# Columbia River Project Water Use Plan

## Columbia River White Sturgeon Management Plan

## Implementation Year 11

## Reference: CLBMON-21

*Mid-Columbia River Juvenile Sturgeon Detection and Habitat Use Study*

**Study Period: 2007 to 2017 Synthesis Report**

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# CLBMON-21: Middle Columbia River Juvenile White Sturgeon Detection and Habitat Use Program 2007 to 2017 Synthesis Report

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Cover Photo: Juvenile White Sturgeon captured in the Middle Columbia River in August 2017. Photo Credit: Evan Smith

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# Executive Summary

The Columbia River White Sturgeon (*Acipenser transmontanus*) population in southeastern British Columbia was listed as endangered under the federal Species at Risk Act (SARA) in 2006 due to recruitment failure. One segment of this population resides in the Middle Columbia River (MCR), a section between Hugh L. Keenleyside Dam (HLK; Castlegar, BC) and Revelstoke Dam (REV; Revelstoke, BC) that encompasses the Arrow Lakes Reservoir (ALR). An estimate of 52 adult White Sturgeon (37 - 92 individuals at 95% CI) were said to remain within the MCR, a population thought to be older than the construction date of HLK Dam (1968). The primary reason for recruitment failure in the MCR is thought to be a lack of juvenile rearing habitat as a function of the construction and operation of the HLK and REV dams.

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

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

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

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

1. Growth and Survival (2007-2017) – evaluating growth and survival of four different release sizes of hatchery-origin sturgeon including larval, small body Age 1, large Body Age 1, and Age 2. Size at release has increased over the 11 years of the program. This study initially focused on the Revelstoke Reach section of the Columbia River (REV to Beaton Flats), however was expanded to include the upper ALR from 2013-2017.
2. Habitat Use (2007-2012) – collection of background data on habitat use by juvenile sturgeon and describing the attributes of those habitats. Acoustic telemetry was used to describe movements of sturgeon using both at large (2007-2010) and fine scale (2011-2012) receiver arrays. Additional habitat use through direct captures was used to complement the telemetry data.

CLBMON-21 was initiated in 2007 and at that time focused on sonic telemetry to locate juvenile and adult White Sturgeon to identify habitat use, and to capture juveniles released by the conservation aquaculture program (marked with passive integrative transponder (PIT) tags) to assess growth and survival. In 2007, a conservation aquaculture program for White Sturgeon was initiated with the objective of determining whether a failsafe population could be established within the ALR and to evaluate growth and survival of juvenile White Sturgeon. To date, 60,987 juvenile White Sturgeon have been released at either Revelstoke (Rkm 230) or Shelter Bay (Rkm 177). To evaluate overwinter survival, fish were released in one of the three following size categories: small body Age 1 (50-80 g), large body Age 1 (170 g) or Age 2 (350-400 g).

A capture program was run from 2007-2017 using gillnets and setlines throughout the study area in an attempt to recapture released fish. To date, only 37 (0.06%) fish have been captured since release. Twenty-one of those captures survived at least one year at large, 10 of which were multi-year survivors. No fish have been captured from the 2010 (released 2011) and 2011 (released 2012) brood years, even though the 2011 release had the second highest number of juveniles released in the MCR. Growth rates of fish captured after at least one year at large was 9.3 cm ± 3.8 in length and mean annual increase in weight was 0.23 kg ± 0.2. As a result of low recapture rates of juvenile White Sturgeon, survival estimates could not be determined.

A study design involving three phases of data collection was developed to assess juvenile White Sturgeon habitat use and movements. During the first phase (2007-2010), data on movements and macro-habitat use were obtained from acoustic-tagged juvenile White Sturgeon using both mobile tracking and anchored receivers. During this phase, 200 (50 each year) acoustic-tagged juvenile Sturgeon were released in the upper section of the MCR and data was collected from receivers placed 5 km apart along the thalweg of the study area. Based on the movements of those fish post-release, the release sites were changed in 2009 and 2010, and sturgeon were released at five different locations spread throughout the upper 30 km of the study area. Many juveniles used the area between Greenslide Creek and Beaton Flats (RKm 180) area during the summer months and tended to make downstream movements in the fall. The mean net movement of tagged fish was similar across all years, and fish remained within an approximate 21 – 26 km length of the reservoir despite differences in release patterns, which suggests juvenile Sturgeon are selecting for specific habitats. Juvenile White Sturgeon prefer deep (>10 m), slow moving areas with fine substrates, and tend to make the longest movements during the night.

The second phase, implemented in 2011 (Year 5), was to determine the feasibility and best location of the Vemco Positioning System (VPS) array that would describe localized movements and habitat use which informed the third phase, deployment of the fine-scale array in 2012. The data collected from the fine-scale array allowed analysis of movement patterns as related to daylight, habitat type, REV discharge effects at the study area, ALR elevation for 2012, and seasons. Tag locations clearly showed that juvenile White Sturgeon have a preference for thalweg areas in all seasons, however were also found in shallow and floodplain sites in summer and fall (when reservoir levels were high) but rarely in spring (when reservoir levels are low). Movement speeds were greatest in the summer, however were similar between daytime and nighttime. This data also showed Sturgeon made the longest distance movements out of the shallows when the reservoir was emptying. Overall, results from the VPS telemetry array suggest that juvenile White Sturgeon used a wider range of depths, and made more frequent, longer, and faster movements in the summer when the reservoir is full compared to spring (reservoir filling) or fall (reservoir emptying). Studies on juvenile White Sturgeon in other areas of the upper Columbia River Basin have shown a preference for depths greater than 10 m, which may suggest depth is a factor in influencing seasonal habitat selection by juveniles in the MCR.

The current state of knowledge for the juvenile White Sturgeon program in the Middle-Columbia River with respect to BC Hydro's Management Questions is provided in the table below.

| Management Question | Status |
|---|---|
| 1. Where are the habitat locations utilized by juvenile Sturgeon in the Middle-Columbia? | Based on data collected using both acoustic telemetry and direct capture efforts, juvenile White Sturgeon exhibit highest use of habitats near Greenslide Cr. (RKm 212) downstream to Beaton Flats (Rkm 55) and, to a lesser extent, further south into Arrow Lakes Reservoir. Much of the habitat use observed has been within the river-reservoir interface zone around Beaton Flats and upstream towards Revelstoke. Juveniles have not been directly captured below the Beaton Flats area in large numbers but telemetry has identified a few individuals further downstream towards Nakusp. |
| 2. What are the physical and hydraulic properties of this habitat that define its suitability as juvenile Sturgeon habitat? | Juvenile White Sturgeon use deep (>10 m), low velocity (<0.5 m/s) habitats with fine substrates (sand/silt/clay). This is based primarily on movements of acoustically tagged juveniles (n=250) and general locations of capture. When releases occurred at the City of Revelstoke (RKm 229, 2007-2012), juveniles were found to move quickly downstream to Mulvehill and Greenslide Creeks, and Akolkolex River areas and further downstream into the reservoir where conditions are more favorable. Accordingly, the release site was moved to Shelter Bay (RKm 177) in 2013 to ensure release in closer proximity to suitable habitats. |
| 3. What is the quantity of available habitat meeting these conditions in the Middle-Columbia? | The amount of available preferred habitat for juvenile White Sturgeon is related to the ALR water elevation which is influenced by discharge from REV. Recruitment does not appear to be limited by juvenile habitat quality and quantity; however, this hypothesis cannot be rejected at this time. Relative weights of juveniles captured in the MCR are near expected for their size, indicating that the surviving fish are growing at near normal rates. This finding does not support a hypothesis that food resources in the MCR are limiting juvenile survival and growth. |
| 4. How do hydraulic conditions resulting from dam and reservoir | Both REV discharges and Arrow Lakes Reservoir operations influence habitat quality and quantity. |

| | |
|---|---|
| operations relate to habitat suitability for juvenile White Sturgeon in the Middle-Columbia? | Discharge from REV influences the quality and quantity of habitat in riverine sections; however the effects diminish with downstream distance. Higher reservoir elevations backwatering the river section result in greater availability of deeper, lower velocity habitats further upstream. The ALR levels affect Sturgeon movements in the river section and attenuate the effects of varying dam discharges on Sturgeon habitat. |
| 5. What are the survival rates of juvenile White Sturgeon in the Middle-Columbia River? | Survival has not been estimated due to low recapture rates, which are attributed to a large study area and low capture efficiency. On average for all recaptured fish, total annual growth was 11.9 cm/year in length and 210 g/year in weight. This is comparable the juveniles released and recaptured in the Lower Columbia River juvenile sturgeon program. While most fish in the MCR have been captured in the same year they were released, one of the captured juveniles had survived to age-10. Additional capture data are required to adequately address the survival question. |
| 6. Can modifications be made to the operations of Revelstoke Dam and/or Arrow Lakes Reservoir to protect or enhance juvenile White Sturgeon habitat? | The main areas of habitat use by juvenile Sturgeon are situated >25 km downstream from REV, where it is unlikely that significant dam operational improvements can be made. Detecting a response to operational modifications from REV would also be difficult as many juvenile White Sturgeon move quickly downstream to RKm 200 – 205 following release. At this distance from the dam, large changes in flows are ameliorated and backwatering from the reservoir likely changes the flow dynamics. The landforms around the preferred area of the Walter Hardman Generation Station and Akolkolex River (Rkm 200) constrict the Columbia River, which may be creating conditions that are more suitable to juvenile rearing for at least some of the year.<br>For the reservoir, maintaining the ALR water elevation at levels that ensure a deep thalweg (425-430 MASL) around Greenslide Creek (RKm 212) will maximize the amount of preferred habitat that is currently being used by juveniles in this area. |

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# 1.0 Introduction

White Sturgeon (*Acipenser transmontanus*) are the largest and longest lived freshwater fish species in North America, and are native to the Columbia River drainage in British Columbia, Canada. The population of White Sturgeon in the upper Columbia River was listed as Endangered under the Canadian Species at Risk Act (SARA) in 2006 as the population is undergoing recruitment failure (Fisheries and Oceans 2014).

A small segment of the population from the pre-dam era occurs within the Arrow Lakes, a section of the Middle Columbia River (MCR) spanning from the Revelstoke Dam (REV) to the Hugh L. Keenleyside Dam (HLK). Population abundance is estimated at approximately 52 adult White Sturgeon for the Arrow Lakes (37 - 92 individuals at 95% confidence level; Golder 2006b), all of which are assumed to have been present prior to the building of HLK Dam in 1968. Using the estimated annual adult survival rate of 97%, the estimated adult White Sturgeon abundance in 2017 would near 34 fish (DFO 2014).

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

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

An experimental conservation aquaculture program was initiated in 2007 with releases of hatchery-origin juveniles occurring annually. An 11-year monitoring program was developed to investigate juvenile survival, growth, movement, habitat use, and habitat availability to support building a self-sustaining population in this section of the Columbia River. The program has been implemented adaptively, and as the monitoring progressed, additional questions around fish movement within preferred habitats and potential issues with smaller body size at release increasing survival risk were incorporated into the study design of the program.

## 1.1 Management Questions

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

1. Where are the habitat locations utilized by juvenile Sturgeon in the MCR?
2. What are the physical and hydraulic properties of this habitat that define its suitability as juvenile Sturgeon habitat?
3. What is the quantity of available habitat meeting these conditions in the MCR?

4. How do hydraulic conditions resulting from dam and reservoir operations relate to habitat suitability for juvenile White Sturgeon in the MCR?
5. What are the survival rates of juvenile White Sturgeon in the Middle Columbia River?
6. Can modifications be made to the operations of REV and/or Arrow Lakes Reservoir to protect or enhance juvenile White Sturgeon habitat?

## 1.2 Management Hypotheses

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

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

**$H1_A$:** Quality and quantity of White Sturgeon juvenile habitat in the MCR is directly related to discharge from the dam.

**$H1_B$:** Quality and quantity of White Sturgeon juvenile habitat in the MCR is directly related to water elevation in Arrow Lakes Reservoir.

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

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

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

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

This report summarizes the key findings of the CLBMON 21 Program since its inception in 2007 to 2017. Additional details are provided in annual reports (Golder 2008, 2009, 2010, 2011, 2012, Golder and ONA 2013, ONA 2016, 2017), that are referenced collectively as the CLBMON-21 annual report series[1].

## 1.3 Key Water Use Decision

The key operating decision affected by the results of this monitoring program is the implementation of seasonal flow treatments from Revelstoke Dam. A seasonal flow treatment was to be implemented if 0+ and 1+ juvenile Sturgeon releases show relatively strong survival during the first 4 years of study (BC Hydro 2007). Results are being used to inform BC Hydro on the value of the 142 $m^3/s$ minimum flow at the end of the review period for the Columbia WUP. The juvenile White Sturgeon monitoring program will provide evidence towards deciding if natural recruitment and rearing can be re-established for the Middle Columbia Sturgeon population.

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[1] https://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/columbia-sturgeon.html

# 2.0 Methods

The following provides a brief discussion of the methods used over the course of the 11-year study program and highlights changes in methodology that occurred over this period. Additional details are provided in the CLBMON-21 annual report series.

## 2.1 Study Location and Period

The MCR is a portion of the Columbia River spanning 230 km from REV downstream to HLK near Castlegar, BC. The MCR includes the Arrow Lakes Reservoir (ALR; both the Upper and Lower Arrow Lakes) and the Revelstoke Reach, defined as the section of Columbia River from REV downstream to the Beaton Flats area (*Figure 1*). The Revelstoke Reach is approximately 50 km in length and varies in width from approximately 150 m at points below Revelstoke Dam (RKm 234.5) to over 2 km at Arrowhead (RKm 184). This section of the Columbia River is continually influenced by discharge from REV, with water level changes of over 3-5 m with large daily velocity changes, and the filling and draining of the ALR, which changes the location of the river-reservoir interface throughout the year due to backwatering. The Beaton Flats area (RKm 184 to 180) is a transitional area between the river and the deeper ALR, with some years having sites located within the adjacent Beaton Arm to the east. The ALR is approximately 73 km from Beaton Flats (RKm 180) to the downstream end of the Arrow Lake Narrows (RKm 107). The entire study area was approximately 127 km in length. The juvenile White Sturgeon study location and study periods have varied for different components of the study over the years of the program.

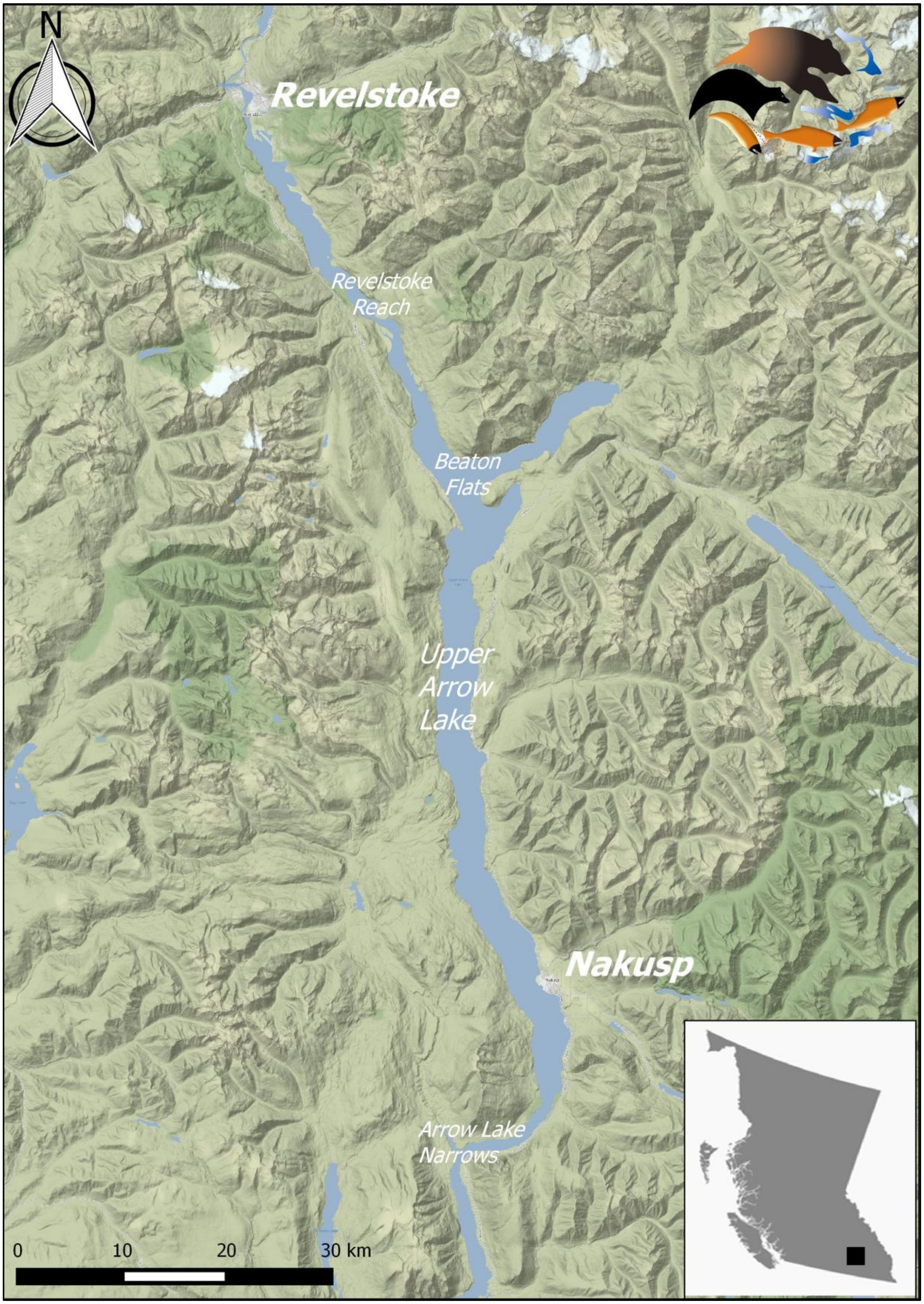


Figure 1: Map of the Middle Columbia River study area from 2007 to 2017.

## 2.2 Physical Habitat Parameters

### 2.2.1 Discharge, Water Temp and Reservoir Elevations

Hourly discharge data for the Columbia River at Revelstoke Dam and water elevation data for ALR were obtained from BC Hydro Power recording stations. Water temperature data were obtained from various sources. Thermistors were deployed in selected locations within the study area to collect water temperatures representative of the different areas being studied during each implementation year. CLBMON-15a temperature loggers (Solinst data loggers) at Stations 3 (RKm 227.9), 5 (RKm 219.9), and 6 (RKm 216) were located in stand pipes along the shoreline upstream of the study area. In 2011 and 2012, submersible thermistors (Onset StowAway Tidbits™; ± 0.2°C accuracy) were attached to sonic receiver (VR2W) station moorings and set to measure and record at hourly intervals. In 2016, three stations (Greenslide Creek, Shelter Bay, and near Nakusp) were established using Hobo™ Tidbit temperature loggers to record water temperatures at Greenslide Creek, Shelter Bay, and in the ALR near Nakusp (Figure 1). In 2017, a fourth Hobo tidbit temperature logger was added mid-channel at the upstream of the Narrows (RKm 120). For precise locations and data, refer to the CLBMON-21 annual report series (2017 data in Appendix A). On sample days, surface water temperatures were obtained by the field crew using a lab grade (± 0.1°C accuracy) hand-held thermometer.

### 2.2.2 Meso-Habitat Measurements

Over the 11 years of the program, a range of meso-habitat parameters were recorded in the immediate vicinity of where acoustic-tagged juvenile White Sturgeon were detected and at gill net and set line sites (*Table 1*). Data collected were:

- depth (determined by boat sounder to the nearest 0.1 m);
- current velocity (determined using a Marsh-McBirney electromagnetic flowmeter accurate to ± 2% of reading);
- surface water temperature (determined by a calibrated alcohol thermometer accurate to ± 0.1°C);
- turbidity (mid-column water samples taken using a Van Dorn sampler; turbidity determined using an OrbecoHellige Model 966 portable turbidity meter accurate to 0.01 NTU in the lowest range);
- Secchi depth (to nearest cm, deployed on shaded side of the boat);
- substrate and cover (percent composition; determined by visual assessment using underwater video or a Ponar Grab sampler; and
- UTM coordinates (determined using a Trimble differential GPS unit and/or a handheld Garmin unit).

Table 1: Summary of meso-habitat measurements taken near juvenile White Sturgeon detection and capture sites in the MCR from 2007 to 2017.

| Study Year | Depth (m) | Water Temperature | | Turbidity | Secchi depth (m) | Current Velocity | | Substrate Type | UTM |
|---|---|---|---|---|---|---|---|---|---|
| | | Surface | Bottom | | | No. of Locations | Seasonal Data [a] | | |
| 2007 | √ | √ | | √ | √ | 12 sites | | √ | √ |
| 2008 | √ | √ | | | | | | | √ |
| 2009 | √ | √ | | | | √ | | | √ |
| 2010 | √ | √ | | √ | √ | 32 sites | | √ | √ |
| 2011 | √ | √ | | √ | | 2 sites | √ | | √ |
| 2012 | √ | √ | √ | √ | √ | 32 sites | | | √ |
| 2013 | √ | √ | | | | | | | √ |
| 2014 | √ | √ | | | | | | √ | √ |
| 2015 | √ | √ | | | | | | √ | √ |
| 2016 | √ | √ | √ | | √ | | | √ | √ |
| 2017 | √ | √ | √ | | √ | | | √ | √ |

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

During most years of the program, the majority of habitat data was collected in the summer period (August to October). In Year 5 (2011), meso-habitat data was collected over three different sample sessions, in May, August, and October. In 2012, physical habitat measurements were taken at four representative locations within the study area during VPS downloading sessions near the Walter Hardman Generating Station (August to October; Golder and ONA 2013). Habitat related data from 2013 onwards was collected at juvenile White Sturgeon capture sites.

Water quality parameters collected within the Revelstoke Reach were limited to surface water temperature and turbidity. A standard suite of basic water quality parameters (continuous daily water temperature regimes and routine water quality parameters) was obtained under a separate program (CLBMON-15a Mid-Columbia River Physical Habitat Monitoring).

In Year 1 (2007), meso-habitat data was collected near the locations of sonic-tagged Sturgeon. The boat was equipped with a sounding reel and arm connected to a 45.5 kg lead “fish”. An Aqua-Vu underwater camera and the flowmeter were attached to the “fish” and lowered into the water. Current velocities were obtained at 0.36 m above bottom and at 0.8 and 0.2 of the total depth at the site. In Year 3 (2009), a decision was made to maximize fish capture efforts, therefore habitat data collection was limited to surface water temperature, depth (as determined by the boat depth sounder) and a visual assessment of surface current velocity conducted by observing floating debris moving past a stationary float (from sample gear).

From 2007 to 2010, visual estimates of benthic substrate were obtained using an Aqua-Vu SV-120™ (Aqua-Vu) used to assess the substrate characteristics and cover type and availability at locations where habitat measurements were obtained. The camera was also used for an underwater video survey of Big Eddy on 27 September 2007 to check for the presence of juvenile

White Sturgeon. The Aqua-Vu unit consisted of a compact camera in a plastic housing (equipped with multi-coloured lights), a 30 m cable, and a weather resistant 10 $cm^2$ monitor.

Benthic substrates were physically collected at a subsample of Sturgeon capture sites from 2014 to 2017 using a Ponar Grab with a grab capacity of 2,376 $cm^3$. Grab samples were stored in glass containers with ethanol preservative until processing. Substrate sample volume was recorded prior to sorting. Samples were sorted using size 105 or 500 micron stainless steel screening depending on sample type. Samples were differentiated by dominant and secondary substrate types (fine-medium-coarse sand/clay/granule/pebbles) and recorded for contents.

## 2.3 Juvenile Sturgeon Releases

### 2.3.1 Conservation Aquaculture and Origin of Stock

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

Since 2007, juvenile Sturgeon have been produced from either direct gamete crosses (broodstock; 2007-2014) or from eggs and larvae collected in the wild. From 2007 to 2014, mature adult White Sturgeon (broodstock) captured in the lower Columbia River (HLK to the Canada-US Border) were transported to the Kootenay Trout and Sturgeon Hatchery (KTSH), spawned, and returned to the river (details in FFSBC 2014). More recently, research has identified genetic diversity can be increased in supplemental progeny by collecting naturally produced eggs and larvae in the wild (Crossman et. al. 2011; Jay et al. 2014). This led to a change in the conservation aquaculture program and the broodstock program was ceased in 2014. Juvenile Sturgeon reared from eggs or larvae captured from natural spawning events are referred to as 'wild origin' juveniles. The first wild origin juveniles (approximately 10 months old) for release in the MCR originated from collections on the Columbia River south of the border in Washington with the objective of testing size at release effects on survival. These were surplus fish to the US juvenile release program and were transported across the border to the KTSH for an additional year of rearing and subsequent release (as 22 month-old fish) in the MCR in 2016 and 2017.

### 2.3.2 Marking and Tagging

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

Sturgeon collected in the wild as fertilized embryos or larvae, and then reared in the hatchery before release had a strip of three scutes taken from the right side of the fish directly below the dorsal fin.

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

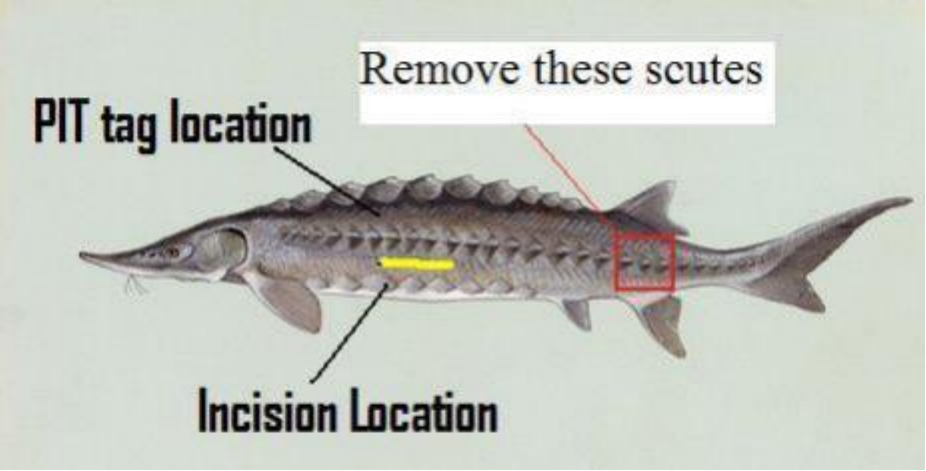


Figure 2: Juvenile White Sturgeon showing the PIT tag location, sonic tag incision location and scute removal pattern. Figure from FFSBC (2017).

### 2.3.2 Size at Release Study

The size of fish being released through the conservation aquaculture program has been increased over the years of the program to determine the most successful size-at-release strategy for hatchery-raised juveniles. There have been four different size categories released within the Revelstoke Reach. This has resulted in three age classes of Sturgeon for the conservation aquaculture program with Age 1 fish grown to two different weight categories (*Table 2*).

Size at release categories were determined through consultation with the UCWSRI TWG. From 2007 to 2015, hatchery origin White Sturgeon juveniles were reared at the KTSH to 10 months of age before they were transported to the MCR for release. These 10 month old (~Age1) fish can be further categorized into small bodied form (2007-2012) and large bodied form (2013-2015) fish. Mean annual fork length (FL, cm) and weight (g) of these fish is presented in *Table 2*. The juveniles released in 2016 and 2017 were reared in the hatchery for 22 months (~Age 2) to allow for additional growth before being released into the MCR. Mean annual FL and weight of these fish were at least double that of the Age-1 fish.

Table 2: Size categories by age and average length and weight of larval and juvenile White Sturgeon released in the MCR from 2007 to 2017.

| Size Category | Age at release | Study Year Released | Number Released | Average Length (cm) | Average Weight (g) |
|---|---|---|---|---|---|
| Larval | 1 to 60 days | 2008, 2009, 2010 | 1,370,749 | n/a | n/a |
| Age 1<br>Small bodied | 10 months | 2007 to 2012 | 42,828 | 20.7 | 67 |
| Age 1<br>Large bodied | 10 months | 2013 to 2015 | 15,245 | 27.5 | 169 |
| Age 2 | 22 months | 2016 to 2017 | 2,914 | 39.3 | 402 |

In 2008, the UCWSRI TWG approved the release of fed and unfed larvae below REV (FFSBC 2010). A dedicated portable hatchery facility, located at the Kootenay Trout and Sturgeon Hatchery, housed six 3 m aluminum troughs with four MacDonald jars per trough that contained eggs from Sturgeon broodstock. Approximately 619,480 larvae (fed and unfed combined) from this facility were released at the confluence of the Columbia and Jordan Rivers in 2008 and 260,000 (fed and unfed) larvae were released in 2009. In 2010, 336,270 unfed day-old larvae were released in the upper Revelstoke Reach as part of an experiment to assess the effects of substrate modifications on larval retention and growth (Crossman and Hildebrand 2012). The monitoring described in this report is expected detect any survival of these larvae to the juvenile life stage.

### 2.3.3 Release Locations

The location of juvenile Sturgeon release was also tested in conjunction with the acoustic-tagged fish movement study. Fifty acoustic-tagged juvenile Sturgeon were released at single locations in both 2007 and 2008 (Moses Creek and Big Eddy; *Table 3*) to observe initial dispersal movements. In both years, the fish release was also split into two times of day: 25 fish were released at noon, and 25 fish were released at midnight. In 2009 and 2010, 10 acoustic-tagged juvenile Sturgeon were released at one of five locations: Big Eddy, Begbie Creek, Mulvehill Creek, Tree Island, and Arrowhead during the day.

Table 3: Summary of the release location and time of day study for hatchery juvenile White Sturgeon released in the middle Columbia River below Revelstoke Dam, 2007 - 2010.

| Release Date | Brood Year | River Kilometre | Release |  | Sonic-Tagged? | Number of Fish |
|---|---|---|---|---|---|---|
|  |  |  | Location[a] | Time |  |  |
| 23-Apr-10 | 2009 | 225.8 | Centennial Launch | Day | No | 400 |
|  |  | 228.3 | Big Eddy | Night | No | 9175 |
| 22-Apr-10 |  | 228.3 | Big Eddy | Day | Yes | 10 |
|  |  | 216 | Begbie Creek | Day | Yes | 10 |
|  |  | 206.1 | Mulvehill Creek | Day | Yes | 10 |
|  |  | 203 | Tree Island | Day | Yes | 10 |
|  |  | 194.1 | Arrowhead | Day | Yes | 10 |
| **2010 Release Total** |  |  |  |  |  | **9625** |
| 23-Apr-09 | 2008 | 225.8 | Centennial Launch | Day | No | 600 |
|  |  | 228.3 | Big Eddy | Night | No | 7518 |
|  |  | 228.3 | Big Eddy | Day | Yes | 10 |
|  |  | 216 | Begbie Creek | Day | Yes | 10 |
|  |  | 206.1 | Mulvehill Creek | Day | Yes | 10 |
|  |  | 203 | Tree Island | Day | Yes | 10 |
|  |  | 194.1 | Arrowhead | Day | Yes | 10 |
| **2009 Release Total** |  |  |  |  |  | **8168** |
| 29-Apr-08 | 2007 | 225.8 | Centennial Launch | Day | No | 600 |
|  |  | 228.3 | Big Eddy | Night | No | 5884 |
|  |  | 228.3 | Big Eddy | Night | Yes | 50 |
| **2008 Release Total** |  |  |  |  |  | **6534** |
| 3-May-07 | 2006 | 233 | Moses Creek | Noon | No | 1984 |
|  |  |  | Moses Creek | Midnight | No | 2172 |
|  |  |  | Moses Creek | Noon | Yes | 25 |
|  |  |  | Moses Creek | Midnight | Yes | 25 |
| **2007 Release Total** |  |  |  |  |  | **4206** |

[a] See Figure 1 for locations.

## 2.4 Juvenile Sturgeon Movement and General Habitat Use

### 2.4.1 Study Design

There were two components to the juvenile Sturgeon movement study. During 2007 to 2010, the study focused on larger movements of juvenile Sturgeon using receivers anchored year-round in a linear array within the Revelstoke Reach (RKms 229.7 to 179). Acoustic receivers were placed along the thalweg of the study area, approximately every 5 km. Juvenile Sturgeon implanted with acoustic tags were released from six sites and their movements were recorded on acoustic receivers anchored within Revelstoke Reach. Mobile acoustic tracking was conducted in Years 1 to 4 (2007-2010) in Revelstoke Reach during September and October (*Table 4*). These early studies provided data on large scale movements (e.g., movements of several kilometres or greater) and identified the general areas and macro-habitats used by these fish, but did not identify fine scale movements or micro-habitats. The low number of captures precluded statistical analysis of survival and life history parameters.

A better understanding of fine scale movements was desired to contribute to the overall knowledge base, including habitat use as the ALR fills and empties, and the need to improve capture rates that would help to answer the other management questions. The second phase, implemented in 2011 (Year 5), was to determine the feasibility and best location of the VPS. The third phase (fine scale array deployment) was implemented in 2012 (Year 6) by concentrating all the acoustic receivers into a 3 km section of river near the Walter Hardman Generation Station and Akolkolex River confluence over the period of five months (May to October). The three different phases are described in the following sections.

Table 4: Timing of annual tracking activities for acoustic-tagged juvenile and adult Sturgeon in the MCR from 2007 to 2012. Grayed cells indicate activity during that year.

| Year | VR2W Linear Array | Mobile Tracking | VPS 2D Grid Array | Adult Acoustic Tracking [a] |
|---|---|---|---|---|
| 2007 | Installed April 2007; RKm 228 to 179 | 28 Sept – 6 Oct; RKm 223 to 204 | | Using both VR2W Array and Mobile Tracking |
| 2008 | Continuous; RKm 228 to 179 | 7 Sept – Near Mulvehill Creek; RKm 210 to 205 | | Using both VR2W Array and Mobile Tracking |
| 2009 | Continuous; RKm 228 to 180 | 18-19 Sept; RKm 202 - 195 | | |
| 2010 | Continuous; RKm 228 to 112 | Winter (Feb); RKm 184 to 153 [b] | | |
| 2011 | Array remove 24 May 2011 | | Acoustic range testing, 2D array development | |
| 2012 | | | 15 May to 30 Oct 2012; RKm 203 to 200 | |

a Due to remnant active acoustic-tagged adult Sturgeon in the study area, acoustic tags were tracked and reported in this program at the same time as juveniles. See Golder 2007.

b There was no summer mobile tracking program in 2010. CLBMON-31 submitted mobile tracking results for Sturgeon tags located in Arrow Lake Reservoir during the Burbot tracking program in February.

### 2.4.2 Passive Acoustic Array

The acoustic receivers used during the present study were Vemco (VR2W) single channel receivers. VR2W receivers are submersible, single channel acoustic receivers that operate at a frequency of 69 kHz and are capable of identifying and decoding Vemco Ltd. sonic transmitter signals. The receivers are housed in a corrosion resistant cylindrical plastic high pressure case and incorporate an integral hydrophone. For each tag detection, the date and time is recorded along with the transmitter code. Data are stored in flash memory until downloaded and reinitialized using a VR2W Communications Key, Bluetooth® wireless technology, and a lap top computer running Vemco User Environment (VUE) software. Each VR2W uses a Tadiran TL-5930/F lithium 3.6 volt “D” cell battery with an operating life of approximately 15 months. Time was synchronized among receivers during initialization, which matched the time on each receiver to that of the lap top computer.

In April 2007, prior to the first release of acoustic-tagged juvenile White Sturgeon below REV, 18 remote telemetry receivers were deployed in a linear array within the MCR (passive acoustic array; Golder 2008). This passive array, located from RKm 233 (Moses Creek) to RKm 180 (Beaton Flats) was in constant operation until spring 2011, although the configuration changed over time. By 2010, the passive acoustic array consisted of 19 VR2W stations; 11 stations were located between Big Eddy (RKm 228.3) and Arrowhead (RKm 184), 5 were located in the Beaton Flats and mouth of Beaton Arm area, and 3 were located at the Narrows (Burton area, RKm 112 -

110). The design of the array allowed collection of large scale movements and general timing of movements within the study area after fish release. Two hundred sonic-tagged juvenile White Sturgeon (50 each in 2007, 2008, 2009, and 2010) were released into the MCR. The life expectancy of these tags is less than one year, so tags released the previous year had expired prior to the release of fish the following year.

Preferred locations for passive acoustic receiver deployment were areas with low water velocities and smooth channel bottom configurations to reduce background noise and interference from islands or underwater obstructions, and help prevent damage or loss of the units. Prior to deployment, VR2Ws were checked *in situ* using a reference tag to confirm their operation. VR2Ws were deployed such that their position in the water column was below the thermocline depth during the summer, as water density changes can interfere with acoustic signal reception.

### 2.4.3 Mobile Tracking

Mobile tracking surveys were conducted to identify locations that acoustic-tagged juveniles were utilizing in sections of river between the VR2W stations, as well as determining sites to sample for specific preferred habitat parameters. Tracking was conducted from a boat using a Vemco VR28T acoustic receiver and towed V-fin.  In areas with fast current, the boat was allowed to drift in the middle of the channel to reduce noise from the engine that could interfere with the reception of the acoustic tag signals. In areas where the river channel was narrow, mobile tracking was conducted by towing the V-fin in the middle of the channel. In areas where the river channel was wider, a “zigzag” pattern was followed, with priority given to coverage of the thalweg.

When an acoustic-tagged juvenile was detected, the directional hydrophone data provided by the receiver were used to “zero in” on the fish. When a strong signal was received indicating close proximity to the tagged fish, the boat was anchored in position over the fish, the location marked using a Garmin 12 GPS unit, and habitat data were obtained. Underwater video surveys (Section 3.3.5) and gill net sampling (Section 3.4.1.2) also were conducted in association with mobile tracking surveys.

During a separate WUP project (CLBMON-31), LGL Limited conducted mobile tracking surveys for acoustic-tagged Burbot from February 8 to 11, 2010. The surveys were focused within the ALR, though juvenile White Sturgeon were also detected (Robichaud *et. al*. 2010) and the tag numbers supplied to this program.

### 2.4.4 Fine Scale Movement Array

The purpose of the 2012 (Year 6) monitoring program was to deploy a VPS array in the MCR to monitor the seasonal (spring, summer, and fall) movements of 50 acoustic-tagged juvenile White Sturgeon released within the array. The array configuration was based on results from the 2011 feasibility assessment and recommendations from Vemco technical advisors, as well as previous studies, which indicated high use of this area by acoustic-tagged hatchery juvenile White Sturgeon (Golder 2008, 2009a, 2010, 2011). The specific objectives were; 1) to describe fine scale movements (<10 m positional accuracy) and associated habitat use by juvenile White Sturgeon and determine if there is a relationship between the movements observed and variables of daylight, flow, and seasonal changes in ALR water surface elevation; and 2) use the movement data obtained to recommend refinements to future capture programs to obtain data on juvenile White Sturgeon life history, population abundance, and survival metrics.

The preliminary receiver and reference tag locations within the VPS array were pre-determined in the office in consultation with Vemco Ltd. and plotted on aerial photos of the study area. Twenty six telemetry receivers were deployed on May 1 and 2, 2012. The pre-selected locations of many receivers had to be adjusted from the original array design because portions of the study area were de-watered at this time due to low ALR water levels (Appendix C). To expand coverage of the array into recently inundated habitats, three additional receiver stations (R27, R28, and R29) were deployed on September 19, 2012. The calculation of a fish's position within the array required detection by a minimum of three co-located receivers. To facilitate triangulation of fish positions, receivers were deployed in a triangular pattern with a target distance of 300 m between receivers along the "sides" of each triangle. Reference tags (*n* = 3) were deployed on May 1, 2012 and were placed within three of the VPS triangles to provide redundancy (i.e., to test the receivers positional accuracy of tags at known positions).

The study area consists primarily of deep, low velocity habitat, and is constricted at the downstream end, which facilitates the identification of tagged fish moving downstream and out of the study area. The study area is far enough downstream of Revelstoke Dam for diel discharge effects to be attenuated, although some minor changes in water velocity and water surface elevations can occur. Individual receivers within the VPS array consisted of an anchor, float line, the VR2W receiver, and a float. Receivers were affixed to the float lines approximately 2 m off the bottom using heavy duty cable ties and submerged with the hydrophone pointing up. A small subsurface float attached to the float line above the receiver maintained the vertical position of the receiver and kept it off the river bottom. Synchronization tags (sync tags) were affixed to the float line approximately 1 m above the receivers. Sync tags were necessary within the VPS array for receiver time synchronization; if a receiver could not be time synced with at least one other receiver, it was not used for signal positioning.

Three additional receiver stations were deployed in the fall to expand coverage of the array into recently inundated habitats. The calculation of a fish's position within the array required detection by a minimum of three co-located receivers. To facilitate triangulation of fish positions, receivers were deployed in a triangular pattern with a target distance of 300 m between receivers along the "sides" of each triangle. Synchronization tags were necessary within the VPS array for receiver time synchronization; if a receiver could not be time synced with at least one other receiver, it was not used for tag positioning.

#### *2.4.4.1 Acoustic Receiver Range Testing*

Range testing was completed for all three phases of the acoustic tag tracking program to assess the tag detection efficiency of the receivers. Range testing involved *in-situ* movements at different distances around VR2W receivers using a tester acoustic tag, either lowered in place and held stationary, or towed by a boat. For the fine-scale array, the efficiency of tag detections within the VPS was tested on May 3 and 14, 2012. Drag tests were conducted by suspending a test tag (Vemco V9-2x) from a boat at approximately 3 m depth and moving through the VPS array either by drifting or under power. Drop tests were conducted by affixing a test tag to an anchored float line and deploying the tag (Vemco V9-2x) at a location for a period of time. A drop test was conducted within a receiver triangle and at the edge of a receiver triangle. Upon completion of the testing, the downloaded data were submitted to Vemco Ltd. for post-processing. The resulting estimated positions indicated VPS effectiveness of 55-78% (ONA and Golder 2013), which is considered at or above the expected rate of positioning success (Vemco analyst, pers. comm.). Specific details regarding range testing activities and results can be found in the CLBMON-21 annual report series.

### 2.4.5 Dispersal and General Movements

Total, upstream, downstream, and net movements were calculated for acoustic-tagged juvenile White Sturgeon released in the MCR in 2009 and 2010 (Golder 2011). The movements analyzed were defined as:

1. total movement: sum of all detected movements, regardless of direction;
2. upstream movement: sum of all detected movements in an upstream direction;
3. downstream movement: sum of all detected movements in a downstream direction; and,
4. net movement: distance between the furthest upstream and furthest downstream locations a fish was detected (i.e., a representation of the range of a particular fish or group of fish).

To assess differences in post-release dispersal patterns of acoustic-tagged juvenile White Sturgeon, two release strategies have been employed in the MCR:

- 2007 and 2008, acoustic-tagged fish were released at or above Big Eddy (RKm 228.3),
- 2009 and 2010, acoustic-tagged fish were released in groups of 10 fish at 10 km intervals between Big Eddy (RKm 228. 3) and Arrowhead (RKm 184).

### 2.4.6 General Macro-habitat Use

General macro-habitat selection by acoustic-tagged juvenile White Sturgeon was examined by calculating the number of tag days (one tag day = one fish detected at a particular station for any portion of a particular day) at VR2W stations in the MCR in 2010 (Golder 2011). This provided data on the temporal (days used) and spatial (the area within approximately 500 m of a particular receiver) use of macro-habitats in the vicinity of the receiver locations. However, since past studies have shown that acoustic tag detection ranges in the MCR can vary substantially on a daily or seasonal basis (Golder 2006b), the tag day data likely represented the minimum period that a tagged fish was present in the area of a particular receiver.

### 2.4.7 Statistical Analyses of Movement

A summary of the methods used to analyze the movement data obtained from the acoustic telemetry receivers is provided. Additional details are provided in the annual report (Golder 2011).

Juvenile White Sturgeon movement data from 2007 to 2010 were condensed from several million detections from the VR2W receivers to several thousand records that identified the time and location of fish when they first arrived at a station and when they moved out of detection range. For example, if a fish was detected 100 times by a VR2W station and not detected at another station during that time, these 100 detections were reduced to two records - when the fish arrived and when the fish moved out of range (the first and last detection).

The time spent near each station between movements and the direction, magnitude, and rate of movements were calculated. The time spent at station parameter has advantages in that it is not dependent upon the location of potential relocation sites, which could bias interpretation of movement data collected after a fish left a particular site. The selected model used release site, month and an interactive term between month and release site as the independent variable and is depicted by the following equation:

$$\mathit{Log\ (Time\ at\ Station)} = B0 + B1\ (\mathit{Release\ Site}) + B2\ (\mathit{Month}) + B3\ (\mathit{Release\ Site} \times \mathit{Month}) + e$$

where: $e$ = normally distributed error term with $u = 0$

The net mean distance moved and the mean residence time at station were selected as the dependent variables after exploratory graphical analysis of the data.

The influence of time of day on movements was examined among seasons and years. Movement frequencies were summarized by hour, month, and year. For the purposes of this analysis, only those fish that left the vicinity of one receiver (departure) and were subsequently detected at another receiver (arrival) were used to represent an actual movement. The onset of the movement was defined as the time that a fish was last detected at the departure receiver. Data from fish that simply “disappeared” from one receiver but were either never relocated or were subsequently relocated at the same receiver were not used since these data may simply have reflected daily differences in the detection range of the receiver.

The hourly discharge rate from REV was used to calculate the average flow in the relationship between flows and fish movements.

Diel patterns of light intensity (solar radiation) were estimated using the SOPOS (Solar Position) model available at the National Renewable Energy Laboratory’s Measurement and Instrument Data Center (http://www.nrel.gov/midc/solpos/solpos.html). Extraterrestrial Global Horizontal Solar Irradiance values (W / $m^2$) were extracted for further analyses. The model was run using 10-minute intervals to predict solar radiation at Revelstoke, BC. After examining the frequency distribution of solar irradiance for each year at the onset of movement, the lack of variation during daylight resulted in the decision to convert these data to a binary variable where 0 = dark and 1 = light. The binary variable was used in subsequent analyses.

The effect of release location on the movements of acoustic-tagged juvenile White Sturgeon was analyzed for Years 3 and 4 (2009 and 2010) and not Years 1 and 2 (2007 and 2008) due to placement of receivers and a larger dataset from more release sites spread over the entire study area. The two release strategies were not otherwise comparable. To provide additional information on the effect of release location on subsequent dispersal patterns and habitat selection, acoustic-tagged fish were released in groups of ten fish at five locations approximately 10 km apart:

- Big Eddy (RKm 228.3);

- near Begbie Creek (RKm 216);
- near Mulvehill Creek (RKm 206.1);
- near Tree Island (RKm 194.1); and,
- near Arrowhead (RKm 184).

### 2.4.8 Movement GLM Model Development

A general linear regression model was developed that included standardized distance travelled after the onset of movement as the dependent variable and independent variables of: daylight (binary day/night), hourly Revelstoke discharge at time of movement initiation, hourly ALR water surface elevation at Nakusp, month, year, and release site. All variables were categorical except for Revelstoke discharge (Q in $m^3/s$) and ALR water surface elevations (masl). $AIC_c$ scores for a set of plausible models were used to select the final model with $AIC_c$ weights calculated for the set of models used in the analysis (model details are described in Golder 2011). Hourly ALR water surface elevations (m above sea level; masl) at Nakusp were used as an independent variable in the analysis.

### 2.4.9 Fine-scale Array Location Analysis

The VPS is based on the principle of range difference positioning [also known as time-difference-of-arrival (TDOA), hyperbolic positioning, and multi-lateration]. If a signal transmitted by the object to be located is detected by two receivers at two different times, the difference between the arrival times was converted into a range difference, using information collected in the testing phase during Year 5 (2011) of the program. In 2-D positioning, each range difference was defined as a hyperbola along which the acoustic signal may be found. By using the overlap of multiple hyperbolas, from different receiver locations, the 2-D position was estimated. For further data analysis details refer to Golder and ONA (2013).

The accuracy of the HPE (horizontal positioning error) values as descriptors of positioning error was examined using sync and reference tags, for which the true position of the tag is known. The error between the VPS estimated position and the true position was defined as HPEm (measured horizontal position error). The relationship between HPE and HPEm values for sync and reference tags was examined to describe error in the estimated positions of tagged fish. Generally, when HPE values were at or below 7, more than 95% of the empirical error values (HPEm) were smaller than the HPE value. Applying this to VPS-generated tagged White Sturgeon locations, the HPE values reported with estimates of tag positions could be viewed as liberal estimates of positioning error, as they will likely overestimate the actual position error in at least 95% of the cases while HPE ≤ 7.

Using the cumulative proportion plot, three HPE values were chosen (HPE = 5, 6, and 7) as the most desirable combination of fine scale positional accuracy. A sensitivity analysis was then conducted to determine the most appropriate cut-off value among these three candidates and its effect on the results. Based on the results of the sensitivity analysis and the cumulative distribution, a threshold HPE value of 7 was chosen, and all tag locations with HPE > 7 were omitted from all subsequent analyses.

### 2.4.10 Analyses of Fine-scale Movement Data

Over the VPS study area, maximum depths in the thalweg area were typically > 10 m (range between approximately 8 and 21 m). Maximum depths in the floodplain area over the same period were typically from 5 to10 m (range between approximately 1 and 16 m) and maximum depths in the shallows area were typically < 5 m (range between approximately 1 and 11 m).

To describe fish movements relative to habitat and environmental variables, the following metrics were determined for each White Sturgeon tag location:

- minimum distance traveled from previous tag location (m).
- movement speed from previous tag location (m/s).
- the time of day (i.e., day or at night); defined using sunrise and sunset times for each day of the study as obtained from http://aa.usno.navy.mil/data/docs/RS_OneYear.php.
- the season:
    - spring (May 15 to June 20)
    - summer (June 21 to September 20)
    - or fall (September 21 to October 30)
- the month, since sample periods in spring and fall were considerably shorter than in the summer, monthly analysis was considered to provide better insight into temporal changes in behaviour.
- whether ALR was:
    - filling
    - full
    - emptying
    - or stable
- what the ALR water surface elevation (masl) stage was:
    - low (430.34 to 433.74 masl)
    - moderate (433.75 to 437.13 masl)
    - or high (437.14 to 440.53 masl)
- the habitat classification where the fish was positioned:
    - the old river channel thalweg (defined as below the 424.0 masl contour)
    - the old river floodplain (defined as within the 424.1 to 429.0 masl contours)
    - the reservoir shallows (defined as between the 429.0 to 440.5 masl contours)

The last metric was used to assign fish position to a defined geomorphic feature and as an indirect means of assessing fish depth selection. The geodetic elevations of these macro-habitat divisions were obtained from Canadian Hydrographic Service chart datum (Chart 3058, Columbia River, Arrowhead to Blanket Creek, 1991), scanned and digitized using ArcGIS 10.1. These data were then used to develop depth ranges for the three channel types over the May 30 to October 30, 2012 monitoring period. The old pre-regulation river channel (thalweg area) provides the greatest depths available in all seasons and since this habitat remains wetted throughout the year, would exhibit the greatest benthic productivity. The floodplain area represents the historical river floodplain that would have been inundated during typical spring freshet levels but is now flooded by reservoir filling during the spring and remains wetted until late fall. The reservoir shallows area represent the area above the historical active floodplain that is now flooded during the late spring to early fall period due to reservoir filling.

The study area was divided into the three habitat classifications and each tag position was categorized into one of these habitat types. To provide confidence intervals for the assignment of habitat type to a fish position, the distance from every estimated fish position to each elevation contour was calculated. The associated HPE values (HPE ≤ 7) were used as liberal 95% confidence intervals, as suggested by the results of quantile regression of synchronization and reference tag HPEm versus HPE. For each fish position, the distance from the position to the nearest habitat classification elevation contour line was compared to the HPE values associated with the VPS position estimate. If distance from the contour line was greater than the HPE, the fish was assigned to the type of habitat it was positioned in (thalweg, floodplain, or shallow). If the distance from the contour line was smaller than the HPE value, the habitat assignment was considered uncertain and was not assigned to a specific habitat classification.

The study area includes the mouth of the Akolkolex River, a major tributary to Revelstoke Reach, which represents a potential source of food (i.e., benthic drift) for juvenile white Sturgeon. This potential food source may serve to attract juvenile White Sturgeon into the shallow bay at the river-reservoir confluence. The depths in the bay were typically < 5 m in the spring and fall periods and < 10 m in the summer at peak ALR levels of 440.5 masl. To describe the extent of movement between the main VPS array and the large shallow bay at the mouth of the Akolkolex River, fish positions using detections at the three receivers closest to the river mouth (R27, R28, and R08; Appendix C) were summarized. All detections at one of the three receivers were categorized by time of day (day or night) and season (spring, summer, or fall).  In addition, detections were categorized based on whether the fish remained within the VPS array near the Akolkolex (continually detected on at least one of the three receivers), left the VPS array (presumably moved into the Akolkolex bay area) for more than 0.5 h, or returned into the VPS array after leaving for longer than 0.5 h.

#### 2.4.11 Underwater Video Surveys

In 2007 and 2009, an Aqua-Vu SV-120™ (Aqua-Vu) was used to assess the substrate characteristics and cover types and availability at locations where habitat measurements were obtained (Golder 2008, 2010). The Aqua-Vu unit consisted of a compact camera in a plastic housing (equipped with multi-coloured lights), a 30 m cable, and a weather resistant 10 $cm^2$ monitor. The camera was also used for an underwater video survey of Big Eddy in 2007 to check for the presence of juvenile White Sturgeon. In 2009, The Aqua-Vu camera was used to look for juvenile Sturgeon presence at multiple locations in the Revelstoke Reach.

### 2.5 Juvenile Sturgeon Capture Efforts to Estimate Growth and Survival

#### 2.5.1 Study Design

The objective of the juvenile White Sturgeon capture program was to estimate the growth and survival of fish released from the conservation aquaculture program. For the first four years (2007 to 2010), the capture and habitat assessment components of the study were limited to Revelstoke Reach, between Beaton Flats and Big Eddy, (RKm 182 – 228) and were closely informed by the movement monitoring results (*Table 5*). Capture activities for juvenile Sturgeon were conducted from mid-August to early October (*Table 6*). In 2013, an abbreviated sampling period was conducted during the last week of September and the first week of October with sample sites only in the ALR (RKm 120 – 186). In 2014 and 2015, the sampling period was extended earlier in the year, from late July to early October, while the study location included sites from Greenslide Creek (RKm 214) to the ALR and Beaton Flats (RKm 185). From 2015 to 2017 the study period was expanded to include sampling efforts from early June to October (Table 6). For these years, the upstream extent of the study location was Greenslide Creek (RKm 214) and included a more concentrated effort along the shoreline of the ALR down to RKm 120. In 2017, sampling also included sites in the Arrow Lake Narrows (between Upper and Lower Arrow Lakes; RKm 107-119).

Table 5: Growth and Survival sample site distribution by year for each river section of the MCR from 2007 to 2017. Grayed area indicates juvenile White Sturgeon capture effort occurred in that river section.

| River Section Description | U/S Rkm | D/S Rkm | 2007 | 2008 | 2009 | 2010 | 2011* | 2012* | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 km d/s Hwy 1 bridge – Big Eddy | 228.3 | 226.1 | - | ▨ | ▨ | ▨ | - | - | - | - | - | - | - |
| 1 km d/s Wells Cr. – 1 km d/s Hwy 1 bridge | 226 | 220 | - | ▨ | ▨ | ▨ | - | - | - | - | - | - | - |
| 3.5 km d/s Begbie Creek – 1 km d/s Wells Creek | 219.9 | 214.1 | ▨ | ▨ | - | ▨ | - | - | - | - | - | - | - |
| 0.8 km d/s Greenslide Creek – 3.5 km d/s Begbie Creek | 214 | 209.8 | ▨ | ▨ | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| 0.7 km u/s Blanket Creek – 0.8 km d/s Greenslide Creek | 209.7 | 205.6 | ▨ | ▨ | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| 0.6 km u/s Walter Hardman – 0.7 km u/s Blanket Creek | 205.5 | 201.9 | ▨ | ▨ | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| Tree Island – 0.6 km u/s Walter Hardman | 201.8 | 197.6 | - | ▨ | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| 1 km u/s Crawfrd Creek – Tree Island | 197.5 | 192.1 | - | - | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| 1.5 km d/s Wallis Creek – 1 km u/s Crawfrd Creek | 192 | 186.6 | - | ▨ | ▨ | ▨ | - | - | - | ▨ | ▨ | ▨ | ▨ |
| Arrowhead – 1.5 km d/s Wallis Creek | 186.5 | 182.1 | - | ▨ | ▨ | ▨ | - | - | ▨ | ▨ | ▨ | ▨ | ▨ |
| Beaton Arm | | | - | - | ▨ | - | - | - | ▨ | - | - | ▨ | - |
| Beaton flats | 182 | 179 | - | - | ▨ | ▨ | - | - | ▨ | ▨ | ▨ | ▨ | ▨ |
| Arrow Lake to Nakusp | 179 | 134 | - | - | - | - | - | - | ▨ | ▨ | ▨ | ▨ | ▨ |
| Nakusp to u/s of Arrow Lake Narrows | 133.9 | 119 | - | - | - | - | - | - | ▨ | ▨ | ▨ | ▨ | ▨ |
| Arrow Lake Narrows | 118.9 | 107 | - | - | - | - | - | - | - | - | - | - | ▨ |

* capture sessions were not conducted in 2011 and 2012

Table 6: Seasonal distribution of juvenile White Sturgeon capture sample effort by week time period in the MCR from 2007 to 2017. Grayed area indicates sampling occurred for at least 3 days during that week.

| Season | Month | Week | 2007 | 2008 | 2009 | | 2010 | | 2011* | 2012* | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gill | Gill | Gill | Set | Gill | Set | none | none | Gill | Set | Gill | Set | Gill | Set | Gill | Set | Gill | Set |
| Spring | June | Week 1 | | | | | | | | | | | | | | | ▨ | ▨ | | |
| | | Week 2 | | | | | | | | | | | | | | | | | ▨ | ▨ |
| | | Week 3 | | | | | | | | | | | | | | | | | | |
| Summer | | Week 4 | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ |
| | July | Week 1 | | | | | | | | | | | | | | | | | | |
| | | Week 2 | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ |
| | | Week 3 | | | | | | | | | | | | | ▨ | ▨ | | | | |
| | | Week 4 | | | | | | | | | | | ▨ | ▨ | | | | | ▨ | ▨ |
| | August | Week 1 | | | | | | | | | | | | | | | ▨ | ▨ | | |
| | | Week 2 | | | | | | | | | | | | | ▨ | ▨ | | | ▨ | ▨ |
| | | Week 3 | | | ▨ | ▨ | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | |
| | | Week 4 | | | ▨ | ▨ | | | | | | | | | ▨ | ▨ | | | ▨ | ▨ |
| | September | Week 1 | | | | | | | | | | | | | | | | | | |
| | | Week 2 | | ▨ | ▨ | ▨ | ▨ | ▨ | | | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ |
| | | Week 3 | | ▨ | ▨ | | ▨ | ▨ | | | | | ▨ | ▨ | | | | | ▨ | ▨ |
| Fall | | Week 4 | | ▨ | | | ▨ | ▨ | | | | | ▨ | ▨ | ▨ | ▨ | ▨ | ▨ | | |
| | October | Week 1 | ▨ | | | | ▨ | ▨ | | | ▨ | ▨ | ▨ | ▨ | | | | | | |
| | | Week 2 | | | | | | | | | | | ▨ | ▨ | | | | | | |

* capture sessions were not conducted in 2011 and 2012

### 2.5.2 Equipment

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

During Years 8 to 11 (2014 to 2017) sampling, 200 gill net and 200 setline potential sites were selected randomly using the general random tessellation stratified (GRTS; Stevens and Olsen, 2004) method design in the statistical package R (R Development Core Team, 2013). This method provided spatially balanced randomly chosen sample locations. Selected sites were randomly distributed along the centerline of the Revelstoke Reach and upper ALR, and assigned a sampling gear type (setline or gill net). Oversample (or extra) sites were also selected, that allowed for the substitution of sites that were rejected in the field due to logistical concerns (depth, velocity, obstructions) to ensure that randomness and spatial representation were maintained within the study design. The generated GRTS sites were used as a guideline, and once in the field, near shore sample locations were selected along a line perpendicular to the center line, to place fishing gear in locations as close as possible to targeted water depths (10 – 30 m).

#### *2.5.2.1 Gill Nets*

Gill nets were 5.1 cm stretch measure multi-filament, horizontal nets but net dimensions and area varied over the course of the program. From 2001 to 2010, 15.2 m long by 1.8 m deep (27.9 $m^2$) and 45.7 m long by 1.8 m deep (83.6 $m^2$) nets were used. From 2013 to 2017 larger nets of 91.5 m long by 1.8 m deep (164.7 $m^2$), with a float and float line and anchors attached to each end of the net. Habitat measurements were recorded at each gill net site (see Section 3.1.2).

Because of the potential risks of injury or mortality to adult White Sturgeon and in consideration of the endangered status of the population, overnight gill net sets were not used in Year 1 (2007) of the study. Based on the lack of capture success using daytime gill nets in 2007, the SARA sampling permit was amended to allow the use of overnight gill nets (with a target 12 hour set duration) in areas where adult White Sturgeon were not likely to be present. During Year 2 (2008) sampling, gill nets were initially deployed overnight, but direct mortality of Bull Trout captured in these overnight sets was high (Golder 2009). Due to this high by-catch mortality, gill net sampling in 2009 and 2010 was changed to short nighttime duration sets of approximately four hours, which reduced direct by-catch mortality. Both full overnight and short duration night time gill nets were used in 2010. From 2013 to 2017, four gill nets would typically be set out each day in the morning and retrieved by mid-afternoon, with a target soak time of 4 hours.

Occasionally, sections of net were damaged due to underwater debris. When time allowed, these damaged areas were repaired. Gill nets not fishing effectively over the full net area due to holes were noted and the area of net being fished was correspondingly reduced for effort calculations. A list of UTM coordinates for all gill net sites are provided in the CLBMON-21 annual report series (UTM data in Appendix A).

#### *2.5.2.2 Setlines*

Based on the low numbers of prey items recorded in juvenile White Sturgeon stomach samples obtained from the MCR in Year 2 (2008) and relatively slow growth of the juveniles captured during Years 1 to 4, food availability was initially considered a potential limiting factor for juvenile White Sturgeon in the MCR (Golder 2009). Therefore, in Year 3 (2009), baited setlines were tested as an alternate method for capturing juvenile White Sturgeon. Setlines were originally deployed similar to gill nets, but fewer in number (e.g., eight gill nets and two setlines per night). As setline sampling continued during the 2009 sampling, but failed to capture any fish, the hook size was reduced from size 10 and 12, to size 5 and 6.

Setlines initially consisted of a 90 m mainline with 30 hooks spaced 3 m apart. An anchor, float line, and with LD-2 floats were affixed to each end. The mainline was marked at 3 m intervals to ensure that hooks were evenly spaced along the length of each setline during deployment. During Session 1 in 2009, small, barbless halibut hooks (size 10, 11, and 12) baited with worms, roe bags, or Kokanee (*Oncorhynchus nerka*) were clipped to the setlines. Based on a lack of captures using these hooks, during Session 2, barbless "J" hooks (size 6 and 7) baited with worms, roe bags, Kokanee, Mountain Whitefish (*Prosopium williamsoni*), or Burbot (*Lota lota*) were used. Setlines were deployed perpendicular to the current (to increase downstream scent dispersal) and were fished overnight. Fishing setlines overnight was initially conducted within a specific river section and not randomizing sample effort over the entire study area each day.

Setlines became the main sample method used in Years 7 to 11 (2013-2017) due to lower bycatch mortality compared to gill netting. During each day, eight setlines were typically deployed. Setlines ranged from 50 to 120 m in length with 10-20 size 6 barbless 'J' hooks per line baited with worms (night crawlers). The mainline was marked at 4 m intervals to ensure hooks were evenly spaced on the line. Setlines were set in the afternoon perpendicular to the flow, left to fish overnight, and pulled the following morning. An anchor, float line and LD-2 float were attached to either end of the setline.

Set and pull times, hook sizes and numbers, bait types, UTM coordinates, surface water temperature, the minimum and maximum depth of the setline, the number of fouled and baitless hooks, and catch details of note were recorded for each setline. A list of UTM coordinates for setline sites are provided in the CLBMON-21 annual report series (Appendix A).

#### 2.5.2.3 Gear Efficacy Testing

In 2016, due to low capture rates in previous study years, additional gear testing to compare efficacy of gear types was conducted from May 2 – 6. The testing was concurrent with the juvenile White Sturgeon release at Shelter Bay (May 3 and 5) to optimize the chances of capture while the density of juvenile Sturgeon was still high near the release site.

Gear efficacy testing was conducted using 4-hour gill net sets and overnight setline sets. Gill nets were and 91.45 m long by 3.05 m deep (278.9 $m^2$) were used and deployed at the bottom of the water column perpendicular to the shoreline. For setlines, different size hooks (4, 5, and 6) and bait types (shrimp, Kokanee and worms) were tested on setlines to assess preference in prey items and recruitment to different sizes of gear. Hook sizes and bait types were differentiated on each setline clip using coloured electrical tape. Hook sizes and bait types were also randomized on each setline.

A total of ten gill net sets and five overnight setline sets were sampled during this test. Gill nets were set for an average duration of four hours, except for three gill net sets that were left sampling for 24 hours due to emergency boat issues.

### 2.5.3 Fish Handling

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

#### *2.5.3.1 Gastric Lavage*

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

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

### 2.5.4 Capture Effort and CPUE

Catch per unit effort (CPUE) was calculated for each year as total juvenile White Sturgeon captures per effort depending on gear type. Gill net hours were calculated to compare different gill net lengths, with and without damaged panels, over the years of the program. Gill net hours were calculated using the formula:

$$(A / 100\ m^2)*(T/24\ h)*D$$

where A = the area of net mesh actively fishing in $m^2$; T = the soak time in hours; and D = the estimated percent of intact net mesh. If the gill net had damaged mesh or panels, the damaged area was estimated as a percentage of the total net area and this value was deducted from the total net area to determine D.

Setline hook hours were calculated by the multiplying the number of hooks on each setline that still had bait attached upon retrieval or had captured a fish by the total hours the setline had been actively fishing. Hooks retrieved that were baitless were conservatively assumed to have not been fishing for the duration of the set. This method was standardized across all years of data.

### 2.5.5 Relative Weight

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

The relative weight index is expressed as a percent and is calculated as:

$$W_r = (W / W_s) \times 100$$

where W is the weight of the sampled fish in kilograms, and $W_s$ is the length-specific standard-weight value for a particular species. For the purposes of this report, the $W_s$ used for calculating $W_r$ was from Beamesderfer (1993):

$$W_s = \alpha \times L^{ß}$$

where α = 2.735 E-6 and ß = 3.232 and L is the fork length of the individual fish in cm. This growth relationship was calculated using growth information from 15 populations of White Sturgeon from the Fraser, Sacremento, and Columbia Rivers (Beamesderfer 1993).

### 2.5.6 Growth

Total and annual growth (fork length (cm) and weight (g)) were calculated for each individual and combined into mean growth metrics by year class.  Total growth was calculated by subtracting the size at release (FL and weight) from the capture size. Annual growth was calculated by dividing the total growth by the number of days at large and multiplying by 365 days. The assumption for annual growth is the total daily growth is constant between release and recapture; we realize growth may vary seasonally and/or with size, but this assumption allows us to compare fish at large for more than one year. Percent growth was calculated by dividing total growth to initial size-at-release.

### 2.5.7 Survival

To date, capture and recapture rates are too low to enable an estimate of survival. Low recapture rates are attributed to a large study area and low capture efficiency. A larger number of recaptures is required to effectively estimate survival.

### 2.5.8 Diet Analysis

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

Benthic substrates were physically collected at a subsample of Sturgeon capture sites from 2014 to 2017 using a Ponar Grab and were stored in glass containers with ethanol preservative until processing. Samples were sorted using size 105 or 500 micron stainless steel screening depending on sample type. All invertebrates in the sorted samples were stored in micro-centrifuge tubes with ethanol preservative. Invertebrates were identified to preliminary taxonomic order in the lab (ONA; A. Duncan) using a dissecting microscope (Motic SMZ-143 Series) and the Guide to Common Freshwater Invertebrates of North America (Voshell 2002).

### 2.5.9 Incidental Catch

All incidentally captured species were identified and measured (fork length or total length as appropriate). Captured Bull Trout were measured for fork length (FL) and weight, and scanned for PIT tags that had either been applied during concurrent sampling programs in the study area (CLBMON-16; Golder and ONA 2017) or that had been applied to hatchery juvenile White Sturgeon that may have been eaten by the Bull Trout. Scale and otolith samples were collected from Bull Trout that succumbed to the sample procedure from 2008 to 2010, and stomach contents were examined for evidence of juvenile White Sturgeon.

## 2.6 Adult White Sturgeon Movement

### 2.6.1 Mobile Tracking

Monitoring adult White Sturgeon equipped with acoustic tags was added as a minor component of the current program to increase the data obtained from the previous adult program (Golder 2006b). In an attempt to detect movements of acoustic-tagged adult White Sturgeon into the Revelstoke spawning area, mobile tracking surveys using a Sonotronics receiver were conducted from Revelstoke Dam to Big Eddy between August 16 and September 4, 2007 and again in 2008 (Golder 2008, 2009). Mobile tracking was discontinued as all adult tags were past the battery life expectations.

### 2.6.2 Passive Array Detection

Of the 26 adult White Sturgeon implanted with acoustic tags in ALR since 1997, six Vemco coded pingers and one Sonotronics tag (Code 5-5-5) were potentially still functional (Golder 2006b, Golder 2008). Four adult White Sturgeon in ALR were expected to still have functional acoustic tags during the 2008 spawning period. The VR2W linear array was checked for adult signals as long as the array was deployed (four years). Further details on adult White Sturgeon detection during the CLBMON-21 program can be found in Golder (2008, 2009).

# 3.0 Results

## 3.1 Physical Habitat Parameters

### 3.1.1 Discharge and Reservoir Elevations

Mean daily discharge levels (cubic meters per second; $m^3/s$) recorded at REV showed different trends when grouped by the time periods before the REV5 flow regime change (Years 1 to 4; 2007 to 2010) and post flow regime change (Years 5-11; 2011-2017). During the pre-REV5 flow period, mean daily discharge from REV ranged from 500 to 1100 $m^3/s$ (*Figure 3*). The daily mean discharge ranged between 500 and 1100 $m^3/s$, with longer periods of lower discharge, (corresponding to reduced power demand) in July and August. The White Sturgeon spawning period, which typically occurs from late July- early August, experienced variable daily average flows between 500 and 900 $m^3/s$.

After the flow regime change (2011 to 2017), daily average discharge from REV ranged between 600 and 1200 $m^3/s$ (Figure *3*). The daily mean discharge ranged between 300 and 1200 $m^3/s$, with longer periods of lower discharge in July and August (Figure *3*). During the White Sturgeon spawning period in late July- early August, REV operations experienced variable daily average flows between 600 and 900 $m^3/s$, which is similar to pre-minimum flow daily mean discharges. Juvenile Sturgeon were generally captured in late August to early October when daily mean discharges were less variable and similar between pre and post minimum flow periods.

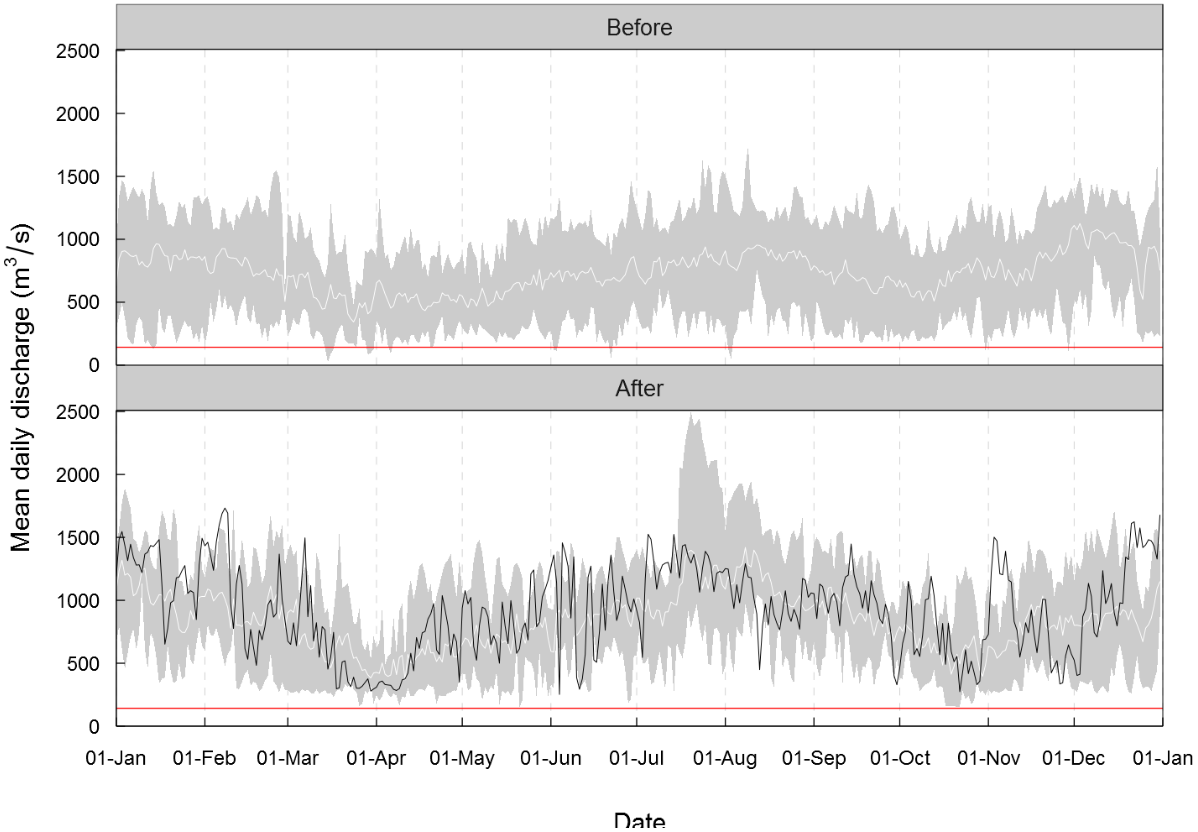


Figure 3: Mean daily discharge of Revelstoke Dam for the 1 May to 30 October periods of 2007 to 2010 combined (grey line) before the implementation of flow regime change (top) and of 2011 to 2017 (grey line) after the implementation of flow regime change (bottom). Red line at bottom of graphs indicate minimum flow of 142 $m^3$/s.

ALR surface elevations (metres above sea level, MASL, measured at the Nakusp gauge site) varied in peak summer elevation between 2007 and 2017 during the May to October study periods; Figure 4). The three highest peak ALR elevation years in June and July occurred as follows: 2012, 2008, and 2013. The lowest reservoir surface elevation occurred in 2015, with the second lowest elevation in 2016. The general trend of decreasing ALR elevations from August through October was similar in rate for all years, except for 2008 where elevation was maintained near peak into November. High ALR elevations in the summer months meant sampling for juvenile White Sturgeon occurred at greater depths in the riverine portion of the MCR than sampling in the spring and fall. In general, ALR elevations in September and October were higher before REV5 flow regime change than after, which would affect the location of the reservoir-river interface zone location within the Revelstoke Reach.

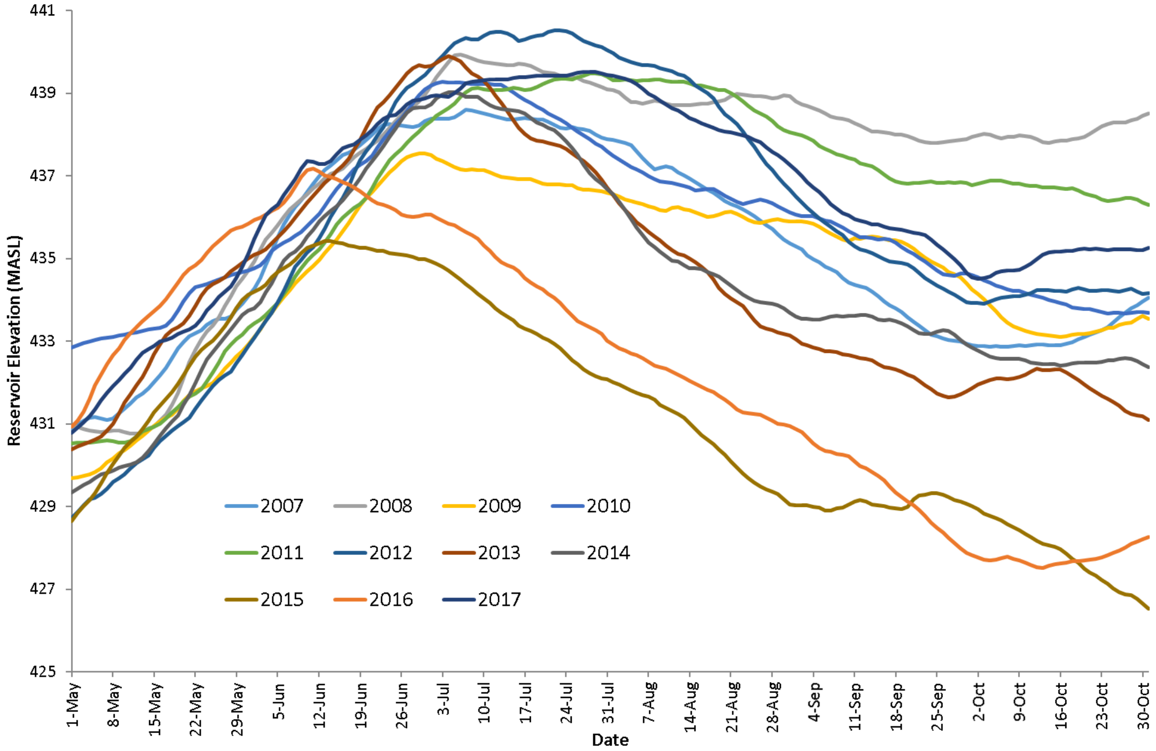


Figure 4: Water surface elevations of Arrow Lakes Reservoir measured at Nakusp, BC from 1 May to 31 October for the 2007-2017 study periods.

#### 3.1.1.1 Reservoir Elevations during Movement Studies

To better compare reservoir elevations effects on acoustic-tagged juvenile Sturgeon movement during Years 1 to 4 (2007 to 2010) and Year 6 (2012) we have graphed these years separately (*Figure 5*). The peak ALR elevation for Years 1-4 (2007-2010) ranged from 437 to 439.8 masl during the dispersal and general movement study, while the peak ALR elevation during the fine-scale movement study in Year 6 (2012) was the highest recorded during the program at 440.5 masl.

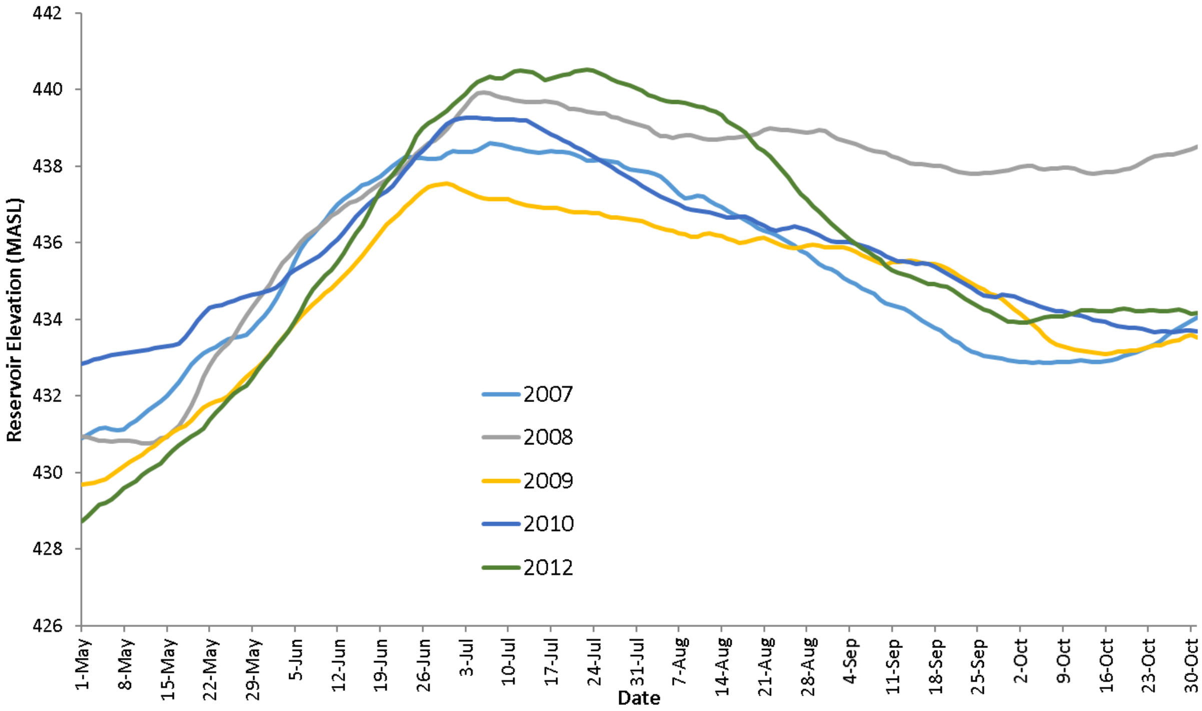


Figure 5: Water surface elevations of Arrow Lakes Reservoir measured at Nakusp, BC from 1 May to 31 October for the 2007 – 2010 and 2012 movement study periods

In 2012, water elevations in ALR (measured at the BC Hydro gauge at Nakusp) were near average from January to the end of May, increased to above the 10 year maximum in July and August, and were slightly above average during the fall (Figure 6). In terms of reservoir operations, ALR was filling from May 15 to July 4, full from July 5 to 31, emptying from August 1 to September 27, and then stable until October 30. ALR elevation (measured at Nakusp) was low (430.34 to 433.74 masl) from May 15 to June 4, moderate (433.75 to 437.13 masl) from June 5 to June 18 and from August 29 to October 30, and high (437.14 to 440.51 masl) from June 19 to August 28 (Figure 8). This general pattern was similar to that observed in past study years (2007 to 2010) except that during 2012, peak reservoir level was higher than in previous study years. During the 2012 filling period, ALR levels increased by approximately 10 m from mid-May (430.3 masl) to early July (440.5 masl) and then declined approximately 6 m from late July to early October.

Over the study period, maximum measured depths in the thalweg area were typically > 10 m (range between approximately 8 and 21 m; Figure 6). Maximum depths in the floodplain area over the same period were typically from 5 to10 m (range between approximately 1 and 16 m) and maximum depths in the shallows area were typically < 5 m (range between approximately 1 and 11 m).

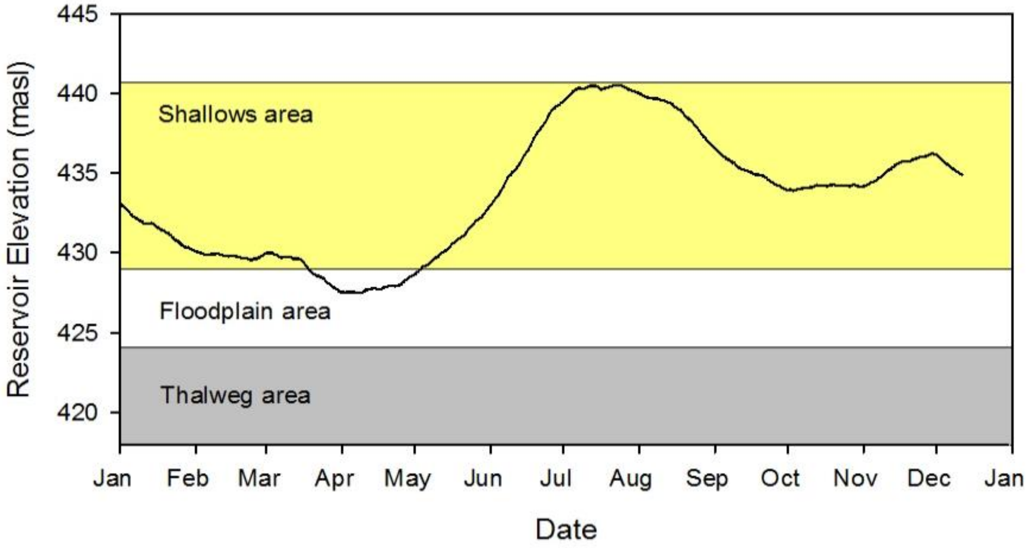


Figure 6: Mean 2012 daily water elevation (metres above sea level) of the Arrow Lakes Reservoir, and the resultant depths at the three habitat classifications (thalweg, floodplain, shallows) available near the Walter Hardman Generation Station for the fine-scale movement study.

### 3.1.2 Water Temperature

As temperatures have been observed to have a strong effect on Sturgeon movements, we reviewed the effect of the REV5 flow regime change on downstream water temperatures and monitored temperatures in the ALR. Mean daily water temperatures over the 1 May to 30 October period were calculated separately for the pre-REV5 (2007 to 2010) and post-flow regime change (2011 to 2017; Figure 77). In general, both periods had similar water temperature pattern; temperatures increased during summer months, with temperature spikes in 2009, 2010, and 2016 which may be attributable to either reductions in ALR levels that changed the water depths at the monitoring stations over the time period, resulting in sampling closer to the top of the water column, or potentially, changes in REV water temperatures that are observed after extended water releases when temperatures change from drawing warmer surface water to cooler hypolimnion water.

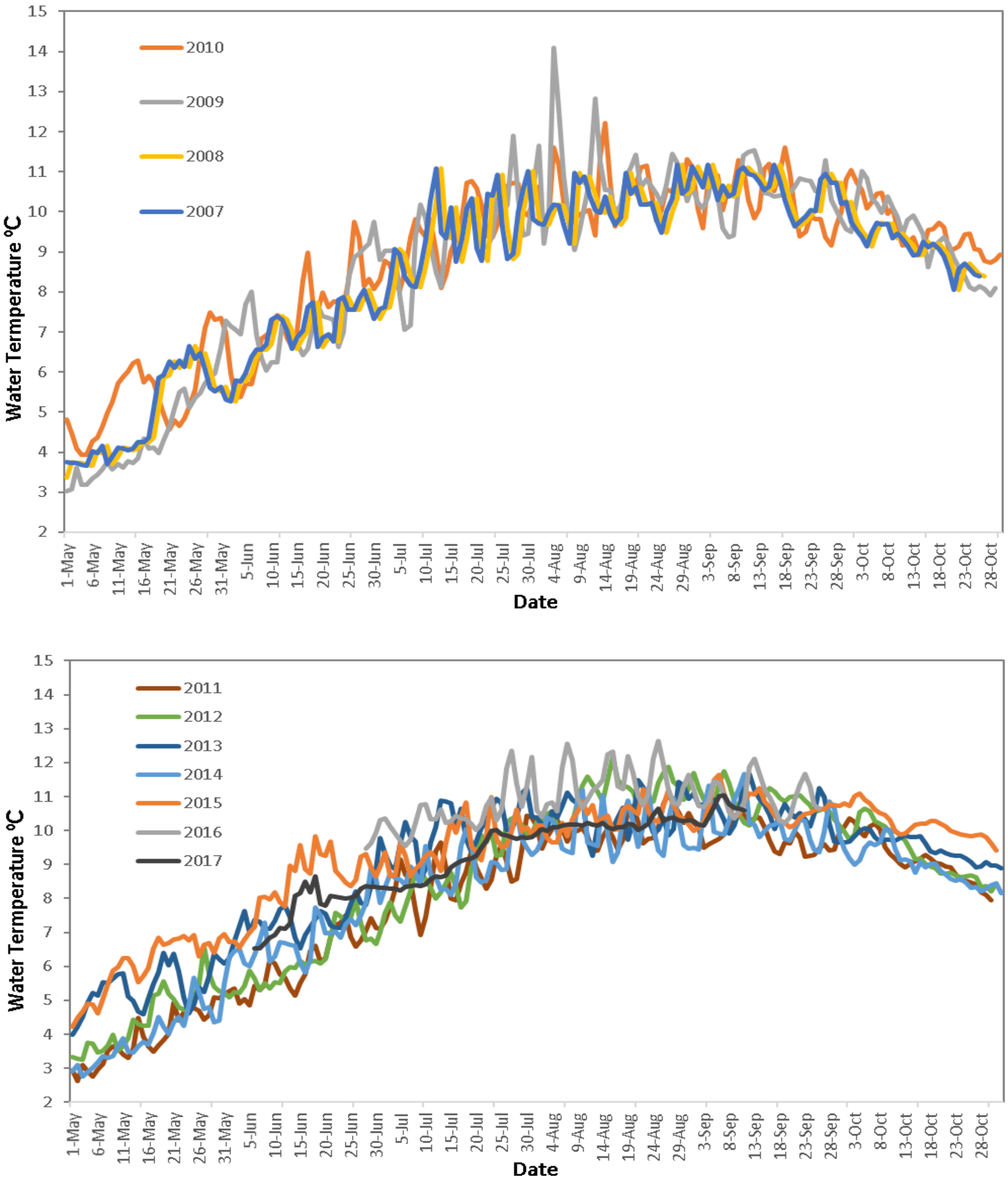


Figure 7: Mean daily water temperature for the Revelstoke Reach from May 1 to Oct 31 for 2007 to 2010 (pre-minimum flow; upper graph) and 2011 to 2017 (post-minimum flow; lower graph). Data for 2007 and 2009-2014 are from Station 6 (CLBMON-15), data for 2008 are from Station 5 (CLBMON-15a), data for 2015 are from Station 3 (BC Hydro), and data for 2016 and 2017 are from portable thermistors moored seasonally downstream from Greenslide Creek.

In 2017, moored temperature thermistors were deployed at three locations within the ALR. Over the three locations, the hourly water temperature was monitored at different depths, ranging from 5 to 15 m deep (Figure 8). Temperatures recorded were generally warmest at the 5 m depth and decreased with increasing depth. However, all three stations recorded similar temperature oscillation patterns that generally rose and fell 2 to 10 ºC over a period of 7-14 days. In a previous ALR limnology study, Pieters *et al*. (1998) observed similar temperature oscillations, even at depths of over 30 m. Pieters *et al.* (1998) suggested that large wind storms create patterns of ‘internal seiche’; lower density warmer water being pushed to one side by the wind combined with the Coriolis effect, starting a ‘rocking’ of the water layers back and forth as the system tries to equilibrate.

Shorter term variations in temperature over a few hours were also recorded, potentially indicating that flow through the reservoir is turbulent. These variations are likely associated with changes in weather patterns and variations in the passage through the system (Pieters *et al.*1998). As water temperature can have a strong influence on Sturgeon movement, these temperature swings may affect Sturgeon movement behaviour in the reservoir along the shoreline in less than 30 m.

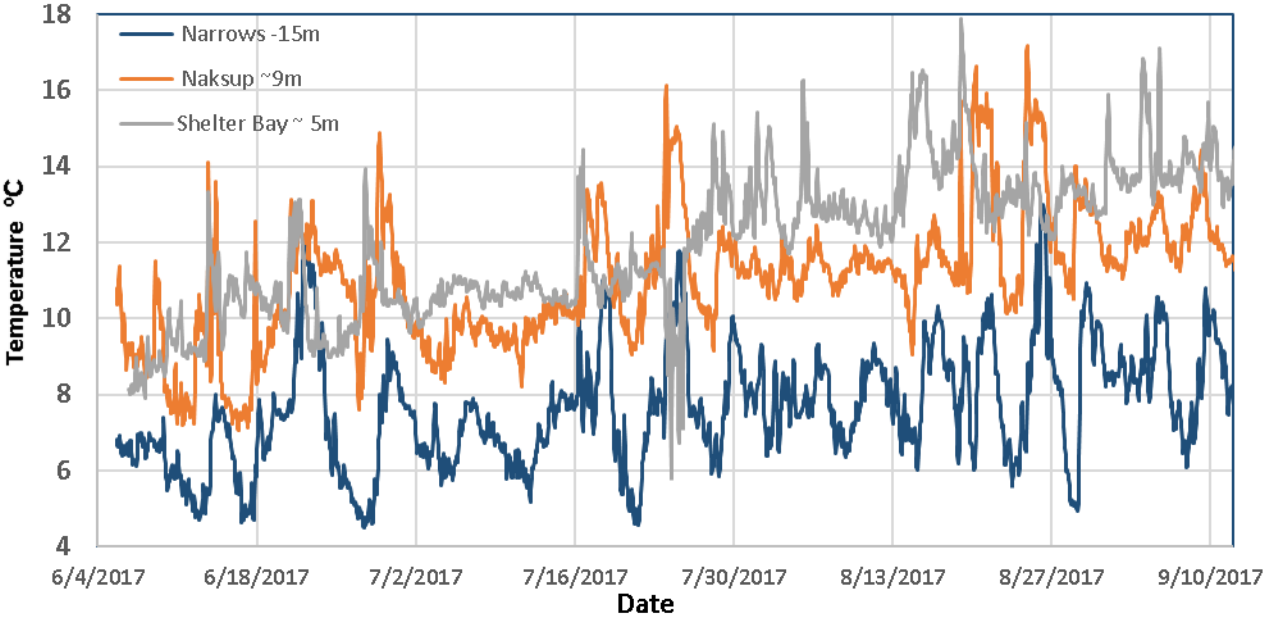


Figure 8: Mean hourly water temperature at three stations in upper Arrow Lakes Reservoir (ALR). The Narrows represents the southern-most limit of the study area, with Nakusp near the middle of the ALR, and Shelter Bay situated near the northern end of the ALR.

### 3.1.3 Meso-Habitat Measurements

In general, surface water velocities in the study area were low (<1 m/s) at all sites and sampling dates but varied seasonally, with the highest velocities during August. Bottom water velocities at the meso-habitat measurement stations associated with the gear that captured juvenile White Sturgeon ranged from 0.0 to 1.0 m/s (Golder 2010).

Turbidity was typically low (≤3 NTU) at all sites except during the one July sampling session (6 NTU) when ALR elevations rose and inundated the exposed shallower sections with predominantly silt-sand substrates (Figure 9). Secchi depth readings (range from 2.1 m to 5.1 m) supported the general seasonal pattern of water clarity as indicated by the turbidity data. Detailed meso-habitat information for the Year 6 (2012) fine-scale movement array study is provided in Appendix C.

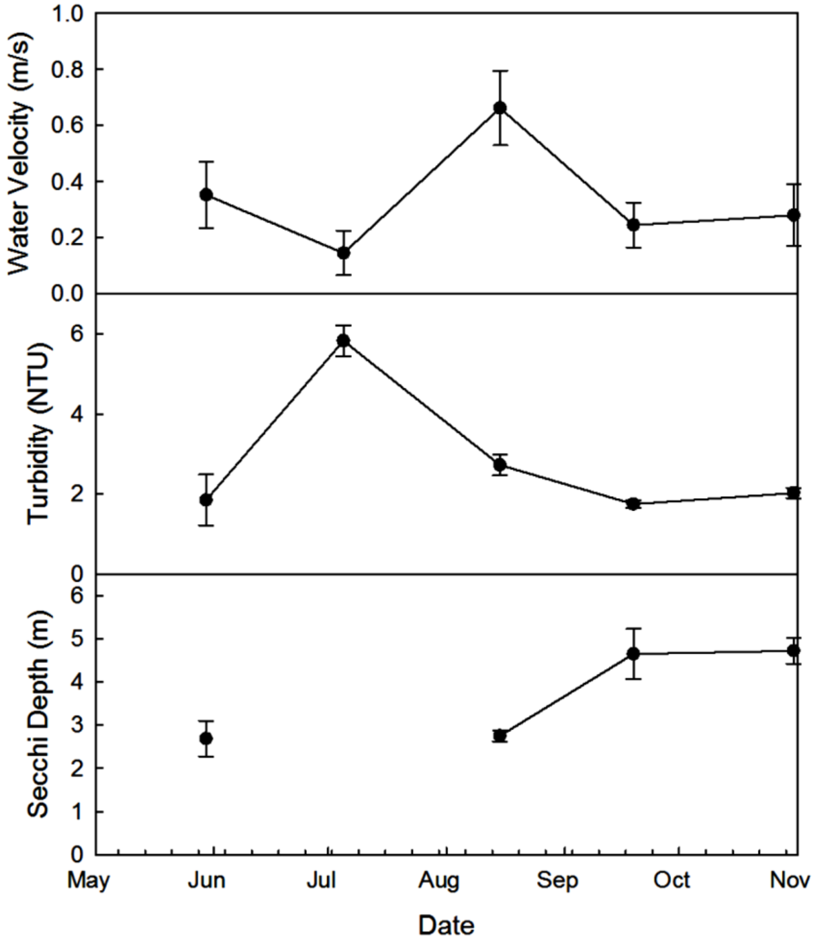


Figure 9: Physical habitat variables measured at four locations within the Middle Columbia River VPS study area at approximately monthly intervals between May 30 and October 30, 2012. Black dots represent the mean values and horizontal bars are standard deviations (graph from ONA and Golder 2013).

## 3.2 Juvenile Sturgeon Releases

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

### 3.2.1 Larval Releases

Under a different program (CLBWORKS-24), the BC Hydro WUP required the release of larval Sturgeon (under 60 days old) into the upper Revelstoke Reach (Table 7**Error! Reference source not found.**). From 2008 to 2009, larval Sturgeon were reared briefly at the portable hatchery at

REV to either a stage just before hatchery feeding would commence (unfed larvae), or after a few weeks of feeding had occurred (fed larvae; FFSBC 2011). These larvae were released at the confluence of the Jordan River and the Columbia River.

In 2010, larval releases also occurred as part of an experiment to assess the effects of substrate modifications in the White Sturgeon spawning area below REV on larval retention and growth (Table 7). One day old unfed larvae were raised at the KTSH then transported to the MCR for release over modified (clean coarse materials placed on the river bottom) and unmodified (natural riverbed) substrates (FFSBC 2011).

Table 7: Summary of unfed and fed larvae and release location from in the MCR from a portable hatchery system located in the REV Generation Station from 2008 to 2009 and from the Kootenay Trout and Sturgeon Hatchery in 2010.

| Study Year | Origin of Larvae | Date of Release | Release Location | River Kilo-metre | No. Juvenile Sturgeon Released | Larval stage | Number of Families |
|---|---|---|---|---|---|---|---|
| 2008 | Portable Hatchery | 4-Jul | Jordan River mouth | 229 | 335,631 | unfed | 2 |
| | | 25-Jul | Jordan River mouth | 229 | 283,848 | fed | |
| 2009 | Portable Hatchery | 5-Jul | Jordan River mouth | 229 | 180,000 | unfed | 1 |
| | | 8-Aug | Jordan River mouth | 229 | 80,000 | fed | |
| 2010 | KTSH Hatchery | 3-Jul | Revelstoke Spawning Area - Control Site | 228.5 | 168,135 | unfed | 6 |
| | | 3-Jul | Revelstoke Spawning Area - Control Site | 228.5 | 168,135 | unfed | |
| | | @ | Centennial Park | 225.2 | 155,000 | fed | |
| | | | | **Total released** | 1,370,749 | | |

@ date not reported in FFSBC, 2011

Results from this study demonstrated that modifications to embedded substrates at known White Sturgeon spawning locations can enhance conditions required for hiding at the yolk sac larvae stage (Crossman and Hildebrand 2012). Fed larvae also were released in 2010 at the Centennial Park boat launch in the Revelstoke town site (Table 7).

All of the ~1.3 million larval released in the MCR were unmarked. No unmarked juveniles have been captured during the sampling program, though it was expected to take a while before these fish reached a size that would recruit to the sampling gear.

### 3.2.2 Juvenile Releases

In total, 60,987 10 to 22-month-old PIT-tagged juvenile White Sturgeon have been released into the MCR from 2007 to 2017 (Table 8*)*. The number of juveniles released annually between REV and Shelter Bay has varied between 1,325 and 9,575 individuals. Between 2007 and 2012, the annual releases included 50 acoustic-tagged fish (250 fish in total;*Table 9)*. With the exception of the 1,589 wild origin juveniles released in May 2017 at the Shelter Bay boat launch, all other releases have been hatchery origin juveniles.

Table 8: Summary of PIT-tagged juvenile White Sturgeon, origin, release date, release location, number of juveniles released, and average length and weight. Does not include juveniles released with an acoustic tag.

| **Study Year** | **Origin of Juveniles** | **Age at release (months)** [a] | **Date of Release** | **Release Location** | **River Kilo-metre** | **No. Juvenile Sturgeon Released** | **Average length** | **Average weight** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **mm** | **grams** |
| 2007 | Hatchery | 10 | 3-May | Moses Creek- Day | 233 | 1,884 | 19.9 | 59 |
| | | | 3-May | Moses Creek-Night | 233 | 2,172 | | |
| 2008 | Hatchery | 10 | 29-Apr | Big Eddy | 228.3 | 5,884 | 20.0 | 61 |
| | | | 29-Apr | Centennial Launch | 225.8 | 600 | | |
| 2009 | Hatchery | 10 | 23-Apr | Big Eddy | 228.3 | 7,518 | 20.8 | 67 |
| | | | 23-Apr | Centennial Launch | 225.8 | 600 | | |
| 2010 | Hatchery | 10 | 23-Apr | Big Eddy | 228.3 | 9,175 | 21.6 | 81 |
| | | | 23-Apr | Centennial Launch | 225.8 | 400 | | |
| 2011 | Hatchery | 10 | 20-Apr | Shelter Bay | 177 | 7,578 | 20.0 | 55 |
| | | | 20-Apr | Centennial Launch | 225.8 | 500 | | |
| 2012 | Hatchery | 10 | 8-May | Shelter Bay | 177 | 6,517 | 22.2 | 81 |
| 2013 | Hatchery | 10-L | 8-May | Shelter Bay | 177 | 5,944 | 27.4 | 159 |
| 2014 | Hatchery | 10-L | 8-May | Shelter Bay | 177 | 3,288 | 28.0 | 202 |
| 2015 | Hatchery | 10-L | 5-May | Shelter Bay | 177 | 6,013 | 27.2 | 144 |
| 2016 | Hatchery | 22 | 3-May | Shelter Bay | 177 | 750 | 40.3 | 451 |
| | | | 5-May | Shelter Bay | 177 | 575 | 39.6 | 442 |
| 2017 | Wild | 22 | 7-May | Shelter Bay | 177 | 1,589 | 38.0 | 313 |
| **Total juvenile White Sturgeon Released All Years** | | | | | | **60,987** | | |

[a] Fish aged 10-L are 10 months but raised on increased feed to grow to larger body size

Table 9: Summary of acoustic-tagged juvenile White Sturgeon origin, release date, release location, number of juveniles released and average length and weight.

| **Study Year** | **Origin of Juvenile** | **Date of Release** | **Release Location** | **RKm** | **No. Juvenile Sturgeon Released** | **Average Length** | **Average Weight** |
|---|---|---|---|---|---|---|---|
| | | | | | | **mm** | **grams** |
| 2007 | Hatchery | 3-May | Moses Creek | 233 | 50 | 31 | 211 |
| 2008 | Hatchery | 29-Apr | Big Eddy | 228.3 | 50 | 31.6 | 229.2 |
| 2009 | Hatchery | 23-Apr | Big Eddy | 228.3 | 10 | 35.1 | 280.9 |
| | | | Begbie Creek | 216 | 10 | | |
| | | | Mulvehill Creek | 206.1 | 10 | | |
| | | | Tree Island | 194.1 | 10 | | |
| | | | Arrowhead | 184 | 10 | | |
| 2010 | Hatchery | 22-Apr | Big Eddy | 228.3 | 10 | 31.5 | 244.8 |
| | | | Begbie Creek | 216 | 10 | | |
| | | | Mulvehill Creek | 206.1 | 10 | | |
| | | | Tree Island | 194.1 | 10 | | |
| | | | Arrowhead | 184 | 10 | | |
| 2011 | No acoustic-tagged juveniles released | | | | | | |
| 2012 | | 15-May | Akolkolex/ Walter Hardman | 203 | 50 | 32 | 250 |
| **Total acoustic-tagged White Sturgeon released - All Years** | | | | | 250 | | |

## 3.2.2 Size at Release

The release size of White Sturgeon juveniles has changed over the 11 years of the program. To observe the effect of size at release, four size categories were released over the study period for a total of 1,370,749 larvae, 42,828 small bodied Age 1 (2007-2012), 15,245 large bodied Age 1 (2013-2015), and 2,914 Age 2 (2016-2017) individuals being released. The hatchery originally produced juveniles 10 months old that averaged approximately 50 to 80 g and were large enough to receive a PIT tag (*Table 8*). Additional fish were raised to 22 months old (age-2) at a weight of 200 to 300 g, a size large enough to accommodate the implantation of acoustic tags (

*Table 9*). For juvenile Sturgeon released in 2012 to 2015, average weight at release for 10-month-old fish increased to approximately 170 grams, categorized as large bodied Age-1. For 2016 and 2017 releases, fish were reared at the hatchery for 22 months (Age-2), which increased weight at release to between 300-450 g (Table 7).

Due to low recaptures of fish released into the MCR it has been difficult to determine the effect of size at release on expected survival. Four hatchery released juvenile white Sturgeon were captured in 2010, for a total of 10 fish captured during the 2007 to 2010 study. Of note, 4 of the ten juveniles captured have been fish equipped with sonic tags at release. These fish were larger at release and grew faster compared to fish without sonic tags. In the MCR, size at release may influence survival. Further discussion on size at release differences in growth are incorporated into the life history results (Section 4.3.1).

## 3.3 Juvenile White Sturgeon Movements and General Habitat Use

At the onset of this program, a fine-scale telemetry study was implemented to track daily movements of acoustically-tagged juvenile White Sturgeon with the objective of investigating movement and habitat use. This study was divided into two components: a longer range dispersal and general movement study (2007-2010), and a fine-scale telemetry study to track daily movements over three seasons at a section of river that was associated with high juvenile Sturgeon detection (2011-2012). As well, mobile tracking for adult White Sturgeon with acoustic tags that were still active from a previous monitoring program were recorded in this program.

### 3.3.1 Passive Array Detection

Movements of acoustic-tagged juvenile White Sturgeon in the study area were continuously monitored by the VR2W linear array from May 2007 to November 2010 (see Golder 2011 for additional details). All 200 acoustic-tagged juvenile White Sturgeon released below Revelstoke Dam between 2007 and 2010 were detected at least once by the array. In total, 3,106,943 detections have been recorded by the array since April 2007. Of these, 1,965,248 detections were juvenile White Sturgeon, 48,795 were adult White Sturgeon, 1,091,771 were Burbot (tagged in 2009 and 2010 in the MCR as part of a separate study program, CLBMON 31), and 1129 were considered false detections (i.e., noise). The approximately 2 million juvenile White Sturgeon detections were reduced down to 3705 (as described in Golder 2011) for the statistical analyses of movement data. The percentage of false presence tag IDs (i.e., noise) recorded by the array was 0.04%, a very low frequency compared to detections accepted as valid.

The number of detections of acoustic-tagged juvenile White Sturgeon recorded in 2010 (450,955) was less than that recorded in 2009 (757,687), but more than in 2008 (402,279) and 2007 (354,327). The greater number of detections in 2009 was initially thought to result from the five release locations that year, compared to one release location in each of 2007 and 2008 (Golder 2010). However, other potential reasons may include natural variation or the much greater number of tagged Burbot detections in 2010 (1,048,307) compared to 2009 (43,464) that reduced the number of juvenile White Sturgeon tags that could successfully be coded out by the receivers.

### 3.3.2 Dispersal for Release Locations

Dispersal patterns of acoustic-tagged Sturgeon were observed by comparing single release upstream locations that were used in 2007 and 2008 with multiple release locations (spaced approximately every 10 km) covering the entire Revelstoke Reach, used in 2009 and 2010. In

April of 2008, 2009, and 2010, downstream dispersal was apparent at all stations (Golder 2011). In 2008, when all acoustic-tagged juveniles were released at Big Eddy, fish were detected as far downstream as Station 212.0 (near Greenslide Creek) within 2 days of release. A similar pattern was apparent in May 2007, when all acoustic-tagged juveniles were released at Moses Creek (RKm 233). These fish exhibited rapid downstream movement past the seven most upstream VR2W stations (Stations 232.3 to 212.0), then spent more time in the vicinity of VR2W stations in deeper, lower velocity habitats near Mulvehill Creek (RKm 207.4) and downstream. A similar pattern was observed in May 2008, as fish released in Big Eddy continued their downstream dispersal, and then began to spend more time near Mulvehill Creek and downstream areas.

In 2009 and 2010, acoustic-tagged juvenile White Sturgeon were released in groups of 10 fish at approximately 10 km intervals in the middle Columbia River between Big Eddy and Arrowhead

*Table 9*). The general post-release dispersal pattern of acoustic-tagged juveniles released at the two most upstream locations (Big Eddy, RKm 228.3 and near Begbie Creek, RKm 216) was characterized by rapid downstream movements through the riverine section of the middle Columbia River to deeper areas with lower water velocities (Golder 2011). These downstream movements were fastest and occurred over the longest distances for fish released at Big Eddy. After these initial movements, the speed and distance travelled decreased and fish generally spent longer periods of time in particular areas. These dispersal patterns (especially for fish released at Big Eddy) were similar to those of fish released at Big Eddy in 2009 (n = 10) and 2008 (n = 50) and upstream at Moses Creek (RKm 233) in 2007 (n = 50).

The dispersal patterns of fish released in 2010 at the three downstream locations (near Mulvehill Creek, RKm 206.1; Tree Island, RKm 194.1; and Arrowhead, RKm 184) were more variable (Golder 2011). A portion of these fish moved rapidly downstream shortly after release, while others remained in the vicinity of their release location. Several fish released at Arrowhead moved upstream within a few weeks of release.

Of the 50 sonic-tagged juveniles released in 2010, 13 (26%) were not detected after May 17 (24 days after release). These fish were represented by fish from each release location: Big Eddy (*n* = 2), near Begbie Creek (*n* = 3), near Mulvehill Creek (*n* = 1), near Tree Island (*n* = 4), and Arrowhead (*n* = 3). This was a higher “early disappearance” rate than the eight (16%) sonic-tagged juveniles released in 2009, but less than the 17 (34%) released in 2008 and the 18 (36%) released in 2007 that were not detected after one month post-release (Golder 2010b). The number of sonic-tagged juveniles not detected after one month post release in 2009 was reduced because three fish that were not detected by the VR2W array after May 11, 2009 were later detected between acoustic receiver locations during mobile tracking surveys. Many of the fish were last detected at the downstream end of the study area, located in the upper ALR.

### 3.3.3 Effect of Release Sites

The analysis focused on an evaluation of the effect of release sites on subsequent Sturgeon behaviour. Initially, all four years of data were examined; however, during initial exploratory analysis there were sufficient differences in other factors (e.g., reservoir water levels) so Year 1 and Year 2 were excluded from the analysis. The variables examined included: time spent on station and movement magnitude and direction after departing station until relocated. Absolute distance travelled was not used as a fish released at a site near the most upstream VR2W station could not be relocated at an upstream site as there were no more receivers. As this bias also affects relative distance travelled following departure from a VR2W station, the time spent on site after arrival would be a stronger parameter on which to evaluate the effects of release site on subsequent behaviour. The parameters and statistical analysis for the two selected models (Log Time at Station and Standardized Distance Travelled) are described in Golder (2011).

There were significant differences in distances moved among release sites (Figure 10). Movements in April and May were generally downstream while there was a general tendency to move upstream after June, although sample sizes (number of detections of tagged fish) decreased, which resulted in greater uncertainty. The Begbie Creek release location (RKm 216) had individuals that were more likely to move upstream in the fall.

With the top ranked models ($AIC_c$ weights >0.1), arrival time (day/night), year, REV discharge (Q), and ALR water surface elevation influenced the time spent on station (*Table 10*; Golder 2011). As there were considerable covariation in the variables month and ALR water surface elevation, the temporal component may contain changes in behaviour related to water levels or discharge. Time spent on site generally increased each month and varied by release site. All years were pooled for the selected model (Figure 11; Golder 2011). Average time spent on station in 2007 was significantly less than in the other years, so the data from fish released at Moses Creek (RKm 232.3) may not reflect site differences, but rather differences among years.

Overall, fish tended to move upstream more often and to stay longer on station during the course of the summer and into the fall. Fish released at RKm 216 tended to be more likely to move upstream and stay on site longer than fish released at other sites. Fish released at the most upstream and downstream sites would be biased to move downstream or upstream, respectively, because of the lack of receivers beyond these release locations (Golder 2011).

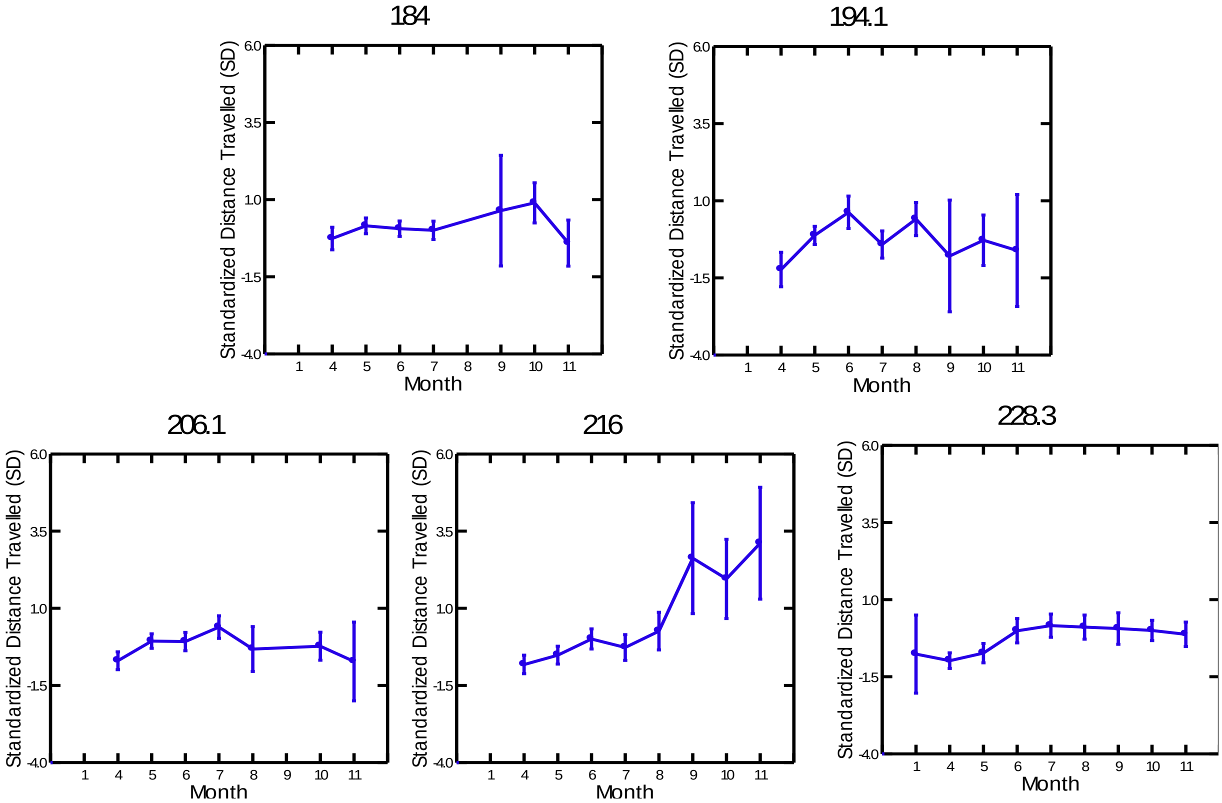


Figure 10: Least Square Means of the standardized distance travelled variable of the selected model of acoustic-tagged juvenile White Sturgeon in the middle Columbia River by month of detection for fish from the five release locations (River kilometre numbers at the top of each graph). Values reflect standardized net distances (positive = upstream movement; negative = downstream movement). The data are from the 2009 and 2010 study years combined. Error bars are SE of the least square means from the general linear model. Graph is from Golder (2011).

Table 10: $AIC_c$ ranking of candidate models for predicting Log of Time at Station after arrival of an acoustic-tagged juvenile White Sturgeon at a station in the MCR. Independent variables are categorical except for REV discharge and Arrow Lakes Reservoir water surface elevation. Table from Golder (2011).

| Dependent Variable | Multiple $R^2$ | $AIC_c$ Weight | $AIC_c$ | Independent Variables | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Release Site** | **Year** | **Month** | **Month x Release Site** | **Daylight (Day/ Night)** | **ALR Water Surface Elevation** | **REV Discharge** |
| **Log Time at Station** | **0.2** | **0.294** | **4965.268** | **x** | | **x** | **x** | | | |
| | 0.202 | 0.241 | 4965.663 | x | | x | x | | x | |
| | 0.201 | 0.171 | 4966.352 | x | | x | x | x | | |
| | 0.201 | 0.11 | 4967.236 | x | | x | x | | | x |
| | 0.2 | 0.102 | 4967.387 | x | x | x | x | | | |
| | 0.202 | 0.082 | 4967.809 | x | | x | x | x | | x |
| | 0.12 | >0.001 | 5010.165 | x | | x | | | | |
| | 0.122 | >0.001 | 5011.163 | x | | x | | x | | x |
| | 0.121 | >0.001 | 5011.171 | x | | x | | | | x |
| | 0.121 | >0.001 | 5011.199 | x | | x | | x | | |
| | 0.123 | >0.001 | 5013.156 | x | x | x | | x | | x |
| | 0.131 | >0.001 | 5041.358 | x | | | x | | | |

Although the trends described are statistically significant, the overall selected models explained only a small amount of the variability observed ($R^2$ ~ 0.2; Golder 2011). Other variables examined for effect on juvenile White Sturgeon movements included: solar radiation (day/night), REV hourly discharge, and ALR water surface elevations. Although there were some slight statistical significance to these parameters (ALR water surface elevations was the strongest), the relationship was confounded by the temporal correlation with fish growth and explained very little of the variability observed in movement patterns. Although thousands of relocations were observed at the various stations, the bulk of the data was from a small number of individuals.

In addition, the dependent variable used (the magnitude and direction of movements and time spent on station) do not have obvious biological interpretations, i.e., is less movement or upstream movement better than more frequent movement or downstream movement? A plausible interpretation is that the extended time spent on station indicated the presence of preferred habitat and food resources, whereas upstream or downstream movements could have indicated that the individual was required to more actively search for food. However, the influence of other factors (e.g., fish in poor condition tend to migrate less frequently) cannot be discounted.

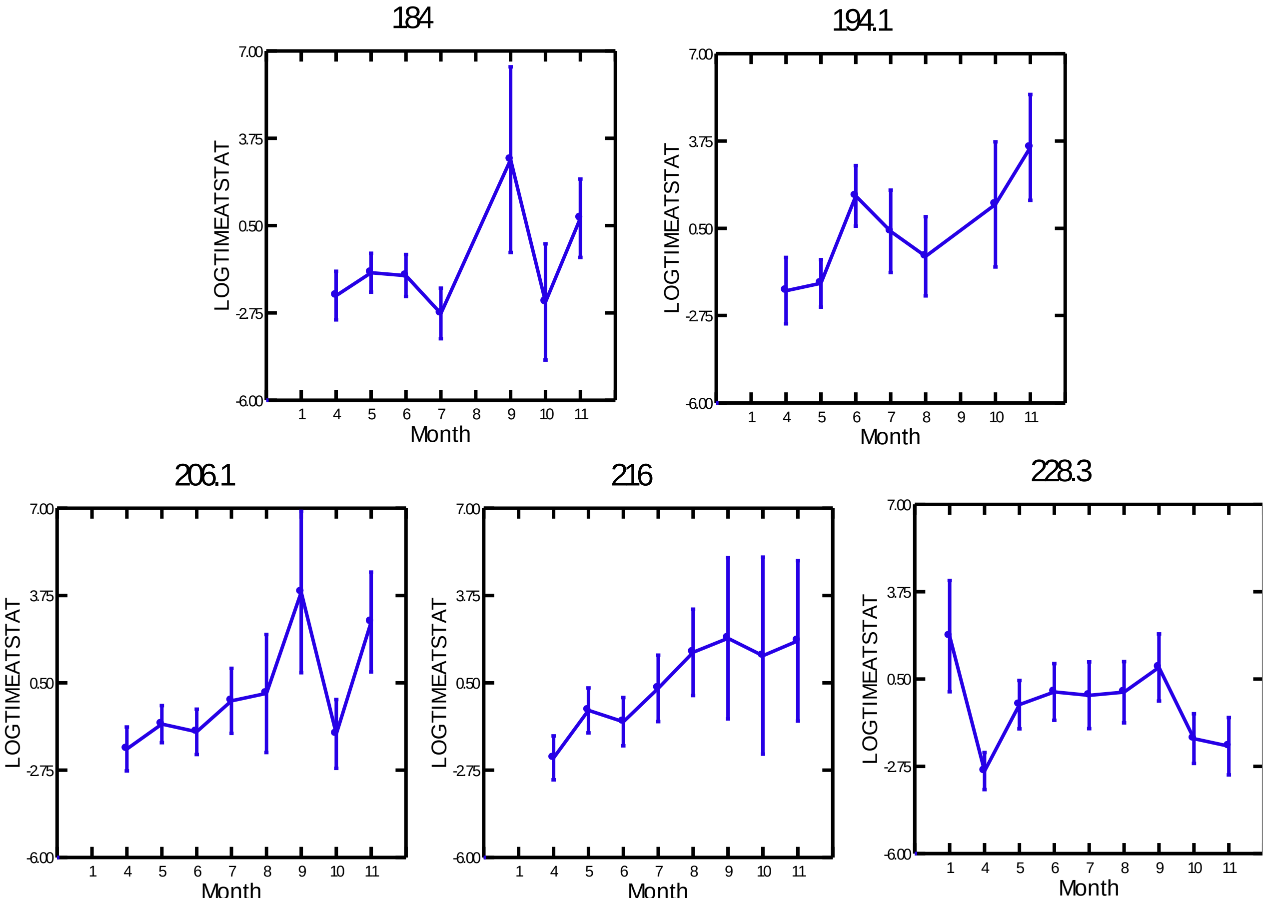


Figure 11: Least Square Means of the Log (Time at Station) by acoustic-tagged juvenile White Sturgeon in the middle Columbia River over each month (River kilometre numbers at the top of each graph). The data are from the 2009 and 2010 study years combined. Graph from Golder (2011).

### 3.3.4 General Macro-Habitat Use

The number of tag days recorded at each VR2W station from 2007 to 2010 provided an indirect indication of rearing use of macro-habitats by juvenile White Sturgeon in the MCR. Macro-habitat in this context is defined as the sum of all meso- or micro-habitat types within the detection range of the station. The presence of a tagged juvenile White Sturgeon in the vicinity of the station, even if only transitory, was considered as a use of available habitats within that area. Insufficient data were collected on habitat parameters occupied by individual fish to categorize habitats on smaller spatial scales.

The mean net movement of sonic-tagged juvenile White Sturgeon, an indication of the length of river used (or the range of these fish), was similar in all four study years despite the differences in release patterns (Table 11). This suggests an active selection for deeper, lower velocity habitat and an apparent avoidance of higher velocity habitats in the middle Columbia River. The sonic-tagged juveniles remained within an approximate 21 to 26 km length of river/reservoir. The movement of one fish downstream of the VR2Ws in the Beaton Flats area was confirmed by its detection at the Narrows; however, undetected movements downstream of this area likely occurred, which could have resulted in an increase in net and total movements. Additionally, undetected movements within the study area could also have occurred.

Table 11: Mean net movement of acoustic-tagged juvenile White Sturgeon after released in the middle Columbia River, 2007 to 2010.

| Year | Mean net movement (km) | Range (km) | S.D. | Number of detections (±SD) |
|---|---|---|---|---|
| 2007 | 23.9 | 0 - 52.3 | 16.2 | 7,087 (± 23,133) |
| 2008 | 25.7 | 0 – 48.3 | 15.3 | 8,046 (± 11,455) |
| 2009 | 21.4 | 2.6 – 68.3 | 14.1 | 15,154 (± 21,361) |
| 2010 | 21.7 | 0 - 104 | 18.2 | 9,019 (± 19,552) |

The average total distance moved by acoustic-tagged juvenile White Sturgeon released in 2010 was 47.1 km. This was greater than the average total movement of juveniles released in 2009 (37.9 km), but similar to 2008 (49.1 km) and 2007 (44.1 km; Table 12). The lower mean total movement in 2009 was likely due to the different release locations used in 2009, though 2010 had the same release locations and should the greatest range of travel. ALR elevations were also lowest in 2009 (compared to 2007-08 and 2010), which may have provided hydraulic conditions that were preferable for juvenile White Sturgeon. The difference in mean total movement between 2010 and 2009 may have been due to ALR levels, which were approximately 2 m higher in 2010 at the time of release and remained higher until late August. This likely resulted in lower water velocity in downstream areas, which may have affected movement patterns. The statistical analysis of movements (described in Section 4.4.6) determined that ALR water surface elevations were a significant variable that affected net movement.

Table 12: Mean total movement of acoustic-tagged juvenile White Sturgeon after released in the middle Columbia River, 2007 to 2010.

| Year | Mean Total Movement (km) | Range (km) | S.D. | Number of detections (±SD) |
|---|---|---|---|---|
| 2007 | 44.1 | 0 – 214.3 | 46.5 | 7,087 (± 23,133) |
| 2008 | 49.1 | 0 – 237.1 | 49.6 | 8,046 (± 11,455) |
| 2009 | 37.9 | 2.6 – 136.0 | 30.3 | 15,154 (± 21,361) |
| 2010 | 47.1 | 0 – 296.1 | 57.5 | 9,019 (± 19,552) |

On average, the 50 acoustic-tagged juveniles released in 2010 moved approximately twice as far downstream (31 km) as upstream (16 km). Seven fish were detected more than 1.3 km upstream of their release location. One fish was detected at the Narrows (RKm 112; 68 km downstream of Beaton Flats and 104 km downstream of its release location), which is out of the study area.

Eighteen juveniles did not exhibit any upstream movement, although nine of these fish were not detected after May 9, 2010 (18 days after their release).

In June 2009, during the lowest ALR peak elevation of the four years of the larger scale movement study, a substantial increase in the use of Beaton Flats and mouth of Beaton Arm was apparent. Use of these areas in June 2010 was substantially less than in June 2009, but still greater than in 2007 and 2008. The use of the area near Tree Island (Station 195.0) was also substantially greater in June 2009 than in previous years. The use of this area in June 2010 was substantially less than in 2009, but was still greater than in 2007 and 2008. In June 2007 and 2008, sonic-tagged juveniles exhibited a high use of areas between Station 207.4 (Mulvehill Creek area) and 200.0 (near the Akolkolex River). Sonic-tagged juveniles exhibited substantially less use of this area in June 2009. In June 2010, use of the Mulvehill Creek area (Station 207.4) was similar to June 2009, but use of the area between Blanket Creek area (Station 203.5) and the Akolkolex River area (Station 200.0) was substantially higher in June 2010 than June 2009.

In 2009, compared to 2007 and 2008, the substantial increase in use of the Beaton Flats area continued until November. Use of this area was also higher in 2010 than in 2007 and 2008 during this period, but less than the use exhibited in 2009. Sonic-tagged juveniles exhibited higher use of the Tree Island area (Station 195.0) in July and August 2009 and 2010 than in 2007 and 2008. Use of the Akolkolex River area (Station 200.0) was substantially higher in July and August 2009 compared to 2007 and 2008. Use of this area was lower in July and August 2010 than in all other study years. From July to November 2008, use of the Mulvehill Creek area (Station 207.4) was substantially higher than in all other study years.

From 2007 to 2010, the stations where the highest use (measured as tag days on site) by sonic-tagged juvenile White Sturgeon was recorded were located between Station 212.0 (upstream of Greenslide Creek) and Station 195.0 (Tree Island area; 56% of total tag days), and the Beaton Flats area (RKm 180; 14% of total tag days; Figure 12). High use of the area between Stations 212.0 and 195.0 occurred during all study years (63% of total tag days in 2007, 71% in 2008, 43% in 2009, and 51% in 2010; Golder 2011). The multiple release locations in 2009 and 2010 resulted in lower overall use (47%) of this area than the single upstream release locations used in 2007 and 2008 (68%).

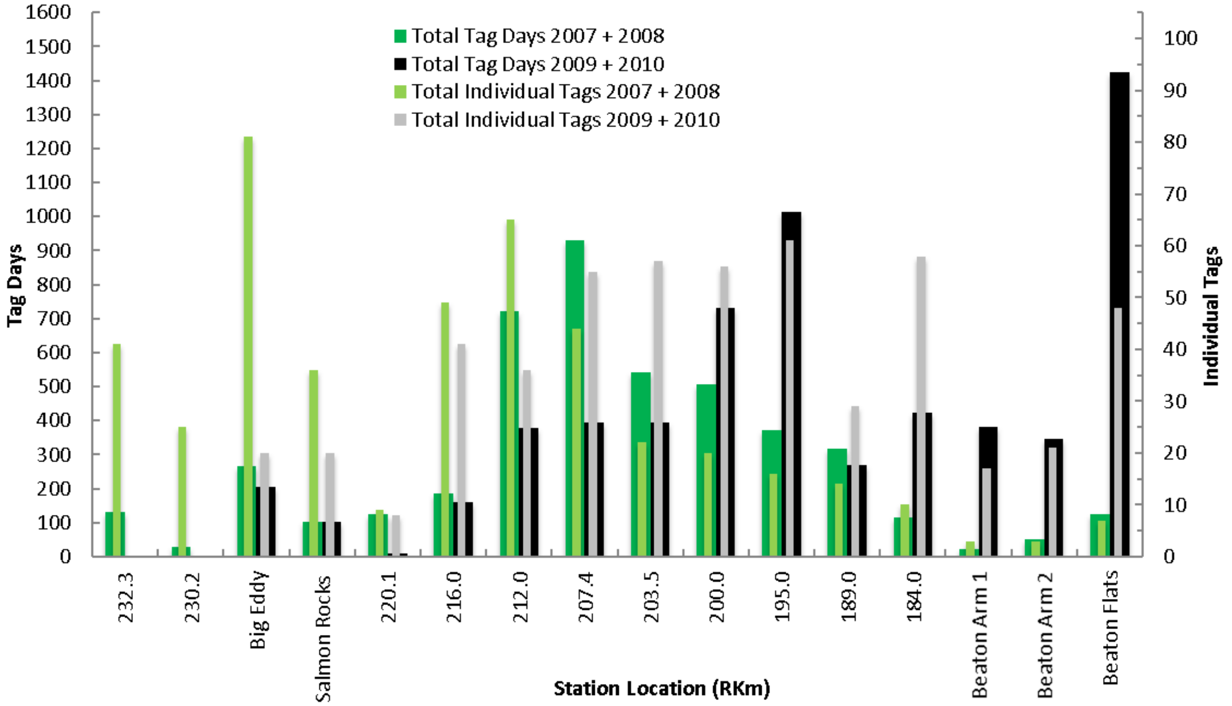


Figure 12: Total tag days and total individual tags recorded of acoustic-tagged juvenile White Sturgeon movements in the middle Columbia River for 2007 and 2008 fish (single release location at RKm 233) and 2009 and 2010 fish grouped (5 release locations spread from Big Eddy to RKm 184) recorded in the middle Columbia River, 2007 to 2010. Graph from Golder (2011).

The highest overall use occurred at Beaton Flats (14% of total tag days; Figure 12). This was due to a greater use of this area in 2009 and 2010 (23%) than in 2007 and 2008 (3%; Golder 2011). Use of the areas from Blanket Creek (Station 203.5) upstream was greater in 2007 and 2008 (67%), whereas use of the areas from the Akolkolex River (Station 200.0) downstream was greater in 2009 and 2010 (74%).

The macro-habitat conditions in the areas where the most tag days were recorded were similar in terms of depth, velocity, and substrate (Golder 2011). These areas were characterized by depths in excess of 10 m (and often 15 m), water velocities of less than 0.5 m/s, and substrates composed mainly of fines. These areas exhibited more lentic conditions for longer periods, as opposed to upstream areas that exhibited lotic conditions for longer periods of the year.

### 3.3.5 Movement Out of Study Area/Post-release Mortality

In 2007, five acoustic-tagged juvenile White Sturgeon moved steadily downstream after release, apparently past the Beaton Flats stations and out of the study area. In 2008, four acoustic-tagged fish exhibited the same movement pattern (Golder 2009). The detection of eight acoustic-tagged juveniles downstream of the Beaton Flats VR2W stations during mobile tracking in 2009 provided further verification that some of hatchery-released juveniles move beyond the study area. In 2010, 30 tags were last located in either Arrowhead or Beaton Flats receiver stations at the downstream end of the Revelstoke Reach over the study period. The size and depth of ALR downstream of the study area (approximately 180 km long) presents substantial logistical difficulties in terms of monitoring juvenile White Sturgeon and their use of the reservoir.

The fate of acoustic-tagged juveniles remains unknown. Results from 2009 suggested that a portion of tag “disappearance” is due to fish moving downstream beyond coverage of the VR2W array. In 2007 and 2008, the relatively high proportion of tags that were not detected beyond one month post-release (36% and 34%, respectively) suggested potential post-release mortality (Golder 2009), though high ALR levels in 2008 could have allowed fish more river width to move undetected past the receiver array stations. However, this proportion was substantially lower in 2009 (16%), due in part to mobile tracking surveys that located three acoustic-tagged juveniles that had not been detected by the VR2W array for approximately 5 to 7 months. The four potential reasons for the disappearance of some tags shortly after release are:

1. Movement out of the study area (outside range of acoustic receivers).
2. The fish remain in portions of the study area that are out of all acoustic receiver station’s detection range (for example, one tag was located by mobile tracking after disappearing from station data.).
3. Post-release mortality (for example, fish dies in between stations or at stations and tag does not move any further for the year).
4. Occasional equipment malfunction or battery failure that may be responsible for tags disappearing, which is impossible to confirm without relocating tag.

It is possible that tag “disappearance” is due partly to all of these reasons. Additional VR2Ws were deployed in the Burton area (approximately 80 km downstream of the study area at a narrow point in ALR) in 2009. In 2010, one fish was identified at the Narrows station, but it was not possible to determine if this fish continued downstream or returned to ALR. Sampling in 2014 to 2017 was extended to the entire upper Arrow Lake basin. During these four years only one juvenile fish was captured in the ALR in a gill net on the west shoreline at RKm 124.0 in June, 2017 (Appendix A).

### 3.3.6 Diel Movement Analyses

Diel movements during Years 1 to 4 (2007 to 2010) were predominantly initiated during the periods of darkness from 21:00 until 06:00 (Figure 13). Downstream movements were more frequent than upstream movements (not illustrated), but both followed the same diel pattern. This pattern has been observed in each of the four years of the study (Golder 2008, 2009, 2010).

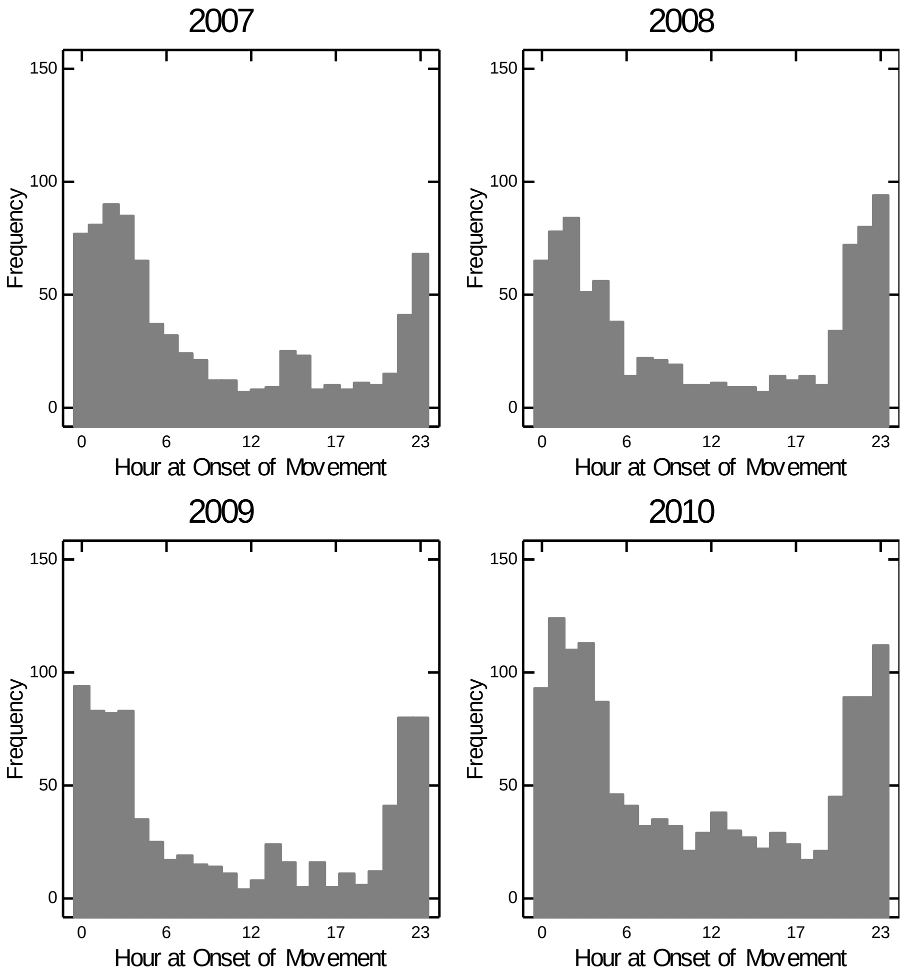


Figure 13: Frequency of the onset of movements by hour of the day (0 = midnight) of acoustic-tagged juvenile White Sturgeon in the Middle Columbia River, 2007 to 2010. Graph from Golder (2011).

Examination of the frequency distribution of light intensity [hourly diel solar radiation patterns (watts/m$^2$) measured at Revelstoke, BC] at the onset of movements did not indicate any variability in movements during daylight as a result of light intensity (Golder 2011). Consequently, daylight was used as a binary variable (day/night) during subsequent analyses.

### 3.3.7 Revelstoke Dam Discharge

Annual hourly average discharge (Q in m$^3$/s) from REV between 2007 and 2010 was also examined as it was related to the hour at the onset of movement (Figure 14; Golder 2011). The recorded flows at the onset of movements were less during 2010 and 2009 than 2008, and less in 2008 than 2007.

The REV discharge variable was positively related to downstream movement but was of minor significance. The results indicated that release site significantly affected movements, but only in the context of a particular month. The inclusion of an interactive term significantly improved the model but also was essential to evaluation of seasonal changes in behavior (Golder 2011).

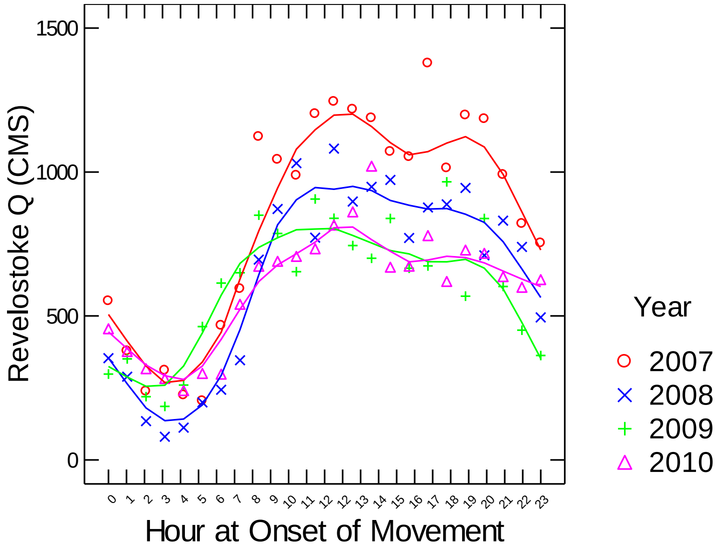


Figure 14: Annual hourly average discharge ($m^3/s$) from Revelstoke Dam vs. hour of the day in the middle Columbia River, 2007 to 2010. Curve fitting the data is from LOWESS (tension = 0.25). Graph from Golder (2011).

### 3.3.8 Fine-scale Array Detection

In total, 202,186 tag positions were calculated based on data collected during study period (May 15 to October 30, 2012). Out of the total dataset, 21% of the total number of tag positions had HPE ≤ 5, 60% had HPE ≤ 6, and 71% had HPE ≤ 7 (HPE defined in Section 3.3.4.4). In the restricted dataset (HPE ≤ 7) HPE values ranged from 2.5 to 7, with a mean of 5.3 and a median of 5.5. Once the first two weeks of data were removed to eliminate acclimation movements, the dataset included 128,601 tag positions estimated between May 29 and October 30, 2012.

Sensitivity analysis indicated little difference between HPE cutoff values of 5 and 6 (ONA and Golder 2013). However with a HPE cutoff value of 7, a few cases emerged where estimated swimming speed was high (> 2 m/s), as to be expected with lower positioning accuracy.

Using HPE values as a 95% confidence interval for fish positioning (Section **Error! Reference ource not found.**), only 3.1% of the fish assigned to the thalweg were less than the HPE distance from the nearest floodplain/thalweg contour line; i.e., the position's confidence interval overlapped the thalweg/floodplain contour line in 3.1% of the cases. Therefore, 96.9% of the Sturgeon positions were assigned to the thalweg stratum. Out of the fish positions assigned to the floodplain, 5.6% were less than the HPE distance from the shallows/floodplain contour line; therefore, 94.4% were assigned to the floodplain stratum. Out of the fish positions assigned to the shallow stratum, only 0.1% was less than the HPE distance from the shallows/floodplain contour line, and therefore, could have been in deeper water than estimated

### 3.3.9 Fine-scale Movements

The data collected from the fine-scale array allowed analysis of movement patterns as related to daylight, habitat type, REV discharge effects at the study area, ALR elevation for 2012, and seasons. Half of the 50 acoustic-tagged juvenile White Sturgeon that were released into the vicinity of the VPS array on May 15, 2012 were only recorded during the spring session and were absent from the VPS study area in the summer and fall. Of the remaining 25 juveniles that stayed within range of the VPS system for more than two weeks, 12 fish left before the beginning of the summer. Thirteen individuals were present in the area during the summer, and only five were recorded in the fall. Throughout the May 29 to October 30, 2012 study period, juvenile White Sturgeon spent 0.03% to 25.3% of the time within the VPS array (mean = 4.8 ± 6.0%, median = 6.6%).

### 3.3.10 Meso-habitat Movements of RKm 203 to RKm 200

The fine-scale array allowed for detailed movement monitoring of tagged Sturgeon within a high use habitat area of RKm 203 to RKm 200 near Walter Hardman Generation Station. Tag locations by time of day, season, and habitat depth classification (Figure 15) clearly showed that juvenile White Sturgeon were found in shallow and floodplain sites in summer and fall but rarely in spring. Minimum distances traveled between consecutive positions within the array were usually less than 100 m throughout the study period (mean ± SD = 5.4 ± 10.6 m, median = 2.3 m). In the summer, minimum traveled distances were slightly longer than in the spring, with more cases of 50 to 100 m distances traveled between tag locations (spring: mean ± SD = 3.8 ± 6.9 m, median = 2.4 m; summer: mean ± SD = 6.04 ± 11.2 m, median = 2.8 m).

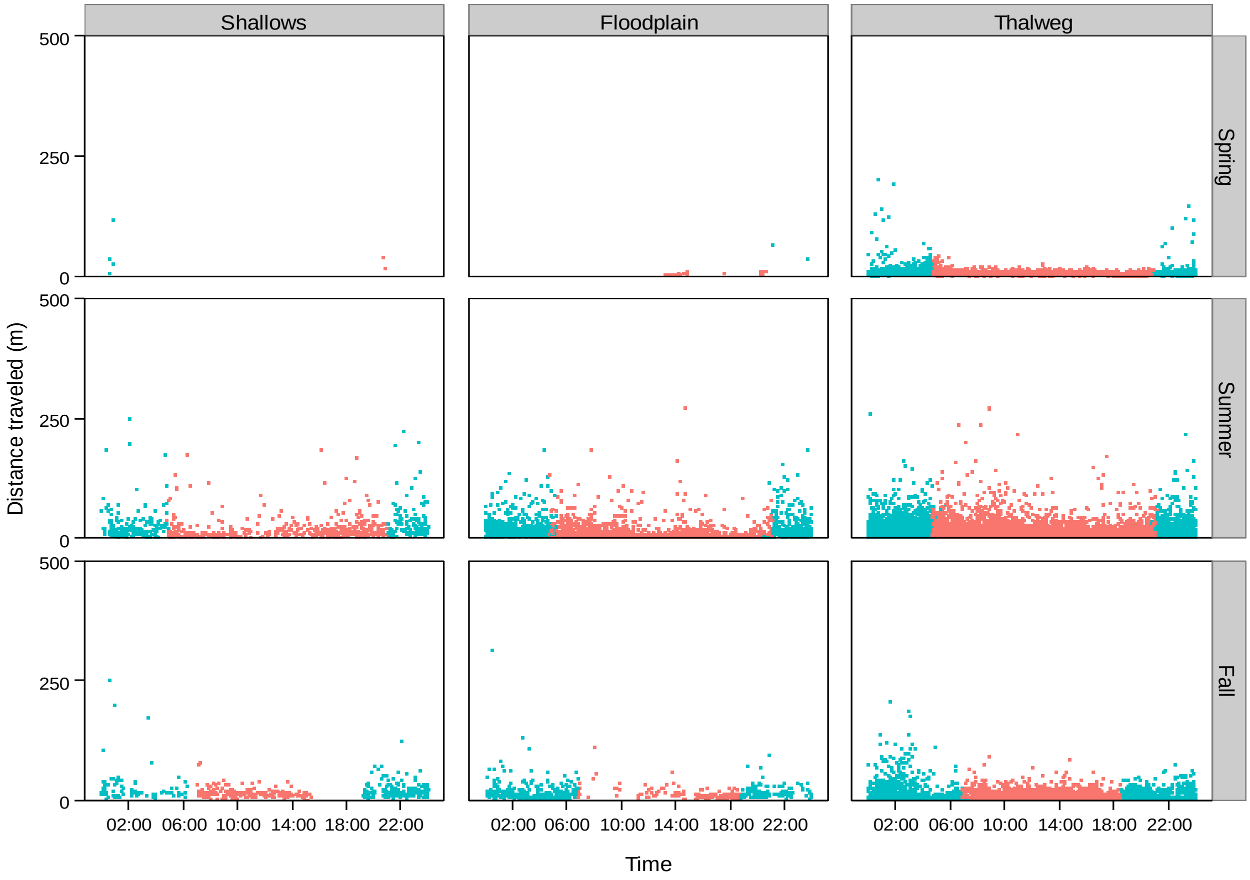


Figure 15: Minimum distance traveled between positions (m) of White Sturgeon juveniles in the VPS array, plotted by time of day, season, and habitat classification (thalweg, floodplain or shallows).

Minimum movement speeds changed seasonally, with highest rates estimated in the summer, in comparison to spring and fall months (**Table 13**). Estimated minimum movement speeds were 0.02 ± 0.03 m/s (mean ± SD, median = 0.01 m/s) in spring time, 0.03 ± 0.06 m/s (mean ± SD, median = 0.02 m/s) in summer time, and 0.02 ± 0.05 m/s (mean ± SD, median = 0.01 m/s) in the fall. Movement speeds were similar between nighttime and daytime. For example, in fish located in the thalweg at night time, swimming speed was 0.02 ± 0.05 m/s (mean ± SD, median = 0.01 m/s), while daytime swimming speed was 0.02 ± 0.04 m/s (mean ± SD, median = 0.01 m/s).

Table 13: Summary statistics of minimum movement speed (m/s) of juvenile White Sturgeon, separated by day/night, season, and habitat type (thalweg, floodplain, shallows); values are means ± standard deviations.

| **Habitat Classification** | **Spring (m/s)** | **Summer (m/s)** | **Fall (m/s)** |
|---|---|---|---|
| Thalweg | 0.04 ± 0.1 | 0.09 ± 0.48 | 0.02 ± 0.05 |
| Floodplain | 0.08 ± 0.17 | 0.30 ± 0.99 | 0.09 ± 0.07 |
| Shallows | 0.11 ± 0.10 | 0.18 ± 0.35 | 0.1 ± 0.05 |

When examining fine-scale data, juvenile White Sturgeon used shallow water under all ALR elevations (Figure 16). The longest, most consistent movements traveled in the shallows were observed when the reservoir was emptying. In the thalweg, the majority of the traveled distances were typically short (25th, 50th, and 75th quantiles of 0, 0.9, 2.1, and 4.9 m; ONA and Golder 2013).

Seasonal differences in fish locations were apparent (Figure 16). During springtime, movements were usually restricted to the thalweg. In comparison, in summer and fall the fish took advantage of the increasing amount of habitat and were detected further from the thalweg. However, there was considerable individual variability in habitat use (described in Golder and ONA 2013). For example, in the summer, the Sturgeon with tag numbers WSG34 and WSG38 remained in the thalweg, while WSG19, WSG23, WSG26, and WSG30 had wider distributions. In the fall, WSG01 and WSG41 utilized the shallows, while WSG25 and WSG30 remained in the thalweg.

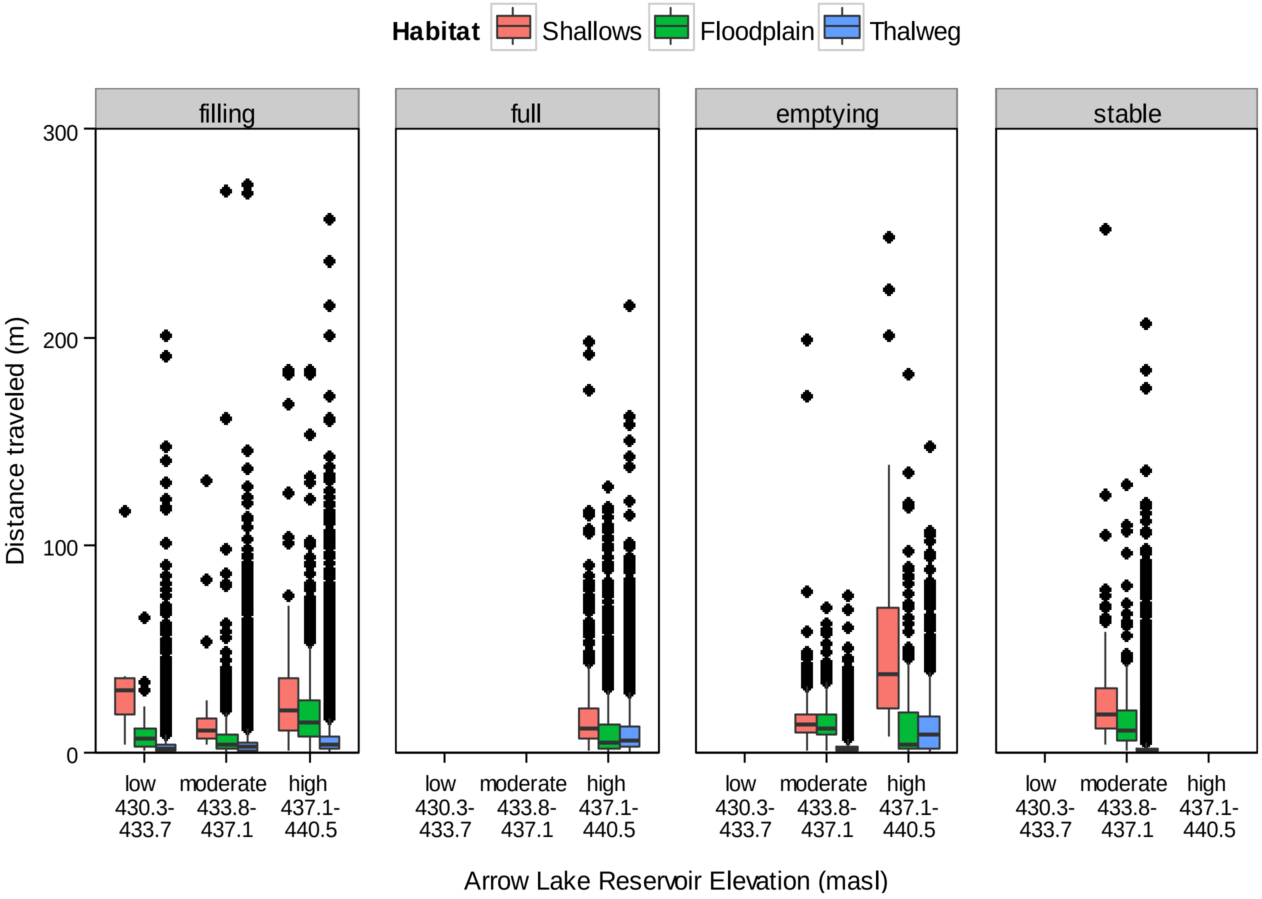
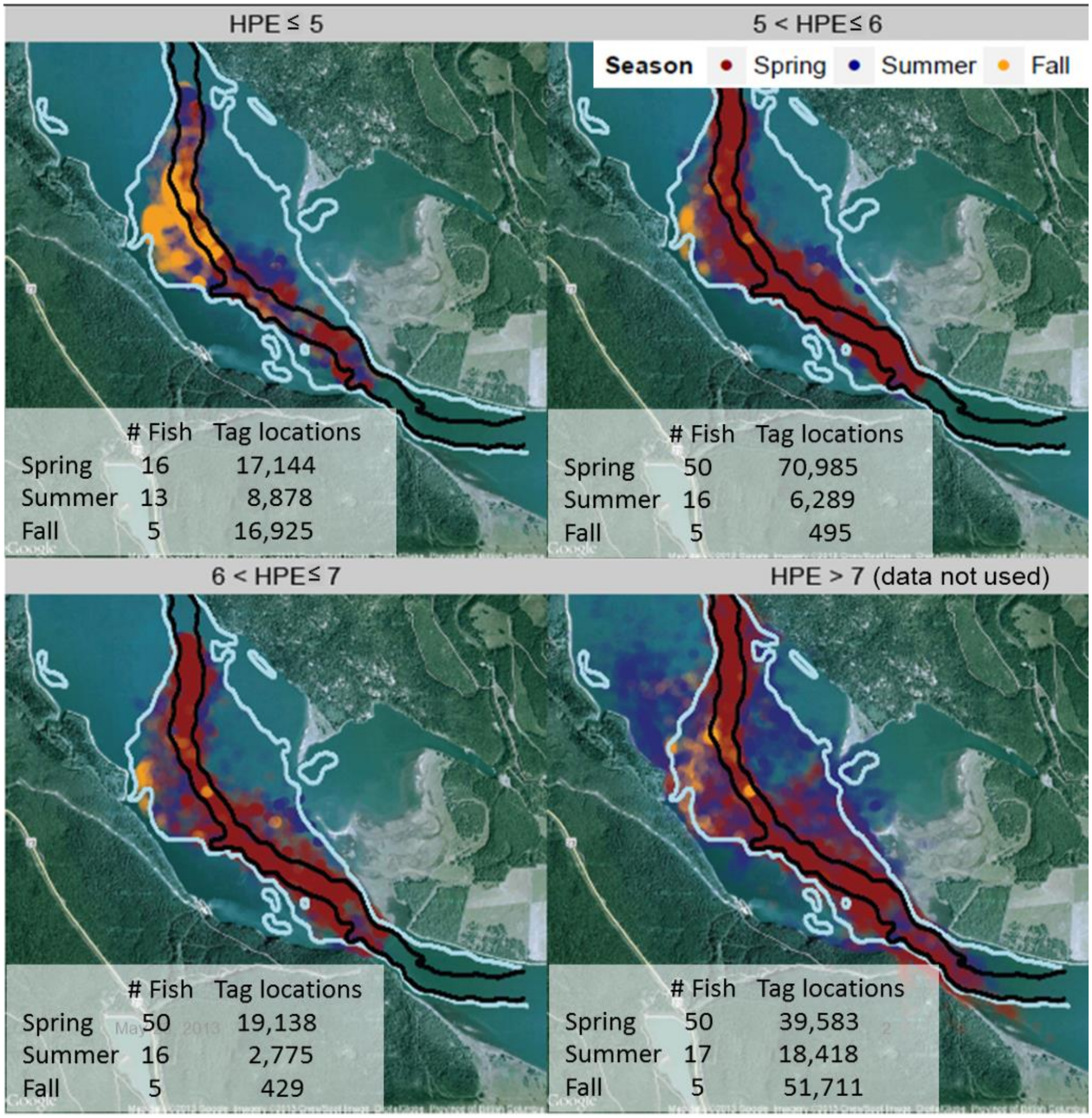


Figure 16: Minimum distance traveled between tag positions (m), separated by habitat classification (thalweg, floodplain or shallows), ALR elevation (low, moderate, and high), and ALR status (filling, full, emptying, and stable). Each box represents the 25th and 75th quantiles (bottom and top lines, respectively), and the median (middle, bold line); whiskers extend to 1.5 times the interquartile distance; outliers are shown as individual points.



HPE ≤ 5

|  | # Fish | Tag locations |
|---|---|---|
| Spring | 16 | 17,144 |
| Summer | 13 | 8,878 |
| Fall | 5 | 16,925 |

5 < HPE ≤ 6

|  | # Fish | Tag locations |
|---|---|---|
| Spring | 50 | 70,985 |
| Summer | 16 | 6,289 |
| Fall | 5 | 495 |

6 < HPE ≤ 7

|  | # Fish | Tag locations |
|---|---|---|
| Spring | 50 | 19,138 |
| Summer | 16 | 2,775 |
| Fall | 5 | 429 |

HPE > 7 (data not used)

|  | # Fish | Tag locations |
|---|---|---|
| Spring | 50 | 39,583 |
| Summer | 17 | 18,418 |
| Fall | 5 | 51,711 |

Figure 17: Positions of juvenile White Sturgeon within the VPS array. Panels show the positions included using various horizontal position cut-off (HPE) values (see Section 3.3.4.4). Point colour corresponds to season, and colour strength corresponds to use, with more solid colours representing heavier use. The thalweg is between the black lines, and floodplain is in between the black and light-blue lines. The number of fish and positions in each season within each HPE stratum are provided. Fish positions were plotted as partly transparent, to show differences between areas used rarely (transparent) and often (solid). Maps are based on Google Earth maps, taken Dec-31-2001, when ALR elevation at Nakusp was approximately 423 m. Only positions obtained from the third week post-release and onward are included. Figure from Golder and ONA 2013.

The extent of minimum daily movement (daily distance traveled by individual fish) varied by season and habitat type (Figure 18). In the spring, the majority of the recorded daily movement was less than 2 km, and 11 out of the 13 recorded fish remained in the thalweg. In the summer, the extent of fish movements increased, with daily movements up to 5 km; similar numbers of fish were recorded in the thalweg and the floodplain area, and 12 fish were recorded in the shallows, where they moved up to 2.5 km per day. In the fall, the patterns of movement appeared to be similar to those in the spring, although direct comparison was difficult due to the quickly decreasing sample size over time (only five juveniles were recorded in the thalweg in the fall).

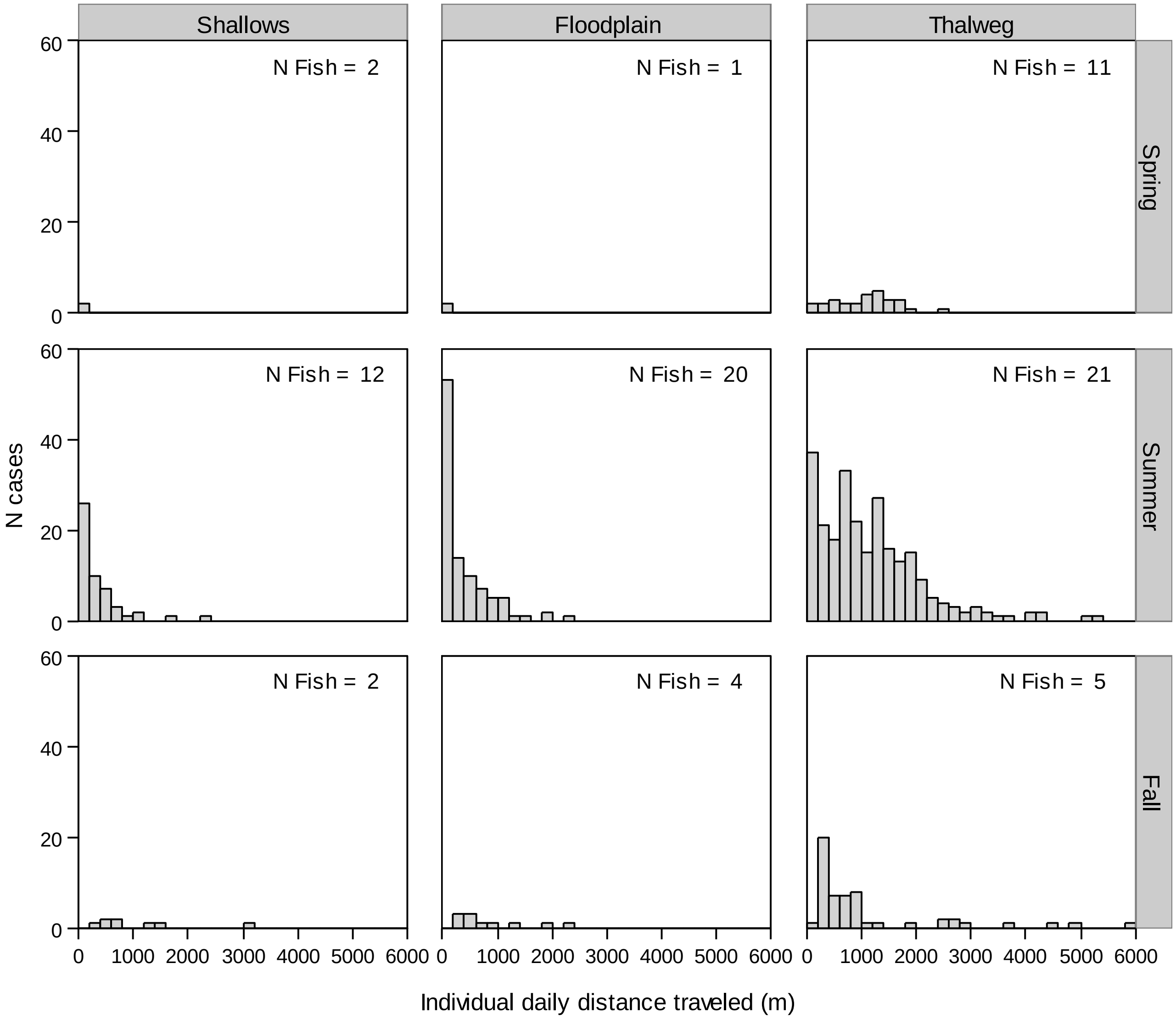


Figure 18: Histogram of minimum daily distances traveled by individual juvenile White Sturgeon, by season and habitat classification. (shallows, floodplain, or thalweg). The number of fish (N cases) within each stratum is provided; plots include only positions that were at most 0.5 h apart. Figure from Golder and ONA (2013).

The total movement (minimum distance travelled throughout study period) ranged between 117 m and 50 770 m (median = 13 849 m). The minimum distance travelled by the five White Sturgeon that remained in the VPS area throughout the entire study ranged from 4872 m (WSG25) to 44 816 m (WSG41).

The breakdown of movement by month, rather than season, indicated that the shift between spring and summer behaviours occurred in late June, since early-mid June was classified as spring, when fish exhibited the majority of movement in the thalweg (Figure 18), whereas the total distribution of June movements shows increased use of shallows and thalweg (Figure 19). A decrease in use of non-thalweg habitat occurred in October. In September, juvenile White Sturgeon traveled over 2,000 m in the floodplain and shallow areas compared to October when only two movements, both at or below 500 m, were observed (Figure 18). The shifts in behaviour in late June and (likely) early October suggest that the division by season used in this analysis is appropriate.

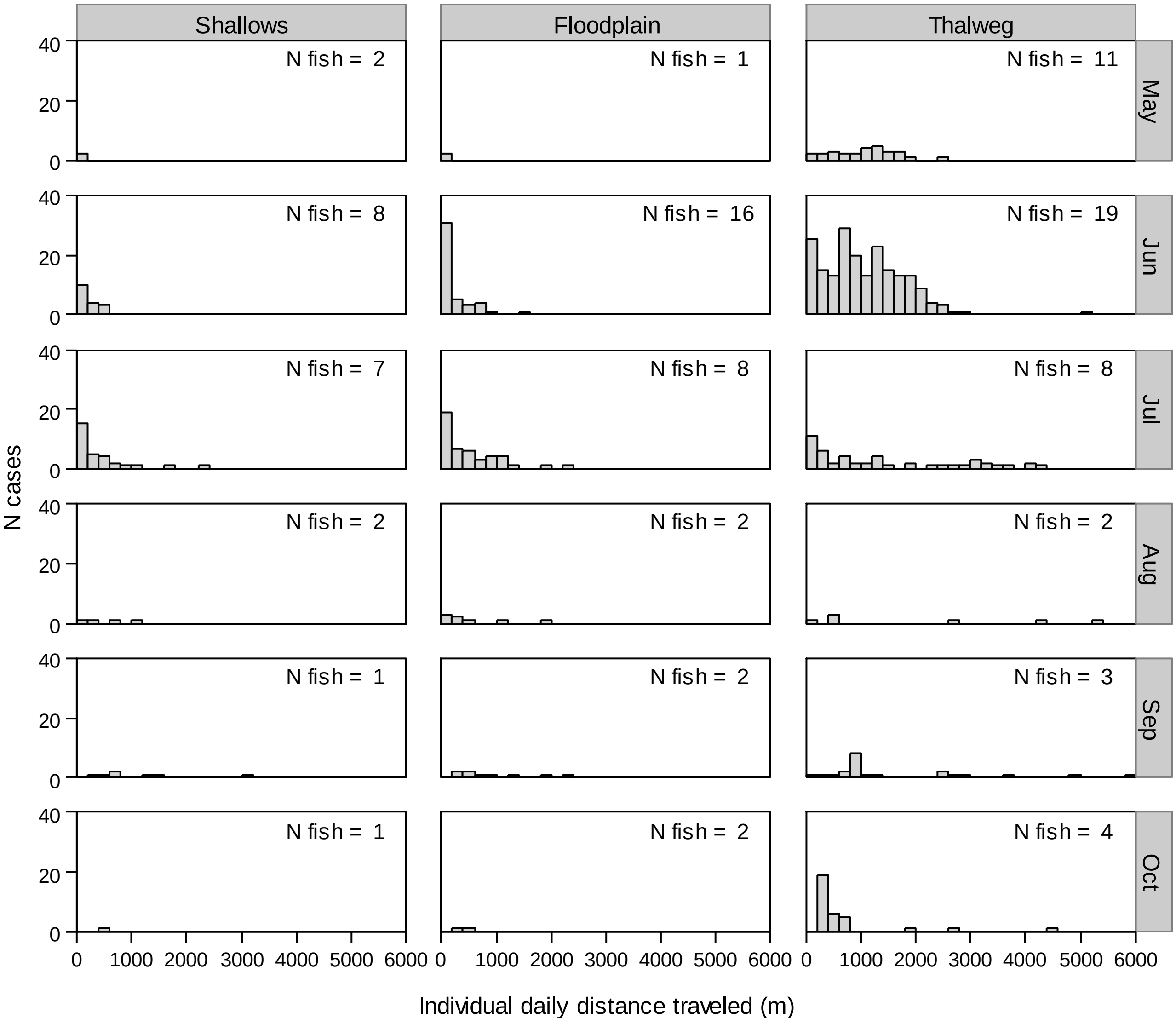


Figure 19: Histograms of daily distances traveled by individual juvenile White Sturgeon, classified by month (May to October) and habitat. The number of fish within each stratum is provided on each panel. Note that the period shown for May only includes May 29 - 31; plots include only positions that were at most 0.5 h apart. Figure from Golder and ONA 2013.

The division of time spent in different habitat classifications by month rather than by season provided similar findings (Figure 19). The shift from thalweg-only positions to use of floodplain and shallow habitats occurred in late June; throughout the summer, all three habitats were used, although juvenile White Sturgeon still spent the longest periods of time in the thalweg. In October, a shift from the floodplains and shallows to the thalweg occurred. Even though the number of fish observed in the array was similar between September and October, the amount of time spent in the shallows and floodplain decreased considerably, while the length of time spent in the thalweg increased (Figure 20). Based on a visual assessment of plotted data, there were no clear relationships between traveled distance or movement speed and REV discharge throughout the study period.

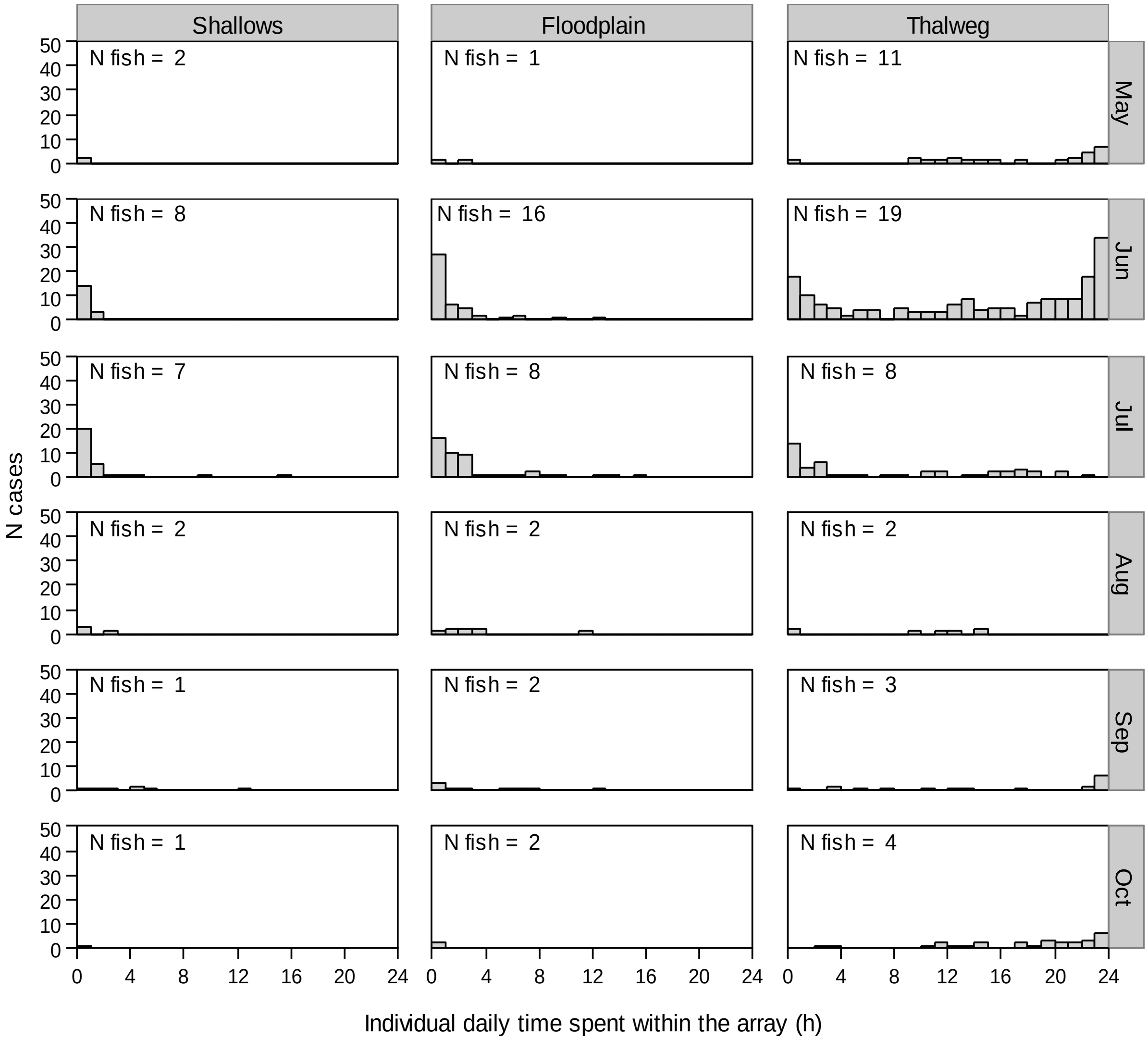


Figure 20: Histograms of daily lengths of time spent by individual juvenile White Sturgeon within each habitat classification in each month. The number of fish recorded within each stratum is provided within the panels. Note that the period shown for May only includes May 29 - 31; plots include only positions that were at most 0.5 h apart). Figure from Golder and ONA 2013.

### 3.3.11 Akolkolex Bay Use

Juvenile White Sturgeon were found in the Akolkolex Bay area more often in daytime than nighttime. The majority of the fish recorded near the mouth of the Akolkolex were categorized as fish that remained near the array, since the periods between tag locations were less than 0.5 h. A considerably lower number were categorized as fish that left or returned into the array area. The frequency of fish leaving the VPS array by the mouth of the Akolkolex ranged from 80 cases in springtime (52 daytime, 28 nighttime), and 75 cases in the fall (44 daytime, 31 nighttime). The frequency of return of fish into the array in the Akolkolex area was similar to the frequency of fish leaving the array (Golder and ONA 2013). Overall, the results indicate that juvenile White Sturgeon did not foray into the Akolkolex River bay very often, since the majority of fish remained within the VPS array. However, when fish did leave the array and enter the bay area, they were more likely to do so during daytime than nighttime.

## 3.4 Juvenile Sturgeon Capture Efforts to Estimate Growth and Survival

### 3.4.1 Capture Effort

Fishing effort increased for both gill nets and setlines over the nine years that fish sampling activities occurred (Table 14). For the first four years of the study, the fishing effort was focused at locations where acoustic-tagged fish were detected and in areas considered to have a high probability of encountering a Sturgeon (e.g., the channel thalweg, sandy flats) and areas where tagged Sturgeon were previously captured. Both full overnight (n = 52) and short duration night time (n = 64) gill nets were used in 2010. During 2014 to 2017, a GRTS stratified sampling design was introduced to ensure random coverage in the Revelstoke Reach and the upper ALR to determine if juvenile Sturgeon were using other habitat types and locations. Significantly more effort was allocated in these two years with the objective of capturing sufficient numbers of juvenile Sturgeon to determine growth and survival metrics. Even with this increased level of effort, very few juvenile Sturgeon were captured. Details on within-year gill netting and set lining activity are available in the CLBMON-21 annual report series. Details on 2017 fish sampling effort and results are located in Appendix A.

Table 14: Gill net and setline effort, number of juvenile White Sturgeon captured by each sample method and associated CPUE for the MCR from 2007 to 2017.

| Study Year | Gill Net Effort | | | Set Line Effort | | | Total WSG Catch | No. Re-captured |
|---|---|---|---|---|---|---|---|---|
| | Net Units[a] | No. WSG Captured | CPUE (WSG/Net Unit) | Hook Hours[b] | No. WSG Captured | CPUE (WSG/100 Hook Hours) | | |
| 2007 | 2.1 | 0 | 0 | 0.0 | - | - | 0 | - |
| 2008 | 22.3 | 4 | 0 | 0.0 | - | - | 4 | - |
| 2009 [c] | 36.3 | 2 | 0.1 | 1,085.0 | 0 | 0 | 2 | - |
| 2010 [c] | 72.5 | 4 | 0.06 | 14,101.0 | 0 | 0 | 4 | - |
| 2011 | No capture effort undertaken - Sonic tracking range testing | | | | | | | |
| 2012 | No capture effort undertaken - 2D sonic array tracking | | | | | | | |
| 2013 | 8.5 | 0 | 0.000 | 9,686.3 | 0 | 0.000 | 0 | - |
| 2014 [d] | 20.7 | 8 | 0.289 | 34,533.8 | 3 | 0.009 | 11 | - |
| 2015 | 49.1 | 1 | 0.020 | 66,534.4 | 0 | 0.000 | 1 | - |
| 2016 | 82.4 | 0 | 0.000 | 96,142.3 | 8 | 0.008 | 8 | - |
| 2017 | 59.1 | 3 | 0.051 | 101,656.6 | 5 | 0.005 | 7 | 1 |
| **Total** | **353** | **22** | **1** | **323,739** | **16** | **0** | **37** | **1** |

a Net units equal area of gill net fish divided by 100m$^2$ time the soak time divided by 24 hours

b Hook hours equal the number of hooks fishing on the set line divided by the soak time

c For 2009 and first half of 2010,setline hook sizes used were 12 & 10. All other years, hooks were size 7 & 6.

d Detailed gill net catch effort not found; CPUE based onprovided average soak times

During the initial years of the program, sampling was completed in the late summer and early fall. In Years 7 to 10 (2013 to 2016), sites were selected using the GRTS protocol and sampled over a three to four month period starting from the southern end of the study area and moving to the northern end over the study period. Year 10 (2016) also included setline sites in Beaton Arm. In Year 11 (2017), the sampling effort started at sites at the north end of the study area. Greenslide Creek down to Arrowhead were sampled in June to determine if juvenile Sturgeon were using this section of the Revelstoke Reach in late spring. The crew then moved south to the ALR Narrows (RKm 122) and sampled from south to north again, re-sampling the sites from Greenslide Creek to Arrowhead a second time in September (Appendix A). Most (79%) of juvenile White Sturgeon captures in the study area occurred in September (Table 15).

Table 15: Summary of juvenile White Sturgeon captured by year and by gear type in the MCR from 2007 to 2017. Grayed area indicates occurrence of sampling and the value indicates the number of juvenile White Sturgeon captured that week.

| **Month** | **Week** | **2007** | **2008** | **2009** | | **2010** | | **2011*** | **2012*** | **2013** | | **2014** | | **2015** | | **2016** | | **2017** | | **Total Sturgeon Captured** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Gill** | **Gill** | **Gill** | **Set** | **Gill** | **Set** | **none** | **none** | **Gill** | **Set** | **Gill** | **Set** | **Gill** | **Set** | **Gill** | **Set** | **Gill** | **Set** | |
| **June** | Week 1 | | | | | | | | | | | | | | | ▨ | ▨ | | | 0 |
| | Week 2 | | | | | | | | | | | | | | | | | ▨ | ▨ | 0 |
| | Week 3 | | | | | | | | | | | | | | | | | | | |
| | Week 4 | | | | | | | | | | | | | | | ▨ | ▨ | 1 | ▨ | 1 |
| **July** | Week 1 | | | | | | | | | | | | | | | | | | | |
| | Week 2 | | | | | | | | | | | | | | | ▨ | ▨ | ▨ | ▨ | 0 |
| | Week 3 | | | | | | | | | | | | | ▨ | ▨ | | | | | 0 |
| | Week 4 | | | | | | | | | | | ▨ | ▨ | | | | | ▨ | ▨ | 0 |
| **August** | Week 1 | | | | | | | | | | | | | | | ▨ | ▨ | | | 0 |
| | Week 2 | | | | | | | | | | | | | ▨ | ▨ | | | ▨ | ▨ | 0 |
| | Week 3 | | | ▨ | ▨ | | | | | | | 1 | ▨ | ▨ | ▨ | ▨ | ▨ | | | 1 |
| | Week 4 | | | 2 | ▨ | | | | | | | | | 1 | ▨ | | | ▨ | 3 | 6 |
| **September** | Week 1 | | | | | | | | | | | | | | | | | | | |
| | Week 2 | | 2 | ▨ | ▨ | ▨ | ▨ | | | | | | | ▨ | ▨ | ▨ | 4 | 2 | 2 | 10 |
| | Week 3 | | 2 | ▨ | | 1 | ▨ | | | | | 2 | 1 | | | | | ▨ | ▨ | 6 |
| | Week 4 | | ▨ | | | ▨ | ▨ | | | | | 2 | 1 | ▨ | ▨ | ▨ | 4 | | | 7 |
| **October** | Week 1 | ▨ | | | | 3 | ▨ | | | ▨ | ▨ | 1 | 1 | | | | | | | 4 |
| | Week 2 | | | | | | | | | | | 2 | 1 | | | | | | | 3 |
| | **TOTAL** | **0** | **4** | **2** | **0** | **4** | **0** | | | **0** | **0** | **8** | **4** | **1** | **0** | **0** | **8** | **3** | **5** | **38** |

* capture sessions were not conducted in 2011 and 2012

### 3.4.2 Juvenile White Sturgeon Captures

Over the eleven years of the program, no juvenile White Sturgeon were captured upstream of about RKm 214 (downstream of Begbie Creek;Table 16). Depending on the ALR elevation, the highest use area observed for juvenile White Sturgeon starts at approximately this RKm. The reservoir-river interface zone is typically around this area in September. The natural restriction of flow at RKm 201 likely creates its own backwater hydraulic effect in most years, and the sediments in this location are fine and water depth of the thalweg is 5 to 10 m deep. The river section with the largest number of captures was from 0.7 km upstream of Blanket Creek (RKm 209.7) to 0.6 km downstream of Greenslide Creek (RKm 205.6). The second highest number of captures was from Tree Island (RKm 201.8) to 0.6 km u/s Walter Hardman Generating Station (RKm 197.6). A map of capture locations can be found in Appendix B.

Table 16: Summary of location of sample sites and numbers of juvenile White Sturgeon captured by gear type and year, and by river section in the MCR during 2007 to 2017.

| **River Section Description** | **U/S Rkm** | **D/S Rkm** | **2007** | **2008** | **2009** | | **2010** | | **2011** | **2012** | **2013** | | **2014** | | **2015** | | **2016** | | **2017** | | **Total Sturgeon captured** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gill | Gill | Gill | Set | Gill | Set | none | none | Gill | Set | Gill | Set | Gill | Set | Gill | Set | Gill | Set | |
| 1 km d/s Hwy 1 bridge – Big Eddy | 228.3 | 226.1 | - | Y | Y | - | Y | Y | - | - | - | - | - | - | - | - | - | - | - | - | **0** |
| 1 km d/s Wells Cr. – 1 km d/s Hwy 1 bridge | 226 | 220 | - | Y | Y | - | Y | Y | - | - | - | - | - | - | - | - | - | - | - | - | **0** |
| 3.5 km d/s Begbie Creek – 1 km d/s Wells Creek | 219.9 | 214.1 | Y | Y | - | - | Y | Y | - | - | - | - | - | - | - | - | - | - | - | - | **0** |
| 0.8 km d/s Greenslide Creek – 3.5 km d/s Begbie Creek | 214 | 209.8 | Y | Y (3) | Y | - | Y (1) | Y | - | - | | - | Y | Y | Y | Y | Y | Y | Y | Y | **4** |
| 0.7 km u/s Blanket Creek – 0.8 km d/s Greenslide Creek | 209.7 | 205.6 | Y | Y (1) | Y | Y | Y (2) | Y | - | - | | - | Y( 2) | Y (2) | Y | Y | Y | Y (4) | Y | Y | **11** |
| 0.6 km u/s Walter Hardman – 0.7 km u/s Blanket Creek | 205.5 | 201.9 | Y | Y | Y (1) | Y | Y | Y | - | - | | - | Y | Y | Y | Y | Y | Y (2) | Y | Y (1) | **4** |
| Tree Island – 0.6 km u/s Walter Hardman | 201.8 | 197.6 | - | Y | Y | Y | Y | Y | - | - | | - | Y( 3) | Y | Y | Y | Y | Y (2) | Y | Y(3) | **8** |
| 1 km u/s Crawford Creek – Tree Island | 197.5 | 192.1 | - | - | Y (1) | Y | Y | Y | - | - | | - | Y( 2) | Y (1) | Y | Y | Y | Y | Y( 2)* | Y | **6** |
| 1.5 km d/s Wallis Creek – 1 km u/s Crawford Creek | 192 | 186.6 | - | Y | Y | Y | Y (1) | Y | - | - | | - | Y (1) | Y | Y | Y | Y | Y | Y | Y | **2** |
| Arrowhead – 1.5 km d/s Wallis Creek | 186.5 | 182.1 | - | Y | Y | Y | Y | Y | - | - | Y | - | Y | Y | Y | Y | Y | Y | Y | Y | **0** |
| Beaton Arm | | | - | - | Y | - | - | - | - | - | | - | | Y | - | - | Y | Y | - | - | **0** |
| Beaton flats | 182 | 179 | - | - | Y | Y | Y | Y | - | - | Y | - | Y | Y | Y | Y | Y | Y | Y | Y | **0** |
| Arrow Lake to Nakusp | 179 | 134 | - | - | - | - | - | - | - | - | Y | Y | Y | Y | Y (1) | Y | Y | Y | Y | Y | **1** |
| Nakusp to u/s of Arrow Lake Narrows | 133.9 | 119 | - | - | - | - | - | - | - | - | Y@ | Y | Y | Y | Y | Y | Y | Y | Y @ (1) | Y | **1** |
| Arrow Lake Narrows | 118.9 | 107 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | Y | Y | **0** |
| **Total Sturgeon Captured** | | | **-** | **4** | **2** | **0** | **4** | **0** | **-** | **-** | **0** | **0** | **8** | **3** | **1** | **0** | **0** | **8** | **3** | **5** | **38** |

| | |
|---|---|
| Y | gear set during night hours |
| Y | gear set during daylight hours |
| * | includes one sturgeon recaptured in same session |
| @ | gear had both day and overnight sets recorded |

### 3.4.3 Gear Efficacy Testing

Gear efficacy testing was conducted following the 2016 juvenile release at Shelter Bay. Gill nets set in daytime for four hours did not capture any juvenile White Sturgeon. Three unplanned overnight gillnets sets captured 16 juvenile White Sturgeon with no mortalities. This suggested juvenile Sturgeon movements increased during nighttime hours, a conclusion that was supported by movement data collected using the fine-scale array (Section 4.4.1), as well as captures from other unplanned overnight gill net sets. Setlines did not capture any White Sturgeon during the gear efficacy testing. White Sturgeon captured during the gear efficacy testing were not used in other analyses.

### 3.4.4 Growth and Condition

Length and weight measurements and growth calculations of all Sturgeon captured during Years 1 to11 (2007-2017) are shown in Table 18 for fish captured in the same year of release, and in Table 19 for fish captured at least one year following release.

Almost half (46%) of all juvenile Sturgeon recaptured from 2007 to 2017 had been released the same year of recapture (Table 17). Mean length and weight of juveniles at large for their first summer varied depending on size at release. For fish released at 10 months old, mean length was 32.9 cm ± 5.1 cm and mean weight was 0.22 kg ± 0.1 kg. These fish had a mean of growth of 5 cm FL and 40 g in weight, equating to 19.0% and 20.3% growth on their release length and weight, respectively, over the summer months (mean days at large = 141 days).

For those year classes of fish that had been released after 22 months in the hatchery, mean length was 41.6 cm ± 5.2 cm and mean weight was 0.45 kg ± 0.2 kg. On average, these larger fish grew 7.9 cm FL and 120 g in weight, or 27.6% and 69.7% of body length and weight, respectively, over the summer (mean days at large = 136 days; Table 18).

The smaller fish released at 10 months old averaged 41.6 cm FL and 510 g in weight when recaptured after one winter (1.39 years) at large (Table 18). This was similar to the 41.6 cm FL and 450 g size the larger 22-month-old fish attained in 0.38 years after their first summer at large (Table 17). Larger fish released at 22 months of age grew at a faster rate than 10-month-old fish in their first summer at large (Table 17).

Ten Sturgeon survived for at least two years at large (Table 18) ranging in age from 2.3 to 10.3 years at recapture. The largest fish was 86 cm FL and weighed 3.62 Kg. There were no captures from the 2010, 2016 and 2017 year classes during the entire program.

Table 17: Juvenile White Sturgeon captured the same year after release (<365 days at large) from 2007-2017 in the middle Columbia River.

| Capture ID | RKm | Year Class | Years at Large | Days at Large | Release Fork Length (cm) | Release Weight (kg) | Fork Length at Capture (cm) | Weight at Capture (kg) | Relative Weight (%) | Total Growth | | Percent Growth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Length (cm) | Weight (kg) | of Release Length (%) | of Release Weight (%) |
| 2008-1 | 207.4 | 2007 | 0.37 | 134 | 21.0 | 0.07 | 25.1 | 0.08 | 88.7 | 4.1 | 0.01 | 19.5 | 20.9 |
| 2008-2 | 210.2 | 2007 | 0.38 | 137 | 31.0 | 0.23 | 35.6 | 0.22 | 79.3 | 4.6 | 0.00 | 14.8 | -1.3 |
| 2009-1 | 192.5 | 2008 | 0.33 | 121 | 32.0 | 0.25 | 38.5 | 0.35 | 95.6 | 6.5 | 0.10 | 20.3 | 40.3 |
| 2010-3 | 206.4 | 2009 | 0.46 | 167 | 22.0 | 0.08 | 27.5 | 0.11 | 88.0 | 5.5 | 0.02 | 25.0 | 28.6 |
| 2014-6 | 207.7 | 2013 | 0.38 | 139 | 28.0 | 0.20 | 34.0 | 0.22 | 90.3 | 6.0 | 0.02 | 21.4 | 10.0 |
| 2014-7 | 208.5 | 2013 | 0.38 | 139 | 28.0 | 0.20 | 32.1 | 0.18 | 89.0 | 4.1 | -0.02 | 14.6 | -10.0 |
| 2014-8 | 207.5 | 2013 | 0.41 | 148 | 29.0 | 0.22 | 39.0 | 0.38 | 100.1 | 10.0 | 0.16 | 34.5 | 72.7 |
| 2014-9 | 208.0 | 2013 | 0.42 | 154 | 28.0 | 0.20 | 28.0 | 0.13 | 99.9 | 0.0 | -0.07 | 0.0 | -35.0 |
| 2014-10 | 206.0 | 2013 | 0.42 | 155 | 29.0 | 0.22 | 39.0 | 0.33 | 86.9 | 10.0 | 0.11 | 34.5 | 50.0 |
| 2015-1 | 177.8 | 2014 | 0.32 | 117 | 29.0 | 0.19 | 30.5 | 0.24 | 140.0 | 1.5 | 0.05 | 5.2 | 26.3 |
| **Average of 10 month old fish released** | | | **0.39** | **141.1** | **27.7** | **0.19** | **32.9** | **0.22** | **95.8** | **5.2** | **0.04** | **19.0** | **20.3** |
| **Standard Deviation** | | | | | **3.5** | **0.1** | **5.1** | **0.1** | **16.8** | **3.2** | **0.1** | **11.1** | **31.1** |
| 2016-1 | 205.5 | 2014 | 0.35 | 128 | 27.0 | 0.15 | 39.0 | 0.37 | 97.2 | 12.0 | 0.22 | 44.4 | 151.0 |
| 2016-4 | 195.5 | 2014 | 0.37 | 136 | 41.0 | 0.55 | 44.5 | 0.64 | 110.8 | 3.5 | 0.10 | 8.5 | 18.2 |
| 2016-5 | 205.5 | 2014 | 0.39 | 141 | 42.0 | 0.54 | 43.0 | 0.53 | 101.8 | 1.0 | -0.01 | 2.4 | -2.0 |
| 2016-6 | 205.5 | 2014 | 0.38 | 140 | 29.0 | 0.22 | 38.0 | 0.39 | 111.7 | 9.0 | 0.17 | 31.0 | 76.5 |
| 2016-7 | 201.5 | 2014 | 0.39 | 141 | 26.5 | 0.14 | 33.0 | 0.14 | 63.3 | 6.5 | 0.00 | 24.5 | 2.2 |
| 2016-8 | 202.6 | 2014 | 0.39 | 141 | 27.0 | 0.14 | 48.0 | 0.44 | 59.3 | 21.0 | 0.31 | 77.8 | 225.9 |
| 2017-3 | 192.8 | 2015 | 0.34 | 124 | 44.0 | 0.53 | 46.0 | 0.61 | 94.3 | 2.0 | 0.09 | 4.5 | 16.2 |
| **Average of 22 month old fish released** | | | **0.37** | **135.9** | **33.8** | **0.32** | **41.6** | **0.45** | **91.2** | **7.9** | **0.12** | **27.6** | **69.7** |
| **Standard Deviation** | | | | | **8.1** | **0.2** | **5.2** | **0.2** | **21.5** | **7.0** | **0.1** | | |

Table 18: Juvenile White Sturgeon captured over one year after release (>365 days at large) from 2007-2017 in the middle Columbia River.

| Capture ID | RKm | Year Class | Years at Large | Release Fork Length (cm) | Release Weight (kg) | Fork Length at Capture (cm) | Weight at Capture (kg) | Relative Weight (%) | Total Growth | | Growth/Year | | Percent Growth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Length (cm) | Weight (kg) | Length (cm) | Weight (kg) | of Release Length (%) | of Release Weight (%) |
| 2014-1 | 196.2 | 2012 | 1.28 | 30.0 | 0.22 | 41.0 | 0.43 | 96.38 | 11.0 | 0.21 | 8.6 | 0.16 | 36.7 | 95.5 |
| 2014-2 | 192.0 | 2012 | 1.36 | 31.0 | 0.21 | 36.0 | 0.29 | 98.96 | 5.0 | 0.08 | 3.7 | 0.06 | 16.1 | 38.1 |
| 2014-3 | 195.4 | 2012 | 1.37 | 29.0 | 0.18 | 44.5 | - | - | 15.5 | - | 11.3 | - | 53.4 | - |
| 2014-4 | 196.0 | 2012 | 1.37 | 30.0 | 0.20 | 41.5 | 0.52 | 112.08 | 11.5 | 0.34 | 8.4 | 0.25 | 38.3 | 170.0 |
| 2014-5 | 200.1 | 2012 | 1.37 | 28.0 | 0.17 | 36.8 | 0.30 | 95.36 | 8.8 | 0.13 | 6.4 | 0.09 | 31.4 | 76.5 |
| 2008-3 | 210.6 | 2006 | 1.38 | 19.0 | 0.04 | 26.8 | 0.11 | 100.09 | 7.8 | 0.07 | 5.6 | 0.05 | 41.1 | 169.0 |
| 2008-4 | 210.8 | 2006 | 1.38 | 18.0 | 0.04 | 25.3 | 0.08 | 80.02 | 7.3 | 0.03 | 5.3 | 0.02 | 40.6 | 74.4 |
| 2010-1 | 205.9 | 2008 | 1.40 | 34.0 | 0.25 | 54.0 | 0.89 | 81.45 | 20.0 | 0.63 | 14.3 | 0.45 | 58.8 | 249.8 |
| 2014-11 | 199.5 | 2012 | 1.42 | 29.0 | 0.18 | 46.5 | 0.63 | 94.01 | 17.5 | 0.45 | 12.3 | 0.31 | 60.3 | 250.0 |
| 2010-2 | 210.5 | 2008 | 1.45 | 25.0 | 0.12 | 42.6 | 0.43 | 85.56 | 17.6 | 0.31 | 12.1 | 0.22 | 70.4 | 263.0 |
| 2010-4 | 190.7 | 2008 | 1.46 | 41.0 | 0.39 | 62.3 | 1.42 | 82.50 | 21.3 | 1.03 | 14.6 | 0.70 | 52.0 | 263.0 |
| **Average of released 10 month old fish at large for 1 year** | | | **1.39** | **28.5** | **0.18** | **41.57** | **0.51** | **92.64** | **13.0** | **0.33** | **9.3** | **0.23** | **45.4** | **164.9** |
| **Standard Deviation** | | | | **6.4** | **0.1** | **10.7** | **0.4** | **10.2** | **5.6** | **0.3** | **3.8** | **0.2** | | |
| 2009-2 | 202.2 | 2006 | 2.31 | 19.0 | 0.04 | 38.0 | 0.28 | 79.08 | 19.0 | 0.24 | 8.2 | 0.10 | 100.0 | 645.9 |
| 2016-2 | 207.5 | 2013 | 2.36 | 29.0 | 0.22 | 40.5 | 0.38 | 88.62 | 11.5 | 0.16 | 4.9 | 0.07 | 39.7 | 73.5 |
| 2017-2 | 199.5 | 2013 | 3.34 | 28.0 | 0.20 | 55.0 | 1.04 | 90.20 | 27.0 | 0.84 | 8.1 | 0.25 | 96.4 | 417.4 |
| 2017-4 [a] | 192.8 | 2013 | 3.34 | - | - | 55.0 | 1.04 | 90.20 | - | - | - | - | - | - |
| 2016-3 | 195.5 | 2012 | 3.36 | 30.0 | 0.21 | 54.0 | 1.01 | 92.95 | 24.0 | 0.81 | 7.1 | 0.24 | 80.0 | 392.7 |
| 2017-5 | 193.0 | 2012 | 4.30 | 28.0 | 0.17 | 54.5 | 1.43 | 127.75 | 26.5 | 1.26 | 6.2 | 0.29 | 94.6 | 761.4 |
| 2017-8 | 200.7 | 2012 | 4.31 | 28.0 | 0.18 | 46.5 | 0.62 | 92.52 | 18.5 | 0.44 | 4.3 | 0.10 | 66.1 | 244.4 |
| 2017-7 | 205.8 | 2012 | 4.34 | 28.0 | 0.17 | 46.0 | 0.78 | 120.53 | 18.0 | 0.61 | 4.1 | 0.14 | 64.3 | 369.9 |
| 2017-1 | 124.1 | 2011 | 5.15 | 23.0 | 0.09 | 56.5 | 1.65 | 131.19 | 33.5 | 1.56 | 6.5 | 0.30 | 145.7 | 1796.6 |
| 2017-6 [b] | 199.4 | 2007 | 10.30 | 20.0 | 0.06 | 80.4 | 3.62 | 92.04 | 60.4 | 3.56 | 5.9 | 0.35 | 302.0 | 6035.6 |
| **Average of released 10 month old fish at large for over 2 years** | | | **4.05** | **24.4** | **0.15** | **48.23** | **1.06** | **92.33** | **23.4** | **0.92** | **6.2** | **0.21** | | |
| **Standard Deviation** | | | | **4.1** | **0.1** | **11.8** | **1.0** | **18.5** | **14.2** | **1.0** | **1.5** | **0.1** | | |

a Recapture of 2017-2

b PIT tag reader malfunction, scute removal pattern was used, average 2007 release length and weight used

Relative weights for juvenile White Sturgeon captured in the MCR ranged from 63.3% to 140.0% (Tables 18 and 19; Figure 21). The mean relative weight for all the MCR juvenile Sturgeon captured between 2007 and 2017 is 95.3% +/- 16.5% which is higher than the 85.7% +/- 7.4% reported in the first four years of sampling (Golder 2011). Relative weights after one summer at large for the 10-month-old fish averaged 95.8% +/- 16.8%, but for the 22-month-old fish the average was 91.2% +/- 21.5%. Although based on a much smaller sample size, relative weights of White Sturgeon juveniles in the MCR were higher than the 80 and 85% (depending on the year class) recorded for juvenile White Sturgeon in the Keenleyside Reach (BC Hydro 2017). White Sturgeon recapture in Lake Roosevelt Reach from 2003 to 2009 had relative weights of 104 % ± 24 for fish released in Washington and 107% ± 11% for fish released in BC but captured in Washington (Howell and McLellan 2013).

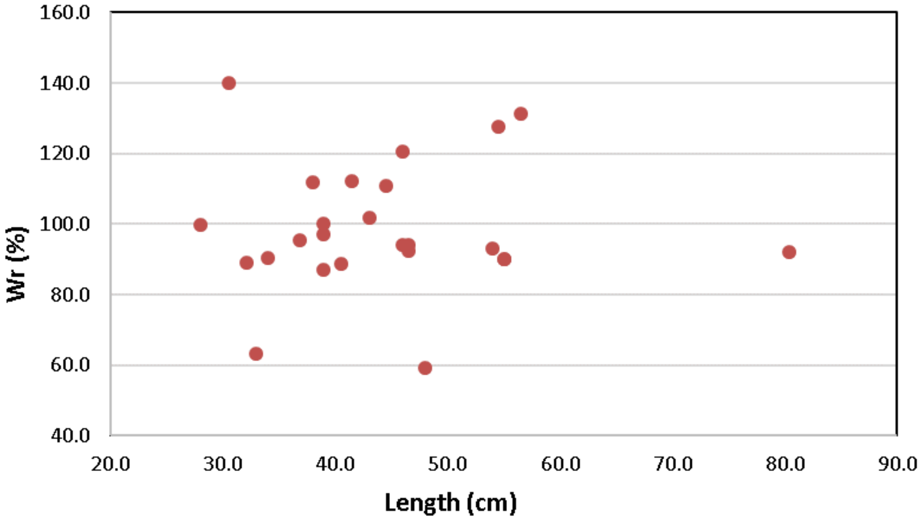


Figure 21: Plot of relative weight (Wr) for juvenile White Sturgeon captured in the MCR from 2007 to 2017 (n =36).

The MCR juvenile White Sturgeon population growth was best described using the equation (Figure 22):

$$W = 2.18e^{-6} * L^{3.277}$$

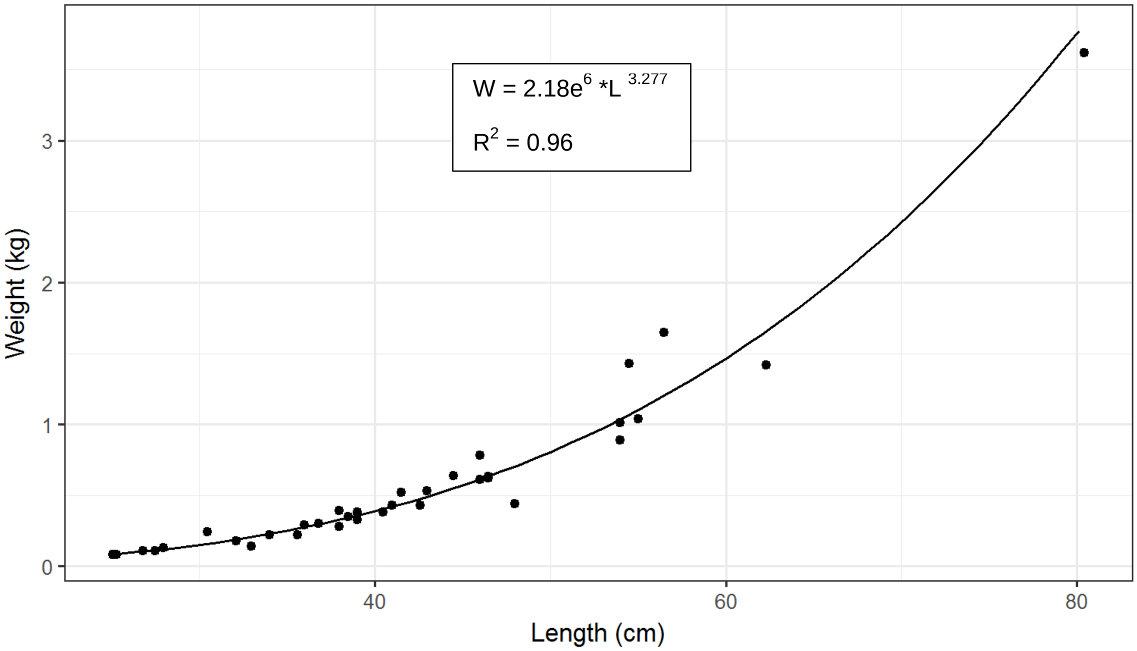


Figure 22: Length-weight regression of juvenile White Sturgeon captured in the MCR between 2007 and 2017 (n= 36).

### 3.4.5 Survival

Survival has not been estimated due to low recapture rates, which are attributed to a large study area and low capture efficiency. On average for all recaptured fish, total annual growth was 11.9 cm/year in length and 210 g/year in weight. This is comparable the juveniles released and recaptured in the Lower Columbia River juvenile sturgeon program. While most fish in the MCR have been captured in the same year they were released, one of the captured juveniles had survived to age-10. Additional capture data are required to adequately address the survival question.

### 3.4.6 Diet

Stomach contents were analyzed to determine juvenile White Sturgeon prey utilization in the MCR. Stomach contents in juvenile White Sturgeon sampled have remained similar between years. Samples from 2010, 2016, and 2017 were composed of:

- *Mysis relicta*, an introduced freshwater shrimp species;
- Chironomid midge larvae and,
- Unidentifiable fish (spinal column, flesh, and internal organs; skin and head not present).

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

The decapod *Mysis relicta* was abundant in some sections of the middle Columbia River study area (Beaton Flats and downstream of Walter Hardman) during underwater video surveys in 2009 (Golder 2010b). Mysids are a key component of the diet of juvenile White Sturgeon downstream of HLK (Golder 2009b) and based on the stomach contents of lavaged fish in 2016 and 2017, are an important food source to MCR fish as well.

### 3.4.7 Incidental Catch

Bycatch summaries for Years 1 to 10 of the program can be found in the CLBMON-21 annual report series. Data for Year 11 (2017) is provided in Appendix A. Generally, the most common bycatch species captured in gillnets were Mountain Whitefish, Peamouth Chub (*Mylocheilus caurinus*), Bull Trout, and Northern Pikeminnow (*Ptychocheilus oregonensis*).

Setline bycatch consisted mainly of Burbot; Burbot mortality on setlines was high due to the depth of setline sets and resultant swim bladder ruptures when the lines were retrieved. Fewer mortalities occurred when Burbot were captured in the shallower Revelstoke Reach. To reduce Burbot mortality, setlines in recent years were not set at depths greater than 25 m and were retrieved at a slow rate.

Boat electrofishing was conducted in the upper section of the MCR (from REV down to RKm 224) since 2001 for a different sampling program (CLBMON-16) and one juvenile Sturgeon (October 30, 2009 at Big Eddy; approx. 80 cm total length) and one adult Sturgeon (third week in September, 2001 at Revelstoke spawning area) were observed by the boat electrofishing crew (ONA and Golder 2017; MCR Fish Indexing Database).

## 3.5 Adult White Sturgeon Movement

### 3.5.1 Mobile Tracking

Acoustic mobile tracking surveys using a Sonotronics receiver were conducted to monitor spawning movements of acoustic-tagged adult White Sturgeon into the Revelstoke spawning area from below Revelstoke Dam to Big Eddy (2007 MCR juvenile White Sturgeon study, five times between August 16 and September 4 2007; Golder 2008). No adult White Sturgeon were detected during these mobile tacking surveys or by the VR2W array receivers located in the vicinity of the Revelstoke spawning area (Big Eddy and upstream). During 2008, none of the adult tags were detected within the ALR or Revelstoke Reach during the mobile tracking session (Golder 2009).

### 3.5.2 VR2W Linear Array Detection

Five of the six adult White Sturgeon equipped with Vemco coded pingers were detected by the VR2W array (Golder 2008). The furthest upstream detection of an acoustic-tagged adult in 2007 was at RKm 195.0 in August, but this fish subsequently moved back downstream to RKm 180 (Beaton Flats; Table 19). The acoustic-tagged adults did not display typical spawning movements and as such, the movements detected were likely feeding related. The lack of detections from January to March 2008 was believed to be due to issues with the VR2W stations moving un-expectantly from their original locations in the Beaton Flats area, as well as the general lack of movement exhibited by Sturgeon during the winter months. Most of these fish were captured and tagged in lower ALR in 2002 and 2003. The fish that were not detected during the present study may have moved back downstream to that area.

Table 19: Locations and number acoustic-tagged adult White Sturgeon detected in the MCR, April to December 2007. Table from Golder 2008.

| **VR2W Station Locations [a] (RKm)** | **Number of Adult White Sturgeon Detected/Month** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| **195.0** | | | | | 1 | | | | |
| **189.0** | | 1 | 1 | 1 | 1 | 1 | | | |
| **184.0** | | 1 | 2 | 1 | 3 | 1 | 2 | | |
| **Beaton Flats/ Arm Area** | 3 | 3 | 2 | 1 | 2 | 3 | 4 | 3 | 3 |

[a] See Golder 2008 for receiver locations; the 5 VR2Ws in the Beaton Flats and mouth of Beaton Arm area were combined in this table.

# 4.0 Discussion

## 4.1 Management Questions

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

While direct captures have been limited to date, the use of acoustic telemetry has been successful in describing habitat use of juvenile White Sturgeon in this program. The results of the CLBMON-21 program indicate that habitat preferences of juvenile White Sturgeon depend on the time of year, as there were defined seasonal differences in meso-habitat use and movements of juvenile White Sturgeon with telemetry tags within the MCR study area. During the spring, juvenile White Sturgeon were detected almost exclusively in the thalweg. During the summer months, juvenile White Sturgeon could be detected in all three meso-habitat areas available (thalweg, floodplain, and shallows), although habitat use was primarily in the thalweg and floodplain areas. In the fall, the greatest usage was again recorded in the thalweg, although limited use of the available floodplain also was observed.

The Beaton Flats area (RKm 180-182) had the highest use by acoustically tagged Sturgeon (by total tag days) in 2009; this may indicate ALR elevations of 434-436 masl may decrease available preferred habitats upstream. In contrast, juvenile Sturgeon showed increased use of areas near Mulvelhill Creek (RKm 207) during the higher ALR elevations in summer and fall of 2008, when surface elevations remained near 439 masl for an extended period. In 2007 and 2010, high use habitat was located between Blanket Creek (RKm 203.1) and Akolkolex River (RKm 200.0) when ALR elevations were approximately 436 to 438 masl. Using ALR elevations may help identify high use locations that can direct capture effort in the future.

The habitat use patterns observed generally corresponded to reservoir water elevation affecting river water depths as well as increases in water temperature. In the spring, floodplain and shallows habitats are limited in availability as the reservoir is low. As the reservoir fills in the late spring and early summer to peak levels, floodplain and shallows habitat increases in availability. ALR levels in the fall tend to be lower than in summer but higher than in spring and as such, floodplain and shallow habitats are still available in the fall. The low use of non-thalweg areas in the fall by juvenile White Sturgeon suggests other factors like temperature may affect habitat use in that period. Hrenchuk *et al.* (2017) observed a seasonal spatial shift in distribution by acoustic-tagged Lake Sturgeon juveniles that vacated the reservoir-river transition zone as winter progressed, moving further downstream and occasionally laterally into backwatered shallows, potentially avoiding extreme ice conditions. After ice break-up, most individuals with active tags returned to the upstream end of the reservoir. These results also suggested factors other than habitat suitability can influence Lake Sturgeon juvenile movement and utilization patterns, similar to what we observed in White Sturgeon.

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

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

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

Juvenile White Sturgeon prefer calm (<0.5 m/s), deep (>10 m) areas with fine substrates within the MCR. The shift from deeper thalweg-only to the use of floodplain and shallow habitats occurred in late June. During the summer months, all three habitats were used, although juvenile White Sturgeon spent the longest periods of time in the thalweg. In October, a shift from using the floodplains and shallows back to mainly using thalweg habitat occurred (Golder and ONA 2013). The timing of these movement patterns generally follows the spring increase and fall decrease in water surface elevations of ALR.

Several studies suggest that the assumption of juvenile White Sturgeon mostly occupying benthic habitats is reasonable. McLellan *et al.* (2011) found that depth measurements of tagged adult and juvenile White Sturgeon typically corresponded to the total depth at the location, which suggests the use of benthic habitat by White Sturgeon in the Lake Roosevelt Reservoir. Diet analyses of juvenile White Sturgeon in Lake Roosevelt showed a high proportion of benthic invertebrates, which also suggested benthic orientation of juveniles (Parsley *et al*. 2010). On the other hand, juvenile White Sturgeon in the ALR are known to forage on mysid shrimp that migrate vertically within the water column between day and night. This raises two possibilities: 1) that White Sturgeon juveniles may feed higher in the water column when foraging on mysids or 2) that mysid shrimp could have moved into shallower benthic areas during nighttime hours.

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

The program to date has not quantified the availability of meso-habitat that is preferred by juvenile White Sturgeon on in the MCR but given that juveniles are selecting calm (<0.5 m/s), deep (>10 m) areas with fine substrates within the MCR it is not expected that habitat is limiting. The dispersal analysis identified that juvenile White Sturgeon prefer lower sections of the MCR to the upper 25 km of river near the city of Revelstoke. This lower section of river that juvenile Sturgeon are using changes substantially over the year due to varying water surface elevations of ALR but is generally deeper with finer substrates and has available eddy habitat (slower water). Though since the transition of the release location to Shelter Bay (rkm 178) in 2011, juveniles now have immediate access to deep slow moving habitat that is not limiting throughout the year. Movements of juvenile White Sturgeon also change by season, with greater distances traveled between habitat types and at faster speeds in summer months compared to spring and fall months. These seasonal changes suggest juvenile White Sturgeon habitat preferences may change over the course of the year.

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

Overall, movements were not strongly associated with the filling/emptying status of the reservoir. Movements of juvenile White Sturgeon were not observed as being directly related to REV discharge. Results from the VPS telemetry array suggest that juvenile White Sturgeon used a wider range of depths, and made more frequent, longer, and faster movements in the summer than in spring and fall. Reasons for these seasonal differences are unknown but could be at least partly related to ALR elevations. ALR was filling during the spring, emptying in the fall, and transitioned from filling, to full (and stable), to emptying during the summer. Hence, ALR elevations were low during the spring, high in the summer, and intermediate in the fall. Thus, shorter spring movements were usually restricted to the thalweg and associated with low reservoir levels, whereas habitats in the floodplain and shallows were only used in the summer and fall, when reservoir levels were higher. Maximum depths in the floodplain (greater than 10 m) and shallows habitats (greater than 5 m) occurred only in the summer season, and were associated with the greatest use of these areas.

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

Juveniles typically selected downstream areas of the Revelstoke Reach study area in the vicinity of the river-reservoir transition zone where the effects of REV discharge fluctuations are attenuated by ALR elevations. White Sturgeon juveniles are also found at the transition zone in higher numbers in Lake Roosevelt Reach during sampling (Howell and McLellan 2013). Further work that summarizes key locations preferred by juvenile White Sturgeon at different ALR elevations could help understand how to target habitat restoration projects in the future.

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

Recapture rates of juveniles in the MCR have been low in all years of sampling (total captures = 38 of 61,237 released fish; 2007-2017) with one of these fish recaptured in the same session, and none recaptured in subsequent sampling events. The lack of recaptures precludes estimating survival at this point.

Juvenile White Sturgeon CPUEs in the MCR ranged from 0.0 to 0.29 fish/net-hour for gill nets and 0.0 to 0.01 fish/hook-hour for setlines. These rates are very low compared to capture rates recorded for similar juvenile White Sturgeon monitoring programs elsewhere in the Columbia drainage. For example, efforts in the Columbia River below HLK monitoring program using setlines have recorded CPUE values of 0.84 and 1.12 in 2011 and 2012, respectively (BC Hydro 2015). In the Kootenay River and Kootenay Lake in 2015, one-hour daytime gill net sets produced a CPUE of 3.1 Sturgeon/net-hour (Stephenson and Evans 2016).

Mean relative weight for all the MCR juvenile Sturgeon captured to date was 95.3% +/- 16.5%, which may indicate that growth is near normal for the survivors that were captured. This finding does not support a hypothesis that food resources are limiting growth and survival of juvenile Sturgeon in the MCR. The mean relative weights of juvenile Sturgeon in the Keenleyside Reach ($W_r$ = 86%; riverine habitat) were 9% lower than in the MCR ($W_r$ - 95%; reservoir habitat). This is similar to findings reported by Millar and Beckman (1992) who reported that juveniles in the reservoir upstream of Bonneville Dam had higher mean growth for the first 7 year classes than juveniles captured in the riverine section below Bonneville Dam.

The program has not yet recaptured any of the juveniles released at the 22-month-old larger size given that they have been released in recent years. The program has also not captured any fish that were released as either fed or unfed larval releases. Therefore, the effects of releasing early life-stage or larger juveniles on growth and survival cannot be determined at this time.

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

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

Based on juvenile captures and movements of acoustic-tagged individuals, juvenile White Sturgeon prefer the section of the MCR between Greenslide Creek to Shelter Bay and downstream. During very low ALR levels, this section of river can experience substantial daily fluctuations in water levels and velocities resulting from REV operations. However, based on the results of the last 11 years of sampling and research, juvenile White Sturgeon that reside in this area select deep, slow moving habitats associated with the thalweg of the Columbia River. These deep-water habitats are less prone to effects of REV discharge variations. Therefore, at present, there are no specific modifications to REV operations that could protect or enhance juvenile habitats.

Macro-habitat with similar depth, velocity, and substrate characteristics as that selected by the 37 juvenile White Sturgeon captured during this study program, is abundantly available in ALR throughout the year and in the MCR during periods of high ALR levels. Results of the first four years of study (2007 to 2010) indicated that juvenile White Sturgeon rarely use the riverine portion of the study area, where Revelstoke Dam and ALR operations have the greatest influence on habitat availability and suitability. Depths and velocities in the river/reservoir transition zone, where many juveniles have been recorded, would be influenced to a lesser degree, and this influence would decrease with increased downstream distance from Revelstoke Dam.

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# 5.0 Recommendations

Based on the results of the past 11 years of this study, our recommendations are:

- The primary uncertainty remaining in this program is survival of fish released from the conservation aquaculture program. Additional sampling is required to address this management question. Further, larger sizes at release have been tested over the course of the program, with the largest release sizes only occurring in recent years. Further monitoring is required to evaluate the effects of size at release on survival.
    - Further investigations of different set line bait types in select habitats to potentially increase the attraction (and capture) of juvenile White Sturgeon to the gear.
- The use of acoustic transmitters with a depth sensor function is recommended for future telemetry investigations in the study area. This would reduce uncertainty about depths and habitats used by juvenile White Sturgeon and better address the studies' management questions
- Develop an interactive platform using current 2D depth and velocity models, and substrate data to refine amount of suitable habitat and potentially locate preferred sites at different river flows over the entire study area. This would allow the combination of the key habitat metrics into a modeling tool to observe the interaction of different ALH and REV operations and their combined effects on specific locations in the Revelstoke Reach. This may identify other preferred habitat locations at different ALR elevations than have been sampled, would assist in determining targeted sampling locations, and help locate habitat restoration options.

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# Appendix A - 2017 Sample Data

# Gillnets

| Set # | Site | Location | | | Set Date | Set Time | Water Temp (°C) | Weather | Pull Date | Pull Time | Water Depth (m) | | Water Temp (°C) Day 2 | Orientation to Flow | Location in water Column | Soak Time (Hours) | Total # WSG | Gillnet Area ($m^2$) | Gillnet Hours | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Zone | Easting | Northing | | | | | | | Min | Max | | | | | | | | |
| 1 | G075B | 11 | 442200 | 5555856 | 6/27/2017 | 9:16 | 15.9 | sunny | 6/27/2017 | 13:07 | 14.5 | 15.3 | 19.2 | oblique | lower | 3.9 | 0 | 278.7 | 1073.0 | |
| 2 | G141B | 11 | 442750 | 5556733 | 6/27/2017 | 9:30 | 16.6 | sunny | 6/27/2017 | 13:15 | 18.8 | 18.8 | 19.4 | oblique | lower | 3.8 | 0 | 58.8 | 220.5 | |
| 3 | G123B | 11 | 442948 | 5557174 | 6/27/2017 | 9:40 | 16.8 | sunny | 6/27/2017 | 13:24 | 27.6 | 28.5 | 19.6 | oblique | lower | 3.7 | 0 | 278.7 | 1039.6 | |
| 4 | G037B | 11 | 441042 | 5557904 | 6/27/2017 | 9:55 | 14.2 | sunny | 6/27/2017 | 13:50 | 8.0 | 11.9 | 17.1 | parallel | lower | 3.9 | 0 | 84.7 | 332.0 | |
| 5 | G129B | 11 | 440950 | 5558797 | 6/27/2017 | 10:05 | 14.1 | sunny | 6/27/2017 | 14:00 | 15.2 | 17.7 | 16.9 | parallel | lower | 3.9 | 0 | 135 | 529.2 | |
| 6 | G005B | 11 | 441046 | 5559086 | 6/27/2017 | 10:15 | 14.0 | sunny | 6/27/2017 | 14:10 | 16.0 | 20.0 | 16.0 | parallel | lower | 3.9 | 0 | 278.7 | 1092.5 | |
| 7 | G103B | 11 | 443520 | 5559289 | 6/28/2017 | 8:46 | 17.3 | sunny | 6/29/2017 | 9:00 | 16.0 | 18.2 | 15.0 | parallel | lower | 24.2 | 0 | 278.7 | 6752.9 | Overnight GN* |
| 8 | G049B | 11 | 443584 | 5559504 | 6/28/2017 | 8:55 | 17.5 | sunny | 6/29/2017 | 9:25 | 18.7 | 22.1 | 15.3 | parallel | lower | 24.5 | 0 | 84.7 | 2075.2 | Overnight GN* |
| 9 | G021B | 11 | 443858 | 5560206 | 6/28/2017 | 9:05 | 17.5 | sunny | 6/29/2017 | 9:46 | 19.7 | 29.2 | 15.4 | parallel | lower | 24.7 | 0 | 278.7 | 6878.3 | Overnight GN* |
| 10 | G083B | 11 | 440947 | 5561168 | 6/28/2017 | 9:16 | 17.5 | sunny | 6/29/2017 | 10:30 | 10.4 | 12.3 | 15.0 | parallel | lower | 25.2 | 0 | 58.8 | 1483.5 | Overnight GN* |
| 11 | G033B | 11 | 440884 | 5561347 | 6/28/2017 | 9:26 | 17.1 | sunny | 6/29/2017 | 11:30 | 9.3 | 17.9 | 15.4 | oblique | lower | 26.1 | 1 | 135 | 3519.5 | Overnight GN* |
| 12 | G111B | 11 | 441015 | 5561902 | 6/28/2017 | 9:36 | 17.2 | sunny | 6/29/2017 | 11:50 | 19.2 | 27.8 | 15.1 | oblique | lower | 26.2 | 0 | 278.7 | 7310.3 | Overnight GN* |
| 13 | G017B | 11 | 443754 | 5563242 | 6/29/2017 | 10:04 | 15.2 | sunny | 6/29/2017 | 14:56 | 15.4 | 18.9 | 17.6 | oblique | lower | 4.9 | 0 | 278.7 | 1357.3 | |
| 14 | G143B | 11 | 443418 | 5563707 | 6/29/2017 | 10:10 | 15.1 | sunny | 6/29/2017 | 15:03 | 17.5 | 20.7 | 15.6 | parallel | lower | 4.9 | 0 | 84.7 | 413.3 | |
| 15 | G101B | 11 | 443443 | 5564086 | 6/29/2017 | 10:16 | 14.2 | sunny | 6/29/2017 | 15:20 | 9.0 | 12.0 | 15.9 | parallel | lower | 5.1 | 0 | 278.7 | 1413.0 | |
| 16 | G001B | 11 | 439831 | 5563937 | 6/29/2017 | 12:05 | 16.0 | sunny | 6/29/2017 | 15:30 | 12.8 | 18.0 | 17.0 | parallel | lower | 3.4 | 0 | 278.7 | 953.2 | |
| 17 | G137B | 11 | 439792 | 5564021 | 6/29/2017 | 12:10 | 16.4 | sunny | 6/29/2017 | 15:43 | 16.2 | 17.9 | 17.0 | oblique | lower | 3.6 | 0 | 135 | 479.3 | |
| 18 | G065B | 11 | 439673 | 5564118 | 6/29/2017 | 12:18 | 16.2 | sunny | 6/29/2017 | 15:55 | 13.0 | 16.0 | 17.3 | perpendicular | lower | 3.6 | 0 | 58.9 | 213.2 | |
| 19 | G065C | 11 | 441161 | 5565415 | 7/6/2017 | 9:12 | 19.2 | sunny | 7/6/2017 | 14:50 | 14.3 | 16.3 | 21.3 | oblique | lower | 5.6 | 0 | 278.7 | 1569.1 | |
| 20 | G002B | 11 | 441002 | 5565763 | 7/6/2017 | 9:21 | 19.5 | sunny | 7/6/2017 | 15:00 | 16.4 | 16.7 | 22.1 | perpendicular | lower | 5.7 | 0 | 58.8 | 332.2 | |
| 21 | G006B | 11 | 441212 | 5567172 | 7/6/2017 | 9:34 | 19.3 | sunny | 7/6/2017 | 15:16 | 16.4 | 19.5 | 22.2 | parallel | lower | 5.7 | 0 | 278.7 | 1588.6 | |
| 22 | G093B | 11 | 438336 | 5567258 | 7/6/2017 | 9:54 | 20.0 | sunny | 7/6/2017 | 15:36 | 12.0 | 16.2 | 23.8 | parallel | lower | 5.7 | 0 | 135 | 769.5 | |
| 23 | G104B | 11 | 438235 | 5568009 | 7/6/2017 | 10:04 | 19.9 | sunny | 7/6/2017 | 15:45 | 14.0 | 17.0 | 23.7 | parallel | lower | 5.7 | 0 | 84.7 | 481.1 | |
| 24 | G067B | 11 | 437951 | 5568496 | 7/6/2017 | 10:14 | 19.9 | sunny | 7/6/2017 | 15:50 | 10.0 | 17.0 | 23.8 | parallel | lower | 5.6 | 0 | 278.7 | 1560.7 | |
| 25 | G050B | 11 | 441059 | 5569628 | 7/7/2017 | 8:54 | 20.0 | sunny | 7/7/2017 | 14:06 | 16.4 | 19.5 | 22.7 | oblique | lower | 5.2 | 0 | 278.7 | 1449.2 | |
| 26 | G121B | 11 | 441091 | 5570271 | 7/7/2017 | 9:00 | 20.1 | sunny | 7/7/2017 | 14:11 | 9.4 | 16.4 | 22.8 | perpendicular | lower | 5.2 | 0 | 84.7 | 438.7 | |
| 27 | G034B | 11 | 440217 | 5571595 | 7/7/2017 | 9:13 | 19.6 | sunny | 7/7/2017 | 14:25 | 14.4 | 18.8 | 22.6 | parallel | lower | 5.2 | 0 | 278.7 | 1449.2 | |
| 28 | G112B | 11 | 437000 | 5570193 | 7/7/2017 | 9:24 | 21.6 | sunny | 7/7/2017 | 14:40 | 19.2 | 20.2 | 23.1 | parallel | lower | 5.3 | 0 | 58.8 | 309.9 | |
| 29 | G073B | 11 | 436623 | 5570612 | 7/7/2017 | 9:34 | 22.1 | sunny | 7/7/2017 | 14:54 | 11.1 | 14.0 | 23.3 | oblique | lower | 5.3 | 0 | 135 | 719.6 | |
| 30 | G018B | 11 | 436296 | 5571312 | 7/7/2017 | 9:44 | 22.2 | sunny | 7/7/2017 | 15:15 | 12.8 | 20.4 | 23.5 | parallel | lower | 5.5 | 0 | 278.7 | 1538.4 | |
| 31 | G045B | 11 | 438648 | 5573277 | 7/8/2017 | 9:15 | 18.3 | overcast | 7/8/2017 | 13:05 | 14.3 | 18.6 | 20.4 | oblique | lower | 3.8 | 0 | 278.7 | 1067.4 | |
| 32 | G029B | 11 | 438445 | 5573583 | 7/8/2017 | 9:21 | 18.0 | overcast | 7/8/2017 | 13:23 | 7.2 | 25.1 | 20.5 | parallel | lower | 4.0 | 0 | 84.7 | 341.3 | |
| 33 | G079B | 11 | 438230 | 5573911 | 7/8/2017 | 9:28 | 18.1 | overcast | 7/8/2017 | 13:32 | 6.9 | 28.0 | 20.8 | oblique | lower | 4.1 | 0 | 278.7 | 1134.3 | |
| 34 | G109B | 11 | 435209 | 5573186 | 7/8/2017 | 9:43 | 20.5 | overcast | 7/8/2017 | 13:45 | 10.6 | 16.8 | 21.9 | parallel | lower | 4.0 | 0 | 135 | 544.1 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35 | G013B | 11 | 435088 | 5573857 | 7/8/2017 | 9:51 | 21.1 | overcast | 7/8/2017 | 13:51 | 6.8 | 9.6 | 22.1 | parallel | lower | 4.0 | 0 | 58.8 | 235.2 | |
| 36 | G061B | 11 | 434803 | 5574066 | 7/8/2017 | 9:59 | 21.5 | overcast | 7/8/2017 | 14:00 | 5.4 | 8.9 | 22.6 | oblique | lower | 4.0 | 0 | 278.7 | 1120.4 | |
| 37 | G145B | 11 | 437479 | 5575951 | 7/9/2017 | 9:15 | 19.1 | overcast | 7/9/2017 | 14:06 | 14.9 | 18.4 | 21.7 | parallel | lower | 4.9 | 0 | 278.7 | 1351.7 | |
| 38 | G091B | 11 | 437014 | 5576535 | 7/9/2017 | 9:24 | 19.2 | overcast | 7/9/2017 | 14:27 | 15.8 | 17.6 | 21.8 | oblique | lower | 5.1 | 0 | 135 | 681.8 | |
| 39 | G057B | 11 | 436798 | 5576965 | 7/9/2017 | 9:33 | 19.4 | overcast | 7/9/2017 | 14:30 | 5.8 | 10.0 | 21.2 | parallel | lower | 5.0 | 0 | 278.7 | 1379.6 | |
| 40 | G147B | 11 | 433656 | 5575890 | 7/9/2017 | 9:47 | 20.2 | overcast | 7/9/2017 | 14:25 | 9.9 | 18.3 | 22.2 | overcast | lower | 4.6 | 0 | 84.7 | 392.2 | |
| 41 | G097B | 11 | 433680 | 5577667 | 7/9/2017 | 9:57 | 20.2 | overcast | 7/9/2017 | 13:06 | 13.2 | 17.0 | 22.2 | perpendicular | lower | 3.2 | 0 | 58.8 | 185.2 | |
| 42 | G131B | 11 | 433917 | 5577860 | 7/9/2017 | 10:07 | 20.3 | overcast | 7/9/2017 | 13:30 | 7.2 | 22.5 | 22.0 | overcast | lower | 3.4 | 0 | 278.7 | 942.0 | |
| 43 | G053B | 11 | 436358 | 5578333 | 7/10/2017 | 9:25 | 19.0 | sunny/windy | 7/10/2017 | 13:06 | 11.1 | 23.2 | 18.7 | oblique | lower | 3.7 | 0 | 278.7 | 1025.6 | |
| 44 | G009B | 11 | 436350 | 5578409 | 7/10/2017 | 9:30 | 18.9 | sunny/windy | 7/10/2017 | 13:13 | 20.1 | 26.4 | 18.8 | oblique | lower | 3.7 | 0 | 58.8 | 218.7 | |
| 45 | G069B | 11 | 433524 | 5579093 | 7/10/2017 | 9:45 | 20.8 | sunny/windy | 7/10/2017 | 13:24 | 7.1 | 15.6 | 20.5 | perpendicular | lower | 3.7 | 0 | 84.7 | 309.2 | |
| 46 | G139B | 11 | 433138 | 5579915 | 7/10/2017 | 9:56 | 21.1 | sunny/windy | 7/10/2017 | 13:35 | 7.8 | 18.0 | 21.7 | oblique | lower | 3.7 | 0 | 135 | 492.8 | |
| 47 | G087B | 11 | 433103 | 5580581 | 7/10/2017 | 10:13 | 21.1 | sunny/windy | 7/10/2017 | 13:55 | 10.0 | 12.0 | 20.3 | oblique | lower | 3.7 | 0 | 278.7 | 1031.2 | |
| 48 | G041B | 11 | 436532 | 5581532 | 7/19/2017 | 9:47 | 15.0 | sunny/smokey | 7/19/2017 | 13:23 | 16.0 | 20.0 | 14.7 | parallel | lower | 3.6 | 0 | 278.7 | 1003.3 | |
| 49 | G025B | 11 | 436503 | 5582132 | 7/19/2017 | 9:58 | 15.4 | sunny/smokey | 7/19/2017 | 13:30 | 19.0 | 20.3 | 15.2 | parallel | lower | 3.5 | 0 | 58.8 | 207.6 | |
| 50 | G117B | 11 | 436443 | 5583054 | 7/19/2017 | 10:13 | 15.9 | sunny/smokey | 7/19/2017 | 13:42 | 17.6 | 19.0 | 15.8 | parallel | lower | 3.5 | 0 | 278.7 | 969.9 | |
| 51 | G071B | 11 | 433940 | 5583497 | 7/19/2017 | 10:25 | 16.5 | sunny/smokey | 7/19/2017 | 14:06 | 2.9 | 14.9 | 17.2 | parallel | lower | 3.7 | 0 | 135 | 496.8 | |
| 52 | G030B | 11 | 433965 | 5583617 | 7/19/2017 | 10:34 | 16.5 | sunny/smokey | 7/19/2017 | 14:14 | 12.3 | 15.9 | 17.3 | parallel | lower | 3.7 | 0 | 84.7 | 310.8 | |
| 53 | G058B | 11 | 433931 | 5584042 | 7/19/2017 | 10:43 | 16.6 | sunny/smokey | 7/19/2017 | 14:25 | 6.9 | 12.4 | 17.4 | parallel | lower | 3.7 | 0 | 278.7 | 1031.2 | |
| 54 | G088B | 11 | 433351 | 5585962 | 7/20/2017 | 9:00 | 17.3 | overcast | 7/20/2017 | 13:13 | 5.9 | 8.9 | 17.0 | parallel | lower | 4.2 | 0 | 58.8 | 248.1 | |
| 55 | G014B | 11 | 436143 | 5585538 | 7/20/2017 | 9:19 | 14.8 | overcast | 7/20/2017 | 13:30 | 18.4 | 30.2 | 16.1 | parallel | lower | 4.2 | 0 | 278.7 | 1165.0 | |
| 56 | G135B | 11 | 436190 | 5585691 | 7/20/2017 | 9:26 | 14.6 | overcast | 7/20/2017 | 13:40 | 15.8 | 18.7 | 16.5 | parallel | lower | 4.2 | 0 | 135 | 571.1 | |
| 57 | G125B | 11 | 433550 | 5585600 | 7/20/2017 | 9:42 | 17.1 | overcast | 7/20/2017 | 13:06 | 16.8 | 54.2 | 17.1 | parallel | lower | 3.4 | 0 | 278.7 | 947.6 | |
| 58 | G077B | 11 | 432957 | 5586610 | 7/20/2017 | 10:00 | 16.8 | overcast | 7/20/2017 | 13:25 | 10.5 | 13.8 | 17.5 | parallel | lower | 3.4 | 0 | 278.7 | 953.2 | |
| 59 | G042B | 11 | 436347 | 5588053 | 7/21/2017 | 9:32 | 15.9 | sunny/windy | 7/21/2017 | 13:20 | 7.2 | 9.0 | 16.2 | perpendicular | lower | 3.8 | 0 | 278.7 | 1059.1 | |
| 60 | G054B | 11 | 435549 | 5588928 | 7/21/2017 | 9:43 | 15.7 | sunny | 7/21/2017 | 13:30 | 3.8 | 15.0 | 15.0 | parallel | lower | 3.8 | 0 | 135 | 510.3 | |
| 61 | G085B | 11 | 435215 | 5590069 | 7/21/2017 | 9:53 | 15.6 | sunny | 7/21/2017 | 13:38 | 11.4 | 15.6 | 15.5 | parallel | lower | 3.8 | 0 | 58.8 | 220.5 | |
| 62 | G022B | 11 | 432111 | 5590150 | 7/21/2017 | 10:05 | 15.3 | sunny/windy | 7/21/2017 | 13:56 | 16.5 | 20.4 | 15.4 | oblique | lower | 3.9 | 0 | 278.7 | 1073.0 | |
| 63 | G038B | 11 | 432283 | 5590833 | 7/21/2017 | 10:11 | 15.1 | sunny/windy | 7/21/2017 | 14:02 | 13.4 | 16.9 | 15.2 | parallel | lower | 3.9 | 0 | 84.7 | 326.1 | |
| 64 | G115B | 11 | 432161 | 5591370 | 7/21/2017 | 10:18 | 15.1 | sunny/windy | 7/21/2017 | 14:20 | 9.7 | 19.5 | 15.3 | parallel | lower | 4.0 | 0 | 278.7 | 1123.2 | |
| 65 | G107B | 11 | 435111 | 5591145 | 7/23/2017 | 9:31 | 14.1 | overcast | 7/23/2017 | 12:22 | 14.8 | 17.0 | 14.8 | parallel | lower | 2.9 | 0 | 278.7 | 794.3 | |
| 66 | G026B | 11 | 435180 | 5591545 | 7/23/2017 | 9:41 | 13.8 | overcast | 7/23/2017 | 12:37 | 10.1 | 17.8 | 16.0 | parallel | lower | 2.9 | 0 | 135 | 395.6 | |
| 67 | G010B | 11 | 435269 | 5591931 | 7/23/2017 | 9:57 | 13.6 | overcast | 7/23/2017 | 12:50 | 12.0 | 15.0 | 15.6 | parallel | lower | 2.9 | 0 | 278.7 | 802.7 | |
| 68 | G132B | 11 | 432207 | 5593749 | 7/23/2017 | 10:06 | 15.3 | overcast | 7/23/2017 | 13:00 | 12.8 | 17.5 | 15.9 | perpendicular | lower | 2.9 | 0 | 58.8 | 170.5 | |
| 69 | G095B | 11 | 432342 | 5594275 | 7/23/2017 | 10:15 | 15.2 | overcast | 7/23/2017 | 13:08 | 13.4 | 15.8 | 16.6 | parallel | lower | 2.9 | 0 | 84.7 | 243.9 | |
| 70 | G007B | 11 | 432341 | 5594698 | 7/23/2017 | 10:22 | 15.5 | overcast | 7/23/2017 | 13:18 | 4.0 | 9.0 | 16.2 | parallel | lower | 2.9 | 0 | 278.7 | 816.6 | |
| 71 | G105B | 11 | 435926 | 5595233 | 7/24/2017 | 9:37 | 10.1 | sunny | 7/24/2017 | 14:07 | 9.4 | 16.7 | 10.1 | parallel | lower | 4.5 | 0 | 278.7 | 1254.2 | |
| 72 | G130B | 11 | 435973 | 5595427 | 7/24/2017 | 9:42 | 10.1 | sunny | 7/24/2017 | 13:54 | 6.4 | 18.0 | 10.1 | parallel | lower | 4.2 | 0 | 84.7 | 355.7 | |
| 73 | G019B | 11 | 435889 | 5597150 | 7/24/2017 | 9:50 | 10.3 | sunny | 7/24/2017 | 13:32 | 6.6 | 11.8 | 10.0 | parallel | lower | 3.7 | 0 | 58.8 | 217.6 | |
| 74 | G051B | 11 | 432749 | 5597079 | 7/24/2017 | 9:59 | 11.0 | sunny | 7/24/2017 | 12:24 | 3.4 | 8.3 | 11.2 | parallel | lower | 2.4 | 0 | 278.7 | 674.5 | |
| 75 | G035B | 11 | 432824 | 5597842 | 7/24/2017 | 10:08 | 10.9 | sunny | 7/24/2017 | 12:40 | 8.6 | 12.8 | 11.3 | parallel | lower | 2.5 | 0 | 135 | 341.6 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76 | G113B | 11 | 432826 | 5598235 | 7/24/2017 | 10:14 | 10.9 | sunny/windy | 7/24/2017 | 12:52 | 8.0 | 10.4 | 11.4 | parallel | lower | 2.6 | 0 | 278.7 | 733.0 | |
| 77 | G084B | 11 | 435638 | 5598940 | 7/25/2017 | 10:34 | 11.0 | sunny | 7/25/2017 | 12:50 | 11.0 | 16.1 | 12.3 | parallel | lower | 2.3 | 0 | 278.7 | 632.6 | |
| 78 | G144B | 11 | 435696 | 5599075 | 7/25/2017 | 10:41 | 10.3 | sunny | 7/25/2017 | 12:54 | 10.1 | 11.1 | 12.7 | parallel | lower | 2.2 | 0 | 84.7 | 188.0 | |
| 79 | G149B | 11 | 435786 | 5599987 | 7/25/2017 | 10:54 | 10.3 | sunny | 7/25/2017 | 13:09 | 16.8 | 21.6 | 11.9 | parallel | lower | 2.3 | 0 | 278.7 | 627.1 | |
| 80 | G099B | 11 | 432587 | 5601122 | 7/25/2017 | 11:05 | 12.1 | sunny | 7/25/2017 | 13:28 | 9.5 | 15.9 | 13.0 | parallel | lower | 2.4 | 0 | 135 | 321.3 | |
| 81 | G003B | 11 | 432659 | 5602135 | 7/25/2017 | 11:11 | 12.4 | sunny | 7/25/2017 | 13:34 | 10.1 | 10.6 | 12.8 | parallel | lower | 2.4 | 0 | 58.8 | 139.9 | |
| 82 | G102B | 11 | 432621 | 5602340 | 7/25/2017 | 11:21 | 12.2 | sunny | 7/25/2017 | 13:40 | 11.2 | 12.7 | 14.5 | parallel | lower | 2.3 | 0 | 278.7 | 646.6 | |
| 83 | ALN01G | 11 | 439861 | 5552851 | 8/10/2017 | 9:06 | 19.8 | sunny/smokey | 8/10/2017 | 14:12 | 6.8 | 9.8 | 20.0 | oblique | lower | 5.1 | 0 | 135 | 688.5 | |
| 84 | ALN02G | 11 | 437887 | 5550717 | 8/10/2017 | 9:17 | 19.6 | sunny | 8/10/2017 | 13:56 | 12.5 | 14.1 | 19.8 | parallel | lower | 4.7 | 0 | 278.7 | 1296.0 | |
| 85 | ALN03G | 11 | 433770 | 5550535 | 8/10/2017 | 9:30 | 19.4 | sunny/smokey | 8/10/2017 | 13:25 | 6.3 | 11.8 | 19.3 | oblique | lower | 3.9 | 0 | 278.7 | 1092.5 | |
| 86 | ALN04G | 11 | 434545 | 5543587 | 8/11/2017 | 9:20 | 18.1 | sunny/smokey | 8/11/2017 | 12:02 | 16.3 | 17.9 | 19.2 | perpendicular | lower | 2.7 | 0 | 278.7 | 752.5 | |
| 87 | ALN05G | 11 | 434533 | 5542548 | 8/11/2017 | 9:32 | 18.1 | sunny/smokey | 8/11/2017 | 12:12 | 18.8 | 20.4 | 19.3 | perpendicular | lower | 2.7 | 0 | 135.0 | 360.5 | |
| 88 | ALN06G | 11 | 434458 | 5541037 | 8/11/2017 | 9:43 | 18.1 | sunny/smokey | 8/11/2017 | 12:26 | 2.4 | 9.2 | 19.3 | oblique | lower | 2.7 | 0 | 278.7 | 758.1 | |
| 89 | G062B | 11 | 435687 | 5602782 | 8/12/2017 | 9:54 | 19.5 | sunny/smokey | 8/12/2017 | 12:54 | 4.9 | 16.0 | 20.5 | parallel | lower | 3.0 | 0 | 278.7 | 836.1 | |
| 90 | G127B | 11 | 435671 | 5603138 | 8/12/2017 | 10:00 | 19.3 | sunny/smokey | 8/12/2017 | 12:59 | 12.0 | 14.2 | 20.5 | parallel | lower | 3.0 | 0 | 84.7 | 252.4 | |
| 91 | G046B | 11 | 435702 | 5603598 | 8/12/2017 | 10:06 | 19.2 | sunny/smokey | 8/12/2017 | 13:09 | 11.9 | 17.9 | 20.6 | parallel | lower | 3.1 | 0 | 278.7 | 850.0 | |
| 92 | G080B | 11 | 432995 | 5604325 | 8/12/2017 | 10:17 | 18.1 | sunny/smokey | 8/12/2017 | 13:20 | 12.0 | 14.4 | 20.3 | parallel | lower | 3.1 | 0 | 58.8 | 179.3 | |
| 93 | G119B | 11 | 432989 | 5604888 | 8/12/2017 | 10:30 | 18.0 | sunny/smokey | 8/12/2017 | 13:33 | 8.5 | 12.4 | 19.8 | oblique | lower | 3.1 | 0 | 135.0 | 411.8 | |
| 94 | G047B | 11 | 432882 | 5605362 | 8/12/2017 | 10:43 | 18.3 | sunny/smokey | 8/12/2017 | 13:46 | 7.0 | 9.5 | 20.6 | parallel | lower | 3.1 | 0 | 278.7 | 850.0 | |
| 95 | G081B | 11 | 435838 | 5605668 | 8/13/2017 | 9:24 | 17.5 | rain/overcast | 8/13/2017 | 14:13 | 12.0 | 14.1 | 17.7 | parallel | lower | 4.8 | 0 | 278.7 | 1343.3 | |
| 96 | G031B | 11 | 436116 | 5605899 | 8/13/2017 | 9:30 | 17.6 | rain | 8/13/2017 | 14:21 | 19.9 | 24.0 | 17.8 | parallel | lower | 4.9 | 0 | 58.8 | 285.2 | |
| 97 | G110B | 11 | 436493 | 5606065 | 8/13/2017 | 9:45 | 17.5 | rain | 8/13/2017 | 14:40 | 15.4 | 24.9 | 18.0 | parallel | lower | 4.9 | 0 | 278.7 | 1371.2 | |
| 98 | G070B | 11 | 433524 | 5608870 | 8/13/2017 | 9:56 | 15.5 | rain | 8/13/2017 | 14:55 | 8.4 | 14.7 | 17.2 | oblique | lower | 5.0 | 0 | 135.0 | 672.3 | |
| 99 | G011B | 11 | 433613 | 5609244 | 8/13/2017 | 10:06 | 15.2 | rain | 8/13/2017 | 15:07 | 9.5 | 12.1 | 15.9 | perpendicular | lower | 5.0 | 0 | 84.7 | 425.2 | |
| 100 | G055B | 11 | 433948 | 5609336 | 8/13/2017 | 10:15 | 15.2 | rain | 8/13/2017 | 15:15 | 5.2 | 17.3 | 16.1 | perpendicular | lower | 5.0 | 0 | 278.7 | 1393.5 | |
| 101 | G133B | 11 | 437251 | 5606454 | 8/14/2017 | 9:15 | 16.9 | overcast | 8/14/2017 | 13:46 | 10.9 | 36.4 | 17.3 | parallel | lower | 4.5 | 0 | 278.7 | 1259.7 | |
| 102 | G039B | 11 | 438510 | 5608206 | 8/14/2017 | 9:22 | 17.1 | overcast | 8/14/2017 | 13:55 | 6.0 | 9.9 | 17.3 | parallel | lower | 4.6 | 0 | 84.7 | 385.4 | |
| 103 | G142B | 11 | 438733 | 5609049 | 8/14/2017 | 9:31 | 17.4 | overcast | 8/14/2017 | 14:02 | 4.8 | 8.6 | 17.2 | parallel | lower | 4.5 | 0 | 278.7 | 1259.7 | |
| 104 | G124B | 11 | 434793 | 5610310 | 8/14/2017 | 9:42 | 15.4 | overcast | 8/14/2017 | 14:20 | 18.4 | 19.2 | 17.0 | perpendicular | lower | 4.6 | 0 | 135.0 | 625.1 | |
| 105 | G076B | 11 | 434184 | 5611044 | 8/14/2017 | 10:00 | 15.4 | overcast | 8/14/2017 | 14:32 | 5.8 | 11.8 | 16.8 | perpendicular | lower | 4.5 | 0 | 58.8 | 266.4 | |
| 106 | G023B | 11 | 434126 | 5611182 | 8/14/2017 | 10:07 | 15.8 | overcast | 8/14/2017 | 14:41 | 10.4 | 16.4 | 16.5 | parallel | lower | 4.6 | 0 | 278.7 | 1273.7 | |
| 107 | G015B | 11 | 439240 | 5610097 | 8/15/2017 | 9:24 | 16.4 | overcast/smokey | 8/15/2017 | 13:53 | 7.1 | 13.2 | 17.8 | perpendicular | lower | 4.5 | 0 | 278.7 | 1248.6 | |
| 108 | G148B | 11 | 439339 | 5610225 | 8/15/2017 | 9:30 | 16.5 | overcast/smokey | 8/15/2017 | 14:00 | 14.7 | 16.2 | 17.8 | perpendicular | lower | 4.5 | 0 | 84.7 | 381.2 | |
| 109 | G098B | 11 | 439434 | 5610509 | 8/15/2017 | 9:36 | 16.5 | overcast/smokey | 8/15/2017 | 14:17 | 12.0 | 18.1 | 17.8 | perpendicular | lower | 4.7 | 0 | 278.7 | 1304.3 | |
| 110 | G059B | 11 | 433972 | 5612446 | 8/15/2017 | 9:55 | 15.9 | overcast/smokey | 8/15/2017 | 14:36 | 16.7 | 17.6 | 18.0 | perpendicular | lower | 4.7 | 0 | 135.0 | 631.8 | |
| 111 | G027B | 11 | 434451 | 5613682 | 8/15/2017 | 10:05 | 16.4 | overcast/smokey | 8/15/2017 | 14:45 | 14.0 | 14.8 | 17.5 | perpendicular | lower | 4.7 | 0 | 84.7 | 395.5 | |
| 112 | G140B | 11 | 434153 | 5613997 | 8/15/2017 | 10:12 | 16.1 | overcast/smokey | 8/15/2017 | 15:00 | 14.2 | 14.8 | 18.1 | perpendicular | lower | 4.8 | 0 | 278.7 | 1337.8 | |
| 113 | G043B | 11 | 433228 | 5615293 | 8/16/2017 | 9:29 | 16.3 | sunny/smokey | 8/16/2017 | 13:11 | 12.3 | 12.5 | 17.0 | oblique | lower | 3.7 | 0 | 58.8 | 217.6 | |
| 114 | G118B | 11 | 434025 | 5614262 | 8/16/2017 | 9:20 | 16.2 | sunny/smokey | 8/16/2017 | 13:05 | 13.7 | 16.2 | 17.0 | perpendicular | lower | 3.8 | 0 | 278.7 | 1045.1 | |
| 115 | G089B | 11 | 432595 | 5615950 | 8/16/2017 | 9:35 | 16.2 | sunny/smokey | 8/16/2017 | 13:18 | 11.1 | 13.4 | 17.0 | perpendicular | lower | 3.7 | 0 | 278.7 | 1036.8 | |
| 116 | G092B | 11 | 432294 | 5616577 | 8/16/2017 | 9:40 | 16.2 | sunny/smokey | 8/16/2017 | 13:26 | 11.8 | 13.6 | 16.9 | perpendicular | lower | 3.8 | 0 | 135.0 | 509.0 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 117 | G063B | 11 | 431912 | 5617278 | 8/16/2017 | 9:47 | 16.1 | sunny/smokey | 8/16/2017 | 13:34 | 8.9 | 9.2 | 17.1 | perpendicular | lower | 3.8 | 0 | 84.7 | 320.2 | |
| 118 | G146B | 11 | 431800 | 5617657 | 8/16/2017 | 9:54 | 16.2 | sunny/smokey | 8/16/2017 | 13:43 | 8.4 | 9.8 | 17.6 | perpendicular | lower | 3.8 | 0 | 278.7 | 1064.6 | |
| 119 | G004B | 11 | 431735 | 5618219 | 8/23/2017 | 9:56 | 17.4 | sunny | 8/23/2017 | 13:07 | 9.6 | 9.8 | 18.9 | perpendicular | lower | 3.2 | 0 | 278.7 | 886.3 | |
| 120 | G138B | 11 | 431565 | 5618510 | 8/23/2017 | 10:02 | 17.3 | sunny | 8/23/2017 | 13:15 | 8.5 | 8.5 | 18.9 | perpendicular | lower | 3.2 | 0 | 58.8 | 189.3 | |
| 121 | G114B | 11 | 431764 | 5619371 | 8/23/2017 | 10:11 | 16.9 | sunny | 8/23/2017 | 13:30 | 11.8 | 17.3 | 18.9 | perpendicular | lower | 3.3 | 0 | 278.7 | 925.3 | |
| 122 | G036B | 11 | 431635 | 5619703 | 8/23/2017 | 10:18 | 17.2 | sunny | 8/23/2017 | 13:43 | 8.7 | 16.4 | 18.9 | perpendicular | lower | 3.4 | 0 | 135.0 | 461.7 | |
| 123 | G074B | 11 | 431410 | 5620306 | 8/23/2017 | 10:29 | 17.4 | sunny | 8/23/2017 | 13:50 | 15.3 | 15.7 | 19.2 | perpendicular | lower | 3.4 | 0 | 84.7 | 283.7 | |
| 124 | G066B | 11 | 431310 | 5620676 | 8/23/2017 | 10:37 | 16.2 | sunny | 8/23/2017 | 14:05 | 15.4 | 16.4 | 16.6 | perpendicular | lower | 3.5 | 0 | 278.7 | 967.1 | |
| 125 | G020B | 11 | 431174 | 5621114 | 8/24/2017 | 9:26 | 15.1 | overcast | 8/24/2017 | 13:36 | 15.3 | 17.8 | 15.6 | perpendicular | lower | 4.2 | 0 | 278.7 | 1162.2 | |
| 126 | G122B | 11 | 430746 | 5621819 | 8/24/2017 | 9:32 | 14.6 | overcast | 8/24/2017 | 13:45 | 17.1 | 18.6 | 16.3 | perpendicular | lower | 4.2 | 0 | 84.7 | 357.4 | |
| 127 | G052B | 11 | 430022 | 5623054 | 8/24/2017 | 9:40 | 11.8 | overcast | 8/24/2017 | 14:02 | 7.9 | 13.8 | 11.4 | perpendicular | lower | 4.4 | 0 | 278.7 | 1217.9 | |
| 128 | G094B | 11 | 429766 | 5623429 | 8/24/2017 | 9:47 | 11.4 | overcast | 8/24/2017 | 14:20 | 8.2 | 14.3 | 11.1 | perpendicular | lower | 4.6 | 0 | 135.0 | 614.3 | |
| 129 | G008B | 11 | 429719 | 5623421 | 8/24/2017 | 9:54 | 11.2 | overcast | 8/24/2017 | 14:24 | 13.4 | 13.5 | 11.0 | perpendicular | lower | 4.5 | 0 | 58.8 | 264.6 | |
| 130 | G068B | 11 | 429145 | 5624257 | 8/24/2017 | 10:03 | 11.3 | overcast | 8/24/2017 | 14:33 | 8.1 | 18.4 | 11.5 | perpendicular | lower | 4.5 | 0 | 278.7 | 1254.2 | |
| 131 | G086B | 11 | 429286 | 5624593 | 8/25/2017 | 9:48 | 11.0 | sunny/partly cloudy | 8/25/2017 | 13:42 | 16.8 | 17.3 | 10.7 | perpendicular | lower | 3.9 | 0 | 278.7 | 1086.9 | |
| 132 | G116B | 11 | 429208 | 5624936 | 8/25/2017 | 9:54 | 10.8 | overcast | 8/25/2017 | 13:48 | 7.4 | 17.6 | 10.7 | perpendicular | lower | 3.9 | 0 | 84.7 | 330.3 | |
| 133 | G040B | 11 | 429335 | 5625811 | 8/25/2017 | 10:05 | 10.6 | overcast | 8/25/2017 | 14:04 | 17.3 | 19.2 | 10.6 | perpendicular | lower | 4.0 | 0 | 278.7 | 1109.2 | |
| 134 | G106B | 11 | 429045 | 5626195 | 8/25/2017 | 10:14 | 10.7 | overcast | 8/25/2017 | 14:16 | 6.2 | 8.4 | 10.9 | oblique | lower | 4.0 | 0 | 135.0 | 544.1 | |
| 135 | G024B | 11 | 429138 | 5626953 | 8/25/2017 | 10:22 | 10.7 | overcast | 8/25/2017 | 14:28 | 10.5 | 16.0 | 10.9 | oblique | lower | 4.1 | 0 | 278.7 | 1142.7 | |
| 136 | G090B | 11 | 428973 | 5627539 | 8/26/2017 | 9:40 | 10.6 | sunny | 8/26/2017 | 13:47 | 17.4 | 18.0 | 11.1 | perpendicular | lower | 4.1 | 0 | 278.7 | 1148.2 | |
| 137 | G136B | 11 | 427769 | 5628927 | 8/26/2017 | 9:55 | 10.4 | sunny | 8/26/2017 | 14:05 | 14.0 | 14.6 | 11.0 | perpendicular | lower | 4.2 | 0 | 278.7 | 1162.2 | |
| 138 | G060B | 11 | 427448 | 5629078 | 8/26/2017 | 10:00 | 10.3 | sunny | 8/26/2017 | 14:15 | 13.4 | 16.1 | 10.7 | perpendicular | lower | 4.3 | 0 | 135.0 | 573.8 | |
| 139 | G096B | 11 | 427124 | 5629211 | 8/26/2017 | 10:10 | 10.4 | sunny | 8/26/2017 | 14:35 | 10.0 | 11.9 | 10.9 | perpendicular | lower | 4.4 | 0 | 278.7 | 1231.9 | |
| 140 | G126B | 11 | 428865 | 5628160 | 8/26/2017 | 9:46 | 10.4 | sunny | 8/26/2017 | 13:55 | 15.9 | 16.0 | 10.9 | perpendicular | lower | 4.2 | 0 | 84.7 | 351.5 | |
| 141 | G056B | 11 | 426346 | 5629571 | 8/27/2017 | 10:05 | 11.4 | sunny | 8/27/2017 | 14:44 | 13.6 | 14.2 | 14.2 | perpendicular | lower | 4.7 | 0 | 278.7 | 1296.0 | |
| 142 | G134B | 11 | 425859 | 5630339 | 8/27/2017 | 10:13 | 11.3 | sunny | 8/27/2017 | 14:52 | 10.1 | 11.8 | 13.9 | perpendicular | lower | 4.7 | 0 | 84.7 | 393.9 | |
| 143 | G012B | 11 | 425625 | 5630294 | 8/27/2017 | 10:20 | 11.2 | sunny | 8/27/2017 | 15:05 | 12.1 | 12.6 | 14.0 | perpendicular | lower | 4.8 | 0 | 278.7 | 1323.8 | |
| 144 | G108B | 11 | 425560 | 5630909 | 8/27/2017 | 10:29 | 11.2 | sunny | 8/27/2017 | 15:15 | 6.8 | 7.2 | 12.5 | perpendicular | lower | 4.8 | 0 | 120.8 | 576.2 | |
| 145 | G028B | 11 | 424943 | 5631855 | 8/27/2017 | 10:37 | 11.4 | sunny | 8/27/2017 | 15:33 | 6.4 | 6.8 | 12.6 | perpendicular | lower | 4.9 | 0 | 278.7 | 1374.0 | |
| 146 | G078B | 11 | 424642 | 5632658 | 8/28/2017 | 9:58 | 11.6 | sunny | 8/28/2017 | 13:45 | 8.8 | 9.3 | 12.9 | perpendicular | lower | 3.8 | 0 | 278.7 | 1053.5 | |
| 147 | G120B | 11 | 424112 | 5632850 | 8/28/2017 | 10:06 | 11.4 | sunny | 8/28/2017 | 13:55 | 11.7 | 12.8 | 13.0 | perpendicular | lower | 3.8 | 0 | 120.8 | 461.5 | |
| 148 | G082B | 11 | 424016 | 5633183 | 8/28/2017 | 10:12 | 11.5 | sunny | 8/28/2017 | 14:10 | 7.3 | 9.2 | 11.9 | perpendicular | lower | 4.0 | 0 | 278.7 | 1106.4 | |
| 149 | G048B | 11 | 423470 | 5633617 | 8/29/2017 | 10:00 | 11.4 | sunny/smokey | 8/29/2017 | 13:13 | 7.2 | 10.0 | 10.7 | parallel | lower | 3.2 | 0 | 278.7 | 897.4 | |
| 150 | G100B | 11 | 423229 | 5633902 | 8/29/2017 | 10:06 | 11.6 | sunny/smokey | 8/29/2017 | 13:25 | 5.3 | 6.6 | 10.8 | perpendicular | lower | 3.3 | 0 | 120.8 | 401.1 | |
| 151 | G150B | 11 | 422456 | 5633810 | 8/29/2017 | 10:15 | 10.6 | sunny/smokey | 8/29/2017 | 13:44 | 11.9 | 16.2 | 10.8 | perpendicular | lower | 3.5 | 0 | 278.7 | 969.9 | |
| 152 | GA1 | 11 | 429326 | 5624567 | 9/7/2017 | 9:36 | 12.4 | Sunny/Smokey | 9/7/2017 | 13:47 | 15.0 | 15.6 | 12.2 | oblique | lower | 4.2 | 2 | 135.0 | 564.3 | |
| 153 | GA2 | 11 | 428963 | 5624750 | 9/7/2017 | 9:46 | 12.2 | Sunny/Smokey | 9/7/2017 | 14:00 | 4.2 | 6.8 | 11.8 | oblique | lower | 4.2 | 0 | 278.7 | 1178.9 | |
| 154 | GA3 | 11 | 429251 | 5624401 | 9/12/2017 | 9:35 | 11.5 | partly cloudy | 9/12/2017 | 12:45 | 14.8 | 15.6 | 9.7 | perpendicular | lower | 3.2 | 0 | 278.7 | 883.5 | |
| 155 | GA4 | 11 | 429220 | 5624620 | 9/12/2017 | 9:40 | 10.8 | partly cloudy | 9/12/2017 | 12:38 | 15.1 | 16.7 | 9.7 | perpendicular | lower | 3.0 | 0 | 135.0 | 401.0 | |

# Gillnet Bycatch

| Date | Site | Set | Species | Life Stage | Quantity | Live | Dead | Mortality Rate % | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 6/27/2017 | G129B | 5 | BT | A | 1 | 1 | 0 | 0.00 | 360mm - DNA, parsite on left pectoral fin |
| 6/27/2017 | G129B | 5 | MW | A | 2 | 2 | 0 | 0.00 | 235mm, one released before in boat |
| 6/29/2017 | G103B | 7 | BT | A | 3 | 2 | 1 | 0.33 | 330mm,285mm,320mm (dead) |
| 6/29/2017 | G049B | 8 | BT | A | 1 | 0 | 1 | 1.00 | 310mm |
| 6/29/2017 | G049B | 8 | KO | J | 1 | 0 | 1 | 1.00 | 235mm |
| 6/29/2017 | G049B | 8 | Peamouth | A | 3 | 0 | 3 | 1.00 | 235mm,255mm,270mm |
| 6/29/2017 | G021B | 9 | BT | J | 1 | 1 | 0 | 0.00 | 290mm |
| 6/29/2017 | G083B | 10 | BT | J | 1 | 0 | 1 | 1.00 | 255mm |
| 6/29/2017 | G083B | 10 | NSC | A | 1 | 1 | 0 | 0.00 | 290mm |
| 6/29/2017 | G033B | 11 | BB | A | 1 | 1 | 0 | 0.00 | 280mm |
| 6/29/2017 | G033B | 11 | BT | A | 6 | 1 | 5 | 0.83 | 505mm,310mm,270mm,375mm,275mm,360mm,230mm |
| 6/29/2017 | G033B | 11 | CSU | A | 1 | 1 | 0 | 0.00 | 275mm |
| 6/29/2017 | G033B | 11 | KO | J | 2 | 0 | 2 | 1.00 | 225mm,210mm |
| 6/29/2017 | G033B | 11 | LSU | A | 3 | 2 | 1 | 0.33 | 250mm,330mm,NR |
| 6/29/2017 | G033B | 11 | LW | A | 4 | 2 | 2 | 0.50 | 250mm,570mm,240mm,225mm |
| 6/29/2017 | G033B | 11 | MW | A | 16 | 0 | 16 | 1.00 | 250mm,240mm,290mm,290mm,260mm,270mm,365mm,270mm,340mm,230mm,260mm,220mm (half digested), 255mm,260mm,300mm |
| 6/29/2017 | G033B | 11 | NSC | A | 1 | 1 | 0 | 0.00 | 270mm |
| 6/29/2017 | G033B | 11 | Peamouth | J | 2 | 0 | 2 | 1.00 | 240mm,240mm |
| 6/29/2017 | G033B | 11 | Peamouth | A | 7 | 0 | 7 | 1.00 | 255mm,230mm,230mm,250mm,245mm,240mm,210mm |
| 6/29/2017 | G111B | 12 | BT | A | 2 | 2 | 0 | 0.00 | 315mm, 295mm |
| 6/29/2017 | G017B | 13 | BT | A | 2 | 1 | 1 | 0.50 | 430mm, 365mm |
| 6/29/2017 | G017B | 13 | Peamouth | A | 1 | 1 | 0 | 0.00 | N/R |
| 6/29/2017 | G101B | 15 | BT | A | 1 | 0 | 1 | 1.00 | 365mm |
| 6/29/2017 | G101B | 15 | Peamouth | A | 1 | 1 | 0 | 0.00 | 285mm |
| 6/29/2017 | G001B | 16 | Peamouth | A | 3 | 2 | 1 | 0.33 | 260mm, 255mm, 285mm |
| 6/29/2017 | G137B | 17 | Peamouth | A | 1 | 1 | 0 | 0.00 | 230mm |

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|---|---|---|---|---|---|---|---|---|---|
| 7/6/2017 | G065C | 19 | KO | A | 2 | 2 | 0 | 0.00 | 245, 235mm |
| 7/6/2017 | G065C | 19 | MW | A | 1 | 1 | 0 | 0.00 | 265mm |
| 7/6/2017 | G002B | 20 | MW | A | 1 | 0 | 1 | 1.00 | 285mm (DOA) |
| 7/6/2017 | G093B | 22 | BT | A | 1 | 1 | 0 | 0.00 | 325mm |
| 7/6/2017 | G067B | 24 | BT | A | 1 | 0 | 1 | 1.00 | 370mm |
| 7/6/2017 | G067B | 24 | MW | A | 2 | 0 | 2 | 1.00 | 290, 300mm |
| 7/6/2017 | G067B | 24 | RB | A | 1 | 1 | 0 | 0.00 | 320mm |
| 7/7/2017 | G050B | 25 | LW | A | 2 | 2 | 0 | 0.00 | 290, 240mm |
| 7/7/2017 | G050B | 25 | MW | A | 3 | 3 | 0 | 0.00 | 265, 295, 295mm |
| 7/7/2017 | G034B | 27 | BT | A | 1 | 1 | 0 | 0.00 | 350mm |
| 7/7/2017 | G073B | 29 | MW | A | 1 | 1 | 0 | 0.00 | 225mm |
| 7/7/2017 | G018B | 30 | BT | J | 1 | 1 | 0 | 0.00 | 280mm |
| 7/7/2017 | G018B | 30 | MW | A | 1 | 0 | 1 | 1.00 | 290mm |
| 7/8/2017 | G045B | 31 | BT | A | 1 | 0 | 1 | 1.00 | 370mm |
| 7/8/2017 | G045B | 31 | MW | A | 1 | 1 | 0 | 0.00 | 310mm |
| 7/8/2017 | G029B | 32 | BT | A | 1 | 0 | 1 | 1.00 | 350mm |
| 7/8/2017 | G079B | 33 | MW | A | 1 | 1 | 0 | 0.00 | 270mm |
| 7/8/2017 | G109B | 34 | MW | A | 1 | 1 | 0 | 0.00 | 350mm |
| 7/8/2017 | G061B | 36 | MW | A | 1 | 1 | 0 | 0.00 | 250mm |
| 7/9/2017 | G145B | 37 | BT | A | 1 | 1 | 0 | 0.00 | 350mm |
| 7/9/2017 | G145B | 37 | MW | A | 1 | 1 | 0 | 0.00 | escaped |
| 7/9/2017 | G091B | 38 | BT | A | 2 | 0 | 2 | 1.00 | 420, 285mm |
| 7/9/2017 | G057B | 39 | MW | A | 1 | 1 | 0 | 0.00 | 235mm |
| 7/9/2017 | G057B | 39 | Peamouth | A | 1 | 1 | 0 | 0.00 | 275mm |
| 7/9/2017 | G057B | 39 | RB | A | 9 | 9 | 0 | 0.00 | 340, 305, 320, 315, 295, 300, 315mm |
| 7/9/2017 | G131B | 42 | BT | A | 4 | 3 | 1 | 0.25 | 350, 350, 290, 295mm |
| 7/9/2017 | G131B | 42 | MW | A | 3 | 2 | 1 | 0.33 | 280, 260, 285mm |
| 7/10/2017 | G053B | 43 | KO | A | 4 | 4 | 0 | 0.00 | 220, Escaped, 215, 225mm |
| 7/10/2017 | G139B | 46 | BT | A | 1 | 1 | 0 | 0.00 | 420mm |

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|---|---|---|---|---|---|---|---|---|---|
| 7/10/2017 | G139B | 46 | MW | A | 6 | 6 | 0 | 0.00 | 265, 235, 240, 230, 240, 230mm |
| 7/19/2017 | G041B | 48 | BT | A | 1 | 1 | 0 | 0.00 | 310mm |
| 7/19/2017 | G117B | 50 | Peamouth | A | 2 | 2 | 0 | 0.00 | 265, 280mm |
| 7/19/2017 | G071B | 51 | BT | A | 2 | 2 | 0 | 0.00 | 345, 260mm had MW in its mouth |
| 7/19/2017 | G071B | 51 | MW | A | 1 | 0 | 0 | 0.00 | 230mm |
| 7/19/2017 | G071B | 51 | NSC | A | 4 | 2 | 2 | 0.50 | 280, 275, 310, 250mm |
| 7/19/2017 | G058B | 53 | MW | A | 1 | 1 | 0 | 0.00 | 260mm |
| 7/20/2017 | G014B | 55 | BT | A | 2 | 2 | 0 | 0.00 | 285, 295mm |
| 7/20/2017 | G014B | 55 | MW | A | 3 | 3 | 0 | 0.00 | 330, 250mm, escaped |
| 7/20/2017 | G135B | 56 | NSC | A | 1 | 1 | 0 | 0.00 | 240mm |
| 7/20/2017 | G077B | 58 | MW | A | 2 | 2 | 0 | 0.00 | 305, 270mm |
| 7/21/2017 | G042B | 59 | LW | A | 1 | 1 | 0 | 0.00 | 250mm |
| 7/21/2017 | G042B | 59 | MW | A | 3 | 3 | 0 | 0.00 | 305, 270, 275mm |
| 7/21/2017 | G054B | 60 | BT | A | 1 | 1 | 0 | 0.00 | large, escaped |
| 7/21/2017 | G054B | 60 | LSU | A | 1 | 1 | 0 | 0.00 | 320mm |
| 7/21/2017 | G022B | 62 | MW | A | 2 | 2 | 0 | 0.00 | 245, 265mm |
| 7/23/2017 | G026B | 66 | BT | A | 1 | 0 | 1 | 1.00 | 280mm |
| 7/23/2017 | G026B | 66 | MW | A | 1 | 0 | 1 | 1.00 | 305mm |
| 7/23/2017 | G026B | 66 | Peamouth | A | 1 | 1 | 0 | 0.00 | 230mm |
| 7/23/2017 | G010B | 67 | MW | A | 1 | 1 | 0 | 0.00 | 300mm |
| 7/23/2017 | G132B | 68 | MW | A | 1 | 1 | 0 | 0.00 | escaped |
| 7/24/2017 | G105B | 71 | MW | A | 1 | 1 | 0 | 0.00 | 240mm |
| 7/24/2017 | G105B | 71 | NSC | A | 3 | 3 | 0 | 0.00 | 260, 275, 300mm |
| 7/24/2017 | G051B | 74 | BT | A | 1 | 1 | 0 | 0.00 | NR |
| 7/24/2017 | G051B | 74 | NSC | A | 10 | 10 | 0 | 0.00 | 265, 300, 305, 280, 240, 270, 285mm |
| 7/24/2017 | G035B | 75 | BT | A | 1 | 1 | 0 | 0.00 | escaped |
| 7/24/2017 | G035B | 75 | CSU | J | 1 | 1 | 0 | 0.00 | 220mm |
| 7/24/2017 | G035B | 75 | MW | A | 2 | 2 | 0 | 0.00 | 260mm, 280mm |
| 7/24/2017 | G035B | 75 | NSC | A | 7 | 6 | 1 | 0.14 | 255, 295, 260, 240, 245, 285, 250mm |

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|---|---|---|---|---|---|---|---|---|---|
| 7/24/2017 | G035B | 75 | Peamouth | A | 2 | 2 | 0 | 0.00 | 225, 245mm |
| 7/24/2017 | G113B | 76 | NSC | A | 4 | 4 | 0 | 0.00 | 280, 285, 265, 260mm |
| 7/25/2017 | G084B | 77 | NSC | A | 1 | 1 | 0 | 0.00 | 255mm |
| 7/25/2017 | G099B | 80 | CSU | J | 3 | 3 | 0 | 0.00 | 220, 210, 230mm |
| 7/25/2017 | G099B | 80 | LSU | J | 1 | 1 | 0 | 0.00 | 225mm |
| 7/25/2017 | G099B | 80 | MW | A | 5 | 2 | 3 | 0.60 | 270, 280, 290, 265, 240mm |
| 7/25/2017 | G099B | 80 | Peamouth | A | 2 | 1 | 1 | 0.50 | 240, 220mm |
| 7/25/2017 | G102B | 82 | MW | A | 1 | 1 | 0 | 0.00 | escaped |
| 7/25/2017 | G102B | 82 | NSC | A | 1 | 1 | 0 | 0.00 | 270mm |
| 8/10/2017 | ALN01G | 83 | LSU | A | 1 | 1 | 0 | 0.00 | came off net |
| 8/10/2017 | ALN01G | 83 | LW | A | 2 | 2 | 0 | 0.00 | 245mm, 285mm |
| 8/10/2017 | ALN02G | 84 | MW | J | 1 | 1 | 0 | 0.00 | 235mm |
| 8/10/2017 | ALN03G | 85 | MW | A | 1 | 1 | 0 | 0.00 | 265mm |
| 8/11/2017 | ALN04G | 86 | BT | A | 1 | 0 | 1 | 1.00 | 415mm; Dixon Food Fish |
| 8/11/2017 | ALN04G | 86 | KO | A | 1 | 0 | 1 | 1.00 | 235mm; Dixon Food Fish |
| 8/11/2017 | ALN04G | 86 | LW | A | 6 | 2 | 4 | 0.67 | 220, 270, 230, 230, 270, 290mm; mortality = Dixon Food Fish |
| 8/11/2017 | ALN04G | 86 | Peamouth | A | 3 | 0 | 3 | 1.00 | 230, 235, 230mm; Dixon Food Fish |
| 8/11/2017 | ALN05G | 87 | MW | A | 3 | 3 | 0 | 0.00 | 240, 270, 265mm |
| 8/11/2017 | ALN06G | 88 | KO | A | 1 | 0 | 1 | 1.00 | 240mm; Dixon Food Fish |
| 8/11/2017 | ALN06G | 88 | MW | A | 1 | 0 | 1 | 1.00 | Dixon Food Fish |
| 8/11/2017 | ALN06G | 88 | Peamouth | A | 1 | 1 | 0 | 0.00 | 250mm |
| 8/12/2017 | G062B | 89 | MW | A | 1 | 1 | 0 | 0.00 | 270mm |
| 8/12/2017 | G046B | 91 | KO | A | 1 | 1 | 0 | 0.00 | 240mm |
| 8/12/2017 | G119B | 93 | LW | A | 1 | 0 | 1 | 1.00 | 305mm |
| 8/12/2017 | G119B | 93 | MW | A | 4 | 3 | 1 | 0.25 | escaped, 275, 230, 280mm |
| 8/12/2017 | G047B | 94 | NSC | A | 1 | 1 | 0 | 0.00 | 295mm |
| 8/13/2017 | G081B | 95 | NSC | A | 1 | 1 | 0 | 0.00 | 285mm |
| 8/13/2017 | G110B | 97 | BT | A | 1 | 0 | 1 | 1.00 | 285mm |
| 8/13/2017 | G110B | 97 | KO | A | 1 | 1 | 0 | 0.00 | 245mm |

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|---|---|---|---|---|---|---|---|---|---|
| 8/13/2017 | G070B | 98 | BT | A | 1 | 0 | 1 | 1.00 | 290mm |
| 8/13/2017 | G070B | 98 | MW | A | 4 | 3 | 1 | 0.25 | 270, 250, 280, 245mm |
| 8/13/2017 | G055B | 100 | LW | A | 2 | 2 | 0 | 0.00 | 270mm, 260mm |
| 8/14/2017 | G133B | 101 | MW | A | 1 | 1 | 0 | 0.00 | 275mm |
| 8/14/2017 | G124B | 104 | BB | J | 1 | 0 | 1 | 1.00 | 320mm |
| 8/14/2017 | G124B | 104 | LSU | A | 1 | 1 | 0 | 0.00 | 335mm |
| 8/14/2017 | G124B | 104 | LW | J | 3 | 1 | 2 | 0.67 | 255mm, 240mm, 200mm |
| 8/14/2017 | G023B | 106 | LW | A | 1 | 1 | 0 | 0.00 | 260mm |
| 8/14/2017 | G023B | 106 | MW | A | 3 | 3 | 0 | 0.00 | 310mm, 220mm, 240mm |
| 8/15/2017 | G015B | 107 | MW | A | 4 | 2 | 2 | 0.50 | 295, 290, 275, 275mm |
| 8/15/2017 | G098B | 109 | KO | A | 1 | 1 | 0 | 0.00 | escaped |
| 8/15/2017 | G098B | 109 | LW | A | 1 | 1 | 0 | 0.00 | 270mm |
| 8/15/2017 | G098B | 109 | MW | A | 2 | 2 | 0 | 0.00 | 280, 280mm |
| 8/15/2017 | G059B | 110 | BT | A | 1 | 1 | 0 | 0.00 | 420mm |
| 8/15/2017 | G059B | 110 | LW | A | 1 | 1 | 0 | 0.00 | 250, 260, 260mm |
| 8/15/2017 | G140B | 112 | LW | A | 4 | 0 | 0 | 0.00 | 280, 320, 360, 250mm |
| 8/15/2017 | G140B | 112 | MW | A | 2 | 0 | 0 | 0.00 | 270, 240mm |
| 8/16/2017 | G118B | 114 | LW | A | 2 | 2 | 0 | 0.00 | 260, 260mm |
| 8/16/2017 | G092B | 116 | LW | A | 2 | 1 | 1 | 0.50 | 200, 250mm |
| 8/23/2017 | G138B | 120 | MW | A | 1 | 1 | 0 | 0.00 | 230mm |
| 8/23/2017 | G114B | 121 | LW | A | 3 | 3 | 0 | 0.00 | 310mm, 250mm,245mm |
| 8/23/2017 | G114B | 121 | MW | A | 2 | 2 | 0 | 0.00 | 285mm, 260mm |
| 8/23/2017 | G036B | 122 | BT | A | 1 | 1 | 0 | 0.00 | escaped |
| 8/23/2017 | G036B | 122 | MW | A | 5 | 5 | 0 | 0.00 | 285mm.245mm, 255mm, 245mm, 255mm |
| 8/23/2017 | G074B | 123 | KO | A | 1 | 1 | 0 | 0.00 | 230mm |
| 8/23/2017 | G066B | 124 | LW | A | 1 | 1 | 0 | 0.00 | 245mm |
| 8/24/2017 | G020B | 125 | BT | A | 1 | 1 | 0 | 0.00 | 590mm |
| 8/24/2017 | G020B | 125 | MW | A | 2 | 2 | 0 | 0.00 | 250mm, 265mm |
| 8/24/2017 | G122B | 126 | MW | A | 1 | 0 | 1 | 1.00 | 250mm |

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|---|---|---|---|---|---|---|---|---|---|
| 8/24/2017 | G052B | 127 | BT | A | 1 | 0 | 1 | 1.00 | 350mm |
| 8/24/2017 | G052B | 127 | MW | A | 1 | 1 | 0 | 0.00 | 275mm |
| 8/24/2017 | G094B | 128 | LSC | A | 1 | 1 | 0 | 0.00 | 330mm |
| 8/24/2017 | G094B | 128 | LW | A | 1 | 0 | 1 | 1.00 | 285mm |
| 8/24/2017 | G094B | 128 | MW | A | 8 | 3 | 5 | 0.63 | 310, 280, 220, 320, 250, 240,290,245mm |
| 8/24/2017 | G068B | 130 | NSC | J | 3 | 2 | 1 | 0.33 | 290, 265, 245mm |
| 8/25/2017 | G086B | 131 | LW | J | 1 | 1 | 0 | 0.00 | 255mm |
| 8/25/2017 | G040B | 133 | LW | J | 1 | 1 | 0 | 0.00 | 265mm |
| 8/25/2017 | G040B | 133 | NSC | J | 2 | 1 | 1 | 0.50 | 255mm, 290mm |
| 8/25/2017 | G106B | 134 | MW | A | 2 | 2 | 0 | 0.00 | 240mm, 250mm |
| 8/25/2017 | G024B | 135 | MW | A | 1 | 1 | 0 | 0.00 | 265mm; BB eating KO off net - Both escaped |
| 8/26/2017 | G090B | 136 | KO | A | 3 | 2 | 1 | 0.33 | 215mm, 245mm, 215mm |
| 8/26/2017 | G090B | 136 | LW | J | 2 | 2 | 0 | 0.00 | 240mm, 235mm |
| 8/26/2017 | G090B | 136 | NSC | J | 1 | 1 | 0 | 0.00 | 250mm |
| 8/26/2017 | G136B | 137 | BT | A | 1 | 0 | 1 | 1.00 | 380mm |
| 8/26/2017 | G060B | 138 | MW | A | 3 | 1 | 2 | 0.67 | 230mm, 245mm, 290mm |
| 8/26/2017 | G126B | 140 | LW | A | 1 | 1 | 0 | 0.00 | 228mm |
| 8/27/2017 | G056B | 141 | KO | A | 25 | 25 | 0 | 0.00 | 230, 240, 240, 235, 240, 230, 230, 235, 225, 235, 240, 240, 240mm; All ready to spawn |
| 8/27/2017 | G012B | 143 | KO | A | 3 | 3 | 0 | 0.00 | Came off net, 250, 240mm |
| 8/27/2017 | G012B | 143 | MW | A | 1 | 1 | 0 | 0.00 | 320mm |
| 8/27/2017 | G108B | 144 | MW | A | 5 | 3 | 2 | 0.40 | 265, 275, 235, 255, 210mm |
| 8/27/2017 | G108B | 144 | NSC | A | 1 | 1 | 0 | 0.00 | came off net |
| 8/28/2017 | G120B | 147 | KO | A | 1 | 0 | 1 | 1.00 | 210mm |
| 8/28/2017 | G082B | 148 | KO | A | 1 | 1 | 0 | 0.00 | escaped |
| 8/29/2017 | G048B | 149 | KO | A | 1 | 1 | 0 | 0.00 | 255mm |
| 8/29/2017 | G100B | 150 | KO | A | 2 | 2 | 0 | 0.00 | 245mm, 240mm |
| 8/29/2017 | G100B | 150 | MW | A | 2 | 2 | 0 | 0.00 | 225mm, came off net |
| 8/29/2017 | G150B | 151 | KO | A | 16 | 15 | 1 | 0.06 | 230, 210, 235, 245, escaped, 250, 245, 230, 230 |
| 9/7/2017 | GA1 | 152 | MW | A | 3 | 2 | 1 | 0.33 | 260mm, 225mm, 250mm |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9/7/2017 | GA1 | 152 | Sucker Sp. | J | 1 | 1 | 0 | 0.00 | Escaped |
| 9/7/2017 | GA2 | 153 | KO | A | 2 | 2 | 0 | 0.00 | 215mm, 230mm both in spawning coloration |
| 9/12/2017 | GA4 | 155 | KO | A | 1 | 1 | 0 | 0.00 | 250mm |
| 9/12/2017 | GA4 | 155 | Peamouth | A | 2 | 2 | 0 | 0.00 | 215mm, 220mm |
| | | | | **Total :** | 391 | 278 | 106 | 27.1% | |

## Setlines

| Set # | Site | Location | | | Set Date | Set Time | Weather | Water Temp (°C) | Pull Date | Water Temp (°C) Day 2 | Pull Time | Water Depth (m) | | Orientation to Flow | Location in water column | Soak Time (Hours) | # Hooks | Effort (# Hooks * Soak Time) | Retrieved Hooks* | | | | WSG Catch | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Zone | Easting | Northing | | | | | | | | Min | Max | | | | | | B | BL | F | L | | |
| 1 | 66B | 11 | 421411 | 5636945 | 6/6/2017 | 13:27 | overcast/calm | 7.7 | 6/7/2017 | 7.1 | 12:30 | 3.0 | 3.7 | oblique | lower | 23.05 | 20 | 461 | 1 | 19 | 0 | 0 | 0 | |
| 2 | 138B | 11 | 421512 | 5636606 | 6/6/2017 | 13:45 | sunny/overcast/calm | 6.4 | 6/7/2017 | 7.5 | 12:42 | 5.2 | 7.4 | perpendicular | lower | 22.95 | 20 | 459 | 1 | 19 | 0 | 0 | 0 | |
| 3 | 4B | 11 | 421608 | 5636171 | 6/6/2017 | 14:14 | sunny/overcast/calm | 7.1 | 6/7/2017 | 6.6 | 12:50 | 7.8 | 7.9 | perpendicular | lower | 22.60 | 20 | 452 | 1 | 19 | 0 | 0 | 0 | Turbid |
| 4 | 20B | 11 | 421790 | 5635258 | 6/6/2017 | 14:28 | sunny/overcast/calm | 8.9 | 6/7/2017 | 8.6 | 13:01 | 4.3 | 7.1 | oblique | lower | 22.55 | 19 | 428 | 4 | 15 | 0 | 0 | 0 | |
| 5 | 74B | 11 | 421546 | 5634478 | 6/7/2017 | 10:45 | overcast/warm | 7.1 | 6/8/2017 | 7.7 | 10:12 | 11.3 | 18.8 | oblique | lower | 23.45 | 20 | 469 | 0 | 20 | 0 | 0 | 0 | |
| 6 | 114B | 11 | 422042 | 5634323 | 6/7/2017 | 10:57 | overcast/warm | 6.4 | 6/8/2017 | 7.4 | 10:24 | 2.8 | 6.8 | perpendicular | lower | 23.45 | 20 | 469 | 0 | 20 | 0 | 0 | 0 | |
| 7 | 94B | 11 | 422698 | 5633689 | 6/7/2017 | 11:10 | overcast/warm | 6.4 | 6/8/2017 | 6.8 | 10:40 | 9.8 | 14.3 | oblique | lower | 23.50 | 20 | 470 | 1 | 18 | 1 | 0 | 0 | |
| 8 | 52B | 11 | 423218 | 5633486 | 6/7/2017 | 11:24 | overcast/warm | 6.4 | 6/8/2017 | 6.8 | 10:55 | 4.6 | 5.3 | oblique | lower | 23.52 | 20 | 470 | 0 | 20 | 0 | 0 | 0 | |
| 9 | 36B | 11 | 423812 | 5633166 | 6/7/2017 | 13:37 | overcast | 7.1 | 6/8/2017 | 6.7 | 12:49 | 5.7 | 6.4 | perpendicular | lower | 23.20 | 20 | 464 | 0 | 20 | 0 | 0 | 0 | |
| 10 | 122B | 11 | 424192 | 5632815 | 6/7/2017 | 13:47 | partly cloudy | 6.8 | 6/8/2017 | 7.4 | 12:50 | 9.8 | 10.2 | perpendicular | lower | 23.05 | 20 | 461 | 0 | 20 | 0 | 0 | 0 | |
| 11 | 12B | 11 | 424652 | 5632044 | 6/7/2017 | 13:57 | partly cloudy | 6.6 | 6/8/2017 | 7.3 | 13:12 | 6.7 | 7.1 | parallel | lower | 23.25 | 20 | 465 | 0 | 20 | 0 | 0 | 0 | |
| 12 | 108B | 11 | 424744 | 5631818 | 6/7/2017 | 14:05 | partly cloudy | 6.7 | 6/8/2017 | 7.3 | 13:22 | 5.8 | 6.2 | parallel | lower | 23.28 | 20 | 466 | 0 | 20 | 0 | 0 | 0 | |
| 13 | 134B | 11 | 425359 | 5631429 | 6/8/2017 | 11:40 | overcast | 7.4 | 6/9/2017 | 8.7 | 11:07 | 13.5 | 16.4 | oblique | lower | 23.45 | 20 | 469 | 0 | 20 | 0 | 0 | 0 | |
| 14 | 96B | 11 | 425651 | 5630884 | 6/8/2017 | 11:50 | overcast | 7.3 | 6/9/2017 | 8.5 | 11:30 | 6.3 | 11.0 | oblique | lower | 23.67 | 20 | 473 | 0 | 20 | 0 | 0 | 0 | |
| 15 | 28B | 11 | 426043 | 5630169 | 6/8/2017 | 12:29 | overcast | 7.2 | 6/9/2017 | 7.9 | 11:50 | 9.8 | 12.4 | perpendicular | lower | 23.35 | 20 | 467 | 0 | 20 | 0 | 0 | 0 | |
| 16 | 106B | 11 | 426133 | 5629758 | 6/8/2017 | 12:35 | overcast | 7.2 | 6/9/2017 | 8.1 | 12:00 | 13.0 | 15.0 | perpendicular | lower | 23.42 | 20 | 468 | 0 | 20 | 0 | 0 | 0 | |
| 17 | 8B | 11 | 426751 | 5629403 | 6/8/2017 | 14:03 | overcast/rain | 7.2 | 6/9/2017 | 7.7 | 14:06 | 13.3 | 15.9 | oblique | lower | 24.05 | 20 | 481 | 5 | 15 | 0 | 0 | 0 | |
| 18 | 68B | 11 | 426930 | 5629218 | 6/8/2017 | 14:08 | overcast/rain | 7.1 | 6/9/2017 | 7.2 | 14:24 | 11.1 | 15.6 | perpendicular | lower | 24.27 | 20 | 485 | 0 | 20 | 0 | 0 | 0 | Pick up comment: Snagged but retrieved all. |
| 19 | 56B | 11 | 427397 | 5629007 | 6/8/2017 | 14:20 | overcast/rain | 7.1 | 6/9/2017 | 7.2 | 14:36 | 17.0 | 18.1 | oblique | lower | 24.27 | 20 | 485 | 0 | 20 | 0 | 0 | 0 | |
| 20 | 86B | 11 | 427841 | 5628838 | 6/8/2017 | 14:26 | overcast/rain | 7.1 | 6/9/2017 | 7.3 | 14:55 | 10.1 | 17.1 | perpendicular | lower | 24.48 | 20 | 490 | 2 | 18 | 0 | 0 | 0 | |
| 21 | 40B | 11 | 428278 | 5628585 | 6/9/2017 | 12:38 | partly cloudy | 7.1 | 6/10/2017 | 6.9 | 9:43 | 7.5 | 2.3 | parallel | lower | 21.08 | 20 | 422 | 7 | 13 | 0 | 0 | 0 | |
| 22 | 24B | 11 | 428637 | 5628166 | 6/9/2017 | 12:46 | partly cloudy | 7.3 | 6/10/2017 | 7.0 | 9:54 | 10.6 | 12.6 | perpendicular | lower | 21.13 | 20 | 423 | 3 | 17 | 0 | 0 | 0 | |
| 23 | 116B | 11 | 428938 | 5627165 | 6/9/2017 | 12:56 | partly cloudy | 7.3 | 6/10/2017 | 7.2 | 10:20 | 15.4 | 15.5 | oblique | lower | 21.40 | 20 | 428 | 13 | 7 | 0 | 0 | 0 | |
| 24 | 39B | 11 | 428943 | 5626549 | 6/9/2017 | 13:04 | partly cloudy | 7.4 | 6/10/2017 | 7.4 | 11:12 | 15.9 | 18.1 | parallel | lower | 22.13 | 20 | 443 | 7 | 6 | 2 | 5 | 0 | Total lost = 100ft of rope & 5 hooks. Attempted to bring up line for ~ 1 hour. Tried both ends forward and back, attempted to drive in a circle to unwrap it. Bow repeatedly dipped close to the water surface during attemps and rope would not move. Removed 13 hooks from upstream and 2 hooks from downstream. Brought up rope where the last five should have been but they were not there. |
| 25 | 142B | 11 | 429404 | 5625832 | 6/9/2017 | 15:30 | partly cloudy | 7.3 | 6/10/2017 | 7.2 | 13:06 | 17.2 | 18.4 | oblique | lower | 21.60 | 20 | 432 | 19 | 1 | 0 | 0 | 0 | |
| 26 | 105B | 11 | 428880 | 5625501 | 6/9/2017 | 15:39 | partly cloudy | 7.5 | 6/10/2017 | 7.2 | 13:16 | 5.4 | 6.4 | oblique | lower | 21.62 | 20 | 432 | 0 | 20 | 0 | 0 | 0 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 23B | 11 | 428989 | 5625218 | 6/9/2017 | 15:45 | partly cloudy | 7.5 | 6/10/2017 | 7.2 | 13:35 | 4.7 | 5.5 | parallel | lower | 21.83 | 20 | 437 | 0 | 20 | 0 | 0 | 0 | |
| 28 | 76B | 11 | 429148 | 5624785 | 6/9/2017 | 15:54 | partly cloudy | 7.5 | 6/10/2017 | 8.1 | 13:45 | 6.3 | 17.3 | perpendicular | lower | 21.85 | 20 | 437 | 0 | 20 | 0 | 0 | 0 | |
| 29 | 7B | 11 | 429477 | 5623916 | 6/10/2017 | 11:54 | rain | 7.7 | 6/11/2017 | 8.7 | 9:46 | 13.1 | 16.4 | perpendicular | lower | 21.87 | 10 | 219 | 1 | 9 | 0 | 0 | 0 | |
| 30 | 84B | 11 | 429840 | 5623052 | 6/10/2017 | 12:01 | rain | 7.8 | 6/11/2017 | 8.7 | 9:51 | 15.3 | 16.5 | perpendicular | lower | 21.83 | 20 | 437 | 12 | 8 | 0 | 0 | 0 | |
| 31 | 51B | 11 | 430136 | 5622532 | 6/10/2017 | 12:10 | rain | 7.5 | 6/11/2017 | 8.3 | 10:06 | 16.9 | 17.6 | perpendicular | lower | 21.93 | 20 | 439 | 9 | 11 | 0 | 0 | 0 | |
| 32 | 130B | 11 | 430218 | 5622249 | 6/10/2017 | 12:20 | rain | 7.7 | 6/11/2017 | 7.4 | 10:30 | 12.1 | 16.1 | perpendicular | lower | 22.17 | 20 | 443 | 8 | 12 | 0 | 0 | 0 | |
| 33 | 144B | 11 | 430552 | 5621632 | 6/10/2017 | 14:21 | rain | 7.8 | 6/11/2017 | 9.0 | 13:46 | 1.6 | 13.8 | perpendicular | lower | 23.42 | 20 | 468 | 1 | 19 | 0 | 0 | 0 | |
| 34 | 149B | 11 | 431239 | 5621107 | 6/10/2017 | 14:30 | rain | 7.8 | 6/11/2017 | 9.1 | 14:00 | 16.0 | 17.3 | perpendicular | lower | 23.50 | 18 | 423 | 10 | 8 | 0 | 0 | 0 | |
| 35 | 99B | 11 | 431943 | 5620552 | 6/10/2017 | 14:40 | rain | 8.2 | 6/11/2017 | 12.1 | 14:16 | 4.0 | 6.5 | perpendicular | lower | 23.60 | 20 | 472 | 0 | 20 | 0 | 0 | 0 | |
| 36 | 46B | 11 | 432119 | 5619823 | 6/10/2017 | 14:50 | rain | 8.0 | 6/11/2017 | 7.8 | 14:25 | 6.7 | 9.6 | perpendicular | lower | 23.58 | 20 | 472 | 20 | 0 | 0 | 0 | 0 | |
| 37 | S128B | 11 | 421519 | 5634329 | 6/11/2017 | 11:58 | partly cloudy | 9.2 | 6/12/2017 | 7.9 | 10:37 | 5.2 | 7.8 | parallel | lower | 22.65 | 20 | 453 | 10 | 10 | 0 | 0 | 0 | |
| 38 | S150B | 11 | 422406 | 5633987 | 6/11/2017 | 12:06 | partly cloudy | 10.5 | 6/12/2017 | 7.5 | 10:55 | 10.7 | 12.0 | oblique | lower | 22.82 | 20 | 456 | 17 | 3 | 0 | 0 | 0 | |
| 39 | S100B | 11 | 422217 | 5633974 | 6/11/2017 | 12:15 | partly cloudy | 9.2 | 6/12/2017 | 7.4 | 11:15 | 13.9 | 14.1 | perpendicular | lower | 23.00 | 20 | 460 | 19 | 1 | 0 | 0 | 0 | |
| 40 | S48B | 11 | 421781 | 5634199 | 6/11/2017 | 12:19 | partly cloudy | 8.9 | 6/12/2017 | 7.6 | 11:24 | 6.0 | 12.4 | perpendicular | lower | 23.08 | 10 | 231 | 7 | 3 | 0 | 0 | 0 | |
| 41 | S134B | 11 | 429353 | 5626252 | 6/11/2017 | 15:10 | partly cloudy | 8.7 | 6/12/2017 | 10.5 | 12:24 | 12.6 | 14.0 | parallel | lower | 21.23 | 20 | 425 | 5 | 15 | 0 | 0 | 0 | |
| 42 | S116B | 11 | 429257 | 5626559 | 6/11/2017 | 15:19 | partly cloudy | 9.9 | 6/12/2017 | 9.8 | 12:40 | 10.0 | 13.2 | oblique | lower | 21.35 | 20 | 427 | 12 | 8 | 0 | 0 | 0 | |
| 43 | S44B | 11 | 429176 | 5626928 | 6/11/2017 | 15:29 | partly cloudy | 9.8 | 6/12/2017 | 10.4 | 12:53 | 8.8 | 9.2 | perpendicular | lower | 21.40 | 20 | 428 | 18 | 2 | 0 | 0 | 0 | |
| 44 | S126B | 11 | 429084 | 5627759 | 6/11/2017 | 15:37 | partly cloudy | 10.5 | 6/12/2017 | 10.0 | 13:15 | 4.2 | 17.8 | oblique | lower | 21.63 | 20 | 433 | 10 | 10 | 0 | 0 | 0 | |
| 45 | 126B | 11 | 441788 | 5556073 | 6/27/2017 | 11:03 | sunny | 17.0 | 6/28/2017 | 17.9 | 10:43 | 17.0 | 23.4 | oblique | lower | 23.67 | 20 | 473 | 12 | 8 | 0 | 0 | 0 | |
| 46 | 90B | 11 | 441532 | 5556569 | 6/27/2017 | 11:14 | sunny | 15.5 | 6/28/2017 | 17.8 | 10:54 | 16.3 | 16.7 | parallel | lower | 23.67 | 20 | 473 | 1 | 19 | 0 | 0 | 0 | |
| 47 | 44B | 11 | 441467 | 5556752 | 6/27/2017 | 11:24 | sunny | 14.0 | 6/28/2017 | 17.8 | 11:10 | 14.2 | 15.7 | parallel | lower | 23.77 | 20 | 475 | 0 | 20 | 0 | 0 | 0 | |
| 48 | 78B | 11 | 443451 | 5557453 | 6/27/2017 | 11:56 | sunny | 17.9 | 6/28/2017 | 17.9 | 11:28 | 14.4 | 15.4 | parallel | lower | 23.53 | 20 | 471 | 2 | 18 | 0 | 0 | 0 | |
| 49 | 32B | 11 | 443343 | 5557959 | 6/27/2017 | 12:05 | sunny | 17.9 | 6/28/2017 | 18.3 | 11:50 | 13.4 | 19.0 | parallel | lower | 23.75 | 20 | 475 | 0 | 20 | 0 | 0 | 0 | |
| 50 | 72B | 11 | 443496 | 5559164 | 6/27/2017 | 12:16 | sunny | 19.3 | 6/28/2017 | 18.3 | 12:04 | 14.1 | 21.3 | parallel | lower | 23.80 | 20 | 476 | 0 | 20 | 0 | 0 | 0 | |
| 51 | 60B | 11 | 440627 | 5560748 | 6/29/2017 | 14:24 | sunny | 18.1 | 6/30/2017 | 15.2 | 8:40 | 8.0 | 11.0 | oblique | lower | 18.27 | 20 | 365 | 0 | 20 | 0 | 0 | 0 | |
| 52 | 16B | 11 | 440671 | 5560864 | 6/29/2017 | 14:30 | sunny | 18.5 | 6/30/2017 | 15.3 | 8:50 | 4.0 | 7.9 | oblique | lower | 18.33 | 19 | 348 | 0 | 19 | 0 | 0 | 0 | |
| 53 | 136B | 11 | 440709 | 5560868 | 6/29/2017 | 14:37 | sunny | 17.8 | 6/30/2017 | 15.1 | 9:00 | 8.4 | 10.1 | parallel | lower | 18.38 | 20 | 368 | 0 | 20 | 0 | 0 | 0 | |
| 54 | 128B | 11 | 444146 | 5560780 | 7/5/2017 | 14:04 | sunny | 21.6 | 7/6/2017 | 20.8 | 11:00 | 13.0 | 16.9 | parallel | lower | 20.93 | 20 | 419 | 5 | 15 | 0 | 0 | 0 | |
| 55 | 48B | 11 | 444260 | 5561081 | 7/5/2017 | 14:15 | sunny | 21.5 | 7/6/2017 | 20.9 | 11:16 | 15.1 | 15.1 | oblique | lower | 21.02 | 20 | 420 | 12 | 8 | 0 | 0 | 0 | |
| 56 | 64B | 11 | 444349 | 5561258 | 7/5/2017 | 14:20 | sunny | 22.1 | 7/6/2017 | 21.3 | 11:25 | 16.5 | 17.0 | parallel | lower | 21.08 | 20 | 422 | 19 | 1 | 0 | 0 | 0 | |
| 57 | 100B | 11 | 441027 | 5561248 | 7/5/2017 | 15:00 | sunny | 20.8 | 7/6/2017 | 21.1 | 11:46 | 11.1 | 26.3 | oblique | lower | 20.77 | 20 | 415 | 3 | 17 | 0 | 0 | 0 | |
| 58 | 150B | 11 | 440935 | 5562623 | 7/5/2017 | 15:06 | sunny | 20.8 | 7/6/2017 | 20.3 | 12:01 | 9.2 | 14.8 | parallel | lower | 20.92 | 20 | 418 | 2 | 18 | 0 | 0 | 0 | |
| 59 | 120B | 11 | 440499 | 5563144 | 7/5/2017 | 15:15 | sunny | 20.8 | 7/6/2017 | 22.0 | 12:10 | 2.4 | 5.4 | parallel | lower | 20.92 | 20 | 418 | 0 | 20 | 0 | 0 | 0 | |
| 60 | 26B | 11 | 439169 | 5565038 | 7/6/2017 | 13:41 | sunny | 22.2 | 7/7/2017 | 22.8 | 10:03 | 10.0 | 14.4 | parallel | lower | 20.37 | 18 | 367 | 14 | 4 | 0 | 0 | 0 | |
| 61 | 77B | 11 | 438993 | 5565290 | 7/6/2017 | 13:52 | sunny | 22.7 | 7/7/2017 | 22.9 | 10:20 | 19.0 | 20.2 | parallel | lower | 20.47 | 20 | 409 | 7 | 13 | 0 | 0 | 0 | |
| 62 | 107B | 11 | 438784 | 5565538 | 7/6/2017 | 13:57 | sunny | 23.2 | 7/7/2017 | 22.9 | 10:30 | 9.4 | 10.6 | parallel | lower | 20.55 | 20 | 411 | 19 | 1 | 0 | 0 | 0 | |
| 63 | 30B | 11 | 441520 | 5567720 | 7/6/2017 | 14:14 | sunny | 21.9 | 7/7/2017 | 21.7 | 10:47 | 14.2 | 16.0 | parallel | lower | 20.55 | 20 | 411 | 2 | 18 | 0 | 0 | 0 | |
| 64 | 119B | 11 | 441292 | 5568201 | 7/6/2017 | 14:24 | sunny | 20.6 | 7/7/2017 | 21.8 | 11:00 | 14.1 | 19.0 | parallel | lower | 20.60 | 20 | 412 | 0 | 20 | 0 | 0 | 0 | |
| 65 | 80B | 11 | 441406 | 5567855 | 7/6/2017 | 14:33 | sunny | 21.6 | 7/7/2017 | 21.6 | 11:10 | 17.0 | 21.0 | parallel | lower | 20.62 | 20 | 412 | 2 | 18 | 0 | 0 | 0 | |
| 66 | 71B | 11 | 438183 | 5568097 | 7/7/2017 | 12:35 | overcast | 23.0 | 7/8/2017 | 20.8 | 10:20 | 14.0 | 20.0 | parallel | lower | 21.75 | 20 | 435 | 10 | 10 | 0 | 0 | 0 | |
| 67 | 125B | 11 | 437882 | 5568788 | 7/7/2017 | 12:43 | overcast | 23.0 | 7/8/2017 | 20.4 | 10:32 | 14.0 | 17.5 | parallel | lower | 21.82 | 20 | 436 | 10 | 10 | 0 | 0 | 0 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | 88B | 11 | 437694 | 5569164 | 7/7/2017 | 12:52 | overcast | 23.5 | 7/8/2017 | 21.4 | 10:45 | 14.0 | 18.0 | parallel | lower | 21:53 | 20 | 478 | 5 | 15 | 0 | 0 | 0 | |
| 69 | 58B | 11 | 440766 | 5570783 | 7/7/2017 | 13:10 | overcast | 22.1 | 7/8/2017 | 19.9 | 11:07 | 18.3 | 20.0 | parallel | lower | 21:57 | 20 | 478 | 11 | 9 | 0 | 0 | 0 | |
| 70 | 135B | 11 | 439533 | 5572073 | 7/7/2017 | 13:17 | overcast | 21.7 | 7/8/2017 | 19.0 | 10:20 | 14.2 | 15.7 | oblique | lower | 21:03 | 20 | 478 | 5 | 15 | 0 | 0 | 0 | |
| 71 | 42B | 11 | 438748 | 5572663 | 7/7/2017 | 13:24 | overcast | 21.1 | 7/8/2017 | 18.7 | 11:46 | 18.1 | 20.2 | oblique | lower | 22:22 | 20 | 479 | 9 | 11 | 0 | 0 | 0 | |
| 72 | 38B | 11 | 436138 | 5571530 | 7/8/2017 | 13:15 | sunny | 21.9 | 7/9/2017 | 20.5 | 10:30 | 12.1 | 21.4 | parallel | lower | 21.25 | 20 | 425 | 10 | 9 | 1 | 0 | 0 | |
| 73 | 115B | 11 | 435680 | 5572282 | 7/8/2017 | 13:24 | sunny | 22.0 | 7/9/2017 | 20.2 | 10:46 | 5.5 | 16.4 | parallel | lower | 21.37 | 20 | 427 | 10 | 8 | 0 | 2 | 0 | |
| 74 | 22B | 11 | 435443 | 5572657 | 7/8/2017 | 13:30 | sunny | 21.9 | 7/9/2017 | 20.5 | 10:52 | 6.0 | 9.9 | parallel | lower | 21.37 | 20 | 427 | 6 | 14 | 0 | 0 | 0 | |
| 75 | 104B | 11 | 437924 | 5574749 | 7/8/2017 | 14:25 | sunny | 20.1 | 7/9/2017 | 20.0 | 11:10 | 7.0 | 12.9 | parallel | lower | 20.75 | 20 | 415 | 1 | 19 | 0 | 0 | 0 | |
| 76 | 67B | 11 | 437860 | 5574957 | 7/8/2017 | 14:34 | sunny | 19.7 | 7/9/2017 | 20.0 | 11:17 | 9.3 | 14.4 | parallel | lower | 20.72 | 20 | 414 | 6 | 14 | 0 | 0 | 0 | |
| 77 | 95B | 11 | 437665 | 5575539 | 7/8/2017 | 14:46 | sunny | 20.0 | 7/9/2017 | 21.0 | 11:23 | 14.2 | 15.4 | parallel | lower | 20.62 | 20 | 412 | 1 | 19 | 0 | 0 | 0 | |
| 78 | 85B | 11 | 433991 | 5574886 | 7/9/2017 | 12:57 | sunny | 21.9 | 7/10/2017 | 20.7 | 10:37 | 5.8 | 12.0 | parallel | lower | 21.66 | 20 | 433 | 15 | 5 | 0 | 0 | 0 | |
| 79 | 54B | 11 | 433817 | 5575252 | 7/9/2017 | 13:06 | sunny | 20.6 | 7/10/2017 | 20.6 | 10:50 | 14.2 | 17.0 | parallel | lower | 21.73 | 20 | 435 | 8 | 11 | 0 | 1 | 0 | |
| 80 | 132B | 11 | 433737 | 5575603 | 7/9/2017 | 13:12 | sunny | 22.2 | 7/10/2017 | 20.2 | 11:05 | 14.2 | 16.0 | parallel | lower | 21:07 | 19 | 416 | 17 | 2 | 0 | 0 | 0 | |
| 81 | 10B | 11 | 436340 | 5577858 | 7/9/2017 | 13:22 | sunny | 21.1 | 7/10/2017 | 18.9 | 11:34 | 20.0 | 29.0 | parallel | lower | 22.02 | 20 | 440 | 12 | 6 | 2 | 0 | 0 | |
| 82 | 121B | 11 | 436409 | 5578003 | 7/9/2017 | 13:29 | sunny | 21.1 | 7/10/2017 | 18.9 | 11:57 | 12.0 | 16.0 | parallel | lower | 22.47 | 20 | 449 | 3 | 17 | 0 | 0 | 0 | |
| 83 | 50B | 11 | 436306 | 5578577 | 7/9/2017 | 13:36 | overcast | 21.4 | 7/10/2017 | 18.5 | 12:17 | 15.0 | 19.2 | parallel | lower | 22.68 | 20 | 454 | 8 | 10 | 0 | 2 | 0 | |
| 84 | 34B | 11 | 433415 | 5579321 | 7/19/2017 | 12:27 | sunny/smokey | 17.0 | 7/20/2017 | 17.5 | 10:16 | 5.9 | 15.4 | oblique | lower | 21.98 | 20 | 440 | 0 | 20 | 0 | 0 | 0 | |
| 85 | 73B | 11 | 433157 | 5579736 | 7/19/2017 | 12:36 | sunny/smokey | 17.2 | 7/20/2017 | 17.5 | 10:26 | 8.8 | 15.4 | oblique | lower | 21.50 | 20 | 430 | 0 | 20 | 0 | 0 | 0 | |
| 86 | 18B | 11 | 433069 | 5580077 | 7/19/2017 | 12:44 | sunny/smokey | 17.7 | 7/20/2017 | 17.6 | 10:34 | 8.8 | 14.8 | parallel | lower | 21.83 | 19 | 415 | 0 | 19 | 0 | 0 | 0 | |
| 87 | 65B | 11 | 436529 | 5581698 | 7/19/2017 | 12:53 | sunny/smokey | 15.7 | 7/20/2017 | 16.8 | 10:48 | 12.8 | 20.0 | parallel | lower | 21.92 | 20 | 438 | 0 | 20 | 0 | 0 | 0 | |
| 88 | 2B | 11 | 436533 | 5581849 | 7/19/2017 | 13:01 | sunny/smokey | 15.0 | 7/20/2017 | 16.2 | 10:55 | 12.9 | 17.8 | parallel | lower | 21.90 | 20 | 438 | 1 | 18 | 1 | 0 | 0 | |
| 89 | 6B | 11 | 436520 | 5582243 | 7/19/2017 | 13:10 | sunny/smokey | 15.3 | 7/20/2017 | 16.1 | 11:04 | 14.3 | 26.0 | parallel | lower | 21.90 | 20 | 438 | 0 | 20 | 0 | 0 | 0 | |
| 90 | 93B | 11 | 436463 | 5582964 | 7/20/2017 | 11:56 | mostly cloudy | 16.0 | 7/21/2017 | 15.6 | 11:34 | 13.7 | 17.9 | parallel | lower | 23.63 | 20 | 473 | 0 | 20 | 0 | 0 | 0 | |
| 91 | 21B | 11 | 436467 | 5583168 | 7/20/2017 | 12:03 | mostly cloudy | 16.2 | 7/21/2017 | 15.4 | 11:28 | 11.8 | 17.9 | parallel | lower | 23.42 | 20 | 468 | 1 | 17 | 0 | 2 | 0 | |
| 92 | 103B | 11 | 436226 | 5584152 | 7/20/2017 | 12:26 | mostly cloudy | 15.4 | 7/21/2017 | 15.4 | 11:15 | 7.6 | 14.6 | parallel | lower | 22.82 | 20 | 456 | 2 | 13 | 1 | 4 | 0 | |
| 93 | 141B | 11 | 433673 | 5584779 | 7/20/2017 | 12:34 | mostly cloudy | 17.3 | 7/21/2017 | 15.6 | 10:44 | 8.8 | 10.6 | parallel | lower | 22.17 | 20 | 443 | 0 | 20 | 0 | 0 | 0 | |
| 94 | 75B | 11 | 433661 | 5585105 | 7/20/2017 | 12:41 | mostly cloudy | 17.5 | 7/21/2017 | 15.4 | 10:51 | 8.7 | 19.3 | parallel | lower | 22.17 | 20 | 443 | 0 | 20 | 0 | 0 | 0 | |
| 95 | 123B | 11 | 433580 | 5585410 | 7/20/2017 | 12:48 | mostly cloudy | 17.3 | 7/21/2017 | 15.4 | 11:02 | 8.4 | 18.4 | parallel | lower | 22.23 | 20 | 445 | 0 | 20 | 0 | 0 | 0 | |
| 96 | 37B | 11 | 436381 | 5588304 | 7/21/2017 | 12:41 | sunny/windy | 16.0 | 7/22/2017 | 14.0 | 9:39 | 3.2 | 4.1 | oblique | lower | 20.97 | 20 | 419 | 0 | 20 | 0 | 0 | 0 | |
| 97 | 53B | 11 | 436375 | 5588180 | 7/21/2017 | 12:46 | sunny/windy | 15.9 | 7/22/2017 | 14.0 | 9:30 | 6.6 | 9.1 | oblique | lower | 20.73 | 20 | 415 | 1 | 19 | 0 | 0 | 0 | |
| 98 | 131B | 11 | 436459 | 5587929 | 7/21/2017 | 12:52 | sunny/windy | 15.9 | 7/22/2017 | 14.0 | 9:51 | 9.3 | 10.8 | oblique | lower | 20.98 | 20 | 420 | 0 | 20 | 0 | 0 | 0 | |
| 99 | 9B | 11 | 436484 | 5587684 | 7/21/2017 | 12:57 | sunny/windy | 16.0 | 7/22/2017 | 13.7 | 10:01 | 11.8 | 14.7 | oblique | lower | 21.06 | 20 | 421 | 0 | 20 | 0 | 0 | 0 | |
| 100 | 33B | 11 | 436659 | 5587501 | 7/21/2017 | 13:01 | sunny/windy | 16.3 | 7/22/2017 | 13.9 | 10:14 | 10.4 | 15.9 | oblique | lower | 21.22 | 20 | 424 | 5 | 15 | 0 | 0 | 0 | |
| 101 | 101B | 11 | 436712 | 5587754 | 7/21/2017 | 13:09 | sunny/windy | 16.5 | 7/22/2017 | 14.0 | 10:28 | 5.5 | 8.0 | perpendicular | lower | 21.32 | 20 | 426 | 1 | 19 | 0 | 0 | 0 | |
| 102 | 129B | 11 | 432148 | 5591865 | 7/23/2017 | 11:17 | overcast | 16.5 | 7/24/2017 | 11.8 | 10:29 | 8.0 | 13.8 | parallel | lower | 23.20 | 20 | 464 | 1 | 19 | 0 | 0 | 0 | |
| 103 | 49B | 11 | 432188 | 5592321 | 7/23/2017 | 11:25 | overcast | 16.0 | 7/24/2017 | 11.8 | 10:38 | 9.3 | 11.4 | parallel | lower | 23.22 | 20 | 464 | 1 | 19 | 0 | 0 | 0 | |
| 104 | 143B | 11 | 432161 | 5592500 | 7/23/2017 | 11:32 | overcast | 16.5 | 7/24/2017 | 11.5 | 10:47 | 6.8 | 11.4 | parallel | lower | 23.25 | 20 | 465 | 0 | 20 | 0 | 0 | 0 | |
| 105 | 83B | 11 | 435379 | 5593440 | 7/23/2017 | 11:49 | overcast | 14.5 | 7/24/2017 | 10.4 | 11:01 | 8.9 | 16.4 | parallel | lower | 23.20 | 20 | 464 | 0 | 20 | 0 | 0 | 0 | |
| 106 | 87B | 11 | 435412 | 5593639 | 7/23/2017 | 11:55 | overcast | 15.6 | 7/24/2017 | 9.6 | 11:11 | 14.8 | 17.2 | parallel | lower | 23.27 | 20 | 465 | 8 | 12 | 0 | 0 | 0 | |
| 107 | 5B | 11 | 435585 | 5593986 | 7/23/2017 | 12:02 | overcast | 15.7 | 7/24/2017 | 10.2 | 11:19 | 14.7 | 13.8 | parallel | lower | 23.28 | 20 | 466 | 0 | 20 | 0 | 0 | 0 | |
| 108 | 57B | 11 | 432518 | 5596184 | 7/24/2017 | 11:57 | sunny | 11.2 | 7/25/2017 | 12.8 | 11:38 | 8.2 | 11.4 | parallel | lower | 23.68 | 18 | 426 | 0 | 18 | 0 | 0 | 0 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 109 | 97B | 11 | 432616 | 5596483 | 7/24/2017 | 12:03 | sunny/windy | 11.2 | 7/25/2017 | 12.8 | 11:47 | 10.0 | 12.8 | parallel | lower | 23.73 | 20 | 475 | 0 | 20 | 0 | 0 | 0 | |
| 110 | 147B | 11 | 432716 | 5596706 | 7/24/2017 | 12:09 | sunny/windy | 11.1 | 7/25/2017 | 12.9 | 11:56 | 11.2 | 14.3 | parallel | lower | 23.78 | 20 | 476 | 0 | 20 | 0 | 0 | 0 | |
| 111 | 25B | 11 | 435908 | 5597092 | 7/24/2017 | 13:05 | sunny/windy | 10.2 | 7/25/2017 | 12.2 | 12:10 | 10.9 | 13.4 | parallel | lower | 23.08 | 20 | 462 | 0 | 20 | 0 | 0 | 0 | |
| 112 | 117B | 11 | 435785 | 5597771 | 7/24/2017 | 13:14 | sunny/windy | 10.3 | 7/25/2017 | 11.1 | 12:22 | 15.3 | 17.2 | parallel | lower | 23.13 | 20 | 463 | 0 | 20 | 0 | 0 | 0 | |
| 113 | 41B | 11 | 435683 | 5598169 | 7/24/2017 | 13:25 | sunny/windy | 10.0 | 7/25/2017 | 12.4 | 12:34 | 20.4 | 31.3 | parallel | lower | 23.15 | 20 | 463 | 8 | 10 | 1 | 1 | 0 | |
| 114 | ALN01 | 11 | 440947 | 5553777 | 8/9/2017 | 16:50 | sunny/smokey | 20.2 | 8/10/2017 | 19.3 | 9:50 | 10.0 | 12.6 | parallel | lower | 17.00 | 20 | 340 | 0 | 20 | 0 | 0 | 0 | |
| 115 | ALN02 | 11 | 440564 | 5553044 | 8/9/2017 | 16:57 | sunny/smokey | 20.4 | 8/10/2017 | 19.3 | 10:05 | 14.8 | 18.6 | perpendicular | lower | 17.13 | 20 | 343 | 0 | 20 | 0 | 0 | 0 | |
| 116 | ALN03 | 11 | 440483 | 5552055 | 8/9/2017 | 17:09 | sunny/smokey | 19.6 | 8/10/2017 | 19.3 | 10:15 | 9.5 | 11.4 | oblique | lower | 17.10 | 20 | 342 | 0 | 20 | 0 | 0 | 0 | |
| 117 | ALN04 | 11 | 439989 | 5551633 | 8/9/2017 | 17:37 | sunny/smokey | 19.6 | 8/10/2017 | 19.4 | 10:26 | 15.1 | 15.8 | parallel | lower | 16.82 | 20 | 336 | 15 | 5 | 0 | 0 | 0 | |
| 118 | ALN05 | 11 | 439370 | 5551895 | 8/9/2017 | 17:45 | sunny/smokey | 20.0 | 8/10/2017 | 19.6 | 10:50 | 17.5 | 21.1 | perpendicular | lower | 17.08 | 20 | 342 | 10 | 9 | 1 | 0 | 0 | |
| 119 | ALN06 | 11 | 438495 | 5551641 | 8/9/2017 | 17:52 | sunny/smokey | 19.9 | 8/10/2017 | 19.5 | 10:57 | 9.3 | 12.5 | parallel | lower | 17.08 | 20 | 342 | 0 | 20 | 0 | 0 | 0 | |
| 120 | ALN07 | 11 | 432973 | 5548747 | 8/10/2017 | 12:00 | sunny/smokey | 19.4 | 8/11/2017 | 18.2 | 10:05 | 10.2 | 12.7 | parallel | lower | 22.08 | 20 | 442 | 0 | 20 | 0 | 0 | 0 | |
| 121 | ALN08 | 11 | 433503 | 5548616 | 8/10/2017 | 12:06 | sunny/smokey | 19.8 | 8/11/2017 | 18.6 | 10:17 | 3.9 | 6.2 | perpendicular | lower | 22.18 | 20 | 444 | 1 | 19 | 0 | 0 | 0 | |
| 122 | ALN09 | 11 | 433764 | 5547651 | 8/10/2017 | 12:16 | sunny/smokey | 19.9 | 8/11/2017 | 18.2 | 10:33 | 4.6 | 5.0 | perpendicular | lower | 22.28 | 20 | 446 | 1 | 18 | 0 | 1 | 0 | |
| 123 | ALN10 | 11 | 432916 | 5547470 | 8/10/2017 | 12:24 | sunny/smokey | 19.4 | 8/11/2017 | 18.0 | 10:44 | 8.9 | 11.4 | parallel | lower | 22.33 | 20 | 447 | 0 | 20 | 0 | 0 | 0 | |
| 124 | ALN11 | 11 | 433320 | 5546330 | 8/10/2017 | 12:31 | sunny/smokey | 19.3 | 8/11/2017 | 18.3 | 10:55 | 8.1 | 10.2 | parallel | lower | 22.40 | 20 | 448 | 0 | 20 | 0 | 0 | 0 | |
| 125 | ALN12 | 11 | 433673 | 5545453 | 8/10/2017 | 12:40 | sunny/smokey | 19.6 | 8/11/2017 | 19.3 | 11:07 | 6.4 | 7.8 | perpendicular | lower | 22.45 | 20 | 449 | 0 | 20 | 0 | 0 | 0 | |
| 126 | ALN13 | 11 | 433886 | 5544950 | 8/10/2017 | 13:04 | sunny/smokey | 19.6 | 8/11/2017 | 19.3 | 11:20 | 3.8 | 4.9 | perpendicular | lower | 22.27 | 20 | 445 | 0 | 20 | 0 | 0 | 0 | |
| 127 | ALN14 | 11 | 433670 | 5544437 | 8/10/2017 | 13:07 | sunny/smokey | 19.7 | 8/11/2017 | 19.2 | 11:25 | 3.8 | 5.8 | perpendicular | lower | 22.30 | 10 | 223 | 10 | 0 | 0 | 0 | 0 | |
| 128 | 91B | 11 | 432541 | 5603010 | 8/12/2017 | 11:53 | sunny/smokey | 18.2 | 8/13/2017 | 14.0 | 10:41 | 9.6 | 15.6 | parallel | lower | 22.80 | 20 | 456 | 0 | 20 | 0 | 0 | 0 | |
| 129 | 109B | 11 | 432486 | 5603232 | 8/12/2017 | 11:57 | sunny/smokey | 18.3 | 8/13/2017 | 12.8 | 10:56 | 10.4 | 17.4 | parallel | lower | 22.98 | 20 | 460 | 0 | 20 | 0 | 0 | 0 | |
| 130 | 13B | 11 | 432602 | 5603579 | 8/12/2017 | 12:05 | sunny/smokey | 18.1 | 8/13/2017 | 12.8 | 11:17 | 14.1 | 17.5 | parallel | lower | 23.20 | 20 | 464 | 0 | 20 | 0 | 0 | 0 | |
| 131 | 45B | 11 | 435540 | 5604259 | 8/12/2017 | 12:18 | sunny/smokey | 19.5 | 8/13/2017 | 16.9 | 11:33 | 13.0 | 29.6 | parallel | lower | 23.25 | 20 | 465 | 13 | 7 | 0 | 0 | 0 | |
| 132 | 29B | 11 | 435430 | 5604879 | 8/12/2017 | 12:26 | sunny/smokey | 18.7 | 8/13/2017 | 17.9 | 11:44 | 15.5 | 25.0 | parallel | lower | 23.30 | 20 | 466 | 14 | 6 | 0 | 0 | 0 | |
| 133 | 79B | 11 | 435461 | 5604938 | 8/12/2017 | 12:31 | sunny/smokey | 18.6 | 8/13/2017 | 17.6 | 11:54 | 16.4 | 18.2 | parallel | lower | 23.38 | 20 | 468 | 20 | 0 | 0 | 0 | 0 | |
| 134 | 133B | 11 | 433117 | 5605888 | 8/13/2017 | 12:55 | rain | 14.4 | 8/14/2017 | 15.5 | 10:20 | 6.0 | 11.1 | parallel | lower | 21.42 | 20 | 428 | 0 | 20 | 0 | 0 | 0 | |
| 135 | 11B | 11 | 433332 | 5606458 | 8/13/2017 | 13:00 | rain | 14.5 | 8/14/2017 | 15.5 | 10:30 | 8.5 | 21.6 | parallel | lower | 21.50 | 20 | 430 | 2 | 18 | 0 | 0 | 0 | |
| 136 | 70B | 11 | 433479 | 5607168 | 8/13/2017 | 13:10 | rain | 14.8 | 8/14/2017 | 16.3 | 10:40 | 9.9 | 14.6 | parallel | lower | 21.50 | 20 | 430 | 1 | 18 | 0 | 1 | 0 | |
| 137 | 140B | 11 | 436144 | 5605933 | 8/13/2017 | 13:33 | rain | 17.8 | 8/14/2017 | 16.5 | 10:54 | 25.6 | 34.9 | parallel | lower | 21.35 | 20 | 427 | 16 | 2 | 2 | 0 | 0 | |
| 138 | 63B | 11 | 436889 | 5606221 | 8/13/2017 | 13:43 | overcast | 17.7 | 8/14/2017 | 16.8 | 11:15 | 12.4 | 21.8 | parallel | lower | 21.53 | 20 | 431 | 17 | 3 | 0 | 0 | 0 | |
| 139 | 31B | 11 | 437570 | 5606621 | 8/13/2017 | 14:02 | overcast | 17.5 | 8/14/2017 | 17.1 | 11:24 | 12.9 | 17.2 | parallel | lower | 21.37 | 20 | 427 | 5 | 15 | 0 | 0 | 0 | |
| 140 | 81B | 11 | 433574 | 5608916 | 8/14/2017 | 12:36 | overcast | 16.4 | 8/15/2017 | 16.0 | 10:30 | 15.0 | 20.2 | oblique | lower | 21.90 | 20 | 438 | 0 | 20 | 0 | 0 | 0 | |
| 141 | 92B | 11 | 434870 | 5609604 | 8/14/2017 | 12:45 | overcast | 15.4 | 8/15/2017 | 15.9 | 10:41 | 8.4 | 16.2 | parallel | lower | 21.93 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |
| 142 | 47B | 11 | 434747 | 5609776 | 8/14/2017 | 12:58 | overcast | 15.4 | 8/15/2017 | 15.8 | 10:55 | 5.3 | 12.2 | parallel | lower | 21.95 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |
| 143 | 146B | 11 | 438654 | 5608949 | 8/14/2017 | 13:09 | overcast | 17.0 | 8/15/2017 | 16.5 | 11:04 | 7.0 | 9.2 | perpendicular | lower | 21.92 | 20 | 438 | 0 | 18 | 0 | 1 | 0 | |
| 144 | 55B | 11 | 438715 | 5609371 | 8/14/2017 | 13:16 | overcast | 17.2 | 8/15/2017 | 16.7 | 11:13 | 6.2 | 15.3 | perpendicular | lower | 21.95 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |
| 145 | 124B | 11 | 439124 | 5609934 | 8/14/2017 | 13:25 | overcast | 17.2 | 8/15/2017 | 16.8 | 11:22 | 4.8 | 8.2 | parallel | lower | 21.95 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |
| 146 | 148B | 11 | 433950 | 5611759 | 8/15/2017 | 12:53 | overcast/smokey | 17.0 | 8/16/2017 | 16.4 | 10:10 | 16.5 | 17.2 | perpendicular | lower | 21.28 | 20 | 426 | 0 | 20 | 0 | 0 | 0 | |
| 147 | 15B | 11 | 433779 | 5611996 | 8/15/2017 | 12:59 | overcast/smokey | 16.8 | 8/16/2017 | 16.5 | 10:20 | 15.7 | 16.0 | parallel | lower | 21.35 | 20 | 427 | 0 | 20 | 0 | 0 | 0 | |
| 148 | 110B | 11 | 434501 | 5613172 | 8/15/2017 | 13:07 | overcast/smokey | 17.5 | 8/16/2017 | 16.8 | 10:35 | 17.5 | 18.2 | perpendicular | lower | 21.47 | 20 | 429 | 5 | 15 | 0 | 0 | 0 | |
| 149 | 118B | 11 | 434416 | 5613575 | 8/15/2017 | 13:14 | overcast/smokey | 17.6 | 8/16/2017 | 16.8 | 11:11 | 14.0 | 15.4 | perpendicular | lower | 21.95 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | 43B | 11 | 434087 | 5614074 | 8/15/2017 | 13:24 | overcast/smokey | 17.3 | 8/16/2017 | 16.8 | 11:19 | 15.5 | 15.5 | perpendicular | lower | 21.92 | 20 | 438 | 0 | 20 | 0 | 0 | 0 | |
| 151 | 27B | 11 | 433854 | 5614374 | 8/15/2017 | 13:30 | overcast/smokey | 17.3 | 8/16/2017 | 16.6 | 11:30 | 14.7 | 15.8 | perpendicular | lower | 22.00 | 19 | 418 | 0 | 19 | 0 | 0 | 0 | |
| 152 | 27A | 11 | 433964 | 5614500 | 8/16/2017 | 12:19 | sunny/smokey | 16.6 | 8/17/2017 | 16.8 | 9:25 | 13.4 | 15.1 | perpendicular | lower | 21.10 | 20 | 422 | 0 | 20 | 0 | 0 | 0 | |
| 153 | 98B | 11 | 433456 | 5614918 | 8/16/2017 | 12:25 | sunny/smokey | 16.8 | 8/17/2017 | 17.0 | 9:34 | 13.1 | 14.0 | perpendicular | lower | 21.15 | 19 | 402 | 0 | 19 | 0 | 0 | 0 | |
| 154 | 89B | 11 | 433185 | 5615414 | 8/16/2017 | 12:32 | sunny/smokey | 16.9 | 8/17/2017 | 17.1 | 9:41 | 12.3 | 12.8 | perpendicular | lower | 21.15 | 20 | 423 | 0 | 20 | 0 | 0 | 0 | |
| 155 | 59B | 11 | 432910 | 5615742 | 8/16/2017 | 12:38 | sunny/smokey | 16.9 | 8/17/2017 | 17.3 | 9:50 | 12.0 | 13.9 | perpendicular | lower | 21.20 | 20 | 424 | 0 | 20 | 0 | 0 | 0 | |
| 156 | 3B | 11 | 432399 | 5616403 | 8/16/2017 | 12:45 | sunny/smokey | 16.9 | 8/17/2017 | 17.2 | 10:00 | 10.1 | 11.4 | perpendicular | lower | 21.25 | 20 | 425 | 0 | 20 | 0 | 0 | 0 | |
| 157 | 102B | 11 | 432155 | 5616818 | 8/16/2017 | 12:50 | sunny/smokey | 16.9 | 8/17/2017 | 16.9 | 10:10 | 9.3 | 11.3 | perpendicular | lower | 21.33 | 20 | 427 | 0 | 20 | 0 | 0 | 0 | |
| 158 | 19B | 11 | 431868 | 5617358 | 8/23/2017 | 11:34 | sunny | 17.7 | 8/24/2017 | 16.8 | 10:33 | 8.8 | 11.8 | perpendicular | lower | 22.98 | 20 | 460 | 8 | 12 | 0 | 0 | 0 | |
| 159 | 35B | 11 | 431745 | 5618101 | 8/23/2017 | 11:45 | sunny | 18.0 | 8/24/2017 | 18.1 | 11:15 | 10.2 | 10.6 | perpendicular | lower | 23.50 | 20 | 470 | 5 | 15 | 0 | 0 | 0 | |
| 160 | 113B | 11 | 431589 | 5618691 | 8/23/2017 | 11:54 | sunny | 17.6 | 8/24/2017 | 17.7 | 11:28 | 17.7 | 17.9 | perpendicular | lower | 23.57 | 20 | 471 | 8 | 12 | 0 | 0 | 0 | |
| 161 | 127B | 11 | 431617 | 5619129 | 8/23/2017 | 12:01 | sunny | 17.5 | 8/24/2017 | 17.9 | 11:35 | 5.9 | 6.3 | perpendicular | lower | 23.57 | 20 | 471 | 5 | 15 | 0 | 0 | 0 | |
| 162 | 62B | 11 | 431761 | 5619526 | 8/23/2017 | 12:10 | sunny | 18.4 | 8/24/2017 | 18.2 | 11:47 | 17.0 | 17.2 | perpendicular | lower | 23.62 | 20 | 472 | 3 | 17 | 0 | 0 | 0 | |
| 163 | 46C | 11 | 431669 | 5619820 | 8/23/2017 | 12:18 | sunny | 18.7 | 8/24/2017 | 17.0 | 11:58 | 15.2 | 16.7 | perpendicular | lower | 23.67 | 20 | 473 | 5 | 15 | 0 | 0 | 0 | |
| 164 | 99C | 11 | 431335 | 5620359 | 8/24/2017 | 12:49 | overcast | 17.3 | 8/25/2017 | 10.8 | 10:40 | 14.9 | 15.5 | oblique | lower | 21.85 | 20 | 437 | 0 | 20 | 0 | 0 | 0 | |
| 165 | 149C | 11 | 431047 | 5620877 | 8/24/2017 | 12:57 | overcast | 14.5 | 8/25/2017 | 10.8 | 10:54 | 14.4 | 14.7 | perpendicular | lower | 21.95 | 20 | 439 | 0 | 20 | 0 | 0 | 0 | |
| 166 | 144C | 11 | 430828 | 5621642 | 8/24/2017 | 13:06 | overcast | 15.0 | 8/25/2017 | 10.9 | 11:05 | 16.1 | 17.3 | perpendicular | lower | 21.98 | 20 | 440 | 0 | 20 | 0 | 0 | 0 | |
| 167 | 130C | 11 | 430346 | 5622402 | 8/24/2017 | 13:12 | overcast | 12.4 | 8/25/2017 | 10.9 | 11:15 | 14.3 | 17.8 | perpendicular | lower | 22.05 | 20 | 441 | 0 | 20 | 0 | 0 | 0 | |
| 168 | 51C | 11 | 430364 | 5622563 | 8/24/2017 | 13:17 | overcast | 11.4 | 8/25/2017 | 10.8 | 11:26 | 10.4 | 11.4 | parallel | lower | 22.15 | 20 | 443 | 1 | 19 | 0 | 0 | 0 | |
| 169 | 84C | 11 | 430180 | 5623144 | 8/24/2017 | 13:24 | overcast | 11.4 | 8/25/2017 | 10.8 | 11:30 | 7.1 | 8.2 | perpendicular | lower | 22.10 | 20 | 442 | 0 | 20 | 0 | 0 | 0 | |
| 170 | 7C | 11 | 429569 | 5623940 | 8/25/2017 | 12:43 | overcast/windy | 10.7 | 8/26/2017 | 11.3 | 10:26 | 6.5 | 8.0 | perpendicular | lower | 21.72 | 20 | 434 | 0 | 20 | 0 | 0 | 0 | Lost 1 bouy |
| 171 | 76C | 11 | 429259 | 5624720 | 8/25/2017 | 12:51 | overcast | 10.7 | 8/26/2017 | 11.1 | 10:50 | 16.8 | 17.2 | perpendicular | lower | 21.98 | 20 | 440 | 0 | 20 | 0 | 0 | 1 | PIT: 985121021237435 |
| 172 | 23C | 11 | 428985 | 5625234 | 8/25/2017 | 12:59 | overcast | 10.7 | 8/26/2017 | 11.2 | 11:00 | 5.7 | 6.3 | perpendicular | lower | 22.02 | 20 | 440 | 11 | 9 | 0 | 0 | 0 | |
| 173 | 105C | 11 | 429334 | 5625900 | 8/25/2017 | 13:06 | overcast | 10.7 | 8/26/2017 | 10.6 | 11:14 | 17.5 | 18.4 | perpendicular | lower | 22.13 | 20 | 443 | 2 | 18 | 0 | 0 | 0 | |
| 174 | 142C | 11 | 428951 | 5625820 | 8/25/2017 | 13:17 | overcast | 10.8 | 8/26/2017 | 10.4 | 11:20 | 4.8 | 7.0 | perpendicular | lower | 22.05 | 20 | 441 | 1 | 19 | 0 | 0 | 0 | |
| 175 | 39C | 11 | 429006 | 5626504 | 8/25/2017 | 13:26 | overcast | 10.8 | 8/26/2017 | 10.5 | 11:45 | 15.5 | 19.0 | perpendicular | lower | 22.32 | 20 | 446 | 0 | 20 | 0 | 0 | 0 | Snagged on bottom, everything retrieved |
| 176 | 116C | 11 | 429030 | 5627332 | 8/26/2017 | 12:46 | sunny | 10.5 | 8/27/2017 | 11.8 | 11:08 | 16.3 | 16.4 | perpendicular | lower | 22.37 | 20 | 447 | 0 | 20 | 0 | 0 | 0 | |
| 177 | 24C | 11 | 428749 | 5628302 | 8/26/2017 | 12:58 | sunny | 10.8 | 8/27/2017 | 12.1 | 11:20 | 8.9 | 13.4 | oblique | lower | 22.37 | 20 | 447 | 8 | 12 | 0 | 0 | 0 | |
| 178 | 40C | 11 | 428179 | 5628848 | 8/26/2017 | 13:07 | sunny | 10.6 | 8/27/2017 | 11.6 | 11:30 | 8.0 | 8.3 | oblique | lower | 22.38 | 20 | 448 | 0 | 20 | 0 | 0 | 0 | |
| 179 | 86C | 11 | 427784 | 5628837 | 8/26/2017 | 13:13 | sunny | 10.8 | 8/27/2017 | 11.6 | 11:39 | 8.2 | 12.8 | perpendicular | lower | 22.43 | 20 | 449 | 0 | 20 | 0 | 0 | 0 | |
| 180 | 56C | 11 | 427333 | 5629112 | 8/26/2017 | 13:20 | sunny | 10.7 | 8/27/2017 | 11.7 | 12:30 | 15.3 | 16.2 | perpendicular | lower | 23.17 | 20 | 463 | 0 | 20 | 0 | 0 | 1 | PIT: NA Reader Malfunction |
| 181 | 68C | 11 | 426845 | 5629229 | 8/26/2017 | 13:27 | sunny | 10.9 | 8/27/2017 | 12.7 | 12:45 | 14.6 | 15.1 | perpendicular | lower | 23.30 | 20 | 466 | 0 | 20 | 0 | 0 | 0 | |
| 182 | 8C | 11 | 426648 | 5629375 | 8/27/2017 | 13:36 | sunny | 12.7 | 8/28/2017 | 11.6 | 10:25 | 14.1 | 14.4 | perpendicular | lower | 20.82 | 20 | 416 | 12 | 8 | 0 | 0 | 0 | |
| 183 | 106C | 11 | 426200 | 5629716 | 8/27/2017 | 13:44 | sunny | 13.3 | 8/28/2017 | 11.5 | 10:54 | 13.3 | 14.1 | perpendicular | lower | 21.17 | 20 | 423 | 10 | 10 | 0 | 0 | 1 | PIT: 985121021006766 |
| 184 | 28C | 11 | 425993 | 5629876 | 8/27/2017 | 13:50 | sunny | 12.9 | 8/28/2017 | 11.6 | 11:18 | 15.7 | 16.2 | perpendicular | lower | 21.47 | 20 | 429 | 13 | 6 | 1 | 0 | 0 | |
| 185 | 96C | 11 | 425624 | 5630829 | 8/27/2017 | 13:59 | sunny | 13.3 | 8/28/2017 | 12.1 | 11:26 | 6.7 | 8.0 | perpendicular | lower | 21.45 | 20 | 429 | 16 | 4 | 0 | 0 | 0 | |
| 186 | 134C | 11 | 425157 | 5631465 | 8/27/2017 | 14:09 | sunny | 13.9 | 8/28/2017 | 11.9 | 11:35 | 11.1 | 12.2 | perpendicular | lower | 21.43 | 20 | 429 | 17 | 3 | 0 | 0 | 0 | |
| 187 | 108C | 11 | 424903 | 5631919 | 8/27/2017 | 14:17 | sunny | 13.3 | 8/28/2017 | 11.8 | 11:47 | 6.1 | 6.7 | perpendicular | lower | 21.50 | 20 | 430 | 11 | 9 | 0 | 0 | 0 | |
| 188 | 12C | 11 | 425052 | 5632200 | 8/28/2017 | 12:46 | sunny | 12.1 | 8/29/2017 | 11.1 | 10:30 | 14.1 | 16.8 | perpendicular | lower | 21.73 | 20 | 435 | 11 | 9 | 0 | 0 | 0 | |
| 189 | 122C | 11 | 424359 | 5633016 | 8/28/2017 | 12:55 | sunny | 12.0 | 8/29/2017 | 10.9 | 10:44 | 11.8 | 13.2 | perpendicular | lower | 21.82 | 20 | 436 | 1 | 19 | 0 | 0 | 0 | |

| | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 190 | 36C | 11 | 423744 | 5633145 | 8/28/2017 | 13:02 | sunny | 13.0 | 8/29/2017 | 11.2 | 10:55 | 6.2 | 7.4 | oblique | lower | 21.88 | 20 | 438 | 12 | 8 | 0 | 0 | 0 | |
| 191 | 52C | 11 | 423026 | 5633247 | 8/28/2017 | 13:11 | sunny | 11.1 | 8/29/2017 | 11.1 | 11:10 | 15.2 | 17.3 | perpendicular | lower | 21.98 | 20 | 440 | 11 | 9 | 0 | 0 | 0 | |
| 192 | 94C | 11 | 422784 | 5633517 | 8/28/2017 | 13:19 | sunny | 11.1 | 8/29/2017 | 10.2 | 11:24 | 13.2 | 17.1 | perpendicular | lower | 22.08 | 20 | 442 | 14 | 6 | 0 | 0 | 0 | |
| 193 | 114C | 11 | 422177 | 5634074 | 8/28/2017 | 13:30 | sunny | 10.7 | 8/29/2017 | 10.1 | 11:34 | 14.2 | 14.4 | perpendicular | lower | 22.07 | 20 | 441 | 7 | 13 | 0 | 0 | 0 | |
| 194 | 76D | 11 | 429196 | 5624746 | 9/7/2017 | 10:37 | sunny/smokey | 11.7 | 9/8/2017 | 12.2 | 10:00 | 15.3 | 16.0 | perpendicular | lower | 23.38 | 20 | 468 | 0 | 20 | 0 | 0 | 0 | |
| 195 | 23D | 11 | 429194 | 5625251 | 9/7/2017 | 10:46 | sunny/smokey | 11.5 | 9/8/2017 | 10.9 | 10:12 | 4.1 | 13.5 | perpendicular | lower | 23.43 | 20 | 469 | 0 | 20 | 0 | 0 | 0 | |
| 196 | 105D | 11 | 428916 | 5625603 | 9/7/2017 | 10:57 | sunny/smokey | 11.6 | 9/8/2017 | 10.6 | 10:32 | 4.2 | 5.3 | perpendicular | lower | 23.58 | 20 | 472 | 0 | 20 | 0 | 0 | 0 | |
| 197 | 142D | 11 | 429358 | 5625894 | 9/7/2017 | 11:05 | sunny/smokey | 11.5 | 9/8/2017 | 10.7 | 10:37 | 11.4 | 17.2 | perpendicular | lower | 23.53 | 20 | 471 | 0 | 20 | 0 | 0 | 0 | |
| 198 | 39D | 11 | 428862 | 5625931 | 9/7/2017 | 12:25 | sunny/smokey | 12.3 | 9/8/2017 | 10.8 | 12:31 | 2.3 | 5.3 | perpendicular | lower | 24.10 | 20 | 482 | 0 | 20 | 0 | 0 | 0 | |
| 199 | 116D | 11 | 428932 | 5627223 | 9/7/2017 | 12:35 | sunny/smokey | 11.8 | 9/8/2017 | 11.3 | 12:46 | 14.2 | 14.5 | perpendicular | lower | 24.18 | 10 | 242 | 0 | 10 | 0 | 0 | 0 | |
| 200 | 24D | 11 | 428952 | 5628295 | 9/7/2017 | 12:52 | sunny/smokey | 11.9 | 9/8/2017 | 10.8 | 12:57 | 11.8 | 14.4 | perpendicular | lower | 24.08 | 20 | 482 | 0 | 20 | 0 | 0 | 0 | |
| 201 | 40D | 11 | 428221 | 5629101 | 9/7/2017 | 13:04 | sunny/smokey | 11.6 | 9/8/2017 | 12.2 | 12:45 | 13.1 | 14.0 | oblique | lower | 23.68 | 20 | 474 | 0 | 20 | 0 | 0 | 0 | |
| 202 | 86D | 11 | 427856 | 5628933 | 9/8/2017 | 11:10 | sunny/smokey | 10.7 | 9/9/2017 | 10.7 | 10:08 | 11.7 | 13.4 | perpendicular | lower | 22.97 | 20 | 459 | 1 | 19 | 0 | 0 | 0 | |
| 203 | 56D | 11 | 427451 | 5629049 | 9/8/2017 | 11:18 | sunny/smokey | 10.8 | 9/9/2017 | 11.0 | 10:16 | 15.9 | 16.4 | oblique | lower | 22.97 | 20 | 459 | 0 | 20 | 0 | 0 | 0 | |
| 204 | 68D | 11 | 427628 | 5628745 | 9/8/2017 | 11:29 | sunny/smokey | 10.5 | 9/9/2017 | 10.3 | 10:24 | 5.8 | 6.2 | perpendicular | lower | 22.92 | 20 | 458 | 0 | 20 | 0 | 0 | 0 | |
| 205 | 8D | 11 | 426658 | 5629297 | 9/8/2017 | 11:37 | sunny/smokey | 10.7 | 9/9/2017 | 10.2 | 10:38 | 14.8 | 15.5 | oblique | lower | 23.02 | 20 | 460 | 0 | 20 | 0 | 0 | 0 | |
| 206 | 106D | 11 | 426322 | 5629715 | 9/8/2017 | 13:45 | sunny/smokey | 11.5 | 9/9/2017 | 11.6 | 12:46 | 12.2 | 12.9 | perpendicular | lower | 23.02 | 20 | 460 | 3 | 16 | 1 | 0 | 0 | |
| 207 | 28D | 11 | 426038 | 5629943 | 9/8/2017 | 13:53 | sunny/smokey | 11.1 | 9/9/2017 | 10.2 | 12:56 | 12.2 | 13.5 | perpendicular | lower | 23.05 | 10 | 231 | 0 | 10 | 0 | 0 | 0 | |
| 208 | 96D | 11 | 425438 | 5630714 | 9/8/2017 | 14:05 | sunny/smokey | 10.8 | 9/9/2017 | 10.0 | 13:06 | 5.5 | 5.9 | perpendicular | lower | 23.02 | 20 | 460 | 0 | 20 | 0 | 0 | 0 | |
| 209 | 134D | 11 | 425369 | 5631643 | 9/8/2017 | 14:13 | sunny/smokey | 10.6 | 9/9/2017 | 10.1 | 13:17 | 9.0 | 11.0 | perpendicular | lower | 23.07 | 20 | 461 | 8 | 11 | 1 | 0 | 0 | |
| 210 | 108D | 11 | 425179 | 5631923 | 9/9/2017 | 11:23 | overcast/foggy/rain | 10.4 | 9/10/2017 | 10.4 | 9:54 | 12.7 | 15.1 | perpendicular | lower | 22.52 | 20 | 450 | 0 | 20 | 0 | 0 | 0 | |
| 211 | 12D | 11 | 424809 | 5632355 | 9/9/2017 | 11:31 | overcast/foggy/rain | 10.4 | 9/10/2017 | 10.2 | 10:10 | 10.8 | 11.9 | perpendicular | lower | 22.65 | 20 | 453 | 6 | 14 | 0 | 0 | 0 | |
| 212 | 122D | 11 | 424215 | 5632435 | 9/9/2017 | 11:46 | overcast/foggy/rain | 10.5 | 9/10/2017 | 10.2 | 10:20 | 6.9 | 15.6 | perpendicular | lower | 22.57 | 20 | 451 | 8 | 12 | 0 | 0 | 0 | |
| 213 | 36D | 11 | 423901 | 5632865 | 9/9/2017 | 11:55 | overcast/foggy/rain | 9.7 | 9/10/2017 | 10.4 | 10:30 | 12.5 | 14.7 | perpendicular | lower | 22.58 | 20 | 452 | 13 | 7 | 0 | 0 | 0 | |
| 214 | 52D | 11 | 423093 | 5633263 | 9/9/2017 | 13:50 | overcast/foggy/rain | 10.2 | 9/10/2017 | 10.6 | 12:58 | 14.9 | 15.4 | perpendicular | lower | 23.13 | 20 | 463 | 9 | 11 | 0 | 0 | 1 | Pit tag #: 985121021058457<br>Secci disc - 0.80m,<br>lavage - warm only.<br>Pectoral fins deformed |
| 215 | 94D | 11 | 422777 | 5633518 | 9/9/2017 | 13:56 | overcast/foggy/rain | 10.2 | 9/10/2017 | 11.0 | 13:19 | 14.9 | 15.3 | perpendicular | lower | 23.38 | 20 | 468 | 13 | 7 | 0 | 0 | 0 | |
| 216 | 114D | 11 | 421928 | 5634102 | 9/9/2017 | 14:05 | overcast/foggy/rain | 10.4 | 9/10/2017 | 10.6 | 13:27 | 10.3 | 13.3 | perpendicular | lower | 23.37 | 10 | 234 | 2 | 8 | 0 | 0 | 0 | |
| 217 | 74D | 11 | 421669 | 5634298 | 9/9/2017 | 14:15 | overcast/foggy/rain | 10.3 | 9/10/2017 | 10.7 | 13:36 | 8.1 | 10.3 | perpendicular | lower | 23.35 | 20 | 467 | 4 | 16 | 0 | 0 | 0 | |
| 218 | 20D | 11 | 421647 | 5635436 | 9/10/2017 | 11:08 | partly cloudy | 10.5 | 9/11/2017 | 10.4 | 10:20 | 6.9 | 8.8 | perpendicular | lower | 23.20 | 20 | 464 | 10 | 10 | 0 | 0 | 0 | |
| 219 | 4D | 11 | 421788 | 5636185 | 9/10/2017 | 11:29 | partly cloudy | 10.9 | 9/11/2017 | 10.5 | 10:30 | 6.1 | 8.2 | perpendicular | lower | 23.02 | 20 | 460 | 0 | 20 | 0 | 0 | 0 | |
| 220 | 138D | 11 | 421895 | 5636635 | 9/10/2017 | 11:37 | partly cloudy | 11.4 | 9/11/2017 | 10.1 | 10:40 | 4.3 | 4.6 | perpendicular | lower | 23.05 | 20 | 461 | 5 | 15 | 0 | 0 | 0 | |
| 221 | 66D | 11 | 422234 | 5637017 | 9/10/2017 | 11:47 | partly cloudy | 11.6 | 9/11/2017 | 10.4 | 11:56 | 6.6 | 7.5 | perpendicular | lower | 24.15 | 20 | 483 | 12 | 8 | 0 | 0 | 0 | |
| 222 | 68E | 11 | 425454 | 5630026 | 9/10/2017 | 14:10 | partly cloudy | 11.0 | 9/11/2017 | 10.0 | 11:50 | 10.0 | 16.2 | perpendicular | lower | 21.67 | 20 | 433 | 17 | 3 | 0 | 0 | 0 | |
| 223 | 138E | 11 | 426219 | 5629757 | 9/10/2017 | 14:16 | partly cloudy | 11.1 | 9/11/2017 | 10.0 | 11:58 | 12.6 | 12.7 | perpendicular | lower | 21.70 | 20 | 434 | 10 | 10 | 0 | 0 | 0 | |
| 224 | 4E | 11 | 426765 | 5629251 | 9/10/2017 | 14:24 | partly cloudy | 11.0 | 9/11/2017 | 10.6 | 13:39 | 13.0 | 14.9 | perpendicular | lower | 23.25 | 20 | 465 | 3 | 17 | 0 | 0 | 0 | |
| 225 | 20E | 11 | 427213 | 5629031 | 9/10/2017 | 14:33 | partly cloudy | 10.3 | 9/11/2017 | 10.1 | 13:15 | 13.9 | 17.2 | perpendicular | lower | 22.70 | 20 | 454 | 1 | 18 | 0 | 1 | 1 | Pit tag #: 985121021069957,<br>caught twice in the same week.<br>Sicci disc - 0.80m, lavage done<br>and ponar complete |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 226 | 142E | 11 | 425760 | 5629564 | 9/11/2017 | 12:33 | sunny | 10.1 | 9/12/2017 | 9.7 | 9:56 | 8.5 | 10.7 | oblique | lower | 21.38 | 20 | 428 | 10 | 10 | 0 | 0 | 0 | |
| 227 | 105E | 11 | 425695 | 5629927 | 9/11/2017 | 12:43 | sunny | 10.2 | 9/12/2017 | 9.4 | 10:09 | 4.5 | 7.1 | oblique | lower | 21.43 | 20 | 429 | 0 | 20 | 0 | 0 | 0 | |
| 228 | 116E | 11 | 425987 | 5629960 | 9/11/2017 | 12:48 | sunny | 10.0 | 9/12/2017 | 9.6 | 10:20 | 12.7 | 14.6 | parallel | lower | 21.53 | 20 | 431 | 1 | 19 | 0 | 0 | 0 | |
| 229 | 39E | 11 | 427506 | 5628962 | 9/11/2017 | 12:58 | sunny | 10.1 | 9/12/2017 | 9.5 | 10:32 | 9.9 | 15.4 | perpendicular | lower | 21.57 | 20 | 431 | 1 | 19 | 0 | 0 | 0 | |
| 230 | 7E | 11 | 427777 | 5629175 | 9/11/2017 | 14:15 | sunny | 10.7 | 9/12/2017 | 9.9 | 10:55 | 12.7 | 13.2 | perpendicular | lower | 20.67 | 20 | 413 | 0 | 20 | 0 | 0 | 0 | |
| 231 | 84E | 11 | 428180 | 5629220 | 9/11/2017 | 14:23 | sunny | 10.6 | 9/12/2017 | 10.0 | 11:07 | 14.4 | 15.0 | oblique | lower | 20.73 | 20 | 415 | 0 | 20 | 0 | 0 | 0 | |
| 232 | 23E | 11 | 428684 | 5628800 | 9/11/2017 | 14:28 | sunny | 10.4 | 9/12/2017 | 9.5 | 11:24 | 8.5 | 16.4 | perpendicular | lower | 20.93 | 20 | 419 | 0 | 20 | 0 | 0 | 0 | |
| 233 | 76E | 11 | 428924 | 5628411 | 9/11/2017 | 14:36 | sunny | 10.4 | 9/12/2017 | 9.9 | 11:35 | 12.4 | 14.1 | oblique | lower | 20.98 | 20 | 420 | 0 | 20 | 0 | 0 | 0 | |

*Note: B = Baited, BL = Baitless, F = Fouled, L = Lost

# Setline Bycatch

| Pull Date | Site | Set | Species | Life Stage | Quantity | Live | Dead | Mortality Rate (%) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 6/7/2017 | 66B | 1 | CSU | A | 1 | 1 | 0 | 0 | 410mm |
| 6/7/2017 | 66B | 1 | NSC | A | 1 | 1 | 0 | 0 | 385mm |
| 6/8/2017 | 114B | 6 | CSU | A | 1 | 1 | 0 | 0 | 410.5mm |
| 6/8/2017 | 94B | 7 | CSU | A | 2 | 2 | 0 | 0 | 430mm, 405mm |
| 6/8/2017 | 122B | 10 | CSU | A | 1 | 1 | 0 | 0 | 400mm |
| 6/9/2017 | 8B | 17 | CSU | A | 1 | 1 | 0 | 0 | 470mm |
| 6/9/2017 | 68B | 18 | CSU | A | 1 | 1 | 0 | 0 | 470mm |
| 6/10/2017 | 116B | 23 | BB | A | 1 | 1 | 0 | 0 | 745mm |
| 6/10/2017 | 116B | 23 | Peamouth Chub | A | 1 | 0 | 1 | 1 | 220mm - In burbot mouth |
| 6/10/2017 | 39B | 24 | BB | A | 2 | 2 | 0 | 0 | 530mm, 660mm |
| 6/11/2017 | 130B | 32 | BB | A | 4 | 3 | 1 | 0.25 | 585mm, 400mm, 575mm, N/A (released due to condition) |
| 6/11/2017 | 144B | 33 | BB | A | 2 | 2 | 0 | 0 | 600mm, got off hook |
| 6/11/2017 | 149B | 34 | BB | A | 1 | 1 | 0 | 0 | 500mm |
| 6/11/2017 | 99B | 35 | BB | A | 1 | 1 | 0 | 0 | 700mm |
| 6/12/2017 | S128B | 37 | BB | A | 1 | 1 | 0 | 0 | 820mm |
| 6/12/2017 | S150B | 38 | BB | A | 2 | 2 | 0 | 0 | 500mm, 870mm |
| 6/12/2017 | S48B | 40 | BB | A | 1 | 1 | 0 | 0 | 700mm |
| 6/12/2017 | S134B | 41 | BB | A | 3 | 2 | 1 | 0.333333333 | 550mm (DOA), 380mm, 650mm |
| 6/12/2017 | S126B | 44 | BB | A | 2 | 2 | 0 | 0 | 550mm, 650mm |
| 6/28/2017 | 126B | 45 | BB | A | 9 | 4 | 5 | 0.555555556 | 450mm,600mm,555mm,630mm,560mm,545mm,505mm,550mm,505mm |
| 6/28/2017 | 90B | 46 | BB | A | 1 | 1 | 0 | 0 | 530mm |
| 6/28/2017 | 44B | 47 | BB | A | 6 | 6 | 0 | 0 | 560mm,560mm,610mm,550mm,460mm,580mm |
| 6/28/2017 | 78B | 48 | BB | A | 1 | 1 | 0 | 0 | 490mm |
| 6/28/2017 | 32B | 49 | BB | A | 2 | 2 | 0 | 0 | 415mm,545mm |
| 6/30/2017 | 136B | 53 | BB | A | 1 | 1 | 0 | 0 | length N/R got off hook - he was eating peamouth (240mm) |
| 6/30/2017 | 136B | 53 | Peamouth Chub | A | 1 | 0 | 1 | 1 | 240mm - partially eaten by burbot |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7/6/2017 | 128B | 54 | BB | A | 1 | 0 | 1 | 1 | 640mm |
| 7/6/2017 | 48B | 55 | BB | A | 2 | 1 | 1 | 0.5 | 580, 620mm |
| 9/10/2017 | 108D | 56 | Peamouth Chub | J | 1 | 0 | 1 | 1 | 235mm |
| 7/6/2017 | 100B | 57 | BB | A | 1 | 0 | 1 | 1 | 580mm |
| 7/6/2017 | 150B | 58 | BB | A | 2 | 2 | 0 | 0 | 570, 460mm |
| 7/6/2017 | 120B | 59 | Peamouth Chub | A | 1 | 0 | 1 | 1 | 270mm |
| 7/7/2017 | 77B | 61 | BB | A | 1 | 0 | 1 | 1 | 610mm |
| 7/7/2017 | 107B | 62 | BB | A | 1 | 1 | 0 | 0 | 575mm |
| 7/7/2017 | 119B | 64 | BB | A | 1 | 1 | 0 | 0 | 410mm |
| 7/8/2017 | 71B | 66 | BB | A | 2 | 2 | 0 | 0 | 550, 400mm |
| 7/8/2017 | 125B | 67 | BB | J | 1 | 1 | 0 | 0 | 370mm |
| 7/8/2017 | 88B | 68 | BB | A | 1 | 1 | 0 | 0 | 565, 570mm |
| 7/8/2017 | 42B | 71 | BB | A | 7 | 5 | 2 | 0.285714286 | 620, 530, 385, 585, 425, 570, 565mm |
| 7/9/2017 | 38B | 72 | BB | A | 1 | 1 | 0 | 0 | 540mm |
| 7/9/2017 | 95B | 77 | BB | A | 1 | 1 | 0 | 0 | 545mm |
| 7/10/2017 | 54B | 79 | BB | A | 1 | 0 | 1 | 1 | 510mm |
| 7/10/2017 | 10B | 81 | BB | A | 4 | 2 | 2 | 0.5 | 605, 545, 560mm, NR |
| 7/10/2017 | 50B | 83 | BB | A | 1 | 1 | 0 | 0 | 565mm |
| 7/22/2017 | 33B | 100 | BB | A | 1 | 1 | 0 | 0 | 555mm |
| 7/25/2017 | 117B | 112 | BB | A | 1 | 1 | 0 | 0 | 450mm |
| 8/10/2017 | ALN03 | 116 | Peamouth Chub | A | 1 | 0 | 1 | 1 | 265mm |
| 8/10/2017 | ALN04 | 117 | BB | A | 1 | 0 | 1 | 1 | 630mm |
| 8/10/2017 | ALN05 | 118 | BB | A | 2 | 2 | 0 | 0 | 505mm, 530mm |
| 8/11/2017 | ALN08 | 121 | NSC | A | 1 | 0 | 1 | 1 | 440mm |
| 8/13/2017 | 91B | 128 | BB | A | 1 | 0 | 1 | 1 | 590mm |
| 8/13/2017 | 109B | 129 | BB | A | 1 | 0 | 1 | 1 | 520mm |
| 8/13/2017 | 109B | 129 | NSC | A | 1 | 1 | 0 | 0 | escaped |
| 8/13/2017 | 13B | 130 | BB | A | 2 | 2 | 0 | 0 | 580mm, 445mm |
| 8/13/2017 | 45B | 131 | BB | A | 1 | 1 | 0 | 0 | 560mm |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8/13/2017 | 29B | 132 | BB | A | 1 | 1 | 0 | 0 | 520mm |
| 8/13/2017 | 79B | 133 | BB | A | 1 | 1 | 0 | 0 | 450mm |
| 8/14/2017 | 140B | 137 | BB | A | 1 | 0 | 1 | 1 | 560mm |
| 8/14/2017 | 63B | 138 | BB | A | 1 | 1 | 0 | 0 | 540mm |
| 8/15/2017 | 81B | 140 | BB | A | 1 | 1 | 0 | 0 | 550mm |
| 8/16/2017 | 110B | 148 | BB | A | 5 | 2 | 3 | 0.6 | 460, 535, 480, 520mm, NR |
| 8/16/2017 | 110B | 148 | NSC | A | 1 | 0 | 1 | 1 | 340mm |
| 8/16/2017 | 118B | 149 | BB | A | 1 | 1 | 0 | 0 | 580mm |
| 8/17/2017 | 27A | 152 | BB | A | 1 | 1 | 0 | 0 | 550mm |
| 8/24/2017 | 19B | 158 | BB | A | 8 | 7 | 1 | 0.125 | 560, 575, 505, 545, 500, 520, 500, 770mm |
| 8/24/2017 | 19B | 158 | NSC | A | 1 | 1 | 0 | 0 | 350mm |
| 8/24/2017 | 35B | 159 | BB | A | 3 | 3 | 0 | 0 | 525mm, 580mm, 515mm |
| 8/24/2017 | 113B | 160 | BB | A | 3 | 3 | 0 | 0 | 605mm, 580mm, NR |
| 8/24/2017 | 62B | 162 | BB | A | 1 | 1 | 0 | 0 | 510mm |
| 8/24/2017 | 46C | 163 | BB | A | 1 | 1 | 0 | 0 | 575mm |
| 8/25/2017 | 99C | 164 | BB | A | 1 | 1 | 0 | 0 | 595mm |
| 8/25/2017 | 144C | 166 | BB | A | 1 | 1 | 0 | 0 | 550mm |
| 8/25/2017 | 130C | 167 | BB | A | 1 | 1 | 0 | 0 | 52, also espaced unidentified silver fish, RB swimming around line. |
| 8/25/2017 | 51C | 168 | BB | A | 1 | 1 | 0 | 0 | 610mm |
| 8/26/2017 | 105C | 173 | BB | A | 1 | 1 | 0 | 0 | 535mm |
| 8/27/2017 | 116C | 176 | BB | A | 4 | 3 | 1 | 0.25 | 480mm, 575mm, 365mm, 400mm |
| 8/27/2017 | 86C | 179 | BB | A | 1 | 1 | 0 | 0 | 610mm |
| 8/27/2017 | 56C | 180 | BB | A | 2 | 2 | 0 | 0 | 530mm, 620mm |
| 8/27/2017 | 68C | 181 | Peamouth Chub | A | 1 | 0 | 1 | 1 | 260mm |
| 8/28/2017 | 106C | 183 | BB | A | 2 | 2 | 0 | 0 | 605mm, 640mm |
| 8/28/2017 | 28C | 184 | BB | A | 1 | 1 | 0 | 0 | 565mm |
| 8/28/2017 | 108C | 187 | CSU | A | 1 | 1 | 0 | 0 | 420mm |
| 8/29/2017 | 122C | 189 | BB | A | 1 | 1 | 0 | 0 | 700mm |
| 8/29/2017 | 52C | 191 | BB | J | 1 | 1 | 0 | 0 | 345mm |

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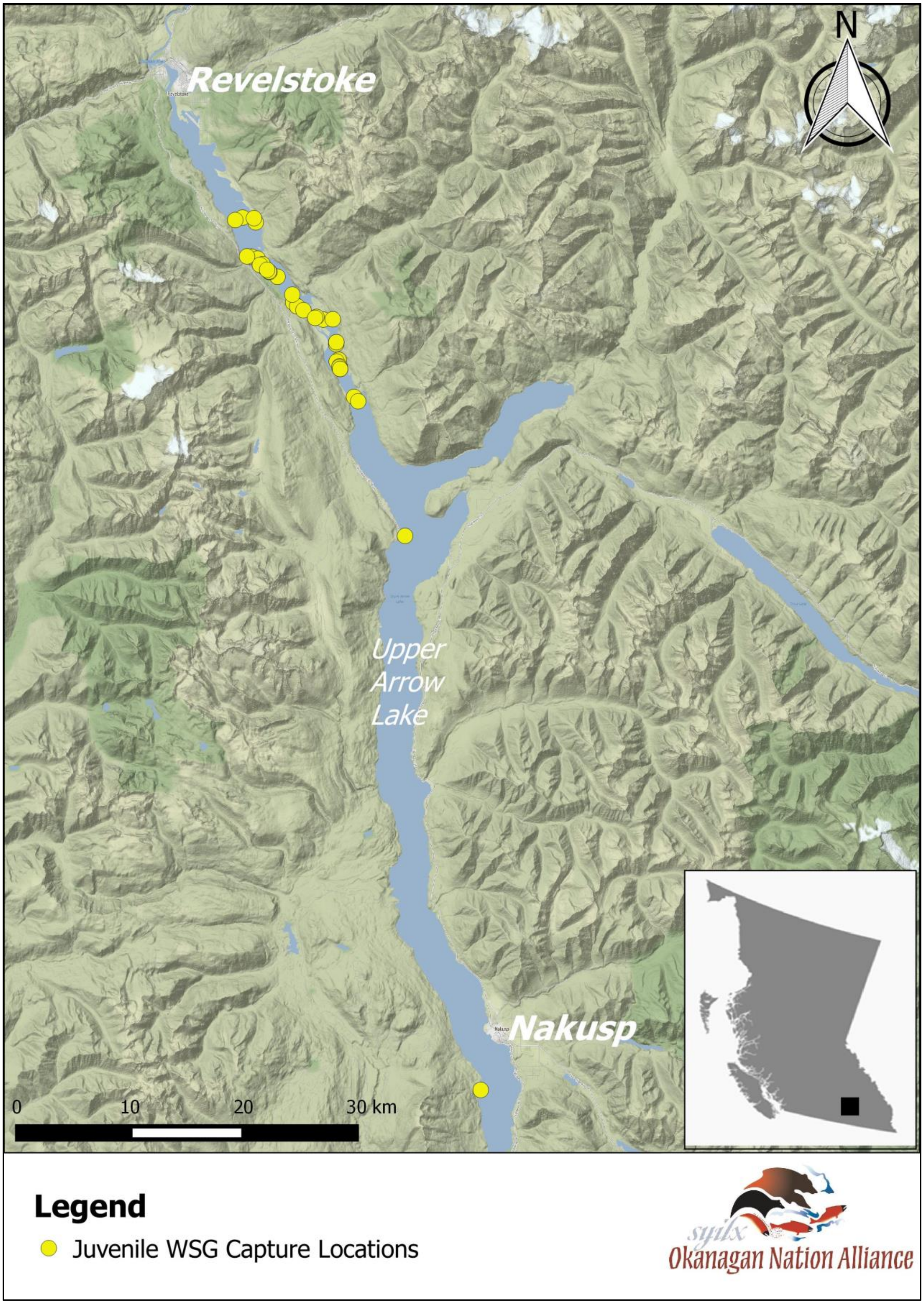
|---|---|---|---|---|---|---|---|---|---|
| 9/8/2017 | 105D | 196 | NSC | A | 1 | 0 | 1 | 1 | 325mm |
| 9/8/2017 | 39D | 198 | BB | A | 1 | 1 | 0 | 0 | escaped |
| 9/8/2017 | 39D | 198 | NSC | A | 1 | 1 | 0 | 0 | 425mm |
| 9/8/2017 | 116D | 199 | BB | A | 1 | 1 | 0 | 0 | 480mm |
| 9/8/2017 | 40D | 201 | BB | A | 1 | 1 | 0 | 0 | 575mm |
| 9/9/2017 | 8D | 205 | CSU | A | 1 | 1 | 0 | 0 | escaped |
| 9/10/2017 | 108D | 210 | BB | A | 1 | 1 | 0 | 0 | 515mm |
| 9/10/2017 | 52D | 214 | BB | J | 1 | 1 | 0 | 0 | 320mm |
| 9/10/2017 | 74D | 217 | BB | J | 1 | 1 | 0 | 0 | 460mm |
| 9/11/2017 | 20D | 218 | BB | A | 3 | 3 | 0 | 0 | 420mm, 440mm, 450mm |
| 9/11/2017 | 138D | 220 | NSC | A | 1 | 1 | 0 | 0 | 340mm |
| 9/11/2017 | 68E | 222 | BB | J | 1 | 1 | 0 | 0 | 410mm |
| 9/11/2017 | 4E | 224 | BB | JJA | 3 | 3 | 0 | 0 | 345mm,365mm,540mm |
| 9/12/2017 | 105E | 227 | BB | A | 1 | 1 | 0 | 0 | 595mm |
| 9/12/2017 | 116E | 228 | BB | A | 1 | 1 | 0 | 0 | 530mm |
| 9/12/2017 | 39E | 229 | BB | JA | 2 | 2 | 0 | 0 | 370mm, 590mm |
| 9/12/2017 | 7E | 230 | BB | A | 1 | 0 | 1 | 1 | 420mm |
| 9/12/2017 | 84E | 231 | BB | A | 3 | 3 | 0 | 0 | 515mm, 610mm,530mm |
| 9/12/2017 | 23E | 232 | BB | A | 3 | 3 | 0 | 0 | 560mm, 525mm, 600mm,560mm |
| 9/12/2017 | 76E | 233 | NSC | A | 1 | 1 | 0 | 0 | 355mm |
| | | | | | 171 | 136 | 35 | 20.5% | |

# Appendix B - Location Map of Juvenile White Sturgeon Captures


N
Revelstoke
Upper Arrow Lake
Nakusp
0
10
20
30 km
Legend
● Juvenile WSG Capture Locations
syilx
Okanagan Nation Alliance

# Appendix C - Summary of Meso-Habitat Conditions

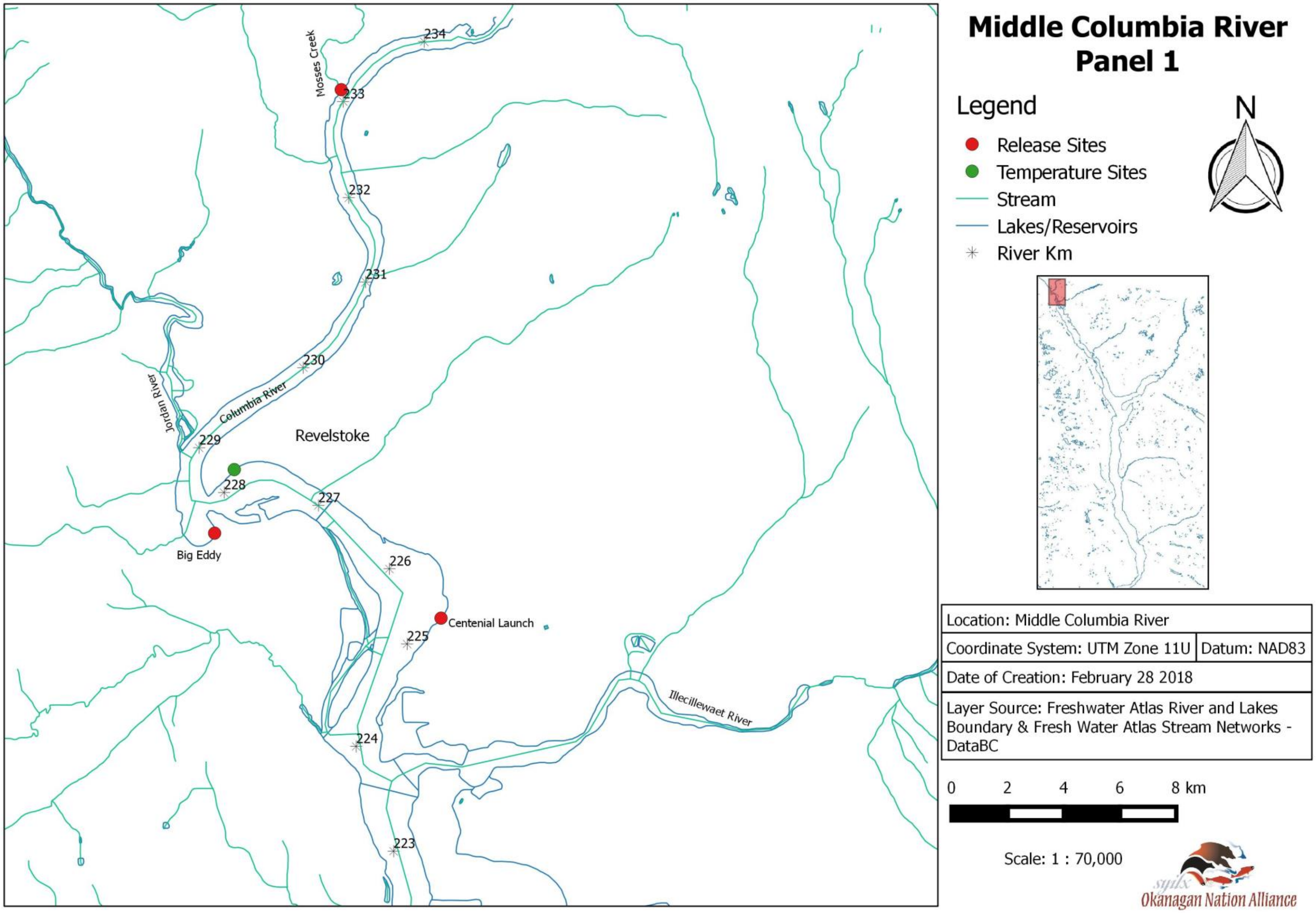
| Year | Station | Date | Time | Water Temp. (°C) |  | Depth (m) | Secchi Depth (m) | Turbidity (NTU) | Velocity (m/s) |  |  |  | Substrate | Cover | Gill Nets in Area | Set Lines in Area | Contents in Substrate Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Surface | Bottom |  |  |  | Surface | 0.2 | 0.8 | Bottom |  |  |  |  |  |  |
| 2010 | H189.6 | 9/9/10 | 20:30 | 13.9 | 11.3 | 13.6 |  |  | 0 | 0 | 0 | 0 | fines (silt) | none | GN189.6A-D | SL189.6 |  |  |
| 2010 | H189.3 | 9/9/10 | 22:02 | 13.5 | 11.6 | 13.0 |  |  | 0 | 0 | 0 | 0 | fines (silt) | none | GN189.3A-D | SL189.3 |  |  |
| 2010 | H194.4 | 9/11/10 | 10:15 | 11.5 |  | 10.9 |  |  | 0.11 | 0.06 | 0.03 | 0.03 | fines | none | GN194.4A-C | none |  |  |
| 2010 | H193.7 | 9/11/10 | 10:30 | 11.5 |  | 14.3 |  |  | 0.12 | 0.07 | 0.04 | 0.04 | fines | none | GN193.7A-C | none |  |  |
| 2010 | H197.3 | 9/13/10 | 11:15 | 11.5 |  | 14.2 |  |  | 0.05 | 0.04 | 0.03 | 0.03 | fines | none | GN197.3A-C, 197.2,197.1 | none |  |  |
| 2010 | H196.5 | 9/13/10 | 11:00 | 12.0 |  | 16.5 |  |  | 0.23 | 0.21 | 0.07 | 0.07 | fines | none | GN196.6, 196.5, 196.4 | none |  |  |
| 2010 | H201.1 | 9/14/10 | 8:47 | 11.0 |  | 11.5 |  |  | 0.05 | 0.04 | 0.02 | 0.05 | fines | none | GN201.0A-D | none |  |  |
| 2010 | H205.9 | 9/15/10 | 7:45 | 10.5 |  | 14.3 | 3.50 |  | 0.07 | 0.10 | 0.06 | 0.05 | fines/SG | none | GN205.9A-D | SL205.9 |  | juvenile white sturgeon captured by GN205.9C |
| 2010 | H212.3 | 9/16/10 | 7:20 | 11.0 |  | 13.8 | 6.20 |  | 0.20 | 0.24 | 0.15 | 0.15 | C/B/G/fines | minimal interstitial | GN212.3A-C | SL212.3 |  | C/B/G embedded in fines |
| 2010 | H214.8 | 9/16/10 | 9:05 | 10.8 |  | 6.2 | 6.50 |  | 0.45 | 0.47 | 0.33 | 0.25 | C/B/fines | minimal interstitial | GN214.8A-C | none |  |  |
| 2010 | H181.0 | 9/28/10 | 20:30 | 13.5 |  | 15.3 |  | 1.5 | 0.02 | 0.00 | 0.03 |  | fines (silt) | none | GN181.0A-C | SL181.0 |  |  |
| 2010 | H179.0 | 9/29/10 | 19:00 | 13.5 |  | 21.4 |  | 1.6 | 0.01 | 0 | 0 | 0 | fines (silt) | none | GN179.0A-C | SL179.0 |  |  |
| 2010 | H180.1 | 9/29/10 | 20:55 | 12.0 |  | 12.0 |  | 5.3 | 0.17 | 0.15 | 0.07 | 0 | fines | none | GN180.1A-C | SL180.1 |  |  |
| 2010 | H180.3 | 9/29/10 | 22:00 | 13.5 |  | 13.1 |  | 1.6 | 0 | 0 | 0 | 0 | fines | none | GN180.3A-C | SL180.3 |  |  |
| 2010 | H180.7 | 9/30/10 | 20:40 | 13.5 |  | 15.0 |  | 1.0 |  |  | 0 |  | fines | none | GN180.7A-C | SL180.7 |  |  |
| 2010 | H181.6 | 9/30/10 | 21:35 | 13.5 |  | 13.2 |  | 1.2 | 0 | 0.03 | 0 | 0.01 | fines | none | GN181.6A-C | SL180.7 |  |  |
| 2010 | H183.8 | 10/1/10 | 21:10 | 13.4 |  | 12.7 |  | 1.7 | 0.02 | 0.02 |  |  | fines | none | GN183.8A-C | SL183.8 |  |  |
| 2010 | H184.5 | 10/1/10 | 22:00 | 13.5 |  | 14.6 |  | 2.6 | 0.02 | 0.00 |  |  | fines | none | GN184.5A-C | SL184.5 |  |  |
| 2010 | H185.8 | 10/2/10 | 20:13 | 12.5 |  | 13.7 |  | 2.1 | 0.01 | 0.06 | 0.02 | 0.02 | fines (silt/sand) | none | GN185.8A-C | SL185.8 |  |  |
| 2010 | H185.4 | 10/2/10 | 21:29 | 12.5 |  | 15.5 |  | 1.7 | 0.01 |  |  |  | fines | none | GN185.4A-C | SL185.4 |  |  |
| 2010 | H207.5 | 10/3/10 | 21:36 | 11.5 |  | 14.2 |  | 4.5 | 0.22 | 0.27 | 0.18 |  | fines | none | GN207.5A-C | SL207.5 |  | Lots of material being moved @ bottom (sediment, OD) |
| 2010 | H208.5 | 10/3/10 | 22:41 | 10.5 |  | 10.8 |  | 3.2 | 0.04 | 0.09 | 0.09 | 0.11 | fines | none | GN208.5A-C | SL208.5 |  | back eddy |
| 2010 | H209.7 | 10/4/10 | 20:15 | 10.5 |  | 7.4 |  | 4.0 | 0.03 | 0.04 | 0.08 | 0.05 | fines | none | GN209.7A-C | SL209.7 |  |  |
| 2010 | H210.5 | 10/4/10 | 20:56 | 10.5 |  | 7.7 |  | 4.2 | 0.06 | 0.03 | 0.07 | 0.04 | fines | none | GN210.5A-C | SL210.5 |  | juvenile white sturgeon captured by GN210.5B |
| 2010 | H203.9 | 10/5/10 | 19:10 | 10.5 |  | 12.4 |  | 3.4 | 0.06 | 0.03 | 0.06 | 0.01 | fines | none | GN203.9A+B | SL203.9 |  |  |
| 2010 | H206.4 | 10/5/10 | 20:00 | 10.0 |  | 13.4 |  | 2.9 | 0.23 | 0.20 | 0.16 | 0.10 | fines | none | GN206.4A+B | SL206.4 |  | juvenile white sturgeon captured by GN206.4B |
| 2010 | H201.3 | 10/6/10 | 21:00 | 10.0 |  | 8.7 |  | 2.6 | 0.11 | 0.11 | 0.04 | 0.04 | fines | none | GN201.3A+B | none |  | substrate forms small "dunes" |
| 2010 | H200.1 | 10/6/10 | 21:21 | 10.5 |  | 11.4 |  | 2.6 | 0.18 | 0.10 | 0.05 | 0.04 | fines | none | GN200.1A+B | none |  | substrate forms small "dunes" |
| 2010 | H190.7 | 10/8/10 | 10:50 | 10.5 |  | 13.1 | 3.95 | 2.4 | 0.28 | 0.27 | 0.08 | 0.09 | fines/ some OD | none | GN190.7A+B | none |  | juvenile white sturgeon captured by GN190.7B |
| 2010 | H191.4 | 10/8/10 | 11:20 | 10.5 |  | 12.7 | 3.95 | 2.7 | 0.21 | 0.17 | 0.11 | 0.08 | fines (sand/silt) | minimal OD, WD, BT | GN191.4A+B | none |  |  |
| 2010 | H193.3 | 10/8/10 | 11:40 | 10.5 |  | 13.3 | 4.00 | 2.3 | 0.25 | 0.21 | 0.07 | 0.05 | fines/ scattered G | WD | GN193.3A+B | none |  | some algae on substrate |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | H196.0 | 10/8/10 | 12:07 | 10.5 | | 12.3 | 4.00 | 2.1 | 0.22 | 0.29 | 0.21 | 0.16 | fines (sand/silt) | none | GN196.0A+B | none | | |
| 2011 | HM1-1 | 5/27/11 | 12:30 | | | 5.6 | | 11 | 0.37 | 0.3 | 0.2 | 0.18 | | | | | | |
| 2011 | HM1-2 | 5/27/11 | 13:00 | | | 9.1 | | | 0.51 | 0.3 | 0.3 | 0.13 | | | | | | |
| 2011 | HW1-1 | 5/27/11 | 14:38 | | | 10 | | 9.6 | 0.27 | 0.1 | 0.1 | 0.06 | | | | | | |
| 2011 | HW1-2 | 5/27/11 | 14:58 | | | 8.5 | | | 0.38 | 0.2 | 0.1 | 0.11 | | | | | | |
| 2011 | HM2-1 | 8/9/11 | 17:58 | | | 14.8 | | 1.1 | 0.19 | 0.1 | 0.1 | 0.05 | | | | | | |
| 2011 | HM2-2 | 8/9/11 | 18:15 | | | 15.1 | | 2 | 0.13 | 0 | 0 | 0.01 | | | | | | |
| 2011 | HW2-1 | 8/9/11 | 17:00 | | | 14.2 | | 2.4 | 0.3 | 0.2 | 0.1 | 0.03 | | | | | | |
| 2011 | HW2-2 | 8/9/11 | 17:34 | | | 12 | | 2.4 | 0.24 | 0.3 | 0.1 | 0.01 | | | | | | |
| 2011 | HM3-1 | 10/19/11 | 13:45 | | | 9.6 | | 1 | 0.15 | 0.1 | 0.1 | 0.04 | | | | | | |
| 2011 | HM3-2 | 10/19/11 | 14:10 | | | 12.7 | | 0.9 | 0.18 | 0.1 | 0 | 0.04 | | | | | | |
| 2011 | HW3-1 | 10/19/11 | 14:40 | | | 13.7 | | 1 | 0.16 | 0.1 | 0.1 | 0.05 | | | | | | |
| 2011 | HW3-2 | 10/19/11 | 14:55 | | | 11.9 | | 1 | 0.12 | 0.1 | 0.1 | 0.07 | | | | | | |
| 2014 | 2014-1 | 9/21/16 | | | | | | | | | | | Sand | | | | None | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-2 | 9/21/16 | | | | | | | | | | | Sand | | | | Biting Midge | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-3 | 9/23/16 | | | | | | | | | | | Clay (sand) | | | | Biting Midge | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-4 | 9/23/16 | | | | | | | | | | | Sand | | | | None | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-5 | 9/24/16 | | | | | | | | | | | Pebbles (Sand) | | | | None | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-6 | 9/24/16 | | | | | | | | | | | Sand | | | | None | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-7 | 9/24/16 | | | | | | | | | | | Sand | | | | 6 Non-biting Midges | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-8 | 9/23/16 | | | | | | | | | | | Sand (Clay) | | | | None | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-9 | 9/22/16 | | | | | | | | | | | Sand (Pebble) | | | | Non-Biting Midge and Larvae | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2014 | 2014-10 | 9/22/16 | | | | | | | | | | | Sand | | | | 3 Red Non-biting Midges | Samples taken in 2016 at sites where sturgeon were captured in 2014 |
| 2015 | 9GB | 9/1/15 | 14:36 | 11.2 | | 9 | | | | | | | Clay | None | 9GB | None | None | Juvenile Sturgeon Caught on Gillnet 9GB; Sediment samples taken on August 24 2016 |
| 2016 | S004B | 9/12/16 | 11:35 | 10.5 | | 10.8 | | | | | | | Sand | None | None | S004B | None | Juvenile Sturgeon Caught in Setline S004B |
| 2016 | S020B | 9/13/16 | 11:30 | 11 | | 9.5 | | | | | | | Pebbles (Sand) | None | None | S020B | Biting Midge | Juvenile Sturgeon Caught in Setline S020B |
| 2016 | S119A | 9/18/16 | 11:50 | 9.8 | | 10 | | | | | | | Sand | None | None | S119A | None | 2 Juvenile Sturgeon Caught in Setline S119A |
| 2016 | S8A | 9/23/16 | 11:25 | 10.6 | | 8.25 | | | | | | | Sand (Pebble) | None | None | S8A | None | 2 Juvenile Sturgeon Caught in Setline S8A |
| 2016 | S19A | 9/25/16 | 12:45 | 9.5 | | 7 | | | | | | | | | | | | |
| 2016 | S16A | 9/25/16 | 12:16 | 9.5 | | 6.25 | | | | | | | | | | | | |
| 2017 | G033B | 6/29/17 | 11:30 | 15.4 | | 13.6 | | | | | | | Clay (Sand) | None | G033B | None | None | Depth Averaged; Juvenile Sturgeon Caught in Gillnet G033B |
| 2017 | 20E | 9/11/17 | 13:15 | 10.1 | | 15.55 | 0.80 | | | | | | Sand | None | None | 20E | Caddis Fly Casing | Depth Averaged; Juvenile Sturgeon Caught in Setline 20E |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | GA1 | 9/7/17 | 13:47 | 12.2 | | 15.3 | 3.10 | | | | | | Sand (Clay) | None | GA1 | None | None | Depth Averaged;<br>2 Juvenile Sturgeon Caught in Gillnet GA1 |
| 2017 | 76C | 8/26/17 | 10:50 | 11.1 | | 17 | 3.90 | | | | | | Sand (Pebbles) | None | None | 76C | None | Depth Averaged;<br>Juvenile Sturgeon Caught in Setline 76C |
| 2017 | 56C | 8/27/17 | 12:30 | 11.7 | | 15.75 | 3.87 | | | | | | Sand | None | None | 56C | None | Depth Averaged;<br>Juvenile Sturgeon Caught in Setline 56C |
| 2017 | 52D | 9/10/17 | 12:58 | 10.6 | | 15.15 | 0.87 | | | | | | Sand | None | None | 52D | None | Depth Averaged;<br>Juvenile Sturgeon Caught in Setline 52D |
| 2017 | 106C | 8/28/17 | 10:54 | 11.5 | | 13.7 | 4.65 | | | | | | Sand (Clay) | None | None | 106C | None | Depth Averaged;<br>Juvenile Sturgeon Caught in Setline 106C |

*Blue indicates Sturgeon Capture Location

# Appendix D - Detailed maps of RKm, Release Sites and Temperature Stations



# Middle Columbia River
## Panel 1

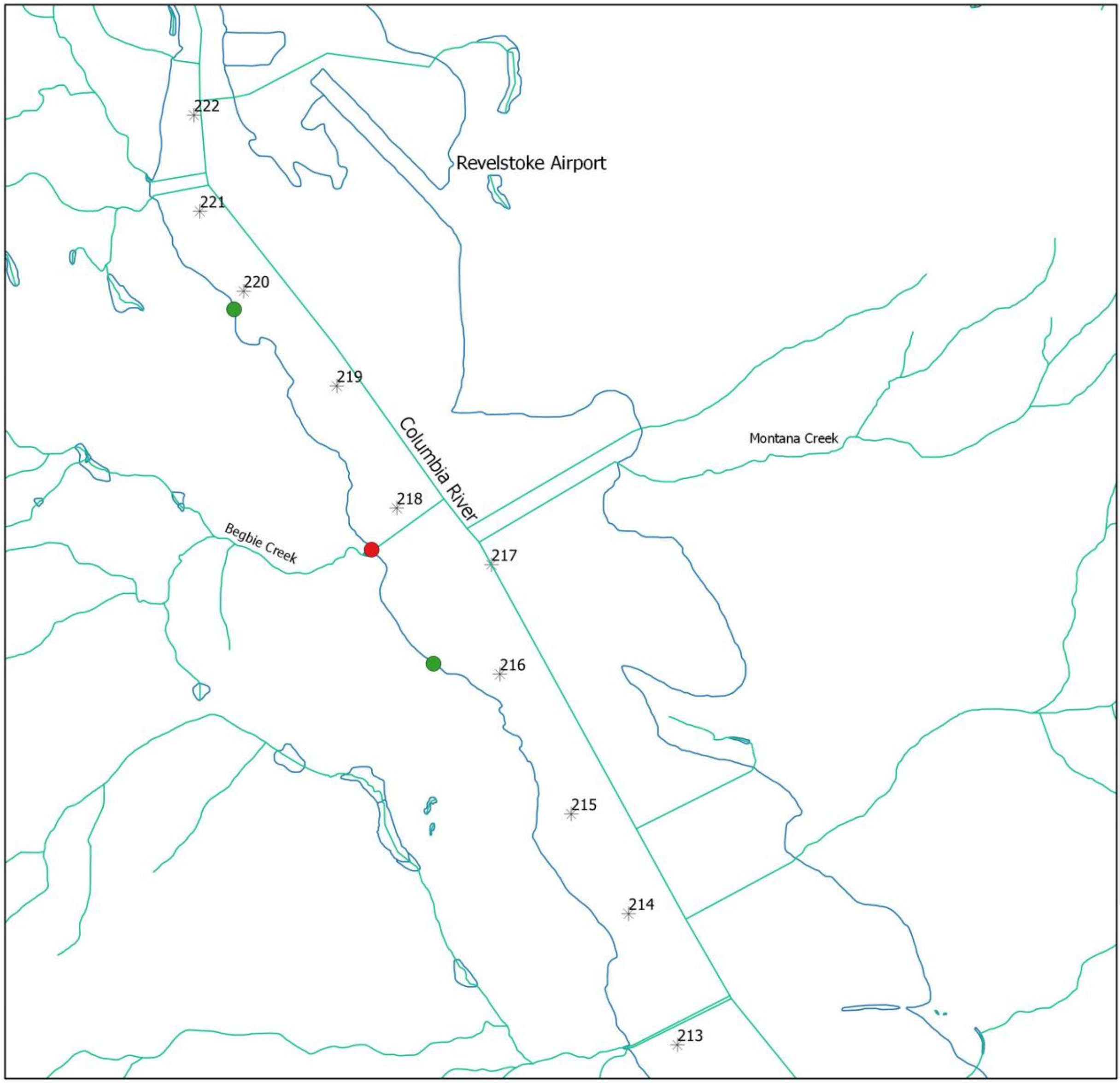
Legend

● Release Sites
● Temperature Sites
— Stream
— Lakes/Reservoirs
✳ River Km

| | |
|---|---|
| Location: Middle Columbia River | |
| Coordinate System: UTM Zone 11U | Datum: NAD83 |
| Date of Creation: February 28 2018 | |
| Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC | |

Scale: 1 : 70,000

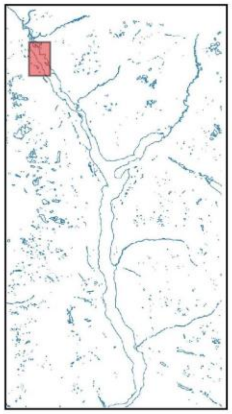
syilx Okanagan Nation Alliance



## Middle Columbia River
## Panel 2

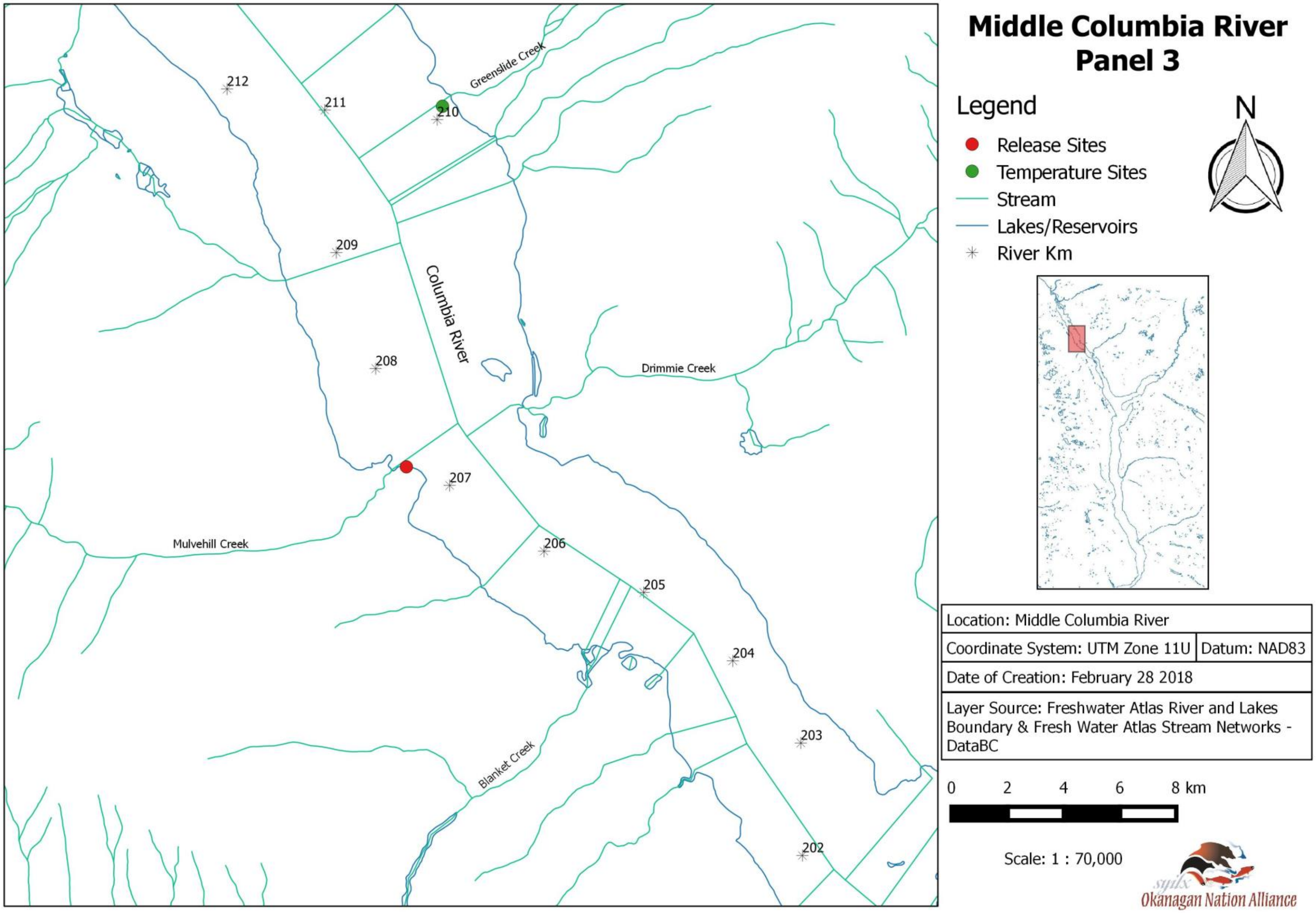
Legend

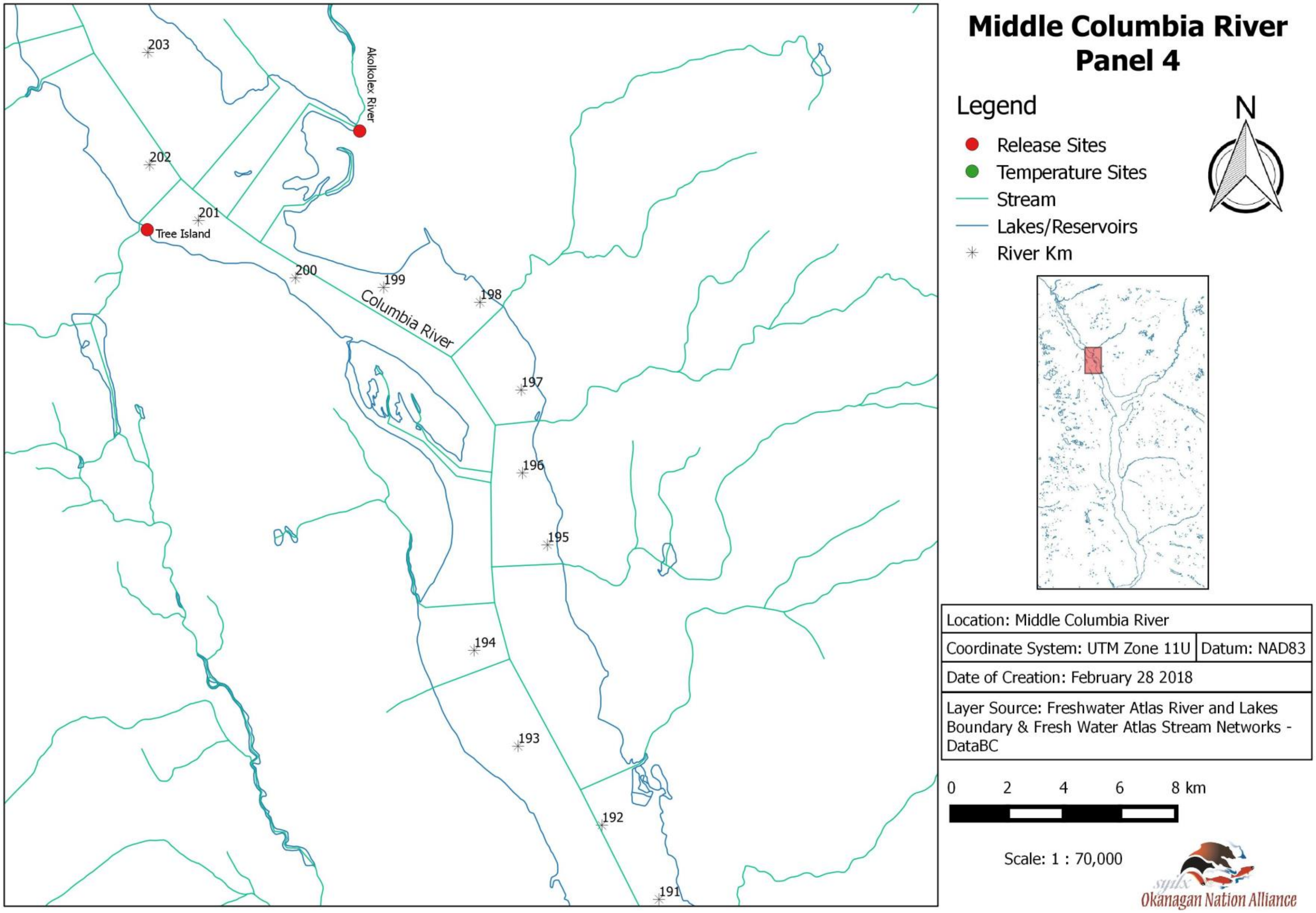
- ● Release Sites
- ● Temperature Sites
- — Stream
- — Lakes/Reservoirs
- ✳ River Km



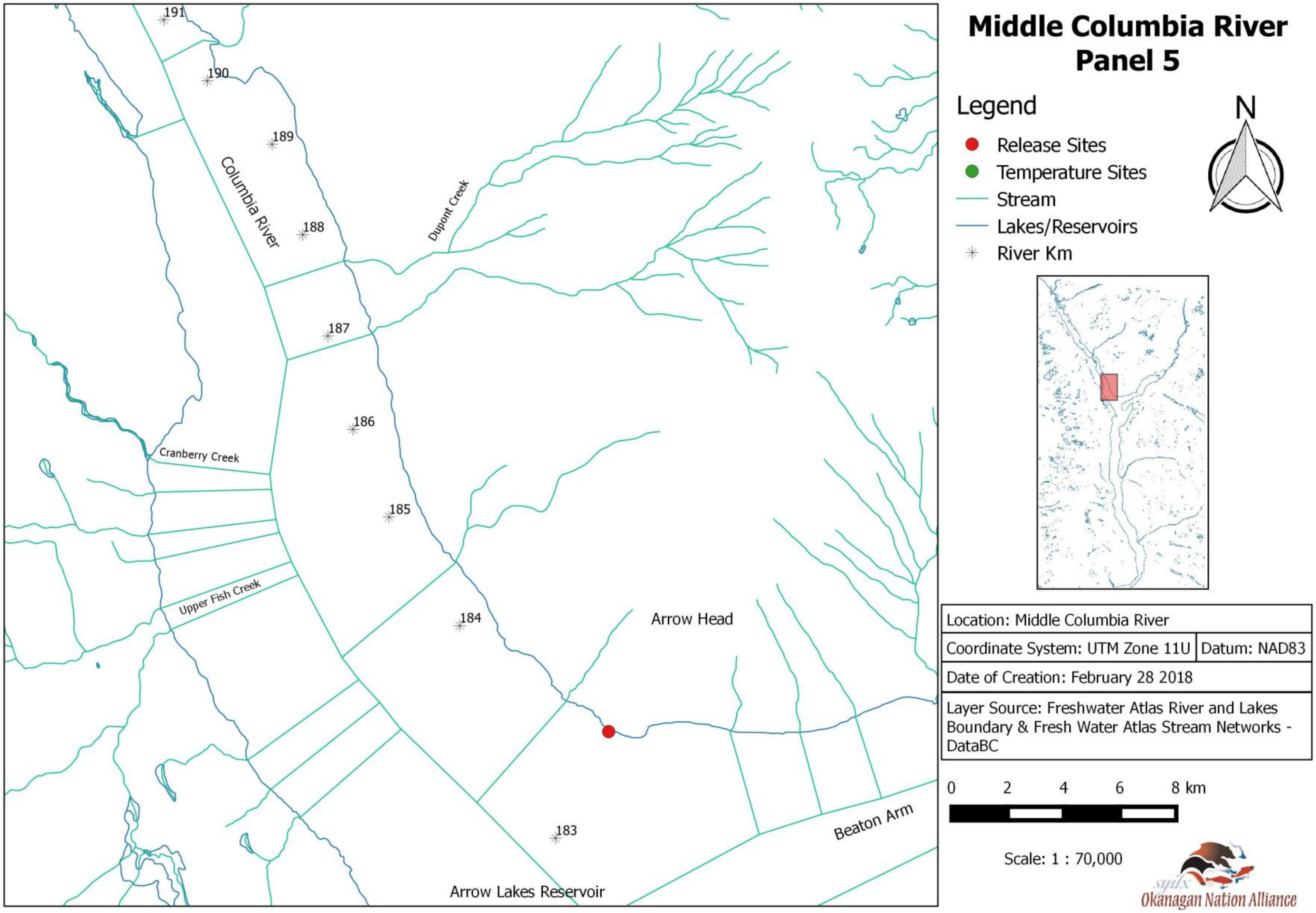
| | |
|---|---|
| Location: Middle Columbia River | |
| Coordinate System: UTM Zone 11U | Datum: NAD83 |
| Date of Creation: February 28 2018 | |
| Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC | |

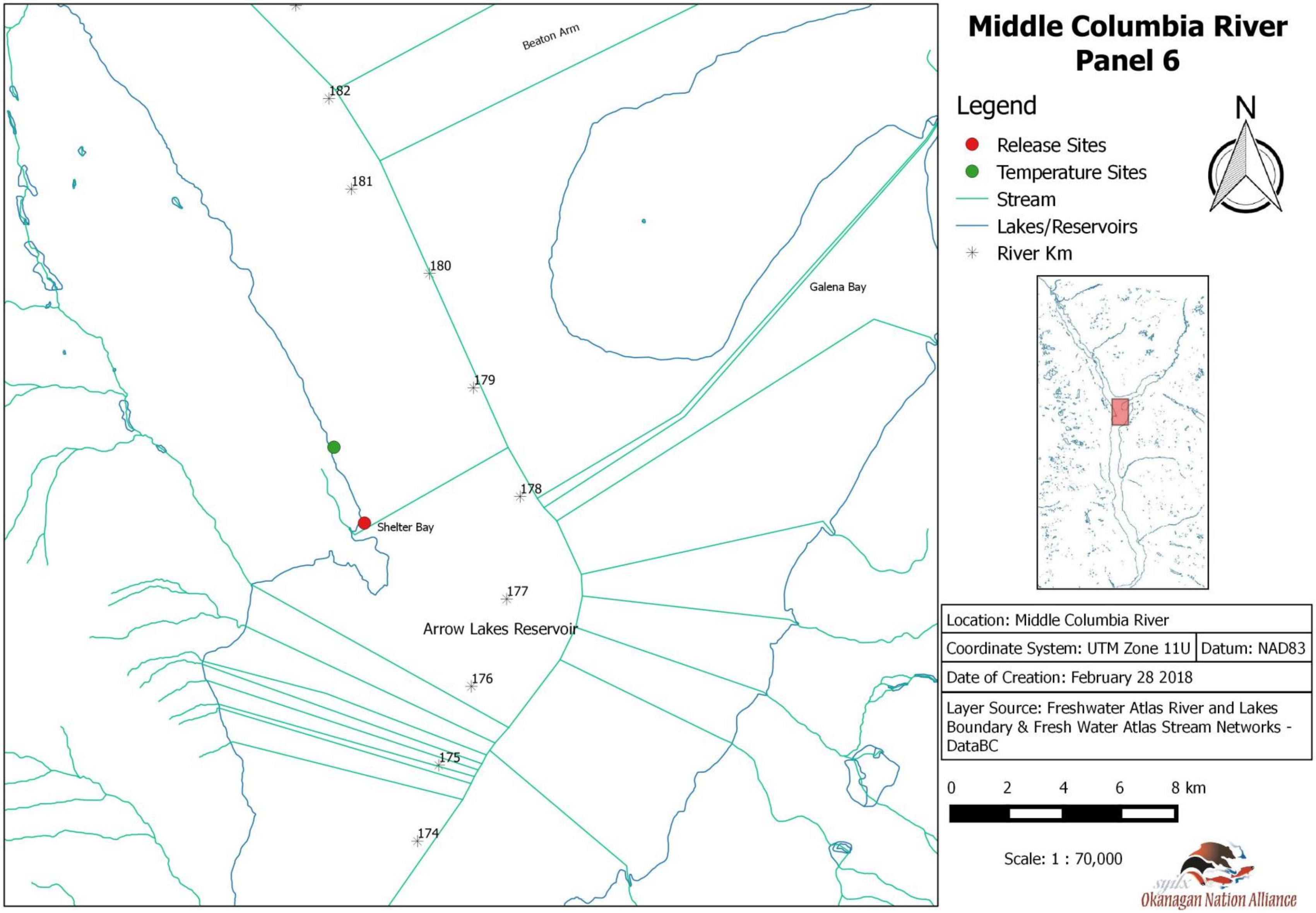
Scale: 1 : 70,000


Middle Columbia River
Panel 3
Legend
● Release Sites
● Temperature Sites
Stream
Lakes/Reservoirs
✳ River Km
N
Greenslide Creek
Columbia River
Drimmie Creek
Mulvehill Creek
Blanket Creek
212
211
210
209
208
207
206
205
204
203
202
Location: Middle Columbia River
Coordinate System: UTM Zone 11U
Datum: NAD83
Date of Creation: February 28 2018
Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC
0 2 4 6 8 km
Scale: 1 : 70,000
syilx Okanagan Nation Alliance



| | |
|---|---|
| Location: Middle Columbia River | |
| Coordinate System: UTM Zone 11U | Datum: NAD83 |
| Date of Creation: February 28 2018 | |
| Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC | |


Middle Columbia River
Panel 5
Legend
● Release Sites
● Temperature Sites
Stream
Lakes/Reservoirs
✳ River Km
N
191
190
189
188
187
186
185
184
183
Columbia River
Dupont Creek
Cranberry Creek
Upper Fish Creek
Arrow Head
Beaton Arm
Arrow Lakes Reservoir
Location: Middle Columbia River
Coordinate System: UTM Zone 11U
Datum: NAD83
Date of Creation: February 28 2018
Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC
0 2 4 6 8 km
Scale: 1 : 70,000
Okanagan Nation Alliance

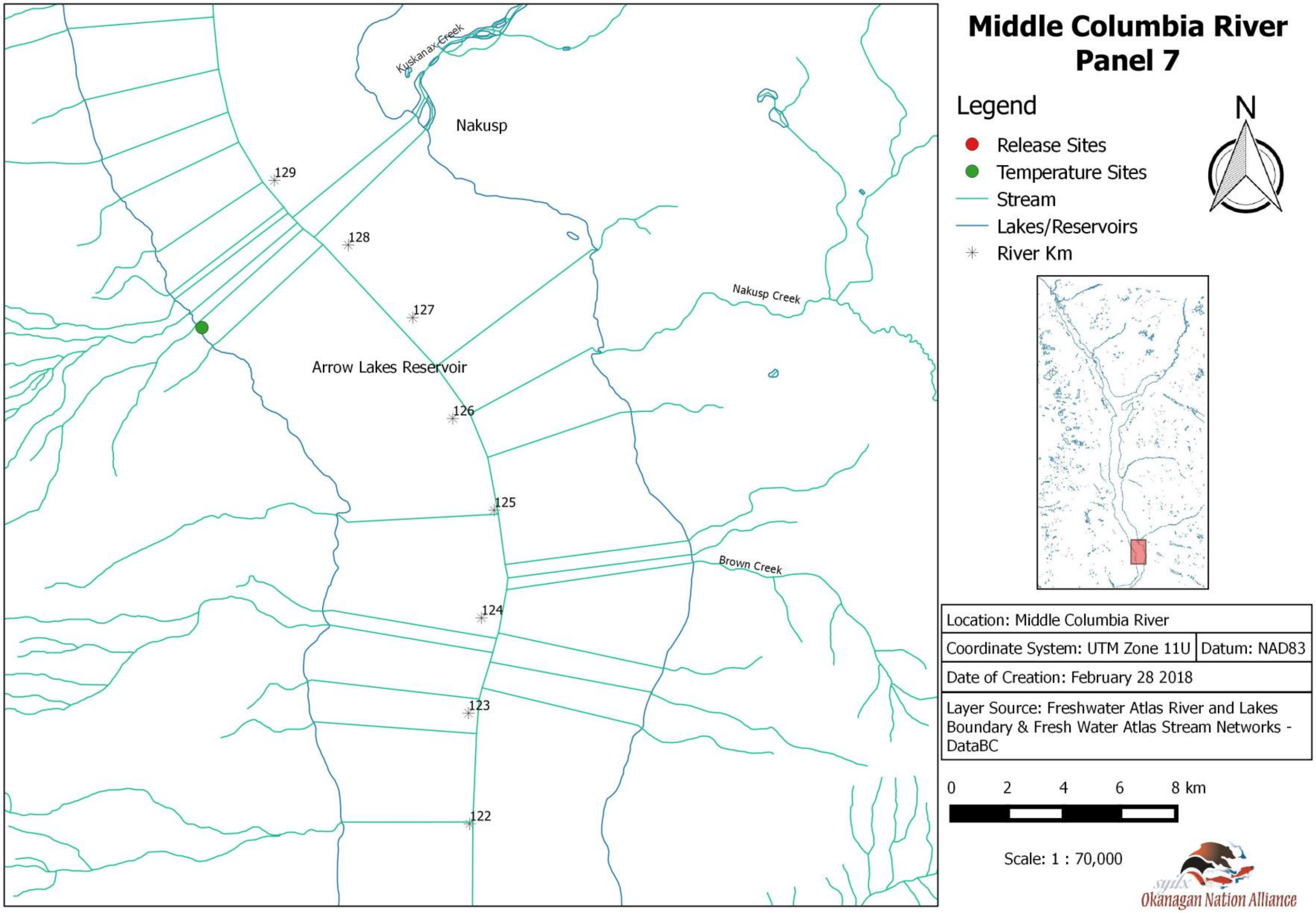


Location: Middle Columbia River

Coordinate System: UTM Zone 11U | Datum: NAD83

Date of Creation: February 28 2018

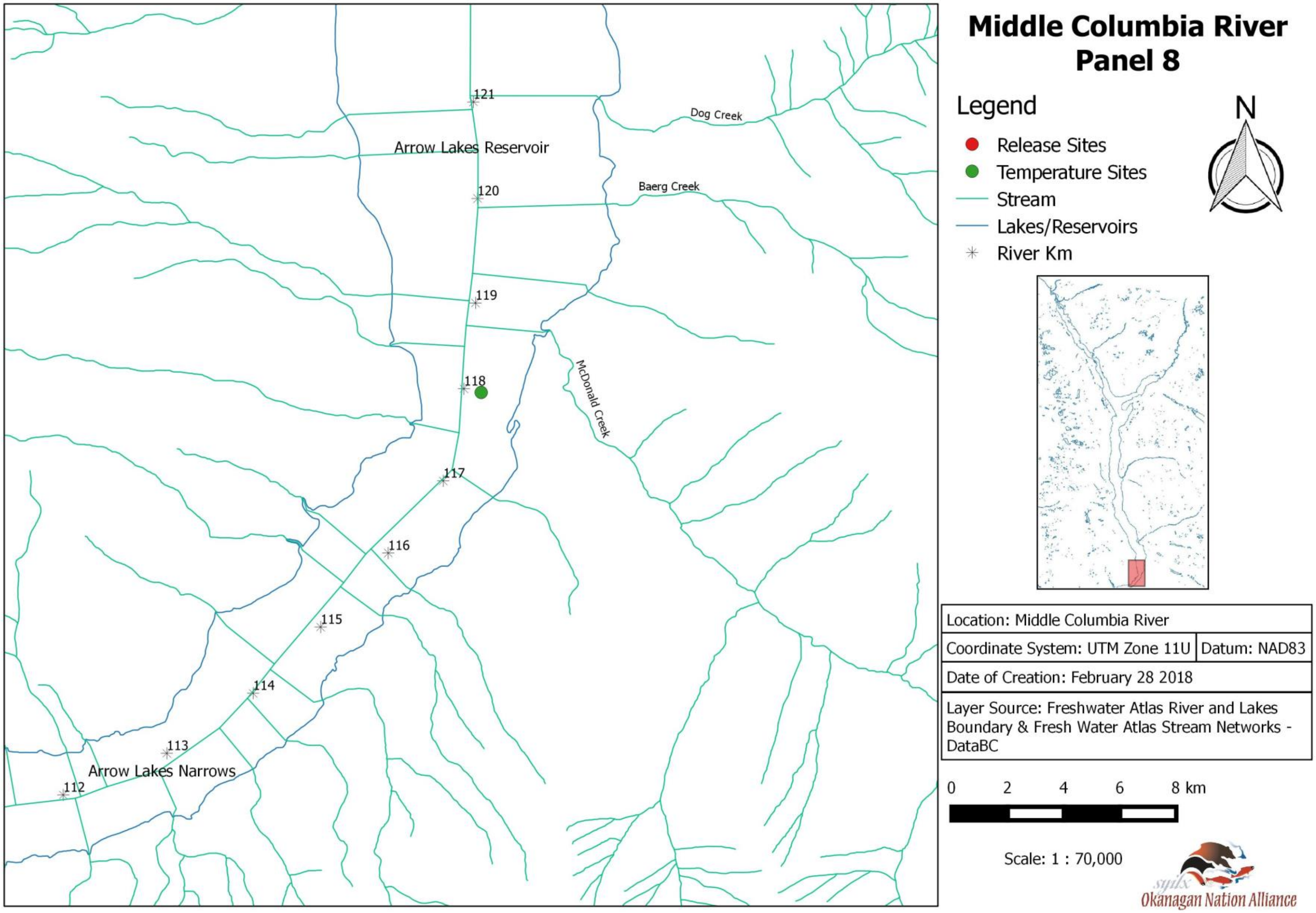
Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC



**Middle Columbia River
Panel 7**

| | |
|---|---|
| Location: Middle Columbia River | |
| Coordinate System: UTM Zone 11U | Datum: NAD83 |
| Date of Creation: February 28 2018 | |
| Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC | |

Scale: 1 : 70,000


Middle Columbia River
Panel 8
Legend
● Release Sites
● Temperature Sites
Stream
Lakes/Reservoirs
River Km
N
Arrow Lakes Reservoir
Arrow Lakes Narrows
Dog Creek
Baerg Creek
McDonald Creek
121
120
119
118
117
116
115
114
113
112
Location: Middle Columbia River
Coordinate System: UTM Zone 11U
Datum: NAD83
Date of Creation: February 28 2018
Layer Source: Freshwater Atlas River and Lakes Boundary & Fresh Water Atlas Stream Networks - DataBC
0 2 4 6 8 km
Scale: 1 : 70,000
Okanagan Nation Alliance