Bridge River Project Water Use Plan

Lower Bridge River Spiritual and Cultural Value Monitoring

Implementation Year: 5

Reference: BRGMON-16

Final Report

Study Period: 2014 to 2018

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Table 1: OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES for the BRGMON-16 SPIRITUAL AND CUTURAL VALUE MONITORING PROJECT

Study Objectives	Management Questions	Management Hypotheses	Year 5 (2017-2018) Status
Collect information needed on the smell, sound, movement and interaction of people and water of the Lower Bridge River under the 6 cms/y flow regime and use this information to evaluate the cultural and spiritual objective that was discussed in the Consultative Committee process.	How does the smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime compare with that in the Yalakom River, an adjacent unregulated tributary of the Lower Bridge River?	The smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime does not differ from the Yalakom River.	There are higher spiritual and cultural values in the Yalakom River in comparison to the Lower Bridge River. Results contribute to the conclusion that the spiritual and cultural values are largely insensitive to water flow discharges over the five years of observations. This was demonstrated by the relatively small or no change in the spiritual and cultural scores over a large range of discharges.

Executive Summary

The BRGMON-16 Water Use Plan (WUP) monitoring project was undertaken by BC Hydro and St’át’imc Eco-Resources to measure and monitor a set of cultural and spiritual attributes in relation to different flow discharges in the Lower Bridge River below Terzhagi Dam. The information was collected to incorporate non-tangible inputs into a future long-term flow decision for the Lower Bridge River. During the project, between six to nine St’át’imc elders participated as evaluators to score their perceptions of cultural and spiritual values at different water flow discharges ranging between 1.5 cms in October 2016 and 109.5 cms in June 2017. The Yalakom River was adopted as an adjacent (unregulated) control river and four seasonal surveys undertaken over five years were simultaneously conducted in both river systems. A total of nine variables were evaluated at ten sites with a scoring system that ranged between 0 (least favorable) and 4 (most favorable).

The nine variables were analyzed by means of: 1) General Linear Interactive Modeling (GLIM); 2) histogram analysis; and 3) determining relationships between flow discharge and spiritual/cultural parameters by plotting scatter plots. Modestly higher parameter scores were obtained in the Yalakom River demonstrating that this river is perceived by St’át’imc elders to provide higher spiritual and cultural values than the Lower Bridge River. This conclusion should be interpreted with caution as the elders were aware that the Lower Bridge River is regulated whereas the Yalakom River is not. Counter intuitively, statistical analysis results indicated little variation in the parameter scores across different seasons, thereby allowing direct analysis of the effects of flow discharge in the absence of seasonally confounding effects. Analyses indicated that despite the large variations in flow conditions over the five years of monitoring, spiritual and cultural values in the Lower Bridge River were largely insensitive to flow variations over the range of flows that were examined.

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Introduction

The BRGMON-16 monitoring project was undertaken between July 31, 2013 and August 24, 2018 to monitor some of the intangible but culturally significant attributes of different flows in the Lower Bridge River and their influence on peoples' perceptions of river health. This work was designed to assess the influence of flow changes associated with the Bridge River Power Development Water Use Plan (WUP) on biological components and human perceptions of the ecosystem.

A structured decision-making framework was developed to address nine different objectives or endpoints. Eight of these - salmon, river health, riparian health, riverine birds, species of concern, financial impacts, learning, and stewardship – were measurable via empirical monitoring. The spiritual and cultural objective, concerned with changes in the smell, sound, movement, and interaction associated with different flows of water in the Lower Bridge River, is expressed through scales for which input can be obtained only from members of the St’át’imc community. This report describes a 5-year duration project that St’át’imc Eco Resources undertook on behalf of BC Hydro to monitor the impact of changing Bridge River flows on spiritual and cultural values. Unlike the original project design developed in the early 2000's, which involved comparative observations of 0, 3, and 6 cms mean annual discharges (MAD), flow discharge conditions at the start-up of the project in 2013 only covered 6 cms MAD rendering the original project design inapplicable. Instead, the project was modified to include comparative observations from the Yalakom River, a tributary of the Lower Bridge River with similar flow characteristics.

During 2016-2018, there was a requirement to pass excess water down the Lower Bridge River because of the reduced capacity to route flows into Seton Lake via the Bridge 1 and Bridge 2 Generating Stations due to their de-rated generator units and outages required for maintenance and upgrade. For the BRGMON-16 project, the June surveys, which occurred simultaneously with high flow discharges of 96 cms (2016), 109.5 cms (2017) and 100.5 cms (2018) provided opportunities to gauge the perceptions of the elders to the unusually high flow conditions.[1]

Background

St’át’imc elders speak of the “spirit” or “voice” of the Lower Bridge River. They have observed that when the water budget increased from 0 to 3 cms/y there were noticeable improvements in conditions for tangible outcomes like fish, wildlife, and riparian vegetation. But in addition, and distinct from these, there have been improvements in the “spirit” or “voice” of the river. Across the range of proposed flows relevant for the establishment of a long-term flow hydrograph for the Lower Bridge

[1] Note that the peak flows in 2016 were 96 cms, in 2017 were 126 cms and in 2018 were 102 cms. The flows stated here were on the day that the observers were in the field.

River, it was anticipated that there is potential for additional beneficial change to these important spiritual and cultural values.

Four key qualitative components of cultural and spiritual quality were defined for testing under the BRGMON-16 project:

Sound:

- The voice of the water (a variable defined by the observers individually)
- Birdsong (an integration of songbird presence)

Smell:

- The smell of the river itself (as determined by the observers individually)[2]
- The ambient smell at water's edge (as determined by the observers individually)

Movement:

- Movement of water (seasonally appropriate)
- Diversity of movement (pools/riffles)

Interaction (of people and water):

- Shore access (ability to easily walk to the shoreline)
- "Wadeability" (the ability to walk in and/or across the river at certain locations)

Prior to the initiation of the first session of field work in the summer of 2013, a 9th variable, **Water Clarity** (self-explanatory) was added to the survey.

These nine components clearly do not provide a universal definition of cultural or spiritual quality. They define aspects of cultural and spiritual quality believed to be relevant for the evaluation by St'át'imc elders of alternative flow regimes on the Lower Bridge River. It was intended that the information on spiritual and cultural values would provide an important measure that can be integrated with other social and environmental measures in an overall evaluation of alternate flow regimes.

The Yalakom River has been described by Komori (1997; p.14):

[2] as measured at approximately 10 m from the water's edge

"The Yalakom River is 56 km in length and provides the majority of accessible stream length for salmonids within the Bridge River system.... the stream gradient in the Yalakom River is generally very steep, averaging 2.5% over the 15 km most commonly utilized by anadromous salmonids below the partial barrier. The typical annual hydrograph closely follows the cycle of highland snowmelt runoff causing water temperatures to be lower than the regional averages. Discharge in the Yalakom River varies from 1.4 to 28.1 cms. The torrential nature of this stream, low average temperatures and limited fish habitat reduces the production potential in the Yalakom River"

The Bridge River originates in the ice fields of the Coast Mountains and flows east for 154 km before entering the Fraser River 5 km north of Lillooet. The Lower Bridge River is confined to a narrow valley downstream on Terzhagi Dam, partly cut in bedrock but often incised into glacio-lacustrine and glacio-fluvial deposits (Komori 1997). The Lower Bridge River floodplain was shaped by historical (pre-impoundment) flow levels of approximately 100 cms/year on average and ranging as high as 700 cms during former freshet periods (Golder 1999). Thus, the WUP flows represent approximately 3-6% of the former mean annual discharge. When compared with the Yalakom River, the Lower Bridge River has a relatively broad flood plain reflecting the pre-impoundment flow discharges that were an order of magnitude larger than presently.

Literature Review

There are a few examples of projects which have integrated spiritual and cultural values in water resource management, notably in Australia (Collings 2012). The latter study presents the results of 6 pilot projects involving spiritual and cultural value components (Table 2). The focus of these projects is integration, while the focus of BRGMON-16 is on the measurement of variables which were selected due to their close alignment with spiritual and cultural values. Overall Collings (2012) concluded:

"Integrating the cultural and spiritual values of Indigenous people into water quality management requires careful and considered planning and follow-up, as well as due respect for Indigenous law, custom and traditional knowledge."

Econometric approaches to the valuation of ecosystem services in river basins (Loomis et al. 2000) rely on "willingness to pay" interviews with local residents as a means for estimating resource values. The main methodological approach involves interviews with local stakeholders (Klain et al. 2014) and providing a monetary equivalent for the ecosystem good or service that is being studied. For the BRGMON-16 study, the monetization of spiritual and cultural values is not applicable and such considerations are not within the realm of the St’át’imc world view. Satterfield et al. (2013) concluded that:

"Characterization of cultural benefits and impacts is least amenable to methodological solution when prevailing worldviews contain elements fundamentally at odds with efforts to quantify benefits/impacts, but that even in such cases some improvements are achievable if decision-makers are flexible regarding processes for consultation with community members and how quantification is structured."

Table 2. Key findings from Australian case studies undertaken to integrate spiritual and cultural values into water quality management. Source: Collings (2012).

Case Study	Key Findings
Adelaide Coastal Water Quality Improvement Plan, (ACWQIP) South Australia	During the development phase of the draft ACWQIP, the South Australia Environmental Protection Agency (EPA) reports that stakeholders have been generally satisfied with the consultation and engagement processes. A key lesson is to ensure early engagement with Kaurna People to help achieve effective outcomes. The correct people need to be identified from the outset.
Police Lagoons Conceptual Model, Queensland	The conceptual models for Police Lagoons integrate science with cultural, spiritual and ecological values in order to inform integrated natural resource management of the lagoons. The objective is to support community goals to maintain and improve the wetland's values.
Engaging with and incorporating the views of the Queensland Far South West Aboriginal Natural Resource Management Group in water quality management planning, Queensland	The Far South West Aboriginal Natural Resource Management Group's values for the waters within the region will be incorporated into the future statutory environmental values and water quality objectives for the waters of south west Queensland under the *Environmental Protection (Water) Policy 2009*. The establishment of water quality objectives to protect aquatic ecosystem values is considered to generally afford protection of the cultural and spiritual values for the waters of the region.
Prioritising rock-holes of aboriginal and ecological significance in the Gawler Ranges, South Australia	One of the lessons learnt is that for projects like this, with a range of stakeholders from diverse backgrounds, it is very important to develop, implement and maintain a comprehensive communication/stakeholder engagement strategy prior to project initiation that continues throughout the project including follow-up.
Recognising indigenous cultural and spiritual values in maintaining river health of the Daly River, Northern Territory	Indigenous people possess intimate knowledge of their local environment and have complex value systems in connection with water and biodiversity. This knowledge is integral to holistic management planning to maintain river and ecosystem health.
Kungun Ngarrindjeri Yunnan (KNY) engagement with natural resource management	Protocols of engagement provide an important framework to recognize the values and status of Indigenous people in managing natural resources. The KNY Agreement provides a framework to assist and guide interactions with Ngarrindjeri people and for the most culturally appropriate and sensitive way of doing business on Ngarrindjeri traditional lands and waters.

An interview approach was undertaken as a separate and complementary component of the BRGMON-16 project to document St'át'imc knowledge in relation to a broad spectrum of environmental resources and conditions (Appendix 2). In these cases, group or individual interviews provided a relevant approach for compiling information on spiritual and cultural resources. Both the interview activities and the empirical approach reported here complement each other and provide different lenses for understanding spiritual and cultural values in relation to water resource management.

Objectives and Scope

The original objective of this program, (presently inapplicable due to present and future spilling requirements) was to collect information on the smell, sound, movement and interaction of people and water in the Lower Bridge River under a 6 cms/y flow regime and to use this information to evaluate the cultural and spiritual objective. While this management question was the focus of the monitoring, an opportunity arose during 2016-2018 to additionally evaluate how the smell, sound, movement and interaction (of people and water) in the Lower Bridge River varies as a function of flow discharge.

Management Question

The management question that was addressed by this monitoring program was:

> *How does the smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime compare with that in the Yalakom River, an adjacent unregulated tributary of the Lower Bridge River?*

During 2018, due to the high flows in the Lower Bridge River, flow deviated from 6 cms/y to a mean annual discharge of 17.95 cms/y. Mean Annual Discharges in the Lower Bridge River over the 5 years of monitoring were:

	Mean Annual Discharge (CMS)
2014	6.03
2015	6.58
2016	21.87
2017	18.59
2018	17.95

Hypotheses Tested by the Monitoring

The primary management question was tested using the following hypothesis:

H_O: *The smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime does not differ from the Yalakom River.*

Key Water Use Decisions Affected

The key water use decision affected by this monitoring program is the long-term flow regime for the Lower Bridge River. Information from BRGMON-16 monitoring program will be used along with other performance measures to evaluate the 6 cms/y flow regime. Note that this water use decision will be deferred or altered in view of current water management considerations within the Bridge - Seton system.

Study Area

The Study Area for this project extends between Terzhagi Dam and the Bridge River/Fraser River confluence. Consistent with the other WUP monitoring projects on the Lower Bridge River, the Study Area was divided into 4 reaches utilizing existing reach boundaries. Reaches 2, 3 and 4 were analyzed (Figure 1) consistent with the Terms of Reference for BRGMON-16. Reach 1 was excluded from the analysis since the effect of the Terzhagi Dam release attenuates in a downstream direction due to increasing influence of groundwater inflows coupled with the combined Lower Bridge River tributary inputs. Several other monitoring studies (e.g. BRGMON-1: Lower Bridge River Aquatic Monitoring) have also focused exclusively on Reaches 2, 3 and 4 due to the attenuation of Terzhagi Dam flow release effects in a downstream direction from the Dam.

Reach boundaries of the Lower Bridge River and the locations of the sampling sites are shown in the map below. There were 6 observation sites in the Lower Bridge River (B1 - B6) and 4 observation sites in the Yalakom River (Y1 - Y4). Specific site locations were selected based on ease of access to the river shorelines within reaches to maintain safe operating procedures and low risk of falling/injury.

The annual hydrographs for the two study rivers are shown in Figure 2. Note that while the 3 cms and 6 cms hydrographs for the Lower Bridge River are specified in the WUP, BC Hydro obtained variances from the BC Water Comptroller between 2016 - 2018 that authorized large departures from the approved hydrographs. The net effect of the additional water releases was to increase the mean annual discharge from 6 cms/y to 17.9 cms/y (calendar year from Jan. 1, 2018 to Dec. 31, 2018).

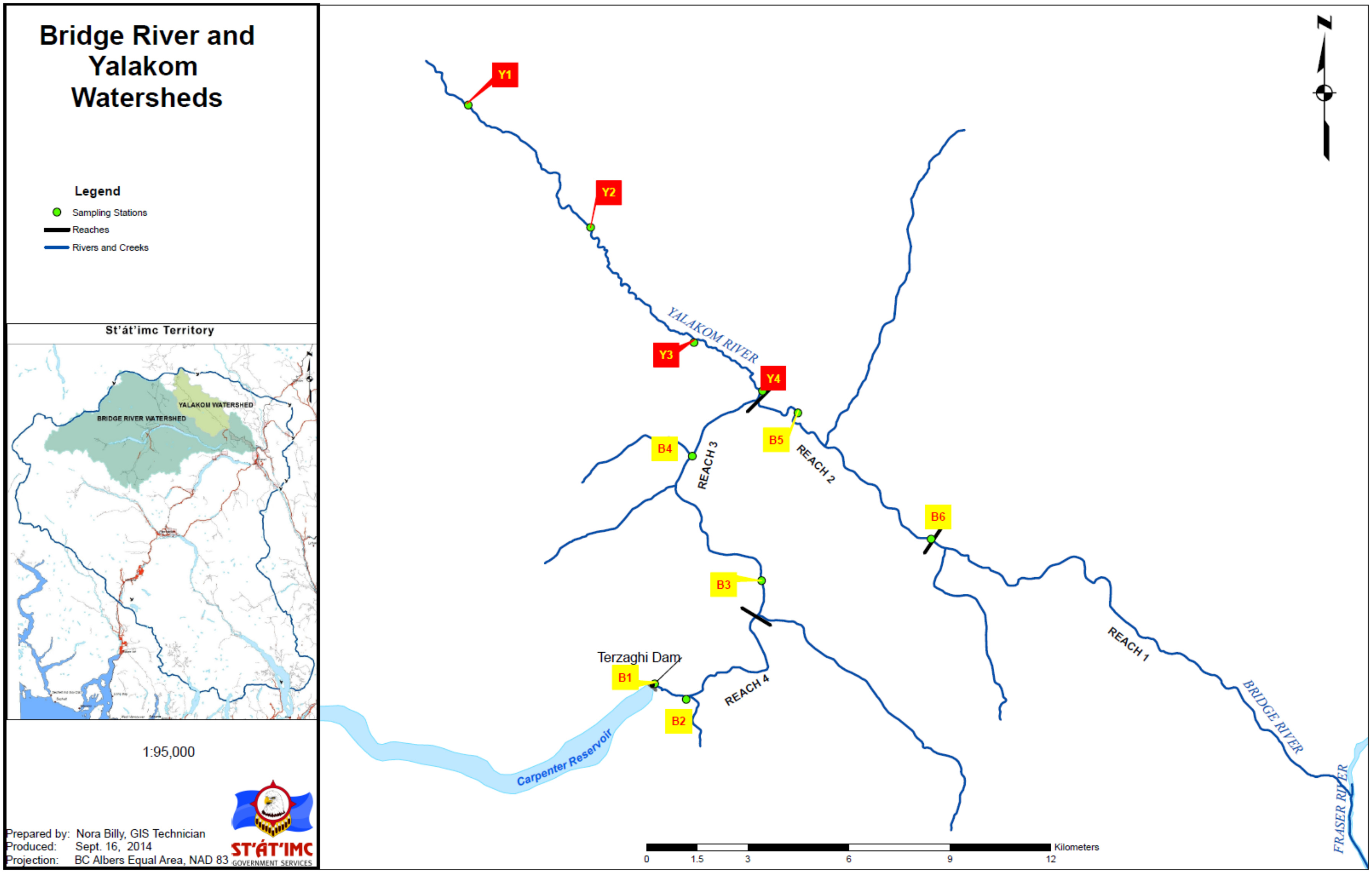


Figure 1. Location of sampling sites in the Yalakom River and Lower Bridge River.

The hydrograph for the Yalakom River (Figure 2) based on averaged Water Survey of Canada data for the period 1981 - 1990 (Station 08ME025) is shown in relation to the target flows for the Lower Bridge River under 3 cms and 6 cms discharges. The Yalakom River data were collected as part of a hydrology and water use investigation in the Bridge Seton Watershed (Rood and Hamilton 1995) that was commissioned by Fisheries and Oceans Canada (DFO) during Fraser River Action Plan investigations. The Lower Bridge River flow discharges for 2013 - 2015 (Figure 3) were obtained from BC Hydro records. The selection of the Yalakom River as an unregulated control river for conditions in the Lower Bridge River was predicated on the occurrence of similar hydrographs in the two systems (Figure 2).

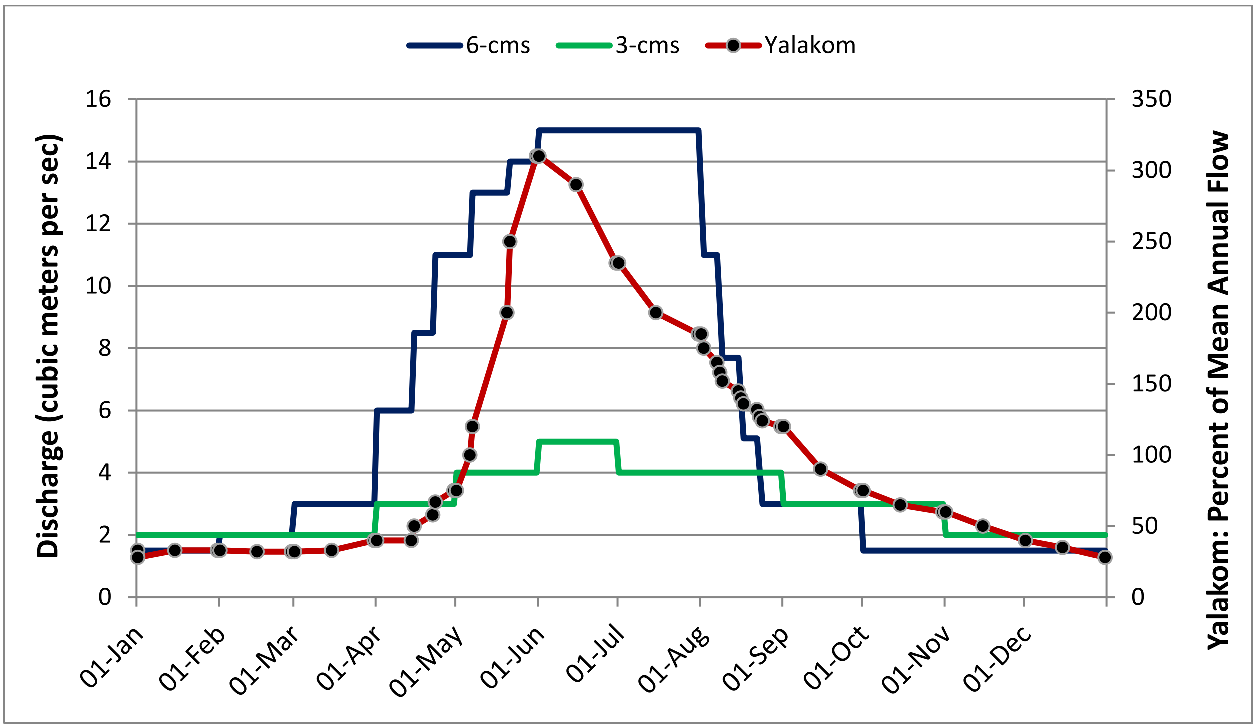


Figure 2. Comparison of Lower Bridge River flow discharges at 3 cms and 6 cms (annualized mean flow) in relation to averaged Water Survey of Canada data for the period 1981 - 1990 (Rood and Hamilton 1995). The annual mean Yalakom River flow over this period was 4.11 cms.

The Lower Bridge River hydrographs prior to higher flows released from the dam in 2016-2018 (Figure 3) show the idealized flow discharges as described in BC Hydro's 2011 Order from Comptroller of Water Rights in relation to actual flows between 2013 - 2015. Actual flows conformed closely with the idealized target flows over the period of BRGMON-16 data collection between July 31, 2013 and March 7, 2015.

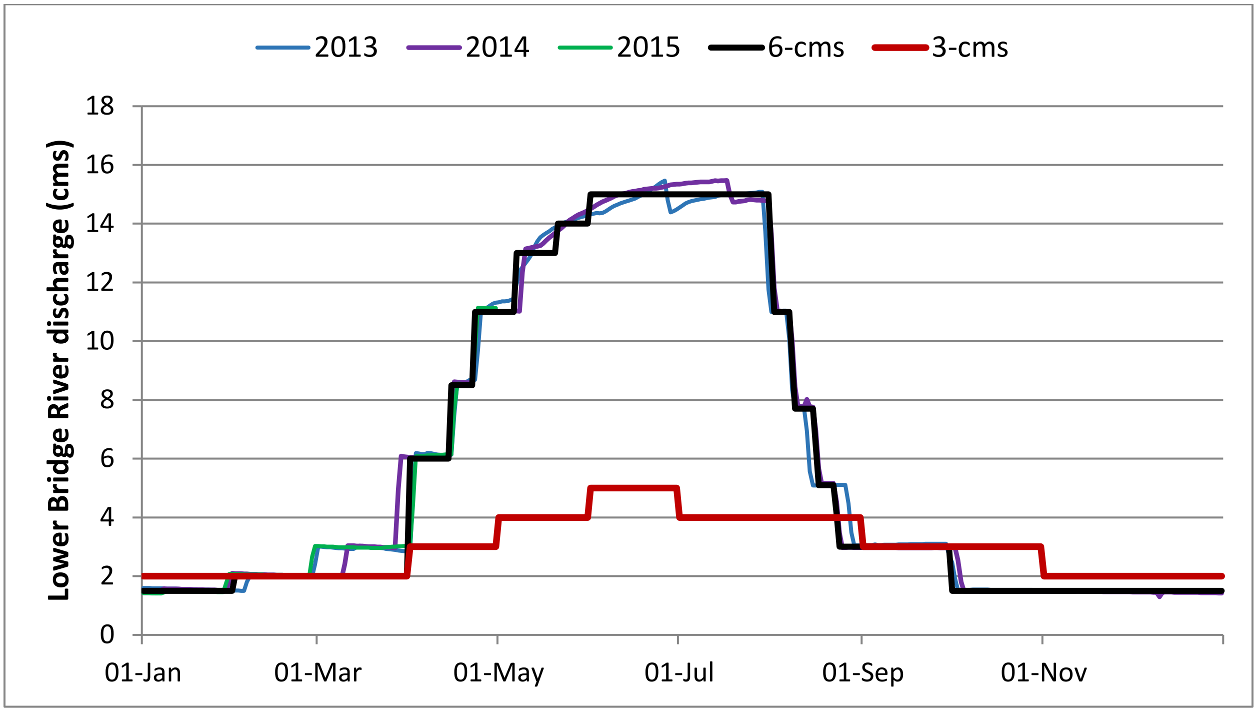


Figure 3. Actual flow discharges in the Lower Bridge River between 2013 - 2015. Flow discharge data provided by BC Hydro, Power Records.

As mentioned in the Introduction there was a need to spill excess water into the Lower Bridge River in 2016, 2017 and 2018 with discharges that reached a peak of 96, 126 and 102 cms in 2016, 2017 and 2018 respectively. Field data collection was scheduled close to the peak flows in the three high flow years to provide statistical contrast within the datasets. Hydrographs depicting the discharge over the entire BRGMON-16 study period are shown in Figure 4. Figure 5 provides a visual perspective of how flows varied during the project.

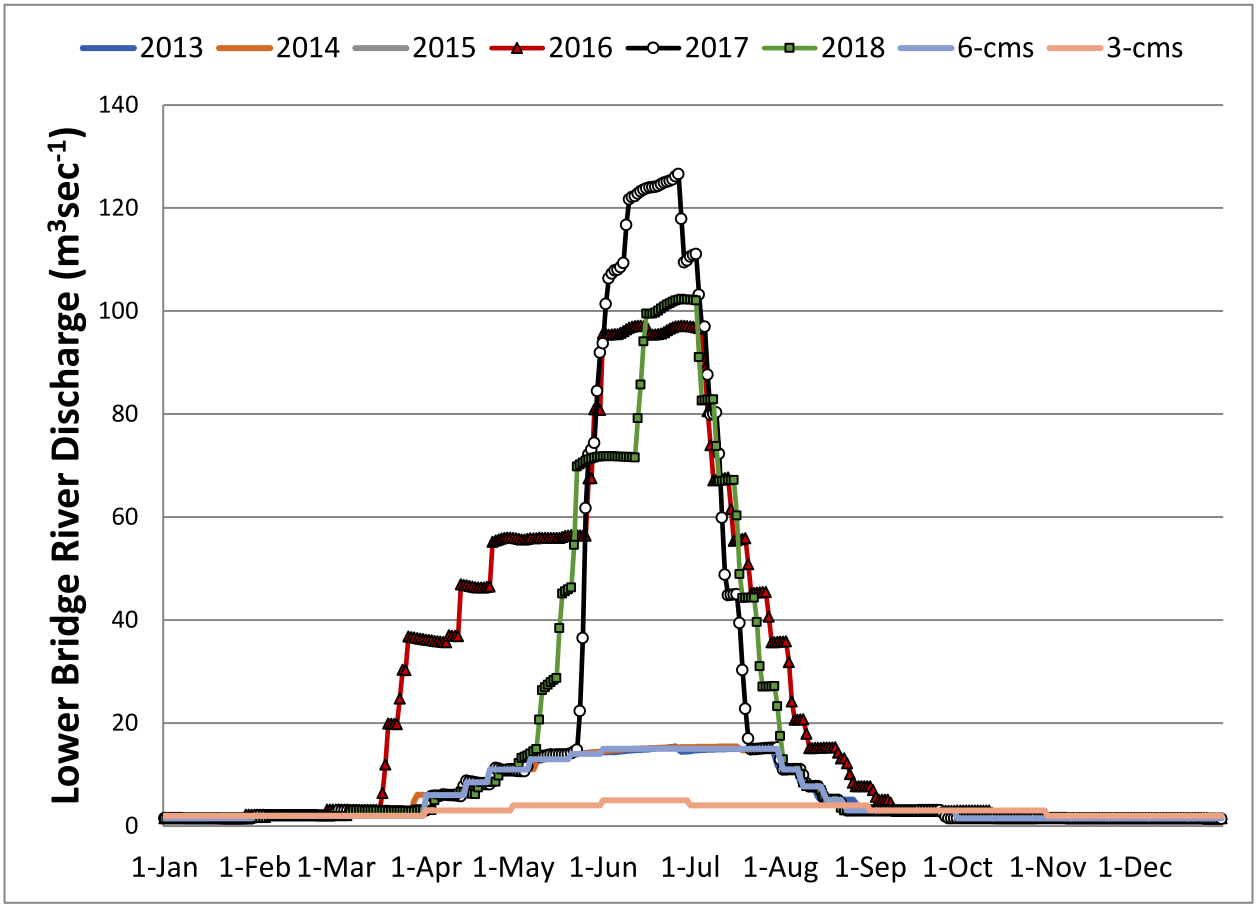


Figure 4. Hydrographs for the Lower Bridge River over the 5 years of observations.

Figure 5. Photos from 2014 (prior to spilling) and 2016-17 (during spilling) taken from the Camoo Bridge in the Lower Bridge River (left) and the Yalakom River (right).

Approach and Methods

To maintain consistency and transparency in assessment, a ***Cultural and Spiritual Quality Scale*** and a protocol for measuring it, was utilized. The approach involved:

1. Six to nine St'át'imc elders who acted as observers. Continuity in membership was maintained in most instances so that consistency in the conduct of measurements was achieved. However due to logistical realities the number of participating elders varied between 6 to 9 over the five-year duration of monitoring.
2. Observations taken four times per year under a range of flows: September (low flows, spawning fish present), March (low flows, winter conditions), April (moderate flows, spring conditions), June (peak flows, summer conditions, relatively low fish abundance/visibility). Sampling dates were replicated between years, with minor variations due to logistical constraints.
3. Observations taken at two Lower Bridge River sites per reach over reaches 4, 3 and 2;
4. Observations taken at four Yalakom River sites;
5. A simple and transparent scoring system for assigning scores to each component in each reach. On the designated date and site, each observer assigned a score of 0 to 4 for each of the five components (sound, smell, movement, interaction as well as water clarity), where 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality;
6. Analysis of aggregate scores across observers, components, reaches and seasons; and,
7. Statistical evaluation of results using a General Linear Interactive Model and by examining relationships between flow discharge and spiritual/cultural parameters using cumulative link models for ordinal regression.

Anticipating that the elders would be unfamiliar with the adopted scoring system, the method was calibrated during a classroom session prior to the first field trip in 2013. During the session, elders scored their preference for 3 flavors of potato chips - salt and vinegar, barbeque, and regular - according to the 0-4 scoring system above. Results demonstrated clear preferences for different chip flavours with barbeque rated highest preference and with salt and vinegar lowest. The exercise reinforced the elders understanding of the method for scoring the spiritual and cultural variables.

Collected data were subjected to three different methods of analysis: 1) graphical analysis by plotting histograms that displayed the mean and standard deviations of the spiritual and cultural attribute scores, 2) General Linear Interactive Modeling (GLIM) a statistical software program for fitting generalized linear models (GLMs) and, 3) a discharge analysis in the Lower Bridge River comparing flow discharge and spiritual/cultural parameters using scatter plots.

It was advantageous to apply three independent analytical procedures to the BRGMON-16 data set to understand the convergence and divergence between the three methods.

The GLIM procedure involved the following steps. First, the model with all fixed effects of interest, including interactions, was fitted to the data. Next, the least significant interaction was removed and the model was refit to the data. Lastly, the preceding step was repeated until the model only contained significant interactions and main effects (note that non-significant main effects were retained in models where they were part of a significant interaction).

Schedule

The Terms of Reference for the project indicated September (low flows, spawning fish present), February (low flows, winter conditions), April (moderate flows, spring conditions), and June (peak flows, summer conditions, relatively low fish abundance/visibility) as the preferred sampling dates. Minor departures from the TOR schedule were unavoidable due to logistical constraints, however, the deviations were small and observations during 2016-2018 in particular covered a wide range of flow conditions. As discussed below, the scheduling deviations were informative by generating contrast in flow variations within the data set.

Results

Comparisons of the mean of the nine different measurement variables obtained in the different rivers (aggregating across sampling sites) are shown in Figures 6 – 10. Following are the sample sizes on the different sampling dates:

July 31, 2013	6
Oct. 7, 2013	6
Apr. 7, 2014	6
May 14, 2014	6
Aug. 19, 2014	6
Oct. 7, 2014	8
March 17, 2015	8
May 14, 2015	7
Aug. 10, 2015	7
Oct. 14, 2015	7
March 14, 2016	7
June 1, 2016	6
Aug. 9, 2016	8
Oct. 11, 2016	9
Apr. 6, 2017	8
June 29, 2017	9
Aug. 29, 2017	8
June 21, 2018	8
Aug. 23, 2018	8

In the histograms that follow below error bars depict ±1 standard deviation about the mean. Scores of 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

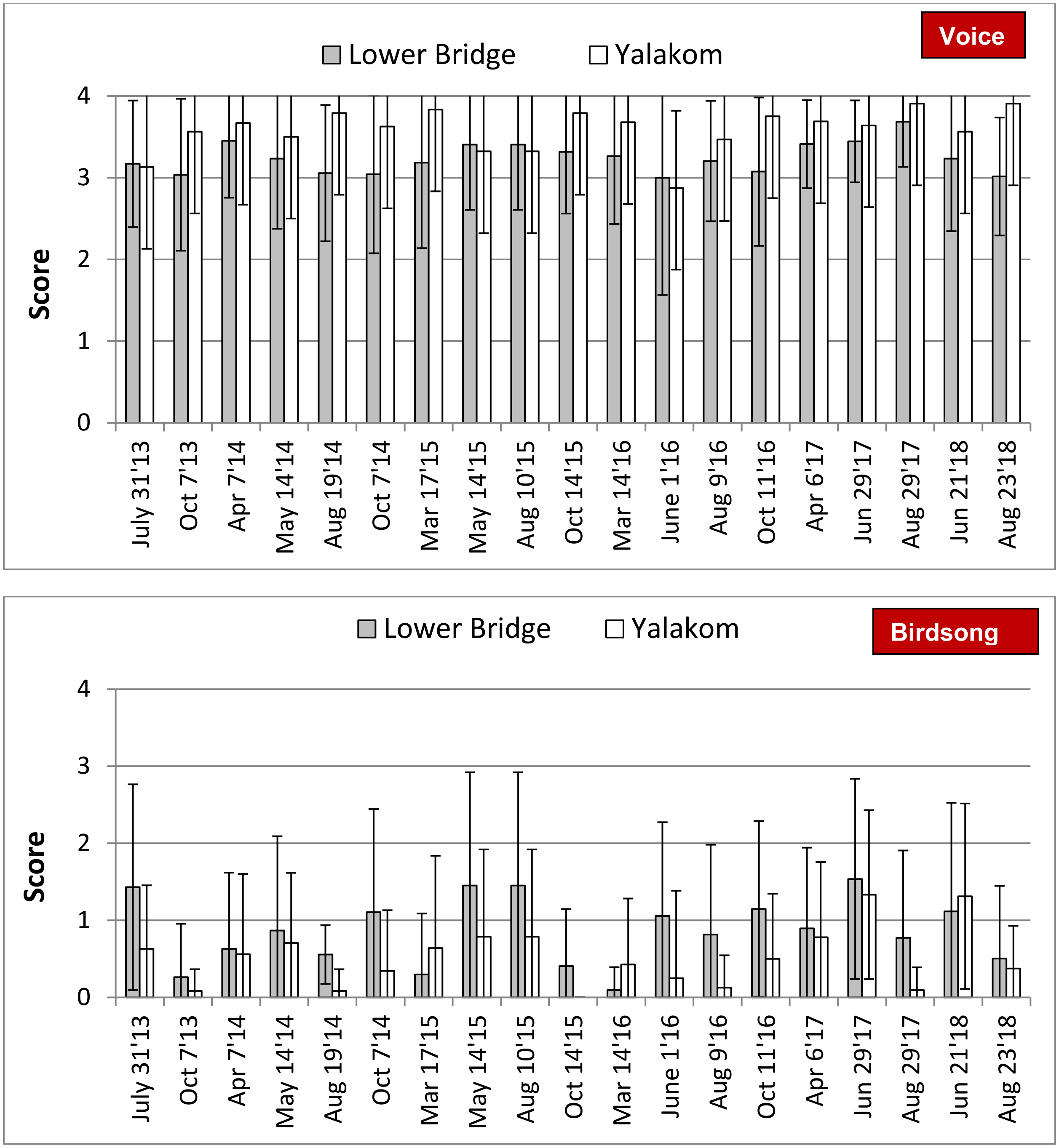


Figure 6. Time series of mean Voice and Birdsong scores in the Lower Bridge and Yalakom Rivers.

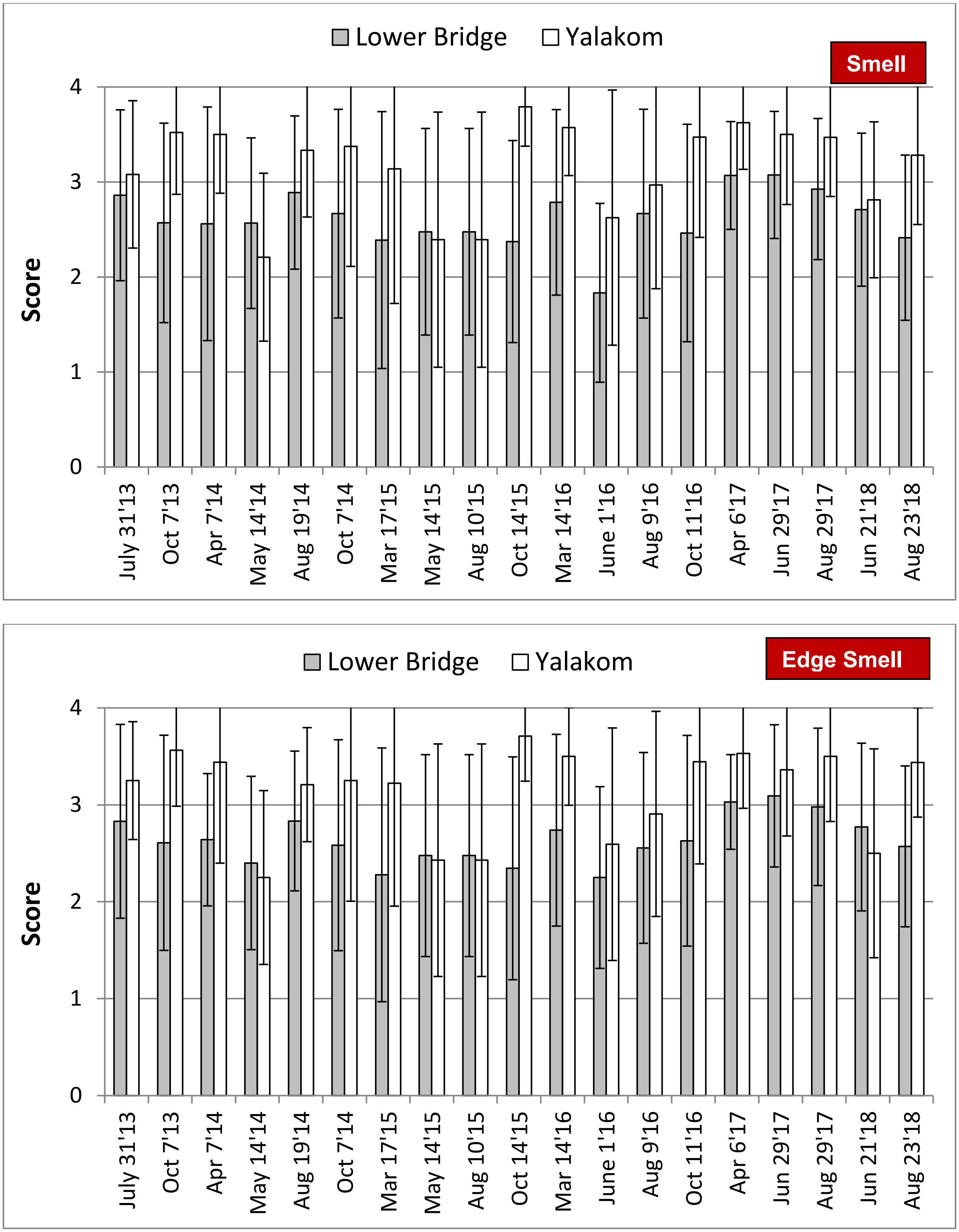


Figure 7. Time series of mean Smell and Edge Smell scores in the Lower Bridge and Yalakom Rivers.

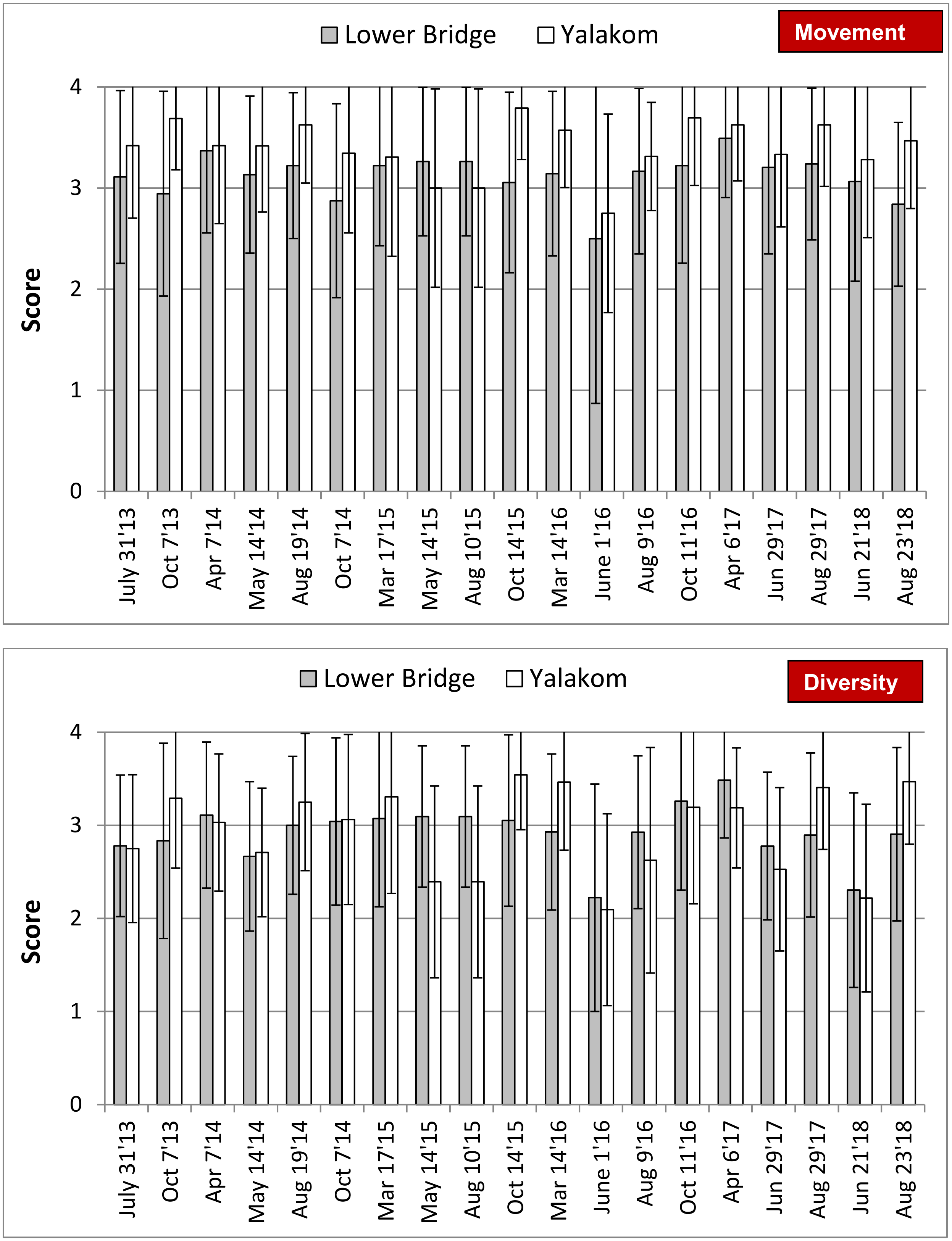
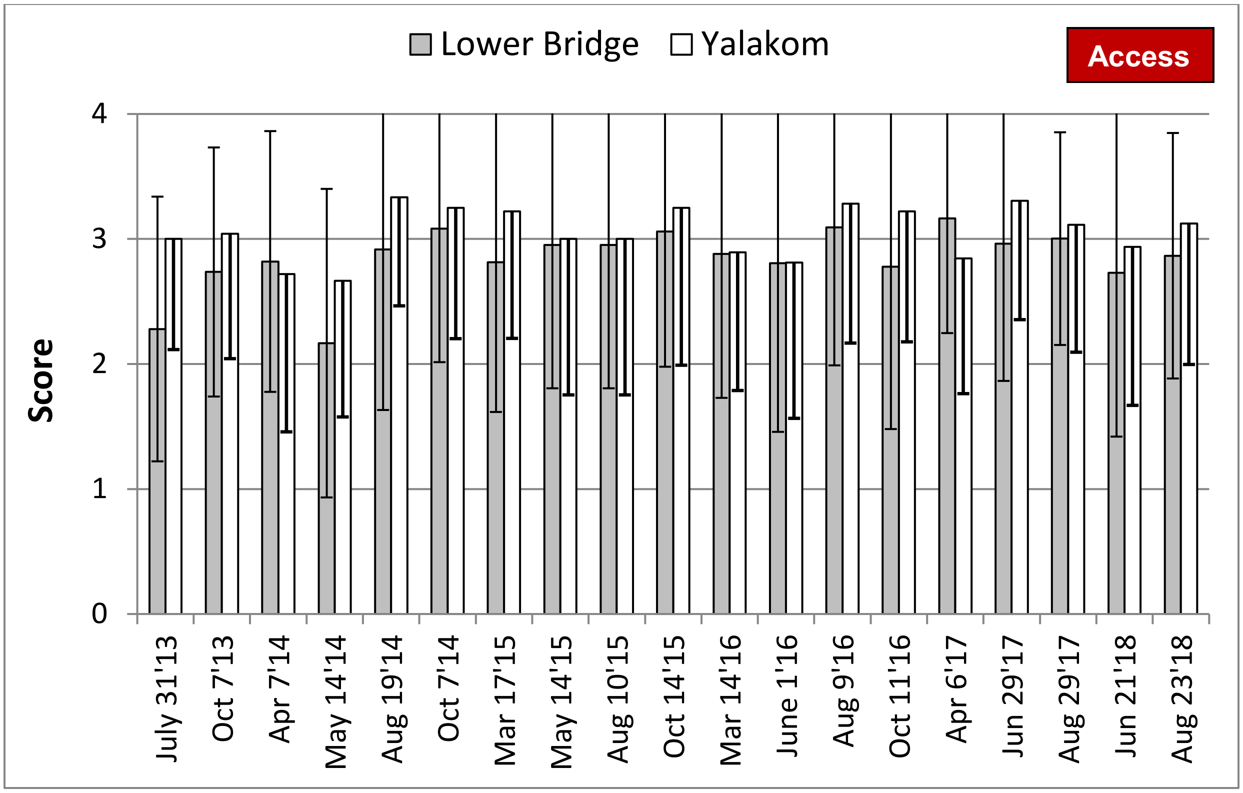


Figure 8. Time series of mean Movement and Diversity scores in the Lower Bridge and Yalakom Rivers.



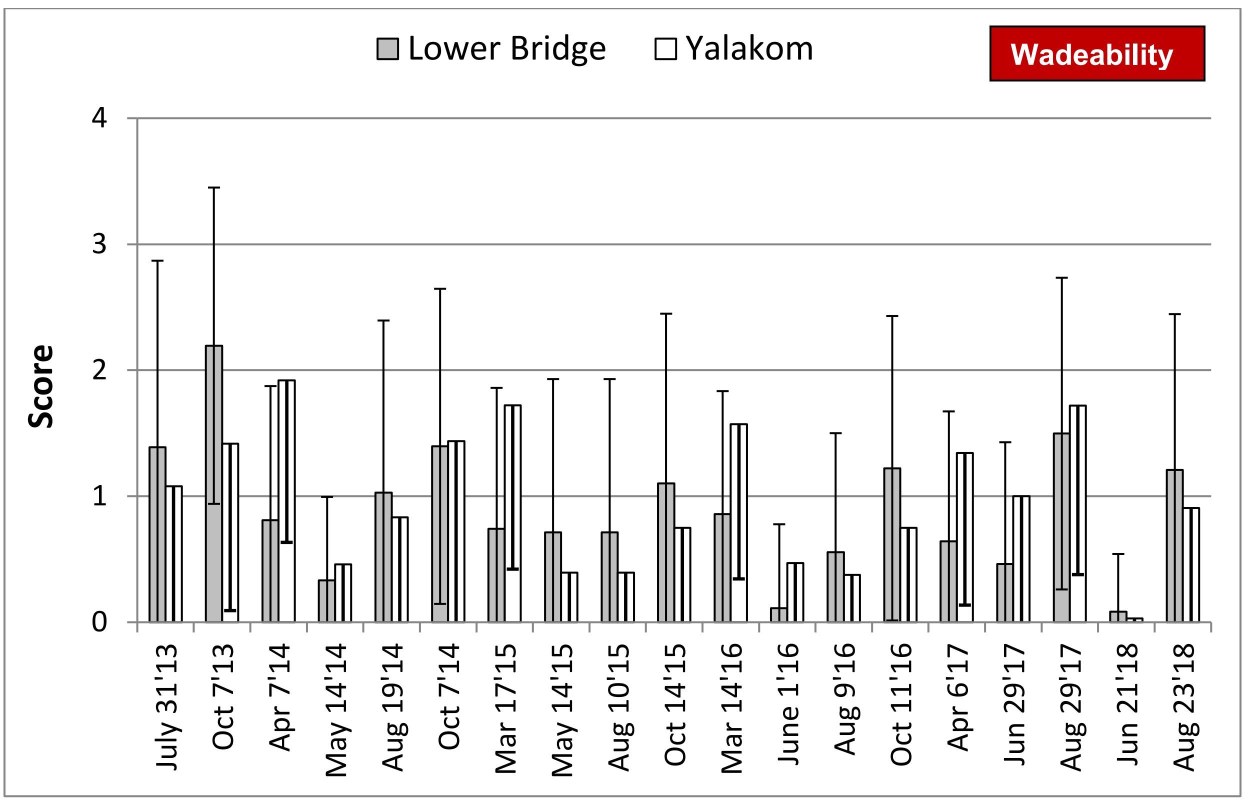


Figure 9. Time series of mean Access and Wadeability scores in the Lower Bridge and Yalakom Rivers.

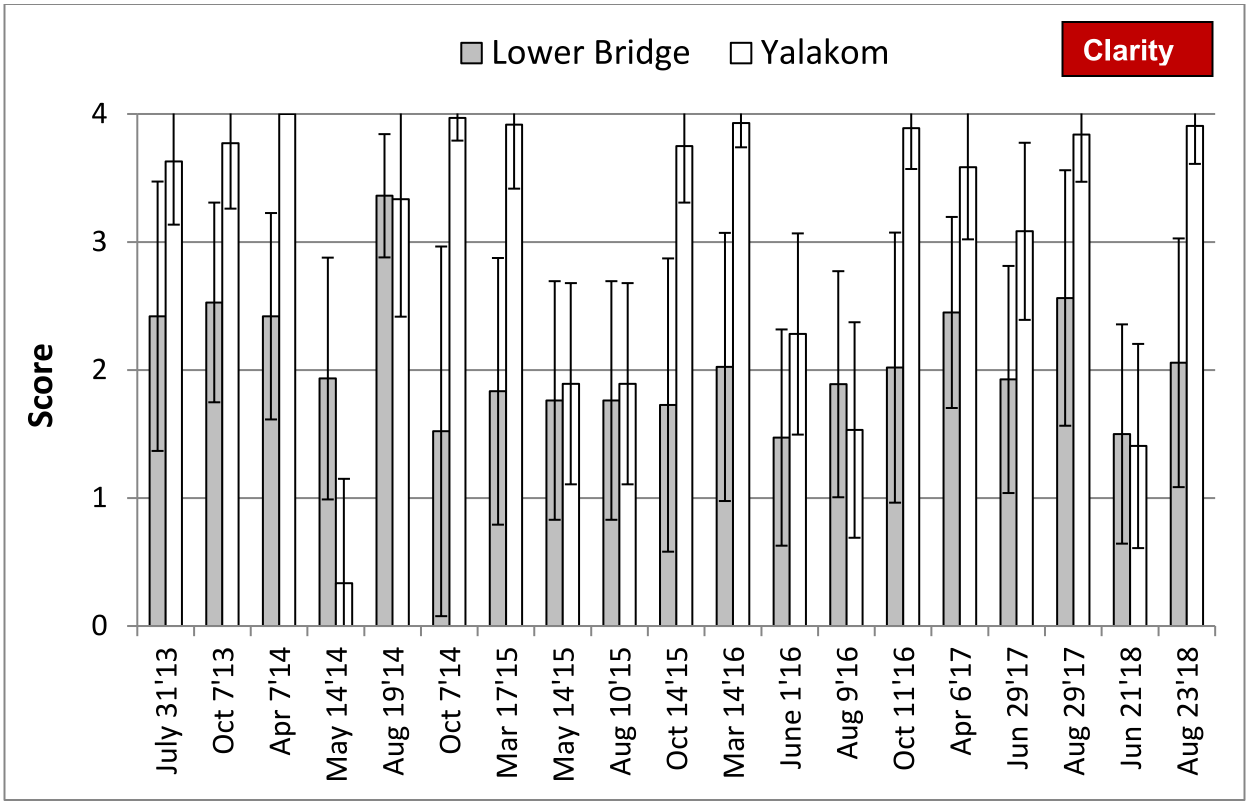


Figure 10. Time series of mean Clarity scores in the Lower Bridge and Yalakom Rivers.

To examine the effects of flow discharge on spiritual and cultural values, scatter plots of discharge values and the mean for the cultural and spiritual value scores (Figures 11-13 were prepared to provide visual comparisons of the monitoring observations.

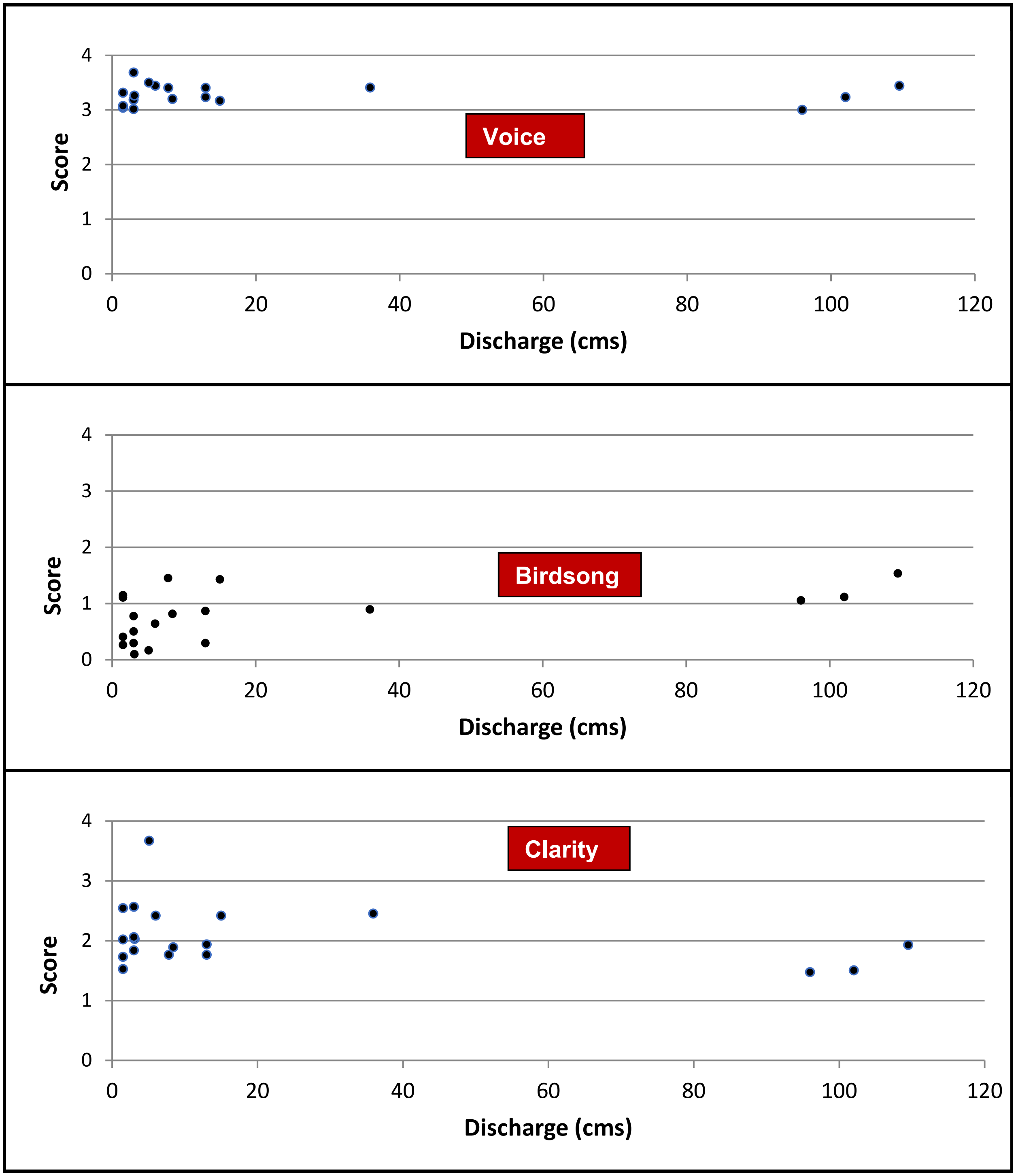


Figure 11. Scatter plots showing mean scores for Voice, Birdsong, and Clarity in relation to Lower Bridge River flow discharges between 2013 - 2018. Scores of 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality

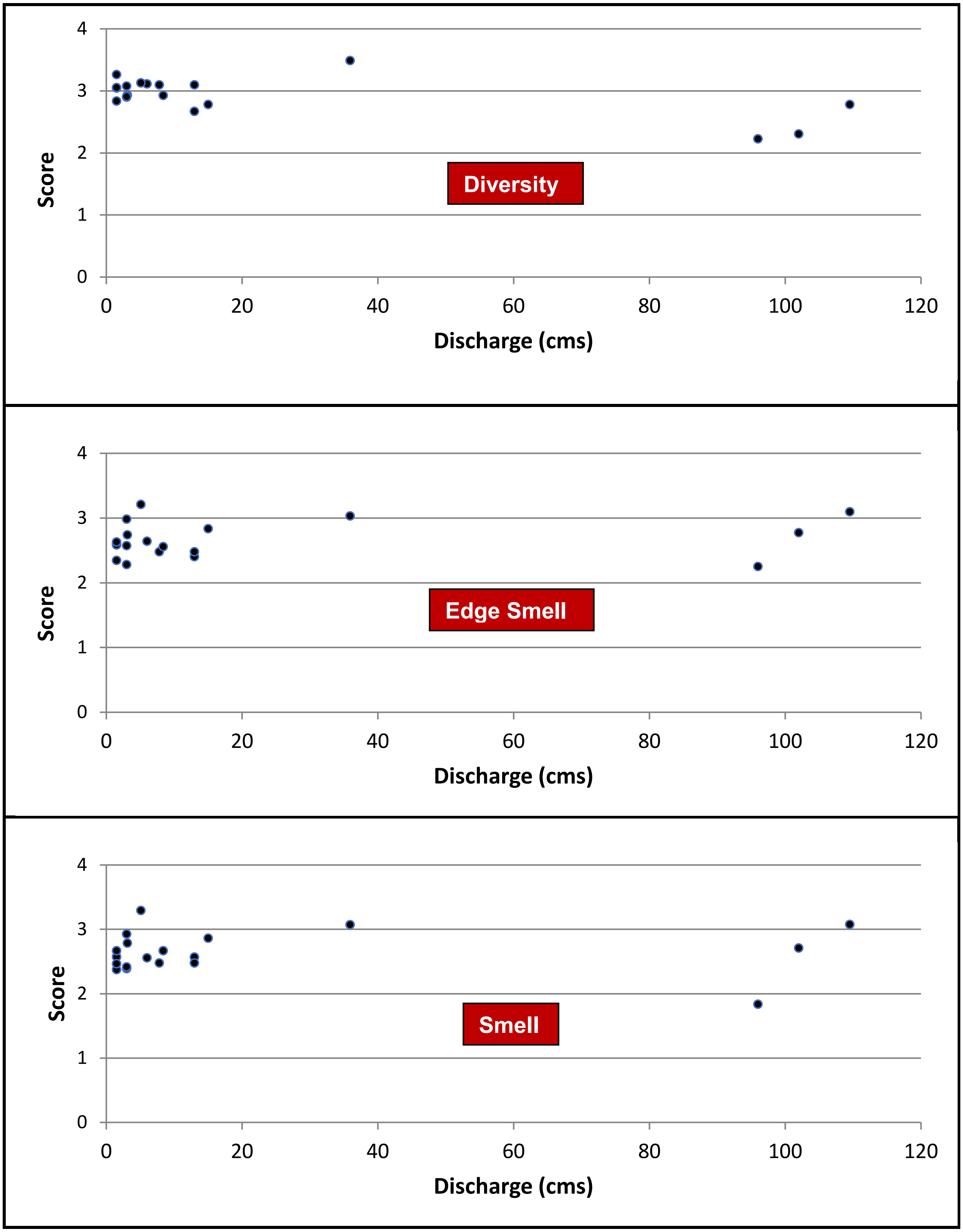


Figure 12. Scatter plots of mean scores for Diversity, Edge Smell, and Smell in relation to Lower Bridge River flow discharges between 2013 - 2018.

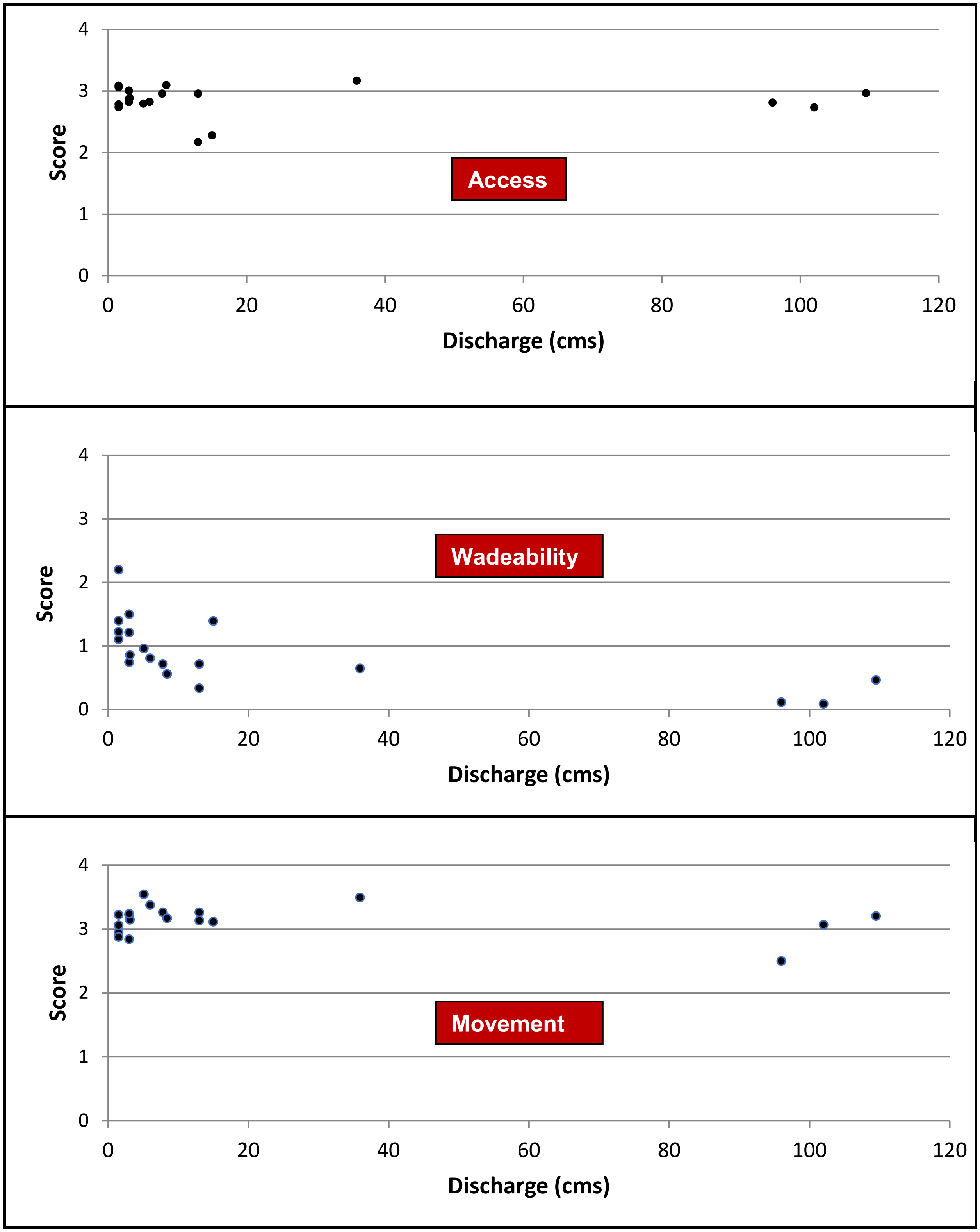


Figure 13. Scatter plots of mean scores for Access, Wadeability and Movement in relation to Lower Bridge River flow discharge between 2013 - 2018.

Flow Analysis Results

Accurate flow discharge data were available for the Lower Bridge River but not the Yalakom River, therefore this analysis focussed exclusively on the Lower Bridge River. The conclusions from the correlation analysis are summarized in Table 3.

Table 3. Observed flow effects on parameter scores as indicated by the scatter plots on Figures 7-9.

Voice	The effect of flow on Voice scores is positive, indicating that higher scores are more likely with increases in flow.
Birdsong	The effect of flow on Birdsong scores is positive, indicating that higher scores are more likely with increases in flow.
Smell and Edge Smell	The effect of flow on Smell and Edge Smell scores is positive, indicating that higher scores are more likely with increases in flow.
Movement	The effect of flow on Movement scores is negative, indicating that higher scores are less likely with increases in flow.
Diversity	The effect of flow on Diversity scores is negative, indicating that higher scores are less likely with increases in flow.
Access	The effect of flow on Access scores is negative, indicating that higher scores are less likely with increases in flow.
Wadeability	The effect of flow on Wadeability scores is negative, indicating that higher scores are less likely with increases in flow.
Clarity	The effect of flow on Clarity scores is negative, indicating that higher scores are less likely with increases in flow.

Statistical Analysis Results

Statistical analysis (GLIM) of BRGMON-16 data was undertaken by Dr. Eduardo Martins from the University of Northern BC. The analysis investigated whether the scores varied between Rivers and among Seasons, while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). As reported in the 2014 and 2015 BRGMON-16 Annual Reports, "Year" was treated as a fixed effect since there were only 1 or 2 years of observations. For the 2016 and subsequent analyses there were 3 to 5 years of observations available, respectively, justifying the consideration of "Year" as a random effect.

The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually.
3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
   - Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season was found to be significant at $\alpha = 0.05$.

During the analysis, the response variable (score 0-4) was treated as "continuous" and bounded between 0-4, making it relatively straightforward to fit a mixed model with a normal error distribution.

Appendix 1 provides the statistical outputs. Main results are described below and summarized in Table 3. Note: S1 = summer; S2 = fall; S3 = winter; S4 = spring. A significant result reflects an F-value that was statistically different from zero (at alpha = 0.05).

Interaction plots showing mean scores ($\pm$ 1SE) for the 9 parameters by river and season for all years (2013-2018) are shown in Figures 14-15.

Table 4. Summary of statistical results (✹ indicates significant at alpha = 0.05; ns = not significant). F-values are indicated by the numbers below the significance designations and provide an indication of the "strength" of the effect.

Parameter	Season	River	Season x River	Interpretation
Access	ns 0.96	ns 0.75	ns 1.96	There was no influence of season or river on Access scores, and no interaction between season and river.
Birdsong	✹ 18.5	✹ 5.17	✹ 4.86	• Bridge River – Scores in Spring were **greater** than in Summer, Fall and Winter • Yalakom River – Scores in Spring were **greater** than in Summer, Fall and Winter
Clarity	✹ 17.06	✹ 8.33	✹ 60.15	• Bridge River – Scores in Summer were **greater** than in Fall, Winter, and Spring • Yalakom River – Scores in Fall and Winter were **greater** than in Summer and Spring • During Summer, Fall and Winter – Scores in the Yalakom River were **greater** than in the Bridge River • During Spring – No significant difference in scores between Rivers.
Diversity	✹ 9.42	ns 0	ns 1.63	• Scores in Spring and Summer were **smaller** than in Fall and Winter • A much larger amount of the variability in scores for **Diversity** was associated with Elders, with about 4 and 3 times as much variation in scores among Elders than among Sites or Years, respectively
Edge Smell	ns 1.8	✹ 9.44	✹ 13.33	• Bridge River – No significant differences between Seasons • Yalakom River – Scores in Spring were **lower** than in Summer, Fall and Winter
Movement	✹ 4.29	ns 3.09	✹ 3.74	• Bridge River – Scores in Winter were **greater** than in Fall • Yalakom River – Scores in Fall were **greater** than in Spring • Summer, Winter, Spring – No significant difference in scores between Rivers. • Fall – Scores in the Yalakom River were **greater** than in the Bridge River

Parameter	Season	River	Season x River	Interpretation
Smell	✹ 2.84	✹ 5.86	✹ 10.24	• Bridge River – No significant differences between seasons • Yalakom River – Scores in Spring and Summer were **smaller** than in Fall and Winter. • Summer and Spring – No significant difference in scores between Rivers. • Fall and Winter – Scores in the Yalakom River were **greater** than in the Bridge River
Voice	✹ 3.71	✹ 4.05	✹ 2.70	• Bridge River – No significant differences between Seasons. • Yalakom River – No significant differences between Seasons. • Summer and Spring – No significant difference in scores between Rivers. • Fall and Winter – Scores in the Yalakom River were **greater** than in the Bridge River
Wadeability	✹ 30.07	ns 0.04	✹ 18.32	• Bridge River – Scores in Fall were **greater** than in Summer, Winter and Spring • Yalakom River – Scores in Winter were **greater** than in Summer, Fall and Spring • Summer, Fall and Spring – No significant difference in scores between Rivers. • Winter – Scores in the Yalakom River were **greater** than in the Bridge River.

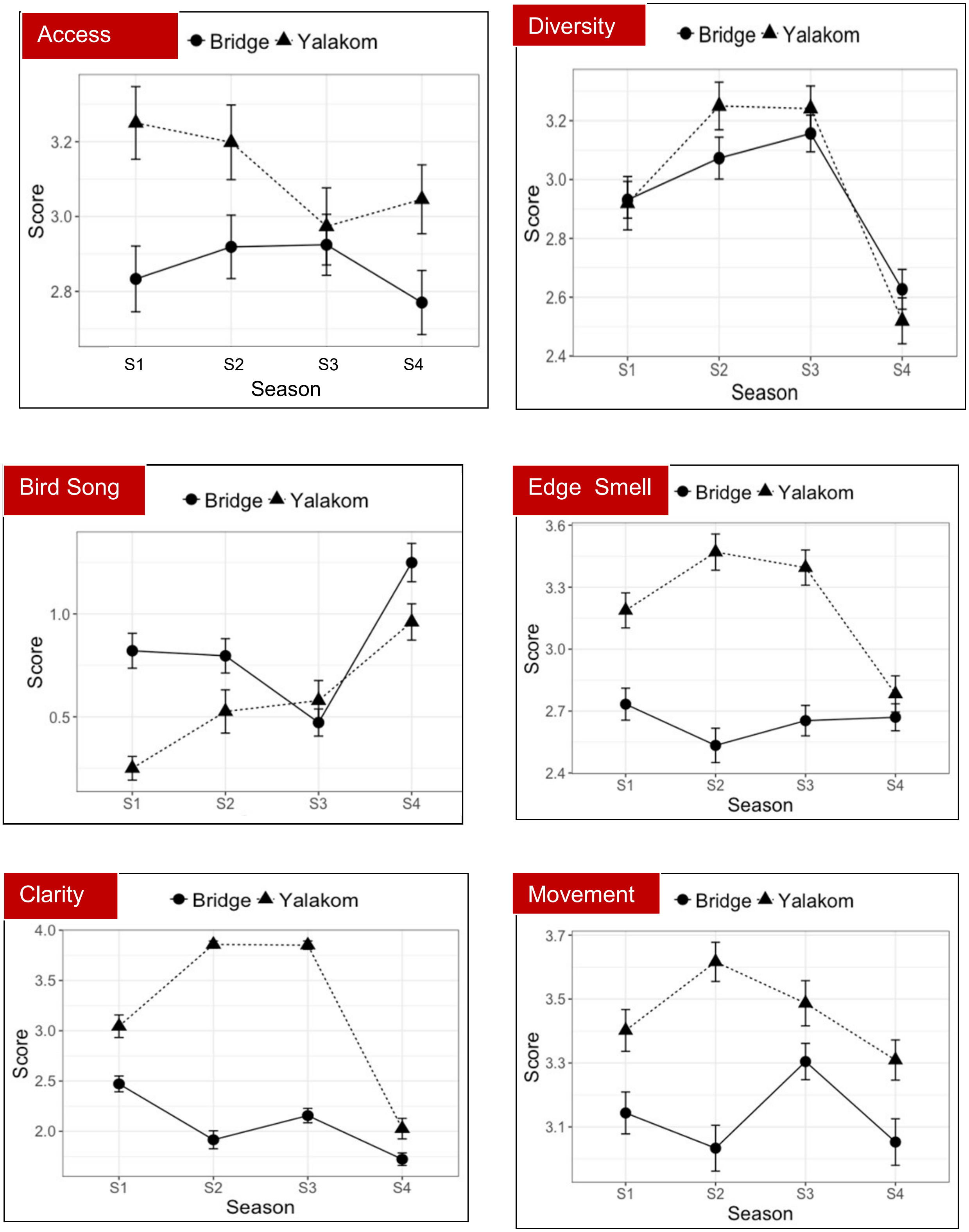


Figure 14. Interaction plots showing mean scores (± 1SE) for the 9 parameters by river and season. S1=summer, S2=fall, S3=winter, S4=spring

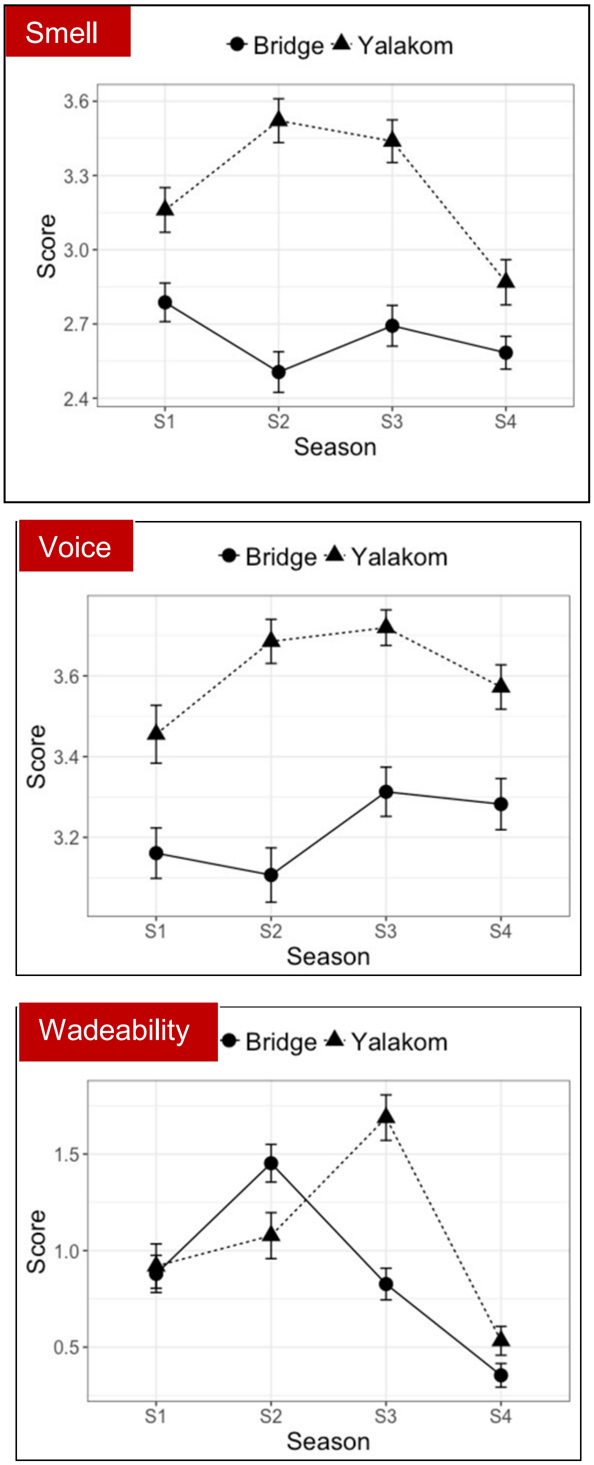


Figure 15. Interaction plots showing mean scores (± 1SE) for the 9 parameters by river and season. S1=summer, S2=fall, S3=winter, S4=spring

Discussion

The main objective of the BRGMON-16 monitoring program is to evaluate whether there are differences in the spiritual and cultural values associated with different flow discharges in two adjacent rivers: the Lower Bridge River (regulated) and the Yalakom River (unregulated). During all 5 years of the project, the field program replicated the approach for assessing cultural and spiritual attributes associated with different water flow discharges.

The high flows in 2016-2018 afforded an opportunity to measure spiritual and cultural attributes associated with high discharges. The high flows, while valuable from an experimental design perspective to better understand the effects of extreme flow discharges on spiritual and cultural attributes, resulted in this study only being able to observe a 6 cms/y water budget for two and a half years out of the five.

Main results obtained by BRGMON-16 are discussed below.

Histogram Plots

Table 4. Interpretation of histogram plots shown on Figures 6-10:

Voice	Higher Voice scores in the Yalakom River on most dates (15 out of the 19 sample dates showed higher scores on the Yalakom River).
Birdsong	Low scores overall when compared to the other variables. Many summer and fall observations were higher in the Lower Bridge River.
Smell and Edge Smell	Higher smell scores in the Yalakom River on most dates reflected both in the Smell and Edge Smell scores which showed large agreement in their respective scores.
Movement	Higher movement scores in the Yalakom River (14 out of the 19 sample dates).
Diversity	Variable results: 7 out of 19 observations had noticeably higher scores in the Yalakom River while 5 of 19 observations had scores noticeably higher in the Lower Bridge River. 7 of 19 observations were similar in the 2 rivers.
Access	Most scores higher in the Yalakom River.(13 out of 19 sample dates).
Wadeability	Variable results: some dates higher in the Yalakom River, some dates lower in the Yalakom River and many dates similar scores.
Clarity	Higher clarity scores obtained from the Yalakom River on most dates. (12 out of 19)

The "Voice" of the water is a variable defined by the elders individually and reflects how the river "speaks" to the observer. The higher voice scores in the Yalakom River reflect a modest preference for the Yalakom River in terms of Voice perception. This could reflect that the

Yalakom River is unregulated and has a natural floodplain compared to the Lower Bridge River's floodplain that was shaped by high pre-impoundment flows that left boulders and large rocks in the river channel. Further, there could be a confounding effect due to the fact that the observers understood that the Lower Bridge River is regulated while the Yalakom River is not. Higher Access scores in the Yalakom River likely reflect that the Yalakom River is a small river (4 cms mean annual discharge) while the Lower Bridge River flood plain reflects historical flows as high as 700 cms (pre-impoundment) that shaped the river bed and deposited large boulders that make Access more difficult. Likewise, the higher Clarity scores in the Yalakom River likely reflect the turbid nature of the Lower Bridge River relative to the Yalakom River.

Out of the 9 variables that were monitored, the variable Voice was of key interest since the Voice parameter integrated a suite of perceptions that were sensed by the elders including the other 8 biophysical and sensory parameters plus many other sensory and cognitive inputs that the elders experienced while undertaking surveys e.g. their previous history within the study area, weather conditions and understanding of flow regulation practices. In comparison with the Lower Bridge River, the histogram plots indicated that Voice was noticeably higher in the Yalakom River on 15 of 19 dates and similar to the Lower Bridge River on 4 dates. No observations indicated a higher Voice score in the Lower Bridge River.

One potential explanation for the higher Yalakom River Voice values is related to the cross-sectional dimensions of the two river channels and respective flow discharge histories. The Lower Bridge River channel was shaped by historical flows that ranged as high as 600 – 700 cms at peak discharge with a mean annual discharge of around 100 cms. Consequently, there are many rocks and boulders that were mobilized in the Lower Bridge River prior to impoundment which are now semi-permanent features of the river bed which contains a relatively wide channel bed. In the contrast, the mean annual flow in the Yalakom River is around 4 cms and the river channel is relatively narrow and confined. The regulation of the Lower Bridge River makes the flow volumes reasonably comparable in the two river systems but that channel shapes are markedly different within the Yalakom River which reflects a natural river hydrograph and the Lower Bridge River channel which reflects much higher historical flows.

General Linear Interactive Modeling

The main results from the GLIM analysis are shown in Table 4. The results of the histogram analysis and the scatter plots were largely consistent with each other which is to be expected since the underlying data are the same.

<u>Access:</u>

Statistical comparisons indicated no effects on access from season, river, or the interaction of season and river. This result was unexpected due to the strong seasonality in flow discharge and the large deviation between Lower Bridge River and Yalakom River flow conditions in June of 2016-2018. The histogram analysis (Figure 5) yielded similar results whereby the access score was not affected by season. Therefore, the outcome is unlikely to be an artifact, rather, it reflects a real perception by the elders that Access is insensitive to flow.

Birdsong:

There was an effect of season, river and an interaction effect of season by river on Birdsong scores. The seasonal effect was a strong one as indicated by the high F-value (18.5) with highest scores observed in the spring. This result relates to the relatively high seasonal abundance of songbirds in the Lower Bridge River and the Yalakom River during spring time. The interaction term was also significant and reflects that Yalakom River Birdsong scores were similar to the Lower Bridge River scores during winter as opposed to August, October and June when they were lower.

Clarity:

There were significant differences between seasons, rivers as well as a strongly significant interaction of season and river (F=60.15). Histograms indicated similar water clarity in summer, and higher water clarity in the Yalakom River during fall and winter. This result was expected due to the turbid nature of the Lower Bridge River.

Diversity:

The statistical analysis results indicated seasonal effects on Diversity but no difference between rivers and no interaction between season and river. The seasonal effect was reflected in the histograms which indicated lowest diversity in June, both in the Lower Bridge River and the Yalakom River. This result was somewhat counterintuitive given the observed seasonal differences in flow conditions in the two rivers on most sampling dates.

Edge Smell and Smell:

Edge Smell and Smell showed similar results with significant effects of river and an interaction between season and river. Smell scores differed between seasons (marginally significant) but the seasonal effect on edge smell was non-significant. Higher scores were obtained in the Yalakom River than the Lower Bridge River in fall and winter whereas spring and summer scores were not statistically different between rivers.

Movement:

Scores varied between seasons and there was a non-significant effect of rivers. This result is somewhat unexpected in view of the large flow variations between rivers. The interaction between rivers and seasons likely reflects differences in the flow hydrographs that have occurred since spilling started in 2016.

Wadeability:

This parameter varied seasonally and there was an interaction between seasons and rivers. Similar to Movement, these results likely reflect the differences in flow discharges in the 2 rivers in comparison with previous years. The seasonal differences reflected the large seasonal flow variability with wadeability being higher under low flows. The non-significant river effect is counterintuitive in view of the large differences in flow discharge between the Yalakom River and the Lower Bridge River.

Voice:

Voice observations varied by season and river and there was a season by river interaction. Scores varied between rivers such that Yalakom River scores were significantly larger than Bridge River scores in the fall and winter. There were no seasonal effects on Voice scores.

Scatter Plots

The scatter plots shown in Figures 7 – 9 suggest no relationship between discharge and six parameters: Access, Bird Song, Clarity, Edge Smell, Voice and Smell. The relationships between discharge and two of the parameters, Diversity and Wadeabilty, appear to be inversely correlated, i.e. higher discharge resulted in slightly lower scores. This may reflect that elder perceptions of Diversity (pool to riffle ratio) decreased as a function of flow and likewise Wadeability scores also decreased as a function of discharge. Smell and Edge Smell scores did not vary in relation to flow discharges as perceived by the elders.

Conclusions

The primary focus of the project was to compare the Spiritual and Cultural aspects of the regulated Lower Bridge River with the unregulated Yalakom River as perceived by the St'at'imc elders, of water flows in the Lower Bridge River in relation to a long-term flow release strategy. During 2016-2018, June surveys overlapped the high Lower Bridge River flows. While the high flows observed in 2016 and 2018 in the Lower Bridge River had environmental impacts, from an experimental design perspective, high flow data points provide good contrast in the data set and are informative to better understand how flow discharge affects spiritual and cultural attributes.

Over the life of BRGMON-16 (2013-2018) data have been analyzed by:

1. Time series of histogram plots for the Lower Bridge River and Yalakom River (Figure 6-10)
2. Statistical analysis via General Linear Modeling (Table 4 and Appendix 1)
3. Evaluating relationships between parameter scores and flow discharge via scatter plots (Figures 7-9)

The three approaches reinforce each other. A robust data set was collected that yielded unique results related to elder perceptions of the effects of flow variations. For variables which co-vary, e.g. discharge and season, histograms indicated that seasonal effects were minimal (e.g. low variation in Voice scores between seasons (within rivers) in Figure 6. In view of low seasonal variation and the elimination of seasonality as a confounding variable with flow discharge, it was justifiable to directly analyze variations in parameter values in relation to flow discharges (Figures 7-9). The latter comparison provides the best measure for determining the influence of flow discharge on spiritual and cultural values. The results of the latter analysis suggested that there was little influence of flow discharge on the measured cultural and spiritual value attributes. It seems counterintuitive that the spiritual and cultural parameters were insensitive to flow discharge but that is the justifiable conclusion from the analysis.

The original management question which provided the framework for Year 1-2 monitoring was:

> "How does the smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime compare with that in the Yalakom River, an adjacent unregulated tributary of the Lower Bridge River?"

This management question has been effectively answered. While the higher spiritual and cultural value results in the Yalakom River are informative, they provide only modest insight for flow management planning in the Lower Bridge River. Results have indicated that spiritual and cultural parameters are largely insensitive to Lower Bridge River discharge and this conclusion will provide a useful input for future Structured Decision Making designed to determine a long-term flow release strategy for the Lower Bridge River.

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Appendix 1: Statistical Analysis of Bridge vs. Yalakom River Scores

Access

This document summarizes the results for the analysis of the scores for **Access**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Access** revealed that the interaction term was not significant (Table 1). The same test was run on the model re-fitted with main effects only, but the results revealed that neither River nor Season were significantly associated with the scores (Table 2). Estimates for individual fixed effects are presented in Table 3.

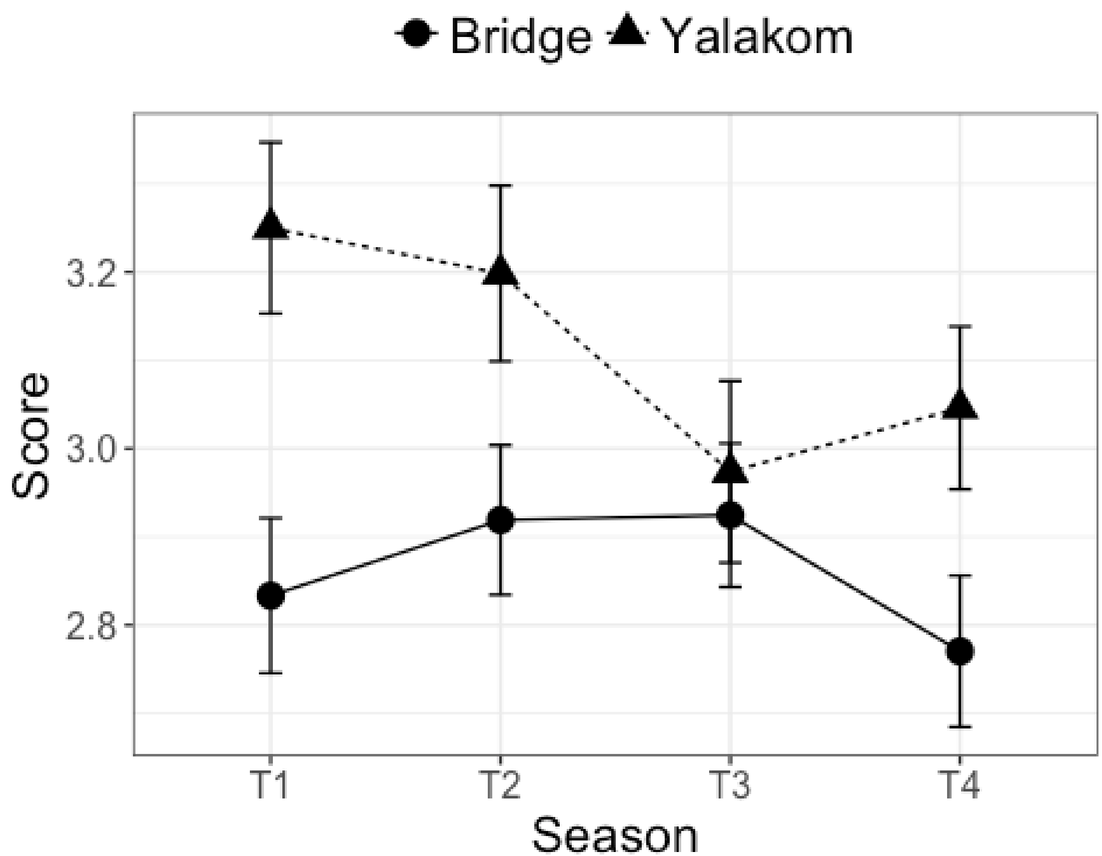


Figure 1: Interaction plot showing mean scores (± 1SE) for **Access** by river and season.

Table 1: Marginal tests of significance for full model of **Access**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1227	131.59	0.00
Season	3	1227	0.43	0.73
River	1	1227	1.87	0.17
Season:River	3	1227	1.96	0.12

Table 2: Marginal tests of significance for model of **Access** containing only the main effects.

	numDF	denDF	F-value	p-value
(Intercept)	1	1230	141.33	0.00
Season	3	1230	0.96	0.41
River	1	1230	0.75	0.39

Table 3: Estimates of main effects in the additive model for **Access** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	2.9161	0.2692	1230	10.8322	0.0000
SeasonT2	0.0020	0.0784	1230	0.0251	0.9800
SeasonT3	-0.0880	0.0788	1230	-1.1169	0.2643
SeasonT4	-0.0961	0.0778	1230	-1.2351	0.2170
RiverYalakom	0.2532	0.3185	1230	0.7948	0.4269

There was as much variation in scores among Elders as among Sites (see SD in Table 4). Variation in scores among years was low, being about one-third of the variation among Elders or Sites (Table 4).

Table 4: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Access**.

Random Effect	SD
Elder	0.4377
Site	0.4861
Year	0.1386
Residual	0.9424

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 5, 6, and 7, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 5: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	0.0920
Albert	-0.8364
Carl	0.1317
Eugene	-0.4720
Gasper	0.7308
Ken	0.2894
Lena	0.0130
Marie	0.0952
Pete	0.0874

Randy	-0.1311

Table 6: Deviation from Intercept by **Site**.

	(Intercept)
B1	0.6861
B2	-0.1515
B3	0.4786
B4	-0.4293
B5	-0.3298
B6	-0.2541
Y1	0.0918
Y2	0.4923
Y3	0.1157
Y4	-0.6998

Table 7: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.1945
2014_15	0.0942
2015_16	0.0567
2016_17	0.0939
2017_18	-0.0502

Bird Song

This document summarizes the results for the analysis of the scores for **Bird Song**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.

4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Bird Song** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

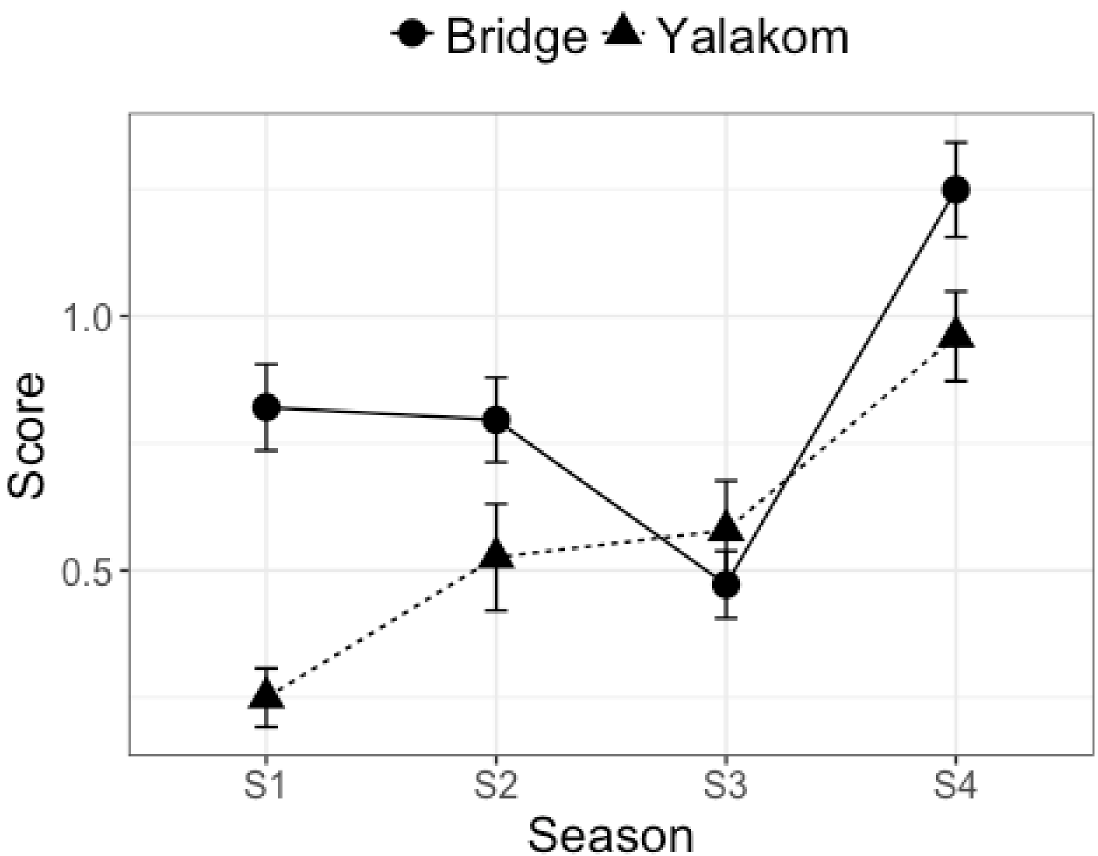


Figure 1: Interaction plot showing mean scores ($\pm$ 1SE) for **Bird Song** by river and season.

Table 1: Marginal tests of significance for full model of **Bird Song**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1226	18.00	0.00
Season	3	1226	18.50	0.00
River	1	1226	5.17	0.02
Season:River	3	1226	4.86	0.00

Table 2: Estimates of fixed effects in the model for **Bird Song** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	0.8838	0.2298	1226	3.8454	0.0001
SeasonS2	-0.0247	0.1049	1226	-0.2355	0.8139
SeasonS3	-0.3373	0.1050	1226	-3.2130	0.0013
SeasonS4	0.4259	0.1041	1226	4.0909	0.0000
RiverYalakom	-0.5271	0.2460	1226	-2.1429	0.0323
SeasonS2:RiverYalakom	0.2589	0.1671	1226	1.5489	0.1217
SeasonS3:RiverYalakom	0.6294	0.1678	1226	3.7503	0.0002
SeasonS4:RiverYalakom	0.2241	0.1590	1226	1.4090	0.1591

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - Scores in S4 were **greater** than in S1, S2, and S3
  - Scores in S3 were **smaller** than in S1 and S2
- Yalakom River
  - Scores in S4 were **greater** than in S1, S2 and S3

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.0247	0.1049	0.2355	1.0000
S1.Bridge - S3.Bridge	0	0.3373	0.1050	3.2130	0.0144
S1.Bridge - S4.Bridge	0	-0.4259	0.1041	-4.0909	0.0005
S2.Bridge - S3.Bridge	0	0.3126	0.1039	3.0092	0.0276
S2.Bridge - S4.Bridge	0	-0.4506	0.1031	-4.3685	0.0002
S3.Bridge - S4.Bridge	0	-0.7631	0.1032	-7.3939	0.0000
S1.Yalakom - S2.Yalakom	0	-0.2342	0.1304	-1.7958	0.4744
S1.Yalakom - S3.Yalakom	0	-0.2922	0.1314	-2.2226	0.2202
S1.Yalakom - S4.Yalakom	0	-0.6499	0.1251	-5.1947	0.0000
S2.Yalakom - S3.Yalakom	0	-0.0580	0.1300	-0.4459	0.9991
S2.Yalakom - S4.Yalakom	0	-0.4157	0.1237	-3.3617	0.0085
S3.Yalakom - S4.Yalakom	0	-0.3578	0.1242	-2.8810	0.0409

Multiple comparisons between rivers within a season showed no significant differences (see detailed results in Table 4 and Figure 1):

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	-0.5271	0.2460	-2.1429	0.0790
S2.Yalakom - S2.Bridge	0	-0.2682	0.2450	-1.0950	0.5160
S3.Yalakom - S3.Bridge	0	0.1023	0.2454	0.4170	0.9558
S4.Yalakom - S4.Bridge	0	-0.3030	0.2394	-1.2657	0.4064

There was about as much variation in scores among Elders than among Sites (see SD in Table 5). Variation in scores among Years was low, being about one-half of the variation among Elders and about two-thirds of the variation among Sites (Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Bird Song**.

Random Effect	SD
Elder	0.3759
Site	0.3333
Year	0.1955
Residual	0.9823

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	-0.2378
Albert	-0.4116
Carl	0.1697
Eugene	-0.2685

Gasper	-0.2795
Ken	0.1107
Lena	-0.0836
Marie	0.0355
Pete	0.8406
Randy	0.1246

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	0.6454
B2	-0.0756
B3	0.2837
B4	-0.2364
B5	-0.1657
B6	-0.4515
Y1	-0.1304
Y2	-0.0438
Y3	0.0310
Y4	0.1432

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.0604
2014_15	-0.0176
2015_16	-0.2532
2016_17	0.2392
2017_18	0.0920

Clarity

This document summarizes the results for the analysis of the scores for **Clarity**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.

2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   – If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   – If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Clarity** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

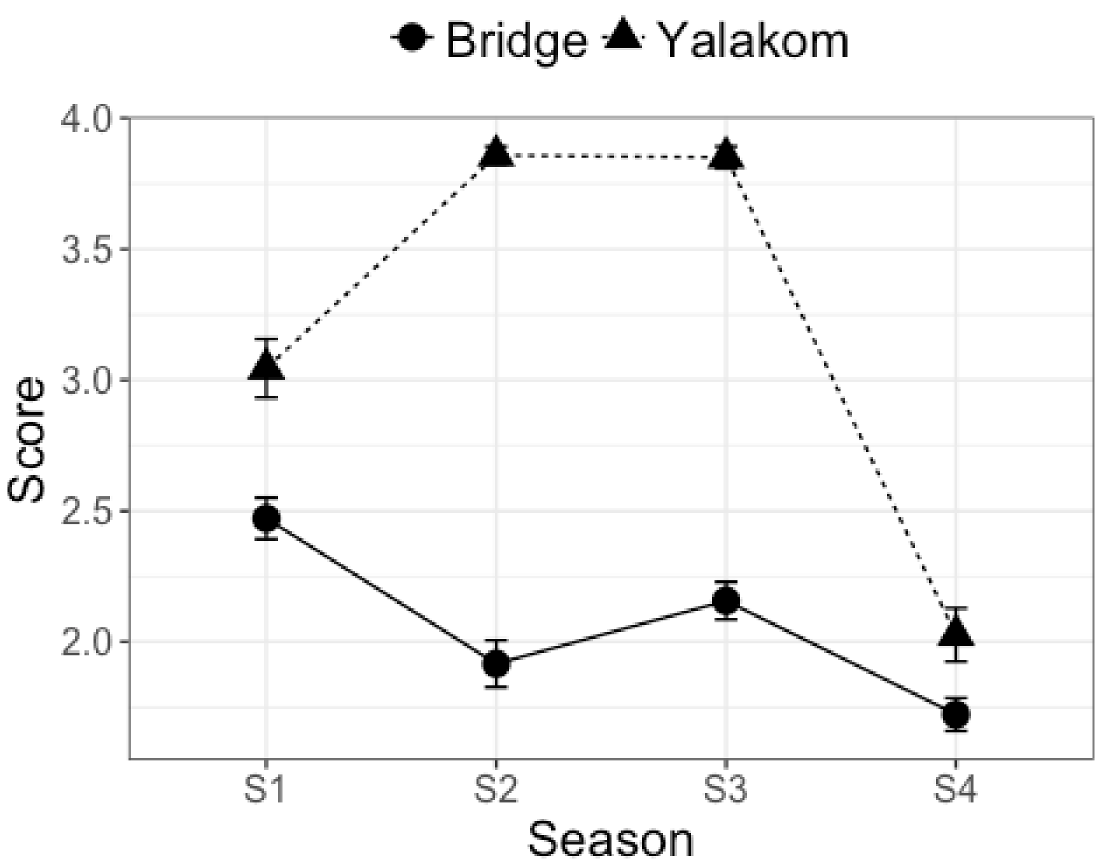


Figure 1: Interaction plot showing mean scores ($\pm$ 1SE) for **Clarity** by river and season.

Table 1: Marginal tests of significance for full model of **Clarity**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1226	175.33	0
Season	3	1226	17.06	0
River	1	1226	8.33	0
Season:River	3	1226	60.15	0

Table 2: Estimates of fixed effects in the model for **Clarity** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	2.3157	0.1962	1226	11.8006	0.0000
SeasonS2	-0.5351	0.0979	1226	-5.4666	0.0000
SeasonS3	-0.2912	0.0979	1226	-2.9752	0.0030
SeasonS4	-0.6363	0.0970	1226	-6.5625	0.0000
RiverYalakom	0.5691	0.2086	1226	2.7280	0.0065
SeasonS2:RiverYalakom	1.3851	0.1560	1226	8.8767	0.0000
SeasonS3:RiverYalakom	1.1430	0.1566	1226	7.2998	0.0000
SeasonS4:RiverYalakom	-0.2654	0.1484	1226	-1.7892	0.0738

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - Scores in S1 were **greater** than in S2, S3, and S4
  - Scores in S3 were **greater** than in S4
- Yalakom River
  - Scores in S1 were **greater** than in S4
  - Scores in S2 were **greater** than in S1 and S4
  - Scores in S3 were **greater** than in S1 and S4

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.5351	0.0979	5.4666	0.0000
S1.Bridge - S3.Bridge	0	0.2912	0.0979	2.9752	0.0306

S1.Bridge - S4.Bridge	0	0.6363	0.0970	6.5625	0.0000
S2.Bridge - S3.Bridge	0	-0.2440	0.0971	-2.5122	0.1125
S2.Bridge - S4.Bridge	0	0.1012	0.0964	1.0500	0.9214
S3.Bridge - S4.Bridge	0	0.3452	0.0963	3.5849	0.0038
S1.Yalakom - S2.Yalakom	0	-0.8500	0.1217	-6.9815	0.0000
S1.Yalakom - S3.Yalakom	0	-0.8518	0.1227	-6.9439	0.0000
S1.Yalakom - S4.Yalakom	0	0.9017	0.1167	7.7262	0.0000
S2.Yalakom - S3.Yalakom	0	-0.0018	0.1213	-0.0152	1.0000
S2.Yalakom - S4.Yalakom	0	1.7517	0.1154	15.1825	0.0000
S3.Yalakom - S4.Yalakom	0	1.7536	0.1159	15.1330	0.0000

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S2
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S3
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S4
  - No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.5691	0.2086	2.7280	0.0188
S2.Yalakom - S2.Bridge	0	1.9542	0.2077	9.4093	0.0000
S3.Yalakom - S3.Bridge	0	1.7121	0.2081	8.2278	0.0000
S4.Yalakom - S4.Bridge	0	0.3037	0.2019	1.5039	0.2967

There was as much variation in scores among Elders as among Sites (see SD in Table 5). Variation in scores among years was low, being about 55-60% of the variation among Elders or Sites (Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Clarity**.

Random Effect	SD
Elder	0.3042
Site	0.2734
Year	0.1731
Residual	0.9171

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	0.1932
Albert	0.4005
Carl	0.3426
Eugene	-0.4113
Gasper	-0.4385
Ken	-0.0101
Lena	0.0148
Marie	-0.2058
Pete	0.0017
Randy	0.1129

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.4512
B2	-0.2798
B3	0.0233
B4	0.0122
B5	0.3604
B6	0.3351

Y1	0.0579
Y2	0.0896
Y3	-0.0499
Y4	-0.0976

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.0213
2014_15	0.0831
2015_16	0.1649
2016_17	0.0337
2017_18	-0.2604

Diversity

This document summarizes the results for the analysis of the scores for **Diversity**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   – If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   – If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Diversity** revealed that the interaction term was not significant (Table 1). The same test was run on the model re-fitted with main effects only, revealing that only Season was significantly associated with the scores (Table 2). Estimates for individual fixed effects are presented in Table 3.

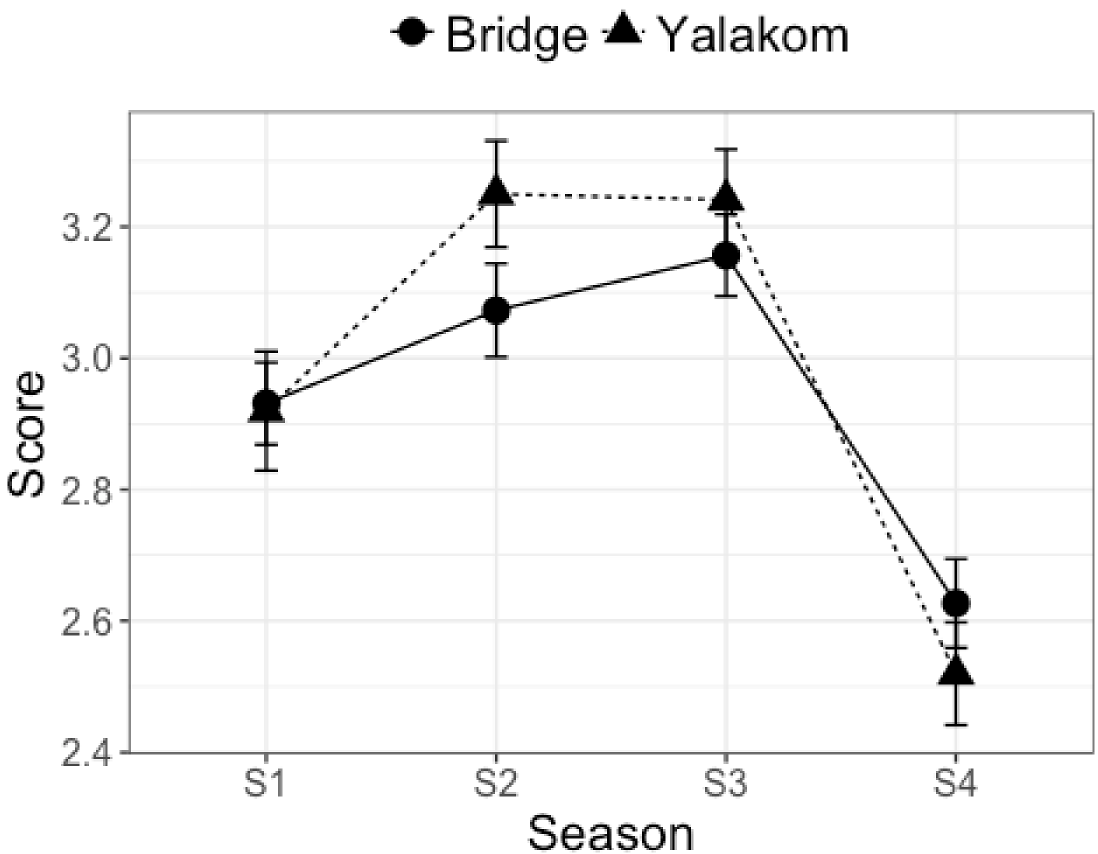


Figure 1: Interaction plot showing mean scores (± 1SE) for **Diversity** by river and season.

Table 1: Marginal tests of significance for full model of **Diversity**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1227	370.87	0.00
Season	3	1227	9.42	0.00
River	1	1227	0.00	1.00
Season:River	3	1227	1.63	0.18

Table 2: Marginal tests of significance for model of **Diversity** containing only the main effects.

	numDF	denDF	F-value	p-value
(Intercept)	1	1230	391.23	0.00

River	1	1230	0.06	0.81
Season	3	1230	23.09	0.00

Table 3: Estimates of main effects in the model for **Diversity** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	2.9137	0.1662	1230	17.5308	0.0000
RiverYalakom	0.0178	0.0809	1230	0.2205	0.8255
SeasonS2	0.1870	0.0696	1230	2.6874	0.0073
SeasonS3	0.2245	0.0699	1230	3.2114	0.0014
SeasonS4	-0.2829	0.0693	1230	-4.0844	0.0000

Multiple comparisons between seasons showed the following significant differences (see detailed results in Table 4 and Figure 1):

- Scores in S1 were **smaller** than in S2 and S3
- Scores in S4 were **smaller** than in S1, S2 and S3

Table 4: Multiple comparisons of scores between seasons. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1 - S2	0	-0.1870	0.0696	-2.6874	0.0365
S1 - S3	0	-0.2245	0.0699	-3.2114	0.0071
S1 - S4	0	0.2829	0.0693	4.0844	0.0003
S2 - S3	0	-0.0376	0.0691	-0.5434	0.9483
S2 - S4	0	0.4698	0.0686	6.8475	0.0000
S3 - S4	0	0.5074	0.0688	7.3799	0.0000

A much larger amount of the variability in scores for **Diversity** was associated with Elders, with about 4 and 3 times as much variation in scores among Elders than among Sites or Years, respectively (see SD in Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Diversity**.

Random Effect	SD
Elder	0.3792
Site	0.0999
Year	0.1380
Residual	0.8354

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	-0.2448
Albert	0.3024
Carl	-0.2926
Eugene	-0.7341
Gasper	0.4311
Ken	-0.1994
Lena	-0.0083
Marie	0.3317
Pete	0.2105
Randy	0.2036

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.0417
B2	0.0279
B3	0.0795
B4	-0.0933
B5	0.0763
B6	-0.0488
Y1	-0.0952
Y2	-0.0341

Y3	0.0069
Y4	0.1224

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.0308
2014_15	0.0984
2015_16	0.0357
2016_17	0.1000
2017_18	-0.2033

Edge Smell

This document summarizes the results for the analysis of the scores for **Edge Smell**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Edge Smell** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

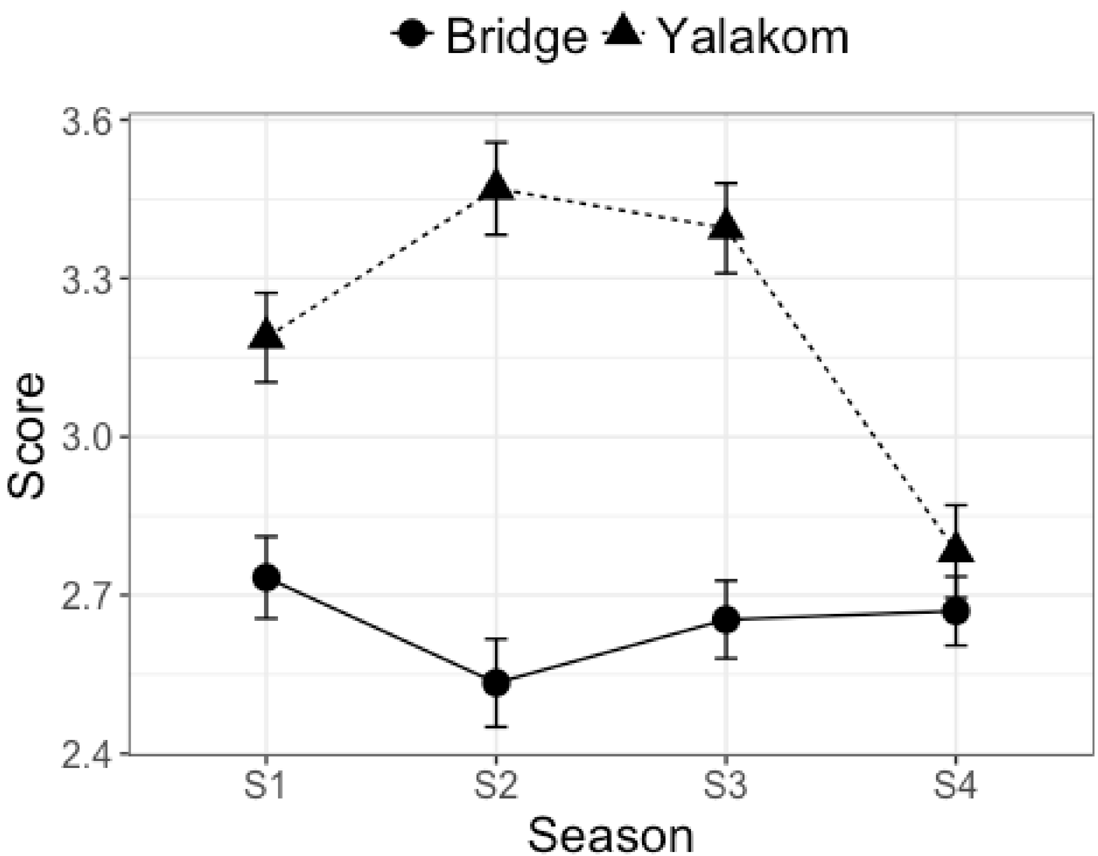


Figure 1: Interaction plot showing mean scores (± 1SE) for **Edge Smell** by river and season.

Table 1: Marginal tests of significance for full model of **Edge Smell**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1217	199.63	0.00
Season	3	1217	1.80	0.15
River	1	1217	9.44	0.00
Season:River	3	1217	13.33	0.00

Table 2: Estimates of fixed effects in the model for **Edge Smell** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	2.7466	0.2131	1217	12.8878	0.0000
SeasonS2	-0.1964	0.0965	1217	-2.0348	0.0421

SeasonS3	-0.0688	0.0964	1217	-0.7129	0.4760
SeasonS4	-0.0115	0.0954	1217	-0.1201	0.9044
RiverYalakom	0.4634	0.1565	1217	2.9607	0.0031
SeasonS2:RiverYalakom	0.4777	0.1525	1217	3.1330	0.0018
SeasonS3:RiverYalakom	0.2617	0.1530	1217	1.7099	0.0875
SeasonS4:RiverYalakom	-0.3743	0.1451	1217	-2.5790	0.0100

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - No significant differences.
- Yalakom River
  - Scores in S4 were **smaller** than in S1, S2 and S3

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.1964	0.0965	2.0348	0.3194
S1.Bridge - S3.Bridge	0	0.0688	0.0964	0.7129	0.9883
S1.Bridge - S4.Bridge	0	0.0115	0.0954	0.1201	1.0000
S2.Bridge - S3.Bridge	0	-0.1276	0.0944	-1.3526	0.7781
S2.Bridge - S4.Bridge	0	-0.1849	0.0934	-1.9811	0.3518
S3.Bridge - S4.Bridge	0	-0.0573	0.0933	-0.6142	0.9947
S1.Yalakom - S2.Yalakom	0	-0.2813	0.1183	-2.3777	0.1559
S1.Yalakom - S3.Yalakom	0	-0.1929	0.1193	-1.6167	0.6015
S1.Yalakom - S4.Yalakom	0	0.3857	0.1133	3.4040	0.0074
S2.Yalakom - S3.Yalakom	0	0.0884	0.1180	0.7491	0.9848
S2.Yalakom - S4.Yalakom	0	0.6670	0.1120	5.9567	0.0000
S3.Yalakom - S4.Yalakom	0	0.5787	0.1124	5.1483	0.0000

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S2

  - Scores in the Yalakom River were **greater** than in the Bridge River
- S3
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S4
  - No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.4634	0.1565	2.9607	0.0112
S2.Yalakom - S2.Bridge	0	0.9411	0.1545	6.0906	0.0000
S3.Yalakom - S3.Bridge	0	0.7251	0.1551	4.6757	0.0000
S4.Yalakom - S4.Bridge	0	0.0891	0.1472	0.6056	0.9280

A larger amount of the variability in scores for **Edge Smell** was associated with Elders, with about 3 to 3.5 times as much variation in scores among Elders than among Sites or Years (see SD in Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Edge Smell**.

Random Effect	SD
Elder	0.5079
Site	0.1736
Year	0.1395
Residual	0.8911

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	-0.0374

Albert	0.1678
Carl	0.1419
Eugene	-1.2687
Gasper	-0.1330
Ken	-0.1255
Lena	0.1227
Marie	0.5799
Pete	0.3253
Randy	0.2271

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.2519
B2	-0.1373
B3	-0.0808
B4	0.0434
B5	0.1679
B6	0.2586
Y1	0.0081
Y2	0.0766
Y3	-0.0027
Y4	-0.0820

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.1388
2014_15	-0.0962
2015_16	0.0167
2016_17	0.1827
2017_18	0.0355

Movement

This document summarizes the results for the analysis of the scores for **Movement**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   – If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   – If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Movement** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

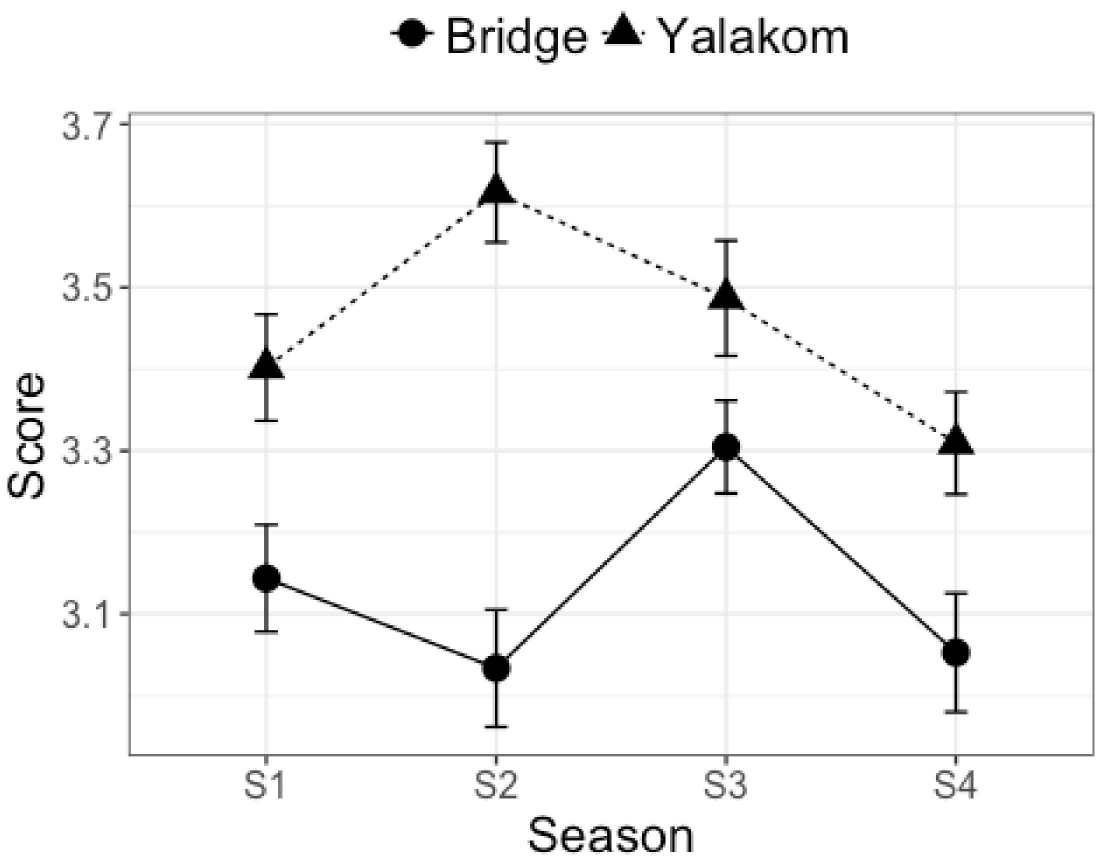


Figure 1: Interaction plot showing mean scores (± 1SE) for **Movement** by river and season.

Table 1: Marginal tests of significance for full model of **Movement**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1227	524.27	0.00
Season	3	1227	4.29	0.01
River	1	1227	3.09	0.08
Season:River	3	1227	3.74	0.01

Table 2: Estimates of fixed effects in the model for **Movement** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	3.1771	0.1565	1227	20.2964	0.0000
SeasonS2	-0.1219	0.0833	1227	-1.4640	0.1435

SeasonS3	0.1501	0.0833	1227	1.8015	0.0719
SeasonS4	-0.0826	0.0813	1227	-1.0158	0.3099
RiverYalakom	0.2644	0.1581	1227	1.6729	0.0946
SeasonS2:RiverYalakom	0.3188	0.1328	1227	2.3996	0.0166
SeasonS3:RiverYalakom	-0.0882	0.1334	1227	-0.6614	0.5085
SeasonS4:RiverYalakom	-0.0083	0.1264	1227	-0.0654	0.9479

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - Scores in S3 were **greater** than in S2
- Yalakom River
  - Scores in S2 were **greater** than in S4

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.1219	0.0833	1.4640	0.7075
S1.Bridge - S3.Bridge	0	-0.1501	0.0833	-1.8015	0.4705
S1.Bridge - S4.Bridge	0	0.0826	0.0813	1.0158	0.9324
S2.Bridge - S3.Bridge	0	-0.2720	0.0826	-3.2925	0.0109
S2.Bridge - S4.Bridge	0	-0.0393	0.0807	-0.4867	0.9986
S3.Bridge - S4.Bridge	0	0.2327	0.0807	2.8827	0.0406
S1.Yalakom - S2.Yalakom	0	-0.1969	0.1037	-1.8990	0.4043
S1.Yalakom - S3.Yalakom	0	-0.0619	0.1045	-0.5921	0.9957
S1.Yalakom - S4.Yalakom	0	0.0909	0.0985	0.9226	0.9570
S2.Yalakom - S3.Yalakom	0	0.1350	0.1034	1.3064	0.8051
S2.Yalakom - S4.Yalakom	0	0.2878	0.0973	2.9562	0.0327
S3.Yalakom - S4.Yalakom	0	0.1527	0.0978	1.5626	0.6399

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - No significant difference in scores between Rivers.
- S2

  - Scores in the Yalakom River were **greater** than in the Bridge River
- S3
  - No significant difference in scores between Rivers.
- S4
  - No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.2644	0.1581	1.6729	0.2391
S2.Yalakom - S2.Bridge	0	0.5832	0.1571	3.7119	0.0008
S3.Yalakom - S3.Bridge	0	0.1762	0.1576	1.1182	0.5641
S4.Yalakom - S4.Bridge	0	0.2562	0.1516	1.6894	0.2322

There was about 1.6 times as much variation in scores among Elders than among Sites (see SD in Table 5). Variation in scores among Elders and Sites were, respectively, about 5 and 3 times greater than variation in mean scores among Years (Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Movement**.

Random Effect	SD
Elder	0.3104
Site	0.1960
Year	0.0612
Residual	0.7812

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	-0.2232
Albert	0.1592
Carl	0.0837
Eugene	-0.5284
Gasper	0.3816
Ken	-0.3896
Lena	0.1934
Marie	0.2903
Pete	0.0729
Randy	-0.0399

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.3730
B2	-0.0442
B3	-0.1300
B4	0.1131
B5	0.2021
B6	0.2319
Y1	0.0102
Y2	0.0640
Y3	-0.0353
Y4	-0.0389

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	0.0084
2014_15	-0.0312
2015_16	-0.0474
2016_17	0.0704
2017_18	-0.0002

Smell

This document summarizes the results for the analysis of the scores for **Smell**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Smell** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

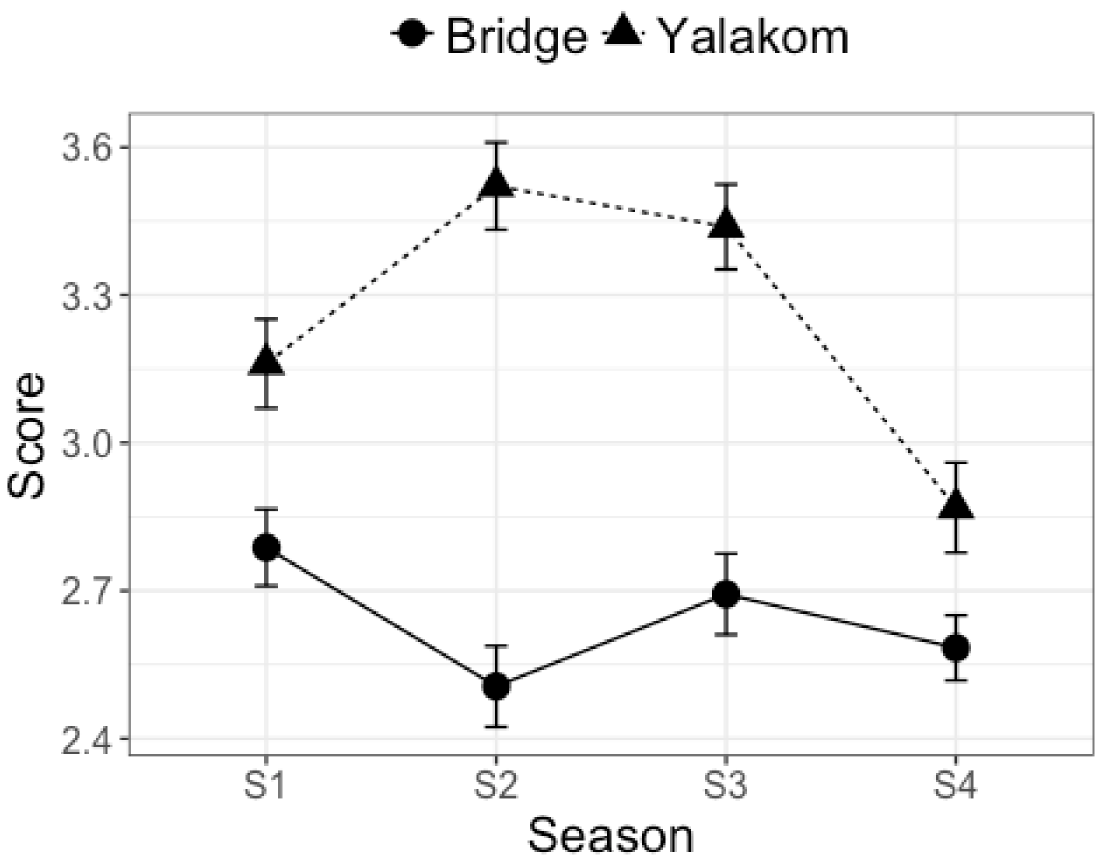


Figure 1: Interaction plot showing mean scores (± 1SE) for **Smell** by river and season.

Table 1: Marginal tests of significance for full model of **Smell**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1227	191.59	0.00
Season	3	1227	2.84	0.04
River	1	1227	5.86	0.02
Season:River	3	1227	10.24	0.00

Table 2: Estimates of fixed effects in the model for **Smell** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	2.7774	0.2197	1227	12.6437	0.0000
SeasonS2	-0.2727	0.0979	1227	-2.7853	0.0054
SeasonS3	-0.0782	0.0980	1227	-0.7975	0.4253

SeasonS4	-0.1572	0.0970	1227	-1.6210	0.1053
RiverYalakom	0.3917	0.1683	1227	2.3269	0.0201
SeasonS2:RiverYalakom	0.6248	0.1562	1227	3.9997	0.0001
SeasonS3:RiverYalakom	0.3422	0.1569	1227	2.1809	0.0294
SeasonS4:RiverYalakom	-0.1230	0.1487	1227	-0.8273	0.4083

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - No significant differences
- Yalakom River
  - Scores in S1 were **smaller** than in S2.
  - Scores in S4 were **smaller** than in S2 and S3.

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.2727	0.0979	2.7853	0.0540
S1.Bridge - S3.Bridge	0	0.0782	0.0980	0.7975	0.9791
S1.Bridge - S4.Bridge	0	0.1572	0.0970	1.6210	0.5985
S2.Bridge - S3.Bridge	0	-0.1945	0.0971	-2.0028	0.3385
S2.Bridge - S4.Bridge	0	-0.1155	0.0962	-1.2010	0.8600
S3.Bridge - S4.Bridge	0	0.0790	0.0963	0.8205	0.9758
S1.Yalakom - S2.Yalakom	0	-0.3521	0.1220	-2.8869	0.0401
S1.Yalakom - S3.Yalakom	0	-0.2640	0.1230	-2.1465	0.2577
S1.Yalakom - S4.Yalakom	0	0.2802	0.1169	2.3966	0.1493
S2.Yalakom - S3.Yalakom	0	0.0881	0.1216	0.7241	0.9873
S2.Yalakom - S4.Yalakom	0	0.6322	0.1155	5.4729	0.0000
S3.Yalakom - S4.Yalakom	0	0.5442	0.1160	4.6930	0.0000

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - No significant difference in scores between Rivers.
- S2

  - Scores in the Yalakom River were **greater** than in the Bridge River
- S3
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S4
  - No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.3917	0.1683	2.3269	0.0637
S2.Yalakom - S2.Bridge	0	1.0165	0.1671	6.0828	0.0000
S3.Yalakom - S3.Bridge	0	0.7339	0.1677	4.3752	0.0000
S4.Yalakom - S4.Bridge	0	0.2687	0.1600	1.6798	0.2536

A larger amount of the variability in scores for **Smell** was associated with Elders, with about 2.5 to 3 times as much variation in scores among Elders than among Sites or Years (see SD in Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Smell**.

Random Effect	SD
Elder	0.5100
Site	0.1955
Year	0.1552
Residual	0.9185

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 6: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	0.0015

Albert	0.2017
Carl	0.1126
Eugene	-1.3346
Gasper	-0.0904
Ken	-0.0577
Lena	0.2481
Marie	0.4077
Pete	0.3280
Randy	0.1830

Table 7: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.2421
B2	-0.1736
B3	-0.1325
B4	0.0250
B5	0.2169
B6	0.3063
Y1	0.0355
Y2	0.0698
Y3	-0.0458
Y4	-0.0594

Table 8: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.1736
2014_15	-0.0693
2015_16	-0.0317
2016_17	0.1960
2017_18	0.0787

Voice

This document summarizes the results for the analysis of the scores for **Voice**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).
3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Voice** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

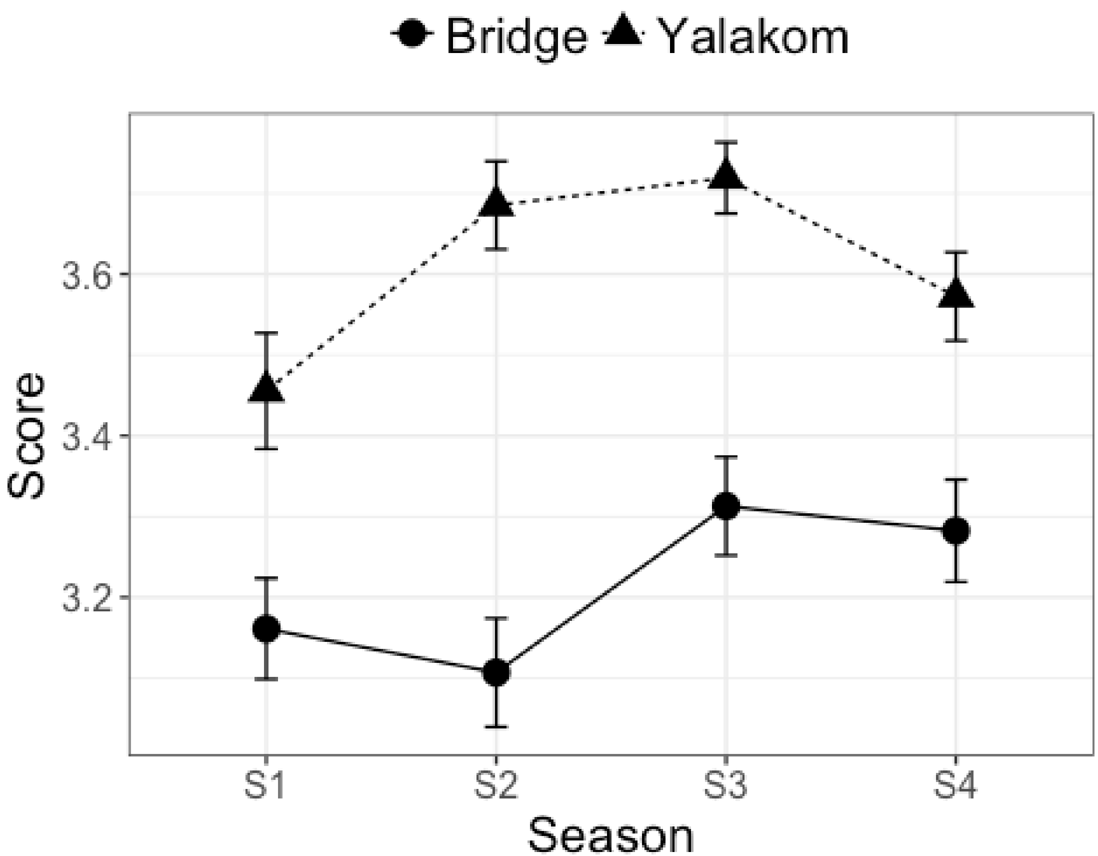


Figure 1: Interaction plot showing mean scores (± 1SE) for **Voice** by river and season.

Table 1: Marginal tests of significance for full model of **Voice**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1226	553.78	0.00
Season	3	1226	3.71	0.01
River	1	1226	4.05	0.04
Season:River	3	1226	2.70	0.04

Table 2: Estimates of fixed effects in the model for **Voice** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	3.1280	0.1485	1229	21.0698	0.0000
RiverYalakom	0.3886	0.1364	1229	2.8489	0.0045
SeasonS2	0.0488	0.0575	1229	0.8492	0.3959

SeasonS3	0.1828	0.0577	1229	3.1689	0.0016
SeasonS4	0.1248	0.0553	1229	2.2566	0.0242

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - No significant differences.
- Yalakom River
  - No significant differences.

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	0.0627	0.0736	0.8520	0.9709
S1.Bridge - S3.Bridge	0	-0.1413	0.0735	-1.9229	0.3886
S1.Bridge - S4.Bridge	0	-0.1261	0.0712	-1.7715	0.4914
S2.Bridge - S3.Bridge	0	-0.2040	0.0730	-2.7942	0.0526
S2.Bridge - S4.Bridge	0	-0.1888	0.0707	-2.6690	0.0747
S3.Bridge - S4.Bridge	0	0.0153	0.0706	0.2160	1.0000
S1.Yalakom - S2.Yalakom	0	-0.2209	0.0915	-2.4136	0.1432
S1.Yalakom - S3.Yalakom	0	-0.2469	0.0922	-2.6766	0.0731
S1.Yalakom - S4.Yalakom	0	-0.1294	0.0865	-1.4958	0.6861
S2.Yalakom - S3.Yalakom	0	-0.0260	0.0913	-0.2849	0.9999
S2.Yalakom - S4.Yalakom	0	0.0915	0.0855	1.0699	0.9146
S3.Yalakom - S4.Yalakom	0	0.1175	0.0858	1.3686	0.7685

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - No significant difference in scores between Rivers.
- S2
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S3
  - Scores in the Yalakom River were **greater** than in the Bridge River
- S4

– No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.2953	0.1549	1.9064	0.1411
S2.Yalakom - S2.Bridge	0	0.5789	0.1542	3.7539	0.0007
S3.Yalakom - S3.Bridge	0	0.4008	0.1545	2.5941	0.0276
S4.Yalakom - S4.Bridge	0	0.2986	0.1498	1.9934	0.1185

There was about 1.6 times as much variation in scores among Elders than among Sites (see SD in Table 5). Variation in scores among Elders and Sites were, respectively, about 12 and 8 times greater than variation in scores among Years (Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Voice**.

Random Effect	SD
Elder	0.3145
Site	0.2020
Year	0.0262
Residual	0.6896

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 5: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	-0.4515
Albert	0.2788
Carl	0.0416
Eugene	-0.3617
Gasper	0.2888
Ken	-0.3926

Lena	0.3886
Marie	0.0943
Pete	0.0001
Randy	0.1135

Table 6: Deviation from Intercept by **Site**.

	(Intercept)
B1	-0.3943
B2	-0.0521
B3	-0.1148
B4	0.2059
B5	0.1769
B6	0.1784
Y1	-0.0815
Y2	-0.0460
Y3	0.1113
Y4	0.0162

Table 7: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	-0.0156
2014_15	-0.0023
2015_16	0.0019
2016_17	0.0198
2017_18	-0.0038

Wadeability

This document summarizes the results for the analysis of the scores for **Wadeability**. The analysis investigates whether the scores varied between rivers (River) and among seasons (Season), while accounting for the random effects of Elder, Site and Year on the Intercept (i.e. mean score). The steps for the analysis were:

1. Fit a model with an interaction between River and Season.
2. Assess model residuals visually (not shown but codes for plots available in the Rmd file).

3. Run marginal tests for testing the significance of the interaction.
   - If the interaction was significant at $\alpha = 0.05$, the full model was used for inference.
   - If the interaction was not significant at $\alpha = 0.05$, the interaction was removed and the model was re-fitted with main effects only.
4. Conduct multiple comparison tests (Tukey's test) if the Interaction or effect of Season were found to be significant at $\alpha = 0.05$.

Figure 1 shows the mean scores ($\pm$ 1SE) by Season and River. Marginal tests of significance applied to the full model for **Wadeability** revealed that the interaction term was significant (Table 1). Therefore, the full model was retained for inference. Estimates for individual fixed effects are presented in Table 2.

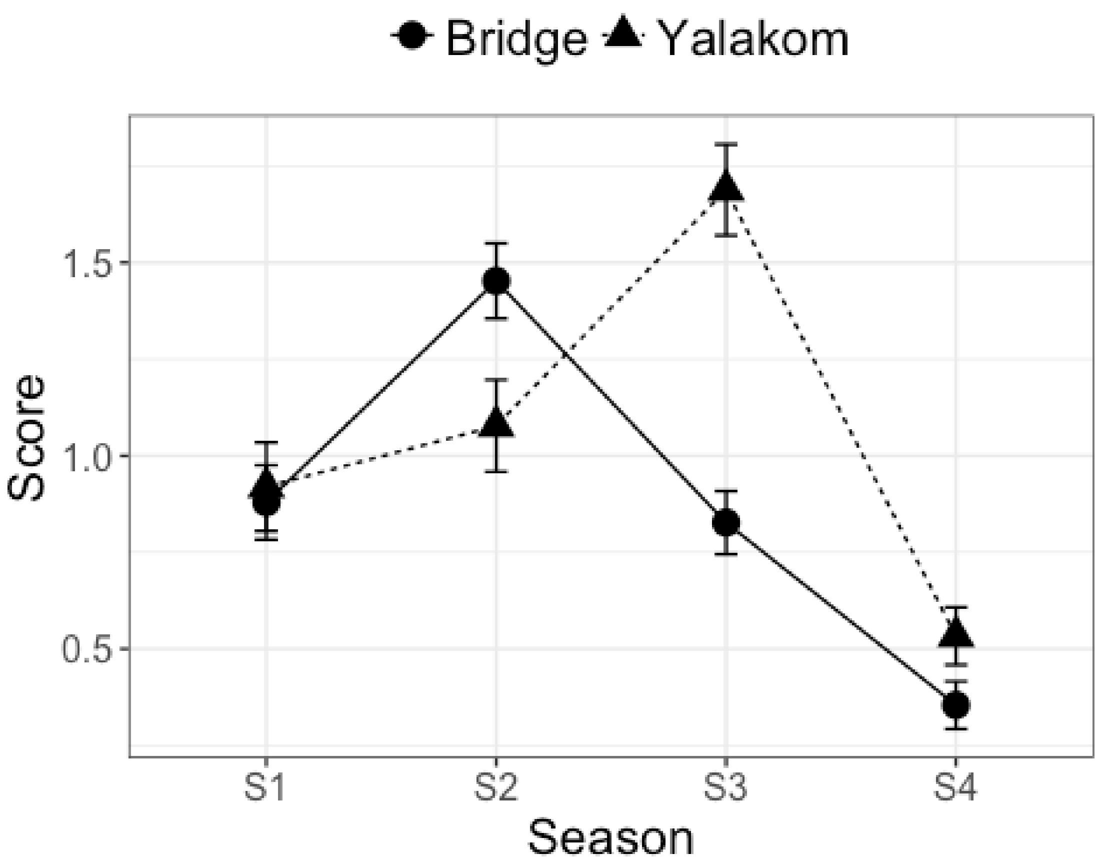


Figure 1: Interaction plot showing mean scores ($\pm$ 1SE) for **Wadeability** by river and season.

Table 1: Marginal tests of significance for full model of **Wadeability**.

	numDF	denDF	F-value	p-value
(Intercept)	1	1227	14.50	0.00
Season	3	1227	30.07	0.00
River	1	1227	0.04	0.84
Season:River	3	1227	18.11	0.00

Table 2: Estimates of fixed effects in the model for **Wadeability** with associated standard error (SE), degrees of freedom (DF), t-test statistic and p-value.

	Value	SE	DF	t_value	p_value
(Intercept)	0.8282	0.2407	1227	3.4405	0.0006
SeasonS2	0.5862	0.1090	1227	5.3783	0.0000
SeasonS3	-0.0418	0.1091	1227	-0.3829	0.7019
SeasonS4	-0.4215	0.1081	1227	-3.8995	0.0001
RiverYalakom	0.0488	0.2626	1227	0.1859	0.8525
SeasonS2:RiverYalakom	-0.4135	0.1739	1227	-2.3782	0.0175
SeasonS3:RiverYalakom	0.8401	0.1746	1227	4.8114	0.0000
SeasonS4:RiverYalakom	0.1068	0.1654	1227	0.6455	0.5187

Multiple comparisons between seasons within a river showed the following significant differences (see detailed results in Table 3 and Figure 1):

- Bridge River
  - Scores in S2 were **greater** than in S1, S3 and S4
  - Scores in S4 were **smaller** than in S1, S2 and S3
- Yalakom River
  - Scores in S3 were **greater** than in S1, S2 and S4
  - Scores in S2 were **greater** than in S4

Table 3: Multiple comparisons of scores between seasons within a river. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Bridge - S2.Bridge	0	-0.5862	0.1090	-5.3783	0.0000
S1.Bridge - S3.Bridge	0	0.0418	0.1091	0.3829	0.9996
S1.Bridge - S4.Bridge	0	0.4215	0.1081	3.8995	0.0011
S2.Bridge - S3.Bridge	0	0.6280	0.1081	5.8076	0.0000
S2.Bridge - S4.Bridge	0	1.0077	0.1073	9.3956	0.0000
S3.Bridge - S4.Bridge	0	0.3797	0.1073	3.5378	0.0046

S1.Yalakom - S2.Yalakom	0	-0.1727	0.1358	-1.2720	0.8240
S1.Yalakom - S3.Yalakom	0	-0.7983	0.1368	-5.8345	0.0000
S1.Yalakom - S4.Yalakom	0	0.3147	0.1302	2.4178	0.1418
S2.Yalakom - S3.Yalakom	0	-0.6257	0.1353	-4.6239	0.0000
S2.Yalakom - S4.Yalakom	0	0.4874	0.1287	3.7882	0.0018
S3.Yalakom - S4.Yalakom	0	1.1130	0.1292	8.6156	0.0000

Multiple comparisons between rivers within a season showed the following significant differences (see detailed results in Table 4 and Figure 1):

- S1
  - No significant difference in scores between Rivers.
- S2
  - No significant difference in scores between Rivers.
- S3
  - Scores in the Yalakom River were **greater** than in the Bridge River.
- S4
  - No significant difference in scores between Rivers.

Table 4: Multiple comparisons of scores between rivers within a season. H0 denotes the null hypothesis being tested (i.e. difference equal to 0).

Contrast	H0	Estimate	SE	Test Statistic	p-value
S1.Yalakom - S1.Bridge	0	0.0488	0.2626	0.1859	0.9975
S2.Yalakom - S2.Bridge	0	-0.3647	0.2616	-1.3942	0.3293
S3.Yalakom - S3.Bridge	0	0.8889	0.2621	3.3920	0.0022
S4.Yalakom - S4.Bridge	0	0.1556	0.2560	0.6079	0.8558

There was as much variation in scores among Elders as among Sites (see SD in Table 5). Variation in scores among Years was about one-half of that among Elders and Sites (Table 5).

Table 5: Standard deviation (SD) estimates for the random effects of Elder, Site and Year in the model for **Wadeability**.

Random Effect	SD

Elder	0.3975
Site	0.3586
Year	0.1897
Residual	1.0225

An estimate of how much the Intercept (equivalent to mean score) changed by Elder, Site and Year is provided in Tables 6, 7, and 8, respectively. Positive and negative values mean the scores given are consistently above or below average (i.e. Intercept), respectively.

Table 5: Deviation from Intercept by **Elder**.

	(Intercept)
Aggie	0.6872
Albert	-0.1741
Carl	0.2513
Eugene	-0.3326
Gasper	-0.5017
Ken	-0.1444
Lena	-0.3933
Marie	0.0696
Pete	0.3975
Randy	0.1404

Table 6: Deviation from Intercept by **Site**.

	(Intercept)
B1	0.3068
B2	0.0154
B3	0.4355
B4	-0.3857
B5	0.0211
B6	-0.3931
Y1	0.2666
Y2	0.3405
Y3	-0.2491

Y4	-0.3580

Table 7: Deviation from Intercept by **Year**.

	(Intercept)
2013_14	0.1897
2014_15	0.1031
2015_16	0.0633
2016_17	-0.1087
2017_18	-0.2474

Appendix 2: Summary of St’át’imc Knowledge Project

Photo showing BRGMON-16 Elders, Technicians, Project Manager and Analyst, UBC student and Professor, SGS, Tsal’alh and Xwisten reps.

1) INTRODUCTION

In the early collaborative stages of development of a Bridge System Water Use Plan (WUP), the Lower Bridge River Technical Working Group identified 9 objectives, 8 (salmon, river health, riparian health, riverine birds, species of concern, financial impacts, learning, and stewardship) of which could be measured through empirical data collection. However, the one objective concerned with changes in the smell, sound, movement, and interaction associated with different flows of water in the Lower Bridge River, could only be collected and measured by the St’at’imc. The St’át’imc elders had spoken of the “spirit” and “voice” of the lower Bridge River, noting the noticeable improvements in conditions for (tangible outcomes like) fish, wildlife, and riparian vegetation, as the minimal flow changed from 0 to 3 cms/year. However, as it was deemed unlikely that the flow regime will depart from 6 cms during the study period, rendering the original project design (of comparative observations under 0, 3 and 6 cms Lower Bridge River flows) inapplicable, the project was modified to include comparative observations from the Yalakom River, a tributary of the Lower Bridge River with similar flow characteristics.” Consequently, BRGMON-16 was established as a WUP project that would incorporate spiritual and cultural values (in conjunction with social and environmental measures) in comparison of the two adjacent rivers, in an overall evaluation of the Lower Bridge River 6 cms /y flow regime. These observations on key components of Cultural and Spiritual Quality, included:

Sound:
- The voice of the water
- Birdsong

Smell:
- The smell of the river itself
- The ambient smell at water's edge

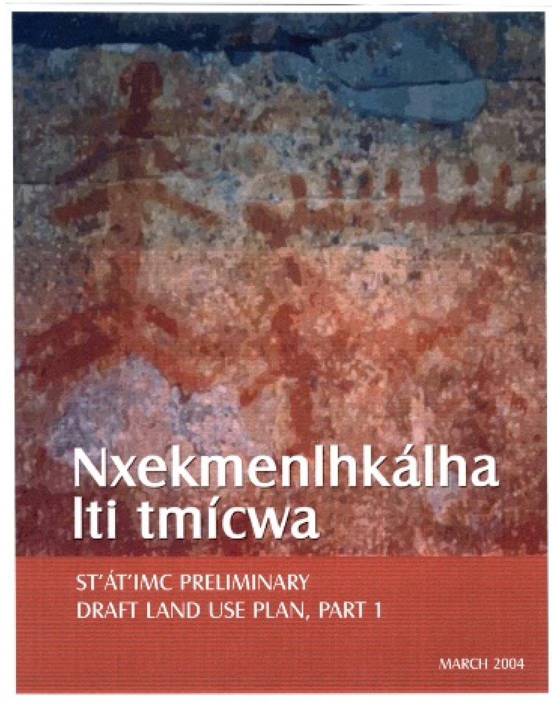
Movement:
- Movement of water (seasonally appropriate)
- Diversity of movement (pools/riffles)

Interaction (of people and water):
- Shore access
- "Wade-ability" (the ability to walk in and/or across the river at certain locations)

Water clarity

The blanket awarding of the 16 Monitoring projects and one Works Project to St'át'imc Eco-Resources (SER), following the completion of the Bridge System Water Use Plan (WUP) in March of 2011, resulted in the need for qualified St'át'imc project managers and technicians. As a result, the St'át'imc Government Services (SGS) agreed to appoint its Stewardship Advisory Co-ordinator (SAC), Larry Casper, to oversee the new BRGMON-16: Lower Bridge River Spiritual and Cultural Value Monitoring project. Larry Casper, Project Manager, and Dr. Dave Levy, Project Analyst, began their work with SER in identifying 8 elders or resource persons from the affected communities of Xwisten and Tsal'alh. Two SER technicians were also identified to provide field survey and technical support. The five year project would encompass four seasonal two-day field trips (Day 1-Lower Bridge River and Day 2-Yalakom River) during each of the project years, from 2013-2018.

2) **<u>ST'ĀT'IMC USE OF THE LAND & RESOURCES</u>** As with many indigenous cultures, the St'át'imc share a distinct connection to the land, passing their knowledge and traditions down from generation to generation, utilizing and incorporating St'át'imc Knowledge in all aspects of St'át'imc life and culture. In recognition of this, the Lillooet Tribal Council based St'át'imc Land & Resource Authority (SLRA) completed a draft St'át'imc Land Use Plan (LUP) in 2004, titled Nxekmenlhkálha lti tmícwa (the laws of our land as taught by our elders). This document incorporated the holistic world view of the St'át'imc, as exemplified in the following excerpts (Vision Statement, and St'át'imc Land Designations [which identified key areas for protection] taken from the LUP document :



ST'ÁT'IMC VISION STATEMENT

Our vision is of a continuing and renewed relationship between St'át'imc people (úcwalmicw) and the land (tmicw) which:

• respects St'át'imc cultural traditions - using the ways (nt'ákmen), laws (nxékmen) and standards of our people as passed down through the generations;
• respects nature – putting the health of the water, the air, the plants, the animals and the land itself before all else;
• is under St'át'imc authority – letting our people decide collectively how the land and resources of the St'át'imc territory will be managed; and,
• serves the St'át'imc communities – recognizing that resources continue to provide

ST'ÁT'IMC LAND DESIGNATIONS

1) Qu7 (Water) Protection Areas
2) Nt'akmenlhkálha (Cultural) Protection Areas
3) Habitat Protection Areas
- Grizzly Protection Areas
- Ts'i7 (Deer) Protection Areas
- St's'úqwaz' (Fish) Protection Areas
- General Habitat Protection Areas
4) Environmentally Sensitive Areas
5) Community Economic Development Areas
6) Restoration Areas

The SLRA approach, “focusing first on what to leave behind on the land to sustain ecology and culture, rather than on what to take from the land through resource extraction,” exemplifies the strong connection to the land by the St’át’imc, recognizing that everything is connected, and that “the Nxekmenlhkálha lti tmícwa provides for the needs of the four- legged people (e.g., deer, grizzly); the winged people (e.g., raptors); the root people (e.g. berries, medicinal plants); as well as the two-legged people (the St’át’imc)". This is the context and holistic approach that is shared by the elders group of BRGMON-16.

3) **FLOW MANAGEMENT EFFECTS** It’s noteworthy that “during 2017 as well as in 2016, high volumes of water were spilled into the Lower Bridge River in response to changed operational requirements at Downton Reservoir, and also due to the derating of generator units at the Bridge 1 and 2 generating stations. Although this resulted in a profound physical impact on the riparian/fisheries habitat/stream bed areas of the Lower Bridge River, this also provided an opportunity for BRGMON-16 team to gather contrasting data from the previous 6 cms average annual flow. However, somewhat surprisingly, but in line with the general findings of this project, the elders did not perceive the higher flows as lower value and their scores were generally unaffected. Consequently, after five project years of study, it is the general summation of this project that the cultural and spiritual attributes are insensitive to flow discharge, even at very high flows (96 cms in 2016, 109.5 cms in 2017 and 102 cms in 2018.)

As noted in the Bridge River Power Development Water Use Plan Implementation St’át’imc Eco-Resources Progress Report of 2016-2017, this result may reflect perceptions by the elders that the Lower Bridge River provides strong spiritual and cultural connections "irrespective of flow” can be supported by the following points:

- Despite the impacts to the Bridge River system, historically and currently with the higher flows, the St’át’imc still view it as a valued sustainer of life. The comments of an elder that “Water is Life,” as he reflected positively on the value of the rivers and his involvement in the five year study, supports this strong holistic connection to the land; and

- Many of the elders group still retain the “knowledge and memory” of the historic flows (100 cms average in comparison with previous low flows of 3 and 6 cms average) of the Lower Bridge River (ie. 4-6 of the participating elders share a common lineage and link with the Bridge River Valley), resulting in general acceptance of a flow that, although circumstantial in nature, is still a reminder that “this was how the Bridge River once flowed in its natural wild state,” hence this may have resulted in the corresponding lack of differentiation of survey results during the high flow periods.

4) **PROJECT RESULTS**

a) St’át’imc Knowledge Sessions: The research process for the Traditional Ecological Knowledge (TEK) group sessions evolved from the informal afternoon Elder debrief and dialogue time upon completion of the second day of field surveys. These discussions were useful in assisting the Elders in dealing with any trauma or emotions brought by witnessing ecological impacts on territory, as well as providing a forum to discuss traditional or current practices within the project study area. During these discussions, it became apparent that the participating Elders were comfortable in discussing their experiences and knowledge of sites of spiritual, cultural, and/or historical importance within the study area and adjacent watersheds. Additionally, multiple purposes were identified by the Project Manager to support this endeavor including; protecting and propagating St'a'timc Knowledge to the next generation, and supporting other St'at'imc based projects.

During 2015, Dave Levy and Larry Casper reached out to UBC Assistant Professor for Indigenous Forestry, Dr. Janette Bulkan, and Graduate Researcher Zachary Zabawa to discuss the opportunity to develop a low cost research methodology to achieve both purposes of enabling group discussions and TEK mapping in the lower Bridge River and Yalakom River valleys. During an introductory meeting on March 15th, 2015 between UBC researchers, Community researcher Tim Peter, and the Elder Working Group (EWG), the TEK sessions were agreed upon in principle. Following this agreement, the research team drafted the requisite UBC-community research agreements, data sharing protocols, and informed consent agreements to be provided to participating Elders and Band Councils. These agreements were signed by the Band Councils of Tsal'alh on 5th Oct. 2015 and Xwisten on 20th July 2015, and by all participating Elders during the subsequent sessions.

b) <u>Research Methodology</u>

Following the stipulations laid out in the agreements, the following methodological practices were followed. While the primary purpose of the TEK sessions was to identify points of interest within the project area, the sessions also experimented with methods and technology as academic literature for group mapping methodologies is sparse. Subsequently, these sessions were held to test both the viability of current direct-to-digital mapping methods available to First Nations and identify additional features such a project should possess in order to meet the specific needs of the leadership and community. This project was determined to be relevant for the Nation as it is currently undertaking a comprehensive land use and occupancy research project. This was accomplished by actively experimenting with the meeting format from meeting to meeting. Ultimately, this process resulted in a robust and collaborative research methodology and TEK maps.

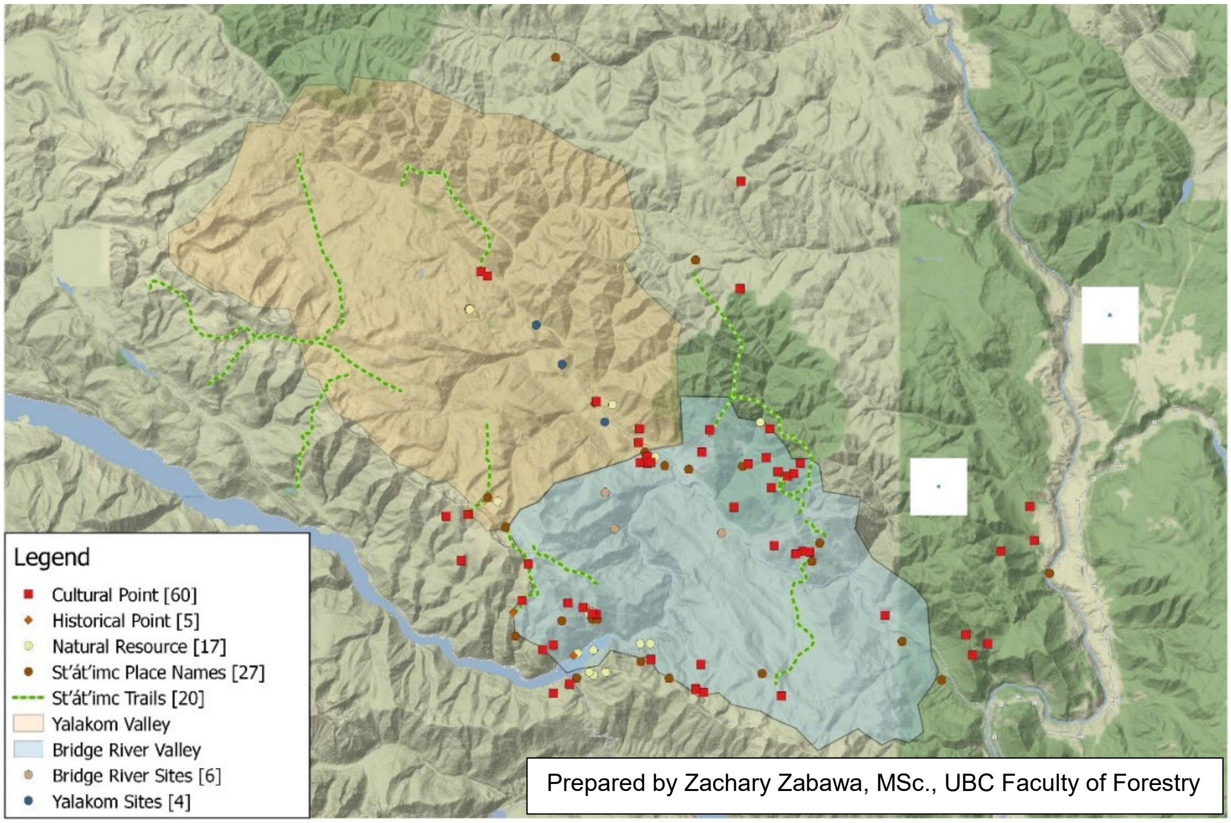
c) <u>Group Mapping</u>

The TEK sessions consisted of group interviews of the EWG utilizing Google Earth's 3D Satellite imagery platform and a Microsoft Access database to identify trails and significant points, and study-related information. Each session was held in either the multipurpose room or gymnasium of the Bridge River Band Offices. After experimentation, the group was arranged around u-shape tables as close to technicians, projector, and microphone as possible to increase audibility and visibility of both researchers and elders, and minimize expensive recording devices.

Elders Working Group Mapping Session. Photo by Zachary Zabawa

Each Elder was given a laser pointer to enable more accurate and less burdensome location of point, polygons, and lines on the projector screen. When a point was identified by an elder, the mapping technician would create a point, polygon, or line on Google Earth located in a date-stamped folder. Each entry would include, within the description field, six corresponding data attributes; the contributor(s) of each point, the St‘át‘imc name, type of use, season of use, first or second-hand knowledge, and approximate timeframe of use. For the documentation of traditional St‘át‘imc names the group relied upon an elder fluent in St‘át‘imets to record each name separately during the sessions. Following each meeting, the technicians would save the date-stamped Google Earth Folder in KML format to a password protected hard-drive along with the audio and video recordings from the session. At a later date, the researchers would then input the KML database file and St’at’imc names into the Access database. The UBC researcher held two training sessions with the community researcher to facilitate use of the technology platform.

In order to properly document each TEK session, the research team developed a relational Access database and associated data entry forms to standardize the data collection process. In addition to the GIS table containing points and associated data, the relational database consisted of mandatory input tables for contributors and technicians present at each meeting, recording devices used, and general comments concerning meeting structure in order to facilitate the ease of use for future researchers. The team primarily relied upon audio and screen recording of the mapping laptop using the free and open source software, Open Broadcasting Studio. Owing to the many responsibilities of the two technicians and the need to reduce data-collection burden on the Elders, real-time database input was limited to the record keeping functions of attendance and inputting points into Google Earth.



d) <u>Individual Interviews</u>

Here it is important to note the current state-of-practice surrounding the use of group interviews in the context of First Nation land use research. Group formats have been identified by practitioners as possibly deterring involvement of less respected or socially marginalized participants, like younger Elders or women, by introducing an avenue to be criticized for offering inaccurate knowledge. The research team did notice the tendency of this format to have the conversation dominated by more powerful personalities within the group. This could be managed by a thoughtful discussion facilitator who can guide the discussion towards the strengths of those not participating. However, this required a high level of familiarity and respect for the Elders, and/or use of the Talking Stick format that may be better suited for a community researcher.

A major critique found in the literature that could not be mitigated through the actions above concerns how the most sacred and familial knowledge is not shared in communal settings. This was the primary reason to conduct the individual interviews. Due to the above critiques of group interviews, the research team decided to implement a mixed methods approach to the mapping interviews to mitigate any shortcomings of any particular interview methodology. The project used group interviews as a means to rapidly survey the study area and identify the area of specialty of each Elder participating in the working group. The group interviews were followed by individual interviews with each member of the EWG. These interviews attempted to cover points identified in the group interviews as demonstrating the potential to corroborate St'át'imc claims by demonstrating ownership or intensive use. However, the research team quickly found the need to keep the interviews partially unstructured to enable the Elders to speak about points and issues they deemed relevant or too sacred for group setting. This proved immensely valuable as points not mentioned in the group sessions were identified. While this points to relevance of critiques surrounding the group mapping methodology, it also could be attributed to current highly-structured research methodologies. This ultimately points to the need for more experimentation with interview methods. While each individual interview varied in format depending materials to be covered and each Elders familiarity with mapping technology, the interviewer was required to complete certain steps. First the researcher had to present the details and commitments found in the signed informed consent agreement before the interview. Second, the entire interview was video recorded and provided to each interviewee if requested.

5) <u>CONCLUSION</u>

St'át'imc TEK project provided a forum to support or provide input to other St'át'imc related projects, such as the SGS Heritage team (Archaeological Management Plan work on 37 sites in the territory), SGS Land, Use and Occupancy Study project, the St'át'imc Chiefs Council RELAW (Revitalizing Environment, Land, Air, Water) project, Xwisten LUOS, Tsal'alh LUOS and the UBC Faculty of Forestry: St'át'imc TEK project, involving Zac Zabawa, Graduate researcher, currently employed within the Tsleil-Waututh Nation: Lands & Resources Department.

The close involvement and technical support provided by the Tsal'alh and Xwisten land and resource reps, Gerald Michel and Tim Peter, along with support by the BRGMON-16 technicians including Zac Zabawa, enabled them to gather valuable TEK info, including proper St'át'imc spelling/pronunciation of place names/objects, derived from the participating elders. Although very general in nature, the project provided baseline data for future ground-truthing efforts by the two communities. This information may then be stored and shared with students and community members as a lasting educational legacy and benefit to future generations.

BRGMON-16 was very much appreciated by the participating Tsal'alh and Xwisten elders and community members. They enjoyed getting onto the land during the field trips and sharing their experiences and knowledge of the various watersheds (including Lower Bridge River and Yalakom River) within the St'át'imc Territory.