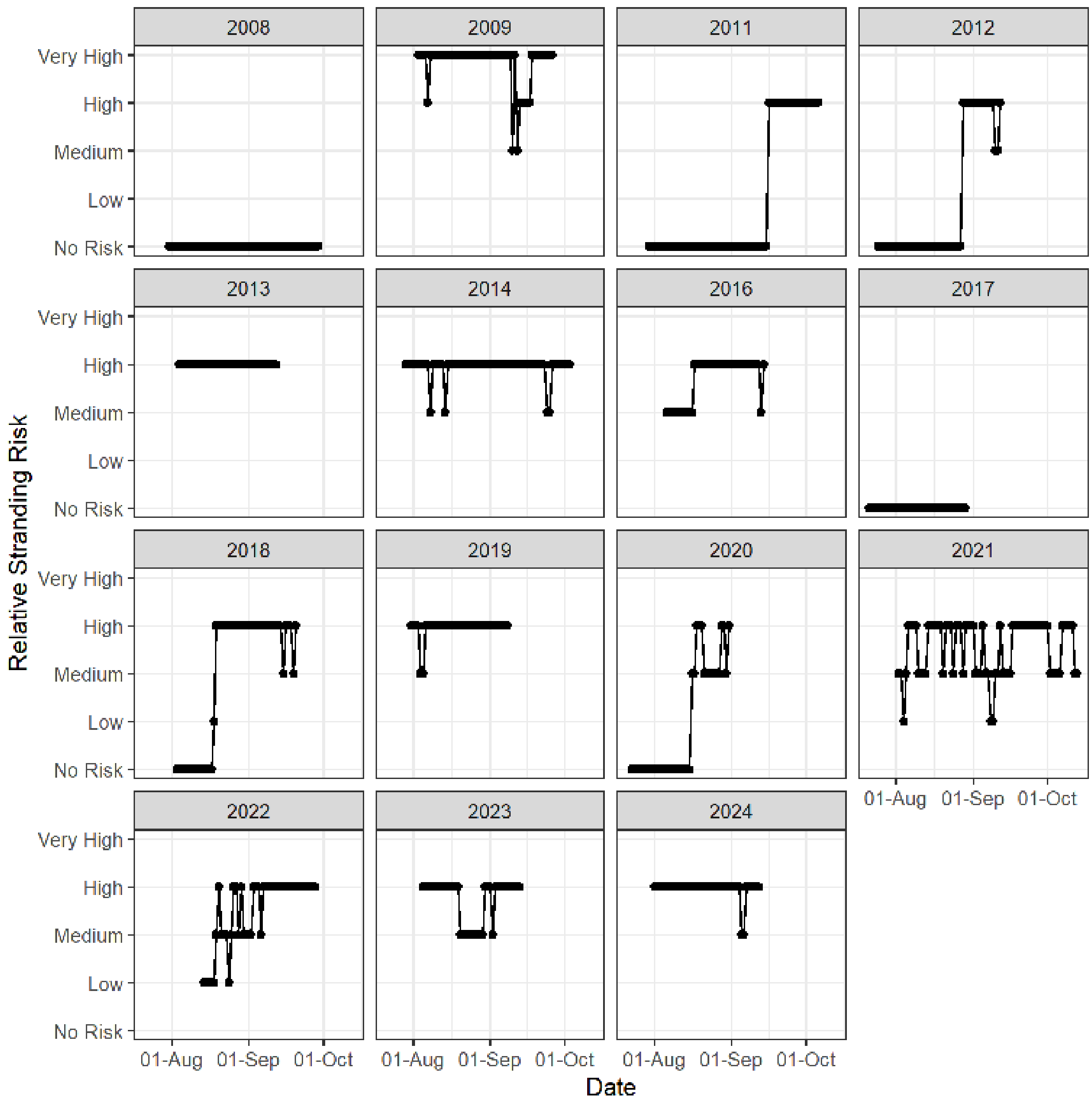

Figure 8. Relative stranding risk of early life stages of c̓əmtus in the nx̌ʷəntkʷitkʷ near snkx̌ykntn by year. Years between 2007 and 2024 when spawning was not detected are not shown.

Table 11. **Percentage of days during risk period that were assigned different stranding risk categories. Percentages were calculated from the daily risk values presented in Figure 8.**

Year	Percentage of Days During Risk Period for Each Relative Stranding Risk Category (%)				
	No Risk	Low	Medium	High	Very High
2008	100.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	3.6	10.9	85.5
2011	69.6	0.0	0.0	30.4	0.0
2012	68.0	0.0	4.0	28.0	0.0
2013	0.0	0.0	0.0	100.0	0.0
2014	0.0	0.0	6.0	94.0	0.0
2016	0.0	0.0	30.0	70.0	0.0
2017	100.0	0.0	0.0	0.0	0.0
2018	30.6	2.0	4.1	63.3	0.0
2019	0.0	0.0	5.0	95.0	0.0
2020	60.0	0.0	25.0	15.0	0.0
2021	0.0	4.1	38.4	57.5	0.0
2022	0.0	13.0	23.9	63.0	0.0
2023	0.0	0.0	27.5	72.5	0.0
2024	0.0	0.0	4.7	95.3	0.0

* Years between 2007 and 2024 when spawning was not detected are not included.

When summarizing hourly risk categories (Table 12), a greater percentage of time was classified as “Low” or “Medium” risk when compared to the daily risk values (Table 11). This was because daily risk was assigned based on the highest hourly risk classification each day. For instance, in 2013 and 2014, risk was classified as “High” on 100.0% and 94.0% of days, respectively, but only 36.1% and 30.5% of hours during those years. Hourly risk was often lower than daily risk because relatively higher stranding risk was assigned during daily low-flows than during higher flows, and low flows were typically only observed during part of the day during hydropeaking operations at REV. Overall, hourly classifications of relative stranding risk were lower than daily classifications in all years.

Table 12. **Percentage of hours during risk period that were assigned different stranding risk categories by year.**

Year	Percentage of Hours During Risk Period for Each Relative Stranding Risk Category (%)				
	No Risk	Low	Medium	High	Very High
2008	100.0	0.0	0.0	0.0	0.0
2009	0.0	26.7	32.3	19.8	21.3
2011	70.5	12.9	6.6	10.0	0.0
2012	69.7	17.4	6.2	6.8	0.0
2013	0.0	48.0	15.8	36.1	0.0
2014	0.0	42.2	27.2	30.5	0.0
2016	0.0	46.5	30.0	23.5	0.0
2017	100.0	0.0	0.0	0.0	0.0
2018	32.3	23.6	24.3	19.7	0.0
2019	0.0	41.4	23.6	35.0	0.0
2020	61.0	16.1	20.1	2.7	0.0
2021	0.0	44.2	35.4	20.3	0.0
2022	0.0	41.5	29.9	28.6	0.0
2023	0.0	34.5	28.3	37.2	0.0
2024	0.0	17.2	26.7	56.0	0.0

* Years between 2007 and 2024 when spawning was not detected are not included.

5.0 Recommendations

The following are recommended to improve egg/larval collection:

1. Continue the adaptive management approach regarding sampling effort to maximize progeny collection.
2. Deploy additional effort or gear at sites that collect progeny (example: if 228.1M has progeny, deploy two D-ring drift nets at 228.1M for the next set).

The following are recommended to reduce mortality:

1. Continue to use the BC Hydro streamside hatchery facility to reduce stress on collected progeny; and
2. Reduce handling of early-stage eggs (when possible); possibly by only staging a subset of captured eggs rather than staging each individual egg.

The following are recommended for standing assessments:

1. After spawning is detected, use BC Hydro REV discharge and reservoir elevation forecast data to run stranding risk assessments for the preceding week. If “High” or “Very High” risk of stranding is forecasted a standing survey will be triggered. This will continue for each week until the field season is complete.
2. Stranding surveys:
    a. Map the exposed gravel bar using the “Track” feature on a Gramin GPS; record start and end time of track.
    b. Opportunistically search for c̓əmtus eggs stranded in interstitial spaces on the gravel bar (detailed stranding survey methods may be developed in Year 18).
    c. Record time, UTM coordinates, and distance to water for all c̓əmtus eggs/larvae observed.
3. Evaluate the accuracy of estimated stranding risk using forecasted discharge and reservoir elevation data by comparing to stranding risk determined by actual discharge and reservoir elevation data.

6.0 References

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APPENDIX A – R-SCRIPT FOR STRANDING ANALYSIS

```
###############################################################################
# CLBMON-23A MCR White Sturgeon Spawning Project 19123348
#
# R Code for qualitative stranding risk analysis 2024
#
# D.Roscoe, February 2020
# minor update July 2020 for houlry stranding risk graph
# update Feb 2021 for 2020 data analysis
# update Feb 2023 for 2021, 2022, and 2023 analyses by Evan Smith (ONA)
# update Mar 2025 for 2024 analyses by Evan Smith (ONA)
###############################################################################

rm(list=ls())

library(dplyr)
library(ggplot2)
library(lubridate)
library(tidyr)

options(tibble.width = Inf)

setwd("C:\Users\esmith\Documents\Projects\CLBMON 23a (765)\Stranding Code")

################################################################################
## Discharge

# Hourly discharge from 2000 to 2018

dat <- readRDS("Rev discharge 2000 to 2018.rds")

dat <- dat %>%
			filter(Year>2006)

summary(dat)

# 2019 Discharge

data <- read.csv("REV discharge and ALR elev 2019-24.csv")

data$Date <- paste(data$Year,data$Month,data$Day,sep="-")
data$Date <- as.Date(strptime(data$Date, "%Y-%m-%d"))

data$Time <- paste(data$Hour,data$Minute,data$Second,sep=":")

data$DateTime <- paste(data$Date, data$Time, sep = " ")
data$DateTime <- as.POSIXct(strptime(data$DateTime, "%Y-%m-%d %H:%M:%S"), tz = "Etc/GMT+8")
```

```
head(data)
str(data)
summary(data)

dat2 <- data %>%
            filter(Station == "REV") %>%
            rename(Discharge = Corrected ) %>%
            select(DateTime,Discharge,Year)

str(dat)
str(dat2)

discharge <- bind_rows(dat,dat2)

ggplot(discharge,aes(x=DateTime,y=Discharge))+geom_point()+geom_line()

##############################################################################
## ALR elevation at Nakusp

# 2000 to 2018

dat <- readRDS("Nakusp Reservoir Elevation.rds")

dat <- dat %>%
            mutate(Year = year(DateTime) )%>%
            filter(Year>2006) %>%
            rename(Elevation = Level)

summary(dat)

dat2 <- data %>%
            filter(Station == "NAK_EL") %>%
            rename(Elevation = Corrected ) %>%
            select(DateTime,Elevation,Year)

elev <- bind_rows(dat,dat2)

summary(elev)

ggplot(elev,aes(x=DateTime,y=Elevation))+geom_point()

############################################################################
## Spawn Timing

data <- read.csv("MCR WSG Spawn Timing 2007 to 2024.csv")

data$FirstSpawningDate <- as.POSIXct(strptime(data$FirstSpawningDate, "%d-%b-%y"))
```

```
data$LastSpawningDate <- as.POSIXct(strptime(data$LastSpawningDate , "%d-%b-%y"))
data$DispersalDate <- as.POSIXct(strptime(data$DispersalDate, "%d-%b-%y"))


data <- data %>% select(-LastSpawningDate) %>%
                              drop_na()

data
str(data)
summary(data)

##############################################

# Look at max, min, and discharge pattern during the
# period when WSG eggs and larvae are present.

discharge$Date <- as.POSIXct(strptime(discharge$DateTime, "%Y-%m-%d"))

str(discharge)

head(discharge)

df <- discharge %>%
          left_join(data)


df$RiskPeriod <- ifelse( df$Date >= df$FirstSpawningDate &
                                        df$Date < df$DispersalDate ,
                                                 "Yes", "No" )

df <- df %>% filter(RiskPeriod == "Yes")

head(df)
str(df)

# check to see if values assigned correctly
df %>% filter(Year==2018,
                              Date >"2018-09-18",
                              Date < "2018-09-20") %>%
          as.data.frame()

# min and max discharge by Year

DischargeDiffs <- df %>%
                    group_by(Year) %>%
                    summarize(       minDischarge = min(Discharge),
                                     maxDischarge = max(Discharge) )
```

```
df <- df %>%
	mutate( Month = month(DateTime),
		Day = day(DateTime),
		Dayte = paste(2000, Month, Day, sep="-"),
		Dayte = as.POSIXct(strptime(Dayte, "%Y-%m-%d")))

tail(as.data.frame(df))
str(df)

df %>% filter(Year>2013) %>%
ggplot(aes(x=Dayte,y=Discharge))+geom_point()+geom_line()+facet_wrap(~Year,ncol=1)

df %>% filter(Year==2013) %>%
ggplot(aes(x=Dayte,y=Discharge))+geom_point()+geom_line()


################################################################################

# Look at ALR elevation during the
# period when WSG eggs and larvae are present.

elev$Date <- as.POSIXct(strptime(elev$DateTime, "%Y-%m-%d"))

df2 <- elev %>%
	left_join(data)
tail(df2)

df2$RiskPeriod <- ifelse( df2$Date >= df2$FirstSpawningDate &
				df2$Date < df2$DispersalDate ,
					"Yes", "No" )

df2$ALRBackWater = ifelse(df2$Elevation>=437, "Yes","No")

df2 <- df2 %>% filter(RiskPeriod == "Yes")

# min and max Elevation by Year

backwater <- df2 %>%
		group_by(Year) %>%
		summarize(	minElev = min(Elevation),
				maxElev = max(Elevation) )

df2 <- df2 %>%
	mutate( Month = month(DateTime),
		Day = day(DateTime),
		Dayte = paste(2000, Month, Day, sep="-"),
```

```
                        Dayte = as.POSIXct(strptime(Dayte, "%Y-%m-%d")))
library(ggforce)

##this is different from 2019 analysis##

p1=ggplot(df2,aes(x=Dayte,y=Elevation)) +
           geom_point() + geom_line()+
            geom_hline(yintercept=437)+
            #geom_text(data=annot,aes(x=x, y=y, label=label),size=3,vjust=6.5)+
            xlab("Date")+
            scale_y_continuous("Elevation (masl)",breaks=seq(431,441,2))+
            coord_cartesian(clip = 'off')+
            theme_bw()+
            theme(axis.text.x = element_text(angle = 90, vjust = 0.5, hjust = 0.5))+
            facet_wrap(~Year)

png("ALR elev during risk period.png", width = 6.93, height = 8, units = "in", res = 220)
p1
dev.off()

###########################################################################

# combine discharge and elevation during the period when WSG egg/larvae present

nrow(df)
nrow(df2)
summary(df)
summary(df2)

dat <- full_join(df,df2)
nrow(dat)
summary(dat)
str(dat)

head(as.data.frame(dat))

# Calculate Previous Maximum Discharge

out <- dat %>%
                      arrange(DateTime) %>%
                      group_by(Year) %>%
                      mutate(MaxPrevDischarge = cummax(Discharge),
                                 DiffDischarge = MaxPrevDischarge - Discharge ) %>%
                      ungroup()

# to check
out %>% filter(Year==2008) %>%
```

```
          select(DateTime,Discharge,MaxPrevDischarge,DiffDischarge)%>%
           as.data.frame()

head(out)
summary(out)

## Assign Stranding Risk

out$StrandingRisk <- "blank"

# At high discharge >1000 m3/s, there is low risk, no matter how high it was previously
# because incubation area still covered

id <- which(out$Discharge >= 1000)
out[id,]$StrandingRisk <- "Low"
# At medium discharge (500-1000), small differences (<200) between past max are Low Risk
# and large differences (>200) are medium risk

id <- which(out$Discharge < 1000 & out$Discharge >= 500 &
                    out$DiffDischarge < 200)
out[id,]$StrandingRisk <- "Low"

id <- which(out$Discharge < 1000 & out$Discharge >= 500 &
                    out$DiffDischarge >= 200)
out[id,]$StrandingRisk <- "Medium"

# At low discharge (142-500), small differences (<100) are low risk,
# medium differences (100-200) are medium risk
# and large differences (>200) are high risk

id <- which(out$Discharge < 500 & out$Discharge >= 142 &
                   out$DiffDischarge <100)
out[id,]$StrandingRisk <- "Low"

id <- which(out$Discharge < 500 & out$Discharge >= 142 &
                   out$DiffDischarge >= 100 &out$DiffDischarge < 200  )
out[id,]$StrandingRisk <- "Medium"

id <- which(out$Discharge < 500 &out$Discharge >= 142 &
                    out$DiffDischarge >=200)
out[id,]$StrandingRisk <- "High"

# At very low discharge (<142), differences of 50-99 are high risk
# and differences >= 100 are very high risk. Very small diffs (<50) are medium risk.

id <- which(out$Discharge < 142 &
                   out$DiffDischarge <100 & out$DiffDischarge >= 50)
```

```
out[id,]$StrandingRisk <- "High"

# no observations in this category

id <- which(out$Discharge < 142 & out$DiffDischarge >=100)
out[id,]$StrandingRisk <- "Very High"

id <- which(out$Discharge < 142 &
                    out$DiffDischarge < 50)
out[id,]$StrandingRisk <- "Medium"
# no observations in this category

# When ALR is backflooding incuation area, there is no risk

id <- which(out$ALRBackWater == "Yes")
out[id,]$StrandingRisk <- "No Risk"

# change STrandingRisk variable to ordered factor

str(out)

out$StrandingRisk <- factor(out$StrandingRisk,ordered=TRUE,
                                        levels=c("No Risk","Low","Medium","High","Very High") )

head(out)
tail(out)

out %>% filter(Discharge < 160) %>%
        select(DateTime,Discharge,MaxPrevDischarge,DiffDischarge) %>%
        as.data.frame()
summary(out)

## AT very low dicharge, DischargeDiff was always >1000 and therefore high risk (except when ALR backflooding)

## Check ranges of Discharge and DiffDischarge by Risk category

out %>%
        group_by(StrandingRisk) %>%
        summarize(      minQ = min(Discharge),
                        maxQ = max(Discharge),
                        minDiffQ = min(DiffDischarge),
                        maxDiffQ = max(DiffDischarge),
                        n = length(Discharge) )

# Assign category values for Discharge and Diff Discharge
```

```
out$DischargeCategory <- "blank"

id <- which(out$Discharge >= 1000)
out[id,]$DischargeCategory <- "High"

id <- which(out$Discharge >=500 & out$Discharge < 1000)
out[id,]$DischargeCategory <- "Medium"

id <- which(out$Discharge >=142 & out$Discharge < 500)
out[id,]$DischargeCategory <- "Low"

id <- which(out$Discharge <142 )
out[id,]$DischargeCategory <- "Very Low"

out$DiffDischargeCategory <- "blank"

id <- which(out$DiffDischarge >= 200)
out[id,]$DiffDischargeCategory <- "Large (>=200)"

id <- which(out$DiffDischarge >=100 & out$DiffDischarge < 200)
out[id,]$DiffDischargeCategory <- "Medium (100-199)"

id <- which(out$DiffDischarge >=50 & out$DiffDischarge < 100)
out[id,]$DiffDischargeCategory <- "Small (50-99)"

id <- which(out$DiffDischarge <50 )
out[id,]$DiffDischargeCategory <- "Very Small (<50)"

out$DischargeCategory <- factor(out$DischargeCategory,ordered=TRUE,
                                levels=c("Very Low","Low","Medium","High"))

out$DiffDischargeCategory <- factor(out$DiffDischargeCategory,ordered=TRUE,
                        levels=c("Very Small (<50)","Small (50-99)","Medium (100-199)","Large (>=200)"))

table(out$DischargeCategory,out$DiffDischargeCategory)

table(out$DischargeCategory,out$DiffDischargeCategory,out$StrandingRisk)

# graph of hourly risk for revised report after J. Crossman comment

out$DayteTime <- stringr::str_sub(out$DateTime, start= 6)
out$DayteTime <- paste("2000","-",out$DayteTime,sep="" )
out$DayteTime <- as.POSIXct(strptime(out$DayteTime, "%Y-%m-%d %H:%M:%S"), tz = "Etc/GMT+8")

out$StrandingRiskNum <- as.numeric(out$StrandingRisk) - 1

labels <- levels(out$StrandingRisk)
```

```
p <- ggplot(out,aes(x=DayteTime,y=StrandingRiskNum))+
        geom_point()+
        geom_line()+
        scale_y_continuous(name="Relative Stranding Risk",breaks=seq(0,4,1),labels=labels)+
        scale_x_datetime("Date",date_breaks = "months",date_labels = "%d-%b" )+
        facet_wrap(~Year)+
        theme_bw()+
        theme(panel.grid.minor.y = element_blank())

png("Hourly Stranding Risk by Year.png", width = 6.93, height = 7, units = "in", res = 220)
p
dev.off()

# Risk for a day is assigned based on the highest risk category observed that day

DailyRisk <- out %>%
                group_by(Year,Date,Dayte) %>%
                summarize(      minRisk = min(StrandingRisk),
                                maxRisk = max(StrandingRisk),
                                maxRiskNumber = as.numeric(maxRisk) -1 )      %>%
                ungroup()

labels <- levels(out$StrandingRisk)

p <- ggplot(DailyRisk,aes(x=Dayte,y=maxRiskNumber))+
        geom_point()+
        geom_line()+
        scale_y_continuous(name="Relative Stranding Risk",breaks=seq(0,4,1),labels=labels)+
        scale_x_datetime("Date",date_breaks = "months",date_labels = "%d-%b" )+
        facet_wrap(~Year)+
        theme_bw()+
        theme(panel.grid.minor.y = element_blank())

png("Stranding Risk by Year.png", width = 6.93, height = 7, units = "in", res = 220)
p
dev.off()

## calculate percentage of hours/days by risk category

library(reshape2)

HourlyPercent <- out %>%
        group_by(Year,StrandingRisk) %>%
        summarize(      n = n()) %>%
        group_by(Year) %>%
        mutate( freq = round(n / sum(n) *100,1) ) %>%
```

```
        select(-n) %>%
        melt(id.vars=c("Year","StrandingRisk")) %>%
        dcast(Year~StrandingRisk)

HourlyPercent
write.csv(HourlyPercent,"Percent Hourly Stranding Risk by Category and Year.csv")

DailyPercent <- DailyRisk %>%
        group_by(Year,maxRisk) %>%
        summarize(      n = n()) %>%
        group_by(Year) %>%
        mutate( freq = round(n / sum(n) *100,1) ) %>%
        select(-n) %>%
        melt(id.vars=c("Year","maxRisk")) %>%
        dcast(Year~maxRisk)

DailyPercent
write.csv(DailyPercent,"Percent Daily Stranding Risk by Category and Year.csv")

## check discharge during substrate dewatering survey

out %>% filter(Date == "2019-08-08") %>% as.data.frame()

discharge %>% filter(Date == "2019-08-08") %>% as.data.frame()

discharge %>% filter(Date == "2019-11-04") %>% as.data.frame()
```

APPENDIX B – 2024 DATA

Table 13. **Egg mat collection data including location, set and pull date and time, site temperature (°C) and depth (m), number of c̓əmtus (WSG) eggs and larvae, and effort (soak time in hours).**

		UTM Zone 11U		Set		Pull		Temperature			Egg Mat Catch				
Session	Station	Easting	Northing	Date in	Time in	Date out	Time out	Set	Pull	Depth (m)	No. WSG Eggs	No. WSG Larvae	Soak Time (days)	Soak Time (hrs)	Stage of WSG
1	227.9L	413411	5651345	31-Jul-24	11:47	7-Aug-24	12:51	10.3	13.2	2.9	0	0	7.04	169.07	-
1	228.8L	413349	5651723	31-Jul-24	11:54	7-Aug-24	12:35	10.2	13.1	2.7	0	0	7.03	168.68	-
1	228.1M	413414	5651324	31-Jul-24	15:35	1-Aug-24	11:28	10.9	10.4	2.4	0	0	0.83	19.88	-
1	227.8M	413515	5651432	31-Jul-24	15:39	1-Aug-24	11:44	10.5	10.5	3.5	0	0	0.84	20.08	-
1	228.6M	413303	5651707	1-Aug-24	7:50	1-Aug-24	11:06	10.6	10.3	2.8	0	0	0.14	3.27	-
1	228.5M	413215	5651533	1-Aug-24	8:26	1-Aug-24	10:49	10.7	10.5	2.3	0	0	0.10	2.38	-
1	227.8M	413515	5651432	1-Aug-24	15:39	7-Aug-24	12:22	10.5	13.1	3.6	0	0	5.86	140.72	-
1	228.1M	413377	5651304	1-Aug-24	16:27	7-Aug-24	11:30	10.1	13.1	3.2	0	0	5.79	139.05	-
1	228.5Ma	413200	5651474	2-Aug-24	8:14	6-Aug-24	14:35	10.1	12.0	2.0	2	0	4.26	102.35	-
1	228.6M	413306	5651703	2-Aug-24	8:54	6-Aug-24	15:02	10.1	12.0	3.1	1	0	4.26	102.13	-
2	228.8L	413349	5651723	7-Aug-24	12:45	14-Aug-24	9:50	13.1	10.7	2.8	0	0	6.88	165.08	-
2	227.9L	413411	5651345	7-Aug-24	13:07	14-Aug-24	10:03	13.2	10.7	2.3	0	0	6.87	164.93	-
2	227.8M	413515	5651432	7-Aug-24	13:04	14-Aug-24	9:20	13.2	10.6	3.4	0	0	6.84	164.27	-
2	228.5M	413214	5651504	7-Aug-24	13:14	14-Aug-24	8:35	13.4	10.6	2.4	0	0	6.81	163.35	-
2	228.1M	413377	5651304	7-Aug-24	14:46	14-Aug-24	9:05	13.8	10.6	1.9	0	0	6.76	162.32	-
2	228.9M	413381	5651784	7-Aug-24	15:17	14-Aug-24	9:38	13.6	10.8	3.3	0	0	6.76	162.35	-
2	228.5Mb	413172	5651282	8-Aug-24	7:42	14-Aug-24	8:48	12.2	10.5	2.3	0	0	6.05	145.10	-
3	228.8L	413349	5651723	14-Aug-24	9:55	19-Aug-24	15:02	10.7	11.1	0.9	0	0	5.21	125.12	-
3	227.9L	413411	5651345	14-Aug-24	10:19	19-Aug-24	15:17	10.8	11.2	1.5	0	0	5.21	124.97	-
3	228.5M	413214	5651504	14-Aug-24	13:06	19-Aug-24	14:07	11.0	11.3	0.8	0	0	5.04	121.02	-
3	227.8M	413515	5651432	14-Aug-24	14:22	19-Aug-24	14:46	11.1	11.4	1.9	0	0	5.02	120.40	-
3	228.5Ma	413200	5651474	15-Aug-24	9:03	19-Aug-24	13:51	11.1	11.2	1.1	0	0	4.20	100.80	-
3	228.5Mb	413172	5651282	15-Aug-24	9:47	19-Aug-24	13:22	11.1	11.4	1.4	0	0	4.15	99.58	-
3	228.1M	413377	5651304	15-Aug-24	10:32	19-Aug-24	14:24	11.1	11.2	0.6	0	0	4.16	99.87	-

Table 14. **D-Ring drift net collection data including location, set and pull date and time, site temperature (°C) and depth (m), number of c̓əmtus (WSG) eggs and larvae, and effort (soak time in hours). Red text indicates damaged sets.**

		UTM Zone 11		Set		Pull		Temperature			D-ring Catch			
Session	**Station**	**Easting**	**Northing**	**Date in**	**Time in**	**Date out**	**Time out**	**Set**	**Pull**	**Depth**	**No. WSG Eggs**	**No. WSG Larvae**	**Soak Time (hrs)**	**Stage of WSG**
1	228.6M	413303	5651707	31-Jul-24	10:16	31-Jul-24	13:05	10.1	10.5	3.1	0	0	2.82	0
1	228.5M	413215	5651533	31-Jul-24	10:38	31-Jul-24	13:45	10.1	10.2	2.7	0	0	3.12	0
1	228.1M	413414	5651324	31-Jul-24	11:13	31-Jul-24	14:17	10.1	10.3	2.4	0	0	3.07	0
1	227.8M	413515	5651432	31-Jul-24	11:30	31-Jul-24	15:12	10.3	10.7	2.6	0	0	3.70	0
1	228.6M	413303	5651707	31-Jul-24	15:45	1-Aug-24	7:49	10.2	10.6	3.4	0	0	16.07	0

		UTM Zone 11		Set		Pull		Temperature			D-ring Catch			
Session	**Station**	**Easting**	**Northing**	**Date in**	**Time in**	**Date out**	**Time out**	**Set**	**Pull**	**Depth**	**No. WSG Eggs**	**No. WSG Larvae**	**Soak Time (hrs)**	**Stage of WSG**
1	228.5M	413215	5651533	31-Jul-24	15:49	1-Aug-24	8:24	10.2	10.7	3.2	44	0	16.58	1
1	228.5M	413215	5651533	1-Aug-24	10:50	1-Aug-24	15:37	10.6	10.5	3.2	37	0	4.78	6, 7
1	228.6M	413303	5651707	1-Aug-24	11:07	1-Aug-24	13:05	10.3	10.3	3.9	10	0	1.97	2
1	228.1M	413414	5651324	1-Aug-24	11:30	1-Aug-24	13:58	10.4	10.3	2.6	0	0	2.47	0
1	227.8M	413515	5651432	1-Aug-24	11:45	1-Aug-24	15:37	10.5	10.3	3.5	1	0	3.87	6
1	228.5M	413215	5651533	1-Aug-24	16:50	2-Aug-24	7:50	10.4	10.3	3.7	2	0	15.00	0
1	228.5Ma	413200	5651474	1-Aug-24	16:43	2-Aug-24	8:15	10.0	10.1	2.9	11	0	15.53	8, 9
2	228.5Mb	413169	5651398	6-Aug-24	15:42	7-Aug-24	7:56	11.8	12.7	2.9	0	0	16.23	0
2	228.5Ma	413200	5651474	6-Aug-24	15:45	7-Aug-24	8:12	11.7	12.5	2.3	5	0	16.45	17, 19
2	228.6M	413300	5651692	6-Aug-24	15:50	7-Aug-24	8:53	11.7	12.6	2.9	18	0	17.05	21, 22
2	228.9M	413381	5651784	6-Aug-24	15:56	7-Aug-24	10:17	11.7	12.6	3.3	4	0	18.35	22
2	228.5Mb	413174	5651313	7-Aug-24	7:57	7-Aug-24	13:17	12.7	12.7	3.2	4	0	5.33	24, 25
2	228.5Ma	413200	5651468	7-Aug-24	8:13	7-Aug-24	13:53	12.5	13.3	2.7	4	0	5.67	25
2	228.9M	413381	5651784	7-Aug-24	10:18	7-Aug-24	14:23	12.6	13.8	3.3	0	0	4.08	0
2	228.1M	413377	5651304	7-Aug-24	11:31	7-Aug-24	14:45	13.1	13.8	2.0	0	0	3.23	0
2	228.5Ma	413200	5651468	7-Aug-24	15:14	8-Aug-24	8:06	13.6	12.1	2.5	14	0	16.87	17, 21, 29, 31
2	228.5Mb	413172	5651282	7-Aug-24	15:22	8-Aug-24	7:41	13.6	12.2	3.0	1	0	16.32	29
3	228.5Ma	413200	5651474	14-Aug-24	8:29	14-Aug-24	12:40	10.5	10.8	1.2	0	0	4.18	0
3	228.5M	413214	5651504	14-Aug-24	8:33	14-Aug-24	13:05	10.6	11.0	0.9	0	0	4.53	0
3	228.5Mb	413172	5651282	14-Aug-24	8:49	14-Aug-24	13:31	10.6	11.0	1.6	0	1	4.70	36
3	228.1M	413377	5651304	14-Aug-24	9:06	14-Aug-24	14:02	10.6	11.2	0.9	0	0	4.93	0
3	227.8M	413515	5651432	14-Aug-24	9:16	14-Aug-24	14:21	10.6	11.2	1.9	0	0	5.08	0
3	225.5Ma	413200	5651474	14-Aug-24	14:57	15-Aug-24	9:03	10.9	11.1	1.2	0	0	18.10	0
3	228.5Mb	413172	5651282	14-Aug-24	15:03	15-Aug-24	9:47	11.0	11.1	1.7	0	2	18.73	36
3	228.1M	413377	5651304	14-Aug-24	15:06	15-Aug-24	10:32	11.0	11.1	1.0	0	0	19.43	0
4	225.0M	415521	5650266	19-Aug-24	13:05	19-Aug-24	15:43	11.6	11.3	1.5	0	0	2.63	0
4	228.5Mb	413172	5651282	19-Aug-24	13:23	19-Aug-24	16:18	11.4	10.9	1.8	0	0	2.92	0
4	228.5Ma	413200	5651474	19-Aug-24	13:52	19-Aug-24	16:38	11.2	11.0	1.3	0	1	2.77	37
4	225.0M	415521	5650266	19-Aug-24	15:43	20-Aug-24	8:32	11.3	10.5	2.1	0	0	16.82	0
4	228.5Mb	413173	5651282	19-Aug-24	16:19	20-Aug-24	9:20	10.9	10.2	2.0	0	8	17.02	37
5	225.0M	415521	5650266	26-Aug-24	12:37	26-Aug-24	15:15	10.3	10.3	1.4	0	0	2.63	0
5	228.5Mb	413172	5651282	26-Aug-24	12:50	26-Aug-24	15:42	10.1	9.8	1.8	0	0	2.87	0
5	228.5Ma	413200	5651474	26-Aug-24	12:54	26-Aug-24	15:56	10.1	9.8	1.5	0	0	3.03	0
5	228.5Mb	413172	5651282	26-Aug-24	15:42	27-Aug-24	8:50	9.8	10.9	1.9	0	1	17.13	38
5	228.5Ma	413200	5651474	26-Aug-24	15:56	27-Aug-24	9:35	9.8	10.9	1.2	0	0	17.65	0
6	228.6M	415521	5650266	3-Sep-24	16:05	4-Sep-24	8:21	11.6	10.9	2.0	0	0	16.27	0
6	228.5Mb	413172	5651282	3-Sep-24	16:14	4-Sep-24	9:55	11.0	11.0	2.3	0	0	17.68	0