Interim Bulletin

Title:

Interim Bulletin: Preliminary Results on Research in Support of Sarita Chinook as an Ecological Indicator and WCVI Chinook Salmon Rebuilding

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Date:February 24, 2025

Introduction

Huu-ay-aht First Nations (HFN) and LGL Limited (LGL) have conducted stock monitoring activities of Sarita Chinook Salmon since 2017 through the HFN Watershed Renewal Program. The results of these studies (see below) will work towards making Sarita Chinook an ecological indicator for the West Vancouver Island, Ocean, South Chinook stock of the West Vancouver Island Management Unit. Sarita Chinook are well positioned to be an ecological indicator owing to the comprehensive research and monitoring that HFN have been doing in collaboration with Fisheries and Oceans Canada (DFO) for the past eight years and longer for escapement monitoring, Chinook Salmon enhancement, and habitat restoration. The watershed renewal program has provided reliable estimates of juvenile Chinook Salmon production and conducted research into optimizing enhancement strategies while promoting conservation of 'wild' Chinook Salmon. The research and activities conducted to date have also aligned with DFO's Follow-the-Fish study to fill information gaps for the West Coast Vancouver Island Chinook Salmon rebuilding initiative.

This Bulletin summarizes the research activities conducted on Sarita Chinook by LGL and HFN with preliminary findings and recommendations as presented during the January 15, 2025, Sarita River Ecological Indicator and Development workshop hosted by DFO. The Sarita research activities presented in this bulletin are:

1. Juvenile Chinook Outmigration Assessment (RST program)
2. Juvenile Chinook Distribution and habitat use in Sarita estuary
3. Juvenile Chinook Distribution and sampling in Numukamis Bay
4. Sarita Chinook Spawning Distribution and Environmental Drivers
5. Sarita Riparian and Aquatic Invertebrates Assessment
6. Remote Sensing of Chinook Predation in the Sarita River

Summaries, preliminary findings and recommendations for each research activity are presented in point form and supporting figures.

1 Juvenile Chinook Outmigration Assessment

- DFO collaboration:
    - 2021-2023, 2025: DFO's Otolith Microchemistry Study (size class subsampling)

  - 2022-2024: Diet Analysis (stomach content)
  - 2023-2024: DFO's Follow-the-Fish Study
  - 2024: DFO's Relative Reproductive Success Study
- Estimates on Naturally produced Chinook outmigrants have occurred annually since 2017 using a rotary screw trap (RST).
- RST has operated daily from early to late February to approximately mid-June (pending water level to operate the RST).
- All wild Chinook captures are enumerated daily and 30 fish per week are measured for weight and fork length.

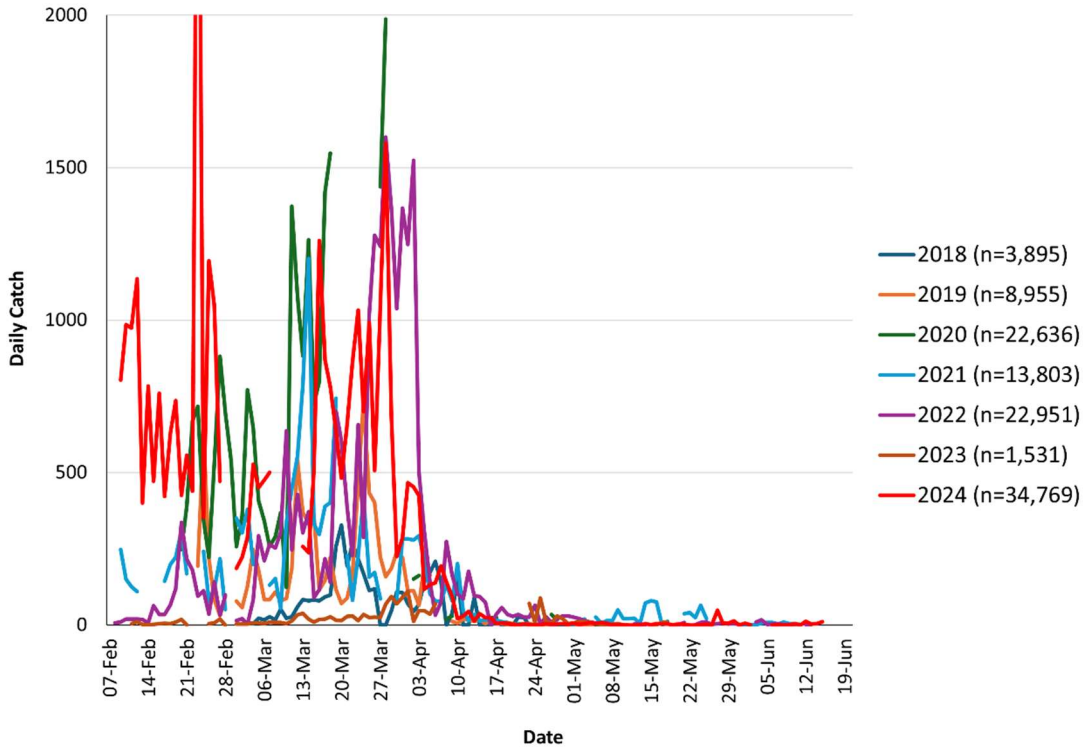


Figure 1. Daily enumeration of wild juvenile Chinook Salmon from the Sarita River RST from 2018 to 2024. 'N' value in legend parentheses are total Chinook counted for that respective year. A count of 3,356 Chinook occurred on 23 February 2024. Small pulses of larger fish occurred in May 2021 and 2024.

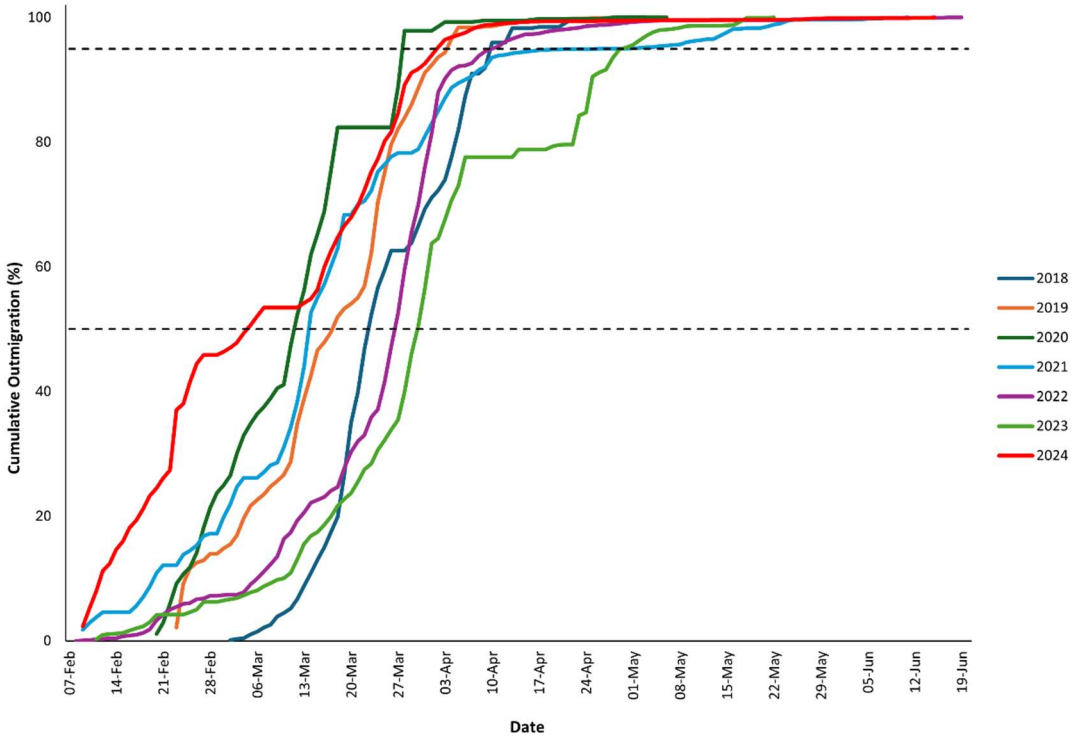


Figure 2. Cumulative daily outmigration of wild Chinook Salmon from the Sarita River RST from 2018-2024. 'Dotted' horizontal lines represent 50% and 95% of the migration. RST operations start and finish dates varied across years with subsequent years starting earlier in response to a learned understanding of early outmigration patterns. End dates were determined by water levels to effectively operate the trap – wetter springs allow the trap to operate later into mid-June. Horizontal lines (i.e., no increase in cumulation) reflect time gaps when the RST was not fished – mostly due to high flow/rain events.

- All wild Chinook captures are marked with Bismark Brown from 4 to 5 consecutive days weekly during RST operation and released upstream at Hunter Creek (1 km upstream) confluence for recapture and quantify trap efficiency to generate an outmigration estimate stratified by week. Estimates are calculated using the time-stratified Bailey estimator.
- 95% of Chinook migrate past the RST before mid-April in all years sampled (Figure 1, Figure 2), and 50% migrate before mid-March. In all years sampled, juvenile Chinook were observed on the first day of RST operation, indicating that the start of outmigration is early and before February. During years with exceptionally warm winters, outmigration was very early (e.g., 800 captures on 09 Feb 2024 representing 2.3% of the total sampling period).
- Annual outmigration estimates ranged from 59,410 (2023) to 832,306 (2022) and an average of 426,590 since 2018 (Figure 3). Factors contributing to this variation include autumn rainfall (i.e., access to South Sarita and upstream reaches on mainstem Sarita) and escapement size (i.e., number of natural spawners). These factors are explained in greater detail in 4. Sarita Chinook Spawning Distribution and Environmental Drivers

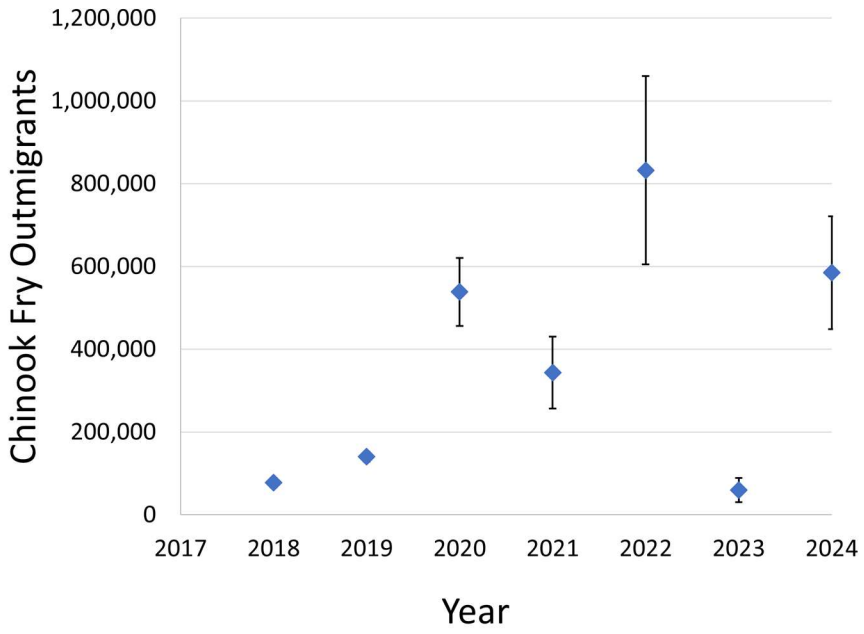


Figure 3. Annual (2018-2024) outmigration estimates of naturally produced Chinook Salmon in the Sarita River. 95% confidence intervals are included with each estimate.

- Egg-to-fry survival estimates were generated per outmigration year monitored and ranged from 2.0 to 37.5 percent (Table 1). Data on sex ratio, escapement and natural spawner estimate, fecundity (i.e., egg count per female) were provided by DFO's Nitinat Hatchery.

Table 1. Egg-to Fry Survival estimates of naturally-produced Chinook Salmon in the Sarita River for outmigration years 2018-2024.

Brood Year	Outmigration Year	Adult Escapement	Num. of Adult River Spawners	Female Ratio (%)	Num. of Females	Average Fecundity	Num. of Eggs deposited	Outmigration Estimate	Egg-to-Fry Survival (%)
2017	2018	2,307	2,063	48.0	990	3,928	3,889,663	77,174	2.0
2018	2019	1,615	1,335	34.9	466	3,256	1,517,019	140,138	9.2
2019	2020	1,727	1,329	29.2	388	3,695	1,433,911	538,276	37.5
2020	2021	1,844	1,390	27.8	386	3,460	1,337,013	343,263	25.7
2021	2022	2,382	1,821	44.1	803	3,489	2,801,880	832,306	29.7
2022	2023	2,870	1,705	18.5	315	3,287	1,036,802	59,410	5.7
2023	2024	4,110	3,128	37.9	1,186	3,148	3,731,992	584,646	15.7
	Average	**2,425**	**1,775**	**32.07**	**587**	**3,389**	**1,965,102**	**426,590**	**20.6**

- The proportion of outmigration past April 30 was less than five percent annually since 2021 and occurred below one percent in 2022 and 2024 (Table 2). According to LaForge et al. 2025, late emigrating large(e.g., >50 mm) Chinook smolts result in a disproportionate make up of the adult return relative to the higher production of early smalls, at about 38% (over 10x greater survival) of the returning wild adults. While early smalls (<50 mm) have a lower survival rate, they comprise over 62% of the returning wild adults and return at an older age class (4- and 5-year-old Chinook). The late larges were typically younger at adult return (3- and 4-year olds).

Table 2. Proportion of the annual outmigration of naturally-produced Chinook Salmon in the Sarita River after April 30 from 2021 to 2024.

Outmigration Year	RST Operations	Early/Smalls Estimate (to April 30)	Late/Larges Estimate (after April 30)	% Late/Larges
2021	09 Feb–11 Jun	326,178	16,567	4.83
2022	08 Feb-19 Jun	825,307	5,614	0.67
2023	11 Feb-22May	56,538	1,859	3.13
2024	09 Feb-15Jun	577,210	5,041	0.87

- In-stream growth of outmigrating wild Chinook smolts occurs from late April onwards and correlates positively with successful foraging (Figure 4, Figure 5). The mean length frequency of early outmigrants (to about mid-April) is similar across years at about 40 mm and varies more notably afterwards with the later outmigrants. Mean water temperature in April and May 2022 was colder than other years which reflects delayed in-stream growth. Late outmigrant (May-June) mean fork length averaged 10 to 15 mm greater across years relative to the early migrants (before May). Most Chinook outmigrants do not feed in-stream in February to April but rather head directly to the estuary to forage. Active feeding is most apparent in May and June and diet was opportunistic which comprised a variety of insects from terrestrial and aquatic origin. For fish biosampled from 2022-2024, stomach fullness (ranked as either 'empty', 'trace', 'half', or 'full') was a statistically significant predictor of fork length ($F_{3,543} = 21.5$, $P < 0.0001$) overall, and for each year individually, with the emptiest fish being the smallest. Fish sampled prior to May had a significantly different distribution of fullness values ($\chi^2 = 113.6$, df = 3, $P < 0.0001$) than fish sampled from May onwards, which the early fish showing a disproportionate number of empty stomachs, and late fish having disproportionately more full and half-full stomachs (Figure 5).

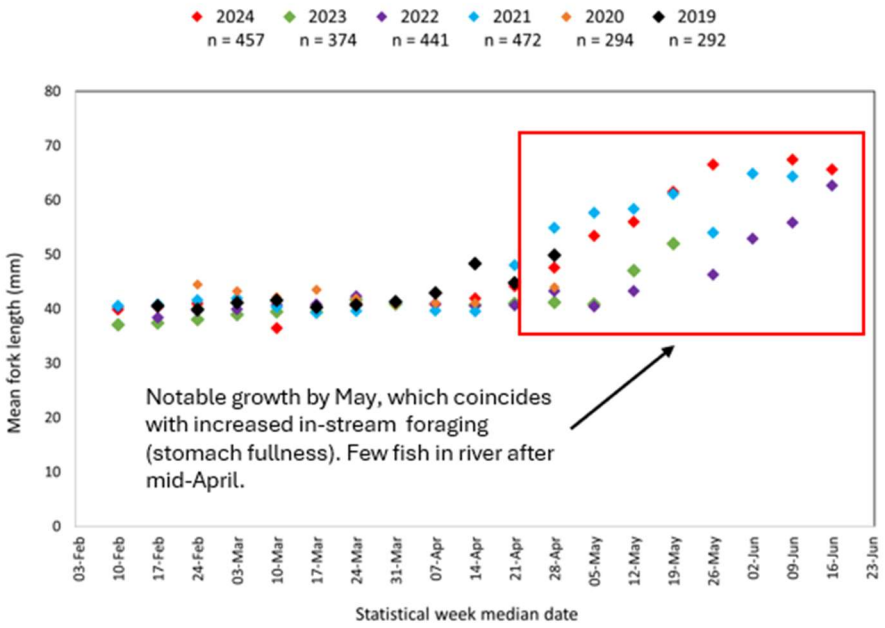


Figure 4. **Mean fork length (mm) of outmigrating wild Chinook Salmon from the Sarita River during RST operations from 2019-2024.** Sample size is the 'n' value under each year in the legend.

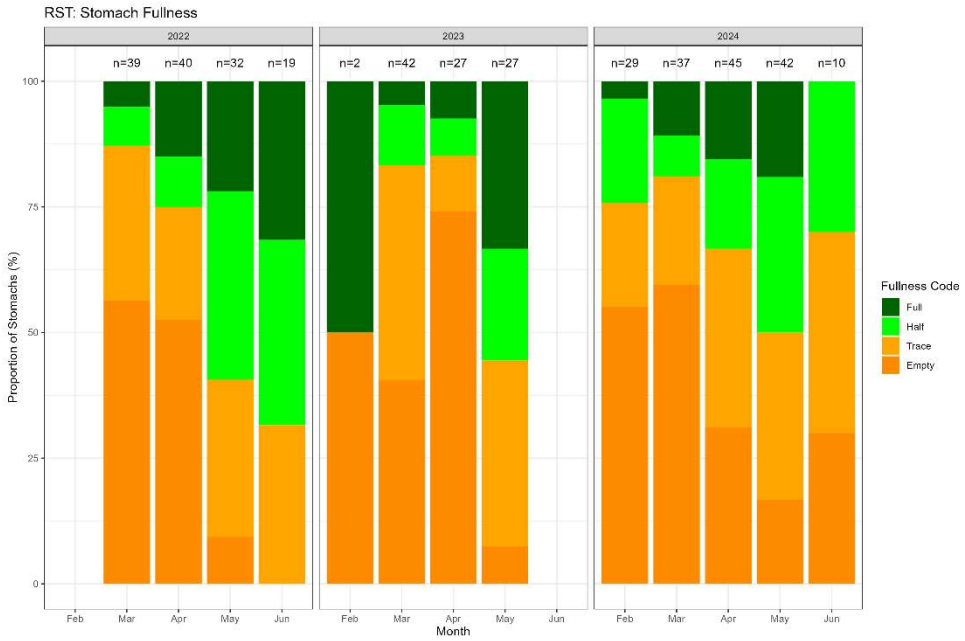


Figure 5. **Stomach fullness proportion by month of sampled wild Chinook outmigrants from the Sarita River RST (Years 2022-2024) as a proxy of in-stream feeding activity/success.** Full and half-full stomachs indicate active/successful feeding, while trace and empty stomachs suggest inactive/poor foraging. 'n' value under each year/month = number of stomachs sampled.

- RECOMMENDATION:
  - Continue RST operations with mark-recapture annually to monitor population productivity.

- Start RST operations earlier (e.g., January) to catch beginning of migration (Chinook outmigrants were observed on first day in all years sampled – e.g., 800 on 09 Feb. 2024). Shift RST earlier as necessary in response to warmer winters and climate change.
- Operate RST in May and June (and later if water levels permit) to assess late/large migrants.
- Operate RST to collect data to support DFO's Westcoast Chinook Rebuilding Plan, and to identify the Sarita River as a key ecological indicator for WCVI Chinook SMU.

2 Juvenile Chinook Distribution and habitat use in Sarita estuary

- Estuary fish sampling commenced in 2017 as part of an environmental impact assessment for the Kwispaa LNG terminal project and for the Huu-ay-aht Watershed Renewal project:
  - 2018: Breached causeway to improve fish access to 'high quality' habitat in two anthropogenic pools (Photo 1).
  - 2020: Constructed distributary channel to connect mainstem to the pools (Photo 2).
  - 2021-2025: Fish sampling from February to July to describe spatial and temporal estuary use by salmon and other fishes and long-term effectiveness of the breached causeway and constructed distributary channel. Part of the BCSRIF project to make Sarita River an ecological indicator for the WCVI Chinook Management Unit.
  - 2024: Chinook sampling supported Follow-the-Fish program.
  - 2023-2024: Eelgrass mapping (Photo 3).

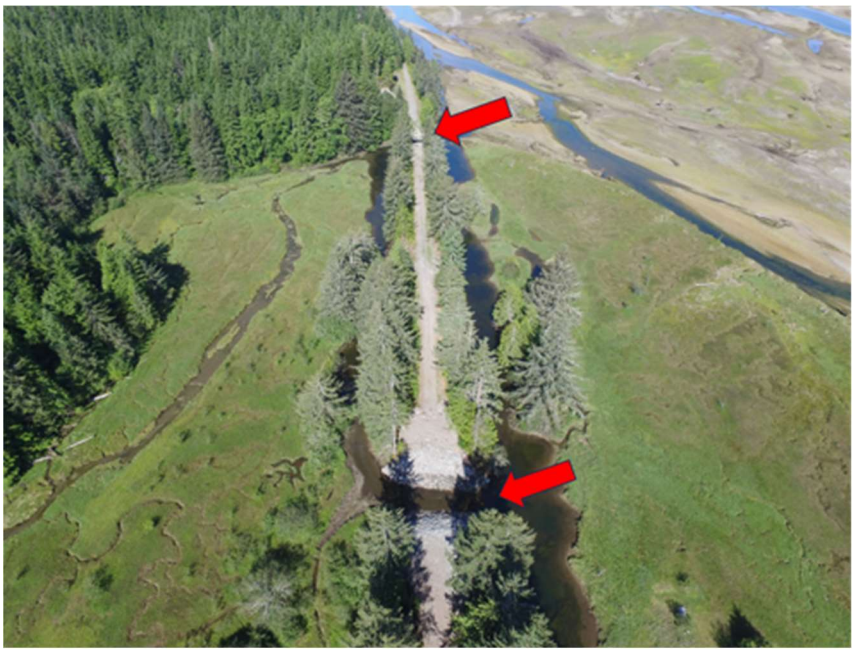


Photo 1. Causeway breaches (red arrows) in the southern portion of the Sarita River estuary.



Photo 2. Constructed distributary channel (red circle) connecting the Sarita mainstem to anthropogenic pools with high-quality fish habitat.

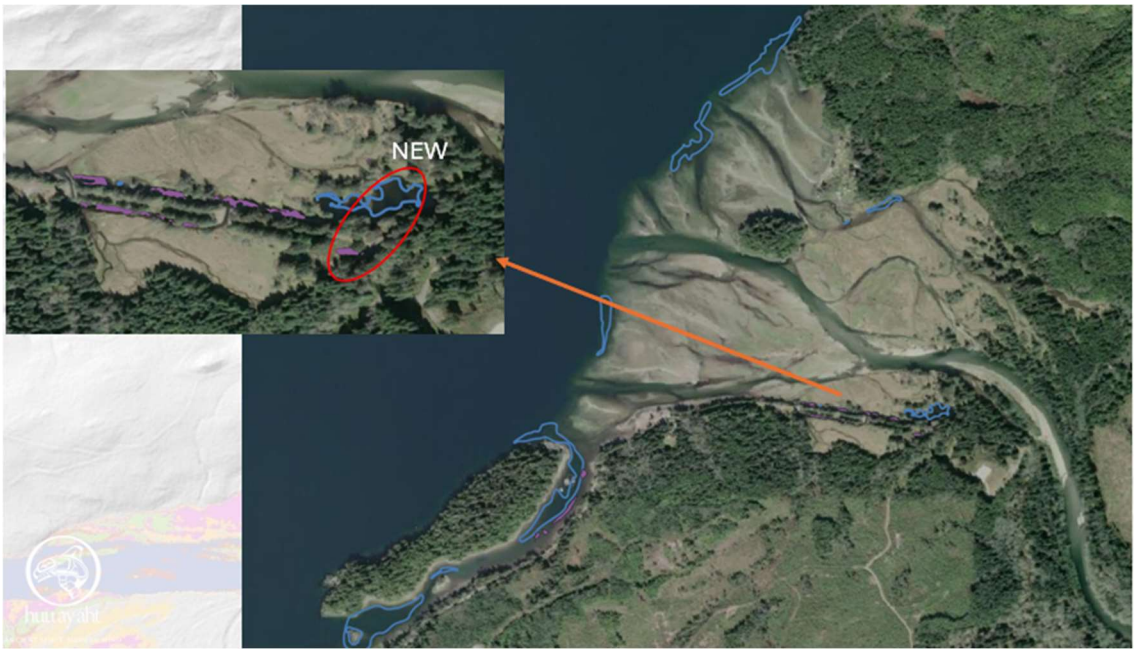


Photo 3. Spatial distribution of eelgrass (*Zostera* sp.) in 2023 as mapped by a single-beam echosounder (blue polygons) and sub-meter GPS delineation by foot (purple polygons). New eelgrass patches (anecdotal) in red circle (inset map) since causeway breaching.

- Estuary fish sampling occurred bi-monthly from March to May and once per month in February and June to July in 2021-2024. 24 stations stratified by habitat were sampled (Figure 6). Beach seining was the primary catch method across sampling stations. A 1 m fyke net was used on the 2020 constructed distributary channel due to its narrow width and tall banks not conducive to beach seining. Chinook smolt presence in the estuary aligned closely with presence in-stream (i.e., freshwater) indicating quick migration

into estuarine environment and short residency in estuary. Chinook smolts occupied all available habitats (including anthropogenic pools and constructed channel) and no pattern was evident in habitat preference. Most Chinook departed estuary by end of April – similar to in-stream emigration.

- Wild Chinook smolt fork length increased substantially from February to July in all years sampled (Figure 7). According to LaForge et al 2025, Chinook smolts enter the estuary in two time periods, each representing different size classes. The distribution of lengths between in-stream outmigrants and estuary fish align very well – minimal increase from February through April (avg. 40-45 mm) and abrupt increase in May through July (increase from 50 to 65 mm). Estuary sampling.
- Hatchery Chinook spend nearly no time in the estuary upon release (late May and June) based on very few catches (Figure 7).
- In all years sampled, wild chinook smolts feed heavily in the Sarita estuary in all months (Figure 8) and more than 75% of sampled stomachs were full or half full in all months. Dietary composition of sampled stomachs was diverse across 12 orders of invertebrate – largely insects (dipterans and unknown insects), amphipods and copepods in all months sampled (Figure 9). Diet origin comprised both terrestrial and aquatic sources indicating Chinook Smolts are opportunistic predators.

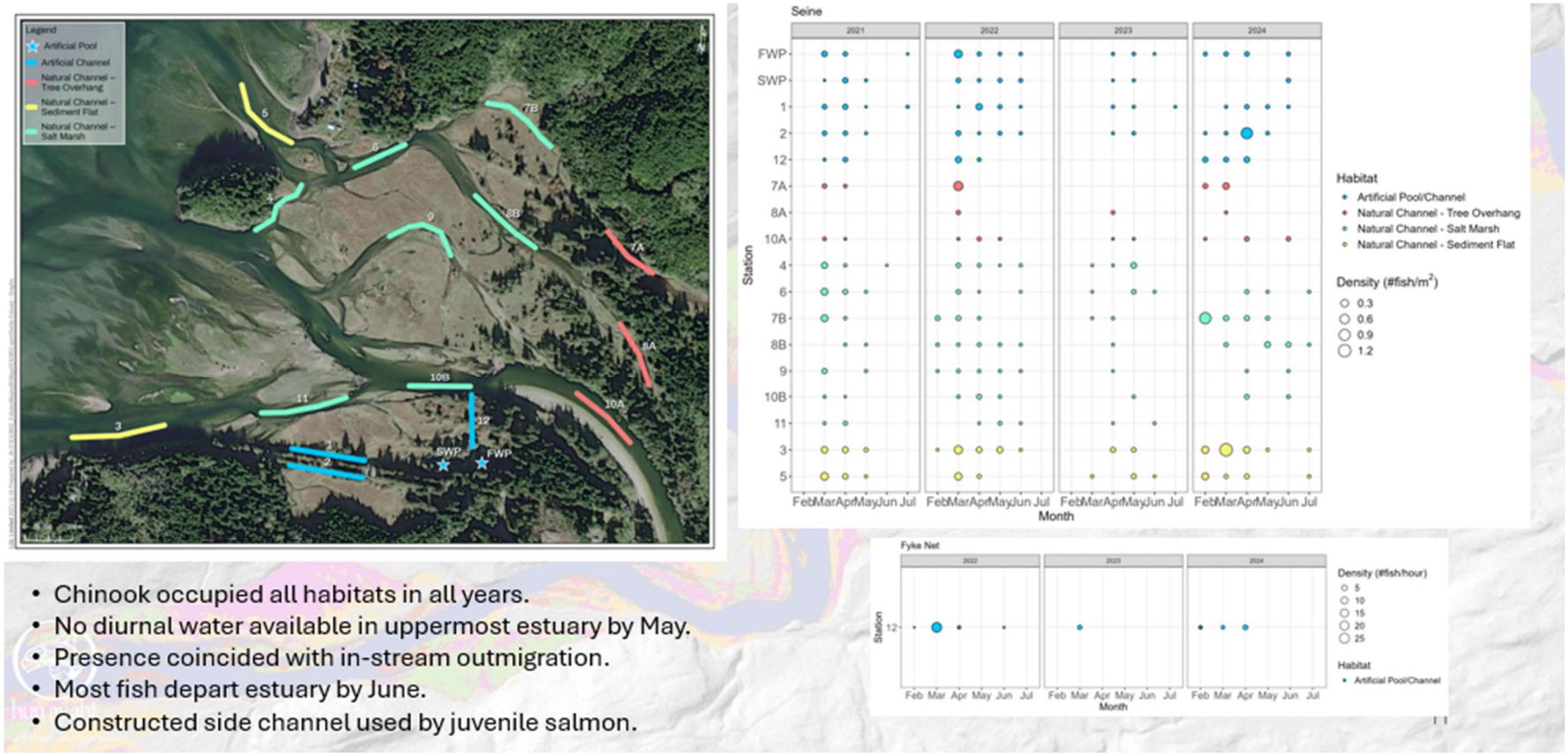


Figure 6. Spatial and temporal distribution of wild Chinook Salmon smolts by month (February to July) across 17 sampling stations representing four habitats in the Sarita estuary, years 2021-2024.

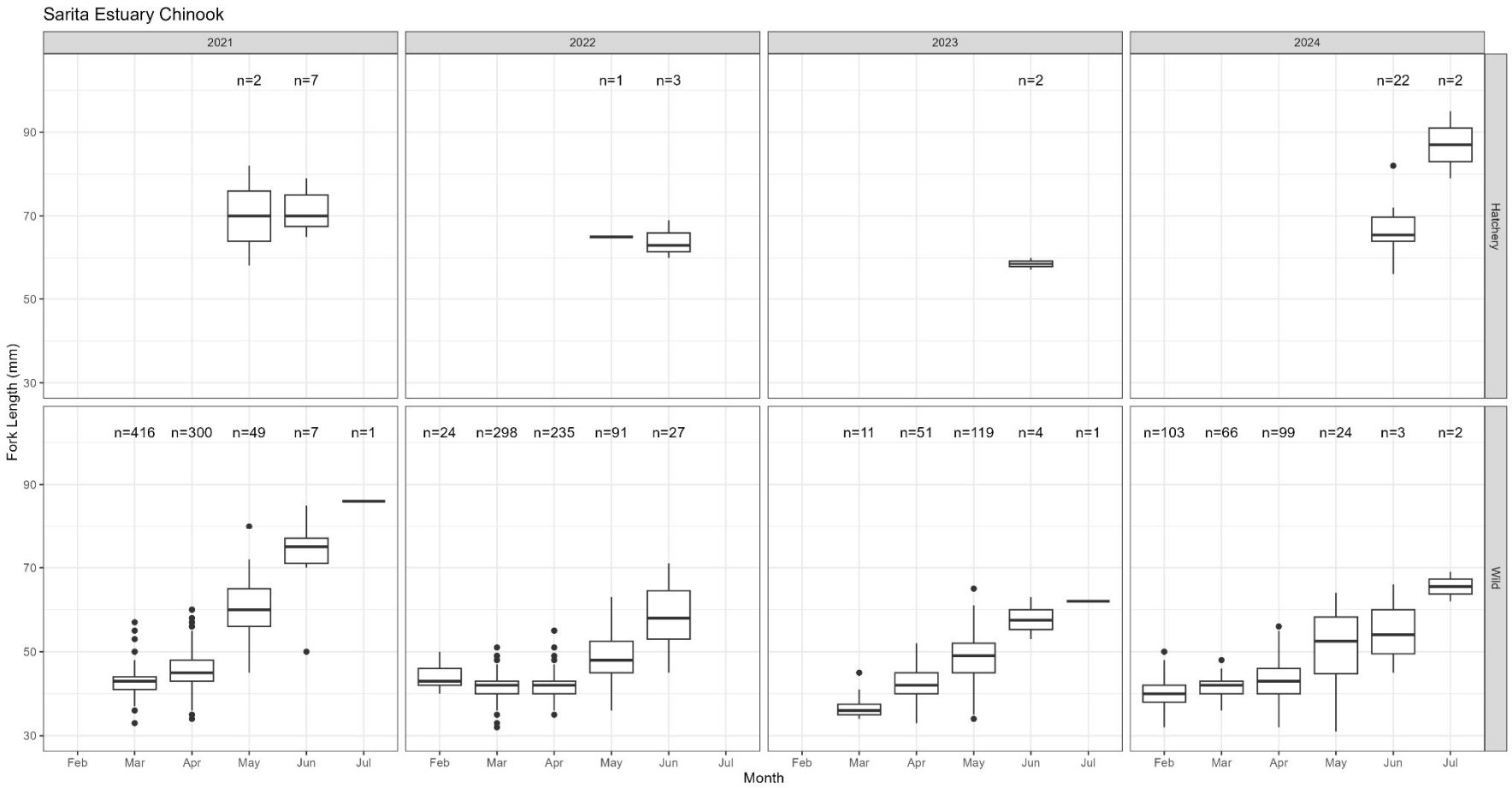


Figure 7. Mean fork length (mm) of hatchery (top row) and wild (bottom row) Chinook Salmon by month (Feb.-Jun.) from the Sarita River estuary 2021-2024. Sample size is the 'n' value under each month/year in the legend.

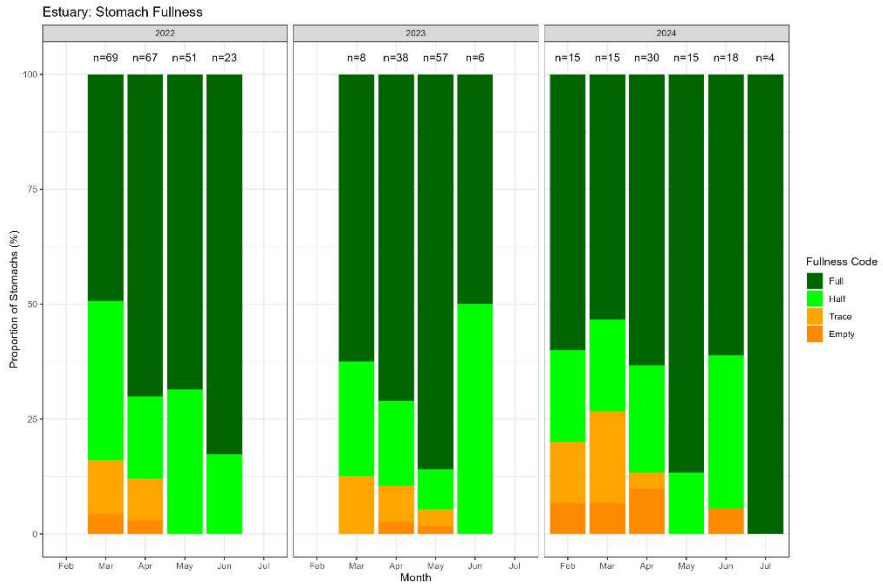


Figure 8. Stomach fullness proportion by month of sampled wild Chinook outmigrants from the Sarita estuary (Years 2022-2024) as a proxy of feeding activity/success. Full and half-full stomachs indicate active/successful feeding, while trace and empty stomachs suggest inactive/poor foraging. 'n' value under each year/month = number of stomachs sampled.

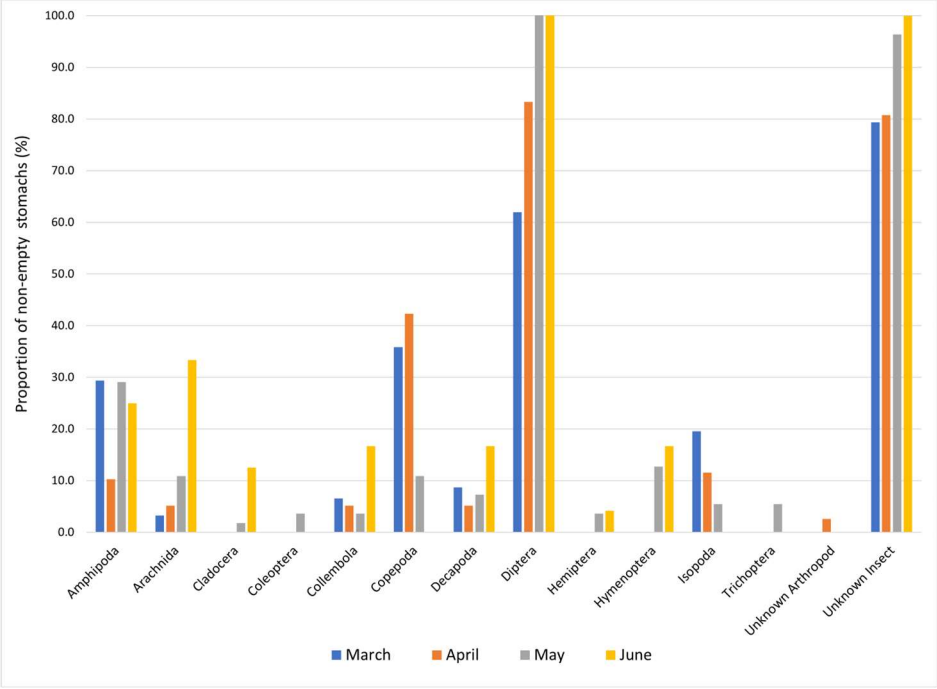


Figure 9. Dietary composition of wild Chinook Salmon smolt stomachs by month (March-June) for years 2022-2024, combined. Invertebrate taxa were categorized by Order.

3 Juvenile Chinook Distribution and sampling in Numukamis Bay

- Sampling for juvenile Chinook Salmon in Numukamis Bay (herein after 'Bay') commenced in 2023 as part of the HFN/LGL BCSRIF research in support of making Sarita Chinook Salmon an ecological indicator for the WCVI Chinook Salmon Rebuilding.
- 2024: Chinook sampling supported Follow-the-Fish program
- Bay sampling occurred bi-monthly June-August (2023), and April-August (2024) across 23 sampling stations spread throughout Numukamis Bay using a combination of beach and purse seine methods. A subsample of catch were subsampled for length and diet analysis (i.e., stomachs). Subsamples were stratified by fish origin (hatchery vs wild) and length (<100 mm and ≥ 100 mm).
- While catch densities were low, Chinook were observed in all stations sampled (Figure 10). Both wild and hatchery-origin fish were observed in shallow water (less than 2 m; beach seine) in April and May before moving into deeper water (greater than 4 m) by June. Nearly all juvenile Chinook were absent in shallow water by July. It is unknown if captured fish were from other rivers as well as Sarita – DNA samples sent to Follow-the-Fish program to determine origin/stock.
- Mean fork length increased over time and exceeded 100 mm by August for wild and hatchery Chinook (Figure 11).
- In both years sampled, juvenile hatchery and wild chinook were mostly full or half full in all months sampled (Figure 12). It is unknown why a larger proportion of stomachs are empty or have trace amounts of food relative to the estuary. Dietary composition of sampled stomachs was diverse across seven orders of invertebrates and one fish (Pacific Herring) originating from both terrestrial (e.g., insect orders) and aquatic (e.g., decapods, amphipods, copepods) sources, indicating opportunistic foraging in midwater column and surface.(Figure 13). There was no temporal prey preference between wild and hatchery fish, however, insects appeared to be the most common prey item for both fish.

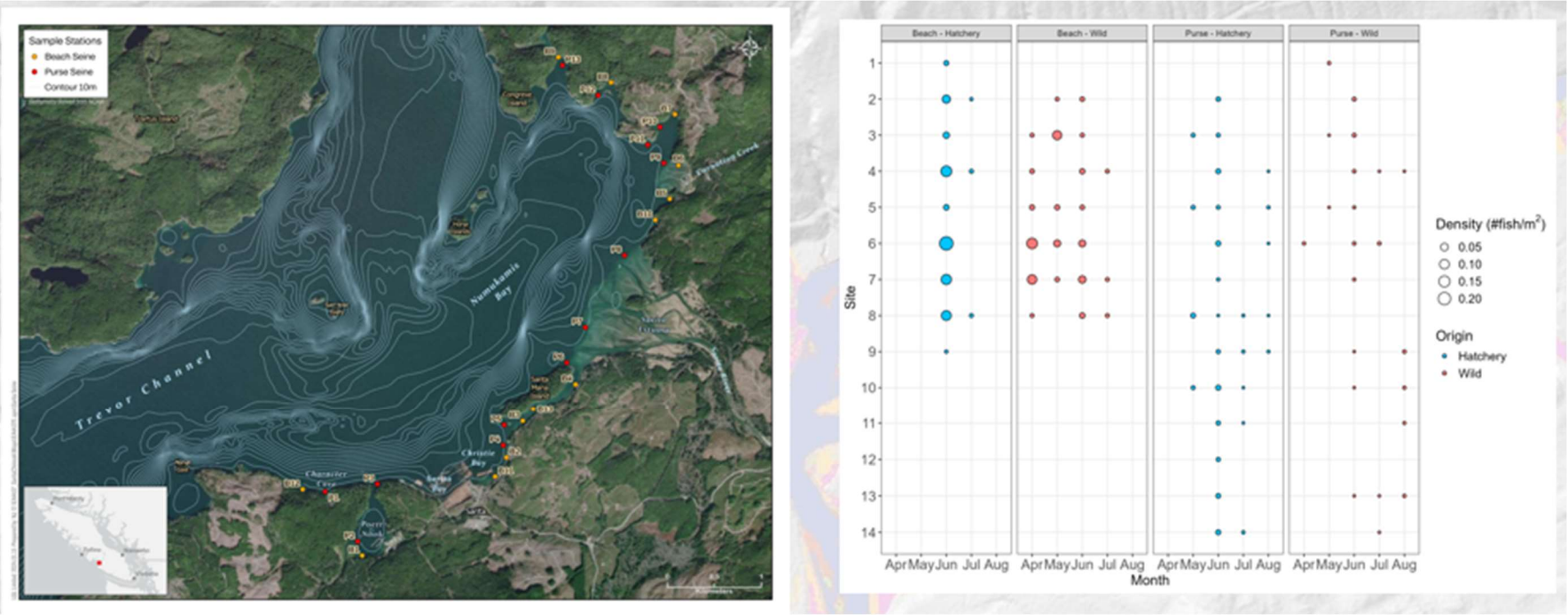


Figure 10. Spatial and temporal distribution of Chinook Salmon smolts (hatchery and wild) by month (April to July) across 23 sampling stations in Numukamis Bay, years 2023-2024. Sampling in 2023 occurred June-August.

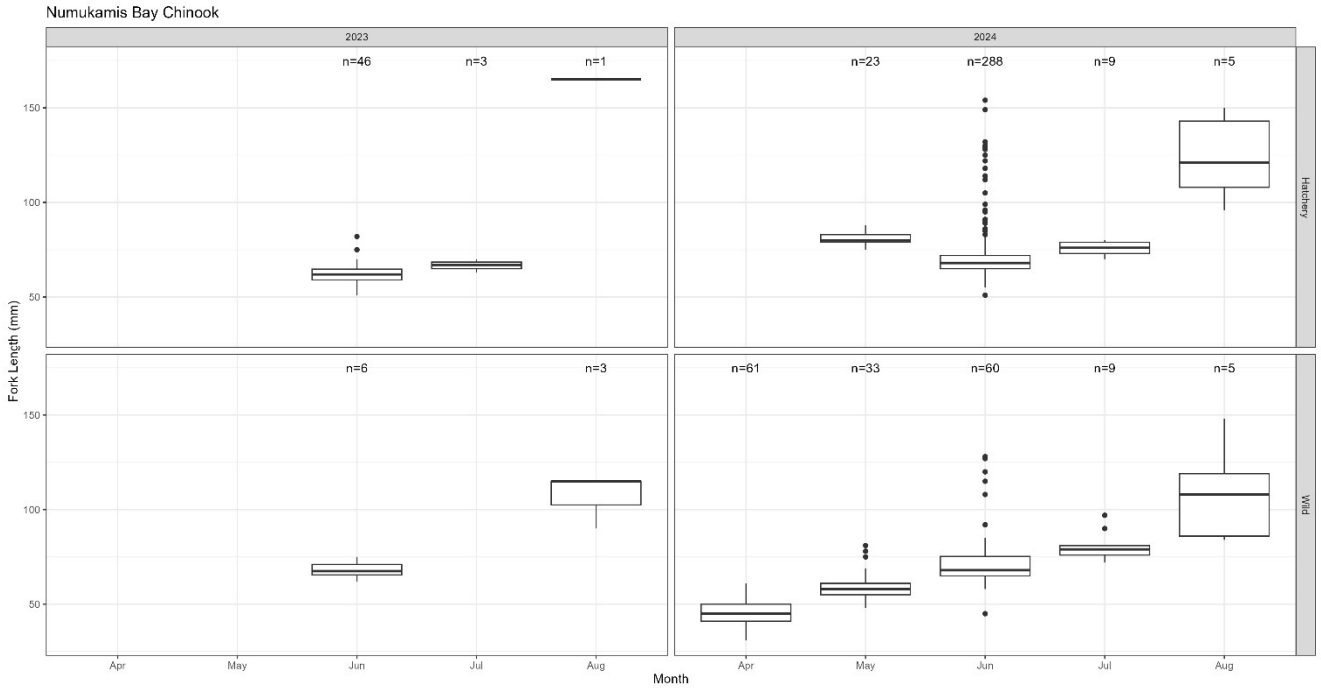


Figure 11. Mean fork length (mm) of hatchery (top row) and wild (bottom row) Chinook Salmon by month (Apr.-Jun.) from Numukamis Bay 2023-2024. Sample size is the 'n' value under each month/year in the legend.

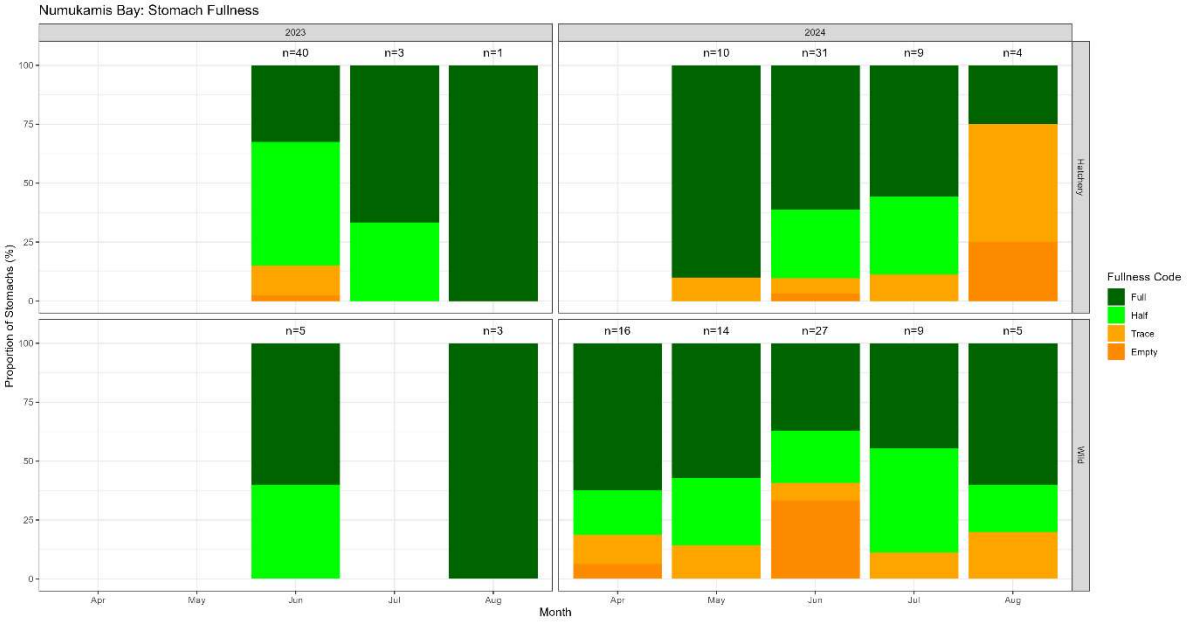


Figure 12. Stomach fullness proportion by month of juvenile hatchery (top row) and wild (bottom row) Chinook Salmon from Numukamis Bay (Years 2023-2024) as a proxy of feeding activity/success. Full and half-full stomachs indicate active/successful feeding, while trace and empty stomachs suggest inactive/poor foraging. 'n' value under each year/month = number of stomachs sampled.

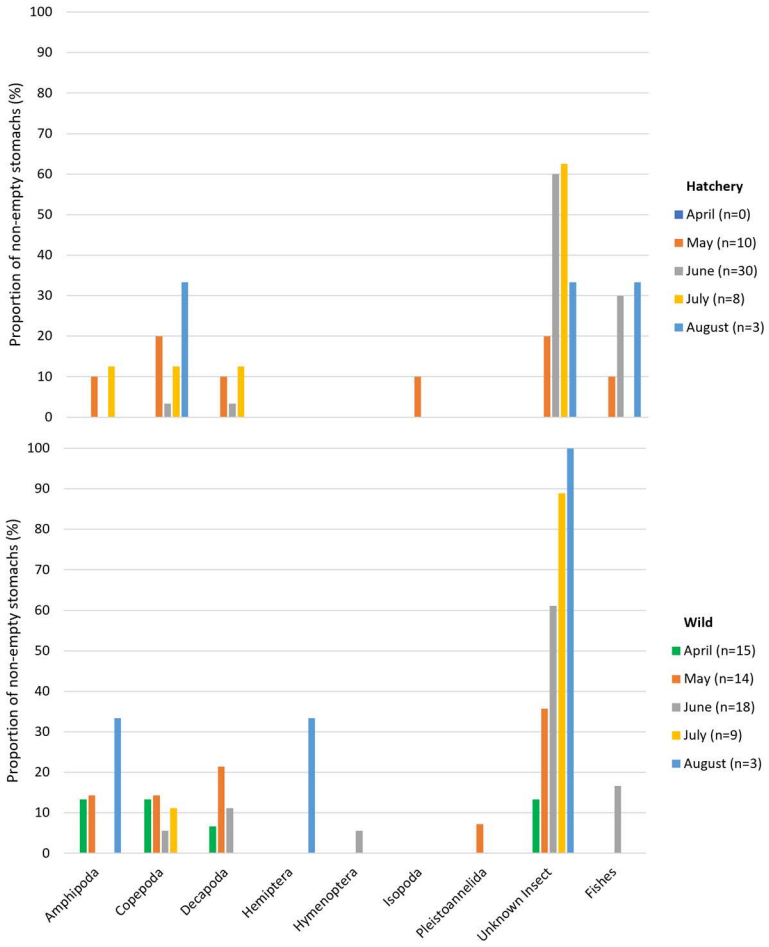


Figure 13. Dietary composition of hatchery (top) and wild (bottom) juvenile Chinook Salmon stomachs by month (April-August) for years 2023-2024, combined. Invertebrate taxa were categorized by Order.

4 Sarita Chinook Spawning Distribution and Environmental Drivers

Background:

- Chinook Salmon redds were mapped in the Sarita River from 2022 – 2024. The final year of redd mapping will occur in 2025. Chinook Salmon redds were also mapped during a spawning superimposition study in 2017 (Burns et al. 2018). Sarita River Chinook Salmon escapement estimates are generated by Huu-ay-aht First Nation (HFN) and DFO. Chinook Salmon fry outmigration estimates are generated by HFN and LGL. Escapement and fry outmigration estimates can be combined to examine productivity measured as fry outmigrants per adult spawner. Annual productivity information can be compared to environmental conditions experienced by spawners to examine drivers of Chinook Salmon productivity in the Sarita River.

Preliminary Results:

- HFN and LGL have observed a wide range of Chinook Salmon fry outmigration abundance since starting the rotary screw trap (RST) program in 2017. Some years fewer than 100,000 fish have emigrated from the system, while in other years the outmigration estimate is greater than 800,000.
- The lowest outmigration estimates have occurred following brood years 2017 (77,174 [65,408 – 88,940]; Burns 2018) and 2022 59,410 (30,452 – 88,368; Roias and Manishin 2024). The Sarita River experienced

drought conditions during the 2017 and 2022 Chinook Salmon spawning seasons. Mean daily discharges of less than 1 m3/s were observed until October 16 in 2017 and Oct 25 in 2022 (Figure 14).

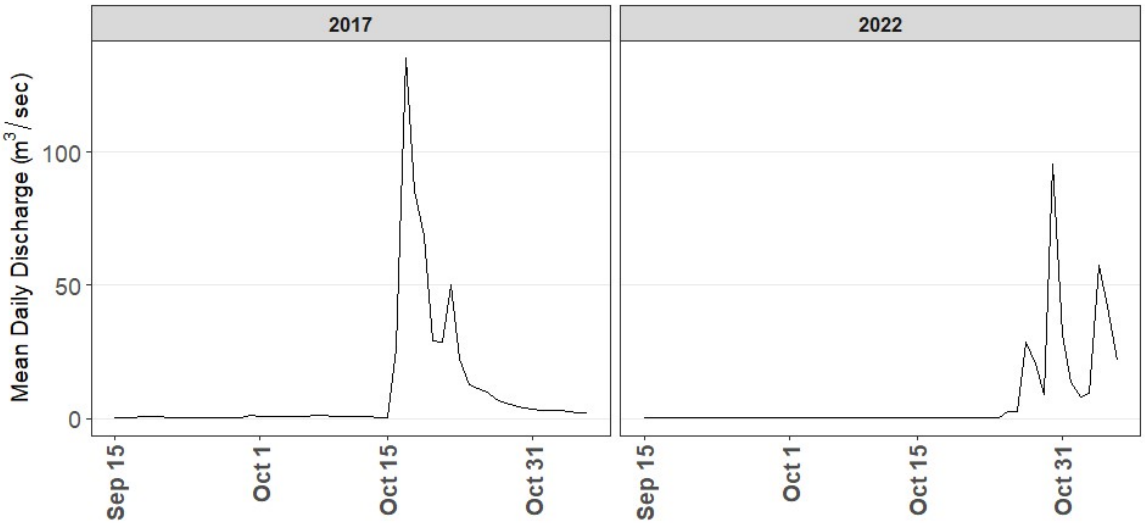


Figure 14. Mean daily discharge of the mainstem Sarita River during the 2017 and 2022 Chinook Salmon spawning seasons. These years represented dry falls (i.e., no rain until mid-late October) and corresponding poor spawning (i.e., limited to lower reaches below South Sarita confluence). Source: Real-time hydrometric data (station 08HB014; Water Survey Canada 2024).

- In both 2017 (Figure 15) and 2022 (Figure 16), the majority of Chinook Salmon spawning took place in the mainstem Sarita River downstream of the confluence with the South Sarita River. Additionally, in 2022 some returning adults were observed spawning in the riffle just above tidal influence. This riffle can be inundated at the highest tides, which would result in saline intrusion into the Chinook Salmon redds and low egg survival. Spawning so far downstream in the Sarita River is not typical for Chinook Salmon.
- The highest outmigration estimates have occurred following brood years 2021 (832,306 [604,630 – 1,059,982]; Roias and Manishin 2023, *revised*) and 2023 (584,646 [448,074 – 721, 218]; Roias and Manishin *unpublished data*). In 2021, the summer drought subsided by September 16 and continued to receive precipitation throughout the Chinook Salmon spawning season. In 2023, precipitation events punctuated low flows on September 25 and October 9 (Figure 17). Redd mapping was not conducted in 2021. Redd mapping in 2023 showed increased Chinook Salmon spawning activity upstream of the confluence with the South Sarita River than in 2017 and 2022 (Figure 18).

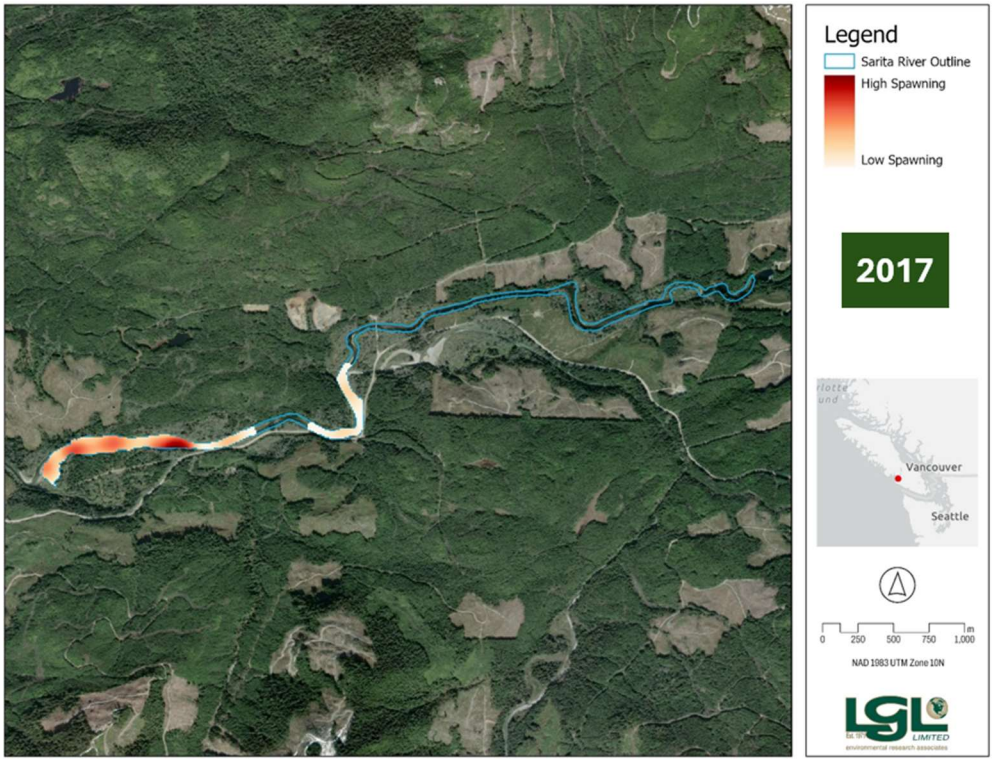


Figure 15. Chinook Salmon spawning intensity along the anadromous section of the mainstem Sarita River, 2017.

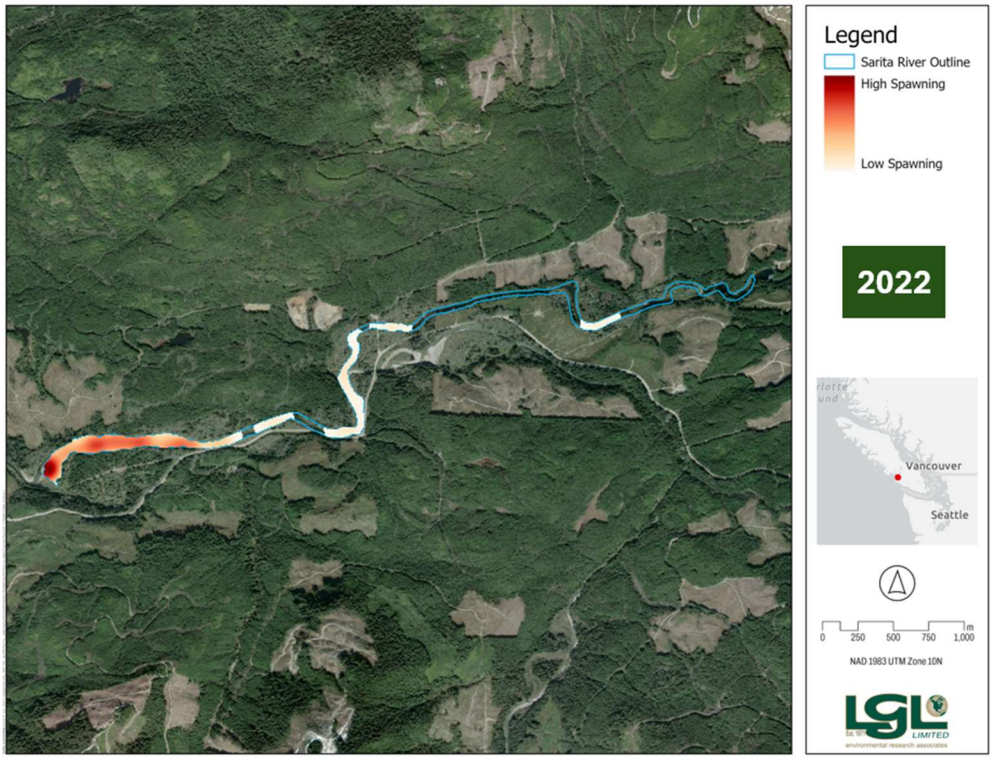


Figure 16. Chinook Salmon spawning intensity along the anadromous section of the mainstem Sarita River, 2022.

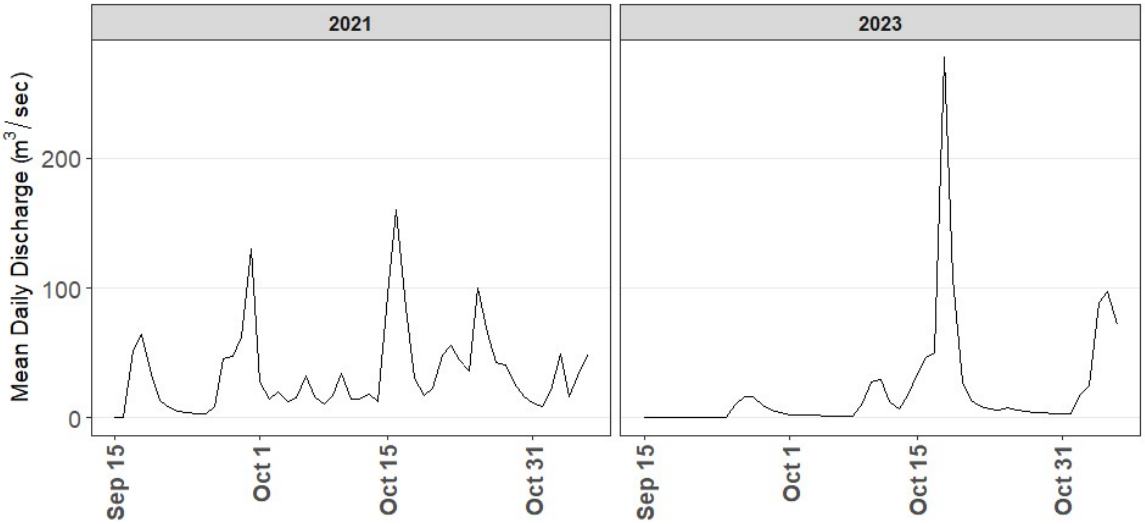


Figure 17. Mean daily discharge of the mainstem Sarita River during the 2021 and 2023 Chinook Salmon spawning seasons. These years represented wet falls (i.e., sufficient rain in October) and corresponding good and widespread spawning. Source: Real-time hydrometric data (station 08HB014; Water Survey Canada 2024).

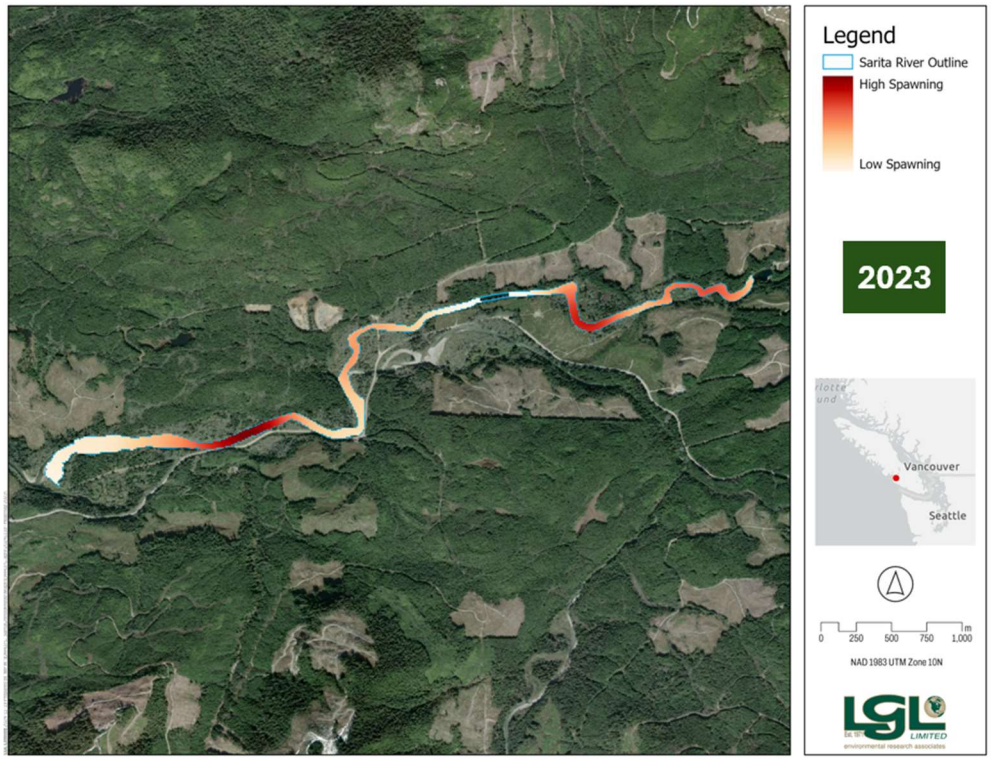


Figure 18. Chinook Salmon spawning intensity along the anadromous section of the mainstem Sarita River, 2023.

- The flow conditions during the Chinook Salmon spawning season can be quantified as the percent of days in October with mean daily discharge greater than 5 m^3/s. When a linear regression is performed to relate this flow statistic to the log of fry per returning adult, the resulting relationship has an adjusted-R^2 of 86% (Figure 19).

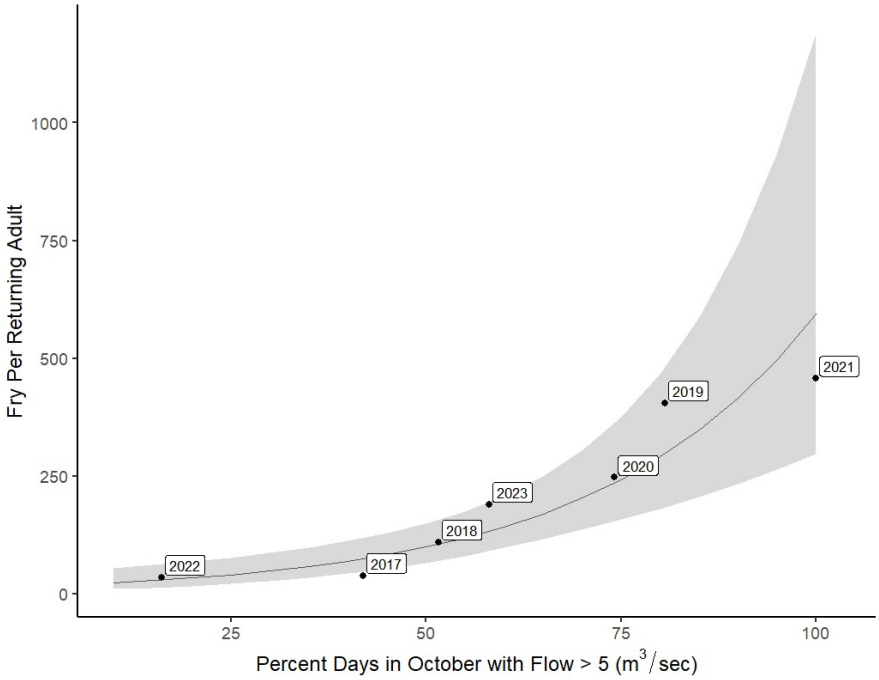


Figure 19. Predicted fry per returning adult (line) and 95% confidence interval (grey band) from a linear regression of percent of days in October with mean daily discharge greater than 5 m^3/s and log of observed fry per returning adult.

Conclusion:

- When drought conditions occur during the Chinook Salmon spawning season, returning adults spawn downstream of the confluence of the South Sarita River and the resulting outmigrating fry per spawner is reduced. Following spawning seasons when precipitation events disrupt the summer drought during the Chinook Salmon spawning season, spawning activity is distributed more evenly upstream and downstream of the confluence with the South Sarita River. An increased number of outmigrating fry per spawner are observed following these wetter falls. Flow during the spawning period can be quantitatively summarized as percent of days in October with mean daily discharge greater than 5 m^3/s. This measure of flow appears to be a good predictor of outmigrating fry per returning adult produced in a given brood year.

Discussion:

- These results show evidence of flow mediated population productivity of Chinook Salmon in the Sarita River. We hypothesize that the mechanism by which flow limits or enables production is through passage past a critical riffle just below the confluence of the mainstem and South Sarita.
- Horel (2021) reported that the lowest reach of the South Sarita River (Reach 20) is aggraded and widening due to bank erosion. Though 1927 air photos indicate this area has always been a depositional zone, channel instability increased when it was logged to the banks during early industrial forestry (1957 airphoto, Horel 2021). Since this extensive riparian logging, a major right bank meander has been migrating downstream toward the confluence with the mainstem, eroding more riparian forest and impinging upon Bamfield Main. Air photos also show increasing sediment accumulation at the Sarita and South Sarita confluence since 2007. A bedrock feature in the Sarita River mainstem extends across approximately 50% of the low-flow channel and appears to be slowing the emigration of sediment delivered to the mainstem from Reach 20. The South Sarita sediment source and mainstem bedrock feature combine to form a critical riffle that requires rapid elevation gain for upstream travel and can dewater at low flows.

- Here we present a potential physical bottleneck to population productivity for Sarita River Chinook Salmon. Major population benefits could be realized if returning adults are able to migrate past the confluence with the South Sarita River under low flow conditions. Additionally, little is known about current and past Chinook Salmon spawning utilization of the South Sarita River itself. Chinook Salmon carcasses have been observed upstream of the aggraded area (Burns and Plate 2018) indicating that some habitat is used when spawners have access. Currently, the downstream end of Reach 20 can completely dewater and block passage higher into this major tributary of the Sarita River. Additional population benefits may also be realized if fish passage is improved through this reach.

5 Sarita Riparian and Aquatic Invertebrates Assessment

- Aquatic macroinvertebrate sampling (kick net) was conducted along four reaches of the Sarita River in March of 2024 (Figure 20) and the timing was chosen to coincide with peak outmigration of juvenile salmon:
    - Reach 1 – Edge of tidal influence, upstream to the confluence with the South Sarita.
    - Reach 2 – Main branch of the Sarita, from the confluence upstream to Sarita Falls.
    - Reach 3 – Upstream of Sarita Falls towards the outlet of Sarita Lake.
    - Reach 4 – South Sarita River, upstream of the confluence.

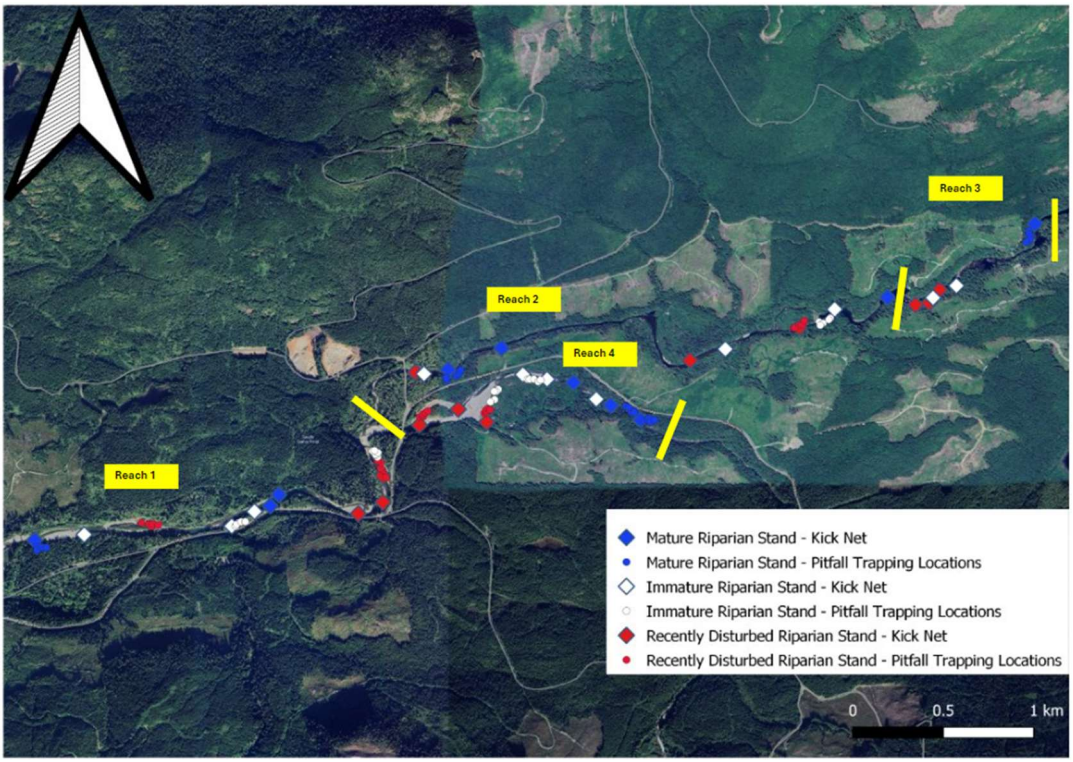


Figure 20. Distribution on invertebrate sampling in three reaches of the Sarita River mainstem and one reach of the South Sarita River.

- Terrestrial arthropod collections (pitfall trapping) took place in riparian areas along the Sarita and South Sarita River in May of 2024. Timing coincides with heighten activity period and emergence timing for most species following completion of overwintering.
    - Terrestrial collections currently undergoing processing and identification.
- Both aquatic and terrestrial collections were stratified across three treatment types.

- Mature Riparian Stand – Established canopy structure primarily comprised of coniferous species.
- Immature Riparian Stand - Established canopy structure primarily comprised of deciduous species.
- Recently Disturbed Riparian Zone – Lack of established canopy structure or vegetation.

- 1809 individuals were collected in kick nets.
- 62% of individuals collected belonged to a guild of organisms known as EPT's (Ephemeroptera, Plecoptera, and Tricopeta) (Figure 21).
  - Organisms are reliable indicators of aquatic health and physical characteristics of the river (Danehy & Moldenke, 2016).
  - Organisms have the potential to serve as high quality food resources for opportunistic juvenile salmon (Grunblatt et al., 2019).
- Diptera also present in large number and 88% of Diptera collected belong to the family Simuliidae which are known to be inversely corelated with Salmon Redds and who are primarily predated upon by other invertebrates as opposed to fish (Minakawa & Gara, 2003; Spier, 1975).

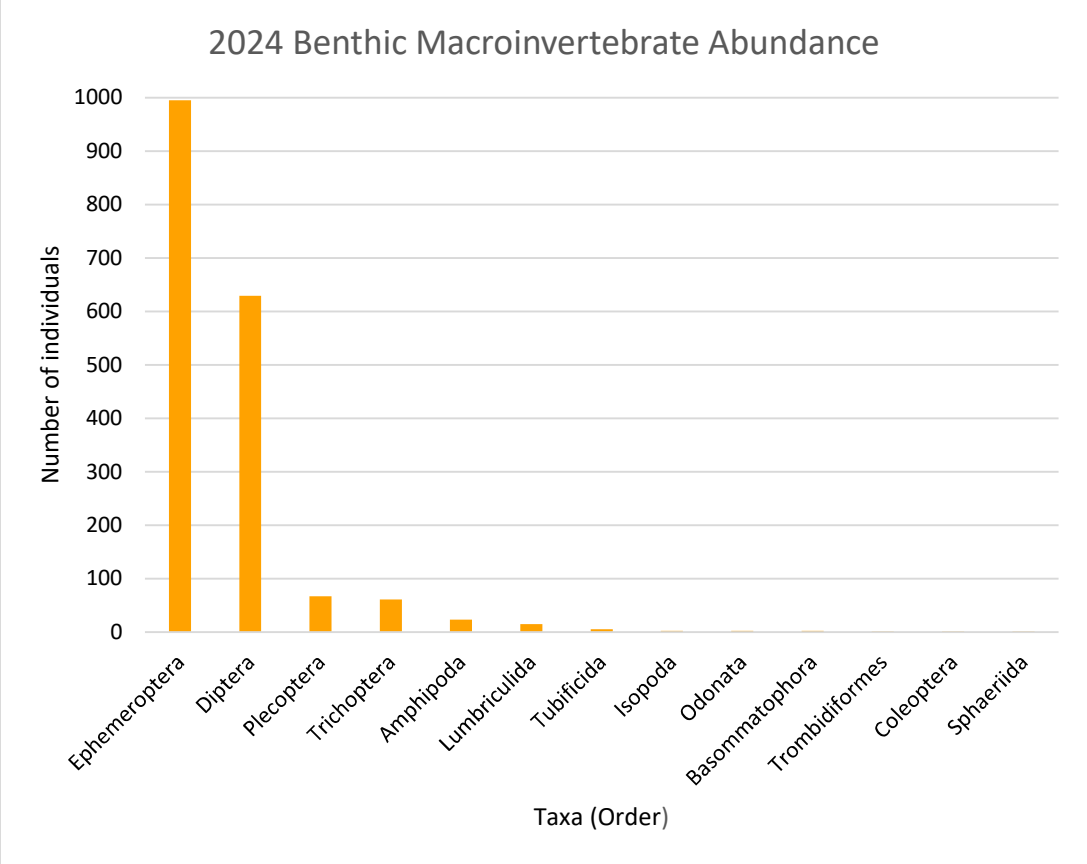


Figure 21. Invertebrate composition (taxonomic order sorted by descending number of individuals) collected from kick net samples in March 2024 from the Sarita River.

- EPT's present in all reaches sampled (Figure 22).
- Ephemeroptera dominant order in reaches 1 and 4, while Diptera was the dominant order collected in reach 2.
  - Reach 2 had two recently disturbed sites (one under a bridge and another right next to an open cut block) where collections were dominated by Simuliid's

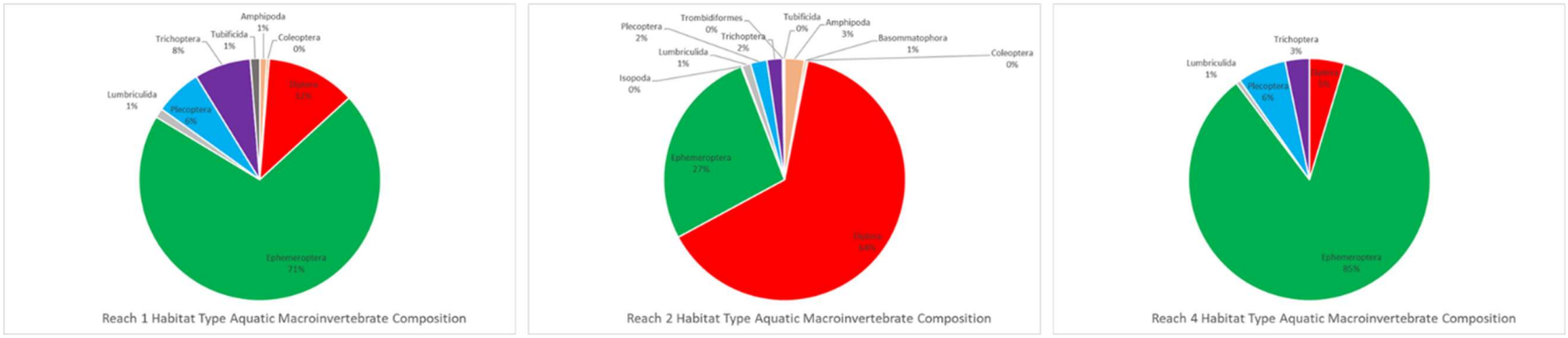


Figure 22. Aquatic invertebrate composition by reach below Sarita falls. Results for reach 3 not presented here as difficulties associated with safely accessing the region resulted in a subset of samples being collected.

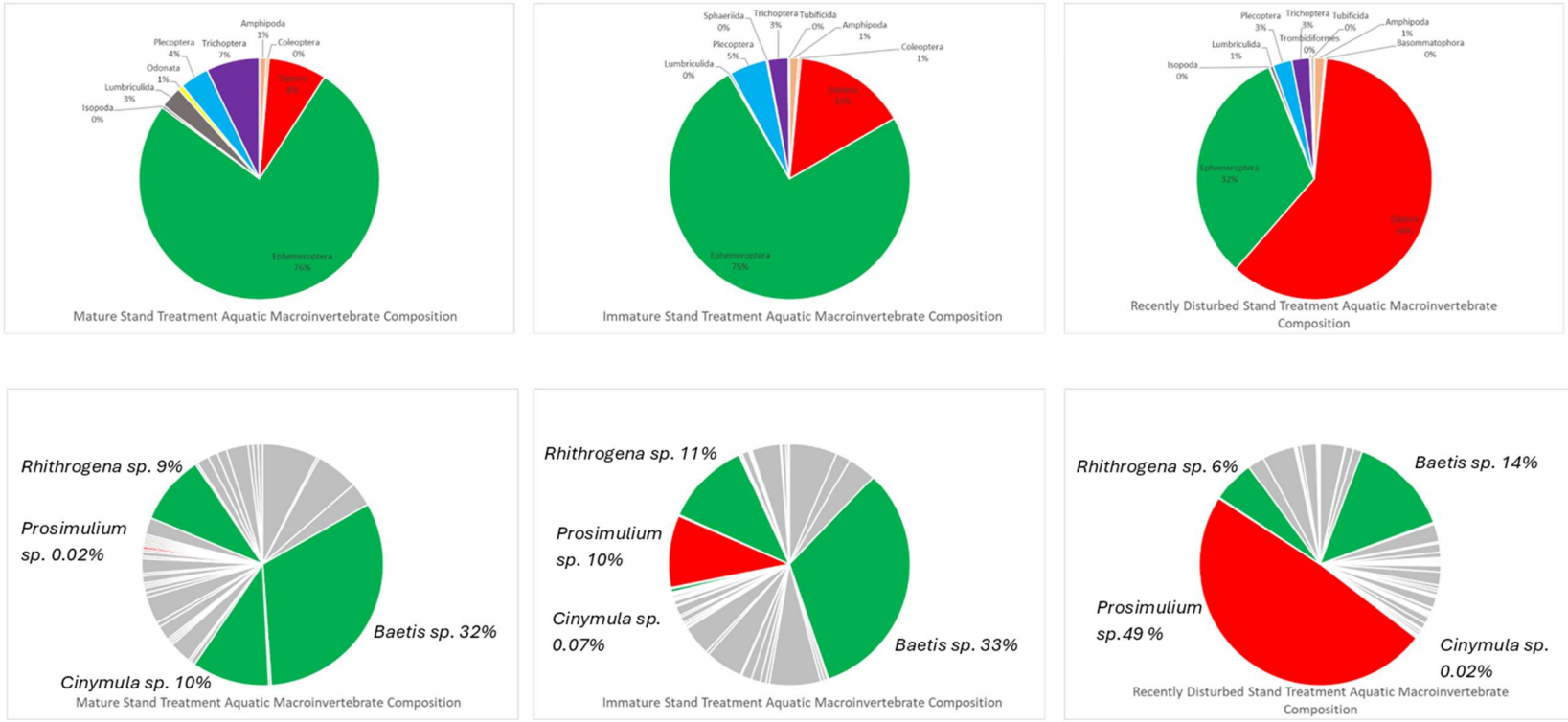


Figure 23. Aquatic invertebrate composition by riparian habitat treatment (mature stand, immature stand, recently disturbed stand) – all reaches combined.

- EPT's present across all habitat treatments (Figure 23).
- EPT's comprise the bulk of samples collected adjacent to mature and immature riparian stand types.
- Cumulative downstream impacts of disturbance appear to be less influential than riparian habitat treatment type.
- *Prosimulium sp*. (Family Simuliidae) present across all habitat treatments but numbers lower in areas adjacent to mature and immature stands.
    - Likely due to predation from higher level invertebrates less tolerant to disturbance.

Recommendations:

- Sample later in the year for in-river invertebrates.
    - Kick Net – Sample in late summer to coincide with the timing of aquatic life stages and continue to monitor aquatic ecosystem health.
    - Drift Net – Sample in late spring or early summer to quantify juvenile salmon food resources present within the water column where late outmigration salmon (who contribute in large proportion to the number of returning salmon) opportunistically feed.
- Continue surveying for in-stream physical parameters.
    - Further data collection related to physical environmental parameters (water quality, bed material composition, flow rate, canopy density, etc.) to better quantify impacts of disturbance on invertebrates and salmon spawning.
- Continued sampling of terrestrial invertebrates.
    - Development of a multi-year dataset allows for monitoring of how the terrestrial riparian arthropod community changes on spatial and temporal scales. This data allows us to assess reclamation trajectory over time and informs on the effectiveness of reclamation treatments to re-introduce forest structural elements.

6 Remote Sensing of Chinook Predation in the Sarita River

Background:

- Purpose: to learn more about predation threats to fish in the Sarita River, especially outmigrating juvenile salmon.
- Which animal species hunt fish in the Sarita River? When are they active? What kind of hunting behaviours/strategies do they employ?

Year 1:

- August 2022 – March 2023.
- Experimented with a variety of camera angles, directions, heights, etc.
    - False triggers from sun glare, turbulent waters, and tidal action in estuary.
- Documented 27 species and several hunting attempts (Figure 24).
    - Most photographed species: American black bear.

Recommendations:

- Consider acoustic monitoring to capture piscivorous birds.
- Position cameras facing north, angled low over water so that opposite bank is in frame.

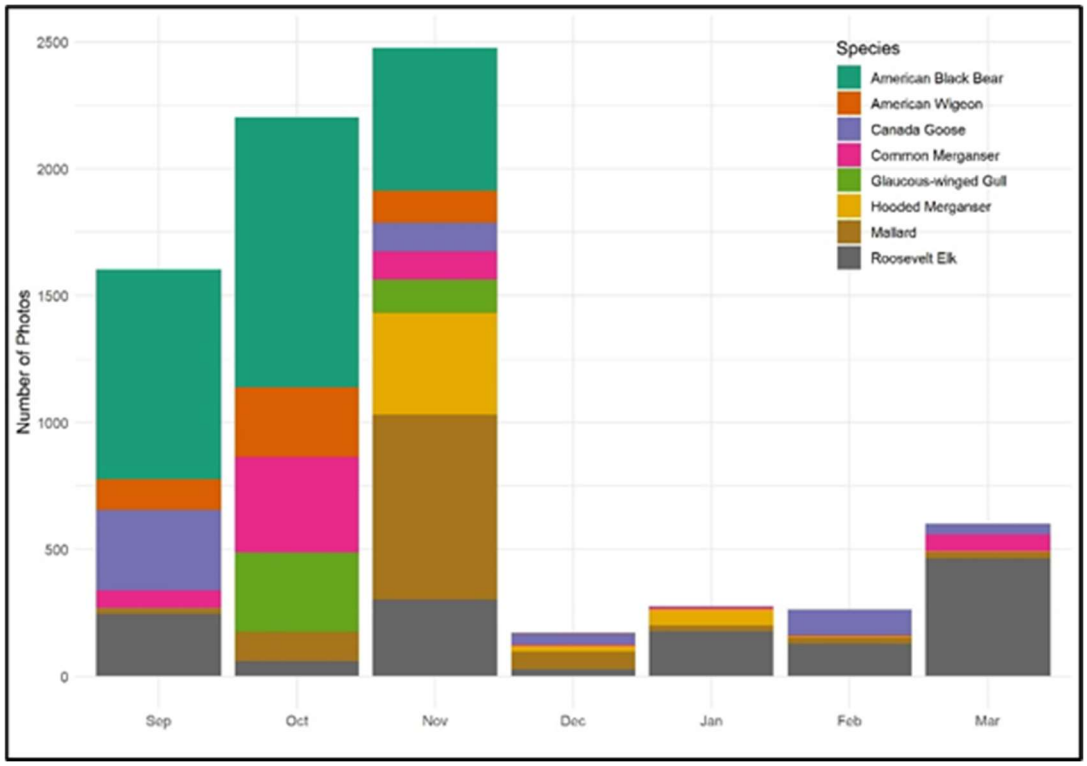


Figure 24. Number of photo detections by animal species per month (September 2022 to March 2023) from cameras deployed along the Sarita River and estuary.

Year 2a:

- September 2023 – March 2024 (Figure 25).
- Cameras were far better positioned – fewer false triggers.
    - Moved away from open water in estuary.
- Documented 25 species in 1,934 independent sightings (used 15-minute threshold to reduce double-counting individual animals.
    - Most common species: American black bear, Glaucous-winged Gull.
    - Seasonal patterns similar to year 1.
- Deployed 3 acoustic recording units.



Figure 25. Distribution of the wildlife camera (n=16) and ARU (n-3) array in 2024 along the Sarita River.

Year 2b

- March – July 2024.
- Acoustic results (Figure 26):
    - Lots of Belted Kingfisher activity.
    - Most activity tapered off in July (end of breeding season).
    - Revealed 9 new piscivorous bird species not previously photographed
        - Including Barred Owl, Northern Pygmy-Owl, American Dipper, Osprey, Merlin, among others.

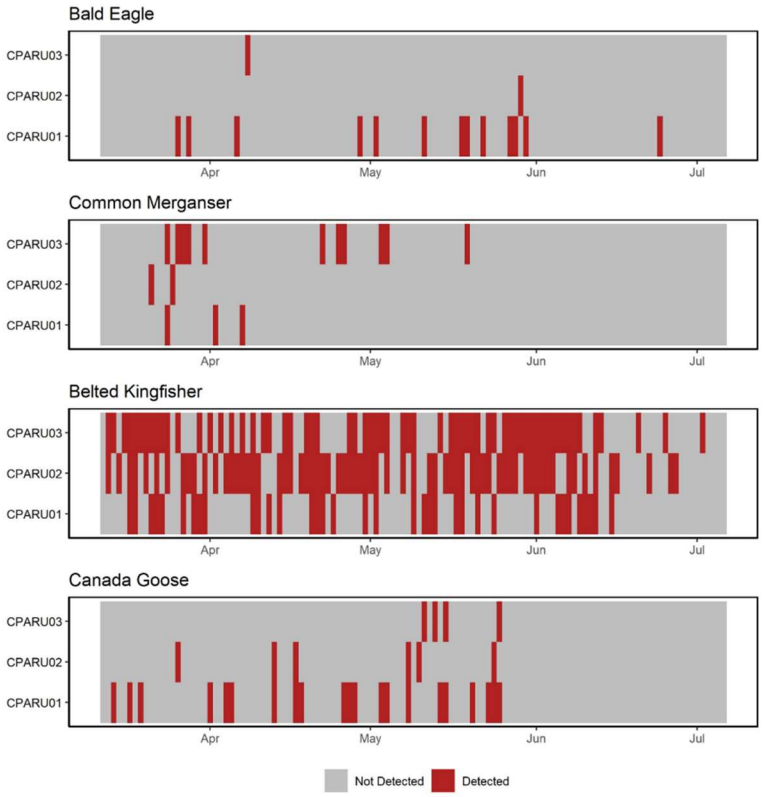


Figure 26. Timeseries of acoustic detections for four of the most commonly recorded fish-eating bird species. Belted Kingfisher were detected on 103 days, the most of any bird species, though they were photographed only twice. Bald Eagle, Canada Goose, and Common Merganser were present at all three ARU stations and documented by several cameras.

Future Direction:

- Link remote sensing data to other Watershed Renewal projects, especially RST fish counts.
- How does piscivore community/relative predation pressure change with factors like river flow rate and water level?

7 References:

Burns, C. W. 2018. Sarita and Pachena watersheds: 2018 Sarita River Chinook Salmon outmigration assessment. LGL Report EA3716B34. Prepared for Huu-ay-aht First Nations, Anacla, BC, by LGL Limited, Sidney, BC.

Burns, C. W., C. McCulloch, and J. Novoa. 2018. Sarita and Pachena watershed renewal: Sarita River Chinook and Chum salmon redd superimposition assessment. LGL Report EA3618B. Prepared for Huu-ay-aht First Nations, Anacla, BC, by LGL Limited, Sidney, BC.

Danehy, R.J. and Moldenke, A.R. 2016. Natural and Anthropogenic Disturbance Influences on Aquatic Biological Diversity in the Pacific Northwest. *Environment and Ecology Research 4*(3), 169-174.

Grunblatt, J., Meyer, B.E. and Wipfli, M.S. 2019. Invertebrate prey contributions to juvenile Coho Salmon diet from riparian habitats along three Alaska streams: Implications for environmental change. *Journal of Freshwater Ecology 34*(1), 617-631.

Horel, G.M. 2021. Watershed Assessment – South Sarita River Basin. Prepared for Huu-ay-aht First Nations, Anaqtl'a, BC, by G.M. Horel Engineering Ltd.

LaForge, N.L., Quindazzi, M.J., Luedke, W., Vos, A. Liao, X., and Ross, A.R. 2025. Marine Entry and Fork Length Relationships of WCVI Chinook for Sarita River based on Otolith Microchemistry. Can. Tech. Rep. Fish. Aquat. Sci. XXX: iv + 30 p.

Minakawa, N. and Gara, R.I. 2003. Effects of Chum Salmon redd excavation on benthic communities in a stream in the pacific northwest. *American Fisheries Society 132*, 598-604.

Roias, S.M. and K.A. Manishin. 2024. Sarita River Juvenile Chinook Salmon Assessment, 2023. LGL Report EA4437A/B/E. Prepared for Huu-ay-aht First Nations, Anaqtl'a, BC, by LGL Limited, Sidney, BC.

Roias, S.M., K.A. Manishin, S.T. Johnson, D. Robichaud, and R.C. Bocking. 2023. Sarita River Outmigration Assessment, 2021 & 2022. LGL Report EA3716B-34. Prepared for Huu-ay-aht First Nations, Anaqtl'a, BC, by LGL Limited, Sidney, BC.

Spier, J.A. 1975. The ecology and production dynamics of four Black Fly species (Diptera: Simuliidae) in western Oregon streams. [PhD Dissertation, University of Oregon].