Hakai

Juvenile Salmon Report

April–September 2018

Recent Key Findings:

- *First proof of the trophic gauntlet hypothesis—that migration through the Discovery Islands and Johnstone Strait is a stressful period for juvenile salmon*
    - *Zooplankton biomass is depleted in the area in support of low secondary production*
    - *Juvenile salmon feeding success reflects prey availability*
    - *Slow juvenile salmon growth corresponding with poor feeding conditions*
- *Dynamic migration behavior revealed through comparison of Hakai and DFO catch and tagging data*
- *Pink salmon dominated 2018 catch*

Scientific Context and Goals

Salmon are iconic in British Columbia. Their abundance has sustained life on this coast since time immemorial. First Nations and commercial fishermen have built their livelihoods on these flashes of silver with succulent red flesh that is as important to the ecosystem as it is to the economy. However, numbers of this natural resource have decreased at an alarming rate and questions remain about the causes of the downturn.

Recent studies have identified that juvenile survival in the marine environment is a critical period of the life cycle where little is known. For juveniles heading to sea from the Fraser River, a majority are thought to travel through the Strait of Georgia, Discovery Islands, and Johnstone Strait. Understanding this early migration from British Columbia's largest fishery is vital to its long-term survival.

Hakai researchers are well-suited to answer these questions about early life history from their base at the Quadra Island Ecological Observatory, in the center of the geographic constrictions that naturally force juvenile salmon into one of a few narrow routes to sea. In partnership with researchers at the University of British Columbia, Simon Fraser University, the Pacific Salmon Foundation, and Fisheries and Oceans Canada (DFO), Hakai brings together a truly interdisciplinary research program with high frequency sampling of oceanographic conditions and trophic ecology using the latest genomic technology to understand the population as it passes through.

From the environment to the individual fish, we are acquiring a data set that will provide us with unparalleled detail into these juveniles. We examine how differences in oceanic conditions through both space and time influence individual fish, their growth, and the broader food web that supports their development. We are also looking into their migration timing, rates of fish passage, and how the specific routes they are using affect their survival. Last, pathogens and parasites that are harmful to the health of the young fish are investigated. Through this work, we will resolve the factors controlling the growth, the condition, and the survival of young salmon during this crucial phase.

Recent Progress

The recent field season was rather productive. We collected over 1,200 fish during the season and, having learned from prior years, we had considerably higher survival rates for our acoustic tagging program. With the Marna Lab on Quadra Island nearing completion

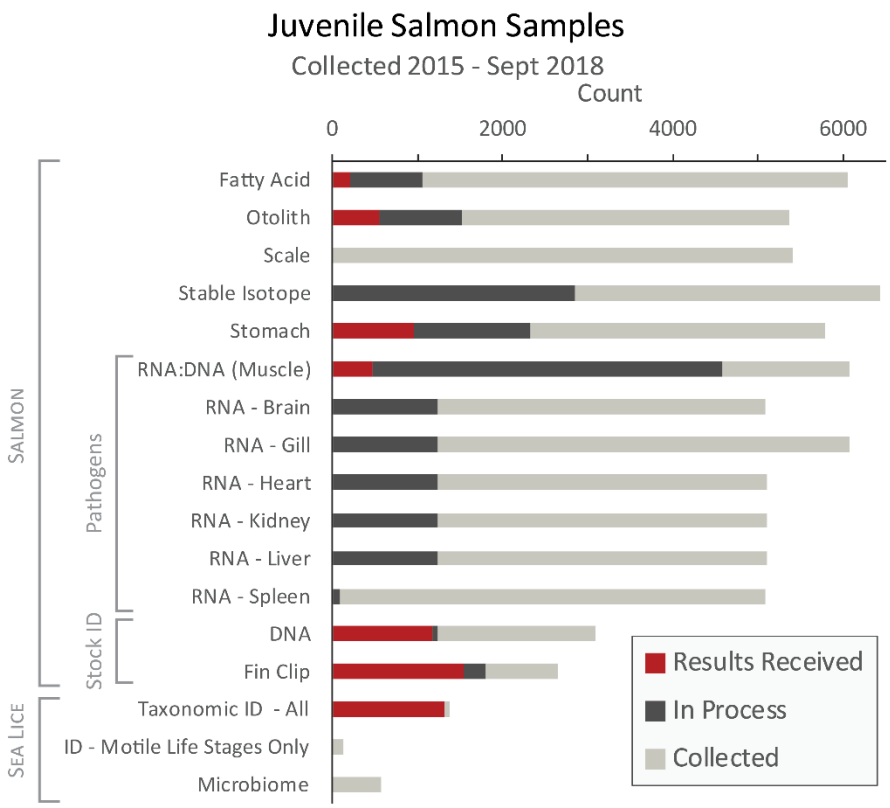

Figure 1: Quantitative summary of all samples collected through the Juvenile Salmon Program.

this summer, we were able to conduct our first fish holding study to examine the effect of surgical tagging on survival. No significant effect was detected indicating that field survival rates are not influenced by tagging.

Of those fish collected, nearly 400 were dissected for sampling and various analyses at the Pacific Biological Station (PBS) through our partnership with Fisheries and Oceans Canada. Also in the lab, we were able to complete the analyses examining both the fatty acids and the ratio of RNA to DNA, which tells us about the growth rate of the individual, from some samples collected in 2015 and 2016. Finally, the sockeye Stock ID from 2017 was completed, also at PBS.

We are proud that early results from this work have been published through the North Pacific Anadromous Fish Commission in two publications detailing the scope of the program and the migration data from 2015 through 2017. Results from our work may also be found online to facilitate communication of results between publications.

Despite some delays to the beginning of fish processing this summer, thanks to prioritizing preparation of samples destined for analyses at PBS, we were able to meet the vast majority of our goals over this six month period. We have refined our protocol for sea lice collection to now occur in the field. The adjustment has led to both more data and more time available in the lab for other tasks.

Looking Ahead

We are currently wrapping up the laboratory processing of fish collected this summer. To improve our technical capacity, Carly Janusson is getting trained by post-doc Jessica Garzke on the RNA:DNA analysis of fish growth rates so that this work may be completed on Quadra in the future.

By the time of this reporting, we will have scheduled the stock ID analysis with DFO and have had a recent workshop to review past data and plan for the 2019 field season. For this season we will be ordering two new seine nets to replace the existing nets which after four seasons are suffering from wear and tear. The additional nets will also lead to greater efficiency during the field season, allowing concurrent sampling of fish for lab analyses and tagging.

Over the winter, four publications are currently in preparation. Spatial variability in zooplankton

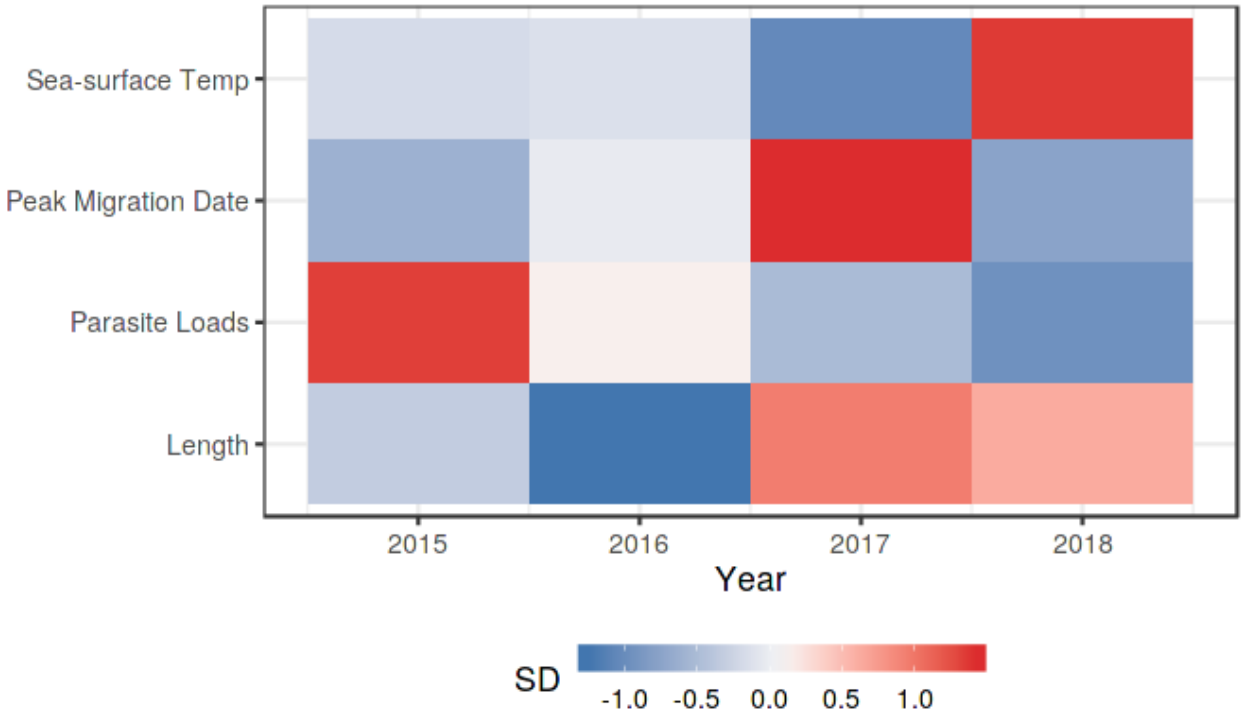

Figure 2: This heat map indicates the Z-score, the number of standard deviations (SD) from the time series average (2015–2018), for key migration parameters for juvenile sockeye salmon captured in the Discovery Islands and Johnstone Strait. Blue color indicates less than average, white indicates average, and red indicates greater than average.

This may be interpreted: Sea-surface temperature was below average temperatures for the record (blue) for 2015–2017, but was much warmer than average in 2018. The peak migration in 2017 was particularly late. Parasite loads have been decreasing throughout the time series. And last, the length of the juveniles has been longer in 2017–2018 than the first years sampled.

Mean sea-surface temperature is 30 m depth integrated temperature from station QU39 in the Northern Strait of Georgia from May and June. Peak migration date is based on the median date of sockeye capture in the Discovery Islands. Parasite load is the average prevalence of all sea lice species in their motile life stage for both the Discovery Islands and Johnstone Strait regions combined. Lengths are compared to the mean length of sockeye from both regions.

communities is being summarized by N. Mahara while juvenile growth rates are being summarized by J. Garzke. Where and how the salmon are migrating and feeding are currently being written by S. Johnson and S. James respectively. Working on these papers for publication will prepare us for the Salmon Ocean Ecology meeting in Portland, Oregon next May.

Collaborations and Summary

This work is done in collaboration with 30 researchers at institutions around British Columbia including DFO, University of British Columbia, Simon Fraser University, and the Pacific Salmon Foundation. Significant (>$100,000) funding has been leveraged in support of the fatty acid and isotopic analyses from DFO's Strategic Program for Ecosystem-Based Research and Advice (SPERA) fund to measure fish health and the food web pathways in the Strait of Georgia. Additional funds (>$200,000) have been leveraged through MITACS partnerships with both the Tula Foundation and the Pacific Salmon Foundation in support of the postdoctoral salaries for D. Costalago, J. Garzke, and H. Dosser, as well as five graduate students in 2017/18. The addition of an NSERC scholarship for Yuliya Kuzmenko and an aboriginal fellowship for Vanessa Fladmark brings the total support leveraged for this work to nearly $500,000.

We look forward to building on our successes and making continued progress this coming year. Now that we have proven the trophic gauntlet hypothesis, we look forward to building on our current findings, including experimentally testing the impacts of ocean conditions on salmon survival. This new understanding about the early life history will further help us to preserve these important species.

Publications (n = 4)

(Hakai researchers in bold)

Hunt, B.P.V., **B.T. Johnson**, S.C. Godwin, M. Krkosek, E.A. Pakhomov, and L. Rogers. 2018. The Hakai Institute Juvenile Salmon Program: early life history of sockeye, pink and chum salmon in British Columbia, Canada. NPAFC Doc. 1788. 14 pp.[PUBLISHED]

Irvine, J.R., T. Beacham, J. King, C. Neville, K. Dunmall, S.C.H. Grant, and **B.P.V. Hunt**. 2018. Canadian research planned for 2018/19 relevant to the 2016–2020 NPAFC Science Plan. NPAFC Doc. 1791. 3 pp. [PUBLISHED]

Johnson, B.T., J.C.L. Gan, C.V. Janusson, and **B.P.V. Hunt**. 2018. Juvenile salmon migration dynamics in the Discovery Islands and Johnstone Strait; 2015–2017. NPAFC Doc. 1790. 10 pp. [PUBLISHED]

Mahara, N., Pakhomov, E.A., **Jackson, J.M.**, **Hunt, B.P.V.,** 2018, Seasonal zooplankton development in a temperature semi-enclosed basin: two years with different spring bloom timing. Journal of Plankton Research. [SUBMITTED]

Conferences and Presentations (n = 10)

Costalago, D., **Hunt B.P.V.**, Forster, I. Plankton food-web pathways to juvenile salmon. Isotope Ecology conference, 30 July – 3 August 2018, Vina del Mar, Chile. Poster.

Hunt, B.P.V. Environmental (e)DNA and its applications in forage fish research. DFO National Workshop on Filling in the Forage Fish Gap, 13-15 Mar 2018, Nanaimo, BC. Oral.

Hunt, B.P.V. Hakai Institute Juvenile Salmon Program – migration dynamics. DFO Salmon Migration workshop, 25 Apr 2018, Nanaimo, BC. Oral.

Hunt, B.P.V., Batten, S., Costalago, D., Espinasse, B. Forster, I., Garzke, J., Neville, C., Pakhomov, E., Perry, I., Smith, W., Integrating stable isotope approaches for Pacific salmon life history analysis. Isotope Ecology conference, 30 July – 3 August 2018, Vina del Mar, Chile. Oral.

James, S., Pakhomov, E.A., **Hunt, B.P.V.** 2018. Characterizing the diets of juvenile Fraser River sockeye salmon across ocean regimes in coastal British Columbia. Pacific Ecology and Evolution Conference, 24 Feb 2018, Bamfield. BC. Oral.

James, S., Pakhomov, E.A., **Hunt, B.P.V.** Characterizing the diets of juvenile Fraser River sockeye salmon across ocean regimes in coastal British Columbia. Salmon Ocean Ecology Meeting, 1 Mar 2018, Newport, Oregon. Oral.

Johnson, B., Hunt, B, Jackson, J., Barrette, J., Hare, A., Quadra Island Ecological Observatory; Ocean Conditions, Juvenile Salmon Migrations, and Data Management. BCSFA Research Priorities workshop, 11–12 Jun 2018, Courtenay, BC. Oral.

Kuzmenko, Y., Pakhomov, E., **Hunt, B.**, Spesivy, T., Egorova, Y., Johnson, S. Food deprivation records in the otoliths of juvenile sockeye salmon (*Oncorhynchus nerka*). 6th International Otolith symposium, Keelung, Taiwan, 15-20 Apr 2018. Poster

Smith, W.D., Espinasse, B., Pakhomov, E.A., **Hunt, B.P.V.**, Retracing habitat use and movement patterns of sockeye salmon (*Oncorhynchus nerka*) in the North Pacific Ocean. 6th International Otolith symposium, 15-20 Apr 2018, Keelung, Taiwan. Poster.

Spesivy, T., Pakhomov, E., **Hunt, B**., Kuzmenko, Y., Hall, M., Extraction of high resolution juvenile life history information from adult otoliths of diadromous fishes. 6th International Otolith symposium, 15-20 Apr 2018, Keelung, Taiwan. Oral.

External Media Coverage (n = 0)