University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

CAMERON FRESHWATER

BSc (Queen's University, 2012)

"Ecological Drivers of Variation in Juvenile Sockeye Salmon Marine Migrations"

Department of Biology

Tuesday, October 17, 2017
1:00 P.M.
Clearihue Building
Room B021

Supervisory Committee:
Dr. Francis Juanes, Department of Biology, University of Victoria (Co-Supervisor)
Dr. Marc Trudel, Department of Biology, Uvic (Co-Supervisor)
Dr. John Dower, Department of Biology, UVic (Member)
Dr. John Volpe, Department of Environmental Studies, UVic (Outside Member)

External Examiner:
Dr. Jonathan Moore, Department of Biological Sciences, Simon Fraser University

Chair of Oral Examination:
Dr. Brian Starzomski, School of Environmental Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Animal migrations are often associated with high mortality due to increased energy expenditure, reduced foraging opportunities, and increased predation risk. Migratory traits such as body size, phenology, or use of stopover habitats may moderate individual risk to mortality mechanisms and influence patterns of survival. However, variability in migratory traits is rarely quantified in detail because tracking many individuals over large areas is logistically challenging. In this dissertation, I used otoliths to examine migratory variability among and within sockeye salmon (*Oncorhynchus nerka*) populations, a species that has recently experienced declines associated with poor survival during juvenile marine migrations. Broadly, I examined the individual and environmental drivers of migratory patterns, as well as how variation across ecological scales (individuals, populations, and years) contributed to migratory diversity. First, I conducted a laboratory study to validate the use of otolith microstructure techniques in sockeye salmon post-smolts. Next, I assessed how a suite of ecological processes could interact to create a latitudinal gradient in sockeye salmon body size. By reconstructing individual growth and migration histories I determined that variation in size was correlated with ocean entry size and phenology, rather than differential marine growth or size-selective mortality. I then used estimates of migratory rate from otoliths to demonstrate that juvenile sockeye salmon exhibited distinct migratory phenotypes associated with ocean entry traits. Larger individuals migrated rapidly offshore, while smaller fish reared for several weeks in nearshore regions. Furthermore, a subset of the smallest individuals entered the ocean late in the year, migrated particularly slowly, and may have overwintered on the continental shelf. These linkages between ocean entry and migratory traits suggest juvenile sockeye salmon exhibit substantial migratory plasticity associated with carry-over effects from freshwater residence; however juvenile salmon may also respond strongly to variable conditions in marine habitats. In my fifth chapter, I compared marine growth and migration phenology in years with low and high competitor densities. After accounting for freshwater density-dependent effects, growth rates were similar in both years, but mean migration rates were nearly 50% faster in the high-density year. Migratory behavior may be used to buffer individuals from the effect of competitive interactions. In my final chapter, I sampled 16 Fraser River sockeye salmon populations to explore variation in the timing and duration of early marine migrations. Although populations differed in downstream migration timing, as well as their duration of residence within nearshore habitats, there was substantial variation within each population and between sampling years. These findings suggest individual characteristics and stochastic processes interact with population-specific strategies to shape migratory phenologies in this metapopulation. Management actions should account for and preserve migratory diversity at multiple ecological scales to maintain resilient salmon populations into the future.