Site C Clean Energy Project

Peace River Fish Community Monitoring Program (Mon-2)

Task 2e – Peace River Tributaries Walleye Spawning and Rearing Use Survey

Construction Year 7 (2021)

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Walleye Spawning and Rearing Use Survey (Mon-2, Task 2e) 2021

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Purpose and Objectives

As per the FAHMFP, "the purpose of the Peace River Tributaries Walleye Spawning and Rearing Use Survey is to assess the habitat characteristics of spawning and rearing areas in the Beatton and Kiskatinaw rivers that are used by the Peace River Walleye population. Data collected under the survey will be provided to the Site C Tributary Mitigation Opportunities Evaluation Program to advise potential future habitat enhancement opportunities for Walleye in these tributaries."

The objectives of this study were to:

1. Summarize the movements of pre-spawn, radio-tagged Walleye (*Sander vitreus*) in the Beatton and Kiskatinaw rivers.
2. Identify potential Walleye spawning areas based on the movement of radio-tagged fish.
3. Describe the habitat characteristics at potential Walleye spawning locations.
4. Confirm juvenile Walleye rearing locations based on juvenile capture.
5. Describe the habitat characteristics in rearing areas situated immediately downstream of potential spawning areas by larval and juvenile Walleye. Habitat attributes will be measured in these areas.

Study Area

The study area includes 58 km of the lower Kiskatinaw River from the Highway 97 Bridge down to the confluence with the mainstem Peace River (Figure 1). The Kiskatinaw River flows north into the Peace River approximately 50 km downstream of Site C and 12 km upstream of the BC/AB border.

The study area also includes the lower 89 km of the mainstem Beatton River from the Milligan Creek Road Bridge down to the confluence with the mainstem Peace River (Figure 2). The Beatton River drains into the Peace River from the north approximately 37 km downstream of Site C and 25 km upstream of the BC/AB border. To be consistent with a BC Hydro study conducted on the Beatton River in 2012 (Mainstream 2013), we stratified our findings into four major reaches that were delineated based on physical habitat characteristics (Table 1). The location of river kilometer (rkm) markers used in this report were derived from GIS vectors that followed the thalwegs of the Kiskatinaw and Beatton rivers, with markers counting upwards starting at the junction with the Peace River (rkm 0 is at the river mouth).

Study Period

Mobile-tracking surveys (Appendix B) were conducted by helicopter in the Kiskatinaw River between 1 and 19 May 2021 (n = 5), and in the Beatton River between 1 May and 7 June 2021 (n = 10). During these respective periods, discharge ranged from 9.6 to 72.0 m^3/s in the Kiskatinaw River and from 28.6 to 121.0 m^3/s in the Beatton River (Figures 3 and 4).

Surveys to assess spawning habitat characteristics in the Beatton River were conducted on 27 and 28 May 2021, when discharge in the Beatton River averaged 43.6 and 53.9 m^3/s, respectively. No spawning habitat assessments were conducted in the Kiskatinaw River in 2021.

Field effort to capture juvenile Walleye in the Beatton River, and to assess rearing habitat characteristics, occurred from 17 to 19 August 2021, when discharge ranged from 15.0 to 18.4 m^3/s.

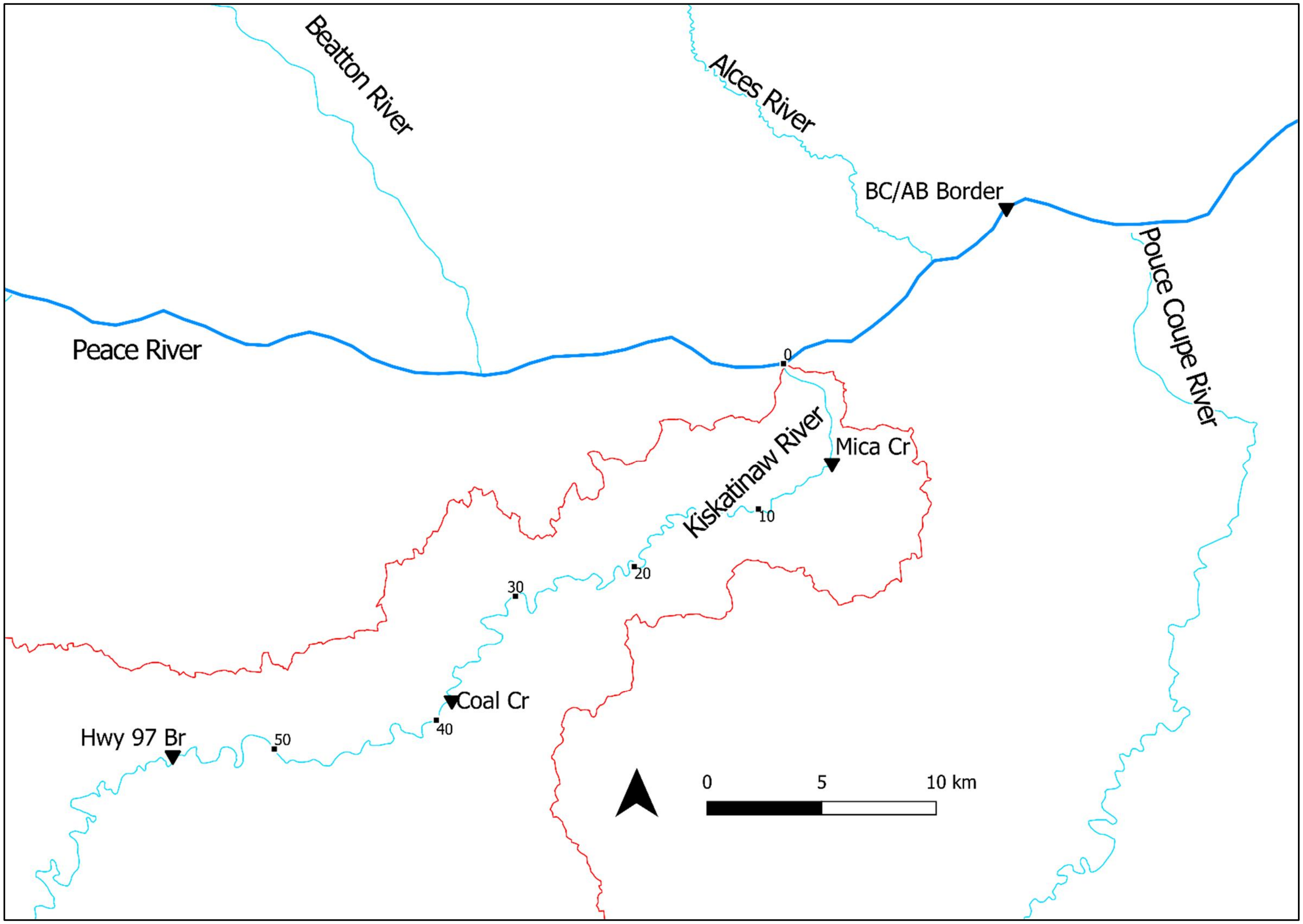

Figure 1. Study area in the Kiskatinaw River extending from the mouth (rkm 0) up to the Highway 97 Bridge (rkm 58), 2021. Every 10th rkm is marked. The 'Kiskatinaw River Watershed' mobile tracking zone (starting at 0.5 km from the mouth) is shown in red.

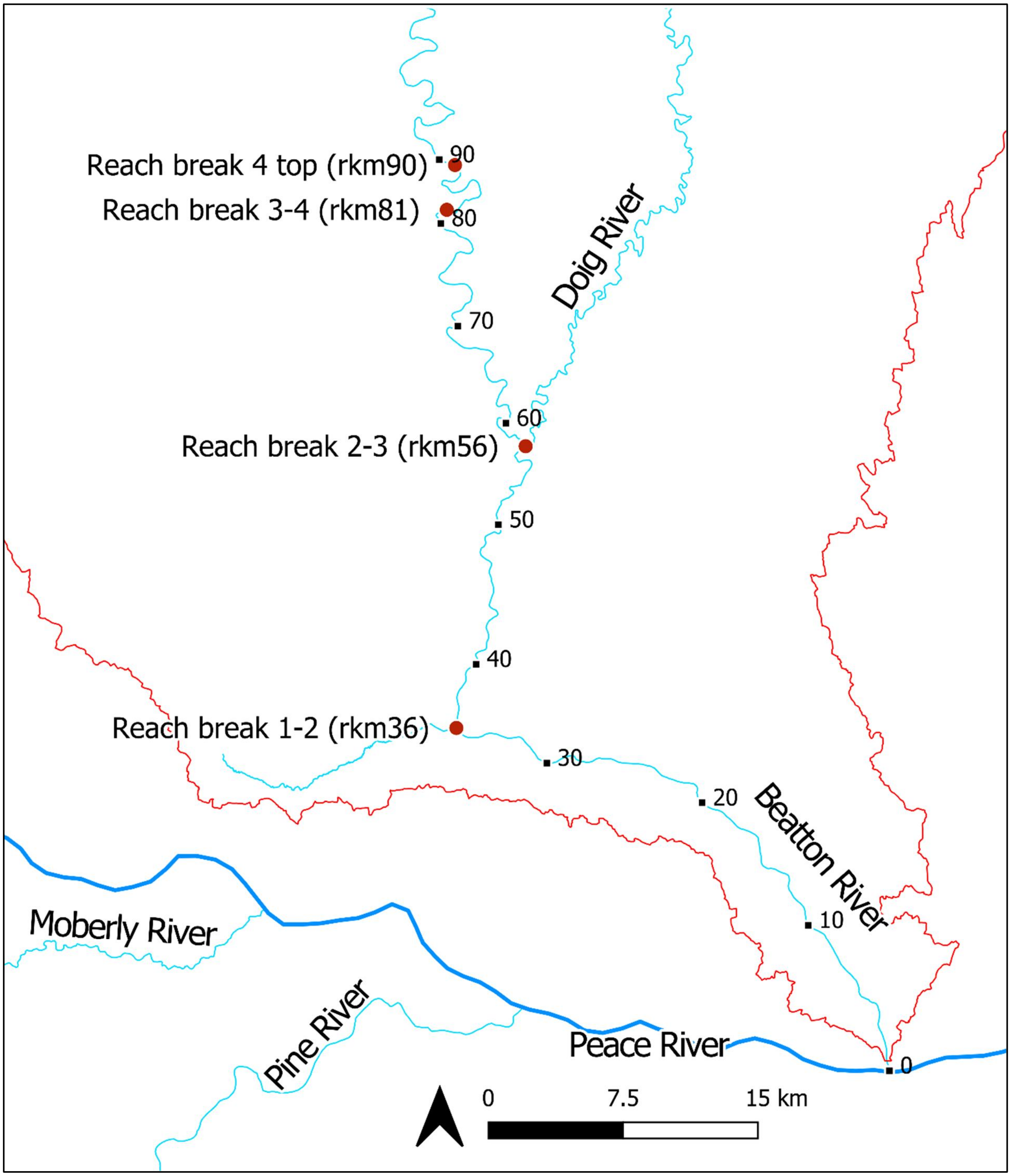

Figure 2. Study area in the Beatton River extending from the mouth (rkm 0) up to the Milligan Creek Road Bridge (rkm 89), 2021. Every 10th rkm is marked. The 'Beatton River Watershed' mobile tracking zone (starting at 0.5 km from the mouth) is shown in red.

Table 1. Reach designations of the Beatton River as adapted from Mainstream (2013).

Reach	Description	Dominant Channel Form	Gradient (m/km)	Dominant Bed Material	Location	Length (km)
1	Frequent riffle complexes interspersed with extended runs with some flats; flats becoming predominant in last 4 km	Regular meanders; occasionally confined	1.2	sands, gravels, cobbles	rkm 36 to 0	36
2	Frequent riffle complexes interspersed with extended runs; some flats	Irregular meanders at the upstream end, shifting to regular meanders; frequently confined	1.8	cobbles, boulders	rkm 56 to 36	20
3	Dominated by runs interspersed with riffles and some rapids	Irregular meanders; frequently confined	1.9	cobbles, boulders	rkm 81 to 56	25
4	Dominated by runs and occasional flats; interspersed with some riffle complexes	Irregular meanders; occasionally confined	1	sands, cobbles, boulders	rkm 89 to 81	8

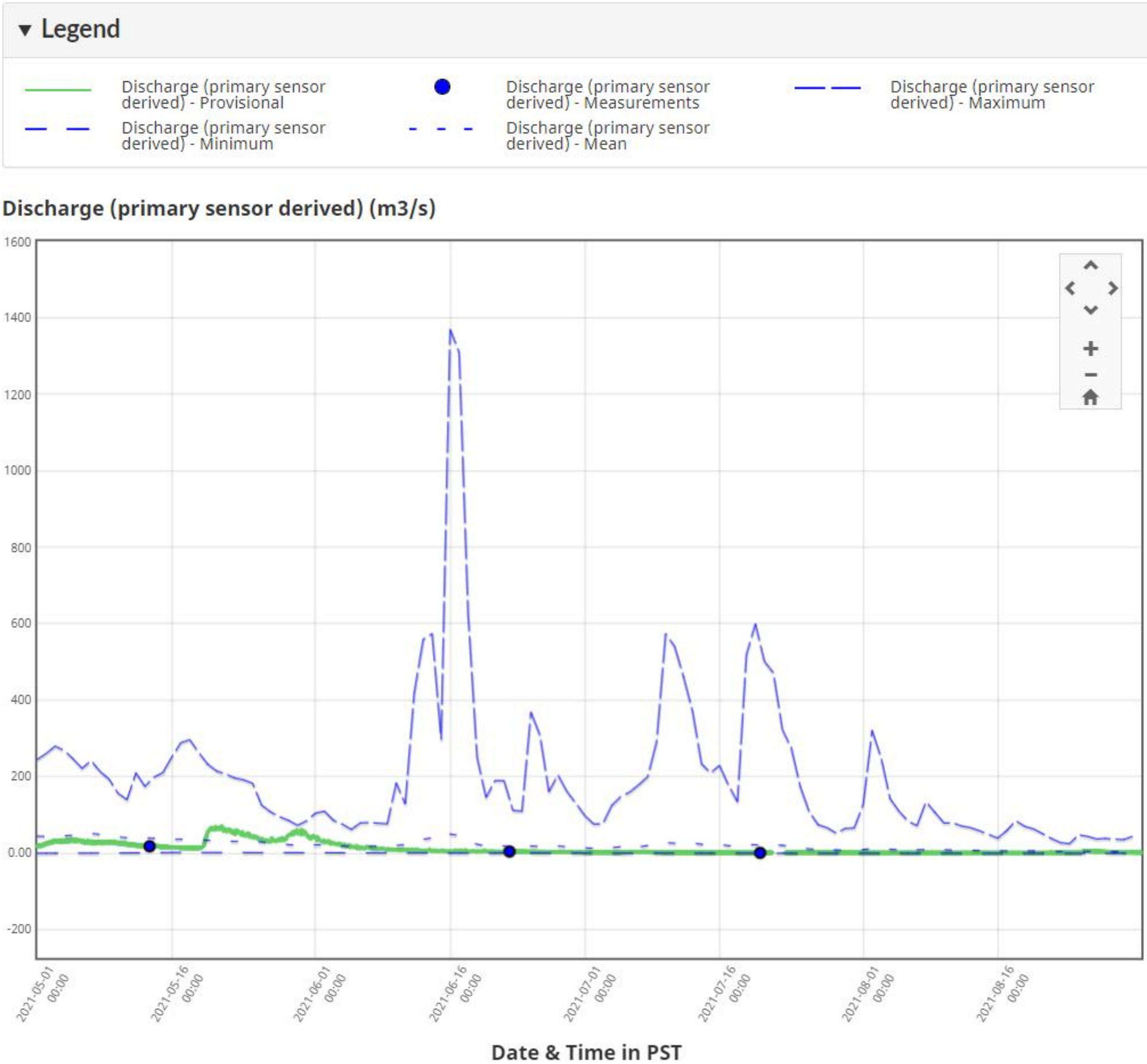

Figure 3. Discharge of the Kiskatinaw River near Farmington (Water Survey of Canada hydrometric Station 07FD001) from 1 May to 31 August 2021. Data were provided at 5-minute intervals. Image was captured from the Water Survey of Canada (WSC) webpage (wateroffice.gc.ca) in November 2021. Note that these discharge data are listed as provisional by the WSC.

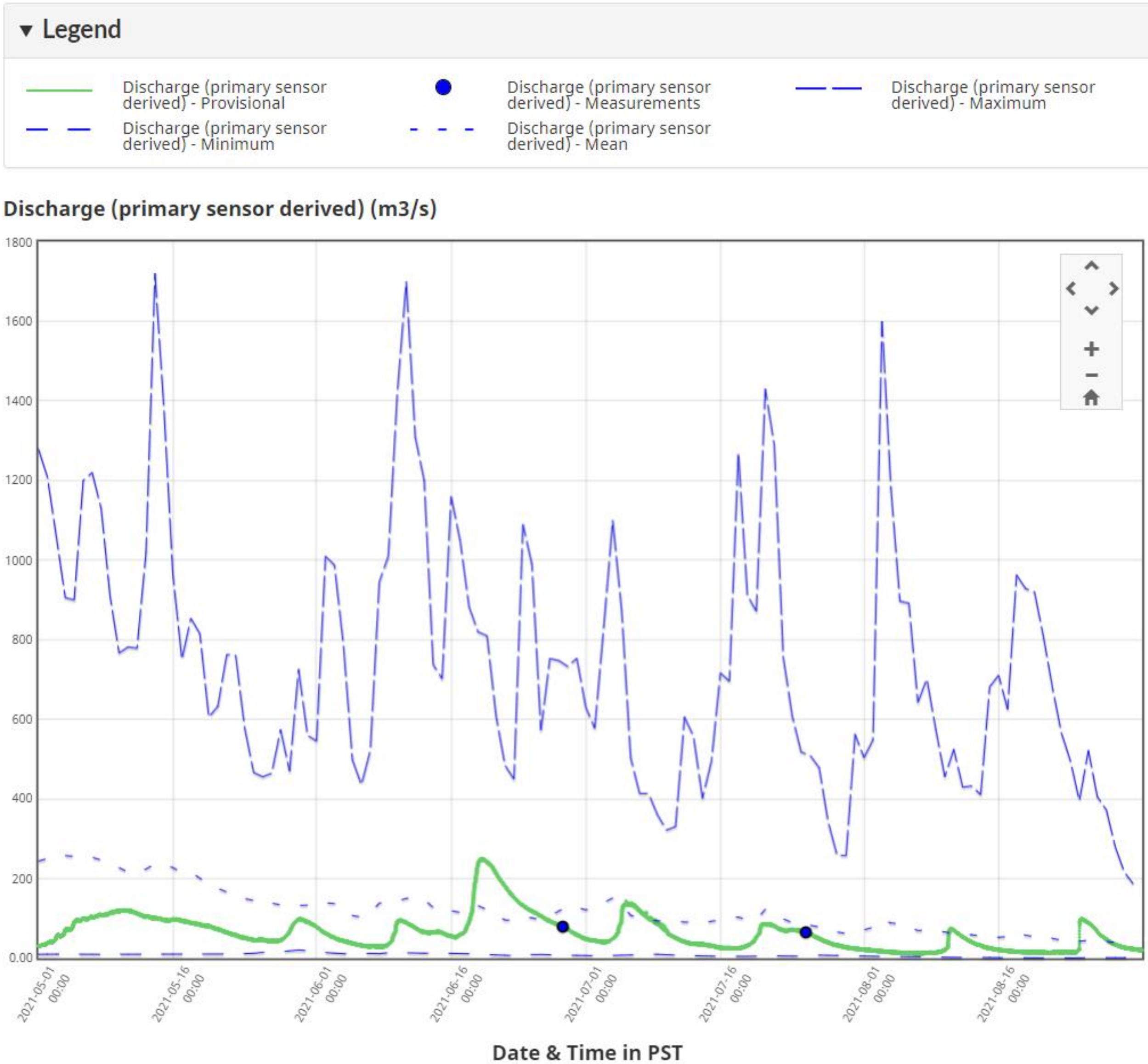

Figure 4. Discharge of the Beatton River near Fort St. John (Water Survey of Canada hydrometric sStation 07FC001) from 1 May to 31 August 2021. Data were provided at 5-minute intervals. Image was captured from the Water Survey of Canada (WSC) webpage (wateroffice.gc.ca) in November 2021. Note that these discharge data are listed as provisional by the WSC.

Figure 5. Twin-engine helicopter equipped with a single H-antenna mounted on the nose for conducting mobile-tracking surveys in the Beatton and Kiskatinaw rivers, 2021.

Methods

Walleye Movements and Identifying Potential Spawning Areas

Past studies, as summarized in Mainstream (2012) and ESSA et al. (2020), have identified the Beatton River as a source of recruitment for Peace River Walleye, and the Kiskatinaw River as a suspected recruitment source. Peace River telemetry studies (e.g., AMEC and LGL 2008a,b,c) have shown that the majority of Walleye presumably spawning in the Beatton River congregate at the river mouth in early-mid April, migrate as far as 30-50 km upstream to spawning areas from around late April through June, and then return to the mouth of the Beatton River. Previous studies did not extensively sample for Walleye in the Kiskatinaw River, but it was assumed that spawning movements, if any, would be similar in timing to those in the Beatton River. In 2021, the pre-season plan was to conduct mobile-tracking surveys in both of these rivers from late April to early June at a frequency of one survey every four days (11 surveys total). The goal of this level of effort was to characterize the upstream migration of radio-tagged Walleye using these systems, and to identify potential spawning areas. During the surveys, there were 125 adult radio-tagged Walleye available for detection, including 60 that were radio-tagged in the Peace River between 27 August and 1 October 2019 (64 fish released, but 4 were expected to have expired batteries), and 65 that were released between 24 August and 6 October 2020 (Hatch et al. 2021).

For each survey, a twin-engine helicopter was equipped with one H-antenna mounted on the nose (Figure 5). Shielded coaxial cable (RG-58) was used to connect the antennas to a single SRX800 receiver that was operated by a biologist in the co-pilot seat. Surveys were flown at low elevation (<50 m) and relatively slow air speeds (<100 km/h). As soon as a radio-tagged Walleye was detected, air speed was reduced to

50 km/h or slower to ensure precise tag locations were recorded for each fish. A GPS signal was fed directly into the SRX800 receiver (producing geo-referenced detection data), and a handheld GPS unit was run to store a complete track of the survey route. The receiver clock was synchronized with the GPS unit prior to each flight. The approximate position and identity of each detected radio tag (tagged fish) was recorded manually on a datasheet by the field crew, as a backup to the electronic systems. Prior to the first survey, a test tag was used to qualitatively confirm detection range at altitude, and test receiver gain settings.

The SRX800 receiver and GPS unit were downloaded after each day, and the data were sent electronically to the office staff for processing. Detections from each day were filtered to remove noise, and erroneous detections from codes that were not associated with active tags. Then, the highest-powered detection of each unique tag was selected, and the timestamp and geographic coordinates of that detection were used to represent that fish's location during the time of the flight survey. Thus, at the end of each flight, each unique tag appeared once in the resulting datafile, on a line containing its ID (frequency, code, species), a timestamp, a latitude and longitude, the number of times it was detected during the flight, and the maximum power reading recorded for that tag.

The geo-referenced data were run through ArcGIS using a Python script that outputted the name of the river/creek in which the detection was located, and a RKM reading. The post-processed data were uploaded into the Site C Fish Movement Assessment Database and processed (see Hatch et al. 2022) to put each new mobile detection in the context of all other detections of that fish.

When processing telemetry data from the Site C Fish Movement Assessment in general (see Hatch et al. 2022), we did not assume that detections within 0.5 km of the mouth of a tributary were committed to continuing upstream. This is because many of these detections could theoretically be of fish that are actually in the Peace River mainstem yet *appear* to be within a tributary as a result of the position of the aircraft, the timing of tag transmissions relative to the motion of the aircraft, or, to a lesser extent, the sampling error of the GPS device (which typically had better than 50 m accuracy). As such, the mobile-tracking zones associated with tributary areas were set to start 0.5 km from their junction with the larger river to which they join (this can be seen in Figures 1 and 2). Since the movement data were processed in this way, it was most straightforward to restrict Walleye movement analyses to detections that were > 0.5 km upstream from the mouths of the Beatton or Kiskatinaw rivers. Thus, tributary entrance was defined by passing that 0.5 km threshold.

To find potential spawning sites, we examined the sequential detections of individuals to look for cessation of upstream movement (recurring detections of an individual in one place over time), which could indicate arrival at a desired location (e.g., Eiler et al. 1992). Where individual fish did not show repeated detection in a single place, we assumed their destination was their farthest upstream location, a standard procedure for fish migrating upstream into a spawning river (similar to Yanusz et al. 2018). For each flight, we looked for potential aggregations by examining the collective detection locations of all the slow or stopped individuals.

Migration speeds (km/d) for individual fish were calculated by dividing the distance traveled between surveys by the length of time between surveys.

Walleye Spawning Habitat Assessment

The crew attempted to assess each potential spawning area to sample the habitat characteristics. Due to limited road access, a two-person crew used a helicopter to access potential spawning sites, and those without a safe nearby helicopter landing zone were not sampled. In rivers, Walleye are known to spawn in riffles, rapids, and areas of faster current (e.g., Hartley and Kelso 1991), but flow conditions and safety concerns precluded sampling habitat across the entire cross-section of the river channel, so the crew focused on nearshore areas that were safely accessible on foot. A variety of habitat parameters were measured at each potential spawning location (see Appendix A for datasheet templates and field definitions), including:

- Date, time, and geodetic location
- Water temperature (± 0.1ºC), pH (± 0.1), and conductivity (± 1% FS, µS/cm) were measured with a portable meter (Hanna Instruments Model HI9811-5)
- Water clarity was visually estimated and scored using a categorical ranking (either turbid, moderately turbid, lightly turbid, or clear)
- Velocity (m/s, averaged over 30 s) was measured in areas that were safely accessible on foot (at 1 to 25 m from the bank, depending on the site, see Appendix C) using a current meter (Swoffer Model 2100)
- D90 (cm) was calculated as the average size of the largest moveable substrate
- Bankfull and wetted channel widths (m) were measured with rangefinders
- Substrate composition, embeddedness, and compaction
- Available fish cover (%)
- Dominant instream and bank habitat type

Juvenile Walleye Rearing Habitat Assessment

Backpack electrofishing and beach seining were the two capture methods used to sample for young-of-the-year (YOY) Walleye in 2021. Electrofishing was used in higher velocity areas, whereas beach seining was used in lower velocity (and deeper) areas. A three-person crew was used for both methods, and sampling was focused in areas that were downstream of potential spawning locations (as identified by tracking radio-tagged adult Walleye, see above). Since habitat for YOY Walleye is one of the least studied aspect of Walleye biology (Bozek et al. 2011), we endeavoured to sample an array of habitat types (i.e., pool, riffle, run, flat) to ensure coverage of all potential rearing areas.

A Smith-Root LR-24 backpack electrofisher was used with the same settings at each site (200 VDC, 60 Hz, 4.2 ms). The operator waded in an upstream direction along the channel margin and sampled potential fish holding areas. Two netters were positioned nearby to collect immobilized fish and place them in a holding bucket. A single pass was used at each location. Sample length, sample width (~1 m), and sample time (s) were recorded at each site.

The beach seine was 5.5 m long and 1.5 m deep with 6.3 mm stretched mesh (18 ft long, 5 ft deep, 0.25 inch mesh). The net was typically set perpendicular to the shoreline and drifted for a short distance downstream (~25 m) before being hauled to shore. Multiple sets were conducted at most sites. Crews rated set effectiveness for each site as either good, moderately good, moderately poor, or poor (see Appendix D). All fish captured were transferred from the seine net to a holding bucket.

For both gear types, all fish were held in an aerated holding bucket prior to sampling. A region-specific term of the Fish Collection Permit (FLNRORD No. FJ21-620914) required aeration be used in buckets when the water temperature exceeded 15ºC. Fish were anesthetized by adding 50 PPM of a clove oil solution (the solution was made from clove oil mixed with 70% ethyl alcohol at a 9:1 alcohol to clove oil ratio) to the aerated water. All fish measuring 30 mm or greater were identified to species, measured for length (to the nearest 1 mm), and weighed (to the nearest 0.1 g; see Appendix A for sample datasheet). Total length was measured for Burbot (*Lota lota*) and sculpins (Cottidae); and fork length was measured for all other species. YOY minnows (Cyprinidae) and sculpins (<30 mm in length) were tallied but not identified to species.

Depending on their size and species, some of the captured fish were scanned for PIT tags, and PIT tags were injected into some of the untagged fish that were in good condition. The species and size criteria were based on those used for the Site C Reservoir Tributary Fish Population Indexing Survey (Golder 2020), which included Arctic Grayling, Burbot, Bull Trout, and Rainbow Trout over 80 mm. When PIT tags were to be implanted, the sizes (i.e., models) of the tags used were again based on fish length criteria (Golder 2020).

Habitat parameters measured at each sampling site were the same as those recorded during the spawning component (see Appendix A for sample datasheet).

Results

Walleye Movements and Potential Spawning Areas

Kiskatinaw River

Five mobile-tracking surveys were conducted along the mainstem of the Kiskatinaw River. On 1 and 5 May, surveys were flown from the Kiskatinaw River mouth (rkm 0) up to the Highway 97 Bridge (rkm 58; Appendix B). Surveys conducted on 9, 14, and 19 May, respectively, were flown from the mouth to rkm 6 (Mica Cr), rkm 38 (Coal Cr) and rkm 10. No radio-tagged Walleye were detected on any of the surveys; thus, no spawning habitat data were collected in the Kiskatinaw River in 2021. Tracking of the Kiskatinaw River was discontinued after 19 May 2021.

Beatton River

Ten mobile-tracking surveys were conducted between 1 May and 7 June 2021 along the mainstem of the Beatton River, covering from the mouth up to rkm 89 (Milligan Creek Road Bridge), although three surveys (1, 26, and 30 May) stopped at rkm 70 (Appendix B) based on in-situ decisions of the field crew. Twenty-six radio-tagged adult Walleye were detected within the Beatton River across all ten surveys. The detected Walleye had originally been tagged and released at a wide variety of locations both upstream and downstream of the Project, including Sections 1, 3, 5, 6 and 7 (Table 2). The detected fish, when released in 2019 or 2020, measured between 325 and 679 mm FL (average 442.3 mm), and weighed between 297 and 3,327 g (average 1,093.2 g; Table 2). Seven of these fish were never detected upstream of rkm 1.5 of the Beatton River (Table 2, Appendix B). The remaining 19 Walleye were larger on average (452 vs. 415 mm; or 1,131 vs 991 g), but the differences were not statistically significant (length: $F_{1,24} = 0.80$, $P = 0.38$; weight: $F_{1,24} = 0.14$, $P = 0.72$). The number of tags detected upstream of the first 0.5 km ranged from 8 (on the last survey, 7 June) to 19 (14 and 19 May; Table 3). The detection efficiency of the Beatton River overflights was 99% (Table 3), having detected 157 of a possible 158 detection events upstream of the river mouth across the ten mobile tracking surveys. Very high detection efficiencies were expected given the method of flying required to pinpoint potential spawning locations.

Based on their most upstream detection location, seven radio-tagged Walleye never moved upstream of rkm 1.5 (stayed in the lower areas of Reach 1), 11 fish made it to the upper areas of Reach 1 (rkm 3.6-35.9), six fish moved into Reach 2, and two fish made it to Reach 3 (Table 3). No radio-tagged Walleye were detected in Reach 4. From the nineteen radio-tagged Walleye that were tracked at or upstream of

Table 2. Release information for the radio-tagged Walleye detected in the Beatton River during mobile-tracking surveys conducted from 1 May to 7 June 2021. See appendices in Golder and Gazey (2020) for locations of release sites.

Tag ID	Tag Channel	Tag Code	Tag Model	Release Date	Release Time	Release Site	Fish Length (mm)	Fish Weight (g)	Passed rkm 1.5
480	3	162	NTF-6-2	22 Sep 2019	14:31:00	0602	418	798	Y
504	3	301	NTF-6-2	17 Sep 2019	13:56:30	07BEA02	429	897	Y
521	3	160	NTF-6-2	24 Sep 2019	15:44:00	07BEA01	482	1,274	Y
532	3	159	NTF-6-2	24 Sep 2019	15:44:00	07BEA01	430	774	Y
713	3	645	NTF-6-2	25 Aug 2020	16:56:32	0511	357	501	Y
736	3	519	NTF-6-2	28 Aug 2020	11:12:20	0609	679	3,226	Y
744	3	521	NTF-6-2	29 Aug 2020	11:52:44	07BEA01	496	1,490	Y
746	3	534	NTF-6-2	29 Aug 2020	12:07:34	07BEA01	419	803	
750	3	515	NTF-6-2	29 Aug 2020	16:49:31	0703	402	675	Y
762	3	527	NTF-6-2	30 Aug 2020	18:38:20	07KIS01	375	596	Y
779	3	537	NTF-6-2	8 Sep 2020	11:12:06	06PIN02	531	1,426	Y
804	3	624	NTF-6-2	12 Sep 2020	16:20:00	0303	511	1,238	Y
820	3	622	NTF-6-2	15 Sep 2020	15:10:00	0312	379	638	Y
830	3	644	NTF-6-2	17 Sep 2020	11:16:49	06PIN01	610	2,876	Y
837	3	588	NTF-6-2	18 Sep 2020	09:50:00	0103	434	930	Y
841	3	630	NTF-6-2	18 Sep 2020	13:07:02	06SC036	383	611	
844	3	584	NTF-6-2	18 Sep 2020	16:20:56	0607	332	400	
857	3	653	NTF-6-2	20 Sep 2020	17:38:00	0301	413	744	Y
863	3	576	NTF-6-2	21 Sep 2020	12:15:15	0610	325	297	Y
865	3	573	NTF-6-2	21 Sep 2020	12:24:29	0610	333	335	
889	3	571	NTF-6-2	23 Sep 2020	14:52:20	OEMMS	406	697	Y
890	3	574	NTF-6-2	23 Sep 2020	15:10:20	0509	537	1,847	Y
902	3	498	NTF-6-2	24 Sep 2020	15:27:04	0512	380	561	Y
910	3	494	NTF-6-2	25 Sep 2020	11:28:32	0708	451	973	
911	3	490	NTF-6-2	25 Sep 2020	11:39:00	0708	360	488	
936	3	530	NTF-6-2	6 Oct 2020	17:22:02	07BEA01	629	3,327	

rkm 1.5 from 1 May to 7 June 2021, we identified sixteen potential spawning sites (rkm 3.6-45.7; Figure 6) – the other three fish were still moving upstream at the time of the last mobile survey (Table 3).

Beatton River entrance timing is shown in Table 3 for the nineteen fish that eventually passed rkm 1.5. For some fish, the exact entrance timing could be calculated using data collected by the fixed-station receiver located at the mouth of the Beatton River (see Hatch et al. 2022), whereas others either entered without being detected by that receiver, or did so during the winter (see dates in Table 3) when the station was demobilized. Entrance was during the winter for four fish, within a few days of the first survey (April 26-30) for seven fish, or on 1 May itself for another four fish (including one prior to the mobile flight and three after the flight was complete). Four other radio-tagged Walleye were detected entering the Beatton River on 4, 5, 7, or 13 May. Of the nineteen radio-tagged Walleye that eventually passed rkm 1.5, twelve were detected beyond the mouth of the Beatton River on the first survey on 1 May, including 10 that had already passed rkm 1.5 before the first flight.

Table 3. Location (river kilometer, rkm) of radio-tagged Walleye detected in the Beatton River during mobile-tracking surveys conducted from 1 May to 7 June 2021, by reach of most upstream detection, tag ID, and survey date. Bold numbers indicate the most upstream detection for each fish. Cells shaded in blue were considered as part of cluster of detections that lent evidence to there being possible spawning activity, and the value in red was the most representative (e.g., central) of the possible spawning location of each fish (three fish that were still moving upstream at the time of the last mobile survey have their tag ID shown in red). Detections within 0.5 km of the mouth are labelled as "mouth". One detection was missed. Blank cells indicate where the fish was known (from its complete detection history) not to be in the Beatton River. Entrance and departure dates determined using the fixed-station receiver at the mouth of the river, and other detection data.

			Location of Tag Detection (rkm), by Survey Date										
Reach	Tag ID	Entrance Date (for fish > 1.5 rkm)	1 May	5 May	9 May	14 May	19 May	22 May	26 May	30 May	3 Jun	7 Jun	Departure Date (for fish > 1.5 rkm)
1	865	-	mouth	0.6									-
(rkm 0.0-1.4)	911	-	mouth	0.6	mouth								-
	910	-							1.1	0.7	mouth	mouth	-
	936	-	0.8	0.7	mouth	mouth	mouth	mouth					-
	841	-	1.1	0.8									-
	844	-	1.3	mouth	mouth	mouth							-
	746	-	mouth		mouth	mouth	0.7	mouth	1.1	mouth		mouth	-
1	890	13 May 2021				2.1	3.6	mouth	mouth	mouth	mouth		22 May 2021
(rkm 1.5-35.9)	532	30 Apr 2021	4.2	6.5	7.3	7.5	7.8	7.4	mouth				26 May 2021
	820	7 May 2021			1.4	11.7	13.8	13.1	13.8	14.7	mouth	mouth	2 Jun 2021
	889	1 May 2021	0.7	11.3	16.6	16.3	18.8	18.4	17.7	mouth	mouth	mouth	26 May 2021
	762	30 Apr 2021	2.0	16.8	21.4	21.3	21.7	21.1	4.5	3.7	0.7		3 Jun 2021
	521	1 May 2021	mouth	12.9	16.5	24.3	29.7	29.5	29.7	30.7	15.4	0.7	7 Jun 2021
	736	30 Apr 2021	3.9	7.9	20.9	32.6							16 May 2021
	713	Dec 2020 - Mar 2021	1.4	2.6	14.5	25.9	26.2	31.0	33.3	33.3	28.0	2.5	24 Jul 2021
	779	30 Apr 2021	2.1	11.6	23.9	27.3	33.9	33.4	34.1	33.9	mouth		1 Jun 2021
	902	4 May 2021		2.1	11.5	18.8	24.3	25.3	33.6	33.7	33.7	34.6	14 Jun 2021
	857	27 Apr 2021	7.2	30.1	35.1	35.7	34.4	35.9	35.7	35.9	23.6	23.6	Did not
2	750	20 - 24 Nov 2020	7.5	24.2	26.0	31.0	36.6	35.8	23.0	mouth	mouth	mouth	27 May 2021
(rkm 36.0-56.8)	744	1 May 2021	mouth	8.7	16.6	38.3	22.7	mouth	0.6	mouth	0.9	mouth	22 May 2021
	504	Oct - Nov 2020	39.5	44.7	45.7	45.6	45.8	45.7	45.7	45.6	44.9	mouth	7 Jun 2021
	480	Nov - Dec 2020	2.4	16.8	24.1	45.5	46.4	45.0	45.0	45.0	mouth	mouth	3 Jun 2021
	837	29 Apr 2021	14.0	36.6	44.4	45.5	44.7	44.4	45.6	44.7	45.3	48.5	Did not
	863	1 May 2021	mouth	2.2	2.1	3.1	12.0	18.1	41.7	miss	48.1	49.9	Did not
3	830	26 Apr 2021	11.2	22.8	33.2	35.8	51.4	51.2	54.5	55.2	55.4	57.5	24 Jun 2021
(rkm 56.9-81.3)	804	5 May 2021	mouth		5.1	6.0	14.6	21.9	51.8	53.4	55.8	69.8	26 Aug 2021
No. Tags Beyond Mouth			15	20	18	19	19	16	18	14	11	8	

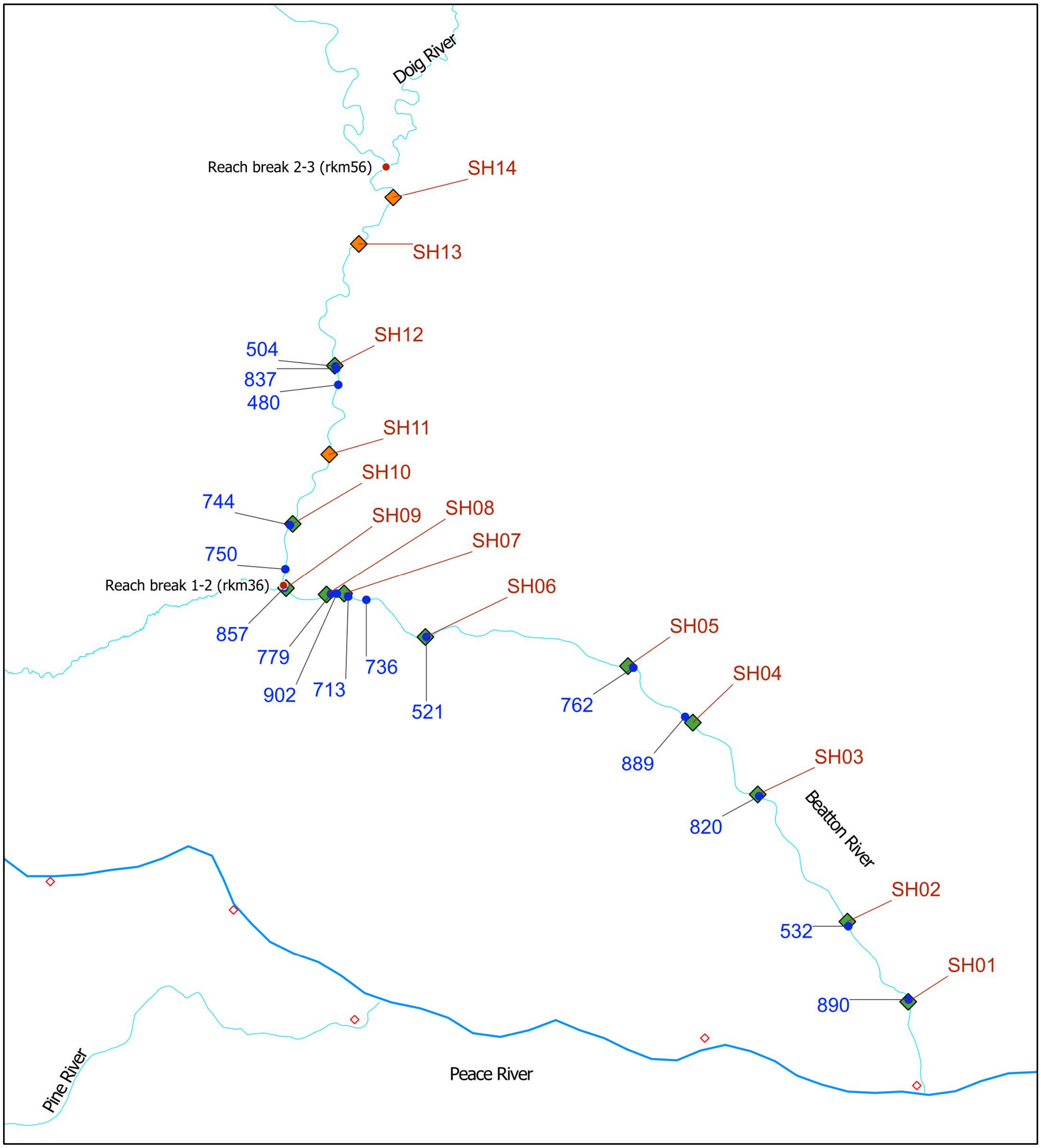

Figure 6. Potential spawning locations for 16 radio-tagged Walleye (blue circles, labelled by Tag ID) based on their detection data during mobile-tracking surveys conducted from 1 May to 7 June 2021. Also shown: fourteen sites (SH01-SH14) where spawning habitat characteristics were sampled on 27-28 May (green diamonds for sites that are within 200 m of a potential spawning location, otherwise orange). Small red diamonds show the fixed-station receivers deployment locations.

Other than Walleye, there were five radio-tagged fish detected. One Arctic Grayling was detected at rkm 0.7 on 7 June 2021. One Rainbow Trout was detected at rkm 4.7 on 24 May (it was detected at the fixed station at the Beatton mouth as it entered the tributary 6.5 hours earlier, and again as it departed two days later). Three Bull Trout were detected: one was in the river from 30 April to 17 May (and was detected moving upstream at rkm 2, 12, 21, and 47 during the mobile tracks on 1, 5, 9, and 14 May, respectively); one has seemingly been resident in the Beatton River since October 2020 (and was detected at rkm 46 during all ten mobile tracks); and one was detected at rkm 0.9 on 22 May 2021, without associated detections at the Beatton Mouth fixed station.

By the time the last survey occurred on 7 June, eight radio-tagged Walleye remained in the Beatton River, all but one upstream of rkm 1.5. Five of these fish were still moving upstream, being detected farther upstream on June 7 than they were on June 3. Using data from the mobile surveys, coupled with the fixed station at the mouth of the river, it is estimated that one fish departed on 16 May, five fish (31%) departed in the week of 21-17 May, four fish (25%) between 1-3 June, and two fish on 7 June. After the surveys ended, we detected two fish departing in late June, one in July, and one in August. Three of the radio-tagged Walleye had not been detected exiting the Beatton River as of January 2022 (Table 3).

The fastest upstream migration speed between surveys was 7.4 km/day (Tag ID 804 moved from rkm 21.9 to rkm 51.8 between the 22 and 26 May surveys). The fastest downstream migration speed within the Beatton River was 5.5 km/d (Tag ID 744 moved from rkm 38.3 to rkm 22.7 between the 14 and 19 May surveys). Maximum speeds for each of the 19 potential spawners are shown in Figure 7.

Walleye Spawning Habitat Assessment

Fourteen potential spawning sites were assessed for habitat characteristics on 27 and 28 May 2021 (Figure 6; Table C-1). At that time, potential spawning sites were determined from tag detection histories through May 26. However, aerial-tracking surveys continued through June 7, so any potential spawning sites that were determined using data from after May 26 were not sampled. Of the 14 sites sampled for habitat characteristics, eleven were in close proximity (<200 m away) to a potential spawning site (six in Reach 1 and two in Reach 2; Figures C-1 to C-11), and three were 800 m or farther downstream of a potential spawning site (one in Reach 2, two in Reach 3). Sampling sites that were > 800 m from a potential spawning location may not be representative of spawning habitat and are shown for comparative purposes, but subsequent results focus on the eleven sites sampled near a potential spawning site.

At the eleven sites sampled in close proximity to a potential spawning site, water temperatures in the Beatton River ranged from 12.1 to 12.8° C, pH ranged from 8.0 to 8.3, conductivity ranged from 147 to 162 µs/cm, water velocities ranged from 0.00 to 0.80 m/s (measured 1 to 25 m from shore at depths of 0.51 to 0.87 m), and the water was turbid (Table C-1). Bankfull and wetted widths ranged from 98 to 140 m and 64 to 108 m, respectively. All of the sites sampled were in runs, and in areas with eroding bank habitat and little to no cover for fish. Substrate composition was mainly cobble and gravel (D90 range: 14 to 35 cm) with low to medium levels of substrate embeddedness and compaction.

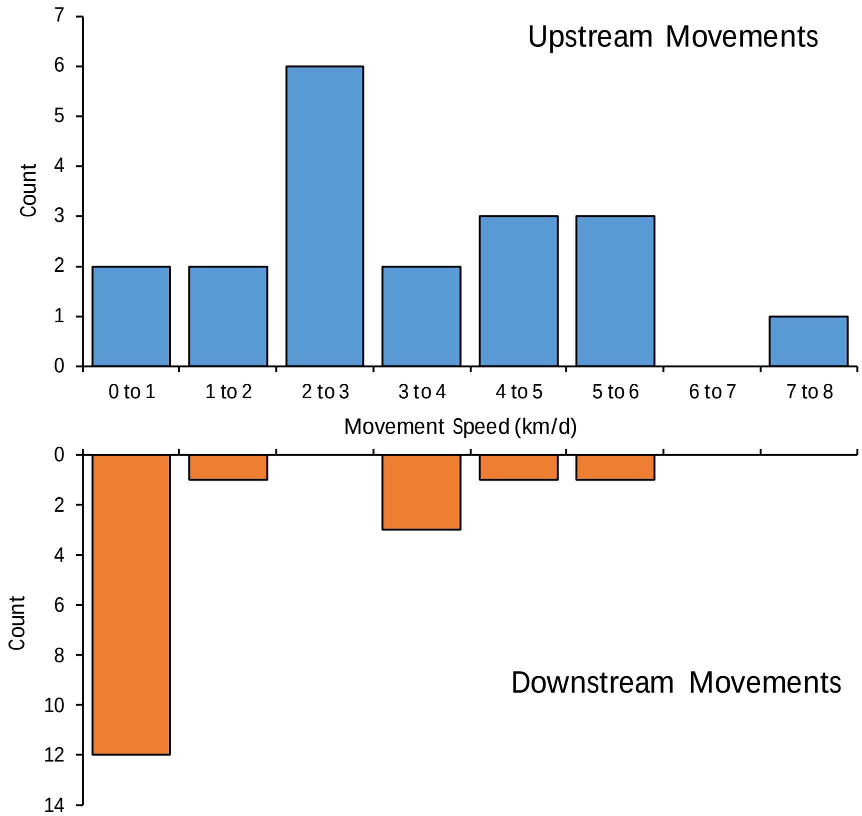

Figure 7. Distribution of maximum observed movement speeds for 19 radio-tagged Walleye that may have spawned in the Beatton River upstream of rkm 1.5 during tracking in the Beatton River from 1 May to 7 June 2021. Movements in the upstream direction are shown in the upper panel; those in the downstream direction are shown below the horizonal axis on the lower panel.

Juvenile Walleye Rearing Habitat Assessment

From 17 to 19 August 2021, six beach seine sites (four in Reach 1, two in Reach 2) and five electrofishing sites (four in Reach 1, one in Reach 2) were sampled for juvenile Walleye in the Beatton River (Figure 8; Table D-1). No sampling was conducted in Reaches 3 or 4. No juvenile Walleye were captured during the sampling program.

In total, 108 fish were caught and identified to species, including 74 Flathead Chub *Platygobio gracilis*, 20 Longnose Dace *Rhinichthys cataractae*, 5 unidentified sculpins *Cottus* spp., 3 Trout-perch *Percopis omiscomaycus*, 2 Redside Shiner *Richardsonius balteatus*, 2 Northern Pikeminnow *Ptychocheilus oregonensis*, 1 Longnose Sucker *Catostomus catostomus*, and 1 White Sucker *Catostomus commersoni* (Table 4; Table D-2; Table D-3). No White Sucker or Trout-perch were caught in Reach 1, and no Longnose Sucker or Redside Shiner were caught in Reach 2. An additional 47 fish (42 *Cyprinid* and 5 *Cottus* spp.) measuring less than 30 mm were captured but not identified to species. No Arctic Grayling, Burbot, Bull Trout, or Rainbow Trout were captured, hence no fish were scanned for PIT tags, and no new tags were applied.

Despite no YOY Walleye being captured, habitat characteristics were recorded for most of the sites sampled (Table D-1; Figures D-1 to D-8). Water temperatures ranged from 17.5 to 20.8°C, pH ranged from 7.9 to 8.1, conductivity ranged from 110 to 130 µs/cm, and the water was turbid. Water velocities ranged from 0.12 to 0.58 m/s when measured 3 to 5 m from shore at depths ranging from 0.10 to 0.37 m. Substrates were composed largely of gravel and cobble (D90 range: 12 to 29 cm) with low to medium levels of embeddedness and compaction. Runs, riffles and flats were sampled with the beach seine, while only runs and riffles were sampled using the backpack electrofisher.

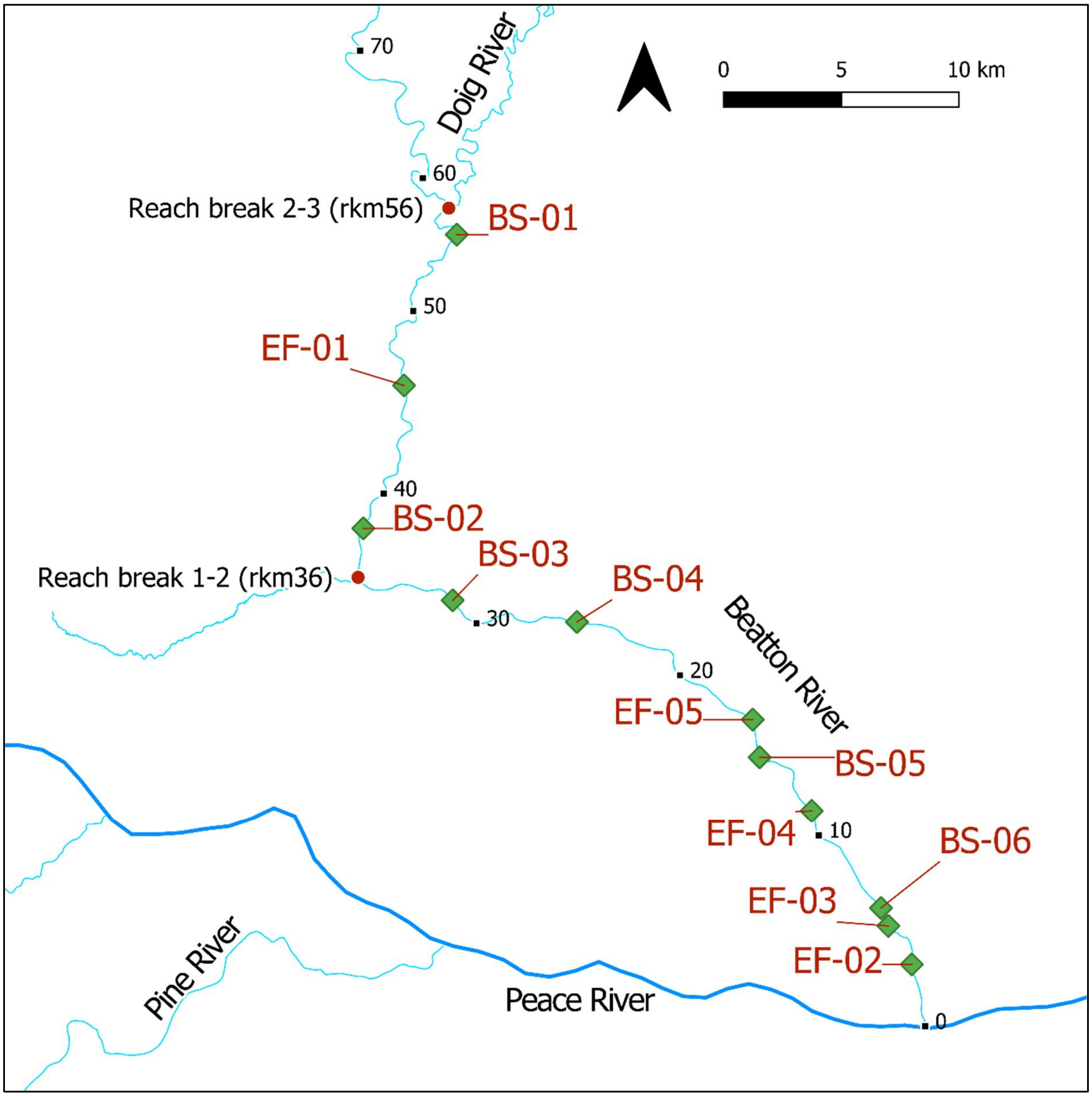

Figure 8. Location of six beach seine (BS) and five electrofishing (EF) sites that were sampled for juvenile Walleye in the Beatton River from 17-19 August 2021.

Table 4. Biological information collected from fish captured in the Beatton River from 17-20 August 2021.

	Beach Seine									Backpack Electrofisher								
		Length (mm)				Weight (g)					Length (mm)				Weight (g)			
Species	Catch	Min	Max	Mean	n	Min	Max	Mean	n	Catch	Min	Max	Mean	n	Min	Max	Mean	n
Longnose Sucker										1	211	211	211	1	114.8	114.8	114.8	1
White Sucker										1	45	45	45	1	1.7	1.7	1.7	1
Flathead Chub	43	50	415	79	43	1.3	30.5	5.3	42	31	22	121	56	31	0.2	17.0	2.6	27
Longnose Dace	1	35	35	35	1	0.6	0.6	0.6	1	19	36	85	51	19	0.4	5.3	1.5	19
Norther Pikeminnow	2	198	415	307	2	81.0	81.0	81.0	1									
Redside Shiner	2	51	97	74	2	1.5	10.2	5.9	2									
Trout-perch	1	66	66	66	1	2.9	2.9	2.9	1	2	40	61	51	2	0.8	2.4	1.6	2
Sculpin spp. > 30 mm	1	35	35	35	1	0.3	0.3	0.3	1	4	33	71	45	4	0.4	0.6	0.5	3
Minnow spp. < 30 mm	27									15								
Sculpin spp. < 30 mm										5								

Discussion

Walleye Movements and Identifying Potential Spawning Areas

Kiskatinaw River

There is no evidence that the Kiskatinaw River was used for spawning in 2021 by adult Walleye that were radio-tagged in the Peace River mainstem in 2019 and 2020. No radio-tagged Walleye were detected in the Kiskatinaw River during mobile-tracking surveys between the mouth and Highway 97 Bridge (rkm 52) from 1 to 19 May 2021. Moreover, the data from the fixed-station receiver operating at the mouth of the Kiskatinaw River showed no radio-tagged Walleye entering or leaving the Kiskatinaw in 2021 (Hatch et al. 2022).

The Kiskatinaw had been identified as a potential source of Walleye recruitment for the Peace River populations (Mainstream 2012). However, analysis of microchemistry from Walleye fin rays and otoliths did not find the Kiskatinaw to be an important natal source for Peace River Walleye populations (Christensen 2020). Ash (1975) reported that no Walleye were captured in a box-style trap (27 April to 14 May), hoop traps (1 to 17 May), or gill net sets (27 to 28 April) operated near the Kiskatinaw River mouth in 1975. During sampling in the fall of 1974, Ash (1975) reported that two juvenile Walleye (72 mm FL, 4.8 g; and 71 mm FL, 3.1 g) were captured in the Kiskatinaw River just downstream of the Highway 97 Bridge; but no Walleye were captured during sampling at the same location in May 1975. The author suggested that the young Walleye captured in the fall of 1974 may have been offspring of a small resident population. Since the Kiskatinaw River does not appear to be a significant spawning tributary for Peace River Walleye, and since none of the radio-tagged Walleye in the area appear to use it for spawning, it was recommended that this system be excluded from future studies that are trying to identify potential spawning areas.

Beatton River

The mobile telemetry data suggest that adult Walleye used the Beatton River for spawning in the spring of 2021. Twenty-six (20.8%) of the 125 available Walleye radio tags were detected in the Beatton River during mobile-tracking surveys from 1 May to 7 June 2021, of which 19 Walleye were tracked upstream of rkm 1.5 (Table 3; Figure 6). These findings were supported by previous radio-telemetry studies (2005-2007, 2019-2020) which documented Walleye movements from the Peace River to the Beatton River (AMEC & LGL 2008a,b,c, 2009; Hatch et al. 2020, 2021). During these studies, radio-tagged Walleye were detected congregating near the mouth of the Beatton River from March to mid-May, moving upstream in the Beatton River in May, and then returning to the Peace River by June.

In 2021, Walleye were tracked up to rkm 69.8 in Reach 3, which was upstream of the Doig River confluence, but no fish were tracked into Reach 4. In 2012, adult Walleye were captured in all four reaches using a boat electrofisher, with the highest catch rates occurring in Reach 1 (1.24 fish/km), followed by Reach 4 (0.92 fish/km), Reach 3 (0.64 fish/km), and Reach 2 (0.40 fish/km; Mainstream 2013).

The timing of the mobile-tracking surveys in 2021 may not have covered the full extent of the Walleye spawning period in the Beatton River. No Walleye that were identified as potential spawners were at their most upstream position on first survey (1 May), indicating that we started tracking during the migratory period, and not prior to the commencement of spawning itself. However, five fish were farther upstream on June 7 than they were on June 3, indicating the spawning period may have ended later than our last flight on 7 June. Since some fish were still moving upstream at the time of the last survey, it is also possible that Walleye spawned farther upstream than rkm 69.8 in 2021.

Walleye Spawning Habitat Assessment

In rivers, gravel and cobbles are the preferred spawning substrate for Walleye (McPhail 2007), although spawning has been documented in other habitats (e.g., Chalupnicki et al. 2010). Based on our Beatton River habitat assessments, conducted on 27 and 28 May 2021, radio-tagged Walleye possibly spawned downstream of rkm 68.9 (in Reaches 1, 2 and 3) in areas dominated by gravel and cobble substrates (D90 range: 14-35 cm; Table C-1).

No radio-tagged Walleye were tracked upstream of rkm 69.8 in Reach 3 in 2021, however it is possible that some tagged fish continued their upstream migration after the last mobile-tracking survey conducted on 7 June and spawned in the upper sections of Reach 3 or farther upstream. Reaches 3 and 4 contained confined sections with faster-moving water and larger substrates, but there were still sections within each reach containing suitable substrate and water velocities for Walleye spawning. Catches of adult Walleye in the upper section of Reach 3 and in Reach 4 in 2012 support this possibility (Mainstream 2013).

The potential spawning sites surveyed in the Beatton River in 2021 had relatively slow water velocities (≤ 0.80 m/s; Table C-1) in nearshore areas that could be sampled. While faster currents are generally associated with suitable Walleye spawning substrates (see Bozek et al. 2011), spawning has also been documented in shallow, slow-velocity habitat (Chalupnicki et al. 2010), and even in areas inundated by terrestrial vegetation (Holzer and Von Ruden 1982, as cited in Bozek et al. 2011). Nevertheless, the flows measured for this study were likely underestimates of those found in all the available microhabitats of our study sites (e.g., areas in the middle of the channel), given that measurements could only be taken in areas that could be safely waded by field personnel. The temperatures recorded when our crews were sampling ranged from 12.1 to 12.8° C (Table C-1) which is in the known range for Walleye spawning (peaks typically at 4°C to 14°C; Bozek et al. 2011). The pH measured at our sites ranged from 8.0 to 8.3, which is within the ideal range for reproduction and incubation of eggs (i.e., from 6.0 to 9.0; e.g., Holtze and Hutchinson 1989, Bergerhouse 1992). The turbidity observed at our sampling sites was consistent with the negative phototaxis observed by Walleye in general (Bulkowski and Meade 1983).

The suspected spawning locations that were identified in 2020 were distributed widely over the available space, with no obvious clusters of fish being tracked to a single or a small number of locations. Since it does require at least two individuals to spawn, the results are suggestive that too few Walleye were being tracked. And while individual Walleye's fidelity to specific sites has been observed in some systems (e.g., Crowe 1962), the lack of one or a few clusters of radio-tracked fish in the Beatton River may indicate that spawning habitat is broadly available. As seen from the overflights, and based on the measurements taken at the sampled sites, the Beatton River is not particularly variable, and nothing stood out as different about the locations that were identified from the telemetry data.

Mobile-tracking surveys were conducted frequently (approximately every 4 days) via a slow-moving helicopter to obtain reasonably precise potential spawning locations. Despite being a suitable method for tracking fish in a large and relatively remote river, there were limitations. Mainly, the location of spawning had to be inferred from periodic detection data, which did not confirm fish behaviour (e.g., migrating vs. holding vs. spawning). Also, the tracking methods used could only identify the position of a tagged fish to within approximately 50 to 100 m of its actual location. Since multiple instream habitat types can be found within a 50 to 100 m river section, at this resolution, it was difficult to match the exact instream habitat type with the estimated spawning location. For better information, oviduct tags have been used to estimate timing and location of spawning (e.g., Binder et al. 20214), but this technique would have required dedicated individual animals to have captured and tagged, which was beyond the scope of this study.

Juvenile Walleye Rearing Habitat Assessment

No juvenile Walleye were captured in the Beatton River during beach seine and backpack electrofishing conducted from 17 to 19 August 2021 (Table D-1), despite having sampled habitat types and using gears that have successful yielded YOY Walleye in the past (e.g., Mainstream 2010, 2011). Eight other fish species of various size classes (including the size class of YOY Walleye) were captured (Table 4), indicating that the methods were successful for capturing fish. It seems unlikely that juvenile Walleye were present in the Beatton River above rkm 2.8 at the time of sampling and simply avoided being captured. Similarly, no juvenile Walleye were captured in the Beatton River using a boat electrofisher, backpack electrofisher, or beach seine between 24 July and 4 August 2012 (Mainstream 2013).

It is possible that young Walleye migrate to the mainstem Peace River by early summer. From microchemical analyses, Christensen (2020) predicted that 91% of Walleye with natal habitat in the Beatton River moved downstream into the Peace River during their first summer. Based on published incubation periods for Walleye eggs (7 days at 14°C or 26 days at 4.5°C, McPhail 2007) and the water temperatures encountered during our spawning assessment surveys (12.1 to 12.8° C), incubation in 2021 was likely 9.5 to 11 days. If the timing of our spawning surveys (27 and 28 May 2021) was correct, then eggs may have hatched by the first week of June, and could have moved downstream thereafter. In fact, exogenous feeding likely begins ~5 days after hatch (McPhail 2007), which could have been in the second week of June in 2021. Indeed, juvenile Walleye have been captured by beach seine in the mainstem Peace River at or near the Beatton River confluence in late summers of 2009 (14-25 July, Mainstream 2010) and 2010 (6-21 July, Mainstream 2011). By contrast, boat electrofishing at the mouths of Section 7 and 8 tributaries, conducted as part of Mon-2's Contingent Goldeye and Walleye Surveys, caught no YOY Walleye despite the sampling occurring as late as mid-July in some years (Golder and Gazey 2019, 2020, Golder 2021).

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Appendices

Appendix A. Datasheets Templates and Definitions

Table A-1. Definition of datasheet fields.

Parameter	Description
Walleye Spawning Habitat Sampling	
Tag Code	Unique tag code(s) of radio-tagged Walleye tracked to this location
UTM	GPS coordinates of sample site (zone, easting, northing)
Temp.	Water temperature measured at the sample site (± 0.1°C)
pH	pH measured at the sample site (± 0.1)
Cond.	Conductivity at the sample site (µS/cm; ± 2% full scale)
Clarity	Categorical ranking of water clarity (turbid, moderately turbid, lightly turbid, clear)
Depth	Water depth measured at a given distance from shore (m)
Velocity	Water velocity measured at a given distance from shore (m/s)
Instream Habitat	Instream habitat type (flat, pool, riffle, run, backwater)
Bank Habitat	Bank habitat type (armoured, canyon, depositional, erosional)
Fish Cover	Percent estimate of available fish cover (e.g., overhead cover, inriver rock/boulders, vegetation)
D90	Average size of substrate material in the 90th percentile (cm)
Substrate Composition	Percent estimate of substrate composition (organics, silt, sand, gravel, cobble, boulder, bedrock)
Embeddedness	Degree to which rock substrates are surrounded and/or covered by fines (low, moderate, high)
Compaction	Degree of substrate looseness, or its ability to be moved during high flow (low, moderate, high)
Photo ID	File number of site photos
Walleye Rearing Habitat Sampling (Page 1)	
Site ID	Unique identifier for each beach seine (BS) and electrofishing (EF) site
UTM-Upstream	GPS location of upstream end of sample site
UTM-Downstream	GPS location of downstream end of sample site
Electrofishing	
Mode/Freq	Mode (AC/DC) and frequency (Hz) used at site
Amps	Current (A) used at site
Volts	Voltage (V) used at site
Sample Length	Length of habitat sampled (m)
Sample Time	Sample effort (s)
Beach Seining	
Haul Dist	Length of habitat sampled (m), which may be the sum of multiple hauls
Effectiveness	Classification of haul effectiveness (good, mod. good, mod. poor, poor)
Catch Summary	Tally of the number of fish of each species captured at the site
Walleye Rearing Habitat Sampling (Page 2)	
Species	Species code of fish
FL	Fork length (mm)
Wt	Weight (g)
Scanned?	Indication of whether the fish was scanned for a PIT tag (yes/no)
PIT Type Applied	Type of PIT tag applied to an untagged fish (12, 23, or 32 mm)
PIT # Applied	Unique PIT tag number applied to an untagged fish
PIT # Recap	Unique PIT tag number of a tagged fish (i.e., recapture)

Table A-2. Common and scientific names of fish species captured in the Beatton River, 2021.

Group	Common Name	Scientific Name	Species Code
Suckers	Longnose Sucker	*Catostomus catostomus*	LSU
	Largescale Sucker	*Catostomus macrocheilus*	CSU
	White Sucker	*Catostomus commersoni*	WSC
Minnows/	Flathead Chub	*Platygobio gracilis*	FHC
Trout-perch	Longnose Dace	*Rhinichthys cataractae*	LNC
	Northern Pikeminnow	*Ptychocheilus oregonensis*	NSC
	Redside Shiner	*Richardsonius balteatus*	RSC
	Trout-perch	*Percopis omiscomaycus*	TP
Sculpins	Prickly Sculpin	*Cottus asper*	CAS
	Slimy Sculpin	*Cottus cognatus*	CCG
	Spoonhead Sculpin	*Cottus ricei*	CRI

Walleye Spawning Habitat Sampling - LGL Limited (EA4105)

Sheet _______ of _______

Date				Time				Crew			
Stream								Tag Code			
UTM:	Z			E				N			
WATER CONDITIONS											
Temp.				pH				Cond.			
Clarity:	Turbid	Moderately turbid	Lightly turbid	Clear							
Depth:	Near			Mid				Far			
Velocity:	Near			Mid				Far			
HABITAT CHARACTERISTICS											
Instream habitat:	Flat	Pool	Riffle	Run	Backwater						
Bank habitat:	Armoured	Canyon	Depositional	Erosional							
Fish cover (%):											
SUBSTRATE											
D90	1	2	3	4	5	6	7	8	9	10	Avg
Substrate Comp (%)	Org	Silt	Sand	Grav	Cob	Bou	Bed				
Embeddedness:	L	M	H	Compaction:	L	M	H				
Photo ID	D/S			LB-to-RB							
	U/S			RB-to-LB							
COMMENTS											

Date				Time				Crew			
Stream								Tag Code			
UTM:	Z			E				N			
WATER CONDITIONS											
Temp.				pH				Cond.			
Clarity:	Turbid	Moderately turbid	Lightly turbid	Clear							
Depth:	Near			Mid				Far			
Velocity:	Near			Mid				Far			
HABITAT CHARACTERISTICS											
Instream habitat:	Flat	Pool	Riffle	Run	Backwater						
Bank habitat:	Armoured	Canyon	Depositional	Erosional							
Fish cover (%):											
SUBSTRATE											
D90	1	2	3	4	5	6	7	8	9	10	Avg
Substrate Comp (%)	Org	Silt	Sand	Grav	Cob	Bou	Bed				
Embeddedness:	L	M	H	Compaction:	L	M	H				
Photo ID	D/S			LB-to-RB							
	U/S			RB-to-LB							
COMMENTS											

Figure A-1. Walleye Spawning Habitat Sampling datasheet, 2021.

Walleye Rearing Habitat Sampling - LGL Limited (EA4105)

Sheet _______ of _______

Date				Time				Crew			
Stream				Site ID (eg, BS-01, EF-03)							
UTM-Upstream:	Z				E				N		
UTM-Downstream:	Z				E				N		
WATER CONDITIONS											
Temp.				pH				Cond.			
Clarity: Turbid Moderately turbid Lightly turbid Clear											
Depth:	1/4:			1/2:				3/4:			
Velocity:	1/4:			1/2:				3/4:			
HABITAT CHARACTERISTICS											
Instream habitat: Flat Pool Riffle Run Backwater											
Bank habitat: Armoured Canyon Depositional Erosional											
Fish cover (%):											
SUBSTRATE											
D90	1	2	3	4	5	6	7	8	9	10	Avg
Substrate Comp (%)	Org	Silt	Sand	Grav	Cob	Bou	Bed				
Embeddedness: L M H				Compaction: L M H							
Photo ID	D/S			LB-to-RB							
	U/S			RB-to-LB							

ELECTROFISHING	BEACH SEINING	
Mode/Freq (AC/DC, Hz):	Haul 1 Dist. (m):	
Amps (avg):	Haul 2 Dist. (m):	
Volts (V):	Haul 3 Dist. (m):	
Sample Length (m):	Effectiveness:	Good Mod. Poor
Sample Time (s):		Mod. Good Poor

CATCH SUMMARY		
Walleye		
Flathead chub		
Lake chub		
Longnose dace		
Pikeminnow		
Trout-perch		

COMMENTS:

Date				Time				Crew			
Stream				Site ID (eg, BS-01, EF-03)							
UTM-Upstream:	Z				E				N		
UTM-Downstream:	Z				E				N		
WATER CONDITIONS											
Temp.				pH				Cond.			
Clarity: Turbid Moderately turbid Lightly turbid Clear											
Depth:	1/4:			1/2:				3/4:			
Velocity:	1/4:			1/2:				3/4:			
HABITAT CHARACTERISTICS											
Instream habitat: Flat Pool Riffle Run Backwater											
Bank habitat: Armoured Canyon Depositional Erosional											
Fish cover (%):											
SUBSTRATE											
D90	1	2	3	4	5	6	7	8	9	10	Avg
Substrate Comp (%)	Org	Silt	Sand	Grav	Cob	Bou	Bed				
Embeddedness: L M H				Compaction: L M H							
Photo ID	D/S			LB-to-RB							
	U/S			RB-to-LB							

ELECTROFISHING	BEACH SEINING	
Mode/Freq (AC/DC, Hz):	Haul 1 Dist. (m):	
Amps (avg):	Haul 2 Dist. (m):	
Volts (V):	Haul 3 Dist. (m):	
Sample Length (m):	Effectiveness:	Good Mod. Poor
Sample Time (s):		Mod. Good Poor

CATCH SUMMARY		
Walleye		
Flathead chub		
Lake chub		
Longnose dace		
Pikeminnow		
Trout-perch		

COMMENTS:

Figure A-2. Walleye Rearing Habitat Sampling datasheet, Page 1, 2021.

Walleye Rearing Habitat Sampling - LGL Limited (EA4105) Date:_________________________ Page ______ of _______

Site ID	Species	FL (mm)	Wt (g)	Scanned? (Y/N)	PIT Type Applied (12, 23, 32 mm)	PIT # Applied (#)	PIT Recap (#)	Comment

Figure A-3. Walleye Rearing Habitat Sampling datasheet, Page 2, 2021.

Appendix B. Mobile-tracking Survey Coverage & Tag Locations

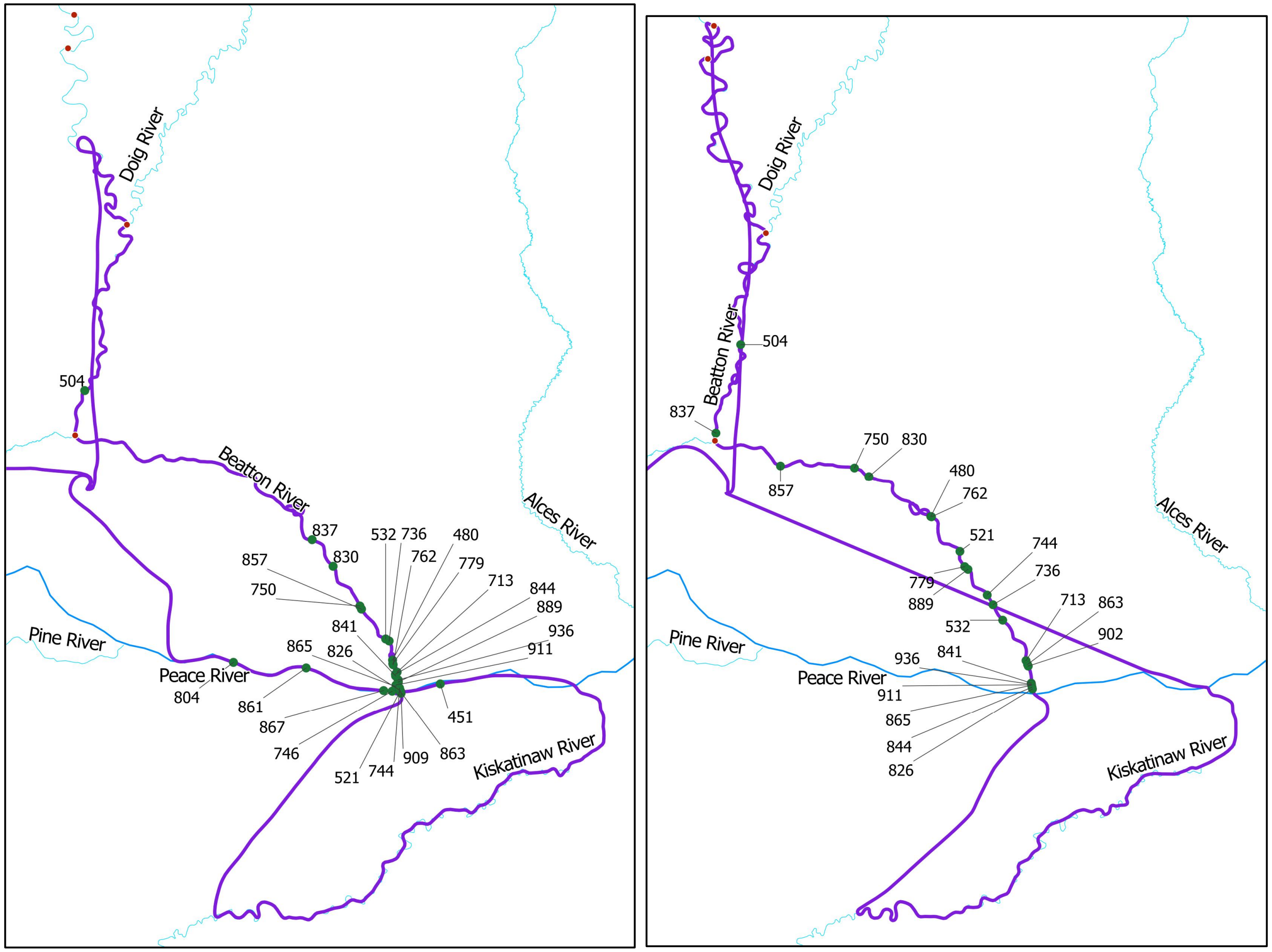


Figure B-1. Flight path and location of radio-tagged Walleye detected in the Beatton and Kiskatinaw rivers during the mobile-tracking surveys on 1 May (left) and 5 May (right) 2021.

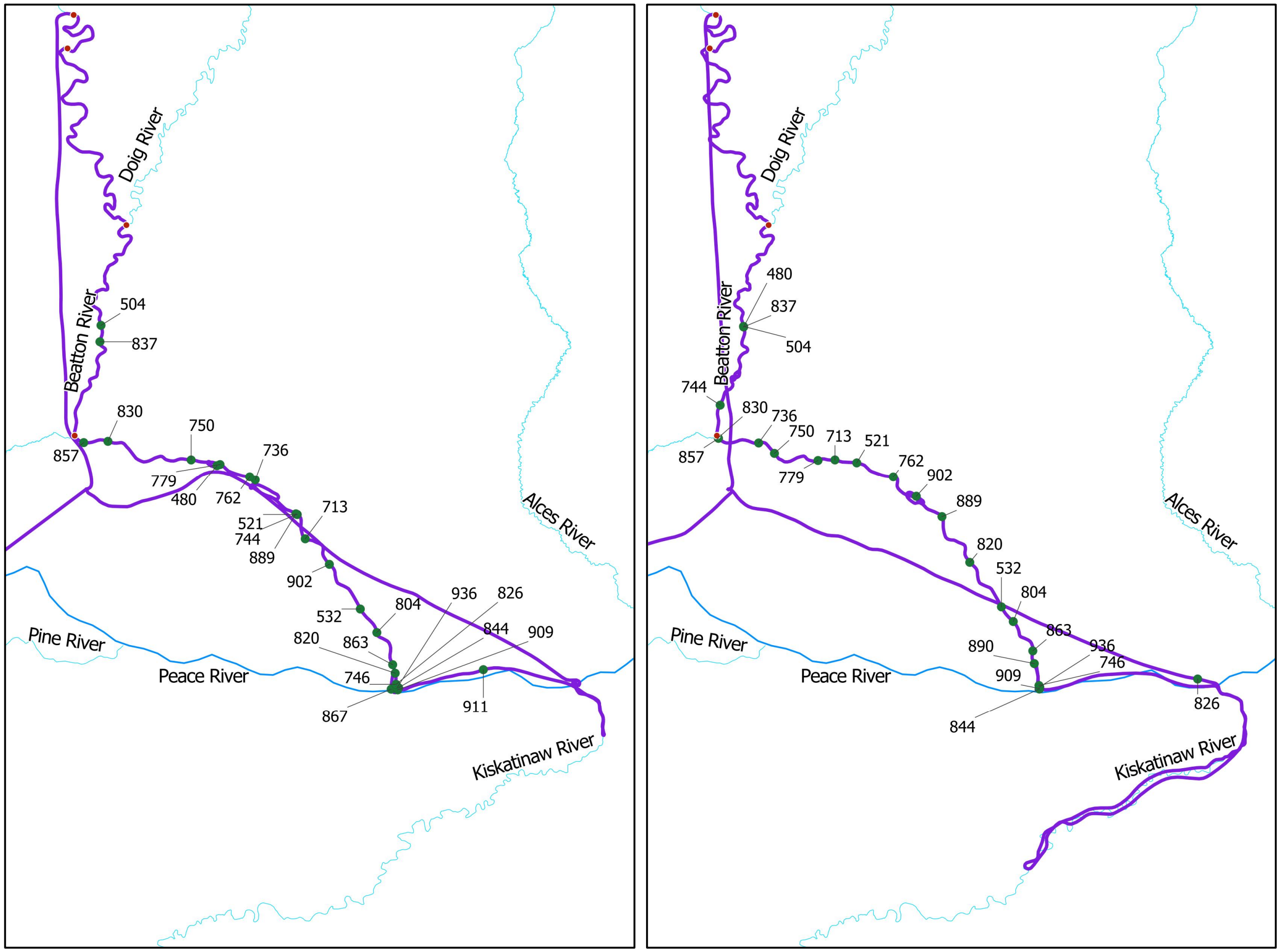


Figure B-2. Flight path and location of radio-tagged Walleye detected in the Beatton and Kiskatinaw rivers during the mobile-tracking surveys on 9 May (left) and 14 May (right) 2021.

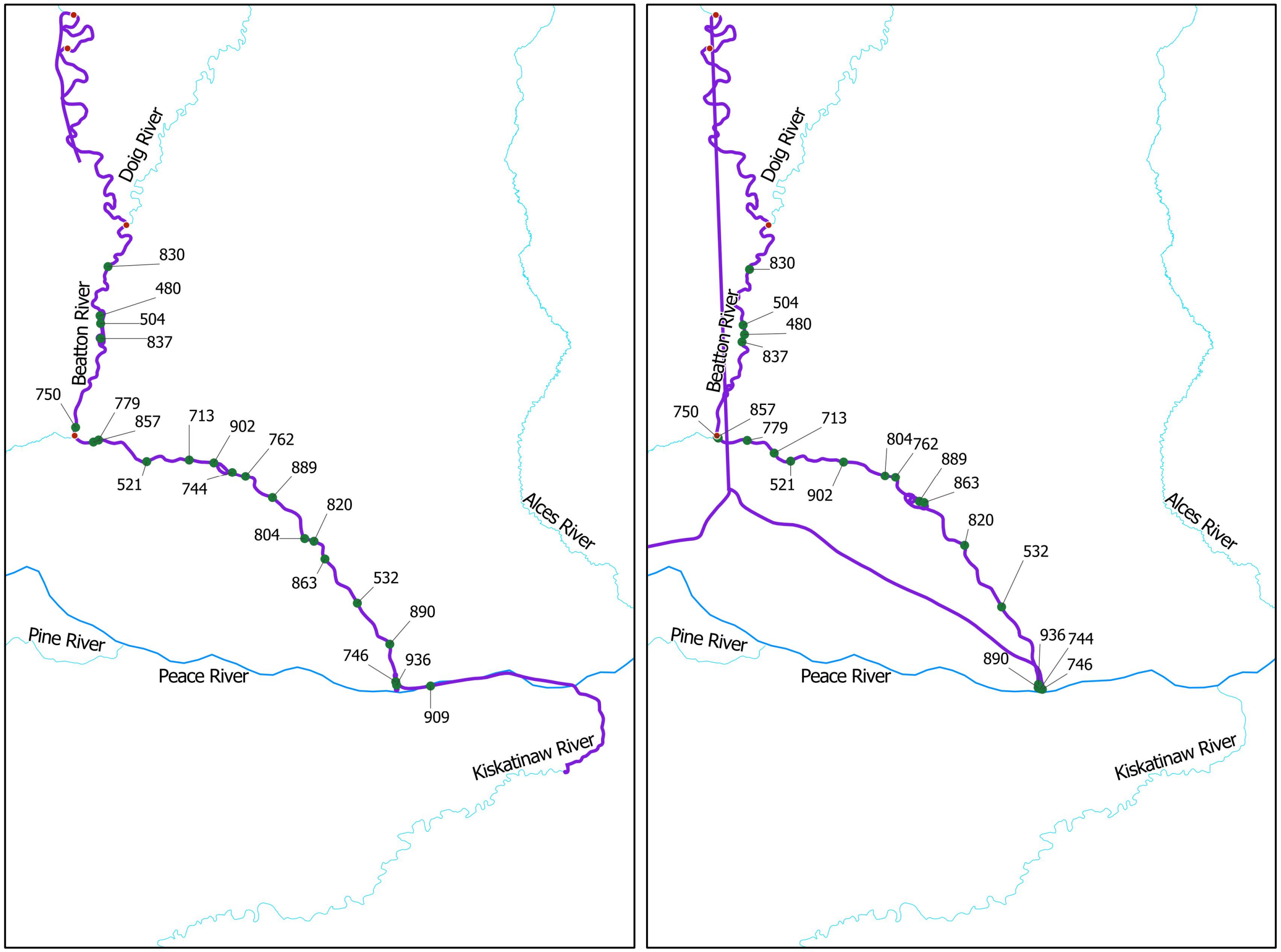


Figure B-3. Flight path and location of radio-tagged Walleye detected in the Beatton and Kiskatinaw rivers during the mobile-tracking surveys on 19 May (left) and 22 May (right) 2021.

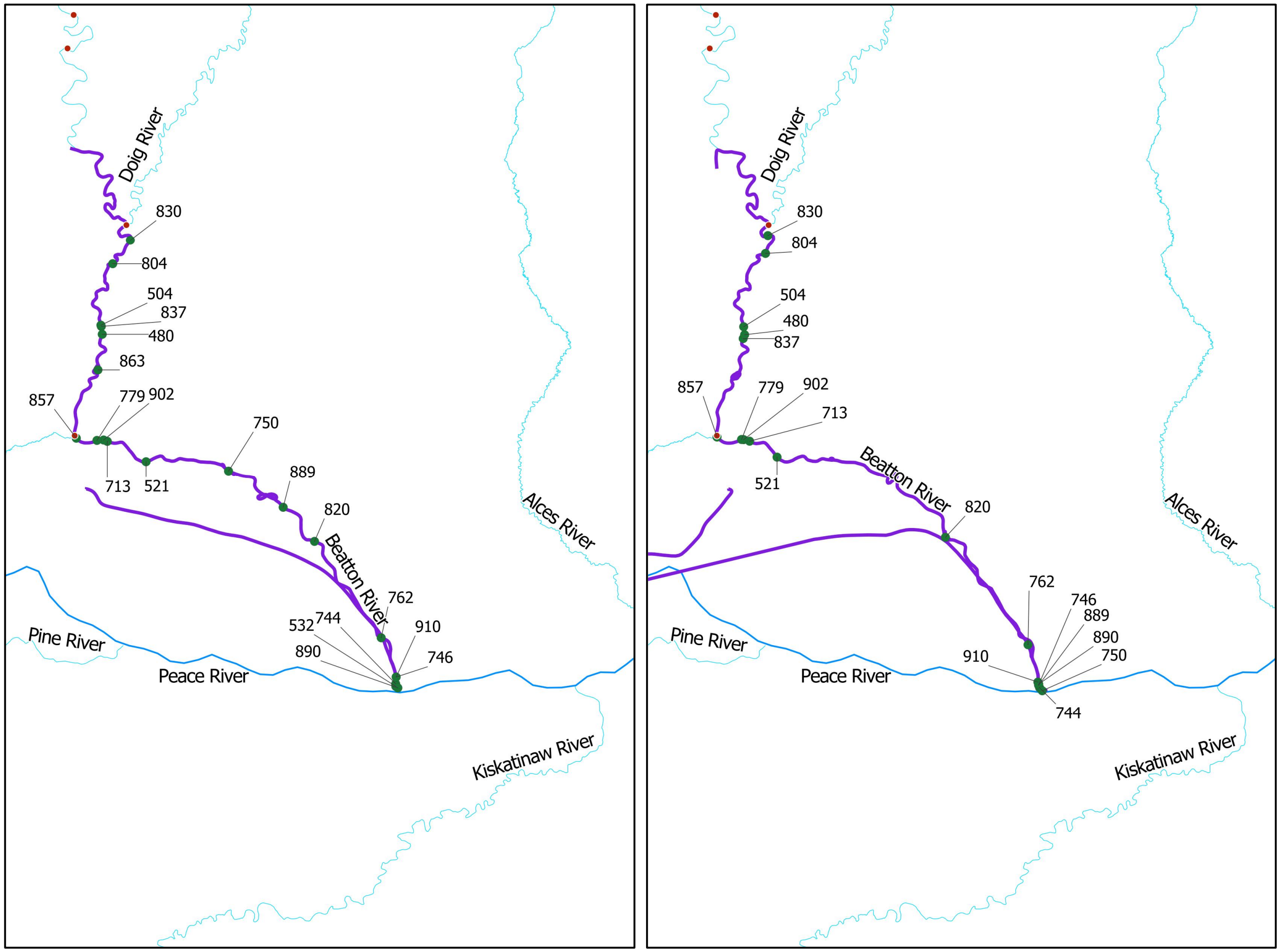


Figure B-4. Flight path and location of radio-tagged Walleye detected in the Beatton River during the mobile-tracking surveys on 26 May (left) and 30 May (right) 2021.

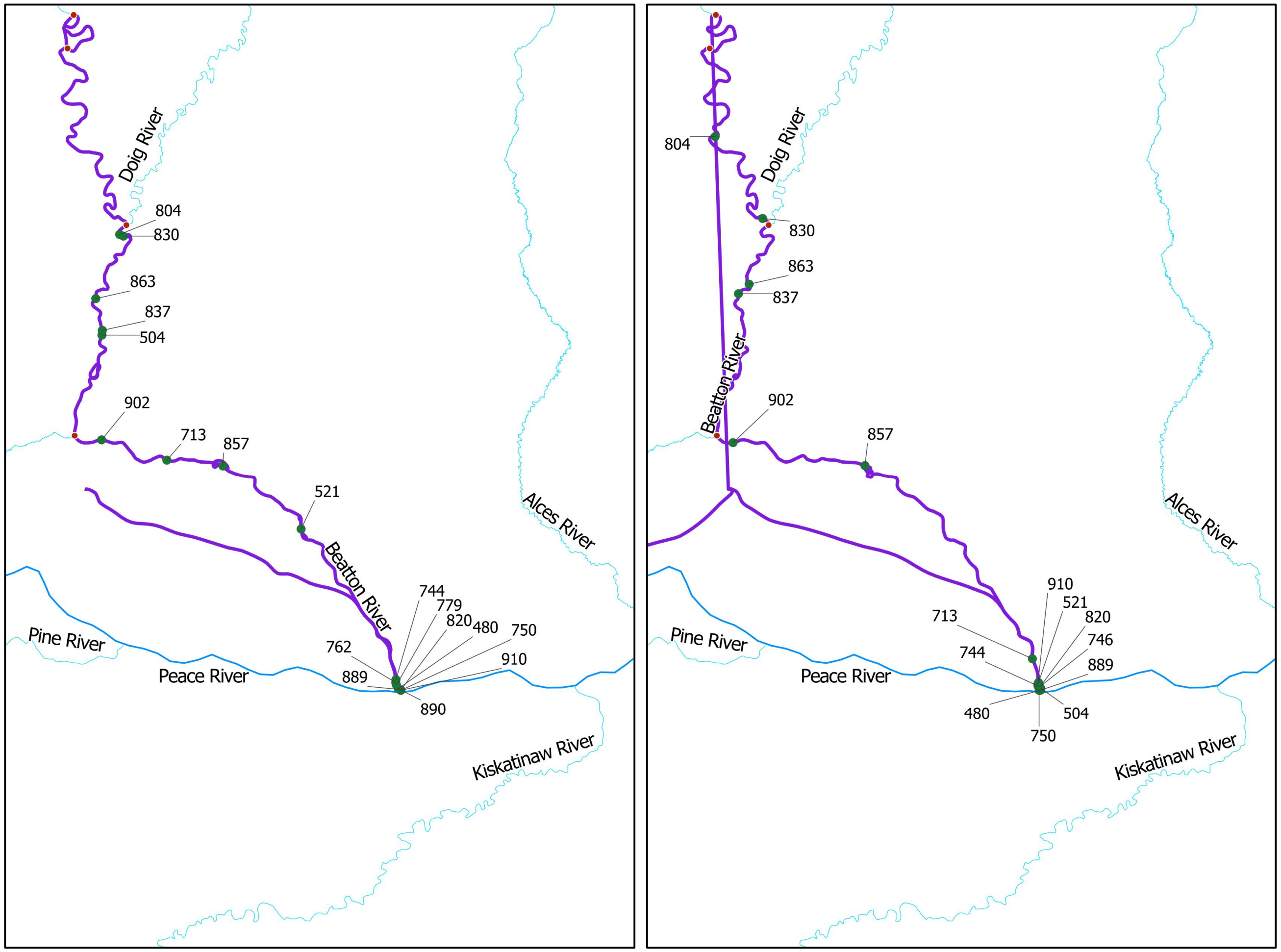


Figure B-5. Flight path and location of radio-tagged Walleye detected in the Beatton River during the mobile-tracking surveys on 3 June (left) and 7 June (right) 2021.

Appendix C. Spawning Habitat Assessment Data

Table C-1. Spawning habitat assessment data collected on the Beatton River, May 27-28, 2021.

Site ID	Reach	River km	Tag ID	Sample Date	Zone	Easting	Northing	Water Conditions						
								Temp. (^{o}C)	pH	Cond.	Clarity	Dist. from bank (m)	Depth (m)	Vel. (m/s)
Sites Sampled Where the Uppermost Tag Location Was Nearby (< 200 m away)														
SH01	1	3.6	890	27 May 2006	10V	662674	6223433	12.5	8.1	162	Turbid	11	0.64	0.21
SH02	1	7.6	532	27 May 2006	10V	660517	6226543	12.8	8.1	158	Turbid	11	0.56	0.43
SH03	1	13.9	820	27 May 2006	10V	657350	6231425	12.7	8.2	156	Turbid	4	0.64	0.00
SH04	1	18.0	889	27 May 2006	10V	655026	6234214	-	-	-	Turbid	8	0.81	0.36
SH05	1	21.5	762	27 May 2006	10V	652679	6236418	12.1	8.3	157	Turbid	19	0.57	0.25
SH06	1	29.7	521	27 May 2006	10V	645120	6237814	-	-	-	Turbid	14	0.60	0.51
SH07	1	33.5	713	28 May 2021	10V	642137	6239560	12.5	8.0	152	Turbid	1	0.52	0.32
SH08	1	34.1	779 902	28 May 2021	10V	641475	6239549	12.6	8.2	151	Turbid	12	0.61	0.49
SH09	1	35.8	857	28 May 2021	10V	639964	6239848	12.2	8.2	147	Turbid	7	0.51	0.49
SH10	2	38.4	744	27 May 2006	10V	640316	6242249	-	-	-	Turbid	25	0.75	0.80
SH12	2	45.7	504 837	27 May 2006	10V	642142	6248083	-	-	-	Turbid	12	0.87	0.45
Sites Sampled Where the Uppermost Tag Location Was Not Nearby (800+ m upstream)														
SH11	2	41.8	-	27 May 2006	10V	641795	6244782	-	-	-	Turbid	12	0.70	0.90
SH13	3	51.8	-	27 May 2006	10V	643236	6252587	11.0	8.3	145	Turbid	8	0.76	0.65
SH14	3	54.5	-	27 May 2006	10V	644597	6254274	11.0	8.4	143	Turbid	9	0.74	0.71

Table C-1. Continued.

Site ID	Habitat Conditions					D90 (Avg)	Substrate Composition (%)								
	Instream Habitat	Bank Habitat	Fish cover (%)	Bankfull Width (m)	Wetted Width (m)		Org	Silt	Sand	Grav	Cob	Bou	Bed	Embedd-edness	Comp-action
Sites Sampled Where the Uppermost Tag Location Was Nearby (< 200 m away)															
SH01	Run	Erosional	0	104	73	14	0	40	0	5	55	0	0	Medium	Medium
SH02	Run	Erosional	0	134	104	25	0	20	0	15	60	5	0	Low	Low
SH03	Run	Erosional	0	99	70	31	0	25	0	0	1	74	0	Medium	Medium
SH04	Run	Erosional	2	110	88	30	0	1	10	15	64	10	0	Low	Low
SH05	Run	Erosional	2	117	104	23	0	10	5	5	79	1	0	Medium	Low
SH06	Run	Erosional	2	140	108	18	0	2	10	10	78	0	0	Low	Low
SH07	Run	Erosional	0	98	70	35	0	0	10	10	40	40	0	Medium	Medium
SH08	Run	Erosional	0	112	83	19	0	5	10	40	45	0	0	Medium	Medium
SH09	Run	Erosional	0	110	86	21	0	14	0	70	15	1	0	Medium	Low
SH10	Run	Erosional	2	125	73	16	0	0	3	25	70	2	0	Low	Low
SH12	Run	Erosional	1	101	64	26	0	10	30	5	54	1	0	Low	Low
Sites Sampled Where the Uppermost Tag Location Was Not Nearby (800+ m upstream)															
SH11	Run	Erosional	1	80	56	27	0	1	30	5	63	1	0	Low	Low
SH13	Run	Erosional	1	75	53	20	0	0	5	45	40	10	0	Low	Low
SH14	Run	Erosional	2	78	44	22	0	0	50	1	40	9	0	Medium	Medium

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-1. Site SH01, rkm 3.6, Reach 1 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-2. Site SH02, rkm 7.6, Reach 1 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-3. Site SH03, rkm 13.9, Reach 1 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-4. Site SH04, rkm 18.0, Reach 1 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-5. Site SH05, rkm 21.5, Reach 1 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-6. Site SH06, rkm 29.7, Reach 1 (27 May 2021).


Downstream view


Upstream view


Left bank to right bank


Right bank to left bank


Substrate

Figure C-7. Site SH07, rkm 33.5, Reach 1 (28 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-8. Site SH08, rkm 34.1, Reach 1 (28 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-9. Site SH09, rkm 35.8, Reach 1 (28 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-10. Site SH10, rkm 38.4, Reach 2 (27 May 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Substrate

Figure C-11. Site SH12, rkm 45.7, Reach 2 (27 May 2021).

Appendix D. Rearing Habitat Assessment Data

Table D-1. Rearing habitat assessment data collected on the Beatton River from 17-19 August2021. See Table A2 for species abbreviations.

				Upstream UTM (10 V)		Water Conditions							Habitat Conditions				
Site ID	Reach	River km	Sample Date	Easting	Northing	Temp. (°C)	pH	Cond.	Clarity	Dist. from bank (m)	Depth (m)	Vel. (m/s)	Instream Habitat	Bank Habitat	Fish cover (%)	Bankfull Width (m)	Wetted Width (m)
EF-02	1	2.8	19 Aug 2021	662701	6222637	17.7	8.0	130	Turbid	3	0.10	0.28	Riffle	Erosional	0		
EF-03	1	5.0	19 Aug 2021	661773	6224304	18.6	8.0	130	Turbid	3	0.15	0.13	Riffle	Erosional	0		
BS-06	1	5.8	18 Aug 2021	661492	6225080	19	8.0	120	Turbid	5	0.30	0.58	Run	Erosional	0	105	75
EF-04	1	11.1	19 Aug 2021	658720	6229319	19.6	8.0	130	Turbid	3	0.12	0.23	Riffle	Erosional	0	140	100
BS-05	1	14.7	18 Aug 2021	656605	6231673	18.9	8.0	120	Turbid	5	0.25	0.12	Run	Erosional	0	92	55
EF-05	1	16.3	19 Aug 2021	656380	6233275	20.8	8.1	130	Turbid	3	0.15	0.17	Riffle	Erosional	0	140	70
BS-04	1	25.4	18 Aug 2021	649085	6237696				Turbid				Riffle	Erosional	0		
BS-03	1	31.5	18 Aug 2021	643851	6238826	17.5	8.0	120	Turbid	5	0.21	0.31	Run	Erosional	0	87	57
BS-02	2	38.1	17 Aug 2021	640179	6242035	19.4	8.0	120	Turbid	5	0.23	0.21	Flat	Erosional	0		
EF-01	2	45.6	17 Aug 2021	642166	6248001	18.5	8.0	120	Turbid	3	0.18	0.15	Run	Erosional	1	101	64
BS-01	2	54.5	17 Aug 2021	644670	6254301	17.8	7.9	110	Turbid	5	0.37	0.20	Run	Erosional	2	78	44

Table D-1. Continued.

Site ID	D90 Avg	Substrate Composition (%)									Electrofishing		Beach Seine		Catch Summary (# fish)									
		Org	Silt	Sand	Grav	Cob	Bou	Bed	Embedd-edness	Comp-action	Sample Length (m)	Sample Time (s)	Total Haul Dist (m)	Effective-ness	LSU	WSC	FHC	LNC	NSC	RSC	TP	Sculp.	Minn. <30mm	Sculp. <30mm
EF-02	21	0	2	5	30	60	3	0	Medium	Medium	110	426					4						1	1
EF-03	12	0	2	5	33	60	0	0	Low	Low	100	511					2	6					8	4
BS-06	16	0	5	10	45	40	0	0	Low	Low			247	Good			6			1			13	
EF-04	20	0	2	5	10	80	3	0	Medium	Low	150	639					6	10				1		
BS-05	23	0	5	10	15	65	5	0	Low	Low			292	Good			10		1	1			6	
EF-05	25	0	0	5	20	70	5	0	Medium	Low	120	417			1		1	2					1	
BS-04													110	Good										
BS-03	29	0	5	5	10	75	5	0	Low	Low			260	Mod-Good			7	1					1	
BS-02	16	0	0	3	25	70	2	0	Low	Low			215	Mod-Good			10					1	7	
EF-01	26	0	10	30	5	54	1	0	Low	Low	80	480				1	18	1			2	3	5	
BS-01	22	0	0	50	1	40	9	0	Medium	Medium			100	Mod-Good			10		1		1			

Table D-2. Biological information collected from fish captured in the Beatton River from 17-20 August 2021. See Table A2 for species abbreviations.

No.	Date	Site ID	Species	FL (mm)	Wt (g)
1	17 Aug 2021	BS-01	NSC	415	
2	17 Aug 2021	BS-01	FHC	114	16.1
3	17 Aug 2021	BS-01	FHC	65	2.9
4	17 Aug 2021	BS-01	FHC	64	2.1
5	17 Aug 2021	BS-01	FHC	65	2.8
6	17 Aug 2021	BS-01	FHC	68	3.4
7	17 Aug 2021	BS-01	FHC	141	28.0
8	17 Aug 2021	BS-01	FHC	63	3.0
9	17 Aug 2021	BS-01	FHC	124	19.4
10	17 Aug 2021	BS-01	TP	66	2.9
11	17 Aug 2021	BS-01	FHC	73	3.5
12	17 Aug 2021	BS-01	FHC	52	1.6
13	17 Aug 2021	EF-01	FHC	30	
14	17 Aug 2021	EF-01	FHC	67	2.8
15	17 Aug 2021	EF-01	FHC	35	0.6
16	17 Aug 2021	EF-01	FHC	54	2.0
17	17 Aug 2021	EF-01	FHC	95	
18	17 Aug 2021	EF-01	FHC	29	
19	17 Aug 2021	EF-01	FHC	60	2.6
20	17 Aug 2021	EF-01	TP	61	2.4
21	17 Aug 2021	EF-01	FHC	59	1.8
22	17 Aug 2021	EF-01	FHC	36	0.4
23	17 Aug 2021	EF-01	FHC	36	0.7
24	17 Aug 2021	EF-01	FHC	45	0.8
25	17 Aug 2021	EF-01	TP	40	0.8
26	17 Aug 2021	EF-01	FHC	33	0.4
27	17 Aug 2021	EF-01	FHC	26	0.2
28	17 Aug 2021	EF-01	FHC	69	2.9
29	17 Aug 2021	EF-01	FHC	59	2.3
30	17 Aug 2021	EF-01	FHC	22	
31	17 Aug 2021	EF-01	Sculp.	33	0.6
32	17 Aug 2021	EF-01	FHC	51	1.3
33	17 Aug 2021	EF-01	FHC	60	2.0
34	17 Aug 2021	EF-01	WSC	45	1.7
35	17 Aug 2021	EF-01	Sculp.	38	0.4
36	17 Aug 2021	EF-01	Sculp.	71	
37	17 Aug 2021	EF-01	LNC	38	0.5
38	17 Aug 2021	BS-02	FHC	55	1.4
39	17 Aug 2021	BS-02	FHC	415	30.5
40	17 Aug 2021	BS-02	FHC	65	2.8
41	17 Aug 2021	BS-02	FHC	54	1.6
42	17 Aug 2021	BS-02	FHC	54	
43	17 Aug 2021	BS-02	FHC	64	2.2
44	17 Aug 2021	BS-02	FHC	62	2.2
45	17 Aug 2021	BS-02	FHC	69	2.9
46	17 Aug 2021	BS-02	FHC	64	1.9
47	17 Aug 2021	BS-02	FHC	50	1.3
48	17 Aug 2021	BS-02	Sculp.	35	0.3
49	18 Aug 2021	BS-03	FHC	65	1.5
50	18 Aug 2021	BS-03	FHC	53	1.7
51	18 Aug 2021	BS-03	FHC	63	2.6
52	18 Aug 2021	BS-03	FHC	64	2.5
53	18 Aug 2021	BS-03	FHC	55	1.6
54	18 Aug 2021	BS-03	FHC	62	2.3
55	18 Aug 2021	BS-03	LNC	35	0.6
56	18 Aug 2021	BS-03	FHC	61	2.1
57	18 Aug 2021	BS-05	FHC	57	1.7
58	18 Aug 2021	BS-05	FHC	65	2.6
59	18 Aug 2021	BS-05	FHC	54	1.6
60	18 Aug 2021	BS-05	FHC	123	15.8
61	18 Aug 2021	BS-05	FHC	57	1.9
62	18 Aug 2021	BS-05	FHC	57	2.0
63	18 Aug 2021	BS-05	FHC	63	2.5
64	18 Aug 2021	BS-05	NSC	198	81.0
65	18 Aug 2021	BS-05	FHC	57	2.0
66	18 Aug 2021	BS-05	FHC	62	2.5
67	18 Aug 2021	BS-05	FHC	63	2.3
68	18 Aug 2021	BS-05	RSC	97	10.2
69	18 Aug 2021	BS-06	FHC	69	2.9
70	18 Aug 2021	BS-06	FHC	62	2.3
71	18 Aug 2021	BS-06	FHC	58	2.0
72	18 Aug 2021	BS-06	FHC	87	5.7
73	18 Aug 2021	BS-06	FHC	115	14.7
74	18 Aug 2021	BS-06	RSC	51	1.5
75	18 Aug 2021	BS-06	FHC	123	18.0
76	19 Aug 2021	EF-02	FHC	61	2.1
77	19 Aug 2021	EF-02	FHC	62	2.4
78	19 Aug 2021	EF-02	FHC	55	1.8
79	19 Aug 2021	EF-02	FHC	59	2.0
80	19 Aug 2021	EF-03	LNC	37	0.4
81	19 Aug 2021	EF-03	LNC	56	1.7
82	19 Aug 2021	EF-03	FHC	64	2.5
83	19 Aug 2021	EF-03	LNC	68	3.0
84	19 Aug 2021	EF-03	LNC	46	1.0
85	19 Aug 2021	EF-03	LNC	38	0.4
86	19 Aug 2021	EF-03	FHC	36	0.5
87	19 Aug 2021	EF-03	LNC	47	1.1
88	19 Aug 2021	EF-04	FHC	83	5.2
89	19 Aug 2021	EF-04	FHC	55	1.5
90	19 Aug 2021	EF-04	FHC	54	1.6

Table D-2. Continued.

No.	Date	Site ID	Species	FL (mm)	Wt (g)
91	19 Aug 2021	EF-04	FHC	56	1.5
92	19 Aug 2021	EF-04	LNC	63	2.3
93	19 Aug 2021	EF-04	FHC	77	4.7
94	19 Aug 2021	EF-04	FHC	121	17.0
95	19 Aug 2021	EF-04	LNC	46	1.0
96	19 Aug 2021	EF-04	Sculp.	39	0.6
97	19 Aug 2021	EF-04	LNC	69	3.2
98	19 Aug 2021	EF-04	LNC	45	0.8
99	19 Aug 2021	EF-04	LNC	48	1.2
100	19 Aug 2021	EF-04	LNC	45	1.3
101	19 Aug 2021	EF-04	LNC	45	0.9
102	19 Aug 2021	EF-04	LNC	85	5.3
103	19 Aug 2021	EF-04	LNC	50	1.8
104	19 Aug 2021	EF-04	LNC	59	1.8
105	19 Aug 2021	EF-05	LSU	211	114.8
106	19 Aug 2021	EF-05	LNC	36	0.5
107	19 Aug 2021	EF-05	FHC	87	6.8
108	19 Aug 2021	EF-05	LNC	48	1.0

Table D-3. Taxon-specific catch and CPUE for backpack electrofisher (Panel A) and beach seine (Panel B) sets conducted in potential juvenile Walleye habitat in the Beatton River from 17-20 August 2021. See text for Reach designations.

Panel A: backpack electrofisher catch and CPUE (number per km per hr)

Reach	River km	Site ID	Date	Time Sampled (s)	Length Sampled (km)	LSU		WSC		FHC		LNC		NSC		RSC		TP		Lrg. Sculp.		Minn. <30mm		Sculp. <30mm		All species	
						No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
2	45.6	EF-01	17 Aug 2021	480	0.08	0	0.00	1	93.75	18	1687.50	1	93.75	0	0.00	0	0.00	2	187.50	3	281.25	5	468.75	0	0.00	30	2812.50
1	2.8	EF-02	19 Aug 2021	426	0.11	0	0.00	0	0.00	4	307.30	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	76.82	1	76.82	6	460.95
1	5.0	EF-03	19 Aug 2021	511	0.1	0	0.00	0	0.00	2	140.90	6	422.70	0	0.00	0	0.00	0	0.00	0	0.00	8	563.60	4	281.80	20	1409.00
1	11.1	EF-04	19 Aug 2021	639	0.15	0	0.00	0	0.00	6	225.35	10	375.59	0	0.00	0	0.00	0	0.00	1	37.56	0	0.00	0	0.00	17	638.50
1	16.3	EF-05	19 Aug 2021	417	0.12	1	71.94	0	0.00	1	71.94	2	143.88	0	0.00	0	0.00	0	0.00	0	0.00	1	71.94	0	0.00	5	359.71

Panel B: beach seine catch and CPUE (number per m^2)

Reach	River km	Site ID	Date	Area Sampled (m^2)	LSU		WSC		FHC		LNC		NSC		RSC		TP		Lrg. Sculp.		Minn. <30mm		Sculp. <30mm		All species	
					No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
2	54.5	BS-01	17 Aug 2021	550.0	0	0.000	0	0.000	10	0.018	0	0.000	1	0.002	0	0.000	1	0.002	0	0.000	0	0.000	0	0.000	12	0.022
2	38.1	BS-02	17 Aug 2021	1182.5	0	0.000	0	0.000	10	0.008	0	0.000	0	0.000	0	0.000	0	0.000	1	0.001	7	0.006	0	0.000	18	0.015
1	31.5	BS-03	18 Aug 2021	1430.0	0	0.000	0	0.000	7	0.005	1	0.001	0	0.000	0	0.000	0	0.000	0	0.000	1	0.001	0	0.000	9	0.006
1	25.4	BS-04	18 Aug 2021	605.0	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
1	14.7	BS-05	18 Aug 2021	1606.0	0	0.000	0	0.000	10	0.006	0	0.000	1	0.001	1	0.001	0	0.000	0	0.000	6	0.004	0	0.000	18	0.011
1	5.8	BS-06	18 Aug 2021	1358.5	0	0.000	0	0.000	6	0.004	0	0.000	0	0.000	1	0.001	0	0.000	0	0.000	13	0.010	0	0.000	20	0.015

Downstream view

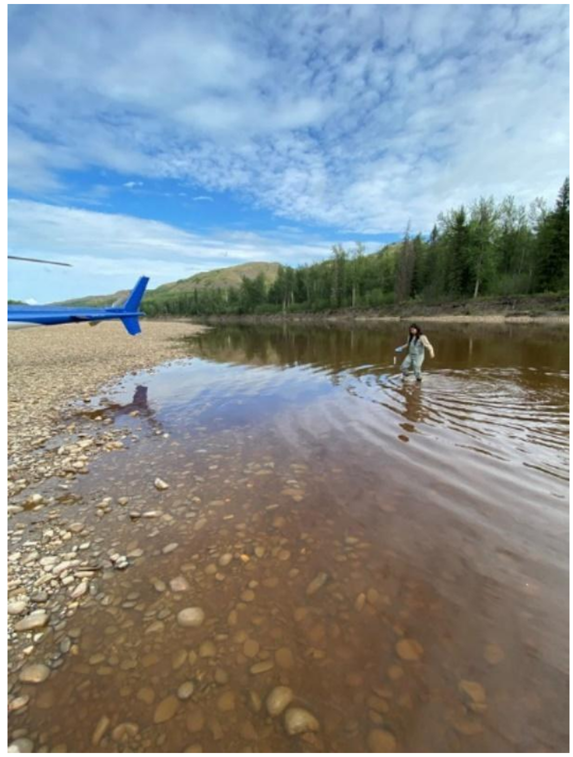
Upstream view

Left bank to right bank

Right bank to left bank

Figure D-1. Site EF-02, rkm 2.8, Reach 1 (19 August 2021).

Downstream view



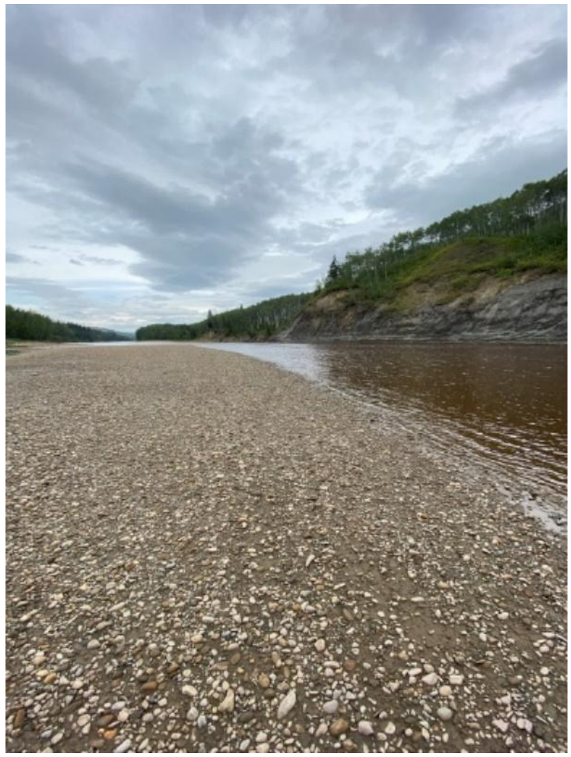
Upstream view

Left bank to right bank

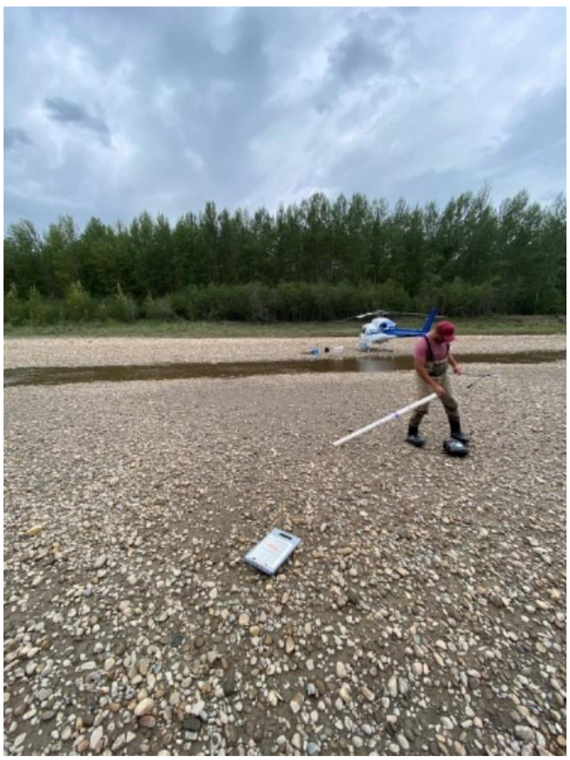
Right bank to left bank

Figure D-2. Site EF-03, rkm 5.0, Reach 1 (19 August 2021).

Downstream view



Upstream view



Left bank to right bank

Right bank to left bank

Figure D-3. Site BS-06, rkm 5.8, Reach 1 (18 August 2021).

Downstream view

Upstream view

Left bank to right bank

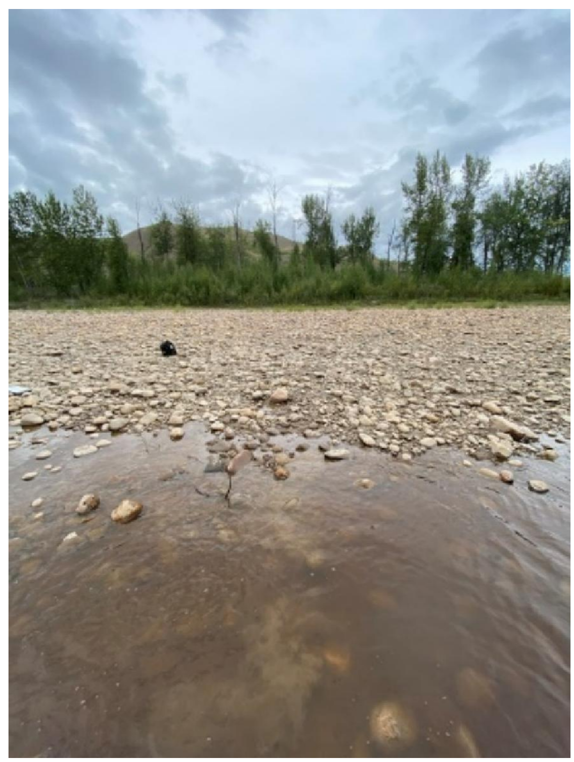
Right bank to left bank

Figure D-4. Site EF-04, rkm 11.1, Reach 1 (19 August 2021).

Downstream view

Upstream view

Left bank to right bank



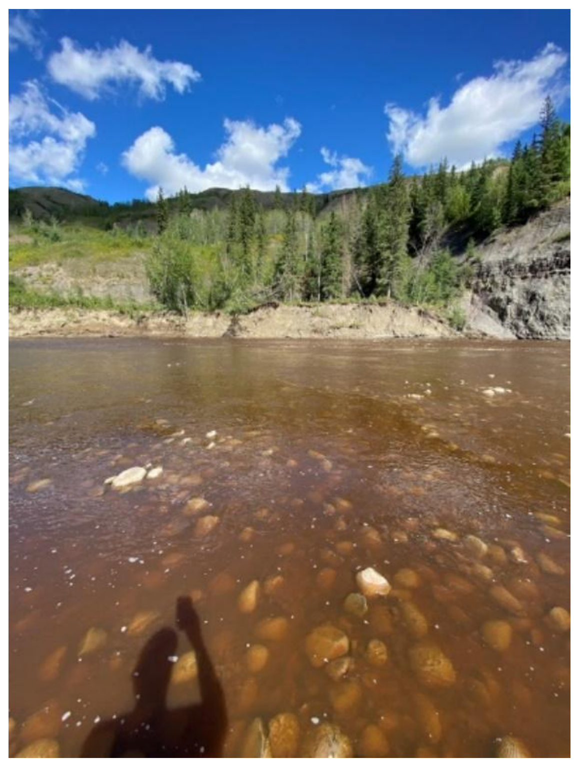
Right bank to left bank

Figure D-5. Site BS-05, rkm 14.7, Reach 1 (18 August 2021).

Downstream view

Upstream view

Left bank to right bank



Right bank to left bank

Figure D-6. Site EF-05, rkm 16.3, Reach 1 (19 August 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Figure D-7. Site BS-03, rkm 31.5, Reach 1 (18 August 2021).

Downstream view

Upstream view

Left bank to right bank

Right bank to left bank

Figure D-8. Site BS-02, rkm 38.1, Reach 2 (17 August 2021).