# Snorkel Surveys

Snorkel surveys were conducted to determine how restoration affected spatial and temporal distribution and density of native and non-native fish, with a focus on juvenile salmonids. Surveys were conducted multiple times throughout the spring rearing season for fall-run Chinook Salmon for two years prior to implementation and two years following Phase I implementation. Prior to restoration implementation, transects were surveyed in control main channel locations upstream and downstream of the Project footprint and upstream, middle, and downstream portions of the unrestored backwater which was converted to side channel habitat during implementation. Post project, surveys were expanded to also include the upstream and downstream portions of newly constructed alcove habitat. All surveys were led by a biologist or senior technician with training and experience conducting snorkel surveys. Snorkeling methods were consistent with other studies (Edmundson et al. 1968, Hankin and Reeves 1988, Jackson 1992, McCain 1992, Dolloff et al. 1996, Cavallo et al. 2003). Habitats were snorkeled by two adjacent snorkelers moving upstream for margin habitats and downstream for mid-channel habitats. Fish were counted by species and size class (0 – 50 mm, 51 – 80 mm, 81 – 100 mm, 101 – 120 mm, 121 – 150 mm, 151 – 200 mm, 201 – 300 mm, and >301 mm) and counts later converted to densities (fish/m2) using transect length and visibility to calculate total area sampled.

In 2014, 2016, 2020 and winter 2021, data was collected on standardized paper datasheets and manually entered into an Access database. Beginning in 2021, data collection was transitioned to a digital collection app built by CFS and data was pushed into Access using R, version 4.0.3 (R Core Team 2020). Paper datasheets all went through a double-blind quality control process wherein a technician compared the datasheets to a report of the data entered into Access. Any changes were made to the database and the process was repeated by a different technician. After two round of quality control, the data was considered fully QC’d and ready for cleaning in R using the *dplyr* package, version 1.0.3 (Wickham et al. 2021) Data cleaning was accomplished by compiling data and running it through a series of checks to ensure that all data was present and fell within appropriate boundaries for each data type. Any outliers or issues were investigated by the data manager and the database was updated and corrected when possible. If crucial data was completely missing, transects or data subsets were excluded from the dataset prior to analysis.

Data were analyzed in R and plots were constructed using the *ggplot2* package, version 3.3.3 (Wickham 2016) and the *ggpubr* package, version 0.4.0 (Kassambara 2020). Separate analyses were conducted for juvenile Chinook salmon and *O. mykiss*. Densities were first compared across locations (upstream, middle, downstream) within habitats to ensure non significance before aggregating transects by habitat. BACI analyses were completed using the aov function from the *stats* package, version 4.0.3 (R Core Team 2017) to construct models containing period (pre-, post-project), treatment (main channel control, Project off channel), month, and the interaction of period and treatment and factor significance was assessed using the Anova function from the *car* package (Fox and Weisberg 2019) to calculate Type II Sums of Squares. For significant effects, pairwise comparisons were performed using Shaffer’s stepwise extension of the Tukey test to control for family-wise error (Shaffer 1986) and the glht function in the *multcomp* package, version 1.4-16 (Hothorn et al. 2008). A threshold of α = 0.05 was used to assess significance of model factors. However, post hoc tests were performed using a family-wise error rate of α = 0.1 because the Tukey test is known to be over-conservative and thus a higher value of α increases the power of post hoc testing with little chance of achieving a family-wise error rate of even 0.05 (Quinn and Keough 2002). Quantitative comparison between off channel habitat types (alcove and side channel) will be conducted when additional years of data have been collected.

# Geospatial Data

Geospatial data (shapefiles) were offloaded from the GPS unit following field data collection, differentially corrected if necessary, exported into the project folder, and visually inspected in ArcGIS or QGIS by a field crew member to ensure the data exported completely and correctly.

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