Columbia River Project Water Use Plan

Middle Columbia River
White Sturgeon Spawning Monitoring

Implementation Year 7

Reference: CLBMON-23A

Year 7 Data Report (2013)

Study Period: July – September 2013

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April 9, 2014

Middle Columbia River White Sturgeon Spawning Monitoring CLBMON-23a Year 7 Data Report (2013)

Submitted to:
BC Hydro

Submitted by:
AMEC Environment & Infrastructure
Nelson, BC

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Middle Columbia River White Sturgeon Spawning Monitoring (CLBMON-23A)

Year 7 Data Report - 2013

Submitted to:

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Castlegar, British Columbia

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Key Words: Middle Columbia River, White Sturgeon, Spawning, Eggs, Free Embryos, Revelstoke Dam

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Bill Green
Jon Bisset
Mark Thomas

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EXECUTIVE SUMMARY

The Columbia River White Sturgeon Management program was initiated to address flow management issues with respect to impacts on White Sturgeon (*Acipenser transmontanus)* spawning events, timing, frequency, egg deposition, and habitat conditions. A small endangered population of White Sturgeon resides in Arrow Lakes Reservoir (ALR), between Hugh L. Keenleyside (HLK) and Revelstoke (REV) dams. Spawning has been documented intermittently since 1999, primarily in an area approximately 5 km downstream of REV adjacent to the Revelstoke Golf Course. Monitoring conducted in 2013 was Year 7 of 10 of the middle Columbia River White Sturgeon spawning monitoring study program (CLBMON-23A).

White Sturgeon spawn monitoring in the middle Columbia River was conducted between July 24 and September 10, 2013 between river Km 228.0 and 230.1. White Sturgeon eggs and free embryos were captured using egg mats and larval drift nets, consistent with methods used in previous years. Egg mats were inspected weekly for the presence of White Sturgeon eggs and/or free embryos. In total, 20,019 hours of egg mat sampling effort resulted in the capture of two White Sturgeon eggs in 2013. Larval drift nets were set weekly during the day (average of 3.2 hours per set) as well as overnight between August 14 and September 10 (average of 16.3 hours per set). In total, 424 hours of larval drift net sampling effort resulted in no white sturgeon eggs/free embryos being captured. A single spawning event was estimated to occur on August 4, 2013 based on the developmental stage of the two eggs at the time of capture and the water temperatures recorded over the spawning grounds.

Discharge from REV reached a peak of 2,118 m^3/s which was lower than the peak discharge observed in 2012, (2,573 m^3/s), but higher than maximum discharge observed prior to the installation of a fifth unit at REV in late 2010 (1757 m^3/s). Backwatering of ALR occurred in the spawning area during the initiation of field sampling, but was not observed after July 30, 2013 resulting in riverine conditions for the majority of the sampling period. In addition, lower discharges and limited ALR backwatering effect enabled sampling of additional mid-channel and right bank habitats compared to 2012.

The current state of knowledge for White Sturgeon spawning below Revelstoke Dam with respect to BC Hydro's management questions for CLBMON-23a is provided below.

Management Question	Status
Where are the primary White Sturgeon incubation sites below Revelstoke Dam?	Based on White Sturgeon spawning studies conducted below Revelstoke Dam since 1999, the primary White Sturgeon incubation area is located within a 1.8 km river section between Km 228.3 and 230.1, which encompassed the area adjacent to the Revelstoke golf course; REV is located at Km 235. Of the 246 eggs and 40 free embryos collected since 1999, 100% were located in this primary incubation area.
How do dam and reservoir operations affect egg and free embryos survival in this area? Specifically, do significant numbers of eggs become dewatered	It is unknown at this time how dam and reservoir operations affect White Sturgeon egg and larval survival because operations have been quite variable over the duration of this monitoring program, the short time period with which

as a result of operations?	monitoring those changes has occurred, and the low number of eggs/larvae that have been collected. However, changes in the operational regime and capacity of REV since December 2010 and observations during low flow periods suggest that a significant numbers of eggs do not become dewatered as a result of operations. Egg stranding has been identified in one of the eight years where spawning has been documented. Changes to the flow regime following the addition of REV5 have increased both the minimum and maximum total wetted area of the MCR, so exposure of this gravel bar may not occur during higher flow years. In 2013, water levels did not fluctuate enough during the White Sturgeon spawning period to completely expose the gravel bar to warrant extensive stranding investigations.
What is the most effective method for monitoring spawning of White Sturgeon?	The most effective method for monitoring White Sturgeon spawning in the mid-Columbia River is a combination of egg mats and drift nets. During the past 7 years of this program, an average of 119 egg mats have been deployed per spawning season for approximately 20,451 hours which resulted in an average catch-rate of 0.01 eggs/free embryos per hour. In contrast, an average of 24 drift nets have been deployed per spawning season for approximately 109 hours which resulted in an average catch-rate of 0.2 eggs/free embryos per hour. Although drift nets seem to have higher catch-rates, they do not fish continuously like egg mats and may miss downstream disbursement of larvae after hatch occurs. In 2013, eggs were only collected on egg mats and no eggs or larvae were captured in drift nets despite four times the level of drift net effort compared to previous years.
Can modifications be made to operation of Revelstoke Dam and Arrow Lakes Reservoir to protect or enhance White Sturgeon incubation habitat?	It is unknown at this time whether additional modifications to REV/ALR operations can be made to protect or enhance White Sturgeon incubation habitat. Flow modifications have already occurred with the addition of REV5. Preliminary information collected during this monitoring program before and after REV5 suggests that recent operational modifications may reduce White Sturgeon egg stranding and spawning has been consistently observed in the past three years since REV5 came online. The influence of REV operations and ALR elevation on physical conditions observed at the spawning area is currently being assessed during concurrent BC Hydro WUP programs, which may provide insights into whether additional operational modifications are necessary to protect or enhance White Sturgeon incubation habitat. These programs include: CLBMON-15a (Middle Columbia River Physical Habitat Monitoring), CLBMON-20 (Middle Columbia River White Sturgeon Spawning Habitat Assessment), CLBMON-27 (Middle Columbia River Sturgeon Incubation and Rearing Study) and CLBMON-54 (Middle Columbia River Effects of Flow Changes on Incubation and Early Rearing Sturgeon).

1.0 INTRODUCTION

White Sturgeon (*Acipenser transmontanus*) have experienced reduced population abundance in the Canadian portion of the Columbia River due to recruitment failure, altered food resources, and degradation or lack of access to suitable habitats (Porto 2008) and were listed as endangered under federal Species at Risk Act (SARA) legislation in 2006. The Columbia River population is considered at significant risk of extinction in the wild given strong evidence that, for several decades, natural recruitment has been too low to sustain this population (Hildebrand and Parsley 2013).

A small component of the Columbia River population resides in the area between Revelstoke Dam (REV) and Hugh L. Keenleyside Dam (HLK), which includes the Arrow Lakes Reservoir (ALR; Figure 1). This population component, referenced as the mid-Columbia River population, is comprised of approximately 52 adult White Sturgeon (population estimate ranges between 37 - 92 individuals at 95% confidence level) that are older than the 1969 age class (Golder 2006); construction of HLK Dam was completed in 1969. This small segment of the Columbia White Sturgeon population has experienced total recruitment failure (Hildebrand and Parsley 2013) even though natural spawning has been documented downstream of the REV tailrace, near the Revelstoke Golf Course since 1999 (R.L. & L. Environmental Services Ltd. 2000). Spawning has been intermittent and naturally produced juvenile White Sturgeon have never been captured (Hildebrand and Parsley 2013). Spawning investigations occurred in 1999, 2000, 2001, 2003, 2006 through 2013 with spawning events documented in 1999, 2003, 2006, 2008, 2009, 2011, 2012 and 2013 (Golder 2012a, AMEC 2013). Spawn timing has been estimated to occur from late July through August and this area represents the only known spawning area for White Sturgeon in the ALR (BC Hydro 2012).

Revelstoke Dam was built in 1984 and its operations are a function of discharges from the Mica Dam and local inflows to Revelstoke reservoir. In turn, Mica Dam discharges are regulated by the Columbia River Treaty (CRT) and the Non-Treaty Storage Agreement. REV is a hydropeaking facility and since early 2011 discharges within a 24 hour period have varied between the operational minimum of 142 m^3/s to approximately 2100 m^3/s (BC Hydro 2012, Golder 2012a). Prior to the installation of a fifth turbine unit in December 2010, referred to as 'REV5', flows could be varied from zero to approximately 1700 m^3/s (Golder 2012a). The effect of hydropeaking operations at REV is a constant variation in flow rates at the White Sturgeon spawning area downstream of the REV tailrace, approximately 5 km from Revelstoke Dam. Further adding to the complex flow regime is a backwatering effect observed as far upstream as REV when ALR water levels exceed 437 meters above sea level, which generally occurs before and during the White Sturgeon spawning period. Changes to the natural hydrograph have been strongly implicated as a cause for White Sturgeon recruitment failure below REV (Hildebrand and Parsley 2013). It remains unknown how enactment of minimum flows influence White Sturgeon spawning.

BC Hydro and others have funded a number of White Sturgeon investigations in ALR since 1995, which has included spawn monitoring downstream of REV since 1999. Annual spawn monitoring below REV is required under the terms of the Columbia River Project Water Licence (WLR) Order to document spawning events, timing, frequency, egg deposition, and habitat conditions (BC Hydro 2012). Spawn monitoring studies under BC Hydro's WLR process were carried out from 2007 to 2011 below REV (CLBMON-23A) with concurrent studies that assessed the feasibility of sonar techniques for detecting adult White Sturgeon within the spawning area (CLBMON-23B; as cited in Golder 2012a; Crossman et al. 2011). An additional five years of spawning investigations were initiated to document spawning events, timing, frequency and egg deposition to inform future management decisions. AMEC has been conducting these additional spawning investigations since 2012.

1.1 Objectives

The primary objectives of this monitoring program are to (BC Hydro 2012):

1. Assess sturgeon incubation sites and conditions downstream of Revelstoke Dam;
2. Relate egg stranding risk to discharge from the dam and water elevation of Arrow Reservoir;
3. Assess the feasibility of underwater videography or other remote sensing techniques for monitoring presence of White Sturgeon spawners (already covered under CLBMON-23B);
4. Select and implement the most effective method (egg mats or videography or other remote sensing) for ongoing monitoring of spawning of White Sturgeon (already covered during previous studies conducted under CLBMON-23A and 23B); and
5. Provide input to recommendations for the water allocation schedule for White Sturgeon spawning and incubation.

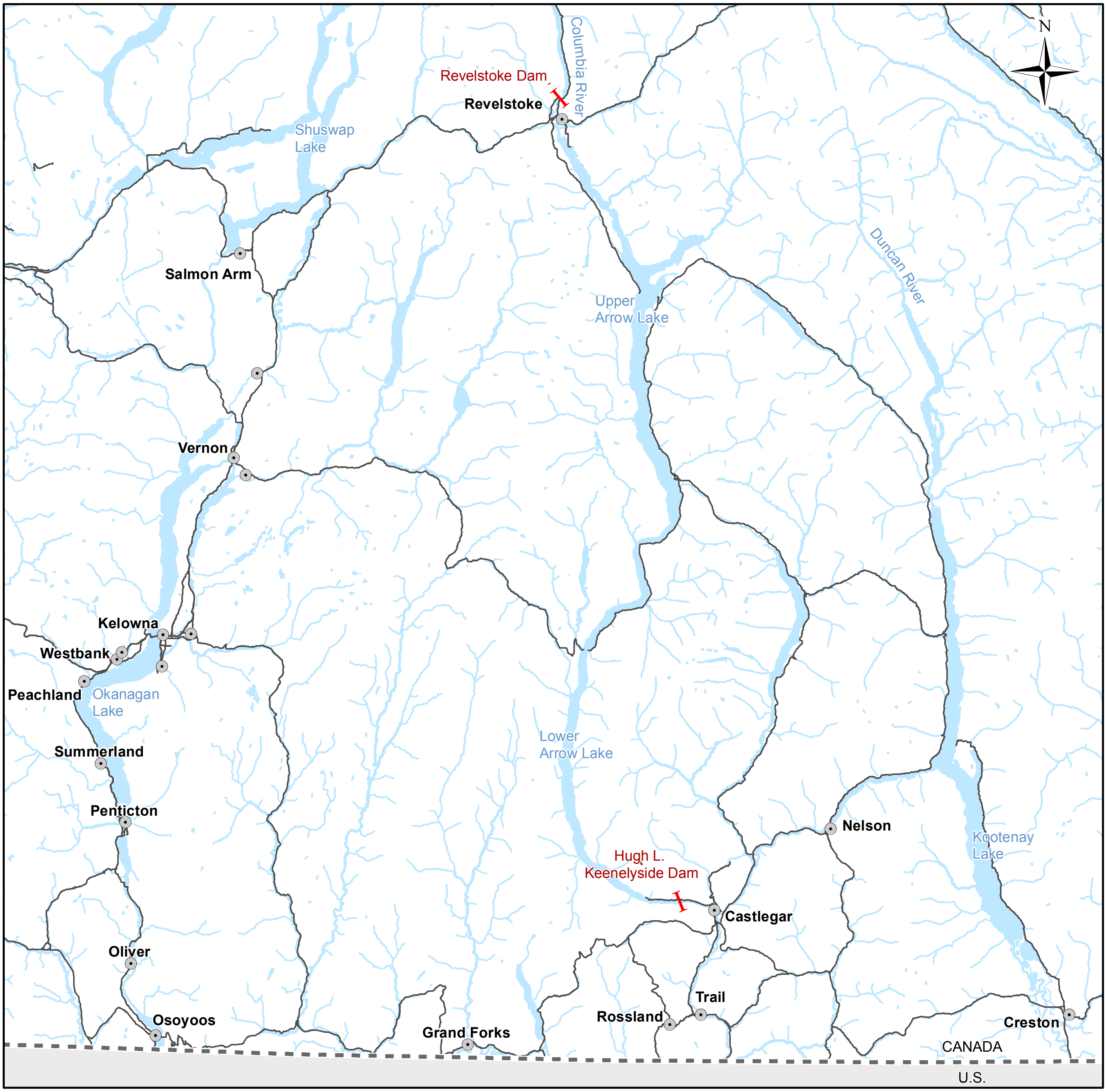
The fundamental Management Questions to be addressed through this study are (BC Hydro 2012):

1. Where are the primary White Sturgeon incubation sites below Revelstoke Dam?
2. How do dam and reservoir operations affect egg and larvae/free embryos 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?[1]
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?

1.2 Purpose

The following report fulfills AMEC's commitment to provide BC Hydro with a data report for studies conducted in 2013 and adds to the dataset collected in previous years.

[1] This management question was addressed under a different program (CLBMON-23B Mid-Columbia River White Sturgeon underwater videography feasibility study; Johnson et al. 2009) and will not be further addressed by the present program.



Legend

- Dams
- City/Town
- Highway
- Stream
- Waterbody

Reference
BC Government Data Distribution

Scale: 1:1,400,000

0 15 30 60
Kilometers

CLIENT:	BC Hydro
PROJECT:	CLBMON-23 Mid-Columbia River White Sturgeon Spawn Monitoring
TITLE:	Overview Map of the Middle Columbia River Depicting Hydroelectric Facilities

DATE:	ANALYST:	
March, 2014	KA	**Figure** 1
JOB No: VE52241	QA/QC: MY	PDF FILE: 01-50-001_v3.pdf
GIS FILE: 01-50-001_v3.mxd		
PROJECTION: UTM Zone 11	DATUM: NAD83	amec

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2.0 METHODS

2.1 Study Area

Spawn monitoring has been conducted in the area from approximately 1 Km downstream of Revelstoke Dam (Km 235) to the mouth of the Illecillewaet River (Km 223.5) (R.L. & L. Environmental Services Ltd. 2001, Golder 2008). The 2013 study area was concentrated in the area where over 97% of White Sturgeon eggs have been captured since 1999, from Km 228 to Km 230 (Golder 2012a; Figure 2).

2.2 Environmental Parameters

In order to help answer Management Questions 2 and 4 pertaining to operations and dewatering, environmental parameters were monitored during the program. Hourly discharge (m^3/s) from REV, separated by turbine and spillway flow, and water surface elevation (meters above sea level) of ALR at Nakusp were obtained from BC Hydro Power Records. Water temperature (°C) and water surface elevation collected under CLBMON-15a Middle Columbia River Physical Habitat Modelling at 10 minute intervals were obtained for Station 2 ("Reach 4 downstream"), which is located at river Km 231.1 on the left downstream bank (UTM Zone 11U, Easting 414925, Northing 5653213). A thermograph station, using Onset TidbiT v2 loggers accurate to 0.2°C, was deployed to provide a backup of hourly water temperature data within the spawning area (Km 229.7L; Figure 2).

2.3 Sample Timing

The sampling period occurred from July 24 to September 10, 2013 during the known White Sturgeon spawning period below Revelstoke Dam. A summary of field sample sessions is provided in Table 1.

Table 1: Sample effort for CLBMON-23 Middle Columbia River White Sturgeon spawn monitoring, 2013.

Date	Activities
July 24 - 26	Deployed ten mid-channel and ten near shore egg mat/drift net sample stations. Drift net sampling
July 30 - 31	Retrieved, checked and redeployed egg mats. Drift net sampling.
August 7 - 8	Retrieved, checked and redeployed egg mats. Drift net sampling.
August 14 - 16	Retrieved, checked and redeployed egg mats. Drift net sampling.
August 22 - 23	Retrieved, checked and redeployed egg mats. Drift net sampling.
August 28 - 29	Retrieved, checked and redeployed egg mats. Drift net sampling.
September 4 - 5	Retrieved, checked and redeployed egg mats. Drift net sampling.
September 8 - 10	Retrieved and checked egg mats. Drift net sampling. Removed sample stations.

2.4 Spawn Monitoring

2.4.1 Egg Collection Mats

In order to maintain consistency across sampling years, standard egg mats (cf. below) were used to collect White Sturgeon eggs/free embryos. This method has been successfully used in the middle Columbia River to monitor White Sturgeon spawning (e.g., Golder 2012a, AMEC 2013) and has been used throughout the Columbia basin in both Canada and the US to monitor other White Sturgeon populations (e.g., McCabe and Beckman 1990). Previous studies have determined that the most effective method for monitoring White Sturgeon spawning in the study area (Management Question 4) is a combination of egg mat and drift net sampling (Golder 2012a).

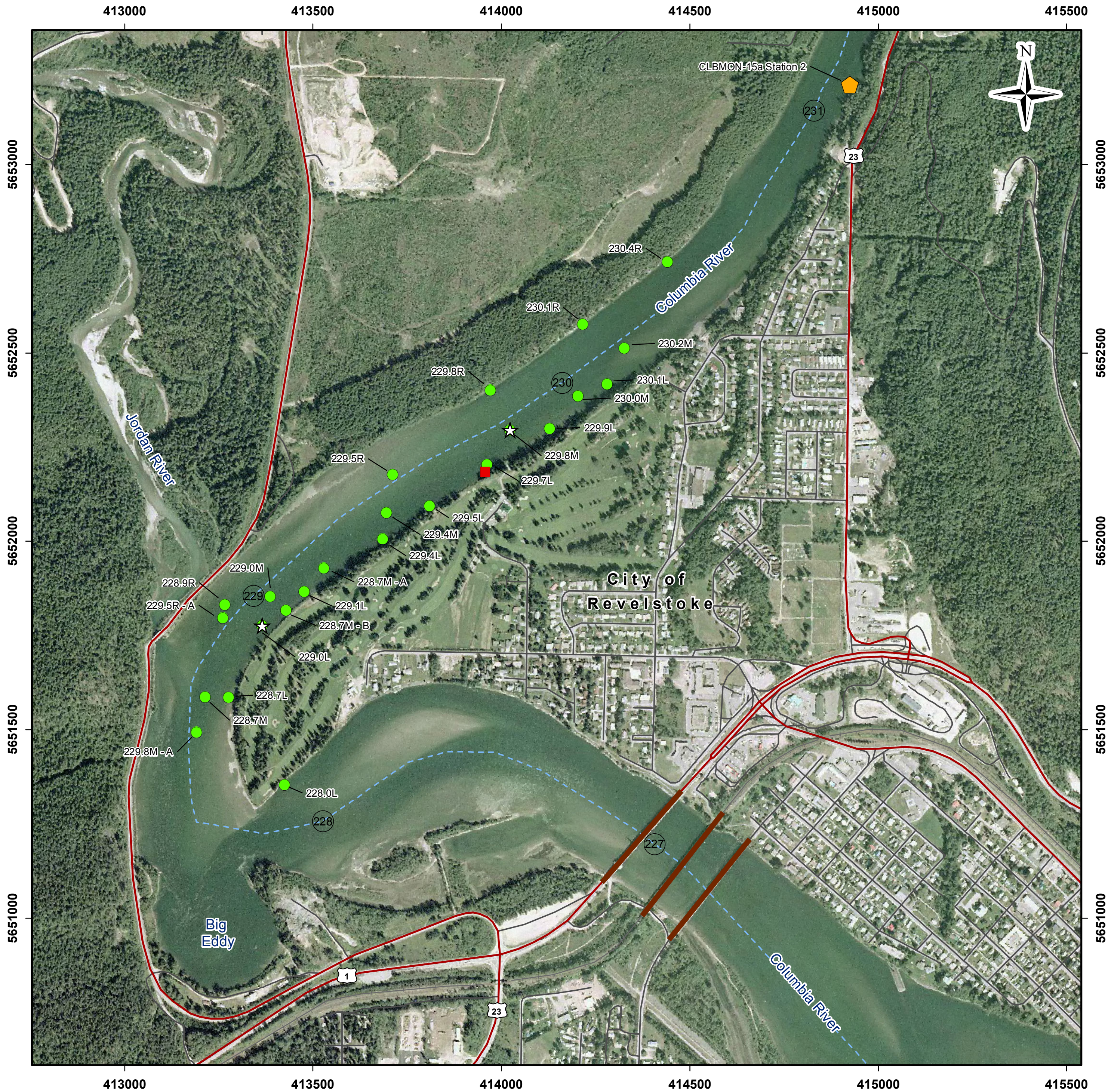
Egg mats were retrieved/deployed from a boat as per BC Hydro's Specific Work Instructions. Between 16 to 20 egg mat stations were deployed (half set to shore and the other half anchored middle channel sets) weekly and concentrated in the spawning area between Km 228.0 and 230.4. The number of egg mat stations deployed depended on station displacement and gear availability. Egg mats were also deployed overnight between the two days of weekly sampling when drift nets were not being set overnight at those locations (Section 2.4.2). A combination of nearshore and mid-channel egg mat sets have been used below REV in an attempt to cover potential spawning areas across the river channel (e.g. Golder 2012a). Nearshore sets included stations on both left and right banks of the spawning area, whereas effort in previous years was mainly concentrated along the left downstream bank. In 2013, water levels were lower and allowed for more mid-channel set coverage compared to 2012, where only 3 mid-channel sets could be deployed.

Each egg mat was comprised of a steel frame that enclosed latex covered animal hair filter material. The filter material was present on both sides of the frame, so when deployed, one side of the filter material was always sitting upward where drifting eggs and free embryos could lodge and attach. Egg mat dimensions were approximately 0.77 m by 0.92 m.

The egg mat system consisted of two 30 kg claw anchors attached to one another with an approximately 6 m galvanized steel chain and a float line which attached to the front anchor; a 10 m rope attached the rear anchor to the egg mat with a second float line (15 to 45 m) coming off the rear of the egg mat for retrieval. The lengths of rope used depended on depth and degree of flow fluctuations that were encountered.

Egg mats had a rope bridle system attached to each end, so that one end was attached to the rope/chain/anchor and the other bridle had a separate float line for retrieval. The retrieval float line was pulled up by the field crew, wrapped around the winch of the boat (which was permanently affixed to the bow) and used to pull the egg mat up. The egg mat was detached from the rope system and a spare egg mat was attached to the rope system and deployed. The boat operator drove to the shore and the field crew inspected the egg mat. Near shore egg mat sample locations were tied to shore instead of having a second float line. Having two float lines on mid-channel sets allowed the field crew to pull up the egg mat directly, but also the float line attached to the anchor provided a secondary means to pull up the egg mat set, should there have been a problem with the egg mat float line.

Data collected at each egg mat included: station name (e.g., J30 = retrieval buoy labelled J30); UTM; channel location (L= left bank when facing downstream and M = mid-channel); set and pull date and time; water temperature; set depth; number of eggs; number of free embryos; number of eggs/free embryos preserved; other species/observations; and, any relevant comments. If egg mats drifted significantly, they were moved back to their original location and noted in the comments; no new site designation was required. Data was recorded on standard data sheets set up for this program (see AMEC 2013). A photograph of each data sheet was taken during each field session to provide a back up. In the office, all data sheets were additionally scanned and then entered into MS Excel. GIS was used to convert each site UTM collected in the field to a river kilometre with channel location designation (e.g. 229.0L = river Km 229.0; L = left downstream bank). QA/QC was completed by a separate person who checked entered data for errors by comparing to field data sheets. The locations of egg mat stations are provided (Figure 2). Catch-per-unit effort (CPUE) was calculated for each egg mat (number of White Sturgeon eggs/hour of effort) for comparison between sampling locations and years (Appendix A).



Legend

- CLBMON-15a Station 2
- Thermologger
- Sample Location
- White Sturgeon Eggs Collected
- River Kilometre
- Bridge
- Highway
- Railway
- Existing Road

Reference

River Kilometre: Measured upstream from Hugh L. Keenleyside Dam
Base Map: British Columbia Imagry WMS
Other Data: National Road Network

Scale: 1:15,000

0 100 200 400
Metres

CLIENT: BC Hydro		
PROJECT: Study Area for White Sturgeon Spawn Monitoring Below Revelstoke Dam		
DATE: February, 2014	ANALYST: WR/KA	**Figure** 2
JOB No: VE52241	QA/QC: MY	PDF FILE: 01-50-003_v8_field1.pdf
GIS FILE: 01-50-003_v8.mxd		amec
PROJECTION: UTM Zone 11	DATUM: NAD83	

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2.4.2 Larval Drift Nets

In addition to the use of egg mats, collection of White Sturgeon eggs/free embryos was monitored using larval drift nets (referred hereafter as drift nets). This method has been successfully used to collect White Sturgeon eggs/free embryos in the middle and lower Columbia rivers as well as throughout the Columbia River in the US. Drift nets consist of a D-shaped metal frame (0.8 m wide by 0.6 m high) with an attached net (3.6 m long, 0.16 cm knotless mesh, 11.4 cm diameter collection bottle). In addition, a flow meter (e.g., General Oceanics) was fixed to the D-ring frame at the top of the opening to measure the volume of water sampled; this method has been used previously for drift net sampling in the middle Columbia River (e.g., Golder 2012a, AMEC 2013).

Drift net sites were selected to cover the upper, middle and lower portion of the spawn monitoring area during each field survey. A minimum of six and maximum of fifteen drift net sets were deployed weekly and concentrated in the spawning area between Km 228.7 and 230.4. Drift nets used egg mat anchor and shoreline sites established during the first field session, with site 229.9L used as a consistent weekly set and other sites used over the study period to distribute effort to additional potential deposition areas. Egg mat sites were removed on the first sampling day, checked for eggs/free embryos and replaced with drift nets. Drift nets were removed after 2 to 8 hours (depending on time available) and replaced with egg mats to soaked overnight. This was repeated on the second sampling day but once drift nets were pulled the egg mat remained in situ for a week. Therefore, drift nets were set on two consecutive days per week within the study area as per previous studies in the middle Columbia River (e.g., Golder 2012a). In 2012, drift nets were only set during the first sample day and overnight sets were not possible due to higher water levels than experienced during this program in the past (AMEC 2013). However, conditions in 2013 permitted the use of overnight sets (i.e. gear was able to withstand overnight debris loading), after an initial trial on August 14. Therefore drift nets sampled for 14-21 hours from late afternoon until the next morning. Overnight sets were used to increase effort to capture free embryos for DNA analysis during the estimated hatch period of WSG eggs, which were collected one week prior.

Two 30 kg claw anchors were used for drift net sites. Anchors had approximately 6 m of galvanized steel chain between them. The first anchor had a float line attached and the second anchor had a section of chain then rope to attach the drift net. The bottom end of the drift net frame was clipped onto this chain/rope line. The drift net was weighted at the front corners (approximately 4.5 kg lead weight attached to each corner) to ensure it remained upright in the water in order to more effectively sample drifting debris/aquatic life (e.g., Howell and McLellan 2006 as cited in Golder 2012a; personal observations). A second float line for retrieval was attached to the top of the drift net frame. Retrieval of the drift net was similar to the egg mat in that the float line was retrieved and the winch used to pull the drift net into the boat. The drift net was detached and the float line reattached. Drift nets were set on the same anchor systems and/or rope used for egg mat sampling (Section 2.4.1). Upon retrieval of the drift nets, the contents of the bottle and drift net were emptied into a white bucket. The contents of the bucket were further diluted with river water into small white wash basins and field crew members sorted through the debris to find any White Sturgeon eggs/free embryos using tweezers.

Data recorded for drift net sampling included: station name (similar to egg mats); river km and channel location; set and pull date and time; water temperature; set depth; start/end readings of the flow meter for calculation of water volume sampled; number of eggs/ free embryos; number preserved; other species observed; and, relevant comments (e.g., drifting of station, quantity of debris, whether eggs/free embryos were alive/dead). Data recording, entry and QA/QC followed that outlined for egg mats above. Locations for drift nets are provided (Figure 2). Catch-per-unit effort (CPUE) was calculated for each drift net (number of White Sturgeon/hour and number/100 m^3 water volume) for comparison with other sampling years.

2.5 Egg Incubation, Staging & Spawn Timing Estimation

White Sturgeon eggs were immediately staged on the boat upon capture. If this was not possible, eggs were to be preserved in Prefer and staged by dissection microscope in the office. Eggs staged in the field were loaded into incubation capsules or trays and fixed in the river in a location close to the point of capture and incubated until free embryos were observed. Incubation capsules consisted of a perforated cylindrical metal sheet capped at both ends with plastic PVC tube ends and measuring approximately 8 cm long by 3 cm diameter. Eggs were transferred to incubation trays when they were collected on August 14, 2013. Incubation trays consisted of flat plastic trays with wells for approximately 100 individual eggs covered by a top plate. Free embryos were then collected and preserved in 90% ethanol to be used in future genetic analyses (e.g. parentage assignment)

Standard egg staging procedures were used as described in Dettlaff et al. (1993) and Wang et al. (1985). Egg and free embryo stages were used with mean water temperatures observed during sampling to estimate the number and timing of spawning events based on developed relationships (Wang et al. 1985). The total number of eggs/free embryos, status (alive/dead/damaged), spawn timing and number of estimated spawning events were summarized. In the case of any free embryo stages falling between those noted by Wang et al. 1985, a range was calculated to cover the possible spawn timing.

2.6 Egg Stranding

In order to address Management Question 2 (Section 1.1), egg stranding surveys are to be conducted when White Sturgeon spawning event(s) are observed, depending on water levels. White Sturgeon eggs have been previously observed to dewater at a cobble/gravel bar across from the mouth of the Jordan River (~Km 228; Figure 2). On August 15, 2013, a cursory search for stranded eggs was conducted in proximity to this stranding location between 09:25 and 10:25 because water levels were observed to be lower compared to the previous sampling day; no eggs were observed. The extent of the exposed area was small and it was determined that a more extensive stranding survey was not required. In addition, flows at the time of sampling were forecasted to be well above the minimum (142 m^3/s) and an increased drift net sampling effort was recommended (J. Crossman, BC Hydro).

3.0 RESULTS

3.1 Environmental Parameters –Elevation, Discharge and Temperature

Arrow Lake Reservoir elevation steadily increased between May and July, reaching a peak elevation of 439.92 m above sea level (masl) in early July and gradually decreased through the remaining study period (Figure 3). Surface elevation at Nakusp above 437 masl backwaters ALR to the spawning area (Golder 2011) and was observed between June 14 and July 30, 2013 (Figure 3).

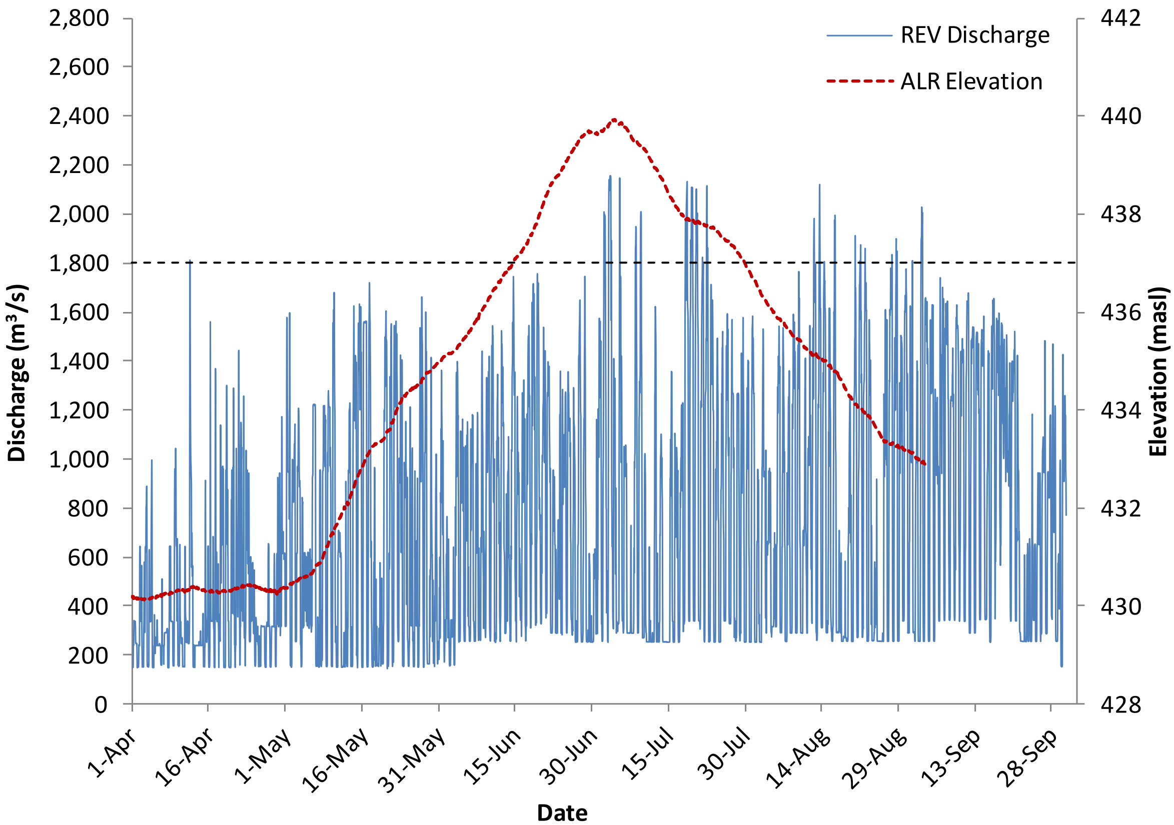


Figure 3: Hourly total discharge (m^3/s) from Revelstoke Dam (REV) and hourly water level elevation (meters above sea level) of Arrow Lakes Reservoir (ALR) as measured in Nakusp, BC, April 1 to September 30, 2013. The black dotted line represents 437 masl elevation when ALR backwaters the spawning area.

Water level elevation over the spawning area reached its summer maximum during early July with the highest elevation of 441.7 masl (as measured at CLBMON-15a Station 2 level logger at Km 231.1) on July 3 at 15:00 (Figure 4). Minimum elevations of 437.8 masl were observed at various times over the study period. Water levels did not lower to seasonal minimums until the end of July, likely due to the backwatering effect of ALR (Figures 3 and 4). Daily fluctuations in elevation ranged between 0.9 and 3.4 m/day for the duration of the study period, except on August 25 when the water level remained at minimum elevation and only fluctuated by 0.1 m/day (Figure 4). Water elevation at the spawning area followed the discharge release pattern from REV over the duration of the study period (Figure 4).

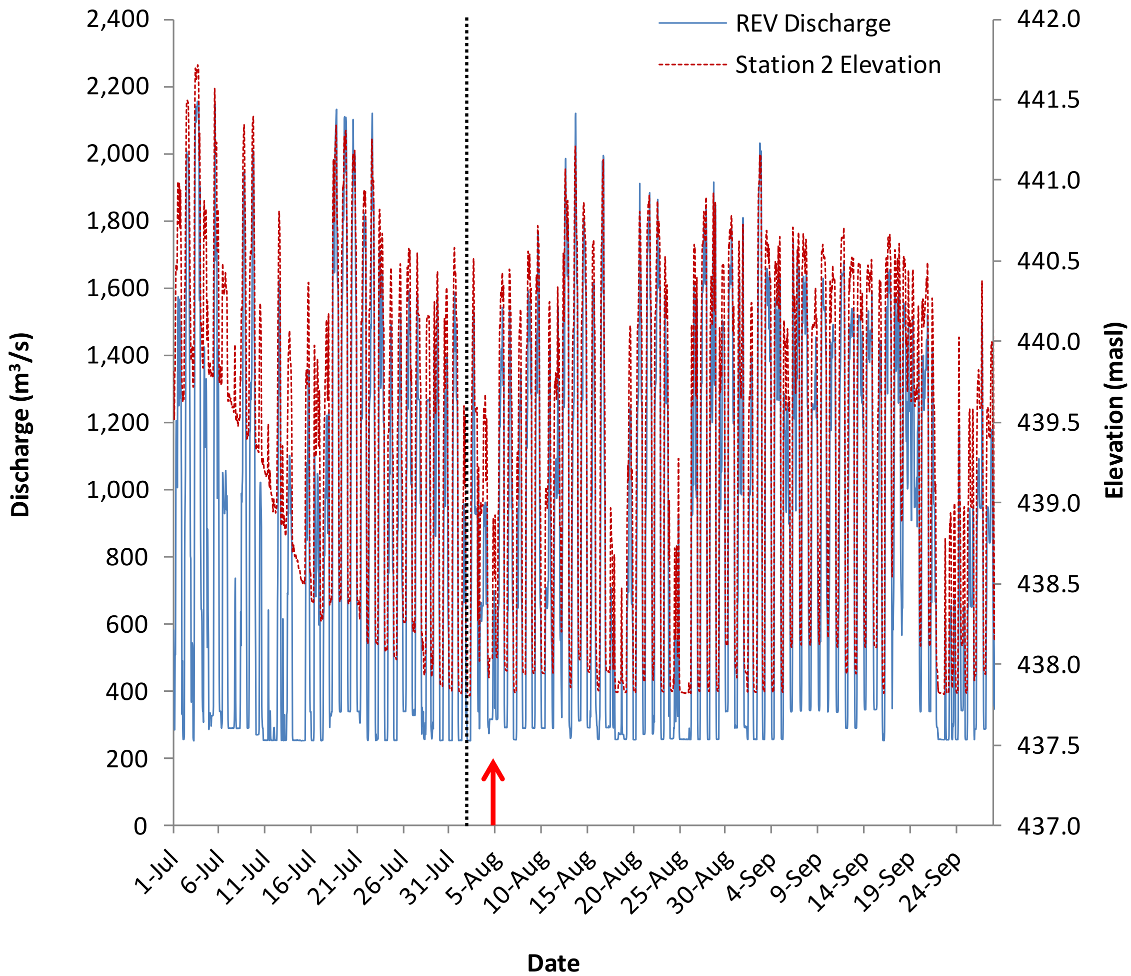


Figure 4: ***Hourly total discharge (m³/s) from Revelstoke Dam (REV) and hourly water surface elevation (meters above sea level) measured at CLBMON-15a Station 2 at Km 227.8, July 1 to September 30, 2013. The red arrow indicates the date when two White Sturgeon eggs were collected and the dotted bar indicates estimated spawn timing.***

Discharge from Revelstoke Dam exhibited daily fluctuation between April 1 and September 30, 2013 due to the hydropeaking operations at the facility (Figure 3). Peak discharge occurred in early July (2,153 m^3/s on July 3 at 07:00) (Figure 4). The maximum daily discharge reached levels up to approximately 2,000 m^3/s through September 2, 2013 (Figure 4). Discharge did not drop below 149 m^3/s throughout the period of record in 2013 (Figure 4). Spill gates were not used during the 2013 WSG spawning period (unpublished data, BC Hydro Power Records, 2013).

Water temperatures at the spawning area are the result of a combination of thermal conditions in the REV forebay, REV discharge volume and the backwater effect from ALR (Golder 2011). In 2013, water temperature fluctuated between 9.1°C and 12.5°C during the July through September period (Figure 4).

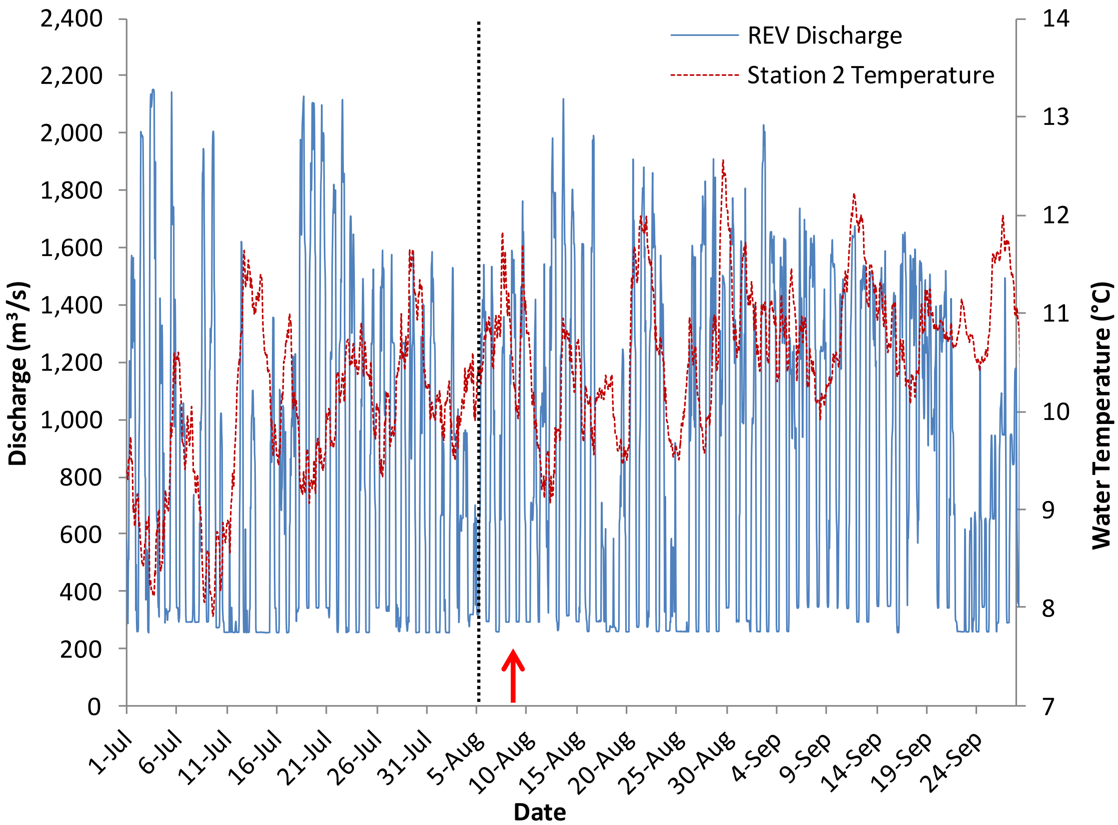


Figure 5: ***Hourly total discharge (m^3/s) from Revelstoke Dam and hourly water temperature (°C) measured at CLBMON-15a Station 2, July 1 to September 30, 2013. The red arrow indicates the date when two White Sturgeon eggs were collected and the dotted bar indicates estimated spawn timing.***

3.2 White Sturgeon Egg & Free Embryo Collection

3.2.1 Egg Collection Mats

Two White Sturgeon eggs were collected by egg mats at stations 229.0L and 229.8M on 7 August 2013 (Table 2; Appendix A). In total, 20,019 mat-hours of effort (mean sample duration per egg mat = 149.4 hours; SD = 43.0) were spent during the 2013 sampling period (Table 2 and 3; Appendix A). A summary of sample effort by year and sampling method is provided in Table 3 and illustrated in Figure 6.

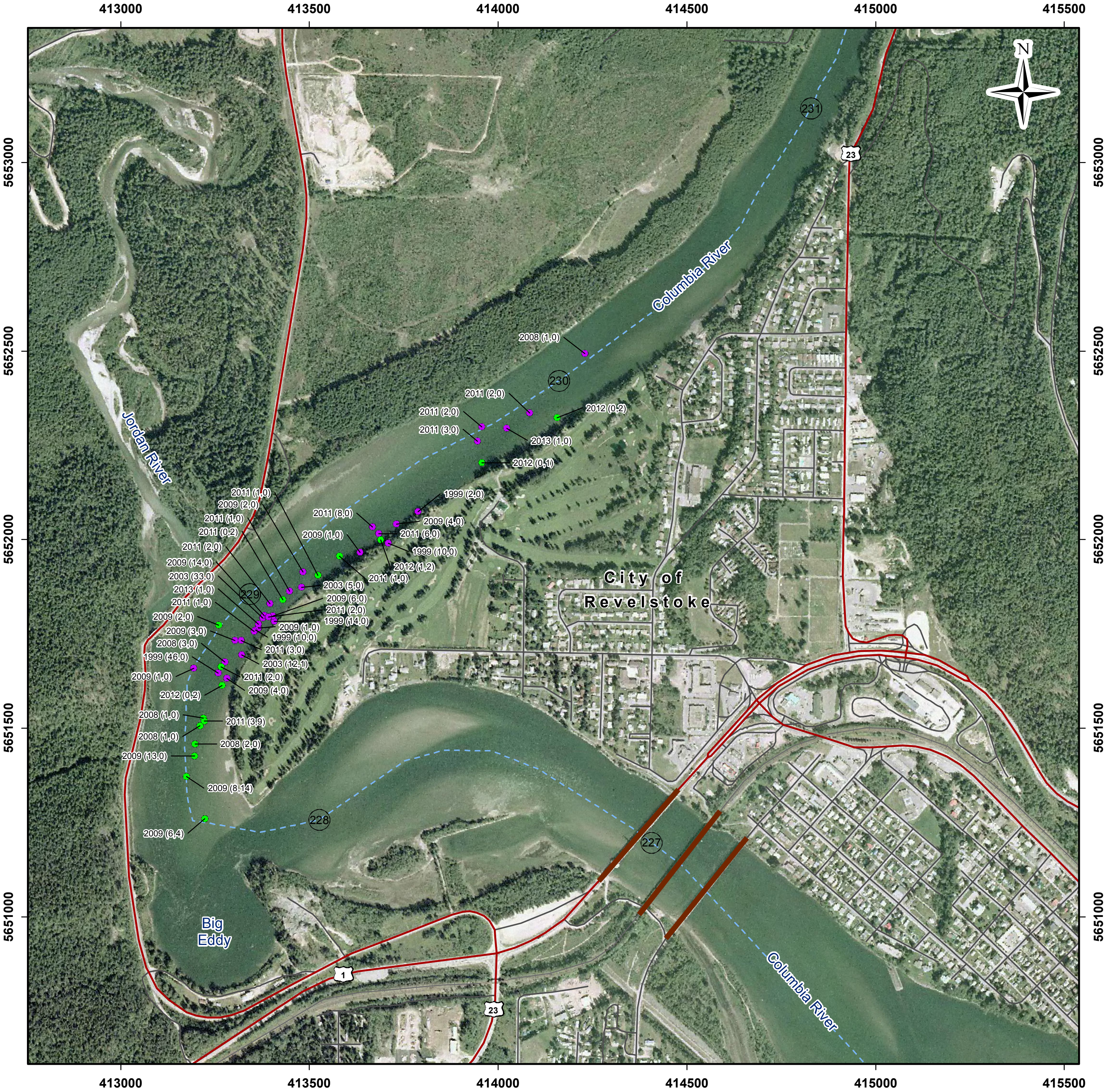
Table 2: Summary of egg collection mat sampling, July 24 to September 10, 2013.

Session	Date	No. Mats Deployed	No. Mats Retrieved	Effort (Mat-Hours)	No. Eggs /Free Embryos	Catch-Per-Unit-Effort (CPUE)[a]	Notes
1	July 24 - 26	24	4	70.03	0	0	4 mats set overnight only
2	July 30 - 31	19	19	2324.92	0	0	1 mat not retrievable
3	August 7 - 8	20	20	3757.85	2	0.0005	1 mat set overnight only
4	August 14 - 16	20	21	3235.09	0	0	2 mats set overnight only
5	August 22 - 23	18	18	3248.37	0	0	
6	August 28 - 29	18	18	2533.23	0	0	
7	September 4 - 5	16	18	2931.65	0	0	
8	September 8 - 10	0	16	1917.97	0	0	
	Totals	***135***	***134***	***20019.11***	***2***	***0.0001***	

[a] CPUE = no. White Sturgeon eggs/24 mat-hours.

Table 3: Summary of egg collection mat and drift net sampling by study year, 2007-2013.

Year	Egg Mats				Drift Nets				Reference
	No. Deployed	Total Effort (hrs)	No. Eggs/Free Embryos Captured	CPUE	No. Deployed	Total Effort (hrs)	No. Eggs/Free Embryos Captured	CPUE	
2013	135	20,019	2	0.0001	67	424.3	0	0	Current Study
2012	61	8,773	0	0	28	106.8	8	0.07	AMEC 2013
2011	128	22,169	30	0.03	23	61.2	18	0.30	Golder 2012
2010	96	20,514	0	0	15	67.4	0	0	Golder 2011
2009	115	18,860	36	0.05	22	65.3	47	0.70	Golder 2010
2008	164	27,009	4	0.004	6	12.6	4	0.30	Golder 2009
2007	136	25,818	0	0	8	24.7	0	0	Golder 2008
Mean	**119**	**20,452**	**10**	**0.01**	**24**	**108.9**	**11**	**0.20**	
Standard Deviation	33	5970	16	0.02	21	142.4	17	0.26	



Legend

- DR = Larval Drift Net
- SM = Egg Collection Mat
- River Kilometre
- Bridge
- Highway
- Railway
- Existing Road

2009 (6,4) = Year (Number of Eggs,Number of Free Embryos)

Reference
River Kilometre: Measured upstream from Hugh L. Keenleyside Dam
Base Map: British Columbia Imagry WMS
Other Data: National Road Network

Scale: 1:15,000

0 100 200 400
Metres

CLIENT: BC hydro		
PROJECT: CLBMON-23a Egg Collection Mat and Drift Net Sampling Location Where White Sturgeon Eggs and/or Free Embryos Were Collected Below Revelstoke Dam, 1999, 2003, 2008, 2009, 2011, 2012 and 2013.		
DATE: April, 2014	ANALYST: PK	**Figure** 6
JOB No: VE52241	QA/QC: CL	PDF FILE: 01-50-003_v9.pdf
GIS FILE: 01-50-003_v9.mxd		amec
PROJECTION: UTM Zone 11	DATUM: NAD83	

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3.2.2 Drift Nets

White Sturgeon eggs were not captured by drift nets in 2013 despite 424 hours of sampling effort (Table 3 and 4; Appendix B). Drift nets were set during the day (n=51) for a total of 163 hours (mean sample duration = 3.2 hours; SD = 1.3) and overnight (n=16) for a total of 261 hours (mean sample duration = 16.3 hours; SD = 2.7; Appendix B). Mean water volume sampled through daytime drift nets was 3,560 m^3 (SD = 2,720) and velocity was 62 cm/s (SD=38; Appendix B). Volume and velocity measurements were not analyzed for overnight sets as the instruments potentially reset themselves over the duration of the set.

Table 4: Summary of drift net sampling, July 24 to September 10, 2013.

Session	Date	No. Drift Nets Deployed	Sample Effort		White Sturgeon Eggs			White Sturgeon Free Embryos			Notes
			Duration (hr)	Estimated Volume (m^3)	No.	Catch-Per-Unit-Effort (CPUE) No./hr	Catch-Per-Unit-Effort (CPUE) No./ 100 m^3	No.	Catch-Per-Unit-Effort (CPUE) No./hr	Catch-Per-Unit-Effort (CPUE) No./ 100 m^3	
1	July 24 - 26	6	20.71	27884	0	0.00	0.00	0	0.00	0.00	3 sets per day
2	July 30 - 31	6	17.82	22841	0	0.00	0.00	0	0.00	0.00	3 sets per day
3	August 7 - 8	6	18.19	23608	0	0.00	0.00	0	0.00	0.00	3 sets per day
4	August 14 - 16	15	138.94	-	0	0.00	-	0	0.00	-	5 sets day one, 3 sets night one, 4 sets day two and 3 sets night two
5	August 22 - 23	9	63.69	-	0	0.00	-	0	0.00	-	3 sets per day, 3 sets overnight
6	August 28 - 29	10	47.26	-	0	0.00	-	0	0.00	-	4 sets per day, 2 sets overnight
7	September 4 - 5	9	48.74	-	0	0.00	-	0	0.00	-	3 sets per day, 3 sets overnight
8	September 8 - 10	6	68.91	-	0	0.00	-	0	0.00	-	3 sets day one, 3 sets overnight
	Totals	***67***	***424.26***	-	***0***	***0.00***	-	***0***	***0.00***	-	

"-" Drift nets set overnight and velocity meter readings could not be determined as meters zeroed themselves an unknown number of times.

3.3 Staging & Estimated Spawn Timing

The two White Sturgeon eggs captured on August 7 were placed into incubation capsules to hatch (Table 2 and 5). Predominant features of the eggs included the closure of the neural tube (stage 24; Table 5). Based on Wang et al. (1985), the time for White Sturgeon eggs to reach stage 24 is approximately 293 hours at 11°C; this resulted in an estimated spawn time of August 3-4 and estimated hatch time of August 15, 2013. Both eggs were observed to have hatched when the incubator was retrieved on August 15 at 12:51. One hatched free embryo was preserved in ethanol, whereas the other escaped from the incubation capsule.

Table 5: Estimated timing of spawning events based on the developmental stages of captured White Sturgeon eggs and free embryos, August 7, 2013.

Collection Date	Sample Location[a]	Egg/Free Embryo	Stage	Spot Water Temperature (°C) When Collected	Estimated Spawn Date[b]	Description
7-Aug-13	229.0L	Egg	24	12.0	8/4/2013 4:00	Closure of the neural tube
7-Aug-13	229.8M	Egg	24	11.6	8/4/2013 4:00	Closure of the neural tube

[a] See Figure 2 for locations.
[b] Based on Wang et al. 1985 and Dettlaff et al. 1993.

3.4 White Sturgeon Spawning and Physical Parameters

A summary of White Sturgeon spawning events and physical parameters observed below Revelstoke Dam during the spawning period (July-August) in years when spawn monitoring was conducted is provided in Table 6. The number of White Sturgeon spawning events recorded between 1999 and 2013 has varied from zero to three (Table 6). Maximum discharges were higher in 2011, 2012 and 2013 compared to other years that spawning monitoring was conducted. Minimum discharge was also higher during the past three years (i.e., zero discharge did not occur in 2011, 2012 and 2013; Table 6); spawning was observed in all three of those years.

Table 6: White Sturgeon spawning events and physical parameters observed below Revelstoke Dam (July-August) during spawn monitoring programs, 1999 to 2013. Note that spawn monitoring was not conducted in 2002, 2004 and 2005. Table updated from Golder (2012a).

Parameter		1999	2000	2001	2003	2006	2007	2008	2009	2010	2011	2012	2013
No. Spawning Events		3	0	0	2	1	0	2	3	0	3	1	1
No. Eggs Captured		82	0	0	50	1	0	8	65	0	37	1	2
No. Free Embryos Captured		0	0	0	1	0	0	0	18	0	11	7	0
Discharge (m^3/s)	**Mean**	1230	1139	682	901	939	1185	712	744	540	957	1506	862
	Min.	0	0	0	0	0	0	0	0	0	145	150	253
	Max	1838	1635	1612	1667	1630	1773	1752	1715	1757	2140	2573	2118
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
	Min.	9.2[a]		6.4	6.9	8	4.5	6.7	7.6	7.5	8	7.8	9.1
	Max	11.6[a]		13.1	13.6	13.1	12.9	11.8	16.2	14.2	12.5	13.5	12.6
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
	Min.	437.2	437.6	427.3	436.2	435.2	435.3	438.7	435.8	436.1	438	436.6	432.9
	Max	440	444	430.4	439	439.8	438.6	439.9	437.5	439.3	439.5	440.5	437.6
No. Zero Flow Events		25	8	36	36	12	8	49	42	39	0	0	0

[a] Temperature data were only available from August 4-31.
[b] Data not available.

4.0 DISCUSSION

The following discussion is structured in accordance with the management questions. As mentioned previously, management question 3 (underwater videography) was addressed under a different program (CLBMON-23B Middle Columbia River White Sturgeon underwater videography feasibility study; Johnson et al. 2009) and will not be further addressed by the present program.

4.1 Management Question 1: Where are the primary White Sturgeon incubation sites below Revelstoke Dam?

Columbia River White Sturgeon typically spawn in turbulent, high velocity areas that have hydraulic complexity and coarse substrates such as turbulent areas below dams (e.g., Parsley et al. 1993 and references cited in Hildebrand and Parsley 2013). Spawning in the mid-Columbia River below Revelstoke Dam has been identified in 8 of 12 years that monitoring has been conducted despite the small population estimated for this area (approximately 52 individuals; Golder 2006) and the fact that mature females may not be available every year to spawn. Based on the spawning studies conducted below Revelstoke Dam since 1999, the primary White Sturgeon egg incubation area is located within a 1.8 km river section between Km 228.3 and 230.1, which encompassed the area adjacent to the Revelstoke golf course (Figure 6); REV is located at Km 235. White Sturgeon spawning monitoring has been conducted between Km 223.5 and 234.0 since 1999 with efforts focused in the primary spawning area in recent years (R.L. & L. Environmental Services Ltd. 2001, Golder 2008, AMEC 2012).

During past study reviews, the primary incubation area was identified as a smaller 0.8 km area that began from the mouth of the Jordan River at Km 228.8 to 229.6 (Golder 2012a). It was suggested that on years when ALR elevation was above 437 masl at Nakusp, the backwatering effect at the spawning area may redistribute spawners slightly upstream (Golder 2012a). Eggs and/or free embryos were captured up to 1 km of this area in 2008, 2011 and 2012 when a backwatering effect was observed during spawning monitoring. However, in 2013 there was no backwater influence from ALR during spawning and one egg was collected at Km 229.8, which is upstream of the previously identified egg incubation area.

4.2 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?

It is unknown at this time how dam and reservoir operations affect White Sturgeon egg and larval survival because of variable operational regimes at REV over the duration of this monitoring program, the addition of REV5 minimum flows, the short time period with which monitoring those changes has occurred, and the low number of eggs/larvae that have been collected. Successful White Sturgeon egg and larval survival requires suitable substrate (gravels/cobbles/boulders), water velocity (>1 m/s), depth (3-25 m) and temperature conditions (10-18°C). Flow conditions at the White Sturgeon spawning area have varied substantially over the years when spawning monitoring has occurred below REV. Prior to the installation of a fifth unit at REV (REV5) in December 2010, REV flows varied between 0 and 1,700 m^3/s during the spawning period and peak discharge was maintained between 2 to 3 days. Therefore, zero-discharge events occurred during the spawn monitoring period (late July to early September) in all years monitoring was conducted (1999 to 2010). Since the enactment of minimum flows (142 m^3/s) in 2011, zero discharge events have not been observed and maximum discharge has increased due to new operating capacities (e.g., 2,100 m^3/s in 2011, 2,573 m^3/s in 2012 and 2,000 m^3/s in 2013). Spawning events have been observed each year since REV5 came online (2011, 2012, 2013), whereas spawning events were not observed in monitoring years prior to REV5 (2000, 2001, 2007, 2010).

In addition, changes in the operational regime and capacity of REV since December 2010 and observations during low flow periods suggest that a significant numbers of eggs do not become dewatered as a result of operations (post REV5). The increase in minimum flows and overall capacity has increased the estimated total wetted river bed area in the middle Columbia River by approximately 37% when ALR elevation is below 425 m (Golder 2012b). Therefore, exposure of the entire gravel bar as observed prior to enactment of minimum flows is no longer likely. During the past 9 years of this program, egg stranding surveys have been conducted twice to investigate dewatering of incubation areas, once in 2009 when minimum REV flow was zero and once in 2011 when minimum REV flow was 145 m^3/s (Golder 2012a). In 2009, seven White Sturgeon eggs were recorded in the 29 m^2 of exposed gravel bar surveyed, which resulted in a density estimate of 0.24 stranded eggs/m^2 and a potential estimated 7,600 stranded eggs over the entire 31,600 m^2 area assuming egg density was the same over the entire gravel bar (Golder 2010). In 2011, no eggs were observed in the 30 m^2 of exposed gravel bar surveyed when approximately 8000 m^2 of the bar was dewatered (Golder 2012a). In 2012 and 2013, water levels did not expose this area sufficiently during spawning monitoring to warrant extensive investigations.

4.3 Management Question 4: What is the most effective method for monitoring spawning of White Sturgeon?

The most effective method for monitoring White Sturgeon spawning in the mid-Columbia River is a combination of egg mats and drift nets. Other methods for monitoring White Sturgeon spawning in this area have included acoustic telemetry and DIDSON monitoring (Golder 2009, Crossman et al. 2011). Although these methods were effective for observing sturgeon in the spawning area, they were ineffective methods for spawning monitoring.

During the past 7 years of this program, an average of 119 egg mats have been deployed per spawning season for approximately 20,451 hours which resulted in an average catch-rate of 0.01 eggs/free embryos per hour. In contrast, an average of 24 drift nets have been deployed per spawning season for approximately 109 hours which resulted in an average catch-rate of 0.2 eggs/free embryos per hour. Although drift nets seem to have higher catch-rates, they are more labour intensive and do not monitor continuously like egg mats. Information suggests that larvae disburse downstream non-volitionally at hatch (J. Crossman pers. comm., 2014), so if drift nets are not deployed during hatch then this dispersal would be missed. However, evidence also suggests that the cooler water temperatures observed in the mid-Columbia River may cause larvae to hatch over a protracted period over several days instead of all at once (Parsley et al. 2011). Therefore, drift nets fished twice per week may have a better chance to overlap with larval downstream disbursement. In 2013, egg mats sampled continuously for approximately 48 days, whereas drift nets covered less than half of this time (18 days). In addition, eggs were only collected on egg mats and no eggs or larvae were captured in drift nets despite four times the level of drift net effort compared to previous years. Therefore, both methods should be used together during sampling.

4.4 Management Question 5: Can modifications be made to operations of Revelstoke Dam and ALR to protect or enhance White Sturgeon incubation habitat?

It is unknown at this time whether additional modifications to REV/ALR operations can be made to protect or enhance White Sturgeon incubation habitat. Flow modifications have already occurred with the addition of REV5 (see Section 4.2). Preliminary information collected during this monitoring program before and after REV5 suggests that recent operational modifications may reduce White Sturgeon egg stranding and spawning has been consistently observed in the past three years since REV5 came online (see Section 4.2).

The REV discharge regime, along with ALR elevation, influence the physical conditions (depth, velocity, substrate and thermal regime) observed at the spawning area. Physical changes observed from REV5 operational modifications includes greater diel variation in water level and less diel variation in temperature, but this was based on only two post-project years and is considered preliminary (Golder 2013). Past analyses did not find any discernable short or long term relationships between spawning and physical parameters (discharge, increasing or declining temperatures, ALR elevations and the frequency of zero flow events) (Golder 2012a), though the mean number of spawning events per year is low.

The influence of REV operations and ALR elevation on physical conditions observed at the spawning area is currently being assessed during concurrent BC Hydro WUP programs, which may provide further insight into whether additional operational modifications are necessary to protect or enhance White Sturgeon incubation habitat. These programs include: CLBMON-15a (Middle Columbia River Physical Habitat Monitoring), CLBMON-20 (Middle Columbia River White Sturgeon Spawning Habitat Assessment), CLBMON-27 (Middle Columbia River Sturgeon Incubation and Rearing Study) and CLBMON-54 (Middle Columbia River Effects of Flow Changes on Incubation and Early Rearing Sturgeon).

5.0 RECOMMENDATIONS

1. Continue to focus sampling effort at the sturgeon egg incubation area adjacent to the Revelstoke Golf Course. Significant sampling effort expended since 1999 have identified this as the predominant incubation area.
2. Repeat 2013 sampling effort and timing for the upcoming 2014 period, if conditions permit. That is, commence surveys during the fourth week of July and continue sampling through early September. Spawning events have been documented between July 25 and August 28.
3. Continue to deploy egg collection mats and drift nets as per the 2013 sampling. Both techniques have demonstrated their effectiveness depending on the flow year.
4. Continue to trial overnight drift netting as per 2013 sampling protocols when flow conditions are appropriate.

5. Continue to incubate eggs to hatch so that tissue samples are available for future genetic analyses.

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APPENDIX A
Egg Collection Mat Sampling

Table A1. Egg collection mat sampling data collected during middle Columbia River White Sturgeon spawning monitoring, July 24 to September 10, 2013.

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	WSG Catch Summary[1]		
		Date (2012)	Time	Water Temp (°C)	Date (2012)	Time	Water Temp (°C)			Eggs	Free Embryos	CPUE Eggs (No./hr)
230.2M	2.1	24-Jul	18:02	10.6	25-Jul	10:40	10.9	16:38	16.63	0	0	0
230.0M	2.7	24-Jul	18:06	10.5	30-Jul	14:54	11.2	140:48	140.8	0	0	0
229.8R	3.7	25-Jul	12:40	10.6	26-Jul	8:40	9.6	20:00	20	0	0	0
229.9L	1.5	25-Jul	15:44	10.2	26-Jul	8:50	9.6	17:06	17.1	0	0	0
229.5L	4.0	25-Jul	16:12	10.2	26-Jul	8:30	9.6	16:18	16.3	0	0	0
229.8M	3.5	25-Jul	10:45	10.7	30-Jul	14:30	11.4	123:45	123.75	0	0	0
229.4M	4.5	25-Jul	11:16	10.7	30-Jul	16:06	10.9	124:50	124.83	0	0	0
229.5R	2.1	25-Jul	11:33	10.7	30-Jul	15:53	10.9	124:20	124.33	0	0	0
230.1L	2.7	25-Jul	12:18	10.6	30-Jul	15:02	11.3	122:44	122.73	0	0	0
230.1R	3.5	25-Jul	12:24	10.7	30-Jul	15:21	11.1	122:57	122.95	0	0	0
228.0L	3.6	25-Jul	13:28	10.5	30-Jul	16:49	10.8	123:21	123.35	0	0	0
228.7M	4.5	25-Jul	14:17	10.6	30-Jul	16:40	10.9	122:23	122.38	0	0	0
228.9R	4.4	25-Jul	14:28	10.3	30-Jul	14:17	11.8	119:49	119.82	0	0	0
229.0L	4.4	25-Jul	14:30	10.2	30-Jul	17:03	10.8	122:33	122.55	0	0	0
229.4L	5.1	25-Jul	14:46	10.2	30-Jul	17:12	10.8	122:26	122.43	0	0	0
230.2M	2.3	25-Jul	15:24	10.2	30-Jul	15:10	11.1	119:46	119.77	0	0	0
228.7L	1.2	25-Jul	15:56	10.5	30-Jul	16:29	10.8	120:33	120.55	0	0	0
229.0M	5.1	25-Jul	16:05	10.2	30-Jul	16:20	10.9	120:15	120.25	0	0	0
229.7L	4.0	25-Jul	12:32	10.6	31-Jul	8:55	10.0	140:23	140.38	0	0	0
230.4R	3.8	25-Jul	16:17	10.1	31-Jul	9:05	10.0	136:48	136.8	0	0	0
229.1L[2]	3.8	25-Jul	12:49	10.6	-	-	-	-	-	-	-	-
229.5L	4.1	26-Jul	11:13	9.5	30-Jul	15:41	11.0	100:28	100.47	0	0	0
229.8R	3.1	26-Jul	11:32	9.6	30-Jul	15:31	11.0	99:59	99.98	0	0	0
229.9L	1.4	26-Jul	11:54	9.6	31-Jul	8:42	10.2	116:48	116.8	0	0	0
230.1L	2.5	30-Jul	15:03	11.3	7-Aug	18:53	11.5	195:50	195.83	0	0	0
230.2M	1.8	30-Jul	15:10	11.1	7-Aug	19:01	11.4	195:51	195.85	0	0	0
229.5L	3.9	30-Jul	15:41	11	7-Aug	17:22	11.6	193:41	193.68	0	0	0
229.5R	2.3	30-Jul	15:53	10.9	7-Aug	18:05	11.6	194:12	194.2	0	0	0
228.7L	1.2	30-Jul	16:29	10.8	7-Aug	16:34	12.2	192:05	192.08	0	0	0
229.0L	4.1	30-Jul	17:03	10.8	7-Aug	16:45	12.0	191:42	191.7	1	0	0.0052
229.4L	4.3	30-Jul	17:12	10.8	7-Aug	17:09	11.8	191:57	191.95	0	0	0
229.8M	4.3	30-Jul	17:36	10.7	7-Aug	17:35	11.6	191:59	191.98	1	0	0.0052
230.0M	2.8	30-Jul	17:46	10.6	7-Aug	19:09	11.4	193:23	193.38	0	0	0
230.1R	3.5	30-Jul	15:21	11.1	8-Aug	9:09	11.2	209:48	209.8	0	0	0

Table A1 continued

Station Name	Set Depth (m)	Set Data: Date (2012)	Set Data: Time	Set Data: Water Temp (°C)	Pull Data: Date (2012)	Pull Data: Time	Pull Data: Water Temp (°C)	Total Time	Hours of Effort	WSG Catch Summary[1]: Eggs	WSG Catch Summary[1]: Free Embryos	WSG Catch Summary[1]: CPUE Eggs (No./hr)
229.8R	3.2	30-Jul	15:31	11	8-Aug	9:33	11.0	210:02	210.03	0	0	0
229.4M	4.6	30-Jul	16:06	10.9	8-Aug	9:42	11.0	209:36	209.6	0	0	0
229.0M	4.8	30-Jul	16:20	10.9	8-Aug	9:56	11.0	209:36	209.6	0	0	0
228.7M	4.4	30-Jul	16:40	10.9	8-Aug	10:07	11.0	209:27	209.45	0	0	0
228.0L	3.4	30-Jul	16:49	10.8	8-Aug	10:23	11.1	209:34	209.57	0	0	0
228.9R	4.3	30-Jul	17:22	10.8	8-Aug	8:57	11.5	207:35	207.58	0	0	0
229.9L	1.4	31-Jul	11:54	10.1	7-Aug	18:25	11.5	174:31	174.52	0	0	0
229.7L	3.7	31-Jul	12:04	10	7-Aug	17:33	11.6	173:29	173.48	0	0	0
230.4R	3.8	31-Jul	12:19	10.1	8-Aug	9:25	11.0	189:06	189.1	0	0	0
229.9L	1.4	7-Aug	18:50	11.6	8-Aug	9:18	11.0	14:28	14.47	0	0	0
229.5L	2.7	7-Aug	17:27	11.6	14-Aug	16:08	10.5	166:41	166.68	0	0	0
229.7L	3.3	7-Aug	17:35	11.6	14-Aug	16:14	10.5	166:39	166.65	0	0	0
230.1L	2.2	7-Aug	18:58	11.6	14-Aug	16:33	10.5	165:35	165.58	0	0	0
230.0M	2.5	7-Aug	19:09	11.4	14-Aug	16:55	10.5	165:46	165.77	0	0	0
228.7L	1.5	7-Aug	19:20	11.4	14-Aug	18:15	10.3	166:55	166.92	0	0	0
229.4L	4.1	7-Aug	19:53	11.4	14-Aug	15:55	11.3	164:02	164.03	0	0	0
229.0L	3.1	7-Aug	20:10	11.4	14-Aug	15:40	11.3	163:30	163.5	0	0	0
229.5R	2.2	7-Aug	18:05	11.6	15-Aug	12:51	10.2	186:46	186.77	0	0	0
230.2M	1.9	7-Aug	19:01	11.4	15-Aug	13:16	10.0	186:15	186.25	0	0	0
229.8M	4.2	7-Aug	17:37	11.6	15-Aug	13:25	10.0	187:48	187.8	0	0	0
230.4R	3.7	8-Aug	9:27	11.0	14-Aug	16:45	10.3	151:18	151.3	0	0	0
228.0L	3.1	8-Aug	10:26	11.1	14-Aug	18:24	10.2	151:58	151.97	0	0	0
229.9L	1.5	8-Aug	12:32	11.8	14-Aug	16:24	10.5	147:52	147.87	0	0	0
229.8R	3.2	8-Aug	9:38	11.0	15-Aug	13:08	10.0	171:30	171.5	0	0	0
229.4M	4.1	8-Aug	9:43	11.0	15-Aug	12:18	10.3	170:35	170.58	0	0	0
229.0M	4.4	8-Aug	9:56	11.0	15-Aug	12:30	10.3	170:34	170.57	0	0	0
228.9R	4.1	8-Aug	12:01	11.4	15-Aug	11:33	10.2	167:32	167.53	0	0	0
230.1R	3.5	8-Aug	12:22	11.4	15-Aug	11:19	10.2	166:57	166.95	0	0	0
228.7M	3.7	8-Aug	10:07	11.0	16-Aug	9:50	10.3	191:43	191.72	0	0	0
230.0M	3.3	14-Aug	16:55	10.5	15-Aug	10:28	10.8	17:33	17.55	0	0	0
230.4R	3.5	14-Aug	16:50	10.3	22-Aug	15:45	11.3	190:55	190.92	0	0	0
228.7L	1.1	14-Aug	17:17	10.3	22-Aug	14:51	11.6	189:34	189.57	0	0	0
228.0L	3.6	14-Aug	18:30	10.2	22-Aug	18:41	11.2	192:11	192.18	0	0	0
229.5L	4.0	14-Aug	18:58	10.2	22-Aug	15:25	11.4	188:27	188.45	0	0	0
229.7L	2.7	14-Aug	19:09	10.2	23-Aug	9:20	10.8	206:11	206.18	0	0	0

Table A1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	WSG Catch Summary[1]		
		Date (2012)	Time	Water Temp (°C)	Date (2012)	Time	Water Temp (°C)			Eggs	Free Embryos	CPUE Eggs (No./hr)
230.1L	1.9	15-Aug	11:16	10.2	15-Aug	18:52	9.8	7:36	7.6	0	0	0
229.9L	1.2	15-Aug	10:25	10.8	22-Aug	17:26	11.3	175:01	175.02	0	0	0
229.8R	3.2	15-Aug	13:13	9.9	22-Aug	15:35	11.4	170:22	170.37	0	0	0
230.2M	2.4	15-Aug	13:16	10.0	22-Aug	15:54	11.4	170:38	170.63	0	0	0
229.0L	3.4	15-Aug	17:23	10.3	22-Aug	15:02	11.6	165:39	165.65	0	0	0
229.4M	3.9	15-Aug	12:18	10.3	23-Aug	12:36	10.8	192:18	192.3	0	0	0
229.0M	4.5	15-Aug	12:30	10.3	23-Aug	10:20	10.9	189:50	189.83	0	0	0
229.5R - A	4.5	15-Aug	12:51	10.2	23-Aug	10:50	10.9	189:59	189.98	0	0	0
229.8M	4.5	15-Aug	13:27	10.0	23-Aug	11:45	11.0	190:18	190.3	0	0	0
230.0M	2.6	15-Aug	18:05	10.5	23-Aug	10:39	10.9	184:34	184.57	0	0	0
230.1R	3.4	15-Aug	18:49	9.8	23-Aug	10:32	10.8	183:43	183.72	0	0	0
228.9R	3.5	16-Aug	10:01	10.3	22-Aug	15:13	11.5	149:12	149.2	0	0	0
230.1L	1.9	16-Aug	10:27	10.1	22-Aug	16:24	11.4	149:57	149.95	0	0	0
229.4L	4.0	16-Aug	9:26	10.9	23-Aug	10:59	11.0	169:33	169.55	0	0	0
229.9L	2.3	22-Aug	17:26	11.3	28-Aug	16:03	10.9	142:37	142.62	0	0	0
228.7L	1.2	22-Aug	17:37	11.4	28-Aug	16:24	11.0	142:47	142.78	0	0	0
228.0L	3.2	22-Aug	18:45	11.2	28-Aug	15:23	10.7	140:38	140.63	0	0	0
229.0L	3.5	22-Aug	15:02	11.6	29-Aug	11:36	12.2	164:34	164.57	0	0	0
229.8R	3.0	22-Aug	15:35	11.4	29-Aug	11:04	12.1	163:29	163.48	0	0	0
230.4R	3.0	22-Aug	15:50	11.3	29-Aug	10:53	12.2	163:03	163.05	0	0	0
230.2M	2.5	22-Aug	15:54	11.4	29-Aug	10:02	12.2	162:08	162.13	0	0	0
228.9R	3.9	23-Aug	9:35	10.9	28-Aug	17:25	11.0	127:50	127.83	0	0	0
228.7M - A	4.2	23-Aug	10:16	10.9	28-Aug	16:50	11.0	126:34	126.57	0	0	0
229.0M	4.8	23-Aug	10:20	10.9	28-Aug	17:15	11.1	126:55	126.92	0	0	0
230.0M	2.9	23-Aug	10:39	10.9	28-Aug	15:44	10.9	125:05	125.08	0	0	0
229.5R - A	4.8	23-Aug	10:51	10.9	28-Aug	17:35	11.0	126:44	126.73	0	0	0
229.7L	3.7	23-Aug	12:16	10.7	28-Aug	15:35	10.8	123:19	123.32	0	0	0
230.1L	2.5	23-Aug	12:26	10.7	28-Aug	16:14	10.9	123:48	123.8	0	0	0
230.1R	3.1	23-Aug	10:35	10.8	29-Aug	10:18	12.1	143:43	143.72	0	0	0
229.8M - A	3.9	23-Aug	11:45	11.0	29-Aug	11:49	12.2	144:04	144.07	0	0	0
229.5L	2.6	23-Aug	12:04	10.7	29-Aug	11:24	12.2	143:20	143.33	0	0	0
229.4M	4.5	23-Aug	12:37	10.8	29-Aug	11:13	12.3	142:36	142.6	0	0	0
228.0L	3.4	28-Aug	15:28	10.7	4-Sep	18:05	10.9	170:37	170.62	0	0	0
230.1L	2.6	28-Aug	16:14	10.9	4-Sep	15:57	11.0	167:43	167.72	0	0	0
228.7M - B	3.8	28-Aug	17:10	11.0	4-Sep	15:33	11.2	166:23	166.38	0	0	0

Table A1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	WSG Catch Summary[1]		
		Date (2012)	Time	Water Temp (°C)	Date (2012)	Time	Water Temp (°C)			Eggs	Free Embryos	CPUE Eggs (No./hr)
228.9R	4.6	28-Aug	17:25	11.0	4-Sep	17:37	11.0	168:12	168.2	0	0	0
228.7L	1.3	28-Aug	18:31	11.2	4-Sep	17:56	10.9	167:25	167.42	0	0	0
230.0M	3.2	28-Aug	15:57	10.9	4-Sep	11:45	11.8	163:48	163.8	0	0	0
229.0M	4.8	28-Aug	17:15	11.1	5-Sep	10:12	11.9	184:57	184.95	0	0	0
229.5R - A	4.9	28-Aug	17:35	11.0	5-Sep	9:51	11.5	184:16	184.27	0	0	0
230.4R	3.3	29-Aug	10:58	12.1	4-Sep	16:05	10.9	149:07	149.12	0	0	0
229.8R	1.4	29-Aug	11:09	12.1	4-Sep	17:25	10.9	150:16	150.27	0	0	0
229.5L	2.7	29-Aug	11:24	12.2	4-Sep	15:42	11.1	148:18	148.3	0	0	0
229.0L	2.7	29-Aug	11:36	12.2	4-Sep	15:23	12.1	147:47	147.78	0	0	0
229.7L	3.5	29-Aug	12:10	12.2	4-Sep	18:50	10.8	150:40	150.67	0	0	0
230.1R	3.6	29-Aug	12:41	12.2	4-Sep	16:19	10.9	147:38	147.63	0	0	0
229.4M	3.9	29-Aug	11:13	12.3	5-Sep	9:12	11.5	165:59	165.98	0	0	0
229.8M - A	3.2	29-Aug	11:49	12.2	5-Sep	11:52	11.8	168:03	168.05	0	0	0
229.9L	1.2	29-Aug	12:19	12.5	5-Sep	9:29	11.5	165:10	165.17	0	0	0
230.2M	1.6	29-Aug	12:22	12.5	5-Sep	9:41	11.5	165:19	165.32	0	0	0
230.1L	2.5	4-Sep	15:57	11.0	9-Sep	16:30	10.7	120:33	120.55	0	0	0
230.4R	4.5	4-Sep	16:09	10.9	9-Sep	16:47	10.7	120:38	120.63	0	0	0
230.1R	2.6	4-Sep	16:19	10.9	9-Sep	17:37	10.6	121:18	121.3	0	0	0
229.8R	2.8	4-Sep	17:29	11.0	9-Sep	17:44	10.6	120:15	120.25	0	0	0
228.7M - B	3.3	4-Sep	18:23	11.0	9-Sep	18:21	10.5	119:58	119.97	0	0	0
228.9R	4.2	4-Sep	17:37	11.0	10-Sep	12:05	11.5	138:28	138.47	0	0	0
228.7L	1.2	4-Sep	17:58	10.9	10-Sep	12:35	11.2	138:37	138.62	0	0	0
228.0L	3.5	4-Sep	18:06	10.9	10-Sep	10:43	11.3	136:37	136.62	0	0	0
229.0L	3.3	4-Sep	18:10	11.1	10-Sep	12:25	11.2	138:15	138.25	0	0	0
229.5L	3.5	5-Sep	12:11	11.6	9-Sep	8:23	10.6	92:12	92.2	0	0	0
229.7L	2.9	5-Sep	12:19	11.6	9-Sep	16:12	10.9	99:53	99.88	0	0	0
229.9L	1.9	5-Sep	12:28	11.7	9-Sep	16:20	10.7	99:52	99.87	0	0	0
230.2M	1.5	5-Sep	12:32	11.7	9-Sep	16:37	10.7	100:05	100.08	0	0	0
229.4M	4.4	5-Sep	9:12	11.5	10-Sep	11:20	11.3	122:08	122.13	0	0	0
229.5R - A	4.4	5-Sep	9:51	11.5	10-Sep	11:50	11.2	121:59	121.98	0	0	0
229.0M	4.4	5-Sep	10:12	11.9	10-Sep	17:22	11.7	127:10	127.17	0	0	0

[1] WSG = White Sturgeon; CPUE = Catch per Unit Effort (no. eggs/hour of effort)

[2] Non-recoverable egg mat; "-" no data available

APPENDIX B
Drift Net Sampling

Table B1. Larval drift net sampling data collected during middle Columbia River White Sturgeon spawning monitoring, July 24 to September 10, 2013.

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	Estimated Volume Sampled (m^3)	White Sturgeon Catch Summary[1]					
		Date (2012)	Time	Water Temp (°C)	Date	Time	Water Temp (°C)				Eggs	Free Embryos	CPUE Eggs (No./hr)	CPUE Free Embryos (No./hr)	CPUE Eggs (No./ 100 m^3)	CPUE Free Embryos (No./ 100 m^3)
229.4L	4.2	25-Jul	10:34	11.1	25-Jul	14:45	10.3	4:11	4.18	7581	0	0	0	0	0	0
230.2M	1.3	25-Jul	10:42	10.9	25-Jul	15:20	10.3	4:38	4.63	8282	0	0	0	0	0	0
229.0L	3.8	25-Jul	11:01	10.7	25-Jul	14:30	10.2	3:29	3.48	7525	0	0	0	0	0	0
229.5L	1.6	26-Jul	8:33	9.6	26-Jul	11:12	9.5	2:39	2.65	2212	0	0	0	0	0	0
229.8R	2.8	26-Jul	8:41	9.6	26-Jul	11:32	9.6	2:51	2.85	457	0	0	0	0	0	0
229.9L	1.0	26-Jul	8:51	9.6	26-Jul	11:46	9.5	2:55	2.92	1827	0	0	0	0	0	0
228.9R	3.7	30-Jul	14:18	11.8	30-Jul	17:22	10.8	3:04	3.07	4209	0	0	0	0	0	0
229.8M	3.8	30-Jul	14:31	11.4	30-Jul	17:34	10.7	3:03	3.05	5957	0	0	0	0	0	0
230.0M	2.5	30-Jul	14:55	11.2	30-Jul	17:46	10.6	2:51	2.85	6054	0	0	0	0	0	0
229.9L	1.1	31-Jul	8:50	10	31-Jul	11:46	10.1	2:56	2.93	1678	0	0	0	0	0	0
229.7L	2.3	31-Jul	8:55	10.0	31-Jul	11:56	10.1	3:01	3.02	799	0	0	0	0	0	0
230.4R	1.4	31-Jul	9:14	10	31-Jul	12:08	10.2	2:54	2.9	4144	0	0	0	0	0	0
228.7L	0.5	7-Aug	16:34	12.2	7-Aug	19:20	11.4	2:46	2.77	5365	0	0	0	0	0	0
229.0L	4.0	7-Aug	16:45	12	7-Aug	20:10	11.4	3:25	3.42	4333	0	0	0	0	0	0
229.4L	4.8	7-Aug	17:09	11.8	7-Aug	19:53	11.4	2:44	2.73	4333	0	0	0	0	0	0
228.9R	4.0	8-Aug	8:57	11.5	8-Aug	12:01	11.4	3:04	3.07	4388	0	0	0	0	0	0

Table B1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	Estimated Volume Sampled (m^3)	White Sturgeon Catch Summary[1]					
		Date (2012)	Time	Water Temp (°C)	Date	Time	Water Temp (°C)				Eggs	Free Embryos	CPUE Eggs (No./hr)	CPUE Free Embryos (No./hr)	CPUE Eggs (No./ 100 m^3)	CPUE Free Embryos (No./ 100 m^3)
230.1R	1.8	8-Aug	9:09	11.2	8-Aug	12:14	11.4	3:05	3.08	3242	0	0	0	0	0	0
229.9L	1.3	8-Aug	9:18	11.0	8-Aug	12:25	10.8	3:07	3.12	1947	0	0	0	0	0	0
229.0L	4.5	14-Aug	15:40	11.3	14-Aug	18:36	10.3	2:56	2.93	1920	0	0	0	0	0	0
229.5L	2.6	14-Aug	16:13	10.5	14-Aug	18:46	10.2	2:33	2.55	3472	0	0	0	0	0	0
229.7L	2.8	14-Aug	16:22	10.5	14-Aug	19:00	10.2	2:38	2.63	1953	0	0	0	0	0	0
229.9L	1.2	14-Aug	16:30	10.5	14-Aug	19:12	10.2	2:42	2.7	994	0	0	0	0	0	0
230.1L	2.4	14-Aug	16:39	10.4	14-Aug	19:30	10.2	2:51	2.85	1596	0	0	0	0	0	0
229.9L	1.5	14-Aug	19:26	10.2	15-Aug	9:26	10.8	14:00	14	-	0	0	0	0	-	-
230.1L□	2.4	14-Aug	19:36	10.2	15-Aug	11:12	10.8	15:36	15.6	-	0	0	0	0	-	-
229.0L	3.8	14-Aug	19:43	10.2	15-Aug	10:40	10.8	14:57	14.95	-	0	0	0	0	-	-
230.0M	1.8	15-Aug	10:28	10.8	15-Aug	18:05	10.5	7:37	7.62	742	0	0	0	0	0	0
229.0L	2.7	15-Aug	10:40	10.8	15-Aug	17:23	10.3	6:43	6.72	4966	0	0	0	0	0	0
230.1R	1.6	15-Aug	11:26	10.2	15-Aug	18:22	10.0	6:56	6.93	11243	0	0	0	0	0	0
228.9R	3.6	15-Aug	11:33	10.3	15-Aug	19:15	9.9	7:42	7.7	11714	0	0	0	0	0	0
229.4L□	4.6	15-Aug	11:50	10.4	16-Aug	9:26	10.9	21:36	21.6	-	0	0	0	0	-	-

Table B1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	Estimated Volume Sampled (m^3)	White Sturgeon Catch Summary[1]					
		Date (2012)	Time	Water Temp (°C)	Date	Time	Water Temp (°C)				Eggs	Free Embryos	CPUE Eggs (No./hr)	CPUE Free Embryos (No./hr)	CPUE Eggs (No./ 100 m^3)	CPUE Free Embryos (No./ 100 m^3)
230.1L	2.2	15-Aug	18:52	9.8	16-Aug	10:15	10.7	15:23	15.38	-	0	0	0	0	-	-
228.9R	4.1	15-Aug	19:15	9.9	16-Aug	10:02	10.3	14:47	14.78	-	0	0	0	0	-	-
228.7L	1.0	22-Aug	14:51	11.6	22-Aug	17:37	11.4	2:46	2.77	2987	0	0	0	0	0	0
228.9R	4.7	22-Aug	15:13	11.5	22-Aug	18:07	11.4	2:54	2.9	1392	0	0	0	0	0	0
229.5L	3.5	22-Aug	15:29	11.4	22-Aug	18:19	11.2	2:50	2.83	3803	0	0	0	0	0	0
230.1L	2.2	22-Aug	16:24	11.4	23-Aug	9:00	10.8	16:36	16.6	-	0	0	0	0	-	-
228.9R	4.7	22-Aug	18:07	11.4	23-Aug	9:35	10.9	15:28	15.47	-	0	0	0	0	-	-
229.5L	1.8	22-Aug	18:31	11.2	23-Aug	8:43	11.0	14:12	14.2	-	0	0	0	0	-	-
229.5L	2.6	23-Aug	8:43	11.0	23-Aug	11:55	10.9	3:12	3.2	4928	0	0	0	0	0	0
230.1L	1.9	23-Aug	9:18	10.8	23-Aug	12:19	10.7	3:01	3.02	4872	0	0	0	0	0	0
229.7L	2.1	23-Aug	9:28	10.8	23-Aug	12:10	10.7	2:42	2.7	10874	0	0	0	0	0	0
229.7L	2.6	28-Aug	15:34	10.8	28-Aug	18:57	11.0	3:23	3.38	1	0	0	0	0	0	0
230.0M	3.2	28-Aug	15:44	10.9	28-Aug	15:57	10.9	0:13	0.22	334	0	0	0	0	0	0
229.9L	1.1	28-Aug	16:03	10.9	28-Aug	19:10	11.1	3:07	3.12	1865	0	0	0	0	0	0
228.7L	0.6	28-Aug	16:24	11.0	28-Aug	18:31	11.2	2:07	2.12	2317	0	0	0	0	0	0

Table B1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	Estimated Volume Sampled (m^3)	White Sturgeon Catch Summary[1]					
		Date (2012)	Time	Water Temp (°C)	Date	Time	Water Temp (°C)				Eggs	Free Embryos	CPUE Eggs (No./hr)	CPUE Free Embryos (No./hr)	CPUE Eggs (No./ 100 m^3)	CPUE Free Embryos (No./ 100 m^3)
229.7L	2.2	28-Aug	19:07	11.1	29-Aug	9:14	12.2	14:07	14.12	-	0	0	0	0	-	-
229.9L	1.1	28-Aug	19:17	11.1	29-Aug	9:28	11.9	14:11	14.18	-	0	0	0	0	-	-
229.7L	2.2	29-Aug	9:11	12.2	29-Aug	12:02	12.1	2:51	2.85	71	0	0	0	0	0	0
229.9L	1.1	29-Aug	9:28	11.9	29-Aug	12:11	12.3	2:43	2.72	2003	0	0	0	0	0	0
230.2M	1.6	29-Aug	10:02	12.2	29-Aug	12:22	12.5	2:20	2.33	3881	0	0	0	0	0	0
230.1R	1.6	29-Aug	10:18	12.1	29-Aug	12:31	12.3	2:13	2.22	2645	0	0	0	0	0	0
229.0L	2.9	4-Sep	15:23	12.1	4-Sep	18:11	11.0	2:48	2.8	3554	0	0	0	0	0	0
228.7M - B	1.1	4-Sep	15:33	11.2	4-Sep	18:23	11.0	2:50	2.83	1917	0	0	0	0	0	0
229.5L	2.4	4-Sep	15:42	11.1	4-Sep	18:34	10.9	2:52	2.87	3800	0	0	0	0	0	0
229.5L	1.6	4-Sep	18:44	10.8	5-Sep	8:55	11.5	14:11	14.18	-	0	0	0	0	-	-
229.7L	2.8	4-Sep	18:52	10.8	5-Sep	9:25	11.4	14:33	14.55	-	0	0	0	0	-	-
229.5L	2.6	5-Sep	9:08	11.4	5-Sep	12:07	11.6	2:59	2.98	3492	0	0	0	0	0	0
229.7L	2.7	5-Sep	9:25	11.4	5-Sep	12:13	11.7	2:48	2.8	2223	0	0	0	0	0	0
229.9L	1.0	5-Sep	9:29	11.5	5-Sep	12:22	11.7	2:53	2.88	2703	0	0	0	0	0	0
230.2M	1.8	5-Sep	9:41	11.5	5-Sep	12:32	11.7	2:51	2.85	2796	0	0	0	0	0	0

Table B1 continued

Station Name	Set Depth (m)	Set Data			Pull Data			Total Time	Hours of Effort	Estimated Volume Sampled (m^3)	White Sturgeon Catch Summary[1]					
		Date (2012)	Time	Water Temp (°C)	Date	Time	Water Temp (°C)				Eggs	Free Embryos	CPUE Eggs (No./hr)	CPUE Free Embryos (No./hr)	CPUE Eggs (No./ 100 m^3)	CPUE Free Embryos (No./ 100 m^3)
229.7L	2.6	9-Sep	16:12	10.9	9-Sep	18:42	10.6	2:30	2.5	1487	0	0	0	0	0	0
229.9L	1.1	9-Sep	16:20	10.7	9-Sep	18:50	10.6	2:30	2.5	2494	0	0	0	0	0	0
230.1L	2.2	9-Sep	16:30	10.7	9-Sep	19:02	10.5	2:32	2.53	2198	0	0	0	0	0	0
229.7L	2.5	9-Sep	18:48	10.6	10-Sep	15:15	11.6	20:27	20.45	-	0	0	0	0	-	-
229.9L	1.0	9-Sep	18:58	10.5	10-Sep	15:25	11.7	20:27	20.45	-	0	0	0	0	-	-
230.1L	1.9	9-Sep	19:06	10.5	10-Sep	15:35	11.4	20:29	20.48	-	0	0	0	0	-	-

[1] CPUE = Catch per Unit Effort (number of eggs or free embryos / hour of effort or 100 m^3 of water sampled).

"-" Drift nets set overnight and velocity meter readings could not be determined as meters zero'ed themselves an unknown number of times.

APPENDIX C
Station Location Coordinates

Table C1. UTM coordinates of sample locations during White Sturgeon spawning monitoring in the middle Columbia River, 2013.

Station Name	UTM Coordinates		
	Zone	Easting	Northing
228.0L	11U	413424	5651353
228.7M	11U	413214	5651587
228.7L	11U	413275	5651586
228.9R	11U	413266	5651832
229.0L	11U	413364	5651776
229.0M	11U	413386	5651854
229.1L	11U	413476	5651866
229.4L	11U	413685	5652006
229.4M	11U	413695	5652076
229.5R	11U	413711	5652177
229.5L	11U	413809	5652094
229.7L	11U	413962	5652204
229.8M	11U	414023	5652295
229.8R	11U	413970	5652401
229.9L	11U	414128	5652299
230.0M	11U	414203	5652386
230.1L	11U	414280	5652417
230.1R	11U	414216	5652576
230.2M	11U	414326	5652513
230.4R	11U	414440	5652741
229.5R - A	11U	413261	5651796
228.7M - A	11U	413528	5651929
229.8M - A	11U	413191	5651493
228.7M - B	11U	413428	5651817