**Shifting patterns of production in Alaska’s largest watersheds**

Introduction

Management and resource allocation of Pacific Salmon present a significant challenge due in part to the diverse life history strategies of salmon subpopulations. It is this diversity, however, which plays a key role in maintaining population stability (Moore et al., 2021). Much in the same way that investment diversity within a financial portfolio stabilizes returns from market variability, genetic and life history diversity among salmon stocks dampen variability in returning spawners by distributing risk among subpopulations in different geographic regions (Schindler et al., 2010, 2015). Shifting configurations of habitat and biological responses across space and time serve to increase population diversity and population resiliency by creating a continuum of habitat types which may be preferable to locally adapted populations under various environmental conditions (Brennan et al., 2019, Stanford et al., 2005, Ward et al., 2002). Maintaining habitat and life history diversity may therefore be key to maximizing climate adaptation and maintaining resilience under global change (Moore and Schindler 2023). However, how salmon stocks respond to environmental changes at regional spatial scales remains poorly documented in systems that remain intact and presumably functioning as they should in the absence of habitat fragmentation and degradation.

Salmon bearing watersheds in Western Alaska have remained relatively untouched compared to their southern counterparts in the U.S. and Canada. However, there has been a recent decline in returns of western Alaska Chinook salmon which has led to significant strife for both subsistence and commercial fisheries (Brown & Godduhn, 2015; Schindler et al., 2013). This has motivated increased interest in strategies to understand the degree of spatial diversity in these watersheds, which may provide insight into regional effects of climate on sub stocks or inform management strategies to maximize life history diversity across space and time. In addition, identifying regions of the watershed which disproportionately contribute to overall run success over multiple years may aid in identifying tributaries or sub-basin regions to be prioritized for conservation purposes. In total, a better understanding of the spatial ecology of Chinook salmon in western Alaska may provide valuable insight into methods to best rebuild and conserve struggling stocks while maximizing population resilience to climate change through the conservation of life history diversity.

Isotope ratios in the ear stones of fishes, or otoliths, have been used to estimate the spatial distribution of provenance for salmon in western Alaska watersheds (Brennan et al., 2017, 2019). Otoliths, which grow continuously and sequentially over the individual’s lifetime, faithfully record elemental and isotopic signatures into a metabolically inert calcium carbonate structure. As a result, these structures act as a time capsule of environmental and life history characteristics of discrete points in the individual’s life. One such signature is the relative ratio of Sr87/Sr86, which varies naturally across the landscape because of geological diversity, has shown to be temporally stable, and is not biologically fractionated as it is incorporated into the otolith. For geologically diverse landscapes such as those in portions of Alaska, the isotope ratio found in the otolith can therefore be used to posthumously estimate a geographic location of provenance for returning salmon caught in the downstream fishery. At the population scale, this method can can therefore be used to reconstruct the spatial distribution natal rearing habitat for fish returning each year.

These reconstructions have been used to demonstrate the highly dynamic patterns of salmon production over space and time, elucidating the scales at which the portfolio effect can contribute to stability in stock productivity through a shifting habitat mosaics of salmon production (Brennan et a., 2019). However, these ecosystem patterns have only been explored at short (3 year) temporal scales and have not been investigated in the Yukon or Kuskokwim River basins, which contribute the majority of Chinook salmon in Alaska. As a result, it is not readily known how patterns of production are distributed across these systems in space, how these patterns change over time, and at how this variability may contribute to a portfolio effect which maximizes population scale resiliency.