Columbia River Project Water Use Plan

Columbia River White Sturgeon Management Plan

Implementation Year 14

Reference: CLBMON-23A

Middle Columbia River White Sturgeon Spawn Monitoring

Study Period: 2020

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March 31, 2021

Middle Columbia River White Sturgeon Spawn Monitoring (CLBMON-23A): 2020 Data Report (Year 14)

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March 2021

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Citation: Okanagan Nation Alliance. 2021. Middle Columbia River White Sturgeon Spawn Monitoring (CLBMON-23A): 2020 Data Report (Year 14). Report prepared for BC Hydro, Castlegar, BC. 21 pp + 2 app.

Executive Summary

The population of *c’m’tus* (White Sturgeon) in the Canadian portion of the Columbia River is listed as Endangered under the federal Species at Risk Act. A small portion of this population exists in salti̓k̓ʷt (Arrow Lakes) Reservoir (ALR) and the Middle Columbia River (MCR), situated between Revelstoke Dam and Hugh L. Keenleyside Dam. The only known spawning location for this segment of the population is located approximately 6 km downstream of Revelstoke Dam adjacent to the Revelstoke 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 MCR White Sturgeon Spawn Monitoring Program (CLBMON-23A) 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 captured eggs and larvae to the Kootenay Sturgeon Hatchery for rearing and subsequent release back into the MCR. Additional objectives were added to the program in 2019 to address key uncertainties identified by the Mid-Columbia River White Sturgeon Technical Forum:

- Sample to improve understanding of the timing and spatial extent of larval dispersal.
- Conduct analyses to assess the risk of eggs or larvae becoming stranded due to hydroelectric operations.

In 2020, egg collection mats and drift nets were used to sample for eggs and larvae in the primary spawning area during the typical spawning season (late July to early September), as defined by previous years of the monitoring program. Larval dispersal monitoring was not conducted in 2020 since little is known about the exogenous larval dispersal and habitat in the MCR and the potential dispersal area is quite large. In total, 201 live eggs, 13 dead eggs and 17 larvae were collected in 2020 using egg mats and drift nets. A total of 200 eggs and 2 live larvae were transferred alive to the conservation aquaculture program. Based on the timing and developmental stages at the time of capture, all the eggs and the larvae were estimated to be from one spawning event, between July 23-27, 2020.

The risk of egg stranding due to hydroelectric operations was assessed qualitatively for all years from 2008 to 2020 based on the potential for substrate dewatering due to discharge variability during the risk period when eggs or larvae were present. The risk classifications were based on the discharge from Revelstoke Dam, the difference between the current hourly discharge and the previous maximum, and the presence or absence of backwatering from Arrow Lakes Reservoir. The relative stranding risk varied between years and was lowest in years or periods when ALR was backwatering the incubation area, and greatest when discharge was less than the minimum flow of 142 m^3/s (pre-2011).

Acknowledgements

The Okanagan Nation Alliance and Golder Associates Ltd. would like to acknowledge the following individuals for their contributions to the program:

BC Hydro

James Crossman, PhD	Biologist, Contract Manager
Margo Sadler	Contract Oversight

Okanagan Nation Alliance

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Nicholas Yaniw, BSc	Biologist, Field Crew
Paul Snow	Field Technician
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Golder Associates Ltd.

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nsyilxcen to English Translation

nsyilxcen Place Names	**English**
saltil̓k̓ʷt	Arrow Lakes Area
snkxy̌ kntn	Revelstoke
nx̌ʷntkʷitkʷ	Columbia River
nsyilxcen Species Names	**English**
c’m’tus	Sturgeon

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1.0 INTRODUCTION

The Canadian population of *c'm'tus* (White Sturgeon, *Acipenser transmontanus*) in the *nx̌ʷ ntkʷitkʷ* (Columbia River) was listed as Endangered under the federal Species at Risk Act in 2006. A small part of this population exists between Hugh L. Keenleyside Dam (HLK) near Castlegar, BC and Revelstoke Dam (REV) near *snkxy̌ kntn* (Revelstoke), BC. This portion of the *nx̌ʷntkʷitkʷ* includes Arrow Lakes Reservoir (ALR) and an approximately 48 km section of the middle Columbia River (MCR) between ALR and REV. The adult population in the MCR was estimated at approximately 50 individuals (Golder 2006). The only known spawning area for this population is located adjacent to the Revelstoke Golf Course, approximately 2 km downstream of REV. Spawning has been documented at this location using egg collection mats and drift nets in many but not all years between 1999 and 2020 (Golder and ONA 2020). However, wild juvenile White Sturgeon surviving from these spawning events have never been captured, which suggests failure to recruit to 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 *c'm'tus* at the only known spawning site between REV and HLK. CLBMON-23 includes two components: the MCR White Sturgeon Spawn Monitoring Program (CLBMON-23A) uses egg collection mats and drift nets whereas the MCR White Sturgeon Underwater Videography Feasibility Study (CLBMON-23B) evaluated the feasibility of monitoring sturgeon using sonar (Johnson et al. 2010). Fourteen years of monitoring have been completed in the CLBMON-23A program to date (2007 to 2020). This report describes the methods and results of egg mat and drift net monitoring for CLBMON-23A in 2020 (Year 14).

CLBMON-23A meets the requirement of the Columbia River 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 Kootenay Sturgeon Hatchery for rearing and subsequent release back into the MCR.

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

1. Where are the primary White Sturgeon 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 White Sturgeon?
4. What is the most effective method for monitoring spawning of White Sturgeon?
5. Can modifications be made to operation of Revelstoke Dam and Arrow Lakes Reservoir to protect or enhance White Sturgeon 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):

- The number of adults contributing to spawning events
- Survival of early life stages
- 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 not part of this program but eggs and larvae that were dead after capture were preserved, provided to BC Hydro, and will be used for genetic analyses in the future. Survival of early life stages (key uncertainty #2) cannot be directly measured or estimated using the data provided by this monitoring program. Stranding risk (key uncertainty #3) was assessed by examining river discharge data and ALR surface elevation data for large flow reductions during periods when there were known to be *c’m’tus* eggs or larvae present in the spawning and incubation area (Section 2.9).

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 Kootenay Sturgeon Hatchery to increase the genetic diversity of the conservation aquaculture program
- Sampling to improve understanding of the timing and spatial extent of larval dispersal

In light of these two objectives, the study design of CLBMON23-A was modified from previous years. A modification to attempt to increase the number of progeny collected for conservation aquaculture was to use an adaptive study design, where the sample sites and duration would be adapted during the sampling season based on the timing and location of capture of eggs or larvae. This differed from previous years, where the index sample sites and schedule were set.

This report summarizes the results from the 2020 study year and compares them to previous years of this program. It also provides recommendations for future sampling years. For detailed background information, interpretation of previous years’ results, and discussion of the status of management questions, readers are referred to reports from previous years of the monitoring program[1].

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[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

2.0 METHODS

2.1 Study Area

The study area for CLBMON23-A extends from the upstream end of the primary spawning area (river kilometer [rkm] 230.3, as measured from the Canada-US border) downstream to the Trans-Canada Highway Bridge (rkm 227). In 2020, the program was focused in the area that all *c'm'tus* eggs and larvae have been captured in previous years of this program (rkm 229.9 and 226.3; Wood 2019, Golder and ONA 2020). In an attempt to maximize captures in 2020, sampling was concentrated during the primary spawning and incubation period and sampling downstream of rkm 226.3 for fall larval dispersal was not conducted.

2.2 Sampling Equipment

Egg collection mats ('egg mats') and drift nets ('drift nets') were used to capture drifting *c'm'tus* eggs and larvae. 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 can adhere to or become lodged in the filter material. Egg mats were deployed either as 'shore-sets' or 'mid-sets'. For shore-sets, egg mats were connected to shore by a section of rope tied to a natural anchor on shore (e.g., boulder or tree). The shore-line was connected to the egg mat via a rope or cable bridle (i.e., approximately 0.5 m rope attached in a V-formation to one end of the egg mat). Shore-sets were retrieved by the shore-line but also had a float line consisting of 10 to 20 m of rope and a LD2 buoy attached to the egg mat as a secondary retrieval method in case the shore-line was severed.

To sample locations further from shore, egg mats were deployed as mid-sets that were held in place by an anchor system. The anchor system consisted of two 30 kg claw anchors connected by steel chain. Mid-sets had a float line and LD2 buoy connected to the front anchor, and a second float line connected to the egg mat or drift net. The egg mat was connected to the downstream anchor by approximately 10 m of rope. In high velocity areas where rope could be abraded by the substrate, 10 m of steel cable was used instead of rope.

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 bottle). 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. All drift nets were deployed using mid-set anchor systems as 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 by the shoreline and mid-sets were retrieved by the float line attached to the egg mat or drift net. The boat was equipped with a bow winch and a side-mounted winch on a davit. Egg mats and drift nets were pulled from the bow or side winch, depending on the site. Generally, the side winch was used when possible, because it allows for better ergonomics for crew members. Use of the bow winch was limited to sites situated in very high water velocities or if rope, anchors or equipment were stuck and required greater force to retrieve.

2.3 Spawn Monitoring

Spawn monitoring used both egg mats and drift nets, as in all previous years of the monitoring program (Wood 2019, Golder and ONA 2020). Spawn monitoring took place from July 22 to September 2, 2020. This timing was selected to cover the historical peak of the spawning period when most eggs and larvae have been captured in past years of the monitoring program (pers. comm., J. Crossman, BC Hydro). During each week of the monitoring period, a two or three-day site visit was conducted. During each site visit, egg mats were retrieved, 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 (16-23 hours). Drift nets create more drag in the water current than egg mats and therefore lower water velocities are required to deploy drift nets safely and without having the nets damaged or lost. Therefore, drift nets 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 by egg mats that were left to sample until the following week.

Sample sites were located between rkm 226.3 and 229.9 between mid-channel and the left bank as viewed facing downstream. Only nine of the twelve sites sampled in 2019 were sampled in 2020 (rkm 226.3M, 226.8M, 227.8M, 228.1M, 228.1L, 228.5M, 228.6M, 228.8L, 229.9M). Exact locations may have been modified slightly in the field depending on river conditions. Similar to 2019, we did not sample near the right bank and further upstream since no eggs or larvae were captured in 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.

Sample sites in 2020 are shown in Figure 1 and GPS coordinates are provided in Appendix A, Table A1. 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 shows the original sample site locations.

Following a review of CLBMON23-A in 2018, the study plan became “adaptive” with the objective of maximizing egg and larvae captures; at sites where eggs or larvae were captured, additional sites would be installed adjacent to (perpendicular to current) or downstream of the capture location. In addition, if significant numbers of eggs or larvae were captured, the session would be extended by one day to continue sampling with drift nets, which often catch more eggs/larvae than egg mats, and maximize catch during periods when spawning was occurring.

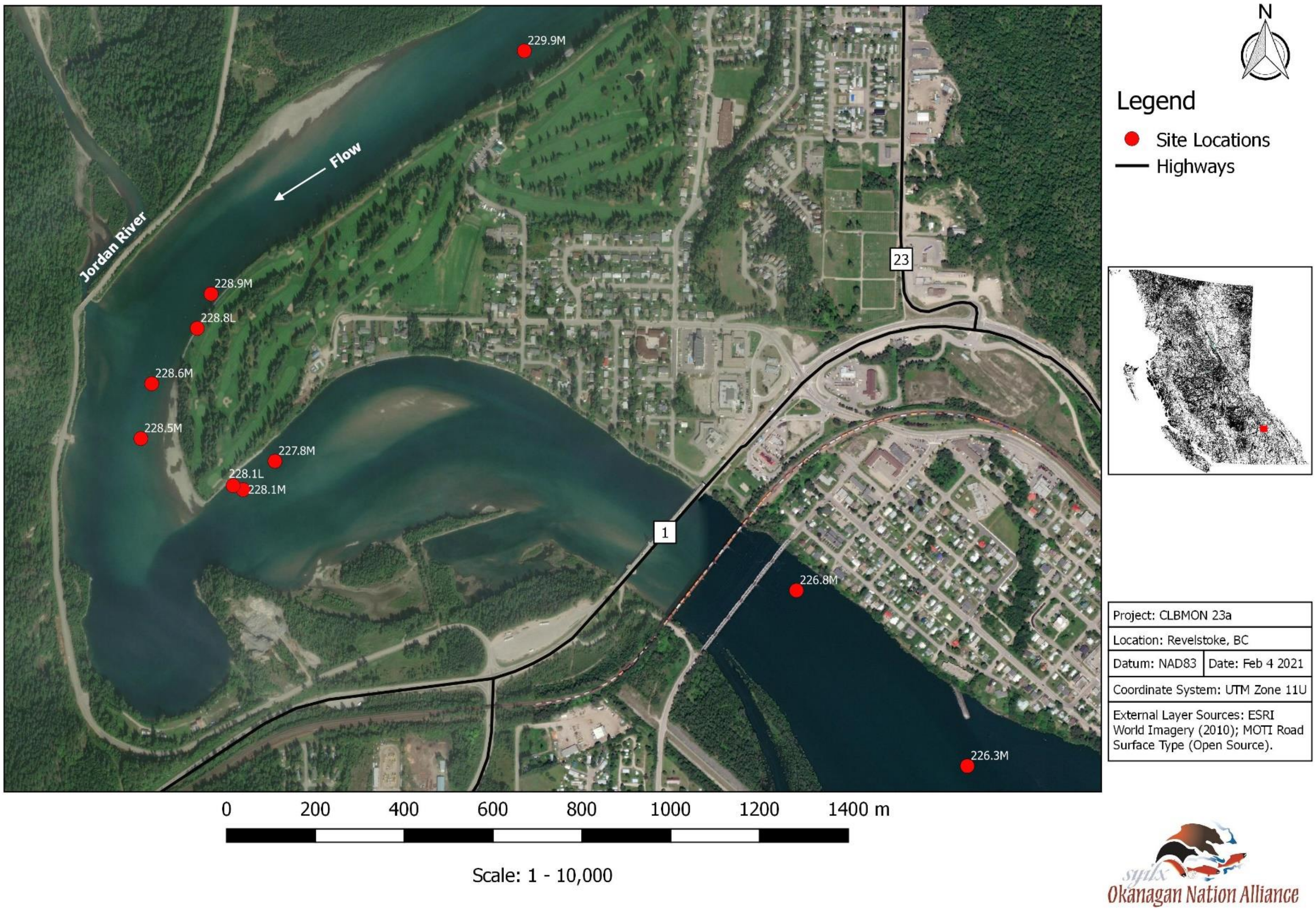

Figure 1. Egg mat sampling locations in the Middle Columbia River in 2020. Site names are representative of the river kilometer with "M" (deep) and "L" (shallow) indicating depth.

2.4 Study Period

Sampling activities and the timing of site visits in 2020 relative to the presumed time periods for spawning and early life history phases of *c'm'tus* are summarized in Table 1.

Table 1. Summary of sampling activities in 2020 relative to the suspected timing of c'm'tus spawning and developmental stages.

Date	***c'm'tus* Early Life History (suspected)[1]**			**CLBMON-23A Sampling in 2020**		
	Spawning	**Yolk sac/hiding phase**	**Larval dispersal**	**Spawn Monitoring**	**Larval Dispersal**	**Activities**
July 22-24	🟩			🟥		Deployed egg mats and anchor stations, initiated drift net sampling
July 28-30	🟩			🟥		Egg mat and drift net sampling
August 5-7	🟩	🟩		🟥		Egg mat and drift net sampling
August 14-15	🟩	🟩		🟥		Egg mat and drift net sampling
August 11-13	🟩	🟩		🟥		Egg mat and drift net sampling
August 18-19	🟩	🟩	🟩	🟥		Egg mat and drift net sampling
Aug 26-27	🟩	🟩	🟩	🟥		Egg mat and drift net sampling
Sept 1-2	🟩	🟩	🟩	🟥		Retrieved egg mats and drift nets
Sept 7 – Oct 2		🟩	🟩			No sampling conducted
Oct 2 – Nov 13			🟩			No sampling conducted

Notes:

1. These are approximate timings based on typical MCR water temperature of approximately 9–11°C and the developmental rates reported in the literature (Beer 1981; Wang et al. 1985, 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 MCR, 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 *c'm'tus* eggs collected were developmentally staged in the field. Eggs were removed from egg mats or drift nets and transferred using forceps or spoons to small containers filled with river water. Eggs were examined using a hand lens or dissecting microscope and developmental stage was assigned using the stages (1 to 35) identified by Dettlaff et al. (1993) and described by Jay *et al*. (2016). If large numbers of eggs were captured in one location, a subsample of eggs were staged to represent the entire sample with the assumption that they all came from the same spawning event. All live eggs and larvae were held in insulated coolers filled with river water and transferred to staff of the Kootenay Sturgeon Hatchery. Any eggs or larvae that were dead at capture were preserved in 90% ethanol and provided to BC Hydro.

2.6 Data Collection

Hourly discharge from REV and reservoir water surface elevation in ALR at Nakusp, BC were obtained from BC Hydro's Columbia Basin Hydrological Database. Water temperature, measured hourly, was obtained from a temperature logger (Levelogger Junior, Solinst, Georgetown, Ontario) deployed in a standpipe on the left downstream bank at Station 2 of the MCR Physical Habitat Monitoring Program (CLBMON-15A). Station 2 is located 1.7 km downstream of REV and 1 km upstream of the upstream end of the CLBMON-23A spawn monitoring study area.

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

- Site name
- GPS location of site
- Time and date of deployment
- Time and date of retrieval
- Water temperature (°C) at deployment and retrieval
- Water depth (m) at deployment
- Start / end readings of flow meter (for drift nets only)
- Number of live eggs / larvae collected and number preserved (dead)
- Developmental stage of eggs / larvae
- Other species observed
- Comments (e.g., station drift, quantity of debris)

Data were recorded in the field on standard data sheets for the monitoring program and later entered into Microsoft Excel spreadsheet software.

2.7 Data Analysis

Spawn timing (spawning dates) were estimated from the date of egg/larvae collection using the egg/larvae developmental stage, the mean daily water temperature, and temperature-dependent rates of development reported in the literature (Beer 1981, Wang et al. 1985, Parsley et al. 2004, 2011). The number of discrete spawning events was then estimated based on the spawning dates and their spatial distribution.

Sampling effort (hours) was calculated from deployment 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 was used to plot the location of sample sites and egg and larva capture locations.

2.8 Stranding Risk Assessment

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 2019). 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 2020 and from annual reports of the monitoring program for previous years (2007–2019)[2].

There is some uncertainty in developmental rates of *c’m’tus* in the cool water temperatures of the MCR (Parsley et al. 2011). Beer (1981) found that egg hatch occurred 11 days after

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[2] 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

fertilization at 10°C, which is similar to typical water temperature in the MCR during the spawning period. However, a study mimicking the temperature regime of the MCR 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 MCR 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 time 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 *c’m’tus*. 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 m³/s, which was 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 m³/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 m³/s), stranding risk was “Low” if the difference between the current and previous maximum discharge was less than 200 m³/s and “Medium” if the difference was greater than 200 m³/s.
- If discharge was low (142–499 m³/s), stranding risk was “Low” if the difference between the current and previous maximum discharge was less than 99 m³/s, “Medium” if the

difference was between 100 and 199 m³/s, and “High” if the difference was greater than 200 m³/s.

- If discharge was very low (<142 m³/s), stranding risk was “Very High” if the difference between the current and previous maximum discharge was greater than 100 m³/s, “High” if the difference was between 50 and 99 m³/s, and “Medium” if the difference was less than 50 m³/s.

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.

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 c'm'tus 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

2.9 Substrate Dewatering

A simple method was used to estimate the approximate amount of area dewatered at the cobble/gravel bar on the left bank (as viewed facing downstream) between Jordan River and Big Eddy, which is a suspected incubation area (Hildebrand et al. 2014). A GPS track was recorded along the water line and up to the permanently vegetated high water mark near the incubation area using a hand-held GPS. GPS tracks were recorded at three different discharge / ALR elevation levels in 2020 and GIS software was used to calculate the area of the bar exposed.

3.0 RESULTS

3.1 Discharge, Water Temperature, and Reservoir Elevation

During sampling in 2020, discharge in the MCR exhibited large daily fluctuations that are typical for the hydropeaking operations at REV (Figure 2). Peak daily discharges during the sampling period were typically between 1500 and 2000 m^3/s and daily minimum discharge ranged from 174 to 520 m^3/s.

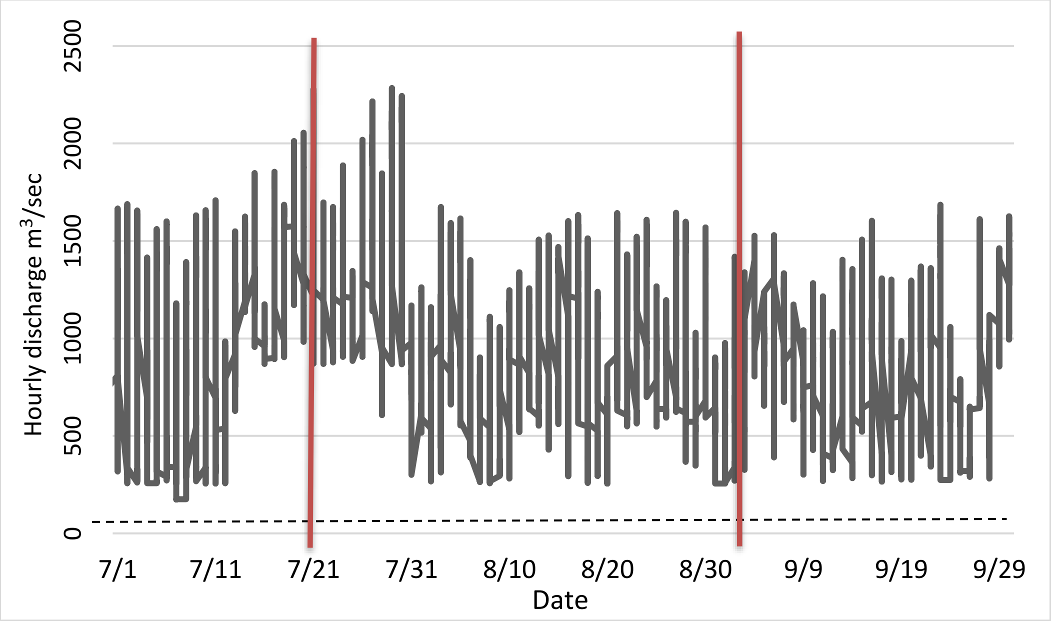

Figure 2. Hourly discharge in the Middle Columbia River downstream of Revelstoke Dam in 2020. The dashed line indicates the minimum flow of 142 m³s and the red lines encompass the CLBMON-23A sample period.

In 2020, surface elevation in ALR was 439.6 masl at the start of the sample period on July 22 and declined to 435.5 masl at the end of the sample period on September 2 (Figure 3). The surface elevation of ALR was higher than 437 masl, the level above which the spawning area is backwatered, for the majority of the sample period (July 22 to September 2).

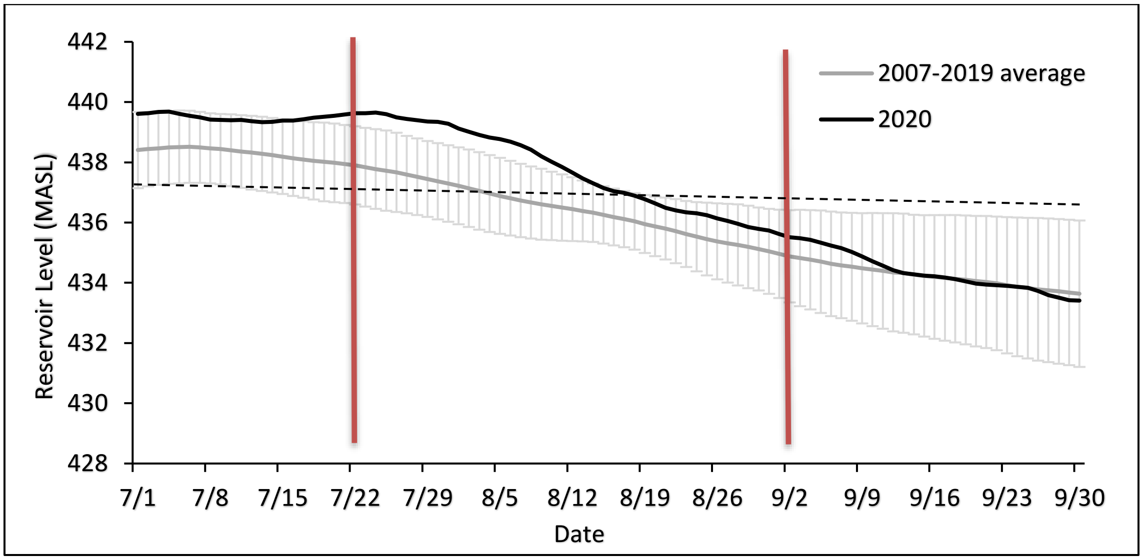

Figure 3. Reservoir surface elevation (masl) in Arrow Lakes Reservoir (ALR) at Nakusp, BC in July – September, 2020. The dashed line represents an elevation of 437 masl, above which the reservoir is thought to backwater the spawning and incubation area (Hildebrand et al. 2014). The CLBMON-23A sample period is shown in red.

Water temperature measured at the spawning area during the sample period averaged around 10.0°C (Figure 4). Typically, water temperatures during the late July to late August spawning season are between 9°C and 11°C.

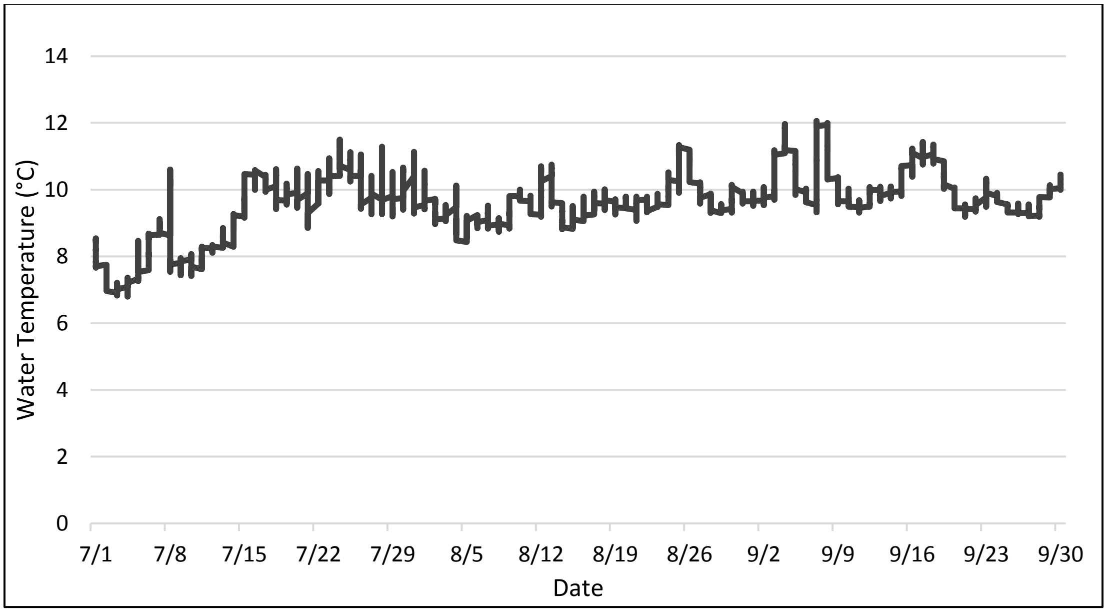

Figure 4. Water temperature in the Middle Columbia River measured at the c'm'tus spawning area in 2020.

3.2 Catch and Effort

Between July 22 and Sept 2, 2020, 4215.6 mat-hours were expended sampling eight sites in the study area (Table 3). In total, one live *c'm'tus* egg was captured using egg mats in 2020. This egg was captured at site 227.8M, which one of the sites encountered around the bend at Big Eddy (Appendix A, Figure A2). Average CPUE using egg mats in 2020 was 0.05 eggs/24h.

Table 3. Egg mat sampling effort, catch of c'm'tus eggs and larvae, and catch-per-unit-effort in the Middle Columbia River in 2020.

Dates	Effort (mat hours)	Effort (mat days)	# Sites	# Live Eggs	# Dead Eggs	# Live Larvae	# Dead Larvae	CPUE (#/24h)
July 22 - 28	502	20.9	5	1	0	0	0	0.048
July 28 - Aug 5	923.3	38.5	5	0	0	0	0	0.000
Aug 5 - 13	632.3	26.4	5	0	0	0	0	0.000
Aug 13 - 18	640.4	26.7	5	0	0	0	0	0.000
Aug 19 - 26	861.9	35.9	5	0	0	0	0	0.000
Aug 26 - Sept 2	655.7	27.3	5	0	0	0	0	0.000

In 2020, 825.5 hours were spent drift net sampling (Overnight drift nets had higher CPUE compared to day sets (0.3 and 0.1 eggs and larvae/hour, respectively).

Table 4). In total, 29 sets were deployed during the day (1–3 hours each), and 38 sets were deployed overnight (15–23 hours each). A total of 200 live eggs, 13 dead eggs, 2 live larvae and 10 dead larvae were captured in drift nets in 2020 (230 total; Appendix A, Figures A3 & A4). The average CPUE for all drift nets was 0.3 eggs and larvae/hour. Overnight drift nets had higher CPUE compared to day sets (0.3 and 0.1 eggs and larvae/hour, respectively).

Table 4. Drift net sampling effort, catch of c'm'tus eggs and larvae, and catch-per-unit-effort in the Middle Columbia River in 2019.

Dates	Effort (mat hours)	# Day Sets	# Overnight Sets	# Live Eggs	# Dead Eggs	# Live Larvae	# Dead Larvae	CPUE (#/h)
July 22-24	102.4	6	5	149	5	0	0	1.504
July 28 - Aug 5	147.4	2	7	50	7	0	0	0.387
Aug 5 - 7	162.8	4	8	1	1	0	5	0.043
Aug 12-13	193.2	9	7	0	0	2	10	0.062
Aug 18-19	79.0	3	4	0	0	0	0	0.000
Aug 26-27	79.8	3	4	0	0	0	0	0.000
Sept 1-2	61.0	2	3	0	0	0	0	0.000

The total number of *c'm'tus* progeny captured in 2020 by date and location are shown in Table 5. The majority (95%) of eggs and larvae were captured within rkm 228. All live eggs and larvae were provided to crews of the Kootenay Sturgeon Hatchery. Dead eggs and larvae were preserved in ethanol for BC Hydro.

Table 5. Number of c'm'tus eggs and larvae captured by location and date inclusive of both drift net and egg mats in the Middle Columbia River, 2020.

Capture Date

Station (Rkm)	23-Jul	24-Jul	28-Jul	29-Jul	30-Jul	6-Aug	7-Aug	12-Aug	13-Aug	18-Aug	19-Aug	26-Aug	27-Aug	1-Sep	2-Sep	**Total**
229.9																**0**
228.9				1												**1**
228.6	1	39		1	14		1									**56**
228.5	78	23		3	23	2	1									**130**
228.1	2	9		12		2		6	1							**32**
227.8	2		1	3			1	2								**9**
226.8								2	1							**3**
226.3																**0**
Total	**83**	**71**	**1**	**20**	**37**	**4**	**3**	**10**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	

Amount of egg mat effort was consistent throughout 2007-18 study years (with the exception of 2012) and however was decreased in 2019-20 with the adaptive study design (Table 6). Drift net effort increased annually from 2008-18 and was highest in 2020. CPUE on average is higher for drift nets in the MCR and was highest in 2009, 2011 and 2020.

Table 6: Summary of annual effort, captures and catch per unit effort (CPUE) for the CLBMON23-A program, 2007-2020.

	Egg Mats				**Drift Nets**			
Year	No. Egg Mats	Effort (hours)	No. WSG Captured	Catch Per Unit Effort (CPUE)	No. Drift Nets	Effort (Hours)	No. WSG Captured	Catch Per Unit Effort (CPUE)
2020	30	4215	1	0.048	67	825.5	230	0.300
2019	82	11569	2	0.004	52	148.5	10	0.070
2018	140	23,068	6	0.010	71	387.2	93	0.240
2017	143	23,263	7	0.010	66	379.5	2	0.010
2016	140	22,771	1	0.001	55	341.6	0	0.000
2015	132	21,560	0	0.000	60	311.0	0	0.000
2014	123	20,850	19	0.020	64	375.9	38	0.100
2013	135	20,019	2	0.002	67	424.3	0	0.000
2012	61	8,773	0	0.000	28	106.8	8	0.070
2011	128	22,169	30	0.030	23	61.2	18	0.300
2010	96	20,514	0	0.000	15	67.4	0	0.000
2009	115	18,860	36	0.050	22	65.3	47	0.700
2008	164	27,009	4	0.004	6	12.6	4	0.300
2007	136	25,818	0	0.000	8	24.7	0	0.000
Mean	116	19318	8	0.013	43	252.3	32	0.149
Standard Deviation	37	6563	12	0	25	226	63	0

3.3 Developmental Staging and Estimated Spawn Timing

Based on the dates of capture, water temperature and egg/larvae stages, it was determined that one spawning event was encountered in 2020. The estimated date(s) of spawning are from July 23 – 27 (Table 7). It is possible spawning took place over a few days, which can occur depending on factors such as water temperature (pers. comm., J. Crossman, BC Hydro). The captures in later weeks indicated an estimated spawn timing up to August 2; however, the confidence of those later estimates is low as most captures were dead and developmental stage was uncertain.

Table 7. Estimated spawning dates based on developmental staging, water temperature and capture date.

Date of Capture	AM / PM	# WSG eggs (live/dead)	Stage(s)	# WSG larvae (live/dead)	Stage(s)	Hours Post Fertilization	Estimated Spawn Date
23-Jul	AM	79 (79/0)	2 - 6	0	-	0-8	23-Jul
	PM	4 (4/0)	-	0	-	0-8	23-Jul
24-Jul	AM	71 (66/5)	1 - 6	0	-	0-8	24-Jul
	PM	0	-	0	-	-	-
28-Jul	AM	1	23	0	-	107	24-Jul
	PM	0	-	0	-	-	-
29-Jul	AM	7 (6/1)	25 - 28	0	-	107-128	July 24 - 25
	PM	13 (13/0)	26, 27	0	-	118-128	July 24 - 25
30-Jul	AM	37 (32/5)	26 - 30	0	-	118-128	25-Jul
	PM	0	-	0	-	-	-
6-Aug	AM	2 (1/1)	35	1 (0/1)	36	256	July 26 - 27
	PM	0	-	1 (0/1)	36	256	27-Jul
7-Aug	AM	0	-	3 (0/3)	36	256	27-Jul
	PM	0	-	0	-	-	-
12-Aug	AM	0	-	7 (2/5)	36-38	256-304	July 30 - Aug 1
	PM	0	-	3 (0/3)	36-38	256-304	Aug 1 - 2
13-Aug	AM	0	-	2 (0/2)	36-38	256-304	July 31 - Aug 2
	PM	0	-	0	-	-	-

* A water temperature of 10°C was used to estimate spawn timing because 10°C is the lowest temperature included in published developmental rates (Beer 1981).

3.4 Stranding Risk Assessment

For years when spawning events were detected during CLBMON-23A (i.e., all years except 2007, 2010, and 2015), relative stranding risk was assessed based on ALR surface elevation, REV discharge, and the difference between current and previous maximum hourly discharge (Figure 5). Some years (2008 and 2017) were classified as “No Risk” for the entire risk period when eggs and larvae were present. “No Risk” was assigned when ALR elevation was greater than 437 masl because it was assumed that the incubation area was backwatered enough to prevent dewatering of eggs and larvae. 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), 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).

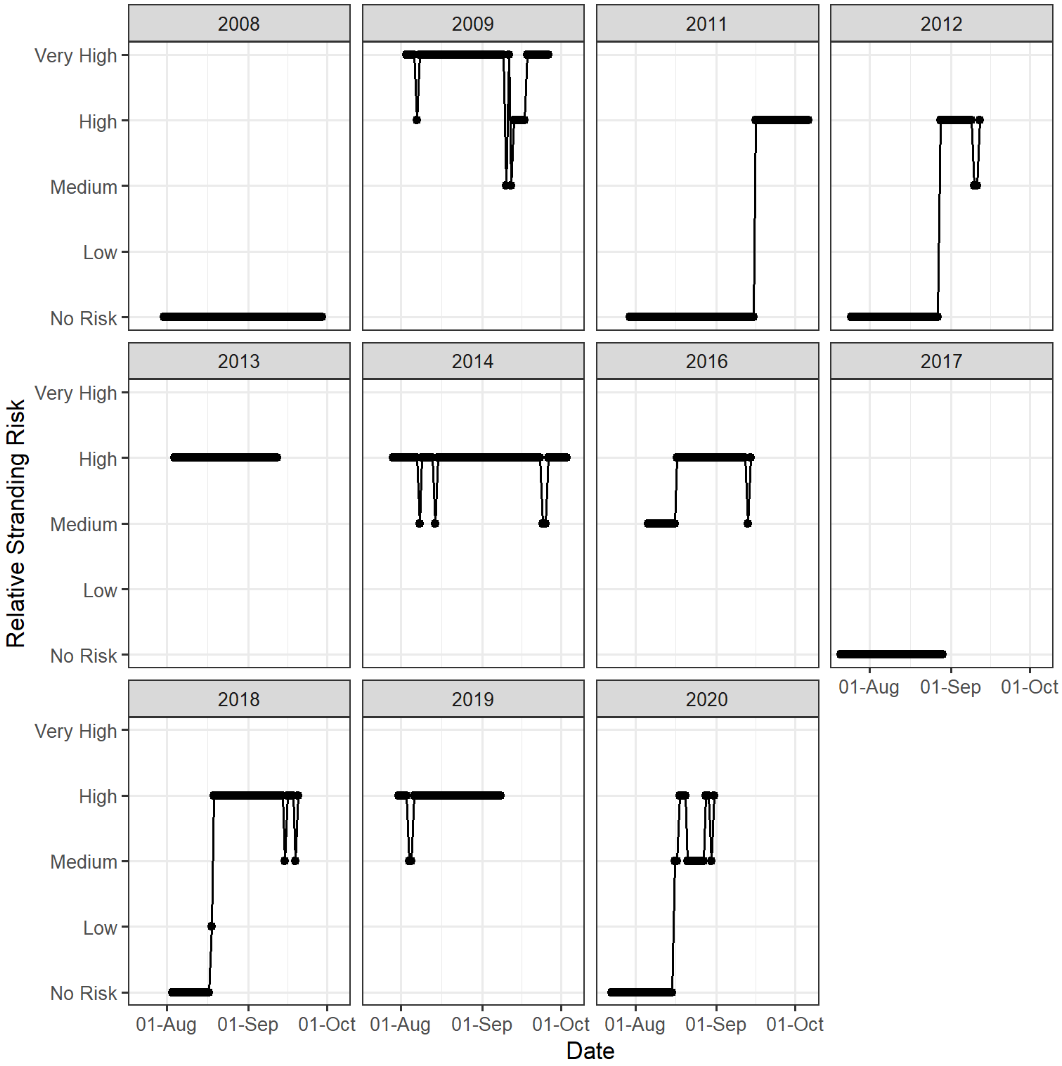

Figure 5. Relative stranding risk of early life stages of c'm'tus in the Middle Columbia River by year. Years between 2007 and 2020 when spawning was not detected are not shown.

A summary of the percentage of days during the risk period assigned to each risk category are shown in Table 88. 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, when 25-30% 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.

When summarizing hourly risk categories (Table 9), a greater percentage of time was classified as "Low" or "Medium" risk when compared to the daily risk values (Table 8). 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 (**Error! Reference source not found.**), and low flows were typically only observed during p art of the day during hydropeaking operations at REV. Overall, hourly classifications of relative stranding risk were lower than daily classifications in all years.

Table 8. Percentage of days during risk period that were assigned different stranding risk categories. Percentages were calculated from the daily risk values presented in Figure 5.

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	25.0	15.0	0.0

* Years between 2007 and 2020 when spawning was not detected are not included.

Table 9. 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	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

* Years between 2007 and 2019 when spawning was not detected are not included.

3.5 Substrate Dewatering

The area of exposed substrate on the gravel/cobble bar corner near Big Eddy was recorded using GPS tracks on three dates in 2020 (Table 10; Figure 7). While transects were recorded, a visual search was conducted looking for dewatered eggs or larvae and none were documented. ALR surface elevation slowly lowered in each consecutive week; this area would have been backwatered during the August 7 & 12 transects when the ALR elevation was above 437 masl.

The largest dewatered area was recorded on September 2, 2020 when discharge was dropping and the ALR elevation had receded.

Table 10. Substrate dewatering measurements from an exposed gravel bar within the spawning area in 2020.

Date	Time	Area of Exposed Bar (m²)	REV Discharge* (m³/s)	ALR surface elevation (masl)
August 7, 2020	9:50 – 10:04	2,728	305.2 m³/s at 9:00 591.2 m³/s at 10:00	438.6
August 12, 2020	14:50 – 14:59	9,927	745.8 m³/s at 14:00 738.8 m³/s at 15:00	437.7
September 2, 2020	9:05 – 9:16	16,190	702.4 m³/s at 9:00 573.2 m³/s at 10:00	435.5

*Hourly discharge at REV; values do not account for the time lag between changes in discharge at REV and the resulting change in downstream flows at the study site.

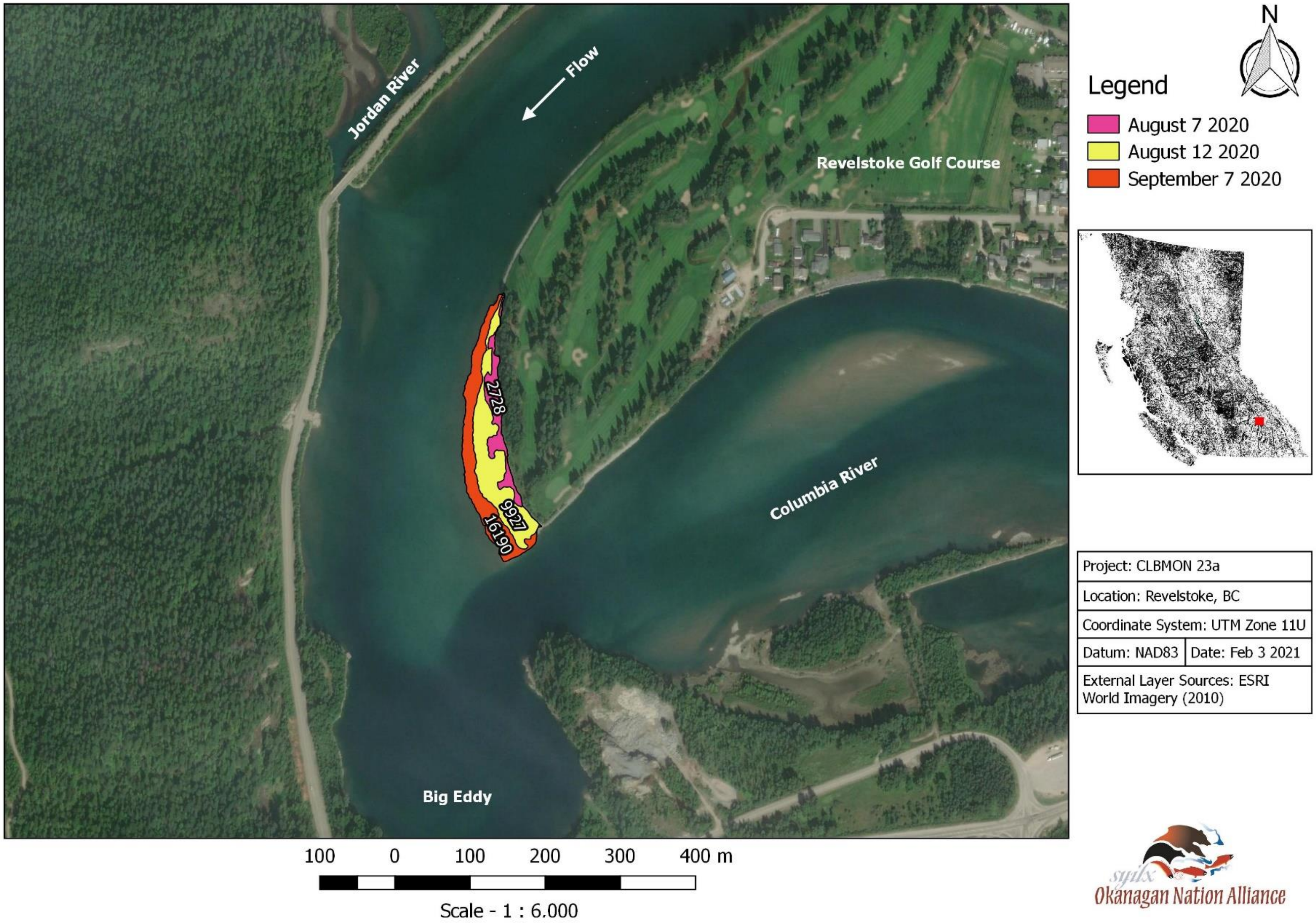

Figure 6: Dewatered areas at the gravel/cobble bar corner near Big Eddy. The numbers within each colored polygon represent the area (m^2) dewatered.

4.0 DISCUSSION AND RECOMMENDATIONS

One *c'm'tus* spawning event was documented in the MCR in 2020, estimated to have taken place between July 23-27. In previous years of the program, spawning dates have ranged between July 21 and August 28 and the number of spawning events detected has ranged between 0 – 6 (Table A2). Spawning has now been detected in 14 of the 19 years that monitoring has been conducted in the MCR.

A total of 231 *c'm'tus* progeny were captured in 2020, the largest number captured in all years of this program. Drift nets captured 99% of the eggs and larvae in 2020 and most were captured using overnight sets; this can likely be attributed to the adaptive methodology utilized in this year where crews extended sampling at locations where progeny were captured. For example, the crew was scheduled for deployment of egg mats and drift nets from July 22-23, however captured 83 eggs in drift nets on July 23, so lengthened the sampling period an additional day, resulting in the capture of an additional 71 eggs on July 24. In previous years of the program, crews have followed a set schedule and sampled set locations. Maintaining an adaptive schedule is recommended to increase capture success in future years of the program.

The Management Questions outlined in the Terms of Reference for CLBMON23-A have been addressed in previous years of this program (Wood et al. 2019); however, results from 2020 can be used to update Management Questions 2, 4 and 5:

<u>Management Question 2</u>: 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 data collected. The stranding risk analysis was updated to include 2020 conditions, however only 15% of the spawning period was considered "high risk" in this year due to backwatering of ALR. 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.

<u>Management Question 4</u>: What is the most effective method for monitoring spawning of White Sturgeon?

> The most effective methods for monitoring *c'm'tus* in the MCR is drift nets and egg mats (Wood et al., Golder and ONA 2020). Throughout this program, a total of 108 progeny have been captured using egg mats (0.01 CPUE) and 450 using drift nets (0.15 CPUE). In 2020, the increase in drift net effort, especially those left over night, resulted in the highest number of captures in all years of the program. Going forward, overnight drift net sets should be prioritized to maximize captures in the MCR.

This data report is intended to detail the methods and results of monitoring in 2020. 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).

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APPENDIX A

SUPPLEMENTARY INFORMATION AND MAPS

Table A1: Sites and UTM coordinates sampled in 2020.

Site	Zone	X	Y
226.3M	11U	415059	5650710
226.8M	11U	414679	5651103
227.8M	11U	413505	5651391
228.1M	11U	413429	5651324
228.1L	11U	413411	5651336
228.5M	11U	413203	5651442
228.6M	11U	413238	5651592
228.9L	11U	413390	5651796
229.9M	11U	414066	5652314

Table A2: Summary of conditions at spawning sites sampled including number of spawning events and capture success in all years of CLBMON23-A Program.

Parameter		1999	2000	2001	2003	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
No. Spawning Events		3	0	0	2	1	0	2	3	0	3	1	1	3	0	1	1	6	1	1
No. Eggs Captured		82	0	0	50	1	0	8	65	0	37	1	2	44	0	1	8	94	11	213
No. Free Embryos Captured		0	0	0	1	0	0	0	18	0	11	7	0	13	0	0	1	5	1	17
Discharge (m^3/s)	**Mean**	1230	1139	682	901	939	1185	712	744	540	957	1506	862	945	1387	1026	1059	1034	860	978
	Min.	0	0	0	0	0	0	0	0	0	145	150	253	152	254	258	254	255	256	255
	Max	1838	1635	1612	1667	1630	1773	1752	1715	1757	2140	2573	2118	2145	2182	2118	1899	2072	2103	2284
Water Temperature (°C)	**Mean**	10.3[a]	-[b]	9.8	9.5	10	9.7	9.2	10.9	11	10.6	10.8	10.5	10.2	10.5	10.5	9.8	10.4	10	9.8
	Min.	9.2[a]		6.4	6.9	8	4.5	6.7	7.6	7.5	8	7.8	9.1	8.5	8.5	8.8	8.5	8.9	9	8.4
	Max	11.6[a]		13.1	13.6	13.1	12.9	11.8	16.2	14.2	12.5	13.5	12.6	12.6	12.2	12.5	13.4	12.9	11.3	11.5
ALR Water Surface Elevation at Nakusp (m above sea level)	**Mean**	438	438.9	429.4	438	438.1	437.5	439.2	436.5	437.7	439	439.5	435.0	435.0	430.7	432.1	438.4	437.6	436	437.7
	Min.	437.2	437.6	427.3	436.2	435.2	435.3	438.7	435.8	436.1	438	436.6	432.9	433.5	428.9	430.3	436.3	435	435	435.5
	Max	440	444	430.4	439	439.8	438.6	439.9	437.5	439.3	439.5	440.5	437.6	437.9	432.9	434.3	439.5	439.7	438	439.6
No. Zero Flow Events		25	8	36	36	12	8	49	42	39	0	0	0	0	0	0	0	0	0	0

[a] Temperature data were only available from August 4-31.

[b] Data not available.

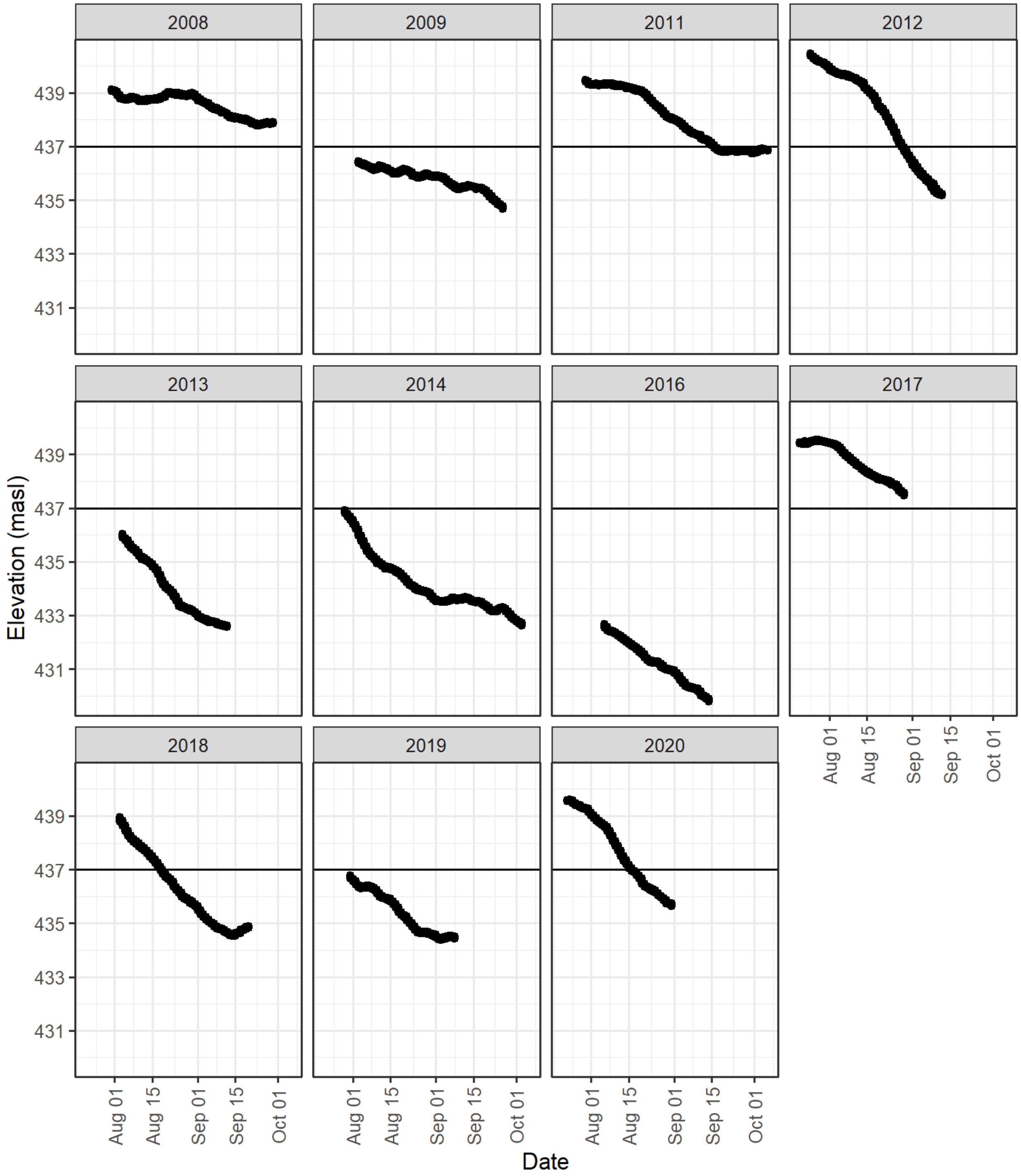

Figure A1: Surface elevation in meters above sea level (masl) of Arrow Lakes Reservoir in years when c'm'tus spawning was detected in the Middle Columbia River. Values are shown during the estimated period when c'm'tus eggs and larvae are present. The horizontal line at 437 masl represents the level above which the reservoir is thought to backwater the spawning and incubation area.

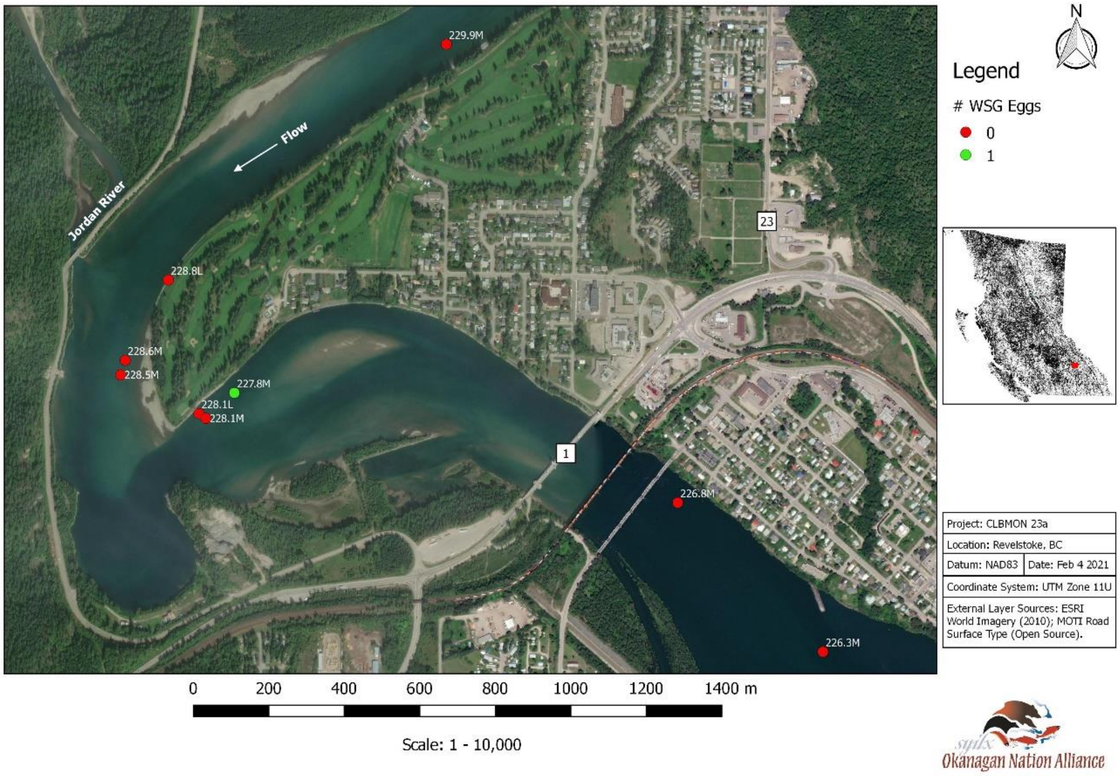

Figure A2: Location of C’m’tus eggs captures using egg mats in 2020.

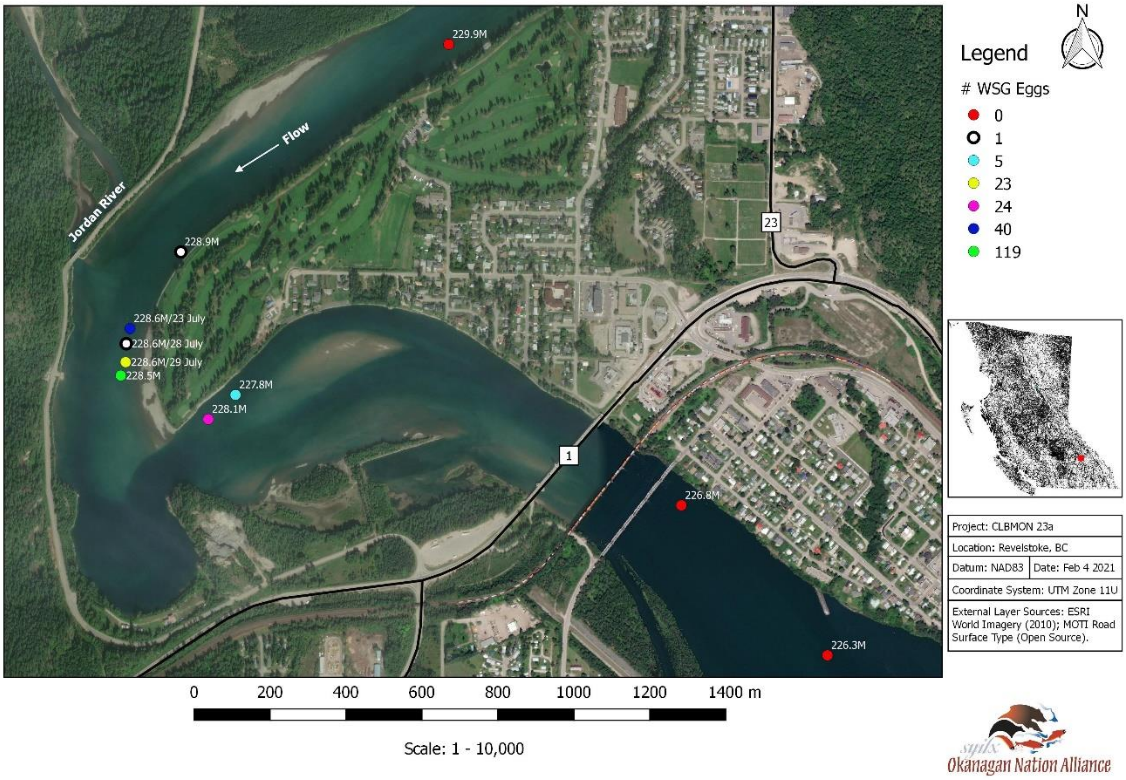

Figure A3: Location of c’m’tus egg captures using drift nets in 2020.

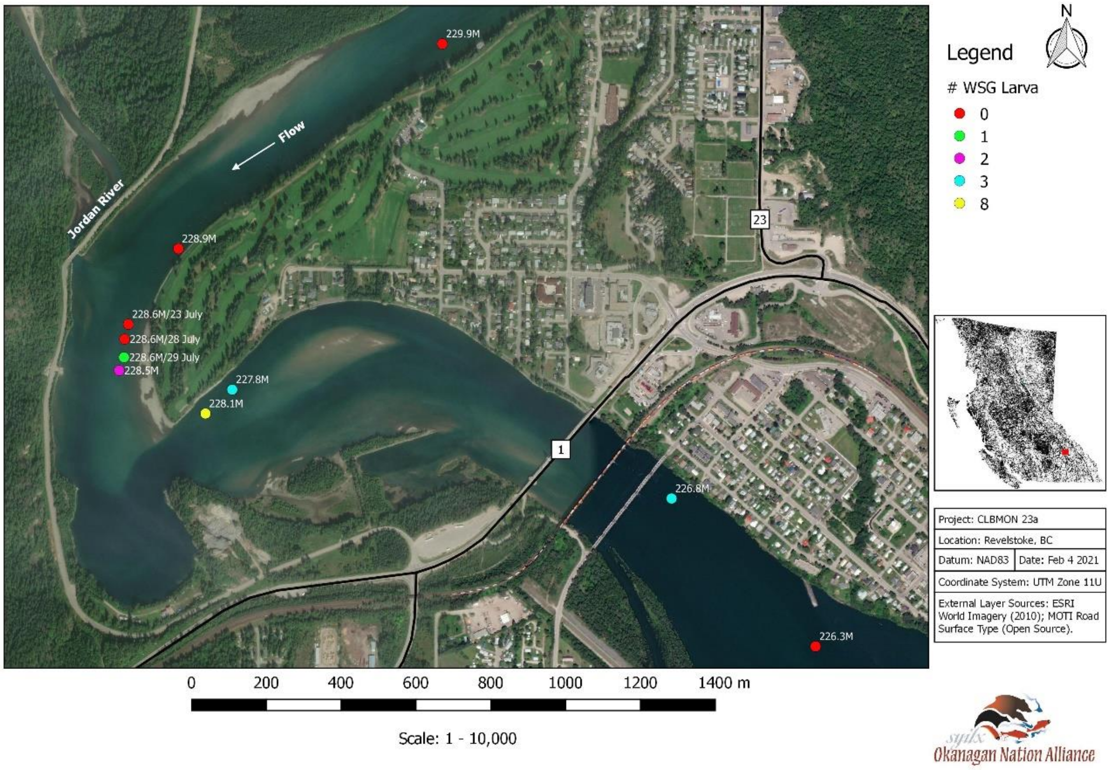

Figure A4: Location of larval captures using drift nets in 2020.

APPENDIX B

DATA

Egg mats		Set			Pull							
Station	WP	Date	Time	Water Temp °C	Date	Time	Water Temp °C	Depth	Number of WSG Eggs	Number of WSG Larvae	Number of UNID Eggs	Comments
228.1L	102	24-Jul-20	11:02	11.2	28-Jul-20	15:28	9.7	4.5	0	0	0	
228.1M	101	24-Jul-20	9:33	11.4	28-Jul-20	14:12	9.9	4.5	0	0	0	
227.8M	102	24-Jul-20	10:53	11.3	28-Jul-20	13:33	10.2	5.4	1	0	0	stage 23
228.5M	101	24-Jul-20	8:55	11.2	28-Jul-20	14:35	9.8	4.2	0	0	0	
228.8L	103	24-Jul-20	11:15	11.2	28-Jul-20	15:53	9.6	3.5	0	0	0	
228.1L	102	28-Jul-20	15:46	9.7	5-Aug-20	15:30	9.1	5	0	0	0	Mat was stuck, covered in fine gravel & sand, some torn fabric.
228.5M	112	28-Jul-20	10:04	10.2	5-Aug-20	13:46	8.9	3.7	0	0	0	Anchor sets didn't move since last week
228.6M	108	28-Jul-20	9:59	10.2	5-Aug-20	14:13	8.9	3.5	0	0	0	Anchor sets didn't move since last week
228.8L	103	28-Jul-20	16:08	9.8	5-Aug-20	16:15	9.1	3.3	0	0	0	Mat beat up, replace
229.9M	111	30-Jul-20	11:09	10.2	5-Aug-20	14:39	9.1	3.8	0	0	0	Net in good shape
228.1L	102	5-Aug-20	16:44	9	13-Aug-20	12:20	10.5	4	0	0	0	
228.8L	103	5-Aug-20	16:37	9.1	11-Aug-20	15:30	9.7	1.4	0	0	0	
227.8M	115	7-Aug-20	8:53	9.6	11-Aug-20	13:58	9.8	3.9	0	0	0	Mat in Good Shape
228.1M	101	7-Aug-20	10:48	9.5	11-Aug-20	14:24	9.8	3	0	0	0	Mat in Good Shape
228.6M	108	7-Aug-20	9:42	9.5	11-Aug-20	14:52	9.9	2.3	0	0	0	Mat Needs Replacement
226.3M	117	13-Aug-20	8:54	11	18-Aug-20	16:37	9.9	4.5	0	0	0	
226.8M	116	13-Aug-20	9:47	10.8	18-Aug-20	14:39	10.2	2.9	0	0	0	Mat Clean, No Damage
228.1L	102	13-Aug-20	12:40	-	19-Aug-20	11:15	9.8	-	0	0	0	Set Temp and depth not recorded
228.1M	119	13-Aug-20	10:58	10.7	18-Aug-20	13:44	10.1	3	0	0	0	Mat in Good Shape, Was Briefly Stuck
228.5M	118	13-Aug-20	11:49	10.5	18-Aug-20	14:15	10.3	2.7	0	0	0	Mat Should be Replaced
226.3M	123	19-Aug-20	8:58	9.9	26-Aug-20	16:04	11.1	3.7	0	0	0	
226.8M	122	19-Aug-20	11:38	9.8	26-Aug-20	14:21	11.2	2.5	0	0	0	Lost egg matt, unhooked from set (Retrieved September 2 2020 @ 12:49 w/ 10.2 water temp.
228.1L	102	19-Aug-20	11:28	9.8	26-Aug-20	16:14	11	3.3	0	0	0	

Egg mats		Set			Pull							
Station	WP	Date	Time	Water Temp °C	Date	Time	Water Temp °C	Depth	Number of WSG Eggs	Number of WSG Larvae	Number of UNID Eggs	Comments
228.1M	120	19-Aug-20	10:33	9.8	26-Aug-20	14:10	11.2	2.3	0	0	0	
228.5M	118	19-Aug-20	9:58	9.6	26-Aug-20	13:40	11.1	2	0	0	0	
228.1L	102	26-Aug-20	16:24	10.9	1-Sep-20	13:57	9.9	2.8	0	0	0	
226.3M	123	27-Aug-20	8:59	10.2	1-Sep-20	14:14	10.1	4.3	0	0	0	
226.8M	127	27-Aug-20	10:14	10.2	1-Sep-20	14:50	10.1	2.9	0	0	0	
228.1M	125	27-Aug-20	10:36	10.2	1-Sep-20	13:41	9.9	2.8	0	0	0	
228.5M	124	27-Aug-20	12:20	10.2	2-Sep-20	9:33	9.7	2.6	0	0	0	Missing Float

Station	WP	Date	Time	Flow Meter Reading	Date	Time	Flow Meter Reading	Set	Pull	Depth	No. WSG Eggs (Total)	No. WSG Eggs (Alive)	No. WSG Eggs (Dead)	No. WSG Larvae	Soak Time (hh:mm)	Soak Time (hrs)	No. UNID eggs	No. UNID Larva	Comments
227.8M	96	22-Jul-20	14:21	99800	22-Jul-20	16:25	240757	9.9	9.9	5.3	0	0	0	0	2:04	2.07	14	7	Flow Meter Serial: 21995/Float A14
228.5M	97	22-Jul-20	14:56	893700	22-Jul-20	16:59	84994	9.9	9.9	4.1	0	0	0	0	2:03	2.05	0	0	Flow Meter Serial: 23181/Float A2
227.8M	96	22-Jul-20	16:25	53200	23-Jul-20	8:28	786398	9.7	10.9	4.8	2	2	0	0	16:03	16.05	0	153	UNID Larva = 15 dead, 137 Alive
228.5M	97	22-Jul-20	17:00	240757	23-Jul-20	9:52	817207	9.7	10.2	4.1	77	77	0	0	16:52	16.87	1	87	2 Dead KO
228.1M	24	22-Jul-20	Test Deployment																WP on Golder Sounder
228.9M	21	22-Jul-20	Test Deployment																WP on Golder Sounder - Just Anchor no D-ring
228.5M	97	23-Jul-20	11:05	817206	23-Jul-20	13:09	77721	10.2	10.2	4.1	1	1	0	0	2:04	2.07	0	14	
228.1M	101	23-Jul-20	11:10	786382	23-Jul-20	13:38	43229	10.2	10.2	4.6	2	2	0	0	2:28	2.47	0	11	
228.6M	98	23-Jul-20	11:58	559122	23-Jul-20	14:16	862050	10.1	10.1	4.8	1	1	0	0	2:18	2.30	0	7	Float A11
228.9M	99	23-Jul-20	12:05	84972	23-Jul-20	14:39	323038	10.1	10.1	5.5	0	0	0	0	2:34	2.57	0	0	Float A3,A15
228.5M	97	23-Jul-20	13:34	77727	24-Jul-20	8:54	953764	10.1	11.2	4.1	23	23	0	0	19:20	19.33	1	19	WSG Eggs Staged 2-6 & 3 Eggs Staged 1
228.1M	101	23-Jul-20	14:12	43228	24-Jul-20	9:32	809077	10.2	11.4	4.5	9	7	2	0	19:20	19.33	2	123	WSG Eggs Staged 1-2
228.6M	100	23-Jul-20	15:01	323054	24-Jul-20	8:17	194133	10	11.5	4.9	39	36	3	0	17:16	17.27	0	11	WSG Eggs Staged 2-6
229.9M	27	23-Jul-20	Test Deployment																WP on Golder Sounder; Just Anchor Set
227.8M	104	28-Jul-20	13:35	194123	29-Jul-20	10:43	552299	10.2	9.8	4.9	3	2	1	0	21:08	21.13	0	76	WSG Eggs Staged 25 & 26
228.1M	105	28-Jul-20	14:14	953755	29-Jul-20	13:15	4295	9.9	9.6	4.4	12	12	0	0	23:01	23.02	3	63	WSG Eggs Staged 26 & 27; 2 Dead KO, 1 Dead Tadpole
228.5M	106	28-Jul-20	14:37	809063	29-Jul-20	8:55	751038	9.8	10.2	4.1	3	2	1	0	18:18	18.30	0	25	Drift Net Fouled Around Rope; Anchors didn't move, no damage to netting or cup.
228.6M	107	28-Jul-20	15:20	953467	29-Jul-20	9:46	955630	9.6	9.9	4.5	1	1	0	0	18:26	18.43	0	7	WSG Eggs Staged 28; Collection cup had 2 holes blown open, replace cup.
228.6M	108	29-Jul-20	9:46	751039	30-Jul-20	8:31	561728	9.9	10.8	3.9	23	18	5	0	22:45	22.75	2	6	WSG Eggs Staged 27-30; 1 Dead KO; Net Drifted d/s to near 228.5M, flow too strong to pull safely so we left overnight - It did not move overnight, 2 holes in collection cup & stick through drift netting.
228.9M	109	29-Jul-20	10:34	955646	29-Jul-20	15:45	455683	9.7	9.4	5.5	1	1	0	0	5:11	5.18	0	0	WSG Eggs Staged 26
229.9M	110	29-Jul-20	13:03	552305	29-Jul-20	16:45	933814	9.6	9.5	3.9	0	0	0	0	3:42	3.70	0	0	
229.9M	111	29-Jul-20	16:45	455683	30-Jul-20	11:07	920893	9.5	10.2	4.1	0	0	0	0	18:22	18.37	0	8	1 Dead KO; 3 Holes damaged in collection cup
228.5M	112	29-Jul-20	17:31	4282	30-Jul-20	10:02	978701	9.9	10.3	4.4	14	14	0	0	16:31	16.52	0	33	WSG Eggs Staged 26-30; No issues with drift net, anchor system hasn't moved.
228.5M	112	5-Aug-20	13:48	-	5-Aug-20	15:49	-	8.9	9.1	3.2	0	0	0	0	2:01	2.02	0	0	Anchor System did not move since deployment; Forgot to record flow meter.
228.6M	108	5-Aug-20	14:15	978715	6-Aug-20	9:26	444774	8.9	9.2	3.2	0	0	0	0	19:11	19.18	0	0	Anchor System did not move since deployment; Sock Ripped at Collection Cup.
228.1M	101	5-Aug-20	15:05	933839	6-Aug-20	11:17	529165	9.1	9.1	3.7	1	1	0	0	20:12	20.20	1	40	WSG Egg Staged 35; all UNIDS Dead; 7 Alive YOY Sculpin, tones of organics and sand
226.3M	35	5-Aug-20	15:20	920091	6-Aug-20	9:58	739217	8.9	9.1	6	0	0	0	0	18:38	18.63	1	11	11 Dead UNID Larva & 20 YOY Sculpin; WP on Golder Sounder

Station	WP	Date	Time	Flow Meter Reading	Date	Time	Flow Meter Reading	Set	Pull	Depth	No. WSG Eggs (Total)	No. WSG Eggs (Alive)	No. WSG Eggs (Dead)	No. WSG Larvae	Soak Time (hh:mm)	Soak Time (hrs)	No. UNID eggs	No. UNID Larva	Comments
228.5M	112	5-Aug-20	16:11	806342	6-Aug-20	8:50	774977	9	9	3.3	1	0	1	1	16:39	16.65	0	5	WSG Egg covered in fungis and could not stage; WSG Larva Staged 36 (Dead).; Cup contained very little debris.
228.9M	113	6-Aug-20	9:21	774973	6-Aug-20	13:18	166124	9.3	9.2	4.3	0	0	0	0	3:57	3.95	0	6	Small tear on vynal part of drift net, little debris in cup.
226.3M	114	6-Aug-20	9:59	444821	6-Aug-20	13:41	708906	9.1	9.1	5.6	0	0	0	0	3:42	3.70	0	3	
228.1M	101	6-Aug-20	11:19	739210	6-Aug-20	14:20	22955	9.1	9	3.3	0	0	0	1	3:01	3.02	0	0	WSG Larva Staged 36 (Dead)
227.8M	115	6-Aug-20	14:15	708908	7-Aug-20	8:54	458021	9.3	9.5	4.3	0	0	0	1	18:39	18.65	0	50	WSG Larva Staged 36 (Dead); UNIDS all Dead
228.5M	112	6-Aug-20	15:15	22953	7-Aug-20	10:27	574678	9.1	9.5	3.1	0	0	0	1	19:12	19.2	0	0	WSG Larva Staged 36 (Dead); Cup hole blew 1/2 open, minimal debris in cup, nose of flow meter missing.
228.1M	101	6-Aug-20	15:20	529169	7-Aug-20	10:48	543239	9.2	9.5	3.4	0	0	0	0	19:28	19.47	0	14	3 Live Sculpin YOY all UNID Dead; Net in good shape, minimal debris, low flows 275
228.6M	108	6-Aug-20	15:34	166114	7-Aug-20	9:41	315250	9.1	9.5	2.9	0	0	0	1	18:07	18.12	0	6	WSG Larva Staged 36 (Dead); all UNIDS Dead; Net in good shape, minimal debris, low flows 275
226.8M	116	11-Aug-20	13:50	458045	11-Aug-20	15:58	665342	9.9	10	3.3	0	0	0	0	2:08	2.13	0	0	
227.8M	115	11-Aug-20	13:59	135265	12-Aug-20	8:59	355005	9.8	10.2	4	0	0	0	2	19:00	19.00	0	30	WSG Larva (1 Alive/1 Dead) - Contact CK for Stage; 15 UNID Alive, minimal debris, net and cup good.
228.1M	101	11-Aug-20	14:25	543263	12-Aug-20	9:56	729473	9.8	10.1	2.5	0	0	0	5	19:31	19.52	0	12	WSG Larva (1 Alive/4 Dead) - Contact CK for Stages; All UNIDS Dead.
228.5M	112	11-Aug-20	14:55	88067	12-Aug-20	11:07	20200	9.7	10.8	2.5	0	0	0	0	20:12	20.20	0	0	Minimal Debris, Cup in good shape
228.9M	103	11-Aug-20	15:23	618790	12-Aug-20	11:40	664275	9.9	10.7	3.6	0	0	0	0	20:17	20.28	0	13	Minimal Debris, Cup in good shape
226.8M	116	11-Aug-20	16:29	665342	12-Aug-20	12:02	222014	9.8	10.8	2.9	0	0	0	2	19:33	19.55	0	38	WSG Larva Dead - Contact CK for Stages; All UNIDS Dead
227.8M	115	12-Aug-20	9:54	355005	12-Aug-20	13:30	717465	10.1	10.7	4	0	0	0	0	3:36	3.60	0	2	All UNIDS Dead
228.1M	101	12-Aug-20	10:59	729475	12-Aug-20	14:13	906737	10.5	10.7	2.3	0	0	0	0	3:14	3.23	0	15	
228.5M	112	12-Aug-20	11:35	20200	12-Aug-20	14:43	396053	10.6	10.7	2.7	0	0	0	0	3:08	3.13	0	0	
226.8M	116	12-Aug-20	12:03	664275	12-Aug-20	15:17	924410	10.8	10.8	3.1	0	0	0	0	3:14	3.23	0	0	
226.3M	123	12-Aug-20	13:22	222033	12-Aug-20	15:54	372683	10.7	10.9	4.8	0	0	0	0	2:32	2.53	0	2	All UNIDS Dead
228.1M	101	12-Aug-20	14:13	717465	12-Aug-20	16:34	937653	10.7	10.5	2	0	0	0	1	2:21	2.35	0	0	WSG Larva Dead - Contact CK for Stage
228.5M	112	12-Aug-20	14:44	906737	13-Aug-20	11:48	627022	10.7	10.5	2.1	0	0	0	0	21:04	21.07	0	12	UNIDS Dead
226.8M	116	12-Aug-20	15:18	396053	13-Aug-20	9:45	764961	10.8	10.8	2.8	0	0	0	1	18:27	18.45	0	13	WSG Larva Dead - Contact CK for Stage; UNIDS Dead, 2 Live YOY Sculpin.
226.3M	117	12-Aug-20	15:54	924410	13-Aug-20	8:53	769657	10.9	11	4.6	0	0	0	0	16:59	16.98	1	37	UNIDS Dead; 1 Live YOY Sculpin; Lots of debris & didymo, net and cup were fine.
228.1M	101	12-Aug-20	17:02	937653	13-Aug-20	10:57	995360	10.5	10.7	2	0	0	0	1	17:55	17.92	0	16	WSG Larva Dead - Contact CK for Stage; All UNIDS Dead
227.8M	121	18-Aug-20	13:41	627007	18-Aug-20	15:02	741162	10.2	10.3	3.9	0	0	0	0	1:21	1.35	0	0	
228.1M	120	18-Aug-20	13:45	764933	18-Aug-20	15:27	979847	10.1	10.2	2.6	0	0	0	0	1:42	1.70	0	3	2 Dead UNIDS
228.5M	118	18-Aug-20	14:16	995388	19-Aug-20	9:57	606668	10.3	9.6	2.5	0	0	0	0	19:41	19.68	0	0	
226.8M	122	18-Aug-20	14:41	372676	18-Aug-20	15:55	558264	10.2	10.2	2.8	0	0	0	0	1:14	1.23	0	3	All UNIDS Dead
228.1M	120	18-Aug-20	15:28	741162	19-Aug-20	10:32	803135	10.2	9.8	3.2	0	0	0	0	19:04	19.07	0	3	All UNIDS Dead

Station	WP	Date	Time	Flow Meter Reading	Date	Time	Flow Meter Reading	Set	Pull	Depth	No. WSG Eggs (Total)	No. WSG Eggs (Alive)	No. WSG Eggs (Dead)	No. WSG Larvae	Soak Time (hh:mm)	Soak Time (hrs)	No. UNID eggs	No. UNID Larva	Comments
226.8M	122	18-Aug-20	15:56	979847	19-Aug-20	11:35	134417	10.2	9.8	3	0	0	0	0	19:39	19.65	0	8	All UNIDS Dead
226.3M	123	18-Aug-20	16:37	558264	19-Aug-20	8:57	462036	9.9	9.9	4.7	0	0	0	0	16:20	16.33	0	19	12 Alive UNIDS
228.5M	124	26-Aug-20	13:41	134426	26-Aug-20	14:59	282990	11.1	11	2.3	0	0	0	0	1:18	1.30	0	0	Float line fouled on drift net just above cup.
228.1M	125	26-Aug-20	14:11	462021	26-Aug-20	15:20	592860	11.2	11	2.4	0	0	0	0	1:09	1.15	0	0	
226.8M	126	26-Aug-20	14:22	803172	26-Aug-20	15:32	945385	11.2	11.1	2.4	0	0	0	0	1:10	1.17	0	1	UNID Dead
228.5M	124	26-Aug-20	15:16	282990	27-Aug-20	12:18	526824	11	10.2	2.2	0	0	0	0	21:02	21.03	0	10	All UNIDS Dead; Velocity Meter half full
228.1M	125	26-Aug-20	15:33	592860	27-Aug-20	11:35	829681	11.1	10.2	2.5	0	0	0	0	20:02	20.03	0	4	All UNIDS Dead
226.8M	126	26-Aug-20	16:01	945385	27-Aug-20	10:13	783202	11.1	10.2	2.3	0	0	0	0	18:12	18.20	0	6	All UNIDS Dead
226.3M	123	26-Aug-20	16:05	606684	27-Aug-20	8:58	254588	11.1	10.2	3.7	0	0	0	0	16:53	16.88	0	50	12 UNIDS Alive
228.6M	128	1-Sep-20	13:24	829671	1-Sep-20	15:06	50252	9.9	10.1	2	0	0	0	0	1:42	1.70	0	0	
228.9M	129	1-Sep-20	13:33	783205	1-Sep-20	15:48	986403	9.9	9.9	3.5	0	0	0	0	2:15	2.25	0	0	
228.6M	128	1-Sep-20	15:43	50252	2-Sep-20	10:55	539758	9.9	9.9	1.9	0	0	0	0	19:12	19.20	0	10	All UNIDS Dead
228.1M	130	1-Sep-20	16:03	986403	2-Sep-20	10:10	879645	9.9	9.8	2.2	0	0	0	0	18:07	18.12	0	0	
226.8M	131	1-Sep-20	16:08	254620	2-Sep-20	11:52	950296	9.9	10.1	2.2	0	0	0	0	19:44	19.73	0	0	