Spatial Ecology of Arctic Grayling in the Parsnip Core Area

Fish and Wildlife Compensation Program
Peace Project No. PEA-F19-F-2593

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Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders.

17-May-2019

Executive Summary

Flooding of the Upper Peace after construction of the W.A.C. Bennett Dam in 1967 resulted in a considerable loss of riverine habitat to Arctic grayling. The decrease in available habitat, alteration of natural hydrology and evidence of drastic reductions in population size caused great concern for the sustainability of Arctic grayling (*Thymallus arcticus*) populations in the Williston Reservoir Watershed. The recent review by Stamford et al. (2017) and monitoring framework by Hagen and Stamford (2017) highlighted a number of critical information gaps related to the spatial ecology of Arctic grayling such as: (1) the unknown distribution of Arctic grayling within the streams of the different core areas (*sensu* Stamford et al. 2017); and (2) the lack of understanding of Arctic grayling migrations. Furthermore, its unknown whether populations of bull trout (*Salvelinus confluentus*) are limiting the abundance of Arctic grayling and their spatial distribution.

The goal of this project is to investigate the spatial ecology of sub-adult and adult Arctic grayling and their interactions with bull trout in the Parsnip River mainstem and tributaries, a core area of Arctic grayling populations in the Williston Reservoir Watershed.

The information gathered in this study will fill in data gaps that were identified as moderate and high immediacy for the Parsnip core area (data gaps 5.1.3a-i in Table 6 of Stamford et al. 2017) and will also be relevant to other core areas in the Williston Reservoir Watershed (2.3.1b-c and 2.3.5 in Table 1 of Stamford et al. 2017). Therefore, the outcomes of this study will primarily address the Priority Actions 1b-3 and 1b-4 of the Streams Action Plan (FWCP 2014). However, given that the study will collect data on bull trout, it will also contribute information to address Priority Actions 1c-3 and 1c-4 of the Streams Action Plan (FWCP 2014).

This report refers to project activities in Year 1 of 4. The methods used to address the study objectives include: acoustic telemetry, capture-recapture, temperature data logging, stable isotope analysis and spatial modeling. Arctic grayling and bull trout were captured by angling. Captured fish were tagged (acoustic transmitters, and/or PIT [Passive Integrated Transponder] and anchor tags), sampled for dorsal fin tissue (stable isotope analysis), and released. Fish tagged with acoustic transmitters have been continuously monitored by an array of acoustic receivers deployed throughout the Parsnip River watershed and in the Pack River. A small subset of the captured fish was sacrificed for muscle tissue sampling to determine the relationship between muscle and fin tissue isotope signatures. Other fish caught by angling and trapping (beach seine) were also sacrificed for stable isotope analysis. Data loggers were deployed to monitor air and water temperature throughout the Parsnip watershed.

A total of 63 fish (50 Arctic grayling and 13 bull trout) were tagged in 2018, mostly in the Anzac River. A total of four tagged Arctic grayling and one tagged bull trout were

recaptured by anglers and reported to our team. All of the four Arctic grayling were recaptured from mid-August to mid-September of 2018 and from the same pools or nearby pools where they had been captured for tagging a few weeks before. The recaptured bull trout, which was captured for tagging in the Parsnip River near the Anzac mouth in early October of 2018, was caught by an angler in the Williston Reservoir near the mouth of the Parsnip River in mid-January of 2019. In addition to the reported recaptures, we detected six acoustically tagged Arctic grayling in the Parsnip River near the Anzac mouth in early October using a mobile acoustic receiver unit.

We deployed 54 acoustic receivers in the Parsnip River watershed and one in the lower Pack River. In the Parsnip River watershed, receivers were deployed along the Parsnip River, Anzac River and Table River as well as a few hundred metres into the lower section of the Missinchinka River, Hominka River and Missinka River.

A total of 48 temperature data loggers were deployed throughout the Parsnip River watershed to monitor water temperature and most (n = 41) were deployed in association with acoustic receivers. Temperature data loggers (n = 32) were also deployed at 16 land sites near the river banks and 10 metres into the vegetation to monitor air temperature.

A total of 89 samples (adipose fin, muscle, invertebrates, plants, particulate organic matter) were obtained for stable isotope analysis of carbon ($\delta 13C$) and nitrogen ($\delta 15N$). The analysis is currently being conducted in the Environmental Isotope Laboratory, University of Waterloo (Waterloo, ON).

Preliminary results on acoustic detections and temperature logging will be available after data offloading in the second year of the project (summer of 2019). During the 2019 field season, we will also focus our efforts on tagging fish in the Table River (using transmitters left from 2018). Another objective for 2019 is to expand tagging and the receiver network to the Hominka and Missinka River. While we consider this a critical activity for the execution of our project, we acknowledge that the challenges of access and uncertainty about environmental conditions (i.e. timing/duration of high flows) may result in our having a short amount of time to expand the study area after servicing currently deployed receivers and loggers and tagging fish in the Table River. If access to sites and environmental conditions in 2019 indicate that expansion to the Hominka River and Missinka River is not feasible, we will continue to focus our efforts in the Anzac River, Table River and Parsnip River by deploying additional receivers in key sites and tagging more fish in the Anzac River and Table River.

We have engaged in six outreach activities including the presentation of project objectives (highlighting opportunities for angler participation with the reporting of the capture of tagged fish) in local events and province-wide in collaboration with the Angler’s Atlas; and by reaching out to First Nations communities in the project area (although most attempts to engage were unsuccessful).

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1. Introduction

The construction of the 183-m high W.A.C. Bennett Dam in 1967, forming the Williston Reservoir flooded roughly 350 km of the Peace, Finlay, and Parsnip River valleys (Hagen and Stamford 2017). Arctic grayling (*Thymallus arcticus*) in the Upper Peace watershed show a fluvial life history form and appear to not use the reservoir (Clarke et al. 2007). Therefore, flooding of the Upper Peace resulted in a considerable loss of riverine habitat. Prior to impoundment, Arctic grayling were widespread and abundant in tributary streams of the Upper Peace, however presently are restricted to just eight of the larger watersheds in the Williston Reservoir watershed (Hagen and Stamford 2017). The decrease in available habitat, alteration of natural hydrology (change from large flowing rivers to reservoir) and evidence of drastic reductions in population size cause great concern for the sustainability of Arctic grayling populations in the Williston Reservoir Watershed (Stamford and Taylor 2005). The recent review by Stamford et al. (2017) and monitoring framework by Hagen and Stamford (2017) highlighted a number of critical information gaps related to the spatial ecology – the causes and consequences of a species distribution over time and space (Hastings et al. 2011) – of Arctic grayling (*Thymallus arcticus*). For example, two important spatial ecology data gaps identified in the review are: (1) the unknown distribution of Arctic grayling within the streams of the different core areas (*sensu* Stamford et al. 2017); and (2) the lack of understanding of Arctic grayling migrations.

Knowledge of a species' spatial ecology is fundamental to the effective development and implementation of enhancement and conservation programs (Allen and Singh 2016, Ogburn et al. 2017). To identify critical habitats and potential limiting factors (e.g. habitat conditions, human impacts, inter-specific interactions), these programs often require detailed information derived from spatial ecology studies describing where, when and why individuals move and are distributed in space (Cooke et al. 2016). Although the description of distribution and migrations is a necessary step in understanding the spatial ecology of Arctic grayling, it is not sufficient to determine its drivers. Both abiotic and biotic factors play an important role in influencing the spatial ecology of species (Royle et al. 2017). Among abiotic factors, the spatio-temporal availability of thermal habitats is one of the most important drivers of fish distribution and migrations in freshwater environments (Lucas and Baras 2001, Isaak et al. 2010). Despite the general perception that the thermal environment in running freshwater is homogeneous, streams actually exhibit substantial thermal variability at small (10 to 100 m) and large (> 1,000 m) spatial scales due, for example, to the variability in riparian vegetation shade and groundwater input along their extension (Kurylyk et al. 2015). Temperature has a strong potential to limit Arctic grayling populations, as highlighted by (Stamford et al. 2017), and it is in fact known that the occurrence of juveniles is negatively related to water temperature (Hawkshaw et al. 2014). Therefore, a full description of the distribution and migrations of Arctic grayling in the Williston

Reservoir Watershed require a detailed characterization of the distribution of thermal habitats.

Biotic interactions (e.g. resource competition, predation) also influence the distribution and migrations of freshwater fishes (Lucas and Baras 2001). In the Williston Reservoir Watershed, Arctic grayling co-occur with bull trout (*Salvelinus confluentus*) in streams of several core areas and there is a strong potential for age-dependent overlap in resource use. For example, as juveniles, both species prey heavily on terrestrial drift, aquatic insects and other invertebrate prey and individuals larger than 150 mm will increasingly include fish as prey (Stewart et al. 2007a,b). Arctic grayling feeding behaviour also appears to be related to the degree of competition for prey resources (Stewart et al. 2007b). Overlap in prey resource use and/or risks of predation by larger bull trout on smaller Arctic grayling, therefore, may significantly influence the spatial ecology of Arctic grayling in ways that limit the potential growth of its populations (Stamford et al. 2017).

2. Objectives and Linkage to FWCP Action Plans and Priority Actions

The goal of this project is to investigate the spatial ecology of sub-adult and adult Arctic grayling and their interactions with bull trout in the Parsnip mainstem and tributaries, a core area of Arctic grayling populations in the Williston Reservoir Watershed. Specifically, the objectives are to:

i. Investigate the migrations of sub-adult and adult Arctic grayling among the Parsnip mainstem, tributaries and a nearby watershed (Pack River);
ii. Describe and define the distribution and thermal habitat use of sub-adult and adult Arctic grayling;
iii. Determine the overlap in distribution patterns of sub-adult and adult Arctic grayling and bull trout;
iv. Determine the patterns of resource use and the resulting trophic relationship between Arctic grayling and bull trout.

The information gathered in this study will fill in data gaps that were identified as moderate and high immediacy for the Parsnip core area (data gaps 5.1.3a-i in Table 6 of Stamford et al. 2017) and will also be relevant to other core areas in the Williston Reservoir Watershed (2.3.1b-c and 2.3.5 in Table 1 of Stamford et al. 2017). Therefore, the outcomes of this study will primarily address the Priority Actions 1b-3 and 1b-4 of the Streams Action Plan (FWCP 2014). However, given that the study will collect data on bull trout, it will also contribute information to address Priority Actions 1c-3 and 1c-4 of the Streams Action Plan (FWCP 2014).

3. Study Area

The project was conducted in the Parsnip River core area (watershed), with a focus on three streams in 2018: Parsnip River, Anzac River and Table River.

3.1. Parsnip River

The Parsnip River system (54.769403°, −122.501018°) has a watershed area of 5,612 km^2 (Hagen et al. 2015). Total river length is 175 km, and the majority of this is low gradient. The river has a wide channel with many meanders, large gravel bars and clay banks. Substrate is a mix of cobble, gravels and fines. The Parsnip River and its major tributaries drain a mountainous area in the Hart Ranges of the Rocky Mountains, which lies east of the Rocky Mountain Trench. The Parsnip has turbid water as a result, and high peak flows from late-May to early June. Substantial glacial influence occurs in the Upper Parsnip River. However, in late summer downstream of the Missinka River (54.578597°, -122.034947°), turbidity improves to be relatively clean (Hagen et al. 2015). The highest flows occur in late May, and the lowest flows occur during the period from September to March (Blackman 2002). Discharge and temperature information is available from a Hydrometric Data gauge located above the confluence with the Missinchinka River confluence (Station 07EE007, Water Survey of Canada). Maximum discharge in 2018 at 1,250 $m^3 \cdot s^{-1}$ occurred mid-May and minimum discharge at 25 $m^3 \cdot s^{-1}$ occurred in mid-October. Maximum temperature in 2018 reached 20 °C in mid-August.

3.2. Anzac River

The Anzac River system (54.902632°, −122.280257°) drains a 939 km^2 watershed and is 78 km in length with an average gradient of 0.7% (Blackman 2002). The stream drains a mountainous region of the Hart Ranges in the Rocky Mountains, on the East side of the Parsnip mainstem. The upper river is characterized by bedrock canyons with a moderate gradient (1-2%). The lower river lies in a wide unconfined valley. As the river nears the Parsnip River confluence it creates large meanders, many oxbows and has a low gradient (<0.5%) (Blackman 2002). Snowmelt causes high river turbidity and flows in the spring months, however the Anzac is low and clear in the late summer months and fall. Substrate is mainly composed of clean cobble and gravel. No hydrometric data is available for the Anzac River.

3.3. Table River

The Table River system (54.755545°, −122.090737°) drains a 506 km^2 watershed and is 56 km in length with an average gradient of 0.7% (Blackman 2002). The stream drains a mountainous region of the Hart Ranges in the Rocky Mountains, on the East side of the

Parsnip mainstem. The upper river has a moderate gradient (1-2%) and is frequently confined by valley walls. The lower river has a low gradient (<0.5%) and contains many oxbows, side channels and abandoned channels (Blackman 2002). No hydrometric data is available for the Table River.

4. Methods

The methods used to address the study objectives include: acoustic telemetry, capture-recapture, temperature data logging, stable isotope analysis and spatial modeling. Arctic grayling and bull trout were captured by angling. Captured fish were tagged (acoustic transmitters, and/or PIT [Passive Integrated Transponder] and anchor tags), sampled for dorsal fin tissue (stable isotope analysis), and released. Fish tagged with acoustic transmitters have been continuously monitored by an array of acoustic receivers deployed throughout the Parsnip River watershed and in the Pack River. A small subset of the captured fish was sacrificed for muscle tissue sampling to determine the relationship between muscle and fin tissue isotope signatures. Other fish caught by angling and trapping (beach seine) were also sacrificed for stable isotope analysis (to fully characterize the food webs where Arctic grayling and bull trout are located). Separate data loggers were deployed to monitor both air and water temperature throughout the Parsnip watershed.

4.1. Fish Capture and Tagging

Captured Arctic grayling and bull trout > 230 g were surgically tagged with acoustic transmitters. For surgical tag implantation, the fish were sedated by electro-anaesthesia (Ward et al. 2017, Abrams et al. 2018) using electric gloves attached to a Transcutaneous Nerve Simulation (TENS) 3000 unit (Koalaty Products Inc., Tampa, USA), while kept in a V-shaped trough filled with ambient water. A small incision (20-30 mm) was made on the ventral midline 30-50 mm posterior to the pectoral fins and an acoustic tag (V9, Vemco, Bedford, Canada) and a PIT tag (12mm HDX, Oregon RFID) were inserted into the peritoneal cavity. The incision was closed with 3-4 simple interrupted sutures (Wagner et al. 2011). The tags as well as the tagging instruments were all disinfected in a bath of Virkon (Lanxess, Germany) for 10 minutes and rinsed with distilled water. The fish were also externally tagged with an anchor tag (below the dorsal fin), measured (fork length), weighed and sampled for fin tissue. After processing, the fish were placed into a recovery bag filled with ambient water and released at the capture site after regaining equilibrium and responding vigorously when grabbed by the tail.

To augment spatial information on Arctic grayling and bull trout, additional fish were captured and tagged with anchor and/or PIT (8mm FDX or 12mm HDX) tags, including fish < 230 g. The captured fish were immobilized by hand and quickly handled in a V-shaped trough filled with ambient water, where they were externally tagged with an anchor tag (below the dorsal fin) and PIT tag (injected into the abdominal cavity), measured (fork length), weighed, and sampled for adipose fin tissue.

The location of capture or recapture of tagged fish was recorded with a GPS. In an effort to increase the number of recaptures, local First Nations and recreational anglers have been asked to report the capture of any tagged fish as well as the date/time and spatial coordinates of capture (see Appendix 1 and 2). We have been working with the Angler's Atlas to use their MyCatch app and their capacity to reach out to thousands of anglers in BC to request that any tagged fish caught by anglers be reported along with the relevant information (date/time, location, and tag number).

4.2. Monitoring of Acoustic Tagged Fish

Arctic grayling and bull trout tagged with acoustic transmitters in 2018 have been continuously monitored by an array of 55 receivers (VR2W, Vemco, Bedford, Canada) deployed in the Parsnip mainstem, Anzac River, Table River and in the lower Pack River. Receivers were deployed in clusters of 2-4 receivers spaced 0.5-2 km from one another, while distributing the receiver clusters widely in the watershed (Royle et al. 2014). The acoustic receivers were moored (concrete block, cable and duckbill anchors) on the streambed with the hydrophones facing the surface. Given the narrow width of the streams (10-60 m) in the area and typical high detection efficiency of acoustic receivers at short distances (< 100m), only one receiver was deployed at each location (approximately 5-20 m from one of the banks). Due to the large size of the study area, difficult access to the sites and seasonally high water, data collected by acoustic receivers from 2018-2019 will be downloaded during the 2019 field season.

4.3. Temperature Monitoring

Air and water temperature data loggers (DS1921Z, Maxim Integrated, San Jose, USA; MX2203 and MX2201, Onset, Bourne, USA) were deployed throughout the study area. The loggers were attached to the acoustic receivers or boulders in the streams (water temperature) and to vegetation on the banks (air temperature) and will record temperature at least every 30 min. Temperature data will be downloaded at the same time as acoustic receivers in the 2019 field season.

4.4. Sampling and processing for stable isotope analysis

In addition to fin tissue sampled from tagged fish, two Arctic grayling were sacrificed (following UNBC Animal Care and Use Committee guidelines) upon capture and sampled for muscle and fin tissue (Figure 1). Muscle was sampled from above the lateral line and anterior to the dorsal fin, whereas fin tissue was taken from the adipose fin. Stomach contents were also collected from the fish. Supplementary sampling of aquatic macro-invertebrates, other potential prey fish, periphyton, particulate organic matter (POM), macrophytes, and terrestrial vegetation was conducted for stable isotope analyses at five sites (Figure 1).

In the laboratory, all collected material was kept in a −30°C freezer until processing for stable isotope analysis. Stable carbon (δ13C) and nitrogen (δ15N) isotope analyses can be used to evaluate consumer dietary ecology, both at the individual and community level (Post 2002, Bearhop et al. 2004), as they integrate prey resource use over time (Bearhop et al. 2004). Samples were dried in a standard laboratory convection oven at 50°C for 48 hours and then ground to a powder using a mortar and pestle. Samples were sent to the Environmental Isotope Laboratory, University of Waterloo (Waterloo, ON) where they will be analyzed (ongoing) using a Delta Plus Continuous Flow Stable Isotope Ratio Mass Spectrometer (Thermo Finnigan, Bremen, Germany) coupled to a Carlo Erba elemental analyzer (CHNS-O EA1108, Carlo Erba, Milan, Italy). Results of these analyses are expected to be ready by the summer of 2019.

5. Results and Outcomes

As mentioned in the Methods, data collected by acoustic receivers and temperature data loggers in 2018-2019 will be downloaded during the 2019 field season. Therefore, below we only provide a detailed description of the 2018 field methods including number of fish captured, tagged and/or sampled for stable isotope analysis; receivers and temperature loggers deployed; and community outreach in 2018.

5.1. Fish Capture, Tagging and Recaptures

A total of 63 fish (50 Arctic grayling and 13 bull trout) were tagged in 2018, mostly in the Anzac River (Figure 2). Access to capture sites in the Table River was limited by construction, deactivated roads, and log jams in the river. All fish were tagged with acoustic transmitters, PIT tags and anchor tags, except for three Arctic grayling and five bull trout, which were tagged with PIT and anchor tags only.

Among tagged Arctic grayling, 19 were identified as females (mean $\pm$1 SD: 371.3 $\pm$ 90.7 g for weight; 32.8 $\pm$ 3.4 cm for fork length), 19 were identified as males (mean $\pm$1 SD: 477.5 $\pm$ 120.4 g for weight; 35.5 $\pm$ 2.0 cm for fork length), and 12 could not have the sex determined (mean $\pm$ 1 SD: 557.7 $\pm$ 196.5 g for weight; 30.3 $\pm$ 7.2 cm for fork length). None of the bull trout caught could have sex determined (mean $\pm$1 SD: 1,242.0 $\pm$ 745.6 g for weight; 43.7 $\pm$ 9.3 cm for fork length), except for two females (weight: 1,500 and 1,600; fork length: 52 and 56 cm).

A total of four tagged Arctic grayling and one tagged bull trout were recaptured by anglers and reported to our team. All Arctic grayling were recaptured from mid-August to mid-September of 2018 and from the same pools or nearby pools where they had been captured for tagging a few weeks before (Figure 2). The recaptured bull trout, which was captured for tagging in the Parsnip River near the Anzac mouth in early October of 2018, was caught by an angler in the Williston Reservoir near the mouth of the Parsnip River in mid-January of 2019 (Figure 2). In addition to the reported recaptures, we detected six acoustically tagged Arctic grayling in the Parsnip River near the Anzac mouth in early October using a mobile acoustic receiver unit (VR100, Vemco, Bedford, Canada). All detected fish had been captured for tagging in the Anzac River and two of them were among the ones that had been recaptured and reported by anglers.

5.2. Receiver and Temperature Logger Deployment

We deployed 54 acoustic receivers in the Parsnip River watershed and one in the lower Pack River (Figure 3). In the Parsnip River watershed, receivers were deployed along the Parsnip River, Anzac River and Table River as well as a few hundred metres into the lower section of the Missinchinka River, Hominka River and Missinka River (Figure 3).

A total of 48 data loggers were deployed throughout the Parsnip River watershed to monitor water temperature and most (n = 41) were deployed in association with acoustic receivers (Figure 4). Another set of data loggers (n = 32) were deployed at 16 land sites near the river banks and 10 metres into the vegetation to monitor air temperature (the data will be used to model water temperature as function of air temperature). This data will be available once collected in the 2019 field season.

5.3. Stable Isotope Sampling

A total of 89 samples were obtained for stable isotope analysis of carbon (δ13C) and nitrogen (δ15N) (Figure 1). Samples included adipose fin tissue (n = 54), muscle tissue (n = 10), invertebrates (n = 7), terrestrial vegetation (n = 10) and aquatic vegetation (n = 4) plants and POM (n = 4). All samples have been dried, pulverized and shipped to the Environmental Isotope Laboratory, University of Waterloo (Waterloo, ON), where they are currently being analyzed.

5.4. Community Outreach

We have engaged in six outreach activities:

i. Presentation to the Polar Coachmen Fly Fishing Club on May 10, 2018 at the Spruce City Wildlife Association building: Presented the project to club members (~20 people in attendance) and requested them to report the capture of any tagged fish caught. See presentation slides in Appendix 1.

ii. Project outreach on July 19, 2018 via Facebook: Brief presentation of project information and request for the report of any tagged fish caught (326 people [~50 in British Columbia] reached at minimum, not considering those reached by the post being shared [16 times]). See communication material distributed via Facebook in Appendix 2.

iii. Partnership with Angler's Atlas: We initiated a partnership with the Angler's Atlas (located in Prince George) to distribute project information to local anglers and request the report of any tagged fish caught via the app MyCatch (developed by Angler's Atlas). Our project has a dedicated page on the Angler's Atlas website in a section that focuses on research (https://www.anglersatlas.com/research/spatial-ecology-of-arctic-grayling-in-the-parsnip-core-area). The project website on Angler's Atlas received 349 visits since launching the page in the summer. An email newsletter dedicated to the project was sent by Angler's Atlas to BC residents on July 27, 2018 (18,056 subscribers). The newsletter was opened 6,227 times (3,727 unique). There were 307 clickthroughs (256 unique).

iv. First Nations Engagement: We communicated with three First Nations - McLeod Lake, West Moberly and Saulteau First Nations to offer an opportunity to participate in the project via employment of a technician. We were successful in engaging with Saulteau First Nations and were able to hire Julian Napoleon, an excellent technician, to help us with the project. Led by Nikolaus Gantner (FLNRORD), we attempted to organize a workshop with the First Nations in the Parsnip area but that was not successful. Continued attempts are being made to engage McLeod Lake Indian Band, whose traditional territory encompasses our study site.

v. Public announcement at International Fly Fishing Film Festival hosted by the Polar Coachmen Fly Fishing Club at the University Northern of British Columbia on February 2, 2019. MSc student Bryce O'Connor outlined the study area, project objectives, methods and proponents. The main goal was to emphasize the mark-recapture component and urge recreational anglers to participate in the project by reporting the capture of any tagged fish. Bryce stressed responsible fish handling and care while identifying tag numbers. Posters displaying information about the project and tag location on the fish were available for attendees to view at intermission and after the films (see Appendix 2). Attendance was approximately 60 people.

vi. Public announcement at Iron Fly Prince George: Fly Tying Meets Iron Chef hosted by Kate Watson at Trench Brewing and Distilling on March 7, 2019. MSc student Bryce O'Connor outlined the study area, project objectives, methods and proponents. The main goal was to emphasize the mark-recapture component and urge recreational anglers to participate in the project by reporting the capture of any tagged fish. Bryce stressed responsible fish handling and care while identifying tag numbers. Posters displaying information about the project and tag location on the fish were available for attendees to view throughout the evening (see Appendix 2). Attendance was approximately 40 people.

6. Discussion

The high water levels that persisted in the Parsnip River watershed until the end of July of 2018 delayed the beginning of fieldwork, which we had planned to start in June (capture and tagging) and July (receiver and temperature logger deployment). Low water levels are necessary for safely working in water and to ensure that the receivers and loggers are deployed in areas that will be ice-free in winter and underwater year-round. Although we were still able to meet our objectives for acoustic receiver and temperature data logger deployment, we were not able to capture all the fish (n = 100) we had planned to tag with acoustic transmitters.

Several factors contributed to smaller than expected number of bull trout captured and tagged. First, fish capture success is low during high water levels. Therefore, fish capture was not efficient until water levels went down in August. Since most of the fieldwork had to be concentrated in August and two weeks in September to early October, the short time remaining in the field season had to be split among all project activities (tagging, receiver and data logger deployment). Another challenge encountered was the difficulty of finding and capturing bull trout (only 13 were tagged). Several fishermen encountered during fieldwork activities and some following our project on the Angler's Atlas website reported the same difficulties in finding bull trout in the Anzac River this year. Finally, capture and tagging of fish in the Table River was limited by construction and deactivation of roads, which prevented us from reaching middle and upper sections of the river where grayling and bull trout occur in high abundance (boat access was not possible due to log jams). However, we were able to successfully catch several Arctic grayling (n = 11) and a few bull trout (n = 2) when we had helicopter access (kindly provided by FLNRORD) to the upper Table River on one day in mid-August.

7. Recommendations

In the second year of the project (field season of 2019), we will first focus our efforts on tagging fish in the Table River (using transmitters left from 2018). For this, we are expecting that roads that were deactivated in 2018 along the Table River will be activated in 2019. A discussion with Canfor representatives scheduled for April 2019 should clarify access issues. If road access along the Table River is not possible, we will use a helicopter (budgeted for 2019) to reach upper sections of the Table River where Arctic grayling and bull trout are abundant.

As outlined in our research proposal, another objective for 2019 is to expand tagging and the receiver network to the Hominka and Missinka River. While we consider this a critical activity for the execution of our project, we acknowledge that the challenges of access and uncertainty about environmental conditions (i.e. timing/duration of high flows) may result in our having a short amount of time to expand the study area after servicing currently deployed receivers and loggers (Anzac River, Table River, Parsnip River and into the mouth of other streams) and tagging fish in the Table River. If access to sites and environmental conditions in 2019 indicate that expansion to the Hominka River and Missinka River is not feasible, we will continue to focus our efforts in the Anzac River, Table River and Parsnip River by deploying additional receivers in key sites and tagging more fish in the Anzac River and Table River.

8. Acknowledgements

A large number of people provided critical support to different phases of this project in 2018: Rioghnach Steiner, Douglas Thompson, John Orlowsky, Kendra Robinson, Bruna Gonçalves, Daniel Erasmus, Brian Smith, Julian Napoleon, Nikolaus Gantner, Ian Spendlow, Ray Pillipow, Zsolt Sary, John Hagen, Dawn Cowie and Michael Stamford. The Ministry of Forests, Lands, Natural Resource Operations and Rural Development kindly provided us with helicopter access to remote sites of the study area. This project is funded by the Fish and Wildlife Compensation Program (FWCP). The FWCP is a partnership between BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders to conserve and enhance fish and wildlife in watersheds impacted by BC Hydro dams.

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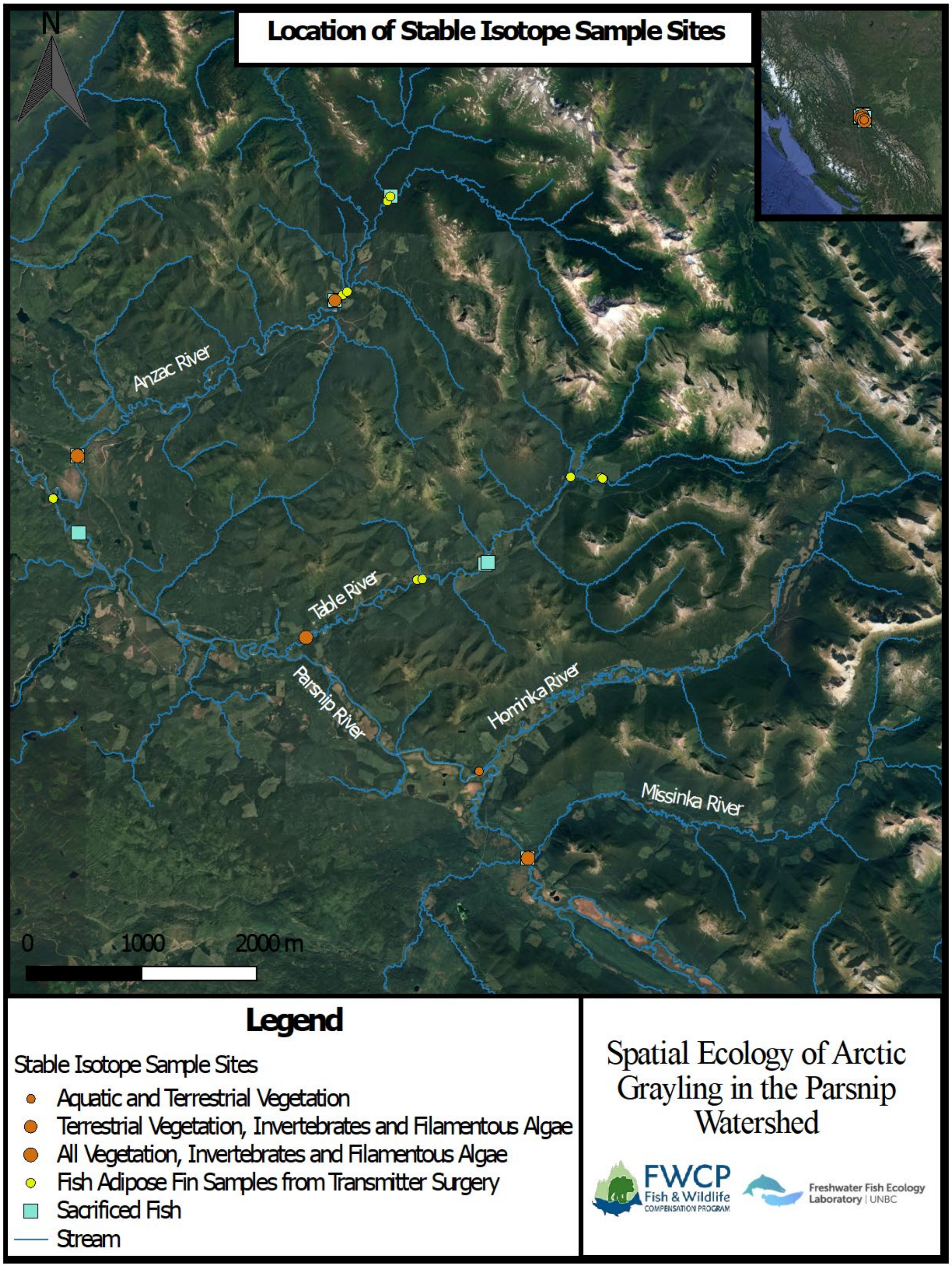

Figure 1. Locations of sampling of specimens and tissues for stable isotope analysis.

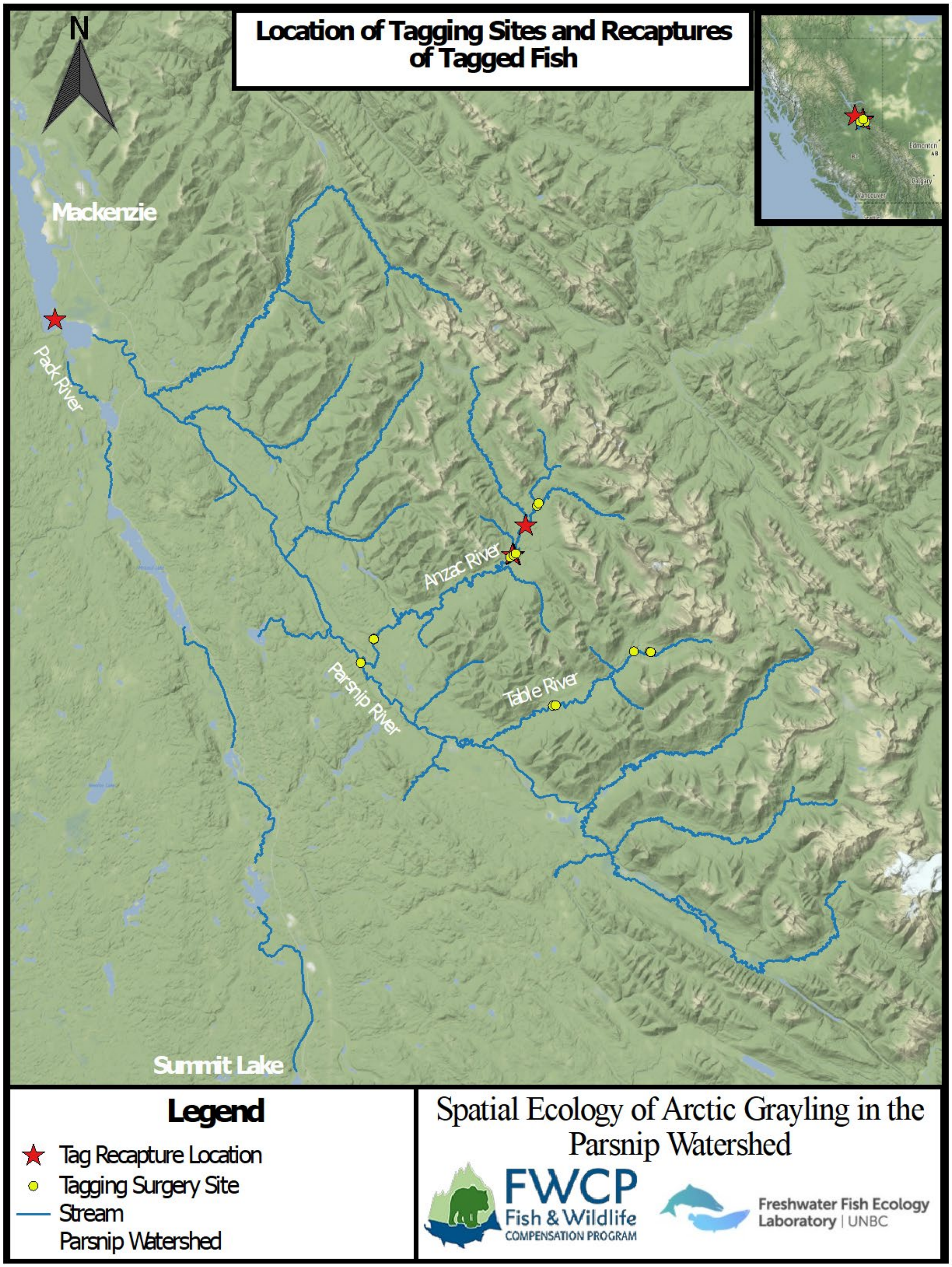

Figure 2. Locations of capture and tag implantation surgery sites, and tag recaptures as of January 2019.

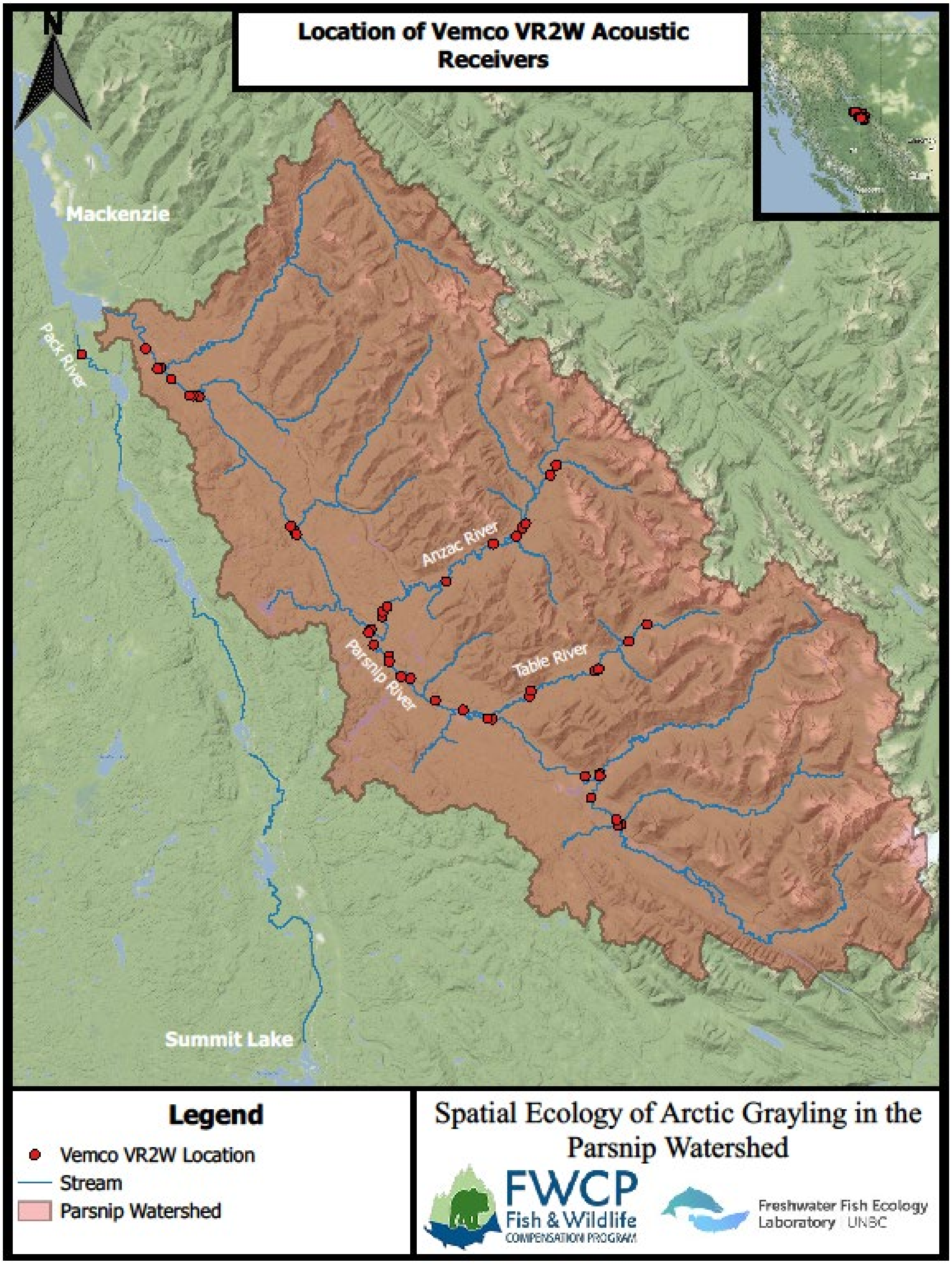

Figure 3. Location of Vemco VR2W acoustic receivers in the Parsnip River and Pack River Watersheds.

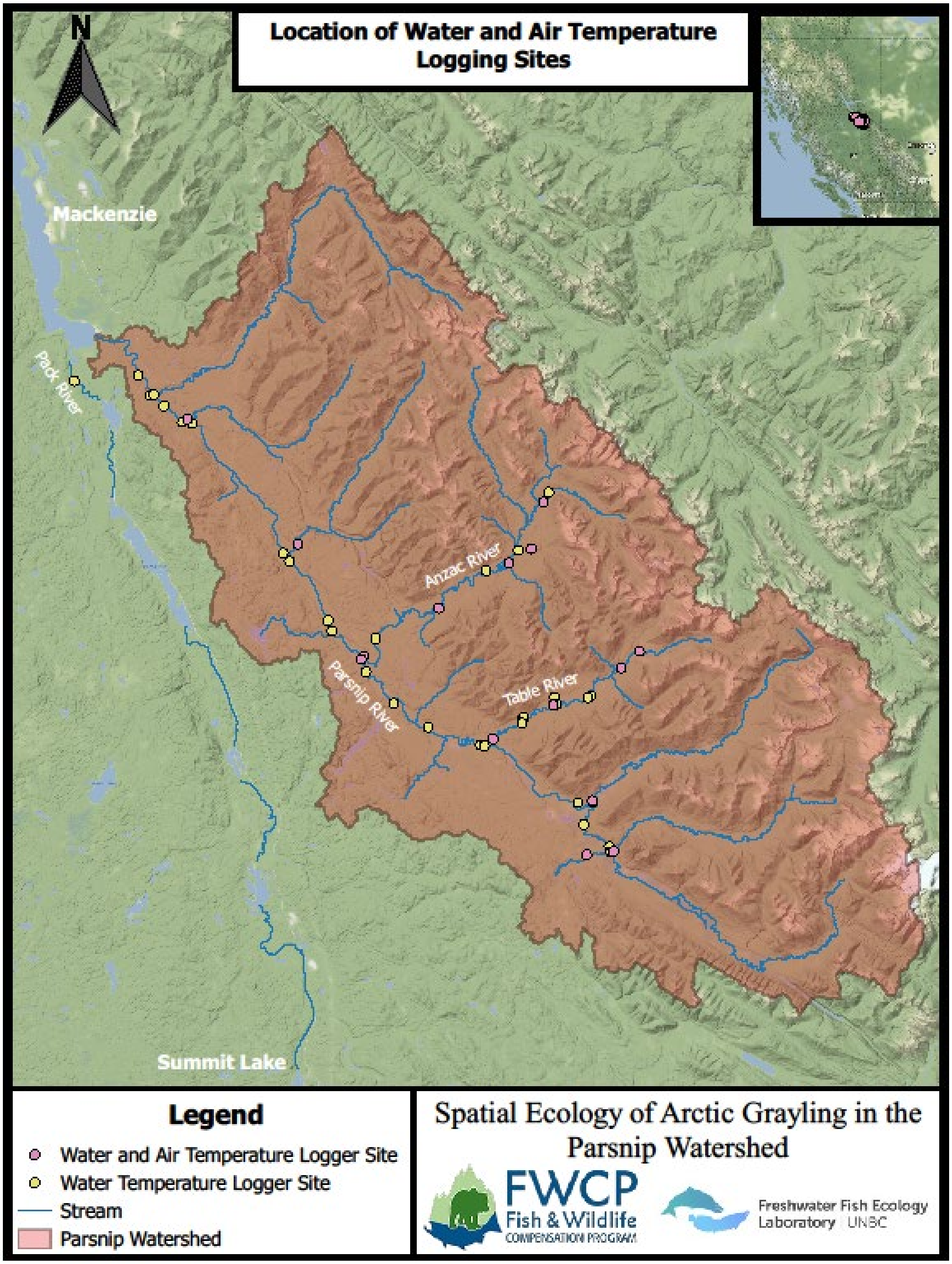

Figure 4. Location of water and air temperature logging sites in the Parsnip and Pack River watersheds.

Appendix 1. Slides shown in project presentation to the Polar Coachmen Fly Fishing Club.

Spatial Ecology of Arctic Grayling in the Parsnip watershed

Eduardo Martins

Assistant Professor

eduardo.martins@unbc.ca

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UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

FWCP Fish & Wildlife COMPENSATION PROGRAM

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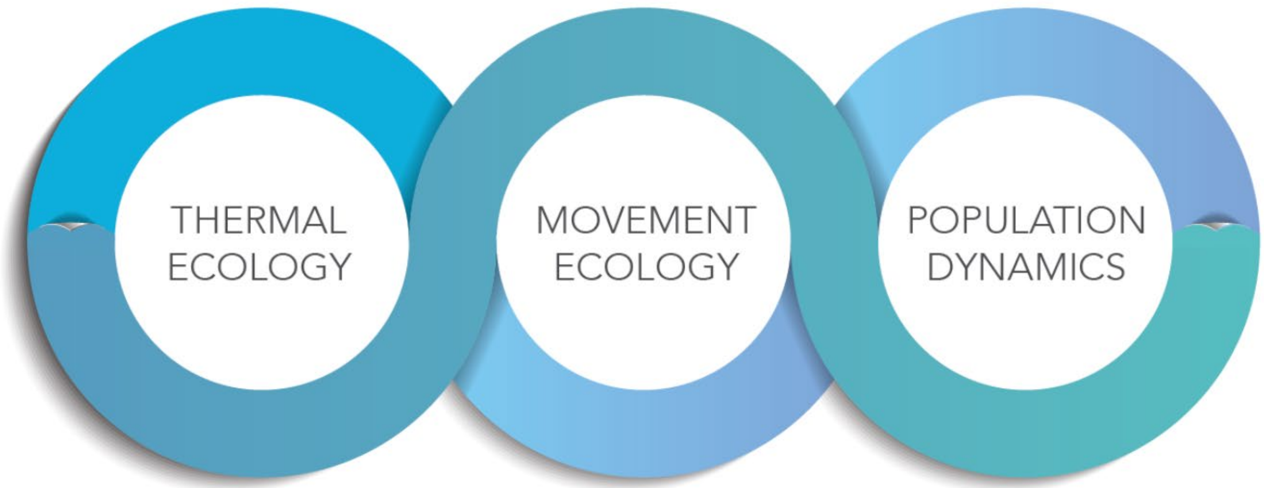

How does temperature affect fish?

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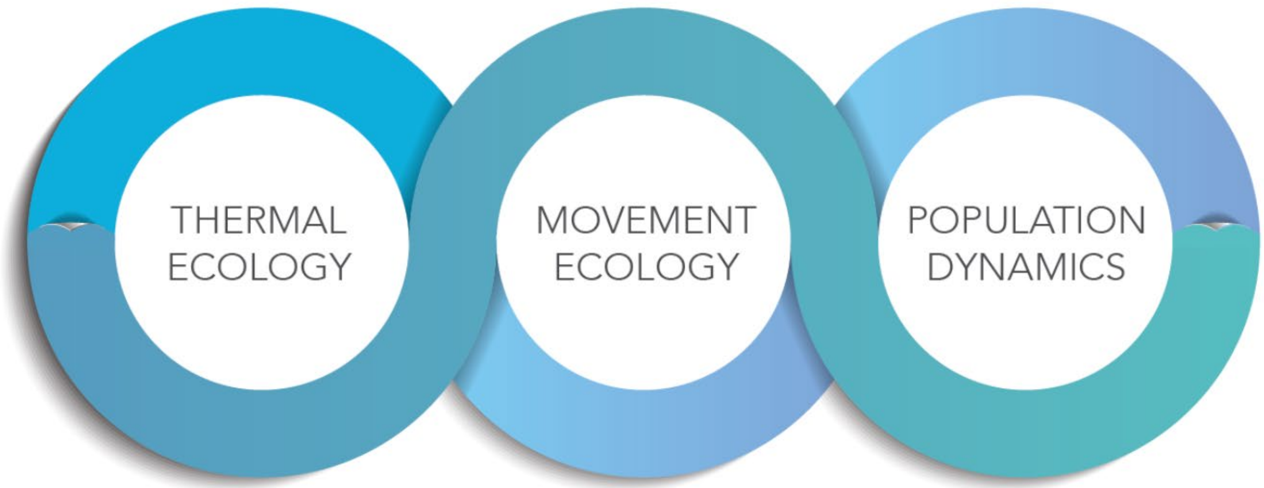

Where, when and why do fish move?

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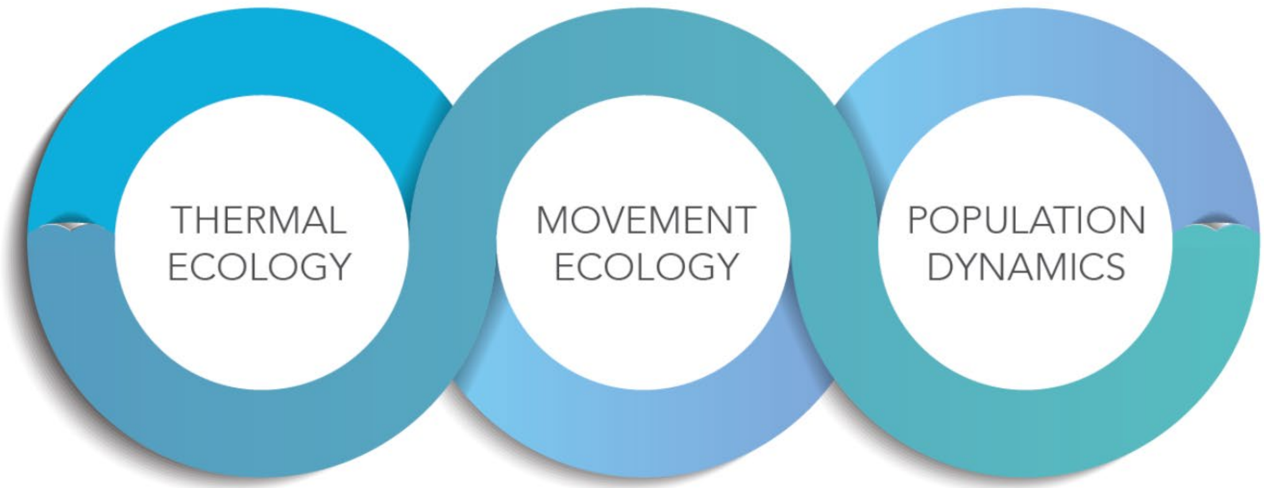


Why does fish abundance change over time and space?

Freshwater Fish Ecology
Laboratory | UNBC

biotelemetry, biologging, lab experiments, modelling

Spatial ecology of Arctic Grayling in the Parsnip watershed

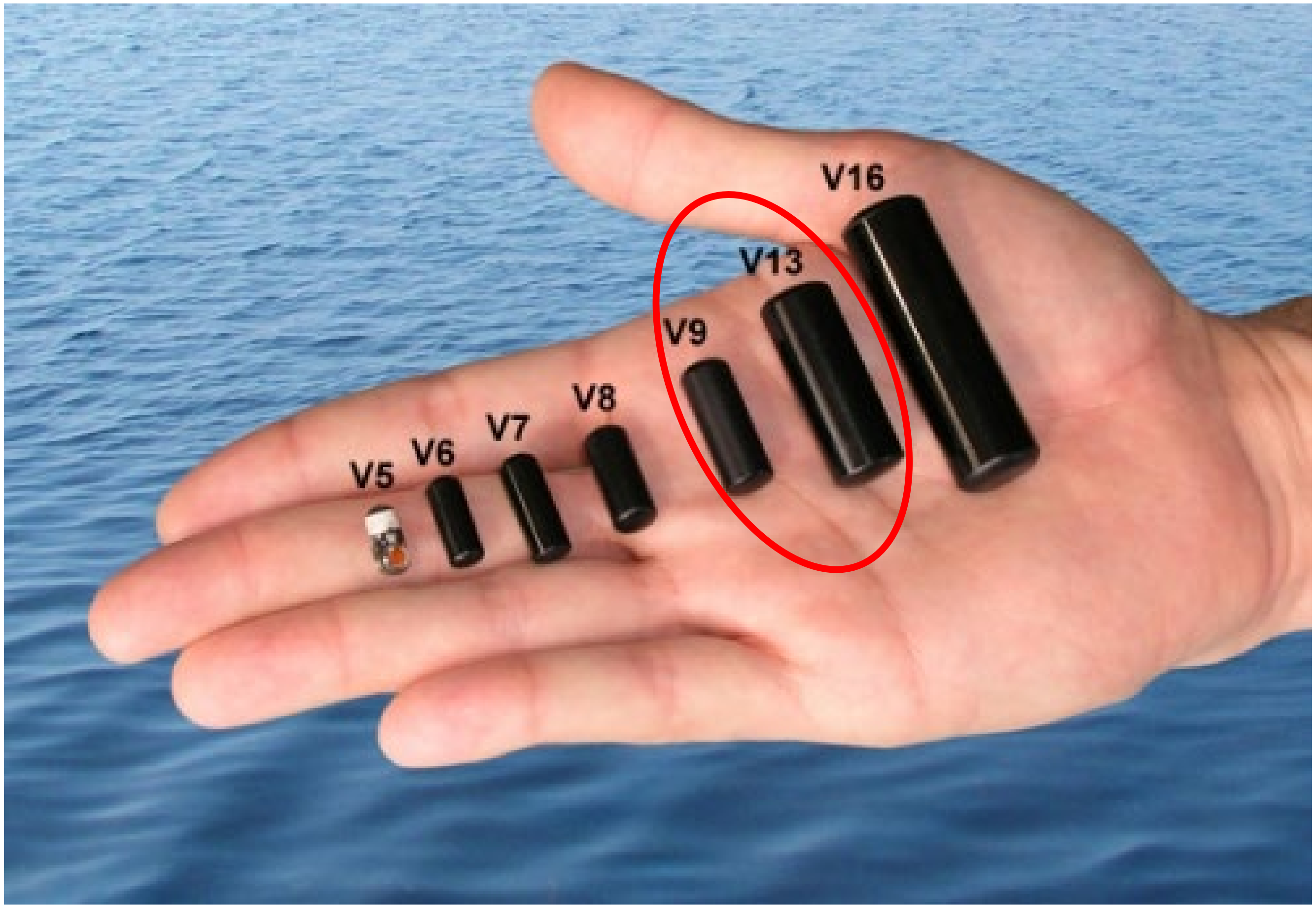
FWCP
Fish & Wildlife
COMPENSATION PROGRAM

Project Objectives

Investigate the spatial ecology of juvenile and adult Arctic grayling and their interactions with bull trout in the Parsnip mainstem and tributaries

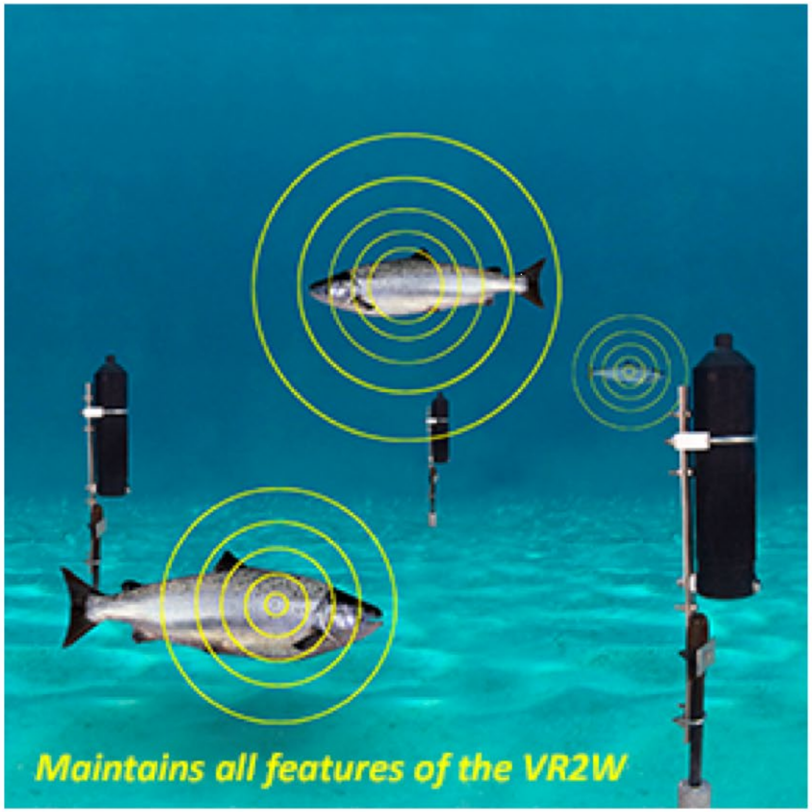
1. Investigate the migrations of juvenile and adult Arctic grayling among the Parsnip mainstem, tributaries and the Pack River;
2. Describe and define the distribution and thermal habitat use of juvenile and adult Arctic grayling;
3. Determine the overlap in distribution patterns of juvenile and adult Arctic grayling and bull trout.

Acoustic Transmitters



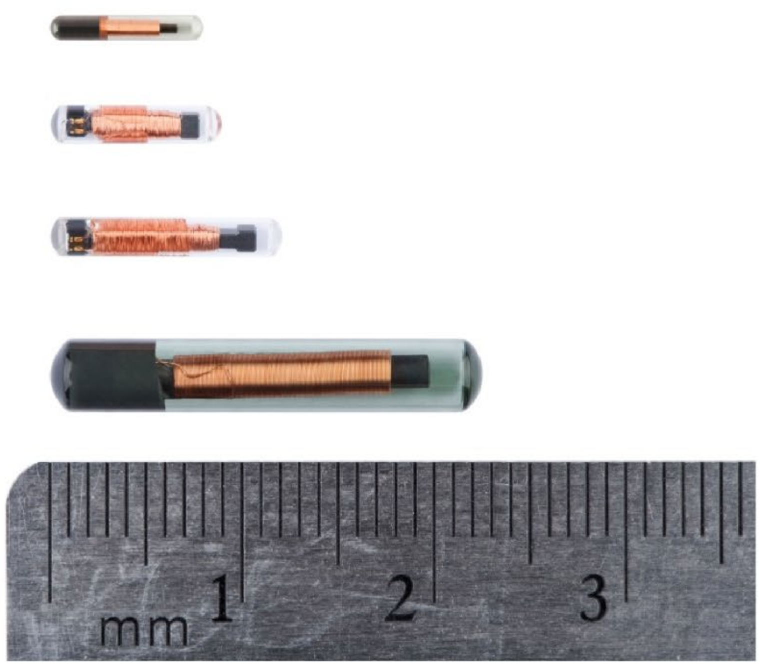
Acoustic Receivers

Monitoring of Acoustic Tagged Fish

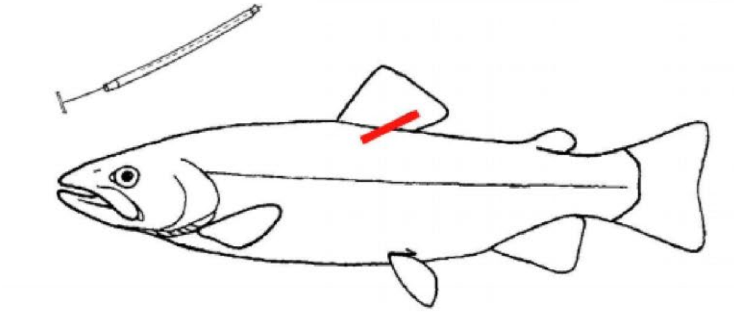


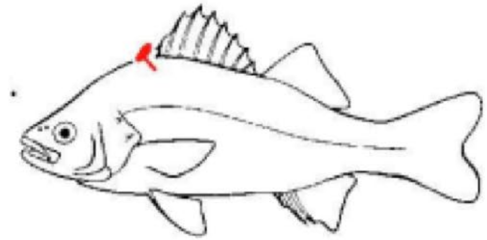
detects tagged fish from 0 km up to 1 km from receivers

PIT Tags

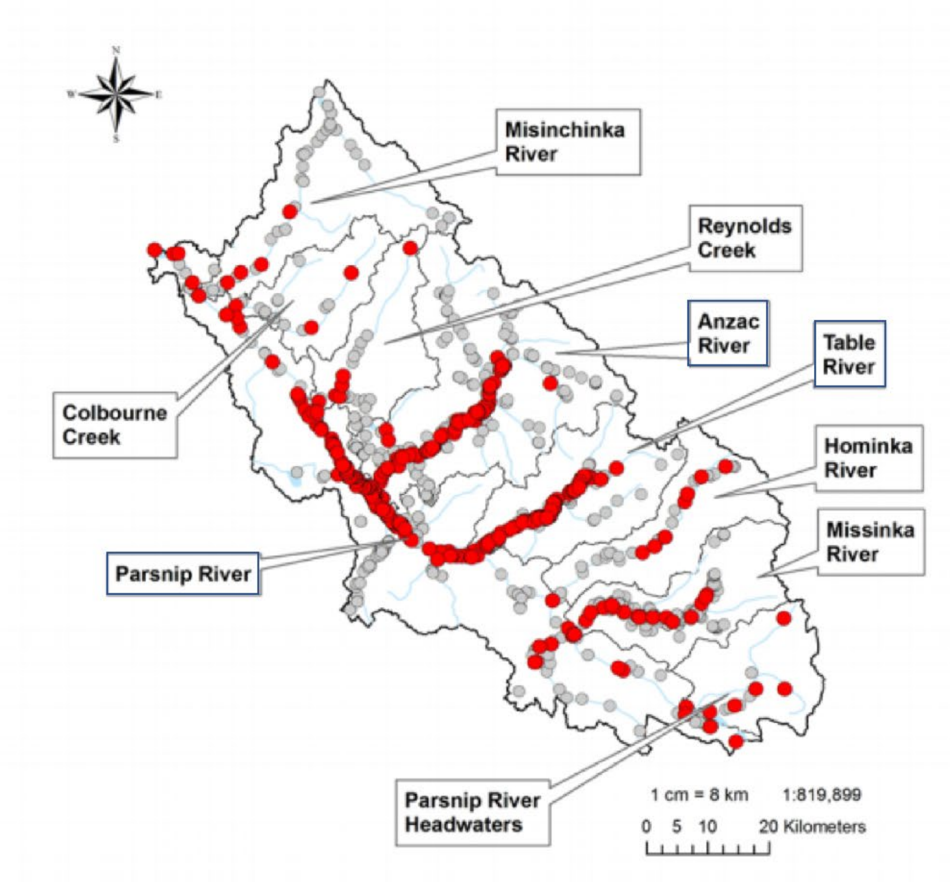


Anchor Tags





Study Area



Tagging

Starts: Jul-Aug 2018

Acoustic: 50 AG & 50 BT

Anchor: 25 / spp / month

Stamford et al (2017)

How You Can Help Us

What We Would Like You To Record

If you capture a **tagged** fish, please record

TAG NUMBER (EXTERNAL)

DATE AND TIME

GPS OF CAPTURE LOCATION

If you retain a **tagged** fish, please return the tags/transmitters to

Eduardo Martins
3333 University Way
Prince George, BC, V2N 4Z9

Thank You Very Much!

Contact

eduardo.martins@unbc.ca

Office: 250-960-5855 | Cell: 604-763-7920

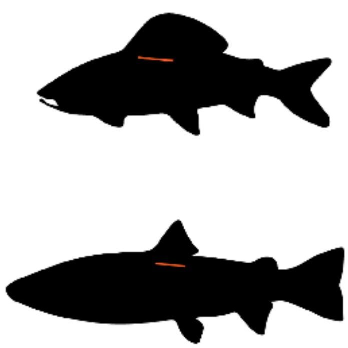
www.ffishlab.ca

Appendix 2. Community outreach information poster.

Looking for anglers to help with our research

The Freshwater Fish Ecology Laboratory at UNBC (ffishlab.ca) is implementing a study of the migration and spatial distribution of Arctic grayling and bull trout in the Parsnip River and tributaries. We are seeking the help of anglers fishing in the Parsnip watershed to help us collect data on tagged fish. If you are planning on fishing in the Parsnip watershed this summer and fall (or sometime over the next 3 years), please see below how you can help us.

What to do if you catch a tagged grayling or bull trout

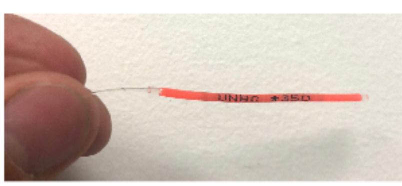


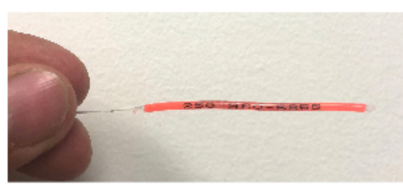
As highlighted in the illustrations above, you will find an orange tag on the left side of the fish's body and just below the dorsal fin.

1. Record the **tag number**, **date**, **time** and **capture/release location**. We need **ALL** these pieces of information to be able to use your contributed data.

2. Submit the recorded information:
   - Using the **MyCatch** app after releasing your fish (location is recorded by your phone's GPS, so please make sure you enter the information where you captured the fish) or;
   - Finding our project page on AnglersAtlas.com/research and then clicking **Report a Tag** to enter the information when you return from your trip (you will be able to indicate the capture location on a map).

The capture location will only be visible to the researchers, so **your secret spot is safe!**





The photos above show how the tag looks like. On one side of the tag, you will see the tag number (left photo), which we would like you to record. The other side of the tag has a telephone number (right photo) where you can reach the project leader (Eduardo Martins).

Freshwater Fish Ecology Laboratory | UNBC   FWCP Fish & Wildlife Compensation Program fwcp.ca   Angler's Atlas

This Project is funded by the Fish and Wildlife Compensation Program (FWCP)