# Bridge River Project Water Use Plan

## Lower Bridge River Spiritual and Cultural Value Monitoring

## Implementation Year 4

## Reference: BRGMON-16

**Study Period: August 2016 to June 2017**

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## GMON-16 STATUS of OBJECTIVES, MANAGEMENT QUESTIONS and HYPOTHESES after Year 4

| Study Objectives | Management Questions | Management Hypotheses | Year 4 (2016-2017) 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.<br>The study is on track for strengthening the conclusion for the management question in Year 5 using the current approach/study design.<br><br>Results contributed to the preliminary conclusion that the spiritual and cultural values are insensitive to water flow levels which is demonstrated by the relatively little to no change experienced by the spiritual and cultural scores over a large range of discharges. |

# Executive Summary

The BRGMON-16 Water Use Plan (WUP) monitoring project is being 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 is needed to incorporate non-tangible inputs into a future long-term flow decision for the Lower Bridge River. During Year 4 of the project, between eight and nine St’át’imc elders participated as evaluators to score their perceptions of cultural and spiritual values at different water flow discharges ranging between 8.4 cubic meters per second (cms) in August 2016, 1.5 cms in October 2016, 35.9 cms in April 2017 and 109.5 cms in June 2017[1]. The Yalakom River was adopted as an adjacent (unregulated) control river and four seasonal surveys were simultaneously conducted in the Lower Bridge River and the Yalakom River. A total of 9 variables were evaluated at 10 sites with a scoring system that ranged between 0 (least favorable) and 4 (most favorable).

The 9 variables were analyzed 1) statistically using General Linear Interactive Modeling (GLIM) 2) graphically by histogram analysis and 3) by directly evaluating relationships between flow discharge and spiritual/cultural parameters. 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, 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, which ranged in the Lower Bridge River between 1.5 cms and 109.5 cms, there was little variation in parameter scores. Scatter plots suggested the nine variables appeared to be insensitive to flow discharge variations in the Lower Bridge River for the range of flows that were examined.

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

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## Introduction

Year 4 of the BRGMON-16 monitoring project was undertaken between August 9, 2016 and June 30, 2017 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 Water Use Plan (WUP) on biological components and human perceptions of the ecosystem (this project).

A structured decision-making framework was developed to address 9 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 is obtained only from members of the St'át'imc community. This report describes the fourth year of a 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 2017, as in 2016, there was a requirement to spill excess water down the Lower Bridge River because of the reduced capacity to pass 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 2017 survey, which occurred during a 109.5 cms flow discharge, provided a unique opportunity to gauge the perceptions of the elders to the unusually high flow conditions.

## Background

St'át'imc elders speak of the "spirit" or "voice" of the Lower Bridge River. They have observed that in moving from a water budget of 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 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)
- "Wade-ability" (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**, 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 is intended that the information on spiritual and cultural values will provide an important measure that can be integrated with other social and environmental measures in an overall evaluation of alternate flow regimes.

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

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

> "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 of 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 present-day 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.

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 1). 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 (Clain 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 1. Key findings from Australian case studies on 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 Environment and Protection Authority 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 of such processes. |
| Police Lagoons Conceptual Model, Queensland | The conceptual models for Police Lagoons integrate science with cultural, spiritual and ecological values 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. |

## Objectives and Scope

The original objective of this program, (presently inapplicable due to present and future spilling requirements) was to collect the information on the smell, sound, movement and interaction of people and water of 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 remains relevant, an opportunity arose in 2017 to investigate how the smell, sound, movement and interaction (of people and water) in the Lower Bridge River varies as a function of flow discharge.

### *Management Questions*

The primary management question that being addressed by this monitoring program is:

> *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 2017, due to the high flows in the Lower Bridge River, mean annual discharge was 18.6 *cms/y*

### *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 the 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 and 6 cms hydrographs for the Lower Bridge River are specified in the WUP, BC Hydro obtained variances from the BC Water Comptroller in 2016 and 2017 that authorized large departures from the idealized hydrographs. The net effect of the additional water releases was to increase the mean annual discharge from 6 cms to 18.6 cms (Calendar Year from Jan. 1, 2017 to Dec. 31,2017).

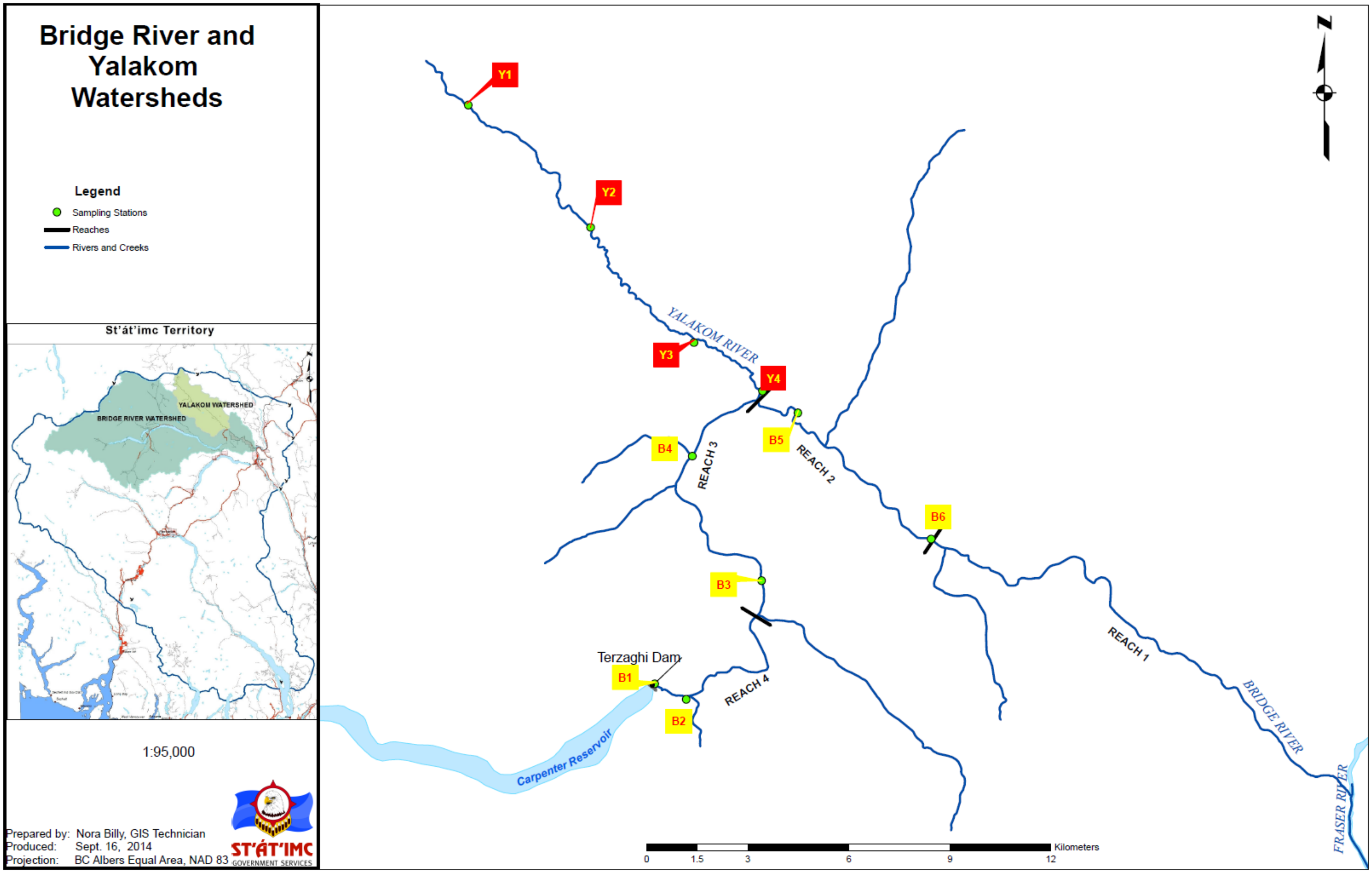



Figure 1. Location of sampling sites in the Yalakom River and Lower Bridge River.

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).

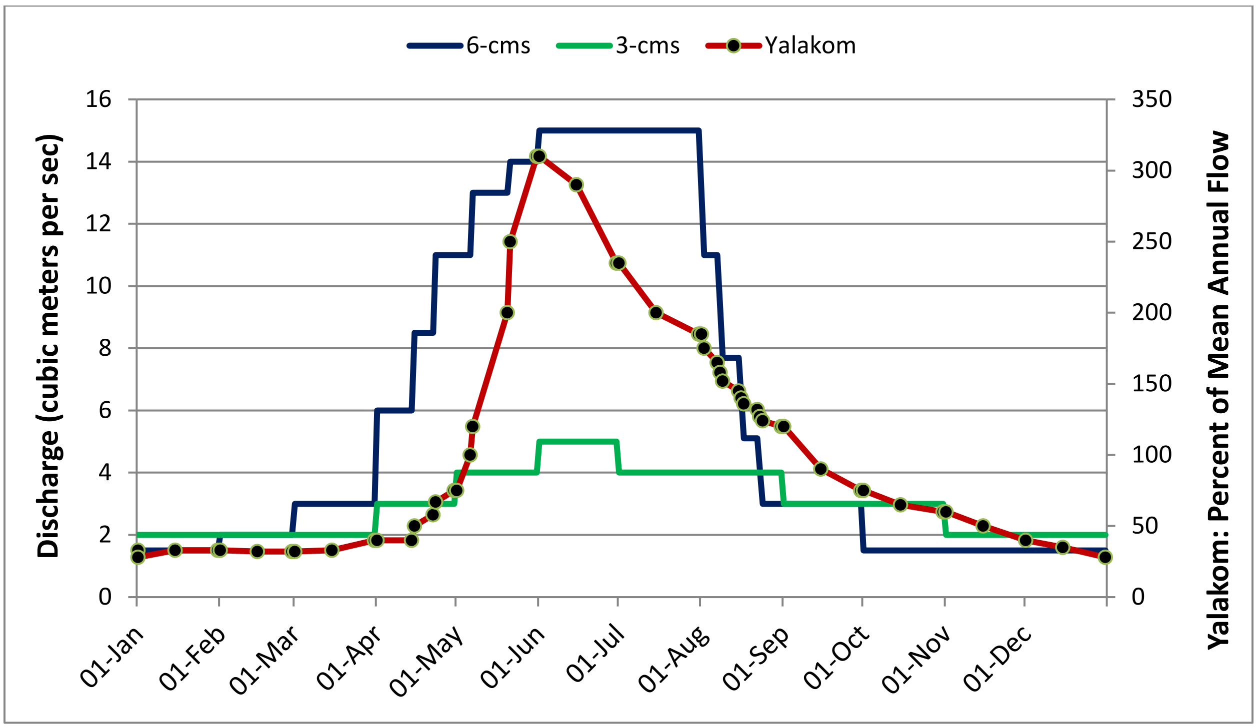



Figure 2. Comparison of Lower Bridge River flow discharges at 3 cms and 6 cms (annualized mean flow) in relation to averaged Water Survey of Canada data for the period 1981 - 1990 (Rood and Hamilton 1995). The annual mean Yalakom River flow over this period was 4.11 cms.

The Lower Bridge River hydrographs prior to higher flows in 2016-2017 (Figure 3) show the idealized flow discharges as agreed upon with the BC Comptroller of Water Rights in relation to actual flows between 2013 - 2015. Actual flows didn't depart significantly from the idealized target flows over the period of BRGMON-16 data collection between July 31, 2013 and March 7, 2015.

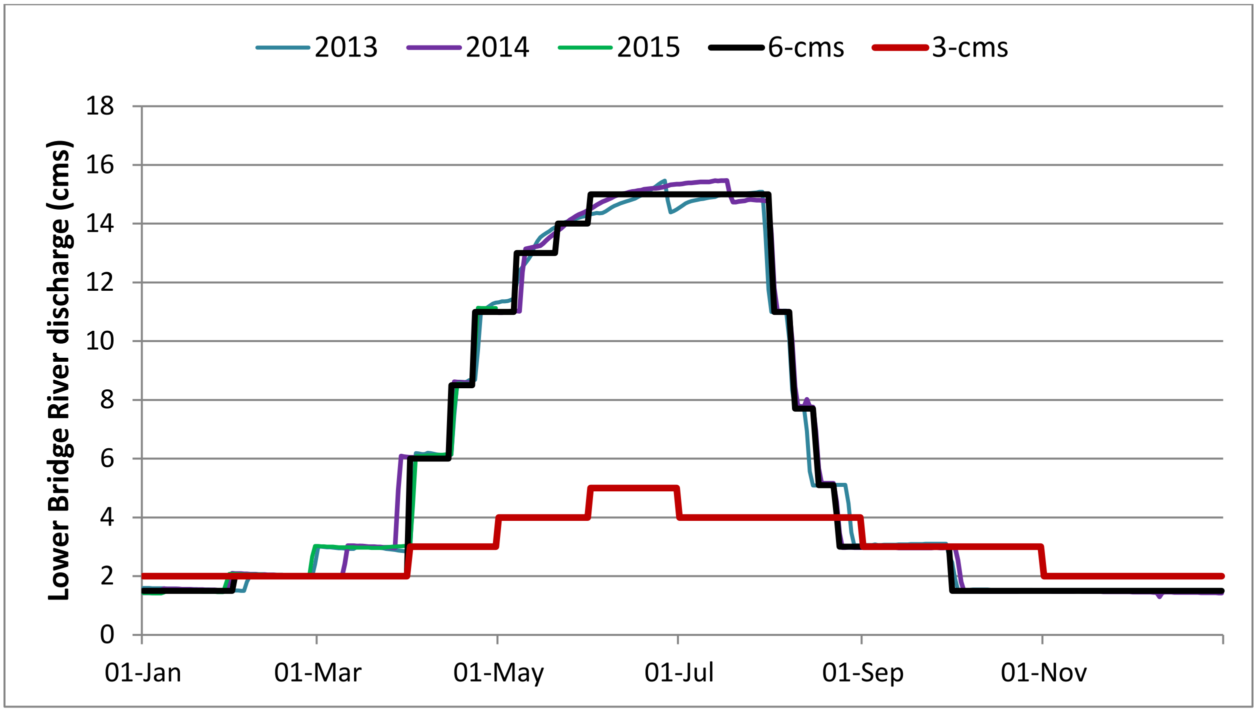



Figure 3. Actual flow discharges in the Lower Bridge River between 2013 - 2015. Flow discharge data provided by BC Hydro, Power Records.

As mentioned in the Introduction there was a need to spill excess water into the Lower Bridge River in 2016 and 2017 with discharges that reached a peak of 96 cms in early June 2016 and 126 cms in June 2017. Hydrographs depicting the discharge over the entire BRGMON-16 study period, until 2017, are shown in Figures 4 and 5.

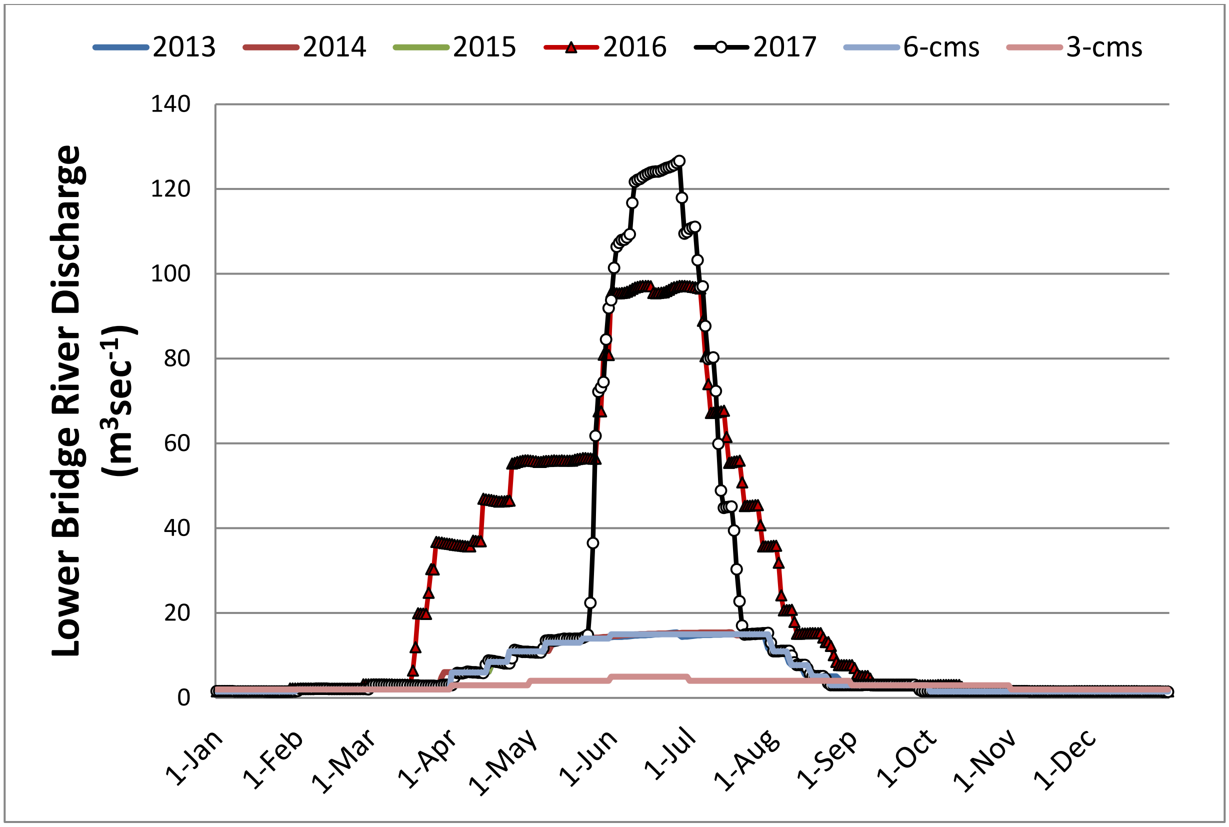



Figure 4. Lower Bridge River Hydrograph, 2013-2017.

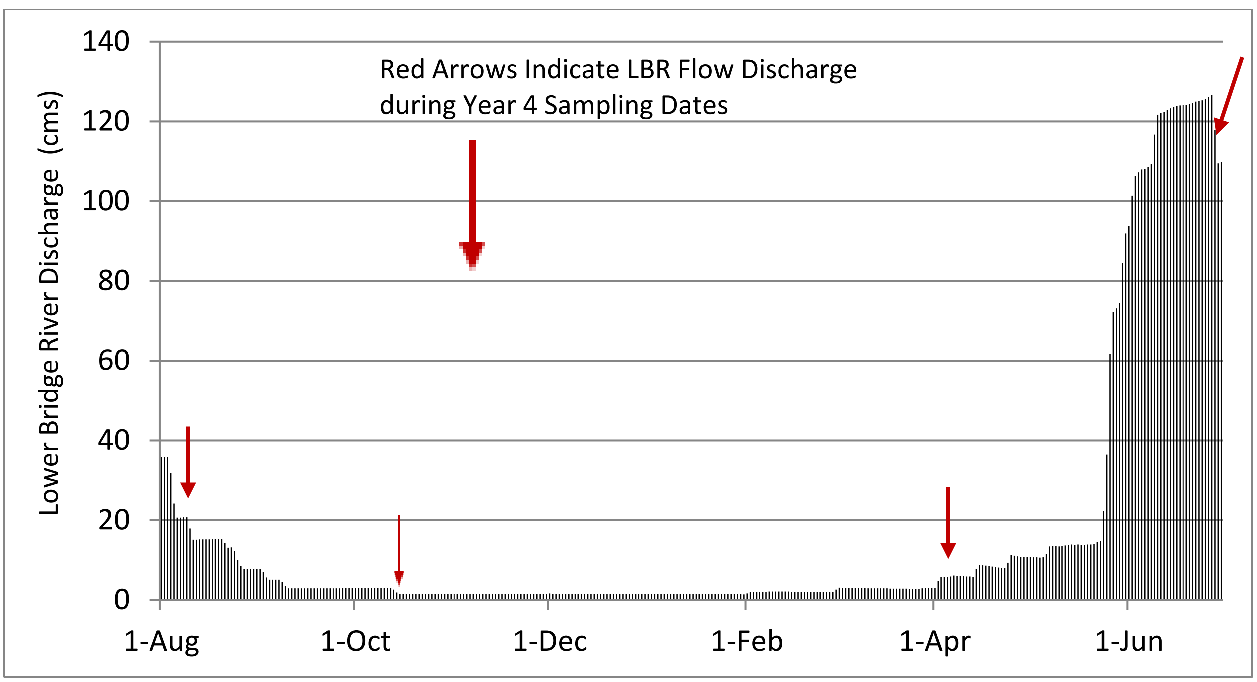



Figure 5. The timing of surveys relative to the 2016-2017 Lower Bridge River hydrograph.

## 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 so that consistency in the conduct of measurements was achieved.
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 four 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.

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) a graphical analysis by plotting histograms that displayed the mean and standard deviations of the spiritual and cultural attribute scores; 2) scatter plots that compared mean parameter scores and discharge; and 3) General Linear Interactive Modeling (GLIM) a statistical software program for fitting generalized linear models (GLMs). It was advantageous to apply two independent analytical procedures to the BRGMON-16 data set to understand the convergence and divergence between the two 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. The actual scheduled surveys during 2016-2017 were Aug. 9-10, 2016, Oct. 11-12, 2016, April 6-7, 2017 and June 29-30, 2017. The timing of the surveys relative to the Lower Bridge River hydrograph, is shown on Figure 5. Minor departures from the TOR schedule were unavoidable due to logistical constraints, however, the deviations were small and observations during 2016-2017 covered a wide range of flow conditions. As discussed below, the scheduling deviations were informative by generating contrast in flow variations in the data set.

The surveys included the following flow conditions:

| | Lower Bridge River Flow | Approximate Yalakom River Flow[3] |
|---|---|---|
| August 9-10, 2016 | 8.4 | 7 |
| October 11-12, 2016 | 1.5 | 3 |
| April 6-7, 2017 | 35.9 | 1.9 |
| June 29-30, 2017 | 109.5 | 10.5 |

[3] extrapolated from Figure 2.

## Results

Comparisons of the different measurement variables obtained in the different rivers (aggregating across sampling sites) are shown in Figures 6a and 6b.

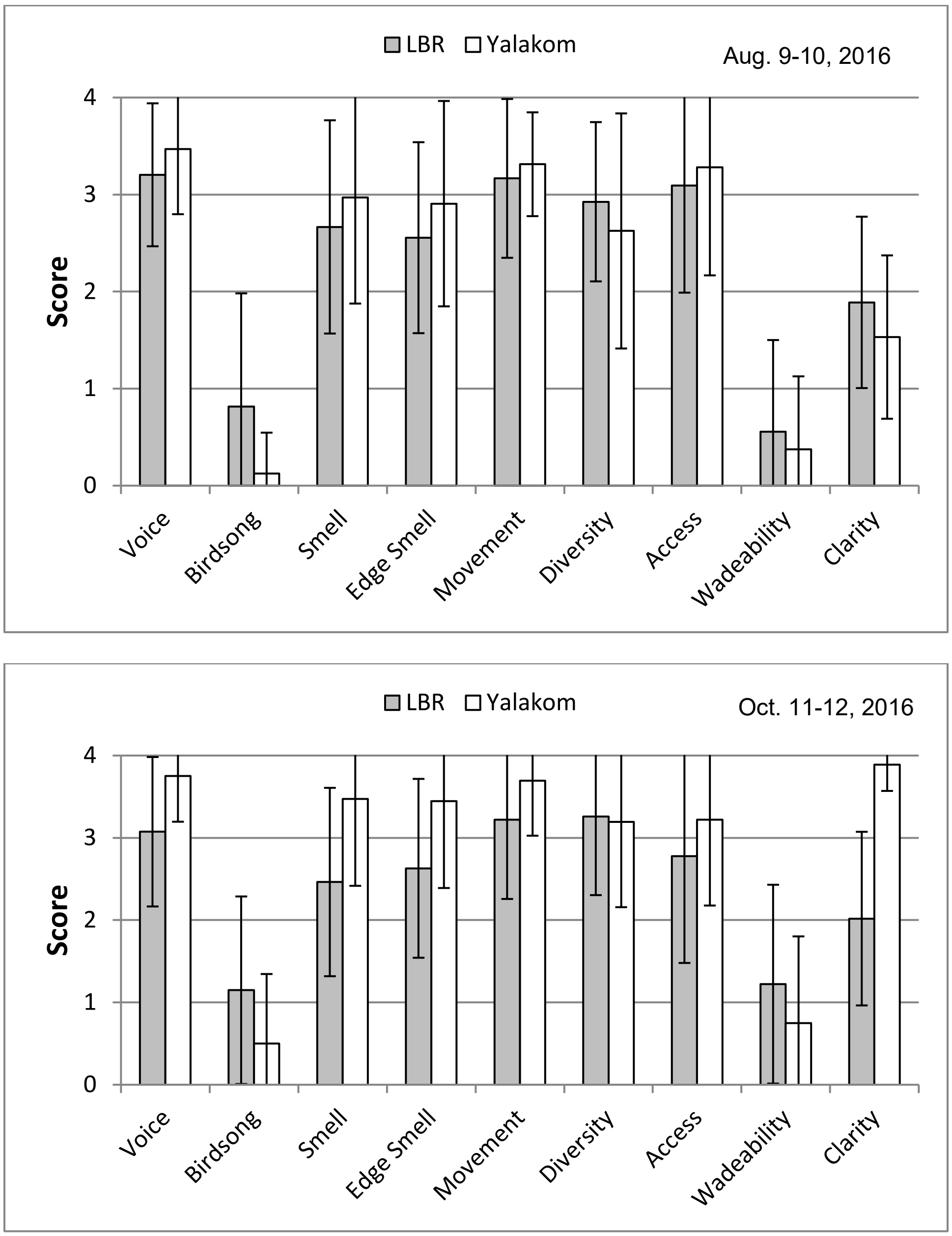



Figure 6a. Spiritual and cultural value scores in the Lower Bridge River and Yalakom River for Aug. 9-10, 2016 (upper; n = 7 elders) and Oct. 14-15, 2015 (lower; n = 8 elders). Error bars indicate ±1 standard deviation. Scores represent 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

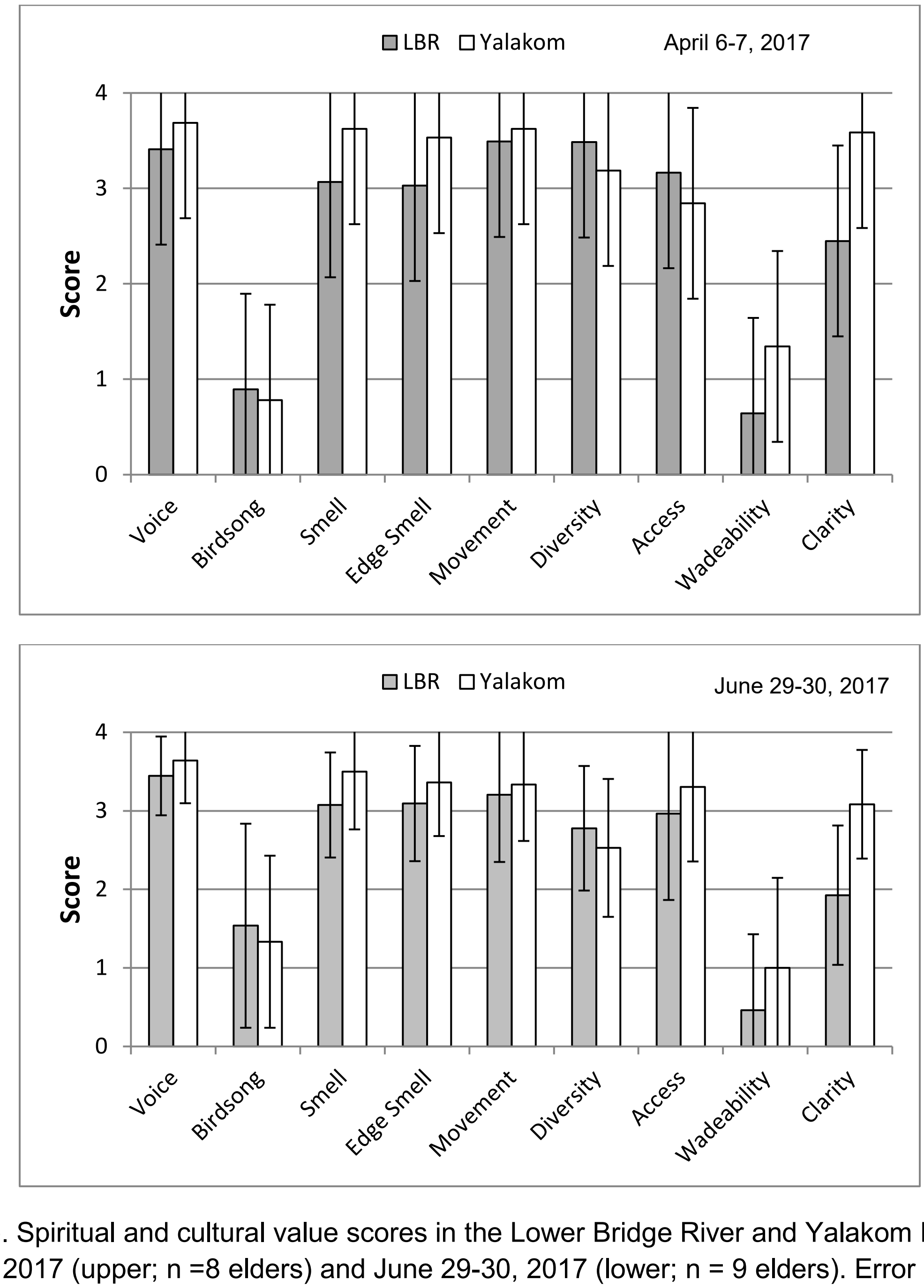



Figure 6b. Spiritual and cultural value scores in the Lower Bridge River and Yalakom River for April 6-7, 2017 (upper; n =8 elders) and June 29-30, 2017 (lower; n = 9 elders). Error bars indicate ±1 standard deviation. Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

To obtain a qualitative evaluation of between-elder variability in scoring trends, the nine different parameters were averaged and compared visually (Figures 7a and 7b).

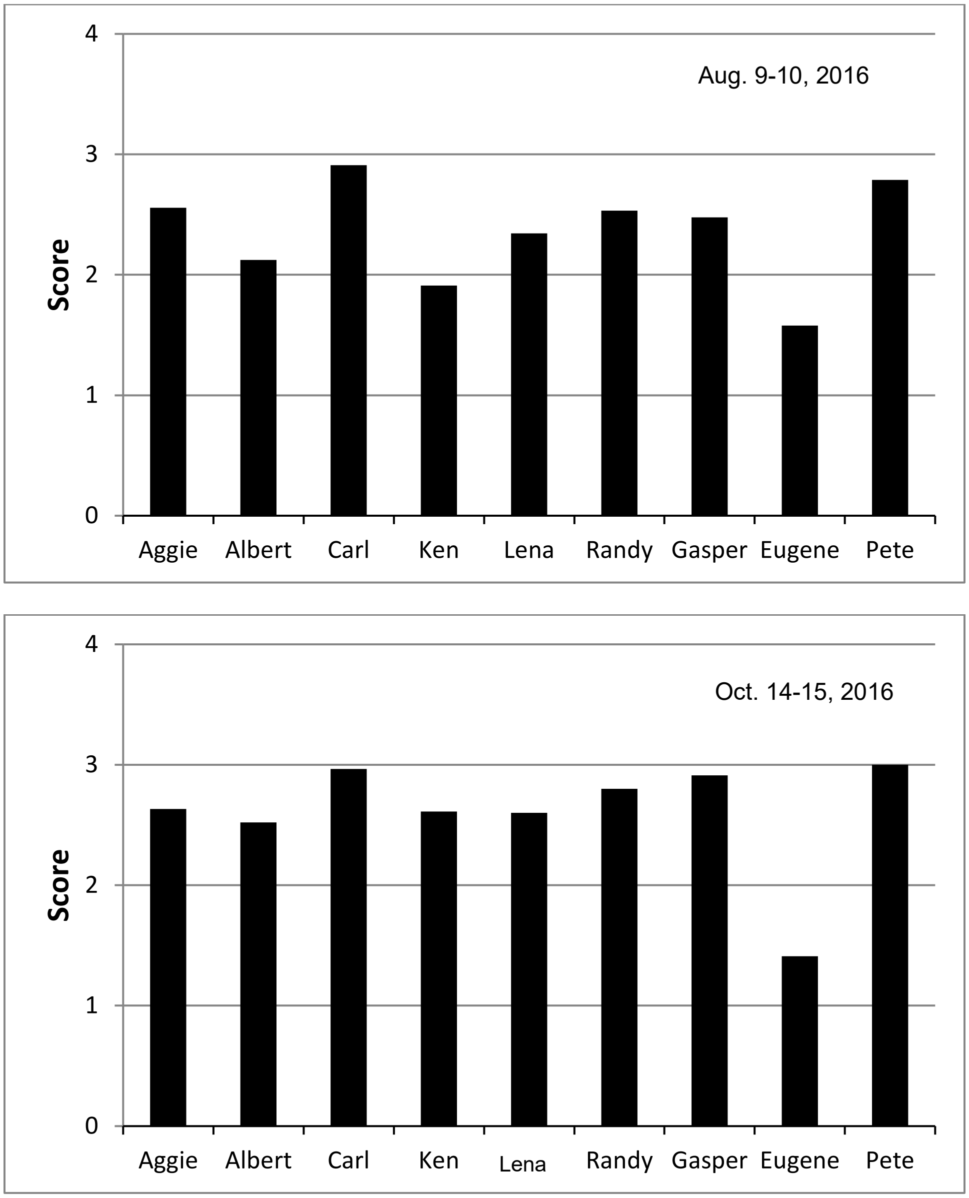



Figure 7a. Combined scores of cultural and spiritual value attributes obtained during Aug. 9-10, 2016 (upper) and Oct. 14-15, 2015 (lower). Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

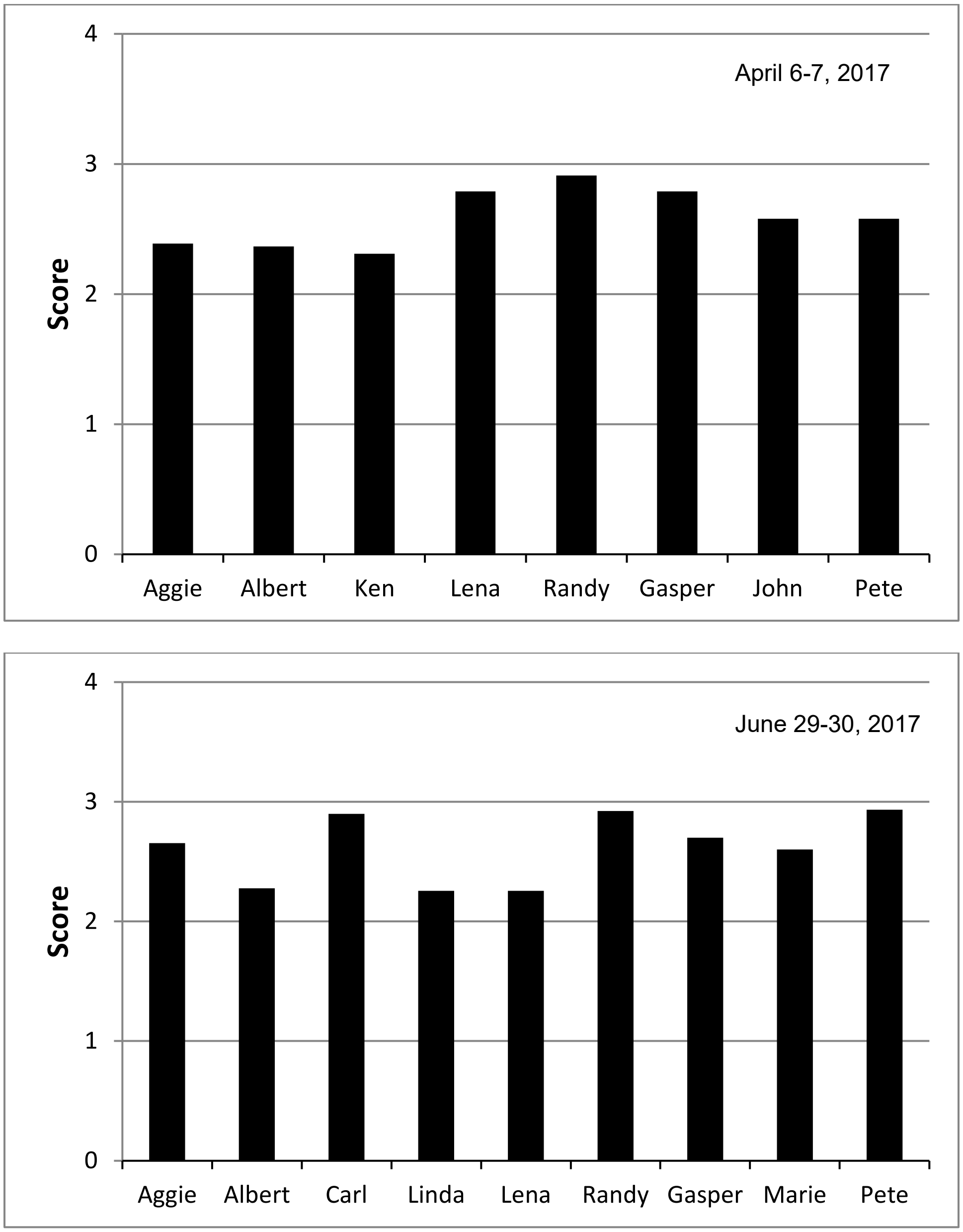



Figure 7b. Combined scores of cultural and spiritual value attributes obtained during April 6-7, 2017 (upper) and June 29-30, 2017 (lower). Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

To evaluate the effects of flow discharge on spiritual and cultural values, the compiled data set obtained in the Lower Bridge River during the 4 years of BRGMON-16 monitoring scatter plots were prepared and are shown in Figures 8 - 10.

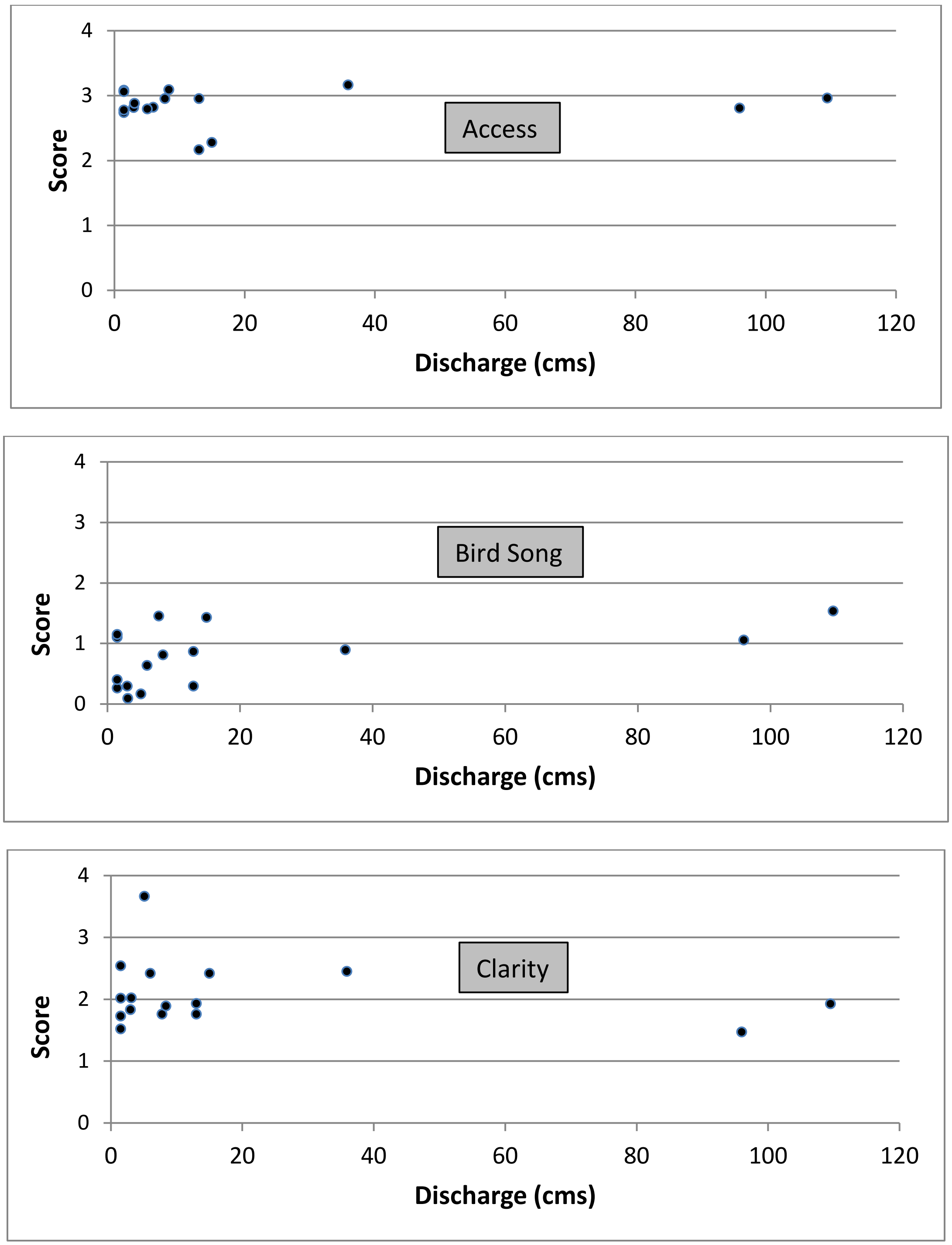



Figure 8. Scatter plots of mean scores for Access, Birdsong, and Clarity in relation to Lower Bridge River flow discharge between 2013 - 2017. Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

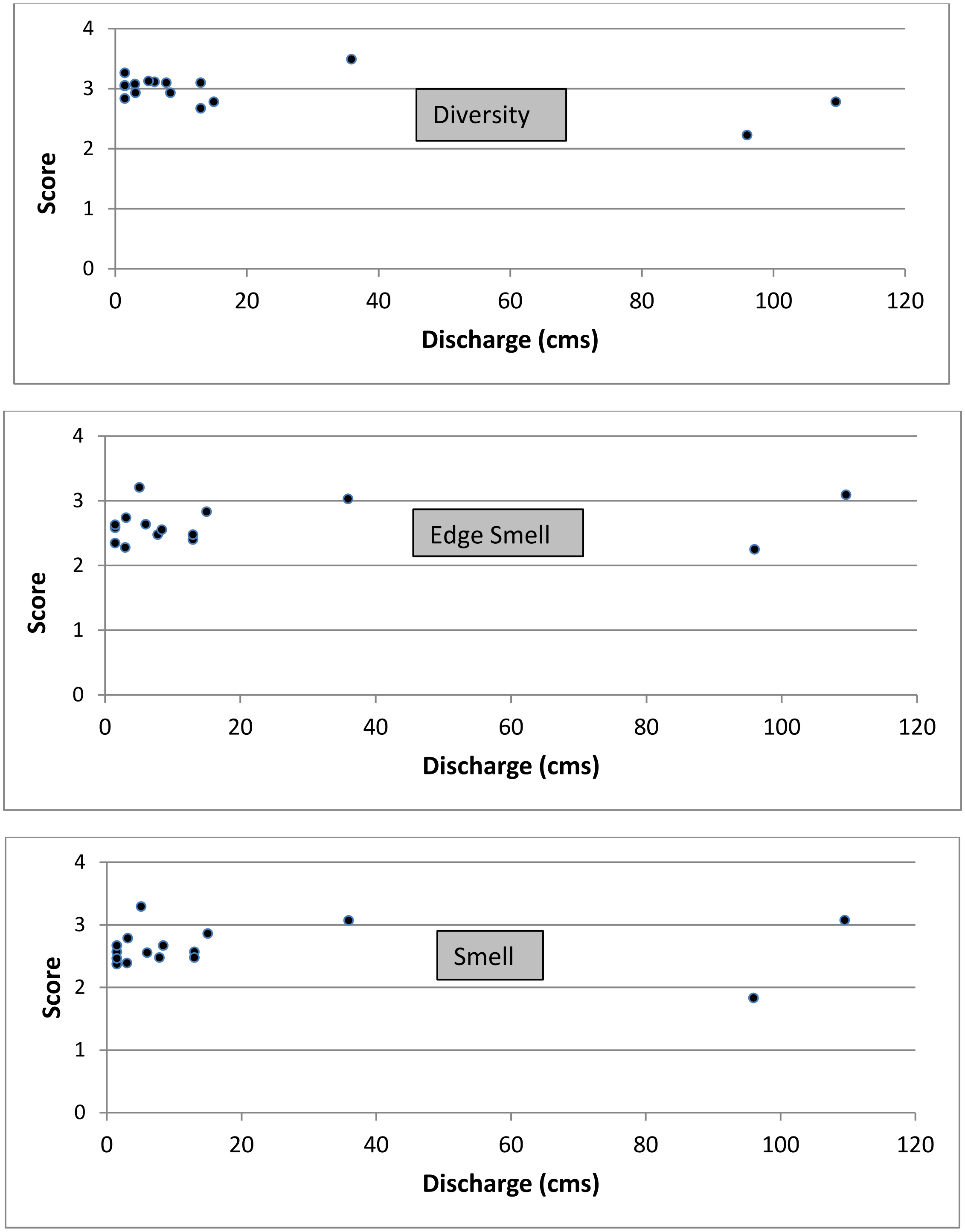
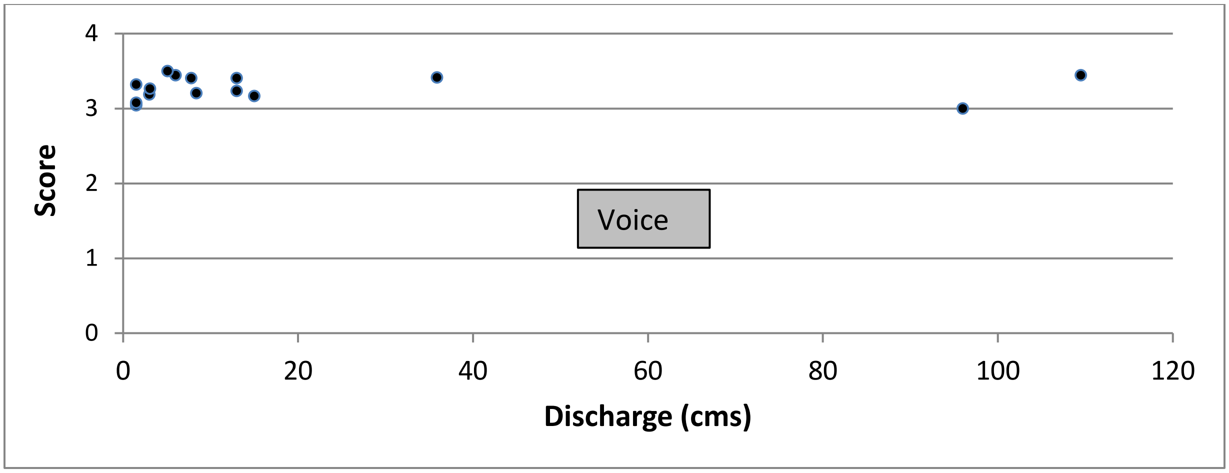
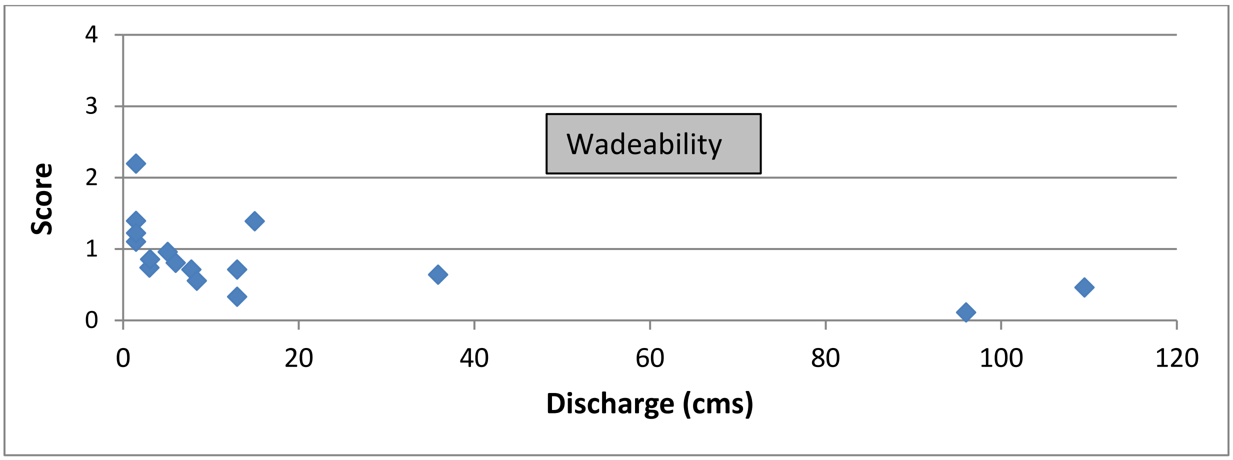



Figure 9. Scatter plots of mean scores for Diversity, Edge Smell and Smell in relation to Lower Bridge River flow discharge between 2013 - 2017. Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.



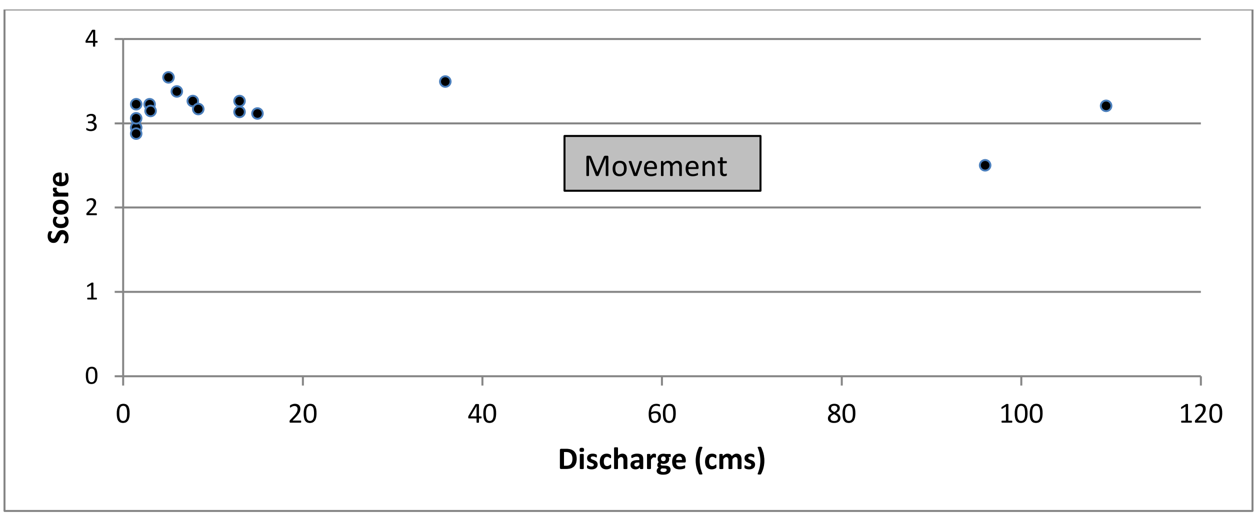




Figure 10. Scatter plots of mean scores for Diversity, Edge Smell and Smell in relation to Lower Bridge River flow discharge between 2013 - 2017. Scores represent: 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.

*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 2017 analyses there were 3 or 4 years of observations available, respectively, justifying the consideration of "Year" as a random effect.

The analysis considered statistical interactions as well as main effects. In statistics, an interaction may arise when considering the relationship among two or more variables and describes a situation in which the effect of one causal variable on an outcome depends on the state of a second causal variable.

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).

Table 3. 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. An expanded interpretation of the statistical results is provided in Appendix 1.

| Parameter | Season | River | Season x River | Interpretation |
|---|---|---|---|---|
| Access | ns<br>0.38 | ns<br>1.87 | ns<br>2.08 | There was no influence of season or river on Access scores, and no interaction between season and river. |
| Birdsong | ✹<br>20.66 | ✹<br>5.52 | ✹<br>5.81 | There were seasonal effects on Birdsong scores, differences between rivers and an interaction between seasons and rivers.<br>In the Bridge River:<br>• Scores were highest in spring and lowest in winter<br>In the Yalakom River:<br>• Scores were highest in spring |
| Clarity | ✹<br>17.22 | ✹<br>7.28 | ✹<br>50.91 | There were seasonal effects on Clarity, differences between rivers and an interaction between season and river.<br>In the Bridge River:<br>• Scores in summer were greater than in fall, winter, and spring<br>In the Yalakom River:<br>• Scores in summer were greater than in spring |
| Diversity | ✹<br>7.51 | ns<br>0 | ns<br>1.66 | There were seasonal effects on Diversity but no difference between rivers and no interaction between season and river. |
| Edge Smell | ns<br>1.58 | ✹<br>9.34 | ✹<br>9.35 | While there was no significant difference between seasons there were significant differences between rivers and an interaction between seasons and rivers. |
| Movement | ✹<br>4.39 | ns<br>2.74 | ✹<br>3.89 | There were seasonal effects on Movement, no differences between rivers and an interaction between season and river. |
| Smell | ✹<br>2.99 | ✹<br>5.74 | ✹<br>8.91 | There were significant differences between seasons and rivers and an interaction between season and river. |
| Voice | ✹<br>4.13 | ✹<br>3.92 | ✹<br>2.85 | There were differences between rivers, seasons and an interaction between season and river. Yalakom River scores were significantly higher than Bridge River scores. |

| Parameter | Season | River | Season x River | Interpretation |
|---|---|---|---|---|
| Wadeability | ✹<br>27.13 | ns<br>0.04 | ✹<br>17.32 | There were seasonal differences in wadeability, no differences between rivers and an interaction between season and river. |

## Discussion (results from 2016-2017)

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 Year 4 of the project, the program replicated the approach of assessing cultural and spiritual attributes associated with different water flow discharges. St'át'imc elders participated as evaluators of nine different parameters related to spiritual and cultural attributes. The motivation for the project is to incorporate St'át'imc spiritual and cultural attribute considerations into a long-term flow release strategy for the Lower Bridge River. The project was designed to inform the selection of either 3 cms or 6 cms mean annual flow discharges.

During 2017, there was a higher peak flow in the Lower Bridge River (maximum discharge of 126 cms) associated with the lowering of Downton Reservoir maximum elevation to 734 m as well as reduced capacity in the system for passing 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.

As in 2016, the 2017 flow afforded an opportunity to measure spiritual and cultural attributes associated with high discharges that approximated the mean annual discharge of the Lower Bridge River prior to impoundment (100 cms). The high flows in 2016 and 2017 served to better understand the effects of extreme flow discharges on spiritual and cultural attributes. Main results obtained in 2016-2017 are discussed below.

### *Histogram Plots*

The following trends were evident in the histograms shown on Figures 6a and 6b:

1. During the summer survey (August 9-10) there were minor differences between rivers in eight of the parameters and only Birdsong was slightly higher in the Lower Bridge River than in the Yalakom River. The standard deviation error bars during this survey, as well as in subsequent surveys, indicate that the measured differences were small in relation to the variation in the data. During the fall (Oct. 11-12), six parameters scored higher in the Yalakom River, except for Birdsong and Wadeability which were slightly higher in the Lower Bridge River. Diversity scores were similar in the 2 rivers. As in the summer survey, the error bars calculated for the 2 rivers overlapped to a large extent, e.g. Voice, Diversity, Access and Movement. The winter survey (April 6-7) indicated that five of the

parameters scored higher in the Yalakom River (Voice, Smell, Edge Smell, Access and Clarity). Birdsong and Wadeability scores were similar in the 2 rivers. During the spring survey (June 29-30) six of the scores were slightly higher in the Yalakom River, and the other three (Birdsong, Diversity and Access) slightly higher in the Lower Bridge River.

While the confidence in these observations is modest due to the relatively large variation in the scores (large and overlapping error bars) there is a systematic trend in the observations, such that the Yalakom River scores appeared to be modestly higher than those in the Lower Bridge River. Similar trends were observed in Years 1-3, and now that 4 years of data are available, there is a good basis for testing these observations statistically (see Summary of Statistical Results, below).

2. There was no consistent trend in the between-elder scores with the exception of Eugene who scored lower than the other elders during the two Year-4 surveys in which he participated. A similar trend in Eugene's scores was noted in Year 3. This suggests that elders can be viewed as a random variable although caution must be exercised when an elder scores consistently higher or lower than the other elders.

### *Discharge Analysis*

The scatter plots shown in Figures 8 - 10 did not suggest any relationship between discharge and eight parameters:  Access, Bird Song, Clarity, Edge Smell, Voice, Diversity Wadeabilty. Care must be exercised however, when interpreting the discharge analysis results in Figures 8 - 10 due to the two high June discharge values of 96 and 109 cms[4] which may have "levered" the data set, possibly leading to false conclusions about the presence/absence of an effect. During Year 5, the final year of the BRGMON-16 project, two of the surveys will be scheduled in June 2018 when it is anticipated that BC Hydro will be spilling excess water, to obtain two additional high flow data observations.

### *Summary of Statistical Results*

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

The main results from the statistical analysis are shown in Table 3. The results of the histogram analysis and the statistical analysis were largely consistent with each other which is to be expected since the underlying data are the same.

Access:

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 2017. The histogram analysis (Figures 6a and 6b) yielded similar results so 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 or the interaction effect of season and river on Birdsong scores. The seasonal effect was a strong one as indicated by the high F-value (20.66) 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=50.91). Histograms indicated similar water clarity in summer, and higher water clarity in the Yalakom River during fall and winter. Lowest clarity occurred in both rivers in spring which was consistent with seasonal variations in turbidity levels.

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.

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 not significant. Higher scores were obtained in the Yalakom River than the Lower Bridge River in October, March and June whereas in August similar scores were obtained in the Lower Bridge River. Lowest smell scores were collected in August and June.

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 between rivers. There was an interaction between seasons and rivers. Similar to Movement, these results likely reflect the differences in flow discharges in the two rivers in 2016 and 2017 when compared 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 an interaction of season and river. Scores varied between rivers such that Yalakom River scores were significantly larger than Bridge River scores.

## Discussion (results from 2013-2017)

During Year 4, the BRGMON-16 project replicated the quarterly monitoring that has been conducted on behalf of BC Hydro since 2013. The primary focus of the project is to understand the influence of different flow discharges on spiritual and cultural attributes, as perceived by the St’át’imc elders. A large volume of water was spilled into the Lower Bridge River during the summer of 2017 reaching a peak discharge of 126cms, shortly after the June survey was undertaken. By comparison, during Years 1 and 2 of the monitoring program, the mean annual flow discharge was 6 cms and the peak was 15 cms.

The Year 4, June 29-30, 2017 survey overlapped the 2017 spill discharge flow. 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 as perceived by St’át’imc elders.

Over the past 4 years BRGMON-16 data have been analyzed by:

1. time series of histogram plots for the Lower Bridge River and Yalakom River (Figures 6a and 6b)
2. statistical analysis via General Linear Modeling (Table 3 and Appendix 1)
3. evaluating relationships between parameter scores and flow discharge (Figures 8 - 9)

The three approaches reinforce each other. With more data, it is possible to draw stronger conclusions and to better understand assumptions. For variables which co-vary, e.g. discharge and season, histograms indicated that counterintuitively, seasonal effects were minimal (e.g. low variation in Voice scores between seasons in Figures 6a and 6b). 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 8 - 9). The latter measure provides the best measure for determining the influence of flow discharge on spiritual and cultural values. The results of the scatter plot analysis suggested that there was little influence of flow discharge on the measured cultural and spiritual value attributes.

The existing management question which provided the framework for 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?"

The data collected in Years 1 to 3 indicated that the Yalakom River may be scoring slightly higher on the Spiritual and Cultural Scores when compared to a 6 cms Mean Annual Discharge for the Lower Bridge River. Further analysis will be undertaken when all the data are collected at the end of Year 5. Yalakom River values were higher on average than Lower Bridge River values when all three years of data (i.e., 2013-2015) were evaluated by General Linear Interactive Modeling. Similar trends were observed in Years 1 - 2 but the differences were small, and the sample size was insufficient to defensibly conclude a significant result for those years. This conclusion will be further tested in Year 5 and the additional monitoring data may further strengthen this conclusion. Year 5 is envisaged as a data synthesis year where the entire data set collected since 2013 will be compiled into a final BRGMON-16 report.

The management question was effectively answered in Year 4. Yalakom River values were consistently higher than Lower Bridge River values when all 4 years of data were evaluated by General Linear Interactive Modeling. Similar trends were observed in Years 1 - 3 but the differences were small and the sample size was inadequate to render a significant result in those years. The Year 4 conclusion will be further tested in Year 5 and the additional monitoring data may further strengthen this conclusion. Year 5 is envisaged as a data synthesis year where the entire data set collected since 2013 will be compiled into a final BRGMON-16 report.

Considering the higher flows experienced in 2016 and 2017, the data collected during these years will not accurately describe a 6 cms Mean Annual Discharge, but instead will provide an opportunity to explore how sensitive the Spiritual and Cultural scores are to high flows that better approximate historical discharges along the Lower Bridge River. As shown in this report, the Spiritual and Cultural scores appear to be insensitive to extreme peak flows that can be up to eight times higher than which occurred in the 2013-2015 years.

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. A sensitivity analysis of the spiritual and cultural scores will generate a useful framework for directly determining the effects of flow discharge on spiritual and cultural values. Further testing in Year 5 will provide a direct monitoring measure to inform flow management practices in the Lower Bridge River. If future monitoring data support the Year 3 and 4 conclusions that spiritual and cultural parameters are largely insensitive to discharge, then this will provide useful information for 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 Results

### *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.
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 **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 associated with the scores (Table 2). Estimates for individual fixed effects are presented in Table 3.

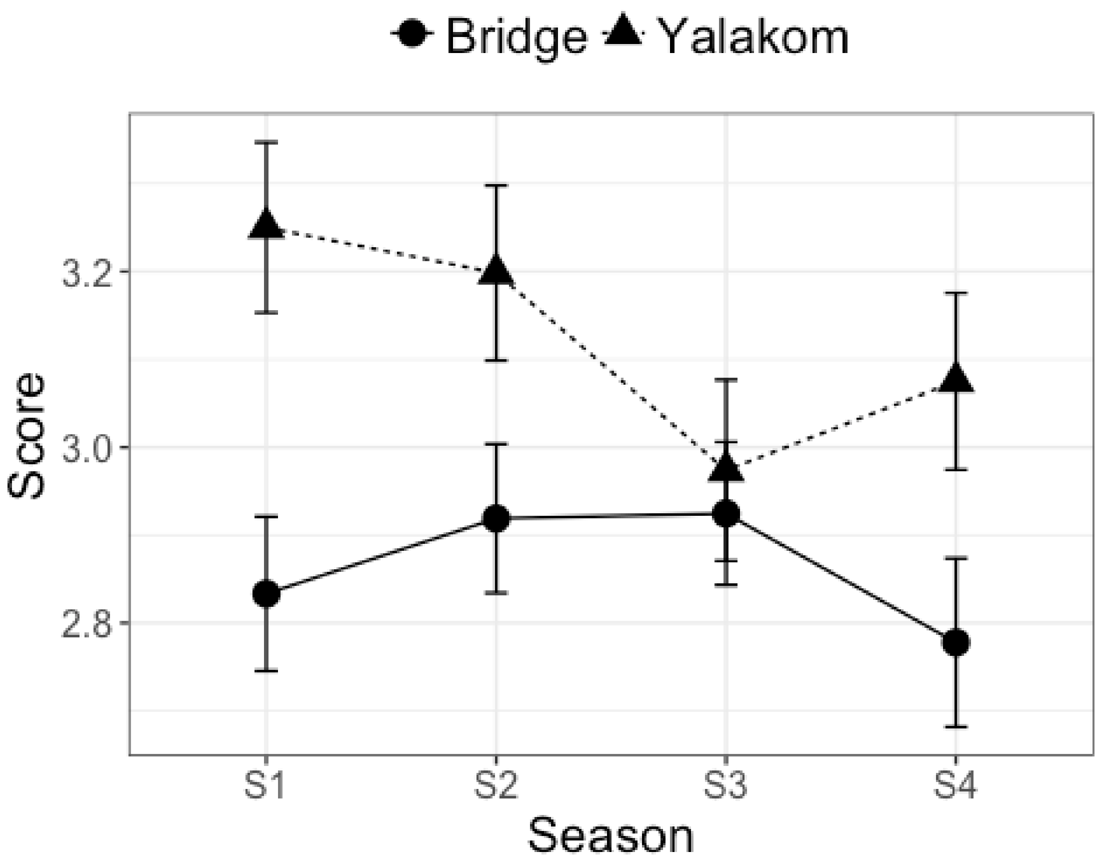


**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Access** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1148 | 123.91 | 0.00 |
| Season | 3 | 1148 | 0.38 | 0.77 |
| River | 1 | 1148 | 1.87 | 0.17 |
| Season:River | 3 | 1148 | 2.08 | 0.10 |

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1151 | 132.65 | 0.00 |
| Season | 3 | 1151 | 0.88 | 0.45 |
| River | 1 | 1151 | 0.76 | 0.38 |

**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) | 2.9248 | 0.2774 | 1151 | 10.5429 | 0.0000 |
| SeasonS2 | -0.0001 | 0.0764 | 1151 | -0.0019 | 0.9985 |
| SeasonS3 | -0.0902 | 0.0768 | 1151 | -1.1740 | 0.2406 |
| SeasonS4 | -0.0863 | 0.0775 | 1151 | -1.1140 | 0.2655 |
| RiverYalakom | 0.2576 | 0.3192 | 1151 | 0.8070 | 0.4198 |

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 | 0.4661 |
| Site | 0.4870 |
| Year | 0.1558 |
| Residual | 0.9183 |

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 | 0.0815 |
| Albert | -0.8191 |
| Carl | 0.1826 |
| Eugene | -0.5760 |
| Gasper | 0.8015 |
| Ken | 0.2761 |
| Lena | 0.0803 |
| Marie | 0.1019 |
| Pete | 0.0842 |
| Randy | -0.2130 |

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

| | (Intercept) |
|---|---|
| B1 | 0.6822 |
| B2 | -0.1877 |
| B3 | 0.5107 |
| B4 | -0.4093 |
| B5 | -0.3073 |
| B6 | -0.2885 |
| Y1 | 0.0937 |
| Y2 | 0.4969 |
| Y3 | 0.0946 |
| Y4 | -0.6852 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.2178 |
| 2014_15 | 0.0882 |
| 2015_16 | 0.0431 |
| 2016_17 | 0.0865 |

***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.
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.

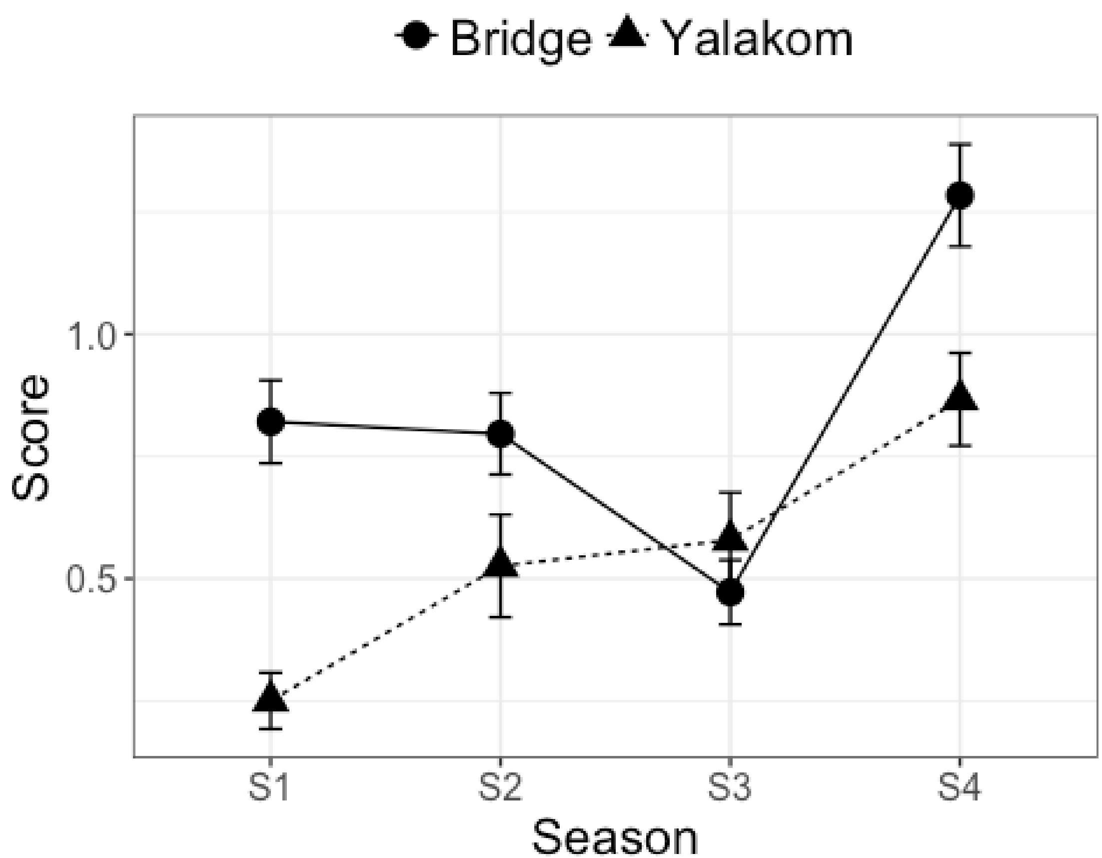


**Figure 1:** Interaction plot showing mean scores ($\pm$ 1SE) for **Bird Song** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1147 | 16.59 | 0.00 |
| Season | 3 | 1147 | 20.66 | 0.00 |
| River | 1 | 1147 | 5.52 | 0.02 |
| Season:River | 3 | 1147 | 5.81 | 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) | 0.8651 | 0.2344 | 1147 | 3.6909 | 0.0002 |
| SeasonS2 | -0.0261 | 0.1024 | 1147 | -0.2547 | 0.7990 |
| SeasonS3 | -0.3388 | 0.1025 | 1147 | -3.3040 | 0.0010 |
| SeasonS4 | 0.4780 | 0.1051 | 1147 | 4.5465 | 0.0000 |
| RiverYalakom | -0.5267 | 0.2375 | 1147 | -2.2181 | 0.0267 |
| SeasonS2:RiverYalakom | 0.2572 | 0.1633 | 1147 | 1.5755 | 0.1154 |
| SeasonS3:RiverYalakom | 0.6288 | 0.1639 | 1147 | 3.8352 | 0.0001 |
| SeasonS4:RiverYalakom | 0.0851 | 0.1645 | 1147 | 0.5173 | 0.6051 |

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

**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 | 0.0261 | 0.1024 | 0.2547 | 1.0000 |
| S1.Bridge - S3.Bridge | 0 | 0.3388 | 0.1025 | 3.3040 | 0.0106 |
| S1.Bridge - S4.Bridge | 0 | -0.4780 | 0.1051 | -4.5465 | 0.0001 |
| S2.Bridge - S3.Bridge | 0 | 0.3127 | 0.1015 | 3.0821 | 0.0220 |
| S2.Bridge - S4.Bridge | 0 | -0.5041 | 0.1042 | -4.8362 | 0.0000 |
| S3.Bridge - S4.Bridge | 0 | -0.8168 | 0.1043 | -7.8299 | 0.0000 |
| S1.Yalakom - S2.Yalakom | 0 | -0.2311 | 0.1274 | -1.8144 | 0.4618 |
| S1.Yalakom - S3.Yalakom | 0 | -0.2900 | 0.1284 | -2.2580 | 0.2044 |
| S1.Yalakom - S4.Yalakom | 0 | -0.5631 | 0.1269 | -4.4390 | 0.0001 |
| S2.Yalakom - S3.Yalakom | 0 | -0.0588 | 0.1270 | -0.4633 | 0.9989 |
| S2.Yalakom - S4.Yalakom | 0 | -0.3320 | 0.1255 | -2.6459 | 0.0796 |
| S3.Yalakom - S4.Yalakom | 0 | -0.2732 | 0.1259 | -2.1702 | 0.2457 |

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 | -0.5267 | 0.2375 | -2.2181 | 0.0680 |
| S2.Yalakom - S2.Bridge | 0 | -0.2695 | 0.2365 | -1.1398 | 0.4951 |
| S3.Yalakom - S3.Bridge | 0 | 0.1020 | 0.2369 | 0.4307 | 0.9543 |
| S4.Yalakom - S4.Bridge | 0 | -0.4416 | 0.2373 | -1.8614 | 0.1477 |

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 | 0.3832 |
| Site | 0.3206 |
| Year | 0.2121 |
| Residual | 0.9594 |

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 | -0.2625 |
| Albert | -0.3804 |
| Carl | 0.1302 |
| Eugene | -0.3021 |
| Gasper | -0.2548 |
| Ken | 0.1417 |
| Lena | -0.1590 |
| Marie | 0.0574 |
| Pete | 0.8553 |
| Randy | 0.1743 |

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

| | (Intercept) |
|---|---|
| B1 | 0.6613 |
| B2 | -0.0477 |
| B3 | 0.1972 |
| B4 | -0.2430 |
| B5 | -0.1439 |
| B6 | -0.4240 |
| Y1 | -0.1017 |
| Y2 | -0.0508 |
| Y3 | 0.0604 |
| Y4 | 0.0921 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.0354 |
| 2014_15 | 0.0039 |
| 2015_16 | -0.2330 |
| 2016_17 | 0.2646 |

***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.
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.

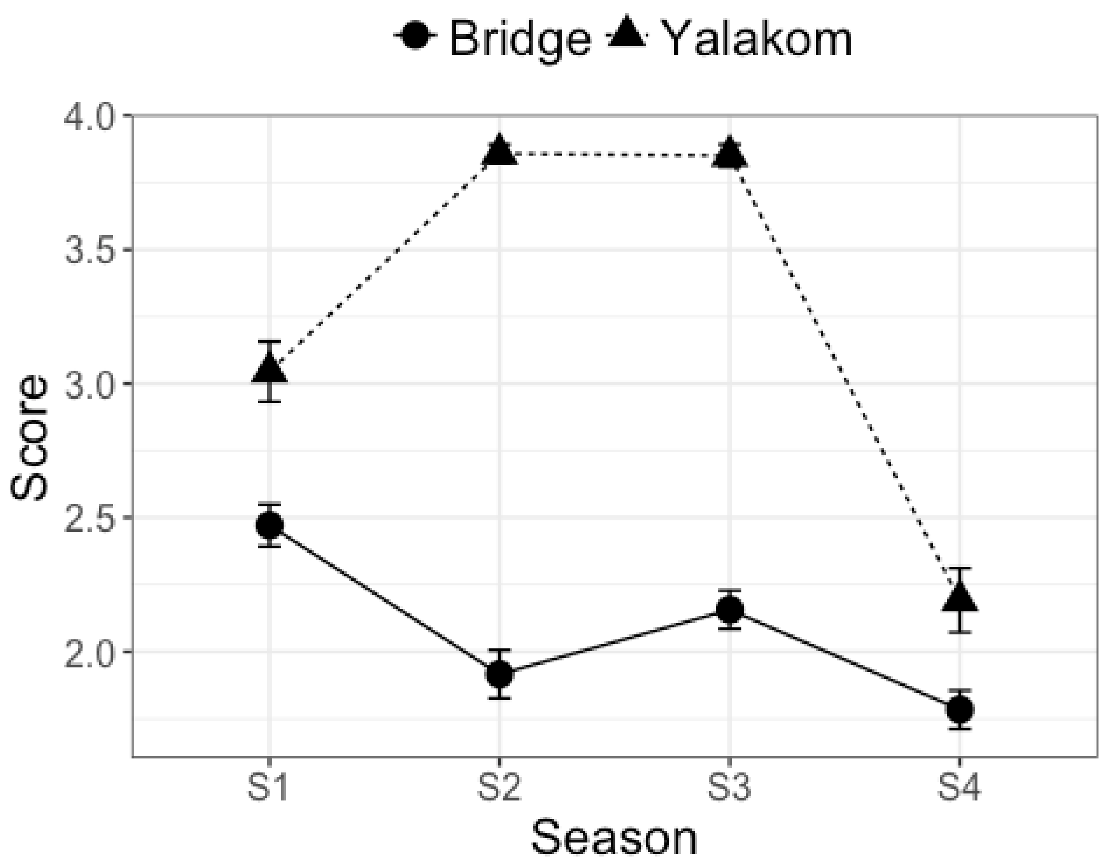


**Figure 1:** Interaction plot showing mean scores ($\pm$ 1SE) for **Clarity** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1147 | 189.15 | 0.00 |
| Season | 3 | 1147 | 17.22 | 0.00 |
| River | 1 | 1147 | 7.28 | 0.01 |
| Season:River | 3 | 1147 | 50.91 | 0.00 |

**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) | 2.3730 | 0.1950 | 1147 | 12.1665 | 0.0000 |
| SeasonS2 | -0.5369 | 0.0972 | 1147 | -5.5233 | 0.0000 |
| SeasonS3 | -0.2915 | 0.0971 | 1147 | -3.0009 | 0.0028 |
| SeasonS4 | -0.6551 | 0.0996 | 1147 | -6.5751 | 0.0000 |
| RiverYalakom | 0.5688 | 0.2245 | 1147 | 2.5342 | 0.0114 |
| SeasonS2:RiverYalakom | 1.3853 | 0.1550 | 1147 | 8.9394 | 0.0000 |
| SeasonS3:RiverYalakom | 1.1459 | 0.1555 | 1147 | 7.3685 | 0.0000 |
| SeasonS4:RiverYalakom | -0.1473 | 0.1561 | 1147 | -0.9441 | 0.3453 |

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 | 0.5369 | 0.0972 | 5.5233 | 0.0000 |
| S1.Bridge - S3.Bridge | 0 | 0.2915 | 0.0971 | 3.0009 | 0.0284 |
| S1.Bridge - S4.Bridge | 0 | 0.6551 | 0.0996 | 6.5751 | 0.0000 |
| S2.Bridge - S3.Bridge | 0 | -0.2454 | 0.0964 | -2.5441 | 0.1039 |
| S2.Bridge - S4.Bridge | 0 | 0.1182 | 0.0991 | 1.1933 | 0.8639 |
| S3.Bridge - S4.Bridge | 0 | 0.3636 | 0.0990 | 3.6727 | 0.0028 |
| S1.Yalakom - S2.Yalakom | 0 | -0.8484 | 0.1209 | -7.0186 | 0.0000 |
| S1.Yalakom - S3.Yalakom | 0 | -0.8544 | 0.1218 | -7.0138 | 0.0000 |
| S1.Yalakom - S4.Yalakom | 0 | 0.8024 | 0.1204 | 6.6657 | 0.0000 |
| S2.Yalakom - S3.Yalakom | 0 | -0.0059 | 0.1205 | -0.0493 | 1.0000 |
| S2.Yalakom - S4.Yalakom | 0 | 1.6509 | 0.1191 | 13.8652 | 0.0000 |
| S3.Yalakom - S4.Yalakom | 0 | 1.6568 | 0.1194 | 13.8724 | 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 | 0.5688 | 0.2245 | 2.5342 | 0.0307 |
| S2.Yalakom - S2.Bridge | 0 | 1.9541 | 0.2236 | 8.7385 | 0.0000 |
| S3.Yalakom - S3.Bridge | 0 | 1.7147 | 0.2240 | 7.6553 | 0.0000 |
| S4.Yalakom - S4.Bridge | 0 | 0.4215 | 0.2243 | 1.8791 | 0.1427 |

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 one-quarter 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 | 0.3310 |
| Site | 0.3027 |
| Year | 0.0697 |
| Residual | 0.9107 |

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 | 0.2529 |
| Albert | 0.4016 |
| Carl | 0.3863 |
| Eugene | -0.5152 |
| Gasper | -0.3991 |
| Ken | -0.0509 |
| Lena | 0.0071 |
| Marie | -0.2307 |
| Pete | -0.0082 |
| Randy | 0.1561 |

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

| | (Intercept) |
|---|---|
| B1 | -0.4872 |
| B2 | -0.3096 |
| B3 | -0.0058 |
| B4 | -0.0018 |
| B5 | 0.4159 |
| B6 | 0.3885 |
| Y1 | 0.0498 |
| Y2 | 0.0905 |
| Y3 | -0.0364 |
| Y4 | -0.1039 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.0613 |
| 2014_15 | 0.0142 |
| 2015_16 | 0.0678 |
| 2016_17 | -0.0207 |

### *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.

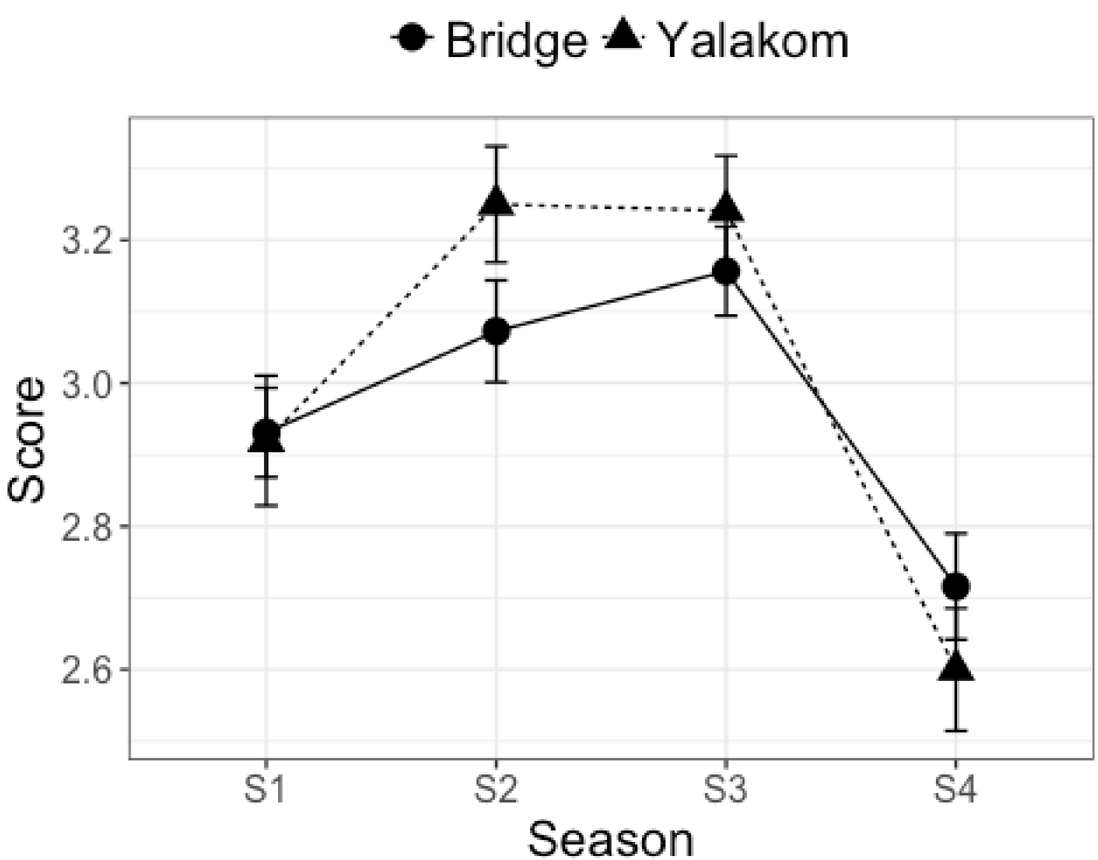


**Figure 1:** Interaction plot showing mean scores ($\pm$ 1SE) for **Diversity** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1148 | 404.08 | 0.00 |
| Season | 3 | 1148 | 7.51 | 0.00 |
| River | 1 | 1148 | 0.00 | 0.99 |
| Season:River | 3 | 1148 | 1.66 | 0.17 |

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1151 | 423.38 | 0.00 |
| River | 1 | 1151 | 0.11 | 0.74 |
| Season | 3 | 1151 | 20.31 | 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) | 2.9722 | 0.1641 | 1151 | 18.1082 | 0.0000 |
| RiverYalakom | 0.0255 | 0.0834 | 1151 | 0.3055 | 0.7601 |
| SeasonS2 | 0.1839 | 0.0676 | 1151 | 2.7185 | 0.0067 |
| SeasonS3 | 0.2219 | 0.0679 | 1151 | 3.2666 | 0.0011 |
| SeasonS4 | -0.2543 | 0.0686 | 1151 | -3.7065 | 0.0002 |

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 | -0.1839 | 0.0676 | -2.7185 | 0.0331 |
| S1 - S3 | 0 | -0.2219 | 0.0679 | -3.2666 | 0.0057 |
| S1 - S4 | 0 | 0.2543 | 0.0686 | 3.7065 | 0.0012 |
| S2 - S3 | 0 | -0.0380 | 0.0672 | -0.5657 | 0.9422 |
| S2 - S4 | 0 | 0.4382 | 0.0680 | 6.4413 | 0.0000 |
| S3 - S4 | 0 | 0.4762 | 0.0681 | 6.9916 | 0.0000 |

A much larger amount of the variability in scores for **Diversity** was associated with Elders, with about 4 and 11 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 | 0.4171 |
| Site | 0.1045 |
| Year | 0.0372 |
| Residual | 0.8126 |

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 | -0.2782 |
| Albert | 0.2775 |
| Carl | -0.2811 |
| Eugene | -0.7934 |
| Gasper | 0.5900 |
| Ken | -0.2568 |
| Lena | 0.0195 |
| Marie | 0.3408 |
| Pete | 0.2217 |
| Randy | 0.1599 |

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

| | (Intercept) |
|---|---|
| B1 | -0.0710 |
| B2 | 0.0225 |
| B3 | 0.0792 |
| B4 | -0.0880 |
| B5 | 0.1134 |
| B6 | -0.0561 |
| Y1 | -0.0935 |
| Y2 | -0.0280 |
| Y3 | 0.0114 |
| Y4 | 0.1100 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.0274 |
| 2014_15 | 0.0187 |
| 2015_16 | -0.0094 |
| 2016_17 | 0.0181 |

***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.

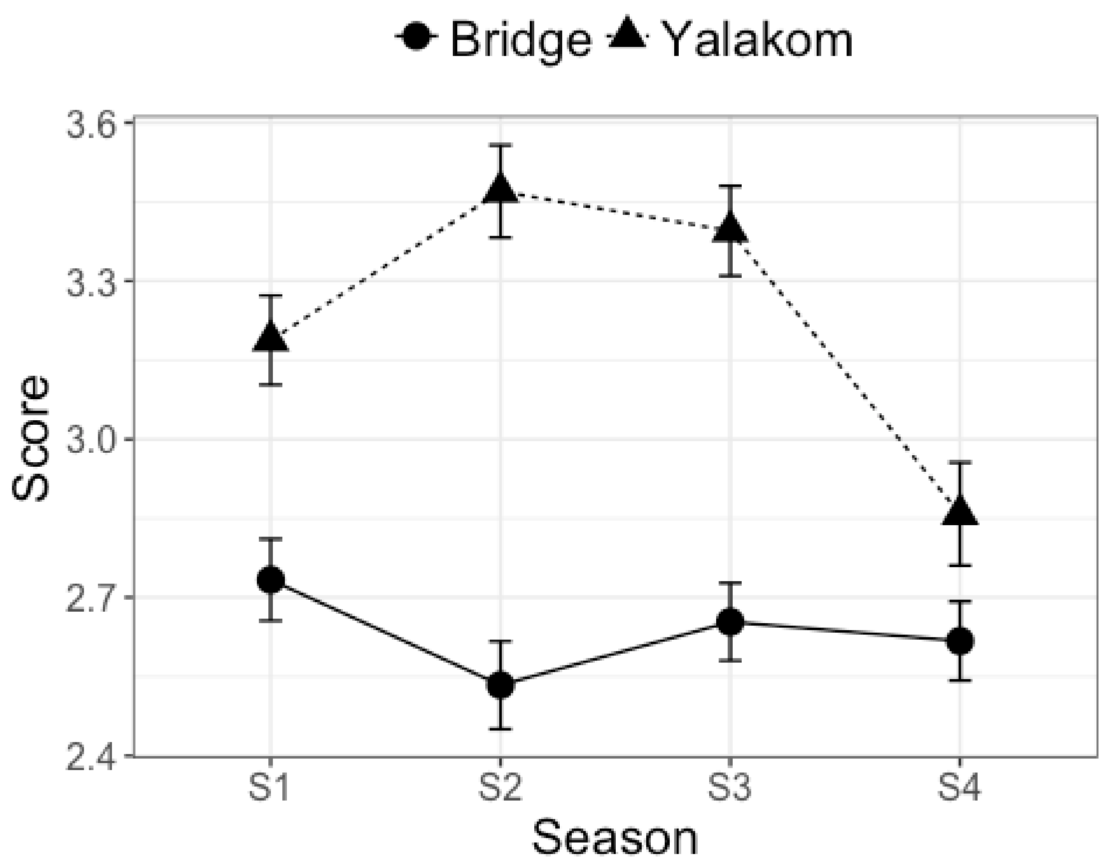

**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Edge Smell** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1138 | 157.82 | 0.00 |
| Season | 3 | 1138 | 1.58 | 0.19 |
| River | 1 | 1138 | 9.34 | 0.00 |
| Season:River | 3 | 1138 | 9.35 | 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) | 2.7243 | 0.2351 | 1138 | 11.5875 | 0.0000 |
| SeasonS2 | -0.1959 | 0.0935 | 1138 | -2.0957 | 0.0363 |
| SeasonS3 | -0.0671 | 0.0934 | 1138 | -0.7189 | 0.4724 |
| SeasonS4 | -0.0582 | 0.0958 | 1138 | -0.6082 | 0.5432 |
| RiverYalakom | 0.4636 | 0.1576 | 1138 | 2.9412 | 0.0033 |
| SeasonS2:RiverYalakom | 0.4813 | 0.1476 | 1138 | 3.2602 | 0.0011 |
| SeasonS3:RiverYalakom | 0.2634 | 0.1482 | 1138 | 1.7778 | 0.0757 |
| SeasonS4:RiverYalakom | -0.2501 | 0.1488 | 1138 | -1.6813 | 0.0930 |

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 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 | 0.1959 | 0.0935 | 2.0957 | 0.2850 |
| S1.Bridge - S3.Bridge | 0 | 0.0671 | 0.0934 | 0.7189 | 0.9878 |
| S1.Bridge - S4.Bridge | 0 | 0.0582 | 0.0958 | 0.6082 | 0.9950 |
| S2.Bridge - S3.Bridge | 0 | -0.1287 | 0.0914 | -1.4090 | 0.7435 |
| S2.Bridge - S4.Bridge | 0 | -0.1376 | 0.0939 | -1.4663 | 0.7062 |
| S3.Bridge - S4.Bridge | 0 | -0.0089 | 0.0938 | -0.0947 | 1.0000 |
| S1.Yalakom - S2.Yalakom | 0 | -0.2854 | 0.1145 | -2.4916 | 0.1186 |
| S1.Yalakom - S3.Yalakom | 0 | -0.1963 | 0.1156 | -1.6985 | 0.5435 |
| S1.Yalakom - S4.Yalakom | 0 | 0.3084 | 0.1142 | 2.7007 | 0.0686 |
| S2.Yalakom - S3.Yalakom | 0 | 0.0891 | 0.1143 | 0.7800 | 0.9814 |
| S2.Yalakom - S4.Yalakom | 0 | 0.5938 | 0.1129 | 5.2593 | 0.0000 |
| S3.Yalakom - S4.Yalakom | 0 | 0.5047 | 0.1132 | 4.4593 | 0.0001 |

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 | 0.4636 | 0.1576 | 2.9412 | 0.0114 |
| S2.Yalakom - S2.Bridge | 0 | 0.9448 | 0.1557 | 6.0666 | 0.0000 |
| S3.Yalakom - S3.Bridge | 0 | 0.7270 | 0.1563 | 4.6519 | 0.0000 |
| S4.Yalakom - S4.Bridge | 0 | 0.2134 | 0.1567 | 1.3619 | 0.4372 |

A larger amount of the variability in scores for **Edge Smell** was associated with Elders, with about 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 **Edge Smell**.

| Random Effect | SD |
|---|---|
| Elder | 0.5722 |
| Site | 0.1810 |
| Year | 0.1677 |
| Residual | 0.8627 |

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 | -0.0086 |
| Albert | 0.1970 |
| Carl | 0.2654 |
| Eugene | -1.4616 |
| Gasper | -0.1355 |
| Ken | -0.1385 |
| Lena | 0.0921 |
| Marie | 0.5993 |
| Pete | 0.3216 |
| Randy | 0.2687 |

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

| | (Intercept) |
|---|---|
| B1 | -0.2752 |

| | |
|---|---|
| B2 | -0.1359 |
| B3 | -0.0747 |
| B4 | 0.0382 |
| B5 | 0.1743 |
| B6 | 0.2733 |
| Y1 | 0.0011 |
| Y2 | 0.0760 |
| Y3 | 0.0044 |
| Y4 | -0.0815 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.1577 |
| 2014_15 | -0.0818 |
| 2015_16 | 0.0288 |
| 2016_17 | 0.2108 |

***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.

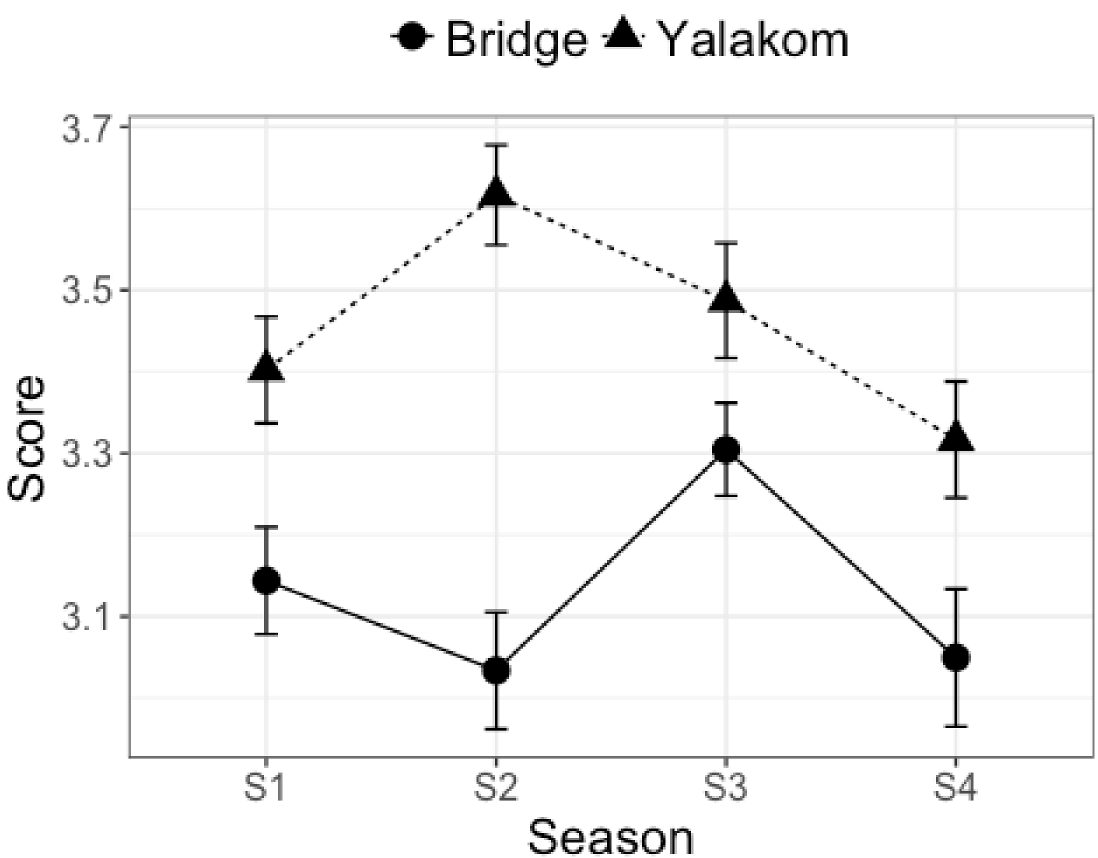

**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Movement** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1148 | 431.34 | 0.00 |
| Season | 3 | 1148 | 4.39 | 0.00 |
| River | 1 | 1148 | 2.74 | 0.10 |
| Season:River | 3 | 1148 | 3.89 | 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) | 3.1692 | 0.1701 | 1148 | 18.6347 | 0.0000 |
| SeasonS2 | -0.1203 | 0.0810 | 1148 | -1.4852 | 0.1378 |
| SeasonS3 | 0.1517 | 0.0811 | 1148 | 1.8714 | 0.0616 |
| SeasonS4 | -0.0784 | 0.0832 | 1148 | -0.9432 | 0.3458 |
| RiverYalakom | 0.2645 | 0.1684 | 1148 | 1.5710 | 0.1165 |
| SeasonS2:RiverYalakom | 0.3218 | 0.1293 | 1148 | 2.4891 | 0.0129 |
| SeasonS3:RiverYalakom | -0.0857 | 0.1298 | 1148 | -0.6604 | 0.5091 |
| SeasonS4:RiverYalakom | 0.0019 | 0.1303 | 1148 | 0.0148 | 0.9882 |

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: 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 | 0.1203 | 0.0810 | 1.4852 | 0.6936 |
| S1.Bridge - S3.Bridge | 0 | -0.1517 | 0.0811 | -1.8714 | 0.4230 |
| S1.Bridge - S4.Bridge | 0 | 0.0784 | 0.0832 | 0.9432 | 0.9523 |
| S2.Bridge - S3.Bridge | 0 | -0.2721 | 0.0804 | -3.3848 | 0.0080 |
| S2.Bridge - S4.Bridge | 0 | -0.0419 | 0.0826 | -0.5072 | 0.9982 |
| S3.Bridge - S4.Bridge | 0 | 0.2302 | 0.0826 | 2.7855 | 0.0539 |
| S1.Yalakom - S2.Yalakom | 0 | -0.2014 | 0.1009 | -1.9963 | 0.3427 |
| S1.Yalakom - S3.Yalakom | 0 | -0.0660 | 0.1017 | -0.6489 | 0.9929 |
| S1.Yalakom - S4.Yalakom | 0 | 0.0765 | 0.1005 | 0.7610 | 0.9836 |
| S2.Yalakom - S3.Yalakom | 0 | 0.1354 | 0.1006 | 1.3460 | 0.7823 |
| S2.Yalakom - S4.Yalakom | 0 | 0.2780 | 0.0994 | 2.7956 | 0.0524 |
| S3.Yalakom - S4.Yalakom | 0 | 0.1425 | 0.0997 | 1.4296 | 0.7303 |

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 | 0.2645 | 0.1684 | 1.5710 | 0.2732 |
| S2.Yalakom - S2.Bridge | 0 | 0.5863 | 0.1675 | 3.4995 | 0.0015 |
| S3.Yalakom - S3.Bridge | 0 | 0.1788 | 0.1680 | 1.0645 | 0.5797 |
| S4.Yalakom - S4.Bridge | 0 | 0.2665 | 0.1683 | 1.5837 | 0.2671 |

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 | 0.3502 |
| Site | 0.2183 |
| Year | 0.0709 |
| Residual | 0.7601 |

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 | -0.2539 |
| Albert | 0.1684 |
| Carl | 0.2063 |
| Eugene | -0.6692 |
| Gasper | 0.3568 |
| Ken | -0.3893 |
| Lena | 0.2173 |
| Marie | 0.3258 |
| Pete | 0.0703 |
| Randy | -0.0324 |

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

| | (Intercept) |
|---|---|

| | |
|---|---|
| B1 | -0.4347 |
| B2 | -0.0289 |
| B3 | -0.1381 |
| B4 | 0.1350 |
| B5 | 0.2159 |
| B6 | 0.2508 |
| Y1 | 0.0054 |
| Y2 | 0.0718 |
| Y3 | -0.0289 |
| Y4 | -0.0483 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.0026 |
| 2014_15 | -0.0295 |
| 2015_16 | -0.0518 |
| 2016_17 | 0.0839 |

### *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.

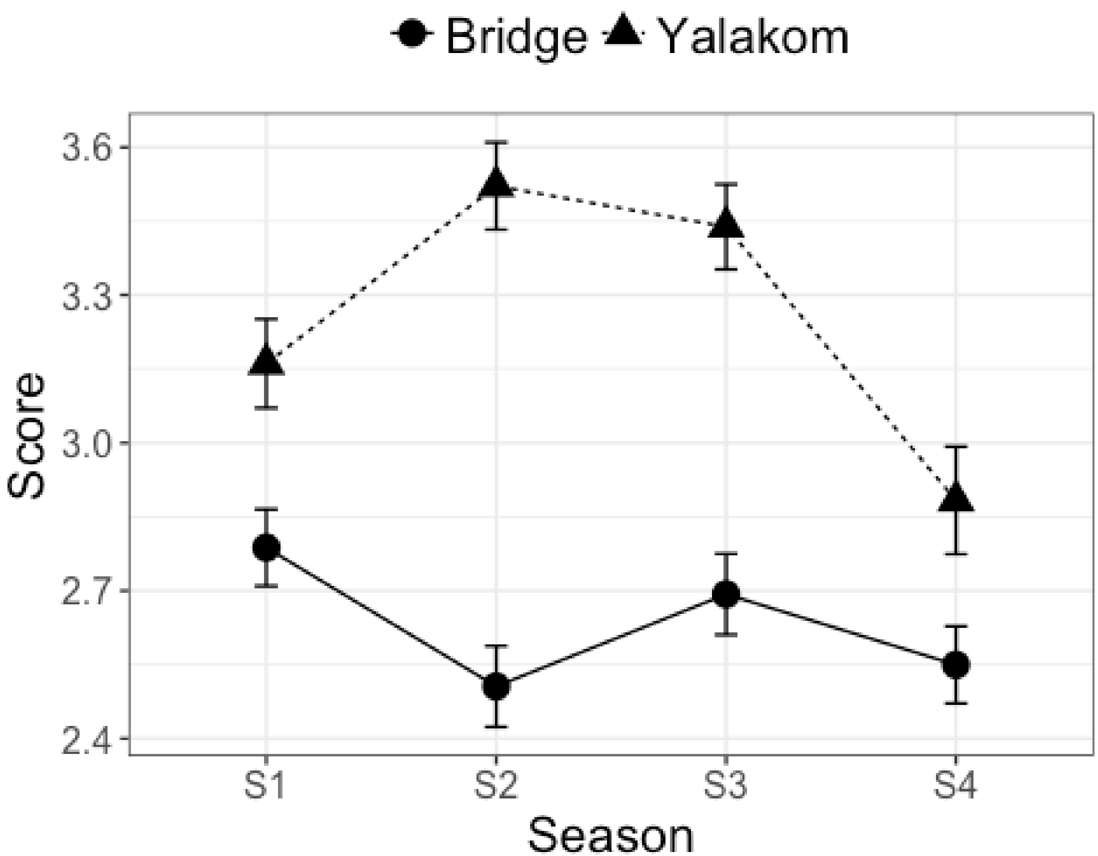


**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Smell** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1148 | 151.08 | 0.00 |
| Season | 3 | 1148 | 2.99 | 0.03 |
| River | 1 | 1148 | 5.74 | 0.02 |
| Season:River | 3 | 1148 | 8.91 | 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) | 2.7454 | 0.2425 | 1148 | 11.3219 | 0.0000 |
| SeasonS2 | -0.2720 | 0.0967 | 1148 | -2.8115 | 0.0050 |
| SeasonS3 | -0.0770 | 0.0968 | 1148 | -0.7953 | 0.4266 |
| SeasonS4 | -0.1766 | 0.0993 | 1148 | -1.7786 | 0.0756 |
| RiverYalakom | 0.3920 | 0.1702 | 1148 | 2.3023 | 0.0215 |
| SeasonS2:RiverYalakom | 0.6271 | 0.1543 | 1148 | 4.0634 | 0.0001 |
| SeasonS3:RiverYalakom | 0.3443 | 0.1550 | 1148 | 2.2210 | 0.0265 |
| SeasonS4:RiverYalakom | -0.0765 | 0.1556 | 1148 | -0.4917 | 0.6230 |

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 | 0.2720 | 0.0967 | 2.8115 | 0.0501 |
| S1.Bridge - S3.Bridge | 0 | 0.0770 | 0.0968 | 0.7953 | 0.9794 |
| S1.Bridge - S4.Bridge | 0 | 0.1766 | 0.0993 | 1.7786 | 0.4868 |
| S2.Bridge - S3.Bridge | 0 | -0.1949 | 0.0960 | -2.0315 | 0.3216 |
| S2.Bridge - S4.Bridge | 0 | -0.0954 | 0.0986 | -0.9673 | 0.9462 |
| S3.Bridge - S4.Bridge | 0 | 0.0996 | 0.0987 | 1.0093 | 0.9344 |
| S1.Yalakom - S2.Yalakom | 0 | -0.3551 | 0.1205 | -2.9473 | 0.0335 |
| S1.Yalakom - S3.Yalakom | 0 | -0.2673 | 0.1215 | -2.1988 | 0.2317 |
| S1.Yalakom - S4.Yalakom | 0 | 0.2531 | 0.1201 | 2.1078 | 0.2784 |
| S2.Yalakom - S3.Yalakom | 0 | 0.0878 | 0.1202 | 0.7310 | 0.9867 |
| S2.Yalakom - S4.Yalakom | 0 | 0.6082 | 0.1187 | 5.1219 | 0.0000 |
| S3.Yalakom - S4.Yalakom | 0 | 0.5204 | 0.1190 | 4.3715 | 0.0001 |

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 | 0.3920 | 0.1702 | 2.3023 | 0.0667 |
| S2.Yalakom - S2.Bridge | 0 | 1.0190 | 0.1691 | 6.0277 | 0.0000 |
| S3.Yalakom - S3.Bridge | 0 | 0.7362 | 0.1697 | 4.3390 | 0.0000 |
| S4.Yalakom - S4.Bridge | 0 | 0.3154 | 0.1701 | 1.8543 | 0.1808 |

A larger amount of the variability in scores for **Smell** was associated with Elders, with about 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 | 0.5764 |
| Site | 0.2013 |
| Year | 0.1795 |

| | |
|---|---|
| Residual | 0.9074 |

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 | 0.0264 |
| Albert | 0.2330 |
| Carl | 0.2113 |
| Eugene | -1.5311 |
| Gasper | -0.0974 |
| Ken | -0.0646 |
| Lena | 0.2392 |
| Marie | 0.4321 |
| Pete | 0.3300 |
| Randy | 0.2210 |

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

| | (Intercept) |
|---|---|
| B1 | -0.2621 |
| B2 | -0.1668 |
| B3 | -0.1374 |
| B4 | 0.0386 |
| B5 | 0.2157 |
| B6 | 0.3120 |
| Y1 | 0.0492 |
| Y2 | 0.0710 |
| Y3 | -0.0528 |
| Y4 | -0.0674 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.1795 |
| 2014_15 | -0.0428 |
| 2015_16 | -0.0106 |
| 2016_17 | 0.2329 |

### *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.

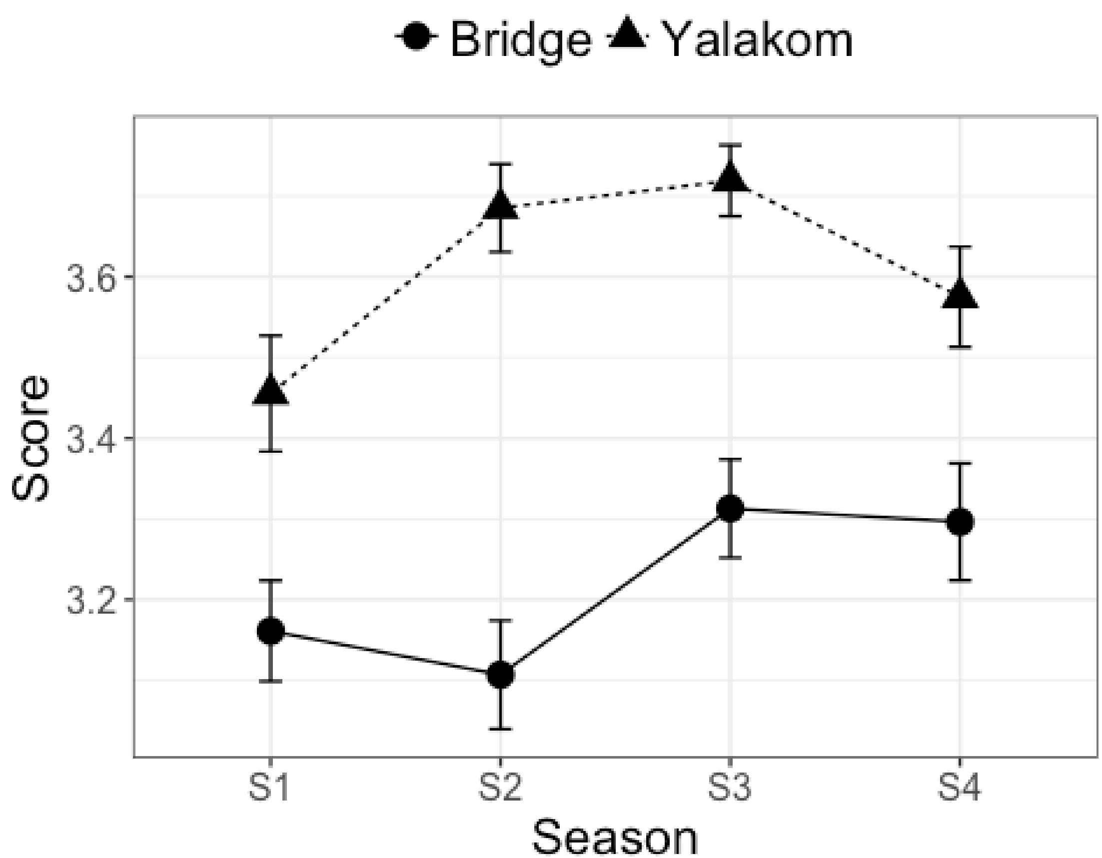

**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Voice** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1147 | 492.03 | 0.00 |
| Season | 3 | 1147 | 4.13 | 0.01 |
| River | 1 | 1147 | 3.92 | 0.05 |
| Season:River | 3 | 1147 | 2.85 | 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) | 3.1199 | 0.1558 | 1150 | 20.0289 | 0.0000 |
| RiverYalakom | 0.3934 | 0.1407 | 1150 | 2.7965 | 0.0053 |
| SeasonS2 | 0.0505 | 0.0564 | 1150 | 0.8968 | 0.3700 |
| SeasonS3 | 0.1847 | 0.0566 | 1150 | 3.2651 | 0.0011 |
| SeasonS4 | 0.1400 | 0.0571 | 1150 | 2.4511 | 0.0144 |

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 **smaller** than in S3 and S4
- 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 | 0.0619 | 0.0721 | 0.8591 | 0.9697 |
| S1.Bridge - S3.Bridge | 0 | -0.1423 | 0.0720 | -1.9756 | 0.3555 |
| S1.Bridge - S4.Bridge | 0 | -0.1464 | 0.0739 | -1.9821 | 0.3515 |
| S2.Bridge - S3.Bridge | 0 | -0.2042 | 0.0715 | -2.8551 | 0.0442 |
| S2.Bridge - S4.Bridge | 0 | -0.2084 | 0.0735 | -2.8357 | 0.0467 |
| S3.Bridge - S4.Bridge | 0 | -0.0042 | 0.0734 | -0.0567 | 1.0000 |
| S1.Yalakom - S2.Yalakom | 0 | -0.2241 | 0.0896 | -2.5003 | 0.1161 |
| S1.Yalakom - S3.Yalakom | 0 | -0.2501 | 0.0904 | -2.7670 | 0.0569 |
| S1.Yalakom - S4.Yalakom | 0 | -0.1390 | 0.0893 | -1.5560 | 0.6448 |
| S2.Yalakom - S3.Yalakom | 0 | -0.0259 | 0.0894 | -0.2902 | 0.9999 |
| S2.Yalakom - S4.Yalakom | 0 | 0.0851 | 0.0883 | 0.9634 | 0.9472 |
| S3.Yalakom - S4.Yalakom | 0 | 0.1111 | 0.0886 | 1.2540 | 0.8338 |

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 | 0.1576 | 1.8734 | 0.1499 |
| S2.Yalakom - S2.Bridge | 0 | 0.5813 | 0.1570 | 3.7038 | 0.0006 |
| S3.Yalakom - S3.Bridge | 0 | 0.4031 | 0.1573 | 2.5631 | 0.0294 |
| S4.Yalakom - S4.Bridge | 0 | 0.2879 | 0.1575 | 1.8275 | 0.1645 |

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 9 and 5 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 | 0.3385 |
| Site | 0.2086 |
| Year | 0.0376 |
| Residual | 0.6754 |

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 | -0.5103 |
| Albert | 0.2689 |
| Carl | 0.1318 |
| Eugene | -0.4396 |
| Gasper | 0.2879 |
| Ken | -0.3728 |
| Lena | 0.4166 |
| Marie | 0.0995 |
| Pete | -0.0066 |
| Randy | 0.1246 |

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

| | (Intercept) |
|---|---|

| | |
|---|---|
| B1 | -0.4086 |
| B2 | -0.0653 |
| B3 | -0.1088 |
| B4 | 0.2114 |
| B5 | 0.1878 |
| B6 | 0.1834 |
| Y1 | -0.0837 |
| Y2 | -0.0453 |
| Y3 | 0.1155 |
| Y4 | 0.0135 |

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

| | (Intercept) |
|---|---|
| 2013_14 | -0.0309 |
| 2014_15 | -0.0029 |
| 2015_16 | 0.0026 |
| 2016_17 | 0.0312 |

### ***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.

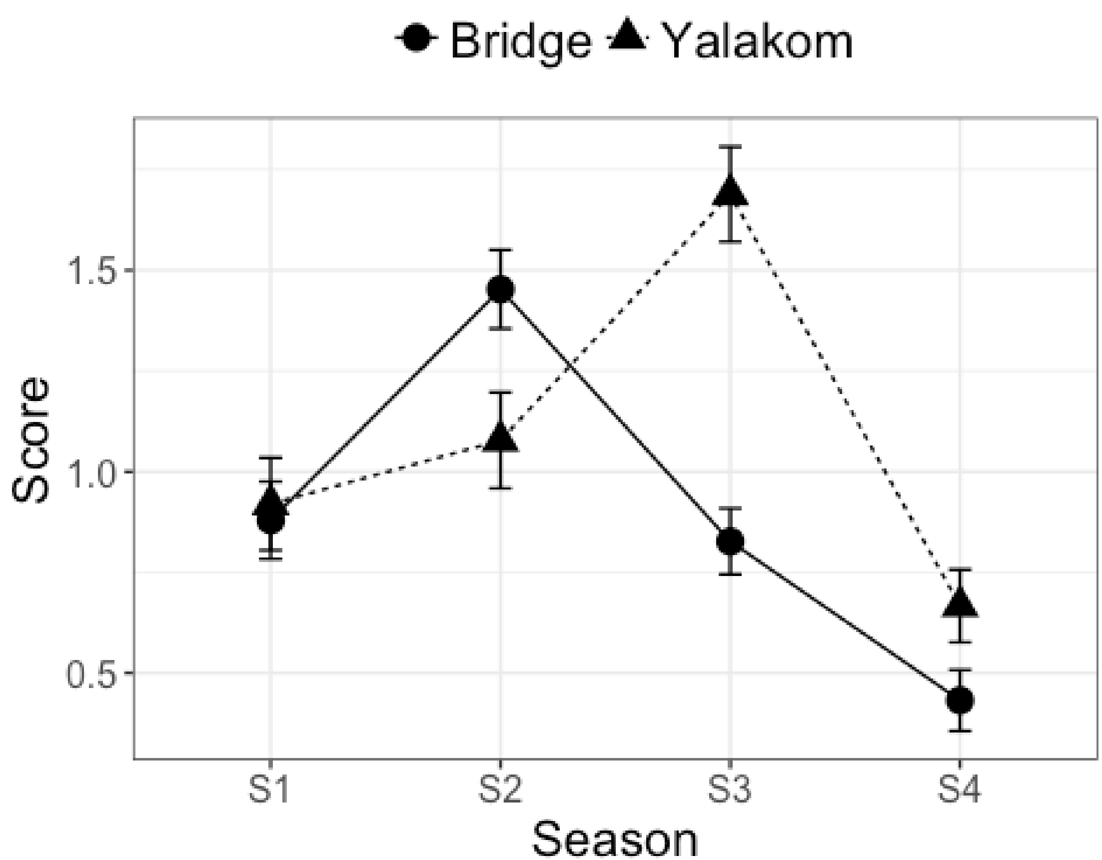

**Figure 1:** Interaction plot showing mean scores (± 1SE) for **Wadeability** by river and season.

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

| | numDF | denDF | F-value | p-value |
|---|---|---|---|---|
| (Intercept) | 1 | 1148 | 16.17 | 0.00 |
| Season | 3 | 1148 | 27.13 | 0.00 |
| River | 1 | 1148 | 0.04 | 0.85 |
| Season:River | 3 | 1148 | 17.32 | 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) | 0.8800 | 0.2435 | 1148 | 3.6133 | 0.0003 |
| SeasonS2 | 0.5879 | 0.1114 | 1148 | 5.2772 | 0.0000 |
| SeasonS3 | -0.0388 | 0.1115 | 1148 | -0.3476 | 0.7282 |
| SeasonS4 | -0.4193 | 0.1144 | 1148 | -3.6666 | 0.0003 |
| RiverYalakom | 0.0488 | 0.2770 | 1148 | 0.1762 | 0.8602 |
| SeasonS2:RiverYalakom | -0.4125 | 0.1777 | 1148 | -2.3210 | 0.0205 |
| SeasonS3:RiverYalakom | 0.8410 | 0.1785 | 1148 | 4.7120 | 0.0000 |
| SeasonS4:RiverYalakom | 0.1691 | 0.1791 | 1148 | 0.9439 | 0.3454 |

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 | -0.5879 | 0.1114 | -5.2772 | 0.0000 |
| S1.Bridge - S3.Bridge | 0 | 0.0388 | 0.1115 | 0.3476 | 0.9998 |
| S1.Bridge - S4.Bridge | 0 | 0.4193 | 0.1144 | 3.6666 | 0.0028 |
| S2.Bridge - S3.Bridge | 0 | 0.6267 | 0.1105 | 5.6699 | 0.0000 |
| S2.Bridge - S4.Bridge | 0 | 1.0072 | 0.1135 | 8.8705 | 0.0000 |
| S3.Bridge - S4.Bridge | 0 | 0.3805 | 0.1136 | 3.3489 | 0.0090 |
| S1.Yalakom - S2.Yalakom | 0 | -0.1754 | 0.1388 | -1.2639 | 0.8286 |
| S1.Yalakom - S3.Yalakom | 0 | -0.8023 | 0.1399 | -5.7362 | 0.0000 |
| S1.Yalakom - S4.Yalakom | 0 | 0.2502 | 0.1382 | 1.8107 | 0.4644 |
| S2.Yalakom - S3.Yalakom | 0 | -0.6269 | 0.1383 | -4.5324 | 0.0001 |
| S2.Yalakom - S4.Yalakom | 0 | 0.4256 | 0.1367 | 3.1139 | 0.0199 |
| S3.Yalakom - S4.Yalakom | 0 | 1.0525 | 0.1371 | 7.6773 | 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 | 0.2770 | 0.1762 | 0.9979 |
| S2.Yalakom - S2.Bridge | 0 | -0.3638 | 0.2760 | -1.3180 | 0.3690 |
| S3.Yalakom - S3.Bridge | 0 | 0.8898 | 0.2765 | 3.2187 | 0.0040 |
| S4.Yalakom - S4.Bridge | 0 | 0.2179 | 0.2768 | 0.7871 | 0.7284 |

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-quarter 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 | 0.4171 |
| Site | 0.3815 |
| Year | 0.1207 |
| Residual | 1.0452 |

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 | 0.7223 |
| Albert | -0.1698 |
| Carl | 0.2868 |
| Eugene | -0.3654 |
| Gasper | -0.5357 |
| Ken | -0.1392 |
| Lena | -0.4088 |
| Marie | 0.0589 |
| Pete | 0.3837 |
| Randy | 0.1671 |

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

| | (Intercept) |
|---|---|
| B1 | 0.3266 |
| B2 | -0.0014 |
| B3 | 0.4723 |
| B4 | -0.4062 |
| B5 | 0.0224 |
| B6 | -0.4137 |
| Y1 | 0.2790 |
| Y2 | 0.3662 |
| Y3 | -0.2643 |
| Y4 | -0.3808 |

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

| | (Intercept) |
|---|---|
| 2013_14 | 0.1043 |
| 2014_15 | 0.0396 |
| 2015_16 | 0.0038 |
| 2016_17 | -0.1477 |