**Interim progress report**

Project title: Keogh River Academic Research 2018-2019

Purpose: Examine linkages between environmental drivers and population dynamics of steelhead and other salmonids on the Keogh River

Project description and progress:

This project examines several facets of the population dynamics of steelhead and other salmonids on the Keogh River. The steelhead life-cycle, among other salmonid species, have been studied since 1976, making it the best dataset in the world on this species. We have several overarching goals for this project including: (1) to quantify temporal trends in salmon productivity on the Keogh River, (2) assess species interactions and environmental drivers controlling salmon productivity, and (3) understand what drives the anadromous life-history strategies in Keogh steelhead. Most recently, PhD candidate Colin Bailey had an article accepted for publication in *Environmental Biology of Fishes* on how steelhead, cutthroat trout, and coho salmon can aggressively interact for limited numbers of pink salmon eggs – but competitive interactions varied by species, densities, and also body sizes. This work highlights the need to understand how these competitive interactions may lead to broader population-level consequences (see section 2).

For section 1, we are assessing the temporal trends in population productivity using historical data on steelhead, coho salmon, pink salmon, dolly varden, and anadromous cutthroat trout. We have accomplished three major aims for this section of the project. First, we have compiled available time-series of population dynamics for all 5 species on the Keogh River since 1976, including additional pink and chum salmon data since 1953 from DFO escapement dataset. This data includes adult spawner abundance, out-migrating smolt abundance, and age- and size-structure of the steelhead population. This dataset is still going through the last stages of quality control to understand and correct for any discrepancies in the recently organized historical dataset and previous applications by provincial biologists in FLNRO. Second, we have developed a simulation test for a version of the time-series analysis that relies on a state-space model to recover accurate estimates of species productivity through time. This model will allow us to quantify the extent of changes in species’ productivity through time. Last, in February 2019 we met with several experts at the University of British Columbia Institute of Oceans and Fisheries on state-space models (Dr. Carl Walters and Roberto Licandeo) to help guide appropriate application of fitting this model to Keogh River stock-recruitment data. Preliminary results from this analysis suggests a changepoint in density-dependent steelhead recruitment occurring in 1992 (supporting previous studies on the Keogh in Atlas et al. 2015).

For section 2, we are using the compiled dataset to evaluate the role of competition (or facilitation) between these species across life stages and marine and freshwater environments. We want to use this information to determine whether changes in marine or freshwater conditions explain observed declines in Steelhead productivity. Analyses for section 2 will follow the model developed in section 1. Briefly, we will use the state-space model to ask whether specific environmental covariates at previous time periods, like temperature or interspecific abundance, influence species abundance at a current time. We will develop this model in such a way to allow us to test competing hypotheses of competition/facilitation, freshwater survival, and marine survival as key drivers of species productivity. The dataset for this model has been nearly finalized, but the model has not yet been applied to test the competing hypotheses.

Section 3 examines what explains steelhead life cycle diversity. The historical dataset for this model has been constructed and has 10,224 individuals measured for body size and age across three life stages (parr, smolt, and adult/kelts). The Keogh dataset captures 20 unique combinations of freshwater and ocean ages showing tremendous diversity in how adult steelhead vary in the timing of their outmigration from freshwaters and their spawning migration from the Pacific Ocean. For comparison, Moore et al. (2014) found 16 unique combinations of freshwater and ocean ages for adult steelhead across the entire Nasa and Skeena watersheds. We have observed ~60 unique manifestations of the anadromous life-history strategy on the Keogh River since 1976. The most common life-history strategies observed including (in order of frequency): the 3.2, 3.3, 2.2, 2.3, 4.2, 3.2s, 3.1s1, and 2.2s life cycles where numbers left of the “.” indicate freshwater age and numbers and letters right of the “.” indicate their adult life cycle (including repeat spawning events and years in the ocean between spawning). In comparison, Moore et al. (2014) found 36 unique manifestations of the life-history strategies across the entire Nass and Skeena watersheds. A word of caution remains as this data will need to have careful quality control as the life-cycle model will be sensitive to biases in freshwater and ocean ages.

Goals to accomplish by end of fiscal:

1. Assess the temporal trends in population productivity (e.g., stock-recruitment) using available data on Steelhead, Coho Salmon, Pink Salmon, Dolly Varden, and anadromous Cutthroat Trout
2. Evaluate the role of interspecific competition (or facilitation) at different life stages and marine and freshwater conditions on changing productivity, particularly regarding Steelhead declines
3. Develop an integrated life cycle model to understand trends and drivers of the tremendous diversity in anadromous life-history strategies within Keogh steelhead.