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

of

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MSc (University of Victoria, 2009)
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“Fine-scale structure in the ecology of juvenile Chinook Salmon at sea”

Department of Biology

Tuesday, December 8, 2020
2:00 P.M.
Conducted Remotely

Supervisory Committee:
Dr. Francis Juanes, Department of Biology, University of Victoria (Supervisor)
Dr. John Dower, Department of Biology, UVic (Member)
Dr. Marc Trudel, Department of Biology, UVic (Member)
Dr. Patrick O’Hara, Department of Geography, UVic (Outside Member)

External Examiner:
Dr. Jeannette Zamon, Research Fisheries Biologist, National Marine Fisheries Service

Chair of Oral Examination:
Dr. Kate Moran, School of Earth and Ocean Sciences, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract
Fisheries oceanography often aims to link large scale atmospheric and oceanic processes to variability and trends in the productivity of economically and ecologically valuable fish species. Declines in productivity of multiple species of Pacific Salmon (genus *Oncorhynchus*) in recent decades have spurred the search for a ‘smoking gun;’ an explanation that could explain trends in productivity across populations, regions and species. Despite extensive investment of research effort and funding, such an explanation remains elusive. The lack of a unifying explanation for declining productivity of Pacific Salmon may be due to the spatial and temporal complexity of their interactions with the marine environment. This complexity has historically been understudied, in part due to logistical limitations of research on Pacific Salmon at sea.

This dissertation reports the results of a detailed study of how juvenile Chinook Salmon *O. tshawytscha* interact with marine habitats during their first summer and fall at sea. I first developed and validated a novel, hook and line-based method of sampling juvenile Chinook Salmon (microtrolling). I then reviewed and empirically compared methods (insulin like growth factor-1 concentration, RNA to DNA ratio, and scale circulus spacing) for indexing growth rate of juvenile salmon sampled in the ocean, a variable which is hypothesized to be related to subsequent survival. I integrated microtrolling with small vessel oceanography to relate distribution, diet, size and growth of juvenile Chinook Salmon to local scale variation in water column properties (stratification) and zooplankton community composition and abundance for five sites in the Southern Gulf Islands of the Salish Sea during a single summer (2015). While both stratification and zooplankton abundance and composition varied between sites, I failed to find support for the hypothesis that juvenile salmon distribution and growth was positively related to water column stratification at fine spatial scales. Juvenile Chinook Salmon were larger and faster growing where juvenile Pacific Herring *Clupea pallasii* were important in their diets, suggesting that Pacific Herring may play an important role in structuring the ecology of juvenile Chinook Salmon at sea. I built on 2015 results to conduct a detailed case study of juvenile Chinook Salmon ecology at two sites in the Southern Gulf Islands: Sansum Narrows and Maple Bay. Juvenile Chinook Salmon were consistently larger, more piscivorous, and faster growing at Sansum Narrows than Maple Bay across two years (2015 and 2016) despite lower zooplankton abundance at Sansum Narrows. Hydroacoustic surveys in September 2017 confirmed prior qualitative observations of elevated occurrence of forage fish schools (likely
age-0 Pacific Herring) at Sansum Narrows, and a novel, mobile acoustic tag tracking survey suggested that fish tagged at Sansum Narrows may co-locate with juvenile Pacific Herring over the tidal cycle. By relating a scale circulus spacing-based growth index to reconstructed size intervals I found that juvenile Chinook Salmon at Sansum Narrows had been faster growing that those at Maple Bay before the transition to piscivory, and perhaps before migration to the ocean. These results suggest that intrinsic growth potential, or growth conditions during freshwater rearing or the transition to marine residence, interact with fine-scale structure in marine habitats to regulate growth potential of juvenile Chinook Salmon at sea. These factors also likely interact with the basin and interannual scale processes that have received extensive study as regulators of marine survival of juvenile Pacific salmon. These complex interactions should be taken into account when designing or interpreting studies to determine factors limiting productivity of Pacific Salmon populations.