Technical Memorandum

Movement and Habitat Use of Adult Chinook Salmon (*Oncorhynchus tshawystcha*) in the Columbia River Released Upstream of Grand Coulee Dam at Northport, WA in 2024

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Abstract

Prior to colonization, the Columbia River drainage was likely the most productive watershed for Pacific salmon (*Onchorhynchus* spp.) in western North America. Although populations were already impacted by overfishing and dam construction in the lower river, the construction of Grand Coulee Dam (GCD) in 1941 blocked access of anadromous salmon to the Upper Columbia River, and many tributaries upstream, in Canada. In recent years, the U.S. Tribes and Canadian First Nations have pursued establishing fish passage and reintroduction to the blocked areas upstream of Chief Joseph Dam (CJD) and GCD through several forums. In preparation for renegotiation of the primary objectives of the Columbia River Treaty, a coalition of 15 Tribes and First Nations from the U.S. and Canada, led by the Upper Columbia United Tribes (UCUT), developed a fish passage and reintroduction plan that lays out how to reintroduce salmon upstream of GCD.

Since 2019 UCUT has been moving adult Chinook Salmon (*O. tshawystcha*) upstream of GCD through trap and haul. In the three years since 2019, some of these adults have been implanted with acoustic transmitters to monitor them after release. In 2020, 50 adults were tagged and released by the Confederated Tribes of the Colville Reservation (CTCR), in collaboration with UCUT partners. In 2022, 58 adults were tagged and released by CTCR and UCUT upstream of GCD, to support a project initiated by the Columbia River Salmon Recovery Initiative (CRSRI) in Canada.

In the summer of 2024, the Sinixt Confederacy, CTCR and UCUT partners initiated a third year of study of acoustically tagged adult Chinook Salmon upstream of GCD, with 60 tagged salmon being released at Northport, WA. The objectives of this study were to:

1) Monitor the timing, behaviour, movement patterns, and habitat use of the adult Chinook Salmon through tracking on acoustic monitoring arrays and mobile tracking;

2) Identify key habitats for holding and spawning, and the timing of spawning using drone surveys in collaboration with Selkirk College; and,

3) Estimate spawning timing and identify spawning locations by ground surveys at keys sites.

There were a total of 33 females ranging in length from 68cm to 89cm (mean 78.8cm) that received a tag. A total of 26 males also received a tag (ranging in length from 67cm to 94cm (mean 75.5cm)). Of the 59 acoustically tagged Chinook Salmon, 47 (79.7%) were tracked moving into Canada at some point during the tracking period (August 6-November 27, 2024). The movements of the salmon into Canada, were categorized into three types. One-time movements into Canada for a short period of time with no spawning (A; 62%). Movements into Canada for a longer period and possible spawning (B; 12%). Multiple movements into Canada for varying periods of time with no spawning (C; 13%).

Females averaged 11.8 days (range 2-64; n=24) in Canada, while males averaged 14.0 days (range 1-97; n=23). It is believed that 6 of the 47 tagged salmon (13%) that moved into Canada spawned, with sites at 9.0 km, 26.0 km, 49.3 km and 56.0 km. These are all sites where there is suitable substrate for Chinook Salmon spawning.

A total of 13 (28%) tagged salmon entered the Kootenay River during the study, with 3 (6%) moving upstream to the base of Brilliant Dam. A total of 4 (8%) of the tagged salmon moved upstream to the base of HLK Dam (0.1 km). No salmon moved upstream into the Arrow Reservoir through the boat lock at HLK Dam.

Visual redd surveys (ground) began on September 13, 2024 and continued through September and October. The data collected suggested that spawning likely started the fourth week of September, and a total of 10 redds were observed. A total of 32 redds were enumerated using drone surveys with the majority of redds found at 9.0 km and 26.0 km. From the drone surveys spawning had started on September 24 and was ongoing until the last survey on October 29. Water temperature at this time ranged between 10.3 and 16.7 ˚C.

This project has demonstrated that the methods used are successful for monitoring adult Chinook Salmon released upstream of GCD, and that these salmon will spawn successfully in the mainstem Columbia River in Canada. Recommendations for further study are put forth.

This technical memorandum summarizes the work conducted in Canada in 2024. It is our intention to bring this information together with the pending analyses in the U.S. for a comprehensive transboundary assessment of post release behaviour.

Acknowledgements

Many people assisted with the completion of this project. Their help is greatly appreciated. This project was wholly funded by the Confederated Tribes of the Colville Reservation and the Sinixt Confederacy.

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Introduction

Prior to colonization, the Columbia River drainage was likely the most productive watershed for Pacific salmon (*Onchorhynchus* spp.) in western North America. It sustained many Indigenous cultures across the Coastal, Plateau and Rocky Mountain regions, and was a keystone ecological species. Additionally, first peoples gathered annually at many significant fishing sites on the mainstem and tributaries.

Sn̓ʕay̓čkstx (Sinixt) people's extensive territory on the upper Columbia River stretches from Kettle Falls (in present day Washington State in the US) to the Big Bend (north of Revelstoke, British Columbia in present day Canada) in the north (Figure 1). Salmon were not only the most important fish obtained by the Sinixt in their economic pursuits, but they were also the staple food for survival (Ray 1947).

The Sinixt have a proven +/-9,000- year, Indigenous cultural focus on Kettle Falls (Sx̌ʷnitkʷ; "roaring water") and its management (Chance 1986; Province of BC 2023), a highly productive historic salmon fishery now flooded by Roosevelt Reservoir with the construction of Grand Coulee Dam (GCD). The Sinixt, together with their cousin-tribe the Skoyelpi, were both seasonally resident at the falls and oversaw the fishery for millennia on behalf of all the tribes of the Interior Plateau. Sinixt people collected and distributed equally the "June hog" Chinook Salmon (*O. tshawytscha*) to all who came and maintained peace through their trademark diplomacy. This annual event from June to early August dominated and shaped the hunting, gathering and soft-agriculture cycle of the entire Interior Plateau. Those fish that were not caught in basket traps, or through harpoon, continued north to spawning grounds and enriched the water and riparian forests of the entire upstream region, their traditional territory, and the territories of other tribes at the headwaters.

And then in less than 100 years, this ecological wonder fell apart as a result from overharvest in the lower river and construction of dams through out the watershed (Figures 2, 3, 4).

Pacific salmon have been blocked from migrating into the upper Columbia River watershed in Canada since 1940 when the construction of GCD was completed. The dam blocked salmon access to approximately 50% (by area) of the Columbia River basin. This completely erased an essential food and important component of a healthy ecosystem for native people in both Canada and the United States.

Prior to colonization of the Pacific Northwest, it has been estimated that the abundance of salmon in the Columbia River was between 7.5 and 16 million returning adults (Chapman 1986; NPPC 1987), and of this 55% were Chinook Salmon, 5% were Coho Salmon (*O. kisutch*),7% were Sockeye Salmon (*O. nerka*), and 31% Steelhead Trout (*O. mykiss*) above Kettle Falls (Scholz 2014). By the time GCD was built, salmon runs to Rock Island Dam were down to a few thousand Chinook and Sockeye, and a few dozen Coho (Brennan 1938).

During planning for the construction of GCD, the US federal government decided not to provide fish passage and instead built salmon hatcheries in three downstream tributaries (Board of

Consultants 1939). This mitigation supplemented downstream sport, commercial and tribal fisheries, but did not mitigate the loss of salmon to the people or the ecosystem upstream of GCD.

In recent years, the U.S. Tribes and Canadian First Nations have pursued establishing fish passage and reintroduction to the blocked areas upstream of Chief Joseph Dam (CJD) and GCD through several forums. In preparation for renegotiation of the primary objectives of the Columbia River Treaty, a coalition of 15 Tribes and First Nations from the U.S. and Canada, led by the Upper Columbia United Tribes (UCUT), developed a fish passage and reintroduction plan that lays out how to reintroduce salmon upstream of GCD (CBTFN 2015). The intent of this approach is to pursue reintroduction using the knowledge gained and successful outcomes derived from sequential phases of research and evaluation.

Phase 1: Pre-assessment planning for reintroduction and fish passage.
Phase 2: Experimental, pilot-scale salmon reintroductions and interim passage facilities.
Phase 3: Construct permanent juvenile and adult passage facilities and supporting propagation facilities. Implement priority habitat improvements.
Phase 4: Monitoring, evaluation, and adaptive management. Continue needed habitat improvements.

As part of this work, monitoring of salmon released upstream of GCD will help determine successful release location, timing, species, and life stage. For example, if adult salmon translocated upstream of GCD fallback through the dam at a high rate, managers would need to adapt by hauling fish to a further upstream location, trap and haul more fish, or try a different stock of fish. Prior to 2024, there have been two previous releases of acoustically tagged adult Chinook Salmon upstream of GCD in 2020 and 2022.

In 2020, 50 adult Chinook Salmon with acoustic tags were released by the Confederated Tribes of the Colville Reservation (CTCR), in collaboration with UCUT partners. They were released upstream of GCD (25 upstream of GCD, and 25 at Northport, WA). This was of the 250 Chinook Salmon moved upstream into the blocked areas. A total of 21 of the 50 tagged salmon, moved upstream into Canada, with some migrating upstream as far as the Castlegar area. This data has not been fully analyzed and reported.

In 2022, 58 adult Chinook Salmon with acoustic tags were released at Northport, WA by CTCR and UCUT upstream of GCD, to support a project initiated by the Columbia River Salmon Recovery Initiative (CRSRI) in Canada. This was of the 447 Chinook Salmon moved upstream into the blocked areas. A total of 43 of the 58 tagged Chinook moved upstream into Canada. Results will be summarized by CRSRI and are as of yet unpublished.

In the summer of 2024, the Sinixt Confederacy, CTCR and UCUT partners initiated a third year of study of acoustically tagged adult Chinook Salmon upstream of GCD, with tagged salmon being released at Northport, WA. The objectives of this study were to:

1) Monitor the timing, behaviour, movement patterns, and habitat use of the adult Chinook Salmon through tracking on acoustic monitoring arrays and mobile tracking;

2) Identify key habitats for holding and spawning, and the timing of spawning using drone surveys in collaboration with Selkirk College; and,

3) Estimate spawning timing and identify spawning locations by ground surveys at keys sites.

This technical memorandum summarizes the work conducted in Canada in 2024. It is our intention to bring this information together with the pending analyses in the U.S. for a comprehensive transboundary assessment of post release behaviour.

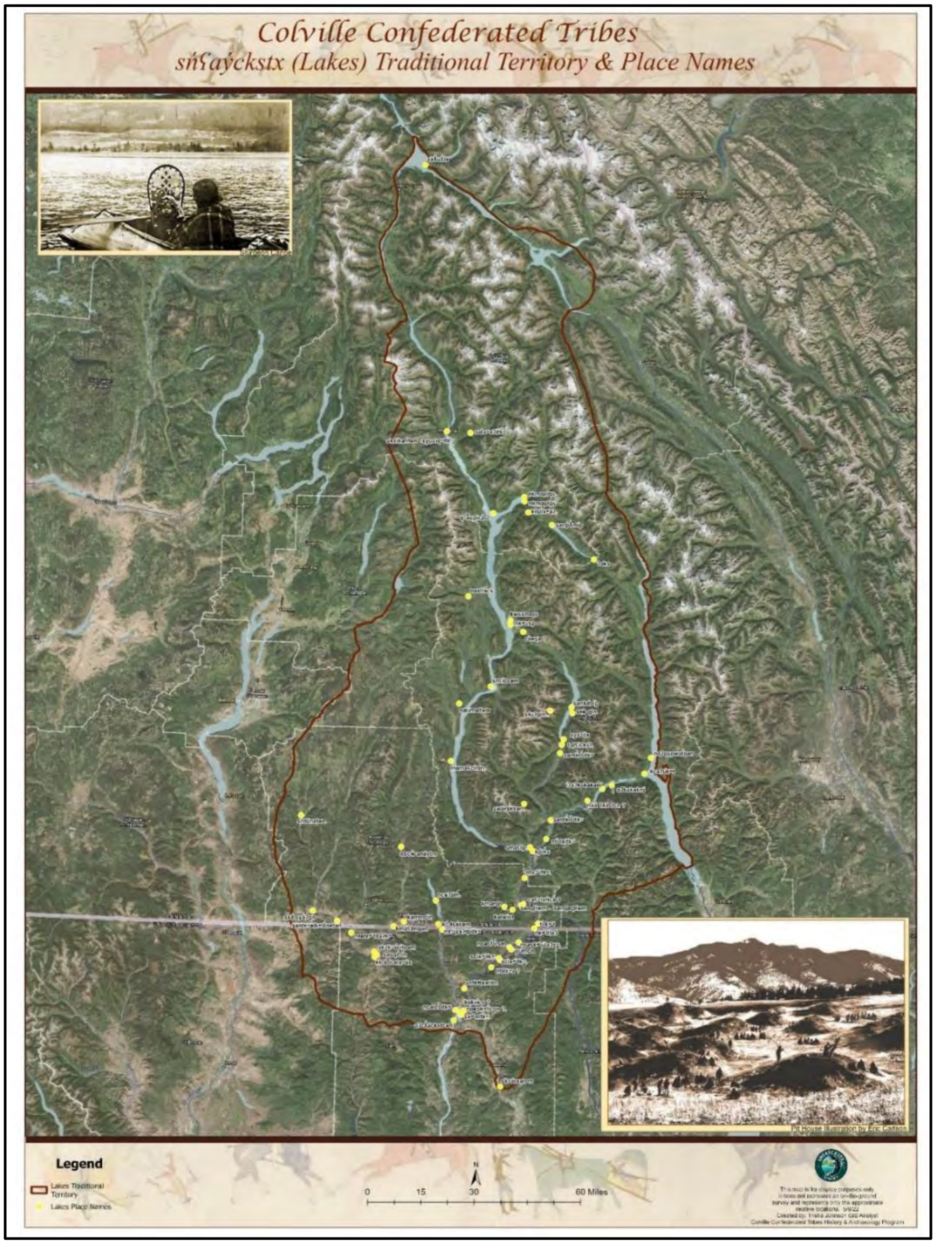

Figure 1. Sn̓ʕay̓ckstx (Sinixt/Lakes) traditional territory map and place names.

Figure 2. An 85 pound Chinook Salmon (*Onchorhynchus tshawytscha*) caught at Astoria, Oregon by angler Tony Canessa in 1925. Photo: Columbia River Maritime Museum (https://www.nwcouncil.org/reports/columbia-river-history/junehogs/).

Figure 3. Painting of salmon fishery at Kettle Falls by Paul Kane (1847).

Figure 4. Chief Jim James of the Colville Tribe, right, his arms folded, and others view fishing sites at Kettle Falls during the Ceremony of Tears (1940). Photo: L85-143.380, Northwest Museum of Arts & Culture, Spokane.

Methods

Physical Data

Water discharge (m3/sec), river stage (m), and water temperature (ºC) of the Columbia River for the study period (August 1 to November 30, 2024) were obtained from the Water Survey of Canada at the Birchbank Station. Data collected were daily averages.

Fish Capture, Tagging and Release

Of the 2,118 Chinook Salmon released above GCD in 2024 (Table 1), a total of 60 Chinook Salmon were implanted esophageally at Wells Hatchery with Innovasea V16-4x acoustic transmitters (see Appendix I for tag specifications). Transmitters were individually coded (58636-58695) on a frequency of 69Hz. The tagged fish were then transported by truck (F-750 with 1,000 gallon tank with oxygenated water) on August 6, 2024 and released at the Northport Boat Launch.

Acoustic Tracking

The study area for this work is the upper Columbia River in Canada from the international border to Hugh Keenleyside (HLK) Dam, and the lower Kootenay River from the confluence to Brilliant (BRD) Dam (Figure 5). Acoustically tagged Chinook Salmon were tracked on a receiver array and through mobile tracking. In Canada, a pre-existing array of 23 stationary acoustic receivers operated and maintained by BC Hydro to monitor White Sturgeon (*Acipenser transmontanus*) was used to record movements of the tagged salmon between August 8, and November 29, 2024. In total this array was downloaded 3 times in this period (September 13, October 16, and November 29). The array is dispersed at intervals across the study area and covers the mainstem Columbia River and the lower Kootenay River (Figures 6, 7, 8). FortisBC also operates a receiver at the base BRD Dam, and provided that data. In addition to the monitoring on the stationary array, a mobile tracking survey was also done from HLK dam to the border from October 10-13, 2024).

Redd Surveys

Although conducting redd surveys was not a major objective of this study. Infrequent redd surveys were conducted on the Columbia River through visual observation throughout September and October of 2024, and a stream walk of Norns Creek on October 5, 2024. Redd locations were noted and their locations recorded with a GPS.

Table 1. Summary of number of Chinook Salmon (*Oncorhynchus tshawytscha*) and Sockeye Salmon (*O. nerka*) released above Grand Coulee Dam in 2024 by release location.

Release Location	Chinook Salmon	Sockeye Salmon
Lake Roosevelt	50	279
Pacific Northwest National Laboratory		26
Rufus Woods	426	
San Poil River	377	
Spokane River	740	
Spokane Tribe of Indians/Harvest	167	
Transboundary Reach	358	
TOTAL	**2118**	**305**

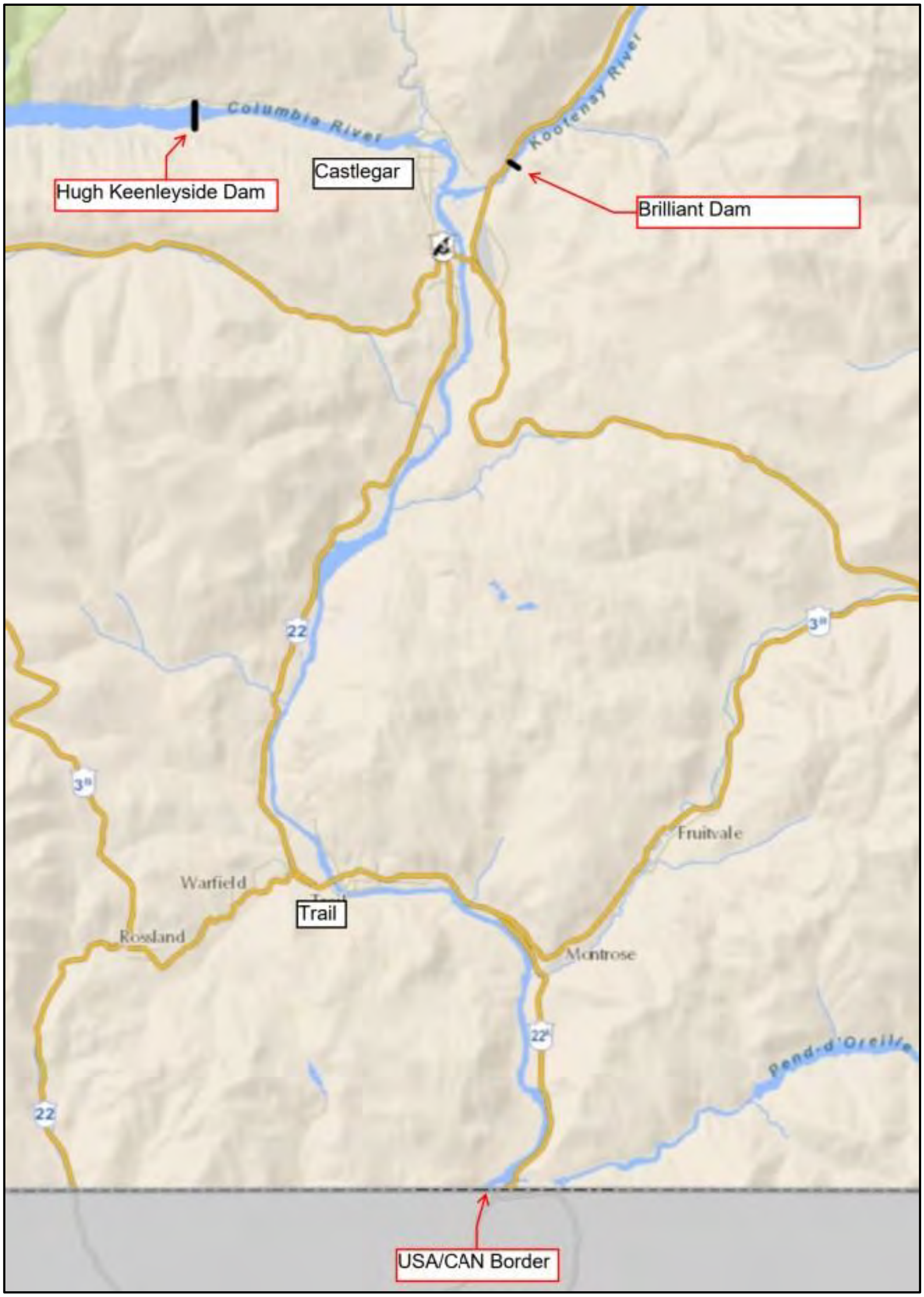

Figure 5. Study area of 2024 Chinook Salmon (*Oncorhynchus tshawytscha*) project in Canada.

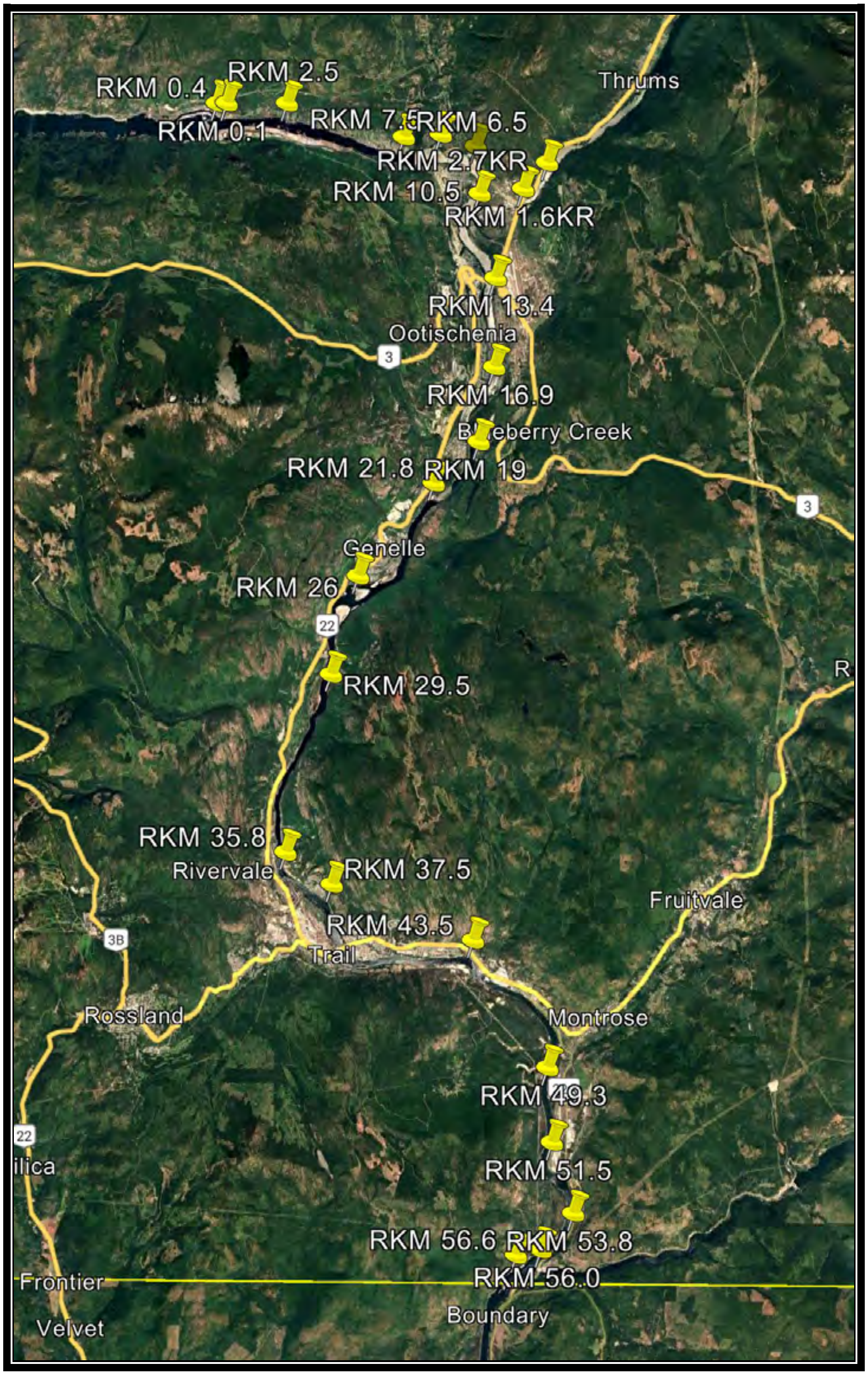

Figure 6. Location of receivers on the BC Hydro acoustic telemetry array in the Columbia River in Canada from HLK Dam to the border, and the Kootenay River from the confluence too BRD Dam. RKM is downstream distance from HLK Dam (0.1 km) to the border (56.6 km), and upstream distance from Kootenay River confluence (0.1 km) to BRD Dam (2.7 km).

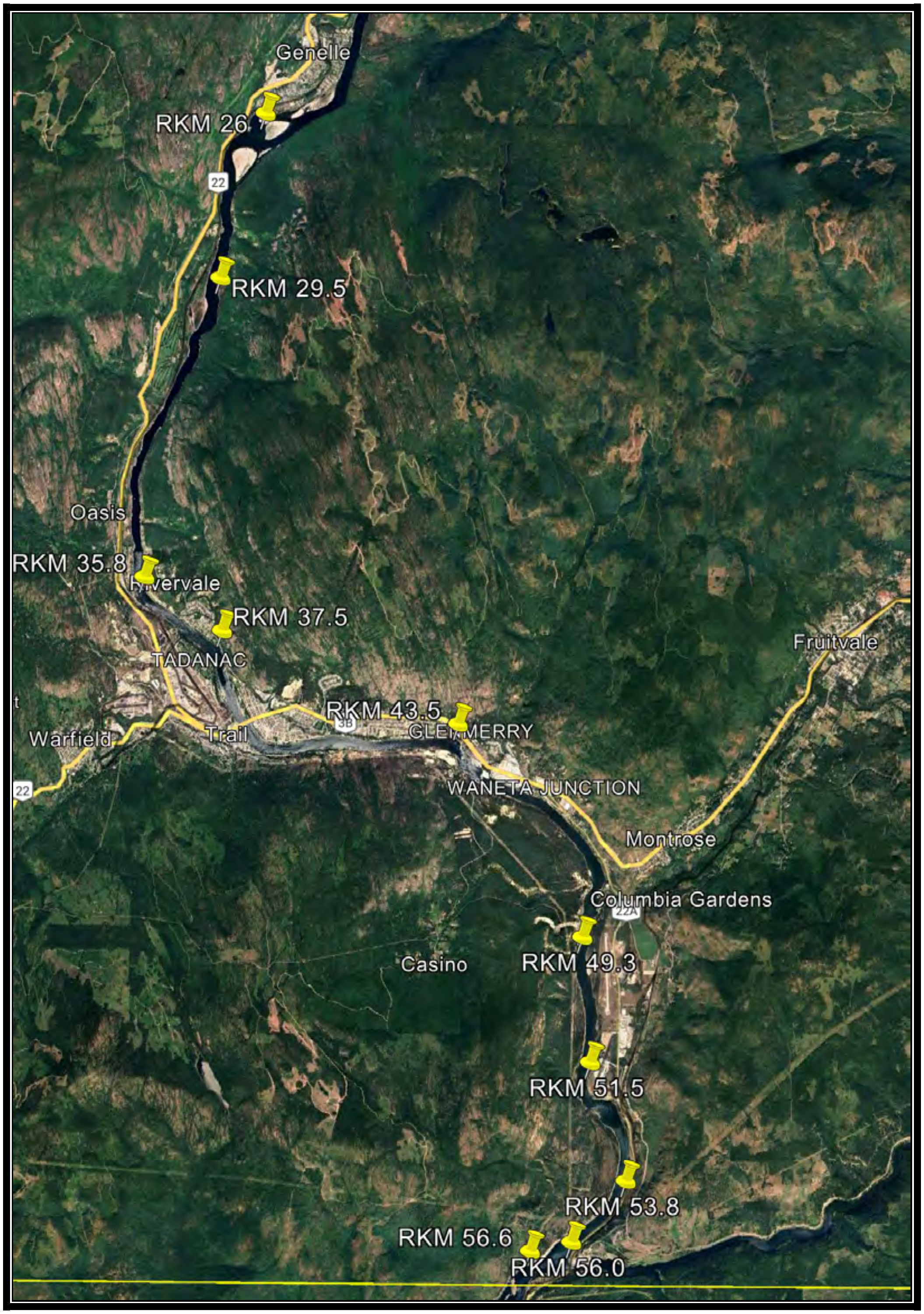

Figure 7. Location of receivers on the BC Hydro acoustic telemetry array in the Columbia River in Canada from Genelle to the border. RKM is downstream distance from HLK Dam (0.1 km) to the border (56.6 km).

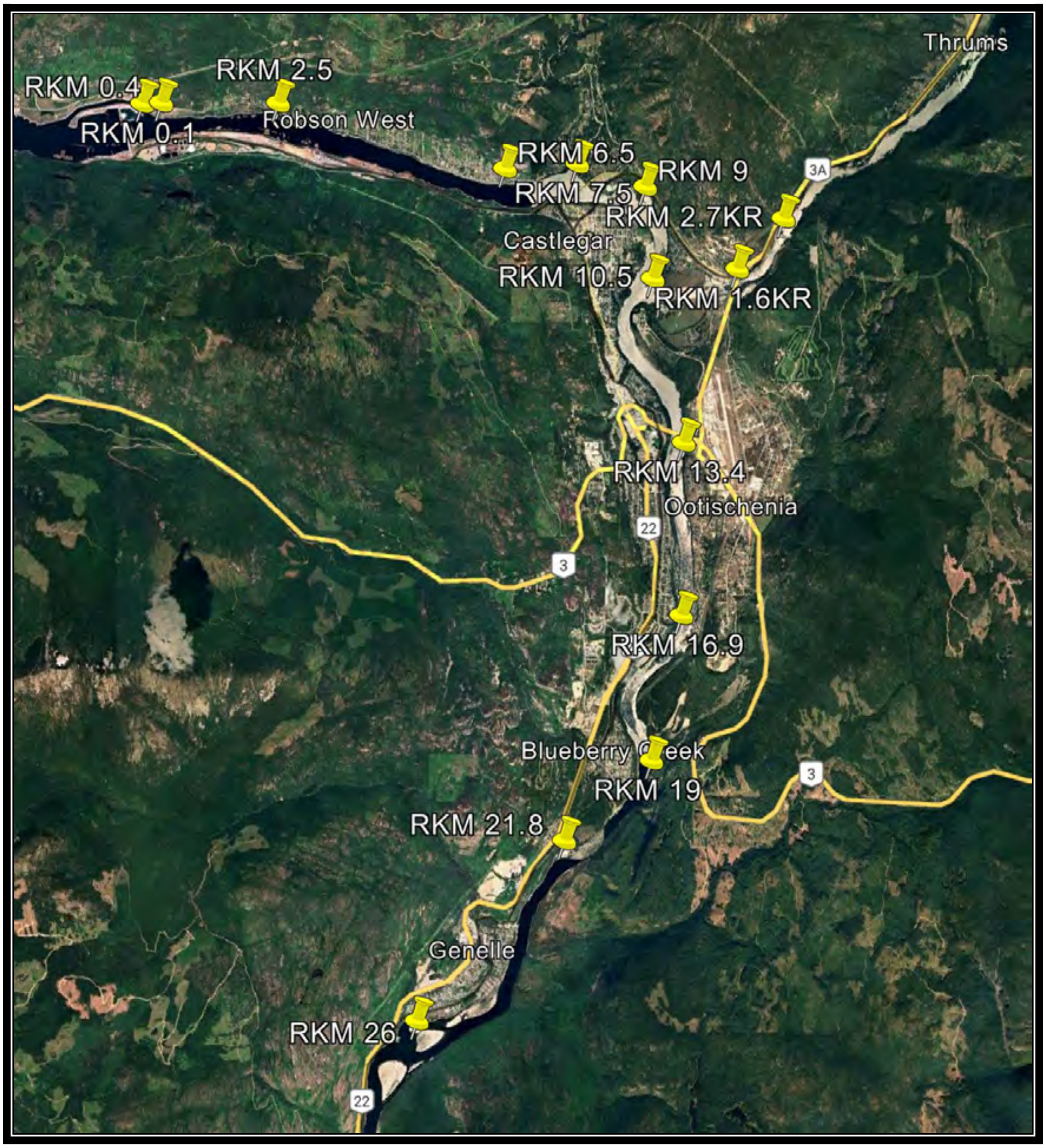

Figure 8. Location of receivers on the BC Hydro acoustic telemetry array in the Columbia River in Canada from HLK Dam to Genelle, and the Kootenay River from the confluence to BRD Dam. RKM is downstream distance from HLK Dam (0.1 km) to the border (56.6 km), and upstream distance from Kootenay River confluence (0.1 km) to BRD Dam (2.7 km).

Drone Surveys

Field Operations

The Sinixt Confederacy worked in partnership (under contract) with Selkirk College (Selkirk Innovates) to complete drone surveys of key habitat areas within the study area (Columbia River-Border to HLK Dam; Kootenay River-Confluence to BRD Dam). Selkirk Innovates produced a detailed report that is found in Appendix IV. We have condensed their report for brevity to provide a simple summary of this report. The reader is encouraged to review the detailed report if they require more detailed information or methodology and results.

Field drone surveillance operations were conducted from September 24 to October 29, 2024. Dates were selected based on current weather and sub-surface illumination conditions. Optimal weather included sunny skies with low cloud cover. The DJI Mavic 3 Pro Cine, equipped with a polarized lens adapter, was used to monitor fish and habitat in the study area.

The locations selected were based on knowledge of historical spawning grounds and preferred habitats. Using this knowledge, the drone operator launched in the relative location of observed spawning areas, viewed the presence of fish on the controller of the drone and descended from approximately 30 meters altitude to 12 meters to observe behaviours and potential spawning activity. Photos and videos were taken of fish and habitat which were believed to be significant to the goals of the study.

Data Analysis and Fish ID

After data was collected, MP4 format videos were backed up on a secure network drive to ensure security and reduce data loss due to corruption. The videos were downloaded onto SSD hard drives for analysis on a large 4k monitor to ensure optimal analysis. The videos were separated into flight dates and locations. Photos taken were analyzed separately on a smaller screen. Visual observations were conducted to count fish, count redds, identify substrate, take notes, and identify behavioural traits. Using an excel spreadsheet, a comprehensive database was created to ensure GPS points can be created in ArcPro. After video and photo analysis is complete, a code was generated to extract accurate GPS data from the SRT file which shows the location of the drone every millisecond as well as relative altitude of the drone. Using this data a csv file was loaded into ArcGIS Pro. Points were generated at every location the drone flew. Then a line is generated which uses the start and end latitude and longitude plus the relative altitude of the flight. Using this relative altitude the ground sampling distance can be used to approximate the area flown and coverage of the river. This is shown using the buffer tool in ArcGIS Pro. Each line generated from the flight was used to create an approximate ground sampling distance based on the average flight height across all flights. The total area surveyed is displayed in the buffer attribute of each flight converted from square meters to Hectares.

To create a map of the area recorded, all buffers were merged and used to create a more general outline of the flight paths as many flights overlap.

Redd locations were generated from the drone GPS location central to the observed redd in frame. A separate database for redds was created to be edited and added to.

Photo locations are displayed as High, Med, Low, and Erase to show photos which are of high significance to the goals of this project.

Fish identification involved careful analysis of drone footage with a focus on key physical traits such as body shape, size, coloration, and movement patterns to differentiate between species. Behavioural observations, including spawning, schooling, shoaling, aggression, swimming, and resting, were recorded to provide a comprehensive understanding of the fish activities and habitat use. Dominate substrate type was also recorded, as it plays a critical role in redd development. Additionally, the drone's GPS data was utilized to accurately record the coordinates of each observation, ensuring precise spatial mapping of redd locations.

Results

Physical Data
Water discharge averaged 1686.32 m3/sec (range 835-2500). River stage averaged 4.35 m (range 2.43-5.91). These results are presented in Figure 9. Water temperature averaged 14.2 ºC (range 7.6-19.4). These results are presented in Figure 10.

Fish Capture, Tagging and Release
In transport one fish had lost its tag, so there were only 59 tagged Chinook Salmon released. (Appendix II). There were a total of 33 females ranging in length from 68cm to 89cm (mean 78.8cm) that received a tag. A total of 26 males also received a tag (ranging in length from 67cm to 94cm (mean 75.5cm).

Acoustic Tracking
Of the 59 acoustically tagged Chinook Salmon, 47 (79.7%) were tracked moving into Canada at some point during the tracking period (August 6-November 27, 2024). The movements of the salmon into Canada, could be categorized into three types. One-time movements into Canada for a short period of time with no spawning (A). Movements into Canada for a longer period and possible spawning (B). Multiple movements into Canada for varying periods of time with no spawning (C).

A total of 29 salmon (62% of salmon moving into Canada) were assigned to the A group (see Figure 11 and 12 for example movement patterns of A group salmon). A total of 12 salmon (26% of salmon moving into Canada) were assigned to the B group (see Figures 13 and 14 for example movement patterns of B group salmon). A total of 6 salmon (13% of salmon moving into Canada) were assigned to the C group (see Figure 15 and 16 for example movement patterns of C group salmon). Migration plots of all tagged salmon are found in Appendix III.

Females averaged 11.8 days (range 2-64; n=24) in Canada, while males averaged 14.0 days (range 1-97; n=23).

It is believed that 6 of the 47 tagged salmon (13%) that moved into Canada spawned, with sites at 9.0 km, 26.0 km, 49.3 km and 56.0 km. These are all sites where there is suitable substrate for Chinook Salmon spawning.

A total of 13 (28%) tagged salmon entered the Kootenay River during the study, with 3 (6%) moving upstream to the base of Brilliant Dam. It is not suspected that any of the tagged salmon spawned in the Kootenay River. A significant number of tagged salmon used the Kootenay confluence (10.5 km) where it flows into the river at Castlegar during tracking.

A total of 4 (8%) of the tagged salmon moved upstream to the base of HLK Dam (0.1 km). No salmon moved upstream into Arrow Lake through the boat lock at HLK Dam.

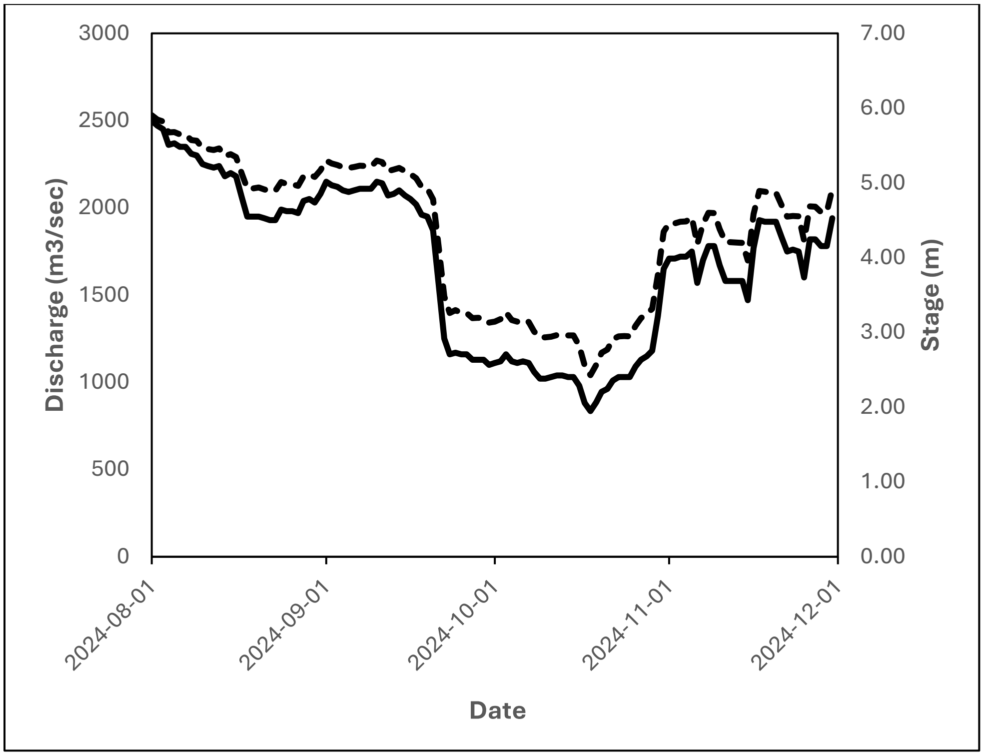

Figure 9. Discharge (m3/sec) and stage (m) for the Columbia River at Birchbank from August 1-November 30, 2024). Dashed line is stage and solid line is discharge.

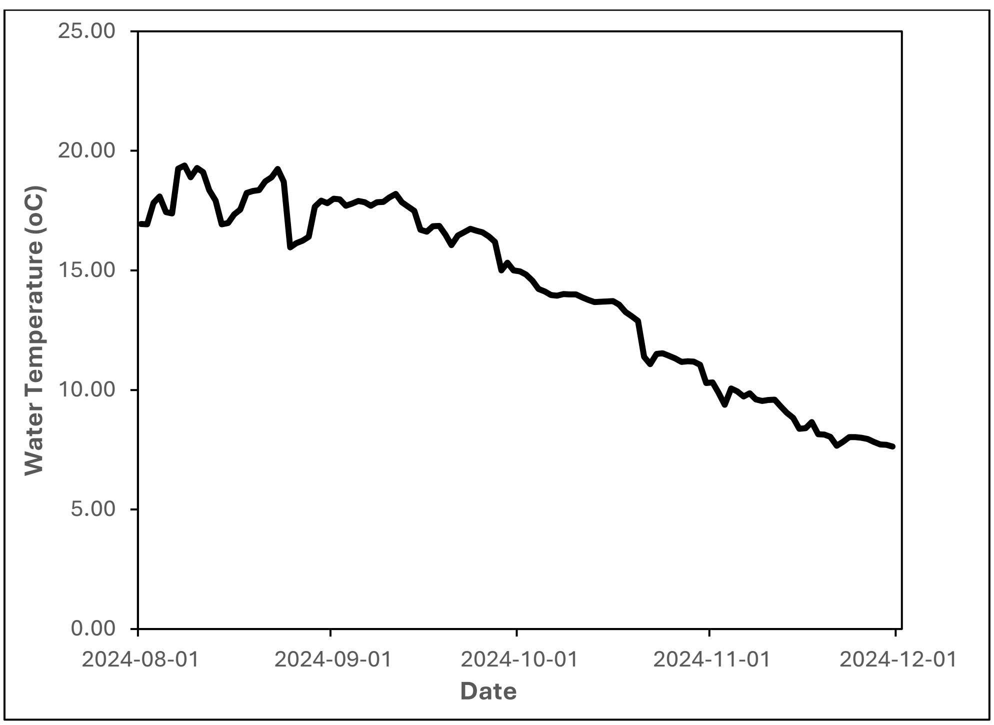

Figure 10. Water temperature (ºC) for the Columbia River at Birchbank from August 1-November 30, 2024).

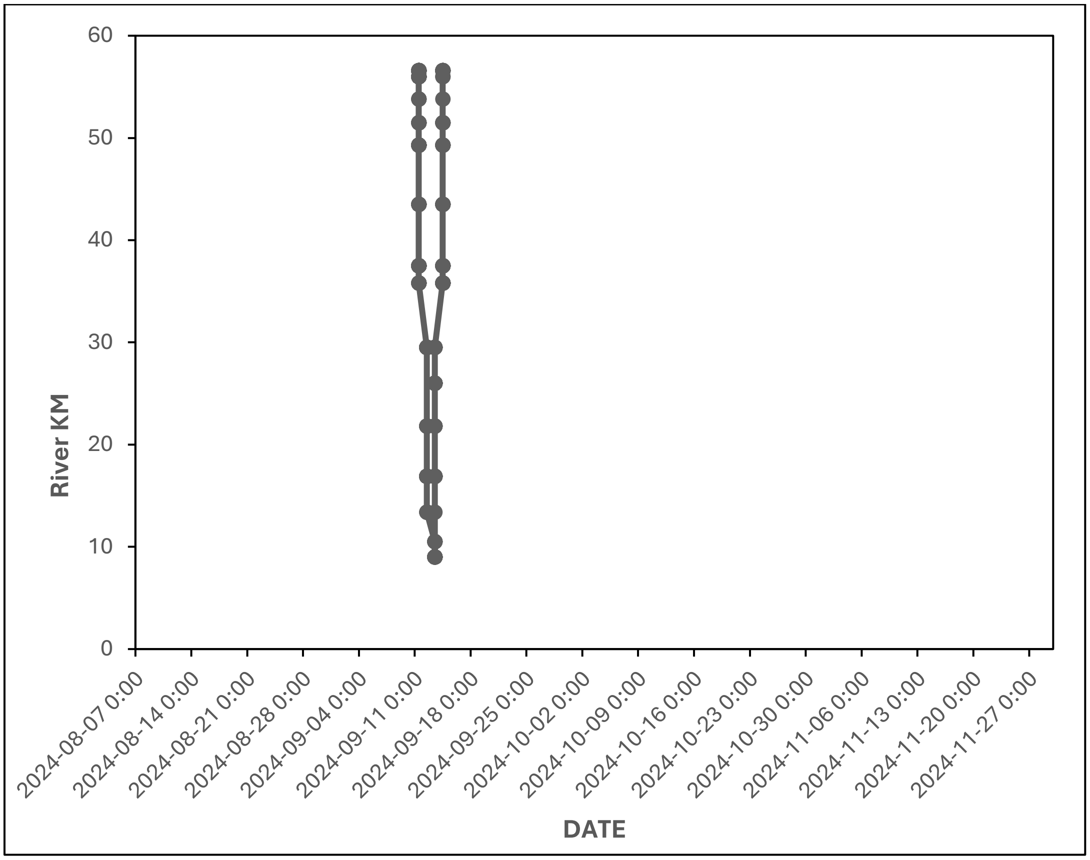

Figure 11. Migration pattern of an 81cm female Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58639) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 9.0 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

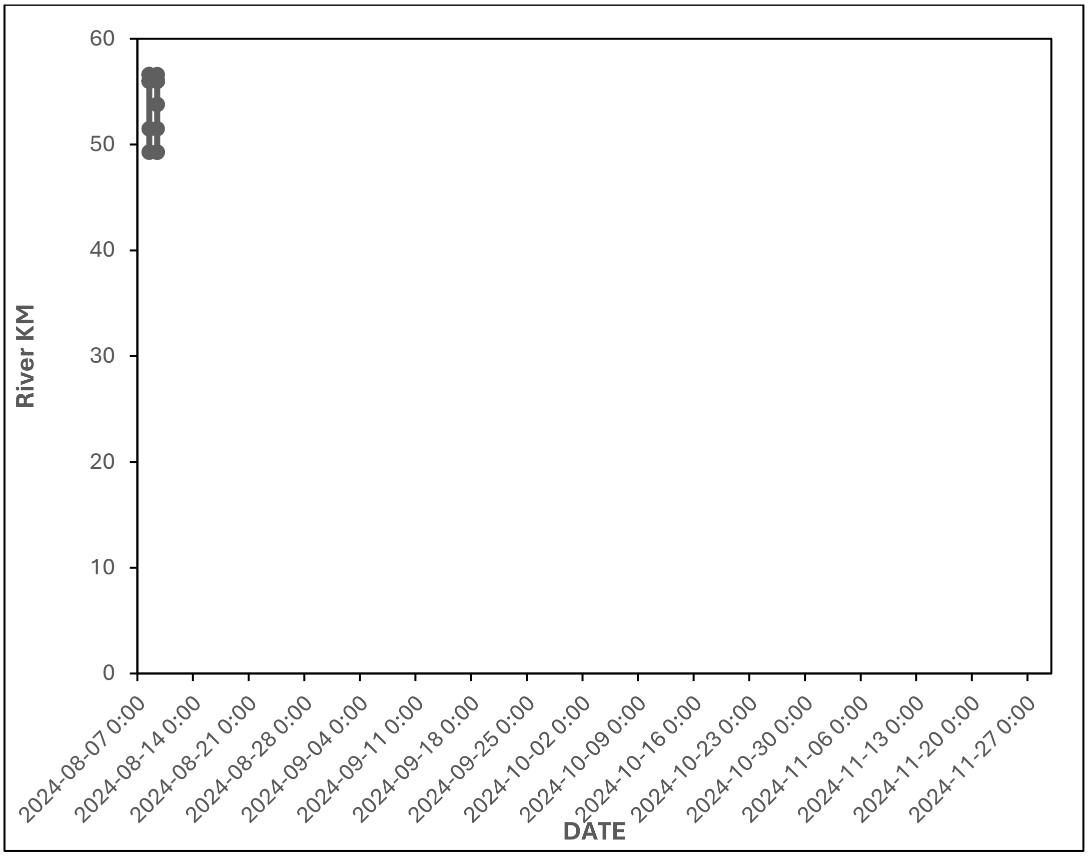

Figure 12. Migration pattern of a 69cm male Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58637) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

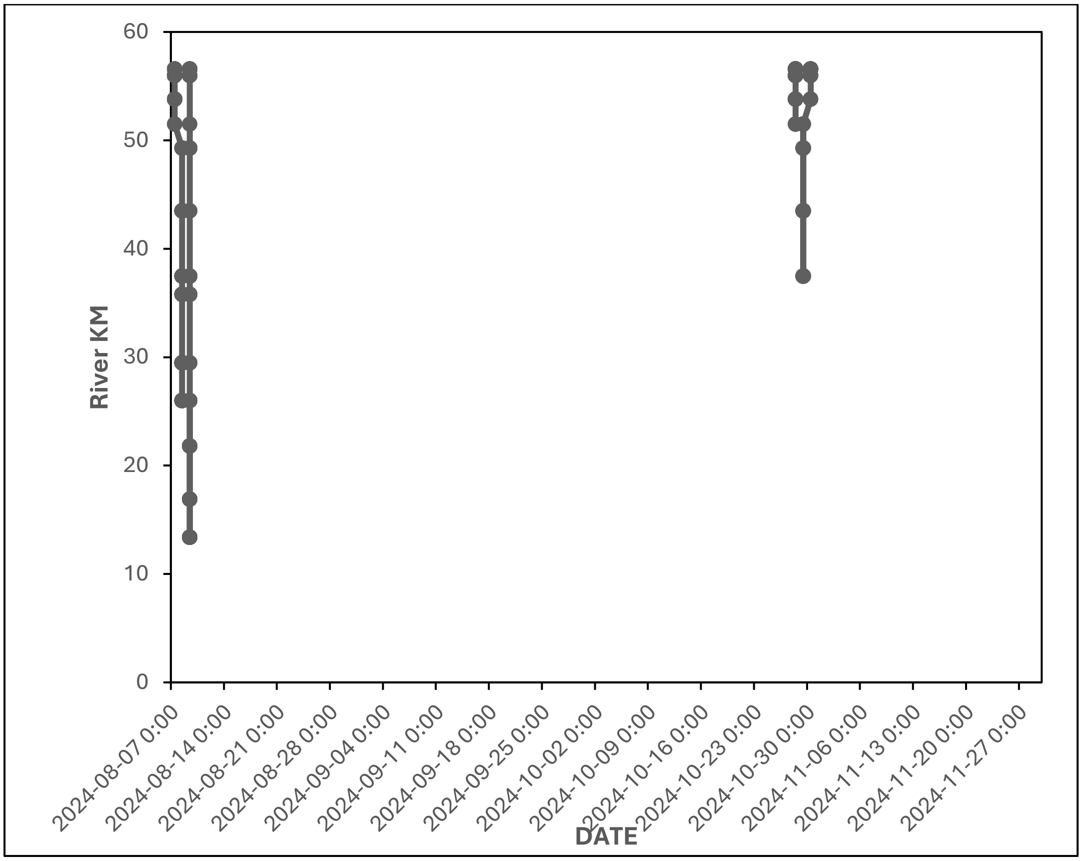

Figure 13. Migration pattern of a 69cm male Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58636) released at Northport, WA on August 6, 2024. This fish moved into Canada on twice and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

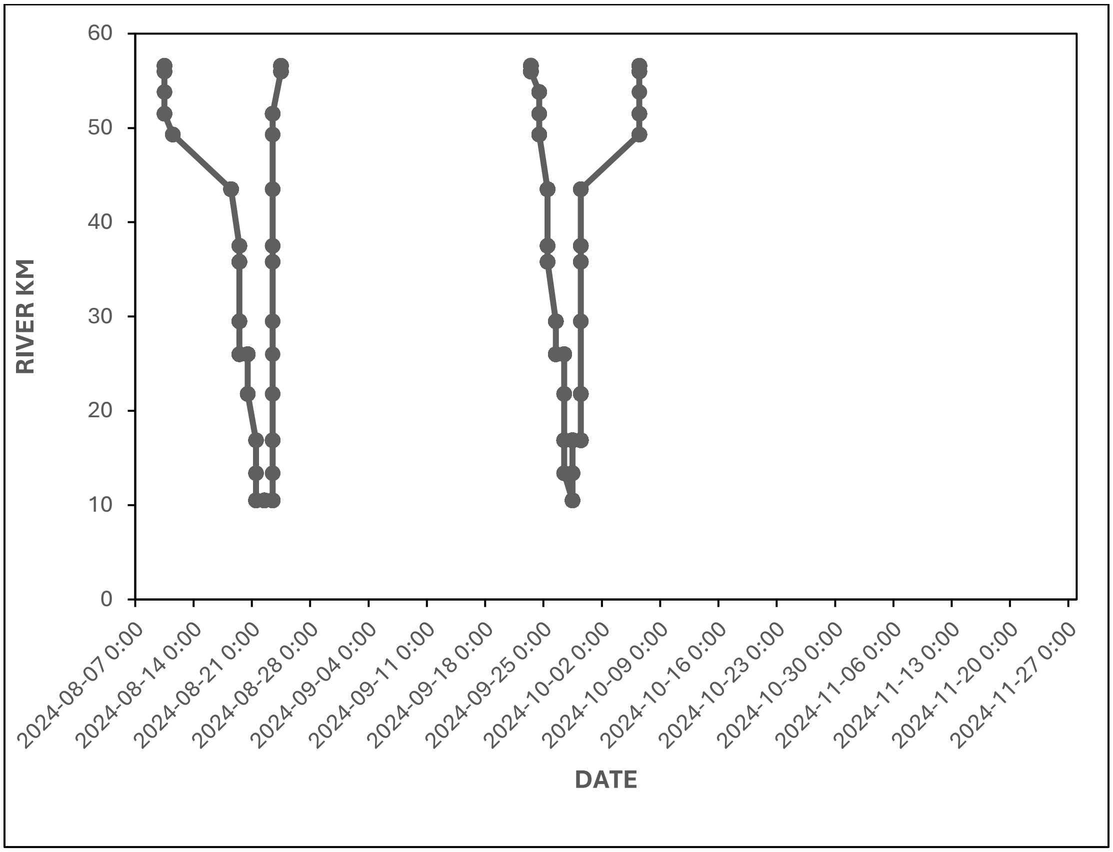

Figure 14. Migration pattern of a 91cm male Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58689) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. It was in Canada for a total of 29 days. This fish did not spawn in Canada.

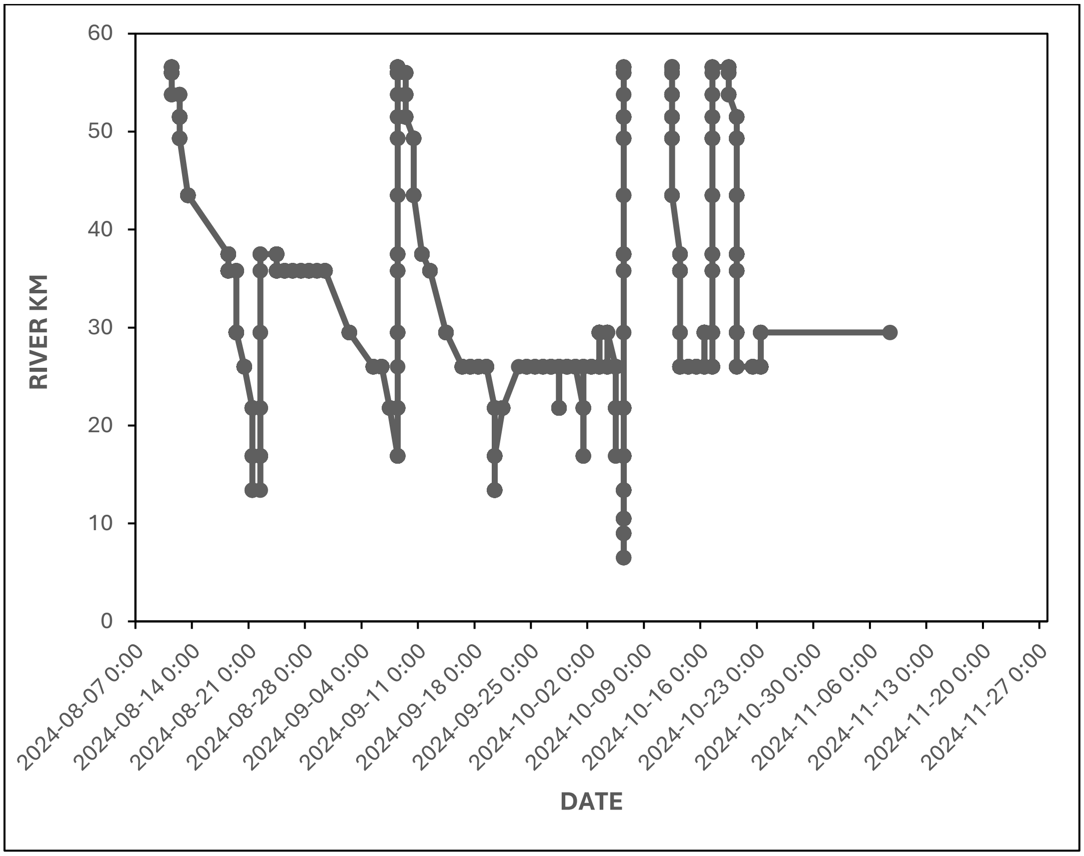

Figure 15. Migration pattern of a 74cm male Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58642) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 6.5 km downstream of HLK Dam. It was in Canada for a total of 80 days. This fish likely spawned at 26.0 km (Genelle).

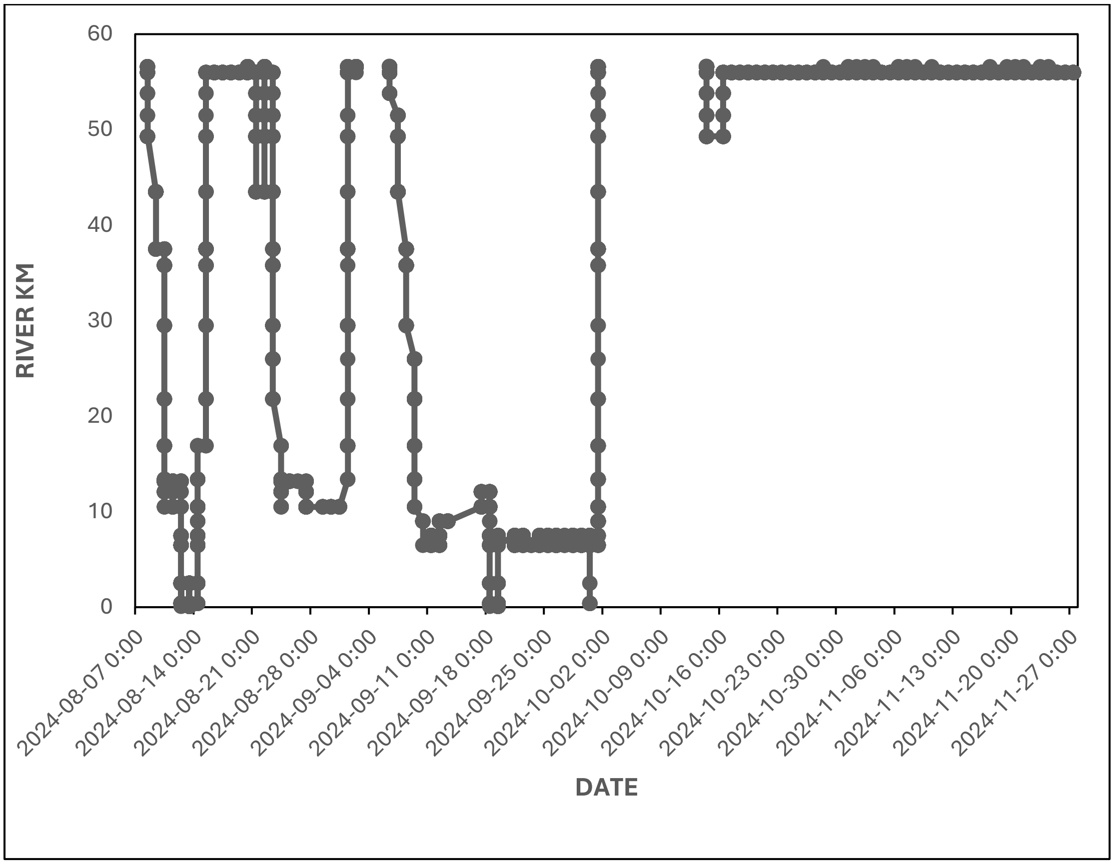

Figure 16. Migration pattern of a 69cm male Chinook Salmon (*Oncorhynchus tshawytscha*) (tag 58695) released at Northport, WA on August 6, 2024. This fish moved into Canada on three occasions and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 2.7km from the confluence for 10 days. It was in Canada for a total of 97 days. This fish likely spawned at 49.3 km or 56.0 km.

Redd Surveys

Visual redd surveys began on September 13, 2024 and two adult Chinook Salmon were seen on spawning habitat in the Kootenay River. There surveys continued infrequently through September and October. Results are presented in Table 2. The data suggested that spawning likely started the fourth week of September. Maps of redd locations seen during redd surveys are found in Figures 17 and 18.

Table 2. Summary of visual observations of Chinook Salmon (*Oncorhynchus tshawytscha*) and redds conducted during ground surveys in September and October of 2024.

Date	Method	Location	Observations
September 13, 2024	Boat	Kootenay River (oxbow)	2 Chinook
September 25, 2024	Ground	Columbia River (Norns Creek fan)	Several Chinook No redds
October 5, 2024	Ground	Columbia River (Norns Creek fan)	No Chinook 3 redds
October 5, 204	Ground	Norns Creek	No Chinook No redds
October 10, 2024	Ground	Columbia River (Genelle)	2 redds
October 18, 2024	Ground	Columbia River (Norns Creek fan)	2 Chinook 1 redd
October 22, 2024	Ground	Columbia River (Norns Creek fan)	3 Chinook 2 redd
October 22, 2024	Ground	Columbia River (Norns Creek fan; downstream of Robson bridge)	10 Chinook 4 Redds

Drone Surveys

Field Operations

Over the project duration, nearly 13 hours of active drone flight time was carried out along 128 KM of manual flight lines to cover 355 Ha of Columbia River waterways of which 257 Ha was suitable (within visible depth range and unobscured) for analysis (Table 3). Some sites were surveyed multiple times when warranted by the presence of potential salmon and their redds.

Up to 32 redds were found in 2024 based on visual observations. Most were located on Norns fan and Genelle (Figure 19), with a few in the Kootenay River and the mainstem Columbia River at Zuckerberg Island (Figure 19).

From the drone surveys spawning had started on September 24 and was ongoing until the last survey on October 29. Water temperature at this time ranged between 10.3 and 16.7 ˚C.

Figure 17 Location of Chinook Salmon (*Oncorhynchus tshawytscha*) redds found at Genelle by ground surveys in September and October of 2024.

Figure 18. Location of Chinook Salmon (*Oncorhynchus tshawytscha*) redds found at Norns Creek Fan by ground surveys in September and October of 2024.

Table 3. Summary of drone survey flights in September and October of 2024.

Date	Distance (km)	Altitude1 (m) (Min/Max)	Max Range (m)	Avg. Speed (m/s)	# of Satellites (Min/Max)	# of Flights
Sept 24th, 2024	22.2	0/91	886.8	1.2	12/26	6
Oct 2nd, 2024	18.46	-2.1/127.5	2288.3	2.0	16/25	3
Oct 3rd, 2024	1.3	0/95.3	321.5	3.4	19/24	1
Oct 7th, 2024	15.4	0/90	1590.9	1.8	15/25	3
Oct 17th, 2024	8.59	0/71	764.2	2.7	12/21	2
Oct 22nd, 2024	11.29	-1.2/81.6	1278.5	1.0	0/24	3
Oct 25th, 2024	19.56	-0.4/119.5	1235	0.9	10/25	7
Oct 28th, 2024	7.25	0/91	1115	1.0	16/24	1
Oct 29th, 2024	24.7	-0.3/125	1240	2.4	15/24	6

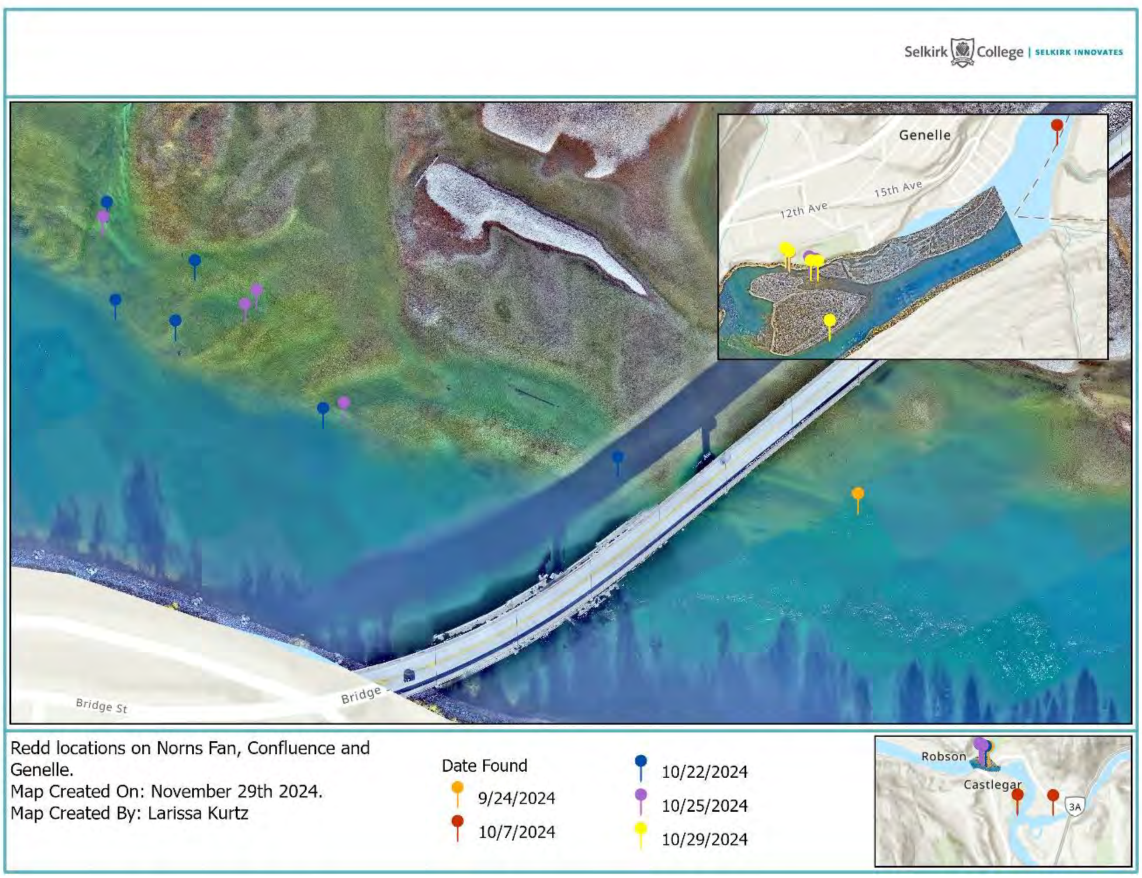

Figure 19. Location of Chinook Salmon (*Oncorhynchus tshawytscha*) redds found in the transboundary reach of the Columbia River in Canada by drone surveys in September and October of 2024.

Data Analysis and Fish ID
Once the footage from the drone surveys was analysed, it was shown that the surveys could identify Chinook and Sockeye Salmon (Figure 20), Chinook Salmon redds (Figures 21 and 22), Chinook Salmon mortalities (Figure 22), White Sturgeon (Figure 23), and Suckers (*Catostomus* spp.; Figure 24). It could also be used to effectively map the main spawning areas (Figures 25 and 26).

Figure 20. Two Sockeye Salmon (*Oncorhynchus nerka*) and one potential Chinook Salmon (*Oncorhynchus tshawytscha*) on Norns Fan, September 24, 2024.

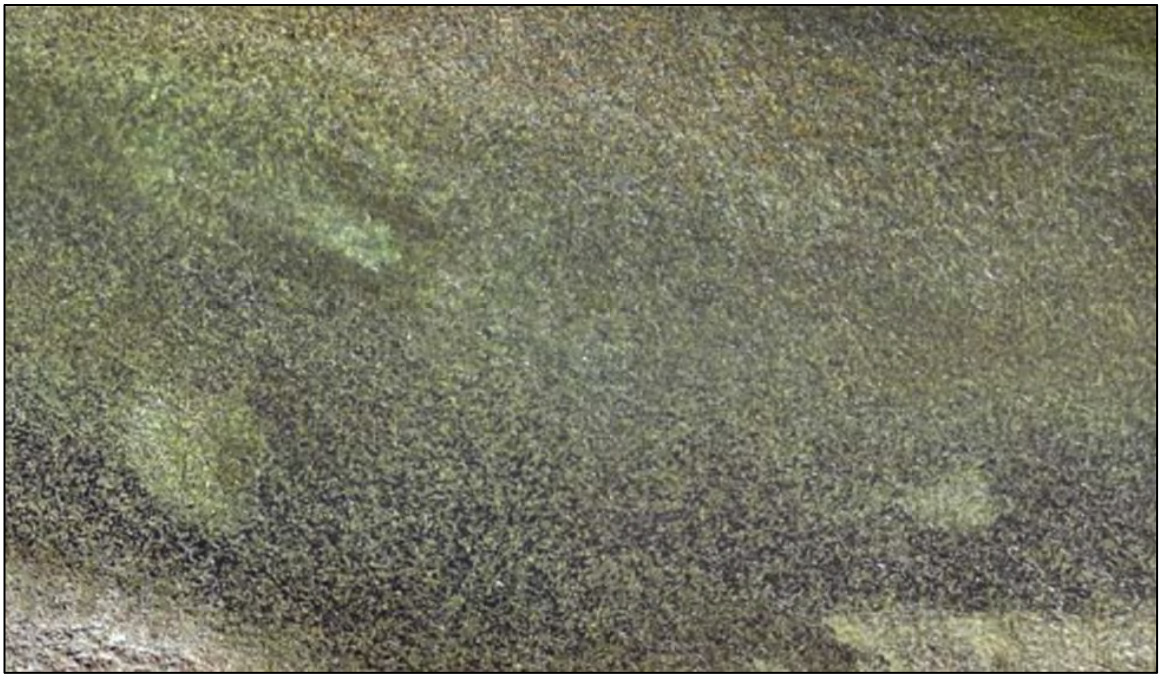

Figure 21. Chinook Salmon (*Oncorhynchus tshawytscha*) redds at Genelle October 29, 2024.

Figure 22. Chinook Salmon (*Oncorhynchus tshawytscha*) redds and a mortality at Genelle on October 25, 2024.

Figure 23. White Sturgeon (*Acipenser transmontanus*) identified during drone surveys on the Columbia River in September and October of 2024.

Figure 24. Suckers (*Catostomus* spp.) identified during drone surveys on the Columbia River in September and October of 2024.

Figure 25. October 29, 2024 site survey of Norns Fan, post-surveillance.

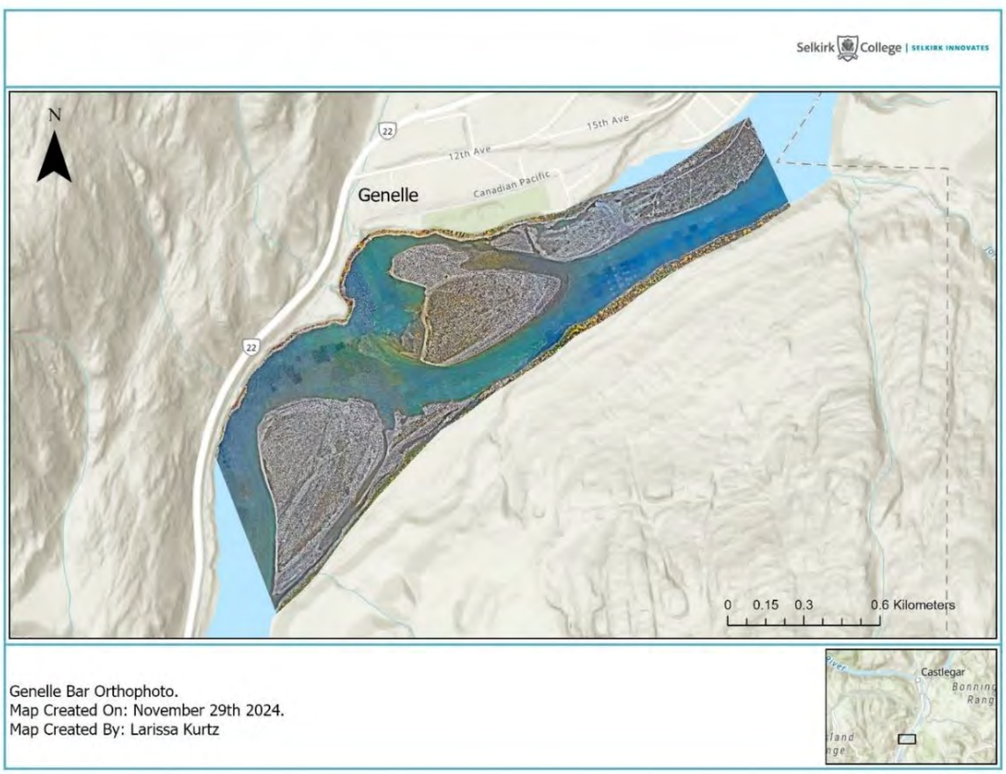

Figure 26. October 29, 2024 site survey of Genelle Bar, post-surveillance.

Discussion

The reintroduction of salmon, and recovery of populations upstream of Grand Coulee Dam (GCD), is a cultural and ecological priority for Native Peoples in the Upper Columbia River watershed. While fish passage options for GCD and Chief Joseph Dam (CJD) are currently being assessed by UCUT through the P2IP Implementation Program, in the short-term adult salmon have been moved upstream via trap-and-haul since 2019. This method is an effective mitigation technique to conserve and maintain salmon populations impacted by dams (Colvin et al. 2018; Kock et al. 2020). This initial phase of trap-and-haul allows the monitoring of colonization behaviour and the documenting of spawning success and locations. It is a critical early step for a reintroduction program.

Large rivers can present a challenge for implementing basic monitoring tasks such as documenting spawning activity. This study successfully utilized three techniques to document behaviour, spawning location, and spawn timing of Chinook Salmon that were reintroduced to the transboundary reach of the Columbia River. Acoustic tracking provided pre-spawn behaviour and movement information and allowed an estimate of the proportion of fish released in the U.S. transboundary reach that made it into Canada and likely spawned in Canada. Analyses of acoustic data suggested that approximately 6% of the fish released in the U.S. transboundary reach likely spawned in Canada. With 358 total Chinook Salmon released in the U.S. transboundary reach, that approach would suggest approximately 21 spawning Chinook in Canadian waters. Ground counts and drone surveys estimated 32 redds in Canada. Assuming one redd per female and a 50:50 sex ratio that would result in approximately 64 Chinook spawning in Canada. Although the estimates were not in perfect alignment in terms of estimated spawning adult salmon, they each provided unique and insightful information to our understanding of this important reintroduction effort. Continued use of multiple methods will be important in future years to better understand the strengths and weaknesses of each so that the program can develop an effective and efficient monitoring program to meet the needs of the reintroduction efforts.

This study was also important as it identified that the tracking coupled with drone surveys was able to be determine spawning timing (late September to the end of October) and spawning locations in the mainstem Columbia River (Norns Creek Fan, Genelle Island complex, and the Kootenay River). Drone surveys are an effective method to identify salmon redds Aerial imagery has the potential to provide insights into redd enumeration as well as many fishery applications across different ecosystems (Aurebach and Fremier 2022). As such, the use of drone surveys to monitor reintroduction efforts should be considered to monitor reintroduction success.

One other key finding is that tagged Chinook Salmon migrated to the base of the Arrow Lakes Generating Station on the Columbia River and the base of Brilliant Dam/Expansion on the Kootenay River. Both of these facilities have implementing fish passage on their Project Approval Certificates once salmon are reestablished to the Columbia River upstream of GCD. Whether trap and haul annually is considered the reestablishment of salmon runs is something for regulatory agencies to decide, but Chinook Salmon have been above GCD since 2019, and they have been successfully spawning. It would be prudent for Canadian agencies to begin implementing passage at these two facilities in anticipation for eventual passage at GCD and CJB. The successful return of salmon to Canada is dependent on passage being achieved at these two facilities.

Reintroduction of salmon to their historic habitat offers an opportunity to increase the production capacity for the population, provide marine derived nutrients to freshwater habitats and restore the salmon culture in areas from which it was cut-off for generations (Bellgraph et al. 2020; Baldwin et al. 2022). This study has shown that the trap and haul of Chinook Salmon above GCD can successfully enable access to habitat in Canada, and that the fish will spawn in suitable habitat on the mainstem Columbia River. Salmon know no borders, and despite these fish being naïve in terms of introduction to an area they are not imprinted to, they will spawn and likely produce juveniles to attempt the migration to the ocean.

Recommendations

1. The work done in this study has demonstrated that some of the adult Chinook Salmon released above Grand Coulee Dam will migrate into Canada, and despite being naïve to these waters, in some cases will find suitable sites to spawn. The three years of acoustic tracking (2020, 2022, and 2024) confirm this. It is recommended that further acoustic tracking studies are not needed at this time as there have been three years of tagging work carried out over five years. We will resume this acoustic tracking work when the U.S. reintroduction efforts begin monitoring the behaviour of returning adults from the blocked area hatchery program releases. This would change of course if there was fish passage put in place at Brilliant Dam or Hugh Keenleyside Dam. It is recommended that discussions be held with Columbia Power Corporation to discuss the results of this study, and dam passage plans at their facilities as tagged Chinook Salmon migrated up to these facilities as far as they could go.

2. The drone surveys conducted this year were an effective survey technique to identify the main spawning areas (Genelle Island complex-26.0 RKM and Norns Creek Fan-9.0 RKM), and to identify adult salmon and post spawning carcasses. As the surveys were conducted over the main spawning period, they were an effective method to estimated spawning timing, through the construction of redds. One method that should be explored with the drones is the quantification of available spawning habitat and the location of this habitat in the study area. As such it is recommended that drone surveys continue in 2025.

3. In addition, the drone surveys it is recommended that aerial surveys via helicopter be conducted in 2025 to fully survey the entire mainstem from the border.

4. Trap and haul of Chinook Salmon above GCD should continue if there are surplus fish to allow this.

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Appendices

Appendix I. Specifications of acoustic tags used in this study.

Customer	Tag Family	VUE Tag ID	Est tag life (days)	Step 1 Status	Step 1 Time (dy hr:min:sec)	Step 1 Power (L/H)	Step 1 Acc. On (sec)	Step 1 Min Delay (sec)	Step 1 Max Delay (sec)	Step 2 Status	Step 2 Time (dy hr:min:sec)
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58636	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58637	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58638	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58639	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58640	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58641	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58642	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58643	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58644	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58645	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58646	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58647	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58648	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58649	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58650	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58651	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58652	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58653	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58654	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58655	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58656	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58657	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58658	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58659	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58660	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58661	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58662	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58663	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58664	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58665	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58666	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58667	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58668	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58669	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58670	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58671	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58672	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58673	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58674	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58675	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58676	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58677	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58678	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58679	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58680	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58681	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58682	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58683	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58684	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58685	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58686	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58687	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58688	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58689	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58690	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58691	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58692	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58693	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58694	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00
CONF. TRIBES OF THE COLVILLE	V16-4x-BLU	A69-1604-58695	1460	ON	135 00:00:00	H		40	80	OFF	365 00:00:00

Appendix II. Biological data of Chinook Salmon (*Oncorhynchus tshawytscha*) used for the acoustic tracking study.

#	Sex	FL (cm)	Acoustic/VUE Tag ID #	Last 4 of PIT	PIT ID #	PIT recap?	PBT ID#	Pathology ID #	COMMENTS	TAGGING TEMP	TAGGING DATE	RELEASE DATE	RELEASE TEMP	RELEASE SITE
1	M	91	58689	EEB5	3DD.003D9CEEB5	NO	0701	1		52	2024-08-05	2024-08-06	62.6	Northport
2	F	71	58686	EEEC	3DD.003D9CEEEC	NO	0702	2		52	2024-08-05	2024-08-06	62.6	Northport
3	F	78	58683	EEEB	3DD.003D9CEEEB	NO	0703	3		52	2024-08-05	2024-08-06	62.6	Northport
4	F	78	58680	EED6	3DD.003D9CEED6	NO	0704	4		52	2024-08-05	2024-08-06	62.6	Northport
5	M	85	58677	EEA1	3DD.003D9CEEA1	NO	0705	5	OPEN WOUND	52	2024-08-05	2024-08-06	62.6	Northport
6	F	85	58674	EEAB	3DD.003D9CEEAB	NO	0706	6		52	2024-08-05	2024-08-06	62.6	Northport
7	M	70	58688	EED5	3DD.003D9CEED5	NO	0707	7		52	2024-08-05	2024-08-06	62.6	Northport
8	F	80	58685	EEDA	3DD.003D9CEEDA	NO	0708	8		52	2024-08-05	2024-08-06	62.6	Northport
9	M	77	58682	EEE4	3DD.003D9CEEE4	NO	0709	9		52	2024-08-05	2024-08-06	62.6	Northport
10	F	71	58679	EEB4	3DD.003D9CEEB4	NO	0710	10	OPEN WOUND	52	2024-08-05	2024-08-06	62.6	Northport
11	F	76	58676	EEC3	3DD.003D9CEEC3	NO	0711	11		52	2024-08-05	2024-08-06	62.6	Northport
12	M	67	58673	EE8D	3DD.003D9CEE8D	NO	0712	12		52	2024-08-05	2024-08-06	62.6	Northport
13	F	72	58687	EE92	3DD.003D9CEE92	NO	0713	13		52	2024-08-05	2024-08-06	62.6	Northport
14	F	76	58684	EED7	3DD.003D9CEED7	NO	0714	14		52	2024-08-05	2024-08-06	62.6	Northport
15	F	74	58681	EECC	3DD.003D9CEECC	NO	0715	15		52	2024-08-05	2024-08-06	62.6	Northport
16	F	68	58678	EEC5	3DD.003D9CEEC5	NO	0716	16		52	2024-08-05	2024-08-06	62.6	Northport
17	F	79	58675	EEC7	3DD.003D9CEEC7	NO	0717	17		52	2024-08-05	2024-08-06	62.6	Northport
18	F	88	58672	EE9D	3DD.003D9CEE9D	NO	0718	18	POST TAG MORT/SHED PIT TAG	52	2024-08-05	2024-08-06	62.6	Northport
19	M	77	58654	EEC1	3DD.003D9CEEC1	NO	0719	19		52	2024-08-05	2024-08-06	62.6	Northport
20	F	78	58669	EE8F	3DD.003D9CEE8F	NO	0720	20		52	2024-08-05	2024-08-06	62.6	Northport
21	F	89	58666	EEAA	3DD.003D9CEEAA	NO	0721	21		52	2024-08-05	2024-08-06	62.6	Northport
22	M	67	58663	EEBC	3DD.003D9CEEBC	NO	0722	22		52	2024-08-05	2024-08-06	62.6	Northport
23	F	88	58660	EEBA	3DD.003D9CEEBA	NO	0723	23		52	2024-08-05	2024-08-06	62.6	Northport
24	F	74	58657	EE91	3DD.003D9CEE91	NO	0724	24		52	2024-08-05	2024-08-06	62.6	Northport
25	M	75	58670	EEB1	3DD.003D9CEEB1	NO	0725	25		52	2024-08-05	2024-08-06	62.6	Northport
26	F	81	58667	EE98	3DD.003D9CEE98	NO	0726	26		52	2024-08-05	2024-08-06	62.6	Northport
27	F	80	58664	EEEF	3DD.003D9CEEEF	NO	0727	27		52	2024-08-05	2024-08-06	62.6	Northport
28	M	92	58661	EEE9	3DD.003D9CEEE9	NO	0728	28		52	2024-08-05	2024-08-06	62.6	Northport
29	M	76	58658	EE96	3DD.003D9CEE96	NO	0729	29		52	2024-08-05	2024-08-06	62.6	Northport
30	M	84	58655	FF04	3DD.003DFFFF04	NO	0730	30		52	2024-08-05	2024-08-06	62.6	Northport
31	F	84	58656	FF43	3DD.003DFFFF43	NO	0731			52	2024-08-05	2024-08-06	62.6	Northport
32	M	79	58662	FF07	3DD.003DFFFF07	NO	0732			52	2024-08-05	2024-08-06	62.6	Northport
33	F	83	58659	FF52	3DD.003DFFFF52	NO	0733			52	2024-08-05	2024-08-06	62.6	Northport
34	M	94	58665	FF47	3DD.003DFFFF47	NO	0734			52	2024-08-05	2024-08-06	62.6	Northport
35	M	75	58668	FF17	3DD.003DFFFF17	NO	0735			52	2024-08-05	2024-08-06	62.6	Northport
36	F	82	58671	FF4C	3DD.003DFFFF4C	NO	0736			52	2024-08-05	2024-08-06	62.6	Northport
37		75	58651	FF25	3DD.003DFFFF25	NO	0737			52	2024-08-05	2024-08-06	62.6	Northport
38	F	83	58638	FF2A	3DD.003DFFFF2A	NO	0738			52	2024-08-05	2024-08-06	62.6	Northport
39	M	87	58645	FF10	3DD.003DFFFF10	NO	0739			52	2024-08-05	2024-08-06	62.6	Northport
40	F	81	58639	FF02	3DD.003DFFFF02	NO	0740			52	2024-08-05	2024-08-06	62.6	Northport
41	M	74	58642	FF29	3DD.003DFFFF29	NO	0741		OPEN WOUND	52	2024-08-05	2024-08-06	62.6	Northport
42	F	75	58646	FF57	3DD.003DFFFF57	NO	0742			52	2024-08-05	2024-08-06	62.6	Northport
43	M	71	58641	FF48	3DD.003DFFFF48	NO	0743			52	2024-08-05	2024-08-06	62.6	Northport
44	F	75	58643	FF1A	3DD.003DFFFF1A	NO	0744			52	2024-08-05	2024-08-06	62.6	Northport
45	F	75	58640	FF2F	3DD.003DFFFF2F	NO	0745			52	2024-08-05	2024-08-06	62.6	Northport
46	M	69	58637	FF0F	3DD.003DFFFF0F	NO	0746			52	2024-08-05	2024-08-06	62.6	Northport
47	F	83	58652	FF22	3DD.003DFFFF22	NO	0748			52	2024-08-05	2024-08-06	62.6	Northport
48	M	63	NONE	FF08	3DD.003DFFFF08	NO	0747			52	2024-08-05	2024-08-06	62.6	Northport
49	M	69	58636	FEFE	3DD.003DFFFEFE	NO	0749			52	2024-08-05	2024-08-06	62.6	Northport
50	M	64	NONE	FF58	3DD.003DFFFF58	NO	0750			52	2024-08-05	2024-08-06	62.6	Northport
51	M	88	58648	FF2D	3DD.003DFFFF2D	NO	0751			52	2024-08-05	2024-08-06	62.6	Northport
52	M	68	58649	FF4F	3DD.003DFFFF4F	NO	0752			52	2024-08-05	2024-08-06	62.6	Northport
53	F	73	58644	FF4D	3DD.003DFFFF4D	NO	0753			52	2024-08-05	2024-08-06	62.6	Northport
54	F	81	58647	FF5E	3DD.003DFFFF5E	NO	0754			52	2024-08-05	2024-08-06	62.6	Northport
55	F	78	58650	FF2C	3DD.003DFFFF2C	NO	0755			52	2024-08-05	2024-08-06	62.6	Northport
56	M	76	58653	FF45	3DD.003DFFFF45	NO	0756			52	2024-08-05	2024-08-06	62.6	Northport
57	F	83	58690	FF38	3DD.003DFFFF38	NO	0757			52	2024-08-05	2024-08-06	62.6	Northport
58	F	83	58694	FF05	3DD.003DFFFF05	NO	0758			52	2024-08-05	2024-08-06	62.6	Northport
59	M	69	58695	FF3B	3DD.003DFFFF3B	NO	0759			52	2024-08-05	2024-08-06	62.6	Northport
60	F	82	58693	FF0A	3DD.003DFFFF0A	NO	0760			52	2024-08-05	2024-08-06	62.6	Northport
61	M	75	58691	FF49	3DD.003DFFFF49	NO	0761			52	2024-08-05	2024-08-06	62.6	Northport
62	M	80	58692	FF01	3DD.003DFFFF01	NO	0762			52	2024-08-05	2024-08-06	62.6	Northport
63	F	79	NONE	FF56	3DD.003DFFFF56	NO	0763			52	2024-08-05	2024-08-06	62.6	Northport
64	M	76	NONE	FF1E	3DD.003DFFFF1E	NO	0764			52	2024-08-05	2024-08-06	62.6	Northport
65	M	70	NONE	FF12	3DD.003DFFFF12	NO	0765			52	2024-08-05	2024-08-06	62.6	Northport

Appendix III. Migration plots of Chinook Salmon (*Oncorhynchus tshawytscha*) acoustically tagged in 2024.

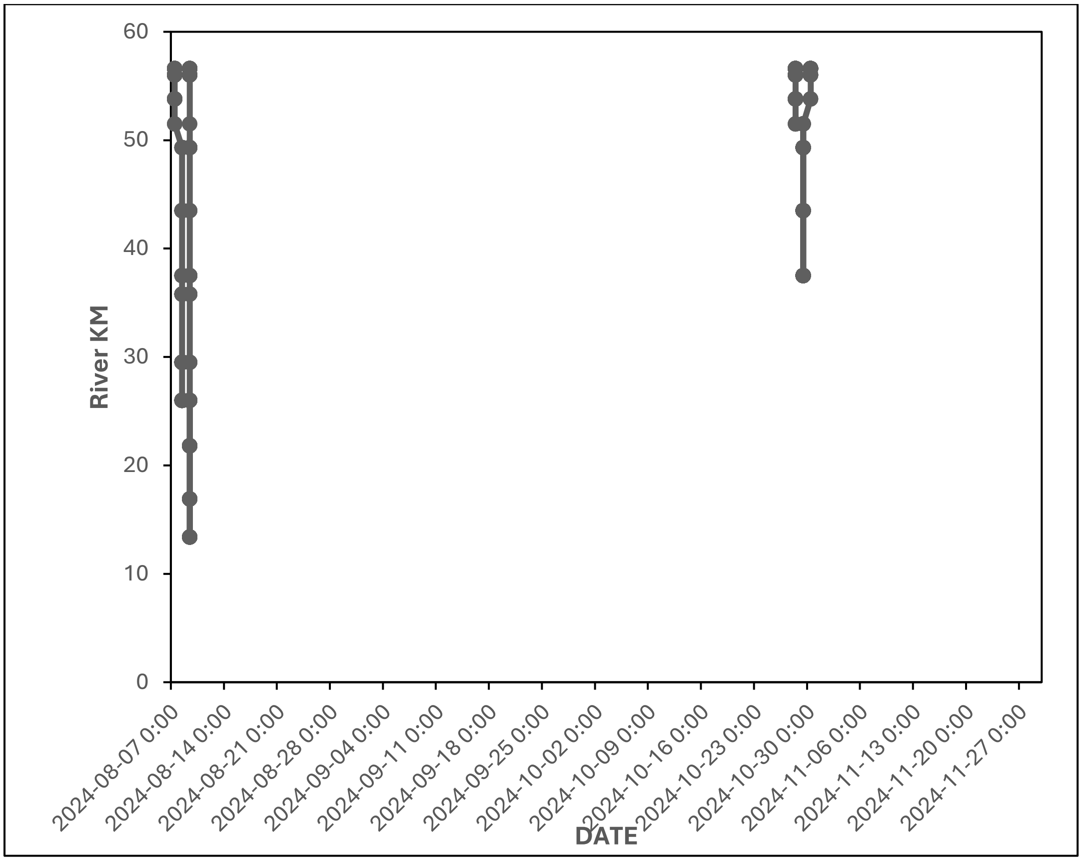

Figure A3.1. Migration pattern of a 69cm male Chinook Salmon (tag 58636) released at Northport, WA on August 6, 2024. This fish moved into Canada on twice and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

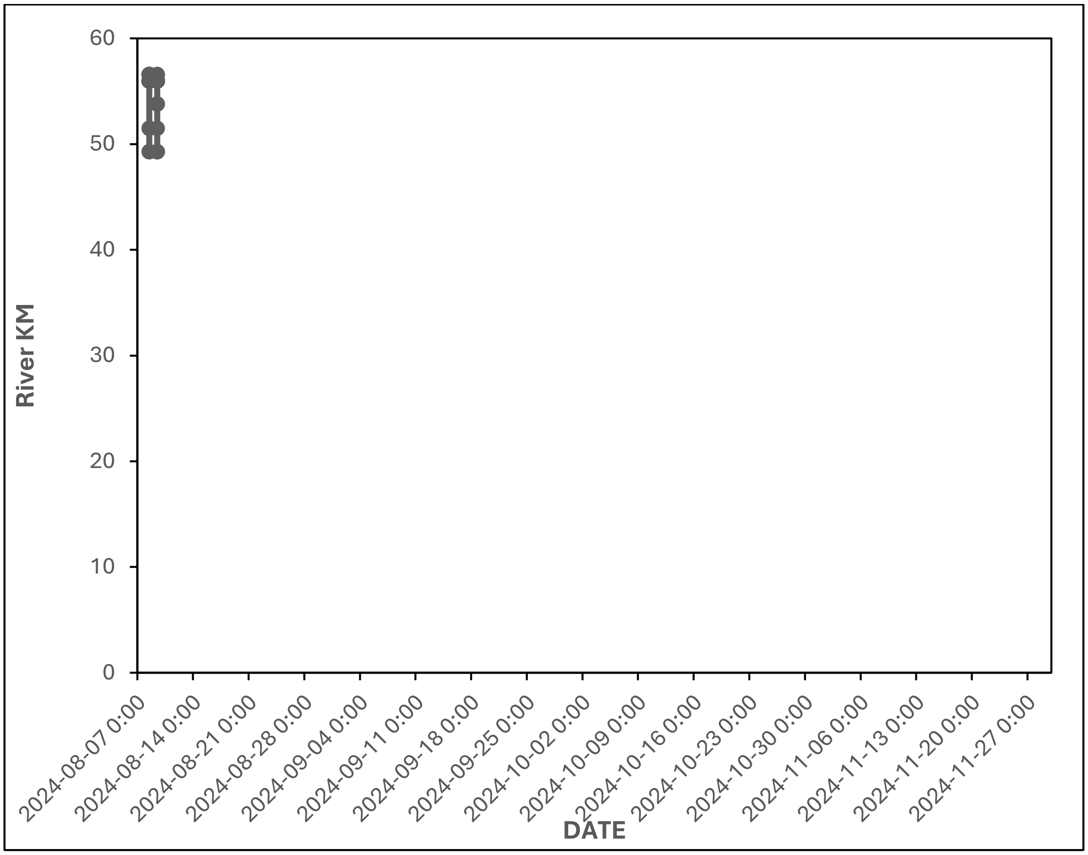

Figure A3.2. Migration pattern of a 69cm male Chinook Salmon (tag 58637) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

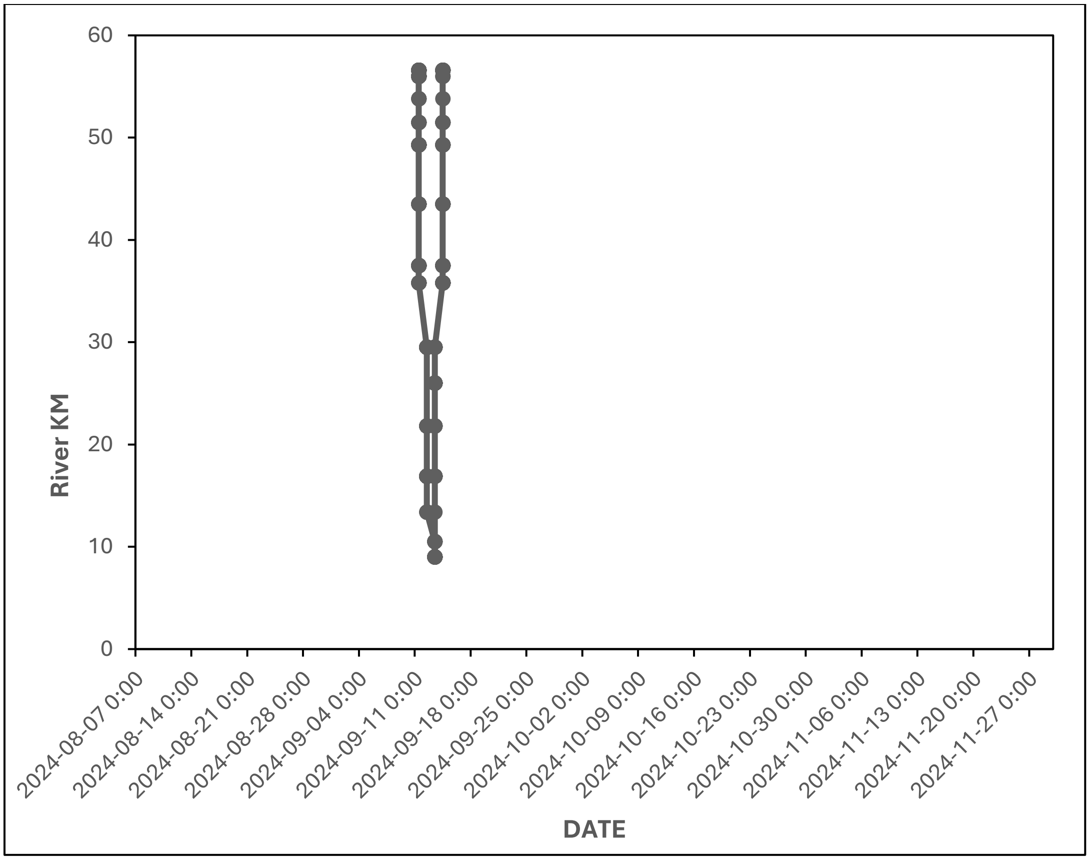

Figure A3.3. Migration pattern of an 81cm female Chinook Salmon (tag 58639) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 9.0 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

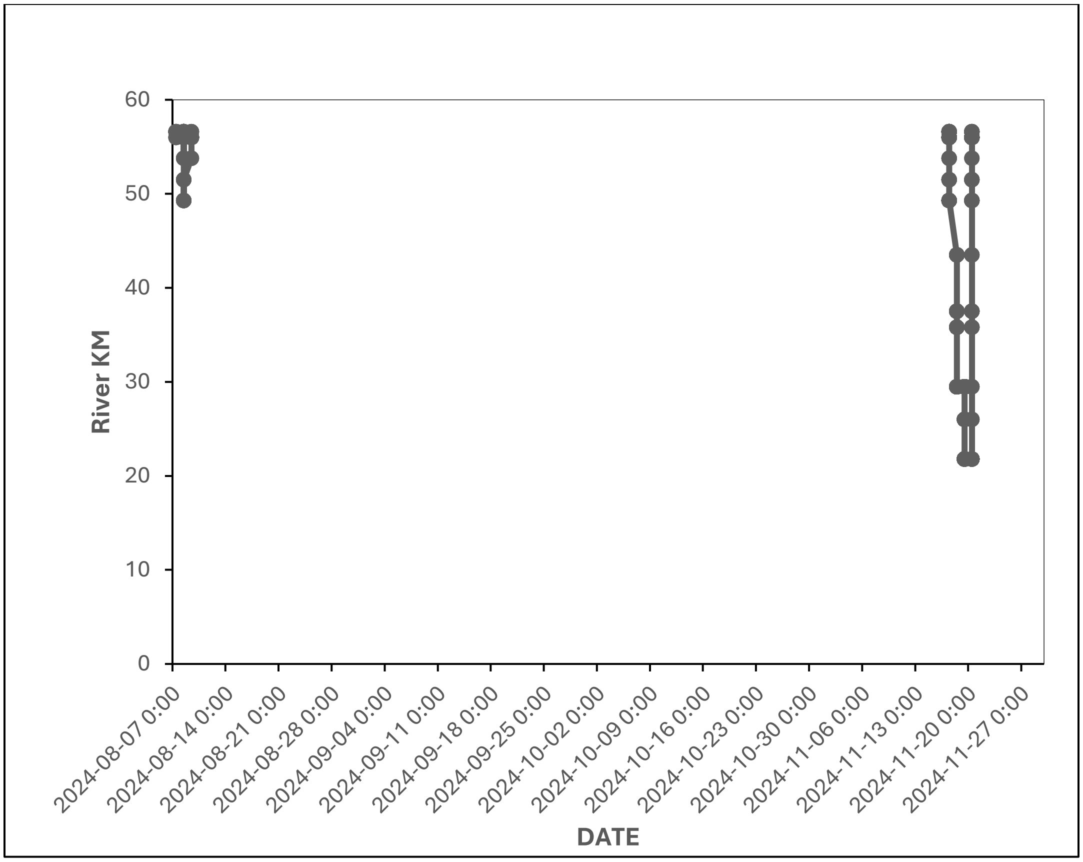

Figure A3.4. Migration pattern of a 75cm female Chinook Salmon (tag 58640) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 21.8 km downstream of HLK Dam. It was in Canada for a total of 7 days. This fish did not spawn in Canada.

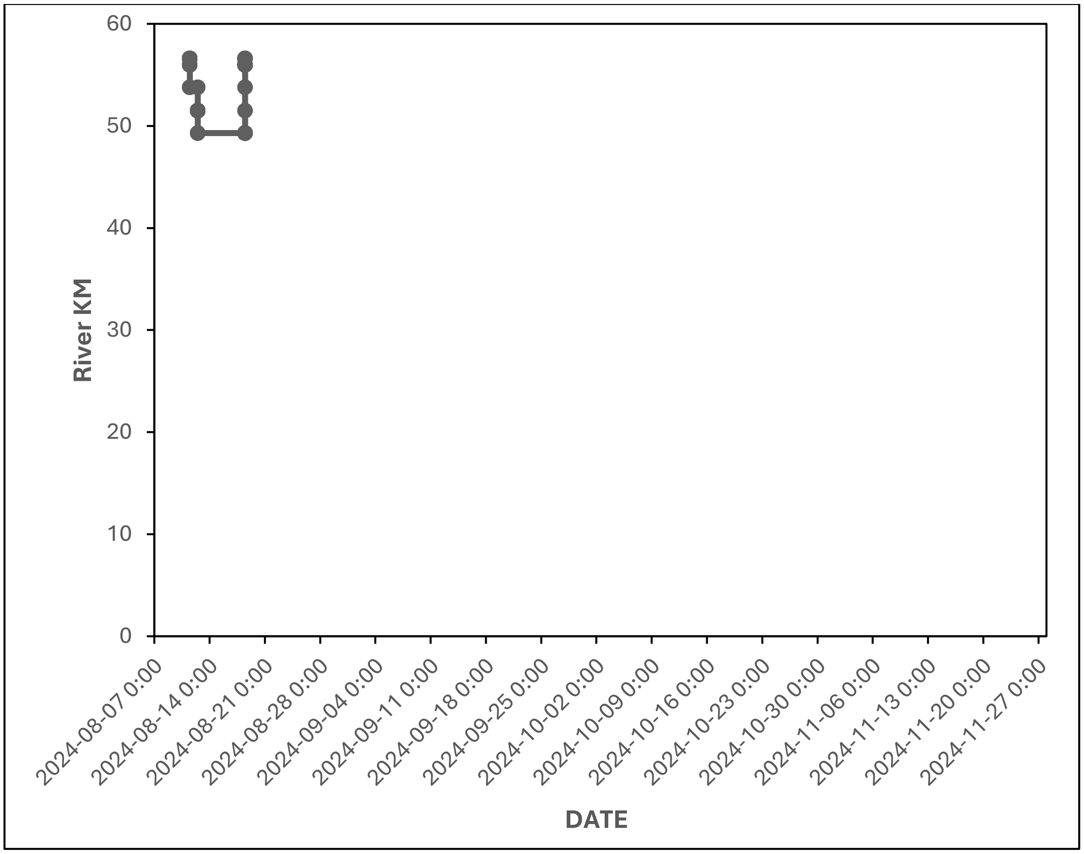

Figure A3.5. Migration pattern of a 71cm male Chinook Salmon (tag 58641) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 8 days. This fish did not spawn in Canada.

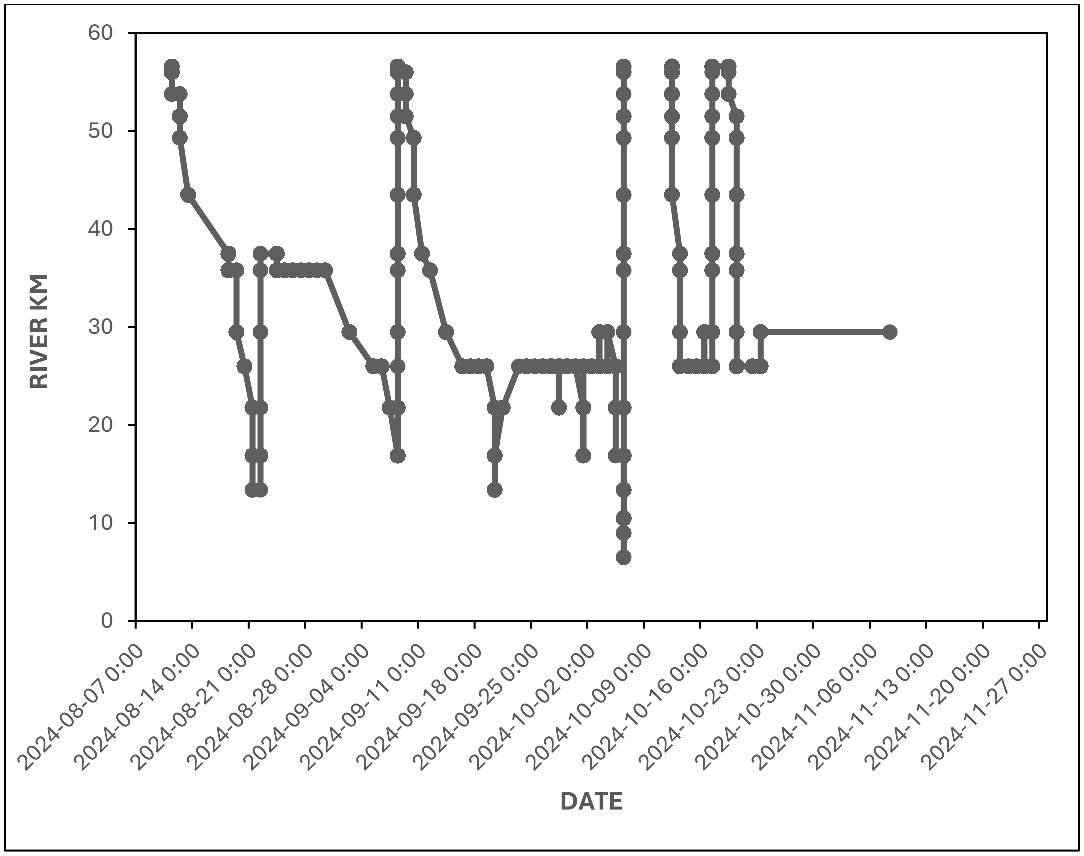

Figure A3.6. Migration pattern of a 74cm male Chinook Salmon (tag 58642) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 6.5 km downstream of HLK Dam. It was in Canada for a total of 80 days. This fish likely spawned at 26.0 km (Genelle).

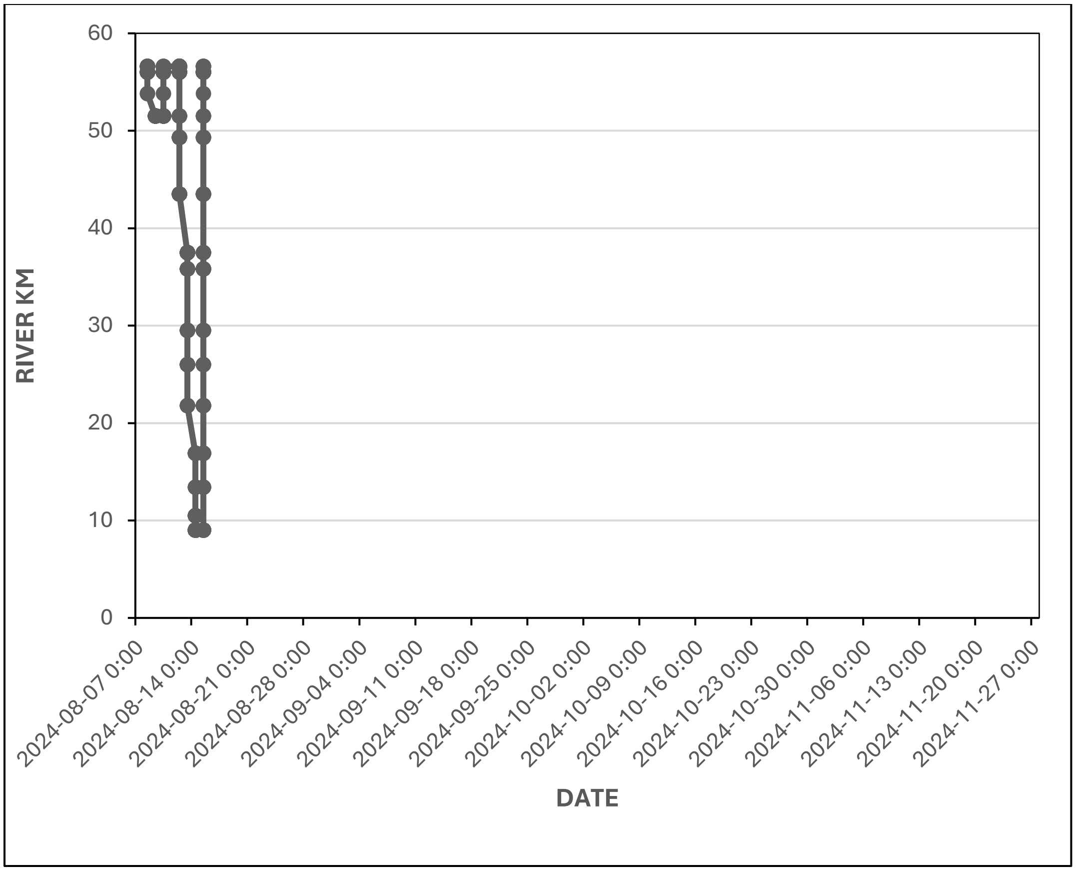

Figure A3.7. Migration pattern of a 75cm female Chinook Salmon (tag 58643) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 9.0 km downstream of HLK Dam. It was in Canada for a total of 7 days. This fish did not spawn in Canada.

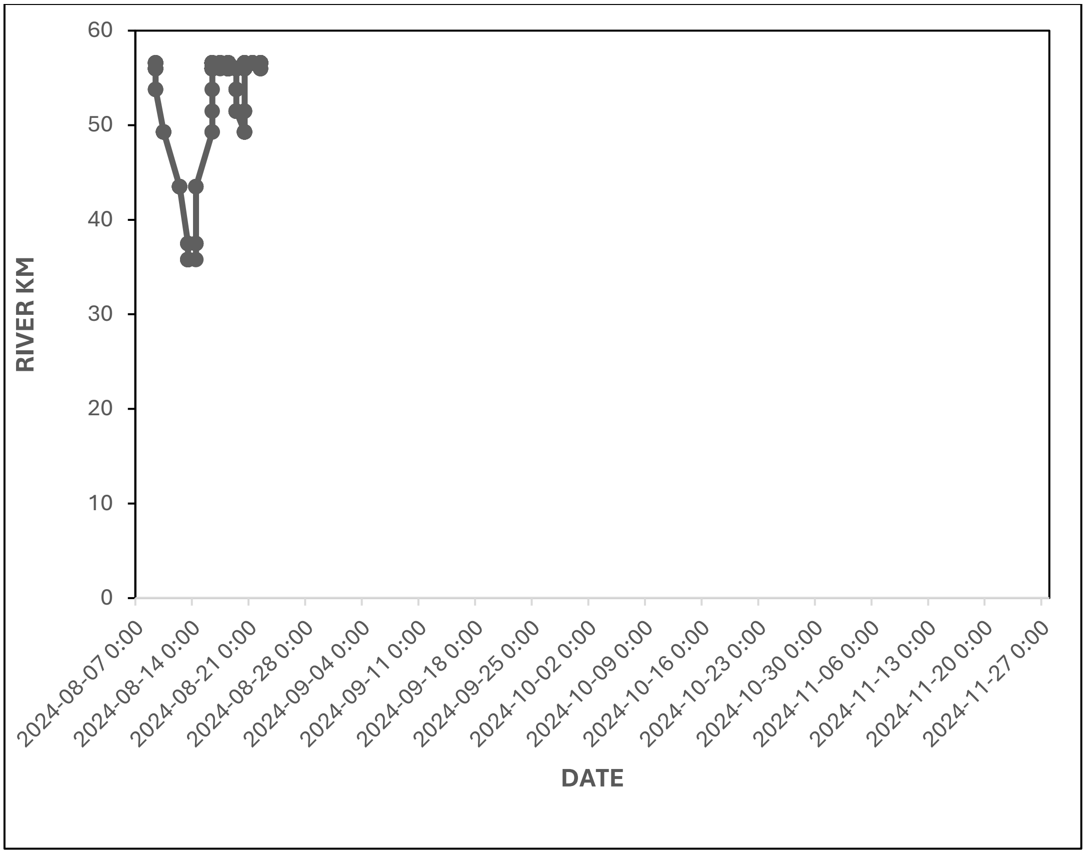

Figure A3.8. Migration pattern of a 73cm female Chinook Salmon (tag 58644) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 35.8 km downstream of HLK Dam. It was in Canada for a total of 12 days. This fish did not spawn in Canada.

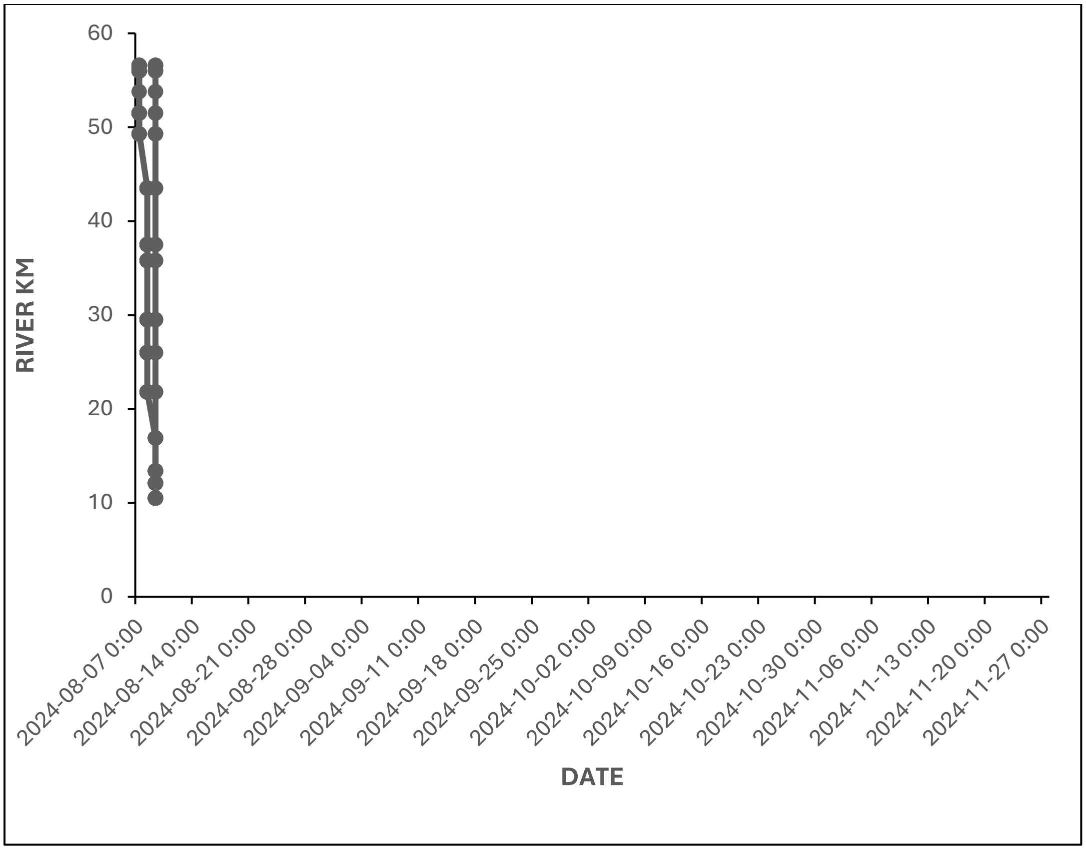

Figure A3.9. Migration pattern of a 75cm female Chinook Salmon (tag 58646) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

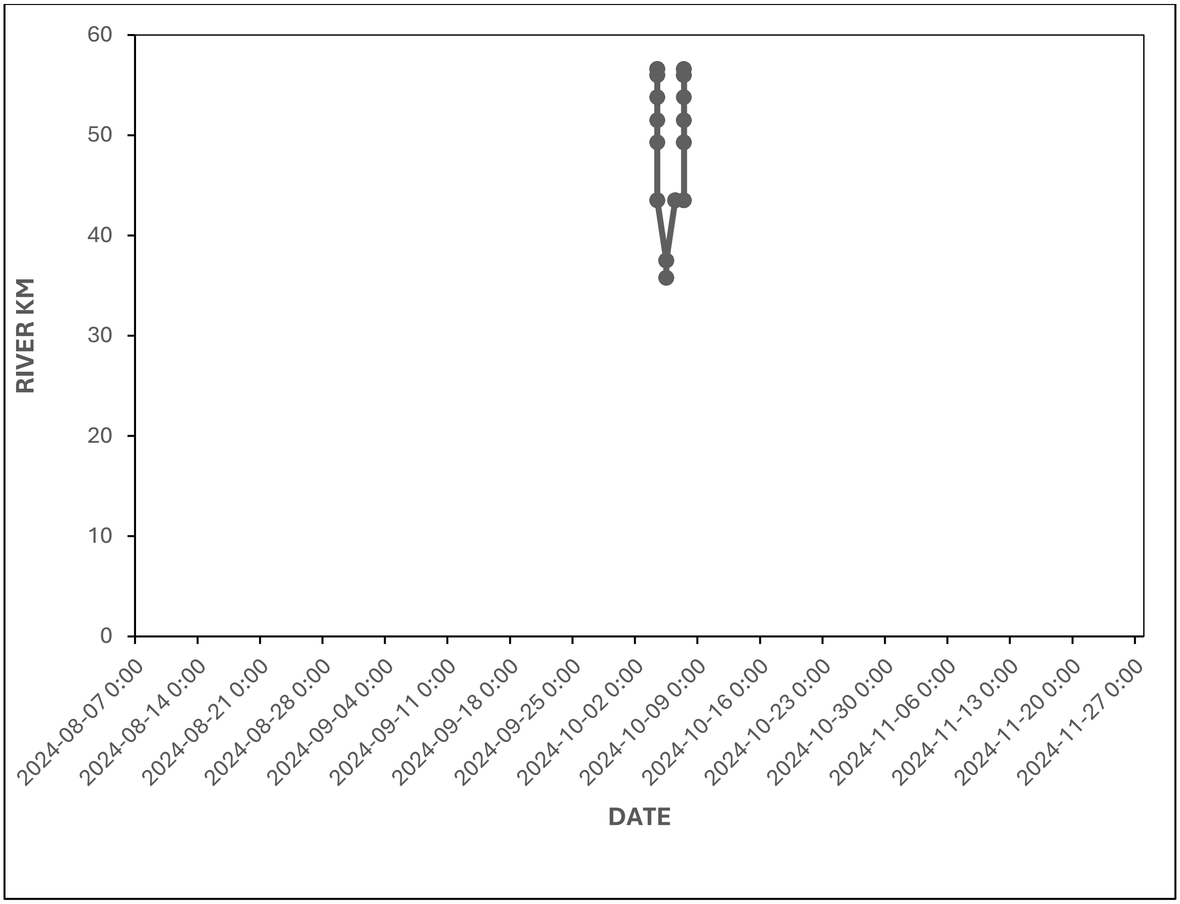

Figure A3.10. Migration pattern of an 81cm female Chinook Salmon (tag 58647) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 35.8 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

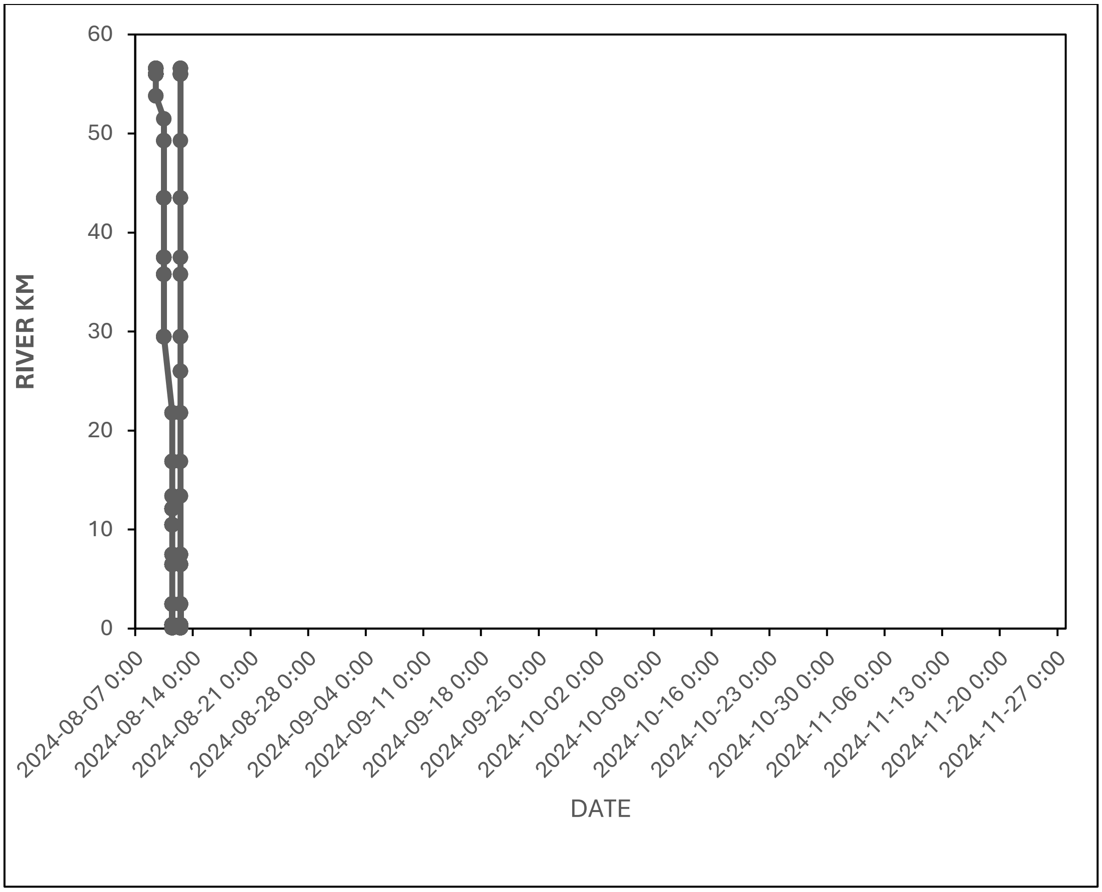

Figure A3.11. Migration pattern of an 88cm male Chinook Salmon (tag 58648) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

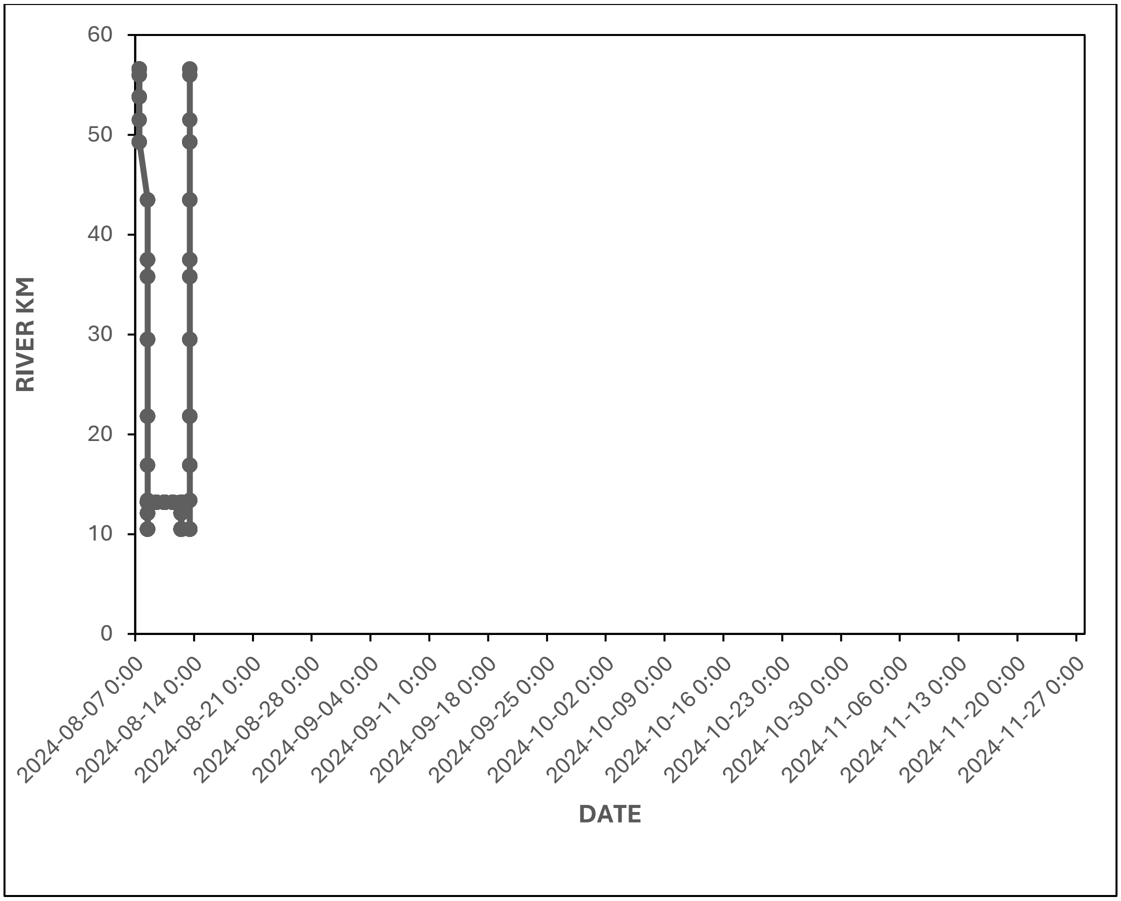

Figure A3.12. Migration pattern of a 68cm male Chinook Salmon (tag 58649) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 2.7 km from the confluence for 5 days. It was in Canada for a total of 7 days. This fish did not spawn in Canada.

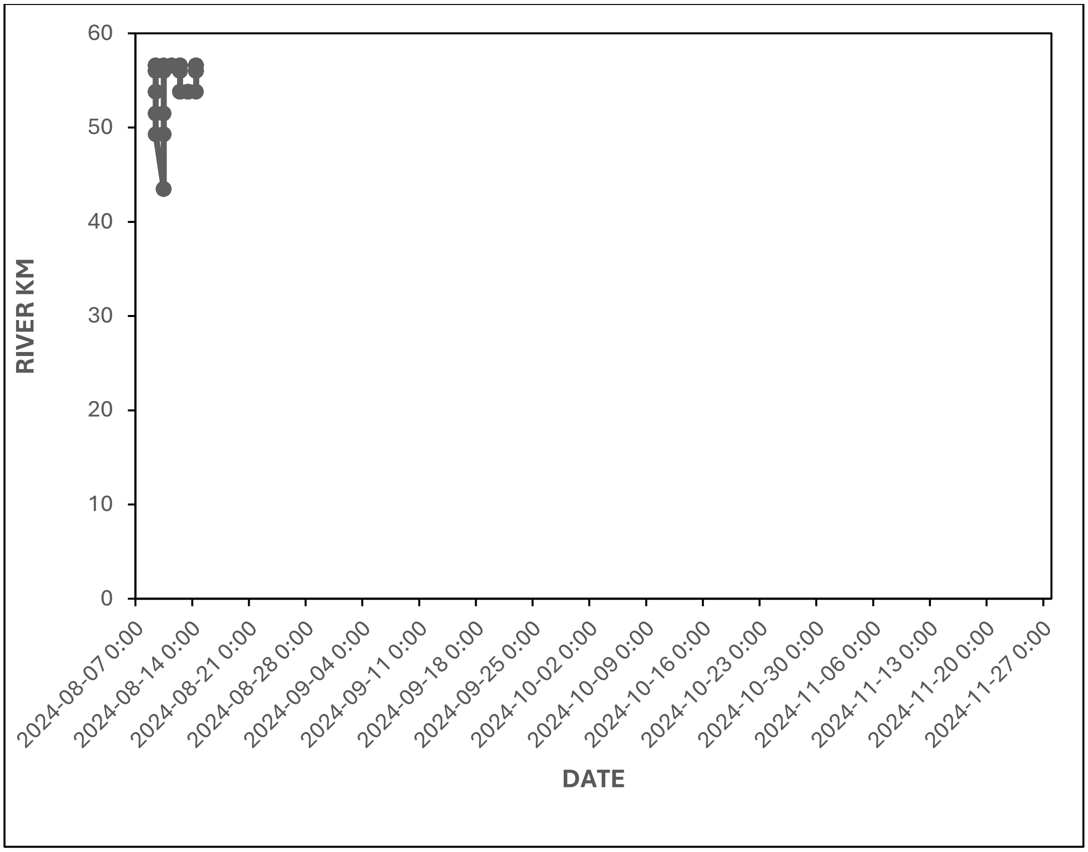

Figure A3.13. Migration pattern of a 78cm female Chinook Salmon (tag 58650) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 43.5 km downstream of HLK Dam. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

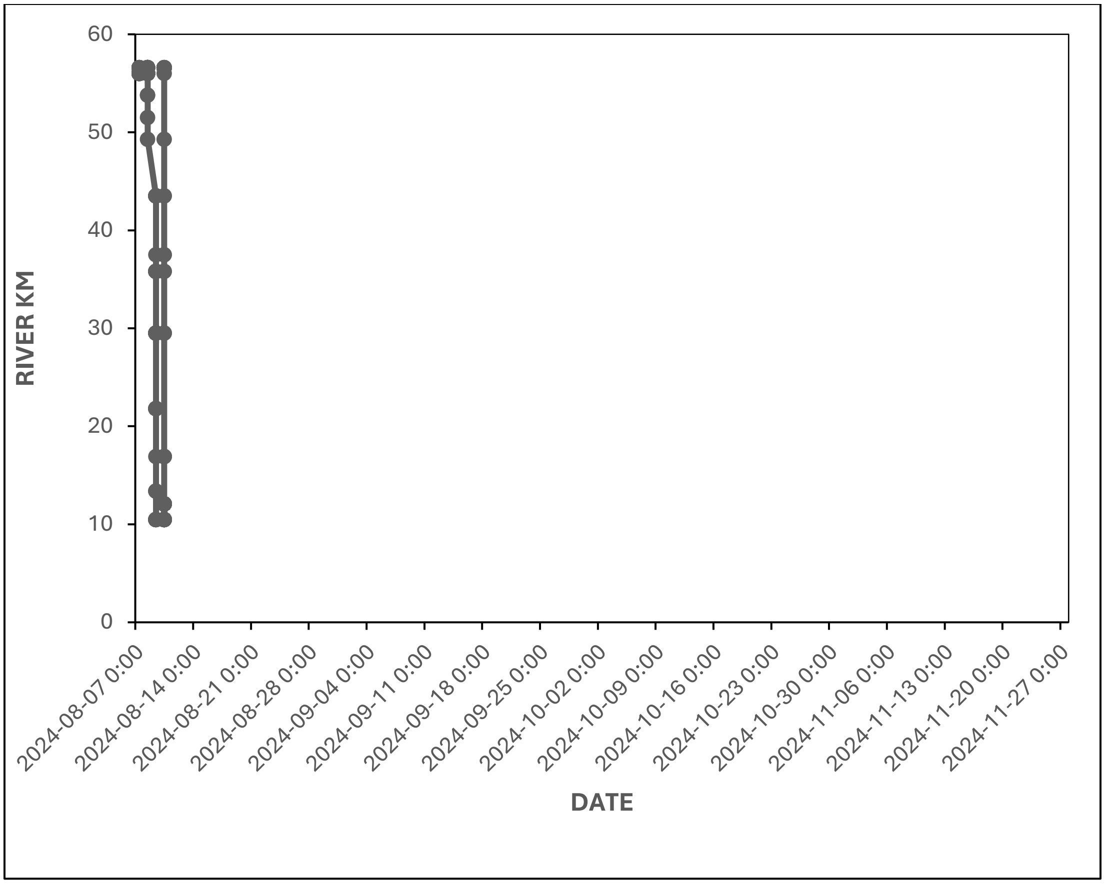

Figure A3.14. Migration pattern of a 75cm Chinook Salmon of unknown sex (tag 58651) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

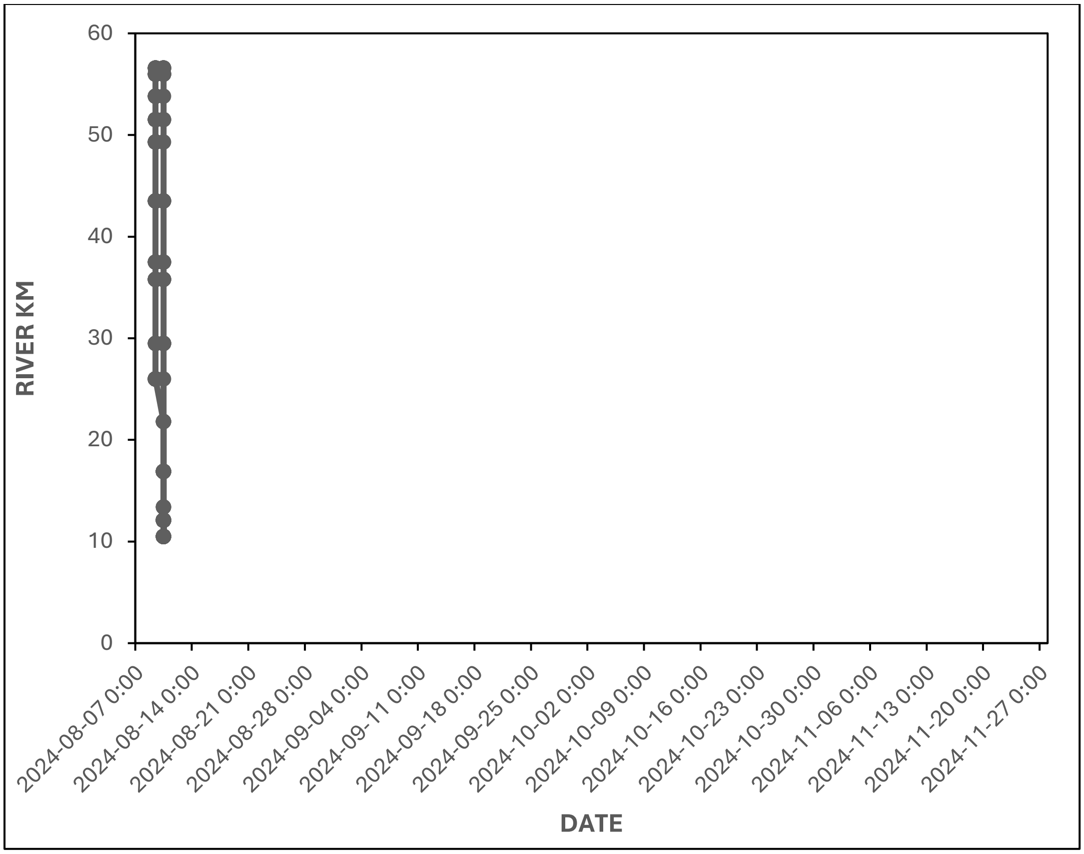

Figure A3.15. Migration pattern of a 76cm male Chinook Salmon (tag 58653) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

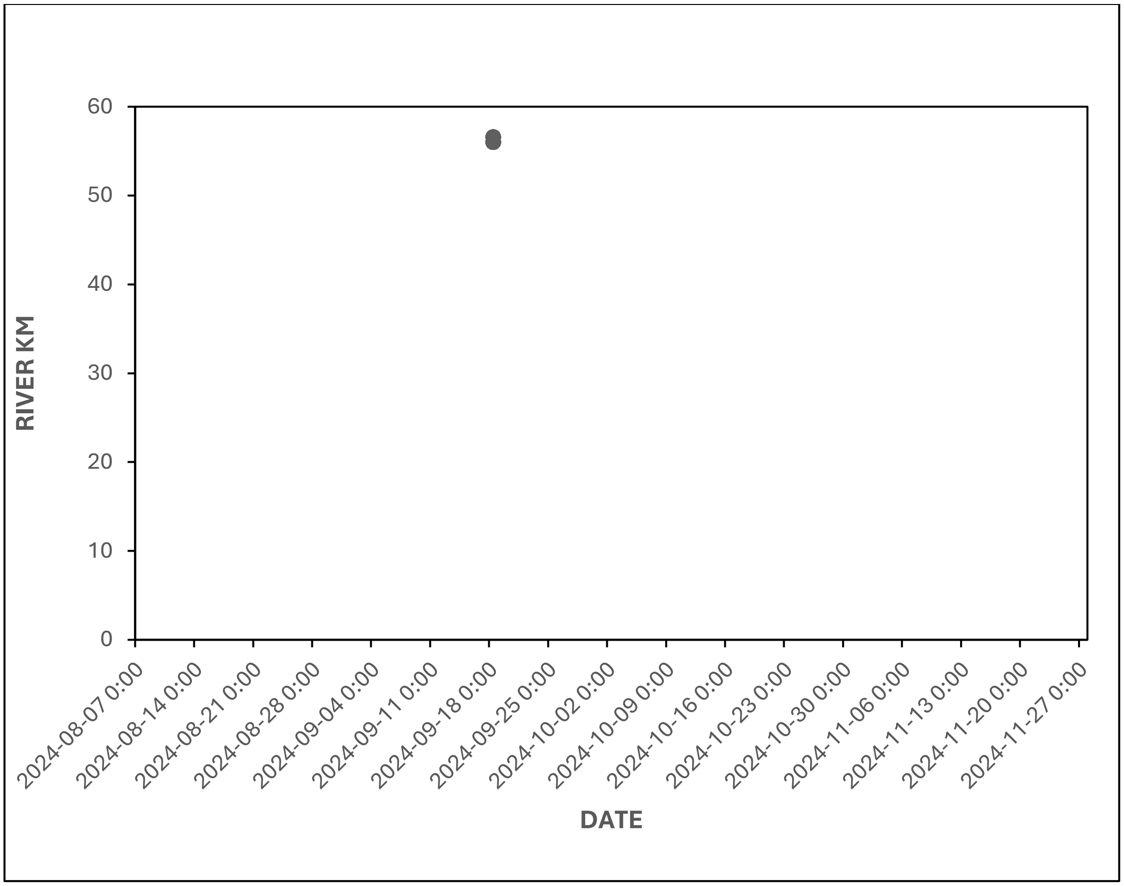

Figure A3.16. Migration pattern of a 77cm male Chinook Salmon (tag 58654) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 56.0 km downstream of HLK Dam. It was in Canada for a total of 1 days. This fish did not spawn in Canada.

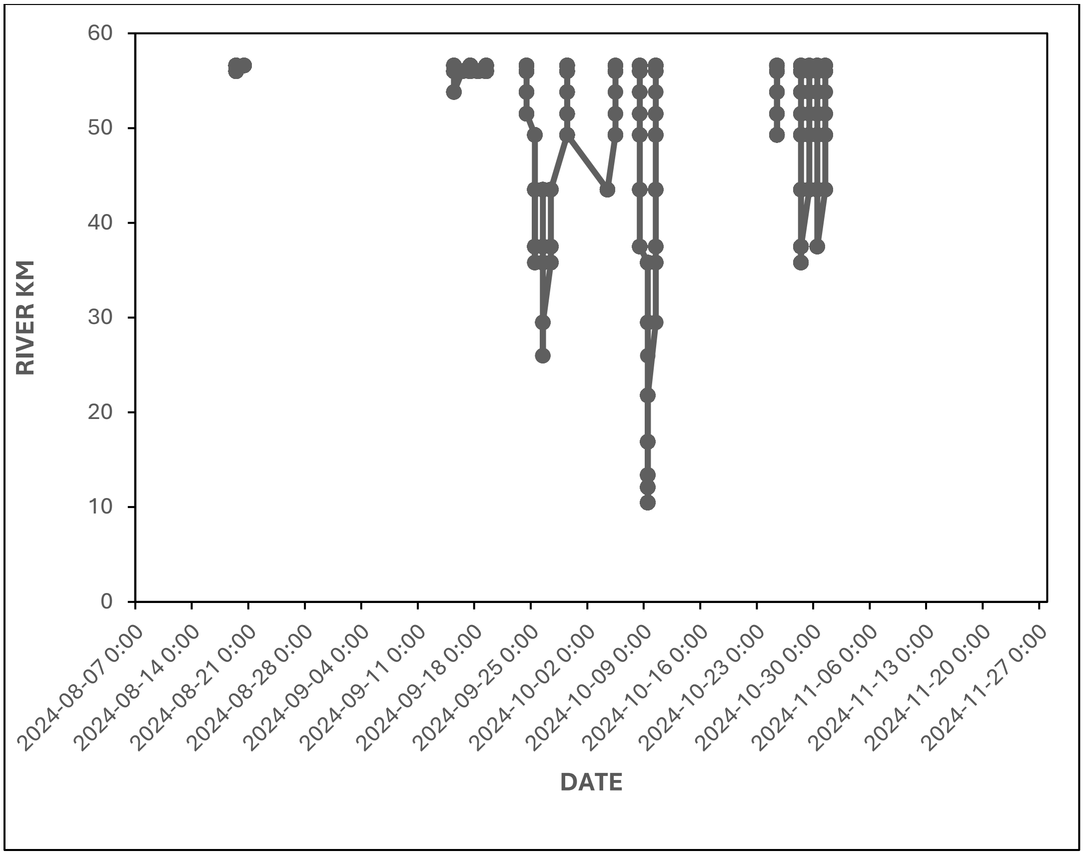

Figure A3.17. Migration pattern of an 84cm male Chinook Salmon (tag 58655) released at Northport, WA on August 6, 2024. This fish moved into Canada on five occasions and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 29 days. This fish did not spawn in Canada.

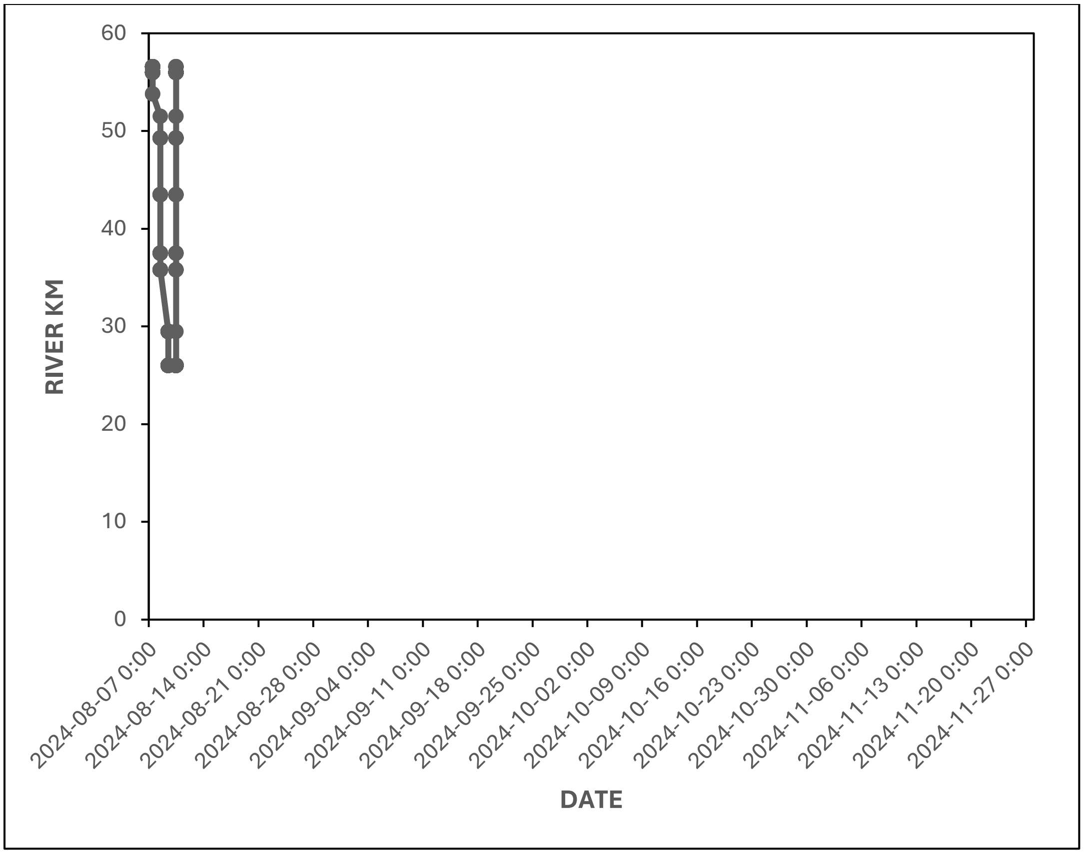

Figure A3.18. Migration pattern of an 84cm female Chinook Salmon (tag 58656) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 26 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

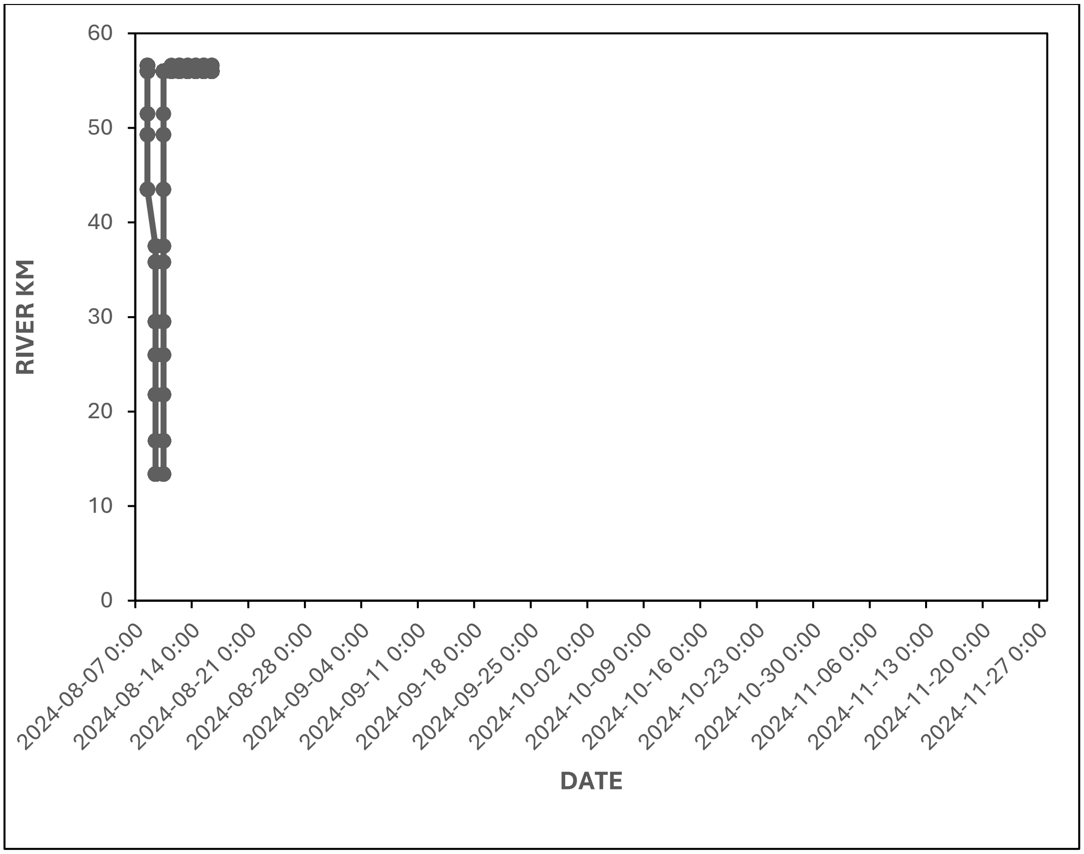

Figure A3.19. Migration pattern of a 74cm female Chinook Salmon (tag 58657) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 9 days. This fish did not spawn in Canada.

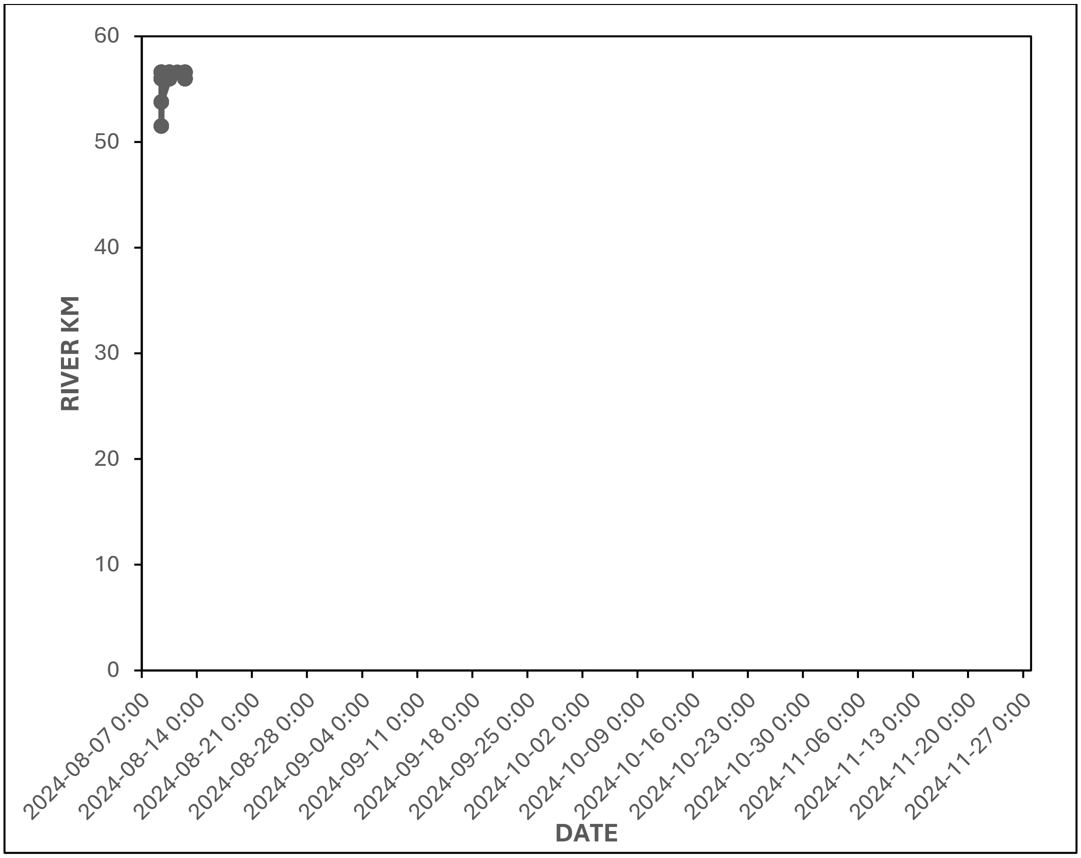

Figure A3.20. Migration pattern of a 76cm male Chinook Salmon (tag 58658) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 51.5 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

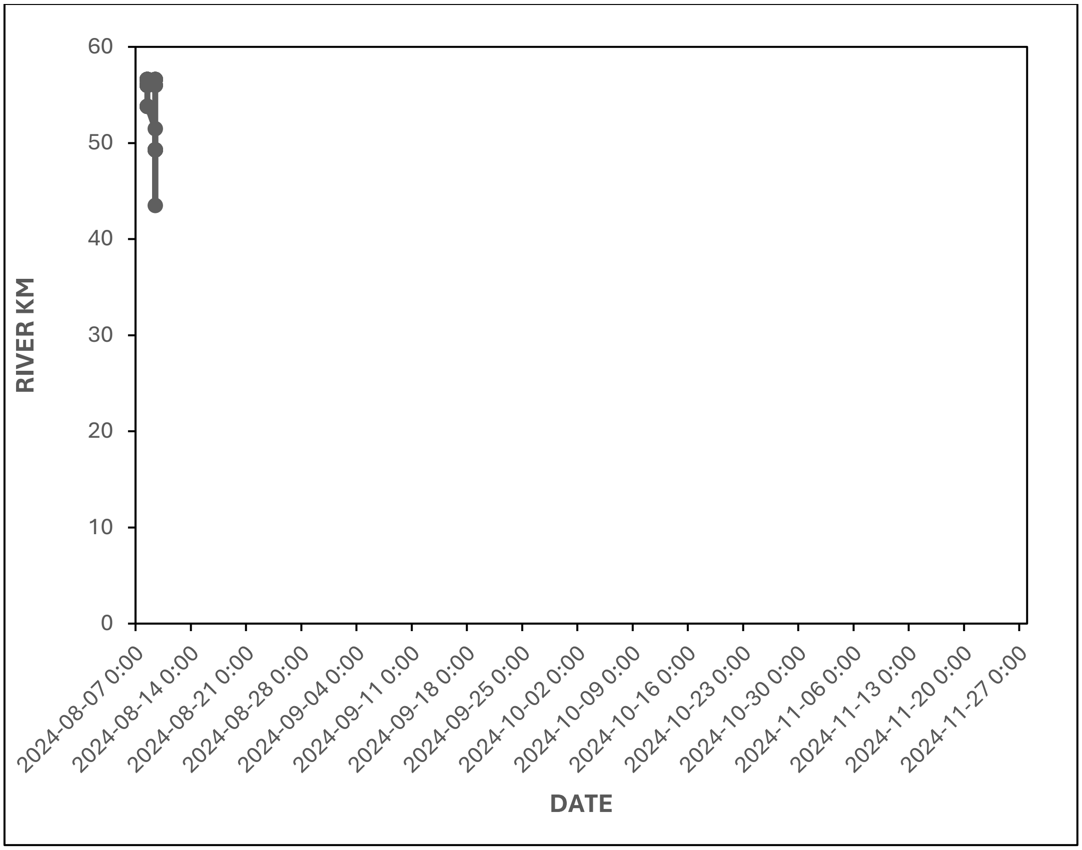

Figure A3.21. Migration pattern of an 83cm female Chinook Salmon (tag 58659) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 43.5 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

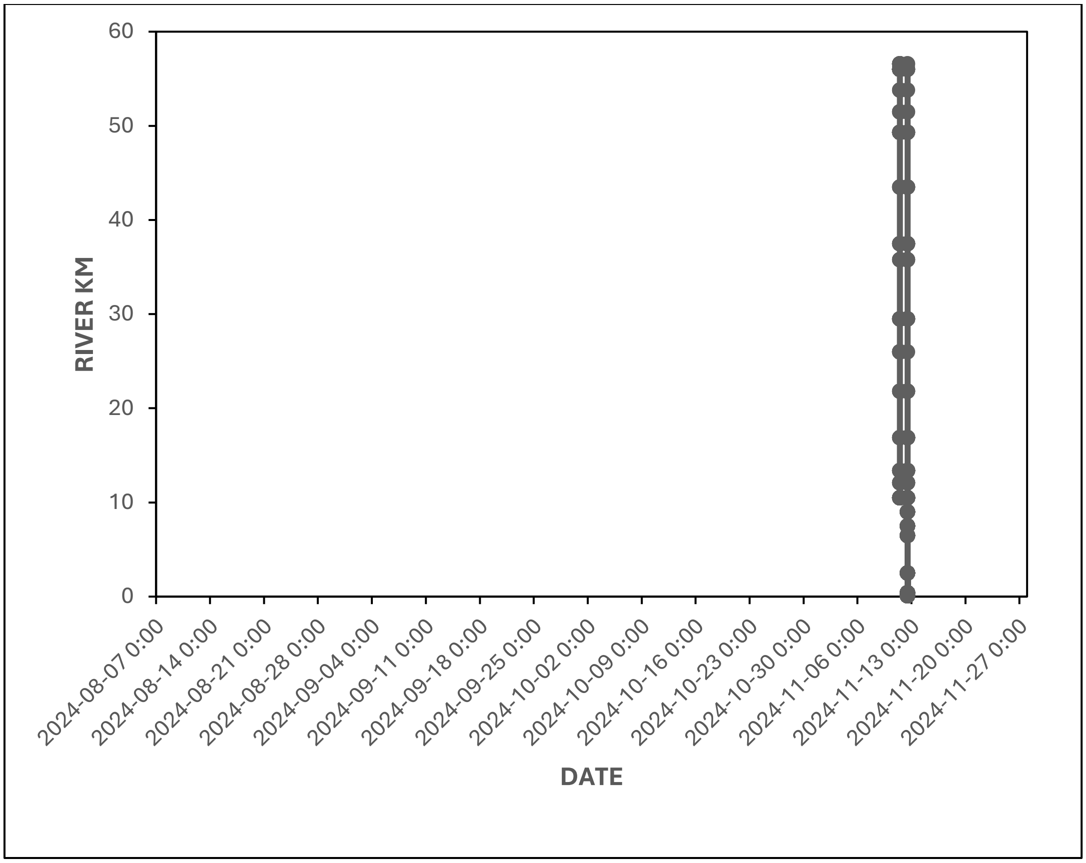

Figure A3.22. Migration pattern of a 92cm male Chinook Salmon (tag 58661) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

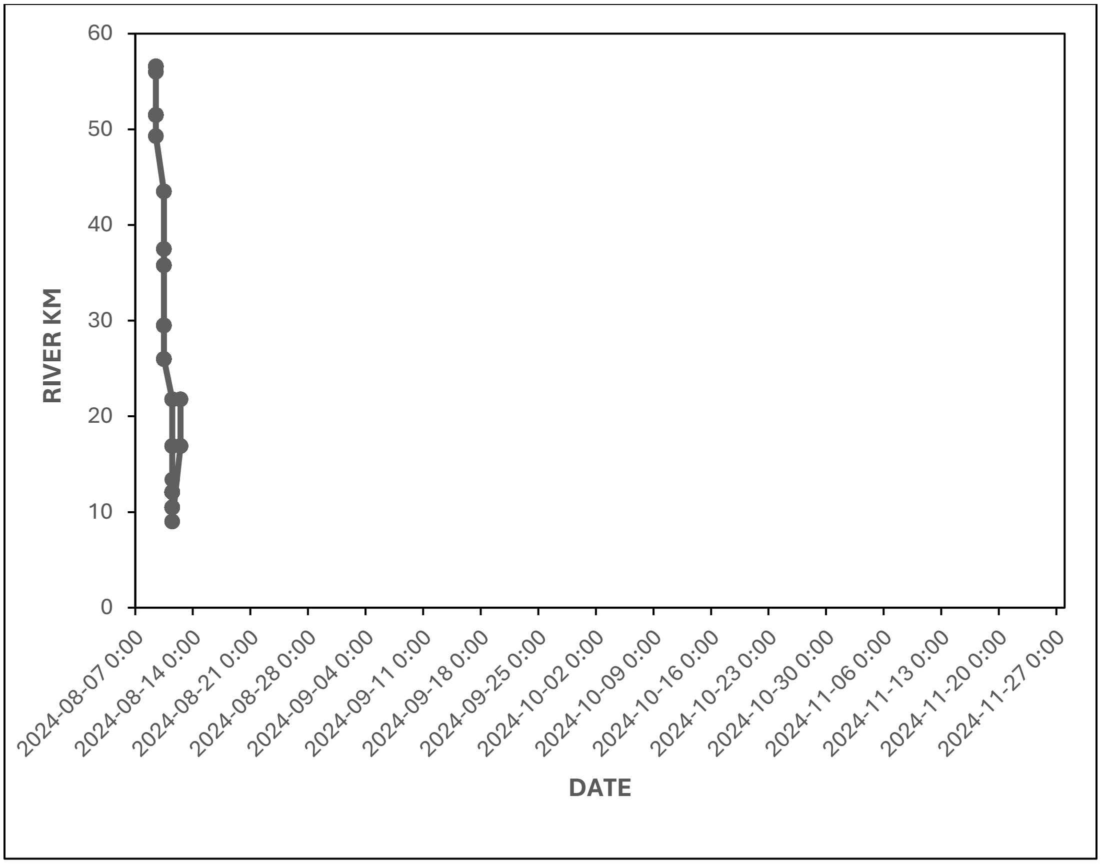

Figure A3.23. Migration pattern of a 79cm male Chinook Salmon (tag 58662) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 9.0 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 1 day. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

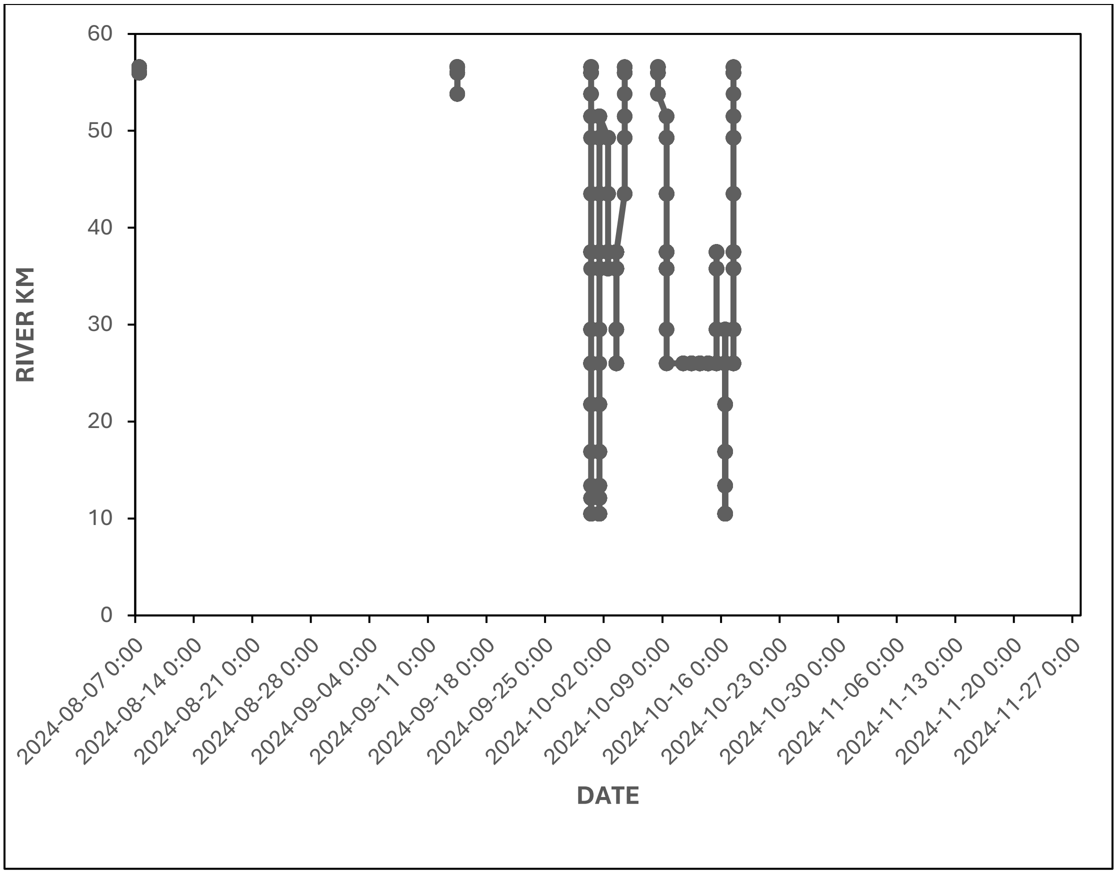

Figure A3.24. Migration pattern of a 94cm male Chinook Salmon (tag 58665) released at Northport, WA on August 6, 2024. This fish moved into Canada on four occasions and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6 km from the confluence for 2 days. It was in Canada for a total of 17 days. It possibly spawned at 26.0 km (Genelle).

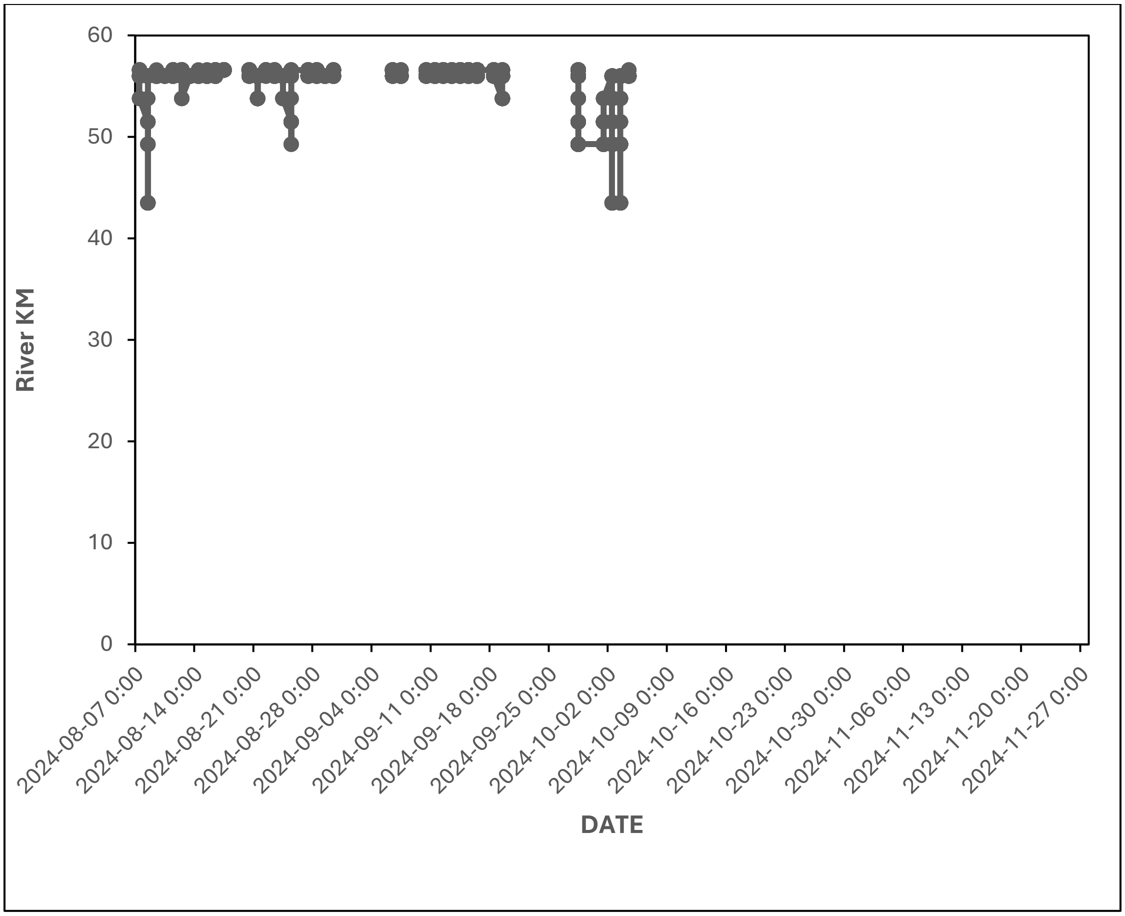

Figure A3.25. Migration pattern of an 89cm female Chinook Salmon (tag 58666) released at Northport, WA on August 6, 2024. This fish moved into Canada on five occasions and the furthest distance travelled into Canada was 43.5 km downstream of HLK Dam. It was in Canada for a total of 39 days. It possibly spawned at 49.3 km.

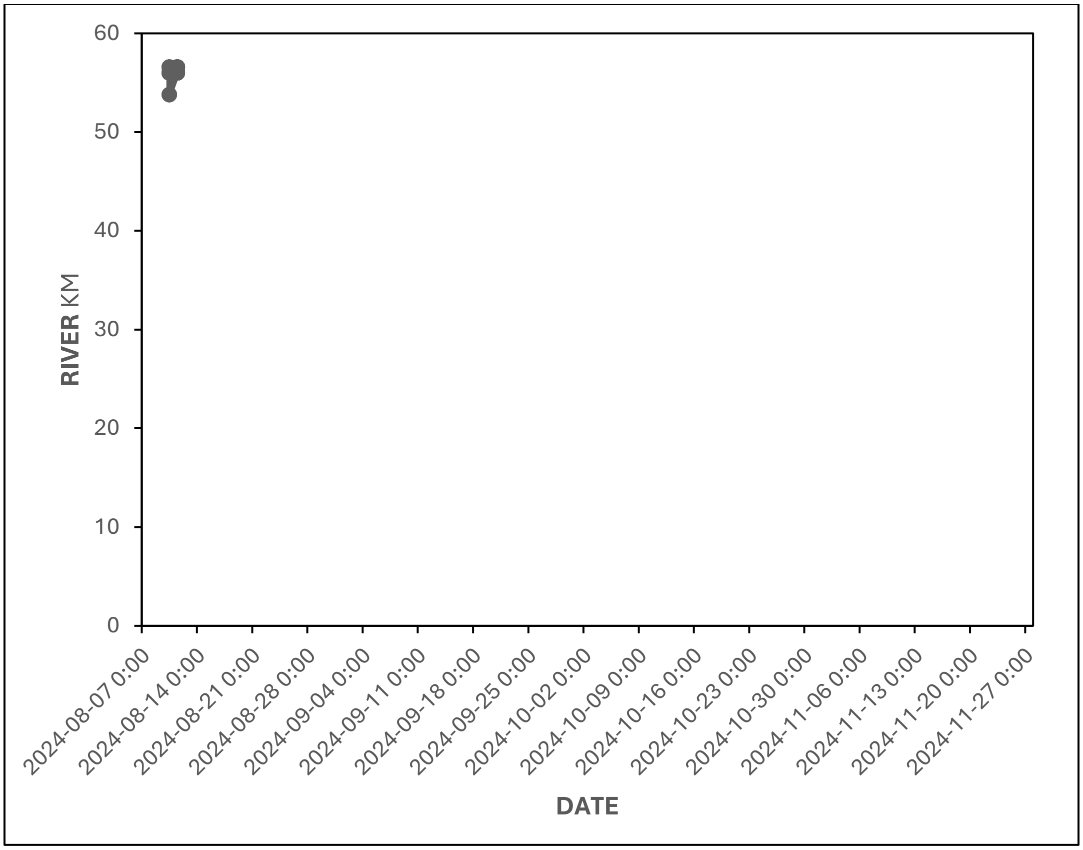

Figure A3.26. Migration pattern of a 75cm male Chinook Salmon (tag 58668) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 53.8 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

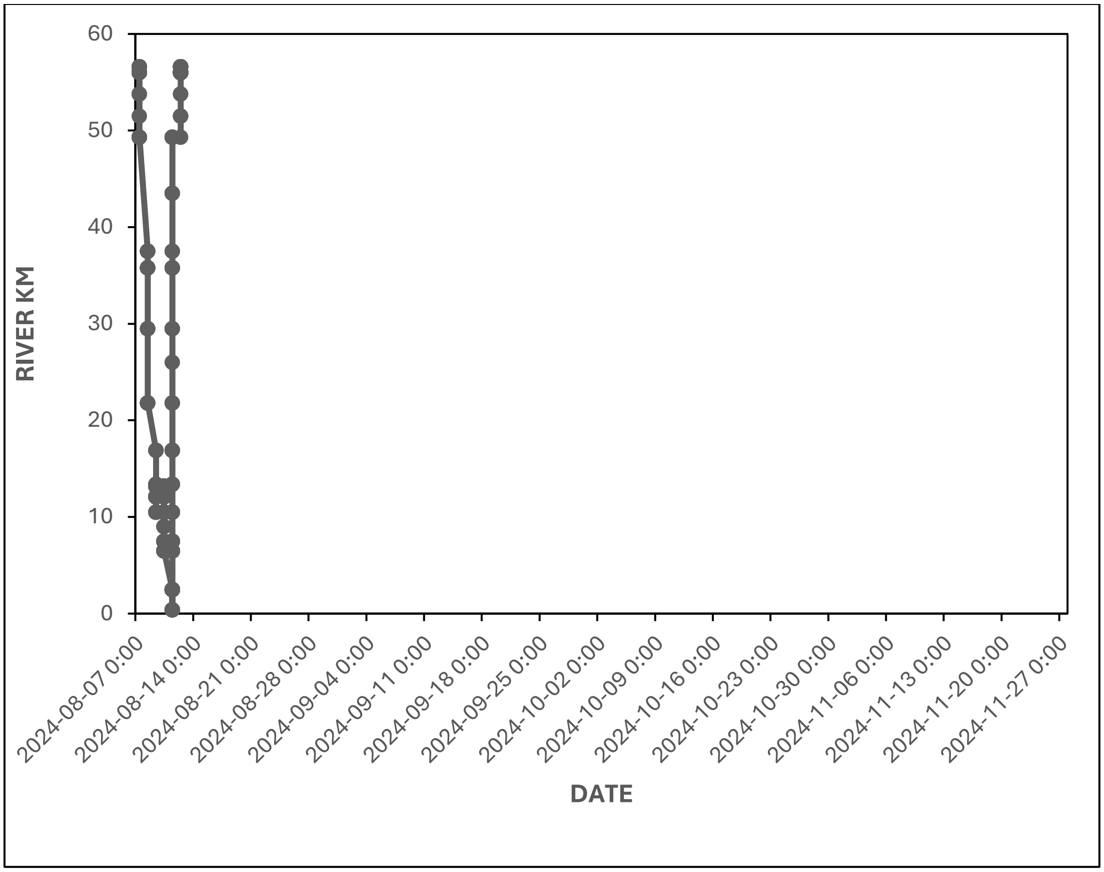

Figure A3.27. Migration pattern of a 78cm female Chinook Salmon (tag 58669) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 2.7 km from the confluence for 2 days. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

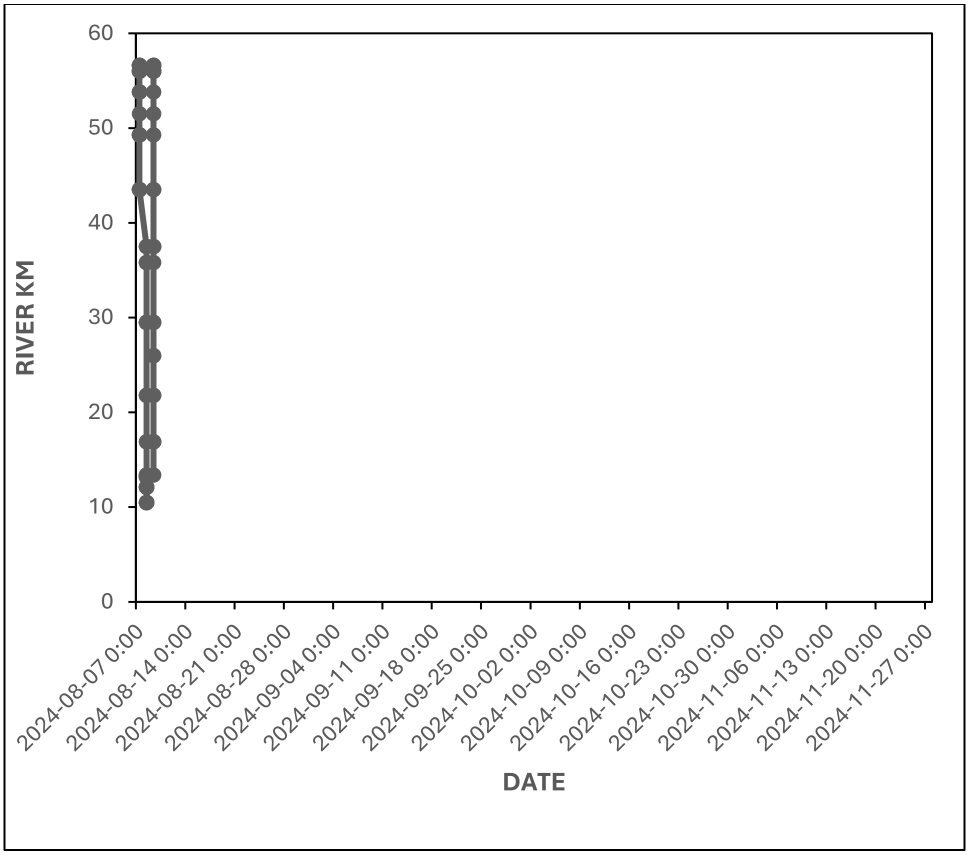

Figure A3.28. Migration pattern of a 75cm male Chinook Salmon (tag 58670) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 2.7 km from the confluence for 1 day. It was in Canada for a total of 3 days. This fish did not spawn in Canada.

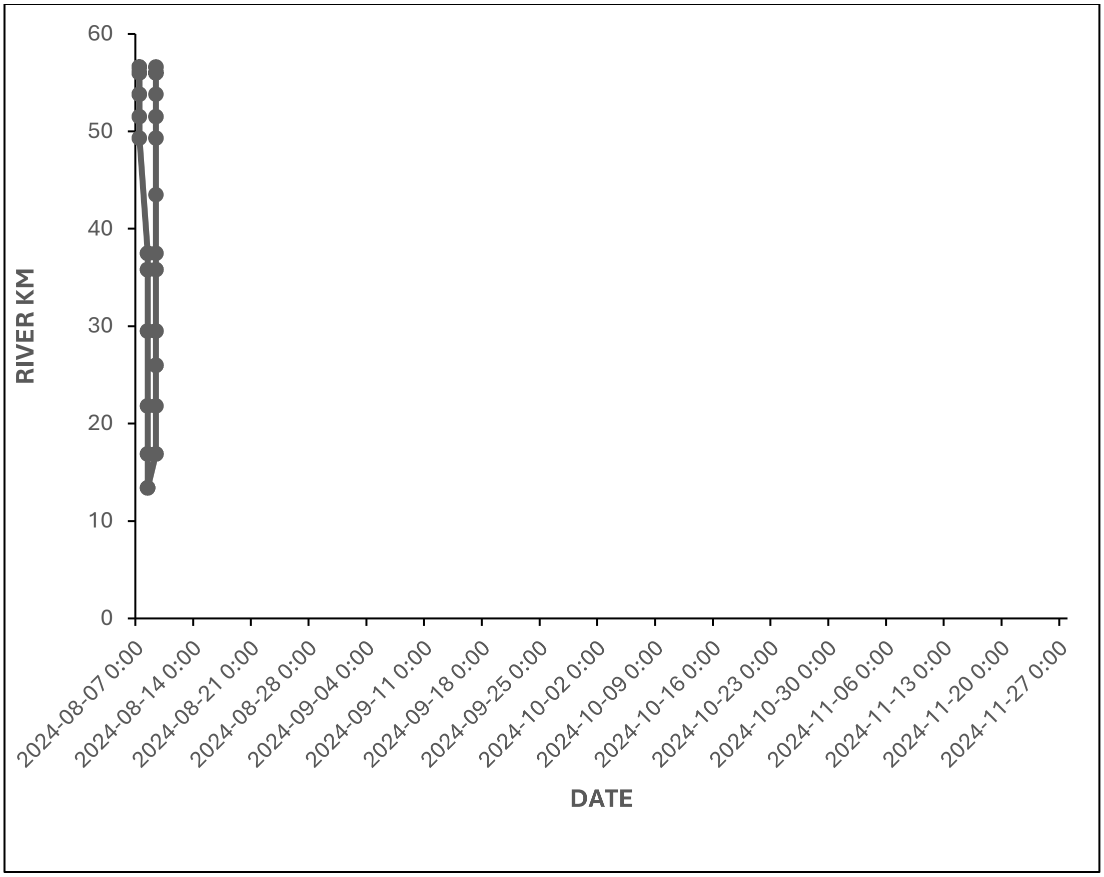

Figure A3.29. Migration pattern of an 82cm female Chinook Salmon (tag 58671) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 3 days. This fish did not spawn in Canada.

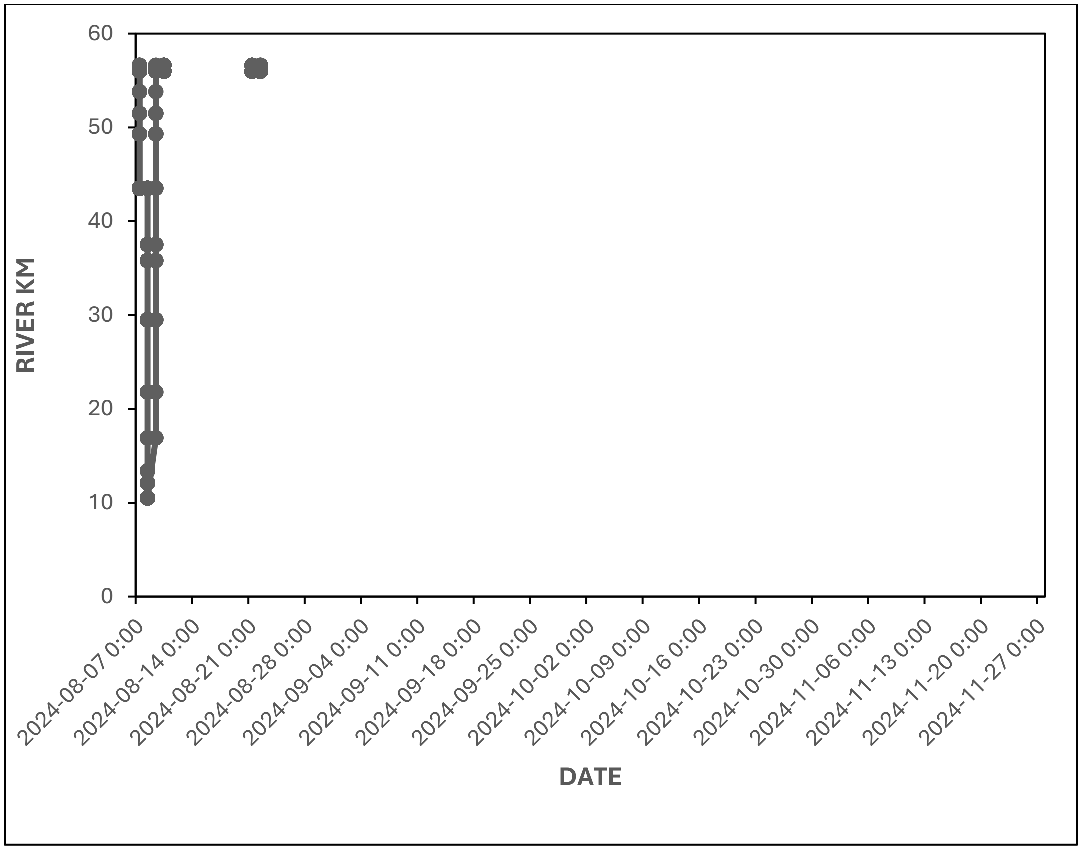

Figure A3.30. Migration pattern of a 67cm male Chinook Salmon (tag 58673) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6km from the confluence for 1 day. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

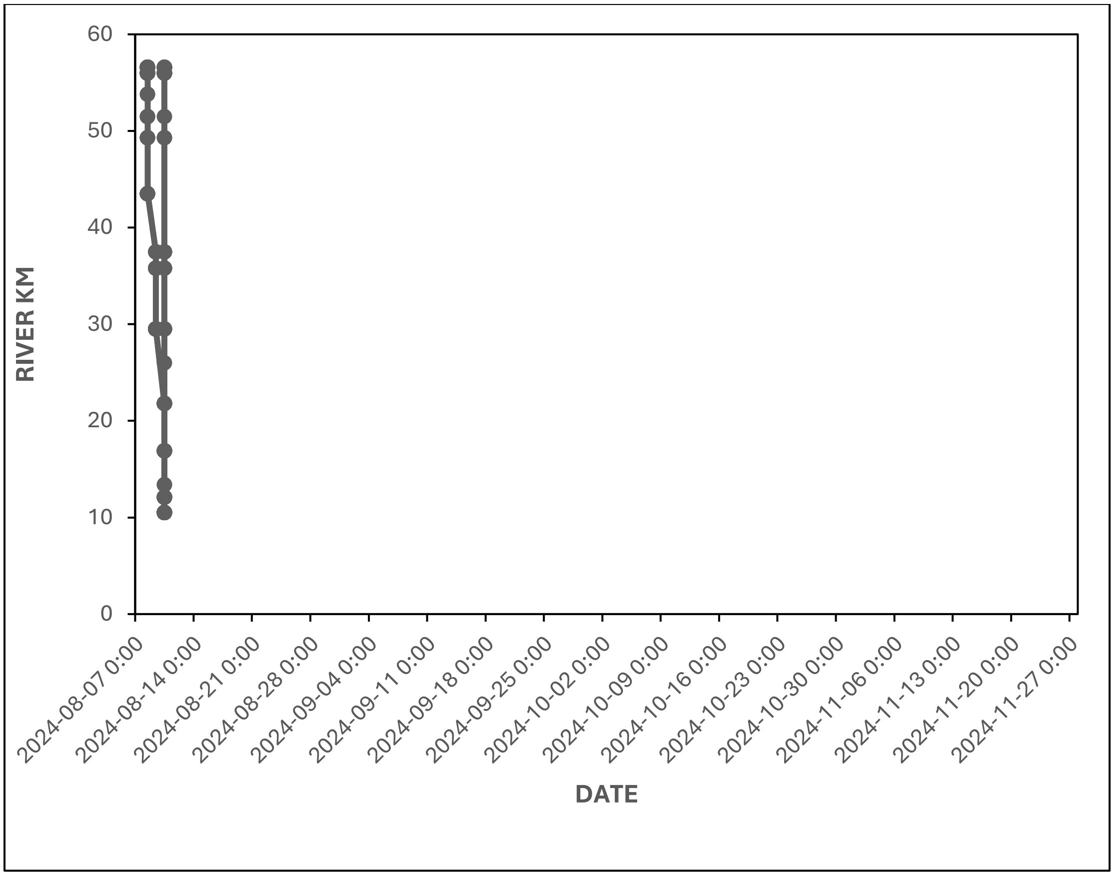

Figure A3.31. Migration pattern of an 85cm female Chinook Salmon (tag 58674) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. It was in Canada for a total of 3 days. This fish did not spawn in Canada.

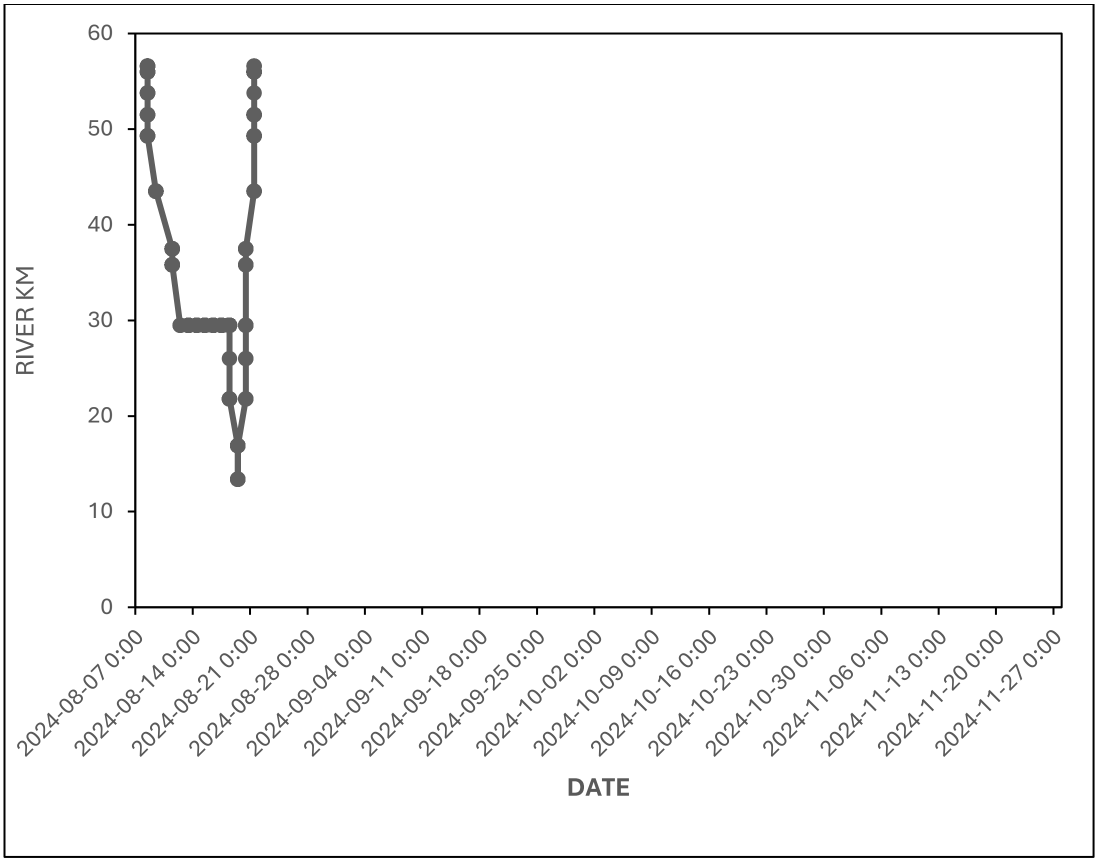

Figure A3.32. Migration pattern of a 79cm female Chinook Salmon (tag 58675) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 10 days. This fish did not spawn in Canada.

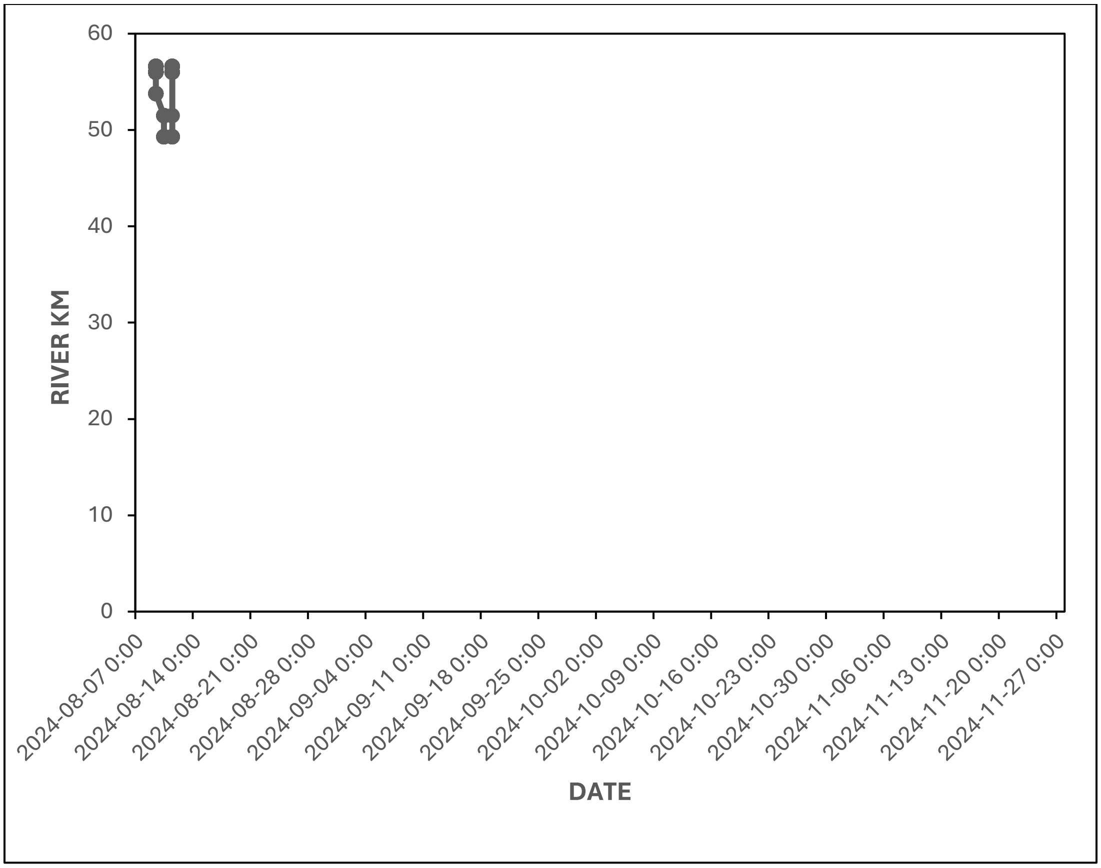

Figure A3.33. Migration pattern of a 76cm female Chinook Salmon (tag 58676) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 3 days. This fish did not spawn in Canada.

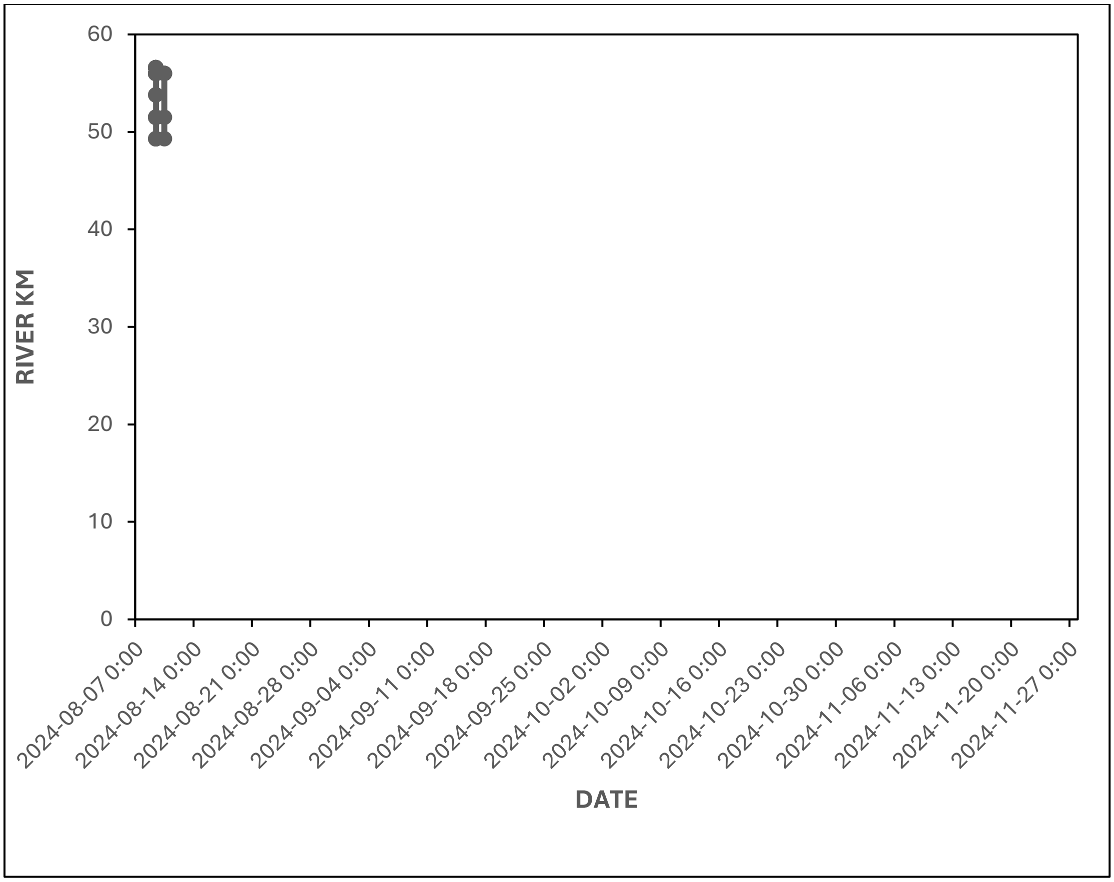

Figure A3.34. Migration pattern of an 85cm male Chinook Salmon (tag 58677) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

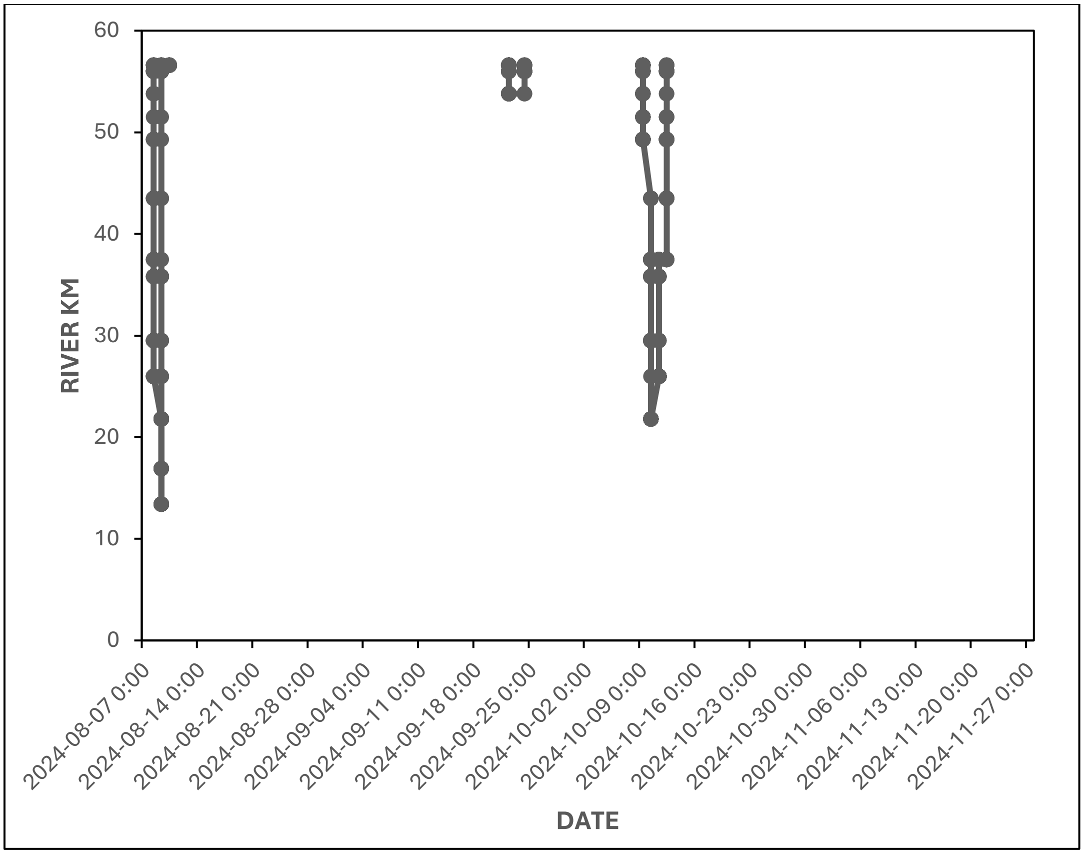

Figure A3.35. Migration pattern of a 68cm female Chinook Salmon (tag 58678) released at Northport, WA on August 6, 2024. This fish moved into Canada on four occasions and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 9 days. This fish did not spawn in Canada.

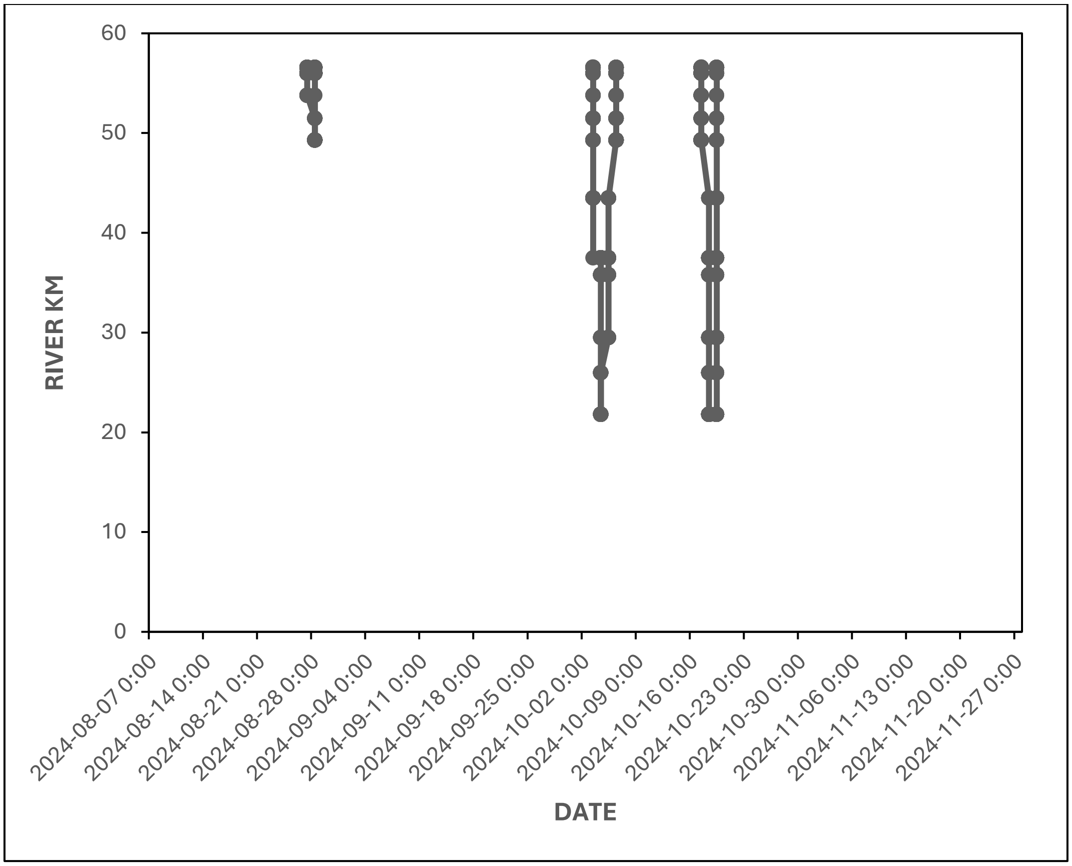

Figure A3.36. Migration pattern of a 71cm female Chinook Salmon (tag 58679) released at Northport, WA on August 6, 2024. This fish moved into Canada on three occasions and the furthest distance travelled into Canada was 21.8 km downstream of HLK Dam. It was in Canada for a total of 8 days. This fish did not spawn in Canada.

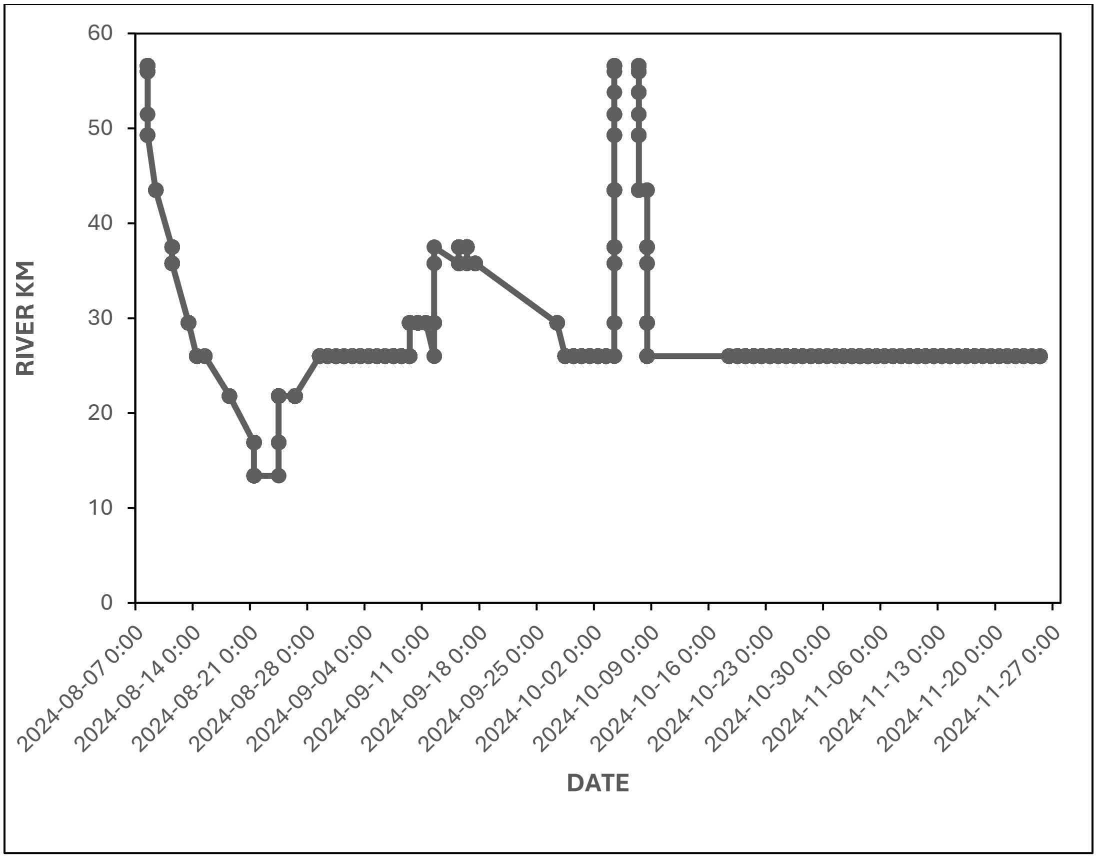

Figure A3.37. Migration pattern of a 78cm female Chinook Salmon (tag 58680) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 58 days. This fish likely spawned at 26.0 km (Genelle).

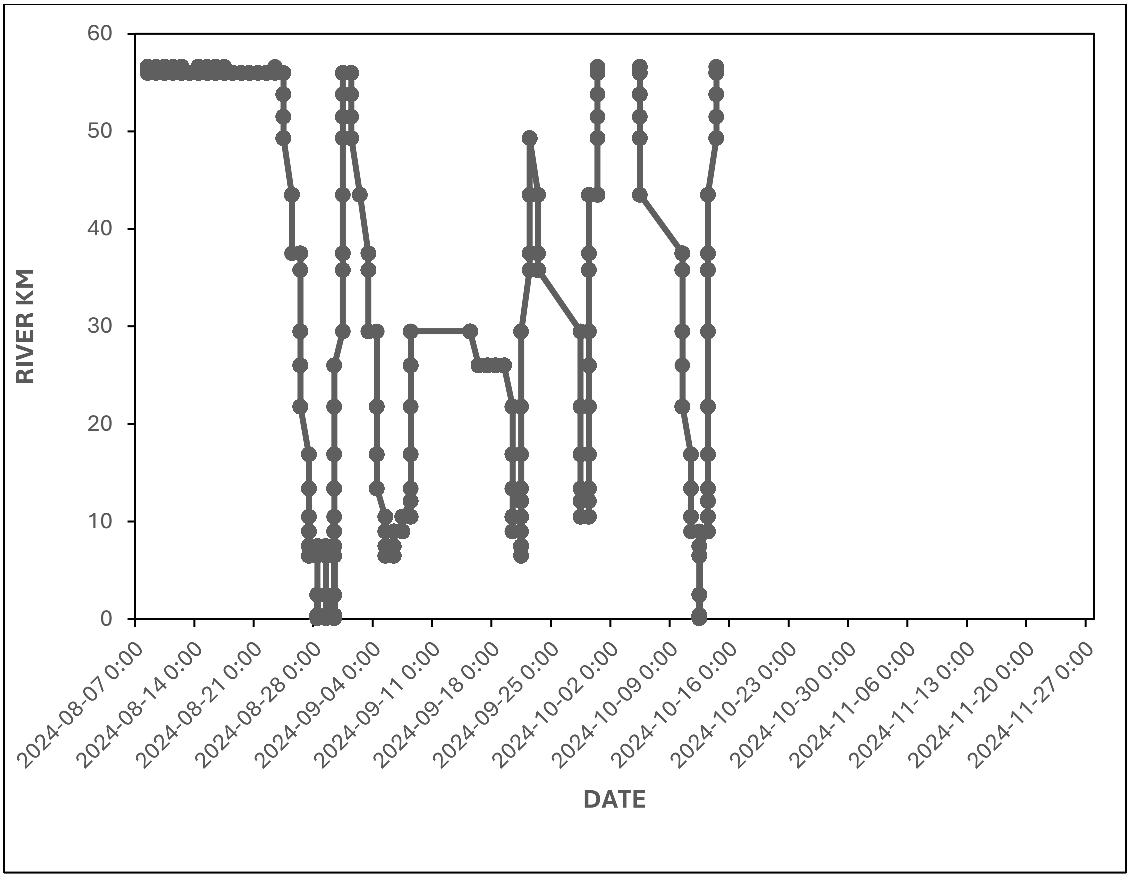

Figure A3.38. Migration pattern of a 74cm female Chinook Salmon (tag 58681) released at Northport, WA on August 6, 2024. This fish moved into Canada on twice and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 1.6km from the confluence for 4 days. It was in Canada for a total of 64 days. This fish possibly spawned at 9.0km.

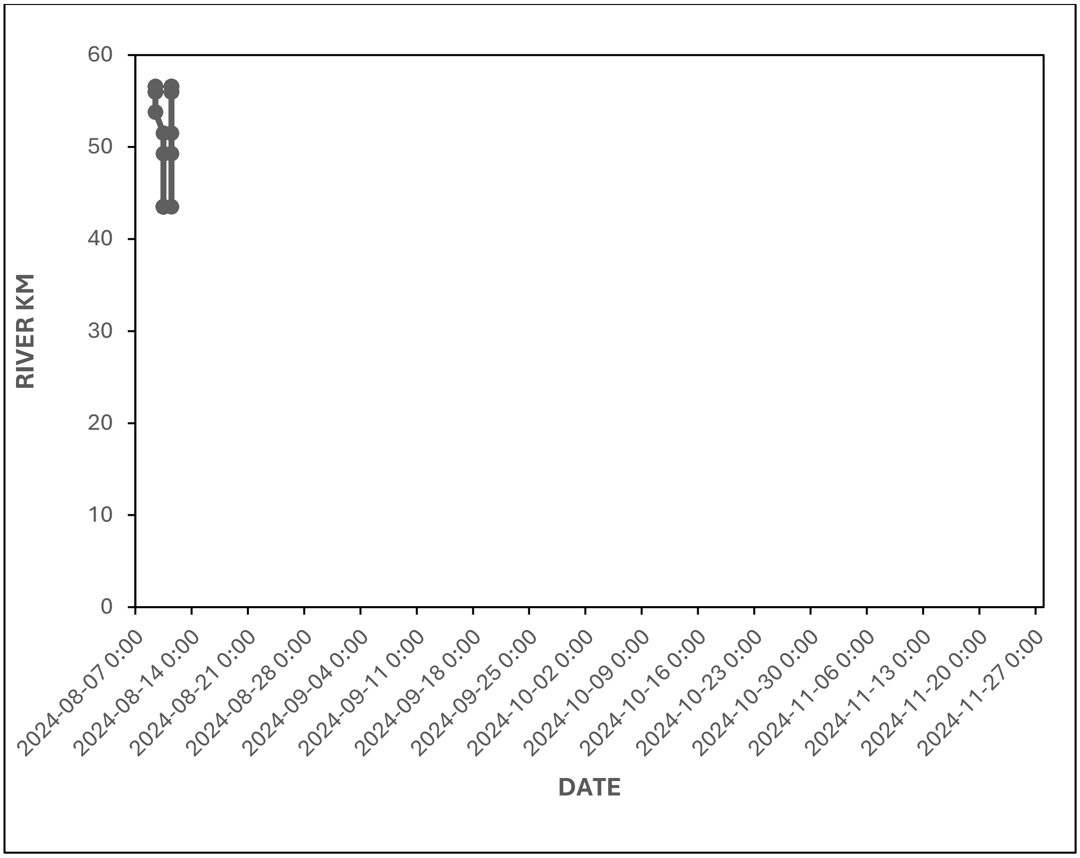

Figure A3.39. Migration pattern of a 78cm female Chinook Salmon (tag 58683) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 43.5 km downstream of HLK Dam. It was in Canada for a total of 3 days. This fish did not spawn in Canada.

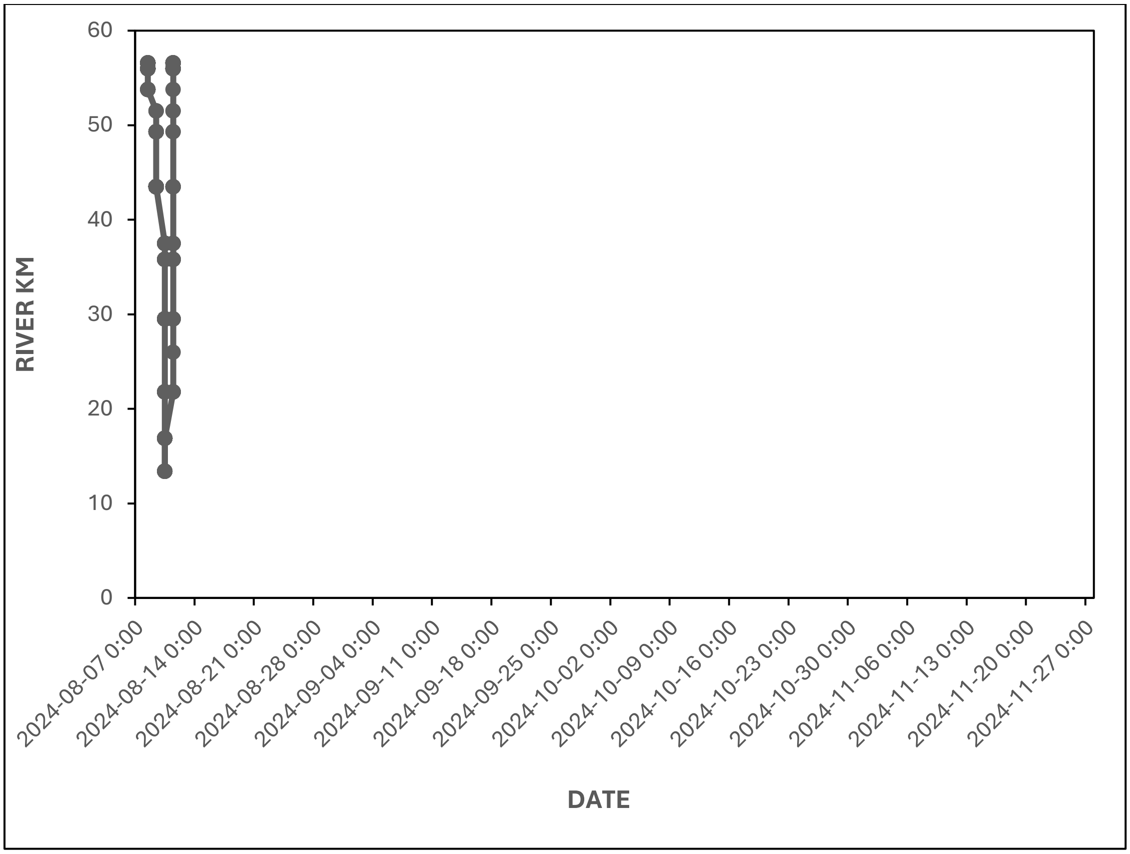

Figure A3.40. Migration pattern of a 76cm female Chinook Salmon (tag 58684) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 13.4 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

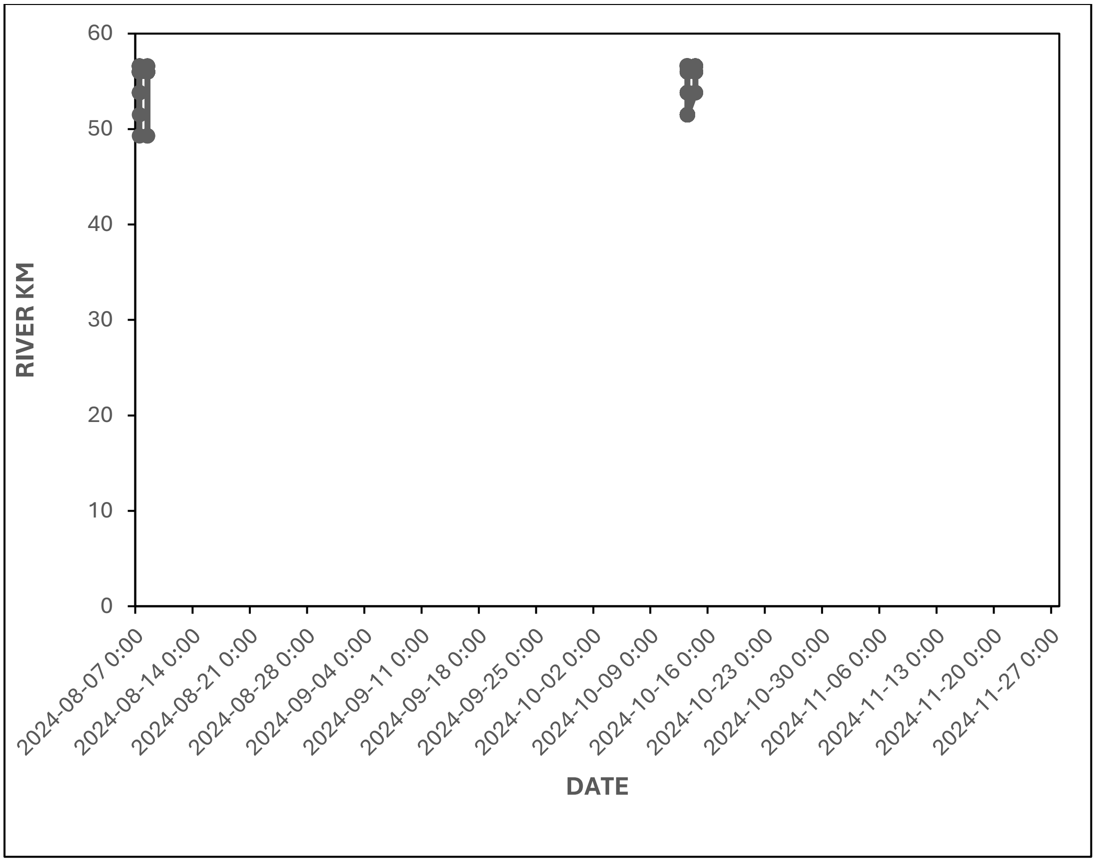

Figure A3.41. Migration pattern of an 80cm female Chinook Salmon (tag 58685) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 49.3 km downstream of HLK Dam. It was in Canada for a total of 4 days. This fish did not spawn in Canada.

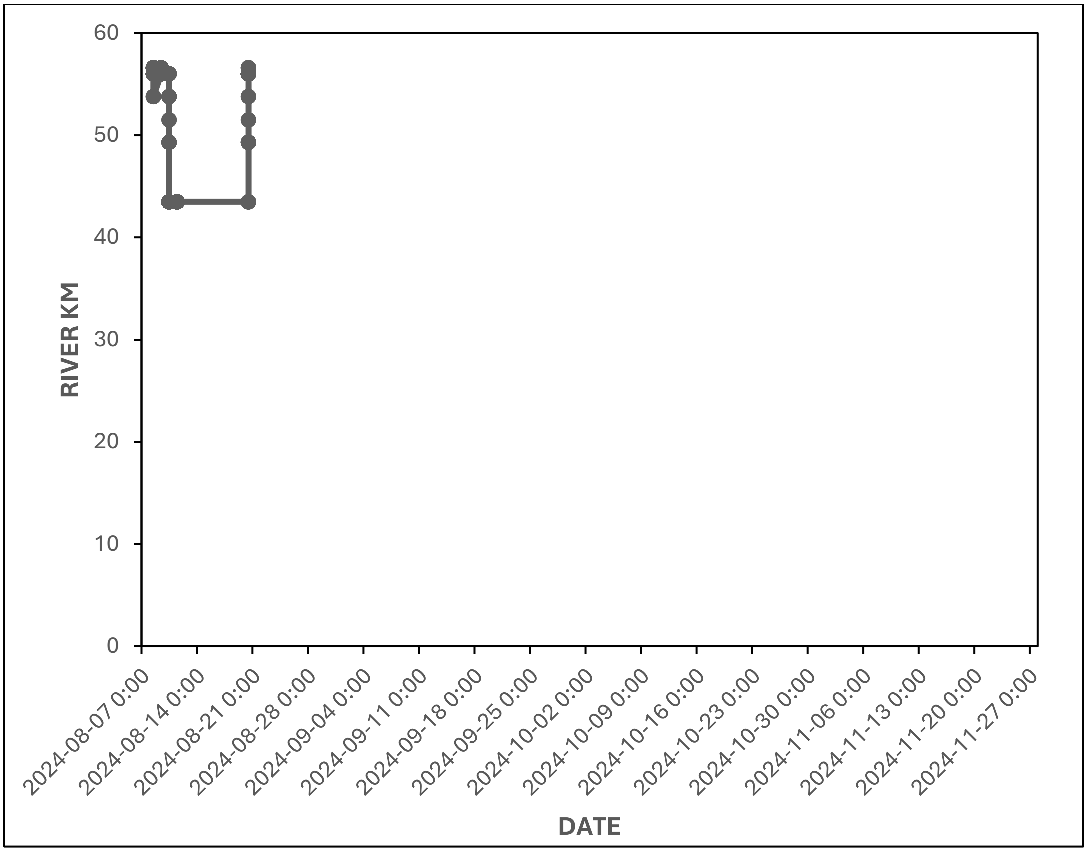

Figure A3.42. Migration pattern of a 72cm female Chinook Salmon (tag 58687) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 43.5 km downstream of HLK Dam. It was in Canada for a total of 13 days. This fish did not spawn in Canada.

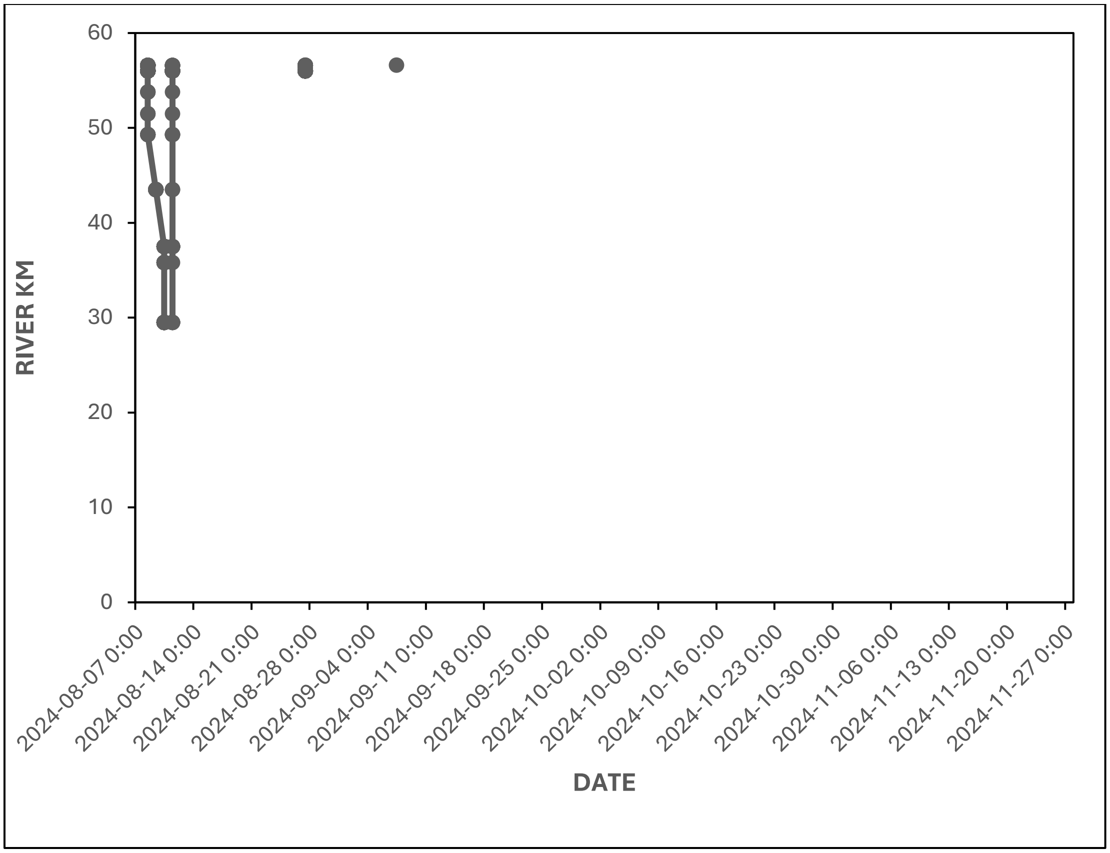

Figure A3.43. Migration pattern of a 70cm male Chinook Salmon (tag 58688) released at Northport, WA on August 6, 2024. This fish moved into Canada on three occasions and the furthest distance travelled into Canada was 29.5 km downstream of HLK Dam. It was in Canada for a total of 6 days. This fish did not spawn in Canada.

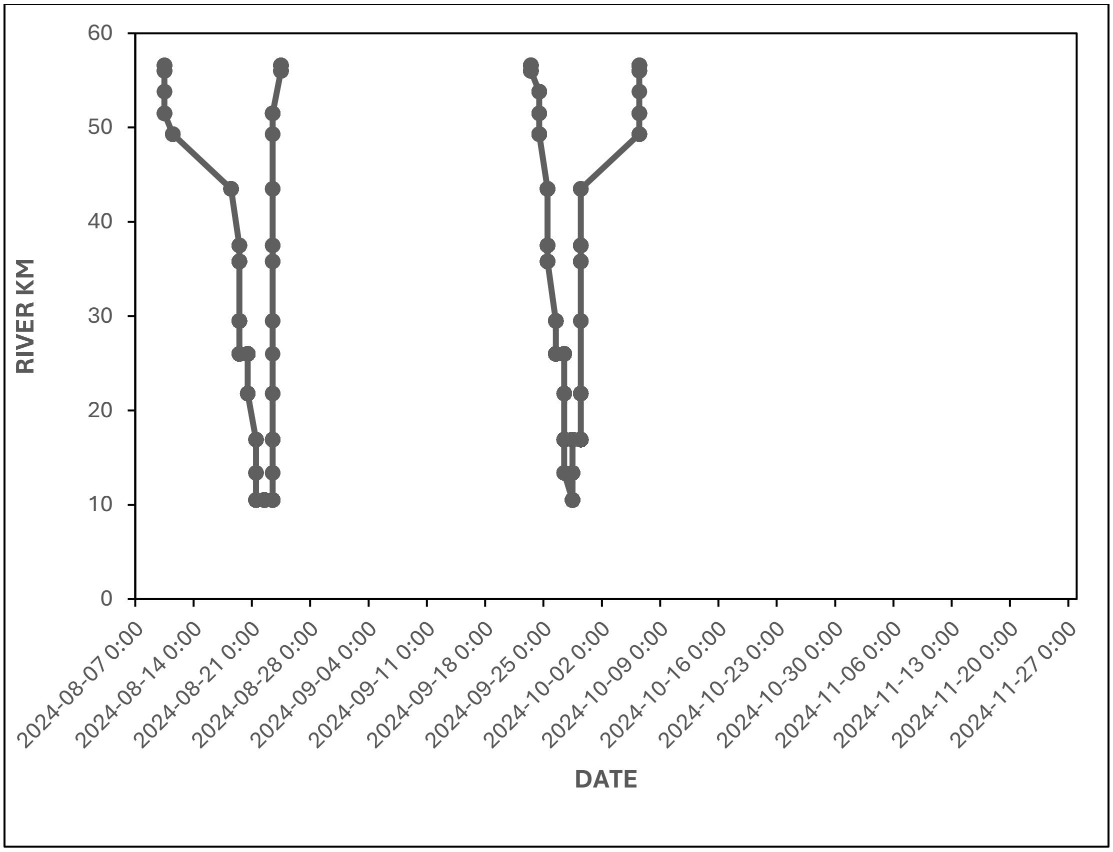

Figure A3.44. Migration pattern of a 91cm male Chinook Salmon (tag 58689) released at Northport, WA on August 6, 2024. This fish moved into Canada twice and the furthest distance travelled into Canada was 10.5 km downstream of HLK Dam. It was in Canada for a total of 29 days. This fish did not spawn in Canada.

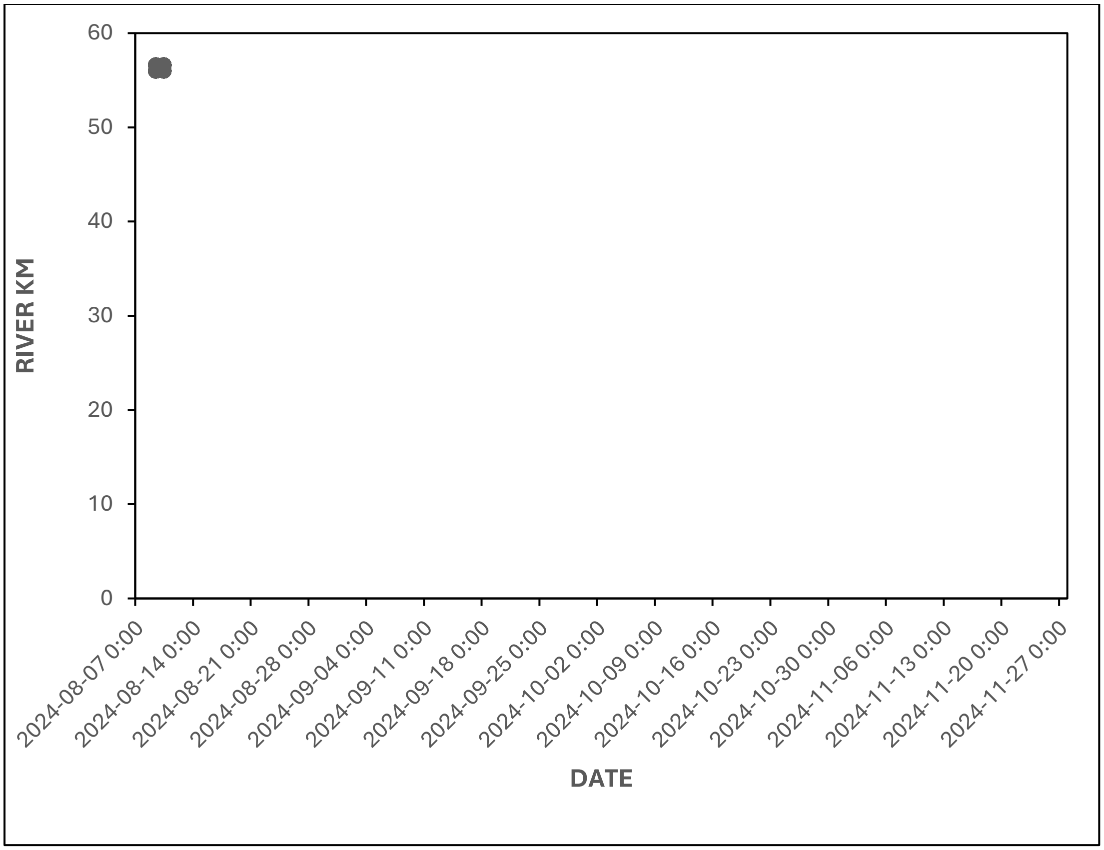

Figure A3.45. Migration pattern of a 75cm male Chinook Salmon (tag 58691) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 56.0 km downstream of HLK Dam. It was in Canada for a total of 2 days. This fish did not spawn in Canada.

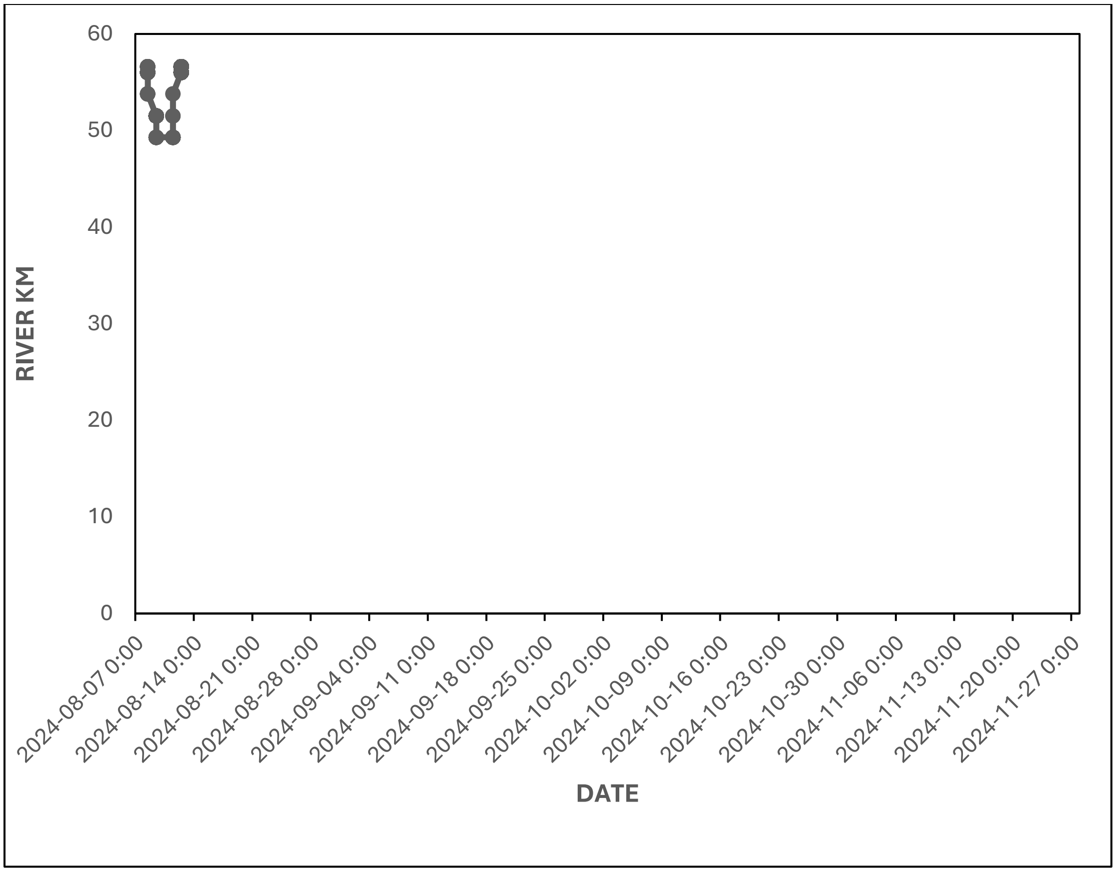

Figure A3.46. Migration pattern of an 80cm male Chinook Salmon (tag 58692) released at Northport, WA on August 6, 2024. This fish moved into Canada once and the furthest distance travelled into Canada was 59.3 km downstream of HLK Dam. It was in Canada for a total of 5 days. This fish did not spawn in Canada.

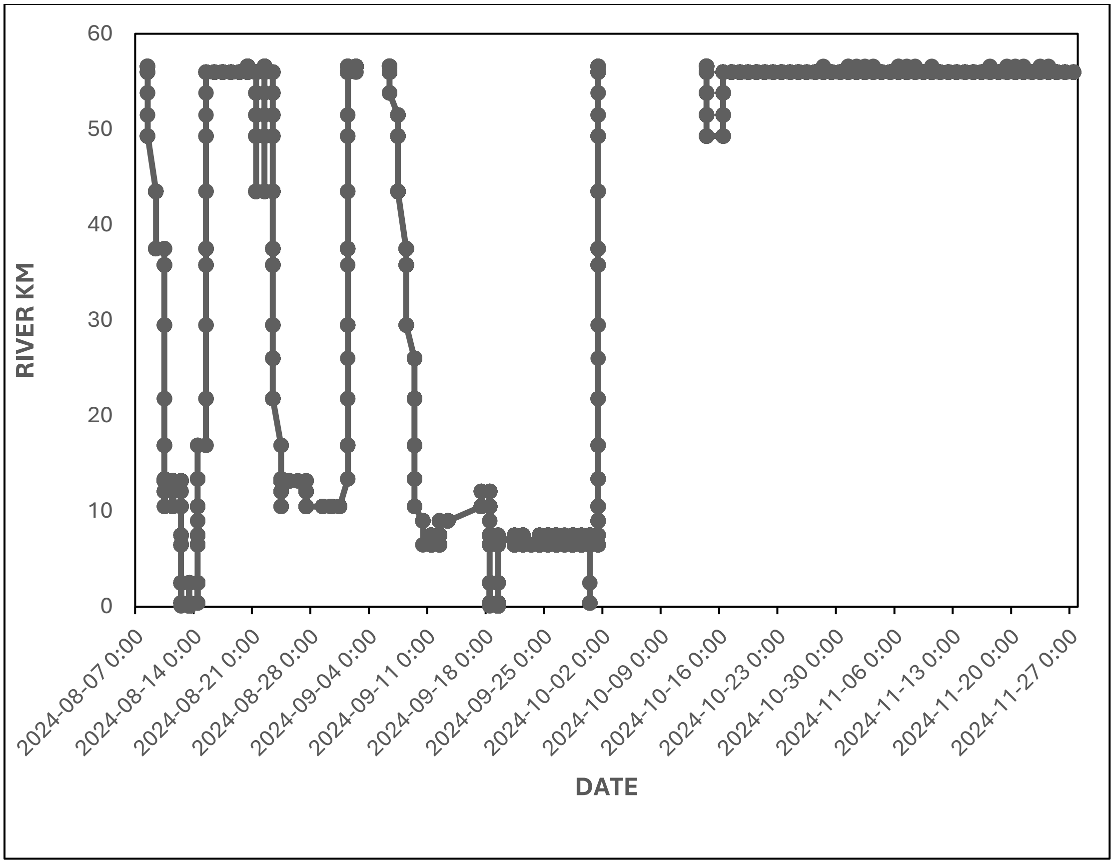

Figure A3.47. Migration pattern of a 69cm male Chinook Salmon (tag 58695) released at Northport, WA on August 6, 2024. This fish moved into Canada on three occasions and the furthest distance travelled into Canada was 0.1 km downstream of HLK Dam. This fish also moved into the Kootenay River to 2.7km from the confluence for 10 days. It was in Canada for a total of 97 days. This fish likely spawned at 49.3 km or 56.0 km.

Appendix IV. Selkirk Innovates Drone Survey Report.

KNOWLEDGE BRIEF

Drone enabled detection surveys for reintroduced salmon in the transboundary reach of the Columbia River

Report prepared for:
The Sinixt Confederacy and the Confederated Tribes of the Colville Reservation

Authors:
Rena Vandenbos, David Greaves, Larissa Kurtz – Selkirk Innovates

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Introduction

Background

Salmon are recognized as a keystone species and hold cultural, spiritual, and ceremonial significance across the Columbia Basin (Baldwin *et al.*, 2022). Industrial development and the escalating impacts of climate change have profoundly affected wildlife, including salmon populations. Dams constructed on the Upper Columbia River greatly harmed fish populations throughout Sinixt territory, from Kettle Falls and beyond along the Columbia. Historically, Chinook Salmon (*Oncorhyncus tshawytscha*) inhabited the entire length of the Columbia River and were adapted to spawn in local areas as distinct populations.

The construction of the Grand Coulee Dam in 1940 blocked all upstream salmon migration, effectively cutting off access to approximately 50% of the Columbia River Basin. Additionally, the development of the Columbia River Treaty Dams and other BC Hydro Dams resulted in the loss of an estimated 1,700 kilometers of riverine habitat (Thorley, 2008). The introduction of hydropower, coupled with overharvesting, had devastating consequences for salmon populations, significantly depleting stocks and disrupting ecosystems.

The Confederated Tribes of the Colville Reservation (CTCR) and the Sinixt Confederacy have led efforts to restore salmon to their traditional territories. This work requires strong partnerships with communities along the Columbia River, including in the United States.

Historical data indicates that salmonid communities above Kettle Falls were comprised of 55% Chinook salmon, 5% Coho salmon (*O. kisutch*), 7% sockeye salmon (*O. nerka*) and 31% Steelhead (*O. mykiss*) (Scholz, 2014). The Sinixt Confederacy selected Chinook and Sockeye salmon as the target species of this project. Chinook Salmon were eradicated from the Canadian portion of the Columbia River system following the construction of the Grand Coulee Dam in 1942, which blocked their migration (James *et al*., 2023). They remain extirpated, but CTCR has been moving adult Chinook and Sockeye salmon upstream of Grand Coulee Dam since 2020.

Redd surveys are essential for monitoring the health and reproductive success of salmon populations, as they provide valuable insights into spawning distribution, habitat conditions, and population trends (Courbois *et al.*, 2008). Salmon redds are nesting sites created by female salmon to lay and protect their eggs spanning 1–2 square meters, they are built in gravel beds of well-oxygenated freshwater streams (Burner, 1951). Females dig shallow pits with their tails, deposit eggs, and cover them with loose gravel to shield them from predators and currents (Burner, 1951). Studies of fall-spawning Chinook salmon have found that redds often cluster in specific areas, likely reflecting localized conditions such as optimal flow, substrate quality, or temperature, even when suitable habitat is widely available (Geist, 1998).

To ensure the success of these reintroduction efforts, continuous monitoring and restoration work are essential. This includes addressing the challenge of invasive species such as northern pike and walleye, which threaten the balance of ecosystems and impact salmon populations, as well as other species like kokanee, sturgeon (*Acipenser transmontanus*), and trout (*Oncorhynchus spp.*).

Over the years salmon at varying life stages have been released into the Columbia River Basin. In 2017, the Spokane Tribe released 752 yearling summer Chinook salmon into Tshimikain Creek (Baldwin *et al.*, 2022). Both Spokane and Coeur d'Alene reservations in 2017 and 2020 detected successful juvenile bypasses of the dams downstream of the Chief Joesph Dam (Baldwin *et al.*, 2022).

In 2020, juvenile releases included 1,453 yearling Chinook Salmon released into Hangman Creek by the Coeur d'Alene Tribe and 765 yearling Chinook Salmon released into the Spokane River by the Spokane Tribe (Baldwin *et al.*, 2022). All juvenile salmon released in 2020 were equipped with Passive Integrated Transponder (PIT) tags to monitor their migration and survival (Baldwin *et al.*, 2022).

For adult salmon releases, 59 adult Chinook Salmon were released with acoustic tags into Rufus Woods Lake in 2019 (Baldwin et al., 2022). In 2020, 50 adult Chinook Salmon with acoustic tags were released into Lake Roosevelt (Baldwin et al., 2022). These tagging efforts enabled scientists to track the movement and survival of both juvenile and adult salmon within the blocked area and beyond. Additionally, in 2024 the Confederated Tribes of the Colville Reservation and their partners the Spokane and Coeur d'Alene tribes released 1,100 adult Chinook Salmon upstream of the Chief Joseph and Grand Coulee dams, these fish will hopefully migrate into Canada as far as the Hugh Keenleyside Dam near Castlegar, British Columbia (Confederated Tribes of the Colville Reservation & Sinixt Confederacy, 2024).

Selkirk College assists in the role of research and monitoring of salmon spawning and other species monitoring. This research aims to identify key characteristics such as spawning timing, annual trends, behavioral patterns, and habitat preferences along the Columbia River and its confluence with the Kootenay River.

To assist in non-invasive monitoring, mid-size professional photography/videography drones were used to observe salmon and other species. By following the shallows of the river, these drones can identify crucial habitat locations, behavioral characteristics and spawning locations. This will help track the success of salmon reintroduction and create a valuable database for future climate change studies.

Measuring progress and identifying potential challenges are essential to the success of salmon reintroduction. Through this project, we aim to support the goals of the Sinixt Confederacy and the broader objectives of the Upper Columbia United Tribes.

Study Area

Primary areas of interest of the study included Norns Fan, located northwest of Robson's Bridge in Castlegar (Figure 1 and 2), traveling east down the Columbia River towards the confluence of the Kootenay River and Columbia River to Brilliant bridge (Figure 3). Following the confluence south, the Area of Interest (AOI) ends at Merry Creek. Another primary AOI included Genelle Bar which extends from China Creek south to Birch Bank Picnic Grounds (Figure 3). Finally, a small area just off Waterloo Eddy Regional Park was surveyed (Figure 4).

Figure 1. September 24th site survey of Norns fan prior to video surveillance.

Figure 2. October 29th site survey of Norns fan, post- surveillance.

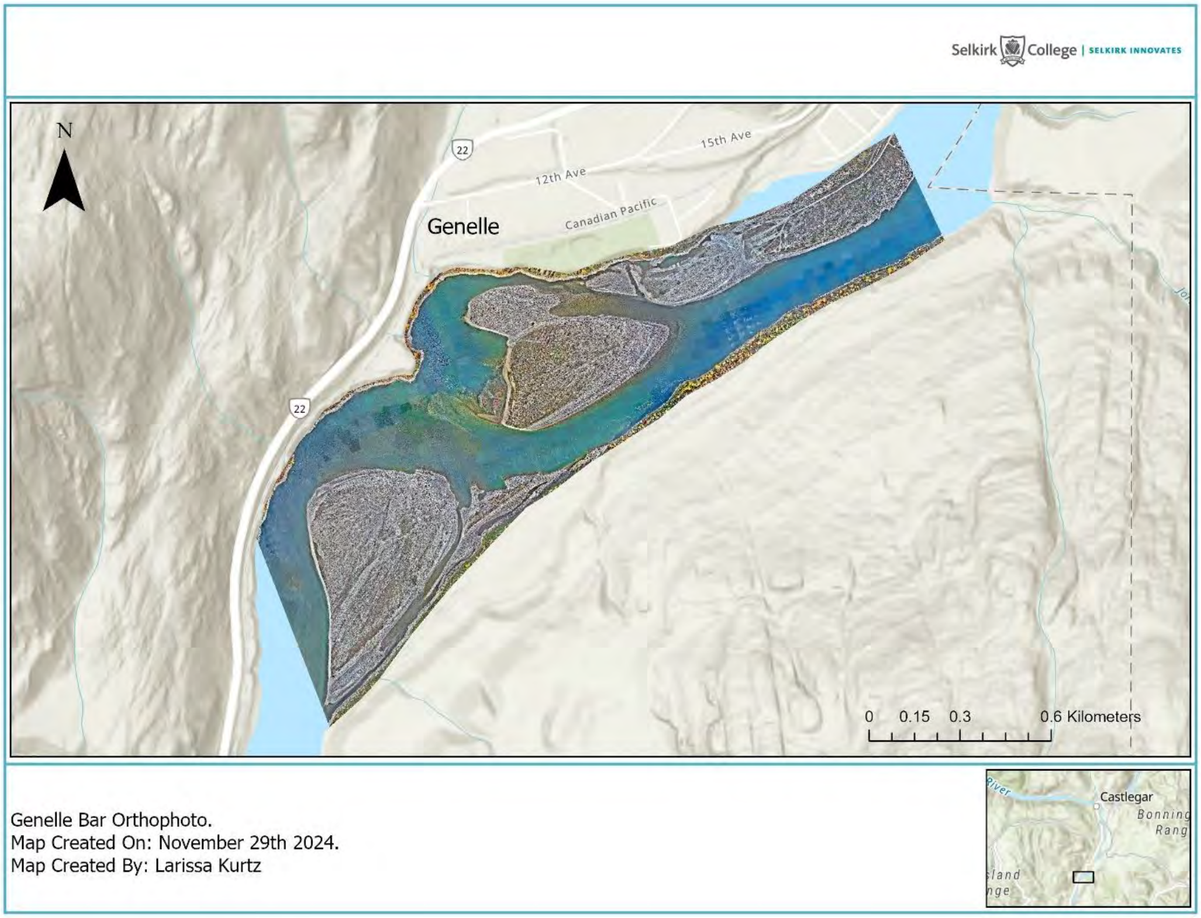

Figure 3. October 29th site survey of Genelle bar, post-surveillance.

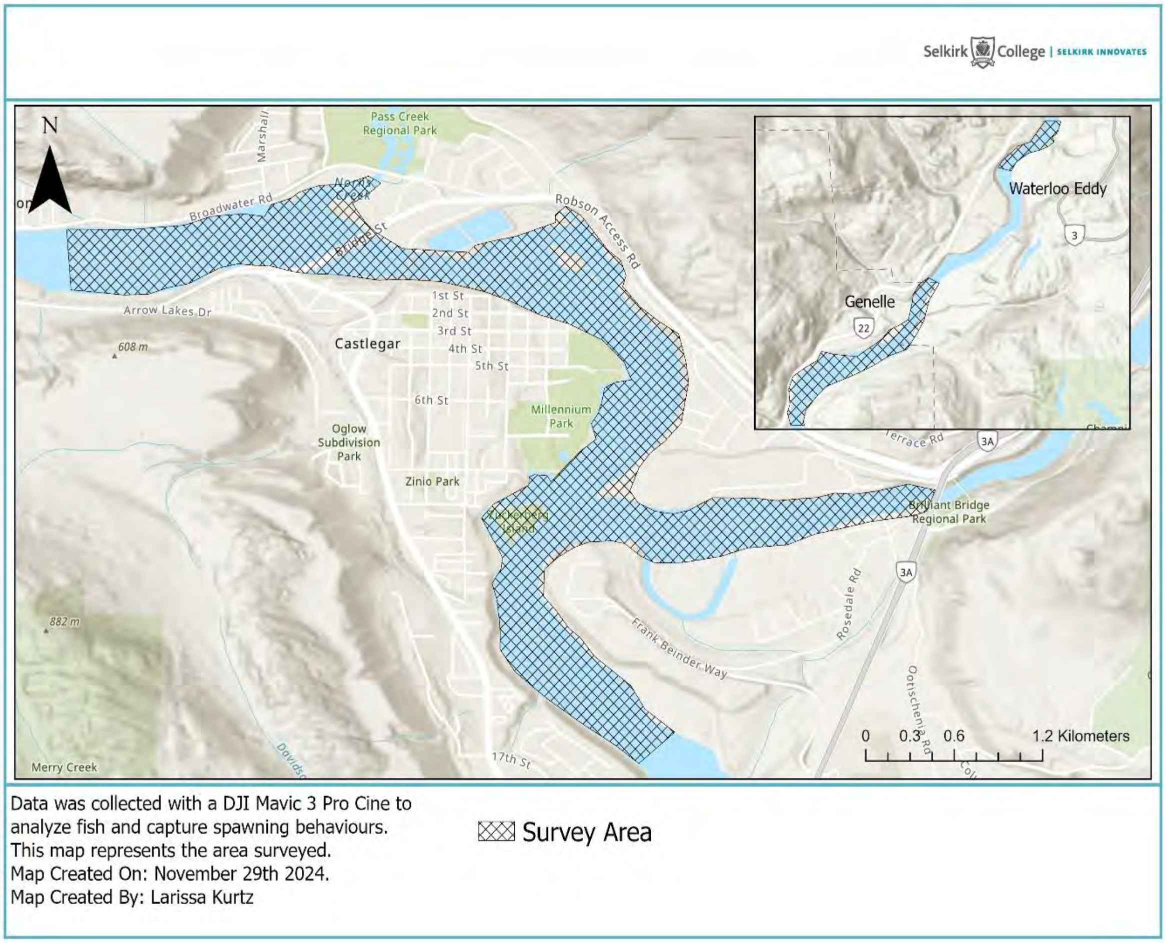

Figure 4. Survey area.

Equipment Used

The study area was flown with a DJI-Mavic-3-Pro-Cine equipped with obstacle avoidance and a polarized lens adapter and neutral density filter to reduce sun glint off the surface so that sub-surface details could be imaged with higher clarity. The DJI-M350 RTK with a DJI Zenmuse P1 camera equipped with a circular polarizer was flown for the initial Norn's Creek site orthomosaic but was later replaced by the Mavic 3 Enterprise Multispectral as the smaller airframe allowed more efficient access to multiple staging areas to ensure regulatory compliance of maintaining the drone within visual line of sight.

Table 1: RPAS and sensors used for data acquisition.

Model and Manufacturer	Purpose	Specs	Photo + Product Link
		RPAS	
Dji Mavic 3 Cine Pro	For RGB aerial observation	43 min max flight time 6000m max flight altitude 12m/s max wind speed resistance 4/3 CMOS Hasselblad L2D-20c, 20MP resolution Maximum video resolution 5.1K -10° to 40°C operating temp Omnidirectional obstacle sensing	 https://enterprise.dji.com/mavic-3-m?site=enterprise&from=nav
DJI M350 RTK	2.7 kg load capable medium size enterprise drone that allows swappable (and multiple) sensor integration	20km max transmission 55 min max flight time 7000m max flight altitude 12m/s max wind speed resistance -20 to 50°C operating temp IP55 rating 6-directional sensing & positioning DJI 03 Enterprise transmission DJI RC plus 400 battery cycles Night vision FPV camera Multi-payload support	 https://enterprise.dji.com/matrice-350-rtk
DJI Zenmuse P1	For collection of photogrammetry data	Accuracy (no GCP) H = 3cm, V = 5cm Covers 3km^2 in a single flight 45 MP Full-frame Sensor 3-axis Stabilized Gimbal Global Mechanical Shutter Shutter Speed 1/2000 Seconds	 https://enterprise.dji.com/zenmuse-p1
DJI Mavic 3 Multispectral	For collection of photogrammetry data	43 min max flight time 6000m max flight altitude 12m/s max wind speed resistance 4/3 CMOS Hasselblad L2D-20c, 20MP resolution Maximum video resolution 4K -10° to 40°C operating temp Omnidirectional obstacle sensing	

Methods

Field Operations.

Field drone surveillance operations were conducted from September 24th to October 29th, 2024. Dates were selected based on current weather and sub-surface illumination conditions. Optimal weather included sunny skies with low cloud cover. The DJI Mavic 3 Pro Cine, equipped with a polarized lens adapter, was used to monitor fish across possible spawning locations along the Columbia River course near Castlegar. Facing the gimbal at -90 degrees (NADIR) allowed for optimal visibility beneath the water surface.

The locations selected were based on expert guidance provided by James Baxter's, Sinixt Confederacy's Principal Biologist, on-site observations and knowledge of historical spawning grounds and preferred habitats. Using this knowledge, the drone operator launched in the relative location of observed spawning areas, viewed the presence of fish on the controller of the drone and descended from approximately 30 meters altitude to 12 meters to observe behaviors and potential spawning activity.

Photos and videos were taken of fish which were believed to be significant to the goals of the study.

Ortho-photos were collected at the start date of the study in Norns Fan as well as at the end of the study period in both Norns Fan and Genelle Bar.

Data Analysis & Fish ID

After data was collected, MP4 format videos were backed up on a secure network drive to ensure security and reduce data loss due to corruption. The videos were downloaded onto SSD hard drives for analysis on a large 4k monitor to ensure optimal analysis. The videos were separated into flight dates and locations. Photos taken were analyzed separately on a smaller screen. Visual observations were conducted to count fish, count redds, identify substrate, take notes, and identify behavioral traits. Using an excel spreadsheet, a comprehensive database was created to ensure GPS points can be created in ArcPro. After video and photo analysis is complete, a code was generated to extract accurate GPS data from the SRT file which shows the location of the drone every millisecond as well as relative altitude of the drone. Using this data a csv file was loaded into ArcGIS Pro. Points were generated at every location the drone flew. Then a line is generated which uses the start and end latitude and longitude plus the relative altitude of the flight. Using this relative altitude the ground sampling distance can be used to approximate the area flown and coverage of the river. This is shown using the buffer tool in ArcGIS Pro. Each line generated from the flight was used to create an approximate ground sampling distance based on the average flight height across all flights. The total area surveyed is displayed in the buffer attribute of each flight converted from square meters to Hectares.

To create a map of the area recorded, all buffers were merged and used to create a more general outline of the flight paths as many flights overlap.

Redd locations were generated from the drone GPS location central to the observed Redd in frame. A separate database for redds was created to be edited and added to.

Photo locations are displayed as High, Med, Low, and Erase to show photos which are of high significance to the goals of this project.

Fish identification involved careful analysis of drone footage with a focus on key physical traits such as body shape, size, coloration, and movement patterns to differentiate between species. Behavioral observations, including spawning, schooling, shoaling, aggression, swimming, and resting, were recorded to provide a comprehensive understanding of the fish activities and habitat use. Dominate substrate type was also recorded, as it plays a critical role in redd development. Additionally, the drone's GPS data was utilized to accurately record the coordinates of each observation, ensuring precise spatial mapping of redd locations.

Results

Field Operations

Over the project duration, nearly 13 hours of active drone flight time was carried out along 128 KM of manual flight lines to cover 355 Ha of Columbia River waterways of which 257 Ha was suitable (within visible depth range and unobscured) for analysis (Figures 5-8, Tables 2 and 4). Some sites were surveyed multiple times when warranted by the presence of potential salmonids and their redds. Variable weather conditions were observed throughout the study period and varied significantly between sites on the same day, largely due to microclimatic influences from localized topography. For instance, sun and cloud cover often created uneven lighting, with some areas shaded while others along the mainstem received better sub-surface illumination. Similarly, wind-induced surface disturbances (riffles) were more common in exposed sections of the mainstem, whereas nearby topographically sheltered waterways remained relatively unaffected; table 3). Frequent shifts in wind direction were common, both presenting opportunities to survey areas previously impacted and hindering those experiencing optimized conditions at time of flight. Despite our best efforts to select forecasted days for ideal conditions, the ability to be adaptable and mobilize from staging area to staging area rapidly proved imperative to attain the best results, yet this was time consuming to pivot and challenging to predict.

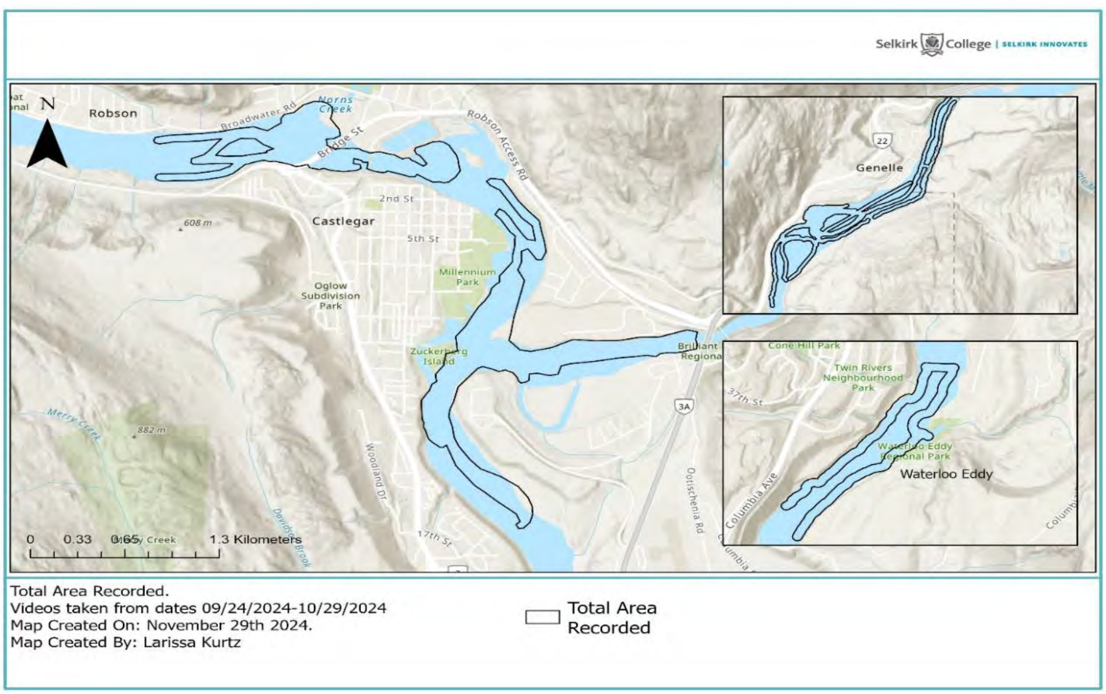

Figure 5. Approximate area recorded.

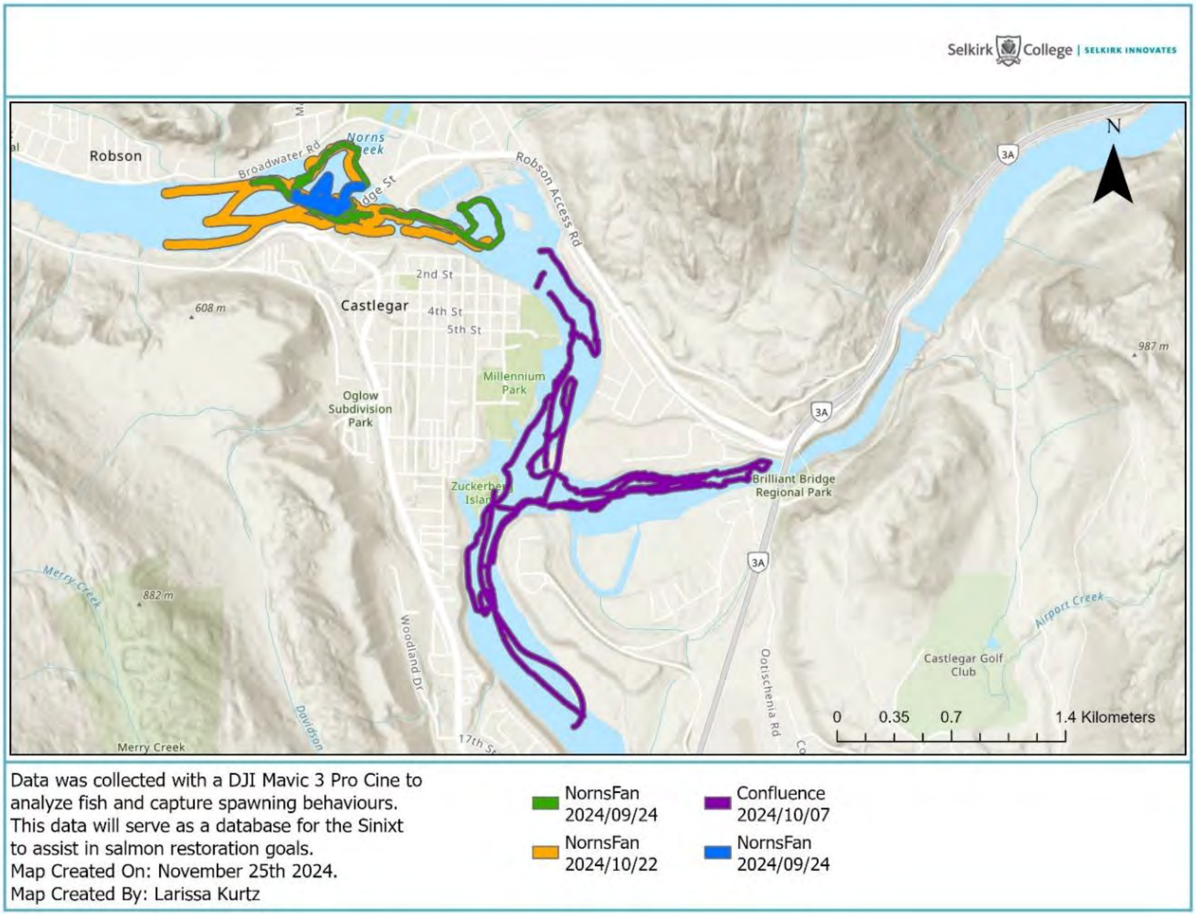

Figure 6. Norns fan and confluence area surveyed September 24th - October 22nd.

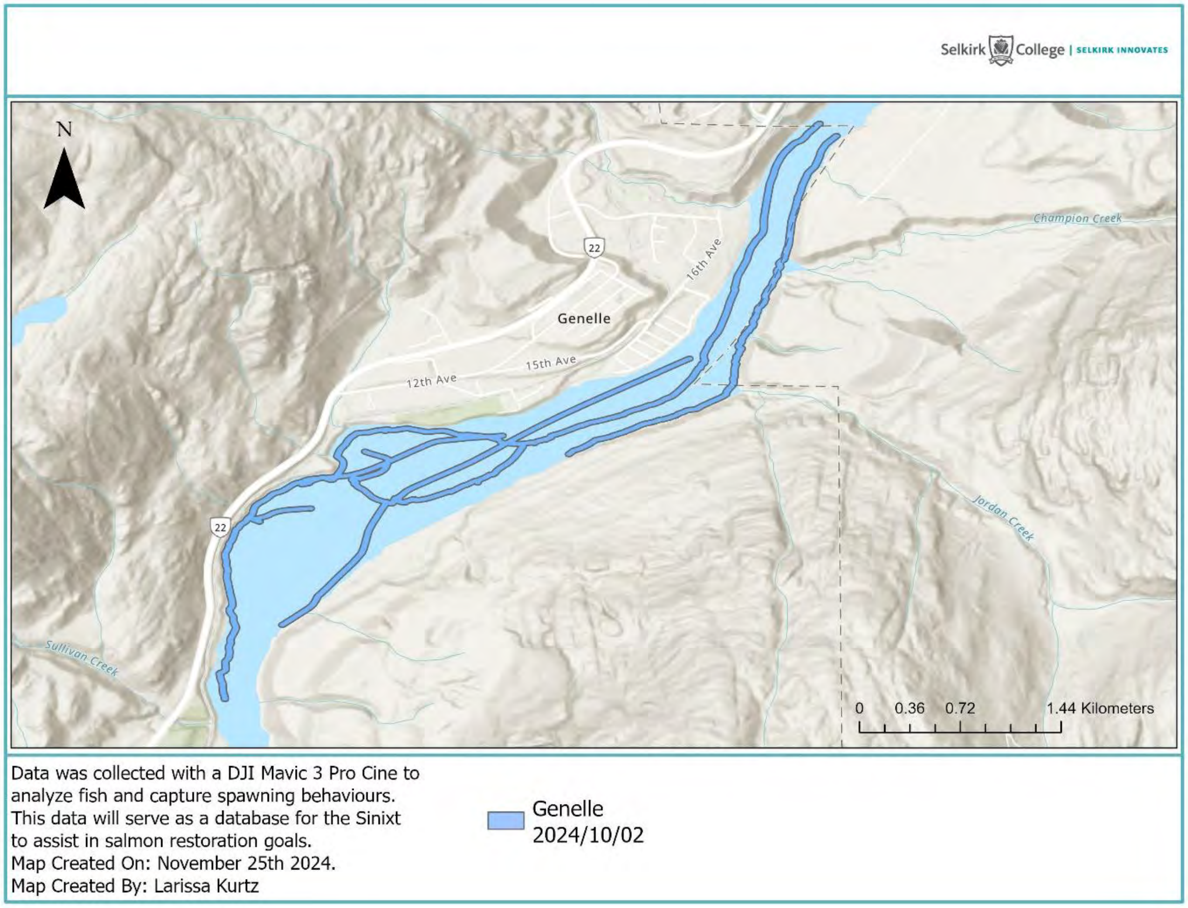

Figure 7. Area surveyed in Genelle on October 2nd.

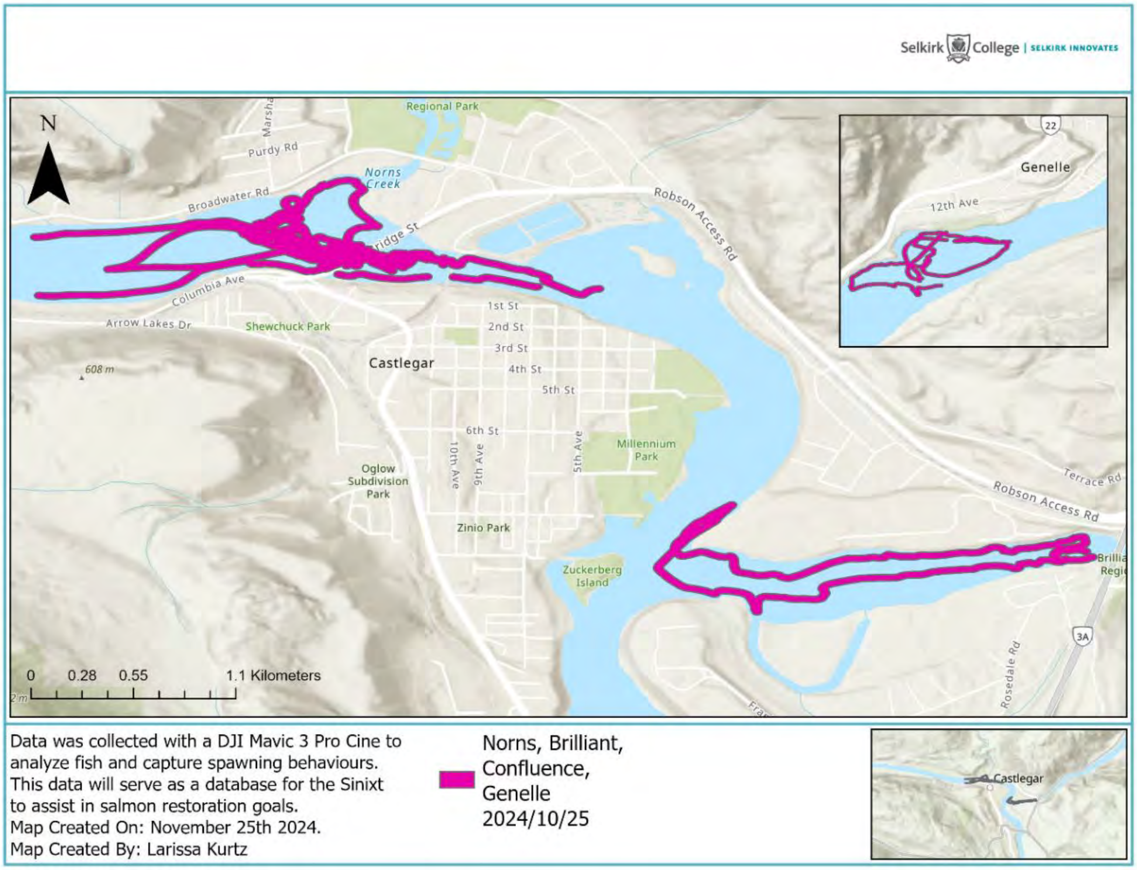

Figure 8. Area Surveyed in Norns, Brilliant, Kootenay confluence and Genelle on October 25th.

Table 2. Flight Data Log.

	Flight Statistics						
	Distance (km)	Altitude[1] (m) (Min/Max)	Max Range (m)	Avg. Speed (m/s)	# of Satellites (Min/Max)	# of Flights	Total Flight Time (hh:mm:ss)
Sept 24th, 2024	22.2	0/91	886.8	1.2	12/26	6	02:08:00
Oct 2nd, 2024	18.46	-2.1/127.5	2288.3	2.0	16/25	3	01:23:51
Oct 3rd, 2024	1.3	0/95.3	321.5	3.4	19/24	1	00:08:04
Oct 7th, 2024	15.4	0/90	1590.9	1.8	15/25	3	01:10:16
Oct 17th, 2024	8.59	0/71	764.2	2.7	12/21	2	00:31:02
Oct 22nd, 2024	11.29	-1.2/81.6	1278.5	1.0	0/24	3	01:14:16
Oct 25th, 2024	19.56	-0.4/119.5	1235	0.9	10/25	7	01:52:03
Oct 28th, 2024	7.25	0/91	1115	1.0	16/24	1	00:46:06
Oct 29th, 2024	24.7	-0.3/125	1240	2.4	15/24	6	01:33:32

Table 3. Weather conditions during field data collection.

Flight Location and Date	Temperature (°C)	Cloud Cover (%)	Visibility (km)	Wind Speed (m/s)	Wind Direction (degrees)	Humidity (%)
Norns Fan, Sept 24th, 2024	25.0°C	0%	10km	2.2m/s	182°	55%
Genelle Oct 2nd, 2024	7.0°C	17%	10km	0.6m/s	325°	66%
Genelle Oct 3rd, 2024	14.0°C	0%	10km	1.1m/s	173°	40%
Confluence Oct 7th, 2024	18.0°C	0%	10km	1.9m/s	181°	43%
Genelle Oct 17th, 2024	9.0°C	41%	10km	2.2m/s	279°	48%
Norns Fan Oct 22nd 2024	2.0°C	66%	10km	0.6m/s	198°	95%
Norns Fan, Confluence, Genelle Oct 25th 2024	4.0°C	67%	10km	0.8m/s	155°	39%
Norns Fan, Waterloo Eddy, Oct 28 th 2024	2.0°C	100%	2km	1.4km/s	178°	96%
Norns Fan, Oct 29th, 2024	5.0°C	94%	10km	0.3m/s	128°	94%
Norns Fan, Oct 29th, 2024	5.0°C	58%	10km	0.6m/s	153°	86%
Genelle Bar, Oct 29th, 2024	6.0°C	22%	10km	0.8m/s	177°	78%

Table 4. Total Flight Area in Hectares, Total Area Surveyed in Hectares.

	Folder Name	Video Coverage	Total Hectares
Norns Fan 2024/09/24	20240924_ NornsFan _Classified	DJI_0221.MP4- DJI_0285.MP4	23
Norns Fan, Genelle 2024/10/29	20241029_NornsFan_GenelleBar _Classified	DJI_0443.MP4- DJI_0448.MP4	49
Norns Fan, Brilliant, Confluence 2024/10/25	20241025_NornsFan_Classified	DJI_0373.MP4- DJI_0418.MP4	96
Confluence 2024/10/07	20241007_M3C_Confluence_Classified	DJI_0321.MP4- DJI_0367.MP4	75
Waterloo Eddy 2024/10/28	20241028_WaterlooEddy_NornsFan	DJI_0427.MP4- DJI_0439.MP4	28
Genelle Bar 2024/10/02	20241002_GenelleBar_Classified	DJI_300.MP4- DJI_0318.MP4	84
Total Flight Area			355 Hectares
Total Area Surveyed			257 Hectares

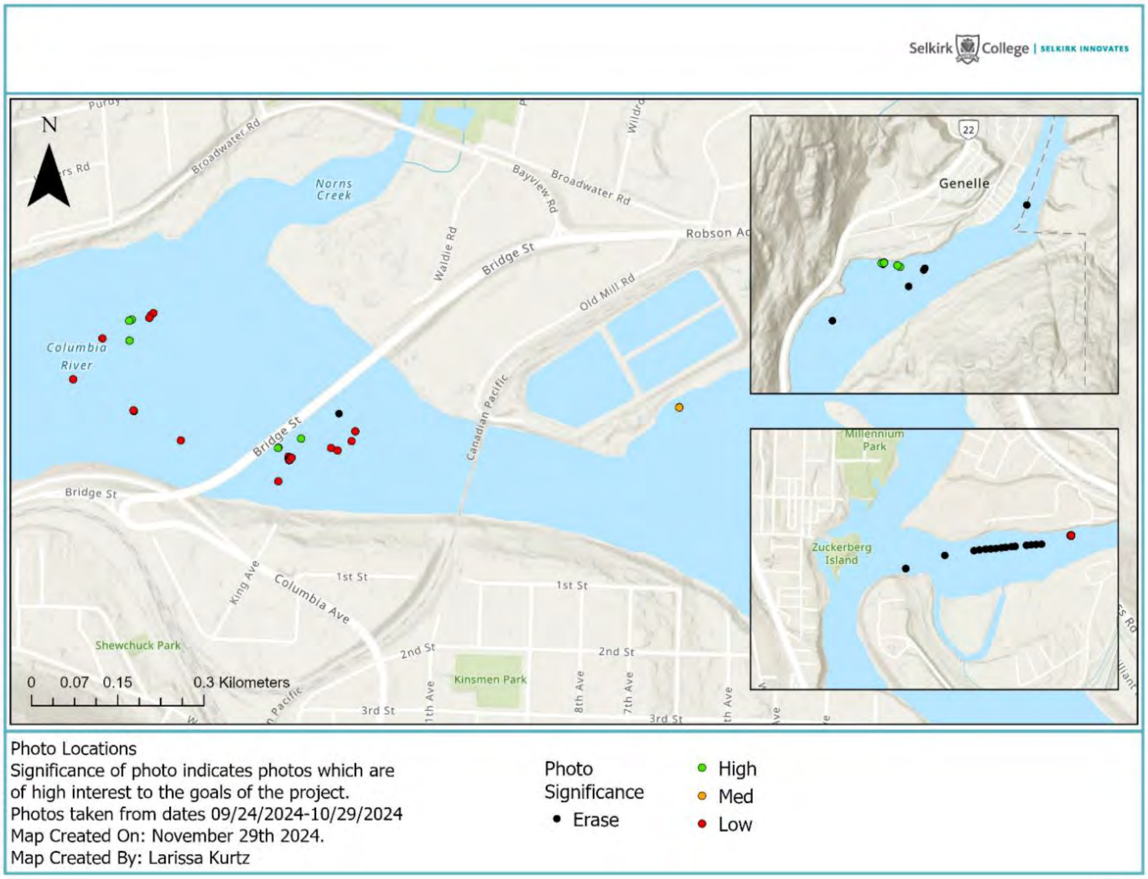

Figure 9. Drone photo locations by significance.

Up to 32 redds were found this season based on visual observation. Most were located on Norns Fan (Figures 10-13). During a survey in Genelle, a Chinook Salmon mortality was discovered and photographed adjacent 2 redds (Figure 13). Additional images were collected of this fish to assist in the confirmation of species identification and are included at various closer proximities in the image/video database (Figures 21 and 22).

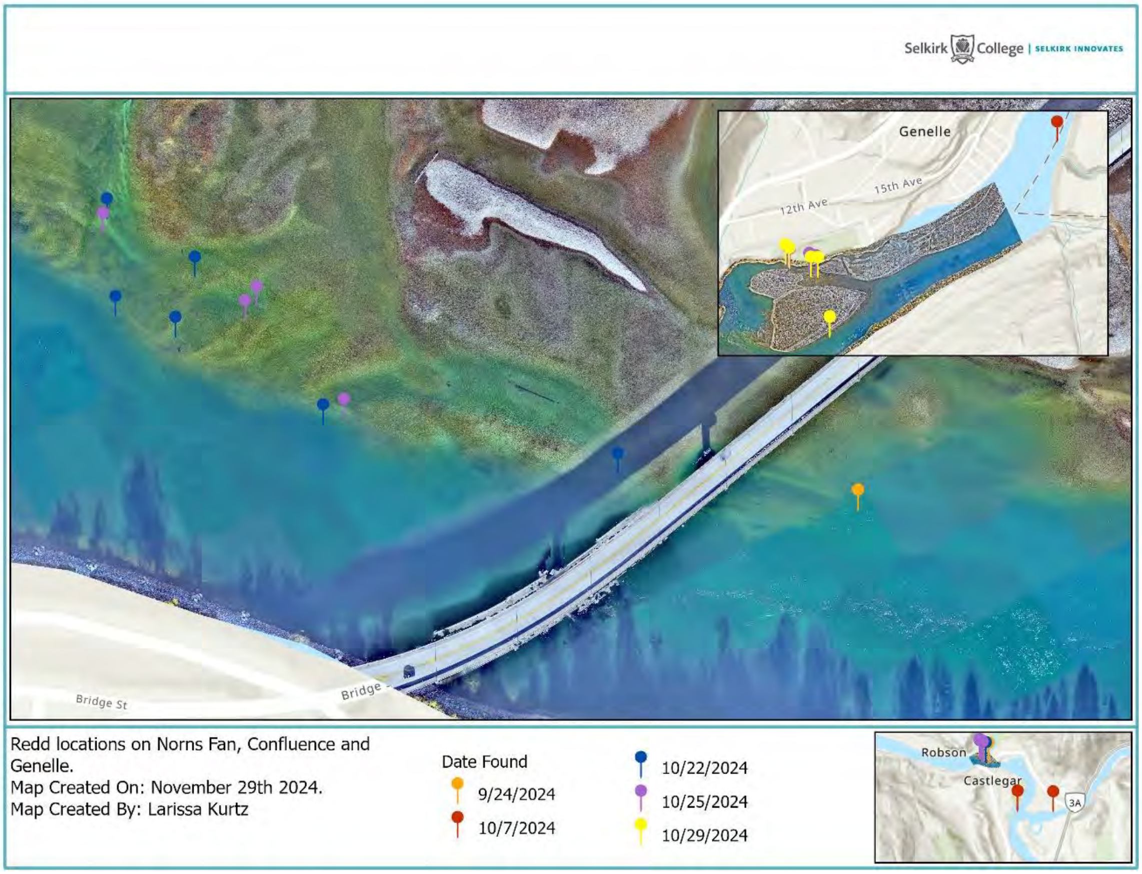

Figure 10. Redds based on video observation.

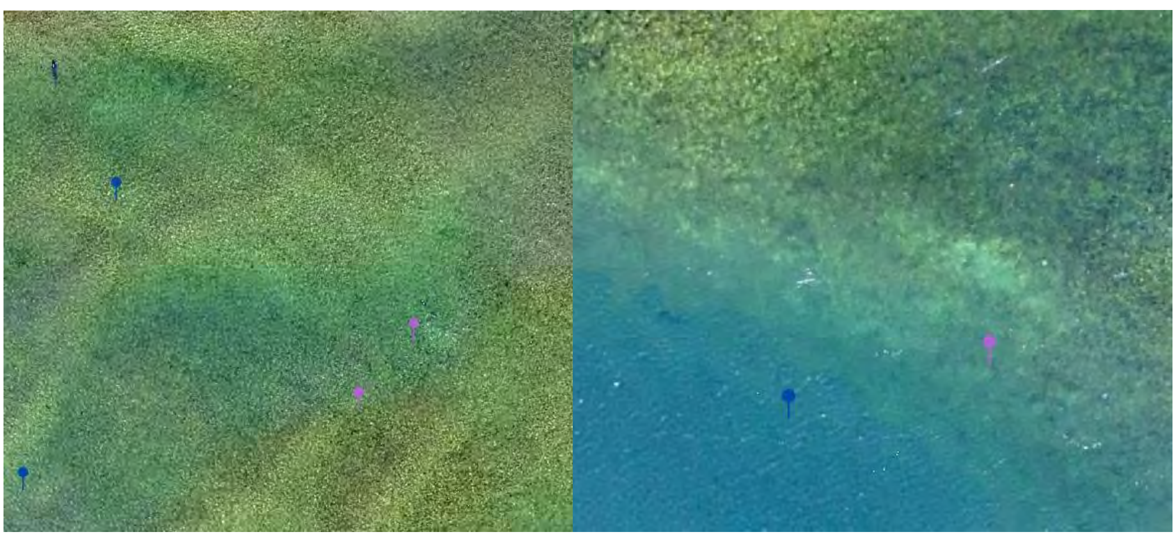

Figure 11. Images of redds found on Norns fan (redds are just visible in orthophoto).

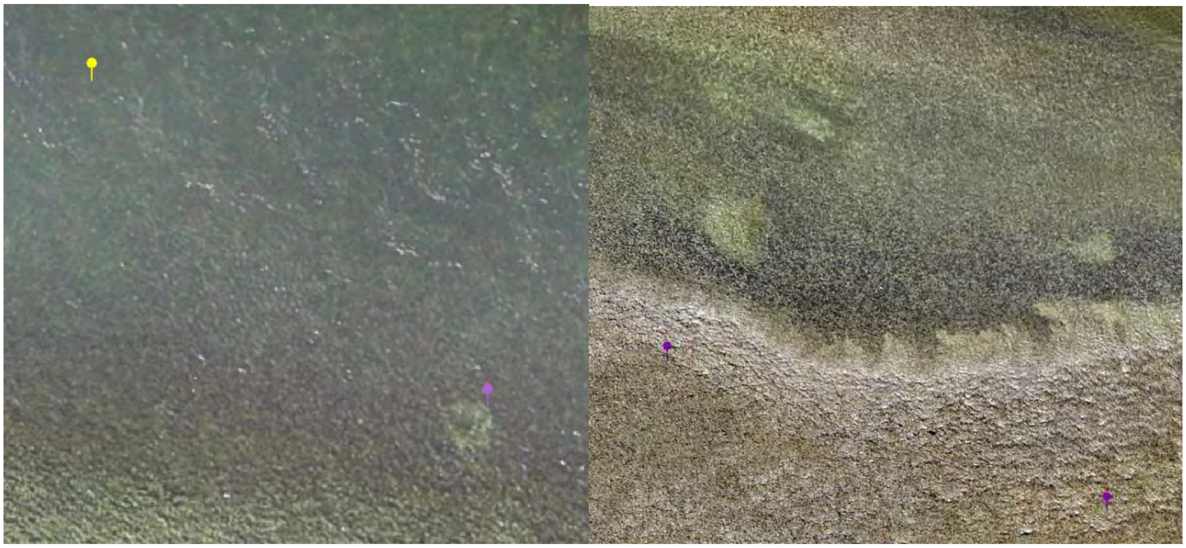

Figure 12. Genelle bar drone-based redd locations. (Left) Potential locational error (Right) identifying redds or new redds appearing in the orthophoto.

Figure 13. Two redds and salmon mortality near Genelle.

Data Analysis & Fish ID

PHOTO EXAMPLES

REDDS:

Figure 14. (a) A wide-angle drone image displaying the salmon redd within the broader fluvial habitat. (b) A closer view of a redd, illustrating the characteristic gravel displacement associated with salmon spawning, where eggs are deposited and buried.

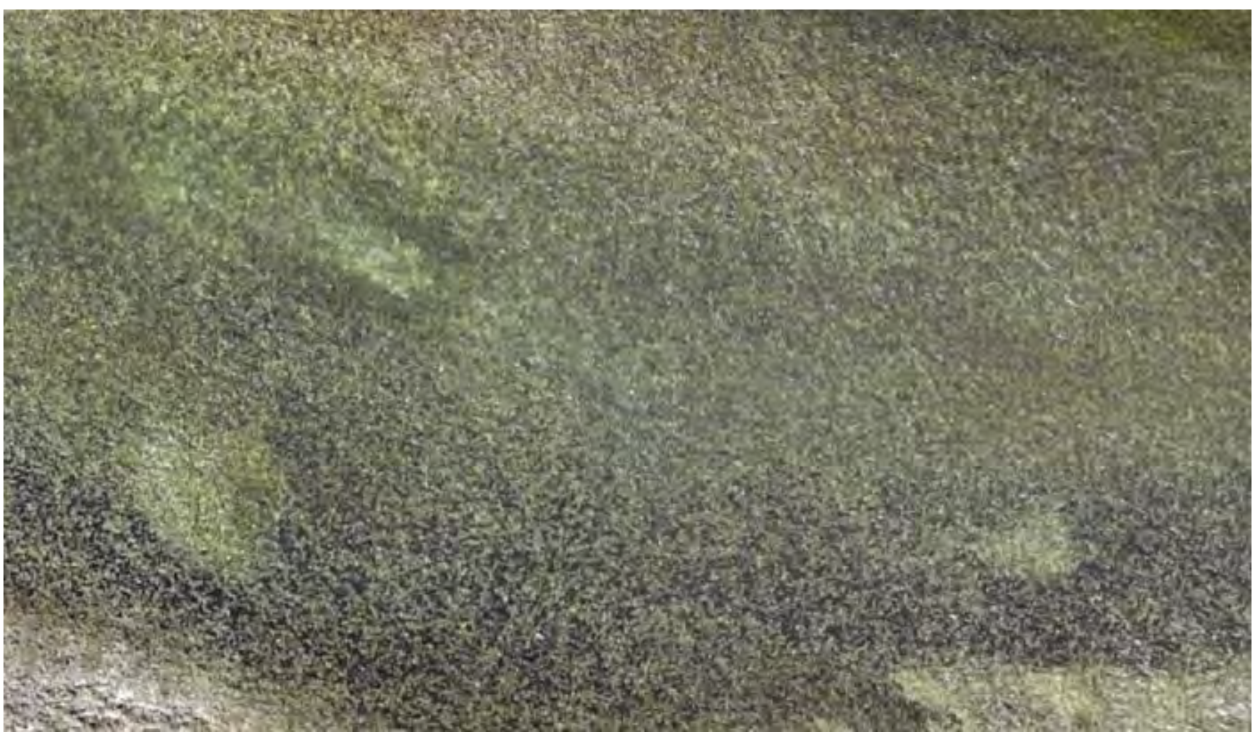

Figure 15. Redds from Genelle Orthophoto on October 29, 2024.

STURGEON

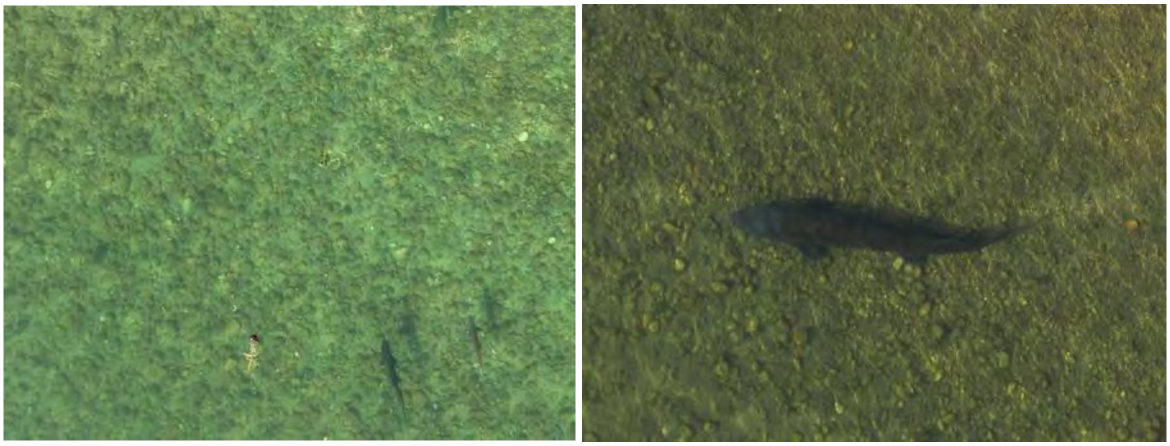

Figure 16. (a) A wide-angle aerial view of a sturgeon in its aquatic environment, showing its elongated body shape and dorsal placement within the water column. (b) A zoomed-in aerial view highlighting key identifying features, including the torpedo-like body, distinct bony scutes along the back, posteriorly located rounded pectoral fins and broad, flattened head.

SALMON

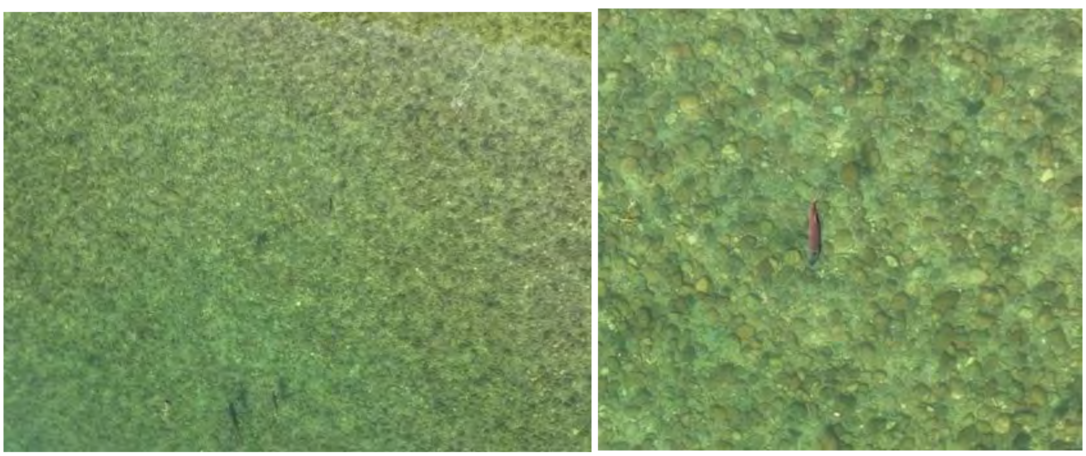

Figure 17. (a) A wide-angle aerial view of two potentially spawning Sockeye Salmon and two Sturgeon, showcasing its distinctive bright red coloration against the gravel substrate from afar. (b) A zoomed-in image highlighting the salmon's vibrant pigmentation and more detailed features, such as the elongated streamlined body shape and more anteriorly located triangular pectoral fins.

SUCKERS

Figure 18. Aerial imagery of a school of fish at the primary Norns Creek channel just above where it meets the Columbia River. The image captures coordinated schooling behavior, a strategy employed for predator avoidance and foraging efficiency.

The results include a database which requires an expert to review and confirm some of the data (Table 5). Changes can be made to this database to further improve upon it. Locations of drone flights will remain, and buffers need to indicate ground sampling distance based on relative distance of flight height.

Table 5. Database file structure example.

Video Folder	Classified Folder	Video numbers	SRT Data Name	Line Data Name	Buffer Name
20240924_ NornsFan	20240924_NornsFan _Classified	221-285mp4	Norns Fan20240924_points	NornsFan_20240924_SRT_secPointToLine	NornsFan_20240924_Buffer
20241002_GenelleBar_Mavic 3Cine	20241002_GenelleBar_Classified	300-318mp4	GenelleBar_20241002_SRT_sec	GenelleBar_20241002_SRT_sec_PointsToLine	GenelleBar_20241002_Buffer
20241007_M3C_Confluence	20241007_M3C _Confluence_Classified	321-367mp4	Confluence_20241007_SRT_sec	Confluence_20241007_SRT_sec_PointsToLine	Confluence_20241007_Buffer
20241025_NornsFan	20241025_NornsFan_Classified	373-418mp4	Norns_BrilliantToConfluence_Genelee_20241025_SRT_sec	Norns_BrilliantToConfluence _Genelle20241025_PointToLine	NornsBrilliantConfluence_20241025 _Buffer
20241028_WaterlooEddy_NornsFan	20241028_WaterlooEddy_NornsFan	427-439mp4	C20241028_WaterlooEddy_NornsFan_output_SRTpoints	WaterlooEddy_20241028_SRT_sec_PointsToLine_p	WaterlooEddy_20241028_Buffer
20241029_NornsFan_GenelleBar	20241029_NornsFan_GenelleBar_classified	443-448mp4	C20241029_NornsFanGenelleBar_ouput_SRT_sec	NornsFanGenellleBar_20241029	NornsFanGenelle_20241029_Buffer

Discussion

Limitations of this project mainly included weather conditions and understanding spawning locations. Since completing the project, we have identified the key areas with optimal visibility and a high likelihood of spotting salmon using the drone. It is not useful to capture sub-surface focused imagery over deep and swift water as the drone cannot clearly see the species or size of the fish. Zooming on the drone camera is limited by substantial reduction in resolution and quality proving difficult for analysis. New lossless optical zoom lens equipped mid-size drones are beginning to be introduced on the market and may offer some advantage in mitigating the risks associated with low altitude flight, however a compromise should be carefully considered between larger vs smaller airframes as this will greatly influence the ability to overcome staging area access encumbrances (i.e. some launch zones in key areas were only accessible by foot or bicycle). Shorter video time-lengths are recommended as those over 10 minutes can result in repeating fields in the database. Moving forward, the target area should be scanned using short, 5-minute videos in a parallel line to ensure nothing is missed. Flying at a lower altitude is helpful for viewing salmon and it appeared that they were not bothered by the sound or presence of the drone so long as it maintained flight altitudes that minimize downwash turbulence on the water's surface. At 18 meters flight altitude smaller schooling fish in shallow water at the mouth of Norn's Fan exhibited disturbed behavior, scattering triggered by the drone's movement (DJI_0267).

A large flight window allows us to see when the salmon are exhibiting spawning behavior and identify changes in seasons. Key areas to continue focusing on are Norns Fan, the confluence of Kootenay and Columbia River close to Zuckerburg island and Genelle Bar. Redds were identified in these areas.

Some key findings during analysis include using a large monitor to ensure optimal viewing of fish as well as separating videos into multiple parts as some are quite long and prove difficult to analyze. Using each flight video's accompanying SRT files, which are made up of timecodes and GPS locations associated with MP4 video files, is a great way to ensure the total area surveyed is included in the maps.

Using high-resolution orthophotos is an effective way to see the aquatic landscape changes at the beginning versus end of the project. Some redds were found through this method and could be a good option for viewing the changes throughout the spawning season. Overall, the Mavic 3 Pro Cine provided extensive data to assist in observing salmon spawning and behaviors which will allow for continued research as assessment of the success of salmon reintroduction projects and other conservation initiatives.

Challenges and recommendations for designing a UAV campaign:

UAV data acquisition faces challenges like optimal conditions for remote sensing, including time of day, sun angle, shadows, weather, seasonality, and canopy cover. Advances in UAV and sensor technology, such as sensor calibration, polarization filters, improved flight planning software, and better RTK GNSS connectivity, help mitigate these issues. Strategic planning and automation can further enhance productivity and accuracy.

Effective UAV surveys require specialized personnel with skills in land surveying, GIS, and GNSS systems, and the ability to adapt to evolving hardware and firmware. Regular troubleshooting is necessary to maintain hardware compatibility. Once a workflow is established, it's crucial to protect the hardware ecosystem from updates that could disrupt data acquisition or survey operations.

The orthomosaic site overview portion of this study used intensive UAV surveys to ensure sufficient sensor overlap for effective SFM software key point detection and image mosaicking. Future research should explore BVLOS flights at higher altitudes with wider flight line spacing. Developing guidelines for survey teams on overlap, altitude vs GSD, and flight speed based on site characteristics could reduce flight time, data storage, and processing needs. Creating orthomosaics over water requires careful planning to overcome challenges like reflections, lack of texture, and surface movement. Avoid relying on tie points over water by masking these areas during processing and use ground control points (GCPs) placed on nearby land for accurate georeferencing. Post-processing may involve manually editing or blending deeper water areas to correct distortions and ensure a clean, accurate final mosaic.

Transport Canada (TC) regulations currently limit RPAS flights to within visual line of sight or with a visual observer, and below 120 m AGL. The Special Flight Operations Certificate program allows specific use cases in low-risk areas but is costly and less flexible. New TC regulations in November 2025 will permit BVLOS and complex missions without an SFOC in low-risk, low population-density environments. A qualified Level 1 Complex Operations RPAS flight team using BVLOS-specific radio protocols could improve efficiency of data collection. Please note that BVLOS operations in controlled airspace and near urban environments will still require an SFOC.

As long-range, vertical takeoff and landing fixed-wing UAVs become more cost-effective and reliable, future studies should use multiple co-aligned sensor arrays for simultaneous data capture. This can reduce alignment issues, errors from changing satellite geometry and RTK connectivity, and variability in lighting and weather.

Further efficiency gains are possible with refined UAV flight mission planning and recent technological advancements. However, it's crucial to ensure these improvements don't compromise data quality. UAVs can also help extract additional complementary fish habitat metrics, such as channel depth and stream flow rate, with further development of semi-automated analysis workflows. Investigating fish habitat metrics from a continuous dataset perspective, rather than random stratified transects, may provide more comprehensive surveys and reduce biases from accessibility, safety, and cost.

Conclusion

Using high resolution RGB drone imagery is an effective way to observe salmon spawning activity, habitat changes, fish behaviors and track long-term success of CRSRI salmon reintroduction goals. 355 Hectares were surveyed and potentially up to 32 visual observations of redds (unconfirmed which species and correct identification). Using a database to track RGB videos and cross reference X,Y points on a map helps us understand crucial spawning areas, substrate type and trends in the data. The database consists of attributes which now can be altered, and additional information can be provided to confirm observations.

This project allowed for further research and efforts in continuing salmon reintroduction projects and can assist in other climate-related research as well as assist in monitoring invasive species removal.

Next Steps

Video editing will improve the quality and quantity of data saved. Phase One video editing comprises of removing videos which are located over deep water, erroneous videos or those which do not contribute to the goals of the project. Phase two can be completed upon further assessment of a fish biologist which will reduce the size of files and allow for the most meaningful videos to remain within the database.

Assistance with real-time drone deployed telemetry for future work could help narrow the drone search area and reduce costs. Drones equipped with telemetry systems could significantly speed up the detection of tagged fish compared to buoy or water vessel-based methods. They can track multiple tagged fish simultaneously, thereby maximizing data collection efforts and reducing survey time. Drones provide real-time data on the location and movement of tagged fish, allowing for immediate insights. They can cover large areas quickly, access remote locations, and cross land/water interfaces without running aground. Unlike vessels, drones are relatively quiet and cause minimal disturbance.

Future research should consider the use of higher altitude telemetry and mapping focused drones to narrow in on where the Chinook are located (simultaneously capturing important fish habitat data) to more strategically target low altitude, smaller video drones to confirm occurrence and monitor behavior.

Appendix

Table 6. Metadata and observational framework for drone-based fish and habitat analysis.

File Name	The name of the video file as recorded during fieldwork.
Date	The date when the video was captured, formatted as MM/DD/YYYY.
Start Latitude	The geographic latitude at the beginning of the video recording.
Start Longitude	The geographic longitude at the beginning of the video recording.
End Latitude	The geographic latitude at the end of the video recording.
End Longitude	The geographic longitude at the end of the video recording.
Start Time	The timestamp indicating the exact time the video recording started (HH:MM:SS).
End Time	The timestamp indicating the exact time the video recording ended (HH:MM:SS).
Fish Count	The total number of visible fish in the video (excluding large schools for practical assessment). Useful for evaluating salmon presence and potential redds.
Fish Presence/ Absence	Indicates whether fish are visible in the video. Marked as Yes (Y) for presence or No (N) for absence.
Species	Identified fish species when possible, aiding client-focused analysis. Examples include Sturgeon, Salmon (Sockeye or Chinook), Other (suckers).
Behaviour ID	Types of observed behavior (e.g., spawning, schooling, resting, digging, swimming).
Fish Description	Identifies the type of fish observed (e.g., Sturgeon, Salmon (Sockeye or Chinook), Other (suckers).
Substrate	The dominant substrate types in the recorded area, such as cobbles, gravel, sand, or silt.
Notes	Additional points of interest noted during observations.
Video/Photo Significance	Classifies the importance of the video; Erase: Unusable footage due to poor visibility or repeated areas. Low: Minimal activity with no notable features. Medium: Some activity, such as potential salmon presence or signs of redds. High: significant footage showing salmon presence, potential redds, or probable habitat. Extreme: Clear evidence of salmon activity, redds, or other critical observations.
Redd Prescence/Absence	Indicates whether redds are visible in the video, including a count of potential redds observed.
Redd Count	Number of Redds Observed
Redd Lat	Locational Latitude of Redd
Redd Long	Locational Longitude of Redd

Table 7. Photo files

Column Name	Description
File Name	Name of video or image.
Latitude	Geographic latitude of recording location.
Longitude	Geographic longitude of recording location.
Start Time	Timestamp marking the beginning of the recording.
End Time	Timestamp marking the ending of the recording.
Fish Count	Number of visible fish (large schools will not be counted). This helps assess potential salmon or redd presence.
Fish Prescence/ Absence	Indicates if fish were observed in the video or photo.
Species	Identified species, if applicable, useful for post analysis by the client.
Behaviour ID	Types of observed behavior (e.g., spawning, schooling, resting, digging, swimming).
Substrate Type	Type of substrate present (e.g., cobbles, gravel, sand, silt).
Notes	Additional points of interest noted during observations.
Video/Photo Significance	Classifies the importance of the video; Erase: No visibility or repeating areas Low: No notable activity Medium: Some activity, potential signs of salmon or redds High: Important video showing salmon presence, potential redds, or probable salmon habitat
Redd Prescence/Absence	Indicates if potential redds were observed and how many.

Figure 19. DJI_0228.MP4. Two Sockeye Salmon and one potential Chinook on Norns fan September 24th, 2024.

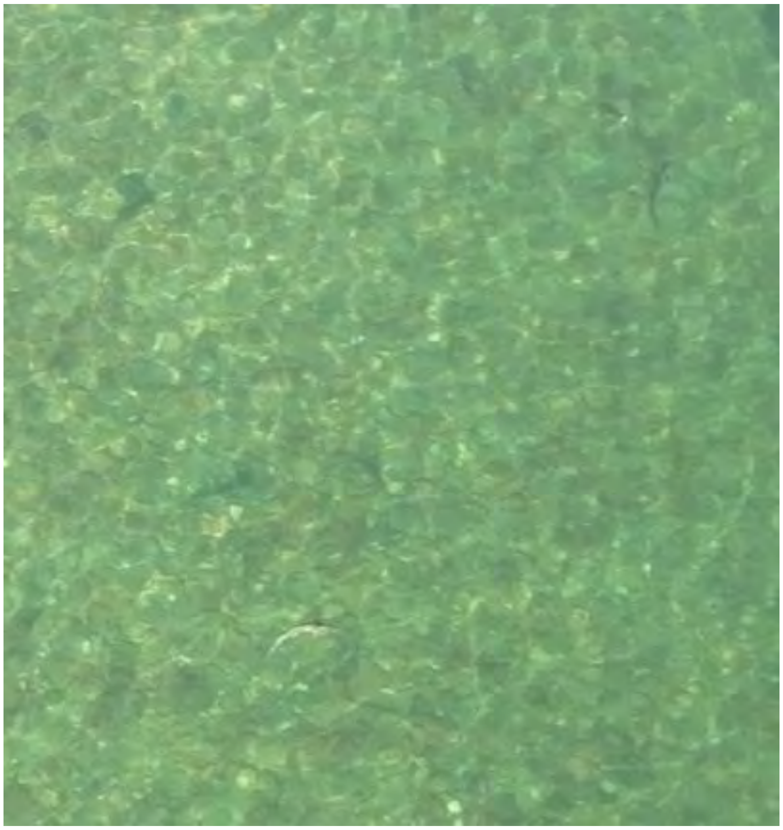

Figure 20. Chinook Salmon. DJI_0249.MP4 September 24th, 2024.

Figure 21. Dead Salmon near redd. Genelle bar October 25th, 2024.

Figure 22. Dead salmon adjacent redds, Genelle bar, October 25th, 2024.

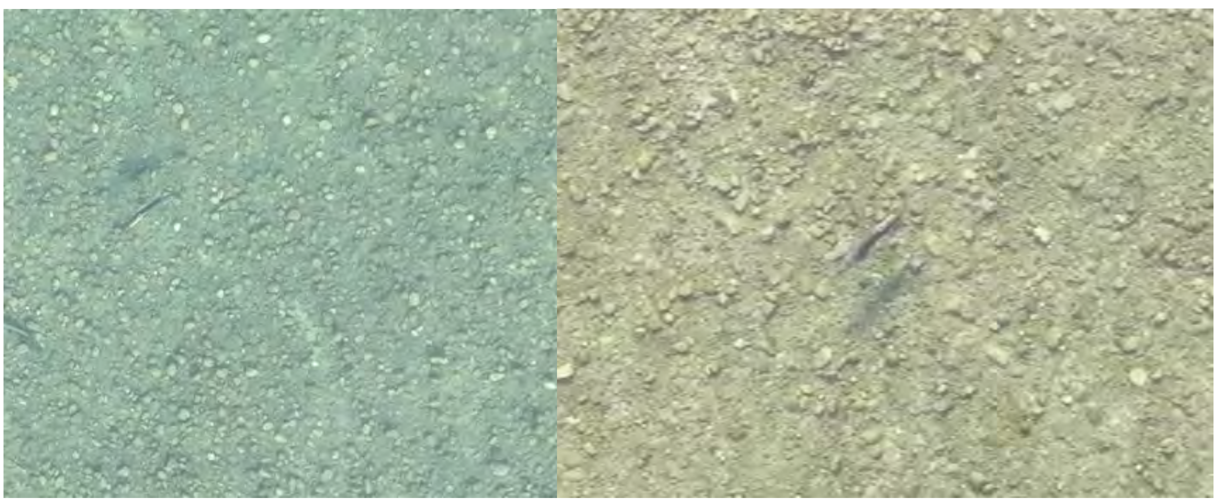

Figure 23. Blueish hue (spawning characteristics). Norns fan DJI_0385.MP4 October 25th, 2024.

Figure 24. 7 Potential Chinook Salmon on redd, below Sturgeon. Confluence DJI_0326.MP4 October 7th, 2024.

Figure 25. September 24th Norns fan.

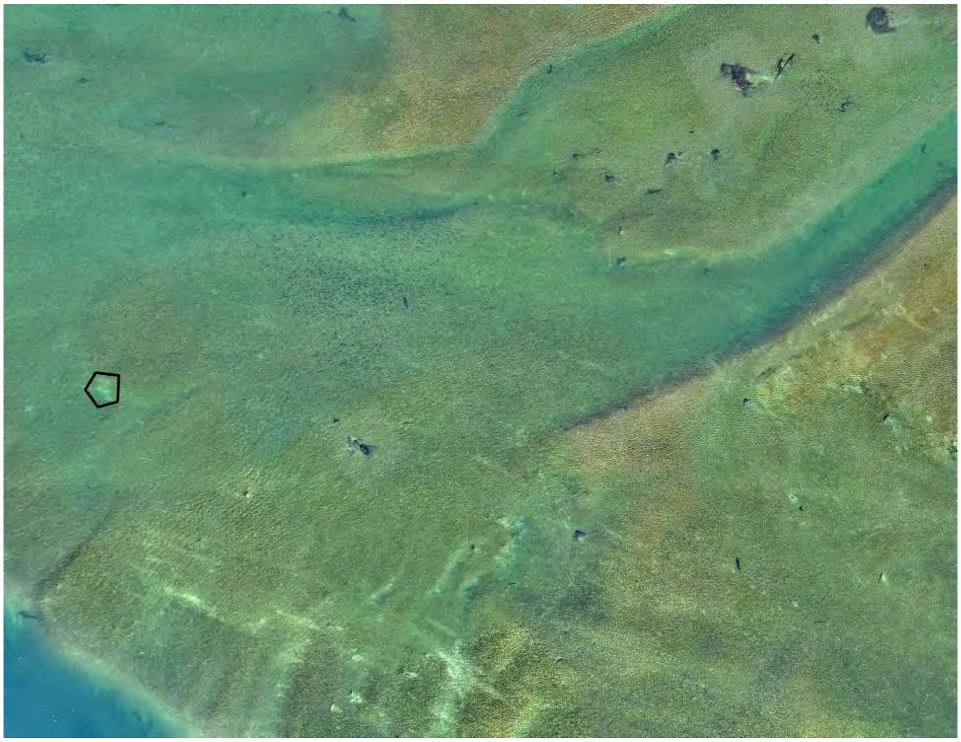

Figure 26. October Norns fan observed redds.

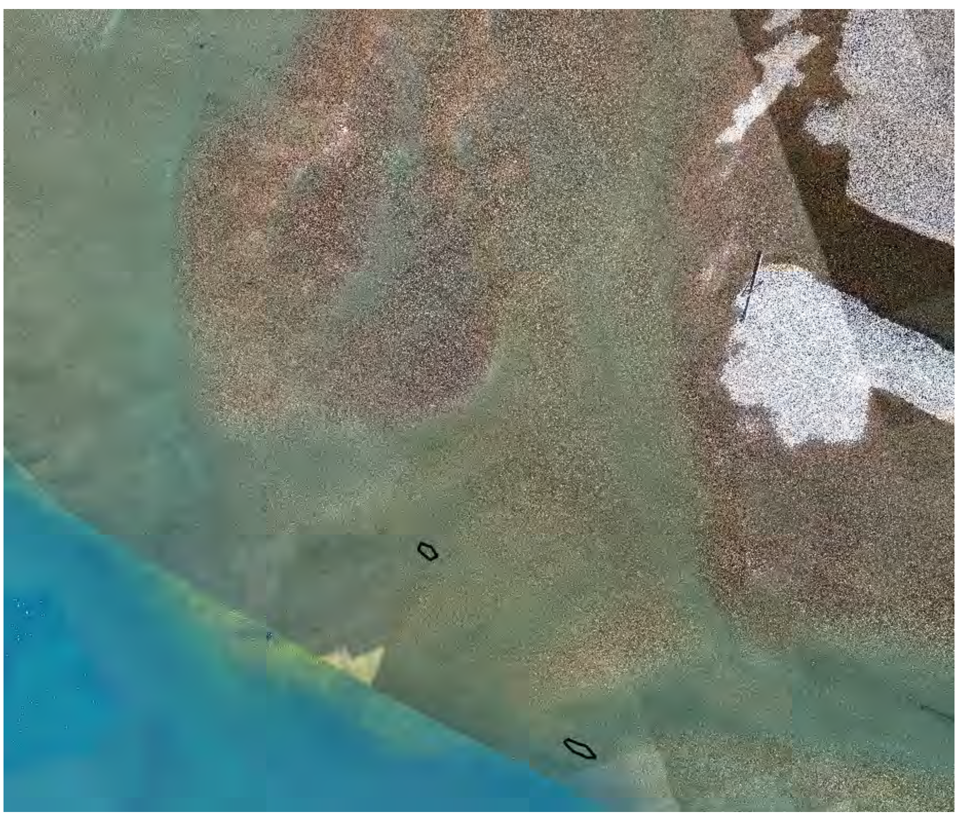

Figure 27. September Norns fan.

Figure 28. October Norns fan observed redds.

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