Juvenile Salmon Migration Dynamics in the Discovery Islands and Johnstone Strait in 2018

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ABSTRACT

The majority of out-migrating juvenile Fraser River salmon (*Oncorhynchus* spp.) pass northwest through the Strait of Georgia, the Discovery Islands, and Johnstone Strait. The Discovery Islands to Johnstone Strait leg of the migration is a region of poor survival for juvenile salmon relative to the Strait of Georgia. To better understand the factors that are driving early marine survival through this region the Hakai Institute Juvenile Salmon Program monitors key aspects of this migration. Here we report on the 2018 migration in comparison to averages from the 2015–2018 study period, which we use to define 'normal' in our building time series. In 2018 sockeye (*O. nerka*), pink (*O. gorbuscha*), and chum (*O. keta*) all migrated earlier than normal, though not more than by a week. The median capture date in the Discovery Isalnds was May 23rd for sockeye, five days earlier than normal; and June 12 for pink and chum, which is five days earlier for pink and three days earlier than normal for chum. Sea lice prevalence was lower than normal for sockeye, pink, and chum. Notably, there were no *Lepeophtheirus salmonis* sea lice observed in Johnstone Strait in 2018. Sockeye were longer than normal in 2018 whereas pink and chum were smaller than normal. Pink salmon dominated the catch in 2018, followed by chum, and then socke Sea surface temperatures in May and June were the warmest on record in the study period (2015–2018). ye.

INTRODUCTION

The first months after marine entry have been identified as a potentially critical period (R. Beamish and Mahnken 2001) for salmon stock recruitment, which may ultimately be responsible for inter-annual variability and long term declines in salmon stocks in British Columbia (Peterman et al. 2010; R. J. Beamish et al. 2012). Pathogens, parasites, predators and the impacts of climate change on food web dynamics have emerged as leading causes for the decline. The Hakai Institute Juvenile Salmon Program has been monitoring juvenile salmon migrations in the Discovery Islands and Johnstone Strait (Figure 1) since 2015 in an effort to understand what factors may be influencing early marine survival of sockeye, pink, and chum (Hunt et al. 2018). This report summarizes migration timing, fish length, parasite loads, species composition, and sea-surface temperature observed from the first 4 years of this research and monitoring program. These estimates will provide the context from which to investigate questions and interpret results related to growth, survival, and the conditions salmon experience during their migration through this critical region.

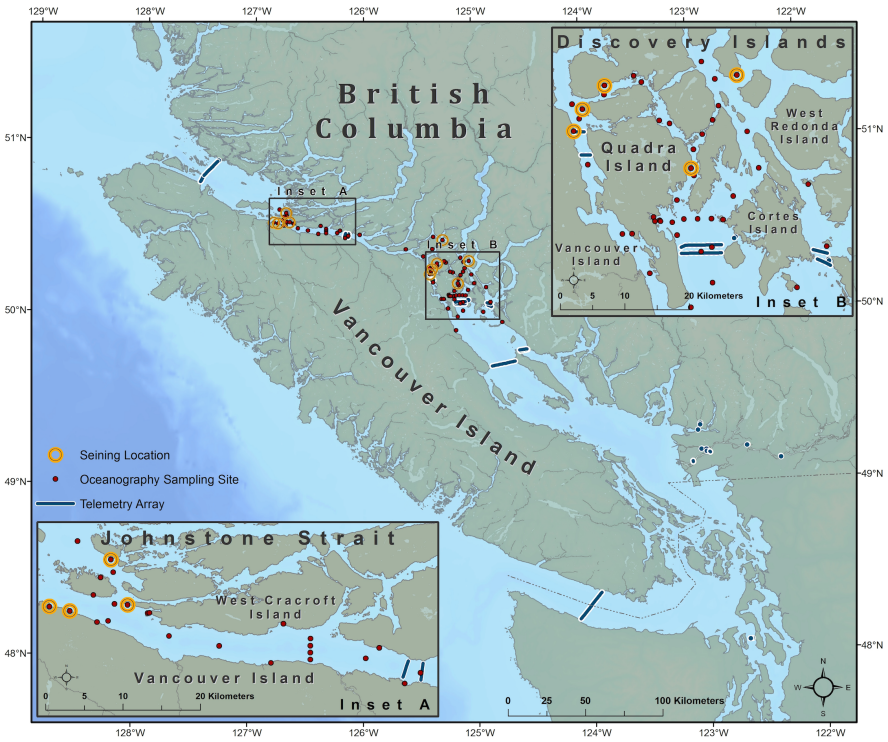

Figure 1. Sampling locations in 2018

METHODS

Field methods

See Hunt et al. (2018) for a detailed description of field and lab methods. Briefly, we collect juvenile salmon weekly from the Discovery Islands and Johnstone Strait during their northward migration from the Strait of Georgia to Queen Charlotte Strait near northern Vancouver Island, British Columbia. Sampling is conducted from May to July each year since 2015 using purse seine nets (bunt: 27 m x 9 m with 13 mm mesh; tow: 46 m x 9 m with 76 mm mesh). We sample in nearshore marine habitats with depth $>$ 10 m and effectively sample sockeye (*Oncorhynchus nerka*), pink (*O. gorbuscha*), chum (*O. keta*) and incidentally capture coho (*O. kisutch*), chinook (*O. tshawytschya*) and Pacific herring (*Clupea pallasii*). All animal care was in accordance with Animal Care Guidelines under permit A16-0101. Temperature data were collected by deploying an RBR conductivity, temperature, and depth profiler to depths $>$ 30 m at station QU39 (Figure 1) in the northern Strait of Georgia.

Statistical methods

All metrics reported are in relation to the time series average (2015-2018). The mean for each parameter of interest was calculated for all years combined, and the z-score was calculated for each parameter to determine the number of standard deviations away from the mean a given parameter was in each year.

The peak migration date for each species was estimated by calculating the median date of capture in the Discovery Islands—the date at which 50 percent of the fish passed through the region. Because very few pink are caught in odd years, only even years were included in the calculation of the time serie average. To visualize migration timing we plotted cumulative catch abundance between May 1st and July 9th each year and fit a logistic growth line. Species proportions were calculated by dividing the total number of each species caught, by the sum of all species caught that season. Only seines that contained sockeye were used in the calculation of species proportions, so in effect this species proportion measure is representative of the salmon community composition that co-migrate with sockeye. Fork length distributions were visualized by calculating kernel density estimates from fork length data. The prevalence, intensity, and abundance of sealice was calculated as detailed in Margolis et al. (1990). The mean sea surface temperature was calculated from the top 30 m of the water column in May and June from

all years. To visualize temperature anomalies we applied a loess regression to sea surface temperatures from all four years to develop a model that would represent the seasonal trend.

RESULTS AND DISCUSSION

Migration Timing

Migration timing in the Discovery Islands in 2018 did not differ from the time series average by more than a week for sockeye, pink, or chum. The peak migration date for sockeye in the Discovery Islands was on May 23, 5 days earlier than average of May 28 (z-score = -0.71) (Figure 2). The peak migration date for pink in the Discovery Islands was on June 12, 5.25 days earlier than average of June 17 (z-score = -0.38). The peak migration date for chum in the Discovery Islands was on June 12, 2.5 days earlier than average of June 14 (z-score = -0.29).

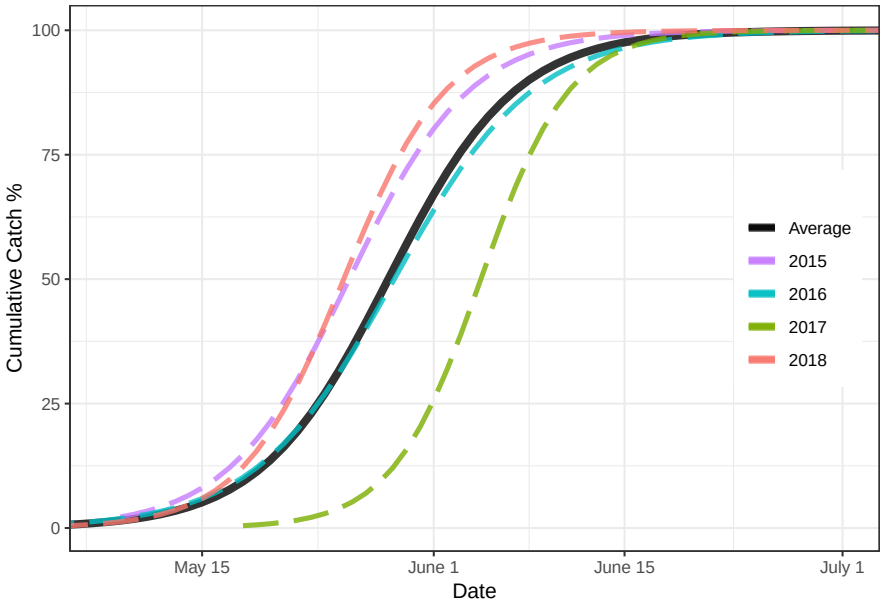

Figure 2. Cumulative catch of juvenile sockeye salmon migrating through the Discovery Islands compared to the average for 2015–2018. Migration curves were predicted by fitting a logistic growth equation to the cumulative percent of sockeye in each year.

Table 1. Migration timing statistics for the cumulative catch of sockeye, pink, and chum salmon in the Discovery Islands in 2018, compared to the time-series average.

Species	Year	Q1	Peak Date	Q3
Sockeye	Average	May 26	May 28	June 04
	2018	May 23	May 23	June 04
Pink	Average	June 06	June 17	June 22
	2018	June 07	June 12	June 12
Chum	Average	June 06	June 14	June 22
	2018	June 07	June 12	June 20

Length

Fish lengths varied between regions, species and year (Figure 3). In 2018 Sockeye lengths were on average 116.9 mm, which is 8.9 mm longer than average ($p < 0.0001$, 95% CI 6.2, 11.7). Pink lengths were on average 96.3 mm, which is 8.8 mm shorter than average ($p < 0.0001$, 95% CI 10.9, 6.7). Chum were on average 103.4 mm, which is 7 mm shorter than average ($p < 0.0001$, 95% CI 8.9, 5).

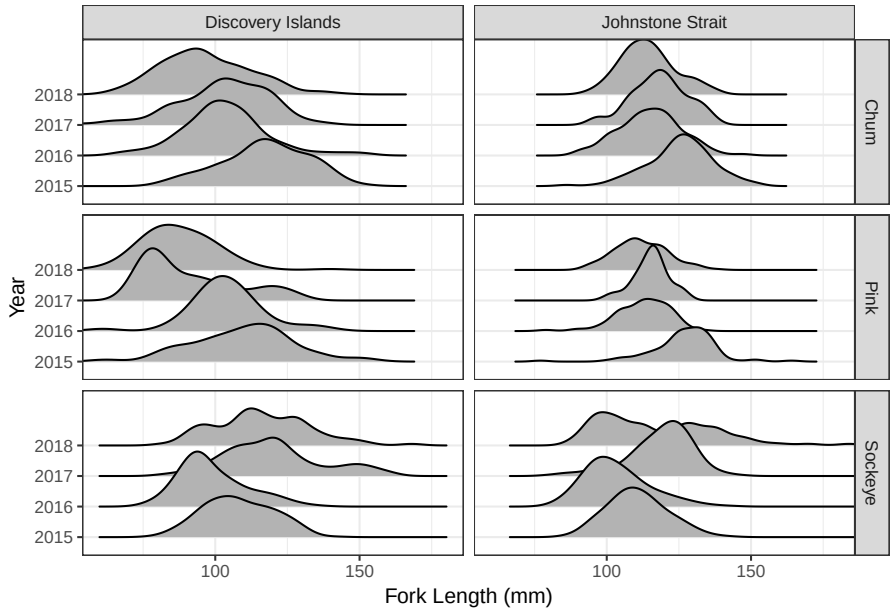

Figure 3. Kernel density distributions of juvenile salmon fork lengths for each year in the selected region. Note that these distributions contain multiple age-classes.

Species Proportions

Pink salmon dominated the catch in the Discovery Islands and Johnstone Strait in 2018 making up 51.9 percent of the catch while chum made up 32.4 percent and sockeye 12.9 (Figure 4).

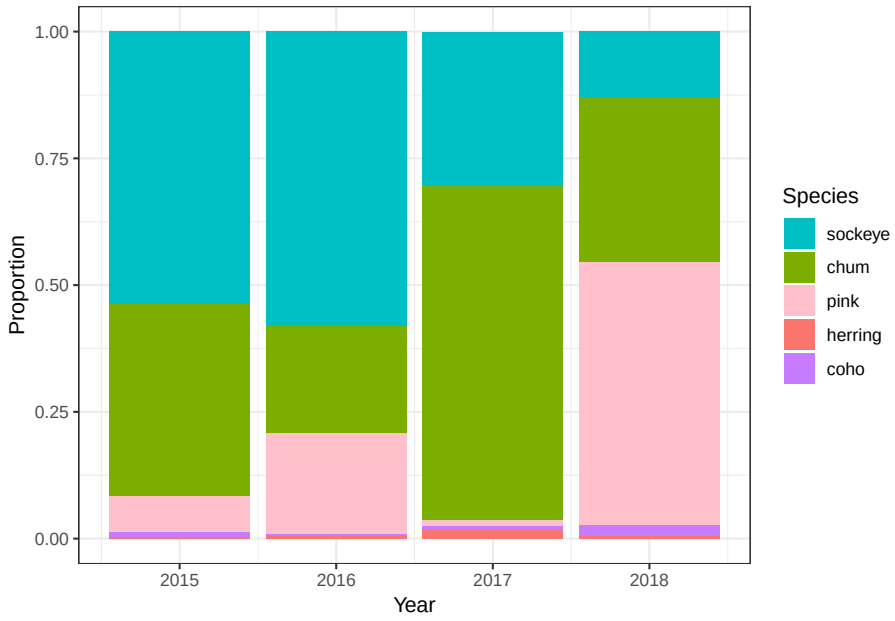

Figure 4. The annual proportion of fish captured in the Discovery Islands and Johnstone Strait combined.

Parasite Loads

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## [1]  1.36612945 -0.42022364  0.03189039 -0.97779620
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Across the Discovery Islands and Johnstone Strait, parasite loads were 11.8 percent less than average (Z = -0.98) The prevalence of motile (pre-adult and adult life stage) sea lice in 2018 was the lowest recorded in the time-series (Figure 5). Notably, no *Lepeophtheirus salmonis* were detected on sockeye in

Johnstone Strait, despite being present in the Discovery Islands. Pink salmon appeared to have higher counts of *Caligus clemensi* in 2018 compared to chum and sockeye.

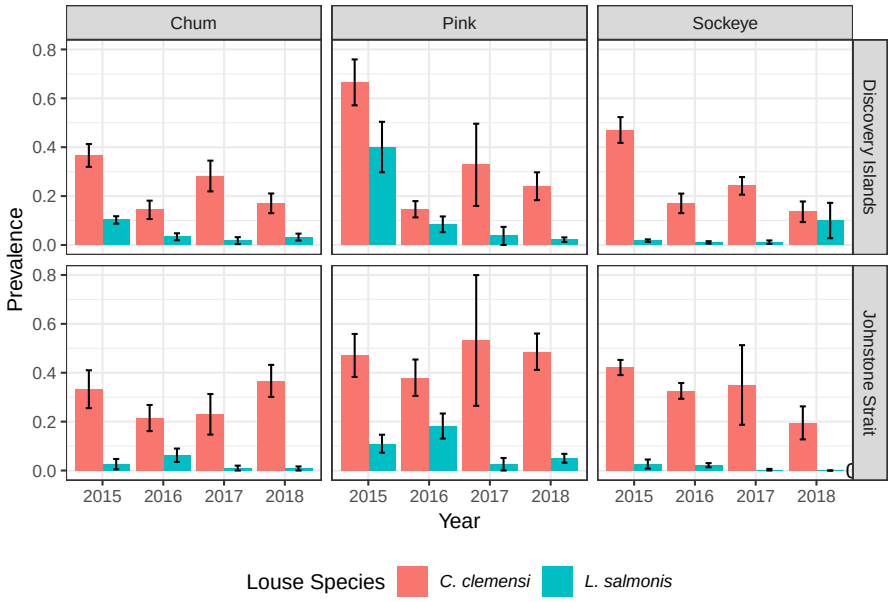

Figure 5. The prevalence (+/-SE) of motile sea lice on juvenile salmon in the Discovery Islands and Johnstone Strait.

Sea Surface Temperature

Sea-surface temperatures in May and June at QU39 in the northern Strait of Georgia was 0.39 degrees C warmer than normal (Z = 1.33). Sea surface temperatures between May and July of 2018 were warmer than the time series average. (Figure 6)

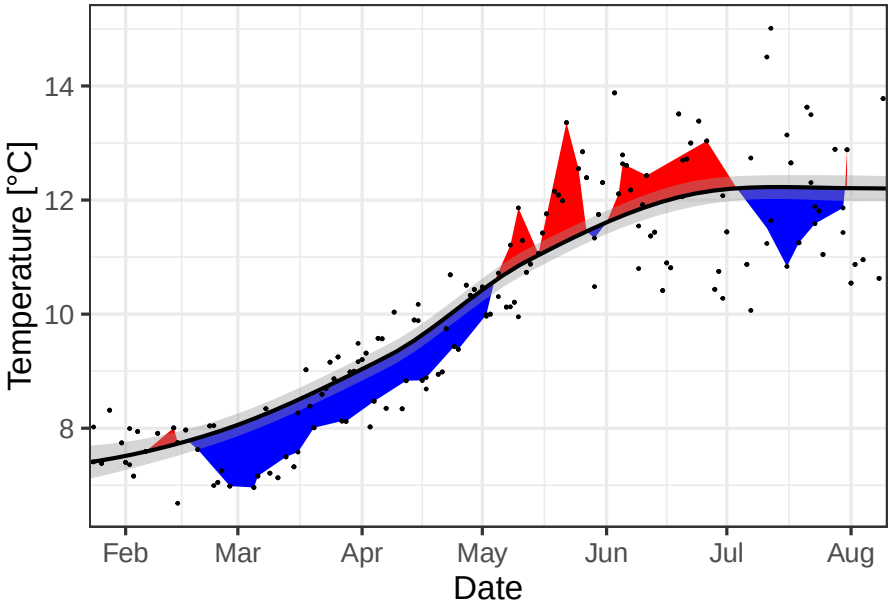

Figure 6. Time series of 30 m depth integrated temperature anomalies observed at Hakai Oceanographic Monitoring station QU39. Blue areas represent temperatures that are below normal, red areas represent above normal temperatures at the selected station in 2018. Normal is the solid black line which is a loess regression based on temperatures from 2015-2018. The shaded grey area is 1 SE of the loess regression. The black dots are the daily minimum and maximum temperatures observed over the time series.

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